UTILITIES KINGSTON

CITY OF KINGSTON WASTEWATER MASTER PLAN UPDATES

WASTEWATER MODEL CALIBRATION REPORT

JANUARY, 2017

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Utilities Kingston

Final Report

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1 INTRODUCTION

This report depicts the review, data collection, calibration and simulation of the City of Kingston InfoSWMM trunk sewer model being used as part of the 2015 Utilities Kingston Wastewater Master Plan to evaluate gaps and review options and alternatives for assessment. WSP has been retained by Utilities Kingston (UK) to complete an update to the supplied trunk sewer model which was originally created as part of the last Sewer Master Plan completed by CH2MHILL and XCG Consultants in 2009 and was recently updated in part by WSP for the *Front Rd. Water Interconnection and Portsmouth PS Forcemain Environmental Assessment (EA)* in 2014.

As part of the evaluation process for the 2015 master plan the model was validated and updated to reflect the current sewer infrastructure and pumping station operations as well as the base future scenario projections of infrastructure and population in Kingston. The calibration is a combination of data verification and model revisions using actual flow data provided by UK to represent current 2014 existing conditions, while future scenarios are prepared for simulation using a combination of growth development and future infrastructure projections using input from UK staff and other technical studies such as detailed in the *Growth Development Report (2015 Master Plan, WSP)*. This report details the model scenario development prior to the models use for infrastructure GAP analysis and design alternative simulation.

2 OVERVIEW AND APPROACH

The InfoSWMM model represents a trunk sewer system which divides the City of Kingston into three main collection areas (Kingston West, Kingston Central, Kingston East) that outlet to two separate waste water treatment facilities. The west system, which generally includes the portion of the City within the urban boundary west of Little Cataraqui Creek, collects and conveys flows to Cataraqui Bay WWTP. The central and east systems, which generally include the area east of the Little Cataraqui Creek, discharge to Ranvensview WWTP. The model represents the City's sewer system with a combination of pipe elements (conduits), pipe junctions (nodes), storage nodes (pump stations, CSO tanks and wet wells) and weirs (combined sewer overflow locations). An overview map of the sanitary system is shown in Figure B-1 in Appendix B.

The approach to update the model for its suitability and use for the Master Plan is a multi-stage process which required the provided InfoSWMM model to be calibrated and validated to represent new or upgraded infrastructure as well as current growth projections based on the City of Kingston Official Plan, Utilities Kinston's current scheduled capital improvement projects, and input from the City of Kingston planning department. The final model includes multiple scenario's representing the existing 2014 calibrated condition, the 2015 existing condition and growth projection and future infrastructure scenarios representing 2021, 2026, 2036, Build-out and Ultimate conditions (detailed in section 4 of this report). The master plan modelling procedure was completed in conjunction with the InfoWater model being developed for the Water Master Plan.

2.1 COMBINED WATER AND WASTEWATER MODELLING APPROACH

The water and wastewater computer models were rebuilt and updated respectively and concurrently so that development synergies were optimized by using the same input and loading information. This procedure increased accuracy by reducing duplication of work and allowed both models to match growth projections across developed scenarios and alternatives. There are four (4) main phase's to the combined modelling approach that is common between both models:

→ **Phase 1:** Is to build/update models to reflect the actual infrastructure in the ground (e.g. Conduit sizes, inverts, materials, geocoded locations, pump stations, etc…).

→ **Phase 2:** Load models with water demand and demand adjusted dry-weather flow consisting of residential and non-residential loads. (Water and Wastewater model respectively)

→ **Phase 3:** Flow monitoring data is compared with initial model simulations and adjustments are made to match model response to actual system response.

→ **Phase 4:** Final model validation and simulations are computed for use in the Master Plan for developed scenarios

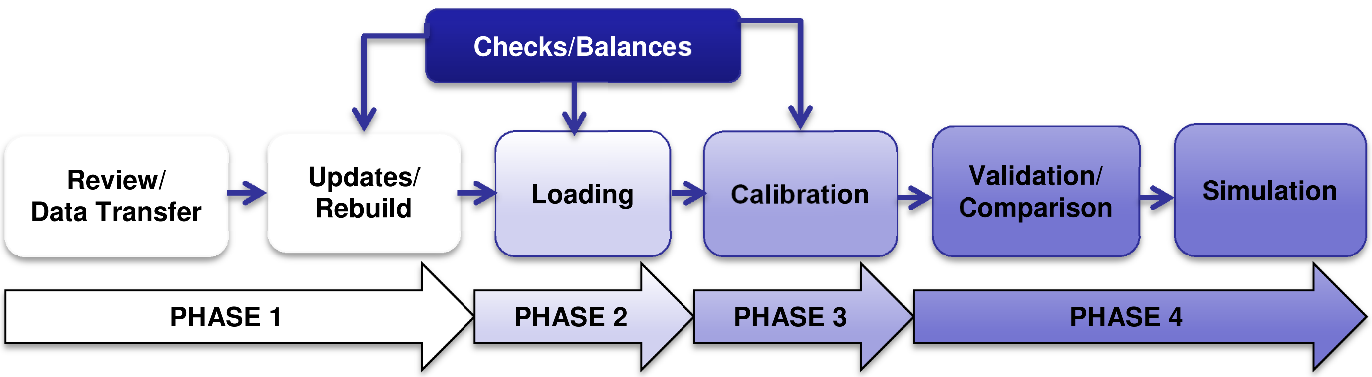

Figure 2-1 Combined Modelling Approach

This section of the report details how this approach was used to complete the hydraulic modelling component of the master plan.

2.2 PHASE 1: REVIEW, DATA TRANSFER AND MODEL UPDATES

The trunk model was last updated by WSP for the Front Rd. Watermain Interconnection and Portsmouth PS Forcemain EA (2014, WSP) to represent sanitary sewer conditions from available 2013 data. The new model update included the review of this and past versions and the addition of new infrastructure representations using data as detailed in the Baseline Report (2015 Master Plan, WSP). In summary the review stage includes:

→ Review of available GIS and SCADA
→ Review of As-build Information and Operational Details
→ Identification of Model Data Gaps

After review the original trunk model is first updated to include the latest and greatest information provided by UK and research including:

- Pump curves for Pump Stations
- As-built drawing details (to confirm pipe diameters, pipe material, and identify high and low points.)
- WWTP drawing details
- Operational detail updates for facilities (CSO, Weirs, Bypasses, etc.)
- Parcel fabric maps including CSO areas and service catchment areas.

During the completion of updates a series of checks and balances were completed in conjunction with the water model, to ensure the models matched the data resources provided.

Any additional gaps identified in the data or information was reviewed and additional details were gathered during field condition assessment review of main facilities to minimize data assumptions. The model information used to complete the updates for each facility is summarized in complied Facility Summary Sheets (Example in Appendix A) which were prepared and documented in the *Condition Assessment Report (2015 Master Plan, WSP).*

2.2.1 2008 AND 2015 INFOSWMM MODEL REVIEW/UPDATE SUMMARY

As previously described, the review of the InfoSWMM model was conducted by WSP for the *Front Rd. Watermain Interconnection and Portsmouth PS Forcemain EA (2014, WSP).* Based on this review, WSP made recommendations for model updates based on observations of the original model and its representation of different infrastructure which are summarized in WSP's *InfoSWMM Sewer Model Update Recommendations Memorandum (2015, WSP)* and presented in Appendix B.

Given that the update for the master plan trunk sewer model uses updated information, a major component of the update includes the adjustment of GIS layers and various model parameters to match new information including model/GIS additions for features not represented in the model previously. Figures B-1 and B-2 of Appendix B summarize the main model updates considered for the 2015 update.

In summary, the following model elements shown in Table 2-1 were updated in the 2015 trunk sewer model using data provided as summarized in section 2.2.2.

Table 2-1 Trunk Sewer Model Updates Summary

FACILITIES			
Pumping Station	**Forcemain Additions**	**Pumping Station**	**Forcemain Updates**
Westbrook Rd	1860m – 150mmø	Hillview Rd	Minor Losses/Pump
Collins Bay Rd	820m – 150mmø	Days Rd	Minor Losses/Size
Ranking St	560m - 150mmø	Lakeshore Blvd	Minor Losses/Pump
Bath-Lower Dr	98m - 100mmø	Crerar Blvd	Minor Losses/Size/Pump
Coverdale	733m – 200mmø	Dalton Ave	Minor Losses/Pump
Bayridge Dr	80m – 150mmø	King – Portsmouth	Minor Losses/Size/Pump
Bath Rd	562m – 150mmø	Barrett Ct	Minor Losses/Pump
Bath-Collings Bay Rd	270m – 150mmø	Highway 15	Minor Losses/Pump
John Counter Blvd	332m – 200mmø	James St	Minor Losses/Pump
Greenview Rd	60m – 250mmø	**CSO Tank Updates**	**Inclusions**
King–Elevator Bay	695m – 250mmø	Emma Martin	Location
King–Lake Ont. Park	455m – 150mmø	King St (O'Kill St)	Location
Yonge St	24m – 75mmø	Collingwood	Pump/Location
Morton St	145m – 150mmø		
Palace Rd	235m – 200mmø		
Kenwoods CL	452m - 200mmø		
Schooner Dr	555m – 150mmø		
LINEAR INFRASTRUCTURE			
Sewer Additions	**Sanitary Pipe Additions**	**Overflow Additions**	
Northwest Collector	675m	PCP#08 – CSO	
Sprucewood Cres Collector	1090m	PCP#09 – CSO	
Redwood Cres Collector	2365m	PCP#34 – SSO	
Midland Ave Collector	845m	PCP#53 – CSO	
North Central Collector	2215m	PCP#68 – CSO	
Halifax Dr Collector	575m	PCP#67 – CSO	
Crossfield Ave Collector	1330m	PCP#70 – CSO	
Lakeshore Collector	1350m	PCP#71 – CSO	
Lappan Collector	1035m	**Overflow Updates**	**Inclusions**
Charles St Collector	1515m	PCP#72 – SSO	Location
Rideau St Collector	810m	PCP#31 – SSO	Location
Collingwood Collector	1465m	PCP#56 – CSO(Collingwood)	Location/Size
Yonge St North Collector	340m	PCP#15 – CSO	Location
Yonge St South Collector	335m	PCP#52 - CSO	Location/Size
George St Collector	535m	PCP#65 - CSO	Location/Size
SEWER SYSTEM MODEL UPDATES			

→ Removal and Replacement of current dry-weather and base I/I

→ Model Elements Represented
- 1100 Nodes (Junctions)
- 1168 Conduits
- 35 Storage Nodes
- 56 Pumps
- 51 Outfalls
- 308 Sub-catchments

2.2.2 DATA COLLECTION AND VALIDATION

To supplement updating and recalibration of the trunk sewer model for current conditions, with 2015 model additions, a variety of data was requested and provided by Utilities Kingston. Data collected supplements the updates described in Table 2-1 in section 2.2.1.

A detailed summary of the data collected is documented in the *Baseline Report (2015 Master Plan, WSP)*. The majority of this data was reviewed with Utilities Kingston and Table 2-2 is a summary of the data collected for validation and use with the wastewater model update.

Table 2-2 Data Collected for Trunk Sewer Model Updates

PRIMARY DATA USED FOR MODEL UPDATES, CALIBRATION AND VALIDATION
GIS Data
→ Catchment and Sub-Catchment layers
→ Sanitary Pipe Layers
→ Storm Pipe Layers
→ City of Kingston parcel Assessment
→ City of Kingston Official Plan Layers
Flow and Level Data
→ SCADA (Supervisory Control and Data Acquisition)
→ Flowworks.com
→ In-Line Flow Monitors
Current Billed Water Consumption
Water Consumption Distribution Areas
As-build forcemain as-built information for pumping stations
System SCADA screenshots for treatment facilities, CSO's and pumping stations.
SUPPLEMENTARY DATA FOR MODEL SCENARIOS AND REPORT DATA
Combined Drainage Area's Update Information
Growth projections summary
Annual reports for Ravensview and Cataraqui Bay WWTP's
Report to Planning Committee - Projected Development
River Street Pump Station Capacity Analysis

2.2.2.1 RAINFALL DATA

Rainfall data for 2013 and 2014 was provided by UK for the River Street PS Weather Station between the months of January-October for each year. Rainfall data was also researched and collected from Queen's University and Environment Canada rain gage data to provide two additional weather stations to verify the data collected and to determine suitable rain event data for use in wet-weather calibration of the InfoSWMM model. A summary of the information collected and selected rainfall events are shown in Figures C-1 and C-2 of Appendix C.

Comparing all weather data, allows for distinct wet-weather events to be selected for model calibration. Observing the data, it was noted that overall there was consistent representation of rainfall between all three weather stations; however the River St PS Weather Station reported periodically no rainfall on days where both of the other stations did report rainfall for both years. Of all the data sets the most consistent data came from the Queen's University Rain Gage and this data was used to generate the model inputs to represent the most realistic simulation result for dynamic model flows fo3 2014. The final modified rain gauge information for 2013 and 2014 used in calibration is detailed in Appendix C.

In addition to the 2013/2014 rain data, UK also provided WSP with the 2008 rain data and AES design storm data for 12-hr events used from the previous master plan model. Both sets of data are appended in Appendix C and were used for design storm and CSO analysis model simulations.

2.2.2.2 FLOW AND LEVEL DATA

UK has provided actual sanitary flow and data for the years of 2013/2014 from various pumping stations, trunk sewers and sewage treatment plants as summarized in the *Baseline Report (2015 Master Plan, WSP)* which includes SCADA, in-line flow monitors and CSO flowworks.com data. In addition to this, UK has also provided additional recently collected data for 2015 and select historical flow data from past years to assist with minimizing data gaps used for the purposes of validating the inflows for the InfoSWMM model for dry-weather and wet-weather calibration. An overview of available and active monitoring information for 2013/2014 is summarized in Figure D-1 of Appendix D. Appendix D also includes a summary of the flow data used and reviewed for the 2015 Master Plan for the purposes of updating the trunk sewer model. The data is further analysed as detailed in section 2.4 of this report.

2.2.2.3 WATER CONSUMPTION DATA

Water consumption data was provided by UK for all billed water distribution areas in Kingston. This data includes Kingston West, Central and East service area data for both 2013 & 2014. The water consumption information from water meters is used as the main source for water demand adjusted dry-weather loading for the trunk model in place of the existing model methodology that used land use coding system and unit-area flow generation for the different land uses. The water meter data was also used for the development of diurnal patterns and model calibration. The use and review of this data is further detailed in section 2.3 of this report.

2.2.2.4 AS-BUILTS, PUMP DATA AND GIS

For the purposes of updating and validating the existing infrastructure to be represented in the model the combination of available as-builts, pump curve data, GIS and SCADA information was collected and used. As described in previous sections this information was provided for various Pumping Stations, CSOs and other PCP's. The main details are compiled into the Hydraulic Summary Sheets and for much of the secondary pumping station and forcemain additions the GIS data was used predominantly to create model representations. Figures B-2 and B-3 of Appendix B depicts the forcemains and pumping stations updated from this information. Provided SCADA screenshot details and researched pump curve data for facilities are included in Appendix E for reference.

2.2.2.5 GROWTH PROJECTION DATA

Growth projection data for use with model simulations was produced for the master plan projection years of 2021, 2026, 2036, Build-Out and Ultimate scenarios as detailed in the *Growth Scenario Report (WSP, 2015)*. Data for both imminent projects for consideration during the projection years and associated increases in sanitary flow for these years are detailed in section 3 of this report.

2.2.2.6 SEWER SEPARATION DATA

In addition to the standard GIS data provided for infrastructure updates, UK 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 which is a projection based on their current sewer separation program. The combined sewer separation was divided into 2012, 2013, 2014, 2020, 2025 and 2035 yearly projections which were then updated to suit the master plan projection years which is detailed in section 3 of this report.

2.3 PHASE 2: LOADING

Loading for the wastewater model is the process of allocating sanitary flow to model elements such as junctions and storage nodes in order to represent the daily flow experienced and expected from the real system. The loading method selected for the 2015 Master Plan was to allocate dry-weather sanitary loading using billed water consumption data from water meter records. This information reflects current empirical data that is a localized representation of sanitary flow when a water demand adjustment factor is applied, however it is to be noted that this representation is also a limitation of the trunk sewer model since loading is required to be applied and adjusted to model junctions often located downstream of larger catchment areas. The application of diurnal patterns allows for the effective use of this method to account for the delay of sanitary flow expected to occur for receiving junctions in the model.

The demand adjustment factor is an important step when using water meter records since it is assumed that not all water demand discharges directly into the sanitary sewer. It may be assumed that in general a range of around 60-80% of the total drinking water volume distributed and used by consumer's transfers to sanitary sewers (Briere F G., 2014). This however is greatly dependent on user functions since direct transference is often seen for general uses such as with bathroom fixtures, while watering lawns would have no direct transference to sanitary sewers. To determine reasonable assumptions of water demand adjustment a review of the City's zoning and land use designation was conducted to make the following demand adjustment assumptions.

- → Residential Meters = 80% Water Demand Adjustment
- → Commercial Meters = 80% Water Demand Adjustment
- → Institutional Meters = 80% Water Demand Adjustment
- → Industrial Meters = 75% Water Demand Adjustment
- → Open Space/Park Meters = 25% Water Demand adjustment

A more detailed review of demand adjustments used to create the 5 main categories presented above and how these adjustments are applied in the InfoSWMM model is exhibited in Appendix F.

2.3.1 LOADING DATA REVIEW AND MODEL ALLOCATION

Using the demand adjustment factors described previously the model was loaded using the 'meter summation' method. This method is a built-in process using InfoSWMM's dry-weather flow allocator tool which assigns each meter record to an appropriate model junction while simultaneously applying the demand adjustment factor and assigning a pre-defined diurnal pattern. The meters of similar classification, such as 'residential' water meters, are then summed together to get a single load (L/s) by classification type per junction as applicable. An example of how the model allocates this allocation is detailed in Figure F-1 of Appendix F.

While the model is loaded with diurnal pattern labels during the loading phase, they are only for the purposes of assigning different dry-weather flow types with a representative classification for its land use designation at this stage. The initial diurnal patterns were then loaded into the InfoSWMM model through a review of

SCADA flow data. Flow readings from monitoring locations around the City were used to generate daily diurnal patterns by area. The analysis focused only on dry weather flow in an attempt to capture the pattern resulting from system users, minimizing the impact of inflow and infiltration. The following Figure 2-2 shows the compiled diurnal pattern results of the data for the City. Further diurnal pattern development details are documented in Appendix G.

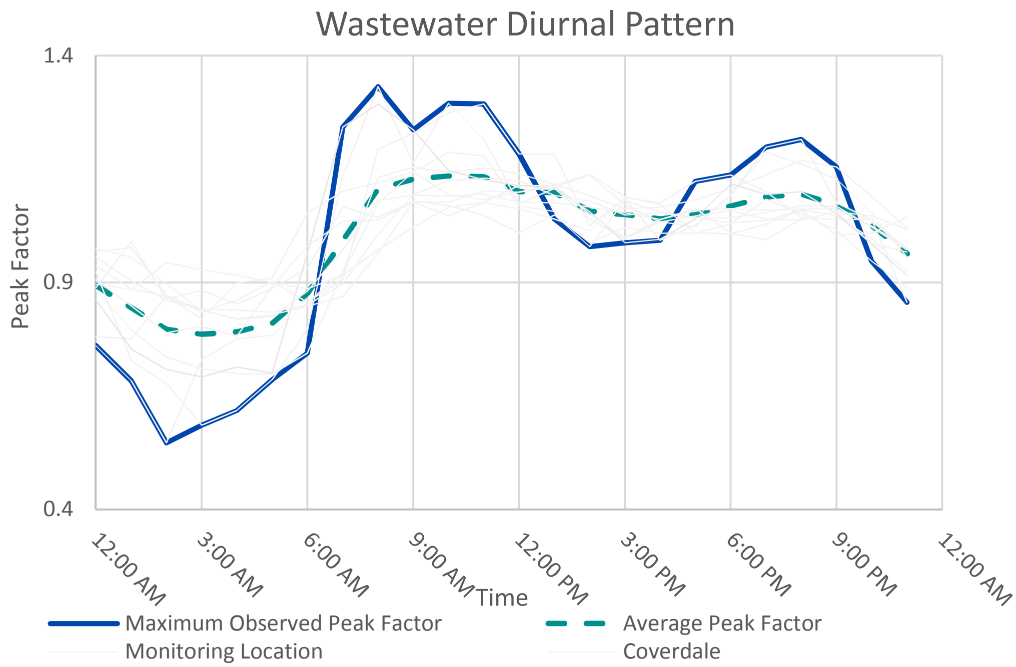

Figure 2-2 Initial Wastewater Diurnal Pattern Development by Area

It is to be noted from Figure 2-2 Initial Wastewater Diurnal Pattern Development by Area

that the patterns vary greatly throughout the city which is a typical representation of areas which represent only one dominant land use type such as industrial or residential properties. It was observed that the peaking factors range from 0.55 to 1.33 over the course of a typical dry-weather day overall. The average peak of the system is plotted along with the maximum observed peak factor (or minimum if below 1). During a 'dry' day the system experienced an inflow from ground water and other factors which dampen the amplitude of user demand. Initial diurnal patterns were applied to junctions during the loading phase by representative areas.

Reviewing the data further it was determined that applying a combination of calculated and typical diurnal patterns for each land use category would provide a more appropriate representation given how localized each water meter is to its junction allocation. The final patterns used for modelling were developed in the calibration phase as detailed in section 2.4 of this report and is found in Appendix I.

2.3.1.1 LOADING ADJUSTMENTS FOR KINGSTON EAST PROPERTIES

Unlike the majority of the City the water demand adjusted sanitary flow applied in the East was calculated for a large portion of the area using a single billed water meter which is representative of the Canadian Forces Base (CFB) properties. In conjunction with the water modelling exercise, new representative meters were created and applied to buildings throughout these properties to account for the approximate location where sanitary flow would be applied in the system. An estimate of the flow for each meter applied was based on an analysis of the land use designations for buildings based on the areas reported in the *Water Supply Master*

Plan – 2013 Update for the Kingston East Water System (CH2MHILL, 2014). The final summary and calculation of flows adjusted in Kingston East for these properties are detailed in the Water Modelling report.

