UTILITIES KINGSTON

CITY OF KINGSTON WASTEWATER MASTER PLAN

POLLUTION PREVENTION AND CONTROL PLAN UPDATE

FEBRUARY 2017

WSP

CITY OF KINGSTON WASTEWATER MASTER PLAN

POLLUTION PREVENTION AND CONTROL PLAN UPDATE

UTILITIES KINGSTON

Prepared for:
Utilities Kingston

Final Report

Project nº : 151-02944-00
Date : February, 2017

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WSP

February, 2017

Mr. Mike Fischer
Client Name
1211 John Counter Blvd
Kingston, ON, K7L 4X7

Subject : **City of Kingston Wastewater Master Plan: Pollution Prevention and Control Plan Update**

Dear Mr. Fischer:

We are pleased to provide our draft of the Pollution Prevention and Control Plan update for the City of Kingston. The purpose of this report is to provide a summary of past updates and works detailing pollution prevention control for the City in accordance with the Ministry of Environment and Climate Change Procedure F-5-5. The update includes a review of past updates and current programs and policies carried out by the City and Utilities Kingston in the efforts of preventing, controlling and reducing pollution into Lake Ontario and immediate receivers.

Details incorporated in this update use information compiled from the 2015 Master Plan technical memorandums and includes an analysis of Combined Sewers Overflows and site-specific recommendations reflecting best management practices towards pollution mitigation for the Kingston Central Collection System.

We would be happy to discuss this report with you at your convenience.

Yours truly,

Matt Morkem, P. Eng
Manager, Infrastructure, Kingston

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REVISION HISTORY

VERSION	DATE	DESCRIPTION
1	12/15/2016	Draft Report
2	01/25/2016	Draft Report
3	02/15/2017	Final Report

SIGNATURES

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1 INTRODUCTION

The City of Kingston (City) with a population of approximately 123,363 people (2011 Census) is serviced by a network of sanitary, storm and combined sewers. As part of an Ontario practice to effective wastewater management a Pollution Prevention and Control Plan (PPCP) is developed and is carried out with the intention to safeguard public health & safety and to follow best practices prescribed by the Ministry of Environment and Climate Change (MOECC) Procedure F-5-5. PPCPs have been created for the City since 1992 and have evolved over the years to include various policy and programs. PPCP updates outline the necessary capital improvements to service the City's growth and adopted goals for Combined Sewer Overflow (CSO) management.

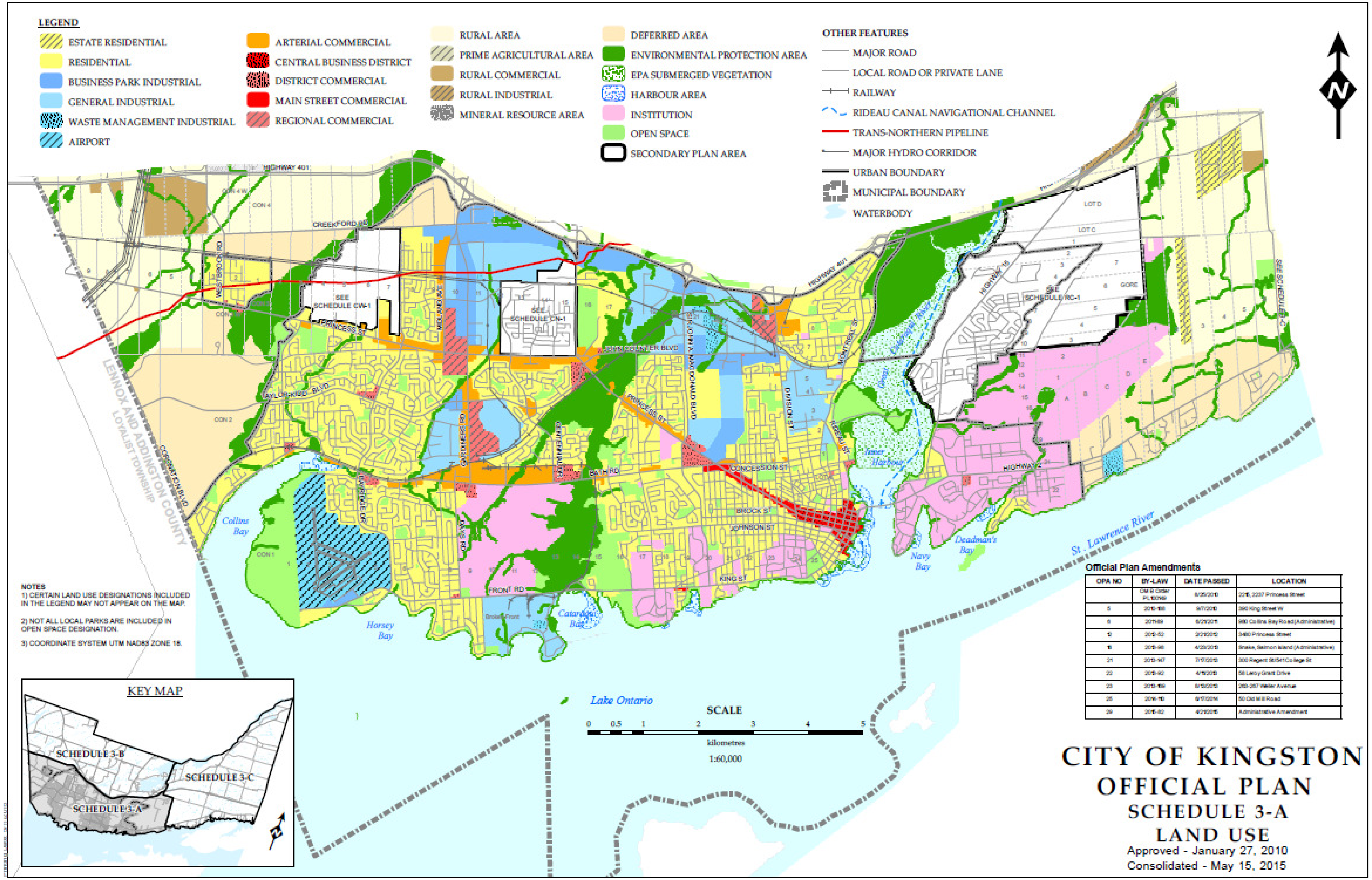
This PPCP plan is an update to the 2010 PPCP Update (CH2MHill) and is prepared for Utilities Kingston (UK) as part of the 2015 Wastewater Master Plan.

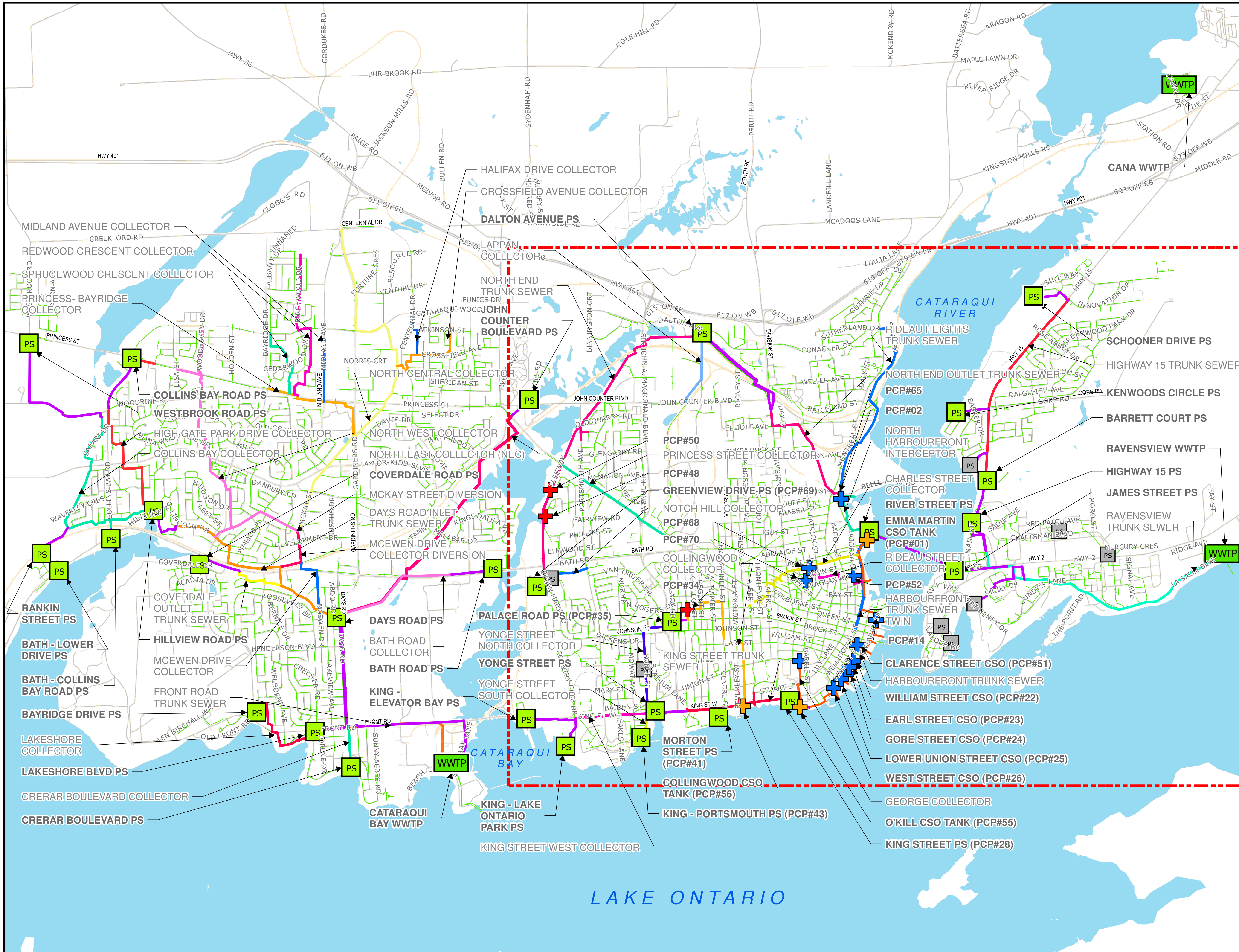
1.1 BACKGROUND

1.1.1 COLLECTION SYSTEM DESCRIPTION

The City is located at the east end of Lake Ontario at the beginning of the St. Lawrence River. The City has a diverse range of land uses as shown in Schedule 3A from the City of Kingston Draft Official Plan, Figure 1-1. For the purposes of this update, the City was divided into three main service area sections as shown in Figure 1-2. Kingston West (3,953 ha) is separated from Kingston Central (2,919 ha) by the Little Cataraqui Creek. The Great Cataraqui River divides Kingston Central from Kingston East (1,386 ha). Both the Kingston West and East service areas generally represent newer sections of the City and are serviced with separated sewers. Kingston Central services a large area with older infrastructure which includes areas serviced by both separated and combined sewers. Figure 1-3 displays the existing area serviced by combined sewers in Kingston Central, which is roughly 15% of the service area and occupies generally the City's downtown area along the waterfront, from the bottom of the Belle Park Landfill (east) to the Portsmouth Harbour (south). The Kingston Central collection system area is the focus of this PPCP update as it contains the City's only remaining combined sewers.

Figure 1-1 Schedule 3-A from the City of Kingston Draft Official Plan





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Legend

WWTP	WASTEWATER TREATMENT PLANT
PS	SANITARY PUMPING STATION
PS	SANITARY PUMPING STATION (NOT MODELLED)
+	COMBINED SEWER OVERFLOW (CSO)
+	TANK OVERFLOW (TO)
+	SANITARY SEWER OVERFLOW (SSO)
—	FORCEMAIN
—	SANITARY SEWER
	WATERBODY
- - -	PPCP STUDY FOCUS AREA

Data Source: Ontario Base Mapping, Ministry of Natural Resources, August 2013. Water and Waste Water Systems, Utilities Kingston, April 2015, City of Kingston.

Scale:
0 300 600 1,200 Meters
1:47,500

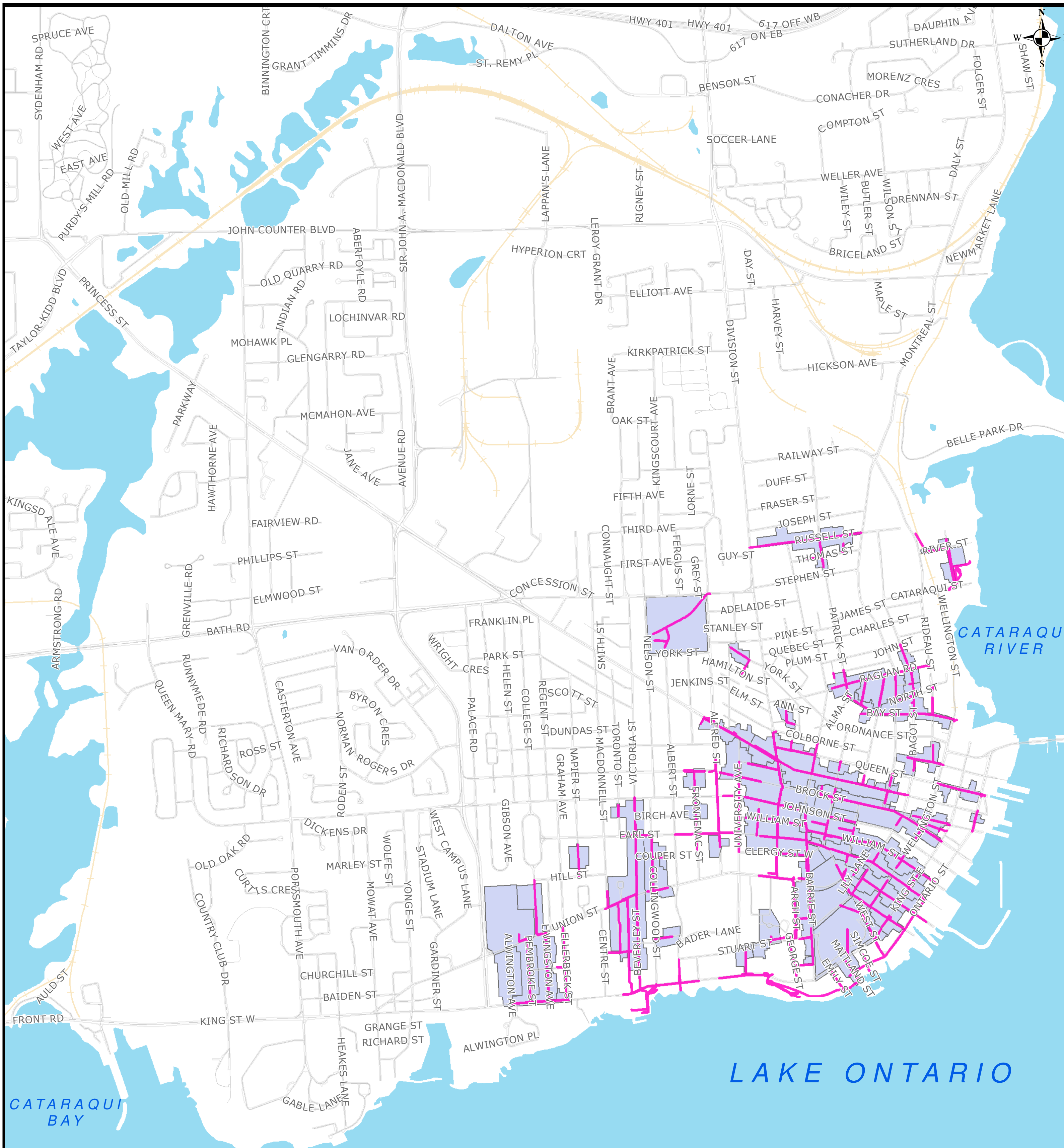
Project:
Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title:
WASTEWATER COLLECTION SYSTEM OVERVIEW MAP

Project No.:	Date:		
151-02944-00	JANUARY, 2017		
Drawn By:	Checked By:	Code:	Figure No.:
CM	MM	PCP	1-2

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.9_PPCP\Maps\151-02944-00_FIG1-2_WW_System_Overview_C.mxd



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Legend

- COMBINED SEWER AREA (line)
- COMBINED SEWER AREA (area)
- WATERBODY

Project: Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title: KINGSTON 2015 COMBINED SEWER SYSTEM

Data Source: Ontario Base Mapping, Minisitry of Natural Resources, August 2013. Water and Waste Water Systems, Utilities Kingston, April 2015, City of Kingston.

Scale:	Project No.:	Date:	Drawn By:	Checked By:	Code:	Figure No.:
0 175 350 700 Meters; 1:27,500	151-02944-00	DECEMBER, 2016	CM	MM	PCP	1-3

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.9_PPCP\Maps\151-02944-00_FIG1-3_CombinedSewerArea.mxd

1.1.2 PAST STUDIES AND PCP UPDATES

1.1.2.1 FIRST POLLUTION CONTROL PLAN AND UPDATES

The first PPCP developed for the City was completed in 1992 and included a study which identified problem areas through-out the City's collection system. Solutions to pollution control were reviewed based on best management practices at the time. The first PPCP made recommendations on upgrades to the collection system, pumping station pumping efficiency, temporary combined sewer storage facilities at selected CSO locations, stormwater disinfection infrastructure and guidance on dry-weather contamination investigation for storm sewer systems.

The first PPCP formed as the reference document which led to the development of new policies, programs, and capital infrastructure improvement carried out by the City and UK. The PPCP was subsequently updated to incorporate the guidelines presented under MOECC Procedure F-5-5 (summarized in Section 1.2.2.1) with the latest update completed in 2010 (summarized in Section 1.1.2.3).

1.1.2.2 KINGSTON COMBINED SEWER CRITICAL EVALUATION

In 2006 an evaluation was conducted separately from the PPCP with a targeted purpose to define a guiding policy for the rehabilitation of combined sewer service areas. The evaluation identified a preferred strategy of reconstruction. In this study, it was established that the favorable option for future reconstruction was to separate storm and sanitary sewers as a means of source control. As a result, the City adopted a policy that wherever possible, sewer separation would be incorporated. Utilities Kingston and the City of Kingston

The Policies and Programs derived from the Kingston Combined Sewer Critical Evaluation continue to influence PPCP updates. After the Critical Evaluation in the 2010 PPCP a long term goal of virtual CSO elimination throughout the collection system was established.

1.1.2.3 2010 POLLUTION CONTROL PLAN UPDATE

As part of the 2010 master planning exercise, CH2M Hill was retained by UK to complete the latest PPCP update which had the following objectives:

- → Review pertinent documentation and summarize works completed to date
- → Quantify the impacts of significant improvements to the sewer system as implemented by UK since the 2000 PPCP Update
- → Update, calibrate, and validate the existing hydraulic model of the trunk sewer system using recent monitoring data
- → Evaluate performance against the requirements of MOECC Procedure F-5-5
- → Define and evaluate alternatives to reach the City's ultimate goal of "virtual elimination" of CSOs and identify preferred alternatives. "Virtual elimination" was defined as containment of typical year wet-weather inflows from combined sewers.

The update focused primarily on Kingston's combined sewer areas, all of which were located in the Central System. These areas were identified as being a major contributor to pollution entering Lake Ontario due to overflow events during wet-weather conditions. The update derived the following conclusions and recommendations:

COMBINED SEWER SEPARATION BY AREA

Based on a review of the combined sewer areas remaining in the City, the following sub-areas were identified and specifically reviewed:

- Area 1 is the area bordered primarily by Sir John A MacDonald to the west, Johnson Street to the north, Collingwood Street to the east and Lake Ontario to the south.
- Area 2 is the area bordered primarily by Albert Street to the west, Princess Street to the north, Barrie Street to the east and King Street to the south
- Area 3 is the area bordered primarily by Nelson Street to the west, Third Avenue to the north, Montreal Street to the east and York Street to the south.
- Area 4 is the area bordered primarily by Division Street to the west, Queen Street to the north, Ontario Street to the east and Johnson Street to the south.
- Area 5 is the area bordered primarily by Barrie Street to the west, Johnson Street to the north and Ontario Street to the east and south.
- Area 6 is the area bordered primarily by Patrick Street to the west, River Street to the north, Rideau Street to the East and Bay Street to the south.

POLLUTION CONTROL ALTERNATIVES

An order of preference for alternatives was established for interim measures and long-term projects to achieve project objectives leading to sewer overflow reduction:

1. Long-term combined sewer separation
2. Operational changes and improvements to existing infrastructure
3. Structural changes and improvements to existing infrastructure
4. Capacity and conveyance system upgrades
5. Storage

Long-term Combined Sewer Separation by Area Priority was ranked in the study as shown in Table 1-1.

Table 1-1 Priority Ranking of Sewer Separation Areas (2010 PPCP Report, CH2M Hill)

RANKING	BASED ON NET EFFECT ON CSO VOLUME	BASED ON COST-BENEFIT BASIS
1	Combined sewer area in downtown core bounded by Brock Street, Princess Street, Queen Street and Barrack Street	Combined sewer area in downtown core bounded by Brock Street, Princess Street, Queen Street and Barrack Street
2	Separation of the remaining combined sewer area directly tributary to King St. (O'Kill) PS and CSO tank	Combined sewer area from West Street to Johnson Street
3	Combined sewer area on Raglan Road, Charles Street, James Street and Cataraqui Street	Combined sewer area on Raglan Road, Charles Street, James Street and Cataraqui Street
4	Separation of the remaining combined sewer area tributary to the Collingwood Street CSO tank	Separation of the remaining combined sewer area directly tributary to King St. (O'Kill) PS and CSO tank
5	Combined sewer area from West Street to Johnson Street	Isolated patched of combined sewer area west of Alfred Street as well as portions of Russell Street, Thomas Street, and Patrick Street
6	Isolated patched of combined sewer area west of Alfred Street as well as portions of Russell Street, Thomas Street, and Patrick Street	Separation of the remaining combined sewer area tributary to the Collingwood Street CSO tank

CONVEYANCE CONTROLS

Specific conveyance control infrastructure improvement recommendations were made based on the study:

- Belle Parke Overflow Structure- North Harbourfront Trunk Interceptor Sewer twinning- 1220mm sewer (840m)
- West Street CSO improvements- raise overflow weir to HTS at West Street, boat ramp by 0.8m
- River Street Pump Station Upgrades - River Street Forcemain Twining Completion (960m)

END OF PIPE OPTIONS

Additional end-of-pipe infrastructure improvements were also recommended based on site-specific upgrades as follows:

- King Street (O'Kill Street) CSO Screening and Flow monitoring
- West Street Outfall Replacement
- West Street CSO Screening

MONITORING

Existing system monitoring programs should be maintained to monitor and confirm results of modifications and provide additional information to assist with final planning and design of recommended works. Special attention should be made to high wet-weather inflow problems. Based on existing monitoring information and modeling, the tributary area for the Portsmouth PS should be a primary candidate for investigating Infiltration and inflow (I&I).

MODELLING

With new monitoring data, the trunk sewer model used in the study should continue to be updated for future updates. The model should be expanded for additional pipe links for reviewing local street level problems, or for the analysis of site specific CSO elimination.

INFILTRATION AND INFLOW REDUCTION

Several areas were shown to have high I/I rates and future I/I study investigations into these locations were recommended:

- Dalton Ave. PS Service Area (North End PS Service Area) (continue with 2008/2009 program)
- Portsmouth PS Service Area (New Program)
- James St. (B40) PS Service Area (New Program)
- North West Collector Service Area (New Program)

PROGRAM AND POLICY RECOMMENDATIONS

The following items we recommended system-wide policies and programs that should either continue or become an additional program /policy for consideration:

1. Sources Control
   - Toilet Replacement Program
   - Rain Barrel Program
   - Roof Leader and Foundation Drain Disconnection Program
   - Pet Litter Control
   - Pesticide Management
   - Citizen's Reports
   - Floatables Control
   - CSO Regulator Inspections and Maintenance
   - Closed Circuit Television (CCTV) inspections
   - Maintenance Hole Rehabilitation
   - Extraneous Flow Reduction
   - Infiltration Measures On site
   - Rooftop Gardens/Green Roofs
   - Porous Pavement
   - Used Oil Recycling
   - Household Hazardous Waste Collection
   - Yellow Fish Road Program
   - Pool Drainage
   - Erosion and Sediment Control
   - Street Cleaning
   - Catchbasin Cleaning
   - Sewer Flushing
   - Inlet Control / Flow Reducers
2. Conveyance System Improvements
   - Sewer Rehabilitation – Lining: Using lining technologies to reduce I/I in identified sections
   - Sewer Rehabilitation – Internal Grouting: Using pressure-injected grouting to repair small joint leaks and cracks to reduce I/I in identified sections

1.1.2.3.1 2010 PPCP IMPLEMENTATION REVIEW

As of 2014, an additional 72 ha of contributing combined sewer area was separated throughout the collection area. Table 1-2 describes the status of the remaining combined sewers based on the areas identified in the 2010 PPCP update.

Table 1-2 Sewer Separation Areas (2010 PPCP Report, CH2MHill)

AREA	DESCRIPTION	2010 STATUS: ORIGINAL AREA (HA)	2014 STATUS: AREA REMAINING (HA)
Area 1	Area bordered primarily by Sir John A MacDonald to the west, Johnson Street to the north, Collingwood Street to the east and Lake Ontario to the south	74	49
Area 2	Area bordered primarily by Albert Street to the west, Princess Street to the north, Barrie Street to the east and King Street to the south	57	53
Area 3	Area bordered primarily by Nelson Street to the west, Third Avenue to the north, Montreal Street to the east and York Street to the south.	18	16
Area 4	Area bordered primarily by Division Street to the west, Queen Street to the north, Ontario Street to the east and Johnson Street to the south.	30	22
Area 5	Area bordered primarily by Barrie Street to the west, Johnson Street to the north and Ontario Street to the east and south.	47	31
Area 6	Area bordered primarily by Patrick Street to the west, River Street to the north, Rideau Street to the East and Bay Street to the south.	44	27
TOTAL		**270**	**198**

The recommendations of the Sewage Infrastructure Master Plan for the City of Kingston Urban Area (CH2MHILL, 2010) suggested focussing efforts on sewer separation with the goal of “virtual elimination of CSO”.

UK produced a technical memorandum dated May 1, 2015 that documented recent progress and projected progress of combined sewer separation as displayed in Table 1-3 and Figure 1-4.

Table 1-3 Combined Sewer Separation 2008-2018 (Current and Projected) (UK, 2015)

YEAR	RATE OF SEWER SEPARATION (BY CITY BLOCK)[1]	REDUCTION IN COMBINED SEWER SERVICE AREA (BY SURFACE AREA)[1]
2008-2011	5.3% avg/yr	4.6% avg/yr
2012	5.1%	1.2%
2013	4.0%	2.0%
2014	2.2%	2.9%
2015	2.2%	12.5%
2016	3.3%	0.6%
2017	5.1%	6.3%
2018	2.5%	1.9%

1) Relative to 2008 conditions

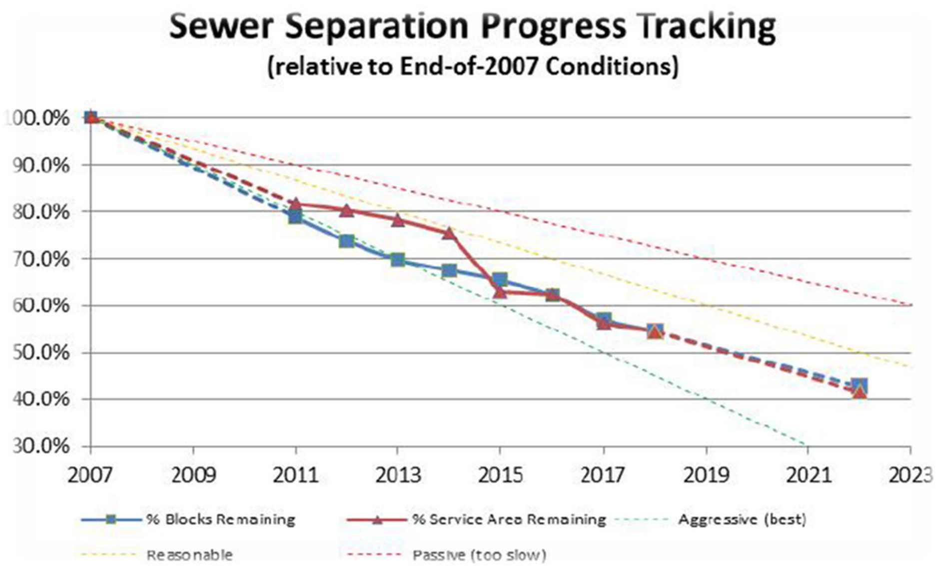


Figure 1-4 Combined Sewer Separation Progress (UK, 2015)

1.1.2.3.2 CAPITAL AND NON-CAPITAL PROJECTS

Further to the combined sewer separation program, the status of the following Capital and Non-Capital Works projects were reviewed and summarized in Table 1-4 and Table 1-5.

Table 1-4 Capital Projects Recommended in the 2010 PPCP Report

PROJECT	WORKS	STATUS
River Street PS and Forcemains	Further analysis to determine a method to increase firm capacity to 1,750 L/s. Options include modification of existing pumps/their operation, add a fifth pump, twin the forcemain on the east side of the Cataraqui River	River Street PS and Forcemains were upgraded which included PS firm capacity upgrades and forcemain twinning on the east side of the Cataraqui River
Harbourfront Trunk Sewer Overflow Weir at West Street Boat Ramp	Overflow weir elevation increased to 75.5 metres, and overflow capacity of 1,000 L/s minimum with liquid level below approx. 75.8 meter elevation	Overflow weir upgrades completed in 2016
West St. Outfall Replacement and CSO Screening	Installation of new CSO screening devices replacement.	West St. local outfall removed (West Street Boat Ramp Overflow Remains). Overflow weir upgrades completed in 2016. No further work completed.
Belle Park Overflow	Increase downstream capacity to River Street PS by twinning the existing North Harbourfront Interceptor Sewer	Not completed to date.
King Street (O'Kill Street) CSO Screening and Flow Monitoring	Installation of new CSO screening devices at CSO tank	CSO screening currently installed and in use at the King St. Pumping Station which dynamically operates with King St. (O'Kill) Tank filling.

Table 1-5 Non-Capital Works Initiatives and Status since 2010 PPCP Report

INITIATIVE	WORKS	STATUS
Monitoring	→Existing system monitoring programs maintained →Continue to include sewer flow monitoring	Ongoing
Modelling	→Ongoing modelling efforts to continue improvement of the tool →Expansion of model to include additional pipe links	Ongoing Model updated for 2015 Master Plan Update to include Secondary PS and active CSOs within the system.
Future PPCP Updates	→Updates to the PPCP should be undertaken in the future as appropriate based on changes to the collection system, updates to the City Official Plan or as required based on regulatory changes →Update within period of 10 years also likely appropriate	Updates being conducted in conjunction with 2015 Master Plan Update (5 years)
Stormwater Management Strategy	→Development of an integrated stormwater management strategy as a companion to the CSO-focused PPCP process →Consideration to expanding existing development related stormwater guidelines into an overall stormwater strategy that also addresses pollutant loading from existing stormwater discharges	Currently storm and sanitary are managed by the City and UK respectively and separately. City of Kingston has a master stormwater management plan used for internal operations and are currently developing a stormwater framework which allows for the identification\characterization and prioritization of elements of future

INITIATIVE	WORKS	STATUS
		programs to inform policy/guideline documents.
Infiltration and Inflow Reduction	1. Dalton Ave. PS Service Area (North End PS Service Area) (continue with 2008/2009 program) 2. Portsmouth PS Service Area 3. Hwy 15 (B40) PS Service Area 4. North West Collector Service Area	1. Sewer relining and rehabilitation conducted in area. Area still under review. 2. Sewer area undergoing I/I study. Ongoing 3. Sewer area upsizing work. No I/I study to date 4. No I/I study to date

1.1.2.4 THE PORTSMOUTH PUMPING STATION FLOW DIRECTION ENVIRONMENTAL ASSESSMENT (WSP, 2014)

The Portsmouth Pumping Station (King – Portsmouth PS), which is centrally located in the City of Kingston, was projected to experience larger volumes of wastewater flow as development continues in the downtown core. The purpose of this Class EA was to investigate the potential to direct portions of the wastewater flow towards the Cataraqui Bay WWTP located in West Kingston. Redirection would aim to decrease the volumes of wastewater flow through the central and eastern portions of the wastewater network, thereby eliminating the need for additional linear infrastructure upgrades. Additionally, this study addressed opportunities to reduce CSOs within the central (downtown) wastewater network. Figure 1-5 shows the Portsmouth service area.

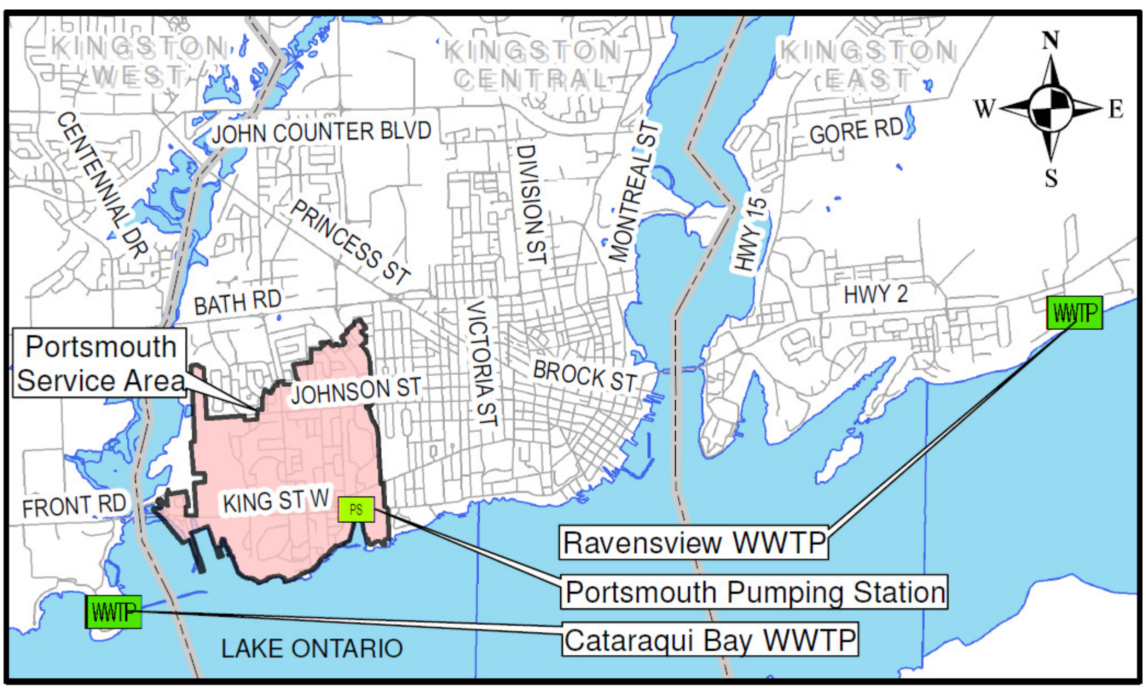


Figure 1-5 Portsmouth Sanitary Service Area (WSP, 2014)

The preferred servicing solution found in the EA was to pump the entire distance to the west using a new forcemain. Additional wastewater flows from sewer catchment areas located between the WWTP and the Portsmouth Pumping Station would be conveyed to the Portsmouth PS. The preferred routing option was to implement a forcemain from the Portsmouth PS along Kennedy Street, Union Street West and King Street West to Portsmouth Avenue where it would follow King Street West and Front Road until Sand Bay Lane where it would connect to Cataraqui Bay WWTP. This preferred solution was chosen based on the evaluation of the impacts posed to the natural, social and cultural, and economic environments by all considered alternatives.

The proposed forcemain routing from the EA is considered an imminent capital infrastructure project in the 2015 Master Plan Study with a project construction date of 2017-2018. This study includes a review of the effects before and after the redirection of the Portsmouth Service Area to the Kingston Central and East collection systems including CSOs.

1.2 PPCP UPDATE OUTLINE

1.2.1 PURPOSE AND RATIONALE

The PPCP update is required to demonstrate continued conformance with MOECC Procedure F-5-5. This procedure provides guidelines for collection systems with existing combined sewers and outlines the best practices to be considered for pollution prevention and control. A standard checklist for PPCP Plan requirements is detailed by MOECC Procedure F-5-5 and is included in Appendix A. Outlined below are the components of the checklist that are considered in this PPCP update.

The following section outlines the procedure's current set of guidelines pertaining to CSO and PPCP infrastructure developments. The full procedure is provided in Appendix B for reference.

1.2.2 POLICY REVIEW

The MOECC regulates municipal infrastructure in Ontario and has established many guidelines regarding the control and discharge of contaminants in wastewater systems. Procedure F-5-5 *"Determination of Treatment Requirements for Municipal and Private Combined and Partially Separated Sewer Systems"*, a subdocument of Guideline F-5-5 *"Levels of Treatment for Municipal and Private Sewage Treatment Works Discharging to Surface Waters",* is the guiding document for works regarding CSOs and PPCPs.

1.2.2.1 MOECC PROCEDURE F-5-5

Procedure F-5-5 outlines the guidelines for the treatment of combined and partially separated sewers in municipal and private areas. The objectives of the procedure are as follows:

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

The Ministry requires that the municipality/operating authority of the system satisfies the following:

1. Develop a Pollution Prevention and Control Plan (PPCP)
2. Meet minimum CSO controls
3. Provide additional controls
   - For beaches impaired by CSOs where water not meeting the PQWO for E. coli
   - Where required by receiving water quality conditions as specified in Procedure B-1-1 *"Water Management – Policies, Guidelines, Provincial Water Quality Objectives of the Ministry of Environment and Energy, July 1994"*

The procedure details a Pollution Prevention and Control Plan, minimum CSO controls, level of treatment, effluent disinfection, beach protection, monitoring, new sanitary and storm connections to combined sewer systems, and enforcement.

1.2.2.2 MINIMUM CSO CONTROLS

The following are the minimum CSO controls outlined by Procedure F-5-5:

1. Eliminate CSOs during dry-weather periods except under emergency conditions
2. Establish and implement Pollution Prevention programs that focus on pollutant reduction activities at the source
3. Establish and implement proper operation and regular inspection and maintenance programs for the combined sewer system in order to ensure continued proper system operation
4. Establish and implement a floatables control program to control coarse solids and floatable materials
5. Maximize the use of the collection system for the storage of wet-weather flows which are conveyed to the Sewage Treatment Plant for treatment when capacity is available
6. Maximize the flow to the Sewage Treatment Plant for the treatment of wet-weather flows

With respect to volume, durations and frequency, Procedure F-5-5 requires the following:

1. During a 7 month period starting within 15 days of April 1st, capture and treat 90% wet-weather volume (for an average year) above the dry-weather flow.
2. Controlling overflow to not more than 2 events per season (June 1 – September 30) for an average year.
3. Combined total duration of CSO events at any one CSO location shall not exceed 48hrs.
4. An additional overflow event may be permitted provided that the PWQO for E.coli based on a geometric mean at beaches is not exceeded for 95% of the four-month season between (June 1 – September 30).

The minimum level of service (LOS) for the CSOs is to satisfy these requirements and continue to reduce the volume of bypass events during an average year.

1.2.2.3 PPCP MOECC PROCEDURE F-5-5 REQUIREMENTS

A PPCP should outline the nature, cause, and extent of pollution issues, analyze alternatives and suggested remedial measures, as well as recommend a program for implementation. More specifically, the following is to be completed to assess the impact of CSOs:

1. Characterization of the combined sewer system (CSS):

- Location and physical description of CSO outfalls in the collection system, emergency overflows at pumping stations, and bypass locations at STPs
- Location and identification of receiving water bodies for all combined sewer outfalls
- Combined sewer system flow and STP treatment capacities; present and future expected peak flow rates during dry and wet-weather
- Capacity of all regulators
- Location of cross connections
- Combined sewer maintenance programs
- Regulator inspection and maintenance programs

2. Additional control alternatives:
   - Source control
   - Inflow/infiltration reduction
   - Operation and maintenance improvements
   - Control structure and collection system improvements
   - Storage and treatment technologies
   - Sewer separation
3. An implementation plan with cost estimates and schedule for all measures to eliminate dry-weather overflows and minimize wet-weather overflows. This plan should show how the criteria of Procedure F-5-5 are being accomplished.

1.2.3 PPCP UPDATE OBJECTIVES

The objective of this update was to review available documents, validate the recommendations made in the 2010 PPCP update, and modify/recommend additional pollution control measures to support the City's goal towards 'virtual elimination' of all CSOs. Additionally, a review of existing policies and programs affecting pollution control measures related to the collection system was carried out. Included in the works was a system model simulation which was calibrated and validated. The results of the simulations were compared to the requirements of the MOECC Procedure F-5-5 and recommendations are based on the Alternatives Solutions Report (WSP, 2016) from the 2015 Wastewater Master Plan completed by WSP for Utilities Kingston.

2 EXISTING CONDITIONS

2.1 COLLECTION AND TREATMENT SYSTEM

As described in Section 1.1.1, the wastewater collection and treatment system in the City is composed of various features. Existing linear infrastructure services an area of approximately 8,258 ha. The system is comprised of a mix of public and private infrastructure that includes 545 km of gravity sewer, 42 pumping facilities, 16 active CSO/SSO locations, 2 CSO storage tanks and 3 wastewater treatment plants. The system includes separated sanitary sewers, combined sewers (collection and conveyance of sanitary and stormwater runoff) and partially separated sewers which, in addition to serving as separated or combined sewers, collect and convey stormwater runoff from subdrains, sump pumps, roof leaders and downspouts. Construction of new linear infrastructure only comprises of separated systems since the City does not allow connection of stormwater laterals to the sanitary system; however, older parts of the City are still serviced by combined systems to date.

For the purposes of the PPCP update for the 2015 Master Plan, Kingston Central and East are the focus areas which represent the City's remaining combined sewers. Wastewater and combined sewer flow collected from Kingston Central is conveyed via pump stations and gravity sewers to the River Street Pumping Station where it is pumped into the gravity portion of the East Collection System. This flow is eventually treated at the Ravensview Wastewater Treatment Plant.

Figure 2-1 below illustrates the configuration of the collection system.

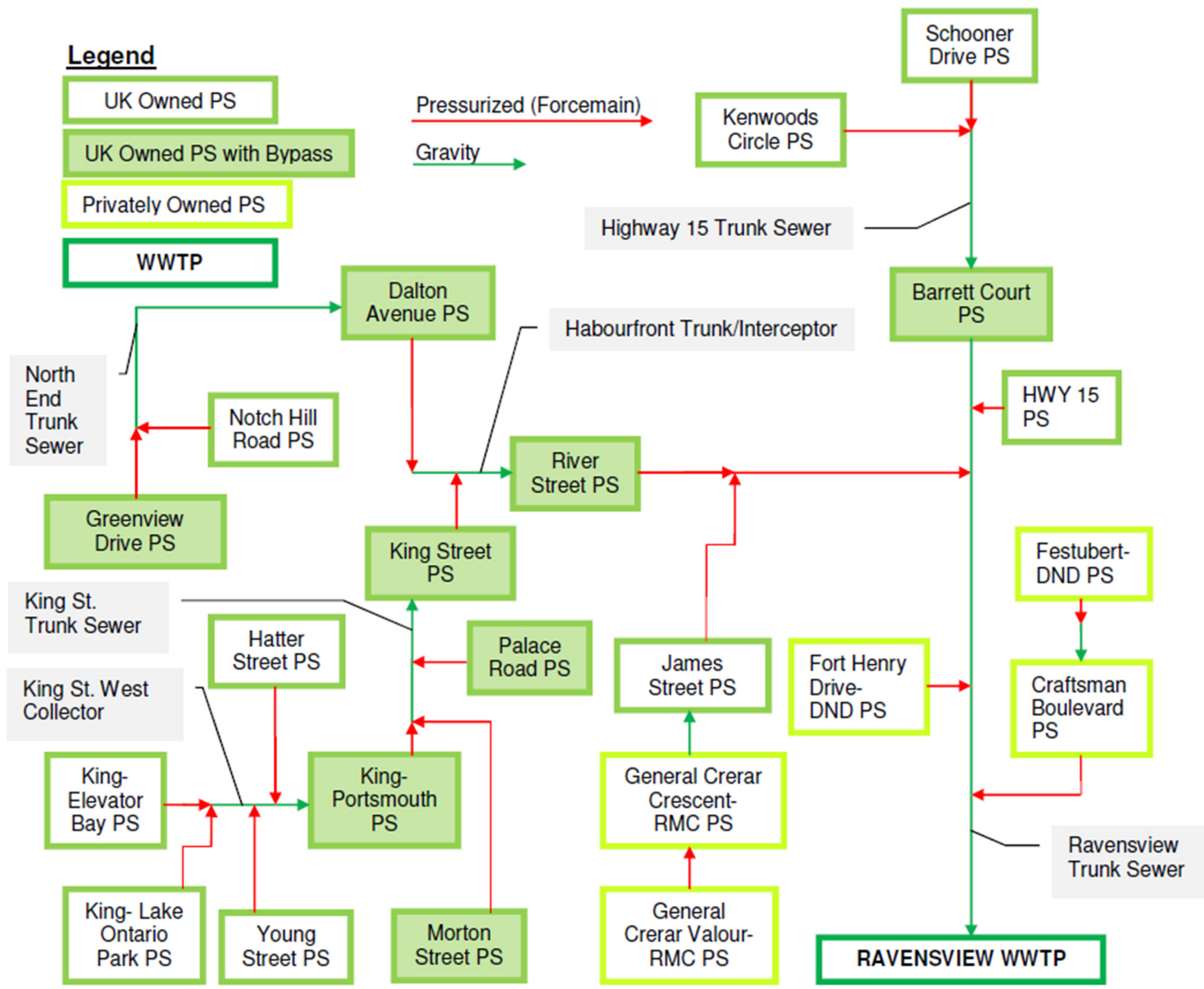


Figure 2-1 Kingston East and Central Collection System

2.2 MAJOR FACILTITIES AND COMBINED SEWER OVERFLOWS

2.2.1 COLLECTION SYSTEM DETAILS

Table 2-1 includes a summary of data available for major facilities in the Kingston Central and East areas including pumping stations, treatment plants and CSO structures located in the City used to complete the system characterization and evaluation.

Table 2-1 Available Facility Information

FACILITY	COLLECTION SYSTEM	LOCATION	C OF A (ECA)	AS - BUILTS	SCADA DATA	PUMP(S) DETAILS
Barrett Ct. PS	East	723 Barret Ct.	N/A	YES	YES	YES
Dalton Ave. PS	Central	266 Dalton Av	N/A	YES	YES	YES
Greenview Dr. PS	Central	38 Greenview Dr.	N/A	YES	YES	YES
Hatter St. PS	Central	91 Hatter St.	N/A	YES	YES	YES
Highway 15 PS	East	Highway 15	N/A	YES	YES	YES
James St. PS	East	213 James St.	N/A	YES	YES	YES
Kenwoods Circle PS	East	84 Kenwoods Circle	N/A	YES	NO	YES
King St. PS	Central	62 King St. West	N/A	YES	YES	YES
King – Elevator Bay PS	Central	1100 Elevator Bay	N/A	NO	YES	YES
King – Lake Ontario Park PS	Central	920 Lake Ontario Park	N/A	NO	YES	YES
King – Portsmouth PS	Central	621 King St. West	N/A	YES	YES	YES
Morton St. PS	Central	1 Morton St.	7501-659PLJ	YES	YES	YES
Notch Hill Rd. PS	Central	60 Notch Hill Rd.	N/A	NO	YES	YES
Palace Rd. PS	Central	270 Palace Rd.	3798-699KEZ	YES	YES	YES
River St. PS	Central	12 River St.	1388-5S6LAN, 2885-67MMWR, 2372-6MWSYZ, 0270-6QBMJ8, 7645-8UDP2S	YES	YES	Yes
Schooner Dr. PS	East	22 Schooner Dr.	N/A	NO	NO	YES
Yonge St. PS	Central	20 Yonge St.	N/A	YES	NO	N/A

FACILITY	COLLECTION SYSTEM	LOCATION	C OF A (ECA)	AS - BUILTS	SCADA DATA	PUMP(S) DETAILS
Clarence St. CSO Storage Tank	Central	0 Clarence St.	N/A	YES	NO	N/A
Collingwood CSO Storage Tank	Central	270 King St.	2414-63TQET	YES	YES	YES
Earl St. CSO Storage Tank	Central	0 Earl St.	N/A	YES	NO	N/A
Emma Martin CSO Storage Tank	Central	7 Orchard St.	1172-64EMDR	YES	YES	YES
Gore St. CSO Storage Tank	Central	0 Gore St.	N/A	YES	NO	N/A
Lower Union St. CSO Storage Tank	Central	0 Lower Union St.	N/A	YES	NO	N/A
King St. CSO Storage Tank	Central	62 King St. West	3-0076-96-006, 0210-8RFRCQ,	YES	YES	N/A
West St. CSO Storage Tank	Central	0 West St.	N/A	YES	YES	N/A
William St. CSO Storage Tank	Central	0 William St.	N/A	YES	NO	N/A
Ravensview WWTP	Central/East	947 Highway 2	5604-63QLWB, 3-1531-92-936, 3861-68CK9P, 4097-6QDMTW	NO	YES	N/A

There are currently 16 active combined sewer overflows (CSO) and sanitary sewer overflows (SSO) in the City of Kingston; all located in Kingston Central. They range from manholes with weirs to more complex multi-chamber tanks with storage capacity. The purpose of these CSOs is to divert flow from combination sewers to storm outlets during large wet-weather flow events. CSO chambers with storage aim to equalize flow rates during wet-weather. These chambers store excess volume during periods of high flow. Once the flow subsides, the stored volume slowly returns into the collection system. Table 2-2 summarizes the existing overflow structures, their location, type, and their respective status at the time of the study (Note: “status” indicates if the structure is in operation or not). In this table each overflow location was given a unique identification called a Pollution Control Plan Number (PCP #). This notation was adopted by UK and used in the last PPCP update and is also used in the 2015 Wastewater Master Plan. CSO/SSOs which have been recently plugged or redirected since the last update are indicated in the table.

Table 2-2 Summary of all Overflow Infrastructure Locations within the City

PCP #	STATUS	REASON IF STATUS = INACTIVE	MANHOLE NUMBER	TYPE	LOCATION
PCP# 02	Active	-	9227E-030	SSO	Belle Park Chamber, Trunks
PCP# 08	Inactive	Temporary Plug	0812-010	CSO	Princess St E of Frontenac
PCP# 09	Inactive	Temporary Plug	5211-010	CSO	Frontenac St S of Princess
PCP# 10	Inactive	Permanent Plug	7106-020	CSO/Storm	North and Wellington Extention
PCP# 14	Active	-	7050-121	CSO	Ontario and Barrack
PCP# 15	Inactive	Permanent Plug	7051-020	CSO	Queen and Ontario
PCP# 21	Inactive	Permanent Plug	6650-011	CSO/Storm	Johnson and Ontario
PCP# 22	Active	-	6551-010	CSO	William St Vortex
PCP# 23	Active	-	6451-020	CSO	Earl d/s of vortex
PCP# 24	Active	-	6351-010	CSO	Gore St vortex
PCP# 25	Active	-	6251-010	CSO	Lower Union d/s of vortex
PCP# 26	Active	-	6001-010	CSO	West and Ontario
PCP# 29	Redirected	Redirected to Tank	5050-010	CSO Captured	George and O'Kill
PCP# 30	Redirected	Redirected to Tank	5002-110	CSO Captured	George N of O'Kill
PCP# 32	Redirected	Redirected to Tank	0037-010	CSO Captured	Collingwood at King
PCP# 36	Redirected	Redirected to Tank	0038-010	CSO Captured	King E of Beverly
PCP# 37	Redirected	Redirected to Tank	9502-020	CSO Captured	Beverly N of King
PCP# 51	Active	-	6752-010	CSO	d/s of Clarence St in-line CSO
PCP# 52	Active	-	7455-020	CSO	Raglan and Rideau

PCP #	STATUS	REASON IF STATUS = INACTIVE	MANHOLE NUMBER	TYPE	LOCATION
PCP# 53	Active	-	9802-020	CSO	Division and Union
PCP# 64	Redirected	Redirected to Tank	0038-030	CSO Captured	King at Beverly
PCP# 65	Active	-	9227E-046	CSO	Belle Park Local SA1200
PCP# 66	Redirected	Redirected to Tank	0039-020	CSO Captured	King at Edgehill ROW
PCP# 67	Inactive	Temporary Plug	5115-020	CSO	Chatham at Elm St
PCP# 68	Active	-	7759-020	CSO	Quebec at Barrie St
PCP# 70	Active	-	7608-010	CSO	Carlisle & Chest Nut
PCP# 71	Inactive	Temporary Plug	9413-010	CSO	Alfred St, north of Princess
PCP# 01	Active	-	7114-003	CSO/PSO	River Street Pump Station
PCP# 05	Active	-	NEPS	PSO	Dalton Ave. (North End) Pumping Station
PCP# 28	Active	-	0034-210	PSO	King St (O'Kill) pump station
PCP# 35	Active	-	PRPS	PSO	Palace Road pump station
PCP# 41	Active	-	MSPS	PSO	Morton Street pump station
PCP# 43	Active	-	KPPS	PSO	King-Portsmouth pump Station
PCP# 69	Active	-	GDPS	PSO	Greenview Drive Pump Station
PCP# 74	Active	-	BCPS	PSO	Barrett Court Pump Station
PCP# 31	Inactive	Permanent Plug	5302-020	SSO	Albert N of King
PCP# 34	Active	-	4356-011	SSO	Helen and Mack

PCP #	STATUS	REASON IF STATUS = INACTIVE	MANHOLE NUMBER	TYPE	LOCATION
PCP# 48	Active	-	2284E-130	SSO	NETS at Sherwood
PCP# 50	Active	-	2284-080	SSO	NETS at Parkway S
PCP# 72	Inactive	Permanent Plug	5304-010	SSO	Albert St at Queen's Cres
PCP# 55	Active	-	0033-002	TO	King St. CSO Tank
PCP# 56	Active	-	x	TO	Collingwood CSO Tank

Combined sewer tank volume details are shown in Table 2-3 below.

Table 2-3 Summary of Tank Locations and Approx. Volumes

PCP #	LOCATION	APPROX. VOLUME (M^3)
PCP# 22	William St.	100
PCP# 23	Earl St.	100
PCP# 24	Gore St.	100
PCP# 25	Lower Union St.	100
PCP# 26	West St at Ontario	100
PCP# 51	Clarence St.	380
PCP# 55	King St. CSO Tank	6,000
PCP# 56[1]	Collingwood CSO Tank	2,400
N/A	Emma Martin Tank	12,000

1 – Active CSO volume is approx. 1,800 m^3. CSO tank is separated into four cells with one cell dedicated solely to storm water.

2.2.1.1 ACTIVE COMBINED SEWER OVERFLOWS

The following details describe the active combined sewer overflow configurations.

PCP #2 – BELLE PARK

PCP# 2 is situated in Belle Park, along with PCP#65, behind 525 Rideau Street. PCP#2/65 includes a fairly large and complex system of chambers, conduit and weirs. It has two 900 mm entering into the structure from the North End Outfall Trunk Sewer and the Rideau Heights Trunk Sewer. The PCP2 chamber also receives the flow from the 1,200 mm from PCP#65. A large 1,800mm conduit passes through and receives the overflows from the chamber, which discharges to Outlet 202.

PCP #8 - PRINCESS STREET

PCP#8 is a CSO from a local collector and is located in a manhole on Princess Street between Frontenac Street and Alfred Street. Under low flow conditions, sanitary flow from the west and south (450 mm and 200 mm respectively) enter the manhole and proceed east to the 375 mm outlet sanitary sewer. It has a 450 mm overflow to the adjacent 1050 mm storm sewer (invert is 500mm higher than the low flow sanitary outlet) and a 450 mm combined sewer outlet (invert is 900 mm higher than the low flow sanitary outlet. As of 2015, PCP#8 has been temporarily plugged.

PCP #9 - FRONTENAC STREET

PCP#9 is a CSO from a local collector located in a manhole on Frontenac Street between Princess Street and Mack Street. Under low flow conditions, sanitary flow from the north and south (225 and 200 mm respectively) enter the manhole and proceed east to the 200 mm outlet sanitary sewer. It has a 300 mm overflow to the adjacent 575 mm storm sewer (invert is 200 mm higher than the low flow sanitary outlet). As of 2015, PCP#9 has been temporarily plugged.

PCP #14 - BARRACK STREET

PCP#14 is a CSO from trunk located in a manhole in the right exit lane of the Wolfe Island Ferry Dock. There is a flap gate preventing lake water from entering. From the 1200 mm trunk sewer, there is a 900 mm outlet to the east that travels into the CSO manhole. Under low flow conditions, sanitary from the east flows west via the 900 mm combined sewer. During an overflow event, sanitary flow from the trunk sewer will back up and flow east to the manhole. The CSO manhole has a weir inside (500 mm higher than low flow outlet) which prevents overflow from entering the adjacent 900 mm storm sewer under low flow conditions.

