Town of Stony Plain
Flood Mitigation Program

Final Report
(REV0)

Prepared for: Town of Stony Plain
Prepared by: Sameng Inc.
Project No.: 1364

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List of Acronyms and Abbreviations

ACRP	Alberta Community Resilience Program
ACRWC	Alberta Capital Region Wastewater Commission
AEP	Alberta Environment and Parks
Ave	Avenue
Blvd	Boulevard
cm	Centimetre
CN	Canadian National Railway
Creek	Whispering Waters Creek (typical)
DFO	Department of Fisheries and Oceans
DWF	Dry Weather Flow
H	Height
ha	Hectare
HWY	Highway
I/I	Inflow / Infiltration
L	Litre
m	Metre
mm	Millimetre
N	North
Rd	Road
s	Second
SWMF	Stormwater Management Facility
W	Width
WWF	Wet Weather Flow

Corporate Authorization

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PROFESSIONAL SEAL

May 8, 2020

Maxime Belanger, M.Sc., P.Eng.

CORPORATE SEAL

2020-05-08

Sameng Inc. – APEGA Permit to Practice P2863

1.0 Introduction

1.1 Project Background

On both July 7th and 15th, 2019, very intense rainfall events hit the Town of Stony Plain. On both days, the peak runoff flow and volume from these rainfalls was so significant that it caused a substantial increase in water level in Whispering Waters Creek and other creeks flowing through the Town. In some section of Whispering Waters Creek, the high-water level overflowed trails, roads, and private properties. Both rainfalls also caused a substantial amount of flooding on roads and private properties throughout the Town. In some areas, the surface ponding flooded residences, businesses, and vehicles. Furthermore, many residences and businesses reported sanitary sewer backups, primarily due to rainwater entering the sanitary sewer system.

1.2 Report Overview

Sameng Inc. (Sameng) was retained by the Town of Stony Plain (the Town) to provide engineering services for the "Town of Stony Plain Flood Mitigation Program" as well as the Town's "Inflow and Infiltration Study". This report focuses on the flood mitigation program, while the inflow and infiltration study report will be submitted under a separate cover.

The following is an overview of the report.

- **Section 1.0** introduces the report including project background and objectives.
- **Section 2.0** provides a summary of data collected and a review of background information.
- **Section 3.0** summarizes the computer modeling efforts including a summary of the model calibration and validation, and wet weather flow characterization.
- **Section 4.0** summarizes the July 2019 rainfall event and summarizes the key flood mechanisms.
- **Section 5.0** focuses on Whispering Waters Creek and includes a description of the Creek, a summary of its current performance and deficiencies, and options to reduce flood risks in and around the Creek.
- **Section 6.0** focuses on flood risks in eight areas of the Town (Area A to Area H). This section provides an overview of current flood risks in these areas, as well as recommended storm and sanitary improvements to achieve a 100-year level of flood protection. This section also summarized sanitary manhole inflows, and recommendations to reduce such inflow.
- **Section 7.0** provides a summary of the costs, benefits and the recommended implementation strategy.
- **Section 8.0** is the conclusion and recommendations.

1.3 Project Objectives and Scope of Work

The key objective of this project is to develop a comprehensive flood mitigation strategy and concept-level designs for the Town of Stony Plain that will identify both short- and long-term flood mitigation solutions such that flood protection of critical areas can be improved as soon as possible or practical.

The scope of work is to identify and assess current flood risk in critical parts of the Town, especially areas that flooded in July 2019; develop cost-effective flood mitigation improvements that will improve the level of flood protection for these areas, including concept-level design drawings; and develop cost estimates, benefit quantification and an implementation strategy.

2.0 Data Collection and Review of Background Information

2.1 Collected Data

Data collected and reviewed during this study include, but may not be limited to:

- **Previous Studies, Reports and Documents:**
  - Town of Stony Plain – Overview of July 2019 Intense Rainfalls and Floods, Preliminary Findings and Recommendations (Sameng Inc., August 2019)
  - Town of Stony Plain – Stormwater Master Plan 2018 (Sameng Inc., April 2019)
  - Town of Stony Plain – Water and Sanitary Master Plan Update (Associated Engineering, March 2019)
  - Alberta Disaster Assistance Guidelines (Government of Alberta, 2019)
  - Town of Stony Plain – Sanitary Collection System – Master Plan Update (Associated Engineering, January 2008)
  - Big Lake Basin Task Force – Big Lake Stormwater Management Plan (Associated Engineering, May 2004) (only the Introduction and the Conclusions and Recommendations sections were available for review)
- **Design and Record Drawings:**
  - Alberta Transportation – Highway 779:02 Water/Drainage Works – Highway Improvements – Town of Stony Plain (Issued for Tender, Associated Engineering, 2017) – used to add new pond and Highway culvert upgrade to system assessment/model.
  - Whispering Cove Lot Grading Plan Drawings (Issued for Town Comments, LWS Group, February 2003)
  - Town of Stony Plain – Central Sanitary Trunk Sewer Rehabilitation (Issued for Tender, Associated Engineering, 1999)
  - Record drawings for most of the Town
- **Computer Models**
  - Storm Computer Model from Stormwater Master Plan 2018 (2019)
  - Sanitary Computer Model from Water and Sanitary Master Plan Update (2019)
- **Others:**
  - Shape File of Town's sanitary and storm sewer systems
  - Cadastral (from Town)
  - LiDAR
  - Flood Photos from July 2019
  - Rainfall Data from Environment and Climate Change Canada for the 'AB Edmonton Stony Plain, XPS' gauge.
  - Air photos (from Google Earth)
  - Land Ownership Map

2.2 Survey and Site Investigations

Surveys and site investigations were completed by Sameng during this and previous studies. Of note:

- On July 29 and August 15, 2019, after the intense Summer storm events, Sameng visited some of the culverts along Whispering Waters Creek (mainly south of the railroad) to confirm their condition and identify any main reason for the flooding. We also had a brief look at the surface condition of sanitary manholes. During this visit, minor damages to culverts were identified, some debris and blockage at some culvert inlets were observed, some sedimentation at the outlet of the culverts was noted, and a few sanitary manholes that were likely flooded by the high Creek flows were identified. There were no major concerns identified with the culverts and the Creek itself. However, we did have concerns with some of the sanitary manholes that are in the floodplain of the Creek, some of which had large gaps between the manhole steel frame and the concrete barrel/rings. More on this in Section 6.13.2.
- From December 18 to 20, 2019, sanitary manholes along Whispering Waters Creek were surveyed to confirm their elevation and inspected to confirm their condition. Other sanitary manholes at critical road depressions throughout the Town were also surveyed to confirm their horizontal alignment and vertical elevation. Key issues and concerns with inspected manholes are summarized in this report.
- On January 7, 2020, culverts along Whispering Waters Creek were surveyed and their diameter measured using a measuring tape for increased measurement accuracy. This report reflects these more accurate measurements.

2.3 Was the Central Sanitary Trunk Upgraded?

According to the City's online GIS database (Figure 2-1), the 'Central Sanitary Trunk Sewer Rehabilitation' project designed in 1999 is considered as 'existing'. This project consists of the twinning of the existing sanitary trunk from Brown Street just north of 50 Avenue, across the railroad, and tying back into the existing sanitary trunk south of 44 Avenue. The existing trunk is 525/600mm in diameter, and the proposed trunk bypass was designed as a 750mm pipe.

However, the collected sanitary model did not include this sanitary trunk bypass pipe. The Town utilities cadastral also does not show this twinning. It should be noted that the design drawings were labeled as "Issued for Tender", not "Issued for Construction" nor "As-Built" nor "Record Drawings", suggesting this may not have been constructed.

Consequently, we investigated to see if we could confirm the presence of the trunk bypass by opening some manholes and seeing if any of the proposed manholes were installed. None of the proposed manholes could be found. The upstream and downstream manholes, where the flow was supposed to split and converge, also showed no visible sign of the proposed bypass pipe. Therefore, for purposes of this study, the bypass sanitary trunk was assumed as inexistent.

The existence or non-existence of this proposed sanitary trunk should be confirmed by the Town.

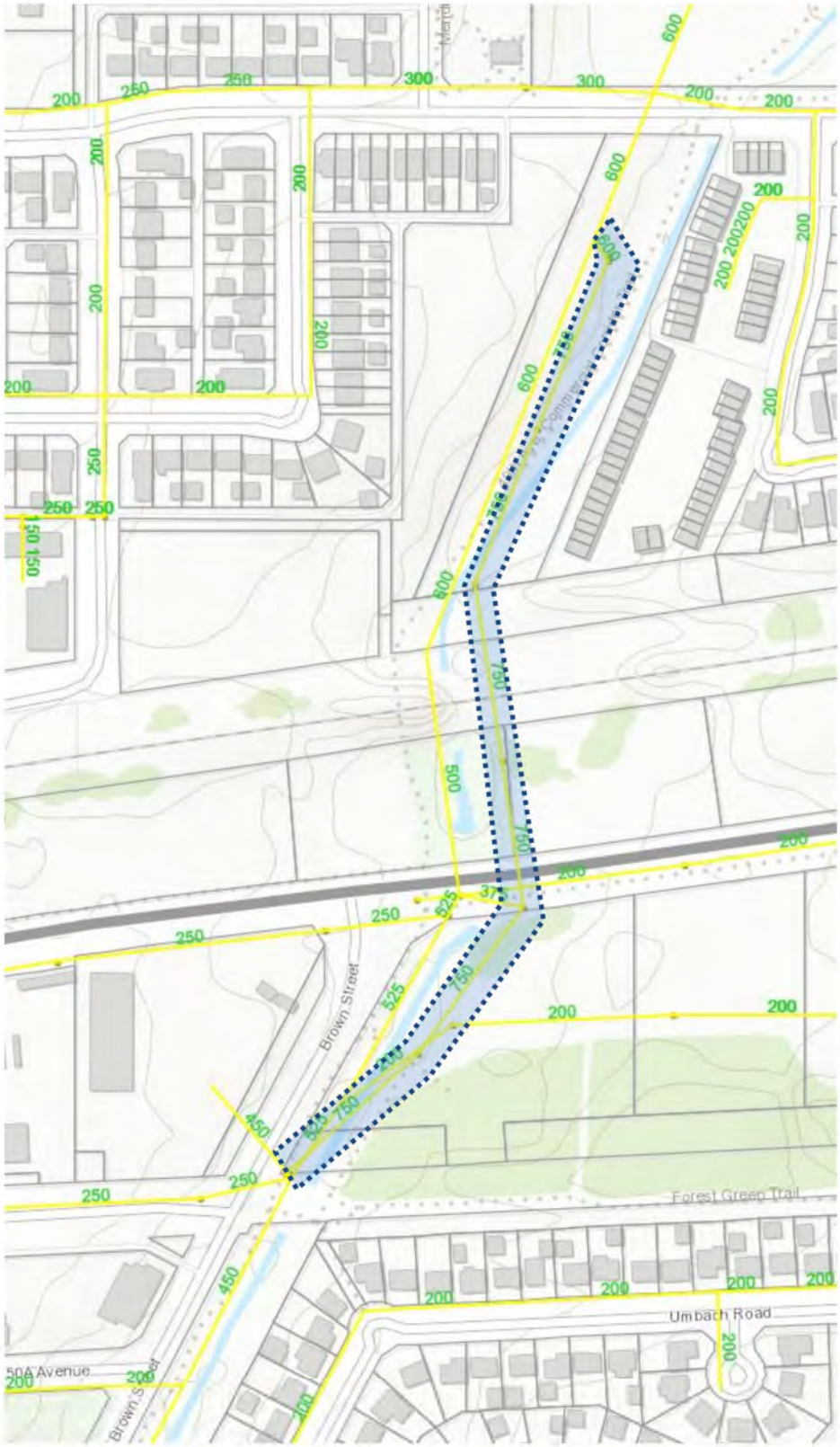


Figure 2-1: Town GIS database available online, showing 750mm bypass sanitary trunk line (in blue hatch). This sewer is believed to be non-existent.

2.4 2020 Monitoring Program

FLOW MONITORING GAUGE – SANITARY SEWER SYSTEM

To better quantify wet weather flow contributions and monitor water level fluctuations in the Town's sanitary sewer system, flow monitoring gauge locations are recommended for the Spring/Summer 2020 season. A list of ten (10) sites for flow monitoring sites were identified, strategically located to collect the best range of data, as listed in Table 2-1 and shown in Figure 2-2. If the Town cannot install that many gauges, the list provided in Table 2-1 is in order of priority; at a minimum, we recommend that the first five listed gauges (F1 to F5) be installed. It first focuses on measuring flows from the Central Trunk and areas which experienced flooding in July 2019, then on flows from each main trunk, and finally on flows from more localized area. If the Town can install even more gauges, additional gauge locations can be provided. The more gauges the better, as it provides a more comprehensive understanding of the flow characteristics in different parts of Town, and it allows to identify areas where high wet weather flows are of concern. These gauges should be installed in early May 2020, remain at the same location for the entire year, and removed prior to cold weather in the Fall. This process should be repeated yearly, at the same or new locations, depending on the gauge location and the findings.

FLOW MONITORING GAUGE – STORM SEWER SYSTEM

We do not recommend installing flow monitoring gauges in the storm sewer system or in any of the creeks at this time; primarily for financial reasons. The flow gauges should be focused on the sanitary sewer system.

RAIN GAUGE

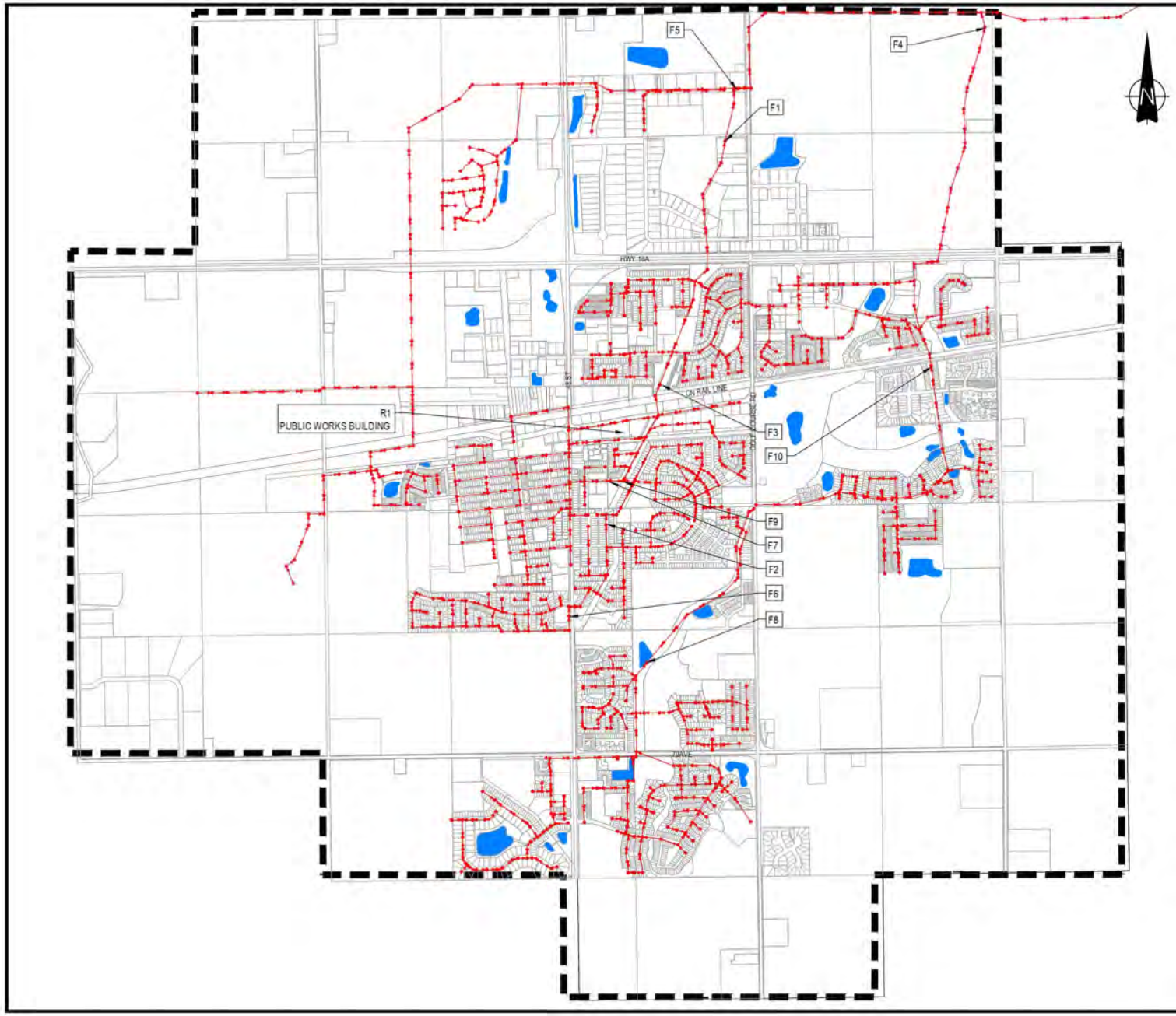
In additional to the flow monitoring gauges, at least one rainfall gauge should be installed and collect local rainfall data at minimum 5 minutes interval. It is recommended that the rainfall gauge be installed at the Town of Stony Plain Public Works Building located on 50 Avenue, west of Brown Street. See R1 on Figure 2-2 for proposed rain gauge location. This site is centralized in the City, such that all the currently developed areas of Town are within 3 km from that site, and majority of the development is within 1.5 km from it. In comparison, in the City of Edmonton, rain gauges are spaced such that most properties are within 2 to 3 km from a rain gauge, with some properties as far as 5 km from a rain gauge, especially in the newer developments.

If the Town wants to invest in a second gauge, it is recommended that the gauge be installed to the south of the Town. This is to capture rainfall data for the upstream portion of each trunk systems, as well as estimating rainfall runoff coming from upstream undeveloped basins, south of the Town boundary. A good location for a second rain gauge site would be near the Highway 779 (48 Street) and Highway 628 (79 Avenue) intersection, potentially on the church site to the southeast which has a large grassed surface, or in the commercial development to the southwest. There is also a pond to the southeast that could be used. The rain gauge site could be fenced for security.

Table 2-1: Proposed Flow Monitoring Gauge Location

Location Name	MH ID	Pipe ID	Pipe Diameter (mm)	Description
F1	CT-03	618	600	At downstream end of Sanitary Central Trunk, in the North Business Park subdivision. This will monitor all flows into the ACRWC system coming from the Central Trunk, which has the most concerns. This gauge will be installed at same location as before.
F2	CT-34	650	450	In the Sanitary Central Trunk, on 46 Street south of 54 Avenue. This will monitor sanitary sewer flows in the upstream section of the trunk where substantial sewer backups happened in July 2019.
F3	CT-18	633	600	In the Sanitary Central Trunk, just downstream of the railroad. This location, combined with Gauge F1 and F2 will be able to characterize sanitary sewer flows for the middle portion of the trunk.
F4	ET-2	680	900	At the downstream end of the Sanitary East Trunk. This will monitor all flows into the ACRWC system coming from the East Trunk, which services a large area. This will be primarily to identify any issues with wet weather flows within that trunk system. If concerns are identified, then it would justify adding more gauges in the upstream reaches of that trunk to pin-point the issues.
F5	R-A14	806	600	At the downstream end of the Sanitary West Trunk, but within the ACRWC system. This will monitor all flows into the ACRWC system coming from the West Trunk and the Meridian Height/North Catchment. This will be primarily to identify any issues with wet weather flows within that trunk system. If concerns are identified, then it would justify adding more gauges in the upstream reaches of that trunk. If unable to install the gauge in the ACRWC system, that gauge would need to be installed further west and multiple gauges may be needed to measure flows coming from various areas.

Location Name	MH ID	Pipe ID	Pipe Diameter (mm)	Description
F6	79-69	400	300	At the upstream end of the Sanitary Central Trunk, this gauge would measure flow rates upstream of the areas most at risk of flooding further north in the trunk system. This would identify any concerns with these upstream flows. The sanitary sewer system in the area is known to have deficiencies and can potentially be surcharged during intense rainfall events.
F7	78-29	264	300	Located near the center of the Sanitary Central Trunk system, this gauge would measure flows coming from the Old Town area west of the trunk, which has a large tributary area. This would help identify any wet weather flow concerns in the older parts of the Town, and further discretize wet weather flow sources in the Central Trunk.
F8	ET-60	707	750	Located further upstream in the Sanitary East Trunk, this gauge would be able to identify the wet weather flow contribution to the East trunk coming from the newer developments to the south.
F9	CT-26	641	450	Located near the center of the Sanitary Central Trunk system, this gauge would measure flows in the trunk coming from between Gauge F2 (upstream) and Gauge F3 (downstream). Also, with F7 measuring flows coming the west, it will be possible to further pinpoint wet weather flow concerns in the part of the Town.
F10	ET-21	672	750	Located near the center/downstream end of the Sanitary East Trunk, this gauge would be able to discretize the wet weather flow contribution to the East trunk coming from the central and downstream part of the East Trunk.



LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY
- EXISTING SANITARY LINE
- EXISTING SANITARY MANHOLE
- R# RAIN GAUGE
- F# FLOW MONITORING IN SANITARY SEWERS

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Client: TOWN OF STONY PLAIN

Project: **Town of Stony Plain Flood Mitigation Program**

Title: Proposed Flow Monitoring and Rain Gauge Locations for 2020 Monitoring Program

Scale: **1:25,000**

Figure: **2-2**

2.5 Summary of "Big Lake Stormwater Management Plan"

According to the "Big Lake Stormwater Management Plan" developed in 2004, the Big Lake Basin Task Force retained Associated Engineering, together with Sameng Inc., to investigate drainage problems in the Big Lake Basin and to recommend stormwater drainage guidelines for the Basin. The following summarizes some of the key information presented in the introduction and conclusions and recommendations sections of the report.

Relevant information from the **introduction** are:

- The Big Lake Basin encompasses an area of 3,500 km^2 to the west of the City of Fort Saskatchewan. It is composed of 8 municipalities located within a major metropolitan area approaching one million people. Land uses are a mix of agricultural, urban, country residential (acreage), and recreational development.
- These kinds of development pressures inevitably put stress on the natural drainage systems. The basin is relatively flat and poorly drained and has limited outfall channel capacity. Drainage and flooding problems have been occurring in the basin including:
  - flooding along Atim Creek,
  - drainage problems in tributary streams,
  - flooding around Big Lake,
  - increasing runoff due to development,
  - encroachment of landowners and developments into the floodplains of the drainage system,
  - problems of water quality in St Albert.
- Big Lake itself is a large and significant waterbody of regional significance and is subject to a host of environmental issues and public concerns including water quality, waterfowl, flooding, and encroachment of development.
- The major issue in the basin is the lack of a clear understanding of the impact that agricultural drainage or urban development may have on flooding in the basin. There is a need for an adequate guideline that specifies how to deal with development applications and the runoff from these developments. Because a clear guideline does not exist, the developers and regulatory agencies have become frustrated.
- The overall objective of the present study is to develop a storm water management plan with long-term solutions for the Big Lake Drainage basin from Lac Ste. Anne to the North Saskatchewan River. Specific objectives of the study are to:
  - review the hydrology and drainage reports completed to date,
  - present a number of potential options and recommendations for long-term solutions that meet the needs of the member municipalities,
  - provide direction to the member municipalities and Alberta Environment for setting stormwater management requirements in future developments.
- Generally, the goals of the stormwater management plan are to:
  - facilitate orderly development,
  - prevent flooding problems downstream of development areas,
  - protect the environment (water quality, drainage and flooding),

  - plan for future generations.
- The member municipalities have created a Task Force to direct the study, as well as a technical committee which will advise the Task Force. A major objective of the study is to work with the technical committee to try to reach a consensus that meets the needs of the member municipalities.

Some **conclusions** specific to Stormwater Management are:

- For areas the size of Stony Plain and Spruce Grove (approximately 25 km^2), the pre-development flows are approximately 2.5 L/s/ha.
- Some form of stormwater management is required for all forms of development including:
  - agricultural,
  - recreational,
  - roadways,
  - rural development,
  - urban development.
- Stormwater management can consist of:
  - urban stormwater management ponds,
  - ditch controls and flow restrictions,
  - routing to natural storage areas and sloughs,
  - local storm water management ponds,
  - regional storm water management ponds,
  - channels, streams, creeks, rivers and lakes.
- The rate of release should not exceed the sub-basin pre-development rate and the downstream floodplain capacity. A stormwater management pond release rate of 2.5 L/s/ha is a reasonable balance between pond sizing and operation and downstream impacts.

  Release rates lower than 2.5 Lis/ha would result in:

  - extended drawdown times exceeding 8 days for a major storm event and an increased risk of back-to-back storm events overloading the stormwater ponds,
  - increased operation and maintenance requirements and safety and aesthetic issues due to more frequent and extended ponding,
  - increased costs to homeowners due to increased pond sizes and increased cost of development servicing.

  Release rates higher than 2.5 Lis/ha would result in:

  - a small cost savings to developers, but
  - higher downstream flows and increased risk of flooding.

Some **recommendations** specific to Stormwater Management are:

- All developments should be required to provide stormwater management including:
  - agricultural,
  - recreational,
  - roadways,
  - rural development,
  - urban development.
- A release rate of 2.5 L/s/ha is recommended for stormwater in the Big Lake basin on the basis that:
  - it is consistent with pre-development flows in the basin,
  - it represents the lower limit of pre-development flows for areas the size of Stony Plain and Spruce Grove,
  - it minimizes the operation and maintenance problems with stormwater management facilities while providing for improvements to water quality,
  - it is consistent with historic drainage facilities in the basin.
- Older areas which were developed without stormwater management should be provided with stormwater management facilities or their impacts should be mitigated.
- A mechanism should be developed whereby the various municipalities could cooperate in drainage improvements and purchase of floodplain lands for mutual benefit outside their municipal boundaries.

3.0 Computer Modeling

3.1 Overview

Computer modeling was a critical component of this project. Modeling results assisted us in identifying key issues and concerns with the drainage systems. The main outcome of the model was the identification of flood risk areas, both in terms of surface flooding and sewer backups. The model was also used to identify the impact of drainage improvements on flood risks reduction. The following provides a summary of how the computer model was used and refined for purposes of this study.

3.2 Computer Model Construction, Refinement and Discussions

The DHI Mike Urban computer modeling software was used for this project.

The model for this project was constructed using the Town's most recent storm drainage system model (dual-drainage model), constructed by Sameng in 2018-2019 for the 'Town of Stony Plain – Stormwater Master Plan 2018' project. The Town's most recent sanitary drainage system model, constructed by Associated Engineering in 2018-2019 for the 'Town of Stony Plain – Water and Sanitary Master Plan Update' project, was also used.

The two models (i.e. storm and sanitary) were combined into a single model that would model both the storm and sanitary sewer systems of the entire Town in an integrated fashion. The main advantage of the combined storm-sanitary dual-drainage model is that it can better identify the impact of surface flooding and Creek flooding on manhole inflow into the sanitary sewer system, especially during extreme rainfall events.

After the two models were combined, Sameng completed many refinements to the now combined sanitary-storm model to better represent actual site conditions. Some examples include:

1) The sanitary model did not include all manholes, and the location of the manholes and alignment of the pipes often did not align with the Town's cadastral or their actual surveyed/observed location. Some refinements to the location of these sanitary manholes and sewer pipes were completed to provide more accurate results, especially where the manhole could be flooded by street ponding. We then revised the elevation of sanitary manholes using survey (where available) and LiDAR, since most of the rim elevation in the sanitary model appeared incorrect. However, it was not in the scope of this project to completely reconstruct the sanitary sewer system in the model.
2) The model was refined particularly in flood risk areas to provide more accurate results in terms of ponding depths and extents, and overflow locations. This includes refinements to the 'surface' model and to local storm sewer system to better represent real-life conditions.
3) We added the new pond and control structure just west of 48 Street (Highway 779) and south of 57 Avenue. We also included the new culvert upgrade across this road, as per our survey, site investigations, and our review of the design drawings.

4) We revised all culvert sizes, all culvert overflow elevations, and all head losses parameters along Whispering Waters Creek. This was to have a better understanding of the flood risks in vicinity of the Creek, and to obtain more accurate results.
5) We confirmed/revised the location and elevation of most sanitary manholes located at street depressions and susceptible to being submerged by surface ponding during intense rainfall events.
6) The 'surface' model was connected to the 'sanitary system' model at all sanitary manholes. These connection points serve to add manhole inflow to the sanitary sewer system when the sanitary manholes are submerged due to large ponding depths. This is mostly necessary when modeling the system during intense rainfall events. The amount of flow entering the sanitary manholes was first estimated based on our experience with similar projects, and then calibrated using available flow monitoring data.

3.3 Model Calibration and Validation

SANITARY SYSTEM

The sanitary portion of the model was calibrated using the rainfall information that was already included in the sanitary model, as well as flow monitoring data published in the 'Water and Sanitary Master Plan Update' report, dated March 2019. It should be noted that the original data was not provided to Sameng for this calibration assessment. The rainfalls used for calibration are May 22, 2016; June 25, 2016; July 9, 2016; and May 23, 2017. See Appendix F for a comparison of measured flow data and modeled flow data, and the return period of each rainfall.

Furthermore, in July 2019, there were many reported floods throughout the Town. Although we do not know the cause for all the flood reports – for example, was it sanitary sewer backup, surface ponding flood, or just a perceived threat of flooding nearby such as high ponding depth on the street – we assumed the perceived flood risks for each area.

The sanitary component calibration consisted of the following:

1- The dry weather flow (DWF) parameters included in the sanitary model was used as-is, since it correlated well with the measured flow data.
2- The wet weather flow (WWF)'s slow-response component parameters were maintained from the original sanitary model. The slow-response WWF is generally insignificant in terms of flood risks. We assume that these parameters were calibrated in the sanitary model.
3- The wet weather flow (WWF)'s fast-response component is divided in two parts:
    a. Inflow as a percentage of the rainfall: A certain percentage of the rainfall volume was modeled to flow directly into the sanitary manholes. The calibrated inflow percentage is 0.7% for areas with weeping tiles connected to the sanitary sewers, and 0.3% for areas without. This follows a similar approach than the previous study's sanitary sewer model.
    b. Direct Manhole Inflow: This was modeled by connecting the surface drainage component to the sanitary manhole assuming four (4) vent holes per manhole. For

the sanitary manholes along the Creek, eight (8) vent holes were assumed. Surface water can only 'enter' the sanitary manhole when the surface water ponds or flows over the manhole. The number of estimated holes has a direct correlation to the amount of inflow in the sanitary sewer system. Through our calibration efforts, it was determined that the four (4) and eight (8) vent hole assumptions are reasonable and match well with the flow monitoring data. It should be noted that Direct Manhole Inflow was not part of the previous study's sanitary sewer model.

c. The above two inflow sources were calibrated conjunctly. For small rainfall events that cause minimal street ponding, the direct manhole inflow component is generally small, and the inflow as a percentage of the rainfall takes priority. This is the main parameter that was adjusted when calibrating to small rainfall events However, for intense rainfall events, the direct manhole inflow component takes priority. The number of vent holes in the sanitary manholes was calibrated for the extreme events.

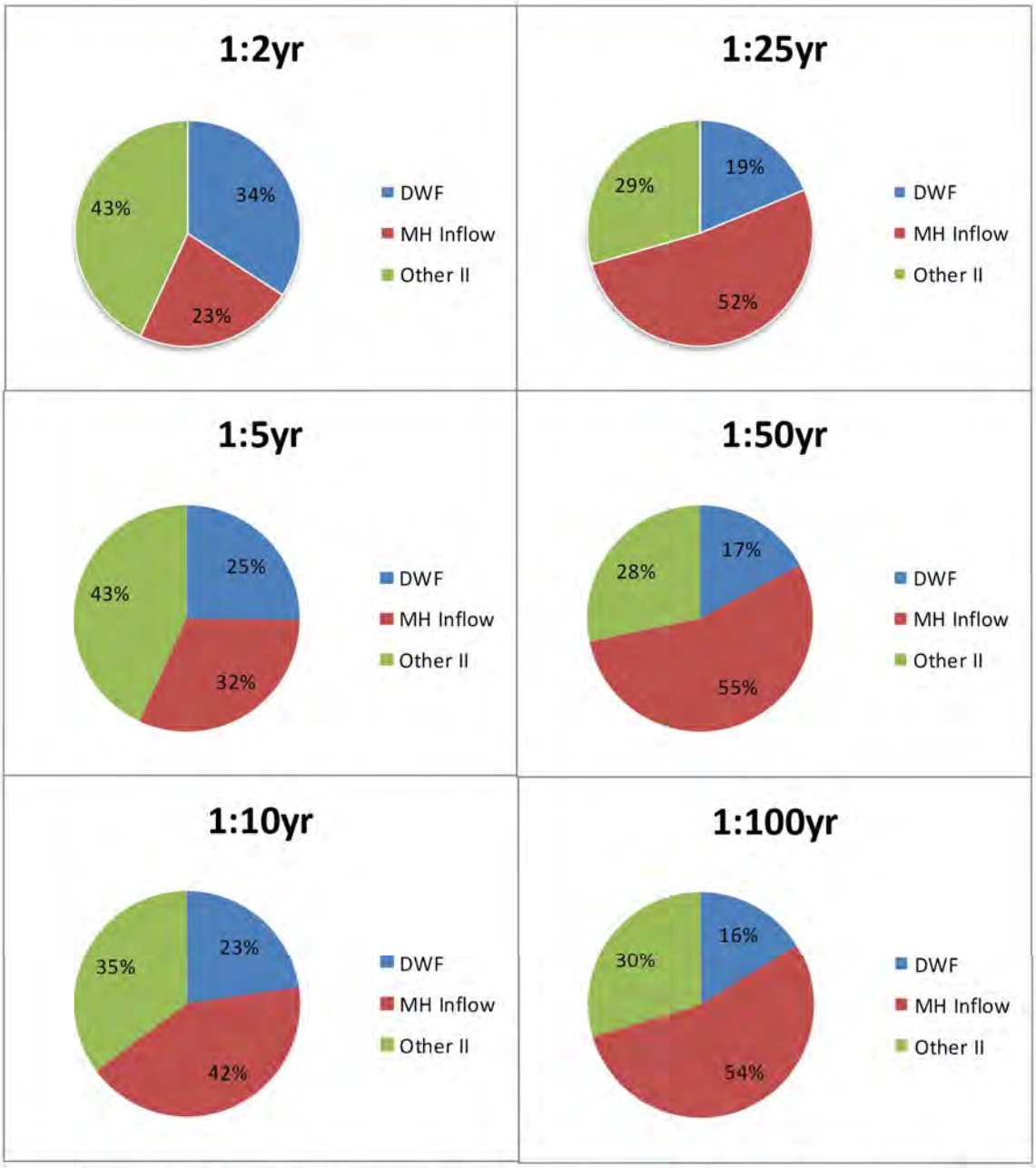
STORM SYSTEM

The storm sewer and surface drainage system model components were not calibrated furthermore during this study, considering there is no storm sewer or Creek flow monitoring data to calibrate to. Some model refinements were completed to improve on the results, especially in the areas at risk of flooding. The modeling results were validated against the street ponding extents and Creek water elevation from the July 2019 rainfalls, and were found to match quite well.

3.4 Wet Weather Flow Contribution

From the computer model and through model calibration efforts, the dry weather flow (DWF) and wet weather flow (WWF) components of the sanitary sewer system at the Sanitary Central Trunk were determined. They are shown in Figure 3-1. From this figure, it can be observed that:

- For the 1:2-year event, the total WWF contribution is 66% of the pipe flow. About 40% of the WWF comes from sanitary manhole inflow, and 60% from other Inflow/Infiltration (I/I).
- For the 1:100-year event, the total WWF contribution increases to 84% of the pipe flow. About 64% of the WWF comes from sanitary manhole inflow, and 36% from other Inflow/Infiltration (I/I).



Events	DWF		MH Inflow		Other II	
1:2yr	42 L/s	34%	28 L/s	23%	53 L/s	43%
1:5yr	42 L/s	25%	53 L/s	32%	72 L/s	43%
1:10yr	42 L/s	23%	78 L/s	42%	65 L/s	35%
1:25yr	42 L/s	19%	116 L/s	52%	66 L/s	29%
1:50yr	42 L/s	17%	133 L/s	55%	69 L/s	28%
1:100yr	42 L/s	16%	141 L/s	54%	77 L/s	30%

Figure 3-1: Peak Dry Weather Flow and Wet Weather flow Contribution in the Whispering Waters Creek according to the Computer Model, under Existing Conditions

4.0 Summary of July 2019 Intense Rainfalls and Understanding of Key Floods Mechanisms in the Town of Stony Plain

4.1 Summary of July 2019 Intense Rainfalls and Floods

On August 15, 2019, Sameng prepared a report entitled 'Overview of July 2019 Intense Rainfalls and Floods, Preliminary Findings and Recommendations'. This report provides a summary of the July 7th and 15th, 2019 intense rainfall events and floods; a preliminary understanding of key flood mechanisms; an overview of Whispering Waters Creek, its corresponding flood risks, and what could be done to mitigate these flood risks; and some overall recommendations and additional investigations that should be completed in the short-term. The following summarizes the two storm events.

- On both July 7th and July 15th, 2019, the Town of Stony Plain was hit by very intense rainfall events. These have resulted in many flooded residences and businesses, vehicles, and have caused many roadways to be covered by rainwater. The water level in Whispering Waters Creek was very high for many hours following the rainfall events.
- The July 7th event was assessed as a 1-in-80 year, 40-minute duration event (44mm of rain) and the peak of the rainfall happened around 3:15PM.
- The July 15th event was assessed as a 1-in-130 year, 50-minute duration event (55mm of rain) and the peak of the rainfall happened around 7:10PM.

4.2 Reported Floods

Historical flood reports are only available for the July 2019 events, and the reported flood data is quite sparse. Many residents called or sent letters to the Town office, Councillors and the Mayor to report flooding. An illustration of all reported flood locations on private properties, as compiled and provided by the Town, is provided in Figure 6-1. To summarize:

- Approximately 46 residences and businesses reported to have flooded to the Town. Many others are believed to have also flooded but have not reported the floods to the Town.
- Most of the reported floods were:
  - in the Downtown area (generally within a couple blocks from the 50th Street and 52nd Avenue intersection) – Area D;
  - along 46 Street from 54 to 55 Avenue – Area F; and
  - along 57 Avenue west of 51 Street – Area H.

Flood reports are particularly useful when trying to identify the flood mechanisms and to establish high risk areas. For example, if there are many flood reports on a given street, the floods were likely caused by a systematic failure of the drainage system, and it might be possible to resolve it through cost-effective sewer and drainage improvements. On the other hand, if only one house on a block reported flooding, then the problem might be considered localized and of low risk.

4.3 Why do Intense Rainfalls cause Floods?

Both the July 7th and the July 15th, 2019 rainfalls were very intense and generated a lot of runoff volume within a short amount of time (within an hour). Such high intensity storms are often responsible for widespread flooding on roads (primarily at depressions) and in areas with a poor major drainage system and no stormwater management facilities (typically in the older areas). This is because the storm sewer system is typically only sized to carry the peak 1:5-year flows within the piped system. Considering that the 1:100-year rainfall event generates about 2.5 times the runoff volume of a 1:5-year rainfall event within the same period of time, this additional runoff must be temporarily stored on the ground surface (often for many hours) and/or overflow to the next depression by gravity (i.e. via the major drainage system). It should be noted that some of the Town storm sewer pipes are too small to even convey the peak 5-year rainfall event such that surface ponding may happen for even smaller rainfall events.

Newer neighbourhoods are designed with sewers sized to convey the 5-year event, and a proper major drainage system that allows the peak 100-year flows to be conveyed safely to a stormwater management facility with controlled surface ponding at shallow depressions. Consequently, newer neighbourhoods rarely flood. When they do flood, the flooding generally only causes minor street flooding, not private property flooding, and is more a nuisance than a flood concern.

Older neighbourhoods (pre-2000) were often constructed with poor or lack of a major drainage system. This is because provincial stormwater management design guidelines were not in place until the late 1990s. This lack of adequate major drainage system is not only a concern in the Town of Stony Plain but in many other municipalities including the City of Edmonton.

4.4 What are the Main Flood Mechanisms?

4.4.1 Overview

Through our experience with flood investigation studies recently completed for other municipalities, through the completion of the Town of Stony Plain's 2018 Stormwater Master Plan and through the completion of this flood mitigation program, we believe that residences and businesses in the Town of Stony Plain will primarily flood due to:

1) Water flowing and/or ponding on the street and reaching buildings, entering buildings through doors, windows, openings and foundation cracks;
2) High flows and high water levels in the many watercourses that flow through the Town, primarily Whispering Waters Creek;
3) Sanitary sewer backups; or
4) Other generally localized issues (e.g. sump pump failure, poor lot grading such that water flows towards the house foundation and window wells, etc.)

Confidently identifying flood mechanisms is challenging because each rainfall event is unique, and often not measured sufficiently to fully understand its spatial and temporal distribution. For example, did the July 2019 events hit the entire City all at the same time and with the same

intensity and duration? Is it likely that a 1:100-year rainfall event will hit all of the Town simultaneously?

Furthermore, each part of the Town is also unique. Some areas have weeping tiles connected to the sanitary sewer system while others have sump pumps discharging to ground or into the storm sewers; some areas have poor lot grading or are constructed at a lower elevation (thus more prone to deep street ponding), while others are well graded; some houses have sanitary backflow preventers while others do not, etc.

Also, the condition and performance of the sewer systems during the event is often unknown. For example: was there some blockage in the pipe during the event? Was hail or leaves blocking some catchbasins thus reducing their capacity? Were all manhole covers installed properly?, etc. The Town may wish to examine historic problem locations with respect to catchbasin design with the goal of improving system reliability.

The following sections provide a general overview of what might have caused flooding in July 2019, in previous years and in future years if no improvements are implemented.

4.4.2 Surface Ponding

Surface ponding generally happens because more runoff reaches the surface depression than what can leave it via the storm sewer system. This is because the storm sewer system is generally designed to convey the peak runoff flows from a 5-year event only (this is an Alberta-wide guideline). Surface ponding is often observed during intense rainfall events that are greater than a 5-year event, such as on July 7th and 15th, 2019.

Some surface ponding can often be tolerated if it is not too deep (less than about 35cm deep), and if it does not contribute to or pose any flood risk to private properties. In fact, some surface ponding in low-risk areas may even be favoured as it buffers the flows in the downstream system. The depth, duration and frequency of surface ponding is often very site-specific.

It is believed that many residences, businesses and vehicles may have flooded in July 2019 due to extensive surface ponding.

4.4.3 High Water Level in Watercourses

The Town has several watercourses conveying drainage from large areas inside and outside of the Town boundary. Many of these watercourses have culverts crossing roads and trails. These culverts are often sized to convey a certain flow rate, with any excess flows forced to backflow and be stored in the upstream reach of the watercourse. As water is stored in the watercourse, the water level rises. As the water level rises, the watercourse might overtop its banks and even overtop the crossing to continue flowing downstream.

It is normal for culverts to not be able to convey extreme flows; it would be very costly to do so. Alberta Environment's Stormwater Management Guidelines (1999) recommends that culverts should be sized to convey the 25-year flow for roads considered urban local, collector or rural

arterial, and 50-year for urban arterial and freeways. The guideline also suggests that these return periods should be modified if the flood hazard in the vicinity of the site is unusually severe.

It is also normal for watercourses to overtop their banks and the crossing itself during extreme flow conditions. Overtopping of crossings and banks is generally of minimal concern unless the water can get so high that adjacent properties and/or buildings are flooded, or if the water is so high that it affects the performance of contributing storm sewer systems and nearby sanitary sewer systems.

It is not believed that residences and businesses have flooded directly due to high water levels in watercourses during the July 2019 rainfalls. However, some roads were covered by water (e.g. Brown Street at 51 Avenue) because Whispering Waters Creek overflowed its banks, and some culvert crossings were overtopped. Also, drainage of some low-lying areas (e.g. 46 Street south of 54 Avenue) would have been much slower since the high Creek water level negatively affected the storm system hydraulics. Furthermore, the Creek is susceptible to flood sanitary manholes when it becomes too high.

4.4.4 Sanitary Sewer Backup

Sanitary sewer backups typically happen when flows in the sanitary sewer system exceed its capacity and surcharges the system. If the sanitary surcharge level exceed the basement floor level, wastewater can flow into basements via the sanitary services and through floor drains and plumbing, such as toilets, tubs, sinks and washing machines. Homeowners are often defenseless during sewer backups. However, there are some options that can be taken by homeowners to reduce the risk of sewer backups, such as installing backflow valves (albeit not failproof).

Sanitary sewer backups are often the main cause of private property floods during very intense rainfall events. Unfortunately, it is also the least understood and hardest to predict as there are many variables that can lead to sewer backups. Through previous studies, Sameng has demonstrated that rainfall induced inflows during intense rainfall events are the leading cause of sanitary sewer backups. The following lists some hypothesis as to why sewer backups were experienced in July 2019. Additional studies would be required to confirm these hypotheses.

1) Most local sanitary sewers in the Town of Stony Plain are 200mm to 300mm in diameter. These pipes have capacities ranging from about 20 to 50 L/s. These pipes are often sized to convey peak sanitary flows, some groundwater flows and minor inflow/infiltration such that sanitary sewer backups are generally uncommon during dry weather periods. However, during intense rainfall events, water can pool on the street for many hours. In some areas, the extent of surface flooding can be quite significant and can cover many sanitary manholes. Most sanitary manholes have four 25mm diameter lifting holes which also serve as air exchange. Assuming a 30cm column of water over one manhole cover, approximately 3.2 L/s of runoff will enter the manhole through these holes and will then flow into the sanitary sewer system. Assuming that ten (10) sanitary manholes are under

water, the inflow rate becomes 32 L/s which is enough to severely surcharge a 200mm diameter sanitary pipe and fill more than half of a 300mm pipe. This is believed to be one of the main reasons why flooded basements may have been reported in Stony Plain in July 2019.

2) A sanitary trunk main was constructed adjacent (west) Whispering Waters Creek decades ago and it services many areas of the Town. Many of the manholes of that sanitary trunk main are in the flood zone of the Creek, such that water from the Creek could enter the manhole and surcharge the surrounding sanitary sewer system. A site visit in July 2019 confirmed that some of these manholes have gaps capable of introducing rainwater directly into the sanitary sewer system. This could be one of the main reasons for the basement floods experienced along the Creek in July 2019 and prior years, but it needs to be confirmed through further field and desktop investigations.
3) Sanitary sewer backups can also be caused by debris and blockage in the sanitary sewers. Such blockage can be found during maintenance, inspection or cleaning of the sanitary sewers. It can be challenging to confirm whether a blockage was responsible for sewer backups.
4) Illegal connection of private roof leaders or other private drains into sanitary sewers: This is typically not common occurrence and would be very challenging to prove. We do not believe that this is a concern in Stony Plain, but it could be investigated furthermore if needed.
5) Illegal connection of catchbasins into sanitary sewers, or sanitary manholes with catchbasin-type covers: Although possible, this is not thought to be a major concern for Stony Plain. A few sanitary manholes with catchbasin-type covers were identified through site investigation; these should be corrected. Flow monitoring data should be able to identify these illegal connections.

5.0 Flood Mitigation of Whispering Waters Creek

5.1 Overview

This section describes the existing condition and performance of Whispering Waters Creek, identifies areas at flood risk along the Creek, as well as recommendations to reduce flood risks associated with high flows and high-water levels in the Creek.

5.2 Whispering Waters Creek Description

Whispering Waters Creek, shown in Figure 5-2, is one of four main watercourses that bisect the Town of Stony Plain. Whispering Waters Creek bisects the Town in a southwest to northeast direction through the older development areas. The following describes the Creek as it flows through Town.

- Drainage tributary to Whispering Waters Creek from outside of the Town boundary generally flows north towards 79 Avenue (Township Road 524) and across the road and into Town limits via a 600mm diameter culvert.
- At the upstream end (southwest corner) of the Town, from 79 Avenue to 48 Street (Highway 779), the Creek is poorly defined, shallow, wide, and generally dry; it also appears to be used for agricultural purposes.
- As it reaches 48 Street, the Creek is diverted around a newly constructed pond and into a new 1500mm diameter culvert across Highway 779. The pond was constructed in 2019 by Alberta Transportation to capture and control post-development flow from the upgraded Highway 779 into the Creek. The culvert goes underneath the St. John Paul II Catholic School parking lot.
- Once the flow gets across 48 Street, the Creek becomes well defined and flows northeast crossing a few roads, trails, a railroad, and a highway. All crossings have culverts with the exception of a few trails that have a bridge.
- To the north, the Creek crosses Golf Course Road north, and exits the Town's boundaries north of the Quance Industrial Park pond.
- The Creek has 15 culvert crossings and crosses 4 trail bridges within the Town boundaries. The most current culvert sizes and inverts are shown in Figure 5-2 to Figure 5-9.
- A total of 24 storm outfalls discharge into the Creek within the Town boundaries.
- The catchment area of Whispering Waters Creek before entering the Town is 230 ha; it is 500 ha within Town boundaries at the railroad; 107 ha between the railroad and Highway 16A; and 204 ha from Highway 16A to the Town's downstream boundary. The total drainage area of the Creek when exiting the Town is approximately 1041 ha.

5.3 Current Whispering Waters Creek Performance and Identification of Flood Risk Areas

The Whispering Waters Creek water level delineations and profiles for the 1:5-year, 1:25-year and 1:100-year design rainfall events are presented in Figure 5-2 to Figure 5-9. The following Table 5-1 identifies the flood risk areas along the Creek for design rainfalls up to the 1:100-year event. Flood risk areas are also identified in the above-mentioned figures. A summary of the key flood risks and issues associated with Whispering Waters Creek during the 1:100-year event are as follows.

WEST OF 48 STREET (THE GLENS SUBDIVISION)

The two townhouses just north of the Creek may be at risk of flooding during the 1:100-year event. The elevation of the townhouses and window wells should be confirmed via survey to confirm the risks.

55 AVENUE TO 50 AVENUE (FOREST GREEN SUBDIVISION)

The culvert at the CN Railroad is small relative to its tributary drainage area, and it causes significant backflow during large flow events. This, in combination with culvert capacity restrictions at 49 Avenue, 50 Avenue Alignment Trail and 52 Avenue results in some high-water levels and flood risks along the Creek.

- There are 3 homes that may be flooded directly due to high Creek water level on 46 Street, between 54 and 55 Avenue.
- It is estimated that an additional 23 private properties may be partially covered with some water (i.e. 46 Street between 54 and 55 Avenue; Whispering Cove north of Oatway Drive, and Umbach Road north of Oatway Drive). Some properties will be very marginally flooded, while for others, up to 0.6m of water may be expected in their backyard. Some detached garages on the back of properties along Umbach Road may be at risk of flooding.
- Brown Street will flood during a 1:25-year and larger events. Flooding of Brown Street will only affect traffic; the flooding is not a direct threat to adjacent private properties.
- 52 Avenue will flood during a 1:100-year event as the Creek water overflows the road. Traffic will be affected on both directions.

SOUTH/UPSTREAM OF HIGHWAY 16A (ST. ANDREWS SUBDIVISION)

Due to the severe flow restrictions at the Highway 16A culvert, significant backflow is expected upstream of the crossing during large flow events.

- It is estimated that 9 private properties may be partially covered with some water (i.e. backyards of properties in the northwest section of St. Andrews Drive). In fact, many of these properties will flood during events smaller than the 1:5-year event. The water will flood landscaping features and maybe some structures and content at the back of the lots, but it should remain low enough not to flood the houses. The Town should conduct field surveys to confirm the lowest house elevation backing on to the Creek, such that the flood risks can be confirmed. The following summarized some key elevations in the area:

- 1:5-year water elevation in Creek: 698.97m
- 1:25-year water elevation in Creek: 699.76m
- 1:100-year water elevation in Creek: 700.30m
- Lowest House Elevation adjacent to Creek (from LiDAR): ±701.00m
- Lowest Property Elevation adjacent to Creek (from LiDAR): ±697.55m
- Creek Bottom Elevation adjacent to properties: ±696.35m

BETWEEN BOULDER BOULEVARD AND GOLF COURSE ROAD NORTH (NORTH BUSINESS PARK SUBDIVISION)

Due to the severe flow restrictions at the Golf Course Road North culverts, significant backflow is expected upstream of the crossing during large flow events, even as small as the 1:5-year event.

- Many industrial properties just west of Golf Course Road North will flood with water covering some of their property. Two of them will be completely under water, including the building footprint.
- Golf Course Road North will overflow for rainfall smaller than the 1:5-year event.

SUBMERGED SANITARY MANHOLES

An estimated eight (8) sanitary manholes along the Creek alignment will be underwater during a 1:100-year event. Six (6) of these will also be underwater during the 1:25-year event. Four (4) of these will be underwater during the 1:5-year event. When submerged, the water pressure over these manholes forces water into the manhole through joints, cracks, and the vent holes in the manhole rim. The amount of water entering the many sanitary manholes can be significant and cause the sanitary sewer system to surcharge.

As a worst-case scenario, if one of these flooded sanitary rims were to become dislodged or shift while being submerged, the amount of Creek water flowing into the sanitary sewer trunk would be considerable and would result in significant surcharge in the sanitary trunk, which in term could lead to substantial sewer backups in low-lying areas. The sanitary manhole rims may be displaced from extreme air pressure trying to escape the sewer system.

Table 5-1: Key Flood Risk Areas and Areas of Concerns

Whispering Waters Creek Reach	Flood Risk Description
79 Avenue (South Town Boundary) to 48 Street (Highway 779) (Figure 5-3 and Figure 5-4)	▪ Water generally stays within the naturalized grassed areas (harvested for hay) along the Creek. ▪ During the 1:100-year event, water might get close to the two townhouses on 57 Avenue (just north of the Creek and just west of 48 Street); LiDAR suggests the buildings would flood at about 705.90m in elevation. The 100-year water level is about 705.77m. The elevation of the buildings' foundation and window wells should be surveyed to confirm the buildings' flood risks.
48 Street (Highway 779) to 57 Avenue (Figure 5-5)	▪ No flood risks or concerns during the 1:100-year event. ▪ Water stays on Town property.
57 Avenue to 55 Avenue (Figure 5-5)	▪ Overflow of trails both west and east of the Creek may occur during the 1:100-year event. ▪ Water stays on Town property.
55 Avenue to 52 Avenue (Figure 5-6)	▪ During the 100-year event, the water level in the Creek will be so high that it will backflow through a storm outfall and flood the depression on 46 Street, north of 55 Avenue. The ponding depth on the street caused directly by the Creek would be about 45cm. This will pose a flood risk to three houses on 46 Street. This should be confirmed through survey of the houses' foundation and window wells. ▪ Overflow of trail on west side of the Creek (just north of 55 Avenue) may occur during the 1:5-year event and maybe even smaller events. ▪ Overflow of trail on west side of the Creek (just south of 52 Avenue) may occur during the 1:25-year and larger events. ▪ Minor flooding of landscaped areas on private properties, both east and west of the Creek primarily between 54 Avenue and 55 Avenue (Oatway Drive), may be expected during the 1:100-year event, with little anticipated damage. An estimated 9 private properties may be affected. ▪ Minor flooding of the grassed portion of Forest Green School (west side). ▪ 52 Avenue will flood during a 1:100-year event.
52 Avenue to 50 Avenue Trail Crossing (Figure 5-6)	▪ Brown Street from just north of 50A Avenue to just south of 51 Avenue will have up to 70cm depth of water during the 1:100-year event, and up to 40cm during the 1:25-year event. ▪ The trail west of the Creek and east of Brown Street will be underwater during the 1:25 year and larger events. It should be just above the 1:5-year water level.

Whispering Waters Creek Reach	Flood Risk Description
	▪ The 50 Avenue alignment trail crossing will be overtopped by the Creek water during the 1:25-year and larger events. ▪ Some flooding of landscaped areas on 14 private properties east of the Creek (on west side of Umbach Road north of Oatway Drive) may be expected during the 1:25-year and larger events. During the 1:100-year event, water may flood some backyards for a distance of about 10m and for a depth of up to 0.6m. Some damage to structure and content in backyard may happen, but houses should be high enough not to flood during the 1:100-year event. ▪ Two sanitary manhole rims will be underwater during the 1:5-year and larger events.
50 Avenue Alignment Trail Crossing to 49 Avenue (Figure 5-6)	▪ Minor flooding of west trail during the 1:100-year event. ▪ Minor flooding of east trail during the 1:5-year event, and significant flooding during the 1:25-year and larger events. ▪ Some flooding of 49 Avenue south trail during 1:25-year and larger events. ▪ One sanitary manhole rim will be underwater during the 1:5-year event, and an additional two (three in total) during the 1:25-year and larger events.
49 Avenue to CN Railroad (Figure 5-6)	▪ Minor flooding of west trail during the 1:100-year event. ▪ Some flooding of private undeveloped commercial property to the east of the Creek (4209 49 Avenue) is anticipated during the 1:25-year and larger events. ▪ The CN Railroad culvert crossing is much smaller in size compared to upstream culverts. It creates a significant increase in hydraulic grade line in the system (1.3m head loss), and it is partly responsible for the high-water levels upstream of the railroad.
CN Railroad to 44 Avenue (Figure 5-7)	▪ Flooding of west trail during the 1:5-year and larger events. ▪ Water stays on Town property. There is the possibility of some overflow of the concrete block wall to the east of the Creek into private property during the 1:100-year event, but it should remain on the grassed surfaces, far away from the townhouses.
44 Avenue to 40 Avenue Alignment Trail Crossing (Figure 5-7)	▪ Flooding of west trail during the 1:5-year and maybe even smaller events. ▪ Flooding of east trail during the 1:5-year and maybe even smaller events. ▪ The 40 Avenue alignment trail crossing will be overtopped by the Creek water during the 1:5-year and larger events. ▪ One sanitary manhole rim will be underwater during the 1:100-year event. ▪ Water stays on Town property.

Whispering Waters Creek Reach	Flood Risk Description
40 Avenue Alignment Trail Crossing to Highway 16A (Figure 5-7)	▪ Flooding of west trail during the 1:5-year and maybe even smaller events. ▪ Some flooding of landscaped areas and backyards on approximately 8 private properties east of the Creek (on St. Andrews Drive from address 135 to 149) may be expected during the 1:5-year and larger events. Some damage to structures and content in backyard may happen, but houses should be high enough not to flood during the 1:100-year event. The lowest house appears to be above 701.2m in elevation (landscape elevation at house), while the 1:100-year Creek elevation is approximately 700.3m. The lowest property abutting the Creek is 697.6m in elevation at the property line, thus well below the 1:5-year elevation of the Creek which is 699.0m. Regular yearly flooding of these low-lying backyards should be expected. ▪ The Highway 16A culvert crossing is much smaller in size compared to upstream culverts. It creates a significant increase in hydraulic grade line in the system (3.3m head loss), and it is mostly responsible for the high-water levels upstream of the highway crossing. ▪ One sanitary manhole rim will be underwater during the 1:5-year and 1:25-year events, and an additional one (two in total) during the 100-year event.
Highway 16A to Boulder Boulevard (Figure 5-8)	▪ No flood risks or concerns during the 1:100-year event. ▪ Water stays on Town property.
Boulder Boulevard to Golf Course Road North (Figure 5-8)	▪ The Golf Course Road North crossing consists of two main crossings. Both are severely undersized considering the upstream flows, but the car wash culvert causes the most restriction and backflow. This backflow causes a large area upstream of the crossing to flood during events as small as the 1:5-year event, including many industrial properties and buildings. The small crossing creates a significant increase in hydraulic grade line in the system (1.8m head loss). ▪ Golf Course Road overflows during the 1:5-year and larger events. ▪ Properties at risk of flooding for events as low as the 1:5-year event are located along Boulder Boulevard, Granite Lane, Crystal Drive and Golf Course Road, adjacent to the Creek. ▪ Flooding of the annexed land to the west of the Creek (east of Boulder Boulevard and west of Golf Course Road North) is also expected during the 1:5-year event given the low-lying areas. This area likely acts as natural storage, thus attenuating the flows downstream, and potential even reducing maximum flood depths in the area and thus mitigate flood risks. This storage was not included in the model. Once the land is developed, this natural storage will likely be eliminated.

Whispering Waters Creek Reach	Flood Risk Description
Golf Course Road North to North Town Boundary (Figure 5-9)	▪ No flood risks or concerns during the 1:100-year event. ▪ Water generally stays within the uncultivated natural areas along the Creek.

5.4 What Governs the Creek Water Level?

The high water level observed in Whispering Waters Creek following intense rainfall events is generally not due to the lack of capacity in the creek itself, but due to the flow restrictions imposed by the many culvert crossings. This can be observed in the Creek water level profiles by a generally flat water surface profile upstream of a culvert crossing (e.g. from 52 Avenue to the railroad in Figure 5-6, for the 1:5-year to the 1:100-year events), and large head losses at the culverts (the culvert head loss is the difference between the upstream and downstream water level at the culvert crossing). This means that even if the Creek has some sediments built-up or dense vegetation along the channel, this will have minimal impact on the Creek's water level during these large flow events. In fact, the culvert entrance type (e.g. mitered or projecting from fill), culvert diameter, and culvert roughness (material) has a much greater impact on the water level in the creek than the creek geometry and vegetation itself. Also, ensuring that the culvert itself is unobstructed, including the culvert inlet and outlet, is necessary to minimize such head losses. The culvert slope has minimal impact on the flows through the culvert during large flow events.

In a few areas, the culverts are not restricting the flows as significantly, and the water level in the Creek is primarily a function of the Creek geometry and roughness (e.g. vegetation type and density). This can be observed for the creek reach from 57 Avenue to 55 Avenue (more so for the 1:5-year event), and for the reach downstream of Golf Course Road North. In those instances where the flow depth is primarily a function of the Creek properties (and not of the culvert capacity), the water surface profile of the Creek has a similar slope than the Creek bottom itself.

Here is an example. Whispering Waters Creek just south of 52 Avenue has a capacity of more than 22 m^3/s at the 1:100-year water level (depth of 2.8m), while the modeled flow rate is only 5.9 m^3/s. The two 1500mm diameter culverts at 52 Avenue (in combination with restrictions imposed by other culverts downstream) are therefore controlling the water level, not the Creek itself. In the best of scenarios (i.e. inlet control condition), these two culverts would not be able to pass more than 12 m^3/s (combined) before the culvert crossing would overflow.

5.5 What are the Conditions of the Existing Culverts?

All culverts of Whispering Waters Creek are in generally good condition, and no significant deterioration was noticed during the survey work conducted in Fall 2018 as part of the Stormwater Master Plan (Sameng, 2019). Additional visits of a few select culverts along the Creek in July/August 2019 also revealed no noticeable concerns with the existing culverts that would affect their performance during a large flow event, with the exception of some debris at culvert inlets. Some culvert inlet and outlets were bend slightly upwards, but the impact on these bends and deflections in the culverts are not believed to affect their hydraulic performance during these high flow events.

5.6 Impact of Culvert Crossing Blockage and Failure on Flood Risks

The hydraulic analysis and water level delineations presented in this report assume that all culverts will function properly (i.e. no failure and no blockage). However, if there is a blockage or failure of the culvert(s), there is the risk that the water level in the upstream reach of the Creek will rise and overflow the crossing itself. This may result in flooding upstream of the crossing, depending on the crossing elevation and geometry.

