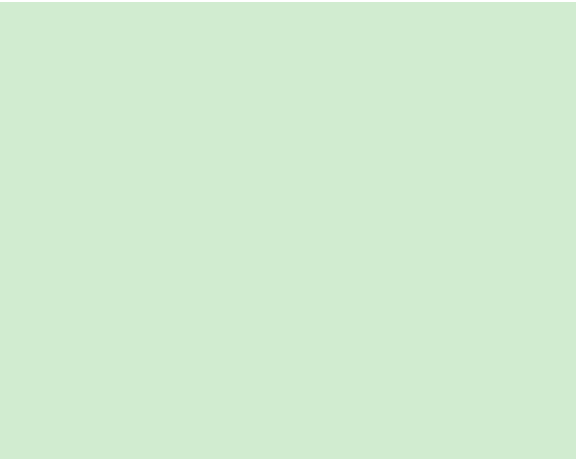




Post-Filing Submission Report for:

2020 Pollution Prevention Control Plan Update & Wastewater Master Servicing Plan

City of Welland

GM BluePlan Project Number: 618057

September 2022

EXECUTIVE SUMMARY

ES-1 INTRODUCTION

The Welland wastewater treatment plant (WWTP) wastewater system (Welland System) services the City of Welland (the City), the Town of Thorold, and the Town of Pelham. The Welland WWTP services an existing population of 68,722 residents and 27,380 jobs (Niagara Region Master Servicing Plan, 2016). The Local Area Municipalities (LAMs) and Niagara Region (Region) have joint responsibility for the management and operation of the Welland wastewater system. The City is forecast to experience significant growth in areas noted in this report. The growth and existing customer base capacity needs must be addressed through system optimization, upgrades, or other infrastructure planning approaches.

ES-1.1 Project Context

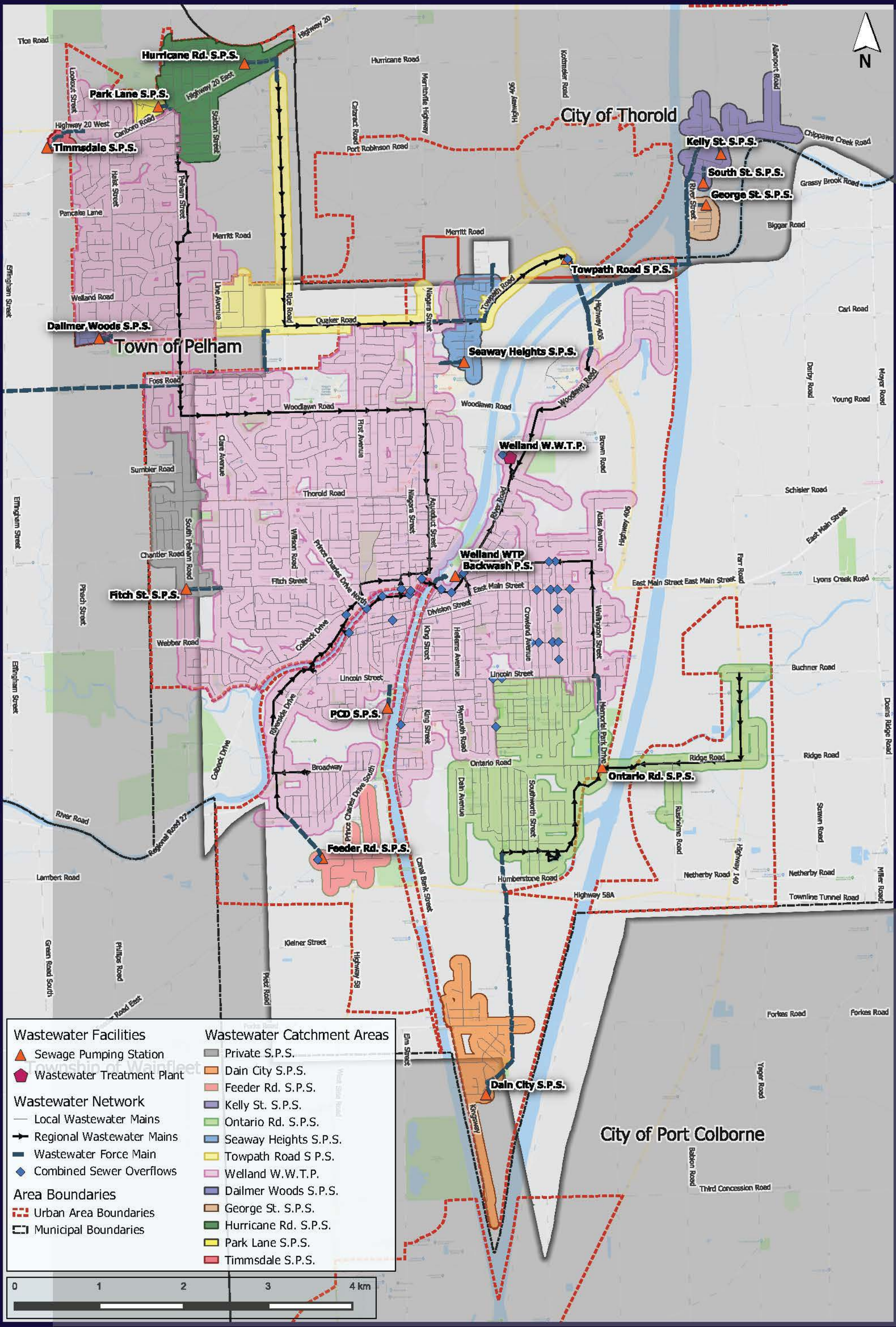
The Welland Pollution Prevention Control Plan and Master Servicing Plan Update (PPCP&MSP) followed Approach 1 of the Municipal Class Environmental Assessment (EA) and is an update to the 2001 Pollution Control Plan. In combination with a master servicing plan, the objective of the 2020 update is to establish a masterplan to meet community growth needs while meeting the goals of the F-5-5 Procedure to reduce combined sewer overflow pollution to the environment. The PPCP & WW MSP assessed existing and future state system performance to determine the nature, cause, and extent of system issues, reviews alternative solutions, and recommend a capital plan for the City.

This update also builds on the findings from the 2016 Niagara Region Master Servicing Plan (MSP) Update. The 2016 MSP outlined a long-term servicing strategy for wastewater infrastructure in the Welland system and incorporated updated population and employment growth to a 2041 planning horizon.

ES-1.2 Wastewater System Overview

A map of the Welland wastewater system is shown in **Executive Summary Figure 1**. The City of Welland wastewater flows are conveyed to the Welland Wastewater Treatment Plant (WWTP), which also receives flows from the Town of Pelham and the southern part of City of Thorold. Within the Welland WWTP system, the Region owns and operates 13 sewage pumping stations within the three municipalities and the City of Welland owns and operates an additional two small sewage pumping stations: Fitch St SPS and one for private residential buildings at the Prince Charles Drive (PCD) Condo.

The City is responsible for the local collection network and any City-owned storage or flow management facilities. The system is divided by the Welland River with combined sewer overflow (CSO) facilities along the river configured to discharge into the receiving water when necessary.



ES-1.3 Project Objectives

The overall study objective is to provide the Region and Municipalities with a strategic plan along with sewer management recommendations.

The 2020 PPCP & WW MSP Update shall provide Strategic Sewer Management Recommendations that:

- Quantify the existing level of service;
- Provide an action plan to maintain and improve levels of service;
- Mitigate sewer surcharge related basement flooding;
- Identify, prevent and ultimately eliminate combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs);
- Eliminate, reduce or delay extraneous flows; and
- Improve operation, maintenance, long-term growth and sustainability of the City's wastewater collection system infrastructure.

This statement was coupled to system performance targets relating to: sewage pumping station capacity, gravity sewer capacity, and wet weather flow characterization.

Further, a key outcome of the PPCP & WW MSP was to determine a strategy for compliance with Ministry of the Environment Conservation and Parks (MECP) Procedure F-5-5, which involves the quantification of untreated discharge released to the environment for the average year. It states the following with respect to volumetric capture of CSO. The following statement outlines the MECP F-5-5 procedure:

“During a seven-month period commencing within 15 days of April 1, capture and treat for an average year all the dry weather flow plus 90% of the volume resulting from wet weather flow that is above the dry weather flow. The volumetric control criterion is applied to the flows collected by the sewer system immediately above each overflow location unless it can be shown through modelling and on-going monitoring that the criterion is being achieved.”

Although the City is meeting the 90% treatment target for combined sewers, the MECP has indicated the system's overflow volume should not increase with growth. A net increase of bypassing will occur if no wet weather flow reductions or system upgrades are implemented.

ES-1.4 Growth and Planning

The City of Welland will experience significant growth to 2041 and beyond. The growth scenarios utilized the most recent planning data from the City which was available at the time of planning analysis. Due to delay from COVID-19, any further planning updates to 2051 will be addressed in the Region's 2021 Master Servicing Plan Update (MSPU) study.

1. **2041 Growth Scenario:** Used to determine long term upgrade needs (sizing) and short-term priorities (project triggers) for the Capital Plan to 2041. The 2041 growth numbers were aligned with the 2019 Development Charges study projections.

2. **Full-Buildout Growth Scenario:** The full build out of all developable lands will facilitate the assessment of ultimate upgrade capacity needs.

Table ES1. 2041 Growth Scenario

	Municipality	Welland	Pelham	Thorold	Total System
Existing Populations	Residential	52,628	17,560	448	70,636
	Employment	18,598	4,540	0	23,138
	Total	71,226	22,100	448	93,774
2041 Totalized Populations	Residential	70,427	25,260	10,912	106,599
	Employment	28,760	6,930	788	36,478
	Total	99,187	32,190	11,700	143,077
Buildout Totalized Populations	Residential	104,383	25,260	10,912	140,555
	Employment	28,760	6,930	788	36,478
	Total	133,143	32,190	11,700	177,033

ES-2 WASTEWATER LEVEL OF SERVICE FRAMEWORK

Execution of reasonable Level of Service (LOS) policies are essential to ensure that planning and design principles are defined and used in developing the detailed servicing strategies, implementing the system capital program, and in operation and maintenance practices. The PPCP & WW MSP outlined a set of LOS objectives that will guide how infrastructure performance is assessed and upgraded. These criteria were established after existing system performance was evaluated and LAM stakeholders were consulted on reasonable performance targets for future. The criteria are listed below.

- Region and LAM design criteria
 - Sewage generation criteria
 - Sewage loading of 275 L/capita/day
 - Harmon's peaking factor
 - Design rain derived inflow and infiltration (RDII) allowance of 0.286 L/s/ha
- Infrastructure
 - Sewers
 - Hydraulic grade line does not exceed pipe obvert using design RDII allowance 0.286 L/s/ha
 - Hydraulic grade line does not exceed basement flooding protection freeboard of 2.4 m
 - Pump stations
 - Flows exceeding capacity using design flows
 - Flows exceed capacity using design storm flows
- Design storms used for existing and future system analysis
 - City IDF curves for existing system analysis
 - City's future 2050 IDF Curve
- Characterization of catchment inflow and infiltration
 - Groundwater infiltration
 - Inflow
 - Inflow response (fast, medium, slow)
 - Average dry weather flow to peak wet weather ratio
- Performance objectives for allowable system overflows governed by the MECP and strategies for overflow management with growth
 - 100% treatment of dry weather flows
 - Greater than 90% treatment of system wet weather flows
 - No volumetric increase to existing overflows with growth areas
- Consideration of climate change impacts on the wastewater system
 - Use of 2050 IDF curves

ES-3 WASTEWATER SYSTEM PERFORMANCE ASSESSMENT

The City's wastewater system infrastructure was assessed in existing and future growth conditions against the system performance criteria.

ES-3.1 Growth Impacts

Addressing the existing high extraneous flows and/or implementation of capacity updated will be required to facilitate growth within these areas:

- Dain City SPS catchment;
- Ontario Rd SPS catchment;
- Broadway (small lots); and
- Daimler Parkway.

ES-3.2 System Wide F-5-5 Performance

The F-5-5 Procedure requires system assessment to be evaluated in an "average year". Analyses were completed using long term rain gauge data at the Region's Humberstone Landfill rain gauge which had the largest available set of data.

Long term trends were established for several variables including the total number of rainfall events, total annual rainfall depths, total duration of rainfall, median event intensity and average event duration which are summarized in Table 19. The average year was determined by normalizing the variables and determining the Least Squared Error across all variables. 2012 was determined to be the most representative of an "average year" for the F-5-5 time period and will be utilized for the average year assessment of the system.

Using the average year analysis, 2012 reported overflows and bypassing, and the modelled flows for 2015 to the WWTP, the existing system treated 99.2% of the wet weather flows to a primary level of treatment or greater in the average year. Based on total volume in the system, there is an estimated capture rate of >99% of wet weather flows, meeting the F-5-5 requirements.

Buildout growth will treat 99.0% of wet weather flows to a primary level of treatment. Although the City is and will meet the 90% treatment target for combined sewers, the MECP has indicated that overflows do not increase with growth.

Inflow and Infiltration, a trade off of wet weather flow removals for growth flows, will be required to facilitate development in the system going forward in order to prevent the volume of spills from increasing as development occurs.

ES-3.3 Key Issue and Opportunities

This section is intended to provide a high-level summary of the issues in the wastewater system and identify opportunities where infrastructure projects can facilitate growth and reduce environmental and basement flooding impacts.

The Welland system currently meets the F-5-5 criteria of treating all dry weather flow and 90% of wet weather flows in an average year, however, many pump stations overflow regularly because they are currently undersized to support the wet weather flows of the existing system using the 0.286 L/s/ha design criteria. More growth will further strain the system in wet weather

conditions which will increase the duration and frequency of overflows and increase basement flooding risks in some areas.

Welland WWTP

The Welland WWTP average flows will pass the 80% plant capacity planning trigger in the 2036-2041 time horizon, indicating that a study should be undertaken for the Welland WWTP Upgrade. The 2041 flows do not exceed 90% design/construction threshold for WWTP capacity upgrades, however the buildout growth flows do exceed the WWTP capacity and will require upgrades post-2041.

Inflow and Infiltration (I&I) Areas

The Welland system had several areas where I&I removal would be beneficial for reducing the risk of basement flooding and facilitating growth. The MECP emphasized the importance of system-wide I&I removal to offset growth flows. Areas classified as having poor or extremely poor performance in terms of I&I were flagged as Priority Areas for the undertaking of I&I reduction programs prior to capacity upgrades. I&I reduction projects do not need to be targeted in the same catchment as growth areas, which provides flexibility to target the worst performing catchments to achieve an affordable overall system I&I reduction. Growth may also occur before or during I&I reduction projects as the MECP recognized that projects can take time to demonstrate results. The City will target 25% removal of inflow and infiltration flows.

Region Facilities

Sewage pump station pumps, storage and forcemains were assessed for deficiencies from:

- Existing design flows exceeding the station operational firm capacity;
- Growth design flows exceeding the station operational firm capacity.

Priority Areas

When reviewing the gravity system performance with growth stresses, large areas showed risks of basement flooding and high I&I. Basement flooding is usually an indicator that the area is subject to high extraneous flows entering the system. Most of these areas with existing issues have growth pressures, which may not be able to proceed into development until existing system issues are resolved.

There is an opportunity to evaluate “priority areas” systematically rather than evaluate individual upgrade projects.

Ten areas that have increased basement flooding risks under the 10-year design storms are identified as PPCP Priority Areas. A priority area may meet any of the following criteria:

- Risk of basement flooding resulting from gravity sewer capacity issues;
- Risk of basement flooding resulting from pump station capacity issues;
- Combined sewer overflows active in existing or future scenarios; and
- Undersized infrastructure for growth.

The priority areas and risks are described below; further data collection in areas with low data maturity (denoted with *) will be needed to confirm the extent and severity of peak wet weather flows.

1. Broadway: The Broadway area is susceptible to basement flooding due to shallow sewers, high I&I and undersized trunk infrastructure.
2. Ontario Road SPS Catchment: This area has areas of historic basement flooding, active overflows, high I&I, and growth pressures.
3. Dain City: This area has historic basement flooding and overflows at the pump station resulting from high I&I. There are significant developments planned in the catchment which will require I&I reduction and pump station upgrades.
4. Plymouth Road*: This area has low data maturity however, the model indicates the existing wet weather flows exceed the pipe capacity which results in sewers surcharging beyond the basement flooding freeboard protection level.
5. Feeder Road SPS Catchment*: This area has low data maturity however, the model indicates the existing wet weather flows exceed the pump station capacity. There is employment growth planned in the catchment which will further exacerbate capacity issues at the station.
6. Prince Charles Drive South* (south on Lincoln Street): Wastewater sewers in the area are small diameter pipes from 250 - 300 mm. Flows are conveyed from Windsor St to the Regional Interceptor, ultimately conveyed to the WWTP by gravity. The sewer surcharging in the PCD priority area appears to be the result of the limited operational capacity of the Interceptor.
7. Clare Ave and Fitch St SPS*: Trunk infrastructure from Clare Ave and Fitch St appear to be undersized, resulting in sewer surcharging and system back up into the Clare Ave local sewers. Fitch St SPS has been flagged for potential decommissioning.
8. Woodlawn Road*: Growth from Pelham and I&I contribute to surcharging in the Woodlawn trunk sewer. This area has low data maturity and requires validation.
9. Daimler Parkway*: This area has low data maturity and has several developments planned which exceed the gravity sewer capacity. Based on the current model state, there are existing basement flooding risks which must be addressed before allowing growth to proceed.
10. Seaway Heights*: This area is flagged as having low data maturity and has growth pressures. There are several developments that can be serviced to this catchment and growth allocations for this assessment were assumed to optimize flows to the station's firm capacity. There are high wet weather flows exceeding the station capacity in existing conditions, further investigation is required before development can proceed.

ES-4 SUMMARY OF RECOMMENDATIONS

The 20-year capital plan was developed to address existing system issues and long term growth needs. The capital plan identifies the estimated cost and timing of each recommended project. Implement the capital plan per the prioritization identified. A summary of the capital plan

categories is presented in Table 2 showing City and Region projects, and provisional projects which may be needed if I&I targets are not achieved. The I&I category may be eligible for Region CSO program funding at 50% Region-City contribution.

Table ES2. Summary of Capital Plan

Category	City	Region	Provisional	Total
Sewer	\$28,212,000	\$0	\$21,219,000	\$49,431,000
Inflow & Infiltration	\$81,310,000	\$0	\$0	\$81,310,000
Sewage Pumping Stations	\$1,514,000	\$11,015,000	\$5,197,000	\$17,726,000
Total	\$111,036,000	\$11,015,000	\$26,416,000	\$148,467,000

- Complete I&I investigations in the identified I&I priority areas and implement recommendations to remove system I&I. These investigations and achieving the target removal rates are required to meet the system F-5-5 targets with projected growth.
- Broadway Priority Area
 - Broadway trunk deepening and upgrade to 600 mm
 - Local sewer reconfiguration on Perenack Ave, Marshall Ave, St George St, Santone Ave, Clifford Ave
 - I&I reduction to limit flows to 340 L/s in the Broadway trunk.
- Ontario Road Priority Area
 - Ontario Road sewer upgrade to 900 mm from Ontario Road SPS to Empress Ave.
 - Empress Ave sewer upgrades to 600 mm from Ontario Road to Sutherland Ave.
 - Sutherland Ave sewer upgrade to 600 mm from Empress Ave to Southworth Ave.
 - Ontario Road sewer extension to accommodate the full buildout of the Union Carbide lands. The City will investigate further options for Region funding or ownership for relevant sections of the proposed trunk sewer.
 - I&I reduction in Lincoln-Coventry area and Ontario South to facilitate decommissioning of L-sites and facilitate growth.
- Dain City
 - East Forks sewer upgrade to 300 mm from proposed development tie in to Crescent Drive.
 - Dain City SPS upgrades to 170 L/s to support new developments.
 - Dain City SPS tank optimization study to maximize available storage.
- Plymouth Road
 - Collect additional data to confirm flows.
 - I&I reduction to limit trunk flows to 395 L/s.
 - 370 m of 900 mm inline storage to improve system resiliency to wet weather flows if I&I reduction target is not met.

- Prince Charles Drive South
 - Collect additional data to confirm flows.
 - I&I reduction to limit trunk flows to 120 L/s.
 - 250 m of 375 mm sewers to improve system resiliency to wet weather flows if I&I reduction target is not met.
- Feeder Road SPS
 - Collect additional data to confirm flows.
 - I&I Reduction of 25% to limit flows to 125 L/s.
 - Feeder Road SPS Storage upgrade to 1,400 m³ if I&I target is not met.
- Woodlawn
 - Collect additional data to confirm flows.
 - I&I reduction to limit trunk flows to 395 L/s.
 - 1000 m of 450 mm sewers on Trelawn Parkway to improve system resiliency to wet weather flows if I&I reduction target is not met.
 - Region trunk upgrade to 750 mm on Woodlawn Road as inline storage if I&I reduction target is not met.
- Clare-Fitch
 - Upgrade Fitch St trunk sewer to mitigate basement flooding in the upstream Clare Ave sewer, if I&I target is not met.
 - Complete Clare Ave I&I Program, pre and post monitoring prior to implementing upgrade.
 - Upgrade 1000 m of existing 375 mm sewers on Clare Ave to 450 mm to improve resilience to basement flooding.
 - Study and Decommissioning of the City-owned Fitch St SPS.
- Daimler Parkway
 - Collect additional data to confirm flows.
 - 500 m of sewer upgrades on Daimler Parkway to at least 450 mm are needed to support the developments to the east of Hwy 406.
 - 150 m of new 250 mm sewer crossing Highway 406 to service the southern lands of the Hunter's Pointe development.
 - 340 m of sewer upgrade on Oxford Road to 250 mm. to support the Hunter's Pointe development. Confirmation of servicing to Hunter's Pointe is needed prior to design. This project must precede Daimler Parkway sewer upgrades.
- Seaway Heights SPS
 - Collect additional data to confirm flows.
 - I&I reduction to limit flows to the SPS to 130 L/s.
- Upgrade the Towpath SPS to 475 L/s.
- Complete the Chippawa Park sewer separation.
- City-wide I&I Program to manage I&I outside of priority areas.
- Conduct study on Welland River inflows through combined sewer overflows.
- Conduct an upgrade study for the Welland WWTP when 80% of capacity is surpassed.

In addition to the capital program, operations, maintenance, and management strategies were recommended for each wastewater system are detailed in Section 12.

- Continue objective-oriented flow monitoring strategies and programs through the City-wide flow monitoring program.
- Develop and enforce policy for new subdivision flow monitoring and acceptance criteria, with support from the Region.
- Maintain sewers, pump stations, and forcemains in a state of good repair. This can be achieved through recommended inspection programs such as CCTV, forcemain inspection and testing, and pump station drawdown performance testing. These inspections should be optimized in a program and degrading performance trends should be monitored and acted upon if necessary.
- Implement manhole and lateral inspection programs, driven and prioritized by the identified I&I priority areas.
- Hire additional staff positions to support the existing system needs and growth to meet level of service goals.
- Continue long-term annual investments on system rehabilitation and replacement based on the City's Asset Management Plan; continue to manage and prioritize this budget based on the capital plan and priority areas.

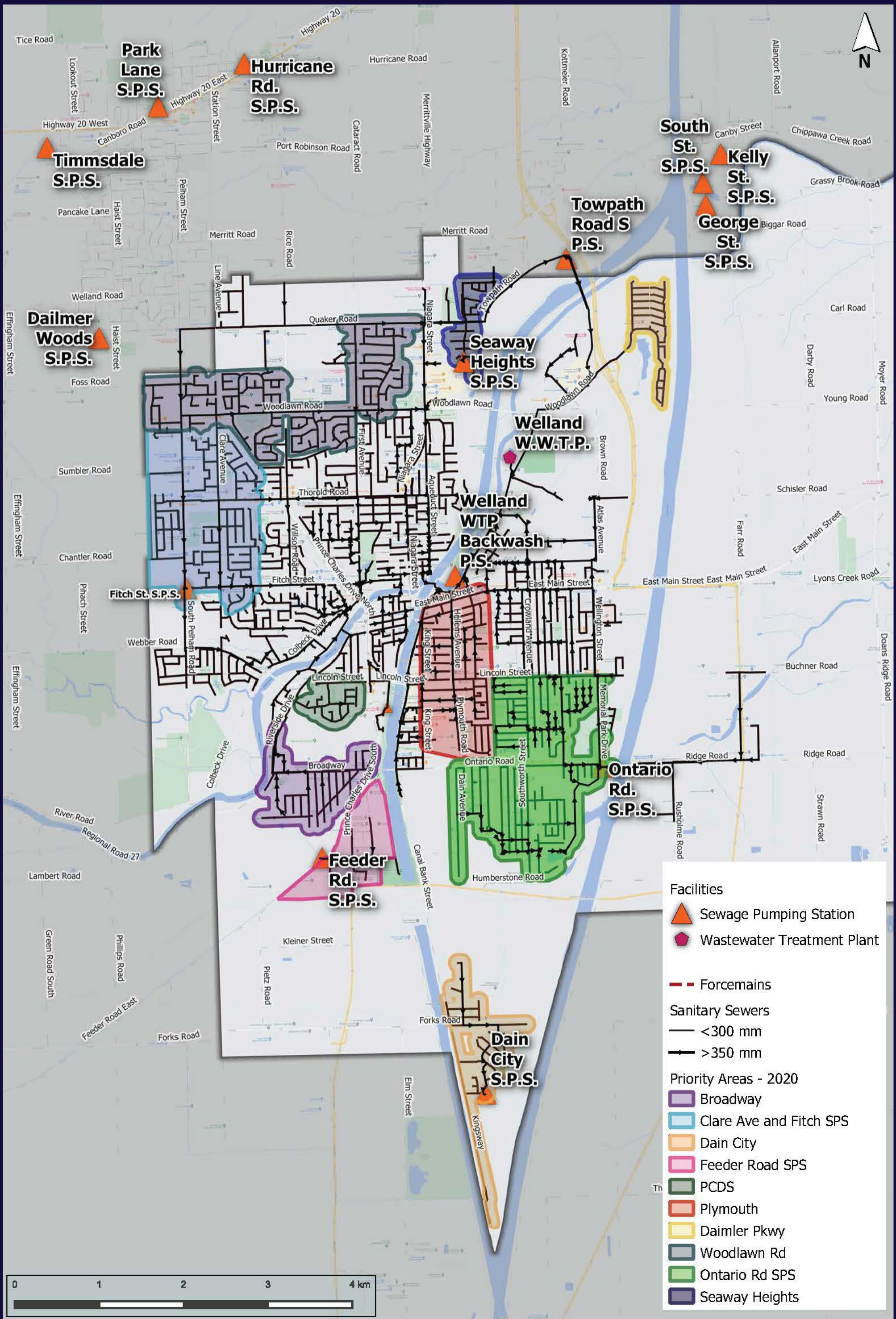


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1. INTRODUCTION

1.1 System Background

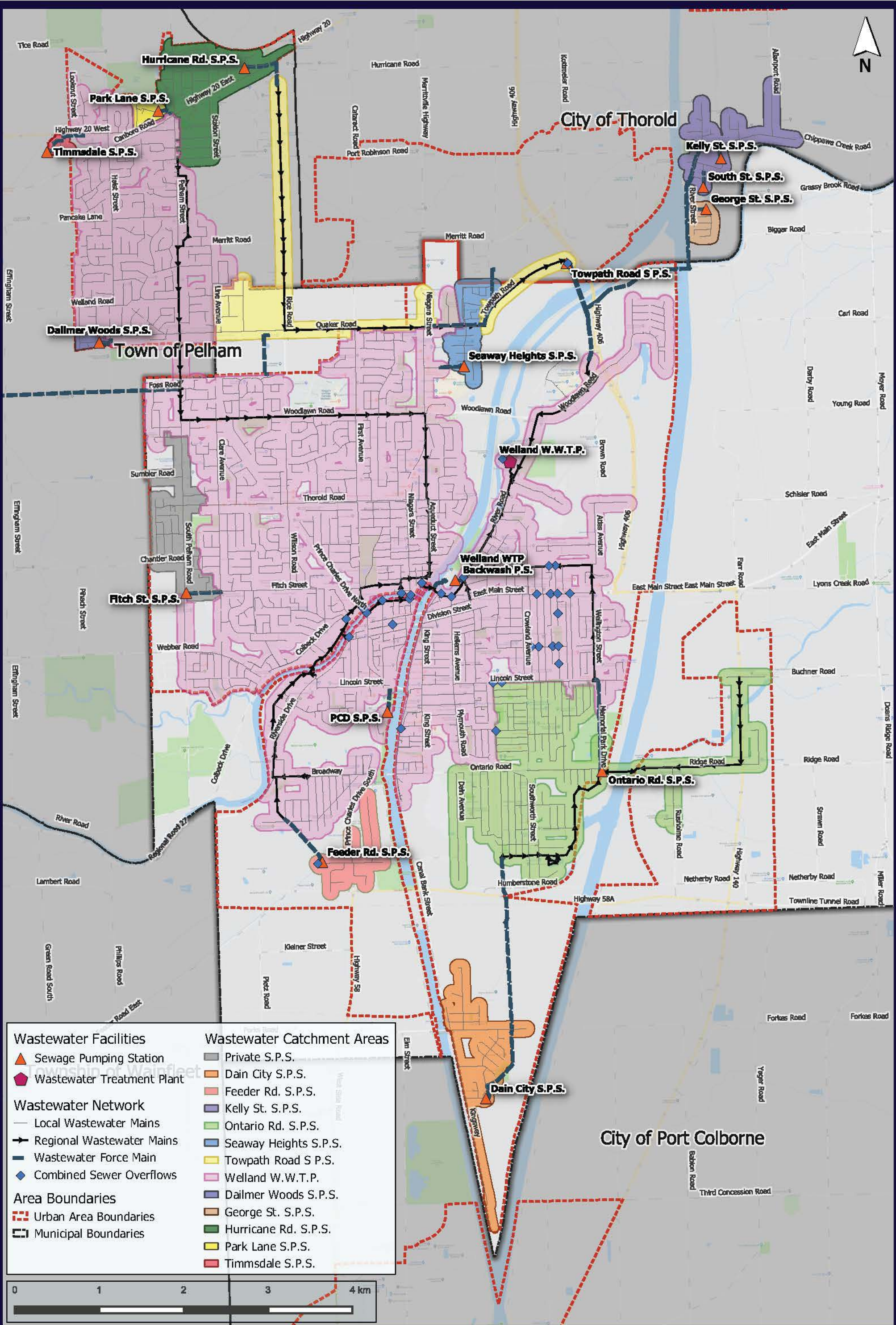
The City of Welland (City) is one of twelve local tier municipalities within Regional Municipality of Niagara (Region). The City of Welland is bounded by the City of Thorold and the Town of Pelham to the north, the City of Port Colborne to the south, the Township of Wainfleet and Town of Pelham to the west and the City of Niagara Falls and Town of Fort Erie to the east.

The City's wastewater system is managed as a two-tier wastewater treatment and collection system. The Region is responsible for treatment and trunk conveyance of wastewater flow through Region's network pumping stations, forcemains and major trunk sanitary sewers that receive flows from the local collection system. The City is responsible for the collection of wastewater flows from customers through the City owned and operated local collection system.

A map of the Welland wastewater system is shown in **Figure 1**. The City of Welland wastewater flows are conveyed to the Welland Wastewater Treatment Plant (WWTP), which also receives flows from the Town of Pelham and the southern part of City of Thorold. Within the Welland WWTP system, the Region owns and operates 12 sewage pumping stations within the three municipalities and the City of Welland owns and operates an additional two small sewage pumping stations: Fitch St SPS and one for private residential buildings at the Prince Charles Drive (PCD) Condo.

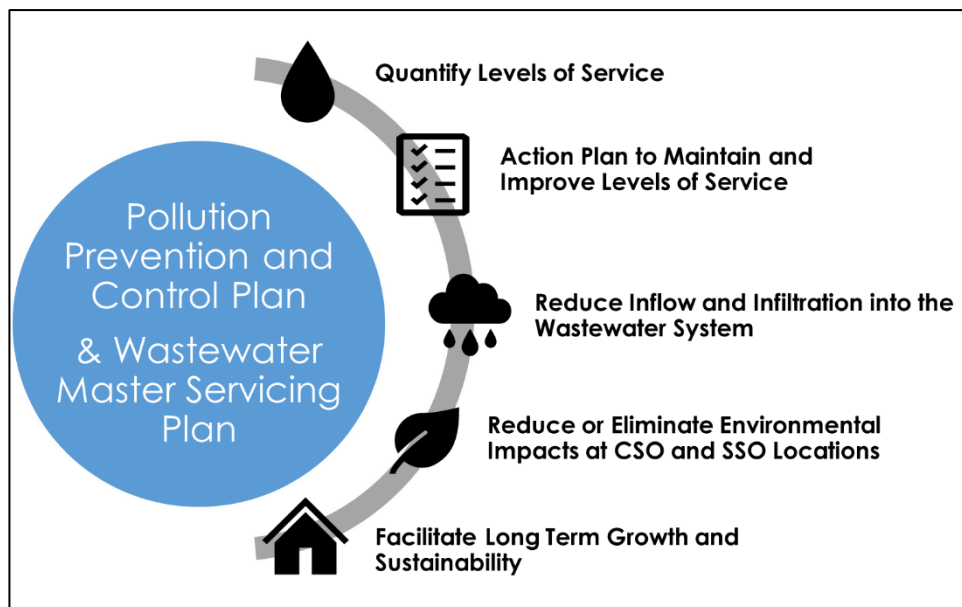
The wastewater system network within the City of Welland is comprised of approximately 300 km of linear infrastructure (gravity sewers and forcemains). The gravity sewers within the City total approximately 264 km including City owned sewers and Region owned trunks; the majority of the Welland wastewater collection system is separated, however, roughly 1.5% of the network is combined sewers. As defined within the MECP's Procedure F-5-5 - Determination of Treatment Requirements for Municipal and Partially Separated Sewer Systems, a combined sewer is "a wastewater collection system which conveys sanitary wastewaters (domestic, commercial and industrial wastewaters) and stormwater runoff through a single pipe system to a Sewage Treatment Plant (STP) or treatment works. Combined sewer systems which have been partially separated and in which roof leaders or foundation drains contribute stormwater inflow to the sewer system conveying sanitary flows are still defined as combined sewer systems."

The City reports on combined sewer overflows (CSOs) as defined in the Region *Combined Sewer Overflow Control & Wet Weather Management Policy* across the system's 17 CSO regulators. These overflows mainly occur due to significant Inflow and Infiltration (I&I) into the sanitary sewer system. Extraneous flow sources from private side connections and aging wastewater infrastructure remain problematic in many sewersheds. Rainfall derived I&I flows have resulted in the surcharging of the wastewater system and localized basement flooding.



1.2 Study Objectives

The City of Welland retained GM BluePlan to update the City's Pollution Prevention and Control Plan (and develop a Wastewater Master Servicing Plan (WW MSP), with the goal of developing a holistic long-term management plan that clearly outlines the short and long-term servicing strategy to manage the City's wastewater system. Integral to the strategy will be the clear demonstration of the City's adherence to the Ministry of Environment, Conservation and Parks (MECP) F-5-5 requirements.



As shown in

Figure 2, the objectives of the PPCP & WW MSP study are to provide the City a strategic plan along with sewer management recommendations that:

- Quantify the existing level of service;
- Provide an action plan to maintain and improve levels of service;
- Mitigate sewer surcharge related basement flooding;
- Identify, prevent and ultimately eliminate combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs);
- Eliminate, reduce or delay extraneous flows; and
- Improve operation, maintenance, long-term growth and sustainability of the City's wastewater collection system infrastructure.

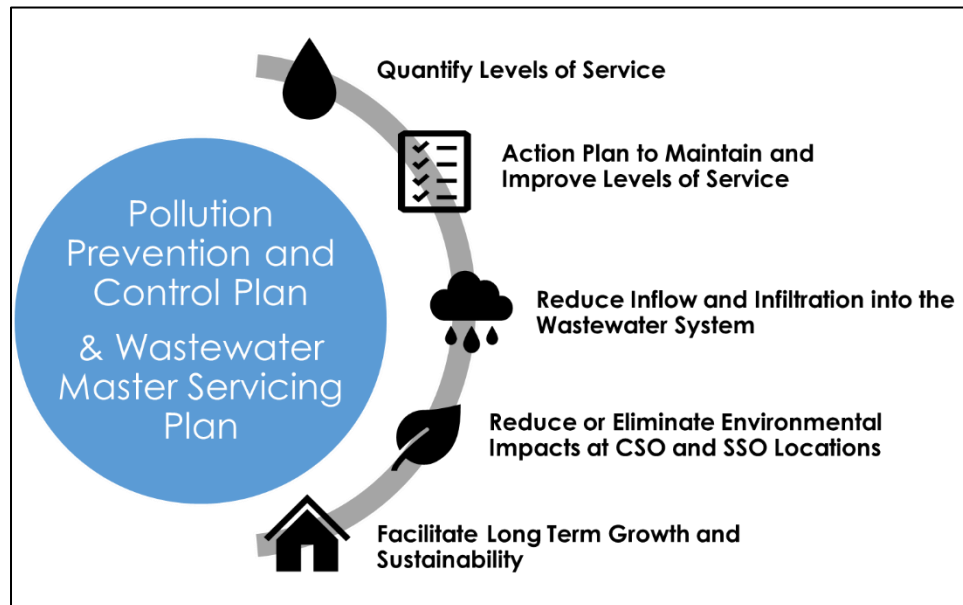


Figure 2. Study Objectives

1.3 Technical Steering Committee

To ensure the PPCP & WW MSP outcomes reflect the needs of the core stakeholders, a Technical Steering Committee was formed to provide strategic guidance throughout the project. The Technical Steering Committee consists of representatives from major stakeholders including the City of Welland, Niagara Region, and the MECP, shown in **Table 1**. The committee met throughout the project and were consulted on policy interpretation, system priorities and how to meet F-5-5 requirements moving forward with the capital plan.

Table 1. Technical Steering Committee

Name	Title	Organization
Matthew Main	Project Manager	City of Welland
Sheri-Marie Miller	Manager of Engineering Services	City of Welland
Ilija Stetic	Infrastructure Planning and Engineering Project Manager	Niagara Region
Sylvain Campbell	Provincial Officer	MECP

1.4 Primary Data Sources

1.4.1 Data Sources

Table 2 summarizes the data sources reviewed and utilized for the PPCP&MSP.

Table 2. Data Sources

City	Niagara Region
• Water billing data (2018) • GIS files – storm, sanitary, combined networks • City flow monitoring data • Growth projections • Sewer separation drawings • City budget (2019) • Public Works and Infrastructure Planning organizational chart • Public Works maintenance logs • Updated 2050 IDF (Intensity-Duration-Frequency) curve • Sanitary sewer condition and risk assessment framework • Wastewater Model (InfoSWMM)	• Region flow monitoring data (2016-2019) • Daily water treatment plant production (2013-2019) • Daily wastewater treatment plant flows (2013-2019) • Pump station drawdown tests • Historic precipitation data • Memorandum of Understanding – Wastewater Servicing (2018)

1.4.2 Previous Studies

Relevant studies that were reviewed for the PPCP & WW MSP include:

- 2001 Pollution Prevention and Control Plan;
- 2014 Cost: Benefit Assessment of an Updated Storm Drainage Design Standard;
- 2015 Comprehensive Asset Management Plan;
- 2016 Niagara Region Master Servicing Plan;
- 2017 The Corporation of the City of Welland Official Plan;
- 2018 Welland System Baseline Review and Inflow and Infiltration Program;
- 2018 Performance Report Lincoln and Coventry Overflows;
- 2018 Annual Sanitary Sewage Overflow Event Reports Empress Sewer Diversion;
- 2015-2019 Combined Sewer Overflow Reports; and
- 2019 Development Charges Study.

A brief summary of the studies and their recommendations are included in **Technical Appendix A – Summary of Previous Studies**.

1.4.3 Model Update

The City of Welland developed and maintains a wastewater hydraulic model of its wastewater collection system. The City's wastewater hydraulic model was updated from a regional trunk model to an all pipes model which was calibrated using flow monitoring data in 2017 by GM BluePlan Engineering. In support of the PPCP & WW MSP study, further review and model updates were completed using the recent Region flow monitoring data (2017-2018).

Details of the model update are included in **Technical Appendix B – Model Update**. For detailed information regarding model calibration, refer to the previous report (Welland Wastewater Model Update Report, 2017).

Additional local calibration was completed in the Broadway and Ontario Road catchments in 2020; the details on the calibration of these areas is found in their respective implementation plan reports in **Technical Appendix C – GMBP Wastewater Reports**.

2. MUNICIPAL CLASS ENVIRONMENTAL ASSESSMENT

A Master Plan and/or Pollution Prevention Control Plan is typically prepared on behalf of a Municipality, subject to approval by Council, but does not normally require approval under the Environmental Assessment Act (EAA). However, any specific projects within a Master Plan must fulfill the Class Environmental Assessment (Class EA) requirements. At a minimum, Master Plans must address Phases 1 and 2 of the Class EA process.

This section describes policy context, the class environmental assessment process and the specific requirements for the preparation of Master Plans.

2.1 Provincial Policy Statement

The Provincial Policy Statement sets the policy foundation for land use planning and development in Ontario. The Provincial Policy Statement provides guidance and support for appropriate land use planning and development while protecting resources of provincial interest, public health and safety, and the quality of the natural and built environment.

The Provincial Policy Statement applies to land use planning decisions made under the Planning Act by provincial ministers, municipal councils, local boards and planning boards, among other approval authorities. All municipal decisions affecting planning matters shall be consistent with the policies outlined in the Provincial Policy Statement.

The Provincial Policy Statement contains policies relevant to water, wastewater, and stormwater infrastructure planning included, but not limited to:

- Requirement that infrastructure be provided in a coordinated, efficient and cost-effective manner with considerations to climate change.
- Planning for infrastructure should be financially viable over their lifecycle and available to meet current and projected needs.
- Optimization of the use of existing infrastructure and public service facilities before developing new infrastructure.

More specifically, the Provincial Policy Statement recommends that wastewater services should:

- Direct and accommodate expected growth in a manner that promotes the efficient use and optimization of existing municipal water and wastewater services.
- Ensure that these systems are provided in a manner that:
 - Can be sustained by the water resources upon which such services rely;
 - Is feasible, financially viable and complies with all regulatory requirements; and
 - Protects human health and the natural environment.
- Promote water conservation and water-use efficiency.
- Integrate servicing and land use considerations at all stages of the planning process.

2.2 Environmental Assessment Act

Ontario's Environmental Assessment Act (EAA) was passed in 1975 and was proclaimed in 1976. The EAA requires proponents to examine and document the environmental effects that

could result from major projects or activities and their alternatives. Municipal undertakings became subject to the EAA in 1981.

The EAA's comprehensive definition of the environment is:

- Air, land or water;
- Plant and animal life, including human life;
- The social, economic and cultural conditions that influence the life of humans or a community;
- Any building, structure, machine or other device or thing made by humans;
- Any solid, liquid, gas, odour, heat, sound, vibration, or radiation resulting directly or indirectly from human activities; and,
- Any part of combination of the foregoing and the interrelationships between any two or more of them, in or of Ontario.

The purpose of the EAA is the betterment of the people of the whole or any part of Ontario by providing for the protection, conservation and wise management of the environment in Ontario (RSO1990, c.18, s.2). An EAA must also ensure that decisions result from a rational, objective, transparent, replicable, and impartial planning process.

As set out in Section 5(3) of the EAA, an EA document must include the following:

- A description of the purpose of the undertaking;
- The undertaking;
- The alternative methods of carrying out the undertaking; and,
- Alternatives to the undertaking.

The EA document must also include a description of:

- The environment that will be affected or that might reasonably be expected to be affected, directly or indirectly, by the undertaking or alternatives to the undertaking;
- The effects that will be caused or that might reasonably be expected to be caused to the environment by the undertaking or alternatives to the undertaking;
- The actions necessary or that may reasonable be expected to be necessary to prevent, change, mitigate or remedy the effects upon or the effects that might reasonably be expected upon the environment by the undertaking or alternatives to the undertaking; and,
- An evaluation of the advantages and disadvantages to the environment of the undertaking, the alternative methods of carrying out the undertaking and the alternatives to the undertaking (RSO1990, c.18, s.2).

2.3 Principles of Environmental Planning

The EAA sets a framework for a rational, objective, transparent, replicable and impartial planning process based on the following five key principles:

- Consultation with affected parties. Consultation with the public and government review agencies is an integral part of the planning process. Consultation allows the proponent to identify and address any concerns cooperatively before final decisions are made. Consultation should begin as early as possible in the planning process.
- Consideration of a reasonable range of alternatives. Alternatives include functionally different solutions, “alternatives to” the proposed undertaking and “alternative methods” of implementing the preferred solution. The “do nothing” alternative must also be considered.
- Identification and consideration of the effects of each alternative on all aspects of the environment. These aspects include the natural, social, cultural, technical, and economic environments.
- Systematic evaluation of alternatives in terms of their advantages and disadvantages to determine their net environmental effects. The evaluation shall increase in the level of detail as the study moves from the evaluation of “alternatives to” to the evaluation of “alternative methods”.

Provision of clean and complete documentation of the planning process followed to allow “traceability” of decision-making with respect to the project. The planning process must be documented in such a way that it may be repeated with similar results.

2.4 Class Environmental Assessment

“Class” Environmental Assessments (Class EAs) were approved by the Minister of the Environment in 1987 for municipal projects having predictable and mitigable impacts. The Municipal Class EA process was revised and updated in 1993, 2000, 2007, 2011 and 2015 and amendment is currently underway (Still ongoing as of March 2022). The Class EA approach streamlines the planning and approvals process for municipal projects that are:

- Recurring;
- Similar in nature;
- Usually limited in scale;
- Predictable in the range of environmental impacts; and,
- Responsive to mitigation.

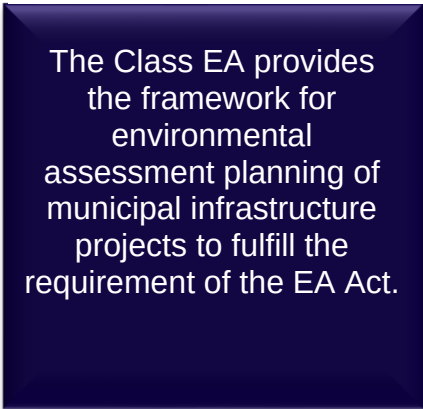
The Municipal Class EA, prepared by the Municipal Engineers Association (October 2000, as amended in 2007, 2011 and 2015) outlines the procedures to be followed to satisfy Class EA requirements for water, wastewater, stormwater management, and road projects. The five phase Class EA planning process was developed by the Municipal Engineers Association (MEA) to simplify and streamline the EAA process. The five phases are as follows:

- **Phase 1:** Problem and Opportunity Definition;
- **Phase 2:** Identification and Evaluation of Alternative Solutions to Determine a Preferred Solution;
- **Phase 3:** Examination of Alternative Methods of Implementation of the Preferred Solution;
- **Phase 4:** Documentation of the Class EA process in the form of an Environmental Study Report (ESR); and
- **Phase 5:** Implementation and Monitoring.

Projects subject to the Class EA process are classified into following four “schedules” depending on the degree of the expected impacts.



The Class EA –
A framework for environmental
planning



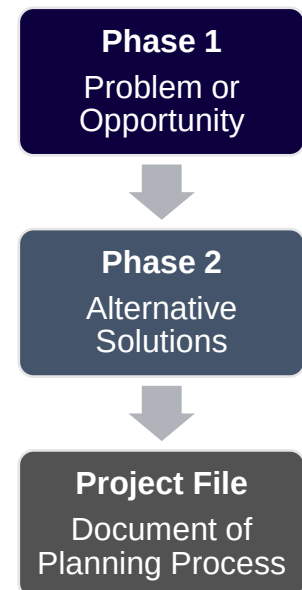
The Class EA provides
the framework for
environmental
assessment planning of
municipal infrastructure
projects to fulfill the
requirement of the EA Act.

Schedule A projects are minor or emergency operational and maintenance activities and are approved without the need for further assessment. These projects are typically smaller in scale and do not have a significant environmental effect.

Schedule A+ projects are also pre-approved; however, the public is to be advised prior to the project implementation. Although projects of this class do not usually have the potential for adverse environmental impacts, they tend to be broader in scale in comparison to Schedule A projects.

Schedule B projects require a screening of alternatives for their environmental impacts and Phases 1 and 2 of the planning process must be completed. The proponent is required to consult with the affected public and relevant review agencies. If outstanding issues remain after the public review period, any party may request that the Minister of the Environment consider a Part II Order, also known as bumping-up the project to a Schedule 'C' Class EA or an Individual EA. Provided that no significant impacts are identified and no requests for a Part II Order to a Schedule 'C' or Individual EA are received, Schedule 'B' projects are approved and may proceed directly to implementation.

Schedule C projects must satisfy all five phases of the Class EA process. These projects have the potential for greater environmental impacts. Phase 3 involves the assessment of alternative methods of carrying out the project, as well as public consultation on the preferred conceptual design. Phase 4 normally includes the preparation of an ESR that is filed for public review. Provided no significant impacts are identified and no requests for Part II Order or "bump-up" to an Individual EA are received, Schedule 'C' projects are then approved and may proceed directly to implementation.



2.5 Master Planning Process

Municipalities recognize the benefits of comprehensive, long-range planning exercises that examine problems and solutions for an overall system of municipal services. The Municipal Class EA for water and wastewater (including stormwater) projects recognizes the importance of master plans as the basis for sound environmental planning. The Class EA defines master plans as:

“Long range plans which integrate infrastructure requirements for existing and future land use with environmental assessment planning principles. These plans examine an infrastructure system(s) or group of related projects in order to outline a framework for planning for subsequent projects and/or developments.”

Master plans have distinguishing features that set them apart from project specific studies. These features include the following:

- Master plans are broad in scope and focus on the analysis of a system for the purpose of outlining a framework for the provision of future works and developments.
- Specific projects recommended in a master plan are part of a larger management system and are distributed geographically throughout the study area. The implementation of specific projects may occur over an extended time frame.

In accordance with the MEA Class EA document, a Master Plan must at least satisfy the requirements of Phases 1 and 2 of the Class EA process and incorporate the five key principles of environmental planning. The Master Plan must document public and agency consultation at each phase of the process and a reasonable range of alternative solutions must be identified and systematically evaluated.

The approach for the Master Plan is to confirm existing planned projects and where applicable, evaluate and develop any new components. This approach would also be scrutinized through a public and agency consultation process and be fully documented.

The 2020 PPCP & WW MSP follows Approach 1 of the Municipal Class EA Master Planning process. This involves preparing a Master Plan at the conclusion of Phases 1 and 2 of the Class EA process, where the level of investigation, consultation and analysis are sufficient to fulfill the requirements for Schedule A and A+ projects. In addition, Approach 1 provides the basis for future investigations for specific Schedule B and C projects.

2.6 Public Consultation

Public consultation is an essential component of any Master Plan or Pollution Prevention Control Plan. This opportunity allows the City to inform the public about the study and solicit input from potentially interested and affected parties. The main objectives of the public consultation process include:

- Presenting clear and concise information to stakeholders at key stages of the study process; and
- Soliciting community, regulatory and stakeholder input.

Table 3 contains a summary of EA activities that have been completed throughout the project.

Table 3. Environmental Assessment Activities

EA Activity	Date
Notice of Commencement and Public Information Centre No. 1	June 27, 2019
Filing Study Commencement with MECF	July 5, 2019
City of Welland Website FAQ	July 11, 2019
Public Information Center No. 1	July 11, 2019
Stakeholder List Maintenance	Throughout
Notice of Public Information Center No. 2	February 3, 2022
Public Information Center No. 2	February 3, 2022- March 4, 2022
Welland City Council Presentation	May 3, 2022
45 Day Filing	June 9, 2022
Notice of Completion	June 9, 2022

Details of the Public Consultation Process and comments received can be found in **Technical Appendix D – Summary of Public Consultation**.

2.7 Indigenous Communities

Indigenous communities were contacted through the project via mailouts, emails, and phone calls. This included opportunities to meet with the project team, notification of Study Commencement, Public Information Centres, and Study Completion. Any input received from these communities throughout the project was documented and taken into consideration. No concerns were raised about the Study or proposed Capital Program projects were raised during the consultation process. One letter was provided by the Mississaugas of the Credit First Nation identifying no concerns with the project.

The Indigenous Communities contact for this study include:

- Haudenosaunee Confederacy Chiefs Council
- Six Nations of the Grand River
- Mississaugas of the Credit

The City will notify the Indigenous Communities of any changes related to the scopes of works in the Capital Program and provide copies of all associated environmental and archaeology reports.

2.8 Vision Statement and Guiding Principles

Through the Municipal Class EA process, Phase 1 requires the identification of the problem or opportunity statement that is being addressed in the EA. The problem or opportunity statement guides the process of establishing preferred alternatives and mitigation measures to address the problem.

The City's servicing principles and policies for the development and evaluation of the PPCP & WW MSP will need to align with the Region for appropriate design and costing criteria. This will ensure reasonable, implementable, robust and sustainable servicing strategies are undertaken.

The 2020 PPCP & WW MSP shall provide Strategic Sewer Management Recommendations that:

- Quantify existing and future levels of service;
- Analyze combined sewer overflows and sanitary sewer overflows;
- Eliminate, reduce or delay inflow and infiltration;
- Enhance the City's wastewater collection system infrastructure;
- Support growth; and
- Identify a clear implementation plan.

3. 2001 PPCP WORKS COMPLETED

The previous PPCP was completed in 2001 by RV Anderson and Associates (RVA). Prior to the 2001 PPCP, 64% of the City's wet weather flows were treated and 24 CSOs were active. At the time of that study, the City was not F-5-5 compliant, meaning that the overflow volume did not meet the regulation capture rate of 90% in an average year. As a result, most of the recommendations were focused on sewer separation to eliminate a large volume of wet weather flows entering the combined sewer system.

Works completed since 2001, in relation to the PPCP recommendations, were determined from a detailed review of City engineering drawings, GIS layers and consultation with City staff, which are summarized in **Table 4**. The most significant work was the Ontario-Atlas-Wellington (OAW) sewer separation, which was completed in 2013 and separated approximately 173 ha of combined catchment areas. A map of combined sewer catchments from before 2001 and today are shown side by side in **Figure 3**.

Additionally, sewer separation of the Prince Charles Drive area and reconfiguration of City and Region sewers in the downstream Mill St area is currently in the design phase. A technical memorandum for the wastewater modelling review component is filed in **Technical Appendix C – GMBP Wastewater Reports**.

Table 4. Status of Works Based on Recommendations from 2001 PPCP

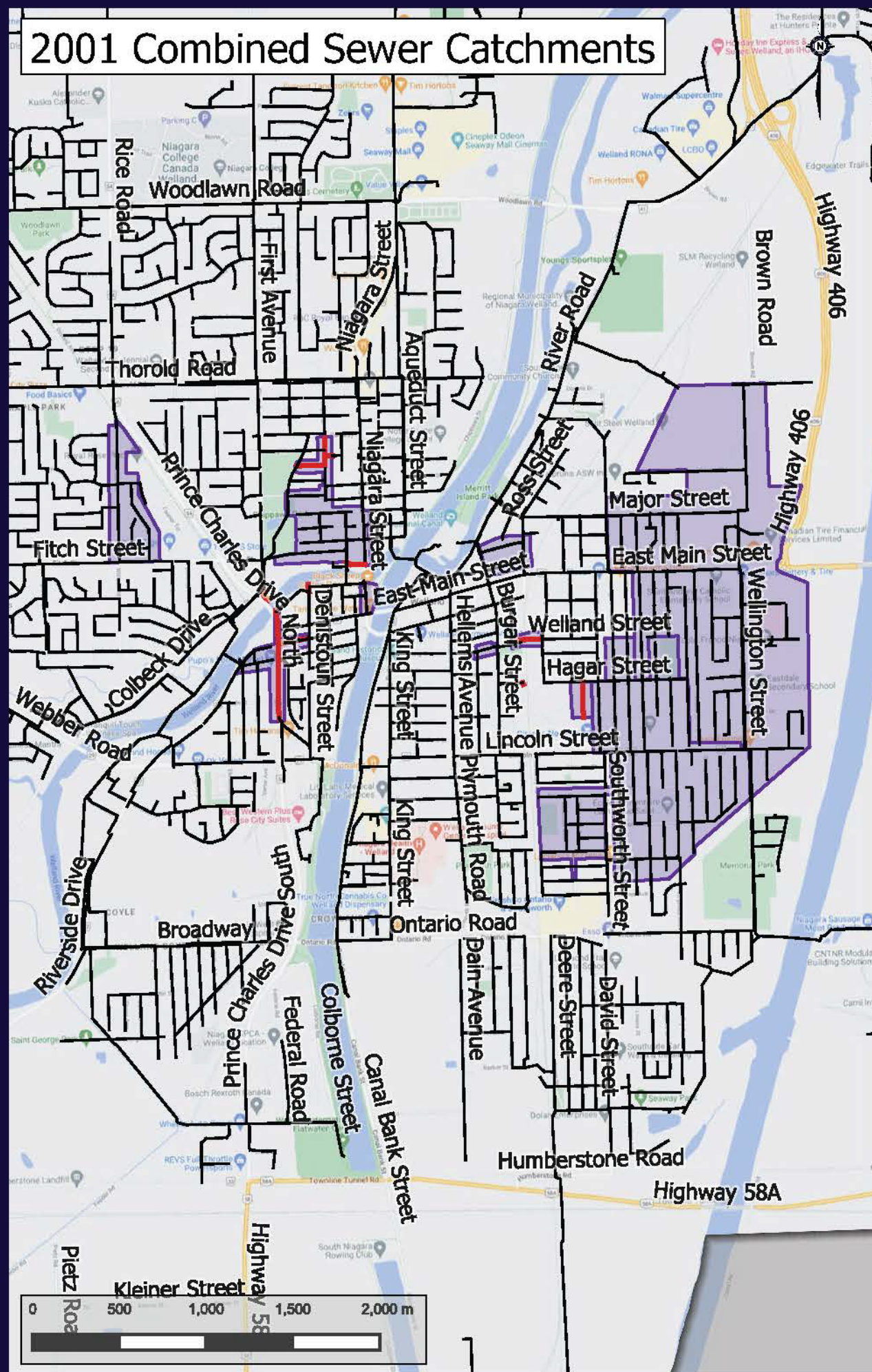
RVA Recommended Works	Project Status	Year Complete
Sewer & Manhole Maintenance and Inspection	80% complete, 20% done annually Manholes were not inspected	Full coverage to be achieved by 2020
CSO Inspection and Maintenance	Minimal information available	
SPS Maintenance	Regular maintenance has been performed	
Pollution Prevention Programs	Ongoing Sewage Water Alleviation Program (SWAP)	
Flow Monitoring Program	Ongoing 2015 to present	
Sewer Separation - Fitch McNab	Complete	2003
Primary Treatment Facility	Deferred	
Sewer Separation - Hellems Ave	Complete	2013
Sewer Separation - King St	Complete but direct storm connections from private remain	Sewer Separation complete in 1996, private connections not removed
Sewer Separation - Burgar St	Complete	2018
Sewer Separation - OAW	Complete	2007-2009, Feb 2013
Sewer Separation - Niagara/ Shotwell/Fell (Mill Street)	In progress 2022 completion	
Sewer Separation - PCD North	Complete	2013
Sewer Separation - PCD South	In progress 2025 completion	
Sewer Separation - Riverside/Maple	Complete	
Sewer Separation - Niagara South	In progress 2024 completion	

Additional related works completed by the City since 2001 that were not in the 2001 PPCP implementation plan are summarized in **Table 5**.

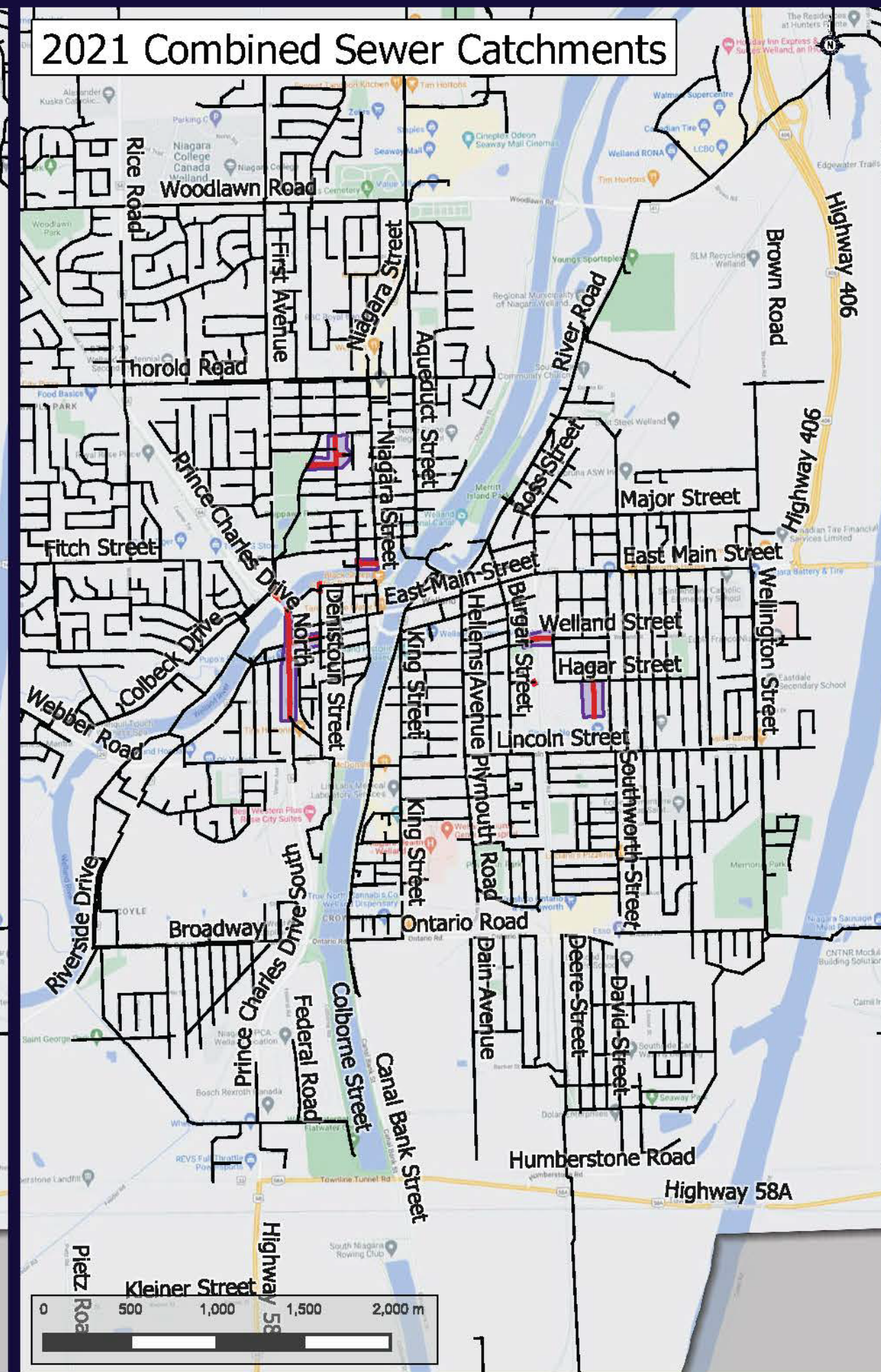
Table 5. Wastewater Infrastructure Studies and Projects

Additional Projects Completed	Description	Year Completed
All Pipes WW Model	Done	2017
Empress Area CSO Diversion to Evelyn Ditch	Empress combined sewer diverted from Lyons Creek Holding Reservoir to the Welland Canal	2016
Empire Area Catch Basin Separations	Sewer separation completed	2018
Fitch St SPS, Partial Diversion	Diversion of partial wastewater flows from Fitch SPS	2012
Lincoln St Plaza	Separation of direct storm connections from the wastewater system	2004
Downspout Inspection Programs	Numerous annual inspections of buildings (residential and commercial) for direct roof drain connections to the wastewater system	Ongoing

2001 Combined Sewer Catchments



2021 Combined Sewer Catchments



2021 Pollution Prevention Control Plan Update
& Wastewater Master Servicing Plan
Figure 3

Combined Sewer Catchments

2001 and Present

- Combined Sewers
- Sewers
- Combined Sewer Catchments

4. WELLAND WASTEWATER SYSTEM

4.1 System Overview

Located in central Niagara Region, the City of Welland covers an area of 645 km². The Region is responsible for treatment and the trunk collection network, including major SPS and large diameter trunk sewer. The City is responsible for the local collection network and any City-owned storage or flow management facilities. The system is divided by the Welland River with combined sewer overflow (CSO) facilities along the river configured to discharge into the receiving water when necessary.

Figure 1 in Section 1 is an overview map showing the wastewater system's key features including sanitary network, sewage pumping stations, combined sewer overflow locations, forcemains and the WWTP.

4.2 Welland Wastewater Treatment Plant

The wastewater system is serviced by the Region-owned Welland Wastewater Treatment Plant, located on 505 River Road. The WWTP has conventional activated sludge treatment, grit removal, effluent disinfection and tertiary filtration.

The WWTP services an existing population of 68,722 residents and 27,380 employees, which represents the three municipalities (Niagara Region MSP, 2016). Welland Wastewater Treatment Plant has a current rated capacity of 54.6 MLD and a peak flow capacity of 136.2 MLD.

4.2.1 Wastewater Flows

The WWTP has an average daily flow capacity of 54.6 MLD and the peak daily flow capacity of 136.2 MLD. Historic average and maximum treated flows at the WWTP are summarized in **Table 6**. The OAW combined sewer separation project (described in Section 3) was completed in 2014 and this is reflected in a downward trend in the average and maximum treated flows after 2014.

Table 6. Historic Treated Flows at WWTP

Year	Average Treated (MLD)	Maximum Treated (MLD)	Peaking Factor
2013	40.6	144.6	3.6
2014	35.9	105.7	2.9
2015	32.2	95	3.0
2016	29.9	92.1	3.1
2017	35.4	104.2	2.9
2018	34.6	97.7	2.8
2019	37.2	98.6	2.7
Historic Average	35.1	105.4	3.0

When compared to the Welland water treatment plant, historic flows to the WWTP show major fluctuations in seasonal flows, the highest flows being generated in the springtime. Reasons for high seasonality include increased infiltration from higher groundwater tables in spring, higher inflow response in spring due to saturated ground and high river levels with potential entry into system (unconfirmed).

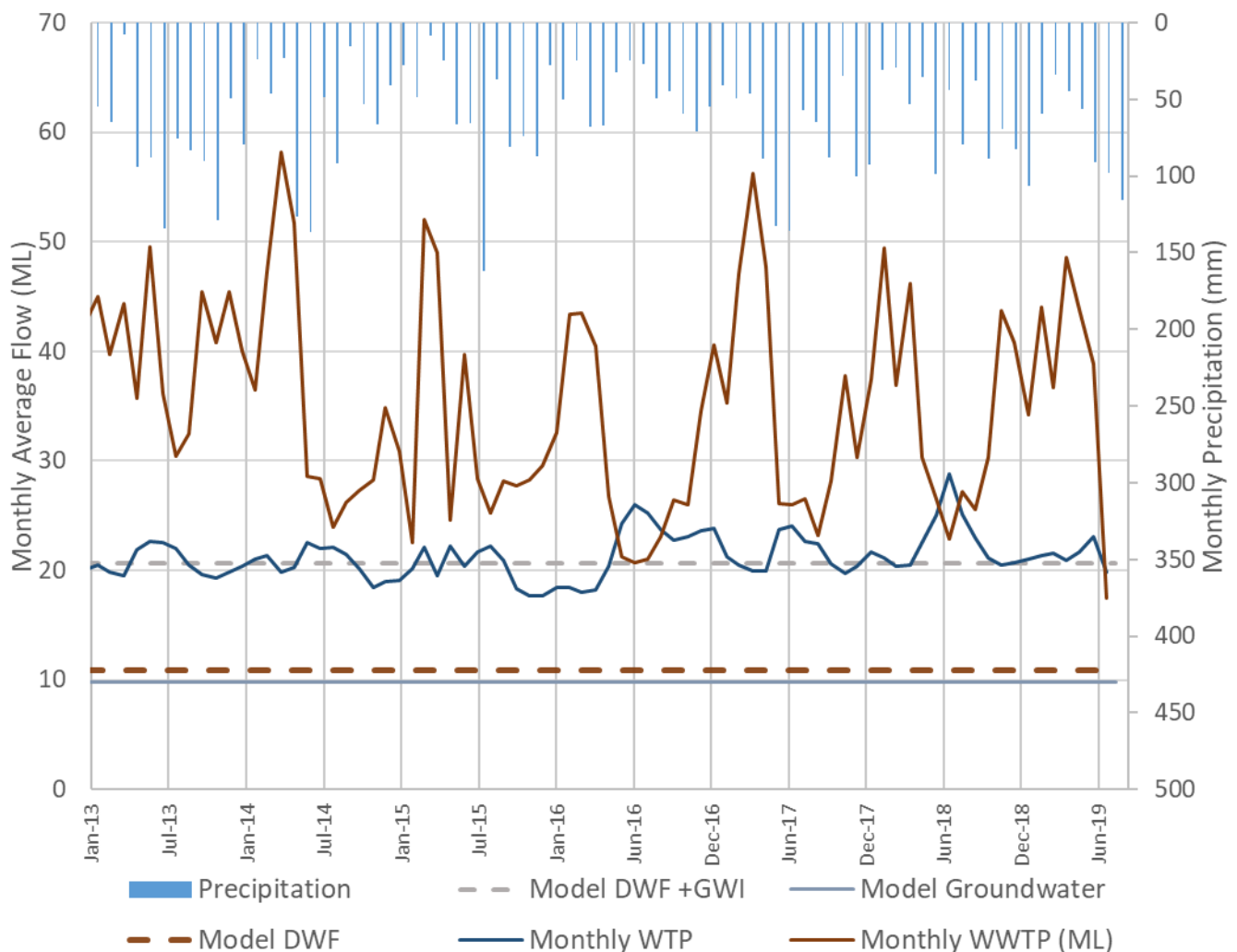


Figure 4. Monthly Average Flows - Water and Wastewater Treatment Plants

4.2.2 Dry Weather Per Capita Flows

WWTP dry weather flows were indexed to the system total equivalent population (people and jobs) to compare dry weather flow to Region design criteria of 275 L/c/d, summarized in **Table 7**. The data demonstrate a downward and levelling trend from 2013 (before OAW disconnection) to 2018, shown in

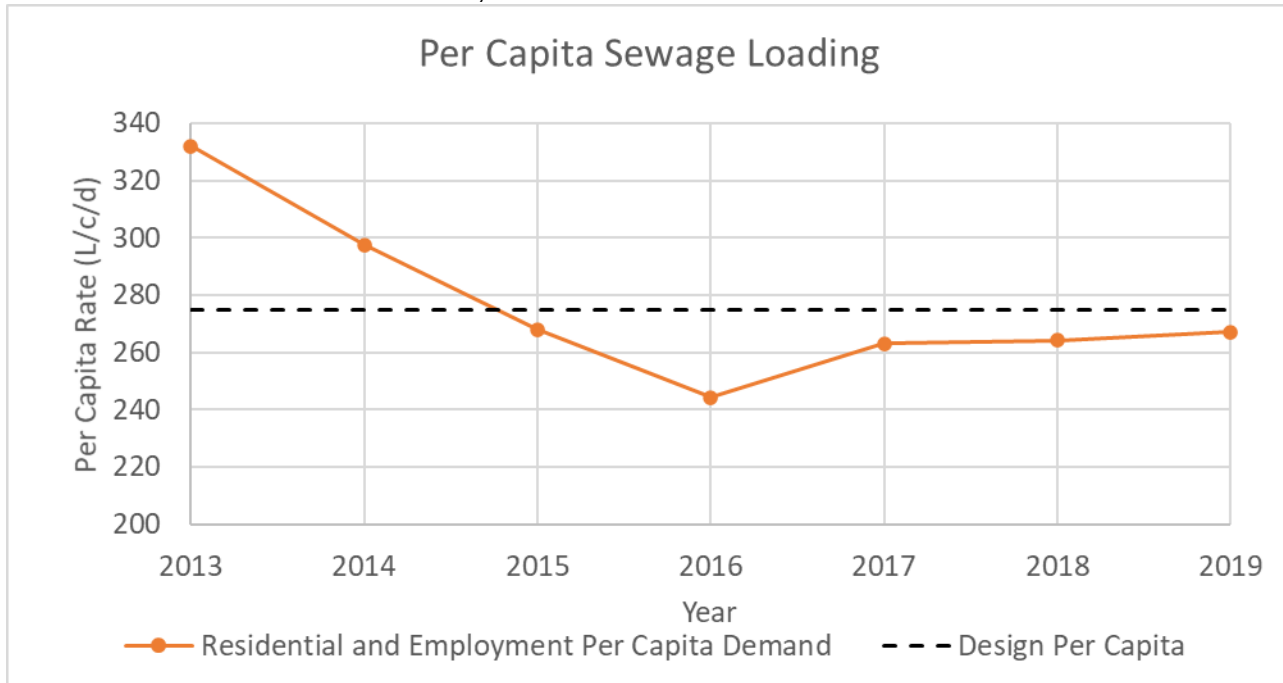


Figure 5. The WWTP data supports the dry weather flow design criteria of 275 L/c/d. Billing data from 2018 indicates a sewage loading of 145 L/c/d, assuming 90% conversion of water billing to sewage loading. This indicates approximately half of the daily WWTP flows are attributed to groundwater infiltration.

Table 7. WWTP Average Daily Dry Weather Flow

Year	Per Capita DWF (L/c/d)
2013	332.1
2014	297.7
2015	267.9
2016	244.2
2017	263.2
2018	264.3
2019	267.1

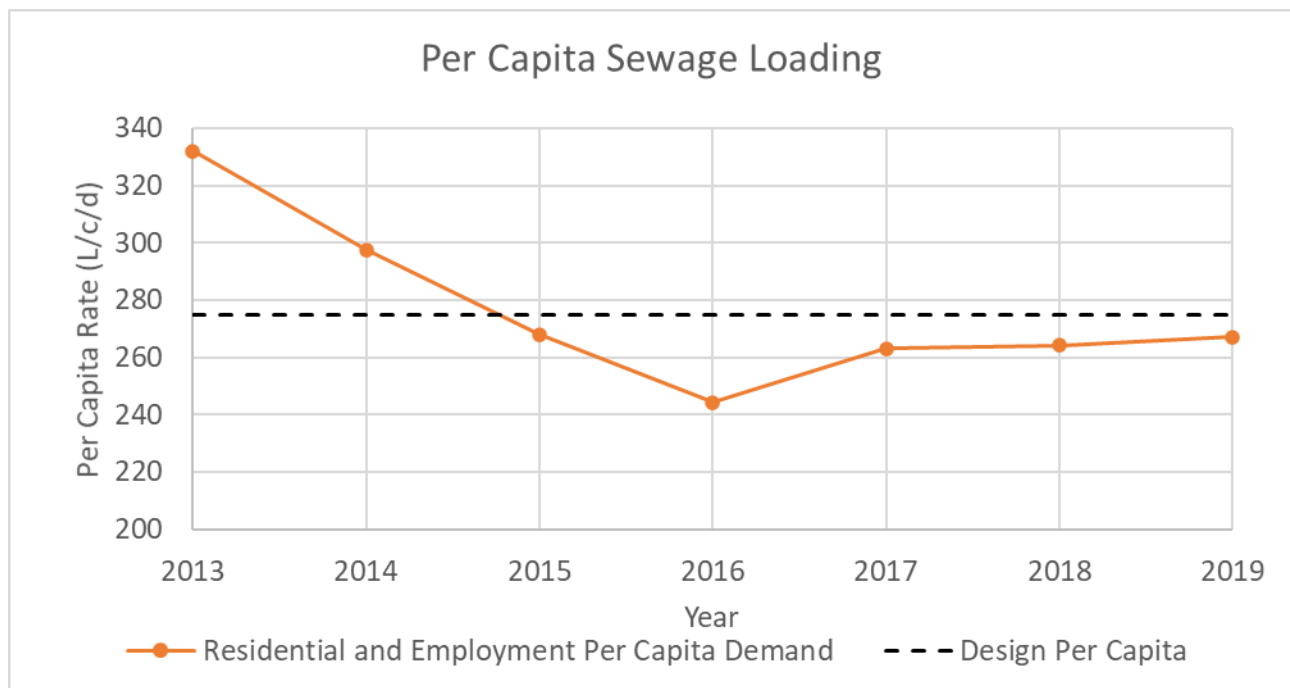


Figure 5. Per Capita DWF Trend by Year

4.2.3 WWTP Secondary Treatment Bypass

The Region reports on all secondary treatment bypass events at the WWTP. All secondary bypass volumes from the Welland WWTP receive primary treatment prior to overflow. **Table 8** summarizes the volumes by year in the disinfection season from April to October, other months and the annual total. Secondary bypass volumes for 2015 to 2018 were previously analyzed for F-5-5 reporting purposes. Rainfall analysis showed that 2016 was an exceptionally dry year, which accounts for the large difference in bypassing volumes in 2016 compared to other years.

Table 8. Secondary Bypass Volumes, in ML

Year	Disinfection Season: April to October	Other Months	Total
2015	489.9	378.8	868.7
2016	72.7	358.9	431.6
2017	688.7	546.6	1,235.4
2018	480.0	594.1	1,074.0
2019	649.5	556.1	1,205.6

4.3 Sewage Pumping Stations

The 2016 Master Servicing Plan Update recommended that Region owned sewage pumping stations be designed to accommodate the I&I design criteria of 0.286 L/s/ha. The basis for this recommendation was overall capital costs to increase the level of service beyond the design criteria.

There are 12 sewage pump stations within the Welland wastewater system (Welland, Thorold, Pelham) that are owned and operated by the Region. **Table 9** summarizes 6 pump station locations that receive flows from the City of Welland. Towpath Rd SPS was identified as requiring upgrades to 300 L/s in the 2016 Region MSP.

Table 9. Sewage Pumping Stations

Sewage Pumping Station	Municipality	Location	Number of Pumps	ECA Firm Capacity (L/s)	Operational Firm Capacity (L/s)	MSP Upgraded Operational Firm Capacity
Towpath Road SPS	Thorold	Towpath Road	2	150	141.7	300
Feeder Road SPS	Welland	Feeder Road	2	44	41	N/A
Seaway Heights SPS	Welland	Lancaster Drive	2	60	65.7	N/A
Ontario Road SPS	Welland	1200 Ontario Road	3	600	600	N/A
Dain City SPS	Welland	144 Logan Avenue	2	115	94*	N/A
Fitch St SPS**	Welland	Fitch St	2	N/A	28	N/A

* The Region is currently undertaking construction of a new forcemain for Dain City. The new forcemain will restore or exceed the ECA firm capacity of 115 L/s.

**Fitch St SPS is owned and operated by the City of Welland and only operates in wet weather .

The City also operates a small pump station at Prince Charles drive condos. No ECA or capacity information was available at the time of the study. The flows generated from these pump stations would be captured in the model from flow calibration.

An emergency bypass pump at Commercial Street is operated by public works in high wet weather flow conditions to protect the local residents from basement flooding.

4.4 Sanitary Sewer Network

4.4.1 Gravity Network

The City owns and maintains approximately 268 km of sanitary and combined gravity sewers, detailed in **Table 10**. Combined sewers represent 1.5% of the gravity network. **Figure 3** showed the remaining combined sewers in Welland. Combined sewers are generally located in the downtown core, adjacent to the Welland River. The F-5-5 defines combined sewer systems which: *have been partially separated and in which roof leaders or foundation drains contribute stormwater inflow to the sewer system conveying sanitary flows are still defined as combined sewer systems*. Therefore, while the City has completed right of way sewer separation, the majority of the sewer system is defined as combined by the F-5-5 Procedure.

Table 10. Separated and Combined Sewers

Sewer Type	Length (km)
Sanitary (Separated Right of Way)	264.0
Combined	4.1

4.4.2 Combined Sewer Overflows

There are 17 CSOs located along the Welland River and 18 CSOs in system. **Figure 6** shows all CSOs and **Table 11** and **Table 12** list CSO elevations and the map legend keys. The elevations for River CSOs were taken from the RVA CSO Schematics from the 2001 PPCP. Internal CSO elevations were sourced from GIS. Schematics for the river CSOs were developed by RVA for the 2001 PPCP Study and are included in **Technical Appendix E – RVA CSO Schematics**.

Table 11. Combined Sewer Overflows on the Welland River

Map Key	CSO	Flow Control Device	Overflow Elevation (m)
1	Downs	Weir	173.74
2	McAlpine	Weir	174.12
3	McMaster	Weir	172.21
4	Burgar	N/A	Abandoned 2018
5	Hellems	Flap gate and check valve	171.08
6	King	Flap gate and check valve	171.59
7	Aqueduct (Merritt and Lock)	Flap gate	172.27
8	Shotwell	Flap gate	173.63
9	Niagara North*	N/A	Abandoned 2018
10	Niagara South	Fiberglass check valve	171.1
11	Denistoun	Rubber duck bill valve	171.1
12	Prince Charles South	Rubber duck bill valve	171.19
13	First East	Weir	173.69
14	First West	Flap gate	171.5
15	Prince Charles North	Rubber inserted check valve	171.88
16	Colbeck	4 rubber duck bill check valves	171.51
17	Riverside and Maple	Flap gate	172.09

The City has an additional 18 internal system CSOs which overflow to the storm system or ditch network, listed in **Table 12**. CSO flow monitoring was conducted by Associated Engineering in 2018 for MECP reporting requirements for the Lincoln-Coventry Area and Empress Ave Area.

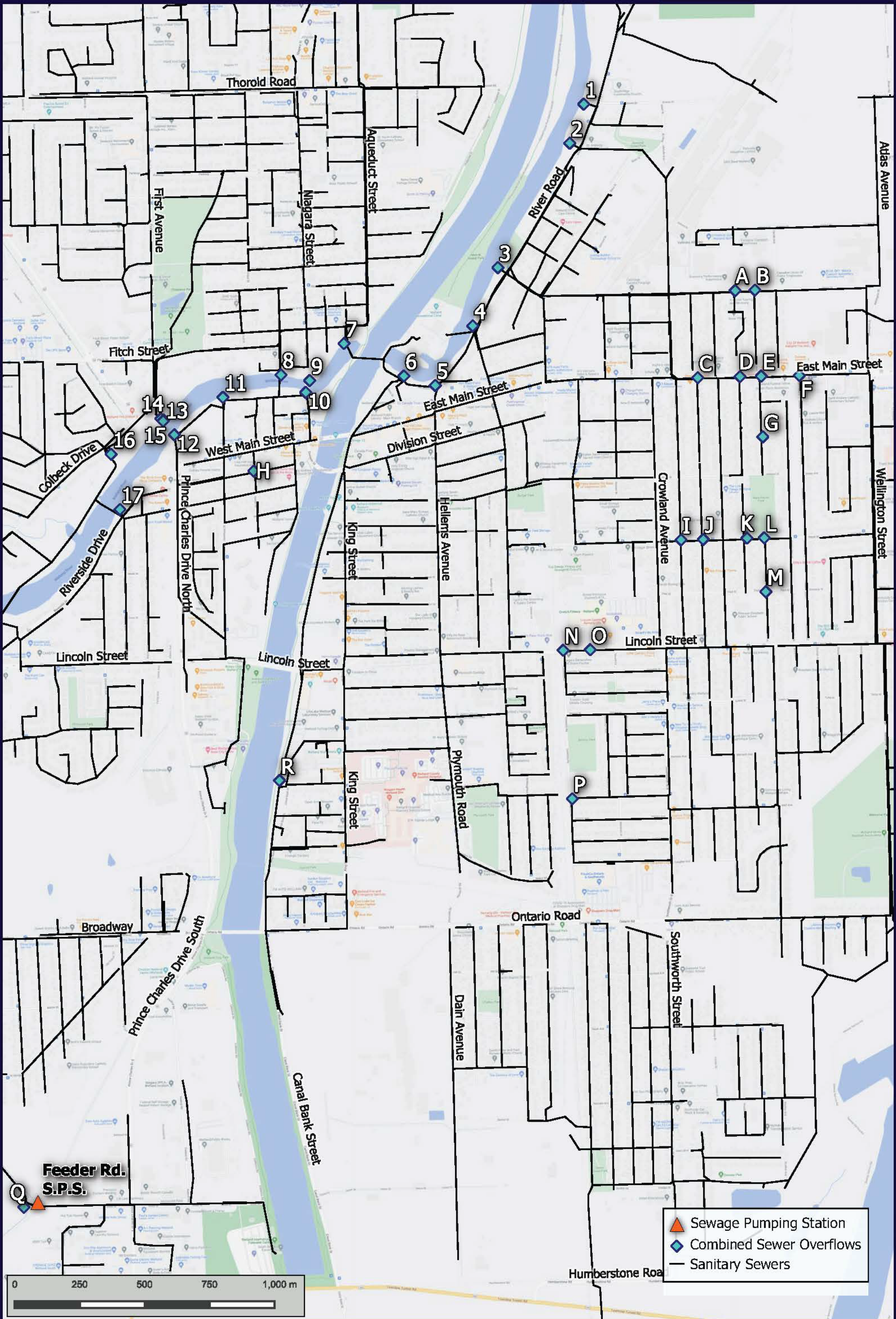
The City currently has temporary Environmental Certificates of Approval for the use of the Lincoln Coventry and the Simpson Coventry overflows, referred to as L1, L2 and L3. The amended ECA requires that these temporary overflows be eliminated by December 2022.

Additionally, there is an emergency overflow at 4th Street to the Government drain (R). This overflow is not anticipated to activate under a 25 year storm.

Table 12. Internal-System CSOs

Map Key	CSO	Overflow Elevation (m)
A	Major Brownleigh	179.62
B	Major White	179.78
C	Main Wallace	183.27
D	Main Lyons	178.13
E	Cameron Main	177.49
F	Main Golden	178.83
G	Cameron	180.33
H	Queen Bald	175.45
I	Hagar McAlpine¹	179.66
J	Hagar Wallace¹	179.03
K	Hagar Lyons	178.95
L	Hagar Camrose¹	179.42
M	Camrose Paul	179.81
N	L2: Lincoln Coventry¹	178.27
O	L3: Lincoln Plaza¹	177.8
P	L1: Simpson Coventry¹	177.5
Q	Feeder Road SPS	174.1
R	4 th Street to Government Drain	173.88

¹The overflows in Table 12 that are bolded are monitored overflows which require MECP volume reporting for each instance of overflow as well as an annual report.



5. LEVEL OF SERVICE FRAMEWORK

Development and documentation of reasonable Level of Service (LOS) policies are essential to ensure that planning and design principles and goals are defined and used in developing the detailed servicing strategies, implementing the system capital program and in operation and maintenance practices.

This section outlines a draft set of LOS objectives that will guide future investments in the system. This approach allows for an environment of continual improvement and encourages the use of informative data beyond simply 'age of pipe' to achieve a balanced investment plan.

The LOS are divided into three main categories and aim to link the analysis of system needs and replacement triggers with customer expectations. The proposed LOS are as follows:

- Customer Levels of Service: Broad, qualitative descriptions of the service to the community in terms that can be understood.
- Technical Performance Criteria: Technical descriptions (can be qualitative or quantitative) of how the City of Welland provides the service and manages the system.
- Key Performance Indicators (KPIs): Measurable metrics to indicate performance related to community or technical performance criteria, which can also be used to monitor achievement towards performance goals and validate the beneficial impact of any given investment.

The system performance criteria are intended to be medium to long-term and will form the basis of a continual improvement program by which each system investment is measured. This approach is consistent with International Best Practices for Infrastructure Planning and Asset Management and aligns fully with *O. Reg. 588/17: Asset Management Planning for Municipal Infrastructure*. This will ensure that the City is positioned appropriately for future funding opportunities from the Provincial and Federal government that mandates finite Level of Service goals for the measurement of Municipal infrastructure performance.

5.1 Levels of Service

A Level of Service workshop was held with City Staff to discuss Community LOS, Technical LOS and Key Performance Indicators for the wastewater system. The following Customer Level of Service is defined below:

To operate & maintain a wastewater collection system that is reliable, affordable and compliant while accommodating growth.

Wastewater Technical Levels of Service as defined in the City's Asset Management Plan (AMP), the following are shown in **Table 13**.

Table 13. City of Welland AMP TLOS

Service Objective	Indicator	Type
Available in urban area	Percentage of properties connected to the municipal wastewater system	Technical – O.Reg.588/17
Available in urban area	Areas/user groups of the municipality connected to the wastewater system - description/maps	Qualitative – O.Reg.588/17
Safe - Minimal overflows to the natural environment	# Effluent violations per year due to wastewater discharge compared to the # properties connected to the municipal wastewater system	Technical – O.Reg.588/17
Safe - Minimal overflows to the natural environment	Description of the effluent that is discharged from sewage treatment plants in the municipal wastewater system.	Qualitative – O.Reg.588/17
Safe - Minimal overflows to the natural environment	Description of the frequency and volume of overflows in combined sewers in the municipal wastewater system that occur in habitable areas or beaches.	Qualitative – O.Reg.588/17
Capacity during high demand or storms	# Events per year where combined sewer flow in the municipal wastewater system exceeds system capacity compared to # properties connected to the municipal wastewater system	Technical – O.Reg.588/17
Capacity even during high demand or storms	Km combined sewers	Technical – O.Reg.588/17

Service Objective	Indicator	Type
Minimal sewage backups in public or private property	# Connection-days per year due to wastewater backups compared to the # properties connected to the municipal wastewater system	Technical – O.Reg.588/17

The above LOS are essential in determining the Key Performance Indicators which couple with the Community and Technical Performance Criteria to guide in the implementation of the 2020 PPCP & WW MSP.

5.2 Technical Performance Criteria

The following section details the Technical Performance Criteria that were developed in consultation with City Staff. These criteria are quantitative measures in which the LOS and KPI will be measured and will be used to estimate growth related flows as well as the decision-making rationale related to infrastructure capacity and the trigger for upgrades.

Table 14 summarizes the wastewater system Technical Performance Criteria, which are further detailed through this section.

Table 14. Niagara Region Wastewater Design Criteria (MSP, 2016)

Flow Projection Methodology	System Performance Criteria	Flow Criteria for Growth
- Utilize starting point methodology - Starting point based on rolling average flows from last 5 years of data - Growth flows applied to starting point using design criteria	- Sizing treatment facilities for average day flows - Sizing of trunk sewer, pumping and collection system for peak wet weather flows - Firm capacity based on largest pump out of service - Plant and facility planning process triggered at 80% capacity - Plant and facility expansion complete before 90% capacity reached - System triggers as follows: - Review if sewer flows are greater than 50% of pipe full (by depth) under peak dry weather flow - Review if sewer flows are greater than 90% of pipe full (by depth) under peak wet weather flow - Review if pumping station flows based on 2 times peak dry weather flows are greater than firm capacity - Review if peak wet weather flows are greater than sewer capacity and pumping station firm capacity - Review if sewer system hydraulic grade line is within 1.8 m depth from surface under peak wet weather flow - Plan the system based on a 2-year design storm - Under the 2-year design storm, allow for a maximum extraneous flow contribution from local catchment areas.	- Residential criteria 275 lpcd - Employment criteria 275 lped - Peaking factor based on Harmon formula with values between 2.0 and 4.0 with consideration to the catchment area performance - Utilize extraneous flow rates of 0.286 L/ha/s as the wet weather Level of Service for triggering and sizing Regional wastewater infrastructure

5.2.1 Welland Wastewater Treatment Plant Capacity

The WWTP has capacity to treat for an average daily flow of 54.6 MLD and the rated capacity for peak daily flow is 136.2 MLD, summarized in **Table 15**.

Table 15. WWTP Rated Design Capacities

WWTP Rated Design	
Rated Capacity: Average Daily Flow	54.6 MLD
Rated Capacity: Peak Daily Flow Rate	136.2 MLD

5.2.2 Dry Weather Flow Projections

Starting Point Methodology

Utilizing a combination of Niagara Region daily treatment plant flow data, City water billing records and in-system flow monitoring results average day flows were identified throughout the Welland WWTP system.

Growth Flow Projections

Future average daily system flows were developed using a starting point methodology. Expected flow due to growth were added to the starting point flows to establish future flows. An example is provided below.

$$2041 \text{ ADF} = \text{Baseline ADF} + (2041 \text{ total EqP} - 2014 \text{ total EqP}) * 275 \text{ Lpcd}$$

$$44.8 \text{ MLD} = 35.6 \text{ MLD} + (129,679 - 96,106) * 275 \text{ Lpcd}$$

5.2.3 Secondary Bypass

The F-5-5 requires 90% treatment of wet weather flows from April to November. Based on existing system performance, the system is meeting the target of treating 90% of wet weather flows over the F-5-5 period. The system upgrades will need to target no increases in CSO volumes above existing levels bypassing secondary treatment at the WWTP with growth.

5.2.4 Sewage Pumping Station (SPS) Capacity

Sewage pumping stations (SPSs) in Niagara Region are owned and operated by the Region. The Region utilizes the following criteria (Niagara Region Water and Wastewater MSP, 2016) to size SPSs for long-term planning purposes.

Pumping stations are sized to provide peak wet weather flows using the (long-term) extraneous flow rate of 0.286 L/ha/s.

The following criterion is used to assess when a pumping station requires expansion:

- Capacity expansion will be triggered once the measured peak wet weather flow reaches the station's maximum capacity (firm capacity).

Once capacity expansion has been triggered, site capacity will be evaluated to determine if a new or expanded site is required.

Where the peak 1:2, 1:5 and 1:10-year design storm peak flows exceed the existing and/or planned SPS upgrades, the City's gravity sewer system performance will be evaluated in the context of the total volume passing through the station (operational capacity).

5.2.5 City and Region Design Criteria

The City's Engineering Design Standards utilize the Region design guidelines for flow generation, which are summarized in **Table 16**.

Table 16. Sewage Generation Design Criteria (Niagara Region MSP, 2016)

Criteria	Existing
Residential and Employment	275 L/c/d
Peaking Factors	Harmon
I&I Allowance	0.286 L/s/ha

5.2.6 Inflow and Infiltration

System capacity is largely contingent upon the type and extent of extraneous flow entering the system and the severity of the runoff event.

For the purposes of this analysis, system performance will be evaluated under the following wet weather conditions

- Infiltration allowance of 0.286 L/s/ha for new subdivisions;
- Actual system response under 1:10 year design storm as determined by field monitoring, using the current IDF curve; and
- Actual system response under 1:10 year design storms as determined by field monitoring, using the 2050 IDF curve for future scenarios.

Actual system wet weather response will be estimated using dynamic sewer system modelling.

5.2.7 Gravity Sewer and Basement Flooding Criteria

Basement flooding when the hydraulic grade line (HGL) exceeds a freeboard (represented by X in

Figure 7) which is higher than the basement's elevation. The City has determined that desired criteria to prevent basement flooding is to maintain a freeboard of 2.4 m, which corresponds to the property line depth requirements in the City's Design Standards.

Causes system surcharging leading to basement flooding are:

- Peak rain derived inflow and infiltration exceeding pipe capacity;
- Structural deficiencies such as pipe deflection;
- Operational deficiencies such as debris build up and blockages;
- Pumping station deficiencies resulting in system backups.

The model assumes the system is functioning as designed and does not reflect structural or operational constraints in the gravity system.

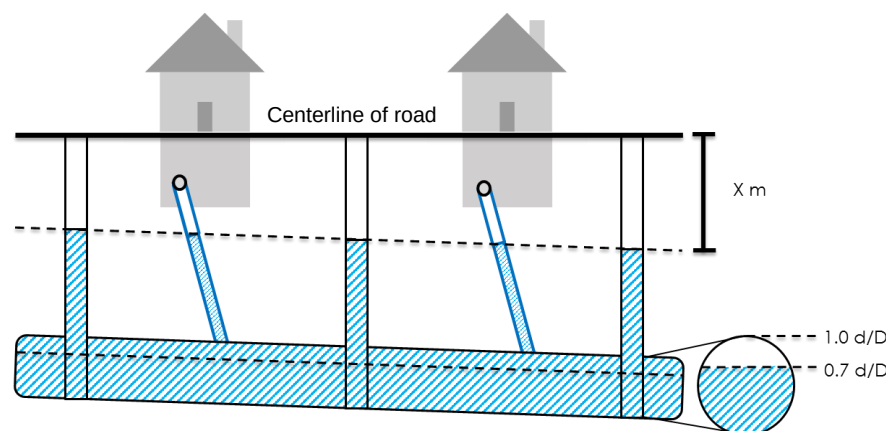


Figure 7. Sewer Surcharging Schematic

5.2.8 Existing Gravity Sewer Capacity

The performance of the gravity sewers will be evaluated on three criteria:

1. d/D : the ratio of hydraulic depth over full pipe depth;
2. q/Q : the ratio of pipe flow to Manning's Capacity flow based on diameter, slope; and
3. HGL: The hydraulic grade line of a surcharging sewer is below the City's basement protection freeboard of 2.4 m.

Combinations of meeting and exceeding the criteria result in 4 classifications: surplus capacity, restrained capacity, surcharging from downstream capacity limitation and capacity limitation causing basement flooding risk. The gravity system performance criteria and classifications are detailed in **Table 17**.

Table 17. Gravity System Performance Criteria

Sewer Classification	Hydraulic Criteria	Description
Surplus Capacity	$d/D < 1$ $q/Q < 1$	- Pipe not surcharging - Flow within pipe capacity
Restrained Capacity	$d/D < 1$ $q/Q = 1$	- Pipe not surcharging - Flow exceeding pipe capacity
Surcharging – Downstream Limitation	$d/D > 1$ $HGL \leq 2.4 \text{ m freeboard}$ $q/Q = 1$	- Pipe surcharging - HGL depth not exceeding criteria - Flow exceeding pipe capacity
Exceeds Capacity and Basement Flooding Risk	$d/D > 1$ $HGL > 2.4 \text{ m freeboard}$ $q/Q = 1$	- Pipe surcharging - HGL depth exceeding criteria - Flow exceeding pipe capacity

5.2.9 New Gravity Sewer Capacity Objective

The objective for upgrades to gravity sewers will be assessed using the City's current Engineering Design Guideline consisting of:

- Minimum and maximum velocity at full pipe capacity shall be 0.6 and 3.0m/s, respectively;
- The minimum pipe size for sanitary sewers shall be 200 mm diameter (with the exception of top end/low flow sewers which can be sized to 150 mm to maintain minimum velocity targets); and
- The minimum HGL shall be 2.40 meters cover below final grade at centreline of road.

5.2.10 Combined and Sanitary Sewer Overflows

MOE F-5-1: Determination of Treatment Requirements for Municipal and Private Sewage Treatment Works Discharging to Surface Waters

MOE Procedure F-5-1 states that:

"All sewage treatment works shall provide secondary treatment or equivalent as the "normal" level of treatment, unless individual receiving water assessment studies indicate the need for higher levels of treatment"

The procedure also contains recommendations for sewage by-pass from nominally separate systems.

The feasibility of meeting the requirements of MOE Procedure F-5-1 in the PPCP & WW MSP Study will be considered, however, the study will focus on continuing to achieve the objectives of Procedure F-5-5 with the consideration of the significant growth anticipated within the City (detailed in Section 11).

The detailed list of F-5-1 effluent design objectives, as per the Region, can be found in **Technical Appendix F – MECP F-5-1 Effluent Criteria**.

MOE F-5-5: Determination of Treatment Requirements for Municipal and Private Combined and Partially Separated Sewer Systems

The goals of MOEE Procedure F-5-5: Determination of Treatment Requirements for Municipal and Private Combined and Partially Separated Sewer Systems are stated as follows:

1. *Eliminate the occurrence of dry weather overflows;*
2. *Minimize the potential for impacts on human health and aquatic life resulting from Combined Sewer Overflows;*
3. *Achieve as a minimum, compliance with body contact recreational water quality Provincial Water Quality Objectives for Escherichia coli at beaches impacted by Combined Sewer Overflows for at least 95% of the four-month period (June 1 to September 30) for an average year.*

The Technical Criteria from MOE Procedure F-5-5 that are required for the Study are as follows:

- *No overflows during dry weather;*
- *Maximize the use of the collection system for the storage of wet weather flows when capacity is available; and*
- *During a seven (7) month period commencing within 15 days of April of an average year, provide 90% volumetric control of wet weather in addition to all of the dry weather flow.*

Additionally, Section 11 of the F-5-5 Regulation mandates that:

“When and where significant combined sewer system deficiencies exist, the Regional Office of the Ministry shall require that the provision of sanitary servicing for additional development tributary to the deficient system be curtailed to prevent aggravation of the problem until the necessary upgrading, as outlined by a Pollution Prevention and Control Plan is carried out in keeping with the requirements of this Procedure. Some development is allowed as upgrading proceeds, conditional upon its progress. The staged upgrading should at a minimum provide for the transmission and treatment of all flows from the additional development. This provision applies to significant development i.e. not to simple, one lot infill cases.”

Therefore, the PPCP Capital Plan will need to take out an equivalent volume of wet weather flows as the City would like to add for new developments, City-wide. Development approvals will

not be limited in advance of the I&I removal but it is encouraged that the City remove I&I at a similar rate of development.

5.2.11 Climate Change

Considerations for climate change will be incorporated into the future scenario analysis by utilizing the City's 2050 IDF for wet weather scenarios. The 2050 IDF curve was developed with AMEC consulting in 2014 and is documented in the report: *Cost Benefit Assessment of an Updated Storm Drainage Standard*, filed in **Technical Appendix G - Welland IDF Update**.

The future 10-year design storm increases the total depth and peak one-hour intensity of rainfall by 26% from the existing IDF curve. This additional rainfall will cause additional I&I to enter the wastewater system and likely contribute to additional overflows; therefore, the infrastructure upgrades will consider increased wet weather flows for sizing of upgraded infrastructure and similarly I&I programs will need to target removing and preventing I&I from entering the wastewater system.

Table 18. Climate Change IDF Curve

	10 y Existing	10 y 2050	Difference
Depth (mm)	80.1	100.8	26%
Peak 1 h (mm/h)	34.9	43.8	26%

5.3 Key Performance Indicators

The following Key Performance Indicators will be further refined and supported through a series of discussions with City Staff, review of current Best Practices in our industry and GM BluePlan staff experience. Recommendations for criteria and KPIs in this PPCP & WW MSP Study will align with the City's 2016 Asset Management Plan Priorities for effective sustainable infrastructure. The project approach, analysis and recommendations will also be consistent with current Region and MOECC Guidelines.

6. ASSESSMENT OF AN AVERAGE PRECIPITATION YEAR

This section is intended to outline the City of Welland's precipitation, allocation approach and assumptions which will be used to support the City's Pollution Prevention Control Plan and Master Plan. Selecting a suitable rainfall year as representative of an 'average year' sets up a transparent and repeatable framework for analysis and forecasting. The growth projections will be used to estimate future system demands and ultimately determine growth related infrastructure needs.

Long term precipitation analysis was completed using data from the Region's Humberstone Landfill rain gauge for April to October from 1998 to 2018. Long term trends were established for several variables including the total number of rainfall events, total annual rainfall depths, total duration of rainfall, median event intensity and average event duration which are summarized in Table 19. The average year was determined by normalizing the variables and determining the Least Squared Error across all variables. 2012 was determined to be the most representative of an "average year" for the F-5-5 time period and will be utilized for the average year assessment of the system.

Table 19. Long Term Annual Rainfall Trends for F-5-5 Period

Year	No. of Rainfall Events	Annual Rainfall Volume (mm)	Annual Rainfall Duration (hrs)	Average Event Rainfall Volume (mm)	Median Event Rainfall Intensity (mm/hr)	Average Event Rainfall Duration (hrs)
1998	48	348.8	489.3	7.3	1.7	10.2
1999	47	423.5	623.7	9.0	0.7	13.3
2000	38	557.0	708.9	14.7	1.1	18.7
2001	48	404.3	742.9	8.4	0.7	15.5
2002	52	464.0	652.3	8.9	0.9	12.5
2003	55	503.8	740.0	9.2	0.7	13.5
2004	53	672.3	739.6	12.7	1.3	14.0
2005	42	490.8	549.3	11.7	1.3	13.1
2006	51	687.8	763.9	13.5	1.0	15.0
2007	39	357.8	559.1	9.2	0.7	14.3
2008	55	513.5	803.3	9.3	0.8	14.6
2009	45	649.3	732.9	14.4	0.9	16.3
2010	49	541.5	646.7	11.1	1.0	13.2
2011	46	639.0	959.5	13.9	0.7	20.9
2012	52	510.0	687.3	9.8	1.0	13.2
2013	46	694.0	719.1	15.1	1.0	15.6
2014	53	539.0	718.5	10.2	0.9	13.6
2015	43	572.8	586.6	13.3	1.1	13.6
2016	42	308.8	461.3	7.4	0.8	11.0
2017	54	613.3	793.8	11.4	0.9	14.7
2018	43	500.5	751.5	11.6	0.7	17.5
Average	47.67	523.4	687.1	11.0	0.9	14.5
Median	48	513.5	718.5	11.1	0.9	14.0
Standard Deviation	5.1	109.9	112.3	2.4	0.3	2.4

7. GROWTH AND DEVELOPMENT

This section is intended to outline the City of Welland's growth projections, allocation approach and the assumptions which were used to support the City's Pollution Prevention Control Plan and Master Plan. The growth projections will be used to estimate future system demands and ultimately determine growth related infrastructure needs. Due to COVID-19 and cut off dates to complete analysis, the planning projections provided by the City at the time of this study are to the 2041 planning horizon. City Growth Studies

The City's Official Plan was updated in 2017; the Official Plan is a statutory document which determines the City's long-term land use plan for growth and development. The Official Plan identified growth numbers and areas to 2031.

In 2019, the City completed a Development Charges Background Study and By-Law Update, through which a detailed projection of growth numbers for residential and employment populations to 2041 was developed, summarized in **Table 20**. The Development Charges Study did not identify specific growth areas for the total projections. Projected growth to 2041 anticipates an additional 17,799 people and 10,162 jobs in the City.

Table 20. Summary of Welland Population Projections from Development Charges Study (2019)

Year	Residential	Employment	Total Equivalent Population	% Increase from 2019
2019	52,628	18,598	71,226	
2031	63,174	22,890	86,064	20.8
2041	70,427	28,760	99,187	39.3

7.1 Data Sources

The City provided the following three shapefiles with locations and unit counts for future developments:

- Future Development Areas
 - Consists of draft plans that have been submitted to the City.
 - This file includes a growth area outside of the urban boundary.
- Intensification Lands
 - Consists of infill development areas in the downtown core.
- Plan Land Supply
 - Represents all other developable lands parcels and the land use from the Official Plan (residential or employment).

Residential population was estimated from the unit counts provided by the City for each development using the average persons per unit (ppu) identified as part of the 2019

Development Charges, listed in **Table 21**. A summary of future development areas provided by the City are provided in **Table 22** and shown in **Figure 8**.

Table 21: Unit Densities by Household Type, Development Charges Study (2019)

Unit Type	Persons Per Unit (ppu)
Single and Semi Detached	2.49
Multiples (Townhomes)	2.24
Apartments (2+ Bedrooms)	2.12
Apartments	1.2
Average	2.29

Table 22: Summary of Planning Data

Shapefile	Area (ha)	Residential Population	Employment Population	Total Equivalent Population
Future Development Areas	489.0	34,098	-	34,098
Intensification	26	7,557	-	7,557
Plan Land Supply	270	3,858	4,205	8,063
Subtotal	785	45,513	4,205	49,718
Future Development Area Outside of Urban Boundary	189	6,236	-	6,236
Total	1,095	29,138	4,205	48,812

The Future Development Areas and Intensification layers were assumed to be residential populations only.

Based on the total land supply, there is substantially more residential growth and less employment growth than the DC study identified for 2041.

Table 23 shows the difference between growth projections from the City planning numbers (2019) and Development Charges Study (2019).

Table 23: Comparison of City Growth Projections to Development Charges Study

Scenario	City Projections (within Urban Boundary, Low Scenario)	Development Charges Study 2019
Residential	38,371	17,799
Employment	4,205	10,162

7.2 Growth Scenarios

Two scenarios are proposed to determine long term upgrade needs (sizing) and short-term priorities (project triggers) for the Capital Plan to 2041:

1. 2041 growth scenario; and
2. High density buildout scenario.

7.2.1 2041 Growth Scenario

The 2041 growth scenarios assume buildout inline with the City's DC growth projections. For the purpose of growth allocation, the following assumptions were applied:

Residential: The DC Study projected 17,799 people for 2041. All Plan Land Supply parcels and downtown intensification were allocated at 100%. The draft plan populations identified in the full build out were allocated proportionally to match the DC study total residential population for 2041 to meet the 17,799 target. Remaining draft plans were assigned in the Buildout Scenario.

Employment: The 4,205 jobs were allocated to the lands identified in the Plan Land Supply shapefile. An additional 5,957 jobs were allocated across all existing employment lands, as identified in the City's Official Plan to match the DC Study employment population of 10,162 jobs.

7.2.2 Build Out Scenario

The full buildout of all developable lands will facilitate the assessment of ultimate upgrade capacity needs, summarized in **Table 24**. Low and high growth estimations were reviewed to evaluate sensitivity to changes in capacity triggers. In general, it was found that:

- There was minimal difference in project triggers and sizing when comparing the low and high population scenarios; and

- Existing and proposed draft plans had development densities generally inline with the high population scenarios.

As such, for the purposes of the PPCP & WW MSP the high growth scenario was used to represent the build out conditions.

Table 24: Full Welland Buildout Sensitivity

Scenario	Residential Population Growth	Employment Population Growth	Total Equivalent Buildout Population
Low	29,138	10,162	39,300
High	51,755		55,960

For the purpose of growth allocation, residential growth will be allocated inline with the City's identified growth areas and employment growth will be allocated in same manner as the 2041 Growth Scenario.

7.3 Contributing Communities

The Welland wastewater system receives flows from the City of Thorold and Town of Pelham.

7.3.1 Thorold

The growth numbers used in the City of Thorold Water Master Servicing Plan (WMSP) were applied to this Study for areas that will contribute flows to the Welland Wastewater System. Growth in Thorold was allocated to the Towpath Rd Sewage Pumping Station Catchment.

7.3.2 Pelham

The growth allocations for the Town of Pelham were assumed to be same as in the Region's 2016 Master Servicing Plan.

7.4 Growth Summary

The entire Welland WWTP population for the growth scenarios are totalized in **Table 25**.

Table 25. Growth Scenario Summary

	Municipality	Welland	Pelham	Thorold	Total System
Existing Populations	Residential	52,628	17,560	448	70,636
	Employment	18,598	4,540	0	23,138
	Total	71,226	22,100	448	93,774
2041 Totalized Populations	Residential	70,427	25,260	10,912	106,599
	Employment	28,760	6,930	788	36,478
	Total	99,187	32,190	11,700	143,077
Buildout Totalized Populations	Residential	104,383	25,260	10,912	140,555
	Employment	28,760	6,930	788	36,478
	Total	133,143	32,190	11,700	177,033

7.5 Allocation and Servicing of Growth Areas

The allocation of growth areas to the wastewater system is based on:

- Proposed servicing strategies based on previous draft planning approval processes;
- Previous completed development servicing reviews; and
- High level assessment of existing grading and potential servicing strategies.

Servicing assumptions should be confirmed at the draft planning approval stage to re-confirm the servicing strategy.

7.5.1 Infill and Redevelopment Areas

Infill and redevelopments areas that are not considered greenfield lands were allocated to the closest node to the property or across multiple nodes in a larger area, such as downtown core intensification.

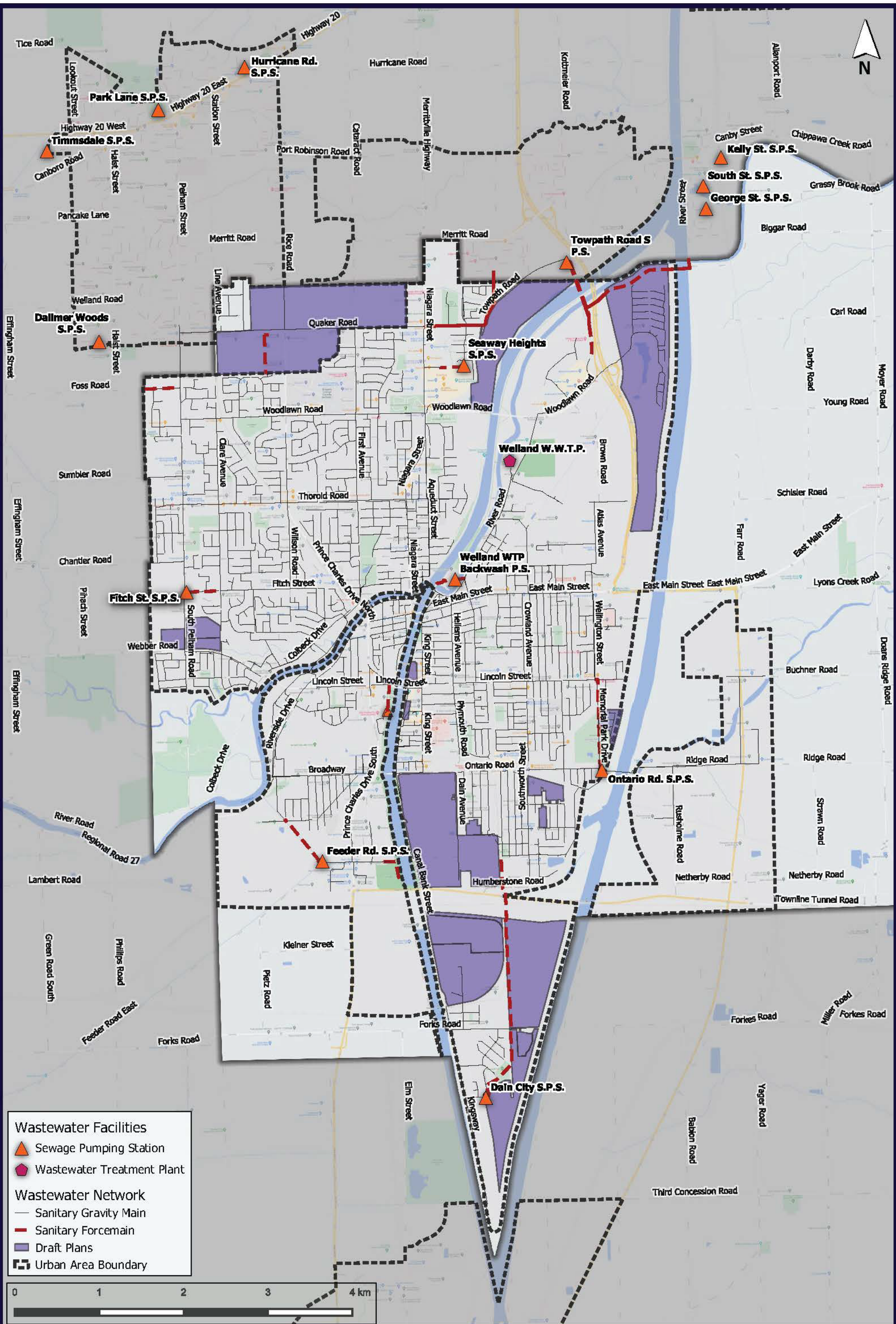
- Allocation for intensification in the downtown core was loaded across all nodes in the downtown area.
- The Welland Official Plan was utilized to distribute employment growth across existing employment lands to match the Development Charges Study Projection of 10,162 jobs.
- Existing service connections were assumed to be maintained.

7.5.2 Various Major Development Areas

Draft plans are development areas which started the draft plan approval process through the City, shown in **Figure 9**. Flows were allocated to the address specified in **Table 26**. Servicing to sites with existing functional servicing reports were maintained.

Table 26. Draft Plan Model Allocation

Development Name	Location	Loading Point	Estimated Population	Area (ha)	ADWF (L/s)	RDII (L/s)
Albert Street	1 Albert Street	280020306	492	2.1	1.6	0.0
Broadway-various	Multiple lots in the Broadway neighbourhood. Service to closest pipe.	Closest manhole to lot	1,688	10.5	5.4	3.0
Chaffey Street	309 Chaffey Street	280019343	103	2.7	0.3	0.8
Denistoun Street	240 Denistoun Street	280022238	202	0.8	0.6	0.0
Empire Homes	South of Ontario Road between Canal Bank Street and Dain Avenue	10001310	8,000	80.0	25.5	22.9
Empire Homes - Dain City Residential	Located north of Forks Rd to Townline Tunnel Road, Michigan Street to Welland Canal	280019518	2,990	72.1	9.5	20.6
Empire Homes - John Deere	Located East of Canal Bank Street between Townline Tunnel Road and St. Clair Drive	280019698	3,200	74.6	10.2	21.3
Forks Common	Located South of the furthest East segment of Forks Road	280019518	190	4.3	0.6	1.2
Fusion Homes	Located East of Kingsway between Talbot Avenue and Haun Road	280019548	492	35.6	1.6	10.2
Hunters Pointe	Located west of Hunters Pointe, Between HWY 406 and Welland Canal, East Main St to Daimler Pkwy and north limit. Servicing to Daimler Pkwy.	280018402	2,500	82.5	8.0	23.6
Hunters Pointe	Located west of Hunters Pointe, Between HWY 406 and Welland Canal, East Main St to Daimler Pkwy and north limit servicing to Oxford Rd	280018425	1,240	27.0	3.9	7.7
King Street	439 King Street	280019316	298	1.3	0.9	0.0
Louise and Iva Street Area	South end of Louise Street	280021297	142	2.1	0.5	0.0
Louise Street Area	Between Sauer Avenue, Southworth Street and Ontario Road	280021135	185	4.1	0.6	0.0
	Between Sauer Avenue, Southworth Street and Ontario Road	280021120	93	4.1	0.3	0.0
Northern Reach	Located East of Towpath Rd, Woodlawn Road to north limit	280021413	3,100	15.7	9.9	4.5
	Located East of Towpath Rd, Woodlawn Road to north limit. Possible Servicing to Seaway Heights	10001444	7,244	36.8	23.1	10.5
Seaway Mall Development	Redevelopment of Seaway Mall Parking lot and Target. Proposed servicing to Seaway Heights SPS.	280021416	1,409	5.0	4.5	0.0
Sparrow Meadows Phase 7	Located north west corner of South Pelham Rd and Webber Road intersection	280022541	172	5.9	0.5	1.7
Viger Estates	East of Memorial Park Drive at Laurent Avenue and Quebec Avenue	280019241	50	7.5	0.2	2.1
West Creek	Located at north east corner of South Pelham Rd and Webber Rd intersection 1	280022478	158	9.0	0.5	2.6
	Located at north east corner of South Pelham Rd and Webber Rd intersection 2	280022478	151	5.2	0.5	1.5
North-West Urban Expansion	Located from Clare Avenue to Niagara Street, Eastwood Drive to northern urban boundary limit	10001405	6,240	164.2	19.9	47.0



8. WASTEWATER SYSTEM PERFORMANCE ASSESSMENT (EXISTING AND FUTURE)

The purpose of this section is to assess the wastewater system infrastructure (Section 4) in existing and future growth conditions against the system performance criteria (Section 6). Once the existing system conditions were established, the impacts of future flows and climate change on the wastewater system were analyzed to develop and evaluate potential servicing alternatives and address potential deficiencies and opportunities. Any system deficiencies will be addressed through Sections 9-12.

The following performance indicators are used as a basis for the City's 20-year capital program by flagging areas in the existing system which may require upgrades. System performance under existing, Growth to 2041 and Growth to Ultimate Buildout scenarios are presented in the following sections. The performance indicators are:

- 8.1 – WWTP Capacity and Secondary Bypass
- 8.2 – Sewage Pumping Stations
- 8.3 – Inflow and Infiltration Indicators
- 8.4 – Gravity System Indicators (pipe capacity)
- 8.5 – CSO/F 5-5 Indicators

Section 8.6 will summarize the Key Issues and Opportunities in the Welland Wastewater System.

8.1 Wastewater Treatment Plant

8.1.1 Treatment Plant Capacity

The capacity of the WWTP is 54.6 MLD. **Figure 10** presents the projected future average daily flows to the Welland Wastewater Treatment Plant (WWTP). The flow projections include contributions from neighbouring communities of Pelham and Thorold with a focus on growth to 2041. Growth flows for the buildout scenario have also been presented in the figure.

Average flows to the plant from 2015 to 2019 were 33.9 MLD. Projected flow to 2041 is 46.4 MLD, which exceeds 80% of the plant's existing capacity. The buildout scenario average flows total 55.7 MLD, which exceeds the plant's existing capacity.

The Region MSP identified a study trigger at 80% plant capacity and design/construction at 90% plant capacity. The WWTP will surpass the 80% capacity study trigger in the 2036-2041 time horizon.

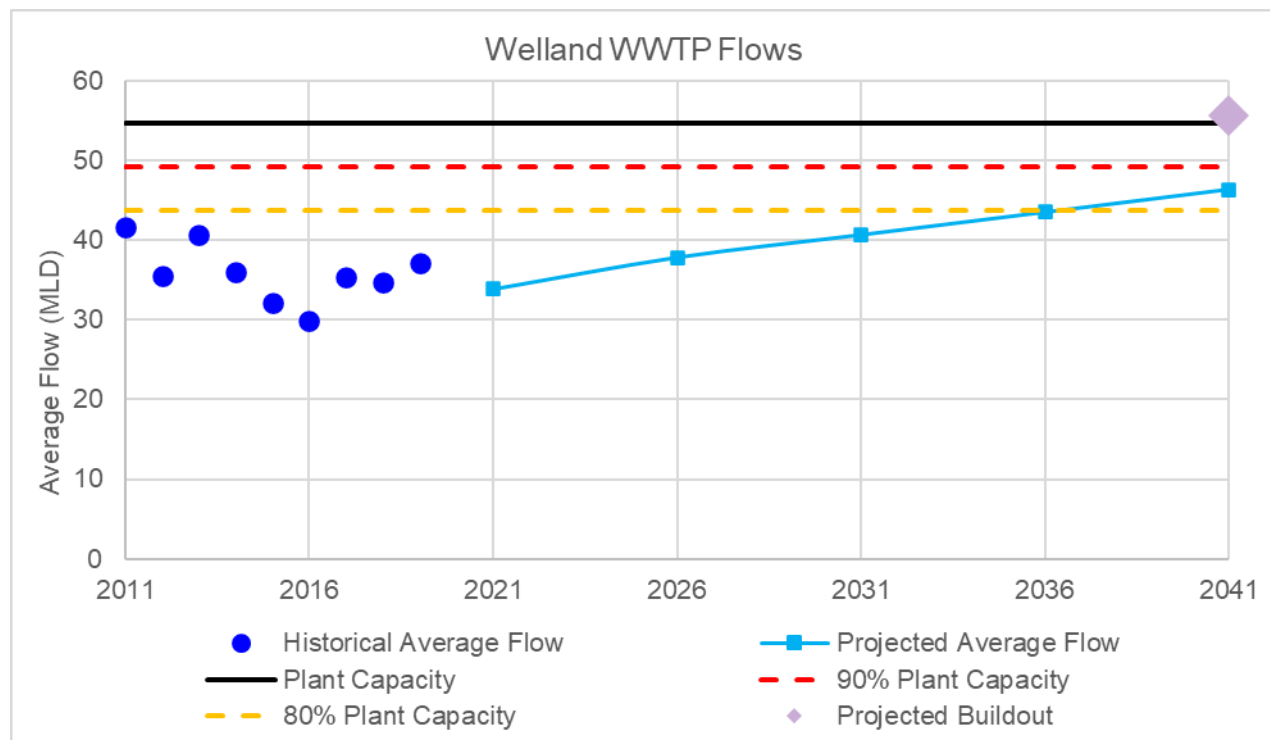


Figure 10. Welland WWTP Flow Projections to 2041 and Buildout

8.1.2 Secondary Treatment Bypass

The volume and duration of WWTP secondary bypasses are reported to the MECP for each bypass event. A summary of bypassed flows in the disinfection season from April to November from 2015 to 2019 are presented in **Table 27**. Future bypass volumes were estimated using the average of the last 5 years and the assumption that new growth areas will contribute peak wet weather flows at a rate of 0.286 L/s/ha.

Table 27. Historic and Estimated Future Secondary Bypasses

Year	Total Overflow Volume (ML)	Duration (h)
2015	489.9	381.9
2016	72.7	71.6
2017	688.7	428.8
2018	480.0	315.0
2019	649.5	506.3
2041	662.9	340.7
Buildout	804.5	340.7

Though the City anticipates implementing appropriate inspection and monitoring practices to minimize the addition of new extraneous flow contributions to the system, growth is anticipated to generally raise baseline flows, which will result in reduced capacity to manage existing extraneous flow. A net increase of bypassing will occur if no wet weather flow reductions or system upgrades are implemented.

8.2 Sewage Pumping Stations

The 2016 Master Servicing Plan Update recommended that Region owned sewage pumping stations be designed to accommodate the I&I design criteria of 0.286 L/s/ha. The basis for this recommendation was based on overall capital costs to increase the level of service beyond the design criteria.

The Region reviews SPS upgrades beyond firm capacity and the 0.286 L/s/ha criteria on a case by case basis. The 2016 MSP identified Towpath SPS as a station requiring upgrades to meet 2041 needs. The 2016 MSP recommended I&I reduction programs to be undertaken within the City to reduce flows exceeding SPS capacity and ultimately wet weather flows to the WWTP and to decrease the secondary bypass volumes at the plant.

Table 28 shows the peak flows to the sewage pumping stations from the model.

Existing Conditions

- Peak flows to the pump stations are below the operational firm capacity using design RDII 0.286 L/s/ha.
- All peak flows to pump stations exceed station capacity when considering design storm flow scenarios.
- The 2016 MSP recommended I&I programs be undertaken prior to evaluating upsizing SPS in Welland.
- Towpath Rd SPS has a planned capacity upgrade to 300 L/s from the 2016 MSP.

Growth to 2041

- Peak flows at the following stations exceed the operational firm capacity using design RDII 0.286 L/s/ha:
 - Towpath Rd SPS.
- All peak flows to pump stations exceed station capacity when considering design storm flow scenarios.
- Towpath Rd SPS future flows exceed the 2016 MSP capacity upgrade to 300 L/s from the 2016 MSP.

Growth to Ultimate Buildout

- Peak flows at the following stations exceed the operational firm capacity using design RDII 0.286 L/s/ha:
 - Dain City SPS
 - Towpath Rd SPS.
- Towpath Rd SPS future flows exceed the 2016 MSP capacity upgrade to 300 L/s from the 2016 MSP.

Table 28. Pump Station Flows

							Peak Flow to Station								
							Existing			2041			Buildout		
Sewage Pumping Station	Location	Number of Pumps	ECA Firm Capacity	Operational Firm Capacity	Catchment Area (ha)	Buildout Catchment Area (ha)	DWF	RDII	10y	2041 DWF	2041 RDII	2041 10y	Buildout DWF	Buildout RDII	Buildout 10y
Dain City SPS	144 Logan Avenue, Welland	2	115*	94	103.3	290	9.3	38.8	247.7	19.0	55.1	302.7	83.3	145.1	341.4
Feeder Road SPS	Feeder Road, Welland	2	44	41	55.8	59.8	4.6	21.0	71.8	8.2	25.3	140.8	8.2	25.3	139.9
Fitch St SPS	Fitch St Welland	2		28	Overflow SPS	Overflow SPS	1.0	11.7	79.2	1.2	12.2	107.9	1.2	12.2	92.9
Ontario Road SPS	1200 Ontario Road, Welland	3	600	600	371.8	521.2	109.8	238.4	974.9	159.5	288.2	956.4	247.5	397.5	1,122.6
Seaway Heights SPS	Lancaster Drive, Welland	2	60	65.7	46.2	61.9	3.8	17.7	100.8	8.0	22.5	117.0	44.1	61.7	129.7
Towpath Road SPS	Towpath Road, Thorold	2	150	141.7	289.3	602.1	9.8	77.6	421.6	132.1	382.7	632.6	220.9	519.8	684.9

*The Region is currently undertaking construction of a new forcemain for Dain City. The new forcemain will restore or exceed the ECA firm capacity of 115 L/s.

8.3 Inflow and Infiltration

I&I sources within the Welland system are likely to be from multiple sources including existing defects within the ageing public and private infrastructure, combined sewers, private side contributors such as directly connected downspouts and weeping tiles, cross-connections from stormwater systems and overland flow entering through potential entry points.

Table 29 summarizes the existing system peak rain derived inflow and infiltration (RDII) rates by major catchments as shown in Figure 11.

Table 29. I&I System Performance

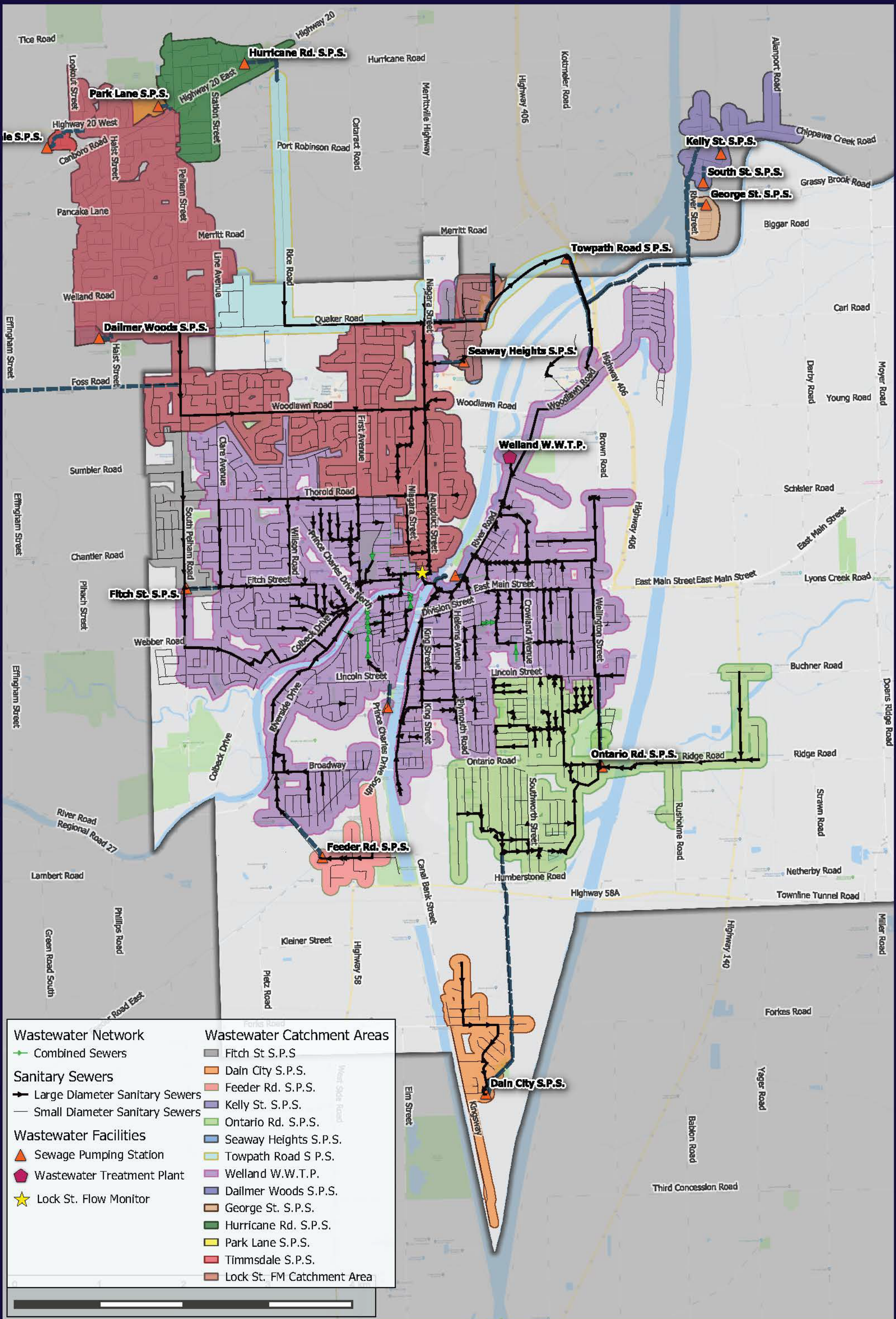
Catchment	Unit RDII (L/s/ha)					
	2Y	5Y	10Y	25Y	50Y	100Y
Dain City SPS	2.1	2.1	2.5	2.6	2.6	2.9
Feeder Road SPS	1.6	1.9	2.1	2.3	2.5	2.6
Fitch St SPS	1.3	1.6	1.8	1.8	2.0	2.9
Ontario Road SPS	1.5	1.6	1.7	2.2	2.5	2.7
Seaway Heights SPS	1.7	1.9	2.1	2.3	2.4	2.5
Towpath Road SPS	1.8	2.0	2.1	2.5	2.7	2.9
Lock St FM	5.7	6.4	6.9	7.7	8.3	8.8
WWTP	1.5	1.8	1.9	2.1	2.2	2.2

- The design criteria for RDII is 0.286 L/s/ha. All catchments exceed the design criteria by a factor of at least 6.
- The catchments with the highest unit RDII contributions in Welland are:
 - Lock St FM: shows very high I&I. While this catchment also receives flows from Pelham, the Pelham contributions can be monitored from the Pelham flume and the majority of contributions are attributed to the Welland system.
 - Dain City SPS: As determined in the Dain City Flooding investigation in 2018, the Dain City area has high I&I and lacks stormwater infrastructure to manage and prevent inflows from entering the wastewater under wet weather conditions.
 - WWTP: The majority of the WWTP catchment is comprised of separated and semi-separated sewers, with a small percentage of combined sewers. Therefore, the I&I flows are mostly from separated and semi-separated areas.

While the City anticipates implementing appropriate inspection and monitoring practices to minimize the addition of new extraneous flow contributions to the system, growth is anticipated to generally raise baseline flows, which will result in reduced capacity to manage existing extraneous flow. The strategy to accommodate growth would then be to eliminate 1 L/s of extraneous flow for every 1 L/s of growth added to the system. The F-5-5 specifies that:

“Monitoring of wastewater flows and overflows should be undertaken at locations within the sewer system for the purposes of assessing upgrading requirements and determining compliance with Ministry requirements.”

Addressing the existing high extraneous flows and/or implementation of capacity upgrades will be required to facilitate growth and encourage the City to remove I&I at a similar rate of developments.



8.4 Gravity System

The dynamic hydraulic model was utilized to determine the performance of gravity sewers under different wet weather scenarios. The criteria for gravity sewer performance is described in Section 7.5. The scenarios for Existing, Growth to 2041 and Growth to Ultimate Buildout conditions were:

- Dry weather flow;
- Design criteria for RDII, 0.286 L/s/ha; and
- 10-year design storm.

The model results showed which pipes or pump stations were insufficient or peak RDII in an area may cause localized flooding. The existing system performance for gravity sewers under 10-year design storms for existing flows as well as under Growth to 2041 and Growth to Ultimate Buildout scenario flows are shown in **Figures 12-14**, respectively.

The system performance maps for all remaining scenarios are in **Appendix H – System Performance Maps**. Corresponding to the system performance maps, the total length and percentage of surcharging sewers by scenario and criteria are summarized in **Table 30**.

In existing conditions, the 10-year design storm scenario surcharges approximately 35% of the system's sewers, 21% of which exceed the HGL criterion for basement flooding.

Adding growth generally exacerbates surcharging where existing issues are present. Sewers outside of the identified priority areas, which currently surcharge in the 10-year storm, but the freeboard exceeds 2.4 m also exceed the freeboard in the growth scenarios.

Alternatives to accommodate growth and reduce existing system flooding will be explored in **Sections 9 and 10**.