PCP #15 - QUEEN STREET

PCP#15 is a CSO from a local collector located in a chamber at the base of Queen Street adjacent to Tim Hortons. Under low flow conditions, sanitary flow from the west and south (450 mm combined sewer and 225 mm sanitary sewer respectively) enters and turns 180° to flow into the 1200 mm trunk sewer to the west. Under high flow conditions, the flow will outlet via the 450 mm storm sewer to the east (240 mm higher than the low flow outlet). PCP#15 was permanently plugged during the 2015 Master Plan study and is no longer active.

PCP #22 - WILLIAM STREET

PCP#22 is a CSO in line tank outlet from a local collector located on William Street between King Street and Ontario Street. It is a 41 m long 1650x1340mm elliptical concrete pipe with a volume of 88 m3. Combined sewer flow from the west (600 mm) enters the tank. The outlet chamber is equipped with a vortex device to limit outflows to 15 L/S. Under low flow conditions, sanitary flow is directed to a 300 mm outlet. Under high flow conditions, flow that cannot be contained in the tank will outlet via the 450 mm storm sewer to the east (storage overflow weir is 2220 mm higher than the low flow outlet).

PCP #23 - EARL STREET

PCP#23 is a CSO in line tank outlet from a local collector located on Earl Street between King Street and Ontario Street. It is a 46m long 2110 x 1340 mm elliptical concrete pipe with a volume of 106 m3. Combined sewer flow from the west (600 mm) enters the tank. The outlet chamber is equipped with a vortex device to limit outflows to 15 L/s. The overflow is located in a manhole downstream of the tank outlet chamber. The downstream manhole has a weir with a 200 mm sanitary orifice which directs low flow to a 200 mm sanitary sewer outlet under low flow conditions. Under high flow conditions, flow that cannot be contained in the tank is directed to a 525 mm storm sewer to the east (storage overflow weir is 3000 mm higher than the low flow outlet and is equipped with a cone sieve at the storm outlet to limit floatables).

PCP #24 - GORE STREET

PCP#24 is a CSO in line tank outlet from a local collector located on Gore Street between King Street and Ontario Street. It is a 61 m long 1095 x 1730 mm elliptical concrete pipe with a volume of 95 m3. 300 mm sanitary and 300 mm storm sewer flow from the west (600 mm) enters the tank. The outlet chamber is equipped with a vortex device to limit outflows to 15 L/S. Under low flow conditions, flow from the sanitary sewer continues to the 200 mm sanitary outlet. Under high flow conditions, storm/sanitary flow that cannot be contained in the tank will outlet via the 375 mm storm sewer outlet (storage overflow weir is 1670mm higher than the low flow outlet).

PCP #25 - LOWER UNION STREET

PCP#25 is a CSO in line tank outlet from a local collector located on Lower Union Street between King Street and Ontario Street. It is a 46m long 1340 x 2110mm elliptical concrete pipe with a volume of 115 m3. Combined sewer flow from the west and north (600 mm and 350 mm respectively) enters the tank. The outlet chamber is equipped with a vortex device to limit outflows to 15 L/S. The overflow is located in a manhole downstream of the tank outlet chamber. Under low flow conditions, the downstream manhole directs flow to a 450 mm sanitary sewer outlet to the east. Under high flow conditions, flow that cannot be contained in the tank is directed over a weir to a 450 mm storm sewer to the east (storage overflow weir is 2550 mm higher than the low flow outlet).

PCP #26 - WEST STREET

PCP#26 is a CSO from a trunk sewer located in a manhole at the bend where West Street turns east becoming Ontario Street. Under low flow conditions, sanitary flow from the west and south (375mm combined sewer and 900 mm sanitary sewer respectively) continues north to the 1200 mm sanitary trunk. Under high flow conditions, combined and sanitary flow will rise above the weir and overflow to the east 900 mm storm sewer (storage overflow weir is 1400 mm higher than the low flow outlet).

PCP #51 - CLARENCE STREET

PCP#51 is a CSO in line tank outlet from a local collector located on Clarence Street between King Street and Wellington Street. It is a 78.5 m long box culvert (half 1800 x 2400mm and half 1800 x 3000 mm) with a volume of 380 m^3. Combined sewer flow from the west (450 mm) enters the tank. Under low flow conditions, the outlet chamber directs flow to a 250 mm sanitary sewer outlet to the east. Under high flow conditions, flows that cannot be contained in the tank is directed over a weir to a 375 mm storm sewer. (Storage overflow weir is 2810mm higher than the low flow outlet).

PCP #52 - RAGLAN ROAD

PCP#52 is a CSO from a local collector located in a manhole on Raglan Road just west of the Rideau Street intersection. Under low flow conditions, combined wastewater flow from the west (900 mm) enters the manhole and proceeds south east to the 375mm outlet sanitary sewer. Under high flow conditions, flows are directed over a weir and into the 900 mm overflow to the adjacent 900 mm storm sewer (weir is 550 mm higher than the low flow sanitary outlet).

PCP #53 - UNION STREET

PCP#53 is a CSO from a local collector located in a manhole on Union Street at the Division Street intersection. Under low flow conditions, combined wastewater flow from the west (1350 mm) enters the manhole and proceeds east to the 1350 mm outlet combined sewer. Under high flow conditions, flows are directed over a weir and into the 900 mm overflow to the adjacent 1050 mm storm sewer.

PCP #55 – KING STREET TANK OVERFLOW

PCP#55 is located in a chamber at the east end of the King St. CSO tank near the Murney Tower parking lot. Combined sewer from the King St. Pump Station enters the CSO tank via a 1200 mm sewer and is stored until it can be pumped back into the King St. Pump Station. During an overflow event, when the tank reaches capacity, combined wastewater is directed into an overflow trough and on to the overflow chamber to a 1350 mm storm sewer.

PCP #56 - COLLINGWOOD STREET STANK OVERFLOW

PCP#56 is located in a chamber at the south west corner of the Collingwood CSO Tank at Collingwood Street south of King Street. Combined sewer enters the CSO tank via a 1200 mm combined sewer pipe and is stored until it can be pumped back to the gravity system via a 250 mm sanitary forcemain. During an overflow event, when the tank reaches capacity, the combined wastewater is directed into an overflow chamber to a 1425 x 1925 mm storm sewer outlet pipe.

PCP #65 - BELLE PARK

PCP#65 is an CSO (Combined Sewer Overflow) from a local collector located in a manhole in Belle Park behind 525 Rideau Street. Low flow from the 1200 mm sanitary enter a 390 mm orifice and proceeds to the main mixing chamber. Flow from the two 900 mm sanitary trunk sewers enter the main mixing chamber. Overflows from the 1200 mm sanitary sewer enter directly to the upper level 1200 mm storm sewer. Low flow from the mixing chamber proceeds to the lower level 1200 mm sewer to River Street Pumping Station. Overflow from the mixing chamber is conveyed to the upper level 1200 mm storm sewer which outlets to the Lake.

PCP #67 - CHATHAM STREET

PCP#67 is a CSO located in a manhole on Chatham Street just north of the intersection with Elm Street. Under low flow conditions, wastewater flow from the west (450 mm) enters the manhole and proceeds east to the 600 mm sanitary sewer. Under high flow conditions, flows are directed into a 900 x 900 mm overflow pipe to the adjacent 1350 mm storm sewer (440 mm higher than the low flow outlet). As of 2015, PCP#67 has been temporarily plugged.

PCP #68 - QUEBEC STREET

PCP#68 is a CSO located in a manhole on Quebec Street in the Barrie Street intersection. Under low flow conditions, wastewater flow from the south and west (300 mm and 375 mm respectively) enters the manhole and proceeds north to the 450 mm sanitary sewer. Under high flow conditions, flows are directed over a weir into a 375 mm overflow pipe to the adjacent 1050 mm storm sewer (770 mm higher than the low flow outlet).

PCP #70 - CARLISLE STREET

PCP#70 is a CSO located in a manhole in the intersection of Carlisle Street and Chestnut Street. Under low flow conditions, wastewater flow from the south and west (300 mm and 225 mm respectively) enters the manhole and proceeds east to the 375 mm sanitary sewer. Under high flow conditions, flows are directed to a 375 mm overflow pipe to the adjacent 1350 mm storm sewer (513 mm higher than the low flow outlet).

PCP #71 - ALFRED STREET

PCP#71 is a CSO located in a manhole on Alfred Street north of Princess Street and south of Elm Street. Under low flow conditions, wastewater flow from the south (375 mm) enters the manhole and proceeds north to the 375 mm sanitary sewer. Under high flow conditions, flows are directed to a 250 mm overflow pipe to the adjacent 450 mm storm sewer (390 mm higher than the low flow outlet). As of 2015, PCP#71 has been temporarily plugged.

2.2.1.2 ACTIVE SANITARY SEWER OVERFLOWS

The following details describe the active sanitary sewer overflow configurations.

PCP #34 – HELEN AND MACK

PCP#34 is located near the intersection of Helen Street and Mack. The overflow is located in a storm manhole where 300mm sanitary pipe passes through. The flow from the 300mm sanitary pipe travels northbound along Helen Street towards MH# 4356-010 under normal flow conditions. In the event of sanitary sewer overflow a rectangular cut out of the pipe collar serves as the overflow into the storm manhole.

PCP #48 – NETS AT SHERWOOD

PCP#48 is a North End Trunk Sewer (NETS) relief overflow point located at the west end of Sherwood Street, just in the trunk ROW. As the HGL levels rise in the inlet trunk sewers the sanitary sewer may overflow via a 300 mm pipe. The overflow outlet is #239 located at the edge of the marsh just to the west of the manhole.

PCP #50 – NETS AT PARKWAY S

PCP#50 is a North End Trunk Sewer (NETS) relief overflow point located at the south end of Parkway. As the HGL levels rise in the inlet trunk sewers the sanitary sewer may overflow via a 450 mm pipe. The overflow outlet is #240 located at the edge of the marsh just to the west of the manhole.

2.3 SYSTEM MONITORING PROGRAM

Monitoring systems operated by UK have facilitated data collection for use in the study and are necessary for tracking of CSO overflow event volumes, frequency and duration. Monitors are installed that gather information relating to levels, flows and pressures at various facilities in the City. The following tables 2-4 and 2-5 and Figure 2-2 provide a summary of system monitors used to characterize the combined sewer system for the Kingston Central area.

Table 2-4 In-Line Sewer Monitor Locations

MONITOR ID	MANHOLE #	STATUS
C7b	8554E-070	Currently Monitored
C1	2285-020	Currently Monitored
C10	N/A	Previously Monitored
C11	0828-010	Currently Monitored
C12	2140-010	Currently Monitored
C13	3213-010	Previously Monitored
C14	7954-160	Previously Monitored
C15	9227E-070	Currently Monitored
C16	5405-030	Currently Monitored
C17	3941E-050	Currently Monitored
C18	0048-030	Currently Monitored
C19	9231-030	Currently Monitored
C2	5402-010	Previously Monitored
C20	N/A	To be determined
C21	8902-010	Currently Monitored
C22	3204-020	Currently Monitored
C23	3406-100	Currently Monitored
C24	3208-010	Planned Site, Pending
C25	3210-010	Planned Site, Pending
C26	0329E-050	Currently Monitored

MONITOR ID	MANHOLE #	STATUS
C27	0329-030	Planned Site, Pending
C28	N/A	
C29	N/A	
C3	9227E-010	Currently Monitored
C30		
C4	7104-010	Previously Monitored
C5	9903-110	Previously Monitored
C6	9729-010	Currently Monitored
C7	8554E-040	Previously Monitored
C8	0004-010	Currently Monitored
C9		N/A

Table 2-5 Kingston Central CSO/SSO Monitor Locations

PCP #	STATUS	MANHOLE NUMBER	MONITOR ID
PCP# 02	Active	9227E-030	Kingston20, Kingston02
PCP# 08	Inactive	0812-010	Kingston24
PCP# 09	Inactive	5211-010	Kingston33
PCP# 10	Inactive	7106-020	Kingston29
PCP# 14	Active	7050-121	SCADA
PCP# 15	Inactive	7051-020	Kingston01
PCP# 21	Inactive	6650-011	
PCP# 22	Active	6551-010	Kingston21
PCP# 23	Active	6451-020	Kingston08
PCP# 24	Active	6351-010	Kingston35
PCP# 25	Active	6251-010	Kingston28
PCP# 26	Active	6001-010	Kingston10
PCP# 29	Redirected	5050-010	
PCP# 30	Redirected	5002-110	
PCP# 32	Redirected	0037-010	
PCP# 36	Redirected	0038-010	
PCP# 37	Redirected	9502-020	
PCP# 51	Active	6752-010	Kingston27
PCP# 52	Active	7455-020	Kingston07
PCP# 53	Active	9802-020	Kingston38
PCP# 64	Redirected	0038-030	
PCP# 65	Active	9227E-046	Kingston20

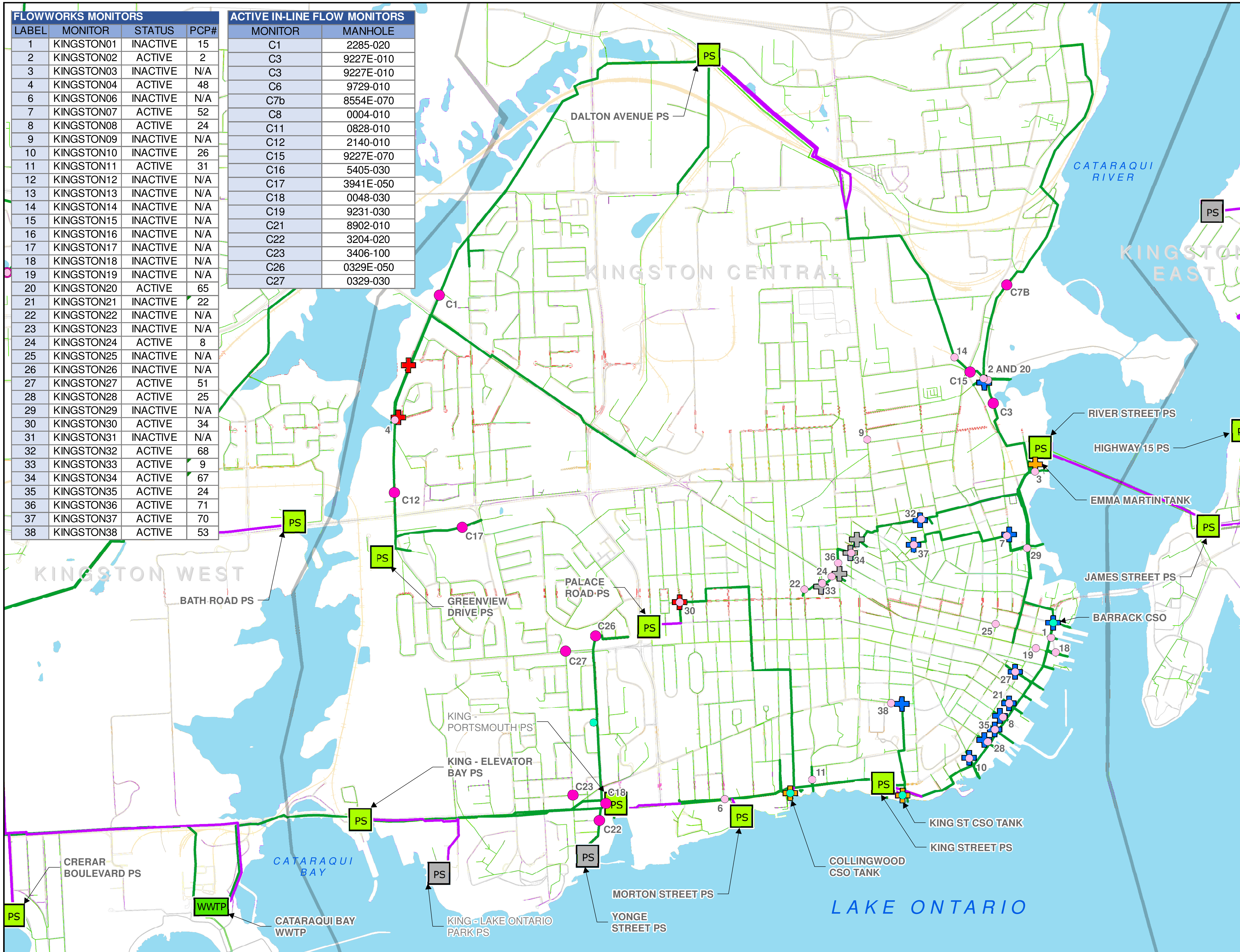
PCP #	STATUS	MANHOLE NUMBER	MONITOR ID
PCP# 66	Redirected	0039-020	
PCP# 67	Inactive	5115-020	Kingston34
PCP# 68	Active	7759-020	Kingston32
PCP# 70	Active	7608-010	Kingston37
PCP# 71	Inactive	9413-010	Kingston36
PCP# 01	Active	7114-003	Kingston03
PCP# 05	Active	NEPS	SCADA
PCP# 28	Active	0034-210	SCADA
PCP# 35	Active	PRPS	SCADA
PCP# 41	Active	MSPS	SCADA
PCP# 43	Active	KPPS	SCADA
PCP# 63	Active	0779-010	
PCP# 69	Active	GDPS	SCADA
PCP# 73	Active	DRPS	SCADA
PCP# 31	Active	5302-020	Kingston11
PCP# 34	Active	4356-011	Kingston30
PCP# 48	Active	2284E-130	Kingston04
PCP# 50	Active	2284-080	
PCP# 72	Inactive	5304-010	
PCP# 55	Active	0033-002	SCADA
PCP# 56	Active	x	SCADA

FLOWWORKS MONITORS

LABEL	MONITOR	STATUS	PCP#
1	KINGSTON01	INACTIVE	15
2	KINGSTON02	ACTIVE	2
3	KINGSTON03	INACTIVE	N/A
4	KINGSTON04	ACTIVE	48
6	KINGSTON06	INACTIVE	N/A
7	KINGSTON07	ACTIVE	52
8	KINGSTON08	ACTIVE	24
9	KINGSTON09	INACTIVE	N/A
10	KINGSTON10	INACTIVE	26
11	KINGSTON11	ACTIVE	31
12	KINGSTON12	INACTIVE	N/A
13	KINGSTON13	INACTIVE	N/A
14	KINGSTON14	INACTIVE	N/A
15	KINGSTON15	INACTIVE	N/A
16	KINGSTON16	INACTIVE	N/A
17	KINGSTON17	INACTIVE	N/A
18	KINGSTON18	INACTIVE	N/A
19	KINGSTON19	INACTIVE	N/A
20	KINGSTON20	ACTIVE	65
21	KINGSTON21	INACTIVE	22
22	KINGSTON22	INACTIVE	N/A
23	KINGSTON23	INACTIVE	N/A
24	KINGSTON24	ACTIVE	8
25	KINGSTON25	INACTIVE	N/A
26	KINGSTON26	INACTIVE	N/A
27	KINGSTON27	ACTIVE	51
28	KINGSTON28	ACTIVE	25
29	KINGSTON29	INACTIVE	N/A
30	KINGSTON30	ACTIVE	34
31	KINGSTON31	INACTIVE	N/A
32	KINGSTON32	ACTIVE	68
33	KINGSTON33	ACTIVE	9
34	KINGSTON34	ACTIVE	67
35	KINGSTON35	ACTIVE	24
36	KINGSTON36	ACTIVE	71
37	KINGSTON37	ACTIVE	70
38	KINGSTON38	ACTIVE	53

ACTIVE IN-LINE FLOW MONITORS

MONITOR	MANHOLE
C1	2285-020
C3	9227E-010
C3	9227E-010
C6	9729-010
C7b	8554E-070
C8	0004-010
C11	0828-010
C12	2140-010
C15	9227E-070
C16	5405-030
C17	3941E-050
C18	0048-030
C19	9231-030
C21	8902-010
C22	3204-020
C23	3406-100
C26	0329E-050
C27	0329-030



WSP

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Utilities Kingston

UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WWTP — WASTEWATER TREATMENT PLANT
- WWTP — WASTEWATER TREATMENT PLANT WITH SCADA
- PS — SANITARY PUMPING STATION
- PS — SANITARY PUMPING STATION WITH SCADA
- COMBINED SEWER OVERFLOW (CSO)
- SANITARY SEWER OVERFLOW (SSO)
- TANK OVERFLOW (TO)
- PLUGGED CSO
- SANITARY SEWER
- SANITARY SEWER (MODELLED)
- FORCEMAIN
- IN-LINE SEWER MONITOR
- FLOWWORKS MONITOR LOCATION
- SCADA MONITOR

Data Source: Ontario Base Mapping, Ministry of Natural Resources, August 2013. Water and Waste Water Systems, Utilities Kingston, April 2015, City of Kingston.

Scale: 0 160 320 640 Meters
1:24,000

Project:
Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title:
MONITOR LOCATION OVERVIEW

Project No.:	Date:		
151-02944-00	JANUARY, 2017		
Drawn By:	Checked By:	Code:	Figure No.:
CM	MM	PCP	2-2

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.9_PPCP\Maps\151-02944-00_FIG2-2_Central_Monitor_Locations.mxd

The SSO/CSO monitoring program includes data loggers that are connected to cellular modems which allow for remote access of the data through a third-party FlowWorks.com account. UK receives notifications when overflow events occur and overflow volumes are recorded at these locations with the software. Information used for the MOECC F-5-5 Combined Sewer Characterization is based on collected monitoring data from the 2014 period. Currently a new CSO monitoring program is being initiated and implemented by Utilities Kingston as described in Section 2.6.4.1 for future data collection.

2.4 TREATMENT SYSTEM DETAILS

2.4.1 RAVENSVIEW WASTEWATER TREATMENT PLANT

The Ravensview WWTP is located at 947 Highway #2 East in the City of Kingston (within the County of Frontenac). The treatment plant is operated under amended Environmental Compliance Approval (ECA) number 4097-6QDMTW.

The Ravensview WWTP is a secondary treatment plant which uses biological aerated filters (BAF) to achieve its effluent objectives. The plant has a rated capacity of 95,000 m^3/d and a peak capacity of 193,000 m^3/d.

This facility receives flow from the Kingston Central and Kingston East collection systems which includes Kingston's remaining combined sewers. The facility is protected from elevated wet-weather peak flows by CSO controls located through-out the collection system. These controls limit the peak flows received from minor and major wet-weather events.

2.4.1.1 UNIT PROCESS DESCRIPTION

Sewage enters the Ravensview WWTP through a 1350 mm diameter gravity sewer. Preliminary treatment consists of coarse mechanically cleaned bar screen and aerated grit tanks.

Primary treatment consists of seven rectangular settling tanks. Primary effluent is directed by gravity to the Intermediate Primary Effluent Pump Station. Settled sludge and scum are pumped to the sludge digestion system. Alum is dosed into the aerated grit tanks to assist with the removal of phosphorus and the settling of solids.

Secondary treatment consists of an 11-cell biological aerated filter. Each BAF cell has a filtration area of 147 m^2. Air is supplied by three positive displacement blowers. A 1,286 m^3 backwash system and two 1,370 m^3 spent backwash water storage tanks are part of the process.

Secondary effluent is disinfected year-round using sodium hypochlorite. The treated effluent from the facility is discharged to the St. Lawrence River.

Waste sludge generated at the site is processed through an anaerobic digestion system consisting of four digester vessels. Stabilized Biosolids are dewatered using a centrifuge and the Biosolids cake is spread on agricultural lands as a nutrient and soil conditioner. Temporary storage of Biosolids cake is provided at the site.

A process flow schematic of the liquid treatment train is presented in Figure 2-3.

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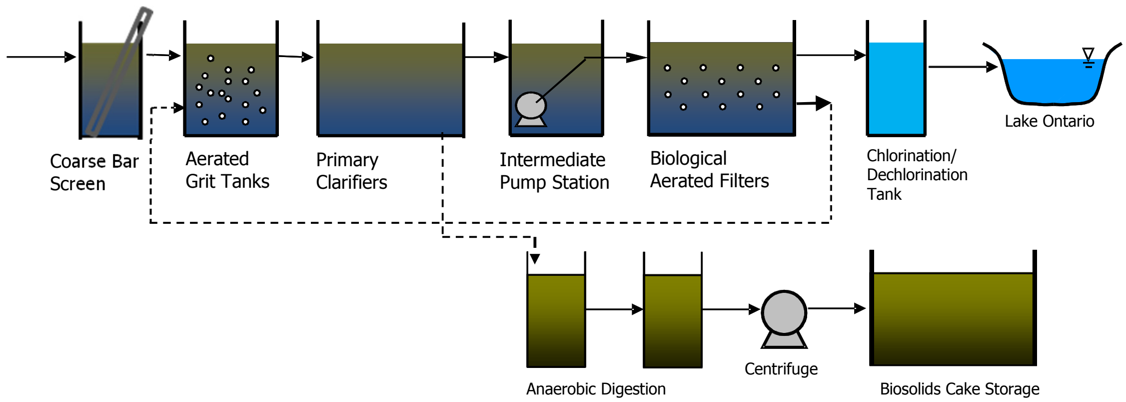


Figure 2-3 Ravensview WWTP Process Schematic

A description of the unit processes is provided in Table 2-6 below.

Table 2-6 Ravensview WWTP Unit Process Design Data

UNIT PROCESS	DESCRIPTION
Inlet Works	1. Three 12 mm mechanical bar screens 2. Two aerated grit tanks (18 m wide, 3.37 m long and 3.8 m deep)
Primary Treatment Facilities	1. Rectangular clarifiers consisting of: → Seven clarifiers, each measuring 31.7 m x 15.25 m x 3.7 m SWD → Two scum pumps, each rated at 13 L/s. 2. Seven progressive cavity raw sludge pumps, each rated at 11 L/s to transfer primary sludge to the sludge digestion process.
Intermediate Primary Effluent Pumping Station	1. A pumping station to transfer primary effluent from the primary clarifiers to the biological aerated filtration system consisting of: → Four submersible pumps, each with a capacity of 2.23 m^3/s.
Secondary Treatment Facilities	1. One Biological Aerated Filter consisting of: → 11 cells each having a filtration area of 147 m^2 and a media depth of 3.5 m. 2. Four high speed centrifugal blowers providing approximately 3,533 cubic metres per hour to the biological aerated filtration tanks.
Phosphorus Removal	Three chemical feed pumps adding alum at a rate of up to 180 L/hr, with two 35 m^3 liquid coagulant storage tanks.
Disinfection	1. One 900 m^3 chlorine contact chamber connected in series with one 960 m^3 baffled chlorine contact tank having the dimensions of 14.3 m x 17.8 m x 5.0 m (SWD). 2. Three chemical feed pumps adding sodium hypochlorite at the rate up to 680 L/hr and chemical storage in three tanks, each with a capacity of 17,000 L. 3. Two chemical metering pumps rated at 10 L/hr to provide disinfection prior to discharge to the St. Lawrence River. The dechlorination agent is stored in one 15 m^3 tank.

UNIT PROCESS	DESCRIPTION
Outlet Works	One outfall, with a diameter of 1,050 mm.
Sludge Digestion Process	1. An anaerobic digestion system consisting of: → Two Primary Digesters with an effective volume of 2,465 m^3 → One Secondary Digester with an effective volume of 3,700 m^3 → One Temperature Phased Anaerobic Digester with a volume of 2,465 m^3 → Three sludge recirculation pumps rated at 30 L/s → Two sludge transfer pumps rated at 11 L/s → Two sludge recirculation pumps rated at 132 L/s → Two Dewatering Centrifuge rated at 9.1 L/s 2. Enclosed Biosolids Cake Storage Facility with a capacity of 6,000 m^3

2.4.1.2 EFFLUENT CRITERIA

The plant is required to meet average monthly concentration and annual average loading limits for $cBOD_5$, total suspended solids, and total phosphorus. The effluent compliance limit for E. coli is 200 organisms per 100 mL based on a monthly geometric mean density. The effluent objectives and limits are summarized in Table 2-7 as per ECA requirements.

Table 2-7 Ravensview WWTP Effluent Objectives and Compliance Criteria

PARAMETER	EFFLUENT OBJECTIVES	NON-COMPLIANCE LIMIT CONCENTRATION	NON-COMPLIANCE LIMIT TOTAL LOADING
$CBOD_5$	15 mg/L	25 mg/L	2,375 kg/d
TSS	15 mg/L	10 mg/L	2,375 kg/d
Total P	0. 8 mg/L	0.6 mg/L	95 kg/d
Total Chlorine		0.04 mg/L	N/A
Total Ammonia Nitrogen	Oct–May 12 mg/L Jun&Sep 7 mg/L Jul-Aug 5 mg/L	N/A	N/A
Acute Lethality		Non-Lethal	N/A
E. coli	100 organisms per 100 mL	200 organisms per 100 mL	N/A
pH	6.0-9.5	6.0-9.5	N/A

2.4.1.3 PROPOSED CAPITAL IMPROVEMENT PROJECTS

There are currently no planned capital improvement projects for the Ravensview WWTP.

2.5 STORM OUTFALL MONITORING AND TREATMENT

Storm outfalls in Kingston are managed through the City of Kingston Public Works Department, while UK maintains water and sanitary systems. Through a partnership, the combined sewers are maintained by UK and upgrade work is jointly shared when sewer separation projects are undertaken. The City's Environment & Sustainable Initiatives Department complete a Storm Water Quality Surveillance Program (SWQSP) each year with the objective to sample storm outfalls and stormwater systems to identify stormwater quality gaps, and pinpoint which outfalls are to be either flagged for further investigation or recommended for remediation work. Since 2003, the SWQSP has identified the suspect locations of sanitary/storm cross-connections throughout the stormwater collection system. Since storm outfalls distribute flow directly to the environment, or through limited quality control structures designed for oil & grit removal, these outfalls receive direct attention based on the findings of the SWQSP studies. Appendix C includes a summary of the storm outfalls that have been identified as priority, based on sampling results from the 2013, 2014 and 2015 programs.

2.6 CITY OF KINGSTON AND UTILITIES KINGSTON POLICIES, PROGRAMS & BYLAWS

2.6.1 CITY OF KINGSTON BYLAWS

Table 2-8 describes the by-laws which address to some degree a component of waste control which puts restrictions on the use of municipal storm and sanitary sewers to prevent waste contamination or excess sewer loading in an effort to control pollution at its sources.

Table 2-8 City of Kingston Bylaws: Addressing Waste Control and Sewer Use to Mitigate Pollution

BYLAW	DESCRIPTION	POLLUTION CONTROL MEASURES
Animals 2004-144	Regulates all animals within the boundaries of the City of Kingston and to the owners of such animals.	Addresses pet waste disposal away from sewers
Building 2005-99	Provide for the construction, demolition, change of use and transfer of permits and inspections.	Connections for sanitary storm to follow Ontario Building Code
Development Related Charges – Impost Fee Bylaw (Water & Wastewater) 2009-138	To impose water and sewer rates to recover the capital cost of installing water and sanitary sewer services.	Concerns the funding element in support of maintaining and developing the sewage collection systems
Garbage 2014-5	To provide for and regulate a solid waste management system	Addresses solid waste disposal and timely removal to avoid sewer contamination
Maintenance and Closure of Laneways and Road Allowances 91-272	To Authorize the Adoption of a Policy with regard to the Maintenance and Closure of Laneways and Road Allowances	Stipulates control and maintenance of sewers during laneway restrictions

Pesticide 2008-28	Regulate the use of pesticides on lawns within the City of Kingston	Addresses the controls necessary which are to be followed to minimize exposure to sewers.
Parks & Rec Facilities 2009-79	Provides for regulation uses of parks and recreation facilities for the Corporation of the City of Kingston.	Stipulates the requirements for waste control and disposal on park property
Property Standards 2005-100	Prescribing standards for the maintenance and occupancy of property within the City of Kingston	Refers to and stipulates care and standards to be met for sewer connections for properties and prohibits cross-connections
Sidewalk 87-136	To authorize the adoption of regulations established for the purpose of dealing with applications for the extended use of sidewalks.	Concerns the maintenance of sewers and access
Streets 2004-190	Regulate the use of City streets.	Dictates that prohibited substances are not to be discharged into sewers.
Waste Water – Waste Discharge 2008-192	Provides for the Regulation of Waste Water Services and Waste Discharges to Municipal Sewers	Primary bylaw addressing the permissive use of storm and sanitary sewers and controls. Prescribes the allowable connections of building connections such as roof leaders, foundation drains and weeping tiles away from sanitary sewers
Watering 2006-122	Provides for the regulation of water supply for the City of Kingston	Addresses the removal and avoidance of cross-connections with sewers.
Yards 2007-136	To provide for maintaining land in a clean and year condition	Addresses the removal of refuse from outdoor property areas which can constitute to the reduction of surface run-off contaminants

2.6.2 DEVELOPMENT APPROVALS PROCESS

Any development application that the City receives for proposed works needs to follow the Development Approvals Process. The process is a comprehensive review that guides proponents through the appropriate steps to receive approvals, but also limits developments to adhere to the policies and standards adopted by the City including the City Subdivision Standard Guidelines. This process aims to review all aspects of the proposal in a single review which leads to the issuance of appropriate permits and approvals for work. Utilities Kingston participates in the review of the applications along with appropriate City departments and organizations such as the Cataraqui Region Conservation Authority.

During the Development Approvals Process the applicable review authorities are able to comment on applications which do not adhere to the City's guidelines or standards which reflect pollution control. The authorities may also indicate what additional studies, Environmental Assessments or Environmental Compliance Approvals are necessary prior to final review of their applications, and relation to re-zoning applications or minor variances also guide proponents on the necessary public consultations required.

Reviews help ensure that new and existing developments follow best-management practices and that new sanitary connections limit connection to aging infrastructure, such as combined sewers, when available.

2.6.3 PROGRAMS AT LARGE

Table 2-9 describes additional programs which are either implemented by the City or through partnerships to address further pollution prevention & control.

Table 2-9 City of Kingston Programs: Addressing Pollution Prevention and Control

PROGRAM	DESCRIPTION	POLLUTION CONTROL MEASURES
Fish and Frogs Forever Program	Educational program that teaches students about the impacts of water pollution on local aquatic ecosystems.	Public awareness: Participants paint "yellow fish' and 'green frogs' beside storm drains and distribute information to residents about ho pollutants affect local aquatic ecosystems
Citizen Reporting	Citizens may report to the City, concerns with potential environmental implication for Beach Quality, Spills and observed natural phenomenon. The City documents and responds to reports based on severity with the intent to provide a quick response to either eliminate problems or minimize environmental damage within capacity.	Public awareness and policy improvement: Identification of environmental implications leads to faster responses but also provides valuable information of location, severity and scale of pollution within the City.
Source Protection Areas	The active identification of source control areas and listing of best management practices to protect water intakes in relation to Ontario Source Protection Act. Source protection plans affiliated with the Cataraqui Region Conservation Authority	Best management practices prescribed for source protection has impacted by-laws, regulation and zoning within the City. The City has zoned Environmental Protection Area's and implement best management practices through design standards, development application review and policy documents.
Brownfield Remediation	Through a Brownfields Improvement Plan and Municipal incentives programs identified sites are encouraged for clean-up through land development within the City. The brownfields in Kinston are generally located near waterfront where old industrial works used to reside.	Remediation of brownfield sites are carried out such that embodied contaminants are removed or remedied in situ to prevent further pollution to surrounding areas.
Toilet Replacement Program	A toilet is the largest water consuming fixture in the home. Utilities Kingston encourages residents to replace older toilets with models that use less water through a toilet replacement rebate program. This involves replacing 1,300 multi-residential toilets and 624 social housing toilets.	Wastewater reduction: In an effort to reduce dry-weather inflows and peak loading into collection systems the program is anticipated to reduce annual water/wastewater reduction of 112,500 m^3 is anticipated.

Rain Barrel Program	This Utilities Kingston program involves encouraging homeowners to direct roof drainage into rain barrels for storage and future use. Rain barrels help reduce the consumption of treated water and partially reduces the generation of wastewater into sewers but they also can help delay runoff from entering the combined collection system.	Wastewater reduction: In an effort to reduce wet-weather inflows and peak loading from runoff this program may contribute to the reduction of overall flows into the collection system.
Rainfall warning program	During periods of anticipated heavy rainfall, Utilities Kingston issues public notices and educational material via social media and their website informing residents about various complications that can be caused during peak wet-weather including sewer back-ups and combined sewer overflows	Public awareness: In the event of suspected basement flooding or awareness of sewer back-up, residents may report occurrences to the Utility which may then responded on a case-by-case basis to address any pollution prevention controls.
'Know What to Flush' campaign	Utilities Kingston posts through social media and their website a 'Know What to Flush' educational series where it informs residents about what should not be flushed into sanitary collection systems and problems that occur from floatables.	Public awareness: the program aims to educate sanitary sewer users to offset issues related to increased floatables in the system and sewer such as blockages and back-ups.
Preventative Plumbing Program	Utilities Kingston provides assistance to homeowners to undertake work on their home to reduce sewage backup with preventative plumbing such as backflow preventers. The provisions for funding to upgrade homes is targeted to reduce the amount of groundwater or stormwater that enters into sanitary sewers during periods of snow melt or heavy rainfall.	Wastewater reduction and public awareness: the program aims to educate homeowners while also providing excess reductions of flow into sanitary sewers.
Household Hazardous Waste Collection	Collection of waste materials that can present characteristics such as corrosivity, ignitability, reactivity and/or toxicity, or are listed as hazardous materials for other means. This source control focuses on the collection of harmful chemicals before they enter into collection system sewers.	Pollution reduction: Integrated with the City of Kingston active Hazardous Waste Collection, this program aims to reduce heavy metals, toxic materials, oil and grease from entering into sewer systems.

2.6.4 UTILITIES KINGSTON: BEST MANAGEMENT PRACTICES

2.6.4.1 SSO/CSO CONTROL MONITORING PROGRAM

The existing SSO/CSO monitoring program includes comprehensive coverage of overflow locations with Ultrasonic sensors where data is collected with data loggers and transmitted remotely to a third-party FlowWorks.com account. Included in the program is regular inspection and maintenance of sensors/data logger's locations and calibration. Data collected from the logger's provide long term flow data appropriate for studies and PPCP updates. The logger's also provide real-time data which informs UK's staff of the occurrence of overflow events so that necessary public notifications and inspection may be conducted through their floatables control program.

In 2015 and 2016 a new CSO monitoring program was initiated to provide the following improvements to the existing program through replacement and/or enhancement of existing flow monitoring locations as follows:

1. Coverage: Full monitoring coverage for all remaining CSO locations
2. Reliability: New monitors installed with grid-power instead of battery powered units and include connection to their in-house SCADA system with hydrostatic sensors.
3. Accuracy: The new hydrostatic sensors are positioned to monitor upstream and downstream hydrostatically for improved HGL, flow and flow direction determination complete with real-time data tracking and alarms systems for overflow events.
4. Transparency: The new program will provide a real-time CSO Status map online which will be made available to the public for improved transparency to promote better health and safety. This is scheduled or public release in the Spring of 2017.

The new CSO monitoring program increases the overall effectiveness of addressing pollution prevention and control by facilitating UK's other programs and data collected is used to supplement and inform capital improvements projects

2.6.4.2 FLOATABLES CONTROL PROGRAM

Floatable controls employed in the City are implemented at various locations throughout the collection system. The primary main floatable controls are installed at larger pumping stations with screening devices at larger CSO locations to ensure removal and operational efficiency. Preventing floatables from reaching local receiving water bodies is also achieved through source control at site-specific discharge locations. To control floatables at overflow locations where control regulators have not been constructed, cone strainers, trash rakes, screens, or other mechanical means of separation have been installed in the past at various locations where floatables were observed. UK performs regular inspections, cleaning, and maintenance on sewer and storage tanks with overflow gates, weirs, bar screens, throttling valves, and sluice gates. It is to be noted that the 2 cone strainers that were installed in the past have since been removed due to operational problems being observed after both were being plugged due to leaves entering the sewers.

In 2015, upgrades to CSO structures also included modification to benching in structures to prevent flow blockages which contribute to the accumulation of floatables. It is to be noted that in the 2010 PPCP update it was recommended that CSO screening devices be installed at the King St. CSO tank. In 2007, the MOECC requested through a Communal Sewer Compliance Inspection Report that the floatable controls program be expanded based on findings of past studies. At this time, the MOECC has indicated that screening devices are not warranted if research confirms that a floatable debris issue does not exist at the location.

In addition to regular inspections of control regulators, inspection of debris and floatables are conducted during post-overflow events after notification is received from remote CSO monitor data loggers. This program involves visual inspection of surface waters in the receiving Lake Ontario at the storm outfall locations for any noticeable debris or floatables.

2.6.4.3 CLOSED CIRCUIT TELEVISION (CCTV) INSPECTIONS AND ASSET MANAGEMENT

UK regularly conducts targeted CCTV inspections throughout the collection systems to review infrastructure condition and pipes that are suspect of high I&I through their asset management program, with the aim to review all pipes throughout their lifespan. The intent of CCTV inspections is to gather details about pipe infrastructure and its condition when warranted and when non-intrusive measures are not an appropriate option. In recent years there has been an increase in CCTV inspection as a component of larger I/I reduction programs, such as in the Portsmouth Servicing Area. CCTV/cleaning of local/collector sewers is conducted over a 12 year reoccurring schedule which trunk sewers are on a 6 year reoccurring cycle. In general the program involves the cleaning/inspection concurrently with trunk sewers being cleaned on an as needed basis from camera inspections. Sanitary sewer assets such as inverted syphons, CSO tanks and vortices are inspected at least once a year.

Other sanitary sewer assets such as maintenance holes are inspected on a less frequent basis by UK. In the event where maintenance holes are to be rehabilitated, efforts are mainly conducted to target deficiencies identified through regular inspections by operations staff. The majority of rehabilitation involves repairing/replacing of covers; however, where warranted, infiltration and inflow are also addressed during the works.

2.6.4.4 EXTRANEOUS FLOW REDUCTION

Upon the discovery of high inflow and infiltration, studies or projects are initiated in an effort to reduce the extraneous flow. Major works include projects such as the North End Trunk Sewer rehabilitation in 2009 which involved approximately 27 km of pipe investigation and rehabilitation. Currently the Portsmouth PS Service area is undergoing a large I&I investigation and an extraneous flow reduction program to curb occurrences of high I&I identified in this area.

During I&I investigations and rehabilitation work, multiple approaches can be applied. Common approaches include CCTV, lot level inspection, maintenance hole inspections, and fog testing. The typical rehabilitation method that has been applied to pipes which have remaining life-span has been cured in place pipe (CIPP) spot repairs and chemical grouting. In areas with high I&I remaining, the extraneous flow reduction programs continue and SSOs remain for emergency purposes.

2.6.5 CITY OF KINGSTON: BEST MANAGEMENT PRACTICES

2.6.5.1 EROSION AND SEDIMENT CONTROL

As an ongoing BMP objective, the control of erosion and sediment from new developments is carried out for new site works projects. This is addressed by the City during the Development Approvals Process. The mitigation of stormwater runoff by trapping unwanted pollutants through settlement and\or other means is an important step in reducing contaminant loading before entering collections systems and is a common approach applied by the developer.

2.6.5.2 STREET AND CATCHBASIN CLEANING

On a regular basis, the City completes street and catchbasin cleaning for streets serviced by storm sewers. Removal of potential runoff contaminants is achieved through the works. As a result, there are direct reductions in sediment, heavy metals, and floatable materials entering into the collection systems. In conjunction with removal of runoff contaminants, the cleaning of catch basins also target removal of potential contaminants which can accumulate within a sump of a structure. The removal increases the effectiveness of stormwater structures to be able to convey flow effectively and to return function of the structures as sediment traps.

2.6.5.3 STORM SEWER FLUSHING

Related to street and catchbasin cleaning, sewer flushing practices are employed on an annual basis by the City's municipal operations to help ensure that pipes operate normally. Cleaning is performed on an as-needed basis in response of identified drainage concerns. The flushing is appropriate for separated storm sewers which are suspect to sediment accumulation. The process helps to remove contaminants and identify blockages if encountered. The sediment removed from the process helps to decrease overall sediment loading to the environment.

2.6.5.4 INLET CONTROLS AND FLOW REDUCERS

On a case-by-case basis, the use of inlet controls is prescribed for various structures through inlet control devices (ICDs). These structures and devices are designed to limit flow within storm or combined sewers. When used effectively they can help to maximize the capacity of the pipes while also redirecting surface runoff flows to other downstream structures which may have capacity. Typically these ICDs are designed under the guidance of the City's Subdivision Guidelines which follow MOECC BMPs for collections systems and sets the appropriate design storm requirements. Reducing flows in controlled means help reduce the peak flows in collection systems, such as combined sewers, which help reduce overflow events further downstream which in turn reduces the potential for environmental harm.

3 MOECC PROCEDURE F-5-5 CONFORMANCE

3.1 SYSTEM CHARACTERIZATION THROUGH EXISTING FLOW MONITORING

Overflow data collected in 2014 through Utilities Kingston Flow Monitoring Program was used to evaluate whether the existing system meets the requirements of MOECC Procedure F-5-5. As previously detailed, limits with respect to volume, duration, and frequency are prescribed by the guideline.

Duration: Combined total duration of CSO events at any one CSO location shall not exceed 48 hours.

Frequency: Controlling overflow to not more than 2 events per season (June 1 – September 30) for an average year.

An additional overflow event may be permitted provided that the PWQO for E.coli based on a geometric mean at beaches is not exceeded for 95% of the four-month season between (June 1 – September 30).

Volume: During a 7 month period starting within 15 days of April 1st, capture and treat 90% wet-weather volume (for an average year) above the dry-weather flow.

Though a review of the 2014 flow data obtained from Utilities Kingston Flow Monitoring Program, the total number of events, their duration, as well as recorded volume were tallied. As detailed in procedure F-5-5, a single event was defined as an overflow event which did not have in intervening time greater than 12 hours. Table 3-1 provides a summary of the activity at each CSO in the system. The data represented in this table depicts raw data collected from Flowworks.com which was updated and edited based on Utilities Kingston's bypass logs for available data where applicable.

Table 3-1 Sewer Overflow Events in 2014

PCP #	LOCATION	CUMULATIVE DURATION (HRS)	# OF EVENTS	TOTAL VOLUME (M^3)	COMMENTS
COMBINED SEWER OVERFLOW (CSO)					
2	Belle Park Chamber, Trunks	50.3	13	18,789	
8	Princess St E of Frontenac*	16.2	10	6,720	Connects to storm sewer and backflow effect may be occurring CSO Temporarily Plugged in 2015
9	Frontenac St S of Princess*	4.0	6	121	Connects to storm sewer and backflow effect may be occurring CSO Temporarily Plugged in 2015
14	Ontario and Barrack	0.5	3	121	
15	Queen and Ontario*	15.3	19	5,430	CSO Plugged in 2015
22	William St Vortex	N/A	N/A	N/A	
23	Earl d/s of vortex	386.8	14	33,191	Largest overflow at this location on record was observed to be due to a blockage
24	Gore St vortex	0.9	2	322	
25	Lower Union d/s of vortex	4.0	8	949	
26	West and Ontario	66.0	8	41,770	
51	d/s of Clarence St in-line CSO	1.0	2	1,019	
52	Raglan and Rideau	1.3	7	2,354	
53	Division and Union	N/A	N/A	N/A	
65	Belle Park Local SA1200	2.4	6	18,978	
67	Chatham at Elm St	2.8	5	816	CSO Temporarily Plugged in 2015

PCP #	LOCATION	CUMULATIVE DURATION (HRS)	# OF EVENTS	TOTAL VOLUME (M^3)	COMMENTS
68	Quebec at Barrie St	2.9	3	82	
70	Carlisle & Chest Nut	N/A	N/A	N/A	
71	Alfred St, north of Princess	8.0	8	1,389	Connects to storm sewer and backflow effect may be occurring CSO Temporarily Plugged in 2015
PUMP STATION OVERFLOW (PSO)					
1	River Street Pump Station	0.0	0	0.0	
5	Dalton Pumping Station	0.0	0	0	
28	King St Pump Station	0.0	0	0	No monitoring currently installed. No reported overflow events observed
35	Palace Road pump station	34.3	8	N/A**	
41	Morton Street Pump Station	0.0	0	0	No monitoring currently installed. No reported overflow events observed
43	King-Portsmouth Pump Station	0.0	0	0.0	
69	Greenview Drive Pump Station	0.0	0	0	No monitoring currently installed. No reported overflow events observed
74	Barrett Court Pump Station	0.0	0	0	No monitoring currently installed. No reported overflow events observed
SANITARY SEWER OVERFLOW (SSO)					
31	Albert N of King	12.2	6	14,627	Connects to storm sewer and backflow effect may be occurring CSO Plugged in 2015
34	Helen and Mack	48.3	10	719	Connects to storm sewer and backflow effect may be occurring
48	NETS at Sherwood	214.1	12	59,710	
50	NETS at Parkway S	N/A	N/A	N/A	No monitoring currently installed
TANK OVERFLOW (TO)					

PCP #	LOCATION	CUMULATIVE DURATION (HRS)	# OF EVENTS	TOTAL VOLUME (M^3)	COMMENTS
55	King St. CSO Tank	136.6	8	6,597	
56	Collingwood CSO Tank	144.1	11	92,607	
	VOLUME ASSESSMENT				
	Total Overflow Volume		306,311		

Meets F-5-5	Exceeds F-5-5

From the table above, it can be concluded that the system does not currently meet procedure F-5-5 with respect to frequency and duration at many of the outfall locations. It should be noted that there are some monitored locations which are suspected of recording inflow from the storm sewer that the sanitary sewer is intended to discharge to. The flow monitoring equipment that Utilities Kingston is currently using does not permit identification of the direction of flow.

Assessment of the requirement to capture and treat 90% wet-weather volume was completed by comparing the captured wet-weather volume to the total recorded overflow volume for the system. The system was analyzed as a whole as many of the CSOs are directly influenced by each other (i.e. increasing restriction at a specific discharge may result in more discharge at another, or the inverse). Additionally, it would be difficult to accurately determine the captured wet-weather volume upstream of the overflow. Determining the 'captured' wet-weather flow was completed by first identifying the average and wet-weather flows at Ravensview Wastewater Treatment Plant. Next, a I&I volume was calculated by taking the difference between the two values. Adding the calculated I&I volume to the measured overflow volume resulted in the 'captured' wet-weather volume for the system. Table-3-2 below details the calculations for the seven month period required by F-5-5.

Table 3-2 Wet-Weather Flow Volume at Ravensview WWTP

MONTH	2014 AVERAGE FLOW (M3/DAY) [1]	AVERAGE DRY-WEATHER FLOW (M^3/DAY) [2]	AVERAGE I/I FLOW (M^3/DAY) [1] – [2] = [3]	# OF DAYS [4]	TOTAL I/I FLOW (M^3) [3] X [4] = [5]	TOTAL OVERFLOW VOLUME (M^3)
Apr.	99,594	60,431	39,163	30	1,174,890	
May	80,653	60,430	20,223	31	626,913	
Jun.	65,762	53,380	12,382	30	371,460	
Jul.	58,199	50,687	7,512	31	232,872	
Aug.	58,661	45,186	13,476	31	417,741	
Sept.	46,004	41,157	4,848	30	145,440	
Oct.	42,530	39,861	2,669	31	82,739	

MONTH	2014 AVERAGE FLOW (M3/DAY) [1]	AVERAGE DRY-WEATHER FLOW (M^3/DAY) [2]	AVERAGE I/I FLOW (M^3/DAY) [1] – [2] = [3]	# OF DAYS [4]	TOTAL I/I FLOW (M^3) [3] X [4] = [5]	TOTAL OVERFLOW VOLUME (M^3)
2014 F5-5-5 Period	64,486	50,161	14,325	214	3,065,489	**306,311**

$$\% \, Wet \, Weather \, Treated = 1 - \frac{Overflow \, Volume}{Total \, {}^{I}/_{I} \, Flow \, + \, Overlfow \, Volume} = 1 - \frac{306{,}311 \, m^3}{3{,}065{,}478 \, m^3 + 306{,}311 \, m^3} = 91\%$$

Based on the results, the following observations were made:

1. The existing system currently meets F-5-5 volumetric criteria.
2. Some instrument readings appear to be uncharacteristically high compared to annual bypass volume and other events. This may be a result of inaccurate instrument readings; however, this could not be confirmed.
3. Several of the CSO locations exceed the maximum number of two events required by F-5-5.
4. Many of these events have a short duration with many lasting less than 60 minutes. Some of the short events may be a result of inaccurate instrument readings; however, this could not be confirmed.
5. It has also been indicated by UK that there is suspected backflow from the storm sewer occurring. This would artificially increase the readings. Currently, events are calculated based on level at the overflow with no ability to identify the direction of flow in the sewer.

3.2 SYSTEM CHARACTERIZATION THROUGH MODEL SIMULATIONS

In the 2015 Master Plan Study an InfoSWMM model was updated to complete the study. The updates included review, data collection, calibration, simulation, and validation in order to determine servicing gaps in the system and develop alternatives and recommendations for the Master Plan Study. The following subsections summarize the updates completed from the Study.

3.2.1 MODEL SETUP

The model is separated into the three collection areas (Kingston West, Kingston Central and Kingston East) and developed to show the trunk sewer system, including other major infrastructure, listed below.

1. Wastewater Treatment Plants
2. Conduits (Pipes)
3. Nodes (Pipe Junctions)
4. Storage Nodes:
   - Pump Stations
   - CSO Tanks
   - Wet Wells

→ Combined Sewer Overflow Locations (Weirs)

The scenarios created for simulation in the model represent the initial 2014 calibrated condition, the existing 2015 condition, and future scenarios (2021, 2026, and 2036). Simulations conducted in the Master Plan Study analysis included both dry-weather and wet-weather analysis that included an extended period CSO simulation analysis where a typical year of rainfall (2014 rainfall) and wetter-then-average year of rainfall (2008 rainfall) were simulated for the months of April through October. The CSO analysis was carried out to determine the severity of CSOs and SSOs, as well as the total volumes of overflows, the number of overflow events, and the duration of these overflow events.

3.2.2 MODEL CALIBRATION AND VALIDATION

After loading, checking, and balancing the updated model, calibration was completed to confirm that simulation of various situations (including major wet-weather events) would provide accurate results. Calibration included comparing dry-weather and wet-weather situations to actual data from 2013 and 2014 and adjusting model parameters to attain alignment/validation. Below is a table of the calibration targets based on the Master Plan objectives.

Table 3-3 Calibration Targets

	DRY-WEATHER TARGETS	WET-WEATHER TARGETS
Trunk Sewer System Calibration	Simulated dry-weather peak flows and volumes to be within ±5% of observed values	Simulated peak wet-weather flows to be within ±15% of observed values
	The timing of simulated peak dry-weather flows to be within 1 hour of observed values	Simulated wet-weather event volumes to be within ±10% of observed values
Collector Sewer System Calibration	Simulated dry-weather peak flows and volumes to be within ±10% of observed values	Simulated peak wet-weather flows to be within -15% to +25% of observed values
	The timing of simulated peak dry-weather flows to be within 1 hour of observed values	Simulated wet-weather event volumes to be within -10% to +20% of observed values

Refer to the 2015 Master Plan Study for a summary with regards to both the dry-weather and wet-weather specific calibration details. These details include:

1. Dry-weather:
   - Calibration periods
   - Inflow and infiltration assignment
   - Diurnal patterns
   - Seasonal variation
   - Checks and balances of facilities, linear infrastructure and combined sewer overflows
2. Wet-weather:
   - Calibration periods
   - Rain catchment areas and combined sewer areas
   - Inflow and infiltration assignment

- Checks and balances

3.2.3 SCENARIOS

Through review of previous Master Plan reports and discussions with Utilities Kingston and the City of Kingston Planning Department, WSP developed a Development Growth Scenario Report in 2015 which was part of the 2015 Master Plan Study. This report outlined the methodology used to project the growth in the City of Kingston within the next 20 years. Scenarios representing existing and future conditions were considered as follows:

1. Calibration – Existing conditions
2. 2021 – Committed and pending development applications
3. 2026 – Remaining committed and pending development applications ("committed conditions")
4. 2036 – Future known potential developments

3.2.3.1 GROWTH

The examination of these scenarios included residential, commercial, industrial and institutional growth. Table 3-4 below summarizes the estimated development and is further detailed in Section 6 of the Growth Scenario Report.

Table 3-4 Development Projections *(Growth Scenario Report, WSP 2015)*

LAND USE	2021	2026	2036
Residential (# of Units)	4,928	3,490	5,070
Residential (# of Off-Campus Students)	1,194	1,800	4,641
Industrial (Ha)	32.7	49.9	66.3
Industrial Business Park (Ha)	47.7	76.5	105.6
Commercial (Ha)	16.3	18.5	24.3*
Institutional (Ha)	Historic flow scaled – based on anticipated growth per institution		

**Converted to hectares assuming 25% lot coverage (Commercial Inventory and Market Analysis, City of Kingston, ON 2008)*

Additionally, flows were generated for each scenario based on the development projections for each land type. Table 3-5 shows the criteria (recommended in the Gap Analysis Report, WSP 2015) for use in generating estimated flow, and Table 3-6 provides the projected increased flow for each land use type

Table 3-5 Flow Generation Criteria *(Gap Analysis Report, WSP 2015)*

LAND USE	RECOMMENDED FLOW CRITERIA
Residential	350 Litres/capita/day
Commercial	28 m^3/hectare/day

Industrial	35 m^3/hectare/day
Industrial Business Park	49 Litres/employee/day
Institutional	Case Dependant

Table 3-6 Projected Flow *(Gap Analysis Report, WSP 2015)*

LAND USE	2021 FLOW (L/S)	2026 FLOW (L/S)	2036 FLOW (L/S)
Residential	46.53	33.69	47.45
Residential Off-Campus Students	7.67	6.42	13.05
Industrial	13.27	6.97	7.13
Industrial Business Park	0.49	0.29	0.3
Commercial	5.27	6.01	7.89
Institutional	11.86	14.89	16.55

3.2.4 CATCHMENT AREAS AND COMBINED SEWER SEPARATION

In addition to the standard GIS data provided for infrastructure updates, Utilities Kingston has also provided sanitary catchment and sub-catchment data for the entire sanitary service area as well as the projected combined sewer separation areas for Kingston Central. The combined sewer separation was divided into 2012, 2013, 2014, 2020, 2025 and 2035 yearly projections based on the best estimations related to trends in past and upcoming sewer separation projects.