As part of this study, we reviewed the impact on flood risks if the culvert crossings were to overflow. Key discussions regarding this topic are as follows (from upstream to downstream):

- 48 STREET: In case of failure or blockage of the 48 Street culvert, water would backup and flood the agricultural fields upstream. The overflow of the culvert crossing is 50m north of the crossing at an elevation of 706.5m. In comparison, the 1:100-year water elevation upstream of the culvert is 705.76m. If the water did overflow 48 Street, the two townhouses on 57 Avenue (just north of the Creek and just west of 48 Street) would be flooded. Other buildings and houses should be safe from flooding.
- 57 AVENUE: Minor flooding on some private properties. No buildings or houses at risk of flooding.
- 55 AVENUE: Minor flooding on some private properties. One house on 46 Street south of 55 Avenue may flood.
- 52 AVENUE: Flood risks upstream of 52 Avenue would be slightly greater than for the 1:100-year event. About 10 houses on the east side of 46 Street between 54 Avenue and 55 Avenue may flood. Otherwise, most of the flooding would remain on landscaped surfaces.
- 50 AVENUE TRAIL: This crossing overflows during the 1:100-year event. Flood risks would be similar.
- 49 AVENUE: About 6 houses on the west side of Umbach Road north of Oatway Drive would be at some risk of flooding if overflow of the 49 Avenue crossing happened.
- RAILROAD: The Creek crosses the CN Railroad just north of 49 Avenue with a single 1800mm diameter culvert. In case of failure or blockage of that culvert, water would start backing up into the Creek and its water depth would increase. The railroad itself is very high (elevation 707.2m) such that overflow of the railroad is unlikely (if it did, it would be catastrophic). Fortunately, there is a pedestrian trail crossing (elevation 702.6m) underneath the railroad immediately west of the culvert crossing. In the unfortunate event that the railroad culvert fails or collapses, the Creek could still cross the railroad via the pedestrian trail crossing. This would generate high water levels in the Creek until the culvert is repaired, but the flooding should be generally contained within the Creek, and not flood any adjacent properties, although flooding of some roads may be possible.
- 44 AVENUE: The townhouses to the east of the Creek may have water really close to their foundation if overflow of the 44 Avenue crossing was to happen.
- 40 AVENUE TRAIL: This crossing overflows during the 1:100-year event. Flood risks would be similar.
- HIGHWAY 16A: The Creek crosses Highway 16A with a single 1400mm culvert. In case of failure or blockage of that culvert, water would start backing up into the Creek and its water depth would increase. If the Highway crossing was to overflow (elevation 700.8m;

this is only 0.5m higher than the 1:100-year water elevation), there should be no flooding of buildings or houses, although it would come really close to about 8 along St. Andrews Drive and about 2 near the 42 Avenue and 42 Street bend. There would also be many flooded yards.

- BOULDER BOULEVARD: If the Creek overflows this crossing, it would do so about 200m east of the crossing, just west of Golf Course Road North. A few industrial yards south of Boulder Boulevard may be flooded in the process, but the flood risks are small.
- GOLF COURSE ROAD NORTH: This crossing overflows during the 1:100-year event. Flood risks would be similar.

Some of the local road and trail culverts are twinned (i.e. two pipes of same size, side by side). In case of failure from one of the culverts, the second culverts should be able to convey lower flows without flooding the crossing. However, during larger flows, the capability of the second culvert to convey the peak flows without substantially increasing flood risks upstream of the crossing will depend on the actual flow rate as well as the elevation and geometry of the crossing that may overflow.

5.7 How High was the Water Level in Whispering Waters Creek in July 2019?

The July 7th and 15th, 2019, rainfall events caused a significant increase in water level in the Creek. The computer model results were compared with the site observation and photos taken during the July 2019 events. These photos, and the estimated return period of the observed water level, are shown in Appendix C.

According to this information, the water level in the Creek in July 2019 may have reached up to a 1:100-year level in one section of the Creek. The 1:25-year return period was the most frequent return period identified for both the July 7th and July 15th events. To some extent, this correlates with the rainfall event which was estimated as a 1-in-80 year, 40-minute duration event on July 7th, and as a 1-in-130 year, 50-minute duration event on July 15th. The water level in the Creek likely did not reach a 1:100-year elevation everywhere because the actual rainfalls were of shorter duration and volume than what was modeled (4-hour duration event was modeled). If the rain fell for a longer period of time on July 7th and July 15th, the water level in the Creek would likely have been higher.

It should be noted that the photos may not have been taken at the peak of the flow/water level in the Creek. It should also be noted that the difference in water elevation between the 1:25-year event and the 1:100-year event is only about 0.1 m to 0.7 m in depth (location specific).

5.8 What is the Impact of High Creek Water Level on Local Street Ponding?

With the exception of a few roads that will overflow with Creek water either due to their low elevation (e.g. Brown Street) or because the road overflows due to lack of capacity at the crossing (50 Avenue trail, Golf Course Road North), the high-water level of Whispering Waters Creek will only backflow into the storm sewer system and cause ponding at one location during the 1:100-year event; that is on 46 Street between 54 Avenue and 55 Avenue. The street ponding depth would be about 45cm during that event, and it may flood 3 houses east of 46 Street (between 54 and 55 Avenue).

Nevertheless, the high-water level in the Creek can still have an impact on maximum ponding depths on local roads. This is because the high-water level of the Creek would fill the storm pipes and reduce the available capacity in the storm sewer pipes. This means that the pipes will not convey as much flow when the Creek water level is high vs. when the Creek is empty.

From our computer model, the peak flows in the local storm sewers and the maximum ponding depths happened when the Creek water level was still quite low (and rising) such that the Creek did not have much impact on local street ponding depths. By the time the Creek reaches its peak water level, most of the local surface ponding and flows had significantly subsided.

5.9 Flood Mitigation Improvements for Whispering Waters Creek

5.9.1 Overview

Two main options were developed to reduce flood risks along Whispering Waters Creek, with a target to achieve a 100-year level of flood protection for the area. The focus of the improvements was to eliminate flood risks to buildings and houses, while some flooding of landscaping on private properties was deemed acceptable. Furthermore, some sanitary manholes are at risk of being submerged due to high Creek levels, and it is necessary to prevent this from happening. Therefore, the focus was to reduce the water level between 55 Avenue and 50 Avenue, as well as between Boulder Boulevard and Golf Course Road North. Reducing the Creek water level furthermore was deemed unnecessary in the short-term, but could be considered in the long-term as culverts are replaced at the end of their service life.

5.9.2 Flood Mitigation Option #1 – Culvert Upgrades

Option 1 focuses on reducing the water level in the Creek by upgrading culverts only. Eight (8) culvert crossings were identified to be upgraded. See Figure 5-10 for an illustration of the proposed upgrades and the reduced water level of the Creek. The following Table 5-2 is a summary of the culvert upgrades. Some comments are as follows:

- To reduce flood risks within the 55 Avenue to 50 Avenue area (Old Town) and not increase flood risks in the downstream sections of the Creek, all the culvert upgrades recommended within would be required.
- To reduce flood risks within the Golf Course Road North area (North Business Park), only the upgrade at the Golf Course Road North crossing (WWC-C-101) would be required.

CULVERTS

- The proposed Railroad crossing (WWC-C-71) would consist of adding a second 1800mm culvert through trenchless installation. Some creek regrading at both the upstream and downstream end of the culverts may be required to accommodate the new culvert. Approval from Canadian National Railway (CN) for the railway culvert crossing will be required.
- The proposed Highway 16A crossing (WWC-C-90) would consist of twinning the existing 1400mm culvert with a 1500mm culvert through trenchless installation. Some creek regrading at both the upstream and downstream end of the culverts may be required to

accommodate the new culvert. It should be noted that this crossing would still hold back some water during the larger flow events, which is recommended to maintain lower sizes for the downstream culverts, and minimize peak flows downstream of the Town boundary. Approval from Alberta Transportation for the Highway 16A culvert crossing will be required.

- The 50 Avenue alignment trail crossing (WWC-C-60) could be completely removed rather than replaced. This crossing is only for a walking trail, for which there is a bridge crossing just 100m to the north. This crossing currently contributes to most of the flood risks from 50 Avenue to 55 Avenue.
- The Golf Course Road North (WWC-C-101) crossing, which would consist of two 3m by 1.5m box culverts, is intended to be installed diagonally across the road. This would avoid the current arrangement where the flow must first be conveyed across the car wash access and then across the road. The car wash access would remain to allow any drainage from the north to flow south towards the new culvert crossing. The triple 900mm culverts across the road would be abandoned.
- All proposed culverts would be installed at same or similar invert elevation as existing, to be confirmed during detailed design.
- The proposed culvert sizes shown in Table 5-2 could be revised to an equivalent box shape or pipe arch to satisfy potential cover or channel width issues.

Table 5-2: Option 1 – List of Upgraded Crossings along Whispering Waters Creek

Culvert ID	Location	Existing Culvert Size (mm)	Proposed Culvert Size (mm)
WWC-C-50	52 Ave.	2x - 1500	2x - 1800
WWC-C-60	50 Ave. (trail)	2x - 1100(H) x 1600(W) arch	2x – 1800 (or remove crossing)
WWC-C-70	49 Ave.	2x - 1600	2x - 1800
WWC-C-71	Railroad	1x - 1800	2x – 1800 (one is existing)
WWC-C-80	44 Ave.	2x - 1500	2x - 2000
WWC-C-90	Hwy 16A	1x - 1400	1x – 1400 (existing) 1x - 1500
WWC-C-91	Boulder Blvd.	2x - 1400	2x - 2000
WWC-C-101	Golf Course Rd. N	3x - 900	2x - 3000(W) x 1500(H) box (diagonal crossing) Abandon ex. 3x – 900 crossing

BUFFER SWMF DOWNSTREAM OF GOLF COURSE ROAD

- For Option 1, a SWMF with 52,600 m^3 of live storage would be required to be constructed downstream of Golf Course Road, ideally within Town Boundary. See Section 5.11 for details.
- This SWMF would only be required prior to upgrading the Golf Course Road Crossing (WWC-C-101).

COST

The cost of the Option 1 upgrades is $2,988,000.

The above costs exclude the construction of the buffer SWMF downstream of Golf Course Road. Such SWMF may cost in the order of $5,100,000 for 52,600 m^3 of storage. The total cost of this option would then be about $8.1 million.

BENEFITS

The benefits of this improvement are primarily to (1) reduce the water level of the Creek between Boulder Boulevard and Golf Course Road North and target a 1:100-year level of flood protection for the area; and (2) reduce the water level between 50 Avenue and 55 Avenue to safer levels during the 1:100-year event.

This option would reduce flood risks to private properties, and reduce the risk of flooding sanitary manholes along the Creek. However, even with this option in place, six (6) of the eight (8) sanitary manhole that would be flooded under existing conditions for the 1:100-year event would still be flooded, but a lesser extent. The other two (2), near 40 Avenue, would not be submerged anymore. Sealing of these six (6) manholes will still be required.

The water level would also be reduced in all other sections of the Creek, thus reducing the flood extent and water depth during large flow events, although the quantifiable benefits in those other areas would be negligible. The most significant reduction in water level would be just south of the Highway 16A crossing, where the upgraded 1:100-year would be lowered by about 0.5m to the existing 1:25-year water elevation.

The Creek improvements will also allow more runoff flow to be put into the Creek through local improvements, without increasing the flood risks along the Creek itself. This includes added flows from the local improvements of Area B, C, D, E, F and H.

STAGING

As to not create a negative impact or increase flood risks to other areas, the culverts should be upgraded from downstream to upstream. This means that all culvert upgrades would need to be in place prior to seeing some noticeable benefits between 50 Avenue and 55 Avenue, which is where some of the higher flood risks properties are located.

To provide immediate flood mitigation benefit for the 46 Street area between 54 and 55 Avenue, there could be the option to first upgrade the 52 Avenue culvert crossing (WWC-C-50) and construct the rest of the upgrades later. This would not be sufficient to achieve a 1:100-year level of flood protection for the area, but it would at least provide some benefits and increase the level of flood protection for the most at-risk areas.

The upgrade at Golf Course Road (WWC-C-101) should be completed in the short-term to mitigate the high flood risks for the North Industrial Park area. The downstream buffer SWMF (see Section 5.11) would need to be in place before the Golf Course Road North culvert crossing (WWC-C-101) is upgraded.

5.9.3 Flood Mitigation Upgrade Option #2 – Pond and Culvert Upgrades

Option 2 was developed as a lower-cost alternative to Option 1, and implementable in a shorter timeframe. It also avoids potentially costly trenchless crossings at the railroad and Highway 16A. Similar to Option 1, this option focuses on reducing the water level in the Creek, but by instead focusing the upgrades on buffering the peak flows through the addition of storage, as well as a small group of culverts. The new dry surge pond would be constructed east of Brown Street (east of Creek) and south of 49 Avenue (south of BMX track), on Town land. Three (3) culvert crossings were identified to be upgraded. See Figure 5-11 for an illustration of the proposed upgrades and the reduced water level of the Creek. The following Table 5-3 is a summary of the culvert upgrades. Some comments are as follows:

- To reduce flood risks within the 55 Avenue to 50 Avenue area (Old Town), and not increase flood risks in the downstream sections of the Creek, the pond and all culvert upgrades south of the railroad are required.
- To reduce flood risks within the Golf Course Road North area (North Business Park), only the upgrade at the Golf Course Road North crossing (WWC-C-101) are required.

DRY POND SOUTH OF RAILROAD

- The proposed dry pond, with details shown in Figure 5-12, would practically consist of the largest and deepest pond possible within the available land south of the BMX track (and south of the sanitary sewer), north of the existing trail, and east of the Creek.
- The pond would require the excavation of between 2.5m and 5.0m of soil depth, for an area of 1.8 ha. The pond would be about 220m long by 80m wide at the top, and 160m long by 35m wide at the bottom. The side slopes of the pond would be 5:1 (20% slope).
- The existing trail would be lowered and act as a weir between the Creek and the pond. When the water in the Creek reaches an elevation of approximately 701.5m, it will overflow into the pond. This is equivalent to a water depth of about 1.0m in the creek, which is an event smaller than a 1:5-year event.
- The peak overflow rate from the Creek into the pond would be 9.5 m^3/s during the 1:100-year event.
- Approximately 65% of the Creek flow is diverted into the pond during the peak 30 minutes of the Creek flow.
- The pond would store about 19,000 m^3 of water during the 100-year event, with a maximum storage depth of 2.3m.
- Once the water level in the pond is below the weir elevation, the pond would release the water back into the Creek, via the outlet pipe, at a flow rate of approximately 100 L/s.
- During the 1:100-year event, the pond would fill in about 2 hours (from start of fill to full storage), would stay full for about 2 hours, it would take another 4 hours to drain down to the weir elevation (about 0.8m of water at deepest point), and then another 24 of 36 hours for the pond to be fully emptied.

CULVERTS

- The 50 Avenue trail crossing (WWC-C-60) could be completely removed rather than replaced. This crossing is only for a walking trail, for which there is a bridge crossing just 100m to the north. This crossing currently contributes to most of the flood risks from 50 Avenue to 55 Avenue.
- The Golf Course Road North culvert is intended to be installed diagonally across the road. This would avoid the current arrangement where the flow must first be conveyed across the car wash access and then across the road. The car wash access would remain to allow any drainage from the north to flow south towards the new culvert crossing (or it could be eliminated, and the ground filled; further investigations are needed to confirm). The triple 900mm culverts across the road would be abandoned.
- All proposed culverts would be installed at same or similar elevation as existing, to be confirmed during detailed design.
- The proposed culvert sizes shown in Table 5-3 could be revised to an equivalent box shape or pipe arch to satisfy potential cover or channel width issues.

Table 5-3: Option 2 – List of Upgraded Crossings along Whispering Waters Creek

Culvert ID	Location	Existing Culvert Size (mm)	Proposed Culvert Size (mm)
WWC-C-50	52 Ave.	2x - 1500	2x - 1800
WWC-C-60	50 Ave. (trail)	2x - 1100(H) x 1600(W) arch	2x – 3000 (W) x 2100 (H) box (or remove crossing)
WWC-C-101	Golf Course Rd. N	3x - 900	2x - 3000(W) x 1500(H) box (diagonal crossing) Abandon ex. 3x – 900 crossing

BUFFER SWMF DOWNSTREAM OF GOLF COURSE ROAD

- For Option 2, a SWMF with 7,800 m^3 of live storage would be required to be constructed downstream of Golf Course Road, ideally within Town Boundary. See Section 5.11 for details.
- This SWMF would only be required prior to upgrading the Golf Course Road Crossing (WWC-C-101).

COST

The cost of the Option 2 upgrades is $2,148,000.

The above costs exclude the construction of a buffer SWMF downstream of Golf Course Road. Such SWMF may cost in the order of $760,000 for 7,800 m^3 of storage. The total cost of this option would then be about $2.9 million.

BENEFITS

The benefits of this improvement are primarily to (1) reduce the water level of the Creek between Boulder Boulevard and Golf Course Road North and target a 1:100-year level of flood protection for the area; and (2) reduce the water level between 50 Avenue and 55 Avenue to safer levels during the 1:100-year event.

This option would reduce flood risks to private properties and reduce the risk of flooding sanitary manholes along the Creek. However, even with this option in place, all eight (8) sanitary manhole that would be flooded under existing conditions for the 1:100-year event would still be flooded, but a lesser extent. Sealing of all these manholes will still be required.

The water level would also be reduced in all other sections of the Creek, thus reducing the flood extent and water depth during large flow events, although the quantifiable benefits in those other areas would be negligible.

The Creek improvements will also allow more runoff flow to be put into the Creek through local improvements, without increasing the flood risks along the Creek itself. This includes added flows from the local improvements of Area B, C, D, E, F and H.

STAGING

The pond and culvert upgrades south of 49 Avenue should all be constructed simultaneously to provide the targeted 1:100-year level of flood mitigation for the area.

To provide immediate flood mitigation benefit for the 46 Street area between 54 and 55 Avenue, there could be the option to first upgrade the 52 Avenue culvert crossing (WWC-C-50) and construct the pond later. This would not be sufficient to achieve a 1:100-year level of flood protection for the area, but it would at least provide some benefits and increase the level of flood protection for the most at-risk areas.

It should be noted that without the 52 Avenue (WWC-C-50) or 50 Avenue trail crossing (WWC-C-60) upgrade or removal, the dry pond would not provide any substantial benefits for the area.

The upgrade at Golf Course Road (WWC-C-101) should be completed in the short-term to mitigate the high flood risks for the North Industrial Park area. This upgrade has no impact on the pond and culvert upgrades south of 50 Avenue.

The downstream buffer SWMF (see Section 5.11) would need to be in place before the Golf Course Road North culvert crossing (WWC-C-101) is upgraded.

5.9.4 Whispering Waters Creek Option 1 and Option 2 Comparison and Discussions

Both Option 1 (Culverts) and Option 2 (Pond + Some Culverts) will achieve the necessary flood risks reduction for the area between 50 Avenue and 55 Avenue in Old Town, as well as for the North Business Park area, just west of Golf Course Road North.

Option 2 can likely be constructed in a much shorter timeframe than Option 1, and it will have a lower construction cost. Option 2 also reduces peak flows along the Creek which is a bonus.

It is anticipated that Department of Fisheries and Oceans (DFO) *Fisheries Act* Approval regarding the culvert upgrades will be necessary as the Creek is a fish bearing watercourse. We

do not anticipate that in-stream studies of fish habitat would be a requirement prior to the detailed design of each upgrade location.

IMPACT OF IMPROVEMENT OPTIONS TO CREEK FLOWS

According to the computer model and as summarized in Table 5-4, during a 1:100-year flow event, Option 1 will increase the peak flow at all key crossings by up to 65%. Option 2 will see some decrease in peak flow at the railroad (-3%), no impact at the Highway 16A crossing, and a 32% increase at Golf Course Road North. Figure 5-1 illustrates the discharge at the Golf Course Road North crossing (combined culvert flow and road overflow rate) during the 100-year event under existing and improved conditions.

The main reason for the increase in peak flow at Golf Course Road North between the existing conditions and Option 2 is mainly associated with the local drainage from the North Business Park industrial area which releases into the Creek uncontrolled. In fact, the peak flow coming from Highway 16A is no different between the existing condition and Option 2. Under existing conditions, the flow from the industrial area would be temporarily stored behind the culverts crossing Golf Course Road North, while for Option 2, the local flows would be conveyed downstream of the crossing without any restriction.

Since both options will see an increase in the downstream peak flows, mainly due to the upgrade of the Golf Course Road North crossing, it would be prudent to construct a stormwater management facility either upstream or downstream of the Golf Course Road North crossing to buffer the flows to match the existing 1:100-year peak flow of 10.3 m^3/s, or lower. The need for this facility should be discussed with Alberta Environment. See Section 5.11 for details.

5.9.5 Recommendations

It is recommended to proceed with Option 2, primarily due to its lower cost, better constructability, and lesser impact to the downstream flows.

Table 5-4: Impact of Creek Upgrades on Peak Flows in Whispering Waters Creek at Key Crossings

Location (Tributary Area)	1:5-year			1:25-year			1:100-year		
	Existing	Option 1	Option 2	Existing	Option 1	Option 2	Existing	Option 1	Option 2
At 48 Street (530 ha)	1.6 m^3/s (3.0 L/s/ha)	1.6 m^3/s (3.0 L/s/ha) (-)	1.6 m^3/s (3.0 L/s/ha) (-)	3.3 m^3/s (6.3 L/s/ha)	3.3 m^3/s (6.3 L/s/ha) (-)	3.3 m^3/s (6.3 L/s/ha) (-)	4.2 m^3/s (7.9 L/s/ha)	4.4 m^3/s (8.3 L/s/ha) (+5%)	4.5 m^3/s (8.5 L/s/ha) (+7%)
At Railroad Crossing (730 ha)	5.8 m^3/s (7.9 L/s/ha)	7.9 m^3/s (10.8 L/s/ha) (+36%)	5.5 m^3/s (7.5 L/s/ha) (-5%)	6.9 m^3/s (9.5 L/s/ha)	10.0 m^3/s (13.7 L/s/ha) (+45%)	6.5 m^3/s (8.9 L/s/ha) (-6%)	7.6 m^3/s (10.4 L/s/ha)	11.0 m^3/s (15.1 L/s/ha) (+45%)	7.4 m^3/s (10.1 L/s/ha) (-3%)
At Highway 16A Crossing (837 ha)	6.3 m^3/s (7.5 L/s/ha)	9.1 m^3/s (10.9 L/s/ha) (+44%)	5.8 m^3/s (6.9 L/s/ha) (-8%)	7.2 m^3/s (8.6 L/s/ha)	11.4 m^3/s (13.6 L/s/ha) (+58%)	7.1 m^3/s (8.5 L/s/ha) (-1%)	7.7 m^3/s (9.2 L/s/ha)	12.7 m^3/s (15.2 L/s/ha) (+65%)	7.7 m^3/s (9.2 L/s/ha) (-)
At Golf Course Road North Crossing (900 ha)	6.4 m^3/s (7.1 L/s/ha)	9.6 m^3/s (10.7 L/s/ha) (+50%)	7.8 m^3/s (8.7 L/s/ha) (+22%)	8.6 m^3/s (9.6 L/s/ha)	13.4 m^3/s (14.9 L/s/ha) (+56%)	10.8 m^3/s (12.0 L/s/ha) (+26%)	10.3 m^3/s (11.4 L/s/ha)	16.8 m^3/s (18.7 L/s/ha) (+63%)	13.6 m^3/s (15.1 L/s/ha) (+32%)

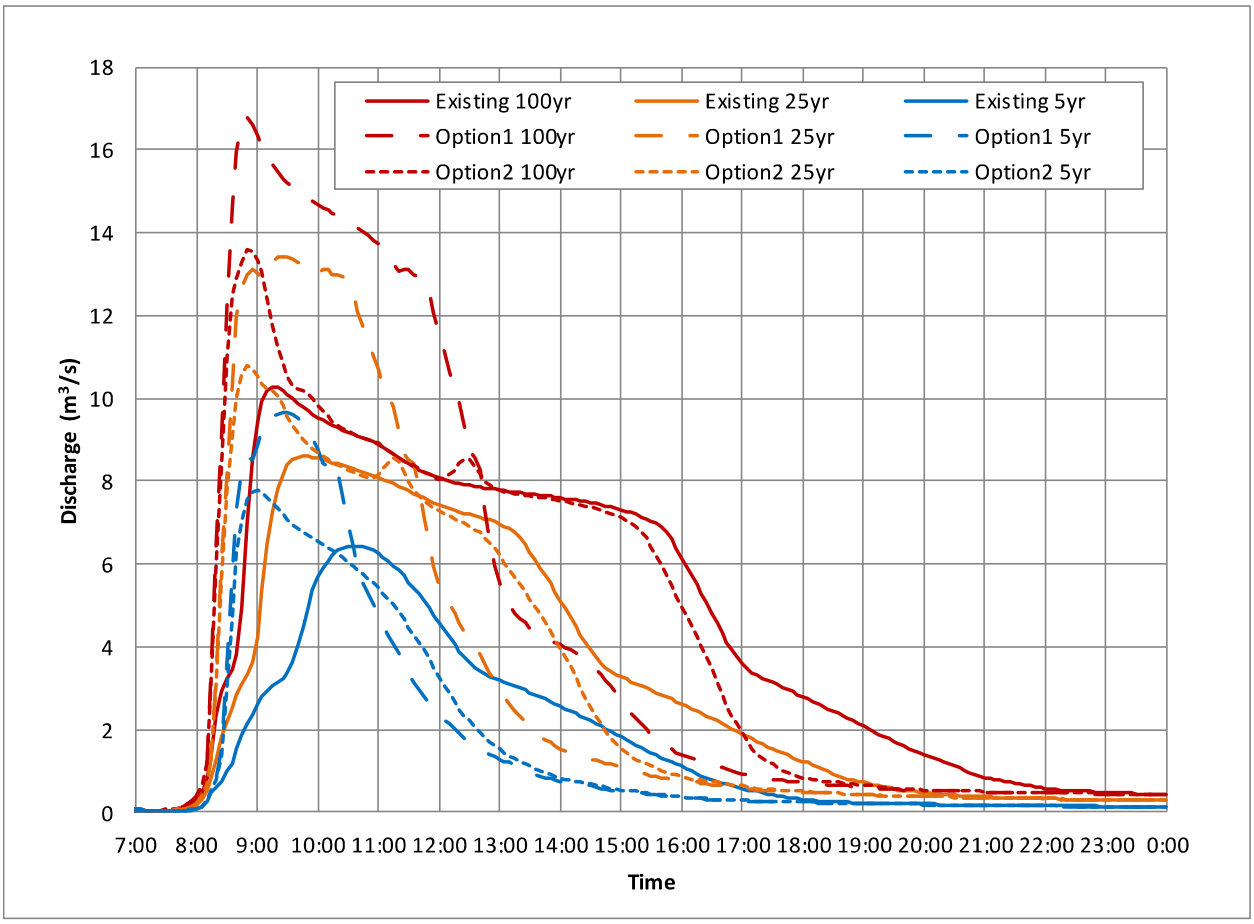


Figure 5-1: Discharge in Whispering Waters Creek downstream of Golf Course Road North Crossing Under Various Flow Conditions

5.10 South Pond (Upstream of 48 Street)

The effectiveness of installing a stormwater management facility at the upstream end of the Town (west of 48 Street) was reviewed during this study. The idea was to reduce peak flows from the Creek across 48 Street. Simulation results suggested that the impact of reducing peak flows across 48 Street on the water surface profile of the Creek was limited, especially further downstream where flood risks exist. This concept was therefore eliminated and is not considered cost-effective at this time.

It should be noted that, as future developments happen upstream, stormwater management facilities will be needed to control the peak flows to 2.5 L/s/ha, which will eventually reduce the peak flows across 48 Street.

5.11 North Pond (Downstream of Golf Course Road North)

As discussed in Section 5.9.4, the proposed upgrades of both Option 1 and 2 will result in an increase in peak flow and also more volume discharged in the downstream reach of Whispering Waters Creek within a shorter timeframe, when compared to existing conditions. Peak flow increases of 63% for Option 1 and 32% for Option 2 are anticipated.

An increase of the Creek's conveyance capacity through culvert upgrades will require approval under the Alberta Environment and Parks (AEP) *Water Act*. It is anticipated that "compensation storage" will need to be created in order to make the proposed conveyance capacity upgrades acceptable basin wide, and to maintain the Creek's discharge in its "current state". This is to meet to objectives of the "Big Lake Stormwater Management Plan" (see Section 2.5 for details) Consultation with AEP should be completed prior to detailed design.

Currently, there are three options contemplated:

1- OPTION A: Let the additional peak flows discharge downstream without any additional control. Although this would increase the peak flow in the downstream watercourses and into Big Lake, the increase in peak flows by the time Whispering Creek crosses Highway 16 and merges into Atim Creek would be quite small compared to existing conditions. A study to identify the impact to the downstream system and to the Creek's floodplain should be completed to confirm. It should be noted that Option 2 would pose less of a negative impact to the downstream system than Option 1, given the smaller peak flows.

2- OPTION B: Construct a stormwater management facility downstream (northeast) of Golf Course Road North at the downstream end of the Town (but still within Town boundary) to buffer the peak flows out of Town limits to the existing 1:100-year peak flow of 10.3 m^3/s. For Option 1, an approximately 52,600 m^3 storage facility would be required. For Option 2, an approximately 7,800 m^3 storage facility would be required. If the Town would like to pursue this option, additional investigations and computer modeling would be needed to confirm the flow contributions from the upstream areas, and the effectiveness of the pond in reducing peak flows and reducing flood risks for the area.

3- OPTION C: Construct a stormwater management facility upstream (west) of Golf Course Road North in the North Business Park Area. There are some undeveloped lands in that area such that providing some storage somewhere on that land should be feasible. This could be a facility that provides control of internal runoff flows (potentially to 2.5 L/s/ha)

from the west (including runoff from the Boulder Boulevard and Granite Drive area), potentially combined with another facility that provides buffer storage for the Creek itself (if needed). This may allow the culvert crossing at Golf Course Road to be smaller, but it would not eliminate the need for a culvert upgrade. If the Town would like to pursue this option, additional investigations and computer modeling would be needed to ensure that this will be effective in reducing peak flows and reducing flood risks for the area.

It is recommended for the Town to approach AEP with Option A, using improvement Option 2 as the recommended option, and obtain AEP approval. If this fails, then it is recommended for the Town to implement Option B combined with improvement Option 2. For Option 2, the pond will only be required once the Golf Course Road crossing is upgraded.

CAN BIG LAKE BE USED FOR STORAGE?

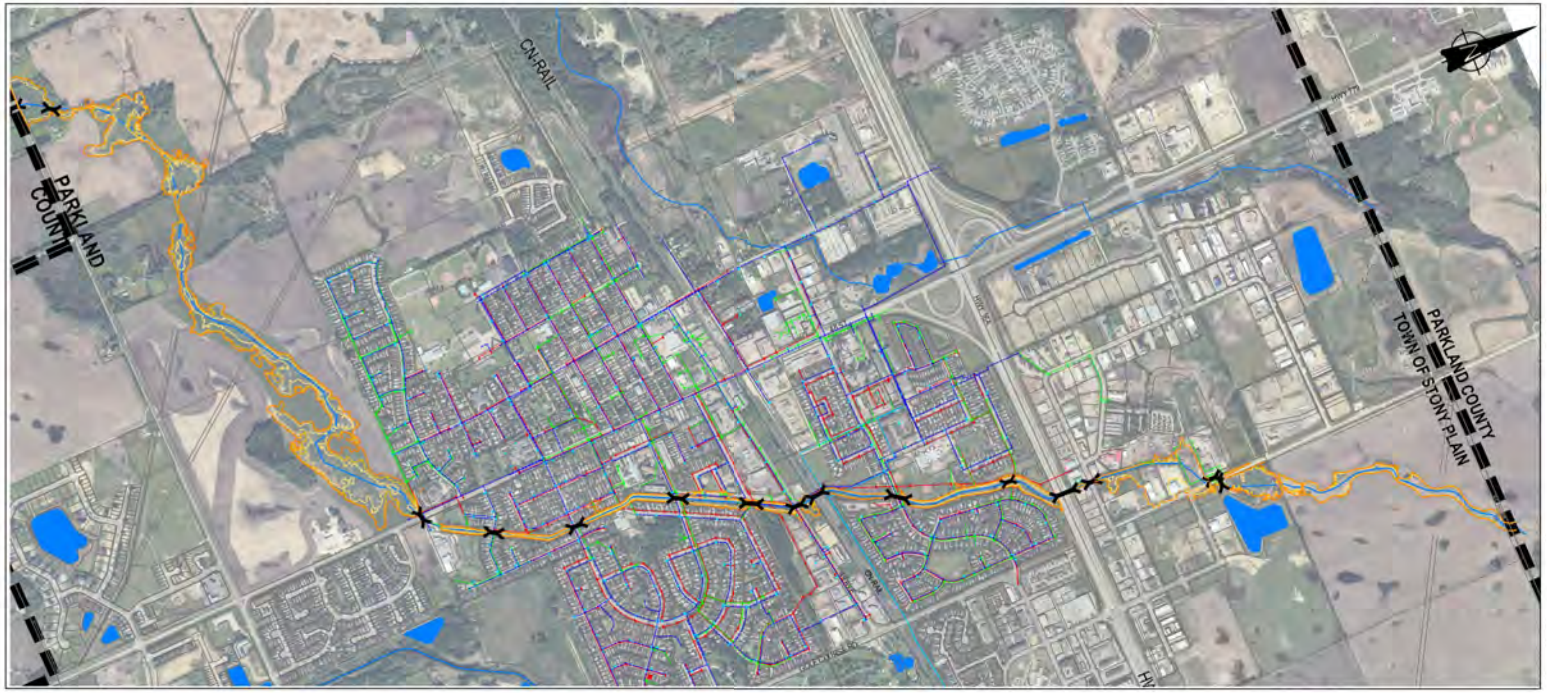
One of the questions that was brough forward is: Can Big Lake be used for storage, rather than adding pond(s) along the Whispering Creek alignment? The simple answer is no.

Whispering Waters Creek, as well as the entire Town of Stony Plain, is a part of the Big Lake Drainage Basin.

As per the 2004 “Big Lake Basin Task Force – Big Lake Stormwater Management Plan” report, summarized in Section 2.5 of this report, “a release rate of 2.5 L/s/ha is recommended for stormwater management in the Big Lake basin”. The 2.5 L/s/ha was established jointly between eight (8) municipalities having jurisdiction tributary to Big Lake and the Sturgeon River. The goal is to prevent flooding of Big Lake and the developed lands along the Sturgeon River and other tributary watercourses.

One of the recommendations of the plan is “Older areas which were developed without stormwater management should be provided with stormwater management facilities or their impacts should be mitigated.” Specific to Stony Plain, our interpretation of this statement is that, since the Town is currently releasing water downstream of Golf Course Road at a rate of about 11.4 L/s/ha during the peak of the 1:100-year rainfall event, we should not increase peak flows furthermore, but rather attempt to maintain or reduce peak flows out of the Town, with a target of 2.5 L/s/ha.

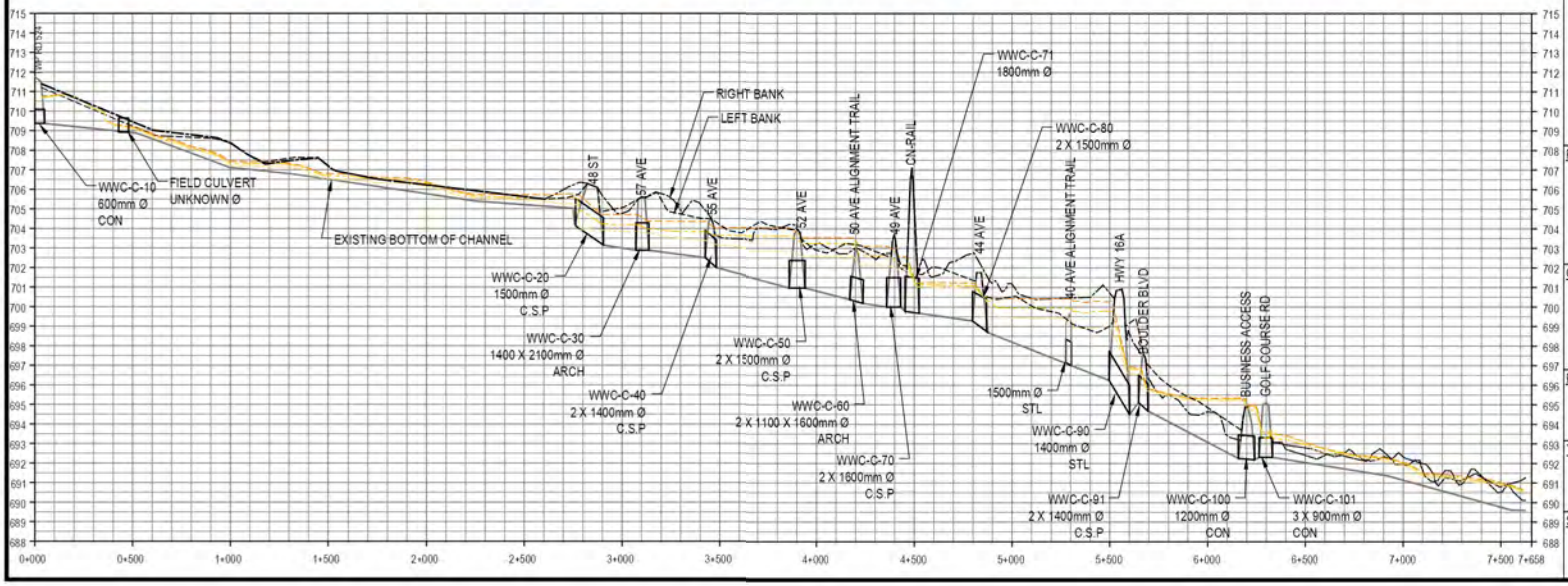
Although sending more water faster into Big Lake appears feasible, given Big Lake’s large storage capacity, this would not align with the recommendation of the “Big Lake Stormwater Management Plan”. The concerns are not necessarily with the storage capacity of Big Lake, but they are associated with the increase in peak flows into Whispering Waters Creek, which discharges into Atim Creek prior to flowing into Big Lake. The increase in peak flow (and consequently in flow depth) will cause more lands adjacent to the Creeks to flood, and will put more pressure on the existing drainage infrastructure downstream of the Town, such as the Highway 16 crossing. There is also the concern that larger flows result in larger velocities and therefore increased potential for erosion and sediment transport of the watercourses.



LEGEND:

- MUNICIPAL BOUNDARY
- EXISTING WATERCOURSE
- EXISTING STORMWATER MANAGEMENT FACILITY
- EXISTING CULVERT
- EXISTING SANITARY LINE
- EXISTING WATER LINE
- EXISTING STORM LINE

SIMULATED WATER LEVEL	RETURN PERIOD:
	1:5 YEAR
	1:25 YEAR
	1:100 YEAR



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Client:

TOWN OF STONY PLAIN

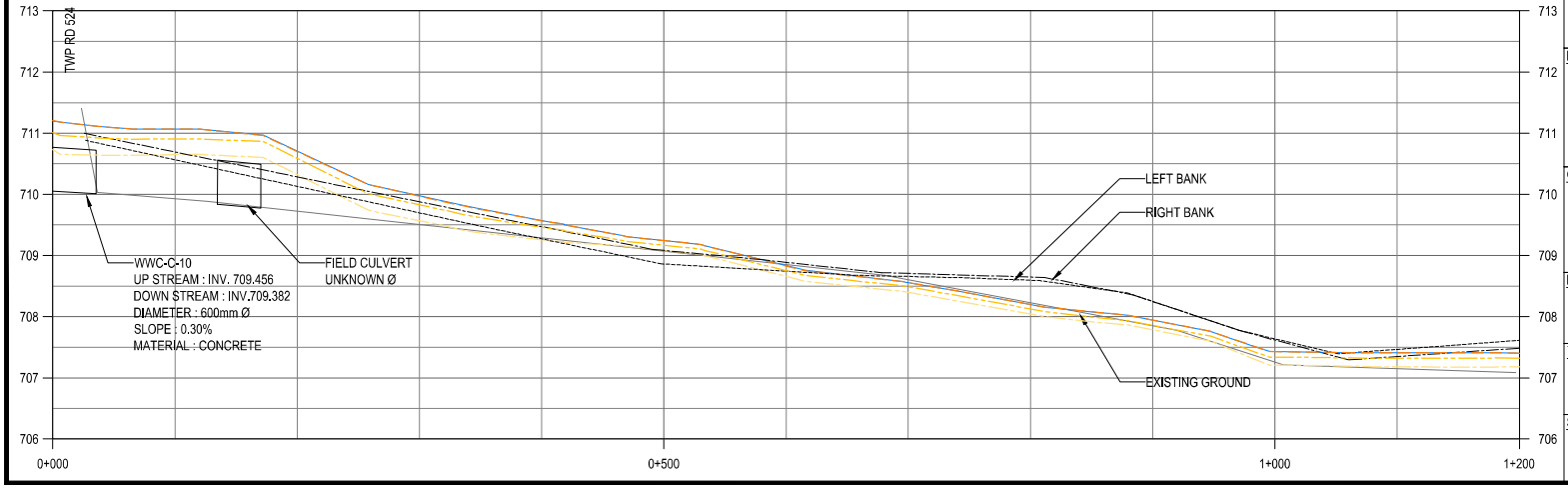
Project:

Town of Stony Plain Flood Mitigation Program

Title:

WHISPERING WATERS CREEK - EXISTING CONDITIONS - PLAN AND PROFILE

Scale:	Figure:
1:25,000	5-2

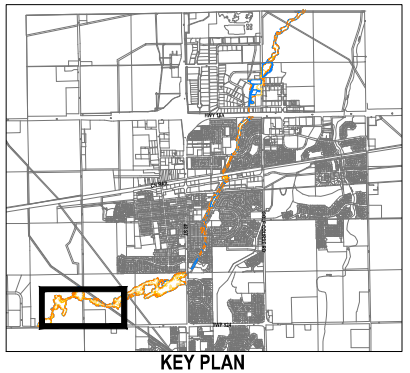


LEGEND:

- MUNICIPAL BOUNDARY
- EXISTING WATERCOURSE
- EXISTING CULVERT

SIMULATED WATER LEVEL	RETURN PERIOD:
	1:5 YEAR
	1:25 YEAR
	1:100 YEAR
	IMPROVED 1:100 YEAR - OPTION 2 (INCLUDE BMX POND) (IF NOT VISIBLE, ASSUME IT IS THE SAME AS EXISTING 1:100 YEAR)

NOTE:FLOODPLAIN DELINEATION ELEVATIONS ARE ACCOUNTING FOR THE RECENTLY CONSTRUCTED CREEK DIVERSION AND POND UPSTREAM OF 48 STREET. HOWEVER, THE FLOODPLAIN DELINEATIONS SHOWN ON THE PLAN VIEW ASSUME THAT THE POND AND DIVERSION CREEK ARE INEXISTENT, SINCE THE LIDAR USED DID NOT HAVE THOSE NEWLY CONSTRUCTED FEATURES.



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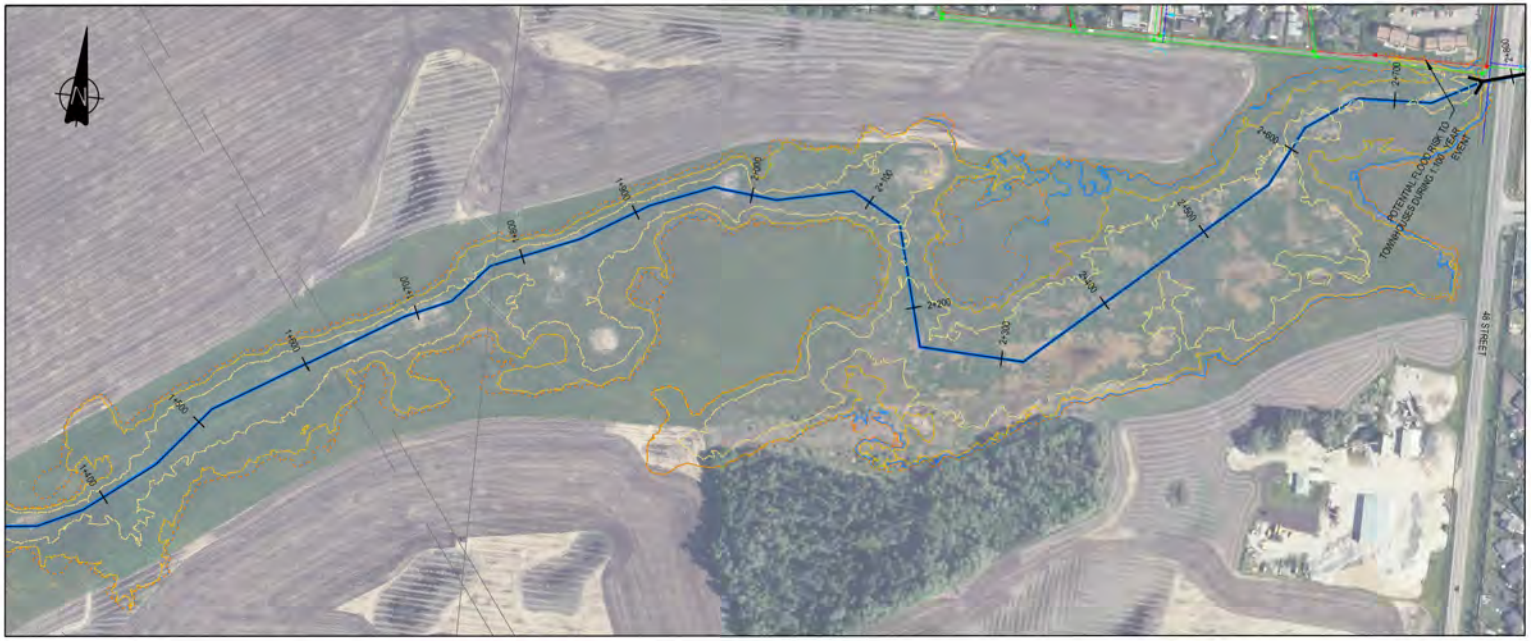
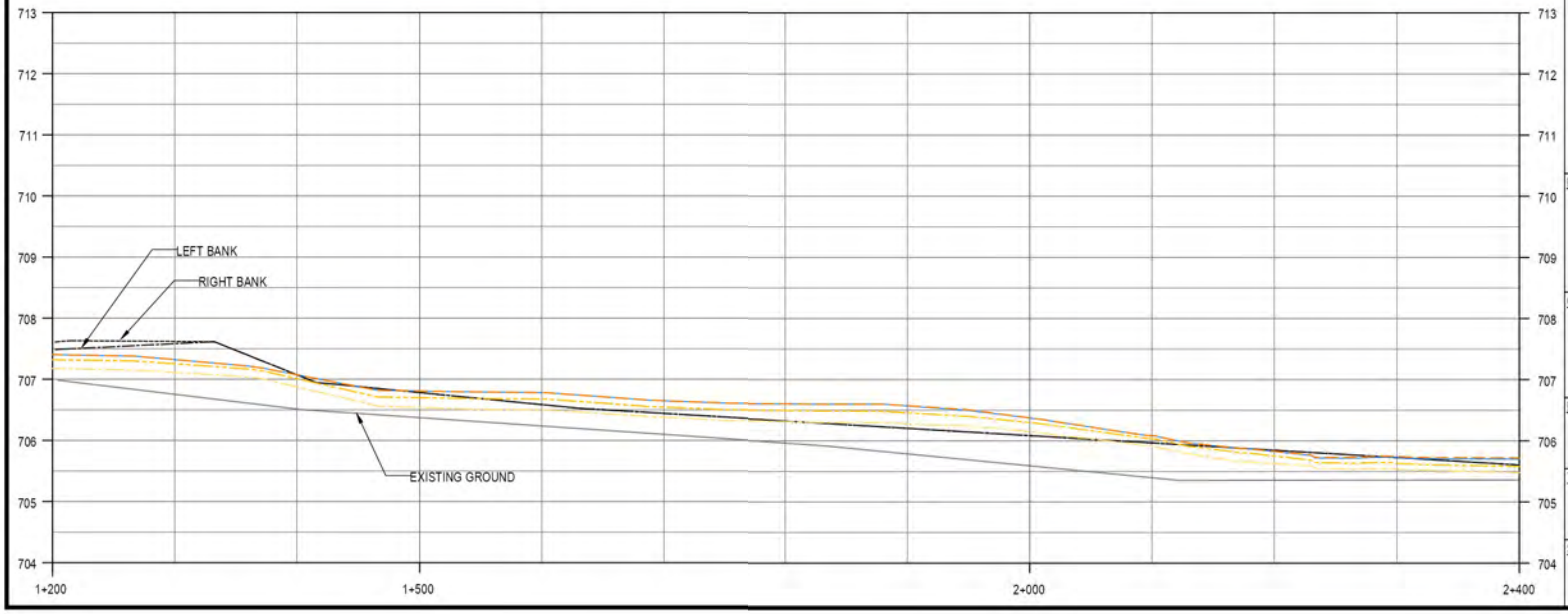
Client: TOWN OF STONY PLAIN

Project: **Town of Stony Plain Flood Mitigation Program**

Title: **WHISPERING WATERS CREEK - WATER SURFACE DELINEATION (FROM 79 AVENUE (SOUTH TOWN BOUNDARY) TO HALF-POINT BETWEEN 79 AVENUE AND 48 STREET / HWY 779)**

Scale:	Figure:
1:4000	5-3



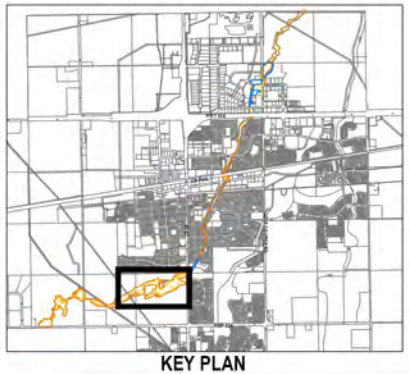


LEGEND:

- MUNICIPAL BOUNDARY
- EXISTING WATERCOURSE
- EXISTING CULVERT
- EXISTING SANITARY LINE
- EXISTING WATER LINE
- EXISTING STORM LINE

SIMULATED WATER LEVEL	RETURN PERIOD:
	1:5 YEAR
	1:25 YEAR
	1:100 YEAR
	IMPROVED 1:100 YEAR - OPTION 2 (INCLUDE BMX POND) (IF NOT VISIBLE, ASSUME IT IS THE SAME AS EXISTING 1:100 YEAR)

NOTE:FLOODPLAIN DELINEATION ELEVATIONS ARE ACCOUNTING FOR THE RECENTLY CONSTRUCTED CREEK DIVERSION AND POND UPSTREAM OF 48 STREET. HOWEVER, THE FLOODPLAIN DELINEATIONS SHOWN ON THE PLAN VIEW ASSUME THAT THE POND AND DIVERSION CREEK ARE INEXISTENT, SINCE THE LIDAR USED DID NOT HAVE THOSE NEWLY CONSTRUCTED FEATURES.



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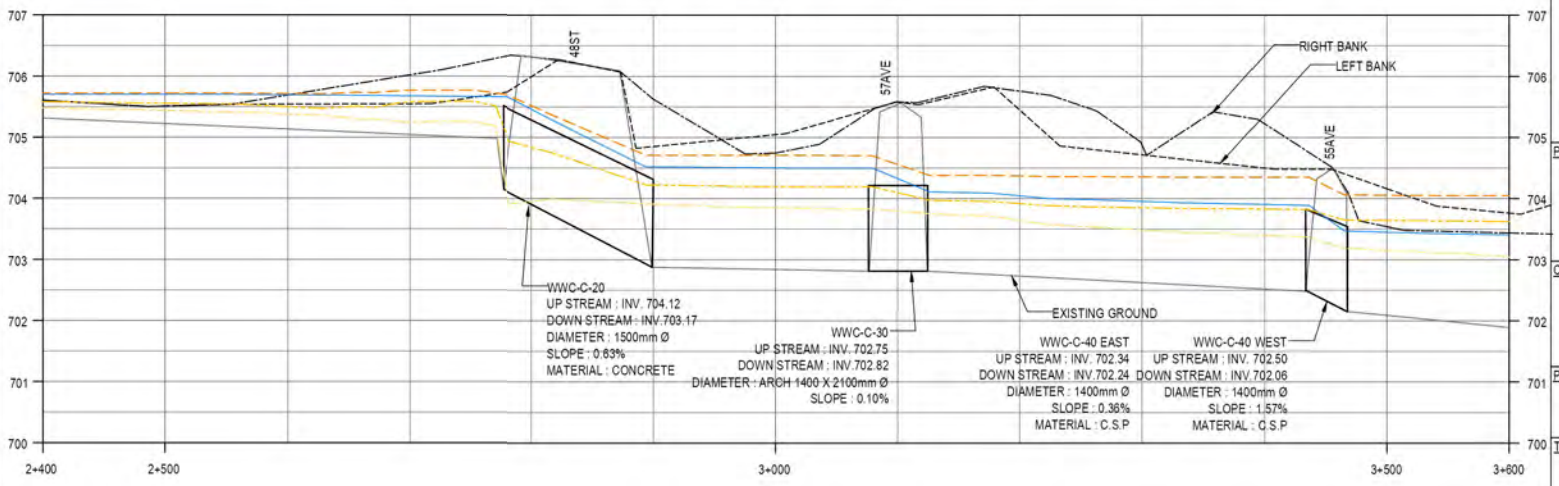
Title: **WHISPERING WATERS CREEK - WATER SURFACE DELINEATION (FROM HALF-POINT BETWEEN 79 AVENUE AND 48 STREET / HWY 779 TO 48 STREET /HWY 779)**

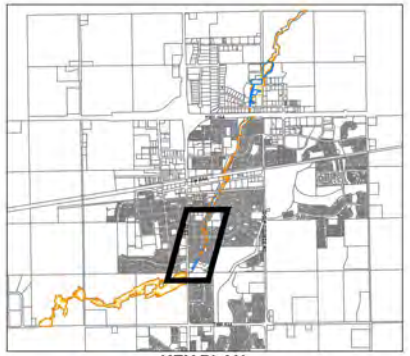
Scale:	Figure:
1:4000	5-4



LEGEND:

- EXISTING WATERCOURSE
- EXISTING CULVERT
- EXISTING SANITARY LINE
- EXISTING WATER LINE
- EXISTING STORM LINE

SIMULATED WATER LEVEL	RETURN PERIOD:
	1:5 YEAR
	1:25 YEAR
	1:100 YEAR
	IMPROVED 1:100 YEAR - OPTION 2 (INCLUDE BMX POND) (IF NOT VISIBLE, ASSUME IT IS THE SAME AS EXISTING 1:100 YEAR)



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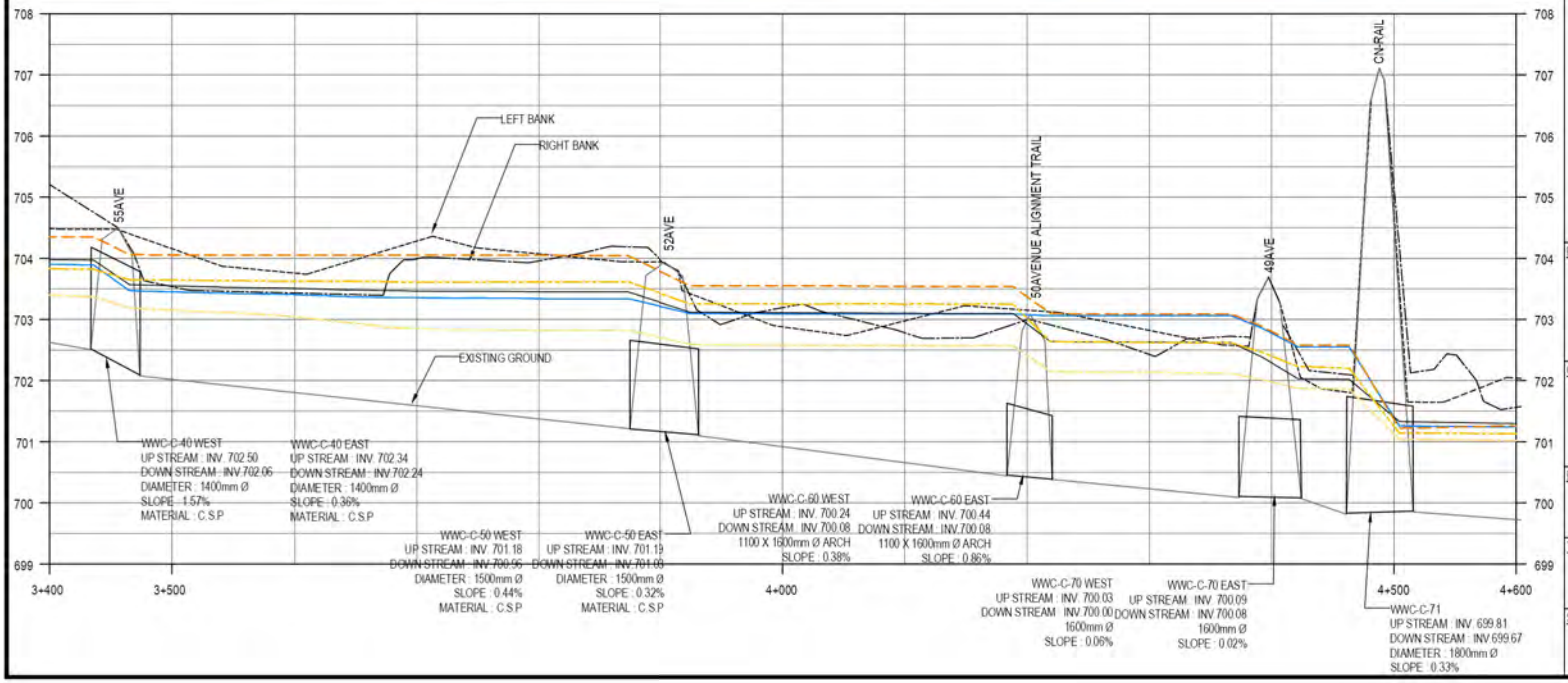
Email: services@sameng.com

Client: TOWN OF STONY PLAIN

Project: **Town of Stony Plain Flood Mitigation Program**

Title: **WHISPERING WATERS CREEK - WATER SURFACE DELINEATION (FROM 48 STREET / HWY 779 TO NORTH OF 55AVENUE)**

Scale:	Figure:
1:4000	5-5

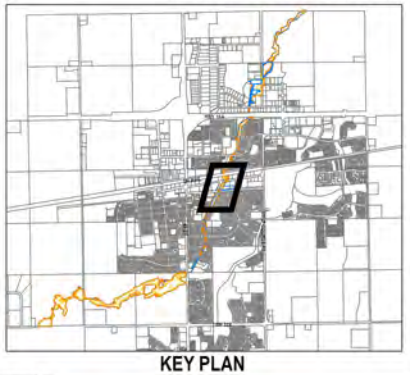


LEGEND:

- EXISTING WATERCOURSE
- EXISTING CULVERT
- EXISTING SANITARY LINE
- EXISTING WATER LINE
- EXISTING STORM LINE

SIMULATED WATER LEVEL RETURN PERIOD:

- 1:5 YEAR
- 1:25 YEAR
- 1:100 YEAR
- IMPROVED 1:100 YEAR - OPTION 2 (INCLUDE BMX POND) (IF NOT VISIBLE, ASSUME IT IS THE SAME AS EXISTING 1:100 YEAR)



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TOWN OF STONY PLAIN

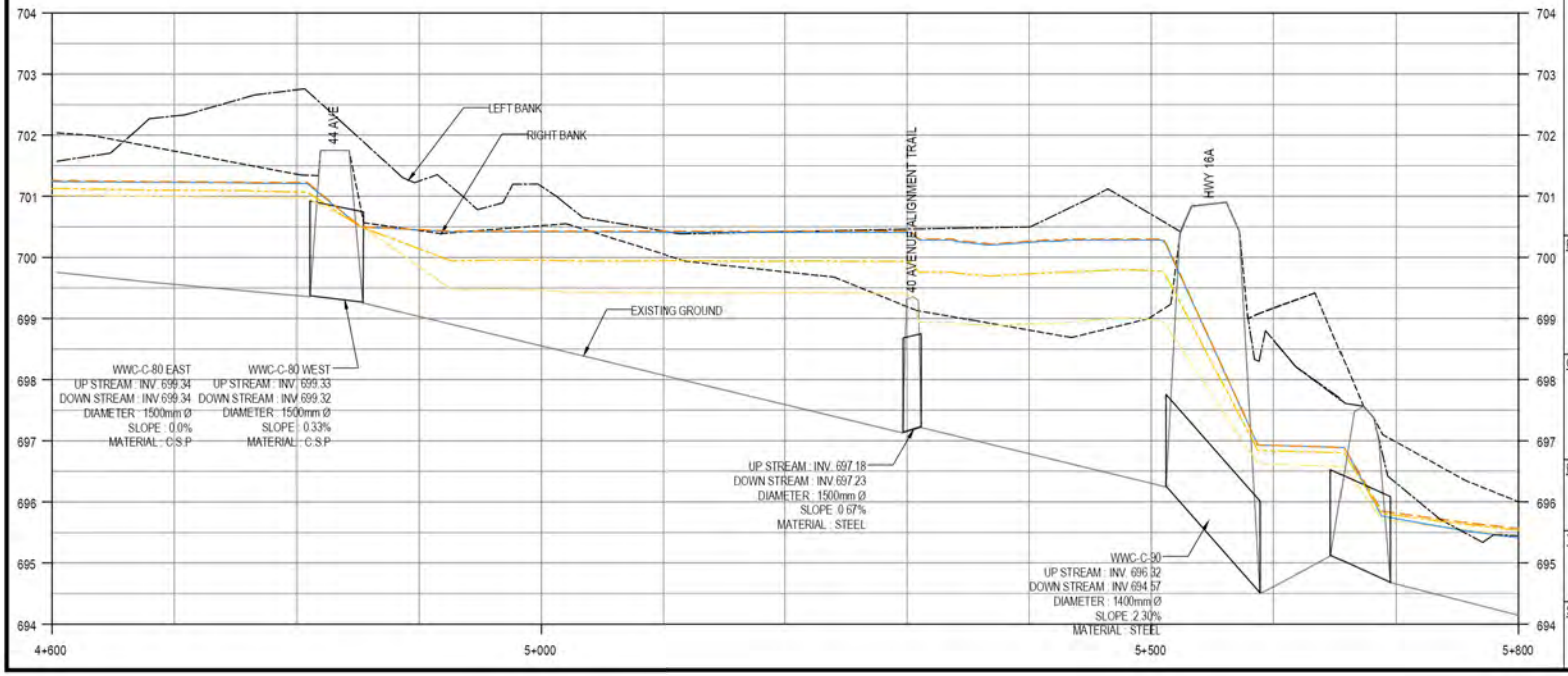
Project:

Town of Stony Plain Flood Mitigation Program

Title:

WHISPERING WATERS CREEK - WATER SURFACE DELINEATION (FROM NORTH OF 55 AVENUE TO RAILROAD)

Scale:	Figure:
1:4000	5-6

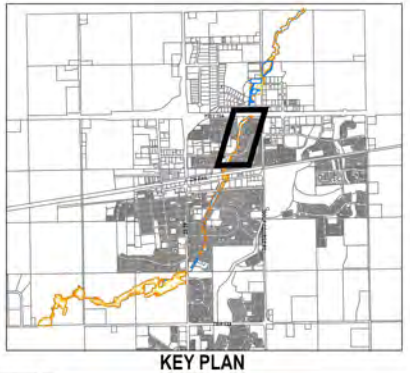


LEGEND:

- EXISTING WATERCOURSE
- EXISTING CULVERT
- EXISTING SANITARY LINE
- EXISTING WATER LINE
- EXISTING STORM LINE

SIMULATED WATER LEVEL — RETURN PERIOD:

- 1:5 YEAR
- 1:25 YEAR
- 1:100 YEAR
- IMPROVED 1:100 YEAR - OPTION 2 (INCLUDE BMX POND) (IF NOT VISIBLE, ASSUME IT IS THE SAME AS EXISTING 1:10-YEAR)



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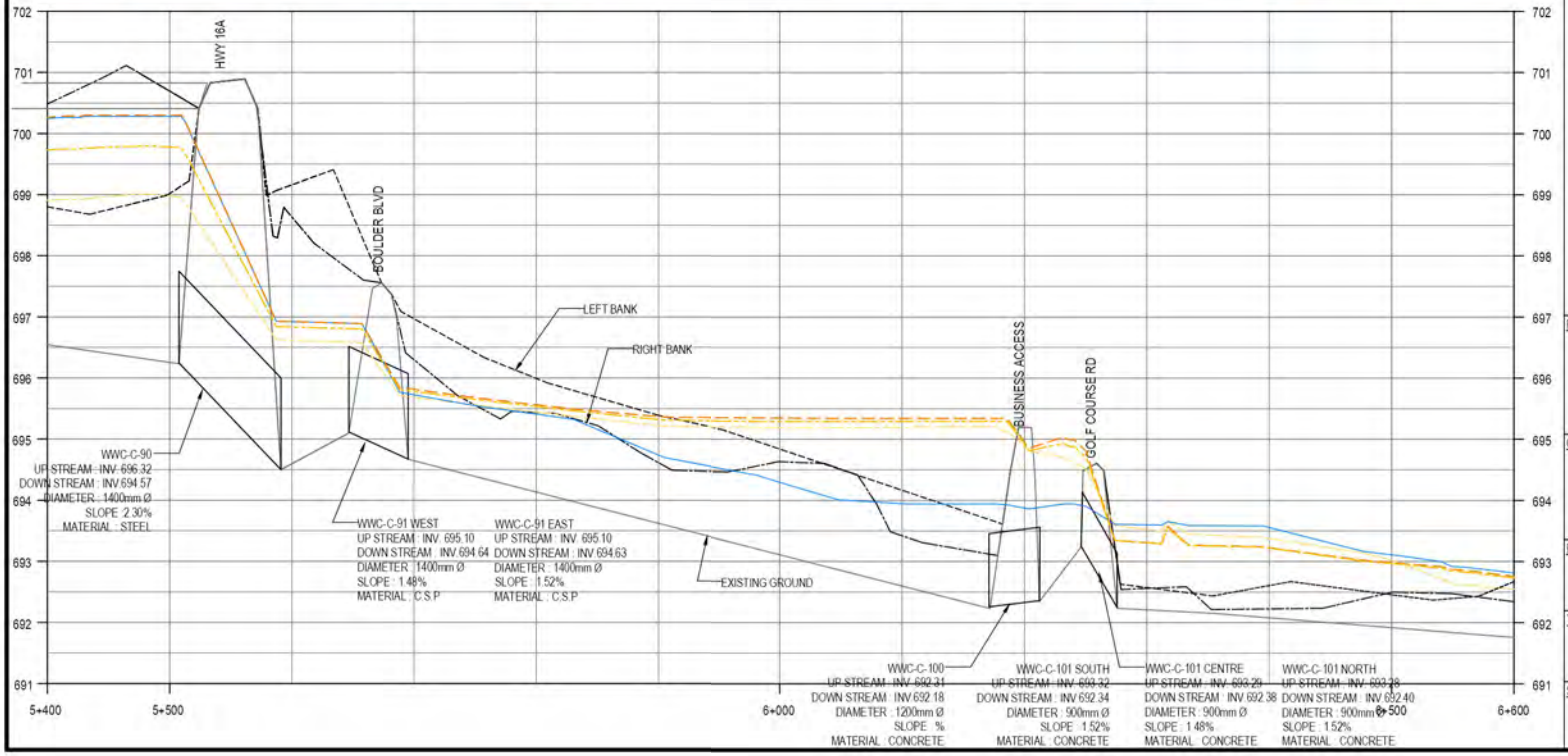
Project: **Town of Stony Plain Flood Mitigation Program**

Title: **WHISPERING WATERS CREEK - WATER SURFACE DELINEATION (FROM RAILROAD TO HWY 16A)**

Scale:	Figure:
1:4000	5-7



LEGEND:

- MUNICIPAL BOUNDARY
- EXISTING WATERCOURSE
- EXISTING STORMWATER MANAGEMENT FACILITY
- EXISTING CULVERT
- EXISTING SANITARY LINE
- EXISTING WATER LINE
- EXISTING STORM LINE

SIMULATED WATER LEVEL — RETURN PERIOD:

- 1:5 YEAR
- 1:25 YEAR
- 1:100 YEAR
- IMPROVED 1:100 YEAR - OPTION 2 (INCLUDE BMX POND) (IF NOT VISIBLE, ASSUME IT IS THE SAME AS EXISTING 1:100-YEAR)

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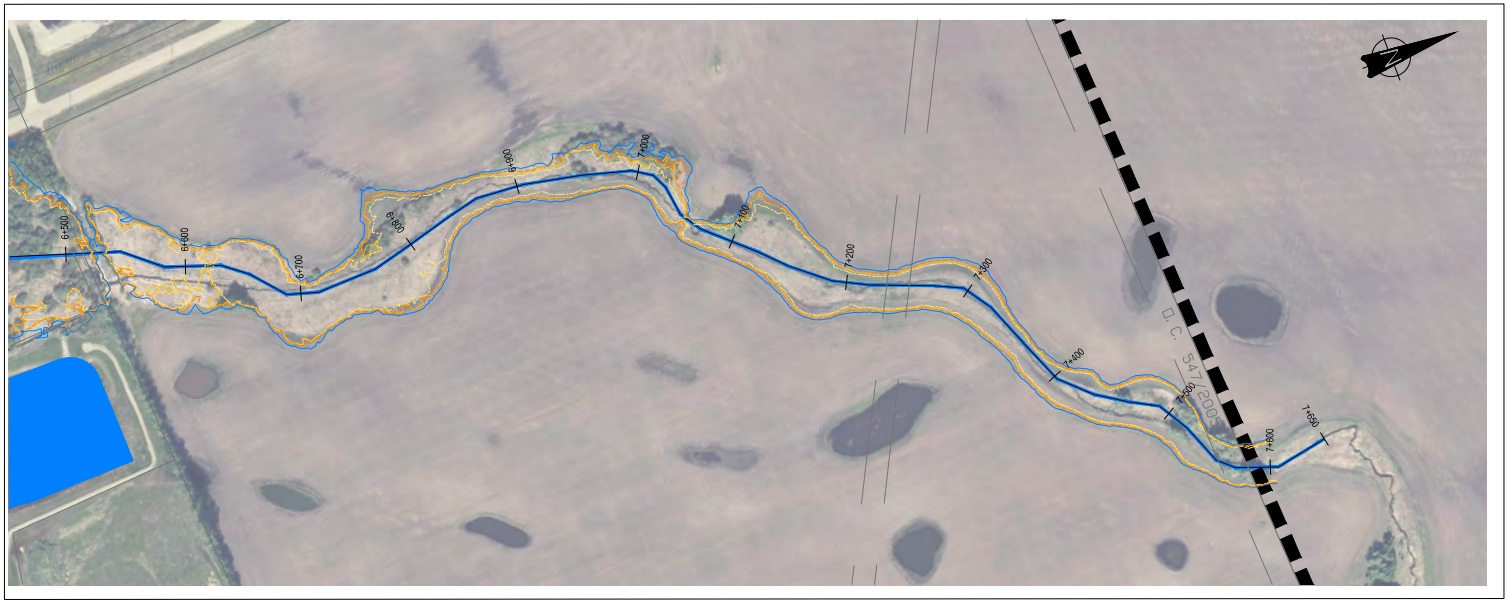
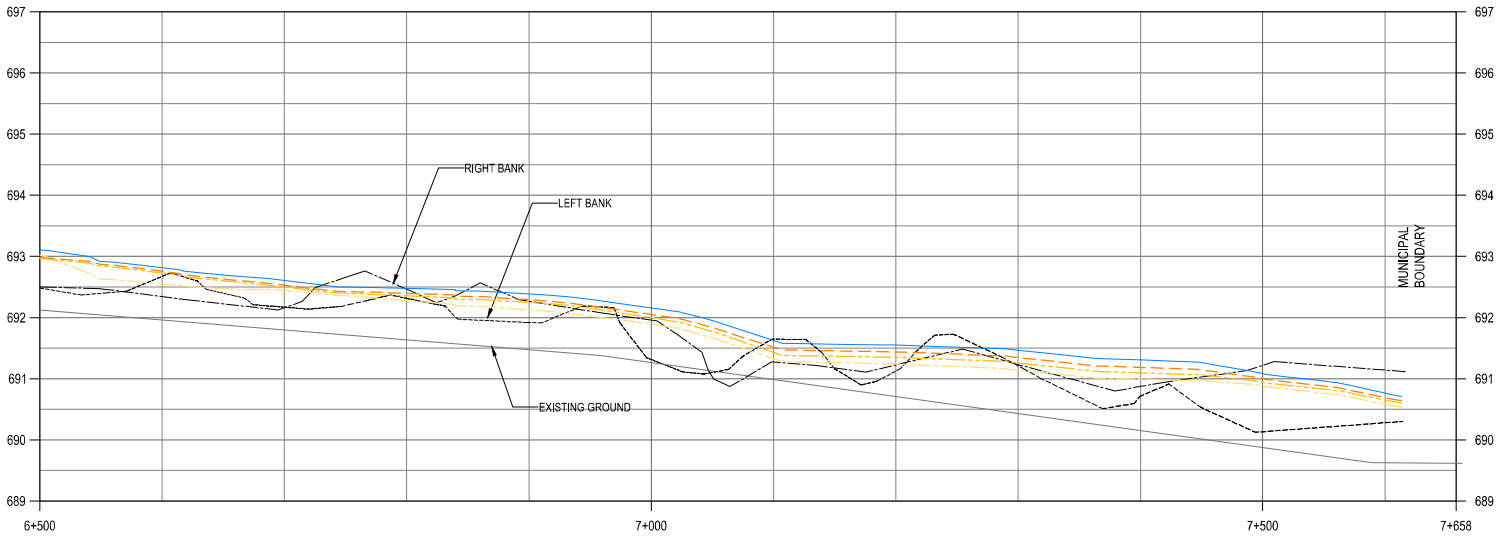
Title: **WHISPERING WATERS CREEK - WATER SURFACE DELINEATION (FROM HWY 16A TO GOLF COURSE ROAD NORTH)**

Scale:	Figure:
1:4000	5-8



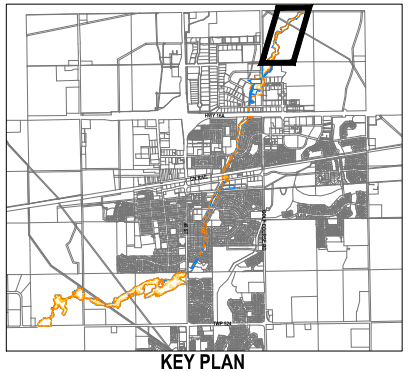


LEGEND:

- MUNICIPAL BOUNDARY
- EXISTING WATERCOURSE
- EXISTING STORMWATER MANAGEMENT FACILITY

SIMULATED WATER LEVEL — RETURN PERIOD:

- 1:5 YEAR
- 1:25 YEAR
- 1:100 YEAR
- IMPROVED 1:100 YEAR - OPTION 2 (INCLUDE BMX POND) IF NOT VISIBLE, ASSUME IT IS THE SAME AS EXISTING 1:100-YEAR)



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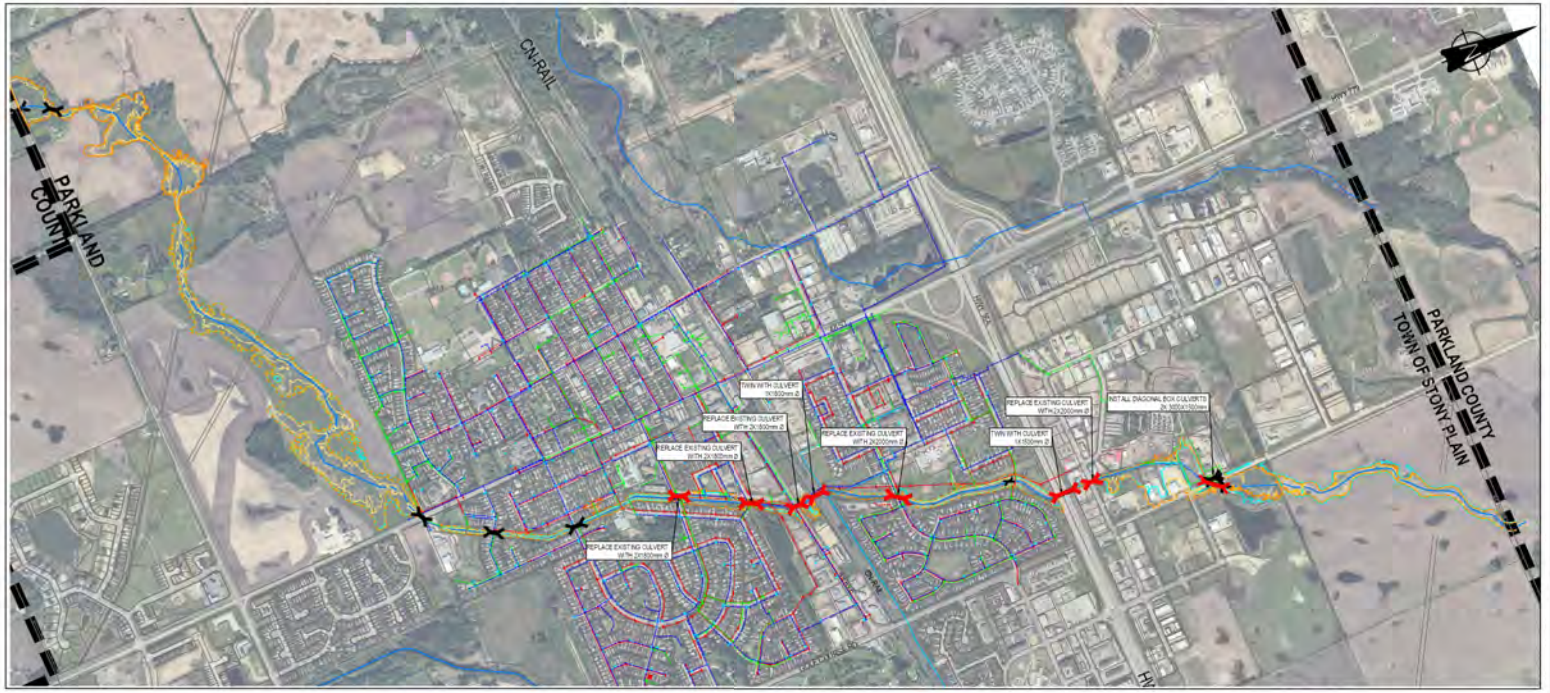
Client: TOWN OF STONY PLAIN

Project: **Town of Stony Plain Flood Mitigation Program**

Title: **WHISPERING WATERS CREEK - WATER SURFACE DELINEATION (FROM GOLF COURSE ROAD NORTH TO NORTH TOWN BOUNDARY)**

Scale:	Figure:
1:4000	5-9

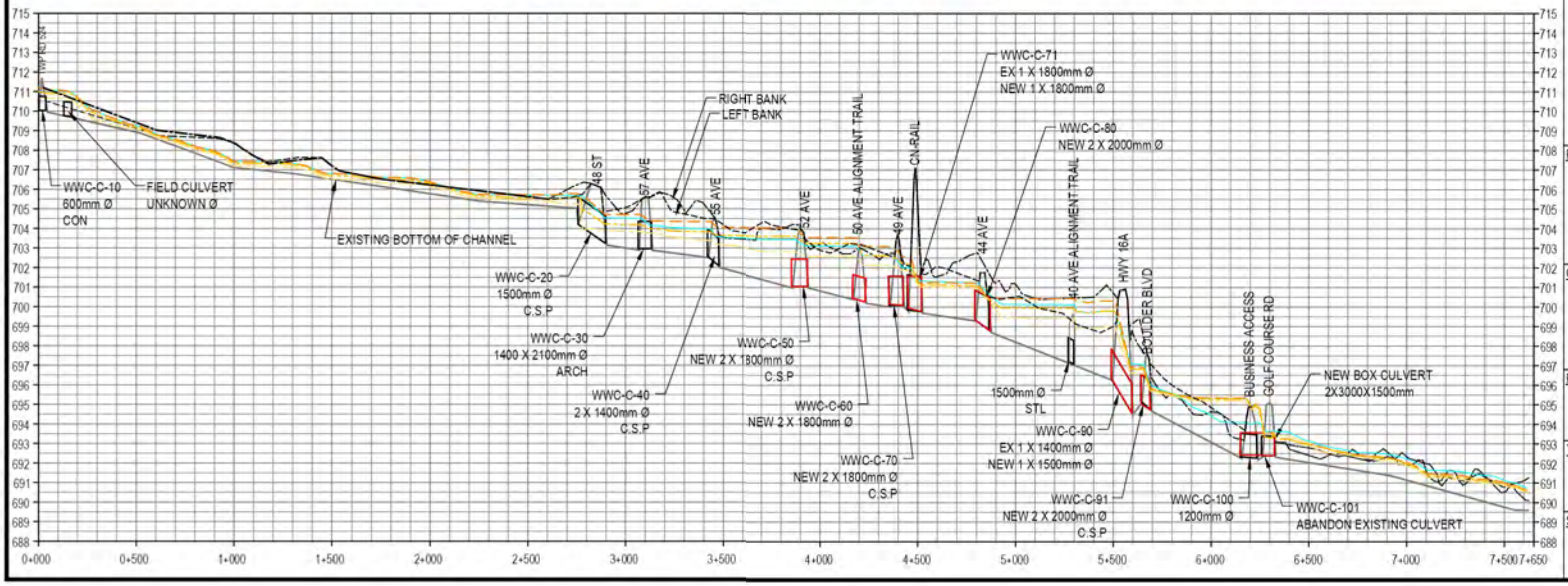


LEGEND:

- MUNICIPAL BOUNDARY
- EXISTING WATERCOURSE
- EXISTING CULVERT
- PROPOSED CULVERT UPGRADES
- EXISTING SANITARY LINE
- EXISTING WATER LINE
- EXISTING STORM LINE

SIMULATED WATER LEVEL — RETURN PERIOD:

- 1:5 YEAR
- 1:25 YEAR
- 1:100 YEAR
- IMPROVED 1:100 YEAR - OPTION 1 (IF NOT VISIBLE, ASSUME IT IS THE SAME AS EXISTING 1:100-YEAR)



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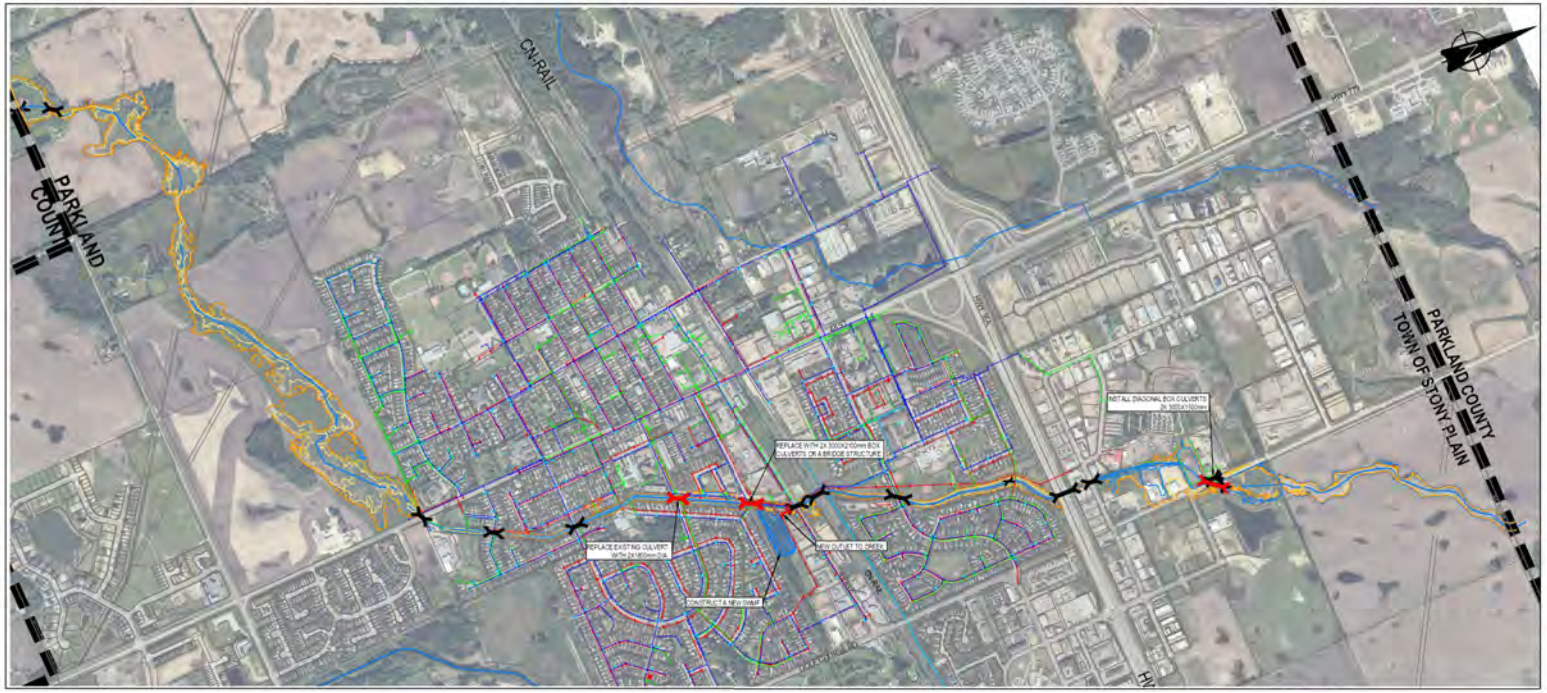
Client: TOWN OF STONY PLAIN

Project: **Town of Stony Plain Flood Mitigation Program**

Title: **WHISPERING WATERS CREEK FLOOD MITIGATION OPTION #1 - OVERALL**

Scale:	Figure:
1:25,000	5-10

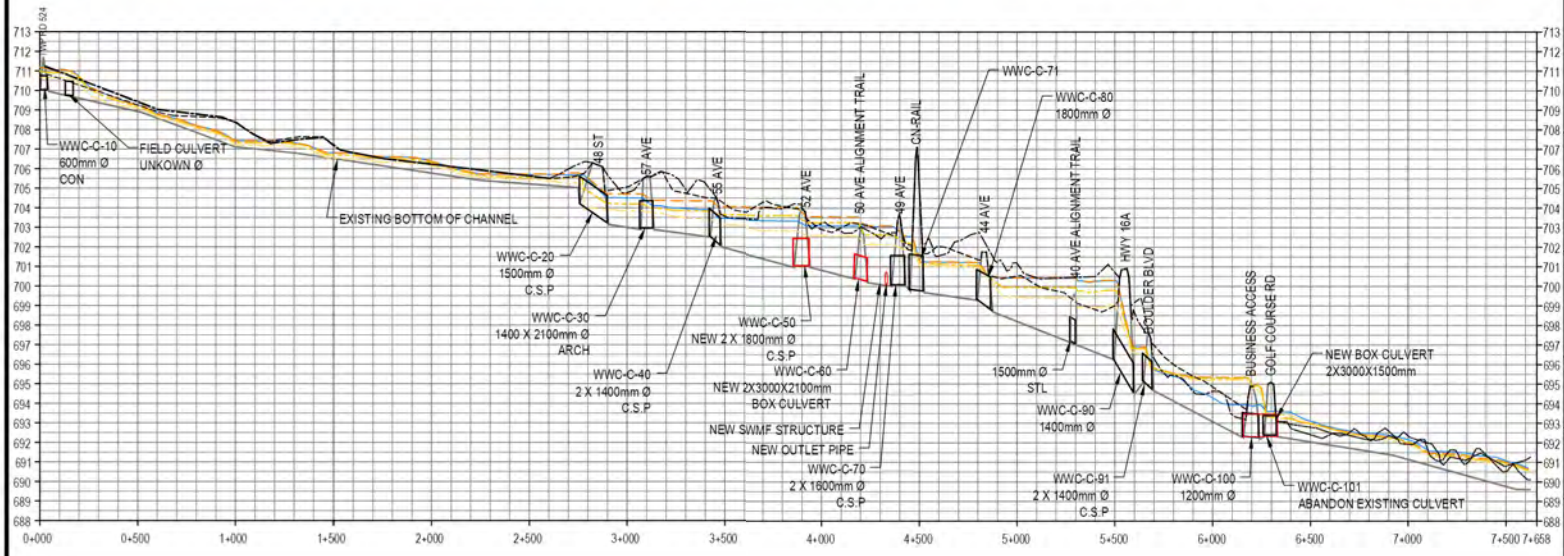


LEGEND:

- MUNICIPAL BOUNDARY
- EXISTING WATERCOURSE
- EXISTING CULVERT
- PROPOSED CULVERT UPGRADES
- PROPOSED SWMF
- PROPOSED OUTLET
- EXISTING SANITARY LINE
- EXISTING WATER LINE
- EXISTING STORM LINE

SIMULATED WATER LEVEL — RETURN PERIOD:

- 1:5 YEAR
- 1:25 YEAR
- 1:100 YEAR
- IMPROVED 1:100 YEAR - OPTION 2 (INCLUDE BMX POND) (IF NOT VISIBLE, ASSUME IT IS THE SAME AS EXISTING 1:100-YEAR)



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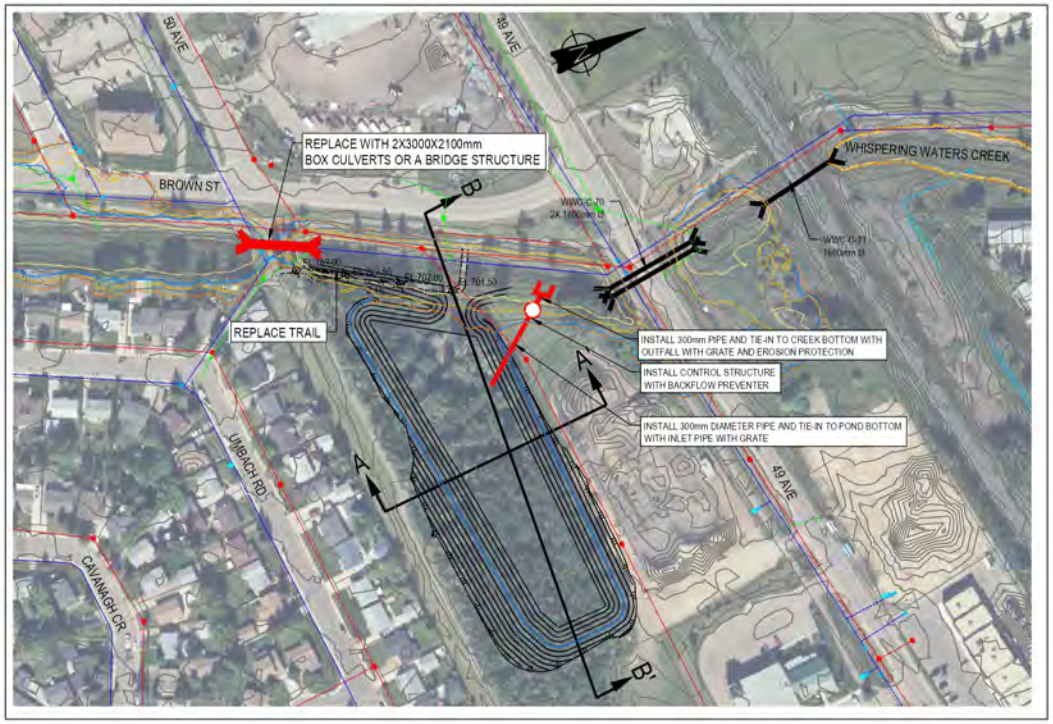
Client: TOWN OF STONY PLAIN

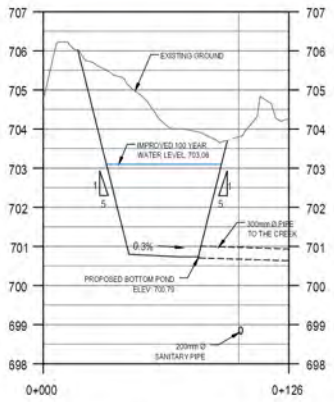
Project: **Town of Stony Plain Flood Mitigation Program**

Title: **WHISPERING WATERS CREEK - FLOODPLAIN DELINEATION OPTION 2 - OVERALL**

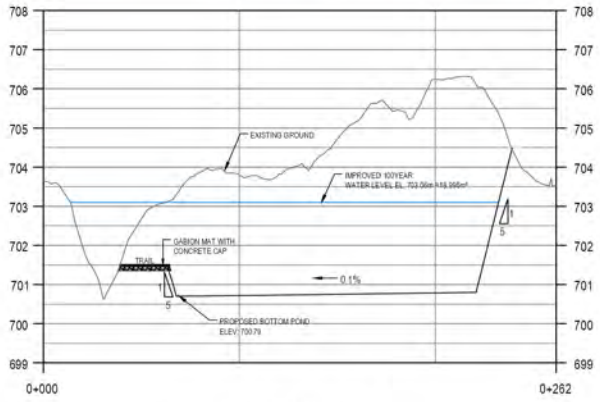
Scale: **1:25,000**

Figure: **5-11**





CROSS-SECTION A - A'



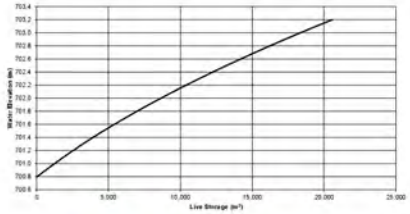
CROSS-SECTION B - B'

LEGEND:

- EXISTING WATERCOURSE
- EXISTING CULVERT
- EXISTING SANITARY LINE
- EXISTING WATER LINE
- EXISTING STORM LINE
- EXISTING CONTOUR (INTERVAL 0.5m)
- PROPOSED OUTLET
- PROPOSED CONTOUR (INTERVAL 0.5m)
- PROPOSED CULVERT

SIMULATED WATER LEVEL RETURN PERIOD:

- 1:5 YEAR
- 1:25 YEAR
- 1:100 YEAR
- IMPROVED 1:100 YEAR - OPTION 2 (INCLUDE BMX POND) (IF NOT VISIBLE, ASSUME IT IS THE SAME AS EXISTING 1:100-YEAR)



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Client:
TOWN OF STONY PLAIN

Project:
Town of Stony Plain Flood Mitigation Program

Title:
WHISPERING WATERS CREEK FLOOD - FLOOD MITIGATION OPTION #2 - 50th AVENUE POND DETAILS

Scale:	Figure:
1:2500	5-12

6.0 Flood Mitigation of Sewer and Surface Drainage Systems

6.1 Overview

This section describes the existing condition and performance of the storm and sanitary sewer systems and of the major drainage (overland drainage) systems, identifies areas at flood risk in select areas of the Town, as well as recommendations to reduce flood risks associated with large ponding depths and sewer backups.

6.2 Background

The 'Water and Sanitary Master Plan Update (Associated Engineering, March 2019)' report identified that the Central Trunk is overloaded with surcharge to basement level in the 1:25 year 4-hour design storm downstream along Oatway Drive (52 Avenue).

The 'Stormwater Master Plan 2018 (Sameng, April 2019)' report identified 7 key areas at an elevated flood risk due to large ponding depths and large surface flows, named Area A to Area G. These are all within the Whispering Waters Creek Drainage Basin.

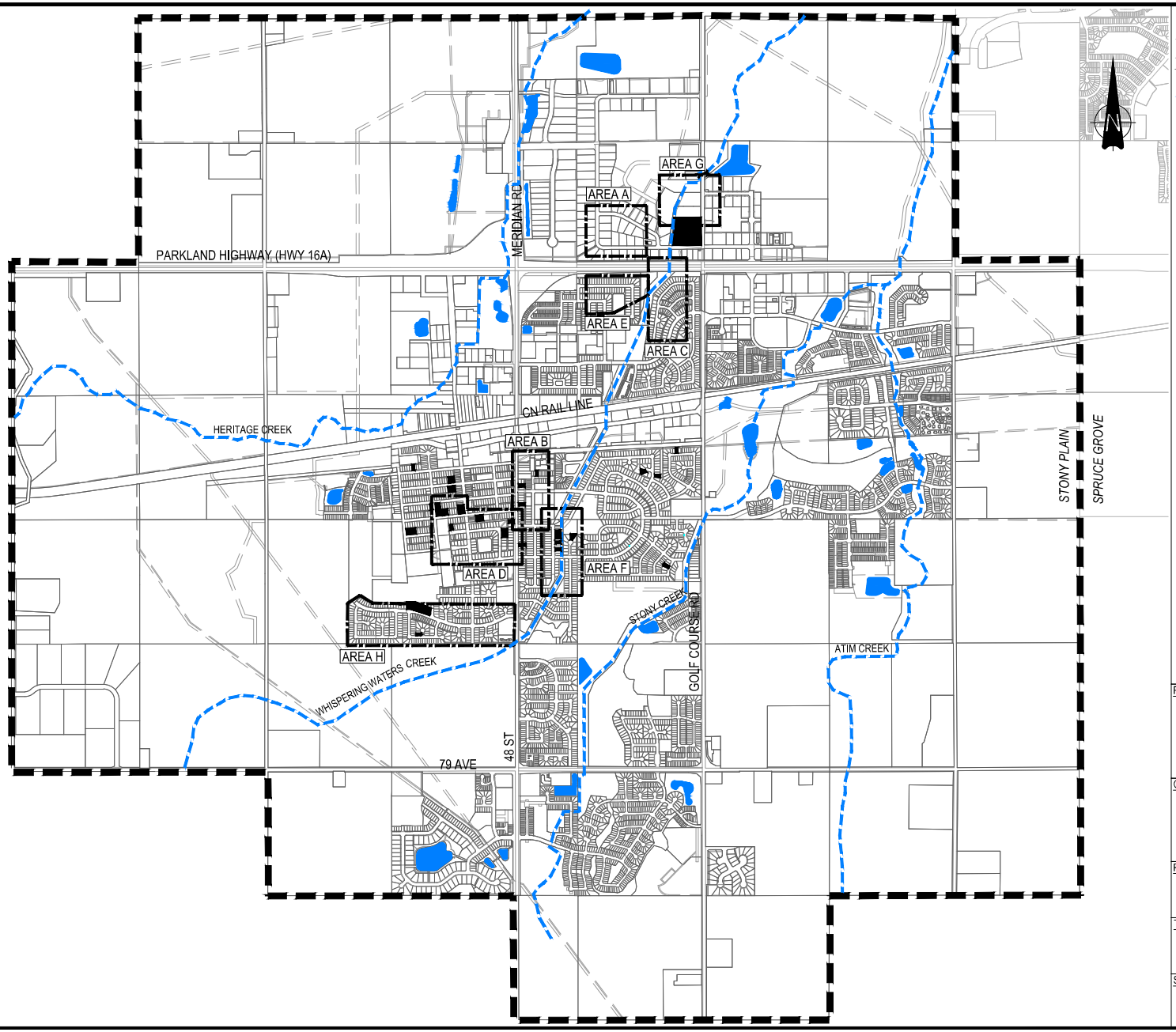
Furthermore, following the flood events of July 2019, an additional area, Area H, was identified as being at risk of flooding, mainly due to overland drainage.

For purposes of this flood mitigation study, flood risks in Area A to Area H due to surface ponding and sewer backups were reviewed and improvement concepts were developed. These are described below. Figure 6-1 illustrates the location of Area A to Area H. Additional flood risks due to significant sanitary sewer surcharge were also identified.

The identification and description of flood risks in other areas of the Town, including the development of improvement concepts, was outside of the scope of this study.

6.3 Existing Flood Risk Areas and Drainage System Performance

Additional assessments and computer modeling were completed to evaluate the flood risks in Areas A to H, as well as along the Sanitary Central Trunk. The following Figure 6-2 to Figure 6-4 show the simulation results of the existing sanitary sewer system and of the storm sewer and overland drainage system under a 1:100-year design rainfall event (using 4-hour Chicago Distribution). Simulation results for other design rainfalls are included in Appendix A. For Area A to H, the current system performance and flood risks are described in the following sections.



LEGEND:

- MUNICIPAL BOUNDARY
- IMPROVEMENT AREAS
- REPORTED FLOOD IN JULY 2019
- EXISTING WATERCOURSE
- EXISTING STORMWATER MANAGEMENT FACILITY

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Project: **Town of Stony Plain Flood Mitigation Program**

Title: **Overview of Flood Risk Area Evaluated during this Study**

Scale:	Figure:
1:25,000	6-1

LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Storm Sewer)

- > 1.0m BELOW GROUND
- 0 TO 1.0m BELOW GROUND
- AT OR ABOVE GROUND

PIPE LOADING FACTOR (Qmax / Qmanning) (Storm Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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Client:

TOWN OF STONY PLAIN

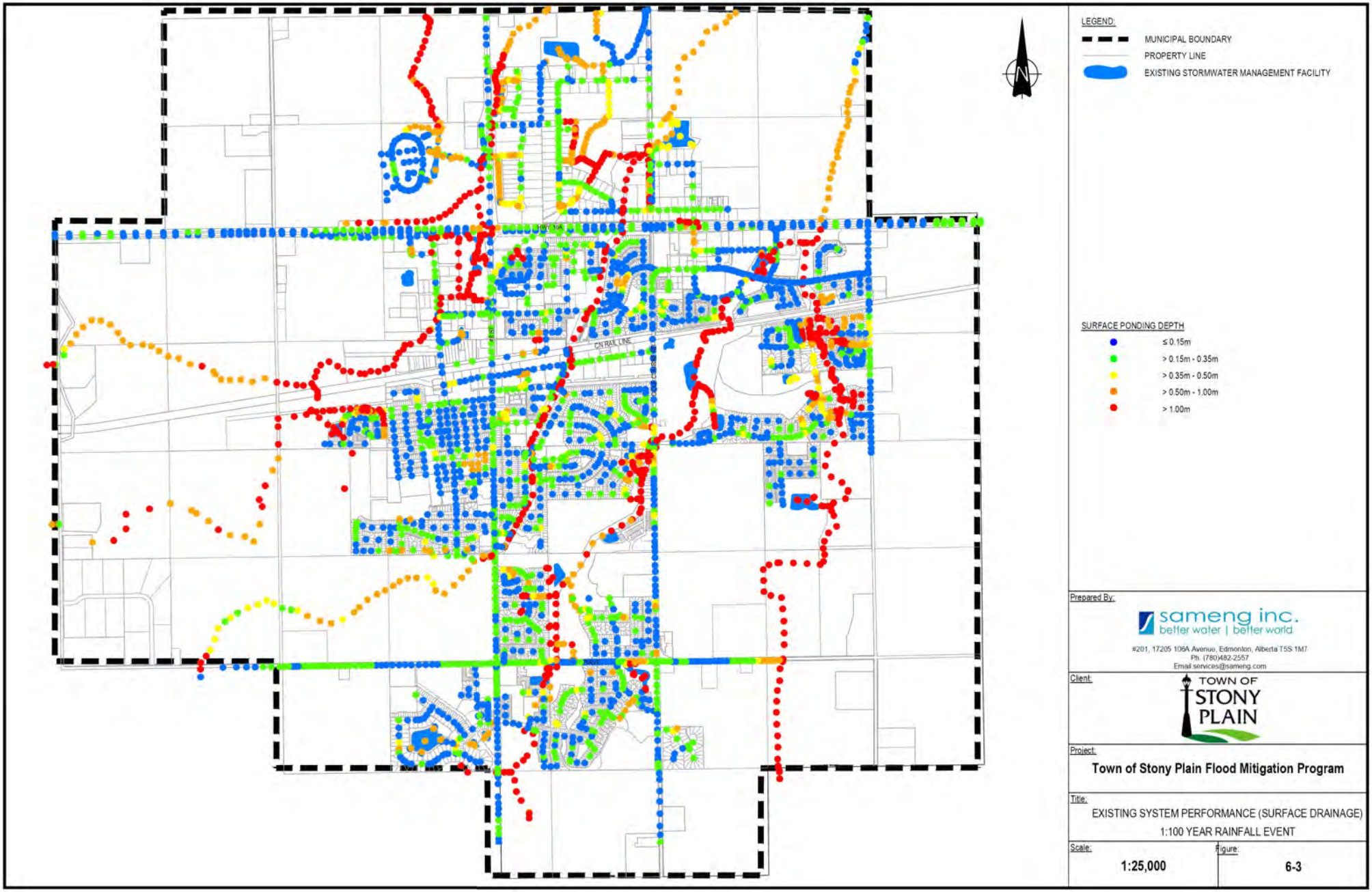
Project:

Town of Stony Plain Flood Mitigation Program

Title:

EXISTING SYSTEM PERFORMANCE (STORM SEWERS)
1:100 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	6-2



LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURFACE PONDING DEPTH

- ≤ 0.15m
- > 0.15m - 0.35m
- > 0.35m - 0.50m
- > 0.50m - 1.00m
- > 1.00m

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Client:

TOWN OF STONY PLAIN

Project:

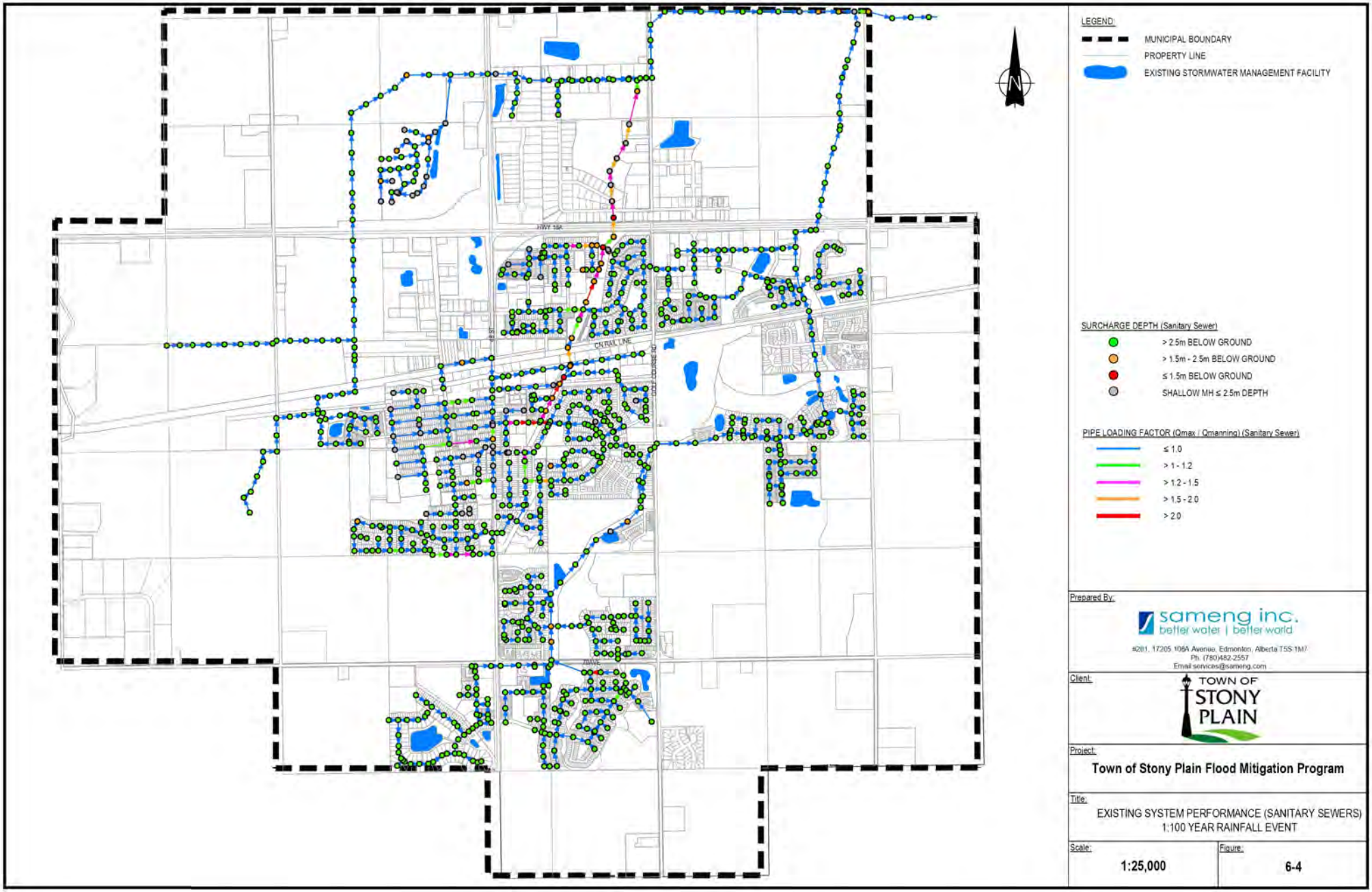
Town of Stony Plain Flood Mitigation Program

Title:

EXISTING SYSTEM PERFORMANCE (SURFACE DRAINAGE)
1:100 YEAR RAINFALL EVENT

Scale: **1:25,000**

Figure: **6-3**



LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Sanitary Sewer)

- > 2.5m BELOW GROUND
- > 1.5m - 2.5m BELOW GROUND
- ≤ 1.5m BELOW GROUND
- SHALLOW MH ≤ 2.5m DEPTH

PIPE LOADING FACTOR (Qmax / Qmanning) (Sanitary Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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Client: TOWN OF STONY PLAIN

Project: **Town of Stony Plain Flood Mitigation Program**

Title: EXISTING SYSTEM PERFORMANCE (SANITARY SEWERS)
1:100 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	6-4

6.4 Area A

6.4.1 Area A – Existing

Area A, shown in Figure 6-5, covers the general area of Boulder Boulevard and Granite Drive in the North Business Park subdivision. This Business Industrial District is north of Highway 16A, between Highway 779 and Golf Course Road.

The drainage issues in this area are more of a nuisance than a flood risk. This is because surface drainage from part of Boulder Boulevard and from the adjacent industrial lots is conveyed towards the southwest curve of Boulder Boulevard where water enters the storm sewer system via catchbasins. When the sewer capacity is exceeded (during large rainfall events), the surface runoff then overflows to the northeast onto a private industrial lot (currently a storage yard) and flows northeast until it reaches a small ditch, flowing northeast. The ponding depth at the Boulder Boulevard southwest curve is small and does not pose a flood risk to the area.

6.4.2 Area A – Proposed Improvements

As illustrated in Figure 6-6, the recommendation is to construct an overflow ditch from the southwest curve of Boulder Boulevard to the existing ditch, and to upsize the existing ditch (and culvert) all the way to Granite Drive. This ditch would need to be constructed on private property, and the Town would need to obtain an easement to construct and maintain the ditch. Concurrently, the Town should obtain an easement for the existing drainage ditch south of Granite Drive.

To develop a design that address the flooding risk at this location, more detailed investigation needs to be completed including a topographical survey of the roadways, of the adjacent properties where water currently overflows, and of the existing ditches. It is recommended that the Town conduct this investigation as a separate, local drainage improvement initiative in order to develop an economical solution. This may include consideration to acquire a suitable easement to upgrade and maintain the ditch through private property.

6.4.3 Area A – Costs and Benefits

The estimated cost to provide flood mitigation for Area A is $48,000. This includes the excavation of 125m of new channel, plus surficial improvements to 350m of existing channel. This cost does not include any easement costs that may arise.

The quantifiable benefits of these improvements are in the reduction of street ponding on Boulder Boulevard. The improvements should limit ponding on the street to less than 35cm during a 100-year storm event, which will reduce the risk of vehicles driving or parked on this roadway. The estimated benefit of the improvements over a 75-year period is $100,000, for a benefit-cost ratio of 2.1.

The benefit quantification does not quantify benefits to the industrial site which currently sees water overflow the site every time the storm sewer system cannot handle the runoff flows. This is because the site is mostly a storage yard at the moment, and flood risks on the site itself is low.

EXISTING FLOOD AREA

IMPROVED FLOOD AREA

LEGEND:

PROPERTY LINE

100 YEAR PONDING EXTENTS

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Client:

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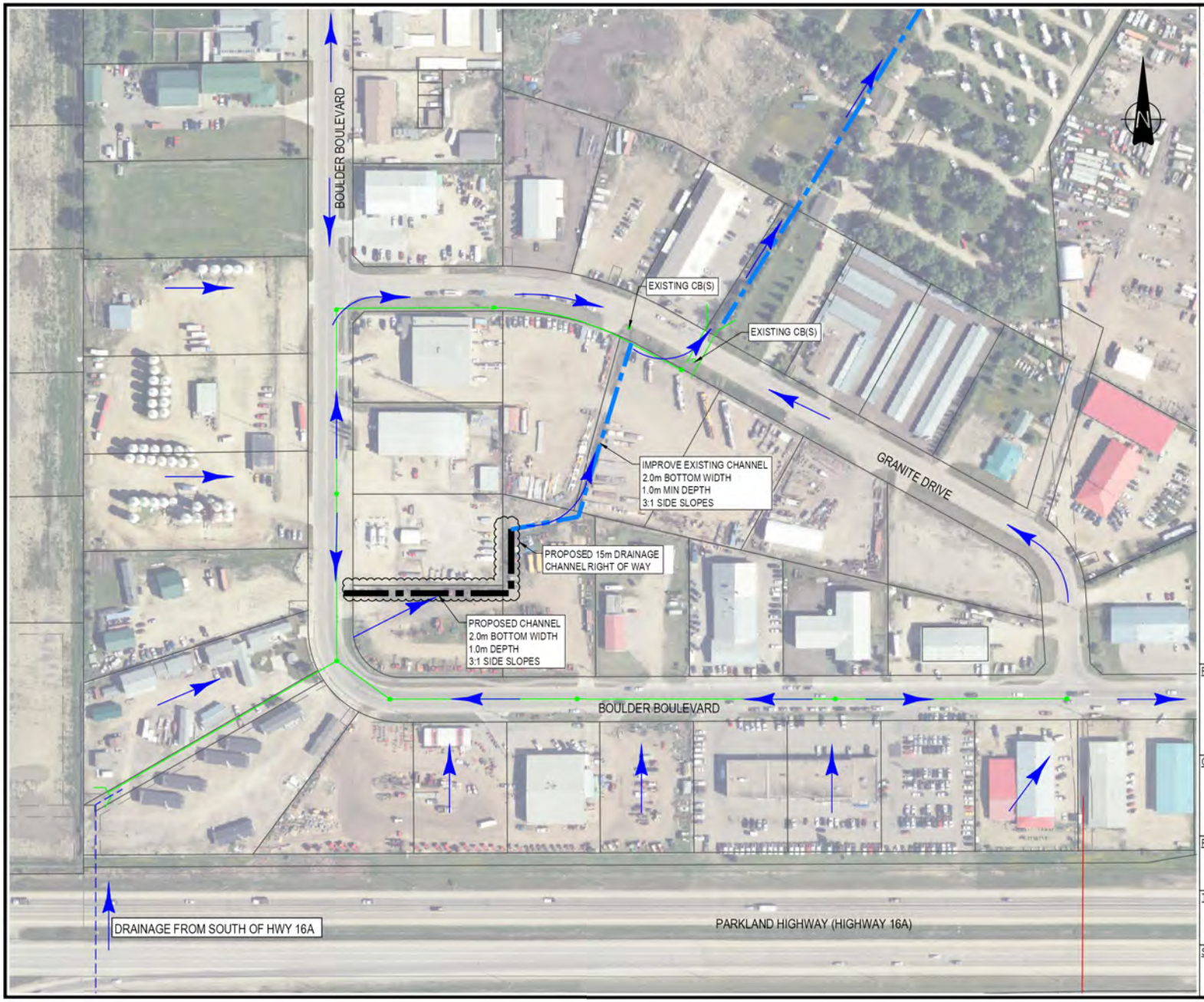
Project:

Town of Stony Plain Flood Mitigation Program

Title:

AREA A - EXISTING AND IMPROVED FLOOD RISKS

Scale:	Figure:
1:5,000	6-5



LEGEND:

- PROPERTY LINE
- EXISTING STORM PIPE
- EXISTING SANITARY PIPE
- EXISTING WATER PIPE
- EXISTING DRAINAGE CHANNEL
- PROPOSED DRAINAGE CHANNEL
- EXISTING MAJOR DRAINAGE FLOW

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Project: **Town of Stony Plain Flood Mitigation Program**

Title: **Area A - Proposed Improvements**

Scale:	Figure:
1:2000	6-6

6.6 Area B

6.6.1 Area B - Existing

Area B, shown in Figure 6-7, covers part of Old Town in the area of 46 to 48 Street and from 50 to 54 Avenue. This area is primarily at flood risks due to excessive surface ponding. However, significant sanitary sewer surcharge in the Central Trunk may also cause some sewer backups in this area. As shown in Figure 6-1, three (3) properties reported flooding in that area, although the cause of the reported flood is unknown.

The depression at the road bend of Egerland Place is subject to frequent flooding. This depression is about 45cm lower than its overflow point which is southeast on 52 Avenue. This ponding depth is not believed to directly flood any houses before it overflows, but the streets and some grass and driveways will be flooded. Runoff can reach and flood this area multiple ways. First, from direct runoff from its catchment area which will start flooding the depression when the catchbasins' capacities are exceeded. Secondly, when the sewer on 52 Avenue is surcharged to ground (which happens during a 1:5-year event), water flows back towards that depression and floods it. Thirdly, major drainage for the Old Town are coming from the west on 52 Avenue will make a left turn onto Egerland Place and flood that depression; a high point further east on 52 Avenue prevents the major drainage from continuing on to the Creek. The flow rate making it from 52 Avenue to Egerland Place is quite significant. Figure D- 4 and Figure D- 5 show the ponding extent on Egerland Place in July 2019.

Similarly, the rear parking lot of 5013 48 Street, just west of the Egerland Place bend/depression, is another 30cm than the depression. It is believed that the catchbasin in that parking lot is connected to the Egerland Place storm sewer and therefore subject to the same flood risks. Many vehicles in that parking lot could be flooded from the deep ponding water.

Similarly, the alley between 48 and 47 Street, south of 52 Avenue, is lower than 52 Avenue and also subject to water backing up into the alley when the surcharge in the 52 Avenue storm trunk is too high.

Similarly the property at 5105 and 5107 48 Street (gas station) has a depression along the back of the property (just north of 52 Avenue) that is subject to flooding from both water flowing down (east) on 52 Avenue as well as from the 52 Avenue storm sewer surcharging into that depression. Figure D- 3 shows the ponding extent behind the gas station in July 2019. Figure D- 2 shows some water ponding/flowing along the front of the gas station.

Similarly, the commercial property at 4613 52 Avenue (especially west side), may be subject to flooding due to high ponding depth and flow depth on 52 Avenue, as well as the high surcharge depth in the trunk.

Although the surface ponding has the potential to flood some buildings/houses and vehicles, it is not so much the depth and extent of ponding that is the issue, but also the frequency of this flooding. According to our computer modeling, this area can see some significant ponding depths for rainfall events as small as the 1:5-year event, and maximum ponding depths (to overflow elevation) are attained at about the 1:10 to 1:25 year event.

6.6.2 Area B – Proposed Improvements

To reduce flood risks due to all the surface ponding in Area B, the recommendation is to upgrade the 600mm storm trunk on 52 Avenue all the way to the outfall into Whispering Waters Creek, and also to upgrade the pipe on Egerland Drive from the Egerland Drive bend to 52 Avenue. The proposed pipe would be sized to convey the peak 100-year storm flows from the area. Additional and/or upgraded catchbasins would also be needed to convey all surface runoff into the storm sewer.

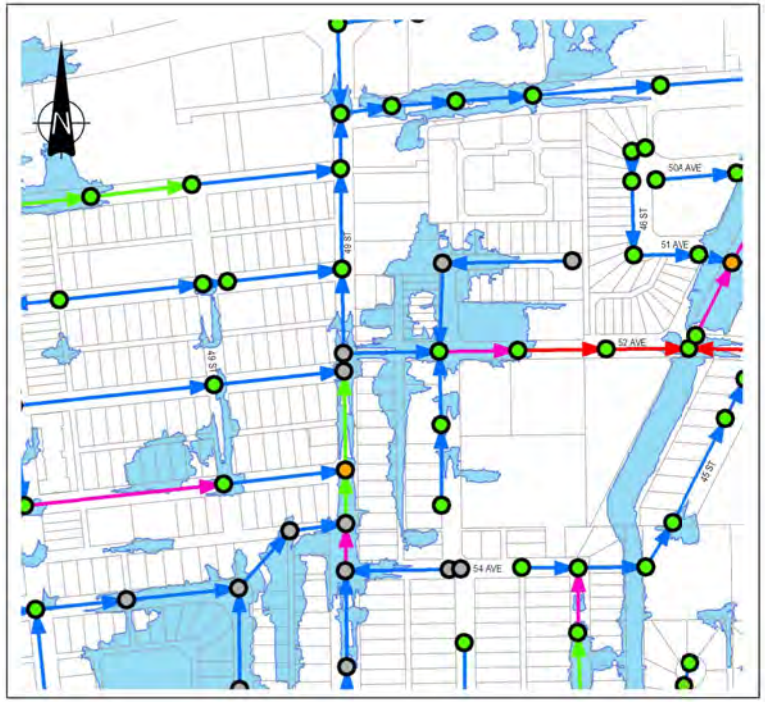
The proposed improvement for Area B was combined with Area D, given the synergy between the two. Details of the proposed upgrade can be found in Section 6.8 and in Figure 6-14 to Figure 6-17.

The proposed improvements should significantly reduce ponding depths in these areas, and practically eliminate all surface ponding flood risks for these areas. Simulation results are shown in Figure 6-7. During the 1:100-year event, the ponding on the street should be reduced to less than what the current 1:5-year produces. The 52 Avenue storm trunk would also not be surcharged to grade during the 1:100-year event.

In addition to the above, it may be possible to regrade a portion of 52 Avenue from Egerland Place towards the east for a distance of about 150m. This would redirect some of the surface drainage from flowing towards Egerland Place and maintain it flowing east into the Creek. Such a solution will require a detailed site-specific roadway survey to determine the most effective modifications.

6.6.3 Area B – Costs and Benefits

See Area D in Section 6.8.3 for costs and benefits for Area B.



EXISTING FLOOD AREA

IMPROVED FLOOD AREA

LEGEND:

PROPERTY LINE

EXISTING FLOOD RISKS

100YEAR PONDING EXTENTS

IMPROVEMENT FLOOD RISKS

PHASE 1 AND 2 IMPROVEMENT ONLY

FULL IMPROVEMENT

SURCHARGE DEPTH (Sanitary Sewer)

- > 2.5m BELOW GROUND
- > 1.5m - 2.5m BELOW GROUND
- ≤ 1.5m BELOW GROUND
- SHALLOW MH ≤ 2.5m DEPTH

PIPE LOADING FACTOR (Qmax / Qmanning) (Sanitary Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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Project:

Town of Stony Plain Flood Mitigation Program

Title:

AREA B - EXISTING AND IMPROVED FLOOD RISKS

Scale:	Figure:
1:5,000	6-7

6.7 Area C

6.7.1 Area C - Existing

Area C, shown in Figure 6-8, covers part of the St Andrews subdivision which is located west of Golf Course Road and south of Highway 16A. There are two main flood risks present in Area C.

To the north of the subdivision along St. Andrew Drive, many properties back on to Whispering Waters Creek and some backyards are partly in the floodplain of the Creek. This flood risk is described in more details in Section 5.3 and will not be repeated here.

Along 44 Avenue, between St. Andrews Drive and St. Andrews Street, there is large and deep depression with no suitable major drainage overflow. The water depth at the lowest road elevation (at the catchbasins in front of 4009 44 Avenue) would need to reach 1.1m before overflowing to the north via St. Andrews Street and ultimately into Whispering Waters Creek. If this ever happened, about 15 houses would be flooded along 44 Avenue, and many more private properties would be under water. According to our simulation results for the 100-year event, the water will get to about 0.65m deep at this depression, and about 12 houses would be at risk of flooding. Three (3) houses are at risk of flooding during a 1:10-year and seven (7) houses are at risk during the 1:25-year. Ponding depths in excess of 35cm are expected for the 1:10-year and larger rainfall events. The main reason for the flooding is a lack of capacity in the storm sewer system to convey large flows, and the obvious lack of major drainage overflow. We identified the main chokepoint in the sewer system to be the existing 750mm outfall which is downstream of a 900mm pipe system.

6.7.2 Area C – Proposed Improvements

To reduce flood risks due to surface ponding in Area C, the recommendation is to upgrade the 750mm outfall, thus increasing its capacity and its peak flow during large rainfalls. See Figure 6-9 and Figure 6-10 for details. One option is to replace the existing 750mm storm pipe with a 1050mm storm pipe. However, the pipe replacement would be quite challenging given the depth of the pipe and the narrow easement. Therefore, we recommend that another 750mm pipe be installed just above the existing 750 mm pipe. This would reduce the hydraulic grade line in the storm sewer system, and therefore increase the flow rate out of the 44 Avenue depression, thus reducing ponding in the area. With this improvement, no house should be at risk of flooding during a 1:25-year event. However, 5 houses will still be at risk of flooding during the 1:100-year event. This is considered Stage 1 of the improvements for Area C.

To increase the level of flood protection from 1:25-year to 1:100-year, there will also be a need to install a new 750mm diameter storm sewer on 44 Avenue from St. Andrews Drive/Aberdeen Way to Whispering Waters Creek (outfall on north side of road) for a distance of 215m, and interconnect with the storm system at the intersection. See Figure 6-11 for details. This is considered Stage 2 of the improvements for Area C. It could also be constructed as Stage 1 and provide similar benefits than the outfall upgrade explained above, but at a larger cost. Instead of a new outfall in the Creek, the flow from this new pipe could be combined with the flow from the existing outfall and replace that outfall to a larger one; this would avoid having two outfalls side-by-side.

This improvement will have for impact to reduce the ponding depth on 44 Avenue during intense rainfall events up to the 1:100-year event, as illustrated in Figure 6-8.