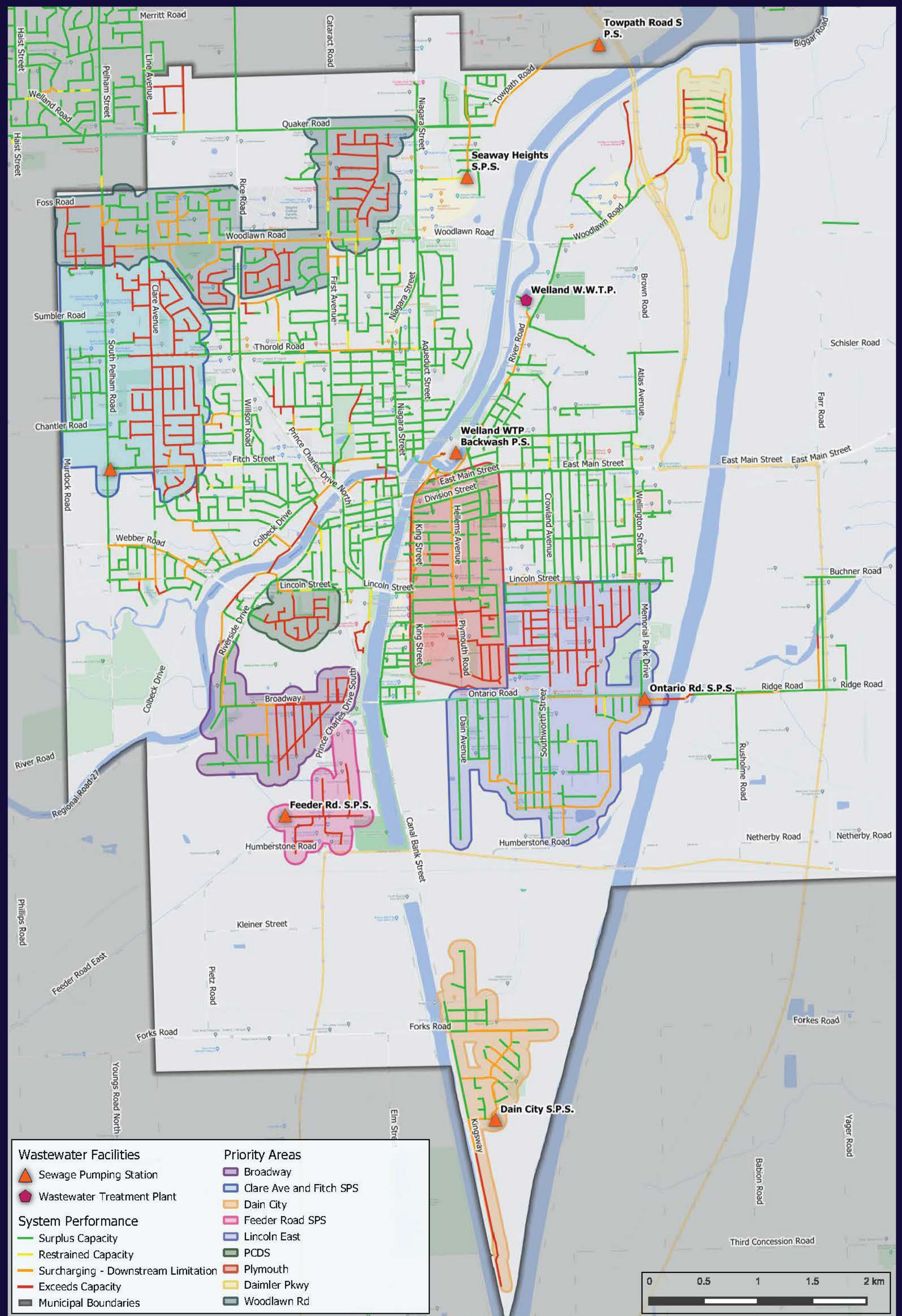


Figure 12
Existing System Performance
10 Year Design Storm

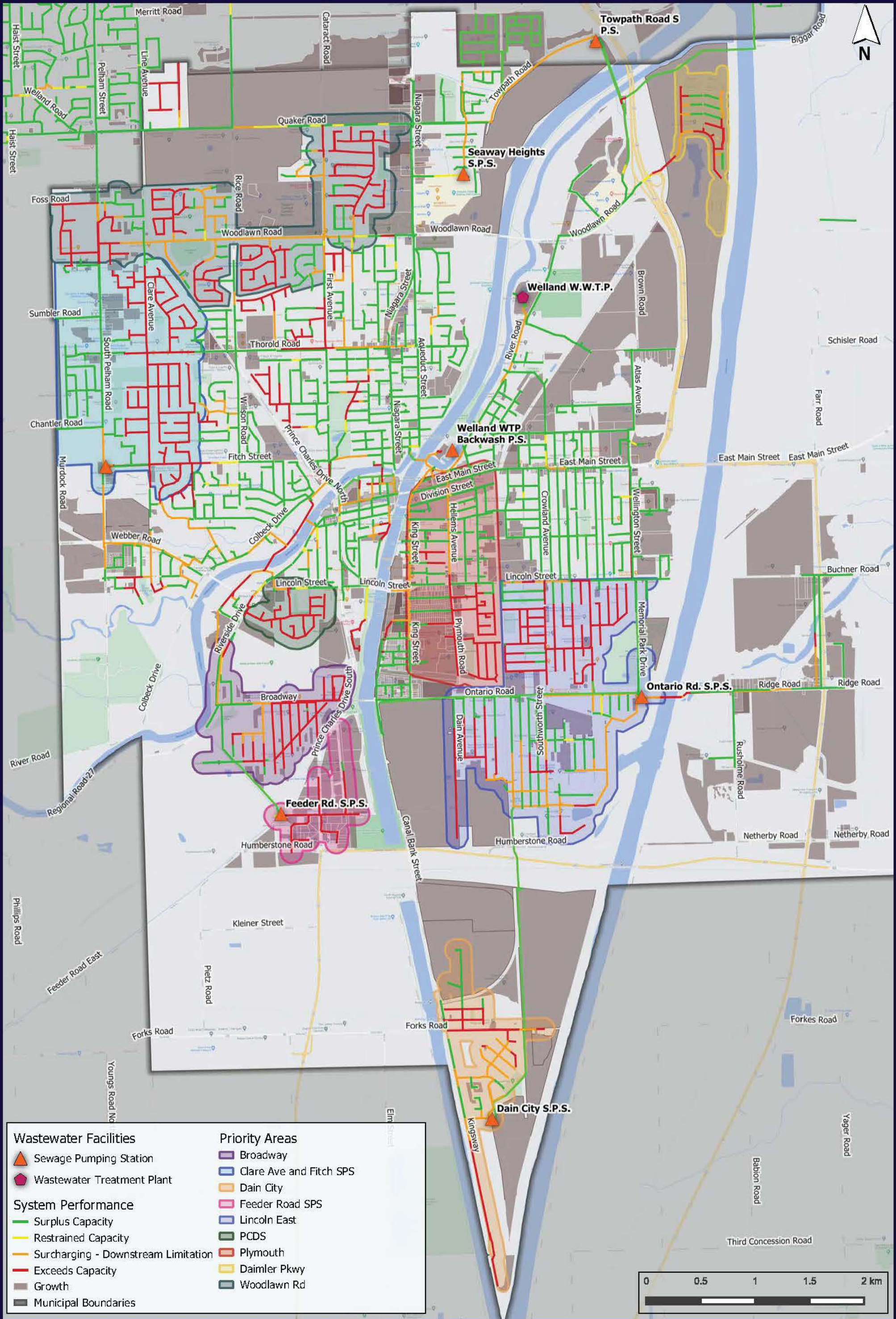


Figure 13
System Performance 2041
10 Year Design Storm

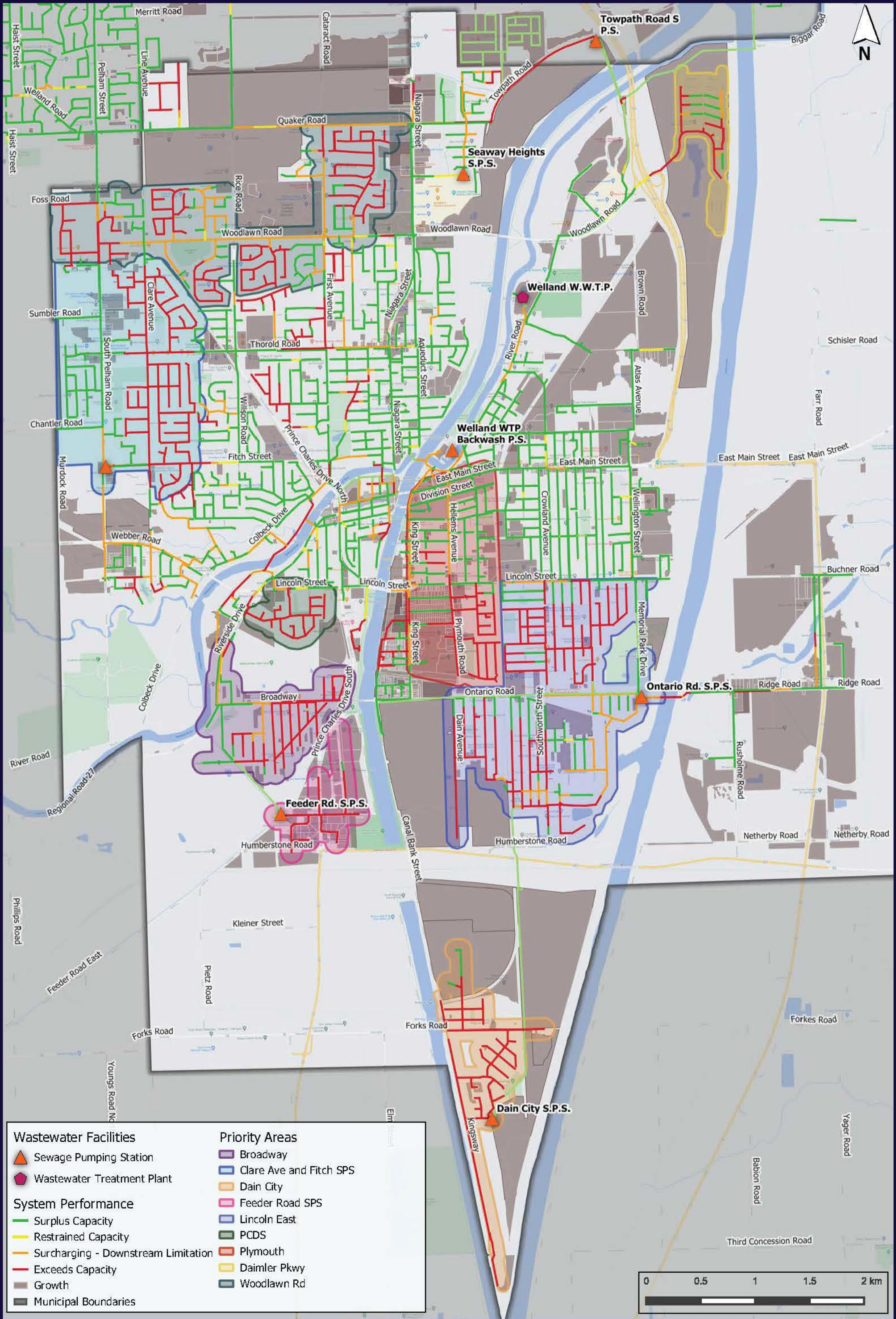


Figure 14
System Performance Build Out
10 Year Design Storm

Table 30. System Performance by Percentage of Total System Length

Percent of Total Length within Welland System

HGL target = 2.4 m	Existing			2041			Buildout		
Evaluation Criteria	Dry Weather Flow	Design RDII (0.286 L/s/ha)	10 year Design Storm	Dry Weather Flow	Design RDII (0.286 L/s/ha)	10 year Design Storm	Dry Weather Flow	Design RDII (0.286 L/s/ha)	10 year Design Storm
Pipe not surcharging, flow under capacity	99%	95%	64%	98%	94%	53%	97%	91%	50%
Pipe not surcharging, flow exceeding capacity	0.3%	1%	2%	0.4%	0.8%	2%	0.8%	0.9%	2%
Pipe surcharging, flow above pipe capacity, surcharging remains below basement flooding freeboard of 2.4m	0.2%	3%	14%	0.4%	4%	15%	1%	3%	14%
Pipe surcharging, flow above pipe capacity, surcharging above basement flooding freeboard of 2.4m	0.3%	0.8%	21%	0.6%	0.7%	29%	0.6%	4.1%	32%

8.5 Combined Sewer Overflows and F-5-5 analysis

The City is required to report on CSOs annually to meet F-5-5 requirements for combined sewer systems. The F-5-5 requires the capture and treatment all dry weather flows plus 90% of the volume resulting from wet weather flows in a 7-month period from April starting within 2 weeks of April 1.

8.5.1 Historic CSO reporting

Summaries of historic annual reporting for CSOs on the Welland River are summarized in **Table 31** and **Table 32**. Annual reports from 2016 to 2018 estimated a capture rate of 99% of wet weather flows, meeting the F-5-5 requirements of a minimum of 90% volume capture of wet weather flows. Generally, overflows have been greatly reduced since 2001 due to the City's progress on sewer separation. **Technical Appendix I – CSO Overflow Reports** contains the 2015-2020 CSO Overflow Reports.

Table 31. Summary of Estimated CSO Events on the Welland River 2015-2020

Year	Total Rainfall April-Oct (mm)	% of annual rainfall causing overflows	Total number of overflow events	Annual CSO overflow volume (ML)
2015	572.8	11%	7	50.9
2016	308.8	1%	7	1.1
2017	709.5	7%	10	22.3
2018	784.3	13%	2	4.3
2019	658.8	53%	9	28.0
2020	403.3	23%	5	15.8

Table 32. Summary of Treated and Untreated Flows on the Welland River

Year	Total WWF (ML)	Total Untreated System Volume (ML)	Total Treated* and Untreated System Overflow (ML)	Treated/Captured Volumetric (%)
2015	1,129	51.4	362	95.5
2016	606	4.5	16	99.6
2017	2,498	22.3	461	99.1
2018	2,554	4.3	480	99.8
2019	2,881	28.0	677.5	99.0

Year	Total WWF (ML)	Total Untreated System Volume (ML)	Total Treated* and Untreated System Overflow (ML)	Treated/Captured Volumetric (%)
2020	2,513	15.8	148.4	99.4

*Includes WWTP secondary by-pass volume

Table 33 summarizes the River CSO volumes for each control structure for modelled design storm scenarios, the modelled “average year” and the reported overflow volumes for 2015-2018. Twelve CSOs appear to be active between the design storm and reported flows.

Table 33. Combined Sewer Overflow Summary from Design Storms and Annual Reporting

CSO	Modelled Overflow Volume (ML)			Reported Overflow Volume by Year: April - Nov Total (ML)						Active CSOs
	DWF	RDII	2012 Existing	2015	2016	2017	2018	2019	2020	
Aqueduct	0	0	0	0	0	0	0	0	0	NO
Burgar	0	0	0	0	0	0	0	0	0	NO
Colbeck (Fitch McNab)	0	0	4.6	0	0	3.7	0	1.8	3.6	YES
Denistoun	0	0	2.5	1.4	0	2.6	1.7	0	2.5	YES
Downs (OAW)	0	0	0	8.4	0	0	0	0	0	NO
First E	0	0	0	0	0	0.1	0	0.6	0	YES
First W	0	0	0.7	0	0	14.5	0	0	0.7	YES
Hellems	0	0	7.5	33.6	0.3	0	2	0	6.8	YES
King	0	0	0.2	0	0	0	0	0	0.3	YES
McAlpine	0	0	0	0	0	0	0	0	0	NO
McMaster	0	0	0	0	0	0	0	0	0	NO
Niagara N	0	0	0	2.3	0	0	0	0	0	NO
Niagara S	0	0	1.3	0	0	0.8	0	4.7	0	YES
Prince Charles N	0	0	0	5.7	4.6	0.7	0.1	5.7	1.0	YES
Prince Charles S	0	0	2.8	0	0	0	0	0.1	0	YES
Riverside and Maple	0	0	0	0	0	0	0	0	0	NO
Shotwell	0	0	0	0	0	0	0	14.5	0	YES
Total Overflow Volume	0	0	19.4	51.4	4.9	22.4	3.8	27.4	14.9	Total Active = 11

Several in-system overflows are monitored and reported for compliance with the amended ECA which requires the temporary overflows in the Lincoln-Coventry area be eliminated by 2022. The overflow volumes are summarized in **Table 34**, which were reported by Associated Engineering in 2 reports:

1. 2018 Performance Report: Lincoln and Coventry Overflows.
2. 2018 Annual Sanitary Sewer Overflow Event Reports: Empress Sewer Diversion/Hagar & Lincoln Overflows/ Evelyn Ditch.

Table 34. Reported In-System Overflow Volumes (Associated Engineering)

Overflow	Overflow Volume (m ³)				
	2015	2016	2017	2018	2019
L1 Simpson Coventry	3,082	4	3,345	2,048.7	261.1
L2 Lincoln Coventry				243.9	327.4
L3 Lincoln Plaza				715.9	716.3
Hagar Camrose	Not Available	Not Available	Not Available	0	0
Hagar McAlpine				0	0
Hagar Wallace				2,870.4	1,812.7

8.5.2 F-5-5 Analysis

Table 35 summarizes anticipated system overflows during “a typical year” under existing and buildout growth scenarios.

Table 35. F-5-5 Analysis on combined sewer overflows volumes

CSO	2012 Overflows (ML)	2012 + Buildout Growth Overflows (ML)
Aqueduct	0.0	0.0
Burgar	0.0	0.0
Colbeck (Fitch McNab)	4.6	11.0
Denistoun	2.5	0.0*
Downs	0.0	0.0
First E	0.0	0.0
First W	0.7	3.6
Hellems	7.5	22.2
King	0.2	3.1
McAlpine	0.0	0.0
McMaster	0.0	0.0
Niagara N	0.0	0.0
Niagara S	1.3	0.0*
Prince Charles N	0.0	0.0
Prince Charles S	2.8	0.0*
Riverside and Maple	0.0	0.0
Shotwell	0.0	0.0
Total Overflow Volume	19.4	39.9

*These overflows are modelled assuming that the sewer separation in design for Prince Charles South combined sewer will lead to decommissioning of the Denistoun, Niagara S, and Prince Charles S overflows. Further monitoring and analysis are recommended as the design is finalized and efficiency of the sewer separation success is measured with post-separation monitoring.

The existing system treats 99.2% of the wet weather flows to a primary level of treatment or greater. Buildout growth will treat 99.0% of wet weather flows to a primary level of treatment. Although the City is meeting the 90% treatment target for combined sewers, the MECP has indicated that the system’s overflow volume should not increase with growth. Similarly, to Section 8.1.1 WWTP Secondary Bypassing and 8.3 Inflow and Infiltration, a trade off of wet weather flow removals will be required to facilitate development going forward in order to prevent the volume of overflows from increasing.

8.6 Key Issues and Opportunities

This section is intended to provide a high-level summary of the issues in the wastewater system and identifies opportunities where infrastructure projects can facilitate growth and reduce environmental and basement flooding impacts.

This section describes problems at a City wide and zoomed in focus, tackling

- Sewer Overflows and Extraneous Flows;
- Servicing of Growth;
- Climate Change Impacts;
- Pumping Stations; and
- Priority Areas to address basement flooding risks and growth.

8.6.1 Sewer Overflows and Extraneous Flows

The Welland wastewater system has several active overflows that spill to the Welland River multiple times in any given year. The root cause of sewer overflows is a high volume of extraneous inflows entering and overwhelming the system in wet weather.

- High extraneous flows cause basement flooding, overflows resulting in water pollution.
- The MECP requires that overflow volumes do not increase, by percentage of flows or by volume, from the current state.
- An I&I reduction strategy will be required to trade system capacity for growth capacity at a rate that matches the pace of development in the City and demonstrates reduction through flow monitoring.
- Areas of I&I reduction do not necessarily need to be directly coordinated with growth areas. There may be opportunities to prioritize I&I reduction within certain areas with higher extraneous flow rates and/or identified deficiencies to offset the need to implement I&I reduction in areas where there is sufficient existing capacity to support growth.

8.6.2 Servicing of Growth

In addition to the construction of new local sewer and/or sewer upgrades to connect new growth areas to the existing sewer system, projected growth is anticipated to exacerbate existing issues sewer capacity issued within the following areas. Addressing the existing high extraneous flows and/or implementation of capacity upgrades will be required to facilitate growth within these areas:

- Dain City;
- Ontario Rd SPS catchment;
- Broadway (small lots); and
- Daimler Parkway.

Further, growth related to the Northern Reach development, the Urban Boundary Expansion, in combination with projected growth within Thorold's Port Robinson Areas are anticipated to

increase the flows to Towpath Rd SPS beyond the MSP Upgrade capacity of 300 L/s. This capacity constraint is primarily the result of increased growth allocations.

8.6.3 Climate Change Impacts

Under sections 9.1, 9.2, 9.3, 9.4 and 9.5, the anticipated impact of climate change on the Welland system were incorporated using the 2050 IDF curve to generate the 10-year design storm. Each future scenario used the 2050 IDF- 10-year design storm for wet weather flows.

8.6.4 Pumping Stations

Pump stations are Region operated and are generally designed to meet the 0.286 L/s/ha wet weather design criteria. Catchments with wet weather flows that exceed station capacity and result in increased basement flooding risks from the station backing up are:

- Feeder Road SPS
- Ontario Rd SPS; and
- Dain City SPS.

Additional growth in the northern areas of the City, including Thorold and Pelham, contributing to Towpath exceed the MSP upgraded capacity to 300 L/s.

8.6.5 Priority Areas

When reviewing the gravity system performance with growth stresses, large areas showed risks of basement flooding and high I&I. Basement flooding is usually an indicator that the area is subject to high extraneous flows entering the system. The majority of these areas with existing issues have growth pressures, which may not be able to proceed into development until existing system issues are resolved.

There is an opportunity to evaluate “priority areas” systematically rather than evaluate individual upgrade projects.

Ten areas that have increased basement flooding risks under the 10-year design storms are identified as PPCP Priority Areas, shown in **Figure 15**. A priority area may meet any of the following criteria:

- Risk of basement flooding resulting from gravity sewer capacity issues;
- Risk of basement flooding resulting from pump station capacity issues;
- Combined sewer overflows active in existing or future scenarios; and
- Undersized infrastructure for growth.

The priority areas and risks are described below; further data collection may be needed to confirm the extent and severity of peak wet weather flows.

1. Broadway

The Broadway area is in Welland South, bounded by the Welland River to the west and the Welland Recreational Canal to the east. The area has a history of chronic basement flooding. The neighbourhood flows are collected by a local 300 – 450 mm trunk along Broadway and ties into the Region Interceptor on Riverside Drive and is

conveyed by gravity to the WWTP. A study conducted in 2007 by XCG Consultants found that the area is susceptible to basement flooding due to shallow sewers, high I&I and undersized trunk infrastructure on Broadway. The hydraulic model shows that flows draining from the area are limited by the levels in the Interceptor sewer, which is influenced by the way the WWTP is operated. Nine flow monitors are currently installed to collect wet weather data for the area.

2. Ontario Rd SPS Catchment

The Ontario SPS area is split into two sub-areas: Lincoln-Coventry which includes the area north of Ontario Road, and Ontario South which includes the area south of Ontario Road. Although the peak wet weather flow using Region criteria is below the pump station's capacity, the peak 10 year wet weather flows are greater than 1,000 L/s which greatly exceed the pump station's 600 L/s design capacity.

Lincoln Coventry

Sewer surcharging in this area is a result of high I&I and undersized sewers on Empress Ave. There are several in-system overflows in this area; notably the Coventry-Simpson (L1), Lincoln-Coventry (L2) and Lincoln Plaza (L3) overflows. In addition to sewer surcharging and basement flooding risk concerns, the Lincoln East area is a high priority for the City because the MECP has mandated that these overflows be decommissioned by 2022. Associated Engineering has completed the MECP overflow monitoring and reporting for the L1-L3 overflows.

Ontario South

The area south of Ontario Road has existing high I&I issues and historic basement flooding in the Commercial Street area which is relieved by an emergency bypass pump. There are significant growth areas planned to the west of the Ontario South area. In addition to local catchment growth, the Gordon sewer collects the flows from the Dain City SPS forcemain which has large growth planned as well.

3. Dain City

The Dain City catchment is in the South of Welland. Flows are collected by a 450 mm trunk and conveyed to the SPS and CSO tank. Approximately 40 houses experienced basement flooding during the April 2018 ice storm as a result of higher than normal inflows and a force main failure at the Dain City SPS. An emergency forcemain is currently in place for the catchment and the EA for the construction of a new forcemain is underway. Dain City was identified as the area with the second highest I&I per hectare, in Section 8.4.

4. Plymouth Rd

The Plymouth Road priority area is located to the west of the Lincoln East priority area. The Plymouth Road sewer is located to the east of the Welland Recreational Canal. Wastewater flows are collected via a 300 mm trunk on Plymouth Rd and conveyed northwards to the Interceptor via a 450 mm trunk on Hellems Ave. The Hellems Ave trunk at Regent St appears to be undersized, which is causing sewer surcharging upstream most severely surcharging in the Plymouth area.

5. Feeder Road

Feeder Road SPS catchment is located south of the Broadway area and north of the Humberstone Landfill. A 450 mm trunk collects and conveys flows to the Feeder Rd SPS. Peak wet weather flows to the SPS exceed the station's capacity. System surcharging occurs as result high extraneous flows that exceed the station capacity.

6. Prince Charles Drive S – South of Lincoln St

The PCD S area from Lincoln St is located to the north of the Broadway area, bounded to the west by the Welland River, Lincoln St to the north and Prince Charles Drive S to the east. Wastewater sewers in the area are small diameter pipes from 250 - 300 mm. Flows are conveyed from Windsor St to the Regional Interceptor, ultimately conveyed to the WWTP by gravity. Similar to the Broadway area, the sewer surcharging in the PCD priority appears to be the result high extraneous flows and therefore limited operational capacity of the Interceptor.

7. Clare Ave & Fitch St SPS

The Clare Avenue priority area is located adjacently to the east of the Fitch St catchment. The area is bounded by Woodlawn Rd to the north and extends slightly south of Fitch St. The Clare Ave trunk is 300 mm and the Fitch St trunk is 375 mm; the Fitch St trunk conveys flows by gravity to the Region Interceptor and ultimately to the WWTP. Trunk infrastructure from Clare Ave and Fitch St appear to be undersized, resulting in sewer surcharging and system back up into the Clare Ave local sewers.

The City retained a consultant in 2014 to evaluate potential solutions to facilitate the decommissioning of the Fitch St SPS. As a result, the Fitch St SPS has been flagged as a priority area of concern for further study.

8. Woodlawn Rd

The Woodlawn Road priority area encompasses several areas contributing high I&I to the Woodlawn sewer, which causes trunk surcharging in wet weather conditions. The Woodlawn Rd trunk sewer is 600 mm to 750 mm in size. Several neighbourhoods are impacted by the surcharging of the trunk which prevent their ability to outlet; in combination with high I&I, the model shows basement flooding risks in several of these areas.

The Trelawn priority area is bounded by Quaker Rd to the north, Woodlawn Rd to the south, First Ave to the west and Niagara St to the east. The Trelawn Parkway sewer is a 300 mm trunk sewer that conveys flows to the Woodlawn Rd/Niagara St trunks, ultimately flowing by gravity to the WWTP. The mechanism for flooding appears to be undersized trunk sewer along the Trelawn Parkway, which is causing backups to local sewers. The area is located within the Lock St Flow Monitoring catchment, which was updated for the PPCP study and greatly increased I&I contributions equally across the catchment. Further data collection may be needed to confirm the extent of local flows in the Trelawn and broader Woodlawn area.

9. Daimler Parkway

The Daimler Parkway priority area is bounded by Highway 406 to the west, the Welland river to the north and the St Lawrence Seaway to the east. This area has several draft plans including Hunter's Pointe development. Based on the current model state, there are existing basement flooding risks which must be addressed before allowing growth to proceed. Flow monitoring can provide certainty for previous upgrade recommendations.

10. Seaway Heights

The Seaway Heights priority area is the area serviced by the Seaway Heights SPS in the area north of Seaway Heights Mall. There are several developments that can be serviced to this catchment and growth allocations for this assessment were assumed to optimize flows to the station's firm capacity. There are high wet weather flows exceeding the station capacity in existing conditions, before development can proceed. Further data collection may be needed to confirm the extent of wet weather flows in the Seaway Heights area.

8.6.6 Data Maturity and Uncertainty

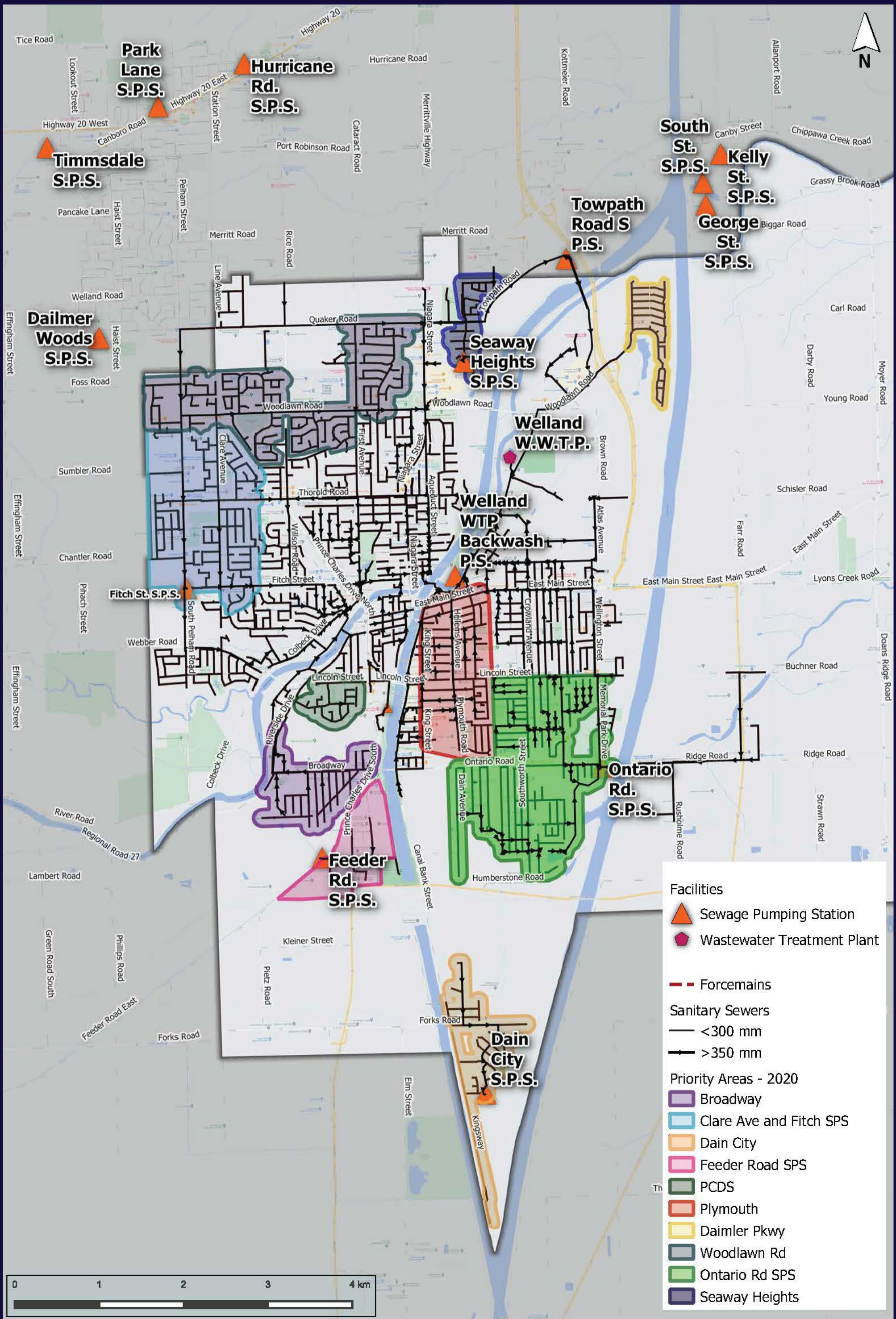
The City has an annual flow monitoring program which has collected data since 2015 across the City. Flow monitoring data was the basis of the hydraulic model calibration. The City's hydraulic model has good volumetric calibration at the WWTP level but may depress peak wet weather flows from subcatchment areas. Some subcatchments have had comprehensive flow monitoring programs and therefore have high data maturity and confidence. There were a number of areas that were identified as having low data maturity from the model build in 2017.

Areas with higher data maturity generate a higher confidence in the model results and recommendations allowing the City to proceed directly with implementation of the recommended projects. Areas with known issues such as basement flooding or active overflows generally have good data maturity and have had studies or model updates based on the latest flow monitoring data. These areas and related studies are listed below.

- Broadway;
- Dain City; and
- Ontario Rd.

Areas with lower data maturity require additional investigation to confirm before implementing proposed solutions. The areas showing poor performance in the model were flagged as potential priority areas with actual flows to be confirmed through flow monitoring in 2020 and beyond.

- Plymouth;
- Feeder Rd SPS;
- Prince Charles Drive South;
- Fitch St SPS;
- Clare Ave;
- Woodlawn Rd;
- Daimler Parkway; and
- Seaway Heights.



9. WASTEWATER SERVICING CONCEPTS

9.1 Evaluation Methodology

The second phase of the Municipal Class EA process involves the identification and evaluation of all feasible solutions to the problem. Evaluations will be undertaken to address the potential advantages and disadvantages of each potential solution.

The alternatives were assessed on their ability to achieve the following PPCP technical objectives:

- **Maintaining or improving wastewater level of service:** Reduce the number of pipes that pose the risk of basement flooding in a 10-year storm.
- **Reduce inflow and infiltration:** Remove excess I&I from the wastewater system to meet the objectives of the F-5-5 Procedure.
- **Reduce combined sewer overflow impacts:** Reduce downstream CSO occurrences and spill volumes to meet the F-5-5 Procedure objectives for a PPCP.
- **Facilitate growth:** Ensure all growth can be accommodated with the alternative, while maintaining or improving the LOS.
- **Resiliency and adaptation to climate change:** Ensure the solutions account for the potential impact of climate change.

Further each alternatives ability to achieve the technical objectives, the following criteria was also used:

- **Environmental Impact:** Minimize the impact and/or maximize the benefit to the environment and natural heritage system resulting from the implementation and ongoing operation and maintenance.
- **Social Cultural Impacts:** Minimize the impact to the public and cultural heritage infrastructure resulting from the implementation and ongoing operation and maintenance.
- **Life Cycle Cost:** Minimize total life cycle cost.

The individual evaluation of each alternative's ability to meet the criteria was completed using the following ranking approach:

Table 36: Ranking Methodology

Symbol	Ranking
	"High" Solution generates beneficial impacts and/or has no substantial technical challenges
	"Medium" Solution to a mix of positive and negative elements with some impacts
	"Low" Solution presents permanent negative impacts and/or presents significant technical challenges

Having ranked each alternative accordingly, the evaluation and selection of a technically preferred solution will be guided by the *Reasoned Argument Approach*. This approach will provide an objective, clear and thorough rationale of the trade-offs between the various evaluation factors and criteria and identify the reasons why one option best meets the servicing needs of each area.

9.2 Servicing Concepts

Servicing concepts were developed under the context of identifying general servicing solutions to address both system wide and local opportunities and constraints.

Improve Level of Service Projects: Any infrastructure upgrade projects that improve or allow for sustained levels of service, such as an increase in the system capacity to accommodate peak flows; this includes works such as increasing conveyance capacity or increasing storage capacity.

State of Good Repair Projects: Any infrastructure projects related to improving and/or maintaining the condition and/or performance of the existing system without increasing the system conveyance or storage capacity. This includes works related to sewer and manhole maintenance, repair and/or replacement which the City is required to undertake periodically in order to maintain the good working order of the wastewater system.

It should be noted that completion of standard State of Good Repair rehabilitation and replacement of existing wastewater infrastructure also provides the additional benefit of reducing overall system I&I through the repair/replacement of pipe and manhole which represent major I&I source contributions.

Policy or Educational Considerations: Changes to administrative or Council policy were considered, if changes would enhance implementation, support or enforcement related to a servicing strategy. Educational programs were also considered if beneficial to the success of a servicing concept. For example, private I&I programs are typically voluntary, relying heavily on the community understanding and buying into the project concepts and benefits, thus making an education program a fundamental factor in the project success.

9.2.1 Concept 1: Do Nothing

This alternative consists of maintaining the status quo with no planned changes to the existing operation and maintenance activities and no new or upgrades to the sewer system and/or facilities beyond those already identified in the 2016 RMON Master Servicing Plan. This alternative was not selected as the preferred alternative as it fails to address the identified system issues and constraints.

9.2.2 Concept 2: State of Good Repair and Reduce I&I

This alternative consists of implementing changes to the City's existing operation and maintenance activities to improve the overall system performance and reduce I&I. This included implementing a City SOGR Program with I&I reduction to reduce peak flows entering the system. This alternative includes education and awareness on I&I reduction for private property programs.

9.2.3 Concept 3: Increase Conveyance Capacity (Sewer and SPS)

This alternative consists of upgrading the system capacity in-line with the existing peak wet weather flows. To accommodate these, significant upgrades to the RMON Trunk infrastructure are also required. Under this alternative no changes to the City's operation and maintenance activities are proposed.

9.2.4 Concept 4: Increase Storage Capacity

This alternative consists of strategically locating system storage to capacity concerns. Under this alternative, no changes to the City's operation and maintenance activities are proposed.

9.2.5 Concept 5: Hybrid of the Above

This alternative consists of implementing changes to the City's existing operation and maintenance activities to improve the overall system performance and reduce I&I, as well as implementing localized upgrade to address identified basement flooding risk areas. This included implementing a City SOGR Program with I&I reduction to reduce peak flows entering the systems.

10. SERVICING EVALUATION AND PREFERRED STRATEGY

Wastewater servicing strategies were carried forward based on the servicing concepts presented in **Section 9** and reviewed for existing and future growth in the City in order to select the best servicing solutions. The following sections summarize the alternative servicing strategies and evaluation of the strategies.

It is noted that the 2021 MSPU will provide an update to Region-owned infrastructure upgrades identified in this report. Upgrade capacities in this report may change, however the strategy to upgrade or work on inflow and infiltration is consistent with the 2021 MSPU.

10.1 System Wide I&I Reduction

Through consultation with the Technical Steering Committee, a minimum of 10% system wide I&I removal will trade off for growth flows to offset an increase in overflows and bypasses. The 10% system-wide target can be achieved by targeting a minimum of 25% I&I reduction in the priority areas. This strategy prioritizes the areas with the worst system performance and high I&I to attain a higher probability of I&I removal in focused areas. Pre and post I&I remediation monitoring is required to confirm system flows and quantify removal.

10.2 Regional Facilities

10.2.1 Wastewater Treatment Plant

Current capacity of the treatment plant is 54.6 MLD and system-wide growth flows in 2041 are projected to be 46.4 MLD. Average flows to the plant from 2015 to 2019 were 33.9 MLD. Projected flow to 2041 is 46.4 MLD, which exceeds 80% of the plant's existing capacity. The buildout scenario average flows total 55.7 MLD, which exceeds the plant's existing capacity.

The Region MSP identified a study trigger at 80% plant capacity and design/construction at 90% plant capacity. The WWTP will surpass the 80% capacity study trigger in the 2036 - 2041 time horizon.

As dry weather flows increase, instances of secondary bypassing at the plant during wet weather inflows will increase in the average year. The average year with growth showed an increase in system overflows of 20.5 ML. The treatment of wet weather flows is 99.0% in the average year, which meets the 90% F-5-5 criteria. The I&I Reduction Program will help to maintain existing overflow volumes and mitigate the additional 20.5 ML of overflows that would occur without I&I activities.

10.2.2 Pump Stations

The 2016 Master Servicing Plan Update recommended that Regional sewage pumping stations be designed to accommodate the I&I design criteria of 0.286 L/s/ha. The Region reviews SPS upgrades, beyond firm capacity and the 0.286 L/s/ha criteria on a case-by-case basis.

The 2016 MSP identified Towpath SPS as a station requiring upgrades to meet 2041 needs. The 2016 MSP recommended I&I reduction programs to be undertaken within the City to reduce flows exceeding SPS capacity and ultimately wet weather flows to the WWTP and to decrease the secondary bypass volumes at the plant.

Existing System

- All pump station firm capacities meet the 0.286 L/s/ha criteria with existing system flows.
- All pump station firm capacities are exceeded from wet weather flows in the 10-year design storm scenario.

2041 Growth

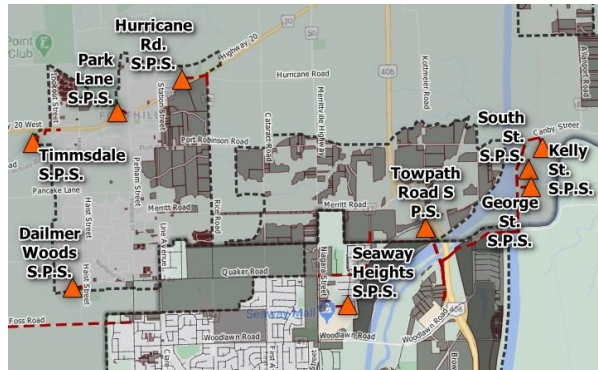
Upgrades to support 2041 growth flows are based on Region Design Criteria of 0.286 L/s/ha for wet weather flows.

- Towpath Rd SPS; and
- Dain City SPS.

Towpath Road SPS

The 2016 MSP identified a capacity upgrade to 300 L/s at the Towpath Rd SPS. 2041 flows using design criteria are projected to be 375 L/s and buildout flows are projected to exceed 500 L/s. The overview and planned upgrades for the Towpath Rd SPS are summarized in **Table 37**.

Table 37. Towpath Rd SPS Planned Upgrades

Towpath Road Sewage Pumping Station	
Overview	
Planned Upgrades	
• Towpath SPS services Pelham, Thorold and Welland lands. • Growth is projected to occur in Pelham, Thorold, and Welland by 2041. • Large developments in the Towpath catchment include Northern Reach and the Welland Urban Bound Expansion Lands. • The Towpath catchment has high rates of I&I. • Upgrades beyond 300 L/s are needed to support growth to 2041 based on design criteria. • Pumping station capacity upgrades are needed to meet 2041 flow targets and additional growth to Ultimate Buildout. • I&I reduction in the catchment is needed reduce peak wet weather flows to the station.	

Dain City SPS

The Dain City SPS has current projects underway to reinstate the ECA capacity of the station and forcemain. The station has 2,000 m³ of additional CSO tank storage.

There are major development areas planned in the Dain City catchment, the timing of which are uncertain. Based on growth loading assumptions which assume 12% of draft plans for the 2041 Growth Scenario, the station capacity is not exceeded using design criteria of 0.286 L/s/ha. However, the peak wet weather flows from a 10-year design storm in the existing system exceed the station capacity and are currently attenuated by the CSO storage tank.

The overview and planned upgrades for the Dain City SPS are summarized in **Table 38**. Additional infrastructure upgrades are assessed in **Section 10.3.3**.

Table 38. Dain City SPS Upgrades

Dain City Sewage Pumping Station	
Overview	
- Dain City has high rates of inflow and infiltration limiting existing pumping station and sewer capacity. - Major developments planned in the catchment will exceed the station's current capacity. - Timing of the developments is uncertain; it is possible that the station's capacity could be exceeded by 2041. - The CSO tank configuration does not currently utilize the full tank volume.	
Proposed Upgrades	
- Pumping station capacity upgrades to at least 175 L/s are needed to meet growth flows based on design criteria and some resiliency to wet weather flows. - Optimization of storage tank configuration through adjustment (lowering) of the weir elevation to the Region owned CSO tank at the SPS.	

10.3 Priority Areas – High Data Maturity

Priority areas with high data maturity have recent or ongoing flow monitoring studies with current, up-to-date data and are not flagged for additional flow monitoring in the next two years. The Broadway, Dain City and Ontario Road Priority Areas have already completed Phase 1 of tactical flow monitoring as they were high priorities for the City with respect to basement flooding risk

management. Each of these areas also have a detailed implementation plan which are included in **Appendix J – Implementation Plans**.

10.3.1 Broadway Priority Area

The Broadway area is a high priority area for the City with chronic basement flooding and growth pressures. This area had comprehensive flow monitoring completed in 2019 and was fast tracked to determine an implementation plan. This plan is included in **Appendix J – Implementation Plans**.

The Broadway PPCP Implementation Plan identified a combination of issues:

- Undersized trunk infrastructure;
- Shallow and complex local sewer configuration;
- High I&I;
- Interceptor surcharging influence; and
- Growth.

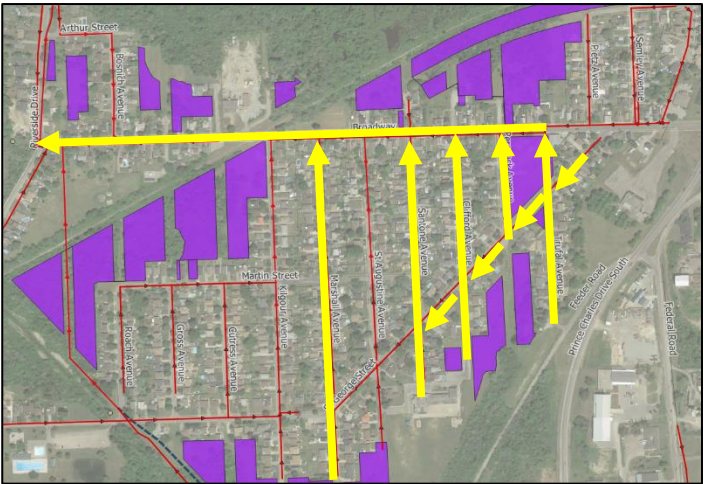
Growth in the Broadway Priority Area was estimated to be 1,687 people, 55 jobs, and 10.5 ha of new serviced area.

The alternative evaluation is detailed in **Table 39**. The preferred alternative is a combination of infrastructure upgrades and I&I reduction program, listed below. The implementation plan breaks up the projects into 5 phases for execution by the City as budget allows and is shown in **Figure 16**.

- Deepening and upsizing the trunk sewer on Broadway to address trunk capacity restrictions and to provide the area with additional storage/protection from the interceptor surcharging/backflow.
- Local sewer reconfiguration and deepening to accommodate existing peak flow and growth capacity needs, while also providing sufficient freeboard to achieve the 2.4 m freeboard level to service objective.
- Implementation of a local I&I reduction plan to address the high wet weather flows and to provide additional growth capacity and basement flooding protection. Public side I&I reduction activities will be implemented and quantified before triggering an exhaustive private side I&I effort.
- Install storm laterals for approximately 280 homes west of Marshall Ave.

The I&I reduction program will be implemented with a target objective of reducing future (including growth) peak 10 year for the entire Broadway area to below 340 L/s, as measured in the Broadway trunk outletting to Riverside Drive. The Broadway target I&I removal target is approximately inline with the 25% reduction target for priority areas. In order to avoid infrastructure upgrades, the 10-year peak wet weather flows in the buildout scenario would need to be reduced to 130 L/s, which is not likely achievable.

Table 39. Broadway Priority Area Alternatives

Broadway Catchment Alternatives				
	Alternative 1: Upgrade trunk and local sewers			
	Alternative 2: Oversize and deepen trunk and reconfigure local sewers			
				
				
Overview	- Upgrade and oversize Broadway trunk sewer - Upgrade and oversize local sewers to mitigate basement flooding			
Sewers	- Maintain existing sewer configuration 2000 m of sewer replacement/upgrade to 375 mm 1000 m of Broadway sewer replacement and upgrade to 1000 mm			
Inflow and Infiltration	- Target 25% I&I removal through Public and Private I&I Reduction Program - Complete storm sewer cross-connection investigation			
Costing	\$\$			
Advantages	Provides additional storage to minimize local HGL impacts			
Disadvantages	- Small, shallow sewers present higher risk for localized basement flooding - Disruptive construction for homeowners			
Four-Point Criteria Evaluation	Technical	Environ-mental	Social & Cultural	Financial
Recommended Alternative	Not Recommended: Minimal flexibility for addressing shallow local sewers			
	Recommended: Phased approach facilitates implementation and beneficial impact measurement of I&I works			

Evaluation Scoring Legend: ● High ● Medium ● Low



Figure 16. Broadway Priority Area Preferred Alternative and Implementation

10.3.2 Ontario Rd Priority Area

The Lincoln-Empress subcatchment encompasses the entirety of the Ontario Rd SPS catchment that is north of Ontario Rd. Sewer surcharging in this area is a result of high I&I and undersized sewers on Empress Ave and Sutherland Ave. There are several in-system overflows in this area, notably the Coventry-Simpson (L1), Lincoln-Coventry (L2), and Lincoln Plaza (L3) overflows. In addition to sewer surcharging and basement flooding risk concerns, the Lincoln East area is a high priority for the City because the MECP has mandated that these overflows be decommissioned by 2022. Associated Engineering completed the MECP overflow monitoring and reporting for the L1-L3 overflows from 2014 to 2020.

The Commercial-Gordon subcatchment faces growth pressures in the Page-Hersey lands adding upwards of 8,000 people on 80 ha, aging local sewers and the re-establishment of the Dain City forcemain capacity. These issues exacerbate existing high wet weather flows and basement flooding risks. Additionally, the Dain City pump station (SPS) will have its capacity reinstated with the completion of the forcemain realignment construction to be complete in 2021.

Growth in the Lincoln-Empress subcatchments was estimated to be 100 jobs.

Growth in the Commercial-Gordon subcatchment was estimated to be 8,523 people, 106 jobs and 82.7 ha of new serviced area.

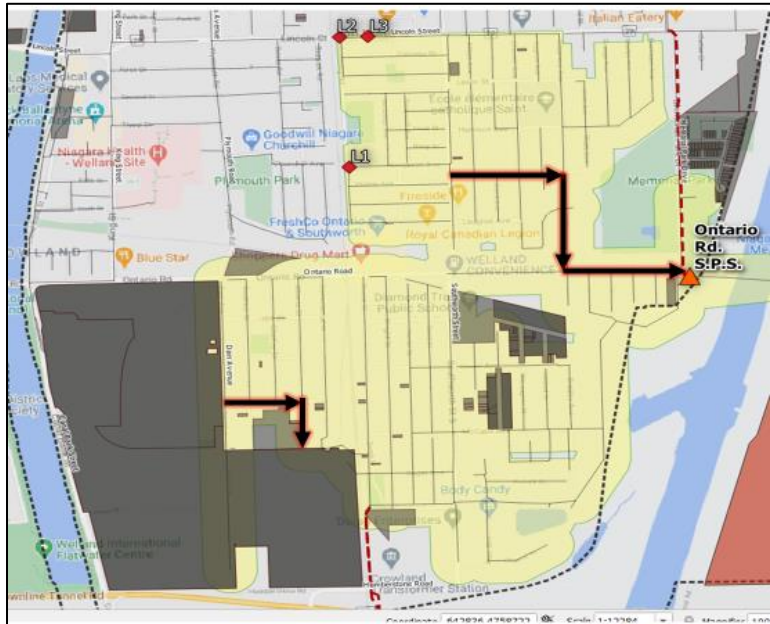
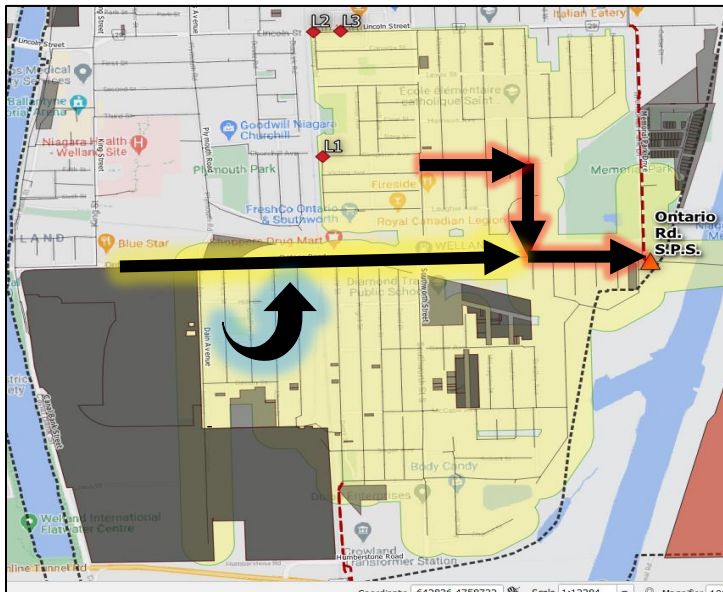
A detailed review of flow monitoring from 2019 identified extremely high inflows from the Harrison neighbourhood in the northeast section of the catchment. Inflows appeared to exceed 600 L/s, which exceeds the Ontario Rd SPS capacity. Flow monitors were deployed in Fall 2020 to pinpoint the source of the inflows. Further, investigation will be needed to determine and eliminate the source of inflows.

The alternative evaluation is detailed in **Table 40**.

An aggressive I&I removal program is needed to locate and remediate the source of the Harrison inflows. With upgrades on Empress Ave, the I&I reduction program will need to target reducing future (including growth) peak 10 year for to below 470 L/s, as measured in the Empress Ave sewer outletting to Ontario Rd to eliminate the activation of the L-sites in a 10 year storm. The peak flow target would achieve through an approximate 25% I&I reduction across the catchment area and a 50% reduction of the Harrison inflows. It is noted that that if a larger proportion of the exiting Harrison peak inflows can be eliminated, there is the potential that a portion of the recommended Empress Ave sewer upgrades requirements can be eliminated

Further, the I&I reduction program with have a target objective of reducing future (including growth) peak 10 year to the Region trunk sewer, as measured upstream of the connection to Hendershot Ave, to below 580 L/s.

Table 40. Alternatives for Ontario Rd Priority Area

Ontario Rd Catchment Alternatives								
	Alternative 1: Upgrade local sewers				Alternative 2: New Trunk on Ontario Rd			
								
Overview	- Upgrade gravity sewers on Ontario Rd, Empress Ave, Sutherland Ave - Potential oversizing to reduce risk of activating L-site overflows - Upgrade gravity sewers from Dain Ave to Commercial Ave - Growth pressures from rezoning and development of industrial lands to residential on Hersey- Page lands and in Dain City. Servicing of Hersey-Page lands to Gordon trunk sewer				- Deepen and upgrade sewers on Ontario Road from SPS to Empress Ave - Oversizing to reduce risk of activating L-site overflows - Growth pressures from rezoning and development of industrial lands to residential on Hersey- Page lands and in Dain City. Servicing of Hersey-Page lands to Ontario Road trunk extension.			
Sewers	500 m Ontario Rd, deepen and upgrade to 900 mm 300 m Empress Ave upgrade to 600 mm 450 m Sutherland Ave upgrade to 600 mm 500 m Devon Ave to Alberta St upgrade to 600 mm				500 m Ontario Rd, deepen and upgrade to 900 mm 300 m Empress Ave upgrade to 600 mm 450 m Sutherland Ave upgrade to 600 mm 1600 m Ontario Rd trunk extension			
Inflow and Infiltration	- Initiate Inflow and Infiltration program to reduce wet weather flows in catchment - Locate and reduce source of Harrison Ave inflows by at least 50%				- Initiate Inflow and Infiltration program to reduce wet weather flows in catchment - Locate and reduce source of Harrison Ave inflows by at least 50%			
Costing	\$\$				\$\$\$ - Funding opportunity with Niagara Region			
Advantages	Minimizes construction on Ontario Rd				- Opportunity for servicing Hersey-Page/Union Carbide lands via Ontario Rd Trunk Extension - Opportunity for servicing Dain-Commercial local sewers under SOGR replacement, which can reduce need for Alberta sewer upgrade - Minimizes local sewer upgrades if I&I removal is achieved - Increases servicing opportunities along Ontario Rd			
Disadvantages	- Does not eliminate need for L-site overflows - Limited servicing flexibility for new developments and SOGR replacement projects - Replaces sewers constructed <15 years				- More expensive option - Disruptions to Ontario Road traffic for trunk extension			
Four-Point Criteria Evaluation	 Technical	 Environ-mental	 Social & Cultural	 Financial	 Technical	 Environ-mental	 Social & Cultural	 Financial
Recommended Alternative	Not Recommended: Minimal flexibility for future servicing				Recommended: Phased approach allows flexibility for servicing current and future lands, is best alternative to reduce activation of L-sites			

Evaluation Scoring Legend:  High  Medium  Low

The preferred alternative is a combination of:

- Ontario Rd Trunk sewer upgrade between the station and Empress Ave;
- Ontario Rd trunk sewer extension;
- I&I reduction programs in Lincoln-Empress and Dain-Gordon areas;
- Additional infrastructure upgrades on Sutherland Ave and Empress Ave, which are triggered if the timing of the development precedes a sufficient reduction of extraneous flows.

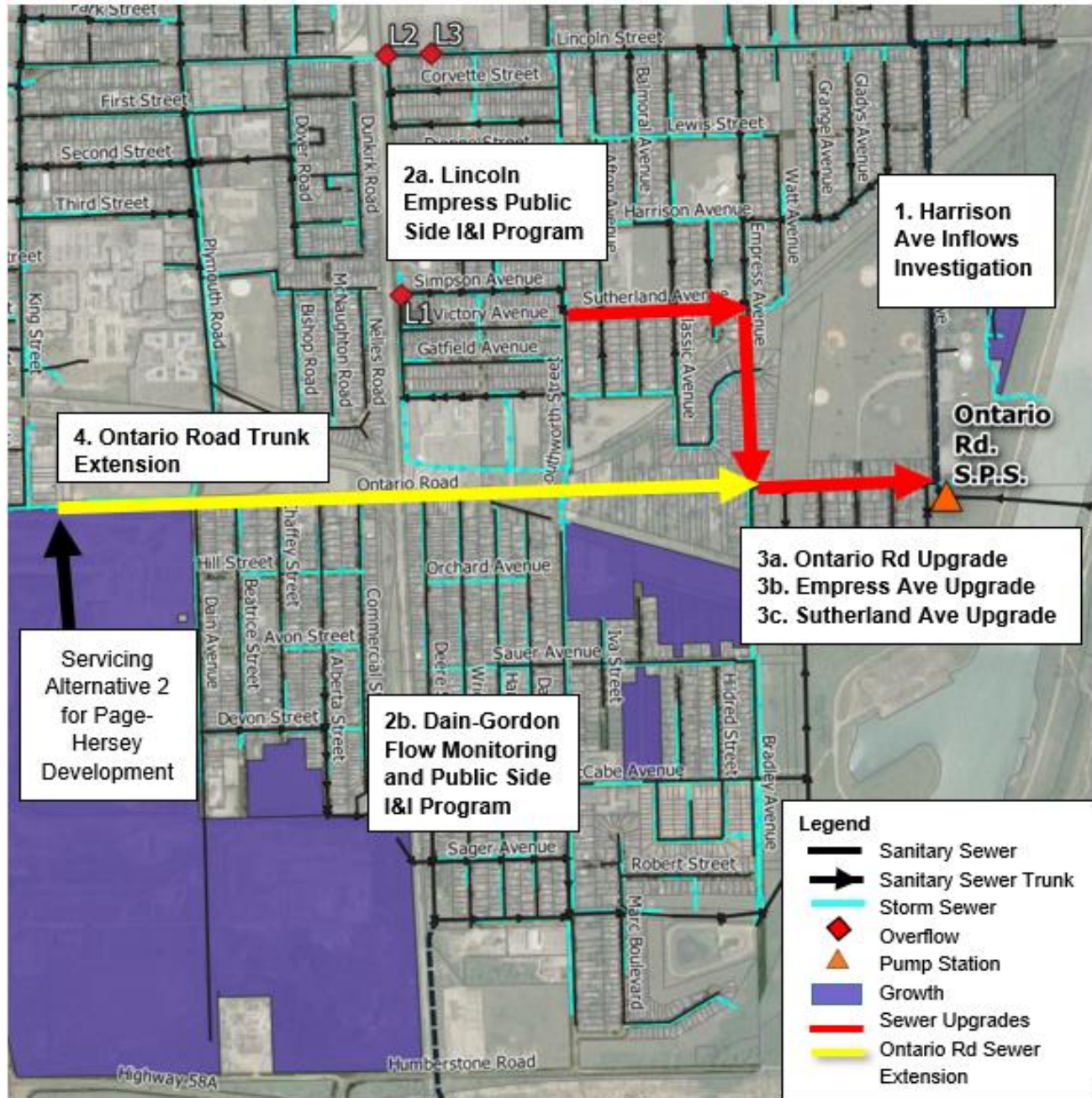


Figure 17. Ontario Road Implementation Plan

10.3.3 Dain City Priority Area

Dain City has been a high priority area for the City since April 2018 when a basement flooding event flagged operating capacity issues at the Dain City SPS. The challenges in Dain City include:

- Basement flooding has occurred in the catchment in April 2018 and July 2020 storm events.
- Interim reduced SPS capacity (90 L/s) and forcemain upgrade and alignment reconstruction underway (in 2020).
- The Dain City area is known to have high I&I contributions greatly exceeding Region design criteria (0.286 L/s/ha).
- Poor drainage and poor condition or lack of storm infrastructure.
- Industrial water quality issues impacting wastewater collection system and pump station infrastructure. The City is working in partnership with the Region to mitigate this issue.
- There are significant growth pressures from the redevelopment of the former John Deere property and adjacent large property on the northeast area of the Dain City SPS catchment. Growth from these two properties alone would add 6,190 people and 147 ha.
 - The timing of these developments is uncertain; using the assumptions of 12% draft plans being developed by 2041 the pump station is not triggered for an upgrade, but it is possible that the developments in Dain City could be built out by 2041.

Buildout growth in Dain City using the Region design criteria is estimated to generate flows of 160 L/s that exceed the station capacity of 115 L/s.

Station upgrades will need to consider some additional capacity for wet weather flows. Capacity at the Dain City SPS will be limited by the 300 mm forcemain, which may be operated at approximately 160 L/s. The station has a 2,000 m³ CSO storage tank, which is activated when the system HGL reaches 170.3 m. Lowering the tank inlet would reduce system backups and optimize the available tank volume. Capacity upgrades to Region infrastructure will be incorporated into the Region's upcoming 2021 MSP study. The alternative evaluation to support growth is detailed in **Table 41**.

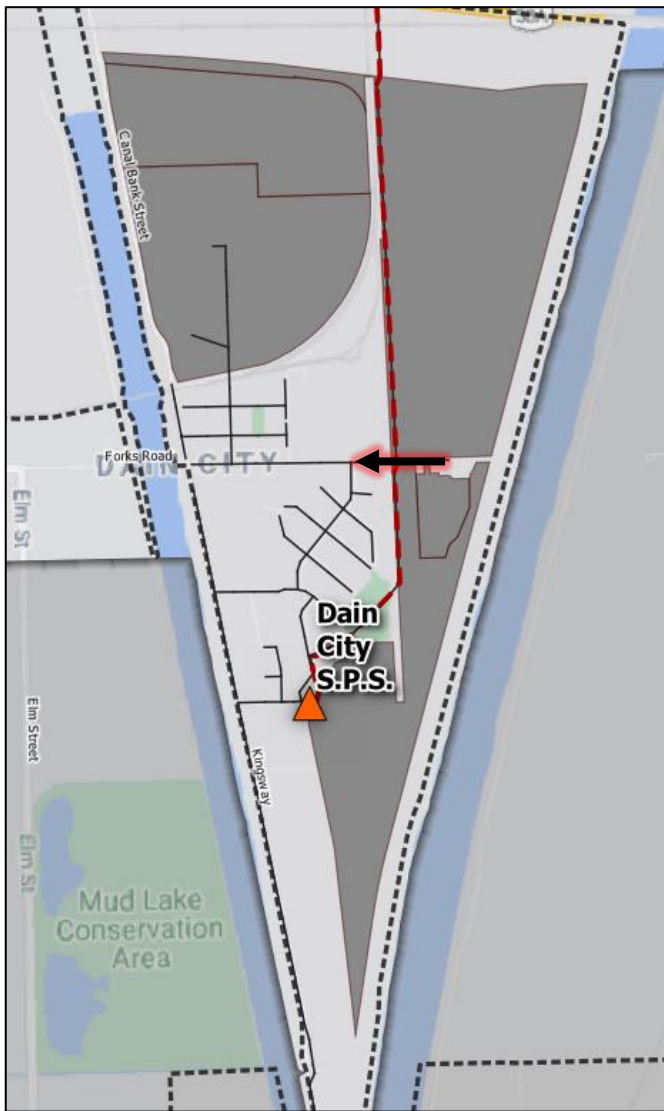
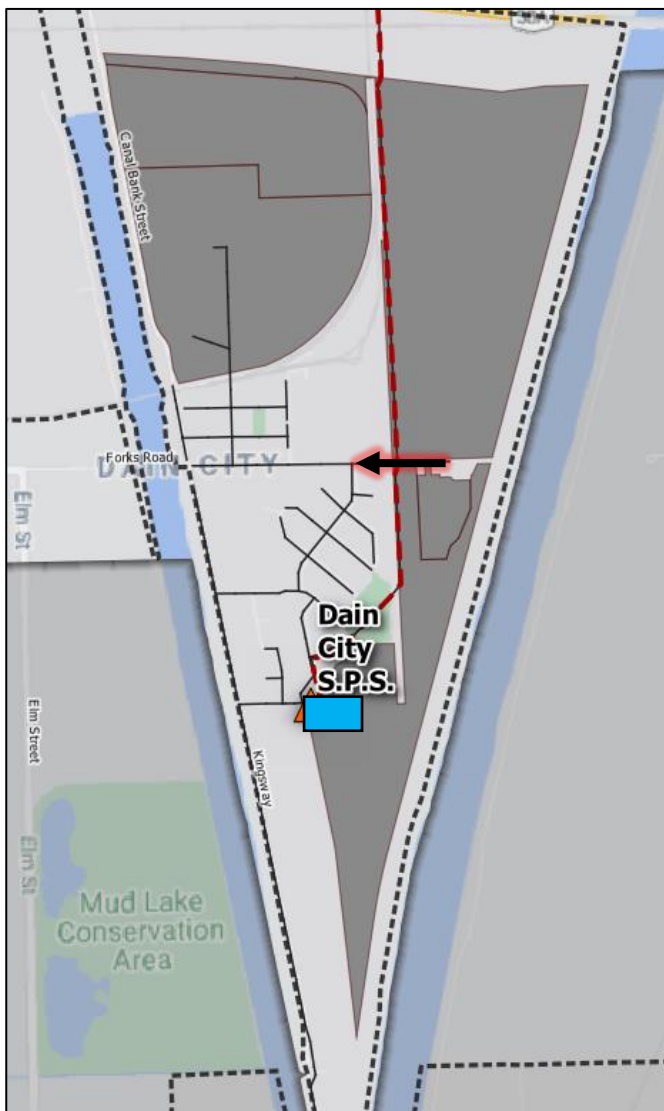
Several studies and capacity assessments have been completed since 2018 by GMBP and are included in **Technical Appendix C**. Recommendations from these studies are to:

- Recommended re-instatement ECA capacity at the SPS;
- Develop I&I reduction program;
- Continue monitoring of grease and lipid deposits from industrial wastewater flows and enforce bylaws;
- Complete a stormwater study and flooding risk assessment; and
- Upgrade sewers on Forks Road from Crescent Drive to the proposed Dain City Community Development.

At the time of this report (2021), a field investigation was underway in Dain City to investigate sources of I&I and provide a local remediation plan to remove I&I and ultimately reduce peak wet weather flows within the Dain City. Works included in the investigation are curbside property surveys for extraneous flow connections, CCTV review, smoke testing and flow monitoring analysis.

The I&I reduction program will be implemented with a target objective of reducing future (including growth) peak 10 year for the entire Dain City area to below 300 L/s, as measured at the inlet sewer to the Dain City SPS, which will allow the existing 2,000 m storage tank to reasonable manage peak flows exceeding the Dain City SPS capacity. The Dain City target I&I removal target is approximately inline with the 25% reduction target for priority areas.

Table 41. Dain City Alternative Evaluation

Dain City Catchment Alternatives								
	Alternative 1: I&I Reduction				Alternative 2: I&I Reduction + Storage Optimization			
								
Overview	Large developments in Dain City require significant station upgrades and I&I reduction to facilitate growth.				- Large developments in Dain City require significant station upgrades and I&I reduction to facilitate growth. - Optimization of existing storage tank (Region project)			
SPS	Upgrade to 170 L/s pumping capacity				Upgrade to 170 L/s pumping capacity			
Sewers	300 m Forks Rd upgrade to 300 mm				300 m Forks Rd upgrade to 300 mm			
SOGRI/ Inflow and Infiltration	- Initiate Inflow and Infiltration program to reduce wet weather flows in catchment assumes, 40% reduction - Improve stormwater infrastructure				- Initiate Inflow and Infiltration program to reduce wet weather flows in catchment, assumes 25% I&I reduction - Improve stormwater infrastructure			
Costing	\$\$				\$\$\$			
Advantages	I&I reduction works toward system wide F-5-5 targets				- I&I reduction works toward system wide F-5-5 targets - Provides additional resilience against basement flooding if I&I targets are not met			
Disadvantages	Will require extensive I&I works and demonstrated removal through flow monitoring				Costly alternative in an area where there is existing storage at the SPS			
Four-Point Criteria Evaluation	 Technical	 Environmental	 Social & Cultural	 Financial	 Technical	 Environmental	 Social & Cultural	 Financial
Recommended Alternative	Not Recommended: Minimal flexibility for future servicing				Recommended: I&I reduction is a priority in the Dain City catchment. Storage needs should be re-assessed in the 2025-2030 time horizon after significant I&I remediation works have been completed in the catchment.			

Evaluation Scoring Legend:  High  Medium  Low

10.4 Priority Areas - Low Data Maturity Areas

Further studies are needed to confirm the flows and system characterization of low data maturity priority areas. All areas will be addressed through the City's annual flow monitoring program starting in 2020. A priority area implementation plan is recommended for each area once flow data is available, similar to the Broadway, Ontario Road and Dain City priority areas. Upgrade needs will be confirmed through the priority area studies.

10.4.1 Plymouth Road Priority Area

Plymouth Road is a low data maturity area showing high risk of basement flooding in existing conditions, in a 10-year design storm. The key issues affecting the Plymouth Road area are:

- Growth pressures: employment area intensification around the hospital in the upstream area and downtown residential intensification downstream;
- High I&I;
- Outlet restriction to the Region Interceptor trunk sewer from the Interceptor surcharge levels; and
- Shallow sewers in the upstream catchment.

Growth in the Plymouth-Hellems subcatchment was estimated to be 2,010 people, 192 jobs and 1.1 ha of new serviced area.

There is limited documented evidence of basement flooding in this area from City staff, however, further investigations are required. Two alternatives were evaluated for this Plymouth Rd priority area:

1. **25% I&I Reduction:** This strategy achieves a local I&I reduction and works towards the system-wide I&I removal target to meet the F-5-5 Regulation.
2. **I&I Reduction and Inline Storage:** If I&I targets are not met in the area and other parts of the City, inline storage may be considered to protect from basement flooding in the upstream area.

The alternative evaluation is detailed in **Table 42**.

Alternative #2 will be carried forward into the capital plan, however, flow monitoring is recommended in the area to confirm existing flows and future flow monitoring is recommended to confirm sizing of inline storage, if it is needed. Areas impacted by the peak levels in the Region Interceptor will benefit from City-wide I&I reduction.

The I&I reduction program will be implemented with a target objective of reducing future (including growth) peak 10 year for the Plymouth Road area to below 300 L/s, as measured in Hellems trunk sewer outletting to the Interceptor, to eliminate the need for any additional infrastructure upgrades. Plymouth Road area I&I removal target does exceed the 25% reduction target for priority areas. As such, if the 300 L/s flow rate objective cannot be achieved, then peak 10 year for target should be to reduce peak flows below 395 L/s to meet the 25% reduction target for priority areas while also implementing the inline storage upgrades.

Table 42. Plymouth Rd Priority Area

Plymouth Catchment Alternatives				
	Alternative 1: I&I Reduction			
	Alternative 2: I&I Reduction and Inline Storage			
Overview	Requires flow monitoring to confirm local flows			
Sewers	No upgrades			
Inflow and Infiltration	Initiate Public and Private I&I Reduction Program, targeting 25% I&I removal			
Costing	\$			
Advantages	- Avoids sewer upgrades - I&I reduction works toward system wide F-5-5 targets			
Disadvantages	Possible that I&I reduction target is not achieved locally			
Four-Point Criteria Evaluation	 Technical	 Environmental	 Social & Cultural	 Financial
Recommended Alternative	Not Recommended: Moderately relies on City-wide I&I for Interceptor peak levels			
	Recommended: Phased monitoring approach facilitates confirmation of existing and future conditions prior to design and construction			

Evaluation Scoring Legend:  High  Medium  Low

10.4.2 Prince Charles Drive South Priority Area

Prince Charles Drive South is a low data maturity area. The key issues affecting the Prince Charles Drive South area are as follows:

- High I&I;
- Interceptor influence at local outlet; and
- Growth intensification of 182 jobs.

There is limited anecdotal evidence of basement flooding in this area from City staff, however, further investigations are required. Two alternatives were evaluated for Prince Charles Drive South priority area:

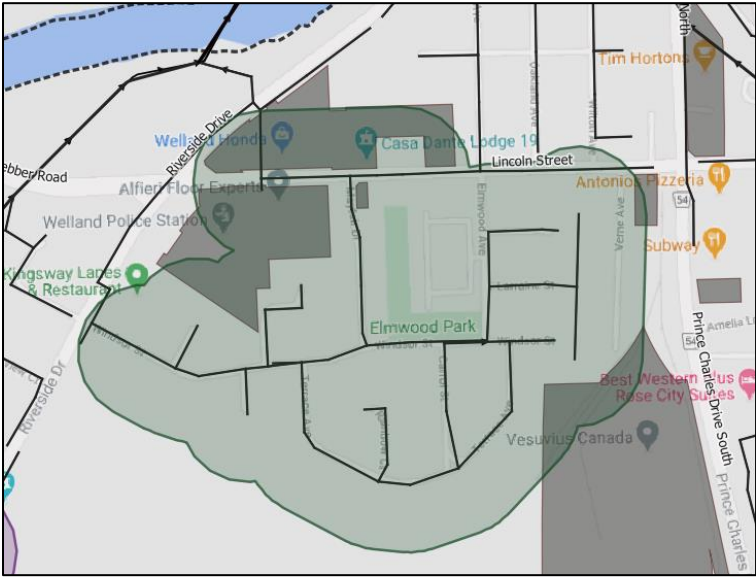
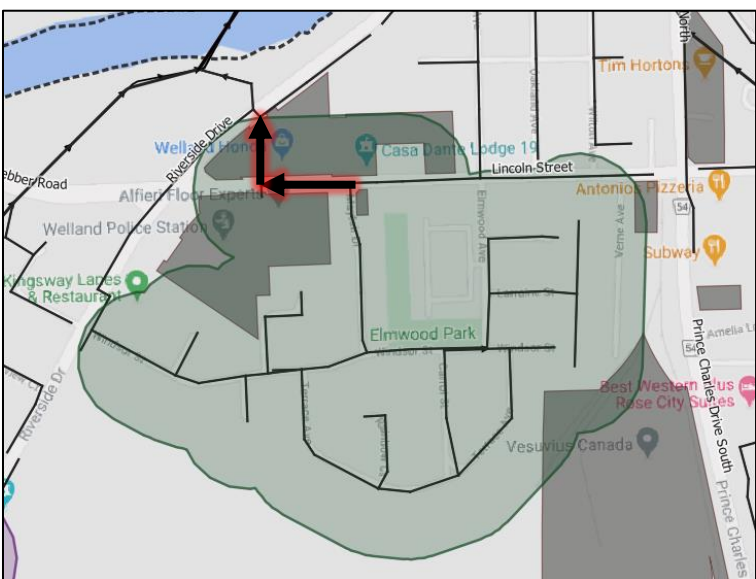
1. **25% I&I Reduction:** This strategy achieves a local reduction in I&I and works towards the system-wide I&I removal target to meet the F-5-5 Regulation.
2. **I&I Reduction and Inline Storage:** If I&I targets are not met in the area and other parts of the City, sewer upgrades may be considered to reduce the HGL in the upstream area. Inline storage needs appear to be 300 m of 375 mm sewer from Riverside Drive to Lincoln St.

The alternative evaluation is detailed in **Table 43**.

Alternative #2 is the preferred alternative and will be carried forward into the capital plan; flow monitoring is recommended in the area to confirm existing flows and future flow monitoring is recommended to confirm sizing of inline storage, if required. As this area is impacted by the peak surcharge levels in the Regional Interceptor, it will also benefit from City-wide I&I reduction.

The I&I reduction program will be implemented with a target objective of reducing future (including growth) peak 10 year for the Prince Charles Drive South area to below 80 L/s, as measured in Prince Charles Drive South sewer outletting to the Interceptor, to eliminate the need for any additional infrastructure upgrades. Prince Charles Drive South area I&I removal target does exceed the 25% reduction target for priority areas. As such, If the 80 L/s flow rate objective cannot be achieved, then peak 10 year for target should be to reduce peak flows below 120 L/s to meet the 25% reduction target for priority areas while also implementing the inline storage upgrades.

Table 43. Prince Charles Drive South Alternative Evaluation

Plymouth Catchment Alternatives								
	Alternative 1: I&I Reduction				Alternative 2: I&I Reduction and Sewer Upgrade			
								
Overview	Requires flow monitoring to confirm local flows				- Requires flow monitoring to confirm local flows - Inline storage in the upstream end of the system for basement flooding protection			
Sewers	No upgrades				Upgrade 250 m of sewers to 375 mm from Riverside Drive to Lincoln Street			
Inflow and Infiltration	Initiate Public and Private I&I Reduction Program, targeting 25% I&I removal				Initiate Public and Private I&I Reduction Program, targeting 25% I&I removal			
Costing	\$				\$\$			
Advantages	- Avoids sewer upgrades - I&I reduction works toward system wide F-5-5 targets				- I&I reduction works toward system wide F-5-5 targets - Provides additional resilience against basement flooding and supports growth			
Disadvantages	Possible that I&I reduction target is not achieved locally or City-wide				More expensive option			
Four-Point Criteria Evaluation	 Technical	 Environmental	 Social & Cultural	 Financial	 Technical	 Environmental	 Social & Cultural	 Financial
Recommended Alternative	Not Recommended: Relies on City-wide I&I to reduce peak levels in the Interceptor				Recommended: Phased monitoring approach facilitates confirmation of existing and future conditions prior to design and construction			

Evaluation Scoring Legend:  High  Medium  Low

10.4.3 Feeder Road Priority Area

Feeder Road is a low data maturity area, therefore further investigation is required. The key issues affecting the Feeder Road area are:

- High I&I
- Growth of 659 jobs and 4 ha of new serviced lands

As noted in Section 10.1.2, growth flows will exceed the station capacity by 2041. Two alternatives were evaluated for the Feeder Road priority area:

1. **25% I&I Reduction:** This strategy achieves a local reduction in I&I and works towards the system-wide I&I removal target to meet the F-5-5 Regulation.
2. **I&I Reduction and Storage:** If I&I targets are not met in the area, storage may be considered to reduce the HGL in the upstream area.

The alternative evaluation is detailed in **Table 44**.

Alternative #2 is the preferred alternative and will be carried forward into the capital plan; flow monitoring is recommended in the area to confirm existing flows and future flow monitoring is recommended to confirm sizing for the SPS upgrade and storage, if required.

The I&I reduction program will be implemented with a target objective of reducing future (including growth) peak 10 year flows for the Feeder Road area to below 125 L/s, as measured at the inlet to the Feeder Rd SPS, to eliminate the need for any additional infrastructure upgrades. The Feeder Road I&I removal target is approximately inline with the 25% reduction target for priority areas.

Table 44. Feeder Road Evaluation Alternatives

Feeder Rd Catchment Alternatives								
	Alternative 1: I&I Reduction and Modified Freeboard Criteria				Alternative 2: I&I Reduction, Modified Freeboard Criteria and Storage			
Overview	- Requires flow monitoring to confirm local flows - Modify/reduce the 2.4m freeboard requirement - Confirm “basements elevations” in industrial area - City-led I&I reduction programming				- Requires flow monitoring to confirm local flows - Modify/reduce the 2.4m freeboard requirement - Confirm “basements elevations” in industrial area - City-led I&I reduction programming			
Region Infrastructure	None				450 m³ storage to mitigate peak flows above upgraded station capacity			
Inflow and Infiltration	Initiate Public and Private I&I Reduction Program				Initiate Public and Private I&I Reduction Program			
Costing	\$				\$\$			
Advantages	I&I reduction works toward system wide F-5-5 targets				I&I reduction works toward system wide F-5-5 targets			
Disadvantages	Industrial I&I works may not be effective				More expensive alternative			
Four-Point Criteria Evaluation	 Technical	 Environ- mental	 Social & Cultural	 Financial	 Technical	 Environ- mental	 Social & Cultural	 Financial
Recommended Alternative	Not Recommended: Minimal flexibility for addressing shallow local sewers				Recommended: Phased monitoring approach facilitates confirmation of existing and future conditions prior to design and construction			

Evaluation Scoring Legend:  High  Medium  Low

10.4.4 Woodlawn Rd Priority Area

Woodlawn Road priority area has been identified as a low data maturity area. The key issues affecting the Woodlawn Priority area are as follows:

- High I&I;
- Undersized trunk on Trelawn Parkway for high wet weather flows; and
- Employment intensification of 462 jobs at Niagara College.

There is limited documented evidence of basement flooding in this area from City staff, however, further investigations are required. Two alternatives were evaluated for the Woodlawn Road priority area:

1. **50% I&I Reduction:** This strategy achieves a local reduction in I&I and works towards the system-wide I&I removal target to meet the F-5-5 Regulation. 50% I&I reduction would be needed.
2. **25% I&I Reduction and Sewer Upgrades:** If I&I targets are not met in the area, sewer upgrades may be considered to prevent basement flooding from peak wet weather flows on Woodlawn Rd and Trelawn Parkway.

The alternative evaluation is detailed in **Table 45**.

Alternative #2 is the preferred alternative and will be carried forward into the capital plan; flow monitoring is recommended in the area to confirm existing flows and future flow monitoring is recommended to confirm sizing sewer upgrades, if needed.

The I&I reduction program will be implemented with a target objective of reducing future (including growth) peak 10 year flows for the Woodlawn Road area to below 925 L/s, to eliminate the need for any additional infrastructure upgrades. The Woodlawn Road I&I removal target is approximately inline with the 25% reduction target for priority areas.

Table 45. Woodlawn Priority Area

Woodlawn Road Catchment Alternatives							
	Alternative 1: I&I Reduction				Alternative 2: Upgrade Sewers		
Overview	Requires flow monitoring to confirm local flows				- Requires flow monitoring to confirm local flows - Sewer Upgrades on Trelawn Parkway and Woodlawn		
Sewers	No upgrades				1000 m Trelawn Parkway Upgrades to 450 mm 500 m upgrade on Woodlawn (Region trunk) to 750 mm, if 25% I&I reduction upstream is not achieved		
Inflow and Infiltration	- Initiate Public and Private I&I Reduction Program - Requires 50% reduction of existing wet weather flows to eliminate need for upgrades				- Initiate Public and Private I&I Reduction Program - Assumes 25% reduction of existing wet weather flows - Prioritize I&I reduction in Trelawn Parkway neighbourhood first		
Costing	\$\$				\$\$\$		
Advantages	Avoids local sewer upgrades				Phased monitoring and I&I programming may avoid the infrastructure upgrades		
Disadvantages	50% I&I reduction from the existing flows may not be feasible - Woodlawn trunk receives some flows from Pelham, which is out of the City's control				Construction on Trelawn Pkwy and Woodlawn Rd would be disruptive to local residents		
Four-Point Criteria Evaluation	 Technical	 Environ- mental	 Social & Cultural	 Financial	 Technical	 Environ- mental	 Social & Cultural
Recommended Alternative	Not Recommended: Alternative is dependent on some I&I reduction in Pelham				Recommended: Sewer upgrades can be carried forward for the EA process and eliminated later if flow monitoring does not indicate need.		

Evaluation Scoring Legend:  High  Medium  Low

10.4.5 Fitch St SPS & Clare Avenue Priority Area

Fitch SPS & Clare Avenue has been identified as a low data maturity area and therefore, further investigations are required. In 2014, Kerry T Howe Engineering completed a study for the Fitch SPS that recommended further monitoring downstream after completion of downstream sewer separation; at the time of this report this monitoring has not been completed. The key issues facing the Clare Avenue and Fitch Street SPS today are as follows:

- High I&I on South Pelham Road and Clare Ave;
- City priority to decommission Fitch St SPS (owned and operated by City); and
- Fitch Street trunk limitations.

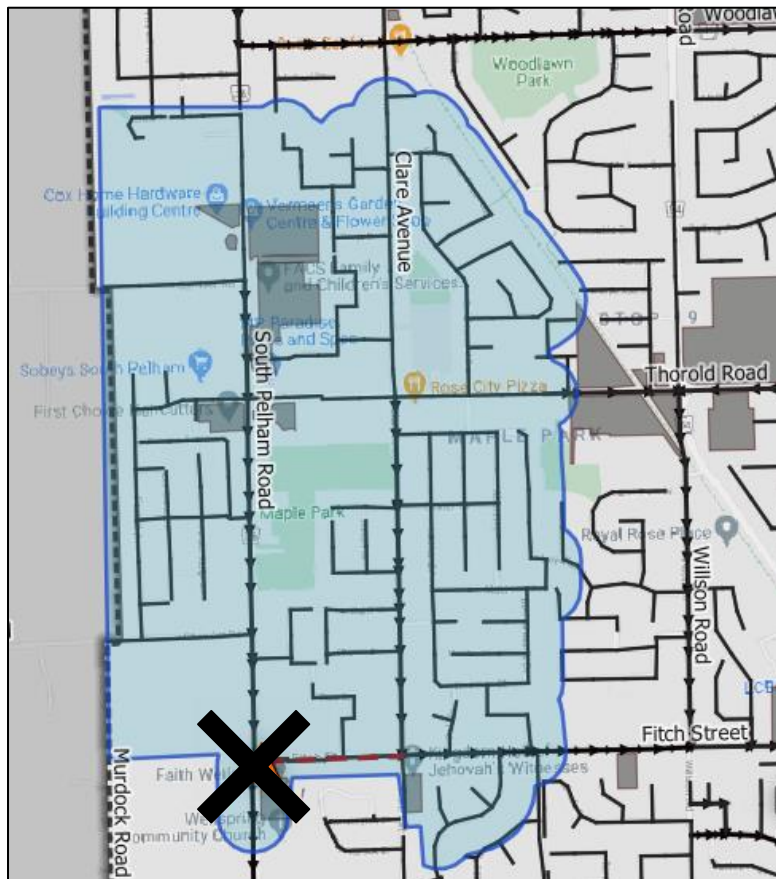
Further investigations are required in this area. The impacts of decommissioning Fitch St on the upstream South Pelham Road trunk are uncertain; the decommissioning of the Fitch St will require a feasibility study.

Two alternatives were evaluated for the Fitch St SPS and Clare Ave priority area:

1. **Fitch St SPS Decommissioning and 75% I&I Reduction:** This strategy achieves a local reduction in I&I and works towards the system-wide I&I removal target to meet the F-5-5 Regulation. 75% I&I reduction would be needed to avoid upgrades.
2. **Fitch St SPS Decommissioning, 25% I&I Reduction and Sewer Upgrades:** If I&I targets are not met in the area, sewer upgrades on Clare Ave. may be considered to prevent basement flooding from peak wet weather flows on Clare Ave and Fitch St.

The alternative evaluation is detailed in **Table 46**. The I&I reduction program will be implemented with a target objective of reducing future (including growth) peak 10 year I&I flows for the entire Fitch St. and Clare Ave. area to below 370 L/s, as measured in the sewer downstream of the intersection of Oak St and Fitch St. The Fitch St SPS and Clare Ave I&I removal target is approximately inline with the 25% reduction target for priority areas. In order to avoid infrastructure upgrades, the 10 year peak wet weather flows in the buildout scenario would need to be reduced to 160 L/s, which is not likely achievable.

Table 46. Clare Ave and Fitch St Priority Area

Clare Ave and Fitch St Catchment Alternatives								
	Alternative 1: I&I Reduction				Alternative 2: Upgrade Sewers			
								
Overview	• High I&I on local sewers • Requires flow monitoring to confirm local flows • Decommissioning of Fitch St SPS, requires study				• High I&I on local sewers • Requires flow monitoring to confirm local flows • Decommissioning of Fitch St SPS, requires study • Sewer Upgrades on Fitch St • Sewer Upgrades on Clare Ave			
Sewers	• No upgrades				• Upgrade 825 m to 750 mm on Fitch St • Upgrade 1000 m to 450 mm on Clare Ave			
Inflow and Infiltration	• 75% I&I reduction targeted through Public and Private I&I Reduction Program				• 25% I&I reduction through Public and Private I&I Reduction Program			
Costing	• \$\$				• \$\$\$			
Advantages	• Avoids sewer upgrades				• Improves resiliency against basement flooding			
Disadvantages	• 75% I&I reduction from the existing flows may not be feasible				• Construction on Fitch St would be disruptive to City Traffic			
Four-Point Criteria Evaluation	 Technical	 Environ- mental	 Social & Cultural	 Financial	 Technical	 Environ- mental	 Social & Cultural	 Financial
Recommended Alternative	• Not Recommended: Uncertain if 75% I&I reduction can be achieved.				• Recommended: Phased monitoring approach facilitates confirmation of existing and future conditions prior to design and construction			

Evaluation Scoring Legend:  High  Medium  Low

10.4.6 Seaway Heights Priority Area

The Seaway Heights priority area has been identified as a low data maturity area. The key issues affecting the Seaway Heights area are as follows:

- High I&I; and
- Significant growth pressures.

Growth in the Seaway Heights subcatchment was estimated to be 4,509 people, 3 jobs and 15.7 ha of new serviced area.

There is limited documented evidence of basement flooding in this area from City staff, however, further investigations are required. Two alternatives were evaluated for the Seaway Heights priority area:

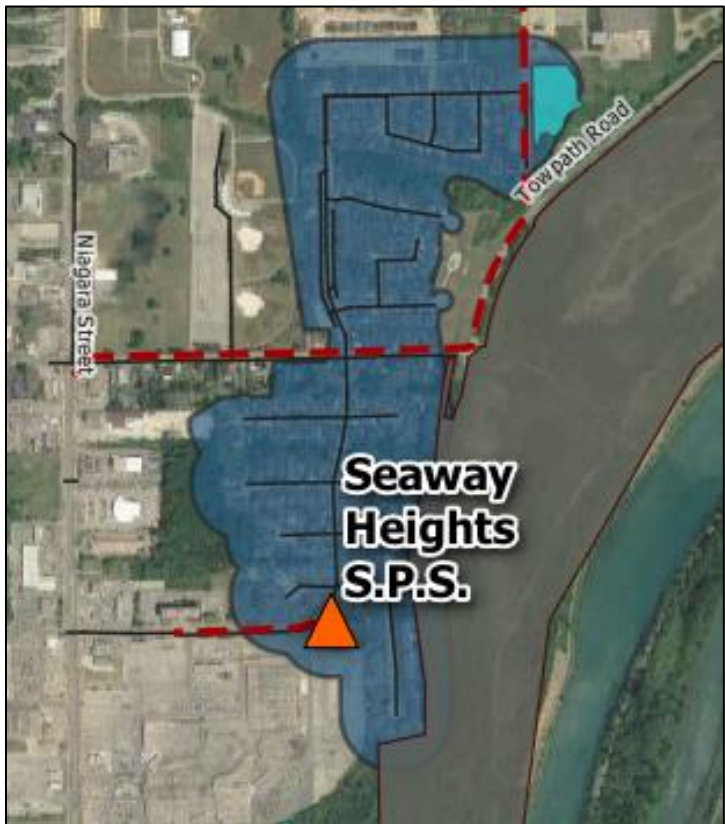
1. **25% I&I Reduction:** This strategy achieves a local reduction in I&I and works towards the system-wide I&I removal target to meet the F-5-5 Regulation.
2. **Maintain current level of service:** If I&I targets are not met in the area, alternative servicing may be considered from the Northern Reach development.

The alternative evaluation is detailed in Table 47.

Alternative #1 is the preferred alternative and will be carried forward into the capital plan; flow monitoring is recommended in the area to confirm existing flows and future flow monitoring is recommended for I&I remediation works.

The I&I reduction program will be implemented with a target objective of reducing future (including growth) peak 10 year I&I flows for the entire Seaway Heights area to below 130 L/s, as measured at the inlet to the Seaway Heights SPS. The Seaway Heights target I&I removal target is approximately inline with the 25% reduction target for priority areas.

Table 47. Seaway Heights Priority Area

Seaway Heights Catchment Alternatives								
	Alternative 1: I&I Reduction				Alternative 2: I&I Reduction and Limit Growth			
								
Overview	Reduce I&I to allow growth and further investigation to confirm existing flows and pump station operational capacity				Reduce I&I beyond 25% or limit growth to maintain the current level of service in line with I&I reduction; confirm existing flows and pump station operational capacity			
Sewers	None				None			
Inflow and Infiltration	25% I&I reduction to achieve the target for Priority Areas				Greater than 25% I&I reduction to maintain the current level of service			
Costing	\$				\$			
Advantages	Achieves 25% I&I reduction target for Priority Areas				Achieves 25% I&I reduction target for Priority Areas			
Disadvantages	Minimal disadvantages				May require additional efforts or cooperation for private side I&I reduction			
Four-Point Criteria Evaluation	 Technical	 Environ- mental	 Social & Cultural	 Financial	 Technical	 Environ- mental	 Social & Cultural	 Financial
Recommended Alternative	Recommended: Current information suggests 25% I&I reduction is sufficient to allow growth allocations				Not Recommended: Possible pushback from developers if challenges arise on Northern Reach property.			

Evaluation Scoring Legend:  High  Medium  Low

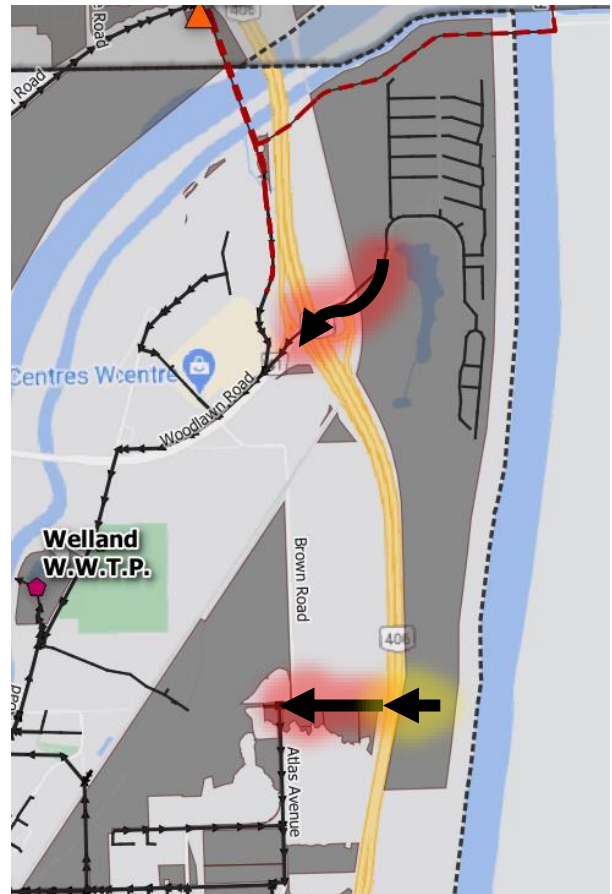
10.5 Local System Servicing Concepts

In addition to the larger catchment concepts that were reviewed, the following planned and proposed local system servicing concepts were presented.

10.5.1 Daimler Parkway Priority Area

Daimler Parkway was previously assessed in support of the Hunter's Pointe development. A summary of previous recommendations is provided in **Table 48**.

Table 48. Hunter's Pointe Planned Upgrades

Daimler Parkway and Oxford Road	
Overview	
- This area was classified as a low data maturity area. Past studies recommended flow monitoring to confirm flows. - Highway 406 crossing is 300 mm and the slope is shallow. - Growth in this area is triggering the need for the upgrade.	
Planned Upgrades	
500 m of sewer upgrades on Daimler Parkway to at least 450 mm are needed to support the developments to the east of Hwy 406. 340 m of sewer upgrades on Oxford Rd to 250 mm. 150 m of new 250 mm sewer to service the southern end of the Hunter's Pointe development area via a new Highway crossing.	

10.5.2 Chippawa Park

Sewer separation upstream from Chippawa Park will reduce wet weather flows causing capacity restrictions. Streets with remaining combined sewers to be separated are Weller Ave, Parkdale Place and Edgar Street.

Table 49. Chippawa Park Sewer Separation

Chippawa Park	
Overview	
- This area was classified as a low data maturity area. Flow monitoring is recommended to confirm flows. - Peak flows in the Chippawa Park sewer cause system surcharging beyond 2.4m freeboard in a 10-year storm. - Sewers upstream from the bottleneck are combined sewers Weller Ave, Parkdale Place and Edgar Street, shown in red. This area is referred to as the Edgar-Elgin area.	
Planned Upgrades	25% I&I reduction can be achieved through sewer separation. 750 m of combined sewers to be separated upstream from Chippawa Park.

10.5.3 Remaining Combined Sewer Separation Projects

Remaining combined sewer separation is integrated into the State of Good Repair Program. Specific areas in the City that are in this priority category are as follows:

- River Road;
- Edgar/Elgin area;
- Riverside Drive; and
- PCD/West Main Area.

10.5.4 Areas Benefitting from System Wide I&I

The following areas are classified as having low data maturity but is not flagged as a priority area. Flow monitoring in the area would be beneficial to confirm flows and needs for infrastructure upgrades. 25% I&I reduction in the area will reduce the risk of basement flooding in the Buildout Growth Scenario.

- Leaside;
- Armoury-Summit; and
- Colbeck.

11. OPERATIONS AND MAINTENANCE

The following section will review the City's operation and maintenance activities, including what activities are being done, the maintenance frequency and approach, staff responsibilities and opportunities to improve and enhance operations and maintenance activities. The purpose of this section is to present improvement recommendations with respect to the City of Welland's operations and maintenance practices in view of current industry best practices.

Maintenance planning and review is important for many reasons including:

- Regulatory reporting/compliance;
- Optimizing resources;
- Risk management;
- Lifecycle planning;
- Cost management; and
- Asset reliability.

11.1 Ongoing Maintenance Activities

The following describes the City's maintenance and operational programs/initiatives that focus on monitoring and maintaining the storm and sanitary sewer system. The aim of these programs is to be proactive in the discovery of system deficiencies so that they may be addressed prior to a system failure.

11.1.1 CCTV Program

The City of Welland conducts Closed-Circuit Television (CCTV) sewer inspections as part of the Sewer Flushing and Inspection Program. The CCTV Program is completed as a contract by a third party; this program aims for 20% system coverage annually. The annual budget for the CCTV Program is \$240,000/annum of which \$150,000/annum is reserved for the storm sewer system. The CCTV Program is active from April through December.

Data collected from CCTV investigations is linked to the City's digital sewer network using asset IDs. A history of past CCTV videos is available along with Pipeline Assessment Certification Program (PACP) deficiencies flags. The data collected from the CCTV is used for sewer risk scoring, Capital Planning inputs and for prioritizing sewer replacements, road resurfacing projects and corridor management. CCTV investigations are typically completed in areas where flushing work was completed the year prior, however, some problem sewer areas are inspected annually. The City has noted that CCTV investigations are also carried out as needed following a rainfall event, which may be triggered by a resident call. Additionally, Niagara Region operates its own CCTV Program which runs on a 3-year cycle.

The City should review the CCTV cycle areas to incorporate new development areas and improve flusher coordination.

11.1.2 Flushing

Sewer flushing is the process of cleaning the storm and sanitary system using high-pressure water to scour the pipes, ensuring that the sewers function properly and to remove any blockages that may

be causing impacts to the environment or public health. The City of Welland Public Works Department targets to flush 20% of the system per year, and coordinates the flushing based on a priority-based program. Annually, problem areas are flushed for grease and debris. In the future, annual scheduled flushing may be replaced by CCTV-driven flushing, meaning that priority areas for flushing will be determined based on the outcomes of the CCTV videos.

The City has two flusher trucks in its fleet, which are often also used for excavation projects. It is noted that flushing operations are limited by the number of flushing trucks and operations staff available.

11.1.3 Flow Monitoring Program

Both the City and the Region manage flow monitoring programs that focus on different objectives. Firstly, the City currently and historically has used flow monitors as a method of overflow monitoring and for some required regulatory monitoring, as well as for monitoring pre and post impacts from rehabilitation projects. Niagara Region's flow monitoring programs cover all pumping stations.

11.1.4 Pump Station Drawdown Testing

Niagara Region is responsible for completing drawdown testing at their pump stations. The current frequency of drawdown testing is low, and some stations show significant performance deterioration between tests. Opportunities exist to use SCADA to determine pumping station performance through wet well level trends and run-time cycles. The City has four small pumping stations, none of which have drawdown information or SCADA.

11.1.5 Special Investigations

Special investigations include sewer inspections such as lateral and manhole inspections, smoke and dye testing. It is noted that special investigations such as lateral inspections are triggered by basement flooding events.

11.1.6 Rehabilitation & Replacement

The City typically determines rehabilitation and replacement needs following the CCTV findings and other growth-related upgrades. In recent years (2014-2016), the program was driven by prioritized PACP structural condition findings as the City's lining program was on hold pending hydraulic analysis. Capital planning has a sewer lining and rehabilitation placeholder in the 10-Year Plan. However, the sewer lining budget frequently gets re-allocated to other projects. Overall, there is more than \$300,000 spent on sewer rehabilitation annually.

Niagara Region is responsible for the following maintenance activities:

- Preventative maintenance activities on pumps;
- Pump inspections including rehabilitation, upgrades and rebuilds;
- Forcemain inspections and cleaning; and
- Annual siphon cleaning.

11.2 Staff Complement

Figure 18 below illustrates the City's organization chart as of October 16th, 2019 for the Infrastructure Services Department – Engineering Services Division. This chart is also available in **Appendix K – Organizational Chart** in a larger format.

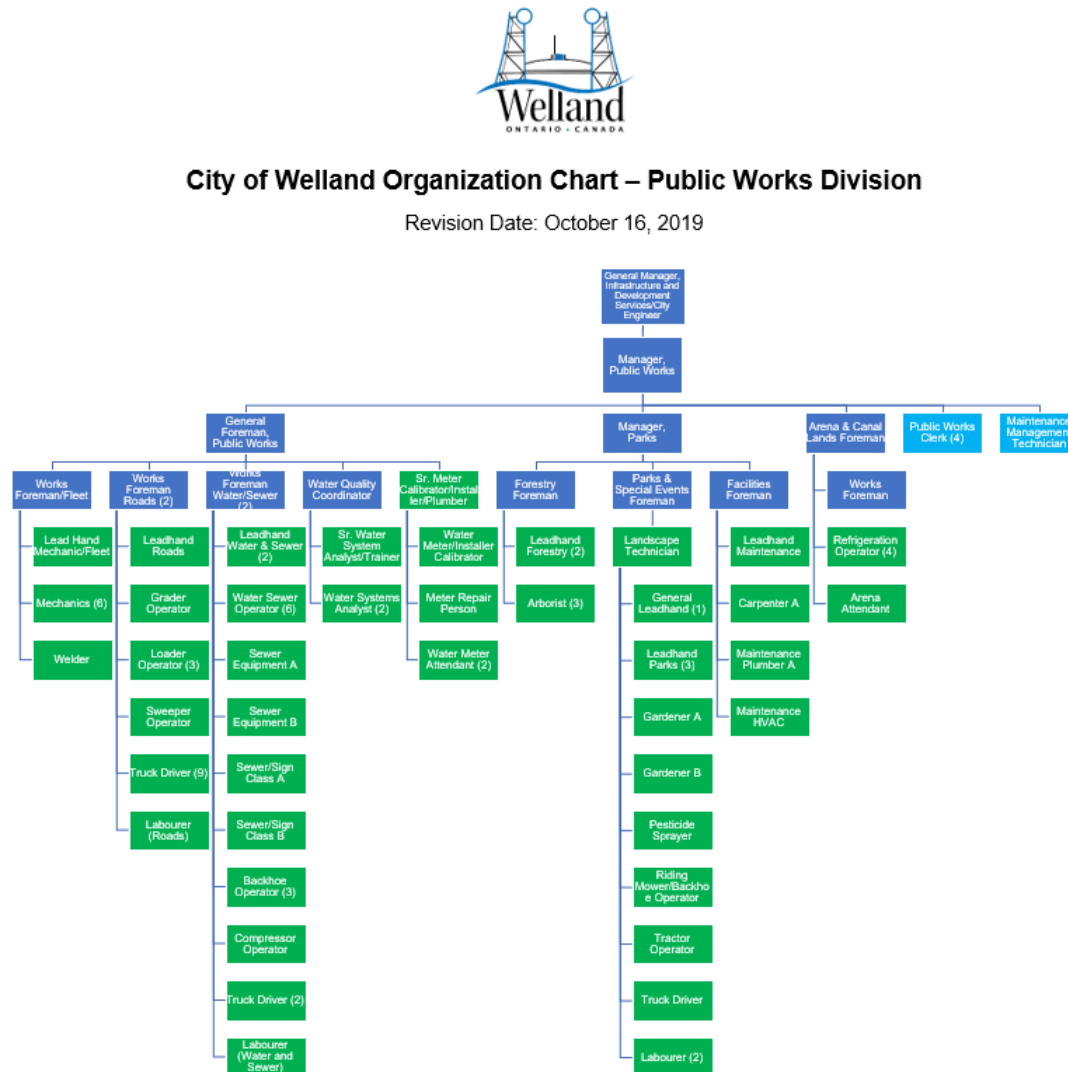


Figure 18. Public Works Staffing Chart

Currently, the City employs the following teams:

- **Public Works Staff**
 - 6 Water-Wastewater Operators: time is split between water and wastewater activities;
 - 2 staff dedicated full-time to operating the City's flusher truck;
 - 2 staff dedicated to sewer rodding however, time is also split on sign activities; and
 - 1 foreman full time on sewers.

- Engineering Staff
 - GIS staff also work on wastewater & stormwater projects.

11.3 Operation and Maintenance Budget

The City spends an approximate of \$4.4 million in 'other operational expenditures' which is outside of water purchase and sewage treatment. Specifically, the City itemizes activities as an export from their work order management system; as an example, for sanitary activities total spent from January 2019 to November 2019 was approximately \$864,000. This work is itemized out by activity, however, is not currently tied to an asset and/or geographical location. It was noted the City overspent on lateral repair work in 2016 and this effort has since resulted in reduced call volumes. As the City undergoes its transition to a new maintenance management system reporting will be improved as the system will be designed to better capture this information on an asset level.

12. PREFERRED RECOMMENDATIONS

The recommended wastewater servicing strategy can be broken down into various components that have different aims but each contributing to the overall improvement of the existing system and service the projected buildout growth.

The preferred servicing strategy was developed to ensure that extension of the wastewater collection system from the expansion lands is supportive of the existing servicing strategy and follows an integrated approach with the City's development plans.

12.1 25% System Wide I&I Plan

The 10% system-wide target can be achieved by targeting a minimum of 25% I&I reduction in the priority areas. This strategy prioritizes the areas with the worst system performance and high I&I to attain a higher probability of I&I removal in focused areas. Pre and post I&I remediation monitoring is required to confirm system flows and quantify removal.

12.2 Recommended Studies

The following section describes recommended studies to be completed.

12.2.1 Flow Monitoring

It is recommended that flow monitoring studies be conducted in areas with low data maturity. Flow monitoring data can be utilized to confirm flows modelled in this study and to prioritize I&I programming. Several areas were monitored in 2020 and that data will be used to update the model on firm recommendations for preferred solution.

Any I&I remediation work completed should have post-works flow monitoring to confirm I&I reduction.

12.2.2 Feasibility Studies for Low Data Maturity

Priority areas identified as having low data maturity require a feasibility study once flow monitoring data is available. The hydraulic model should be calibrated with updated data and the preferred alternative should be re-assessed. Further, preliminary opportunities for I&I remediation planning may be assessed through the feasibility study.

- Plymouth Road Priority Area;
- Prince Charles Drive South;
- Feeder Road Priority Area;
- Woodlawn Rd Priority Area;
- Seaway Heights Priority Area;
- Daimler Parkway; and
- Chippawa Park.

12.2.3 I&I Investigations

Priority Areas have been identified as having high potential for successful I&I removal due to high flows. I&I investigations will take a public-private approach with multiple methods of investigation including tactical flow monitoring to isolate wet weather flow sources, CCTV review, smoke and dye testing, curbside drainage surveys and lateral inspections.

12.2.4 Welland River Inflow

It is recommended to develop an investigation plan for identifying and preventing inflows from the Welland River into the sanitary system.

- Base Risk Assessment: a base study is needed to assess the likelihood of Welland River Inflow at each CSO using river level data from 2015-2019. The risk assessment will help the City prioritize the follow up investigations.
- Field Investigation: Following the risk assessment, the City may select which CSOs require a field investigation to assess the condition of the CSO structure and control and determine if inflow is occurring at the location.
- Flow Monitoring: Flow monitoring may be undertaken at individual CSO locations to quantify flows.
- Backflow prevention should be implemented at the highest risk CSO locations.

12.2.5 New Subdivision Flow Monitoring and Acceptance Criteria

The Region is developing a policy for new subdivision agreements to require newly constructed sewers perform to an acceptance criteria of 0.018 L/s/ha.

Unitized RDII is most often used as a design parameter within design guidelines to ensure that adequate capacity is provided within new wastewater collection infrastructure to prevent sewer surcharging and surcharge-related basement flooding. In the absence of a synthesized design return period or measured precipitation event, unitized RDII remains a design (not performance) parameter. This distinction is important in the context of acceptance criteria which is not currently correlated to a design storm.

Figure 19 identifies different components of wet weather flow and highlights differences between static and dynamic models. Unitized RDII, without relation to a design storm, represents a static wet weather flow value. The amount of “buffer” space remaining during wet weather determines the Level of Service that the system can provide. Thus, a system designed to a higher Level of Service can convey more intense storms, but it is dependent on the tightness of the system. By relating the acceptance criteria to 0.018 L/s/ha to a design storm/Level of Service, the acceptance criteria become performance criteria. Flow monitoring can then be used to evaluate the return period of a storm and associated RDII flow. For example, this report recommended the City meet a 10 year Level of Service for the wastewater system and would require the RDII component to be less than 0.018 L/s/ha generated from an equivalent 10 year design storm.

Therefore, it is recommended that the Region policy relates the acceptance criteria to Levels of Service. The acceptance criteria will help to ensure I&I contributions from new subdivisions are lower than the design criteria and provides flexibility in future as pipes age and crack.

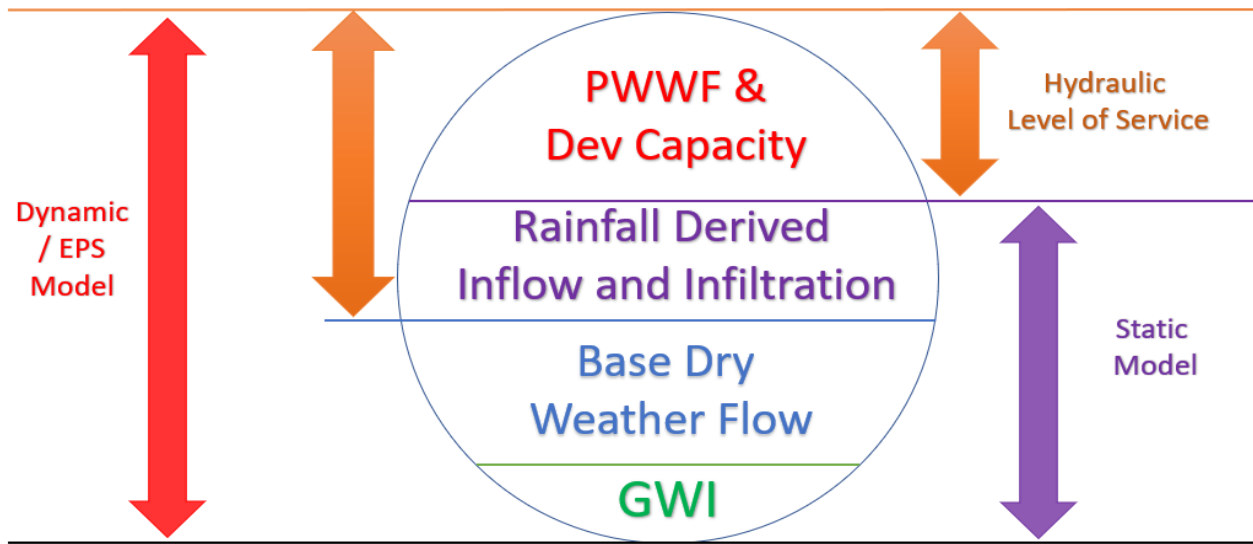


Figure 19. Hydraulic Level of Service

12.3 State of Good Repair Wastewater Replacement Program

The City of Welland has an existing State of Good Repair (SOGR) through the Asset Management Plan (AMP).

12.3.1 Existing Program Prioritization

The City's Comprehensive Asset Management Plan is currently under review, however, existing and approved AMP principles are described below.

Strategic Asset Management Policy SER-002-0007

- As part of its asset management planning for municipal infrastructure, the City is committed to considering climate change. This includes:
 - Identifying the vulnerabilities of the City's existing and proposed infrastructure assets caused by climate change, and subsequent potential costs;
 - Considering the means to address those vulnerabilities, related to operations, levels of service and lifecycle activities;
 - Considering adaptation opportunities that may be undertaken to manage the vulnerabilities; and
 - Considering mitigation approaches to limit the magnitude or rate of long-term climate change (such as greenhouse gas emission reduction objectives), and
 - Considering disaster planning and contingency funding.
- Principle no. 6. Infrastructure planning & investment should ensure infrastructure is designed to be resilient to the effects of climate change; and
- Principle no. 7. Infrastructure planning & investment should minimize the impact of infrastructure on the environment.

Asset Management Strategies (2016 AMP Addendum)

- Combined sewer separation: The separation of combined sewers is among the highest priority projects in Welland. In most cases, the separation of combined sewers is completed through the construction of a storm sewer along the same alignment and the conversion of the combined sewer to function as a sanitary sewer.
- Integrated right-of-way asset replacement: The City strives to optimize when and how assets in the same right-of-way are replaced. This approach provides better value for infrastructure renewal dollars because it is typically more cost effective to replace all of the infrastructure in the same right-of-way. The highest priority projects in Welland are therefore integrated right-of-way projects in which combined sewer separation and cast iron watermain replacement are completed together.

Intervention Triggers (2016 AMP)

- Sanitary Sewers: Replace or rehabilitate when condition state reaches poor or very poor; and
- Combined Sewers: Replace and separate all combined sewers.

Table 50. PACP Rating

Condition State	Condition Information	Percent of Estimated Service Life* Remaining on Asset
Very Good	PACP/WRC Score of 1	75-100%
Good	PACP/WRC Score of 2	50-74%
Fair	PACP/WRC Score of 3	30-49%
Poor	PACP/WRC Score of 4	10-29%
Very Poor	PACP/WRC Score of 5	<10%

*The estimated full-service life of sanitary sewers is 80 years.

Tax/Rate Increases Required (2016 AMP Addendum)

- Average annual expenditure need: \$4.4 Million; and
- Annual wastewater utility rate increase: 8.2% per year for 10 years.

Recommended Priority Projects (2016 AMP Addendum)

Combined sewer separation and cast iron watermain integrated right-of-way replacement:

- The elimination of combined sewers is a priority in Welland. This will significantly reduce the risk that these sewers will cause basement flooding or discharge untreated sewage into the natural environment. Furthermore, the elimination of the combined sewers will reduce the amount of wastewater that Welland has to pay the Region of Niagara to treat, which will free up future resources to fund the replacement of other assets in the City. At the same time, the replacement of cast iron watermain is also a priority because these pipes are associated with high break frequencies and discoloured water complaints. The high break frequency of this pipe cohort also results in an increase to the volume of water that is lost during the break

events that the City has pay the Region to provide. Integrated right-of-way projects that separate combined sewers and replace cast iron watermain are recommended to be a high priority for the City.

- Specific areas in the City that are in this priority category are as follows:
 - River Road;
 - Edgar/Elgin area;
 - Riverside Drive; and
 - PCD/West Main Area.

Replacement of subsurface infrastructure in areas with high leakage watermain or high infiltration sanitary sewers:

- The replacement of watermain in areas that have high leakage rates or the replacement of sewers that have high infiltration rates are also recommended as a high priority in Welland. Watermain with high break frequencies increase the potential for the ingress of untreated water into the distribution system during watermain break events and high infiltration sanitary sewers increase the likelihood of discharging untreated wastewater into the natural environment or the occurrence of basement flooding events. All of these consequences represent health and safety concerns for the local community.
- The replacement of these assets will reduce the costs that the City has to pay to treat water/wastewater, freeing up funds to fund the replacement of other assets. An additional benefit to replacing watermain with high leakage rates is the restoration of the hydraulic capacity of the distribution system and an increase in available fire flows because these are typically older pipes that have a decreased hydraulic capacity due the degradation in the 'C' factor caused by internal corrosion.
- Specific areas in the City that are in this priority category are as follows:
 - McNaughton, Nelles, Bishop (completed);
 - David Street;
 - Dain Avenue;
 - East Wartime (completed); and
 - West Wartime (partially completed).

12.4 Operations and Maintenance Recommendations

12.4.1 Maintenance Activities

The City's flushing program should continue, however, the frequency of flushing should be driven by the results of the CCTV findings; the program should be refined to drive alternate flushing frequencies based on identified reoccurring operational and maintenance defects. Similar to the 5-Year program, this program ensures periodic inspection of the entire system, but makes better use of resources based on the condition rating of individual sewers. Sewers identified as being in poor condition will be inspected more frequently, while sewers in good condition will be inspected less frequently.

For this alternative, the priority and frequency of inspection correspond to the Overall Peak Rating determined by the most recent inspection. As illustrated by **Figure 20** sewers with Overall Ratings of 3 or less are considered Good condition, and are recommended for inspection every 10 years, while sewers with Overall Ratings of 4 or 5 are considered Fair and Poor condition and recommended for inspection every 5 and 2 years respectively.

NOTE: The Overall Rating was used as a guide for budgetary purposes in the development of the inspection program. Despite their condition scores, some sewers may require semi-annual, or more frequent, cleaning and inspection. All inspection frequencies must be reviewed and updated regularly based on the most recent inspection records.

Further, it is recommended the CCTV be utilized to identify areas of Fats, Oils and Grease (FOG) build-up within the network. These can then be prioritized into a scheduled program for removal based on rate of accumulation and pipe blockage.

Overall Peak Rating	Condition	Inspection Priority	Inspection Frequency
0	Good	Low	10 Years
1			
2			
3			
4	Fair	Medium	5 Years
5	Poor	High	2 Years

Figure 20. Inspection Frequency Determined by Overall Peak Rating

Special investigations should continue on an as-needed basis whether they be triggered from a residential call, additional CCTV investigation, capital program, etc.

Flushing management should be reviewed inline with the CCTV cycle to improve coordination. Some considerations to increase flushing to be completed in contracts can relieve Public Works department time constraints.

12.4.2 Staff Complement

The sewer network is projected to grow by 35% to support buildout development, based on existing sewer network density and added lands in Welland. It is anticipated that to meet the increased operational and maintenance needs the City will be required to increase their existing staff complement by adding two (2) Public Works Operations staff and two (2) Project Engineers by 2041.

With the projected growth and resulting infrastructure needs, the City will experience an influx of work specifically, as it relates to contract management. Recognizing both the resource commitment required and the importance of proper contract management it becomes evident the City should consider the addition of one (1) Engineering Technologist.

12.4.3 Maintenance Management System

As the City moves to a new maintenance management work order system the City will have the ability to tag maintenance activities at an asset level. This allows the City to analyze dollars spent on an individual asset and rolled up to a geographical area; for example, sanitary sewer repair works of the same sewer within a few years would trigger further investigation for cause/failure modes. This data can identify necessary alterations to planned maintenance and replacements/rehabilitation works within the capital program.

Further it is our recommendation lifecycle models should be created for each asset type allowing the City to appropriately plan and fund necessary asset interventions across the City's portfolio. These models can also be migrated into the maintenance management system to trigger the necessary maintenance activities that will ensure the asset stays within its projected lifecycle curve.

13. IMPLEMENTATION PLAN

The following sections summarize the recommended upgrade options and corresponding preliminary cost estimates.

13.1 Project Costing

For the purposes of the 2020 PPCP-MSP Update it is expected that all the cost estimates will follow a Class 4 estimate. The wastewater Capital Program project costs were developed using a unit cost approach. A breakdown of the unit cost methodology is included in **Appendix L – Project Costing Methodology**. Costs for Region infrastructure are estimated in this report as the projects will be finalized in the ongoing 2021 Niagara Region MSP Update, which will be completed later in 2021.

The unit costs and all the above components are contained in the 2020 PPCP-MSP Update Capital Program spreadsheet which also include standard project details sheets. The spreadsheets are the working tool that brings all the cost components together to create a project cost estimate and are included in this **Appendix L - Project Costing Methodology** with project costing methodology.

13.2 20-Year Capital Plan

The preferred wastewater servicing strategy has been developed to support the servicing needs of the existing and future growth areas within the City of Welland to 2041 and beyond. The capital costs for each project of the Preferred Strategy were estimated according to the costing methodology.

These projects are listed according to their project number and are shown in **Table 52**. The capital program table contains project descriptions, dimensions, proposed timing and estimated total project cost.

13.2.1 Development Charge Contributions

For each identified wastewater project, the project's estimated growth/benefit to existing related contributions was identified. **Table 51** summarizes the Development Charges benefit to existing classifications

Table 51: Development Charges Benefit to Existing Classifications

Development Charges Benefit to Existing Class	Description
A	Solely supporting new development area
B	Triggered by growth but also services existing users
C	Triggered by growth but also provides some operational improvement
D	Supports both growth and existing users equally
E	Primarily to address existing operational issues but also supports growth
F	Sole benefit to existing users

13.2.2 Project Timing and Triggers

To support the City's long-term budgeting and wastewater rates, a preliminary project timeline for each wastewater Capital Program project has been identified. Project timing has been identified in the following increments.

- 0-5 Years;
- 5-10 Years; and
- 10-20 Years.

The estimated project timeline was based on individual triggers for each project. These triggers are based on either the growth within the system, which can be accommodated before the identified project is required, or requirements to service the expansion lands. The triggers that correlate to the project timing are included in **Table 52**.

Table 52: Project Triggers

Project Timeline	Triggers
0 – 5 Years	Operational improvements (Station rehab and storage) Flow monitoring of low data maturity areas Priority area feasibility studies
5 – 10 Years	System wide growth areas System trunks & SPS upgrades – depends on capacity trigger
10 – 20 Years	Remaining growth projects System trunks & SPS upgrades – depends on capacity trigger
Unknown/Ongoing	Downtown sewers Sewer separation I&I reduction Flow monitoring

There are several projects that have been identified as 0-5 year priorities. Any proposed sewer upgrade projects' timing will depend on the City's other infrastructure works to optimize corridor management. These include:

- Broadway Trunk Upgrades
- Broadway Local Reconfigurations
- Ontario Road Sewer Upgrade
- East Forks Sewer Upgrade
- Chippawa Park Sewer Separation

Region owned infrastructure requires coordination with the Region. One project has been identified:

- Dain City SPS Storage Optimization

I&I reduction programs are an immediate priority for the City to reduce basement flood, overflows and to facilitate growth.

- Ontario Road North (Lincoln-Coventry area) I&I – this area is the top priority given the expiration of the L-site temporary ECA in 2022.
- Dain City I&I –I&I reduction program was initiated in 2020 and recommendations should be executed in the next 2 years.
- Broadway I&I
- Ontario Road South I&I

Finally, the City-wide flow monitoring program is active and ongoing until at least 2023 and should be used to improve data collection in low data maturity areas and to work on tactical I&I remediation.

13.2.3 Studies & Consultation

The 2020 PPCP & WW MSP follows Approach 1 of the Municipal Class EA Master Planning process. As such, upgrades identified as requiring Schedule B and Schedule C Class EA will need to undertake specific EA studies, with supporting field investigation including Species at Risk inventory, to further evaluate alternatives, identify impacts, and present mitigation approaches. However, no Schedule B or C projects have been identified in the Capital Program through this study.

The remaining projects have been identified as Schedule A/A+, indicating that the projects are understood to have minimal potential for adverse environmental impacts. However, notwithstanding the Schedule A/A+ classification, appropriate investigations and screening will need to occur during the conceptual design and detailed design stages. The scope of the investigation will be determined based on the scope of project upgrades but may include the studies listed below. If through the conceptual design and/or supporting investigations an alternate alternative is identified and/or more substantial environmental impacts are identified, a Schedule B EA may be required:

- Stage 1 Archeological Investigation (and subsequent Stage 2 or greater as needed)
- Natural Heritage Inventory and Assessment
- Social Cultural Heritage Inventory and Assessment
- Geotechnical and Hydrogeochemical Assessment
- Phase 1 and 2 Environmental Site Assessment
- Impacts to Utilities
- Excess Material and Waste
- Topographic Survey
- Scoped Environmental Impact Study (for works adjacent to existing wetlands and other significant natural heritage features) as directed by the NPCA.

13.2.4 Potential Effects and Mitigation

Potential effects and mitigation for the upgrades identified as requiring Schedule B and Schedule C will be documented through the subsequent EA.

The remaining projects have been identified as Schedule A/A+ all works are expected to occur within existing municipally owned properties and/or rights-of-way as such the works are expected to have minimal impacts and any impacts are anticipated related to noise and traffic disruptions due to

construction activities. These impacts will be mitigated through traffic management plans, noise and dust control plans, and erosion and sedimentation control plans.

Coordination between the Region and the City will be required to confirm implementation timing. Further, local residents and business should be identified prior to construction.

13.3 Summary – Capital Program Projects

A summary of the required recommended upgrades, projects and studies for the capital program are included in **Table 53**. Provisional projects, which are projects that may be needed if I&I targets are not achieved, are summarized in **Table 54**. The total Capital Program cost to the City is estimated to be \$132.8M over the next 20 years.

Table 53: Wastewater Capital Program Summary – Required Projects

Capital Program ID		Name	Overview	Sanitary Catchment	Priority Area	Project Description	Required Studies	Class EA Schedule	Project Type	Size/Capacity	Length (m)	Infrastructure Owner	Funding Source/ Responsibility	Total Estimated Cost (2020\$)	Timeline	DC Benefit to Existing Class
WW-SS-001	Sewer	Broadway Trunk Upgrade	Trunk upgrade and deepening on Broadway	WWTP	Broadway	Sewer Upgrade of Broadway Trunk		A+	Sewer 10m	600 mm	1,000	City	DC Eligible	\$ 6,145,000	0-5 Years	E
WW-SS-002	Sewer	Broadway Local Sewer Reconfiguration and Upgrades	Trunk upgrade and deepening on Broadway	WWTP	Broadway	Local sewer reconfiguration, deepening, and upgrading to accommodate existing peak flow and growth capacity needs, while also providing sufficient freeboard to achieve the 2.4 m freeboard level of service objective		A+	Sewer 5m	300 mm	2,015	City	DC Eligible	\$ 2,413,000	0-5 Years	E
WW-SS-003	Sewer	Ontario Road Sewer Upgrade	Trunk upgrade and deepening on Ontario Road	Ontario Rd	Ontario Rd	Upgrade and deepen 500 m of the Ontario Rd tank sewer from Ontario Rd SPS to Empress Avenue. The existing sewer will be upgraded to 900 mm and lowered to approximately 10 m depth.		A+	Sewer 10m	900 mm	500	City	DC Eligible	\$ 4,323,000	0-5 Years	D
WW-SS-006	Sewer	Ontario Road Extension	New trunk sewer along Ontario Rd from Empress Ave to King St.	Ontario Rd	Ontario Rd	New 600 mm trunk sewer extending along Ontario Road. Sewer sized to accommodate full buildout and provide storage for wet weather resilience.	Detailed Servicing Study	A+	Sewer 10m	600 mm	1,600	City	DC Eligible	\$ 11,550,000	10-20 Years	B
WW-SS-007	Sewer	East Forks Sewer Upgrade	Upgrade of existing sewers on Forks Road to support Dain City Community Development	Dain City	Dain City	Upgrade 300m of existing sewer to 300 mm on Forks Road from the proposed connection point to Crescent Dr. This upgrade will support servicing to the new development.		A+	Sewer 5m	300 mm	300	City	DC Eligible	\$ 359,000	0-5 Years	A
WW-SS-015	Sewer	New Oxford Road-Highway 406 Crossing	New trunk sewer extending servicing from Oxford Road to the southern end of Hunter's Pointe development	WWTP	Daimler Parkway	150 m of new 250 mm sewer crossing Highway 406 to service the southern lands of the Hunter's Pointe development.		A+	Sewer 5m	300 mm	150	City	DC Eligible	\$ 717,000	10-20 years	A
WW-SS-016	Sewer	Oxford Road Sewer Upgrade	Sewer upgrade to support servicing of Hunter's Pointe development.	WWTP	Daimler Parkway	340 m of sewer upgrade on Oxford Road to 250 mm. to support the Hunter's Pointe development. Confirmation of servicing to Hunter's Pointe is needed prior to design. This project must precede WW-SS-015		A+	Sewer 5m	300 mm	340	City	DC Eligible	\$ 406,000	10-15 Years	B
WW-SS-017	Sewer	Chippawa Park Sewer Separation	Separate combined sewers upstream of the capacity constraint in the park trunk.	WWTP		750 m of combined sewers to be separated. This project is costed as 2 sets of sewer upgrades	Municipal Class EA	A+	Sewer 5m	450 mm	1,500	City	City	\$ 2,299,000	0-5 Years	F
WW-PS-001	PS	Towpath Rd SPS Upgrade	Capacity upgrade to Towpath Rd SPS to facilitate growth to 2041 including the Urban Boundary Expansion and growth in Thorold and Pelham	Towpath Rd SPS		Upgrade to existing SPS to accommodate growth flows from Welland, Pelham, and Thorold. Project to be reviewed in the Region 2021 MSP.		A+	Pumping	475 L/s	-	Region	DC Eligible	\$ 6,519,000 ¹	0-5 Years	B
WW-PS-002	PS	Dain City SPS Upgrades	Upgrade capacity to accommodate future flows.	Dain City SPS	Dain City	Pumping station upgrade to 170 L/s to support new developments		A+	Pumping	170 L/s		Region	DC Eligible	\$ 4,346,000 ¹	10-20 Years	B
WW-PS-003	PS	Dain City SPS Storage Optimization	Optimize existing storage capacity to manage wet weather flows	Dain City SPS	Dain City	Conduct study to optimize the full volume of the storage tank.		A+	Storage		-	Region	DC Eligible	\$ 150,000	0-5 Years	B
WW-PS-004	PS	Fitch St SPS Decommissioning	Study and Decommissioning of the City-owned Fitch St SPS	Fitch St SPS	Clare-Fitch	Study will determine feasibility and next steps to decommission the City's Fitch St SPS.		A+	Pumping		-	City	DC Eligible	\$ 1,514,000	5-10 Years	A
WW-II-001	I&I	Flow Monitoring	City wide flow monitoring program.			City wide flow monitoring program to address existing issues and provide guidance for wet weather flow management practices.		A+	Wet Weather Reduction		-	City	DC Eligible	\$ 8,423,000	0-5 Years	D

Capital Program ID		Name	Overview	Sanitary Catchment	Priority Area	Project Description	Required Studies	Class EA Schedule	Project Type	Size/Capacity	Length (m)	Infrastructure Owner	Funding Source/Responsibility	Total Estimated Cost (2020\$)	Timeline	DC Benefit to Existing Class
WW-II-002	I&I	City Wide I&I Program	Wet weather management program to address growth and existing issues.	WWTP		City wide I&I reduction program based on flow monitoring results to address existing issues.		A+	Wet Weather Reduction		-	City	DC Eligible	\$ 10,000,000	0-5 Years	D
WW-II-003	I&I	Broadway Priority I&I Program	I&I program to manage peak flows in Broadway Priority Area	WWTP	Broadway	Include all properties in Broadway Priority Area. Option to limit to 280 homes where sewer reconfiguration is occurring, and flows are highest.		A+	Wet Weather Reduction	340 L/s	-	City	DC Eligible	\$ 6,158,000	0-5 Years	D
WW-II-004	I&I	Ontario Road Priority Area Study I&I Program (North)	I&I program to manage peak flows in Ontario Road catchment, Lincoln-Coventry area	Ontario Rd	Ontario Rd	Ontario Road catchment is subject to very high I&I in catchment. Initiate I&I program to manage peak flows to free up capacity at existing SPS and facilitate possible decommissioning of the L-sites.		A+	Wet Weather Reduction	470 L/s	-	City	DC Eligible	\$ 8,340,000	0-5 Years	D
WW-II-005	I&I	Ontario Road Priority Area Study I&I Program (South)	I&I program to manage peak flows in Ontario Road catchment, south of Ontario Road	Ontario Rd	Ontario Rd	Ontario Road catchment is subject to very high I&I in catchment and significant growth pressures. The I&I program budget include remediation works.		A+	Wet Weather Reduction	580 L/s	-	City	DC Eligible	\$ 7,589,000	0-5 Years	C
WW-II-006	I&I	Dain City Priority Area Study and I&I Program	I&I program to manage peak flows in Dain City SPS catchment	Dain City	Dain City	The Dain City catchment is subject to high I&I flows and the program will help to facilitate growth in the interim of development from John Deere and Dain City Community Developments. The I&I program budget includes investigation and remediation works.		A+	Wet Weather Reduction	300 L/s	-	City	DC Eligible	\$ 4,784,000	0-5 Years	B
WW-II-007	I&I	Plymouth Rd Priority Area Study and I&I Program	I&I program to manage peak flows in Plymouth Rd priority Area	WWTP	Plymouth Rd	I&I program to manage peak flows in Plymouth Rd priority Area. The I&I program budget includes investigation and remediation works.	Feasibility Study	A+	Wet Weather Reduction	395 L/s	-	City	DC Eligible	\$ 9,866,000	5-10 years	B
WW-II-008	I&I	Prince Charles Drive S	I&I program to manage peak flows in Prince Charles Drive Priority Area	WWTP	PCD South	I&I program to manage peak flows in Prince Charles Drive Priority Area. The I&I program budget includes investigation and remediation works.	Feasibility Study	A+	Wet Weather Reduction	120 L/s	-	City	DC Eligible	\$ 9,866,000	5-10 years	D
WW-II-009	I&I	Feeder Rd Priority Area Study and I&I Program	I&I program to manage peak wet weather flows in the industrial Feeder Road Priority Area.	Feeder Rd	Feeder Rd	A study of the area including flow monitoring to confirm current flows is needed prior to develop the I&I program to manage peak wet weather flows in the industrial Feeder Road Priority Area. The I&I program budget includes investigation and remediation works.	Feasibility Study	A+	Wet Weather Reduction	125 L/s	-	City	DC Eligible	\$ 3,428,000	5-10 years	C
WW-II-010	I&I	Woodlawn Rd Priority Area Study and I&I Program	I&I program to manage peak flows in Woodlawn Rd priority Area	WWTP	Woodlawn	Focus I&I remediation in Trelawn Parkway neighbourhood. The I&I program budget includes investigation and remediation works.	Feasibility Study	A+	Wet Weather Reduction	925 L/s	-	City	DC Eligible	\$ 6,087,000	5-10 years	B
WW-II-011	I&I	Seaway Heights Priority Area Study and I&I Program	I&I program to manage peak flows in Seaway Heights Priority Area	WWTP	Woodlawn	I&I investigation and remediation or facilitate growth. The I&I program budget includes investigation and remediation works.	Feasibility Study	A+	Wet Weather Reduction	200 L/s	-	City	DC Eligible	\$ 5,294,000	5-10 years	B
WW-II-012	I&I	Welland River Inflow Investigation	Field Investigation to identify spring inflows from the Welland River	WWTP	Woodlawn	Field Investigation to identify spring inflows from the Welland River	Feasibility Study	A+	Wet Weather Reduction	0 L/s	-	City	DC Eligible	\$ 1,475,000	0-5 Years	B
CITY TOTAL														\$122,051,000		

* Components of the Ontario Road Trunk sewer upgrades and extension may be eligible for cost-sharing with Niagara Region between Ontario Road SPS and Southworth Street.

¹ – Costs for Region projects were developed from the current draft 2021 Master Servicing Plan Update capital program, which may reflect costing for a different capacity than presented in this study.

Table 54. Provisional Projects

Capital Program ID		Name	Overview	Sanitary Catchment	Priority Area	Project Description	Required Studies	Class EA Schedule	Project Type	Size/ Capacity	Length (m)	Infrastructure Owner	Funding Source/ Responsibility	Total Estimated Cost (2020\$)	Timeline	DC Benefit to Existing Class
WW-SS-004	Sewer	Empress Ave Upgrades	Upgrades to existing sewer to increase system resilience to basement flooding.	Ontario Rd	Ontario Rd	300 m of sewer upgrades to 600 mm along Empress Ave from Ontario Rd to Sutherland Ave. The sewer is approximately 6 m deep.		A+	Sewer 10m	600 mm	300	City	DC Eligible	\$ 1,783,000	5-10 Years	A
WW-SS-005	Sewer	Sutherland Ave Upgrades	Upgrades to existing sewer to increase system resilience to basement flooding.	Ontario Rd	Ontario Rd	450 m of sewer upgrades to 600 mm along Sutherland Ave from Empress Ave to Southworth Ave. The sewer is approximately 6 m deep.		A+	Sewer 10m	600 mm	450	City	DC Eligible	\$ 2,674,000	5-10 Years	A
WW-SS-008	Sewer	Plymouth Rd Inline Storage	Inline storage on Plymouth Rd to improve system resilience to peak wet weather flows and basement flooding mitigation	WWTP	Plymouth Rd	Upgrade 370 m of sewers to 900 mm along Plymouth Rd from Churchill Ave to First St. This project will reduce basement flooding risks which are present in the existing system		A+	Sewer 5m	900 mm	370	City	DC Eligible	\$ 1,353,000	5-10 Years	E
WW-SS-009	Sewer	Riverside-Lincoln Sewer Upgrade	Sewer upgrade to improve resilience against basement flooding.	WWTP	PCD South	Sewer upgrade to improve existing system resilience against basement flooding. 250 m of upgrades to 375 mm, provided 25 I&I reduction is achieved.		A+	Sewer 5m	375 mm	250	City	City	\$ 625,000	5-10 Years	F
WW-SS-010	Sewer	Trelawn Parkway Trunk Upgrade	Upgrade existing trunk sewer on Trelawn Parkway to improve resilience against basement flooding.	WWTP	Woodlawn	Sewer upgrade to improve existing system resilience against basement flooding. 1000 m of upgrades to 450 mm, provided 25 I&I reduction is achieved. Requires a study to confirm flows prior to design. Sizing and length of upgrade to be finalized after I&I reduction program.		A+	Sewer 5m	450 mm	1,000	City	City	\$ 1,397,000	5-10 Years	F
WW-SS-011	Sewer	Woodlawn Trunk Sewer Upgrade	Sewer upgrade to increase resiliency to basement flooding during peak wet weather flows.	WWTP	Woodlawn	Region trunk upgrade on Woodlawn Road to reduce trunk HGL.		A+	Sewer 10m	750 mm	500	Region	DC Eligible	\$ 4,576,000	10- 20 Years	C
WW-SS-012	Sewer	Fitch St Sewer Upgrade	Upgrade Fitch St trunk sewer to mitigate basement flooding in the upstream Clare Ave sewer.	WWTP	Clare-Fitch	Upgrade Fitch St trunk sewer to mitigate basement flooding in the upstream Clare Ave sewer. Complete Clare Ave I&I Program, pre and post monitoring prior to implementing upgrade.		A+	Sewer 5m	750 mm	825	City	City	\$ 4,432,000	5-10 Years	F
WW-SS-013	Sewer	Clare Ave Sewer Upgrades	Upgrades along the Clare Ave sewer to improve system resilience against basement flooding for existing users.	WWTP	Clare-Fitch	Upgrade 1000 m of existing 375 mm sewers on Clare Ave to 450 mm to improve resilience to basement flooding.		A+	Sewer 5m	450 mm	1,000	City	City	\$ 1,534,000	5-10 Years	F
WW-SS-014	Sewer	Daimler Parkway Sewer Upgrade	Upgrade to existing sewer on Daimler Parkway to support new developments.	WWTP	Daimler Parkway	500 m of sewer upgrades on Daimler Parkway to at least 450 mm are needed to support the developments to the east of Hwy 406.		A+	Sewer 5m	450 mm	500	City	DC Eligible	\$ 2,845,000	5-10 years	B
WW-PS-005	PS	Feeder Road SPS Storage Upgrade	Upgrade to existing station storage to provide resilience against wet weather flows	Feeder Rd	Feeder Rd	Upgrade to existing station storage to provide resilience against wet weather flows. With 25% I&I Reduction assumed, 1,400 m3 is needed based on current modelling. Sized for peak two-hour flows to the station		A+	Pumping		-	City	DC Eligible	\$ 5,197,000	5-10 Years	A
CITY TOTAL														\$ 21,840,000		

APPENDIX A:

Summary of Previous Studies

Study	Year	Conducted By	Summary and Recommendations
Pollution Prevention and Control Plan	2001	RVA	Concluded the City was not meeting the F-5-5 Procedure requirements The RVA preferred solution was a high rate treatment facility and sewer separation. The high rate treatment facility was deferred.
Comprehensive Asset Management Plan	2016	GMBP	Established AM goals and framework, workshopped desired levels of service, provided a sustainable strategy for infrastructure renewal, and identified priority projects to achieved desired LOS targets.
Niagara Master Servicing Plan	2016	GMBP	I&I Reduction programs needed to reduce excessive flows to pump stations. No capacity upgrades recommended within City of Welland.
The Corporation of the City of Welland Official Plan	2017	City of Welland	Identified residential and employment growth areas to 2031.
Welland System Baseline Review and Inflow and Infiltration Program	2018	GMBP	Summarized wastewater system performance and determined I&I priority areas. Recommended a long term flow monitoring program to improve model calibration and start I&I reduction catchment prioritization.
Performance Report Lincoln and Coventry Overflows	2018	Associated Engineering	Reported on 2018 overflow volumes based on flow monitoring in the Lincoln- Coventry Area for MECP F-5-5 requirements.
Annual Sanitary Sewage Overflow Event Reports Empress Sewer Diversion	2018	Associated Engineering	Reported on 2018 overflow volumes based on flow monitoring in the Empress Sewer – Hagar Rd Area for MECP F-5-5 requirements.
Development Charges Study	2018	DFA Infrastructure International	Identified residential and employment growth numbers to 2041.

APPENDIX B: Model Update

Wet Weather Flow Update

was reviewed and the model wet weather calibration was updated in two catchments: Lock St Flow Monitor and the WWTP. **Figure 1** shows the Lock FM location and catchment areas.

The model was updated by proportionally adjusting the unit hydrograph R1 values to maintain an overall mass balance of flows to the WWTP, changes are summarized in **Table 1**. The adjustments to the unit hydrographs were applied to the model and the model was run for two large precipitation events: August 4, 2017 and October 9, 2017. Model flow results were compared to the Lock St FM results for peak flow and volume. Calibrated peak flow results were within 90% of the observed flow monitor peak flows and were conservative volumetrically, ranging from 104-119% greater than the flow monitored volumes for the calibration storm periods. Past reporting, prior to this model update, has demonstrated generally conservative flow estimates to the WWTP.

The calibration results for Lock St are summarized in **Table 2**. Daily flows to the WWTP for the August 4, 2017 calibration event are summarized in **Table 3** and continue to be conservative estimates, approximately 125% of observed plant flows in wet weather.

Table 1. Unit Hydrograph Adjustments

Catchment	Area (ha)	Pre-Calibration R1	Post-Calibration R1
Lock St	258.0	7.1%	10.6%
WWTP	630.2	20.5%	18.8%

Table 2. Model Calibration Results at Lock St.