3.2.5 MODEL ADDITIONS

As summarized below in Table 3-7, Utilities Kingston has provided a list of imminent infrastructure additions/upgrades and model considerations for review. WSP reviewed these with Utilities Kingston and summarized the model development alternatives for consideration in accordance with feedback received.

Table 3-7 Alternatives/Inclusions and Infrastructure Additions

MODEL ALTERNATIVES / INCLUSIONS
Calibration to 2013/2014 flow and rainfall data
2013/2014 diurnal patterns developed from flow data

2013/2014 adjusted water consumption loading	
2014, 2015, 2021, 2026, 2036 Combined Sewer Area separation GIS Data	
Alternative for Dry-Weather and Wet-Weather flow for calibrated conditions	
INFRASTRUCTURE ADDITIONS / UPGRADES	
General	Model element additions identified in RFP and from 2015 GIS Data Update (Including secondary pumping stations, CSOs, SSOs, etc.)
Point Works	West St Bypass (PCP#26) weir adjustment to 75.5m (2015)
	Permanent plugging of: 1. Queen St CSO (PCP#15) (2015) 2. North/Wellington CSO (PCP#10) (2015) 3. Brock St (PCP#19, replace temp plug with permanent) (2015) 4. Johnson St CSO (PCP#21) (2015) 5. Lower Albert St CSO (#31) (2015)
	New weir across 900mm overflow pipe on PCP#53 at Union/Division.
Linear Works	Yonge St sewer upsize (Johnson to Portsmouth PS)
	River St PS Forcemain Twinning
	Alfred/Elm Sewer Upsize: Sewer upsize (375mm to 450mm) on Alfred and Elm St.)
	Hwy 15 trunk sewer upsize (450mm & 525mm)
	New 'Riverview PS' forcemain, from new PS location near waterfront to Hwy15 trunk sewer roughly at 0636-010
Facilities	Portsmouth Pumping Station upgrades and Forcemain to Cataraqui Bay WWTP (2019)
	Greenview PS Upgrades (2016)
	Schooner Drive PS will be replaced with a new "Riverview PS" located in the quarry property (2018)
	Hatter Drive PS Decommissioning (2016)
	Westbrook PS update (2017)

3.3 MODEL ASSESSMENT OF EXISTING SYSTEM: MOECC PROCEDURE F-5-5 CONFORMANCE

3.3.1 COMBINED SEWER SYSTEM CHARACTERIZATION – DRY-WEATHER

SEWERS

To determine the capacities of the combined sewers under dry-weather conditions for present and future expected peak flows, the sewers were evaluated using the developed hydraulic model as it was calibrated/validated using all of the existing monitoring data that is available for the sewers and pumping stations, combined with existing and projected demands. To characterize the capacity, the peak flows observed in the sewers were compared to the capacity of the sewers along each trunk sewer. To quantify the severity of the sewer capacity compared to the peak flow rate, a hydraulic conditions criterion was developed. This criterion is based on satisfying MOECC's design guidelines for gravity sewers and maximizing storage capacity while minimizing the risk of basement flooding.

Table 3-8 Sewers Level of Service

	HYDRAULIC CONDITION OF SEWERS		
	FAIR (✓)	MODERATE(▲)	SEVERE (X)
Combined Sewers	Flow < 85% of pipe capacity	Flow > 85% of pipe capacity	Flow > 99% of pipe capacity

The table 3-9 details the sewer capacity versus peak flows based on the above hydraulic condition:

Table 3-9 Sewer Hydraulic Condition

	Hydraulic Condition – Dry-Weather			
	2015	2021	2026	2036
North End Trunk	✓	✓	✓	✓
North End Outlet	✓	✓	✓	✓
North Harbourfront	✓	✓	✓	✓
Harbourfront Trunk	✓	✓	✓	✓
Harbourfront Trunk Twin	✓	✓	✓	✓
King St Trunk	✓	✓	✓	✓
Rideau Heights	✓	✓	✓	✓

	Hydraulic Condition – Dry-Weather			
	2015	2021	2026	2036
Charles St. Collector	✓	✓	✓	✓
Collingwood Collector	✓	✓	✓	✓
George Collector	✓	✓	✓	✓
King St West Collector	✓	✓	✓	✓
Lappan Collector	✓	✓	✓	✓
Notch Hill Collector	✓	✓	✓	✓
Princess St Collector	✓	✓	✓	✓
Rideau St Collector	✓	✓	✓	✓
Yonge St N Collector	✓	✓	✓	✓
Yonge St S Collector	✓	✓	✓	✓

Based on the dry-weather analysis, all of the combined sewers were able to convey the flows without surcharging or bypassing.

PUMPING STATION

The pumping stations that form part of the combined sewer system were also reviewed against their firm and peak capacity. The firm capacity is the capacity of the station with the largest pump out of service. In some cases, a peak capacity of the station was not able to be tested in the field. For these instances, consideration was given to the length of the forcemain to estimate how much the increased headloss during peak flow would impact the output of the pumps. The peak capacity was estimated by taking the sum of the pump outputs and applying the discount based on the forcemain length using the following parameters:

1. 0 -500m = 10%
2. 501m – 1,500m = 15%
3. 1,501m – 2,500m = 20%
4. 2,501m – 3,500 = 25%
5. >3,500m = 30%

Similar to the sewers, a hydraulic condition criterion was developed to determine the severity of the hydraulic conditions:

Table 3-10 Pumping Station Hydraulic Condition Criteria

	HYDRAULIC CONDITION OF PUMPING STATIONS		
	FAIR	MODERATE	SEVERE
Combined Sewer Facilities	Below Firm Capacity	Between Firm and Peak Capacity	Above Peak Capacity

The table below outlines the pumping station capacities, the peak capacity observed at each facility and the hydraulic condition.

Table 3-11 Pump Station Hydraulic Condition

			Hydraulic Condition – Dry-Weather			
			2015	2021	2026	2036
Dalton Ave.	990	1225	124.6	137.3	146.1	155.4
Greenview Dr.	47	85	1.6	1.6	1.6	1.6
King St.[2]	576	731	329.5	266.2	278.8	293.3
King – Elevator Bay+[4]	88	150	1.1	1.1	1.1	1.1
King – Lake Ontario[4]	12	22	0.6	0.6	0.6	0.6
King – Portsmouth[1]	285	405	70.2	77.8	95.9	96.4
King – Portsmouth[1]	425	500	70.2	77.8	95.9	96.4
Morton St.[4]	18	32	0.6	0.6	0.6	0.6
Palace Rd.[3]	22	22	1.7	2.1	2.2	2.9
River St.[2]	1700	2130	709.5	684.9	703.6	779.3
Yonge St.	4	10	0.6	0.6	0.6	0.6

[1]After 2021 Scenario all Flows Pump to Cataraqui Bay WWTP & PS is upgraded
[2]King St. and River St. PS have dynamic inflow based on a relationship with King St. and Emma Martin CSO tanks respectively. Total inflow fluctuates per scenario
[3]Pumping station cannot run 2 pumps at any time
[4]Model calibration based on limited SCADA data ranges and/only level monitoring data and/or anecdotal station data as available

Based on the dry-weather analysis, all of the pumping stations in the combined sewer system were able to convey the flows without surcharging or bypassing.

SEWAGE TREATMENT PLANT

The rated capacity of Ravensview WWTP is listed in Table 3-12 below.

Table 3-12 Rated Capacity

Wastewater Plant	Rated Capacity (m3/day)		
	Peak Flow Rate (Primary)	**Peak Flow Rate (Secondary)**	**Average Daily Flow Rate**
Ravensview	193,000	193,000	95,000

Historical average and maximum day flows to the Ravensview WWTP from 2010 to 2014 are shown in Figure 3-1 along with the ECA effluent flow rate limits. Flow data was obtained from the 2010 to 2014 Wastewater Annual Reports. Historically, the plant has remained in compliance with the average day flow limit of 95,000 m^3/d.

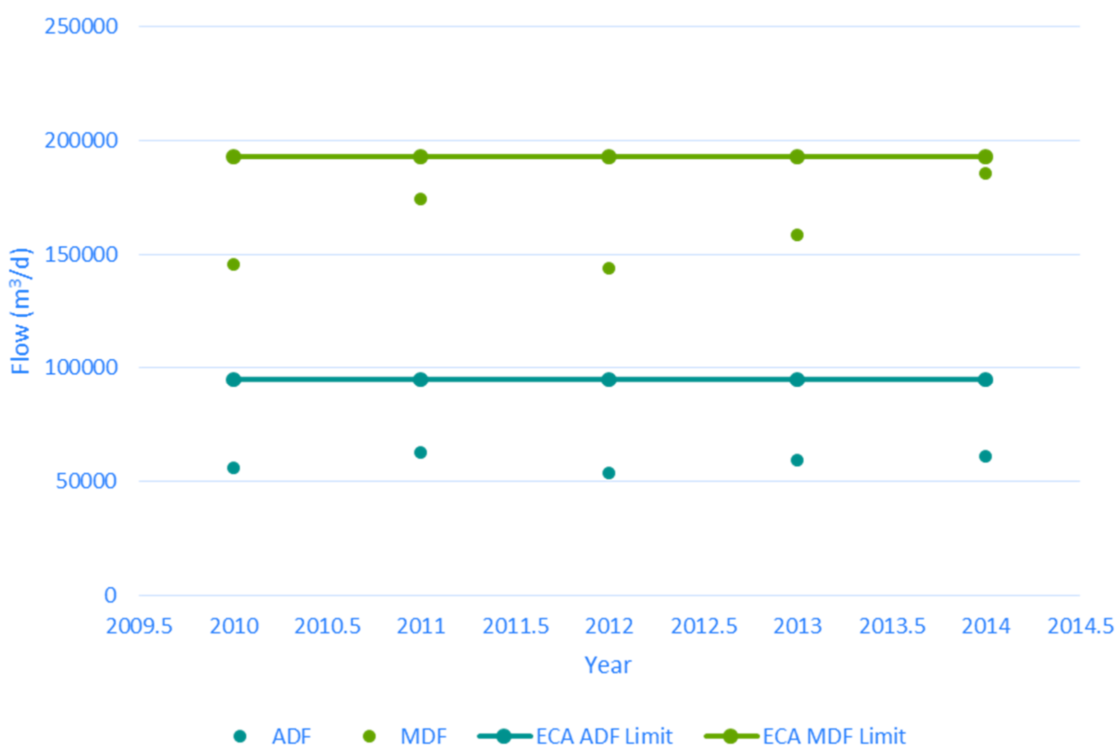


Figure 3-1 Ravensview WWTP Historical Flows

Historical effluent quality, obtained from the Wastewater Annual Reports, is summarized in Table 3-13. On average, limits were not exceeded for any of the effluent parameters from 2010 to 2014.

Table 3-13 Ravensview WWTP Effluent Quality

PARAMETER	2010	2011	2012	2013	2014	LIMIT
CBOD5 (mg/L)	5.6	3.3	2.6	2	2.2	25
Suspended Solids (mg/L)	3.9	2.7	4.1	5.2	4.3	25
Total Phosphorus (mg/L)	0.46	0.39	0.45	0.49	0.42	1
Total Chlorine (mg/L)	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Acute Lethality	pass	pass	pass	pass	pass	pass

Based on the modeling results, Table 3-14 below presents the dry-weather peak flows at the plant for the different scenarios.

Table 3-14 Rated Capacity

SCENARIO	RATED CAPACITY (M^3/DAY)	EXISTING (M^3/DAY)	2021 (M^3/DAY)	2026 (M^3/DAY)	2036 (M^3/DAY)
DRY	193,000	64,559	62,970	66,643	77,674

Based on the rated peak flow versus the dry-weather peaks seen at the plant, there is sufficient capacity to treat the dry-weather flows beyond 2036.

3.3.2 COMBINED SEWER SYSTEM CHARACTERIZATION – WET-WEATHER

Evaluation of the impact of future development on combined sewer overflows was completed by loading the hydraulic model with the projected growth and running simulations with precipitation data from 2014 and 2008. 2014 is intended to represent rainfall from an 'average' year, while 2008 represents rainfall from the 'wetter that average' year. The tables below details frequency, duration, and overflow volume projections for the two conditions during the various analysis periods for the F-5-5 window (April-October).

Table 3-15 Average Year CSO Bypass Volume, Duration and Frequency

		2015			2021			2026			2036		
PCP#	Location	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)
14	Ontario and Barrack	6	1	750	0	0	0	0	0	0	0	0	0

		2015			2021			2026			2036		
PCP#	Location	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)
22	William St Vortex	0	0	0	0	0	0	0	0	0	0	0	0
23	Earl d/s of vortex	5.5	2	176	4	2	160	4	2	160	4	2	162
24	Gore St vortex	5	2	44	0	0	0	0	0	0	0	0	0
25	Lower Union d/s of vortex	5	1	127	1	1	13	1	1	9	0	0	0
26	West and Ontario	52.5	6	30,296	36.5	4	4,610	36	4	4,054	39	4	982
51	d/s of Clarence St in-line CSO	0	0	0	0	0	0	0	0	0	0	0	0
52	Raglan and Rideau	10.5	4	61	10.5	4	61	0.5	1	17	1	1	4
53	Division and Union	17.5	2	367	0	0	0	0	0	0	0	0	0
65	Belle Park Local SA1200	18	4	1,710	0	0	0	0	0	0	0	0	0
68	Quebec at Barrie St	0	0	0	0	0	0	0	0	0	0	0	0
70	Carlisle & Chest Nut	0	0	0	0	0	0	0	0	0	0	0	0
1	River Street Pump Station	0	0	0	0	0	0	0	0	0	0	0	0
5	Dalton Pumping Station	0	0	0	0	0	0	0	0	0	0	0	0
28	King St Pump Station	0	0	0	0	0	0	0	0	0	0	0	0
35	Palace Road pump station	0	0	0	0	0	0	0	0	0	0	0	0
41	Morton Street Pump Station	0	0	0	0	0	0	0	0	0	0	0	0
43	King-Portsmouth Pump Station+	0	0	0	0	0	0	0	0	0	0	0	0

PCP#	Location	2015 Cumulative Duration Bypass (Hrs)	2015 Number of Bypass Events	2015 Total Bypass (m^3)	2021 Cumulative Duration Bypass (Hrs)	2021 Number of Bypass Events	2021 Total Bypass (m^3)	2026 Cumulative Duration Bypass (Hrs)	2026 Number of Bypass Events	2026 Total Bypass (m^3)	2036 Cumulative Duration Bypass (Hrs)	2036 Number of Bypass Events	2036 Total Bypass (m^3)
69	Greenview Drive Pump Station**	0	0	0	0	0	0	0	0	0	0	0	0
2	Belle Park Chamber, Trunks	1.5	1	1,201	0	0	0	0	0	0	0	0	0
34	Helen and Mack	0	0	0	0	0	0	0	0	0	0	0	0
48	NETS at Sherwood*	0	0	0	0	0	0	0	0	0	0	0	0
50	NETS at Parkway S*	0	0	0	0	0	0	0	0	0	0	0	0
55	King St. CSO Tank	209	9	2,116	94.5	8	1,058	94.5	8	1,058	0	0	0
56	Collingwood CSO Tank	71.5	12	39,136	28.5	7	2,303	28.5	7	2,526	30.5	7	2,417
TOTAL OVERFLOW		**402.0**	**44**	**75,987**	**175.0**	**26**	**8,205**	**164.5**	**23**	**7,825**	**73.5**	**14**	**3,565**

** No bypass observed at PCP# 48 and 50*
+ Part of Kingston West System in 2021, 2026, & 2036

Table 3-16 Wetter than Average Year CSO Bypass Volume, Duration and Frequency

PCP#	Location	2015 Cumulative Duration Bypass (Hrs)	2015 Number of Bypass Events	2015 Total Bypass (m^3)	2021 Cumulative Duration Bypass (Hrs)	2021 Number of Bypass Events	2021 Total Bypass (m^3)	2026 Cumulative Duration Bypass (Hrs)	2026 Number of Bypass Events	2026 Total Bypass (m^3)	2036 Cumulative Duration Bypass (Hrs)	2036 Number of Bypass Events	2036 Total Bypass (m^3)
14	Ontario and Barrack	17	3	4,401	6	1	1,671	4.5	1	1,133	2.5	1	360
22	William St Vortex	0	0	0	0	0	0	0	0	0	0	0	0
23	Earl d/s of vortex	15	4	1,870	13	4	1,525	13	4	1,488	12.5	4	1,322
24	Gore St vortex	17	5	1,529	2	1	93	0	0	0	0	0	0
25	Lower Union d/s of vortex	13.5	3	2,740	8	2	1,581	8	2	1,353	7	2	616

PCP#	Location	2015 Cumulative Duration Bypass (Hrs)	2015 Number of Bypass Events	2015 Total Bypass (m^3)	2021 Cumulative Duration Bypass (Hrs)	2021 Number of Bypass Events	2021 Total Bypass (m^3)	2026 Cumulative Duration Bypass (Hrs)	2026 Number of Bypass Events	2026 Total Bypass (m^3)	2036 Cumulative Duration Bypass (Hrs)	2036 Number of Bypass Events	2036 Total Bypass (m^3)
26	West and Ontario	56	9	62,198	21	3	18,093	27.5	4	16,006	10	2	8,310
51	d/s of Clarence St in-line CSO	7	3	708	5.5	2	656	0	0	0	0	0	0
52	Raglan and Rideau	19	5	1,281	6.5	2	1,228	6.5	2	1,228	6	2	1,019
53	Division and Union	33	5	2,184	9.5	3	146	2.5	2	5	0	0	0
65	Belle Park Local SA1200	29.5	7	10,824	4	1	1,336	3.5	1	1,175	1.5	1	140
68	Quebec at Barrie St	0	0	0	0	0	0	0	0	0	0	0	0
70	Carlisle & Chest Nut	0	0	0	0	0	0	0	0	0	0	0	0
1	River Street Pump Station	0	0	0	0	0	0	0	0	0	0	0	0
5	Dalton Pumping Station	0	0	0	0	0	0	0	0	0	0	0	0
28	King St Pump Station	0	0	0	0	0	0	0	0	0	0	0	0
35	Palace Road pump station	0	0	0	0	0	0	0	0	0	0	0	0
41	Morton Street Pump Station	0	0	0	0	0	0	0	0	0	0	0	0
43	King-Portsmouth Pump Station+	0	0	0	0	0	0	0	0	0	0	0	0
69	Greenview Drive Pump Station	0	0	0	0	0	0	0	0	0	0	0	0
74	Barrett Court Pump Station	0	0	0	0	0	0	0	0	0	0	0	0
2	Belle Park Chamber, Trunks	4.5	2	2,421	2.5	1	616	2	1	325	0	0	0

PCP#	Location	2015 Cumulative Duration Bypass (Hrs)	2015 Number of Bypass Events	2015 Total Bypass (m^3)	2021 Cumulative Duration Bypass (Hrs)	2021 Number of Bypass Events	2021 Total Bypass (m^3)	2026 Cumulative Duration Bypass (Hrs)	2026 Number of Bypass Events	2026 Total Bypass (m^3)	2036 Cumulative Duration Bypass (Hrs)	2036 Number of Bypass Events	2036 Total Bypass (m^3)
34	Helen and Mack	0	0	0	0	0	0	0	0	0	0	0	0
48	NETS at Sherwood*	0	0	0	0	0	0	0	0	0	0	0	0
50	NETS at Parkway S*	0	0	0	0	0	0	0	0	0	0	0	0
55	King St. CSO Tank	893	16	5,922	526.5	13	3,369	526.5	13	3,369	0	0	0
56	Collingwood CSO Tank	118	13	71,562	54.5	12	8,286	51.5	12	7,819	53	12	8,682
TOTAL OVERFLOW		**1,222.5**	**75**	**167,640**	**659**	**45**	**38,600**	**645.5**	**42**	**33,901**	**92.5**	**24**	**20,449**

** No bypass observed at PCP# 48 and 50*
+ Part of Kingston West System in 2021, 2026, & 2036

Table 3-17 Average Year Rainfall - Model Simulation CSS Overflow Volumes

	2015	2021	2026	2036
Total Overflow Volume (m^3)	75,987	8,205	7,825	3,565
Total Volume at Ravensview (m^3)	11,482,615	10,926,587	11,413,431	12,751,794
Total Dry-Weather Volume at Ravensview (m^3)	9,537,777	9,621,225	10,211,217	11,455,434
Total Wet-Weather Volume at Ravensview (m^3)	1,944,838	1,305,362	1,202,214	1,296,360
Total Capture Wet-Weather (m^3)	2,020,825	1,313,567	1,210,039	1,299,925
Percent Treated	**96.2%**	**99.4%**	**99.4%**	**99.7%**
Percent Bypassed	**3.8%**	**0.6%**	**0.6%**	**0.3%**

Table 3-18 Wetter than Average Year Rainfall - Model Simulation CSS Overflow Volumes

	2015	2021	2026	2036
Total Overflow Volume	167,640	38,600	33,901	20,449
Total Volume at Ravensview (m^3)	12,016,549	11,282,996	11,762,440	13,058,756
Total Dry-Weather Volume at Ravensview (m^3)	9,537,777	9,621,225	10,211,217	11,455,434
Total Wet-Weather Volume at Ravensview (m^3)	2,478,772	1,661,771	1,551,223	1,603,322
Total Capture Wet-Weather (m^3)	2,646,412	1,700,371	1,585,124	1,623,771
Percent Treated	**93.7%**	**97.7%**	**97.9%**	**98.7%**
Percent Bypassed	**6.3%**	**2.3%**	**2.1%**	**1.3%**

Based on the hydraulic modeling, the system does not currently meet the F-5-5 duration and frequency requirements; however, the system does meet F-5-5 based on the volume required to be treated, and continues to improve into the future under all development scenarios, with the underlying assumption that combined sewer separation continues as projected. It is to be noted that larger total CSO reductions for local sewer outfalls were primarily observed from combined sewer separation of local upstream combined sewer areas. Another observation that can be made from the results is that there is a notable decrease in bypass volume between 2015 and 2021. This is due to the Portsmouth PS service area being redirected, and various sewer separation projects being completed during this analysis period. By the 2036 development scenario, both the volume and duration are within the limits prescribed by F-5-5 during the average year.

3.3.3 POLLUTANT AND LOAD CONTRIBUTIONS: EXISTING SYSTEM

Results from the hydraulic model have been used to estimate the impact of pollutant loading associated with CSO events as a result of continued sewer separation and continued growth and development in the City. Three indicator parameters that are commonly monitored have been used. These include total suspended solids (TSS), biochemical oxygen demand (BOD) and E. coli bacteria. In the absence of recent sampling of actual overflow events, representative pollutant concentration values have been used. These values are based on samples collected by Utilities Kingston in 2008 and the values used in the previous Master Plan, which were supported by published academic literature from the US Environmental Protection Agency and the American Society of Civil Engineers. Pollutant loading used for the Ravensview WWTP is based on average values reported in the 2014 Annual Report.

Table 3-19 Pollutant Loading Values

PARAMETER	VALUE SELECTED FOR LOAD ESTIMATION CSO	VALUE SELECTED FOR LOAD ESTIMATION WWTP
TSS (mg/L)	150	4.3
BOD (mg/L)	30	2.2
E. Coli (#/100mL)	400,000	18

The following tables detail the anticipated pollutant loading at each CSO location. CSO locations which were not active during model simulations have been omitted from the following tables.

Table 3-20 Average Rainfall Year Pollutant Loadings

		2015			2021			2026			2036		
PCP #	Location	TSS (kg)	BOD (kg)	E. Coli (Billions)	TSS (kg)	BOD (kg)	E. Coli (Billions)	TSS (kg)	BOD (kg)	E. Coli (Billions)	TSS (kg)	BOD (kg)	E. Coli (Billions)
14	Ontario and Barrack	113	23	3,000	-	-	-	-	-	-	-	-	-
22	William St Vortex	-	-	-	-	-	-	-	-	-	-	-	-
23	Earl d/s of vortex	26	5	704	24	5	640	24	5	640	24	5	648
24	Gore St vortex	7	1	176	-	-	-	-	-	-	-	-	-
25	Lower Union d/s of vortex	19	4	508	2	0	52	1	0	36	-	-	-
26	West and Ontario	4,544	909	121,184	692	138	18,440	608	122	16,216	147	29	3,928
52	Raglan and Rideau	9	2	244	9	2	244	3	1	68	1	0	16
53	Division and Union	55	11	1,468	-	-	-	-	-	-	-	-	-
65	Belle Park Local SA1200	257	51	6,840	-	-	-	-	-	-	-	-	-
2	Belle Park Chamber, Trunks	180	36	4,804	-	-	-	-	-	-	-	-	-
55	King St. CSO Tank	317	63	8,464	159	32	4,232	159	32	4,232	-	-	-
56	Collingwood CSO Tank	5,870	1,174	156,544	345	69	9,212	379	76	10,104	363	73	9,668
TOTAL OVERFLOW		**11,398**	**2,280**	**303,948**	**1,231**	**246**	**32,820**	**1,174**	**235**	**31,299**	**535**	**107**	**14,260**
EFFLUENT AT RAVENSVIEW		**49,375**	**25,262**	**2,067**	**46,984**	**24,038**	**1,967**	**49,078**	**25,110**	**2,054**	**54,833**	**28,054**	**2,295**

Table 3-21 Wetter than Average Rainfall Year Pollutant Loadings

		2015			2021			2026			2036		
PCP#	Location	TSS (kg)	BOD (kg)	E. Coli (Billions)	TSS (kg)	BOD (kg)	E. Coli (Billions)	TSS (kg)	BOD (kg)	E. Coli (Billions)	TSS (kg)	BOD (kg)	E. Coli (Billions)
14	Ontario and Barrack	660	132	17,604	251	50	6,684	170	34	4,532	54	11	1,440
22	William St Vortex	-	-	-	-	-	-	-	-	-	-	-	-
23	Earl d/s of vortex	281	56	7,480	229	46	6,100	223	45	5,952	198	40	5,288
24	Gore St vortex	229	46	6,116	14	3	372	-	-	-	-	-	-
25	Lower Union d/s of vortex	411	82	10,960	237	47	6,324	203	41	5,412	92	18	2,464
26	West and Ontario	9,330	1,866	248,792	2,714	543	72,372	2,401	480	64,024	1,247	249	33,240
52	Raglan and Rideau	106	21	2,832	98	20	2,624	-	-	-	-	-	-
53	Division and Union	192	38	5,124	184	37	4,912	184	37	4,912	153	31	4,076
65	Belle Park Local SA1200	328	66	8,736	22	4	584	1	0	20	-	-	-
2	Belle Park Chamber, Trunks	363	73	9,684	92	18	2,464	49	10	1,300	-	-	-
55	King St. CSO Tank	888	178	23,688	505	101	13,476	505	101	13,476	-	-	-
56	Collingwood CSO Tank	10,734	2,147	286,248	1,243	249	33,144	1,173	235	31,276	1,302	260	34,728
TOTAL OVERFLOW		**25,146**	**5,029**	**670,560**	**5,790**	**1,158**	**154,400**	**5,085**	**1,017**	**135,604**	**3,067**	**613**	**81,796**
EFFLUENT AT RAVENSVIEW		**51,671**	**26,436**	**2,163**	**48,517**	**24,823**	**2,031**	**50,578**	**25,877**	**2,117**	**56,153**	**28,729**	**2,351**

From the results it can be observed that the effluent loadings for Ravensview WWTP for both TSS and BOD are significantly higher than those resulting from CSO overflows. However, bacteriological loading from CSO events is estimated to be one or two orders of magnitude higher than Ravensview WWTP. This indicates that one of the primary impacts resulting from CSO events is the potential impact on bacteriological water quality. This impact to water quality can result in implications to the safe recreational water use along the waterfront. The Kingston Frontenac Lennox and Addington Health Unit (KFLA) does periodic water sampling at select beaches in its district, which include two along the Kingston waterfront: Richardson Beach and the Collingwood PUC Dock. Sample results from the summer of 2014 were provided for these two locations and are presented below.

Table 3-22 Collingwood PUC Dock Sample Results

SAMPLE DATE (2014)*	RAINFALL RECORDED WITHIN 48 HRS?	SAMPLE 1 E.COLI / 100ML	SAMPLE 2 E.COLI / 100ML	SAMPLE 3 E.COLI / 100ML	SAMPLE 4 E.COLI / 100ML	SAMPLE 5 E.COLI / 100ML	GEOMETRIC MEAN E.COLI / 100ML
Jun 4	YES	30	10	10	10	10	12
Jun 18	YES	10	10	10	10	10	10
Jun 26	YES	10	10	10	10	10	10
Jul 3	YES	10	10	10	10	10	10
Jul 10	YES	10	10	10	10	10	10
Jul 16	YES	50	10	40	10	50	25
Jul 23	NO	10	10	10	10	10	10
Jul 30	YES	10	10	10	10	10	10
Aug 7	NO	10	10	10	10	10	10
Aug 13	YES	10	10	10	10	10	10
Aug 20	YES	10	10	10	10	10	10
Aug 28	NO	<10	<10	<10	<10	<10	10

*Nearest CSO location is PCP#56

Table 3-23 Richardson Beach Sample Results

SAMPLE DATE (2014)*	RAINFALL RECORDED WITHIN 48 HRS?	SAMPLE 1 E.COLI / 100ML	SAMPLE 2 E.COLI / 100ML	SAMPLE 3 E.COLI / 100ML	SAMPLE 4 E.COLI / 100ML	SAMPLE 5 E.COLI / 100ML	GEOMETRIC MEAN E.COLI / 100ML
Jun 4	YES	40	20	30	30	100	37
Jun 18	YES	10	10	10	10	20	11
Jun 25	YES	10	10	20	10	10	11
Jul 3	YES	10	10	10	10	10	10
Jul 10	YES	10	10	10	10	10	10
Jul 16	YES	10	30	20	10	60	20
Jul 23	NO	10	10	10	10	10	10
Jul 30	YES	10	20	10	10	10	11
Aug 7	NO	10	10	20	10	10	11
Aug 13	YES	10	40	40	20	30	25
Aug 20	YES	10	10	10	10	10	10
Aug 28	NO	10	<10	<10	<10	<10	10

*Nearest CSO locations are PCP#55 and PCP#26

F-5-5 requires that the Provincial Water Quality Objectives (PWQO) for E.coli is not exceeded based on a geometric mean at swimming and bathing beaches as a result of CSOs for at least 95% of the four-month season (June 1 to September 30) for an average year. Based on the available data there were no measured exceedances of the (PWQO) for E. coli of 100 E. coli per 100 mL at either location. Given that the sample period lasted three of the four required months and all samples were well below the PWQO, it is anticipated that both of these beaches would be very close to meeting the F-5-5 objective for beach protection, if they don't already. When comparing wet-weather events to E.Coli counts it appears that there is not always a strong relationship between these events and increased levels of e.coli at these sample locations. While larger readings do appear to occur on or within wet-weather events there are many days where wet-weather influence is not seen to directly correlate with any increase in sample readings on multiple days. This would imply that there are other factor effecting the reading besides the CSOs.

4 SEWER SYSTEM ALTERNATIVES INVESTIGATION AND ANALYSIS

4.1 APPROACH TO EVALUATION OF ALTERNATIVES

The alternatives were evaluated using the natural, social, cultural, technical, and economic criteria to determine the preferred servicing alternatives. These criteria are included in an evaluation matrix to objectively assess the impacts and determine the preferred solution. Comparative assessments of the alternative wastewater servicing options were conducted to determine which solutions has the least overall impact.

The following evaluation approach was used to determine the preferred wastewater servicing solutions for the identified issues:

1. **Step 1: Determine Evaluation Criteria** - Evaluation criteria for this project will include the impact on the natural environment, impact on the social and cultural environments, technical & operational merit, and financial & economic impact. The individual impacts will typically fit into these four general categories. A breakdown of the impacts considered under each criterion is defined in the section below.
2. **Step 2: Create an Evaluation System -** In order to be impartial, this system was developed prior to determining the potential impacts associated with each alternative. During the evaluation, each of the alternatives was assigned a colour rating: green for “preferred”, yellow for “less preferred” and orange for “least preferred”, for each of the evaluation criteria. The colour rating reflected how the alternative performs with respect to that criterion. The four evaluation categories were assigned equal weighting as they were considered to have equal importance in the evaluation.
3. **Step 3: Document Potential Impacts** - The individual impacts associated with each alternative were determined and documented. These impacts were categorized under one of the four categories of evaluation criteria described above.
4. **Step 4: Evaluate the Alternatives** - Each of the alternatives was assigned a colour rating for each of the four evaluation criteria using the methodology established in Step 2. The evaluation was based on a qualitative assessment of the individual impacts documented in the table created during Step 3.
5. **Step 5: Determine the Preferred Alternative** - The servicing alternative with the least overall impact was recommended for implementation.

4.1.1 EVALUATION METHODOLOGY

In order to qualitatively evaluate the alternatives, each of the criteria presented in the section below were assessed in a descriptive manner rather than a quantitative manner. Rather than having a numerical or weighted ranking system, the evaluation focuses instead on the strengths and weaknesses of each option to identify the preferred alternative. For each evaluation criterion and for each alternative, the potential effects on the environment were identified and evaluated relative to the other alternatives as being most preferred, less preferred and least preferred. The evaluation is based on the relative advantages and disadvantages of the potential environmental effects of each option.

As explained above, the evaluation approach involves the assessment of the impacts to the environment associated with implementing the water and wastewater system servicing alternatives. A more detailed breakdown of the specific consideration under each category is listed below:

NATURAL ENVIRONMENT CONSIDERATIONS

1. Natural Features
2. Watercourses and Aquatic Habitat
3. Natural Heritage Areas
4. Areas of Natural and Scientific Interest (ANSI)
5. Designated Natural Areas

SOCIAL AND CULTURAL ENVIRONMENT CONSIDERATIONS

1. Proximity of Facilities to Residences, Businesses and Institutions
2. Public health
3. Archaeological and Cultural Features
4. Designated Heritage Features
5. Wells or Wellhead Protection Areas
6. Consistency with Land Use Designations, Approved Development Plans and Proposed Land Use Changes

TECHNICAL SUITABILITY AND OPERATIONAL SUITABILITY

1. Design and Constructability
2. Ease of Connection to Existing Infrastructure & Ease of Modifications Required to Existing Infrastructure
3. Ability to reduce CSOs and meet MOECC F-5-5 target and virtual elimination goal

FINANCIAL & ECONOMIC CONSIDERATIONS

1. Operations and Maintenance Costs
2. Total Capital Costs

4.2 COMBINED SEWER OVERFLOW STRATEGY

One of the larger overall capital projects that the City is undertaking is the reduction of combined sewer areas. In 2006, the Combined Sewer Critical Evaluation was completed with the purpose of developing a guiding policy for the rehabilitation of combined sewer areas. The study concluded that the preferred option was to separate sewers and not replace the combined sewers.

New policies and programs were derived from the Critical Evaluation and later, as detailed in the 2010 PPCP update, the City of Kingston's Council adopted a policy that incorporates local sewer separation with a longer term goal of "virtual elimination" of CSOs. As policies and regulation change, it was determined that the effectiveness of these types of projects should be re-evaluated. A high level analysis of the sewer separation was completed to ensure that this objective is the most effective appropriate for the City of Kingston.

In order to complete an evaluation of sewer separation, high level alternatives were developed. The alternatives were grouped into three main categories to mitigate the occurrence and impacts of CSOs that include:

1. **Source Controls** – the method of removing stormwater that may be directed to the sanitary system by water conservation or lot level methods (i.e. sewer separation)
2. **Conveyance Control** - the method of transferring the flows through the sanitary system to the treatment facility
3. **End of Pipe Controls** – the method of containing the flows within the conveyance system or at the outfalls. These typically include some form of storage or treatment.

Based on these categories, the following alternatives were developed with the goal of each alternative to virtually eliminate CSOs in the central system:

Alternative 1. Do nothing: Status quo or to stop any further upgrades in the central system.

Alternative 2. Source Control: Eliminate all combined sewers in the central system

Alternative 3. Conveyance Control: Upsize/Upgrade the sewers and pumping station within the central system

Alternative 4. End of Pipe Control: Increase/add storage facilities within the central system to contain the flows

Alternative 5. Conveyance & End of Pipe Control: A combination of Alternative 3 and 4.

Table 4-1 Combined Sewer Reduction Analysis

	Alternative 1 Do Nothing	Alternative 2 Source Control	Alternative 3 Conveyance Control	Alternative 4 End-of-Pipe Control	Alternative 5 Conveyance & End-of-Pipe Control
Natural Environmental Considerations					
Impacts to Animal & Vegetative Features	• No reduction in CSO overflow volume has moderate impact on aquatic life in Lake Ontario.	• With reduced CSO volumes will have minor impact on aquatic life in Lake Ontario	• With reduced CSO volumes will have minor impact on aquatic life in Lake Ontario	• With reduced CSO volumes will have minor impact on aquatic life in Lake Ontario	• With reduced CSO volumes will have minor impact on aquatic life in Lake Ontario
Impacts to Water Course	• No reduction in CSO overflow volume has moderate impact to Lake Ontario	• With reduced CSO will have minor impacts to Lake Ontario	• With reduced CSO will have minor impacts to Lake Ontario	• With reduced CSO will have minor impacts to Lake Ontario	• With reduced CSO will have minor impacts to Lake Ontario
Natural Environment Overall Rating	Moderate impacts to Natural Environment	With reduced CSOs will have minimal overall impact to the Natural Environment	With reduced CSOs will have minimal overall impact to the Natural Environment	With reduced CSOs will have minimal overall impact to the Natural Environment	With reduced CSOs will have minimal overall impact to the Natural Environment
Social and Cultural Environmental Considerations					
Number of People Disrupted in Community	• Minor effect to people due to combined sewer overflows into Lake Ontario. No reported issues currently caused by overflows • No effect due to construction	• Potential upgrade would affect significant number of people in a number of different downtown communities based on the location of the combined sewers areas	Potential upgrade would affect moderate number of people in a number of different downtown communities based on the location of the existing infrastructure	• Potential upgrade would affect moderate number of people in a number of different downtown communities based on the location of the existing infrastructure	• Potential upgrade would affect moderate number of people in a number of different downtown communities based on the location of the existing infrastructure
Recent Disruptions to Communities by New Infrastructure	• No effect due to construction	• Some recent infrastructure reconstruction/upgrades have occurred	• Some recent infrastructure reconstruction/upgrades have occurred	• Some recent infrastructure reconstruction/upgrades have occurred	• Some recent infrastructure reconstruction/upgrades have occurred
Traffic Disruption	• No effect due to construction	• Construction of potential upgrades would have significant disruption to local traffic within the downtown core • Multiple traffic congestion periods (i.e. spread out over several years) due to multiple potential upgrades • Potential upgrades would have minimal disruption to commuter traffic as majority of combined sewer area are local roadways	• Construction of potential upgrades would have disruption to local traffic within the downtown core • Multiple traffic congestion periods (i.e. spread out over several years) due to multiple potential upgrades • Potential upgrades would have significant disruption to commuter traffic based on location and size of existing infrastructure	• Construction of potential upgrades would have disruption to local traffic within the downtown core • Multiple traffic congestion periods (i.e. spread out over several years) due to multiple potential upgrades • Potential upgrades would have minimal disruption to commuter traffic based on location and size of potential tanks	• Construction of potential upgrades would have disruption to local traffic within the downtown core • Multiple traffic congestion periods (i.e. spread out over several years) due to multiple potential upgrades • Potential upgrades would have significant disruption to commuter traffic based on location and size of existing infrastructure
Social Disruption	• No disruption to EMS • Negative impact to quality of recreational activities on waterfront from washed up debris	• Moderate disruption to local business as majority of remaining combined sewers are in residential areas • Moderate disruption to EMS	• Significant disruption to local business as majority of existing infrastructure is along commercial corridors • Moderate disruption to EMS	• Moderate disruption to local business as majority of end-of-pipe upgrades would be localized areas • Moderate disruption to EMS	• Significant disruption to local business as majority of conveyance infrastructure is along commercial corridors • Moderate disruption to EMS
Social/Cultural Environment Overall Rating	Minor to little overall disruption to social and cultural aspects	Significant impact as majority of combined sewers areas are local residential street; however significant amount of area is required to be reconstructed.	Significant impacts to people and traffic due to local of existing infrastructure (i.e. along major routes)	Moderate impacts to people and traffic as localize construction for tank installations	Significant impacts to people and traffic due to local of existing infrastructure (i.e. along major routes)
Technical Suitability					

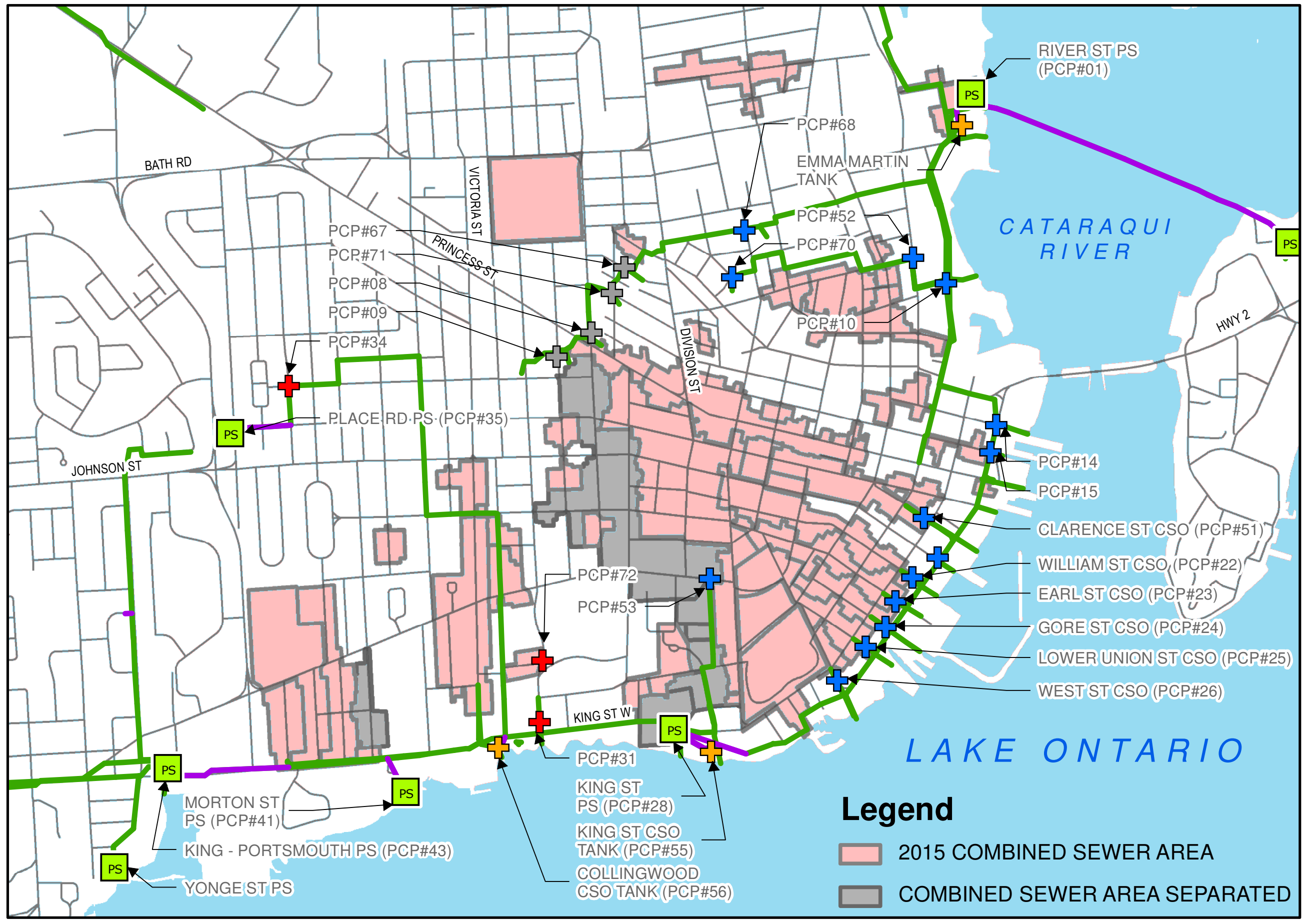
	Alternative 1 Do Nothing	Alternative 2 Source Control	Alternative 3 Conveyance Control	Alternative 4 End-of-Pipe Control	Alternative 5 Conveyance & End-of-Pipe Control
Capacity of Existing Linear Infrastructure	• Existing infrastructure would operate as it currently does and has identified capacity issues.	• Moderate upgrades to existing infrastructure would be required once areas have been separated to eliminate CSOs • Ravensveiw WWTP would have sufficient capacity	• Significant upgrades to the existing infrastructure would be required (i.e. 2 or more time the capacity) to eliminate CSOs • Ravensview WWTP would require a significant upgrade (2 or more time the capacity) to treat peak flows	• Significant upgrades/additions to the existing tanks and/or additional tanks (≈30,000m^3) would be required to eliminate CSOs • Additional infrastructure would be required to be able to fill the tanks as quickly as required and empty them when flows subside • Ravensview WWTP would require an upgrade to treat the additional ADF	• Significant upgrades to the existing infrastructure would be required (i.e. 2 or more time the capacity) to eliminate CSOs • Significant upgrades/additions to the existing tanks and/or additional tanks would be required to eliminate CSOs • Ravensview would require a significant upgrade (2 or more time the capacity) to treat flows
Approximate Amount and Ease of Construction of New Required Infrastructure	• No addition construction completed	• Significant amount of area required to be reconstructed to separate all combined sewer areas • Some difficulties anticipated to reconstruct of existing infrastructure due to high level of development present in the area (Downtown)	• Significant upgrades to the majority of existing combined sewer system infrastructure. • Some difficulties anticipated to reconstruct/upgrade existing infrastructure due to its location. Limited space and high levels of development present in the area (Downtown) • Complex WWTP upgrades required	• Significant tank storage required to eliminate CSO • Significant difficulties anticipated to upgrade/ add addition tank storage based on limited space, location of required storage and high levels of development present in the area (Downtown)	• Significant upgrades to the majority of existing combined sewer system infrastructure • Some difficulties anticipated to reconstruct/upgrade existing infrastructure due to its location. Limited space and high levels of development present in the area (Downtown) • Complex WWTP upgrades required
Ability to reduce CSO's and meet MOECC F-5-5 target and virtual elimination goal	• Does Not reduce CSO's	• Reduces CSO's • Would meet F-5-5 criteria • Would virtually eliminate	• Reduces CSO's • Would meet F-5-5 criteria • Would virtually eliminate	• Reduces CSO's • Would meet F-5-5 criteria • Would virtually eliminate	• Reduces CSO's • Would meet F-5-5 criteria • Would virtually eliminate
Technical/Operational Rating	Does not reduce of CSO volumes	Significant reconstruction of combined sewer areas in downtown core.	Significant upgrades of existing infrastructure. Significant difficulties with installation and limited space in downtown core.	Significant tank size increase/addition and complex infrastructure required to fill and empty.	Significant upgrades of existing infrastructure. Significant difficulties with installation and limited space in downtown core.
Economic Considerations					
Operational/Maintenance Costs	• The same operational and maintenance cost as current levels	• Significantly less operational and maintenance costs above current levels as less flow is pumped and treated. No additional facilities	• Significant increase in operational and maintenance above current levels as more flow would be pumped and treated	• Significant increase in operational and maintenance above current levels as more flow would be pumped and treated	• Significant increase in operational and maintenance above current levels as more flow would be pumped and treated
Capital Costs (incl. Constructability Risk)	• No additional capital costs	• Significant capital cost to install and reconstruction combined sewer areas (Opinion of Probable Cost ≈ 75M) • Moderate constructability risk (common type of work)	• Significant capital cost to upgrade existing combined sewer system (Opinion of Probable Cost ≈ 75M) & upgrade WWTP (Opinion of Probable Cost ≈ 175M), totaling approx. 250M • High constructability risk (large infrastructure and complex WWTP work).	• Significant capital cost to upgrade/add storage tanks (Opinion of Probable Cost ≈ 30M with potential land acquisition in downtown core) & upgrade WWTP (Opinion of Probable Cost ≈ 50M), totaling approx. 80M • High constructability risk as tanks need to be installed in areas near the Lake and there is complex WWTP work	• Significant capital cost to upgrade existing combined sewer system and additional tanks (Opinion of Probable Cost ≈ 50M) & upgrade WWTP (Opinion of Probable Cost ≈ 75M), totaling approx. 125M. • High constructability risk (significant flows and WWTP work).
Economical Overall Rating	Operational and maintenance cost remain the same as current levels	Significant capital cost but less overall operational and maintenance costs	Significant capital cost and operational costs	Significant capital cost but significantly more operational and maintenance costs	Significant capital cost and operational costs
OVERALL PREFERENCE RATING	**5 – Least Preferred**	**1 – Preferred**	**4 – Least Preferred**	**2 – Less Preferred**	**3 – Less Preferred**

4.2.1 REDUCTION PLAN

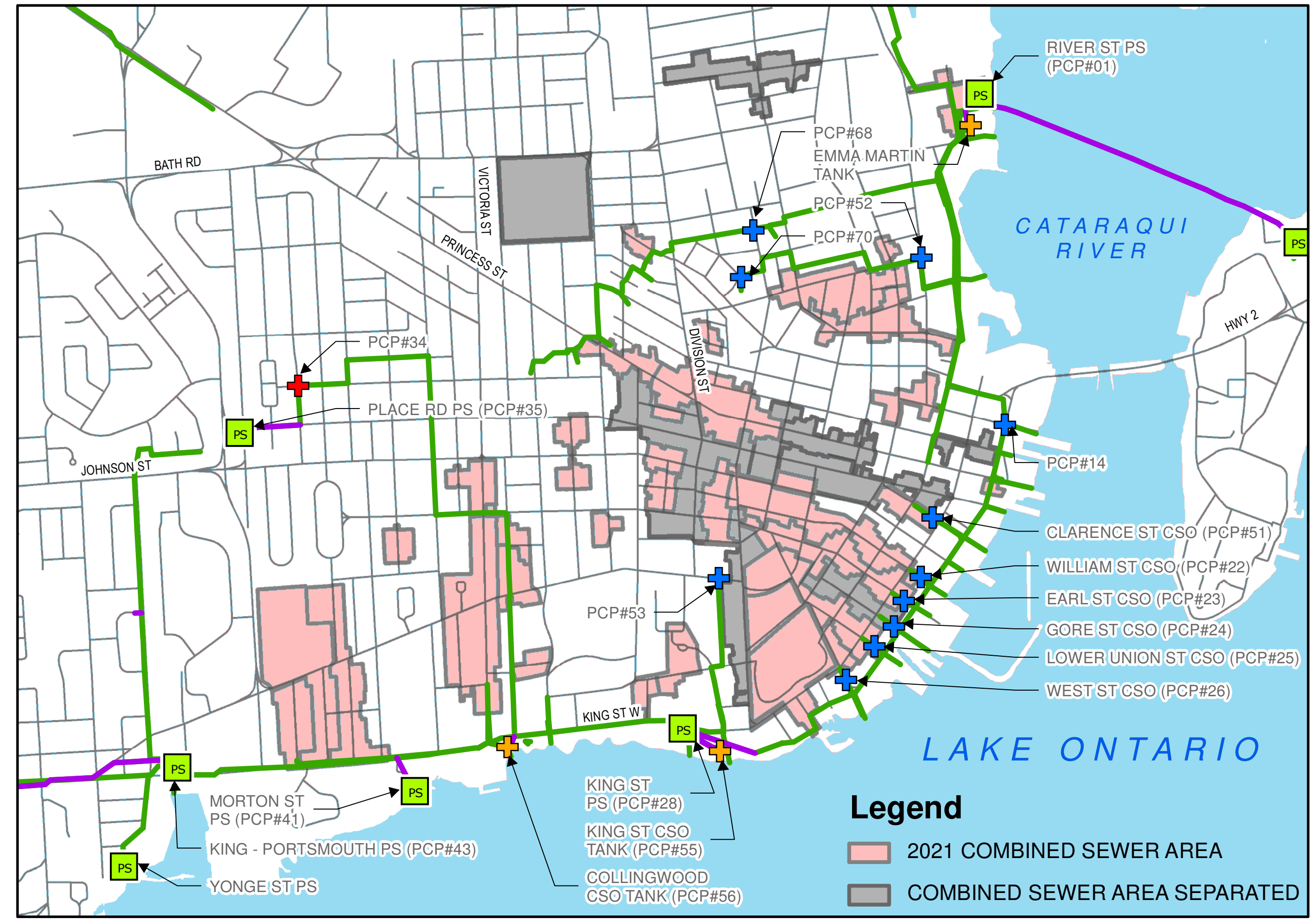
A CSO reduction plan was developed by Utilities Kingston and WSP to project how, when and where the source control measures would be implemented. This reduction plan was developed to estimate the pace and location of future sewer separation work for the purposes of the Master Plan. The estimation is based on an approach consistent with that used during the development of last eight years of capital reconstruction plans. This takes into consideration things such as infrastructure age, priority separation areas, and risk assessment based on the condition of all features within the right-of-way, including road and other utilities. This source control was used to identify initial gaps in the system as it was the current initiative for the City. As it can be seen in the analysis above, combined sewer reduction is still the preferred method for reducing combined sewer volumes. Figure 4-1 shows an overview of the combined sewer area projections by scenario in the central collection system and existing overflow locations.

One of the difficulties with developing a reduction plan that provides projections of roadway reconstruction and combined sewer separation is the certainty of that plan as you move further into the future. Policies and priorities of a City can change based on main factors and criteria that may not be evident today. Therefore, to provide additional understanding of the effects of variation in the reduction plan by 2036, an analysis was completed that reviewed the following alternatives:

- Scenario 1. No additional sewer separation by 2036 (Base Case)
- Scenario 2. 2026 projected sewer separation by 2036 (Slower Case)
- Scenario 3. 2026 project sewer separation + 50% of projected sewer separation between 2026 and 2036 by 2036 (Slow Case)
- Scenario 4. 2036 projected sewer separation by 2036 (Projected Case)
- Scenario 5. All combined sewer separated by 2036 (Faster Case)



1 **2015 COMBINED SEWER AREA**
4-1 1:27,500



2 **2021 COMBINED SEWER AREA**
4-1 1:27,500

3 **2026 COMBINED SEWER AREA**
4-1 1:27,500

4 **2036 COMBINED SEWER AREA**
4-1 1:27,500

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KINGSTON, ONTARIO,
K7L 4X7

Legend

- PS SANITARY PUMPING STATION
- COMBINED SEWER OVERFLOW (CSO)
- TANK OVERFLOW (TO)
- SANITARY SEWER OVERFLOW (SSO)
- PLUGGED CSO
- SANITARY SEWER (MODELLED)
- FORCEMAIN
- ROAD

Data Source: Ontario Base Mapping, Ministry of Natural Resources, August 2013. Water and Waste Water Systems, Utilties Kingston, April 2015, City of Kingston.

Scale:
0 200 400 800 Meters
1:27,500
N E S W

Project:
Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title:
COMBINED SEWER OVERVIEW

Project No.:	Date:		
151-02944-00	DECEMBER 2016		
Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	PCP	4-1

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.9_PPCP\Maps\151-02944-00_PCP_Fig4-1_Combined_Sewer_Overview.mxd

The table below summarizes the CSO analysis under the typical rainfall year for the different alternatives. The analysis was completed for each individual CSO for duration, time, and volume; however, accumulative totals for duration and time at each CSO have been shown in the table and the results have been flagged if any of the individual CSO locations do not meet the F-5-5 criteria (orange), or if all of the CSO locations are meeting the MOECC F-5-5 criteria (green). The MOECC F-5-5 criteria for duration and time are that the combined total duration of CSO events at any one CSO location shall not exceed 48 hours and controlling overflows to not more than two events per season. The volume criteria is a system criteria indicating that 90% of the wet-weather volume of the system (for an Average Year) above the dry-weather flow shall be treated. Refer to Appendix D for the results of the individual CSO not meeting the F-5-5 criteria.