2.3.2 SANITARY CATCHMENTS FOR LOADING

As described in section 2.3.1 and detailed in Appendix F each water meter was allocated to an appropriate model junction based on its location in the Kingston Sanitary sewer system as determined from UK's sanitary catchment GIS layers and orthographic imagery. In order to satisfy the loading requirements for the 'meter summation' method a new Sanitary Catchment shapefile was developed which was also reviewed and tailored to be suitable for other modelling processes including the update to combined sewer catchment areas, RDII junction allocation and future development flow allocation. The synergies of developing a single 'Sanitary Catchment' loading file for these master plan model elements ensured that each junction received the same allocation across modelled scenarios and that distinctions were made between the water and sanitary servicing areas. This distinction ensured that water meters located outside of the catchment boundary were excluded from the model loading since it is not anticipated water used in these locations would transfer to sanitary sewer.

2.3.3 LOADING CHECKS AND BALANCES

To finalize the loading phase a series of checks and balances were completed to ensure that the dry-weather allocated fell within the range of demand adjustment and paired closely with the water consumption flow generation by area. The following Table 2-3 summaries the preliminary water balance observations which is further detailed in Appendix I.

Table 2-3 Phase 3: Loading Checks and Balances Summary

WWTP	WASTEWATER BALANCE USNING DEMAND ADJUSTED 2014 BILLED WATER METER DATA			
	Historical Average Day Flow (2014) (m^3/day)	Billing Data Total (m^3/day)	Total Metered Flow After Demand Adjustment) (m^3/day)	% Total Metered Flow vs Historical Average Day
Cataraqui Bay	27,145	11,178	8,946	33%
Ravesnview	60,919	24,472	19,420	32%

The difference between dry-weather flow allocated and the average dry weather flows using the WWTP annual reported summaries by month are used in part to complete the next phase of the model update which is the calibration. Dry-weather loading is amended with base infiltration and inflow during this phase as well as an adjustment to diurnal patterns.

2.4 PHASE 3: CALIBRATION

The next phase in model updates after loading the model and when preliminary checks and balances were completed is calibration. This is completed to ensure that the updated model provides accurate representations of the sanitary system suitable for simulating various scenarios including major wet-weather events.

2.4.1 CALIBRATION PROGRAM

The calibration program involves the adjustment of model parameters for dry-weather and wet-weather conditions in order to represent sanitary inflows as compared to actual empirical data as a means to ensure effective representation of the trunk sewer system using defined methodologies and assumptions. This is an iterative process involving the evaluation of the current available data for 2013 and 2014 used from the model update and loading phase and additional researched sources. The calibration results are compared directly with the calibration/validation program targets based on the master plan objectives as summarized in Table 2-4. Further calibration program and a summary of calibration sub-tasks are included in Appendix H.

Table 2-4 Phase 3: Loading Checks and Balances Summary

TRUNK SEWER SYSTEM CALIBRATION TARGETS
Dry-Weather Targets: → Simulated dry-weather peak flows and volumes to be within ±5% of observed values → The timing of simulated peak dry-weather flows to be within 1 hour of observed values Wet-Weather Targets: → Simulated peak wet-weathers flows to be within ±15% of observed values → Simulated wet-weather events volumes to be within ±10% of observed values
COLLECTOR SEWER SYSTEM CALIBRATION TARGETS
Dry-Weather Targets: → Simulated dry-weather peak flows and volumes to be within ±10% of observed values → The timing of simulated peak dry-weather flows to be within 1 hour of observed values Wet-Weather Targets: - Simulated peak wet-weathers flows to be within -15% of +25% of observed values Simulated wet-weather events volumes to be within -10% to + 20% of observed values.

To initialize the calibration process the model was first updated from its 2013 condition for all dry-weather inflows which were updated during the loading phase as described in section 4. The dry-weather calibration method was then selected by updating infiltration, inflow and diurnal patterns with minor adjustments to infrastructure representations as required in order meet the pre-defined program targets.

2.4.2 DRY-WEATHER CALIBRATION

The dry-weather calibration includes the input of base infiltration and inflow rates which are to be added from the loading process. Basic diurnal flow patterns are developed at this stage to represent the unique characteristics across the City by comparing to water consumption data trends. Since the model is dynamic, dry-weather periods are compared with actual flow monitoring data when no rainfall is experienced over a course of a week to ensure no residual wet-weather effects are observed during dry-weather calibration. In summary the following dry-weather periods were selected for calibration and validation as shown in Table 2-5.

Table 2-5 Dry-Weather Event Calibration Event Dates

MAIN CALIBRATION DRY-WEATHER EVENTS	
July 23-26, 2014	March 24-30, 2013 (validation)
SECONDARY DRY-WEATHER EVENTS (USED FOR SEASONAL VARIATION CALIBRATION)	
2014	2013 (Validation)
January 20-25	January 20-25
February 23-28	February 5-11
March 23-28	April 2-7
April 19-22	May 18-21
May 26-31	June 18-22
June 7-11	July 25-30
August 25-30	August 5-9
September, 25-30	September, 25-30
October 20-25	October 10-13

It is to be noted from Table 2-5 above that the main dry-weather event selected for calibration is taken from an assumed dry month which was later verified from monthly rain data. A dry month represents a period during the year when the least amount of baseline I&I flow was observed. This month was then selected so that seasonal variation adjustments may be applied on a monthly basis to account for the observations of increased base dry-weather flow during wet periods of the year, such as the spring, when daily flows were observed to be higher on average and in relation to reported average day flows for WWTP.

Later in wet-weather calibration, the use of the dry-month allows for the effects of wet-weather calibration to be applied to observe the system as it responds to single and compounded rain events. With the selection of dry-weather calibration periods the base infiltration and inflow was then applied using a systematic approach.

2.4.2.1 DRY-WEATHER CALIBRATION

The method of assigning dry-weather Infiltration and Inflow (I&I) selected for calibration was based on using the latest available data sources pertaining to the state of the linear infrastructure to assign each model junction representing sanitary maintenance holes with a representative baseline infiltration rate. Sources of I&I vary greatly by location, but there is often a common relationship between the age and material of the linear infrastructure such as sanitary pipes. This relationship correlates to the amount degradation of pipes that may occur over time such that the potential increase in pipe cracking and joint displacement may occur and lead to the increased infiltration (Briere F G, 2014). Inflow from extraneous sources are then applied in addition to adjustments made from this process for different areas on a case-by-case bases until calibration targets for dry-weather peaks and volumes were achieved.

Researching the MOE and City of Kingston design standards for typically accepted I/I design rates (0.028L/s/ha and 0.014L/s/ha respectively) a new set of baseline infiltration ranges were applied after conducting a review of GIS data which contained data sets of documented and known information of sanitary pipe age and material for the City's sewer system. The City's linear infrastructure was divided into representative pipe group areas as shown in Figures I-1 to I-4 of Appendix I. The model was then updated iteratively for each model junction using a designated pipe group range as summarized in Table 2-6.

Table 2-6 Pipe Age/Material Group I&I Adjustment Factors for Calibration

PIPE AGE AND MATERAIL GROUP	TRUNK MODEL I&I RATE (L/S)
0-35 Years Old	0.0 - 0.6
Concrete	0.05 - 0.5
Plastic	0.0 - 0.4
Other or Unknown Materials	0.05 - 0.6
35-75 Years Old	0.1 - 1
Concrete	0.2 - 1
Plastic	0.1 - 0.5
Other or Unknown Materials	0.1 - 1
>75 Years Old	0.1 - 2
Concrete	0.2 - 2
Plastic	0.1 - 2
Other or Unknown Materials	0.2 - 2

It is to be noted that rates shown in Table 2-6 were developed specifically for a trunk sewer representation and is an assumed range based on the pipe groups and areas. This is an important consideration since every model junction represents different sizes of sanitary catchment areas and groups of pipe materials. The ranges presented were not used as the firm I&I restrictions for each node, but rather used as the guiding principle for calibration adjustments to ensure that area's in the model representing infrastructure of similar age and materials received the same I&I adjustments.

In addition to the pipe group adjustments the following extraneous inflow additions, as presented in Table 2-7, was added to specific model junction and storage nodes to meet desired calibration targets on a case-by-case basis where it was observed that additional baseline infiltration was being observed outside of the adjustment factor ranges used for calibration.

Table 2-7 Model Addition of Extraneous Inflow by Location

MODEL ELEMENT ID	ADDED INFLOW (L/S)	LOCATION/DESCRIPTION
Junction ID: 9431031	15	Notch Hill PS Area – North End Trunk Sewer Calibration
Storage ID: 33002	11	King St. CSO Tank – To meet tank filling level observations
Junction ID: 9716010	10	Notch Hill PS Area – North End Trunk Sewer Calibration
Junction ID: 232010	4.5	North End Outlet Trunk Sewer
Junction ID: 4	4.5	Barret Crt PS Wet Well

Adjustments to I&I were further refined until preliminary model simulations for the dry-weather calibration periods showed flows and volumes within the calibration targets for average dry-weather. The final adjustments were made to the baseline I&I after updating diurnal patterns and accounting for seasonal variation.

2.4.2.2 DIURNAL PATTERN ADJUSTMENT AND PERIODIC CALIBRATION

After calibration of average flows and volumes the original diurnal patterns from the loading phase are updated in the model to achieve the periodic calibration targets at key locations within the trunk sewer model as well as the high and low flow peaking. Matching diurnal patterns to reflect the sanitary system responses is often applied by different methods by using a combination of area pattern representations and/or land use designation patterns. The direct dry-weather loading of the trunk sewer typically fluctuates at any given model junction since it is assumed that the sanitary flow does not reach the trunk sewers at the same time. To achieve the best match for calibration the patterns were updated for each dry-weather flow value based on its land use designation and specific water meter location. This process was synergistic with the water modelling calibration work which also applies the same demand diurnal patterns since there is a strong relationship between water consumption and its transference into the sanitary sewer. It is to be noted that a pattern for Industrial, Commercial and Institutional (ICI) properties is based on a researched range which was found to match closely to the Kingston system. The final patterns selected for the model are summarized in Figure 2-3.

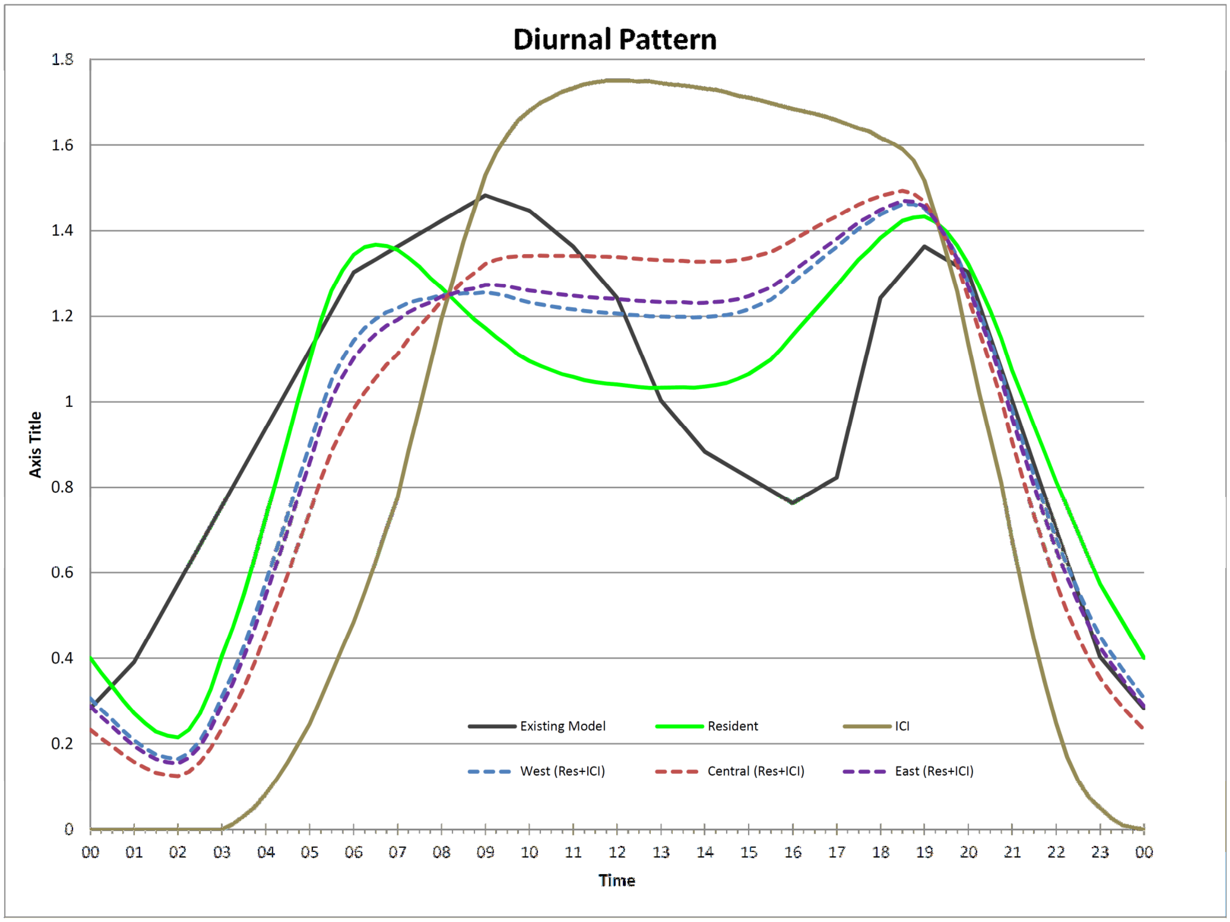

Figure 2-3 Final wastewater Diurnal Patterns by Area and Land Use

As shown in Figure 2-3 the relationship between ICI and Residential meters account for the twin peaks being slightly offset from demand residential patterns alone. The twin peaks represented are a very common sanitary pattern for many municipalities representing the increase of wastewater production by consumers during periods before and after the work day at residential locations. This information correlated closely with the original diurnal patterns derived from empirical data presented earlier in Figure 2-2 of section 2.3.1. After application of the diurnal patterns the calibration targets were achieved in the model for all key calibration locations in the model as shown in Figures I-5 & I-6 in Appendix I. A final review of weekday and weekend peaking factors was conducted and it was found that the model also showed a strong representation for varying weekdays which were within the calibration target range of 1-hr of observed peaking flows.

The final dry-weather calibration graphs are shown in Appendix I for the July 23-26 dry-weather period. These results show the model simulation outputs as compared to the actual 2014 monitoring data and includes the results after the final adjustments to baseline I&I. Overall the results form dry-weather calibration for the selected period shows good calibration through-out the trunk sewer model. Tighter fitting peak flow calibration was achieved for trunk sewers and facilities such as primary pumping stations and WWTP while collector sewers and secondary pumping stations also showed a good fit in comparison to the their respective calibration targets.

2.4.2.3 SEASONAL VARIATION OF DRY-WEATHER

As an additional step to dry-weather calibration to achieve a better representation of model simulation during other dry-weather periods throughout the year was to apply to each node in the model and allocated seasonal variation adjustment factor to globally represent this variation of baseline I&I to account for wetter than average months. The method selected for this approach was to apply additional flat-rate I&I to existing nodes using a time series which is a common approach using InfoSWMM's flow allocation tools. In the previous version of the model a seasonal multiplier factor was applied to only months where higher than expected flow was observed. In the 2015 model update the flat-rate I&I additions using a time series was applied by comparing the 2013 and 2014 flow data on a monthly bases using the secondary dry-weather events presented previously in Table 2-5. The final monthly adjustments are presented in Table 2-8.

Table 2-8 Seasonal Variation Adjustments by Month

MONTH	SEASONAL VARIATION ADJUSTMENT (L/S) (MP-SEASONAL)	DATA OBSERVATIONS
January	0.1	Observed Wet Month during assumed Snow Pack Conditions
February	0.15	King St. CSO Tank – To meet tank filling level observations
March	0.33	Observed highest baseline flow in 2014
April	0.15	Observed highest baseline flow 2013
May	0.1	Seasonal wet periods from spring rain event loading. Large variation between June 2013 and June 2014 data.
June	0.05	King St. CSO Tank – To meet tank filling level observations
July	0	These months for both 2013 and 2014 showed consistent dry-weather flow ranges within 25% of each other.
August	0	King St. CSO Tank – To meet tank filling level observations
September	0.05	King St. CSO Tank – To meet tank filling level observations
October	0.05	Notch Hill PS Area – North End Trunk Sewer Calibration
November	0.05	Limited data available
December	0.1	Limited data available

It is to be noted from Table 2-8 that the flat-rate adjustments were applied based on observation of WWTP inflow data. The final results as compared to this data are presented in Appendix I. While the seasonal variation rates are applicable to the Kingston West, Central and East systems as a whole, it is also to be noted that this approach provides a global adjustment only to the model and variation from wet-weather from specific rain events is conducted in the wet-weather calibration process on an area-by-area basis.

2.4.2.4 DRY-WEATHER CHECKS AND BALANCES

To ensure that model elements represent infrastructure correctly though calibration many checks and balances were conducted in-conjunction with I&I rate and diurnal pattern adjustments. The final details are shown in Appendix I. In summary, the methodology used for infrastructure is based on a wastewater mass balance approach.

2.4.2.4.1 FACILITIES

Facilities including WWTP and PS provide the anchors in the trunk sewer model for appropriate model simulation to represent the current system based on operations. The 2015 master plan update includes the addition of secondary pumping stations and greater system detail was achieved when adjustments to pumps and forcemains were made to account for minor losses researched and documented in the facility summary sheets. The predominant calibration adjustments for facilities are based on comparing the SCADA data for flow and level with model outputs and using available in-line flow monitor data both upstream and downstream of the facilities when data was unavailable. Summary of output assumptions through calibration for pumping station facilities are summarized in Table 2-9 and 2-10 and the detailed calibration graphs are included in Appendix I.

Table 2-9 Kingston West Pumping Station Calibration Adjustments and Comparisons

FACILITY	SCADA DATA	NO. OF PUMPS	SIMULATED DRY WEATHER AVERAGE PUMP RATES (L/S)	C OF A/ECA OR INDICATED RATE* (L/S)	DATA OBSERVATIONS
Bath Rd	Yes	2	25.5	51.4	Calibrated to SCADA data flow range
Bath-Collings Bay Rd	No	2	19.5	18.0	Calibrated to SCADA data and downstream flow Monitor W10
Bath-Lower Dr	No[1]	2	2.5	6.3	Calibrated based on downstream flow at Ranking and Hillview PS.
Bayridge Dr	No	2	24.3	23.0	Calibrated based on downstream flow at Lakeshore PS.
Collings Bay Rd	No[1]	2	21.6	22.0	Calibrated based on downstream flow at Hillview PS.
Coverdale Dr.	Yes	2	58.9	52.6	Close fit between CofA and reported observed flow. Calibrated to SCADA data flow range and downstream flow Monitor W8
Crerar Dr.	Yes	2	15.9	77.0	Calibrated to SCADA data flow range. Observed and modelled flow lower then reported CofA Firm Rate
Days Rd	Yes	4	248.6	1008.0	Calibrated to SCADA data flow range. Multiple upstream and downstream flow monitors. Multiple pumps operate on set-points to simulate VFD range of flow.
Hillview Rd	Yes[1]	2	149.2	192.0	Select dates and minute data used to calibrate PS along with downstream flow at Monitor W8 and W1
John Counter Blvd	Yes[1]	2	54.6	50.6	Calibrated to SCADA and downstream flow at monitor W10
Lakeshore Blvd	Yes	2	127.2	126.0	Calibrated to SCADA data and based on downstream flow at Cataraqui WWTP. Flow range closer to Firm Rate
Ranking Cres.	No[1]	2	21.3	19.1	Calibrated based on downstream flow at Hillview PS.
Westbrook Rd	No	2	13.8	14.6	Calibrated based on downstream flow at Hillview PS and upstream flow at Monitor W9

* Based on data or historical draw down test provided by UK
1 –More Limited SCADA data ranges or anecdotal station data available
2 – Only Level Monitoring Data

Table 2-10 Kingston Central/East Pumping Station Calibration Adjustments and Comparisons

FACILITY	SCADA DATA	NO. OF PUMPS	SIMULATED DRY WEATHER AVERAGE PUMP RATES (L/S)	C OF A/ECA OR INDICATED RATE* (L/S)	DATA OBSERVATIONS
Dalton Ave	Yes	4	162.9	1114.0	Multiple pumps operate on set-points to simulate VFD range of flow. Calibrated to SCADA data and upstream Monitor C1 and downstream Monitor C15
Greenview Dr.	Yes	2	53.2	47.3	Calibrated to SCADA data and adjusted based on downstream flow Monitor C12
Hatter St.	No	2	8.2	N/A	Station decommissioned in 2015
King St.	Yes	4	318.8	726.0	Multiple pumps operate on set-points to simulate VFD range of flow and model uses Real-Time Controls (RTC) to simulate relationship with O'Kill Tank and West St. CSO Level. Calibrated to SCADA data
King-Elevator Bay	Yes[1]	2	82.1	88	Calibrated based downstream flow Monitor C18. Range closer to Firm Rate
King–Lake Ont. Park	Yes[2]	2	12.9	12.6	Calibrated based on downstream flow Monitor C18. Range closer to Firm Rate
King-Portsmouth	Yes	3	273.5	285.0	Calibrated based on SCADA data and upstream flow Monitor C18.
Morton St.	Yes[1]	2	21.2	18.0	Calibrated to SCADA. A closer fit between CofA and reported observed flow.
Palace Rd.	Yes	2	60.9	51.0	Multiple pumps operate on set-points to simulate VFD range of flow. Calibrated to SCADA data.
River St.	Yes	4	1039.2	1260.0	Calibrated to SCADA data. Multiple pumps operate on set-points to simulate VFD range of flow and model RTCs to simulate manual pump operations
Yonge St.	No	2	6.1	4.0	Calibrated based on downstream flow Monitor C22
Barrett Ct	Yes[1]	3	178.9	205.0	Calibrated to SCADA data and upstream flow monitor E1
Highway 15	Yes	2	52.3	54.0	Calibrated based on SCADA data. Range closer to Firm Rate
James St	Yes	3	53.8	74.0	Calibrated to SCADA data and downstream flow at Ravensview WWTP.
Kenwoods Circle	N/A[1]	2	29.7	38.0	Calibrated based on downstream flow Monitor E1.
Schooner Dr.	No	2	17.6	18.0	Calibrated based on downstream flow Monitor E2

* Based on data or historical draw down test provided by UK
1 – More Limited SCADA data ranges or anecdotal station data available

For the WWTP a preliminary wastewater mass balance check was completed after adjustments to I&I and PS facilities were made which is documented in Appendix I. The WWTP received the majority of calibration checks to ensure that the total flow volumes observed at these location were representative of the dry-weather simulation period. In summary Figures 2-4 & 2-5 show the relationship between the calibrated model outputs (red) and the calibration dry-weather timeframe (blue) of July 23-26th, 2014.