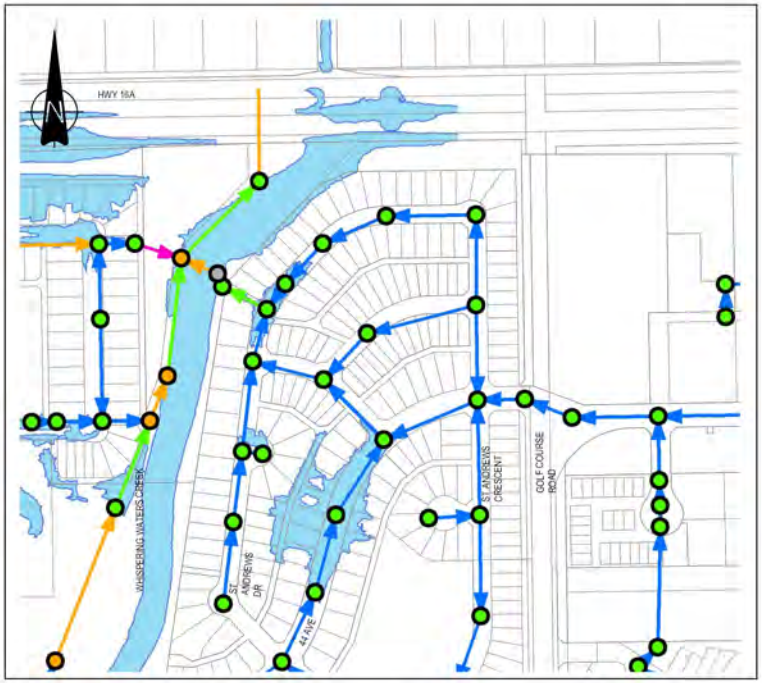
6.7.3 Area C – Costs and Benefits

The costs and benefits of Area C can be divided into two phases to achieve a 1:100-year level of service.

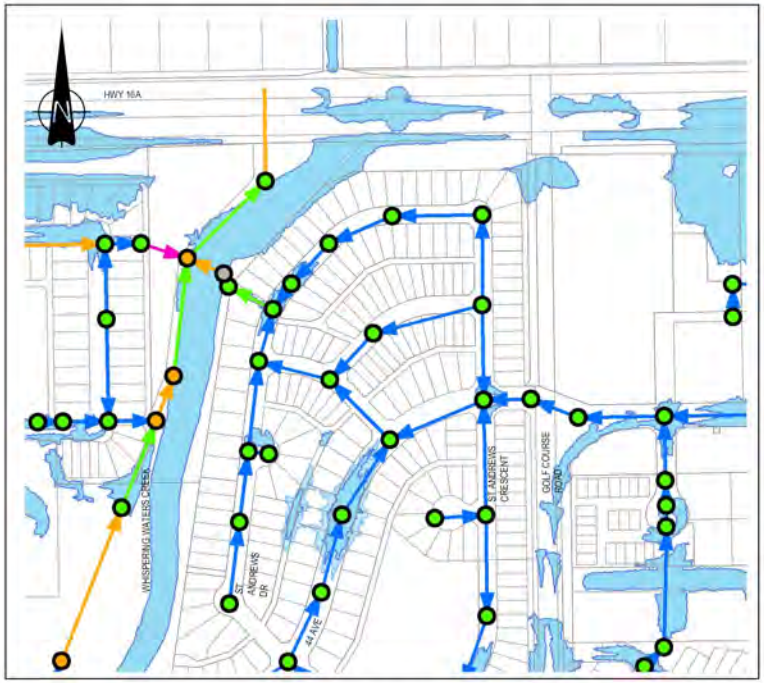
The initial phase of twinning the existing outfall to Whispering Waters Creek is estimated to cost $280,000. This phase will improve the level of service to 1:100-year for 5 homes (12 homes are currently at risk of flooding), with partial mitigation for additional homes, as well as reduced flood risk for parked vehicles. After this improvement is in place, all homes should be safe from flooding during a 1:25-year event. The value of this benefit is quantified to be about $5.2 Million over 75 years. The benefit-cost ratio is 18.7, which is very good.

The second phase of improvements includes the construction of a new outfall pipe along 44 Avenue. The cost of this phase is estimated to be $678,000. The benefit of this pipe is to increase the level of flood protection for the area to a 1:100-year for 7 additional homes, as well as further reducing street ponding and reducing flood risks for parked vehicles. Over 75 years, the value of this additional benefit is quantified to be about $1.4 Million. The benefit-cost ratio of this second phase is 2.1.

The total cost to provide flood mitigation for Area C is $958,000, with a combined benefit-cost ratio of 7.0.



EXISTING FLOOD AREA



IMPROVED FLOOD AREA

LEGEND:

PROPERTY LINE

EXISTI NG FLOOD RISKS

100YEAR PONDING EXTENTS

IMPROVEMENT FLOOD RISKS

PHASE 1 IMPROVEMENT ONLY

FULL IMPROVEMENT

SURCHARGE DEPTH (Sanitary Sewer)

- > 2.5m BELOW GROUND
- > 1.5m - 2.5m BELOW GROUND
- ≤ 1.5m BELOW GROUND
- SHALLOW MH ≤ 2.5m DEPTH

PIPE LOADING FACTOR (Qmax / Qmanning) (Sanitary Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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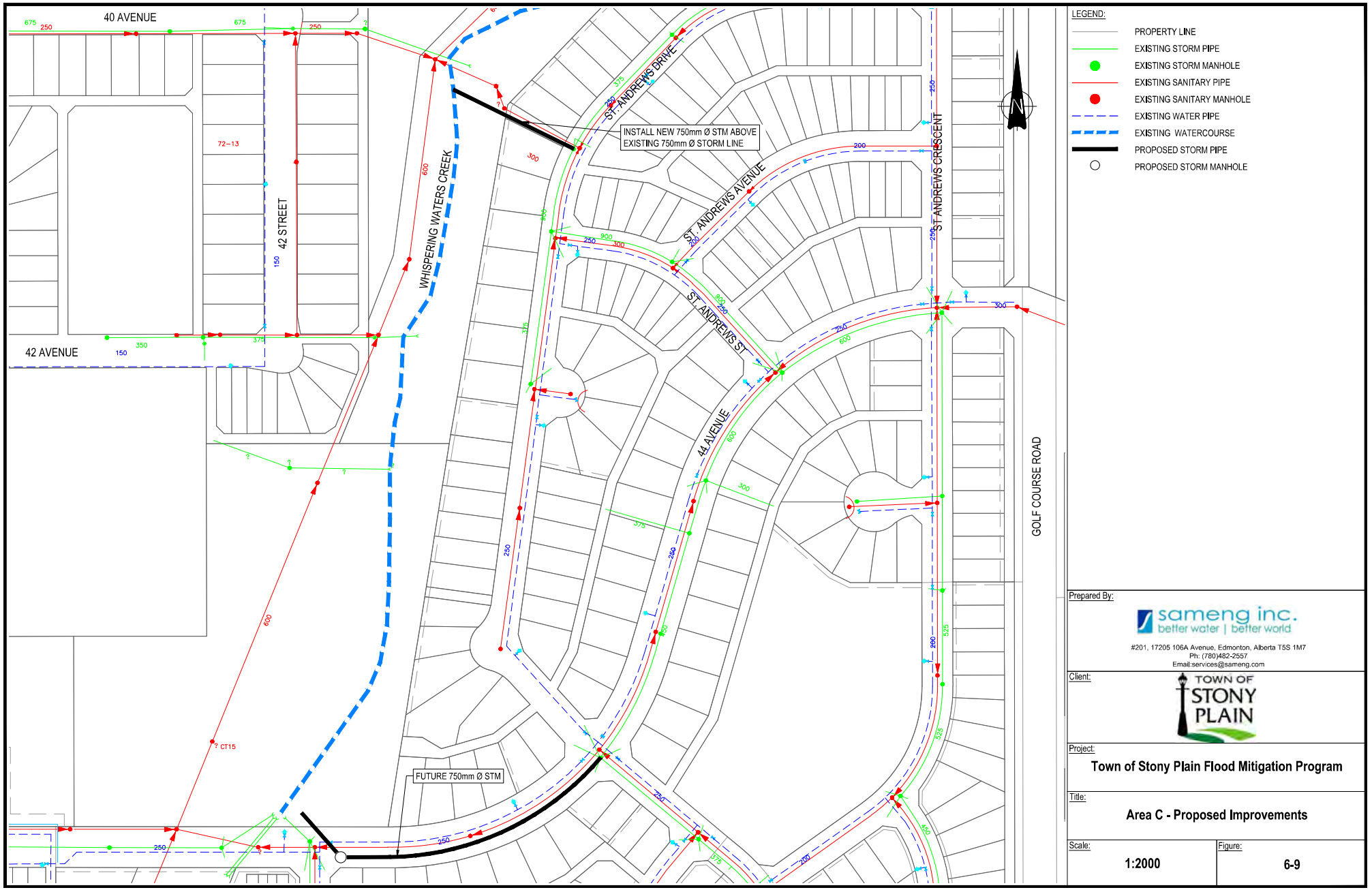
Project:

Town of Stony Plain Flood Mitigation Program

Title:

AREA C - EXISTING AND IMPROVED FLOOD RISKS

Scale:	Figure:
1:5,000	6-8



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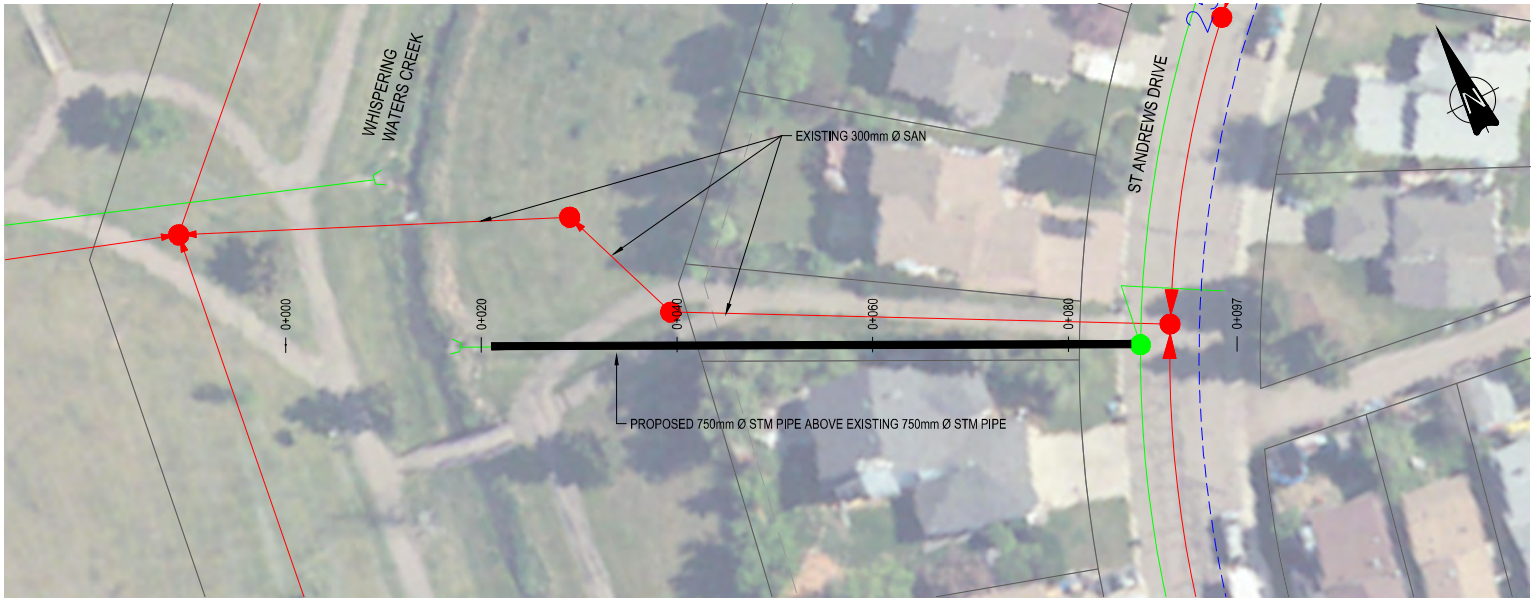
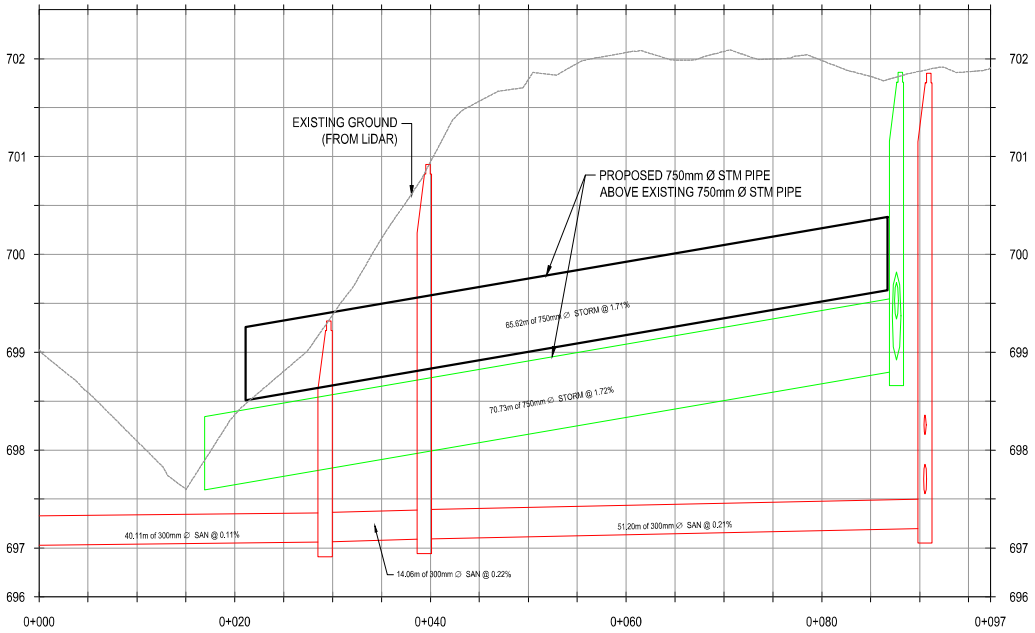
Project: **Town of Stony Plain Flood Mitigation Program**

Title: **Area C - Proposed Improvements**

Scale: **1:2000**

Figure: **6-9**





LEGEND:

- PROPERTY LINE
- EXISTING STORM PIPE
- EXISTING STORM MANHOLE
- EXISTING SANITARY PIPE
- EXISTING SANITARY MANHOLE
- EXISTING WATER PIPE
- EXISTING WATERCOURSE
- PROPOSED STORM PIPE

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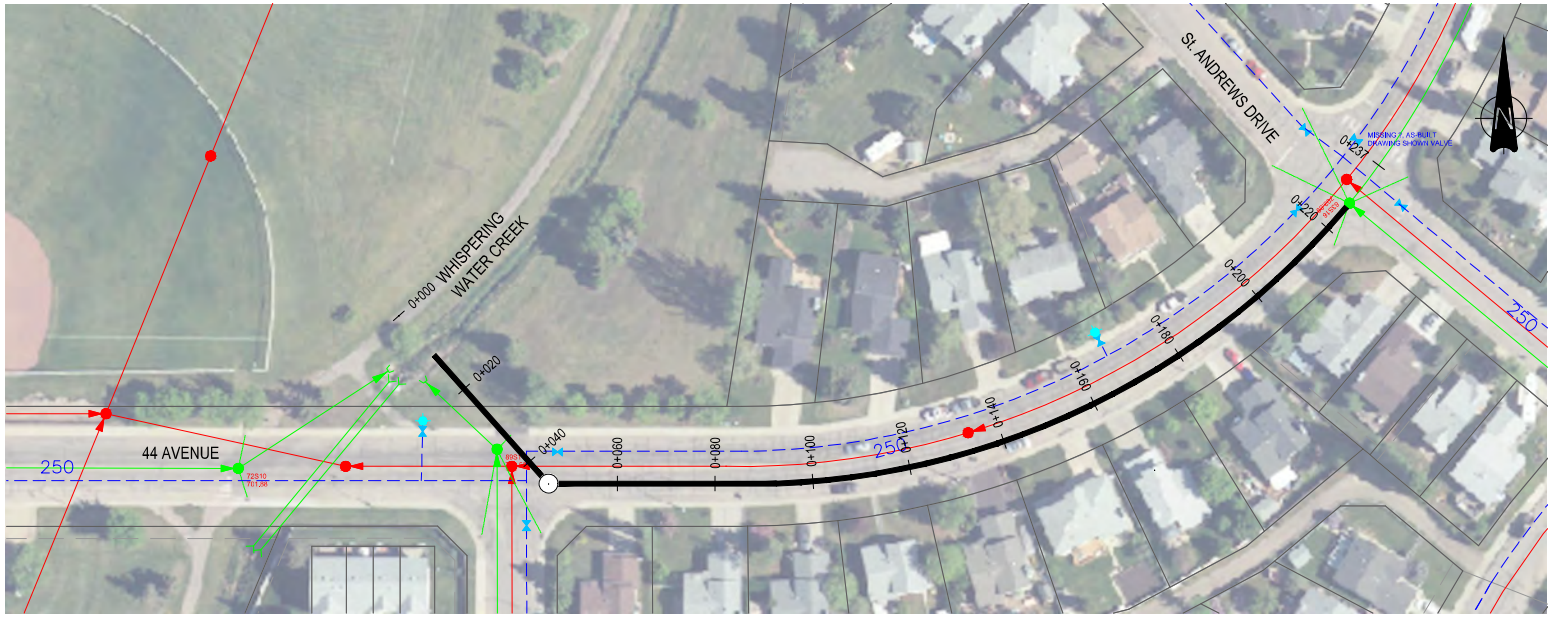
Project:

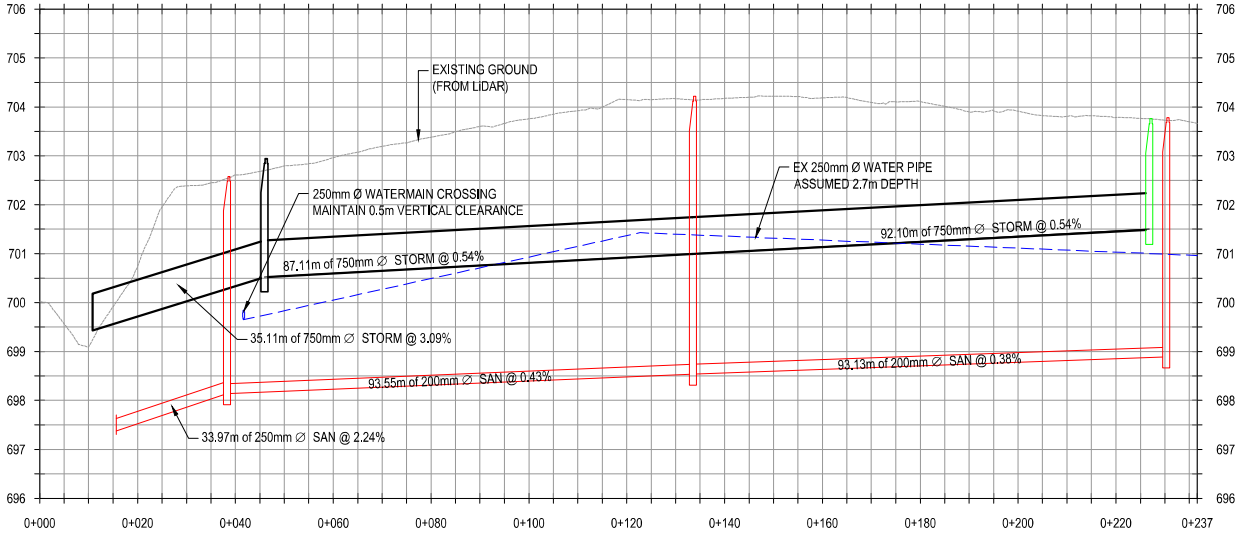
Town of Stony Plain Flood Mitigation Program

Title:

Area C - Proposed Improvements - Plan and Profile for Storm Outfall Twinning

Scale:	Figure:
1:2000	6-10





LEGEND:

- PROPERTY LINE
- EXISTING STORM PIPE
- EXISTING STORM MANHOLE
- EXISTING SANITARY PIPE
- EXISTING SANITARY MANHOLE
- EXISTING WATER PIPE
- PROPOSED STORM PIPE
- PROPOSED STORM MANHOLE

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Project:

Town of Stony Plain Flood Mitigation Program

Title:

Area C - Proposed Improvements - Plan and Profile for 44 Avenue Storm Sewer

Scale:	Figure:
1:2000	6-11

6.8 Area D

6.8.1 Area D - Existing

Area D, shown in Figure 6-12, covers part of Old Town in the area of 48 to 51 Street and from 52 to 55 Avenue. This area is primarily at flood risks due to excessive surface ponding and poor major drainage. As shown in Figure 6-1, about twenty (20) properties reported flooding in that area, although the cause of the reported flood is unknown.

To the west, a significant amount of surface runoff flows towards a depression on 51 Street between 52 and 53 Avenue, where catchbasins convey the surface flows into the storm sewer system, which flows north. Water flowing into this depression comes from an area of about 9.2 ha, coming from as far south as the school yard south of 55 Avenue, as far north as 51 Avenue, as far west as 52 Street and as far east as 50 Street. During large rainfall events, the storm sewer system reaches its capacity and excess water pools on 51 Street. This was observed in July 2019; see Figure D- 9. Unfortunately, due to a poor major drainage system in the area, the excess water will overflow to the east into the alley and then south through many private properties, towards 53 Avenue. In the process of overflowing through these properties, the water will flood many properties and houses. The amount of water overflowing through these properties can be very significant. Many floods were reported in that area.

Once on 53 Avenue, this water will attempt to enter the other storm sewer system flowing east. If at capacity, excess water will overflow south between a house and the school, cause some flood risks in a depression in the alley (one flood was reported there), and make its way towards 54 Avenue. From there, the surface flow will go east.

This surface flow then reaches a few large depressions with poor major drainage, in the area of 54 Avenue and 49 Street.

First, the Lions Playground is at a lower elevation than 54 Avenue and 49 Street. During a large storm event, local drainage as well as backflow from the storm sewer will flood this park area, as well as adjacent properties to the east and north of the park. The playground flooded in July 2019 as shown in Figure D- 11.

Secondly, the depression at the corner of 54 Avenue and 49 Street has no adequate major drainage overflow. When this area receives too much water for the sewer to handle, ponding happens, and properties to the east of 54 Avenue flood and overflow. Three of these properties reported flooding in July 2019. The surface water is then conveyed into the alley behind 54 Avenue.

Once in the alley, water floods a large section of the alley and then overflows to the northeast towards 48 Street, mainly through a low-lying property. See Figure D- 7 showing the extent of flooding around that property, which reported flooding in July 2019. Many detached garages in the alley would be flooded in the process, as well as the house at 5306 48 Street. This alley flooded in July 2019 as shown in Figure D- 8.

Once on 48 Street, the water will flood a section of road and overflow north towards 52 Avenue and east towards the Creek (and into Area B).

According to our computer modeling, all the above-mentioned areas are at risk of flooding and ponding for events as small as the 1:5-year event. As the rainfall increases in intensity and duration, the flood risk increases.

6.8.2 Area D – Proposed Improvements

As illustrated in Figure 6-13, to reduce flood risks due to surface ponding in Area D, the recommendation is to install a new storm sewer system that would intercept all runoff flows from the depression on 51 Street, as well as from the depressions in the area of 54 Street and 49 Avenue, and convey them into the Creek. The piped system would be sized to convey the 1:100-year event with some surcharge. The recommended alignment is to start at the depression on 51 Street, south to 53 Avenue, east to 48 Street, north to 52 Avenue, and east into the Creek. The pipe would be 1200mm at the upstream end, and 1800mm at the downstream end.

The system would also be interconnected to the 54 Avenue storm sewer at two locations: at 50 Street and at 48 Street. This will be to relieve surcharge in that sewer system and further reduce flood risks in the area.

There would also be many catchbasin upgrades, to ensure all surface drainage can enter the proposed storm sewer system, and therefore eliminate surface ponding.

In addition, a dry pond is recommended to be constructed at the Lions Playground. The playground structure would remain, but the rest of the park space would be lowered and converted into a dry surge pond. To the north of the pond, a new storm pipe would connect the storm sewer to the pond. To the east of the pond, the existing catchbasin lead would be replaced with a larger pipe and will act as the main pond outlet, and also for the water to backflow into the pond. The pond would intercept and temporarily store water from the adjacent storm sewer system.

As the pipe is constructed on 52 Avenue, east of 48 Street, it will also benefit Area B. A short interconnection to the 52 Avenue storm sewer at 48 Street is also recommended to reduce the surcharge in the downstream pipes.

At the connection with the Creek along 52 Avenue, it is recommended to connect the new pipe to new culverts in the Creek. One or both culverts in the Creek would have to be upsized accordingly; two 1800mm culverts are recommended (existing is two 1500mm culverts).

STAGING

Given the large scope of this project, it was divided in three phases. The following phases were developed to provide the best cost-benefit in a shorter timeframe for the area. Nevertheless, the Town can construction these phases in any order, or simultaneously.

- Phase 1 would see the construction of the upstream components, thus 51 Street, 53 Avenue from 51 Street to 50 Street, and 50 Street from 53 Avenue to 54 Avenue. Furthermore, the Lions Playground pond would be constructed with the inlets and outlets. The alley catchbasin would also be upgraded. The replaced culverts in the Creek as well as the first pipe segment from that culvert onto 52 Avenue would also be installed. This would provide the greatest benefit for the lowest costs, and target flood mitigation in areas at higher flood risk. However, a 1:100-year level of flood protection would not be attained yet.

- Phase 2 would see the construction of the 52 Avenue section from Egerland Drive to the Creek pipe stub left as part of Phase 1. This would primarily benefit Area B for the moment.
- Phase 3 consists of the remainder of the piped system, along 53 Avenue, 48 Street and 52 Avenue. These pipes would complete the connection between the upstream and downstream pipes, and thus be able to achieve a 1:100-year level of flood protection for the area. It is our understanding that Highway 779 (48 Street) is planned to be reconstructed shortly, such that the Town may want to construct the 48 Street portion of the work as the very first phase instead; this would prevent ripping up the Highway in the near future to install a new storm sewer pipe.

Since this improvement will increase peak flows into Whispering Creek, it is recommended that the Whispering Creek upgrades be first implemented, at least before Stage 2 and 3 as described above are completed.

6.8.3 Area D – Costs and Benefits

The costs and benefits of Area D and Area B are divided into three phases to achieve a 100-year level of service throughout the area.

The initial phase is estimated to be $3.9 Million. Although this phase does not achieve a 100-year level of service, it does provide a 25-year level of service throughout the area, and it improves the condition during a 100-year storm event. Over half the homes currently at risk of flooding would be protected during 100-year event. The value of flood mitigation for this phase is quantified as $20.3 Million over 75 years. The benefit-cost ratio is 5.2.

The second phase focuses on providing benefits for Area B. The cost of this second phase is $3.1 million. The benefits of these improvements include the provision of a 100-year level of service to 12 homes, as well as flood reduction in parking lots and roadways in the downtown area. The value of this flood mitigation is quantified at $10.7 Million over 75 years, including house and parking lot flooding. The benefit-cost ratio of 3.5.

The third and final phase, which should achieve a 100-year level of service for most of the area, is estimated to cost $2.8 million. An additional 12 homes benefit from this improvement during a 1:100-year flood event, with a quantified additional benefit of $2.4 Million over 75 years. The benefit-cost ratio is 0.9.

The total cost to provide flood mitigation for Area B and D is $9.8 million, with a combined benefit-cost ratio of 3.4.

EXISTING FLOOD AREA

IMPROVED FLOOD AREA

LEGEND:

PROPERTY LINE

EXISTING FLOOD RISKS

100YEAR PONDING EXTENTS

IMPROVEMENT FLOOD RISKS

PHASE 1 IMPROVEMENT ONLY

FULL IMPROVEMENT

SURCHARGE DEPTH (Sanitary Sewer)

- > 2.5m BELOW GROUND
- > 1.5m - 2.5m BELOW GROUND
- ≤ 1.5m BELOW GROUND
- SHALLOW MH ≤ 2.5m DEPTH

PIPE LOADING FACTOR (Qmax / Qmanning) (Sanitary Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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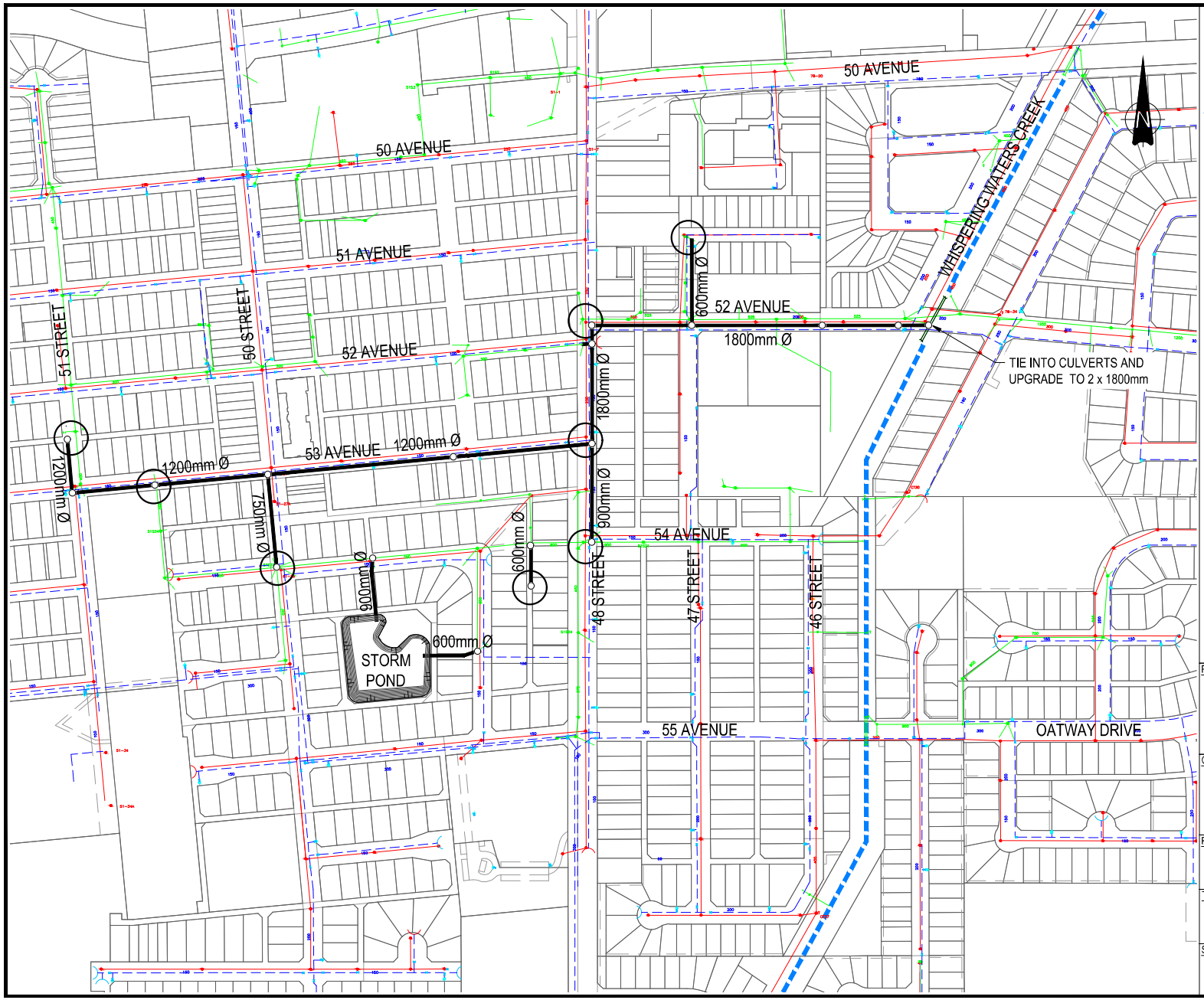
Project:

Town of Stony Plain Flood Mitigation Program

Title:

AREA D - EXISTING AND IMPROVED FLOOD RISKS

Scale:	Figure:
1:5,000	6-12



LEGEND:

- PROPERTY LINE
- EXISTING STORM PIPE
- EXISTING SANITARY PIPE
- EXISTING WATER PIPE
- EXISTING WATERCOURSE
- PROPOSED STORM PIPE
- CATCHBASIN IMPROVEMENTS OR RECONNECTION

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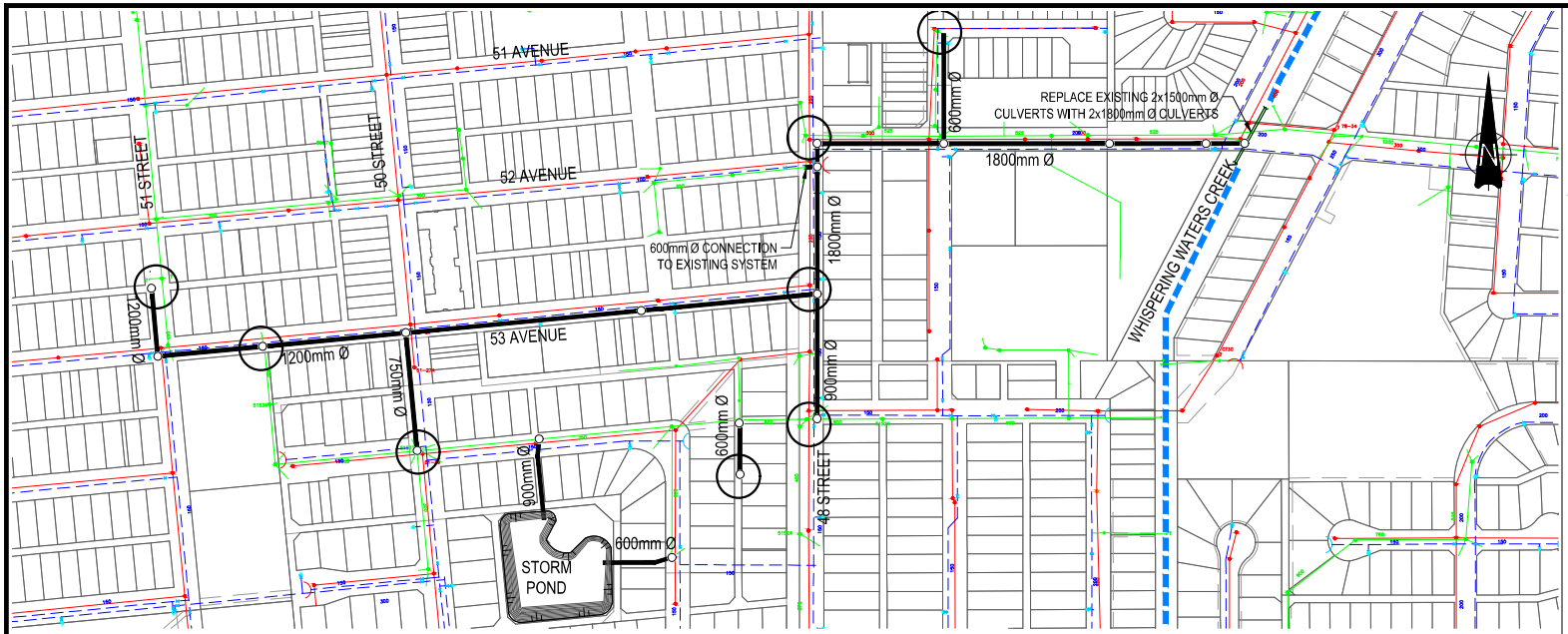
Client: TOWN OF STONY PLAIN

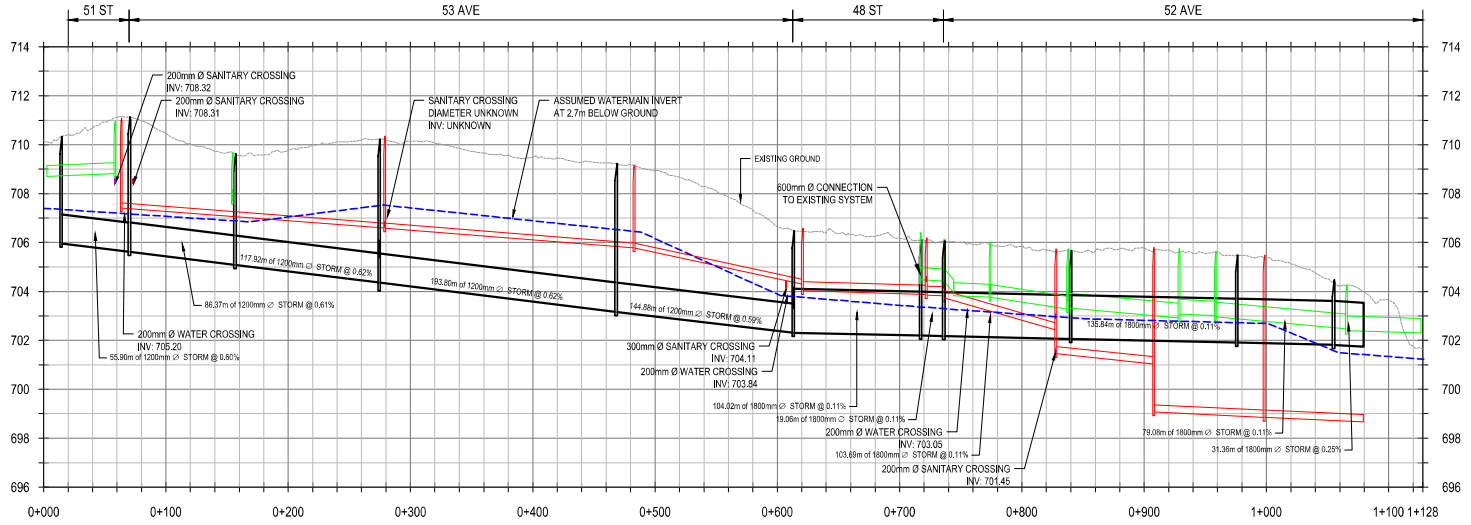
Project: **Town of Stony Plain Flood Mitigation Program**

Title: **Area B and D – Proposed Improvements**

Scale: **N.T.S.**

Figure: **6-13**





LEGEND:

- PROPERTY LINE
- EXISTING STORM PIPE
- EXISTING STORM MANHOLE
- EXISTING SANITARY PIPE
- EXISTING SANITARY MANHOLE
- EXISTING WATER PIPE
- EXISTING WATERCOURSE
- PROPOSED STORM PIPE
- PROPOSED MANHOLE
- CATCHBASIN IMPROVEMENT OR RECONNECTION

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Client:

TOWN OF STONY PLAIN

Project:

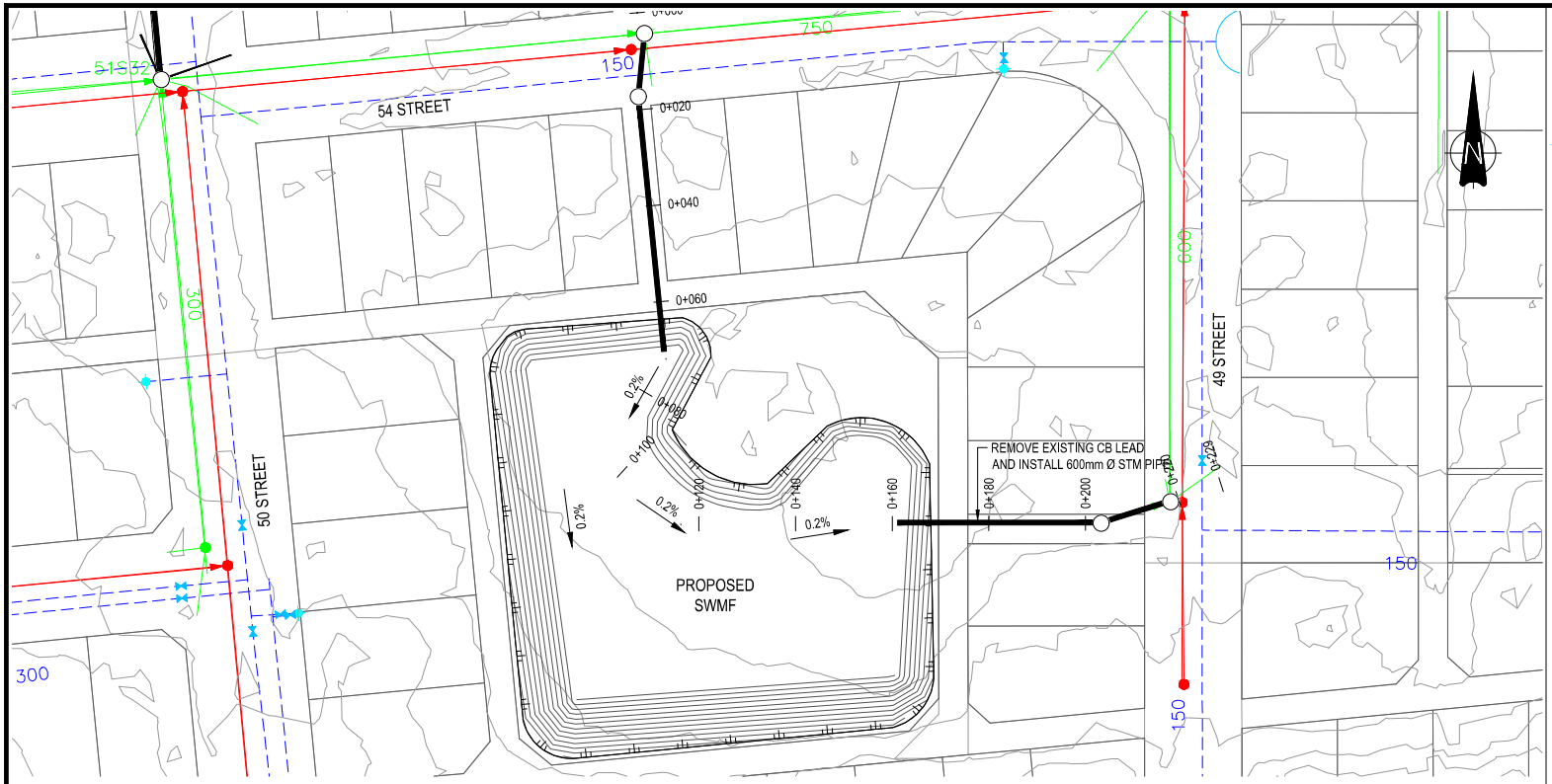
Town of Stony Plain Flood Mitigation Program

Title:

Area B & D - Proposed Improvements Plan and Profile for Main Storm Trunk on 53 Avenue, 48 Street and 52 Avenue

Scale: **1:4000**

Figure: **6-14**

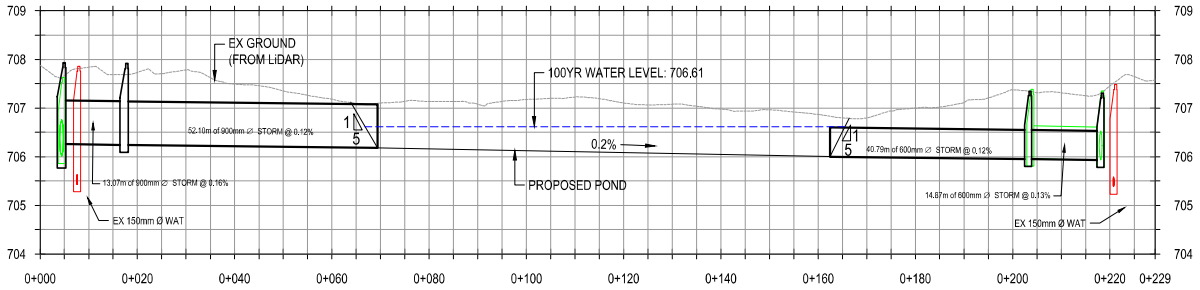


LEGEND:

- PROPERTY LINE
- EXISTING STORM PIPE
- EXISTING SANITARY PIPE
- EXISTING WATER PIPE
- EXISTING WATERCOURSE
- PROPOSED STORM PIPE
- EXISTING CONTOURS (0.5m INTERVAL)
- PROPOSED CONTOURS (0.5m INTERVAL)

POND EXCAVATION VOLUME = 6,280m³

POND BEGINS TO SEE WATER AT THE
2 YEAR RAINFALL EVENT



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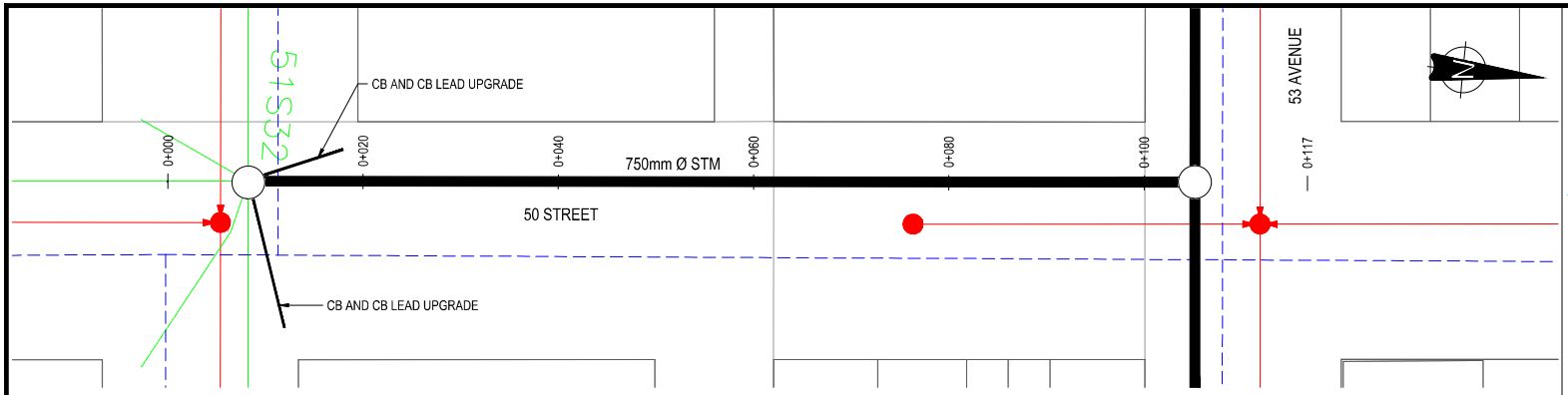
Client: TOWN OF STONY PLAIN

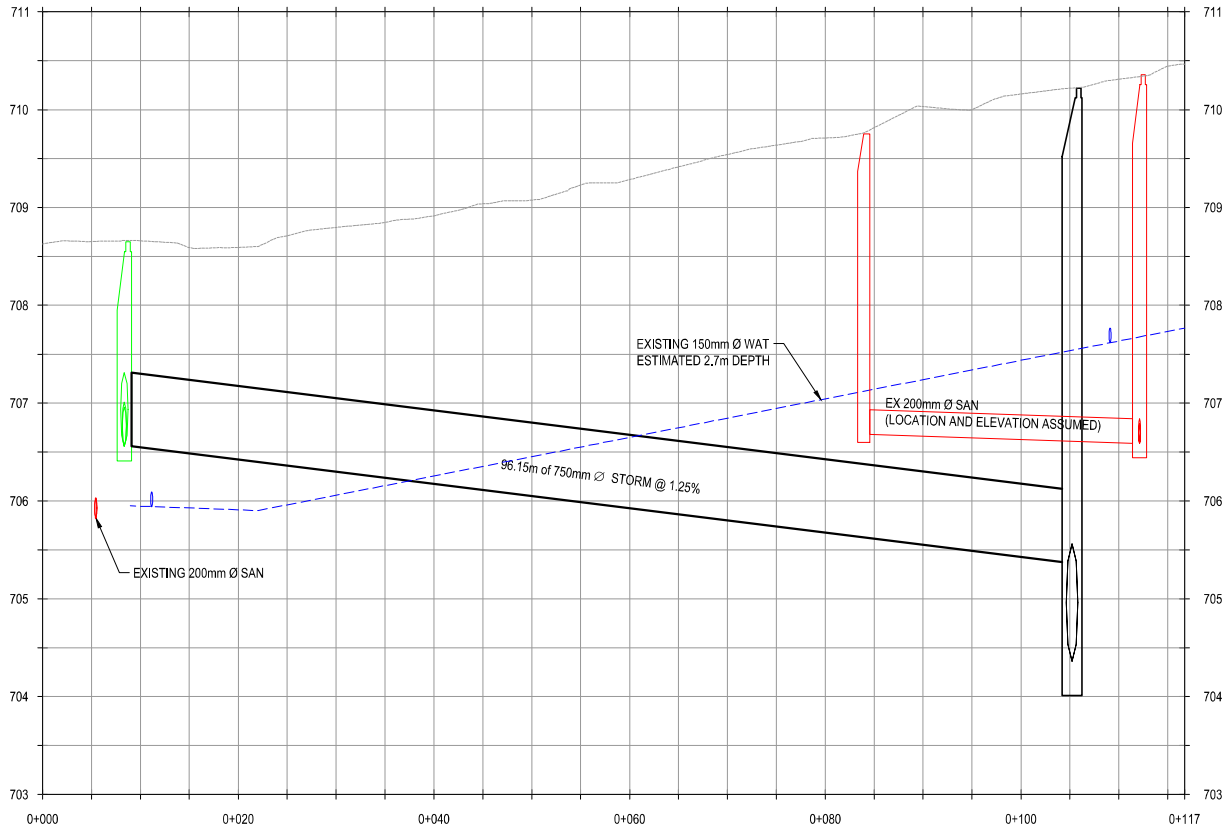
Project: **Town of Stony Plain Flood Mitigation Program**

Title: **Area B & D - Dry Pond at Lions Playground**

Scale: **1:1000**

Figure: **6-15**





LEGEND:

- PROPERTY LINE
- EXISTING STORM PIPE
- EXISTING STORM MANHOLE
- EXISTING SANITARY PIPE
- EXISTING SANITARY MANHOLE
- EXISTING WATER PIPE
- EXISTING WATERCOURSE
- PROPOSED STORM PIPE
- PROPOSED STORM MANHOLE

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Client:
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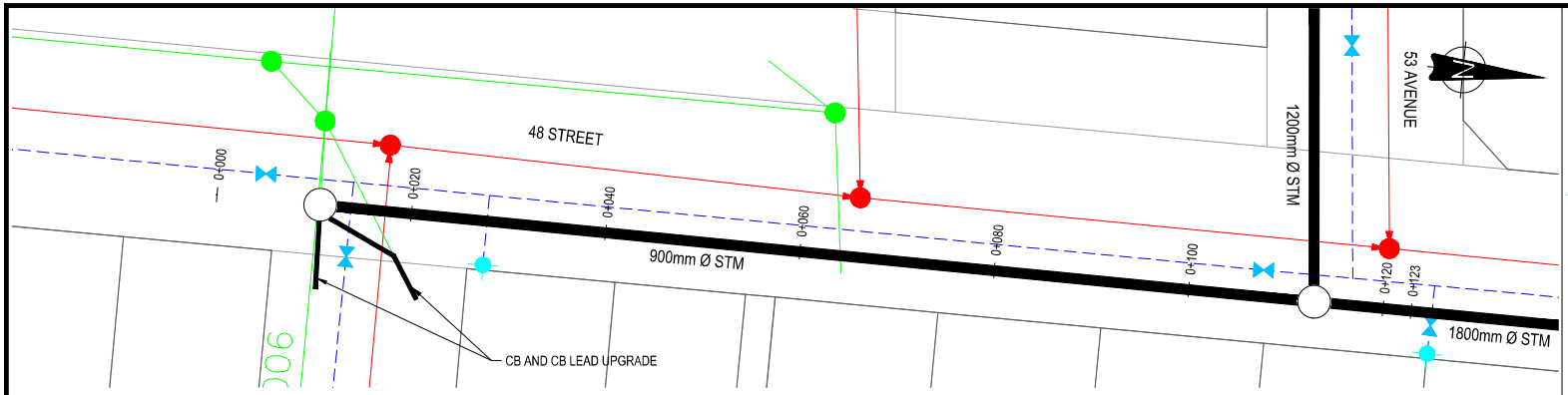
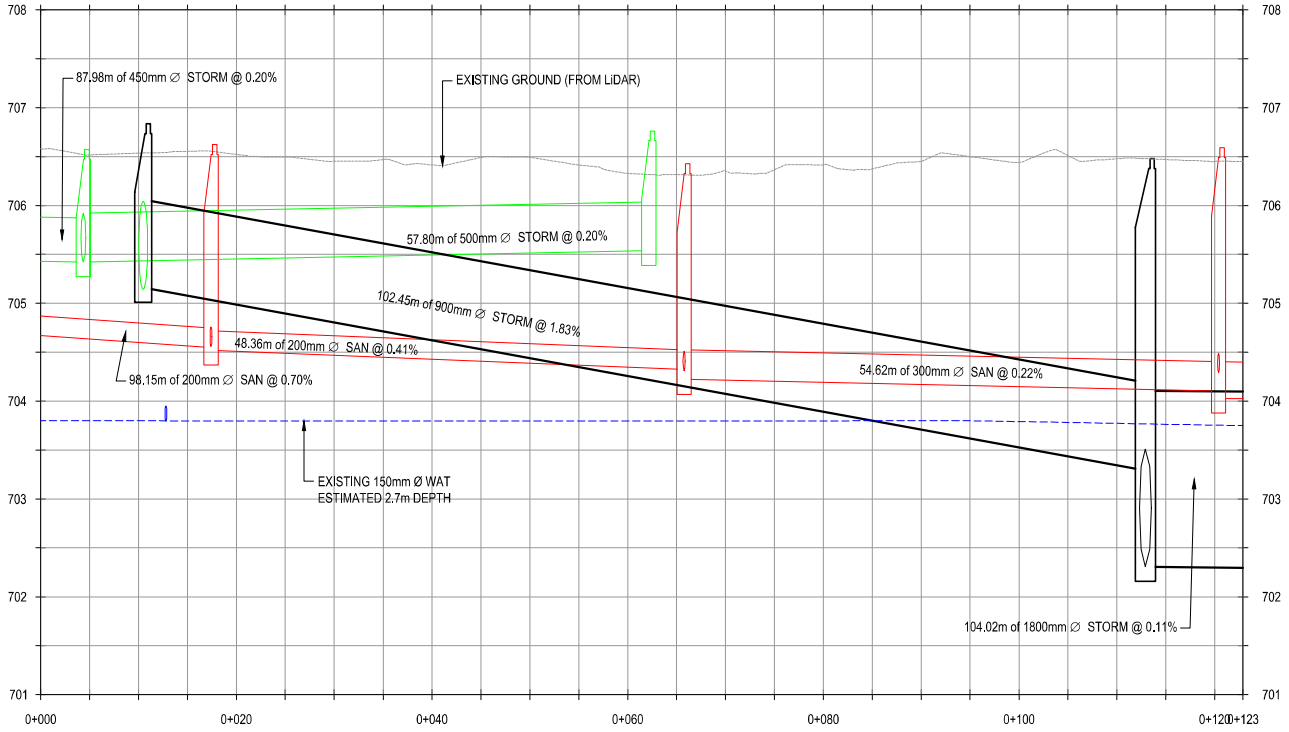
Project:
Town of Stony Plain Flood Mitigation Program

Title:
Area B & D - Plan and Profile for 50 Street

Scale:
1:500

Figure:
6-16





LEGEND:

- PROPERTY LINE
- EXISTING STORM PIPE
- EXISTING STORM MANHOLE
- EXISTING SANITARY PIPE
- EXISTING SANITARY MANHOLE
- EXISTING WATER PIPE
- EXISTING WATERCOURSE
- PROPOSED STORM PIPE
- PROPOSED STORM MANHOLE

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Project: **Town of Stony Plain Flood Mitigation Program**

Title: **Area B & D - Plan and Profile for 48 Street**

Scale:	Figure:
1:500	6-17

6.9 Area E

6.9.1 Area E - Existing

Area E, shown in Figure 6-18, is located in the Meridian Heights subdivision which is located east of Highway 779 and south of Highway 16A. There are two main flood risks present in Area E.

There is a depression at the bend of 41 Avenue and 43 Street that received lots of surface drainage during large rainfall events, and that has poor major drainage overflow. As the water level rises in that depression, some houses are at risk of flooding as the water tries to overflow to the east, through private properties, and towards the alley. Although some street ponding is expected for rainfall events as small as the 1:5-year event, flood risks to the adjacent houses only become apparent during the 1:25-year and larger events.

Sanitary sewer backup from the Sanitary Central trunk also poses some flood risks for the low-lying areas to the northeast of the subdivision during the 1:100-year event.

6.9.2 Area E – Proposed Improvements

To reduce flood risks due to surface ponding at the 41 Avenue and 43 Street bend, the recommendation is to lower the elevation of the path located between 4303 and 4305 41 Avenue to facilitate the overflow from the road into the alley. Furthermore, some lowering of the alley, immediately northeast of the road bend is also recommended to facilitate the flow of water to the south in the alley towards 42 Avenue (the need for the alley regrade portion is to be confirmed through detailed survey of the area). See Figure 6-19 for details. This improvement would allow the area to achieve a 1:100-year level of flood protection against surface overflow, as illustrated in Figure 6-18, and redirect major drainage flow to a suitable location.

Regarding sanitary flood risks, the solution is not local, but global. See Section 6.13 for details.

6.9.3 Area E – Costs and Benefits

The cost of regrading the alley and pathway in Area E is estimated to be $102,000. The improvements will provide a 100-year level of service to 7 at-risk homes, as well as reducing street ponding levels to safe depths, thus protecting flooded vehicles. The value of this flood mitigation over 75 years is about $1.7 Million. The benefit-cost ratio is 16.9, which is very good.

EXISTING FLOOD AREA

IMPROVED FLOOD AREA

LEGEND:

PROPERTY LINE

100 YEAR PONDING EXTENTS

SURCHARGE DEPTH (Sanitary Sewer)

- > 2.5m BELOW GROUND
- > 1.5m - 2.5m BELOW GROUND
- ≤ 1.5m BELOW GROUND
- SHALLOW MH ≤ 2.5m DEPTH

PIPE LOADING FACTOR (Qmax / Qmanning) (Sanitary Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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Project:

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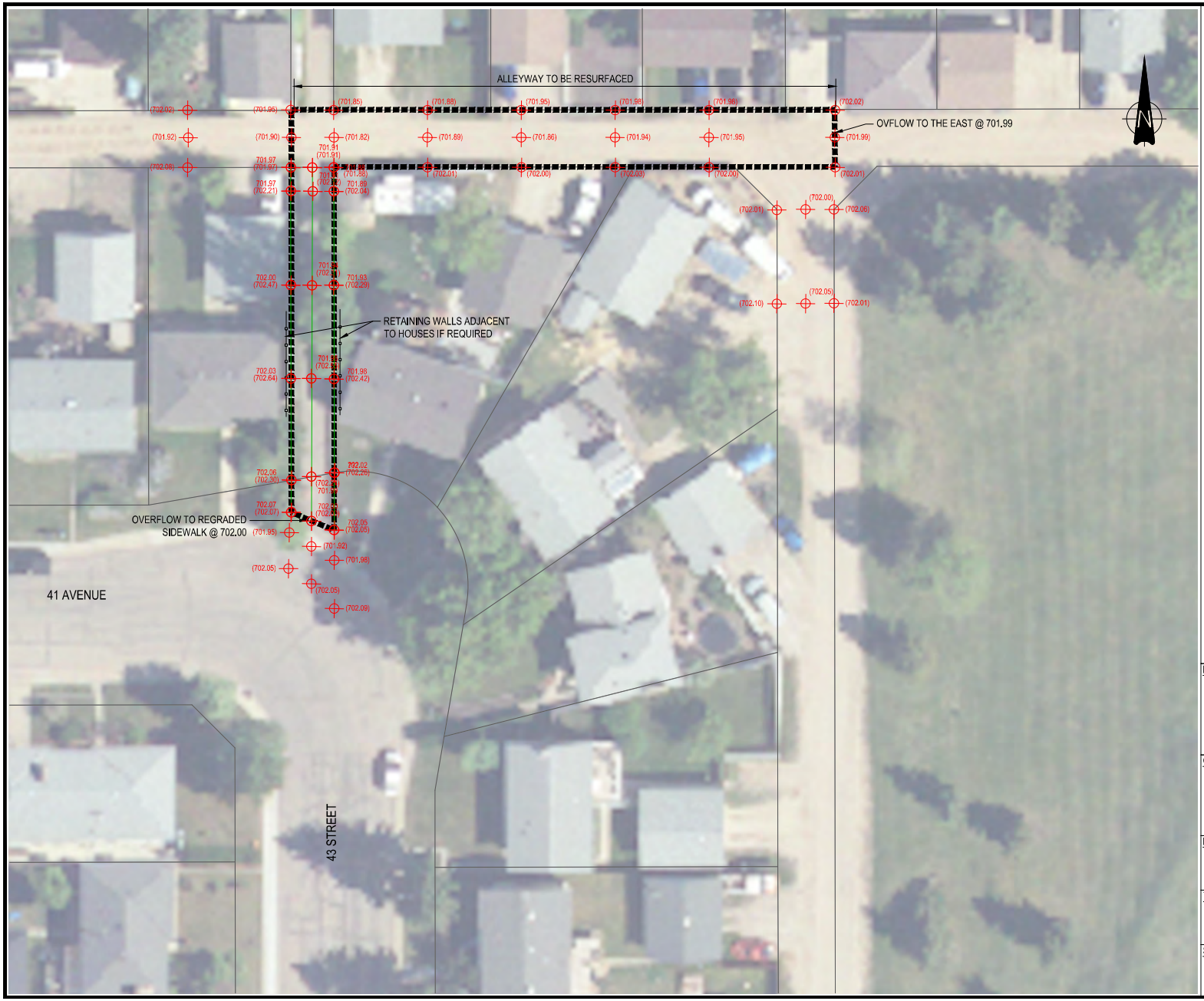
Title:

AREA E - EXISTING AND IMPROVED FLOOD RISKS

Scale:	Figure:
1:5,000	6-18



LEGEND:

- PROPERTY LINE
- EXISTING STORM PIPE
- EXISTING SANITARY PIPE
- EXISTING WATER PIPE
- EXISTING WATERCOURSE
- PROPOSED REGRADE AREA
- (702.12) EXISTING ELEVATION
- 702.12 PROPOSED ELEVATION

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Project: **Town of Stony Plain Flood Mitigation Program**

Title: **Area E - Proposed Improvements**

Scale: **1:400**

Figure: **6-19**

6.10 Area F

6.10.1 Area F - Existing

Area F, shown in Figure 6-20, is located in the Old Town and Woodlands subdivision. The area at risk of flooding is primarily along 46 Street, between 54 and 56 Avenue. There are many flood risks and flood mechanisms present in this area.

First, the depression on 46 Street between 54 and 55 Avenue is so low that the Creek may backflow through the storm outfall of the catchbasins at this depression, and cause ponding at this depression. The anticipated ponding depth would flood 3 properties east of 46 Street. See Section 5.3 for details.

This same depression is also subject to extensive ponding due to lack of capacity in the catchbasins and sewer pipe during intense rainfall events. Excess water ponds on the ground surface and will eventually overflow the properties immediately east and overflow into the Creek. In the process of overflowing through private properties, it poses a flood risks to the adjacent (east of 46 Street) low-lying houses. This overflow may happen for rainfall events as small as the 1:5-year event. At the overflow elevation, the ponding depth on the street will be about 40 cm.

The alley parallel and west of 46 Street also overflows through private properties going east when the catchbasin in the alley in unable to keep up. This overflow will cause some flood risk to a few houses. It is recommended for the Town to review the sewer layout of this alley catchbasin, as well as its size and condition.