Table 4-2 Reduction Plan Alternatives - Average Year

	SCENARIO 1 BASE CASE **2036 GROWTH WITH NO SEPARATION**	**SCENARIO 2** SLOWER CASE **2036 GROWTH WITH 2026 SEPARATION PROJECTIONS**	**SCENARIO 3** SLOW CASE **2036 GROWTH WITH 2026 + 50% OF 2036 SEPARATION PROJECTIONS**	**SCENARIO 4** PROJECTED CASE **2036 GROWTH WITH 2036 SEPARATION PROJECTIONS**	**SCENARIO 5** FASTER CASE **2036 GROWTH WITH ALL SEWER SEPARATED**
Approximately Combined Sewer Area Remaining (ha)	174	90	72	54	0
% of Remaining Combined Area relative to Base Case	-	51.7%	41.4%	31.0%	0.00%
Total Cumulative Duration Bypass (hrs)	348.5	238.5	227.5	73.5	25.0
% Reduction relative to Base Case	-	31.6%	34.7%	78.9%	92.8%
Total Number of Bypass Events	37	24	23	14	2
% Reduction relative to Base Case	-	35.1%	37.8%	62.2%	94.6%
Total By Pass Volume(m^3)	29,173	8,205	5,816	3,565	266
% Reduction relative to Base Case	-	71.9%	80.0%	87.8%	99.1%
Total Wet-Weather Volume at Ravensview (m^3)	1,310,602	913,797	860,949	819,183	794,965
% Reduction relative to Base Case	-	30.3%	34.3%	37.5%	39.3%
Wet-Weather Capture (Bypass / Wet-Weather) (m^3)	97.8%	99.1%	99.3%	99.6%	99.9%

Similar to above, Table 4-3 below presents the results for a wetter than average year for the different alternatives.

Table 4-3 Reduction Plan Alternatives - Wetter Than Average Year

	SCENARIO 1 BASE CASE **2036 GROWTH WITH NO SEPARATION**	**SCENARIO 5** SLOWER CASE **2036 GROWTH WITH 2026 SEPARATION PROJECTIONS**	**SCENARIO 4** SLOW CASE **2036 GROWTH WITH 2026 + 50% OF 2036 SEPARATION PROJECTIONS**	**SCENARIO 4** PROJECTED CASE **2036 GROWTH WITH 2036 SEPARATION PROJECTIONS**	**SCENARIO 5** FASTER CASE **2036 GROWTH WITH ALL SEWER SEPARATED**
Approximately Combined Sewer Area Remaining (Ha)	174	90	72	54	0
% of Remaining Combined Area relative to Base Case	-	51.7%	41.4%	31.0%	0.00%
Total Cumulative Duration Bypass (Hrs)	750.0	634.0	624.0	92.5	5.0
% Reduction relative to Base Case	-	15.5%	16.8%	87.7%	99.3%
Total Number of Bypass Events	63.0	41.0	39.0	24.0	1.0
% Reduction relative to Base Case	-	34.9%	38.0%	61.9%	98.4%
Total By Pass Volume(m^3)	82,538	36,480	30,441	20,449	1,050
% Reduction relative to Base Case	-	55.8%	63.1%	75.2%	98.7%
Total Wet-Weather Volume at Ravensview (m^3)	1,800,624	1,212,304	1,137,885	1,080,651	795,749
% Reduction relative to Base Case	-	32.7%	36.8%	40.0%	55.8%
Wet-Weather Capture (Bypass / Wet-Weather) (m^3)	95.4%	97.00%	97.3%	98.1%	99.9%

It can be seen from the tables above that in the average year, and more so in the wetter-than-average year, continuing with the projected sewer separation has significant benefits to becoming fully compliant with MOECC F-5-5 and the City's goal of "virtual elimination". By continuing with the projected sewer separation plan, significant treatment volume reduction can be achieved that could have significant operational and maintenance cost reductions. Additionally, in both scenarios, there is a significant change in the duration and number of events between the slow case and projected case. This appears to be mainly due to the overall levels in the system and a situation where the levels drop below a “tipping point” that significantly reduces these factors. This is also shown in the bypass reduction as this does not reduce as much, meaning that large wet-weather events still have overflows; however, the system seems to be able to handle some of the smaller events that would increase the number and duration but have less effect on the total volumes.

In consultation with the Ministry of Environment and Climate Control (MOECC) and the Cataraqui Region Conservation Authority (CRCA), while all criteria are important, the volume and duration criteria are typically the more important aspects with the volume being the most important criteria. This is because those criteria have the most significant impact on the environment. The projected case does meet these MOECC F-5-5 criteria and only two locations exceed the number of events (West and Ontario St – PCP#26 and Collingwood CSO Tank – PCP#56).

4.2.2 REMAINING COMBINED SEWER AREAS

Currently, based on the projected combined sewer separation plan, by 2036 scenario there are combined sewer areas which are projected to remain. To compare the effectiveness of sewer separation for the remaining areas, the model was used to simulate the variation in separation with alternative increases in the separation of areas to review the effectiveness of CSO area reduction. This analysis was a sensitivity analysis to determine the most effective remaining areas for separation for two purposes. First to provide guidance for the development of a reduction plan beyond 2036, and secondly, to provide further information if the current reduction plan wishes to be accelerated slightly.

This sensitivity analysis was completed for the 2036 grow scenario by eliminating one of the four remaining areas, as indicated in Figure 4-2. Each area was eliminated while the remaining areas were left unseparated.

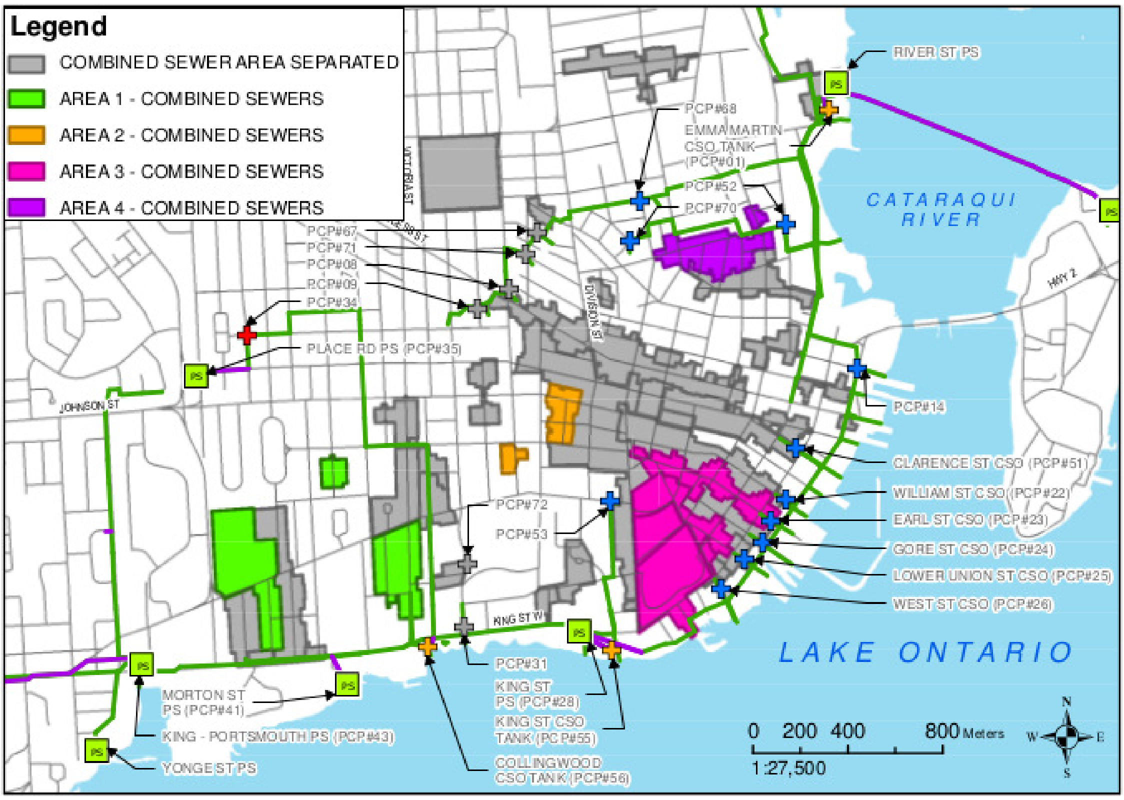


Figure 4-2 Remaining Combined Sewer Areas

As indicated above, the CSO analysis is done based on two criteria;

1. To meet F-5-5 and;
2. To “virtually eliminate” CSOs under a wetter than average year.

To review this, the CSOs were analyzed using the average rainfall year (2014) and the wet rainfall year (2008).

Table 4-4 summarizes the totals from the CSO analysis under the typically rainfall year. The same format and criteria used in the previous section was used to display the results in relation to MOECC Procedure F-5-5 criteria. Refer to Appendix D for the results of the individual CSOs.

Table 4-4 Average Year CSO Overflow Volume, Duration and Frequency by Scenario for 2036 Growth Projection

		2036 GROWTH WITH 2036 SEWER SEPARATION PLUS				
	BASE CASE **NO ADDITIONAL SEWER SEPARATION**	**AREA 1: SEWER SEPARATION**	**AREA 2: SEWER SEPARATION**	**AREA 3: SEWER SEPARATION**	**AREA 4: SEWER SEPARATION**	**FULL SEWER SEPARATION**
Approximately Combined Sewer Area Remaining (ha)	54	36	51	29	47	0
% of Remaining Combined Area relative to Base Case	-	70.6%	94.4%	53.7%	87.0%	0.0%
Total Cumulative Duration Bypass (hrs)	73.5	30.5	45.0	40.0	48.5	25.0
% Reduction relative to Base Case	-	58.5%	38.8%	45.6%	34.0%	66.0%
Total Number of Bypass Events	14.0	6.0	11.0	10.0	12.0	2.0
% Reduction relative to Base Case	-	57.1%	21.4%	28.6%	14.3%	85.7%
Total By Pass Volume(m^3)	3,565	571	1,903	1,456	2,539	334
% Reduction relative to Base Case	-	84.0%	46.6%	59.2%	28.8%	90.6%
Total Wet Weather Volume at Ravensview (m^3)	819,183	720,356	743,151	720,968	730,943	695,033
% Reduction relative to Base Case	-	12.0%	9.3%	12.0 %	10.8%	15.1%
Wet Weather Capture Ratio (Bypass / Wet Weather) (m^3)	99.6%	99.9%	99.7%	99.8%	99.6%	99.9%
Rate of By-Pass Reduction (m3/ha)	-	166.3	554.0	66.5	146.6	61.1

The findings from the CSO sensitivity analysis further shows the effectiveness of sewer reductions for an average rain year. It shows that while Area 1 is the most effective area to reduce the total amount of bypass, Area 2 is the most effective area from a reduction per hectare point of view. Conversely, Area 4 is the least effective area to reduce the overall amount of bypass; however, it is the second most effective area when considering reduction per hectare. The fully separated system demonstrates that the F-5-5 criteria would be met for all parameters once separated. This shows that full separation of the system is an effective and reasonable long term goal to meet the F-5-5 criteria.

Table 4-5 below shows the results of the CSO during the wetter-than-average year.

Table 4-5 Wet Year CSO Overflow Volume, Duration and Frequency by Scenario for 2036 Growth Projection

	BASE CASE	2036 GROWTH WITH 2036 SEWER SEPARATION PLUS				
	NO ADDITIONAL SEWER SEPARATION	**AREA 1: SEWER SEPARATION**	**AREA 2: SEWER SEPARATION**	**AREA 3: SEWER SEPARATION**	**AREA 4: SEWER SEPARATION**	**FULL SEWER SEPARATION**
Approximately Combined Sewer Area Remaining (ha)	54	36	51	29	47	0
% of Remaining Combined Area relative to Base Case	-	70.6%	94.4%	53.7%	87.0%	0.0%
Total Cumulative Duration Bypass (hrs)	92.5	30.5	86.5	67.5	81.0	5.0
% Reduction relative to Base Case	-	67.0%	6.5%	27.0%	12.4%	66.0%
Total Number of Bypass Events	24.0	10.0	22.0	16.0	21.0	1.0
% Reduction relative to Base Case	-	58.3%	8.3%	33.3%	12.5%	85.7%
Total By Pass Volume(m^3)	20,449	6,193	18,170	14,595	17,426	1,050
% Reduction relative to Base Case	-	69.7%	11.1%	28.6%	14.8%	94.9%
Total Wet Weather Volume at Ravensview (m^3)	1,080,651	947,306	987,815	956,474	1,077,628	795,749
% Reduction relative to Base Case	-	12.3%	8.6%	11.5 %	0.3%	26.4%
Wet Weather Capture Ratio (Bypass / Wet Weather) (m^3)	98.1%	99.4%	98.2%	98.5%	98.4%	99.9%
Rate of By-Pass Reduction (m3/ha)	-	792.0	759.6	234.2	431.9	359.2

From the table above, similar results to the average year can be observed. They emphasize even further that by completing the sewer separation as planned, it has a significant reduction in the amount of wastewater overflows. In the wetter than average year, results show that Area 1 is the most effective area to eliminate when considering both total bypass reduction as well as reduction per hectare. Area 2 is the next most effective area to eliminate from a reduction per hectare point of view, second to Area 1 by a small amount. Additionally, as in the average rainfall year, it shows that by eliminating combined sewers it meets the goal of "virtually eliminating" combined sewer overflows. There are some variations in the results between the wetter-than-average year and the average rainfall year. These variations are due to differences in the rain events that occurred in 2014 and 2008.

While the wetter-than-average year had more rainfall overall, there is are variances in how close together the storms are as well as in the individual severity of the storms, causing variances in the results.

4.3 LONG-TERM CSO REDUCTION STRATEGIES

As demonstrated above, sewer separation is the most effective combined sewer overflow reduction plan. By implementing the combined sewer reduction plan, the combined sewer system begins to operate as a typical separated system. In order to understand what upgrades would be required for the system beyond 2036 and help with future planning, an analysis of the system was completed to a similar standard as the analysis of the rest of the system. For pumping stations and sewers, a 1:10yr storm LOS was selected. The following scenarios were developed to provide an outline for potential servicing strategies. Common or reasonable upgrades were identified that can be completed within the currently Master Plan horizon so when the majority of combined sewers are removed, the system can then be reviewed as a separated system:

- Scenario 1. Sewer Separation as planned
- Scenario 2. Aggressive Sewer Separation
- Scenario 3. Redirect Northern Central Flow to East

SCENARIO 1

In this alternative there would be no more sewer separation beyond what is planned for the 2036 development scenario. This option is considered the "do nothing" or base case option.

SCENARIO 2

Alternative 2 consists of the remaining combined sewer areas being eliminated by 2036. This option would be an aggressive reduction program, as it would be above what UK has deemed to be reasonable sewer separation to be completed.

SCENARIO 3

In this alternative, the sewer separation would be as currently planned to 2036, and then the flows from the north portion of the City (North End Trunk Sewer, Dalton, North End Outlet Sewer and the Rideau Heights Trunk Sewer) would be re-directed away from the downtown combined sewer system. A new pumping station and forcemain would be constructed at the intersection of the North End Outlet Sewer and the Rideau Heights Trunk Sewer, pumping across the Cataraqui River between John Counter Boulevard and Gore Road (i.e. Third Crossing) to the Highway 15 trunk sewer. This option was developed to provide an understanding of the upgrades to the downtown system if some flows were diverted away from the River Sreet PS.

Each component of infrastructure was reviewed in each of the alternatives to determine the level of upgrade required to meet the 2036 1:10yr LOS. Table 4-6 below illustrates those upgrades.

Table 4-6 Alternative Strategies for Conveyance Improvements

INFRASTRUCTURE	SCENARIO 1: SEWER SEPARATION AS PLANNED	SCENARIO 2: FULLY SEPARATED SEWER	SCENARIO 3: REDIRECT NORTHERN CENTRAL FLOW TO EAST
River St. PS	Firm capacity Increase by approximately 110% to 3600 L/s (Peak Flow)	Firm capacity Increase by approximately 90% to 3200 L/s (Peak Flow)	Firm capacity Increase by approximately 40% to 2400 L/s (Peak Flow)
King St. PS	Firm capacity Increase by approximately 50% to 1050 L/s (Peak Flow) Forcemain Twinning	No Upgrade Required	Firm Capacity Increase by Approximately 50% to 1050 L/s (Peak Flow) Forcemain Twinning
North Harbourfront Interceptor	Twinning or Sewer Upsizing (Approximately 750 m) From MH9227-041 to 7114-010 (Rideau to Cataraqui St.)	No Upgrade Required	No Upgrade Required
Harbourfront Trunk Sewer	Twinning Required (Approximately 2200 m) MH6051-010 to 9903-010 (Emily St. to Wellington St.) and MH7114-030 to River St. PS (Cataraqui St. to River St. PS)	Twinning Required (Approximately 250 m) MH7114-030 to River St. PS (Cataraqui St. to River St. PS)	Twinning Required (Approximately 2200 m) MH6051-010 to 9903-010 (Emily St. to Wellington St.) and MH7114-030 to River St. PS (Cataraqui St. to River St. PS)
Rideau St Collector	Upsizing of Sewer Required (Approx. 350 m) MH7455-025 to 7106-020) (Wellington St. to Reglan Rd.) from a 375 mm to a 600 mm	Upsizing of Sewer Required (Approx. 350 m) MH7455-025 to 7106-020) (Wellington St. to Reglan Rd.) from a 375 mm to a 600 mm	Upsizing of Sewer Required (Approx. 350 m) MH7455-025 to 7106-020) (Wellington St. to Reglan Rd.) from a 375 mm to a 600 mm
George St. Collector	No Upgrade Necessary	No Upgrade Necessary	No Upgrade Necessary
Ravensview Trunk Sewer	Twinning or Sewer Upsizing of Entire Length (Approximately 3400 m)	Twinning or Sewer Upsizing of Entire Length (Approximately 3400 m)	Twinning or Sewer Upsizing of Entire Length (Approximately 3400 m)
Barret Crt PS.	No Upgrade Required	No Upgrade Required	Firm Increase by Approximately 80% to 1350 L/s (Peak flow) Forcemain upsizing/ twinning
Ravensview WWTP	Capacity Increase for Peak flow (1:10yr Storm) by approximately 75% to 335,000 m^3/day.	No Upgrade Required	Capacity Increase for Peak flow (1:10yr Storm) by approximately 30% to 250,000 m^3/day.

As it can be seen from the different servicing strategies above, there is a variety of upgrades that would be required to treat the current combined sewer system as a separated system, and meet the 1:10yr storm LOS.

4.4 WET-WEATHER INFLOW IN SEPARATED SEWERS

An important component of CSO reduction is the need is to reduce the amount of wet-weather inflow in separated areas as well. In order to review this, the area of interest was expanded to include the west and east systems for this component. Wet-weather inflow reduction is a difficult process to fully identify and quantify within a specific area. Many causes can affect the inflow into a sanitary system including:

1. Inflow to pipes at damaged joints or broken pipe sections
2. Private connections of building foundation/footing drains, roof leaders and/or sump pump connections
3. Direct inflow from manhole lids or manholes in poor condition (i.e. leaks)
4. Unknown direct connections of storm system component to the sanitary system (i.e. within a site)

Typically, in order to reduce the amount of inflow in a system, a systematic investigation is required that uses a variety of inputs to identify the issues including:

→ Sewer flow monitoring
→ Condition assessments of manholes
→ Smoke and dye tests of sewers
→ CCTV inspection of sewers
→ Property surveys of storm connections system monitoring

With information from these methods, a wet-weather reduction strategy can be developed; however, these types of studies take time and need to be focused on specific areas to deliver meaningful results. To provide a guide for focused investigations, an analysis of the catchment area has been completed. The City of Kingston still has a number of combined sewer area serviced by combined sewers which would have a direct impact on inflow. Utilities Kingston has developed a combined sewer separation plan to eliminate these areas. This section is mainly related to areas that do not have known combined sewers, in order to identify areas with higher inflow influence than others. Existing flow monitoring data and the InfoSWMM model was used to analyze inflow.

The InfoSWMM model uses a dynamic approach to rainfall response or Rain-Derived Infiltration and Inflow (RDII). RDII in the InfoSWMM model is customized for unique rainfall responses based on area and location. This process assigns rainfall loading into the sanitary system using the combination of short, medium, and long term responses, intended to represent the natural behavior of direct rainfall runoff, delayed rainfall runoff with initial infiltration, and saturated ground infiltration over a longer time period respectively. Based on the catchment area size for each model element, wet-weather calibration was based on adjustment of these for Kingston West, Central and East. The adjustment of parameters was made to ensure that the model response matched the anecdotal information provided by UK staff in combination with flow monitoring data. This RDII process ensures that the responses or results from the model for wet-weather are consistent with actual events and are somewhat correlated to the specifics of that catchment area.

Using the results from the modeling of 2015 for the dry-weather and a two year return period provides an indication of the wet-weather response of the system. In order to provide a meaningful review, a system has been developed to flag or prioritize catchment areas. This system was developed to include two factors:

1. Inflow Versus Area

2. Overall Benefit

INFLOW VERSUS AREA

In order to determine the scale of the potential repairs to the system (i.e. a large catchment area and a small catchment area have the same amount of inflow, but the larger area would potentially need more repairs for the same amount of reduction), the wet-weather flow (2yr peak flow – the dry peak flow) was compared to the area. Once this was calculated, a scoring method using the following ranges was used:

Inflow Rate (L/s/ha)	Score
0.0 – 0.15	1
0.16 – 0.45	2
0.46 – 1.0	3
>1.0	4

OVERALL BENEFIT

Some areas have significant wet-weather flow and others have smaller amounts, therefore the overall potential reduction or wet-weather amount is also considered. Once this was determined, it was scored using the following criteria:

Wet-Weather Flow (L/s)	Score
0-10	1
11 -100	2
101 – 250	3
>250	4

Based on these criteria, Table 4-7 provides a summary of this analysis. Note that in order to focus on specific catchment area, any catchment area draining into downstream catchment areas have been removed.

Table 4-7 **Inflow Analysis**

Region	Catchment Area	Service Area	Adjusted Service Area	DW Peak Inflow	2-yr Peak Inflow	Wet Weather Flow	Adjusted Wet Weather Flow	Wet Weather	Inflow Rate	Adjusted Inflow Rate	inflow	I&I Rating
		(ha)	(HA)	(L/s)	(L/s)	L/S	L/s		L/s/ha	L/s		
		A	A1	B	C	D=C-B	D1	E	F=D/A	F1=D1/A1	G	H=E*G
West	Bath Rd.	31.2	31.2	4.45	15.12	10.67	10.67	2.00	0.342	0.342	2.00	4.00
West	Bath – Collins Bay	7.6	7.6	1.55	14.22	12.67	12.67	2.00	1.668	1.668	4.00	8.00
West	Bath – Lower	4.9	4.9	0.32	2.45	2.13	2.13	1.00	0.435	0.435	2.00	2.00
West	Bayridge Dr.	10.8	10.8	0.82	8.44	7.62	7.62	1.00	0.706	0.706	3.00	3.00
West	Collins Bay Rd.	15.5	15.5	0.58	2.67	2.09	2.09	1.00	0.135	0.135	1.00	1.00
West	Coverdale Dr.	59.7	59.7	5.67	14.42	8.75	8.75	1.00	0.147	0.147	1.00	1.00
West	Crerar Blvd.	59	59.0	14.56	63.93	49.37	49.37	2.00	0.837	0.837	3.00	6.00
West	Days Rd.	1998.9	1425.4	221.02	623.31	402.29	235.38	3.00	0.201	0.165	2.00	6.00
West	Hillview Rd.	317.8	215.3	53.01	118.23	65.22	37.99	2.00	0.205	0.176	2.00	4.00
West	John Counter Blvd.	3.3	3.3	0.47	6.13	5.66	5.66	1.00	1.716	1.716	4.00	4.00
West	Lakeshore Blvd.	142.9	132.1	44.99	72.38	27.39	19.77	2.00	0.192	0.150	1.00	2.00
West	Rankin Cres.	15.6	10.7	8.60	10.94	2.34	0.21	1.00	0.150	0.020	1.00	1.00
West	Westbrook Rd.	58.9	58.9	2.61	10.61	8.00	8.00	1.00	0.136	0.136	1.00	1.00
Central	Dalton Ave.	827.9	821.1	124.61	588.55	463.94	453.33	4.00	0.560	0.552	3.00	12.00
Central	Greenview Dr.	6.8	6.8	1.62	12.22	10.60	10.60	2.00	1.559	1.559	4.00	8.00
Central	King St.	607.1	258.1	329.52	859.09	529.56	363.00	4.00	0.872	1.406	4.00	16.00
Central	King – Elevator Bay	5.4	5.4	1.11	7.15	6.04	6.04	1.00	1.119	1.119	4.00	4.00
Central	King – Lake Ontario	15.2	15.2	0.64	3.04	2.40	2.40	1.00	0.158	0.158	2.00	2.00
Central	King - Portsmouth	291.5	291.5	70.17	206.81	136.64	136.64	3.00	0.469	0.469	3.00	9.00
Central	Morton St.	9.8	9.8	0.55	10.10	9.55	9.55	1.00	0.974	0.974	3.00	3.00
Central	Palace Rd.	26	26.0	1.683	12.923	11.24	11.24	2.00	0.432	0.432	2.00	4.00
Central	River St.3	2224.9	789.9	709.50	1978.60	1269.09	275.59	4.00	0.570	0.349	2.00	8.00
Central	Yonge St.	1.1	1.1	0.58	1.28	0.70	0.70	1.00	0.633	0.633	3.00	3.00
East	Barrett Ct.	292.2	266.6	36.41	64.01	27.61	17.48	2.00	0.094	0.066	1.00	2.00
East	Highway 15	69	69.0	3.52	11.94	8.42	8.42	1.00	0.122	0.122	1.00	1.00
East	James St.	76.9	76.9	49.74	51.11	1.37	1.37	1.00	0.018	0.018	1.00	1.00
East	Kenwoods Cir.	6.9	6.9	1.28	3.20	1.92	1.92	1.00	0.278	0.278	2.00	2.00
East	Schooner Dr.	18.7	18.7	1.90	10.10	8.20	8.20	1.00	0.439	0.439	2.00	2.00

Good	Moderate	High	Very High

While the intent of the above analysis was not specifically for areas with combined sewers, they were reviewed as indicators for the benefits of sewer separation. It can be seen that King St. has the highest overall rating, as it has significant combined sewers in its catchment area. While River St. does not rate as high as King St., it also has significant number of combined sewers; however, it has more overflow control that reduces the amount of flow at the station and, therefore, reduces its overall rating.

Dalton Ave. PS has the second highest rating, and has had reports of high wet-weather influence. Greenview PS, which drains into Dalton Ave. PS, also has a high rating that could have some influence on Dalton Ave. PS rating. Both of these stations have significant piping in low lying areas near the Little Cataraqui Creek and therefore are more likely to be susceptible to wet-weather influences.

Bath Collins Bay PS indicates a high rating; however, it has been noted that the data used to calibrate this station in the model is limited and may need further analysis.

Crerar PS has a high rating, and has been noted to have significant wet-weather influence. Part of this high flow is due to the discharge of water from the Point Pleasant Water Treatment Plant. This discharge is being removed and, therefore, may need further analysis once removed.

King - Portsmouth also has a high rating. This area was indicated as having high wet-weather influence in the 2010 Master Plan and Utilities Kingston is currently in the process of completing an I&I study and improvements in the drainage area.

Days Rd. PS does indicate a high rating; however, based on the process of eliminating upstream drainage areas and the number of upstream drainage areas it is difficult to fully eliminate their influence. Therefore, a separate analysis of the main tributary areas has been completed to provide additional information and can be seen in Table 4-8 below.

Table 4-8 Analysis of Main Tributary Areas

CATCHMENT AREA	SERVICE AREA (HA) A	DW PEAK INFLOW (L/S) B	2-YR PEAK INFLOW (L/S) C	WET-WEATHER FLOW (L/S) D=C-B	WET-WEATHER E	INFLOW RATE L/S/HA F=D/A	INFLOW G	I&I RATING H=E*G
Day Rd Inlet	420	49.9	117.3	67.4	2	0.160	2	4.00
Northwest Collector	305.4	45.5	123.5	78	2	0.255	2	4.00
Northcentral Collector	869.4	67.5	180.2	112.7	3	0.130	1	3.00
Northeast Collector	269.8	23.7	60.3	36.6	2	0.136	1	2.00
Remaining Area	134.3	34.42	142.01	107.588	3	0.801	3	9.00

As it can be seen from the analysis above, the area around the Days Rd. Pumping Station has the highest rating while the other areas, mainly north of Bath Rd., have a moderate to good rating.

5 RECOMMENDED STRATEGIES

5.1 PAST RECOMMENDED STRATEGIES AND PROJECTS

5.1.1 SEWER SEPARATION PROGRAM

The projected sewer separation for the 2021, 2026 and 2036 scenarios was analyzed in the 2015 Master Plan Study. The results support the sewer separation recommendations from the past PPCP updates. Sewer separation is a primary CSO reduction strategy as a source control measure. It is recommended as the leading strategy to reduce combined sewer overflows in the system and supports the goal of 'virtual elimination' of overflows in wetter than average year. Impacts to PCP #'s and their site-specific recommendations based on this strategy are presented in Section 0.

5.1.2 KING-PORTSMOUTH PUMPING STATION REDIRECTION

The King-Portsmouth PS service area redirection was evaluated in the Portsmouth Flow Direction Environmental Assessment in the 2010 PPCP update. The re-direction of the Portsmouth PS in the previous PPCP demonstrated that it was an effective solution to reduce sanitary loading to the Kingston Central/East collection systems which also contributed to reductions in combined sewer overflows; however, it was not recommended to re-direct the flows, I&I reduction was indicated as the preferred alternative. In 2014 a new environmental assessment study (EA) was completed by WSP where influencing critieria had changed and, therefore, the redirection was examined in further detail. In the EA redirection of sanitary flow to the Cataraqui Bay WWTP (Kingston West) was determined as the recommended route with a new forcemain. Redirection of flows from this catchment area demonstrated in the study to provide reductions in overflows at the PCPs located directly downstream of the King-Portsmouth PS forcemain outlet. This includes the Collingwood CSO Tank overflow and King St. PS/King St. CSO Tank overflows. Further reductions were also seen along the Harbourfront Trunk Sewer at locations such as the West St. CSO. Model simulations in the study showed upwards of 30% reductions in total CSO volumes during a wetter than average year simulation.

It is recommended that this project continue in conjunction with the sewer separation strategy. The results from the modeling study for the 2015 Master Plan Study also support the findings of the EA, and upgrades currently underway at the Cataraqui Bay WWTP are able to accommodate the diverted flows from this service area. Impacts to PCP #'s and their site-specific recommendations is presented in Section 5.4.

5.1.3 CAPITAL PROJECTS REMAINING

5.1.3.1 NORTH HARBOURFRONT INTERCEPTOR TWINNNING

Increasing the downstream sewer capacity by twinning the existing North Harbourfront Interceptor was recommended in the 2010 PPCP Update as a means of relieving bottlenecks in the trunk sewer which were observed to contribute to overflows at the Belle Park Overflow location (PCP#2 & 65). This recommendation was reviewed in the 2015 Master Plan. It was observed that downstream bottlenecks occurring at the River St. PS during wet-weather simulations raise the hydraulic grade line (HGL) in the North Harbourfront Interceptor due to sewer back-up. This, in turn, causes overflows to occur at this structure. While twinning this sewer would reduce the HGL, it was not found that twinning alone would reduce the HGL enough to prevent regular overflows at this location during wet-weather model simulations.

It is recommended that sewer separation continue to alleviate the wet-weather surcharging into the trunk sewers and that under the new CSO monitoring program there are monitors capable of determining the flow direction and sewer back-up condition in the North Harbourfront Interceptor to confirm these conditions in future studies.

It is also recommended reviewing the operation and hydraulics of the chamber after upstream combined sewer separation is completed related to PCP 65.

5.1.3.2 KING STREET TANK (O'KILL STREET) CSO SCREENING AND FLOW MONITORING

It was recommended that the CSO screening be installed at the King St. CSO Tank where it receives direct flows from combined sewers. Currently CSO screening is provided at the King St. Pumping Station. Continued screening is recommended in support of the Floatables Control Program.

5.1.3.3 WEST ST. CSO (PCP#26)

It was recommended that the CSO screening and a weir height adjustments be considered at the West St. CSO given the frequency, duration and volumes of overflows at this location. Work has been completed increase the weir height adjustment at this location in 2016. CSO screening may be considered under the Floatables Control Program, however currently a large amount screening is already provided upstream of this location for flows received from the King St. Pumping Station. Continued monitoring of any floatable control issues is recommended prior to any additional CSO screening installations at this locations.

5.1.4 NON-CAPITAL PROJECTS

5.1.4.1 CSO MONITORING PROGRAM

CSO monitoring is recommended to continue and be expanded to include CSOs not currently monitored, or those that are currently only monitored to indicate the occurrence of an overflow event. Monitoring systems that permit the source of flow (storm or sanitary), volume, duration, and frequency should be installed or updated to continue to support monitoring system performance. UK should continue to use MOECC Procedure F-5-5 criteria as the minimum objective for reducing sewer overflows. UK should also continue to use the monitoring program to work towards the goal of "virtual elimination", where overflows only occur during major rainfall events or during unusually long periods of wet-weather as supported by a review of CSO flow monitoring data.

Flow monitoring may be considered to improve future updates to hydraulic models and to support future Master Plans and PPCP updates. To support this, it is recommended that data collected, which provides an indication of flow direction, duration, frequency, level, and volume, be considered for a minimum of two years prior to study updates. In-line flow monitors, SCADA, and remote level monitors may be used in conjunction to support the data collection with monitors to be strategically located around CSOs, SSOs, PSOs, pumping stations and contributing local and trunk sewers within the scope of analysis.

5.1.4.2 MODELING UPDATES

The wastewater trunk model developed in past Master Plan Studies and updated in the 2015 Master Plan is recommended to be used in future studies. Model rebuilds, updates, and calibration may be expanded to make the best use of available data and should be improved to support system analysis for dry-weather and wet-weather sewer conditions to reflect existing conditions as the collection system evolves. This may include, but is not limited to:

1. An all-pipe model rebuild
2. Trunk sewer model collection system expansion/rebuild based on latest GIS data
3. Facility updates for new and existing assets including pumping stations
4. Secondary sewers/pumping stations for consideration in future works to be added.

5. Model updates related to any changes in facility operations throughout the collection systems.

5.1.4.3 INTEGRATED STORMWATER MANAGEMENT STRATEGY

Currently the City and UK manage storm sewers and sanitary sewers separately. However, pollution control is required for all collection system types. Synergies in management may be achieved through an integrated stormwater management strategy. It is recommended that consideration be given to expanding stormwater guidelines into an overall stormwater strategy that also addresses pollutant loading from existing stormwater discharges.

5.1.4.4 INFILTRATION AND INFLOW (I&I) REDUCTION

JAMES ST. PS SERVICE AREA

The James St. (B-64) PS service area was previously identified in the 2010 Sewage Infrastructure Master Plan update as an area observed with high I&I and was warranted as a candidate for extraneous flow reduction. In the 2015 Master Plan, the area was re-evaluated using the latest flow monitoring data, as described in Section 4.3, and did not receive a high I&I rating under the criteria. It is to be noted that the 2015 Master Plan used an updated model configuration for this area. Based on the findings, the James Street PS service area is not recommended for additional extraneous I&I reduction studies or works, although continued monitoring is recommended at the James St. PS.

NORTHWEST COLLECTOR SERVICE AREA

The North West Collector service area was previously recommended for a review of I&I based on findings in the 2010 PPCP Update. In the 2015 Master Plan, the service area was re-evaluated using the latest flow monitoring data as described in Section 4.3. The collector did not receive a high I&I rating under current rating conditions and it is recommended that the area is continued to be monitored to confirm these conditions.

RECOMMENDED I&I STUDIES AND REVIEWS

Based on the results reviewed in Section 4.3, below is a summary of the conclusions:

1. Complete additional localized flow monitoring for Bath - Collins Bay to verify the wet-weather influence.
2. Complete additional flow monitoring for Crerar PS once the Point Pleasant discharge is removed to verify the wet-weather influence.
3. Develop I&I strategy for the localized high wet-weather area for the Days Rd. PS.
4. Develop I&I strategy for Greenview Dr. and Dalton Ave. PS.
5. Continue with Portsmouth I&I reduction program.

It should be noted that I&I investigations do not always identify the sources and therefore do not always lead to a wet-weather reduction to the extent that a capacity increase could be avoided. The success of I&I reduction projects may be increased when multi-phased programs are implemented which approach investigations of public and private systems systematically with and targeted approach to locating I&I sources and tracking I&I reduction targets throughout the reduction project.

5.1.5 RECOMMENDATIONS FOR STORM OUTFALLS

5.1.5.1 DRY-WEATHER DISCHARGES AT OUTFALLS

In past PPCP updates and studies there was reported dry-weather seepage for isolated cases at storm outfall locations which were suspect of possible cross-connections with sanitary sewers in separated sewer areas. Dry-weather discharges by storm outfalls are a pollution risk to receiving water bodies as no regular transference to combined sewers or treatment occurs. To date, areas identified under the regular SWQSP program are recommended for review and remediation upon the discovery of pollution during dry-weather.

Recommendations for the discovery of sewage debris at storm outfalls are to continue from the previous programs which includes:

1. Inspections to determine if there is any sewage debris at storm outfalls.
2. Collection of water samples on two or three occasions at identified outfalls that have significant dry-weather flow (e.g. 5 L/sec or more) during summer months, and analysis for indicator bacteria (E. Coli).
3. If contamination is found, an investigation is triggered. Investigation may include sampling at upstream maintenance holes, and TV inspections to find sources of dry-weather flows.

It is to be noted that dry-weather discharges were not observed in the 2015 Master Plan Study when simulating the sanitary and combined sewer trunk sewers in the model simulations for present and future conditions. This is in part due to all the capacity upgrades completed and the installation of storage tanks which hold combined sewer flows until they can be conveyed through the rest of the collection system towards treatment facilities.

Monthly or more frequent checks of all storm outfalls during the summer season is recommended. Dedicated storm outfalls of priority, identified for review in the past, include:

1. Inspections to determine if there is any sewage debris at storm outfalls.
2. Storm outfalls at the Portsmouth Olympic Harbour
3. Albert Street Storm Outfall
4. Kingscourt Storm Outfall
5. Lower Princess Street Outfall
6. Little Cataraqui Creek from Princess Street Storm Outfall

As indicated in section 5.1.4.3 the storm, sanitary and combined sewers require pollution prevention and control planning which is why they are indicated in the PPCP update, however while the 2015 Wastewater Master Plan provides recommendations for the sanitary and combined sewers, there are no direct recommendations for storm sewers as assets are managed directly by City of Kingston. An integrated stormwater management strategy would allow for better dissemination of joint pollution prevention control programs, projects and policies.

5.1.5.2 WET-WEATHER DISCHARGES AT OUTFALLS

Wet-weather discharges at storm outfalls include the CSO control structures which occur during major weather events. The recommended strategy for reducing and eliminating wet-weather discharges for storm outfalls related to CSO control structures is to follow the short-term and long term CSO Reduction Strategy as presented in Section 5.4 & 5.4 respectively.

Other storm outfalls are managed and reviewed under the City of Kingston' Public Works and through the SWQSP program and their storm water management practices. As detailed for dry-weather discharges in the previous section, there are no direct recommendations for storm sewers as assets are managed by the City of Kingston separately.

5.2 2015 MASTER PLAN RECOMMENDATIONS

Table 5-1 and 5-2 shows pumping station and sewer upgrade recommendations from the 2015 Master Plan Study, respectively, which are related to overflow reduction in Kingston's wastewater collection system. PPCPs and their site-specific recommendations related to the 2015 Master Plan Study recommendations is further detailed in Section 0.

Table 5-1 Summary of Pumping Station Recommendations

PUMPING STATION	GAP/ISSUE IDENTIFIED	UPGRADE RECOMMENDED	TIMING	PCP#
Crerar Blvd. PS	PS firm capacity exceedance during major storm events. Reported basement flooding in service area.	Hydraulic Review and Continued Flow Monitoring after WTP process water is removed	By 2021	57
Days Road PS	PS firm capacity exceedance during major storm events. In poor condition. Basement flooding in service area documented.	Firm capacity increase to 1200 L/s	By 2021	73
Bath-Collins Bay Road PS	PS firm capacity exceedance during major storm events	Additional Flow monitoring	By 2021	61
Lakeshore Boulevard PS	Reported issues of basement flooding in service area	Continued Flow monitoring	By 2021	58
Dalton Road PS	Basement flooding in service area documented	Continue with PS study and flow monitoring	N/A	5
King-Portsmouth PS	Meets required Level of Service after PS upgrade (Imminent project) Basement flooding in service area documented	Continue with Portsmouth Redirection and I&I reduction program.	N/A	43
Palace Road PS	Meets required Level of Service Flooding in service area documented and overflows	Continue to monitor and if power outages are a regular occurrence, consider permanent back-up power at this location.	N/A	35

Table 5-2 Summary of Sewer Recommendations: Central Collection System

TRUNK / COLLECTOR SEWER	GAP/ISSUE IDENTIFIED	UPGRADE RECOMMENDED	TIMING	PCP# (IMPACTED BY WORKS)
Notch Hill Collector	Surcharging within 2 m of surface during storms larger than the 10yr storm	Upgraded the sewer between Portsmouth Ave. and Runnymede Rd. to a 600 mm sewer	2026	48 & 50
North End Trunk Sewer (NETS)	Surcharging within 2 m of surface during storms larger than the 10yr storm Flooding in service area documented and overflows	Twin the following sections of sewers: Greenview Dr. to Sherwood Cres. & Princess St. to Portsmouth Ave. John Counter Blvd. to Dalton Ave.	Phased completion by the following dates: By 2021 By 2036	48 & 50
Princess St Collector	Surcharging within 2 m of surface during storms larger than the 10yr storm	Upgrade the following sections of sewers: Indian Rd. to The Pkwy Rd. to a 525 mm West of Sir John A. MacDonald Blvd. to Indian Rd. to a 450/525 mm East of Mooalim Pl. to west of Sir John A. MacDonald Blvd. to a 450 mm	Phased completion by the following dates: By 2021 By 2026 By 2036	48 & 50
King St West Collector	Surcharging within 2 m of surface during storms larger than the 50yr storm	Upgrade the sewers between County Club Dr. and McDonald Ave. to a 450 mm sewer	By 2021	43
Collingwood Collector	Surcharging within 2 m of surface during storms larger than the 50yr storm Flooding in service area documented and overflows	Upgrade the sewers between Helen and Regent St. to a 375 mm	By 2021	34
Charles St Collector	Surcharging within 2 m of surface during storms large than the 2yr between 2015 and 2026	Confirm Local Sewer Capacity	By 2036	8, 9, 67, 68 & 71

5.3 SITE SPECIFIC RECOMMENDATIONS

Based on the findings, each PCP location was reviewed for any site-specific recommendations to support the effort of reduction and 'virtual elimination' of overflows. The long-term overflow reduction strategy effects were reviewed for each PCP location in conjunction with the primary servicing strategies and capital improvement recommendations that were identified.

Table 5-2 provides a summary of all remaining PCPs and their site-specific recommendations.

Along with discussions and input from Utilities Kingston, the identified strategy for elimination of PCPs includes cohesion with the long-term strategic approach before plugging/removal. Common among all locations is that overflow infrastructure should be maintained until demonstrated elimination of overflows is observed as evidenced from flow monitoring. These control structures themselves continue to provide an important service of protecting public safety with the reduction of sewer back-ups which in turn may cause basement flooding. The general overflow elimination priorities by type are listed below:

1. **Sanitary Sewer Overflows (SSO)** – SSOs are recommended to be plugged through capital works as these areas no longer receive direct runoff from combined sewers and form part of a separated sewer system. These locations are often observed to have contributions from high I&I. SSOs should only be plugged/removed if flow monitoring confirms that overflows no longer occur from historic data. SSO locations are currently required to provide emergency relief that prevents sewer back-up and basement flooding. Remaining SSO's
2. **Combined Sewer Overflows (CSO)** – Combined sewers should be reviewed on a case-by-case basis for CSOs located along local systems once combined sewers are removed upstream of them before considering plugging/elimination. CSOs located along trunk systems should be maintained until combined sewer areas are removed upstream and flow monitoring supports their elimination.
3. **Tank Overflows (TO)** – Tank overflows are recommended to remain for emergency overflow conditions.
4. **Pumping Station Overflows (PSO)** – Pumping station overflows are recommended to remain for emergency overflow conditions

Table 5-3 Summary of Site-Specific Recommendations for PCP

ID# (PCP#)	DESCRIPTION OF LOCATION	TYPE OF DISCHARGE	TRUNK, LOCAL OR OTHER	CURRENT OVERFLOW ACTIVITY	IMPACT FROM SEWER SEPARATION PROJECTION	IMPACT FROM PORTSMOUTH SERVICE AREA REDIRECTION	ADDITIONAL SITE-SPECIFIC RECOMMENDATIONS	COMMENTS
Combined Sewer Overflow (CSO)								
2	Belle Park Chamber, Trunks	CSO	Trunk	MODERATE	MODERATE	MODERATE	None. Continue to maintain and monitor as sewer separation progresses under existing chamber configuration. It is recommended reviewing the operation and hydraulics of the chamber after upstream combined sewer separation is completed related to PCP 65. Overflows are observed in PCP 2 and 65 up to the 2036 scenario due to contributing combined sewer back-ups downstream of this location.	This location shares a chamber configuration with PCP 65.
8	Princess St E of Frontenac	CSO	Local	N/A	HIGH	N/A	Permanently plug after completion of hydraulic review and removal of remaining combined sewers.	Temporarily Plugged in 2015. Work upstream and along the Charles St. Collector affects review of PCPs 8, 9, 67 and 71.
9	Frontenac St	CSO	Local	N/A	HIGH	N/A	Permanently plug after completion of hydraulic review and removal of remaining combined sewers.	Temporarily Plugged in 2015. Work upstream and along the Charles St. Collector affects review of PCPs 8, 9, 67 and 71.
14	Ontario and Barrack	CSO	Local	LOW	HIGH	MODERATE	None. Continue to maintain and monitor as sewer separation progresses.	This is a major trunk overflow responsible for significant HGL control along the entire Harbourfront Trunk Sewer and is important to maintain.
22	William St Vortex	CSO	Trunk	LOW	HIGH	LOW	None. Continue to maintain and monitor as sewer separation progresses.	Combined sewer separation upstream of local overflow necessary for further reductions in CSO
23	Earl d/s of vortex	CSO	Local	HIGH	HIGH	LOW	None. Continue to maintain and monitor as sewer separation progresses.	Work being completed in early 2017 to improve benching to reduce overflows caused by debris plugging
24	Gore St vortex	CSO	Local	LOW	LOW	LOW	None. Continue to maintain and monitor as sewer separation progresses. As this CSO services a local catchment area which is already largely separated, a review of flow monitoring data may be conducted after the remaining upstream combined sewers are completed to determine if the CSO may be plugged/eliminated or redirected in the long-term. Overflows were projected to discontinue by the 2026 scenario at this location.	Combined sewer separation upstream of local overflow necessary for further reductions in CSO.
25	Lower Union d/s of vortex	CSO	Local	LOW	MODERATE	LOW	None. Continue to maintain and monitor as sewer separation progresses.	Combined sewer separation upstream of local overflow necessary for further reductions in CSO
26	West and Ontario	CSO	Trunk	HIGH	HIGH	MODERATE	None. Continue to maintain and monitor as sewer separation progresses.	This is a major trunk overflow responsible for significant HGL control along the entire Harbourfront Trunk Sewer and is important to maintain. Weir height adjustment to 75.5m completion in 2016.
51	d/s of Clarence St in-line CSO	CSO	Local	LOW	HIGH	LOW	None. Continue to maintain and monitor as sewer separation progresses.	A review of flow monitoring data may be conducted after the projected sewer separation of the remaining upstream combined sewers are completed to determine if the CSO may be plugged/eliminated in the long-term.

ID# (PCP#)	DESCRIPTION OF LOCATION	TYPE OF DISCHARGE	TRUNK, LOCAL OR OTHER	CURRENT OVERFLOW ACTIVITY	IMPACT FROM SEWER SEPARATION PROJECTION	IMPACT FROM PORTSMOUTH SERVICE AREA REDIRECTION	ADDITIONAL SITE-SPECIFIC RECOMMENDATIONS	COMMENTS
52	Raglan and Rideau	CSO	Local	MODERATE	MODERATE	N/A	Complete Rideau St. collector upgrades. Plugging when work and flow monitoring is completed in conjunction with sewer separation work in the long-term	Review flow monitoring in conjunction with PCP#70.
53	Division and Union	CSO	Local	MODERATE	MODERATE	N/A	None. Continue to maintain and monitor as sewer separation progresses. Hydraulic review of weir height adjustment may be conducted to confirm operation.	New weir across 900mm overflow pipe completed in 2016.
65	Belle Park Local SA1200	CSO	Local	MODERATE	MODERATE	LOW	None. Continue to maintain and monitor as sewer separation progresses under existing chamber configuration. It is recommended reviewing the operation and hydraulics of the chamber after upstream combined sewer separation is completed. Overflows are observed in PCP 2 and 65 up to the 2036 scenario due to contributing combined sewer back-ups downstream of this location.	This location shares a chamber configuration with PCP 2 and currently maintains an orifice plate to limit flow rates. Removal of the orifice plate may increase the rate of sanitary flow discharge from the chamber under normal conditions, in the event of a sewer back-up event there would be potential but limited influences to CSO volumes due to the unrestricted flow entering from the 1200mm CSP. In a sewer back-up condition there is also the potential that the current configuration may actually restrict backflow entering into the local 1200mm CSP sewer which may contribute to decreasing the HGL in this sewer. Removing the orifice plate may potentially decrease the overall HGL in other upstream sewers, such as the Rideau Heights Trunk Sewer,
67	Chatham St	CSO	Local	N/A	MODERATE	N/A	Permanently plug after completion of hydraulic review and removal of remaining combined sewers.	Temporarily Plugged in 2015. Work upstream and along the Charles St. Collector affects review of PCPs 8, 9, 67 and 71.
68	Quebec at Barrie St	CSO	Local	LOW	MODERATE	N/A	None. Continue to maintain and monitor as sewer separation progresses.	Review in conjunction with hydraulic review of Charles St. Collector and PCP#'s 8,9,67 and 71. Permanently plug in the long-term following sewer separation and flow monitoring work.
70	Carlisle & Chest Nut	CSO	Local	LOW	MODERATE	N/A	Recommend Rideau St. Collector upgrades. Plugging when work and flow monitoring is completed in conjunction with sewer separation work in the long-term.	Review flow monitoring in conjunction with PCP#52
71	Alfred St	CSO	Local	N/A	MODERATE	N/A	Permanently plug after completion of hydraulic review and removal of remaining combined sewers.	Temporarily Plugged in 2015. Work upstream and along the Charles St. Collector affects review of PCPs 8, 9, 67 and 71.
Pump Station Overflows (PSO)								
1	River Street Pump Station	CSO/PSO	Trunk	VERY LOW	HIGH	MODERATE	None. Continue to maintain for emergency overflow purposes and monitor	PS overflow provides servicing for emergency conditions. Station receives flows from all combined sewer areas in Kingston Central.
5	Dalton Ave Pump Station	PSO	Trunk	VERY LOW	N/A	N/A	None. Continue to maintain for emergency bypass purposes and monitor	PS overflow provides servicing for emergency conditions. Other work upstream of the NETS PS w.r.t. PCP #48 and #50 is recommended and is related to PS operations.
28	King St Pump Station	CSO/PSO	Trunk	LOW	HIGH	HIGH	None. Continue to maintain for emergency overflow purposes and monitor. Forcemain upsizing as part of long-term strategy	PS overflow provides servicing for emergency conditions. Overflows are related to PS operations, King St. tank filling (PCP#55) and through SCADA configuration related to West St. (PCP#26) flow/level monitoring.

ID# (PCP#)	DESCRIPTION OF LOCATION	TYPE OF DISCHARGE	TRUNK, LOCAL OR OTHER	CURRENT OVERFLOW ACTIVITY	IMPACT FROM SEWER SEPARATION PROJECTION	IMPACT FROM PORTSMOUTH SERVICE AREA REDIRECTION	ADDITIONAL SITE-SPECIFIC RECOMMENDATIONS	COMMENTS
								CSO Tank PS overflow provides servicing for emergency conditions. Overflows are related to PS operations, King St. tank filling (PCP#55) and through SCADA configuration related to West St. (PCP#26) flow/level monitoring.
35	Palace Road Pump Station	PSO	Local	LOW	LOW	N/A	None. Continue to maintain and monitor. Backup power to be installed for increased reliability	PS overflow provides servicing for emergency conditions. Work affects overflows at PCP#34 New monitoring equipment is to be installed to track frequency, duration and volume of overflows
41	Morton Street Pump Station	PSO	Local	Very Low	LOW	N/A	None. Continue to maintain for emergency overflow purposes and monitor	PS overflow provides servicing for emergency conditions
43	King-Portsmouth pump Station	PSO	Local	Very Low	N/A	N/A	PS to be upgraded. Continue to maintain for emergency overflow purposes and monitor.	PS overflow provides servicing for emergency conditions. New monitoring equipment is to be installed to track frequency, duration and volume of overflows in conjunction with PS upgrades. I&I study currently being completed in 2016
57	Crerar Blvd. Pump Station	PSO	Local	Very Low	N/A	N/A	None. Continue to maintain for emergency overflow purposes and monitor	PS overflow provides servicing for emergency conditions
58	Lakeshore Pump Station	PSO	Local	Very Low	N/A	N/A	None. Continue to maintain for emergency overflow purposes and monitor	PS overflow provides servicing for emergency conditions
59	Coverdale Pump Station	PSO	Local	Very Low	N/A	N/A	None. Continue to maintain for emergency overflow purposes and monitor	PS overflow provides servicing for emergency conditions
61	Bath and Collins Bay	PSO	Local	Very Low	N/A	N/A	None. Continue to maintain for emergency overflow purposes and monitor	PS overflow provides servicing for emergency conditions
62	Rankin Pump Station	PSO	Local	Very Low	N/A	N/A	None. Continue to maintain for emergency overflow purposes and monitor	PS overflow provides servicing for emergency conditions
63	Bath Rd West Pump Station	PSO	Local	Very Low	N/A	N/A	None. Continue to maintain for emergency overflow purposes and monitor	PS overflow provides servicing for emergency conditions
69	Greenview Drive Pump Station	PSO	Local	Very Low	N/A	N/A	None. Continue to maintain for emergency bypass purposes and monitor.	PS overflow provides servicing for emergency conditions. Station is being upgraded. New monitoring equipment is being installed to track frequency, duration and volume of overflows.
73	Days Road Pump Station	PSO	Trunk	Very Low	N/A	N/A	None. Continue to maintain for emergency bypass purposes and monitor.	PS overflow provides servicing for emergency conditions. Station has been recommended for upgrade. New monitoring equipment is recommended to be installed to track frequency, duration and volume of overflows.
74	Barrett Court Pump Station	PSO	Trunk	Very Low	N/A	N/A	None. Continue to maintain for emergency bypass purposes and monitor.	PS overflow provides servicing for emergency conditions
75	Westbrook Pump Station	PSO	Local	Very Low	N/A	N/A	None. Continue to maintain for emergency bypass purposes and monitor.	PS overflow provides servicing for emergency conditions.

ID# (PCP#)	DESCRIPTION OF LOCATION	TYPE OF DISCHARGE	TRUNK, LOCAL OR OTHER	CURRENT OVERFLOW ACTIVITY	IMPACT FROM SEWER SEPARATION PROJECTION	IMPACT FROM PORTSMOUTH SERVICE AREA REDIRECTION	ADDITIONAL SITE-SPECIFIC RECOMMENDATIONS	COMMENTS
								Station is being upgraded. New monitoring equipment is being installed to track frequency, duration and volume of overflows
Sanitary Sewer Overflows (SSO)								
34	Helen and Mack	SSO	Local	MODERATE	LOW	N/A	Collingwood Collector upgrades to be completed. Permanently plug/remove after completion of this work	Work projected for completion. Upstream flows contributed by the Palace Road PS.
48	NETS at Sherwood	SSO	Trunk	LOW	N/A	N/A	NETS twinning upgrades to be completed. Plugging when work and flow monitoring is completed after hydraulic and Dalton Ave PS flow review.	This is a large trunk sewer with high I&I documented and is subject to overflows/basement flooding. Overflows to remain in place until works are completed and monitoring clearly illustrates a stop to overflow activity.
50	NETS at Parkway S	SSO	Trunk	VERY LOW	N/A	N/A	NETS twinning upgrades to be completed. Plugging when work and flow monitoring is completed after hydraulic and Dalton Ave PS flow review.	This is a large trunk sewer with high I&I documented and is subject to overflows/basement flooding. Overflows to remain in place until works are completed and monitoring clearly illustrates a stop to overflow activity.
Tank Overflows (TO)								
55	King St. CSO Tank	TO	Trunk	HIGH	HIGH	HIGH	None. Continue to maintain and monitor as sewer separation progresses.	Tank returns captured flow back into the trunk sewer. Overflows occur during wet-weather conditions King St. Tank filling (PCP#55) is dynamically related to SCADA configuration related to West St. (PCP#26) flow/level monitoring and King St. PS operation (PCP#28)
56	Collingwood CSO Tank	TO	Trunk	HIGH	HIGH	HIGH	None. Continue to maintain and monitor as sewer separation progresses.	Tank returns captured flow back into the trunk sewer. Overflows occur during wet-weather conditions
Other Structures								
	Emma Martin Tank	N/A	Trunk				None. Continue to maintain and monitor.	Tank not contributing to direct overflows under current configuration. Tank returns captured flow back into the Trunk Sewer.