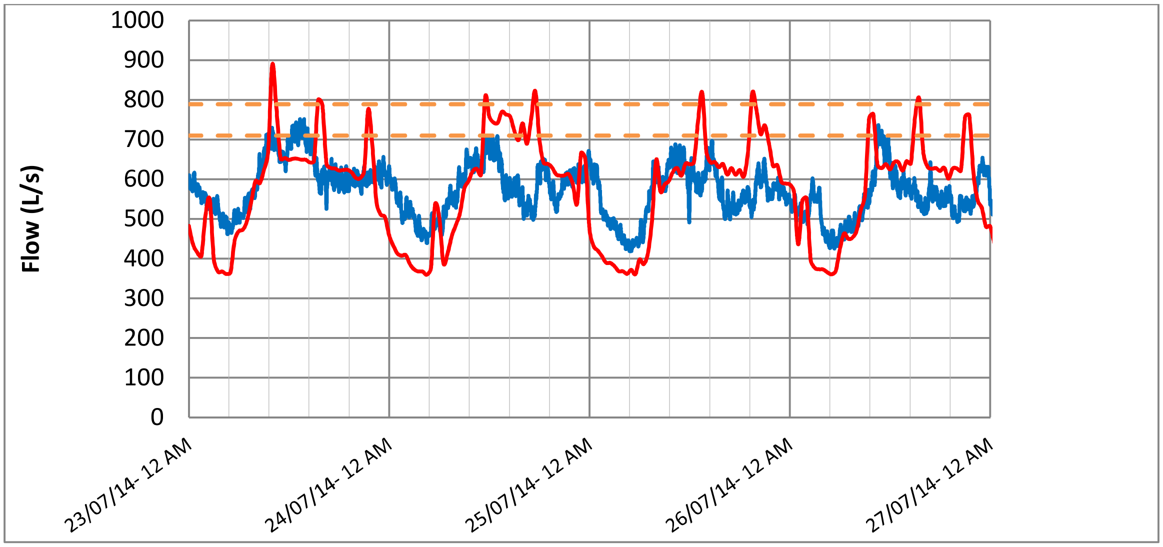

Figure 2-4 Ravensview Dry-Weather Period Calibration Graph

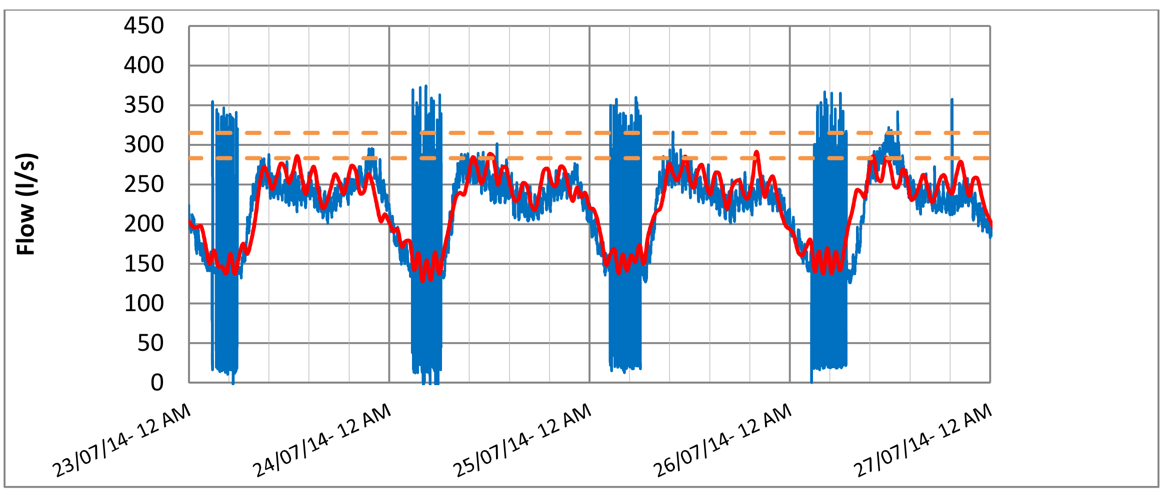

Figure 2-5 Cataraqui Bay Dry-Weather Period Calibration Graph

As a general note from observing Figure 2-4 and Figure 2-5 it is to be described that the final calibration is taken from adjustments and review of multiple date ranges as indicated in Table 2-5. This means that general conformance to calibration is represented in the graphs as indicated by the upper calibration range (orange) however the variations between actual recorded data (blue) and model simulated results (Red) are typical to vary between seasonal dates. This also allows for data discontinuities, such as the sporadic flows observed in the actual data for Cataraqui Bay during low flow periods as shown in Figure 2-5, to be accounted for in calibration such that the average calibration targets are achieved for multiple date ranges.

From these results the overall dry-weather calibration provides a very good fit within calibration targets for flow for WWTP's. The final checks for dry-weather calibration are related to optimizing linear infrastructure.

2.4.2.4.1 LINEAR INFRASTRUCTURE

To calibrate linear infrastructure minor adjustments were made to model representations for pipe infrastructure from the original data derived from the GIS and as-built data incorporated in the original model. The addition of new trunk sewers and forcemains for secondary pumping stations, predominately in Kingston West, were given the most attention to ensure that their representation reflected nearby in-line flow monitor data. The following Table 2-11 shows a summary of the main cases where linear infrastructure was adjusted to better simulate the sanitary system response during dry-weather calibration. Detailed calibration graphs are included in Appendix I.

Table 2-11 Linear Infrastructure Adjustments for Model Calibration

LINEAR INFRASTRUCTURE	ADJUSTMENT	RATIONALE
North West Collector	Connecting Conduit CDT-1468 height adjustment	Adjusted to Calibrate Monitor W1
McKay Street Diversion	Conduit P497 between Junction 33022021 & 33022011 height adjustment	Adjusted to Calibrate Monitor W31 & W32
PCP#2 and PCP#65	Minor losses applied to connecting Conduit P788	Adjusted to Calibrate PCP#2 and PCP#65

2.4.2.4.2 COMBINED SEWER OVERFLOWS AND CATCHMENT AREAS

The methodology for calibrating CSO's, SSO's and PSO's was through review and comparison of documented overflow event volumes and frequencies. For select locations there is a large amount of data available from Flowworks.com and available SCADA data that was used to compare to model simulated results.

Given that these system infrastructure components function during wet-weather events the final calibration of their model representation adjustments is completed in the next phase of calibration.

2.4.3 WET-WEATHER CALIBRATION

The wet-weather calibration method selected involves adjustment of model parameters in order to represent the sanitary systems dynamic flows as compared to documented flow/level monitoring data during rainfall periods using rain-derived infiltration and inflow (RDII). This step is important for calibration to ensure that overflows and eye-witness accounts are being simulated in the model and that combined sewer areas appropriately reflect the storm water loading during these rain events. The wet-weather calibration also better equips the model for representing separated sewer areas such as Kingston West and East where flow monitoring indicates delayed response from rainfall in addition to base dry-weather infiltration and inflow. The first step of this calibration included a review and update to the models rain catchment areas. The final results for wet-weather calibration and representative rain event periods selected over two years of rainfall data is found in Appendix J

It is to be noted that the previous version of the InfoSWMM model was originally calibrated to various rain events during 2013 which was considered a typical year for rain fall when comparing the total volume of rainfall with previous years. 2014 rainfall was also found to be a typical rainfall year and wet-weather events for February, May and August were selected to represent a range of events with seasonal variation.

Table 2-12 Wet-Weather Calibration Events

MAIN CALIBRATION WET-WEATHER EVENTS

2014	2013 - (validation)
July 23-26	February 26-28
August 9-16	May, 19-26
July 23-26, 2014	June, 5-19

To update the model separate from dry-weather calibration model parameters, the use of rain catchment areas and Rain-Derived infiltration and inflow solvers are used in InfoSWMM which utilizes the EPA SWMM solver for rain data inputs. The researched rain gage data as described in section 2.2.2.1 for 2014 is used.

2.4.3.1 RAIN CATCHMENT AREAS AND COMBINED SEWER AREA SET-UP

Rain catchment areas are used as one means to simulate rainfall influences using the EPA SWMM solver functions. In InfoSWMM for each model node junction/storage element there was a catchment area representation created in the last model update and catchment area parameters were then adjusted to calibrate the model. The use of subcatchments in the model however provides only a limited amount of representation and requires many assumptions about how the catchment areas assets, such as the total km of pipes, would likely receive rainfall influence. This also limits the long dynamic relationship of rainfall loading into sanitary sewers from delayed runoff or infiltration over long time steps.

To update the model to use the RDII solver all catchments were updated save and except catchments representing combined sewer areas. The non-combined sewer areas where updated to represent no rainfall influence by setting their representative area to zero since the allocation of RDII in the model will account for these locations. Another method to perform this update would be to simply delete the subcatchments from the model; however the area boundaries provide valuable information about what contributes to each individual model element. The combined sewer catchment areas were then updated based on area, width and imperviousness using the latest Ariel photography. (The width parameter is a calibration factor to represent the peakiness of rainfall influence and is estimated for each catchment area.)

Since the EPA SWMM solver may generate wet-weather loading from both the RDII and subcatchment solvers simultaneously it was decided to retain these combined sewer catchments since it allows for their individual separation for master plan projection year model simulation. The final combined sewer catchment parameters adjusted in the model are presented in Appendix J.

2.4.3.2 RAIN-DERIVED INFILTRATION AND INFLOW (RDII) ALLOCATION AND CALIBRATION

The main approach selected to represent the dynamic rainfall response of the sanitary system was to use RDII R-T-K Hydrographs. These hydrographs are used in the EPA SWMM solver to represent the rainfall loading into the sanitary system using the combination of short, medium and long term responses intended to represent the natural behaviour of direct rainfall runoff, delayed rainfall runoff with initial infiltration, and saturated ground infiltration over a longer time period respectively. Figure 2-6 illustrates the typical variation between R-T-K Hydrographs used and how the total RDII hydrograph is generated for rainfall flow simulation in the model.

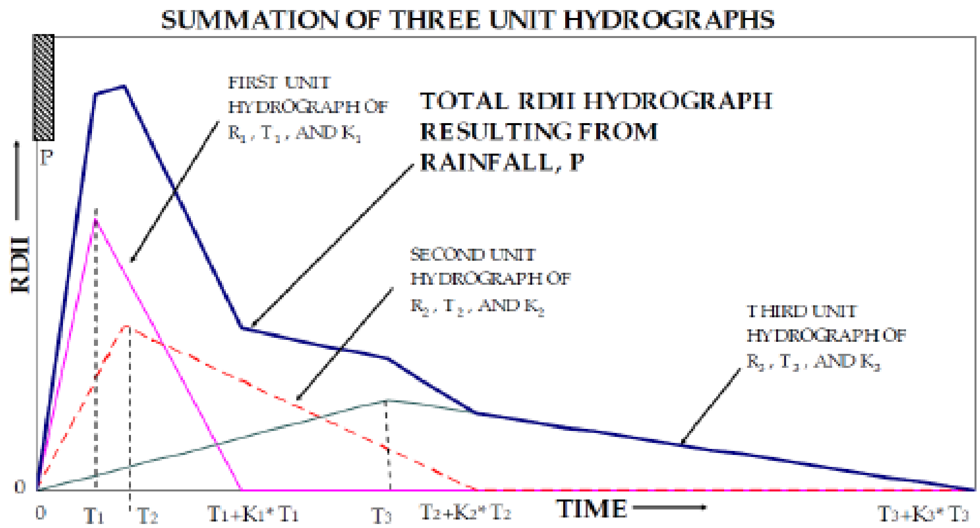

Figure 2-6 R-T-K Synthetic Hydrographs *(Vallabhaneni et al, 2007)*

The InfoSWMM modelling software uses the RDII as one of the tools for the EPA SWMM solver and it provides a large amount of customization for unique rainfall responses based on area and location. RDII was first allocated in the model using the subcatchment shapefile previously created for the loading phase. This allocation process assigned a new R-T-K hydrograph group representation based on the catchment area size for each model element and wet-weather calibration was based on adjustment of these for Kingston West, Central and East. In cases where these base R-T-K graphs did not adequately represent an area, such as for a secondary pumping station catchment area, a unique hydrograph group was created to represent it in the model. This process continued iteratively until the areas represented real world system responses to wet-weather. The final hygrographs used in the model are presented in Appendix J, the following tables 2-13 and 2-14 provides a summary of the hydrographs allocation and their model representation based on available data.

The adjustment of R-T-K parameters was made to ensure that calibration targets were achieved to reflect the anecdotal information provided from UK staff in combination with flow monitoring data. It is to be noted that the target ranges for wet-weather varies for collector and trunk sewer areas and higher emphasis was made to calibrate trunk sewer area's which received more upstream wet-weather flow. The final calibration results for the calibration months are presented in Appendix J. Overall the results are a good representation of simulation results to flow and volume data. A series of checks and balances were then conducted to ensure facilities and linear infrastructure

Table 2-13 Wet-Weather R-T-K Hydrograph Allocation Summary – Nodes

R-T-K HYDROGRAPH MODEL LABEL	MODEL NODES REPRESENTED	KINGSTON AREA REPRESENTED	AREA SIZE/RANGE (HC)	DATA OBSERVATIONS
HYDRO-W-T	144	West	0.14 – 1	Moderate direct influence from rainfall. Delayed response from infiltration
HYDRO-W-S	91	West	1 – 5	
HYDRO-W-M	55	West	5 – 25	
HYDRO-W-L	23	West	25 – 100	
HYDRO-W-VL	3	West	100 – 350	
HYDRO-E-T	2	East	0.6 - 1	Minor direct influence from and little to no delayed response from infiltration
HYDRO-E-S	6	East	1 – 5	
HYDRO-E-M	10	East	5 - 25	
HYDRO-E-L	7	East	25 - 100	
HYDRO-E-VL	1	East	182	
HYDRO-C-T1	47	Central	0.6 - 1	Moderate direct influence from rainfall. Moderate response form infiltration
HYDRO-C-S	47	Central	1 - 5	
HYDRO-C-M	38	Central	5 - 25	
HYDRO-C-L	17	Central	25 - 100	
HYDRO-C-VL	2	Central	100 – 115	
HYDRO-C-O-T	30	Central	0.17 - 1	Large direct influence from rainfall. Moderate response form infiltration. Represents select nodes representing older pipe areas within Central Area.
HYDRO-C-O-S	22	Central	1 – 5	
HYDRO-C-O-M	9	Central	5 - 25	
HYDRO-C-O-L	6	Central	25 – 100	
HYDRO-C-H-T	3	Central	0.2 – 1	Large direct influence from rainfall. Heavy response form infiltration. Represents select nodes from Harborfront Area
HYDRO-C-H-S	17	Central	1 – 5	
HYDRO-C-H-M	7	Central	5 - 25	
HYDRO-C-H-VL	1	Central	138	

Table 2-14 Wet-Weather R-T-K Hydrograph Allocation Summary – Pumping Stations

R-T-K HYDROGRAPH MODEL LABEL	KINGSTON AREA REPRESENTED	AREA SIZE/ RANGE (HC)	DATA OBSERVATIONS (REFERENCED OR ASSUME DATA USED)
HYDRO-W-WESTBROOKE	West	65.1	In-line flow monitor readings
HYDRO-W-VL-BATH	West	45.3	SCADA data & downstream flow
HYDRO-W-S-BATH-LOWER	West	4.0	Assumed response using downstream flow
HYDRO-W-M-BATH-CB	West	8.7	Assumed response using downstream flow
HYDRO-W-L-JOHNCOUNTER	West	10.9	Based on SCADA data & downstream flow
HYDRO-W-L-DAYS	West	51.6	SCADA data, upstream & downstream flow
HYDRO-W-L-CRERAR	West	61.8	SCADA data & downstream flow
HYDRO-W-BAYRIDGEPS	West	288.4	Assumed response using downstream flow
HYDRO-E-M-KENWOODS	West	7.9	Assumed response using downstream flow
HYDRO-E-L-SCHOONER	West	33	Assumed response using downstream flow
HYDRO-E-L-PS	East	25 - 100	Represents Barret Crt & HWY 15 PS
HYDRO-C-T-YONGE	Central	0.9	Assumed response using downstream flow
HYDRO-C-S-NOTCHHILL	Central	2.1	Assumed response using downstream flow
HYDRO-C-M-PALACE	Central	22.1	SCADA data & downstream flow
HYDRO-C-M-MORTON	Central	11.7	Assumed response using downstream flow
HYDRO-C-M-KING-LOP	Central	15.2	Assumed response using downstream flow
HYDRO-C-M-KING-EB	Central	9.7	SCADA data & downstream flow
HYDRO-C-L-GREENVIEW	Central	34	SCADA data & downstream flow

2.4.3.2.1 KINGSTON WEST OBSERVATIONS

In the Kingston West area serviced by the Cataraqui Bay WWTP there is in general a limited response from rainfall being that the sewer represents a separated storm and sanitary system with no combined sewers. The Kingston West system does have large areas with aging pipe infrastructure which is commonly located in residential areas and the observed flow monitoring data does show initial rainfall runoff responses which result in increased total flow. A typical wet-weather response in this system is shown in Figure 2-7.

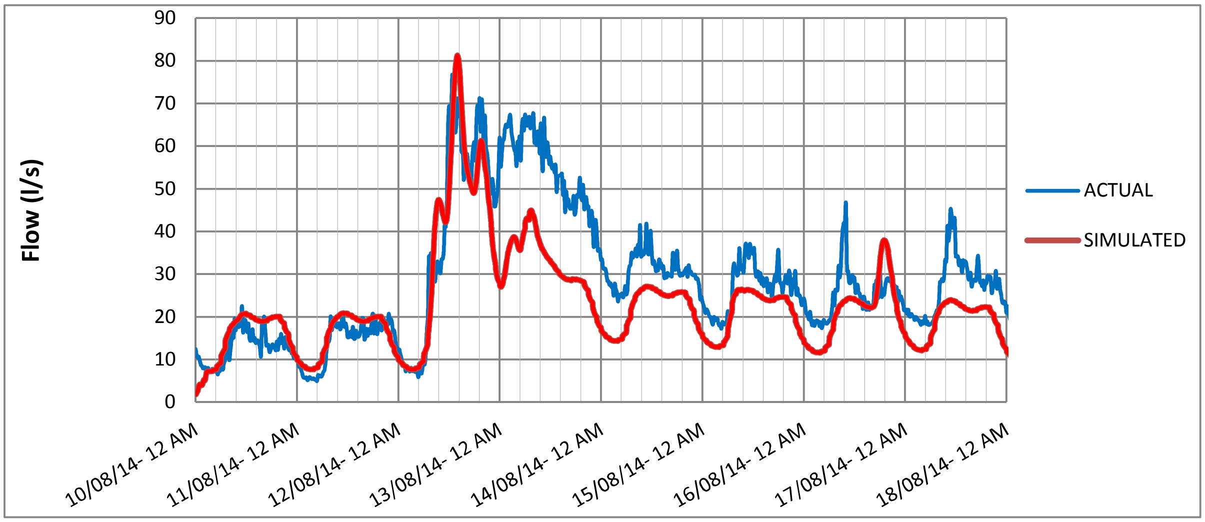

Figure 2-7 Kingston West Typical Rain Response Results – Monitor W13 Inflow

The R-T-K hydrographs allocated in the model to represent this system shows in general a good match to the wet-weather response for most periods of rainfall and matches well for rain events selected throughout different times of the year. The delay from rain response over longer periods of time represents that there is a long wet-weather infiltration period experienced in the west system. Representing a good calibration fit for wet-weather in the Kingston West system it was observed that there were large variations between seasonal. As documented in Appendix J for the wet-weather calibration graphs it is observed that the August month overall saw larger model responses for heavy and intense rainfall, while smaller longer duration rainfall observed in May saw an overall smaller model response for wet-weather generated flows. To ensure proper calibration between the different wet-weather events, a balance is determining between seasonal variations to ensure that the model is able to simulate the typical wet-weather response through-out the year.

2.4.3.2.2 KINGSTON CENTRAL OBSERVATIONS

The Kingston Central sanitary system area, which in combination with Kingston East is serviced by the Ravensview WWTP, contains a combination of fully separated and combined sewers. This system as includes the oldest pipe infrastructure found in the city and in general there is a very large response from rainfall activity in all areas. Towards the northern part of this area, the typical wet-weather response is shown in Figure 2-8.

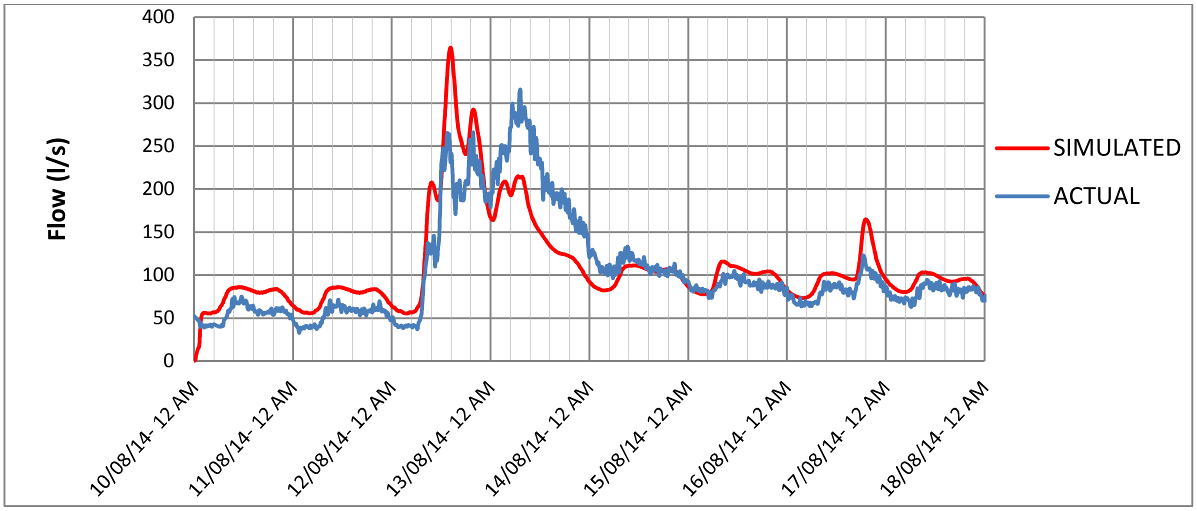

Figure 2-8 Kingston Central Calibration Results – Monitor C1 Inflow

In general the wet-weather response for initial runoff is very high in this area even with the separation of combined sewer catchment areas. A strong match between model simulation calibration results and actual observations was observed.