Many houses along 46 Street, between 54 and 56 Avenue, suffered from sewer backups during the July 2019, suggesting some issues exist with the sanitary sewer system in the area. Of note, the north-flowing sanitary sewer on 46 Street is a main trunk that conveys a significant amount of wastewater from upstream (south) towards the Sanitary Central Trunk. This includes wastewater from the Glens area, the southern portion of Woodlands and Southridge from the east. Our computer modeling simulations, which are based on calibration and validation with some historical flow monitoring data, suggests that there should be no flood risks due to sanitary sewer backup in the area during the 1:100-year rainfall event, although the model did indicate that the sanitary sewer would flow under surcharged conditions. One hypothesis is that the model underestimates inflows into the sanitary sewer system during very intense rainfall events. For example, maybe the inflow coming from the Glens area was higher than modeled (this area had lots of surface ponding during the July 2019 rainfall event), or maybe the inflow from the Creek in the sanitary manholes was underestimated. Another hypothesis is that a physical property of the sanitary sewer system is not accurately represented in the model; this could be a wrong pipe diameter, a sanitary manhole with a catchbasin cover, a catchbasin connected to the sanitary sewer system, etc. A third hypothesis is that the sanitary manholes that are submerged by Creek water for several hours, accept much more inflow than modeled. This could be due to a significant gap between the manhole rim and the manhole barrel, for example. Lastly, maybe something wrong happened during the rainfall event. For example, a sanitary manhole lid submerged under water (street ponding or Creek) was displaced, letting a significant amount of water entering the sanitary sewer system. Another possibility is that the sanitary sewer system had blockages that reduced the effective flow area in the sanitary trunk and thus reduced its capacity.

6.10.2 Area F – Proposed Improvements

To reduce flood risks due to surface ponding on 46 Street, it is recommended to regrade the property line between the properties of 5423 and 5421 46 Street, as illustrated in Figure 6-21 and Figure 6-22. This would include the lowering of the elevations along the property line to facilitate the overflow into the Creek. Window wells on this side of the houses should be improved, as needed, to prevent flooding of these houses. The fence would likely need to be replaced. An easement should also be acquired for this swale (and the existing outfall pipe).

The alley west of 46 Street has a catchbasin that should be replaced and reconnected to the existing pipe and outfall system just east on 46 Street or north on 54 Avenue. The alignment of the proposed pipe would need to be identified during the detailed design stage.

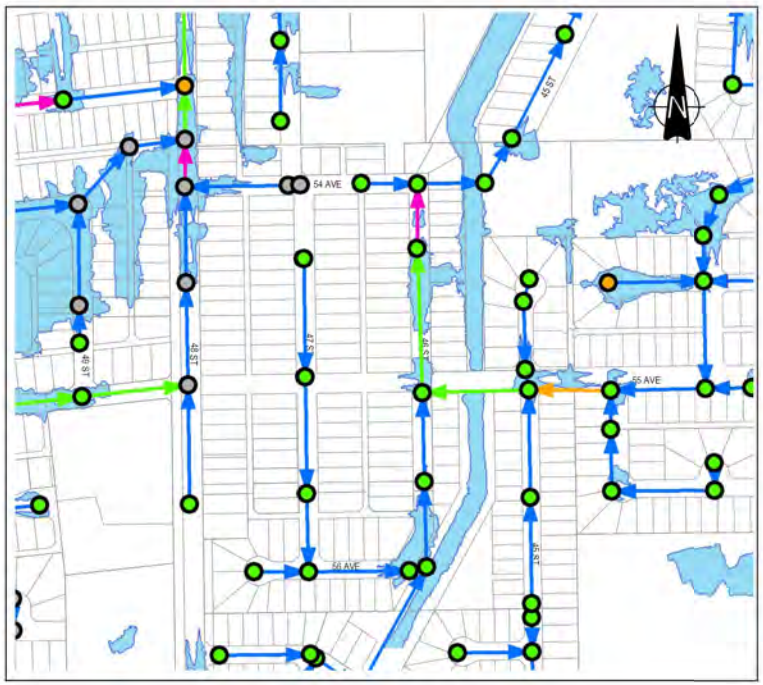
The replacement of the existing storm outfall between 54 and 55 Avenue was contemplated. However, these is no easement where the outfall pipe is currently installed, and there is not sufficient space to dig a new pipe between the two houses. This option is not deemed constructible.

At the 54 Avenue and 46 Street bend, it is recommended to upgrade the existing catchbasins, or to add new catchbasins. This would intercept all surface drainage flows coming through this area (from the west) and convey it directly into the Creek, rather than flowing to the depression further south on 46 Street.

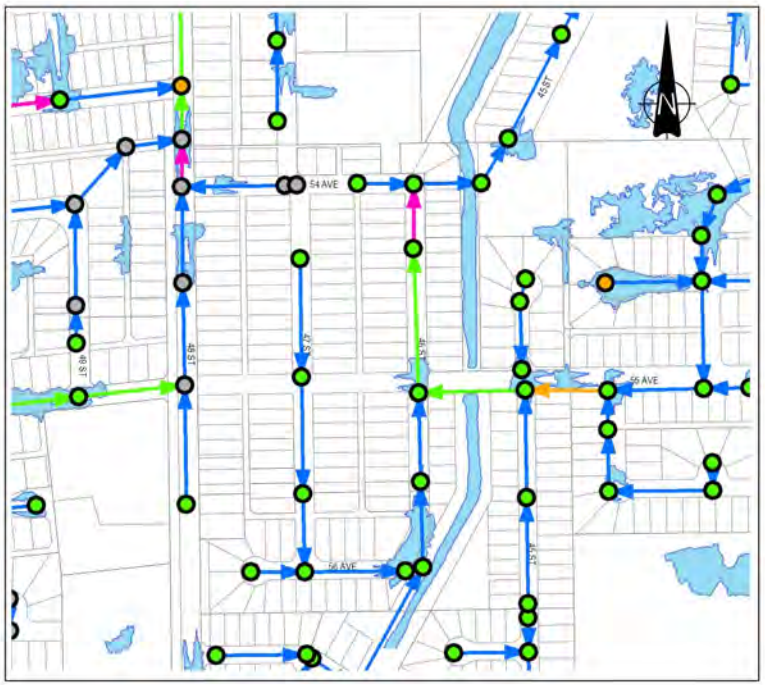
To mitigate sanitary sewer backups in the area, it is recommended to focus the efforts on sanitary manhole sealing. See Section 6.13 for details.

6.10.3 Area F – Costs and Benefits

The cost of improvements in Area F are estimated to be $435,000. This should prevent flooding in the area during a 100-year event and protect 5 at-risk homes from surface ponding. The reduction in ponding on the street will also reduce the risk of damage to vehicles driving or parked on the roadway. The combined value of flood mitigation is quantified as $4.1 Million over 75 years. The benefit-cost ratio is 9.5, which is very good.



EXISTING FLOOD AREA



IMPROVED FLOOD AREA

LEGEND:

PROPERTY LINE

100 YEAR PONDING EXTENTS

SURCHARGE DEPTH (Sanitary Sewer)

- > 2.5m BELOW GROUND
- > 1.5m - 2.5m BELOW GROUND
- ≤ 1.5m BELOW GROUND
- SHALLOW MH ≤ 2.5m DEPTH

PIPE LOADING FACTOR (Qmax / Qmanning) (Sanitary Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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Client:

TOWN OF STONY PLAIN

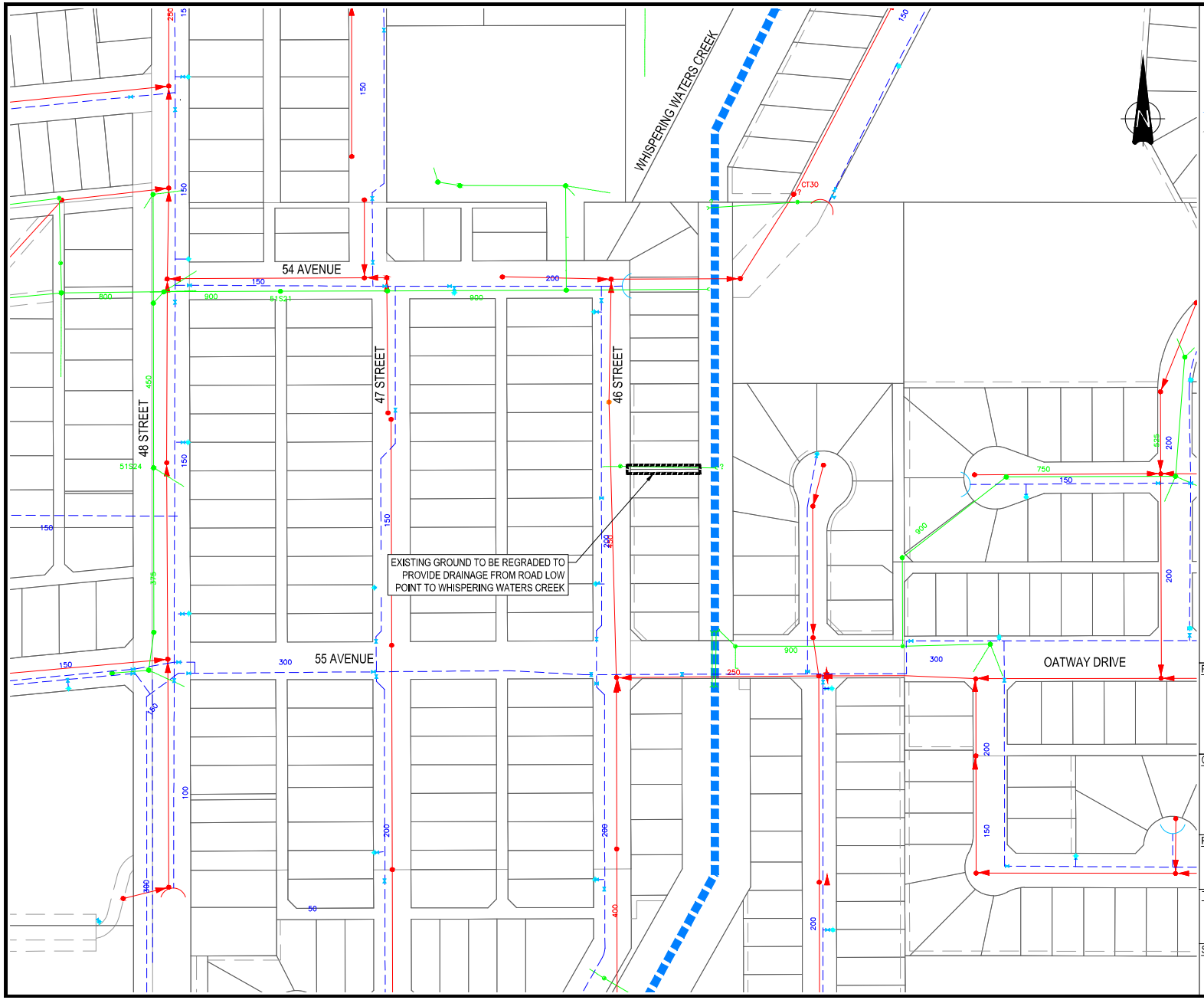
Project:

Town of Stony Plain Flood Mitigation Program

Title:

AREA F - EXISTING AND IMPROVED FLOOD RISKS

Scale:	Figure:
1:25,000	6-20



LEGEND:

- PROPERTY LINE
- EXISTING STORM PIPE
- EXISTING SANITARY PIPE
- EXISTING WATER PIPE
- EXISTING WATERCOURSE
- PROPOSED REGRADE AREA

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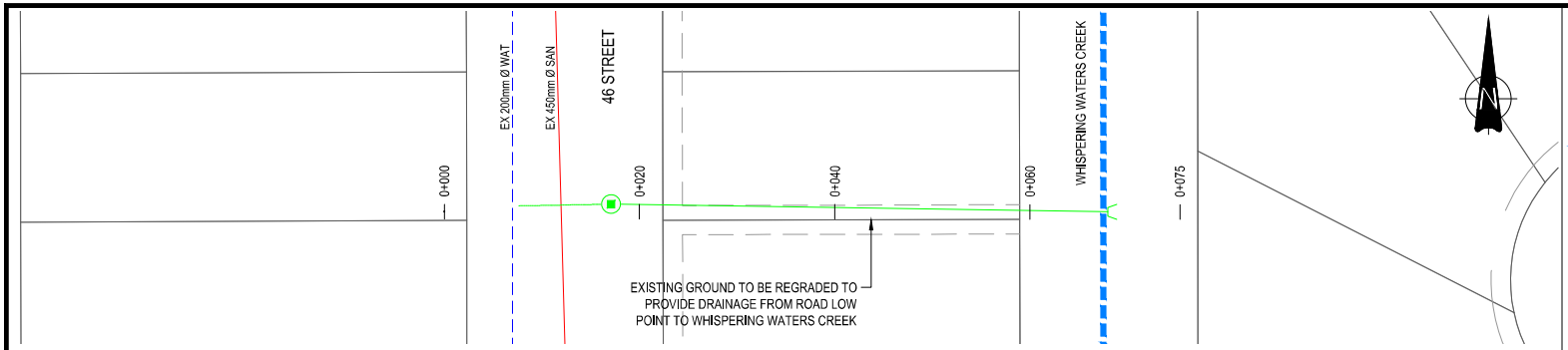
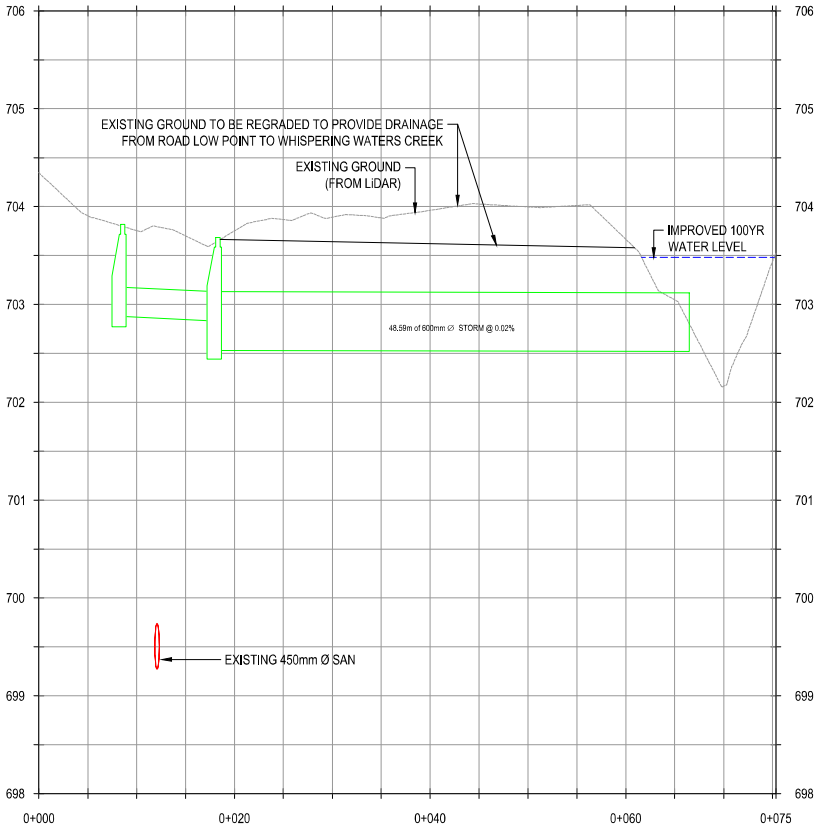
Project: **Town of Stony Plain Flood Mitigation Program**

Title: **Area F - Proposed Improvements**

Scale: **1:2000**

Figure: **6-21**





LEGEND:

- PROPERTY LINE
- EXISTING STORM PIPE
- EXISTING SANITARY PIPE
- EXISTING WATER PIPE
- EXISTING WATERCOURSE

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Project: **Town of Stony Plain Flood Mitigation Program**

Title: **Area F - Proposed Improvements - Regrading Between Properties**

Scale: **1:2000**

Figure: **6-22**

6.11 Area G

Area G consists of the area located between Boulder Boulevard and Golf Course Road North. The area is subject to significant flooding due to a lack of capacity at the Golf Course Road North culvert crossings. The recommendation for Area G is to upsize the Golf Course Road North crossing to reduce ponding depths to safe level (minimal ponding of industrials yard, and no ponding to buildings). See Section 5.9 for details regarding the recommended improvements for this area.

6.12 Area H

6.12.1 Area H - Existing

Area H, shown in Figure 6-23, is primarily focused in The Glens subdivision. The area at risk of flooding is primarily along 57 Avenue, west of 51 Street (north side of road backing school yard), and along the south end of the subdivision primarily along Glenwood Crescent. Flooding due to excessive surface flow and poor major drainage is the main flood risk here, although some sanitary backup flood risks may also exist.

Let us start at the north end of the problem areas, at the Stony Plain Central School yard. A sizable portion of the school yard (12.8 ha) slopes to the south towards 57 Avenue. However, a berm at the south end of the school yard prevents surface runoff from flowing directly into the alley north and parallel of 57 Avenue. A catchbasin, which outflow into the storm sewer system of 57 Avenue and controlled by an orifice, conveys that surface runoff underground. Unfortunately, the catchbasin is unable to keep up during large rainfall-runoff events, and ponding at the south end of the school yard, south of the playground structure, happens. In some cases, the volume of runoff coming from the field will exceed the ponding volume available in the school yard and water will start overflowing the berm into the alley. In small quantities, this overflow is not too concerning. However, when the overflow rate is very high, this water starts overflowing the alley into private properties and poses flood risks to many homes. The overflow rate during the 1:100-year event would be in the order of 1 to 2 m^3/s. According to the computer model, the overflow of the berm may happen as often as every 5 years. See Figure D- 12 and Figure D- 13 showing the ponding in the school yard and overflowing to the alley in July 2019. Figure D- 14 shows the overflow between two houses.

Now let us head down south to Glenwood Crescent. The southern portion of this Crescent has some of the lowest elevations of the subdivision. It is at the downstream end of a major drainage system for the western portion of The Glens and the eastern portion of Heritage Estates. It is also where all the water that is overflowing from the school yard (as described above) will end up. Simulation results suggest that some street ponding would be expected during the 1:5-year event, and the entire southern portion of the road would be underwater during the 1:25-year and larger events, to depths of 0.5m at the deepest locations. Although this is undesirable and some vehicles may be at risk of flooding, the direct threat of flooding houses caused by this ponding is low. This water eventually overflows to the south at the far east end of the road near the cul-de-sac. See Figure D- 15 to Figure D- 19 for photos of the flooding on Glenwood Crescent in July 2019.

Finally, although the computer model suggests that there should not be any sewer backups in the area during a 1:100-year event, some surcharge in the sewer system along Glenwood Crescent is expected. Therefore, there may some flood risks due to sewer backups in the area.

6.12.2 Area H – Proposed Improvements

To reduce flood risks due to surface overflow to the north of 57 Avenue (school yard overflow), it is recommended to construct a shallow dry pond at the south end of the school yard, sized to capture the 1:100-year runoff volume of the yard, such that there would be no more overflow of the berm in the alley or onto private property. See Figure 6-24 and Figure 6-25 for details. The pond would require about 1.5m of soil to be excavated for a total excavated volume of 5,750 m^3.

The 1:100-year storage volume would be about 3,200 m^3, and the ponding depth would be 1.45m at the deepest. Additionally, the south berm would need to be increased in elevation, the catchbasin rim lowered, and the catchbasin orifice removed.

Along Glenwood Crescent, the fact that the school yard should not overflow for rainfall events as intense as the 1:100-year event will reduce the quantity and frequency of ponding in the area. In addition, it is recommended to lower the overflow elevation at the east end of the crescent to lower the maximum ponding depth along the road. Some ponding would still be expected during the 1:100-year event, but it should be improved over existing conditions. See Figure 6-26 for details. Detailed survey of the overflow location should be completed to confirm the design.

Similar to Glenwood Crescent, it is recommended to reduce the overflow elevation of Glenmanor Crescent. Flood risks in that area was quite small, but the cost to improve the overflow is worth the benefits. See Figure 6-26 for details. Detailed survey of the overflow location should be completed to confirm the design.

6.12.3 Area H – Costs and Benefits

The cost of the improvements in Area H is estimated at $426,000. This cost assumes that the land used to construct the pond (owned by School Board) would be available at no cost to the Town.

The main benefit of these improvements is the dramatic reduction in street ponding, with an estimated 40 fewer vehicles flooded during a 100-year event. About 7 currently at-risk homes would also be protected. The combined flood mitigation benefit for these improvements is quantified at about $2.9 Million over 75 years. The benefit-cost ratio is 6.8.

EXISTING FLOOD AREA

IMPROVED FLOOD AREA

LEGEND:

PROPERTY LINE

100 YEAR PONDING EXTENTS

SURCHARGE DEPTH (Sanitary Sewer)

- > 2.5m BELOW GROUND
- > 1.5m - 2.5m BELOW GROUND
- ≤ 1.5m BELOW GROUND
- SHALLOW MH ≤ 2.5m DEPTH

PIPE LOADING FACTOR (Qmax / Qmanning) (Sanitary Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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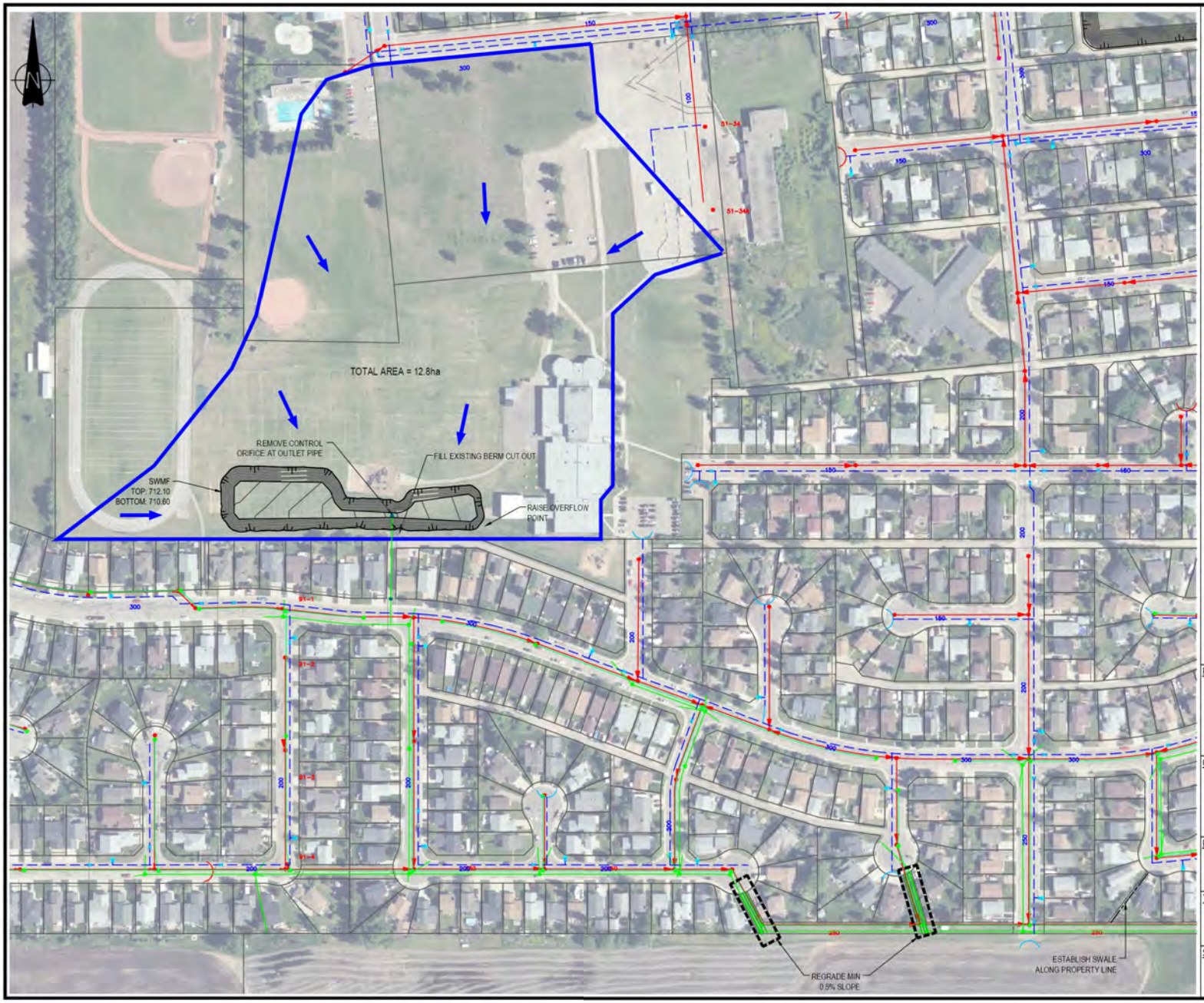
Project:

Town of Stony Plain Flood Mitigation Program

Title:

AREA H - EXISTING AND IMPROVED FLOOD RISKS

Scale:	Figure:
1:25,000	6-23



LEGEND:

- PROPERTY LINE
- EXISTING STORM PIPE
- EXISTING STORM MANHOLE
- EXISTING SANITARY PIPE
- EXISTING SANITARY MANHOLE
- EXISTING WATER PIPE
- EXISTING WATERCOURSE
- PROPOSED STORM PIPE
- PROPOSED STORM MANHOLE
- PROPOSED REGRADE AREA
- BASIN BOUNDARY
- OVERLAND DRAINAGE DIRECTION

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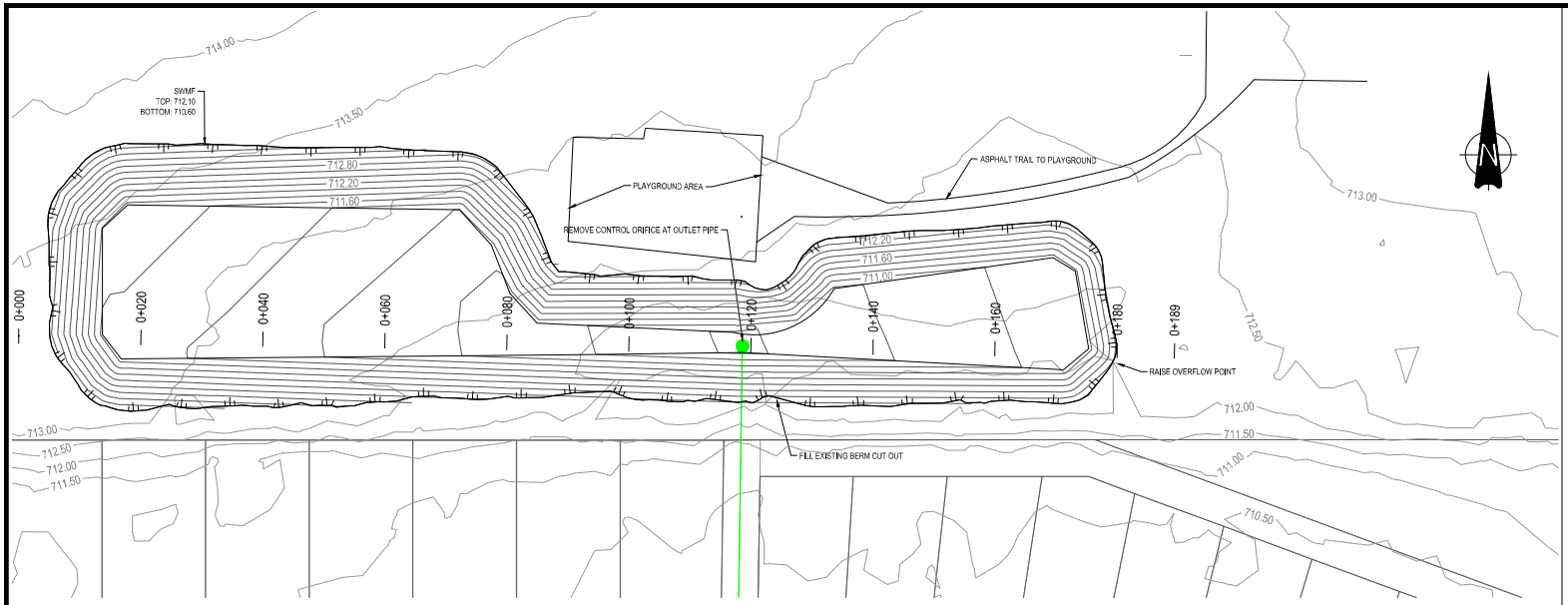
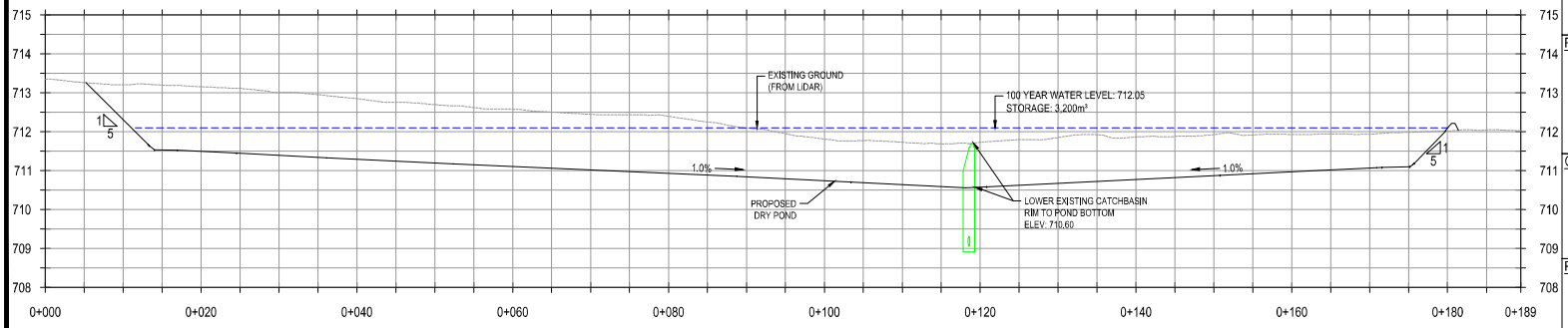
Project: **Town of Stony Plain Flood Mitigation Program**

Title: **Area H - Proposed Improvements**

Scale: **1:2500**

Figure: **6-24**





LEGEND:

- PROPERTY LINE
- EXISTING STORM PIPE
- EXISTING SANITARY PIPE
- EXISTING WATER PIPE
- EXISTING CONTOURS (0.5m)
- PROPOSED CONTOURS (0.5m)

POND EXCAVATION VOLUME = 5,750m³

POND BEGINS TO SEE WATER PONDING AT THE 2 YEAR RAINFALL EVENT

Prepared By:

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Client:

TOWN OF STONY PLAIN

Project:

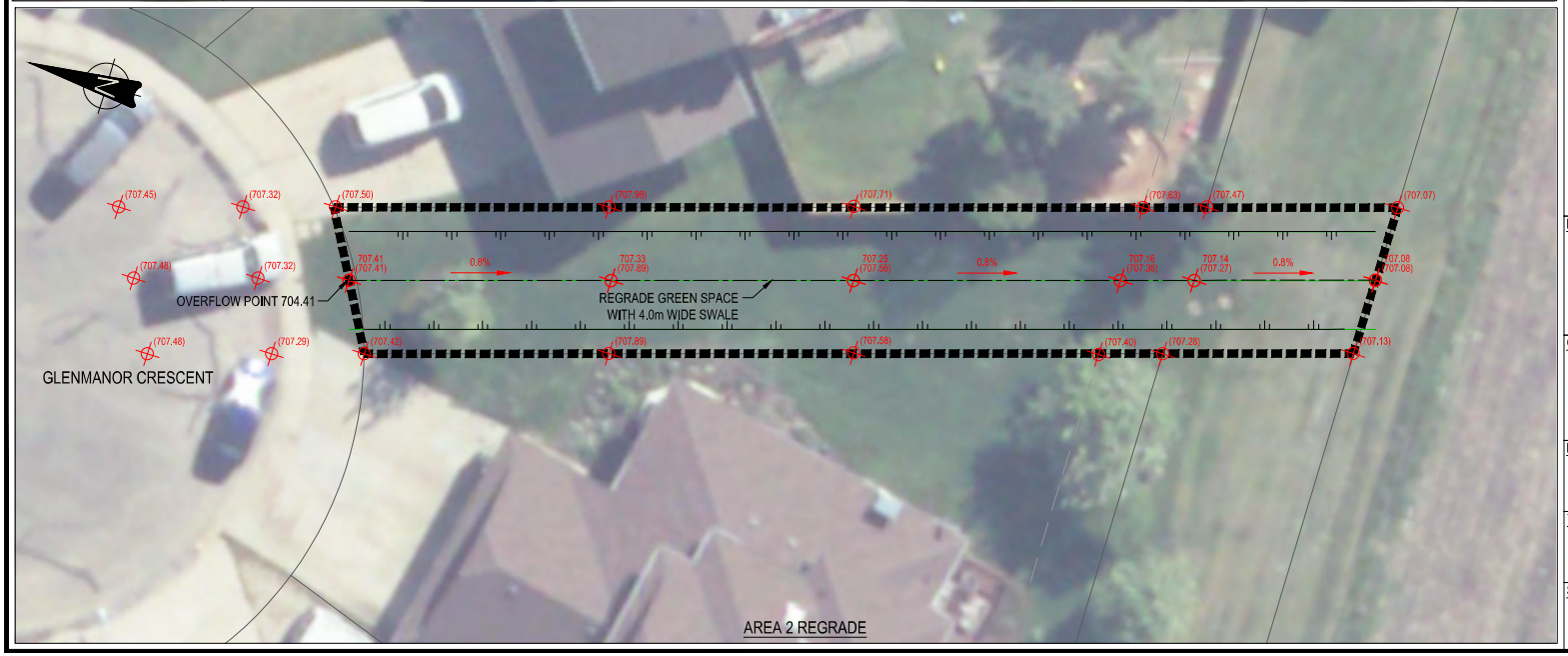
Town of Stony Plain Flood Mitigation Program

Title:

Area H - Proposed Dry Pond in School Yard

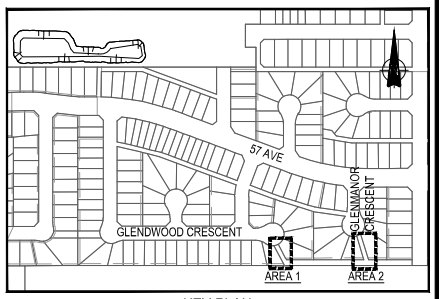
Scale: **1:800**

Figure: **6-25**



LEGEND:

- PROPERTY LINE
- EXISTING STORM PIPE
- EXISTING SANITARY PIPE
- EXISTING WATER PIPE
- EXISTING WATERCOURSE
- PROPOSED REGRADE AREA
- (702.12) EXISTING ELEVATION
- 702.12 PROPOSED ELEVATION



KEY PLAN

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Client: TOWN OF STONY PLAIN

Project:
Town of Stony Plain Flood Mitigation Program

Title:
Area H - Proposed Overflow Regrading for Glenwood Crescent and Glenmanor Cresecent

Scale:	Figure:
1:2500	6-26

6.13 Sanitary Manhole Inflow and Sanitary Manhole Sealing

6.13.1 General

Through previous flood risk studies completed for other municipalities in Alberta, it was determined that sanitary manhole inflow is one of the main wet weather flow component of the sanitary sewer system during intense rainfall events, and often the leading cause of sewer backup during those events. Manhole inflow in defined as surface runoff that directly enters the sanitary sewer system via manholes; this can be into the manhole rim vent holes or through cracks and joints. The computer model developed as part of this study suggests that manhole inflow accounts for about half of the wet weather flow component of the sanitary sewer system during the most intense rainfall events.

In the Town of Stony Plain, there are three main sources of manhole inflow:

1. Manhole inflow due to high Creek water level overflowing some sanitary manholes along the Creek.
2. Manhole inflow due to street ponding, or due to water flowing along the street.
3. Sanitary manholes with catchbasin-type covers.

6.13.2 Sanitary Manhole Inflow along Creek

As described in Section 5.3, four (4) sanitary manholes of the Sanitary Central Trunk will be underwater during a 1:5-year flow event in Whispering Waters Creek, six (6) during a 1:25-year event, and eight (8) during a 1:100-year event. These flooded manholes are located between 52 and 49 Avenue (5 of them), and between 42 and 40 Avenue (3 of them).

Through the computer modeling phase, it was estimated that each of the manhole covers along the Creek would allow the equivalent of about 8 L/s into the manhole when submerged. This is the equivalent of water flowing through eight 1-inch (25mm) diameter vent holes during the 1:100-year event. Multiplying eight manholes by 8 L/s, it is estimated that 64 L/s would enter the sanitary sewer system via these eight manholes only during the 1:100-year event, which is quite significant. For a 1:5-year event, the manhole inflow would be about 32 L/s. Considering the pipefull capacity of the Sanitary Central Trunk is 136 L/s at the railroad and 194 L/s at the Highway 16A crossing, this inflow rate is important.

Through some cursory investigations completed in late-July 2019, two sanitary manholes along the Creek between 52 and 49 Avenue were visited and the rim/cover inspected. The review found that both of these manholes, which are in the 1:5-year floodplain of the Creek, have significant deficiencies that may allow lots of Creek water into the sanitary sewer system.

- Manhole CT-24 located between Brown Street and Whispering Waters Creek just south of 51 Avenue, shown in Figure 6-27, was found to have a gap between the steel rim and the top concrete ring. It was possible to slide a ½-inch diameter pen between the two. It is estimated that the gap went most of the way around. Assuming an average ½-inch (13mm) gap around half of the manhole circumference, the corresponding manhole inflow during a 1:100-year, from this gap alone, would be about 31 L/s (27 L/s during a 1:25-year, 11 L/s during a 1:5-year). Now let us add the inflow contribution from the one

vent hole, which would be about 1.3 L/s during a 100-year event (1.1 L/s during a 1:25-year, 0.5 L/s during a 1:5-year).

- Manhole CT-21 located between Brown Street and Whispering Waters Creek, north of the 50 Avenue trail crossing and just south of the pedestrian bridge, shown in Figure 6-28, was found to have a visible opening along one side because the manhole rim was shifted from the concrete rings. The visible opening averaged 8" x 1" (20cm x 2.5cm). The corresponding manhole inflow during a 1:100-year, from this gap alone, would be about 19 L/s (17 L/s during a 1:25-year, 13 L/s during a 1:5-year). Now let us assume that because the steel rim is not sealed to the concrete, there is an average of a 1/16" inch (1.6mm) gap all around the manhole rim where water can enter the manhole. This would result in additional manhole inflow of about 12 L/s during a 100-year event (10 L/s during a 1:25-year, 8 L/s during a 1:5-year).
- As per the above, the inflow from the Creek into both Manhole CT-21 and CT-24 during a 100-year event is estimated at 63 L/s during a 1:100-year event, 55 L/s during a 1:25-year event and 33 L/s during 1:5-year event. Considering the pipefull capacity of the Sanitary Central Trunk is about 136 L/s at this location, inflow from these two manholes can utilize 46% of the sanitary trunk's capacity by themselves. In comparison, the peak dry weather flow (DWF) at this location is 27 L/s. This does not leave much capacity for any other wet weather flows. The inflow from the other six (6) submerged sanitary manholes along the Creek during a 100-year event may also add significant amount of inflow in the sanitary trunk, and likely cause some surcharge.

The above confirms that the model likely underestimated manhole inflow from the Creek, at least at these two manholes, by a factor of about 4.

Worst-Case Scenario Simulation

A worst-case modeling scenario was completed where one of the sanitary manholes in the Creek (CT-21) had no cover and water from the Creek could inflow into the Sanitary Central Trunk without much restrictions (> 800 L/s of allowable manhole inflow). CT-21 was chosen since it is quite low and was observed to be flooded in July 2019. It was also observed to have large gaps between the manhole steel rim and the concrete manhole (see above for details).

The 1:100-year results are presented in Figure 6-30 (profile) and Figure 6-31 (plan view). The profile clearly shows that the hydraulic grade line of the sanitary sewer trunk is at the Creek's water surface at manhole CT-21 and spreading in all directions from there. The plan view shows that about 232 properties would be at risk of sewer backup during this scenario.

This suggests that some of the sewer backups experienced in July 2019, such as on 46 Street between 54 and 55 Avenue, was likely caused by flooded sanitary manholes along the Creek with large gaps, allowing large quantities of creek flow into the sanitary sewer system. Although this is an extreme case of manhole inflow, it does suggest that there is a real threat of this happening and causing significant basement floods in the area.

Figure 6-27: Sanitary Manhole CT-24 located between Brown Street and Whispering Waters Creek, just south of 51 Avenue

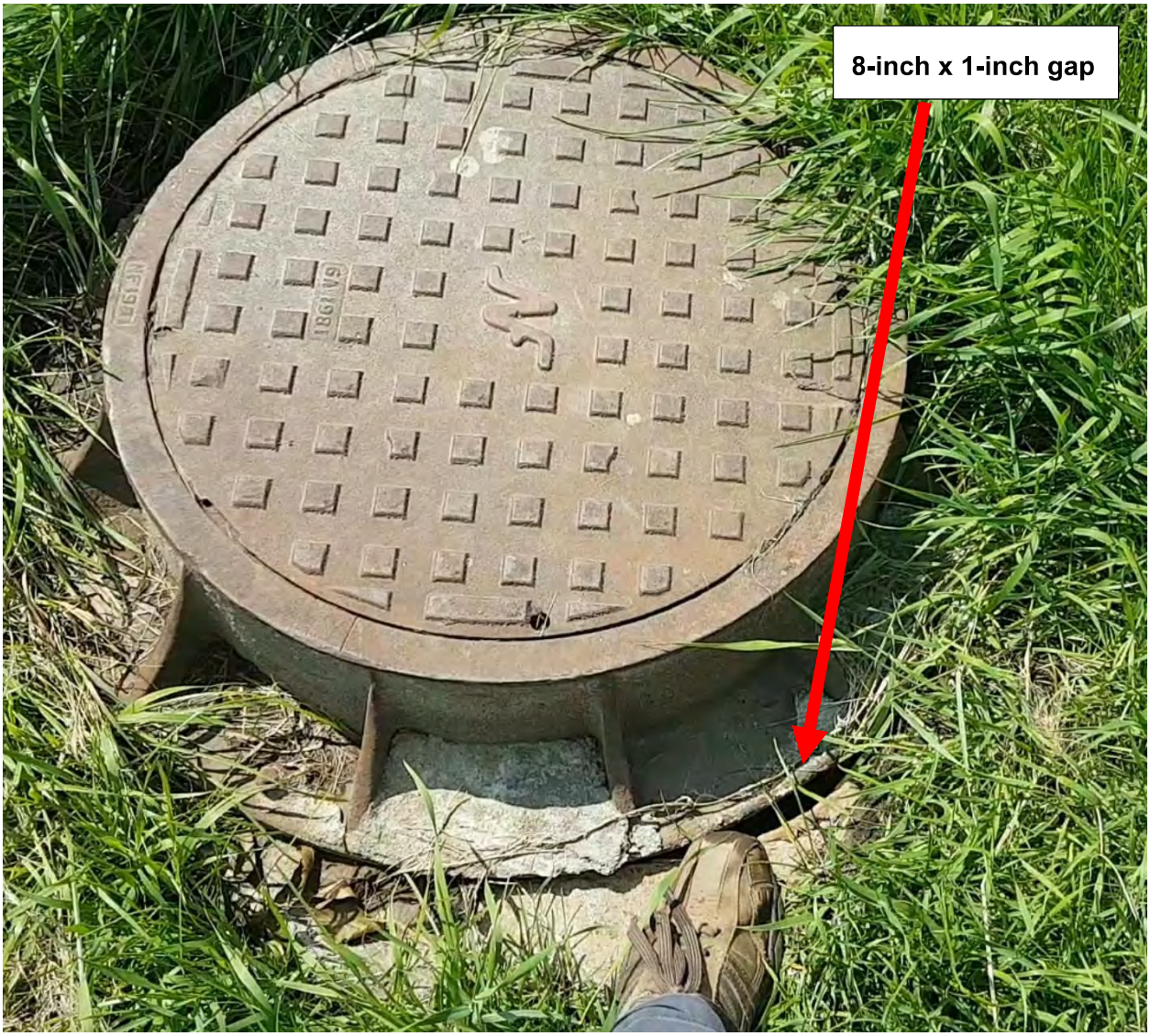


Figure 6-28: Sanitary Manhole CT-21 located between Brown Street and Whispering Waters Creek, North of 50 Avenue Trail and just South of Pedestrian Bridge

6.13.3 Sanitary Manhole Inflow on Roads

There are many sanitary manholes throughout the Town that are susceptible to being submerged by water during large rainfall events. When submerged with water, the surface drainage can flow into the manhole cover via one of the vent holes (there are typically four 1-inch (25mm) hole in each manhole cover, some have one, some have none). Water can also enter the sanitary manholes via joints and cracks in the upper portion of the manhole. Assuming 4 vent holes and 15 cm of water over these holes, about 2.3 L/s of water could flow into the sanitary manhole. At 35 cm of ponding depth, the inflow increases to 3.5 L/s. The computer model used for this study assumed 4 holes per sanitary manholes (except along the Creek where 8 holes were assumed). In areas where many sanitary manholes can be submerged, the manhole inflow can rapidly fill a sanitary sewer pipe, especially in upstream reaches where pipes are often only 200 mm in diameter, and have a pipefull capacity in the order of 20 to 30 L/s.

6.13.4 Sanitary Manholes with Catchbasin-Type Covers

Through our sanitary manhole investigation, we found that one sanitary manhole, located on the Sanitary Central Trunk just north of Highway 16A along the property line of 44 and 46 Boulder Boulevard, had a cover with 16 holes in it. See Figure 6-29 for a photo. Although it doesn't appear to capture a significant amount of drainage, the volume of rainfall-runoff entering the sanitary sewer system at this location could be significant.

Another manhole (CT-37) located just west of Whispering Waters Creek near 56 Avenue was also observed to have a cover with 16 holes. The manhole cover likely doesn't get much runoff flowing into it, but the cover should be replaced regardless.

It is recommended for the Town to complete a thorough investigation of all its sanitary manholes to identify any other potential locations where sanitary manholes have catchbasin-type covers.

Figure 6-29: Catchbasin-Type Cover on Sanitary Manhole at 44/46 Boulder Boulevard

6.13.5 Recommended Sanitary Manhole Sealing Program

The recommendation is to seal sanitary manholes that are susceptible to add large amount of surface water into the sanitary sewer system. See Figure 6-32 for location of the sanitary manholes, as well as Appendix G for a list of the manholes to be sealed. Details regarding the various sealing methods are illustrated in Figure 6-33.

- **HIGH PRIORITY (STAGE 1):**
  - All eight (8) sanitary manholes that would be submerged by Whispering Waters Creek during a 1:100-year event, as well as five (5) sanitary manholes that are within 0.3m from the 1:100-year floodplain of the Creek.
    - As soon as possible, these manhole rims should be repositioned to minimize gaps between the steel rim and the concrete manhole barrel. The steel rim and the concrete manhole barrel should also be grouted together and sealed; this can be done at little cost and time, and provide a significant benefit.
    - For all these manholes, the manhole is to be extended to 0.3m above the current 1:100-year water surface elevation of the Creek with a waterproof section, and properly sealed to prevent Creek water from entering into the manhole.
  - Just north of Highway 16A along the property line of 44 and 46 Boulder Boulevard, replace the sanitary manhole cover to a regular sanitary manhole cover, and seal the manhole. This manhole currently has a cover with many holes and is along the Sanitary Central Trunk.
  - For manhole CT-37 located just west of Whispering Waters Creek near 56 Avenue, replace the sanitary manhole cover to a regular sanitary manhole cover, and seal manhole.
  - Seal 23 sanitary manholes on roads that are generally located in depressions and high flow areas where significant manhole inflow might occur.
    - The manhole sealing for these sanitary manholes is to include an inspection of the top section of the manhole barrel, and either a replacement of the top barrel including sealing and bowl installation, or only the rim and cover sealing and bowl installation.
- **MEDIUM PRIORITY (STAGE 2):**
  - Forty-three (43) sanitary manholes on roads that contribute a significant amount of inflow in the sanitary sewer system.
    - After these and the above listed higher priority sanitary manholes have been sealed, it is estimated that all sanitary manholes that currently contribute to 90% of the total manhole inflow will be eliminated.
    - The manhole sealing for these sanitary manholes is to include an inspection of the top section of the manhole barrel, and either a replacement of the top barrel including sealing and bowl installation, or only the rim and cover sealing and bowl installation.

- **LOW PRIORITY (STAGE 3):**
    - Another seventy-nine (77) manholes were identified to contribute some sanitary manhole inflow (more than 0.5 L/s each during the 1:100-year event). These are low priority given the lower benefit for the same cost as sealing the higher priority upgrades.

6.13.6 Costs and Benefits of Manhole Sealing

The cost to complete the Stage 1 sanitary manhole sealing is about $550,000. The benefit of sealing these manholes is two-folds.

- First, sealing the 13 sanitary manholes along the Creek will provide a significant reduction in manhole inflow and significantly mitigate flood risks in the area. When these manholes are submerged by Creek water, it is estimated that up to 232 residences would be at flood risk due to sewer backup. By sealing these 13 low-lying manholes in the Creek, this should eliminate this flood risk. The estimated benefit from these manholes sealing is nearly $48 million in mitigated flood risk during a 75-year period. This is well worth the cost.
- Secondly, sealing the other 23 sanitary manholes and replacing the 2 catchbasin-type manhole covers will further decrease manhole inflows into the sanitary sewer system, and provide more confidence that there will not be sewer backups during intense rainfall events.

The cost to complete the Stage 2 sanitary manhole sealing (43 manholes) is about $553,450. The key benefit is a further reduction in the hydraulic grade line and surcharge in the sanitary sewer system, and more reduction of wet weather flows. However, the benefits in terms of flood mitigation is not quantifiable since there should not be any sewer backups during the 1:100-year event after the Stage 1 manhole sealings have been completed.

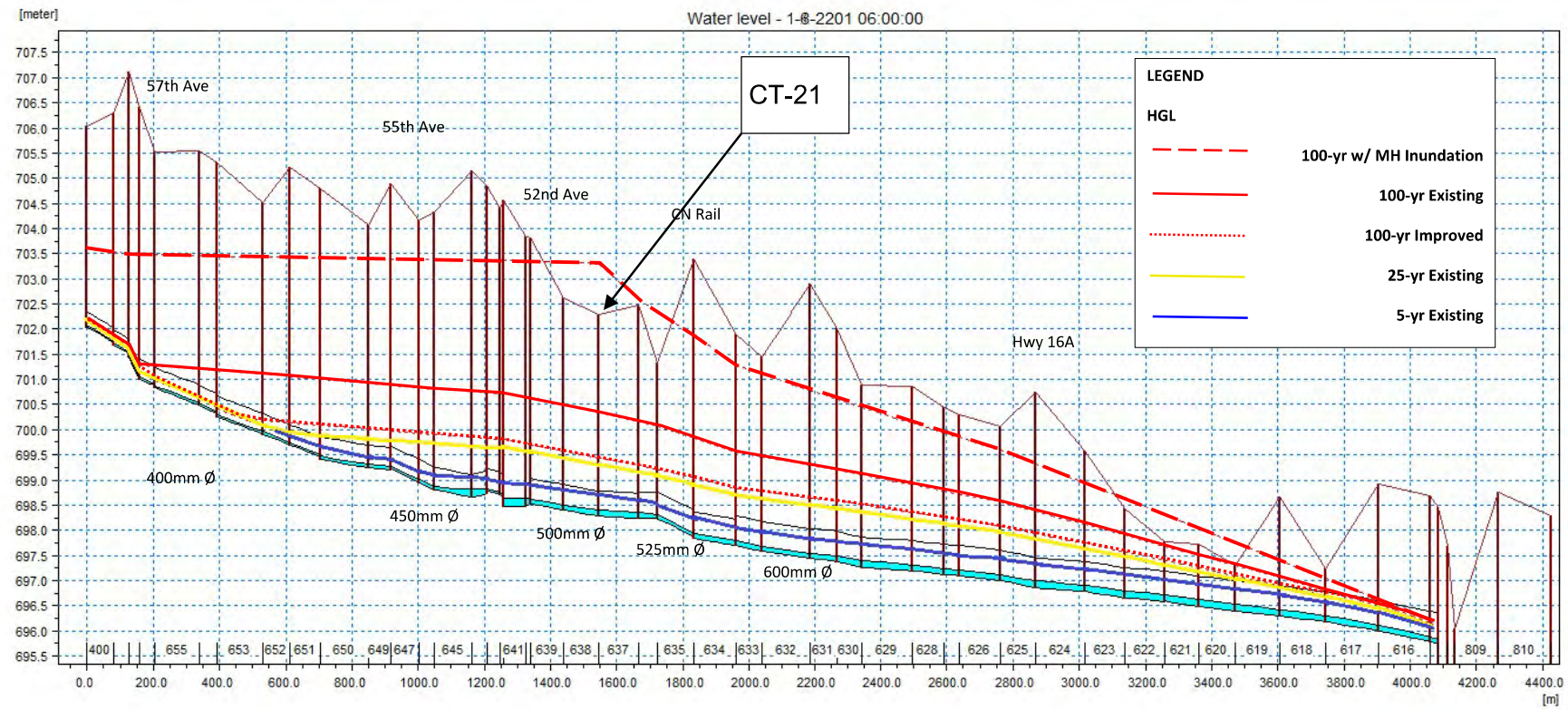
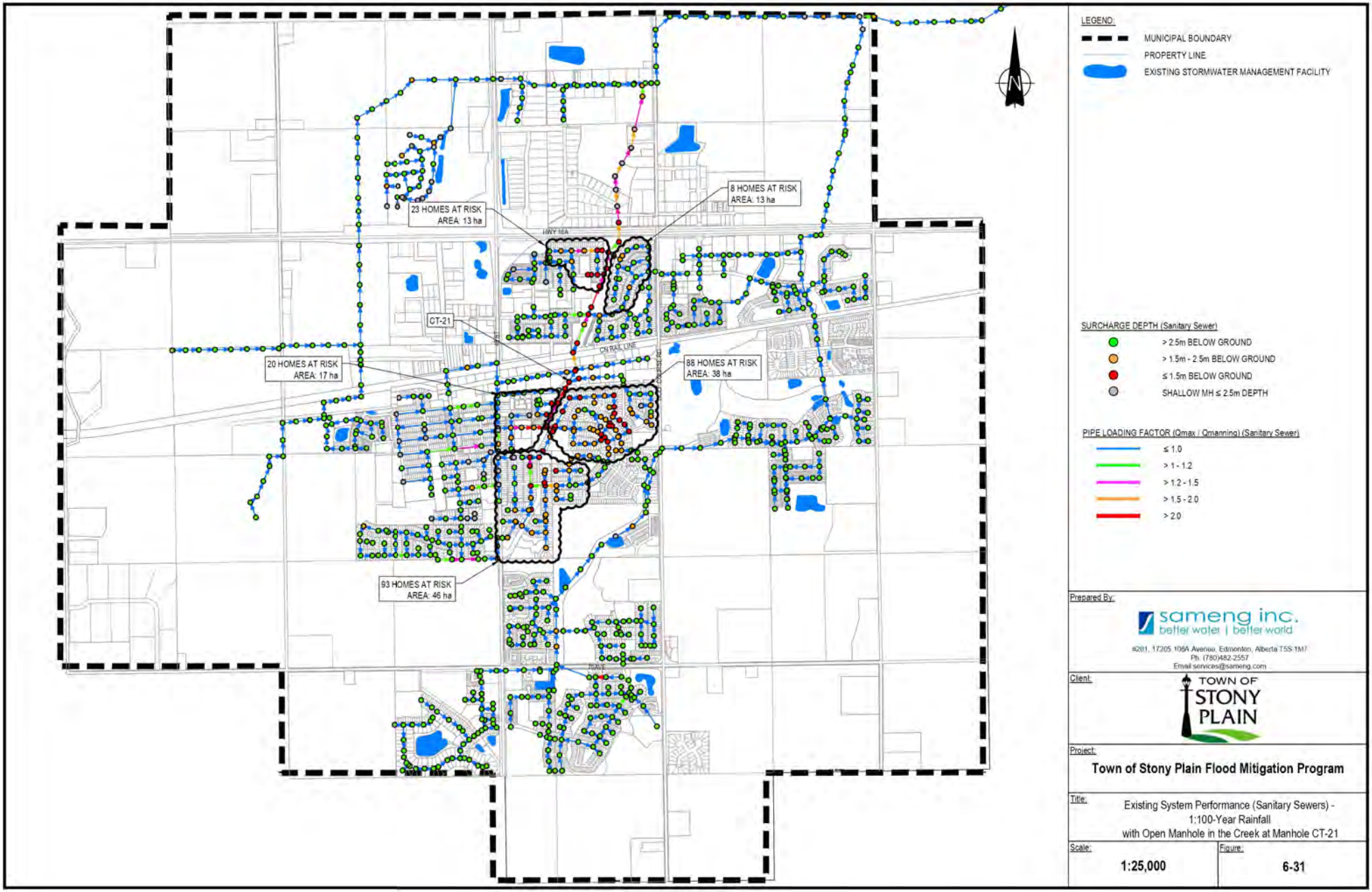


Figure 6-30: Profile of Sanitary Surcharge in Sanitary Central Trunk for Various Rainfall Events



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TOWN OF STONY PLAIN

Project:

Town of Stony Plain Flood Mitigation Program

Title:

Existing System Performance (Sanitary Sewers) -
1:100-Year Rainfall
with Open Manhole in the Creek at Manhole CT-21

Scale:	Figure:
1:25,000	6-31

LEGEND:

- PROPERTY LINE
- EXISTING SANITARY PIPE
- STAGE 1 - 13 SANITARY SEALING WITH CHIMNEY EXTENSION
- STAGE 1 - 25 SANITARY MANHOLE SEALING LOCATIONS
- STAGE 2 - 43 SANITARY MANHOLE SEALING LOCATIONS
- STAGE 3 - 77 SANITARY MANHOLE SEALING LOCATIONS

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Client:

TOWN OF STONY PLAIN

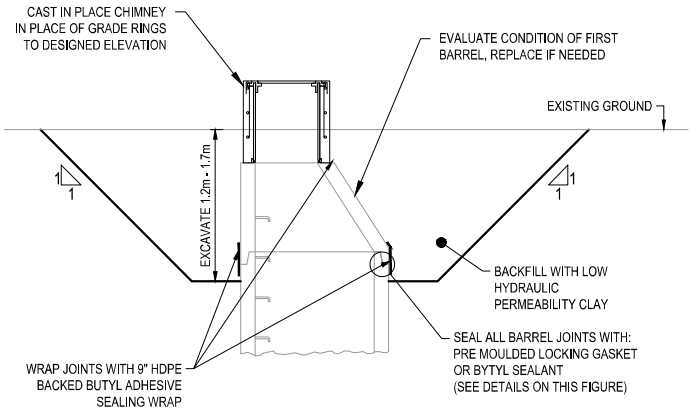
Project:

Town of Stony Plain Flood Mitigation Program

Title:

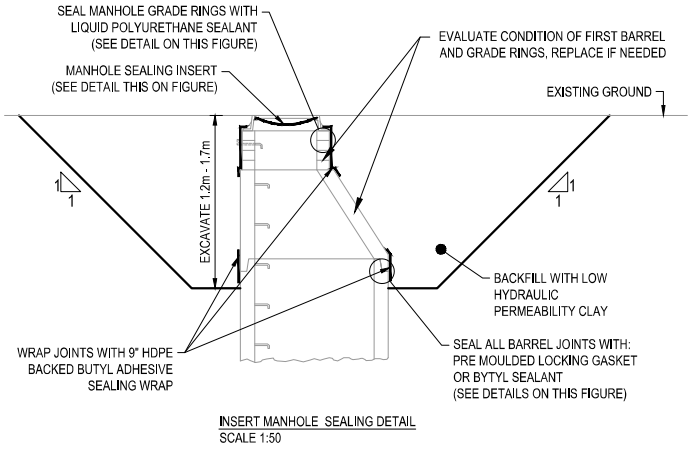
Proposed Sanitary Manhole Sealing Locations

Scale:	Figure:
1:10,000	6-32



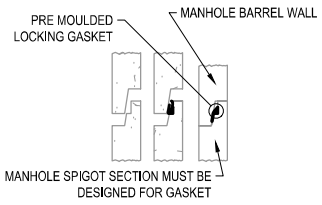
CHIMNEY MANHOLE SEALING DETAIL
SCALE 1:50

PHOTO OF MANHOLE CHIMNEY REBAR

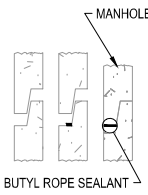


INSERT MANHOLE SEALING DETAIL
SCALE 1:50

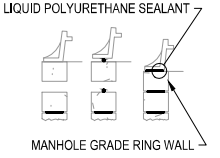
PHOTO OF MANHOLE JOINT WRAP WITH 9" HDPE BACKED
BUTYL ADHESIVE SEALING WRAP



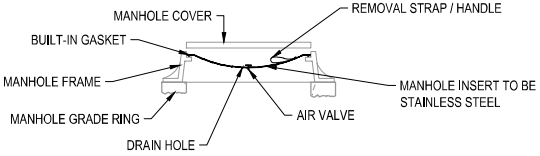
PRE MOULDED LOCKING GASKET
SCALE 1:25



BUTYL ROPE SEALANT
SCALE 1:25



LIQUID POLYURETHANE SEALANT
SCALE 1:25



MANHOLE INSERT
SCALE 1:25

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TOWN OF STONY PLAIN

Project:
Town of Stony Plain Flood Mitigation Program

Title:
Sanitary Manhole Sealing Details

Scale:
-

Figure:
6-33

6.14 Local Drainage Concerns – Whispering Cove North of Oatway Drive

The Town asked to review potential drainage issues at the north end of Whispering Cove, north of Oatway Drive. The following provides our findings and recommendations.

Review of available information:

- This cul-de-sac road drains in a south direction towards Oatway Drive with no street ponding issues. All properties have split drainage. The backyard drainage of the lots at the northeast end of the road is east towards the back of the properties into a common grassed swale on public land. This swale should drain north at 0.5% according to the lot grading plan provided under Figure 6-34. At the north end of that swale, the swale turns west and into the backyard of the lots of 27, 26, 25, and 24 Whispering Cove, in that order. The swale is located in a 3m wide easement along the back of these properties; see Figure 6-34 and Figure 6-36 for reference of easement within properties. The swale in that easement should have a slope of 0.5% towards the Creek according to the grading plan.

Some observations:

- The LiDAR elevation data, shown in Figure 6-35, does not show any noticeable drainage issues in the area. However, this data is likely not of high-enough resolution to identify any issues with the swale at the north end of the properties, such that some minor pooling may actually exist.
- If a swale exists within the 3.0m easement on private properties, it is not noticeable from the LIDAR.
- The property at 26 Whispering Cove appears to have done some work within the easement. At the northeast corner, there appears to be a raised garden box inside the easement. This box likely blocks some of the drainage coming from the east. The property also has a large shed or structure at the northwest of the property, also well within the easement, and also likely blocking the swale drainage.
- The property at 25 Whispering Cove also appears to have done some landscaping work within the easement, but no physical structure that would block surface drainage is visible.

Recommendations:

- We are not aware of the exact drainage issues in this area, which makes it challenging to recommend a firm remediation solution. The next steps should be to properly understand the drainage concerns and determine the best course of action forward. This will likely require some site investigations and survey on these properties to review the condition of the swale, identify the legality of constructing structures (i.e. land title, permit) within the rear easement on these residential lots, and identify the need to restore the swale.
- With the assumption that a swale needs to be reestablished to improve drainage in the area, it is our recommendation for a new swale to be constructed just north of the existing properties, within the school's property. See Figure 6-37 for a concept. The swale could be concrete or grassed, to be determined at detailed design. The swale would be constructed to be low enough to convey drainage from the upstream (east) grassed swale, and low enough to capture drainage from the residential lots to the south. The swale would slope towards Whispering Waters Creek to the west. At the east end of the proposed swale, the asphalt trail may need to be reconstructed to make way for the new

swale alignment. About eight (8) mature trees on the school property may have to be removed to make way for the swale, although it may be possible to work around some of them (to be confirmed at detailed design). An easement (minimum 3m wide recommended) would need to be acquired for maintenance of the swale on the school's property; this will require discussions and approval from the school board.