Calibration Event Date	Precipitation (mm)	Metric	Flow Monitor Observed	Updated Model	Percent Difference
8/4/2017	45	Peak Flow (L/s)	1183.2	1085.3	92%
		Volume (ML)	21.8	26.0	119%
10/9/2017	60	Peak Flow (L/s)	1802.4	1683.6	93%
		Volume (ML)	36.4	37.8	104%

Table 3. WWTP Daily Flow Comparison for August 7 Calibration Event

Date	Modelled WWTP Flows (MLD)		Observed WWTP Flows (MLD)			% Difference (Calibrated/ Observed)
	Pre-Calibration	Post-Calibration	Treated Flows	Secondary By Pass	Total	
3-Aug-17	26.2	19.9	23.4		23.4	85%
4-Aug-17	111.5	111.1	65.5	24.0	89.5	124%
5-Aug-17	70.5	69.6	56.1		56.1	124%
6-Aug-17	31.2	28.9	29.6		29.6	98%

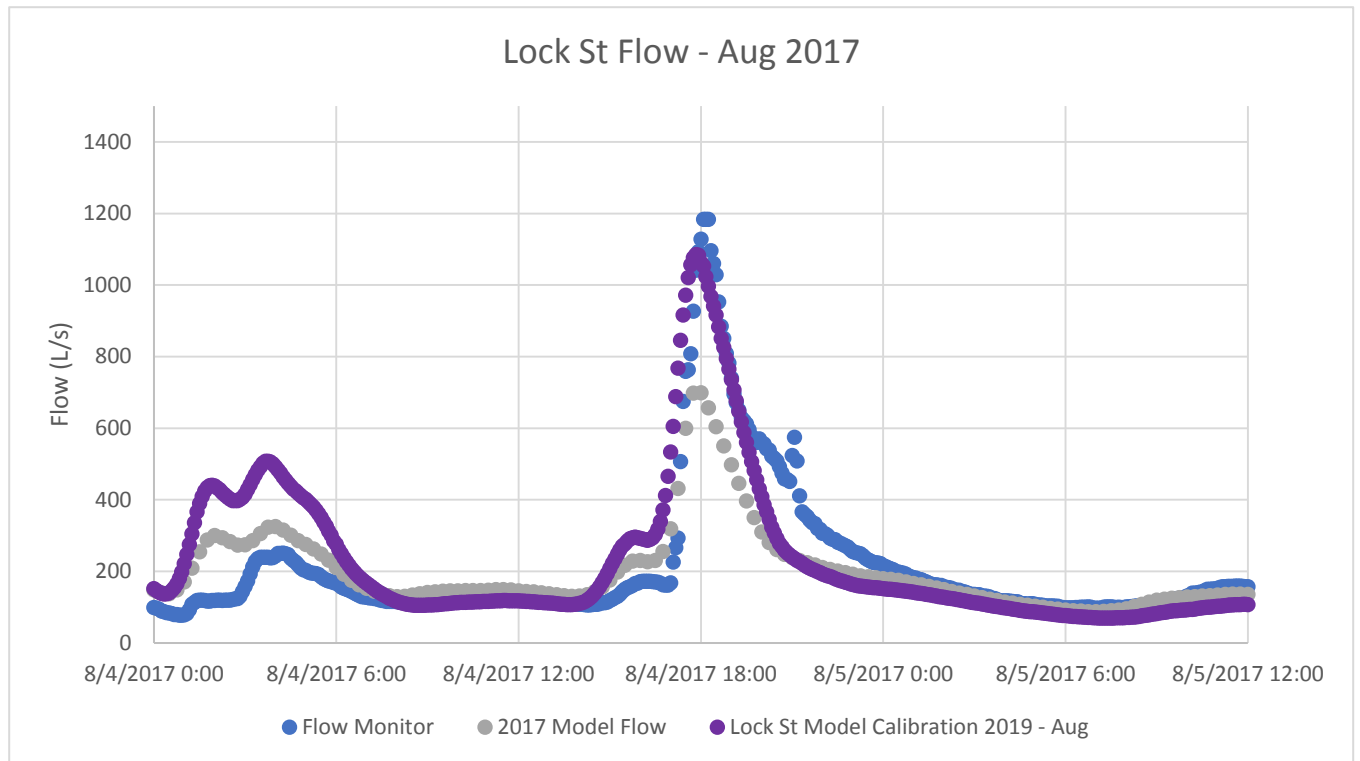


Figure 2. Lock St Calibration - August 2017

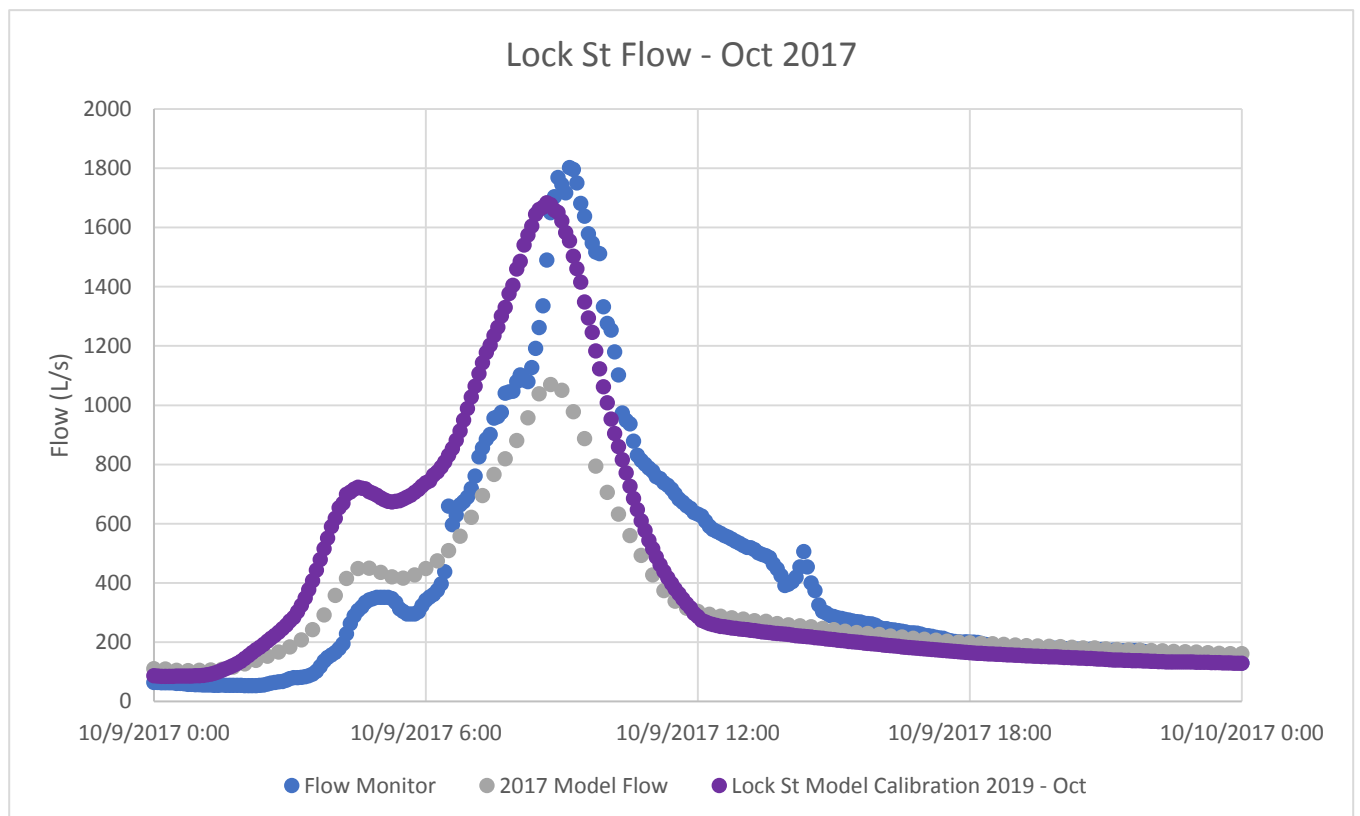


Figure 3. Lock St Calibration - October 2017

APPENDIX C:

GMBP Wastewater Reports



Date:	4/6/2020	File:	418024
To:	Marvin Ingebrigtsen		
From:	Julien Bell, P.Eng., Elaine Samuel, E.I.T.		
Project:	Mill Street Sewer Separation		
Subject:	Wastewater Modelling Review		

TECHNICAL MEMO

1. Project Introduction

The City of Welland (the City) is currently undertaking the design of the Prince Charles Drive (PCD) combined sewer separation; this work is being designed by Kerry T Howe Engineering (KTH). KTH has proposed eliminating the downstream Regional Mill Street interceptor sewer, which runs parallel to the Welland River and redirecting flow to a new sewermain along West Main Street, Franklin Street and Mill Street to the 750 mm Welland River crossing from downtown. This construction work will be completed in phases from 2020 to 2023.

The City retained GM BluePlan Engineering to review the proposed network diversion with existing and future flows.

2. Prince Charles Drive Combined Sewer and Downstream System

The PCD sewer is a 900 mm combined (storm and sanitary) sewer which flows south to north on Prince Charles Drive. It collects flows from a approximately 25 ha residential area, which are situated south of downtown Welland. The PCD sewer connects to the smaller Niagara Region (Region) 350 mm then 450 mm Mill Street interceptor sewer. At the connection point of the PCD sewer and the Mill Street interceptor there is the Prince Charles Drive South combined sewer overflow (CSO), which relieves the system of excess wet weather flows that exceed the Mill Street sewer's capacity.

The Mill Street interceptor sewer runs parallel to the Welland River and collects the local flows from downtown at Denistoun Street, Franklin Street, and Albina Street. There is also a CSO to Denistoun Street allowing overflows from the Densitoun sewer when the Mill Street interceptor capacity is exceeded. The interceptor becomes a 750 mm sewer which crosses under the Welland River to convey flows to the Region interceptor on the north side of the Welland River. **Figure 1** shows the PCD sewer and the downtown area bounded by the Welland River and Welland Canal, which also drains to the 750 mm Welland River crossing. Finally, there is a third CSO upstream and east of the river crossing at Niagara Street South. All three (3) CSOs discharge to the Welland River, and can be seen in **Figure 1**, represented by blue diamonds.

GROWTH

The downtown area is expected to have some intensification growth of approximately 7,560 people by 2041, which is equivalent to 24 L/s average dry weather flow. As the downtown is separated by the Welland Canal, approximately half of the intensification may occur in the study area. The areas for intensification are shown in **Figure 1** in blue.



Figure 1. Prince Charles Drive Combined Sewer, Mill Street Interceptor Sewers and Downstream Area

* Combined sewers are depicted in orange and sanitary sewers are depicted in red.

3. Proposed Sewer Diversion

The PCD sewer separation is one of the last areas in the City with combined sewers and is also one of the last projects recommended from the 2001 Pollution Prevention and Control Plan (PPCP). KTH has proposed a diversion of the PCD flows away from the Mill Street interceptor sewer, to the West Main right of way (ROW), which would connect to the 750 mm river crossing via Franklin Street and Mill Street. Further, KTH has proposed local network improvements to the downtown area draining into the river crossing. This includes separating the Niagara Street combined sewer and eliminating the sewers connecting Franklin Street and Albina Street to the Mill Street run under private properties, thereby reducing the sewers out of the City's ROW. The proposed changes are depicted by blue arrows in **Figure 2**, white X's represent potential sewer segments to be abandoned.

The potential abandonment of the Mill Street interceptor sewer presents some opportunities to explore reducing or eliminating the CSOs:

- Through decommissioning all (3) existing CSOs and adding one new CSO at the river crossing to prevent basement flooding from interceptor sewer backup
- Possible use of the Mill Street sewer as inline storage in combination with maintaining Denistoun as a CSO relief to the interceptor backup.

As the sewer separation is currently in the design phase, the City has yet to determine the preferred future option. For the purpose of this assignment, the scenarios considered will be the existing flows with the proposed network and future growth flows determined from the PPCP.



Figure 2 Proposed Network Changes. White X marks represent sewers for abandonment, blue arrows represent new sewers.

4. Methodology

DATA SOURCES

Documents used for the review and development of the network modifications in the model are listed below.

- Kerry T Howe Engineering
 - Mill Street Sewer Separation Preliminary Design Report – August 9, 2019
 - Sewer Separation Drawings
 - 19-002-PP1-PP8 August 2019
 - 19-002-Sam Rev 2 February 19, 2020
- City of Welland Municipal Standards
- 2016 Niagara Region Master Servicing Plan
- GM BluePlan 50% Submission Welland PPCP and MSP (PPCP)

FLOW MONITORING AND MODEL CALIBRATION

Six monitors have been installed in the Mill Street/downtown area in varying time periods from 2016 to 2019. The monitors and calibration results are detailed in **Appendix A**.

The model calibration followed the RTK method, which is an industry standard. R represents the percentage of rainfall that enters the wastewater system in a catchment. R1 represents fast inflow, R2 represents medium catchment response which could include inflow and infiltration, R3 represents slower infiltration response after rainfall.

The proposed network was represented in the model through the following adjustments and assumptions:

- The proposed diversion was incorporated to the model based on drawings and drainage plans provided by KTH.
- Calibrated existing dry weather and wet weather flows were loaded onto the proposed network.
- Mill Street interceptor was assumed to be entirely abandoned.
- The 3 CSOs were assumed to be disconnected for the system to determine the peak hydraulic grade line (HGL) attained by the interceptor without relief.
- To conservatively estimate the benefits of the PCD sewer separation on reducing existing wet weather flow contributions to the downstream sewer system, the existing calibrated Prince Charles Drive FM catchment percent of rainfall (R1, inflow factor) entering the system (Cv value) was reduced by 50% (from 40% as a combined sewer to 20%).
 - The total Cv (%) for the existing PCD combined sewer is 56%, this is estimated to drop to 36%, once separated.
 - Post construction monitoring will be required to validate the effectiveness of the sewer separation and to support the final design decisions.

Additional information about model calibration and network update sizes are summarized in **Appendix A**.

LEVEL OF SERVICE AND PERFORMANCE CRITERIA

Following the recommendations of the 2020 PPCP study, which the wastewater system performance criteria and level of service to ensure the HGL does not exceed 2.4 m below ground level in the 10 year storm. This depth requirement is in place to protect basements from flooding as a result of sewer system surcharging.

The KTH proposed network was modelled using 2 scenarios in the calibrated model:

- Existing conditions in a 10 year design storm
- Growth conditions in a future (climate change) 10 year design storm

5. Assessment of System Performance

BASEMENT FLOODING RISK ASSESSMENT

The modelling using a 10 year design storm showed the following system impacts:

- The proposed local system sizing appears to be appropriate size to support existing and future flows.
- The HGL in the local sewers in a 10 year design storm remain below the 2.4 m depth to prevent basement flooding.
- There is some risk of possible basement flooding due to the interceptor surcharging. The system is impacted by the HGL of the Region interceptor sewer which peaks 1.5 m below ground level at the manhole immediately upstream from the river crossing, in the existing and future scenarios. There is one other manhole located at Franklin Street and Mill Street which exceeds an HGL 1.95 m below grade. Surcharging is shown in **Figure A2**, in the Appendix.
- This implies a need for relief before the river crossing to prevent basement flooding in this drainage area upstream. Implementing a new overflow at the Welland River crossing at 171.1 m elevation would provide basement flooding protection from the interceptor surcharging.

It is anticipated that levels in the interceptor sewer will lower over time as the PPCP recommendations are implemented and inflow and infiltration removal occur system-wide.

COMBINED SEWER OVERFLOWS

Based on the modelling of the proposed network, it may be possible to eliminate the Niagara St S, Denistoun, and Prince Charles Drive S overflows. The model runs were completed with the assumption that the overflows would be closed. Post-construction monitoring is recommended to confirm flows and interceptor influence on the local network and trunks sewers prior to decommissioning any system overflows.

Options to be modelled or evaluated later may include:

- Decommissioning of all (3) existing CSOs and adding one new CSO at the river crossing to prevent basement flooding from interceptor sewer backup

- Possible use of the Mill Street sewer as inline storage in combination with maintaining Denistoun as a CSO relief, instead of adding a new one.
 - This option would require a CCTV assessment of the Mill Street sewer to confirm condition and that it is not actively leaking I&I into the wastewater system.

6. Conclusions

The proposed network elevations and sizing appear to be adequate for existing and future flows in the downtown area. Post-construction flow monitoring is recommended to confirm flows prior to determining if decommissioning of any CSOs is possible.

Appendix A



Figure A1. Flow Monitors and Catchments

The flow monitors used for calibration and validation are listed in **Table A1** below. Some challenges existed due to different time periods of the monitors being installed. The Prince Charles Drive monitor was calibrated first using 2019 data. Once adjusted, the flows were compared to the 2016 flow monitoring results at the Mill Street flow monitor, downstream from the PCD FM.

Table A1. Flow monitors used for calibration and validation.

Flow Monitor	Time period
Prince Charles Drive	July – Dec 2019
Denistoun Street	2016
Niagara Street	2016
Mill Street - 250	2016
Mill Street- 450	2016
403	2016

Events used for model calibration are listed in **Table A2**.

Table A2. Calibration events.

Start of Rain	End of Rain	Duration (hours)	Peak 1-hr (mm)	Total Depth (mm)
9/10/2016 6:55	9/11/2016 0:55	18.0	4.25	14.25
9/17/2016 11:30	9/17/2016 18:40	7.2	9.00	17.25
8/21/2019 1:50	8/21/2019 5:45	3.9	5.50	11.50
10/1/2019 16:50	10/3/2019 12:05	43.2	8.75	23.75

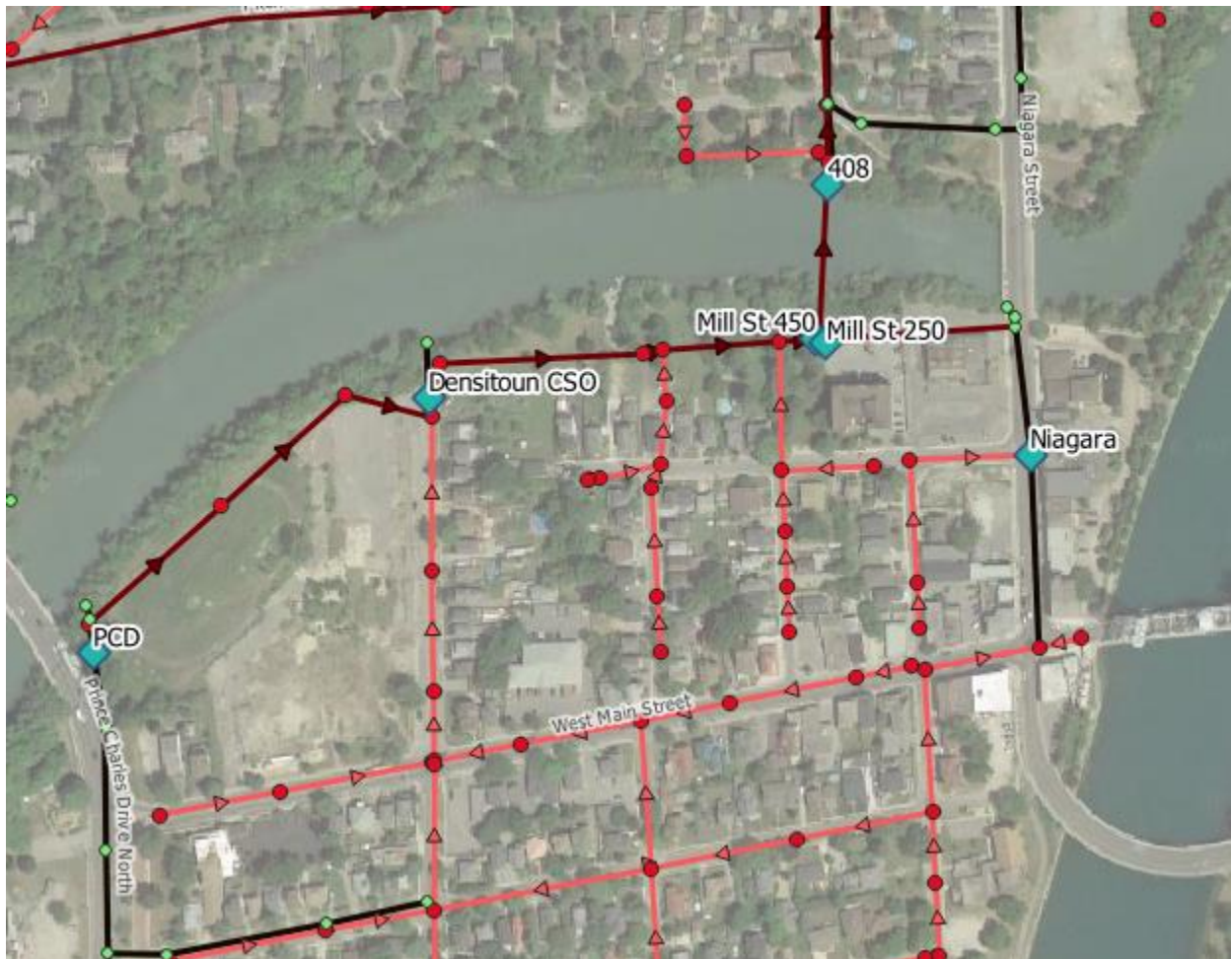
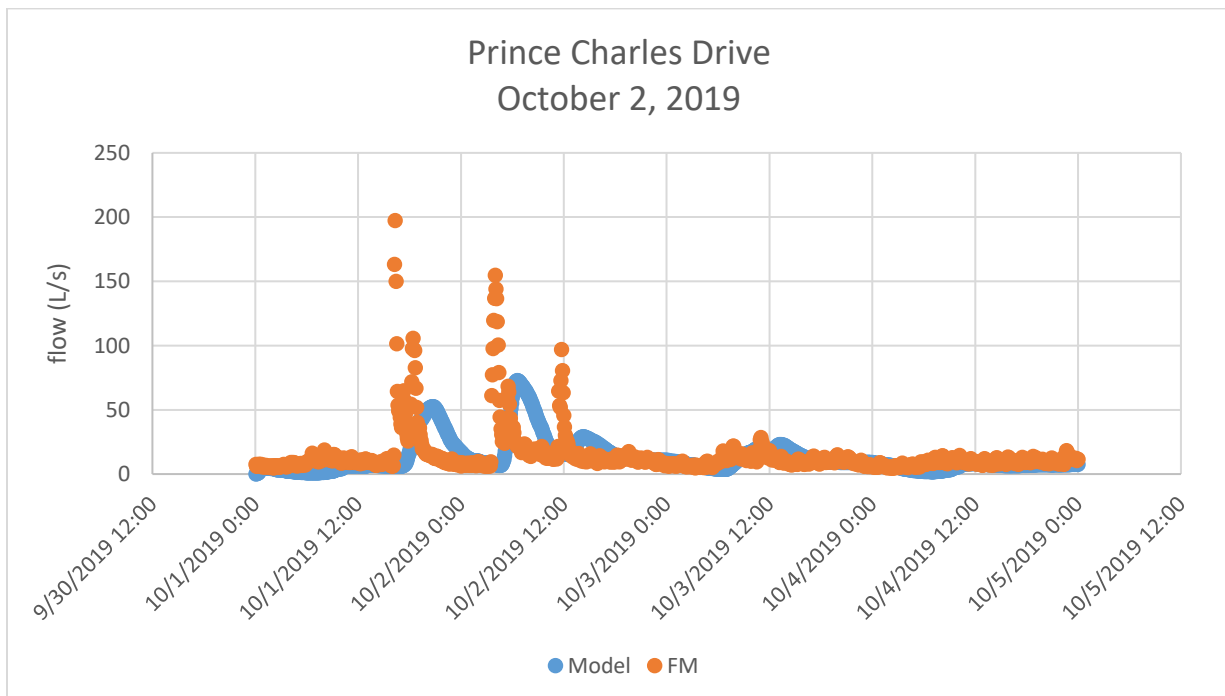
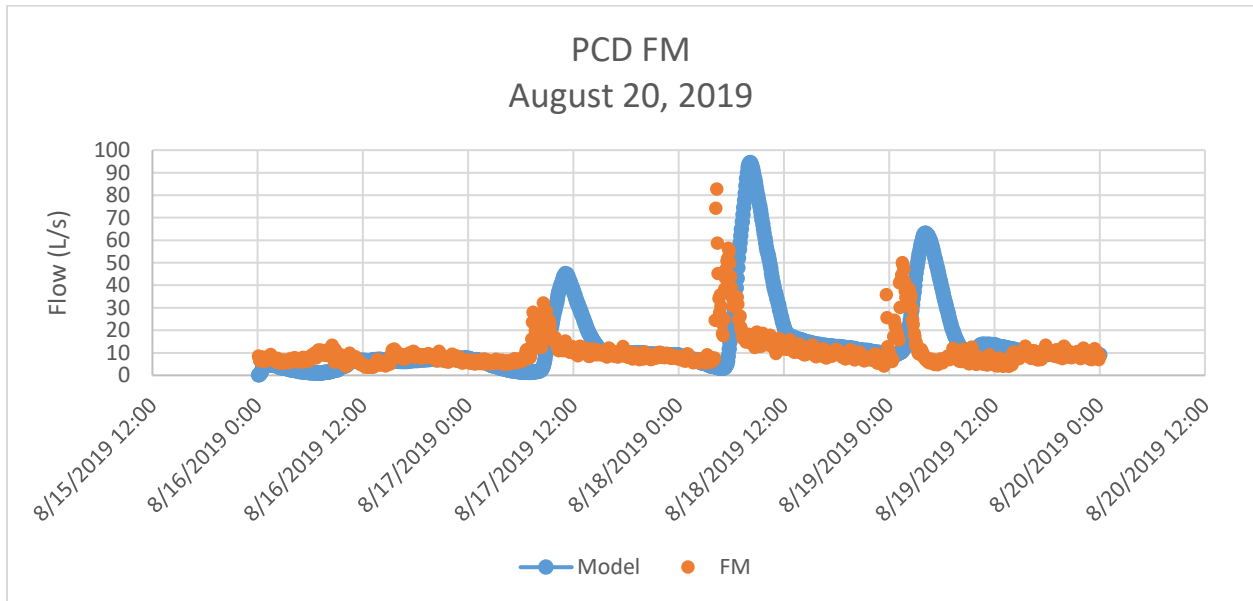


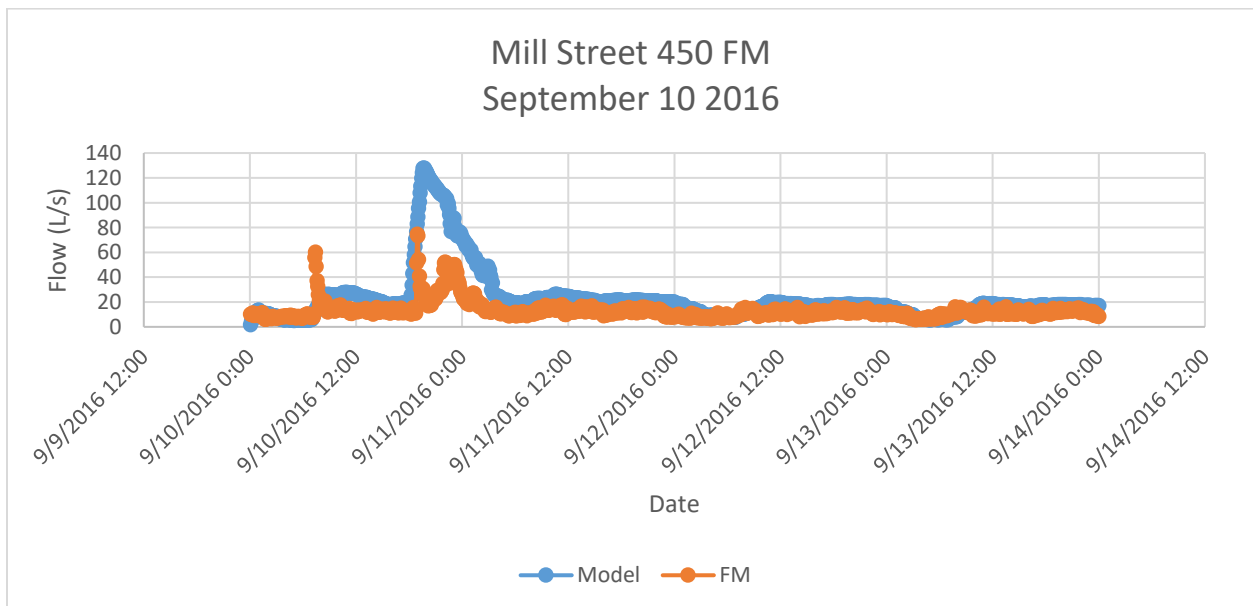
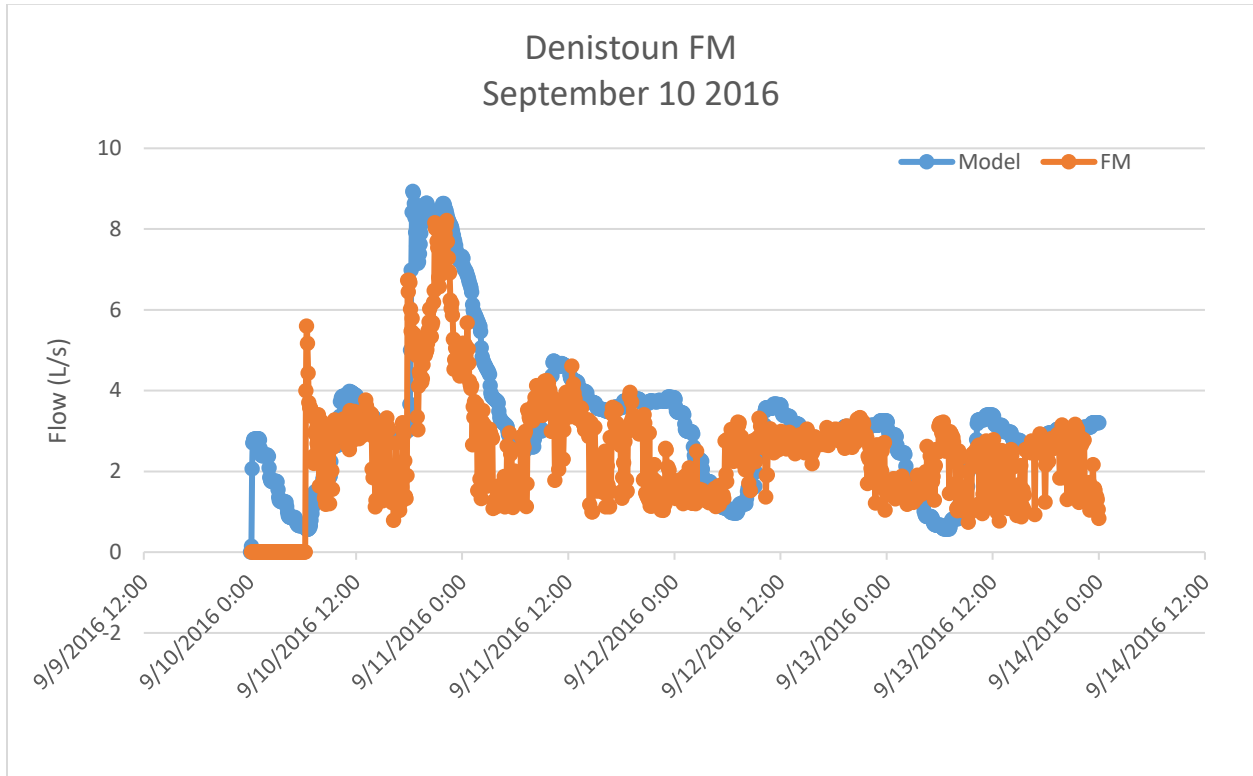
Figure A2. Flow Monitors

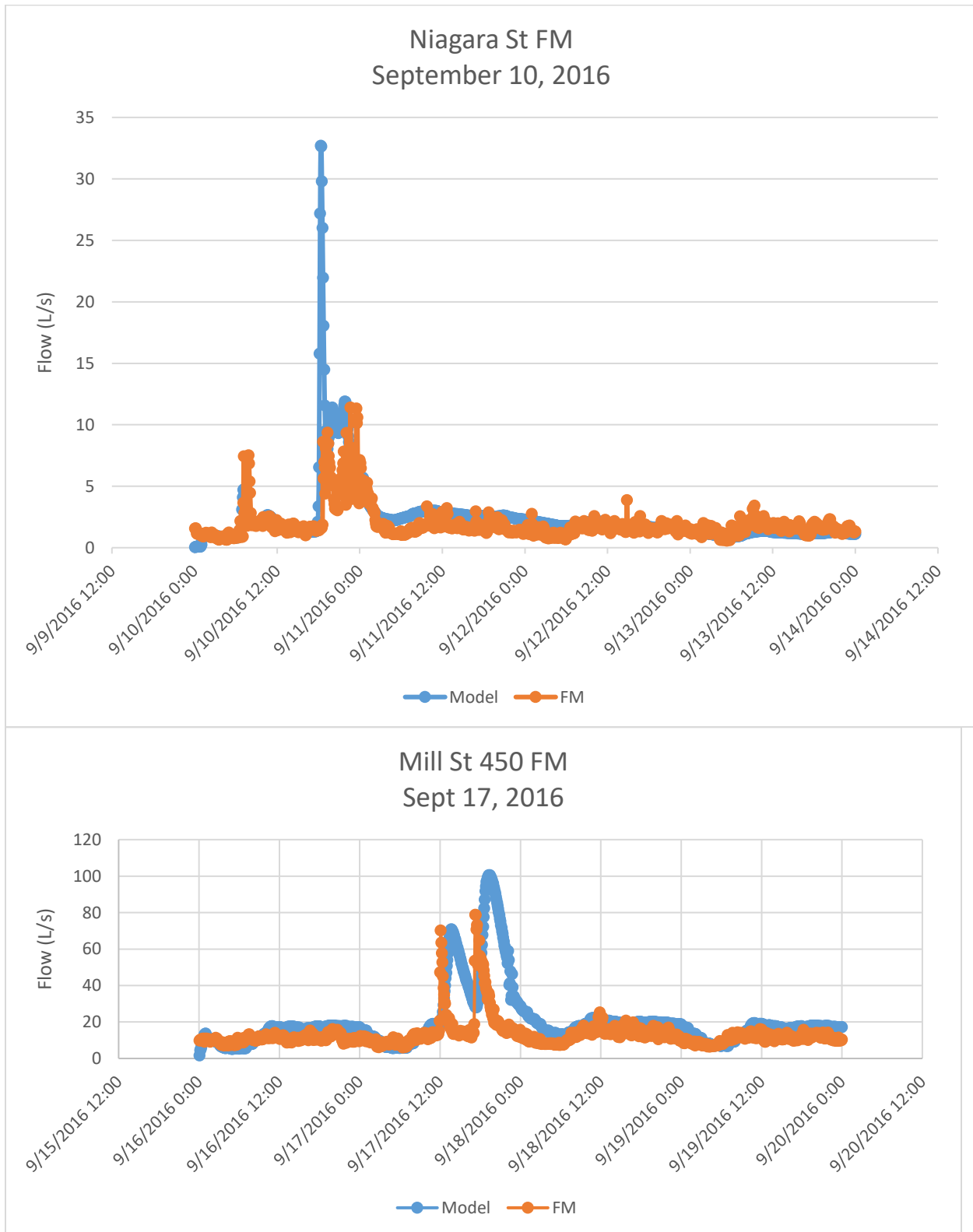
The graphs below show the observed flow monitor response vs modelled wet weather response. Generally, the model shows a conservative estimate of flows compared to the flow monitor response.

Prince Charles Drive 2019



September 9-13 2016





The model calibration followed the RTK method, which is an industry standard. R represents the percentage of rainfall that enters the wastewater system in a catchment. R1 represents fast inflow, R2 represents medium catchment response which could include inflow and infiltration, R3 represents slower infiltration response after rainfall.

PCD Pre and Post separation values – R1 was reduced by 50%.

Unit hydrograph	R ₁	R ₂	R ₃	C _v (%)
PCD_FM_2019 (existing conditions, combined sewer)	0.4	0.079	0.078	56%
PCD-Separated	0.2	0.079	0.078	36%

Final C_v values for calibrated catchments.

Unit hydrograph	Model Area (ha)	R ₁	R ₂	R ₃	C _v (%)
Mill_st_450	2.6129	0.05	0.03	0.03	11%
NIAGARA_ST_SPS_HYDROGRAPH	7.5018	0.1	0.095714	0.159385	36%
PCD-Separated	24.5244	0.2	0.079	0.078	36%
Denistoun-2016	6.8879	0.05	0.05	0.05	15%

Proposed network sizes as of April 9, 2020 that were verified in this review.

Sewermain	Diameter (mm)
Prince Charles Drive	450
West Main Street (west of Franklin St, trunk)	600
West Main (west of Franklin St, local)	250
West Main (east of Frazer St)	450
Denistoun	300
Franklin Street	600
Mill Street	600
Mill Street to River Crossing	600
River Crossing (Existing)	750
Niagara Street	250
Mill Street (east of River Crossing connector)	250

HGL Profile with Maximum Data of Links MS-C1,MS-C6,...,289008794

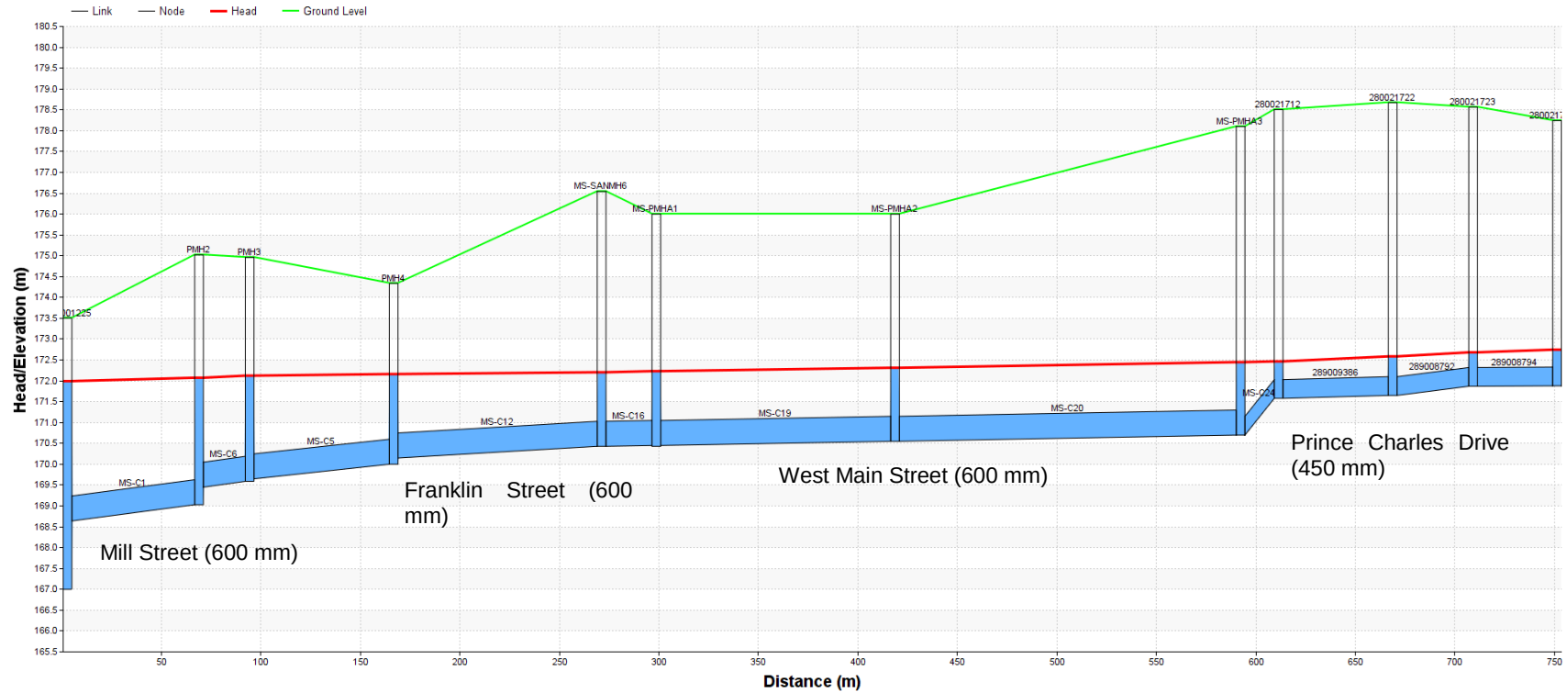


Figure A3. HGL Profile from Welland River Crossing (left) to Prince Charles Drive, showing the hydraulic grade line in a 10 year 2050 IDF design storm



Date: March 22, 2018 File: 418024
To: Marvin Ingebrigtsen
From: Julien Bell, Elaine Samuel
Project: City of Welland- Modelling Support
Subject: Dain City Community Development Review

TECHNICAL MEMO

This technical memo summarizes the results of the wastewater system capacity review for the Dain City SPS system in support of the Dain City Community Development. This proposed residential development is generally bounded by the Welland Canal (east), Forks Road (south), and the CN Railway tracks (to the north and west).

1.1 City's All Pipes Model

This capacity assessment was completed utilizing the City's recently completed all pipes sanitary sewer hydraulic model.

2 BASELINE UNDERSTANDING

2.1 Dain City System - Summary of Existing Capacity

Sanitary flows from the Dain City area drain via a local gravity sewer network to the Region's Dain City SPS. Ultimately, these flows are conveyed to the Region's Welland WWTP via the City and Region's wastewater network by way of the Ontario Road SPS.

Table 1 provides a summary of the Dain City SPS configuration and capacity as outlined in the Region's 2017 MSP.

Table 1- Summary of Dain City SPS Capacity

Sewage Pumping Station	Number of Installed Pumps	ECA Firm Capacity (L/s)	Operational Firm Capacity (L/s)	Total Dynamic Head (m)	Storage Capacity (m ³)
Dain City SPS	3	115	94	43	~1,100

Table 2 presents the existing and peak development flows to the station for existing and 2041 flows identified by the Master Servicing Plan. The projected peak 2 year, 5 year, and 10 year flows to the Dain City SPS were estimated utilizing the City's recently completed hydraulic model.

The baseline results also indicate that the actual observed wet weather flows to the station exceed both the Region's 0.286 L/s/ha design allowance as well as the station's existing operational firm capacity. The estimated peak flow for a 2 year storm is above the station's existing operational capacity but below the ECA firm capacity. Estimated flows for the 5 and 10 year design storms are above the ECA firm capacity, but remain below the estimated full installed capacity of 180 L/s.

Table 2- Existing and projected flows to Dain City SPS.

Scenario	Peak Flows (L/s)	
	Existing	MSP 2041
Dry Weather Flow	4.7 ²	41.2 ³
Design Wet Weather Flow (Using Regional Design Criteria of 0.286 L/s)	37.7 ¹	70.7 ³
2yr 24h Design Storm	113.6 ²	154.8 ³
5yr 24h Design Storm	132.4 ²	173.6 ³
10yr 24h Design Storm	147.3 ²	188.5 ³

¹ Calculated using Region Design Allowance

² Estimate of actual flows based on City calibrated model

³ As provided in the Region MSP

⁴ Estimated by adding projected MPS growth to existing peak wet weather flows

The existing ~ 1,000 m² overflow storage tank at the Dain City SPS provides storage relief during high wet weather events, when peak inflows exceed the current station operation capacity. This helps minimize sewer surcharging in the upstream sewer.

The Region's Master Plan identifies the following growth and performance indicators for the Dain City SPS catchment area.

- The existing operational firm capacity of Dain City SPS is 94 L/s,
- Projected growth of 3,207 people and 211 jobs by 2041 (total 3,418 equivalent growth population) for a total design peak wet weather flow of 71 L/s (existing + growth) to the SPS, or peak 5 year wet weather flows of 173 L/s.

The Region's Master Plan has not identified future upgrades to Dain City SPS to support existing peak wet weather flow capacity and to accommodate growth utilizing the Region's design inflow and infiltration allowance of 0.286 L/s/ha.

It should be noted that although no SPS upgrades are identified in the Region's Master Plan for the Dain City SPS, inflow and infiltration funds have been identified for the City of Welland to support inflow and infiltration reduction programs across the system. These funds are to be targeted in areas where the actual observed peak wet weather flows exceed the Regional design standard that leads to localized sewer surcharging or potential pump station overflows; of which the Dain City SPS catchment would meet this criteria.

3 DAIN CITY - FUTURE DEVELOPMENT

The Dain City Community Development, as highlighted in Figure 1, proposed site is bounded by the Welland Canal (east), Forks Road (south), and CN Railway tracks (north and west). The development buildout population and wastewater demands for the Dain City Community Development were based on unit ranges of 731 to 982 as provided by the developer.

Further, GM BluePlan previously reviewed the system capacity for the John Deere industrial development in the Dain City SPS catchment, highlighted in Figure 1. This industrial development is located on Canal Bank Street, north of St. Clair Drive, and also drains to the Dain City SPS. For the purposes of this assignment, the joint impacts of both developments proceeding were considered. The John Deere property development is expected to introduce new flows to the system of up to 19 million liters per year.

Figure 1- Dain City Community Development Boundaries-
 1) John Deere Industrial Development, 2) Dain City Community Development



The developer provided a range of units for low and high buildout scenarios. The buildout of both the John Deere property and the Dain City Community Development would have a combined effect on downstream system capacity. As such, the receiving capacity of the wastewater system was reviewed under three scenarios:

- Scenario 1: Existing system with proposed development flows for 731 units.
- Scenario 2: Existing system with proposed development flows for 982 units.
- Scenario 3: Existing system with proposed development flows for 982 units AND John Deere industrial development.

Table 3 summarizes the proposed developments' design flows. A population density of 3 persons per unit and residential design flows of 275 L/cap/day (Niagara Region) were assumed.

Table 3 – Design flows for Dain City Community Development.

Scenario	Growth Population	Estimated Average Dry Weather Flow (L/s)	Estimated Peak Dry Weather Flows ² (L/s)	New Service Area (ha)	Estimated Wet Weather Flow ³ (L/s)	Estimated Peak Wet Weather Flow (L/s)
731 units	2,193	7.0	24.8	63	18.0	42.8
982 units	2,946	9.4	33.3	63	18.0	51.3
982 units + industrial	2,946	10.0 ¹	35.7	92	26.3	62.0

¹ – John Deere Property to add 0.6 L/s average flow

² – Estimated using Harmon's peaking factor

³ – Using 0.286 L/s/ha

The full buildout of the Dain City Community Development is expected to introduce new peak wet weather flows of 42 to 51 L/s. The John Deere industrial development will introduce new peak wet weather flows of up to 11 L/s.

These two developments generally represent the entirety of the projected MSP growth within the Dain City SPS. However, due to the proposed total greenfield and contributing I&I, the growth area is higher than assumed in the MSP, resulting in the overall higher peak wet weather flows than identified in the MSP.

4 CAPACITY ASSESSMENT

The following section summarizes the results of the development capacity review. The proposed Dain City Community development will drain into the existing 250 mm sewer on Forks Road, then into a 450 mm sewer on Crescent Drive, which ultimately drains to the Dain City SPS.

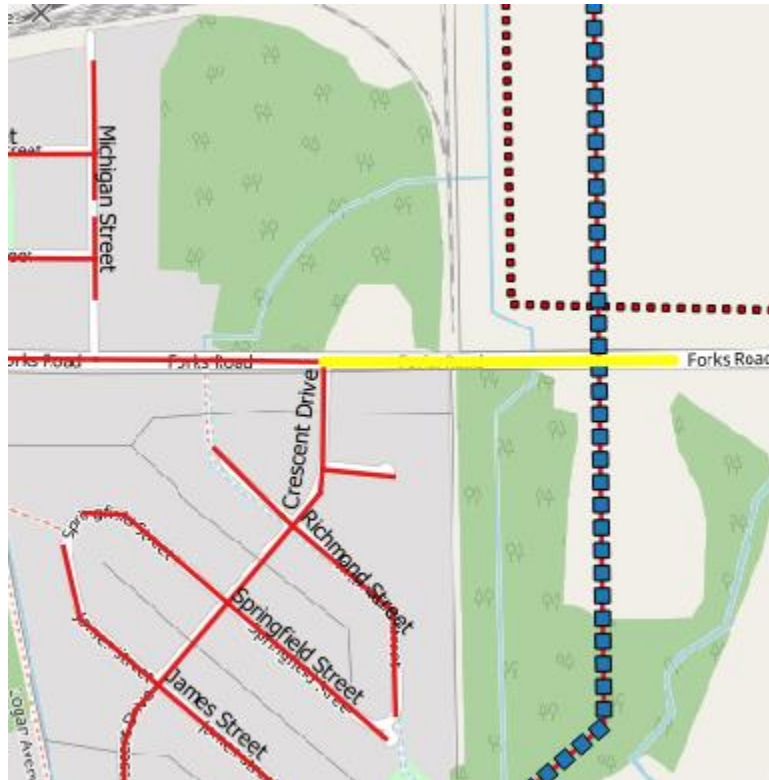
4.1 Gravity Sewer Capacity

Figure 2 and Figure 3 illustrates the peak HGL in Scenario 3 (982 units and industrial development) for a 10 year design storm in the sewer downstream of the proposed development.

- Figure 2 shows the downstream sewer performance with no capacity restrictions at the Dain City SPS, and is meant to evaluate the sewer capacity.
- Figure 3 shows the estimated sewer performance with the existing Dain City SPS, and is meant to evaluate the existing system performance and existing risk of basement flooding.

In combination with existing flows, the Dain City Community Development full buildout flows of 51.3 L/s exceed the capacity of the existing 250 mm pipe along Forks Road from Crescent Drive to the development. An upgrade to a 300 mm diameter pipe at the slope and depth of existing pipes will accommodate full buildout flows.

Figure 2. Pipe upgrades required in Forks Road sewers from the Dain City Community Development to the intersection of Forks Road and Crescent Drive. Yellow indicates an upgrade need to 300 mm.



The sewer downstream of Forks Road has sufficient capacity to convey the proposed development flows; however, due to existing capacity limits at the Dain City SPS, sewer surcharging is expected. The proposed development flow is expected to increase sewer surcharging; however, surcharging is expected to remain <1.8 m below grade under a 10 year design storm, which is the level of service target for basement flooding surcharging.

4.2 Dain City SPS Capacity

Table 4 summarizes the design and modeled flows to the Dain City SPS.

Table 4- Summary of Dain City SPS Capacity with design and wet weather flows. Peak development flows for varying buildout scenarios include existing flows.

Scenario	Existing	Existing + 731 units	Existing + 982 units	Existing + 982 Units + JD Property
Dry Weather Flow (L/s)	4.7	29	38	49
Niagara Design Wet Weather Flow (L/s)	37.7	77	85	96
2yr 24h Design Storm (L/s)	113.6	155	164	175
5yr 24h Design Storm (L/s)	132.4	175	183	194
10yr 24h Design Storm (L/s)	147.3	190	198	209

Under the full buildout of the Dain City Community Development, the design peak wet weather flows to the Dain City SPS, using the Region's Design RDII allowance of 0.286 L/s for the contributing catchment, are below the station's operational firm capacity of 94 L/s. The combined buildout of the Dain City Community Development and John Deere property marginally exceeds the operational firm capacity of 94 L/s, but are below the ECA capacity of 115 L/s.

These design flows are greater than the MSP 2041 growth flows to the station of 71 L/s, due largely to the proposed total greenfield, and contributing I&I, the growth area is higher than assumed in the MSP resulting in the overall higher peak wet weather flows.

Under the 2 year, 5 year, and 10 year design storm flows, the developments will further increase flows to the SPS above the station's operational firm and ECA capacity, 94 L/s and 115 L/s respectively. The station's overflow storage facility (~1,100 m³) will continue to provide peak flow relief during major wet weather flow events; however, development is expected to increase the frequency at which the overflow tank is utilized.

As identified in Section 2.1, under the current station Firm Capacity, the peak 10, and 25 year design storm sewer HGL remains below the 1.8 m below grade, due to deep pipes and the storage facility, Figure 3, 4, and 5, respectively.

5 SUMMARY AND RECOMMENDATIONS

Based on the capacity analysis,

- The existing gravity sewer immediately downstream of the proposed development along Forks Road does not have sufficient capacity to support the development flows. A full buildout of the development would require an upgrade to 300 mm at the slope and depth of the existing pipes.
- The existing gravity sewer downstream of Forks Road has adequate capacity to support both the full buildout of the Dain City Community Development and the John Deere Industrial Development.
- Utilizing the Regional design inflow and infiltration allowance, the existing Dain City SPS has sufficient capacity to support the proposed development at full buildout and is marginally above capacity when the combined flows of the John Deere industrial development and Dain City Community Development are considered.
- Actual peak wet weather flows to the Dain City SPS currently exceed the Region's RDII analysis, resulting in utilization of the station overflow storage, and surcharging of the upstream trunk sewer.
- The existing overflow facility (~1,000 m³) mitigates the full impact of peak wet weather flows under existing conditions and appears to be sufficient at accommodating flow under growth scenarios. The full buildout of the Community Development and the John Deere Industrial Development, under the 10 year design storm, results in a peak HGL that does not exceed the basement flooding level of 1.8 m below grade.

Based on the above, the following is needed to support development of the Dain City Community Development:

- 300 mm upgrade of the existing Forks Road Sewer from Crescent Drive to the development.
- The Region should explore opportunities to re-establish the Dain City SPS operation firm capacity to match the ECA firm capacity.
- The Region should consider a catchment-wide inflow and infiltration reduction program to minimize the existing peak wet weather flows, and to manage the potential impacts related to the Dain City Community Development and the John Deere industrial development.

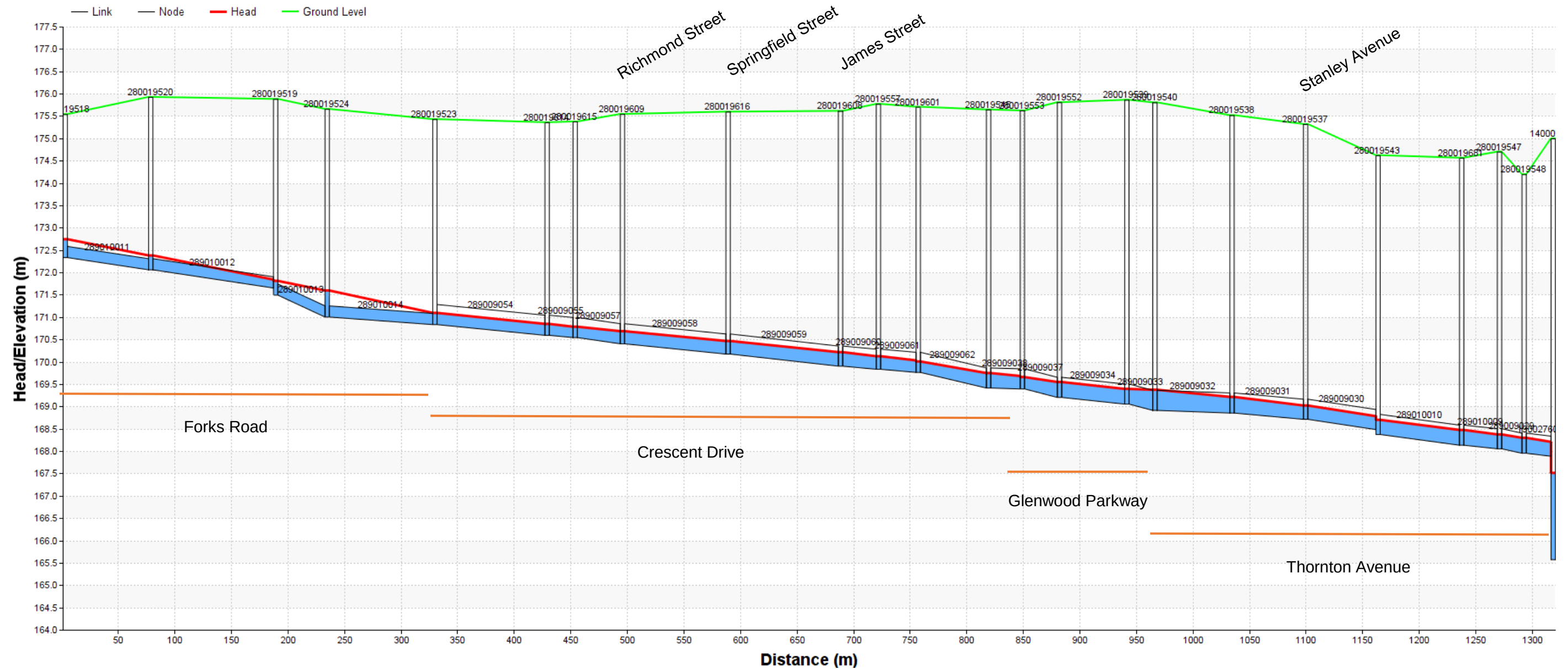


Figure 3. Profile showing peak HGL under a 10 year design storm from Dain City Community Development to Dain City SPS with no downstream pumping restrictions.

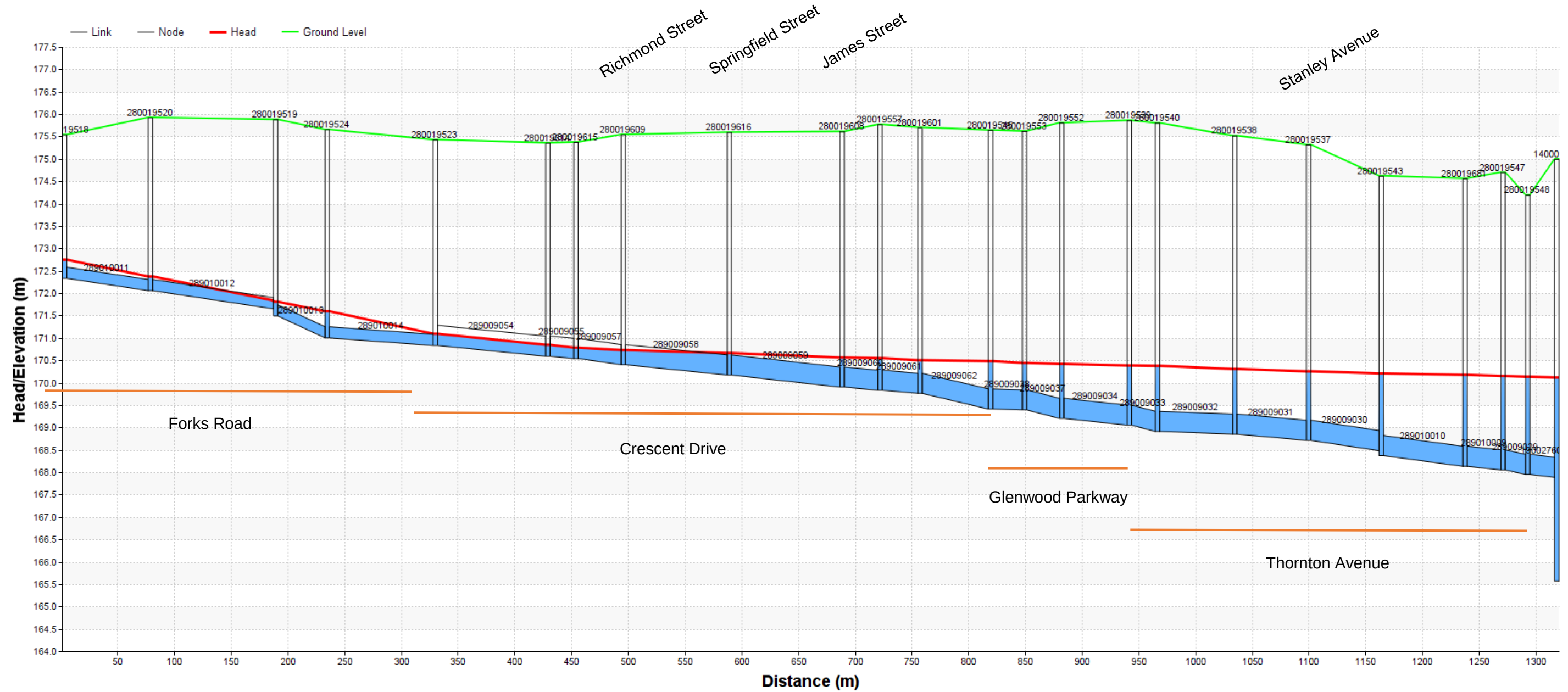
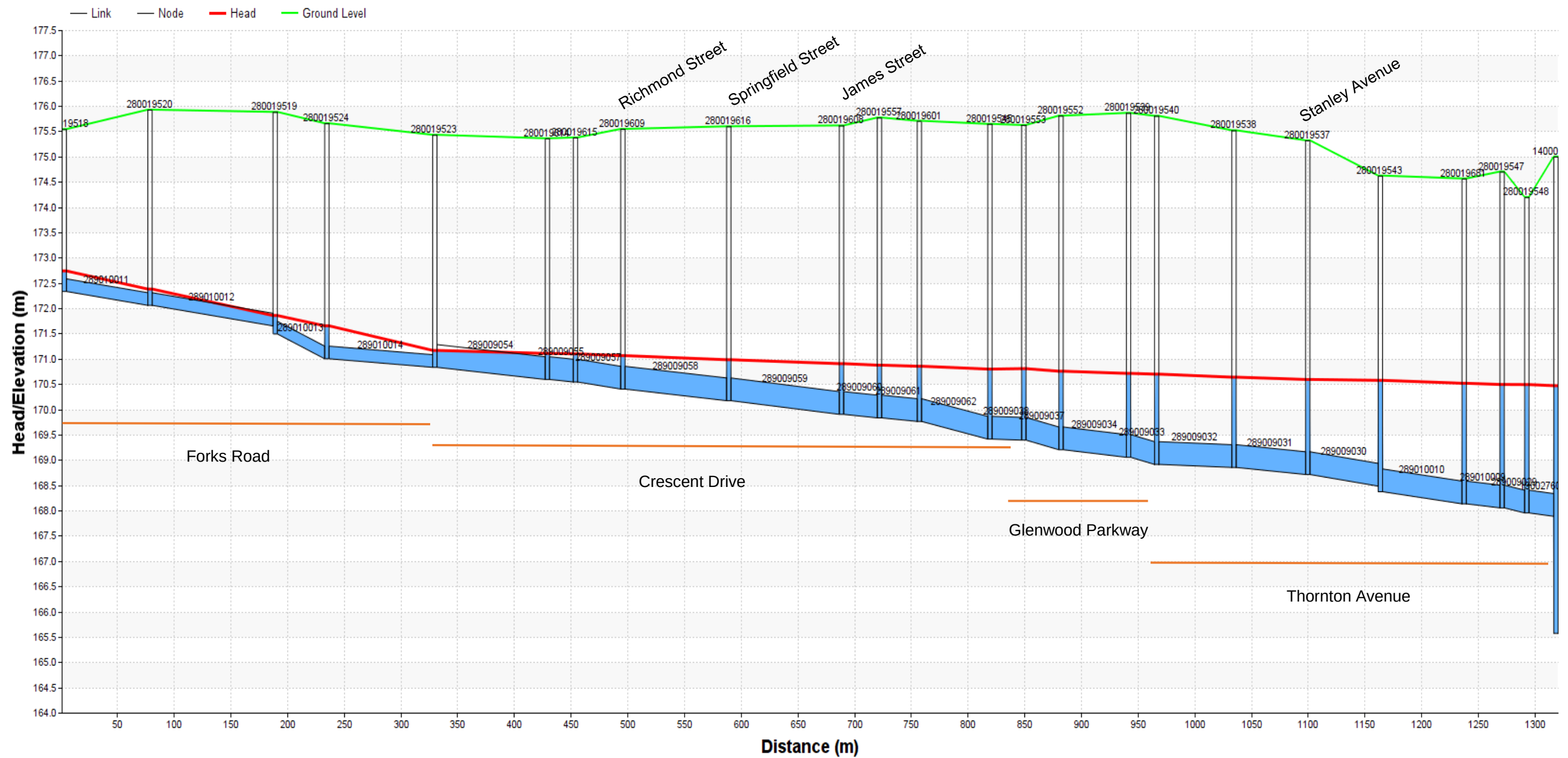


Figure 4. Profile showing peak HGL under a 10 year design storm from Dain City Community Development to Dain City SPS, SPS operating at firm capacity, 94 L/s.





Date:	7/12/2019	File:	418024
To:	Marvin Ingebrigtsen		
From:	Julien Bell, Elaine Samuel		
Project:	Dain City Development Review		
Subject:	Dain City Forcemain Replacement Capacity Review		

TECHNICAL MEMO

INTRODUCTION

This technical memo summarizes the results of a high-level assessment of the growth capacity risks related to the future Dain City Forcemain Replacement.

Baseline Understanding

The Region is currently undertaking the design to replace the existing Dain City SPS forcemain with a new 300 mm forcemain. Since the new forcemain was initially sized at 300 mm, the City undertook a pre-consultation for a potential large-scale development within the Dain City SPS catchment; which exceeds the previous planning projections.

Further, The Dain City SPS catchment has a history of high wet weather flows and basement flooding. Through additional investigation undertaken during 2018, the City now has a better understanding of the existing system flows and basement flooding risk.

This review assesses the capacity of the proposed 300 mm forcemain to accommodate the increased growth flows and to address the potential increased basement flooding risk that the growth flows may pose on the Dain City neighbourhood. Through this review, it will be determined if further upsizing of the forcemain should be considered.

Forcemain Capacity

The final alignment of the new 300 mm forcemain has yet to be finalized, however, the expected impact on the Dain City SPS performance was estimated assuming that the new forcemain will have the same inlet and outlet locations and will have a similar total length as the existing forcemain. Figure 1 presents the estimated changes in the Dain City system curve.

Based on a preliminary estimate, the new 300 mm forcemain is expected to increase the Dain City operational capacity to ~ 150 L/s with two pumps in operation, assuming no other changes are made to the existing pump station. Further, at 150 L/s, the velocity within the forcemain is expected to be ~2.1 m/s. This velocity is less than the Region's design criteria of 2.5 m/s, providing further opportunity to increase the operational capacity of the forcemain through pump upgrades at the Dain City SPS.

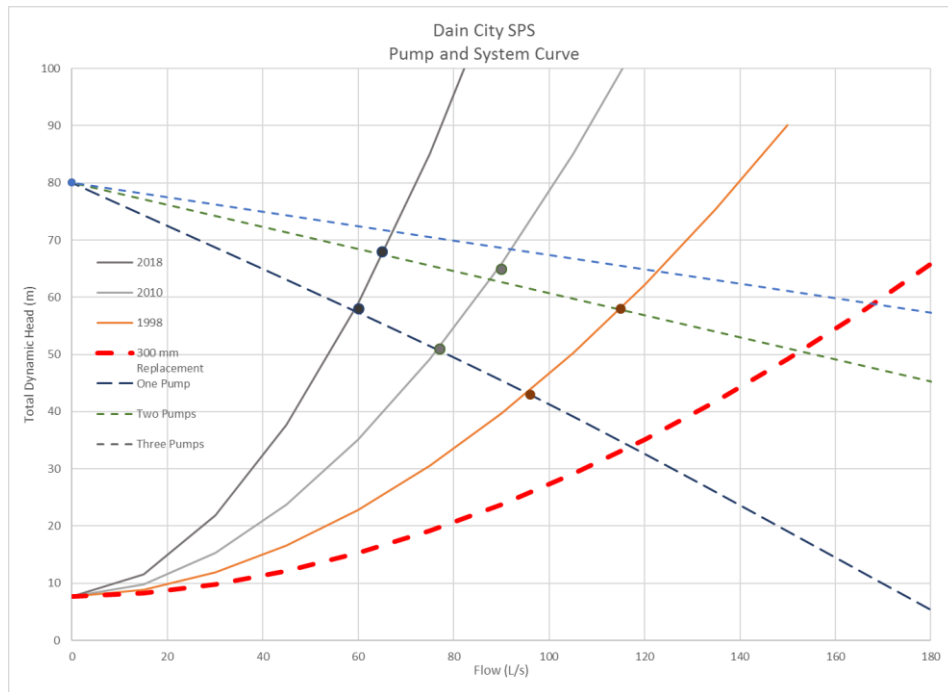


Figure 1: Dain City Sanitary Pumping Station Pump and System Curve

Dain City Developments

Figure 2 highlights the two major residential developments that have been proposed within the Dain City catchment. The full buildout densities of these two developments are currently unknown, but based on pre-consultation and previous development submissions, the two developments are estimated to yield approximately 1,650 to 2,000 units. Other small-scale developments are also anticipated to occur within the catchment area. For the intents of this high-level review, these additional developments were not considered. Table 1 summarizes the potential growth flows. Wet weather flows from the developments were calculated using the design value 0.286 L/s/ha.



Concept A - South
DAIN CITY, WELLAND, ONTARIO

Figure 2: Two Major Proposed Residential Developments Within Dain City Catchment

Table 1: Potential Growth Sanitary Flows

Units	Population	Development Area (ha)*	Average Dry Weather Flow (L/s)	Peak Dry Weather Flow (L/s)	Wet Weather Flow (L/s)	Peak Flow (L/s)
1650	4191	100	13.3	44.2	28.6	72.8
2000	5080	100	16.2	52.4	28.6	81.0

* Estimated net new catchment area

Dain City SPS – Existing Flows

Table 2 summarizes the current flows to the Dain City SPS, from the calibrated hydraulic model. The model was calibrated using flow monitoring data from 2016-2017. As demonstrated in Table 2, the existing flows to the Dain City SPS exceed the design flow allowance as well as both the station's existing operational capacity of 70 L/s and the ECA capacity of 115 L/s. To compensate for the high wet weather flows, there is a 1,200 m² CSO tank on site to help store and attenuate peak flows to protect against system overflows and basement flooding.

Table 2: Current Flows to the Dain City Sanitary Pumping Station

Design Scenario	Flow to Station (L/s)	Unit RDII (L/s/ha)
ADWF	4.7	NA
Design PWWF (0.286 L/s/ha)	37.7	0.286
2-year	182	1.644
5-year	210	1.920
10-year	230	2.108
25-year	247	2.276
100-year	279	2.583

Dain City SPS – Performance Analysis

Table 3 summarizes how the proposed forcemain upgrade and growth flows are expected to impact the performance of the Dain City SPS, and how it will affect basement flooding risk within the local neighbourhood.

Currently, with the Dain City SPS operating at 70 L/s, there is sufficient storage at the station to accommodate up to the 25-year design storm before triggering the overflow pumping alarm and placing the system at a risk of basement flooding, which was assumed to be 1.8 m below grade.

Assuming no wet weather flow reduction work is implemented within the Dain City SPS, the new forcemain is expected to increase the system's protection against basement flooding up to the 100-year design storm.

With an additional 2,000 units expected in the Dain City catchment, design flows to the station would:

- Remain below the potential station capacity of 150 L/s, based on the system curve (Figure 1) However, the level of basement flooding protection would be reduced to a 25-year design storm, which is in line with the existing state.
- Utilize the remain available station capacity if the Region limited station flows to the current ECA capacity of 115 L/s. However, limiting flows would reduce the basement flooding protection to a 2-year design storm, increasing the risk of basement flooding relative to existing state

Currently, wet weather flows within the Dain City catchment are estimated to be 2.583 L/s/ha under a 100-year storm. To improve basement flooding protection up to the 100-year level of service while allowing for the 2,000-unit development:

- A 20% reduction of wet weather would need to be achieved (assuming a station capacity of 150 L/s). This would still allow for wet weather flows to be within the range of 2.1 L/s/ha, or 7 times the existing design standard.
- A 30% reduction of wet weather would need to be achieved (assuming a station capacity of 115 L/s). This would still allow for wet weather flows to be within the range of 1.8 L/s/ha, or 6 times the existing design standard.

CLOSING

Based on the above, it is our assessment that upsizing the forcemain to beyond 300 mm is likely not required.

Table 3. Level of Service Matrix

Design Scenario	Existing Flow to Station (L/s)	Future Flow to Station (L/S)		Emergency Forcemain - Current Capacity (70 L/s)		ECA Capacity (115 L/s)		ECA Capacity (115 L/s) + 2000 units		300 FM Upgrade (150 L/s)		300 FM Upgrade (150 L/s) + 2000 Units	
		1650 Units	2000 Units	Within Station Capacity	Within CSO Tank Capacity	Within Station Capacity	Within CSO Tank Capacity	Within Station Capacity	Within CSO Tank Capacity	Within Station Capacity	Within CSO Tank Capacity	Within Station Capacity	Within CSO Tank Capacity
ADWF	4.7	18	20.19	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Design PWWF (0.286 L/s/ha)	37.7	110.5	118.7	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓
2-year	182	255	263	✗	✓	✗	✓	✗	✓	✗	✓	✗	✓
5-year	210	283	291	✗	✓	✗	✓	✗	✗	✗	✓	✗	✓
10-year	230	303	311	✗	✓	✗	✓	✗	✗	✗	✓	✗	✓
25-year	247	320	328	✗	±	✗	✓	✗	✗	✗	✓	✗	±
100-year	279	352	360	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗

APPENDIX D:

Summary of Public Consultation

Type	Contact	Title	Organization	Address	City	Postal Code	Phone	Email
Provincial Agency	Lisa Myslicki	Environmental Advisor	Infrastructure Ontario	1 Dundas Street West, Suite 2000	Toronto	M5G 2L5		
Provincial Agency	Colleen Fitzgerald-Hubble	Director	Ministry of Agriculture, Food and Rural Affairs, Environmental Management Branch	1 Stone Road W, 3rd Floor S	Guelph	N1G 4Y2		colleen.fitzgerald-hubble@ontario.ca
Provincial Agency	Adam Redish	Assistant Deputy Minister	Ministry of Economic Development , Employment and Infrastructure, Infrastructure Policy Division	777 Bay St., 21st Floor	Toronto, ON	M5G 2N4	416-314-5148	adam.redish@ontario.ca
Provincial Agency	Alex Earthy	Senior Housing Advisor	Ministry of Municipal Affairs and Housing	777 Bay Street, 17th Floor	Toronto	M5G 2E5		
Provincial Agency	Ian Thornton	District Supervisor	Ministry of Natural Resources and Forestry, Guelph District	1 Stone Road W, Ontario Government Building	Guelph	N1G 4Y2	226-820-5050	ian.thornton@ontario.ca
Provincial Agency	David Marriott	District Planner	Ministry of Natural Resources and Forestry, Guelph District	1 Stone Road W, Ontario Government Building	Guelph	N1G 4Y2		
Provincial Agency	Kingsley Laurin	Director	Ministry of the Attorney General, Aboriginal Justice Division	720 Bay Street, 4th Floor	Toronto	M7A 2S9		
Provincial Agency	Sylvain Campbell	Provincial Officer, Niagara District Office	Ministry of the Environment, Conservation & Parks, Niagara District Office	301 St. Paul Street, 9th Floor, Suite 15	St. Catharines	L2R 3W8		
Provincial Agency	Joan Del Villar Cuicas	EA/Planning Coordinator	Ministry of the Environment, Conservation & Parks, West-Central Region	119 King Street West, 12th Floor	Hamilton	L8P 4Y7		Joan.delvillarcuicas@ontario.ca
Provincial Agency	Teepu Khawja	Regional Director - Central Region	Ministry of Transportation, Central Region Office	159 Sir William Hearst Ave, Building D, 2nd Floor	Toronto, ON	M3M 1J8	416-235-5400	teepu.khawja@ontario.ca
Provincial Agency	Michael Spencer	Surface Water Group Leader	Ministry of the Environment, Conservation & Parks, West Central Region	119 King Street West, 12th Floor	Hamilton	L8P 4Y7		
Provincial Agency	Jennifer Hay	Regional Advisor	Ministry of Tourism, Culture and Sport	201 St. Paul Street, 9th Floor	St. Catharines	L2R 7R4		
Provincial Agency	Marcelo Gruosso	Senior Director	Niagara Parks Commission, Engineering, Parking & Transportation	7400 Portage Road, Box 150	Niagara Falls	L2E 6T2		
Provincial Agency			Ministry of Indigenous Affairs	4th Floor, 160 Bloor Street East	Toronto	M7A 2E6		
Provincial Agency	Glenn Dunphy	Regional Manager	Ministry of Transportation, Regional Operations - Central West	1550 Enterprise Rd, 2nd Floor, Suite 228	Mississauga, ON	L4W 4P4	905-564-5265	glenn.dunphy@ontario.ca
Provincial Agency	Jonathan Boone	Head - Construction and Engineering	Ministry of Transportation	301 St. Paul Street, 2nd Floor	St. Catharines, ON	L2R 7R4	905-704-2601	jonathan.boone@ontario.ca
Indigenous Communities			Haudenosaunee Confederacy Chiefs Council	16 Sunrise Court, Suite 417, P.O. Box 714	Ohswegen	N0A 1M0	519-445-4222	info@hdi.land
Conservation Authority	Natalie Green	Project Manager, Niagara River Remedial Action Plan	Niagara Peninsula Conservation Authority	251 Thorold Road West, 3rd Floor	Welland, ON	L3C 3W2		
Conservation Authority	Joshua Diamond	Water Quality Specialist	Niagara Peninsula Conservation Authority	252 Thorold Road West, 3rd Floor	Welland, ON	L3C 3W2		
Indigenous Communities	Lonny Bomberry	Director of Lands and Resources	Six Nations of the Grand River	2498 Chiefswood Road, P.O. Box 5000	Ohswegen	N0A 1M0	519-753-0665	lonnybomberry@sixnations.ca
Indigenous Communities	Abby LaForme	Acting Consultation Coordinator	Mississaugas of the Credit First Nation	6 First Line Rd, Unit 1, RR #6	Hagersville	N0A 1H0		Abby.LaForme@mncfn.ca
Indigenous Communities	Mark LaForme	Director	Mississaugas of the Credit First Nation	6 First Line Rd, Unit 1, RR #6	Hagersville	N0A 1H0		Mark.LaForme@mncfn.ca

Type	Contact	Title	Organization	Address	City	Postal Code	Phone	Email
Municipality	Clerk Ann-Marie Norio	Regional Clerk	Niagara Region					ann-marie.norio@niagararegion.ca
Municipality	Clerk Donna Delvecchio	Municipal Clerk	City of Thorold					clerk@thorold.com
Municipality	Clerk Bill Matson	Municipal Clerk	City of Niagara Falls					bmatson@niagarafalls.ca
Municipality	Clerk Nancy Bozzato	Municipal Clerk	Town of Pelham					nbozzato@pelham.ca
Regional Municipality	Carolyn Ryall	Director, Transportation Services	Niagara Region	1815 Sir Isaac Brock Way, PO Box 1042	Thorold	L2V 4T7	905-980-6000 ext 3620	carolyn.ryall@niagararegion.ca
Regional Municipality	Joe Tonellato	Director, Water and Wastewater Services	Niagara Region	1815 Sir Isaac Brock Way, PO Box 1042	Thorold	L2V 4T7		joseph.tonellato@niagararegion.ca
Regional Municipality	Tony Cimino	Associate Director, Water & Wastewater Engineering	Niagara Region	1815 Sir Isaac Brock Way, PO Box 1042	Thorold	L2V 4T7		tony.cimino@niagararegion.ca
Utility	Bill McKenzie	Manager	Bell Canada, Niagara Implementation	63 King Street, 2nd Floor, P.O. Box 190, Access Network Provisioning	St. Catharines	L2R 3H6		william.mckenzie@bell.ca
Utility	Rob D'Onofrio	Planning and Design	Enbridge Gas Distribution Inc.	3401 Schmon Parkway, P.O. Box 1051, Planning & Design Special Projects	Thorold	L2V 5A8		robert.donofrio@enbridge.com
Utility	Ann Newman	Supervisor	Enbridge Pipelines Inc., Right-of-Way Services	1086 Modeland Road, Building 1050, 1st Floor	Sarnia	N7S 6L2		ann.newman@enbridge.com
Utility	Mark Kuhlmann	Construction Coordinator	Niagara Region Broadband Networks	623 South Service Road, Unit #5	Grimsby	L3M 4E8		mark.kuhlmann@nrbn.ca
Utility	Ian Chisholm	Maintenance Manager	TransCanada Pipelines, Maple/Niagara Facilities	1020 Rymal Road, Canada Pipeline Operations, Eastern Region	Hamilton	L8W 3N6		ian_chisholm@transcanada.com
Regional Municipality	Phill Lambert	Director, Infrastructure Planning	Niagara Region	1815 Sir Isaac Brock Way, PO Box 1042	Thorold	L2V 4T7		
Regional Municipality	Ilija Stetic	Project Manager, Water and Wastewater Engineering	Niagara Region	1815 Sir Isaac Brock Way, PO Box 1042	Thorold	L2V 4T7		
Interest Group	Ed Lucchetta	President	Niagara Home Builders Association	34 Scott Street	St. Catharines	L2R1C9		info@niagarahomebuilders.ca
Utility	Patrick Beaudoin	Engineer	Canadian Niagara Power Inc., Planning	1130 Bertie Street, P.O. Box 1218	Fort Erie	L2A 5S1		
Utility	Chase Peterson		Cogeco Cable Inc.	695 Lawrence Road	Hamilton	L8K 6P1		
Utility	Rhonda Nicholson		Enbridge Consumers Gas	3401 Schmon Parkway, P.O. Box 1051	Thorold	L2V 5A8		
Conservation	Kim Peters	Senior Strategic Advisor	Niagara Escarpment Commission	232 Guelph Street	Georgetown	L7G 4B1	905-877-5191	Kim.Peters@ontario.ca
Education	Warren Hoshizaki	Director of Education	District School Board of Niagara	191 Carlton Street	St. Catharines	L2R 7P4	905-641-1550	KAREN.BELLAMY@DSBN.ORG
Education	Camillo Cipriano	Director of Education & Secretary/Treasurer	Niagara Catholic District School Board	417 Rice Road	Welland	L3C 7C1	905-735-0240 ext. 220	camillo.cipriano@ncdsb.com
Utility		Supervisor, Right of Way	Trans Canada Pipelines	200 Bay Street, Suite 200, P.O. Box 43, South Tower, Royal Bank Plaza	Toronto	MJ5 2J1		
Interest Group	Ben Embir		Niagara Health	1200 Fourth Avenue, NHS Corporate Office	St. Catharines	L2S 0A9		ben.embir@niagarahealth.on.ca

Type	Contact	Title	Organization	Address	City	Postal Code	Phone	Email
Interest Group	Donald Hall		Niagara Health	1200 Fourth Avenue, NHS Corporate Office	St. Catharines	L2S 0A9		donald.hall@niagarahealth.on.ca
Provincial Agency		EA Notification	Ministry of the Environment, Conservation & Parks, Niagara District Office	119 King Street West, 12th Floor	Hamilton	L8P 4Y7		eanotification.wregion@ontario.ca
Municipality	Sherri-Marie Millar	Director of Infrastructure Services	City of Welland	60 East Main Street	Welland	L3B 3X4	905-735-1700	sherri-marie.millar@welland.ca
Municipality	Livia McEachern	Manager of Engineering	City of Welland	60 East Main Street	Welland	L3B 3X4	905-735-1700	livia.mceachern@welland.ca
Municipal Council	Adam Moote	Ward One Councillor	City of Welland	60 East Main Street	Welland	L3B 3X4		adam.moote@welland.ca
Municipal Council	Mary Ann Grimaldi	Ward One Councillor	City of Welland	60 East Main Street	Welland	L3B 3X4		maryann.grimaldi@welland.ca
Municipal Council	David McLeod	Ward Two Councillor	City of Welland	60 East Main Street	Welland	L3B 3X4		david.mcleod@welland.ca
Municipal Council	Leo Van Vliet	Ward Two Councillor	City of Welland	60 East Main Street	Welland	L3B 3X4		leo.vanvliet@welland.ca
Municipal Council	John Chiocchio	Ward Three Councillor	City of Welland	60 East Main Street	Welland	L3B 3X4		john.chiocchio@welland.ca
Municipal Council	Bryan Green	Ward Four Councillor	City of Welland	60 East Main Street	Welland	L3B 3X4		Bryan.green@welland.ca
Emergency Services	Carol Taylor		Niagara Regional Police	5700 Valley Way	Niagara Falls	L2E 1X8	905-688-4111	
Municipal Council	Tony Dimarco	Ward Four Councillor	City of Welland	60 East Main Street	Welland	L3B 3X4		tony.dimarco@welland.ca
Conservation	Susan Murray	VP Communications and Operations	Friends of the Greenbelt	661 Yonge Street, #500	Toronto	M4Y 1Z9	416-960-0001	
Municipal Council	Claudette Richard	Ward Five Councillor	City of Welland	60 East Main Street	Welland	L3B 3X4		claudette.richard@welland.ca
Municipal Council	Graham Speck	Ward Five Councillor	City of Welland	60 East Main Street	Welland	L3B 3X4		graham.speck@welland.ca
Municipal Council	Bonnie Fokkens	Ward Six Councillor	City of Welland	60 East Main Street	Welland	L3B 3X4		bonnie.fokkens@welland.ca
Municipal Council	Jim Larouche	Ward Six Councillor	City of Welland	60 East Main Street	Welland	L3B 3X4		jim.larouche@welland.ca
Utility	Jessica Polak	VP Operations - Niagara Operations	Ontario Power Generation	14000 Niagara River Parkway, RR #1	Niagara-on-the-Lake, ON	L0S 1J0		
Conservation Authority	David Deluce	Manager, Plan Review & Regulations	Niagara Peninsula Conservation Authority	250 Thorold Road West, 3rd Floor	Welland, ON	L3C 3W2		
Municipality	Geoff Holman	Director of Public Works and Community	City of Thorold	3450 Schmon Parkway, P.O. Box 1044	Thorold	L2V 4A7	905-227-6613	thoreng@thorold.com
Municipality	Jason Marr	Director of Public Works	Town of Pelham	20 Pelham Town Square	Fonthill	L0S 1E0	905-892-2607 ext. 313	JMarr@pelham.ca
Municipality	Derek Young		Town of Pelham	20 Pelham Town Square	Fonthill	L0S 1E0		DYoung@pelham.ca
Municipality	Ryan Cook		Town of Pelham	20 Pelham Town Square	Fonthill	L0S 1E0		RCook@pelham.ca
Utility	Darlene Quilty	Planning Coordinator	MHBC Planning, Urban Design & Landscape Architecture	113 Collier St.	Barrie	L4M 1H2	705-728-0045 ext. 243	dquilty@mhbcplan.com

Type	Contact	Title	Organization	Address	City	Postal Code	Phone	Email
Utility	John Pendykoski	System Project Planner	Cogeco Cable Hamilton/Niagara	7170 McLeod Road	Niagara Falls	L2G 3H2		
Utility	Dean Norton	Advisor	Ontario Power Generation, Public Affairs and Property Management	14000 Niagara River Parkway, R.R. #1	Niagara-on-the-Lake	L0S 1J0		
Interest Group	Cassie Kelly	Manager of Engineering	St. Lawrence Seaway					ckelly@seaway.ca
Utility	Cassandra Patterson	Plant System Support Manager	Ontario Power Generation	14000 Niagara River Parkway, RR #1	Niagara-on-the-Lake, ON	L0S 1J0		cassandra.patterson@opg.com
Indigenous Communities	Chief Ava Hill	Chief	Six Nations of the Grand River	2498 Chiefswood Road, P.O. Box 5000	Ohsweken	N0A 1M0	519-445-2201	avahill@sixnations.ca
Indigenous Communities	Chief Stacey LaForme	Chief	Mississaugas of the Credit First Nation	2789 Mississauga Rd, RR #6	Hagersville	N0A 1H0	519-768-1133	stacey.laforme@mncfn.ca
Indigenous Communities	Chief Mark B. Hill	Chief	Six Nations of the Grand River	2789 Mississauga Rd, RR #6	Hagersville	N0A 1H0	519-768-1133	markhill@sixnations.ca
Municipality	Clerk Tara Stephens	Municipal Clerk	City of Welland				905-735-1700 ext. 2159	clerk@welland.ca
Municipal Council	John Mastroianni	Ward Three Councillor	City of Welland	60 East Main Street	Welland	L3B 3X4		john.mastroianni@welland.ca
Regional Council	Frank Campion	Mayor	Niagara Region	60 East Main Street	Welland	L3B 3X4		frank.campion@niagararegion.ca
Regional Council	Pat Chicchio	Councillor	Niagara Region	160 Creekside Dr	Welland	L3C 0B4		pat.chicchio@niagararegion.ca
Regional Council	Leanna Villella	Councillor	Niagara Region	59 Church St	Welland	L3C 4N7		leanna.villalla@niagararegion.ca
Emergency Services	Adam Eckhart	Fire Chief	Welland Fire and Emergency Services	636 King St	Welland	L3B 3L1	905-737-1700 Ext 2403	fire@welland.ca
Indigenous Communities	Robbin Vanstone	Consultation Supervisor	Six Nations of the Grand River	2498 Chiefswood Road, P.O. Box 5000	Ohsweken	N0A 1M0	519-753-0665	rvanstone@sixnations.ca



NOTICE OF STUDY COMMENCEMENT AND PUBLIC INFORMATION CENTRE NO.1

Pollution Prevention Control Plan Update and Wastewater Master Servicing Plan

What is this Study All About?

The City of Welland has initiated a Pollution Prevention Control Plan Update and Wastewater Master Servicing Plan. This Update will serve as an opportunity to summarize previous recommendations that have been implemented and support long term growth, sustainability, and management of the wastewater system.

How is this Study Being Undertaken?

This Update will satisfy Phase 1 and 2 requirements of a Municipal Class Environmental Assessment (October 2000, as amended in 2007, 2011 and 2015), which is approved process under the Ontario Environmental Assessment Act.

How can I Participate in this Study?

There is an opportunity at any time during the study process for members of the public to provide comments and concerns to the attention of the project managers.

There will also be two Public Information Centres during this study. The first Public Information Centre will focus on the project objectives and background. Members of the project team will be available at the Public Information Centre to answer questions and discuss the study progress to date.

**Public Information Centre No. 1 will
be held:**

Public Information Centre No. 1

Date/Time:

Thursday, July 11, 2019 from 5:00 – 7:00 p.m.

Location:

Community Room, Welland Civic Square,
60 East Main Street, Welland, ON L3B 3W3

If you would like to submit comments or be notified about future study activities, please contact

Marvin Ingebrigtsen, P.Eng

City Project Manager
City of Welland
marvin.ingebrigtsen@welland.ca
905-735-1700 ext. 2209

Julien Bell, P.Eng

Consultant Project Manager
GM BluePlan Engineering Ltd.
julien.bell@gmblueplan.ca
519-748-1440 ext. 4264

With the exception of personal information, all comments received during the Pollution Prevention Control Plan and Wastewater Master Servicing Plan Update will become part of the public record of the study.

**This notice was first issued on June 27,
2019**

July 3, 2019



**RE: Notice of Study Commencement and Public Information Centre No.1
Welland Pollution Prevention Control Plan Update and Wastewater
Master Servicing Plan**

Please find attached the Notice of Study Commencement and Public Information Centre No.1 for the Welland Pollution Prevention Control Plan Update and Wastewater Master Servicing Plan. This update provides an opportunity to review the previous recommendations that have been implemented and look at ways to support Welland's wastewater system in the future.

This study is being undertaken in accordance with Approach 1 of the Master Planning process as set out in the Municipal Class Environmental Assessment (EA) (October 2000, as amended in 2007, 2011 and 2015), which is an approved process under the Ontario Environmental Assessment Act. This approach involves the preparation of a master plan document at the conclusion of Phases 1 and 2 of the Class EA process.

This study will identify the impacts growth has already had on the wastewater system and evaluate alternatives to support the long-term sustainability and management of the system. There are many factors to consider and the purpose of the EA is to evaluate all of these factors in order to make an informed decision.

The City will ensure that key stakeholders and the public have a voice at each step along the way to help create a plan that works for the community.

We look forward to your involvement through this Class EA process.

Sincerely,

Marvin Ingebrigtsen, P.Eng.

Project Manager

City of Welland

60 East Main Street

Welland, ON L3B 3X4

marvin.ingebrigtsen@welland.ca

905-735-1700 ext. 2209

Julien Bell, P.Eng.

Project Manager

GM BluePlan Engineering

1266 South Service Road, Unit C31

Stoney Creek, ON L8E 5R9

julien.bell@gmblueplan.ca

519-748-1440 ext. 4264

Enclosed: Notice of Study Commencement and Public Information Centre No.1



WELLAND CIVIC NEWS

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NOTICE OF STUDY COMMENCEMENT AND PUBLIC INFORMATION CENTRE NO.1

Pollution Prevention Control Plan Update and Wastewater Master Servicing Plan

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Public Information Centre No. 1

Date / Time:

Thursday, July 11, 2019 from 5:00 – 7:00 p.m.

Location:

Community Room, Welland Civic Square, 60 East Main Street, Welland, ON L3B 3W3

If you would like to submit comments or be notified about future study activities, please contact:

Marvin Ingebrigtsen, P.Eng

City Project Manager
City of Welland
marvin.ingebrigtsen@welland.ca
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Julien Bell, P.Eng

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519-748-1440 ext. 4264

With the exception of personal information, all comments received during the Pollution Prevention Control Plan and Wastewater Master Servicing Plan Update will become part of the public record of the study.

This notice was first issued on June 27, 2019



YourChannel
yourchannel.welland.ca

CIVIC SQUARE, 60 EAST MAIN STREET, WELLAND, ONTARIO, L3B 3X4 905-735-1700

LOCAL

COFFEE SHOP LATTE SALES TO BENEFIT HOSPICE NIAGARA

FUNDRAISER FOR HOSPICE NIAGARA RUNS UNTIL JULY 30

DAVE JOHNSON

Buying a \$5 emerald latte at Welland's Black Sheep Lounge could help a Niagara organization that works to improve the quality of life for people living with life-limiting illnesses, dying, death, loss and grief.

Black Sheep Lounge owner Lucas Spinoso decided to make Hospice Niagara the focus of a month-long fundraiser at his coffee shop after listening to his girlfriend, Katie Cornwall, talk about it.

"Kate was in school (Niagara College) for practical nursing and worked at Hospice Niagara. She fell in love with palliative care and taught me a lot about it."

Spinoso, a councillor for Ward 3, said Cornwall taught him a lot about the organization and that's why he decided to do the fundraising.

The organization offers its programs and services at no cost to clients and operates the Stabler Centre in St. Catharines, which provides quality palliative care in a homelike setting. The 10-bedroom residence is for people in the last weeks of



Dave Johnson, Torstar
Black Sheep Lounge owner Lucas Spinoso holds an emerald latte inside his coffee shop Tuesday. The drink's sales are going toward Hospice Niagara.

their lives who are unable to remain in their homes.

With green being the colour of Hospice, he came up with a green, maple-flavoured steamer as the fundraising drink. "Everything we make from it goes right to Hospice."

Last year, the coffee shop had a pink latte campaign which raised more than \$1,500 for the Canadian Can-

cer Society, specifically toward breast cancer research.

Spinoso is hoping to break that mark. The fundraising campaign runs until July 30. He said if people don't like emerald lattes, they can always make a cash donation when they come in.

The Black Sheep Lounge is at 64 Niagara St.



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CANADA**
with MANDARIN

July 1 - July 31

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MANDARIN
A Celebration of Taste

2019 FINAL RESIDENTIAL TAX BILLING

PROPERTY CLASSES invoiced on this FINAL TAX BILLING: Residential, Farmlands & Managed Forests

INSTALLMENT DUE DATES:

Tuesday, July 2, 2019

Tuesday, September 3, 2019

PAYMENT OF THE FINAL BILLING MAY BE MADE AS FOLLOWS:

City Hall, 60 East Main Street, Monday through Friday, 8:30 a.m. to 4:30 p.m. After Hours - Mail Slot at front entrance closest to Cross Street, by CHEQUE ONLY.

Chartered Banks, Caisse Populaire, Credit Union, Trust Companies. Payments accepted on or before installment due date only.

Please take advantage of our Pre-Authorized Payment Plan. Information available at City Hall or on our web site, www.welland.ca.

LATE PAYMENTS are subject to Penalty at 1.25% per month, applicable on the first day after due date.

Failure to receive a tax bill does not excuse a taxpayer from the responsibility for payment of taxes and penalties.

Steve Zorbas, CPA, CMA, B. Comm, DPA

General Manager, Corporate Services/ Chief Financial Officer/Treasurer



The City of Welland is
Initiating a Municipal Class

ENVIRONMENTAL ASSESSMENT STUDY



**Pollution Prevention
Control Plan &
Wastewater Master
Servicing Plan**

PUBLIC OPEN HOUSE – THURSDAY, JULY 11, 2019

5:00 p.m. to 7:00 p.m. in the Community Room
Welland Civic Square, 60 East Main Street

Marvin Ingebrigtsen, P.Eng

City Project Manager
City of Welland

marvin.ingebrigtsen@welland.ca
905-735-1700 ext. 2209

Julien Bell, P.Eng

Consultant Project Manager
GM BluePlan Engineering Ltd.
Julien.Bell@gmblueplan.ca
519-748-1440 ext. 4264

CANADA DAY HOURS (Monday, July 1, 2019)

www.welland.ca

The City of Welland (City Hall), and all departments and services listed below, will be closed on Monday, July 1, 2019, for Canada Day:

**Welland Transit, WellTrans, Transcab, and
Niagara Region Transit Service**

Main and Jack Ballantyne (Youth) Arenas;

**Welland Community Wellness Complex;
and Public Works.**

FOR URGENT ROAD, WATER, SEWER, FACILITIES, AND FORESTRY SERVICES:

Please call the City's 24 hour response line at (905) 735-1700, ext. 3000.

BILL PAYMENTS FOR TAXES AND/OR

WATER: Payment of bills may still be made by utilizing the drop box located at the easterly front entrance of Civic Square, 60 East Main Street.

From	To	Date Received	Type	Comment	Action	Status
City of Welland	Niagara This Week	6/27/2019	Newspaper Ad	Notice of Commencement and Public Information Centre #1.	Placed newspaper ad in Niagara This Week.	Complete
City of Welland	E-Bulletin	6/27/2019	Online Ad	Notice of Commencement and Public Information Centre #1.	Biweekly e-bulletin distributed.	Complete
City of Welland	Welland Tribune	7/8/2019	Newspaper Ad	Notice of Commencement and Public Information Centre #1.	Place newspaper ad in Welland Tribune.	Complete
City of Welland	Stakeholder List	7/5/2019	Letter	Notice of Commencement and Public Information Centre #1.	Sent letter with Notice of Commencement and PIC #1.	Complete
City of Welland	Stakeholder List	7/5/2019	Email	Notice of Commencement and Public Information Centre #1.	Sent email with Notice of Commencement and PIC #1.	Complete
City of Welland	MECP	7/5/2019	Email	Notice of Commencement and Public Information Centre and Streamlined Application excel sheet.	Sent email with Notice of Commencement and PIC #1 for the Pollution Prevention Control Plan Update and Wastewater Master Servicing Plan Streamlined Application excel sheet.	Complete
MECP	Julien Bell, Marvin Ingebrigtsen	7/22/2019	Email	Acknowledgement of Study Commencement	Received Acknowledgement of Study Commencement letter from MECP with Indigenous Community contacts.	Complete
City of Welland	Welland Tribune	2/3/2022	Newspaper Ad	Notice of Public Information Centre #2	Sent letter with Notice of PIC #2.	Complete
City of Welland	Stakeholder List	2/3/2022	Email	Notice of Public Information Centre #2	Sent letter with Notice of PIC #2.	Complete
City of Welland	Stakeholder List	2/3/2022	Letter	Notice of Public Information Centre #2	Sent letter with Notice of PIC #2.	Complete
Stakeholder	Project Team	2/14/2022	PIC#2	fix the leaks, remove fixed cost from bill	Response provided to stakeholder.	Complete
City of Welland	Stakeholder List	6/9/2022	Email	Notice of Completion	Sent email with Notice of Completion.	Complete
City of Welland	Stakeholder List	6/9/2022	Mail	Notice of Completion	Sent mail with Notice of Completion.	Complete
City of Welland	Welland Tribune	6/9/2022	Newspaper Ad	Notice of Completion	Placed newspaper ad in Welland Tribune.	Complete
Enbridge	City of Welland	6/30/2022	Email	Notice of Completion Comments	Response provided to stakeholder.	Complete
MECP	Julien Bell, Matt Main	7/21/2022	Email	Notice of Completion Comments	Response provided to stakeholder.	Complete
City of Welland	Mississaugas of the New Credit First Nation	8/1/2022	Phone Call	Follow up Indigenous Community consultation after receiving MECP comments	Left a message with contact information for follow up.	Complete
City of Welland	Six Nations of the Grand River	8/1/2022	Phone Call	Follow up Indigenous Community consultation after receiving MECP comments	Left a message with contact information for follow up.	Complete
City of Welland	Mississaugas of the New Credit First Nation	8/1/2022	Email	Follow up Indigenous Community consultation after receiving MECP comments	Sent email follow up about phone call and opportunity for questions/comments.	Complete
City of Welland	Six Nations of the Grand River	8/1/2022	Email	Follow up Indigenous Community consultation after receiving MECP comments	Sent email follow up about phone call and opportunity for questions/comments.	Complete

From	To	Date Received	Type	Comment	Action	Status
Mississaugas of the New Credit First Nation	Project Team	8/15/2022	Email	Formal written response to post- Notice of Completion Indigenous Communnity engagement noting no issues with Study	Response of receipt provided to the stakeholder.	Complete
City of Welland	Enbridge	10/11/2022	Email	Post-Filing correspondence to Notice of Completion Comments	Sent to stakeholder, copy of correspondence in Appendix D	Complete
City of Welland	Joan Del Villar, MECP	10/11/2022	Email	Post-Filing correspondence to Notice of Completion Comments	Sent to stakeholder, copy of correspondence in Appendix D	Complete

Welcome!



Welland Pollution Prevention Control Plan and Master Plan

Public Information Centre No. # 1

**Thursday, 07/11/2019, 5-7 PM
Community Room, Welland City Hall**

Civic Square

60 East Main Street
Welland, ON L3B 3X4
905-735-1700

Please provide feedback throughout the study

Stay Involved:

- Sign up for project updates
- Complete a feedback form
- Attend a future Public Information Centre
- Explore the project through Welland's YourChannel

Today

- Learn about the City's wastewater system and the system's issues and challenges
- Introduction to the Pollution Prevention Control Plan and Master Plan and the study's objectives
- See the Project Information on display and chat with the Project Team



Public Information Center 2

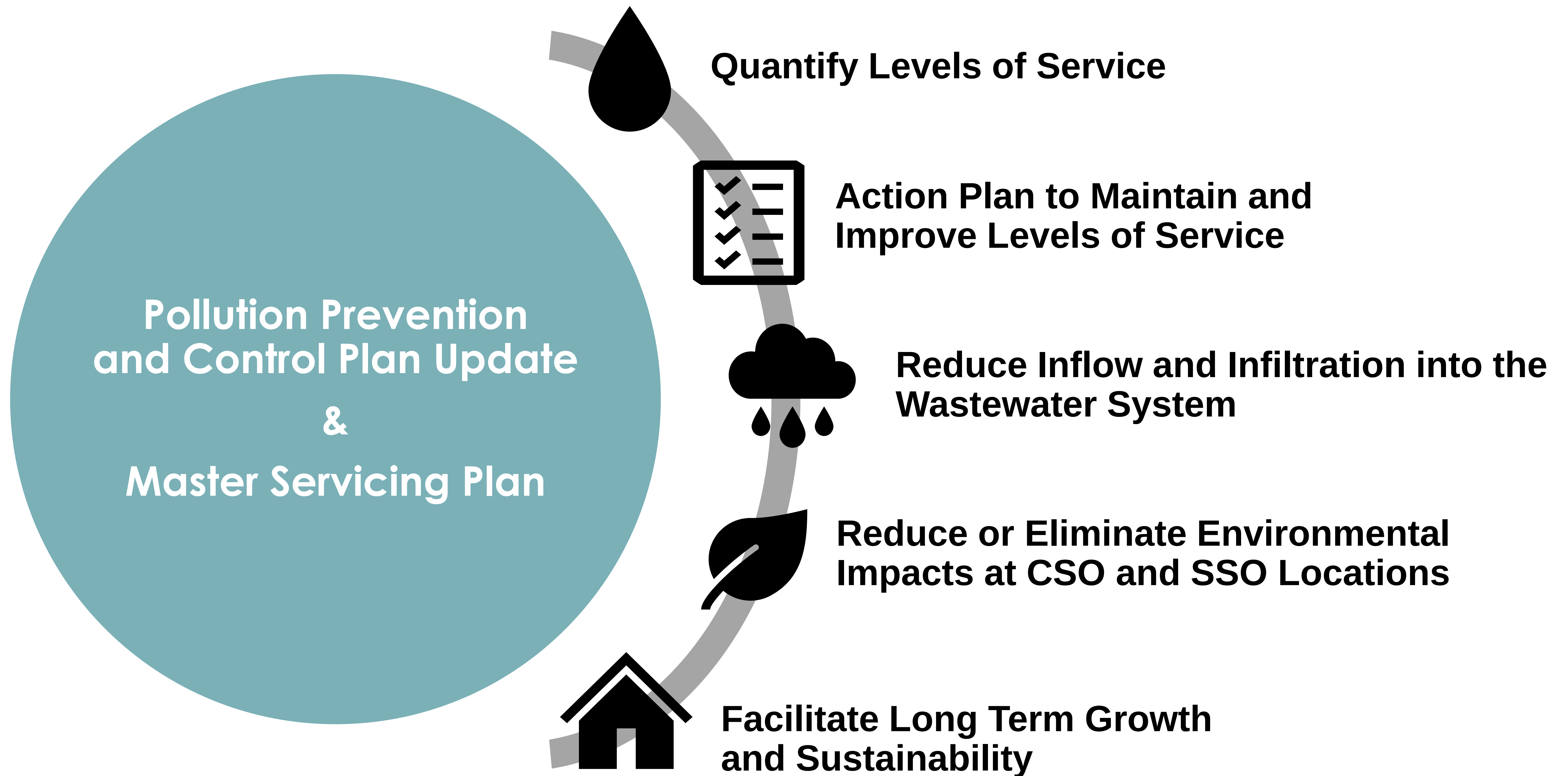
- Presents the Preliminary Preferred Solution
- Provides Input on the Alternatives Evaluation and Study Recommendations



Civic Square

60 East Main Street
Welland, ON L3B 3X4
905-735-1700

Project Objectives



Problem and Opportunity Statement

The 2019 PPCP & MP shall provide Strategic Sewer Management Recommendations that:

Quantify Existing and Future Levels of Service

Analyze Combined Sewer Overflows and Sanitary Sewer Overflows

Eliminate, Reduce or Delay Inflow and Infiltration

Enhance the City's Wastewater Collection System Infrastructure

Support Growth

Identify a Clear Implementation Plan



Civic Square

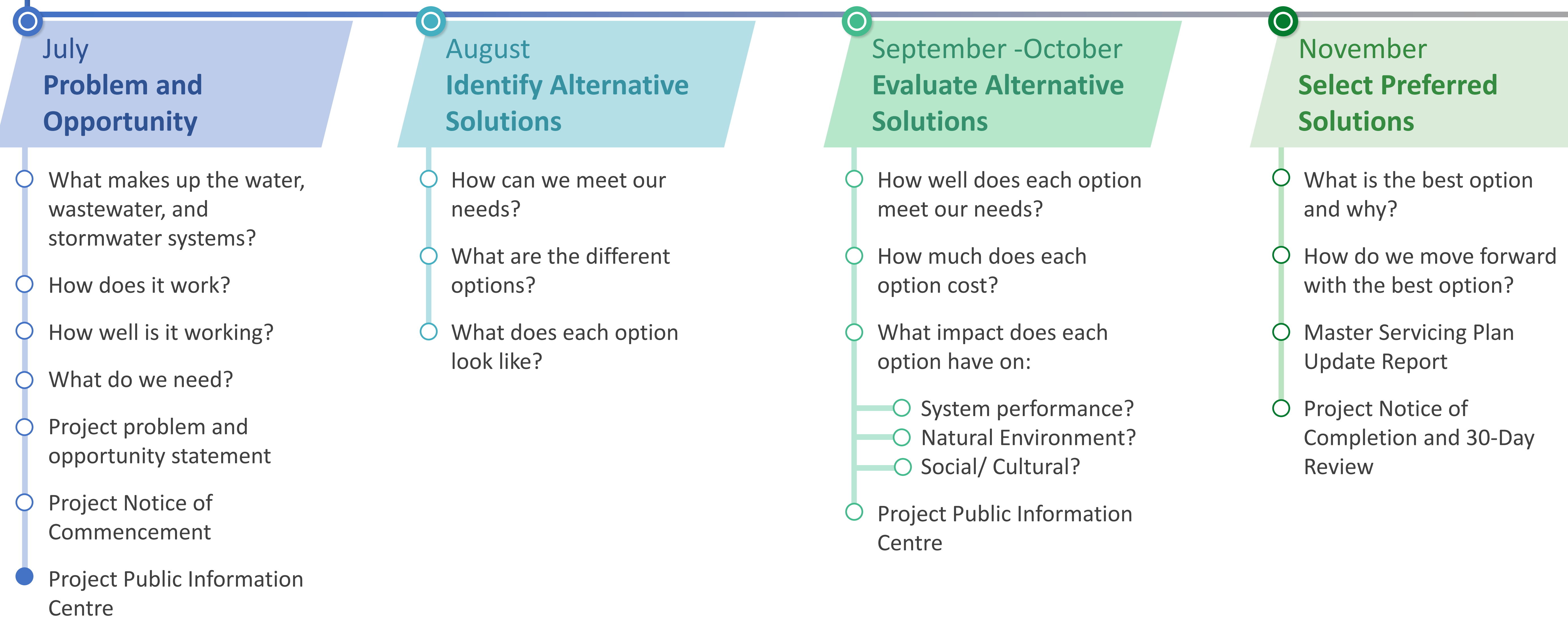
60 East Main Street
Welland, ON L3B 3X4
905-735-1700

Welland Pollution Prevention Control Plan Update and Wastewater Master Servicing Plan

Municipal Class EA Process

The Welland PPCP Update and Wastewater Master Plan involve the completion of Phases 1 and 2 of the MEA Municipal Class EA Process

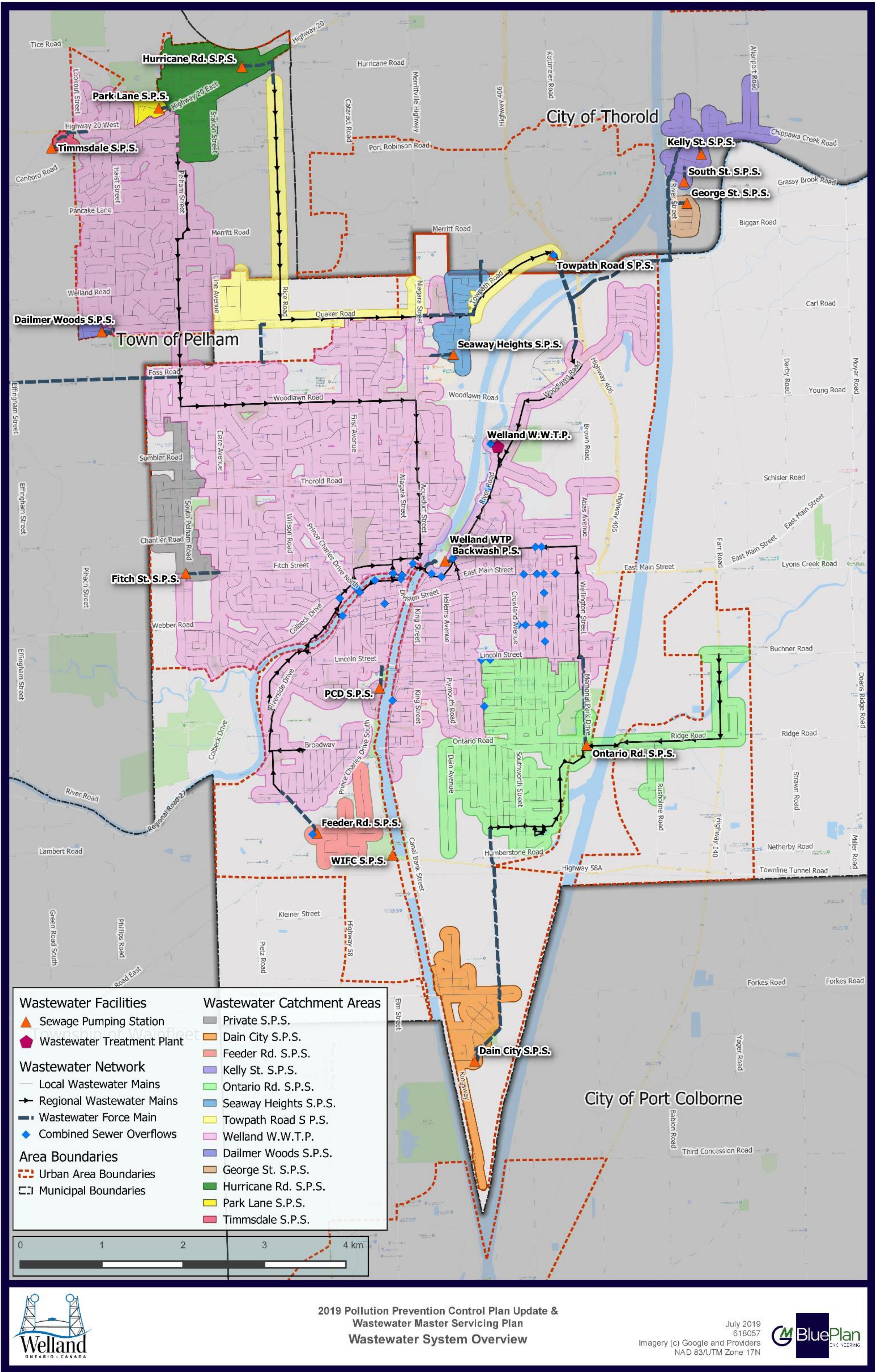
Environmental Assessment Process



Civic Square
60 East Main Street
Welland, ON L3B 3X4
905-735-1700

Welland Pollution Prevention Control Plan Update and Wastewater Master Servicing Plan

Wastewater System Overview



Civic Square
60 East Main Street
Welland, ON L3B 3X4
905-735-1700

Welland Pollution Prevention Control Plan Update and Wastewater Master Servicing Plan

Issues and Challenges

Manage extraneous flows for areas experiencing sewer capacity restraints, sewer overflows to environment, risks of basement flooding

Manage the impacts of growth and intensification

Opportunities to prioritize and coordinate sewer upgrades with sewer replacement and other infrastructure upgrades

Consider ongoing renewal and replacement of existing sewers

Evaluate full life cycle costs of alternative solutions

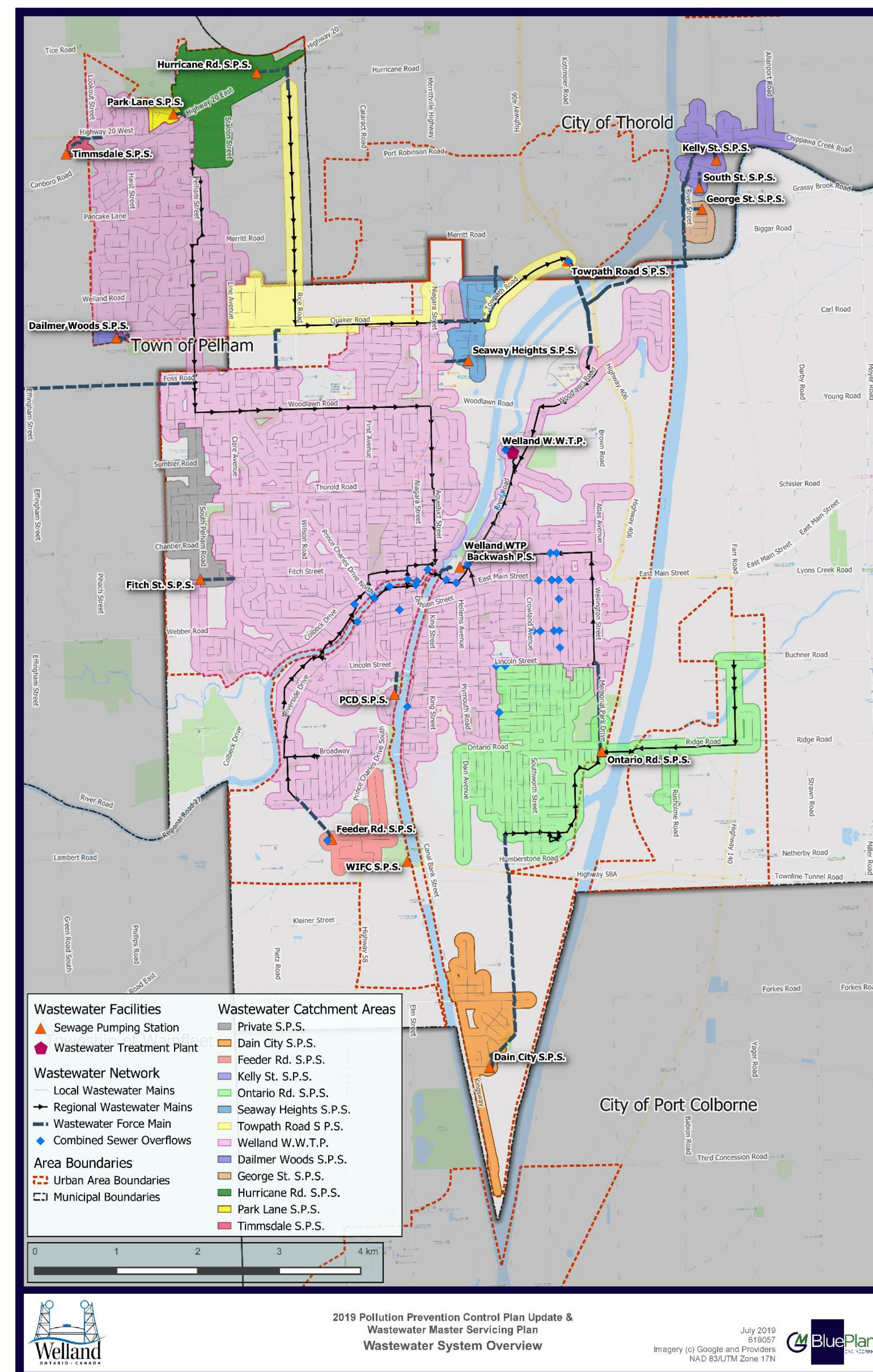
Integrate recommendations with Regional Infrastructure Upgrade Plan

Optimize operational and maintenance activities

Develop sewer Capital Program

Consider performance targets and climate change impacts

Consider incoming wastewater flows from Pelham and Thorold



Civic Square
60 East Main Street
Welland, ON L3B 3X4
905-735-1700

Planning for Growth

Growth Uncertainty

- Location of Growth – what infrastructure is needed?
- Rate of Growth – When is infrastructure needed?

The Study will Focus on Buildout Potential

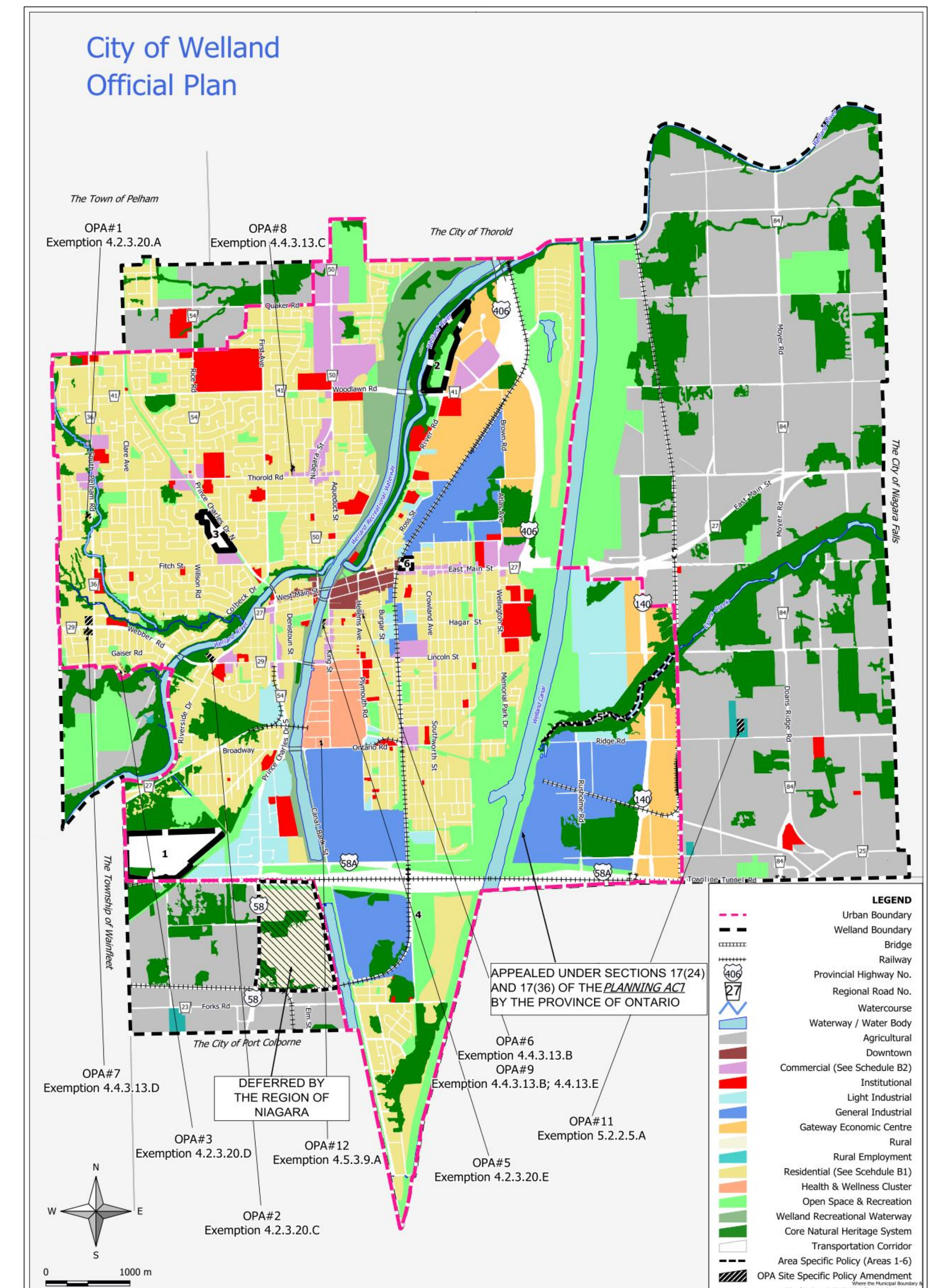
- Clarity in long-term needs
- Flexibility to respond to changes
- Helps to guide and manage growth

Short Term Capital Program

- Identifies build out needs and triggers
- Develops short term capital program for projects within the 2041 horizon
- Provides prioritization of projects in the short term (to 2031)

80 Year Infrastructure Plan

- Reviews the long term financial sustainability of the wastewater system
- Sewer replacement prioritization based on infrastructure condition, performance, and impact



Civic Square

60 East Main Street
Welland, ON L3B 3X4
905-735-1700

Thank You for Your Participation!

We want to hear from you!

- Your feedback is important: please fill out a feedback form
- Your input will be used to inform the development of alternatives and evaluation criteria
- This information will be presented at the second Public Information Centre which will be scheduled in the Fall
- If you have any questions or comments, or want to stay up to date on the project, please contact:

Marvin Ingebrigtsen, P.Eng.

City Project Manager
City of Welland
60 East Main Street
Welland, ON L3B 3X4
Tel: 905-735-1700 ext. 2209
Email: marvin.ingebrigtsen@welland.ca

Julien Bell, P.Eng.

Consultant Project Manager
GM BluePlan Engineering Limited
330 Trillium Drive, Unit D
Kitchener, Ontario N2E 3J2
Tel: 519-748-1440 ext. 4264
Email: julien.bell@gmblueplan.ca

With the exception of personal information, all comments will become part of the public record of the study. The study is being conducted according to the requirements of the Municipal Class Environmental Assessment, which is a planning process approved under Ontario's Environmental Assessment Act.



Civic Square

60 East Main Street
Welland, ON L3B 3X4
905-735-1700

Welland Pollution Prevention Control Plan Update and Wastewater Master Servicing Plan



City of Welland
Pollution Prevention Control Plan &
Wastewater Master Servicing Plan
Public Information Centre

Thank you for taking the time to fill out this comment form. Please place it in the box provided or email it to the address below. Your input is important. Comments will become part of the public record with the exception of personal information.

1. How did you hear about this Public Information Event?

☐ Newspaper ad

☐ Personal letter or email

☐ Word of mouth

☒ Website

☐ Other _____

2. What was your main reason for attending the Public Information Event?

AS A WELLAND RIVER KEEPER I AND
NUMEROUS OTHERS WOULD LIKE TO BE ABLE TO
SWIM IN THE WELLAND R. BUT CAN'T DUE
TO ITS E. COLI POLLUTION LEVELS, TO
IMPROVE WATER QUALITY OF THE WELLAND R.
IS A HIGH PRIORITY FOR ME AND MY FRIENDS.

3. Did this Public Information Event meet your information needs?

☐ Yes

☒ Somewhat

☐ No

Please explain: I WANTED TO LEARN MORE ABOUT

THE NUMBER OF TIMES OUR STP EXCEEDED
ITS TREATMENT LIMITS BUT WAS TOLD
THAT EVEN THOUGH THE CITY HAS THIS INFO
I SHOULD GO TO THE REGION TO ANSWER
MY QUESTION.



City of Welland
Pollution Prevention Control Plan &
Wastewater Master Servicing Plan
Public Information Centre

4. If you asked a question, did the representatives available answer your question sufficiently?

☐ Yes

☒ Somewhat

☐ No

Please explain: _____

5. Other questions or comments:

WOULD IT BE POSSIBLE TO GIVE A
MANDATE TO THE HUMBERSTON LANDFILL
TO PUMP THEIR LEACHATE INTO A

DEDICATED SEWER SO THAT IT WOULD NOT
POLLUTE THE WELLAND RIVER WHEN THE STP IS OVERLOADED?

If you would like to receive updates about the Pollution Prevention Control Plan and Wastewater Master Servicing Plan, please provide your name and contact information:

Name: MIKE DICKMAN

Affiliation: ~~116 RIVERSIDE DR~~ WELLAND RIVER KEEPERS

Address: 116 RIVERSIDE DR

City/Province: WELLAND Postal Code: L3C 3E2

Email: mdickman39715@yahoo.com

Thank you for taking the time to fill out this comment form. For additional questions or concerns regarding this project, please contact:

Marvin Ingebrigtsen, P.Eng.
Project Manager
City of Welland
marvin.ingebrigtsen@welland.ca
905-735-1700 ext. 2209

Julien Bell, P.Eng.
Project Manager
GM BluePlan Engineering
julien.bell@gmblueplan.ca
519-748-1440 ext. 4264



NOTICE OF PUBLIC INFORMATION CENTRE NO. 2 Pollution Prevention Control Plan Update and Wastewater Master Servicing Plan

What is this Study All About?

The City of Welland has initiated a Pollution Prevention Control Plan Update and Wastewater Master Servicing Plan. This Update will provide new recommendations to ensure the wastewater system can accommodate further growth expected by 2041 and beyond and meet the regulatory requirements established by the Ministry of Environment, Conservation and Parks.

How is this Study being Undertaken?

This study is being completed in accordance with the requirements of the Municipal Engineers Association Class Environmental Assessment process for master planning (2000, as amended in 2007, 2011 and 2015). The study will satisfy Phase 1 and 2 requirements of a Municipal Class Environmental Assessment for Mater Plans.

How can I participate in this Study?

There is an opportunity at any time during the study process for members of the public to provide comments and concerns to the attention of the project managers.

Public feedback is important. Information about the project will be available on the City of Welland's website as part of Public Information Centre (PIC) No. 2. You can learn about this project, how it will contribute to the City of Welland's overall growth, the preferred alternatives and how you can get involved.

Public Information Centre No. 2 Details: Information regarding the Pollution Prevention Control Plan Update and Wastewater Master Servicing Plan will be made available on the website starting **Thursday, February 3, 2022**. This will be followed by a 30 day period to submit PIC related comments to the Project Team. Access the project website using the link below or by scanning the QR Code with your smart phone:



<https://www.engagewelland.ca/municipal-class-environmental-assessment-study>

If you would like to submit comments or be notified about future study activities, please contact

Matthew Main, P.Eng
Infrastructure and Asset Manager
City of Welland
matthew.main@welland.ca
905-735-1700 ext. 2217

Julien Bell, P.Eng
Consultant Project Manager
GM BluePlan Engineering Ltd.
julien.bell@gmblueplan.ca
519-748-1440 ext. 4264

With the exception of personal information, all comments received during the Pollution Prevention Control Plan and Wastewater Master Servicing Plan Update will become part of the public record of the study.

This notice was first issued on February 3rd, 2022.



Welland Pollution Prevention and Control

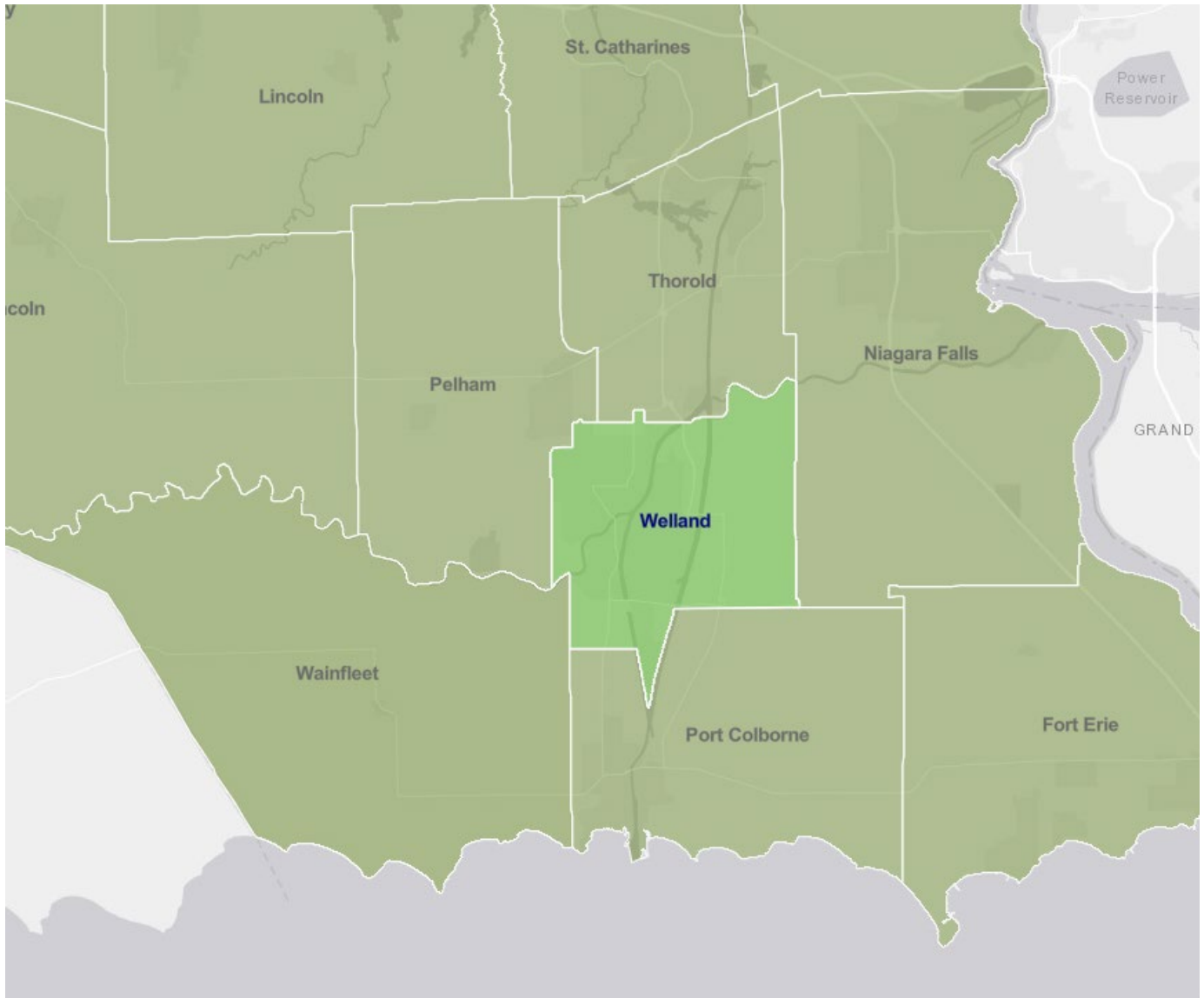
Pollution Prevention and Control Plan and Wastewater Master Servicing Plan Update

Virtual Public Information Centre #2 | February 3, 2022

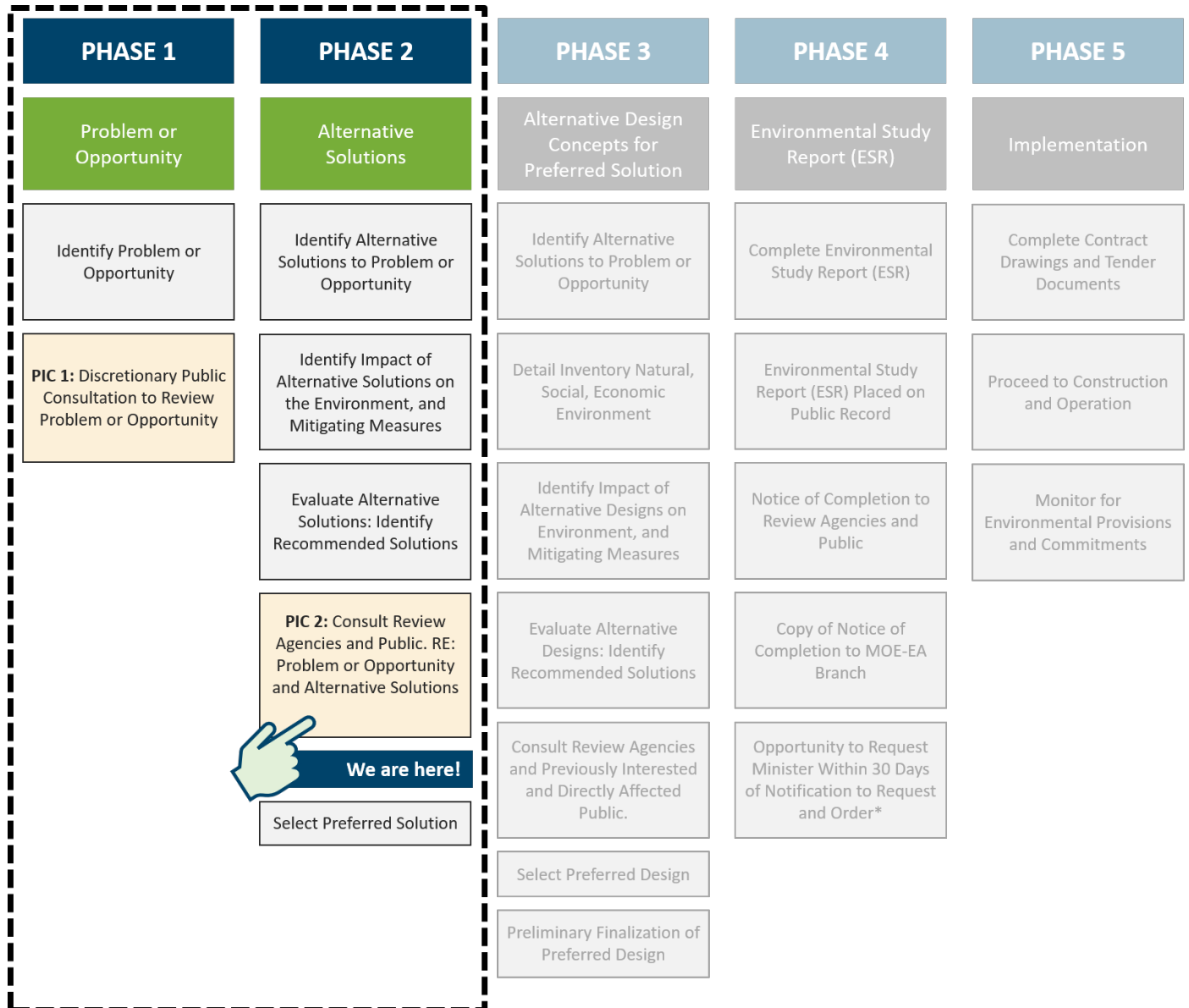
This document is provided as an alternative format that is originally hosted using ESRI StoryMaps. It is provided for those who may not have the compatible browser to view the original virtual public information materials online.

Project Background

The City of Welland (the City) is completing the Welland Wastewater Pollution Prevention Control Plan and Wastewater Master Servicing Plan Update. The study will identify future servicing needs to reduce overflows, to support long term growth, and ensure the sustainability of the wastewater system.



This study follows the Municipal Engineers Association Class Environmental Assessment process and will satisfy Phases 1 and 2 of the Class Environmental Assessment process. The objective of this study is to establish a masterplan to meet community growth needs while meeting the goals of the Ministry of Environment, Conservation, and Parks F-5-5 Procedure to reduce combined sewer overflow pollution to the environment.



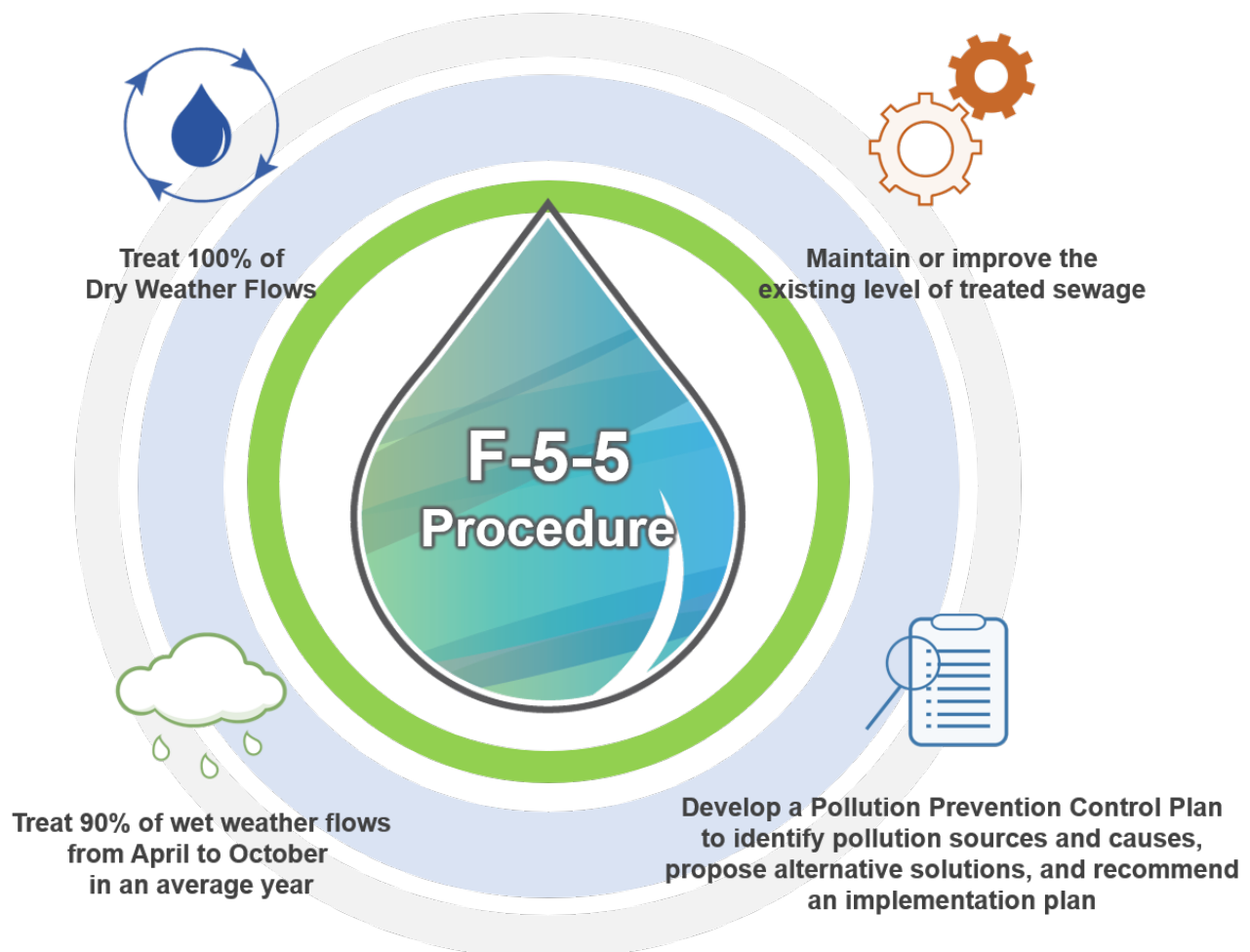
MECPP F-5-5 Procedure

The Ministry of Environment, Conservation, and Parks F-5-5 Procedure defines the rules for treating municipal and private combined and partially separated sewers. Combined sewers receive sanitary sewage and stormwater flows in the same pipe. Partially separated sewers may receive stormwater from private connections such as downspouts and foundation drains. When it rains, sewer capacity can be used up from stormwater and cause the sewer system to be overwhelmed. Sewer systems have regulators, or combined system overflows, which release untreated sewage and stormwater to the environment when the system is overwhelmed.

The F-5-5 Procedure requires wastewater systems to:

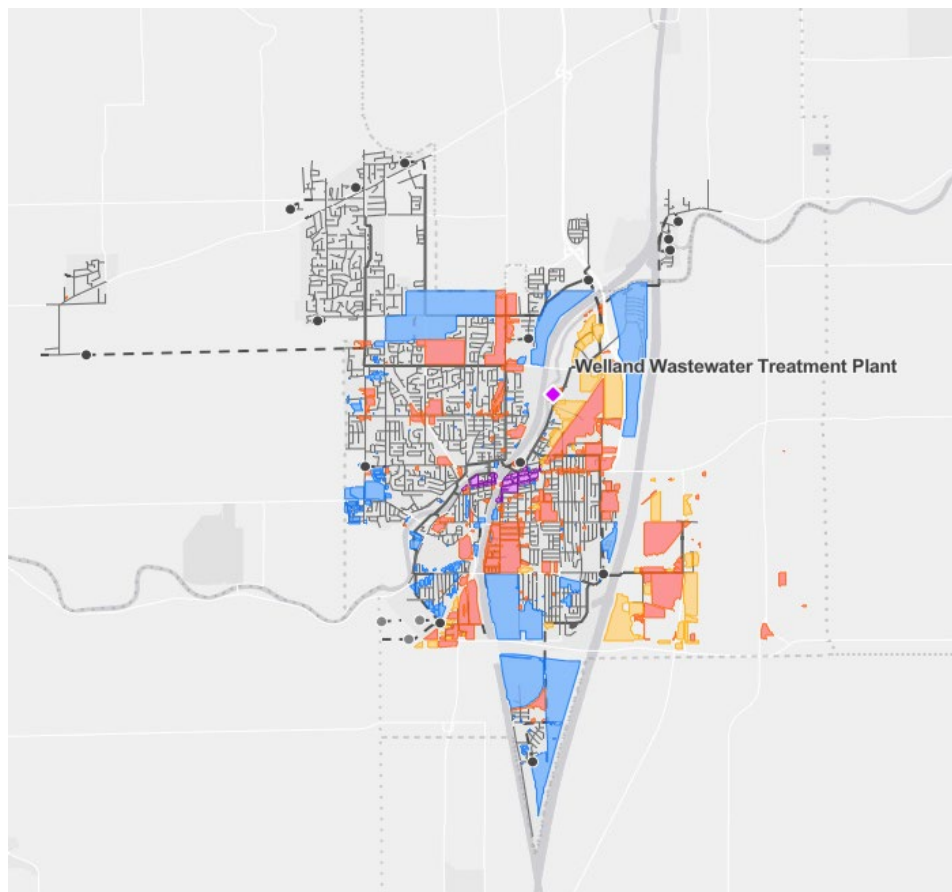
- Treat 100% of dry weather flows.
- Treat 90% of wet weather flows from April to October in an average year.
- Maintain or improve the existing level of treated sewage.
- Develop a Pollution Prevention Control Plan to identify pollution sources and causes, propose alternative solutions, and recommend an implementation plan.

The recommendations from this study, including the implementation plan, will satisfy the F-5-5 Procedure.



Growth

This wastewater master plan focuses on growth within the City in order to provide clarity in the long-term infrastructure needs and to provide more flexibility to respond to changes due to growth uncertainty. The location and rate of growth are two factors which impact the City's infrastructure needs and when they should be implemented. Growth was allocated from the City's tracked Development Application process, the Official Plan, Development Charges Study, and growth from Pelham and Thorold were allocated from the Niagara Region 2016 Master Servicing Plan and City of Thorold Water Master Servicing Plan, respectively.



The map below shows the different City growth plan areas including residential, employment and intensification developments in the City of Welland servicing area. The existing population is 71,226 people and jobs. By 2041, the City will grow to a total population of 99,137 people and jobs, which is in line with the City's Development Charges Study (2019) projections. Buildout growth considers all possible growth areas but does not assign a timeline for when the growth will happen; buildout growth is used for long-term infrastructure planning such as sewer sizing. The buildout growth for the City is projected to be 133,143 people and jobs.