Simulating the active combined sewer area of Kingston Central it is very evident that the initial runoff into the sewer is immediate. In this area many additional R-T-K Hydrographs were used in conjunction with the sanitary catchment areas for combined sewers to simulate the wet-weather response throughout. Additional details about the CSO calibration is provided in section 2.4.3.3.2. Figure 2-9 shows the typical response observed at the River St. PS.

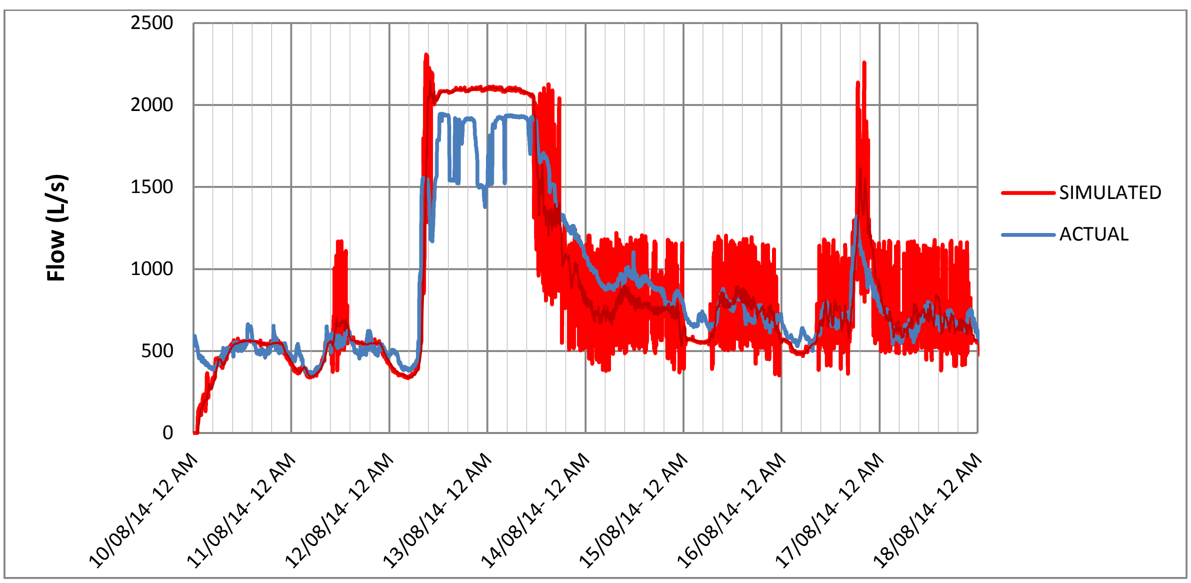

Figure 2-9 Kingston Central Calibration Results – River St. PS Discharge

2.4.3.2.3 KINGSTON CENTRAL OBSERVATIONS

Kingston East represents a smaller overall area, but many of its areas towards the North include some of the City's newest residential communities which represent newer pipe infrastructure. The system response in this separated sewer systems shows the least amount of rainfall influence and only moderate direct runoff response is observed. Figure 2-10 shows the typical wet-weather calibration results for Monitor E1 which is located just upstream of the Barret Crt PS.

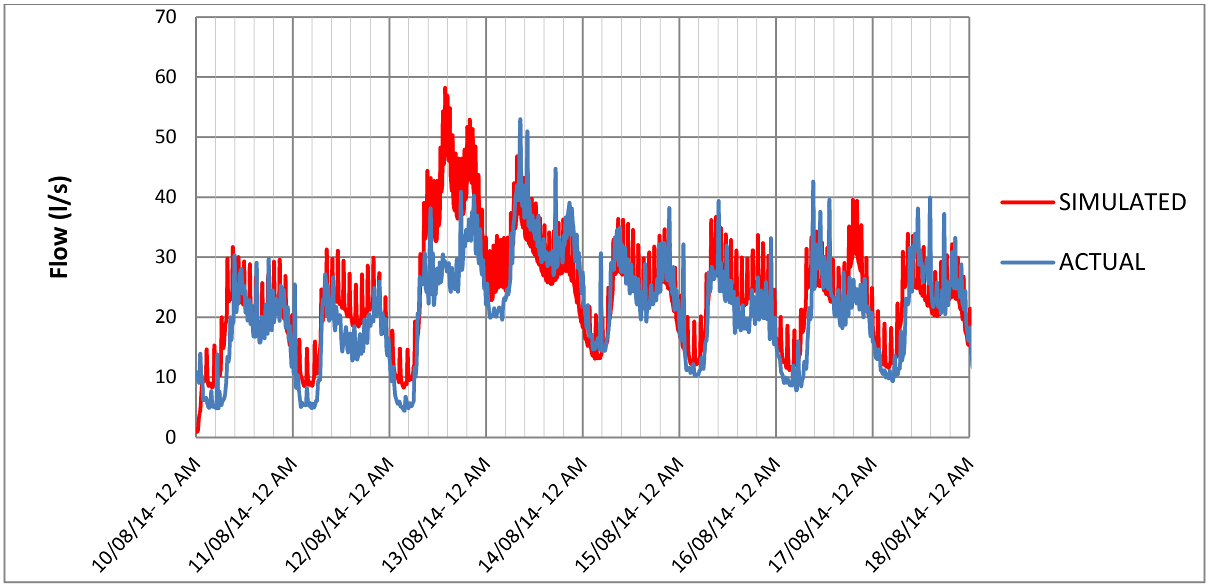

Figure 2-10 Kingston East Calibration Results – Monitor E1

Overall, the wet-weather calibration provided good representation of rain event responses throughout all of Kingston's pipe systems. On a case-by-case bases there was observed data trends in parts of Kingston where higher than usual rainfall response was observed in wetter months such as in May, while large response events in August are currently being underrepresented in the model for collectors, however these are balanced such that the peak flows are balanced in calibration for primary trunk sewers and facilities. The final step in wet-weather calibration is the review of these assets through checks and balances.

2.4.3.3 WET-WEATHER CHECKS AND BALANCES

2.4.3.3.1 FACILTIES

As indicated above, the predominant calibration adjustments for facilities are based on comparing the SCADA data for flow and level with model outputs and using available in-line flow monitor data both upstream and downstream of the facilities when data was unavailable. As indicated in the dry weather calibration, the same calibration points were used (i.e. pumping station SCADA data or in-line flow monitor etc.) for the wet weather calibration. The facilities were only updated or adjusted during wet weather calibration for pumping set points to ensure that that the facilities were pumping at suitable rates. The data observations and comments towards output assumptions through calibration for pumping station facilities are summarized in Table 2-9 and 2-10 and observations are based on the pumping response observed in the model from wet-weather with the application of R-T-K Hydrographs.

Table 2-15 Kingston West PS Calibration Observations August 10-16, 2014 Rain-Event

FACILITY	SCADA DATA	NO. OF PUMPS	SIMULATED WET WEATHER AVERAGE PUMP RATES (L/S)	C OF A / ECA OR INDICATED RATE* (L/S)	DATA OBSERVATIONS /COMMENTS
Bath Rd	Yes	2	26.2	51.4	Hydrograph applied to PS based on SCADA data. Higher frequency pumping observed
Bath-Collings Bay Rd	No	2	19.5	18.0	Assumed hydrograph applied to PS. Higher frequency pumping observed
Bath-Lower Dr	No[1]	2	4.5	6.3	Assumed hydrograph applied to PS. Higher frequency pumping observed
Bayridge Dr	No	2	25.4	23.0	Assumed hydrograph applied to PS. Higher frequency pumping observed
Collings Bay Rd	No	2	21.8	22.0	Assumed hydrograph applied to PS. Higher frequency pumping observed
Coverdale Dr.	Yes	2	58.9	52.6	Assumed hydrograph applied to PS. Higher frequency pumping observed
Crerar Dr.	Yes	2	43.4	77.0	Hydrograph applied to PS based on SCADA data. Higher frequency pumping observed
Days Rd	Yes	4	632.8	1008.0	Hydrograph applied to PS based on SCADA data. Higher frequency pumping observed. Varies by pumps.
Hillview Rd	Yes[2]	2	149.2	192.0	Wet-weather applied from upstream hydrographs. Higher frequency pumping observed
John Counter Blvd	Yes[2]	2	52.6	50.6	Hydrograph applied to PS based on SCADA data. Higher frequency pumping observed.
Lakeshore Blvd	Yes	2	128.9	126.0	Wet-weather applied from assumed upstream hydrographs. Higher frequency pumping observed
Ranking Cres.	No	2	21.3	19.1	Wet-weather applied from assumed upstream hydrographs. Higher frequency pumping observed
Westbrook Rd	No	2	13.8	14.6	Hydrograph applied to PS based on SCADA data. Higher frequency pumping observed.

* Based on data or historical draw down test provided by UK
1 –Only Limited SCADA or anecdotal station data available
2 – Only select dates ranges available for calibration

Table 2-16 Kingston Central/East Pumping Station Calibration Adjustments and Comparisons

FACILITY	SCADA DATA	NO. OF PUMPS	SIMULATED WET WEATHER AVERAGE PUMP RATES (L/S)	C OF A / ECA OR INDICATED RATE* (L/S)	DATA OBSERVATIONS / COMMENTS
Dalton Ave	Yes	4	575	1114.0	Wet-weather applied from upstream hydrographs. Higher frequency pumping observed Varies by pumps.
Greenview Dr.	Yes	2	54.8	47.3	Hydrograph applied to PS based on SCADA data. Higher frequency pumping observed.
Hatter St.	No	2	8.4	N/A	Assumed hydrograph applied to PS. Higher frequency pumping observed
King St.	Yes	4	782.4	726.0	Wet-weather applied from upstream hydrographs. Higher frequency pumping observed Varies by pumps.
King-Elevator Bay	Yes[1]	2	82.1	88	Assumed hydrograph applied to PS. Higher frequency pumping observed
King–Lake Ont. Park	Yes[1]	2	12.9	12.6	Hydrograph applied to PS based on SCADA data. Higher frequency pumping observed.
King-Portsmouth	Yes	3	289.5	285.0	Wet-weather applied from upstream hydrographs. Higher frequency pumping observed Varies by pumps.
Morton St.	Yes[1]	2	21.2	18.0	Hydrograph applied to PS based on SCADA data. Higher frequency pumping observed.
Palace Rd.	Yes	2	65.8	51.0	Hydrograph applied to PS based on SCADA data. Higher frequency pumping observed.
River St.	Yes	4	2135.7	1260.0	Wet-weather applied from upstream hydrographs. Higher frequency pumping observed Varies by pumps.
Yonge St.	No	2	6.1	4.0	Hydrograph applied to PS based on in-line flow monitoring data. Higher frequency pumping observed.
Barrett Ct	Yes[1]	3	183.9	205.0	Wet-weather applied from upstream hydrographs. Higher frequency pumping observed. Varies by pumps.
Highway 15	Yes	2	52.3	54.0	Hydrograph applied to PS based on SCADA data. Higher frequency pumping observed.
James St	Yes	3	63.2	74.0	Wet-weather applied from upstream hydrographs. Higher frequency pumping observed Varies by pumps.
Kenwoods Circle	No	2	29.9	38.0	Assumed hydrograph applied to PS. Higher frequency pumping observed
Schooner Dr.	No	2	19.3	18.0	Assumed hydrograph applied to PS. Higher frequency pumping observed

* Based on data or historical draw down test provided by UK
1 –Only Limited SCADA or anecdotal station data available
2 – Only select dates ranges available for calibration

2.4.3.3.2 COMBINED SEWER OVERFLOWS AND CATCHMENT AREAS

Checking the calibration for CSO's, SSO's and PSO's was through review and comparison of documented overflow event volumes and frequencies. For select locations there is a large amount of data available from Flowworks.com and available SCADA data that was used to compare to model simulated results. To calibrate a strong relationship between the wet-weather generated runoff and the model system response to overflows key anchor calibration points were used and the calibration results are summarized on Figure J-3 in Appendix J.

The use of the key anchor calibration points for the Collingwood CSO tank, O'Kill CSO tank, Emma Martin CSO Tank, Barrack St. CSO and West St. CSO presents the most reliable information from SCADA and the use of level data was used to determine a strong calibration. Level data provides important information about the CSO system since it provides an indication when CSO weirs or orifices set-points are exceeded which in turn generates an overflow in a model simulation. Observing the level and rate that an anchor point used in calibration relates to actual data indicates a stronger model simulation response. An example is shown in Figure 2-11.

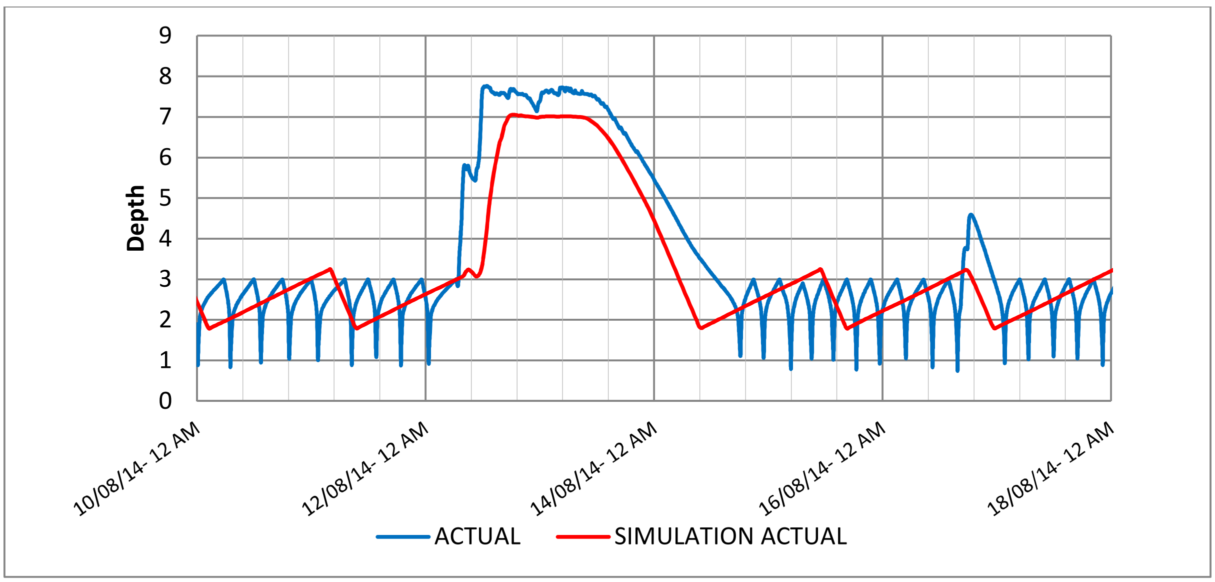

Figure 2-11 King St. CSO Tank (PCP#55) - Levels

Given good calibration of dry-weather and wet-weather model simulation the next phase in the combined modelling approach is model validation

2.5 PHASE 4: VALIDATION, COMPARISON & SIMULATION

The final phase of the combined modelling approach is to validate the model prior to final simulation for reporting. This step included a review of the model outputs with documented sources including the past results from the last model update completed for the *Front Rd. Watermain Interconnection and Portsmouth PS Forcemain EA (2014, WSP)*. Final simulations were then conducted to support the various goals of the master planning exercise and in support of model projection scenario development. Figure K-1 and K-2 of Appendix K shows the main validation results and summary for dry-weather and wet-weather respectively when comparing to 2013 modelled data.

2.5.1 VALIDATION PROCESS

The model validation process conducted included the following review of available reports and information:

- Documented Studies (as provided by UK)
- Portsmouth PS Environmental Assessment
- Comparisons to past master plan sewer models

In review the use of documented studies and comparisons to the past master plan models were completed by in the Portsmouth PS EA as documented by WSP in 2014. In the 2015 Master Plan model update the results from this study were compared directly with the model outputs for the 2013 data and the 2014 data since these data sets provide the most complete information available for validation of the model. 2013 and 2014 rain data were both used to complete this validation.

2.5.2 VALIDATION RESULTS

The validation results are shown in Appendix K. The overall results show a very good 2013 model representation when compared to the 2014 calibration. In general, with the use of more up-to-date facility information and with the inclusion of secondary pumping stations and collector sewers, the model was able to be calibrated to better represent areas where limited information was available in the past version of the model. The strongest advantage of the updated model is its updated representation of adjusted diurnal pattern application with the use of meter loading. The diurnal pattern adjustments are best observed in Kingston West as shown in Figure 2-12 and while both current and pre-calibration results show a good representation within their respective calibration targets, the 2014 data has attained greater periodic accuracy of diurnal flow peaking.

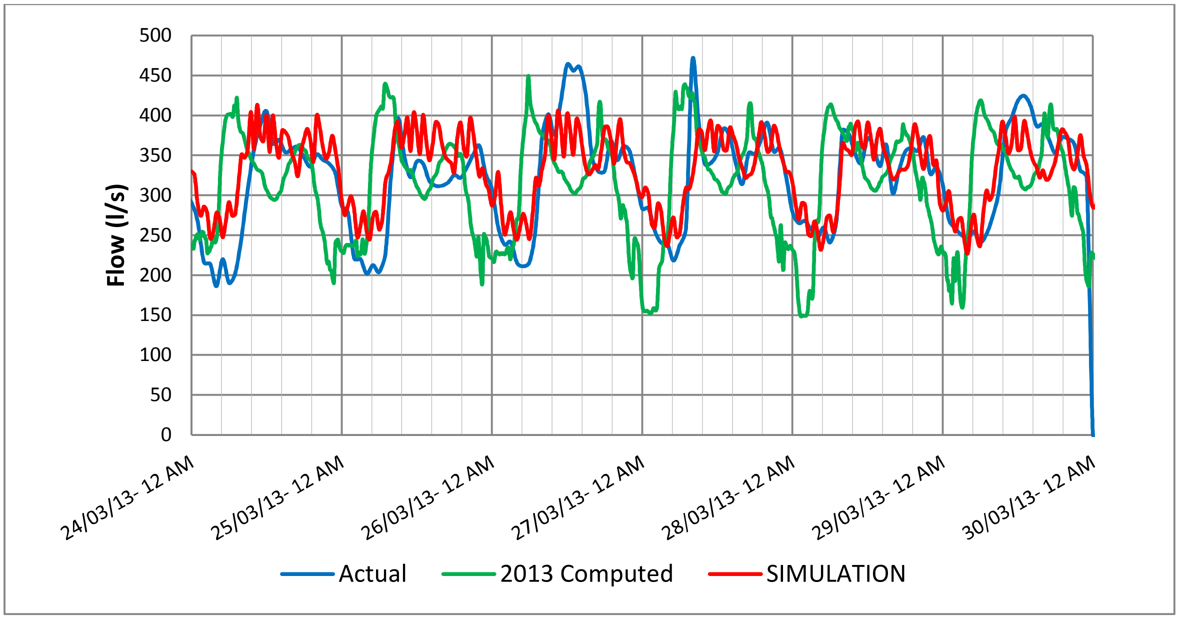

Figure 2-12 King St. CSO Tank (PCP#55) – Flow Validation

3 MODEL SCENARIO DEVELOPMENT

After completion of trunk sewer model validation, the model was then further updated to include the simulation scenarios developed for use in the 2015 Master Plan analysis of infrastructure gaps and for review of design alternatives. The base scenario's created for the growth projection years were developed in conjunction with the water model and were inputted during the loading phase in order to utilize InfoSWMM's scenario editor tools which allow for the inheritance of model properties to be checked and verified at the same time as model development iteratively. The growth development modelling scenario's represent development projections based on direct feedback and input from Utilities Kingston and City of Kingston planning staff and include the projection flows calculated in the *Growth Scenario Report (2015 Master Plan, WSP)*. Table 3-1 shows a summary of the scenario's developed for the master plan and each scenarios primary inclusions and additions from the original calibration scenario.

Table 3-1 Base Model Scenario's and Inclusions for the 2015 Master Plan

SCENARIO NAME & MODEL LABEL(S)	ALTERNATIVES/INCLUSIONS	INFRASTRUCTURE ADDITIONS (MP-F ONLY)
2015 Calibrated Condition (MP-C-2015)	→ Calibrated to 2013/2014 flow and rainfall data → 2013/2014 diurnal patterns developed from flow data → 2014 demand adjusted water consumption loading (Included in all scenarios) → 2014 combined sewer areas	→ 2014/2015 GIS Update (provided by UK) → Model element additions/updates including secondary pumping stations, CSO's, SSO' etc…) → West St Bypass (PCP#26) weir adjustment to 75.5m
2015 Existing Condition (MP-E-2015 & MP-F-2015)	→ 2014 combined sewer areas	→ Permanent plugging of; Queen St CSO (PCP#15), North/Wellington CSO (PCP#10), Brock St (PCP#19), Johnson St CSO PCP#21), Lower Albert St CSO (PCP#31) → New weir across 900mm overflow pipe on PCP#53 at Union/Division. Elevation approx. 88.0m → Hatter Drive PS Decommissioning (2015)
2021 (MP-E-2021 & MP-F-2021)	→ 2021 projected growth and developments. → 2021 combined sewer areas	→ Portsmouth Pumping Station upgrades and Forcemain to Cataraqui Bay WWTP → Pipe/Junction Additions for New Developments → Yonge St sewer upsize (Johnson to Portsmouth PS) → River St PS Forcemain Twinning → Alfred/Elm Sewer Upsize: Sewer upsize (375mm to 450mm) on Alfred St. and Elm St. → Hwy 15 trunk sewer upsize (450mm & 525mm) → New 'Riverview PS' forcemain (replaces Schooner Drive PS – Included in design Alternative Review) → Greenview PS Upgrades
2026 Committed Condition (MP-E-2026 & MP-F-2026)	→ 2026 projected growth and developments → 2026 combined sewer areas	→ Pipe/Junction Additions for New Developments
2036 (MP-E-2036) (MP-F-2036)	→ 2036 projected growth and developments → 2036 combined sewer areas	→ Pipe/Junction Additions for New Developments

SCENARIO NAME & MODEL LABEL(S)	ALTERNATIVES/INCLUSIONS	INFRASTRUCTURE ADDITIONS (MP-F ONLY)
Full Build-Out (MP-E-BUILDOUT) (MP-F-BUILDOUT)	→ 2036 projected growth and developments with additional residential and ICI growth based on zoning and scaling factor → No combined sewer areas	→ Pipe/Junction Additions for New Developments
Ultimate (MP-E-ULT) (MP-F-ULT)	→ Full Build-Out plus specific urban boundary extensions → No combined sewer areas	→ Pipe/Junction Additions for New Developments

It is to be noted that for each primary growth scenario listed in Table 3-1 that there are two versions developed in the model. The first version represents future population growth and sewer separation with 2015 infrastructure conditions (MP-E). The second represents future population growth and sewer separation with imminent infrastructure projects represented where design details are already known (MP-F). The two sub-scenarios are used in conjunction during gap analysis and review of design alternatives to simulate the effectiveness of different infrastructure enhancement options in the model. The active model element details for each scenario are further detailed in Appendix L.