- Alternatively, options to reestablish the swale on private property within the existing easement could be considered. This would require further investigations which are beyond the scope of this flood mitigation project. This may include moving the raised garden box, installing small pipe(s) underneath the shed/structure (trenchlessly) to maintain drainage across the structure, and reestablishing the drainage within the landscaped portion of the swale.

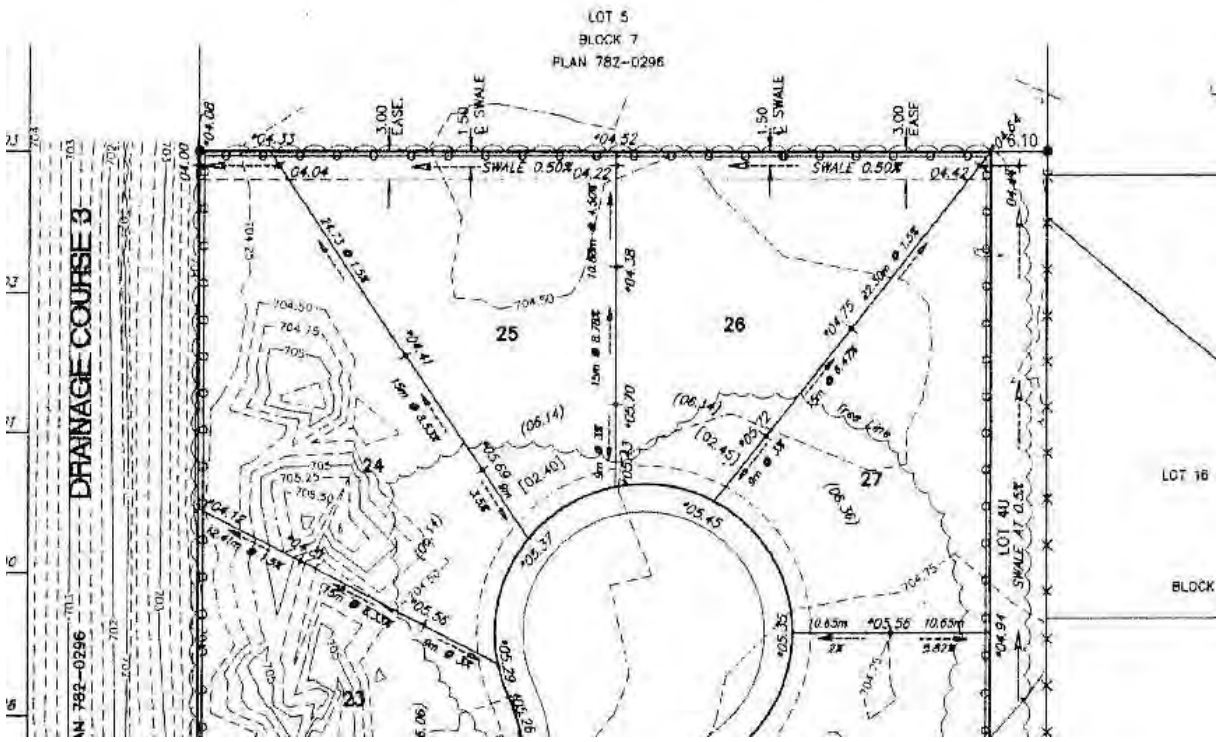

Figure 6-34: Lot Grading Plan (dated 2003) for Whispering Cove

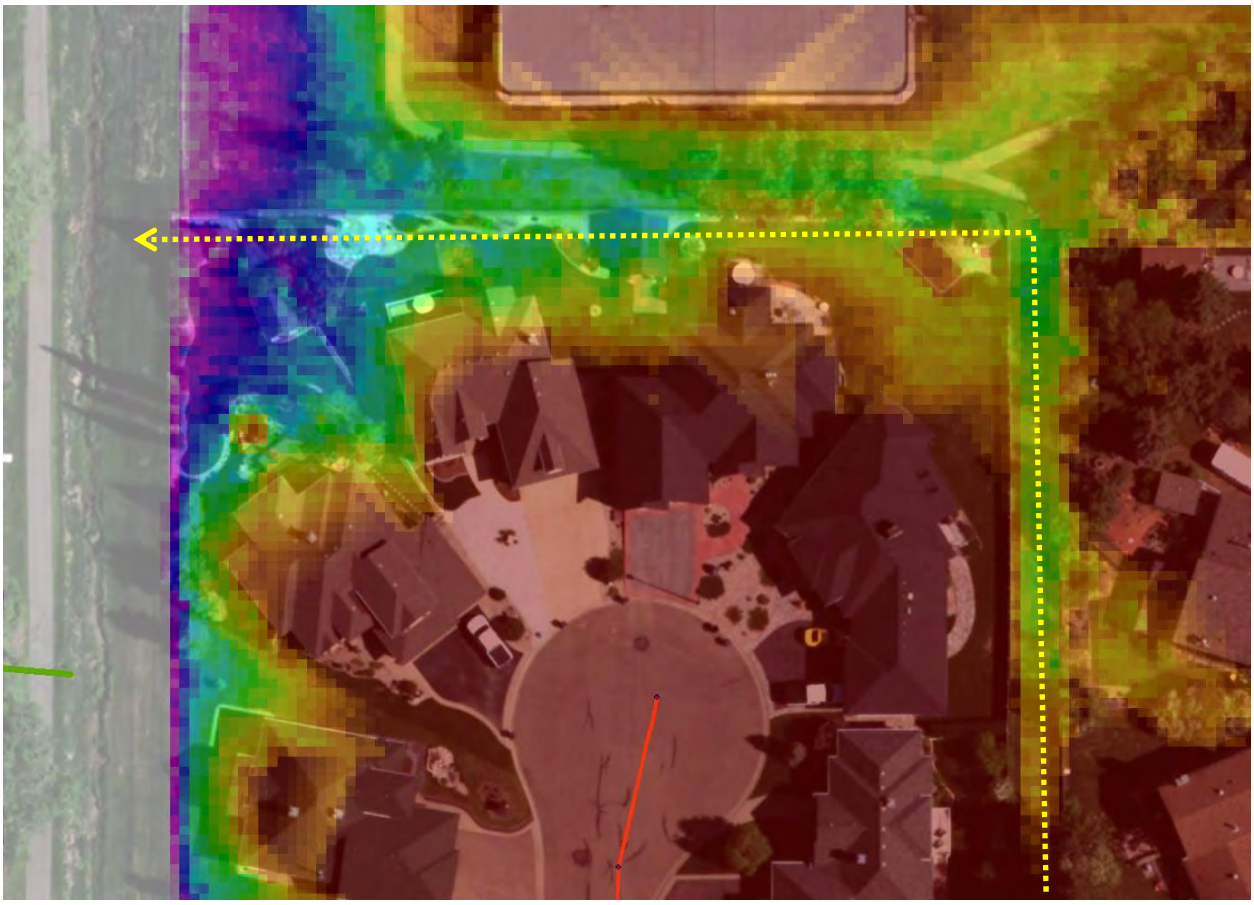

Figure 6-35: Local Drainage Concerns - Whispering Cove North of Oatway Drive (White color is LIDAR below 703.9m (1:100-year Creek water elevation), Red color is LIDAR above 705.0m. The yellow dotted line is the alignment of the swale.

Figure 6-36: Local Drainage Concerns - Whispering Cove North of Oatway Drive – Air Photo showing Backyard Swale Area and Easement (yellow line is property line, red dashed line is 3m easement limit in property)

Figure 6-37: Conceptual Drainage Improvements for Whispering Cove North of Oatway Drive(yellow line is property line, red dashed line is proposed 3m easement on school property)

6.15 Post-Improvement Flood Risk Areas and System Performance Results

As explained in the previous sections, improvements were identified for Areas A to H, in addition to sanitary manhole sealing throughout, in order to reduce flood risks due to surface ponding and sewer backup. The following Figure 6-38 to Figure 6-40 show the simulation results of the improved sanitary sewer system and of the storm sewer and overland drainage system under intense rainfall events from the 1:5-year to the 1:100-year rainfall event (using 4-hour Chicago Distribution). These results assume that all improvements are in place, including the Whispering Waters Creek Option 2 upgrades.

LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Storm Sewer)

- > 1.0m BELOW GROUND
- 0 TO 1.0m BELOW GROUND
- AT OR ABOVE GROUND

PIPE LOADING FACTOR (Qmax / Qmanning) (Storm Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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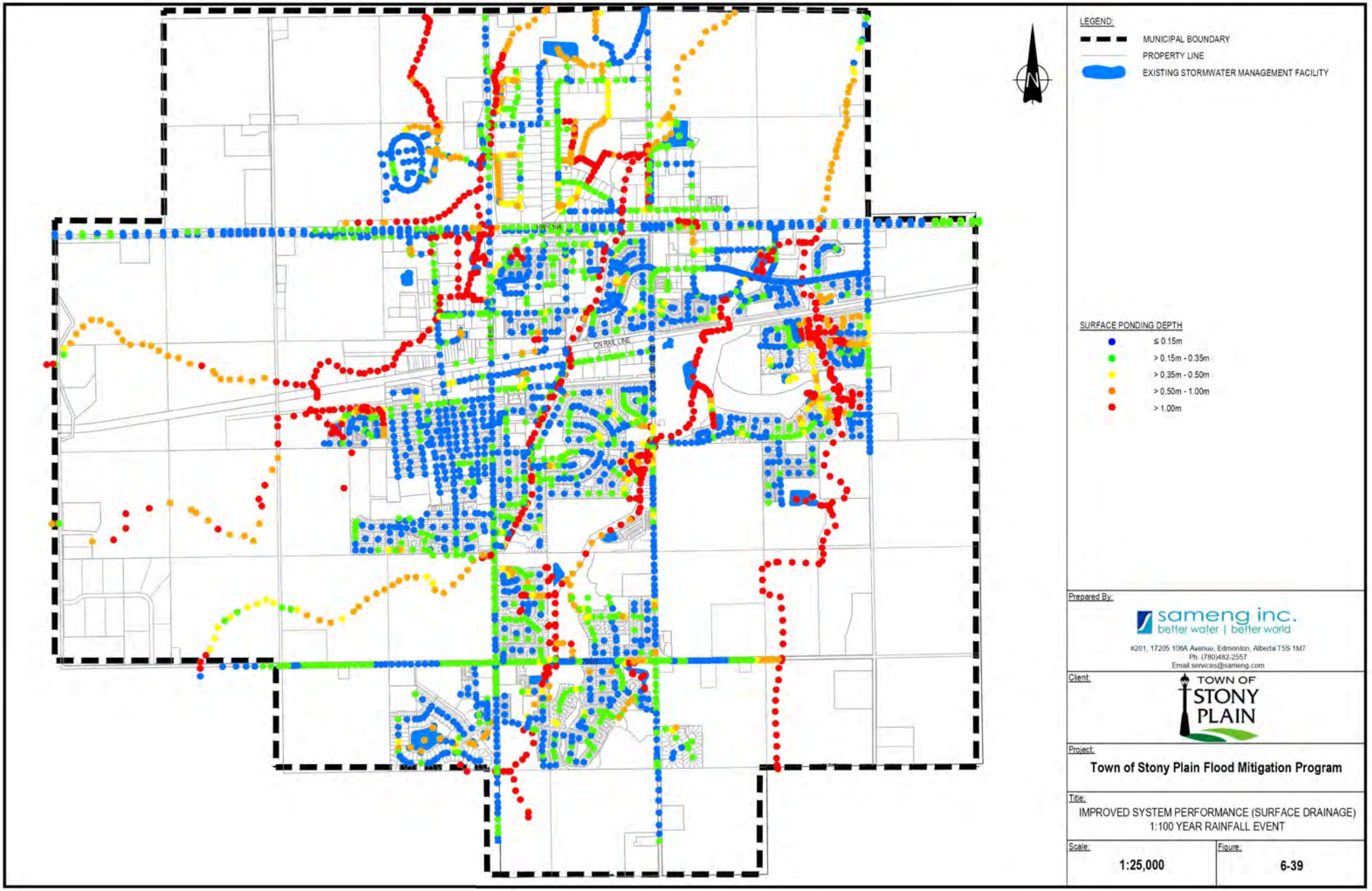
Project: **Town of Stony Plain Flood Mitigation Program**

Title: IMPROVED SYSTEM PERFORMANCE (STORM SEWERS)
1:100 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	6-38


LEGEND:
MUNICIPAL BOUNDARY
PROPERTY LINE
EXISTING STORMWATER MANAGEMENT FACILITY
SURFACE PONDING DEPTH
≤ 0.15m
> 0.15m - 0.35m
> 0.35m - 0.50m
> 0.50m - 1.00m
> 1.00m
CN RAIL LINE
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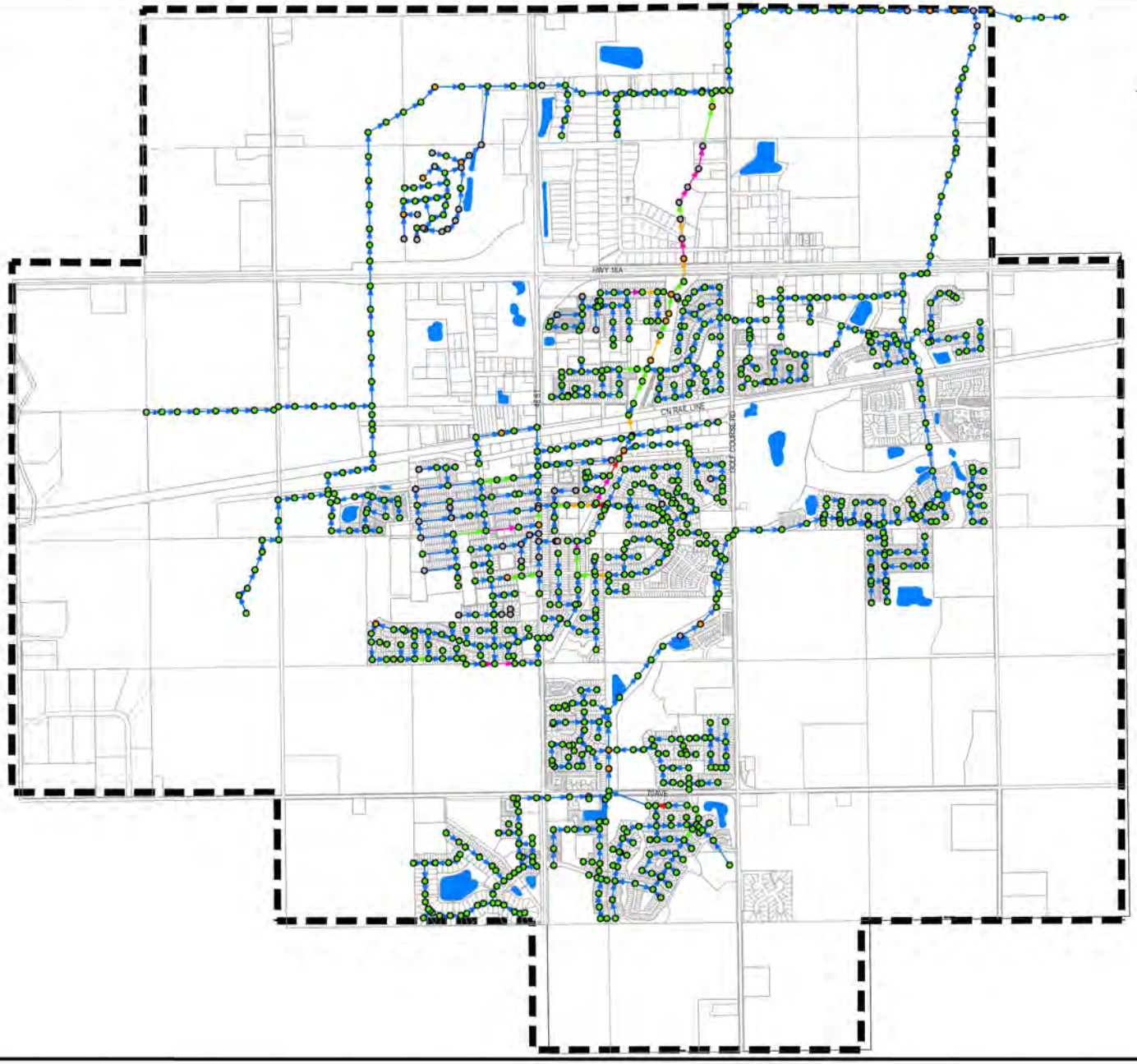
TOWN OF STONY PLAIN
Project:
Town of Stony Plain Flood Mitigation Program
Title:
IMPROVED SYSTEM PERFORMANCE (SURFACE DRAINAGE)
1:100 YEAR RAINFALL EVENT
Scale:
1:25,000
Figure:
6-39



LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Sanitary Sewer)

- > 2.5m BELOW GROUND
- > 1.5m - 2.5m BELOW GROUND
- ≤ 1.5m BELOW GROUND
- SHALLOW MH ≤ 2.5m DEPTH

PIPE LOADING FACTOR (Qmax / Qmanning) (Sanitary Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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Project: **Town of Stony Plain Flood Mitigation Program**

Title: IMPROVED SYSTEM PERFORMANCE (SANITARY SEWERS)
1:100 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	6-40

7.0 Flood Mitigation Evaluation and Implementation Strategy

7.1 Overview

The following summarizes the costs and benefits for all proposed flood mitigation improvements. This section concludes with a recommended implementation plan, first focusing on areas at higher flood risks and with better cost-benefit.

7.2 Costs

Cost estimates were developed for all improvements presented in this report. Table 7-1 summarizes the estimated costs, while detailed costs breakdowns are provided in Appendix E. All costs include 30% contingency and 15% of engineering (or more for small projects).

- The Whispering Waters Creek Improvements will cost about $8.1 million for Option 1 and $2.9 million for Option 2. Option 2 is the recommended option.
- For the local area improvements, the total costs are about $11.8 million, with 83% of the costs to mitigate flood risks in Area B and D.
- The sanitary manhole sealing program is estimated to cost $550,000 for Stage 1 (38 manholes including 13 along Creek) and $553,450 for Stage 2 (43 manholes) for a total of $1,103,450.
- In total, all recommended improvements are estimated to cost around $15.8 million.

Table 7-1: Cost Estimates for all Improvements

Description	Cost
Whispering Waters Creek Improvements ***(only one option needs to be constructed)***	
Option 1: Culvert Improvements Along Whispering Waters Creek + Downstream Buffer Pond	$ 2,988,000 + $ 5,100,000 = $ 8,088,000
Option 2: Overflow Pond and Culvert Improvements + Downstream Buffer Pond	$ 2,148,000 + $ 760,000 = $ 2,908,000
Local Area Improvements	
Area A Improvements	$ 48,000
Area B and D Improvements	$ 9,799,000
Stage 1 (Dry Pond and Upstream Storm Pipes)	*$ 3,928,000*
Stage 2 (52 Avenue, east of 48 Street)	*$ 3,094,000*
Stage 3 (Upstream to Downstream Connection)	*$ 2,777,000*
Area C Improvements	$ 958,000
Stage 1 (Outfall Twinning)	*$ 280,000*
Stage 2 (44 Avenue Storm Relief Pipe and Outfall)	*$ 678,000*
Area E Improvements	$ 102,000
Area F Improvements	$ 435,000
Area G Improvements	Included in Whispering Waters Creek Improvements
Area H Improvements	$ 426,000
Sanitary Manhole Sealing	
Stage 1 (High Priority)	$ 550,000
Stage 2 (Medium Priority)	$ 553,450
Total **(using Option 2 for Creek)**	**$ 15,779,450**

7.3 Benefits

7.3.1 Overview

Benefits were quantified for each improvement in terms of reduction of flood risks to houses and buildings, vehicles parked on the street, and sewer backups. The following summarizes the methodology used to quantify benefits and summarizes the expected benefit from each improvement.

7.3.2 Flood Risk and Benefit Quantification Methodology

Sameng used a benefit quantification methodology that has been applied for many City of Edmonton projects as well as other municipalities. The following summarizes the key methodology used to assess and quantify these benefits.

HOUSE FLOODING DUE TO SURFACE PONDING

The simulation results show the water depth and extent of surface ponding for various rainfall events. For areas where street surface ponding would be higher than the curb (typically 15cm depth) we looked at nearby homes to judge the likelihood of the water reaching the foundation of the building, based on LiDAR topography. Where flooding would reach houses, there is a risk that the water would flow through the lowest opening (basement windows typically) and inundate the basement.

The cost of basement flood is a function of the size of the home and the value of the contents. For estimating purposes, previous analyses have used an average cost of basement flooding (due to surface overflow flooding) of $150,000 per flood.

The number of homes at risk of flooding due to overflow were counted in each area, and for each simulated event (i.e. 100-yr, 50-yr, 25-yr, 10-yr, 5-yr, 2-yr).

VEHICLE FLOODING DUE TO SURFACE PONDING

Flooding on roadways and parking lots is a hazard to vehicles, whether parked on the street or moving. Even a small depth of water can cause vehicles to lose contact with the roadway, creating a serious hazard, and vehicles with a low carriage may suffer damage from relatively shallow street ponding depths.

For the purposes of this study, we considered a depth of 35cm as sufficient to cause significant damage to a typical parked vehicle. To estimate the number of vehicles that could be affected, we looked at air photos to judge how much parking spaces would be typically utilized. Factors included whether homeowners parked on streets or in driveways/garages, whether parking lots were available, and the apparent demand for parking. For a typical street, it was found that we could assume vehicles parked on the street at a spacing of about 16m on each side (about half of potential capacity). Parking lots were also considered, where modeled, with the assumption that half of all parking stalls would be filled during a storm event.

The cost of a vehicle flood was estimated to be $15,000 per vehicle.

SEWER BACKUP

For sewer backups, it is assumed that if the sanitary sewer surcharge at the house connection is 1.5m or less below ground, the house would experience sanitary sewer backup. This is because at this depth, the surcharge elevation would likely be above the basement floor. If the sewer surcharge is between 1.5m and 2.5m below ground, it is assumed that 50% of the houses will suffer from sewer backup.

The cost of sanitary sewer backup is on average $55,000, and account for structural damage and content damage.

7.3.3 Risk Aggregation

For cost/benefit assessment, it is useful to aggregate the risk of rare flood events as well as more common ones. A horizon of 75 years was chosen as the typical lifespan of drainage infrastructure.

To calculate the aggregate risk/benefit over 75 years, the sum of events up to 100 years was taken and factored by 0.75. In a statistical 100 years period, we expect the following event to happen: one 1:100-year event, one 1:50-year event, two 1:25-year events, six 1:10-year events, ten 1:5 year events, and thirty 1:2-year events. Thus, more frequent events are weighted more in the total.

7.3.4 Non-Quantified Benefits

Not all benefits from the proposed improvements are quantifiable. The following provides some non-quantifiable benefits that should be considered.

- Surface ponding and flows create safety hazards to traffic and pedestrians. A few centimetres of fast-moving water can knock a person off their feet, and any amount of water on a roadway can cause hydroplaning of a moving vehicle. Even shallow depths can present a drowning hazard to small children.
- Frequent ponding on streets also presents a cost to infrastructure. Pothole formation is influenced by improper drainage, and surface ponding can deposit sediment and debris that can clog catchbasins and culverts, as well as require more frequent maintenance/cleaning. Flooded roads and trails may result in saturated soils for many days following the flood event and thus have less-load bearing capacity.
- Ponding on private properties may also damage landscaping features, such as wood mulch that can float away, dirt can be displaced, flowers and vegetation can be severally damaged, trees can die if flooded for too long, etc.
- Flooding affects people's lives. When a residence gets flooded, the damage is both physical and psychological. Objects of sentimental value could get destroyed. People have to take some time off work to clean up. Historical flooding may impact property value and resale value. There could also be health issues if the cleanup was inadequate and mold grows.
- Climate change may result in more frequent intense rainfall events. It is important to adapt to the changing climate and rainfall patterns.

7.3.5 Summary of Benefit Quantification

The benefits to each area are summarized in Table 7-2. For detailed benefit quantification for each area, see their respective sections earlier in the report.

Table 7-2: Benefits of Local Improvements by Area

Description	Homes at Risk During 100-year Storm Event	Homes Benefited to 100-year Event	Fewer Vehicle Floods during 100-year event	Benefit over 75 Years	Costs from Table 7-1	Benefit-Cost Ratio
Area A Improvements	-	-	4	$ 100,000	$ 48,000	2.1
Area B and D Improvements	39	39	41	$ 33,410,000	$ 9,799,000	3.4
Stage 1 (Dry Pond and Upstream Storm Pipes)	*39*	*15*	*6*	*$ 20,280,000*	*$ 3,928,000*	*5.2*
Stage 2 (52 Avenue, east of 48 Street)	*27*	*12*	*25*	*$ 10,700,000*	*$ 3,094,000*	*3.5*
Stage 3 (Upstream to Downstream Connection)	*15 (remainder from Stage 1)*	*12*	*10*	*$ 2,430,000*	*$ 2,777,000*	*0.9*
Area C Improvements	12	12	8	$ 6,680,000	$ 958,000	7.0
Stage 1 (Outfall Twinning)	*12*	*5*	*2*	*$ 5,240,000*	*$ 280,000*	*18.7*
Stage 2 (44 Avenue Storm Relief Pipe and Outfall)	*7 (remainder from Stage 1)*	*7*	*6*	*$ 1,440,000*	*$ 678,000*	*2.1*
Area E Improvements	7	7	5	$ 1,720,000	$ 102,000	16.9
Area F Improvements	5	5	4	$ 4,130,000	$ 435,000	9.5
Area G Improvements					Included in Whispering Waters Creek Improvements	
Area H Improvements	9	7	40	$ 2,880,000	$ 426,000	6.8
Sanitary Manhole Sealing	232	232	0	$ 47,850,000	$ 1,077,000	44.4
Stage 1	*232*	*232*	*0*	*$ 47,850,000*	*$ 550,000*	*87.0*
Stage 2	*0*	*0*	*0*	*$ 0*	*$ 553,450*	*0.0*
Total	**304**	**302**	**102**	**$ 96,770,000**	**$ 12,845,000**	**7.5**

7.4 Implementation Strategy

Based on our understanding of the current flood risks and the level of efforts needed to improve the level of flood protection for these areas, and also understanding that these improvements likely cannot all be completed within a short-timeframe for budgetary reasons, an implementation strategy was developed. This implementation strategy, provided in Table 7-3, outlines the order that improvements should be implemented/constructed to achieve the greater benefits at the lowest costs. Improvements eligible for ACRP grant were prioritized above others, even though the benefit-cost ratio may not have been as high. Areas that flooded in July 2019 were also prioritized over other areas where no flooding was reported.

The last column of Table 7-3 indicates whether we believe the improvement should be eligible for grant funding from the Alberta Community Resilience Program (ACRP), and the amount that could be eligible for the grant. This would include ponds and culvert upgrades. We also believe that the sanitary manhole sealing along Whispering Waters Creek should be eligible for grant funding since the flooding of these manholes is associated with high water levels in the Creek. Rather than spending millions of dollars to lower the Creek water level enough to not flood these manholes, the manholes will be sealed at a fraction of the costs and will provide similar benefits.

Table 7-3: Recommended Implementation Strategy

Priority	Improvement Name	Description	Cost (Benefit-Cost Ratio)	ACRP Grant Eligibility
1	**Manhole Sealing - Stage 1**	This will prevent the Whispering Waters Creek from flooding the sanitary manholes along the Creek, as well as reduce sanitary manhole inflows at critical locations. This should be done immediately. This should avoid widespread sewer backups during intense rainfall events.	$ 550,000 (87.0)	YES (13 Creek sanitary manholes) ± $180,000
2	**Whispering Waters Creek Option 2 (BMX Pond and Upstream Culvert Upgrades)**	This will reduce high water levels in the Creek upstream of the railroad and allow local improvements to discharge more flow into the Creek. This will also assist with the sanitary manhole sealing along the Creek.	$ 1,957,000 (N/A)	YES (all) ± $1,957,000
3	**Area B and D – Stage 1 – Improvements**	This will reduce ponding depths in the Old Town area and around the Lions Park, particularly for the smaller intense storm events, but not necessarily for the 1:100-year event.	$ 3,928,000 (5.2)	YES (pond and creek culvert) ± $1,800,000
4	**Area F Improvements**	This will reduce flood risks in the area of 46 Street by reducing ponding depths, at a low cost and high benefit.	$ 435,000 (9.5)	NO
5	**Area H – Improvements**	This will reduce overflow from the school yard into the alley and thus protect many houses from flooding. It will also significantly reduce ponding depths on Glenwood Crescent for all storm events.	$ 426,000 (6.8)	YES (pond) ± $421,000
6	**Whispering Waters Creek Option 2 / Area G (Golf Course Road Upgrade and Downstream Pond)**	This improvement will reduce flooding between Boulder Boulevard and Golf Course Road, which can be quite frequent.	$ 951,000 (N/A)	YES (all) ± $951,000

Priority	Improvement Name	Description	Cost (Benefit-Cost Ratio)	ACRP Grant Eligibility
7	**Area C – Stage 1 – Improvements**	This will reduce ponding depths along 44 Avenue and reduce flood risks to many low-lying houses. This might not achieve a 1:100-year level of flood protection for all residences, but it will be close.	$ 280,000 (18.7)	NO
8	**Area E improvements**	This will reduce flood risk in the area of 41 Avenue and 43 Street due to large ponding depth at this depression at a low cost and high benefit.	$ 102,000 (16.9)	NO
9	**Area B and D – Stage 2 – Improvements**	This improvement will benefit a few residences from flooding during some more frequent intense rainfall events.	$ 3,094,000 (3.5)	NO
10	**Area B and D – Stage 3 – Improvements**	This improvement will achieve a 1:100-year level of flood protection for part of the Old Town area.	$ 2,777,000 (0.9)	NO
11	**Manhole Sealing - Stage 2**	Stage 2 of the manhole sealing program will have little benefit. The need for these additional manhole sealings should be reviewed through inflow/infiltration studies.	$ 563,450 (N/A)	NO
12	**Area C – Stage 2 – Improvements**	This Stage 2 is recommended to be done at a later date to allow additional detailed modeling for the area, and confirmation of effectiveness of Stage 1.	$ 678,000 (3.5)	NO
13	**Area A Improvements**	This improvement is of low priority given the low benefit. This should be considered once a building is constructed on site.	$ 48,000 (2.1)	NO

8.0 Conclusions and Recommendations

8.1 Conclusions

Key conclusions of this study are:

(1) On both July 7th and July 15th, 2019, the Town of Stony Plain was hit by very intense rainfall events. These rainfalls have resulted in 46 reported flooded residences and businesses, vehicles, and have caused many roadways to be covered by rainwater.

(2) Whispering Waters Creek has 15 culvert crossings within the Town limits, all of which control the peak flows and water surface elevation of the Creek during large flow events. The Highway 16A crossing and the Golf Course Road North crossing are two of the most significant bottlenecks along the Creek.

(3) Whispering Waters Creek will overflow its banks, flood trails and flood some private properties during intense rainfall events, as small as the 1:5-year event in some areas. Nevertheless, the number of residences and building at risk of flooding due to high water level in the Creek is quite small, even during the 1:100-year event. The most at-risk areas due to high Creek water levels are Area F (46 Street from 54 to 55 Avenue) and Area G (west of Golf Course Road North and north of Boulder Boulevard), as well as a few other properties backing on to the Creek.

(4) A few areas in the Town, especially in the order neighbourhoods, are at risk of flooding due to surface ponding and overland drainage. These areas typically have a poor major drainage system, with water flooding and overflowing through private properties. This is primarily the case for Area A, Area B, Area C, Area D, Area E, Area F and Area H.

(5) Sanitary manhole inflow along Whispering Waters Creek due to high water levels in the Creek is in large part responsible for some flooded basements along the Creek, such as in Area F. There are eight sanitary manholes that can be submerged by Creek water during a 1:100-year event, four of these will be submerged during a 1:5-year event. These manholes should be sealed immediately.

(6) Excluding the potential inflows from the Creek into the sanitary sewer system, flood risks due to sewer backups are generally low during a 1:100-year event. Nevertheless, the sanitary system is still expected to surcharge in some areas during large rainfall events.

8.2 Recommendations

Key recommendations of this study are:

(1) Implement flood mitigation improvements to improve the level of flood resilience in the Town following the recommended implementation strategy. This includes:

a. Sanitary manhole sealing along Whispering Waters Creek and throughout Town, at an estimated cost of $1.1 million and a benefit-cost ratio of 43 (excellent ratio).

b. Upgrades to Whispering Waters Creek including a dry pond south of 49 Avenue and some culvert upsizing, at an estimated cost of $2.9 million.

c. Drainage improvements for Area A to Area H including new pipes with enhanced capacity, surface regrading work, and dry ponds. The recommended improvements that achieve a 1:100-year level of flood protection for these areas total $11.7 million and has a benefit-cost ratio of 4.2.

(2) Apply for the Alberta Community Resilience Program (ACRP) grant program for some of the proposed upgrades. This includes for the 13 sanitary manhole sealings along the Creek, the Option 2 pond and culvert upgrades for Whispering Waters Creek, the pond and creek culvert of Area B and D (Stage 1), and the pond in Area H. About $5.3M of recommended improvements is believed to be eligible for grant funding.

(3) Install up to ten sanitary sewer flow monitoring gauges at key locations to monitor sewer flow under dry weather and wet weather flow conditions. Similarly, install a permanent rain gauge to record rainfall intensity and duration.

(4) Consult with key stakeholders and affected residents to confirm the feasibility of constructing these improvements. Also consult with regulatory bodies for any improvements that require approvals and/or permits.

(5) Proceed with Inflow/Infiltration Study to further confirm wet weather flow contribution in the sanitary sewer, and identify potential sources of wet weather flows.

Appendix A: Simulation Results – Existing System

LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Storm Sewer)

- > 1.0m BELOW GROUND
- 0 TO 1.0m BELOW GROUND
- AT OR ABOVE GROUND

PIPE LOADING FACTOR (Qmax / Qmanning) (Storm Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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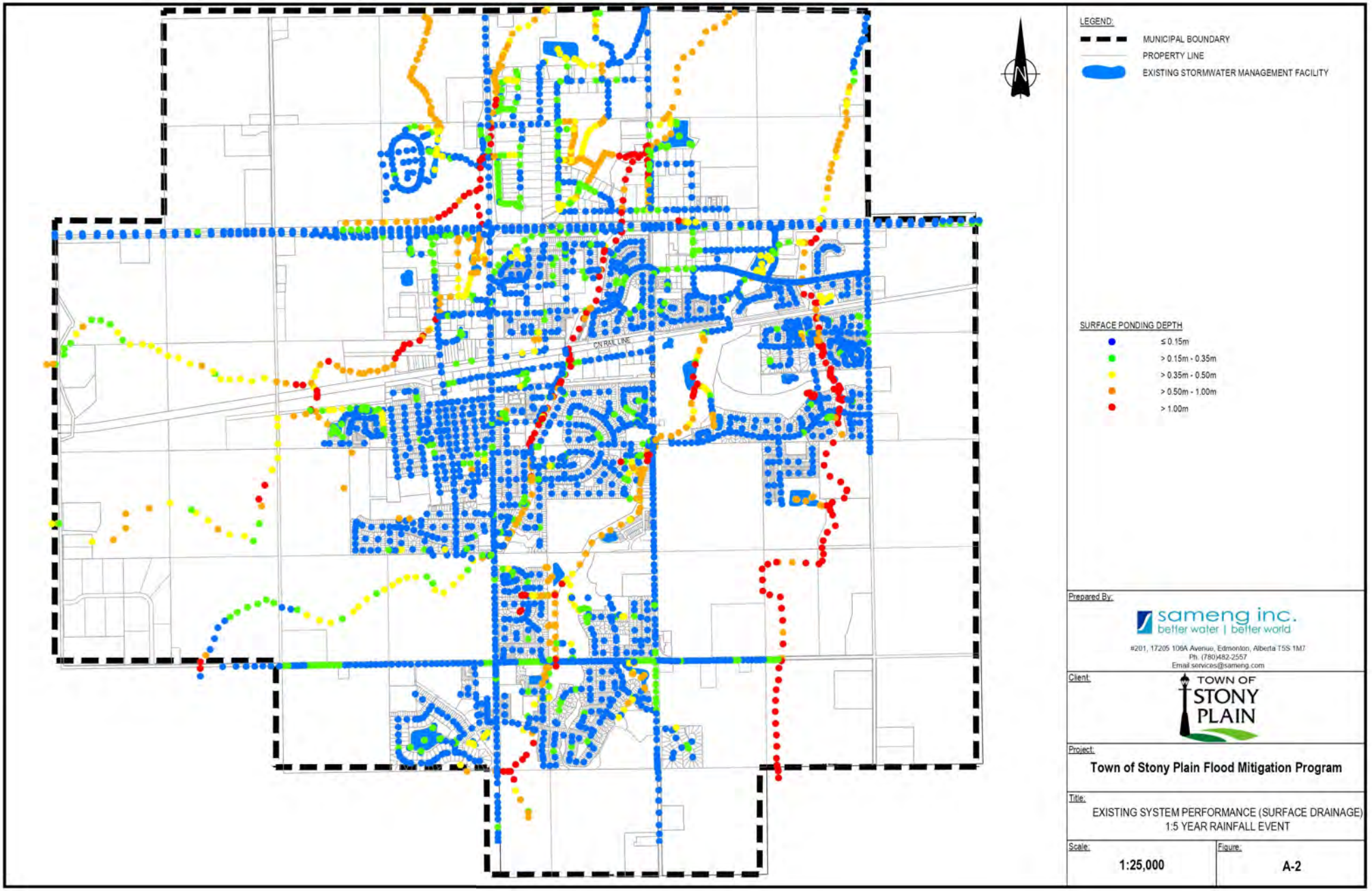
Project: **Town of Stony Plain Flood Mitigation Program**

Title: EXISTING SYSTEM PERFORMANCE (STORM SEWERS)
1:5 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	A-1



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Client:

TOWN OF STONY PLAIN

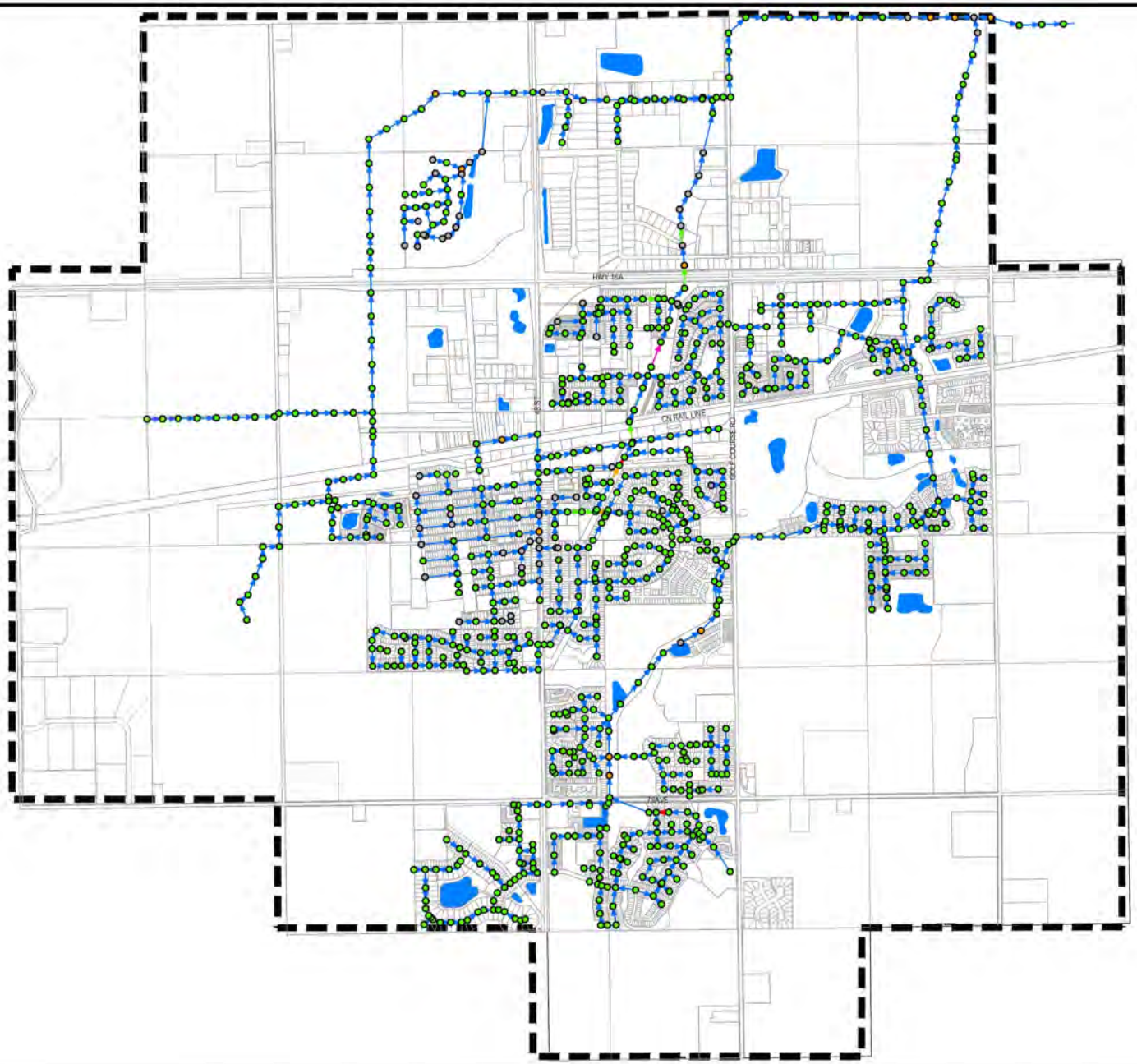
Project:

Town of Stony Plain Flood Mitigation Program

Title:

EXISTING SYSTEM PERFORMANCE (SURFACE DRAINAGE)
1:5 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	A-2



LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Sanitary Sewer)

- > 2.5m BELOW GROUND
- > 1.5m - 2.5m BELOW GROUND
- ≤ 1.5m BELOW GROUND
- SHALLOW MH ≤ 2.5m DEPTH

PIPE LOADING FACTOR (Qmax / Qmanning) (Sanitary Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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Town of Stony Plain Flood Mitigation Program

Title:

EXISTING SYSTEM PERFORMANCE (SANITARY SEWERS)
1:5 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	A-3

LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Storm Sewer)

- > 1.0m BELOW GROUND
- 0 TO 1.0m BELOW GROUND
- AT OR ABOVE GROUND

PIPE LOADING FACTOR (Qmax / Qmanning) (Storm Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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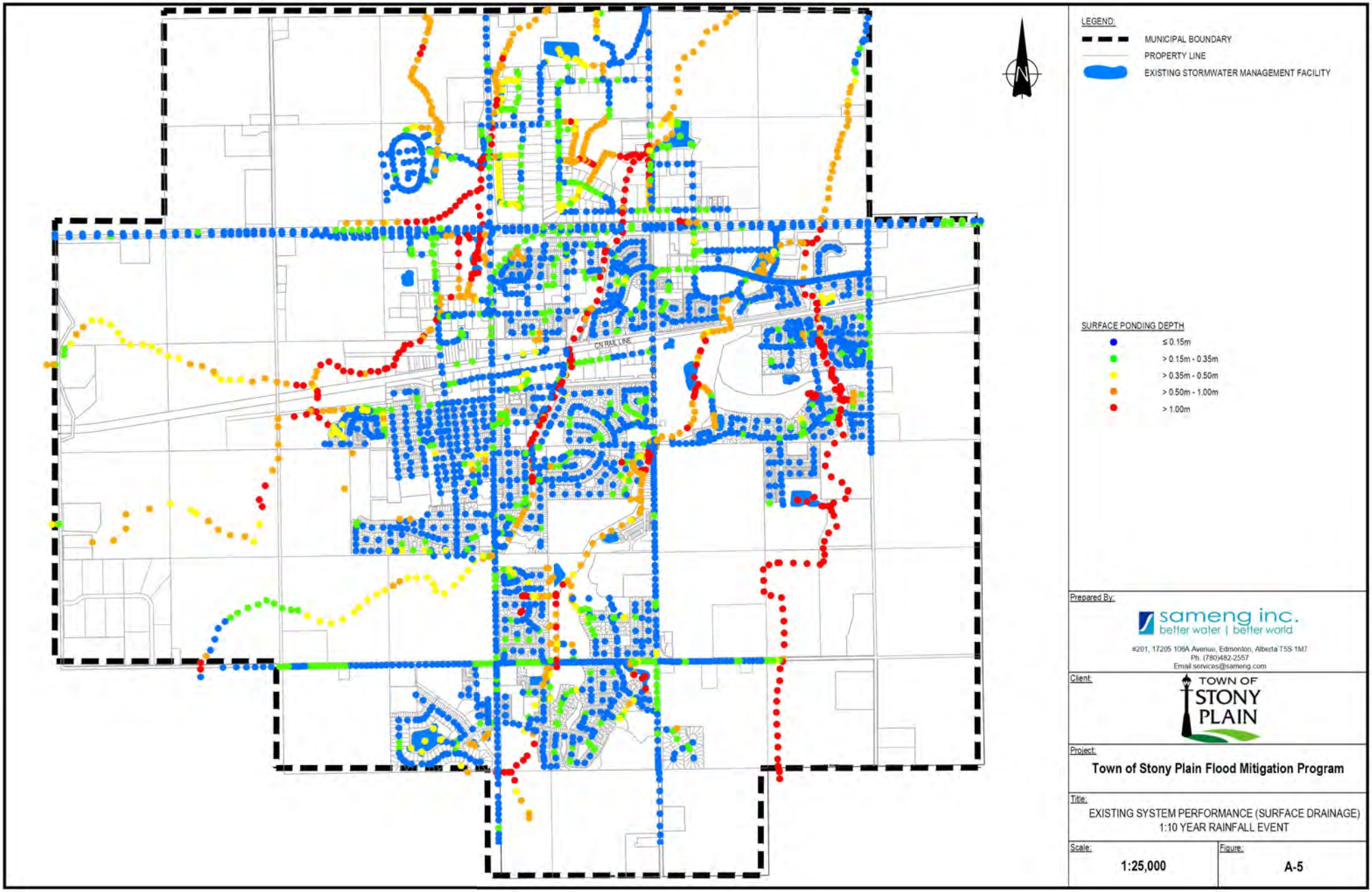
Project:

Town of Stony Plain Flood Mitigation Program

Title:

EXISTING SYSTEM PERFORMANCE (STORM SEWERS)
1:10 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	A-4



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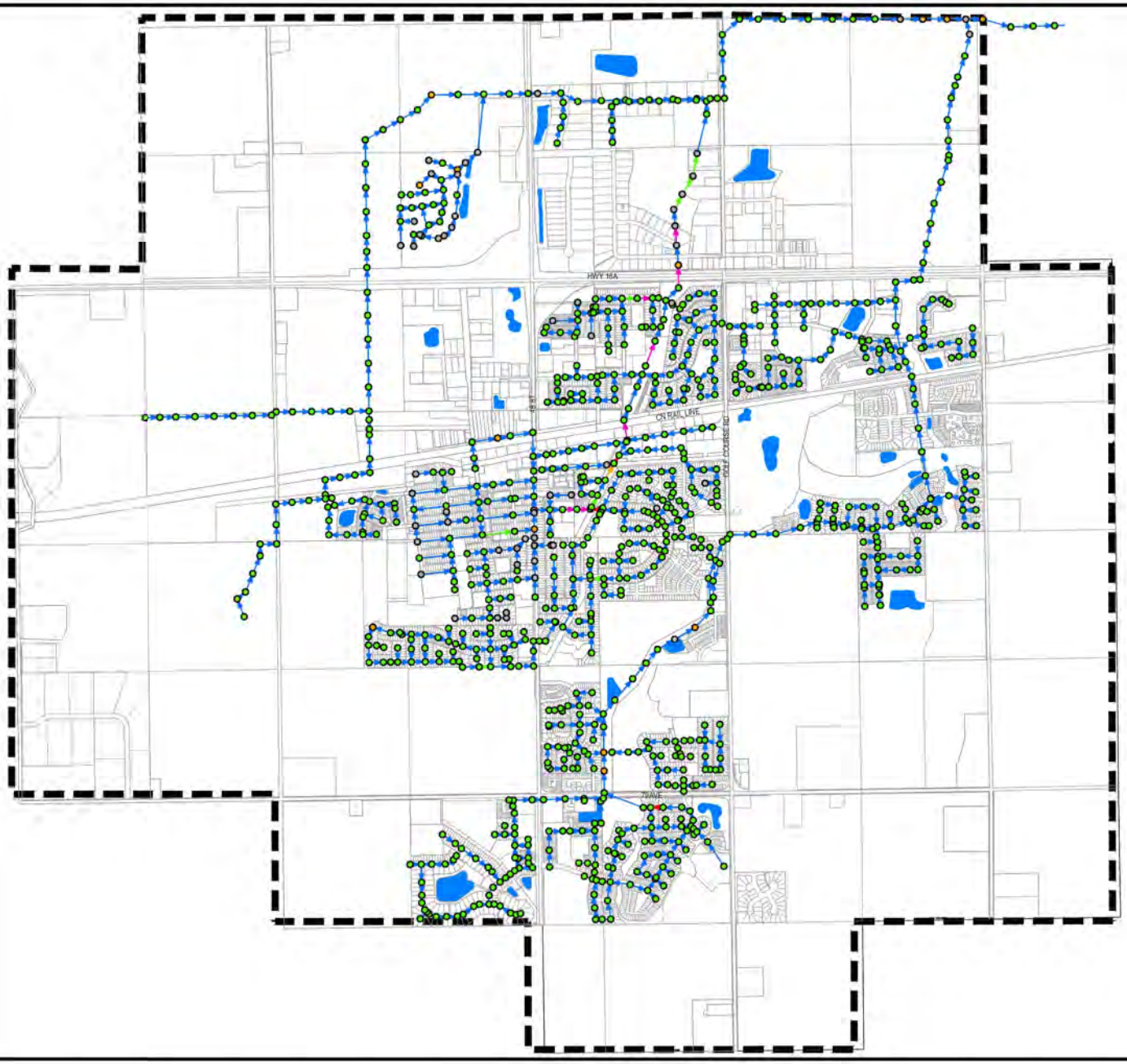
Title: EXISTING SYSTEM PERFORMANCE (SURFACE DRAINAGE)
1:10 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	A-5



LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Sanitary Sewer)

- > 2.5m BELOW GROUND
- > 1.5m - 2.5m BELOW GROUND
- ≤ 1.5m BELOW GROUND
- SHALLOW MH ≤ 2.5m DEPTH

PIPE LOADING FACTOR (Qmax / Qmanning) (Sanitary Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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Title: EXISTING SYSTEM PERFORMANCE (SANITARY SEWERS)
1:10 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	A-6

LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Storm Sewer)

- > 1.0m BELOW GROUND
- 0 TO 1.0m BELOW GROUND
- AT OR ABOVE GROUND

PIPE LOADING FACTOR (Qmax / Qmanning) (Storm Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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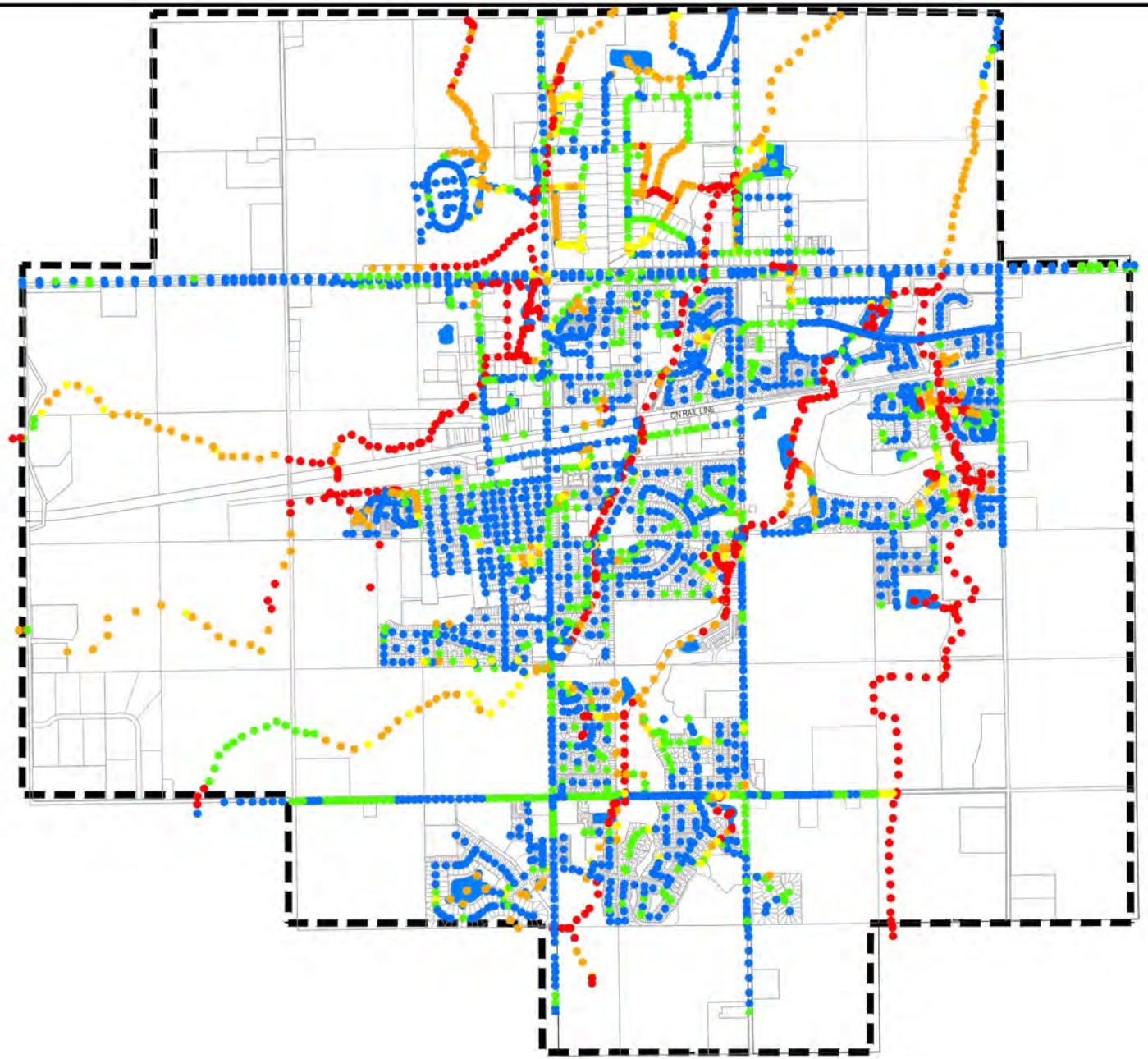
Title: EXISTING SYSTEM PERFORMANCE (STORM SEWERS)
1:25 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	A-7



LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURFACE PONDING DEPTH

- ≤ 0.15m
- > 0.15m - 0.35m
- > 0.35m - 0.50m
- > 0.50m - 1.00m
- > 1.00m

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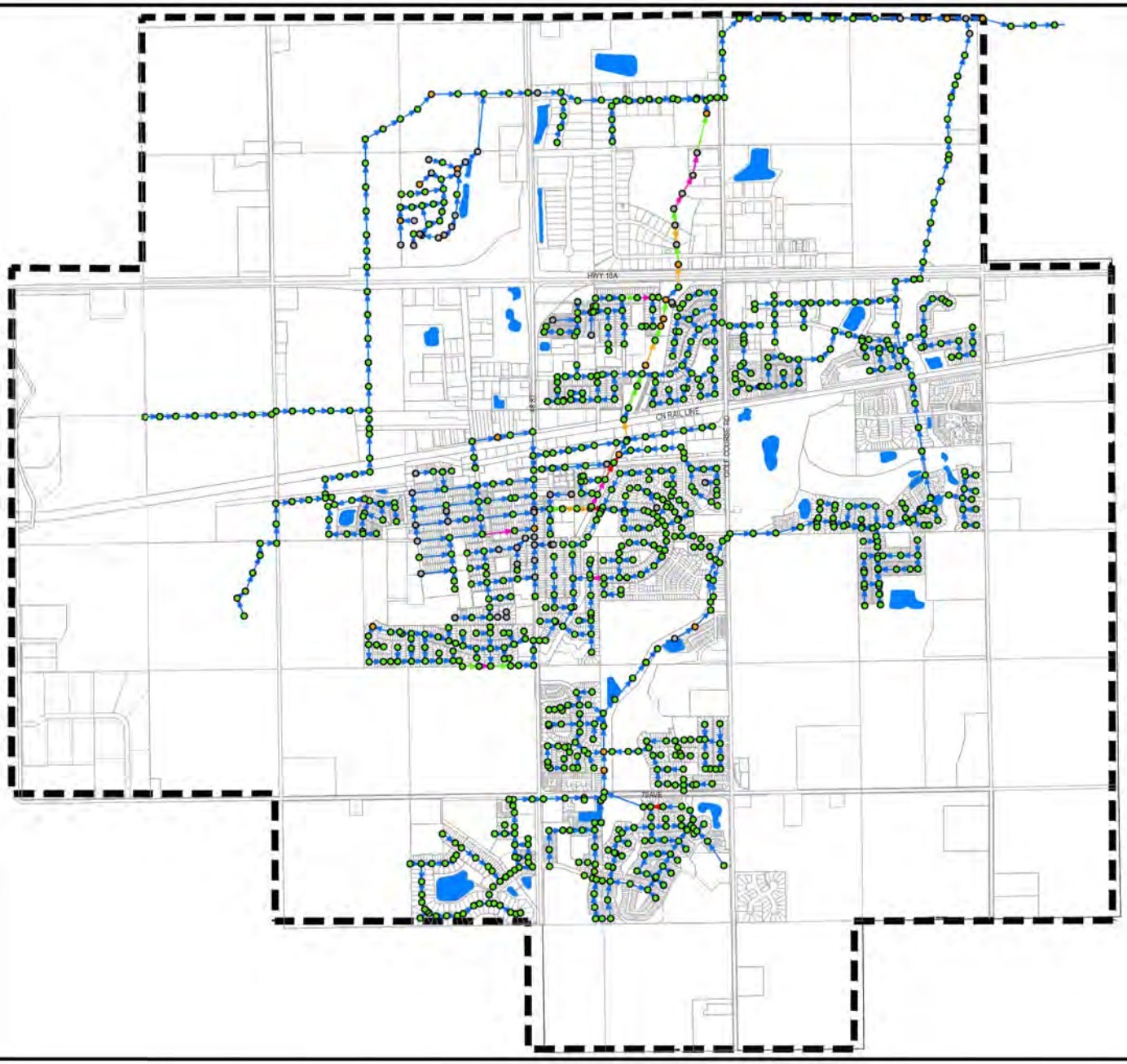
Project:

Town of Stony Plain Flood Mitigation Program

Title:

EXISTING SYSTEM PERFORMANCE (SURFACE DRAINAGE)
1:25 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	A-8



LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Sanitary Sewer)

- > 2.5m BELOW GROUND
- > 1.5m - 2.5m BELOW GROUND
- ≤ 1.5m BELOW GROUND
- SHALLOW MH ≤ 2.5m DEPTH

PIPE LOADING FACTOR (Qmax / Qmanning) (Sanitary Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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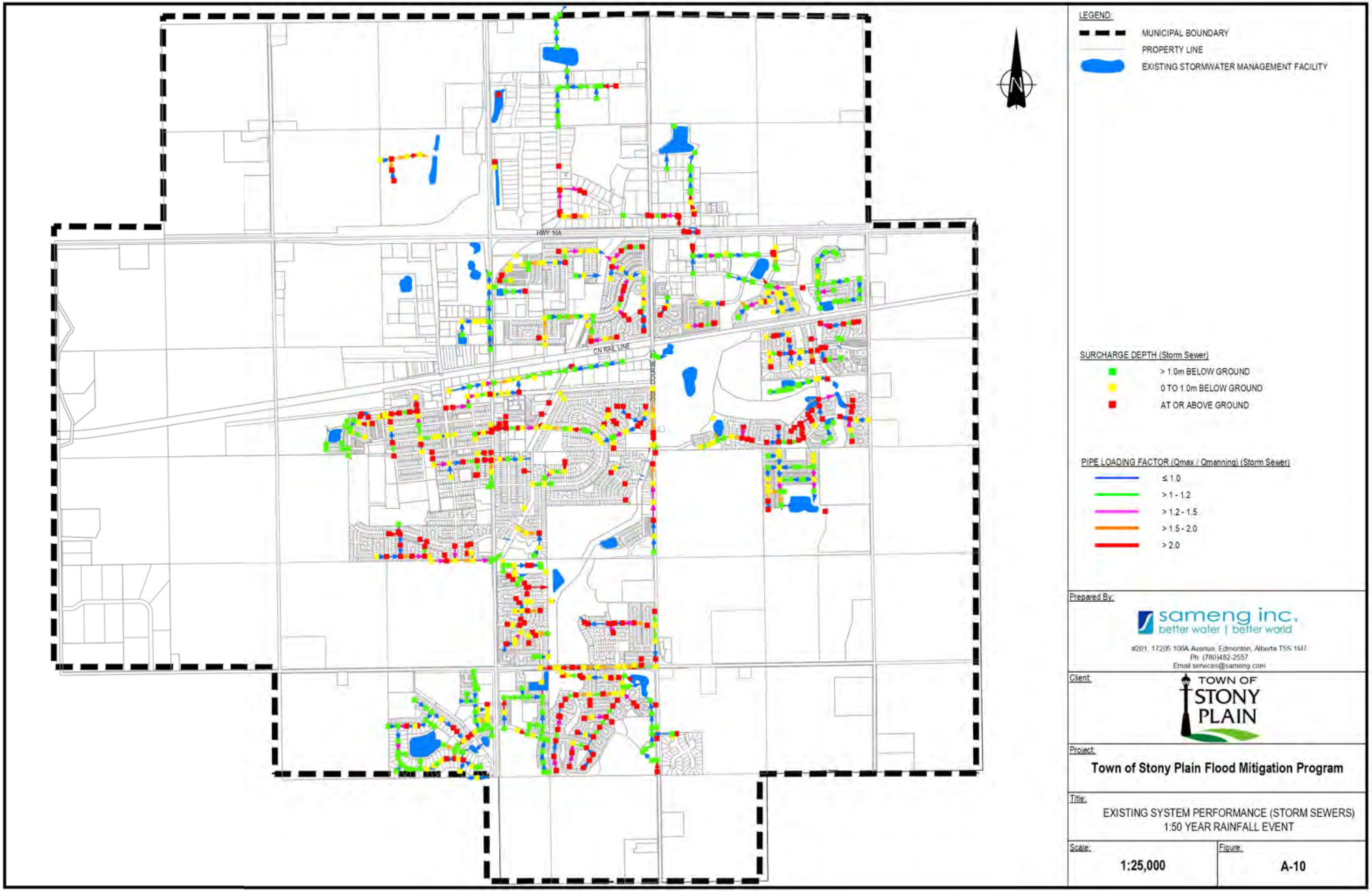
Title: EXISTING SYSTEM PERFORMANCE (SANITARY SEWERS)
1:25 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	A-9



LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Storm Sewer)