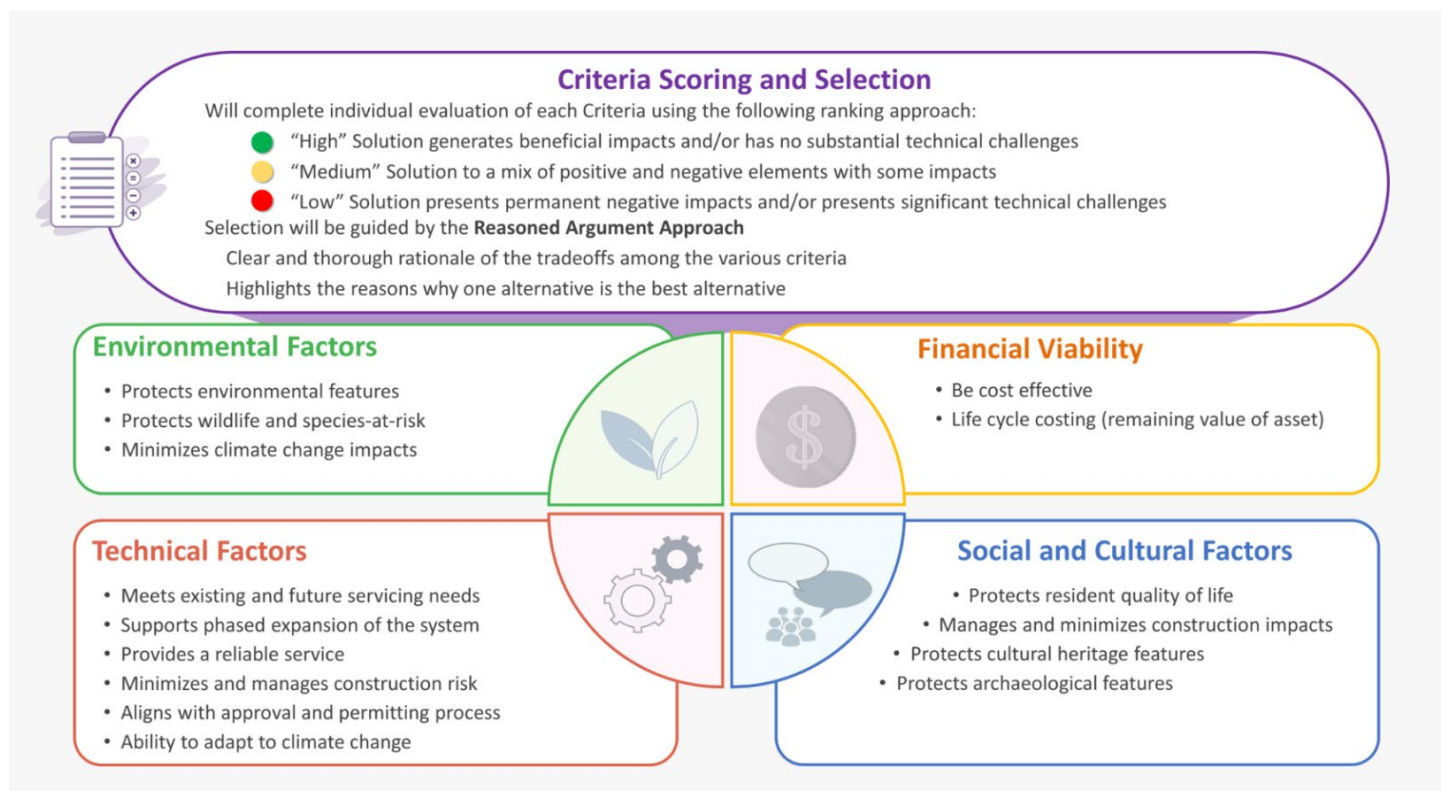
Projected Equivalent Population	
2019 Existing Total Population	71,226
2041 Total Population	99,187
Buildout Total Population	133,143

Evaluation Methodology

Alternative servicing concepts were developed to address the Welland Wastewater Treatment Plant (WWTP) system's existing and future opportunities and constraints. Each servicing concept was evaluated based on its technical, environmental, socio-cultural, and financial components to select the preferred servicing strategy.

This process uses the reasoned argument approach to provide a clear and thorough rationale of trade-offs among each alternative based on the anticipated impacts caused by the evaluation criteria. The basis of this approach is to qualitatively evaluate the relative advantages, disadvantages, and impacts of each alternative against the established criteria.

The alternatives were evaluated for each problem area and the preferred strategies are presented in this virtual public information centre.

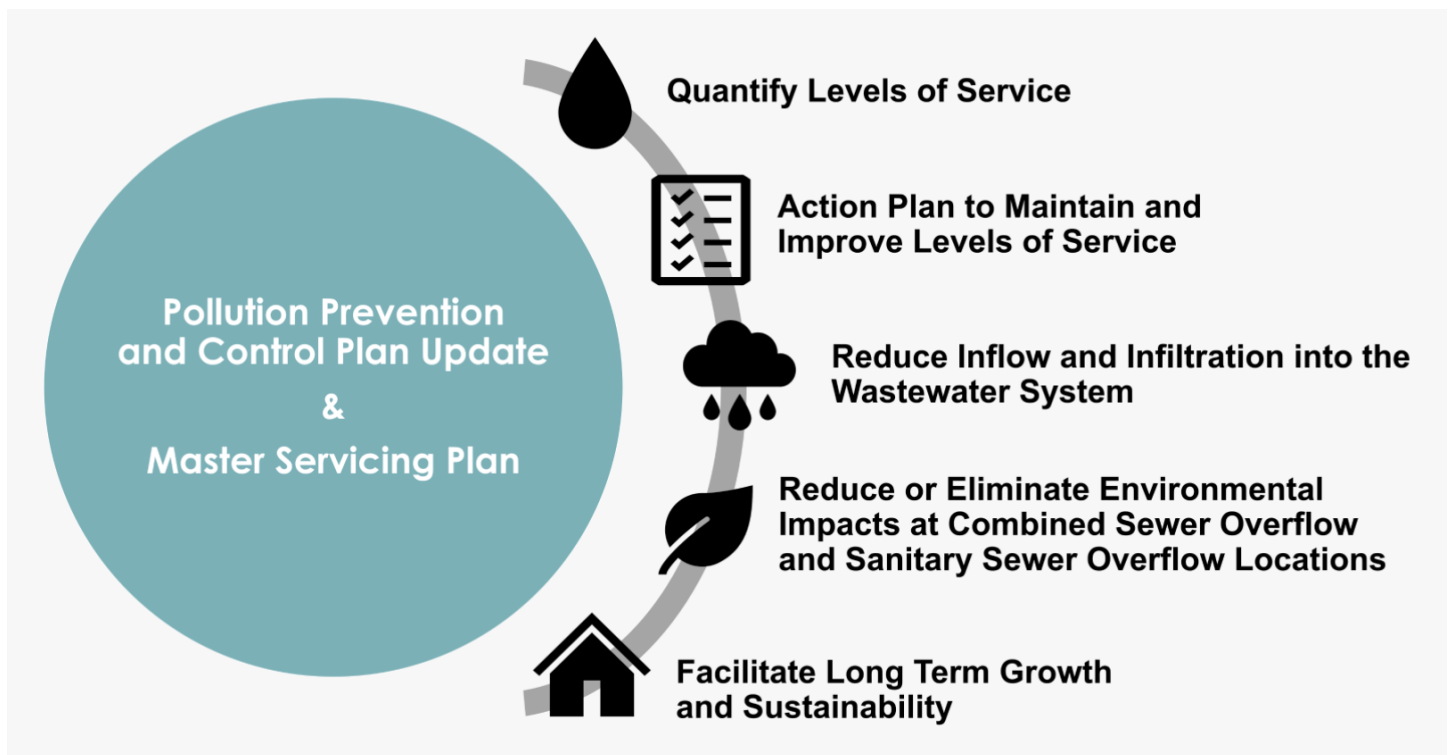


Problem and Opportunity Statement

The City's servicing principles and policies for the development and evaluation of the Pollution Prevention and Control Plan and Wastewater Master Servicing Plan will need to align with the Region for appropriate design and costing criteria. This will ensure reasonable, implementable, robust and sustainable servicing strategies are undertaken.

The 2020 Welland Pollution Prevention Control Plan and Wastewater Master Servicing Plan Update shall provide Strategic Sewer Management Recommendations that:

- Quantify existing and future levels of service;
- Analyze combined sewer overflows and sanitary sewer overflows;
- Eliminate, reduce, and or delay inflow and infiltration;
- Enhance the City's wastewater collection system infrastructure;
- Support growth; and,
- Identify a clear implementation plan.



Public Information Centre Objectives

The objectives of the virtual Public Information Centre are to:

1. Provide background information and context for servicing needs.
2. Outline the existing baseline system and what impacts growth has on it.
3. Establish preferred servicing strategies.
4. Provide technical information to support staff through implementation.
5. Answer any questions you may have about the project process or potential outcomes.

Key Dates

February 3, 2022

Public Information Centre #2 materials posted to project website

February 3 to March 7, 2022

Submit questions or comments related to Public Information Centre #2 materials

March 14, 2022

Responses to questions and comments posted



Provide Background information and context for servicing needs.



Outline the existing baseline system and what impacts growth has on it.



Establish preferred servicing strategies.



Provide technical information to support staff through implementation.



Answer any questions you may have about the project process or potential outcomes.

This is the last of two Public Information Centres for this study.

System Opportunities and Challenges

The Welland wastewater system currently meets the F-5-5 requirements for dry and wet weather flow treatment; however, allowing the projected growth without any system upgrades or action will result in increased overflows to the environment. Therefore, a "do nothing" option is not viable to meet the F-5-5 Regulation. Challenges bring opportunities to address multiple issues at once.

Current and future system issues and challenges include:

- Sewers at and/or near capacity that needs to be addressed to avoid overflows and basement flooding, and to properly manage inflow and infiltration from rainwater.
- Managing increasing wastewater flows as a result of growth and intensification.
- Managing incoming wastewater from Pelham and Thorold.

There are several opportunities that can be addressed through this study:

- Integrate recommendations with Regional Infrastructure Plan.
- Opportunity to develop a sewer Capital Program.
- Ability to consider climate change impacts.
- Consider ongoing renewal and replacement of existing sewers.
- Optimize operational and maintenance.
- Coordinate sewer upgrades with other infrastructure upgrades.
- Evaluate full life cycle costs of alternative solutions.

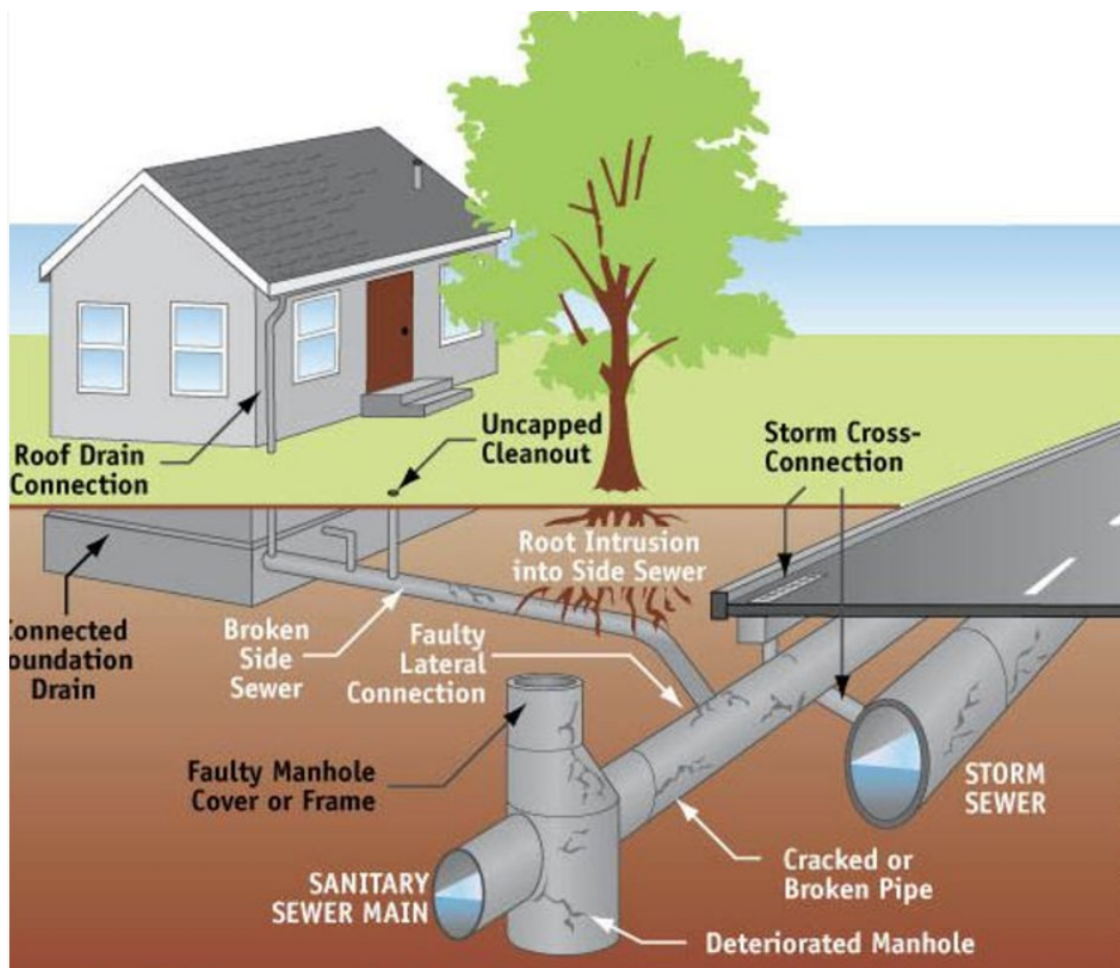
What is Inflow and Infiltration

Inflow and infiltration refers to groundwater and stormwater that enters the wastewater sewer system that causes problems such as basement flooding, overflows into the environment, reduced system capacities, reduced treatment plant efficiencies, and increased costs to residents. Some potential sources of inflow and infiltration can include:

- Roof drain connections.
- Uncapped sewer cleanouts.
- Storm sewer cross connections.
- Faulty wastewater sewer lateral connections from buildings.
- Faulty manhole covers or frames.

Although certain rates of inflow and infiltration is expected and incorporated in the design of all municipal wastewater infrastructure, the goal is to minimize inflow and infiltration in order to minimize additional cost of pumping and treating extraneous flows and to maximize existing capacities. Types of inflow and infiltration reduction projects include:

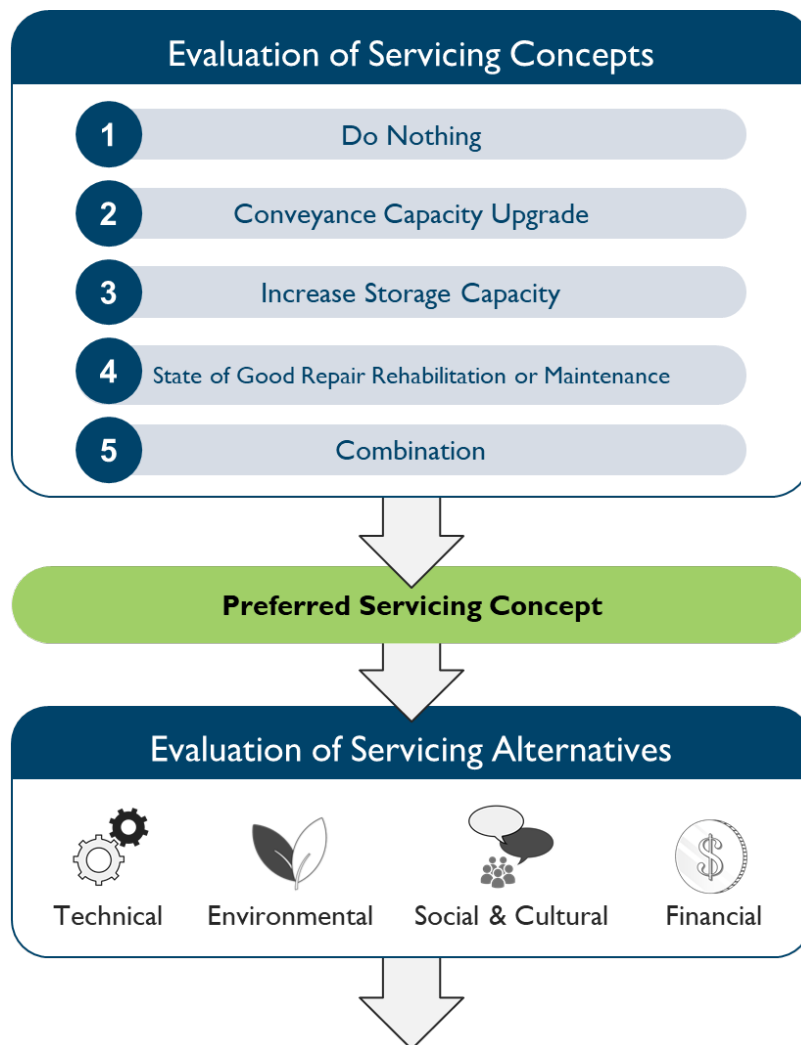
- Removing cross-connections from storm sewers and catchbasins.
- Sewer lining or replacement.
- Maintenance hole lining.
- Disconnection of downspouts and weeping tile drains.



Servicing Concepts

Several servicing concepts were proposed to address the system challenges and meet the goals of the Pollution Prevention Control Plan and Master Servicing Plan. These concepts include:

- Do nothing
- System-wide inflow and infiltration reduction through targeted programming.
- Upgrade sewer (conveyance) capacity.
- Upgrade storage capacity.
- State of good repair works such as rehabilitation or maintenance activities.
- Policy or educational considerations which could enhance implementation or enforcement of a servicing strategy.
- Combination of options.



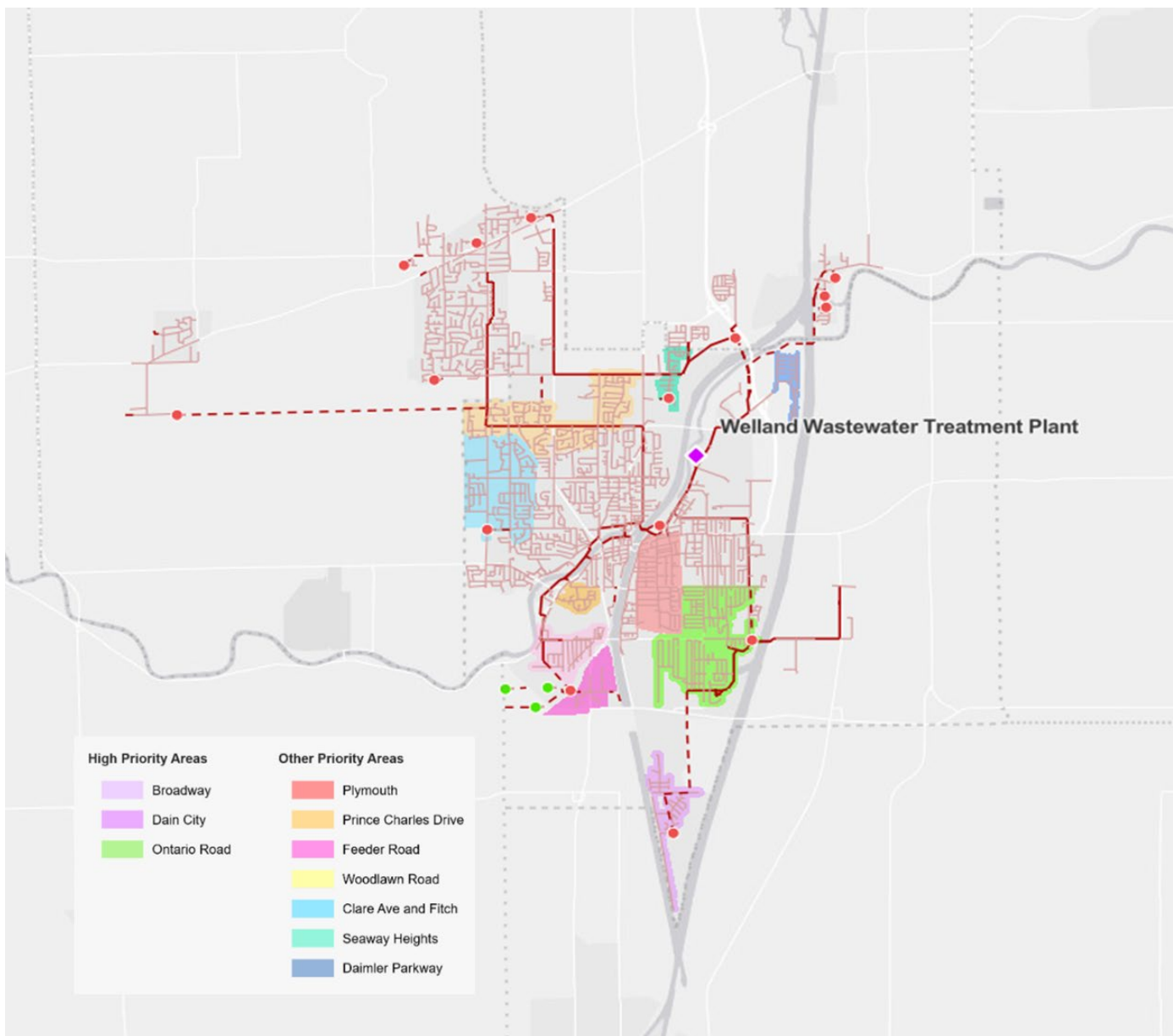
Preferred Strategies

Priority areas were ranked based on the following constraints that are present in the existing system:

- Sewers and Sewage Pumping Stations are undersized for growth.
- Risk of basement flooding from limited infrastructure capacity.
- Active combined sewer overflows.

These projects are recommended in order to improve the overall Welland Wastewater Treatment Plant System capacity to facilitate growth and reduce overflows to the environment.

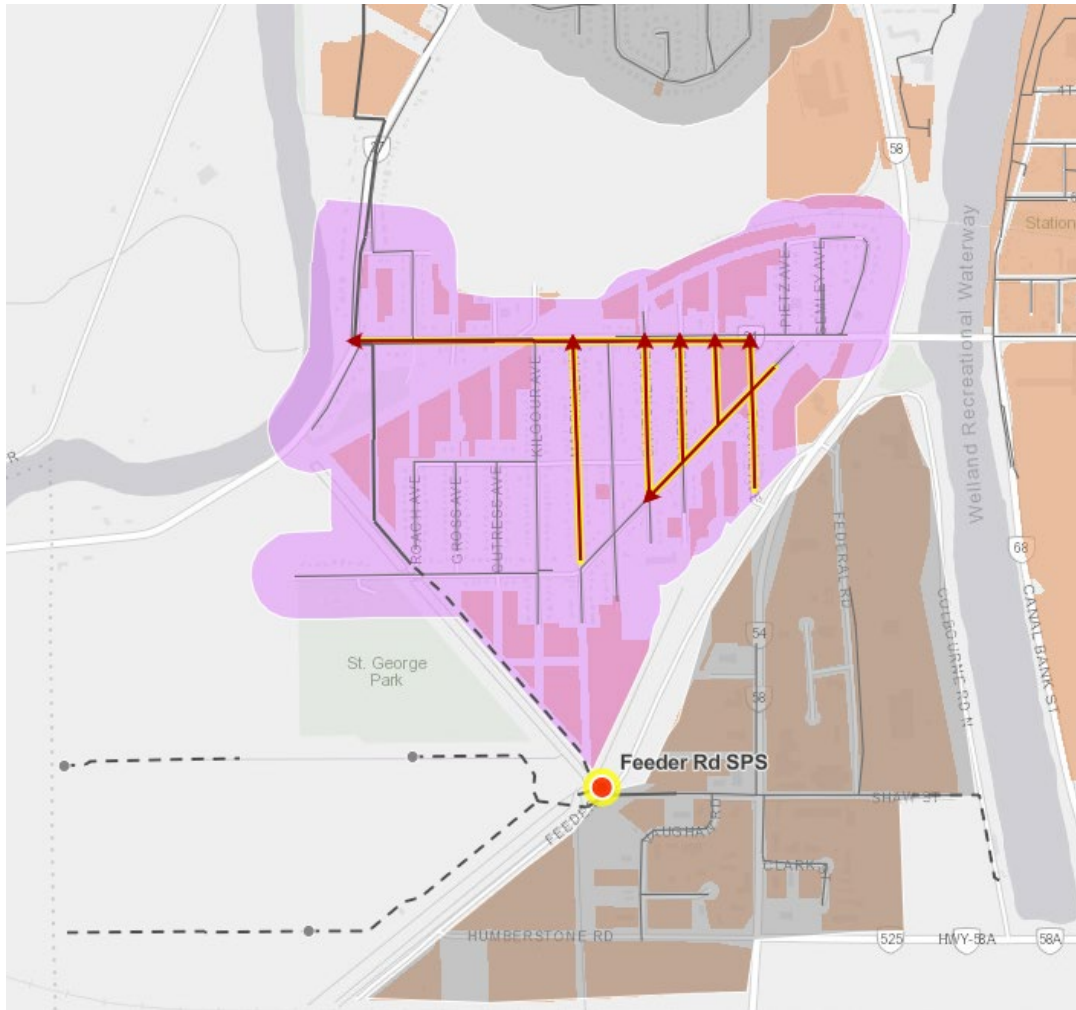
There are a total of 10 different priority areas, 3 of which are ranked as high priority (Broadway, Dain City, Ontario Road).



High Priority Areas

There are 3 different priority areas ranked as high: Broadway, Dain City, and Ontario Road Sanitary Pumping Station.

Broadway High Priority Area



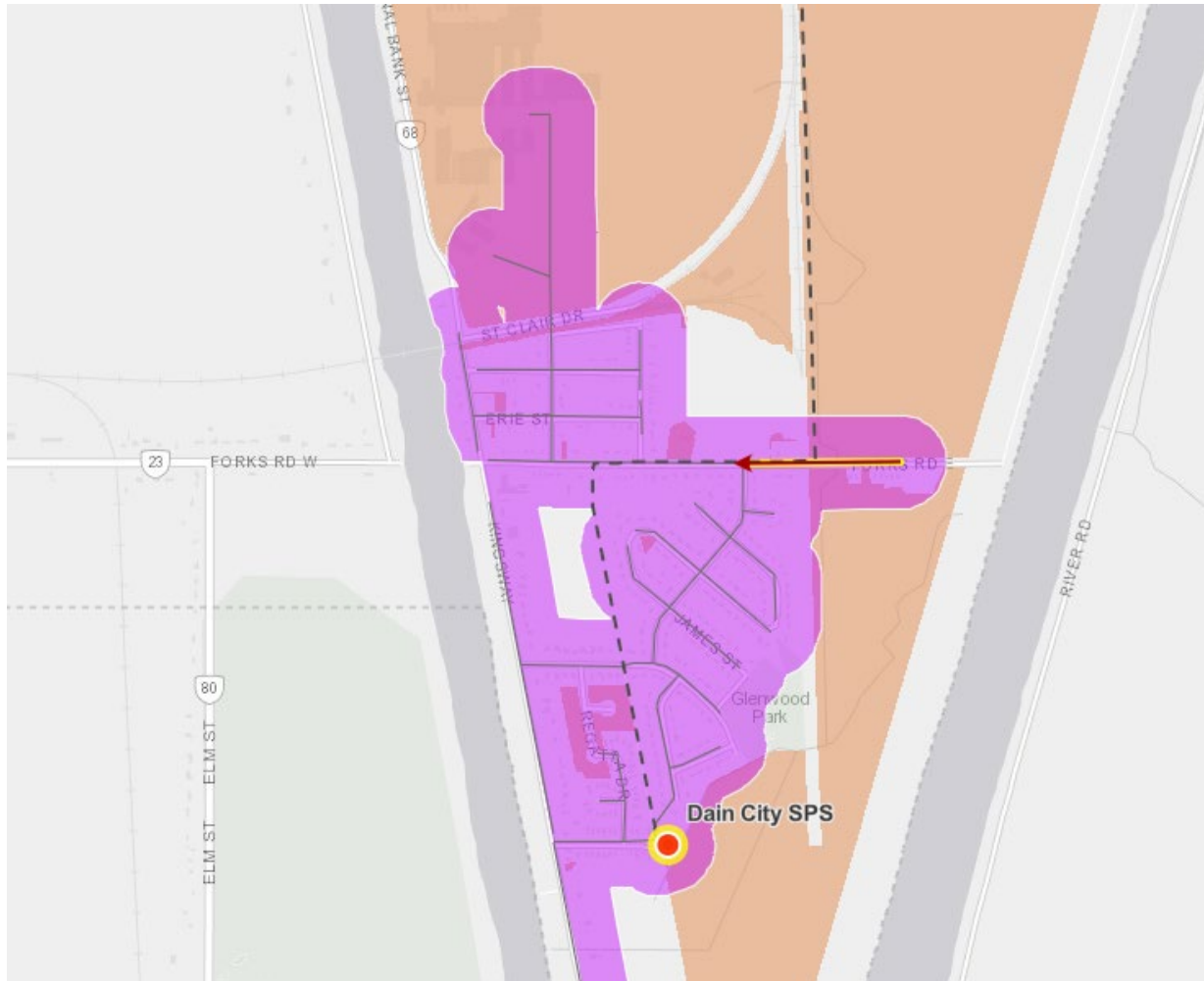
System Issues: This area experiences high inflow and infiltration, has growth areas, and has existing capacity issues in local sewers.

Growth Impacts: There are several lots that will contribute growth flows within the Broadway Area.

Preferred Strategy for the Broadway High Priority Area:

- Reduce inflow and infiltration.
- Strategic sewer upsizing to support existing users and growth.
- Reconfiguration, deepening and upsizing of local sewers and Broadway trunk sewer.
- Prioritize and coordinate sewer upgrades with the City's other infrastructure projects.

Dain City High Priority Area



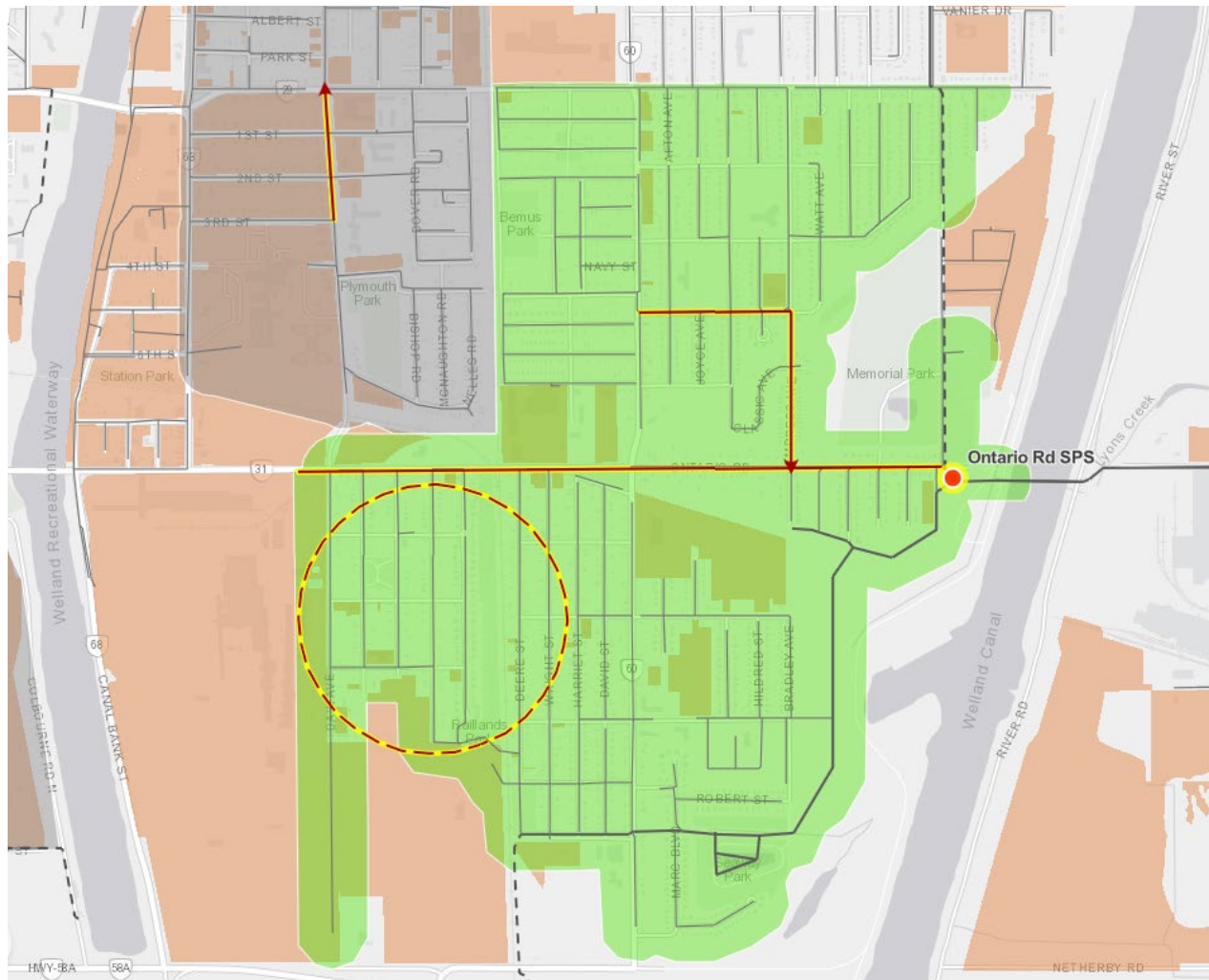
System Issues: This area experiences high inflow and infiltration, has growth areas, and buildout growth will require a pump station upgrade.

Growth Impacts: There are several major developments planned for Dain City.

Preferred Strategy for the Dain City High Priority Area:

- Reduce inflow and infiltration.
- Sewer upgrade on Forks Road East to support new developments.
- Prioritize and coordinate sewer upgrades with the City's other infrastructure projects.
- Optimize storage tank at pump station.

Ontario Road High Priority Area



System Issues: This area experiences high inflow and infiltration, has growth areas, has existing capacity issues in local sewers and experiences sewer overflows in the Lincoln Coventry area.

Growth Impacts: There are large redevelopments of industrial lands and infill areas that will contribute growth flows to the area.

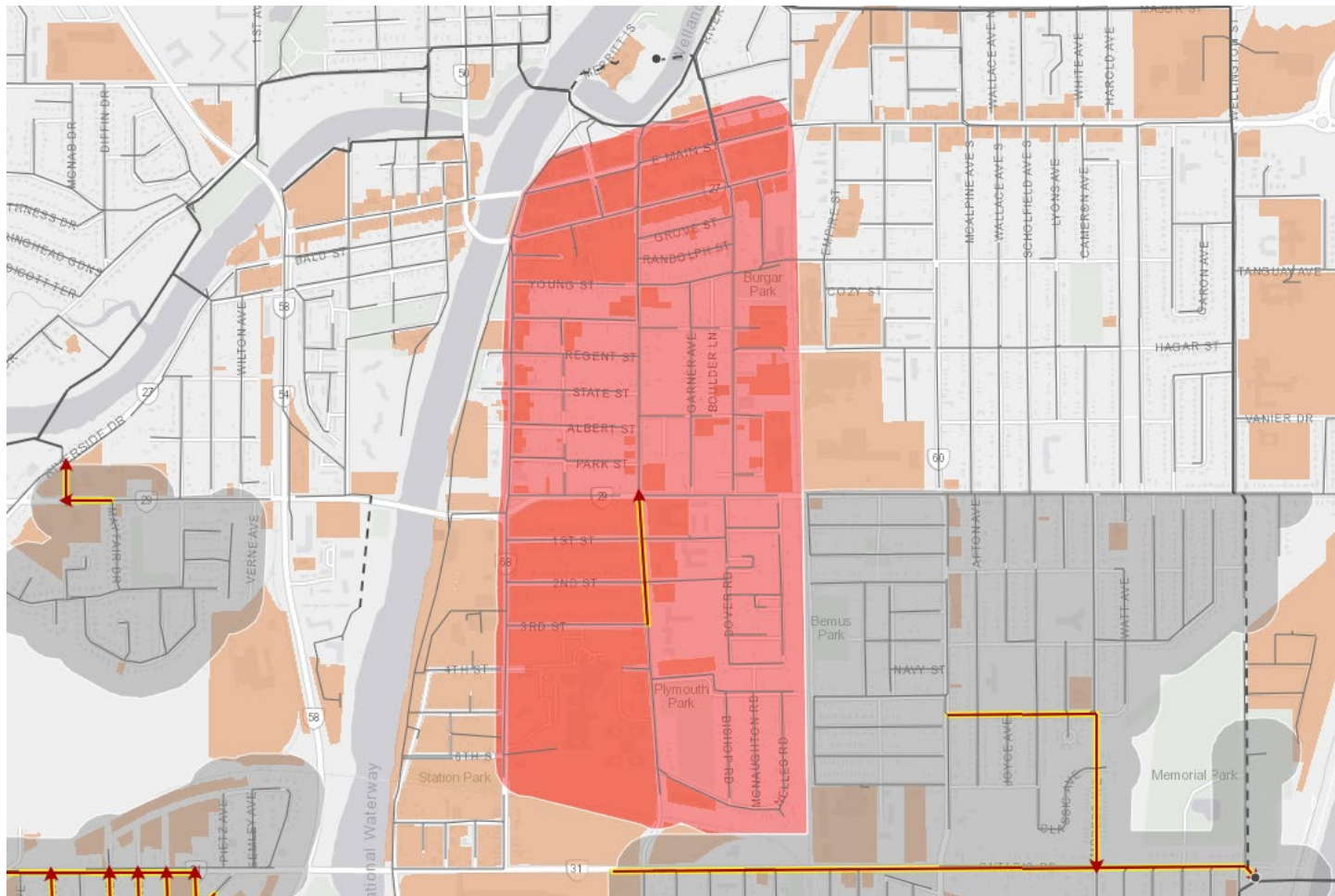
Preferred Strategy for the Ontario Road High Priority Area:

- Reduce inflow and infiltration in the north and south areas.
- New trunk sewer on Ontario Road.
- Potential servicing strategy changes.
- Strategic sewer upsizing to support existing users and growth, if in flow and infiltration targets are not achieved.
- Prioritize and coordinate sewer upgrades with the City's other infrastructure projects.

Other Priority Areas

The following upgrades are recommended other priority areas: Plymouth, Prince Charles, Feeder, Woodlawn, Clare and Fitch, and Seaway Heights. Click the buttons below to see the different project areas.

Plymouth Priority Area



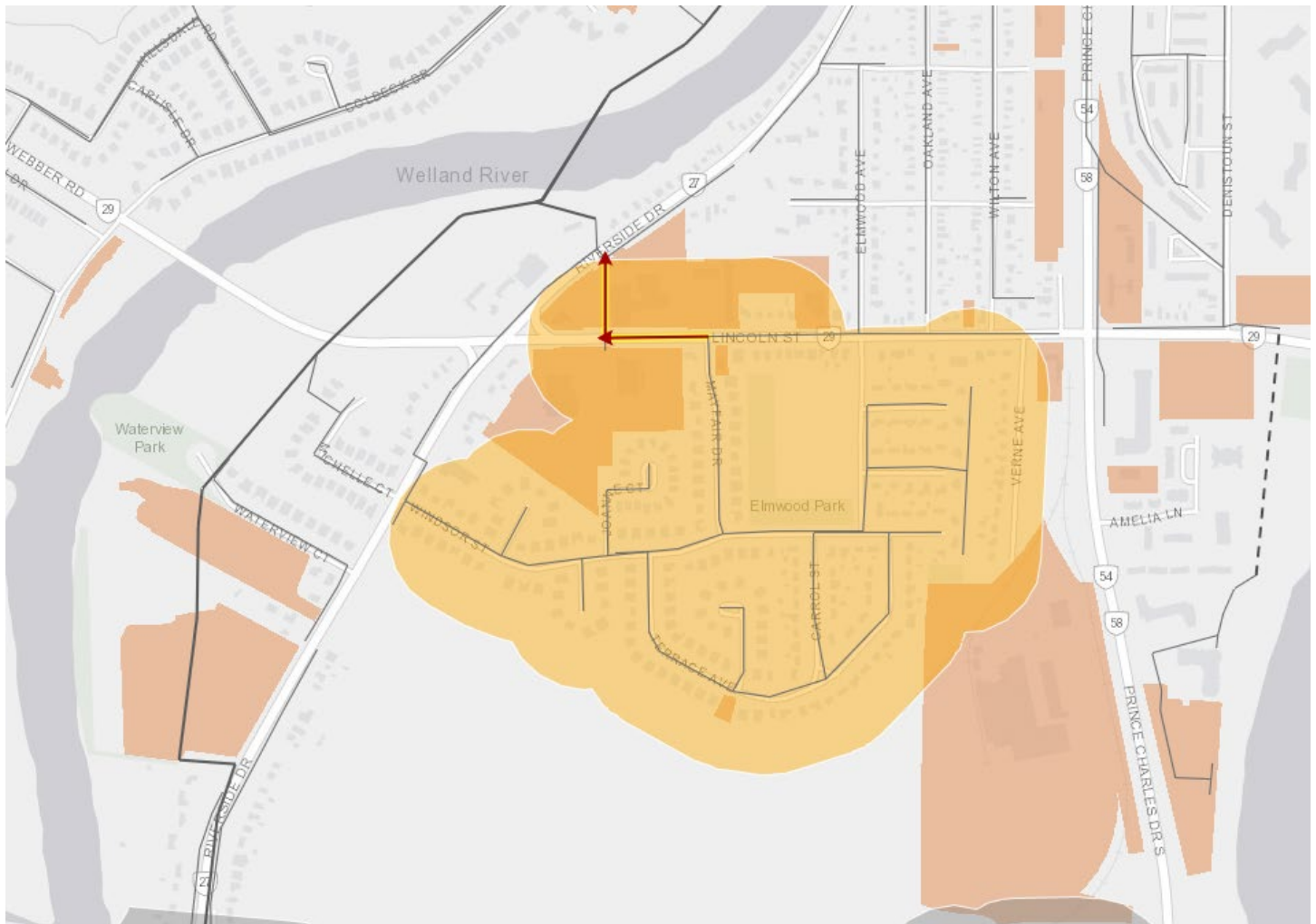
System Issues: This area experiences high inflow and infiltration, has growth areas, and has existing capacity issues in local sewers.

Growth Impacts: There is planned intensification in the downtown area and employment intensification in the areas surrounding the hospital.

Preferred Strategy for the Plymouth Road Priority Area:

- Reduce inflow and infiltration.
- Strategic sewer inline storage to support existing users and growth.
- Prioritize and coordinate sewer upgrades with the City's other infrastructure projects.

Prince Charles Drive South Priority Area



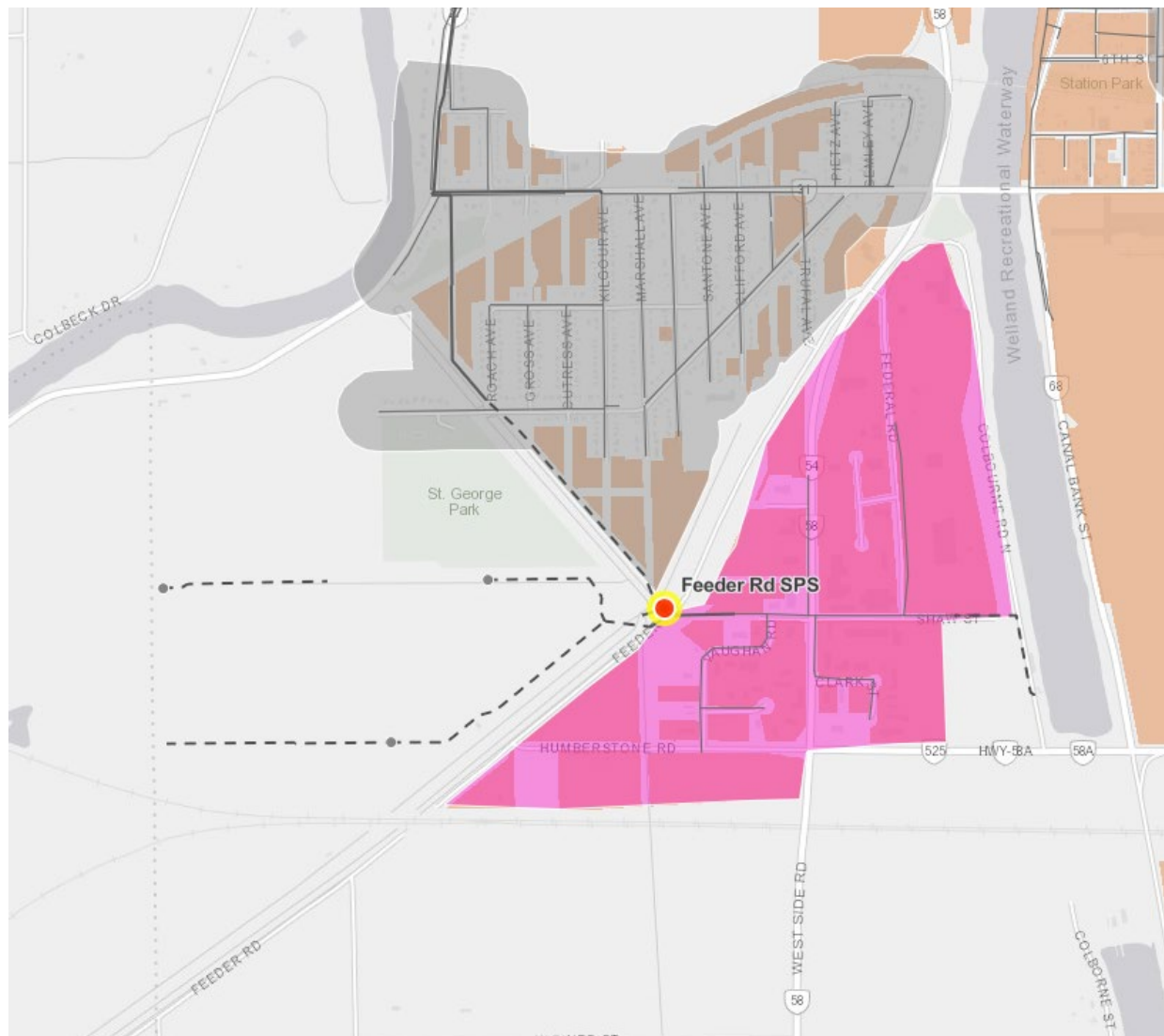
System Issues: This area experiences high inflow and infiltration, has growth areas, and has existing capacity issues in local sewers.

Growth Impacts: There are lots that will contribute growth within the Prince Charles Drive South area.

Preferred Strategy for the Prince Charles Drive South Priority Area:

- Reduce inflow and infiltration.
- Strategic sewer upsizing to support existing users and growth if inflow and infiltration reduction targets are not met.
- Prioritize and coordinate sewer upgrades with the City's other infrastructure projects.

Feeder Road Priority Area



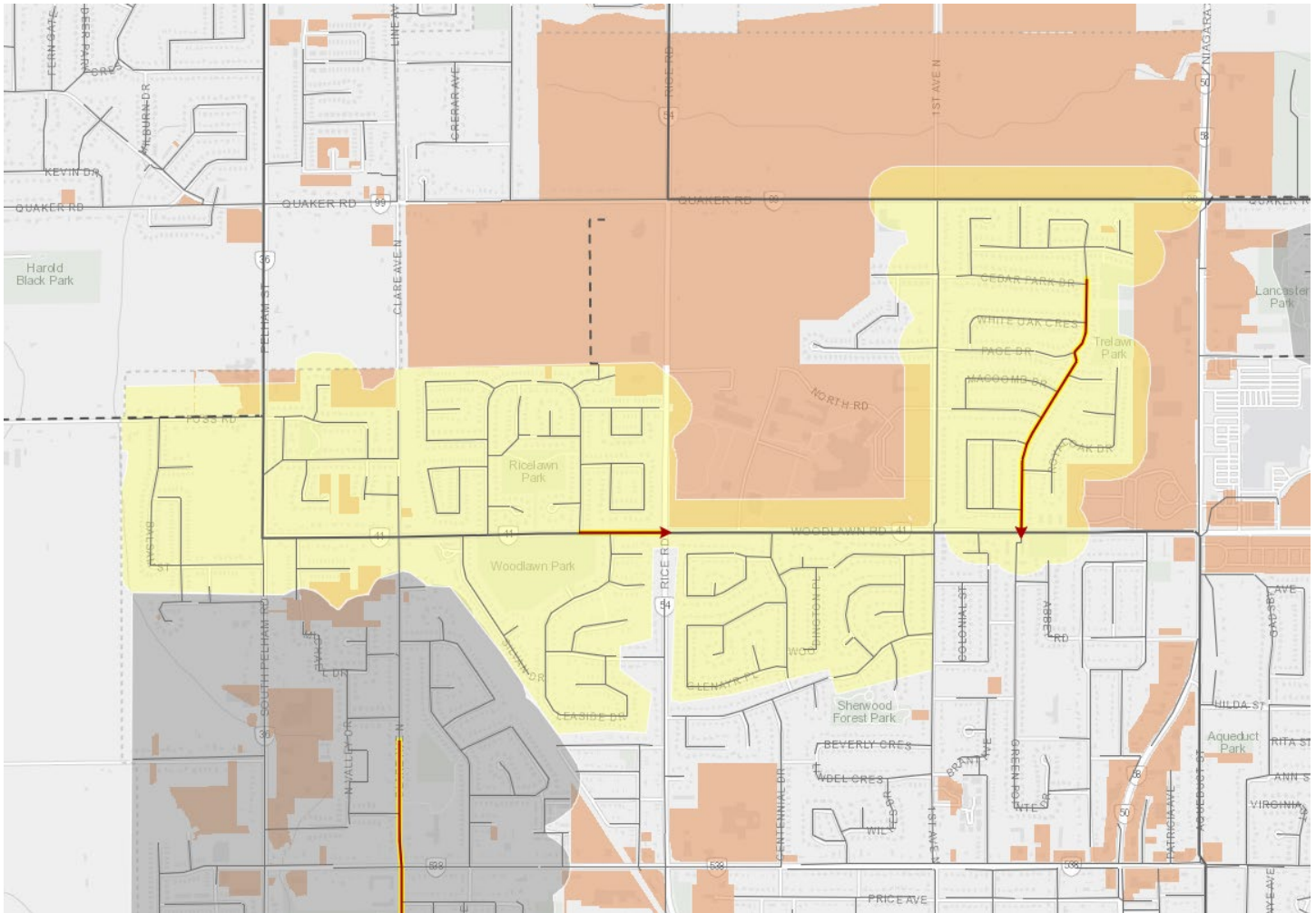
System Issues: This area experiences high inflow and infiltration, has employment growth and intensification, and has existing capacity issues in local sewers.

Growth Impacts: There is planned employment intensification and new lots in the Feeder Road area.

Preferred Strategy for the Feeder Road Priority Area:

- Reduce inflow and infiltration first.
- Pump station storage upgrade if inflow and infiltration targets are not met.

Woodlawn Road Priority Area



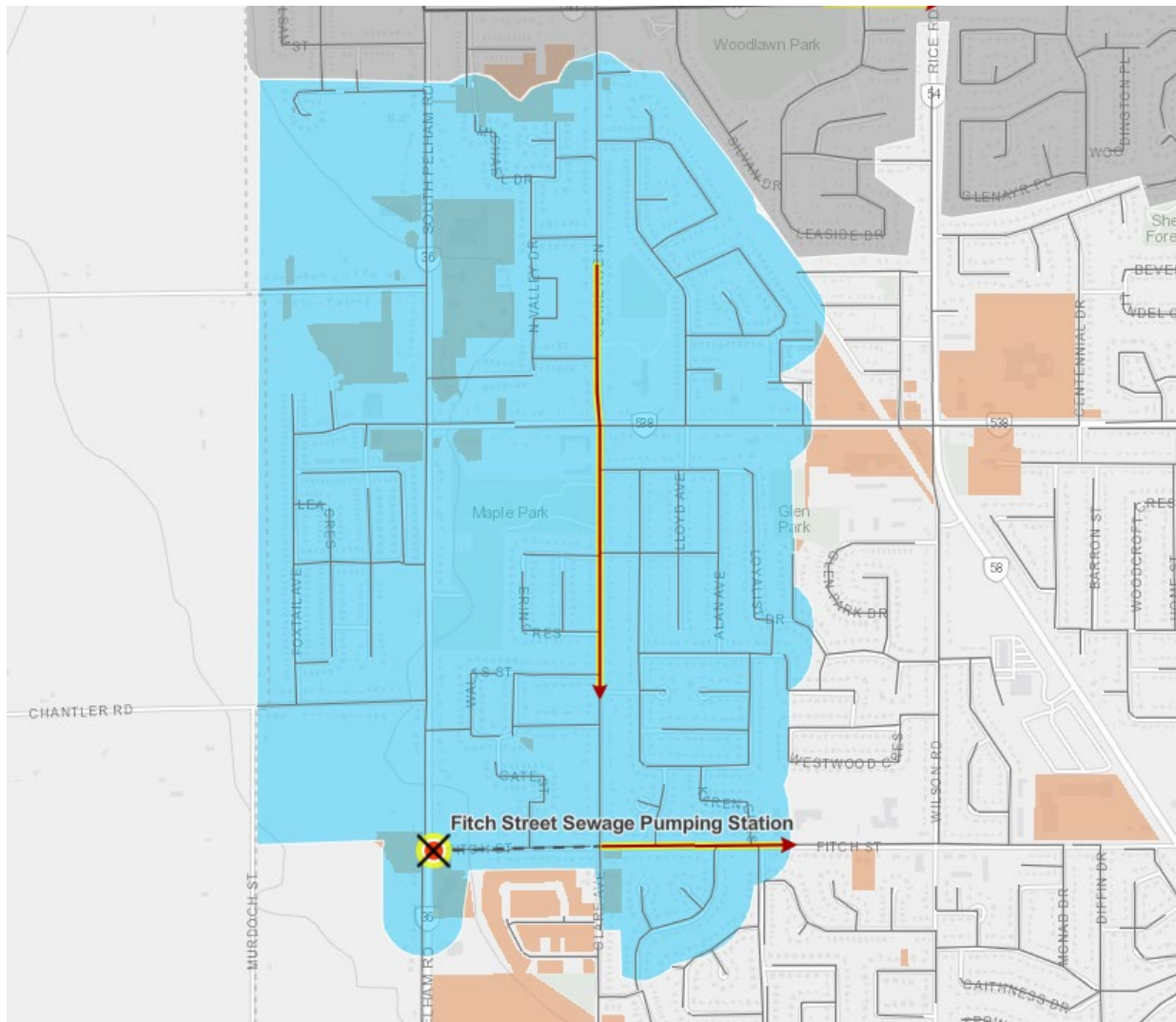
System Issues: This area experiences high inflow and infiltration, has future growth areas, and has existing capacity issues in local sewers.

Growth Impacts: There is potential for growth on the Woodlawn Road corridor.

Preferred Strategy for the Woodlawn Road Priority Area:

- Reduce inflow and infiltration.
- Strategic sewer upsizing to support existing users and growth if inflow and infiltration targets are not met.
- Prioritize and coordinate sewer upgrades with the City's other infrastructure projects.

Clare Avenue and Fitch Street Priority Area



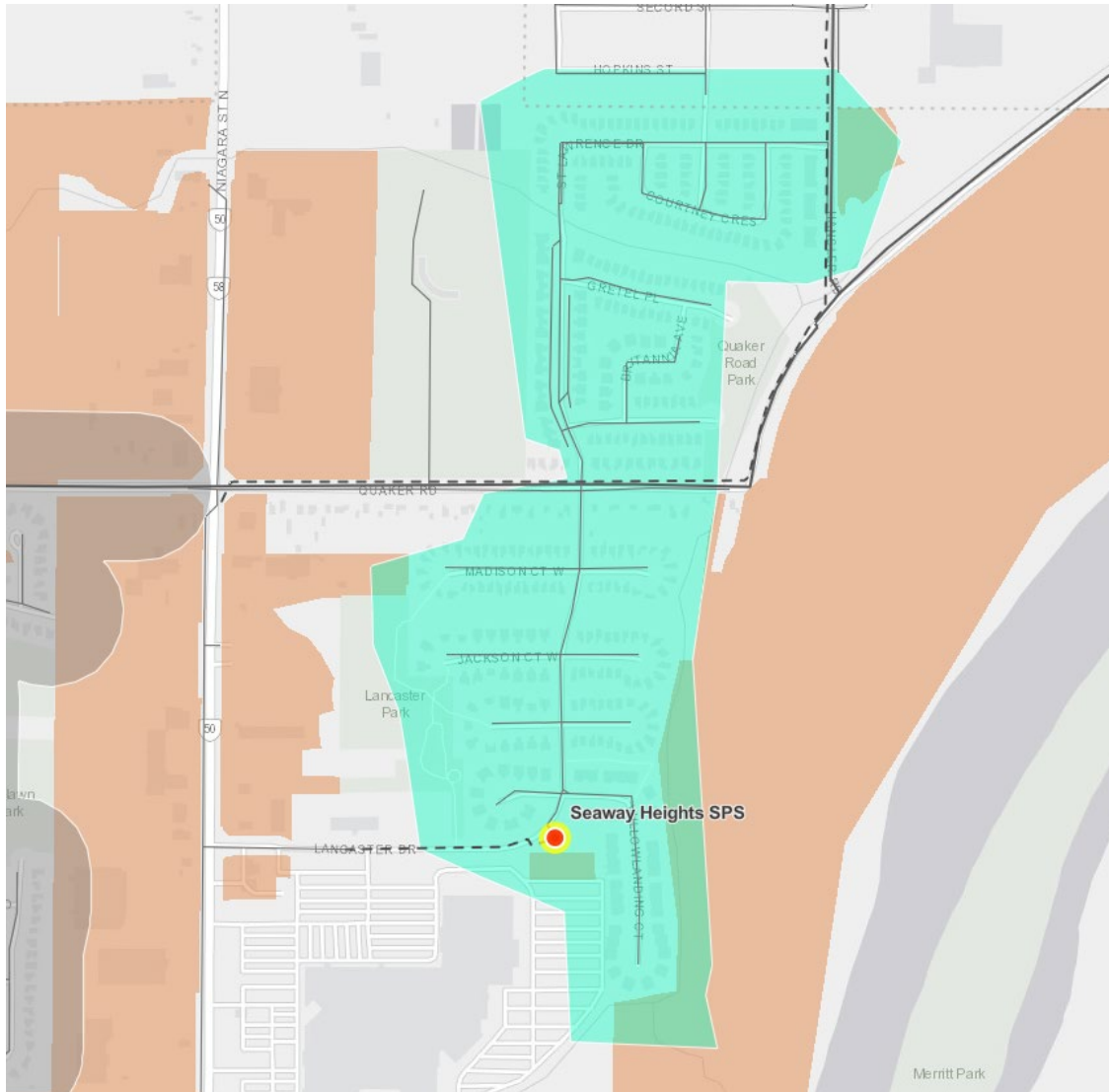
System Issues: This area experiences high inflow and infiltration, has future growth areas, and has existing capacity issues in local sewers.

Growth Impacts: There are growth areas on South Pelham Road upstream of the Fitch Street Sanitary Pumping Station.

Preferred Strategy for the Clare Avenue and Fitch Street Priority Area:

- Reduce inflow and infiltration.
- Strategic sewer upsizing to support existing users and growth if inflow and infiltration targets are not met.
- Prioritize and coordinate sewer upgrades with the City's other infrastructure projects.
- Decommission of the Fitch Street Sewage Pumping Station.
- Seaway Heights Priority Area

Seaway Heights Priority Area



System Issues: This area experiences high inflow and infiltration, and has growth areas.

Growth Impacts: There draft plan areas to the east and south planned to the Seaway Heights Sanitary Pumping Station.

Preferred Strategy for the Seaway Heights Priority Area:

- Reduce inflow and infiltration.
- Limit growth from draft plans to within the existing station capacity.

Additional Infrastructure Projects

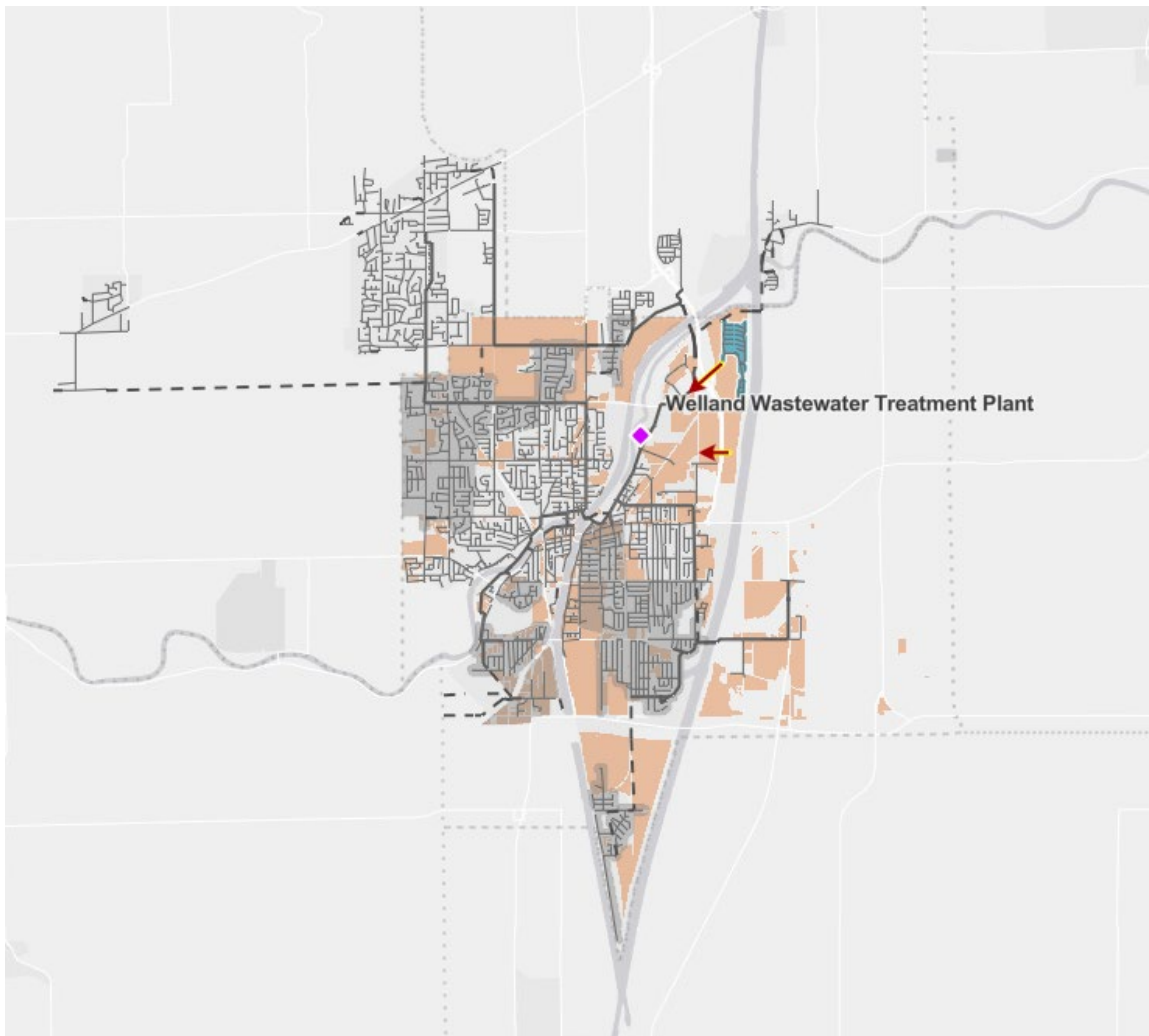
The following upgrades are recommended at Daimler Parkway and Oxford Road.

System Issues: This area has undersized sewers for growth area.

Growth Impacts: Growth in the area triggers need for upgrades.

Sewer Separation Projects in the Daimler Parkway and Oxford Priority Area:

- Chippawa Park.
- River Road.
- Riverside Drive.
- Prince Charles and West Main Area.
- Merritt Street.
- Margaret-Nye-Gadsby Area.



Capital Program

A preliminary recommended Capital Program was developed from this study and includes the upgrades anticipated between 2021 and 2041. The City will take these projects into consideration in the development of its comprehensive annual capital projects which would integrate sanitary sewer system projects with other infrastructure projects.

Capital Program		
Project Type	Description	Estimated Capital Cost
Sewer Capacity Upgrades	Higher Priority	\$29 million
	Lower Priority	\$20 million
Inflow and Infiltration Reduction	Higher Priority	\$26 million
	Lower Priority	\$36 million
Citywide Wastewater Infrastructure Management	Additional Programming	\$20 million
		\$132 million Total

Sewer Capacity Upgrades

Higher priority upgrades are estimated at \$29 million, while lower priority upgrades are estimated at \$20 million. High priority upgrades are located within the high priority areas: Broadway, Ontario Road, and Dain City, and are required in the next 10 years. Lower priority upgrades are located anywhere else in the City.

Inflow and Infiltration Reduction

Higher priority inflow and infiltration reduction programs are estimated at \$26 million, while lower priority inflow and infiltration reduction are estimated at \$36 million. High priority inflow and infiltration reduction programs are located within the high priority areas: Broadway, Ontario Road, and Dain City and are required in the next 10 years. Lower priority inflow and infiltration reduction programs will be focused in the other priority areas after the Broadway, Ontario Road, and Dain City have been addressed.

Additional programming of citywide wastewater infrastructure management are estimated at \$20 million, **totaling the capital program at an estimated \$132 million.**

What's Next? Get Involved!

Public feedback is important. Sign-up to be added to the study contact list and submit any questions or comments to the Project Team.

Key Dates

- **02/03/2022:** Virtual Public Information Centre #2 online and running for two (2) weeks accepting questions and/or comments
- **03/07/2022:** Deadline to submit questions and/or comments related to the project
- **03/14/2022:** Responses to questions and comments to be published on Project Website

[Submit Comments / Questions](#)

Contact Us

Matthew Main, P.Eng, City Project Manager, City of Welland | Matthew.Main@Welland.ca

Julien Bell, P.Eng, Consultant Project Manager, GM BluePlan Engineering Ltd. | Julien.Bell@GMBLuePlan.ca

Visit the Project Website

The City of Welland is embarking on a Municipal Class Environmental Assessment Study to update its current Pollution Prevention Control Plan an...

<https://www.engagewelland.ca>



Privacy and Accessibility

Niagara Region is committed to reviewing its practices, processes and the built environment for barriers to access for persons with disabilities. View this virtual public information event in an alternative format [here](#) . If you require additional or other formats for communicating, contact Niagara Region to make arrangements.

Please note that information related to this study will be collected in accordance with the Freedom of Information and Protection of Privacy Act. All comments related will become part of the public record and may be included in the study documentation prepared for public review.

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**Ministry of the Environment,
Conservation and Parks**

**Ministère de l'Environnement,
de la Protection de la nature
et des Parcs**

Environmental Assessment
Branch

Direction des évaluations
environnementales

1st Floor
135 St. Clair Avenue W
Toronto ON M4V 1P5
Tel.: 416 314-8001
Fax.: 416 314-8452

Rez-de-chaussée
135, avenue St. Clair Ouest
Toronto ON M4V 1P5
Tél. : 416 314-8001
Télec. : 416 314-8452

Via E-mail Only

July 21, 2022

Matthew Main
City Project Manager
City of Welland
matthew.main@welland.ca

Julien Bell
Consultant Project Manager
GM BluePlan Engineering Ltd.
julien.bell@gmblueplan.ca

**Re: Pollution Prevention Control Plan Update and Wastewater Master Servicing Plan
City of Welland
Municipal Class Environmental Assessment – Master Plan (Approach #1)
Project Review Unit Comments – Final Report**

Dear Matthew Main and Julien Bell,

This letter is in response to the Notice of Completion provided for the Master Plan Report (Report) for the above noted Class Environmental Assessment (EA) project. Our understanding is that in order to improve the City's current wastewater collection system to mitigate the impacts of wet weather sewer system overflows on the environment and to meet the future needs in the community, the City of Welland (the proponent) has determined that the preferred alternative is to undertake various upgrades, some of which will require more detailed future investigations. The Ministry of the Environment, Conservation and Parks (ministry) provides the following comments for your consideration.

Class EA Process

- 1) The Report does not explicitly identify any recommended upgrades as being Schedule B or C Class EA projects. If this Master Plan will be used in support of future investigations for specific Schedule B or C projects, these projects should be identified in the Report.
- 2) Recognizing that more detailed investigations will be done at the specific projects level. The Report should provide a general description of the potential impacts and identify mitigation measures.

Planning and Policy

- 3) A discussion of the provincial planning and policy context, particularly of the Provincial Policy Statement (PPS), 2020, is missing from the Report. As noted in Section C.1.1.1 of the Municipal Class EA document (<https://municipalclassea.ca/manual/page45.html>), the PPS is a key consideration for identifying land-use planning objectives and evaluating alternative solutions in Phases 2 and 3 of the Class EA process.

Agency Consultation

- 4) Please note Barbara Slattery is not longer MECP employees (retired). Please update the stakeholder contact list with my contact information for future correspondence.

Indigenous Consultation

- 5) The ministry recommends that proponents include a summary of questions, comments and concerns raised by communities, and how they have been or will be addressed. If no comments or concerns were raised during the consultation process, the ministry recommends that a statement indicating this be included in the main body of the Report.
- 6) Please ensure that all records of consultation including emails, follow ups, courier receipts, read receipts for emails and telephone logs recording calls and messages are documented in the record of consultation that accompanies the Class EA documentation.
- 7) The proponent should continue to engage with all communities that have been engaged with to date as the Class EA process proceeds.

Thank you for circulating this Report for the ministry's consideration. Please document the receipt of this Project Review Unit Comments letter in the final report. We look forward to receiving a written response from the City of Welland to address our comments provided above.

Should you or any members of your project team have any questions regarding the material above, please contact me at joan.delvillarcuicas@ontario.ca

Sincerely,

A handwritten signature in purple ink, reading "Joan Del Villar C". The signature is stylized with a large, sweeping underline that extends to the right.

Joan Del Villar C
Regional Environmental Planner
Project Review Unit, Environmental Assessment Branch
Ontario Ministry of the Environment, Conservation and Parks

cc Katy Potter, Project Unit Supervisor, MECP



**City of Welland
Infrastructure Services**

Engineering Division

60 East Main Street, Welland, ON L3B 3X4

Phone: 905-735-1700 | **Fax:** 905-735-7184

Email: eng@welland.ca | www.welland.ca

September 28, 2022

Environmental Assessment Branch

1st Floor, 135 St Clair Avenue West
Toronto, Ontario, M4V 1P5

Sent via email to: joan.delvillarcuicas@ontario.ca

RE: MECP Comments Regarding the Welland Pollution Prevention & Control Plan Update & Wastewater Master Servicing Plan

Dear Joan Del Villar,

Thank you for the Ministry of Environment Conservation and Parks comments related to the Welland Pollution Prevention & Control Plan Update & Wastewater Master Servicing Plan. In regard to your comments and concerns we would like to note the following:

- Planning and Policy
 - We note that a reference to the Class Environmental Assessment Process is provided in Section 2 of the report; however, we do acknowledge that it is a simplified overview and does not discuss the updated 2020 Provincial Policy Statement. Section 2 of the post filing update to the Report has been updated to include additional discussion.
- Indigenous Consultation
 - Additional Indigenous consultation was completed after the Notice of Completion end date through phone calls and follow up emails with Indigenous groups. The extended communications resulted in one letter of acknowledgement from the Mississaugas of the Credit First Nation noting no issues with the Study.
 - Appendix D – Summary of Public Consultation has been updated to further highlight the First Nations Consultation Process.
- Public Consultation
 - Appendix D – has been updated to show the Notice of Completion comments and response.

If you have any other questions or require additional information, please feel free to contact the undersigned.



City of Welland
Engineering Division
60 East Main Street, Welland, Ontario, L3B 3X4
Telephone: 905-735-1700
www.welland.ca

Sincerely,

Matthew Main, P.Eng.
Infrastructure and Asset Manager
Engineering Division
City of Welland
60 East Main Street,
Welland, Ontario, L3B 3X4
matthew.main@welland.ca
905-735-1700

Julien Bell, P.Eng.
Project Manager
GM BluePlan Engineering
1266 South Service Road, Unit C31
Stoney Creek, ON L8E 5R9
julien.bell@gmblueplan.ca
519-748-1440 ext. 4264

June 30, 2022

City of Welland
60 East Main Street
Welland, ON L3B 3X4

Sent via email to: matthew.main@welland.ca

ATTN: Matthew Main, City Project Manager
RE: Notice of Completion - Welland PPCP & Wastewater MSP
Your File #: N/A
Our Reference #: ENB_R220616-004ON

Thank you for sending Enbridge notice of this project. B&A Planning Group is the land use planning consultant for Enbridge's Liquids Pipeline network across Canada. On behalf of Enbridge, we work with municipalities and stakeholders regarding planning and development in proximity to their pipeline infrastructure to ensure that it occurs in a safe and successful manner.

We request that this response package is provided in full to the landowner / applicant as it contains useful and important information, including certain requirements that must be followed, in respect of development in proximity of pipelines.

Description of Proposed Development

We understand that this application is a notice that the City of Welland has completed a Pollution Prevention Control Plan Update and Wastewater Master Servicing Plan. This Update will serve as an opportunity to summarize previous recommendations that have been implemented and support long term growth, sustainability, and management of the wastewater system.

As demonstrated in **Attachment 01 | Approximate Location of Pipeline Infrastructure** the City of Welland does have Enbridge pipeline infrastructure located within its municipal boundaries.

Assessment & Requirements

The Pollution Prevention Control Plan Update and Wastewater Master Servicing Plan notice was reviewed, and does not appear to contain any maps, statements or policies related to development in proximity of pipeline infrastructure. Therefore, Enbridge would like to recommend inclusion of the maps, statements and policies detailed in the recommendations below.

Policy Recommendations:

- 1) **Mapping:** We recommend that Enbridge's pipelines (and any other pipelines) and facilities be indicated on one or more maps within the Pollution Prevention Control Plan Update and Wastewater Master Servicing Plan. Requests for GIS data from Enbridge should be sent to notifications@Enbridge.com.
- 2) As per Federal and Provincial Regulatory Requirements and Standards, pipeline operators are required to monitor all new development in the vicinity of their pipelines that results in an increase in population or employment. To ensure that all development within the pipeline assessment area is referred to Enbridge for review and comment, we recommend inclusion of the following policy:

"When a neighbourhood plan, zoning amendment, subdivision application or development permit application is proposed that involves land within 200m of a pipeline, as demonstrated in "Map xx: ____" (per recommendation #1), Administration shall refer the matter to the pipeline company for review and input."
- 3) To ensure that no unauthorized ground disturbance or pipeline crossings occur when development progresses, we recommend the following policy be included within the Pollution Prevention Control Plan Update and Wastewater Master Servicing Plan:

"All development within 30m or crossings of a pipeline shall require written consent from the pipeline company and is the responsibility of the applicant to obtain prior to development approval."

Future Development Requirements

Although the Pollution Prevention Control Plan Update and Wastewater Master Servicing Plan; details a long-term future development vision, there are development requirements that will be mandatory at the subdivision and development stage that will be helpful to consider prior to application submission. Please review [Attachment 02 | Enbridge Development Requirements](#) for requirements for planning and development in proximity of pipelines. In addition, for more information about when written consent is required and how to submit an application, see [Attachment 03 | Enbridge Pipeline Crossing Guidelines](#). For additional resources on safe development in proximity of Enbridge's pipeline network please view [Enbridge's Public Awareness Brochures](#) or visit the [Land Use Planning and Development website](#).

Please continue to keep us informed about the outcome of the project and any future policy, land use, subdivision, and development activities in proximity to Enbridge's pipelines and facilities. All future project notifications should be sent to notifications@Enbridge.com, while questions about the details of this letter may be sent to the contact listed below. Thanks again for providing us with the opportunity to provide comments on this project and we look forward to working with you in the future.

Sincerely,



Joanna Ilunga

Community Planner | BA (Hons), MScPI

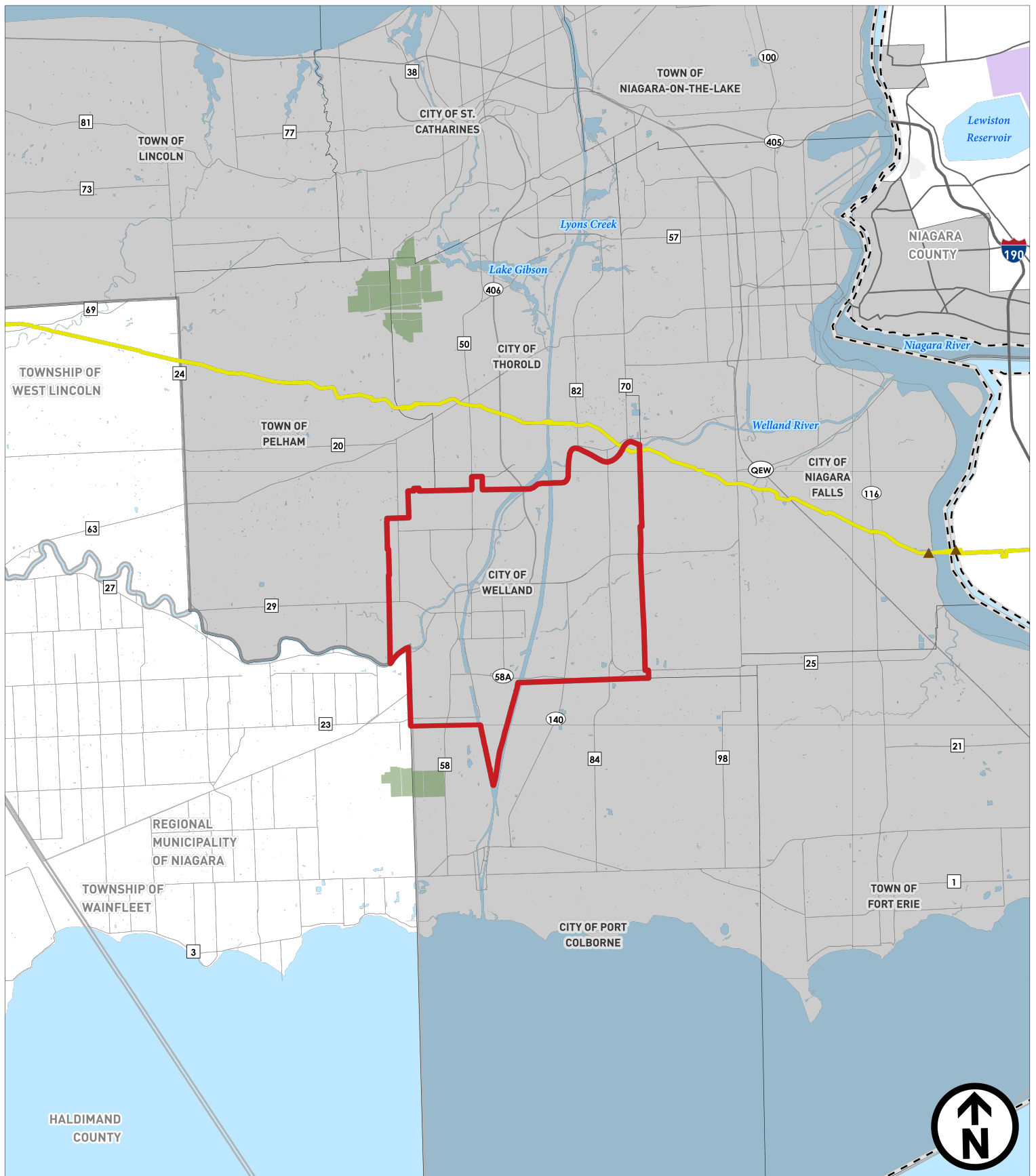
403.692.5231 | jilunga@bapg.ca

B&A Planning Group | 600, 215 – 9 Avenue SW | Calgary, AB T2P 1K3 | www.bapg.ca

Attachment 01 | Approximate Location of Pipeline Infrastructure

Attachment 02 | Enbridge Development Requirements

Attachment 03 | Enbridge Pipeline Crossing Guidelines



Geographic Coordinates: -79.2289, 42.9910
 Coordinate System: NAD 1983 UTM Zone 17N
 Date Saved: Jun 16, 2022
 Map File: Referral_Mapping.aprx

0 1 2 3 4 kilometres 1:200,000



Legend

- | | | |
|-------------------|----------------------|----------------------|
| Subject Site | US / State Route | Unincorporated Place |
| Enbridge Facility | Native American Area | USA Border |
| Enbridge Pipeline | Municipality - Rural | Waterbody |
| Major Road | Municipality - Urban | |
| Interstate | Park/Protected Area | |

Regional Context

Municipal Plan

City of Welland

Referral ID: **R220616-0040N**

June 2022

Map and data are conceptual and for informational and planning purposes only.



Geographic Coordinates: -79.2289, 42.9910
 Coordinate System: NAD 1983 UTM Zone 17N
 Date Saved: Jun 16, 2022
 Map File: Referral_Mapping.aprx

0 700 1,400 2,100 2,800 metres **1:70,000**



Legend

- | | |
|---------------------------------|----------------------|
| Subject Site | Railway |
| Enbridge Pipeline | Municipality - Rural |
| Pipeline Assessment Area (220m) | Municipality - Urban |
| Prescribed Area (30m) | Park/Protected Area |

Local Context

Municipal Plan

City Of Welland

Referral ID: **R220616-0040N**

June 2022

Map and data are conceptual and for informational and planning purposes only.

Attachment 02 | Enbridge Development Requirements

Definitions

- A **Right-of-Way (ROW)** is a strip of land where property rights have been acquired for pipeline systems by the pipeline company. It is a surveyed area of a specific width which grants legal rights of access to operate and maintain the infrastructure within it.
- The **Prescribed Area** is an area of 30 m (100 ft) perpendicularly on each side from the centreline of a pipeline. Excavation or ground disturbance within this zone requires written consent from the pipeline company pursuant to the Canadian Energy Regulator Pipeline Damage Prevention Regulations (Authorizations). Depending on the pipeline location and regulator this may also be known as a “controlled area” or “safety zone”.
- The **Pipeline Assessment Area** identifies lands on either side of a pipeline in which new development must be monitored by the pipeline operator. The requirement for and scope of this monitoring is governed by the Canada Energy Regulator (CER) and CSA Z662:19. Depending on the pipeline location, operator, and regulator this may also be known as the “notification zone”, “referral area” or “class location assessment area”.

Locating the Pipeline | Click Before You Dig

Any person planning to construct a facility across, on, along or under a pipeline (including the right-of-way), conduct a ground disturbance activity within 30 metres of the centreline of a pipe, or operate a vehicle or mobile equipment across a right-of-way, must first request a locate service. To identify the precise alignment of the pipeline on the subject lands, Locate Requests can be made online, via mobile apps, or via phone (see table below),

The locate request must be made a minimum of three (3) business days in advance of the construction, ground disturbance, or vehicle or mobile equipment crossing. The One-Call Centre will notify Enbridge to send a representative to mark the facilities, explain the significance of the markings and provide you with a copy of the locate report. Enbridge requests a minimum of five (5) business days’ notice for any work involving explosives.

Canadian One-Call Centres			
Province	Phone	Website	Mobile App
British Columbia	1.800.474.6886	www.bc1c.ca	
Alberta	1.800.242.3447	www.albertaonecall.com	Dig Info AB
Saskatchewan	1.866.828.4888	www.sask1stcall.com	Sask1st Call
Manitoba	1.800.940.3447	www.clickbeforeyoudigmb.com	
Ontario	1.800.400.2255	www.on1call.com	
Quebec	1.800.663.9228	www.info-ex.com	Info-Excavation
Nova Scotia & New Brunswick	1.800.344.5463	www.info-ex.com	Info-Excavation
Northwest Territories	Contact pipeline and facility owner directly		
www.clickbeforeyoudig.com			

Right-of-way

A right-of-way is a strip of land where property rights have been acquired for pipeline systems by the pipeline company. It is a surveyed area of a specific width which grants legal rights of access to operate and maintain the infrastructure within it:

- No permanent structures are permitted within the pipeline right-of-way area without Enbridge's prior written consent.
- Enbridge must have the ability to access Enbridge's pipeline right-of-way at all times for construction, maintenance, operation, inspection, patrol, repair, replacement and alteration of the pipeline(s). Therefore, the Enbridge pipeline right-of-way shall be maintained as green space, park belt or open space.
- No work shall take place on Enbridge's pipeline right-of-way without the presence of an Enbridge representative.
- Storage of materials and/or equipment, grading or placing fill on Enbridge's pipeline right-of-way is not permitted without prior written consent from Enbridge.

Written Consent

Any proposed crossings of the pipeline right-of-way or ground disturbance within the Prescribed Area or pipeline right-of-way are subject to Enbridge's written consent in accordance with the Canadian Energy Regulator Act and regulations including the Canadian Energy Regulator Pipeline Damage Prevention Regulations as amended or replaced from time to time (or for pipelines contained within Alberta, the Pipeline Act (Alberta) and Pipeline Rules as amended or replaced from time to time).

The applicant will require Enbridge's written consent or a crossing agreement prior to undertaking the following activities:

- Constructing or installing a facility across, on, along or under an Enbridge pipeline right-of-way;
- Conducting any activity that would cause ground disturbance (excavation or digging) on an Enbridge's pipeline right-of-way or within 30m perpendicularly on each side from the centerline of Enbridge's pipe (the "Prescribed Area");
- The operation of a vehicle, mobile equipment or machinery across an Enbridge pipeline right-of-way; outside of the travelled portion of a highway or public road;
- Using any explosives within 300m of Enbridge's pipeline right-of-way.

For more information about when written consent is required and how to submit an application, please see [Attachment 03 | Enbridge Pipeline Crossing Guidelines](#).

Prescribed Area

The Prescribed Area is an area of 30 m (approximately 100 ft) perpendicularly on each side from the centreline of a pipeline. Excavation or ground disturbance within this zone requires written consent from the pipeline company pursuant to the Canadian Energy Regulator Pipeline Damage Prevention Regulations (Authorizations). Depending on the pipeline location and regulator this may also be known as a "controlled area" or "safety zone".

For pipelines crossing provincial boundaries, Enbridge is regulated by the Canada Energy Regulator and is subject to the Canadian Energy Regulator Act and its regulations as amended or replaced from time to time.

- Section 335(1) of the Canadian Energy Regulator Act prohibits any person to construct a facility across, on, along or under a pipeline or engage in an activity that causes a ground disturbance within the Prescribed Area unless the construction or activity is authorized by the pipeline company.
- Section 335(2) of the Canadian Energy Regulator Act prohibits any person to operate a vehicle or mobile equipment across a pipeline unless the vehicle or equipment is operated within the travelled portion of a highway or public road or such operation is authorized under section 13(1) of the Canadian Energy Regulator Pipeline Damage Prevention Regulations (Authorizations).

For pipelines contained within Alberta, Enbridge is regulated by the Alberta Energy Regulator and is subject to the Pipeline Act and Pipeline Rules as amended or replaced from time to time.

- As per the Alberta Energy Regulator, any person who plans to engage in an activity that causes a ground disturbance within the pipeline right-of-way must obtain the written consent of the pipeline company.

Crossings

- Written consent from Enbridge is required for all crossings of the pipeline.
- The written authorization request must include:
 - Drawings with cross sections of the proposed new road and road widening to verify the depth of cover from both sides of the road.
 - Drawings should include any new utilities that will cross the ROW.
- No vehicles or mobile equipment, including heavy machinery, will be permitted to cross Enbridge's pipeline right-of-way without the prior written consent of Enbridge. Please complete Enbridge's Equipment Specification and Data Sheet(s) to make an application for temporary equipment crossing including timeframe, type and weight of equipment per axle together with the name of the applicant, address, contact name and phone number/email.
- Where future development such as a roadway or a parking area is proposed over the pipeline right-of-way, Enbridge may be required to carry out pipeline inspection and recoating of the existing pipeline(s) prior to the start of the development. **The costs of Enbridge's design, inspection, recoating work and any other pipeline alteration as a result of the crossing will be borne by the Developer.**

Ongoing Activities

- Written consent must be obtained from Enbridge for ongoing activities such as mowing or maintenance of the pipeline right-of-way on public lands.

Class Monitoring in the Pipeline Assessment Area

As per Federal and Provincial Regulatory Requirements and Standards, pipeline operators are required to monitor all new development in the vicinity of their pipelines that results in an increase in population or employment. Therefore, please keep us informed of any additional development being proposed within the Pipeline Assessment Area indicated in **Attachment 01 | Approximate Location of Pipeline Infrastructure**.

- If a pipe replacement is necessary because of the proposed development, temporary workspace shall be granted to Enbridge on terms and conditions to be (or as) negotiated. This workspace will be adjacent to the existing pipeline right-of-way and may be up to a maximum of 15m wide on either or both sides. Grading or landscaping of the workspace is not permitted until the replacement has been completed.

Subdivisions

- Lot lines are not to be incorporated over Enbridge's pipeline right-of-way. If lot lines are incorporated over Enbridge's pipeline right-of-way, the owner agrees, in writing to include the following warning clause in all offers of sale and purpose and/or lease:
"Future residents are advised that Enbridge owns and operates _____ pipeline(s) within an _____ m pipeline right-of-way on the property. As a result, there are conditions that apply to various activities over the pipeline right-of-way that must be approved by Enbridge."
- All display plans in the lot/home sales office shall identify the Enbridge pipeline right-of-way-corridor within the proposed linear park block(s).

Structures and Setbacks

Development setbacks from pipelines and rights-of-way are recommended in support of damage prevention and to allow both pipeline operators and developers buffer lands for operations and maintenance purposes.

- No permanent structures are permitted within the pipeline right-of-way area without Enbridge's prior written consent.

Other Development

Wells / Septic Systems

Wells or septic systems shall not be located on Enbridge's pipeline right-of-way. Construction of any septic system within 30m of the pipeline right-of-way requires prior written notification to Enbridge to ensure the septic bed will not adversely impact the integrity of the pipeline and pipeline right-of-way. Written consent from Enbridge must be received prior to the start of any work.

Aerial Power Lines

Aerial power lines crossing the pipeline right-of-way require aerial warning devices installed and properly maintained. No poles, pylons, towers, guys, anchors or supporting structures of any kind are permitted on the pipeline right-of-way.

Pathways, Fencing & Landscaping

Fencing Along ROW

- For development along an Enbridge right-of-way, permanent fencing shall be erected and maintained by the Developer at the Developer's cost along the limits of Enbridge's pipeline right-of-way. The fence erected must meet Enbridge's and the governing municipality's specifications concerning type, location and height. Any excavations for fence posts on, or within 30m of the pipeline must be done by hand or hydrovac. There shall be no augers operated on the pipeline right-of-way. The Developer shall notify Enbridge three business (3) days prior to any excavation for fence posts located on or within 30m of the pipeline.
- Limits of the pipeline right-of-way parallel to the pipeline shall be delineated with permanent fencing to prevent gradual encroachment by adjacent landowners. Suitable barriers shall be installed at all road accesses to prevent unauthorized motor vehicles from entering Enbridge's pipeline right-of-way.
- Enbridge's written consent must be obtained and One Call notifications must be completed prior to any fence installations.

Landscaping

No landscaping shall take place on Enbridge's pipeline right-of-way without Enbridge's prior written consent and where consent is granted such landscaping must be performed in accordance with Enbridge's Pipeline Crossing Guidelines, as follows:

- The landowner / developer shall ensure a 5m continuous access way in the pipeline right-of-way is provided for the Enbridge repair crews.

In order to maintain a clear view of the pipeline for the purposes of right-of-way monitoring, which is required by federal regulation, trees and shrubbery planted in proximity to the pipeline must meet the following criteria:

- Enbridge permits the following vegetation within the pipeline right-of-way: Flowerbeds, vegetable gardens, lawns and low shrubbery (under 1 m in height), and
- The mature growth height of vegetation does not exceed 1.5 m (5 ft) at maturity and must maintain a minimum distance of 3 m (10 ft) from the nearest pipeline.

Pathways / Trails

No pathways shall be installed on Enbridge's pipeline right-of-way without Enbridge's prior written consent and where consent is granted pathways must be designed in accordance with Enbridge's requirements:

- A pathway crossing Enbridge's pipeline right-of-way shall be installed as close as possible to a ninety (90) degree angle to the Enbridge pipeline(s).
- The width of the pathway shall not exceed 3m.
- A parallel pathway within Enbridge pipeline right-of-way shall maintain a minimum 5m separation from the edge of the Enbridge pipeline(s).
- Enbridge's pipeline(s) must be positively identified at certain intervals as directed by Enbridge's representative for parallel installation.
- Enbridge shall install pipeline markers at all road, pathway and other crossings throughout the development area at Developer's cost.

Drainage and Erosion

- The Developer shall ensure drainage is directed away from the pipeline right-of-way so that erosion will not adversely affect the depth of cover over the pipeline(s).
- Any large-scale excavation adjacent to the pipeline right-of-way, which is deeper than the bottom of the pipe, must maintain a slope of 3:1 away from the edge of the pipeline right-of-way.
- Depth of cover over Enbridge pipeline(s) shall not be compromised over the life of the Developer's facility due to rutting, erosion or other means.

Construction

- During construction of the site, temporary fencing must be erected and maintained along the limits of the pipeline right-of-way by the Developer to prevent unauthorized access by heavy machinery. The fence erected must meet Enbridge's specifications concerning type, height and location. The Developer is responsible for ensuring proper maintenance of the temporary fencing for the duration of construction. The Developer is responsible for the cost of material, installation and removal.
- Original depth of cover over the pipeline(s) within Enbridge's pipeline right-of-way shall be restored after construction. This depth of cover over the pipeline(s) shall not be compromised over the life of the Developer's facility due to rutting, erosion or other means.
- In the event Enbridge's pipeline(s) suffer contact damage or other damage as a result of construction, work shall stop immediately and Enbridge to be immediately notified.

Liability

In no event shall Enbridge be liable to the developer and/or landowner(s) for any losses, costs, proceedings, claims, actions, expenses or damages (collectively "Claims") the Developer and/or landowner(s) may suffer or incur as a result of or arising out of the presence of Enbridge pipeline(s) and/or operations on the pipeline right-of-way. The Developer and/or landowner(s) shall be responsible for all costs and expenses incurred to install, repair, replace, maintain or remove the Developer's and/or landowner(s) installations on or near the pipeline right-of-way and shall indemnify and save harmless Enbridge from all Claims brought against, suffered or incurred by Enbridge arising out of the activities of the Developer and/or landowner(s) in respect of the development or arising out of the presence, operation or removal of the Developer's and/or landowner(s) installations on or near Enbridge's pipeline right-of-way.

Enbridge Pipeline Crossing Guidelines, Canada

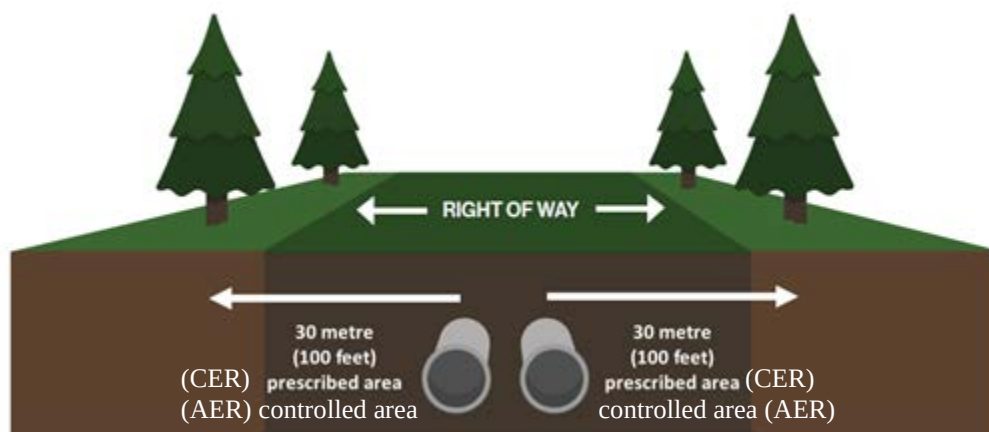
Application Guidance Details
May 2020 v2.0

Application Guidance Details

1. WHO REQUIRES CONSENT?

Consent is governed by the Canada Energy Regulator (CER) for interprovincial or international (federally regulated) pipelines and the Alberta Energy Regulatory (AER) for intra-provincial (provincially regulated) pipelines within the Province of Alberta. To ensure our pipelines and facilities operate safely written consent from Enbridge must be obtained in Canada before any of the following occur:

- ❖ Construction or installation of a new facility across, on, along or under Enbridge's pipeline and/or right-of-way;
- ❖ Ground disturbance activities in the prescribed area (CER) or controlled area (AER) which extends 30m from each side of the centerline of the pipeline;
- ❖ Operation or movement of vehicles, mobile equipment or machinery across Enbridge's right-of-way, outside of the travelled portion of a highway or public road;
- ❖ Using explosives within 300m of Enbridge's pipeline right-of-way;
- ❖ Use of the prescribed area or controlled area for storage or workspace purposes;
- ❖ Subdivision development across, on, along or over Enbridge's pipeline and/or right-of-way;
- ❖ Landowners wishing to install agricultural drainage tile across, on, along or under Enbridge's pipeline and/or right-of-way.



Activities that cause a ground disturbance include, but are not limited to, the following:

- | | |
|---------------------------|---|
| ❖ digging | ❖ clearing and stump removal |
| ❖ excavation | ❖ subsoiling |
| ❖ trenching | ❖ blasting/using explosives |
| ❖ ditching | ❖ quarrying |
| ❖ tunneling | ❖ grinding and milling of asphalt/concrete |
| ❖ boring/drilling/pushing | ❖ seismic exploration |
| ❖ augering | ❖ driving fence posts, bars, rods, pins, anchors or pilings |
| ❖ topsoil stripping | ❖ plowing to install underground infrastructure |
| ❖ land levelling/grading | ❖ crossing of buried pipelines or other underground infrastructure by heavy loads off the travelled portion of a public roadway |
| ❖ tree or shrub planting | ❖ installing agricultural drainage tile |

Under section 2 of the Canadian Energy Regulator Act, ground disturbance does not include:

- ❖ Cultivation to a depth of less than 45cm below the surface of the ground
- ❖ Any activity to a depth of less than 30cm and that does not result in reduction of the depth of earth cover over the pipeline less than that approved at time of construction

2. CROSSING A PIPELINE WITH AN AGRICULTURAL VEHICLE OR MOBILE EQUIPMENT

For pipelines regulated by the Canada Energy Regulator, the *Canadian Energy Regulator Pipeline Damage Prevention Regulations – Authorizations* provides that persons operating agricultural vehicles or mobile equipment across pipelines may do so in low-risk areas, under certain conditions:

- ❖ the loaded axle weight and tire pressures of the vehicle or mobile equipment are within the manufacturer's approved limits and operating guidelines; AND
- ❖ the point of crossing has not been the subject of a notification from the pipeline company that crossing at that location could impair the pipeline's safety or security.

This applies to vehicles or mobile equipment used for agricultural activities in the production of crops and the raising of animals and includes pasturing and cultivation activities such as tillage, plowing, disking and harrowing.

For pipelines regulated by the Alberta Energy Regulator, the *Pipeline Regulation (under the Pipeline Act)* provides that persons operating vehicles or equipment used for farming operations; or use of off-highway vehicles [as defined in section 117(a)(iii) to (viii) of the Traffic Safety Act] or use of private passenger vehicles (as defined in section 1(1)(jj) of the Traffic Safety Act) less than ¾ ton may temporarily cross over an AER regulated pipeline without further approval from Enbridge.

However, if neither of the above requirements can be met then an application must be submitted to Enbridge for further review and processing.

3. HOW TO APPLY FOR ENBRIDGE CONSENT

The applicant must submit a written request, either by completing the Application Form (attached) or a letter with equivalent information, together with the applicable drawing(s) to the respective Enbridge crossings department as set out in the *Contact Us* section of this document.

The drawing(s) must be prepared in accordance with the minimum standards as set out in the *Drawing Requirements* section of this document.

Enbridge's Equipment Specification and Data Sheet (attached) must also be completed for any vehicle/ mobile equipment crossing applications.

For federally regulated pipelines, the applicant may petition the Commission for approval of construction activity if:

- ❖ the applicant cannot comply with the terms and conditions as set out in the company's written consent;
- ❖ the applicant feels the terms and conditions in the company's written consent are excessive; or
- ❖ If the company refused to grant approval to the applicant for reasons of pipeline integrity, public safety or company policy.

An application can be filed with the Commission by writing to:

Secretary of the Commission
Canada Energy Regulator
Suite 210, 517 – 10th Ave SW
Calgary AB T2R 0A8
Phone: 1-877-288-8803
Online: www.cer-rec.gc.ca

Applications may be filed with the Commission by mail, courier or facsimile by calling the toll-free number at 1-877-288-8803. Applications can also be uploaded through the CER's Applications and Filings Portal on the CER website at Home / Applications and Filings / Submit Applications and Regulatory Documents / File under the CER Act / OPR: CER Act – Guide C (<http://www.cer-rec.gc.ca/pplctnflng/sbmt/nbpr-eng.html>).

4. DRAWING REQUIREMENTS

The following represents the minimum information that is required to be shown on the drawing(s) in order for Enbridge to review your application. Dimensions must be shown on the drawing(s) and may be done in either imperial or metric units (if metric, then to one decimal point).

NOTE: incomplete drawings and/or an incomplete application will be rejected back to the applicant.

(a) Permanent Installations

All proposed permanent installation drawings MUST contain the following items:

1. Plan Number, including any revision number and the respective date;
2. North Arrow;
3. Scale;
4. Legend;
5. Location indicator including: legal land description, PIN, GPS coordinates;
6. Plan view of whole quarter section or affected area including:
 - ❖ Lot lines, road limits
 - ❖ Proposed facilities (including curbs, footing, guard rails, guy wires, poles, fences, etc.) with tie dimensions to lot survey line preferably along pipeline and/or right-of-way boundary
 - ❖ Location of cathodic test lead terminals (if applicable);
7. Cross section view and/or profile view including:
 - ❖ For surface structures, show profile along pipeline(s) with highest elevation
 - ❖ For underground facilities show profile along facility
 - ❖ Property lines, pipeline(s) and depth of cover
 - ❖ All underground facilities must maintain an even elevation across the entire width of right-of-way except for gravity type facilities or those facilities installed by HDD;
 - ❖ Drill path plan for HDD installations
 - ❖ Unsupported span (m) of Enbridge pipeline for open cut installations
8. Crossing Angle;
9. Crossing location circled in red;
10. Identify all affected Enbridge facilities, right-of-way(s) and pipeline markers;
11. Method of Installation (MOI) (**Refer to Interpretation/Definitions section*);
12. Minimum Clearance (**Refer to Interpretation/Definitions section*);
13. Facility specifications:
 - ❖ PIPE/CABLE: pipe diameter, pipe material, product conveyed, cable size, if cable is within a conduit, conduit material, cable voltage; unsupported span (meters) of existing pipeline if MOI is open cut;
 - ❖ ROAD: width of road, cover at ditch, cover at center of road, surface material, road type/use; design loading calculation; indicate if any Government or Provincial setback requirements
 - ❖ OVERHEAD POWER: pole number(s), location of pole/guy wire/anchors/etc., method of installation of pole/guy wire/anchors/etc., horizontal clearance to pipe from proposed pole/guy wire/anchors/etc., vertical clearance to ground/grade, voltage, type of power (AC/DC), AC mitigation plan may be required;
 - ❖ PIPE RACK: height of pipe rack, pile location(s), pile clearance to Grantor's facility, pile installation method; alternate access route provided for rural locations
 - ❖ DRAINAGE TILE: location of tiles and incremental cost analysis.
14. Complete the Equipment Specification and Data Sheet, when required.

(b) Temporary Activities

All temporary drawings MUST contain the following:

1. Plan Number, including any revision number and the respective date;
2. North Arrow;
3. Scale;
4. Legend;
5. Location indicator including: legal land description, PIN, GPS coordinates;
6. Plan view of whole quarter section or affected area;
7. Temporary activities location circled in red;
8. Identify all affected Enbridge facilities, right of way(s) and/or PLA/easement ownership;
9. Facility specifications:
 - ❖ WORKSPACE: location, measurement of workspace, purpose;
 - ❖ ACCESS OF ROW: location, kilometer usage of ROW, width of access; egress/ingress points, complete the Equipment Specification and Data Sheet (attached);
 - ❖ EQUIPMENT CROSSING: complete the Equipment Specification and Data Sheet (attached);
 - ❖ ROAD USE: indicate road(s) to be utilized, km usage, reason required, frequency of use; complete the Equipment Specification and Data Sheet (attached);
 - ❖ GEOPHYSICAL: project/prospect name, number of reading units/lines, type of source, CER approval required (Y/N).

5. INTERPRETATION / DEFINITIONS

For crossing application purposes, Enbridge defines the following as:

Grantee means the applicant or the facility owner; a company, a person, a municipality or government body, etc.

Method of Installation means OPEN CUT or HDB or HDD; all defined as follows:

OPEN CUT

Enbridge defines open cut as trench methodology wherein access is gained to the required level underground for the proposed installation, maintenance or inspection of a pipe, conduit or cable. The excavated trench is then backfilled and the surface restored.

HORIZONTAL DIRECTIONAL BORE (HDB)

Enbridge defines horizontal directional bore as meeting ALL of the following:

- (a) The designed horizontal distance of the crossing shall be less than or equal to 150m (500ft) in length; AND
- (b) The depth of the pipeline installation shall be limited to 8m (25ft) to the centre (cross-section) of the pilot hole and measured to the corresponding surface location; AND
- (c) Straight alignment in the horizontal plane; AND
- (d) Pilot bit is steerable and trackable.

HORIZONTAL DIRECTIONAL DRILL (HDD)

Enbridge defines horizontal directional drill as an *HDB* that DOES NOT meet all of the criteria for an *HDB*. An *HDD* will satisfy some but not all of: a, b and c above and will satisfy d.

Minimum Clearance means the required distance between the existing Enbridge facility and the proposed facility based on the selected *Method of Installation*.

Minimum clearance required for installation ABOVE Enbridge facility by OPEN CUT is 0.3m
Minimum clearance required for installation BELOW Enbridge facility by OPEN CUT is 0.6m
Minimum clearance required for installation BELOW Enbridge facility by HDB is 1.0m
Minimum clearance required for installation BELOW Enbridge facility by HDD is 3.0m
Minimum clearance required for road installation from bottom of ditch to top of Enbridge facility is 0.9m and from centerline of road to top of Enbridge facility is 1.2m
Minimum clearance required for railway installation from bottom of ditch to top of Enbridge <i>uncased</i> facility is 1.83m and from centerline of rail bed to top of Enbridge <i>uncased</i> facility is 3.05m
Minimum clearance required for railway installation from bottom of ditch to top of Enbridge <i>cased</i> facility is 0.91m and from centerline of rail bed to top of Enbridge <i>cased</i> facility is 1.68m

6. WRITTEN CONSENT

After applying for written consent, Enbridge will review the proposed installation and/or temporary activities application in order to ensure that the proposed work will not pose a risk to existing Enbridge facilities, as well as, to ensure that any access required to existing facilities for maintenance or in an emergency situation will not be impeded.

Some applications may require further engineering assessment which will require additional time to review the proposed installation and/or temporary activities prior to Enbridge issuing consent. All efforts will be made to provide an agreement within an appropriate timeframe, however, please ensure that your application request is submitted with ample lead time.

7. CONTACT US

To obtain written consent from Enbridge, please contact the respective office as set out below:

REGION	CONTACT INFORMATION
LIQUIDS PIPELINES - WESTERN CANADA (Alberta, Saskatchewan, Manitoba and Norman Wells)	Lands & ROW 330, 10180 – 101 Street Edmonton AB T5J 3S4 Email: crossingrequests@enbridge.com Phone: 780-378-2228
LIQUIDS PIPELINES - EASTERN CANADA (Ontario and Quebec)	Lands & ROW 1 st Floor, 1086 Modeland Road, Bldg 1050 Sarnia ON N7S 6L2 Email: est.reg.crossing@enbridge.com Phone: 1-800-668-2951
GAS PIPELINES / STORAGE - BRITISH COLUMBIA	Lands & ROW 200, 425 – 1 Street SW Calgary AB T2P 3L8 Email: crossings@enbridge.com Phone: 587-747-6538

GAS STORAGE - ONTARIO	3501 Tecumseh Road Mooretown ON N0N 1M0 Email: chris.pincombe@enbridge.com Phone: 519-862-6092
GAS PIPELINE - ALLIANCE	Lands & ROW 600, 605 – 5 Ave SW Calgary AB T2P 3H5 Email: crossings@alliancepipeline.com Phone: 403-266-4464

For more information on Enbridge Gas Distribution please click the link: <https://www.enbridgegas.com/gas-safety/pipeline-safety.aspx>

8. ONE CALL CENTRES

Before putting a shovel in the ground, whether it is in your backyard or a commercial jobsite, please do a locate request to safely identify any buried utility lines at www.clickbeforeyoudig.com.

Your local one call centre can also be reached by phone as shown below:

CALL OR CLICK BEFORE YOU DIG!! Contact your respective one-call centre	
British Columbia https://www.bconecall.bc.ca/ 1-800-474-6886	Alberta http://albertaonecall.com 1-800-242-3447
Saskatchewan www.sask1stcall.com 1-866-828-4888	Manitoba http://www.clickbeforeyoudigmb.com/ 1-800-940-3447
Ontario www.on1call.com 1-800-400-2255	Quebec www.info-ex.com 1-800-663-9228
Northwest Territories 1-867-587-7000 Or contact the pipeline company directly	

9. REGULATORS

In Canada, Enbridge has pipelines that are regulated by both the federal government and provincial governments. For more information on any of the regulators please visit their respective website.

Canada Energy Regulator: www.cer-rec.gc.ca

Alberta Energy Regulator: www.aer.ca

10. DEVELOPMENT ON OR NEAR THE RIGHT-OF-WAY

Enbridge should be consulted early in the design phase with regards to proposed subdivisions, roads and utilities, and municipal landscaping.

Subdivisions – Enbridge highly recommends that our right-of-way be used as a passive green space or as part of a linear park system. Permanent structures on the right-of-way are not permissible.

Roads and Utilities – Roads may be permitted to cross and/or run parallel to the right-of-way but no portion of a road allowance can be located on the right-of-way (apart from approved road crossings). Enbridge will review the location of utilities which are often proposed within the road allowance.

Landscaping – Projects such as pedestrian pathways may be permitted as long as they do not impede Enbridge's access along its right-of-way for operational and/or maintenance activities. Enbridge's written consent will specify the permitted landscaping requirements.

11. DAMAGE PREVENTION

Enbridge's underground facilities must be positively identified, to Enbridge's satisfaction, prior to the start of any proposed construction activities.

Enbridge's representative(s) have the authority to stop work at any time due to safety, environmental or operational concerns and/or unforeseen circumstances or emergency situations.

****IMMEDIATELY NOTIFY ENBRIDGE IF YOU COME INTO CONTACT WITH THE PIPE! ****

As a small scratch or dent in the pipeline's coating can impact long term safety of the pipeline and must be assessed by Enbridge.

Please note that obstacles or un-approved above ground installations located on an Enbridge right-of-way, such as sheds, trailers, boats and pools can interfere with Enbridge's access of their right-of-way. Permanent structures on the right-of-way are NOT permissible.

Enbridge must be contacted before conducting any blasting activities within 300m of the pipeline right-of-way so that Enbridge can review the proposed plans in order to see if there might be potential impacts to its facilities. Blasting activities related to prospecting for mines and minerals within 40m of a federally regulated pipeline right-of-way requires permission from the Canada Energy Regulator.

12. EMERGENCY SITUATIONS

In an emergency situation please provide as much notice, as is practicable, to Enbridge prior to commencement of any construction, excavation, installation or temporary crossing of existing pipelines and/or right-of-ways in order to access the emergency site.

Enbridge classifies an emergency situation as:

- ❖ A risk to human life;
- ❖ Required emergency repairs of public services; or
- ❖ To contain an environmental emergency.

In an emergency situation please call: **1-877-420-8800** (toll free) and/or contact your local One Call provider at the numbers listed in section 8.

DISCLAIMER: THESE GUIDELINES ARE INTENDED TO PROVIDE USEFUL CROSSING APPLICATION GUIDANCE INFORMATION TO THE APPLICANT. SUBMISSION OF AN APPLICATION MEETING THE REQUIREMENTS AS SET OUT HEREIN DOES NOT CONSTITUTE WRITTEN CONSENT FROM ENBRIDGE. ALL APPLICATIONS WILL BE REVIEWED BY ENBRIDGE TO DETERMINE WHETHER THE APPLICATION WILL BE APPROVED.

APPLICANT INFORMATION**Grantee* Full Legal Name for Agreement:****Regulator:****Other:****Grantee Address for Service:****Grantor/Enbridge Entity****Application by Broker/Land Consultant**Yes ☐ No ☐**Broker/Land Consultant Name:****Contact Person Name:****Contact Person Phone Number:****File Number:****Broker/Land Consultant Address:****CROSSING INFORMATION****Expected construction start and end date(s):****Permanent Installation** ☐**Temporary Activities** ☐Crossing ☐Drainage Tile ☐Pole/Pile Installation ☐Other ☐Workspace ☐Equipment Crossing ☐Access of ROW ☐Geophysical ☐Road Use ☐Proximity ☐Other ☐**Location indicator including affected legal land description(s), PIN and GPS Coordinates (Latitude and Longitude Decimal Degree):****Grantor's Affected Disposition(s) (Alberta) (i.e. PLA # or License # or Line #):****Grantee's Field Contact Information:**

Name:

Phone:

Email:

Details of Grantee's Proposed Permanent Installation and/or Purpose of Temporary Activities**Method of Installation*** *(For permanent installations)*Open Cut ☐ HDB ☐ HDD ☐**Drawing(s) Attached**Yes ☐ No ☐**Drawing Requirements Met ***Yes ☐ No ☐**Equipment Specification and Data Sheet Attached ***Yes ☐ No ☐ N/A ☐**Notes/Additional Information:****SUBMIT TO:**

LIQUIDS PIPELINES WESTERN CANADA (Alberta, Saskatchewan, Manitoba and Norman Wells)	LIQUIDS PIPELINES EASTERN CANADA (Ontario and Quebec)
Department: Lands & ROW	Department: Lands & ROW
Address: 330, 10180 – 101 Street Edmonton AB T5J 3S4	Address: 1 st Floor, 1086 Modeland Road, Bldg 1050 Sarnia ON N7S 6L2
Email: crossingrequests@enbridge.com	Email: est.reg.crossing@enbridge.com

Equipment Specification and Data Sheet(s)



In order to properly conduct an analysis on the requested crossing the following general information and appropriate data sheets are required to be completed.

Steps:

1. Complete the *Applicant – Information and Details* document for each crossing application
2. Add and complete the *Data Sheet – Equipment or Vehicle with Tires* for EACH piece of equipment
3. Add and complete the *Data Sheet – Equipment with Tracks* for EACH piece of equipment
4. Return fully completed general information and data sheets and any other pertinent information

Applicant Information

Applicant Name:	
Applicant Contact Person Name:	
Email:	
Phone Number:	
Applicant Reference/File Number:	

Details

Description and Purpose of Crossing:			
Location Indicator (legal land description, PIN, etc.)			
GPS Coordinates:(Latitude and Longitude Decimal Degree)			
Duration:	Temporary ☐	Permanent ☐	
Start Date:		End Date:	
Equipment or Vehicle with Tires:	Yes ☐	No ☐	Datasheet:
Equipment with Tracks:	Yes ☐	No ☐	Datasheet:

Save Form

Reset Form

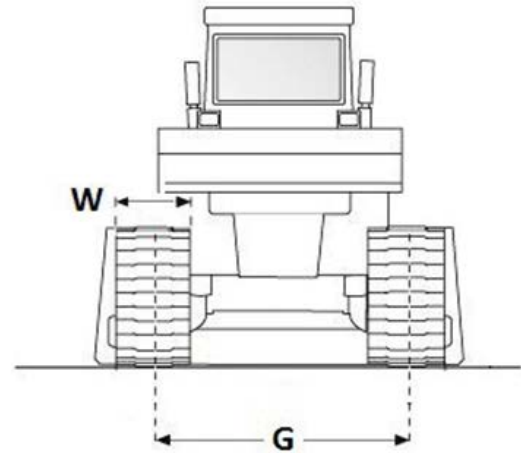
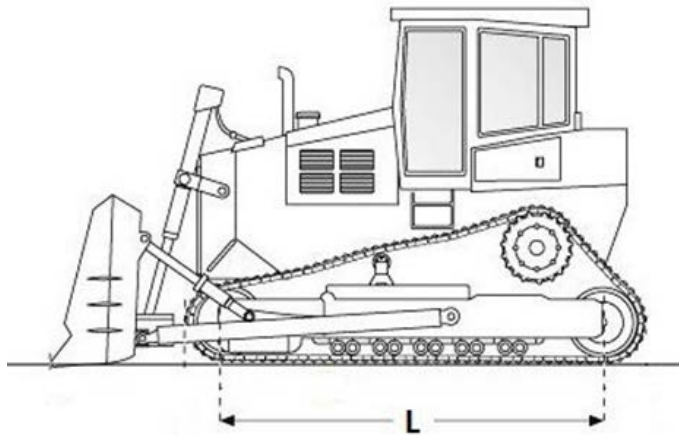
Data Sheet – Equipment with Tracks

Complete this data sheet for each piece of equipment with tracks.

Equipment with Tracks

INDICATE UNITS

Manufacturer:			
Model:			
Equipment Description:			
Fully Loaded Gross Vehicle Weight:		Weight Unit v	
	Track Shoe Width (refer to W below)	Track Length on Ground (refer to L below)	Track Gauge (on center) (refer to G below)
Units	Select Unit v	Select Unit v	Select Unit v
Track			



Add Page

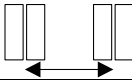
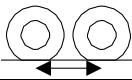
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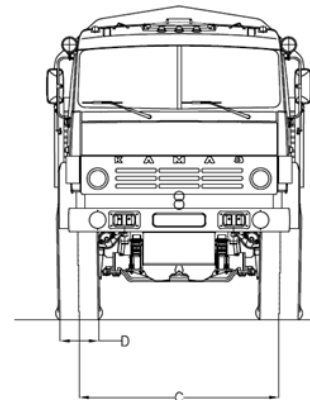
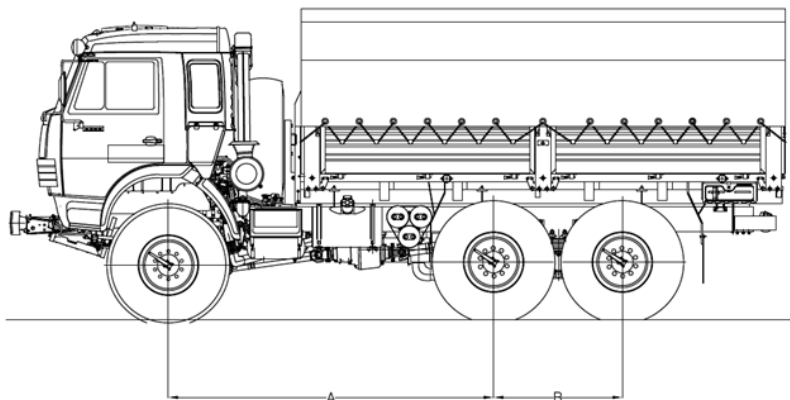
Data Sheet – Equipment or Vehicle with Tires

Complete this data sheet for **EACH** piece of equipment or vehicle with tires.
EXCLUSION: pick up trucks of one ton or less

Equipment or Vehicle with Tires

INDICATE UNITS

Manufacturer:						
Model:						
Equipment Description:						
Fully Loaded Gross Vehicle Weight:					Weight Unit v	
Road legal without overweight permit?		Yes ☐			No ☐	
Axle	Maximum Loaded Weight PER Axle	Number of Tires PER Axle	Tire Width (refer to D below)	Tire Pressure	Distance between Tire Set Centerlines (refer to C below) 	Centerline Distance to Previous Axle (refer to A below) (refer to B below) 
Units	Select Unit v		Select Unit v	Select Unit v	Select Unit v	Select Unit v
Steering						
2 nd						
3 rd						
4 th						
5 th						
6 th						
7 th						



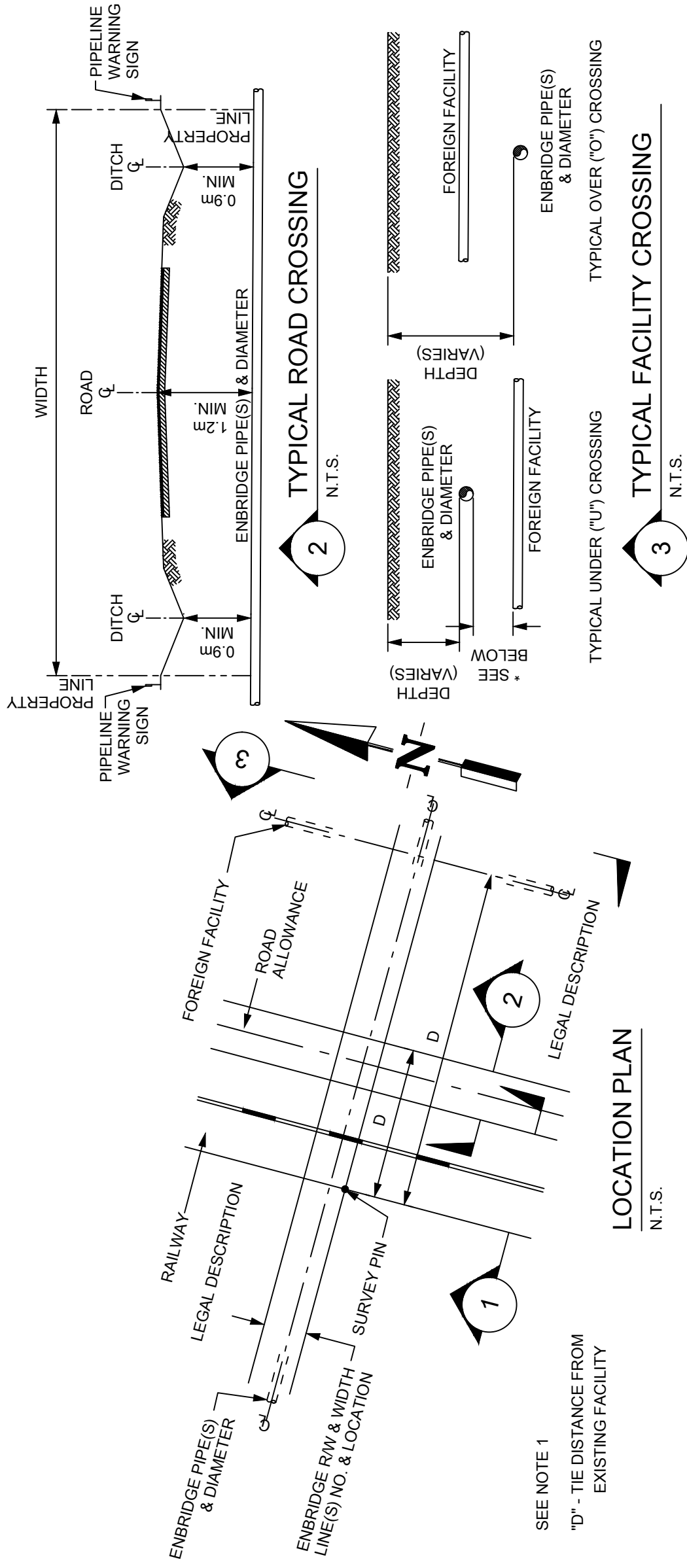
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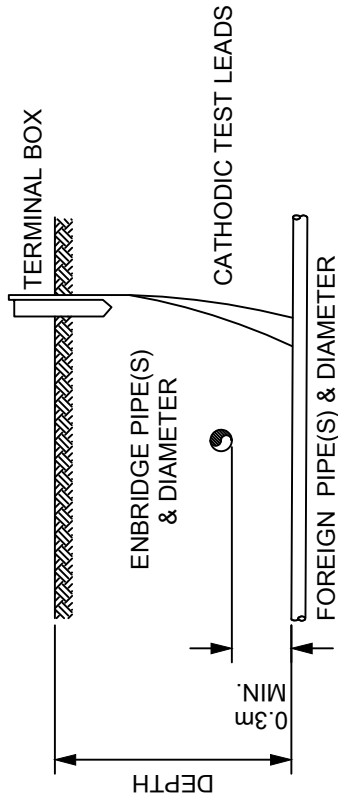
NOTE:

1.ENBRIDGE PIPELINES
OPERATE UNDER HIGH PRESSURE
THEREFORE ENBRIDGE
REPRESENTATIVE(S) MUST BE
PRESENT DURING CONSTRUCTION.

2. THIS DRAWING IS FOR
REFERENCE ONLY. ACTUAL SITE
DETAILS OR REQUIREMENTS MAY
VARY.



* MINIMUM CLEARANCE:
-0.3m IF OPEN CUT ABOVE ENBRIDGE PIPES
-0.6m IF OPEN CUT BELOW ENBRIDGE PIPELINES
-1.0m IF HDB UNDER ENBRIDGE PIPELINES
-3.0m IF HDD UNDER ENBRIDGE PIPELINES

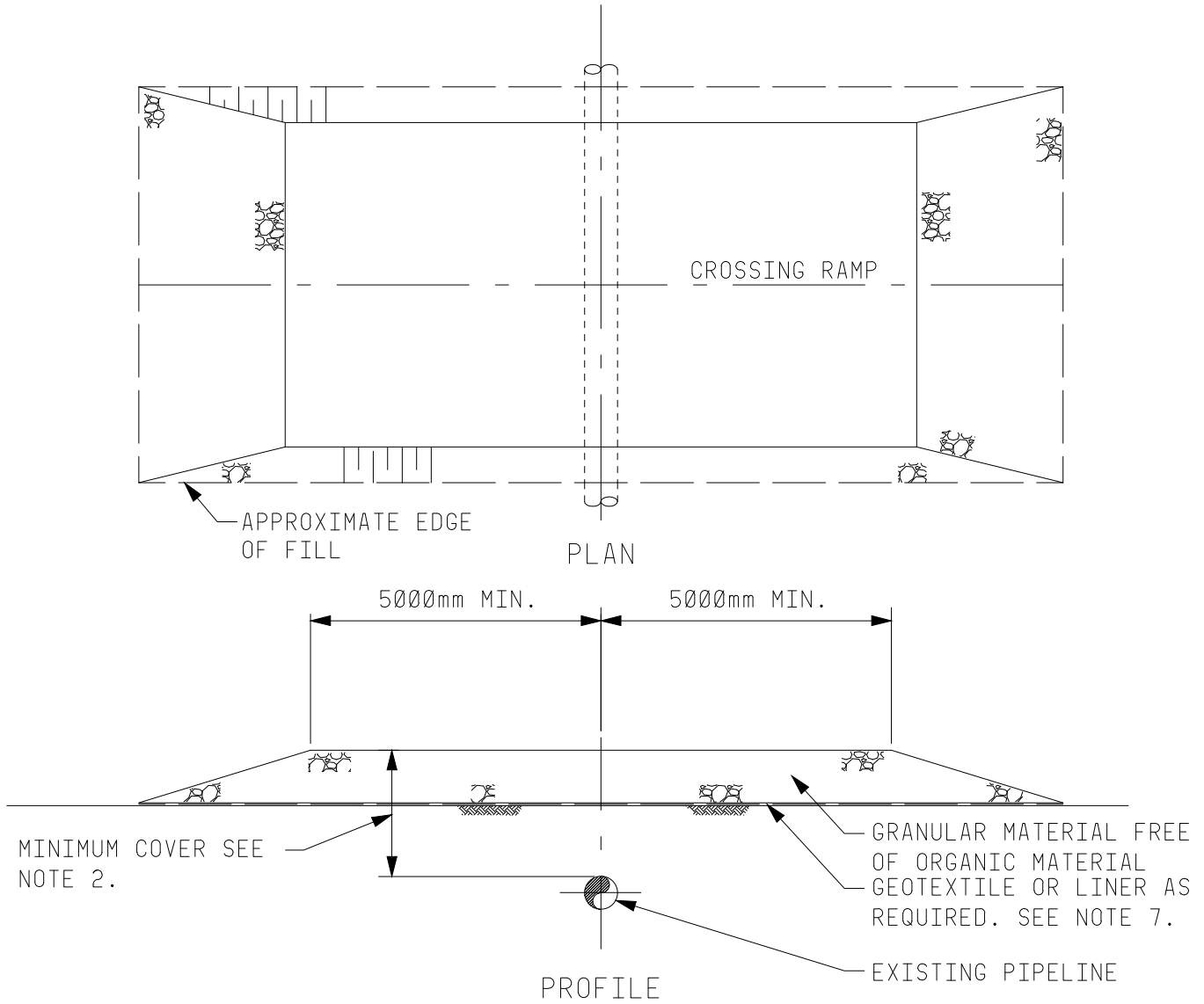


* MINIMUM CLEARANCE:	"A"	"B"
CASED	0.91m	1.68m
UNCASED	1.83m	3.05m

TYPICAL TEST LEAD CONNECTION

N.T.S.
(STEEL PIPELINES)

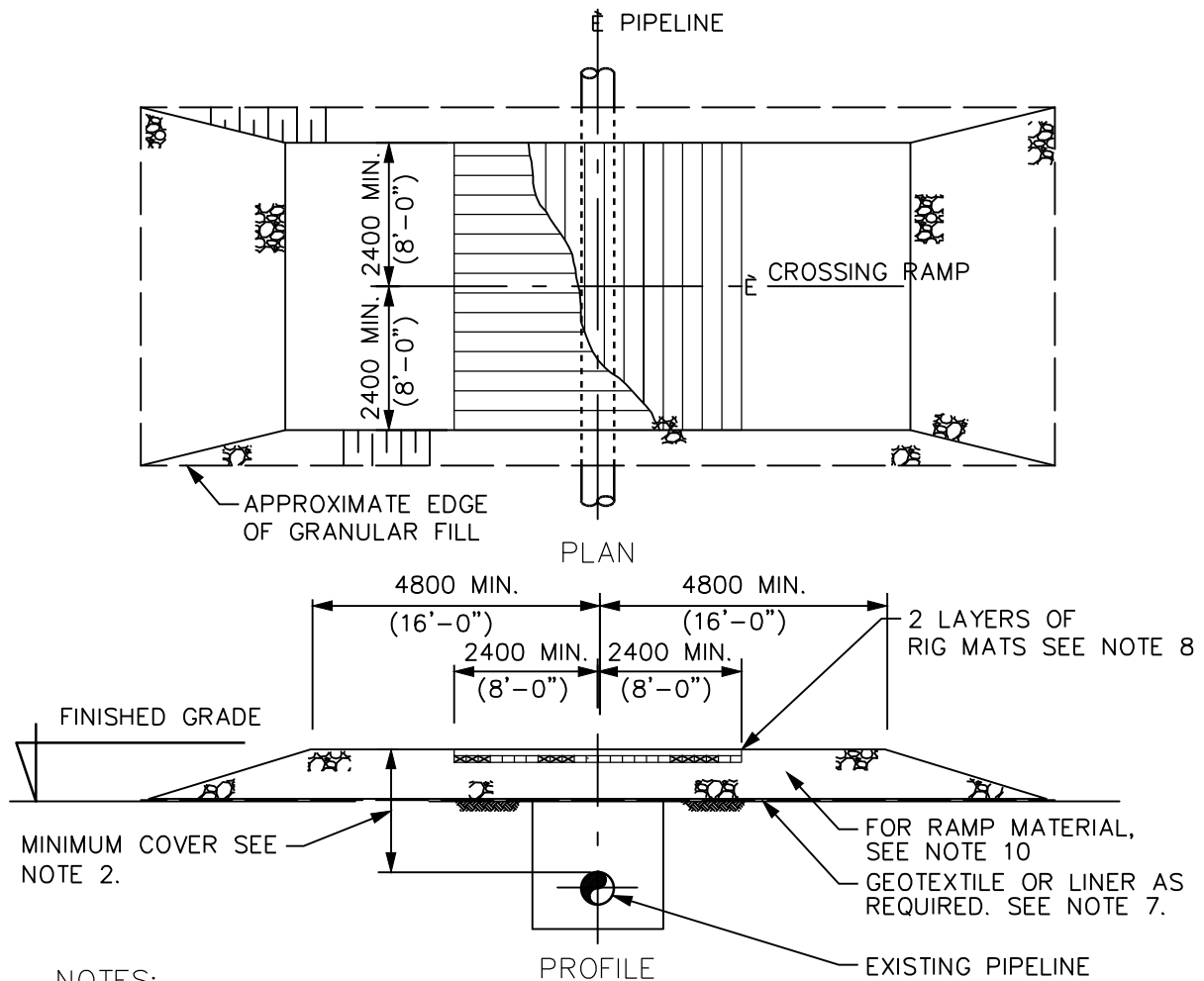
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NOTES:

- ON COMPLETION OF CONSTRUCTION, CONTRACTOR SHALL REMOVE COMPLETE RAMP AND RESTORE AREA TO ORIGINAL CONDITION.
- MINIMUM COVER SHALL BE AS SPECIFIED IN THE CROSSING AGREEMENT.
- LENGTH OF RAMP TO VARY IN ACCORDANCE WITH CROSSING ANGLE.
- RAMP WIDTH SHALL BE MINIMIZED AS MUCH AS POSSIBLE, AND SHALL NOT ENCROACH BOUNDARIES SET IN THE CROSSING AGREEMENT.
- RAMP SIDE SLOPE SHALL NOT BE STEEPER THAN 1V:4H.
- RAMP SHALL BE COMPACTED, AND HAVE A CROSS FALL TO ENSURE THAT WATER WILL NOT POND ON THE RAMP CAUSING EXCESSIVE RUTTING.
- A GEOTEXTILE OR LINER BARRIER TO BE INSTALLED AT THE DISCRETION OF THE ENBRIDGE FIELD REPRESENTATIVE.
- REFER TO DRAWING A-1.8-43105 FOR FRENCH VERSION.
REFERE AU DESSIN A-1.8-43105 POUR VERSION FRANCAISE.

A-1.8-43105-0		TYPICAL DESIGN DETAIL		2	
REFERENCE DRAWINGS					
2	FRENCH TRANSLATION REFERENCE AS PER IDR 583	2019 JAN 11	BLB	ENB	
1	AS BUILT INTERNAL DRAFTING ID 304	20 MAR 18	GB	ENBRIDGE	
REV NO.	REVISION DESCRIPTION	DATE BY	CHK	APPR.	
COPYRIGHT © THIS DRAWING IS THE PROPERTY OF ENBRIDGE AND SHALL NOT BE REPRODUCED EITHER IN WHOLE OR IN PART WITHOUT PRIOR WRITTEN CONSENT OF ENBRIDGE.					
TYPICAL DESIGN DETAIL TYPICAL TEMPORARY CROSSING RAMP WITH EARTH					
BY: GB	CHK: GG	ENG. :	ENB APPR:		
DATE: 14 FEB 18	SCALE: NTS	STATUS: AS BUILT			
DWG. NO.:	A-1.8-42872-0				REV. NO. 2



NOTES:

1. ON COMPLETION OF CONSTRUCTION, CONTRACTOR SHALL REMOVE COMPLETE RAMP AND RESTORE AREA TO ORIGINAL CONDITION.
2. MINIMUM COVER SHALL BE AS SPECIFIED IN THE CROSSING AGREEMENT.
3. LENGTH OF RAMP TO VARY IN ACCORDANCE WITH CROSSING ANGLE.
4. RAMP WIDTH SHALL BE MINIMIZED AS MUCH AS POSSIBLE, AND SHALL NOT ENCROACH BOUNDARIES SET IN THE CROSSING AGREEMENT.
5. RAMP SIDE SLOPE SHALL NOT BE STEEPER THAN 1V:4H.
6. RAMP SHALL BE COMPACTED, AND HAVE A CROSS FALL TO ENSURE THAT WATER WILL NOT POND ON THE RAMP CAUSING EXCESSIVE RUTTING.
7. A GEOTEXTILE OR LINER BARRIER TO BE INSTALLED DURING SPRING, SUMMER AND FALL SEASONS.
8. RIG MATS SHALL BE STAGGERED OR PLACED IN A PERPENDICULAR ORIENTATION FROM THE PREVIOUS LAYER SO THAT THE EDGES DO NOT LINE UP.
9. ALL DIMENSIONS ARE IN mm UNLESS OTHERWISE NOTED.
10. SNOW OR ICE CAN BE USED AT THE DISCRETION OF THE ENBRIDGE FIELD REPRESENTATIVE.
11. REFER TO DRAWING A-1.8-43106 FOR FRENCH VERSION.
REFERE AU DESSIN A-1.8-43106 POUR VERSION FRANCAISE.

A-1.8-43106-0 TYPICAL DESIGN DETAIL			
REFERENCE DRAWINGS			
3	AS BUILT DR. IDR 743	20 JUN 19 MF	AE ENB
2	FRENCH TRANSLATION REFERENCE AS PER IDR 583	11 JAN 19 MM	BLB ENB
1	AS BUILT INTERNAL DRAFTING ID 304	20 MAR 18 BLB	GB ENBRIDGE
REV. NO.	REVISION DESCRIPTION	DATE BY	CHK APPR.
COPYRIGHT © THIS DRAWING IS THE PROPERTY OF ENBRIDGE AND SHALL NOT BE REPRODUCED EITHER IN WHOLE OR IN PART WITHOUT PRIOR WRITTEN CONSENT OF ENBRIDGE.			
ENBRIDGE			
TYPICAL DESIGN DETAIL TYPICAL TEMPORARY CROSSING RAMP WITH RIG MATS			
BY: GB	CHK: GG	ENG.:	ENB APPR:
DATE: 14 FEB 18	SCALE: NTS	STATUS: AS BUILT	
DWG. NO.:	A-1.8-42873-0		REV. NO.: 3



City of Welland
Infrastructure Services
Engineering Division
60 East Main Street, Welland, ON L3B 3X4
Phone: 905-735-1700 | **Fax:** 905-735-7184
Email: eng@welland.ca | www.welland.ca

September 28, 2022

Enbridge
10175 101 St NW
Edmonton, Alberta, T5J 0H3

Sent via email to: jilunga@bapq.ca

RE: Enbridge Comments Regarding the Welland Pollution Prevention & Control Plan Update and Wastewater Master Servicing Plan

Dear Joanna Ilunga,

Thank you for your response noting the presence of Enbridge pipelines in the City of Welland municipal boundary. The City acknowledges the request to include the Enbridge pipeline mapping and additional recommendations for the **Welland Pollution Prevention & Control Plan & Wastewater Master Servicing Plan (PPCP and WW MSP)**; however,

- The City notes that the identified pipeline and associated 200 m buffer areas crossing the northeast Welland municipal boundary are not located in the vicinity of any developments identified through PPCP and MSP study, which were limited within the Welland urban boundary area.
- In Section 13.2.3, the report acknowledges that projects identified in the capital program will include studies to proceed including Impacts to Utilities. At the time of those further studies or design phases, the Utility would be contacted per existing City policies and agreements with Enbridge.

The requirements outlined will be further reviewed and applied as required as part of the subsequent detailed design process, and through construction.

If you have any other questions or require additional information, please feel free to contact the undersigned.

Sincerely,

Matthew Main, P.Eng.
Infrastructure and Asset Manager
Engineering Division
City of Welland
60 East Main Street,
Welland, Ontario, L3B 3X4
matthew.main@welland.ca
905-735-1700

Julien Bell, P.Eng.
Project Manager
GM BluePlan Engineering
1266 South Service Road, Unit C31
Stoney Creek, ON L8E 5R9
julien.bell@gmbblueplan.ca
519-748-1440 ext. 4264

Aug. 15, 2022

Matthew Main
City Project Manager
City of Welland

Dear Matthew,

We are the Mississaugas of the Credit First Nation (MCFN), the descendants of the Mississaugas of the River Credit. Our traditional territory extends from the Rouge River Valley in the east, across to the headwaters of the Thames River, down to Long Point on Lake Erie, and back along the shores of Lake Erie, the Niagara River, and Lake Ontario to the Rouge River Valley. It encompasses present-day London, Hamilton, and Toronto, as well as our communal lands. Our traditional territory has defined and sustained us as a First Nation for countless generations, and must continue to do so for all our generations to come.

Thank you for your notification on *Welland Pollution Prevention Control Plan* dated July 5, 2019. The MCFN has treaty rights across its traditional territory, including the area contemplated by your project. For further information, please see our website, <http://www.newcreditfirstnation.com/>. MCFN continues to exercise treaty rights which include, but are not limited to, rights to harvest, fish, trap and gather species of plants, animals and insects for any purpose including food, social, ceremonial, trade and exchange purposes. The MCFN also has the right to use the water and resources from the rivers, creeks and lands across the MCFN traditional territory.

At this time, MCFN *does not* have a high level of concern regarding the proposed project and therefore, by way of this letter, approves the continuation of this project. However, MCFN requests that you continue to notify us about the status of the project. **In addition, we respectfully ask you to immediately notify us if there are any changes to the project as they may impact MCFN's interests and that you please provide us with a copy of all associated environmental and archaeology reports.** This includes, but is not limited to changes related to the scope of work and expected archaeological and environmental impacts.

Additionally, MCFN employs Field Liaison Representatives ("FLRs") to act as official representatives of the community and who are answerable to MCFN Chief and Council through the Department of Consultation and Accommodation. The FLRs' mandate is to ensure that

DEPARTMENT OF CONSULTATION AND ACCOMMODATION

Mississaugas of the Credit First Nation
4065 Hwy #6, Hagersville, Ontario N0A 1H0



Phone: (905) 768-4260



MCFN's perspectives and priorities are considered in the field and to enable MCFN to provide timely, relevant, and meaningful comment on the Project. Therefore, **it is MCFN policy that FLRs are on location whenever any fieldwork for environmental and/or archaeological assessments are undertaken.** It is expected that the proponent will cover the costs of this FLR participation in the fieldwork. Please also provide the contact information of the person, or consultant, in charge of organizing this work so they may facilitate the participation of the MCFN FLRs.

Nothing in this letter shall be construed as to affect the Aboriginal or Treaty rights and hence shall not limit any consultation and accommodation owed to MCFN by the Crown or any proponent, as recognized by section 35 of the Constitution Act, 1982.