3.1 COMBINED SEWER SEPARATION

As described previously in section 2.2.2.6, the combined sewers for Kingston Central are currently projected to be upgraded to a fully separation system based on UK's sewer separation program. The rate and review of sewer separation was based on the catchment area size and locations as well as the age of pipe infrastructure. The final sewer separation areas are detailed in Figure L-1 of Appendix L. It is projected that by the full build-out scenario that all combined sewer areas are to be virtually eliminated, however this timeline will be based on the program's effectiveness in eliminating combined sewer overflows in accordance with MOE F-5-5 regulations.

3.2 GROWTH FLOW PROJECTION AND ALLOCATION

Each scenario was loaded with demand adjusted dry-weather flow per projection year based on additional flow calculated in the *Growth Scenario Report (2015 Master Plan, WSP).* The locations of the development areas associated with future flow protections are detailed in Figures L-2 in Appendix L. The flow allocation method is common with the loading approach described in section 2.3.1 for the loading phase and the same diurnal patterns developed for the existing condition as are applied to each projection flow for consistency.

After further review of the largest growth development parcels which would include additions to sanitary sewers for new subdivision developments and an allotment of additional I&I using the City of Kingston design guidelines rate of 0.014 L/s/ha was applied and new RDII representations were assigned for wet-weather. Figure L-3 of Appendix L describes the additional loading adjustments for these large development areas for RDII where the assumption was made by added by applying R-T-K Hydrographs similar to those developed in Kingston East, which contribute the most new pipe systems by area and was estimated to be the best representation for future areas based on calibration.

3.3 GROWTH DEVELOPMENT SCENARIO DETAILS

3.3.1 2015 SCENARIO – CALIBRATION CONDITION

This scenario represents the calibrated model conditions using 2013/2014 flow & level data as described previously in section 2. The conditions represent Kingston's sanitary sewer system up-to the end of 2014 and does not include any of the imminent projects listed for 2015 as shown in Table 3-1. The calibrated condition scenario is used to validate the model for used as a comparison scenario for simulation analysis. Figure B-1 of Appendix B shows the model elements included in this scenario.

3.3.2 2015 SCENARIO – EXISTING CONDITION

The 2015 existing condition scenario represents current infrastructure completed by the end of 2014 including recent sewer separation and permanent plugging of CSO's/SSO's. The 2014 demand adjusted dry-weather loading and base I/I applied from calibration is also carried forward, as it is for all future projection scenarios to ensure that these simulations are comparable to the calibrated conditions. This scenario best reflects Kingston currently active sanitary sewer system network and is often used as the base case for analysis. In this scenario there were multiple adjustments to the model and further details of model element updates are presented in Figure B-1 of Appendix B.

3.3.3 2021 SCENARIO

The first 5-year projection scenario was selected to represent the year 2021 and includes the majority of imminent infrastructure projects pre-planned for implementation by Utilities Kingston. Of these imminent projects is the Portsmouth PS flow redirection to the Cataraqui WWTP along with continued separation of combined sewers. The capital improvement projects to be evaluated beyond the 2021 scenario are limited to just infrastructure required to represent growth development areas where new projected flow allocations are made. It is to be noted that the new Riverview PS which is to replace the Schooner PS is omitted in the initial scenario set-up for 2021 as it is included in the design alternative review process for model simulation. Figure L-5 of Appendix L describes further details of this scenarios model set-up.

3.3.4 2026 SCENARIO – COMMITTED CONDITION

The second 5-year projection scenario was selected to represent the year 2026 and includes additional growth and development representations. This scenario also includes the remainder of pending or committed development growth development which makes it suitable for committed condition analysis. As with previous scenario's, further combined sewer separation is accounted for in this scenario. Further details may be found on Figure L-6 of Appendix L.

3.3.5 2036 SCENARIO

The 2036 scenario is an approximate 20 year planning projection of future growth and combined sewer separation. WSP estimated sewer separation for this projection by using a 2.5% area reduction per year based on Utilities Kingston current sewer separation trends as detailed in the *Baseline Report (2015 Master Plan, WSP).* Areas selected for sewer separation were based on areas with the oldest pip infrastructure first and is further detailed in Figure L-7 of Appendix L.

3.3.6 BUILD-OUT SCENARIO

The build-out scenario was developed was to project future growth beyond a 20 year period in situation where also the remainder of Kingston's combined sewer has also be separated. This scenario includes much more addition land area for growth development and used in the analysis to make long term capital improvement recommendations from simulation analysis during the design alternative review. Additional details are presented on Figure L-8 of Appendix L.

3.3.7 ULTIMATE SCENARIO

The final primary scenario developed for model simulations is the ultimate scenario. The 2015 Master Plan uses the ultimate scenario to represent build-out conditions with select growth developments located beyond Kingston's current urban boundary. These growth developments are projected to account for potentially large residential developments and their inclusion in model simulation allows for evaluation of service options for these potential growth areas. In most cases there is little to no existing sanitary infrastructure in these areas so the sanitary loading for this scenario was assigned to the nearest downstream trunk model connections based on the existing ground profile assuming these area's would be serviced via gravity sewers. More details about the Ultimate scenario set-up for the trunk model are included on Figure L-9 of Appendix L.

3.4 GAP REPORTING SCENARIOS AND DEVELOPMENT

The wastewater model allows for simulations that can predict system responses to events under a wide range of conditions. Using hydraulic simulations, problems can be anticipated in proposed or existing systems, and solutions can be evaluated before time, money, and materials are invested in a real-world project. Simulations can either be for dry-weather or wet-weather conditions using an extended-period model analysis with the InfoSWMM software.

Simulations conducted in the gap analysis include dry-weather and wet-weather design storm analysis (for 1:2, 1:5, 1:10, 1:25, 1:50 and 1:100 year design storm events for Kingston) and an extended-period CSO simulation analysis where a typical year of rainfall (2014 rainfall) and wetter-then-average year of rainfall (2008 rainfall) was simulated for the months of April-October. The design storm analysis is used to evaluate the firm/peak capacities of pumping stations and the capacities of pipes including gravity sewers and forcemains. The CSO analysis is carried out to determine the severity of CSO's and SSO's as well as the total volumes of by-passes, the number of by-pass events and the duration of these by-pass events.

Reporting result details are presented in the Wastewater Gap Analysis Report for the Master Plan. Additional Gap reporting scenario development details are found in Appendix L

3.5 ALTERNATIVES REPORTING SCENARIOS AND DEVELOPMENT

The main tool used to evaluate alternative solutions is the InfoSWMM wastewater model which builds on the previously calibrated and developed scenarios used in the Gap Analysis. This model was updated with new scenarios representing conditions with future and upgraded infrastructure to demonstrate how the flow conveyance is possible to meet the desired LOS.

Discussions of the LOS results and recommendations for the West, Central and East collection systems are presented in the Wastewater Alternatives report for the Master Plan. Additional Alternatives reporting scenario development details are found in Appendix L

4 REFERENCES

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Front Rd. Watermain Interconnection and Portsmouth PS Forcemain EA (2014, WSP)

Baseline Report (2015 Master Plan, WSP)

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Sewage Infrastructure Master Plan for the City of Kingston Urban Area, *"Master Plan Growth Scenarios and Guiding principles - Technical Memorandum No. 4"*, CH2MHILL/XCG Consultants, June 2009

Technical memorandum *"River Street Pump Station Capacity Analysis"*, CH2MHILL Consultants, June 2010

Appendix A

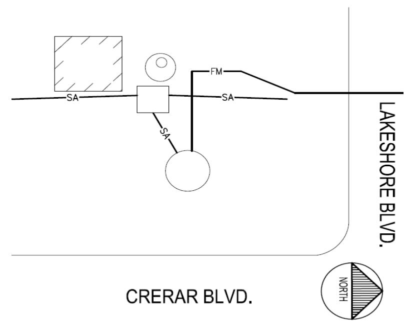
FACILITY SUMMARY SHEET EXAMPLE

Pump Station Facility Summary

				Notes:
Facility Name:	Crerar Boulevard			
Facility Address:	Corner of Crerar and Lakeshore BLVD			
Community/Service Area:	Cataraqui Bay WWTP			
Coordinates (Lat./Long.):	374,718.71E 4,896,564.21N			
Reference Drawing(s): Include Revision(s) & Date(s)	541-1 & 541-2, Aug 1994			
Page No.	Page 1 of 2			
Inflow and Outflow Types	**Units**	**Length**	**Diameter**	
Inflow Pipe Length & Dia.:	**m**	5.50	0.38	
Main Pipeline Length & Dia.:	**m**	570.00	0.20	
Main Discharge Location.	**n/a**	Crerar Blvd. Collector		
Overflow Pipe Length & D.:	**m**	N/A	0.30	
Overflow Discharge Loc.:	**n/a**	Junction MH		
Backup Power?:	**n/a**	No		
Site Fencing?:	**n/a**	No		
CofA/ECA?:	**n/a**	Yes		

Photo: Exterior

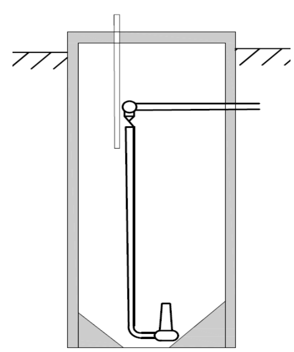
Plan View:



Storage Well & Pump Suction Details				
Operational Data	**Units**	**HGL**	**Level**	**Notes:**
Reference Drawing Number:	**n/a**	541-2		
Base Elevation & Level:	**m**	71.05	**0.00**	
Low Alarm Elevation:	**m**	71.50	0.45	
Minimum Elevation:	**m**	71.36	0.31	
Initial/Normal Elev. & Level:	**m**	72.40	1.35	
Maximum Elevation:	**n/a**	75.11	4.06	
High Alarm Elevation:	**m**	74.20	3.15	
Ground Elevation:	**m**	78.25	7.20	
Physical Data:	**Units**			
Section (circular, oval, etc...)	**n/a**	Circular		
Average Cross-Section Area:	**sq.m**	10.50		
Length & Width (or Diam.):	**m**	1.83		

Photo: Interior

Profile View:



Pump Station Facility Summary

Facility Name:	Crerar Boulevard	**Notes:**
Facility Address:	Corner of Crerar and Lakeshore	
Community/Service Area:	Cataraqui Bay WWTP	
Coordinates (Lat./Long.):	374,718.71E 4,896,564.21N	
Reference Drawing(s): Include Revision(s) & Date(s)	541-1 & 541-2, Aug 1994	
Page No.	Page 2 of 2	

Pump Details

Number of Pumps	2	**Notes:** Firm capacity estimated based on flow reports. Peak capacity estimated.
SCADA Flow?	Yes	
SCADA Level?	Yes	

Pump Type		**Lead**	**Lag 1**			
Make:		Flygt				
Model ID or Rating:		CP-3152 20 Hp				
Impeller ID or Size:		No. 492 (210mm)				
Variable-Speed?:		No	No			
Year Installed		1994.00				
Pump Curve ID in Model:		FP 3152 LT 3~ 492				
Flow and Level Set Points	**Units**	**Lead**	**Lag 1**			
Firm Capcity	**L/s**	57.00				
Peak Capacity	**L/s**	96.90				
Tested Flow (e.g.: Drawdown):	**L/s**	N/A	N/A			
ECA Rated Flow:	**L/s**	77.00	77.00			
ECA Rated Head:	**m**	25.00	25.00			
Elevation On:	**m**	72.40	72.70			
Elevation Off:	**m**	71.76	71.76			
Pump (Impeller) Elevation:	**m**	71.36	71.36			

Piping Details					**Minor Losses**	
Description (Year Installed)	**Units**	**Length**	**Diameter**	**Mat.**	**Qty.**	**Type**
Suction Line ( ):	**m**	N/A	N/A	N/A	N/A	N/A
Discharge Line (1994):	**m**	5.34	0.15	CML	1/1/1	CV, GV, 90EL
Pump Station (1994):	**m**	2.20	0.15	CML		GV, TF
Yard Piping (1994):	**m**	N/A	0.15/0.2	PVC	2/1	GV, FL
Main Pipeline (1994):	**m**	5/570	0.2/0.15	PVC	2/1/1/1	40EL, 90EL, GV, C
Exit Elevation:	**m**	76.99				

Legend:
CML = Cement Lined Ductile Iron, 90EL = 90 DEG Elbow, CV = Check Valve, MF = Magnetic Flow Meter, GV = Gate Valve, 45EL = 45 Deg Elbow, E = Expansion, LAT = Lateral

Notes:
Problem with natural gas L.P. alarm

Appendix B

MODEL REVIEW AND UPDATE SUMMARY MAPS

Appendix B – Contents

InfoSWMM Sewer Model Update Recommendations

Figure B-1: Wastewater Collection System Overview Map

Figure B-2: Sewer Systems Upgrades Map – Kingston West

Figure B-3: Sewer System Upgrades Map – Kingston Central and East

MEMORANDUM

To:	Mike Fischer, P.Eng. Utilities Engineer, Utilities Kingston	
Date:	January 22, 2015	
From:	Matt Morkem & Michael Flowers	
Project:	Portsmouth Pumping Station Flow Direction EA	WSP No.: 131-18048-00
Subject:	InfoSWMM Sewer Model Update Recommendations	

Background

WSP (formerly GENIVAR) was retained by Utilities Kingston to update the Kingston sanitary InfoSWMM sewer model as part of the Portsmouth Pumping Station Flow Direction Environmental Assessment (EA). WSP was requested to provide a list recommendations for future model updates based on the findings and from discussions held with Mike Fischer on December 11, 2014.

Summary of Model Observations

The InfoSWMM model was originally developed as a trunk sewer representation of Kingston, completed by XCG/CH2M Hill Consultants in 2009. A more detailed review of the existing model was conducted during the 2014 update for the EA, as documented in the Portsmouth Pumping Station Flow Direction Hydraulic Modelling Memorandum completed by WSP in May, 2014.

In summary, it was observed from the results that the diurnal dry-weather flow patterns were representative of the original documented results; however there were reductions to the total observable flow at peak conditions as compared to the actual flow data. There were also a few model results where flow conveyed through pumping stations (PS), such as the Portsmouth Ave. PS and King St. PS, were consistent with dry-weather events but not with wet-weather events – this may indicate the systems were altered after the original calibration. Furthermore, it was observed that there were a series of infrastructure assumptions that were not optimized or represented in the original model; most specifically in Kingston East where the James St. and Hwy 15 (B64) PS do not have any sanitary inflow represented despite being in developed areas.

Drawings 1-1, 1-2 and 1-3 in **Appendix A** show the summary of model observations and the model updates previously completed as part of the model calibration process. It is to be noted that the updates completed for the environmental assessment were intended to support the flow direction analysis of the Portsmouth PS only. Additional parameters or model Scenarios may be required to update the model in a permanent manner, suitable for other types of decision support.

Model Update Recommendations for Sewer Master Plan

Based on the InfoSWMM model observations and discussion with Utilities Kingston, the following recommendations are provided for the Sewer Master Plan update:

WSP Canada Inc.
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www.wspgroup.com

- Update existing infrastructure from GIS/As-Built data currently not represented in the trunk sewer model which tie-in directly to the sewer. Including, but not limited to:

    - Secondary (Collector) PS's
    - Barrett CT Pumping Station and Forcemain
    - Hwy 15 Pumping Station and Forcemain
    - James St. Pumping Station and Forcemain

- Infrastructure including CSO's, PS's and forcemains should be updated based on up-to-date flow monitoring/drawdown studies to improve accuracy of calibration.

- It is recommended that new rain and dry-weather diurnal patterns be developed based on most up-to-date rain gauge, water billing, and flow data.

- New sanitary inflows and catchment areas should be added to the model for existing and future conditions, based on recent zoning information and water billing data. Combined sewer catchment areas should be updated based on UK's current and projected (for future Scenarios) sewer separation program.

- Existing and projected design alternatives should be included in the model and organised as separate 'Design Scenario's' for proposed infrastructure.

- Documentation of model assumptions, inputs, sanitary loading methods and processes is necessary. Updates should be traceable and logical to support future (third party) amendments, in a file and document format suitable for UK's internal use. A documented method should be provided if InfoSWMM tools are used specifically to develop sanitary loading.

- It is suggested that new calibration targets be set, given availability of current data as follows:

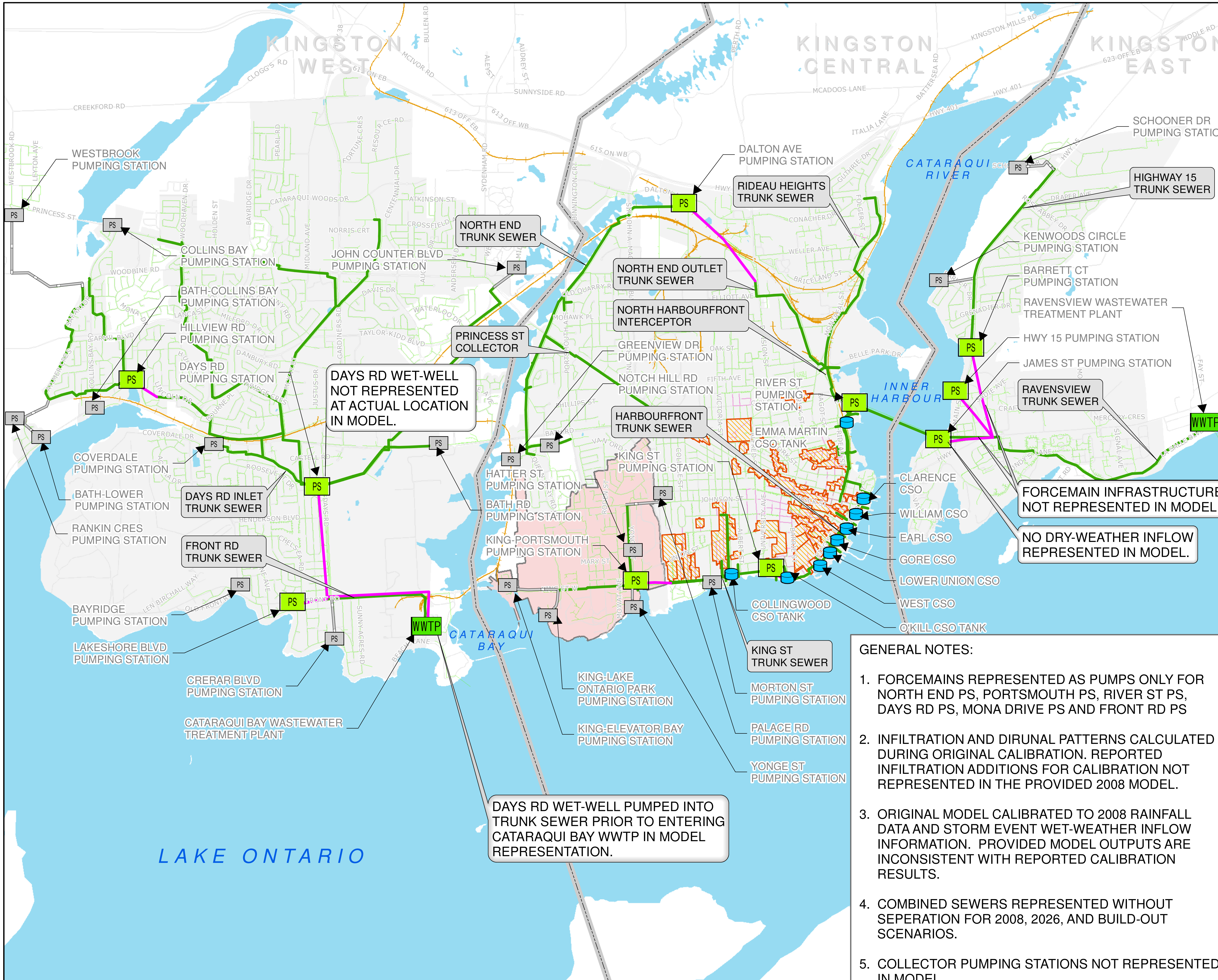
Trunk Sewer System Calibration Targets
Dry-Weather Targets: - Simulated dry-weather peak flows and volumes to be within ±5% of observed values - The timing of simulated peak dry-weather flows to be within 1 hour of observed values.
Wet-Weather Targets: - Simulated peak wet-weathers flows to be within ±15% of observed values - Simulated wet-weather events volumes to be within ±10% of observed values.
Collector Sewer System Calibration Targets
Dry-Weather Targets: - Simulated dry-weather peak flows and volumes to be within ±10% of observed values - The timing of simulated peak dry-weather flows to be within 1 hour of observed values.
Wet-Weather Targets: - Simulated peak wet-weathers flows to be within -15% of +25% of observed values - Simulated wet-weather events volumes to be within -10% to + 20% of observed values.

Conclusion

A properly calibrated and up-to-date sanitary sewer model will help ensure that recommendations analysed and evaluated as part of the Sewer Master Plan update will reflect higher accuracy, in support of decisions concerning proposed capital projects. Consistent and thorough documentation of model updates are also very important to ensure the long-term effectiveness of the sewer model, both for internal use or for future third-party amendments and studies. The goal is to link the SCADA, GIS and sewer model into a decision-support tool that keeps its value over the long term, allowing different people to leverage the data conversion and verification investment. Processes should be transparent and technologies kept open to maintain access to a broad base of professionals, be they staff or consultant.

A

MODEL OBSERVATION MAPS



GENERAL NOTES:

1. FORCEMAINS REPRESENTED AS PUMPS ONLY FOR NORTH END PS, PORTSMOUTH PS, RIVER ST PS, DAYS RD PS, MONA DRIVE PS AND FRONT RD PS
2. INFILTRATION AND DIRUNAL PATTERNS CALCULATED DURING ORIGINAL CALIBRATION. REPORTED INFILTRATION ADDITIONS FOR CALIBRATION NOT REPRESENTED IN THE PROVIDED 2008 MODEL.
3. ORIGINAL MODEL CALIBRATED TO 2008 RAINFALL DATA AND STORM EVENT WET-WEATHER INFLOW INFORMATION. PROVIDED MODEL OUTPUTS ARE INCONSISTENT WITH REPORTED CALIBRATION RESULTS.
4. COMBINED SEWERS REPRESENTED WITHOUT SEPERATION FOR 2008, 2026, AND BUILD-OUT SCENARIOS.
5. COLLECTOR PUMPING STATIONS NOT REPRESENTED IN MODEL.