- degree of activity based on duration, frequency and volumes of overflows based on historical data

HIGH	Very active overflows with large volumes, multiple events and long duration events
MODERATE	Medium volume overflow events with multiple records in a given year, over medium durations
LOW	Low volume overflow events with a few records a year over short durations
VERY LOW	Trace volume of overflow events recorded with only a few records in a year over short durations or no activity reported
N/A	Inactive or plugged

- degree of impact from 2021, 2026 and 2036 sewer separation projection from master plan

HIGH	Separation projections greatly impact and have strong influence on reducing/eliminating overflows
MODERATE	Separation projections have a moderate impact on reducing/eliminating overflows
LOW	Separation projections have little impact on reducing/eliminating overflows
N/A	Separation projections work do not impact reducing/eliminating overflows

- degree of impact from Portsmouth PS Service area redirection from master plan

HIGH	Redirection greatly impact and have strong influence on reducing/eliminating overflows
MODERATE	Redirection has a moderate impact on reducing/eliminating overflows
LOW	Redirection has little impact on reducing/eliminating overflows
N/A	Redirection projections work do not impact reducing/eliminating overflows

5.4 LONG TERM CSO REDUCTION STRATEGY

5.4.1 SEWER SEPARATION PROGRAM

As analyzed and reviewed in the 2015 Master Plan and the alternatives presented in Section 4, it is recommended that the projected sewer separation reduction continue, at a minimum, as the primary strategy for reducing combined sewer overflows. This strategy reduces the scale of major infrastructure conveyance improvements required throughout the systems.

Adjustments to the projected sewer separation program may be made as updated CSO monitoring data is made available and in future PPCP/Master Plan Update Studies which continue to improve the accuracy of projected overflows in the existing system. All source control efforts which work to eliminate direct wet-weather inflow support the goal toward 'virtual elimination' of CSOs within the system. The study analysis shows that accelerating the program would provide additional reduction of overflows. Reducing the rate of sewer separation has been shown to prolong achievement of the goal of 'virtual elimination' of CSOs.

5.4.2 ADDITIONAL COMPONENTS OF THE LONG-TERM STRATEGY

As previously described in Section 4.3 various long-term strategies were reviewed and additional capital improvements were analyzed to complement to the primary sewer separation program since CSO was observed in model simulations beyond the 2036 projections. Based on the analysis of the long-term CSO strategy which is in support of 'virtual elimination' of CSOs in the future, there are some common infrastructure upgrades that would be required to fully service the central area in the future. The following infrastructure upgrades are recommended to ensure this is achievable:

KING ST FORCEMAIN TWINNING

The King St. PS forcemain is a short length forcemain (282 m) that is currently experiencing high velocities. The twinning will provide the additional capacity that is required in each of the servicing strategies, as well as relieve the high velocities currently being seen in the forcemain under peak conditions, and provide redundancy to a critical pumping station.

RIVER STREET PUMP STATION INLET SEWER TWINNING

There is a small section of sewer between Cataraqui St. and the River St. Pumping Station that was not twinned when the Harbourfront Trunk Sewer upstream was completed. It is recommended that this 250 m section be completed.

RIDEAU ST COLLECTOR

There is a 250 m section of the sewer at the downstream end before it connects in the Harbourfront Trunk Sewer that reduces from a 600 mm to a 375 mm pipe. Replacing this section of the sewer with a 600 mm will relieve issues seen here. Once this upgrade is complete, PCP#52 should be monitored for a period of time and, if no overflows are experience, could be removed.

RAVENSVIEW TRUNK SEWER

The trunk sewer takes all of the flow from the central and east systems and transfers it to the Ravensview WWTP. By transferring more flow from the central area, the Ravensview Trunk Sewer is required to be twinned. Additionally, an EA was already completed for this project that recommended a twinning along Highway 2.

TIMING

Based on the current issues at these locations and the status of the sewer separation, the following timing is recommended:

1. King St. Forcemain Twinning – by 2026
2. Harbourfront Trunk Sewer Twinning – by 2036
3. Rideau Collector Upgrades – by 2036
4. Ravensview Trunk Sewer – by 2036

5.5 SYSTEM-WIDE POLICIES AND PROGRAM RECOMMENDATIONS

The following lists the policies and programs that are recommended to continue as previously described in Section 2.4:

1. Bylaws/policies addressing waste control and sewer use to mitigate pollution:
   - Animals Bylaw No. 2004-144s
   - Building Bylaw No. 2005-99
   - Development Related Charges – Impost Fee Bylaw (Water & Wastewater) No. 2009-138
   - Garbage Bylaw No. 2014-5
   - Maintenance and Closure of Laneways and Road Allowances Bylaw No. 91-272
   - Pesticide Bylaw No. 2008-28
   - Parks & Rec. Facilities Bylaw No. 2009-79
   - Property Standards Bylaw No. 2005-100
   - Sidewalk Bylaw No. 87-136
   - Streets Bylaw No. 2004-190
   - Waste Water – Waste Discharge Bylaw No. 2008-192
   - Watering Bylaw No. 2006-122
   - Yards Bylaw No. 2007-136
   - Development Approvals Process
2. Programs at large that support pollution control measures:
   - Fish and Frogs Forever Program
   - Citizen Reporting

- Source Protection Areas
- Brownfield Remediation
- Toilet Replacement Program
- Rain Barrel Program
- Rainfall Warning Program
- ‘Know What to Flush’ Campaign
- Household Hazardous Waste Collection

3. Recommended additional policies or programs that may be expanded or considered into existing ones:
   - **Low Impact Development**: Incorporation of stormwater infrastructure that promotes natural infiltration as opposed to increasing runoff for new developments or retrofit projects may be considered to help reduce peak runoff into the collection systems.
   - **Spring Melt and Rain-on-Snow Monitoring**: Overflows observed during these events may be considered the equivalent of major rainfall events, however there are multiple factors that may contribute during these situations. Where applicable, mitigation in areas where known regular overflows are observed may be reviewed as part of a strategy for reducing overflows.

5.6 BEST MANGEMENT PRACTICES FOR UTILITIES KINGSTON AND THE CITY OF KINGSTON

The following BMPs for existing practices are recommended to continue to support pollution control mitigation:

1. Floatables Control Program
2. CCTV Inspections
3. Maintenance Hole Rehabilitation
4. Extraneous Flow Reduction
5. Erosion and Sediment Control
6. Street and Catchbasin Cleaning
7. Sewer Flushing
8. Inlet Controls – Flow Reducers

6 SUMMARIZED RECOMMENDATIONS

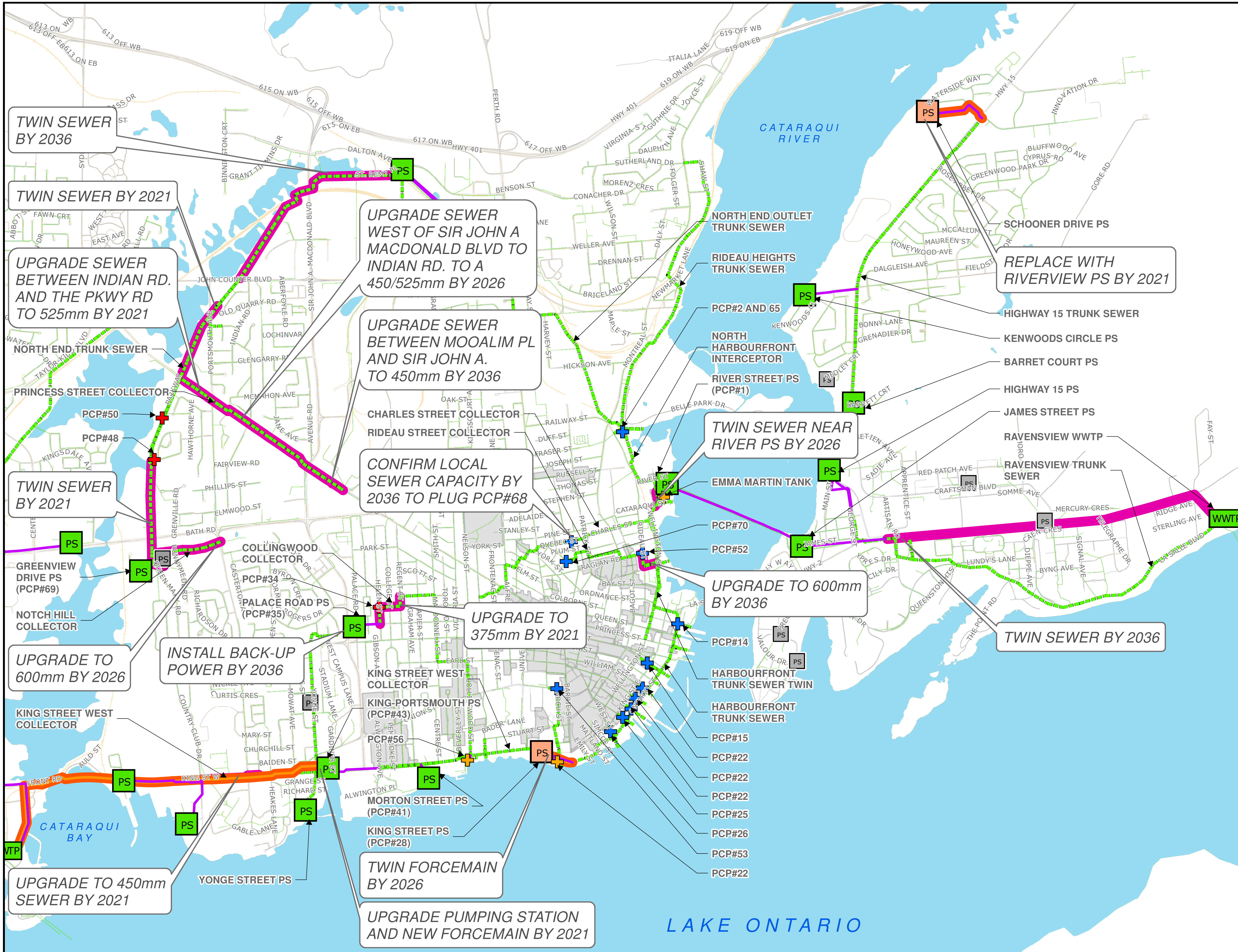
6.1.1 SUMMARY OF CAPITAL IMPROVEMENTS

Based on the recommendations, the projects were reviewed to outline an implementation plan and estimate the costs in relation to the study findings. The following table 6-1 summarizes the implementation plan and timing schedule for the projected scenarios related to combined sewer reduction and improvements to Pollution Control Plan initiatives, such as improved monitoring of collection system components. The location of the capital improvement projects listed in this table are detailed in Figure 6-1.

Table 6-1 Wastewater Capital Improvement Projects

PROJECT	DESCRIPTION	EA SCHEDULE	TIMING	COST	COMMENTS
Sewer Separation	Continue with sewer separation projects as projected	'A', 'A+'	Ongoing (Yearly)	$51.7M	Separation of approximately 117 Ha of combined sewer area by 2036.
King-Portsmouth PS - Capacity Upgrade and Flow Redirect	Upgrade the capacity of King-Portsmouth PS to 425 L/s firm capacity and install new forcemain to redirect flow to Cataraqui Bay WWTP	'B'	2021	$10.0M	King-Portsmouth PS - Capacity Upgrade and Flow Redirect (EA is complete) Impacts PCP#1, 2, 14, 26, 43, 55, 56 & 65
Multiple Locations - Flow Monitoring	Conduct flow monitoring at Crerar Collector, McEwen Dr. collector, Bath-Collins Bay Road PS, Lakeshore Boulevard PS	'A', 'A+'	2021	$20K	Multiple Locations - Flow Monitoring Impacts PCP#57, 58, 61 & 73
Princess St. Collector - Upsize Phase 1	Indian Rd. to the Pkwy Rd. to a 525mm	'A', 'A+'	2021	$1.2M	Princess St. Collector Impacts PCP# 48 & 50
Alfred/Elm Sewer Upsize	Upsize sewer from 375 mm to 450 mm on Alfred (Princess to Elm) and Elm (Alfred to Chatham).	'A', 'A+'	2021	$450K	Alfred/Elm Sewer Upsize Impacts PCP#8, 9, 67, 68 & 71
North End Trunk Sewer – Twinning Phase 1	Twinning of the sewer along Queen Mary heading north from Greenview Dr. to Sherwood Cres (manhole 9341-010 to 2284-131) & Twin from Princess St. heading north to Portsmouth Ave. (manhole 2284-010 to 509081) approximately 1600 m	'A', 'A+'	2021	$3.0M	North End Trunk Sewer – Twinning Impacts PCP# 48 & 50
Notch Hill Collector - Upsize	Upsizing of the sewer along Notch Hill Rd from Portsmouth to Runnymede Rd (between manholes 9716-010 to 3942-030) from a 450 mm to a 60 0mm, approximately 350 m	'A', 'A+'	2026	$660K	Notch Hill Collector – Upsize. May be able to be deferred if I&I is reduced. Impacts PCP# 48 & 50
King St PS - Twin Forcemain	Twin 282 m of 600 mm forcemain	'A', 'A+'	2026	$560K	King St. PS - Twin Forcemain Impacts PCP#26, 28, and 55

PROJECT	DESCRIPTION	EA SCHEDULE	TIMING	COST	COMMENTS
River Street Pump Station Inlet Sewer - Twinning	Twin 250 m of sewer between Cataraqui St. and River St. pumping station	'A', 'A+'	2036	$1.1M	River Street Pump Station Inlet Sewer – Twinning Impacts PCP#1, 2, 14, 26 & 65
Collingwood St. Collector - Upsize	Upsizing of the sewer along Helen St. to Mack, along Mack to Regent St. and along Regent St. to Dundas St. (manhole 0423-010 to 04511-020) from a 300 mm to a 375 mm, approximately 400 m	'A', 'A+'	2026	$600K	Collingwood St. Collector – Upsize Impacts PCP#34
Princess St. Collector - Upsize Phase 2	West of Sir John A. MacDonald Blvd. to Indian Rd. to a 450/525 mm	'A', 'A+'	2026	$1.9M	Princess St. Collector Impacts PCP# 48 & 50
Palace Road PS - Back Up Power	Install permanent backup generator	'A', 'A+'	2036	$150K	Palace Road PS - Back Up Power Impacts PCP# 34 & 35
Rideau St. Collector - Upsize	Upsize a 250 m section of the sewer at the downstream end before it connects in the Harbourfront Trunk Sewer from a 375 to a 600 mm	'A', 'A+'	2036	$460K	Rideau St. Collector – Upsize Impacts PCP# 52, 70
North End Trunk Sewer Phase 2	Twin sewer along John Counter Blvd. heading north to Dalton Ave. (manhole 614091 to 1760-010), approximately 1900 m.	'A', 'A+'	2036	$3.4M	North End Trunk Sewer Impacts PCP# 48 & 50
Charles St. Collector - Capacity Investigation	Confirm Local Sewer Capacity, Plug PCP#68	'A', 'A+'	2036	$12K	Charles St. Collector - Capacity Investigation Impacts PCP#8, 9, 67, 68 & 71
Ravensview Trunk Sewer - Twinning	Twinning Ravensview Trunk Sewer entire length, approximately 3400 m	'B'	2036	$27.0M	Ravensview Trunk Sewer – Twinning. EA is complete.
Princess St. Collector - Upsize Phase 3	East of Mooalim Pl. to west of Sir John A. MacDonald to a 450 mm	'A', 'A+'	2036	$1.2M	Princess St. Collector Impacts PCP# 48 & 50



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Legend

- WWTP — WASTEWATER TREATMENT PLANT
- COMBINED SEWER OVERFLOW
- SANITARY SEWER OVERFLOW
- TANK OVERFLOW
- PS — ALTERNATIVE PUMPING STATION
- <all other values>
- PS — GOOD
- PS — NOT MODELLED
- FORCEMAIN
- ALTERNATIVE FORCEMAIN
- TRUNK SEWER
- ALTERNATIVE TRUNK SEWER
- EXISTING SANITARY SEWER
- COMBINED SEWER AREA TO BE SEPARATED (ONGOING)
- Lake

Data Source: Ontario Base Mapping, Ministry of Natural Resources, August 2013. Water and Waste Water Systems, Utilities Kingston, April 2015, City of Kingston.

Scale: 0 200 400 800 Meters
1:30,000

Project:
Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title: CENTRAL-EAST COLLECTION SYSTEM RECOMMENDED ALTERNATIVE SOLUTIONS SUMMARY

Project No.:		Date:	
151-02944-00		JANUARY, 2016	
Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	PCP	6-1

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.9_PPCP\Maps\151-02944-00_PCP_FIG6-1_Central-East_Collection_System_Recommended_Alternative_Solutions_Summary.mxd

Appendix A

MOECC PROCEDURE F-5-5 CHECKLIST

MOE – Procedure F-5-5 Checklist

EVALUATING POLLUTION AND PREVENTION CONTROL PLANS

CRITERIA	
Developed a Pollution Prevention and Control Plan (PPCP) (within the last five years)	
A) Characterization of the combined sewer system (CSS)	
▪ Monitoring	Complete
▪ Modeling	Complete
▪ Other appropriate means	Complete
▪ Determination of the location of CSOs	Complete
▪ Determination of the frequency of CSOs	Complete
▪ Determination of the volume of CSOs	Complete
▪ Concentrations and mass of pollutants resulting from CSOs	Complete
▪ Data collected on frequency of dry weather overflows	Complete
▪ Data collected on frequency of wet weather overflows	Complete
▪ Records kept on:	
– Location and physical description of CSO outfalls in the collection system, emergency overflows at pumping stations, and bypass locations at STPs	Complete
– Location and identification of receiving water bodies for all combined sewer outfalls	Complete
– CSS flow and STP capacities; <u>present</u> expected peak flow rates during dry weather	Complete
– CSS flow and STP capacities; <u>present</u> expected peak flow rates during wet weather	Complete
– CSS flow and STP capacities; <u>future</u> expected peak flow rates during dry weather	Complete
– CSS flow and STP capacities; <u>future</u> expected peak flow rates during wet weather	Complete
– Capacity of all regulators	Complete
– Location of cross-connections	Complete
▪ Operational procedures developed for CSS including:	
– Combined sewer maintenance programs	Complete
– Regulator inspection and maintenance programs	Complete
B) Examination of non-structural and structural CSO control alternatives:	
– source control	Complete
– inflow/infiltration reduction	Complete
– operation and maintenance improvements	Complete
– control structure improvements	Complete
– collection system improvements	Complete
– storage technologies	Complete
– treatment technologies	Complete
– sewer separation	Complete

EVALUATING POLLUTION AND PREVENTION CONTROL PLANS

CRITERIA	
C) Implementation plan with cost estimates and schedule of all practical measures to eliminate dry weather overflows and minimize wet weather overflows	Complete
– Demonstrate how minimum CSO prevention and control requirements and other criteria are achieved	Complete
Established Plan - Meet minimum CSO controls	
A) Eliminate CSOs during dry-weather periods except under emergency conditions	Complete
– Demonstrate that CSS are adequate for transmission and treatment of all peak dry weather flows	Complete
B) Focus on pollutant reduction activities at source	Complete
C) Establish proper operation and regular inspection and maintenance programs for the CSS	Complete
D) Establish a floatables control program	Complete
E) Maximize the use of the collection system for the storage of wet weather flows which are conveyed to the STP for treatment when capacity is available	Complete
F) Maximize the flow to the STP for treatment of wet weather flows	Complete
G) 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	Complete
H) **Any additional controls provided for beaches or where required by receiving water quality**	
I) Monitoring program specified in PPCP	Complete
Implemented Plan - Meet minimum CSO controls	
Eliminate CSOs during dry-weather periods except under emergency conditions	Complete
Focus on pollutant reduction activities at source	Complete
Proper operation and regular inspection and maintenance programs for the CSS	Complete
Floatables control program	Complete
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	Complete
Monitoring program specified in PPCP	Complete

Appendix B

MOECC PROCEDURE F-5-5

PROCEDURE F-5-5

DETERMINATION OF TREATMENT REQUIREMENTS FOR MUNICIPAL AND PRIVATE COMBINED AND PARTIALLY SEPARATED SEWER SYSTEMS

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1. RATIONALE

Procedure F-5-5 is a supporting document for Guideline F-5 "Levels of Treatment for Municipal and Private Sewage Treatment Works Discharging to Surface Waters".

A Combined Sewer System (CSS) is a wastewater collection system designed to convey both sanitary wastewater and stormwater runoff through a single-pipe system to a sewage treatment works. During dry weather, it conveys sanitary wastewater. During a precipitation event (rainfall or snowmelt) the capacity of the CSS and/or treatment facility may be exceeded by the total wastewater flow. This results in the occurrence of a combined sewer overflow (CSO) which is an untreated mixture often containing high levels of floatables, pathogenic microorganisms, suspended solids, oxygen-demanding organic compounds, nutrients, oil and grease, toxic contaminants and other pollutants. The CSOs represent a potential health hazard and can have adverse effects on aquatic life, recreational uses and water supplies. The goals of this Procedure are to:

(a) eliminate the occurrence of dry weather overflows
(b) minimize the potential for impacts on human health and aquatic life resulting from CSOs
(c) achieve as a minimum, compliance with body contact recreational water quality objectives (Provincial Water Quality Objectives (PWQO) for Escherichia coli (E. coli)) at beaches impacted by CSOs for at least 95% of the four-month period (June 1 to September 30) for an average year.

2. DEFINITIONS

A "combined sewer system (CSS)" 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 in this Procedure.

A "combined sewer overflow (CSO)" is a discharge to the environment from a combined sewer system that usually occurs as a result of a precipitation event when the capacity of the combined sewer is exceeded. It consists of a mixture of sanitary wastewater and stormwater runoff and often contains high levels of floatables, pathogenic microorganisms, suspended solids, oxygen-demanding organic compounds, nutrients, oil and grease, toxic contaminants and other pollutants.

An "overflow event" occurs when there is one or more CSOs from a combined sewer system, resulting from a precipitation event. An intervening time of twelve hours or greater separating a CSO from the last prior CSO at the same location is considered to separate one overflow event from another.

"Dry weather flow" is sewage flow resulting from both:

(i) Sanitary wastewater (combined input of industrial, domestic and commercial flows); and
(ii) Infiltration and inflows from foundation drains or other drains occurring during periods with an absence of rainfall or snowmelt.

"Wet weather flow" is the combined sewage flow resulting from:

(i) Sanitary wastewater; and
(ii) Infiltration and inflows from foundation drains or other drains resulting from rainfall or snowmelt; and
(iii) Stormwater runoff generated by either rainfall or snowmelt that enters the combined sewer system.

A "regulator" is any structure that in dry weather permits the passage of all flows to treatment and in wet weather permits discharge to an outfall or relief sewer of all flows in excess of some specific flowrate.

An "average year" refers to:

(i) the long term average of flow based on using simulation of at least twenty years of rainfall data and/or
(ii) a year in which the rainfall pattern (e.g. intensity, volume and frequency) is consistent with the long-term mean of the area; and/or
(iii) a year in which the runoff pattern resulting from the rainfall (e.g. rate, volume and frequency) is consistent with the long-term mean of the area.

A "swimming and bathing beach" is a strip of shoreline with the physiographic, climatic, access, and ownership attributes necessary to accommodate significant water contact and non-contact recreation under favourable aquatic conditions.

3. SEPARATE VERSUS COMBINED SEWERS

The Ministry "Guidelines for the Design of Sanitary Sewage Systems, July 1985" states that

"All new sewer construction within the Province of Ontario should be of the 'separate' type, with all forms of storm and groundwater flow being excluded to the greatest possible extent. New 'combined' sewer systems will not be approved."

However, existing combined sewers may undergo rehabilitation or be replaced by new combined sewers provided the municipality or operating authority has met the Ministry requirements as set out in this document.

4. MINISTRY REQUIREMENTS FOR MUNICIPAL & PRIVATE COMBINED SEWER SYSTEMS

To meet the goals of this Procedure each municipality or operating authority of a combined sewer system will be expected to:

(a) develop a Pollution Prevention and Control Plan (PPCP) as outlined in Section 5;
(b) meet minimum CSO controls as outlined in Section 6; and
(c) provide additional controls
- for beaches impaired by CSOs where water quality is not meeting the PWQO for E. coli as outlined in Section 9
- where required by receiving water quality conditions as specified in Procedure B-1-1 "Water Management - Policies, Guidelines, Provincial Water Quality Objectives of the Ministry of Environment and Energy, July 1994".

The site-specific nature and impacts of CSOs are recognized in this Procedure. There is flexibility for selecting controls for local situations.

5. POLLUTION PREVENTION AND CONTROL PLAN (PPCP)

A Pollution Prevention and Control Plan (PPCP) should be developed to meet the goals of the Procedure by:

- outlining the nature, cause and extent of pollution problems;
- examining alternatives and proposing remedial measures; and,
- recommending an implementation program.

Water quality problems may be caused primarily by combined sewer overflows or by a combination of sources including CSOs. Where the pollution problem is due to a combination of sources, the discharges will be investigated and prioritized based on the relevant significance of the various discharges. In some cases the receiving water quality and pollutant transport mechanisms will be assessed in the PPCP.

To address the impact of CSOs the components of the PPCP shall include:

(a) characterization of the combined sewer system (CSS);

- Monitoring, modelling and other appropriate means shall be used to characterize the CSS and the response of the CSS to precipitation events. The characterization shall include the determination of the location, frequency and volume of the CSOs as well as the concentrations and mass of pollutants resulting from CSOs. Through this process the existence and severity of suspected deficiencies will be confirmed. Records shall be kept for combined sewer systems including the following:

- location and physical description of CSO outfalls in the collection system, emergency overflows at pumping stations, and bypass locations at STPs;
- location and identification of receiving water bodies for all combined sewer outfalls;
- combined sewer system flow and STP treatment capacities; present and future expected peak flow rates during dry weather and wet weather;
- capacity of all regulators; and
- location of cross-connections.

- Operational procedures shall be developed for combined sewer systems including the following:

  - combined sewer maintenance programs; and,
  - regulator inspection and maintenance programs.

(b) an examination of non-structural and structural CSO control alternatives that may include:

- source control;
- inflow/infiltration reduction;
- operation and maintenance improvements;
- control structure improvements;
- collection system improvements;
- storage technologies;
- treatment technologies;
- sewer separation.

(c) an implementation plan with cost estimates and schedule of all practical measures to eliminate dry weather overflows and minimize wet weather overflows.

- The implementation plan should show how the minimum CSO prevention and control requirements and other criteria in this Procedure are being achieved.

6. MINIMUM COMBINED SEWER OVERFLOW (CSO) CONTROLS

The minimum CSO controls consist of the following :

(a) Eliminate CSOs during dry-weather periods except under emergency conditions.

- Each municipality shall demonstrate that the combined sewer system, including the regulators, and associated treatment facilities are adequate for the transmission and treatment of all peak dry weather flows from the service area.
- An emergency condition would exist when e.g. basement flooding, damage to equipment at treatment works or pumping stations, or treatment process washout was occurring or was imminent.

(b) Establish and implement Pollution Prevention programs that focus on pollutant reduction activities at source e.g. reduced use of potential pollutants like fertilizer and pesticides in parks; public education programs on e.g. anti-littering and illegal dumping of used motor oil and other materials into catchbasins; water conservation to reduce dry weather sanitary flow and hence CSOs; street cleaning to reduce CSO floatables; roof-leader disconnection and installing rain barrels to reduce flows into the sewer system; education/assistance for industries to minimize the use/discharge of pollutants; and enforcement of municipal by-laws or regulations.

(c) Establish and implement proper operation and regular inspection and maintenance programs for the combined sewer system in order to ensure continued proper system operation.

(d) Establish and implement a floatables control program to control coarse solids and floatable materials e.g. by reducing the amount of street litter that enters the catchbasins and the CSS; by removing debris from CSOs at the outfalls using measures such as trash racks and screens; and by removing floatables from the surface of the receiving water after a CSO occurs.

(e) Maximize the use of the collection system for the storage of wet weather flows which are conveyed to the Sewage Treatment Plant for treatment when capacity is available e.g. by adjusting regulator settings.

(f) Maximize the flow to the Sewage Treatment Plant for the treatment of wet weather flows e.g. by removing obstructions to flow.

- The secondary treatment capacity should be utilized as much as possible for treating wet weather flows with the balance of flows being subject to primary treatment. Measures to increase the wet weather hydraulic capacity at the Sewage Treatment Plant (e.g. Step Feed operation) should be investigated.

(g) 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 on a system-wide basis. No increases in CSO volumes above existing levels at each outfall will be allowed except where the increase is due to the elimination of upstream CSO outfalls. During the remainder of the year, at least the same storage and treatment capacity should be maintained for treating wet weather flow. The treatment level for the controlled volume is described in Section 7.

7. LEVEL OF TREATMENT

The treatment processes of the sewage treatment plants should be optimized to minimize the pollutant loadings under wet weather conditions. The Pollution Prevention and Control Planning study should evaluate the operation of the Sewage Treatment Plant under wet weather conditions in consultation with Ministry Regional staff. This may lead to wet weather-specific operating conditions which may produce lower overall pollutant loadings.

During wet weather, the minimum level of treatment required for flows above the dry weather flow (as specified in sections 6 and 9) from combined sewer systems is primary treatment or equivalent. The effluent guideline for primary treatment is 30% carbonaceous biochemical oxygen demand (BOD_5) removal and 50% total suspended solids (TSS) removal for an average year during the seven month period as specified in section 6(g). The baseline for the calculation of the average pollutant removal is the influent passing the headworks of the treatment facility under wet weather conditions.

The dry weather flow from combined sewer systems is subject to the process effluent concentration criteria of the STP whether they are primary treatment plants or secondary treatment plants. During wet weather, for secondary treatment plants, the flows through the secondary treatment capacity will be subject to the process effluent concentration criteria of the STP. The flows in the STP which bypass the secondary treatment will be subject to a minimum level of primary treatment.

The treatment of wet weather flows from combined sewer systems may occur at the central Sewage Treatment Plant or at other locations such as satellite treatment facilities. Satellite treatment facilities may be built to treat wet weather flows where there are space limitations or limited capacity in the collection system to get the wet weather flows to the STP. There are a number of satellite treatment technologies some examples of which are vortex separators, high-rate sedimentation, dissolved air flotation and high-rate filtration. Satellite treatment facilities when used to treat wet weather flows from combined sewer systems are subject to the minimum level of primary treatment requirements specified above. In addition, for satellite treatment facilities the effluent concentration for total suspended solids should not exceed 90 mg/l for more than 50 % of the time for an average year during the seven-month period as specified in section 6(g).

8. EFFLUENT DISINFECTION

Effluent disinfection is required where the effluent affects swimming and bathing beaches and other areas where there are public health concerns. The local Medical Officer of Health identifies public health concerns such as e.g. whether recreational beaches are safe for swimming.

The interim effluent quality criterion for disinfected combined sewage during wet weather is a monthly geometric mean not exceeding 1000 E. coli per 100 ml. This criterion may be modified by the Regional staff of the Ministry on a case-by-case basis due to site-specific conditions.

In cases where chlorination is used as the disinfection process, subsequent dechlorination of the sewage works effluents shall be used to minimize the adverse effects of chlorine residuals on public health and the aquatic environment where necessary.

All bypasses at the Sewage Treatment Plant should be subjected to the disinfection process where available in order to reduce the bacterial loadings at discharge.

9. BEACH PROTECTION

Additional controls above the minimum CSO controls (section 6) are required for swimming and bathing beaches affected by CSOs and consist of the following :

(a) There should be no violation of the body contact recreational water quality objective (Provincial Water Quality Objectives (PWQO)) for E. coli of 100 E. coli per 100 ml. based on a geometric mean at swimming and bathing beaches as a result of CSOs for at least 95% of the four-month season (June 1 to September 30) for an average year.

(b) Controlling to not more than two overflow events per season (June 1 to September 30) for an average year in a combined sewer system with the combined total duration of the CSOs at any single CSO location being less than 48 hours and ensuring that the controlled combined sewage which does not overflow receives a level of treatment (as specified in section 7) plus disinfection (as specified in section 8) is deemed to satisfy section 9(a). An additional overflow event per season may be allowed if the proponent can demonstrate that section 9(a) will still be satisfied and the combined total duration of the CSOs at any single CSO location will be less than 48 hours.

10. MONITORING

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. The nature of monitoring programs shall be specified in the Pollution Prevention and Control Plan or as determined by the Ministry through its Regional staff. The responsibility for providing monitoring shall rest with the municipality or operating authority of the combined sewer system.

11. NEW SANITARY CONNECTIONS TO COMBINED SEWER SYSTEMS

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.

12. NEW STORM CONNECTIONS TO COMBINED SEWER SYSTEMS

New storm drainage systems shall not be permitted to connect to existing combined systems if that increases the gross area serviced by the combined sewer system except where evaluations indicate that circumstances allow no other practical alternative. The evaluations must be documented as part of a Pollution Prevention and Control Plan.

"Piece-meal" construction on existing combined sewer systems will be permitted only with overriding justification such as for the purpose of relocation (e.g., to accommodate underground utilities, subway structures, new buildings and pedestrian tunnels, etc.) or for the purpose of capacity improvement (e.g., to relieve basement flooding or to provide emergency additional conveyance capacity to treatment works to reduce overflows) or for rehabilitating deteriorated sewer conditions.

13. ENFORCEMENT

Procedure F-5-5 will be used to:

(a) review applications for approval to ensure that the proponent is in compliance with the Procedure prior to the issuance of a Certificate of Approval.

(b) assist regional staff in setting minimum requirements in preparing Control Orders to bring systems into compliance with the Procedure.

(c) assist enforcement staff in evaluating a combined sewer system operator's due diligence when investigating violations of the Environmental Protection Act and/or the Ontario Water Resources Act.

Any deviation or relaxation from this Procedure should be reviewed by the Regional Director and the Director, Program Development Branch.

Appendix C

STORM WATER QUALITY SURVEILLANCE PROGRAM REPORTS

CITY OF KINGSTON – ENVIRONMENT & SUSTAINABLE INITIATIVES DEPARTMENT

STORM WATER QUALITY SURVEILLANCE PROGRAM 2013

PREPARED BY: BRIANNE HICKNELL & KEITH JARRELL

AUGUST 28TH, 2013

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EXECUTIVE SUMMARY

The annual Storm Water Quality Surveillance Program (SWQSP) was conducted by the Environment Division of the City of Kingston for the summer of 2013.

The main objectives of this program include:

- Determining possible cross-connections of storm and sanitary sewer systems
- Identifying infrastructure in need of repair

Through storm water outfall locating and sampling, outfalls were analyzed for the following parameters:

- pH
- Conductivity
- Total Dissolved Solids (TDS)
- Temperature
- Total Coliforms
- Fecal Coliforms
- Ammonia
- Total Chlorine
- Free Chlorine
- Metals (as per O. Reg. 153/04)
- Polyaromatic Hydrocarbons (PAHs)

Results from analysis conducted both in the field and by AGAT Laboratories found that 84% of outfalls exceeded Provincial Water Quality Objectives (PWQO) for total coliforms; 52% for fecal coliforms; 80% for total chlorine; 24% for ammonia; 0% for PAHs and 6% for metals.

INTRODUCTION

BACKGROUND INFORMATION

Each year the Storm Water Quality Surveillance Program (SWQSP) is conducted by the Environment Division in order to detect substandard storm water systems within the City of Kingston. The program launched in 2003 and focuses on storm water sampling and the identification of possible cross-connections with sanitary sewer systems. The existence of a cross-connection is typically indicated by the presence of coliforms and chlorine in a storm water outfall sample.

SCOPE

The scope of the project was limited to storm sewer systems owned and maintained by the City of Kingston. Sampling was conducted in the field for the following parameters:

- pH
- Conductivity
- Total Dissolved Solids (TDS)
- Temperature
- Total Chlorine
- Free Chlorine

All samples were analyzed in the laboratory for the following parameters:

- Total Coliforms
- Fecal Coliforms
- Ammonia

Select samples were analyzed in the laboratory for the following parameters:

- Polyaromatic Hydrocarbons (PAHs)
- Metals (as per O. Reg. 153/04)

METHODS

OUTFALL LOCATING

Storm sewer outfalls were located using KingMAPS, the mapping application commissioned by the City of Kingston. Utilizing the infrastructure option within the “More Maps” tab, storm outfalls, storm manholes, catchbasins and storm sewers were mapped and printed. These maps were used to make daily work plans and to locate the storm outfalls in the field. Reference maps of the outfalls chosen for analysis can be viewed in Appendix B.

FIRST ROUND OUTFALL SAMPLING

To ensure that sampled flow was only a result of cross-connections, a period of 24 hours without rain was observed prior to each of the nine sampling days.

Outfalls were sampled using a pole sampler with an attached transfer bottle. If the outfall was submerged or inaccessible, the upstream storm manhole was used to collect a sample.

Safety measures were implemented where necessary. These included pylons, four way flashing lights, the roof mounted light-bar on the vehicle, life preservers and steel toed boots. Nitrile gloves were worn at all times during sampling to preserve the integrity of the sample and for protection against direct contact with chemicals.

TOTAL COLIFORMS, FECAL COLIFORMS, AMMONIA, METALS AND PAHs

AGAT Laboratories bottles were filled with sample in order to analyze total coliforms, fecal coliforms, ammonia, metals (as per O. Reg. 153/04) and PAHs.

200 mL of sample was transferred to the 250 mL plastic coliform bottle containing a preservative of $Na_2S_2O_3$.

Approximately 100 mL of sample was transferred to the plastic ammonia bottle containing a preservative of H_2SO_4.

If metals were being analyzed, a 0.45 micron field filter was attached to the transfer bottle. A 100 mL plastic bottle with an HNO_3 preservative was filled with sample.

If PAHs were being analyzed, a 1 L glass amber bottle with a Teflon lined cap was filled with sample.

The sample bottles were placed into a cooler and preserved with ice packs until they were delivered to the lab at the end of each sampling day.

TOTAL AND FREE CHLORINE

Total chlorine was tested using a portable HACH pocket colourimeter. Using distilled water a blank was created and placed into the colourimeter for calibration. 10 mL of sample was transferred into a second vial. The total chlorine reagent was added to the vial and the solution was mixed for 20 seconds. After 3 to 6 minutes this vial was placed into the colourimeter and analyzed.

If the total chlorine reading was 0.5 mg/L or higher, free chlorine was tested. The vial was emptied, triple-rinsed with the sample then refilled. The free chlorine reagent was added to the vial and mixed then immediately tested.

PH, CONDUCTIVITY, TOTAL DISSOLVED SOLIDS AND TEMPERATURE

The field parameters were measured using a HANNA multiparameter meter. The probe of the instrument was placed into the transfer bottle containing the sample. The parameters were measured and documented.

SECOND ROUND OUTFALL SAMPLING

Select samples which showed high chlorine or high bacteria counts were chosen for further analysis. The storm system for these outfalls were mapped and key manholes were selected for a second round of sampling in order to further constrict the source of the cross-connection.

Sampling in these situations was conducted using the methods described above in *First Round Sampling Methods*.

RESULTS

DATA

A list of outfalls visited along with the dates and field notes can be found in Table 3 of Appendix A. The field parameters and laboratory results can be viewed in full in Appendix A in Table 4, Table 5 and Table 6. The laboratory documents associated with these results can be viewed in Appendix C.

CONCLUSIONS

DATA ANALYSIS

As indicated in Table 4, it is quite clear that most of the outfalls exceed the Provincial Water Quality Objectives (PWQO) guidelines for total and fecal coliforms as well as for total chlorine. This indicates the possibility of cross-connections of storm and sanitary sewer systems across the City of Kingston, which affects the vast majority of outfalls sampled in 2013.

Table 5 in Appendix A shows that most PAHs do not exceed the PWQO regulations, however, there are eight parameters in which the minimum detection limit (MDL) is higher than the PWQO limit. Therefore it cannot be conclusively determined that the samples meet these criteria.

The results for metals are available in Table 6. Both metals samples exceed the PWQO limit for zinc.

OUTFALLS OF CONCERN

The data collected during the SWQSP was used to determine outfalls of concern outlined in Table 1. The following outfalls should be the first to be analyzed in the 2014 program. Outfalls in need of repair can be viewed in Table 2, which uses data provided from Table 3 in Appendix A.

TABLE 1: OUTFALLS OF CONCERN WHICH CONTAIN HIGH VALUES OF THE RESPECTIVE PARAMETERS

Fecal Coliforms	Ammonia	Total Chlorine
17	95	141
91	100	193
93	141	533
94	167	1470
95		
101		
141		
167		
237, 199		

Note: Total coliforms are not necessarily indicative of cross-connections. The total coliforms parameter includes *Escherichia*, *Enterobacter*, *Klebsiella* and *Citrobacter*. *Enterobacter* can originate from soil and vegetation. Fecal coliforms (*Escherichia, Klebsiella and Citrobacter*) found in human and animal waste, are a more useful indicator for determining cross-connections.

TABLE 2: OUTFALLS IN NEED OF REPAIR

Outfalls Missing Grates	Overgrown Outfalls
5	200
17	201
24	
69	
79	
92	
96	
138	
139	
152	
202	
234	
254	
1470	

RECOMMENDATIONS FOR 2014

START SAMPLING IN MAY

The SWQSP should be started as soon as possible. This year's program began in mid-July and ended in mid-August leaving a very short amount of time for outfall sampling. Sampling was completed over only nine days in 2013. A longer project timeframe would allow for more first and second round sampling, which would greatly help pinpoint cross-connection sources.

EMPHASIZE SECOND ROUND SAMPLING

Second round sampling is useful in narrowing down the source of the contamination. It is advised that a smaller amount of outfalls be investigated for first round sampling, allowing for more second round testing. There is a vast amount of yearly data collected over the program's span, and the problem zones should be narrowed in order to remedy the known issues.

TEST OUTFALLS WITH NO DATA

There are many outfalls within the City of Kingston that have never been tested in the SWQSP and thus potentially many unidentified outfalls with cross-connections. A small number of untested outfalls should be added to the program each year for all future years with the goal of eventually having data from each outfall and a greater understanding of the health of the City's storm water system.

POLE SAMPLER

It is recommended that a new pole sampler be purchased at the beginning of the season. The existing pole sampler is difficult to extend and often does not reach the required depth for manhole sampling. If possible, a sampler with a snap or clip extending mechanism should be purchased, as the current twist release is prone to stick.

APPENDIX A – FIELD NOTES AND RESULTS

TABLE 3: OUTFALLS INCLUDED IN THE 2013 SWQSP

Outfall	Reason for Sampling	Date Visited	Comments
1	Limited high bacteria	19-Jul-13	Outfall located, unable to sample
5	Limited high chlorine	19-Jul-13	No flow, no grate
14	Consistent high bacteria and chlorine	16-Jul-13	No flow
16	Consistent high bacteria and chlorine	16-Jul-13	No flow
17	Consistent high bacteria and chlorine	16-Jul-13	Sampled, no grate
23	Limited high chlorine	-	-
24	Consistent high bacteria and chlorine	17-Jul-13	No flow, no grate
29	Limited high bacteria	23-Jul-13	No flow
36	Limited high chlorine	17-Jul-13	Unable to locate
40	Consistent high bacteria and chlorine	23-Jul-13	No flow
55	Limited high bacteria and chlorine	23-Jul-13	No flow
61	Consistent high bacteria and chlorine	17-Jul-13	No flow
69	Limited high bacteria	23-Jul-13	Sampled, no grate
		7-Aug-13	No flow (69-Dev)
70	Limited high chlorine	23-Jul-13	No flow
74	Limited high chlorine	-	-
78	-	23-Jul-13	Sampled
79	Limited high chlorine	23-Jul-13	No flow, no grate
91	Limited high bacteria	16-Jul-13	Sampled
92	-	16-Jul-13	No flow, no grate
93	Consistent high bacteria	15-Jul-13	Sampled
		2-Aug-13	No flow in north manhole (93-Gard NE)
		2-Aug-13	Sampled at south manhole (93-Gard S)
94	Consistent high bacteria and chlorine	16-Jul-13	Sampled
95	Consistent high bacteria and chlorine	23-Jul-13	Sampled
		2-Aug-13	Sampled at manhole (95-Cly)
		7-Aug-13	No flow (95-Cat)
96	Limited high bacteria	23-Jul-13	No flow, no grate
97	Limited high bacteria and chlorine	23-Jul-13	No flow
100	Limited high bacteria	15-Jul-13	Sampled
		7-Aug-13	No flow (100-Kat S)
		7-Aug-13	No flow (100-Kat N)
		7-Aug-13	No flow (100-Wood)
101	Consistent high bacteria and chlorine	15-Jul-13	Sampled
102	Consistent high bacteria	-	-
107	Limited high chlorine	-	-
109	Limited high chlorine	23-Jul-13	No flow

Outfall	Reason for Sampling	Date Visited	Comments
117	Limited high bacteria	19-Jul-13	No flow
122	Consistent high bacteria	16-Jul-13	No flow
		31-Jul-13	No flow
137	Limited high bacteria	19-Jul-13	No flow
138	Consistent high bacteria	19-Jul-13	No flow, no grate
139	Consistent high bacteria	19-Jul-13	Sampled, no grate
		7-Aug-13	No flow at manhole (139-Gre)
		7-Aug-13	No flow at manhole (139-Mac)
141	Consistent high bacteria and chlorine	19-Jul-13	Unable to locate, sampled upstream
		7-Aug-13	Sampled at manhole (141-Dal)
		7-Aug-13	No flow (141-Wel)
145	Consistent high bacteria	23-Jul-13	Reconfigured, not sampled
152	Limited high chlorine	23-Jul-13	No flow, no grate
154	Limited high chlorine	-	-
155	Consistent high bacteria	-	-
162	Limited high bacteria	31-Jul-13	Sampled
164	Limited high chlorine	-	-
165	Consistent high bacteria	19-Jul-13	Sampled
167	Consistent high bacteria and chlorine	16-Jul-13	Sampled
171	Limited high chlorine	15-Aug-13	Unable to locate
177	Limited high bacteria	-	-
180	Consistent high bacteria	19-Jul-13	Unable to locate
181	Limited high bacteria and chlorine	19-Jul-13	Unable to locate
184	Limited high chlorine	-	-
186	Limited high chlorine	-	-
190	Limited high chlorine	15-Aug-13	Unable to locate
191	Limited high bacteria	15-Aug-13	Unable to locate
193	Limited high bacteria and chlorine	15-Aug-13	Sampled
198	Metals	31-Jul-13	No flow
		2-Aug-13	No flow
		7-Aug-13	No flow
		15-Aug-13	No flow
200	Metals	31-Jul-13	No flow, overgrown
		2-Aug-13	No flow,
		7-Aug-13	No flow,
		15-Aug-13	No flow,

Outfall	Reason for Sampling	Date Visited	Comments
201	Metals	31-Jul-13	No flow, overgrown
		2-Aug-13	No flow,
		7-Aug-13	No flow
		15-Aug-13	No flow
202	Metals	31-Jul-13	No flow, no grate
		2-Aug-13	No flow,
		7-Aug-13	Not sampled,
		15-Aug-13	Sampled upstream
207	Limited high bacteria	-	-
221	Limited high bacteria and chlorine	-	-
229	Limited high bacteria and chlorine	15-Aug-13	Sampled
234	Limited high bacteria and chlorine	15-Aug-13	No flow, no grate
235	Limited high bacteria	15-Aug-13	Unable to locate
236	Limited high bacteria	-	-
237,199	Metals	31-Jul-13	Sampled upstream
243	Limited high chlorine	-	-
249	Limited high chlorine	-	-
254	Limited high bacteria and chlorine	23-Jul-13	No flow, no grate
256	Limited high chlorine	17-Jul-13	Unable to locate
257	Limited high chlorine	-	-
506	Limited high bacteria and chlorine	15-Aug-13	Unable to locate
533	Limited high bacteria and chlorine	15-Aug-13	Sampled
534	Limited high chlorine	15-Aug-13	No flow
538	Limited high chlorine	15-Aug-13	No flow
542	Limited high bacteria and chlorine	15-Aug-13	Sampled
548	Limited high chlorine	-	-
550	Limited high chlorine	-	-
555	Limited high chlorine	23-Jul-13	No flow
556	Limited high chlorine	23-Jul-13	Unable to locate
654	Limited high chlorine	23-Jul-13	Sampled
		7-Aug-13	No flow (654-Day)
1022	Limited high chlorine	-	-
1470	Limited high bacteria and chlorine	15-Aug-13	Sampled, no grate

TABLE 4: RESULTS FROM FIELD AND LAB ANALYSIS

LAB & FIELD RESULTS											
Outfall #	**Location**	**Date Sampled**	**Total Coliforms (cts/100 mL)**	**Fecal Coliforms (cts/100 mL)**	**Ammonia (µg/L)**	**pH**	**Conductivity (mS)**	**Total Dissolved Solids (ppt)**	**Temperature (°C)**	**Total Chlorine (µg/L)**	**Free Chlorine (µg/L)**
PWQO Guideline (mg/L)			1000	100	20	-	-	-	-	50	
17	Mona Dr at Hillsview	16-Jul-13	OG	OG	<20	8.08	0.80	0.40	19.2	40	-
69	Development Dr	23-Jul-13	OG	84	<20	8.13	0.93	0.46	19.5	50	-
78	Taylor Kidd at Old Colony Rd	23-Jul-13	26	19	<20	7.65	0.37	0.36	21.7	50	-
91	Princess E of Gardiners	16-Jul-13	OG	278	20	7.91	1.07	0.53	20.7	60	-
93	Princess E of Gardiners	15-Jul-13	OG	OG	<20	8.10	1.05	0.52	23.3	310	-
93-GardS	Gardiners Rd Canadian Tire Parking Lot (E edge)	2-Aug-13	OG	10700	20	7.99	0.37	0.18	22.7	190	-
94	Princess E of Gardiners	16-Jul-13	OG	OG	<20	8.03	1.55	0.75	20.9	0	-
95	South end of Clyde Crt	23-Jul-13	OG	146	30	8.27	0.92	0.46	19.8	240	-
95-Cly	Middle of Clyde Crt	2-Aug-13	OG	300	<20	7.78	0.99	0.50	21.1	210	-
100	West side of retention pond on Woodbine Rd	15-Jul-13	OG	88	80	7.86	0.72	0.36	29.8	90	-
101	East side of retention pond on Woodbine Rd	15-Jul-13	OG	OG	<20	8.36	0.86	0.43	23.3	120	-
139	Shaw St by train tracks	19-Jul-13	OG	49	<20	7.82	0.47	0.23	20.8	50	-
141	Montreal St N of Weller Ave	19-Jul-13	OG	OG	<20	7.75	0.37	0.18	23.3	1490	1160
141-Dal	Parking lot of 1130 Montreal St	7-Aug-13	OG	OG	5400	7.54	0.50	0.25	20.6	360	-
162	K&P Trail in North Shore of Belle Park off of Montreal St	31-Jul-13	6100	70	<20	8.25	1.12	0.56	20.2	170	-
165	Lake Ontario Park	19-Jul-13	1	0	<20	8.07	0.73	0.37	20.4	180	-
167	Providence Care off Gable Lane	16-Jul-13	OG	OG	200	7.91	0.57	0.28	26.4	220	-
193	East end of Princess at Holiday Inn	15-Aug-13	23	0	23	7.99	0.89	0.44	22.2	700	420
202	K&P Trail in South Shore of Belle Park off of Montreal St	15-Aug-13	OG	2	<20	7.81	0.63	0.31	20.0	290	-
229	On Kingston Mills Rd by Locks	15-Aug-13	5000	100	<20	7.81	0.76	0.38	17.6	140	-
237, 199	Rideau St at Dufferin St	31-Jul-13	OG	2000	<20	8.15	1.02	0.52	16.8	160	-
533	Windmill St at Lundy's Lane	15-Aug-13	0	0	<20	8.04	0.37	0.18	21.1	1040	720
542	South end of Signal Ave	15-Aug-13	8500	384	1040	7.82	0.75	0.37	18.5	60	-
654	North end of Days Rd	23-Jul-13	OG	46	<20	7.90	1.64	0.81	19.9	90	-
1470	South end of Simcoe Rd E outfall	15-Aug-13	OG	0	<20	8.05	0.37	0.17	25.1	910	490

*Yellow = exceeds PWQO regulations, Red = presence unexpected, Orange = both yellow and red

TABLE 5: POLYAROMATIC HYDROCARBONS RESULTS FROM AGAT LABORATORIES

POLYAROMATIC HYDROCARBON RESULTS																				
Outfall #	Location	Date Sampled	Napthalene (µg/L)	Acenaphthalylene (µg/L)	Acenaphthene (µg/L)	Fluorine (µg/L)	Phenanthrene (µg/L)	Anthracene (µg/L)	Fluoranthene (µg/L)	Pyrene (µg/L)	Benz(a)anthracene (µg/L)	Chrysene (µg/L)	Benzo(b)fluoranthene (µg/L)	Benzo(k)fluoranthene (µg/L)	Benzo(a)pyrene (µg/L)	Indeno(1,2,3-cd)pyrene (µg/L)	Dibenz(a,h)anthracene (µg/L)	Benzo(g,h,i)perlene (µg/L)	2 & 1 methyl Naphthalene (µg/L)	Chrysene-d12 (µg/L)
PWQO Guideline (µg/L)			7	NV	NV	0.2	0.03	0.0008	0.0008	NV	0.0004	0.0001	NV	0.0002	NV	NV	0.0002	0.00002	2 & 2	50-140
237, 199	Rideau St at Dufferin St	31-Jul-13	<0.2	<0.2	<0.2	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.01	<0.2	<0.2	<0.2	<0.2	61
202	K&P Trail in South Shore of Belle Park off of Montreal St	15-Aug-13	<0.2	<0.2	<0.2	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.01	<0.2	<0.2	<0.2	<0.2	71

*Blue = inconclusive as to exceeding the PWQO regulation

TABLE 6: O. REG. 153(511) METALS RESULTS FROM AGAT LABORATORIES

METALS RESULTS																				
Outfall #	**Location**	**Date Sampled**	Antimony (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Beryllium (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Cobalt (µg/L)	Copper (µg/L)	Lead (µg/L)	Molybdenum (µg/L)	Nickel (µg/L)	Selenium (µg/L)	Silver (µg/L)	Thallium (µg/L)	Uranium (µg/L)	Vanadium (µg/L)	Zinc (µg/L)
PWQO Guideline (µg/L)			20	100	NV	11	200	0.2	8.9	0.9	5	25	40	25	100	NV	0.3	5	6	20
237, 199	Rideau St at Dufferin St	31-Jul-13	<0.5	<1	69.8	<0.5	158	<0.2	<2	<0.5	2.1	<0.5	3.3	<1	1.8	<0.2	<0.3	0.8	0.5	37.1
202	K&P Trail in South Shore of Belle Park off of Montreal St	15-Aug-13	<0.5	<1	44.7	<0.5	43.5	<0.2	<2	<0.5	1.9	<0.5	1.3	<1	<1	<0.2	<0.3	<0.5	0.4	34.3