MCFN reserves the right in relation to any development project or decision, to decide whether it supports a project and to: comment to regulators, participate in regulatory processes and hearings, seek intervener funding or status, or to challenge and seek remedies through the courts.

MCFN expects the Crown and all proponents to act according to the following best practices:

- Engage early in the planning process, before decisions are made
- Provide information in meaningful and understandable formats.
- Convey willingness to transparently describe the project and consider MCFN concerns.
- Recognize the significance of cultural activities and traditional practices of the MCFN
- Demonstrate a respect for MCFN knowledge and uses of land and resources.
- Understand the importance of youth and elders in First Nation communities.
- Act with honour, openness, transparency and respect.
- Be prepared to listen and allow time for meaningful discussion.

Sincerely,



Abby LaForme
Acting Consultation Coordinator
MCFN Department of Consultation and Accommodation

cc – Mark LaForme; Director, Department of Consultation and Accommodation

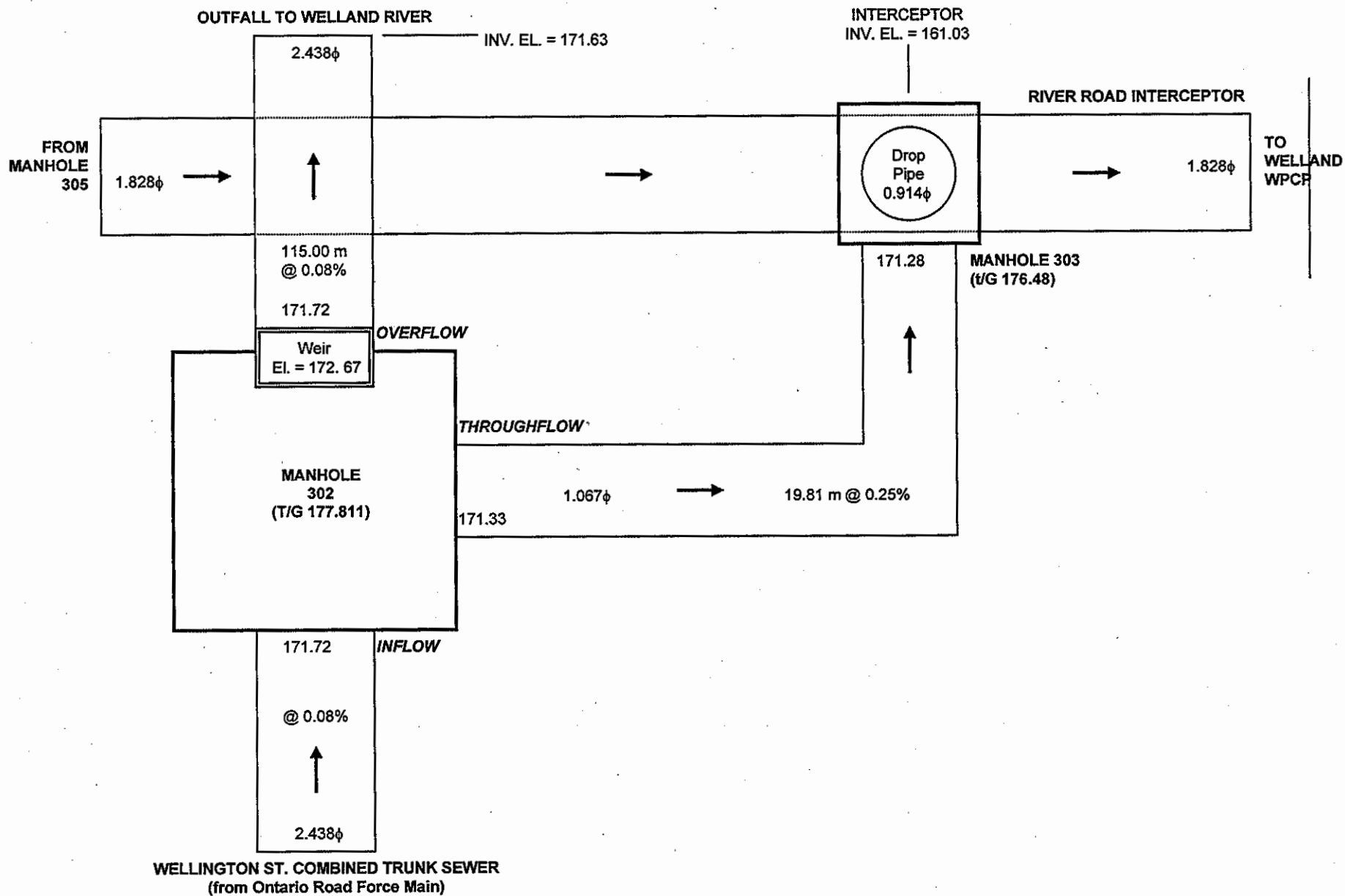


APPENDIX E:

RVA CSO Schematics

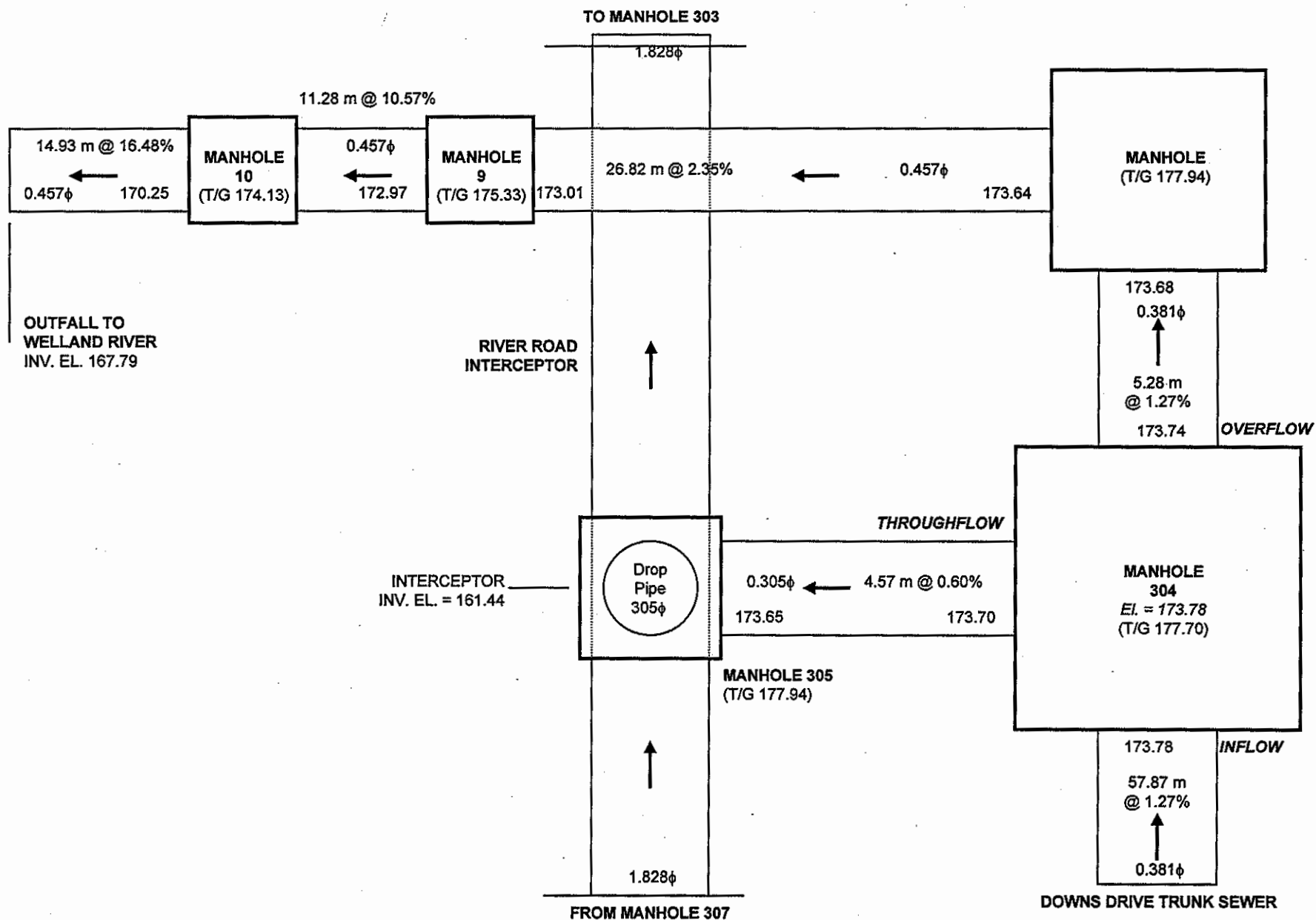
OAW REGULATOR SCHEMATIC

All values in metres. Not to scale.



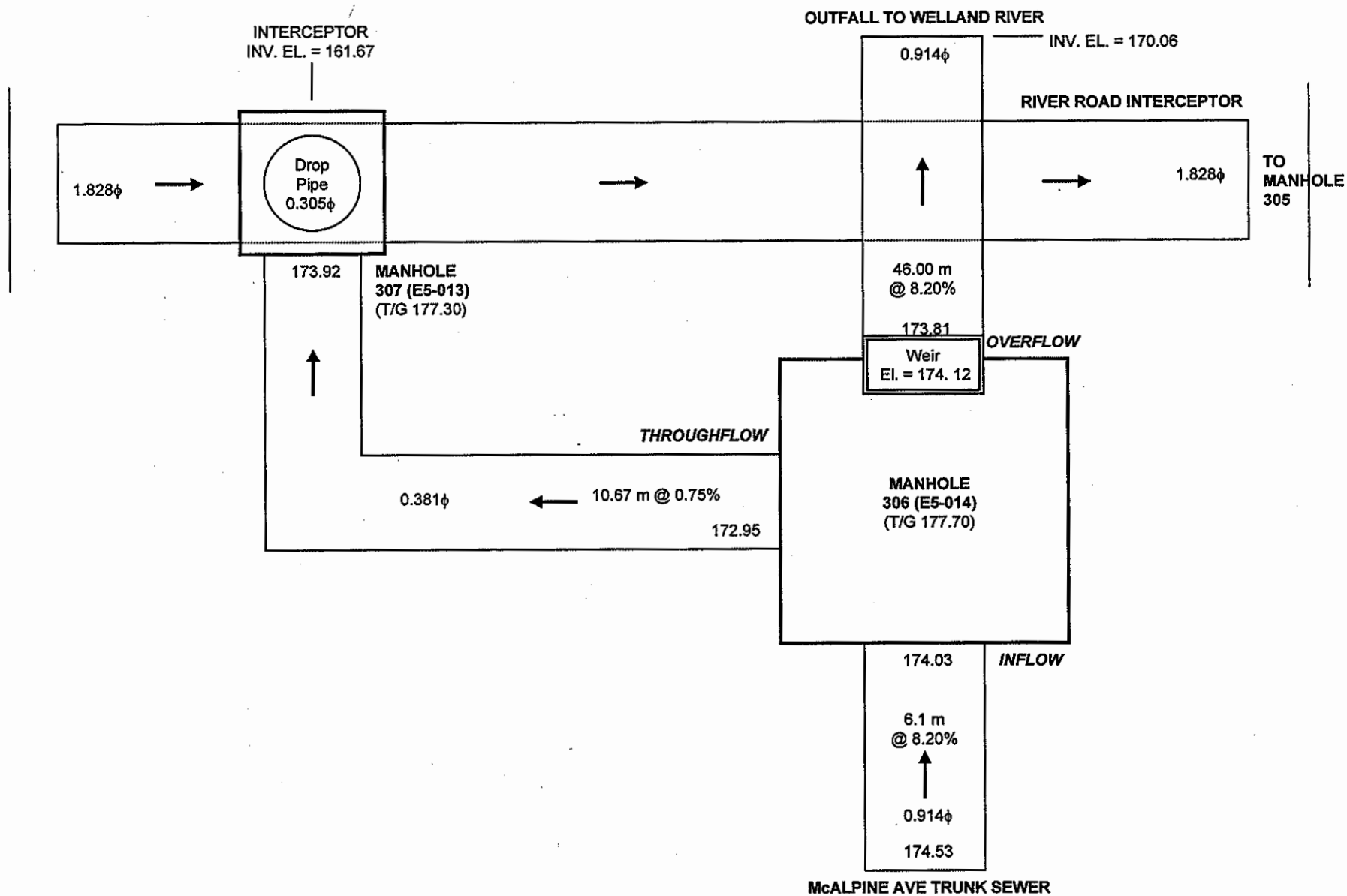
DOWN'S DRIVE REGULATOR SCHEMATIC

All values in metres. Not to scale.



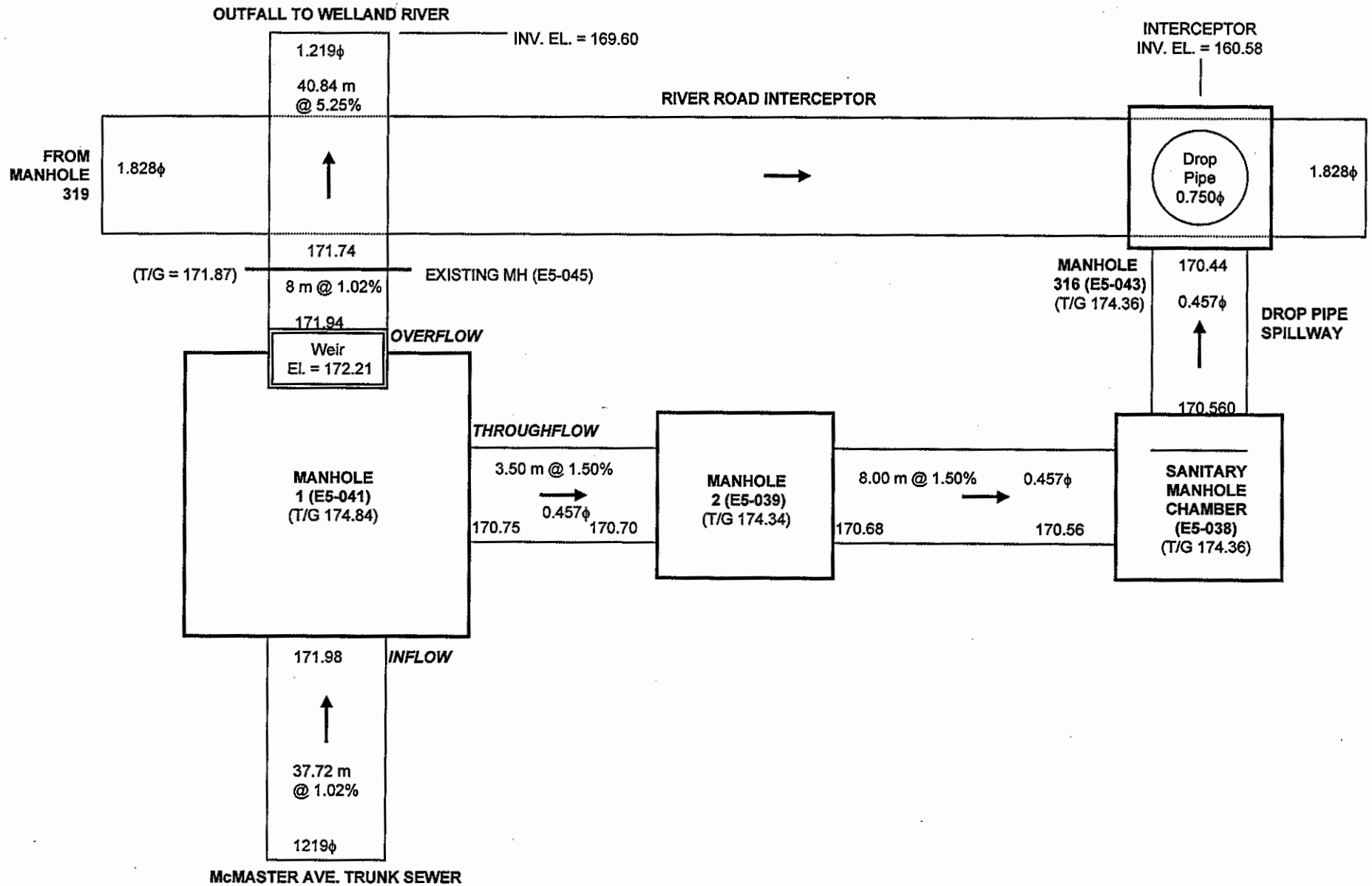
McALPINE AVENUE REGULATOR SCHEMATIC

All values in metres. Not to scale.



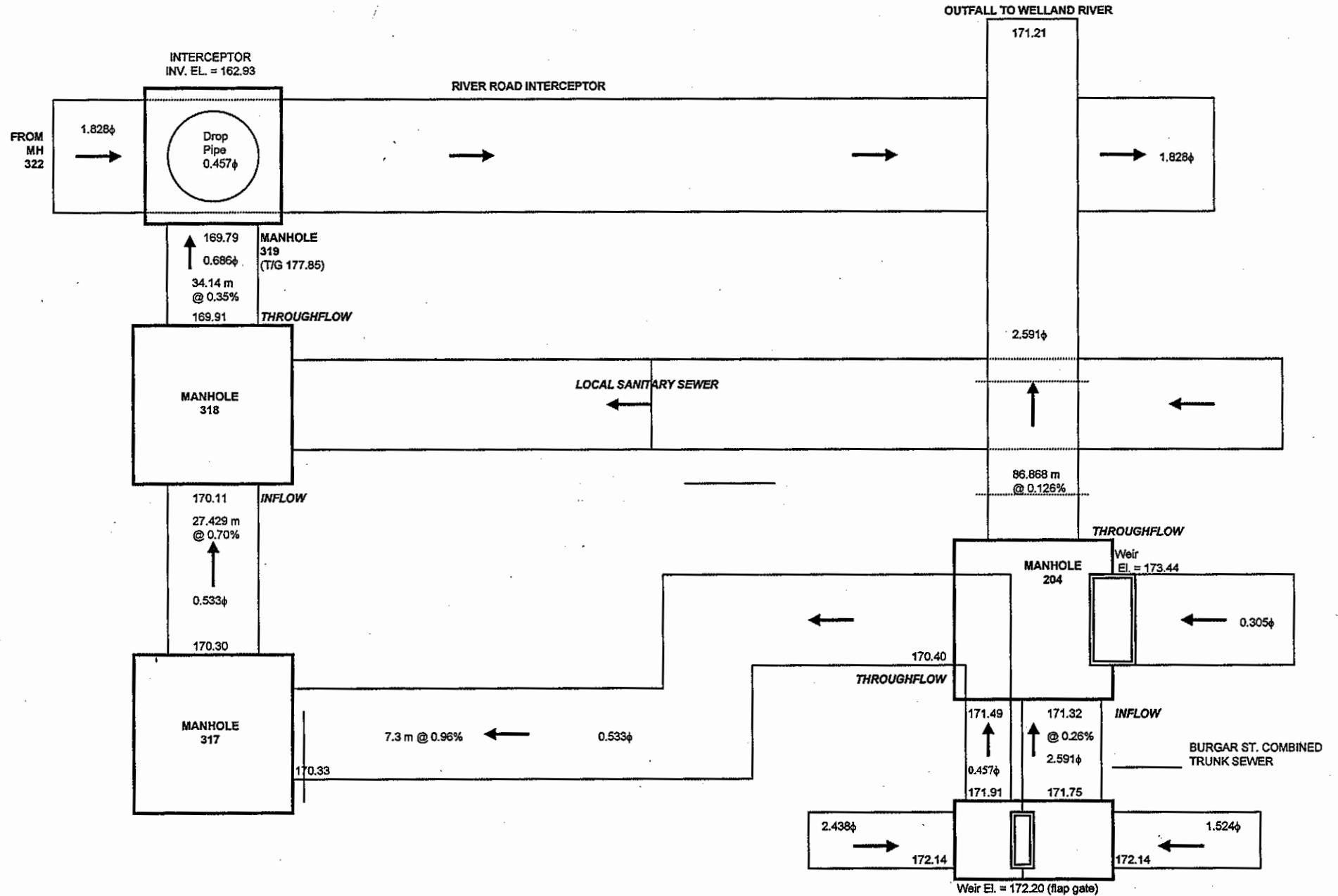
McMASTER AVENUE REGULATOR SCHEMATIC

All values in metres. Not to scale.



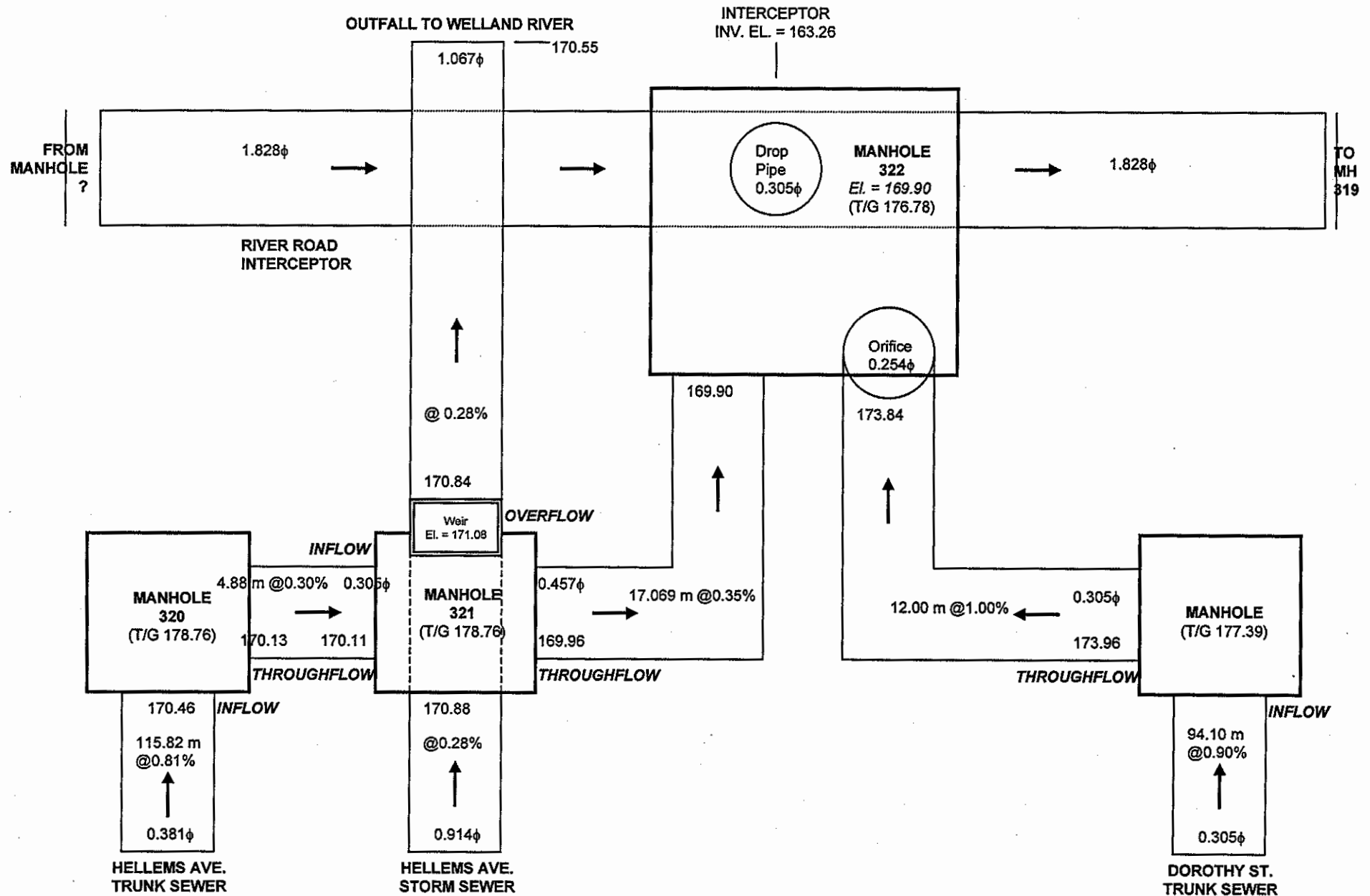
BURGAR STREET REGULATOR SCHEMATIC

All values in metres. Not to scale.



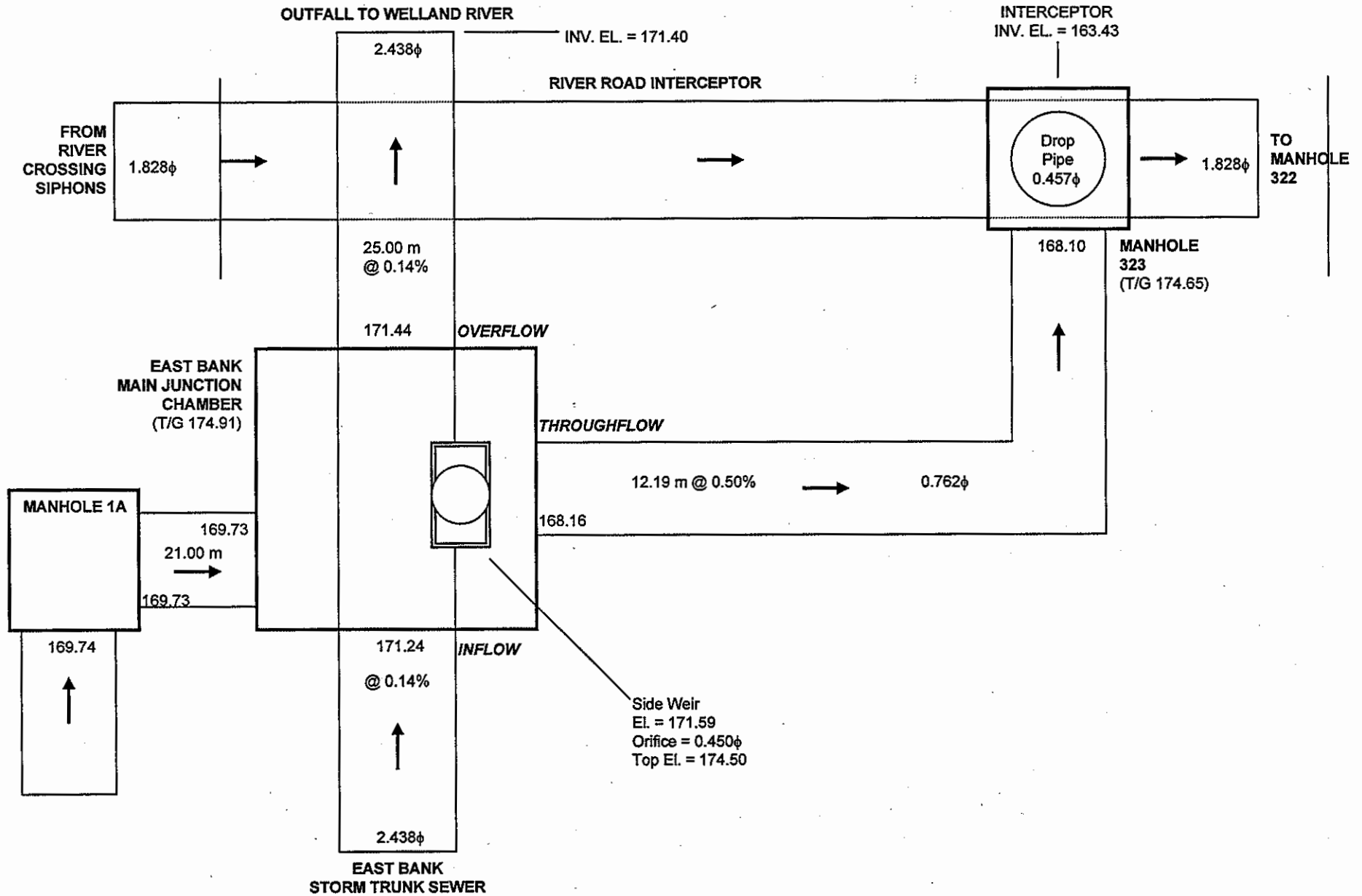
HELLEMS AVENUE REGULATOR SCHEMATIC

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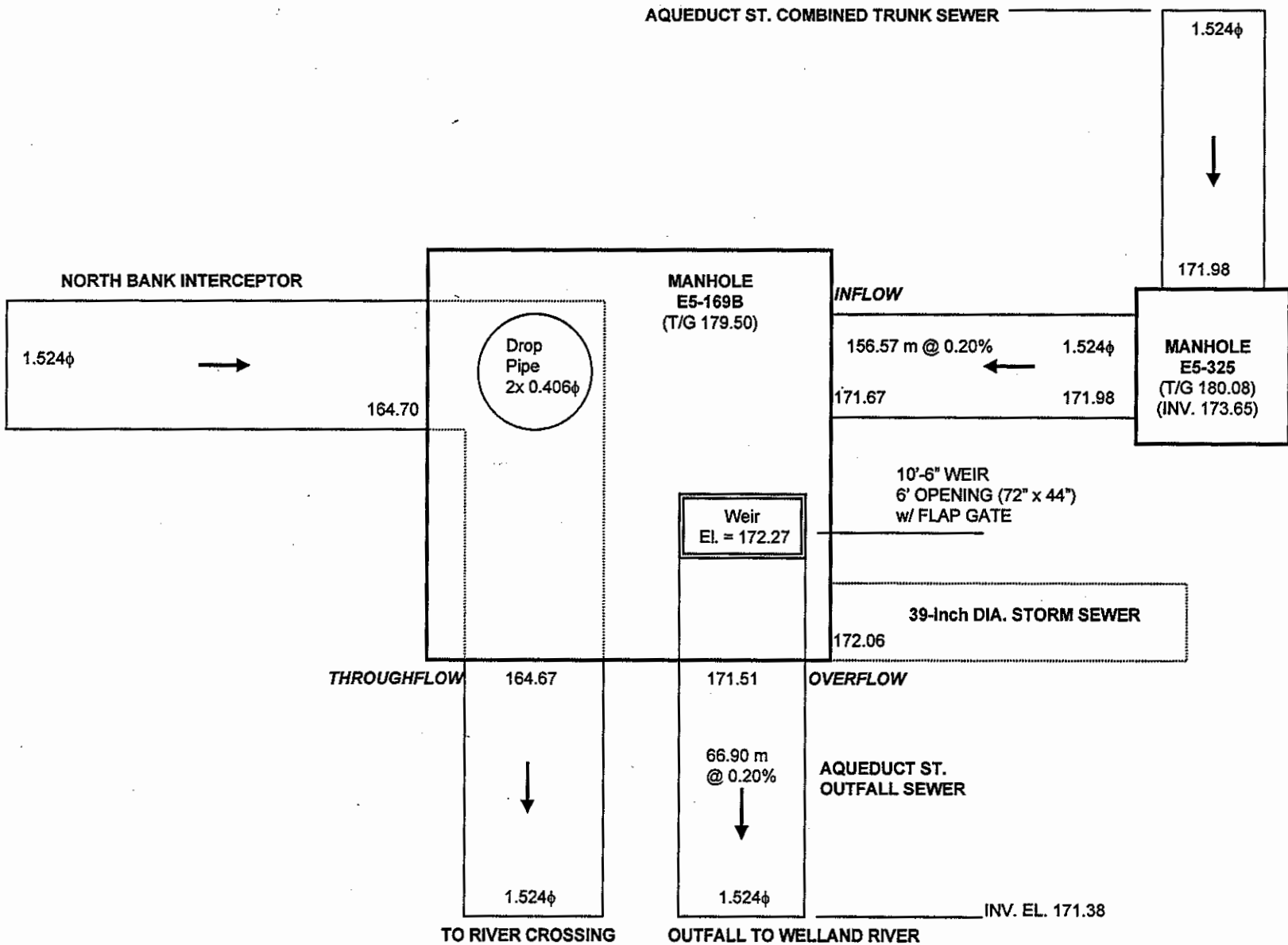
KING STREET REGULATOR SCHEMATIC

All values in metres. Not to scale.



AQUEDUCT STREET REGULATOR SCHEMATIC

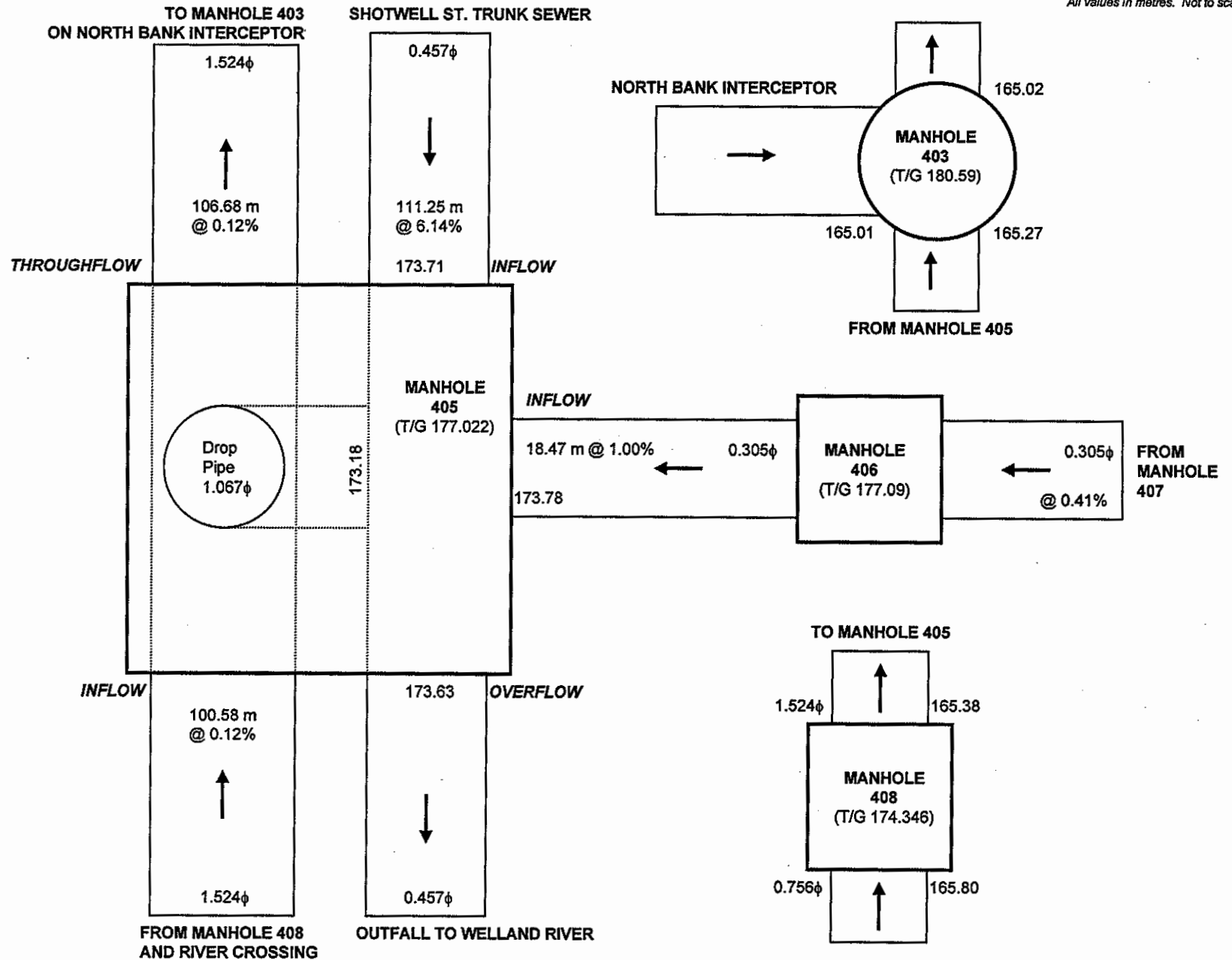
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INTERCEPT _____
INV. EL. = 165.567

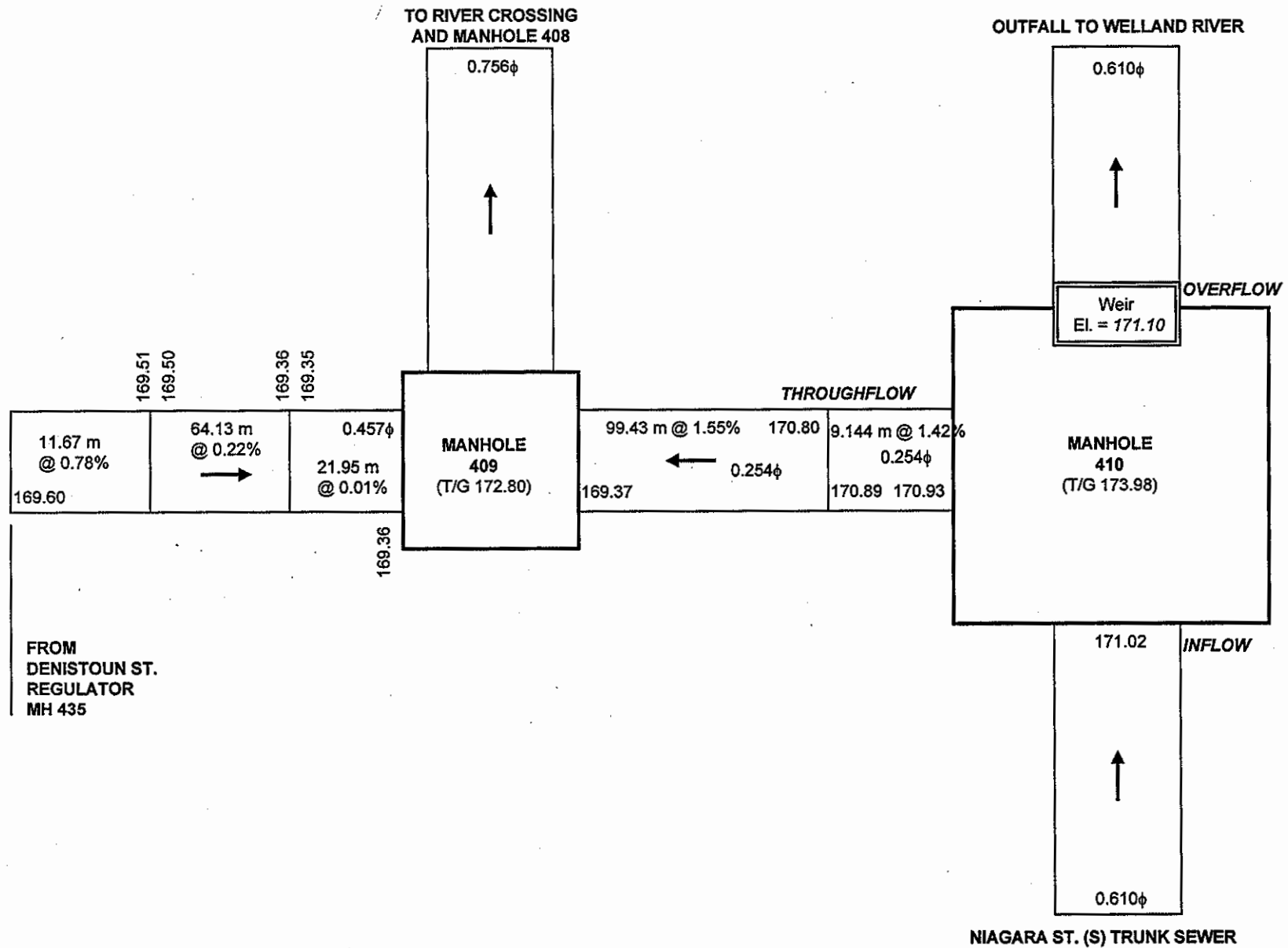
SHOTWELL STREET REGULATOR SCHEMATIC

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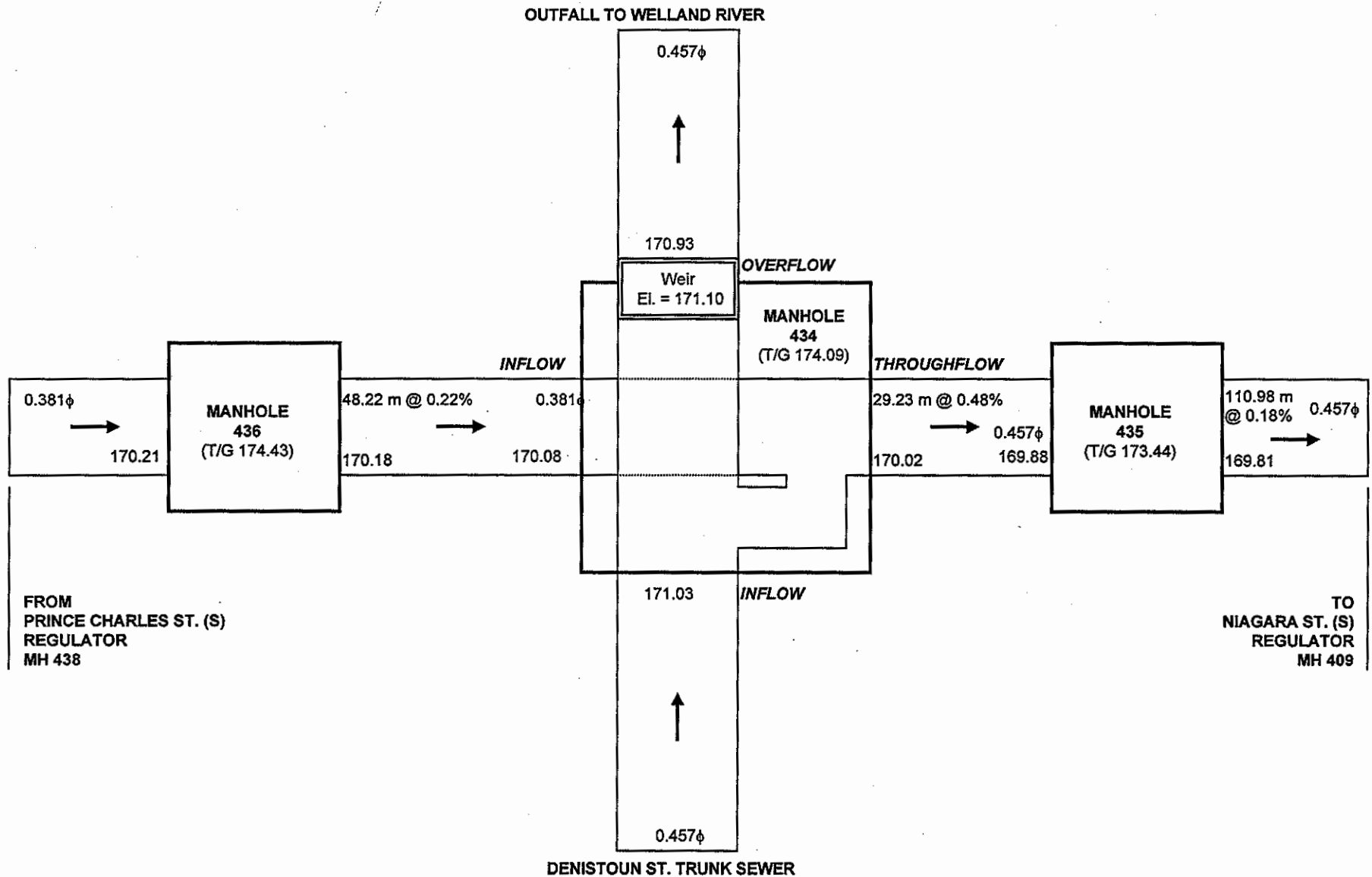
NIAGARA STREET (S) REGULATOR SCHEMATIC

All values in metres. Not to scale.



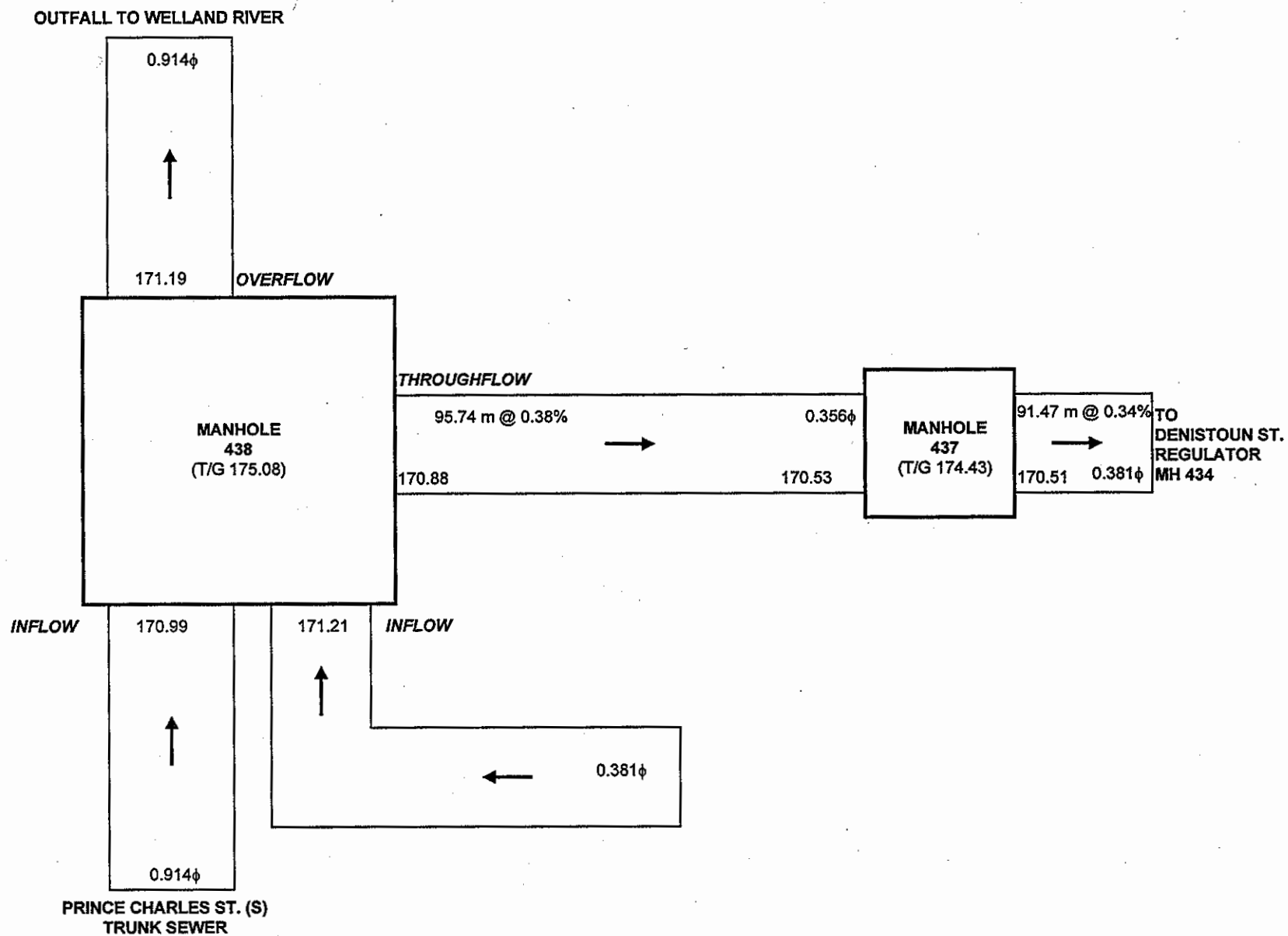
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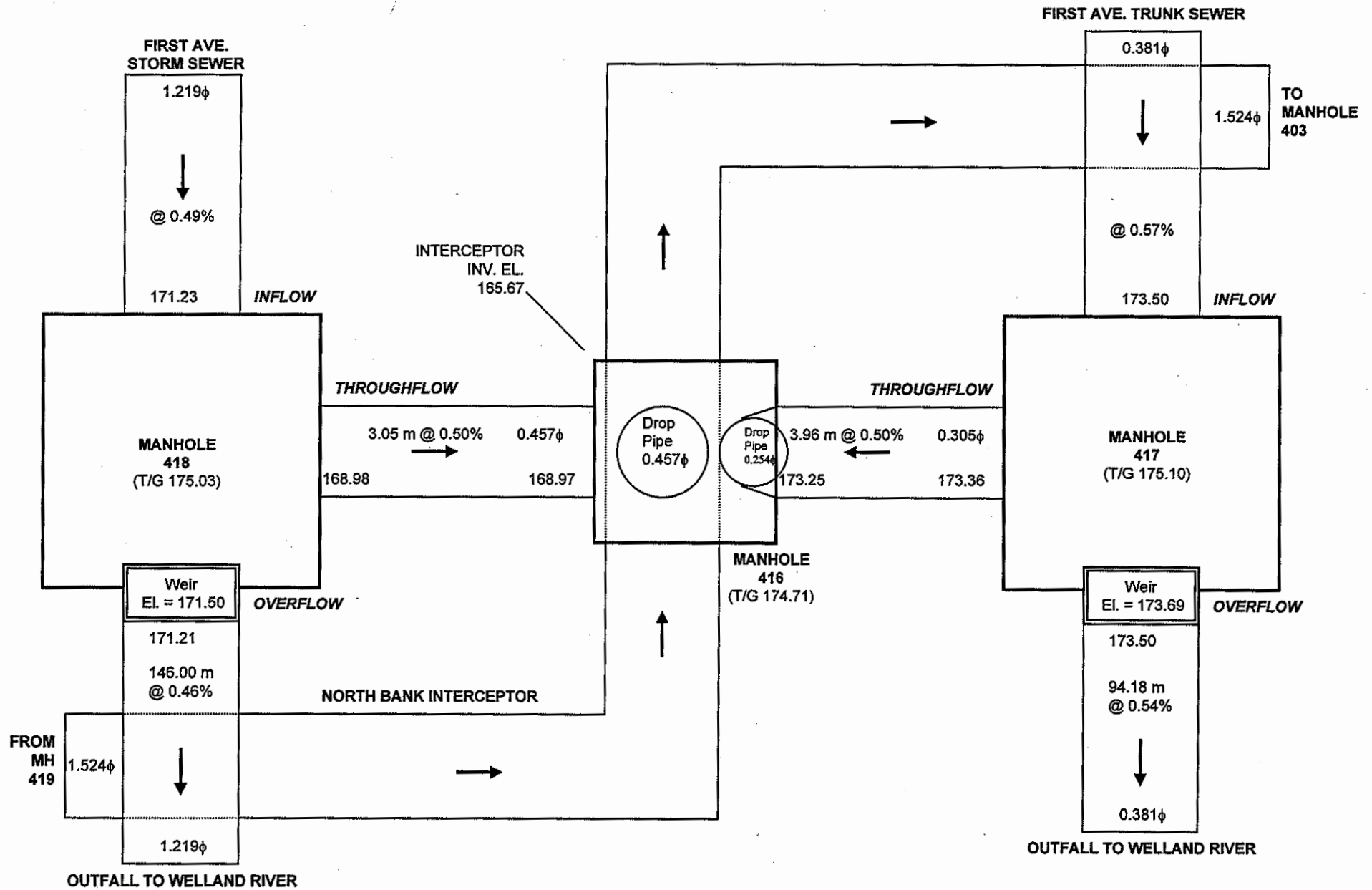
PRINCE CHARLES STREET (S) REGULATOR SCHEMATIC

All values in metres. Not to scale.



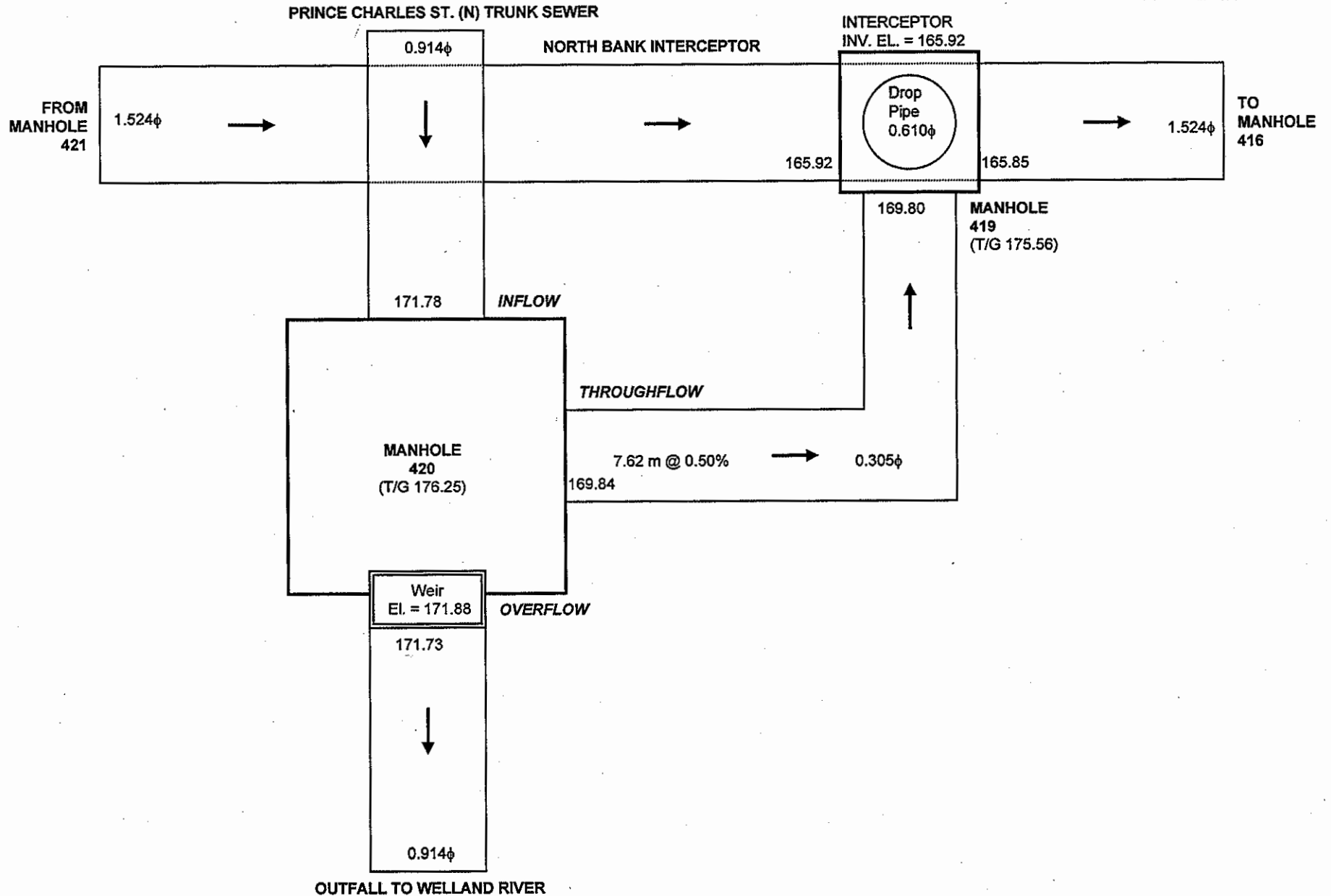
FIRST AVENUE REGULATOR SCHEMATIC

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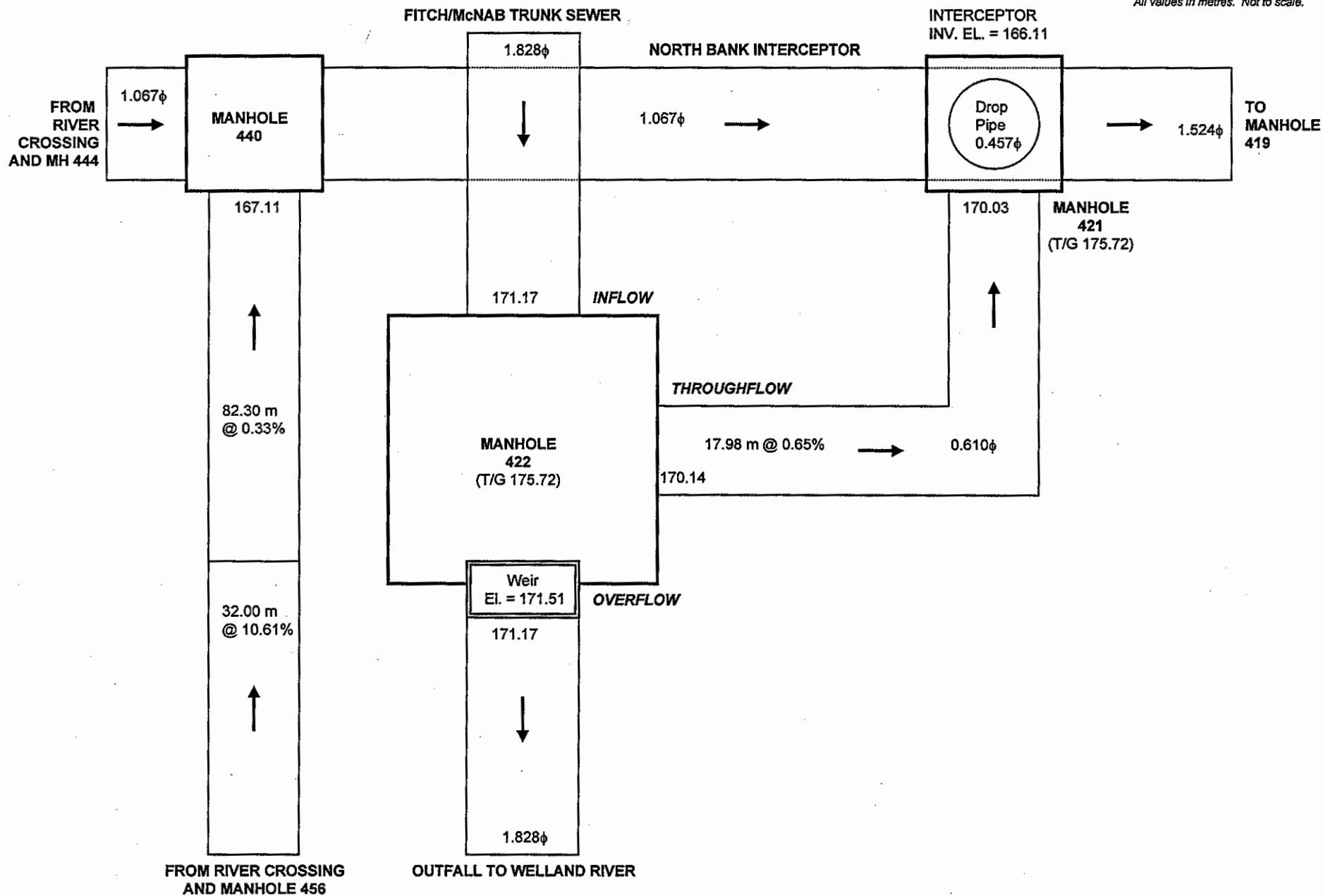
PRINCE CHARLES STREET (N) REGULATOR SCHEMATIC

All values in metres.. Not to scale.



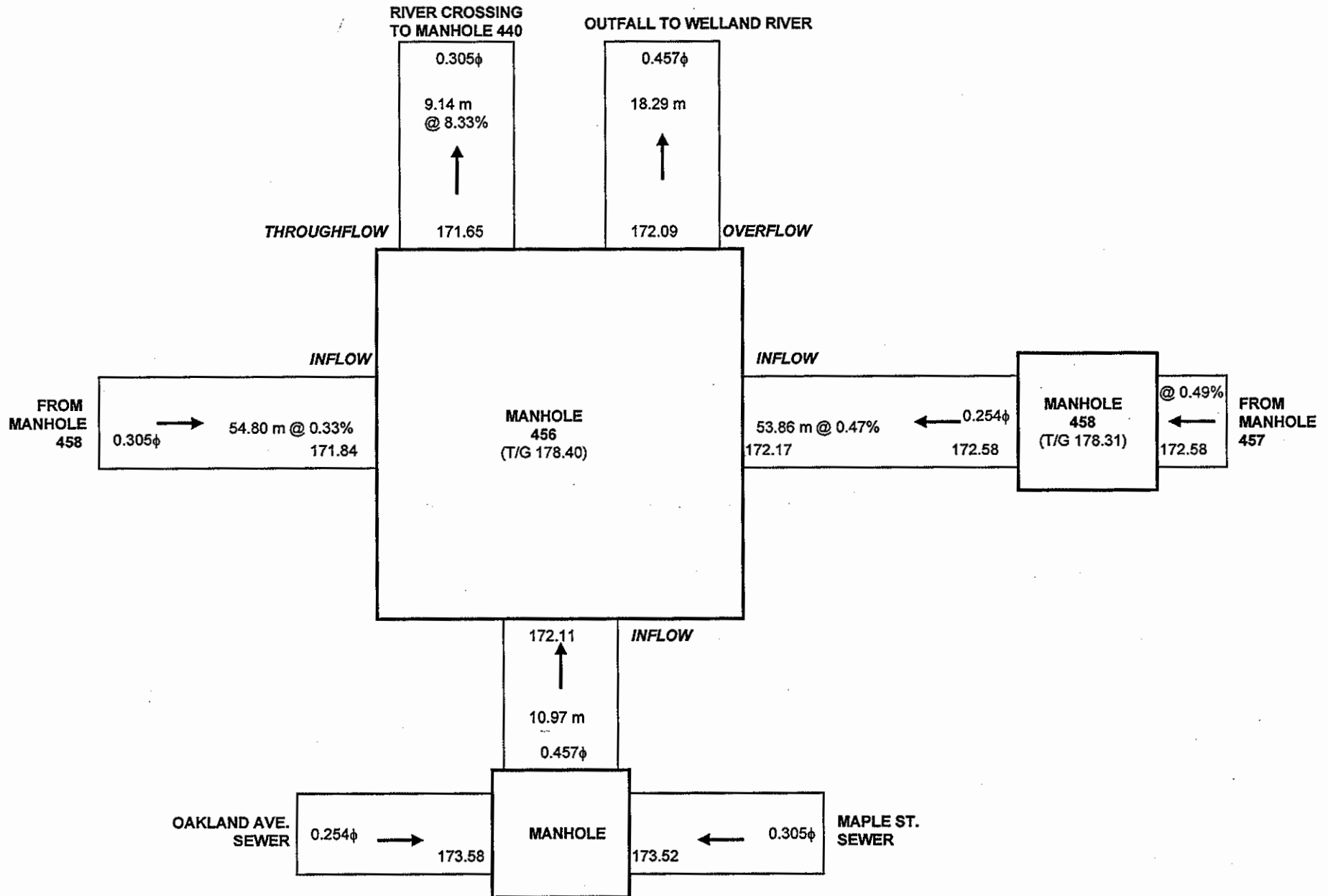
FITCH/McNAB REGULATOR SCHEMATIC

All values in metres. Not to scale.



RIVERSIDE DRIVE AND MAPLE STREET REGULATOR SCHEMATIC

All values in metres. Not to scale.



APPENDIX F:

MECP F-5-1 Effluent Criteria

MOECC F-5-1 Effluent Criteria for Secondary Treatment or Equivalent

Treatment Level and Processes ¹	Effluent Design Objectives (mg/L) - BOD ₅	Effluent Design Objectives (mg/L) - SS	Effluent Design Objectives (mg/L) - TP	Effluent Design Objectives (mg/L) - (NH ₃ +NH ₄ ⁺)-N	Effluent Guidelines (mg/L) - BOD ₅	Effluent Guidelines (mg/L) - SS
Conventional Activated Sludge without TP removal	15	15	n/a	n/a	25	25
Conventional Activated Sludge with TP removal	15	15	1.0	n/a	25	25
Contact Stabilization with TP removal	20	20	n/a	n/a	25	25
Extended Aeration without TP removal	15	15	n/a	n/a	25	25
Continuous Discharge Lagoon without TP removal	25	30	n/a	n/a	30	40
Continuous Discharge Lagoon with TP removal	25	30	1.0	n/a	30	40
Seasonal Retention Lagoon without TP removal	25	30	n/a	n/a	30	40
Seasonal Lagoon with TP removal by batch chemical dosage	15	20	0.5 to 1.0	n/a	25	25
Seasonal Retention Lagoon with TP removal by continuous chemical dosage	25	30	1.0	n/a	30	40
Physical-chemical Treatment	20	20	1.0	n/a	25	25

¹ <https://www.ontario.ca/page/f-5-1-determination-treatment-requirements-municipal-and-private-sewage-treatment-works>. Accessed 20 September, 2019

APPENDIX G: Welland IDF Update



**CITY OF WELLAND
COST:BENEFIT ASSESSMENT OF AN
UPDATED STORM DRAINAGE DESIGN STANDARD**

Prepared by:

AMEC Environment & Infrastructure
(a Division of AMEC Americas Limited)
3215 North Service Road
Burlington, Ontario, Canada
L7N 3G2



June 2014

Report No.: TP113081-001



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Please note that this document has been formatted for double sided printing

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APPROVALS

DRAFT

June 20, 2014

Prepared by: Peter Nimmrichter, M.Eng., P.Eng.
Ben Harding., P.E.

Date

DRAFT

June 20, 2014

Reviewed by: Ron Scheckenberger, P.Eng., Project Manager

Date

Rev.	Description	Prepared By	Checked	Date
1	Draft for Client Review	BH, PN	RS	June 20, 2014



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1 INTRODUCTION

A comprehensive climate change risk assessment and adaptation planning study was completed for the City of Welland in February 2012. The assessment considered impacts to the municipality's stormwater and wastewater collection infrastructure, including the wastewater treatment plant. The risk assessment followed the climate change vulnerability assessment protocol developed by the Public Infrastructure Engineering Vulnerability Committee (PIEVC) of Engineers Canada (ref. AMEC, 2012).

A component of the risk assessment study was an update of the City of Welland's 1960's vintage Intensity-Duration-Frequency (IDF) rainfall data and development of projected IDF curves. The objective of the projected IDF work effort was to develop IDF curves reflective of the changes in the characteristics of precipitation that might be caused by projected changes in climate. IDF relationships were obtained/developed for the present (namely the 2000 Environment Canada IDF relationship¹) and two future time frames, namely 2020 and 2050.

It was anticipated that review of this compendium of past, present and future IDF data would establish appropriate direction for re-definition of rainfall design standards for the City of Welland. However, this review suggested that adoption of the 2000 IDF data over the 1963 would effect a relaxation of planning standards for many types of infrastructure. Further, uncertainties embodied within the projected IDF relationships did not establish a clear path forward in this regard.

As such, the following recommendations were made as an outcome of the risk assessment of City of Welland infrastructure, coupled with the development of current and projected IDF relationships for the Environment Canada weather stations at Port Colborne:

- Firstly, it was recommended that the implications (as related to performance and life cycle costing) of the application of the current Environment Canada (i.e., 2000) or the projected (i.e., 2020 and 2050) IDF relationships, developed for the risk assessment, be evaluated to determine long-term applicability for the storm sewer collection system design, operation and maintenance.
- Secondly, it was recommended that the implications of a change from the current design standard, namely a 2 year design rainfall event, to a 5 year or a 10 year design rainfall event should be evaluated in the context of current sewer infrastructure capital plans, performance metrics and long-term sewer objectives.

This report documents evaluations completed towards addressing the matters identified in these two recommendations.

¹ This IDF relationship was published by Environment Canada in 2007 but only included data to 2000.

1.1 Project Objectives

The main objectives for this project are:

- Update of the projected IDF relationships incorporating the newly published (2012/02/09) Environment Canada IDF data for Port Colborne.
- Assessment of the influence of the various IDF rainfall relationships on the design of stormwater management end-of-pipe systems, largely related to stormwater management quantity control, as well as conveyance systems.
- Assessment of a shift in the current municipal design criteria for sizing of storm sewers, 2 year return period, to a 5 year return period or a 10 year return period.

2 IDF RELATIONSHIPS UPDATE

2.1 Overview

An objective of the 2012 climate change risk assessment study was the update the City of Welland's 1960's vintage Intensity Duration Frequency (IDF) rainfall data (see Table 2-1A, Table 2-1B and Appendix A). This objective was extended to also include development of future IDF data for the project time periods (2020 and 2050). The update and projection effort was based on rainfall data published by Environment Canada in 2010 for the weather station at Port Colborne (gauge #6136606).

The current study has updated the projected IDF curves to incorporate a newly-issued historical IDF curve published in 2012. All methodologies for developing the projected IDF curves have remained the same. The background data behind one component of the IDF projection analysis was updated and the results of that update are described in detail below. The historical IDF curve used in the previous version of the report was published in 2010, though it only contained data through 2000. In 2012, an updated IDF curve (referred to in this addendum as the 2012 historical IDF) was issued based on analysis of observations at the Port Colborne station through 2007, hence offering an additional seven (7) years of recent rainfall data.

Table 2-1A: Current City of Welland Design Rainfall Data ²				
Return Period (yrs)	a	b	c	$i = \frac{a}{(t + b)^c}$ <i>i</i> = intensity (mm/hr) <i>t</i> = storm duration (min)
2	755	8.0	0.789	
5	830	7.3	0.777	
10	860	6.5	0.763	
25	900	5.2	0.745	
50	960	5.1	0.736	
100	1020	4.7	0.731	

Table 2-1B: Current City of Welland Design Rainfall Intensity						
Duration	Rainfall Intensity (mm/hr) by Return Period (yrs)					
	2	5	10	25	50	100
5 min	99.8	118.1	133.4	159.5	175.0	193.8
10 min	77.2	90.6	101.3	118.5	130.2	143.0
15 min	63.6	74.4	82.8	95.9	105.5	115.4
30 min	42.8	49.9	55.3	63.4	70.0	76.3
1 hr	27.0	31.5	35.0	40.1	44.4	48.4
2 hr	16.4	19.2	21.4	24.7	27.5	30.0
4 hr	9.8	11.5	12.9	14.9	16.8	18.3
6 hr	7.1	8.4	9.5	11.1	12.5	13.7
12 hr	4.2	5.0	5.6	6.7	7.5	8.3
24 hr	2.4	2.9	3.3	4.0	4.5	5.0

² Source: City of Welland, 2011

2.2 Updated Historical IDF Curves

The 2012 historical IDF curve was obtained from Environment Canada. This IDF was published in 2012 and incorporates extreme event data from 1964 through 2007; the historical IDF data used for the previous work was published in 2010 and incorporates extreme event data from 1964 through 2000. Figure 2-1 shows the 2012 historical IDF curve. Table 2-2 shows the underlying data. Table 2-3 shows the precipitation intensities from the 2012 historical IDF curve from Environment Canada. The 2010 historical IDF curve from Environment Canada is also presented in Table 2-3 for comparison purposes. As indicated in the comparison table (ref. Table 2-3), the change in IDF relationships based on the additional seven (7) years of data is minor for short duration events (up to 2 hours) across all return periods but slightly larger (up to about 7%) for longer durations and less frequent events. Table 2-4 provides Chicago Storm hyetograph parameterization for the 2010 and 2012 Environment Canada IDF data, respectively.

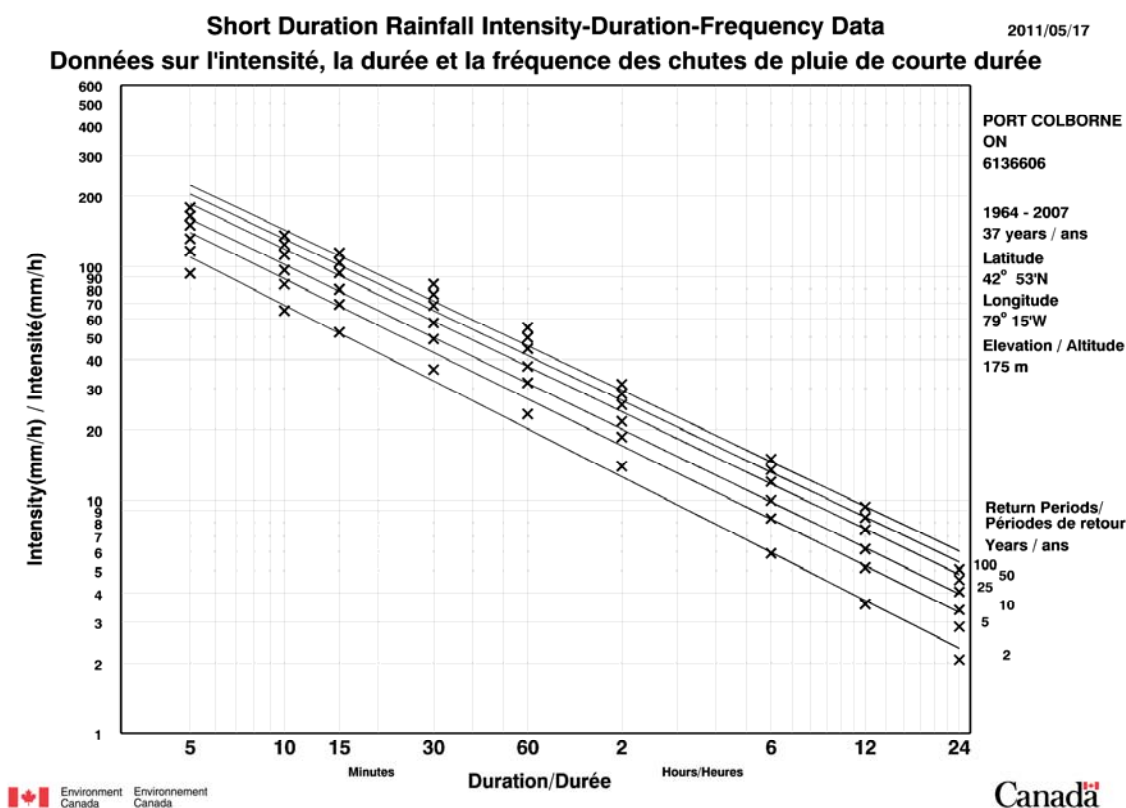


Figure 2-1: 2012 Historical IDF Curve, Port Colborne (#6136606)

Table 2-2: Historical Annual Maximum (mm) Precipitation Events for Port Colborne (#6136606)									
Year	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
1964	8.6	13.2	14.7	28.4	34.3	45.5	56.9	56.9	64.3
1965	5.8	6.3	8.9	13.7	19.8	26.4	33	33	42.4
1966	6.9	10.7	10.7	10.7	14	15	22.1	26.2	26.7
1967	7.6	12.2	17	26.2	26.7	26.7	26.7	36.1	59.9
1968	8.1	14.5	16.8	19.8	26.9	42.4	81.3	101.3	112.5
1969	6.9	10.2	12.4	12.7	19.8	22.6	32	37.3	43.2
1970	8.4	10.9	12.2	16	19.3	20.3	26.4	33.3	39.6
1971	8.1	12.4	15	21.8	24.6	25.7	26.7	29.5	30.5
1972	5.8	9.4	13.7	17.3	23.4	23.4	27.4	33.8	36.8
1973	7.6	12.7	17.3	25.4	36.6	37.6	39.4	39.9	40.4
1974	6.9	7.9	8.6	11.7	15.2	25.7	29.7	29.7	33
1975	12.7	20.3	24.6	31.7	32	32	32.5	33.5	33.5
1976	4.8	7.9	9.1	11.4	19	23.9	23.9	38.1	47.2
1977	12.2	14.5	16.6	33.3	37.6	37.6	42.2	48	51.3
1978	6.9	8.8	11.1	15.5	25.7	31.6	35.5	42	42
1979	8	11.4	16.2	26	34.2	47.6	80.6	116.4	123
1980	11.1	14.8	15.3	17	25.5	32.8	33.8	41.9	44.4
1981	8.2	9.6	9.6	11.6	14.4	25.7	32.9	37.2	44.6
1983	8	10.5	15.2	27.4	29.3	32	44.2	46.5	56.3
1984	9.8	15	18	26.9	28.9	30.7	30.8	51.8	54.2
1985	7.6	9.5	10.5	12.5	16.2	17.2	23.7	38.9	54.2
1986	12.4	18.4	21.2	24.7	26.5	30.6	35.1	43	46.6
1987	8.1	13	15.3	21.9	34.8	46.4	56.5	56.5	69.4
1988	8	11.3	12.9	14.7	17	20	22.7	42.7	47.2
1989	8.7	9.9	10.5	10.8	17.9	20.5	20.7	24.2	27.6
1990	7.2	9	13.1	21.8	28	32.8	35.9	44.9	50.4
1991	14.2	20	29	34	60	64.2	65	65	65.3
1992	6	10.4	13.5	20.4	28.4	30.3	32.3	42.9	46
1993	6.7	7.5	8.3	12.1	17.6	24.6	42.3	43.8	46.9
1994	7.2	8.5	11.5	14.3	18.3	24.4	50.4	74.6	86.9
1996	7.6	11.1	14.1	25.7	30.8	34.6	36	36	40.6
1997	7.6	9.6	12.3	15.5	17.6	23.2	45.8	54.2	58.2
1998	3.6	3.9	4.4	5.5	7.1	10.5	18.2	26.2	46.5
1999	9.4	14.1	16.6	20.7	22.2	29.7	38.5	45	49.2
2000	6.8	7.4	7.4	8.3	8.5	13.5	24.3	30.3	41
2001	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9
2002	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9
2003	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9
2004	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9
2005*	7	9.6	11.6	18.9	30.9	41.8	83.2	100.9	104.5
2006*	8.4	10.8	13.7	22.2	29.6	31.2	33.4	44	64.5
2007*	10.4	16.8	18.8	25.5	28.2	28.2	28.4	-99.9	56
NOTES:									
1. the historical IDF updated in 2012 included additional data points from 2005, 2006 and 2007									
2. -99.9 indicates missing data from Environment Canada									

Table 2-3: Historical IDF Data for Port Colborne (#6136606) Precipitation intensities over the specified duration, mm/hr						
Duration	Return Interval, Years					
	2	5	10	25	50	100
2012						
5 min	93.4	116.3	131.5	150.7	164.9	179.0
10 min	65.0	84.0	96.6	112.4	124.2	135.9
15 min	52.5	69.0	80.0	93.9	104.2	114.4
30 min	36.2	49.1	57.6	68.3	76.2	84.1
1 hr	23.3	31.8	37.4	44.5	49.8	55.0
2 hr	14.0	18.6	21.7	25.6	28.5	31.4
4 hr	7.9	11.1	13.5	16.1	17.7	19.2
6 hr	5.9	8.3	10.0	12.0	13.5	15.0
12 hr	3.6	5.1	6.2	7.5	8.4	9.4
24 hr	2.1	2.9	3.4	4.1	4.6	5.0
2010						
5 min	92.8	116.3	131.8	151.5	166.0	180.5
10 min	64.5	83.6	96.2	112.2	124.1	135.8
15 min	52.1	69.1	80.3	94.5	105.1	115.5
30 min	35.7	48.9	57.6	68.7	76.9	85.0
1 hr	22.9	31.6	37.4	44.7	50.2	55.5
2 hr	13.8	18.6	21.7	25.7	28.6	31.6
4 hr	7.7	10.8	13.3	15.7	17.4	18.8
6 hr	5.8	8.1	9.5	11.4	12.8	14.2
12 hr	3.5	4.9	5.9	7.1	7.9	8.8
24 hr	2.0	2.8	3.3	3.9	4.4	4.8
Change from 2010						
5 min	0.6%	0.0%	-0.2%	-0.5%	-0.7%	-0.8%
10 min	0.8%	0.5%	0.4%	0.2%	0.1%	0.1%
15 min	0.8%	-0.1%	-0.4%	-0.6%	-0.9%	-1.0%
30 min	1.4%	0.4%	0.0%	-0.6%	-0.9%	-1.1%
1 hr	1.7%	0.6%	0.0%	-0.4%	-0.8%	-0.9%
2 hr	1.4%	0.0%	0.0%	-0.4%	-0.3%	-0.6%
4 hr	2.6%	2.8%	1.5%	2.5%	1.7%	2.1%
6 hr	1.7%	2.5%	5.3%	5.3%	5.5%	5.6%
12 hr	2.9%	4.1%	5.1%	5.6%	6.3%	6.8%
24 hr	5.0%	3.6%	3.0%	5.1%	4.5%	4.2%
indicates 2012 IDF data < 2010 IDF data						

Table 2-4: Chicago Storm Hyetograph Parameters for Historical IDF Data			
Return Period (yrs)	a	b	c
2010 Environment Canada IDF Data			
2	625.336	7.356	0.789
5	850.571	8.571	0.785
10	1003.859	9.143	0.784
25	1250.340	10.340	0.791
50	1379.029	10.318	0.788
100	1604.983	11.414	0.796
2012 Environment Canada IDF Data			
2	586.560	6.570	0.775
5	806.863	8.189	0.772
10	1001.075	9.903	0.778
25	1169.542	10.338	0.773
50	1312.801	10.756	0.773
100	1549.713	12.284	0.783

2.3 Approach

To update the results from the previous report, values from the 2012 historical IDF were used in place of values from the previous (2010) historical IDF. All other components of the process remained the same as described in the risk assessment report (ref. AMEC, 2012)³.

2.4 Results

2.4.1 Projections of Precipitation Intensities

The precipitation intensities, as defined by the 2012 historical IDF data, were adjusted by the projected change, as described in City of Welland, 2012, to obtain the projected precipitation intensities, which are shown for the three projection periods in Tables 2-5 and 2-6. Projected precipitation intensities are reported as the maximum, mean and 90th percentile of the values estimated based on 112 climate projections.

2.4.2 Comparison of Results with 1963 IDF Curves

Table 2-6 shows a comparison of the existing (1963) Welland IDF curve with the updated Port Colborne 2012 historical IDF curve. The changes are relative to the 1963 curve, so a negative value indicates that the precipitation intensity in the 2012 curve is lower than the value in the 1963 curve for the corresponding duration/return interval. Blank cells are combinations of duration and return interval that are not available in the 1963 curve.

³ National Engineering Vulnerability Assessment of Public Infrastructure to Climate Change, City of Welland, Stormwater and Wastewater Infrastructure Assessment, completed by AMEC Environment & Infrastructure, February 2012

Table 2-7 shows that the 1963 curve was, generally, conservative (i.e., higher) relative to the estimates made in the 2012 curve. However, the 2012 IDF curve is conservative for the 2 hour and 6 hour for the 2 year return interval. This could have implications on the design of stormwater infrastructure as the present design standard for storm sewers in the City of Welland is based on a 2 year frequency. Further, stormwater infrastructure (such as stormwater management facilities) is in many cases assessed with modeling using a 4 hour Chicago Storm distribution.

Tables 2-8 and 2-9 show the same comparison for the projected values for both 2020 and 2050.

2.4.3 Comparison of 2010 Projected IDF Results with the 2012 Projected IDF Results

Tables 2-10 and 2-11 show a comparison of the 2020 and 2050 projected IDF results based on the 2010⁴ Port Colborne IDF data and the 2012 data. The comparison between the projected IDF data which were generated based on the 2010 and 2012 published IDF data for the Port Colborne station is analogous to the comparison on the published data (see Section 2.2) wherein the changes are minor for short duration events (up to 2 hours) across all return periods but slightly larger (up to about 7%) for longer durations and less frequent events.

2.4.4 Chicago Storm Hyetograph Parameterization

Tables 2-12 and 2-13 provide Chicago Storm hyetograph parameterization for the 2020 and 2050 IDF data relationships which will be used for the modelling component of this project as described in Section 3.0.

⁴ See Appendix A projected IDF data based on the 2010 Environment Canada rainfall data for Port Colborne.

Table 2-5: Projected IDF Data for 2020 based on 2012 Historical IDF Data Precipitation intensities over the specified duration, mm/hr						
Duration	Return Interval, Years					
	2	5	10	25	50	100
Maximum						
5 min	134.8	150.6	162.9	179.5	192.3	205.1
10 min	90.6	103.7	113.7	126.9	137.0	147.3
15 min	72.1	83.6	92.3	103.8	113.1	123.1
30 min	49.7	61.5	69.5	79.9	87.5	95.3
1 hr	32.5	40.2	45.5	52.3	57.5	62.6
2 hr	19.5	23.5	26.4	30.1	32.9	35.8
4 hr	11.4	14.4	16.4	18.9	20.7	22.6
6 hr	8.5	10.9	12.6	14.5	16.0	17.5
12 hr	4.8	6.5	7.7	9.1	9.9	10.9
24 hr	2.9	3.8	4.3	5.0	5.5	5.9
90 th Percentile						
5 min	114.1	133.1	146.6	164.2	177.5	190.9
10 min	77.2	92.2	102.9	117.4	128.8	140.1
15 min	62.2	75.2	85.4	98.6	108.3	118.4
30 min	43.2	54.9	63.1	73.6	81.4	89.3
1 hr	27.7	35.7	41.1	48.1	53.4	58.5
2 hr	16.8	20.9	23.9	27.7	30.6	33.4
4 hr	9.8	12.7	14.7	17.3	19.1	21.0
6 hr	7.3	9.5	11.2	13.2	14.7	16.2
12 hr	4.1	5.7	6.9	8.2	9.1	10.1
24 hr	2.5	3.3	3.8	4.5	5.0	5.4
Mean						
5 min	104.9	125.3	139.4	157.6	171.2	184.7
10 min	71.3	87.6	99.1	114.1	125.5	137.0
15 min	58.0	72.2	82.6	96.1	106.2	116.3
30 min	39.6	52.1	60.4	70.9	78.8	86.6
1 hr	25.5	33.7	39.2	46.2	51.5	56.7
2 hr	15.4	19.7	22.7	26.6	29.5	32.3
4 hr	8.9	11.9	14.0	16.5	18.4	20.2
6 hr	6.5	8.9	10.6	12.6	14.1	15.5
12 hr	3.7	5.3	6.5	7.8	8.7	9.7
24 hr	2.3	3.1	3.6	4.3	4.8	5.2

Table 2-6: Projected IDF Data for 2050 based on 2012 Historical IDF Data Precipitation intensities over the specified duration, mm/hr						
Duration	Return Interval, Years					
	2	5	10	25	50	100
Maximum						
5 min	143.7	158.2	170.0	186.2	198.6	211.3
10 min	96.4	108.7	118.4	131.3	141.4	151.5
15 min	76.5	87.3	95.8	107.2	115.8	124.5
30 min	51.1	62.7	70.8	81.1	88.7	96.5
1 hr	33.4	41.0	46.3	53.2	58.3	63.4
2 hr	20.1	24.0	26.9	30.6	33.4	36.2
4 hr	11.8	14.6	16.7	19.2	21	22.9
6 hr	8.8	11.1	12.8	14.8	16.3	17.8
12 hr	4.9	6.6	7.9	9.2	10.1	11.1
24 hr	3.0	3.9	4.4	5.1	5.6	6.0
90th Percentile						
5 min	121.8	139.6	152.7	169.9	183.0	196.1
10 min	82.1	96.4	106.9	120.4	131.2	141.6
15 min	65.8	78.1	87.6	100.7	110.4	120.4
30 min	45.7	57.5	65.7	76.2	83.9	91.7
1 hr	29.7	37.5	42.7	49.6	54.9	60.0
2 hr	17.9	21.9	24.8	28.6	31.4	34.3
4 hr	10.4	13.3	15.4	17.9	19.7	21.6
6 hr	7.6	10.0	11.7	13.7	15.2	16.7
12 hr	4.3	5.9	7.2	8.5	9.4	10.4
24 hr	2.6	3.5	4.0	4.7	5.2	5.6
Mean						
5 min	109.6	129.1	142.9	160.8	174.2	187.6
10 min	74.2	89.8	100.9	115.2	126.3	137.5
15 min	60.1	73.9	83.9	97.2	107.2	117.3
30 min	41.1	53.4	61.6	72.1	79.9	87.7
1 hr	26.5	34.5	40.0	47.0	52.2	57.4
2 hr	16.0	20.2	23.2	27.0	29.9	32.8
4 hr	9.3	12.2	14.3	16.8	18.7	20.6
6 hr	6.8	9.1	10.8	12.8	14.3	15.8
12 hr	3.8	5.5	6.7	8.0	8.9	9.9
24 hr	2.3	3.2	3.7	4.4	4.9	5.3

Table 2-7: Comparison of 1963 IDF Data with 2012 Historical IDF Data Percent change in 2012 IDF data (Table 2-3) compared to the 1963 IDF data (Tables 2-1A&B)						
Duration	Return Interval, Years					
	2	5	10	25	50	100
5 min	-6%	-2%	-1%	-6%	-6%	-8%
10 min	-16%	-7%	-5%	-5%	-5%	-5%
15 min	-17%	-7%	-3%	-2%	-1%	-1%
30 min	-15%	-2%	4%	8%	9%	10%
1 hr	-14%	1%	7%	11%	12%	14%
2 hr	-15%	-3%	1%	4%	4%	5%
4 hr	-19%	-3%	5%	8%	5%	5%
6 hr	-17%	-1%	5%	8%	8%	9%
12 hr	-14%	2%	11%	12%	12%	13%
24 hr	-13%	0%	3%	2%	2%	0%
indicates 2012 IDF data < 1963 IDF data						

Table 2-8: Comparison of 1963 IDF Data with Projected 2020 IDF Data Percent change in 2020 IDF data (Table 2-4) compared to the 1963 IDF data (Tables 2-1A&B)						
Duration	Return Interval, Years					
	2	5	10	25	50	100
Maximum						
5 min	35.1%	27.5%	22.1%	12.5%	9.9%	5.9%
10 min	17.4%	14.5%	12.3%	7.1%	5.2%	3.0%
15 min	13.3%	12.4%	11.5%	8.3%	7.2%	6.6%
30 min	16.1%	23.3%	25.8%	26.0%	25.0%	24.9%
1 hr	20.4%	27.6%	30.0%	30.4%	29.5%	29.3%
2 hr	18.9%	22.4%	23.4%	21.9%	19.6%	19.3%
4 hr	16.3%	25.2%	27.1%	26.8%	23.2%	23.5%
6 hr	19.7%	29.8%	32.6%	30.6%	28.0%	27.7%
12 hr	14.3%	30.0%	37.5%	35.8%	32.0%	31.3%
24 hr	20.8%	31.0%	30.3%	25.0%	22.2%	18.0%
90th Percentile						
5 min	14.4%	12.7%	9.9%	2.9%	1.4%	-1.5%
10 min	0.0%	1.8%	1.6%	-0.9%	-1.1%	-2.0%
15 min	-2.2%	1.1%	3.2%	2.8%	2.7%	2.6%
30 min	0.9%	10.1%	14.2%	16.1%	16.3%	17.0%
1 hr	2.6%	13.3%	17.4%	20.0%	20.3%	20.9%
2 hr	2.4%	8.9%	11.7%	12.1%	11.3%	11.3%
4 hr	0.0%	10.4%	14.0%	16.1%	13.7%	14.8%
6 hr	2.8%	13.1%	17.9%	18.9%	17.6%	18.2%
12 hr	-2.4%	14.0%	23.2%	22.4%	21.3%	21.7%
24 hr	4.2%	13.8%	15.2%	12.5%	11.1%	8.0%
Mean						
5 min	5.1%	6.1%	4.5%	-1.2%	-2.2%	-4.7%
10 min	-7.6%	-3.3%	-2.2%	-3.7%	-3.6%	-4.2%
15 min	-8.8%	-2.9%	-0.2%	0.2%	0.7%	0.7%
30 min	-7.5%	4.5%	9.3%	11.8%	12.6%	13.5%
1 hr	-5.6%	7.0%	12.0%	15.2%	16.0%	17.1%
2 hr	-6.1%	2.6%	6.1%	7.7%	7.3%	7.7%
4 hr	-9.2%	3.5%	8.5%	10.7%	9.5%	10.4%
6 hr	-8.5%	6.0%	11.6%	13.5%	12.8%	13.1%
12 hr	-11.9%	6.0%	16.1%	16.4%	16.0%	16.9%
24 hr	-4.2%	6.9%	9.1%	7.5%	6.7%	4.0%
indicates 2020 IDF data < 1963 IDF data						

Table 2-9: Comparison of 1963 IDF Data with Projected 2050 IDF Data Percent change in 2050 IDF data (Table 2-5) compared to the 1963 IDF data (Tables 2-1A&B)						
Duration	Return Interval, Years					
	2	5	10	25	50	100
Maximum						
5 min	44.0%	34.0%	27.4%	16.7%	13.5%	9.1%
10 min	24.9%	20.0%	16.9%	10.8%	8.6%	6.0%
15 min	20.3%	17.4%	15.7%	11.8%	9.8%	7.9%
30 min	19.4%	25.7%	28.1%	27.9%	26.8%	26.4%
1 hr	23.7%	30.2%	32.3%	32.7%	31.3%	31.0%
2 hr	22.6%	25.0%	25.7%	23.9%	21.5%	20.7%
4 hr	20.4%	27.0%	29.5%	28.9%	25.0%	25.1%
6 hr	23.9%	32.1%	34.7%	33.3%	30.4%	29.9%
12 hr	16.7%	32.0%	41.1%	37.3%	34.7%	33.7%
24 hr	25.0%	34.5%	33.3%	27.5%	24.4%	20.0%
90 th Percentile						
5 min	22.1%	18.2%	14.5%	6.5%	4.6%	1.2%
10 min	6.4%	6.4%	5.5%	1.6%	0.8%	-1.0%
15 min	3.4%	5.0%	5.8%	5.0%	4.7%	4.3%
30 min	6.8%	15.3%	18.9%	20.2%	19.9%	20.2%
1 hr	10.0%	19.0%	22.0%	23.7%	23.6%	24.0%
2 hr	9.1%	14.1%	15.9%	15.8%	14.2%	14.3%
4 hr	6.1%	15.7%	19.4%	20.1%	17.3%	18.0%
6 hr	7.0%	19.0%	23.2%	23.4%	21.6%	21.9%
12 hr	2.4%	18.0%	28.6%	26.9%	25.3%	25.3%
24 hr	8.3%	20.7%	21.2%	17.5%	15.6%	12.0%
Mean						
5 min	9.8%	9.3%	7.1%	0.8%	-0.5%	-3.2%
10 min	-3.9%	-0.9%	-0.4%	-2.8%	-3.0%	-3.8%
15 min	-5.5%	-0.6%	1.4%	1.4%	1.6%	1.6%
30 min	-4.0%	7.1%	11.5%	13.7%	14.2%	14.9%
1 hr	-1.9%	9.5%	14.3%	17.2%	17.6%	18.6%
2 hr	-2.4%	5.2%	8.4%	9.3%	8.7%	9.3%
4 hr	-5.1%	6.1%	10.9%	12.8%	11.3%	12.6%
6 hr	-4.2%	8.3%	13.7%	15.3%	14.4%	15.3%
12 hr	-9.5%	10.0%	19.6%	19.4%	18.7%	19.3%
24 hr	-4.2%	10.3%	12.1%	10.0%	8.9%	6.0%
indicates 2050 IDF data < 1963 IDF data						

Table 2-10: Comparison of Projected 2020 IDF Data Percent change in 2012 based projected IDF data compared to the 2010 based IDF data						
Duration	Return Interval, Years					
	2	5	10	25	50	100
Maximum						
5 min	0.7%	0.0%	-0.2%	-0.6%	-0.6%	-0.8%
10 min	0.8%	0.5%	0.4%	0.2%	0.1%	0.1%
15 min	0.7%	-0.1%	-0.3%	-0.7%	-0.9%	-1.0%
30 min	1.4%	0.5%	0.0%	-0.5%	-1.0%	-1.0%
1 hr	1.9%	0.8%	0.0%	-0.6%	-0.9%	-0.9%
2 hr	1.6%	0.0%	0.0%	-0.7%	-0.6%	-0.6%
4 hr	0.9%	2.1%	1.9%	2.2%	2.5%	2.7%
6 hr	1.2%	2.8%	5.0%	5.1%	5.3%	5.4%
12 hr	2.1%	4.8%	4.1%	5.8%	5.3%	6.9%
24 hr	3.6%	5.6%	2.4%	4.2%	3.8%	3.5%
90th Percentile						
5 min	0.6%	0.0%	-0.3%	-0.5%	-0.7%	-0.8%
10 min	0.8%	0.4%	0.4%	0.2%	0.1%	0.1%
15 min	0.8%	-0.1%	-0.4%	-0.6%	-0.9%	-1.0%
30 min	1.4%	0.4%	0.0%	-0.7%	-1.0%	-1.0%
1 hr	1.8%	0.8%	0.0%	-0.4%	-0.7%	-1.0%
2 hr	1.2%	0.0%	0.0%	-0.4%	-0.3%	-0.6%
4 hr	2.1%	1.6%	2.1%	3.0%	2.7%	2.4%
6 hr	2.8%	2.2%	5.7%	5.6%	5.8%	5.9%
12 hr	5.1%	3.6%	4.5%	5.1%	5.8%	6.3%
24 hr	4.2%	3.1%	2.7%	4.7%	4.2%	3.8%
Mean						
5 min	0.7%	0.0%	-0.3%	-0.5%	-0.6%	-0.9%
10 min	0.7%	0.5%	0.4%	0.2%	0.1%	0.1%
15 min	0.7%	-0.1%	-0.4%	-0.6%	-0.8%	-0.9%
30 min	1.3%	0.6%	0.0%	-0.6%	-0.9%	-1.0%
1 hr	1.6%	0.6%	0.0%	-0.4%	-0.8%	-0.9%
2 hr	1.3%	0.0%	0.0%	-0.4%	-0.3%	-0.9%
4 hr	1.1%	1.7%	2.9%	2.5%	2.8%	2.0%
6 hr	1.6%	2.3%	6.0%	5.9%	6.0%	5.4%
12 hr	2.8%	3.9%	4.8%	5.4%	6.1%	6.6%
24 hr	4.5%	3.3%	2.9%	4.9%	4.3%	4.0%
indicates 2012 based IDF data < 2010 based IDF data						

Table 2-11: Comparison of Projected 2050 IDF Data Percent change in 2012 based projected IDF data compared to the 2010 based IDF data						
Duration	Return Interval, Years					
	2	5	10	25	50	100
Maximum						
5 min	0.6%	0.0%	-0.2%	-0.5%	-0.7%	-0.8%
10 min	0.7%	0.5%	0.4%	0.2%	0.1%	0.1%
15 min	0.8%	-0.1%	-0.4%	-0.6%	-0.9%	-1.0%
30 min	1.4%	0.3%	0.0%	-0.5%	-0.9%	-1.0%
1 hr	1.8%	0.5%	0.0%	-0.4%	-0.9%	-0.9%
2 hr	1.5%	0.0%	0.0%	-0.3%	-0.3%	-0.8%
4 hr	1.7%	1.4%	2.5%	2.1%	2.4%	2.2%
6 hr	1.1%	1.8%	4.9%	5.0%	5.2%	6.0%
12 hr	2.1%	3.1%	5.3%	5.7%	6.3%	6.7%
24 hr	7.1%	5.4%	2.3%	4.1%	3.7%	3.4%
90th Percentile						
5 min	0.7%	0.0%	-0.2%	-0.5%	-0.7%	-0.8%
10 min	0.7%	0.4%	0.5%	0.2%	0.1%	0.1%
15 min	0.8%	-0.1%	-0.5%	-0.6%	-0.9%	-0.9%
30 min	1.3%	0.3%	0.0%	-0.5%	-0.9%	-1.1%
1 hr	1.7%	0.5%	0.0%	-0.6%	-0.7%	-0.8%
2 hr	1.7%	0.0%	0.0%	-0.3%	-0.3%	-0.6%
4 hr	2.0%	2.3%	2.7%	2.3%	2.6%	2.4%
6 hr	1.3%	3.1%	5.4%	5.4%	5.6%	5.7%
12 hr	2.4%	3.5%	5.9%	4.9%	5.6%	6.1%
24 hr	4.0%	6.1%	2.6%	4.4%	4.0%	3.7%
Mean						
5 min	0.6%	0.0%	-0.3%	-0.6%	-0.7%	-0.8%
10 min	0.8%	0.4%	0.5%	0.2%	0.1%	0.1%
15 min	0.8%	-0.1%	-0.4%	-0.6%	-0.8%	-0.9%
30 min	1.5%	0.6%	0.0%	-0.7%	-0.9%	-1.1%
1 hr	1.5%	0.6%	0.0%	-0.4%	-0.8%	-0.9%
2 hr	1.3%	0.0%	0.0%	-0.4%	-0.3%	-0.6%
4 hr	2.2%	1.7%	2.9%	2.4%	2.7%	2.5%
6 hr	1.5%	2.2%	4.9%	4.9%	5.1%	5.3%
12 hr	2.7%	5.8%	6.3%	5.3%	6.0%	6.5%
24 hr	4.5%	3.2%	2.8%	4.8%	4.3%	3.9%
indicates 2012 based IDF data < 2010 based IDF data						

Table 2-12 Chicago Storm Hyetograph Parameters for 2020 IDF Data			
Return Period (yrs)	a	b	c
2020 IDF Data – Maximum – based on 2012 IDF Data			
2	859.539	7.197	0.783
5	977.816	8.390	0.762
10	1172.554	10.560	0.768
25	1329.713	11.277	0.763
50	1469.657	11.710	0.765
100	1713.509	13.324	0.775
2020 IDF Data – 90th Percentile – based on 2012 IDF Data			
2	736.264	7.188	0.783
5	901.052	8.572	0.770
10	1098.797	10.657	0.775
25	1267.087	11.208	0.771
50	1416.121	11.724	0.772
100	1650.140	13.170	0.782
2020 IDF Data – Mean – based on 2012 IDF Data			
2	645.665	6.189	0.778
5	848.268	8.163	0.771
10	1040.832	10.128	0.776
25	1212.134	10.722	0.772
50	1359.085	11.204	0.773
100	1572.952	12.400	0.780

Table 2-13 Chicago Storm Hyetograph Parameters for 2050 IDF Data			
Return Period (yrs)	a	b	C
2050 IDF Data – Maximum – based on 2012 IDF Data			
2	859.598	6.194	0.779
5	960.907	7.276	0.756
10	1154.068	9.551	0.762
25	1326.610	10.547	0.761
50	1471.161	11.265	0.762
100	1711.102	12.973	0.772
2050 IDF Data – 90th Percentile – based on 2012 IDF Data			
2	816.747	7.575	0.792
5	920.885	8.244	0.766
10	1109.418	10.368	0.770
25	1280.360	11.071	0.767
50	1423.713	11.570	0.768
100	1667.077	13.205	0.778
2050 IDF Data – Mean – based on 2012 IDF Data			
2	746.368	7.507	0.796
5	849.134	7.880	0.766
10	1042.440	9.949	0.772
25	1210.480	10.583	0.768
50	1355.401	11.105	0.769
100	1595.818	12.704	0.780



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3 IDF SHIFT AND INFLUENCES ON STORMWATER MANAGEMENT

3.1 Overview

This component of the analysis has focused on assessing the influence of changing design rainfall on the design of stormwater management end-of-pipe systems, largely related to stormwater management quantity control. For this assessment, a pilot study area and hydrologic model was provided by the City as a base, which could then be evaluated using the current design storm approach (based upon the existing IDF information) and then compared against the proposed 2020 and 2050 IDF relationships. The 2 year through 100 year design storms have been evaluated and the requisite flood storage for post- to pre-development land use determined accordingly. This analysis has required the execution of Existing, Future without stormwater management, and Future with stormwater management Land Use Conditions and stormwater management volumes have been derived accordingly. The difference in the required stormwater management volumes have then been assessed as to additional construction costs and additional land requirements, which have been converted into a cost premium as a percentage over the existing design.

3.2 Hydrologic Model for evaluation

The hydrologic model (MIDUSS) provided by the City for this evaluation represents the Brookhaven Estates residential development located in the north-west area of the City near the intersection of South Pelham Road and Woodlawn Road (see Figure 3-1). The development consists of 23 residential lots for Phase 1 and an additional 15 lots for Phase 2 covering an area of about 2.5 ha). The stormwater management plan for the development expanded an existing stormwater management facility located on the north side of the development which also serves a portion of the residential area to the north (an area of about 8.4 ha) known as the Meadows Subdivision.

The stormwater management facility has been designed based on post development peak flows being maintained equal to, or less than, pre-development peak flows for the 2, 5, 10, 25, 50 and 100 year storm events and has the following features:

- Facility bottom elevation of 181.45 m
- 5:1 (H:V) transition from facility bottom to elevation 183.15 m
- 3:1 (H:V) transition from elevation 183.15 m to elevation 184.20 m
- An outlet configuration consisting of a 100 mm diameter orifice (invert at elevation 183.10 m) plus an overflow weir with crest at elevation 183.80 m having length 1.829 m and thickness of 200 mm.
- The 2 year and 100 year facility elevations documented as 183.75 m and 184.10 m, respectively.
- The overall facility has a length of 101.3m and a width of 24.4 m as measured to elevation 184.10 m
- The stage-storage-discharge relationship for the stormwater management facility is outlined in Table 3-1.

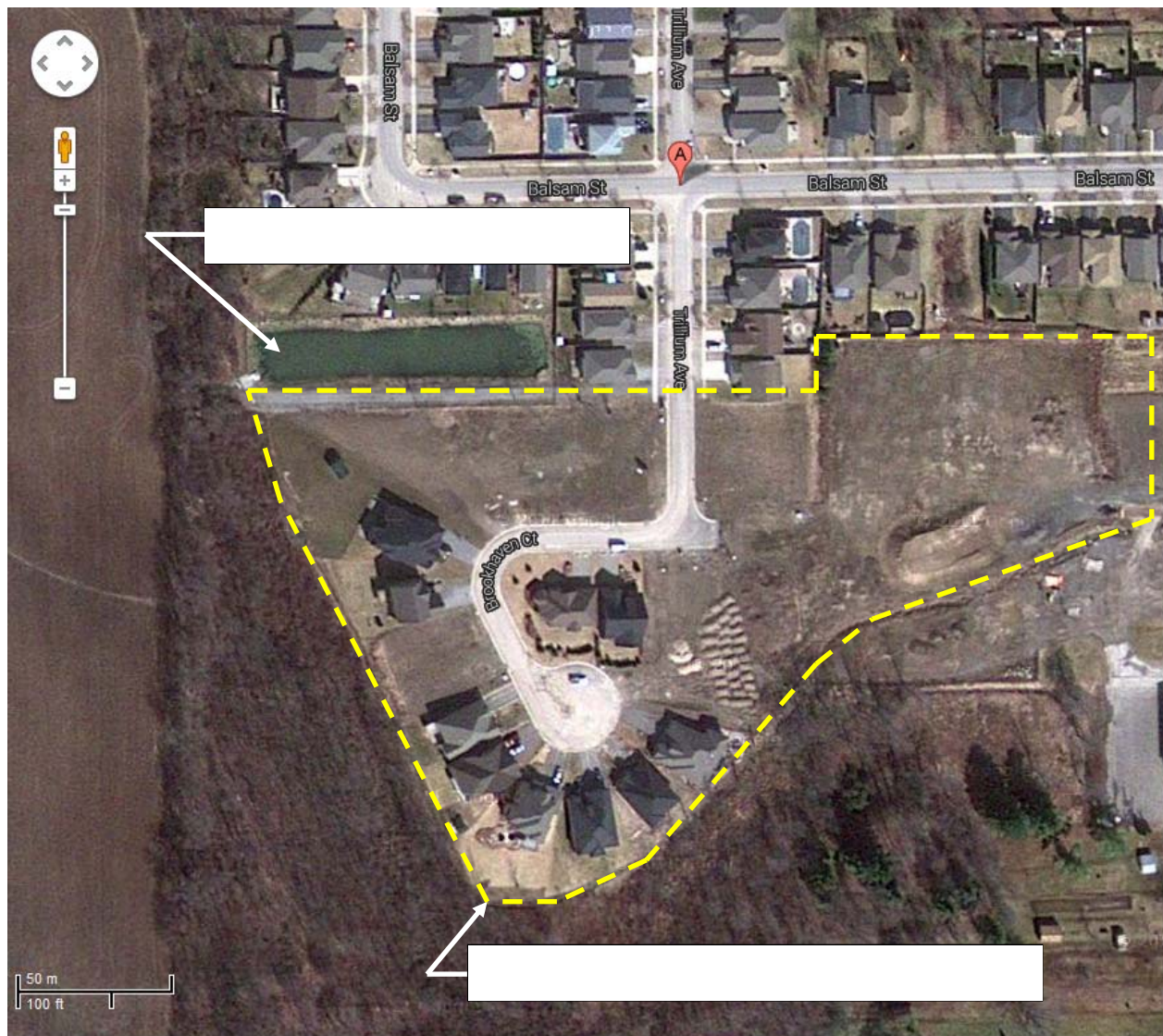


Figure 3-1 : Brookhaven Estates Location

Table 3-1: Stage-Storage-Discharge Relationship from MIDUSS Model		
Level (m)	Discharge (m ³ /s)	Volume (m ³)
183.10	0	0
183.15	0.001	77.7
183.20	0.003	157.1
183.25	0.006	238.2
183.30	0.008	321.0
183.35	0.009	405.5
183.40	0.011	491.8
183.45	0.012	579.8
183.50	0.013	669.6
183.55	0.014	761.1
183.60	0.014	854.4
183.65	0.015	949.5
183.70	0.016	1046.3
183.75	0.017	1145.0
183.80	0.017	1245.5
183.85	0.049	1347.8
183.90	0.106	1451.9
183.95	0.180	1557.8
184.00	0.267	1665.6
184.05	0.366	1775.2
184.10	0.475	1886.7
184.15	0.594	2000.0
184.20	0.721	2115.3

3.3 Design Based on Existing IDF Design Rainfall

Using the datasets provided by the City, the results outlined in Table 3-2 have been computed using MIDUSS version 2.07 rev. 379. The base models provided by the City were originally modelled with version 2.05 rev. 349 of the software. It was confirmed that the modelling results were unchanged between the two versions of the software.

Table 3-2: MIDUSS Results based on the Current IDF Design Standard						
Return Period (yrs)	Event Duration (hrs)	Peak Flows (m ³ /s)			SWM Facility Metrics	
		Pre	Post no controls	Post with controls	Level (m)	Volume (m ³)
2	4	0.089	0.589	0.051	183.85	1350
5	4	0.143	0.766	0.098	183.89	1437
10	4	0.195	0.920	0.145	183.93	1507
25	4	0.287	1.171	0.229	183.98	1618
50	4	0.388	1.369	0.326	184.03	1730
100	4	0.474	1.583	0.421	184.08	1831

3.4 SWM Facility Performance and Design Based on Other IDF Data

Tables 3-3 through 3-6 document the scenario whereby the current City of Welland IDF design standard is used to design the volumetric requirements of the stormwater management (SWM) facility for the Brookhaven Estates development and then at some point in the future, the facility must perform under alternate rainfall conditions, as represented by the various IDF relationships previously discussed.

The results of this analysis suggest that, although facility performance would be degraded, the facility would be able to safely pass stormwater runoff resulting from all of the evaluated rainfall events with the exception of two (2), namely the 100 year storm (maximum variation) for 2020 and 2050. It would be expected that under these two rainfall conditions overtopping of the SWM facility embankment would occur resulting in possible failure of the containment embankment. It should also be noted that under numerous other rainfall conditions that freeboard under maximum computed water levels would be essentially zero (0).

Tables 3-7 and 3-8 summarizes the assessment of SWM facility design based on the alternate design rainfall IDF relationships. For this evaluation, an estimate of the additional land area required to support additional storage volume requirements has also been included. In this case the facility width has been maintained as constant and the length varied to develop the additional storage required. Based on the known location and dimensions for the approved SWM facility for the development, it is clear that this assumption would not have been an option as the current SWM facility essentially occupies all of the available land up to the creek allowance. Expansion of the facility area to develop additional storage would have most likely required a re-configuration of the lots within the development.

Notwithstanding the limitations of the assumptions used in this regard, an estimate of the value of the land has been based on information provided by the City of Welland Integrated Services - Planning Division. The City indicated that a sale value of approximately \$1,400 to \$1,500 per linear foot of frontage would be a reasonable estimate. This approximate valuation was associated with a standard lot within the development which has dimensions 14.39m (frontage) by 33.49m (depth). This results in a valuation of about \$71,000 for a lot or about \$150 per square metre. This unit value of land has been used to estimate the additional cost associated with the alternate facility designs.

Table 3-3: MIDUSS Results based on the 2010 Environment Canada IDF Data								
Return Period (yrs)	Event Duration (hrs)	Peak Flows (m ³ /s)			SWM Facility Metrics		Change from Design	
		Pre	Post no controls	Post with controls	Level (m)	Volume (m ³)	Level (m)	Volume (m ³)
2	4	0.049	0.448	0.016	183.72	1093	-0.13	-258
5	4	0.135	0.715	0.090	183.89	1423	-0.01	-14
10	4	0.213	0.918	0.162	183.94	1532	0.01	25
25	4	0.341	1.180	0.288	184.01	1687	0.03	71
50	4	0.463	1.401	0.409	184.07	1819	0.04	89
100	4	0.585	1.618	0.534	184.13	1943	0.05	112

Table 3-4: MIDUSS Results based on the 2012 Environment Canada IDF Data

Return Period (yrs)	Event Duration (hrs)	Peak Flows (m ³ /s)			SWM Facility Metrics		Change from Design	
		Pre	Post no controls	Post with controls	Level (m)	Volume (m ³)	Level (m)	Volume (m ³)
2	4	0.051	0.458	0.017	183.74	1120	-0.11	-230
5	4	0.142	0.725	0.097	183.89	1435	0.00	-2
10	4	0.227	0.918	0.175	183.95	1551	0.02	44
25	4	0.360	1.181	0.307	184.02	1709	0.04	91
50	4	0.487	1.391	0.431	184.08	1842	0.05	112
100	4	0.613	1.598	0.560	184.14	1968	0.06	137

Table 3-5: MIDUSS Results based on the 2020 IDF Design Standard

Return Period (yrs)	Event Duration (hrs)	Peak Flows (m³/s)			SWM Facility Metrics		Change from Design	
		Pre	Post no controls	Post with controls	Level (m)	Volume (m³)	Level (m)	Volume (m³)
Maximum								
2	4	0.145	0.785	0.099	183.89	1439	0.04	89
5	4	0.275	1.036	0.218	183.97	1605	0.08	168
10	4	0.386	1.211	0.332	184.03	1737	0.11	230
25	4	0.540	1.473	0.499	184.11	1910	0.13	292
50	4	0.674	1.673	0.607	184.16	2012	0.13	282
100 ¹	4	0.846	1.884	OT	OT	OT	N/A	N/A
90 th Percentile								
2	4	0.092	0.611	0.054	183.86	1358	0.00	7
5	4	0.198	0.863	0.146	183.93	1509	0.03	72
10	4	0.303	1.046	0.245	183.99	1638	0.06	130
25	4	0.450	1.309	0.397	184.06	1808	0.09	189
50	4	0.564	1.514	0.520	184.12	1929	0.09	199
100	4	0.713	1.716	0.639	184.17	2041	0.09	210
Mean								
2	4	0.067	0.535	0.025	183.81	1269	-0.04	-81
5	4	0.164	0.792	0.118	183.91	1469	0.01	32
10	4	0.260	0.978	0.207	183.97	1591	0.04	83
25	4	0.399	1.238	0.346	184.04	1753	0.06	135
50	4	0.506	1.441	0.469	184.10	1880	0.07	149
100	4	0.658	1.658	0.596	184.15	2002	0.08	170

Notes:

1. The 100 yr pond elevation attained a water level of 184.21 m.

Table 3-6: MIDUSS Results based on the 2050 IDF Design Standard								
Return Period (yrs)	Event Duration (hrs)	Peak Flows (m³/s)			SWM Facility Metrics		Change from Design	
		Pre	Post no controls	Post with controls	Level (m)	Volume (m³)	Level (m)	Volume (m³)
Maximum								
2	4	0.158	0.846	0.108	183.90	1455	0.05	105
5	4	0.285	1.097	0.229	183.99	1619	0.09	182
10	4	0.409	1.275	0.354	184.04	1762	0.12	254
25	4	0.546	1.528	0.514	184.12	1924	0.14	306
50	4	0.708	1.736	0.634	184.17	2037	0.14	306
100 ¹	4	0.880	1.932	OT	OT	OT	N/A	N/A
90 th Percentile								
2	4	0.108	0.670	0.069	183.87	1384	0.02	34
5	4	0.219	0.928	0.168	183.94	1540	0.05	103
10	4	0.324	1.106	0.274	184.00	1673	0.08	165
25	4	0.488	1.367	0.433	184.08	1844	0.10	226
50	4	0.602	1.573	0.531	184.13	1959	0.10	228
100	4	0.766	1.784	0.687	184.19	2085	0.11	253
Mean								
2	4	0.078	0.567	0.037	183.83	1310	-0.02	-41
5	4	0.178	0.829	0.130	183.92	1486	0.02	49
10	4	0.277	1.011	0.222	183.97	1610	0.05	102
25	4	0.420	1.272	0.366	184.05	1776	0.07	158
50	4	0.530	1.475	0.489	184.11	1900	0.08	169
100	4	0.678	1.676	0.612	184.16	2017	0.08	185
Notes:								
1. The 100 yr pond elevation attained a water level of 184.22 m.								

Table 3-7: Comparison of SWM Facility Designs based on Alternate Design Rainfall						
IDF	Peak Flows (m ³ /s)		SWM Facility Metrics			
	Post No Controls	Post with Controls	Level (m)	Total Volume Required (m ³)	Additional Volume Required	
					(m ³)	(%)
Current City of Welland	1.583	0.421	184.08	1831.6	----	----
2010	1.618	0.426	184.09	2198.7	367.1	20%
2012	1.598	0.425	184.08	2299.7	468.1	26%
2020 - Maximum	1.884	0.423	184.08	3280.4	1448.8	79%
2020 – 90 th Percentile	1.716	0.426	184.08	2652.1	820.5	45%
2020 - Mean	1.658	0.432	184.08	2428.3	596.7	33%
2050 - Maximum	1.932	0.424	184.08	3455.3	1623.7	89%
2050 – 90 th Percentile	1.784	0.426	184.08	2881.4	1049.8	57%
2050 - Mean	1.676	0.423	184.08	2532.2	700.6	38%

Table 3-8: Comparison of SWM Facility Costs based on Alternate Design Rainfall									
IDF	Facility Bottom Area (m ²)	Facility Top					Approximate Additional Cost		
		Width (m)	Length (m)	Land Required (m ²)	Additional Land Required		Land ¹ \$\$\$	Construction ² \$\$\$	Total \$\$\$
					(m ²)	(%)			
Current City of Welland	1537	24.4	103.7	2530.8	--	--	---	--	---
2010	1850	24.4	122.8	2996.4	465.7	18%	\$69,852	\$23,861	\$93,713
2012	1950	24.4	128.9	3145.2	614.5	24%	\$92,170	\$30,426	\$122,595
2020 - Maximum	2800	24.4	180.7	4409.9	1879.1	74%	\$281,865	\$94,171	\$376,036
2020 – 90 th Percentile	2250	24.4	147.2	3591.6	1060.8	42%	\$159,121	\$53,332	\$212,453
2020 - Mean	2050	24.4	135.0	3294.0	763.2	30%	\$114,487	\$38,785	\$153,271
2050 - Maximum	2950	24.4	189.9	4633.0	2102.3	83%	\$315,340	\$105,540	\$420,880
2050 – 90 th Percentile	2450	24.4	159.4	3889.1	1358.4	54%	\$203,755	\$68,236	\$271,991
2050 - Mean	2150	24.4	141.1	3442.8	912.0	36%	\$136,804	\$45,538	\$182,342
NOTES:									
1. The cost of the additional land required is based \$150 per square metre.									
2. Construction costs estimated as \$65 per cubic metre including excavation, landscaping and surface treatment.									



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4 CHANGE IN MUNICIPAL DESIGN STANDARD

4.1 Overview

The City of Welland currently uses a 2 year design criteria in conjunction with the IDF relationship outlined in Table 2-1A and Table 2-1B for design of municipal storm sewers. This component of the evaluation has quantified: (1) impacts resulting from a shift in sizing of storm sewers to one of the other IDF relationships and (2) an alternate return period design basis. Based upon the change in sewer geometry, a cost premium has been developed as a percentage over the development. This assessment provides a level of financial impact, which can then be weighed against the increased benefit associated with reduced minor system flood risk.

A brief review of storm sewer/minor drainage system design standards has been completed for a number of municipalities in Ontario as outlined in Table 4-1. For the municipalities reviewed, the majority have designated a 5 year design standard and a few have moved even beyond that level to a 10 year or 25 year design basis. In light of this, a change to a 5 year design basis for Welland's minor system may simply be in keeping with the more general evolution of the design standard for municipalities across the Province.

Table 4-1 Minor System Design Standards for Local Municipalities			
2 year	5 year	10 year	25 year
London Toronto Oakville ¹ Welland	Barrie Burlington Fort Erie Grimsby Haldimand County Hamilton Niagara Falls Ottawa Pickering Region of Waterloo Richmond Hill St Catharine's Whitby	Brampton Mississauga Oakville ² Region of Peel	Windsor
NOTES: 1. low / medium residential 2. high value commercial / downtown area			

In review of the various design standards for municipalities, it has been determined that some have requirements whereby the maximum conveyance capacity in a storm sewer is determined as a percentage of full pipe flow. This value is generally 95% and in some jurisdictions lower. Restricting maximum allowable pipe flow to a percentage of full pipe flow represents another aspect of safety factor in storm sewer design.

When making decisions that will be affected by climate, it is important to consider that the industry's understanding of climate and climate change will increase with time, so a decision that can be delayed may benefit from new and better information. As such, the IDF

relationships upon which the storm sewer rainfall design standard is based should be periodically reviewed. The review of municipal design standards has indicated that many municipalities review IDF relationships on a 5 year cycle.

The general expectation of extreme rainfall in southern Ontario, as influenced by climate change, suggests less days with rain but larger (higher volume and intensity) rainfall events when they do occur. Some research even suggests the return period associated with specific rainfall events will be halved, that is, the current 100 year rain will become the future 50 year rain, the current 10 year rain will become the future 5 year rain, and so on. In light of this, a change to a less frequent return period design rainfall may be considered good engineering judgment and a means of ensuring adequate performance of newly designed stormwater infrastructure.

Another consideration may be the comparison of design rainfall events across the various IDF relationships. Tables 4-2 and 4-3 summarize a number of comparisons between IDF relationships across return periods as a means of identifying overlap, whereby an IDF with a higher return period has a distribution that is somewhat analogous to an IDF with lesser return period, suggesting one may be somewhat interchangeable with the other. A comparison of intensities indicates the 2012 5 year IDF values are bounded by the 2 year 2020 Maximum and 90th Percentile IDF values. Similarly, the 2012 5 year IDF values are generally bounded by the 2 year 2050 Maximum and 90th Percentile IDF values. A simply averaged percentage comparison between the IDF values over the various durations suggests alignment between the 2012 5 year IDF values and the 2020 Maximum IDF relationship. However, as discussed in Section 3.5, the maximum value is typically excluded as the basis for planning decisions, therefore the next best alignment is between the 2012 5 year IDF values and the 2 year 2050 90th percentile IDF values. A similar comparison between the 2012 10 year IDF values and the other 5 year IDF values also shows good alignment with the 5 year 2050 90th percentile IDF values.

4.2 Storm Sewer Design Based on Existing IDF Design Rainfall

4.2.1 Brookhaven Estates

Storm sewer design sheets for the Brookhaven Estates residential development were made available from the City of Welland and formed the basis of this component of the assessment (see Appendix A). The design sheets describe six (6) storm sewer segments over a linear length of about 300 m. The design for the system is summarized in Table 4-4⁵.

As noted in Appendix C, the design conveyance capacity provides an excess of capacity over what is required based on the computations. In the case of pipe #3, this excess represents about 50% of the conveyance capacity of the storm sewer which is already at the minimum available pipe size. Excess capacities for this network are greater or equal to 8%.

⁵ Detailed storm sewer sizing using the alternates IDF relationships is provided in Appendix C for the Brookhaven Estates storm sewer network.

This is noted as this simple network and the extra capacity available in the design may in fact mask issues associated with storm sewer design based on alternate IDF relationships as reflected in this assessment.

Table 4-2 Rainfall IDF Relationships							
Duration	IDF Relationships Precipitation intensities over the specified duration (mm/hr)						
	2012	2020 Maximum	2020 90 th Percentile	2020 Mean	2050 Maximum	2050 90 th Percentile	2050 Mean
2 year							
5 min	93.4	134.8	114.1	104.9	143.7	121.8	109.6
10 min	65	90.6	77.2	71.3	96.4	82.1	74.2
15 min	52.5	72.1	62.2	58	76.5	65.8	60.1
30 min	36.2	49.7	43.2	39.6	51.1	45.7	41.1
1 hr	23.3	32.5	27.7	25.5	33.4	29.7	26.5
2 hr	14	19.5	16.8	15.4	20.1	17.9	16
4 hr	7.9	11.4	9.8	8.9	11.8	10.4	9.3
6 hr	5.9	8.5	7.3	6.5	8.8	7.6	6.8
12 hr	3.6	4.8	4.1	3.7	4.9	4.3	3.8
24 hr	2.1	2.9	2.5	2.3	3	2.6	2.3
5 year							
5 min	116.3	150.6	133.1	125.3	158.2	139.6	129.1
10 min	84	103.7	92.2	87.6	108.7	96.4	89.8
15 min	69	83.6	75.2	72.2	87.3	78.1	73.9
30 min	49.1	61.5	54.9	52.1	62.7	57.5	53.4
1 hr	31.8	40.2	35.7	33.7	41	37.5	34.5
2 hr	18.6	23.5	20.9	19.7	24	21.9	20.2
4 hr	11.1	14.4	12.7	11.9	14.6	13.3	12.2
6 hr	8.3	10.9	9.5	8.9	11.1	10	9.1
12 hr	5.1	6.5	5.7	5.3	6.6	5.9	5.5
24 hr	2.9	3.8	3.3	3.1	3.9	3.5	3.2
10 year							
5 min	131.5	162.9	146.6	139.4	170	152.7	142.9
10 min	96.6	113.7	102.9	99.1	118.4	106.9	100.9
15 min	80	92.3	85.4	82.6	95.8	87.6	83.9
30 min	57.6	69.5	63.1	60.4	70.8	65.7	61.6
1 hr	37.4	45.5	41.1	39.2	46.3	42.7	40
2 hr	21.7	26.4	23.9	22.7	26.9	24.8	23.2
4 hr	13.5	16.4	14.7	14	16.7	15.4	14.3
6 hr	10	12.6	11.2	10.6	12.8	11.7	10.8
12 hr	6.2	7.7	6.9	6.5	7.9	7.2	6.7
24 hr	3.4	4.3	3.8	3.6	4.4	4	3.7

Table 4-3 Identifying Overlap in the IDF Relationships							
Duration	2012	2020 Maximum	2020 90 th Percentile	2020 Mean	2050 Maximum	2050 90 th Percentile	2050 Mean
Comparison of the 2 year IDF intensities with the 5 year 2012 intensities							
5 min	80%	116%	98%	90%	124%	105%	94%
10 min	77%	108%	92%	85%	115%	98%	88%
15 min	76%	104%	90%	84%	111%	95%	87%
30 min	74%	101%	88%	81%	104%	93%	84%
1 hr	73%	102%	87%	80%	105%	93%	83%
2 hr	75%	105%	90%	83%	108%	96%	86%
4 hr	71%	103%	88%	80%	106%	94%	84%
6 hr	71%	102%	88%	78%	106%	92%	82%
12 hr	71%	94%	80%	73%	96%	84%	75%
24 hr	72%	100%	86%	79%	103%	90%	79%
Average	74%	104%	89%	81%	108%	94%	84%
Comparison of the 5 year IDF intensities with the 10 year 2012 intensities							
5 min	88%	115%	101%	95%	120%	106%	98%
10 min	87%	107%	95%	91%	113%	100%	93%
15 min	86%	105%	94%	90%	109%	98%	92%
30 min	85%	107%	95%	90%	109%	100%	93%
1 hr	85%	107%	95%	90%	110%	100%	92%
2 hr	86%	108%	96%	91%	111%	101%	93%
4 hr	82%	107%	94%	88%	108%	99%	90%
6 hr	83%	109%	95%	89%	111%	100%	91%
12 hr	82%	105%	92%	85%	106%	95%	89%
24 hr	85%	112%	97%	91%	115%	103%	94%
Average	85%	108%	96%	90%	111%	100%	93%
Notes:							
1. Maximum values presented for comparison purposes only.							

Table 4-4 Summary of the Original Storm Sewer Design – Brookhaven Estates							
Pipe #	Length (m)	Diameter (mm)	Slope (%)	Required Capacity (cms)	Provided Capacity (cms)	Excess Capacity	Velocity (m/s)
1	60.0	450	0.20	0.117	0.128	9%	0.80
2	23.4	450	0.20	0.111	0.128	15%	0.80
3	84.3	525	0.16	0.145	0.172	19%	0.80
4	41.0	300	0.35	0.037	0.057	54%	0.81
5	49.0	525	0.20	0.178	0.192	8%	0.89
6	34.6	525	0.20	0.172	0.192	12%	0.89

4.2.2 Webber Estates

The limitations noted in regard to the Brookhaven Estates storm sewer network design suggest that an assessment using a larger, more complex storm network with larger pipe elements may reflect a different and potentially more meaningful outcome. As a result of this concern, the City of Welland provided a larger storm sewer network design comprising 40 pipes ranging in size from 200 mm to 1200 mm diameter. This network was designed for the Webber Estates residential development (see Table 4-5).

The Webber Estates residential development, located on the east side of the southern Clare Avenue extension and south of Webber Road, is comprised of sixty-five (65) single family homes and thirty-seven (37) townhouses. A general site layout is illustrated in Figure 4-1.

Storm sewer design sheets for the Webber Estates development were made available from the City of Welland and formed the basis of this component of the assessment (see Appendix A).

Excess capacities for this network are greater or equal to 4% and vary significantly over the range of pipe diameter as indicated below:

Pipe Diameter (mm)	Excess Capacity (%)
200	67%
300-450	16%
525-675	4%
1200	10%

It is also noted that the storm sewer design for Webber Estates integrated a 1.016 Imperial units equivalency factor for computation of flow capacity for the selected sewer pipe. This factor converts the named pipe size to the actual inside pipe diameter as outlined in Table 4-6.

4.3 Storm Sewer Design Based on Other IDF Data

Table 4-7 summarizes the results of the alternate storm sewer designs based on the other IDF relationships for the Brookhaven Estates development. The evaluation has been completed for all alternate IDF data for the 2 year, 5 year, 10 year and 25 year design return periods.

Table 4-8 similarly summarizes the results of the alternate IDF design basis assessment for the Webber Estates storm sewer network. The results in Table 4-8 have been limited to "Total Pipe Cost" and "% of Original Cost" given the large sewer network. A similar colour shading association is reflected where the storm sewer design is common across alternate IDF relationships.

Detailed storm sewer sizing using the alternates IDF relationships is provided in Appendix C for the Webber Estates storm sewer network.

Table 4-5 Summary of Original Storm Sewer Design – Webber Estates							
Pipe #	Length (m)	Diameter (mm)	Slope (%)	Required Capacity (cms)	Provided Capacity (cms)	Excess Capacity	Velocity (m/s)
A1	45.5	200	1.58	0.015	0.043	66%	1.33
A2	41.5	200	2.48	0.017	0.054	68%	1.66
A3	45.5	200	2.24	0.015	0.051	70%	1.58
A4	41.5	200	3.28	0.018	0.062	71%	1.91
A5	87.6	375	0.35	0.103	0.108	5%	0.95
A6	45.6	200	2.94	0.015	0.059	75%	1.81
A7	41.0	200	3.78	0.013	0.067	81%	2.05
A8	45.6	200	2.72	0.021	0.056	62%	1.74
A9	77.4	450	0.35	0.171	0.176	3%	1.07
A10	59.7	200	1.73	0.020	0.045	56%	1.39
A11	30.6	450	0.45	0.191	0.200	4%	1.22
A12	41.1	200	2.38	0.019	0.053	63%	1.63
A13	94.5	525	0.3	0.238	0.246	3%	1.10
A14	22.3	525	0.35	0.260	0.265	2%	1.19
A15	12.2	200	8	0.023	0.097	76%	2.98
A15a	88.2	525	0.4	0.276	0.284	3%	1.27
A16	23.0	200	0.95	0.020	0.033	41%	1.03
A17	94.1	375	0.5	0.107	0.129	17%	1.13
A18	55.1	200	3	0.037	0.059	37%	1.83
A19	65.9	450	0.35	0.162	0.176	8%	1.07
A20	42.6	450	0.4	0.180	0.188	4%	1.15
A21	41.5	200	3.33	0.009	0.062	86%	1.93
A22	41.5	200	2.96	0.017	0.059	72%	1.82
A23	41.5	200	3	0.012	0.059	80%	1.83
A24	100.0	375	0.25	0.080	0.092	13%	0.8
A25	41.4	200	3	0.018	0.059	70%	1.83
A26	41.2	200	3	0.018	0.059	70%	1.83
A27	100.0	450	0.25	0.143	0.149	4%	0.91
A27a	23.0	600	0.25	0.314	0.320	2%	1.10
A27b	32.5	600	0.25	0.310	0.320	3%	1.10
A28	30.5	675	0.5	0.600	0.620	3%	1.68
A29	30.5	675	0.65	0.633	0.707	10%	1.91
A30	31.9	300	0.5	0.038	0.071	47%	0.98
A31	81.4	375	0.5	0.067	0.129	48%	1.13
A32	81.4	375	0.5	0.093	0.129	28%	1.13
A33	8.0	1200	0.15	1.424	1.575	10%	1.35
A34	73.7	1200	0.15	1.502	1.575	5%	1.35
A35	73.7	1200	0.15	1.482	1.575	6%	1.35
A36	51.2	1200	0.25	1.766	2.034	13%	1.74
A37	24.1	1200	0.28	1.776	2.152	17%	1.84

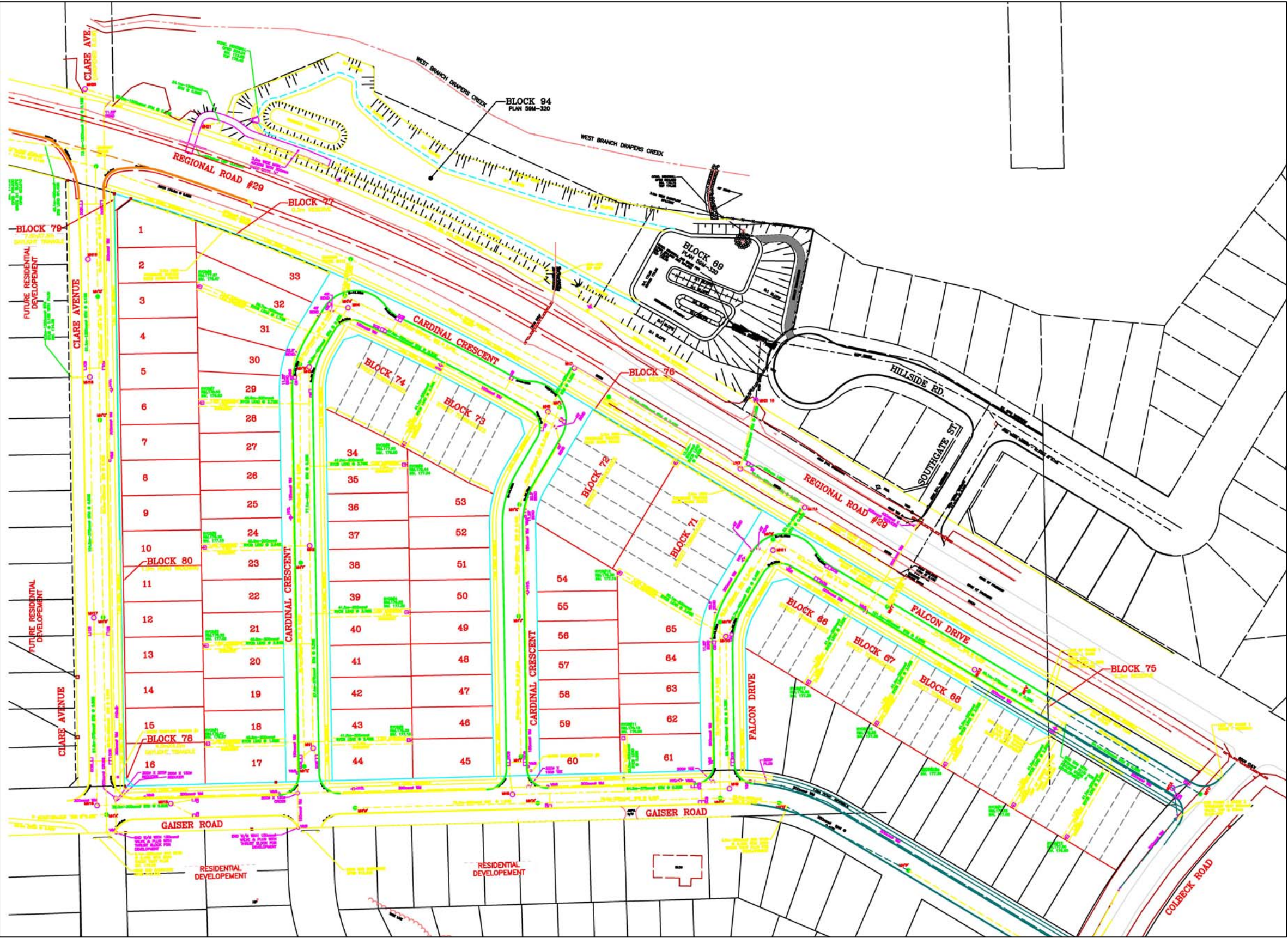


Figure 4-1: Webber Estates Residential Development – General Layout

Table 4-6: Imperial Units Equivalency Factor			
Imperial Internal Diameter (inches)	Industry Metric Standard (mm)	Direct Conversion (mm)	Factor
12	300	305	1.017
15	375	381	1.016
18	450	457	1.016
21	525	534	1.017
24	600	610	1.017
30	750	762	1.016
36	900	915	1.017
42	1050	1067	1.016
48	1200	1219	1.016
54	1350	1370	1.015
60	1500	1524	1.016
72	1800	1829	1.016
84	2100	2134	1.016
96	2400	2438	1.016
120	3000	3048	1.016
144	3600	3658	1.016
Average			1.016

Table 4-7 Storm Sewer Design Summary – Brookhaven Estates									
Feature	Current Design IDF	EC IDF	EC IDF	Maximum IDF	90 th Percentile IDF	Mean IDF	Maximum IDF	90 th Percentile IDF	Mean IDF
	1963	2010	2012	2020			2050		
	Pipe Sizes (mm) and Costs based on a 2 Year Design Rainfall								
Total Pipe Cost	\$28,352	\$28,352	\$28,352	\$35,102	\$28,352	\$28,352	\$35,102	\$31,360	\$28,352
% of Original Cost	100%	100%	100%	124%	100%	100%	124%	111%	100%
	Pipe Sizes (mm) and Costs based on a 5 Year Design Rainfall								
Total Pipe Cost	\$32,069	\$32,069	\$32,069	\$35,102	\$35,102	\$32,069	\$35,102	\$35,102	\$35,102
% of Original Cost	113%	113%	113%	124%	124%	113%	124%	124%	124%
	Pipe Sizes (mm) and Costs based on a 10 Year Design Rainfall								
Total Pipe Cost	\$35,102	\$35,102	\$35,102	\$35,102	\$35,102	\$35,102	\$35,102	\$35,102	\$35,102
% of Original Cost	124%	124%	124%	124%	124%	124%	124%	124%	124%
	Pipe Sizes (mm) and Costs based on a 25 Year Design Rainfall								
Total Pipe Cost	\$35,102	\$35,102	\$35,102	\$45,144	\$41,310	\$35,102	\$45,144	\$42,142	\$41,310
% of Original Cost	124%	124%	124%	159%	146%	124%	159%	149%	146%
		City of Welland Approved Design							
	Colour coded cells	Each colour represents a unique storm sewer system design (see legend below)							

	Base Case – system as designed with the current municipal IDF
	System design analogous to the base case
	System design at +11% cost premium over the base case
	System design at +13% cost premium over the base case
	System design at +24% cost premium over the base case
	System design at +46% cost premium over the base case
	System design at +49% cost premium over the base case
	System design at +59% cost premium over the base case

Table 4-8 Storm Sewer Design Summary – Webber Estates									
Feature	Current Design IDF	EC IDF	EC IDF	Maximum IDF	90 th Percentile IDF	Mean IDF	Maximum IDF	90 th Percentile IDF	Mean IDF
	1963	2010	2012	2020			2050		
	Costs based on a 2 Year Design Rainfall								
Total Pipe Cost	\$310,580	\$310,580	\$310,580	\$333,125	\$312,289	\$310,580	\$333,125	\$323,656	\$310,580
% of Original Cost	100%	100%	100%	107%	101%	100%	107%	104%	100%
	Costs based on a 5 Year Design Rainfall								
Total Pipe Cost	\$333,125	\$325,733	\$325,733	\$333,125	\$332,865	\$333,125	\$337,132	\$333,125	\$333,125
% of Original Cost	107%	105%	105%	107%	107%	107%	109%	107%	107%
	Costs based on a 10 Year Design Rainfall								
Total Pipe Cost	\$333,125	\$333,125	\$333,125	\$360,730	\$333,125	\$333,125	\$368,218	\$337,132	\$333,125
% of Original Cost	107%	107%	107%	116%	107%	107%	119%	109%	107%
	Costs based on a 25 Year Design Rainfall								
Total Pipe Cost	\$352,083	\$352,083	\$352,083	\$369,752	\$369,752	\$360,730	\$370,496	\$369,752	\$363,517
% of Original Cost	113%	113%	113%	119%	119%	116%	119%	119%	117%
		City of Welland Approved Design							
	Colour coded cells	Each colour represents a unique storm sewer system design (see legend below)							

	Base Case – system as designed with the current municipal IDF
	System design analogous to the base case
	System design at +1% cost premium over the base case
	System design at +4% cost premium over the base case
	System design at +5% cost premium over the base case
	System design at +7% cost premium over the base case
	System design at +9% cost premium over the base case
	System design at +13% cost premium over the base case
	System design at +16% cost premium over the base case
	System design at +17% cost premium over the base case
	System design at +19% cost premium over the base case

5 SUMMARY AND RECOMMENDATIONS

5.1 IDF Shift and Influences on Stormwater Management

5.1.1 Summary

The performance and design basis for the stormwater management (SWM) facility serving a portion of the Brookhaven Estates residential development has been evaluated for various design rainfall conditions, as described by the City's current design rainfall IDF relationships as well as relationships for the Environment Canada weather station at Port Colborne for 2010, and 2012. Additionally, the projected IDF relationships for the future periods of 2020 and 2050 periods have been applied based on a statistical analysis of an ensemble of downscaled climate data resulting in IDF relationships representing the maximum, 90th percentile and mean of the underlying ensemble.