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KINGSTON, ONTARIO,
K7L 4X7

Legend:

- WWTP - WASTEWATER TREATMENT PLANT
- PS - PUMPING STATION (TRUNK)
- PS - PUMPING STATION (COLLECTOR)
- CSO/CSO TANK
- SANITARY SEWER
- COMBINED SEWER
- TRUNK FORCEMAIN/SEWER
- PUMP (MODEL REPRESENTATON)
- COLLECTOR FORCEMAIN/SEWER
- CATCHMENT AREA
- COMBINED SEWER CATCHMENT
- PORTSMOUTH PS SERVICE AREA

Data Source: Ontario Base Mapping, Ministry of Natural Resources, August 2013. Sewer System, Utilities Kingston, July 2013, City of Kingston.

Scale: 0 500 1,000 2,000 Metres
1:50,000

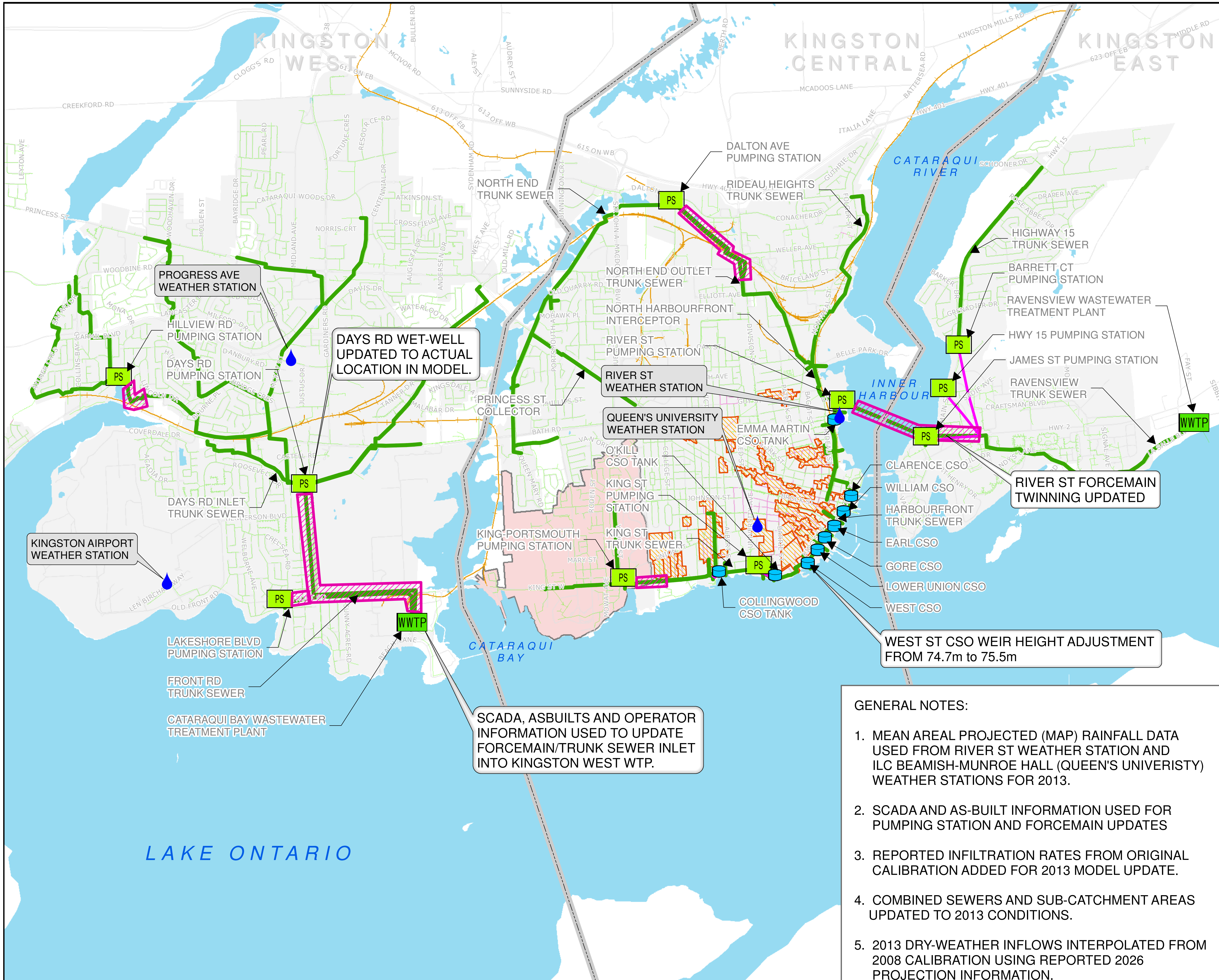
N E S W

Project:
Portsmouth Pumping Station Flow Direction Environmental Assessment

City of Kingston, Ontario

Title: 2008 TRUNK SEWER MODEL OVERVIEW MAP

Project No.:		Date:
131-18048-00		JANUARY 2015
Drawn By:	Checked By:	Drawing No.:
STR	MM	1-1



GENERAL NOTES:

1. MEAN AREAL PROJECTED (MAP) RAINFALL DATA USED FROM RIVER ST WEATHER STATION AND ILC BEAMISH-MUNROE HALL (QUEEN'S UNIVERISTY) WEATHER STATIONS FOR 2013.
2. SCADA AND AS-BUILT INFORMATION USED FOR PUMPING STATION AND FORCEMAIN UPDATES
3. REPORTED INFILTRATION RATES FROM ORIGINAL CALIBRATION ADDED FOR 2013 MODEL UPDATE.
4. COMBINED SEWERS AND SUB-CATCHMENT AREAS UPDATED TO 2013 CONDITIONS.
5. 2013 DRY-WEATHER INFLOWS INTERPOLATED FROM 2008 CALIBRATION USING REPORTED 2026 PROJECTION INFORMATION.

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Legend:

- WWTP - WASTEWATER TREATMENT PLANT
- PS - PUMPING STATION (TRUNK)
- WEATHER STATION
- CSO/CSO TANK
- SANITARY SEWER
- COMBINED SEWER
- TRUNK FORCEMAIN/SEWER
- PUMP (MODEL REPRESENTATON)
- UPDATED FORCEMAIN
- CATCHMENT AREA
- COMBINED SEWER CATCHMENT
- PORTSMOUTH PS SERVICE AREA

Data Source: Ontario Base Mapping, Minisitry of Natural Resources, August 2013. Sewer System, Utilities Kingston, July 2013, City of Kingston.

Scale:
0 500 1,000 2,000 Meters
1:50,000

N W E S

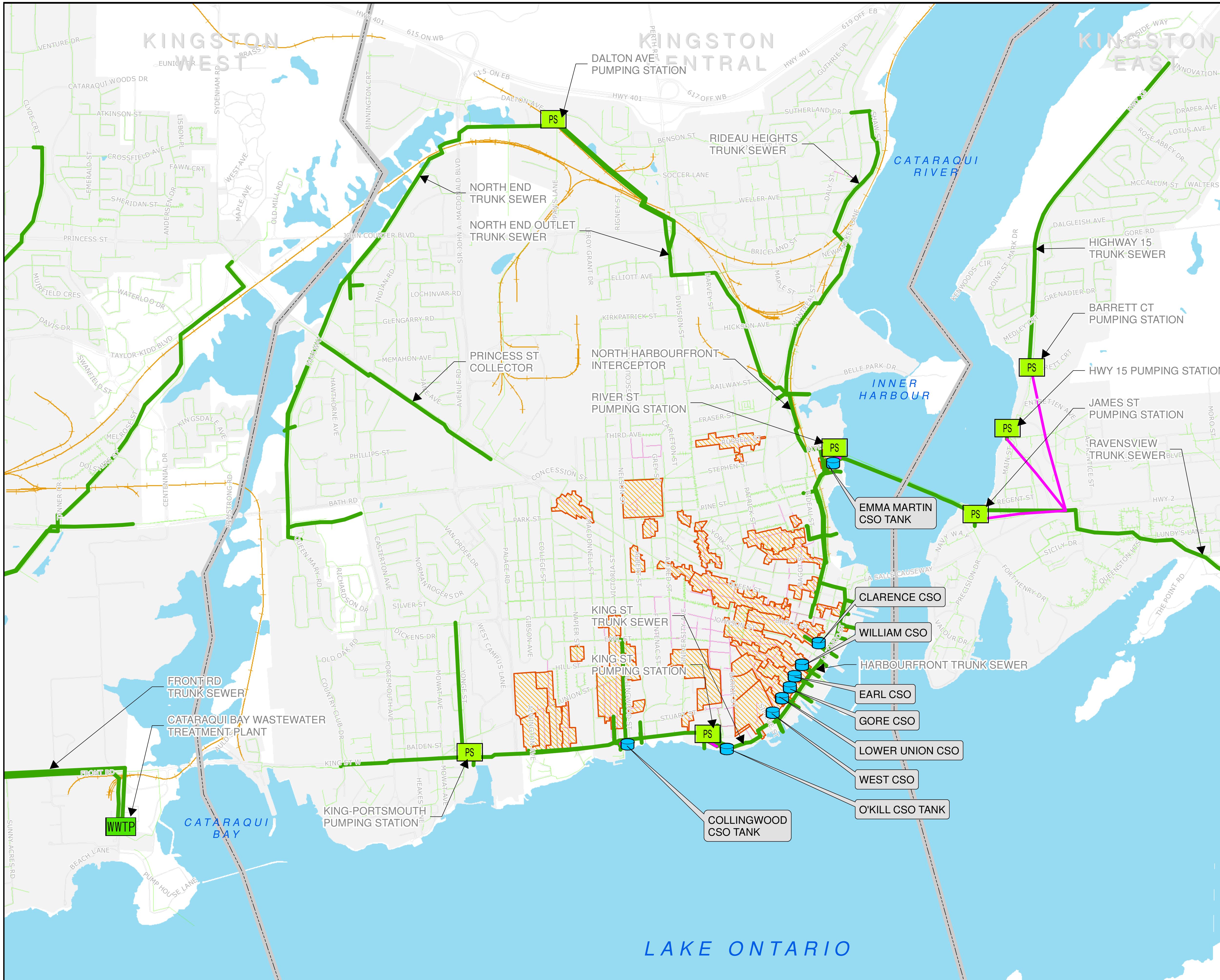
Project:
Portsmouth Pumping Station Flow Direction Environmental Assessment

City of Kingston, Ontario

Title:
DATA REVIEW:
SEWER SYSTEMS UPGRADES MAP

Project No.:	Date:
131-18048-00	JANUARY 2015

Drawn By:	Checked By:	Drawing No.:
STR	MM	1-2



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Legend:

- WWTP - WASTEWATER TREATMENT PLANT
- PS - PUMPING STATION (TRUNK)
- CSO/CSO TANK
- SANITARY SEWER
- COMBINED SEWER
- TRUNK FORCEMAIN/SEWER
- PUMP (MODEL REPRESENTATON)
- CATCHMENT AREA
- COMBINED SEWER CATCHMENT
- PORTSMOUTH PS SERVICE AREA

Data Source: Ontario Base Mapping, Minisitry of Natural Resources, August 2013. Sewer System, Utilties Kingston, July 2013, City of Kingston.

Scale:
0 300 600 1,200 Meters
1:30,000

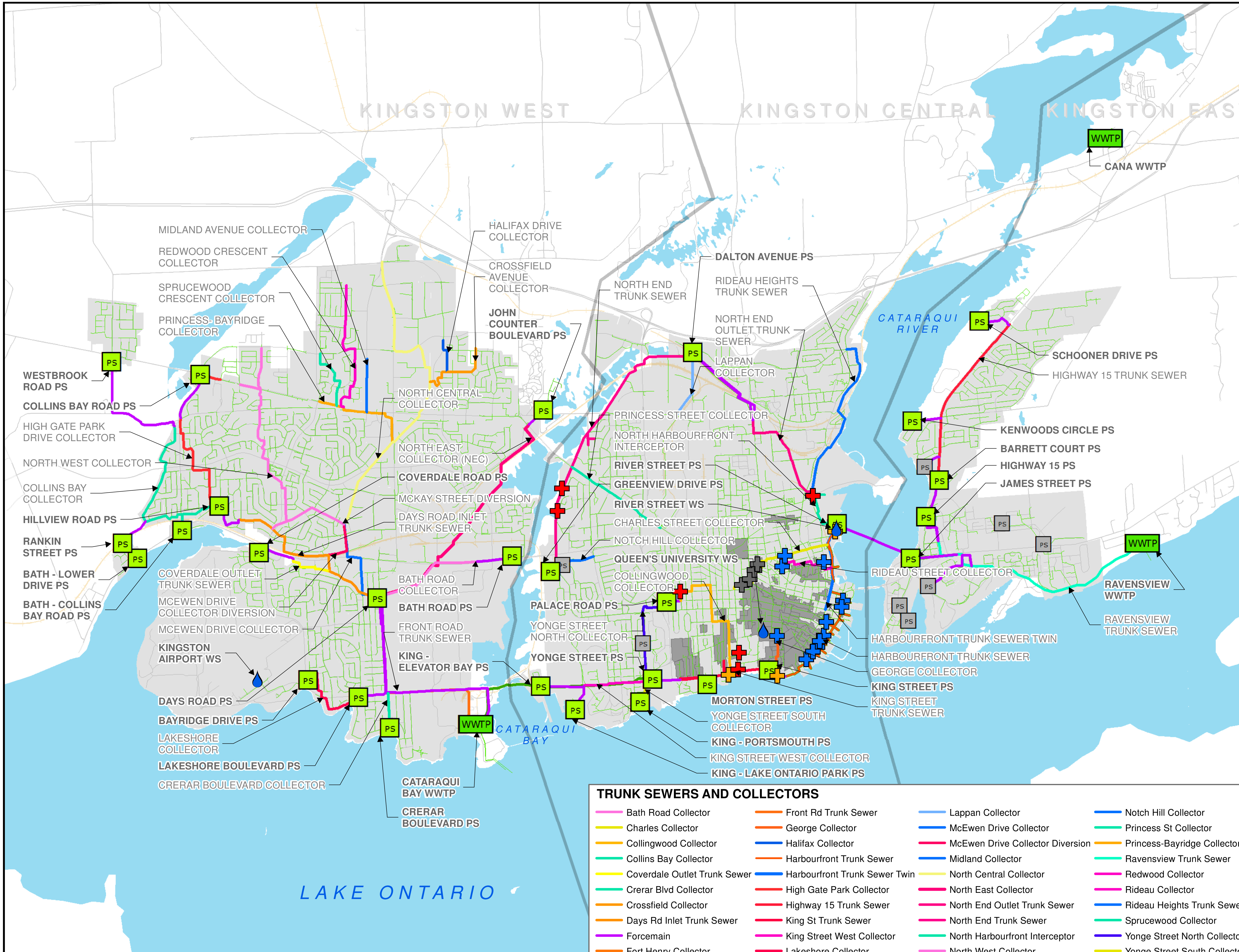
N E S W

Project:
Portsmouth Pumping Station Flow Direction Environmental Assessment

City of Kingston, Ontario

Title: DATA REVIEW: KINGSTON CENTRAL AREA

Project No.: 131-18048-00		Date: JANUARY 2015
Drawn By: STR	Checked By: MM	Drawing No.: 1-3



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Legend

- WWTP — WASTEWATER TREATMENT PLANT
- PS — SANITARY PUMPING STATION
- PS — SANITARY PUMPING STATION (NOT MODELLED)
- FORCEMAIN
- SANITARY SEWER
- WEATHER STATION
- COMBINED SEWER OVERFLOW
- SANITARY SEWER OVERFLOW
- TANK OVERFLOW
- OVERFLOW TEMPORARILY PLUGGED
- EXISTING COMBINED SEWER AREA
- SANITARY CATCHMENT AREA
- WATERBODY

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

Scale:
0 355 710 1,420 Meters
1:55,000

N W E S

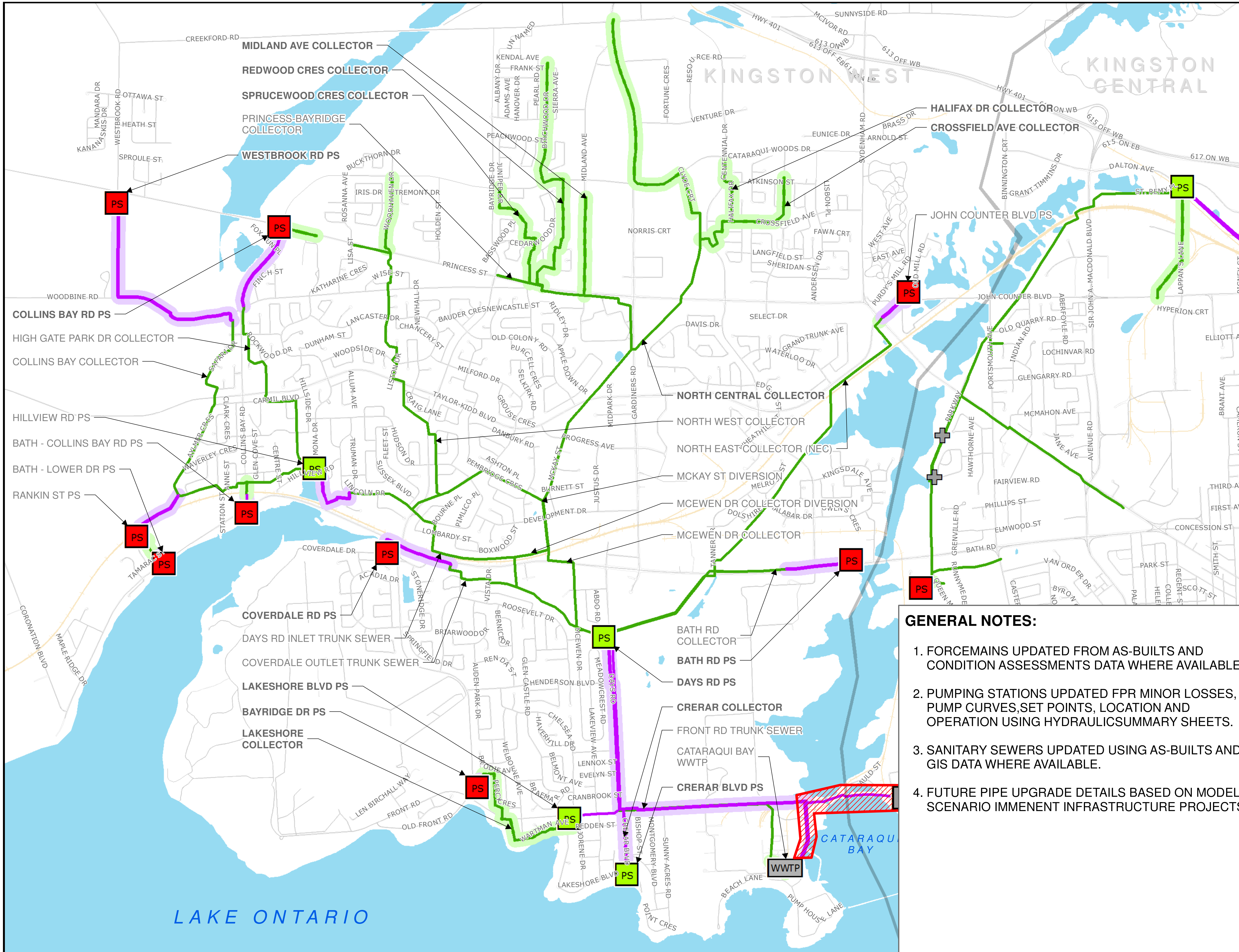
Project:
Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title:
WASTEWATER COLLECTION SYSTEM OVERVIEW MAP

Project No.:	Date:		
151-02944-00	MARCH, 2016		
Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	WWM	B-1

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.6_Wastewater Model\Maps\Calibration Report Maps\B_ReviewSumMaps\151-02944-00_WW_System_Overview.mxd



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Legend

WWTP	WASTEWATER TREATMENT PLANT
PS	SANITARY PUMPING STATION
PS	SANITARY PUMPING STATION UPGRADE
PS	SANITARY PUMPING STATION ADDITION
	PCP OVERFLOW
	PCP OVERFLOW UPGRADE
	PCP OVERFLOW ADDITION
	SANITARY SEWER (MODELLED)
	SANITARY SEWER ADDITION
	FORCEMAIN UPGRADE
	FUTURE PIPE UPGRADE

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

GENERAL NOTES:

1. FORCEMAINS UPDATED FROM AS-BUILTS AND CONDITION ASSESSMENTS DATA WHERE AVAILABLE.
2. PUMPING STATIONS UPDATED FPR MINOR LOSSES, PUMP CURVES,SET POINTS, LOCATION AND OPERATION USING HYDRAULICSUMMARY SHEETS.
3. SANITARY SEWERS UPDATED USING AS-BUILTS AND GIS DATA WHERE AVAILABLE.
4. FUTURE PIPE UPGRADE DETAILS BASED ON MODEL SCENARIO IMMENENT INFRASTRUCTURE PROJECTS.