*Yellow = exceeds PWQO regulations

APPENDIX B – REFERENCE MAPS

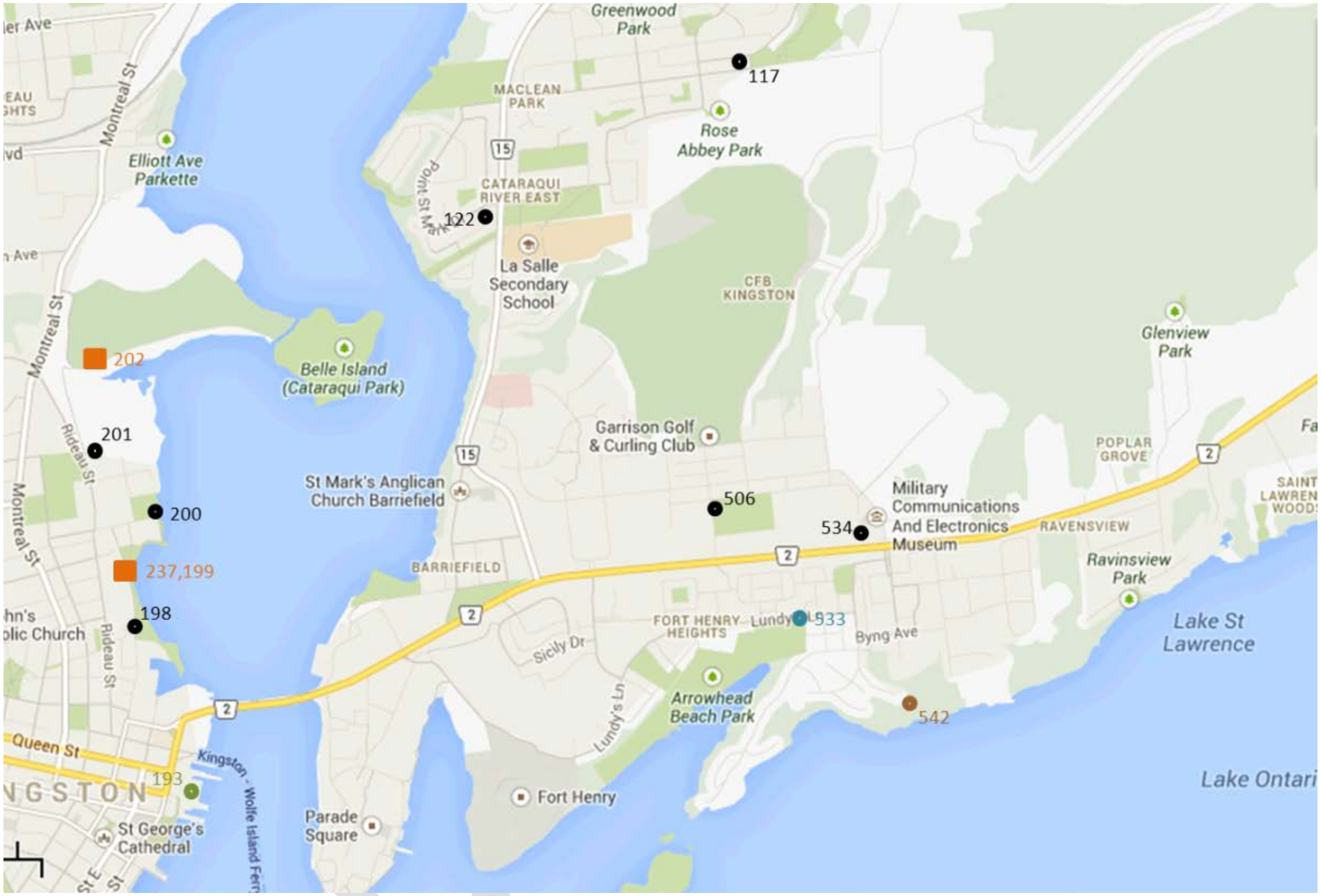

FIGURE 1: EAST KINGSTON OUTFALLS

Legend

- Not tested
- High Cl and coliforms
- High NH3, Cl and coliforms
- High coliforms
- High Cl
- High NH3 and Cl
- High Cl, coliforms and Zn
- No exceedance

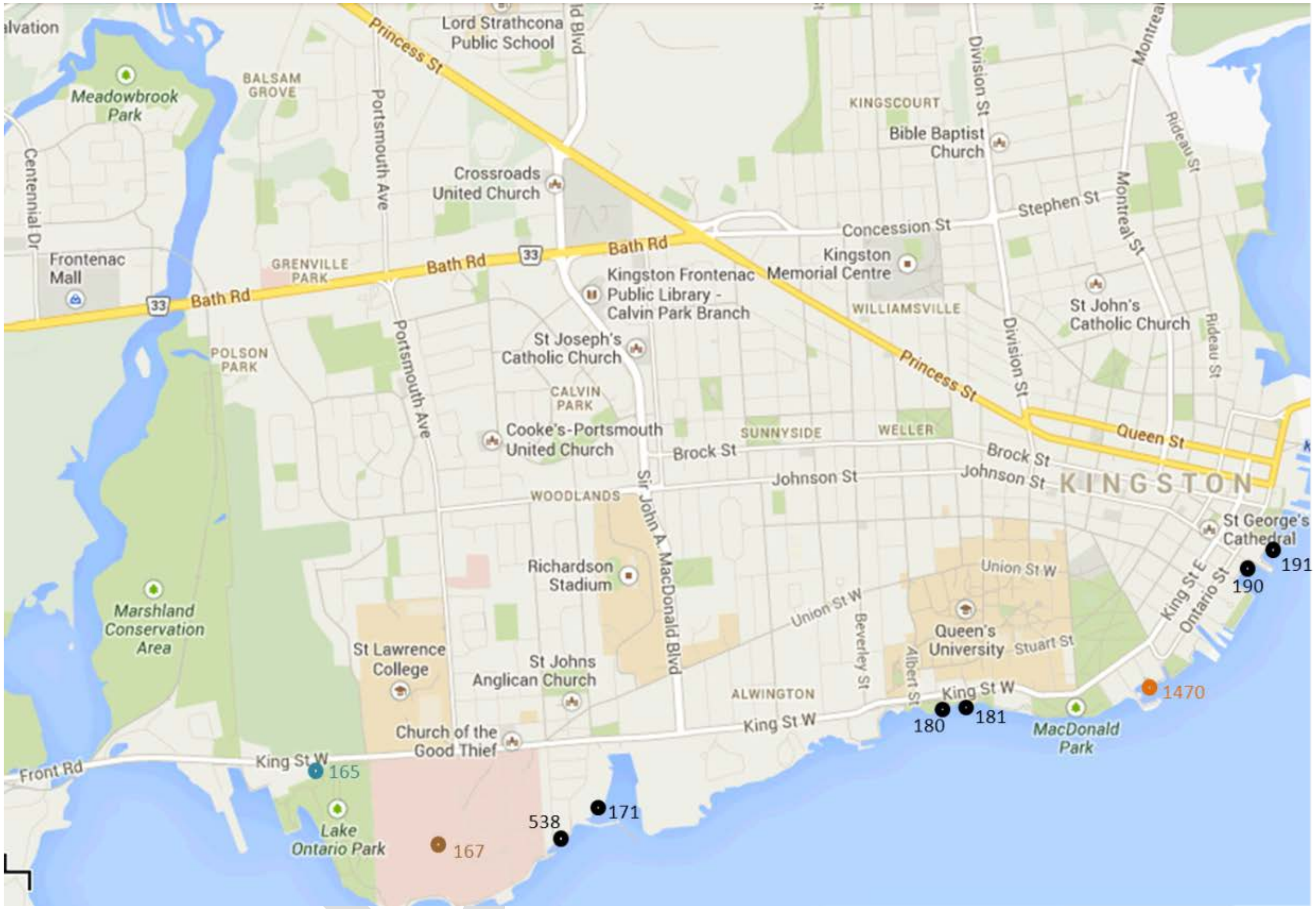

FIGURE 2: SOUTH CENTRAL KINGSTON OUTFALLS

Legend

- Not tested
- High Cl and coliforms
- High NH3, Cl and coliforms
- High coliforms
- High Cl
- High NH3 and Cl
- High Cl, coliforms and Zn
- No exceedance

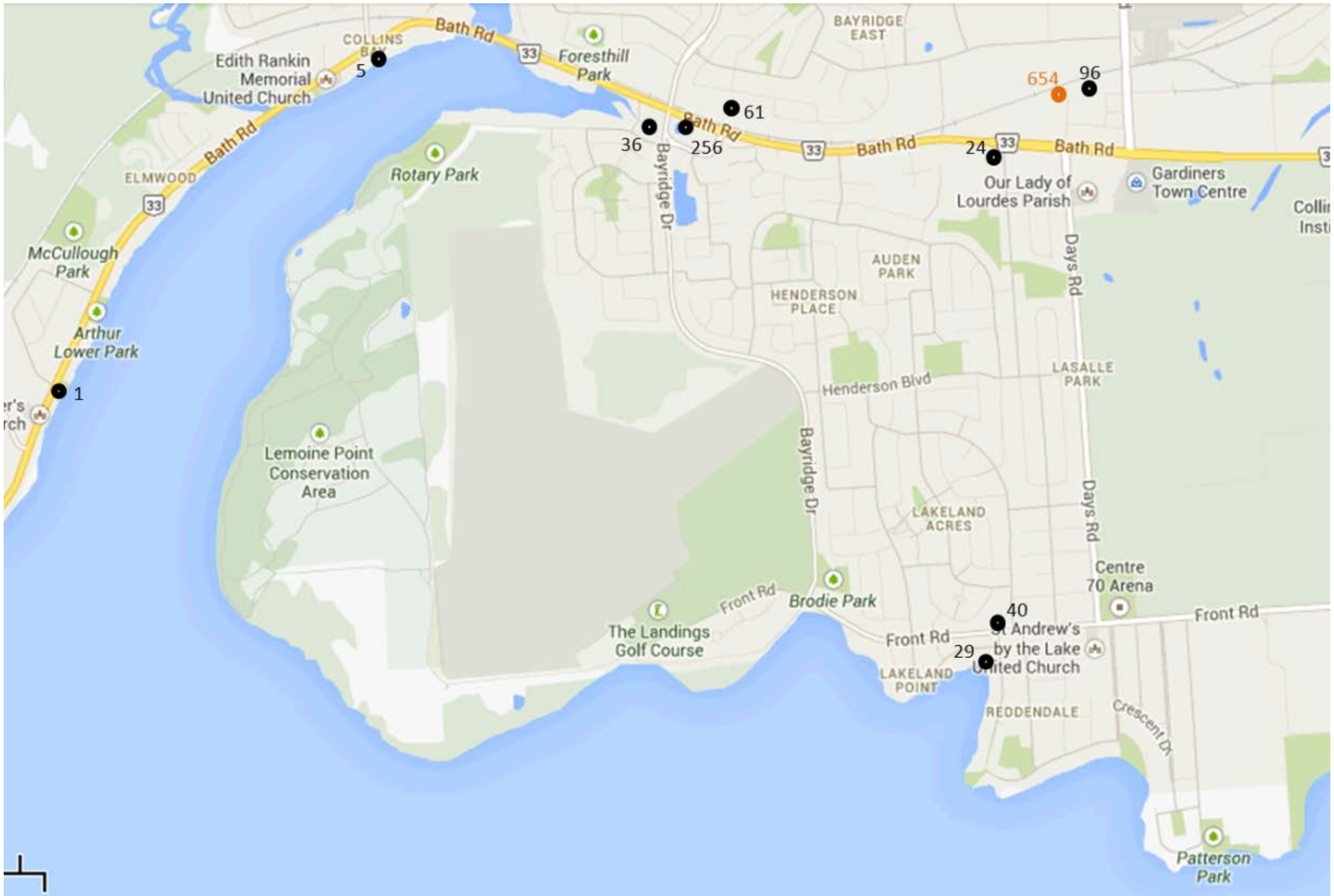

FIGURE 3: SOUTH WEST KINGSTON OUTFALLS

Legend

Not tested	High NH3, Cl and coliforms	High Cl	High Cl, coliforms and Zn
High Cl and coliforms	High coliforms	High NH3 and Cl	No exceedance

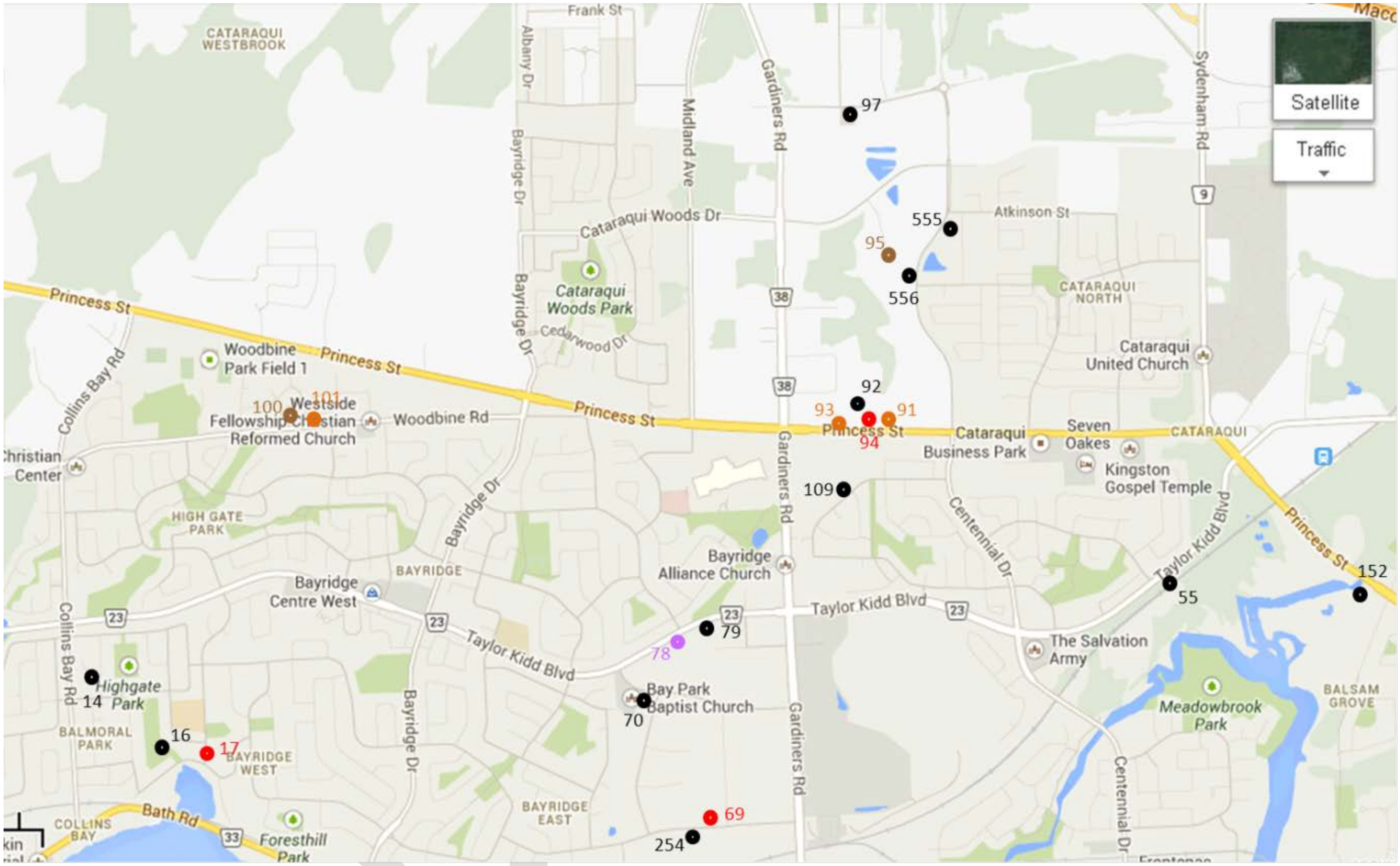

FIGURE 4: NORTH WEST KINGSTON OUTFALLS

Legend

- Not tested
- High NH3, Cl and coliforms
- High Cl
- High Cl, coliforms and Zn
- High Cl and coliforms
- High coliforms
- High NH3 and Cl
- No exceedance

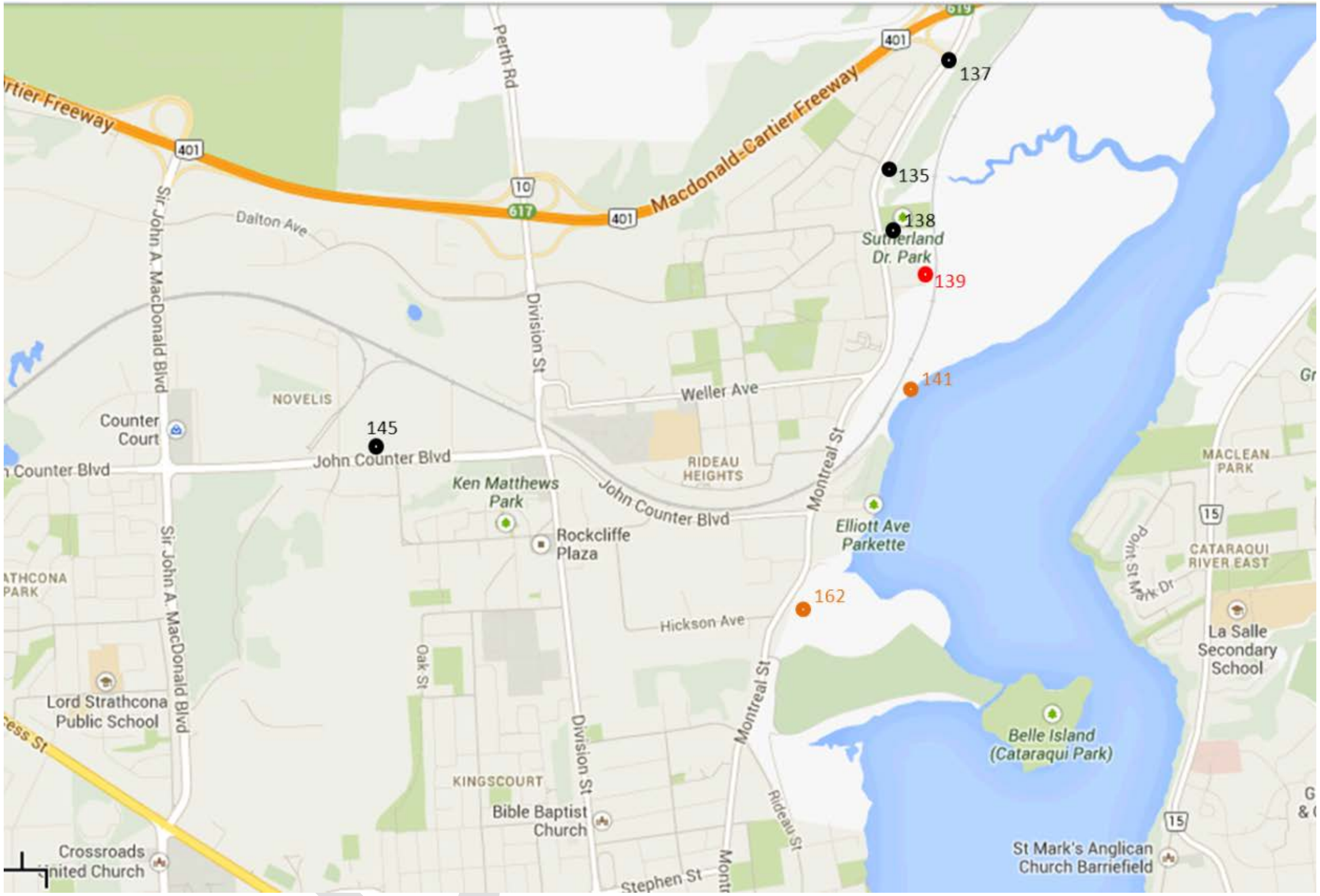

FIGURE 5: NORTH CENTRAL KINGSTON OUTFALLS

Legend

- Not tested
- High Cl and coliforms
- High NH3, Cl and coliforms
- High coliforms
- High Cl
- High NH3 and Cl
- High Cl, coliforms and Zn
- No exceedance

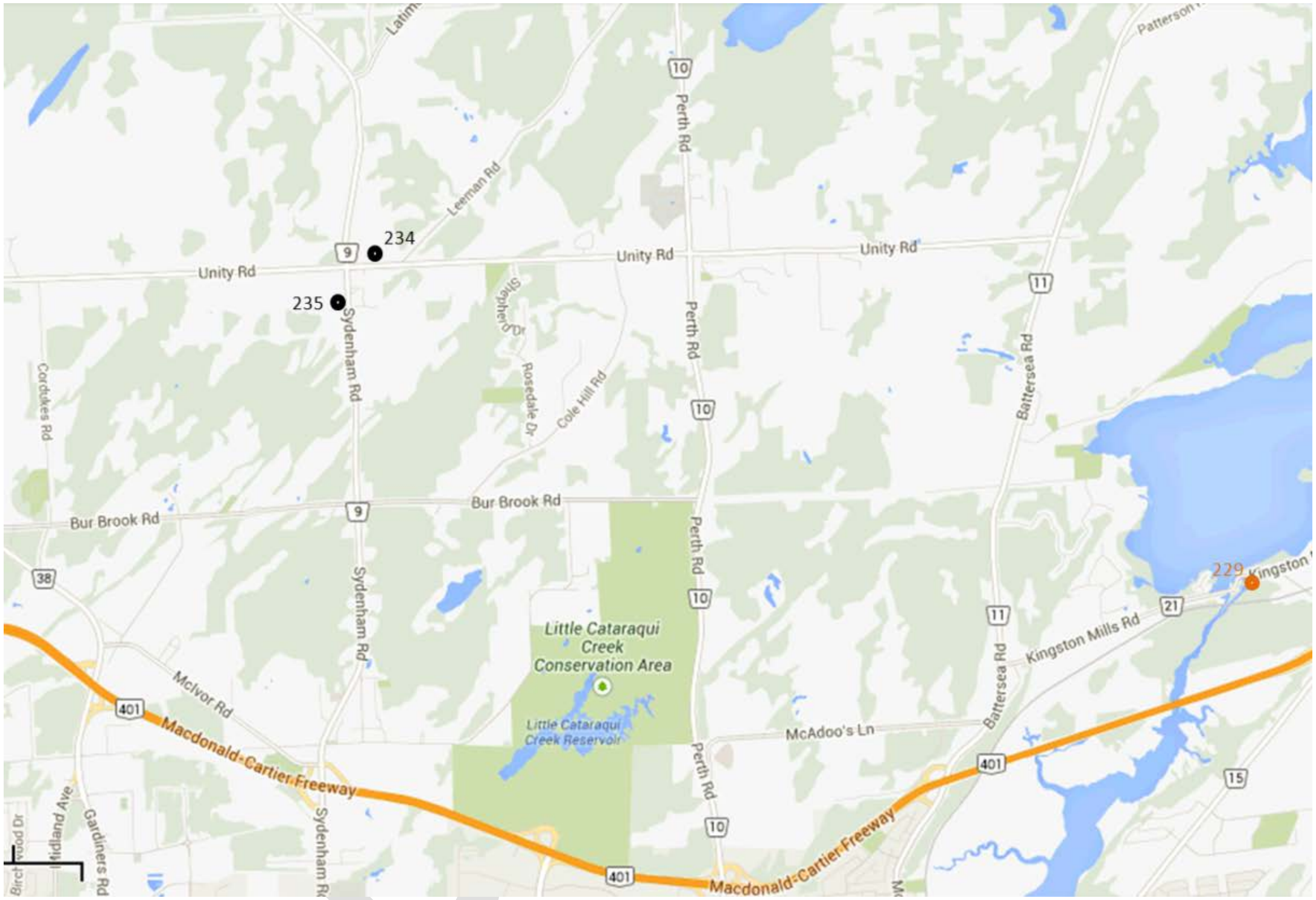

FIGURE 6: NORTH KINGSTON OUTFALLS

Legend

- Not tested
- High Cl and coliforms
- High NH3, Cl and coliforms
- High coliforms
- High Cl
- High NH3 and Cl
- High Cl, coliforms and Zn
- No exceedance

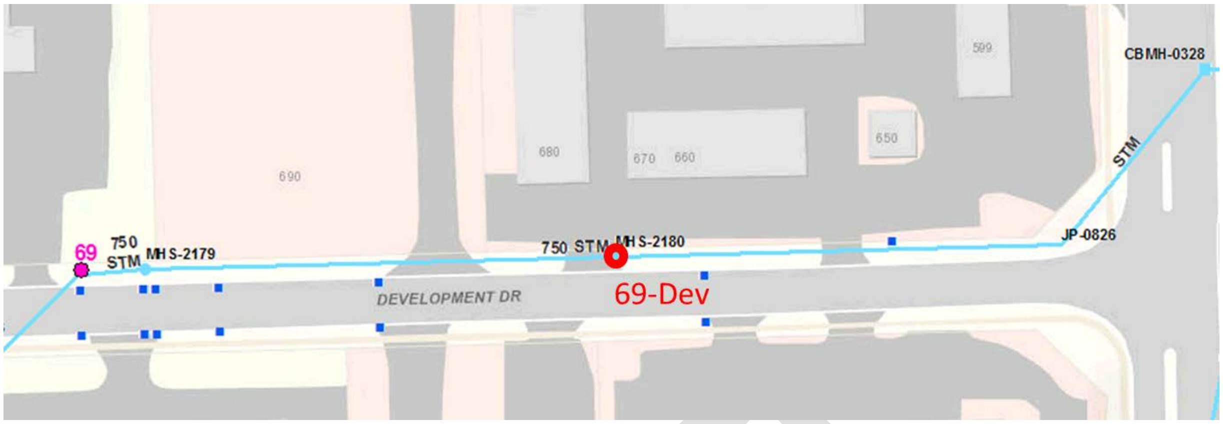

FIGURE 7: SECONDARY SAMPLING OUTFALL 69

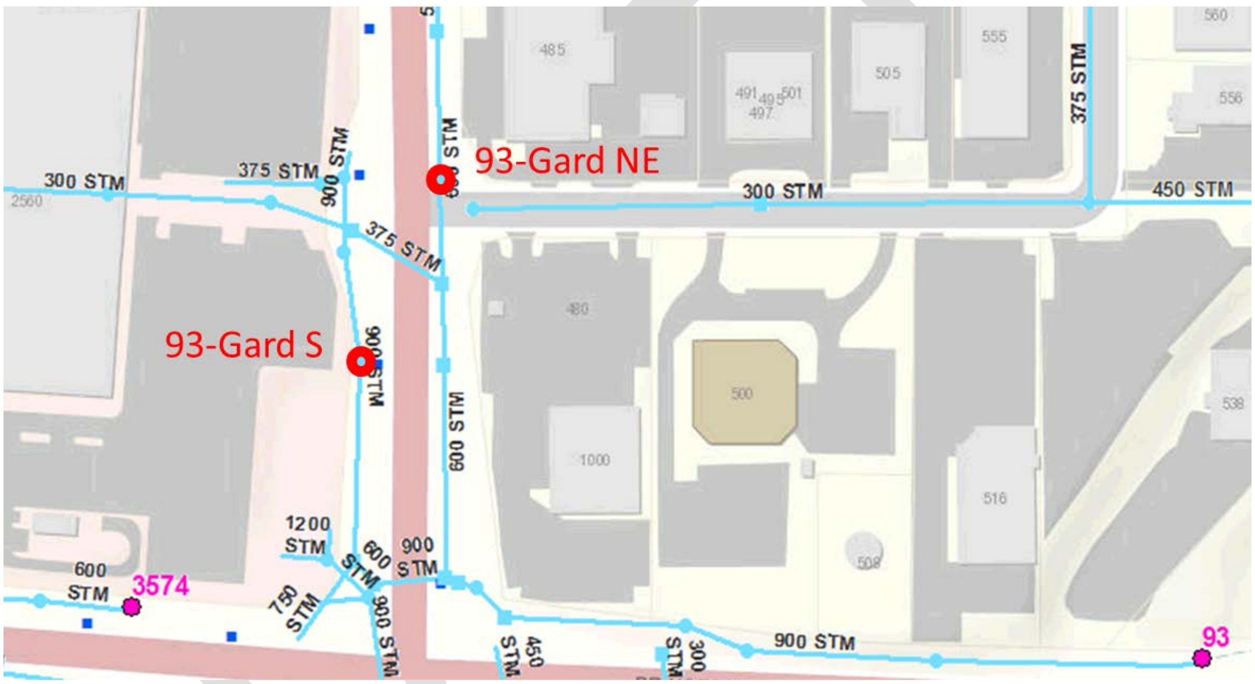

FIGURE 8: SECONDARY SAMPLING OUTFALL 93

FIGURE 9: SECONDARY SAMPLING OUTFALL 95

FIGURE 10: SECONDARY SAMPLING OUTFALL 100

FIGURE 11: SECONDARY SAMPLING OUTFALL 139

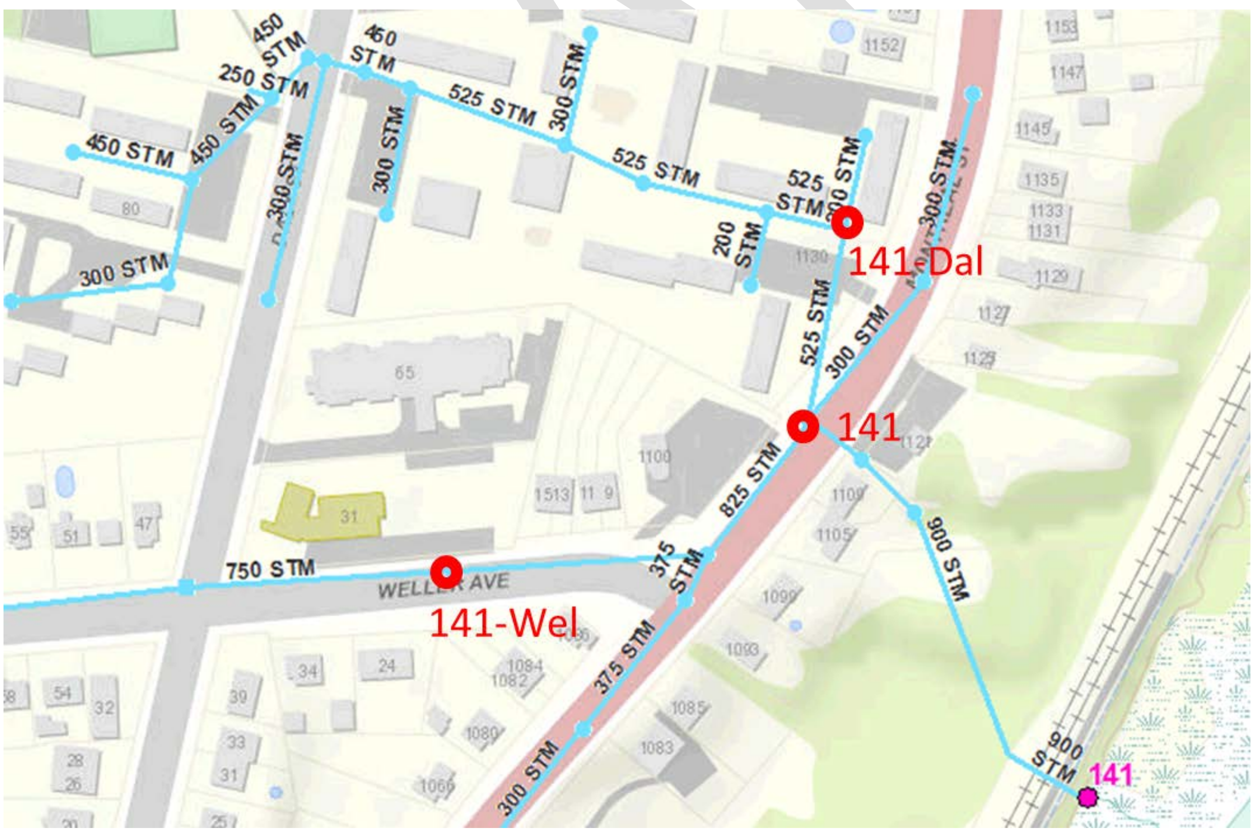

FIGURE 12: SECONDARY SAMPLING OUTFALL 141

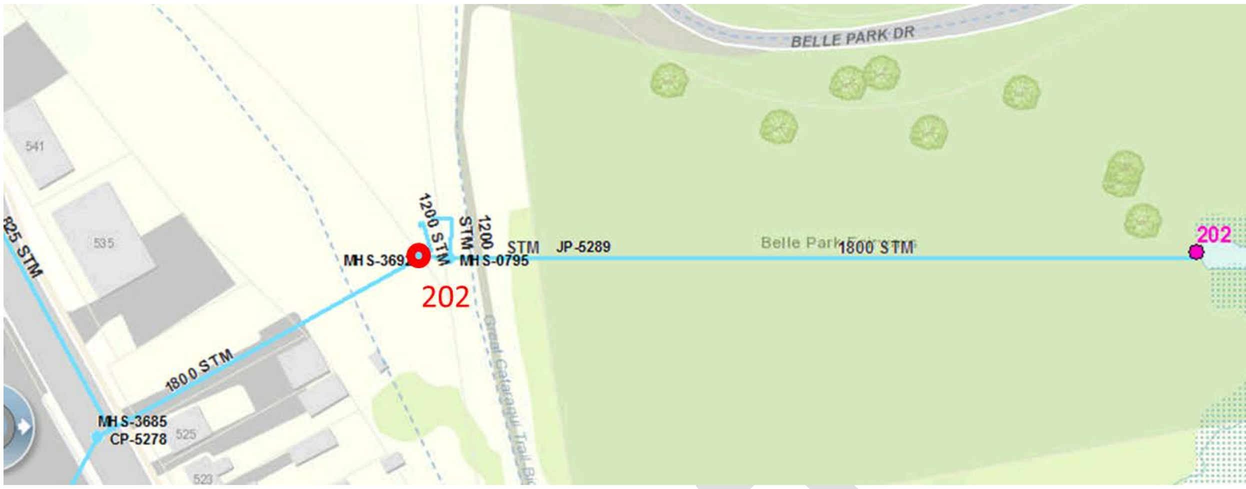

FIGURE 13: SECONDARY SAMPLING OUTFALL 202

FIGURE 14: SECONDARY SAMPLING OUTFALL 237,199

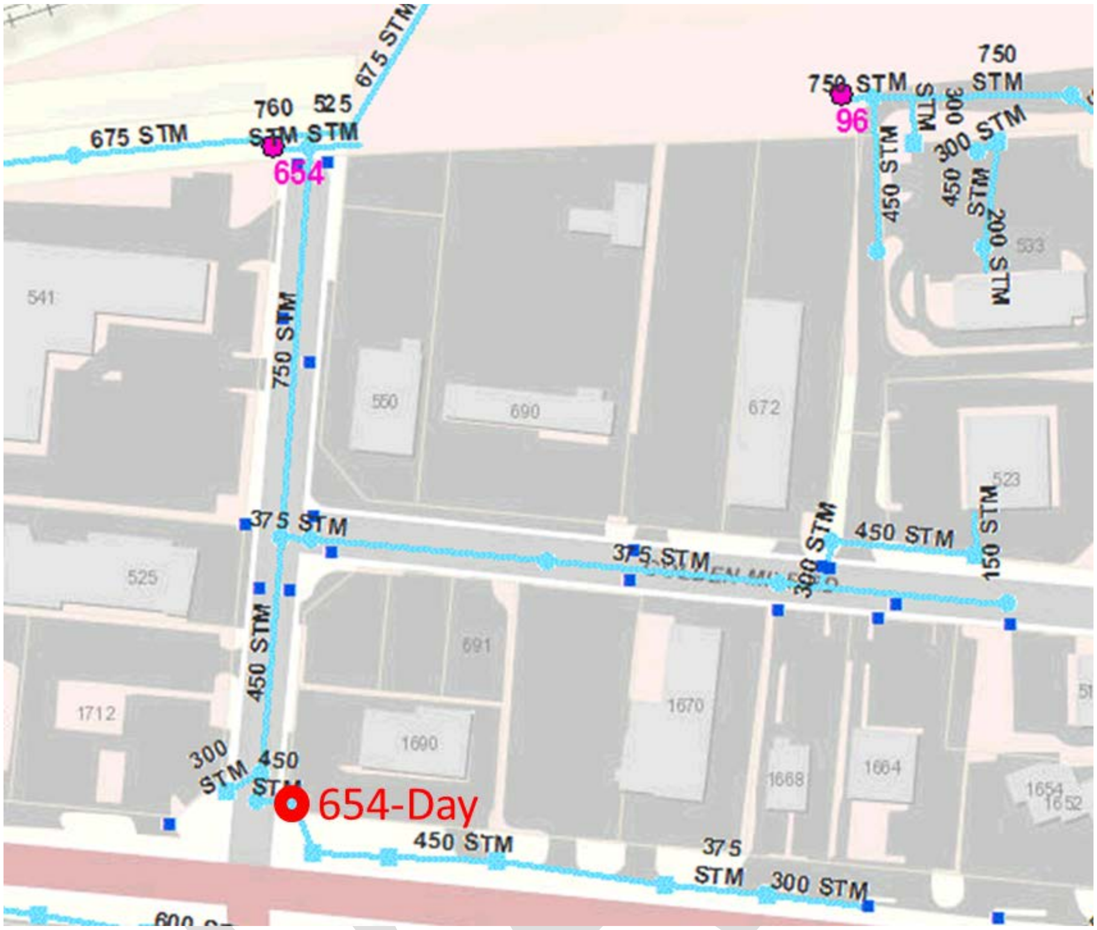

FIGURE 15: SECONDARY SAMPLING OUTFALL 654

APPENDIX C – LAB DOCUMENTS

City of Kingston – Environment & Sustainable Initiatives Department

Storm Water Quality Surveillance Program 2014

Prepared By: Stephanie Carswell and Nick Gannon
August 28, 2014

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1.0 Introduction

1.1 Background Information

The City of Kingston's Environment & Sustainable Initiatives Division conducts the Storm Water Quality Surveillance Program (SWQSP) each year. The SWQSP began in 2003 with the purpose of sampling outfalls and storm water systems to identify sub-standard storm water systems and cross-connections with sanitary sewers. The program also aims to identify outfalls of concern and outfalls in need of repair in order to provide the City of Kingston with recommendations for further action.

1.2 Scope

The scope of the SWQSP was limited to storm sewer systems owned and maintained by the City of Kingston. Additionally, only storm sewers in lower traffic areas were accessed (i.e. did not open manholes on Princess Street or other high traffic areas). Samples were tested in the field for pH, conductivity, total dissolved solids (TDS), and temperature using the multi-parameter water meter. Each sample was also tested for total chlorine and free chlorine using the colorimeter. The lab analyzed each sample for ammonia, total coliforms, and fecal coliforms.

2.0 Methodology

2.1 Outfall Planning and Locating

By reviewing SWQSP reports from previous years and other SWQSP data, a list of outfalls of concern was compiled. Outfalls that had little or no data previously recorded were also identified and were added to the list of outfalls to be visited.

Using the City of Kingston's GIS Software, KingMaps, outfalls were located using the storm water map layers within the infrastructure setting. These maps were then printed and used to create a daily plan of action. The outfalls were located in the field using information from the printed maps. Once outfalls had been sampled and the results had been returned from the laboratory, more detailed maps were printed to show the entire storm sewer system for a specific outfall. The detailed maps helped identify manholes and catch basins for further sampling and helped distinguish between sanitary and storm sewer systems in the field.

2.2 Outfall Sampling

A minimum period of 24 hours without rain was observed prior to visiting outfalls. The dry period ensures that water sampled is the result of a cross-connection rather than storm water working its way through the sewer system.

A telescoping pole sampler with an attached transfer bottle was used to collect samples from flowing outfalls or manholes. If the outfall was partially submerged, inaccessible, or could not be located, upstream manholes were used to collect a sample if applicable.

Storm sewer systems where a sample was collected were revisited for further sampling to help determine the source of the cross contamination more specifically. When sampling specific storm sewer system, manholes or catch basins were visited. Samples were collected from manholes or catch basins where a flow was observed and the water was deep enough to enter the transfer bottle.

While obtaining samples from manholes with a low water level, it was difficult to obtain enough sample in the transfer bottle attached to the pole sampler. Small amounts of sample would be collected multiple times and mixed together in a separate transfer bottle in order to obtain enough water to be analyzed.

After a sample was attained, the probe of the multi-parameter water meter was inserted into the transfer bottle. Results for pH, conductivity, TDS, and temperature were recorded in the field book along with a description of the water. The probe was rinsed with distilled water after use and the rubber cap was filled with distilled water and replaced back onto the probe. At the end of the day, the distilled water in the cap was replaced with the storage solution for the meter.

10 mL of sample was carefully poured into two glass vials. One vial of sample was used as a blank and placed into the colorimeter for calibration. The total chlorine reagent was then added to one vial and the free chlorine reagent was added to the other. The solution was then mixed and let sit for 3 minutes. After 3 minutes, a paper towel was used to clean the glass of each vial before the vials were placed in the colorimeter for analysis. Following analysis, the vials were emptied and rinsed with distilled water. At the end of the day, the inside of the vials were dried using a paper towel.

Bottles from AGAT Laboratories were filled with sample in order to analyze for total coliforms, fecal coliforms and ammonia. 200 mL of sample was transferred to the 250 mL plastic coliform bottle containing a preservative of $Na_2S_2O_3$. Approximately 100 mL of sample was transferred to the plastic ammonia bottle containing H_2SO_4. The bottles were then placed in a cooler with ice packs until they were delivered to AGAT Laboratories at the end of the day.

The transfer bottle(s) that were used to collect the samples were emptied of any remaining sample, and then rinsed with distilled water to prevent cross-contamination between samples.

2.3 Safety Procedures

Necessary safety measures were used at all times while in the field. CSA approved steel toed boots and long pants were worn at all times to ensure worker safety. Nitrile gloves were used at all times while sampling to preserve the integrity of all samples and to protect the skin of the person sampling from coming into contact with the contents of the samples. If working on or near a roadway, high visibility safety vests were worn and pylons, four way hazard lights, and the roof mounted light bar on the vehicle were used. When working near water, life preservers were worn and a throw rope was brought to the sampling area. Sampling was never conducted alone; while one student collected the sample from the outfall or manhole, the other student was nearby in case of emergency.

3.0 Results

The laboratory results for each sample can be seen in Table A1 of Appendix A. These results were then compared to the Provincial Water Quality Objectives (PWQO). The PWQO limits for the selected parameters can be seen in Table 1. Results that exceeded the PWQO regulations were highlighted. Each sample exceeded PQWO regulations for three or more of the tested parameters; therefore all outfalls and manholes tested this year are areas of concern and should continue to be investigated for cross-connections. The amount of fecal coliforms is a better indication of cross-connections than the amount of total coliforms because total coliforms can originate from other sources and cannot conclusively identify cross connections.

Table 1: PWQO limits

Parameter	PWQO limit
Total Coliforms	1000 cts/100 mL
Fecal Coliforms	100 cts/100 mL
Total Chlorine	0.05 mg/L
Free Chlorine	0.05 mg/L
Ammonia	0.02 mg/L
pH	6.5-8.5

cts/100mL – Counts per 100 mL

3.1 Outfalls Investigated at Multiple Locations

Of the 15 outfalls sampled during the 2014 SWQSP, 7 were investigated further by visiting manholes and catch basins that were part of the storm sewer system for those outfalls. Additional samples were obtained when possible.

3.1.1 Outfall 17

Outfall 17 had been previously identified as an area of concern. When the outfall was first visited, it was observed that the outfall was partially submerged and could therefore not be sampled directly. A sample was obtained from a manhole on the corner of Tacoma Crescent and Lincoln Drive and was called OF 17 – TL. This sample retuned from the lab with the highest amount of Fecal Coliforms out of all the samples. The result was NDOGT which means No Data, Overgrown with Target, or that the sample had so many fecal coliforms that no data could be collected.

The outfall was revisited to investigate other areas of the storm sewer system. Further investigation did not prove to be very useful because one target manhole was inaccessible, and one was bolted shut. Two other manholes were successfully opened, one contained some standing water and was not flowing, the other had water flowing at a level that was too low to obtain any sample in the transfer bottle. A map of the manholes visited can be seen in Figure 1.

Areas of the storm sewer system coloured red indicate a known problem. Areas coloured green indicate areas that are dry and therefore not the source of a cross connection. Areas coloured yellow indicate not enough data has been collected to determine if the area is or is not the source of a cross-connection. The circles highlight the locations visited. Blue circles were used to show manholes that could not be accessed.

Figure 1: Map of Outfall 17

3.1.2 Outfall 93

The sampled from this outfall exceeded PWQO for all parameters tested, excluding pH. Further investigation of outfall 93 was attempted. However, due to the high volume of traffic in the area, only a couple manholes located off of the road were accessible. The map of the outfall system and areas visited is shown in Figure 2.

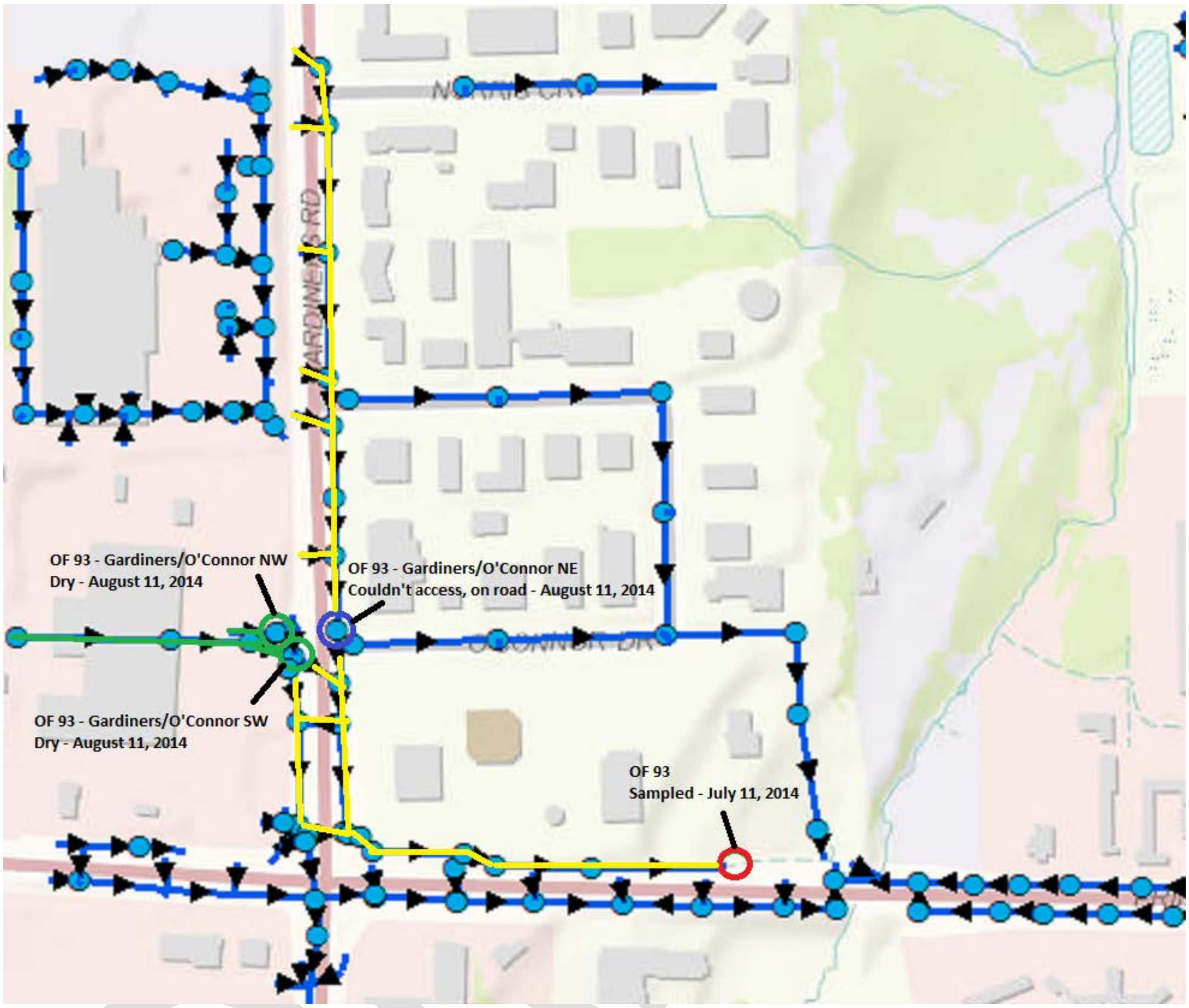

Figure 2: Map of Outfall 93

3.1.3 Outfall 95

The sample results from outfall 95 and locations along the storm sewer system for outfall 95 did not exceed PWQO limits for fecal coliforms. The total and free chlorine limits did exceed the PWQO and could account for the lower results for fecal coliforms. It cannot be confirmed that the water flowing through this system is the result of a cross-connection.

It was noted that there was a large volume of water flowing through this sewer system. The area where this outfall is located is an industrial and commercial area. The water may contain other contaminants that were not tested for during the 2014 SWQSP.

This storm sewer system is accessed through catch basins rather than manholes. Samples were obtained from catch basins throughout the entire storm sewer system. It can be concluded that the entire sewer system for this outfall is of concern. The locations sampled can be seen in Figure 3.

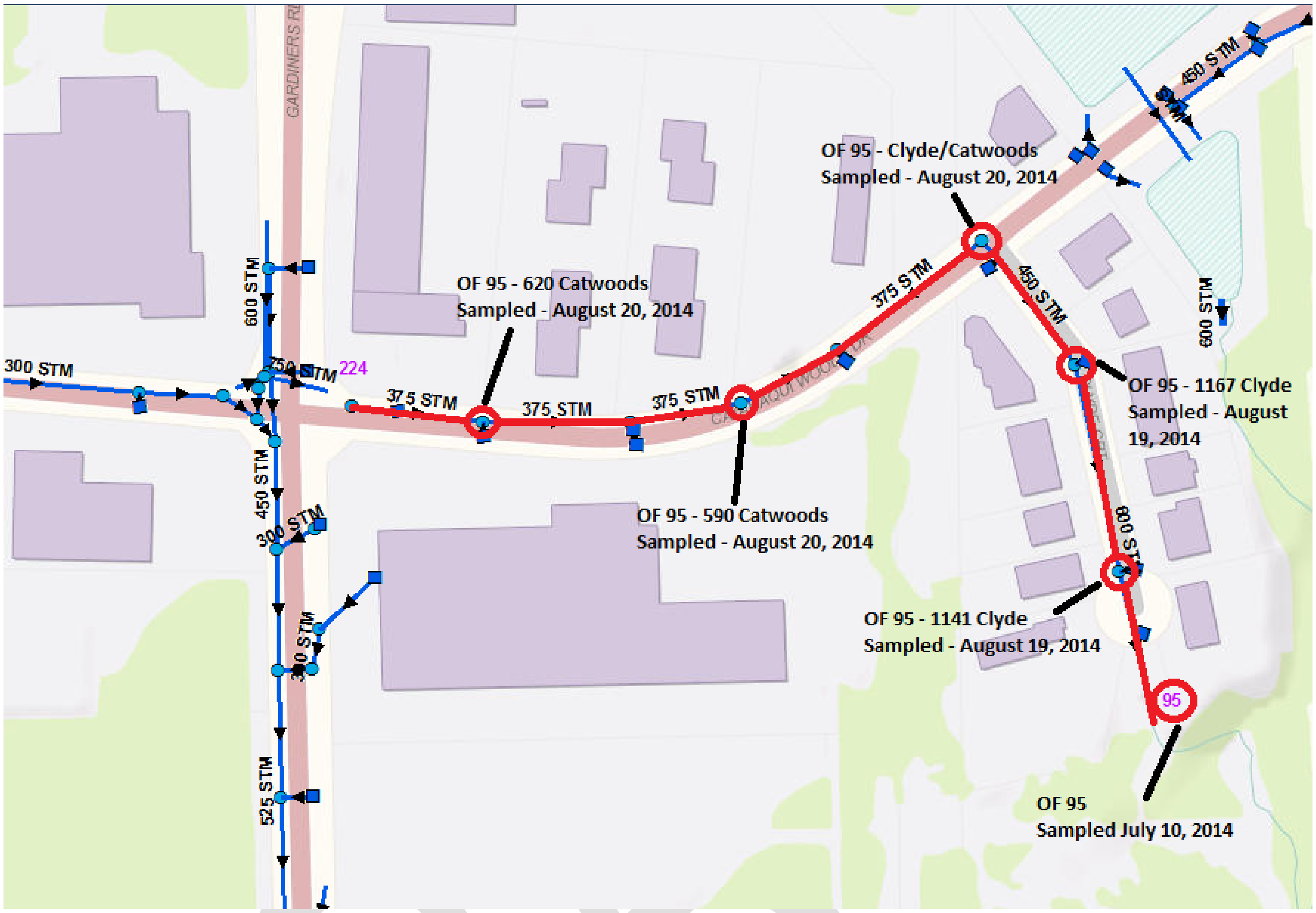

Figure 3: Map of Outfall 95

3.1.4 Outfall 100

A sample was not obtained for outfall 100 this year. The outfall empties into a pond but is enclosed by a metal cage. Water was observed flowing from the outfall but could not be sampled due to the cage. Two manholes on Katherine Crescent were visited and observed to be dry. The manholes on Woodbine Road were targeted in the sampling plan, but could not be located. The map of the system is shown in Figure 4.

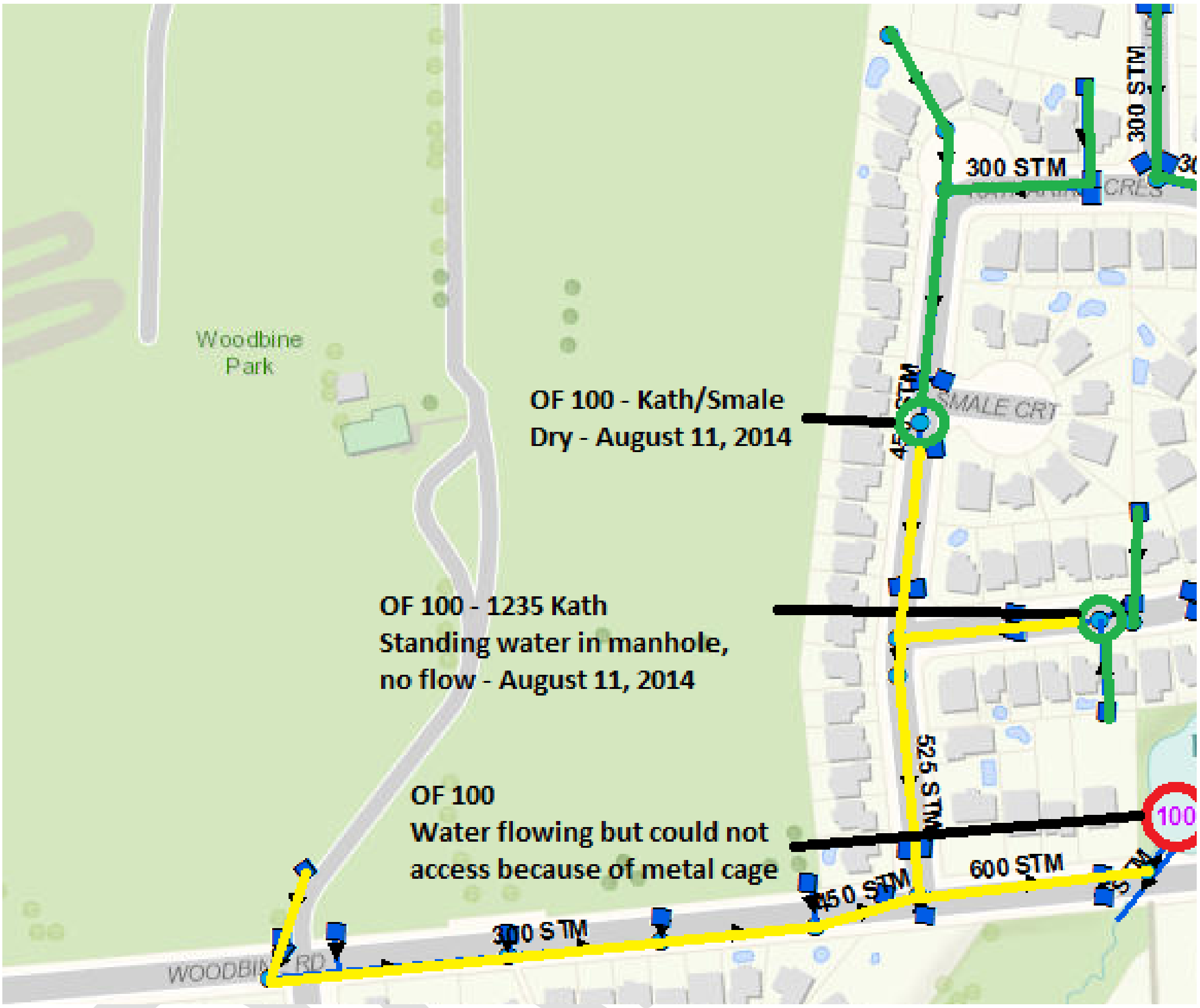

Figure 4: Map of Outfall 100

3.1.5 Outfall 101

The sample from outfall 101 returned from the lab with the second highest result for fecal coliforms. Six manholes from this storm sewer system were visited. The manhole sampled at the intersection of Wise Street and Woodbine Road in front of Holy Cross Secondary School exhibited a large increase in the amount of fecal coliforms from 138 CFU/100 mL at the manhole near the Woodbine Road and Newhall Drive intersection to 12700 CFU/100 mL. This indicates that a large problem exists between these two manholes with less of a problem existing past the manhole near the Woodbine Road and Newhall Drive intersection. Although the area past this intersection showed a lower level of fecal coliforms, it was still above the PWQO limit and is likely the source of a cross-connection and is therefore an area of concern. The map for outfall 101 is shown in Figure 5.

Figure 5: Map of Outfall 101

3.1.6 Outfall 102

The sample from this outfall had the third highest result for fecal coliforms. Between the manholes at 1177 and 1185 Katherine Crescent the amount of fecal coliforms jumped from 70 CFU/100 mL to 1000 CFU/100 mL. This indicates that a major cross-connection occurs between these two manholes. Although the area between 1177 and 1185 Katherine crescent is an area of concern, the entire storm sewer system from 1165 Katherine Crescent down to the outfall could be contributing contamination as the result of a cross connection. A map showing the locations sampled and visited is shown in Figure 6.