- > 1.0m BELOW GROUND
- 0 TO 1.0m BELOW GROUND
- AT OR ABOVE GROUND

PIPE LOADING FACTOR (Qmax / Qmanning) (Storm Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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TOWN OF STONY PLAIN

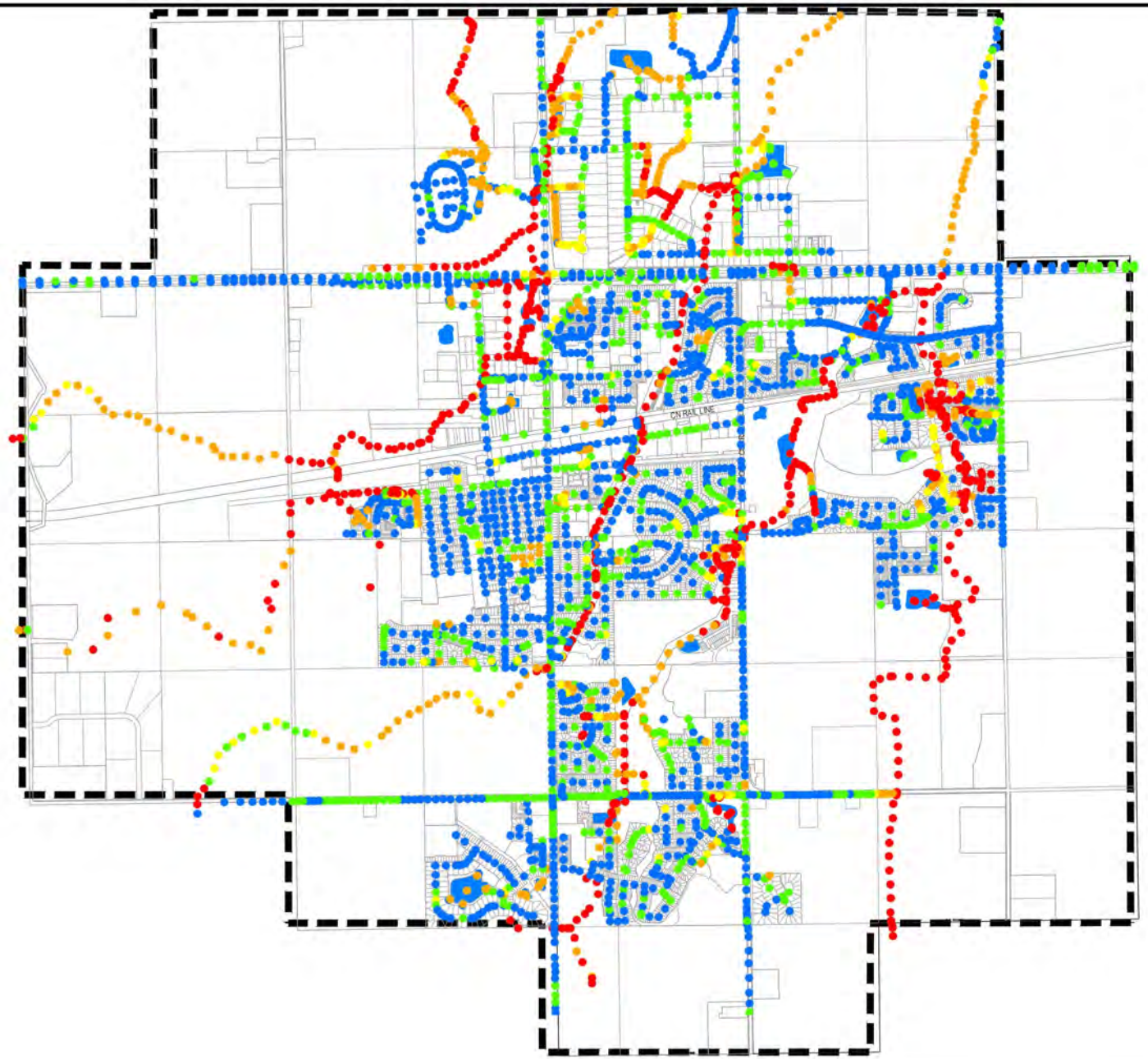
Project:

Town of Stony Plain Flood Mitigation Program

Title:

EXISTING SYSTEM PERFORMANCE (STORM SEWERS)
1:50 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	A-10



LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURFACE PONDING DEPTH

- ≤ 0.15m
- > 0.15m - 0.35m
- > 0.35m - 0.50m
- > 0.50m - 1.00m
- > 1.00m

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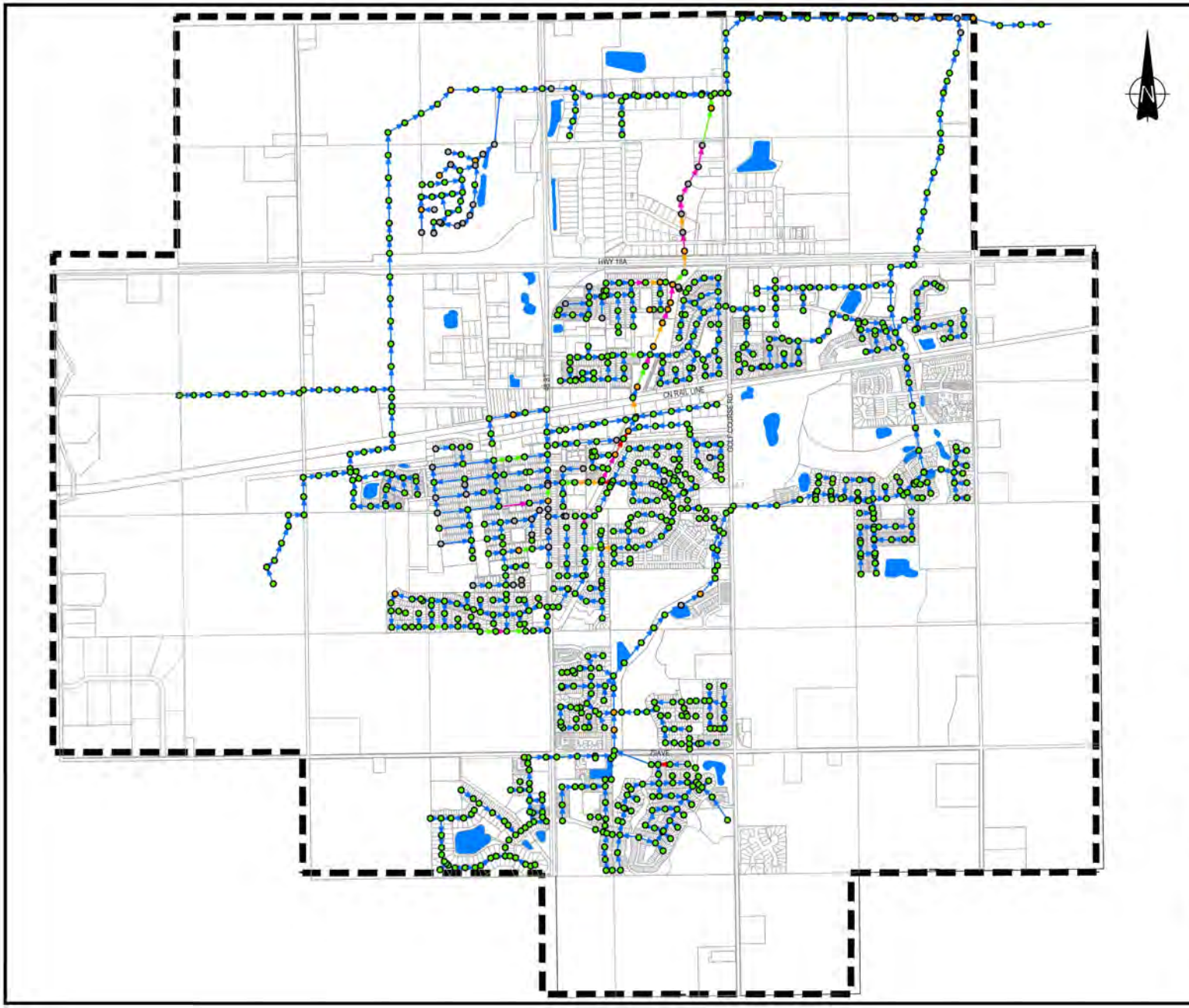
Project:

Town of Stony Plain Flood Mitigation Program

Title:

EXISTING SYSTEM PERFORMANCE (SURFACE DRAINAGE)
1:50 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	A-11



LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Sanitary Sewer)

- > 2.5m BELOW GROUND
- > 1.5m - 2.5m BELOW GROUND
- ≤ 1.5m BELOW GROUND
- SHALLOW MH ≤ 2.5m DEPTH

PIPE LOADING FACTOR (Qmax / Qmanning) (Sanitary Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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Title:

EXISTING SYSTEM PERFORMANCE (SANITARY SEWERS)
1:50 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	A-12

LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Storm Sewer)

- > 1.0m BELOW GROUND
- 0 TO 1.0m BELOW GROUND
- AT OR ABOVE GROUND

PIPE LOADING FACTOR (Qmax / Qmanning) (Storm Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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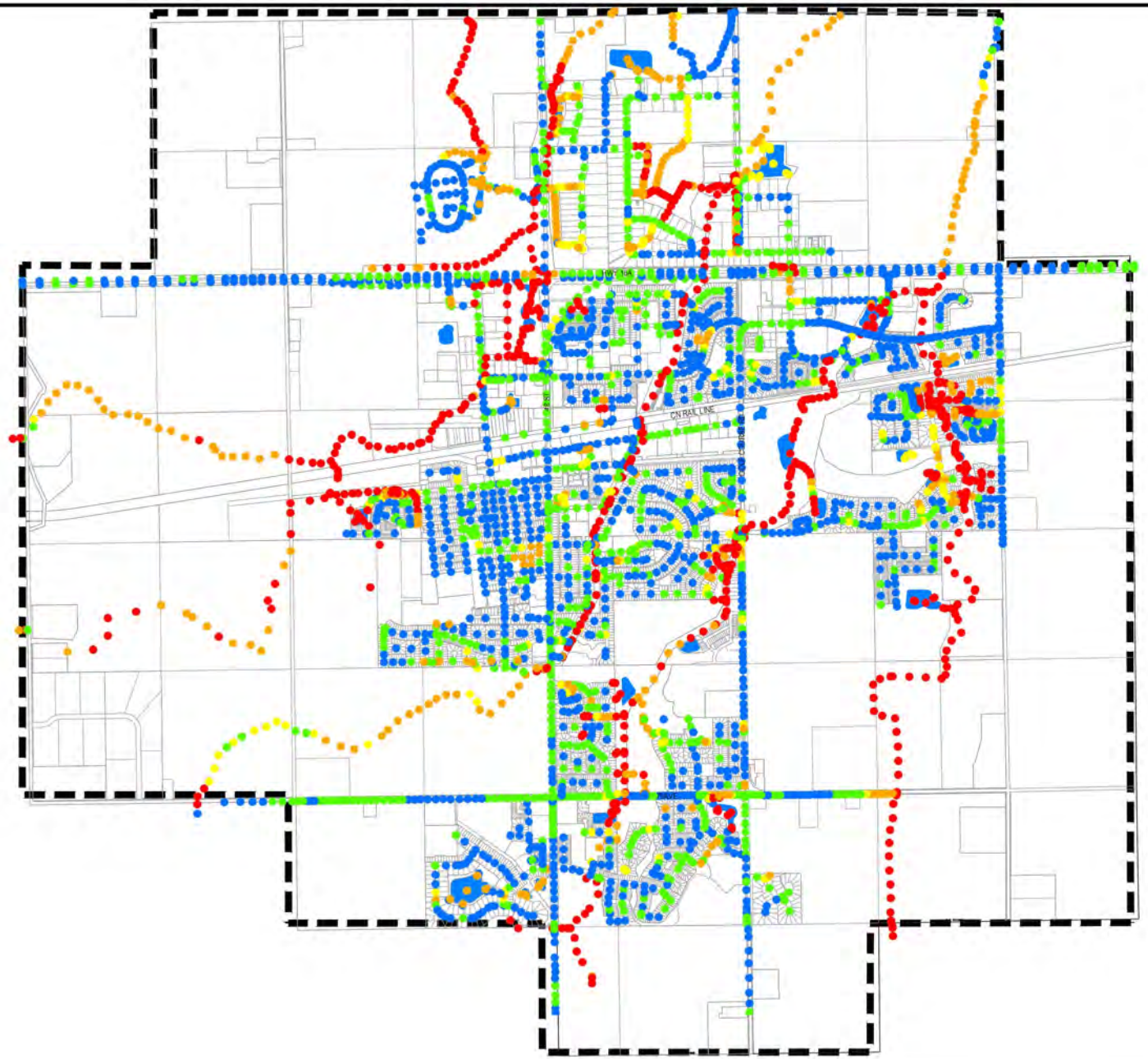
Title:

EXISTING SYSTEM PERFORMANCE (STORM SEWERS)
1:100 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	A-13



LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURFACE PONDING DEPTH

- ≤ 0.15m
- > 0.15m - 0.35m
- > 0.35m - 0.50m
- > 0.50m - 1.00m
- > 1.00m

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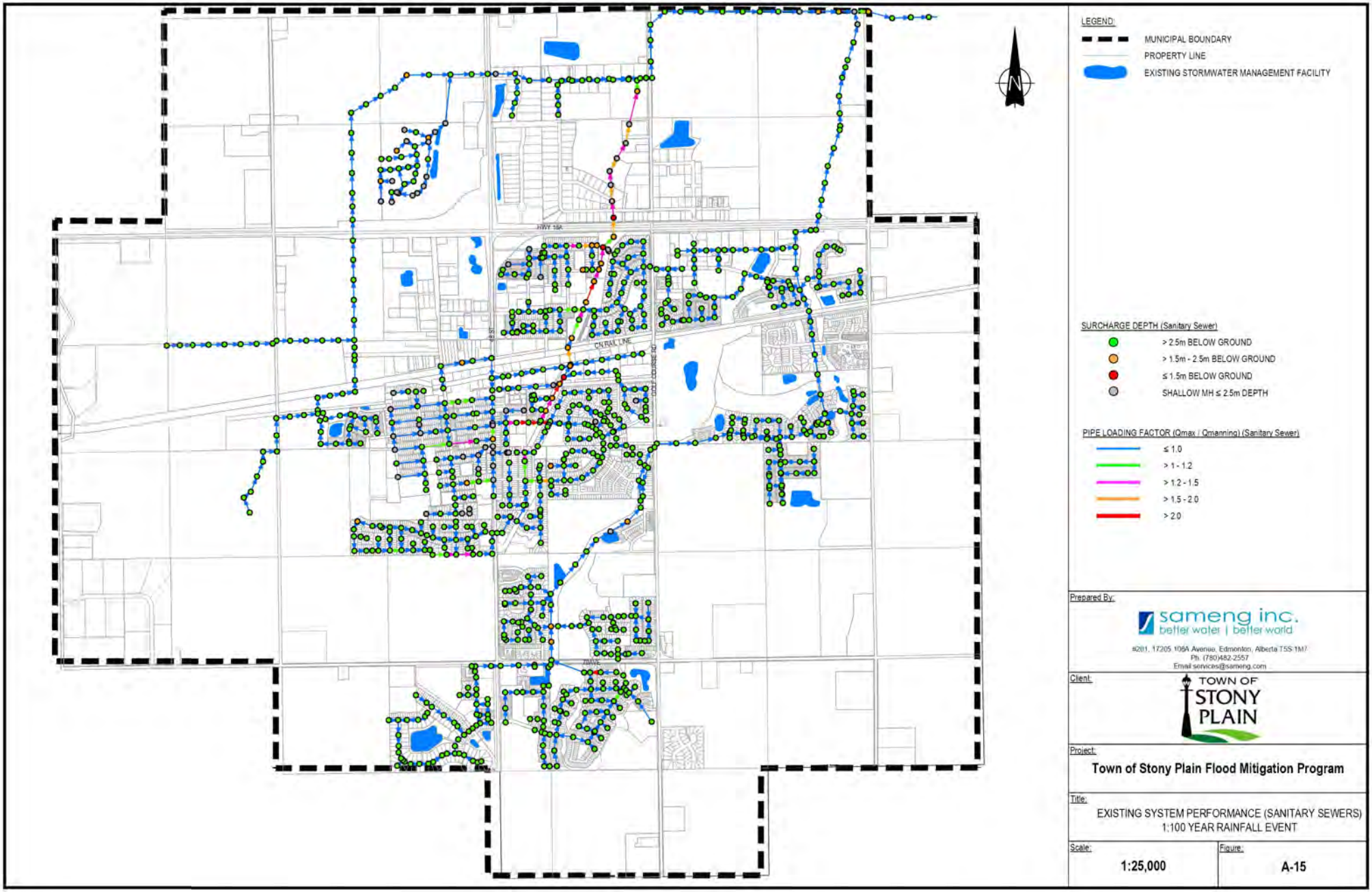
Title:

EXISTING SYSTEM PERFORMANCE (SURFACE DRAINAGE)
1:100 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	A-14



LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Sanitary Sewer)

- > 2.5m BELOW GROUND
- > 1.5m - 2.5m BELOW GROUND
- ≤ 1.5m BELOW GROUND
- SHALLOW MH ≤ 2.5m DEPTH

PIPE LOADING FACTOR (Qmax / Qmanning) (Sanitary Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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Title: EXISTING SYSTEM PERFORMANCE (SANITARY SEWERS)
1:100 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	A-15

Appendix B: Simulation Results – Improved System

LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Storm Sewer)

- > 1.0m BELOW GROUND
- 0 TO 1.0m BELOW GROUND
- AT OR ABOVE GROUND

PIPE LOADING FACTOR (Qmax / Qmanning) (Storm Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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Project:

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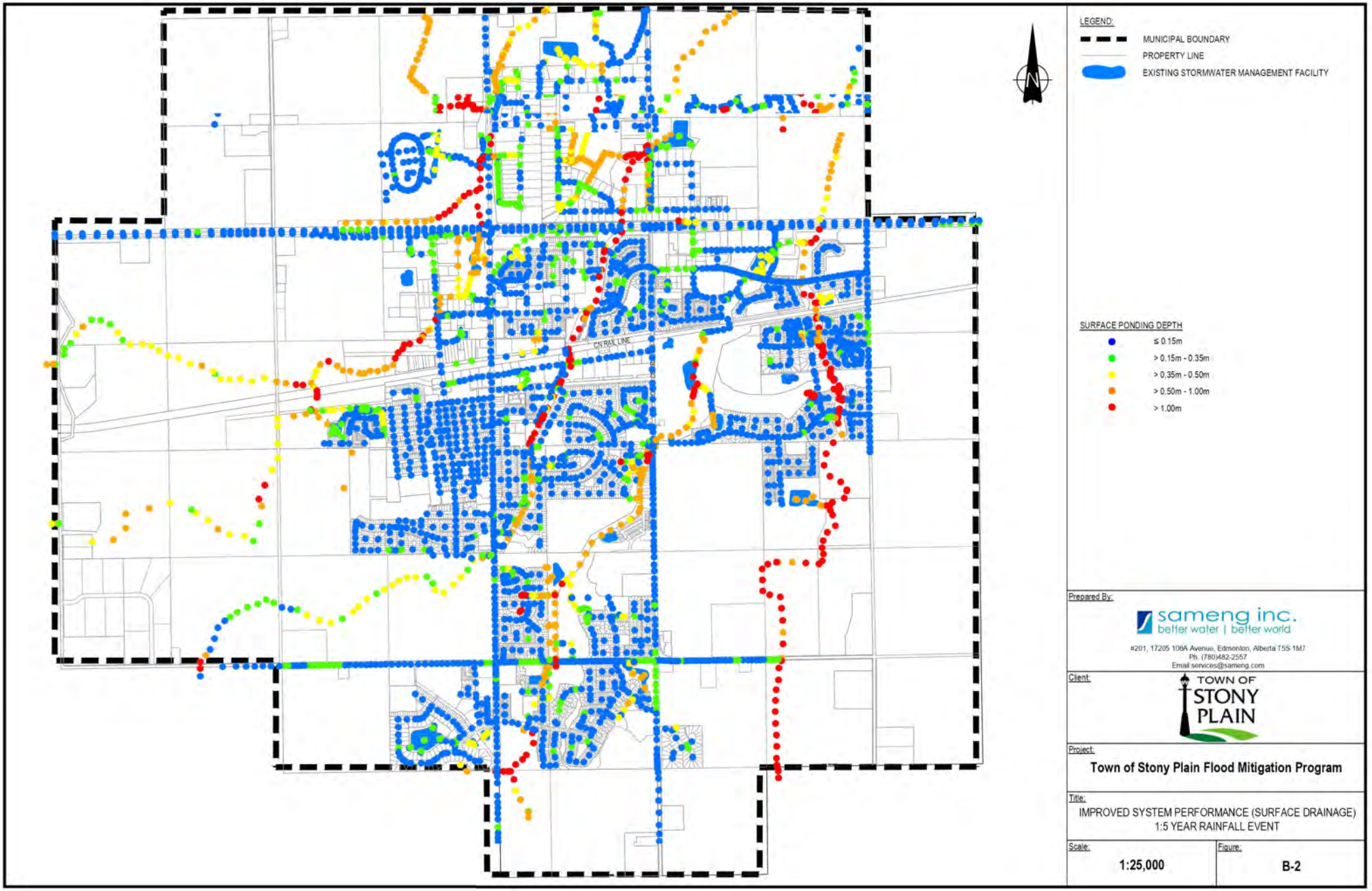
Title:

IMPROVED SYSTEM PERFORMANCE (STORM SEWERS)
1:5 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	B-1



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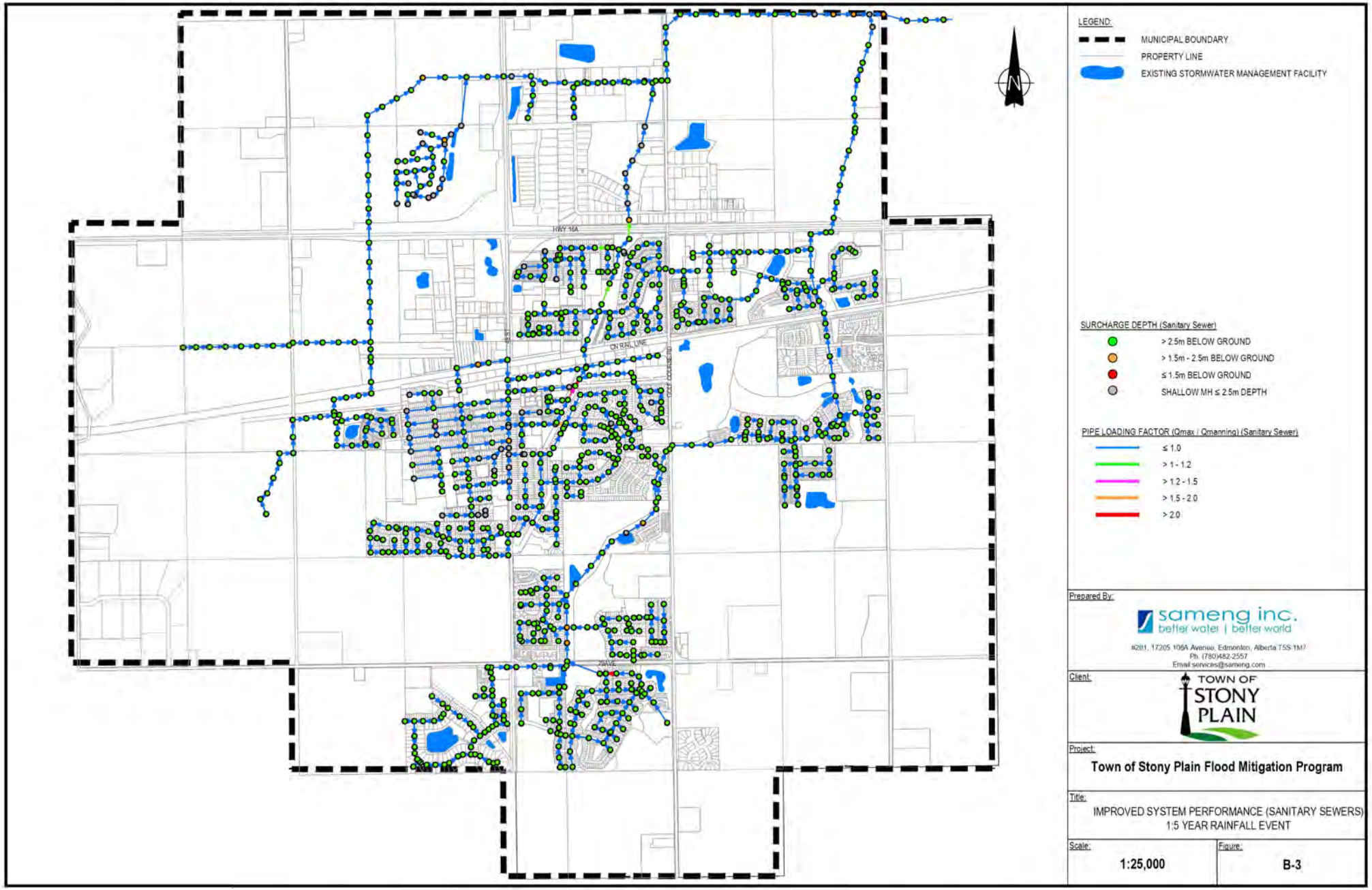
Title: IMPROVED SYSTEM PERFORMANCE (SURFACE DRAINAGE)
1:5 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	B-2



LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Sanitary Sewer)

- > 2.5m BELOW GROUND
- > 1.5m - 2.5m BELOW GROUND
- ≤ 1.5m BELOW GROUND
- SHALLOW MH ≤ 2.5m DEPTH

PIPE LOADING FACTOR (Qmax / Qmanning) (Sanitary Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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Title:
IMPROVED SYSTEM PERFORMANCE (SANITARY SEWERS)
1:5 YEAR RAINFALL EVENT

Scale:
1:25,000

Figure:
B-3

LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Storm Sewer)

- > 1.0m BELOW GROUND
- 0 TO 1.0m BELOW GROUND
- AT OR ABOVE GROUND

PIPE LOADING FACTOR (Qmax / Qmanning) (Storm Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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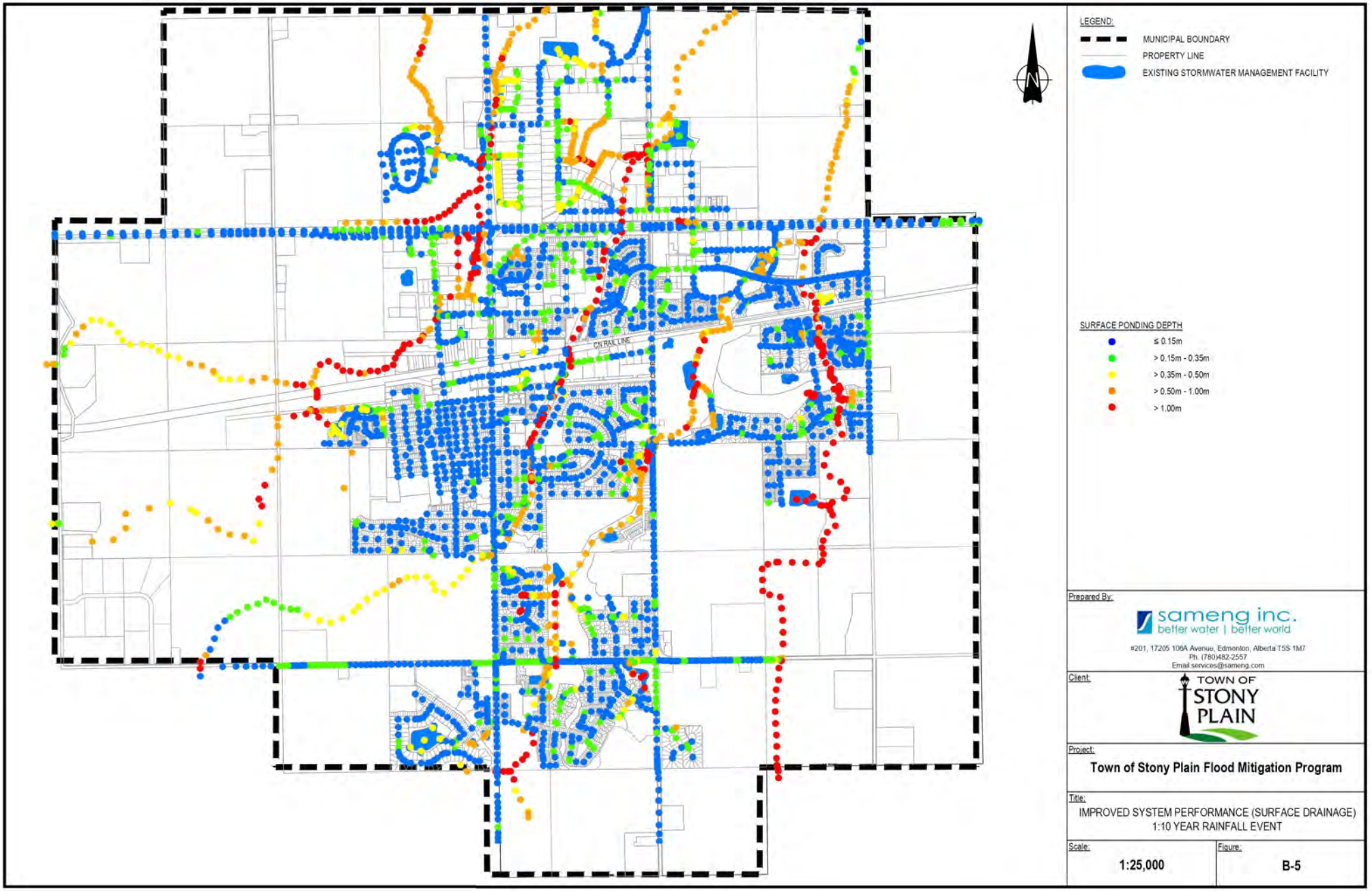
Title: IMPROVED SYSTEM PERFORMANCE (STORM SEWERS)
1:10 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	B-4



LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURFACE PONDING DEPTH

- ≤ 0.15m
- > 0.15m - 0.35m
- > 0.35m - 0.50m
- > 0.50m - 1.00m
- > 1.00m

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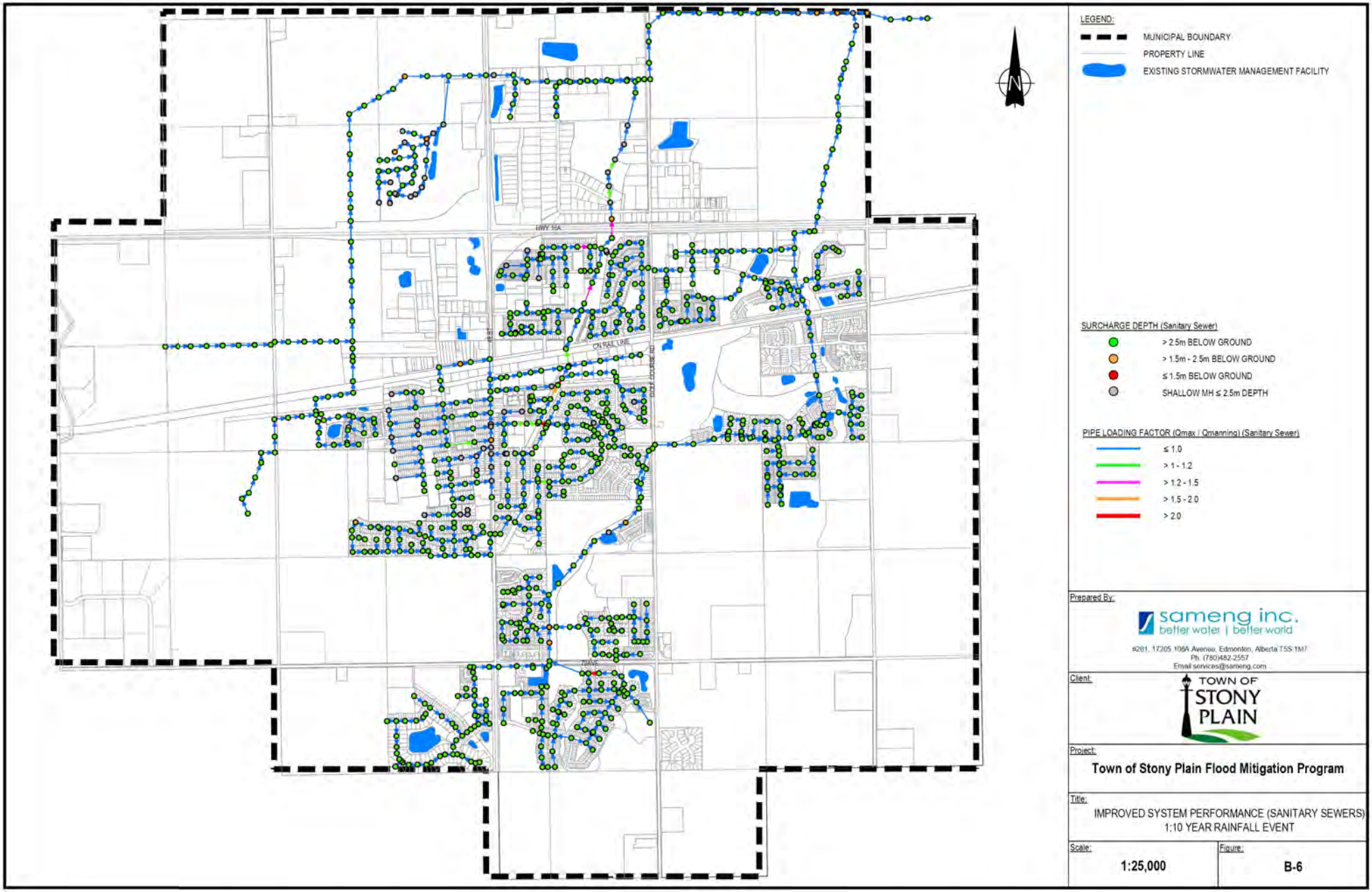
Project:

Town of Stony Plain Flood Mitigation Program

Title:

IMPROVED SYSTEM PERFORMANCE (SURFACE DRAINAGE)
1:10 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	B-5



LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Sanitary Sewer)

- > 2.5m BELOW GROUND
- > 1.5m - 2.5m BELOW GROUND
- ≤ 1.5m BELOW GROUND
- SHALLOW MH ≤ 2.5m DEPTH

PIPE LOADING FACTOR (Qmax / Qmanning) (Sanitary Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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Project:

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Title:

IMPROVED SYSTEM PERFORMANCE (SANITARY SEWERS)
1:10 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	B-6

LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Storm Sewer)

- > 1.0m BELOW GROUND
- 0 TO 1.0m BELOW GROUND
- AT OR ABOVE GROUND

PIPE LOADING FACTOR (Qmax / Qmanning) (Storm Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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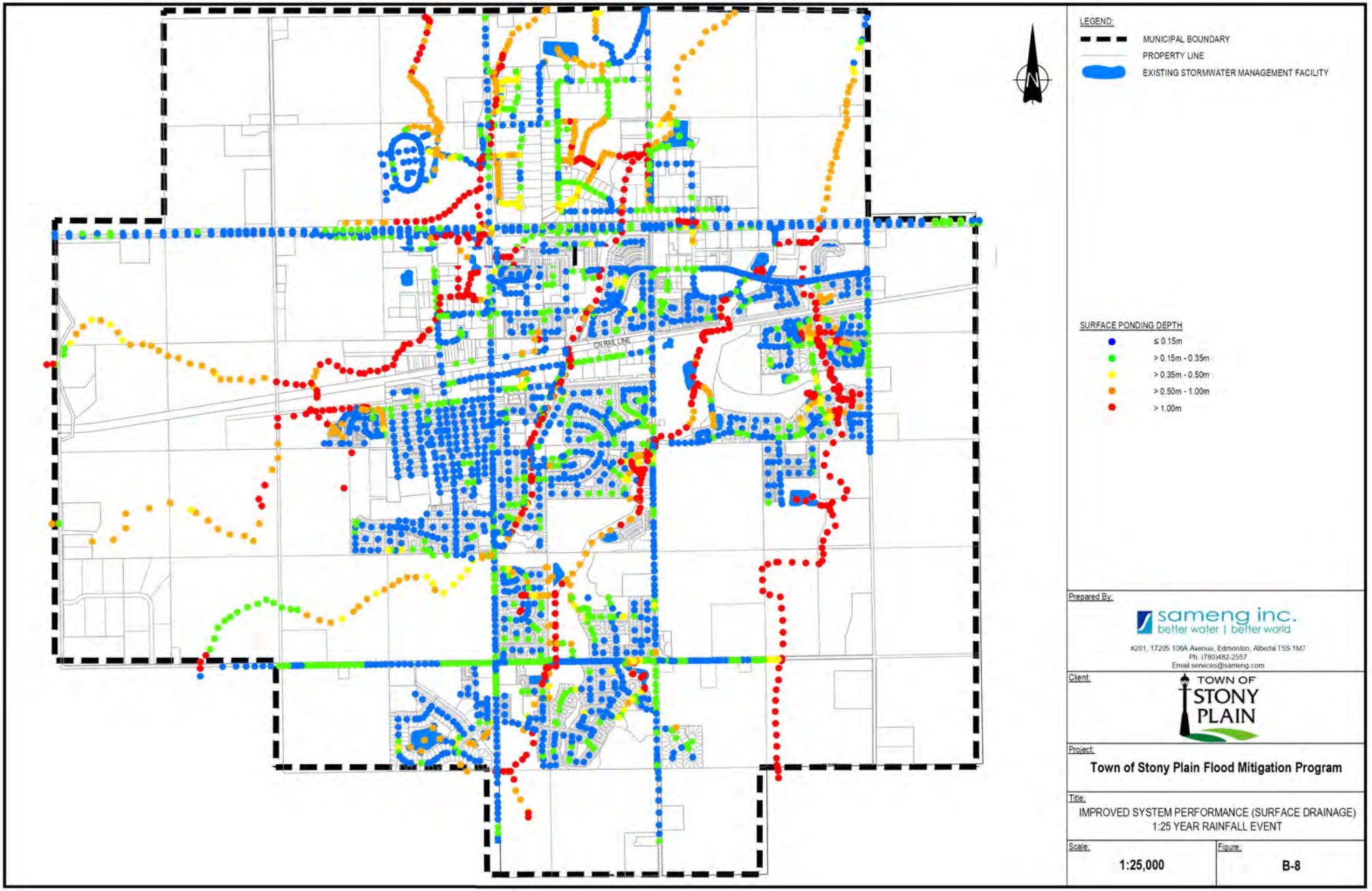
Project:

Town of Stony Plain Flood Mitigation Program

Title:

IMPROVED SYSTEM PERFORMANCE (STORM SEWERS)
1:25 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	B-7



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Project: **Town of Stony Plain Flood Mitigation Program**

Title: IMPROVED SYSTEM PERFORMANCE (SURFACE DRAINAGE)
1:25 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	B-8

LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Sanitary Sewer)

- > 2.5m BELOW GROUND
- > 1.5m - 2.5m BELOW GROUND
- ≤ 1.5m BELOW GROUND
- SHALLOW MH ≤ 2.5m DEPTH

PIPE LOADING FACTOR (Qmax / Qmanning) (Sanitary Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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Title: IMPROVED SYSTEM PERFORMANCE (SANITARY SEWERS)
1:25 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	B-9

LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Storm Sewer)

- > 1.0m BELOW GROUND
- 0 TO 1.0m BELOW GROUND
- AT OR ABOVE GROUND

PIPE LOADING FACTOR (Qmax / Qmanning) (Storm Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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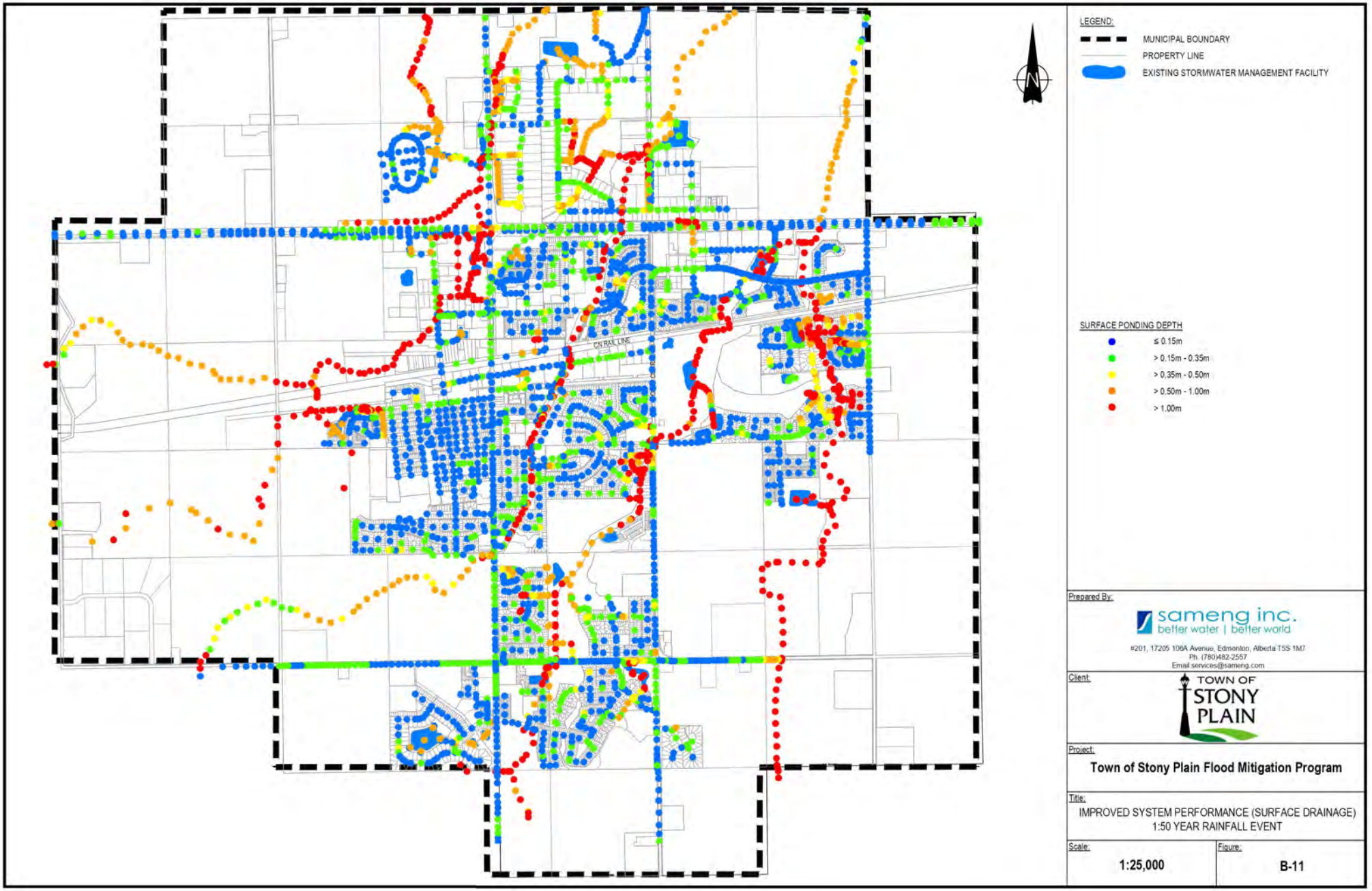
Title: IMPROVED SYSTEM PERFORMANCE (STORM SEWERS)
1:50 YEAR RAINFALL EVENT

Scale: **1:25,000**

Figure: **B-10**



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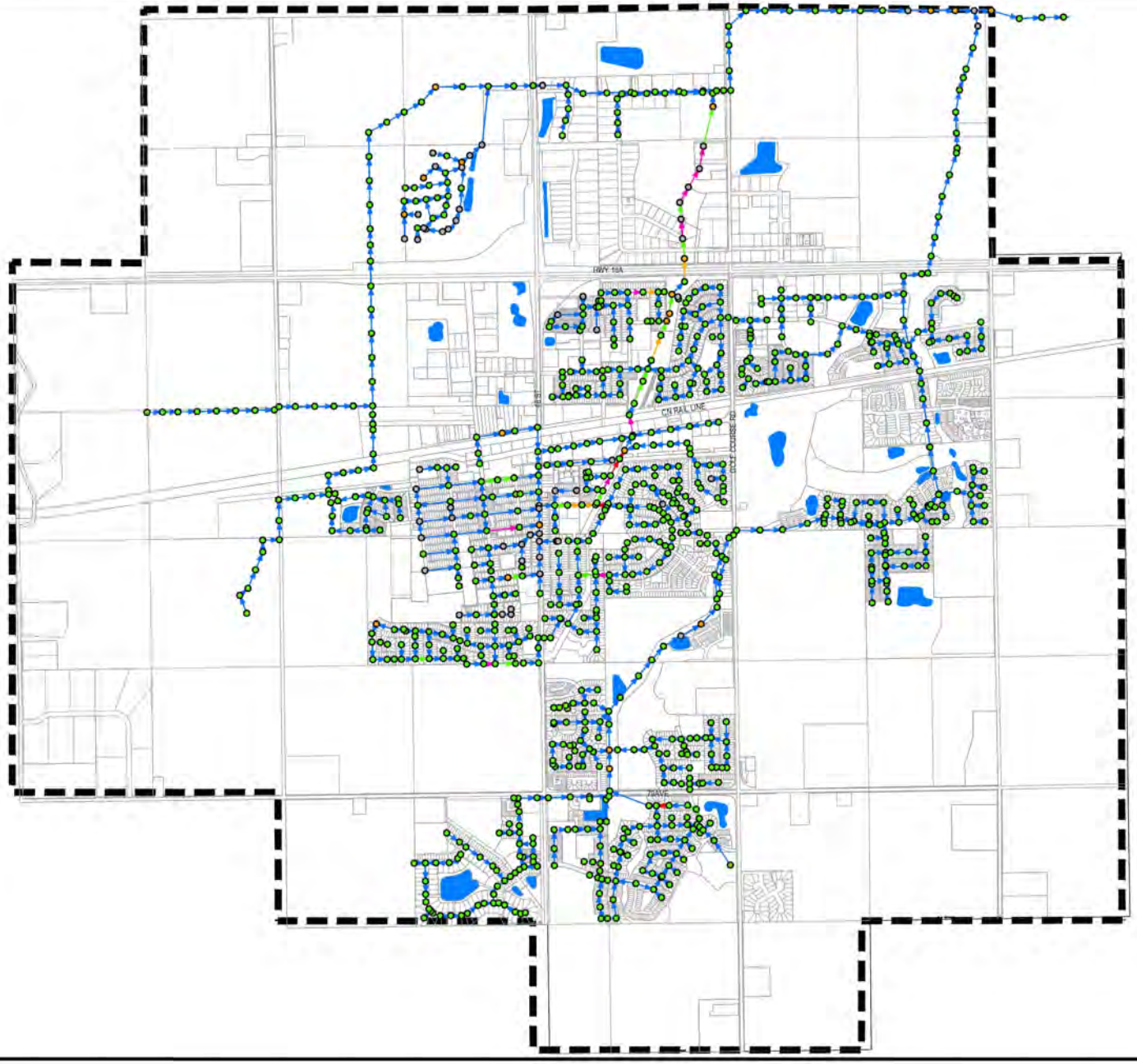
Title: IMPROVED SYSTEM PERFORMANCE (SURFACE DRAINAGE)
1:50 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	B-11



LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH

- > 2.5m BELOW GROUND
- > 1.5m - 2.5m BELOW GROUND
- ≤ 1.5m BELOW GROUND
- SHALLOW MH ≤ 2.5m DEPTH

PIPE LOADING FACTOR (Qmax / Qmanning)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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Title:
IMPROVED SYSTEM PERFORMANCE (SANITARY SEWERS)
1:50 YEAR RAINFALL EVENT

Scale:
1:25,000

Figure:
B-12

LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Storm Sewer)

- > 1.0m BELOW GROUND
- 0 TO 1.0m BELOW GROUND
- AT OR ABOVE GROUND

PIPE LOADING FACTOR (Qmax / Qmanning) (Storm Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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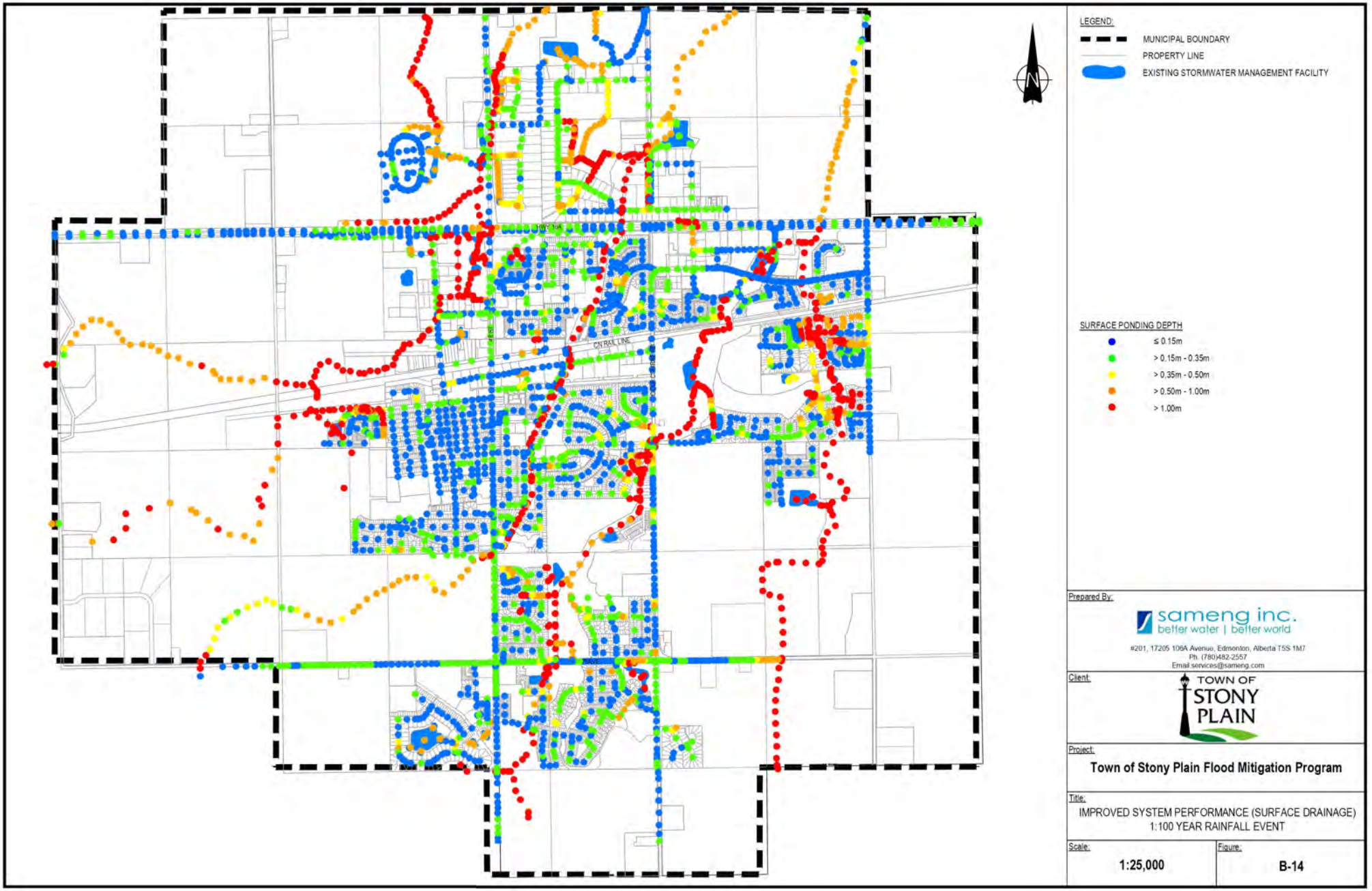
Title: IMPROVED SYSTEM PERFORMANCE (STORM SEWERS)
1:100 YEAR RAINFALL EVENT

Scale:	Figure:
1:25,000	B-13


LEGEND:
MUNICIPAL BOUNDARY
PROPERTY LINE
EXISTING STORMWATER MANAGEMENT FACILITY
SURFACE PONDING DEPTH
≤ 0.15m
> 0.15m - 0.35m
> 0.35m - 0.50m
> 0.50m - 1.00m
> 1.00m
CN RAIL LINE
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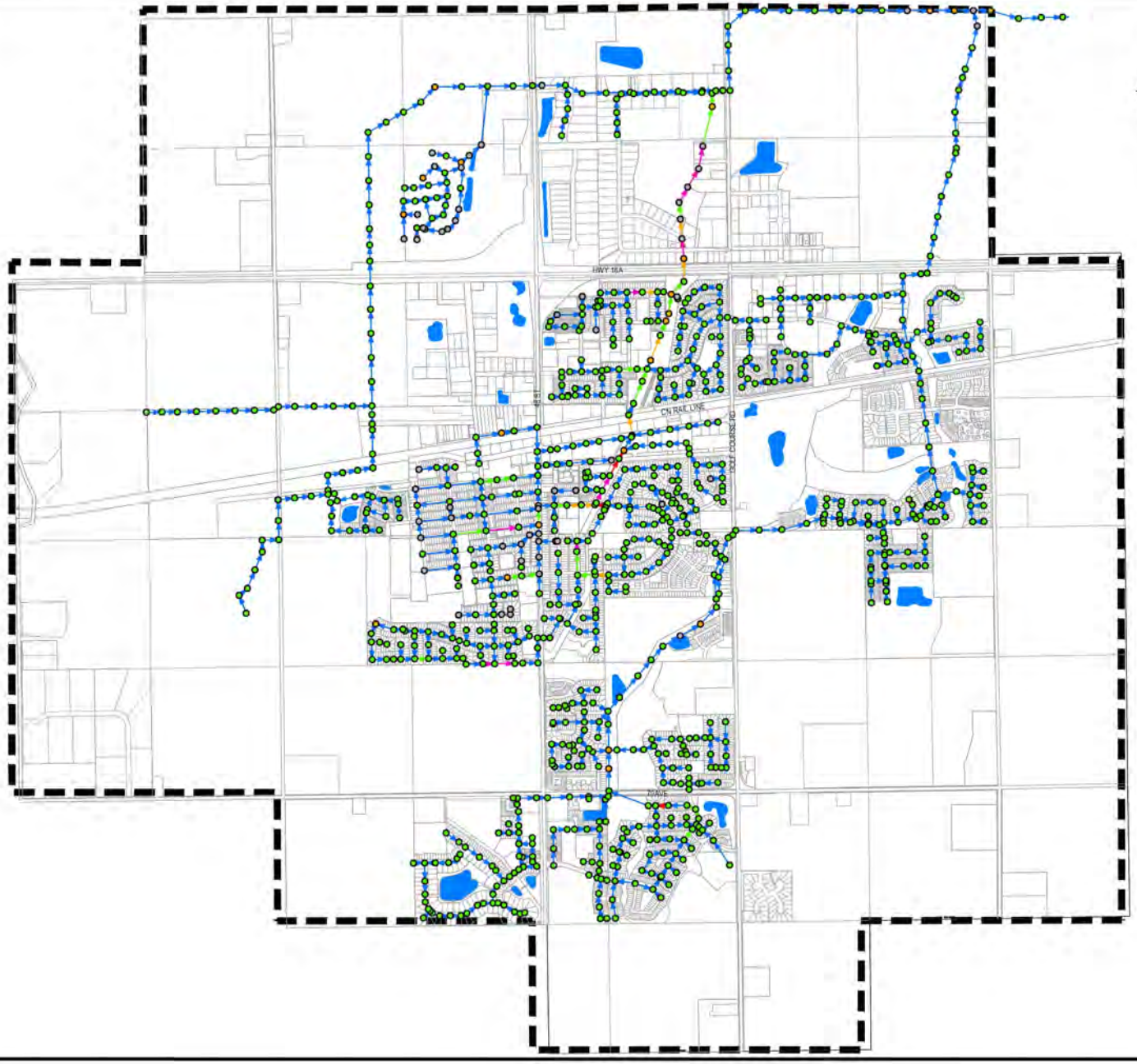
IMPROVED SYSTEM PERFORMANCE (SURFACE DRAINAGE)
1:100 YEAR RAINFALL EVENT
Scale:
1:25,000
Figure:
B-14



LEGEND:

- MUNICIPAL BOUNDARY
- PROPERTY LINE
- EXISTING STORMWATER MANAGEMENT FACILITY

SURCHARGE DEPTH (Sanitary Sewer)

- > 2.5m BELOW GROUND
- > 1.5m - 2.5m BELOW GROUND
- ≤ 1.5m BELOW GROUND
- SHALLOW MH ≤ 2.5m DEPTH

PIPE LOADING FACTOR (Qmax / Qmanning) (Sanitary Sewer)

- ≤ 1.0
- > 1 - 1.2
- > 1.2 - 1.5
- > 1.5 - 2.0
- > 2.0

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IMPROVED SYSTEM PERFORMANCE (SANITARY SEWERS)
1:100 YEAR RAINFALL EVENT

Scale:
1:25,000

Figure:
B-15

Appendix C: Flood Pictures from July 7 and July 15, 2019 in Stony Plain, AB – Whispering Waters Creek

The number on the figure corresponds to the figure number where the photo is located (e.g. 2 is Figure C-2). The arrow points in direction photo was taken.

Figure C- 1: Whispering Waters Creek – Photo Location Plan

Figure C- 2: Whispering Waters Creek – North of 55 Avenue (looking north) – July 7, 2019 and July 29, 2019 for comparison of normal flow depth.

Figure C- 3: Whispering Waters Creek – North of 52 Avenue (looking northeast) – July 7 or July 15, 2019

Figure C- 4: Whispering Waters Creek – Brown Street between 50a Avenue and 51 Avenue (looking northeast) – July 15, 2019 at 7:56PM

Figure C- 5: Whispering Waters Creek - Pedestrian Bridge east of Brown Street between 49 Avenue and 50 Avenue (looking east) – July 7, 2019 (left) and July 15, 2019 (right), and July 29, 2019 for comparison of normal flow depth.