Two evaluations have been completed using MIDUSS as the modelling platform, namely:

1. The performance of the SWM facility, as reflected by resulting water levels and storage usage, has been assessed based on the stormwater runoff generated from the application of each of the alternate IDF rainfall data.
2. The storage component of the design of the SWM facility has been altered such that the 100 year water level in the facility under the actual design (based on the City's current design IDF relationship) conditions has been maintained.

For the first evaluation it has been determined that under the maximum 2020 and 2050 IDF relationships, overtopping of the facility embankment (crest height is presently 184.20 m) would occur for the 100 year event. Such an event could result in failure of the containment embankment and loss of the facility. In addition, the freeboard available under a number of other design rainfall conditions would be less than 5 centimetres.

The SWM facility as constructed has a maximum freeboard at the 100 year water level of only 0.12 m and a top of bank elevation of 184.20 m. As an extension of the first evaluation, it has been determined that a facility embankment crest having elevation 184.52 m would contain all modelled events (with no overtopping) and, similarly, maintain a minimum 0.3 m freeboard.

The SWM facility as constructed controls the 100 year design event runoff to a water level of 184.08 m while utilizing a storage volume of about 1800 m³. As a result of the second evaluation, it has been determined that both the 2010 and 2012 IDF relationships would result in higher runoff (volume and peak flow) which, in turn, would result in the need for a SWM facility having a larger volume. It has further been determined that a SWM facility having a maximum operational volume of about 3500 m³ would be required to adequately contain the 100 year event (for the 2050 Maximum IDF) while maintaining a maximum water level of 184.08 m. This required storage volume is about 90% more than the approved design.

All of the alternate IDF relationships evaluated resulted in a larger SWM facility with additional required volume in the range of 20% to 89% above that in the approved SWM facility.

Based on the added required storage volumes for the alternate rainfall conditions, an estimate of the land area required to accommodate the added volume has been determined. Using land value data from the City and average SWM facility construction costs an estimate of the extra cost required to build the additional storage has been determined. The extra costs range from about \$95,000 to about \$420,000. The latter cost associated with building the extra storage required to control the 100 year 2050 Maximum design storm.

It should also be noted that⁶:

- The 1963 curves are conservative relative to the current (2012) estimates and even relative to the projected (2020 and 2050) values for some duration/return interval combinations. In those instances, it may be reasonable to retain the 1963 intensities. However, doing so does not ensure that those intensities will be appropriate, it simply maintains current practice.
- The projected IDF curves display significant differences across the Mean, the 90th Percentile and the Maximum values. Conventionally, the maximum value is excluded as the basis for planning decisions as it represents a single estimate from the ensemble database and can therefore be sensitive to error. Quantile values, such as the 90th percentile value and the mean, are estimated in the context of all values in the ensemble database and are therefore not as sensitive.
- For most duration/return period combinations there is not a large difference in estimated intensity between 2020 and 2050. Therefore, it is reasonable to use estimates from either time frame, but a mildly conservative choice would be to use the 2050 estimates.

5.1.2 Recommendations

The following recommendations stem from the analysis:

- i) It is recommended that a freeboard requirement be adopted; good engineering practice is to allow for a freeboard of at least 0.3 m above the maximum design water level in a SWM facility. Allowance for freeboard provides a margin of safety in a design.
- ii) It is recommended that a requirement for an emergency overflow above 100 year level for SWM facilities be adopted.
- iii) It has been determined that use of the Environment Canada 2010 and 2012 IDF relationships result in a SWM facility that would be larger than that approved for the Brookhaven Estates development by the City. This indicates that the current rainfall design basis used by the City results in undersized stormwater control infrastructure in consideration of the current estimate of the 100 year event. As the Environment Canada

⁶ These issues were originally documented in the 2012 climate change vulnerability assessment for the City of Welland in Section 6.3.1 of the final report.

2012 IDF relationship best represents current expected rainfall patterns in Welland, it is recommended that, as a minimum, the City consider adopting at least this rainfall design standard.

- iv) It is further recommended that the City give consideration to adopting either the 2020 Mean or the 2050 Mean IDF relationship as the new rainfall design basis for the City. Both of these relationships are based on the Environment Canada 2012 IDF relationship and as such reflect the current expectation of rainfall patterns in the City, however also incorporate potential climate change influences as represented by the mean expectation of the ensemble database of future projections. Both of these relationships would add only a minor premium over the use of the Environment Canada 2012 IDF itself, and as such given the minor differences between the 2020 and 2050, a mildly conservative choice would be to use the 2050 Mean IDF relationship.

5.2 Change In Municipal Design Standard

5.2.1 Summary

The City of Welland currently uses a 2 year design criteria for sizing storm sewers. This component of the evaluation has quantified the potential impacts resulting from a shift in sizing of storm sewers to one of the other IDF relationships and an alternate return period basis (including a 5 year, 10 year and 25 year design criteria).

It has been noted that the simple network (i.e., Brookhaven Estates) used for the analysis and the extra capacity available in the approved design may likely be masking issues associated with the storm sewer design based on alternate IDF relationships as reflected in this assessment. As such, a larger, more complex storm network with larger pipe elements was also evaluated.

The results of the analysis for the Brookhaven Estates storm sewer network indicate the following:

- i) Maintaining a 2 year design basis would result in a change in the approved design with the 2020 Maximum and the 2050 Maximum and 90th Percentile IDF relationships.
- ii) Use of the 2 year Maximum IDF relationships both result in a storm sewer design using larger pipe sizes (5 of the 6 pipes require an increase to the next larger pipe size) representing a 24% premium in cost over the approved design.
- iii) Use of the 2 year Environment Canada 2012 IDF relationship or the 2020 or 2050 Mean IDF relationship all result in a storm sewer design unchanged from the approved design.
- iv) Use of the existing City of Welland IDF design relationship and a 5 year design basis results in a storm sewer design using larger pipe sizes (4 of the 6 pipes require an increase to the next larger pipe size) representing a 13% premium in cost over the approved design.

- v) Use of the Environment Canada 2012 IDF or the 2020 Mean IDF relationship results in the same storm sewer design as that based on the 5 year current City of Welland IDF relationship.
- vi) Use of the 2050 Mean IDF relationship results in a storm sewer design using larger pipe sizes (1 of the 6 pipes require an increase to the next larger pipe size when compared with the 5 year City of Welland IDF based design) representing a 24% premium in cost over the approved design.
- vii) Use of a 10 year design basis results in the same storm sewer design across all IDF relationships representing a 24% premium in cost over the approved 2 year based design.
- viii) The storm sewer design based on the 2 year 2050 90th Percentile IDF relationship is analogous to that developed with the 5 year 2012 IDF relationship reflective of the overlap in the IDF relationships as discussed previously.
- ix) The storm sewer design based on the 5 year 2050 90th Percentile IDF relationship is the same as that developed with the 10 year 2012 IDF relationship reflective of the overlap in the IDF relationships as discussed previously.
- x) Use of the 5 year 2050 Mean IDF relationship results in the same storm sewer design as those based on 10 year design basis for all alternate IDF relationships. Further, the design is the same as those based on the 25 year existing, 2010, 2012 and 2020 Mean IDF relationships.

The results of the analysis for the Webber Estates storm sewer network indicate the following:

- xi) Similar relationships and comparisons between the storm sewer designs associated with the alternate design IDF relationships can also be made for the Webber Estates storm sewer network. Although, it is clear from this assessment that different storm sewer networks will be impacted differently under various design precipitation scenarios.
- xii) Of importance, though, in comparison between the results for the Brookhaven Estates and the Webber Estates scenarios is where common storm sewer designs result. For the Brookhaven Estates scenario a common design results in 20 (124% of original cost estimate) of the 36 alternate design IDF relationships. Similarly, for Webber Estates a common design results in 13 (107% of original cost estimate) of the 36 alternate design IDF relationships.

5.2.2 Recommendations

- i) Stationarity is founded upon the idea that natural systems are variable only within a defined boundary. It implies that any variable, including precipitation, has a probability density function that does not change with time, and whose characteristics can be estimated from a time series of data collected in the field (Milly et al, 2008). With projected changes in climate variability, precipitation included, it is suggested that changes will also occur in the characteristics of the associated probability density function. This would suggest that reliance on historical data as a means of estimating future occurrence may not be the best

approach. As such, it is recommended that preference be given to selection of either a 2020 or 2050 based IDF design relationship over maintaining the current 1963 relationship or selection of the 2012 IDF relationship.

- ii) When considering how to interpret the projected values the first aspect to consider is whether to use the 2020 or 2050 estimates. For most duration/return-interval combinations there is not a large difference in estimated intensity between 2020 and 2050. Therefore, it is reasonable to use estimates from either time frame, but a mildly conservative choice would be to use the 2050 estimates.
- iii) It has been noted in the vulnerability assessment (AMEC, 2012), that the Maximum IDF representation is typically excluded as the basis for planning decisions as it represents a single estimate of future rainfall, from the ensemble of estimates, and may be, therefore, quite sensitive to error or artifacts. Quantile values, such as the 90th Percentile value and the Mean, are estimated in the context of all ensemble values and are therefore not as volatile. As the Mean IDF representation embodies the broadest base of future precipitation estimates, it is recommended that a Mean IDF representation be selected as the new standard.
- iv) Brought together, the aforementioned findings lead to the recommendation to select the 2050 Mean IDF design relationship. Consideration has been given to the 2050 90th Percentile IDF design relationship however, the 2050 Mean yields an analogous storm sewer design as that developed using the 2050 90th Percentile IDF relationship for the examples provided. Further, the storm sewer design developed using the 2050 Mean IDF relationship also accommodates the 10 year return period events for many of the IDF relationships evaluated.
- v) This result suggests that adopting a 10 year design standard is possible with no additional financial impact when compared with a 5 year design standard for the 2050 Mean IDF relationship. This holds true across both storm sewer network examples. This would require additional investment in infrastructure (over existing) as demonstrated by this analysis in the range 7% to 24% however, the benefits would be tangible in less frequent major system flooding and development of adequate minor system capacity to accommodate expected changes in future rainfall patterns for more frequent rainfall events. In general, adopting a higher design standard would also align the City with other municipalities and in keeping with the general evolution of this storm sewer design standard for municipalities across the Province.
- vi) In regard to a review cycle for the design IDF relationship, it is recommended that the City adopt a 5 year review cycle for IDF relationships upon which the storm sewer rainfall design standard is based. This will allow for integration of new Environment Canada recorded rainfall data, as available, and new climate projections and methodologies for rainfall projection, as relevant, into the City of Welland rainfall IDF design basis.

vii) In regard to storm sewer design standards, it is recommended that the City consider two additional issues, namely:

- Adoption of a maximum allowable pipe flow restriction as represented by a percentage of full pipe flow (e.g., 95%) as a means of integrating another manner of safety factor into storm sewer design.
- Standardization of pipe sizes for flow computation. For the two examples evaluated one (Webber Estates) included a factor (1.016 imperial/metric equivalency factor) to convert the named (or nominal) metric pipe diameter to the actual metric pipe diameter and the other (Brookhaven Estates) did not. Designating use of the named (or nominal) metric pipe diameter would represent another means of integrating a safety factor into storm sewer design.

6 REFERENCES

City of Welland (2011). *Municipal Standards*, February 2011.

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R.V. Anderson and Associates Limited (1963). *Report on Sewage and Drainage Works in the City of Welland*.

Kerry T. Howe Engineering Limited (2006). *Rainbow Country Estates (aka Brookhaven Estates)*, City of Welland, Stormwater Management Report, March 2006.

Milley et al (2008). P. C. D. Milly, Julio Betancourt, Malin Falkenmark, Robert M. Hirsch, Zbigniew W., Kundzewicz, Dennis P. Lettenmaier, Ronald J. Stouffer, *Stationarity Is Dead: Whither Water Management?*, Science, Volume 319, No. 1, February 2008.



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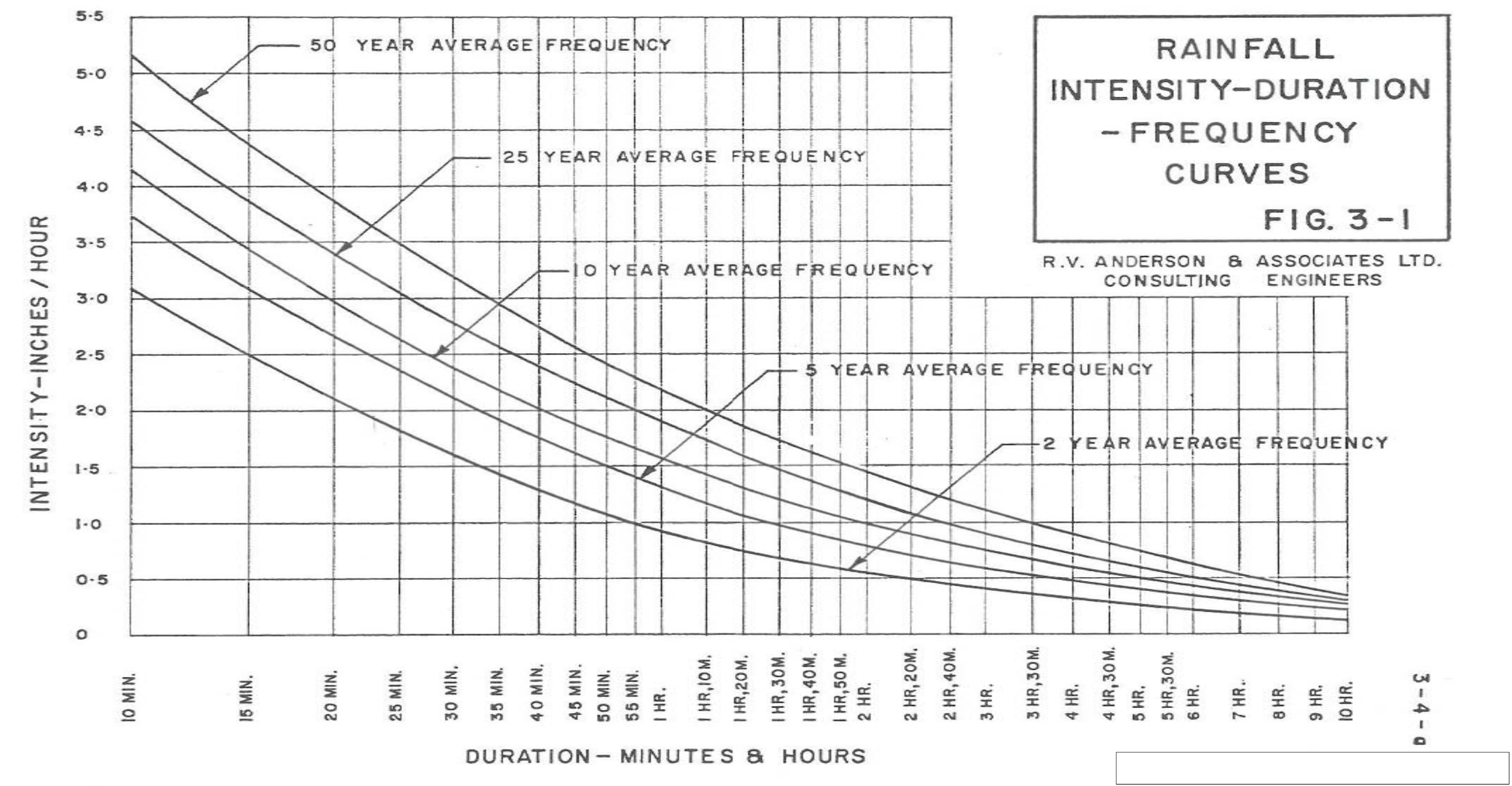
APPENDIX A

PROJECT DATA

- **CITY OF WELLAND 1960'S VINTAGE IDF DATA**
- **BROOKHAVEN ESTATES STORM SEWER DESIGN SHEET**
- **WEBBER ESTATES STORM SEWER DESIGN SHEETS**



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CITY OF WELLAND
2 YEAR STORM $i = 755 / (tc + 8)^{0.789}$
 $Q = A \cdot R / 360$
 $N = 0.013$

Brookhaven Estates Storm Sewer Design Sheet

UPPER CANADA CONSULTANTS
261 MARTINDALE ROAD, UNIT #1
ST. CATHARINES, ONTARIO, L2W 1A1
TEL: 905-688-9400

RAINFALL PARAMETERS:
2 YEAR DESIGN STORM EVENT
CITY OF WELLAND IDF CURVE

A = 755.00 mm/hr
B = 8.00 minutes
C = 0.789

MUNICIPALITY: CITY OF WELLAND
PROJECT NAME: WEBBER ESTATES
PROJECT NO.: 0321

STORM SEWER DESIGN SHEET

LICENSED PROFESSIONAL ENGINEER
J. P. SCHOOLEY
May 25/06
PROVINCE OF ONTARIO

BY: J. SCHOOLEY
DATE: MARCH 2006

SEWER DESIGN:
PIPE ROUGHNESS: 0.013 FOR MANNING'S EQUATION
PIPE SIZES: 1.016 IMPERIAL EQUIVALENT FACTOR
PERCENT FULL: TOTAL PEAK FLOW / CAPACITY

LOCATION			STORMWATER ANALYSIS								STORM SEWER DESIGN					
DESCRIPTION	From M.H.	To M.H.	A Area (hectares)	R Runoff Coeff.	A*R	Accumulated A*R	Time of Concentration (min)	Flow Time (min.)	Rainfall Intensity (mm/hr)	Peak Flow (L/s)	Length (m)	Diameter (mm.)	Slope (%)	Full Flow Capacity (L/s)	Full Flow Velocity (m/s)	Percent Full
A21	RYCB 13	SEWER	0.07	0.60	0.042	0.042	10.00	0.36	77.2	9.0	41.5	200	3.33	62.4	1.93	14.4%
A22	RYCB 14	SEWER	0.13	0.60	0.078	0.078	10.00	0.38	77.2	16.7	41.5	200	2.96	58.9	1.82	28.4%
A23	RYCB 15	SEWER	0.09	0.60	0.054	0.054	10.00	0.38	77.2	11.6	41.5	200	3.00	59.3	1.83	19.5%
A24	MH12	MH13	0.34	0.60	0.204	0.378	10.38	2.08	75.9	79.7	100.0	375	0.25	91.5	0.80	87.2%
A25	RYCB 16	SEWER	0.14	0.60	0.084	0.084	10.00	0.38	77.2	18.0	41.4	200	3.00	59.3	1.83	30.4%
A26	RYCB 17	SEWER	0.14	0.60	0.084	0.084	10.00	0.38	77.2	18.0	41.2	200	3.00	59.3	1.83	30.4%
A27	MH13	MH11	0.32	0.60	0.192	0.738	12.46	1.84	69.8	143.0	100.0	450	0.25	148.7	0.91	96.2%
	MH11	MH14			0.000	1.678	13.40	0.35	67.3	313.9	23.0	600	0.25	320.3	1.10	98.0%
	MH14	MH7			0.000	1.678	13.75	0.49	66.5	309.9	32.5	600	0.25	320.3	1.10	96.8%
A28	MH7	MHDI 15	0.79	0.40	0.316	3.584	16.64	0.30	60.3	599.9	30.5	675	0.50	620.1	1.68	96.7%
A29	MHDI 15	EX. MH	0.59	0.40	0.234	3.818	16.94	0.00	59.7	632.9		675	0.65	707.0	1.91	89.5%
A30	MH15	MH16	0.44	0.40	0.176	0.176	10.00	0.54	77.2	37.7	31.9	300	0.50	71.3	0.98	52.9%
A31	MH16	MH17	0.36	0.40	0.144	0.320	10.54	1.20	75.4	67.0	81.4	375	0.50	129.3	1.13	51.8%
A32	MH17	MH18	0.37	0.40	0.148	0.468	11.74	1.20	71.8	93.3	81.4	375	0.50	129.3	1.13	72.1%
FUTURE WESTERLY EXTERNAL AREA	PARK		1.63	0.25	0.408	0.408										
	TOWNHOUSE		2.85	0.60	1.710	2.118										
	APARTMENT		2.99	0.70	2.093	4.211										
	RESIDENTIAL		16.04	0.40	6.416	10.627	24.67	Tc = 10+1100m / 1.25m/s / 60s/min								
A33	STUB	MH18	23.51	0.45		10.627	24.67	0.10	48.2	1423.7	8.0	1200	0.15	1575.3	1.35	90.4%
A34	MH18	MH19	0.35	0.40	0.140	11.235	24.77	0.91	48.1	1501.5	73.7	1200	0.15	1575.3	1.35	95.3%
A35	MH19	MH20	0.24	0.40	0.096	11.331	25.68	0.91	47.1	1482.0	73.7	1200	0.15	1575.3	1.35	94.1%
A36	MH20	MH21	6.14	0.40	2.456	13.787	26.59	0.49	46.1	1765.6	51.2	1200	0.25	2033.7	1.74	86.8%
A37	MH21	OUTLET	0.59	0.40	0.234	14.021	27.08	0.22	45.6	1775.8	24.1	1200	0.28	2152.2	1.84	82.5%

APPENDIX B

PROJECTED IDF DATA BASED ON THE 2010 ENVIRONMENT CANADA RAINFALL DATA FOR PORT COLBORNE



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Projected IDF Data for 2020 based on 2010 Historical IDF Data

Duration	Maximum					
	Return Interval, Years					
	2	5	10	25	50	100
5 min	133.9	150.6	163.3	180.5	193.5	206.8
10 min	89.9	103.2	113.2	126.7	136.9	147.2
15 min	71.6	83.7	92.6	104.5	114.1	124.3
30 min	49	61.2	69.5	80.3	88.4	96.3
1 hr	31.9	39.9	45.5	52.6	58	63.2
2 hr	19.2	23.5	26.4	30.3	33.1	36
4 hr						
6 hr	8.4	10.6	12	13.8	15.2	16.6
12 hr	4.7	6.2	7.4	8.6	9.4	10.2
24 hr	2.8	3.6	4.2	4.8	5.3	5.7

Duration	90th Percentile					
	Return Interval, Years					
	2	5	10	25	50	100
5 min	113.4	133.1	147	165.1	178.7	192.5
10 min	76.6	91.8	102.5	117.2	128.7	140
15 min	61.7	75.3	85.7	99.2	109.3	119.6
30 min	42.6	54.7	63.1	74.1	82.2	90.2
1 hr	27.2	35.4	41.1	48.3	53.8	59.1
4 hr						
2 hr	16.6	20.9	23.9	27.8	30.7	33.6
6 hr	7.1	9.3	10.6	12.5	13.9	15.3
12 hr	3.9	5.5	6.6	7.8	8.6	9.5
24 hr	2.4	3.2	3.7	4.3	4.8	5.2

Duration	Mean					
	Return Interval, Years					
	2	5	10	25	50	100
5 min	104.2	125.3	139.8	158.4	172.3	186.3
10 min	70.8	87.2	98.7	113.9	125.4	136.9
15 min	57.6	72.3	82.9	96.7	107.1	117.4
30 min	39.1	51.8	60.4	71.3	79.5	87.5
1 hr	25.1	33.5	39.2	46.4	51.9	57.2
2 hr	15.2	19.7	22.7	26.7	29.6	32.6
4 hr						
6 hr	6.4	8.7	10	11.9	13.3	14.7
12 hr	3.6	5.1	6.2	7.4	8.2	9.1
24 hr	2.2	3	3.5	4.1	4.6	5

Projected IDF Data for 2050 based on 2010 Historical IDF Data

Duration	Maximum					
	Return Interval, Years					
	2	5	10	25	50	100
5 min	142.8	158.2	170.4	187.1	200	213.1
10 min	95.7	108.2	117.9	131.1	141.2	151.4
15 min	75.9	87.4	96.2	107.9	116.8	125.7
30 min	50.4	62.5	70.8	81.5	89.5	97.5
1 hr	32.8	40.8	46.3	53.4	58.8	64
2 hr	19.8	24	26.9	30.7	33.5	36.5
4 hr	11.6	14.4	16.3	18.8	20.5	22.4
6 hr	8.7	10.9	12.2	14.1	15.5	16.8
12 hr	4.8	6.4	7.5	8.7	9.5	10.4
24 hr	2.8	3.7	4.3	4.9	5.4	5.8

Duration	90th Percentile					
	Return Interval, Years					
	2	5	10	25	50	100
5 min	121	139.6	153	170.8	184.2	197.7
10 min	81.5	96	106.4	120.2	131.1	141.5
15 min	65.3	78.2	88	101.3	111.4	121.5
30 min	45.1	57.3	65.7	76.6	84.7	92.7
1 hr	29.2	37.3	42.7	49.9	55.3	60.5
2 hr	17.6	21.9	24.8	28.7	31.5	34.5
4 hr	10.2	13	15	17.5	19.2	21.1
6 hr	7.5	9.7	11.1	13	14.4	15.8
12 hr	4.2	5.7	6.8	8.1	8.9	9.8
24 hr	2.5	3.3	3.9	4.5	5	5.4

Duration	Mean					
	Return Interval, Years					
	2	5	10	25	50	100
5 min	108.9	129.1	143.3	161.7	175.4	189.2
10 min	73.6	89.4	100.4	115	126.2	137.4
15 min	59.6	74	84.2	97.8	108.1	118.4
30 min	40.5	53.1	61.6	72.6	80.6	88.7
1 hr	26.1	34.3	40	47.2	52.6	57.9
2 hr	15.8	20.2	23.2	27.1	30	33
4 hr	9.1	12	13.9	16.4	18.2	20.1
6 hr	6.7	8.9	10.3	12.2	13.6	15
12 hr	3.7	5.2	6.3	7.6	8.4	9.3
24 hr	2.2	3.1	3.6	4.2	4.7	5.1

APPENDIX C

STORM SEWER DESIGN DETAILS FOR WEBBER ESTATES and BROOKHAVEN ESTATES



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Storm Sewer Design Summary – Brookhaven Estates									
Pipe #	Current Design IDF	EC IDF	EC IDF	Maximum IDF	90 th Percentile IDF	Mean IDF	Maximum IDF	90 th Percentile IDF	Mean IDF
	1963	2010	2012	2020			2050		
	Pipe Sizes (mm) and Costs based on a 2 Year Design Rainfall								
1	450	450	450	525	450	450	525	450	450
2	450	450	450	525	450	450	525	450	450
3	525	525	525	600	525	525	600	525	525
4	300	300	300	300	300	300	300	300	300
5	525	525	525	600	525	525	600	600	525
6	525	525	525	600	525	525	600	600	525
Total Pipe Cost	\$28,352	\$28,352	\$28,352	\$35,102	\$28,352	\$28,352	\$35,102	\$31,360	\$28,352
% of Original Cost	100%	100%	100%	124%	100%	100%	124%	111%	100%
	Pipe Sizes (mm) and Costs based on a 5 Year Design Rainfall								
1	525	525	525	525	525	525	525	525	525
2	525	525	525	525	525	525	525	525	525
3	525	525	525	600	600	525	600	600	600
4	300	300	300	300	300	300	300	300	300
5	600	600	600	600	600	600	600	600	600
6	600	600	600	600	600	600	600	600	600
Total Pipe Cost	\$32,069	\$32,069	\$32,069	\$35,102	\$35,102	\$32,069	\$35,102	\$35,102	\$35,102
% of Original Cost	113%	113%	113%	124%	124%	113%	124%	124%	124%
	Pipe Sizes (mm) and Costs based on a 10 Year Design Rainfall								
1	525	525	525	525	525	525	525	525	525
2	525	525	525	525	525	525	525	525	525
3	600	600	600	600	600	600	600	600	600
4	300	300	300	300	300	300	300	300	300
5	600	600	600	600	600	600	600	600	600
6	600	600	600	600	600	600	600	600	600
Total Pipe Cost	\$35,102	\$35,102	\$35,102	\$35,102	\$35,102	\$35,102	\$35,102	\$35,102	\$35,102
% of Original Cost	124%	124%	124%	124%	124%	124%	124%	124%	124%
	Pipe Sizes (mm) and Costs based on a 25 Year Design Rainfall								
1	525	525	525	600	525	525	600	525	525
2	525	525	525	600	525	525	600	525	525
3	600	600	600	600	600	600	600	600	600
4	300	300	300	450	300	300	450	450	300
5	600	600	600	675	675	600	675	675	675
6	600	600	600	675	675	600	675	675	675
Total Pipe Cost	\$35,102	\$35,102	\$35,102	\$45,144	\$41,310	\$35,102	\$45,144	\$42,142	\$41,310
% of Original Cost	124%	124%	124%	159%	146%	124%	159%	149%	146%
		City of Welland Approved Design							
	Colour coded cells	Each colour represents a unique storm sewer system design							

Storm Sewer Design Summary – Webber Estates – 2 Year									
Pipe #	Current Design IDF	EC IDF	EC IDF	Maximum IDF	90 th Percentile IDF	Mean IDF	Maximum IDF	90 th Percentile IDF	Mean IDF
	1963	2010	2012	2020			2050		
	Pipe Sizes (mm) and Costs based on a 2 Year Design Rainfall								
A1	200	200	200	200	200	200	200	200	200
A2	200	200	200	200	200	200	200	200	200
A3	200	200	200	200	200	200	200	200	200
A4	200	200	200	200	200	200	200	200	200
A5	375	375	375	450	375	375	450	450	375
A6	200	200	200	200	200	200	200	200	200
A7	200	200	200	200	200	200	200	200	200
A8	200	200	200	200	200	200	200	200	200
A9	450	450	450	525	450	450	525	525	450
A10	200	200	200	200	200	200	200	200	200
A11	450	450	450	525	450	450	525	525	450
A12	200	200	200	200	200	200	200	200	200
A13	525	525	525	600	525	525	600	600	525
A14	525	525	525	525	525	525	525	525	525
A15	200	200	200	200	200	200	200	200	200
A15a	525	525	525	600	525	525	600	600	525
A16	200	200	200	200	200	200	200	200	200
A17	375	375	375	375	375	375	375	375	375
A18	200	200	200	200	200	200	200	200	200
A19	450	450	450	450	450	450	450	450	450
A20	450	450	450	525	450	450	525	525	450
A21	200	200	200	200	200	200	200	200	200
A22	200	200	200	200	200	200	200	200	200
A23	200	200	200	200	200	200	200	200	200
A24	375	375	375	450	375	375	450	375	375
A25	200	200	200	200	200	200	200	200	200
A26	200	200	200	200	200	200	200	200	200
A27	450	450	450	525	450	450	525	525	450
A27a	600	600	600	675	675	600	675	675	600
A27b	600	600	600	675	600	600	675	675	600
A28	675	675	675	675	675	675	675	675	675
A29	675	675	675	750	675	675	750	675	675
A30	300	300	300	300	300	300	300	300	300
A31	375	375	375	375	375	375	375	375	375
A32	375	375	375	375	375	375	375	375	375
A33	1200	1200	1200	1200	1200	1200	1200	1200	1200
A34	1200	1200	1200	1200	1200	1200	1200	1200	1200
A35	1200	1200	1200	1200	1200	1200	1200	1200	1200
A36	1200	1200	1200	1350	1200	1200	1350	1200	1200
A37	1200	1200	1200	1200	1200	1200	1200	1200	1200
Total Pipe Cost	\$310,580	\$310,580	\$310,580	\$333,125	\$312,289	\$310,580	\$333,125	\$323,656	\$310,580
% of Original Cost	100%	100%	100%	107%	101%	100%	107%	104%	100%
City of Welland Approved Design Colour coded cells Each colour represents a unique storm sewer system design									

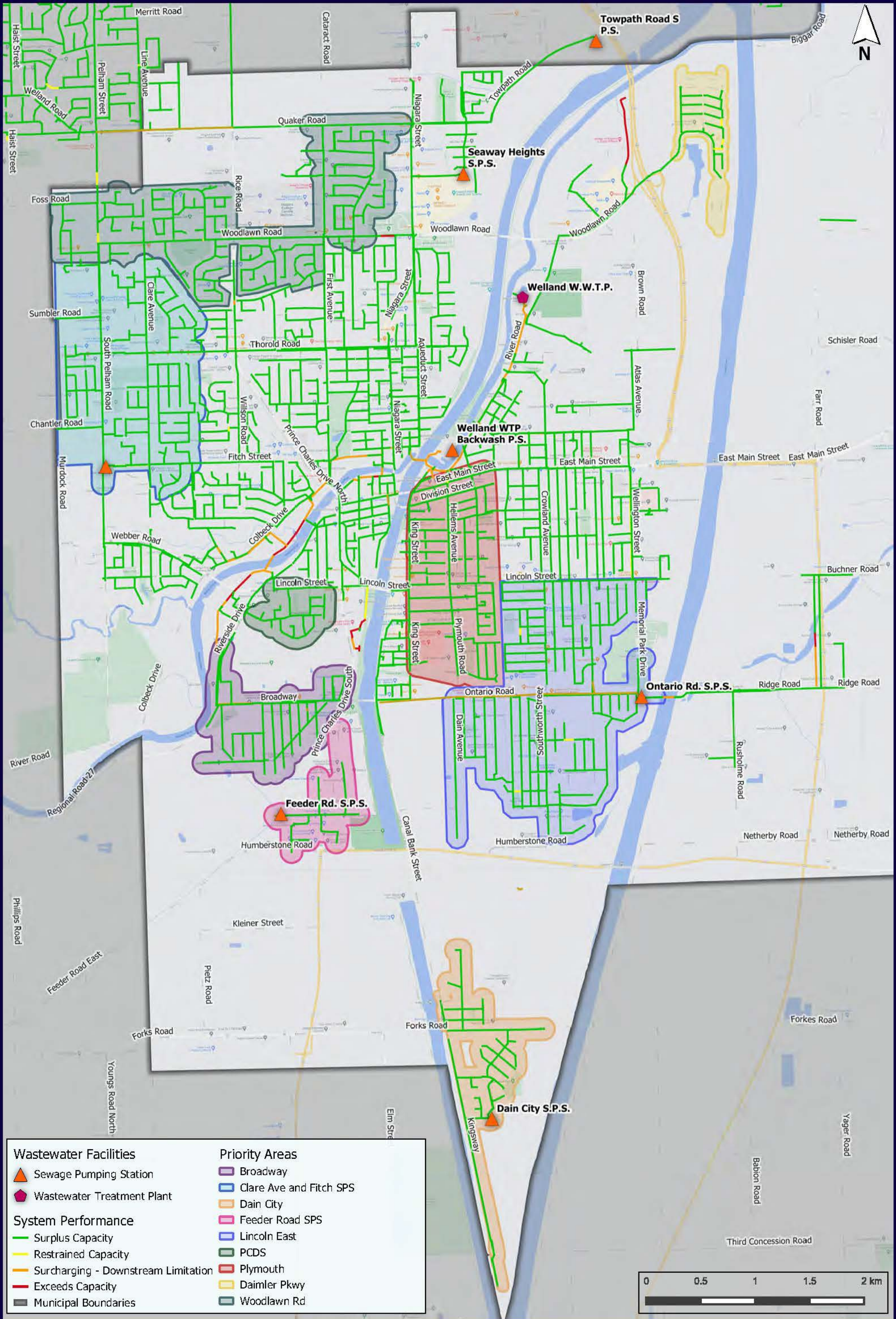
Storm Sewer Design Summary – Webber Estates – 5 Year									
Pipe #	Current Design IDF	EC IDF	EC IDF	Maximum IDF	90 th Percentile IDF	Mean IDF	Maximum IDF	90 th Percentile IDF	Mean IDF
	1963	2010	2012	2020			2050		
	Pipe Sizes (mm) and Costs based on a 5 Year Design Rainfall								
A1	200	200	200	200	200	200	200	200	200
A2	200	200	200	200	200	200	200	200	200
A3	200	200	200	200	200	200	200	200	200
A4	200	200	200	200	200	200	200	200	200
A5	450	450	450	450	450	450	450	450	450
A6	200	200	200	200	200	200	200	200	200
A7	200	200	200	200	200	200	200	200	200
A8	200	200	200	200	200	200	200	200	200
A9	525	525	525	525	525	525	525	525	525
A10	200	200	200	200	200	200	200	200	200
A11	525	525	525	525	450	525	525	525	525
A12	200	200	200	200	200	200	200	200	200
A13	600	600	600	600	600	600	600	600	600
A14	525	525	525	525	525	525	525	525	525
A15	200	200	200	200	200	200	200	200	200
A15a	600	600	600	600	600	600	600	600	600
A16	200	200	200	200	200	200	200	200	200
A17	375	375	375	375	375	375	375	375	375
A18	200	200	200	200	200	200	200	200	200
A19	450	450	450	450	450	450	450	450	450
A20	525	525	525	525	525	525	525	525	525
A21	200	200	200	200	200	200	200	200	200
A22	200	200	200	200	200	200	200	200	200
A23	200	200	200	200	200	200	200	200	200
A24	450	375	375	450	450	450	450	450	450
A25	200	200	200	200	200	200	200	200	200
A26	200	200	200	200	200	200	200	200	200
A27	525	525	525	525	525	525	525	525	525
A27a	675	675	675	675	675	675	750	675	675
A27b	675	675	675	675	675	675	750	675	675
A28	675	675	675	675	675	675	675	675	675
A29	750	750	750	750	750	750	750	750	750
A30	300	300	300	300	300	300	300	300	300
A31	375	375	375	375	375	375	375	375	375
A32	375	375	375	375	375	375	450	375	375
A33	1200	1200	1200	1200	1200	1200	1200	1200	1200
A34	1200	1200	1200	1200	1200	1200	1200	1200	1200
A35	1200	1200	1200	1200	1200	1200	1200	1200	1200
A36	1350	1200	1200	1350	1350	1350	1350	1350	1350
A37	1200	1200	1200	1200	1200	1200	1200	1200	1200
Total Pipe Cost	\$333,125	\$325,733	\$325,733	\$333,125	\$332,865	\$333,125	\$337,132	\$333,125	\$333,125
% of Original Cost	107%	105%	105%	107%	107%	107%	109%	107%	107%
City of Welland Approved Design Colour coded cells Each colour represents a unique storm sewer system design									

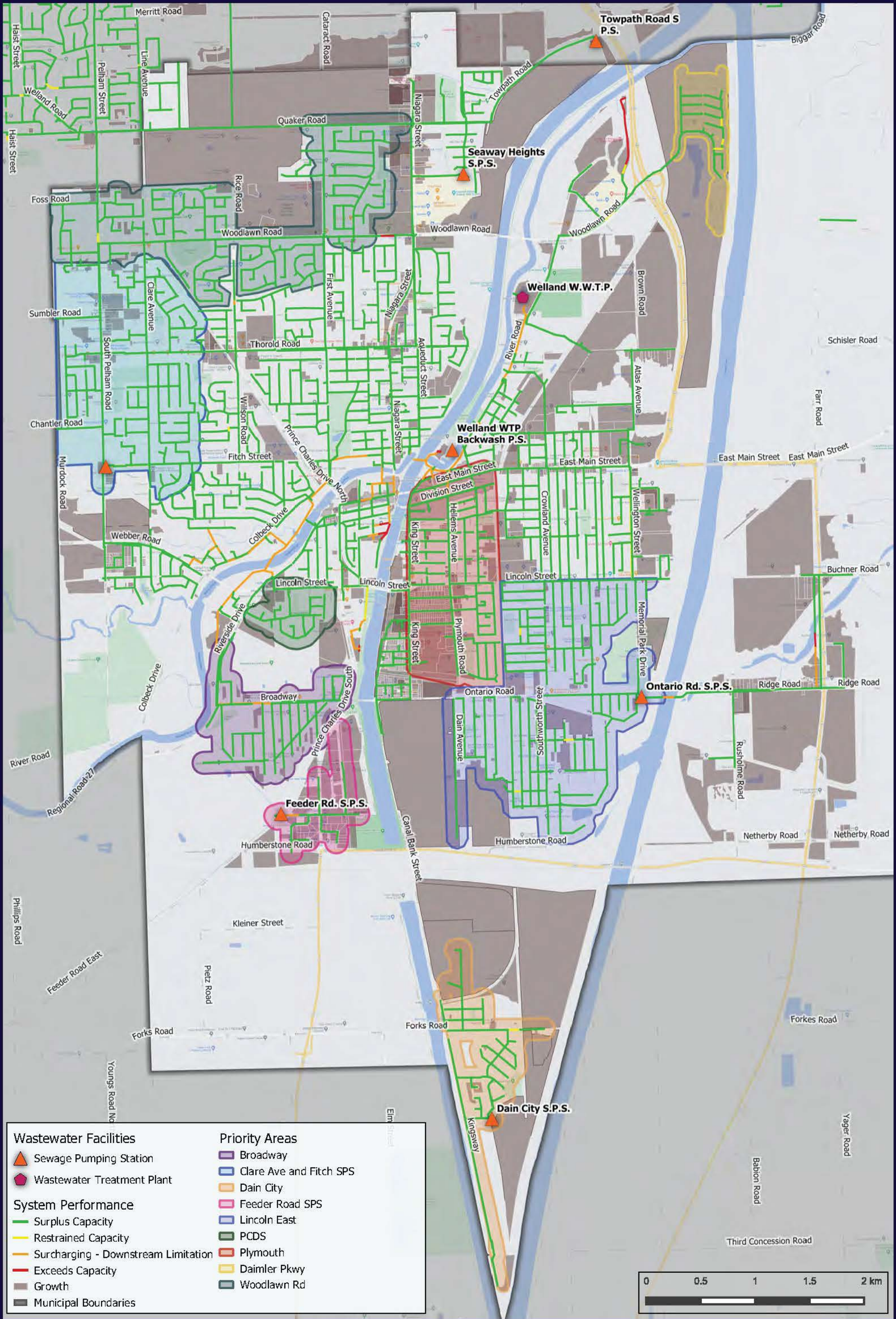
Storm Sewer Design Summary – Webber Estates – 10 Year									
Pipe #	Current Design IDF	EC IDF	EC IDF	Maximum IDF	90 th Percentile IDF	Mean IDF	Maximum IDF	90 th Percentile IDF	Mean IDF
	1963	2010	2012	2020			2050		
	Pipe Sizes (mm) and Costs based on a 10 Year Design Rainfall								
A1	200	200	200	200	200	200	200	200	200
A2	200	200	200	200	200	200	200	200	200
A3	200	200	200	200	200	200	200	200	200
A4	200	200	200	200	200	200	200	200	200
A5	450	450	450	450	450	450	450	450	450
A6	200	200	200	200	200	200	200	200	200
A7	200	200	200	200	200	200	200	200	200
A8	200	200	200	200	200	200	200	200	200
A9	525	525	525	525	525	525	600	525	525
A10	200	200	200	200	200	200	200	200	200
A11	525	525	525	525	525	525	600	525	525
A12	200	200	200	200	200	200	200	200	200
A13	600	600	600	675	600	600	675	600	600
A14	525	525	525	525	525	525	525	525	525
A15	200	200	200	200	200	200	200	200	200
A15a	600	600	600	675	600	600	675	600	600
A16	200	200	200	200	200	200	200	200	200
A17	375	375	375	375	375	375	375	375	375
A18	200	200	200	200	200	200	200	200	200
A19	450	450	450	450	450	450	450	450	450
A20	525	525	525	525	525	525	525	525	525
A21	200	200	200	200	200	200	200	200	200
A22	200	200	200	200	200	200	200	200	200
A23	200	200	200	200	200	200	200	200	200
A24	450	450	450	450	450	450	450	450	450
A25	200	200	200	200	200	200	200	200	200
A26	200	200	200	200	200	200	200	200	200
A27	525	525	525	525	525	525	600	525	525
A27a	675	675	675	750	675	675	750	750	675
A27b	675	675	675	750	675	675	750	750	675
A28	675	675	675	675	675	675	675	675	675
A29	750	750	750	825	750	750	825	750	750
A30	300	300	300	300	300	300	300	300	300
A31	375	375	375	375	375	375	375	375	375
A32	375	375	375	450	375	375	450	450	375
A33	1200	1200	1200	1200	1200	1200	1200	1200	1200
A34	1200	1200	1200	1200	1200	1200	1200	1200	1200
A35	1200	1200	1200	1200	1200	1200	1200	1200	1200
A36	1350	1350	1350	1500	1350	1350	1500	1350	1350
A37	1200	1200	1200	1200	1200	1200	1200	1200	1200
Total Pipe Cost	\$333,125	\$333,125	\$333,125	\$360,730	\$333,125	\$333,125	\$368,218	\$337,132	\$333,125
% of Original Cost	107%	107%	107%	116%	107%	107%	119%	109%	107%
City of Welland Approved Design Colour coded cells Each colour represents a unique storm sewer system design									

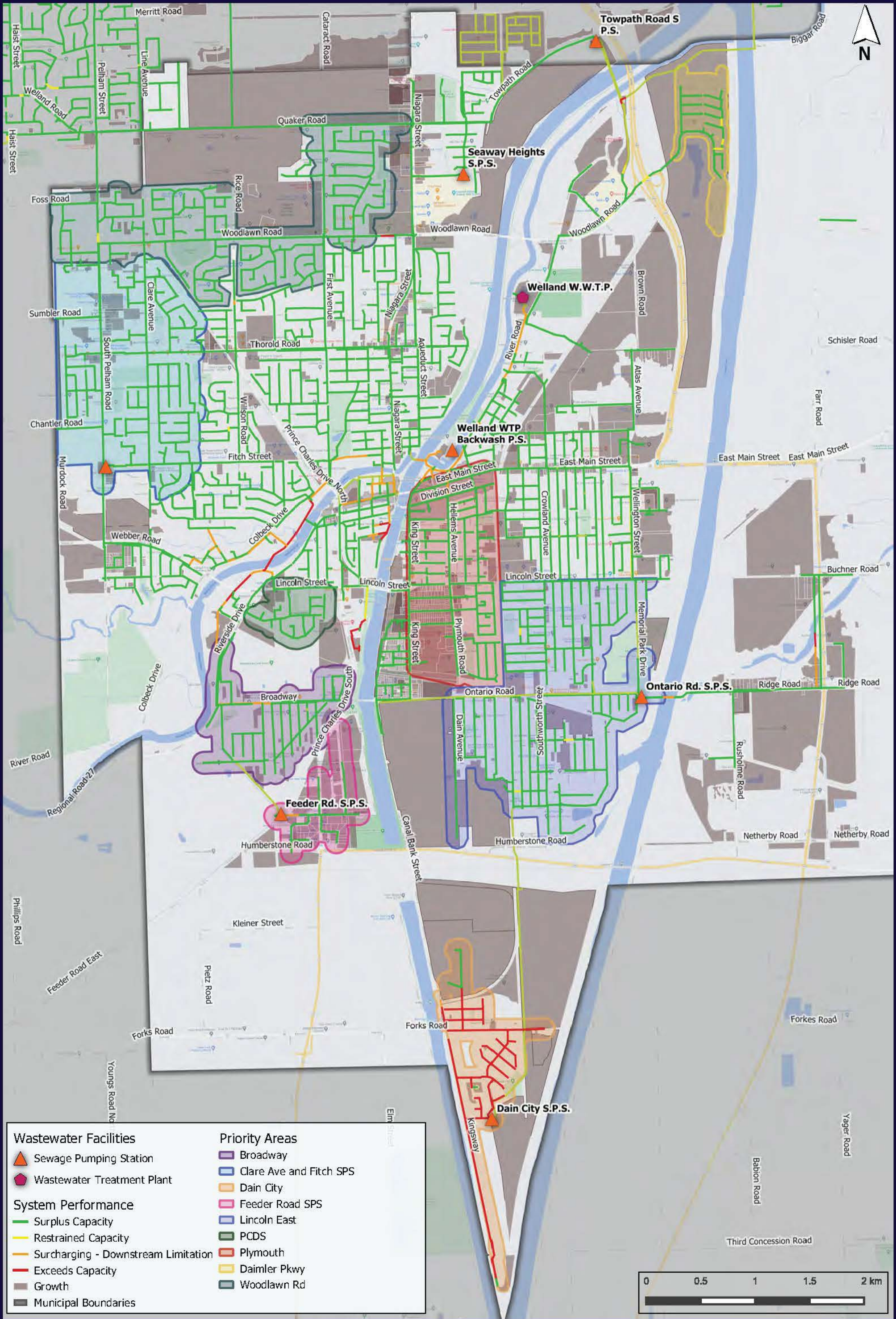
Storm Sewer Design Summary – Webber Estates – 25 Year									
Pipe #	Current Design IDF	EC IDF	EC IDF	Maximum IDF	90 th Percentile IDF	Mean IDF	Maximum IDF	90 th Percentile IDF	Mean IDF
	1963	2010	2012	2020			2050		
	Pipe Sizes (mm) and Costs based on a 25 Year Design Rainfall								
A1	200	200	200	200	200	200	200	200	200
A2	200	200	200	200	200	200	200	200	200
A3	200	200	200	200	200	200	200	200	200
A4	200	200	200	200	200	200	200	200	200
A5	450	450	450	450	450	450	525	450	450
A6	200	200	200	200	200	200	200	200	200
A7	200	200	200	200	200	200	200	200	200
A8	200	200	200	200	200	200	200	200	200
A9	525	525	525	600	600	525	600	600	600
A10	200	200	200	200	200	200	200	200	200
A11	525	525	525	600	600	525	600	600	525
A12	200	200	200	200	200	200	200	200	200
A13	675	675	675	675	675	675	675	675	675
A14	525	525	525	525	525	525	525	525	525
A15	200	200	200	200	200	200	200	200	200
A15a	675	675	675	675	675	675	675	675	675
A16	200	200	200	200	200	200	300	200	200
A17	375	375	375	375	375	375	375	375	375
A18	200	200	200	300	200	200	300	300	200
A19	450	450	450	450	450	450	450	450	450
A20	525	525	525	600	600	525	600	600	525
A21	200	200	200	200	200	200	200	200	200
A22	200	200	200	200	200	200	200	200	200
A23	200	200	200	200	200	200	200	200	200
A24	450	450	450	450	450	450	450	450	450
A25	200	200	200	200	200	200	200	200	200
A26	200	200	200	200	200	200	200	200	200
A27	525	525	525	600	600	525	600	600	525
A27a	750	750	750	750	750	750	750	750	750
A27b	750	750	750	750	750	750	750	750	750
A28	675	675	675	675	675	675	675	675	675
A29	825	825	825	825	825	825	825	825	825
A30	300	300	300	300	300	300	300	300	300
A31	375	375	375	375	375	375	375	375	375
A32	450	450	450	450	450	450	450	450	450
A33	1200	1200	1200	1200	1200	1200	1200	1200	1200
A34	1200	1200	1200	1200	1200	1200	1200	1200	1200
A35	1200	1200	1200	1200	1200	1200	1200	1200	1200
A36	1350	1350	1350	1500	1500	1500	1500	1500	1500
A37	1200	1200	1200	1200	1200	1200	1200	1200	1200
Total Pipe Cost	\$352,083	\$352,083	\$352,083	\$369,752	\$369,752	\$360,730	\$370,496	\$369,752	\$363,517
% of Original Cost	113%	113%	113%	119%	119%	116%	119%	119%	117%
City of Welland Approved Design Colour coded cells Each colour represents a unique storm sewer system design									

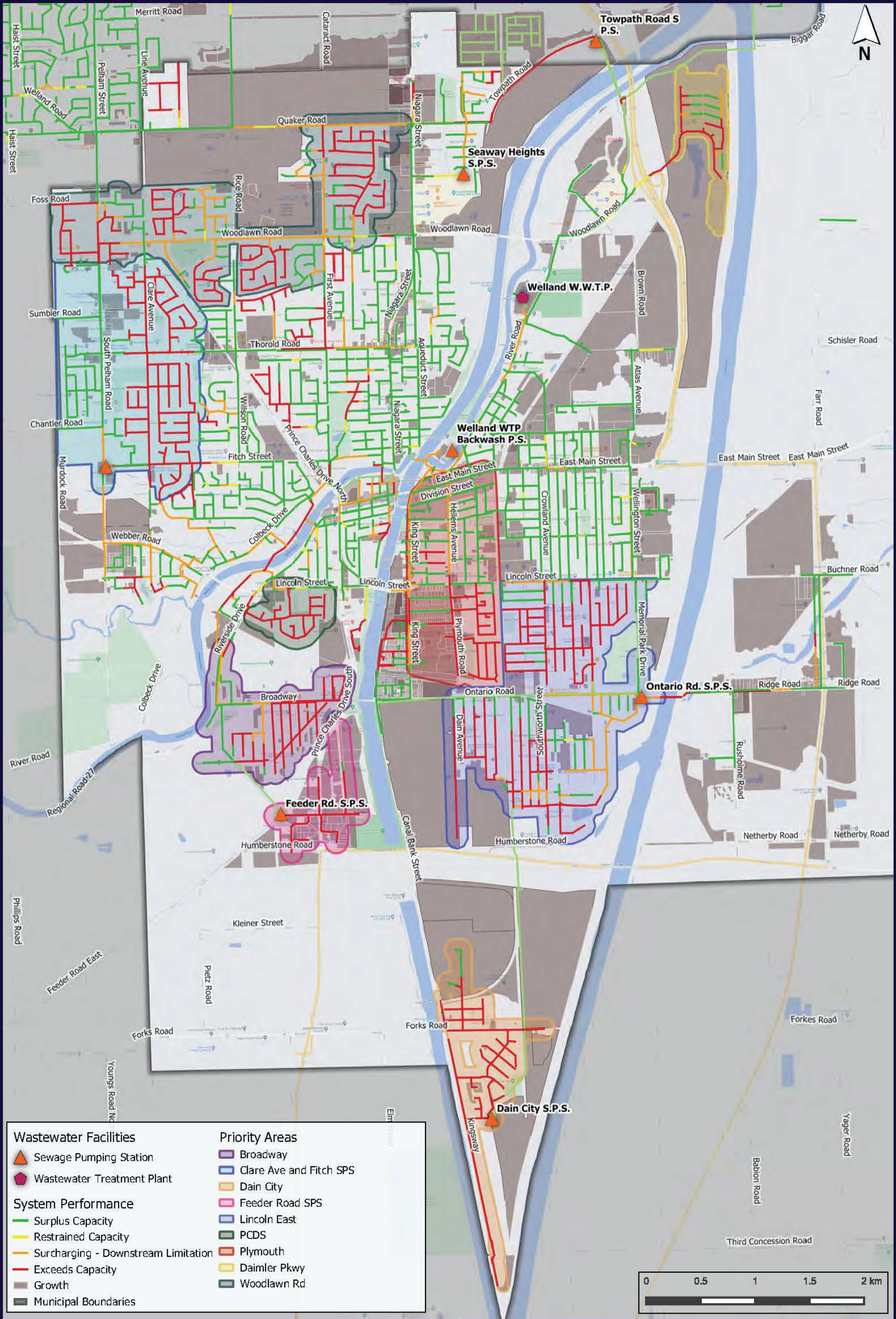
APPENDIX H:

System Performance Maps









APPENDIX I:

CSO Overflow Reports

Prepared By:



City of Welland

Combined Sewer Overflow Reporting 2015 Monitoring Period

GMBP File: 715023-3

June 2018



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1. INTRODUCTION

The City of Welland retained GM BluePlan Engineering (GMBP) to support with the City's Annual CSO reporting requirements. This task was completing leveraging the recently completed "all-pipe" model of the City of Welland's existing wastewater system to estimate both system performance and overflow volumes.

1.1 Project Background

GMBP was retained jointly by the City of Welland (City) and the Regional Municipality of Niagara (RMON) to update the Region's existing InfoSWMM trunk sewer model with the goal of developing a dynamic "all-pipe" model of the City's existing wastewater system. This model will provide both RMON and City staff with an improved and more detailed understanding of the performance of the existing wastewater collection system.

The hydraulic model will continue to be utilized to support the City's annual overflow report to the Ministry of Environment and Climate Change (MOECC), and to support development of the City's planned Inflow and Infiltration Monitoring and reduction program.

1.2 Report Scope

The scope of this report focuses on the City's 2015 Overflow Reporting to the MOECC, and outlines:

- Regulatory and reporting requirements;
- Analysis methodology and assumptions; and
- Annual CSO volumes and loading.

2. METHODOLOGY

The proposed methodology to estimate total CSO volume and pollutant loadings is as follows:

- Complete dynamic wet weather RTK modelling of the 2015 year using:
 - Available precipitation records
 - Available Welland River levels as provided by Niagara Peninsula Conservation Authority. This data allows for the modelling of CSO discharge from CSO outfalls that may be surcharged due to submersion
- Utilize model results to complete CSO flow and volume analysis consistent with MOECC Procedure F-5-5
- Complete pollutant loading utilizing typical concentration methodology

For further detail on the dynamic wet weather RTK model development and assumptions please refer to *Welland Wastewater Model Update Report (2017)* document.

2.1 Water Quality Data

It is our understanding that the annual CSO report will provide information on both the annual CSO volumes based on the previous year's rainfall reports, and the total Carbonaceous Biological Oxygen Demand (CBOD) and Total Suspended Solids (TSS) loading, utilizing the typical concentration methodology applied in the provided 2014 Annual Report authored by Amec Foster Wheeler.

The pollutant loading characteristics are based on the CBOD and TSS concentrations as reported in previous Annual Reporting documents. It is our understanding that these CBOD and TSS concentrations are based on a sampling program conducted as part of the *City of Welland Sewage Environmental Assessment Study* in 2000. The program gathered water quality data for combined sewage flows at the following three sites during three wet weather events:

- Overflow pipe at Oxford Atlas Wellington Sewer;
- Upstream of the diversion structure at McMaster Avenue sewers;
- Influent channel of the Welland Wastewater Treatment Plant (WWTP) immediately downstream of the pumping station.

Table 1 summarizes the range of CBOD and TSS concentrations that were utilized in this annual report.

Table 1: CBOD and TSS Concentrations – Previous Water Sampling Program

Parameter	Concentration (mg/L)		
	Mean	Min.	Max.
CBOD	20.6	19.0	27.4
TSS	129.0	20.0	360.0

Total pollutant mass loading is estimated by taking the minimum, mean and maximum concentrations for CBOD and TSS and multiplying these concentrations by the calculated overflow volumes.

2.2 CSO Analysis

The model results are based on the following calculations:

- The frequency of CSO events is calculated by counting the number of non-consecutive overflow events, where inter event time exceeds 12 hours. This approach is consistent with the requirements of *Procedure F-5-5*.
- The total volume:
 - Direct CSO overflow volumes are calculated by utilizing the model results. Regardless of whether the event is combined or not, the total volume is the actual volume of combined sewage discharged from the overflow structure.
 - Bypassing at the Plant is measured and reported by the Region.
- The total duration is the duration of combined CSO events with less than 12 hours of intervening time between them. It is considered to be the duration of the time that combined sewage is discharging from the overflow structure, ensuring the gap in events is not considered in the duration.
- The CBOD and TSS mass loadings are calculated by multiplying the minimum, mean and maximum predetermined concentrations for CBOD and TSS by the overflow volumes, and assumes all WWTP bypass flows have received primary treatment.

2.3 CSO Locations

The CSO Analysis was completed for the 17 River Based CSO's located within the City. Figure 1 highlights the locations of the 17 CSO's.

3. MOECC REGULATIONS

Procedure F-5-5 was developed by the Ministry of the Environment and Climate Change as documentation in support of *Guideline F-5: Levels of Treatment for Municipal and Private Sewage Treatment Works Discharging to Surface Waters*. The key objectives of Procedure F-5-5 are understood to be:

- Eliminate instances of dry weather overflow;
- Minimize impacts on human life and aquatic life and habitat; and,
- Achieve compliance with objectives for recreational Provincial Water Quality.

The Technical Criteria from MOECC Procedure F-5-5 are required as follows:

- No overflows during dry weather;
- Maximize the use of the collection system for the storage of wet weather flows when capacity is available;
- During a seven (7) month period commencing within 15 days of April 1st of an average year, provide 90% volumetric control of wet weather in addition to all of the dry weather flow.

Treatment levels for the controlled volume are described in Section 7 of Procedure F-5-5.



Annual CSO Reporting

Wastewater Facilities

Wastewater Treatment Plant

Sanitary Pumping Stations

Pumping Station (Regional)

Pumping Station (Municipal)

CSO Locations

Wastewater Network

Sanitary Gravity Mains (Local)

Sanitary Gravity Mains (Regional)

Sanitary Forcemains

Catchments

* Catchment limits are shown based on property boundaries and are within 100 m of sewers.

Towpath Road S.P.S.

Welland W.W.T.P.

Seaway Heights S.P.S.

Private

Feeder Rd. S.P.S.

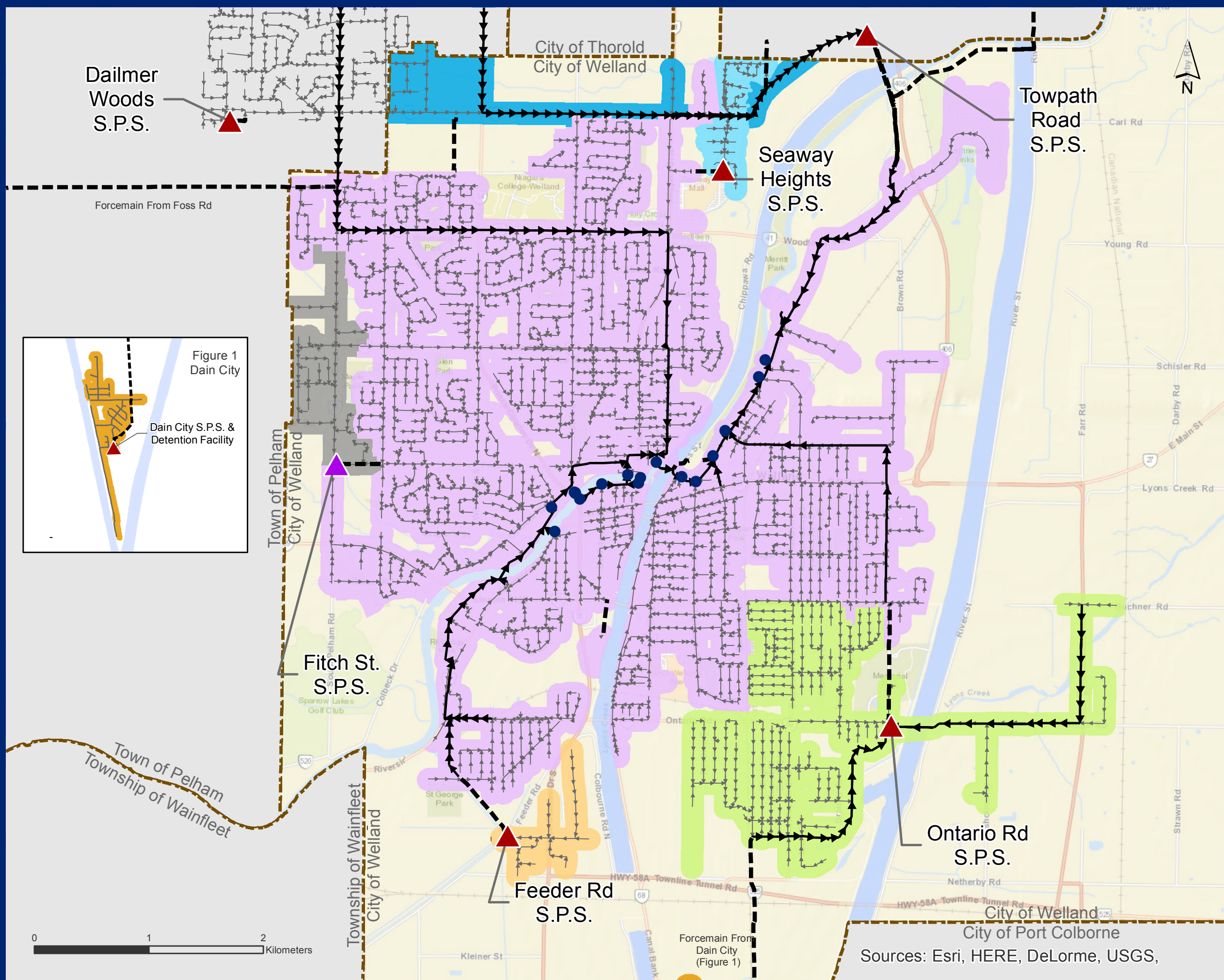
Ontario Rd. S.P.S.

Dain City S.P.S.

Welland System Overview



December, 2017
715023-3-WW-001
NAD 1983 UTM Zone 17N



4. RAINFALL DATA AND ANALYSIS

The 2015 rainfall data was gathered by the City as part of their annual sanitary sewer flow monitoring program. As part of the 2015 program, two (2) monitors were installed in the following locations:

- WWTP;
- Maple Park Pool.

The rainfall data was utilized to complete the 2015 dynamic wet weather modelling analysis in order to determine the total estimated 2015 system wet weather flows and system overflows.

4.1 Long-Term Rainfall Analysis

Table 2 was extracted from the AMEC 2014 CSO report, and it summarizes the long-term rainfall records used to select a typical rainfall year. It is stated in the 2014 CSO report that the 1999 year was used as the basis for a typical rainfall year.

The 2015 rainfall data was added to the information provided in the 2014 report. It should be noted that the detailed methodology of the values contained within the precipitation table are not explicitly stated; however, it is assumed that the pre-1994 data is representative of the April to October time period exclusively. As such, direct comparison to the various data sets may not be directly achievable.

Based on the above, the 2015 year was generally in-line with the typical rainfall year; however, indicated slightly lower total precipitation volumes, slightly higher intensity and shorter duration storm events.

5. SUMMARY OF 2015 FLOW RESULTS

The model was run from the 15th of April to the 30th of October, 2015. Utilizing the model flow results, the total volume, duration, and mass loading of CBOD and TSS for each CSO event was calculated. It should be noted that a comparison of flows to the WWTP and the Welland River for the month of April show very high baseline inflows to the plant, even without corresponding rainfall events, which are likely the indication of high groundwater levels and residual spring freshet.

Table 3 outlines the monthly and total results for the 2015 CSO Events, including the frequencies, durations, volumes and mass loadings of TSS and CBOD. Table 4 presents monthly flows by CSO location.

As a requirement of MOECC, the City is required to report the percentage of combined sewage flows that are being captured / treated by the WWTP. Table 5 presents a summary of the estimated treated flows.

As per MOECC Procedure F-5-5, all dry weather flows and 90% of the wet weather flows must be captured and treated at the WWTP. When rainfall events are compared to CSO events, it is evident that CSO events are attributed to wet weather flows and not dry weather flows. Based on the calculated CSO volumes and treated / captured WWF volumes (see Table 5), approximately 96% of flows reached the WWTP in 2015, which is within the allowable overflows defined by the MOECC procedure requirements.

Table 6 summarizes the previously reported volumetric system capture against the estimated 2015 volume. 2015 represents a higher capture rate than observed in previous years. This increased capture rate is likely due to events being distributed in fewer but more intense rainfall events, whereas the system tends to overflow under long duration, high volume events. It is also likely that I&I reduction measures implemented by the City contributed to a reduction in system overflows.

Table 2: Long-Term Rainfall Records

Year**	No. of Rainfall Events	Annual Rainfall Volume (mm)	Annual Rainfall Duration (hrs)	Average Event Rainfall Volume (mm)	Average Event Rainfall Intensity (mm/hr)	Average Event Rainfall Duration (hrs)
1964	40	282	249	7.05	1.05	6.23
1965	97	622	523	6.42	1.34	5.49
1966	92	511	535	5.55	1.04	5.82
1967	81	576	568	7.11	1.28	7.01
1968	119	855	806	7.18	1.04	6.77
1969	111	743	662	6.7	1.06	5.96
1970	110	701	702	6.37	1.12	6.38
1971	80	492	482	6.14	1.34	6.03
1972	82	579	554	7.06	1	6.76
1973	91	538	462	5.91	1.19	5.08
1974	69	428	431	6.2	1.05	6.25
1975	54	395	269	7.31	1.45	4.98
1976	77	605	471	7.86	1.45	6.12
1977	77	744	429	9.66	1.99	5.57
1978	74	576	453	7.78	1.65	6.12
1979	78	608	454	7.8	1.14	5.82
1980 (Typical)	72	552	448	7.67	1.46	6.22
1981	62	457	403	7.38	1.17	6.5
1982	28	132	122	4.73	1.47	4.36
1983	62	526	347	8.49	1.52	5.6
1984	82	610	444	7.44	1.5	5.42
1985	51	342	253	6.72	1.2	4.96
1986	75	552	343	7.36	1.77	4.57
1987	71	593	404	8.36	1.6	5.69
1988	64	375	289	5.86	1.71	4.52
1989	81	483	484	5.96	1.05	5.98
1990	64	596	476	9.32	1.19	7.44
1991	50	367	253	7.34	1.89	5.06
1992	90	719	607	7.99	1.1	6.74
1993	74	463	435	6.25	1.16	5.88
1994	69	541	406	7.84	1.16	5.88
1999*** (Long Term Avg.)	103	603	565	9.43	1.21	7.53
2009*	109	833	445	5.76	1.72	4.08
2010*	98	726 (463)	255	4.83	1.59	2.44
2011*	136	898 (558)	345	3.97	1.26	2.39
2012*	117	735 (479)	321	4.25	1.12	2.75
2013*	134	1074 (731)	365	5.27	1.69	2.72
2014*	130	784 (509)	349	3.82	1.34	2.58
2015	62	572.75	282.25	9.24	1.87	4.55

* Source 2 COMBINED SEWER OVERFLOW MODEL 2014 MONITORING PERIOD CITY OF WELLAND – AMEC Foster Wheeler

Table 3: 2015 Monthly CSO Events

Month	Obs. Precip. (mm)	Frequency	Volume (m³)	Duration (min)	CBOD Mass Loading (kg)					
					Mean	Min.	Max.	Mean	Min.	Max.
April ¹	24.8	0	0	0	0	0	0	0	0	0
May	65.3	1	5,642	195	116	107	155	728	113	2,031
June	161.8	1	27,216	1,065	561	517	746	3,511	544	9,798
July	37.0	1	0	0	0	0	0	0	0	0
August	81.0	1	2,718	195	56	52	74	351	54	978
September	74.3	0	0	0	0	0	0	0	0	0
October	87.3	1	15,825	675	326	301	434	2,041	316	5697
Total	531.3	5	51,401	2,130	1,059	977	1,408	6,631	1,028	18,504

1 – Data for April 15 -30

Table 4: Monthly Overflow Volume by CSO (in cubic meters)

CSO	April	May	June	July	August	September	October	Total by Overflow Structure
Aqueduct	0	0	0	0	0	0	0	0
Burgar	0	0	0	0	0	0	0	0
Colbeck	0	0	1,356	0	0	0	66	1,422
Denistoun	0	906	4,238	0	618	0	2,620	8,383
Downs	0	0	0	0	0	0	0	0
First E	0	0	0	0	0	0	0	0
First W	0	0	41	0	0	0	0	41
Hellems	0	3,890	17,673	0	1,806	0	10,200	33,568
King	0	0	0	0	0	0	0	0
McAlpine	0	0	0	0	0	0	0	0
McMaster	0	0	0	0	0	0	0	0
Niagara N	0	0	0	0	0	0	0	0
Niagara S	0	299	1,228	0	74	0	665	2,266
Prince Charles N	0	0	0	0	0	0	0	0
Prince Charles S	0	547	2,680	0	219	0	2,274	5,721
Riverside and Maple	0	0	0	0	0	0	0	0
Shotwell	0	0	0	0	0	0	0	0
Total Untreated Overflows	0	5,642	27,216	0	2,717	0	15,825	51,401
WWTP Bypass	47,125	36,900	85,300	14,500	13,500	60,500	53,960	311,785
Total Overflows	47,125	42,542	112,516	14,500	16,218	60,500	69,785	363,186

Table 5: 2015 Model Flows

Month	A Precipitation	B Total Measured Flows WWTP (ML)	C Modelled Flow at WWTP (ML)	D Total DWF at WWTP (ML)	E Total WWF at WWTP (ML)	F Total Untreated System Overflow Volume (ML)	G Estimated Treated WWTP By Pass (ML) ³	H Total WWF (ML)	I Total System Overflow Volume (ML)	J Treated / Captured Volumetric Percentage
April	24.8	1,458.0	729.8	645.4	84.4	0.0	47.1	84.4	47.1	100%
May	65.3	748.0	851.0	795.5	55.5	5.6	36.9	61.2	42.5	91%
June	161.8	1,176.7	1,013.7	632.4	381.3	27.2	85.3	408.5	112.5	93%
July	37.0	862.7	721.2	653.5	67.7	0.0	14.5	67.7	14.5	100%
August	81.0	764.7	828.2	653.5	174.6	2.7	13.5	177.4	16.2	98%
September	74.3	831.9	844.9	686.9	158.0	0.0	60.5	158.0	60.5	100%
October	87.3	848.3	866.8	709.8	157.0	15.8	54.0	172.8	69.8	91%
Total	531.3	5,961.2	5,855.5	4,777.1	1078.5	51.4	311.8	1,129.9	363.2	95%

1 – Data for April 15 -30

2 – Data for April 1-30

A: Precipitation at the WWTP rain gauge.

B: Measured flows to the WWTP, Niagara Region data.

C: Modelled flow at WWTP, model estimation.

D: Dry Weather Flow at WWTP, model estimation.

E: Wet Weather Flow at WWTP, calculated $E = C - D$.

F: Total Overflow Volume, model estimation.

G: Measured WWTP Bypass Volume, primary treatment, Niagara Region data.

H: Total Wet Weather Flow, calculated $H = E + F + G$.

I: Total Overflow Volume (treated and untreated), calculated $I = F + G$.

J: Volumetric Percentage of Wet Weather Flow Captured and Treated, $J = (H-F) / H$.

Table 6: Treated / Captured Volumetric Percentage

Year	Treated/Captured Volumetric (%)
2010	96.6
2011	82.5
2012	82.5
2013	80.9
2014	78.7
2015	95.5

6. RECOMMENDATIONS

The above analysis is based on the recently updated hydraulic all-pipes model of the Welland system. This model was calibrated using the best available information. It should be noted that the flow monitors used to calibrate the model were positioned such that the City system was subdivided into a number of very small catchments, and very large catchments, with a number of key flow monitoring locations used to calibrate relatively large catchments. As such, the overall wet weather response was averaged over the full catchment area. Based on this, it is expected that the actual response within the large catchments are very diverse, however, additional details pertaining to this variability are not available without more discretized system monitoring.

It is recommended that in future flow monitoring programs, the City should consider further separating these larger catchments into several sub-catchments to allow for a more detailed analysis of the local system, and to support future model updates.

7. SUMMARY AND CONCLUSIONS

GM BluePlan completed hydraulic modelling of the 2015 rainfall year to evaluate total overflow volumes for 17 combined sewer overflow locations along the Welland River. The model determined overflow volumes, durations, frequencies and mass loadings of CBOD and TSS at each overflow location on a monthly basis, from April 15th to October 30st 2015. It was determined that a total of 51,400 m³ was discharged from the combined sewer system during this time whereas approximately 1,078,500 m³ of wet weather flows were captured and fully treated by the WWTP, and an additional estimated volume of 311,785 m³ received primary treatment before overflowing at the WWTP. Thus, approximately 4.5% of the total flows exited via in system overflow structures, and a further 28% receiving only primary treatment.

Based on GMBP's review, the ratio of calculated total overflow volume to the total influent volume at the WWTP yielded a percentage of combined sewage being treated at the WWTP to be 96%. In regards to MOECC Procedure F-5-5, the City met the allowable limits of the combined sewer overflow volume percentages in 2015, within the allowable limits of 10% untreated wet weather overflows discharging to the environment.

Prepared By:



City of Welland

Combined Sewer Overflow Reporting 2016 Monitoring Period

GMBP File: 715023-3

June 2018



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1. INTRODUCTION

The City of Welland retained GM BluePlan Engineering (GMBP) to support with the City's Annual CSO reporting requirements. This task was completing leveraging the recently completed "all-pipe" model of the City of Welland's existing wastewater system, which was utilized to estimate total system flow and overflow volumes

1.1 Project Background

GMBP was retained jointly by the City of Welland (City) and the Regional Municipality of Niagara (RMON) to update the Region's existing InfoSWMM trunk sewer model with the goal of developing a dynamic "all-pipe" model of the City's existing wastewater system. This model will provide both RMON and City staff with a better and more detailed understanding of the performance of the existing wastewater collection system.

The hydraulic model will continue to be utilized to support the City's annual overflow report to the Ministry of Environment and Climate Change (MOECC), and support development of the City's planned Inflow and Infiltration Monitoring and reduction program.

1.2 Report Scope

The scope of this report focuses on the City's 2016 Overflow Reporting to the MOECC, and outlines:

- Regulatory and reporting requirements;
- Analysis methodology and assumptions; and
- Annual CSO volumes and loading.

2. METHODOLOGY

The proposed methodology to estimate total CSO volume and pollutant loadings is as follows:

- Complete dynamic wet weather RTK modelling of the 2016 year using:
 - Available precipitation records
 - Available Welland River levels as provided by Niagara Peninsula Conservation Authority
- Utilize model results to complete CSO flow and volume analysis consistent with MOECC Procedure F-5-5
- Complete pollutant loading utilizing typical concentration methodology

For further detail on the dynamic wet weather RTK model development and assumptions please refer to *Welland Wastewater Model Update Report (2017)* document.

2.1 Water Quality Data

It is our understanding that the annual CSO report will provide information on both the annual CSO volumes based on the previous year's rainfall reports, and the total Carbonaceous Biological Oxygen Demand (CBOD) and Total Suspended Solids (TSS) loading, utilizing the typical concentration methodology applied in the provided 2014 Annual Report.

The pollutant loading characteristics are based on the CBOD and TSS concentrations as reported in previous Annual Reporting documents. It is our understanding that these CBOD and TSS concentrations are based on a sampling program conducted as part of the *City of Welland Sewage Environmental Assessment Study* in 2000. The program gathered water quality data for combined sewage flows at the following three sites during three wet weather events:

- Overflow pipe at Oxford Atlas Wellington Sewer;
- Upstream of the diversion structure at McMaster Avenue sewers;
- Influent channel of the Welland WWTP immediately downstream of the pumping station.

Table 1 summarizes the range of CBOD and TSS concentrations that will be utilized in this annual report.

Table 1: CBOD and TSS Concentrations - Previous Water Sampling Program

Parameter	Concentration (mg/L)		
	Mean	Min.	Max.
CBOD	20.6	19.0	27.4
TSS	129.0	20.0	360.0

Total pollutant mass loading is estimated by taking the minimum, mean and maximum concentrations for CBOD and TSS and multiplying these concentrations by the calculated overflow volumes.

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The model results are based on the following calculations:

- The frequency of CSO events is calculated by counting the number of non-consecutive overflow events, where inter event time exceeds 12 hours. This approach is consistent with the requirements of *Procedure F-5-5*.
- The total volume:
 - Direct CSO overflow volumes are calculated by utilizing the model results. Regardless of whether the event is combined or not, the total volume is the actual volume of combined sewage that spills over the overflow structure. No other volumes are considered in the total.
 - Bypassing at the Plant is measured and reported by the Region.
- The total duration is the duration of combined CSO events with less than 12 hours of intervening time between them. It is considered to be the duration of the time that combined sewage is actually spilling over the overflow structure ensuring the gap in events is not considered in the duration.
- The CBOD and TSS mass loadings are calculated by multiplying the minimum, mean and maximum predetermined concentrations for CBOD and TSS by the overflow volumes, and assumes all WWTP bypass flows have received primary treatment.

2.3 CSO Locations

The CSO Analysis was completed for the 17 River Based CSO's located within the City. Figure 1 highlights the locations of the 17 CSO's.

3. MOECC REGULATIONS

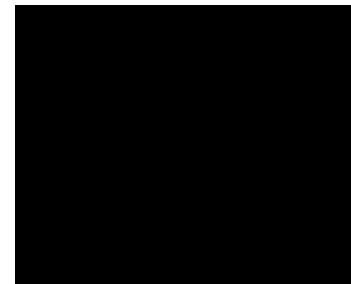
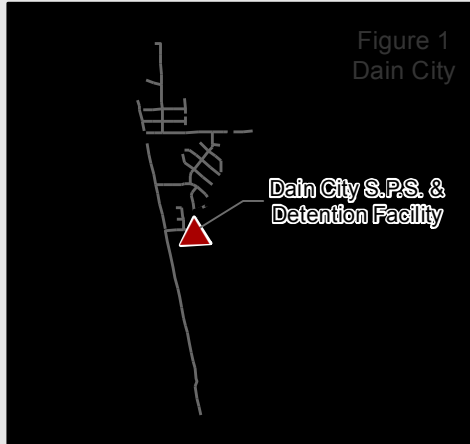
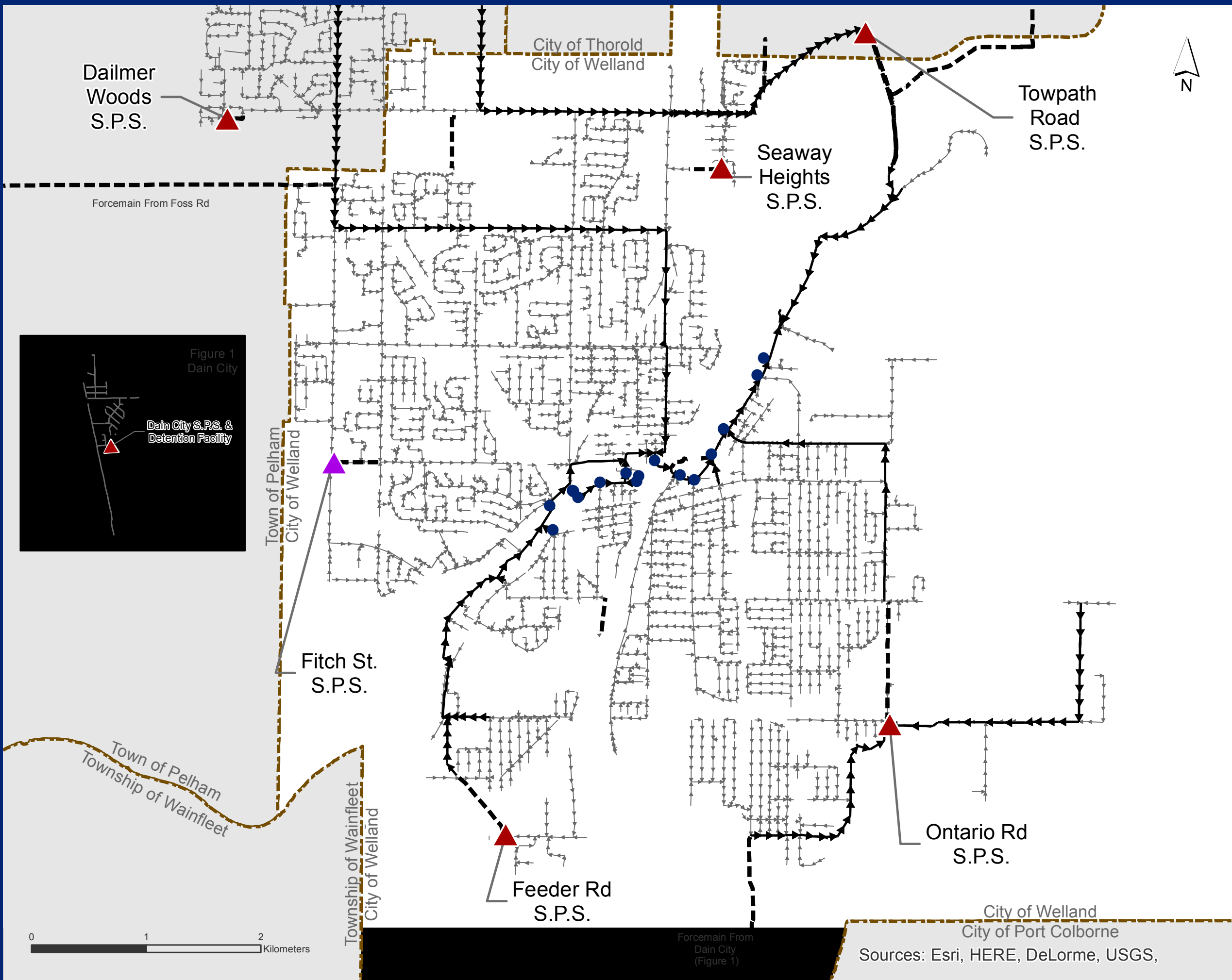
Procedure F-5-5 was developed by the Ministry of the Environment and Climate Change as documentation in support of *Guideline F-5: Levels of Treatment for Municipal and Private Sewage Treatment Works Discharging to Surface Waters*. The key objectives of Procedure F-5-5 are to:

- Eliminate instances of dry weather overflow;
- Minimize impacts on human life and aquatic life and habitat; and,
- Achieve compliance with objectives for recreational Provincial Water Quality
-

The Technical Criteria from MOE Procedure F-5-5 that are required for the (MP&PPCP) Study are as follows:

- No overflows during dry weather;
- Maximize the use of the collection system for the storage of wet weather flows when capacity is available;
- During a seven (7) month period commencing within 15 days of April 1st of an average year, provide 90% volumetric control of wet weather in addition to all of the dry weather flow.

Treatment levels for the controlled volume are described in Section 7 of Procedure F-5-5.



Annual CSO Reporting

Wastewater Facilities

- Wastewater Treatment Plant
- Sanitary Pumping Stations
 - Pumping Station (Regional)
 - Pumping Station (Municipal)
 - CSO Locations

Wastewater Network

- Sanitary Gravity Mains (Local)
- Sanitary Gravity Mains (Regional)
- Sanitary Forcemains

Catchments

* Catchment limits are shown based on property boundaries and are within 100 m of sewers.

- Towpath Road S.P.S.
- Welland W.W.T.P.
- Seaway Heights S.P.S.
- Private
- Feeder Rd. S.P.S.
- Ontario Rd. S.P.S.
- Dain City S.P.S.

Welland System Overview



December, 2017
715023-3-WW-001
NAD 1983 UTM Zone 17N

City of Welland
City of Port Colborne
Sources: Esri, HERE, DeLorme, USGS,

4. RAINFALL DATA AND ANALYSIS

The 2016 rainfall data was gathered by the Region as part of their ongoing flow monitoring program. The following Regional gauges were used for 2016;

- At the Welland WWTP
- At Humberstone Landfill

This above rainfall data was utilized to complete the 2016 dynamic wet weather modelling in order to determine total estimated 2016 system wet weather flows and system overflows.

4.1 Long-Term Rainfall Analysis

Table 2 was extracted from 2014 AMEC CSO report, and it summarizes the long-term rainfall records used to select a typical rainfall year. It is stated in the 2014 CSO report that the 1980 year was used as the basis for a typical rainfall year.

The 2016 rainfall data was added to the information provided in the 2014 report. It should be noted that the detailed methodology of the values contained within the precipitation table are not explicitly stated; however, it is assumed that the pre-1994 data is representative of the April to October time period exclusively. As such, direct comparison to the various data sets may not be directly achievable.

Based on the above, the 2016 year was a relatively dry year with total precipitation depth well below the 1980 typical year, with slightly higher intensity but lower volume and shorter duration storm events.

5. SUMMARY OF 2016 FLOW RESULTS

The model was run from the 15th of April to the 30th of October, 2016. Utilizing the model flow results, the total volume, duration, and mass loading of CBOD and TSS for each CSO event was calculated.

Table 3 outlines the results 2016 Monthly CSO Events, including the frequencies, durations, volumes and mass loadings of TSS and CBOD. Table 4 presents monthly flows by CSO location.

As a requirement of MOECC, the City must report the percentage of combined sewage flows that are being captured / treated by the WWTP. Table 5 presents a summary of the estimated treated flows.

As per MOECC Procedure F-5-5, all dry weather flows and 90% of the wet weather flows must be captured and treated at the WWTP. When rainfall events are compared to CSO events, it is evident that CSO events are attributed to wet weather flows and not dry weather flows. Based on the calculated CSO volumes and treated / captured WWF volumes (see Table 5), approximately 99% of flows reached the WWTP in 2016, which is in line with MOECC procedure.

Table 6 summarizes the previously reported volumetric system capture against the estimated 2016 volume. 2016 represent a very higher capture rate that observed in previous years. This increase capture rate is likely due to the very low precipitation that was observed during the reporting period. It is also likely that I&I reduction measures implemented by the City contributed to a reduction in system overflows.

Table 2: Long-Term Rainfall Records

Year**	No. of Rainfall Events	Annual Rainfall Volume (mm)	Annual Rainfall Duration (hrs)	Average Event Rainfall Volume (mm)	Average Event Rainfall Intensity (mm/hr)	Average Event Rainfall Duration (hrs)
1964	40	282	249	7.05	1.05	6.23
1965	97	622	523	6.42	1.34	5.49
1966	92	511	535	5.55	1.04	5.82
1967	81	576	568	7.11	1.28	7.01
1968	119	855	806	7.18	1.04	6.77
1969	111	743	662	6.7	1.06	5.96
1970	110	701	702	6.37	1.12	6.38
1971	80	492	482	6.14	1.34	6.03
1972	82	579	554	7.06	1	6.76
1973	91	538	462	5.91	1.19	5.08
1974	69	428	431	6.2	1.05	6.25
1975	54	395	269	7.31	1.45	4.98
1976	77	605	471	7.86	1.45	6.12
1977	77	744	429	9.66	1.99	5.57
1978	74	576	453	7.78	1.65	6.12
1979	78	608	454	7.8	1.14	5.82
1980 (Typical)	72	552	448	7.67	1.46	6.22
1981	62	457	403	7.38	1.17	6.5
1982	28	132	122	4.73	1.47	4.36
1983	62	526	347	8.49	1.52	5.6
1984	82	610	444	7.44	1.5	5.42
1985	51	342	253	6.72	1.2	4.96
1986	75	552	343	7.36	1.77	4.57
1987	71	593	404	8.36	1.6	5.69
1988	64	375	289	5.86	1.71	4.52
1989	81	483	484	5.96	1.05	5.98
1990	64	596	476	9.32	1.19	7.44
1991	50	367	253	7.34	1.89	5.06
1992	90	719	607	7.99	1.1	6.74
1993	74	463	435	6.25	1.16	5.88
1994	69	541	406	7.84	1.16	5.88
1999*** (Long Term Avg.)	103	603	565	9.43	1.21	7.53
2009*	109	833	445	5.76	1.72	4.08
2010*	98	726 (463)	255	4.83	1.59	2.44
2011*	136	898 (558)	345	3.97	1.26	2.39
2012*	117	735 (479)	321	4.25	1.12	2.75
2013*	134	1074 (731)	365	5.27	1.69	2.72
2014*	130	784 (509)	349	3.82	1.34	2.58
2015	62	572.75	282.25	9.24	1.87	4.55
2016	57	308.75	221.25	5.42	1.55	3.88

* Source 2 COMBINED SEWER OVERFLOW MODEL 2014 MONITORING PERIOD CITY OF WELLAND – AMEC Foster Wheeler

Table 3: 2016 Monthly CSO Events

Month	Obs. Precip. (mm)	Freq.	Volume (m ³)	Duration (min)	CBOD Mass Loading (kg)			TSS Mass Loading (kg)		
					Mean	Min.	Max.	Mean	Min.	Max.
April	11.25	1	108	0	2	2	3	14	2	39
May	24.5	1	332	0	7	6	9	43	7	120
June	26.75	1	341	90	7	6	9	44	7	123
July	49.5	1	1,364	435	28	26	37	176	27	491
August	44.75	1	589	30	12	11	16	76	12	212
September	59.75	1	824	0	17	16	23	106	16	297
October	70.75	1	963	45	20	18	26	124	19	347
Total	287.25	7	4,520	600	93	86	124	583	90	1,627

1 – Data for April 15 -30

Table 4. Monthly Overflow Volumes by CSO (in cubic meters)

CSO	April ¹	May	June	July	August	September	October	Total
Aqueduct	0	0	0	0	0	0	0	0
Burgar	0	0	0	0	0	0	0	0
Colbeck	0	0	0	0	0	0	0	0
Denistoun	0	0	0	35	0	0	0	35
Downs	0	0	0	0	0	0	0	0
First E	0	0	0	0	0	0	0	0
First W	0	0	0	0	0	0	0	0
Hellems	0	0	0	293	0	0	0	293
King	0	0	0	0	0	0	0	0
McAlpine	0	0	0	0	0	0	0	0
McMaster	0	0	0	0	0	0	0	0
Niagara N	0	0	0	0	0	0	0	0
Niagara S	0	0	0	0	0	0	0	0
Prince Charles N	0	0	0	0	0	0	0	0
Prince Charles S	108	332	341	1,036	589	824	963	4,636
Riverside and Maple	0	0	0	0	0	0	0	0
Shotwell	0	0	0	0	0	0	0	0
Total Untreated Overflows	108	332	341	1,364	589	824	963	4,964
WWTP Bypass	0	0	0	0	0	0	14,800	14,800
Total	108	332	341	1,364	589	824	963	19,764

1 – Data for April 15 -30

Table 5: 2016 Model Flows

	B	C	D	E	F	G	H	I	J
Month	Total Measured Flows WWTP (ML)	Modelled Flow at WWTP (ML)	Total DWF at WWTP (ML)	Total WWF at WWTP (ML)	Total Untreated System Volume (ML)	Estimated Treated WWTP By Pass (ML) ³	Total WWF (ML)	Total System Overflow Volume (ML)	Treated / Captured Volumetric Percentage
April ¹	1,212.7	677.7	645.4	32.3	0.1	0.0	32.4	0.1	100%
May	828.0	848.1	795.5	52.7	0.3	0.0	53.0	0.3	99%
June	638.7	682.6	632.4	50.2	0.3	0.0	50.5	0.3	99%
July	640.3	749.5	653.5	95.9	1.4	0.0	97.3	1.4	99%
August	652.7	751.6	653.5	98.1	0.6	0.0	98.6	0.6	99%
September	691.2	813.2	686.9	126.3	0.8	0.0	127.1	0.8	99%
October	818.1	858.8	709.8	149.1	1.0	14.8	150.0	15.8	89%
Total	4,875.3	5,381.5	4,777.1	604.5	4.5	14.8	608.9	19.3	96.8%

1 – Data for April 15 -30

2 – Data for April 1-30

A: Precipitation at the WWTP rain gauge.

B: Measured flows to the WWTP, Niagara Region data.

C: Modelled flow at WWTP, model estimation.

D: Dry Weather Flow at WWTP, model estimation.

E: Wet Weather Flow at WWTP, calculated $E = C - D$.

F: Total Overflow Volume, model estimation.

G: Measured WWTP Bypass Volume, primary treatment, Niagara Region data.

H: Total Wet Weather Flow, calculated $H = E + F + G$.

I: Total Overflow Volume (treated and untreated), calculated $I = F + G$.

J: Volumetric Percentage of Wet Weather Flow Captured and Treated, $J = (H-F) / H$.

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Prepared By:



City of Welland

Combined Sewer Overflow Reporting 2017 Monitoring Period

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June 2018



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The scope of this report focuses on the City's 2017 Overflow Reporting to the MOECC, and outlines:

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2. METHODOLOGY

The proposed methodology to estimate total CSO volume and pollutant loadings is as follows:

- Complete dynamic wet weather RTK modelling of the 2017 year using:
 - Available precipitation records;
 - Available Welland River levels as provided by Niagara Peninsula Conservation Authority. This data allows for the modelling of CSO discharge from CSO outfalls that may be surcharged due to submersion.
- Utilize model results to complete CSO flow and volume analysis consistent with MOECC Procedure F-5-5;
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For further detail on the dynamic wet weather RTK model development and assumptions please refer to *Welland Wastewater Model Update Report (2017)* document.

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It is our understanding that the annual CSO report will provide information on both the annual CSO volumes based on the previous year's rainfall reports, and the total Carbonaceous Biological Oxygen Demand (CBOD) and Total Suspended Solids (TSS) loading, utilizing the typical concentration methodology applied in the provided 2014 Annual Report authored by Amec Foster Wheeler.

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 - Bypassing at the Plant is measured and reported by the Region.
- The total duration is the duration of combined CSO events with less than 12 hours of intervening time between them. It is considered to be the duration of the time that combined sewage is discharging from the overflow structure,
- The CBOD and TSS mass loadings are calculated by multiplying the minimum, mean and maximum predetermined concentrations for CBOD and TSS by the overflow volumes, and assumes all WWTP bypass flows have received primary treatment.

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The CSO Analysis was completed for the 17 River Based CSOs located within the City. Figure 1 highlights the locations of the 17 CSOs.

3. MOECC REGULATIONS

Procedure F-5-5 was developed by the Ministry of the Environment and Climate Change as documentation in support of *Guideline F-5: Levels of Treatment for Municipal and Private Sewage Treatment Works Discharging to Surface Waters*. The key objectives of Procedure F-5-5 are understood to be:

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Annual CSO Reporting

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Welland System Overview



December, 2017
715023-3-WW-001
NAD 1983 UTM Zone 17N

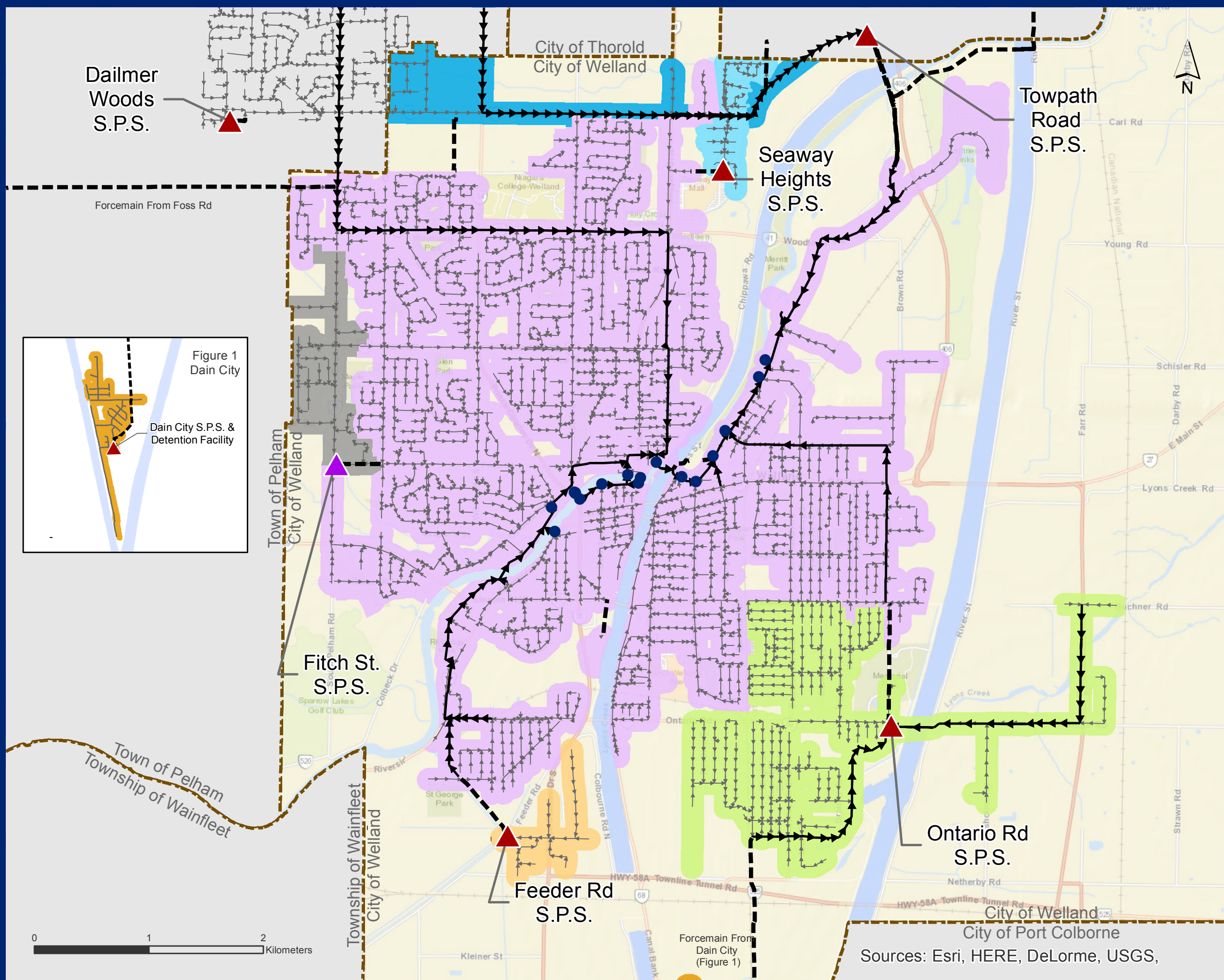


Figure 1
Dain City

Dain City S.P.S. &
Detention Facility

4. RAINFALL DATA AND ANALYSIS

The 2017 rainfall data was gathered by the City as part of their annual sanitary sewer flow monitoring program. As part of the 2017 program, two (2) monitors were installed in the following locations:

- Welland WWTP
- Humberstone Landfill

This rainfall data was utilized to complete the 2017 dynamic wet weather modelling analysis in order to determine total estimated 2017 system wet weather flows and system overflows.

4.1 Long-Term Rainfall Analysis

Table 2 was extracted from 2014 CSO report, and it summarizes the long-term rainfall records used to select a typical rainfall year. It is stated in the 2014 CSO report that the 1980 year was used as the basis for a typical rainfall year.

The 2017 rainfall data was added to the information provided in the 2014 report. It should be noted that the detailed methodology of the values contained within the precipitation table are not explicitly stated; however, it is assumed that the pre-1994 data is representative of the April to October time period exclusively. As such, direct comparison to the various data sets may not be directly achievable.

An analysis of precipitation events triggering overflows, found that the majority of overflows to the Welland River, within the Welland wastewater collection system, were primarily triggered by larger volume events of medium to high intensity. With high intensity lower volume events generating limited to no overflows. This relationship is likely related to the configuration and utilization of the larger interceptor sewers as a system CSO storage.

Table 2 further summarizes 2015 to 2017 major storm events (critical events), representing a total rainfall depth of 25 mm or more with an average intensity of 2 mm/hr (1 inch of rain in half a day).

Table 2. Major Precipitation-CSO Event Summary.

Year	Number of critical events	Sum of Event Depth (mm)	Total Rainfall April Oct (mm)	% of rainfall	Total number of overflow events	Annual CSO overflow volume (ML)	% of overflow events
2015	4	74.9	572.75	11%	7	50.86	100%
2016	1	4.3	308.75	1%	7	1.08	25%
2017	5	41.6	709.5	7%	10	22.29	50%

Based on the above, the 2017 year was a relatively wet year with total precipitation depth above the 1980 typical year, however, the majority of the rainfall occurred in shorter and/or smaller volume event, leading to smaller CSO overflow as percentage of total wet weather flows volumes when compared against other comparable precipitation years.

Table 3: Long-Term Rainfall Records

Year**	No. of Rainfall Events	Annual Rainfall Volume (mm)	Annual Rainfall Duration (hrs)	Average Event Rainfall Volume (mm)	Average Event Rainfall Intensity (mm/hr)	Average Event Rainfall Duration (hrs)
1964	40	282	249	7.05	1.05	6.23
1965	97	622	523	6.42	1.34	5.49
1966	92	511	535	5.55	1.04	5.82
1967	81	576	568	7.11	1.28	7.01
1968	119	855	806	7.18	1.04	6.77
1969	111	743	662	6.7	1.06	5.96
1970	110	701	702	6.37	1.12	6.38
1971	80	492	482	6.14	1.34	6.03
1972	82	579	554	7.06	1	6.76
1973	91	538	462	5.91	1.19	5.08
1974	69	428	431	6.2	1.05	6.25
1975	54	395	269	7.31	1.45	4.98
1976	77	605	471	7.86	1.45	6.12
1977	77	744	429	9.66	1.99	5.57
1978	74	576	453	7.78	1.65	6.12
1979	78	608	454	7.8	1.14	5.82
1980 (Typical)	72	552	448	7.67	1.46	6.22
1981	62	457	403	7.38	1.17	6.5
1982	28	132	122	4.73	1.47	4.36
1983	62	526	347	8.49	1.52	5.6
1984	82	610	444	7.44	1.5	5.42
1985	51	342	253	6.72	1.2	4.96
1986	75	552	343	7.36	1.77	4.57
1987	71	593	404	8.36	1.6	5.69
1988	64	375	289	5.86	1.71	4.52
1989	81	483	484	5.96	1.05	5.98
1990	64	596	476	9.32	1.19	7.44
1991	50	367	253	7.34	1.89	5.06
1992	90	719	607	7.99	1.1	6.74
1993	74	463	435	6.25	1.16	5.88
1994	69	541	406	7.84	1.16	5.88
1999***	103	603	565	9.43	1.21	7.53
2009*	109	833	445	5.76	1.72	4.08
2010*	98	726 (463)	255	4.83	1.59	2.44
2011*	136	898 (558)	345	3.97	1.26	2.39
2012*	117	735 (479)	321	4.25	1.12	2.75
2013*	134	1,074 (731)	365	5.27	1.69	2.72
2014*	130	784 (509)	349	3.82	1.34	2.58
2015	62	572.75	282.25	9.24	1.87	4.55
2016	57	308.75	221.25	5.42	1.55	3.88
2017	87	709.50	336.08	8.16	2.13	3.86

* Source 2 COMBINED SEWER OVERFLOW MODEL 2014 MONITORING PERIOD CITY OF WELLAND – AMEC Foster Wheeler

*** Long term Average

5. SUMMARY OF 2017 FLOW RESULTS

The model was run from the 15th of April to the 30th of October, 2017. Utilizing the model flow results, the total volume, duration, and mass loading of CBOD and TSS for each CSO event was calculated.

Table 4 outlines the monthly and total results for the 2017 Monthly CSO Events, including the frequencies, durations, volumes and mass loadings of TSS and CBOD. Table 5 presents monthly overflows by CSO by location.

As a requirement of MOECC, the City must report the percentage of combined sewage flows that are being captured / treated by the WWTP.

Table 6 presents a summary of the estimated treated flows. As per MOECC Procedure F-5-5, all dry weather flows and 90% of the wet weather flows must be captured and treated at the WWTP. When rainfall events are compared to CSO events, it is evident that CSO events are attributed to wet weather flows and not dry weather flows. Based on the calculated CSO volumes and treated / captured WWF volumes (see Table 6), approximately 99% of flows reached the WWTP in 2017, which is within the allowable overflows defined by the MOECC procedure requirements. Table 7 summarizes the previously reported volumetric system capture against the estimated 2017 volume. 2017 represents a higher than expected capture rate than observed in previous years. This increased capture rate is likely due to the lower precipitation depth and shorter duration of storms in 2017 when compared to 2015. It is also likely that I&I reduction measures implemented by the City contributed to a reduction in system overflows.

Table 7 presents average overflow event statistics by year. Table 2 presents the number of events that occurred in each year where the depth was greater than 25 mm and the intensity was greater than 2 mm/h. As per this criteria, in 2015, 4 storms resulting in overflows accounted for 11% of the total precipitation depth and 100% of the overflow volume. In 2017, 5 storms resulting in overflows accounted for 7% of the total precipitation depth and 99% of the CSO volume. While 2017 was overall a wetter year than 2015, the 2017 storms had lower depths and therefore resulted in fewer CSO overflows.

Table 4: 2017 Monthly System CSO Events

Month	Obs. Precip (mm)	Freq.	Volume (m ³)	Duration (min)	CBOD Mass Loading (kg)			TSS Mass Loading (kg)		
					Mean	Min	Max	Mean	Min	Max
April ¹	90	2	1,080	285	22	21	30	139	22	389
May	145	2	1,553	255	32	30	43	200	31	559
June	66.25	1	1	15	0	0	0	0	0	0
July	90	2	4,188	225	86	80	115	540	84	1,508
August	86.75	1	327	105	7	6	9	42	7	118
September	43.75	0	0	0	0	0	0	0	0	0
October	109.75	1	15,140	600	312	288	415	1,953	303	5,450
Total	631.5	9	22,289	1,485	459	423	611	2,875	446	8,024

1 – Data for April 15 -30

Table 5: Monthly Overflow Volume by CSO (in cubic meters)

CSO	April ¹	May	June	July	August	September	October	Total
Aqueduct	0	0	0	0	0	0	0	0
Burgar	0	0	0	0	0	0	0	0
Colbeck	0	0	0	241	0	0	3,494	3,735
Denistoun	1	46	0	959	254	0	1,377	2,638
Downs	0	0	0	0	0	0	0	0
First E	0	0	0	0	0	0	0	0
First W	0	0	0	0	0	0	126	126
Hellems	1,088	1,478	0	2,559	61	0	9,273	14,459
King	0	0	0	0	0	0	10	10
McAlpine	0	0	0	0	0	0	0	0
McMaster	0	0	0	0	0	0	0	0
Niagara N	0	0	0	0	0	0	0	0
Niagara S	2	24	0	202	5	0	587	820
Prince Charles N	0	0	0	0	0	0	0	0
Prince Charles S	0	21	0	269	10	0	426	726
Riverside and Maple	0	0	0	0	0	0	0	0
Shotwell	0	0	0	0	0	0	0	0
<i>Total Untreated Overflows</i>	<i>1,091</i>	<i>1,569</i>	<i>0</i>	<i>4,230</i>	<i>330</i>	<i>0</i>	<i>15,293</i>	<i>22,514</i>
WWTP ByPass	147,522	173,527	10,750	32,500	24,480	0	50,180	438,959
Total Overflows	148,613	175,096	10,750	36,730	24,810	0	65,473	461,473

1 – Data for April 15 -30

Table 6: 2017 Model Flows

Month	A Precipitation	B Total Measured Flows WWTP (ML)	C Modelled Flow at WWTP (ML)	D Total DWF at WWTP (ML)	E Total WWF at WWTP (ML)	F Total Untreated System Volume (ML)	G Estimated Treated WWTP By Pass (ML) ³	H Total WWF (ML)	I Total System Overflow Volume (ML)	J Treated / Captured Volumetric Percentage
April ¹	90.0	1,686.4	8,73.9	645.4	228.5	1.1	147.5	229.6	148.6	100%
May	145.0	1,477.3	1,353.3	795.5	557.9	1.6	173.5	559.4	175.1	100%
June	66.3	782.1	945.2	632.4	312.8	0.0	10.8	312.8	10.8	100%
July	90.0	807.3	1,020.5	653.5	366.9	4.2	32.5	371.1	36.7	99%
August	86.8	824.2	1,015.8	653.5	362.3	0.3	24.5	362.6	24.8	100%
September	43.8	694.1	953.9	686.9	267.0	0.0	0.0	267.0	0.0	100%
October	109.8	873.9	1,090.1	709.8	380.4	15.1	50.2	395.5	65.3	96%
Total	631.5	6,302.0	7,252.7	4,777.1	2,475.7	22.3	439.0	2,498.0	461.2	99%

1 – Data for April 15 -30

2 – Data for April 1-30

A: Precipitation at the WWTP rain gauge.

B: Measured flows to the WWTP, Niagara Region data.

C: Modelled flow at WWTP, model estimation.

D: Dry Weather Flow at WWTP, model estimation.

E: Wet Weather Flow at WWTP, calculated $E = C - D$.

F: Total Overflow Volume, model estimation.

G: Measured WWTP Bypass Volume, primary treatment, Niagara Region data.

H: Total Wet Weather Flow, calculated $H = E + F + G$.

I: Total Overflow Volume (treated and untreated), calculated $I = F + G$.

J: Volumetric Percentage of Wet Weather Flow Captured and Treated, $J = (H - F) / H$.

Table 7- Treated/Captured Volumetric Percentage

Year	Observed Precipitation April Oct (mm)	Total WWF (ML)	Total Untreated System Volume (ML)	Total Treated and Untreated System Overflow (ML)	Treated/Captured Volumetric (%)
2015	531	1,129	51.4	362	95.5
2016	287	606	4.5	16	99.6
2017	632	2,498	22.3	461	99.1

6. RECOMMENDATIONS

The above analysis is based on the recently updated hydraulic all-pipes model of the Welland system. This model was calibrated using the best available information. It should be noted that the flow monitors used to calibrate the model were positioned such that the City system was subdivided into a number of very small catchments, and very large catchments, with a number of key flow monitoring locations used to calibrate relatively large catchments. As such, the overall wet weather response was averaged over the full catchment area. Based on this, it is expected that the actual response within the large catchments are very diverse, however, additional details pertaining to this variability are not available without more discretized system monitoring.

It is recommended that in future flow monitoring programs, the City should consider further separating these larger catchments into several sub-catchments to allow for a more detailed analysis of the local system, and to support future model updates.

7. SUMMARY AND CONCLUSIONS

GM BluePlan completed hydraulic modelling of the 2017 rainfall year to evaluate total overflow volumes for 17 combined sewer overflow locations along the Welland River. The model determined overflow volumes, durations, frequencies and mass loadings of CBOD and TSS at each overflow location on a monthly basis, from April 15th to October 31st 2017. It was determined that a total of 22.3 ML was discharged from the combined sewer system during this time whereas approximately 2,475 ML of wet weather flows were captured and treated by the WWTP, and an additional estimated volume of 439 ML received primary treatment before overflowing at the WWTP.. Thus, approximately 1% of the total flows exited via overflow structures, and 99% of the flows were captured and treated by the WWTP, and a further 18% receiving only primary treatment. 2017 was characterized by short, high intensity storms with smaller event depths. Based on model overflow event analysis from 2015 to 2017, it appears that the Welland system overflows under long duration storms with high precipitation depths more frequently than under short duration storms with high intensity.

The greatest CSO overflow event was the result of a high volume precipitation event on October 9, 2017. The event depth was 63 mm and resulted in overflows at Colbeck, Denistoun, Hellems, Niagara South, and Prince Charles S.

Based on GMBP's review, the ratio of calculated total overflow volume to the total influent volume at the WWTP yielded a percentage of combined sewage being treated at the WWTP to be 99%. In regards to MOECC Procedure F-5-5, the City met the allowable limits of the combined sewer overflow volume percentages in 2017, within the allowable limits of 10% untreated wet weather overflows discharging to the environment.

Prepared By:



City of Welland

Combined Sewer Overflow Reporting 2018 Monitoring Period

GMBP File: 418024

February 2019



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1. INTRODUCTION

The City of Welland retained GM BluePlan Engineering (GMBP) to support with the City's Annual CSO reporting requirements. This task was completing leveraging the recently completed "all-pipe" model of the City of Welland's existing wastewater system to estimate both system performance and overflow volumes.

1.1 Project Background

GMBP was retained jointly by the City of Welland (City) and the Regional Municipality of Niagara (RMON) to update the Region's existing InfoSWMM trunk sewer model with the goal of developing a dynamic "all-pipe" model of the City's existing wastewater system. This model will provide both RMON and City staff with an improved and more detailed understanding of the performance of the existing wastewater collection system.

The hydraulic model will continue to be utilized to support the City's annual overflow report to the Ministry of Environment and Climate Change (MOECC), and support development of the City's planned Inflow and Infiltration Monitoring and Reduction Program.

1.2 Report Scope

The scope of this report focuses on the City's 2018 Overflow Reporting to the MOECC, and outlines:

- Regulatory and reporting requirements;
- Analysis methodology and assumptions; and
- Annual CSO volumes and loading.

2. METHODOLOGY

The proposed methodology to estimate total CSO volume and pollutant loadings is as follows:

- Complete dynamic wet weather RTK modelling of the 2018 year using:
 - Available precipitation records;
 - Available Welland River levels as provided by Niagara Peninsula Conservation Authority. This data allows for the modelling of CSO discharge from CSO outfalls that may be surcharged due to submersion.
- Utilize model results to complete CSO flow and volume analysis consistent with MOECC Procedure F-5-5;
- Complete pollutant loading utilizing typical concentration methodology.

For further detail on the dynamic wet weather RTK model development and assumptions please refer to *Welland Wastewater Model Update Report (2017)* document.

2.1 Water Quality Data

It is our understanding that the annual CSO report will provide information on both the annual CSO volumes based on the previous year's rainfall reports, and the total Carbonaceous Biological Oxygen Demand (CBOD) and Total Suspended Solids (TSS) loading, utilizing the typical concentration methodology applied in the provided 2014 Annual Report authored by Amec Foster Wheeler.

The pollutant loading characteristics are based on the CBOD and TSS concentrations as reported in previous Annual Reporting documents. It is our understanding that these CBOD and TSS concentrations are based on a sampling program conducted as part of the *City of Welland Sewage Environmental Assessment Study* in 2000. The program gathered water quality data for combined sewage flows at the following three sites during three wet weather events:

- Overflow pipe at Oxford Atlas Wellington Sewer;
- Upstream of the diversion structure at McMaster Avenue sewers;
- Influent channel of the Welland WWTP immediately downstream of the pumping station.

Table 1 summarizes the range of CBOD and TSS concentrations that will be utilized in this annual report.

Table 1: CBOD and TSS Concentrations - Previous Water Sampling Program

Parameter	Concentration (mg/L)		
	Mean	Min.	Max.
CBOD	20.6	19.0	27.4
TSS	129.0	20.0	360.0

Total pollutant mass loading is estimated by taking the minimum, mean and maximum concentrations for CBOD and TSS and multiplying these concentrations by the calculated overflow volumes.

2.2 CSO Analysis

The model results are based on the following calculations:

- The frequency of CSO events is calculated by counting the number of non-consecutive overflow events, where inter event time exceeds 12 hours. This approach is consistent with *Procedure F-5-5*.
- The total volume:
 - Direct CSO overflow volumes are calculated by utilizing the model results. Regardless of whether the event is combined or not, the total volume is the actual volume of combined sewage discharged from the overflow structure.
 - Bypassing at the Plant is measured and reported by the Region.
- The total duration is the duration of combined CSO events with less than 12 hours of intervening time between them. It is considered to be the duration of the time that combined sewage is discharging from the overflow structure,
- The CBOD and TSS mass loadings are calculated by multiplying the minimum, mean and maximum predetermined concentrations for CBOD and TSS by the overflow volumes, and assumes all WWTP bypass flows have received primary treatment.

2.3 CSO Locations

The CSO Analysis was completed for the 17 River Based CSOs located within the City. Figure 1 highlights the locations of the 17 CSOs.

3. MOECC REGULATIONS

Procedure F-5-5 was developed by the Ministry of the Environment and Climate Change as documentation in support of *Guideline F-5: Levels of Treatment for Municipal and Private Sewage Treatment Works Discharging to Surface Waters*. The key objectives of Procedure F-5-5 are understood to be:

- Eliminate instances of dry weather overflow;
- Minimize impacts on human life and aquatic life and habitat; and,
- Achieve compliance with objectives for recreational Provincial Water Quality

The Technical Criteria from MOECC Procedure F-5-5 are required as follows:

- No overflows during dry weather;
- Maximize the use of the collection system for the storage of wet weather flows when capacity is available;
- During a seven (7) month period commencing within 15 days of April 1st of an average year, provide 90% volumetric control of wet weather in addition to all of the dry weather flow.

Treatment levels for the controlled volume are described in Section 7 of Procedure F-5-5.



Annual CSO Reporting

Wastewater Facilities

Wastewater Treatment Plant

Sanitary Pumping Stations

Pumping Station (Regional)

Pumping Station (Municipal)

CSO Locations

Wastewater Network

Sanitary Gravity Mains (Local)

Sanitary Gravity Mains (Regional)

Sanitary Forcemains

Catchments

* Catchment limits are shown based on property boundaries and are within 100 m of sewers.

Towpath Road S.P.S.

Welland W.W.T.P.

Seaway Heights S.P.S.

Private

Feeder Rd. S.P.S.

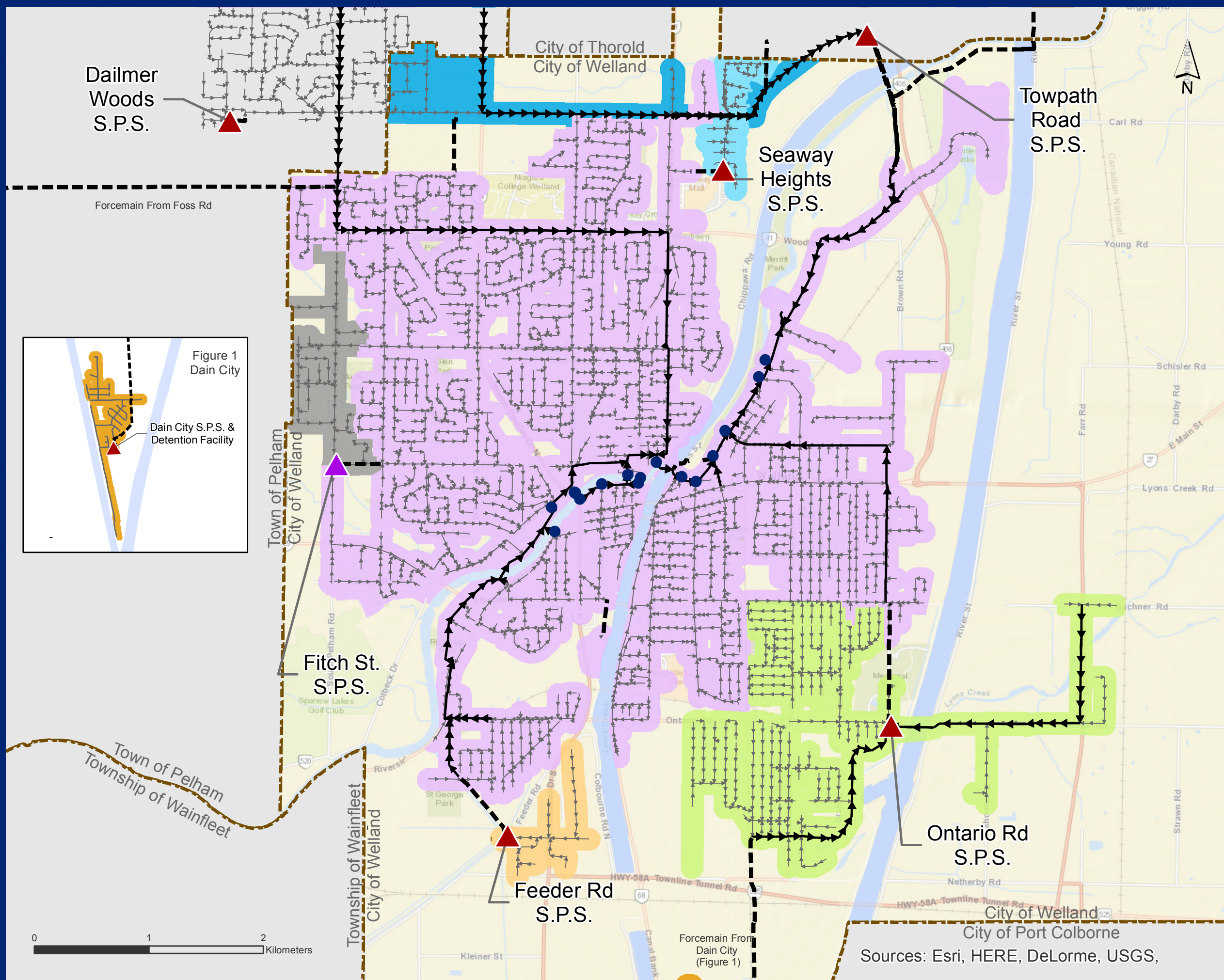
Ontario Rd. S.P.S.

Dain City S.P.S.

Welland System Overview



December, 2017
715023-3-WW-001
NAD 1983 UTM Zone 17N



4. RAINFALL DATA AND ANALYSIS

Niagara Region rainfall data from the Humberstone Landfill Rain Gauge rainfall data was utilized to complete the 2018 dynamic wet weather modelling analysis in order to determine total estimated 2018 system wet weather flows and system overflows.

4.1 Long-Term Rainfall Analysis

Table 3 summarizes the long-term rainfall records used to select a typical rainfall year. Long term rainfall records from the AMEC 2014 CSO report were updated with statistics from recent years. It is stated in the 2014 CSO report that the 1980 year was used as the basis for a typical rainfall year.

The 2018 rainfall data was added to the information provided in the 2014 AMEC report and previous 2015-2017 CSO reporting completed by GMBP. It should be noted that the detailed methodology of the values contained within the precipitation table are not explicitly stated; however, it is assumed that the pre-1994 data is representative of the April to October time period exclusively. As such, direct comparison to the various data sets may not be directly achievable.

Based on the above, the 2018 year was a relatively wet year with total precipitation depth above the 1980 typical year. Of note, the rainfall that occurred on April 15 through 16, accounted for approximately 8% of the year's total rainfall and represents a significant rain on snow event that generated an overwhelming volumetric response entering the wastewater system. The remainder of the year is characterized by frequent storms of longer than average duration and depth.

Table 2: Long-Term Rainfall Records

Year**	No. of Rainfall Events	Annual Rainfall Volume (mm)	Annual Rainfall Duration (hrs)	Average Event Rainfall Volume (mm)	Average Event Rainfall Intensity (mm/hr)	Average Event Rainfall Duration (hrs)
1964	40	282	249	7.05	1.05	6.23
1965	97	622	523	6.42	1.34	5.49
1966	92	511	535	5.55	1.04	5.82
1967	81	576	568	7.11	1.28	7.01
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1970	110	701	702	6.37	1.12	6.38
1971	80	492	482	6.14	1.34	6.03
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1973	91	538	462	5.91	1.19	5.08
1974	69	428	431	6.2	1.05	6.25
1975	54	395	269	7.31	1.45	4.98
1976	77	605	471	7.86	1.45	6.12
1977	77	744	429	9.66	1.99	5.57
1978	74	576	453	7.78	1.65	6.12
1979	78	608	454	7.8	1.14	5.82
1980 (Typical)	72	552	448	7.67	1.46	6.22
1981	62	457	403	7.38	1.17	6.5
1982	28	132	122	4.73	1.47	4.36
1983	62	526	347	8.49	1.52	5.6
1984	82	610	444	7.44	1.5	5.42
1985	51	342	253	6.72	1.2	4.96
1986	75	552	343	7.36	1.77	4.57
1987	71	593	404	8.36	1.6	5.69
1988	64	375	289	5.86	1.71	4.52
1989	81	483	484	5.96	1.05	5.98
1990	64	596	476	9.32	1.19	7.44
1991	50	367	253	7.34	1.89	5.06
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1994	69	541	406	7.84	1.16	5.88
1999*** (Long Term Avg.)	103	603	565	9.43	1.21	7.53
2009*	109	833	445	5.76	1.72	4.08
2010*	98	726 (463)	255	4.83	1.59	2.44
2011*	136	898 (558)	345	3.97	1.26	2.39
2012*	117	735 (479)	321	4.25	1.12	2.75
2013*	134	1,074 (731)	365	5.27	1.69	2.72
2014*	130	784 (509)	349	3.82	1.34	2.58
2015	62	572.75	282.25	9.24	1.87	4.55
2016	57	308.75	221.25	5.42	1.55	3.88
2017	87	709.50	336.08	8.16	2.13	3.86
2018	78	784.25	659.42	10.05	1.52	6.43

1964 to 2014 Data was extracted from Amec Foster Wheeler, Combine Sewer Overflow Model – 2014 Report. Dated February 2016. This data included the following notations:

* Annual rainfall data for 2009 – 2014 was downloaded from the Environment Canada Database; Rainfall in brackets is for the monitoring periods (April to October/ November) downloaded from the Cole Engineering Remote Data Access site.

** Rainfall data from 1964 to 1994 was extracted from RV Anderson CSO Study Environmental Study Report, 2003.

*** Rainfall data for 1999 was obtained from Welland Climate Impact Study Determination of Average Precipitation Year (2011).

The data in red from 2015-2018 reflects GM BluePlan precipitation analyses.

5. SUMMARY OF 2018 FLOW RESULTS

The model was run from the 1st of April to the 30th of October 2018 to meet the 7 month reporting requirements of the F-5-5 Procedure.

The City experienced a rain on snow precipitation event from April 14 to 18, 2018. Based on findings from the Dain City Flooding Investigation, the model was run using modified Rain Derived Inflow and Infiltration (RDII) parameters for the April 14 to April 20, 2018 event to better represent unique runoff and sewer inflow characteristics that were observed across the City.

An analysis of precipitation events triggering overflows found that most overflows to the Welland River, within the Welland wastewater collection system, were primarily triggered by larger volume events of medium to high intensity. With high intensity- low volume events generating limited to no overflows. This relationship is likely related to the configuration and utilization of the larger interceptor sewers as a system CSO storage.

Table 3 compares major storm events to CSO overflow events from 2015 to 2018. Major storm events are characterized by a total rainfall depth of 25 mm or more, and an average intensity of 2 mm/hr (1 inch of rain in half a day). Table 3 shows that the majority of overflow events do occur during major storm events; however, due to other external and climatic factors, major storm events do not always induce overflows; further, overflows may occur during other storm events (snow melt or other). Both overflow events in 2018 were triggered by major storm events.

Table 3. Major Precipitation-CSO Event Summary.

Year	Number of critical events	Sum of Event Depth (mm)	Total Rainfall April Oct (mm)	% of annual rainfall causing overflows	Total number of overflow events	Annual CSO overflow volume (ML)	% of overflow events caused by critical events
2015	4	74.9	572.75	11%	7	50.86	100%
2016	1	4.3	308.75	1%	7	1.08	25%
2017	5	41.6	709.5	7%	10	22.29	50%
2018	7	434.3	784.25	13%	2	4.3	100%

Utilizing the model flow results, the total volume, duration, and mass loading of CBOD and TSS for each CSO event was calculated. Table 4 outlines the frequency, duration, volume and mass loading of TSS and CBOD of CSO overflows that occurred in 2018. Table 4 presents monthly overflow volumes by CSO location.

Table 4: 2017 Monthly System CSO Events

Month	Rainfall (mm)	Freq .	Volume (m ³)	Duration (min)	CBOD Mass Loading (kg)			TSS Mass Loading (kg)		
					Mean	Min	Max	Mean	Min	Max
April	98.8	1	4,284.5	495.0	88.3	81.4	117.4	552.7	85.7	1,542
May	44.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
June	79.3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
July	37.5	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
August	89.0	1	29.1	45.0	0.6	0.6	0.8	3.8	0.6	10
September	69.3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
October	82.8	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	500.5	2	4,313.6	540.0	88.9	82.0	118.2	556.5	86.3	1,552.91

Table 5: Monthly Overflow Volume by CSO (ML)

CSO	April	May	June	July	August	September	October	Total (ML)
Aqueduct	0	0	0	0	0	0	0	0
Burgar	0	0	0	0	0	0	0	0
Colbeck	0	0	0	0	0	0	0	0
Denistoun	1.714	0	0	0	0.013	0	0	1.7
Downs	0	0	0	0	0	0	0	0
First E	0	0	0	0	0	0	0	0
First W	0	0	0	0	0	0	0	0
Hellems	2.027	0	0	0	0	0	0	2.0
King	0	0	0	0	0	0	0	0
McAlpine	0	0	0	0	0	0	0	0
McMaster	0	0	0	0	0	0	0	0
Niagara N	0.440	0	0	0	0.017	0	0	0.4
Niagara S	0	0	0	0	0	0	0	0
Prince Charles N	0.104	0	0	0	0	0	0	0.1
Prince Charles S	0	0	0	0	0	0	0	0
Riverside and Maple	0	0	0	0	0	0	0	0
Shotwell	0	0	0	0	0	0	0	0
Total Untreated Overflows	4.285	0	0	0	0.029	0	0	4.3
WWTP ByPass	1,438	996	888	809	931	928	945	6,939
Total Overflows (ML)	1,442	996	888	809	931	928	945	6,943

As per MOECC Procedure F-5-5, all dry weather flows and 90% of the wet weather flows must be captured and treated at the WWTP. Table 6 summarizes the reported volumetric system capture against the model-based estimated volume for the 2018 reporting period.

Based on the estimated CSO overflow volumes and the system wet weather flows (see

Table 6), approximately 99.8% of wet weather flows reached the WWTP in 2018, which is within the allowable overflows defined by the MOECC procedure requirements.

It is noted that during this event an additional 0.3 ML of wastewater was estimated to be discharged to the environment at the Dain City SPS. This volume was not included in the total CSO assessment. However, if included this volume would not materially impact the capture ratios listed in this report.

Table 6: 2018 Model Flows

	A	B	C	D	E	F	G	H	I	J
Month	Precipitation	Total Measured Flows WWTP (ML)	Modelled Flow at WWTP (ML)	Total DWF at WWTP (ML)	Total WWF at WWTP (ML)	Total Untreated System Volume (ML)	Estimated Treated WWTP By Pass (ML)	Total WWF (ML)	Total System Overflow Volume (ML)	Treated / Captured Volumetric Percentage
April	98.8	1386.278	2,229.7	1,075.7	1,154.0	4.28	282.0	1,158.3	286.3	99.6%
May	44.0	941.471	998.1	795.5	202.6	0.00	0.0	202.6	0.0	100.0%
June	79.3	796.005	888.7	632.4	256.2	0.00	32.0	256.2	32.0	100.0%
July	37.5	709.383	807.9	653.5	154.4	0.00	16.8	154.4	16.8	100.0%
August	89.0	842.19	934.9	653.5	281.4	0.03	64.5	281.4	64.6	99.9%
September	69.3	765.59	931.6	686.9	244.7	0.00	36.3	244.7	36.3	100.0%
October	82.8	938.702	943.2	686.9	256.4	0.00	48.4	256.4	48.4	100.0%
Total	500.5	6,379.6	7,734.1	5,184.4	2,549.6	4.3	480.0	2,553.9	484.3	99.8%

A: Precipitation at the WWTP rain gauge.

B: Measured flows to the WWTP, Niagara Region data.

C: Modelled flow at WWTP, model estimation.

D: Dry Weather Flow at WWTP, model estimation.

E: Wet Weather Flow at WWTP, calculated $E = C - D$

F: Total Overflow Volume, model estimation.

G: Measured WWTP Bypass Volume, primary treatment, Niagara Region data.

H: Total Wet Weather Flow, calculated $H = E + F$

I: Total Overflow Volume (treated and untreated), calculated $I = F + G$

J: Volumetric Percentage of Wet Weather Flow Captured and Treated, $J = (H-F) / H$

Table 7- Treated/Captured Volumetric Percentage

Year	Observed Precipitation April Oct (mm)	Total WWF (ML)	Total Untreated System Volume (ML)	Total Treated and Untreated System Overflow (ML)	Treated/Captured Volumetric (%)
2015	531	1,129	51.4	362	95.5
2016	287	606	4.5	16	99.6
2017	632	2,498	22.3	461	99.1
2018	501	2,554	4.3	480	99.8

Table 7 provides an overview of the system 2018 represents a similar capture rate observed in previous years. This high capture rate is likely due to the lower precipitation depth of storms in 2018 when compared to 2015. Trends imply the Welland system CSOs are more likely to overflow under high volume storms with extended durations. It is also likely that I&I reduction measures implemented by the City contributed to a reduction in system overflows.

6. RECOMMENDATIONS

The above analysis is based on the recently updated hydraulic all-pipes model of the Welland system. This model was calibrated using the best available information. It should be noted that the flow monitors used to calibrate the model were positioned such that the City system was subdivided into a number of very small catchments, and very large catchments, with a number of key flow monitoring locations used to calibrate relatively large catchments. As such, the overall wet weather response was averaged over the full catchment area. Based on this, it is expected that the actual response within the large catchments are very diverse, however, additional details pertaining to this variability are not available without more discretized system monitoring.

It is recommended that in future flow monitoring programs, the City should consider further separating these larger catchments into several sub-catchments to allow for a more detailed analysis of the local system, and to support future model updates.

7. SUMMARY AND CONCLUSIONS

GM BluePlan completed hydraulic modelling of the 2018 rainfall year to evaluate total overflow volumes for 17 combined sewer overflow locations along the Welland River. The model determined overflow volumes, durations, frequencies and mass loadings of CBOD and TSS at each overflow location on a monthly basis, from April 1st to October 30th, 2018. It was determined that a total of 4.3 ML was discharged from the combined sewer system during this time whereas approximately 2,550 ML of wet weather flows were captured by the WWTP, with 480 ML (18%) only receiving primary treatment before overflowing at the WWTP. Thus, approximately <1% of the total wet weather flows exited via overflow structures, 18% of the total wet weather flows receiving only primary treatment, and the remaining 82% of flow receiving full treatment. 2018 was characterized by frequent low intensity storms with larger than average event depths. Based on model overflow event analysis from 2015 to 2018, it appears that the Welland system overflows under long duration storms with high precipitation depths more frequently than under short duration storms with high intensity.

The greatest CSO overflow event was the result of a high volume precipitation event on April 15-16, 2018. The event depth was 63 mm and resulted in overflows at Denistoun, Hellems, Niagara North, and Prince Charles N.

Based on GMBP's review, the ratio of calculated total overflow volume to the total influent volume at the WWTP yielded a percentage of combined sewage being treated at the WWTP to be 99%. In regards to MOECC Procedure F-5-5, the City met the allowable limits of the combined sewer overflow volume percentages in 2017, within the allowable limits of 10% untreated wet weather overflows discharging to the environment.

Prepared By:



City of Welland

Combined Sewer Overflow Reporting 2019 Monitoring Period

GMBP File: 418024

January 2020



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1. INTRODUCTION

The City of Welland retained GM BluePlan Engineering (GMBP) to support with the City's Annual CSO reporting requirements. This task was completing leveraging the recently completed "all-pipe" model of the City of Welland's existing wastewater system to estimate both system performance and overflow volumes.

1.1 Project Background

GMBP was retained jointly by the City of Welland (City) and the Regional Municipality of Niagara (RMON) to update the Region's existing InfoSWMM trunk sewer model with the goal of developing a dynamic "all-pipe" model of the City's existing wastewater system. This model will provide both RMON and City staff with an improved and more detailed understanding of the performance of the existing wastewater collection system.

The hydraulic model will continue to be utilized to support the City's annual overflow report to the Ministry of Environment and Climate Change (MOECC), and support development of the City's planned Inflow and Infiltration Monitoring and Reduction Program.

1.2 Report Scope

The scope of this report focuses on the City's 2019 Overflow Reporting to the MOECC, and outlines:

- Regulatory and reporting requirements;
- Analysis methodology and assumptions; and
- Annual CSO volumes and loading.

2. METHODOLOGY

The proposed methodology to estimate total CSO volume and pollutant loadings is as follows:

- Complete dynamic wet weather RTK modelling of the 2019 year using:
 - Available precipitation records;
 - Available Welland River levels as provided by Niagara Peninsula Conservation Authority. This data allows for the modelling of CSO discharge from CSO outfalls that may be surcharged due to submersion.
- Utilize model results to complete CSO flow and volume analysis consistent with MOECC Procedure F-5-5;
- Complete pollutant loading utilizing typical concentration methodology.

For further detail on the dynamic wet weather RTK model development and assumptions please refer to *Welland Wastewater Model Update Report (2017)* document.

2.1 Water Quality Data

It is our understanding that the annual CSO report will provide information on both the annual CSO volumes based on the previous year's rainfall reports, and the total Carbonaceous Biological Oxygen Demand (CBOD) and Total Suspended Solids (TSS) loading, utilizing the typical concentration methodology applied in the provided 2014 Annual Report authored by Amec Foster Wheeler.

The pollutant loading characteristics are based on the CBOD and TSS concentrations as reported in previous Annual Reporting documents. It is our understanding that these CBOD and TSS concentrations are based on a sampling program conducted as part of the *City of Welland Sewage Environmental Assessment Study* in 2000. The program gathered water quality data for combined sewage flows at the following three sites during three wet weather events:

- Overflow pipe at Oxford Atlas Wellington Sewer;
- Upstream of the diversion structure at McMaster Avenue sewers;
- Influent channel of the Welland WWTP immediately downstream of the pumping station.

Table 1 summarizes the range of CBOD and TSS concentrations that will be utilized in this annual report.

Table 1: CBOD and TSS Concentrations - Previous Water Sampling Program

Parameter	Concentration (mg/L)		
	Mean	Min.	Max.
CBOD	20.6	19.0	27.4
TSS	129.0	20.0	360.0

Total pollutant mass loading is estimated by taking the minimum, mean and maximum concentrations for CBOD and TSS and multiplying these concentrations by the calculated overflow volumes.

2.2 CSO Analysis

The model results are based on the following calculations:

- The frequency of CSO events is calculated by counting the number of non-consecutive overflow events, where inter event time exceeds 12 hours. This approach is consistent with *Procedure F-5-5*.
- The total volume:
 - Direct CSO overflow volumes are calculated by utilizing the model results. Regardless of whether the event is combined or not, the total volume is the actual volume of combined sewage discharged from the overflow structure.
 - Bypassing at the Plant is measured and reported by the Region.
- The total duration is the duration of combined CSO events with less than 12 hours of intervening time between them. It is considered to be the duration of the time that combined sewage is discharging from the overflow structure,
- The CBOD and TSS mass loadings are calculated by multiplying the minimum, mean and maximum predetermined concentrations for CBOD and TSS by the overflow volumes, and assumes all WWTP bypass flows have received primary treatment.

2.3 CSO Locations

The CSO Analysis was completed for the 17 River Based CSOs located within the City. Figure 1 highlights the locations of the 17 CSOs. Note that the Downs Rd CSO was decommissioned in 2014. It is listed on the map and shown in the tables; however, no sewage overflows occur at this location.