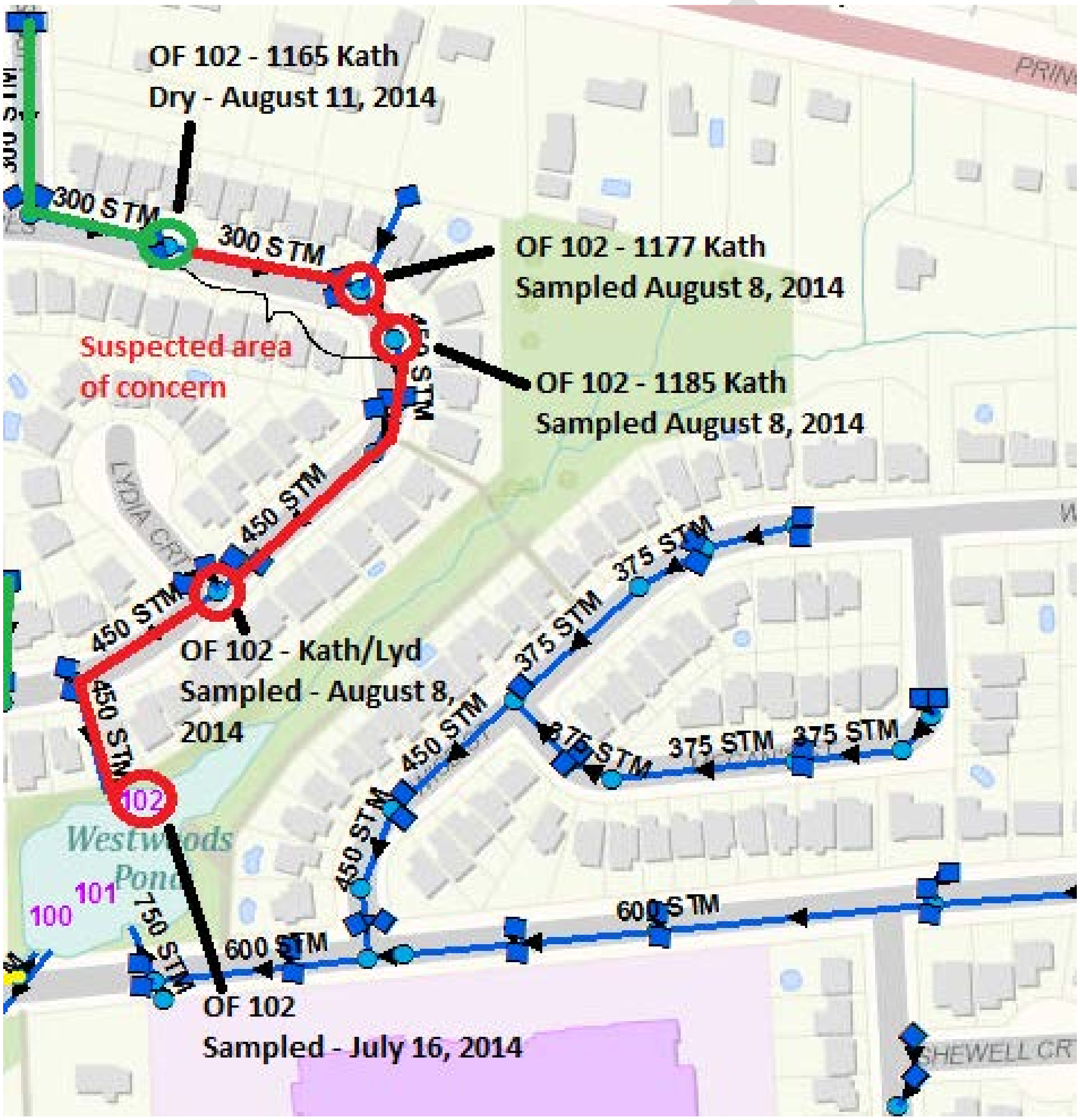

Figure 6: Map of Outfall 102

3.1.7 Outfall 249

Of the outfalls that were investigated in depth this year, outfall 249 had the largest storm sewer system. The results for the sample taken from the outfall exceeded PWQO limits for fecal coliforms; however, the samples taken from manholes during further investigation did not. A large part of this sewer system does not have data to make conclusions about if it is or is not a problem area. While locating manholes within this area, many were inaccessible because they were in the middle of the road or an intersection. As many locations as was possible were visited. The map of this system can be seen in Figure 7.

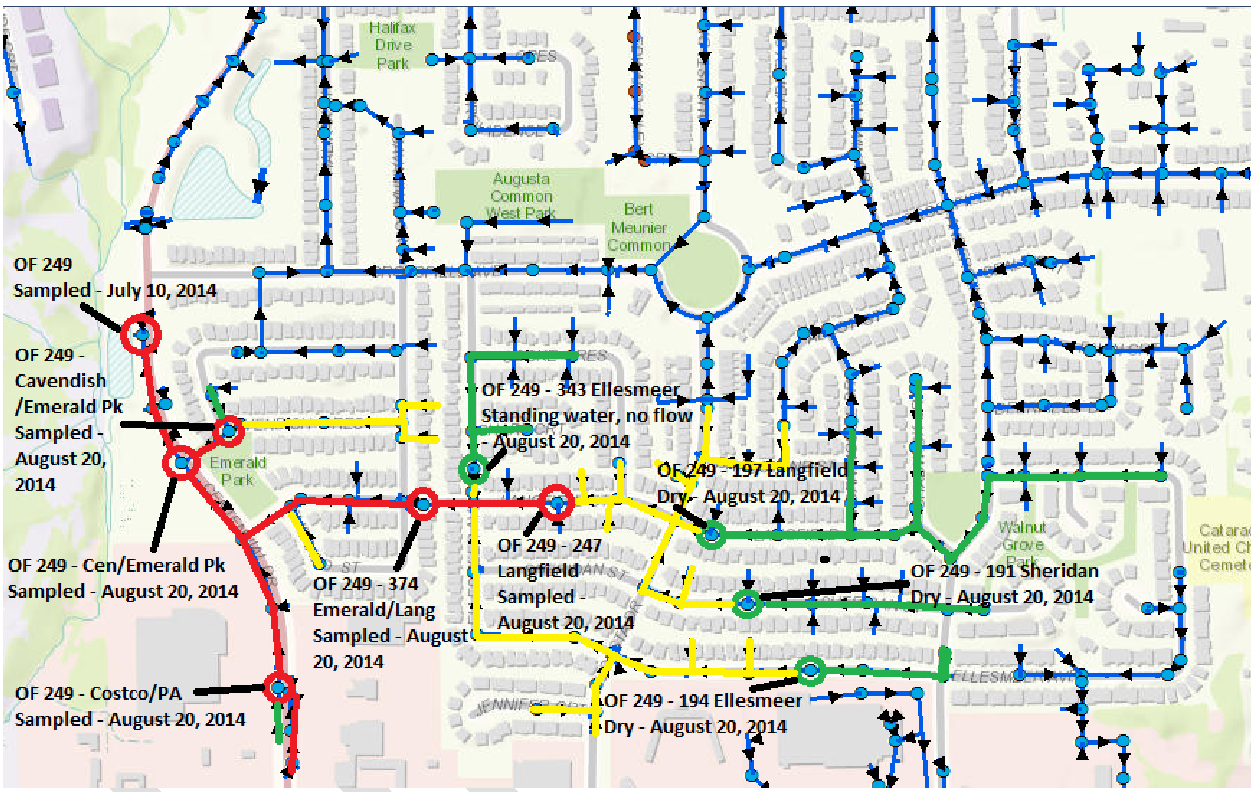

Figure 7: Map of Outfall 249

3.2 Outfalls Not Investigated With Multiple Locations

Eight of the fifteen outfalls sampled were not investigated further by visiting manholes and catch basins due to time restrictions. Maps for these outfalls can be viewed in Appendix B.

3.2.1 Outfalls 142 & 1470

Outfalls 142 and 1470 had the lowest amount of total and fecal coliforms. No fecal coliforms and 2 CFU/100 mL of total coliforms were detected for the outfall 142 sample and only 2 CFU/100 mL of fecal coliforms and 4 CFU/100mL of total coliforms were detected for the 1470 sample. These two samples also had the highest results for total and free chlorine. The high amounts of chlorine could account for the low amounts of total and fecal coliforms because the chlorine could have killed the bacteria.

These two outfalls are both located near city splash pads which could account for the high levels of chlorine. However, the water flowing from the outfall could also be the result of a cross-connection that cannot be identified based on these results because the chlorine could have killed the bacteria.

3.2.2 Outfalls 270 & 556

The samples from these two outfalls did exceed the PWQO limits for fecal coliforms. However, these two outfalls are not connected to a storm sewer system; they transport water between retention ponds. The fecal coliforms could have originated from the outfall storm sewer systems that empty into these retention ponds.

3.2.3 Outfall 28

The sample from outfall 28 exceeded the PWQO limit for fecal coliforms. This is likely the result of a cross-connection.

3.2.4 Outfalls 94, 162, & 552

The samples from these outfalls did not exceed the PWQO limit for fecal coliforms. The samples did exceed PWQO limits for several of the other parameters tested but did not have notably high or low results in any category.

4.0 Recommendations

4.1 Immediate Action

4.1.1 Outfalls 101 and 102

This autumn, storm sewer systems for outfalls 101 and 102 should be investigated using camera equipment as these two outfalls have been thoroughly investigated in the 2014 SWQSP by sampling manholes.

It is recommended that the investigation for outfall 101 should start at the end of the storm sewer system and continue all the way down to the outfall to identify cross-connections. The main area of concern for outfall 101 is between the manhole in front of Holy Cross Secondary School at the intersection of Woodbine Road and Wise Street and the manhole near the intersection of Woodbine Road and Newhall Drive.

The investigation for outfall 102 should begin at the manhole in front of 1165 Katherine Crescent and continue until the end of the system at the outfall to identify cross-connections. The area of concern is mainly between 1177 and 1185 Katherine Crescent.

These two areas of concern have been identified because of a large increase in fecal coliforms occurring from one manhole sampled to the next. Although these two identified areas contribute high amounts of fecal coliforms, other areas in the storm sewer system might also have cross-connections.

4.1.2 Outfall 95

Outfall 95 should be tested for more parameters (for example, metals) in each location that was sampled during the 2014 SWQSP. After the results are obtained from further testing, a camera investigation should also be conducted in this area. Although there are not high amounts of fecal coliforms in the water, this area is of high concern because it is an industrial/commercial area and might have other contaminants in the water. This area is also of concern because of the large volume of water passing through the storm sewer system.

4.2 2015 SWQSP

The 2015 Storm Water Quality Surveillance Program should focus more on identifying cross-connections rather than visiting new outfalls.

4.2.1 Outfalls of Concern

Outfalls of concern that were partially investigated this year and should be finished investigating in 2015 are:

- OF 17
- OF 93
- OF 100
- OF 249

Outfalls of concern that were not further investigated this year and should be investigated further in 2015 are:

- OF 28
- OF 94
- OF 142
- OF 162
- OF 270
- OF 552
- OF 556
- OF 1470

4.2.2 Accessing Inaccessible Manholes

Some outfalls have not been investigated further because the manholes are in areas of high traffic or the middle of a road or intersection, inaccessible because they are behind houses, or not able to be opened because the cover is bolted shut, broken, or paved over. During the first days of outfall sampling and further outfall investigation, manholes that cannot be accessed should be identified. After these manholes have been identified, additional help should be given to investigate these areas safely.

4.2.3 Start and End Sampling Earlier

Training should be done earlier in the summer in order for sampling to begin earlier. Sampling should start earlier so that more outfalls can be investigated further for cross-connections, and more outfalls can be identified for the 2016 SWQSP to investigate. Due to the observance of a 24 hour period without rain prior to sampling, many days were not suitable for sampling. There are many areas to sample and more time for sampling would be ideal.

It is also recommended that sampling end earlier. During the 2014 SWQSP, samples were collected until midway through the second last week of the summer. This required the samples to be rushed in order to obtain the results in time to write the report. The results were required to write the last two sections of the report, and not receiving the results until part way through the last week of the summer did not leave much time to finish the report. A more comprehensive report could be created if sampling ended during mid-August, leaving more time to dedicate to the report.

4.3 Equipment

4.3.1 Pole Sampler

The current pole sampler is broken. The part of the pole sampler that holds the transfer bottle is cracked where it screws on to the pole. This needs to be replaced because the bottle holder and transfer bottle could fall off during sampling. If the bottle holding part of the pole sampler is available for sale separately, just this part could be purchased as there is nothing wrong with the extending pole. If this part is not sold separately, a new pole sampler will need to be purchased.

4.3.2 Transfer Bottle

When further investigation storm sewer systems and sampling from manholes, the flow is sometimes very low. The current transfer bottles have an opening that is smaller than the bottle itself and is often too high from the bottom of the storm sewer to obtain any sample. If possible, bottles with a larger opening that would sit lower to the bottom of the storm sewer should be purchased for use in these situations.

4.4 Outfalls In Need Of Repair

Six outfalls and one catch basin were identifies as in need of repair during the 2014 SWQSP. A list of the outfalls and catch basin in need of repair can be seen in Table 2.

Table 2: Outfalls in Need of Repair

OF 24	Outfall pipe is cracked	
OF 95 – 590 Catwoods	Catch basin cover is cracked	
OF 104	Some holes in the outfall pipe	

OF 110	Is covered by dirt and grass	
OF 138	Metal grate detached and sitting downstream	N/A
OF 215	Opening of outfall completely blocked by concrete	
OF 503	Outfall pipe cracked	

Appendix A – Results

Table A 1: Sample Results

Sample ID	Date	pH	Conductivity (ms)	TDS (ppt)	Total Chlorine (mg/L)	Free Chlorine (mg/L)	Temperature (°C)	Total Coliforms (CFU/100mL)	Fecal Coliforms (CFU/100mL)	Ammonia (mg/L)
OF 17 - TL	July 22, 2014	8.02	1.00	0.50	0.04	0.17	18.5	NDOGT	NDOGT	0.11
OF 28	July 25, 2014	7.66	1.02	0.51	0.11	0.06	20.1	5000	146	0.11
OF 93	July 11, 2014	7.55	1.05	0.53	0.11	0.07	16.2	7000	180	0.08
OF 94	July 11, 2014	7.75	1.98	0.98	0.09	0.04	17.3	2200	94	0.08
OF 95	July 10, 2014	8.03	1.13	0.57	0.09	0.45	18.0	180	62	0.11
OF 95 - 1141 Clyde	August 19, 2014	7.50	0.89	0.44	0.17	0.22	17.1	1000	46	0.13
OF 95 - 1167 Clyde	August 19, 2014	7.61	0.89	0.44	0.29	0.24	17.4	1100	40	0.16
OF 95 - Clyde/Catwoods	August 20, 2014	7.41	1.02	0.51	0.15	0.25	15.8	2200	64	0.10
OF 95 - 590 Catwoods	August 20, 2014	7.02	0.93	0.47	0.13	0.14	16.9	1200	28	0.14
OF 95 - 620 Catwoods	August 20, 2014	7.06	0.97	0.49	0.23	0.12	16.6	600	34	0.15
OF 101	July 11, 2014	8.07	0.91	0.46	0.14	0.23	18.4	NDOGT	19600	0.13
OF 101 - Wise/Woodbine HCSS	August 7, 2014	8.42	1.10	0.54	0.24	0.11	22.1	NDOGT	12700	0.14
OF 101 - Woodbine/Newhall	August 19, 2014	7.72	1.07	0.56	0.26	0.17	19.0	1600	138	0.14
OF 101 - 989 Woodbine	August 19, 2014	7.13	0.98	0.49	0.29	0.15	19.3	2500	200	0.12

OF 102	July 16, 2014	8.28	1.31	0.66	0.06	0.04	19.1	7800	4200	0.12
OF 102 - Kath/Lyd	August 8, 2014	8.16	1.20	0.60	0.18	0.19	19.8	2000	1000	0.14
OF 102 - 1185 Kath	August 8, 2014	7.40	0.94	0.46	0.23	0.15	18.7	3000	1000	0.14
OF 102 - 1177 Kath	August 11, 2014	7.54	1.12	0.54	0.05	0.09	17.5	5300	70	0.15
Of 142	July 17, 2014	7.45	0.34	0.17	1.15	0.90	17.6	2	ND	0.12
OF 162	July 18, 2014	7.90	1.05	0.52	0.05	0.05	16.1	8000	60	0.13
OF 249	July 10, 2014	7.46	1.03	0.52	0.04	0.00	17.8	5200	292	0.11
OF 249 - Cen/Emerald Pk	August 20, 2014	7.57	1.04	0.52	0.05	0.14	18.6	2300	46	0.36
OF 249 - Cavendish/Emerald Pk	August 20, 2014	7.71	1.04	0.52	0.10	0.14	18.7	3200	62	0.17
OF 249 - 374 Emerald/Lang	August 20, 2014	7.36	1.07	0.53	0.06	0.15	18.4	2200	64	0.11
OF 249 - 247 Langfield	August 20, 2014	7.19	1.03	0.51	0.06	0.08	17.8	3100	90	0.16
OF 270	July 22, 2014	7.52	0.99	0.55	0.17	0.03	25.7	NDOGT	234	0.34
OF 552	July 21, 2014	7.19	1.12	0.56	0.06	0.07	17.1	9700	10	0.16
OF 556	July 10, 2014	7.36	0.83	0.42	0.19	0.29	21.1	2800	248	0.22
OF 1470	July 17, 2014	7.50	0.64	0.33	0.47	0.32	17.9	4	2	0.13

CFU - Colony forming units
ND - Not detected

NDOGT - No data, overgrown with target
Exceeds PWQO limits

Appendix B – Maps for Outfalls Not Investigated With Multiple Locations

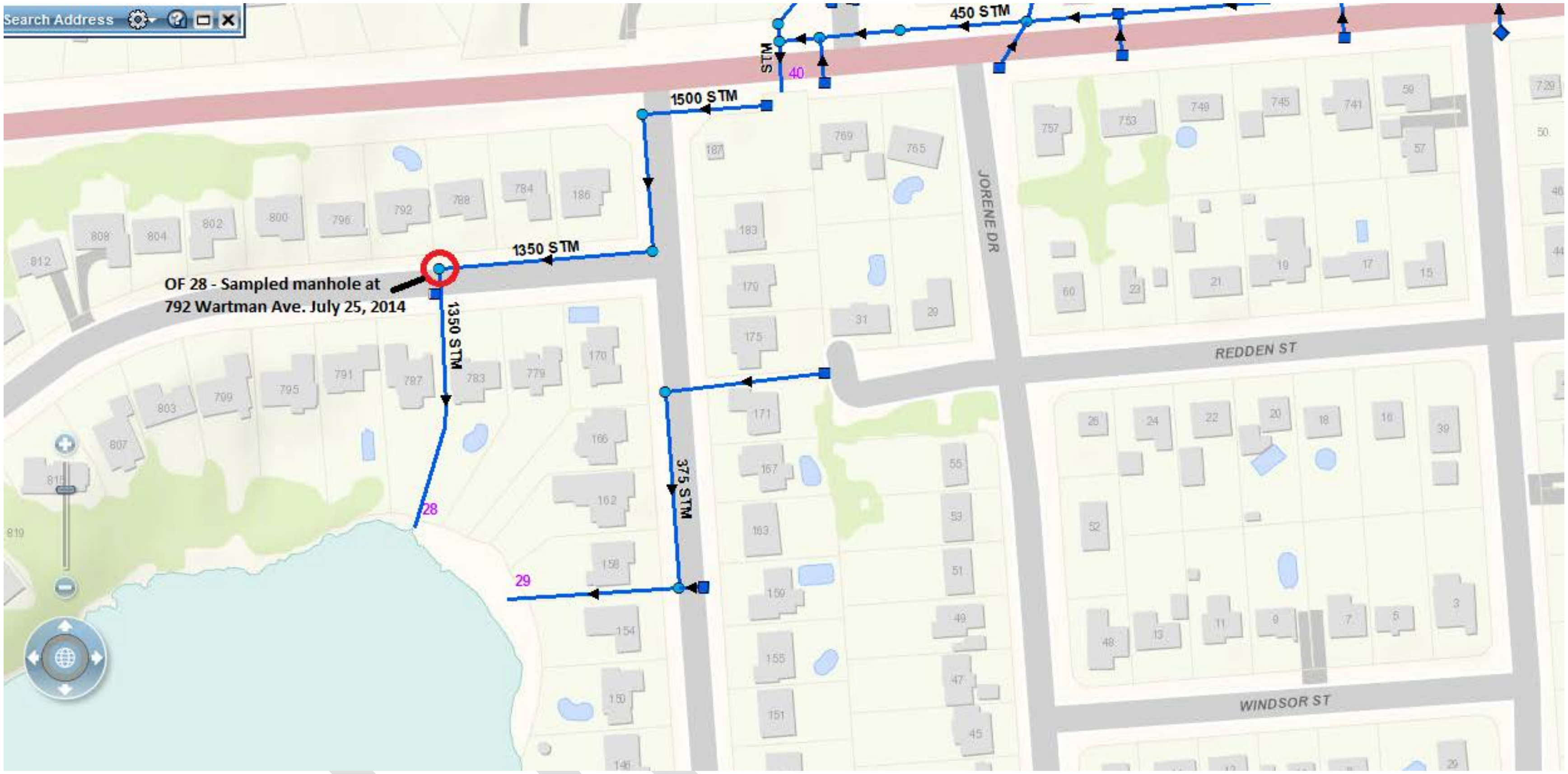

Figure B 1: Map of Outfall 28

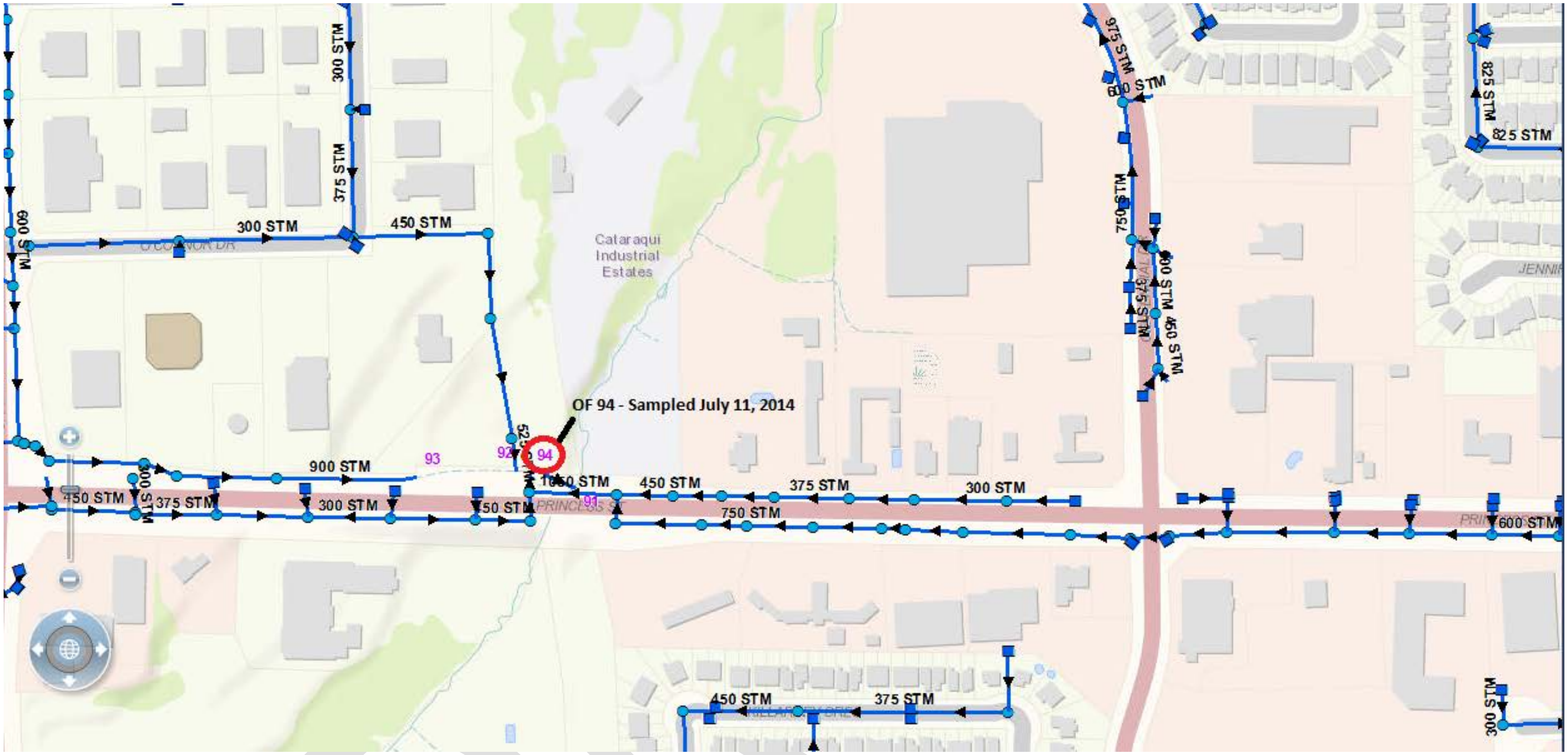

Figure B 2: Map of Outfall 94

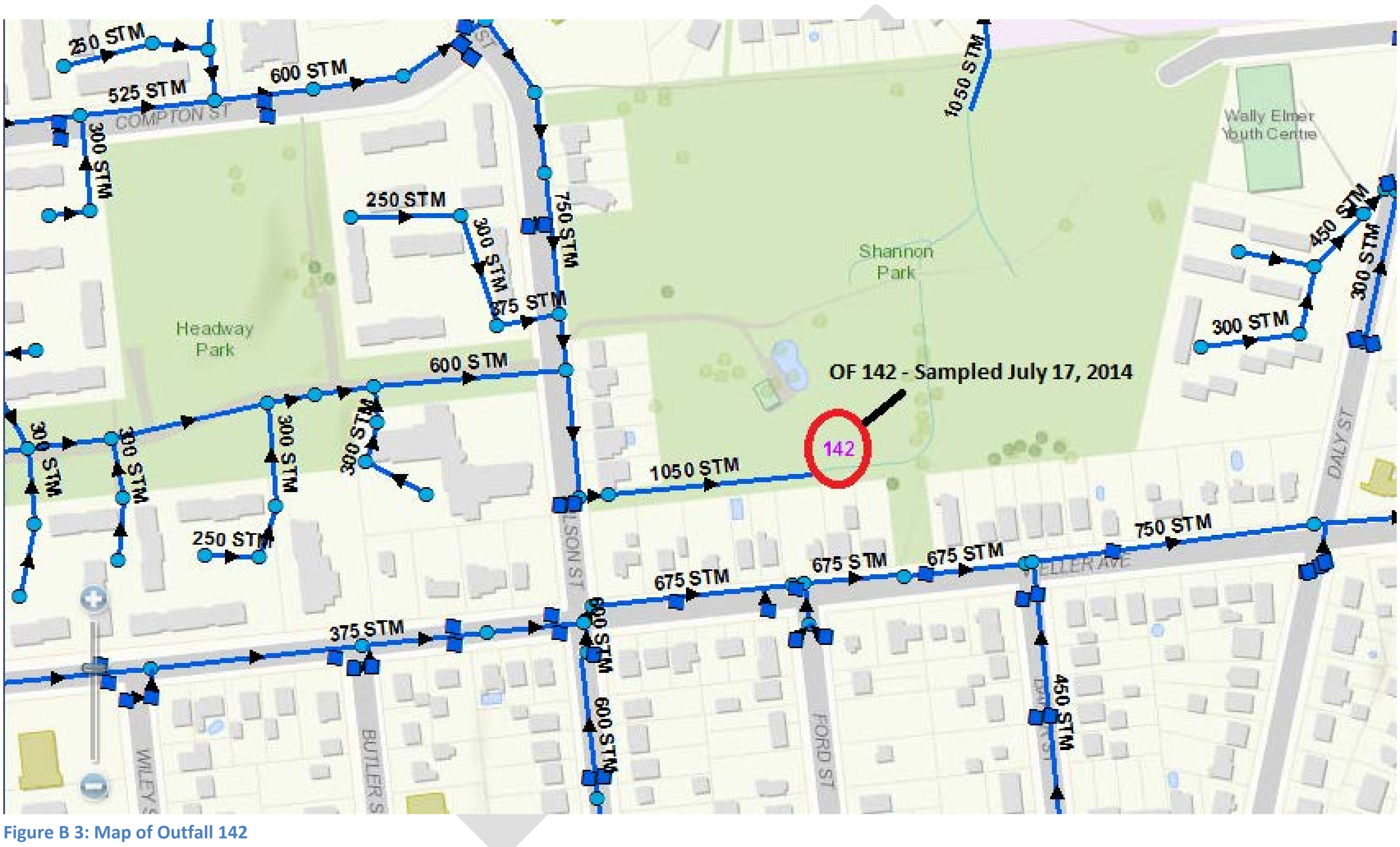

Figure B 3: Map of Outfall 142

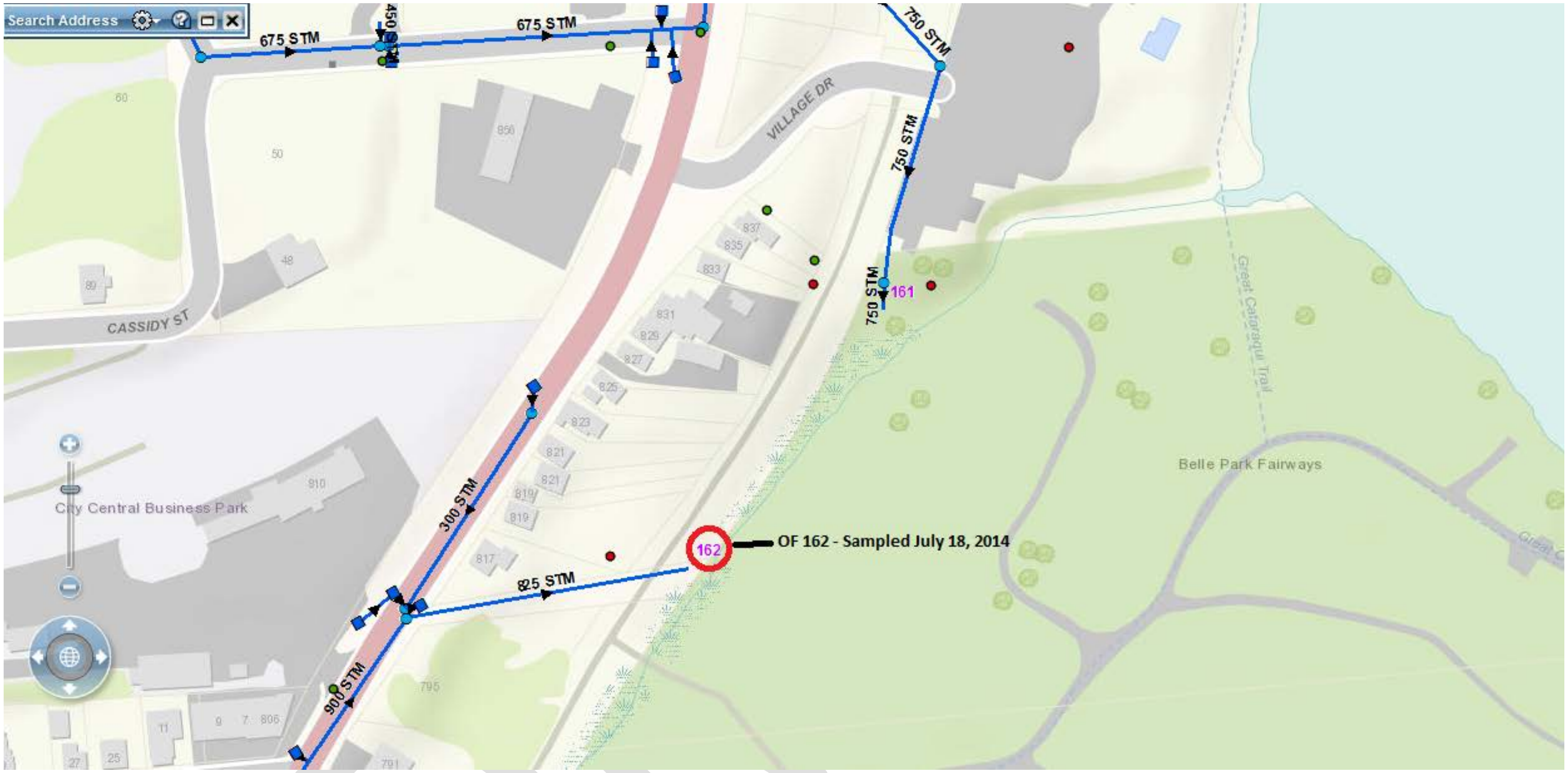

Figure B 4: Map of Outfall 162

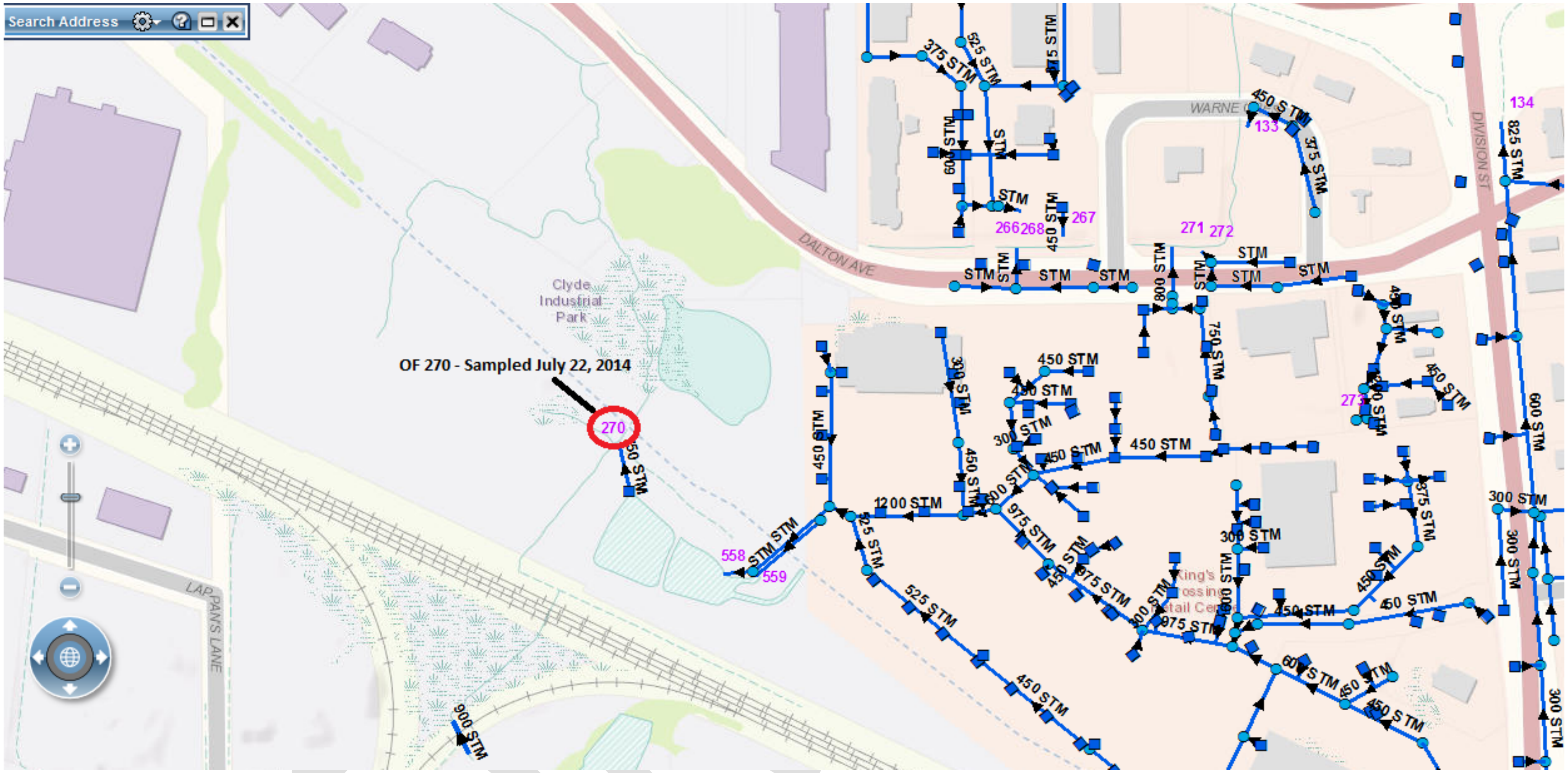

Figure B 5: Map of Outfall 270

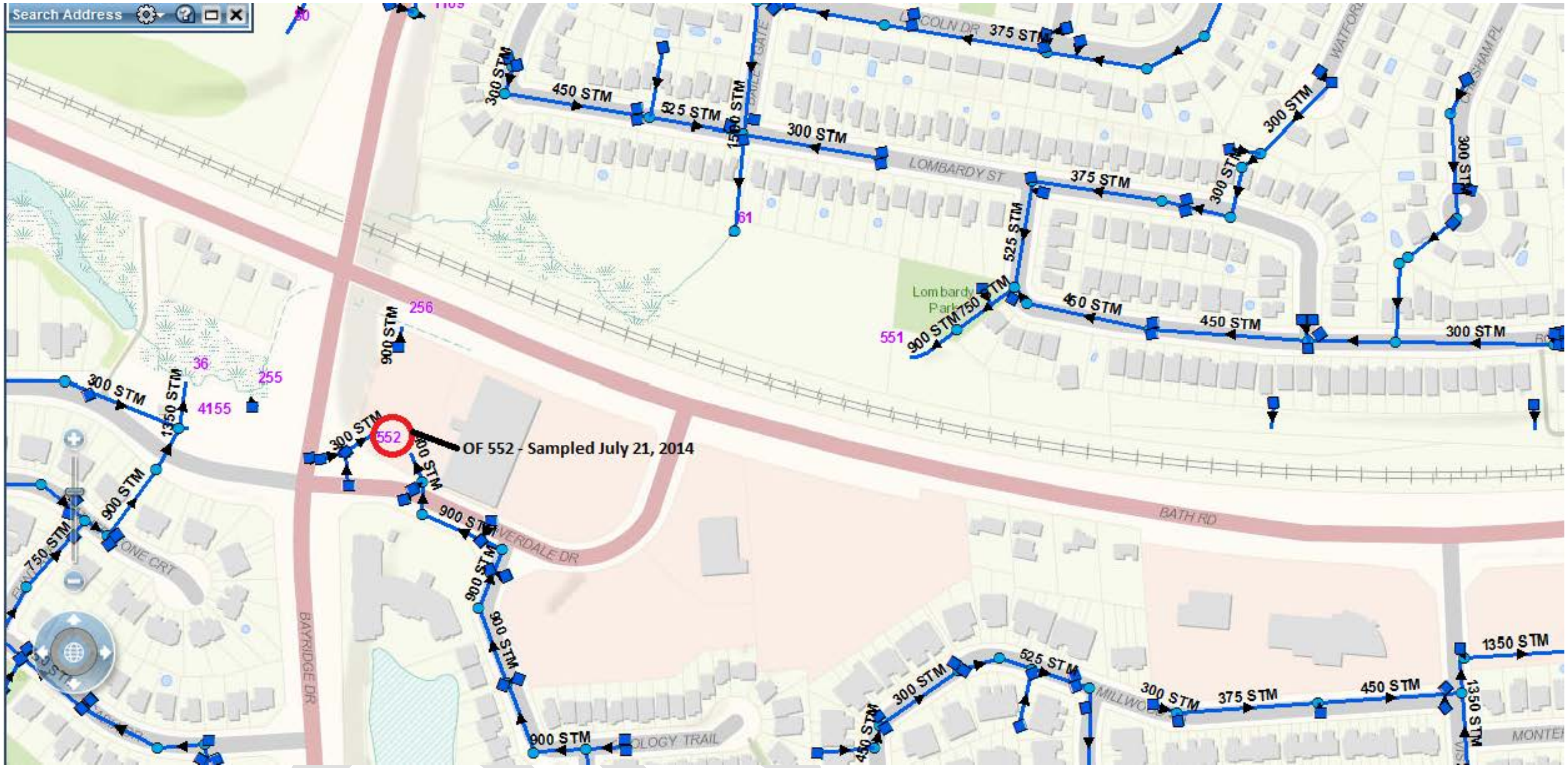

Figure B 6: Map of Outfall 552

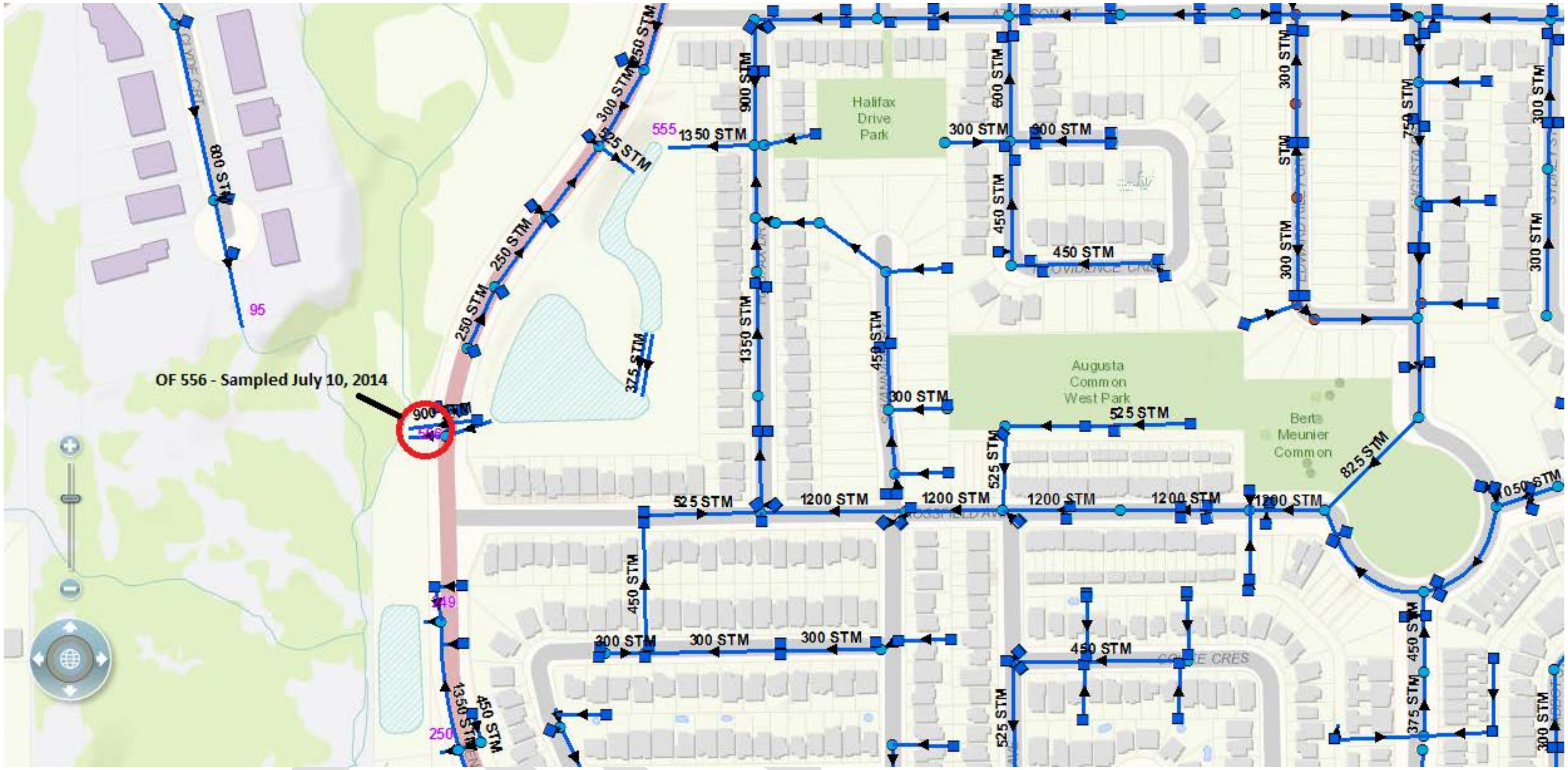

Figure B 7: Map of Outfall 556

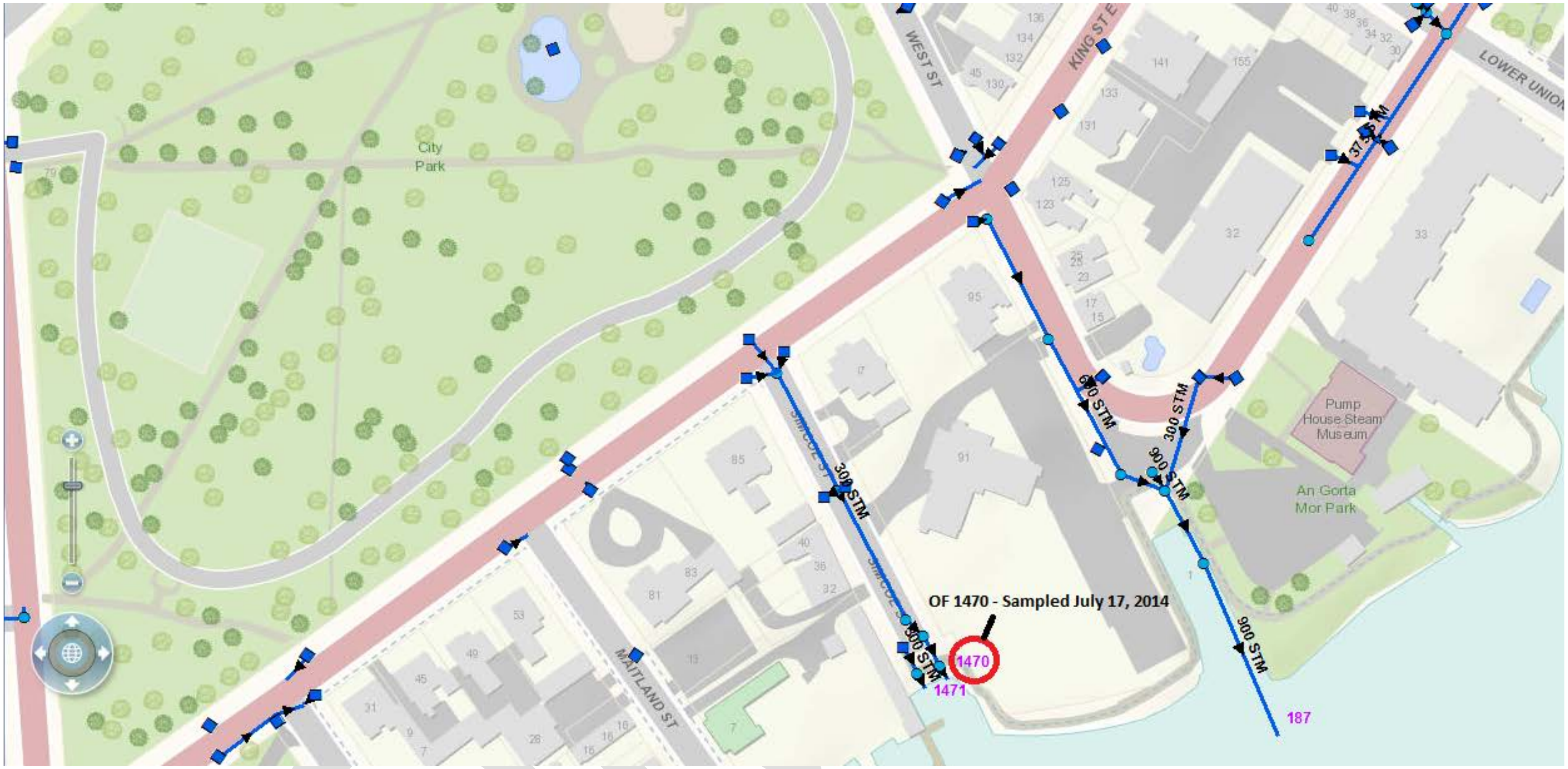

Figure B 8: Map of Outfall 1470

Appendix C – Field Notes

City of Kingston – Environment & Sustainable Initiatives Department

Storm Water Quality Surveillance Program 2015

Prepared By: Stephanie Wright and Don Lougheed

2015

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1.0 Introduction

1.1 Background Information

The City of Kingston's Environment & Sustainable Initiatives Division conducts the Storm Water Quality Surveillance Program (SWQSP) each year. The SWQSP began in 2003 with the purpose of sampling outfalls and storm water systems to identify sub-standard storm water systems and cross-connections with sanitary sewers. The program also aims to identify outfalls of concern and outfalls in need of repair in order to provide the City of Kingston with recommendations for further action.

1.2 Scope

The scope of the 2015 SWQSP was limited to storm sewer systems owned and maintained by the City of Kingston. Additionally, only storm sewers in lower traffic areas were accessed to ensure the safety of the individuals sampling. Samples were tested in the field for pH, conductivity, total dissolved solids (TDS), and temperature using a multi-parameter water meter, and each sample was tested for total and free chlorine using a colorimeter. Samples were analyzed for Total and Fecal Coliform counts by AGAT Laboratories. The focus of this year's program was to identify specific areas of cross connection so that Utilities Kingston could be alerted to the issues.

2.0 Methodology

2.1 Outfall Planning and Locating

Several outfalls were identified in past SWQSP report as problem areas and these were prioritized for visit this year. Maps were utilized from these reports, or generated with the help of KingMaps (WebGIS), to aid in locating the outfalls in the field.

2.2 Outfall Sampling

A minimum period of 24 hours without rain was observed prior to visiting outfalls. The dry period ensures that water sampled is the result of cross-connection rather than storm water working its way through the storm system. Manholes were accessed and closed with the use of a pickaxe. Occasionally it was necessary to remove excess asphalt or other debris from the edge to enable lifting.

A telescoping pole sampler with an attached transfer bottle was used to collect samples from flowing outfalls or manholes. If the outfall was submerged, obstructed, or otherwise inaccessible manholes immediately upstream of the outfall were opened and sampled.

Steady flow conditions were required in order to sample. In some instances flow was present and constant, but the water level was too low for the transfer bottle to be submerged past the opening lip. In these circumstances, the transfer bottle was modified by cutting a rectangular hole in the outer rim of the bottle, enabling much lower levels of flow to enter. An example of the modifications made can be found in Appendix B. Care was taken when using this technique to ensure that no sediment from the chamber was introduced to the sample.

After a sample was obtained it was analyzed for pH, conductivity, TDS, and temperature with a Hanna 991301 multiparameter meter. The probe was rinsed and stored with de-ionized (DI) water between each use.

Chlorine levels were measured with a Hach Pocket colorimeter ii. Designated 10 mL sample cells were used for Total and Free chlorine measurements to ensure consistency between measurements. Each cell was thoroughly rinsed with the sample before each measurement, and rinsed with DI water between each use. Care was taken to ensure proper resting times for samples upon addition of reagent. For free chlorine measurements this was <1 min, and for total chlorine measurements this was at least 3 minutes. The exterior of the sample cells were thoroughly dried with a soft cloth before insertion into the colorimeter.

Bottles from AGAT Laboratories were filled with sample in order to analyze for total and fecal coliforms. A 200 mL sample was transferred to the 250 mL plastic coliform bottle containing a preservative ($Na_2S_2O_3$). The bottles were then placed in a cooler with ice packs until they were delivered to AGAT Laboratories at the end of the day.

The transfer bottle(s) that were used to collect the samples were emptied of any remaining sample, and then rinsed with DI water to prevent cross-contamination between samples.

2.3 Safety Procedures

Necessary safety measures were used at all times while in the field. CSA approved steel toed boots and long pants were worn at all times to ensure worker safety. Nitrile gloves were used at all times while sampling to preserve the integrity of all samples and to protect the skin of the person sampling from coming into contact with the contents of the samples. If working on or near a roadway, high visibility safety vests were worn and pylons, four way hazard lights, and the roof mounted light bar on the vehicle were used. When working near water, life preservers were worn and a throw rope was brought to the sampling area. Sampling was never conducted alone.

3.0 Results

The laboratory results for each sample can be found in Appendix A. These results were then compared to the Provincial Water Quality Objectives (PWQO). The PWQO limits for the selected parameters can be seen in Table 1. Results that exceeded the PWQO regulations were highlighted. The amount of fecal coliforms is a better indication of cross-connections than the amount of total coliforms because total coliforms can originate from other sources such as wetlands and cannot conclusively identify cross connections.

Table 1: PWQO limits

Parameter	PWQO limit
Total Coliforms	1000 CFU/100mL
Fecal Coliforms	100 CFU/100mL
Total Chlorine	0.05 mg/L
Free Chlorine	0.05 mg/L
pH	6.5-8.5

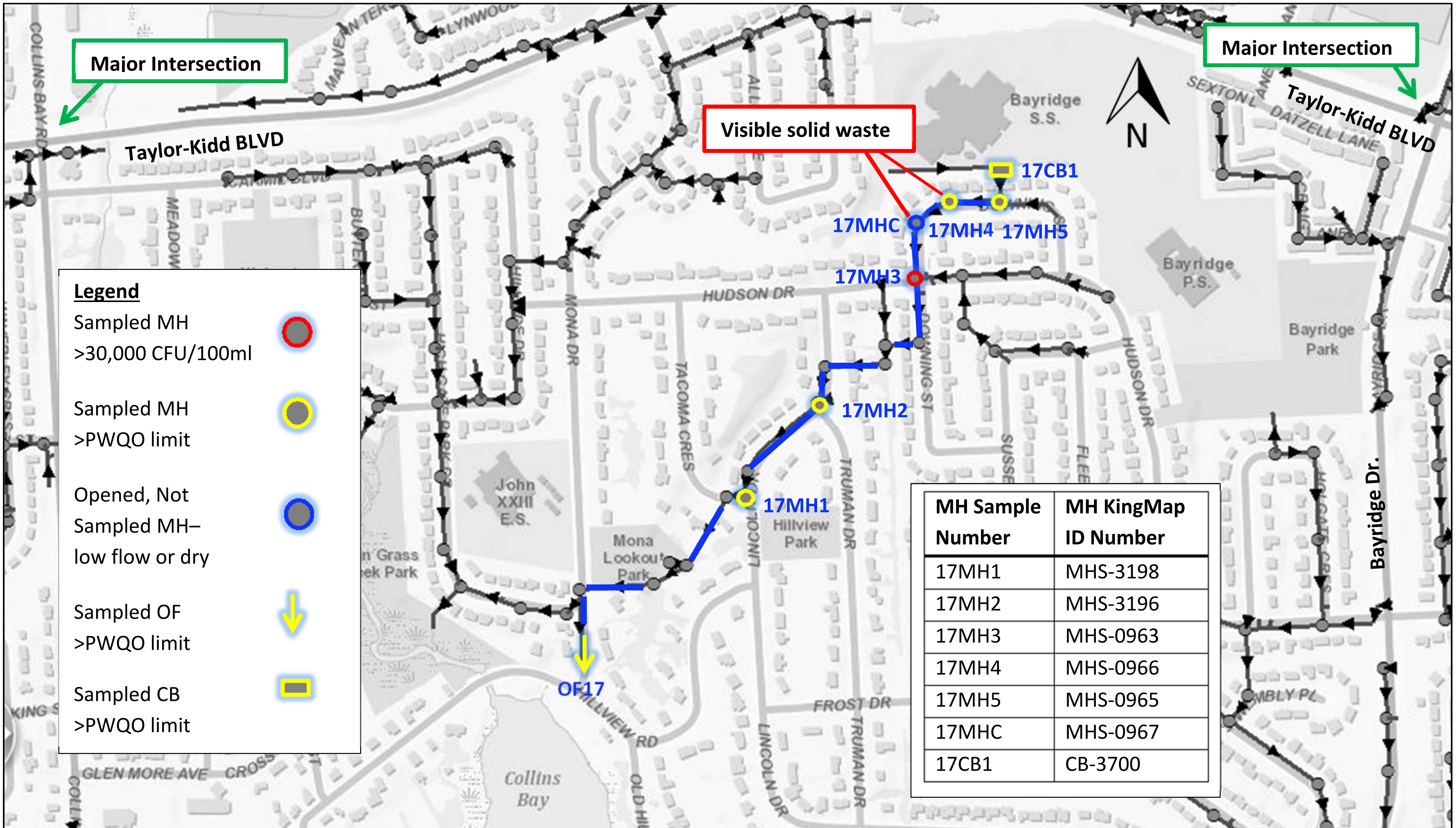
CFU/100mL – Colony forming units per 100 mL

3.1 Outfall 17

Data from past years sampling programs identified Outfall 17 as a potential problem area. An outfall sample taken at OF-17 detected elevated levels of total and fecal coliforms (9600 and 6800 CFU/100 mL, respectively) (see Table 2 in Appendix A). During sampling along Downing Street, upstream of OF-17, immediately north of the west intersection with Hudson Drive, solid waste was observed within the storm system manhole basin. The coliform counts from these manholes displayed a significant increase from the levels observed at the outfall. The numbers for 15-17MH3 were particularly high; at 49000 and 32000 CFU/100 mL for total and fecal counts, respectively, they represented the highest coliform levels observed by this year's sampling program. It is believed that the presence of solid waste, along with the elevated fecal coliform counts downstream of it, indicate a potential cross-connection between the storm and sanitary systems in this area. A map has been attached (Fig. 3) that details the locations of the manholes accessed, and photographs of each basin displaying the observed solid waste have been included (Fig. 1-2). Upon inspection, solid waste was observed in the chambers of manholes C and 4 (15-17MHC and 15-17MH4), and a strong fecal odor was noted. Waste was not observed in manhole 5 (15-17MH5) immediately upstream of MH4. It is believed that this evidence warrants further investigation to confirm the cross connection.