Project:
Water and Wastewater Master Plan Updates

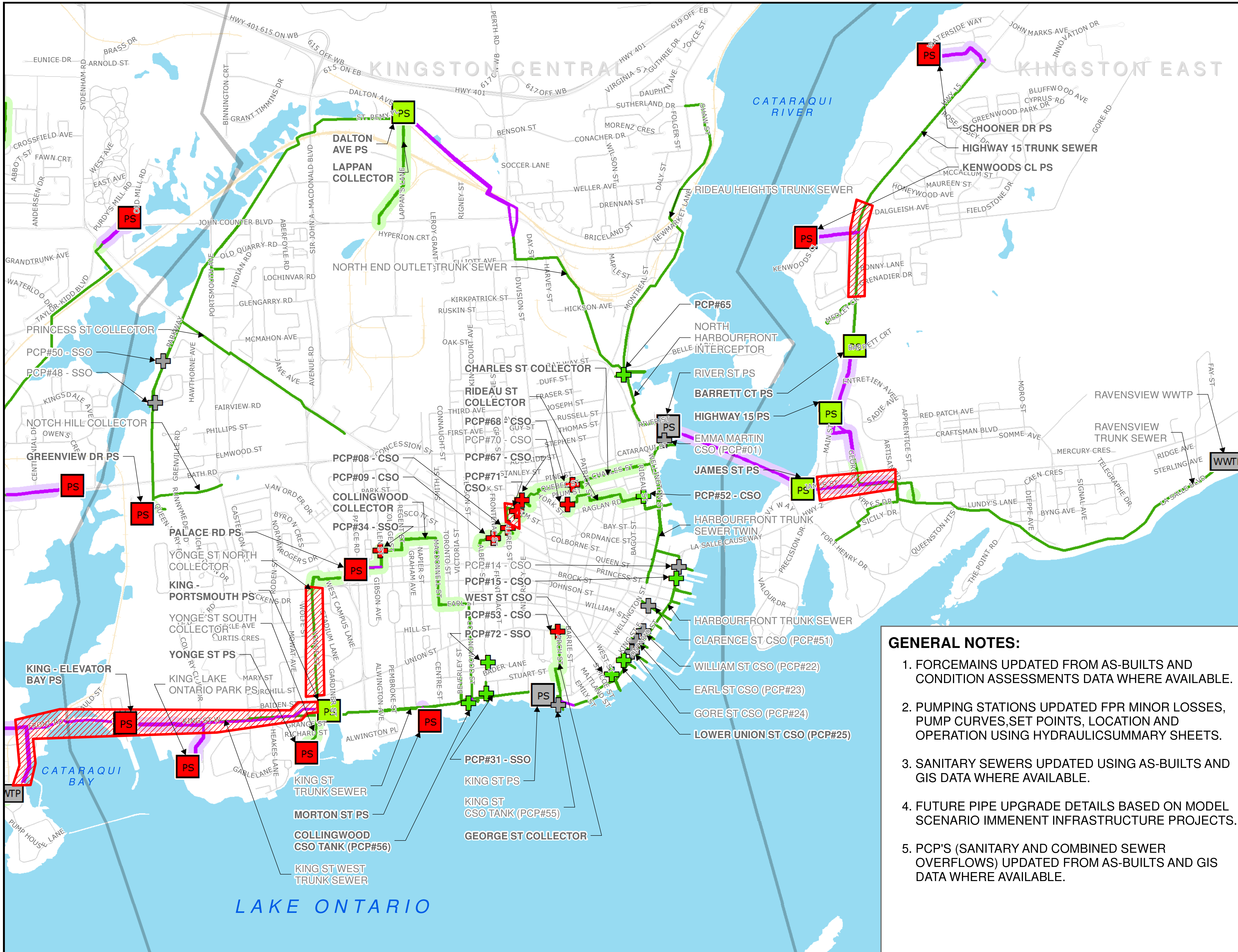
City of Kingston, Ontario

Title:
SEWER SYSTEMS UPGRADES MAP - KINGSTON WEST

Project No.:	Date:
151-02944-00	MARCH, 2016

Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	WWM	B-2

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.6_Wastewater Model\Maps\Calibration Report Maps\B_ReviewSumMaps\151-02944-00_SewerSystems_Upgrades_West.mxd



GENERAL NOTES:

1. FORCEMAINS UPDATED FROM AS-BUILTS AND CONDITION ASSESSMENTS DATA WHERE AVAILABLE.
2. PUMPING STATIONS UPDATED FPR MINOR LOSSES, PUMP CURVES,SET POINTS, LOCATION AND OPERATION USING HYDRAULICSUMMARY SHEETS.
3. SANITARY SEWERS UPDATED USING AS-BUILTS AND GIS DATA WHERE AVAILABLE.
4. FUTURE PIPE UPGRADE DETAILS BASED ON MODEL SCENARIO IMMENENT INFRASTRUCTURE PROJECTS.
5. PCP'S (SANITARY AND COMBINED SEWER OVERFLOWS) UPDATED FROM AS-BUILTS AND GIS DATA WHERE AVAILABLE.

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

Project:
Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title:
SEWER SYSTEM UPGRADES MAP - KINGSTON CENTRAL AND EAST

Project No.:	Date:		
151-02944-00	MARCH, 2016		
Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	WWM	B-3

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Appendix C

RAINFALL DATA

Appendix C – Contents

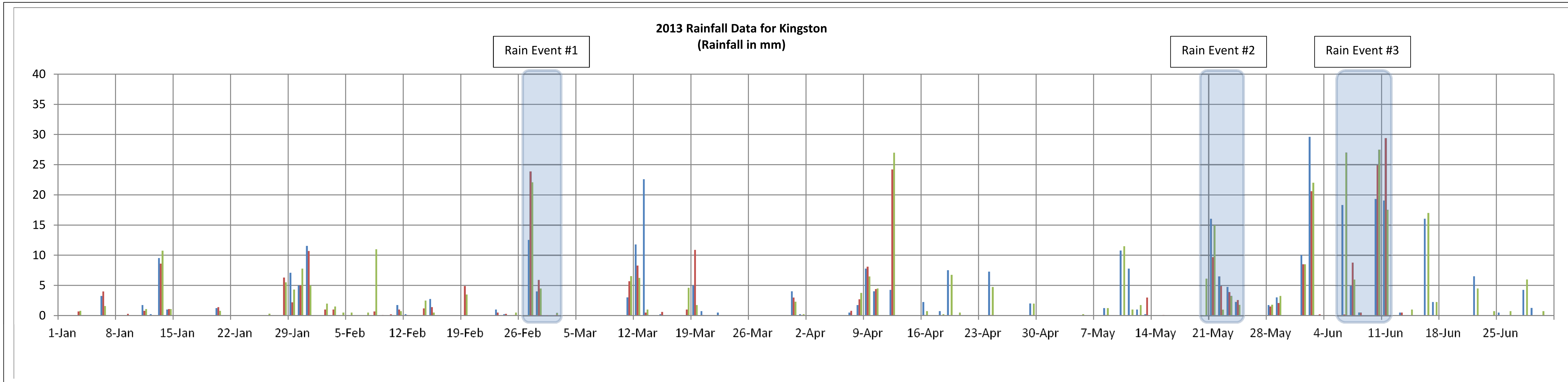
2013 Rainfall Data Summary for Kingston

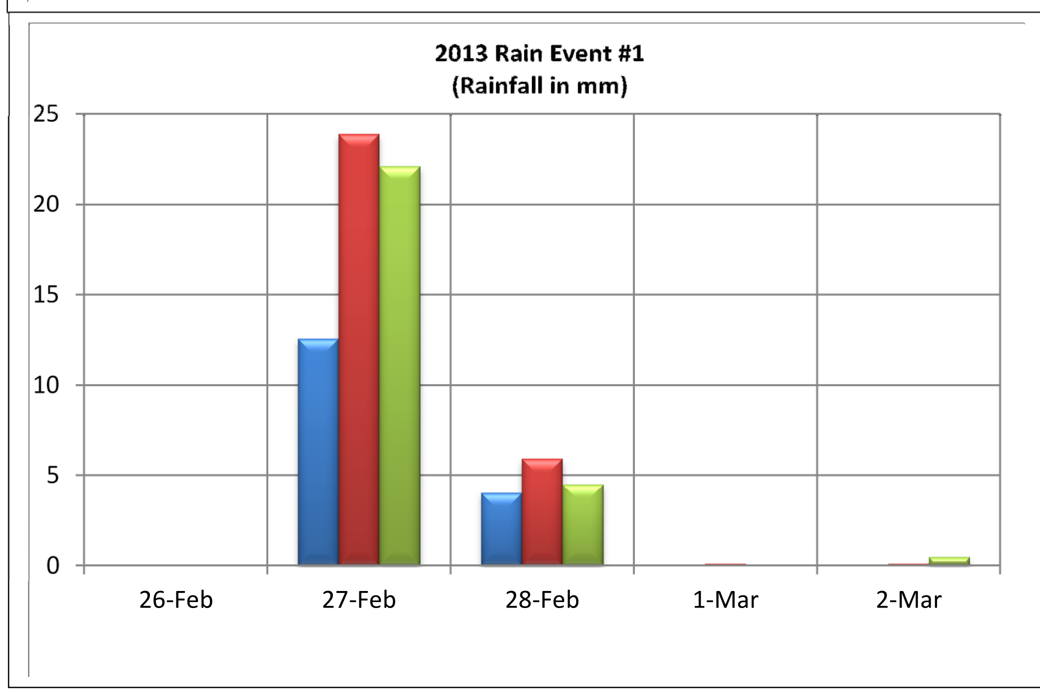
2014 Rainfall Data Summary for Kingston

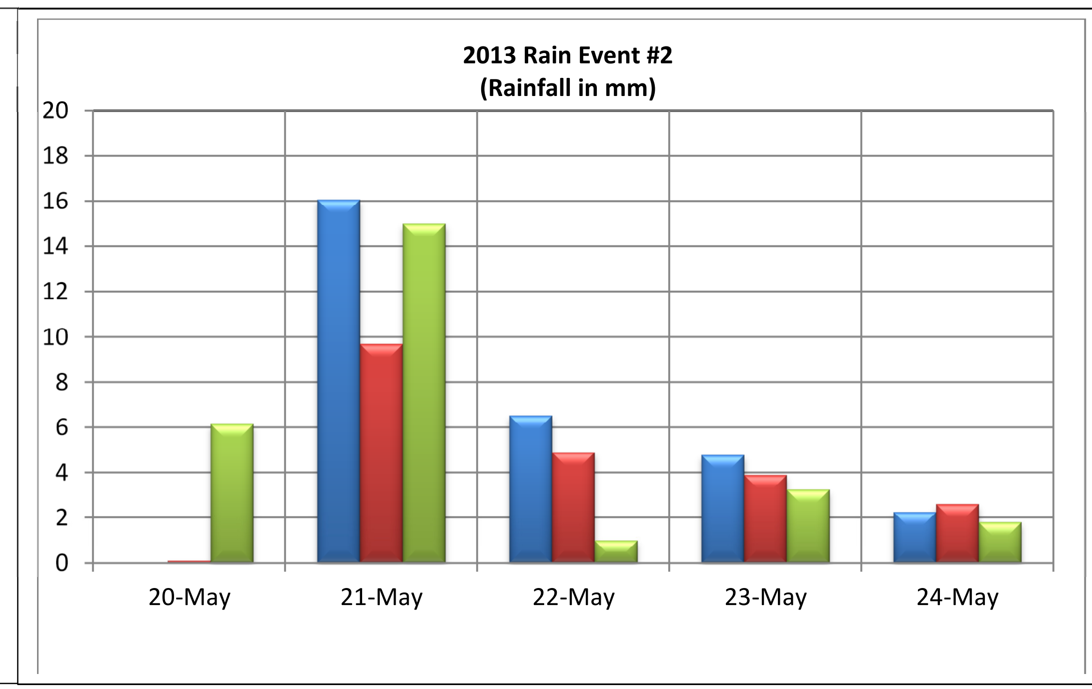
2013 MAP Rain Data Jan-Sept

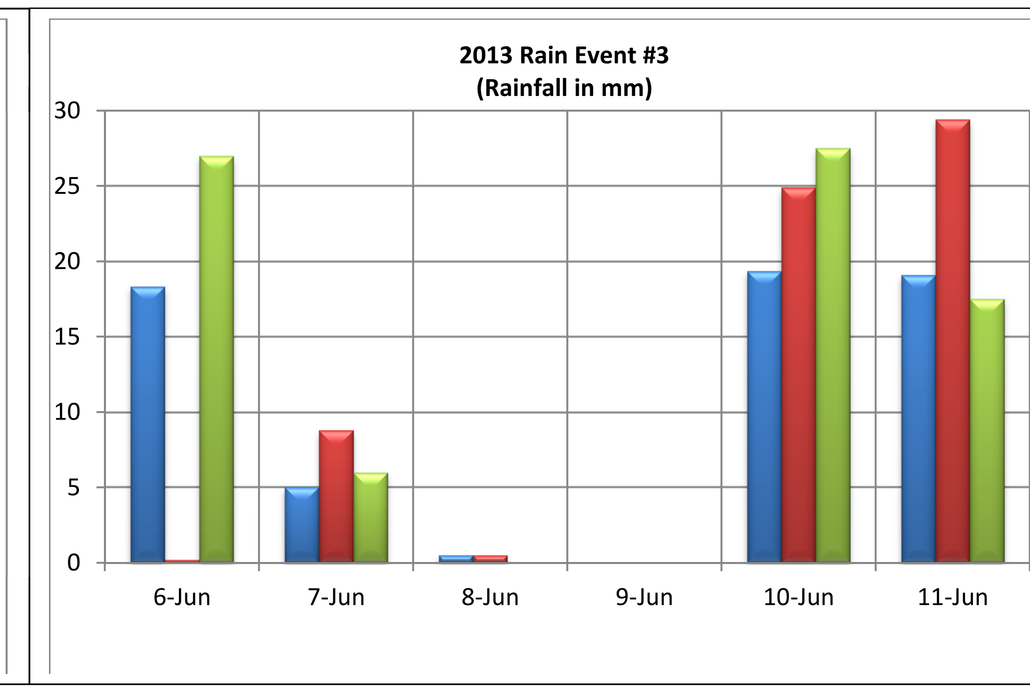
2014 ILC Rain Data

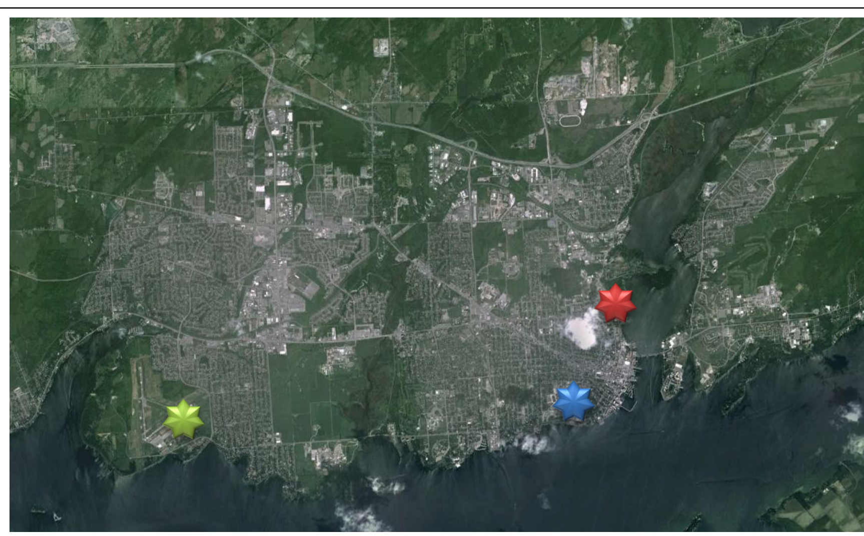
AES-12 Hour Design Storms







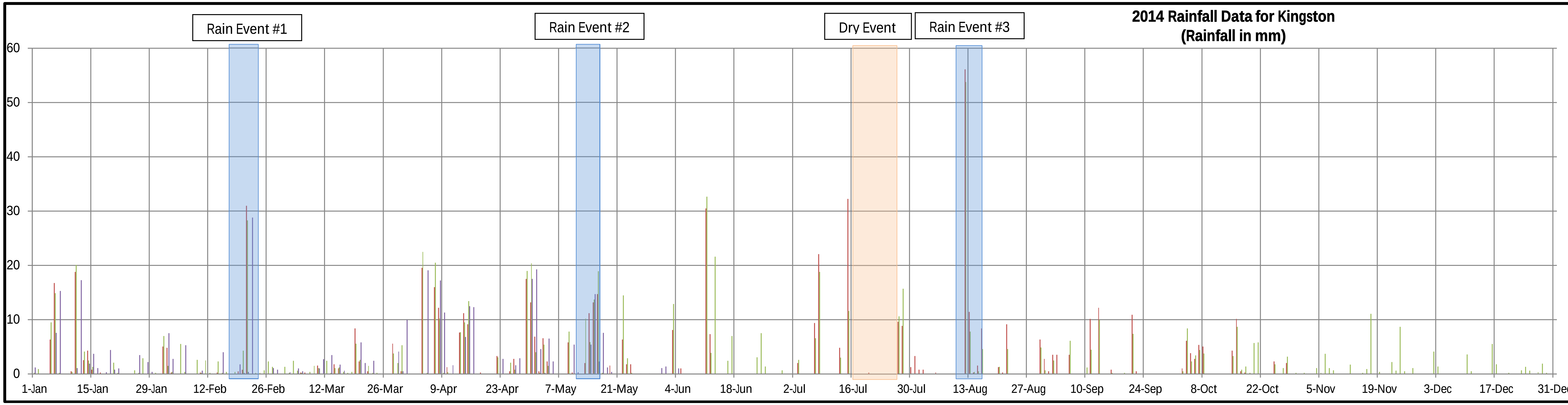


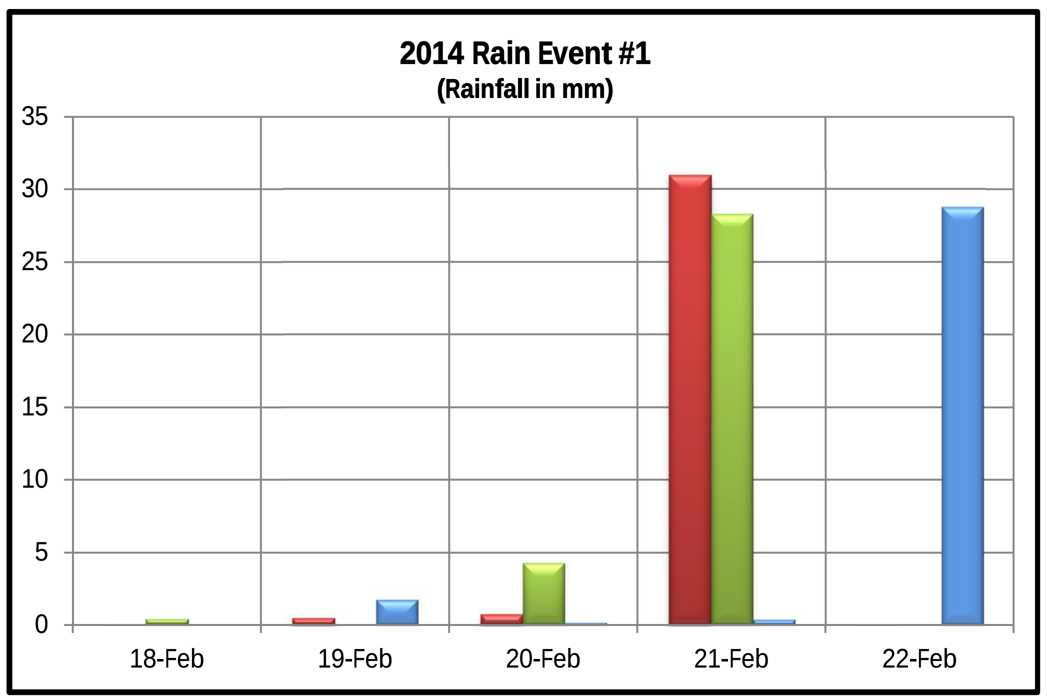


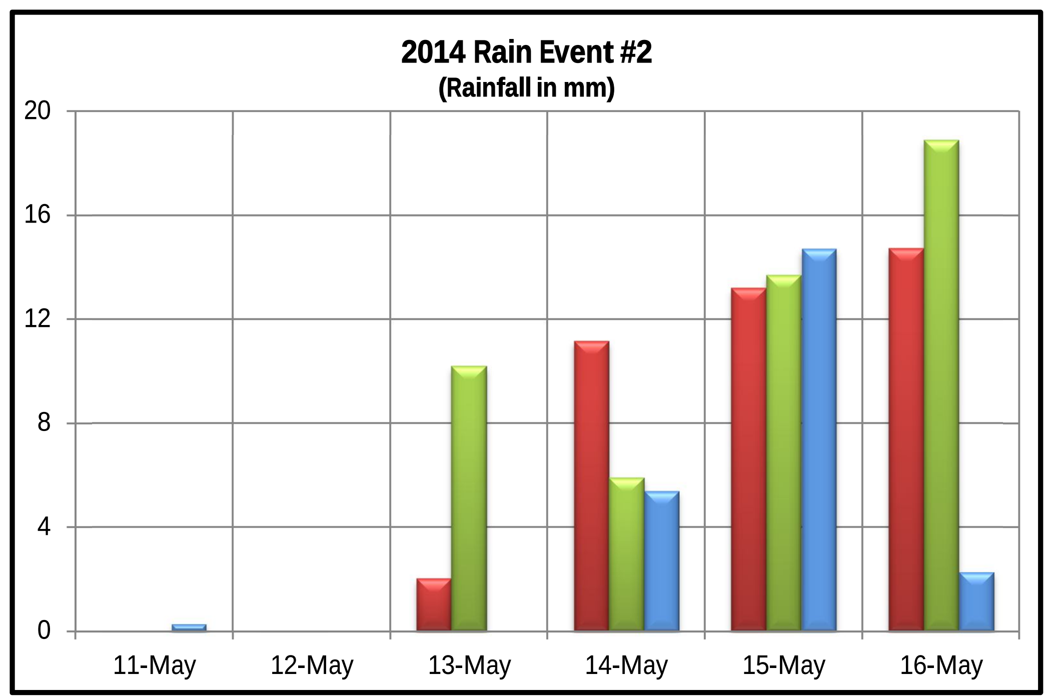
River Street PS Weather Station
Information provided by Utilities Kingston

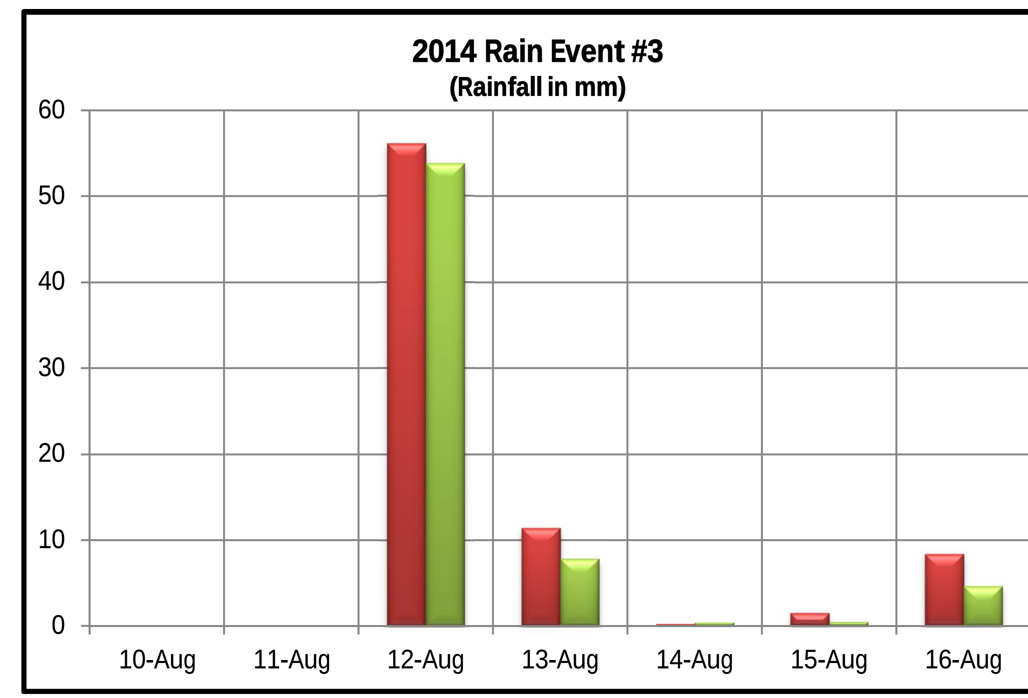
Queen's University – ILC Weather Station
Information collected from Queen's University