3. MOECC REGULATIONS

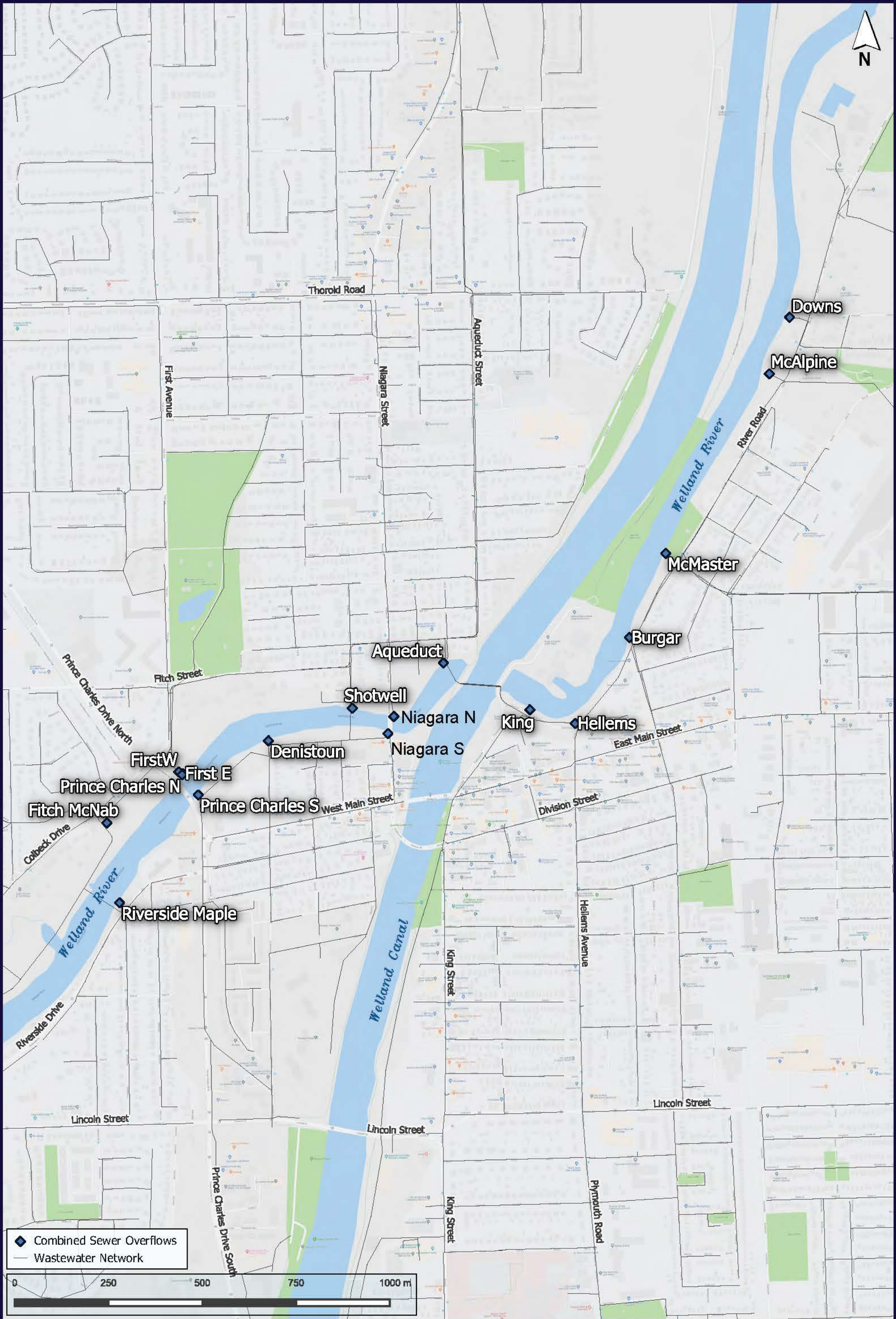
Procedure F-5-5 was developed by the Ministry of the Environment and Climate Change as documentation in support of *Guideline F-5: Levels of Treatment for Municipal and Private Sewage Treatment Works Discharging to Surface Waters*. The key objectives of Procedure F-5-5 are understood to be:

- Eliminate instances of dry weather overflow;
- Minimize impacts on human life and aquatic life and habitat; and,
- Achieve compliance with objectives for recreational Provincial Water Quality

The Technical Criteria from MOECC Procedure F-5-5 are required as follows:

- No overflows during dry weather;
- Maximize the use of the collection system for the storage of wet weather flows when capacity is available;
- During a seven (7) month period commencing within 15 days of April 1st of an average year, provide 90% volumetric control of wet weather in addition to all of the dry weather flow.

Treatment levels for the controlled volume are described in Section 7 of Procedure F-5-5.



4. RAINFALL DATA AND ANALYSIS

Niagara Region rainfall data from the Humberstone Landfill Rain Gauge rainfall data was utilized to complete the 2019 dynamic wet weather modelling analysis in order to determine total estimated 2019 system wet weather flows and system overflows.

4.1 Long-Term Rainfall Analysis

Table 3 summarizes the long-term rainfall records used to select a typical rainfall year. Long term rainfall records from the AMEC 2014 CSO report were updated with statistics from recent years. It is stated in the 2014 CSO report that the 1980 year was used as the basis for a typical rainfall year.

The 2019 rainfall data was added to the information provided in the 2014 AMEC report and previous 2015-2018 CSO reporting completed by GMBP. It should be noted that the detailed methodology of the values contained within the precipitation table are not explicitly stated; however, it is assumed that the pre-1994 data is representative of the April to October time period exclusively. As such, direct comparison to the various data sets may not be directly achievable. The GMBP analyses from 2016-2019 are based on full year precipitation data. Based on the above, the 2019 year was a relatively wet year with total precipitation depth above the 1980 typical year.

Table 2: Long-Term Rainfall Records

Year**	No. of Rainfall Events	Annual Rainfall Volume (mm)	Annual Rainfall Duration (hrs)	Average Event Rainfall Volume (mm)	Average Event Rainfall Intensity (mm/hr)	Average Event Rainfall Duration (hrs)
1964	40	282	249	7.05	1.05	6.23
1965	97	622	523	6.42	1.34	5.49
1966	92	511	535	5.55	1.04	5.82
1967	81	576	568	7.11	1.28	7.01
1968	119	855	806	7.18	1.04	6.77
1969	111	743	662	6.7	1.06	5.96
1970	110	701	702	6.37	1.12	6.38
1971	80	492	482	6.14	1.34	6.03
1972	82	579	554	7.06	1	6.76
1973	91	538	462	5.91	1.19	5.08
1974	69	428	431	6.2	1.05	6.25
1975	54	395	269	7.31	1.45	4.98
1976	77	605	471	7.86	1.45	6.12
1977	77	744	429	9.66	1.99	5.57
1978	74	576	453	7.78	1.65	6.12
1979	78	608	454	7.8	1.14	5.82
1980 (Typical)	72	552	448	7.67	1.46	6.22
1981	62	457	403	7.38	1.17	6.5
1982	28	132	122	4.73	1.47	4.36
1983	62	526	347	8.49	1.52	5.6
1984	82	610	444	7.44	1.5	5.42
1985	51	342	253	6.72	1.2	4.96
1986	75	552	343	7.36	1.77	4.57
1987	71	593	404	8.36	1.6	5.69
1988	64	375	289	5.86	1.71	4.52
1989	81	483	484	5.96	1.05	5.98
1990	64	596	476	9.32	1.19	7.44
1991	50	367	253	7.34	1.89	5.06
1992	90	719	607	7.99	1.1	6.74
1993	74	463	435	6.25	1.16	5.88
1994	69	541	406	7.84	1.16	5.88
1999*** (Long Term Avg.)	103	603	565	9.43	1.21	7.53
2009*	109	833	445	5.76	1.72	4.08
2010*	98	726 (463)	255	4.83	1.59	2.44
2011*	136	898 (558)	345	3.97	1.26	2.39
2012*	117	735 (479)	321	4.25	1.12	2.75
2013*	134	1,074 (731)	365	5.27	1.69	2.72
2014*	130	784 (509)	349	3.82	1.34	2.58
2015	62	572.75	282.25	9.24	1.87	4.55
2016	57	308.75	221.25	5.42	1.55	3.88
2017	87	709.50	336.08	8.16	2.13	3.86
2018	78	784.25	659.42	10.05	1.52	6.43
2019	104	899.3	602.7	8.1	1.4	5.8

1964 to 2014 Data was extracted from Amec Foster Wheeler, Combine Sewer Overflow Model – 2014 Report. Dated February 2016. This data included the following notations:

* Annual rainfall data for 2009 – 2014 was downloaded from the Environment Canada Database; Rainfall in brackets is for the monitoring periods (April to October/ November) downloaded from the Cole Engineering Remote Data Access site.

** Rainfall data from 1964 to 1994 was extracted from RV Anderson CSO Study Environmental Study Report, 2003.

*** Rainfall data for 1999 was obtained from Welland Climate Impact Study Determination of Average Precipitation Year (2011).

The data in red from 2015-2019 reflects GM BluePlan precipitation analyses.

5. SUMMARY OF 2019 FLOW RESULTS

The model was run from the 1st of April to the 31st of October 2019 to meet the 7 month reporting requirements of the F-5-5 Procedure.

An analysis of precipitation events triggering overflows found that most overflows to the Welland River, within the Welland wastewater collection system, were primarily triggered by larger volume events of medium to high intensity. With high intensity- low volume events generating limited to no overflows. This relationship is likely related to the configuration and utilization of the larger interceptor sewers as a system CSO storage.

Table 3 compares major storm events to CSO overflow events from 2015 to 2019. Major storm events are characterized by a total rainfall depth of 25 mm or more, and an average intensity of 2 mm/hr (1 inch of rain in half a day). Table 3 shows that the majority of overflow events do occur during major storm events; however, due to other external and climatic factors, major storm events do not always induce overflows; further, overflows may occur during other storm events (snow melt or other). All overflow events in 2019 were triggered by major storm events.

Table 3. Major Precipitation-CSO Event Summary.

Year	Number of critical events	Sum of Event Depth (mm)	Total Rainfall April Oct (mm)	% of rainfall	Total number of overflow events	Annual CSO overflow volume (ML)	% of overflow events
2015	4	74.9	572.75	11%	7	50.9	100%
2016	1	4.3	308.75	1%	7	1.1	25%
2017	5	41.6	709.5	7%	10	22.3	50%
2018	7	434.3	784.25	13%	2	4.3	100%
2019	9	290.5	658.75	44%	9	28.0	100%

Utilizing the model flow results, the total volume, duration, and mass loading of CBOD and TSS for each CSO event was calculated. Table 4 outlines the frequency, duration, volume and mass loading of TSS and CBOD of CSO overflows that occurred in 2019. Table 4 presents monthly overflow volumes by CSO location.

Table 4: 2019 Monthly System CSO Events

Month	Obs. Precip (mm)	Freq.	Volume (m ³)	Duration (min)	CBOD Mass Loading (kg)			TSS Mass Loading (kg)		
					Mean	Min	Max	Mean	Min	Max
April	91.0	1	6,129.1	180	126.3	116.5	167.9	790.7	122.6	2,206.5
May	98.3	1	235.1	120	4.8	4.5	6.4	30.3	4.7	84.6
June	115.5	1	938.9	75	19.3	17.8	25.7	121.1	18.8	338.0
July	50.8	1	7,332.9	195	151.1	139.3	200.9	945.9	146.7	2,639.8
August	73.0	1	4,722.0	150	97.3	89.7	129.4	609.1	94.4	1,699.9
September	118.0	3	5,698.4	360	117.4	108.3	156.1	735.1	114.0	2,051.4
October	112.3	1	2,966.9	150	61.1	56.4	81.3	382.7	59.3	1,068.1
Total	658.8	9.0	28,023.3	1230	577.3	532.4	767.8	3615.0	560.5	10,088.4

Table 5: Monthly Overflow Volume by CSO (ML)

CSO	April	May	June	July	August	September	October	Total (ML)
Aqueduct	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Burgar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Colbeck (Fitch/McNab)	0.4	0.0	0.1	0.4	0.3	0.4	0.2	1.8
Denistoun	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Downs	-	-	-	-	-	-	-	-
First E	0.2	0.0	0.0	0.3	0.1	0.1	0.0	0.6
First W	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hellems	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
King	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
McAlpine	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
McMaster	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Niagara N	0.1	0.1	0.0	0.1	0.1	0.2	0.0	0.6
Niagara S	1.1	0.0	0.0	1.6	0.8	1.0	0.2	4.7
Prince Charles N	1.1	0.1	0.3	1.3	0.9	1.2	0.8	5.7
Prince Charles S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Riverside and Maple	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shotwell	3.2	0.0	0.5	3.6	2.5	2.9	1.8	14.5
Total Untreated Overflows	6.1	0.2	0.9	7.3	4.7	5.7	3.0	28.0
WWTP ByPass (ML)	1,538.3	1,243.6	1,136.6	928.0	960.2	1,165.7	1,093.9	8,066.1
Total Overflows (ML)	1,544.4	1,243.8	1,137.6	935.3	964.9	1,171.4	1,096.8	

As per MOECC Procedure F-5-5, all dry weather flows and 90% of the wet weather flows must be captured and treated at the WWTP. Table 6 summarizes the reported volumetric system capture against the model-based estimated volume for the 2019 reporting period.

Based on the estimated CSO overflow volumes and the system wet weather flows (see Table 6), approximately 99.0% of wet weather flows reached the WWTP in 2019, which is within the allowable overflows defined by the MOECC procedure requirements.

Table 6: 2019 Model Flows

	A	B	C	D	E	F	G	H	I	J
Month	Precipitation	Total Measured Flows WWTP (ML)	Modelled Flow at WWTP (ML)	Total DWF at WWTP (ML)	Total WWF at WWTP (ML)	Total Untreated System Volume (ML)	Primary Treated WWTP By Pass (ML)	Total WWF (ML)	Total System Overflow Volume (ML)	Treated / Captured Volumetric Percentage
April	91.0	1,456.4	1,538.3	1,075.7	462.6	6.1	185.9	468.7	192.0	98.7%
May	98.3	1,357.7	1,243.6	795.5	448.1	0.2	148.7	448.3	148.9	99.9%
June	115.5	1,166.1	1,136.6	632.4	504.2	0.9	86.9	505.1	87.9	99.8%
July	50.8	770.4	928.0	653.5	274.4	7.3	25.3	281.8	32.7	97.4%
August	73.0	805.7	960.2	653.5	306.6	4.7	18.7	311.4	23.4	98.5%
September	118.0	951.4	1,165.7	686.9	478.8	5.7	79.7	484.5	85.4	98.8%
October	112.3	1,039.9	1,093.4	686.9	406.5	3.0	104.3	409.5	107.3	99.3%
Total	658.8	7,547.7	8,065.7	5,184.4	2,881.3	28.0	649.5	2,909.3	677.5	99.0%

A: Precipitation at the WWTP rain gauge.

B: Measured flows to the WWTP, Niagara Region data.

C: Modelled flow at WWTP, model estimation.

D: Dry Weather Flow at WWTP, model estimation.

E: Wet Weather Flow at WWTP, calculated $E = C - D$

F: Total Overflow Volume, model estimation.

G: Measured WWTP Bypass Volume, primary treatment, Niagara Region data.

H: Total Wet Weather Flow, calculated $H = E + F$

I: Total Overflow Volume (treated and untreated), calculated $I = F + G$

J: Volumetric Percentage of Wet Weather Flow Captured and Treated, $J = (H - F) / H$

Table 7- Treated/Captured Volumetric Percentage

Year	Observed Precipitation April Oct (mm)	Total WWF (ML)	Total Untreated System Volume (ML)	Total Treated and Untreated System Overflow (ML)	Treated/Captured Volumetric (%)
2015	531	1,129	51.4	362	95.5
2016	287	606	4.5	16	99.6
2017	632	2,498	22.3	461	99.1
2018	501	2,554	4.3	480	99.8
2019	659	2,881	28.0	677.5	99.0

Table 7 provides an overview of the system 2019 represents a similar capture rate observed in previous years. This higher than average capture rate is likely due to the higher precipitation depth of storms in 2019 when compared to 2016 and 2018. Trends imply the Welland system CSOs are more likely to overflow under high volume storms with extended durations. It is also likely that I&I reduction measures implemented by the City contributed to a reduction in system overflows compared to 2015.

6. SUMMARY AND CONCLUSIONS

GM BluePlan completed hydraulic modelling of the 2019 rainfall year to evaluate total overflow volumes for 16 active combined sewer overflow locations along the Welland River. The model determined overflow volumes, durations, frequencies and mass loadings of CBOD and TSS at each overflow location on a monthly basis, from April 1st to October 31st, 2019. It was determined that a total of 28.0 ML was discharged from the combined sewer system during this time whereas approximately 2,881 ML of wet weather flows were captured by the WWTP, with 650 ML (23%) only receiving primary treatment before overflowing at the WWTP. Thus, approximately <1% of the total wet weather flows exited via overflow structures, 23% of the total wet weather flows receiving only primary treatment, and the remaining 77% of flow receiving full treatment. 2019 was characterized by frequent low intensity storms with larger than average event depths. Based on model overflow event analysis from 2015 to 2019, it appears that the Welland system overflows under long duration storms with high precipitation depths more frequently than under short duration storms with high intensity.

The greatest CSO overflow event was the result of a low volume precipitation event, totaling 21.5 mm of rainfall over 4 days. The event resulted in overflows at Colbeck, First E, Niagara South, McAlpine, Shotwell, Prince Charles N and Prince Charles S. The untreated overflow volume to the River was 7.3 ML and the WWTP reported Secondary Bypassing of 25.3ML.

Based on GMBP's review, the ratio of calculated total overflow volume to the total influent volume at the WWTP yielded a percentage of combined sewage being treated at the WWTP to be 99%. In regards to MOECC Procedure F-5-5, the City met the allowable limits of the combined sewer overflow volume percentages in 2017, within the allowable limits of 10% untreated wet weather overflows discharging to the environment.

7. RECOMMENDATIONS

The above analysis is based on the recently updated hydraulic all-pipes model of the Welland system. This model was calibrated using the best available information. It should be noted that the flow monitors used to calibrate the model were positioned such that the City system was subdivided into a number of very small catchments, and very large catchments, with a number of key flow monitoring locations used to calibrate relatively large catchments. As such, the overall wet weather response was averaged over the full catchment area. Based on this, it is expected that the actual response within the large catchments are very diverse, however, additional details pertaining to this variability are not available without more discretized system monitoring. It is recommended that in future flow monitoring programs, the City should consider further separating these larger catchments into several sub-catchments to allow for a more detailed analysis of the local system, and to support future model updates.

Prepared By:



City of Welland

Combined Sewer Overflow Reporting 2020 Monitoring Period

GMBP File: 620027

January 2021



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1. INTRODUCTION

The City of Welland retained GM BluePlan Engineering (GMBP) to support with the City's Annual CSO reporting requirements. This task was completing leveraging the recently completed "all-pipe" model of the City of Welland's existing wastewater system to estimate both system performance and overflow volumes.

1.1 Project Background

GMBP was retained jointly by the City of Welland (City) and the Regional Municipality of Niagara (RMON) to update the Region's existing InfoSWMM trunk sewer model with the goal of developing a dynamic "all-pipe" model of the City's existing wastewater system. The hydraulic model was utilized to support the City's annual overflow report to the Ministry of Environment and Climate Change (MOECC), and support development of the City's planned Inflow and Infiltration Monitoring and Reduction Program.

1.2 Report Scope

The scope of this report focuses on the City's 2020 Overflow Reporting to the MOECC, and outlines:

- Regulatory and reporting requirements;
- Analysis methodology and assumptions; and
- Annual CSO volumes and loading.

2. METHODOLOGY

The proposed methodology to estimate total CSO volume and pollutant loadings is as follows:

- Complete dynamic wet weather RTK modelling of the 2020 year using:
 - Available precipitation records;
 - Region Rain Gauges (RG)
 - City Rain Gauges
 - Available Welland River levels as provided by Niagara Peninsula Conservation Authority. This data allows for the modelling of CSO discharge from CSO outfalls that may be surcharged due to submersion.
- Utilize model results to complete CSO flow and volume analysis consistent with MOECC Procedure F-5-5;
- Complete pollutant loading utilizing typical concentration methodology.

For further detail on the dynamic wet weather RTK model development and assumptions please refer to *Welland Wastewater Model Update Report (2017)* document.

2.1 Water Quality Data

It is our understanding that the annual CSO report will provide information on both the annual CSO volumes based on the previous year's rainfall reports, and the total Carbonaceous Biological Oxygen Demand (CBOD) and Total Suspended Solids (TSS) loading, utilizing the typical concentration methodology applied in the provided 2014 Annual Report authored by Wood, formerly Amec Foster Wheeler.

The pollutant loading characteristics are based on the CBOD and TSS concentrations as reported in previous Annual Reporting documents. It is our understanding that these CBOD and TSS concentrations are based on a sampling program conducted as part of the *City of Welland Sewage Environmental Assessment Study* in 2000. The program gathered water quality data for combined sewage flows at the following three sites during three wet weather events:

- Overflow pipe at Oxford Atlas Wellington Sewer;
- Upstream of the diversion structure at McMaster Avenue sewers;
- Influent channel of the Welland WWTP immediately downstream of the pumping station.

Table 1 summarizes the range of CBOD and TSS concentrations that will be utilized in this annual report.

Table 1: CBOD and TSS Concentrations - Previous Water Sampling Program

Parameter	Concentration (mg/L)		
	Mean	Min.	Max.
CBOD	20.6	19.0	27.4
TSS	129.0	20.0	360.0

Total pollutant mass loading is estimated by taking the minimum, mean and maximum concentrations for CBOD and TSS and multiplying these concentrations by the calculated overflow volumes.

2.2 CSO Analysis

The model results are based on the following calculations:

- The frequency of CSO events is calculated by counting the number of non-consecutive overflow events, where inter event time exceeds 12 hours. This approach is consistent with *Procedure F-5-5*.
- The total volume:
 - Direct CSO overflow volumes are calculated by utilizing the model results. Regardless of whether the event is combined or not, the total volume is the actual volume of combined sewage discharged from the overflow structure.
 - Bypassing at the Plant is measured and reported by the Region.
- The total duration is the duration of combined CSO events with less than 12 hours of intervening time between them. It is considered to be the duration of the time that combined sewage is discharging from the overflow structure,
- The CBOD and TSS mass loadings are calculated by multiplying the minimum, mean and maximum predetermined concentrations for CBOD and TSS by the overflow volumes, and assumes all WWTP bypass flows have received primary treatment.

2.3 CSO Locations

The CSO Analysis was completed for the 17 River Based CSOs located within the City. **Figure 1** highlights the locations of the CSOs that outfall to the Welland River. Note that the Downs Rd CSO was decommissioned in 2014. It is listed on the map and shown in the tables; however, no sewage overflows occur at this location.

The City has additional in-system overflows which have mandated monitoring and reporting which are L1, L2, L3, Hagar-Camrose, Hagar-Wallace, and Hagar McAlpine. These sites have mandatory reporting requirements separate from this report, the total overflows at these sites are summarized in **Appendix A – MECP Overflow Reporting**.

3. MOECC REGULATIONS

Procedure F-5-5 was developed by the Ministry of the Environment and Climate Change as documentation in support of *Guideline F-5: Levels of Treatment for Municipal and Private Sewage Treatment Works Discharging to Surface Waters*. The key objectives of Procedure F-5-5 are understood to be:

- Eliminate instances of dry weather overflow;
- Minimize impacts on human life and aquatic life and habitat; and,
- Achieve compliance with objectives for recreational Provincial Water Quality

The Technical Criteria from MOECC Procedure F-5-5 are required as follows:

- No overflows during dry weather;
- Maximize the use of the collection system for the storage of wet weather flows when capacity is available;
- During a seven (7) month period commencing within 15 days of April 1st of an average year, provide 90% volumetric control of wet weather in addition to all of the dry weather flow.

Treatment levels for the controlled volume are described in Section 7 of Procedure F-5-5.

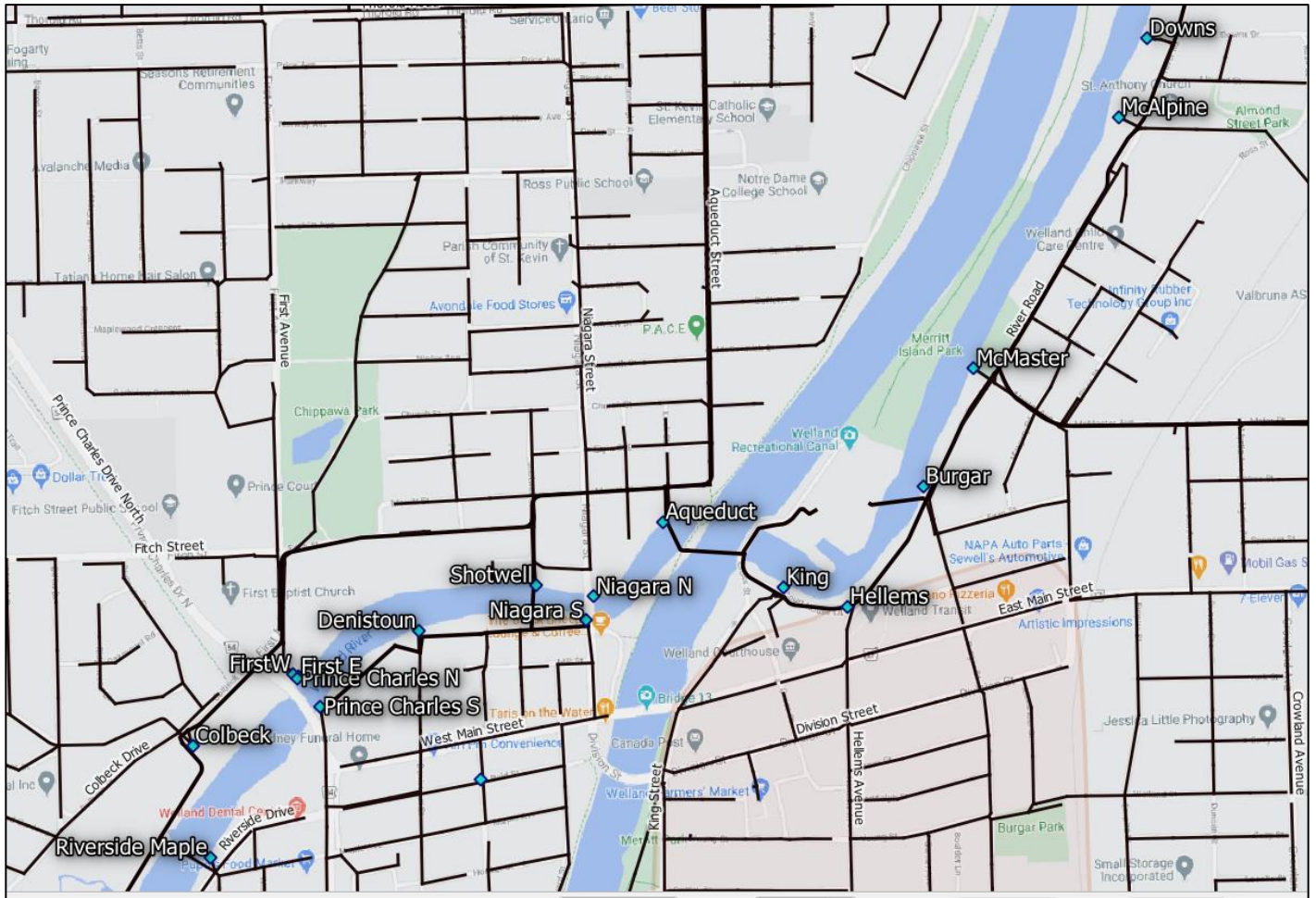


Figure 1. Welland River CSOs

4. RAINFALL DATA AND ANALYSIS

4.1 Data Sources

Niagara Region rainfall data from the following stations were utilized in the model for the 2020 modelling period:

- Humberstone Landfill RG
- Ontario Rd SPS RG
- River Road RG

Data from a rain gauge installed at the Dain City SPS were also utilized. Note that the City's flow monitoring program changed consultants in June 2020.

- Associated Engineering/Civica Dain City RG – April 1-June 30, 2020
- GM BluePlan Engineering Ltd/AMG Environmental RG – July 1 -October 31, 2020

4.2 Long-Term Rainfall Analysis

Long term rainfall records from the Region Humberstone Rain Gauge were analyzed for the 2020 Pollution Prevention and Control Plan (PPCP) to determine to average year (April to October) for the F-5-5 Procedure. Long term trends were analyzed based on an inter-event time of 24 hours, to be consistent with rain analysis completed for the PPCP. Table 2 summarizes the long-term rainfall trends; 2012 was determined to be the average year based on a multi-variable analysis. The 2020 rainfall data was analyzed on the same variables completed in the PPCP. Compared to the average year, 2020 was a dry year, with 12% fewer rainfall events and 20% less rainfall by volume. The average duration of storms was longer, resulting in lower event intensities, on average.

While the year had less intense storms on average, the City experience a small number of very intense storms which only occurred with extreme intensities at the Ontario Road and Dain City rain gauges. For example, at the Dain City RG:

- June 28th was a 17 mm storm with a peak 5 min intensity of 128 mm/h, the return period registered as a 7 year storm based on the 5 min peak intensity.
- July 9th was a 70 mm storm with a peak 5 min intensity of 161 mm/h, the return period registered as greater than 200 year storm, based on the 30 min peak intensity.

Table 2: Long-Term Rainfall Trends at Humberstone RG

Year	No. of Rainfall Events	Annual Rainfall Volume (mm)	Annual Rainfall Duration (hrs)	Average Event Rainfall Volume (mm)	Average Event Rainfall Intensity (mm/hr)	Average Event Rainfall Duration (hrs)
1998	48	349	489	7	2.5	10
1999	47	424	624	9	1.6	13
2000	38	557	709	15	2.3	19
2001	48	404	743	8	1.3	15
2002	52	464	652	9	3.1	13
2003	55	504	740	9	1.9	13
2004	53	672	740	13	2.3	14
2005	42	491	549	12	2.9	13
2006	51	688	764	13	1.5	15
2007	39	358	559	9	1.2	14
2008	55	514	803	9	2.8	15
2009	45	649	733	14	1.7	16
2010	49	542	647	11	2.9	13
2011	46	639	960	14	3.4	21
2012*	52	510	687	10	1.7	13
2013	46	694	719	15	2.7	16
2014	53	539	719	10	1.3	14
2015	43	573	587	13	1.9	14
2016	42	309	461	7	1.7	11
2017	54	613	794	11	2.2	15
2018	43	501	752	12	1.4	17
2019	57	715	935	13	1.5	16
2020	46	403	786	9	1.5	17

*2012 was determined to be the average year across a multi-variable analysis determined in the PPCP.

5. SUMMARY OF 2020 FLOW RESULTS

The model was run from the 1st of April to the 31st of October 2020 to meet the 7 month reporting requirements of the F-5-5 Procedure.

An analysis of precipitation events triggering overflows found that most overflows to the Welland River, within the Welland wastewater collection system, were primarily triggered by larger volume events of medium to high intensity. With high intensity- low volume events generating limited to no overflows. This relationship is likely related to the configuration and utilization of the larger interceptor sewers as a system CSO storage.

Table 3 compares major storm events to CSO overflow events from 2015 to 2020. Major storm events are characterized by a total rainfall depth of 25 mm or more, and an average intensity of 2 mm/hr (1 inch of rain in half a day). In 2020 no events met both of these major storm criteria; however, three events (exceeded 25 mm event depth and one exc

Table 3 shows that the majority of overflow events do occur during major storm events; however, due to other external and climatic factors, major storm events do not always induce overflows; further, overflows may occur during other storm events (snow melt or other). All overflow events in 2020 were triggered by major storm events.

Table 3. Major Precipitation-CSO Event Summary.

Year	Number of Major Storms	Sum of Major Storm Depth (mm)	Total Rainfall April-Oct (mm)	% of rainfall	Total number of overflow events	Annual CSO overflow volume (ML)	% Of Overflow Events From Major Storms
2015	4	74.9	572.75	11%	7	50.9	100%
2016	1	4.3	308.75	1%	7	1.1	25%
2017	5	41.6	709.5	7%	10	22.3	50%
2018	7	434.3	784.25	13%	2	4.3	100%
2019	9	352.25	658.75	53%	9	28.0	100%
2020	3	94	403.25	23%	5	15.8	100%

Utilizing the model flow results, the total volume, duration, and mass loading of CBOD and TSS for each CSO event was calculated. Table 4 outlines the frequency, duration, volume and mass loading of TSS and CBOD of CSO overflows that occurred in 2020. Table 4 presents monthly overflow volumes by CSO location.

Table 4: 2020 Monthly System CSO Events

Month	Rainfall (mm)	Number of Overflow Events	Volume (m ³)	Duration (min)	CBOD Mass Loading (kg)			TSS Mass Loading (kg)		
					Mean	Min	Max	Mean	Min	Max
April	67.3	0	0	0	0	0	0	0	0	0
May	53.0	0	0	0	0	0	0	0	0	0
June	58.3	1	532	50	11	10	15	69	11	192
July	68.8	2	15,019	400	309	285	412	1,937	300	5,407
August	31.5	0	0	0	0	0	0	0	0	0
September	54.0	1	287	55	6	5	8	37	6	103
October	70.5	1	0	0	0	0	0	0	0	0
Total	403.3	5	15,838	505	326	301	434	2,043	317	5,702

Table 5: Monthly Overflow Volume by CSO (ML)

CSO	April	May	June	July	August	September	October	Total (ML)
Aqueduct	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Burgar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Colbeck	0.0	0.0	0.0	3.6	0.0	0.0	0.0	3.6
Denistoun	0.0	0.0	0.1	2.4	0.0	0.1	0.0	2.5
Downs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
First E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
First W	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.7
Hellems	0.0	0.0	0.3	6.4	0.0	0.1	0.0	6.8
King	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3
McAlpine	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
McMaster	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Niagara N	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.9
Niagara S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Prince Charles N	0.0	0.0	0.1	0.8	0.0	0.1	0.0	1.0
Prince Charles S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Riverside and Maple	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shotwell	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Untreated Overflows	<i>0.0</i>	<i>0.0</i>	<i>0.5</i>	<i>15.0</i>	<i>0.0</i>	<i>0.3</i>	<i>0.0</i>	15.8
WWTP ByPass (ML)	1,460	1,188	1,009	1,066	896	980	1,098	7,697
Total Overflows (ML)	1,460	1,188	1,009	1,081	896	980	1,098	

As per MOECC Procedure F-5-5, all dry weather flows and 90% of the wet weather flows must be captured and treated at the WWTP. Table 6 summarizes the reported volumetric system capture against the model-based estimated volume for the 2020 reporting period.

Based on the estimated CSO overflow volumes and the system wet weather flows (see Table 6), approximately 99.4% of wet weather flows reached the WWTP in 2020, which is within the allowable overflows defined by the MOECC procedure requirements.

Table 6: 2019 Model Flows

	A	B	C	D	E	F	G	H	I	J
Month	Precipitation	Total Measured Flows WWTP (ML)	Modelled Flow at WWTP (ML)	Total DWF at WWTP (ML)	Total WWF at WWTP (ML)	Total Untreated System Volume (ML)	Primary Treated WWTP By-Pass (ML)	Total WWF (ML)	Total System Overflow Volume (ML)	Treated / Captured Volumetric Percentage
April	67.3	1,124	1,460	1,076	385	0.0	69.4	385	69.4	100.0%
May	53.0	1,039	1,188	795	393	0.0	10.8	393	10.8	100.0%
June	58.3	858	1,009	632	376	0.5	0.0	377	0.5	99.9%
July	68.8	910	1,066	654	413	15.0	43.0	428	58.0	96.5%
August	31.5	726	896	654	243	0.0	0.0	243	0.0	100.0%
September	54.0	708	980	687	293	0.3	9.4	293	9.7	99.9%
October	70.5	832	1,098	687	411	0.0	0.0	411	0.0	100.0%
Total	403.3	6,198	7,697	5,184	2,513	15.8	132.6	2,529	148.4	99.4%

A: Precipitation at the WWTP rain gauge.

B: Measured flows to the WWTP, Niagara Region data.

C: Modelled flow at WWTP, model estimation.

D: Dry Weather Flow at WWTP, model estimation.

E: Wet Weather Flow at WWTP, calculated $E = C - D$

F: Total Overflow Volume, model estimation.

G: Measured WWTP Bypass Volume, primary treatment, Niagara Region data.

H: Total Wet Weather Flow, calculated $H = E + F$

I: Total Overflow Volume (treated and untreated), calculated $I = F + G$

J: Volumetric Percentage of Wet Weather Flow Captured and Treated, $J = (H - F) / H$

Table 7- Treated/Captured Volumetric Percentage

Year	Observed Precipitation April-Oct (mm)	Total WWF (ML)	Total Untreated System Volume (ML)	Total Treated and Untreated System Overflow (ML)	Treated/Captured Volumetric (%)
2015	531	1,129	51.4	362	95.5
2016	287	606	4.5	16	99.6
2017	632	2,498	22.3	461	99.1
2018	501	2,554	4.3	480	99.8
2019	659	2,881	28	678	99.0
2020	403	2,513	15.8	148	99.4

Table 7 provides an overview of the system 2020 represents a similar capture rate observed in previous years.

This higher than average capture rate is likely due to the lower precipitation depth of storms in 2020 when compared to 2017 to 2019. Trends imply the Welland system CSOs are more likely to overflow under high volume storms with extended durations. It is also likely that I&I reduction measures implemented by the City contributed to a reduction in system overflows compared to 2015.

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GM BluePlan completed hydraulic modelling of the 2020 rainfall year to evaluate total overflow volumes for 16 active combined sewer overflow locations along the Welland River. The model determined overflow volumes, durations, frequencies and mass loadings of CBOD and TSS at each overflow location on a monthly basis, from April 1st to October 31st, 2020. It was determined that a total of 15.8 ML was discharged from the combined sewer system during this time whereas approximately 2,513 ML of wet weather flows were captured by the WWTP, with 132.6 ML (5%) only receiving primary treatment before overflowing at the WWTP. Thus, approximately <1% of the total wet weather flows exited via overflow structures, 5% of the total wet weather flows receiving only primary treatment, and the remaining 94% of flow receiving full treatment. 2020 was characterized by frequent low intensity storms with lower than average event depths.

The greatest CSO overflow event(s) occurred on July 10/11 and was the result of a high intensity and volume event, totaling 70 mm of rainfall, with a peak 1 hour intensity of 19.75 mm/hr. The event resulted in overflows at Colbeck, Denistoun, First W, Niagara North, King, Hellems, and Prince Charles N. The untreated overflow volume to the River was 15.0 ML and the WWTP reported Secondary Bypassing of 43 ML from the 10th to the 11th.

Based on GMBP's review, the ratio of calculated total overflow volume to the total influent volume at the WWTP yielded a percentage of combined sewage being treated at the WWTP to be 99%. In regards to MOECC Procedure F-5-5, the City met the allowable limits of the combined sewer overflow volume percentages in 2020, within the allowable limits of 10% untreated wet weather overflows discharging to the environment.

7. RECOMMENDATIONS

The above analysis is based on the recently updated hydraulic all-pipes model of the Welland system. This model was calibrated using the best available information. It should be noted that the flow monitors used to calibrate the model were positioned such that the City system was subdivided into a number of very small catchments, and very large catchments, with a number of key flow monitoring locations used to calibrate relatively large catchments. As such, the overall wet weather response was averaged over the full catchment area. Based on this, it is expected that the actual response within the large catchments are very diverse, however, additional details pertaining to this variability are not available without more discretized system monitoring. It is recommended that in future flow monitoring programs, the City should consider further separating these larger catchments into several sub-catchments to allow for a more detailed analysis of the local system, and to support future model updates.

Appendix A

2020 Overflows Summary for Hagar & L-Site Overflow Locations

Station	Hagar & Camrose	Hagar & McAlpine	Hagar & Wallace	L1	L2	L3	Total Overflow		Rainfall			In Lab Sample #	MOE Incident Report #
Location	Intersection of Hagar St. and Camrose Ave.	Intersection of Hagar St. and McAlpine Ave.	Intersection of Hagar St. and Wallace Ave.	Intersection of Coventry Rd. and Simpson Ave.	Intersection of Coventry Rd. and Lincoln St.	In front of plaza at 317 Lincoln St.							
Monitor(s)	A/V (OF) A/V (MC)	A/V (OF) A/V (MC)	A/V (OF) A/V (MC)	A/V (OF) Ultrasonic (MC)	A/V (OF) Ultrasonic (MC)	A/V (OF) Ultrasonic (MC)							
FROM Asset User ID (GIS)	446019MH04	436089MH01	436099MH01	435949MH04	436045MH01	436055MH02	Evelyn (Canal)	Burgar (River)	Pelham*	River Rd*	Dain City*		
TO Asset User ID (GIS)	446019MH02	436089MH02	436099MH02	435949MH05	436045MH03	436055MH03							
Receiving Body	Canal	Canal	Canal	Canal	River	River							
OF Invert Elevation u/s	179.42	179.24	179.03	177.5	178.27	177.81							
OF Invert Elevation d/s	179.37	179.14	179.11 ^c	178.13 ^c	178.16	177.8							
Overflow Dates & Volumes (m³)							(m³)	(m³)	(mm)	(mm)	(mm)		
11-Jan-20 25-Jan-20 18-Feb-20 20-Mar-20 28-Mar-20 29-Mar-20 13-Apr-20 30-Apr-20 9-Jul-20 10-Jul-20 16-Jul-20 13-Sep-20	0.0	0.0	32.1	0.0	0.0	0.0	32.1	0.0	24.0	32.3	26.1	579-5181-1 579-5181-2	904003
	0.0	0.0	185.5	0.0	0.0	0.0	185.5	0.0	18.8	24.5	22.8	579-5199-1 579-5199-2 579-5199-3	904101
	0.0	0.0	11.8	0.0	0.0	0.0	11.8	0.0	5.5 ^a	6.8 ^a	CO o	579-5228-1	904128
	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.0	6.3	6.8	8.6	*No samples collected ^b	904211
	0.0	0.0	0.8	0.0	0.0	0.0	0.8	0.0	7.8	10.5	10.5	*No samples collected ^b	904276
	0.0	0.0	2.2	0.0	0.0	0.0	2.2	0.0	8.3	10.8	5.8	*No samples collected ^b	904277
	0.0	0.0	4.3	0.0	0.0	0.0	4.3	0.0	10.8	14.5	14.0	*No samples collected ^b	904310
	0.0	0.0	4.3	0.0	0.0	0.0	4.3	0.0	10.8	14.5	14.0	*No samples collected ^b	904372
	92.7	14.9	246.2	735.4	0.0	596.9	1089.2	596.9			70.1	*No samples collected ^b	904589
	0.0	0.0	12.9	0.0	0.0	0.0	12.9	0.0			9.0	*No samples collected ^b	904590
	0.0	0.0	1.9	0.0	0.0	0.0	1.9	0.0			21.0	*No samples collected ^b	904591
	0.0	0.0	1.4	0.0	0.0	0.0	1.4	0.0			18.0	*No samples collected ^b	904589
Totals (m³)	92.7	14.9	503.7	735.4	0.0	596.9	1346.7	596.9					

* Rainfalls associated w/OF event

^a It is suspected that this overflow event was caused by a combination of snowmelt, rainfall, and debris build up at or near Hagar Wallace

^b No samples collected due to worker health & safety concerns during COVID-19 pandemic

APPENDIX J: Implementation Plans



Date: August 5, 2020 File: 618057-002

To: Marvin Ingebrigtsen

From: Julien Bell, P.Eng. , Elaine Samuel, EIT

Project: City of Welland PPCP Extension

Subject: Broadway Pilot Priority Area

TECHNICAL MEMO

The purpose of this pilot priority area study is to provide the City an implementation plan of the Welland Pollution Prevention Control Plan and Master Servicing Plan Study (PPCP) recommended wastewater system improvement for the Broadway Priority Area.

1 BROADWAY AREA

The Broadway neighbourhood, shown in **Figure 1**, was identified as a priority area in the PPCP. The area, located in Welland South, bounded by the Welland River to the west and the Welland Recreational Canal to the east, was identified as a priority area of concern for the City due to growth pressures and existing state of high basement flooding risks. The Broadway area has been identified as an area subject to frequent system surcharging under wet weather conditions, which results in periodic basement flooding if no mitigative measure are undertaken.

1.1 Wastewater System Overview

The Broadway area is serviced by local sewers (200-300 mm) which collect flows from the local residences and conveying flows to the Broadway trunk sewer. The Broadway trunk sewer collects all local flows and discharges to the Regional 1650 mm interceptor on Riverside Drive.

The Broadway trunk sewer consist of; a 300 mm City owned section from Prince Charles Drive to Kilgour Ave, a 450 mm Region owned section from Kilgour Ave to Forster Ave; and a 525 mm Region owned sewer from Forster Ave to Riverside Drive.

Further to the Broadway trunk sewer, the Feeder Road Sewage Pump Station forcemain, which services the 55 ha industrial area south of the Broadway area, also connects to Regional 1650 mm interceptor inline storage sewer on Riverside Drive via a separate 300 mm sewer. Flows from Broadway and Feeder Rd are conveyed through the 1650 mm sewer to the 900 mm interceptor, by gravity, to the Welland Wastewater Treatment Plant (WWTP).

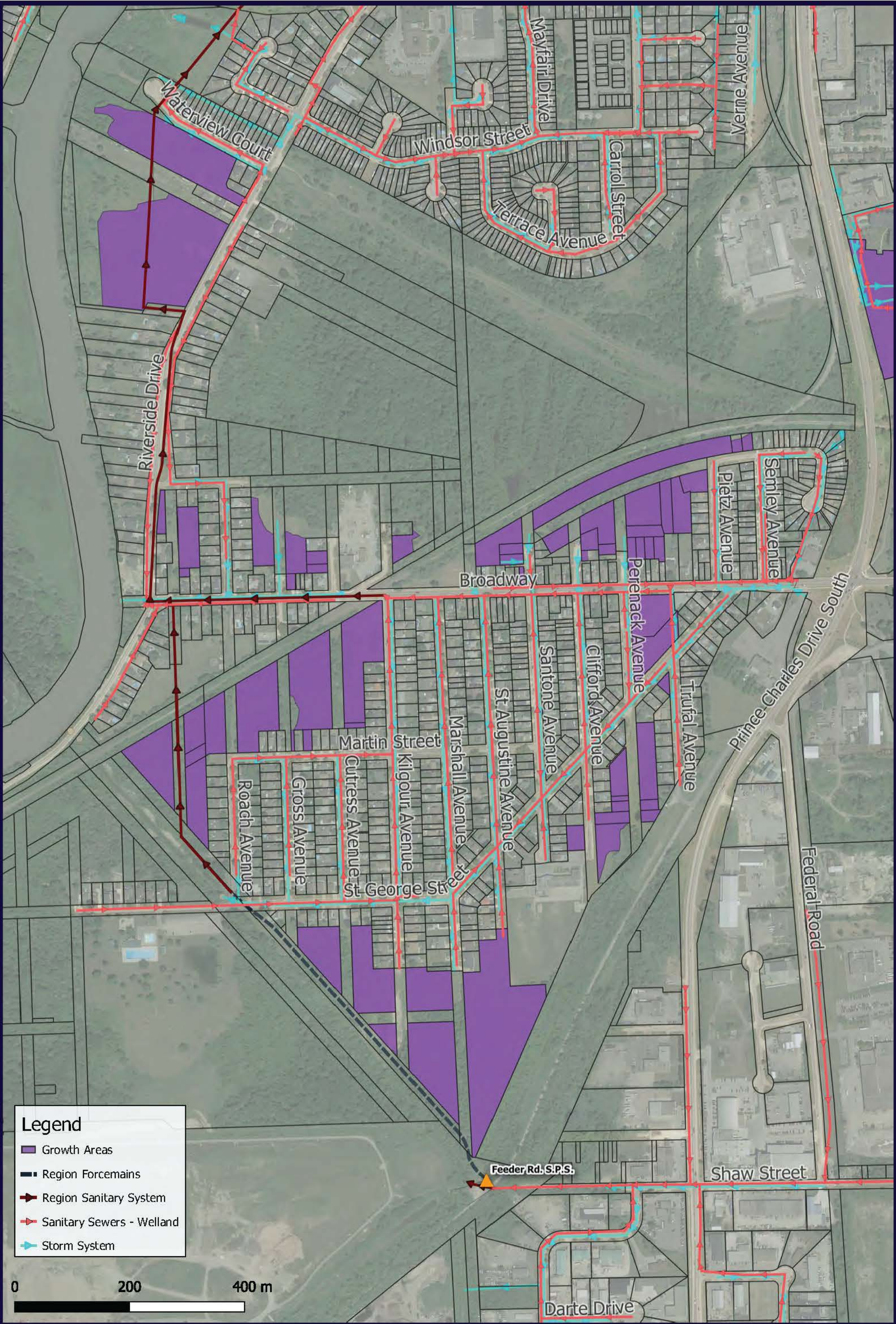
Generally, the local 200-300 mm sewers were built less at a depth of 1.5 to 2 meters and include flow splits on St George Street at Clifford Ave and Santone Ave.

1.2 Storm System

The Broadway is also served by an existing storm sewer network that outlets to an engineered channel at Roach Avenue and St George Street, which outlets to the Welland River.

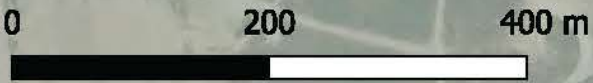
1.3 Growth

Growth in the Broadway area is estimated to consist of the infilling of remaining existing vacant lands and/or the redevelopment of existing larger parcels. Growth potential is estimated at 1,268 people across 23 ha, which is approximately 80% infill. Average dry weather flow of the growth areas is approximately 4 L/s and additional RDII flows of 5.2 L/s. Growth areas are shown in purple in **Figure 1**.



Legend

- Growth Areas
- Region Force mains
- Region Sanitary System
- Sanitary Sewers - Welland
- Storm System



2 BROADWAY WASTEWATER SYSTEM PERFORMANCE

2.1 Level of Service and Performance Criteria

Following the recommendations of the 2020 PPCP study, the wastewater system level of service is to ensure the hydraulic grade line (HGL) does not exceed 2.4 m below ground level in the 10 year storm. This depth requirement is in place to protect basements from flooding as a result of sewer system surcharging.

2.2 Background Review and Flow Monitoring

A study conducted in 2007 by XCG Consultants identified the 300 mm City trunk sewer to be undersized and contributing to basement flooding. As such, nine (9) flow monitors were installed in 2019 to collect wet weather data for the area to assess current wet weather flows.

Flow monitoring showed extremely high wet weather flows compared to dry weather flows and design values.

2.2.1 Broadway Trunk

The average dry weather flow for the Broadway area is approximately 5 L/s. The design wet weather flows, using 0.286 L/s/ha, to the Broadway trunk are estimated at 36 L/s. Comparatively peak flows in a 10 year storm at the west end of the trunk are estimated to be 230 L/s, based on observed flow monitoring results and model simulations in a 10 year storm .

Based on the flow monitoring data, the system rain derived inflow and infiltration (RDII) for a 10 year design storm is 1.9 L/s/ha, which is 7 times the design RDII of 0.286 L/s/ha.

Further details about flow monitoring and calibration can be found in **Appendix A**.

2.3 Broadway System Performance – Existing System

2.3.1 Broadway Trunk Sewer

The Broadway trunk sewer experiences surcharging above obvert west of Kilgour Ave and significant surcharging past the basement flooding protection east of Marshall Ave in a 10 year design storm.

The capacity of the 525 mm Broadway sewer (west end) is 160 L/s. Peak flows are approximately 230 L/s. The 300 mm Broadway trunk sewer (east end) has a limiting capacity of 55 L/s but experiences a peak wet weather flow 145 L/s in a 10 year design storm. Excessive flows are contributing to surcharging of the entire Broadway trunk. Further, the capacity restrictions in the Broadway area are additionally limited by the levels in the Region's Interceptor sewer, which cause backflow influenced by the broader system flows and operations of the WWTP.

The Broadway trunk surcharges due to two factors:

1. Influence of backflow from the Region's Interceptor sewer, which causes the HGL to exceed pipe obvert and limits the ability of the Broadway area to outlet flows
2. The eastern 300 mm section of the sewer is undersized. This exacerbates the HGL in the local sewers and contributes to basement flooding conditions

The local shallow sewers are also subject to high flows from I&I and surcharging from the undersized Broadway trunk infrastructure. The homes with the highest reported basement flooding are on St George Street, which corresponds to where sewers are the shallowest.

The Broadway wastewater system performance in a 10 year design storm is shown in **Figure 1**. The Broadway trunk HGL profile is shown in **Figure 2**, this including future flows.

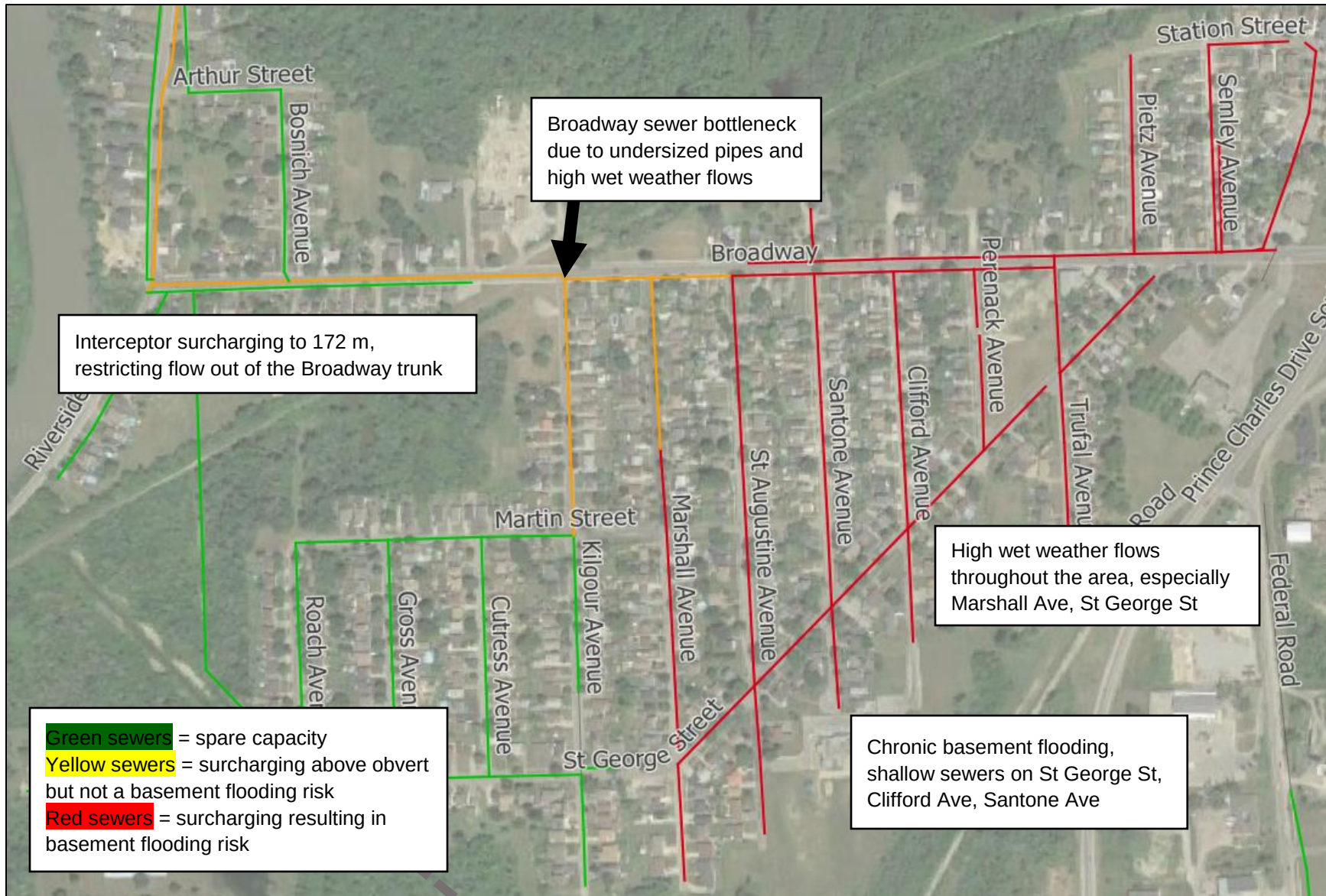


Figure 1. Broadway Sewer System Performance in a 10 year storm

HGL Profile with Maximum Data of Links 19000876,19000162,...,289009653

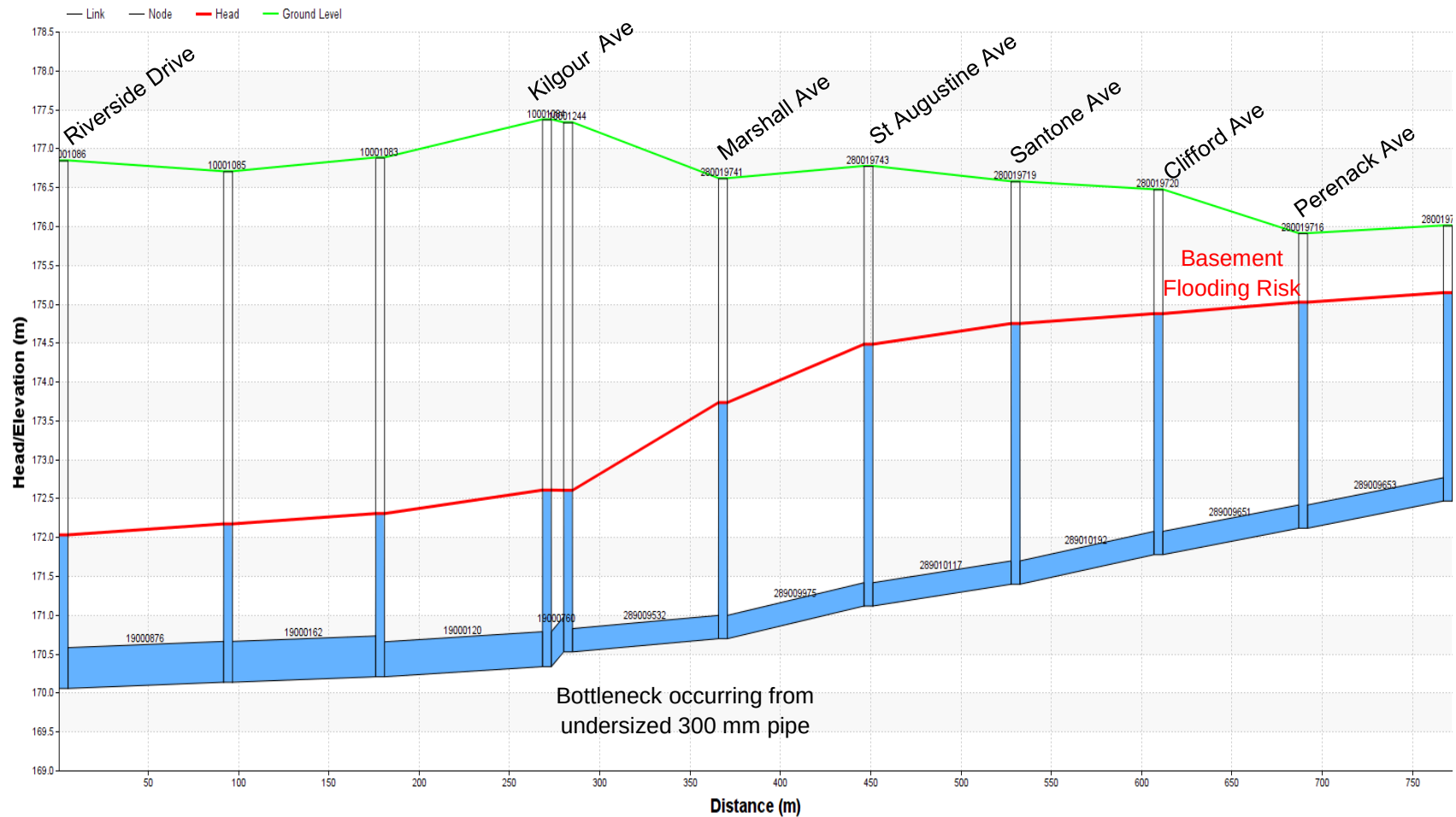


Figure 2. Broadway Trunk Sewer HGL - in a 10 year design storm. Profile showing Riverside Drive to Perenack Ave

3 ALTERNATIVE EVALUATION

3.1 Alternatives

Through the PPCP, the following alternatives for the Broadway area were considered:

The alternatives for Broadway were:

1. **Do nothing:** Leave the Broadway area as it is now.
2. **I&I Reduction:** Private side I&I investigation study and remediation program.
3. **Oversizing and Deepening of Broadway Trunk:** Increasing the size of the Broadway trunk to 600 mm and deepen the City-owned section.
4. **Upsizing/Reconfiguration Local Sewers:** Upgrade and deepen local sewers and deepen sewers.
5. **Storage:** Inline storage using the Broadway trunk upgraded size to 1000 mm.
6. **Combination:** Options 2, 3, 4 together.

3.2 Evaluation Approach

The alternatives were assessed on achieving PPCP technical objectives:

- **Maintaining or improving wastewater level of service:** Reduce the number of pipes that pose the risk of basement flooding in a 10 year storm.
- **Reduce inflow and infiltration:** Remove excess I&I from the wastewater system to meet the objectives of the F-5-5 Procedure.
- **Reduce combined sewer overflow impacts:** Reduce downstream CSO occurrences and spill volumes to meet the F-5-5 Procedure objectives for a PPCP.
- **Facilitate growth:** Ensure all growth can be accommodated with the alternative, while maintaining or improving the LOS.

The individual evaluation of each alternative's ability to meet the criteria was completed using the following ranking approach:

- "High" Solution generates beneficial impacts and/or has no substantial technical challenges (Red)
- "Medium" Solution to a mix of positive and negative elements with some impacts (Yellow)
- "Low" Solution presents permanent negative impacts and/or presents significant technical challenges (Green)

3.3 Evaluation

The alternatives were carefully reviewed, and the hydraulic model was used to confirm the level of service (protection from basement flooding in a 10 year storm). The evaluation matrix is shown in **Table 1**.

1. **Do Nothing:** Doing nothing is not a viable option due to the high occurrence of basement flooding in the area.
2. **I&I Reduction:** The I&I in this area is excessive and even a 50% reduction will not fully address basement flooding issues due to the shallow sewers, undersized Broadway trunk and influence from the interceptor. It would be very challenging to achieve 50% I&I reduction through private side I&I reduction alone. Public side I&I measures would begin

with a field investigation following up from high flows found from flow monitoring. The rehabilitation projects would be determined after the field investigation. Lining the local pipes would further reduce the diameter and not facilitate the growth expected in the area.

3. **Oversize Broadway Trunk:** Oversizing the trunk will alleviate some basement flooding risks by lowering the HGL and providing some buffer storage from the interceptor backflows. This alternative is not likely to reduce a significant amount of I&I, which is a major objective of the PPCP implementation plan. Further, the upsizing of the Broadway trunk may or may not reduce downstream CSOs.
4. **Local Sewer Reconfiguration:** Deepening and upsizing the local sewers will alleviate some basement flooding risks by lowering the HGL and increasing local capacity for wet weather and growth. This option must be completed with Alternative #2, deepening the Broadway trunk will facilitate deepening local sewers. This alternative may reduce some I&I through replacing leaky pipes in poor condition. This alternative will not likely reduce downstream CSOs as flows.
5. **Storage:** Extensive oversizing of the Broadway Trunk to 1000 mm provides similar pros and cons as Alternative #3, but it is more expensive.
6. **Combination 2,3,4:** Deepening and upsizing the local and Broadway sewers will provide the most protection against localized sewer surcharging and interceptor backflows. Public and private I&I in combination with the local sewer upgrades may present opportunities to ensure weeping tile foundation drains are connected to the storm sewer. Reducing I&I by 25% while improving the infrastructure satisfies the most technical objectives, to the fullest extent.

Table 1. Alternative Evaluation Matrix

Alternative	Maintain or Improve LOS	Reduce I&I	Reduce CSO Impacts	Facilitate Growth
Do Nothing				
I&I Reduction				
Sewer Upgrade - Oversize Broadway Trunk				
Local Sewer Reconfiguration				
2800 m ³ Storage				
Combination: I&I Reduction Oversized Trunk 1500 m Sewer Reconfiguration				

4 PREFERRED ALTERNATIVE

Based on the evaluation, the preferred alternative was a combination of alternatives as shown in **Figure 3** and outlined below:

- Deepening and upsizing the trunk sewer on Broadway to address trunk capacity restrictions and to provide the area with additional storage/protection from the interceptor surcharging/backflow
- Local sewer reconfiguration and deepening to accommodate existing peak flow and growth capacity needs, while also providing sufficient freeboard to achieve the 2.4 m freeboard level to service objective
- Implementation of a local I&I reduction plan to address the high wet weather flows and to provide additional growth capacity and basement flooding protection. Sewer Replacements

Table 2 summarizes the recommended sewer upgrades. The sewer replacement of the Broadway trunk and several local sewers are required to facilitate the deepening of the St. George sewers. Further, the system reconfiguration provides an opportunity to eliminate flow splits on St George.

Table 2. Sewer Replacement Costs

Street	Length (m)	Size (mm)
Marshall Ave	500	300
Clifford	400	300
Santone Ave	465	300
Perenack Ave	200	300
St George	450	300
Broadway Trunk (City owned)	500	600
<i>Broadway Trunk (Region owned)</i>	<i>500</i>	<i>600</i>
Total length to be deepened/upsized	3015	

The local sewers were sized conservatively to accommodate growth, assuming the possibility of limited I&I reduction achieved from sewer replacement.

The simplification of the west end of the Broadway trunk/corridor will require coordination with the Region with respect to ownership implications for the Feeder Road forcemain connection.

4.1 I&I Reduction

It is recommended that the I&I reduction program be implemented with a minimum target objective of reducing peak 10 year I&I flows by 25%, approximately 50 L/s peak flow removal in the entire Broadway area.

Based on the results from flow monitoring, the worst inflows are south of Broadway and east of (and including) Marshall Ave; which aligns with local sewer improvement areas. As such, the first phase of the I&I reduction program would consist of works within the public right of way that can be completed concurrently with sanitary sewer construction. Phase 1 works would include:

- Comprehensive stormwater cross-connection investigation, including confirmation of private storm service cross-connections, and removals. The cross connection investigation would consist of smoke and dye testing.

- Improvement of roadway drainage and sewer manhole placement to eliminate surface water runoff into the sanitary system.
- Replacement of sewers, manholes, and service tees to reduce sources of groundwater infiltration.

Phase 2 would consist of a private side I&I reduction plan, for the target area of approximately 280 homes including potential:

- Downspout and foundation drain disconnection, and sump pump installation
- Service lateral replacement and service check valve installation

There may be opportunities to combine and coordinate Stage 1 and Stage 2 works.

Phase 3, if required would consist of private side I&I reduction plan for the remaining Broadway Trunk sewer area.



Figure 3. Preferred Solution

4.2 Program Cost

The total cost for the preferred solution is \$7.8 M; \$6.4 M for the sewer replacements and \$1.4 M for the I&I field study. A summary of the program costing is provided in **Table 4**; detailed unit costs for sewer replacements are summarized in **Appendix B**. A 40% engineering and contingency cost is included in the sewer replacement estimation.

Storm lateral replacement to property line was conservatively estimated to be \$3,500 per home in the Phase 2 target area.

The I&I reduction program uses an estimate of \$5,000 per home in the target area. This cost includes public and private field investigation, educational/promotional material development, homeowner engagement, and disconnection of private connections. The \$5,000 is an average cost as many homeowners will not choose to participate.

The City may evaluate the entire corridor for improvements, however the costing currently only includes wastewater works, assuming a 2 m trench.

Table 3. Broadway Priority Area Implementation Plan Costs

Plan Component	Description	Estimated Cost
Oversize and deepen Broadway Trunk	Upgrade the Region sewers to 600 mm Deepen and upgrade the City sewer to 600 mm	\$2,265,000 City <u>\$2,265,000 Region</u> \$4,530,000 Total
Reconfigure Local Sewers	Marshall Ave, Clifford Ave, Santone, Perenack, St George	\$1,840,000
I&I Reduction (Phase 2 Only)	Focus on south east of Broadway and Marshall Ave, 280 homes @\$5,000 per home	\$1,400,000
Storm Laterals	Homes west of Marshall Ave, south of Broadway will have storm laterals installed to property line, \$3,500 per home. 280 homes with 40% engineering and contingency	\$1,372,000
Total		\$9,142,000

4.3 Implementation Plan

Development cannot proceed in the Broadway area until the sewers have been replaced and the beneficial impact flow monitoring has confirmed capacity in the new system (see section 4.4.1). The phased implementation is shown in detail in **Table 3** and the phasing areas are shown in **Figure 4**.

The prioritized list of projects for the Broadway Area are as follows:

1. Deepen and upgrade the Broadway trunk sewer
2. Reconfigure and deepen the Marshall Ave, Clifford Ave, Santone, Perenack, St George St sewers.
3. Public I&I Program targeted in distinct areas
4. Private Side I&I, if wet weather flow reduction targets are not by 1-3.

These projects are further described below and in Table 3.

Stage 1 works of the Broadway Priority Area Wastewater Improvement program would include:

- Comprehensive stormwater cross-connection investigation, including confirmation of private storm service cross-connections, and removals.
- Improvement of roadway drainage and sewer manhole placement to eliminate surface water runoff into the sanitary system.
- Replacement of sewers, manholes, and service tees to reduce sources of groundwater infiltration.

Beneficial impact flow monitors should be installed on the Broadway trunk immediately after replacement to be the assessment of new flows and to measure the impact of public and private I&I works.

Stage 2 would focus on the investigation and rehabilitation (if needed) of the St Augustine sewer. The 375 mm is sized adequately for the current and future flows, however rehabilitation of the sewer may reduce I&I.

Stage 3 would consist of a private side I&I reduction plan, for the target area (shown in green) of approximately 280 homes including potential:

- Downspout and foundation drain disconnection,
- Service lateral replacement and service check valve installation

If the targeted 25% I&I removal is not achieved through the planned target area of Stage 1-3, the City should proceed with Stages 4 and 5.

Stage 4 would expand the public I&I program to the areas west of Kilgour and north of Broadway, with a focus on sewer and manhole rehabilitation, and storm cross connection investigations/disconnections.

Stage 5 would expand the private side I&I program to the same areas as Stage 4.

Table 3 shows the proposed phasing of improvement activities.

Table 4. Implementation Plan Phasing

Timing	Sewer Replacement	Public I&I	Private I&I
Stage 1 Target Area Sewer Replacement and Public I&I Program	Detailed design and replacement of sewers	- Comprehensive stormwater cross-connection investigation, including confirmation of private storm service cross-connections. - Improvement of roadway drainage and sewer manhole placement to eliminate surface water runoff into the sanitary system. - Replacement of sewers, manholes, and capping service tees to reduce sources of groundwater infiltration. - Identify and isolate known abandoned and inactive service laterals. - Service lateral replacement to property line	- Promotion/public outreach and education and installation of check valves - Promote service lateral replacement on property
Stage 2 St. Augustine Inspection and Sewer Rehabilitation	Establish semi permanent flow monitoring network to measure the beneficial impact sewer replacement	Implement a sewer and manhole rehabilitation and replacement program.	
Stage 3 Target Area Private I&I Program			Private side I&I reduction plan, for the target area of approximately 280 homes including potential: - Downspout and foundation drain disconnection, - Service lateral replacement

Stage 4 Public Sewer Rehabilitation Program		For remaining Broadway Area: • Implement a sewer and manhole rehabilitation and replacement program for other sewers in the Broadway area that were not identified for replacement.	
Stage 5 Private I&I Program			For remaining Broadway Area: Private side I&I reduction plan, for the target area of approximately 280 homes including potential: • Downspout and foundation drain disconnection, • Service lateral replacement

Further details on the implementation of the private side I&I program are found in **Appendix B**.

4.3.1 Beneficial Impact Assessment

Flow monitoring pre and post area improvements will confirm the effectiveness of the implemented solution. Three (3) flow monitoring locations are recommended to confirm the I&I reduction and HGL.

1. Broadway 300
2. Broadway North
3. Interceptor or new location at Riverside and Broadway

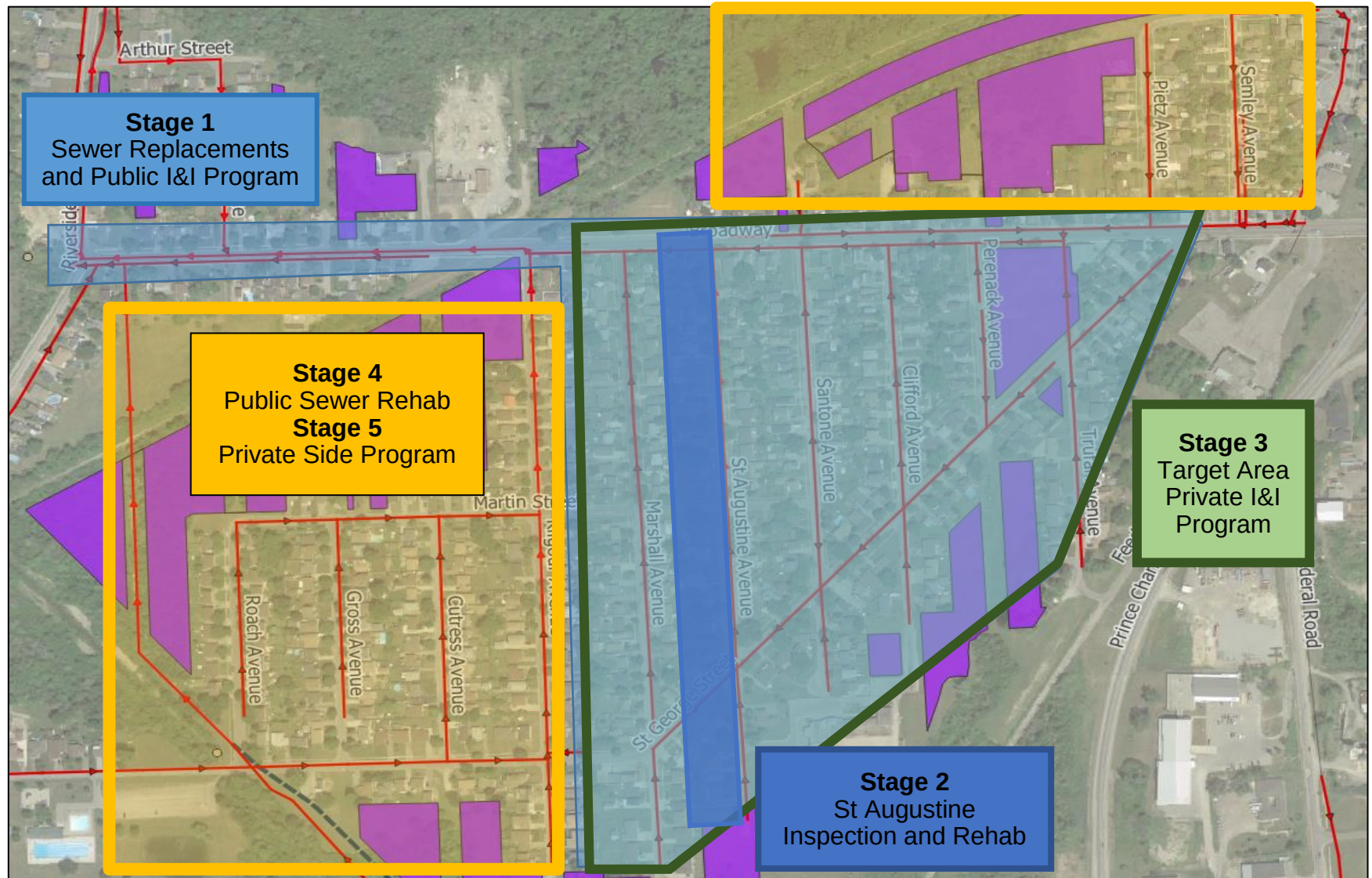


Figure 4. Implementation Plan Phasing

APPENDIX A – FLOW MONITORING DATA AND ANALYSIS

The 9 flow monitors were in place from July to December 2019. The monitor locations and corresponding catchments are shown in Figure A1. below. The catchment areas are listed in Table A1 below.

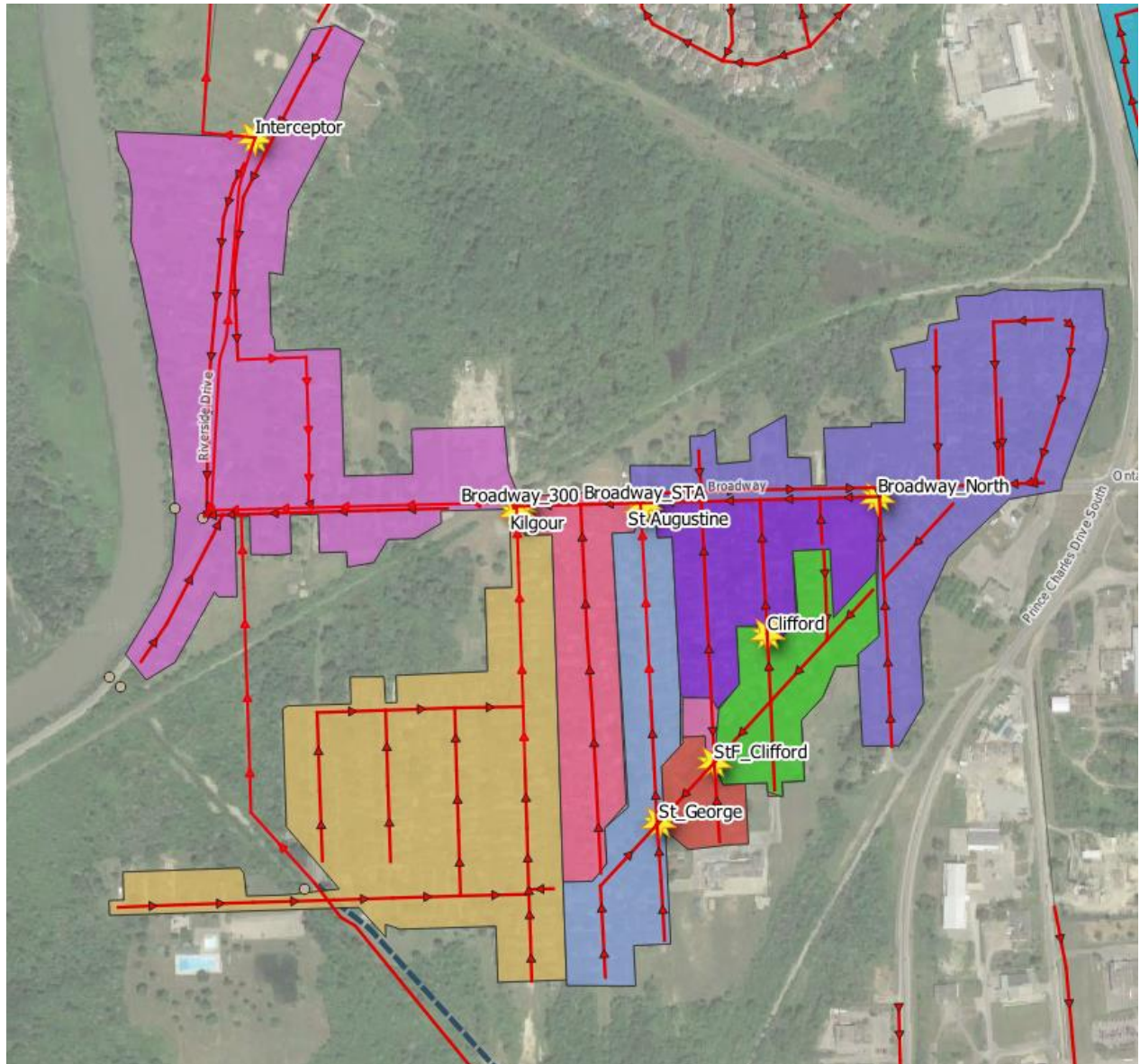


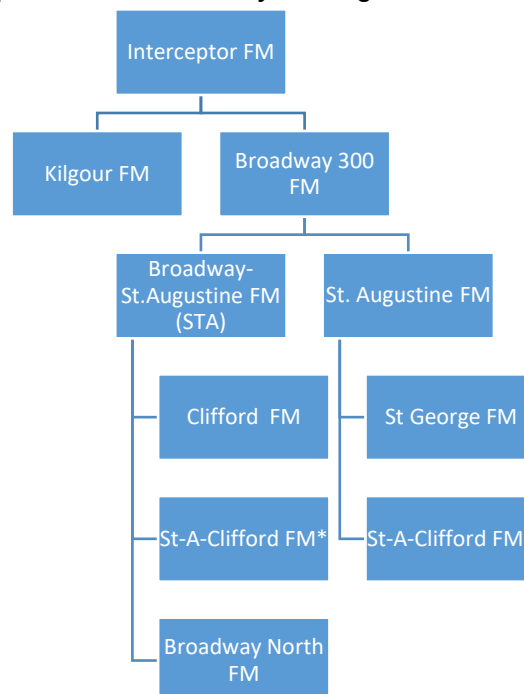
Figure A1. 2019 Flow Monitoring Catchments

*NB: STA-Clifford and Clifford have potentially overlapping catchments as there is a flow split at St George and was indeterminate which direction the flows go.

TableA1. Flow Monitoring Catchment Areas

FM	Catchment Area (ha)
Interceptor	17.33
Kilgour	15.16
Broadway 300	4.64
Broadway StA	4.91
St Augustine	5.35
STA Clifford	3.51
St George	1.31
Clifford	3.62
Broadway North	12.4

The flow monitors are represented in the hierarchy below, with the Interceptor FM being the most downstream. The St-Augustine -Clifford FM had some flow splits, which made it difficult to determine if the catchment is upstream of Broadway-St-Augustine or the St Augustine FM.



FigureA2. Flow Monitoring Hierarchy

Although there were 9 flow monitors, some had similar flow characteristics so fewer hydrographs were used in the model to represent the area. The model calibration followed the RTK method, which is an industry standard. R represents the percentage of rainfall that enters the wastewater system in a catchment. R1 represents fast inflow, R2 represents medium catchment response which could include inflow and infiltration, R3 represents slower infiltration response after rainfall. The catchments with the highest RDII are Broadway 300, St George and the Interceptor. The percentage of rainfall entering the wastewater system is approximately 33% over the whole Broadway area. The table below (area contributing to the bottleneck) shows the parameters used to calibrate the model.

Table 56. RTK Parameters - Catchment Rainfall Coefficients

Unit Hydrograph	Area (ha)	R1	R2	R3	Total CV
BROADWAY_INT	17.3	40%	8%	8%	56%
BROADWAY_300	3.2	60%	5%	5%	70%
BROADWAY_KILGOUR	15.2	17%	2%	0%	19%
BROADWAY_NORTH	12.4	10%	3%	1%	14%
BROADWAY_STA	5.4	20%	5%	5%	30%
BROADWAY_STG	1.3	40%	5%	5%	50%

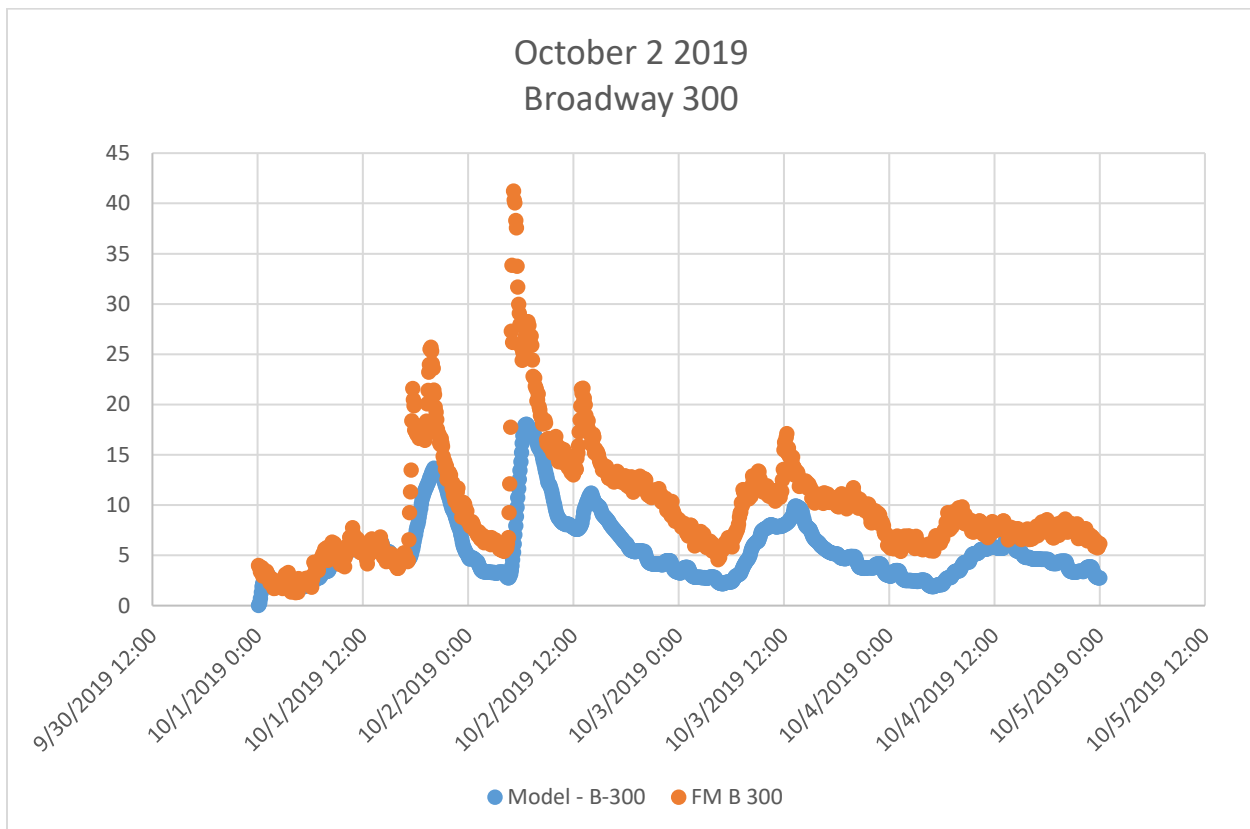
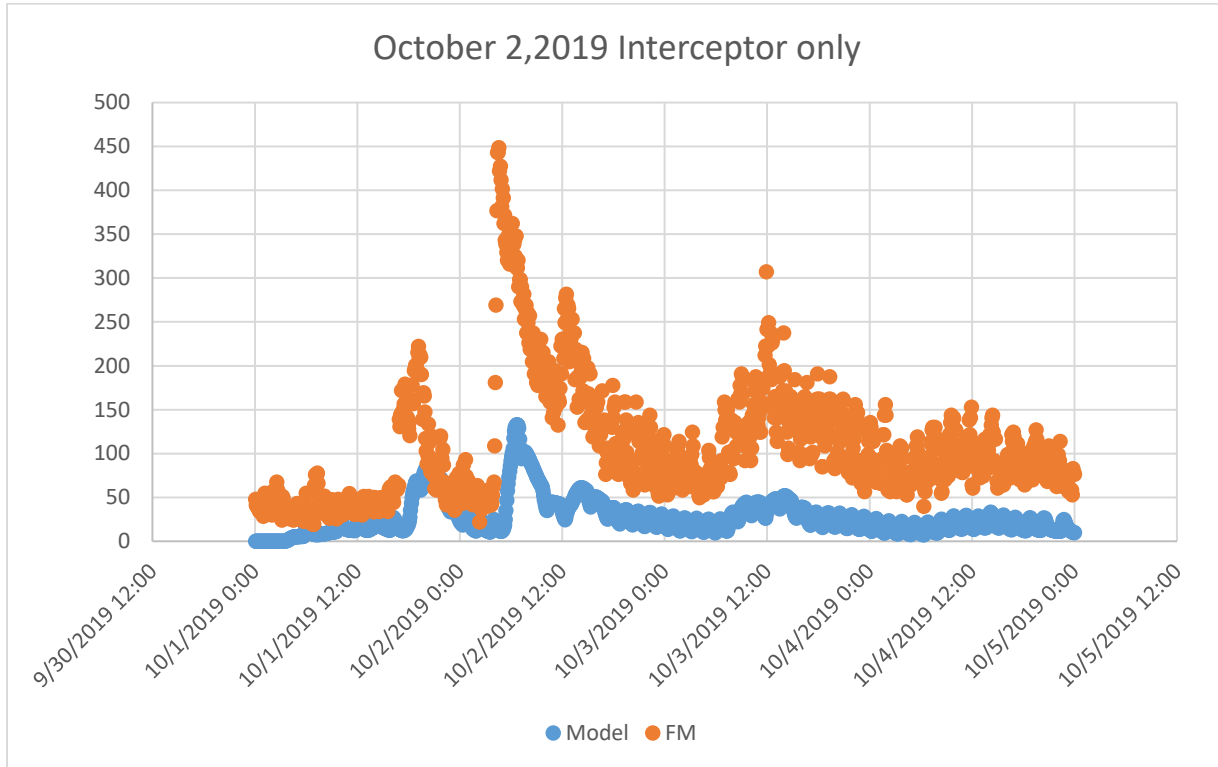
Flow Monitoring Calibration

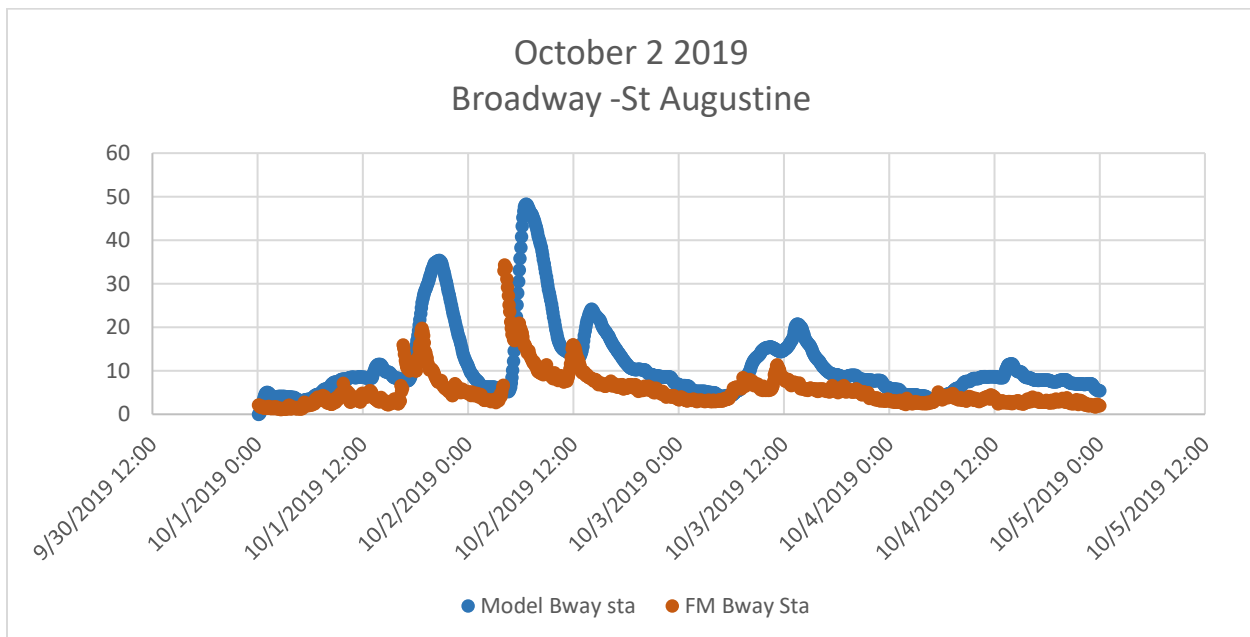
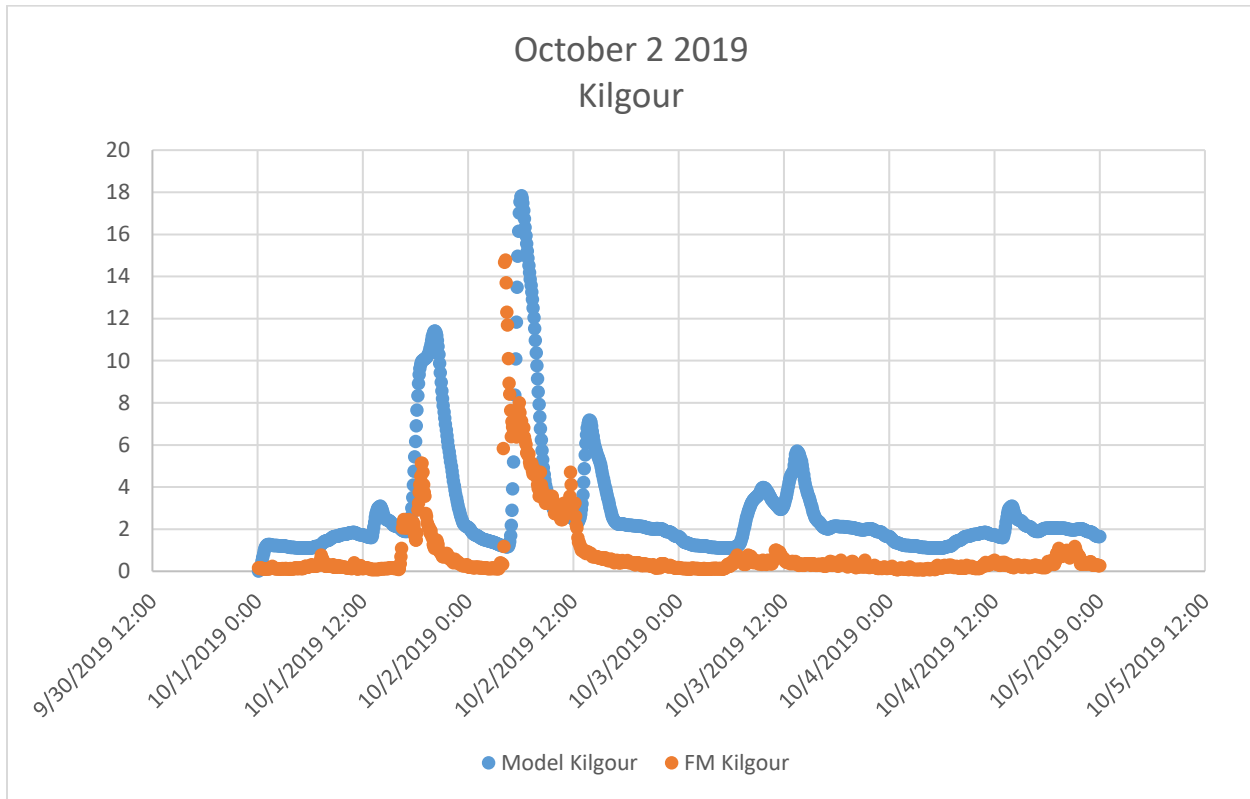
Overall, a conservative calibration was achieved to represent the wet weather flows. Events used for model calibration are listed in the table below. Note that the storms were all long duration events, this was due to the data at the Interceptor FM, which had very high interference from the backflow of the interceptor. Longer high-volume events were used due to better quality data at all monitor locations.

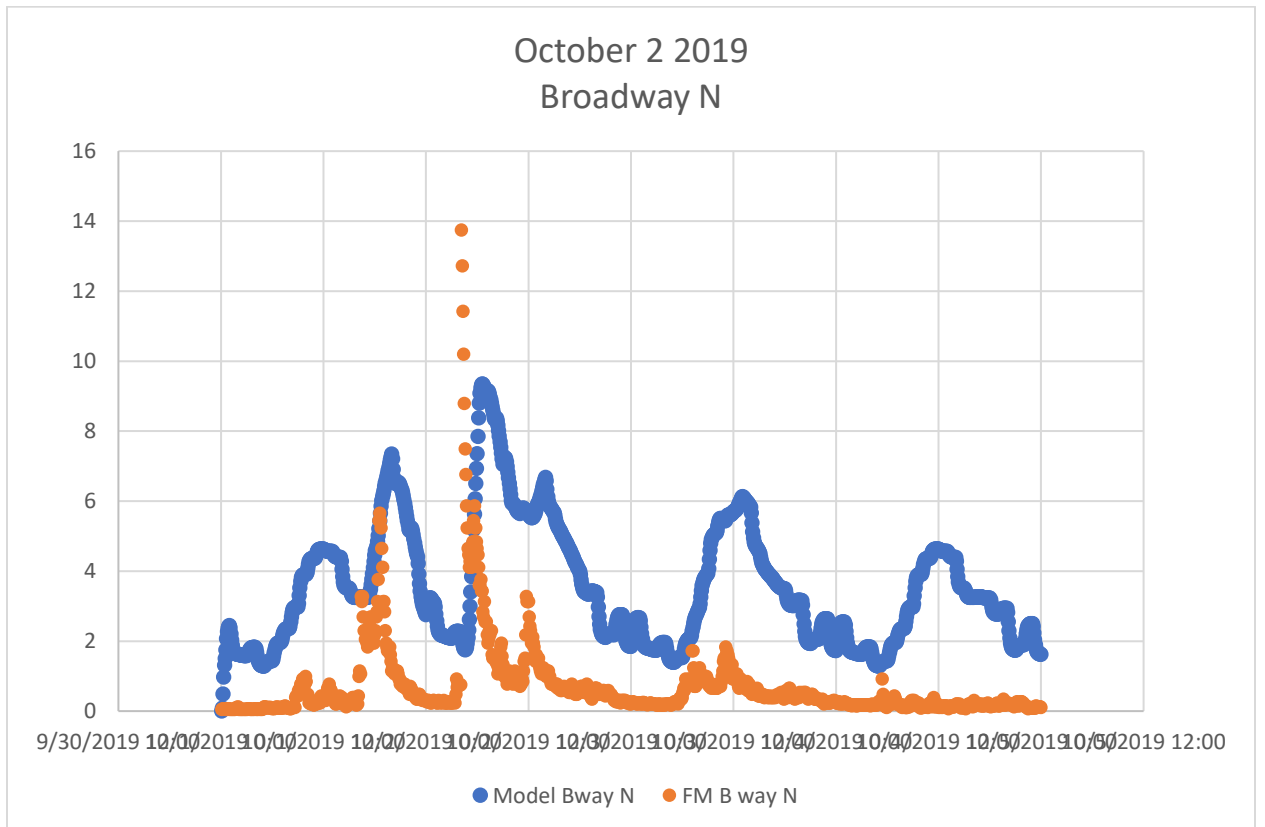
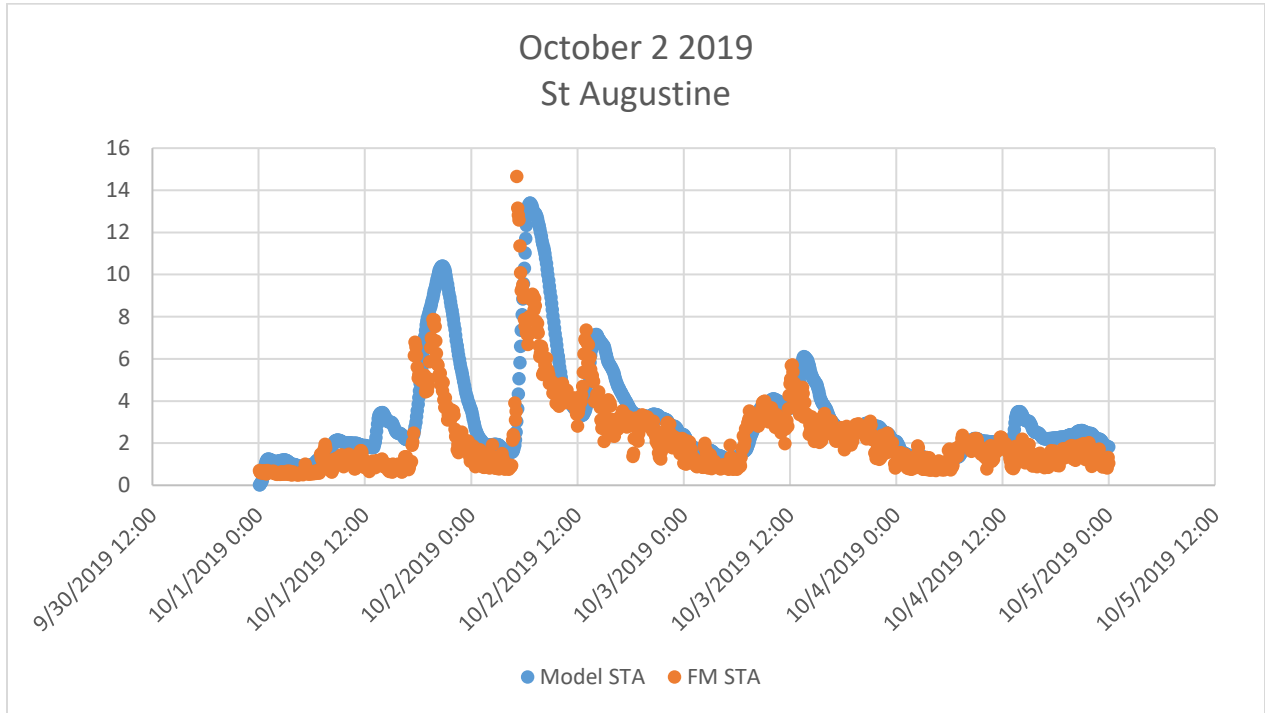
Table 67. Rainfall Events for Model Calibration

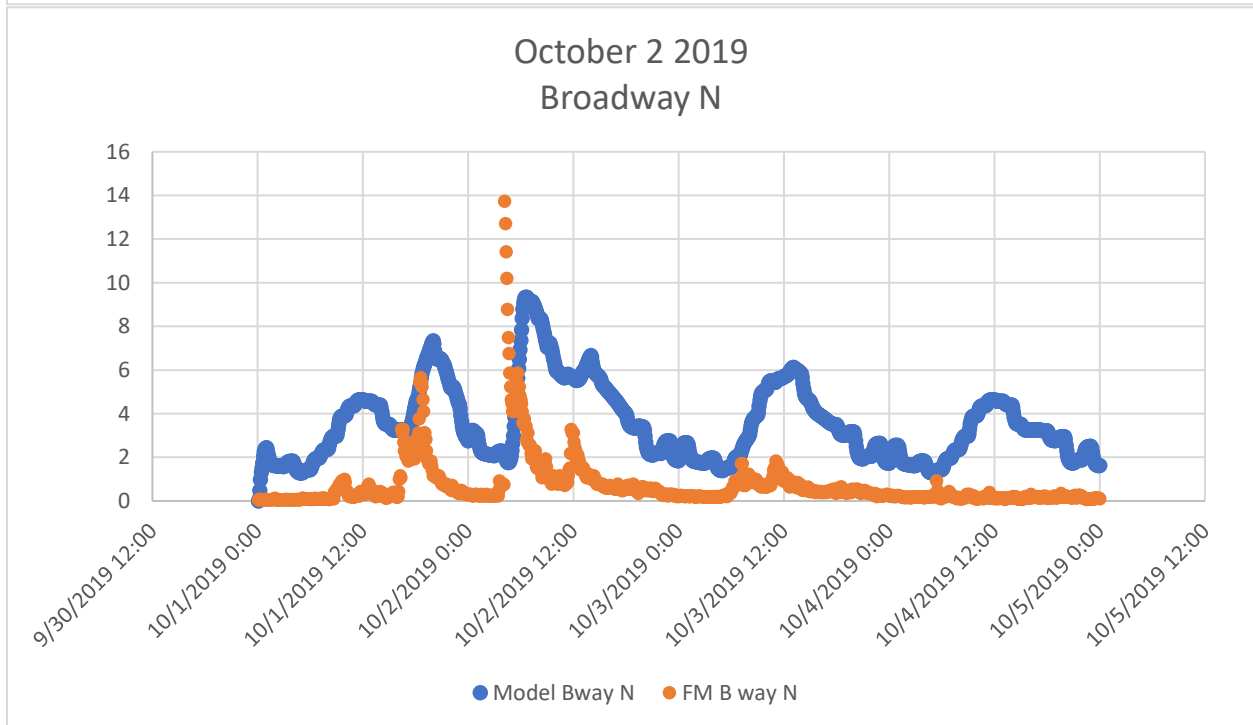
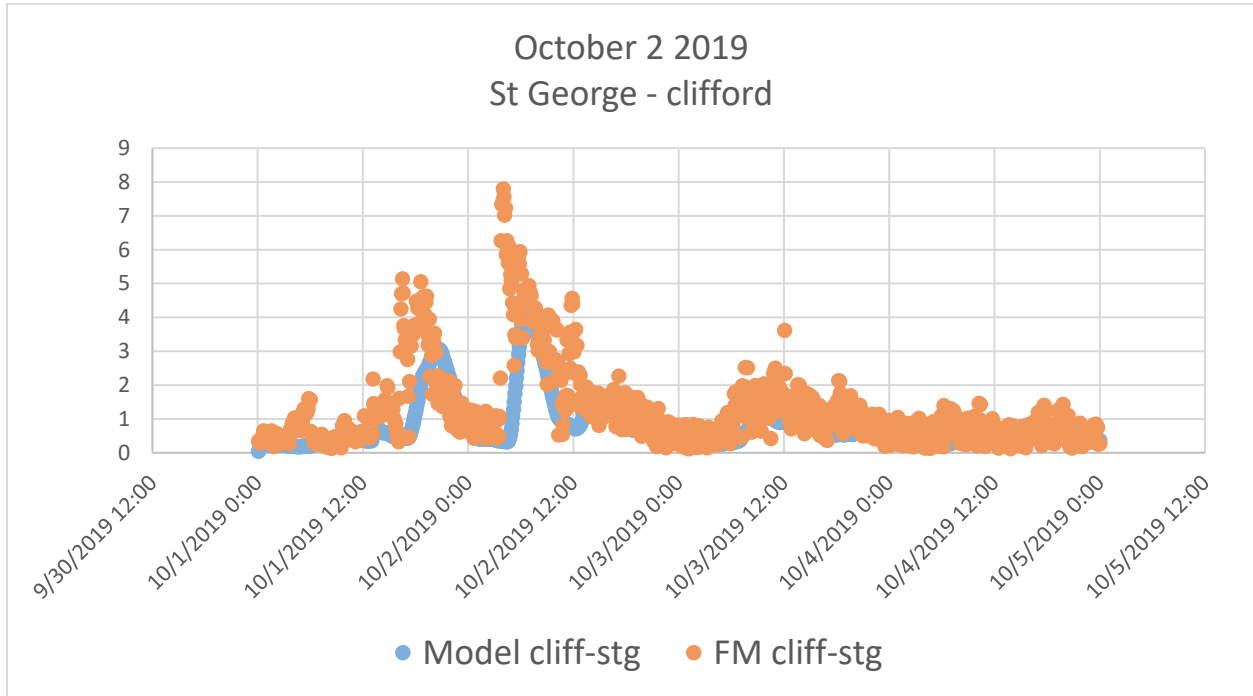
Start of Rain	End of Rain	Duration (hours)	Peak 1-hr (mm)	Total Depth (mm)
8/17/2019 7:45	8/19/2019 3:35	43.8	8.25	28.25
10/1/2019 16:50	10/3/2019 12:05	43.2	8.75	23.75
10/25/2019 18:10	10/27/2019 14:45	44.6	8.75	28.50

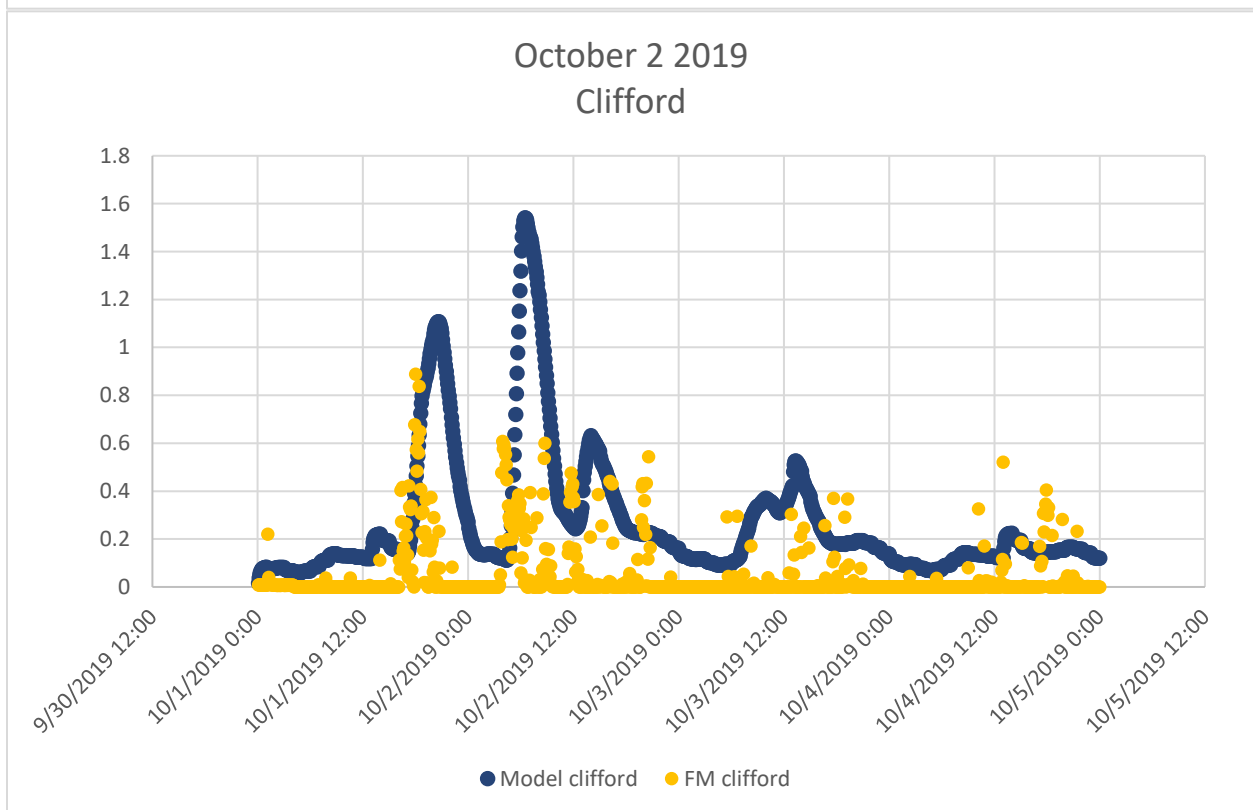
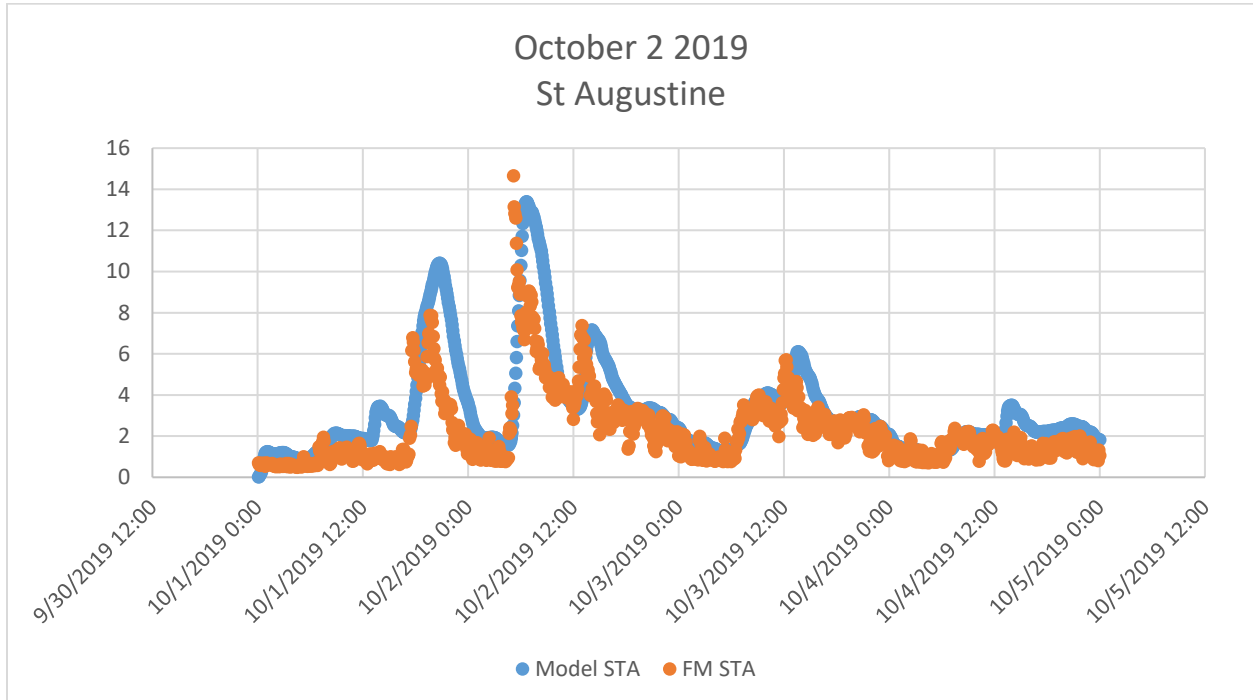
The model flows for the October 1-3 event at all locations are shown in the following 9 figures.

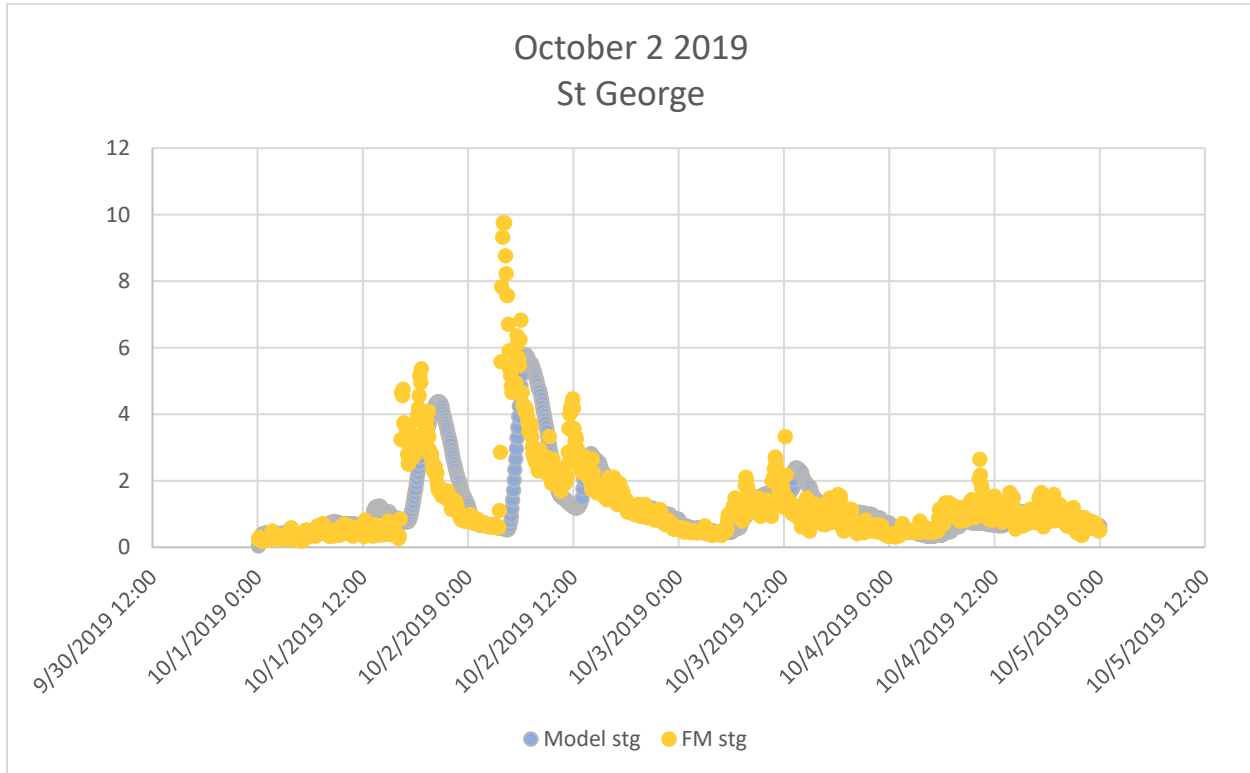














APPENDIX B – SEWER REPLACEMENT UNIT COSTING

Table 78. Unit Costs for Sewer Replacement (<5m depth)

Diameter	Outer Diameter	Depth to Invert	Min Trench Width	Excavation			Granular Bedding			Pipe				Backfill			Subtotal Unit Cost	Restoration (2012)	Restoration - Inflated from '12	Manhole Allowance	Total Unit Cost
				Volume	Cost	Unit Cost	Volume	Cost	Unit Cost	Supply Cost	Install (2012)	Install - Inflated from '12	Pipe Supply + Install	Vol	Cost	Unit Cost					
(mm)	(m)	(m)	(m)	(m³/m)	(\$/m³)	(\$/m)	(m³/m)	(\$/m³)	(\$/m)	(\$/m)		(\$/m)	(\$/m)	(m³/m)	(\$/m³)	(\$/m)	(\$/m)	(\$/m)	(\$/m)	(\$/m)	(2020 \$/m)
200	0.445	5	1.0	5.0	32	\$ 160	1.0	67	\$ 67	\$ 95	\$ 41	\$ 48	\$ 143	4.0	14	\$ 56	\$ 427	\$ 98	\$ 115	\$ 110	\$ 651
250	0.445	5	1.0	5.0	32	\$ 160	1.0	67	\$ 67	\$ 95	\$ 41	\$ 48	\$ 143	4.0	14	\$ 56	\$ 427	\$ 98	\$ 115	\$ 110	\$ 651
300	0.445	5	1.0	5.0	32	\$ 160	1.0	67	\$ 67	\$ 95	\$ 41	\$ 48	\$ 143	4.0	14	\$ 56	\$ 427	\$ 98	\$ 115	\$ 110	\$ 651
375	0.52	5	1.1	5.5	32	\$ 176	1.0	67	\$ 67	\$ 117	\$ 41	\$ 48	\$ 165	4.5	14	\$ 63	\$ 472	\$ 98	\$ 115	\$ 110	\$ 697
450	0.58	5	1.2	6.0	32	\$ 192	1.1	67	\$ 74	\$ 151	\$ 41	\$ 48	\$ 199	4.9	14	69	\$ 534	\$ 99	\$ 116	\$ 110	\$ 760
525	0.66	5	1.3	6.5	32	\$ 208	1.2	67	\$ 81	\$ 182	\$ 41	\$ 48	\$ 230	5.3	14	75	\$ 593	\$ 100	\$ 117	\$ 110	\$ 820
600	0.76	5	1.4	7.0	32	\$ 224	1.4	67	\$ 94	\$ 240	\$ 41	\$ 48	\$ 288	5.6	14	79	\$ 684	\$ 100	\$ 117	\$ 250	\$ 1,052
675	0.88	5	1.7	8.5	32	\$ 272	1.9	67	\$ 128	\$ 363	\$ 49	\$ 57	\$ 420	6.6	14	93	\$ 912	\$ 113	\$ 132	\$ 250	\$ 1,295
750	0.97	5	1.8	9.0	32	\$ 288	2.0	67	\$ 134	\$ 479	\$ 49	\$ 57	\$ 536	7.0	14	98	\$ 1,057	\$ 114	\$ 134	\$ 250	\$ 1,440
825	1.06	5	1.9	9.5	32	\$ 304	2.2	67	\$ 148	\$ 556	\$ 49	\$ 57	\$ 613	7.3	14	103	\$ 1,167	\$ 115	\$ 135	\$ 250	\$ 1,552
900	1.14	5	1.9	9.5	32	\$ 304	2.4	67	\$ 161	\$ 666	\$ 49	\$ 57	\$ 723	7.1	14	100	\$ 1,289	\$ 116	\$ 136	\$ 400	\$ 1,824
975	1.23	5	2.0	10.0	32	\$ 320	2.5	67	\$ 168	\$ 767	\$ 49	\$ 57	\$ 824	7.5	14	105	\$ 1,418	\$ 128	\$ 150	\$ 400	\$ 1,968
1050	1.32	5	2.3	11.5	32	\$ 368	3.1	67	\$ 208	\$ 878	\$ 49	\$ 57	\$ 935	8.4	14	118	\$ 1,629	\$ 129	\$ 151	\$ 400	\$ 2,181
1200	1.46	5	2.5	12.5	32	\$ 400	3.4	67	\$ 228	\$ 1,100	\$ 49	\$ 57	\$ 1,157	9.1	14	128	\$ 1,913	\$ 131	\$ 153	\$ 400	\$ 2,467
1350	1.67	5	2.7	13.5	32	\$ 432	3.9	67	\$ 262	\$ 1,413	\$ 55	\$ 64	\$ 1,477	9.6	14	135	\$ 2,306	\$ 133	\$ 156	\$ 333	\$ 2,795
1500	1.81	5	2.8	14.0	32	\$ 448	4.2	67	\$ 282	\$ 1,729	\$ 55	\$ 64	\$ 1,794	9.8	14	138	\$ 2,662	\$ 146	\$ 171	\$ 333	\$ 3,166
1800	2.16	5	3.2	16.0	32	\$ 512	5.1	67	\$ 343	\$ 2,504	\$ 55	\$ 64	\$ 2,568	10.9	14	153	\$ 3,576	\$ 150	\$ 176	\$ 333	\$ 4,085
2100	2.51	5	3.5	17.5	32	\$ 560	6.0	67	\$ 403	\$ 3,328	\$ 55	\$ 64	\$ 3,393	11.5	14	162	\$ 4,517	\$ 153	\$ 179	\$ 400	\$ 5,097
2400	2.88	5	3.9	19.5	32	\$ 624	7.0	67	\$ 470	\$ 4,427	\$ 55	\$ 64	\$ 4,491	12.5	14	176	\$ 5,761	\$ 157	\$ 184	\$ 400	\$ 6,345
3000	3.56	5	4.6	23.0	32	\$ 736	9.0	67	\$ 605	\$ 6,783	\$ 55	\$ 64	\$ 6,848	14.0	14	197	\$ 8,385	\$ 164	\$ 192	\$ 400	\$ 8,977

Table 89. Unit Costs for Sewer Replacement (>5m depth)

Diameter	Outer Diameter	Depth to Invert	Min Trench Width	Excavation			Granular Bedding			Pipe				Backfill			Subtotal Unit Cost	Restoration (2012)	Restoration - Inflated from '12	Manhole Allowance	Total Unit Cost
				Volume	Cost	Unit Cost	Volume	Cost	Unit Cost	Supply Cost	Install (2012)	Install - Inflated from '12	Pipe Supply + Install	Vol	Cost	Unit Cost					
(mm)	(m)	(m)	(m)	(m³/m)	(\$/m³)	(\$/m)	(m³/m)	(\$/m³)	(\$/m)	(\$/m)		(\$/m)	(\$/m)	(m³/m)	(\$/m³)	(\$/m)	(\$/m)	(\$/m)	(\$/m)	(\$/m)	(2020 \$/m)
300	0.445	10	1.0	35.0	\$ 45	\$ 1,575	1.0	67	\$ 67	\$ 95	\$ 41	\$ 48	\$ 143	34.0	14	478	\$ 2,263	\$ 180	\$ 211	\$ 200	\$ 2,674
375	0.52	10	1.1	36.0	\$ 45	\$ 1,620	1.0	67	\$ 67	\$ 117	\$ 41	\$ 48	\$ 165	35.0	14	492	\$ 2,345	\$ 180	\$ 211	\$ 200	\$ 2,756
450	0.58	10	1.2	37.0	\$ 45	\$ 1,665	1.1	67	\$ 74	\$ 151	\$ 41	\$ 48	\$ 199	35.9	14	505	\$ 2,443	\$ 185	\$ 217	\$ 200	\$ 2,860
525	0.66	10	1.3	38.0	\$ 45	\$ 1,710	1.2	67	\$ 81	\$ 182	\$ 41	\$ 48	\$ 230	36.8	14	517	\$ 2,538	\$ 185	\$ 217	\$ 200	\$ 2,955
600	0.76	10	1.4	39.0	\$ 45	\$ 1,755	1.4	67	\$ 94	\$ 240	\$ 41	\$ 48	\$ 288	37.6	14	529	\$ 2,665	\$ 187	\$ 219	\$ 350	\$ 3,234
675	0.88	10	1.7	42.0	\$ 45	\$ 1,890	1.9	67	\$ 128	\$ 363	\$ 49	\$ 57	\$ 420	40.1	14	564	\$ 3,001	\$ 189	\$ 221	\$ 350	\$ 3,573
750	0.97	10	1.8	43.0	\$ 45	\$ 1,935	2.0	67	\$ 134	\$ 479	\$ 49	\$ 57	\$ 536	41.0	14	576	\$ 3,182	\$ 192	\$ 225	\$ 350	\$ 3,757
825	1.06	10	1.9	44.0	\$ 45	\$ 1,980	2.2	67	\$ 148	\$ 556	\$ 49	\$ 57	\$ 613	41.8	14	588	\$ 3,328	\$ 199	\$ 233	\$ 350	\$ 3,912
900	1.14	10	1.9	44.0	\$ 45	\$ 1,980	2.4	67	\$ 161	\$ 666	\$ 49	\$ 57	\$ 723	41.6	14	585	\$ 3,450	\$ 201	\$ 236	\$ 600	\$ 4,285
975	1.23	10	2.0	45.0	\$ 45	\$ 2,025	2.5	67	\$ 168	\$ 767	\$ 49	\$ 57	\$ 824	42.5	14	598	\$ 3,615	\$ 203	\$ 238	\$ 600	\$ 4,453
1050	1.32	10	2.3	48.0	\$ 45	\$ 2,160	3.1	67	\$ 208	\$ 878	\$ 49	\$ 57	\$ 935	44.9	14	631	\$ 3,935	\$ 206	\$ 241	\$ 600	\$ 4,776
1200	1.46	10	2.5	50.0	\$ 45	\$ 2,250	3.4	67	\$ 228	\$ 1,100	\$ 49	\$ 57	\$ 1,157	46.6	14	655	\$ 4,291	\$ 208	\$ 244	\$ 600	\$ 5,134
1350	1.67	10	2.7	52.0	\$ 45	\$ 2,340	3.9	67	\$ 262	\$ 1,413	\$ 55	\$ 64	\$ 1,477	48.1	14	676	\$ 4,755	\$ 208	\$ 244	\$ 567	\$ 5,566
1500	1.81	10	2.8	53.0	\$ 45	\$ 2,385	4.2	67	\$ 282	\$ 1,729	\$ 55	\$ 64	\$ 1,794	48.8	14	686	\$ 5,147	\$ 208	\$ 244	\$ 567	\$ 5,957
1800	2.16	10	3.2	57.0	\$ 45	\$ 2,565	5.1	67	\$ 343	\$ 2,504	\$ 55	\$ 64	\$ 2,568	51.9	14	730	\$ 6,205	\$ 215	\$ 252	\$ 567	\$ 7,024
2100	2.51	10	3.5	60.0	\$ 45	\$ 2,700	6.0	67	\$ 403	\$ 3,328	\$ 55	\$ 64	\$ 3,393	54.0	14	759	\$ 7,255	\$ 227	\$ 266	\$ 733	\$ 8,254
2400	2.88	10	3.9	64.0	\$ 45	\$ 2,880	7.0	67	\$ 470	\$ 4,427	\$ 55	\$ 64	\$ 4,491	57.0	14	801	\$ 8,643	\$ 234	\$ 274	\$ 733	\$ 9,651
3000	3.56	10	4.6	71.0	\$ 45	\$ 3,195	9.0	67	\$ 605	\$ 6,783	\$ 55	\$ 64	\$ 6,848	62.0	14	872	\$ 11,519	\$ 252	\$ 295	\$ 733	\$ 12,548



Date:	January 15, 2021	File:	618057-002
To:	Marvin Ingebrigtsen		
From:	Julien Bell, P.Eng. , Elaine Samuel, P.Eng.		
Project:	City of Welland PPCP Extension		
Subject:	Ontario Road Pilot Priority Area		

TECHNICAL MEMO

The objective of this report is to provide an implementation plan for the Ontario Road priority area, which was identified in the Welland Pollution Prevention Control Plan and Master Servicing Plan Study (PPCP), the PPCP is to be completed by Fall 2020.

1 ONTARIO ROAD PRIORITY AREA

The Ontario Road catchment area is tributary to the Ontario Rd SPS, shown in **Figure 1**, and for the purposes of this report is split into two subcatchments: Lincoln-Empress subcatchment is situated north of Ontario Rd and the Commercial-Gordon subcatchment area is south of Ontario Rd. Each area has its unique issues and pressures; however, an effective and holistic solution may be viable when considering the catchment as a whole.

The entire catchment experiences extremely high wet weather inflows. Sources for these high flows include:

- Aging infrastructure of poor condition
- Suspected inflows entering through overflow sites (L-sites)
- Storm system cross connections

The Lincoln-Empress subcatchment encompasses the entirety of the Ontario Rd SPS catchment that is north of Ontario Rd. Sewer surcharging in this area is a result of high I&I and undersized sewers on Empress Ave and Sutherland Ave for the current wet weather flows. There are several in-system overflows in this area; notably the Coventry-Simpson (L1), Lincoln-Coventry (L2), and Lincoln Plaza (L3) overflows. In addition to sewer surcharging and basement flooding risk concerns, the Lincoln East area is a high priority for the City because the MECP has mandated that these overflows be decommissioned by 2022. Associated Engineering completed the MECP overflow monitoring and reporting for the L1-L3 overflows from 2014 to 2020. The MECP expects that a closure plan will be in place this summer (2020).

The Commercial-Gordon subcatchment faces growth pressures in the old Union Carbide (Page-Hersey) lands adding upwards of 8,000 people on 80 ha, aging local sewers, and the re-establishment of the Dain City forcemain capacity. These issues exacerbate existing high wet weather flows and basement flooding risks, particularly in the Commercial Street area. Additionally, the Dain City pump station (PS) will have its capacity reinstated with the completion of the forcemain realignment construction to be complete in 2021.

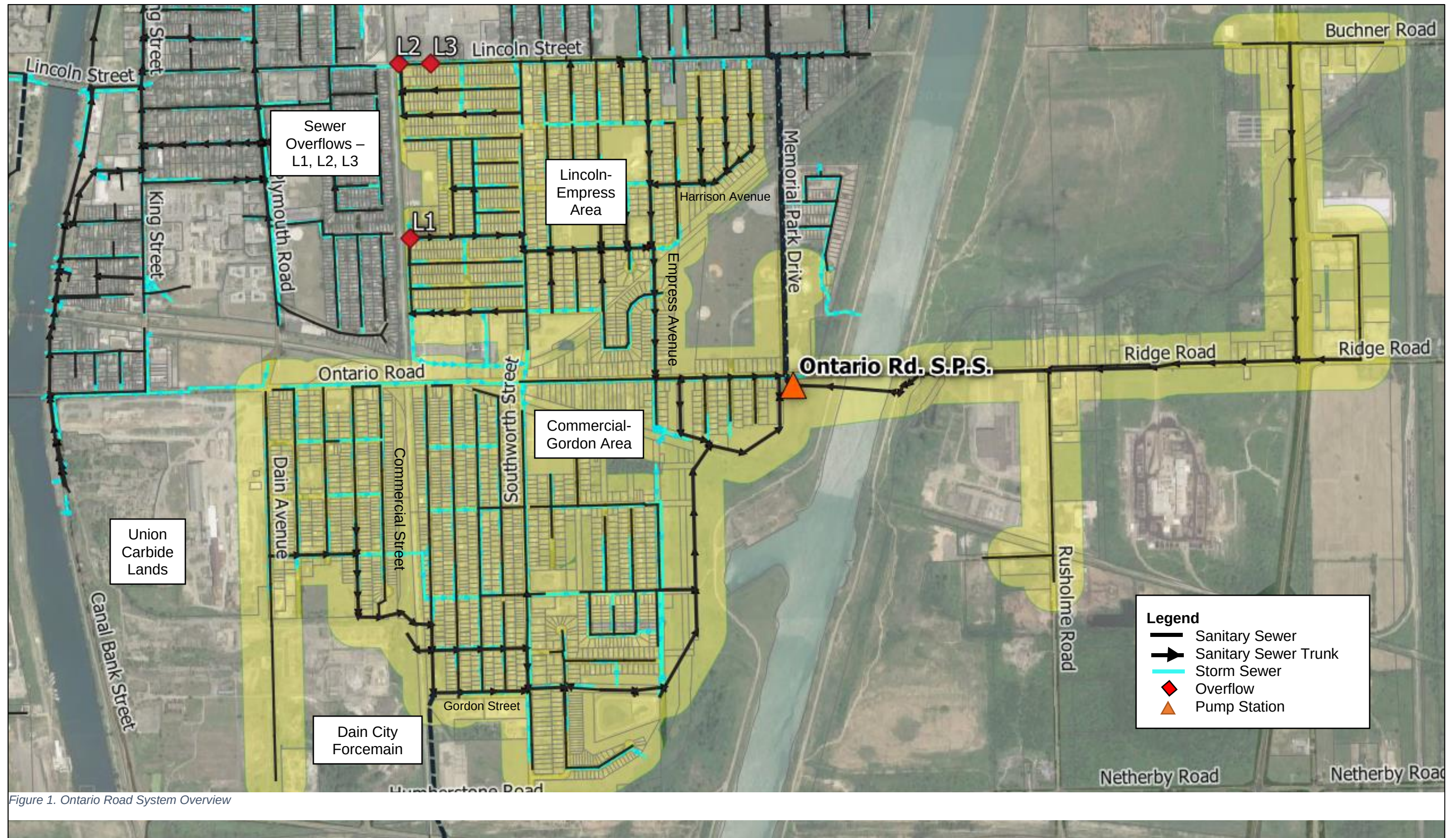


Figure 1. Ontario Road System Overview

1.1 Wastewater System Overview

The Ontario Rd priority area is serviced by the Ontario Rd sewage pumping station (SPS) which has an operational firm capacity of 600 L/s. The SPS pumps sewage to the 1200 mm Wellington trunk sewer and ultimately conveys flow by gravity to the Welland Wastewater Treatment Plant (WWTP).

In the Lincoln-Empress area, the historically combined sewer system was separated in the late 2000's. High wet weather remains an issue after separation, such that a temporary ECA for the L-site overflows was re-instated in 2007 to 2022. The area has local 200-300 mm sewers, and 375 mm collector sewers. The area is serviced by a 450 mm trunk from Empress Ave to the Ontario Rd SPS.

The Commercial-Gordon area south of Ontario Road is comprised of local 200 to 300 mm sewers which tie into the 600 mm trunk from Alberta St to Gordon St. The trunk is a 750 mm sewer from the west of Gordon St to Bradley Ave. East of Bradley, the trunk is 900 mm sewer to the Ontario Rd SPS. The sewers in the Dain Ave to Commercial Street neighbourhood were constructed in the 1950s and are approaching the end of their service life.

The eastern part of the catchment, east of the Welland Canal, is comprised of industrial lands.

The Dain City SPS is located upstream of the Ontario Rd PS and its forcemain currently connects to the west end of Gordon St. The Dain City forcemain will return the station's operational capacity of 115 L/s. In the future, the Region and City may consider increasing the station capacity to fully utilize the new forcemain capacity of 150 L/s to accommodate large growth plans in the Dain City catchment.

1.1.1 System Condition

The Lincoln-Empress area has sewers from the 1960s to 1980s with pockets of newer sewers from the 1990s. South of Ontario Road, most sewers date from the 1950s to the 1980s. The sewer ages are shown in **Figure 2**.

The neighbourhood from Dain Ave to Alberta Ave sewers were installed in the 1950s and are nearing the estimated service life. This neighborhood also has cast iron watermain; the City is looking to streamline replacement of watermain and sewers in this neighbourhood in the next 10 years. This area may benefit from servicing options to an Ontario Road trunk sewer.

The City has noted condition issues in the Gordon St sewer relating to H₂S corrosion from an upstream source, likely resulting from the Dain City forcemain and industrial sources west of Gordon.

Further, system blockages in the sections downstream from the Dain City forcemain may have blockages resulting from glycerine build up. Glycerine buildup is an ongoing maintenance issue in the Dain City system and Dain City SPS forcemain and may be present anywhere downstream in the Welland system. The trunk sewer from Gordon Street to the SPS, the pump station, and the forcemain should be inspected for potential glycerine blockages.

1.2 Storm System

The Ontario Road area is served by several existing storm sewer networks which outlet to the Welland Canal and the Welland River. Storm sewers are shown in **Figure 1** in light blue.

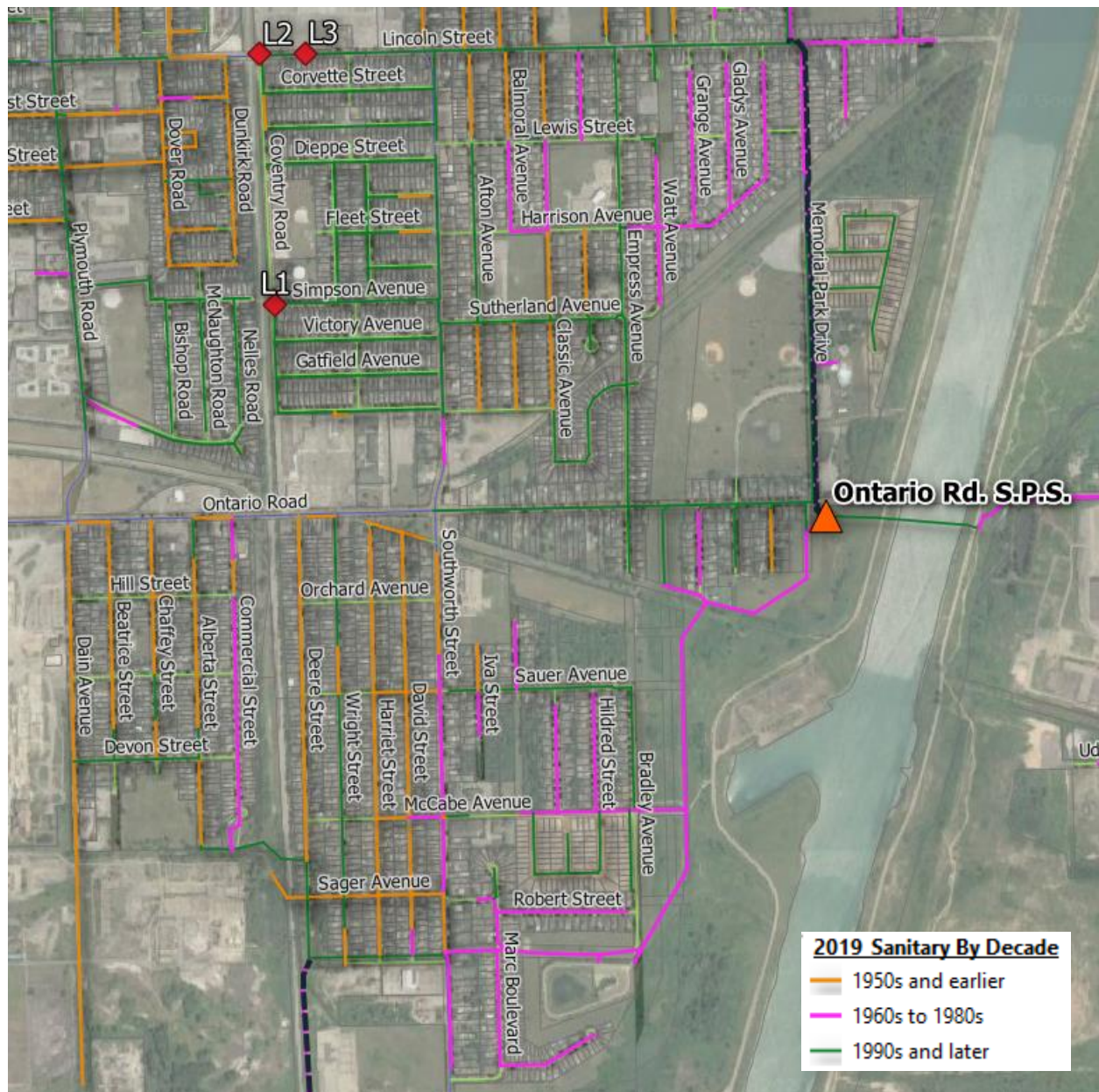


Figure 2. Sanitary System Age

1.3 Growth

Growth in the Ontario Road area consists of the infilling of remaining existing vacant lands, the redevelopment of existing growth lands, and draft plans for the Page-Hersey site.

1.3.1 Draft Plan

Within the Ontario Rd catchment, a major development is expected in the former Page-Hersey lands, bounded by Ontario Rd to the north, Canal Bank St to the west, Dain Ave to the east, and Humberstone Rd to the south. Estimates on this property range from 6,900 people to 8,000 people

on 80 ha. Original servicing concepts assumed a portion of the development would be serviced to the north, reaching the WWTP by gravity via the Canal Bank St sewer. However, discussions with the City and Kerry T Howe Engineering, this servicing strategy was deemed unviable. Two new strategies were developed in May 2020. They are:

1. Tie in to existing 750 mm Gordon Street sewer
2. Ontario Road trunk sewer (new sewer)

A sensitivity analysis will be used to determine the triggers and consequences of the new development. The two design alternatives will be modelled with future scenarios to determine trunk sizes and determine optimal servicing allocation of the Page-Hersey property.

1.3.2 Dain City Developments

Substantial growth is also expected in the Dain City catchment. Draft plans reviewed for the PPCP and Empire Homes Review (Jan 2020) estimated residential populations of 2,800 people. To accommodate future buildout of these draft plans, it is possible that the Dain City SPS forcemain may contribute upwards of 150 L/s at buildout to the 750 mm Gordon Street sewer.

Growth areas are shown in purple in **Figure 3**.