Figure 1: Visible Solid waste in 17MHC

Figure 2: Visible Solid Waste in 17MH4



MH Sample Number	MH KingMap ID Number
17MH1	MHS-3198
17MH2	MHS-3196
17MH3	MHS-0963
17MH4	MHS-0966
17MH5	MHS-0965
17MHC	MHS-0967
17CB1	CB-3700

Figure 3: Overview of OF17 Storm Water System Sampling

3.2 Outfall 28

Work completed in previous years identified OF-28 as a potential area of cross connection due to elevated levels of total and fecal coliforms in a sample taken from a manhole immediately upstream from the outfall (See Table 3). A second sample, taken from the same manhole this year, confirmed that there are elevated levels of total and fecal coliforms present. Manholes upstream, along Chelsea Road, were opened and sampled in an attempt to constrain the source of the contamination. A map of the area and the manholes opened can be seen in Figure 6. Solid waste was observed near the north end of the line, in two separate locations. Photos of the waste are included in Figures 4 and 5. Manholes were opened on several side streets that feed into the central Chelsea Road line, though many were dry at the time of sampling and as such were not sampled. One sample was obtained from a manhole on Chelsea Street, immediately East of Chelsea Road. The sample showed high levels of both total and fecal coliforms (9000 and 2700 CFU/100mL respectively). This area could contain multiple cross connections, and further investigation will be necessary to constrain the sources.

Figure 4: 350 Chelsea Rd – Solid waste visible in manhole

Figure 5: 373 Chelsea Rd – Solid waste visible in manhole

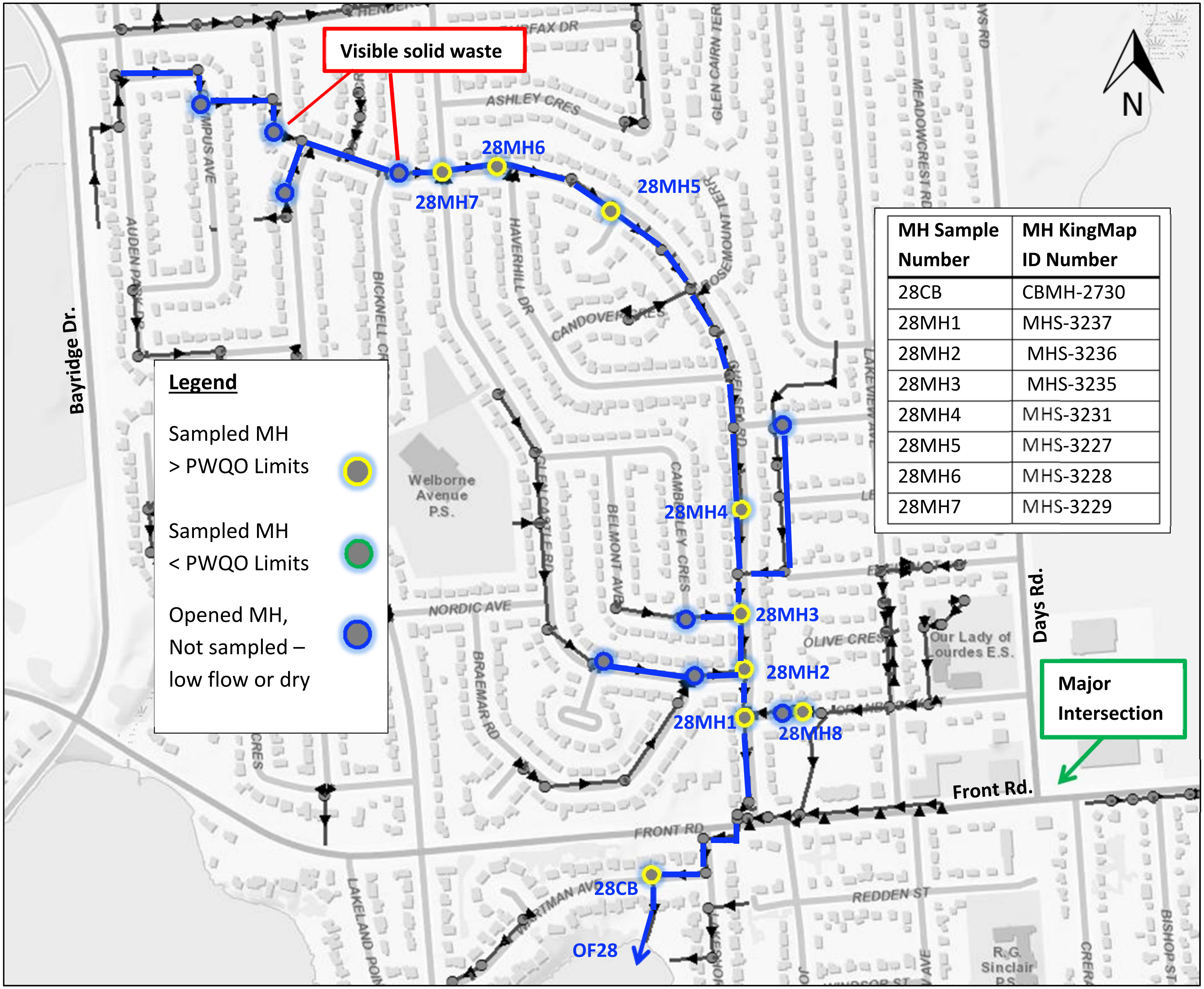
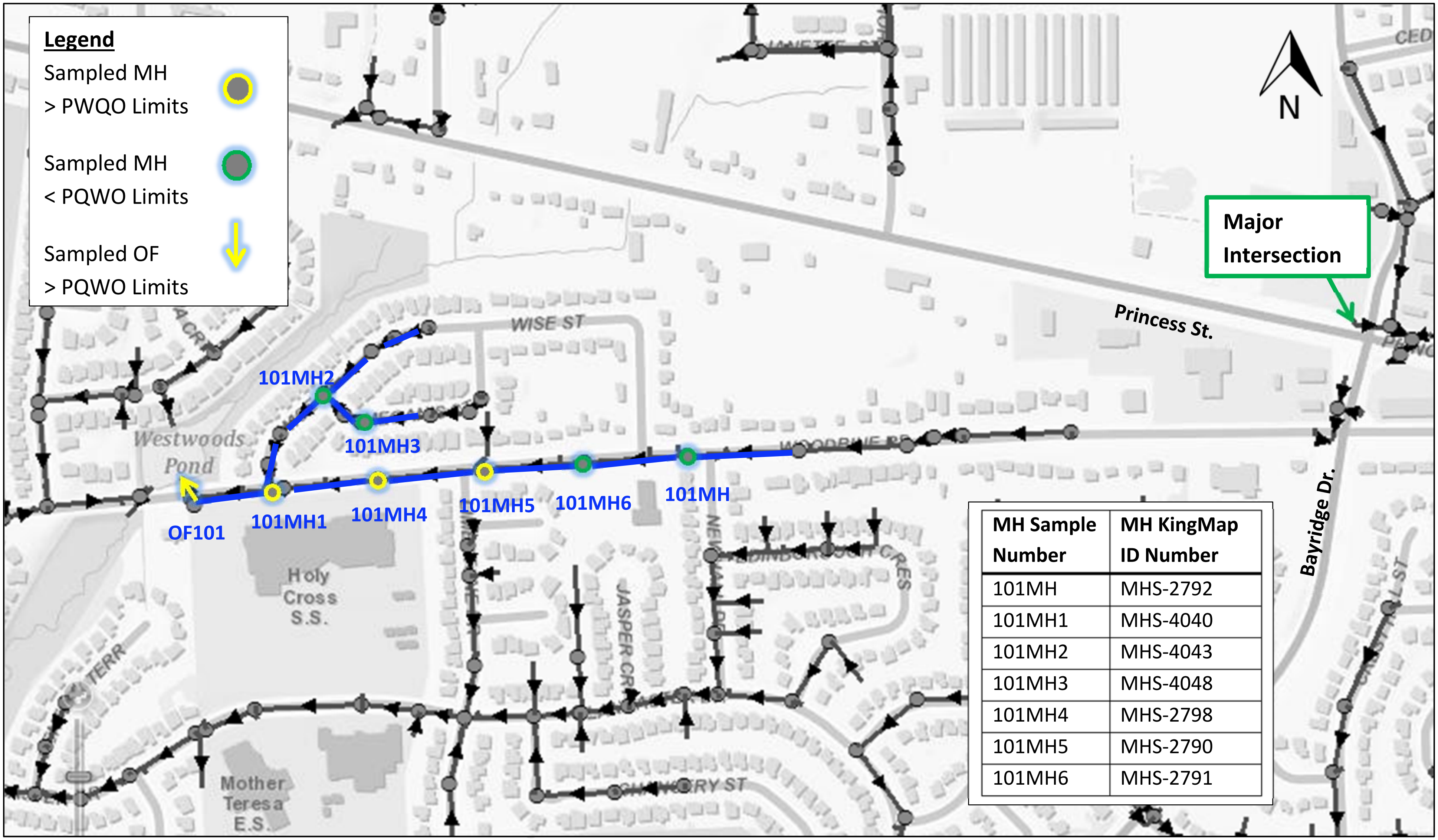


Figure 6: Overview of OF-28 Storm Water System Sampling

3.3 Outfall 101

Work completed in previous years identified Outfall 101 as a potential area of cross connection. An outfall sample taken at OF-101 detected elevated levels of total and fecal coliforms (4000 and 360 CFU/100 mL, respectively). Further sampling upstream of the outfall, to the east along Woodbine Road, constrained the problem area further. Samples taken from a connecting system to the north of Woodbine along Wise Street did not display problematic levels of coliforms, and the heightened levels eventually diminished to acceptable levels along Woodbine to the east. 15-101MH5 appears to be the extent of the cross connected area, with the fecal coliform counts dropping to acceptable levels upon reaching 15-101MH6 (130 CFU/100mL for MH5, compared to 60 CFU/100 mL for MH6). This limits the area for cross connection to the stretch of Woodbine road starting at outfall 101 and terminating between manholes 5 and 6 to the east. Data has been compiled into a map highlighting problem areas (Fig. 7) and in Table 4 found in Appendix A. The area of cross-connection has been confined to an area small enough to warrant further and more thorough investigation.

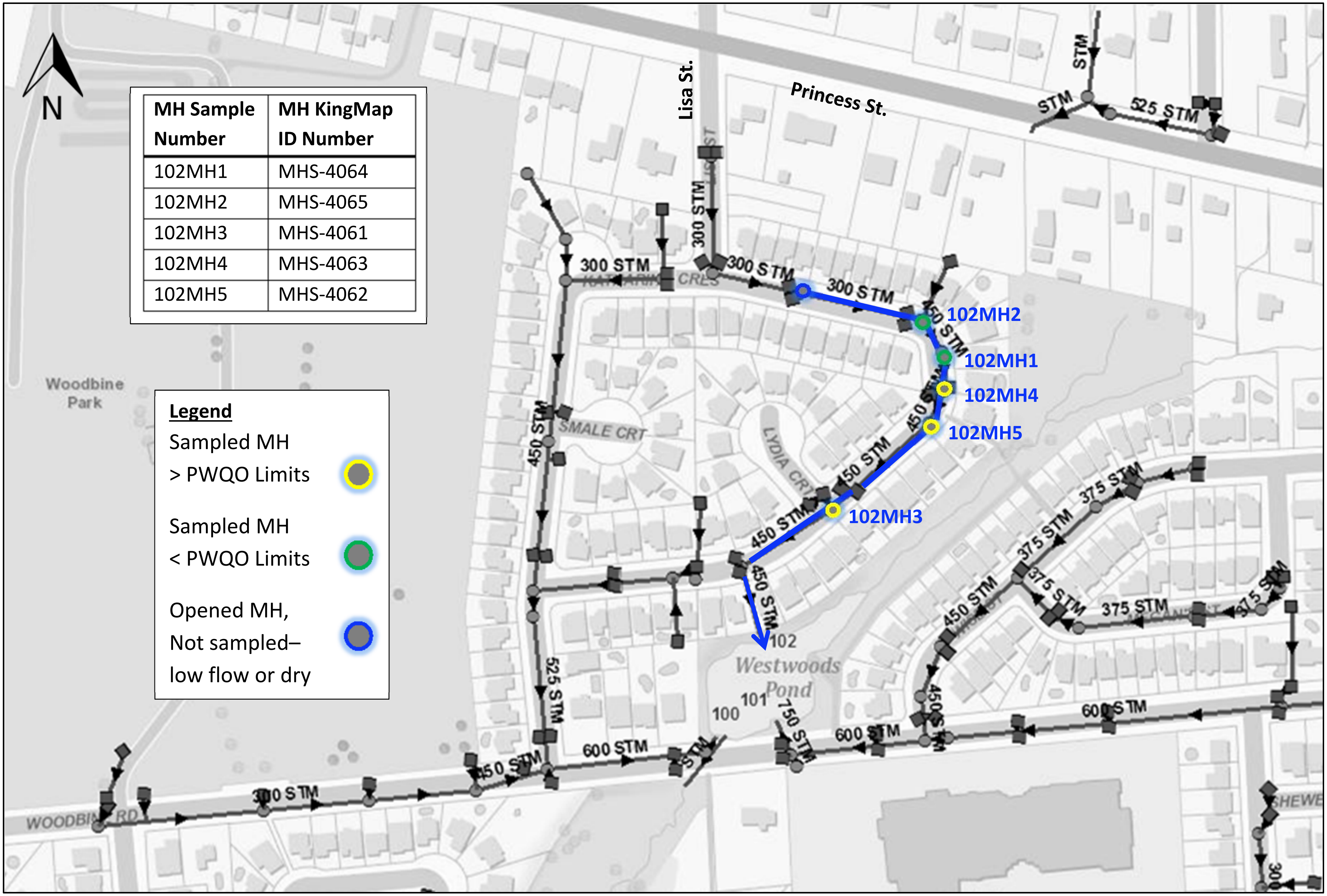


MH Sample Number	MH KingMap ID Number
101MH	MHS-2792
101MH1	MHS-4040
101MH2	MHS-4043
101MH3	MHS-4048
101MH4	MHS-2798
101MH5	MHS-2790
101MH6	MHS-2791

Figure 7: Overview of OF101 Storm Water System Sampling

3.4 Outfall 102

Work completed in previous years identified OF-102 as a potential area of cross connection due to elevated levels of total and fecal coliforms in a sample taken from the outfall. In 2014, total and fecal counts were measured at 7800 and 4200 CFU/100 mL, respectively. Upon inspection this year a sample was not obtained from the outfall as it was submerged in the pond it empties into. Instead, manholes upstream of the outfall along Katharine Crescent were opened and sampled. The data from this sampling has been compiled in Table 5 found in Appendix A. Three manholes were accessed and sampled before flow terminated. The results show a jump in fecal coliforms between two of the manholes, 15-102MH1 and 15-102MH3. The fecal count jumps from 18 to 680 CFU/100 mL in this area, which indicates a potential cross-connection. A map has been attached (Fig. 8) that details the locations of the manholes accessed. It is believed that this evidence warrants further investigation to confirm the cross connection.



MH Sample Number	MH KingMap ID Number
102MH1	MHS-4064
102MH2	MHS-4065
102MH3	MHS-4061
102MH4	MHS-4063
102MH5	MHS-4062

Figure 8: Overview of OF102 Storm Water System Sampling

3.5 Outfalls 142 & 1470

These two outfalls are each located in very close proximity to city splash pads. Both displayed very high volumes of flow, and samples analyzed on site displayed high levels of both total and free chlorine. Outfall 142 had total and free chlorine levels of 1.29 and 0.92 mg/L, respectively. For the same parameters, outfall 1470 displayed levels of 1.26 and 0.87 mg/L. For each sample an odor was noted as being very similar to that of tap water. In addition to the elevated chlorine levels, the temperature of the samples was also quite high (>20°C). These numbers suggest that the areas warrant further consideration in the future.

3.6 Outfalls 249, 552 & 556

These outfalls were recommended by the 2014 sampling program for further investigation. All outfalls have values for fecal coliforms less than the PWQO limits. The results for these outfalls can be found in Table 6 found in Appendix A. The levels of total coliforms did exceed PWQO limits. The cause of such high values in 249 and 556 are likely due to the system being connected to retention ponds. The lack of high fecal coliform levels, combined with the presence of likely sources of total coliforms, suggests that cross connections are likely not present in these areas.

4.0 Recommendations

4.1 Immediate Action

Outfalls 17, 28, 101 and 102 require further action to identify exact sources of cross connection. More accurate methods will need to be employed to further constrain the problem areas, likely involving cooperation with Utilities Kingston. Notifying Utilities Kingston of this report's findings is the first step in this process.

It is recommended that the OF-28 storm network be further investigated upstream from where the solid waste was identified. Due to low flow or dry conditions, an exact source of the cross contamination could not be located. All manholes upstream from 28MH7 should be reopened and a sample should be obtained. As well, the system to the east along Cranbrook Street should be investigated more thoroughly to constrain the source of the elevated coliform counts observed in sample 15-28MH8-01.

The storm system for outfall 93 and 94 should also be further investigated. This outfall was recommended for further investigation by previous year's sampling programs due to high fecal coliform values. This year, OF-94 was above the PWQO limits slightly, but OF-93 had levels less than the PWQO limits. It is possible these low values were due to the time at which the samples were obtained and should be confirmed or denied by another round of sampling.

This year, the problem areas that were identified by previous years were all further investigated. It is recommended that the 2016 sampling program look at areas of Kingston that have not been sampled within the last 5-10 years. Since the majority of the problem areas identified in this report are subdivisions in the West End of Kingston, off Bayridge Drive, this area could warrant further examination.

4.2 Equipment

One of the sample cells for the pocket colorimeter was broken while in use. It is recommended that caution be used while handling the second sample cell and place an order for a new one.

4.3 Outfall and Manholes In Need Of Repair

Three manholes and one outfall were found to be in need of repair and cleaning and can be found below in figures 9 through 12.

Figure 9: 15-102MH3-1 – Lydia Crt. and Katherine Street – Wood debris

Figure 10: OF 249 – Garbage and Debris Clogging Outfall

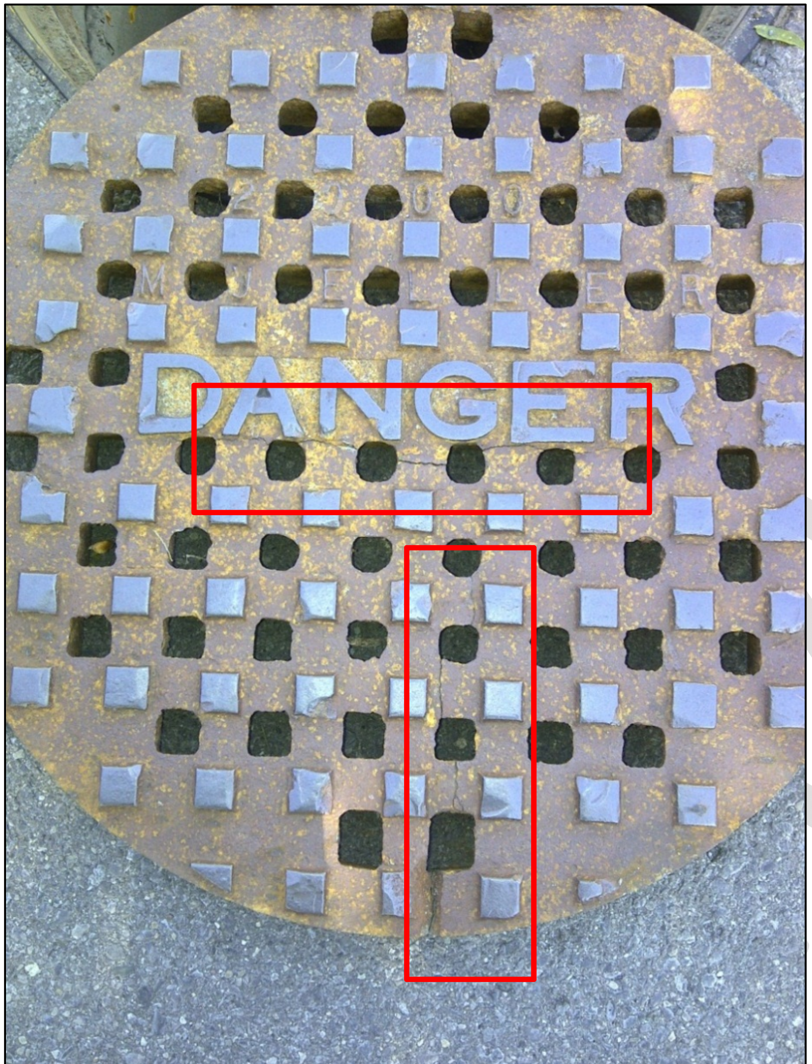


Figure 11: 15-102MH5-1 – 1191 Katherine Street – Cracked Manhole Cover

Figure 12: Manhole in Front of 305 Olympus – Brick Debris

Appendix A – Results

Table 2: Sample Results for OF17 Storm System

Sample ID	Date	pH	Conductivity (ms)	TDS (ppt)	Temp (°C)	Total Chlorine (mg/L)	Free Chlorine (mg/L)	Total Coliforms (CFU/100mL)	Fecal Coliforms (CFU/100mL)	Description
2015-17-01	07/06/15	7.64	1.00	0.49	17.70	0.02	0.01	9600	6800	Clear, no odor
15-17MH1-01	07/16/15	7.45	1.30	0.64	18.30	0.06	0.01	14000	5300	Clear, no odor
15-17MH2-01	07/16/15	7.55	1.04	0.51	17.30	0.05	0.01	15000	5500	Clear, no odor
15-17MH3-01	07/16/15	NA	NA	NA	NA	0.03	0.03	49000	32000	Clear, no odor
15-17MH4-01	07/17/15	7.27	1.19	0.64	16.40	0.03	0.04	Sample damaged in transit	Sample damaged in transit	Clear, visible solid waste in MH
15-17MH4-02	07/22/15	NA	NA	NA	NA	NA	NA	NDOGT	880	Clear, visible solid waste in MH, strong fecal odor from MH
15-17MH5-01	07/17/15	7.24	1.18	0.58	15.60	0.06	0.01	Sample damaged in transit	Sample damaged in transit	Clear, visible solid waste in MH
15-17MH5-02	07/22/15	NA	NA	NA	NA	NA	NA	NDOGT	750	Clear, visible solid waste in MH
15-17CB1-01	07/17/15	7.26	1.80	0.59	15.50	0	0	Sample damaged in transit	Sample damaged in transit	Clear, no odor
15-17CB1-02	07/22/15	NA	NA	NA	NA	NA	NA	NDOGT	650	Clear, no odor

(yellow)	Exceeds PWQO Limits
(red)	> 9000 CFU/100mL or NDOGT
NA	Not Analyzed
NDOGT	No Data, Over Grown with Target

Table 3: Sample Results for OF28 Storm System

Sample ID	Date	pH	Conductivity (ms)	TDS (ppt)	Temp (°C)	Total Chlorine (mg/L)	Free Chlorine (mg/L)	Total Coliforms (CFU/100mL)	Fecal Coliforms (CFU/100mL)	Description
15-CB28-01	07/07/15	7.42	1.01	0.50	17.90	0.15	0.00	4700	870	Clear, no odor
15-28MH1-01	07/23/15	7.51	1.10	0.57	19.50	0.08	0.02	2700	200	Clear, no odor
15-28MH2-01	07/29/15	NA	NA	NA	NA	0.03	0.00	NDOGT	260	Clear, no odor
15-28MH3-01	07/29/15	NA	NA	NA	NA	0.08	0.00	3500	410	Clear, no odor
15-28MH4-01	07/29/15	7.73	0.66	0.32	19.10	0.04	0.01	3100	260	Clear, no odor
15-28MH5-01	07/31/15	7.07	0.85	0.42	18.80	0.01	0.01	4400	350	Clear, no odor
15-28MH6-01	07/31/15	6.74	0.69	0.34	19.00	0.05	0.02	1400	120	Clear, no odor
15-28MH7-01	07/31/15	6.96	0.66	0.32	19.60	0.03	0.01	6800	540	Clear, no odor
15-28MH8-01	08/13/15	6.65	NA	NA	16.8	NA	NA	9000	2700	Clear, no odor

(yellow)	Exceeds PWQO Limits
(red)	> 9000 CFU/100mL or NDOGT
NA	Not Analyzed
NDOGT	No Data, Over Grown with Target

Table 4: Sample Results for OF101 Storm System

Sample ID	Date	pH	Conductivity (ms)	TDS (ppt)	Temp (°C)	Total Chlorine (mg/L)	Free Chlorine (mg/L)	Total Coliforms (CFU/100mL)	Fecal Coliforms (CFU/100mL)	Description
15-101-01	07/06/15	7.45	1.38	0.68	18.50	0.09	0.02	4000	360	Clear, no odor
15-101MH-01	07/06/15	6.95	1.16	0.57	18.00	0.00	0.01	1200	56	Clear, no odor
15-101MH1-01	07/07/15	7.70	1.10	0.56	18.60	0.05	0.02	4000	640	Clear, no odor
15-101MH2-01	07/07/15	NA	NA	NA	NA	0.00	0.00	5900	50	Clear, no odor
15-101MH3-01	07/07/15	7.64	1.12	0.56	18.20	0.00	0.01	2400	12	Clear, no odor
15-101MH4-01	07/23/15	NA	NA	NA	NA	0.04	0.03	9500	110	Clear, no odor
15-101MH5-01	07/23/15	NA	NA	NA	NA	0.09	0.04	2500	130	Clear, no odor
15-101MH6-01	07/23/15	NA	NA	NA	NA	0.09	0.02	1500	60	Clear, no odor

(yellow)	Exceeds PWQO Limits
(red)	> 9000 CFU/100mL or NDOGT
NA	Not Analyzed
NDOGT	No Data, Over Grown with Target

Table 5: Sample Results for OF102 Storm System

Sample ID	Date	pH	Conductivity (ms)	TDS (ppt)	Temp (°C)	Total Chlorine (mg/L)	Free Chlorine (mg/L)	Total Coliforms (CFU/100mL)	Fecal Coliforms (CFU/100mL)	Description
15-102MH1-1	07/13/15	7.01	1.44	0.73	17.20	0.01	0.01	4600	16	Clear, no odor
15-102MH2-1	07/13/15	6.92	1.43	0.71	17.20	0.13	0.02	3000	18	Clear, no odor
15-102MH3-1	07/13/15	7.55	1.38	0.69	17.60	0.02	0.00	5800	680	Clear, no odor
15-102MH4-1	07/31/15	NA	NA	NA	NA	0.06	0.02	6900	180	Clear, no odor
15-102MH5-1	07/31/15	7.00	2.24	1.16	17.70	0.13	0.07	12800	380	Clear, no odor

	Exceeds PWQO Limits
	Notably High for Category
	> 9000 CFU/100mL
NA	Not Analyzed
NDOGT	No Data, Over Grown with Target

Table 6: Sample Results for Miscellaneous Storm Systems

Sample ID	Date	pH	Conductivity (ms)	TDS (ppt)	Temp (°C)	Total Chlorine (mg/L)	Free Chlorine (mg/L)	Total Coliforms (CFU/100mL)	Fecal Coliforms (CFU/100mL)	Description
2015-94-01	07/06/15	7.44	1.63	0.81	16.60	0.00	0.02	9000	152	Clear, no odor
OF 142	07/07/15	7.05	0.53	0.25	21.00	1.29	0.92	NA	NA	No sample taken, clear, smells like tap water
2015-249-01	06/19/15	NA	NA	NA	NA	0.26	0.16	3300	40	Clear, no odor
15-552-01	07/17/15	7.96	1.32	0.66	17.4	0.04	0.01	Sample damaged in transit	Sample damaged in transit	Clear, no odor
15-552-02	07/22/15	NA	NA	NA	NA	NA	NA	4100	ND	Clear, no odor
2015-556-01	06/19/15	NA	NA	NA	NA	0.29	0.05	1800	32	Clear, no odor
OF 1470	07/07/15	6.84	0.53	0.26	21.20	1.26	0.87	NA	NA	No sample taken, clear, smells like tap water

(yellow)	Exceeds PWQO Limits
(red)	> 9000 CFU/100mL
NA	Not Analyzed
ND	Not Detected
NDOGT	No Data, Over Grown with Target

Appendix B

Figure 13: Transfer Bottle Modification for Low Flow Conditions

Appendix D

INDIVIDUAL CSO RESULTS FOR ALTERNATIVES

Average Rainfall Year (2014)		2015							2036 Growth - 2015 Sewer Separation							2036 Growth - 2026 Sewer Separation						
PCP#	Location	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Total Volume (m^3)	Total Dry Weather Volume at Ravensview (m^3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Total Volume (m^3)	Total Dry Weather Volume at Ravensview (m^3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Total Volume (m^3)	Total Dry Weather Volume at Ravensview (m^3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)
COMBINED SEWER OVERFLOW (CSO)																						
14	Ontario and Barrack	6.0	1	750	11,482,615	9,537,777	1,944,838	0.04%	1.5	1	62	12,766,036	11,455,434	1,310,602	0.04%	0	0	0	12,369,231	11,455,434	913,797	0.00%
22	William St Vortex	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0	0	0	12,369,231	11,455,434	913,797	0.00%
23	Earl d/s of vortex	5.5	2	176	11,482,615	9,537,777	1,944,838	0.01%	4.0	2	162	12,766,036	11,455,434	1,310,602	0.01%	4	2	162	12,369,231	11,455,434	913,797	0.01%
24	Gore St vortex	5.0	2	44	11,482,615	9,537,777	1,944,838	0.00%	5.0	2	45	12,766,036	11,455,434	1,310,602	0.00%	0	0	0	12,369,231	11,455,434	913,797	0.00%
25	Lower Union d/s of vortex	5.0	1	127	11,482,615	9,537,777	1,944,838	0.01%	1.0	1	54	12,766,036	11,455,434	1,310,602	0.01%	1	1	9	12,369,231	11,455,434	913,797	0.00%
26	West and Ontario	52.5	6	30,296	11,482,615	9,537,777	1,944,838	1.56%	44.5	4	20,680	12,766,036	11,455,434	1,310,602	1.56%	33	4	4,302	12,369,231	11,455,434	913,797	0.08%
51	d/s of Clarence St in-line CSO	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0	0	0	12,369,231	11,455,434	913,797	0.00%
52	Raglan and Rideau	10.5	4	61	11,482,615	9,537,777	1,944,838	0.00%	11.0	4	63	12,766,036	11,455,434	1,310,602	0.00%	1	1	4	12,369,231	11,455,434	913,797	0.00%
53	Division and Union	17.5	2	367	11,482,615	9,537,777	1,944,838	0.02%	19.5	2	424	12,766,036	11,455,434	1,310,602	0.02%	0	0	0	12,369,231	11,455,434	913,797	0.00%
65	Belle Park Local SA1200	18.0	4	1,710	11,482,615	9,537,777	1,944,838	0.09%	15.5	4	1,553	12,766,036	11,455,434	1,310,602	0.09%	0	0	0	12,369,231	11,455,434	913,797	0.00%
68	Quebec at Barrie St	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0	0	0	12,369,231	11,455,434	913,797	0.00%
70	Carlisle & Chest Nut	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0	0	0	12,369,231	11,455,434	913,797	0.00%
PUMP STATION OVERFLOW (PSO)																						
1	River Street Pump Station	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
5	Dalton Pumping Station	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
28	King St Pump Station**	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
35	Palace Road pump station	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
41	Morton Street Pump Station**	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
43	King-Portsmouth Pump Station	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
57	Crerar Pump Station**	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
58	Lakeshore Pump Station**	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
59	Coverdale Pump Station**	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
61	Bath-Collins Bay**	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
62	Rankin Pump Station**	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
63	Bath Rd Pump Station**	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
69	Greenview Drive Pump Station**	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
73	Days Road Pump Station**	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
74	Barrett Court Pump Station**	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
75	Westbrook Pump Station**	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
SANITARY SEWER OVERFLOW (SSO)																						
2	Belle Park Chamber, Trunks	1.5	1	1,201	11,482,615	9,537,777	1,944,838	0.06%	1.5	1	1,360	12,766,036	11,455,434	1,310,602	0.06%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
34	Helen and Mack	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
48	NETS at Sherwood**	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
50	NETS at Parkway S**	0.0	0	0	11,482,615	9,537,777	1,944,838	0.00%	0.0	0	0	12,766,036	11,455,434	1,310,602	0.00%	0.0	0	0	12,369,231	11,455,434	913,797	0.00%
TANK OVERFLOW (TO)																						
55	O'Kill CSO Tank	209.0	9	2,116	11,482,615	9,537,777	1,944,838	0.11%	215.0	9	2,126	12,766,036	11,455,434	1,310,602	0.11%	170.0	9	1,112	12,369,231	11,455,434	913,797	0.00%
56	Collingwood CSO Tank	71.5	12	39,136	11,482,615	9,537,777	1,944,838	2.01%	30.0	7	2,644	12,766,036	11,455,434	1,310,602	2.01%	30.5	7	2,615	12,369,231	11,455,434	913,797	0.19%
	TOTAL OVERFLOW VOLUME	**402.0**	**44.0**	**75,987**	**11,482,615**	**9,537,777**	**1,944,838**	**3.91%**	**348.5**	**37.0**	**29,173**	**12,766,036**	**11,455,434**	**1,310,602**	**97.77%**	**238.5**	**24.0**	**8,205**	**12,369,231**	**11,455,434**	**913,797**	**99.10%**

Average Rainfall Year (2014)		2036 Growth - 2026 Sewer Separation + 50% additional separation between 2036							2036 - 2036 Sewer Separation							2036 - Area 1: Sewer Separation						
PCP#	Location	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Total Volume (m^3)	Total Dry Weather Volume at Ravensview (m^3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Total Volume (m^3)	Total Dry Weather Volume at Ravensview (m^3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Total Volume (m^3)	Total Dry Weather Volume at Ravensview (m3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)
COMBINED SEWER OVERFLOW (CSO)																						
14	Ontario and Barrack	0	0	0	12,316,383	11,455,434	860,949	0.00%	0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
22	William St Vortex	0	0	0	12,316,383	11,455,434	860,949	0.00%	0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
23	Earl d/s of vortex	4	2	162	12,316,383	11,455,434	860,949	0.01%	4	2	162	12,274,617	11,455,434	819,183	0.01%	4.0	2	162	12,175,790	11,455,434	720,356	0.02%
24	Gore St vortex	0	0	0	12,316,383	11,455,434	860,949	0.00%	0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
25	Lower Union d/s of vortex	0	0	0	12,316,383	11,455,434	860,949	0.00%	0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
26	West and Ontario	29	4	2,391	12,316,383	11,455,434	860,949	0.08%	39	4	982	12,274,617	11,455,434	819,183	0.08%	25.5	3	406	12,175,790	11,455,434	720,356	0.06%
51	d/s of Clarence St in-line CSO	0	0	0	12,316,383	11,455,434	860,949	0.00%	0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
52	Raglan and Rideau	1	1	4	12,316,383	11,455,434	860,949	0.00%	1	1	4	12,274,617	11,455,434	819,183	0.00%	1.0	1	4	12,175,790	11,455,434	720,356	0.00%
53	Division and Union	0	0	0	12,316,383	11,455,434	860,949	0.00%	0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
65	Belle Park Local SA1200	0	0	0	12,316,383	11,455,434	860,949	0.00%	0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
68	Quebec at Barrie St	0	0	0	12,316,383	11,455,434	860,949	0.00%	0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
70	Carlisle & Chest Nut	0	0	0	12,316,383	11,455,434	860,949	0.00%	0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
PUMP STATION OVERFLOW (PSO)																						
1	River Street Pump Station	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
5	Dalton Pumping Station	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
28	King St Pump Station**	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
35	Palace Road pump station	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
41	Morton Street Pump Station**	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
43	King-Portsmouth Pump Station	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
57	Crerar Pump Station**	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
58	Lakeshore Pump Station**	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
59	Coverdale Pump Station**	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
61	Bath-Collins Bay**	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
62	Rankin Pump Station**	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
63	Bath Rd Pump Station**	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
69	Greenview Drive Pump Station**	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
73	Days Road Pump Station**	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
74	Barrett Court Pump Station**	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
75	Westbrook Pump Station**	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
SANITARY SEWER OVERFLOW (SSO)																						
2	Belle Park Chamber, Trunks	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
34	Helen and Mack	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
48	NETS at Sherwood**	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
50	NETS at Parkway S**	0.0	0	0	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
TANK OVERFLOW (TO)																						
55	O'Kill CSO Tank	164.0	9	1,058	12,316,383	11,455,434	860,949	0.00%	0.0	0	0	12,274,617	11,455,434	819,183	0.00%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
56	Collingwood CSO Tank	30.5	7	2,201	12,316,383	11,455,434	860,949	0.19%	30.5	7	2,417	12,274,617	11,455,434	819,183	0.19%	0.0	0	0	12,175,790	11,455,434	720,356	0.00%
	TOTAL OVERFLOW VOLUME	**227.5**	**23.0**	**5,816**	**12,316,383**	**11,455,434**	**860,949**	**99.32%**	**73.5**	**14.0**	**3,565**	**12,274,617**	**11,455,434**	**819,183**	**99.56%**	**30.5**	**6.0**	**571**	**12,175,790**	**11,455,434**	**720,356**	**99.92%**

Average Rainfall Year (2014)		2036 - Area 2: Sewer Separation							2036 - Area 3: Sewer Separation							2036 - Area 4: Sewer Separation						
PCP#	Location	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Total Volume (m^3)	Total Dry Weather Volume at Ravensview (m3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m3)	Total Volume (m^3)	Total Dry Weather Volume at Ravensview (m3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Total Volume (m^3)	Total Dry Weather Volume at Ravensview (m3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)
COMBINED SEWER OVERFLOW (CSO)																						
14	Ontario and Barrack	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
22	William St Vortex	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
23	Earl d/s of vortex	4.0	2	162	12,198,585	11,455,434	743,151	0.02%	0.5	1	3	12,176,402	11,455,434	720,968	0.00%	4.0	2	132	12,186,377	11,455,434	730,943	0.02%
24	Gore St vortex	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
25	Lower Union d/s of vortex	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	4.5	2	391	12,186,377	11,455,434	730,943	0.05%
26	West and Ontario	27.0	3	840	12,198,585	11,455,434	743,151	0.11%	25.5	3	551	12,176,402	11,455,434	720,968	0.08%	27.0	3	1,117	12,186,377	11,455,434	730,943	0.15%
51	d/s of Clarence St in-line CSO	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
52	Raglan and Rideau	1.0	1	4	12,198,585	11,455,434	743,151	0.00%	1.0	1	4	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
53	Division and Union	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
65	Belle Park Local SA1200	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
68	Quebec at Barrie St	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
70	Carlisle & Chest Nut	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
PUMP STATION OVERFLOW (PSO)																						
1	River Street Pump Station	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
5	Dalton Pumping Station	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
28	King St Pump Station**	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
35	Palace Road pump station	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
41	Morton Street Pump Station**	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
43	King-Portsmouth Pump Station	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
57	Crerar Pump Station**	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
58	Lakeshore Pump Station**	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
59	Coverdale Pump Station**	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
61	Bath-Collins Bay**	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
62	Rankin Pump Station**	0.0	0	0	12,198,585	11,455,434	743,151	***	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
63	Bath Rd Pump Station**	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
69	Greenview Drive Pump Station**	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
73	Days Road Pump Station**	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
74	Barrett Court Pump Station**	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
75	Westbrook Pump Station**	0.0	0	0	12,198,585	11,455,434	743,151	***	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
SANITARY SEWER OVERFLOW (SSO)																						
2	Belle Park Chamber, Trunks	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
34	Helen and Mack	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
48	NETS at Sherwood**	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
50	NETS at Parkway S**	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
TANK OVERFLOW (TO)																						
55	O'Kill CSO Tank	0.0	0	0	12,198,585	11,455,434	743,151	0.00%	0.0	0	0	12,176,402	11,455,434	720,968	0.00%	0.0	0	0	12,186,377	11,455,434	730,943	0.00%
56	Collingwood CSO Tank	13.0	5	898	12,198,585	11,455,434	743,151	0.12%	13.0	5	898	12,176,402	11,455,434	720,968	0.12%	13.0	5	898	12,186,377	11,455,434	730,943	0.12%
	TOTAL OVERFLOW VOLUME	**45.0**	**11.0**	**1,903**	**12,198,585**	**11,455,434**	**743,151**	**99.74%**	**40.0**	**10.0**	**1,456**	**12,176,402**	**11,455,434**	**720,968**	**99.80%**	**48.5**	**12.0**	**2,539**	**12,186,377**	**11,455,434**	**730,943**	**99.65%**

Average Rainfall Year (2014)		2036 - Full Sewer Separation						
PCP#	Location	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Total Volume (m^3)	Total Dry Weather Volume at Ravensview (m^3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)
COMBINED SEWER OVERFLOW (CSO)								
14	Ontario and Barrack	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
22	William St Vortex	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
23	Earl d/s of vortex	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
24	Gore St vortex	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
25	Lower Union d/s of vortex	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
26	West and Ontario	2.0	1	334	12,150,467	11,455,434	695,033	0.02%
51	d/s of Clarence St in-line CSO	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
52	Raglan and Rideau	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
53	Division and Union	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
65	Belle Park Local SA1200	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
68	Quebec at Barrie St	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
70	Carlisle & Chest Nut	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
PUMP STATION OVERFLOW (PSO)								
1	River Street Pump Station	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
5	Dalton Pumping Station	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
28	King St Pump Station**	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
35	Palace Road pump station	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
41	Morton Street Pump Station**	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
43	King-Portsmouth Pump Station	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
57	Crerar Pump Station**	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
58	Lakeshore Pump Station**	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
59	Coverdale Pump Station**	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
61	Bath-Collins Bay**	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
62	Rankin Pump Station**	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
63	Bath Rd Pump Station**	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
69	Greenview Drive Pump Station**	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
73	Days Road Pump Station**	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
74	Barrett Court Pump Station**	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
75	Westbrook Pump Station**	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
SANITARY SEWER OVERFLOW (SSO)								
2	Belle Park Chamber, Trunks	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
34	Helen and Mack	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
48	NETS at Sherwood**	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
50	NETS at Parkway S**	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
TANK OVERFLOW (TO)								
55	O'Kill CSO Tank	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
56	Collingwood CSO Tank	0.0	0	0	12,150,467	11,455,434	695,033	0.00%
	TOTAL OVERFLOW VOLUME	**2.0**	**1.0**	**334**	**12,150,467**	**11,455,434**	**695,033**	**99.95%**

PCP#	Location	2015							2036 - 2015 Sewer Separation							2036 Growth - 2026 Sewer Separation						
2008 Rainfall Year		Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Total Volume (m^3)	Total Dry Weather Volume at Ravensview (m^3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Total Volume (m^3)	Total Dry Weather Volume at Ravensview (m3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Total Volume (m^3)	Total Dry Weather Volume at Ravensview (m3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)
	COMBINED SEWER OVERFLOW (CSO)																					
14	Ontario and Barrack	17.0	3	4,401	12,016,549	9,537,777	2,478,772	0.18%	11.5	2	3,130	13,256,058	11,455,434	1,800,624	0.17%	3.0	1	404	12,667,738	11,455,434	1,212,304	0.03%
22	William St Vortex	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
23	Earl d/s of vortex	15.0	4	1,870	12,016,549	9,537,777	2,478,772	0.08%	13.0	4	1,696	13,256,058	11,455,434	1,800,624	0.09%	12.5	4	1,369	12,667,738	11,455,434	1,212,304	0.11%
24	Gore St vortex	17.0	5	1,529	12,016,549	9,537,777	2,478,772	0.06%	16.0	5	1,260	13,256,058	11,455,434	1,800,624	0.07%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
25	Lower Union d/s of vortex	13.5	3	2,740	12,016,549	9,537,777	2,478,772	0.11%	8.5	2	2,224	13,256,058	11,455,434	1,800,624	0.12%	7.0	2	959	12,667,738	11,455,434	1,212,304	0.08%
26	West and Ontario	56.0	9	62,198	12,016,549	9,537,777	2,478,772	2.51%	37.5	6	44,182	13,256,058	11,455,434	1,800,624	2.45%	19.0	3	20,272	12,667,738	11,455,434	1,212,304	1.67%
51	d/s of Clarence St in-line CSO	7.0	3	708	12,016,549	9,537,777	2,478,772	0.03%	5.5	3	765	13,256,058	11,455,434	1,800,624	0.04%	1.5	1	52	12,667,738	11,455,434	1,212,304	0.00%
52	Raglan and Rideau	19.0	5	1,281	12,016,549	9,537,777	2,478,772	0.05%	6.5	2	1,229	13,256,058	11,455,434	1,800,624	0.07%	6.0	2	1,019	12,667,738	11,455,434	1,212,304	0.08%
53	Division and Union	33.0	5	2,184	12,016,549	9,537,777	2,478,772	0.09%	36.5	5	2,332	13,256,058	11,455,434	1,800,624	0.13%	3.0	2	8	12,667,738	11,455,434	1,212,304	0.00%
65	Belle Park Local SA1200	29.5	7	10,824	12,016,549	9,537,777	2,478,772	0.44%	27.5	7	9,675	13,256,058	11,455,434	1,800,624	0.54%	1.5	1	154	12,667,738	11,455,434	1,212,304	0.01%
68	Quebec at Barrie St	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
70	Carlisle & Chest Nut	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
	PUMP STATION OVERFLOW (PSO)																					
1	River Street Pump Station	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
5	Dalton Pumping Station	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
28	King St Pump Station**	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
35	Palace Road pump station	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
41	Morton Street Pump Station**	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
43	King-Portsmouth Pump Station	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
57	Crerar Pump Station**	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
58	Lakeshore Pump Station**	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
59	Coverdale Pump Station**	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
61	Bath-Collins Bay**	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
62	Rankin Pump Station**	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
63	Bath Rd Pump Station**	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
69	Greenview Drive Pump Station**	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
73	Days Road Pump Station**	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
74	Barrett Court Pump Station**	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
75	Westbrook Pump Station**	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
	SANITARY SEWER OVERFLOW (SSO)																					
2	Belle Park Chamber, Trunks	4.5	2	2,421	12,016,549	9,537,777	2,478,772	0.10%	4.0	2	1,288	13,256,058	11,455,434	1,800,624	0.07%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
34	Helen and Mack	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
48	NETS at Sherwood**	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
50	NETS at Parkway S**	0.0	0	0	12,016,549	9,537,777	2,478,772	0.00%	0.0	0	0	13,256,058	11,455,434	1,800,624	0.00%	0.0	0	0	12,667,738	11,455,434	1,212,304	0.00%
	TANK OVERFLOW (TO)																					
55	O'Kill CSO Tank	893.0	16	5,922	12,016,549	9,537,777	2,478,772	0.24%	526.5	13	3,595	13,256,058	11,455,434	1,800,624	0.20%	527.0	13	3,380	12,667,738	11,455,434	1,212,304	0.28%
56	Collingwood CSO Tank	118.0	13	71,562	12,016,549	9,537,777	2,478,772	2.89%	57.0	12	11,162	13,256,058	11,455,434	1,800,624	0.62%	53.5	12	8,863	12,667,738	11,455,434	1,212,304	0.73%
	TOTAL OVERFLOW VOLUME	**1,222.5**	**75.0**	**167,640**	**12,016,549**	**9,537,777**	**2,478,772**	**93.24%**	**750.0**	**63.0**	**82,538**	**13,256,058**	**11,455,434**	**1,800,624**	**95.42%**	**634.0**	**41.0**	**36,480**	**12,667,738**	**11,455,434**	**1,212,304**	**96.99%**

* = CSO Plugged in 2015

2008 Rainfall Year		2036 Growth - 2026 Sewer Separation + 50% additional separation between 2036							2036 Growth - 2036 Separation							2036 - Area 1: Sewer Separation						
PCP#	Location	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Total Volume (m^3)	Total Dry Weather Volume at Ravensview (m3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Total Volume (m^3)	Total Dry Weather Volume at Ravensview (m3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Total Volume (m^3)	Total Dry Weather Volume at Ravensview (m3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)
COMBINED SEWER OVERFLOW (CSO)																						
14	Ontario and Barrack	0.0	1	0	12,593,319	11,455,434	1,137,885	0.00%	2.5	1	360	12,536,085	11,455,434	1,080,651	0.03%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
22	William St Vortex	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
23	Earl d/s of vortex	12.0	4	1,328	12,593,319	11,455,434	1,137,885	0.12%	12.5	4	1,322	12,536,085	11,455,434	1,080,651	0.12%	12.0	4	1,291	12,402,740	11,455,434	947,306	0.14%
24	Gore St vortex	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
25	Lower Union d/s of vortex	7.0	2	683	12,593,319	11,455,434	1,137,885	0.06%	7.0	2	616	12,536,085	11,455,434	1,080,651	0.06%	4.5	2	338	12,402,740	11,455,434	947,306	0.04%
26	West and Ontario	16.5	3	15,161	12,593,319	11,455,434	1,137,885	1.33%	10.0	2	8,310	12,536,085	11,455,434	1,080,651	0.77%	8.0	2	3,545	12,402,740	11,455,434	947,306	0.37%
51	d/s of Clarence St in-line CSO	1.5	1	52	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
52	Raglan and Rideau	6.0	2	1,019	12,593,319	11,455,434	1,137,885	0.09%	6.0	2	1,019	12,536,085	11,455,434	1,080,651	0.09%	6.0	2	1,019	12,402,740	11,455,434	947,306	0.11%
53	Division and Union	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
65	Belle Park Local SA1200	1.5	1	140	12,593,319	11,455,434	1,137,885	0.01%	1.5	1	140	12,536,085	11,455,434	1,080,651	0.01%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
68	Quebec at Barrie St	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
70	Carlisle & Chest Nut	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
PUMP STATION OVERFLOW (PSO)																						
1	River Street Pump Station	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
5	Dalton Pumping Station	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
28	King St Pump Station**	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
35	Palace Road pump station	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
41	Morton Street Pump Station**	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
43	King-Portsmouth Pump Station	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
57	Crerar Pump Station**	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
58	Lakeshore Pump Station**	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
59	Coverdale Pump Station**	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
61	Bath-Collins Bay**	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
62	Rankin Pump Station**	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
63	Bath Rd Pump Station**	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
69	Greenview Drive Pump Station**	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
73	Days Road Pump Station**	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
74	Barrett Court Pump Station**	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
75	Westbrook Pump Station**	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
SANITARY SEWER OVERFLOW (SSO)																						
2	Belle Park Chamber, Trunks	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
34	Helen and Mack	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
48	NETS at Sherwood**	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
50	NETS at Parkway S**	0.0	0	0	12,593,319	11,455,434	1,137,885	0.00%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
TANK OVERFLOW (TO)																						
55	O'Kill CSO Tank	526.5	13	3,369	12,593,319	11,455,434	1,137,885	0.30%	0.0	0	0	12,536,085	11,455,434	1,080,651	0.00%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
56	Collingwood CSO Tank	53.0	12	8,689	12,593,319	11,455,434	1,137,885	0.76%	53.0	12	8,682	12,536,085	11,455,434	1,080,651	0.80%	0.0	0	0	12,402,740	11,455,434	947,306	0.00%
	TOTAL OVERFLOW VOLUME	**624.0**	**39.0**	**30,441**	**12,593,319**	**11,455,434**	**1,137,885**	**97.32%**	**92.5**	**24.0**	**20,449**	**12,536,085**	**11,455,434**	**1,080,651**	**98.11%**	**30.5**	**10.0**	**6,193**	**12,402,740**	**11,455,434**	**947,306**	**99.35%**

* = CSO Plugged in 2015

2008 Rainfall Year		2036 - Area 2: Sewer Separation							2036 - Area 3: Sewer Separation							2036 - Area 4: Sewer Separation						
PCP#	Location	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Total Volume (m^3)	Total Dry Weather Volume at Ravensview (m3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Total Volume (m^3)	Total Dry Weather Volume at Ravensview (m3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Total Volume (m^3)	Total Dry Weather Volume at Ravensview (m3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)
	COMBINED SEWER OVERFLOW (CSO)																					
14	Ontario and Barrack	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
22	William St Vortex	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
23	Earl d/s of vortex	12.0	4	1,291	12,443,249	11,455,434	987,815	0.13%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	12.0	4	1,291	12,533,062	11,455,434	1,077,628	0.12%
24	Gore St vortex	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
25	Lower Union d/s of vortex	5.0	2	395	12,443,249	11,455,434	987,815	0.04%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	4.5	2	391	12,533,062	11,455,434	1,077,628	0.04%
26	West and Ontario	10.5	2	6,783	12,443,249	11,455,434	987,815	0.69%	8.5	2	4,894	12,411,908	11,455,434	956,474	0.51%	11.5	3	7,061	12,533,062	11,455,434	1,077,628	0.66%
51	d/s of Clarence St in-line CSO	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
52	Raglan and Rideau	6.0	2	1,019	12,443,249	11,455,434	987,815	0.10%	6.0	2	1,019	12,411,908	11,455,434	956,474	0.11%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
53	Division and Union	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
65	Belle Park Local SA1200	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
68	Quebec at Barrie St	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
70	Carlisle & Chest Nut	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
	PUMP STATION OVERFLOW (PSO)																					
1	River Street Pump Station	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
5	Dalton Pumping Station	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
28	King St Pump Station**	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
35	Palace Road pump station	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
41	Morton Street Pump Station**	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
43	King-Portsmouth Pump Station	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
57	Crerar Pump Station**	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
58	Lakeshore Pump Station**	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
59	Coverdale Pump Station**	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
61	Bath-Collins Bay**	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
62	Rankin Pump Station**	0.0	0	0	12,443,249	11,455,434	987,815	***	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
63	Bath Rd Pump Station**	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
69	Greenview Drive Pump Station**	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
73	Days Road Pump Station**	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
74	Barrett Court Pump Station**	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
75	Westbrook Pump Station**	0.0	0	0	12,443,249	11,455,434	987,815	***	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
	SANITARY SEWER OVERFLOW (SSO)																					
2	Belle Park Chamber, Trunks	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
34	Helen and Mack	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
48	NETS at Sherwood**	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
50	NETS at Parkway S**	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
	TANK OVERFLOW (TO)																					
55	O'Kill CSO Tank	0.0	0	0	12,443,249	11,455,434	987,815	0.00%	0.0	0	0	12,411,908	11,455,434	956,474	0.00%	0.0	0	0	12,533,062	11,455,434	1,077,628	0.00%
56	Collingwood CSO Tank	53.0	12	8,682	12,443,249	11,455,434	987,815	0.88%	53.0	12	8,682	12,411,908	11,455,434	956,474	0.91%	53.0	12	8,682	12,533,062	11,455,434	1,077,628	0.81%
	TOTAL OVERFLOW VOLUME	**86.5**	**22.0**	**18,170**	**12,443,249**	**11,455,434**	**987,815**	**98.16%**	**67.5**	**16.0**	**14,595**	**12,411,908**	**11,455,434**	**956,474**	**98.47%**	**81.0**	**21.0**	**17,426**	**12,533,062**	**11,455,434**	**1,077,628**	**98.38%**

* = CSO Plugged in 2015

2008 Rainfall Year		2036 - Buildout Sewer Separation						
PCP#	Location	Cumulative Duration Bypass (Hrs)	Number of Bypass Events	Total Bypass (m^3)	Total Volume (m3)	Total Dry Weather Volume at Ravensview (m^3)	Total Wet Weather Volume at Ravensview (m^3)	Ratio (Bypass / Wet Weather) (m^3)
	COMBINED SEWER OVERFLOW (CSO)							
14	Ontario and Barrack	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
22	William St Vortex	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
23	Earl d/s of vortex	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
24	Gore St vortex	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
25	Lower Union d/s of vortex	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
26	West and Ontario	5.0	1	1,050	12,251,183	11,455,434	795,749	0.13%
51	d/s of Clarence St in-line CSO	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
52	Raglan and Rideau	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
53	Division and Union	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
65	Belle Park Local SA1200	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
68	Quebec at Barrie St	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
70	Carlisle & Chest Nut	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
	PUMP STATION OVERFLOW (PSO)							
1	River Street Pump Station	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
5	Dalton Pumping Station	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
28	King St Pump Station**	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
35	Palace Road pump station	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
41	Morton Street Pump Station**	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
43	King-Portsmouth Pump Station	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
57	Crerar Pump Station**	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
58	Lakeshore Pump Station**	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
59	Coverdale Pump Station**	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
61	Bath-Collins Bay**	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
62	Rankin Pump Station**	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
63	Bath Rd Pump Station**	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
69	Greenview Drive Pump Station**	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
73	Days Road Pump Station**	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
74	Barrett Court Pump Station**	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
75	Westbrook Pump Station**	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
	SANITARY SEWER OVERFLOW (SSO)							
2	Belle Park Chamber, Trunks	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
34	Helen and Mack	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
48	NETS at Sherwood**	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
50	NETS at Parkway S**	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
	TANK OVERFLOW (TO)							
55	O'Kill CSO Tank	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
56	Collingwood CSO Tank	0.0	0	0	12,251,183	11,455,434	795,749	0.00%
	TOTAL OVERFLOW VOLUME	**5.0**	**1.0**	**1,050**	**12,251,183**	**11,455,434**	**795,749**	**99.87%**

* = CSO Plugged in 2015