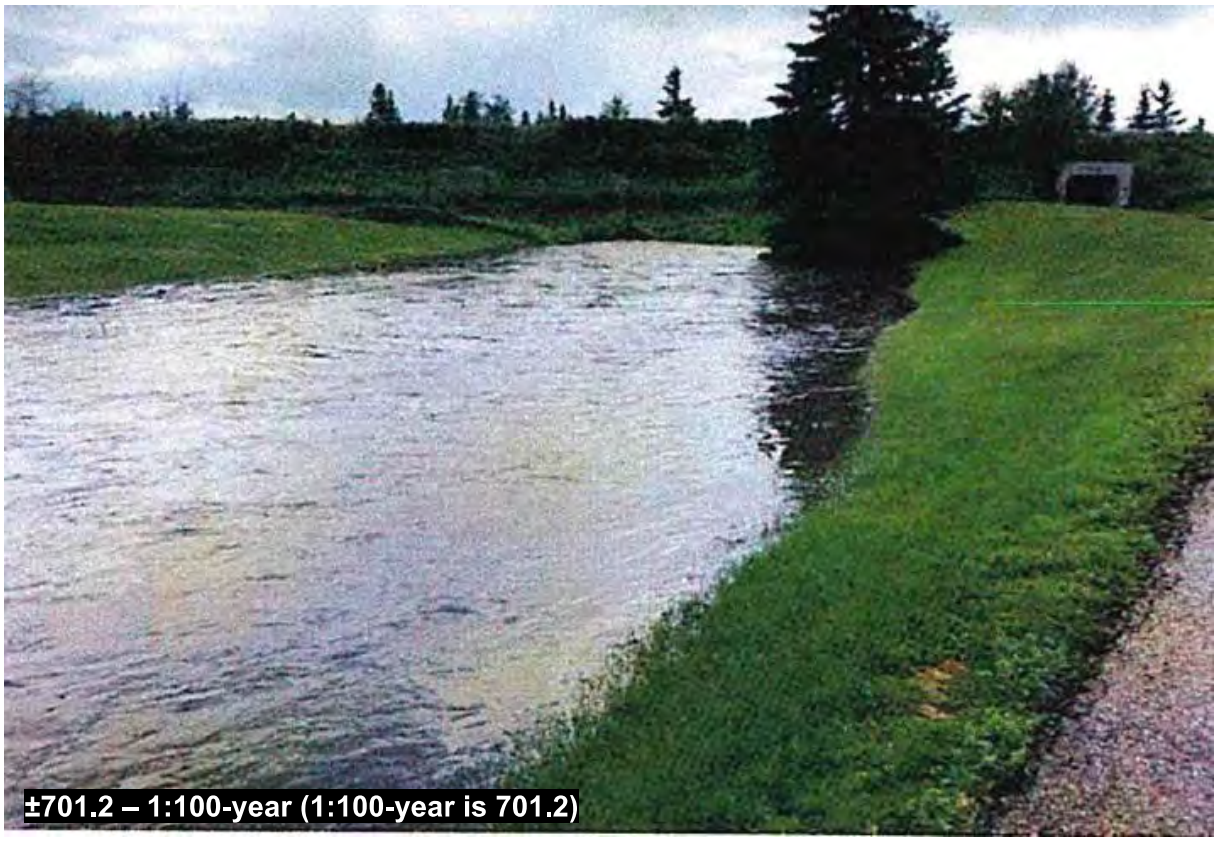


Figure C- 6: Whispering Waters Creek - North of Railroad Crossing (looking south) – July 7, 2019

Figure C- 7: Whispering Waters Creek – South of 44 Avenue (looking east) – July 7, 2019

Figure C- 8: Whispering Waters Creek – South of 44 Avenue (looking southwest) – July 7, 2019

Figure C- 9: Whispering Waters Creek – North of 44 Avenue (looking north) – July 15, 2019 (7:20PM)

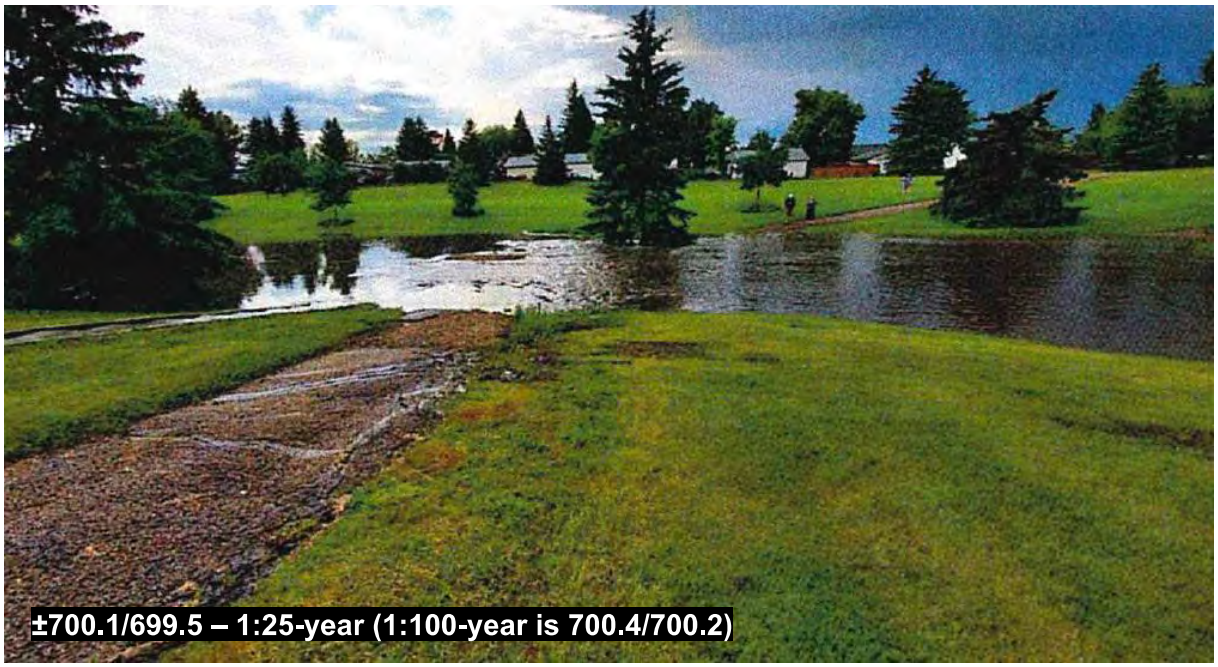


Figure C- 10: Whispering Waters Creek – South of Highway 16A at 40 Avenue trail culvert crossing (looking west) – July 7, 2019

Figure C- 11: Whispering Waters Creek – South of Highway 16A at 40 Avenue trail culvert crossing (looking south) – July 15, 2019 (7:24PM)

Appendix D: Flood Pictures from July 7 and July 15, 2019 in Stony Plain, AB – Localized Areas

Figure D- 1: Town of Stony Plain Local Areas – Photo Location Plan

Figure D- 2: Area B – East of 48 Street and 52 Avenue intersection looking north towards 48 Street. Showing ponding on the road and on private property. July 15, 2019 – 7:10PM

Figure D- 3: Area B – East of 48 Street and 52 Avenue intersection looking north from 52 Avenue towards the parking lot behind the buildings. Showing ponding on the road and on private property. July 15, 2019 – 7:10PM

Figure D- 4: Area B – Egerland Place bend, looking east towards Egerland Place, showing significant ponding on the road. July 15, 2019

Figure D- 5: Area B – At Egerland Place bend north of 52 Avenue, looking southwest, showing significant ponding on the road. July 15, 2019

Figure D- 6: West of Area B, North of Area D – 50 Avenue, east of 50 Street, looking north into parking lot of commercial site. July 15, 2019 – 7:12PM

Figure D- 7: Area D – 48 Street, south of 53 Avenue, looking west at local road and house. July 15, 2019 – 7:39PM

Figure D- 8: Area D – Alley Parallel and west of 48 Street, south of 53 Avenue, looking south. July 7 or July 15, 2019

Figure D- 9: Area D – Southwest corner of 51 Street and 52 Avenue, looking south at flooded roads and property. July 7, 2019

Figure D- 10: Just north of Area D – Alley Parallel and East of 50 Street, north of 52 Avenue, looking west towards commercial buildings. July 7, 2019

Figure D- 11: Area D – Lion's Playground West of 49 Street and South of 54 Avenue, looking east (top) and at playground structure (bottom), showing significant ponding in alley and park area. July 15, 2019

Figure D- 12: Area H – School Yard north of 57 Avenue flooding and overflowing into the alley and towards 57 Avenue, just west of Glenwood Crescent. July 15, 2019

Figure D- 13: Area H – 57 Avenue just west of Glenwood Crescent, looking north in the alley and the school yard, showing significant amount of surface drainage flowing from the school yard towards 57 Avenue via the grass surface and the staircase. July 15, 2019

Figure D- 14: Area H – 57 Avenue just west of Glenwood Crescent, looking north between two properties that overlook the school playground to the back, showing significant amount of surface drainage flowing from the school yard towards 57 Avenue. July 15, 2019

Figure D- 15: Area H – Glenwood Crescent (south section) showing significant ponding on the road and onto private properties. July 15, 2019

The number on the figure corresponds to the figure number where the photo is located (e.g. 2 is Figure D-2)

Figure D- 1: Town of Stony Plain Local Areas – Photo Location Plan

Figure D- 2: Area B – East of 48 Street and 52 Avenue intersection looking north towards 48 Street. Showing ponding on the road and on private property. July 15, 2019 – 7:10PM

Figure D- 3: Area B – East of 48 Street and 52 Avenue intersection looking north from 52 Avenue towards the parking lot behind the buildings. Showing ponding on the road and on private property. July 15, 2019 – 7:10PM

Figure D- 4: Area B – Egerland Place bend, looking east towards Egerland Place, showing significant ponding on the road. July 15, 2019

Figure D- 5: Area B – At Egerland Place bend north of 52 Avenue, looking southwest, showing significant ponding on the road. July 15, 2019

Figure D- 6: West of Area B, North of Area D – 50 Avenue, east of 50 Street, looking north into parking lot of commercial site. July 15, 2019 – 7:12PM

Figure D- 7: Area D – 48 Street, south of 53 Avenue, looking west at local road and house. July 15, 2019 – 7:39PM

Figure D- 8: Area D – Alley Parallel and west of 48 Street, south of 53 Avenue, looking south. July 7 or July 15, 2019

Figure D- 9: Area D – Southwest corner of 51 Street and 52 Avenue, looking south at flooded roads and property. July 7, 2019

Figure D- 10: Just north of Area D – Alley Parallel and East of 50 Street, north of 52 Avenue, looking west towards commercial buildings. July 7, 2019

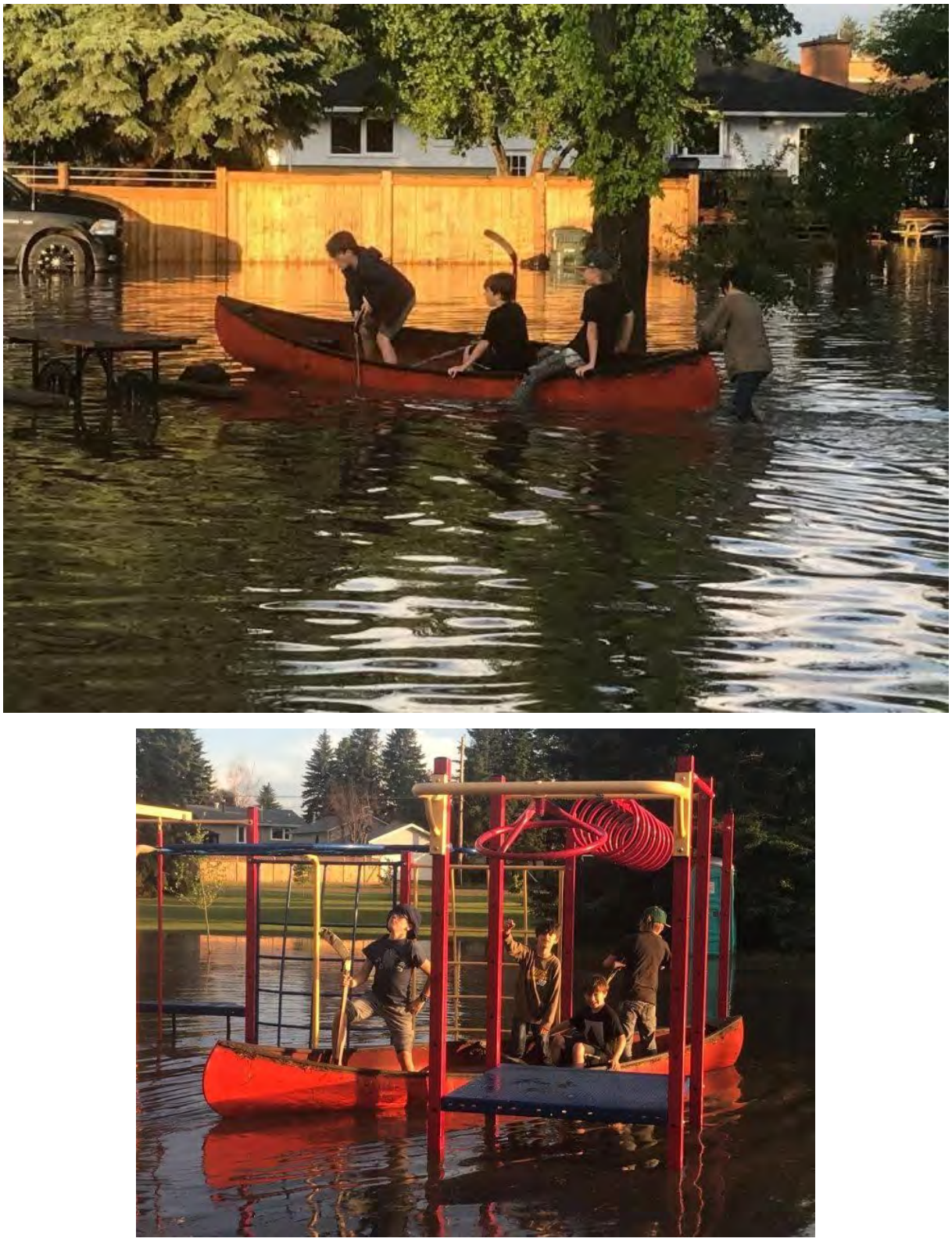


Figure D- 11: Area D – Lion's Playground West of 49 Street and South of 54 Avenue, looking east (top) and at playground structure (bottom), showing significant ponding in alley and park area. July 15, 2019

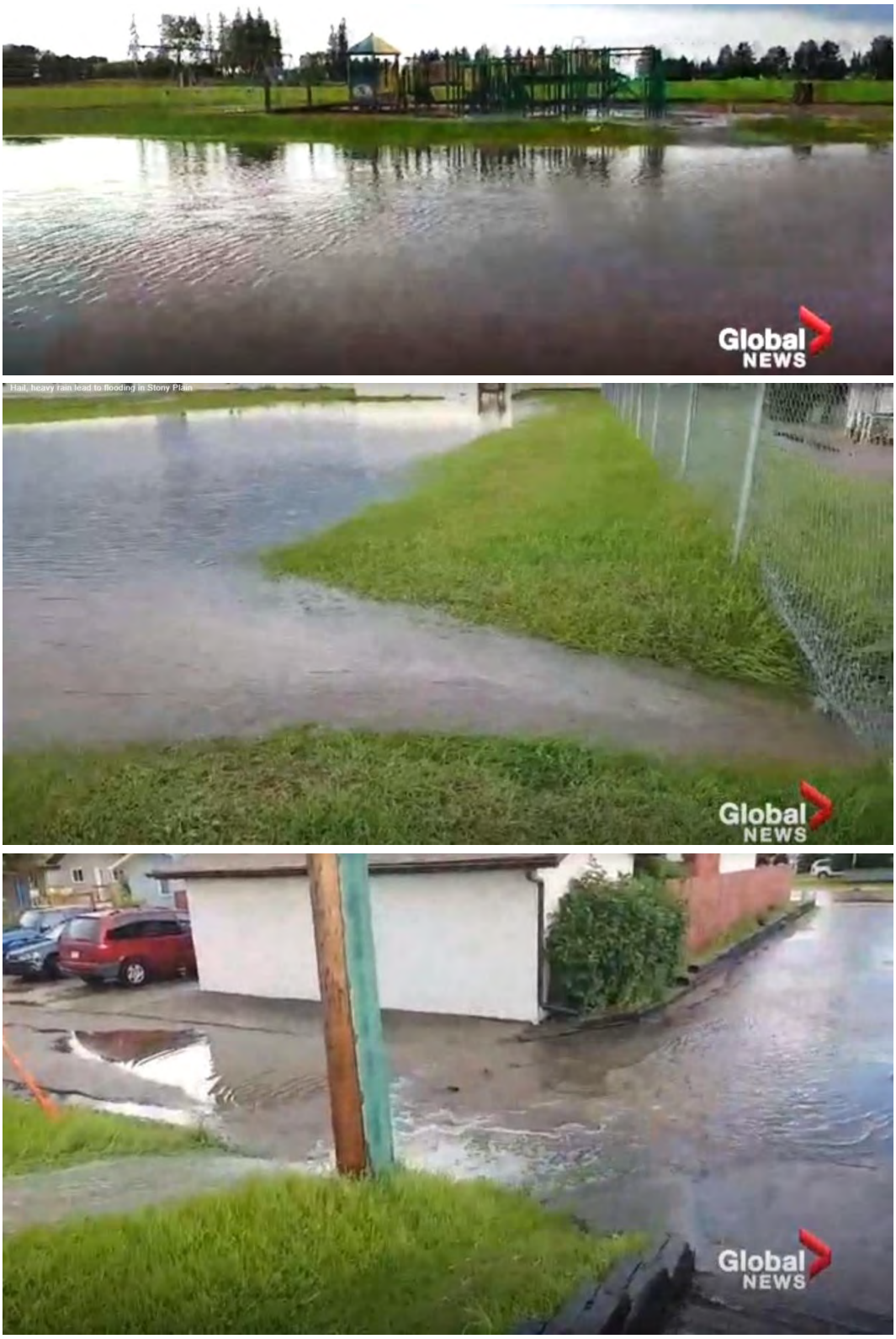


Figure D- 12: Area H – School Yard north of 57 Avenue flooding and overflowing into the alley and towards 57 Avenue, just west of Glenwood Crescent. July 15, 2019

Figure D- 13: Area H – 57 Avenue just west of Glenwood Crescent, looking north in the alley and the school yard, showing significant amount of surface drainage flowing from the school yard towards 57 Avenue via the grass surface and the staircase. July 15, 2019

Figure D- 14: Area H – 57 Avenue just west of Glenwood Crescent, looking north between two properties that overlook the school playground to the back, showing significant amount of surface drainage flowing from the school yard towards 57 Avenue. July 15, 2019

Figure D- 15: Area H – Glenwood Crescent (south section) showing significant ponding on the road and onto private properties. July 15, 2019

Figure D- 16: Area H – Glenwood Crescent (south section) looking east, showing significant ponding on the road and onto private properties. July 15, 2019

Figure D- 17: Area H – Glenwood Crescent (southwest section) looking south, showing significant ponding on the road and onto private properties. July 15, 2019

Figure D- 18: Area H – Glenwood Crescent (east section), south of 57 Avenue, looking south, showing significant ponding on the road and alley, and onto private properties. July 7 or July 15, 2019

Figure D- 19: Area H – Glenwood Crescent (southeast cul-de-sac), looking east, showing significant ponding on the road. July 7 or July 15, 2019

Appendix E: Detailed Cost Estimates

Cost Estimate for Detailed Design for Flood Mitigation and II Study Improvements

Area A Improvements

Item	Description	Qty	Unit	Unit Price ($ CDN)	Extended Price ($ CDN)
	Mobilization, Demobilization, Survey, Tree Protection, Erosion and Sediment Control Measures and General Requirements	1	L.S.	$ 3,000.00	$ 3,000.00
	Proposed Channel	125	l.m.	$ 90.00	$ 11,250.00
	Improved Existing Channel	350	l.m.	$ 45.00	$ 15,750.00
				Area A Improvements Total	**$ 30,000.00**
				Contingency (30%)	$ 9,000.00
				Engineering (30%)	$ 9,000.00
				Area A Improvements Grand Total	**$ 48,000.00**

Area B/D Improvements					
Area D1 Improvements					
Item	**Description**	**Qty**	**Unit**	**Unit Price ($ CDN)**	**Extended Price ($ CDN)**
General Site Activities					
	Mobilization, Demobilization, Survey, Tree Protection, Erosion and Sediment Control Measures and General Requirements	1	L.S.	$ 270,000.00	$ 270,000.00
				General Site Activities Total	$ 270,000.00
Pond					
	Topsoil and Overburden Excavation and Disposal (Hauling Off-Site), incl. grading	6,300	m^3	$ 18.00	$ 113,400.00
	Topsoil (150mm Thickness), incl. final grading and Sod	6,300	m^2	$ 22.00	$ 138,600.00
	Weeping Tile Field Drainage System	200	l.m.	$ 250.00	$ 50,000.00
	Trees	800	each	$ 15.00	$ 12,000.00
	Landscaping Maintenance	1	L.S.	$ 40,000.00	$ 40,000.00
	600 mm Pipe	65	l.m.	$ 1,500.00	$ 97,500.00
	900 mm Pipe	65	l.m.	$ 1,800.00	$ 117,000.00
	1500mm Manholes	4	each	$ 15,000.00	$ 60,000.00
	Asphalt Pavement and Road Structure Removal	60	m^2	$ 22.00	$ 1,320.00
	Concrete Curb and Gutter Removal	10	l.m.	$ 42.00	$ 420.00
	Concrete Walkway Removal	15	m^2	$ 45.00	$ 675.00
	Asphalt Pavement and Structure incl. Granular Material, Soil-Cement and Asphalt	65	m^2	$ 100.00	$ 6,500.00
	Road Grind and Overlay (50mm Depth)	250	m^2	$ 45.00	$ 11,250.00
	Concrete Curb and Gutter	10	l.m.	$ 350.00	$ 3,500.00
	Concrete Sidewalk c/w Granular Base (Including Ramps)	15	m^2	$ 250.00	$ 3,750.00
				Pond Construction Total	$ 655,915.00
51 Street to 50 Street					
	750 mm Pipe	100	l.m.	$ 1,700.00	$ 170,000.00
	900 mm Pipe	150	l.m.	$ 1,900.00	$ 285,000.00
	1200 mm Pipe	260	l.m.	$ 2,200.00	$ 572,000.00
	CB Leads (Removal and Replacement)	6	each	$ 2,200.00	$ 13,200.00
	1500mm Manholes	1	each	$ 15,000.00	$ 15,000.00
	2100mm Manholes	3	each	$ 24,000.00	$ 72,000.00
	2400mm Manholes	1	each	$ 28,000.00	$ 28,000.00
	CB (Removal and Replacement)	6	each	$ 12,000.00	$ 72,000.00
	Asphalt Pavement and Road Structure Removal	750	m^2	$ 22.00	$ 16,500.00
	Concrete Curb and Gutter Removal	18	l.m.	$ 42.00	$ 756.00
	Concrete Walkway Removal	27	m^2	$ 45.00	$ 1,215.00
	Asphalt Pavement and Structure incl. Granular Material, Soil-Cement and Asphalt	750	m^2	$ 100.00	$ 75,000.00
	Road Grind and Overlay (50mm Depth)	3,000	m^2	$ 45.00	$ 135,000.00
	Concrete Curb and Gutter	18	l.m.	$ 350.00	$ 6,300.00
	Concrete Sidewalk c/w Granular Base (Including Ramps)	27	m^2	$ 250.00	$ 6,750.00
				51 Street to 50 Street Total	$ 1,468,721.00
Whispering Waters Creek at 52 Street Upgrades					
	3000mm Manholes	1	each	$ 35,000.00	$ 35,000.00
	1800 mm Pipe	25	l.m.	$ 3,000.00	$ 75,000.00
	Asphalt Pavement and Road Structure Removal	100	m^2	$ 22.00	$ 2,200.00
	Asphalt Pavement and Structure incl. Granular Material, Soil-Cement and Asphalt	100	m^2	$ 100.00	$ 10,000.00
	Road Grind and Overlay (50mm Depth)	300	m^2	$ 45.00	$ 13,500.00
	52 Avenue remove existing and install 2x 1800mm Culverts	51	l.m.	$ 3,500.00	$ 178,500.00
				Whispering Waters Creek at 52 Street Total	$ 314,200.00
				Area D1 Improvements Total	**$ 2,708,836.00**
				Contingency (30%)	$ 812,650.80
				Engineering (15%)	$ 406,325.40
				Area D1 Improvements Grand Total	**$ 3,927,812.20**

Area D2 Improvements					
Item	**Description**	**Qty**	**Unit**	**Unit Price ($ CDN)**	**Extended Price ($ CDN)**
General Site Activities					
				General Site Activities Total	$ 190,000.00
50 Street to 48 Street					
	900 mm Pipe	0	l.m.	$ 1,800.00	$ -
	1200 mm Pipe	340	l.m.	$ 2,200.00	$ 748,000.00
	1800 mm Pipe	125	l.m.	$ 3,000.00	$ 375,000.00
	CB Leads (Removal and Replacement)	9	each	$ 2,200.00	$ 19,800.00
	1500mm Manholes	1	each	$ 15,000.00	$ 15,000.00
	2100mm Manholes	2	each	$ 24,000.00	$ 48,000.00
	2400mm Manholes	2	each	$ 28,000.00	$ 56,000.00
	3000mm Manholes	1	each	$ 35,000.00	$ 35,000.00
	CB (Removal and Replacement)	9	each	$ 12,000.00	$ 108,000.00
	Asphalt Pavement and Road Structure Removal	1,150	m^2	$ 22.00	$ 25,300.00
	Concrete Curb and Gutter Removal	27	l.m.	$ 42.00	$ 1,134.00
	Concrete Walkway Removal	40	m^2	$ 45.00	$ 1,800.00
	Asphalt Pavement and Structure incl. Granular Material, Soil-Cement and Asphalt	1,150	m^2	$ 100.00	$ 115,000.00
	Road Grind and Overlay (50mm Depth)	3,500	m^2	$ 45.00	$ 157,500.00
	Concrete Curb and Gutter	27	l.m.	$ 350.00	$ 9,450.00
	Concrete Sidewalk c/w Granular Base (Including Ramps)	40	m^2	$ 250.00	$ 10,000.00
				50 Street to 48 Street Total	$ 1,724,984.00
				Area D2 Improvements Total	**$ 1,914,984.00**
				Contingency (30%)	$ 574,495.20
				Engineering (15%)	$ 287,247.60
				Area D2 Improvements Grand Total	**$ 2,776,726.80**

Area B1 Improvements					
Item	**Description**	**Qty**	**Unit**	**Unit Price ($ CDN)**	**Extended Price ($ CDN)**
General Site Activities					
	Mobilization, Demobilization, Survey, Tree Protection, Erosion and Sediment Control Measures and General Requirements	1	L.S.	$ 230,000.00	$ 230,000.00
				General Site Activities Total	$ 230,000.00
48 Street to Whispering Waters Creek					
	900 mm Pipe	90	l.m.	$ 1,900.00	$ 171,000.00
	1800 mm Pipe	365	l.m.	$ 3,000.00	$ 1,095,000.00
	CB Leads (Removal and Replacement)	2	each	$ 2,200.00	$ 4,400.00
	52 Avenue remove existing and install 2x 1800mm Culverts	51	l.m.	$ 3,300.00	$ 168,300.00
	1500mm Manholes	1	each	$ 15,000.00	$ 15,000.00
	2400mm Manholes	1	each	$ 28,000.00	$ 28,000.00
	3000mm Manholes	2	each	$ 35,000.00	$ 70,000.00
	CB (Removal and Replacement)	2	each	$ 12,000.00	$ 24,000.00
	Asphalt Pavement and Road Structure Removal	1,250	m^2	$ 22.00	$ 27,500.00
	Concrete Curb and Gutter Removal	12	l.m.	$ 42.00	$ 504.00
	Concrete Walkway Removal	18	m^2	$ 45.00	$ 810.00
	52 Avenue Road Restoration	1	L.S.	$ 20,000.00	$ 20,000.00
	Asphalt Pavement and Structure incl. Granular Material, Soil-Cement and Asphalt	1,250	m^2	$ 100.00	$ 125,000.00
	Road Grind and Overlay (50mm Depth)	2,900	m^2	$ 45.00	$ 130,500.00
	Concrete Curb and Gutter	12	l.m.	$ 350.00	$ 4,200.00
	Concrete Sidewalk c/w Granular Base (Including Ramps)	18	m^2	$ 250.00	$ 4,500.00
	Landscaping Restoration	1	L.S.	$ 15,000.00	$ 15,000.00
				48 Street to Whispering Waters Creek Total	$ 1,903,714.00
				Area B1 Improvements Total	**$ 2,133,714.00**
				Contingency (30%)	$ 640,114.20
				Engineering (15%)	$ 320,057.10
				Area B1 Improvements Grand Total	**$ 3,093,885.30**
				Area B/D Improvements Grand Total	**$ 9,798,424.30**

Area C-1 Improvements

Item	Description	Qty	Unit	Unit Price ($ CDN)	Extended Price ($ CDN)
	Mobilization, Demobilization, Survey, Tree Protection, Erosion and Sediment Control Measures and General Requirements	1	L.S.	$ 19,000.00	$ 19,000.00
	750 mm Pipe	80	l.m.	$ 1,700.00	$ 136,000.00
	1500mm Manholes	1	each	$ 15,000.00	$ 15,000.00
	Asphalt Pavement and Road Structure Removal	10	m²	$ 22.00	$ 220.00
	Concrete Curb and Gutter Removal	5	l.m.	$ 42.00	$ 210.00
	Concrete Walkway Removal	8	m^2	$ 45.00	$ 360.00
	Asphalt Pavement and Structure incl. Granular Material, Soil-Cement and Asphalt	10	m²	$ 100.00	$ 1,000.00
	Road Grind and Overlay (50mm Depth)	50	m^2	$ 45.00	$ 2,250.00
	Concrete Curb and Gutter	5	l.m.	$ 350.00	$ 1,750.00
	Concrete Sidewalk c/w Granular Base (Including Ramps)	8	m^2	$ 250.00	$ 2,000.00
	Outfall Structure for 750mm Pipe	1	each	$ 10,000.00	$ 10,000.00
	Landscaping Restoration	1	L.S.	$ 5,000.00	$ 5,000.00
				Area C-1 Improvements Total	**$ 192,790.00**
				Contingency (30%)	$ 57,837.00
				Engineering (15%)	$ 28,918.50
				Area C-1 Improvements Grand Total	**$ 279,545.50**

Area C-2 Improvements

Item	Description	Qty	Unit	Unit Price ($ CDN)	Extended Price ($ CDN)
	Mobilization, Demobilization, Survey, Tree Protection, Erosion and Sediment Control Measures and General Requirements	1	L.S.	$ 68,000.00	$ 68,000.00
	750 mm Pipe	187	l.m.	$ 1,600.00	$ 299,200.00
	1500mm Manholes	1	each	$ 15,000.00	$ 15,000.00
	Asphalt Pavement and Road Structure Removal	210	m²	$ 22.00	$ 4,620.00
	Concrete Curb and Gutter Removal	5	l.m.	$ 42.00	$ 210.00
	Concrete Walkway Removal	8	m^2	$ 45.00	$ 360.00
	Asphalt Pavement and Structure incl. Granular Material, Soil-Cement and Asphalt	210	m²	$ 100.00	$ 21,000.00
	Road Grind and Overlay (50mm Depth)	900	m^2	$ 45.00	$ 40,500.00
	Concrete Curb and Gutter	5	l.m.	$ 350.00	$ 1,750.00
	Concrete Sidewalk c/w Granular Base (Including Ramps)	8	m^2	$ 250.00	$ 2,000.00
	Outfall Structure for 750mm Pipe	1	each	$ 10,000.00	$ 10,000.00
	Landscaping Restoration	1	L.S.	$ 5,000.00	$ 5,000.00
				Area C-2 Improvements Total	**$ 467,640.00**
				Contingency (30%)	$ 140,292.00
				Engineering (15%)	$ 70,146.00
				Area C-2 Improvements Grand Total	**$ 678,078.00**
				Area C Improvements Grand Total	**$ 957,623.50**

Area E Improvements					
Item	**Description**	**Qty**	**Unit**	**Unit Price ($ CDN)**	**Extended Price ($ CDN)**
	Mobilization, Demobilization, Survey, Tree Protection, Erosion and Sediment Control Measures and General Requirements	1	L.S.	$ 5,000.00	$ 5,000.00
	Regrade Ally (Remove and Rebuild)	250	m^2	$ 145.00	$ 36,250.00
	0.5m Retaining Walls	60	l.m	$ 200.00	$ 12,000.00
	3.0m Asphalt Path (Remove and Rebuild)	90	m^2	$ 120.00	$ 10,800.00
				Area E Improvements Total	**$ 64,050.00**
				Contingency (30%)	$ 19,215.00
				Engineering (30%)	$ 19,215.00
				Area E Improvements Grand Total	**$ 102,480.00**

Area F Improvements					
Item	**Description**	**Qty**	**Unit**	**Unit Price ($ CDN)**	**Extended Price ($ CDN)**
	Mobilization, Demobilization, Survey, Tree Protection, Erosion and Sediment Control Measures and General Requirements	1	L.S.	$ 30,000.00	$ 30,000.00
	CB Installation	2	each	$ 10,000.00	$ 20,000.00
	CB Lead Installation	40	l.m.	$ 2,200.00	$ 88,000.00
	Asphalt Pavement and Road Structure Removal	10	m^2	$ 22.00	$ 220.00
	Asphalt Pavement and Structure incl. Granular Material, Soil-Cement and Asphalt	10	m^2	$ 100.00	$ 1,000.00
	Road Grind and Overlay (50mm Depth)	40	m^2	$ 45.00	$ 1,800.00
	Concrete Curb and Gutter Removal	4	l.m.	$ 42.00	$ 168.00
	Concrete Curb and Gutter	4	l.m.	$ 350.00	$ 1,400.00
	Concrete Sidewalk c/w Granular Base (Including Ramps)	4	m^2	$ 250.00	$ 1,000.00
	Land Acquisition and Legal	1	L.S.	$ 150,000.00	$ 150,000.00
	Remove and Rebuild Fence	20	l.m.	$ 250.00	$ 5,000.00
	Build Swale on Property Line	40	l.m.	$ 40.00	$ 1,600.00
				Area F Improvements Total	**$ 300,188.00**
				Contingency (30%)	$ 90,056.40
				Engineering (15%)	$ 45,028.20
				Area F Improvements Grand Total	**$ 435,272.60**

Area H Improvements					
Item	**Description**	**Qty**	**Unit**	**Unit Price ($ CDN)**	**Extended Price ($ CDN)**
	Mobilization, Demobilization, Survey, Tree Protection, Erosion and Sediment Control Measures and General Requirements	1	L.S.	$ 30,000.00	$ 30,000.00
	Topsoil and Overburden Excavation and Disposal (Hauling Off-Site), incl. grading	5,780	m^3	$ 18.00	$ 104,040.00
	Topsoil (150mm Thickness), incl. final grading	5,730	m^2	$ 10.00	$ 57,300.00
	Sod	5,730	m^2	$ 12.00	$ 68,760.00
	Landscaping Maintenance	1	L.S.	$ 20,000.00	$ 20,000.00
	Existing CB Adjustment	1	L.S.	$ 10,000.00	$ 10,000.00
	Build Swales on Green Space Corridors	80	l.m.	$ 45.00	$ 3,600.00
				Area H Improvements Total	**$ 293,700.00**
				Contingency (30%)	$ 88,110.00
				Engineering (15%)	$ 44,055.00
				Area H Improvements Grand Total	**$ 425,865.00**

Sanitary Manhole Sealing					
Item	**Description**	**Qty**	**Unit**	**Unit Price ($ CDN)**	**Extended Price ($ CDN)**
	Mobilization, Demobilization, Survey, Tree Protection, Erosion and Sediment Control Measures and General Requirements	1	L.S.	$ 75,000.00	$ 75,000.00
	Phase 1 - Sanitary Manhole Sealing (Sealing to First Joint)	23	each	$ 8,000.00	$ 184,000.00
	Phase 1 - Sanitary Manhole Sealing (Cast In Place Chimney)	13	each	$ 12,000.00	$ 156,000.00
	Phase 1 - Replace Sanitary Manhole Cover	2	each	$ 1,000.00	$ 2,000.00
	Phase 2 - Sanitary Manhole Sealing (Sealing to First Joint)	43	each	$ 8,000.00	$ 344,000.00
	Phase 2 - Sanitary Manhole Sealing (Cast In Place Chimney)	0	each	$ 12,000.00	$ -
				Manhole Sealing Improvements Total	**$ 761,000.00**
				Contingency (30%)	$ 228,300.00
				Engineering (15%)	$ 114,150.00
				Manhole Sealing Improvements Grand Total	**$ 1,103,450.00**

Option 1 - Whispering Waters Creek Culvert Upgrades

Item	Description	Qty	Unit	Unit Price ($ CDN)	Extended Price ($ CDN)
	Mobilization, Demobilization, Survey, Tree Protection, Erosion and Sediment Control Measures and General Requirements	1	L.S.	$ 200,000.00	$ 200,000.00
	52 Avenue remove existing and install 2x 1800mm Culverts	51	l.m.	$ 3,000.00	$ 153,000.00
	52 Avenue Road Restoration	1	L.S.	$ 20,000.00	$ 20,000.00
	50 Avenue remove existing and install 2x 1800mm Culverts	31	l.m.	$ 3,000.00	$ 93,000.00
	50 Avenue Landscape Restoration	1	L.S.	$ 5,000.00	$ 5,000.00
	49 Avenue remove existing and install 2x 1800mm Culverts	49	l.m.	$ 3,000.00	$ 147,000.00
	49 Avenue Road Restoration	1	L.S.	$ 20,000.00	$ 20,000.00
	CN-Rail install 1800mm Culvert (Directional Bore)	42	l.m.	$ 7,500.00	$ 315,000.00
	CN-Rail Landscape Restoration		L.S.	$ 5,000.00	$ -
	44 Avenue remove existing and install 2x 2000mm Culverts	44	l.m.	$ 4,000.00	$ 176,000.00
	44 Avenue Road Restoration	1	L.S.	$ 20,000.00	$ 20,000.00
	HWY 16A install 1500mm Culvert (Directional Bore)	77	l.m.	$ 6,500.00	$ 500,500.00
	HWY 16A Landscape Restoration	1	L.S.	$ 5,000.00	$ 5,000.00
	Boulder Boulevard remove existing and install 2x 2000mm Culverts	31	l.m.	$ 4,000.00	$ 124,000.00
	Boulder Boulevard Road Restoration	1	L.S.	$ 20,000.00	$ 20,000.00
	Access on Golf Course Road remove existing and install 2000mm Culvert	40	l.m.	$ 2,500.00	$ 100,000.00
	Access/Retaining Wall on Golf Course Road Restoration	1	L.S.	$ 30,000.00	$ 30,000.00
	Golf Course Road remove existing and install 2400mm x 1200mm Box Culvert	28	l.m.	$ 4,000.00	$ 112,000.00
	Golf Course Road Restoration	1	L.S.	$ 20,000.00	$ 20,000.00
				Option 1 Total	**$ 2,060,500.00**
				Contingency (30%)	$ 618,150.00
				Engineering (15%)	$ 309,075.00
				Option 1 Grand Total	**$ 2,987,725.00**

Option 2 - Whispering Waters Creek 50th Avenue Pond

Item	Description	Qty	Unit	Unit Price ($ CDN)	Extended Price ($ CDN)
	Mobilization, Demobilization, Survey, Tree Protection, Erosion and Sediment Control Measures and General Requirements	1	L.S.	$ 130,000.00	$ 130,000.00
	Topsoil and Overburden Excavation and Disposal (Hauling Off-Site), incl. grading	49,300	m^3	$ 15.00	$ 739,500.00
	Topsoil (150mm Thickness), incl. final grading	17,540	m^2	$ 10.00	$ 175,400.00
	Grass Seeding	14,750	m^2	$ 3.00	$ 44,250.00
	Trees	800	each	$ 20.00	$ 16,000.00
	Landscaping Maintenance	1	L.S.	$ 80,000.00	$ 80,000.00
	150 mm Pipe	50	l.m.	$ 400.00	$ 20,000.00
	Golf Course Road remove existing and install 2400mm x 1200mm Box Culvert	28	l.m.	$ 4,000.00	$ 112,000.00
	Golf Course Road Restoration	1	L.S.	$ 20,000.00	$ 20,000.00
	50 Avenue remove existing and install 2x 2100mm x 3000mm Box Culverts	31	l.m.	$ 4,500.00	$ 139,500.00
	Landscaping Restoration	1	L.S.	$ 5,000.00	$ 5,000.00
				Option 2 Total	**$ 1,481,650.00**
				Contingency (30%)	$ 444,495.00
				Engineering (15%)	$ 222,247.50
				Option 2 Grand Total	**$ 2,148,392.50**

Improvement	Totals	
Area A Improvements	$	48,000.00
Area B1 Improvements	$	3,093,885.30
Area D1 Improvements	$	3,927,812.20
Area D2 Improvements	$	2,776,726.80
Area C-1 Improvements	$	279,545.50
Area C-2 Improvements	$	678,078.00
Area E Improvements	$	102,480.00
Area F Improvements	$	435,272.60
Area H Improvements	$	425,865.00
Sanitary Manhole Sealing	$	1,103,450.00
Option 1 - Whispering Waters Creek Culvert Upgrades	$	2,987,725.00
Option 2 - Whispering Waters Creek 50th Avenue Pond	$	2,148,392.50
Total (Option 2)	$	15,019,507.90

Appendix F: Model Calibration Assessment Data

Rainfall Events used for Model Calibration

Date	Duration	5min	15min	30min	1hr	2hr	4hr	6hr	12hr	24hr
5/22/2016	Return Period (Year)	<1.01	<1.01	<1.01	<1.01	1.01	1.1	2.06	3.09	**3.95**
	Rainfall (mm/hr)	10.8	8.4	6.2	5.3	4.9	4.3	3.9	2.8	**1.9**
6/25/2016	Return Period (Year)	1.1	1.5	1.5	3.24	**4.17**	3.79	3.63	3.28	2.71
	Rainfall (mm/hr)	49.2	34.0	24.0	18.3	**12.6**	7.2	5.2	2.9	1.5
7/9/2016	Return Period (Year)	9.95	26.02	**30.48**	26.45	12.75	6.8	4.94	4.53	6.56
	Rainfall (mm/hr)	110.4	87.2	**59.8**	37.2	18.7	9.3	6.2	3.5	2.5
5/23/2017	Return Period (Year)	<1.01	<1.01	<1.01	1.01	1.01	1.1	1.1	**1.5**	1.1
	Rainfall (mm/hr)	8.4	7.6	6.8	6.5	5.3	3.9	3.3	**2.1**	1.1

May 22, 2016

- A low-intensity long-duration rainfall event, with no period of high intensity.
- The return period is about 1:4-year for a 24-hour duration.
- The calibrated model shows good fit with the monitoring data.

June 25, 2016

- A low-intensity medium-duration rainfall event with a single-peak of higher intensity, although not that intense.
- The return period is about 1:5-year for a 2-hour duration.
- The calibrated model shows good fit with the monitoring data.

July 9, 2016

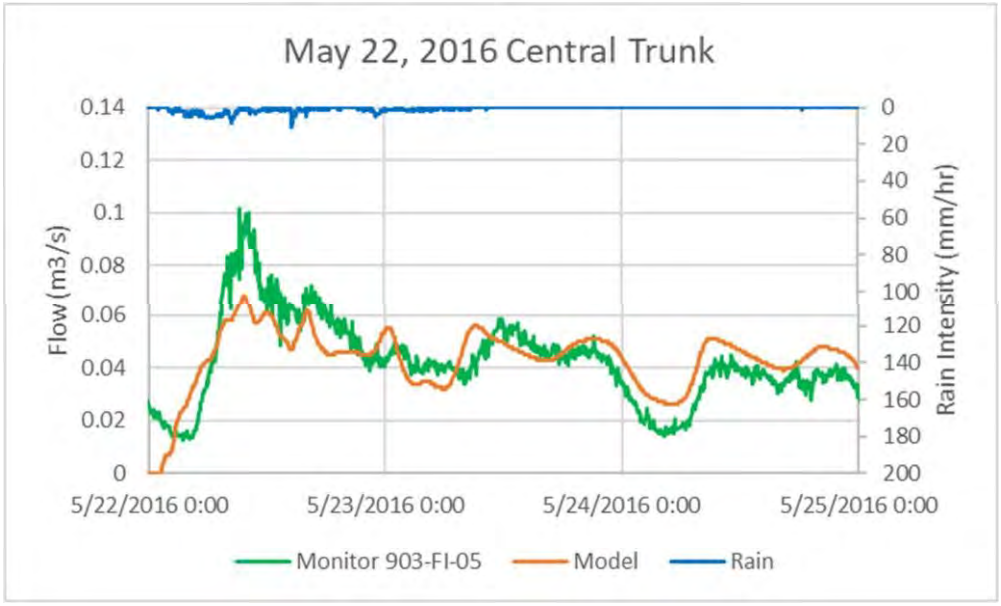
- An intense rainfall event with multiple peaks.
- The return period of the highest peak is above a 1:30-year for 30 minutes duration.
- In the model, the rainfall was applied evenly across the entire town, but in reality the measured high intensity might have only hit one area of the town more than others. Therefore, the modeling results showing a higher peak than the measured flow.

May 23, 2017

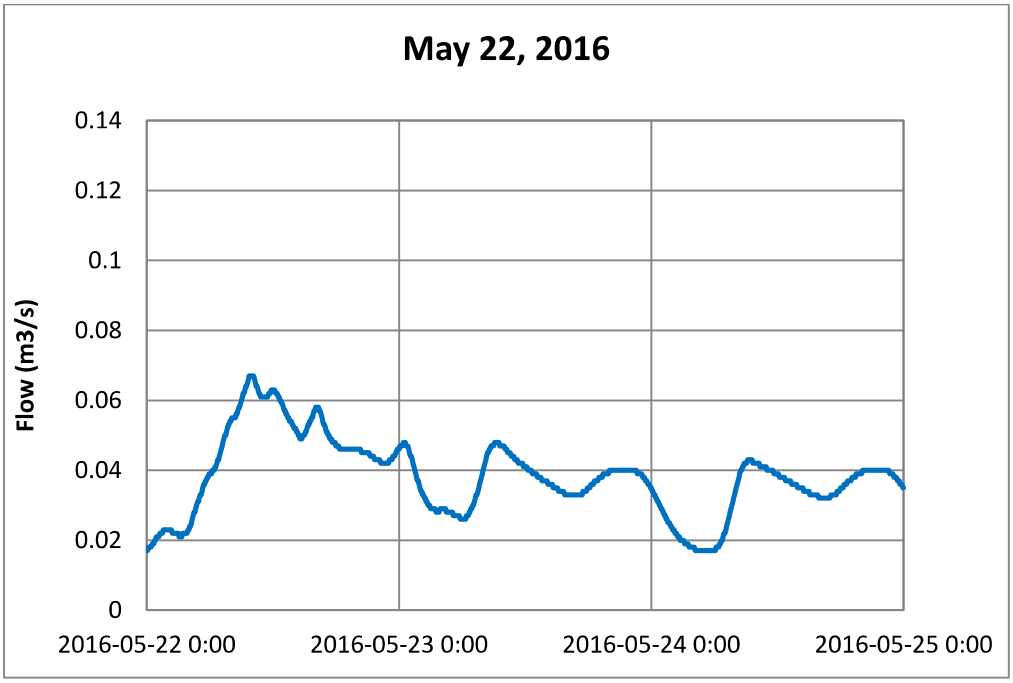
- A frequent event with medium duration and no period of high intensity.
- The return period is less than 1:2-year for any duration.
- The calibrated model matches with the measured peak, even though it shows a shorter duration than the flow monitoring data. This may be due to the inaccuracy of the rainfall data which was only collected at one location.

May 22, 2016

Original Sanitary Model (the orange 'model' plot shown here is not from this flood mitigation study and should be ignored)

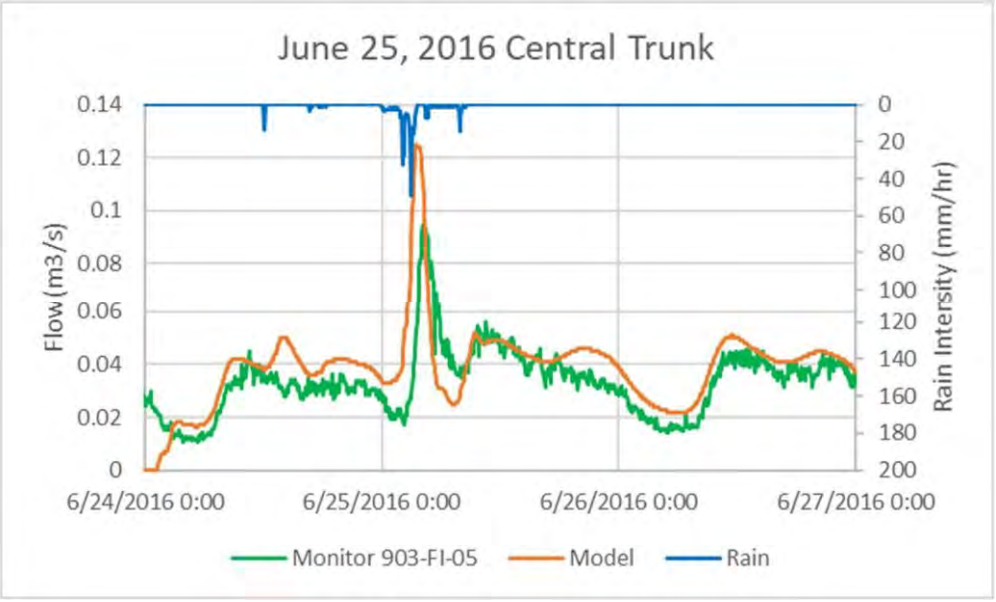


Calibrated Dual Storm-Sanitary Model (from this flood mitigation study)

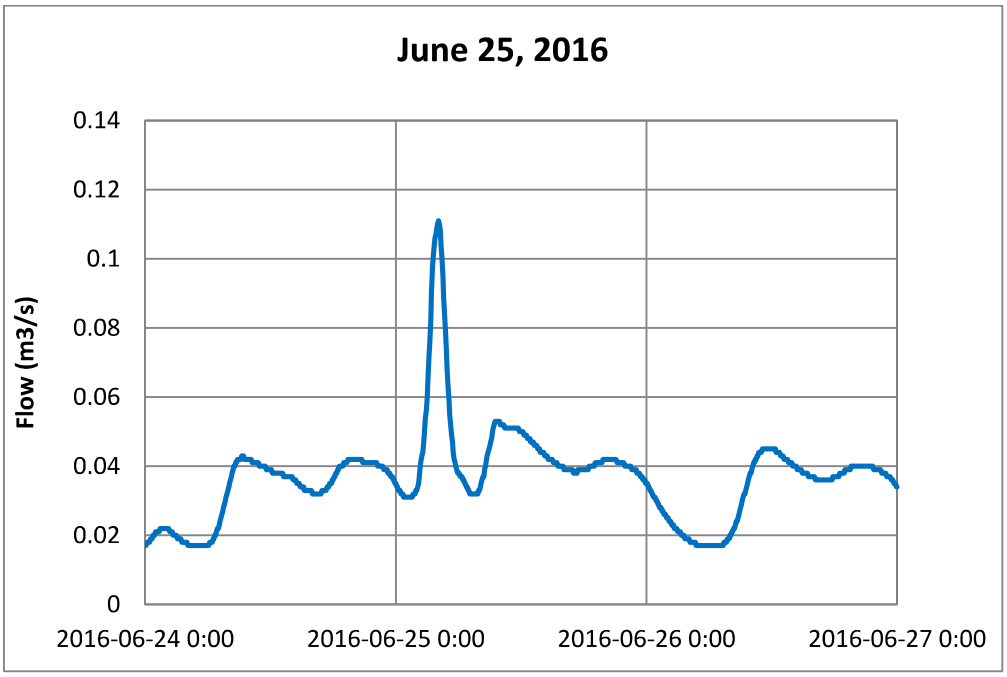


June 25, 2016

Original Sanitary Model (the orange 'model' plot shown here is not from this flood mitigation study and should be ignored)

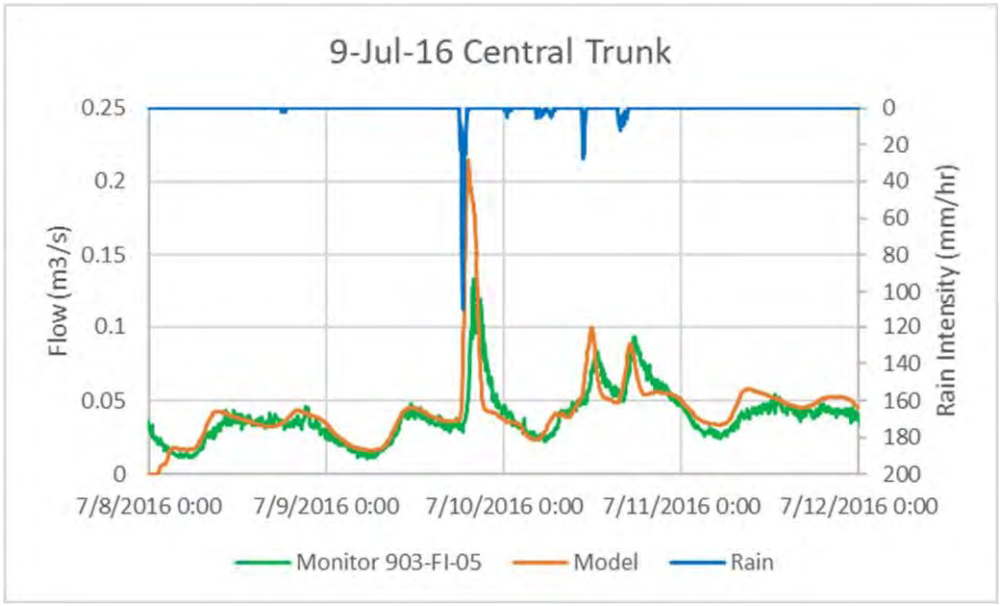


Calibrated Dual Storm-Sanitary Model (from this flood mitigation study)

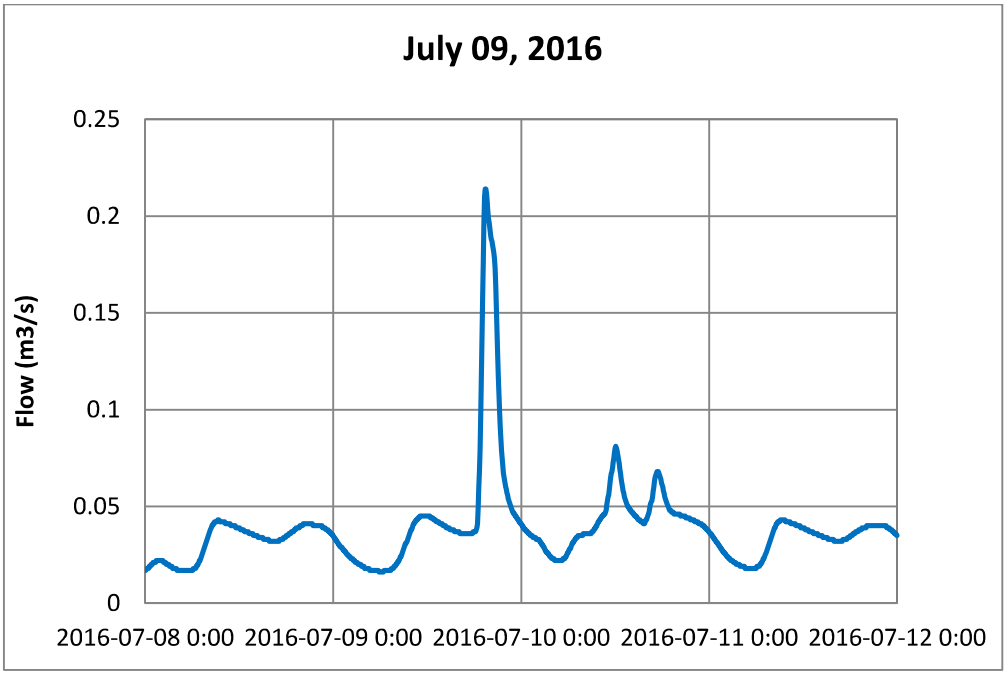


July 09, 2016

Original Sanitary Model (the orange 'model' plot shown here is not from this flood mitigation study and should be ignored)

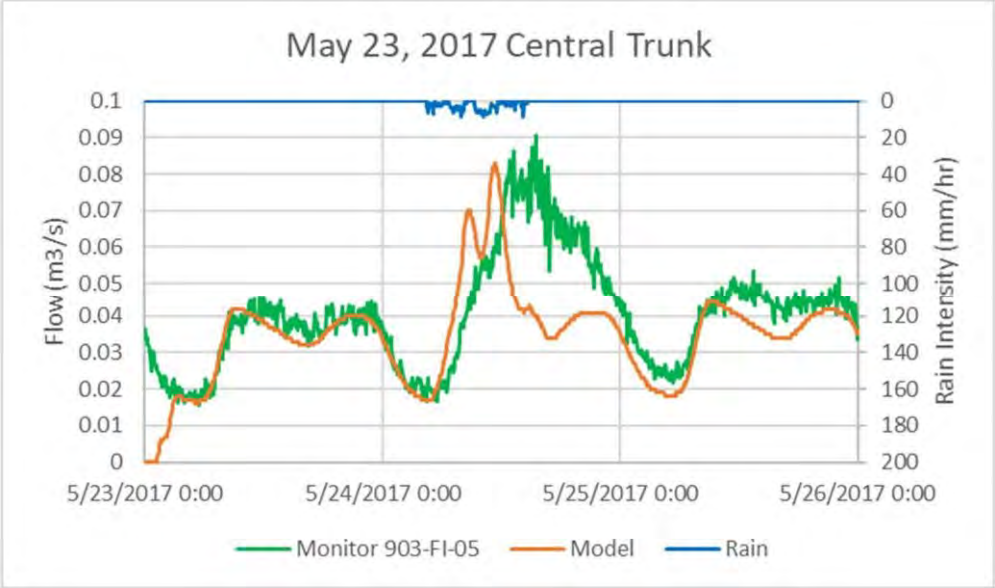


Calibrated Dual Storm-Sanitary Model (from this flood mitigation study)

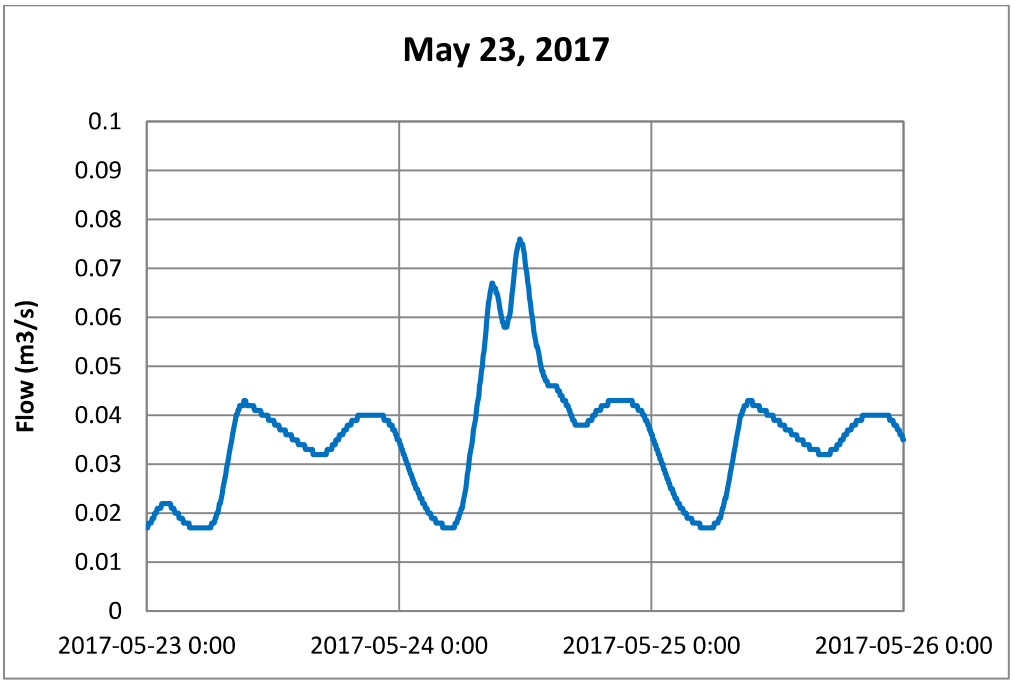


May 23, 2017

Original Sanitary Model (the orange 'model' plot shown here is not from this flood mitigation study and should be ignored)



Calibrated Dual Storm-Sanitary Model (from this flood mitigation study)



Appendix G: Sanitary Manhole Sealing Details

Manhole ID	Existing Peak Flow 1:100-year (L/s)	Existing Peak Volume 1:100-year (m^3)	Priority	Seal Type
03-36	8	115.6	Stage1	Chimney
CT-11	4	42.8	Stage1	Chimney
CT-12	3	24.7	Stage1	Chimney
CT-21	13	241.7	Stage1	Chimney
CT-22	6	73.4	Stage1	Chimney
CT-23	11	186.3	Stage1	Chimney
CT-24	9	135.6	Stage1	Chimney
83-1	1	0.7	Stage1	Chimney
01-22	3	10.9	Stage1	Normal
51-35	2	8.8	Stage1	Normal
51-37	4	26.5	Stage1	Normal
51-44	3	18.8	Stage1	Normal
72-16	3	11.8	Stage1	Normal
72-24	3	9.2	Stage1	Normal
73-2	3	47.3	Stage1	Normal
78-31A	4	29.5	Stage1	Normal
78-61	3	9.9	Stage1	Normal
78-63	3	11.0	Stage1	Normal
78-67	3	10.6	Stage1	Normal
79-36	3	10.7	Stage1	Normal
79-49	2	8.7	Stage1	Normal
79-59	3	20.7	Stage1	Normal
79-61	4	19.5	Stage1	Normal
79-8	4	51.9	Stage1	Normal
84-7	2	5.3	Stage1	Normal
84-8	3	9.5	Stage1	Normal
88-11	3	9.9	Stage1	Normal
88-4	4	13.3	Stage1	Normal
CT-09	0	0.0	Stage1	Normal
CT-25	5	32.5	Stage1	Normal
CT-26	5	32.5	Stage1	Normal
CT-40	3	8.6	Stage1	Normal
CT-37	0	0.0	Stage1	Normal
79-67	0	0.0	Stage1	Chimney
79-68	0	0.0	Stage1	Chimney
83-2	0	0.0	Stage1	Chimney
CT-13	0	0.0	Stage1	Chimney
CT-18	0	0.0	Stage1	Chimney
01-21	2	8.3	Stage2	Normal
02-50	2	5.1	Stage2	Normal
03-35	0	0.0	Stage2	Normal
11MC	2	2.5	Stage2	Normal
51-19	2	4.4	Stage2	Normal
51-4	2	5.9	Stage2	Normal
72-29	2	8.1	Stage2	Normal
72-31	2	8.5	Stage2	Normal
78-10	2	10.1	Stage2	Normal
78-15	2	5.3	Stage2	Normal
78-16	2	8.0	Stage2	Normal
78-22	0	0.0	Stage2	Normal
78-24	0	0.0	Stage2	Normal
78-30	2	3.9	Stage2	Normal
78-31	2	7.4	Stage2	Normal
78-43	2	5.2	Stage2	Normal
78-51	2	2.6	Stage2	Normal
78-52	2	3.7	Stage2	Normal
79-11	2	2.1	Stage2	Normal
79-38	2	12.3	Stage2	Normal
79-60	2	3.4	Stage2	Normal
79-62	2	4.9	Stage2	Normal
79-64	2	5.3	Stage2	Normal
79-69	0	0.0	Stage2	Normal
83-3	2	3.7	Stage2	Normal
88-1	2	5.4	Stage2	Normal
88-16	2	3.8	Stage2	Normal
91-4	2	5.3	Stage2	Normal
92-12	2	4.1	Stage2	Normal
92-9	2	7.1	Stage2	Normal
92-C	2	5.7	Stage2	Normal
CT-10	0	0.0	Stage2	Normal

Manhole ID	Existing Peak Flow 1:100-year (L/s)	Existing Peak Volume 1:100-year (m^3)	Priority	Seal Type
CT-16	0	0.0	Stage2	Normal
CT-17	0	0.0	Stage2	Normal
CT-19	0	0.0	Stage2	Normal
CT-34	1	0.4	Stage2	Normal
CT-35	2	4.2	Stage2	Normal
CT-38	0	0.0	Stage2	Normal
CT-39	2	3.8	Stage2	Normal
CT-14	0	0.0	Stage2	Normal
CT-20	0	0.0	Stage2	Normal
CT-31	0	0.0	Stage2	Normal
CT-15	0	0.0	Stage2	Normal
02-49	1	1.4	Stage3	Normal
04MC	1	0.3	Stage3	Normal
0506	1	0.2	Stage3	Normal
07MC	1	0.4	Stage3	Normal
101W	1	0.4	Stage3	Normal
12A	1	0.6	Stage3	Normal
12MC	1	0.7	Stage3	Normal
51-10	1	1.8	Stage3	Normal
51-11	1	6.1	Stage3	Normal
51-17	1	1.0	Stage3	Normal
51-18	1	1.6	Stage3	Normal
51-25	1	0.6	Stage3	Normal
51-28	1	1.2	Stage3	Normal
51-3	1	1.3	Stage3	Normal
51-46	1	2.3	Stage3	Normal
51-51	1	0.9	Stage3	Normal
51-56	1	0.5	Stage3	Normal
51-57	1	0.3	Stage3	Normal
51-62	1	0.8	Stage3	Normal
51-63	1	2.3	Stage3	Normal
72-12	1	1.0	Stage3	Normal
72-14A	1	0.9	Stage3	Normal
72-19	1	0.5	Stage3	Normal
72-23	1	2.9	Stage3	Normal
72-26	1	5.2	Stage3	Normal
72-30	1	0.3	Stage3	Normal
72-35	1	1.5	Stage3	Normal
72-8	1	0.7	Stage3	Normal
78-13	1	1.7	Stage3	Normal
78-14	1	1.3	Stage3	Normal
78-17	1	4.5	Stage3	Normal
78-20	1	2.3	Stage3	Normal
78-21	1	1.1	Stage3	Normal
78-33	1	0.3	Stage3	Normal
78-34	1	0.2	Stage3	Normal
78-35	1	0.5	Stage3	Normal
78-50	1	2.2	Stage3	Normal
78-60	1	1.2	Stage3	Normal
78-65	1	1.9	Stage3	Normal
78-68	1	2.1	Stage3	Normal
78-7	1	0.6	Stage3	Normal
78-80	1	6.5	Stage3	Normal
79-1	1	1.4	Stage3	Normal
79-16	1	0.8	Stage3	Normal
79-37	1	2.3	Stage3	Normal
79-43	1	0.4	Stage3	Normal
79-45	1	0.7	Stage3	Normal
79-50	1	1.8	Stage3	Normal
79-51	1	0.2	Stage3	Normal
79-53	1	2.1	Stage3	Normal
79-65	1	1.1	Stage3	Normal
79-7	1	0.9	Stage3	Normal
83-20	1	1.1	Stage3	Normal
83-23	1	0.5	Stage3	Normal
83-25	1	0.2	Stage3	Normal
83-5	1	0.5	Stage3	Normal
83-6	1	0.7	Stage3	Normal
83-8	1	0.6	Stage3	Normal
84-13	1	0.3	Stage3	Normal

Manhole ID	Existing Peak Flow 1:100-year (L/s)	Existing Peak Volume 1:100-year (m^3)	Priority	Seal Type
88-13	1	1.2	Stage3	Normal
88-8	1	0.8	Stage3	Normal
89-2	1	0.6	Stage3	Normal
92-A	1	0.9	Stage3	Normal
93-1	1	1.7	Stage3	Normal
93-3	1	5.0	Stage3	Normal
93-4	1	7.1	Stage3	Normal
96-1b	1	0.4	Stage3	Normal
96-2	1	0.4	Stage3	Normal
98-3	1	2.4	Stage3	Normal
CT-27	1	0.4	Stage3	Normal
CT-28A	1	0.3	Stage3	Normal
CT-30	1	7.9	Stage3	Normal
CT-41	1	1.5	Stage3	Normal
84-15	1	1.5	Stage3	Normal
84-3	1	0.3	Stage3	Normal
84-5	1	1.0	Stage3	Normal
84-9	1	0.3	Stage3	Normal

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