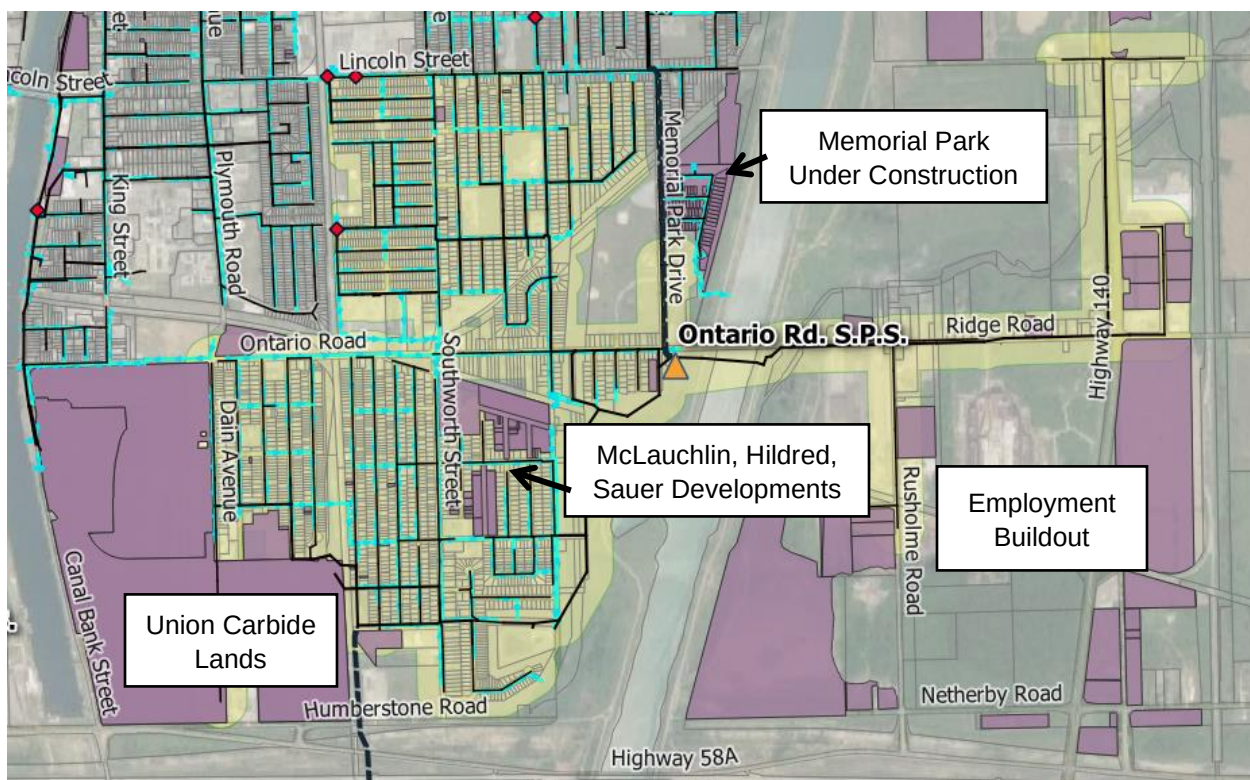


Figure 3. Growth areas

2 WASTEWATER SYSTEM PERFORMANCE

2.1 Level of Service and Performance Criteria

Following the recommendations of the 2020 PPCP study, the wastewater system target level of service is to ensure the hydraulic grade line (HGL) does not exceed 2.4 m below ground level in the 10 year storm. This depth requirement is in place to protect basements from flooding from sewer system surcharging.

2.2 Data Collection and Model Update

Flow monitoring data from 2019 was used to complete a model calibration update for the Lincoln East area, north of Ontario Road. Five monitors were used to calibrate the area and conservative results were achieved at all locations. Flow monitoring showed extremely high wet weather flows compared to dry weather flows and design wet weather allowances. Catchment wet weather exceeds the 0.286 L/s/ha design allowance; observed storms without the Harrison inflows have exceeded 1.7 L/s/ha, which is 6 times the allowance. The 2019 Harrison flow monitor is shown in **Figure 4**.

Further details about flow monitoring and model calibration can be found in **Appendix A**.

2.2.1 Harrison Empress Flow Monitor

Extremely high inflows of approximately 500 to 600 L/s were observed twice in the monitoring period, on September 2, 2019 and October 26, 2019 for a duration of 2h20 min and 45 min; and coincide with the observed overflows at the Lincoln Temporary Overflows (L-sites). These peak flows appear to be like a step function, once a certain depth and intensity of storm are surpassed, occurring during larger high intensity events, where one hour intensity of the storm is greater than 10 mm/h and the storm depth exceeds 30 mm. Further these peak 500 to 600 L/s inflows appear to start and stop very suddenly, indicating that they are likely the result of stormwater system overflow into the wastewater sewer.

Additional analysis was completed in an attempt to validate the likelihood of the stormwater system inflow. It was found that without the inclusion of these 500 to 600 L/s inflows, the model was unable to replicate the observed L-site overflows; however, the inclusion of the inflows did trigger overflows at all 3 L-sites on both dates, which correlated with the observed overflow instances. Given the repeat observation of the inflows and the corresponding modelling analysis; there is a strong likelihood that there is indeed a stormwater system overflow in the Harrison Empress area contributing 500 to 600 L/s inflows during larger storm events.



Figure 4. Harrison Flow Monitor and Catchment

For the purposes of system analysis, existing condition scenarios were modified to include a 600 L/s at the upstream manhole from the Harrison Empress FM, when the design storm's intensity exceeds 10 mm/h.

2.2.2 Further Flow Monitoring Required

Due to the potential identification of a storm sewer overflow into the wastewater system, it is recommended that the City continue monitoring the Harrison Ave sewer with flow monitoring configurations that will allow for backflow volume check and total depth of surcharge.

2.3 Existing System Performance

The Ontario Rd SPS has average dry weather flows of 49.2 L/s (DWF) and RDII design flows of 212.9 L/s (Niagara Region MSP, 2016). As the catchment was formerly a combined sewer network, the existing trunk sewers are generally oversized to manage wet weather flows.

The 10 year design storm (with Harrison inflows) causes surcharging in the trunk sewers to the north and south due to extremely high wet weather inflows into the system. The Harrison inflows, which are roughly the same as the capacity of the Ontario Road SPS area resulting in systems backups from the pump station. The trunk systems then have restrained capacity to outlet, causing system backups.

In the Lincoln-Empress area, the Ontario Rd-Empress Ave 450 trunk sewer has a capacity restriction in addition to the SPS constraint; this results in system backups to the L sites, causing overflows, and local sewers basement flooding risks in the Simpson neighbourhood. The Ontario Rd-Empress Ave sewer indicates a capacity issue in the 10 year storm even without the Harrison inflows. **Figure 5** shows the HGL from Dain Ave to the Ontario Rd SPS to L2 on Lincoln Street, without the Harrison inflows.

South of Ontario Rd, the large trunk sewer network is fully utilized to surcharging conditions due to the high wet weather inflows from the entire catchment exceeding the pump station capacity. The trunk sewers do not have capacity issues when the outlet is not constrained.

System capacity in the model is derived from ideal conditions, so any capacity restrictions could result in worse conditions.

2.4 Future System Performance

(existing network, do nothing)

The future performance of the existing system is dominated by the effects of high wet weather, exacerbated by the large areas new developments adding new flows to the system.

As described above, the Harrison inflows alone result in a capacity deficiency at the pump station. The additional flows in the system from growth at Union Carbide development and in Dain City result in the limited remaining system capacity and result in surcharging to basement levels in the Dain-Commercial area upstream.

Figure 6 shows the HGL from Dain Ave to the Ontario Rd SPS to L2 on Lincoln Street, without the Harrison inflows, with future buildout pressures.

I

HGL Profile with Maximum Data of Links 289008549,289007432,...,289015746

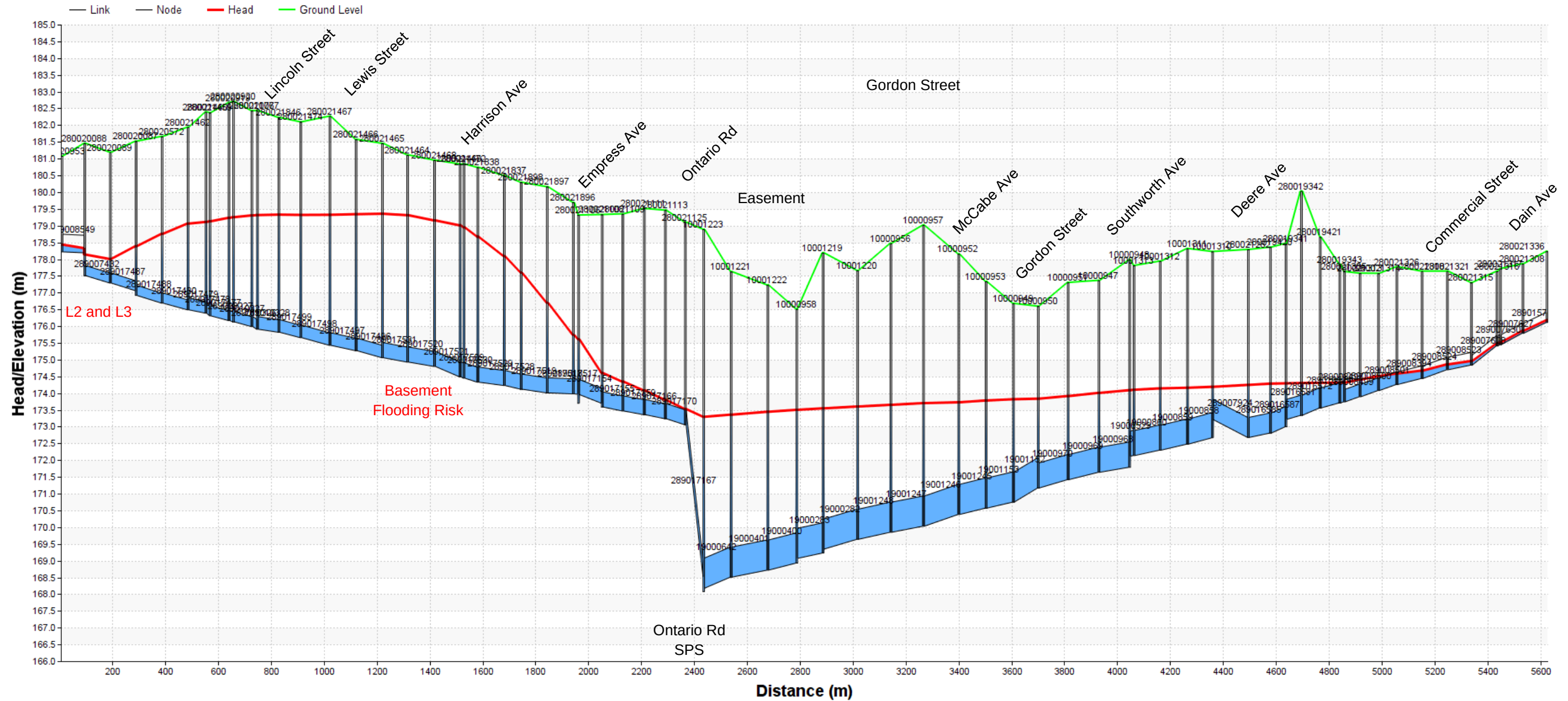


Figure 5 HGL Profile from L2/3 to Ontario Rd SPS to Dain Ave existing system, 10 year design storm

HGL Profile with Maximum Data of Links 289008549,289007432,...,289015746

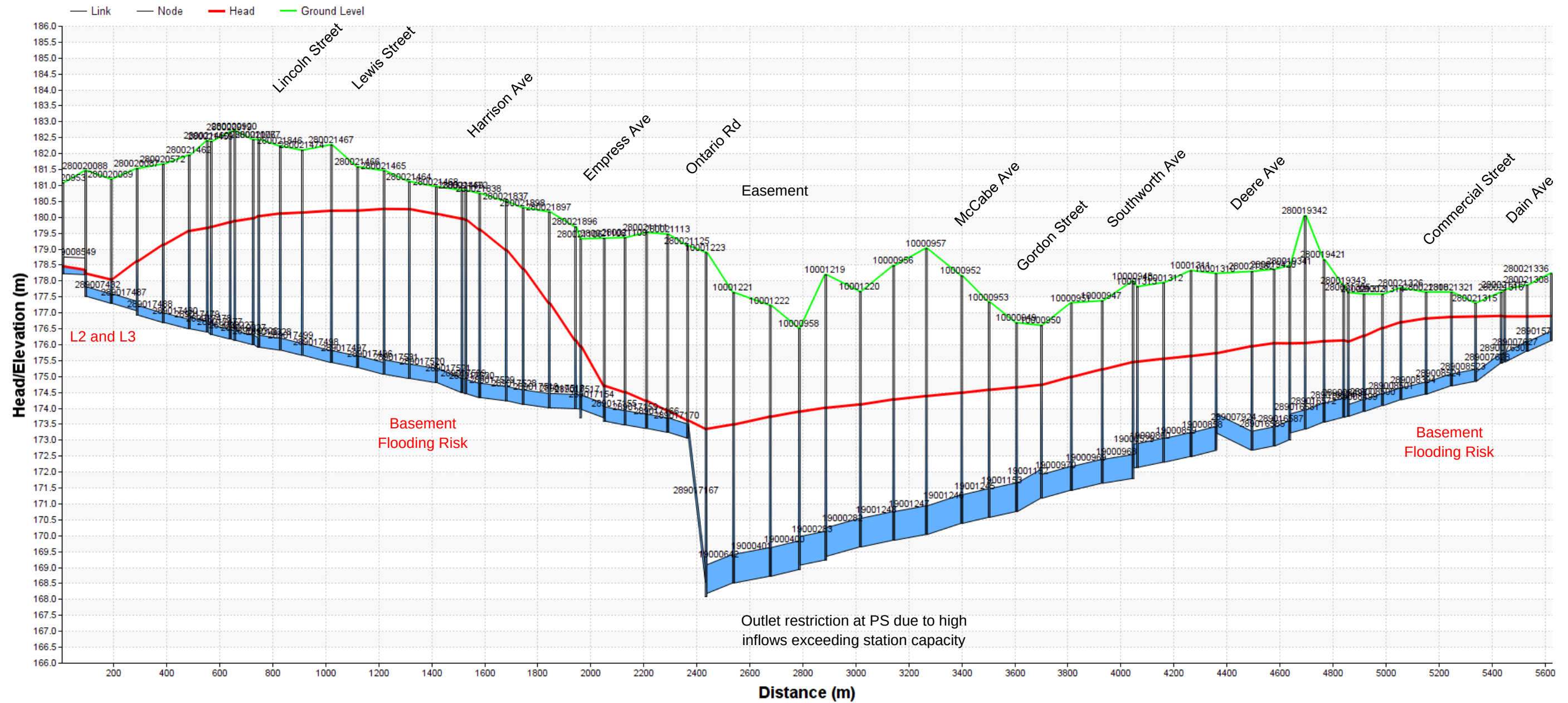


Figure 6. HGL Profile from L2/3 to Ontario Rd SPS to Dain Ave in future 10 year buildout, Empire Homes loaded to Gordon Street.

3 OPPORTUNITIES AND CONSTRAINTS

The following highlights the key system considerations when developing and evaluating potential servicing alternatives for the Ontario Road priority area. The system opportunities and constraints are shown in **Figure 7**.

3.1 Ontario Road Pump Station

- Overall, the entire Ontario Rd SPS catchment experiences high wet weather inflow and infiltration, which results in the station peak wet weather flows exceeding the station's operational capacity, resulting in upstream sewer surcharging.
 - Ontario Road SPS has sufficient capacity to accommodate typical dry weather conditions and the Region's I&I design allowance of 0.286 L/s/ha, under both existing and buildout conditions.
 - The design 10 year flow (the City's sewer design criteria), is approximately 900 L/s, which far exceed the station's capacity. This high I&I rate is exacerbated by Harrison inflows, which estimated to range from 500 to 600 L/s during larger storm events.
- Upgrades to the Ontario Road SPS capacity are not considered viable options for the following reasons:
 - The station's capacity currently exceeds the Region's design allowance under both existing and buildout criteria, as such has not been identified as requiring an upgraded with the Region's long-term capital program.
 - Upgrading the station would increase the flows to the downstream system feeding the treatment plant, which would likely increase overflows to the Welland River and at the treatment plant.
 - Upgrading the station would be costly and would still not resolve the high inflows in the catchment which could still result in localized flooding issues and overflows.
- Peak flow issues will need to be addressed through the implementation of upstream I&I reduction.

3.2 Lincoln-Empress Area (North of Ontario Road)

- The Lincoln-Empress area experiences high wet weather inflow and infiltration, which causes the flows to exceed sewer system capacity on Empress Ave, Sutherland Ave, and Ontario Road; which leads to sewer surcharging into the local system and leading to overflows at the L-Sites.
 - A major contribution to I&I is suspected to be from the Harrison stormwater overflow, with observed 500-600 L inflows during major events. This significant inflow appears to be isolated in nature and presents an opportunity for substantial I&I reduction.
 - Partial or full removal of the Harrison inflows is essential to supporting the future decommissioning of the L-site overflows and allowing any development in the Ontario Rd SPS catchment.
 - However, removal of the Harrison inflows alone is not sufficient to address all sewer surcharging issues and additional system wide I&I removal, in line with the PCPC 25% I&I removal target is recommended.

- The Empress Ave, Sutherland Ave and Ontario Road sewers are generally undersized relative to their contributing catchment areas and high I&I which present a major bottleneck. Upsizing of the sewers will be required to support the closing of the L sites even with successful I&I remediation. I&I removal needed to achieve flows within existing pipe capacity to avoid upgrades are:
 - The limiting capacities of the Ontario Road sewer are 199 L/s, 10 year flows, without the Harrison inflows are estimated to be 435 L/s.
 - The limiting capacities of the Empress Ave sewers are 64 and 116 L/s (shallow slopes), 10 year flows to this section of sewer, without the Harrison inflows, are estimated to be 300 L/s.
 - The limiting capacities of the 375 mm Sutherland Ave sewers are 55-75 L/s, 10 year flows, without the Harrison inflows are estimated to be 180 L/s.
- There is an opportunity to deepen and oversize the Ontario Rd trunk from the station to Empress Ave to facilitate future a trunk extension west on Ontario Road and to provide inline storage for the downstream Ontario Road Pump Station.

3.3 Commercial- Gordon Area (South of Ontario Road)

- The Commercial-Gordon area also contributes significant I&I to the Ontario Road PS; however, these high flows do not directly lead to local sewer surcharging issues.
 - System wide I&I removal, in line with the PCPC 25% I&I removal target is recommended.
- Sewer surcharging in the Commercial-Gordon area is the results of excessive flows to the Ontario Road SPS resulting in sewer backups along the southern 900 mm trunk sewer from the pump station all the way as far as the Dain Avenue sewer.
 - Currently the peak HGL from the 10 year design storm is maintained within the basement flooding protection cover.
 - Under current conditions, the addition the Page-Hersey property flows to the Gordon Street sewer has the potential to increase local sewer surcharging beyond the basement flooding criteria upstream from Dain Ave to Alberta Ave; if no system I&I reduction is achieved.
 - Future increases in flows from the Dain City SPS also present a risk of additional local sewer surcharging, if no system I&I reduction is achieved.
- The condition of the Gordon Street is poor, the City has referenced H₂S issues and there is a possibility of glycerine deposits from the Dain City forcemain from the forcemain connection to the Ontario Road PS. The condition of the sewer may impact sewer capacity and upstream HGL.
- The 440,000 m³ Lyons Creek Holding Reservoir (LCHR) is a Region facility which is not currently in use; it has a capacity of. Historically the site was used to hold combined sewage flows during wet weather until the pump station was able to pass the wet weather flow. As this facility is not officially decommissioned, there is an opportunity to bring the storage facility back online to hold wet weather flows. This solution would provide surcharging relief and lower the HGL in the system but would not address any wet weather issues. Further negotiations with the MECP would likely be required to use the facility.

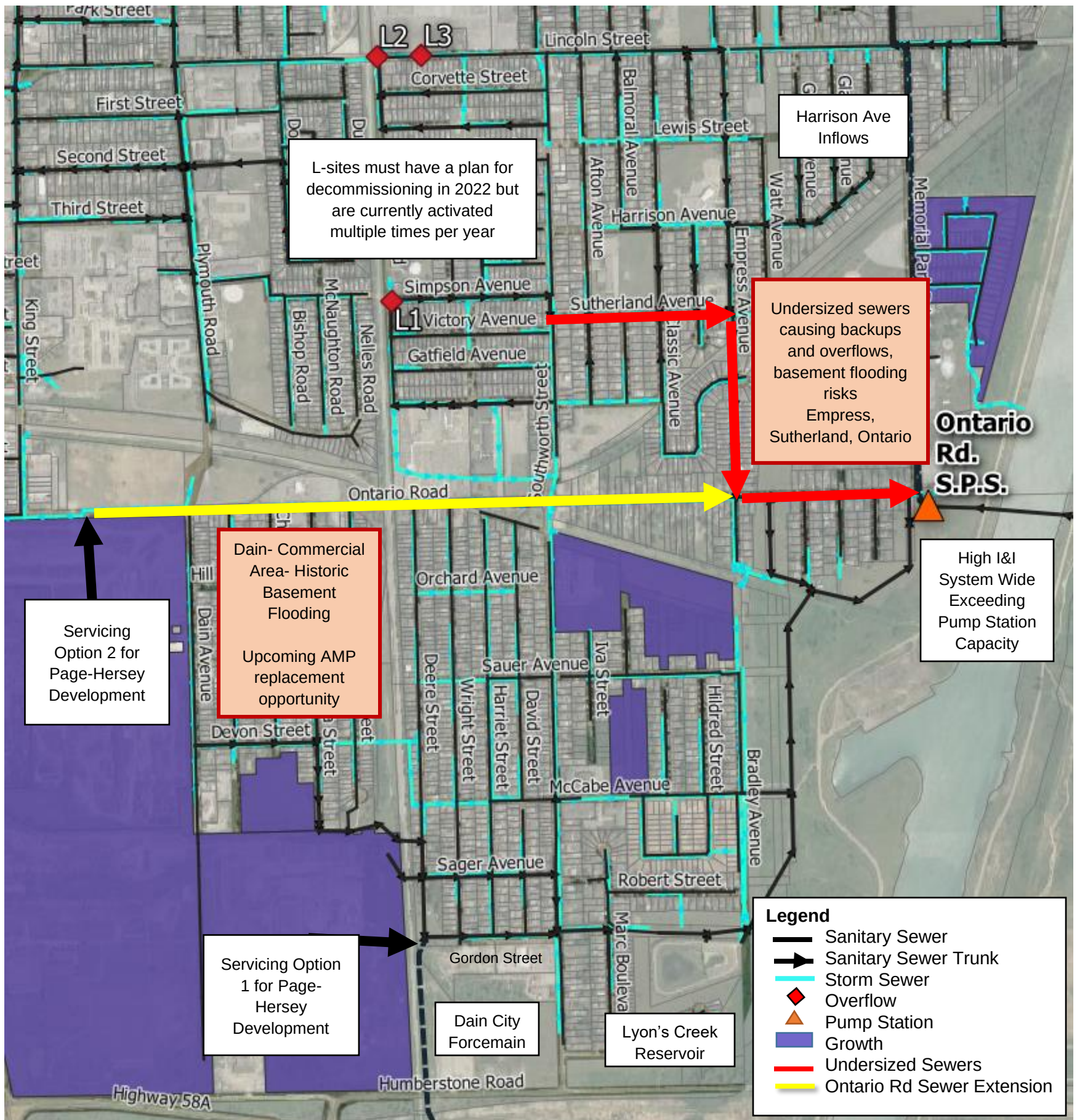


Figure 7. System Opportunities and Constraints

4 SERVICING ALTERNATIVES

4.1 PPCP and Ontario Road Objectives

The PPCP four primary servicing objectives are as follows.

- **Maintaining or improving wastewater level of service:** Reduce the number of pipes that pose the risk of basement flooding in a 10 year storm.
- **Reduce inflow and infiltration:** Remove excess I&I from the wastewater system to meet the objectives of the F-5-5 Procedure.
- **Reduce combined sewer overflow impacts:** Reduce downstream CSO occurrences and spill volumes to meet the F-5-5 Procedure objectives for a PPCP.
 - Specifically, does the alternative facilitate the decommissioning of the L-sites, not just to reduce overflow volumes.
- **Facilitate growth:** Ensure all growth can be accommodated with the alternative, while maintaining or improving the LOS.

Additional objectives

In addition to the PPCP objectives, the following additional objectives were considered when developing and evaluating servicing alternatives for the Ontario Road Area:

- Servicing flexibility of the Page-Hersey land as condition of the Gordon St sewer and downstream trunk is uncertain.
- Opportunities to coordinate/align sewer upgrades with future planned sewer replacement projects

4.2 Existing System Servicing Solutions

Based on the existing system constraints in the Ontario Rd system; the City must undertake remedial work to meet the terms of the ECA for the L-sites and reduce basement flooding risks for existing residents.

The I&I in the entire Ontario Rd area is very high and a 25% reduction alone will not fully address basement flooding risks and overflow issues due high I&I and undersized sewers. Therefore a combination of I&I removal and infrastructure upgrades are needed to address the Ontario Rd system needs.

These terms must be met and demonstrated before allowing any development to proceed in the catchment.

- **I&I Reduction:** Public side I&I measures would begin with a field investigation following up from high flows found from flow monitoring. The rehabilitation projects would be determined after the field investigation. Private side I&I measures could be pursued once public side opportunities have been exhausted.
- **Upgrade sewers:** Upgrading the sewers on Empress, Sutherland, and Ontario Rd will reduce basement flooding risks and eliminate L-site overflows in a 10 year storm provided that 25% I&I reduction and at least 50% of the Harrison inflows are removed.
 - **Ontario Rd:** Deepening the sewer will lower the HGL in the Lincoln Empress area, reducing overflows and basement flooding risks, and will provide servicing flexibility for the future development of the Page-Hersey property and Dain/Commercial areas. The scope of these upgrades include:

- i. 500 m of sewer on Ontario Road from Empress Ave to Ontario Road SPS to be deepened to 8 m and upgraded to 900 mm.
- **Empress Ave and Sutherland Ave:** Upgrading the sewers will reduce the HGL in Lincoln Empress area and reduce the occurrence and volume of overflows at the L-sites. The City may wait until I&I reduction projects have been completed and measured to confirm that the upgrades are required or modify sizing. The scope of these upgrades include:
 - i. 300 m of sewer on Empress Ave to be upgraded from Sutherland Ave to Ontario Rd; the current size is 450 mm and the upgrade size is 600 mm.
 - ii. 450 m of sewer on Sutherland from Empress Ave to Southworth Ave; the current size is 375 mm and the upgrade size is 600 mm.

These measures will require post-works monitoring to confirm I&I reductions and that HGL levels are maintained within the basement flooding cover. When system wide I&I targets have been achieved, development approvals may be considered in the Ontario Road catchment.

4.3 Page-Hersey Servicing Alternatives

Two servicing alternatives were considered for the future development of the Page-Hersey property when the above solutions have been implemented. Ultimately it will be up to the developer to determine the best solutions for the property.

Alternative 1 – Gordon Street:

- Servicing the Page-Hersey property to the Gordon Street sewer causes the HGL in the upstream sewer to exceed the basement flooding cover from Dain Ave to Alberta Ave if I&I targets are not met catchment wide. Upgrades to the 450 mm Dain-Alberta trunk to 600 mm would be needed to facilitate servicing of Page-Hersey to the Gordon Street sewer and manage high HGL resulting from system backups. The scope of these upgrades include:
 - i. Upgrade the Dain-Alberta trunk to 600 mm to facilitate servicing of Page-Hersey to the Gordon Street sewer and manage high HGL resulting from system backups.

Alternative 2 – Ontario Trunk Extension:

- Service the Page-Hersey development via a new trunk sewer on Ontario Road. The trunk would be deep in order to facilitate service the entire property, if needed. This solution is dependent on the Ontario Road upgrade also including lowering the sewer elevation.
- This solution provides the City a number of benefits
 - i. to service the Dain-Commercial neighbourhood to the new Ontario trunk sewer, which could be accommodated with the upcoming replacement of water and sanitary systems in that area.
 - ii. Servicing the Page-Hersey development to a new trunk would leave capacity in the Gordon Street sewer for a future upgrade of the Dain City PS beyond 115 L/s.
 - iii. Slightly oversizing any segments of the trunk extension will provide additional inline storage in wet weather, further reducing the risk of overflows and basement flooding.
- The scope of the new Ontario Road trunk sewer would entail:

- i. 1300 m of 600 mm sewer at 6-8 depth to service the Dain-Commercial area
- ii. 300 m extension to service the Page-Hersey property.

5 SOLUTION IMPLEMENTATION

5.1 Implementation Plan

The implementation of the preferred solution is as follows:

1. Harrison inflows need to be reduced by at least 50% to reduce PS limitations causing system backups
 - flow monitoring in the Harrison Ave sewer and upstream
 - smoke testing
 - field investigation in powerline areas adjacent to sewers
 - CCTV review
2. I&I catchment-wide
 - a. Prioritize the Lincoln-Empress area to prepare to meet the ECA requirements for the L-sites
 - b. Flow monitoring from 2020 will help direct target areas in the south. As the Dain-Commercial neighbourhood will be replaced soon, it is not recommended that I&I field investigation be targeted in that area.
 - c. Complete public side I&I works first and proceed with private side I&I works if 25% target is not achieved.
3. Sewer Upgrades
 - a. Upgrade and deepen the Ontario Rd trunk sewer for interim HGL relief, increased inline storage, and servicing flexibility for future extension
 - b. Upgrade Empress Ave if I&I reduction targets are not met
 - c. Upgrade Sutherland Ave if I&I reduction targets are not met
4. Extend the Ontario Road Trunk Sewer
 - a. To the Dain-Commercial neighbourhood
 - b. From Dain Ave to the Page-Hersey development

Once the implementation plan has been measurably successful, servicing options can be further considered in partnership with the developer.

The phasing of the Ontario Road solution is shown **Figure 8**.

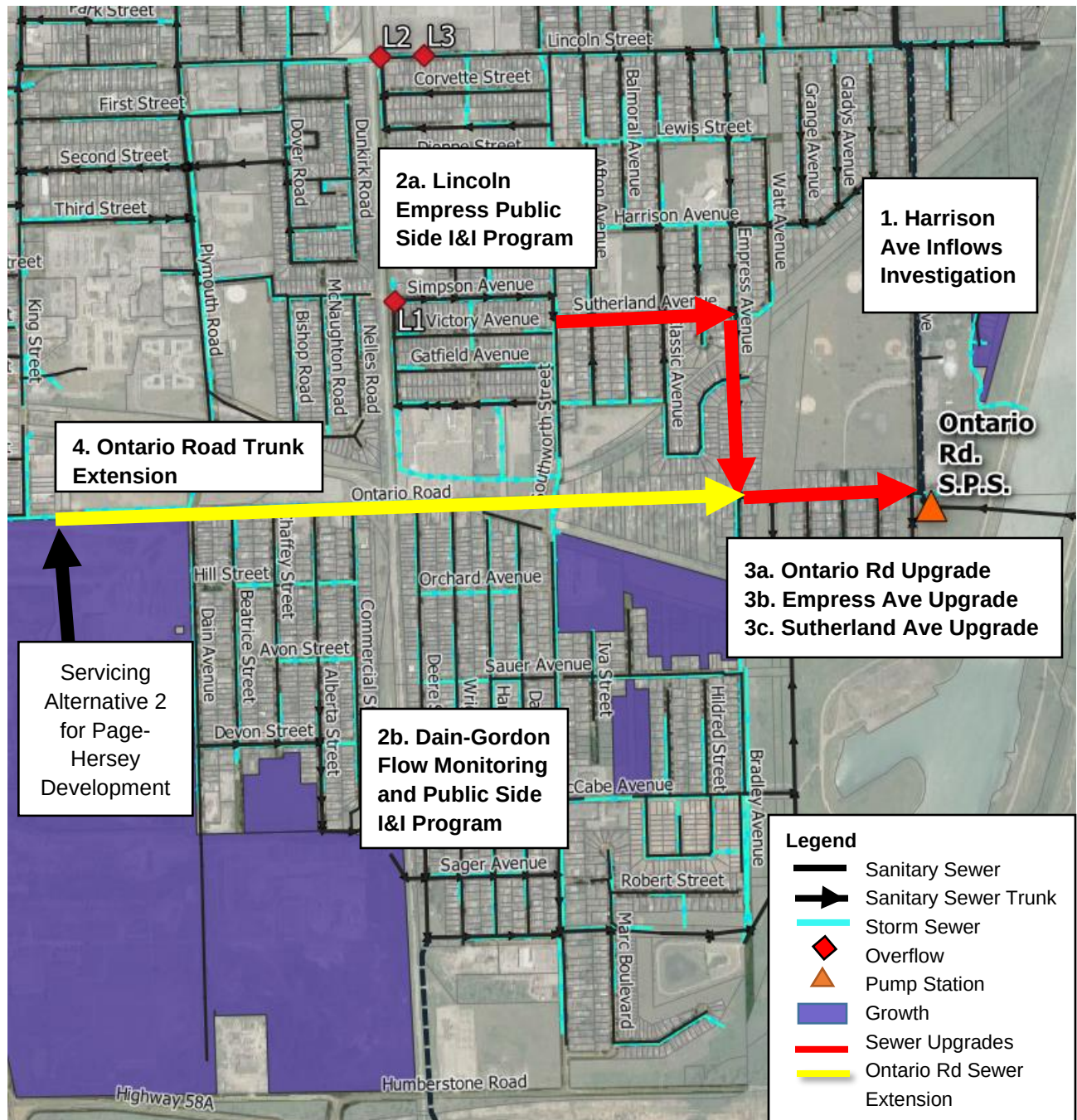


Figure 8. Ontario Road Servicing Solution and Implementation Plan

5.2 Detailed I&I Reduction Program

It is recommended that the I&I reduction program be implemented with a minimum target objective of reducing peak 10 year I&I flows by 25% AND that the Harrison Ave inflows are reduced by at least 50%.

Based on the results from 2019 flow monitoring, the worst inflows are coming from Harrison Ave. First, the field investigation works will focus on finding the Harrison inflows

- Comprehensive stormwater cross-connection investigation, including confirmation of private storm service cross-connections, and removals.
- Improvement of roadway drainage and sewer manhole placement to eliminate surface water runoff into the sanitary system.
- Replacement of sewers, manholes, and service tees to reduce sources of groundwater infiltration.
- Additional flow monitoring in the Harrison sewer and upstream to locate flows
- Smoke testing

This approach can be applied throughout the Ontario Road catchment, expanding from the Harrison Ave study to the remaining Lincoln Empress area to facilitate meeting the ECA requirements for the L-sites. Finally, this approach should also be applied to the Gordon area.

5.2.1 Harrison Ave Flow Monitoring Investigation

The City is already undertaking additional flow monitoring in the Harrison Ave area. There will be 5 sanitary monitors and 1 storm monitor to:

1. Pinpoint the possible sources of the inflows
2. Improve understanding of system backups from Empress
3. Improve the understanding of the relationship between the storm and sanitary sewers on Harrison Ave

A map of the monitors is shown in **Appendix A**.

The upgrades I&I remediation and post-works flow monitoring will be needed to confirm the effectiveness of I&I removal and HGL reduction in wet weather storms in the Empress Ave sewer.

5.2.2 Additional flow monitoring in Ontario Rd catchment

As part of the 2020 flow monitoring program, there are currently 6 monitors installed in the Ontario Rd catchment, in addition to the 3 L-site overflow monitors. The map of these monitors is Figure 9. The monitors in the south catchment will help to confirm the model analyses completed for this assignment. If flows in the southern catchment are larger than the model is currently calibrating to, then the recommendations for the southern part of the catchment and Commercial Road area should be re-assessed.

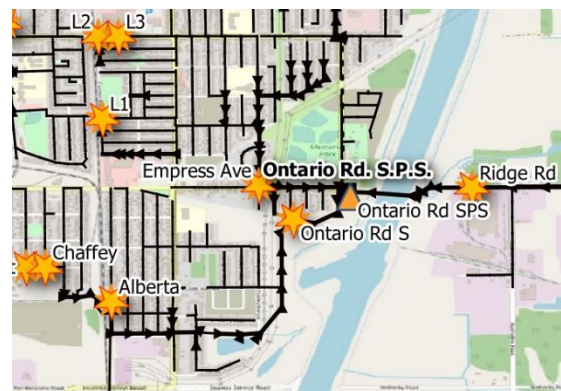


Figure 9. 2020 FM Program

5.3 Detailed Sewer Upgrade Plan

A summary of the sewer upgrade preliminary sizing and lengths are in Table 2.

Table 1. Proposed Sewer Upgrades and Extension

Sewer	Length (m)	Existing Size	Size (mm)
Ontario Road (Deepen and upsize)	500	450	900
Empress Ave	300	450	600
Sutherland Ave	450	375	600
Ontario Road Extension to Dain Ave	1300	n/a	600
Ontario Road Extension from Dain Ave to Page-Hersey	300	n/a	450-600
Total length to be deepened/upsized	2850		

The local sewers were sized conservatively to accommodate growth, assuming the possibility of 25% I&I reduction and 50% removal of the Harrison inflows. If aggressive I&I removal is successful in the Lincoln-Empress area, it may be possible to avoid sewer upgrades on Empress and Sutherland.

5.4 Program Cost

The total cost for the preferred solution is \$23.4 M; \$11.3 M for the sewer replacements and \$12 M for the I&I field study. This costing assumes all upgrades are required to meet the ECA conditions. A summary of the program costing is provided in **Table 4**; detailed unit costs for sewer replacements are summarized in **Appendix B**. A 40% engineering and contingency cost is included in the sewer replacement estimation.

The I&I reduction program uses an estimate of \$5,000 per home in the target area. This cost includes public and private field investigation, educational/promotional material development, homeowner engagement, and disconnection of private connections. The \$5,000 is an average cost as many homeowners will not choose to participate.

5.5 Beneficial Impact Assessment

Flow monitoring pre and post area improvements will confirm the effectiveness of the implemented solution and confirm if further I&I works are needed on private property to achieve the 25% reduction target and lowered HGL. Flow monitoring in the Harrison area should continue after the field investigation to quantify the extent that inflows have been reduced or eliminated.

Table 2. Ontario Road Priority Area Implementation Plan Costs

Plan Component	Description	Estimated Cost including 40% engineering/contingency
Harrison FM	Based on quote from AMG for 5 monitors for 6 months	\$27,000
I&I Program North	Public and private – 1,088 homes	\$6,500,000
I&I Program South	Public and private – 900 properties, excluding Dain Ave to Alberta Ave	\$5,500,000
Subtotal I&I Program		\$12,027,000
Ontario Road Upgrades	500 m of upgrades to 900 m at 8 m depth from Empress Ave to Ontario SPS.	\$3,000,000
Empress Ave Upgrades	300 m of upgrades to 600 mm from Sutherland Ave to Ontario Road. This sewer is currently approximately 6 m depth.	\$442,000
Sutherland Ave Upgrades	450 m of upgrades to 600 mm from Empress Ave to Southworth Ave. This sewer is currently approximately 6 m depth.	\$2,038,000
Ontario Road Extension to Dain Ave	1300 m of sewer – assumed size 600 mm. Deep trunk sewer.	\$5,887,000
Ontario Road Extension from Dain Ave to Page-Hersey	300 m of sewer – assumed size 600 mm. Deep trunk sewer.	\$1,359,000
Subtotal Infrastructure Upgrades		\$11,367,000
Total		\$23,394,000

Appendix A – Flow Monitoring Data and Analysis

The 5 flow monitors were in place from July to December 2019. The monitor locations and corresponding catchments are show in Figure A1. below. The catchment areas are listed in Table A1 below.

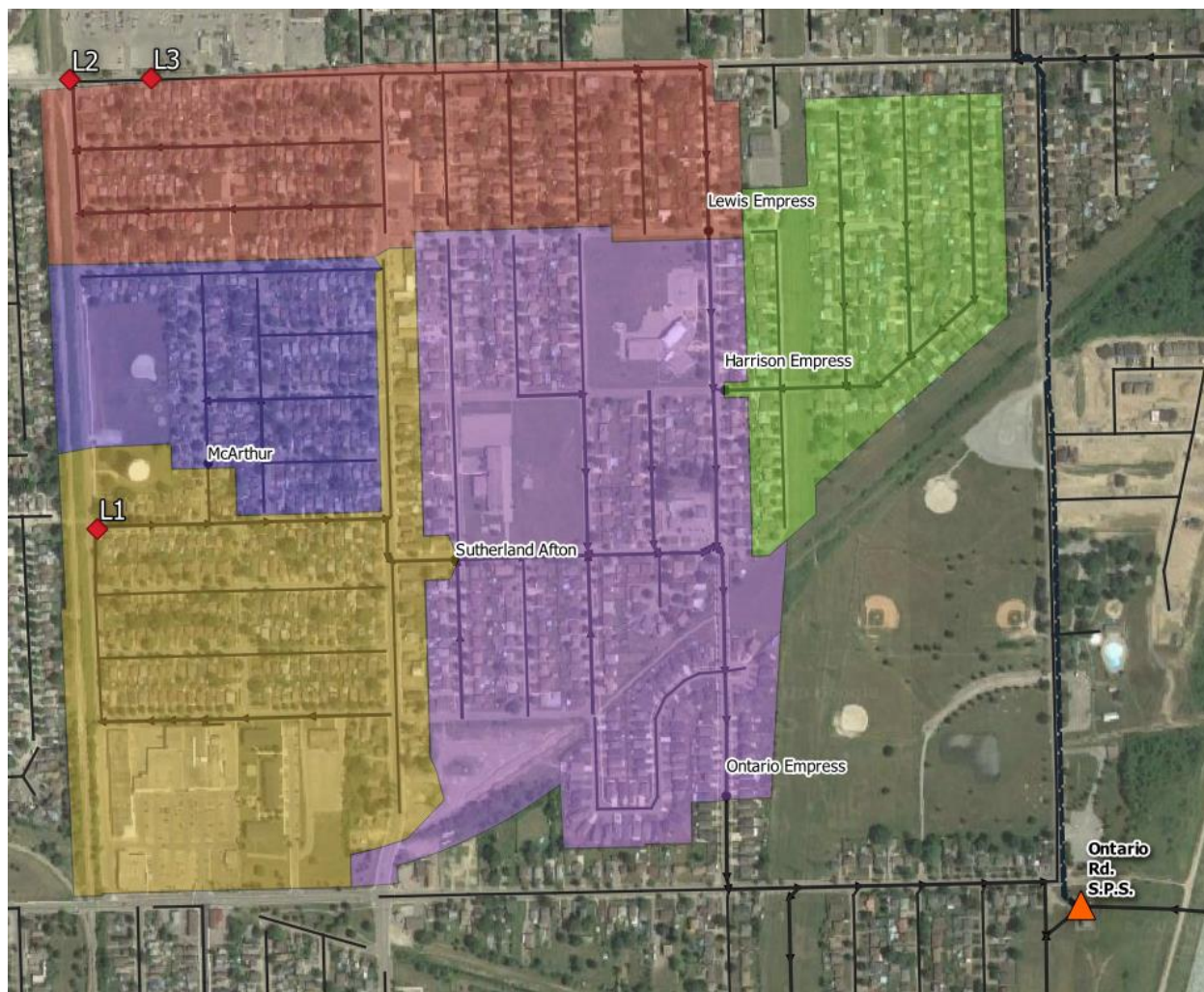


Figure A1. 2019 Flow Monitoring Locations

Table A1 Flow Monitoring Catchment Areas

FM	Catchment Area (ha)
Lewis Empress	20.0
McArthur	11.6
Harrison Empress	13.6
Sutherland Afton	25.3
Ontario Empress	32.7

The flow monitors are represented in the hierarchy shown in Figure A2, with the Ontario Empress FM being the most downstream.

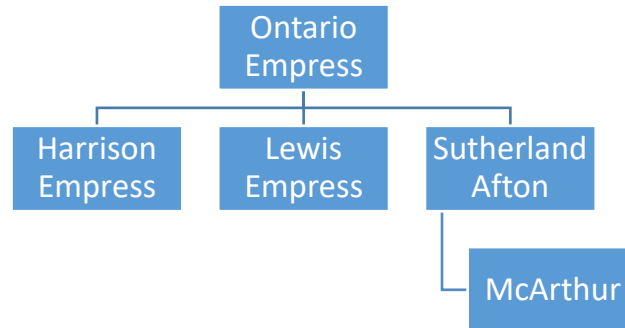


Figure A2. Flow Monitoring Hierarchy

Flow Monitoring Calibration

Overall, a conservative calibration was achieved to represent the wet weather flows. Events used for model calibration are listed in Table A2.

The high system flows result in the Ontario Road SPS and trunk sewer capacity being exceeded resulting in sewer system surcharging. This surcharging results in unreliable data conditions downstream at the Ontario Empress FM. Therefore, the flows at the pump station were also considered in the model calibration. However, it must be noted that no data was available for the South and Eastern areas of the Ontario Rd catchment.

Several flow monitors have been installed in the South as part of the City's 2020 flow monitoring program to better quantify the wet weather flows incoming to the area.

Table A2. Rainfall Events for Model Calibration

Start of Rain	End of Rain	Rainfall Duration (hh:mm)	Total Depth (mm)	Peak 1-hr (mm/hr)	Peak 5-min (mm/hr)	Overflow Triggered?
8/17/2019 7:55	8/19/2019 4:20	44:25	26	7	15	
8/21/2019 2:00	8/21/2019 5:55	03:55	23	15	69	
9/1/2019 17:10	9/2/2019 8:00	14:50	63	15	54	All overflows
10/1/2019 16:55	10/3/2019 11:55	43:00	24	9	30	
10/25/2019 18:20	10/27/2019 10:50	40:30	32	11	21	All overflows

Peak flows in a 10 year storm were estimated using an envelope method and are shown below, with the exception of the Harrison monitor, the peak flows estimated are equivalent to the

inflows. Unit RDII may vary as the system surcharges and causes overflow; not all flows are captured and flows may be attributed incorrectly to catchments due to backups. Table A3 summarizes flow monitoring results and 10 year storm flow projections.

Table A3. Flow Monitoring Results

FM	Catchment Area (ha)	Average DWF (L/s)	10Y RDII (L/s)	10 y unit rdii (L/s/ha)	Peak observed Cv (%) excluding Harrison events
Lewis Empress	20.0	3.1	173	8.7	15%
Harrison Empress	13.4	1.1	>600*	na	25%
Ontario Empress	32.7	13	362	11.1	44%
McArthur	11.6	0.4	76	6.6	12%
Sutherland Afton	25.3	6.2	144	5.7	13%

*PWWF uses observed plateau peak, rather than a projection based on a design storm

The model calibration for the October 1-3 event at all locations are shown on the following page.



APPENDIX B – SEWER REPLACEMENT UNIT COSTING

Table 3. Unit Costs for Sewer Replacement (<5m depth)

Diameter	Outer Diameter	Depth to Invert	Min Trench Width	Excavation			Granular Bedding			Pipe				Backfill			Subtotal Unit Cost	Restoration (2012)	Restoration - Inflated from '12	Manhole Allowance	Total Unit Cost
				Volume	Cost	Unit Cost	Volume	Cost	Unit Cost	Supply Cost	Install (2012)	Install - Inflated from '12	Pipe Supply + Install	Vol	Cost	Unit Cost					
(mm)	(m)	(m)	(m)	(m³/m)	(\$/m³)	(\$/m)	(m³/m)	(\$/m³)	(\$/m)	(\$/m)		(\$/m)	(\$/m)	(m³/m)	(\$/m³)	(\$/m)	(\$/m)	(\$/m)	(\$/m)	(\$/m)	(2020 \$/m)
200	0.445	5	1.0	5.0	32	\$ 160	1.0	67	\$ 67	\$ 95	\$ 41	\$ 48	\$ 143	4.0	14	\$ 56	\$ 427	\$ 98	\$ 115	\$ 110	\$ 651
250	0.445	5	1.0	5.0	32	\$ 160	1.0	67	\$ 67	\$ 95	\$ 41	\$ 48	\$ 143	4.0	14	\$ 56	\$ 427	\$ 98	\$ 115	\$ 110	\$ 651
300	0.445	5	1.0	5.0	32	\$ 160	1.0	67	\$ 67	\$ 95	\$ 41	\$ 48	\$ 143	4.0	14	\$ 56	\$ 427	\$ 98	\$ 115	\$ 110	\$ 651
375	0.52	5	1.1	5.5	32	\$ 176	1.0	67	\$ 67	\$ 117	\$ 41	\$ 48	\$ 165	4.5	14	\$ 63	\$ 472	\$ 98	\$ 115	\$ 110	\$ 697
450	0.58	5	1.2	6.0	32	\$ 192	1.1	67	\$ 74	\$ 151	\$ 41	\$ 48	\$ 199	4.9	14	69	\$ 534	\$ 99	\$ 116	\$ 110	\$ 760
525	0.66	5	1.3	6.5	32	\$ 208	1.2	67	\$ 81	\$ 182	\$ 41	\$ 48	\$ 230	5.3	14	75	\$ 593	\$ 100	\$ 117	\$ 110	\$ 820
600	0.76	5	1.4	7.0	32	\$ 224	1.4	67	\$ 94	\$ 240	\$ 41	\$ 48	\$ 288	5.6	14	79	\$ 684	\$ 100	\$ 117	\$ 250	\$ 1,052
675	0.88	5	1.7	8.5	32	\$ 272	1.9	67	\$ 128	\$ 363	\$ 49	\$ 57	\$ 420	6.6	14	93	\$ 912	\$ 113	\$ 132	\$ 250	\$ 1,295
750	0.97	5	1.8	9.0	32	\$ 288	2.0	67	\$ 134	\$ 479	\$ 49	\$ 57	\$ 536	7.0	14	98	\$ 1,057	\$ 114	\$ 134	\$ 250	\$ 1,440
825	1.06	5	1.9	9.5	32	\$ 304	2.2	67	\$ 148	\$ 556	\$ 49	\$ 57	\$ 613	7.3	14	103	\$ 1,167	\$ 115	\$ 135	\$ 250	\$ 1,552
900	1.14	5	1.9	9.5	32	\$ 304	2.4	67	\$ 161	\$ 666	\$ 49	\$ 57	\$ 723	7.1	14	100	\$ 1,289	\$ 116	\$ 136	\$ 400	\$ 1,824
975	1.23	5	2.0	10.0	32	\$ 320	2.5	67	\$ 168	\$ 767	\$ 49	\$ 57	\$ 824	7.5	14	105	\$ 1,418	\$ 128	\$ 150	\$ 400	\$ 1,968
1050	1.32	5	2.3	11.5	32	\$ 368	3.1	67	\$ 208	\$ 878	\$ 49	\$ 57	\$ 935	8.4	14	118	\$ 1,629	\$ 129	\$ 151	\$ 400	\$ 2,181
1200	1.46	5	2.5	12.5	32	\$ 400	3.4	67	\$ 228	\$ 1,100	\$ 49	\$ 57	\$ 1,157	9.1	14	128	\$ 1,913	\$ 131	\$ 153	\$ 400	\$ 2,467
1350	1.67	5	2.7	13.5	32	\$ 432	3.9	67	\$ 262	\$ 1,413	\$ 55	\$ 64	\$ 1,477	9.6	14	135	\$ 2,306	\$ 133	\$ 156	\$ 333	\$ 2,795
1500	1.81	5	2.8	14.0	32	\$ 448	4.2	67	\$ 282	\$ 1,729	\$ 55	\$ 64	\$ 1,794	9.8	14	138	\$ 2,662	\$ 146	\$ 171	\$ 333	\$ 3,166
1800	2.16	5	3.2	16.0	32	\$ 512	5.1	67	\$ 343	\$ 2,504	\$ 55	\$ 64	\$ 2,568	10.9	14	153	\$ 3,576	\$ 150	\$ 176	\$ 333	\$ 4,085
2100	2.51	5	3.5	17.5	32	\$ 560	6.0	67	\$ 403	\$ 3,328	\$ 55	\$ 64	\$ 3,393	11.5	14	162	\$ 4,517	\$ 153	\$ 179	\$ 400	\$ 5,097
2400	2.88	5	3.9	19.5	32	\$ 624	7.0	67	\$ 470	\$ 4,427	\$ 55	\$ 64	\$ 4,491	12.5	14	176	\$ 5,761	\$ 157	\$ 184	\$ 400	\$ 6,345
3000	3.56	5	4.6	23.0	32	\$ 736	9.0	67	\$ 605	\$ 6,783	\$ 55	\$ 64	\$ 6,848	14.0	14	197	\$ 8,385	\$ 164	\$ 192	\$ 400	\$ 8,977

Table 4. Unit Costs for Sewer Replacement (>5m depth)

Diameter	Outer Diameter	Depth to Invert	Min Trench Width	Excavation			Granular Bedding			Pipe				Backfill			Subtotal Unit Cost	Restoration (2012)	Restoration - Inflated from '12	Manhole Allowance	Total Unit Cost
				Volume	Cost	Unit Cost	Volume	Cost	Unit Cost	Supply Cost	Install (2012)	Install - Inflated from '12	Pipe Supply + Install	Vol	Cost	Unit Cost					
(mm)	(m)	(m)	(m)	(m³/m)	(\$/m³)	(\$/m)	(m³/m)	(\$/m³)	(\$/m)	(\$/m)		(\$/m)	(\$/m)	(m³/m)	(\$/m³)	(\$/m)	(\$/m)	(\$/m)	(\$/m)	(\$/m)	(2020 \$/m)
300	0.445	10	1.0	35.0	\$ 45	\$ 1,575	1.0	67	\$ 67	\$ 95	\$ 41	\$ 48	\$ 143	34.0	14	478	\$ 2,263	\$ 180	\$ 211	\$ 200	\$ 2,674
375	0.52	10	1.1	36.0	\$ 45	\$ 1,620	1.0	67	\$ 67	\$ 117	\$ 41	\$ 48	\$ 165	35.0	14	492	\$ 2,345	\$ 180	\$ 211	\$ 200	\$ 2,756
450	0.58	10	1.2	37.0	\$ 45	\$ 1,665	1.1	67	\$ 74	\$ 151	\$ 41	\$ 48	\$ 199	35.9	14	505	\$ 2,443	\$ 185	\$ 217	\$ 200	\$ 2,860
525	0.66	10	1.3	38.0	\$ 45	\$ 1,710	1.2	67	\$ 81	\$ 182	\$ 41	\$ 48	\$ 230	36.8	14	517	\$ 2,538	\$ 185	\$ 217	\$ 200	\$ 2,955
600	0.76	10	1.4	39.0	\$ 45	\$ 1,755	1.4	67	\$ 94	\$ 240	\$ 41	\$ 48	\$ 288	37.6	14	529	\$ 2,665	\$ 187	\$ 219	\$ 350	\$ 3,234
675	0.88	10	1.7	42.0	\$ 45	\$ 1,890	1.9	67	\$ 128	\$ 363	\$ 49	\$ 57	\$ 420	40.1	14	564	\$ 3,001	\$ 189	\$ 221	\$ 350	\$ 3,573
750	0.97	10	1.8	43.0	\$ 45	\$ 1,935	2.0	67	\$ 134	\$ 479	\$ 49	\$ 57	\$ 536	41.0	14	576	\$ 3,182	\$ 192	\$ 225	\$ 350	\$ 3,757
825	1.06	10	1.9	44.0	\$ 45	\$ 1,980	2.2	67	\$ 148	\$ 556	\$ 49	\$ 57	\$ 613	41.8	14	588	\$ 3,328	\$ 199	\$ 233	\$ 350	\$ 3,912
900	1.14	10	1.9	44.0	\$ 45	\$ 1,980	2.4	67	\$ 161	\$ 666	\$ 49	\$ 57	\$ 723	41.6	14	585	\$ 3,450	\$ 201	\$ 236	\$ 600	\$ 4,285
975	1.23	10	2.0	45.0	\$ 45	\$ 2,025	2.5	67	\$ 168	\$ 767	\$ 49	\$ 57	\$ 824	42.5	14	598	\$ 3,615	\$ 203	\$ 238	\$ 600	\$ 4,453
1050	1.32	10	2.3	48.0	\$ 45	\$ 2,160	3.1	67	\$ 208	\$ 878	\$ 49	\$ 57	\$ 935	44.9	14	631	\$ 3,935	\$ 206	\$ 241	\$ 600	\$ 4,776
1200	1.46	10	2.5	50.0	\$ 45	\$ 2,250	3.4	67	\$ 228	\$ 1,100	\$ 49	\$ 57	\$ 1,157	46.6	14	655	\$ 4,291	\$ 208	\$ 244	\$ 600	\$ 5,134
1350	1.67	10	2.7	52.0	\$ 45	\$ 2,340	3.9	67	\$ 262	\$ 1,413	\$ 55	\$ 64	\$ 1,477	48.1	14	676	\$ 4,755	\$ 208	\$ 244	\$ 567	\$ 5,566
1500	1.81	10	2.8	53.0	\$ 45	\$ 2,385	4.2	67	\$ 282	\$ 1,729	\$ 55	\$ 64	\$ 1,794	48.8	14	686	\$ 5,147	\$ 208	\$ 244	\$ 567	\$ 5,957
1800	2.16	10	3.2	57.0	\$ 45	\$ 2,565	5.1	67	\$ 343	\$ 2,504	\$ 55	\$ 64	\$ 2,568	51.9	14	730	\$ 6,205	\$ 215	\$ 252	\$ 567	\$ 7,024
2100	2.51	10	3.5	60.0	\$ 45	\$ 2,700	6.0	67	\$ 403	\$ 3,328	\$ 55	\$ 64	\$ 3,393	54.0	14	759	\$ 7,255	\$ 227	\$ 266	\$ 733	\$ 8,254
2400	2.88	10	3.9	64.0	\$ 45	\$ 2,880	7.0	67	\$ 470	\$ 4,427	\$ 55	\$ 64	\$ 4,491	57.0	14	801	\$ 8,643	\$ 234	\$ 274	\$ 733	\$ 9,651
3000	3.56	10	4.6	71.0	\$ 45	\$ 3,195	9.0	67	\$ 605	\$ 6,783	\$ 55	\$ 64	\$ 6,848	62.0	14	872	\$ 11,519	\$ 252	\$ 295	\$ 733	\$ 12,548



Technical Memorandum

Dain City Inflow & Infiltration Investigation and Remediation Action Plan



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GMBP Project #: 420110
June 2021



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Appendix A.1	IDF Matrices
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1 INTRODUCTION

GM BluePlan Engineering (GMBP) was retained by the City of Welland (the City) to conduct an Inflow & Infiltration (I/I) Field Investigation Program and develop a Remediation Action Plan for the Dain City area. The objectives of this assignment are, to:

- Isolate sources of I/I at street-level and characterize the type of response for each Sewer System Evaluation Area (SSEA); i.e. fast inflow, medium inflow/infiltration, or slow infiltration;
- Conduct field investigation to identify potential sources of inflow (i.e. downspout connections, weeping tile connections, cross-connections with the storm system, etc.);
- Conduct site surveys to confirm low lying areas, locations of lateral inspection tees, visual inspection of downspouts, etc.;
- Review CCTV data and videos to enhance understanding of sanitary and storm sewer condition, which will inform recommendations for rehab candidates;
- Review the Dain City Stormwater Risk Assessment (November 2020), completed recently by Wood, and incorporate the recommendations into the development of the Remediation Action Plan.

Note: It is understood that recommendations related to local Stormwater System improvements and Operation & Maintenance improvements will be addressed under separate initiatives; as such, the scope of this project was limited to reducing I/I within the City's wastewater system. However, as stated in the objectives, all existing recommended stormwater system improvements will be considered and incorporated into the findings of this report, as coordination with the stormwater capital upgrades will provide the greatest overall benefit to the sanitary system.

1.1 Study Area and Background

The Dain City area, presented in Figure 1, is situated in the southernmost end of the City of Welland, bounded by the Welland Canal to the East and the Welland Recreational Waterway to the West. Dain City is comprised of industrial areas in the North and residential areas in the South. Wastewater flows from the Dain City neighborhood are conveyed via the City owned gravity sewer network to the Niagara Region owned and operated Dain City sewage pumping station (SPS), located on Talbot Avenue. The Dain City SPS flows are pumped to the Ontario Road SPS and ultimately to the Welland Wastewater Treatment Plant. The Dain City SPS has an offline Combined Sewer Overflow CSO tank, which is utilized to attenuate peak flow to the Dain City SPS and to help protect the system against basement flooding.

A multi-day rain on snow precipitation event on April 16, 2018 caused an extensive basement flooding event of 30 homes in the Dain City neighborhood. Basement flooding

was generally widespread including properties on and south of Forks Road. During the flooding event, the following system performance was also observed:

- The existing storage tank at the Dain City SPS was full, and operators were relief pumping to the environment with the objective of minimizing sanitary sewer surcharging;
- There was significant surcharging, flow above sewer obverts, within the trunk sewer from the Dain City SPS to Forks Road.

This was one of multiple flooding incidents in the past 5 years. It should be noted that the Dain City area is flat with minimal stormwater infrastructure. The stormwater infrastructure that is available for surface drainage is in relatively poor condition. Low lying areas and poor drainage between the two water bodies is likely contributing to the issues observed in the sanitary system during intense precipitation events. Also, due to the relatively low and flat area between the Welland Canal and the Welland Recreational Waterway, there is significant base infiltration due to a relatively high groundwater table.

1.2 Benefits of Addressing Inflow and Infiltration

Addressing I/I within the Dain City area is a high-priority initiative for the City. It was identified in the City's (Draft) Pollution Prevention Control Plan (PPCP) as a high-risk area (for basement flooding and system overflow to the environment) with limited to no capacity for development. Some of the key benefits of reducing the I/I, are:

- Increased Level of Service (i.e. reduced system surcharging and basement flooding);
- Increased system capacity;
- Cost savings by limiting the need for system upsizing;
- Reduction in peak flows at pumping stations and wastewater treatment plant (WWTP);
- Reduction in sewer overflows, a positive for public health.



Figure 1: Study Area

1.3 Sources of Inflow and Infiltration

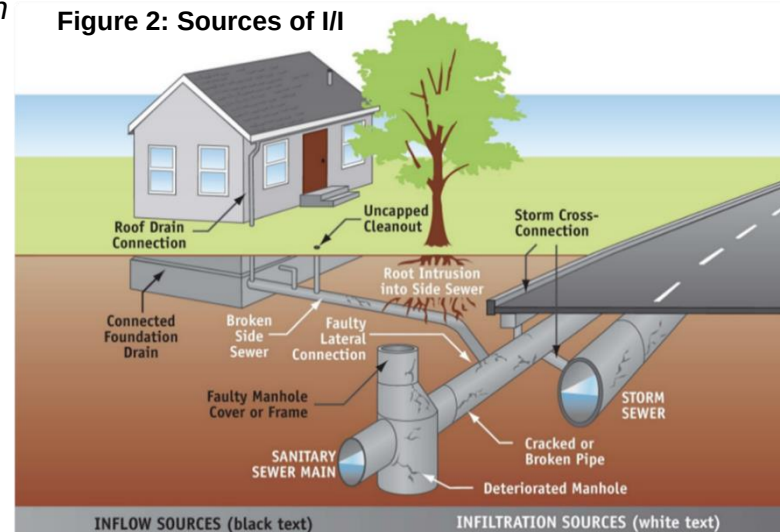
There are various ways that unwanted groundwater and stormwater can enter the sanitary system. Each type will result in a certain flow response, which can be captured by the in-system flow monitors. Furthermore, each type of source will warrant a different type of field investigation, to confirm the entry points of the I/I. Figure 2 presents a typical cross-section of common I/I sources.

Table 1: Inflow and Infiltration Sources

Source			Response	Field Investigation
Public	Infiltration	Defective Mainline Sewers	Slow	CCTV
		Defective Laterals	Slow	CCTV
		Defective Manholes	Slow	CCTV/Scan
	Inflow	Catch Basin Connections	Fast	Smoke/Dye Testing + CCTV to confirm
		Submerged Manhole Lids	Fast	Topography Review and/or Site Surveys
		Direct Stormwater/Sanitary Connections	Fast	Smoke/Dye Testing + CCTV to confirm
		¹ Indirect Stormwater/Sanitary Connections	Medium/Fast	Smoke/Dye Testing + CCTV to confirm
Private	Inflow	Downspout Connections	Fast	Smoke Testing + Site Surveys
	Infiltration	Weeping Tile Connections	Medium	Smoke Testing + Resident/House Surveys <i>*potentially confirmed through lateral CCTV</i>
		Defective Laterals	Slow	CCTV
Other	Defective Lateral Inspection Tees		Slow	Site Surveys
	Backflow from water bodies (streams, rivers)		N/A	Flow Data + Video

¹stormwater flowing from storm sewer to sanitary sewer through infrastructure defects (can appear like inflow if active for long periods of time)

Figure 2: Sources of I/I



1.4 Dain City Stormwater Risk Assessment (Wood, November 2020)

The Dain City Stormwater Risk Assessment (November 2020) was recently completed by Wood to assess the state and performance of the existing stormwater infrastructure and the overall stormwater drainage within the Dain City area.

Several future capital works were proposed to address the drainage system deficiencies and improve the resiliency to flooding, summarized below. These recommendations were taken into consideration when developing the I/I Remediation Action Plan for the sanitary system.

1. Construction of a new storm sewer system along Forks Road, between the Recreational Waterway and Crescent Drive (600 m +/-), including road reconstruction and grading improvement to the extent possible.
2. Construction of a new storm sewer system along James Street and Springfield Street to the north of Crescent drive (400 m +/-), including road reconstruction and grading improvements to the extent possible. In conjunction with these works, construct a storm sewer outlet along the pedestrian walkway to Logan Avenue, to connect to the proposed storm sewer on Forks Road (additional 200 m +/-).
3. Grading and drainage improvements in the rear yard areas of houses fronting on Stanley Street to improve conveyance and reduce surface ponding. These works could potentially be combined in conjunction with the more extensive works along the existing watercourse (Priority #4) or in conjunction with the planned re-development in this area.
4. Clean-out and rehabilitate the existing watercourse between Forks Road and the Kingsway (1,700 m +/-), including culvert crossings as required. Clean-out and re-grading of the storm sewer outfall area at the eastern end of Glenwood Park should be completed in conjunction with these works. These works may potentially be combined with the Stanley Street works (Priority #3).
5. Storm sewer and roadway reconstruction along Richmond Street as well as the section of storm sewer at the south limits of James Street through Glenwood Park (which could potentially be re-directed into the re-constructed Richmond Street trunk).

Of specific interest for this assignment is #1 and #2, presented in Figure 3. In addition to the above capital works, it was noted that considerations should be made for residential storm laterals where the new storm system is to be constructed, which would allow for possible disconnection of foundations from the sanitary system. The storm system should be sized accordingly, as discharging overland would present additional problems given that drainage is already an issue.



Figure 3: Stormwater Risk Assessment (WOOD, Nov 2020)

2 PHASED WORK PLAN

The workplan for this assignment was broken up into three phases.

2.1 Flow Monitoring Analysis

Flow monitoring data, collected as part of the City's existing Flow Monitoring Program, was utilized for this assignment. Short-term monitors were installed at various locations within the Dain City area to divide the system into small neighbourhood-level or street-level blocks, also referred to as Sewer System Evaluation Areas (SSEAs), which allows for area prioritization, characterization of the response to rain, and targeted I/I investigation.

The Flow Monitoring Analysis is provided in Appendix A.

2.2 Field Investigation

The recommendations from the flow monitoring analysis were carried out through various field investigations, including:

- a) Site Surveys
- b) Resident Survey
- c) Review CCTV Data and Videos (sanitary and storm)
- d) Smoke Testing

The data collected as part of the field investigations was reviewed and presented with maps and figures, and key observations/recommendations summarized.

The Field Investigation Work is provided in Appendix B.

2.3 Documentation of Findings and Summary of Recommendations

The findings from the flow monitoring analysis and field investigations were used to inform the development of the Remediation Action Plan, which is the focus of this document.

3 REMEDIATION ACTION PLAN

3.1 Development of the Remediation Action Plan

The Remediation Action Plan was developed using:

- the observations from the flow analysis,
- findings from the field investigations,
- recommendations from the Stormwater Risk Assessment Report, and
- assessing the stormwater and sanitary systems as one.

It is recommended that the Remediation Action Plan be implemented in three Phases, first focusing on and exhausting all opportunities for I/I reduction in the road right-of-way (i.e. public infrastructure) and “quick wins”.

It is not anticipated that Phase 1 will be enough to meet the City’s reduction targets and it is likely that Phase 2 will be required, which focuses on new stormwater infrastructure and rehabilitation of laterals. It should be noted that without a proper stormwater system in place, I/I reduction will be a chasing exercise with an outcome that will still likely require adequate storm infrastructure. Furthermore, a proper stormwater system will provide proper drainage to a very flat area, decreasing the risk of overland flooding as well.

Finally, if additional I/I reduction is required, a private-side foundation disconnection program should be considered (Phase 3).

3.1.1 Remedial Works and Follow-up Actions (Phase 1)

Phase 1 focuses primarily on I/I reduction opportunities within the road right-of-way, to ensure that the public infrastructure is in adequate condition.

- 1) Implement a rehabilitation program for sanitary sewers in poor condition, either spot repair or full-length liners. Figure 6 presents the assessment of the CCTV dataset and Table 2 summarizes 14 candidate sewers for rehabilitation considerations.
- 2) Collect condition data on all manholes in fair to poor SSEAs (orange and red polygons in Figure 11).
 - a. Assess data and develop rehabilitation plan.
 - b. Seal manholes that are likely contributing I/I, especially in low lying areas.
 - c. Note: infiltration observed in two manholes during smoke testing.
 - i. Manhole ID: 435600MH01
 - ii. Manhole ID: 435609MH02.

Table 2: Recommended Rehabilitation of Sanitary System (sewers)

City GIS Object ID (sewer layer)	DS Manhole	US Manhole	I/I related repairs	Recommendation
3874	435626MH01	435627MH01	Some infiltration runners at connections and a fracture worth repairing (MH sealing, 2 connection liners, Trenchless Full Length)	should repair
3875	435626MH01	435625MH01	Infiltration at connection and MH worth repairing (MH sealing, connection liner)	should repair
3841	435605MH01	425695MH01	Multiple gushers at connections, repair 5 (or all connections to be safe)	must repair
3858	435605MH01	435615MH01	Full length lining, connection or lateral liner	must repair
3898	435652MH02	435651MH01	Manhole sealing, no pipe work	must repair
2343	435604MH01	425694MH02	Spot repair at Fracture	must repair
3840	435604MH02	435604MH01	Connection liner at 11m	should repair
3886	435634MH01	435624MH01	Spot repair at beginning (grout)	must repair
3903	435654MH01	435664MH01	One fracture multiple and multiple open joints, worth repairing	should repair
3904	435664MH01	435674MH01	Infiltration runner in MH, pressure test and grout joints (joints look separated), no need for structural repair	should repair
3830	435538MH01	435539MH02	Trenchless Full Length, open joint, fracture multiple, SRI, active I/I	must repair
2333	425685MH01	425686MH01	Trenchless Full Length, multiple open joints, Fracture, active I/I	must repair
2342	425685MH02	425694MH01	Full Length Trenchless, appear to be multi defective joints (not coded)	should repair
2336	425686MH02	425687MH01	Trenchless Full Length, multiple open joints, active I/I	must repair

As part of Phase 1, it is recommended that the City also investigate the potential sources of inflow, as they could be considered “quick wins”. The locations for the Remedial Works (B) items are presented in Figure 8, Figure 9, and Figure 10.

- 3) Perform dye-testing of the catch basins along Regatta Street, which smoked during smoke testing, and disconnect if a direct connection to the sanitary system is found. If no direct connection is found, investigate potential for defective sanitary sewers and/or laterals crossing underneath defective stormwater sewers, a source of inflow found in other local area municipalities.
- 4) Investigate downspouts that smoked and disconnect if directly connected to the sanitary system; see Appendix B for addresses (section 3).
- 5) Investigate cleanouts that smoked, ensure they are in good condition and not an active source of I&I; repair as required. See Appendix B for addresses (section 3).
- 6) Investigate the following areas that smoked and disconnect if a connection to the sanitary system is found:
 - Drainage basin in backyard (90 James Street)
 - Smoke coming from deck (56 Erie Street)
 - Smoke from random pipe (124 Forks Road)
 - Lateral to empty lot, has gravel and clear flow (Manhole ID: 435519MH02)
 - Hole in ground smoking (362 Kingsway).

3.1.2 Remedial Works and Follow-up Actions (Phase 2)

It is believed that the lack of proper stormwater drainage is the greatest contributor to RDII in the sanitary system. The poor condition of the existing storm sewers (see Figure 7) is likely resulting in stormwater exfiltrating from the pipes into defective laterals or sanitary sewer trenches. Where there is a lack of stormwater infrastructure, shallow flat swales fill up and do not drain properly, likely resulting in rapid infiltration into laterals, sewer trenches, and inspection tees, something seen by GMBP in other municipalities.

- 7) Complete additional flow monitoring to enhance understanding of I&I within priority areas at the street-level; Figure 4 presents the proposed survey and additional details are provided in Appendix A. The analysis from this flow survey will be used to inform the remainder of the Phase 2 remedial works and follow-up actions
- 8) Expand on the proposed stormwater capital works from the Wood report – see Figure 5. In addition, it is recommended that:
 - a. Confirmation of property connections be acquired for all properties adjacent to new storm sewers and considerations be made for disconnection from sanitary system.
 - b. Rehabilitation/replacement needs of sanitary sewers adjacent to new storm sewers be reviewed prior to construction of storm works.

- 9) Collect lateral condition data on all laterals in poor SSEAs (red polygons in Figure 11). However, the final list of laterals to be included will be confirmed after the completion of the flow survey).
 - a. In addition to completing CCTV of the laterals, “wet CCTV” of the sanitary sewers and thermal string technology (captures change in water temperature along a sewer segment) can help identify leaky laterals.
 - b. Use the condition data and other information to prioritize laterals for rehabilitation; rehabilitation of laterals must include the entire lateral not just to property line.
 - c. Rehabilitation of laterals is an opportunity to replace/repair inspection tees, which may be contributing I&I.
 - d. Rehabilitation of laterals is an opportunity to work with homeowners on disconnecting foundations, while receiving a new lateral; public outreach and communication is critical to the success of such a program.

3.1.3 Remedial Works and Follow-up Actions (Phase 3)

After Phase 1 and Phase 2 are complete, it is recommended that a flow monitoring survey be completed to assess the effectiveness of the first two phases of the Remediation Action Plan. If additional reductions are still required to meet the I/I reduction objectives, it is recommended that the City focus its investigation and efforts on the private side and implement a private side disconnection program. This will require a feasibility study to:

- Identify where foundations are connected,
 - House Inspections
 - Lateral CCTV
 - “Wet CCTV” of Sanitary Sewer
 - Thermal String Technology in Sanitary Sewer
- Assess the benefits of disconnections,
- Quantify the costs associated with such a program,
- Develop communication material to provide the public,
- Develop a funding program.

The locations of potentially connected foundations were identified through the smoke testing and resident survey and are presented in Figure 8, Figure 9, and Figure 10; see Appendix B for addresses (section 3). It should be noted that a non-smoking property does not mean that it is disconnected; backwater valves, sump pumps filled with water, smoke hidden at the back of properties, and other barriers could have led to unobserved smoke. Furthermore, just because it smokes does not mean that it is connected; it must be confirmed through CCTV of lateral and/or house inspection.

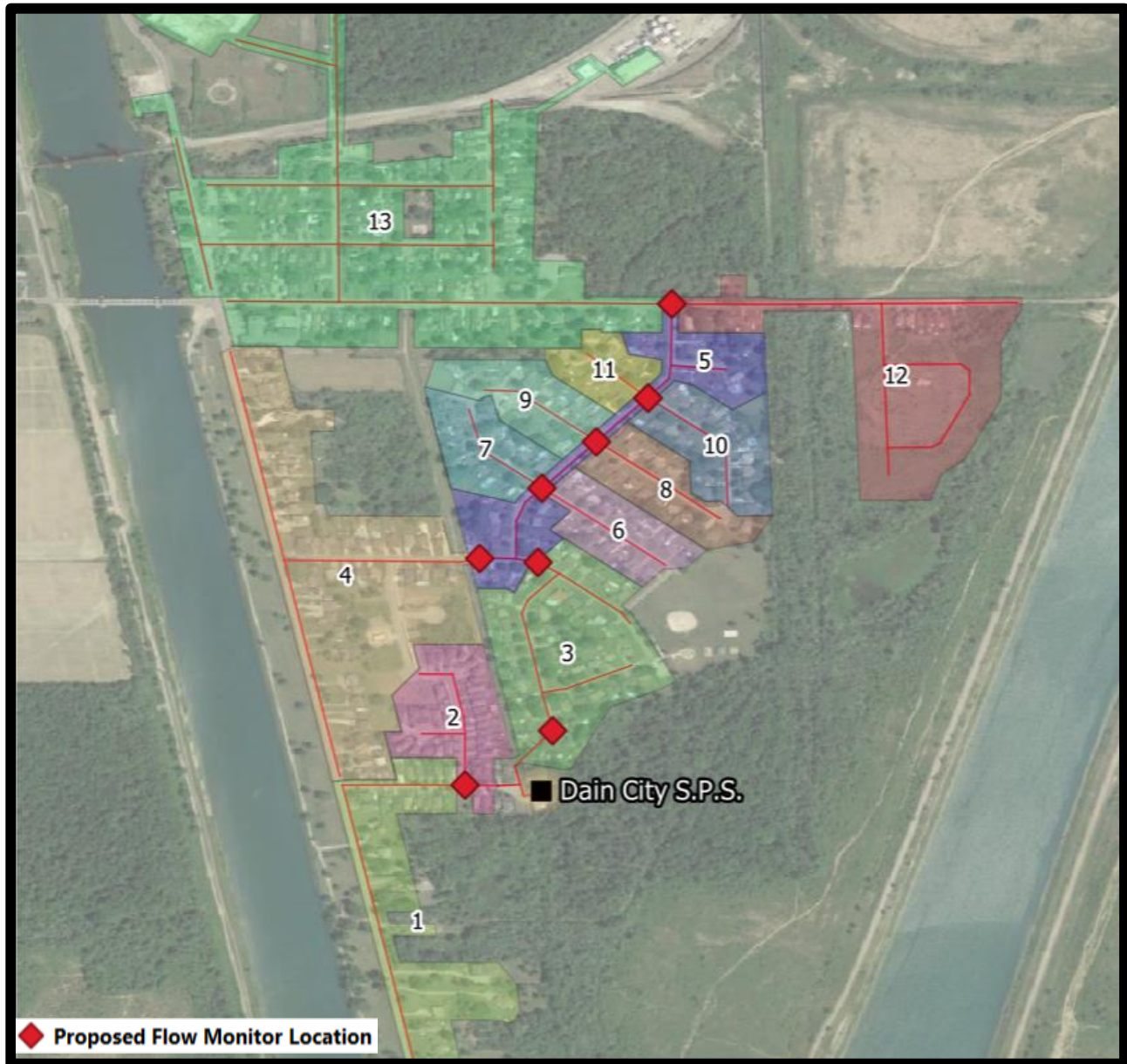


Figure 4: Proposed Flow Monitoring Survey

Figure 5 presents the three proposed stages of stormwater capital works, which will help with overall drainage in the high priority areas. Furthermore, these networks are generally within the areas with historical flooding and existing shallow flat swales that are not properly draining, thereby leading to infiltration through defective sanitary infrastructure.

- Stage 1 builds off the Wood report, which includes Forks Road, and James/Springfield (north of Crescent Drive)
- Stage 2 is primarily a replacement of existing stormwater sewers along Richmond and Springfield (South of Crescent Drive)
- Stage 3 is new stormwater infrastructure along Stanley Street, Thornton Avenue, and Glenwood Parkway

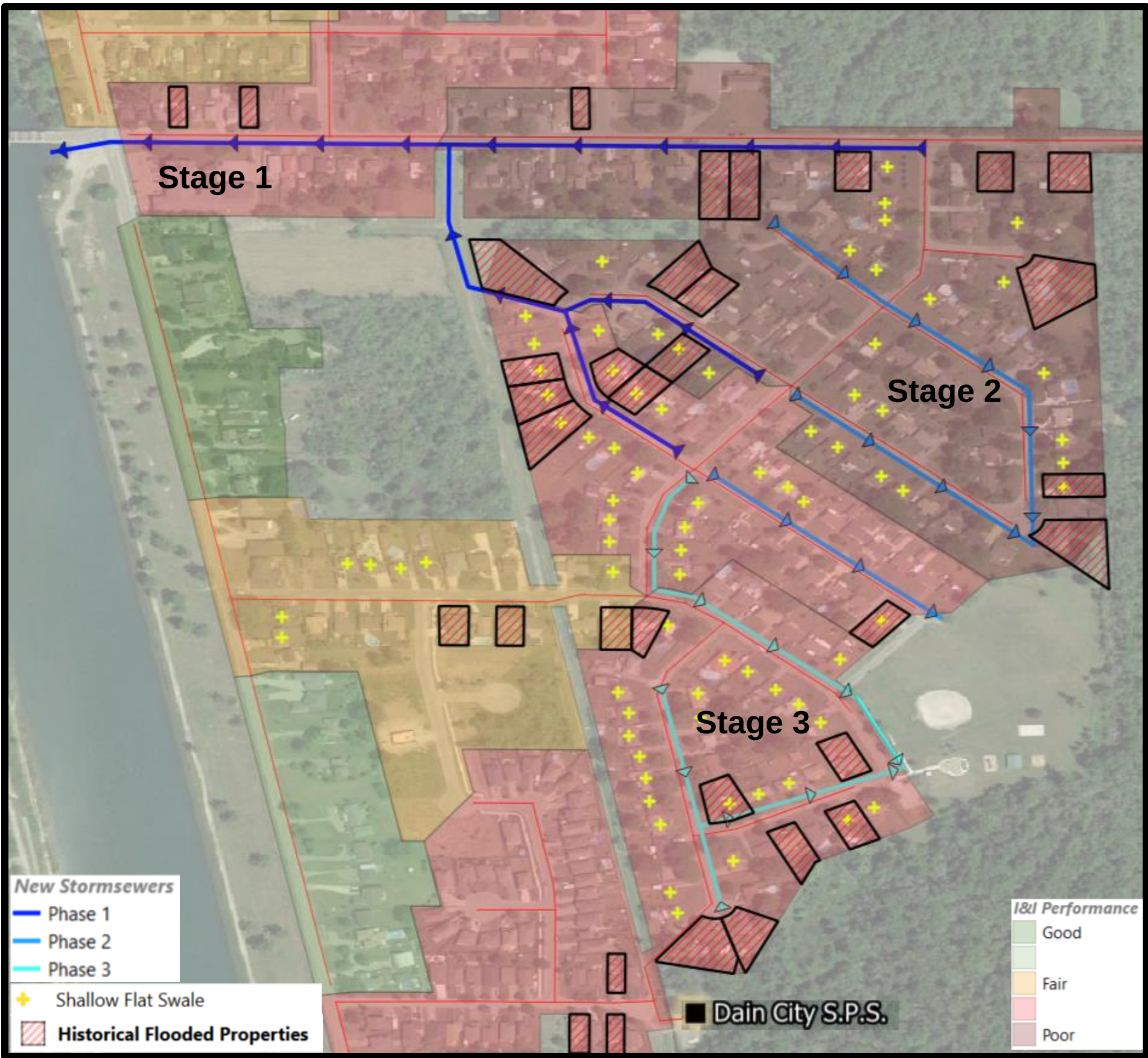


Figure 5: Recommended Stormwater Capital Works

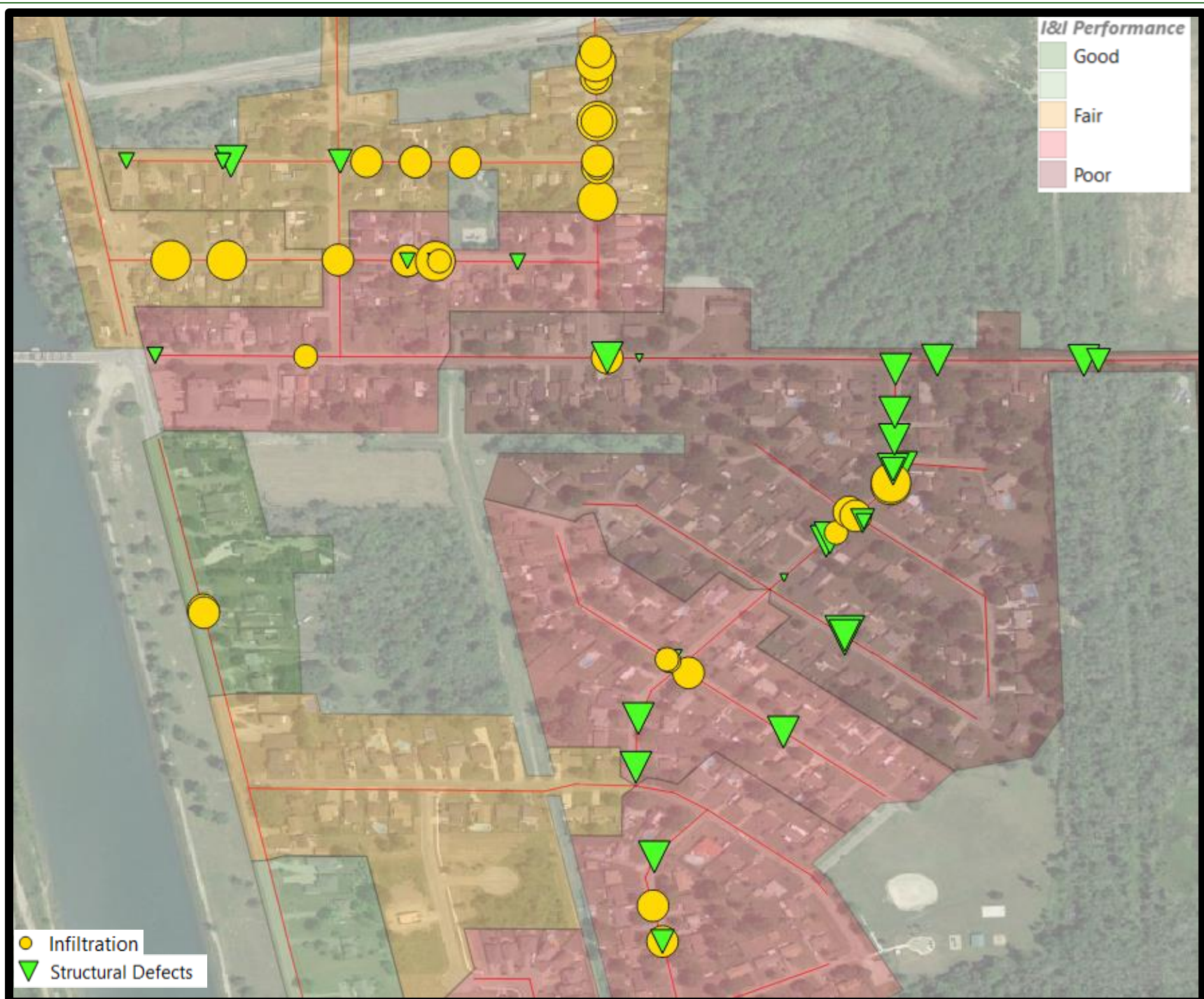


Figure 6: 2020 CCTV Survey for Sanitary Sewers

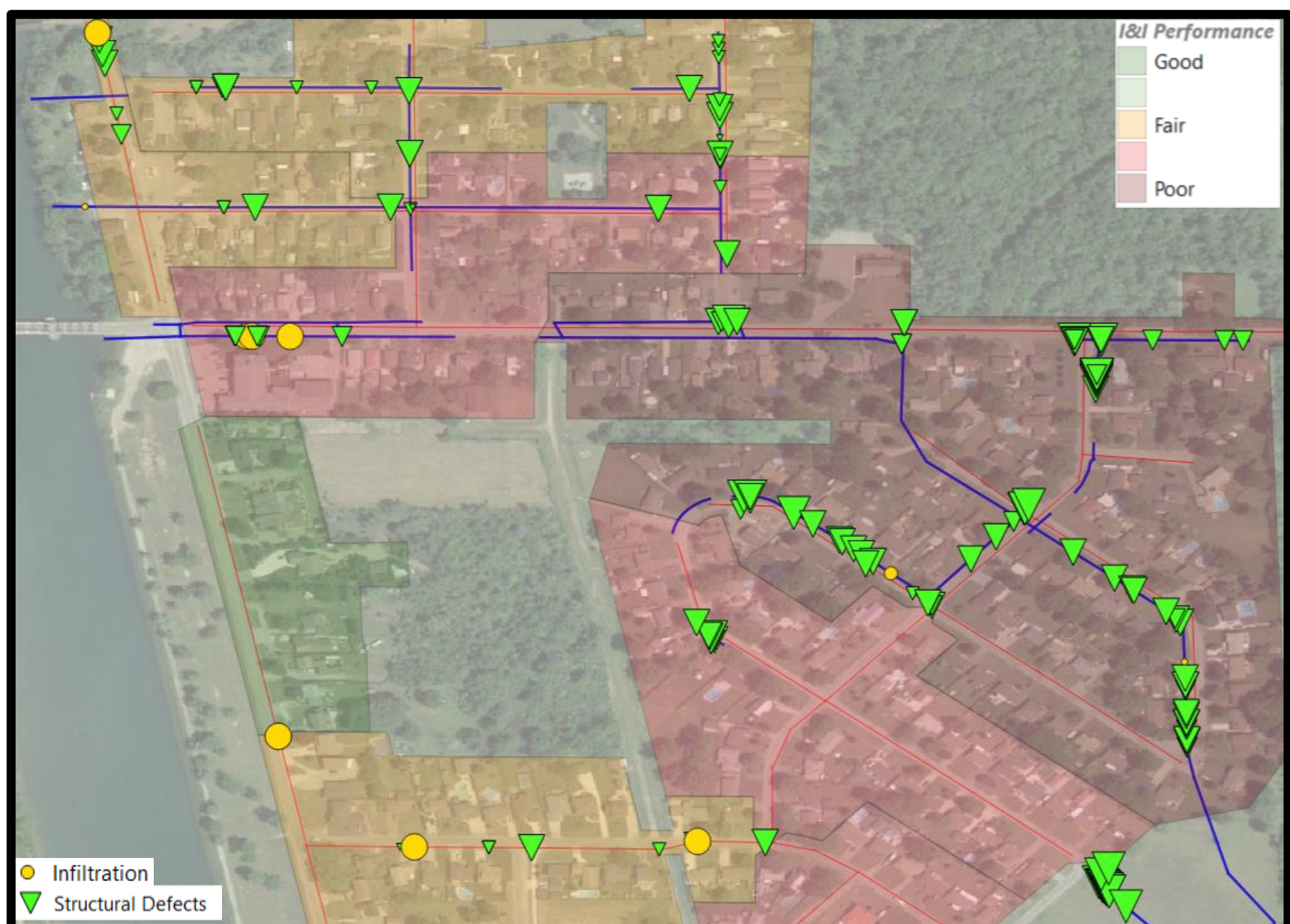


Figure 7: 2019 CCTV Survey for Storm Sewers

Special Notes

- 1) Infiltration runner in manhole benching (Manhole ID: 435609MH02)
- 2) Smoke coming from deck (56 Erie Street)
- 3) Smoke from random pipe (124 Forks Road)
- 4) Drainage basin identified in backyard from a resident (90 James Street)
- 5) Infiltration in manhole (Manhole ID: 435600MH01)
- 6) Lateral leading to empty lot, has gravel and clear flow (Manhole ID: 435519MH02)
- 7) Storm manhole smoking, in addition to the catch basins (Regatta Drive) (Figure 9)
- 8) Hole in ground smoking (362 Kingsway) (Figure 10)

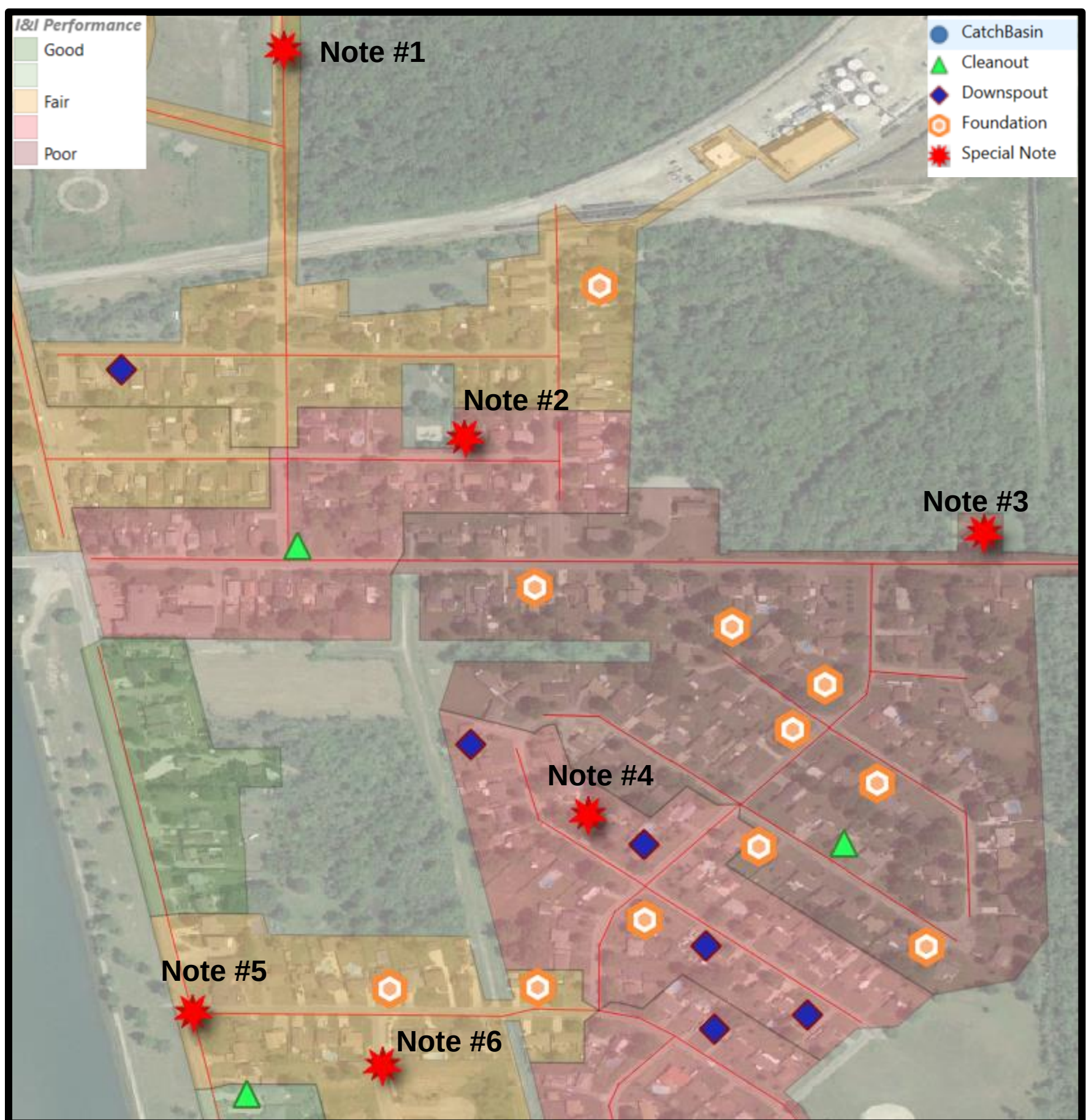


Figure 8: Smoke Testing Observations – North/Central

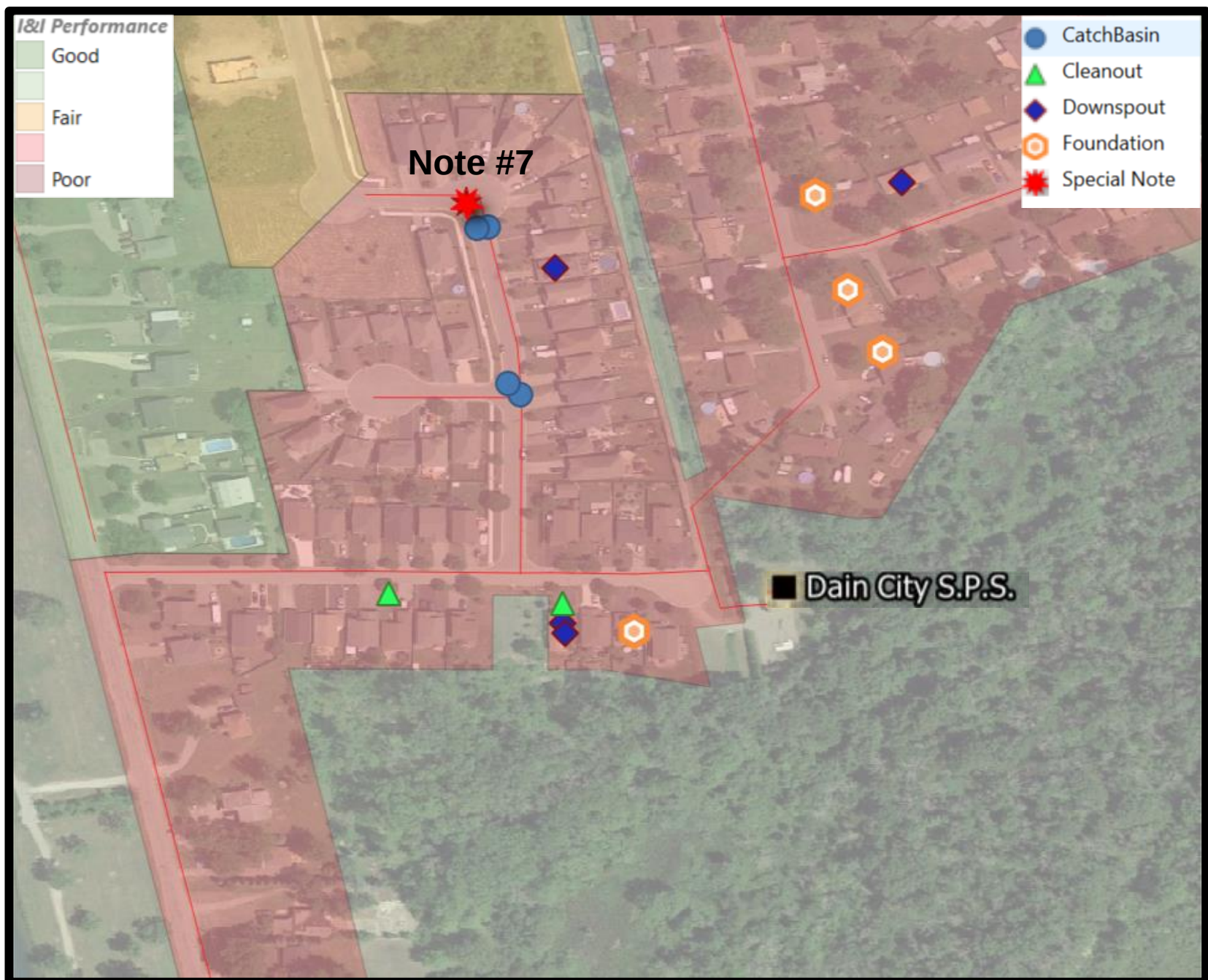


Figure 9: Smoke Testing Observations – Central

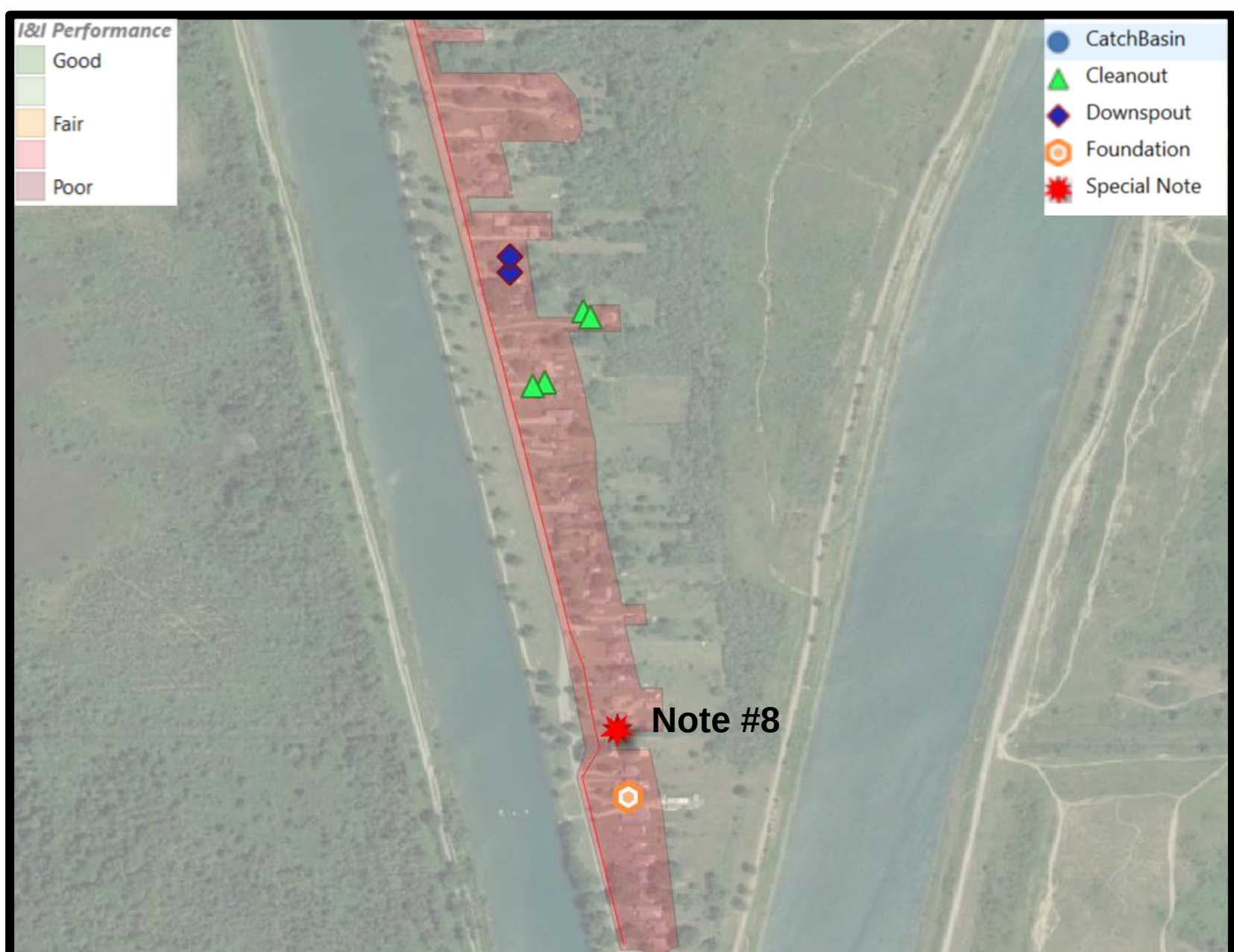


Figure 10: Smoke Testing Observations – South

3.2 Breakdown of RDII Contribution by SSEA

Figure 11 presents the estimated RDII contribution by SSEA based on the interpretation of the flow analysis results in Appendix A. This understanding of area based RDII contribution in conjunction with the field investigation output in Appendix B informed a high-level estimate of I/I reduction impact for each remedial action (Section 3.3).

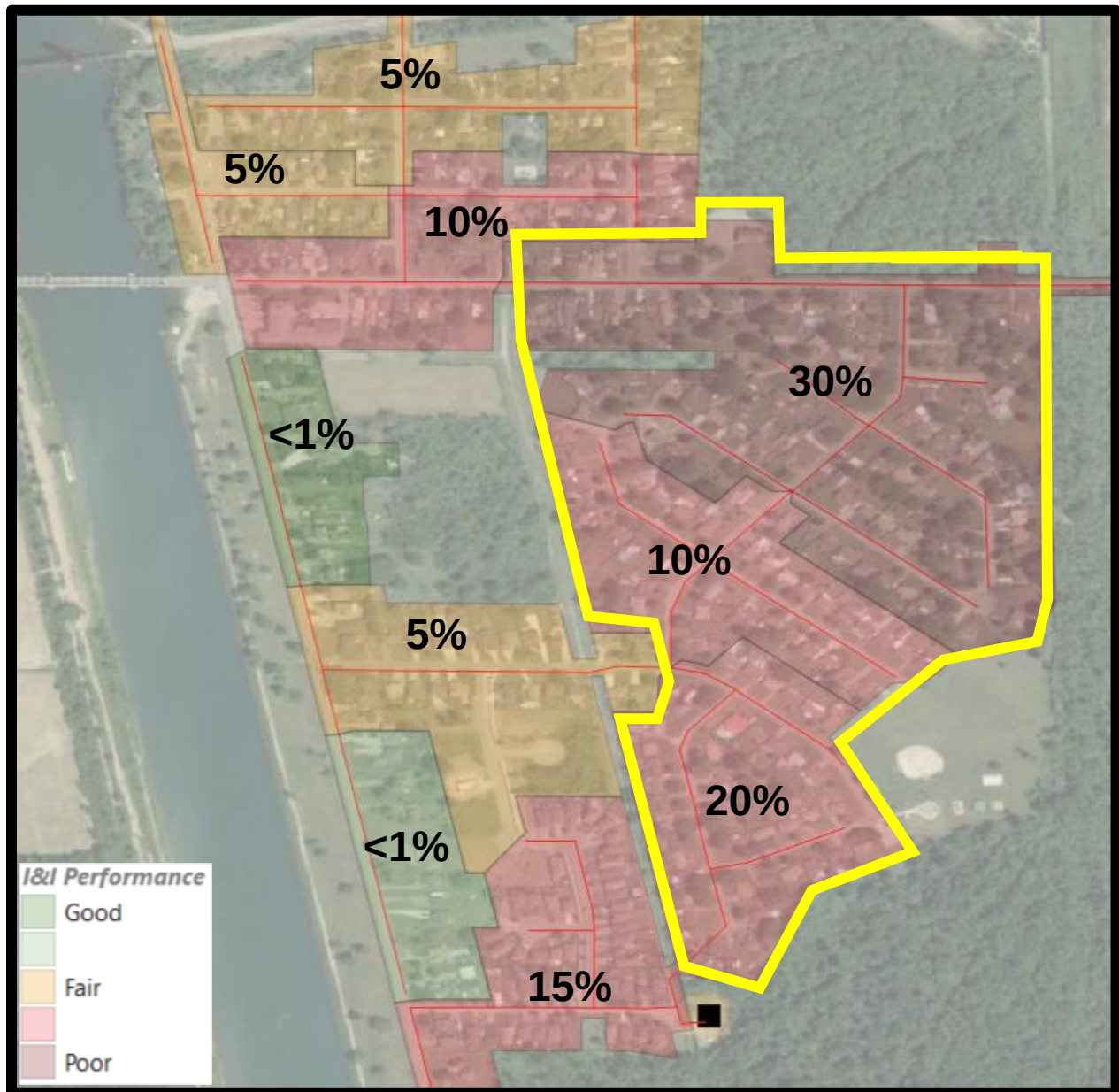


Figure 11: Overview of RDII Contribution by SSEA

3.3 Breakdown of I/I Sources

Based on the breakdown of RDII Contribution, the RTK Analysis, and the field investigation data, the following is the justification for the high-level estimates of remedial action impact on I/I reduction:

- Phase 1: more condition data is required; however, it does not appear as though rehabilitation of manholes and mainline sewers will result in greater than 20% reduction in system RDII. There are significant defects in the Bay-Erie area, however, this only accounts for 10% of the overall RDII Contribution.
- Phase 2: 60% of the RDII contribution is from areas with poor condition stormwater infrastructure, or a lack of stormwater infrastructure all together. These areas have shallow flat swales that do not drain and stormwater is likely infiltrating into poor condition laterals and sanitary trenches (see Yellow box in Figure 11).
- Phase 3: the remaining RDII is likely from foundation connections, however, further investigation would be required to identify exactly how many and where.

Note: the estimated RDII reduction should be revised once the additional investigations are complete and the additional data is assessed.

Table 3: Estimated RDII Reduction by Remediation Type

Phase	Remedial Action	Estimated Impact on I/I Reduction	Additional Investigation Required
Phase 1	Rehabilitation of Mainline Sanitary Sewers	10%	Review CCTV videos and develop program
	Rehabilitation of Sanitary Manholes	10%	Collect condition data, develop program, seal priority manholes
	Various Potential Sources of Inflow	5-15%	Confirmation of sources through dye testing, drawings, CCTV
Phase 2	Improve Drainage through new Storm Sewer Network	20-30%	▪ Considerations for adjacent foundation disconnections ▪ Considerations for rehabilitation of adjacent sanitary sewers
	Rehabilitation of Laterals	15-25%	Collect condition data, develop program, rehabilitate priority laterals ▪ Considerations for repair of inspection tees ▪ Considerations for property disconnection
Phase 3	Disconnection of Private Properties (foundations)	10-20%	*TBD after implementation of Phase 1 and Phase 2

3.4 Cost of Recommendations

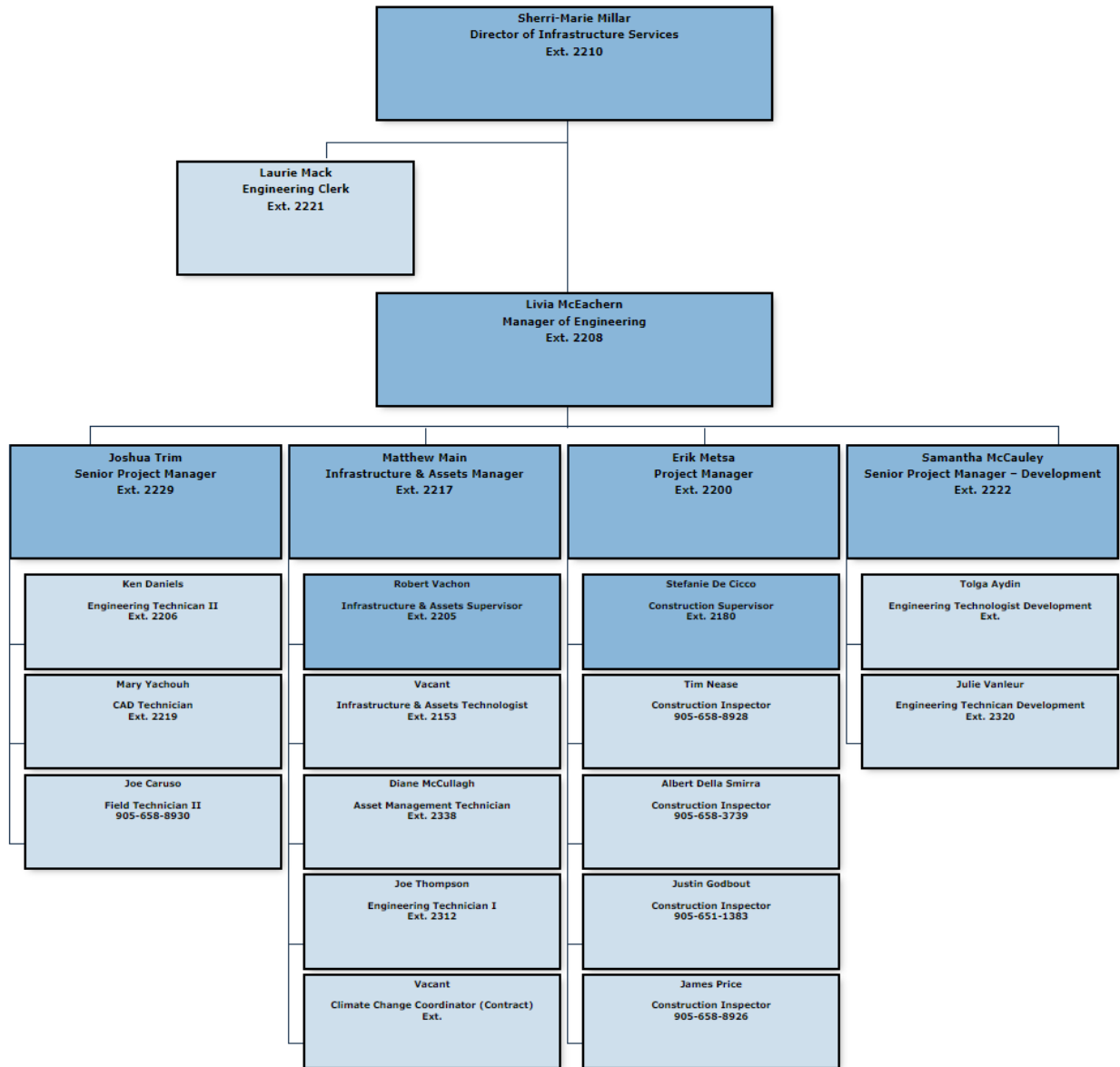
Table 4 is a preliminary cost estimate for the recommended Remediation Action Plan. Additional investigation is required prior to finalizing these costs as the rehabilitation work of lateral, manholes, and mainline sewers will depend on quantities, and the various potential sources of inflow require confirmation prior to determining a cost.

Note: the cost for the additional stormwater infrastructure (Stage 2 and Stage 3) were calculated using a unit cost from the Stage 1 plan in the Stormwater Risk Assessment Report. These costs will need to be revised once a conceptual design is complete, which is beyond the scope of work for this assignment.

Table 4: Preliminary Cost of Recommended Remediation Action Plan

	Remedial Action		Commentary	Cost (000s)
Phase 1	Rehabilitation of Sanitary Sewers	Rehabilitation Program	*pricing will depend on quantities put forth	\$250 - \$350
	Rehabilitation of Manholes	Data Collection + Program Development	130 manholes	\$50
		Sealing Program	*assumed 20 manholes	\$25
				\$325 - \$425
	Removal of Various Sources of Inflow	Investigation	*placeholder	\$10
		Removal	*placeholder	\$10 - 25
				\$20 - \$35
Total Phase 1				\$345 - \$460
Phase 2	Flow Monitor Survey	Data Analysis and Reporting	*data is collected as part of Flow Monitoring Program	\$10
				\$10
	New Storm Network	Stage 1 – 1,200m (existing recommendation)	Cost from Stormwater Risk Assessment Report	\$2,660
		Stage 2 – 900m (remaining Crescent Dr area)	*Calculated based on unit cost of Phase 1	\$1,800
		Stage 3 – 800m (Thornton Ave)	*Calculated based on unit cost of Phase 1	\$1,600
				\$6,060
	Rehabilitation of Laterals	Data Collection + Program Development	200 laterals in priority areas	\$50
		Lining Program	*assumed 50 laterals to be lined	\$75
				\$125
Total Phase 2				\$6,185
Phase 3	Private Side Disconnection Program	*from \$5,000 - \$15,000 per foundation depending on difficulty and available		TBD

APPENDIX K: Organizational Chart



Engineering Organizational Chart

APPENDIX L:

Project Costing Methodology

1. Project Costing

The cost estimation approach used for the MSP Update, uses a classification system to categorize different cost estimate classes. These classes represent different phases of planning and design, and subsequently different methods of cost estimation and levels of accuracy. This framework complements the generic approach developed by the Association of Advancement in Cost Estimating (AACE) International and has similarities to the Government of Canada (GOC) approach. For the purposes of the 2020 MSP Update it is expected that all the cost estimates will follow a Class 4 estimate; however, it is important to establish the level of accuracy that can be expected and as the project matures through planning to design, how the higher-class estimates refine the costs. Each of the key components is described below, including:

- Cost Estimate Classes
- Project Complexity
- Area Condition
- Estimate Accuracy Range
- Construction and Project Contingency
- Construction Provisional and Allowance
- Additional Costs

The unit costs and all the above components are contained in the 2020 MSP Update Capital Program spreadsheet which also include standard project details sheets. The spreadsheets are the working tool that brings all the cost components together to create a project cost estimate and are included in this Appendix.

1.1 Unit Rates

Suggested unit rates, detailed in **Section 1.8**, are based on supplier material costs, tender analysis, and historic project costs from multiple municipalities across southern Ontario. In this recommended approach the unit rates are the starting point or base for a cost estimate. Many other factors and criteria are applied to the unit rates. As such, caution is advised when comparing recommended unit rates in isolation with those used for previous studies. Only full and complete costs estimates should be compared.

1.2 Cost Estimate Classes

Table 1 provides a description of the proposed estimate classes and their end usage or deliverables.

Table 1: Cost Estimation Classes

Estimate Class	Estimate Class Description	End Usage / Major Deliverables
Class 4	Planning Cost Estimate	Infrastructure Planning/Master Planning. Justification for project planning funding. Minimum information requirements.
Class 3	Concept Design Cost Estimate	Basis for budgeting and approvals.
Class 2	Preliminary Design Cost Estimate	Used for project cost control during design; initial detailed estimate.
Class 1	Detailed Design Cost Estimate	Final cost review in preparation for construction; tender ready.

1.3 Project Complexity

Table 2 provides a general definition of project complexity.

Table 2: Project Complexity Descriptions

Project Complexity	Complexity Description
High Complexity	Projects with high cost, broad scope of work, multiple alternatives/alignments, etc.
Low Complexity	Projects with low cost, defined scope of work, few if any alternatives

1.4 Area Condition

Area Condition provides an allowance for the increased cost of constructing in built-up areas, applied to the base construction cost. **Table 3** below provides a general definition and the construction uplift cost percentage of the area condition.

Table 3: Area Condition Descriptions

Construction Environment	Environment Description	Construction Cost Uplift %
Rural	Greenfield construction with no environmental constraints	0%
Suburban	Developed built up environment	20%
Urban	Heavily developed built up environment – downtown area	30%

1.5 Estimated Accuracy Range

The accuracy range is defined by the cost estimate class and the project complexity. **Figure 1** shows how the estimate varies based on the two input criteria. The accuracy percentage applies to the total base cost plus all allowances and contingencies.

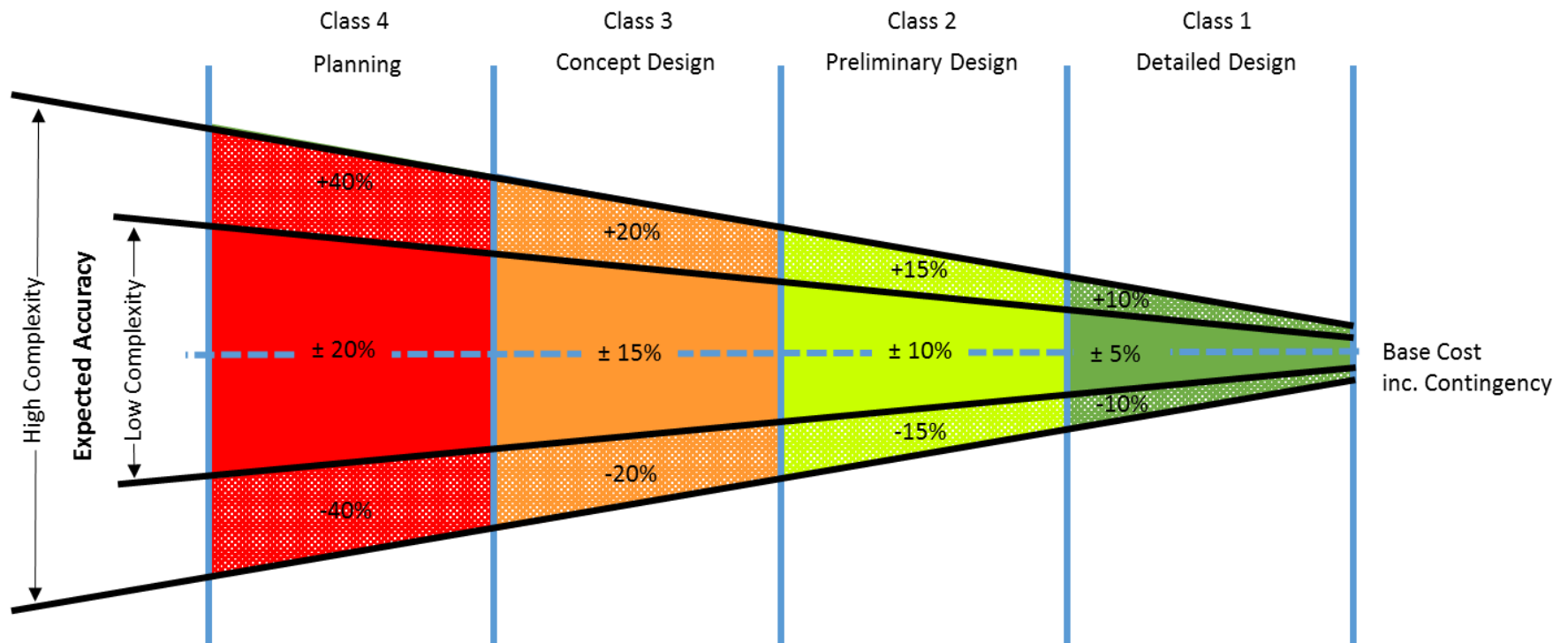


Figure 1: Cost Estimate Accuracy Ranges

An accuracy range is an acknowledgment that even with a formal cost estimation framework, and appropriate contingencies, actual costs may still vary because of 'unknown unknowns', such as changes in the economy or new future innovative technologies. These unknowns can just as easily result in a lower final cost as a higher one, even with the application of an appropriate contingency. A recent example is the value of the Canadian dollar. In 2013, the Canadian dollar was at par with the American dollar, and in 2018 it is \$0.77. If an American supplier is being used for the project, a final cost in 2020 will significantly vary from that estimated in 2013. This variance should not be associated with the contingency amount.

The accuracy range is not an additional contingency and should not be used for budgeting or funding purposes but rather be a representation of the level of confidence or vulnerability associated with a cost estimate (base + contingency). The concept of an accuracy range is that after the inclusion of an appropriate contingency, it is just as likely that the final cost will be below the estimate as above and it is therefore expected that the long-term aggregate of cost estimates (base + contingency), within each class, will balance out.

The accuracy range for each class is comprised of a high and low value to provide flexibility with respect to the project complexity and corresponding levels of cost estimating confidence.

In summary, as the class and project details increase (left to right in **Figure 1**), or as the project complexity decreases (top to bottom in **Figure 1**), the cost estimate is less vulnerable to 'unknown unknowns' and therefore the extent of the accuracy range will be narrower.

1.5.1 Construction and Project Contingency

There is a certain amount of risk and uncertainty associated with each class of cost estimation. The associated risk and uncertainty are minimized with the addition of a contingency.

Contingencies are an allowance for risks that are known or anticipated at early stages of the project definition, i.e. they represent probable events that are 'known unknowns' and experience has shown are likely to occur. They cannot be attributed to specific items in the base estimate but need to be considered in addition to the base cost. It should be noted that a project contingency does not cover changes in scope, which are dealt with on their own and should be defined in the project management plan.

Two types of contingency are recommended for use; construction contingency and project contingency.

1.5.2 Construction Contingency

Construction contingency is a percentage contingency amount applied to the base construction costs. It accounts for any additional construction costs not included in the unit rates, valves, and crossings. It includes Mobilization/Demobilization, connections, inspection, hydrants, signage, traffic management, bonding, and insurance. Construction contingency changes with project complexity, as follows:

- Low Complexity Construction Contingency: 10%
- High Complexity Construction Contingency: 20%

1.5.3 Project Contingency

Project contingency is a percentage applied to the entire project cost inclusive of all soft costs and fees. It accounts for any additional cost associated to any part of the project including soft cost such as consultant engineering and design, geotechnical and property costs. As such the project contingency changes with project complexity as well as project estimate class, as shown in **Figure 2**.

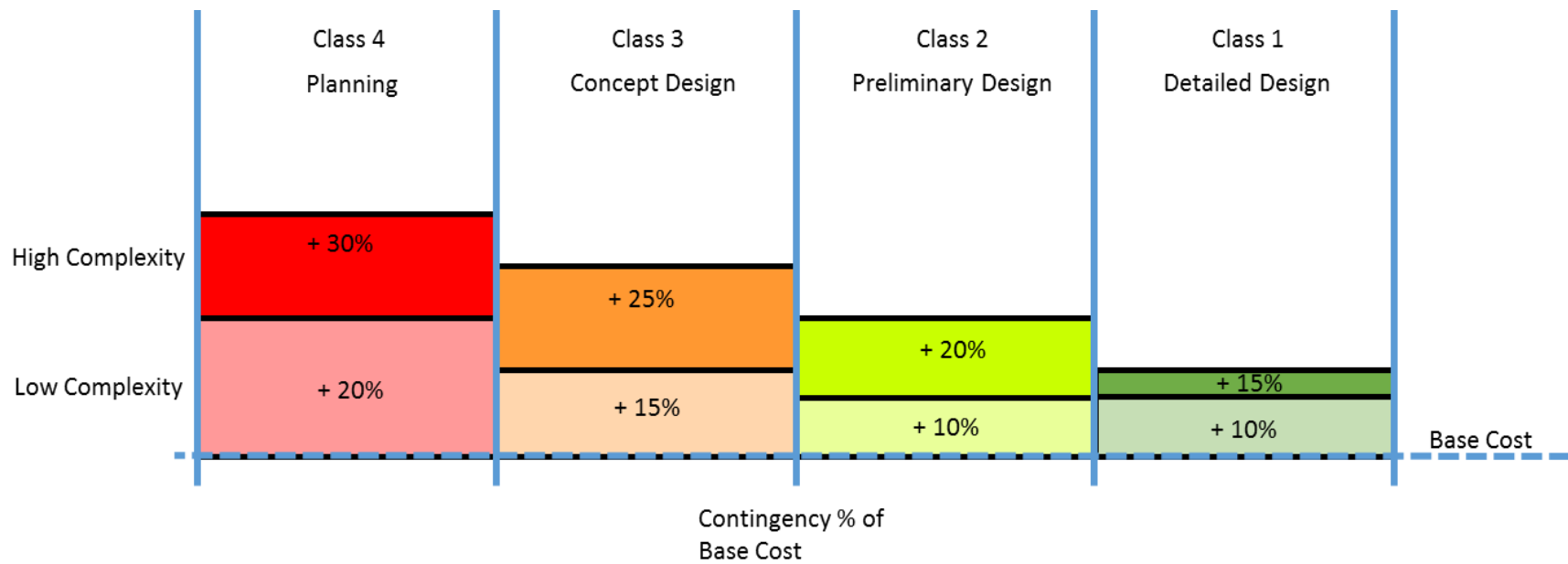


Figure 2: Cost Estimate Contingency Amounts

1.6 Construction Provisional and Allowance

It is recommended that a provisional amount be applied to the base construction costs in the event of increased construction labour and or material costs. Provisional Project Costs remain separate from the primary project cost but must be included for budgeting purposes.

Regardless of estimate class or project complexity it is recommended that 10% of the base construction cost is applied as a Provisional Allowance.

1.7 Additional Costs

Additional Costs capture all soft costs associated with the project. If available, actual quoted costs should be used. In the absence of actual costs, percentage amounts, applied to the base construction costs, are recommended. Such costs are related to project complexity and total project cost, as such percentages vary accordingly. **Table 4** shows the percentages to be applied for high and low complexity and different value projects.

Table 4: Additional Cost Components

Cost Component		High Complexity	Low Complexity
Geotechnical / Hydrogeological / Materials		2% of construction cost	0.5% of construction cost
Property Requirements (including property acquisition)		2% of construction cost	1% of construction cost
Consultant Engineering/Design	Total Construction Cost <\$10M	15% of construction cost	
	Total Construction Cost \$10M to \$50M	12% of construction cost	
	Total Construction Cost >\$50M	10% of construction cost	
In House Labour/Engineering / Wages/CA	Total Construction Cost <\$10M	8% of construction cost	
	Total Construction Cost \$10M to \$50M	6% of construction cost	
	Total Construction Cost >\$50M	4% of construction cost	
Non-refundable HST		1.76% of Total costs	

1.8 Unit Rates

Unit rates used in the capital plan are summarized in this section.

Appendix C Table 1: Trenchless construction unit rates for watermain or sanitary sewers

Diameter	Total Unit Cost	Diameter	Total Unit Cost	Diameter	Total Unit Cost
(mm)	(\$/m)	(mm)	(\$/m)	(mm)	(\$/m)
150	\$1,300	500	\$6,450	1200	\$10,600
200	\$1,350	525	\$6,500	1350	\$11,500
250	\$1,400	600	\$8,000	1500	\$12,000
300	\$1,450	675	\$8,100	1650	\$12,500
325	\$1,500	750	\$8,200	1800	\$13,000
350	\$1,550	825	\$9,800	2100	\$14,000
375	\$6,300	900	\$10,000	2400	\$14,500
400	\$6,350	975	\$10,200	3000	\$16,000
450	\$6,400	1050	\$10,400		

Anticipated trenchless methodology is as follows:

- 1350 mm – 3000 mm: Microtunnel or TBM
- 825 mm – 1200 mm: Microtunnel, Auger Boring, Guided Auger Boring
- 375 mm – 750 mm: Axis Guided Boring, Auger Boring, Guided Auger Boring
- 150 mm – 350 mm: Axis Guided Boring, Horizontal Directional Drilling

Note: Trenchless Cost estimate table provides estimated high level cost for tunnelling, pipe installation and shafts for ranges of diameter. Tunnelling project costs can vary widely depending on project details that are not fully known at the Master Plan / DC stage (e.g., number of shafts, subsurface conditions, site conditions, contractor preferred tunnelling method, depth, location (urban, greenfield) etc.).

Appendix C Table 2: Facilities

Facility	Total Unit Cost	Unit
Reservoirs - New Construction	\$900,000	(\$/ML)
New Water / Sewage Pumping Stations ≤ 150 L/s	\$23,000	(\$/L/s)
New Water / Sewage Pumping Stations > 150 L/s ≤ 600 L/s	\$13,000	(\$/L/s)
New Water / Sewage Pumping Stations > 600 L/s	\$11,000	(\$/L/s)

Notes: Unit rate is intended to provide the base construction cost for a basic pumping facility. These costs are not assumed to account for force mains (for WWPS) or overflow storage tanks (WWPS) or unique items such as deep wet wells (WWPS), extensive architectural features or extensive site works.

Appendix C Table 3: Sanitary sewer unit rates for 5-meter deep open cut construction

Diameter	Excavation			Granular Bedding			Pipe			Backfill			Subtotal Unit Cost	Restoration (2020 \$)	Manhole Allowance	Total Unit Cost
	Volume	Cost	Unit Cost	Volume	Cost	Unit Cost	Supply Cost	Installation (2020 \$)	Pipe Supply +Install	Vol	Cost	Unit Cost				
(mm)	(m3/m)	(\$/m3)	(\$/m)	(m3/m)	(\$/m3)	(\$/m)	(\$/m)	(\$/m)	(\$/m)	(m3/m)	(\$/m3)	(\$/m)	(\$/m)	(\$/m)	(\$/m)	(2020\$/m)
300	5.0	32	\$ 160	1.0	67.2	\$ 67	\$ 95	\$ 48	\$ 143	4.0	14	\$ 56	\$ 427	\$ 115	\$ 110	\$ 651
375	5.5	32	\$ 176	1.0	67.2	\$ 67	\$ 117	\$ 48	\$ 165	4.5	14	\$ 63	\$ 472	\$ 115	\$ 110	\$ 697
450	6.0	32	\$ 192	1.1	67.2	\$ 74	\$ 151	\$ 48	\$ 199	4.9	14	\$ 69	\$ 534	\$ 116	\$ 110	\$ 760
525	6.5	32	\$ 208	1.2	67	\$ 81	\$ 182	\$ 48	\$ 230	5.3	14	\$ 75	\$ 593	\$ 117	\$ 110	\$ 820
600	7.0	32	\$ 224	1.4	67	\$ 94	\$ 240	\$ 48	\$ 288	5.6	14	\$ 79	\$ 684	\$ 117	\$ 250	\$ 1,052
675	8.5	32	\$ 272	1.9	67	\$ 128	\$ 363	\$ 57	\$ 420	6.6	14	\$ 93	\$ 912	\$ 132	\$ 250	\$ 1,295
750	9.0	32	\$ 288	2.0	67	\$ 134	\$ 479	\$ 57	\$ 536	7.0	14	\$ 98	\$ 1,057	\$ 134	\$ 250	\$ 1,440
825	9.5	32	\$ 304	2.2	67	\$ 148	\$ 556	\$ 57	\$ 613	7.3	14	\$ 103	\$ 1,167	\$ 135	\$ 250	\$ 1,552
900	9.5	32	\$ 304	2.4	67.2	\$ 161	\$ 666	\$ 57	\$ 723	7.1	14	\$ 100	\$ 1,289	\$ 136	\$ 400	\$ 1,824
975	10.0	32	\$ 320	2.5	67.2	\$ 168	\$ 767	\$ 57	\$ 824	7.5	14	\$ 105	\$ 1,418	\$ 150	\$ 400	\$ 1,968
1050	11.5	32	\$ 368	3.1	67	\$ 208	\$ 878	\$ 57	\$ 935	8.4	14	\$ 118	\$ 1,629	\$ 151	\$ 400	\$ 2,181
1200	12.5	32	\$ 400	3.4	67	\$ 228	\$ 1,100	\$ 57	\$ 1,157	9.1	14	\$ 128	\$ 1,913	\$ 153	\$ 400	\$ 2,467
1350	13.5	32	\$ 432	3.9	67	\$ 262	\$ 1,413	\$ 64	\$ 1,477	9.6	14	\$ 135	\$ 2,306	\$ 156	\$ 333	\$ 2,795
1500	14.0	32	\$ 448	4.2	67	\$ 282	\$ 1,729	\$ 64	\$ 1,794	9.8	14	\$ 138	\$ 2,662	\$ 171	\$ 333	\$ 3,166
1800	16.0	32	\$ 512	5.1	67	\$ 343	\$ 2,504	\$ 64	\$ 2,568	10.9	14	\$ 153	\$ 3,576	\$ 176	\$ 333	\$ 4,085
2100	17.5	32	\$ 560	6.0	67	\$ 403	\$ 3,328	\$ 64	\$ 3,393	11.5	14	\$ 162	\$ 4,517	\$ 179	\$ 400	\$ 5,097
2400	19.5	32	\$ 624	7.0	67	\$ 470	\$ 4,427	\$ 64	\$ 4,491	12.5	14	\$ 176	\$ 5,761	\$ 184	\$ 400	\$ 6,345
3000	23.0	32	\$ 736	9.0	67	\$ 605	\$ 6,783	\$ 64	\$ 6,848	14.0	14	\$ 197	\$ 8,385	\$ 192	\$ 400	\$ 8,977

Appendix C Table 4: Sanitary sewer unit rates for 10-meter deep open cut construction

Diameter	Excavation			Granular Bedding			Pipe			Backfill			Subtotal Unit Cost	Restoration (2020 \$)	Manhole Allowance	Total Unit Cost
	Volume	Cost	Unit Cost	Volume	Cost	Unit Cost	Supply Cost	Installation (2020 \$)	Pipe Supply +Install	Vol	Cost	Unit Cost				
(mm)	(m3/m)	(\$/m3)	(\$/m)	(m3/m)	(\$/m3)	(\$/m)	(\$/m)	(\$/m)	(\$/m)	(m3/m)	(\$/m3)	(\$/m)	(\$/m)	(\$/m)	(\$/m)	(2020\$/m)
300	35.0	45	\$ 1,575	1.0	67.2	\$ 67	\$ 95	\$ 48	\$ 143	34.0	14	\$ 478	\$ 2,263	\$ 211	\$ 200	\$ 2,674
375	36.0	45	\$ 1,620	1.0	67.2	\$ 67	\$ 117	\$ 48	\$ 165	35.0	14	\$ 492	\$ 2,345	\$ 211	\$ 200	\$ 2,756
450	37.0	45	\$ 1,665	1.1	67.2	\$ 74	\$ 151	\$ 48	\$ 199	35.9	14	\$ 505	\$ 2,443	\$ 217	\$ 200	\$ 2,860
525	38.0	45	\$ 1,710	1.2	67.2	\$ 81	\$ 182	\$ 48	\$ 230	36.8	14	\$ 517	\$ 2,538	\$ 217	\$ 200	\$ 2,955
600	39.0	45	\$ 1,755	1.4	67	\$ 94	\$ 240	\$ 48	\$ 288	37.6	14	\$ 529	\$ 2,665	\$ 219	\$ 350	\$ 3,234
675	42.0	45	\$ 1,890	1.9	67	\$ 128	\$ 363	\$ 57	\$ 420	40.1	14	\$ 564	\$ 3,001	\$ 221	\$ 350	\$ 3,573
750	43.0	45	\$ 1,935	2.0	67	\$ 134	\$ 479	\$ 57	\$ 536	41.0	14	\$ 576	\$ 3,182	\$ 225	\$ 350	\$ 3,757
825	44.0	45	\$ 1,980	2.2	67	\$ 148	\$ 556	\$ 57	\$ 613	41.8	14	\$ 588	\$ 3,328	\$ 233	\$ 350	\$ 3,912
900	44.0	45	\$ 1,980	2.4	67	\$ 161	\$ 666	\$ 57	\$ 723	41.6	14	\$ 585	\$ 3,450	\$ 236	\$ 600	\$ 4,285
975	45.0	45	\$ 2,025	2.5	67.2	\$ 168	\$ 767	\$ 57	\$ 824	42.5	14	\$ 598	\$ 3,615	\$ 238	\$ 600	\$ 4,453
1050	48.0	45	\$ 2,160	3.1	67.2	\$ 208	\$ 878	\$ 57	\$ 935	44.9	14	\$ 631	\$ 3,935	\$ 241	\$ 600	\$ 4,776
1200	50.0	45	\$ 2,250	3.4	67	\$ 228	\$ 1,100	\$ 57	\$ 1,157	46.6	14	\$ 655	\$ 4,291	\$ 244	\$ 600	\$ 5,134
1350	52.0	45	\$ 2,340	3.9	67	\$ 262	\$ 1,413	\$ 64	\$ 1,477	48.1	14	\$ 676	\$ 4,755	\$ 244	\$ 567	\$ 5,566
1500	53.0	45	\$ 2,385	4.2	67	\$ 282	\$ 1,729	\$ 64	\$ 1,794	48.8	14	\$ 686	\$ 5,147	\$ 244	\$ 567	\$ 5,957
1800	57.0	45	\$ 2,565	5.1	67	\$ 343	\$ 2,504	\$ 64	\$ 2,568	51.9	14	\$ 730	\$ 6,205	\$ 252	\$ 567	\$ 7,024
2100	60.0	45	\$ 2,700	6.0	67	\$ 403	\$ 3,328	\$ 64	\$ 3,393	54.0	14	\$ 759	\$ 7,255	\$ 266	\$ 733	\$ 8,254
2400	64.0	45	\$ 2,880	7.0	67	\$ 470	\$ 4,427	\$ 64	\$ 4,491	57.0	14	\$ 801	\$ 8,643	\$ 274	\$ 733	\$ 9,651
3000	71.0	45	\$ 3,195	9.0	67	\$ 605	\$ 6,783	\$ 64	\$ 6,848	62.0	14	\$ 872	\$ 11,519	\$ 295	\$ 733	\$ 12,548

Appendix C Table 5: Watermain and forcemain unit rates for open cut construction

Diameter	Excavation			Granular Bedding			Pipe			Backfill			Subtotal Unit Cost	Restoration (2020 \$)	Total Unit Cost
	Volume	Cost	Unit Cost	Volume	Cost	Unit Cost	Supply Cost	Installation (2020 \$)	Pipe Supply +Install	Volume	Cost	Unit Cost			
(mm)	(m3/m)	(\$/m3)	(\$/m)	(m3/m)	(\$/m3)	(\$/m)	(\$/m)	(\$/m)	(\$/m)	(m3/m)	(\$/m3)	(\$/m)	(\$/m)	(\$/m)	(\$/m)
150	2.3	32	\$ 72	1.0	67	\$ 67	\$ 227	\$ 59	\$ 285	1.3	14	\$ 18	\$ 442	\$ 115	\$ 557
200	3.3	32	\$ 104	1.0	67	\$ 67	\$ 227	\$ 60	\$ 287	2.3	14	\$ 32	\$ 489	\$ 115	\$ 604
250	4.3	32	\$ 136	1.1	67	\$ 74	\$ 227	\$ 61	\$ 288	3.2	14	\$ 44	\$ 542	\$ 115	\$ 657
300	5.3	32	\$ 168	1.2	67	\$ 81	\$ 227	\$ 62	\$ 289	4.1	14	\$ 57	\$ 594	\$ 115	\$ 709
350	5.3	32	\$ 168	1.4	67	\$ 94	\$ 312	\$ 62	\$ 374	3.9	14	\$ 54	\$ 690	\$ 115	\$ 805
400	5.3	32	\$ 168	1.9	67	\$ 128	\$ 352	\$ 62	\$ 414	3.4	14	\$ 47	\$ 757	\$ 116	\$ 873
450	5.3	32	\$ 168	2.0	67	\$ 134	\$ 438	\$ 62	\$ 500	3.3	14	\$ 46	\$ 848	\$ 116	\$ 964
500	6.3	32	\$ 202	2.2	67	\$ 148	\$ 550	\$ 62	\$ 612	4.1	14	\$ 58	\$ 1,019	\$ 117	\$ 1,136
600	6.3	32	\$ 202	2.4	67	\$ 161	\$ 626	\$ 176	\$ 802	3.9	14	\$ 55	\$ 1,220	\$ 117	\$ 1,337
750	8.9	32	\$ 286	2.5	67	\$ 168	\$ 680	\$ 176	\$ 856	6.4	14	\$ 90	\$ 1,399	\$ 134	\$ 1,533
900	13.3	32	\$ 426	3.1	67	\$ 208	\$ 733	\$ 176	\$ 909	10.2	14	\$ 143	\$ 1,686	\$ 136	\$ 1,822
1050	14.4	32	\$ 461	3.4	67	\$ 228	\$ 940	\$ 205	\$ 1,145	11.0	14	\$ 155	\$ 1,990	\$ 151	\$ 2,141
1200	16.9	32	\$ 542	3.9	67	\$ 262	\$ 1,148	\$ 239	\$ 1,387	13.0	14	\$ 183	\$ 2,374	\$ 153	\$ 2,528
1350	20.6	32	\$ 660	4.2	67	\$ 282	\$ 1,418	\$ 328	\$ 1,747	16.4	14	\$ 231	\$ 2,920	\$ 156	\$ 3,076
1500	22.1	32	\$ 706	3.1	67	\$ 207	\$ 1,689	\$ 376	\$ 2,065	19.0	14	\$ 267	\$ 3,245	\$ 171	\$ 3,416
1650	23.6	32	\$ 756	5.1	67	\$ 343	\$ 2,024	\$ 411	\$ 2,435	18.5	14	\$ 260	\$ 3,794	\$ 171	\$ 3,966
1800	27.6	32	\$ 882	3.5	67	\$ 233	\$ 2,359	\$ 431	\$ 2,790	24.1	14	\$ 339	\$ 4,244	\$ 176	\$ 4,419
2100	30.6	32	\$ 980	6.0	67	\$ 403	\$ 2,658	\$ 431	\$ 3,090	24.6	14	\$ 346	\$ 4,819	\$ 179	\$ 4,998