Kingston Airport Weather Station
Information collected from Environment Canada









Queen's University – ILC Weather Station
Information collected from Queen's University

Kingston Airport Weather Station
Information collected from Environment Canada

River Street PS Weather Station
Information collected from Utilities Kingston

;2013 MAP for Kingston
;Includes MAP of Queen's Univeristy ILC Beamish-Munroe Hall and River St. Weather Station Data

;Location	Year	Month	Day	Hour	Minute	Rain (mm)
Kingston	2013	1	6	6	15	0.502
Kingston	2013	1	6	6	30	0.251
Kingston	2013	1	6	7	0	0.251
Kingston	2013	1	6	8	45	0.251
Kingston	2013	1	6	12	15	0.251
Kingston	2013	1	6	12	30	0.251
Kingston	2013	1	6	12	45	0.251
Kingston	2013	1	6	13	15	0.251
Kingston	2013	1	6	13	45	0.251
Kingston	2013	1	6	14	15	0.251
Kingston	2013	1	6	14	30	0.251
Kingston	2013	1	6	17	0	0.251
Kingston	2013	1	11	15	30	0.251
Kingston	2013	1	11	15	45	0.251
Kingston	2013	1	11	17	15	0.251
Kingston	2013	1	11	18	0	0.251
Kingston	2013	1	11	18	15	0.251
Kingston	2013	1	11	18	30	0.251
Kingston	2013	1	11	20	0	0.251
Kingston	2013	1	12	2	45	0.251
Kingston	2013	1	13	6	30	0.251
Kingston	2013	1	13	6	45	1.004
Kingston	2013	1	13	7	0	0.753
Kingston	2013	1	13	7	15	0.251
Kingston	2013	1	13	7	45	0.753
Kingston	2013	1	13	8	0	0.502
Kingston	2013	1	13	8	15	0.251
Kingston	2013	1	13	8	30	1.757
Kingston	2013	1	13	8	45	1.255
Kingston	2013	1	13	9	0	1.255
Kingston	2013	1	13	9	15	0.753
Kingston	2013	1	13	22	0	0.251
Kingston	2013	1	13	22	30	0.251
Kingston	2013	1	13	23	0	0.251
Kingston	2013	1	14	3	0	0.502
Kingston	2013	1	14	3	15	0.251
Kingston	2013	1	14	4	0	0.251
Kingston	2013	1	20	4	45	0.251
Kingston	2013	1	20	5	0	0.251
Kingston	2013	1	20	5	30	0.251
Kingston	2013	1	20	5	45	0.251
Kingston	2013	1	20	6	15	0.251
Kingston	2013	1	29	21	39	0.254
Kingston	2013	1	29	21	46	0.254
Kingston	2013	1	29	21	52	0.254
Kingston	2013	1	29	21	56	0.254
Kingston	2013	1	29	22	3	0.254
Kingston	2013	1	29	22	10	0.254
Kingston	2013	1	29	22	14	0.254
Kingston	2013	1	29	22	17	0.254
Kingston	2013	1	29	22	20	0.254
Kingston	2013	1	29	22	26	0.254
Kingston	2013	1	29	22	31	0.254
Kingston	2013	1	29	22	33	0.254
Kingston	2013	1	29	22	35	0.254
Kingston	2013	1	29	22	36	0.254
Kingston	2013	1	29	22	38	0.254
Kingston	2013	1	29	22	39	0.254
Kingston	2013	1	29	22	41	0.254

Kingston	2013	1	29	22	42	0.254
Kingston	2013	1	29	22	44	0.254
Kingston	2013	1	29	22	46	0.254
Kingston	2013	1	29	22	50	0.254
Kingston	2013	1	29	22	55	0.254
Kingston	2013	1	29	23	3	0.254
Kingston	2013	1	29	23	12	0.254
Kingston	2013	1	29	23	17	0.254
Kingston	2013	1	29	23	22	0.254
Kingston	2013	1	29	23	28	0.254
Kingston	2013	1	29	23	43	0.254
Kingston	2013	1	30	9	15	0.251
Kingston	2013	1	30	12	0	0.502
Kingston	2013	1	30	12	15	0.753
Kingston	2013	1	30	12	30	0.502
Kingston	2013	1	30	13	0	0.251
Kingston	2013	1	30	22	45	0.251
Kingston	2013	1	30	23	0	0.753
Kingston	2013	1	30	23	15	0.502
Kingston	2013	1	30	23	30	0.502
Kingston	2013	1	30	23	45	0.753
Kingston	2013	1	31	0	0	1.004
Kingston	2013	1	31	0	15	0.276
Kingston	2013	1	31	0	30	0.9789
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Kingston	2013	3	12	0	30	0.753
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Kingston	2013	3	12	7	30	0.251
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Kingston	2013	3	12	8	30	0.251
Kingston	2013	3	12	9	0	0.251
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Kingston	2013	3	13	12	0	0.251
Kingston	2013	3	15	12	15	0.251
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Kingston	2013	4	8	21	15	0.251
Kingston	2013	4	8	21	30	0.251
Kingston	2013	4	8	21	45	0.251
Kingston	2013	4	8	22	0	0.251
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Kingston	2013	4	24	17	15	0.251
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Kingston	2013	5	10	23	15	2.259
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Kingston	2013	6	7	3	15	0.251
Kingston	2013	6	7	4	0	0.251
Kingston	2013	6	7	4	45	0.251
Kingston	2013	6	7	6	30	0.251
Kingston	2013	6	7	7	45	0.251
Kingston	2013	6	7	8	45	0.251
Kingston	2013	6	7	9	30	0.251
Kingston	2013	6	7	13	45	0.251
Kingston	2013	6	7	15	0	0.251
Kingston	2013	6	7	17	15	0.251
Kingston	2013	6	7	17	30	0.251
Kingston	2013	6	8	0	30	0.251
Kingston	2013	6	8	17	15	0.251
Kingston	2013	6	10	16	45	0.251
Kingston	2013	6	10	17	15	0.251
Kingston	2013	6	10	17	30	0.251
Kingston	2013	6	10	17	45	0.251
Kingston	2013	6	10	18	0	0.502
Kingston	2013	6	10	18	15	0.251
Kingston	2013	6	10	18	30	0.502
Kingston	2013	6	10	18	45	0.753
Kingston	2013	6	10	19	0	0.251
Kingston	2013	6	10	19	15	0.251
Kingston	2013	6	10	19	30	0.502
Kingston	2013	6	10	19	45	0.502
Kingston	2013	6	10	20	0	0.251
Kingston	2013	6	10	20	15	0.251
Kingston	2013	6	10	20	30	0.753
Kingston	2013	6	10	20	45	1.506
Kingston	2013	6	10	21	0	1.757
Kingston	2013	6	10	21	15	2.259
Kingston	2013	6	10	21	30	1.255
Kingston	2013	6	10	21	45	0.753
Kingston	2013	6	10	22	0	1.757
Kingston	2013	6	10	22	15	2.761
Kingston	2013	6	10	22	30	0.502
Kingston	2013	6	10	22	45	0.502
Kingston	2013	6	10	23	0	0.502
Kingston	2013	6	11	0	0	0.251

Kingston	2013	6	11	1	15	0.251
Kingston	2013	6	11	1	30	1.506
Kingston	2013	6	11	1	45	1.255
Kingston	2013	6	11	2	15	1.004
Kingston	2013	6	11	2	30	1.506
Kingston	2013	6	11	2	45	1.255
Kingston	2013	6	11	3	0	0.251
Kingston	2013	6	11	3	15	1.004
Kingston	2013	6	11	3	30	2.259
Kingston	2013	6	11	3	45	1.255
Kingston	2013	6	11	4	0	1.004
Kingston	2013	6	11	4	15	0.753
Kingston	2013	6	11	4	30	0.251
Kingston	2013	6	11	5	15	0.251
Kingston	2013	6	11	6	15	0.251
Kingston	2013	6	11	7	45	0.251
Kingston	2013	6	11	8	45	0.251
Kingston	2013	6	11	9	15	0.502
Kingston	2013	6	11	9	30	0.502
Kingston	2013	6	11	10	0	0.251
Kingston	2013	6	11	10	15	0.251
Kingston	2013	6	11	11	15	0.753
Kingston	2013	6	11	11	30	1.757
Kingston	2013	6	11	11	45	0.251
Kingston	2013	6	13	14	15	0.251
Kingston	2013	6	13	15	45	0.251
Kingston	2013	6	16	10	0	0.251
Kingston	2013	6	16	10	15	0.251
Kingston	2013	6	16	10	45	0.251
Kingston	2013	6	16	11	0	0.251
Kingston	2013	6	16	11	15	0.502
Kingston	2013	6	16	11	30	0.502
Kingston	2013	6	16	11	45	1.004
Kingston	2013	6	16	12	0	3.514
Kingston	2013	6	16	12	15	3.263
Kingston	2013	6	16	12	30	3.012
Kingston	2013	6	16	12	45	2.761
Kingston	2013	6	16	13	0	0.251
Kingston	2013	6	16	13	30	0.251
Kingston	2013	6	17	11	15	0.251
Kingston	2013	6	17	12	30	1.4307
Kingston	2013	6	17	12	45	0.5773
Kingston	2013	6	22	15	30	0.251
Kingston	2013	6	22	15	45	0.502
Kingston	2013	6	22	16	0	0.502
Kingston	2013	6	22	16	15	0.753
Kingston	2013	6	22	16	30	1.757
Kingston	2013	6	22	16	45	1.255
Kingston	2013	6	22	17	0	1.004
Kingston	2013	6	22	22	45	0.251
Kingston	2013	6	22	23	0	0.251
Kingston	2013	6	25	10	30	0.251
Kingston	2013	6	25	12	30	0.251
Kingston	2013	6	28	5	0	0.251
Kingston	2013	6	28	6	0	0.251
Kingston	2013	6	28	6	30	0.251
Kingston	2013	6	28	7	30	0.251
Kingston	2013	6	28	8	30	0.251
Kingston	2013	6	28	10	0	0.251
Kingston	2013	6	28	10	30	0.251
Kingston	2013	6	28	10	45	0.753
Kingston	2013	6	28	11	0	0.251
Kingston	2013	6	28	12	15	0.251

Kingston	2013	6	28	12	30	0.251
Kingston	2013	6	28	13	0	0.251
Kingston	2013	6	28	14	30	0.251
Kingston	2013	6	28	17	15	0.251
Kingston	2013	6	28	17	30	0.251
Kingston	2013	6	29	0	15	1.28
Kingston	2013	7	4	10	0	1.004
Kingston	2013	7	4	10	15	0.251
Kingston	2013	7	5	5	15	0.251
Kingston	2013	7	5	6	0	0.251
Kingston	2013	7	5	6	15	0.502
Kingston	2013	7	5	6	30	0.502
Kingston	2013	7	5	6	45	0.251
Kingston	2013	7	5	7	45	0.251
Kingston	2013	7	7	6	45	0.251
Kingston	2013	7	7	10	30	0.251
Kingston	2013	7	8	19	15	0.502
Kingston	2013	7	8	19	30	0.502
Kingston	2013	7	9	1	15	0.251
Kingston	2013	7	9	18	15	1.255
Kingston	2013	7	9	18	30	0.502
Kingston	2013	7	9	19	0	0.251
Kingston	2013	7	10	8	45	0.251
Kingston	2013	7	10	9	0	0.502
Kingston	2013	7	10	9	30	0.502
Kingston	2013	7	10	9	45	0.502
Kingston	2013	7	11	14	0	0.251
Kingston	2013	7	11	14	45	0.251
Kingston	2013	7	11	18	15	0.251
Kingston	2013	7	19	18	0	0.251
Kingston	2013	7	19	20	0	1.255
Kingston	2013	7	19	20	15	3.012
Kingston	2013	7	19	20	30	2.51
Kingston	2013	7	19	20	45	0.502
Kingston	2013	7	19	21	0	0.753
Kingston	2013	7	19	21	15	0.502
Kingston	2013	7	19	21	30	0.502
Kingston	2013	7	20	4	30	0.502
Kingston	2013	7	20	4	45	0.753
Kingston	2013	7	20	5	15	0.502
Kingston	2013	7	20	5	30	0.502
Kingston	2013	7	20	11	30	0.251
Kingston	2013	8	9	9	45	0.251
Kingston	2013	8	9	10	0	0.251
Kingston	2013	8	9	10	15	0.251
Kingston	2013	8	9	9	45	0.254
Kingston	2013	8	9	10	0	0.254
Kingston	2013	8	9	10	15	0.254
Kingston	2013	8	14	5	15	0.254
Kingston	2013	8	14	5	30	0.762
Kingston	2013	8	14	5	45	0.254
Kingston	2013	8	22	13	45	2.8448
Kingston	2013	8	22	14	0	1.2192
Kingston	2013	8	22	14	15	1.016
Kingston	2013	8	22	14	30	0.254
Kingston	2013	8	22	14	45	0.254
Kingston	2013	8	22	15	0	0.508
Kingston	2013	8	22	15	15	0.254
Kingston	2013	8	22	16	45	0.508
Kingston	2013	8	25	23	30	0.508
Kingston	2013	8	26	1	0	0.254
Kingston	2013	8	26	10	0	0.254
Kingston	2013	8	26	16	15	0.254

Kingston	2013	8	26	16	30	0.254
Kingston	2013	8	26	16	45	0.254
Kingston	2013	8	26	17	0	0.508
Kingston	2013	8	26	17	15	0.762
Kingston	2013	8	26	17	30	0.508
Kingston	2013	8	26	17	45	4.826
Kingston	2013	8	26	18	0	5.588
Kingston	2013	8	26	18	15	0.508
Kingston	2013	8	26	18	30	0.254
Kingston	2013	8	26	18	45	0.254
Kingston	2013	8	26	19	0	0.254
Kingston	2013	8	26	20	30	0.254
Kingston	2013	8	26	21	30	0.254
Kingston	2013	8	26	21	45	0.254
Kingston	2013	8	28	4	45	0.254
Kingston	2013	8	31	3	15	0.762
Kingston	2013	8	31	3	30	0.254
Kingston	2013	8	31	3	45	0.254
Kingston	2013	8	31	4	45	0.254
Kingston	2013	8	31	5	0	0.762
Kingston	2013	8	31	5	15	1.524
Kingston	2013	8	31	5	30	1.016
Kingston	2013	8	31	5	45	0.254
Kingston	2013	8	31	14	45	0.254
Kingston	2013	9	1	23	0	0.254
Kingston	2013	9	1	23	15	0.762
Kingston	2013	9	1	23	30	0.762
Kingston	2013	9	1	23	45	3.81
Kingston	2013	9	2	0	0	0.9398
Kingston	2013	9	2	0	15	1.0922
Kingston	2013	9	2	0	45	1.778
Kingston	2013	9	2	1	0	1.016
Kingston	2013	9	2	1	15	0.254
Kingston	2013	9	7	17	15	0.254
Kingston	2013	9	7	18	45	0.0508
Kingston	2013	9	7	19	0	0.2032
Kingston	2013	9	7	20	45	0.254
Kingston	2013	9	10	5	15	0.508
Kingston	2013	9	10	6	0	0.762
Kingston	2013	9	10	6	15	0.508
Kingston	2013	9	10	6	30	0.508
Kingston	2013	9	10	6	45	10.1092
Kingston	2013	9	10	7	0	1.3208
Kingston	2013	9	10	7	15	0.254
Kingston	2013	9	10	7	30	0.254
Kingston	2013	9	10	7	45	0.254
Kingston	2013	9	12	1	30	0.254
Kingston	2013	9	12	2	0	0.254
Kingston	2013	9	12	2	15	0.508
Kingston	2013	9	12	2	45	0.762
Kingston	2013	9	12	3	45	0.254
Kingston	2013	9	12	7	0	0.254
Kingston	2013	9	12	7	30	1.778
Kingston	2013	9	12	7	45	1.016
Kingston	2013	9	12	8	0	0.254
Kingston	2013	9	15	19	45	2.794
Kingston	2013	9	15	20	0	0.762
Kingston	2013	9	15	20	15	0.254
Kingston	2013	9	15	20	30	0.254
Kingston	2013	9	15	20	45	0.254
Kingston	2013	9	15	21	0	0.254
Kingston	2013	9	15	21	15	0.254
Kingston	2013	9	15	21	45	0.508

Kingston	2013	9	15	22	0	0.508
Kingston	2013	9	15	22	15	0.508
Kingston	2013	9	15	22	30	0.254
Kingston	2013	9	15	22	45	0.254
Kingston	2013	9	15	23	15	0.254
Kingston	2013	9	15	23	30	0.254
Kingston	2013	9	16	0	45	0.254
Kingston	2013	9	16	1	0	0.254
Kingston	2013	9	16	1	15	0.254
Kingston	2013	9	16	1	30	0.254
Kingston	2013	9	16	2	15	0.254
Kingston	2013	9	16	9	45	0.254
Kingston	2013	9	21	4	0	1.524
Kingston	2013	9	21	4	15	0.254
Kingston	2013	9	21	7	45	0.254
Kingston	2013	9	21	8	15	3.1496
Kingston	2013	9	21	8	30	1.1684
Kingston	2013	9	21	10	0	0.254
Kingston	2013	9	21	10	15	1.27
Kingston	2013	9	21	10	30	2.286
Kingston	2013	9	21	10	45	0.508
Kingston	2013	9	21	11	45	0.508
Kingston	2013	9	21	12	0	0.762
Kingston	2013	9	21	12	15	0.254
Kingston	2013	9	21	12	30	1.524
Kingston	2013	9	21	13	15	0.254
Kingston	2013	9	21	13	30	1.016
Kingston	2013	9	21	14	0	0.254
Kingston	2013	9	21	14	15	0.508
Kingston	2013	9	21	14	30	0.762
Kingston	2013	9	21	14	45	1.016
Kingston	2013	9	21	15	0	1.016
Kingston	2013	9	21	15	15	2.286
Kingston	2013	9	21	15	30	1.524
Kingston	2013	9	21	15	45	0.762
Kingston	2013	9	21	16	0	1.016
Kingston	2013	9	21	16	15	1.016
Kingston	2013	9	21	16	30	1.524
Kingston	2013	9	21	16	45	1.016
Kingston	2013	9	21	17	0	0.254
Kingston	2013	9	21	17	15	1.016
Kingston	2013	9	21	17	30	0.762
Kingston	2013	9	21	17	45	0.254
Kingston	2013	9	21	18	0	0.762
Kingston	2013	9	21	18	15	0.762
Kingston	2013	9	21	18	30	0.508
Kingston	2013	9	21	18	45	0.508
Kingston	2013	9	21	19	0	0.508
Kingston	2013	9	21	19	15	0.508
Kingston	2013	9	21	19	30	0.508
Kingston	2013	9	21	20	0	0.254
Kingston	2013	9	21	20	30	0.254
Kingston	2013	9	21	20	45	0.254
Kingston	2013	9	21	21	0	0.254
Kingston	2013	9	21	21	30	0.508
Kingston	2013	9	21	21	45	1.27
Kingston	2013	9	21	22	0	0.254
Kingston	2013	9	21	22	15	0.762
Kingston	2013	9	21	22	30	0.254
Kingston	2013	9	21	23	15	0.254
Kingston	2013	9	22	0	0	0.254
Kingston	2013	9	22	0	30	0.254

;2014 MAP for Kingston
;Includes MAP of Queen's Univeristy ILC Beamish-Munroe Hall

Location	Year	Month	Day	Hour	Minute	Daily Rain (mm)
Kingston	2014	1	5	20	30	0.254
Kingston	2014	1	5	20	53	0.254
Kingston	2014	1	5	20	57	0.254
Kingston	2014	1	5	21	11	0.254
Kingston	2014	1	5	21	15	0.254
Kingston	2014	1	5	21	26	0.254
Kingston	2014	1	5	21	29	0.254
Kingston	2014	1	5	21	37	0.254
Kingston	2014	1	5	21	40	0.254
Kingston	2014	1	5	21	46	0.254
Kingston	2014	1	5	21	48	0.254
Kingston	2014	1	5	21	54	0.254
Kingston	2014	1	5	21	55	0.254
Kingston	2014	1	5	21	59	0.254
Kingston	2014	1	5	22	0	0.254
Kingston	2014	1	5	22	3	0.254
Kingston	2014	1	5	22	5	0.254
Kingston	2014	1	5	22	7	0.254
Kingston	2014	1	5	22	8	0.254
Kingston	2014	1	5	22	47	0.254
Kingston	2014	1	5	23	27	0.254
Kingston	2014	1	5	23	37	0.254
Kingston	2014	1	5	23	38	0.254
Kingston	2014	1	5	23	43	0.254
Kingston	2014	1	5	23	57	0.254
Kingston	2014	1	6	0	5	0.254
Kingston	2014	1	6	0	14	0.254
Kingston	2014	1	6	0	37	0.254
Kingston	2014	1	6	0	52	0.254
Kingston	2014	1	6	0	59	0.254
Kingston	2014	1	6	1	5	0.254
Kingston	2014	1	6	1	9	0.254
Kingston	2014	1	6	1	16	0.254
Kingston	2014	1	6	1	18	0.254
Kingston	2014	1	6	1	22	0.254
Kingston	2014	1	6	1	28	0.254
Kingston	2014	1	6	1	36	0.254
Kingston	2014	1	6	1	41	0.254
Kingston	2014	1	6	1	53	0.254
Kingston	2014	1	6	2	5	0.254
Kingston	2014	1	6	2	13	0.254
Kingston	2014	1	6	2	21	0.254
Kingston	2014	1	6	2	27	0.254
Kingston	2014	1	6	2	31	0.254
Kingston	2014	1	6	2	41	0.254
Kingston	2014	1	6	2	45	0.254
Kingston	2014	1	6	2	51	0.254
Kingston	2014	1	6	2	55	0.254
Kingston	2014	1	6	3	1	0.254
Kingston	2014	1	6	3	10	0.254
Kingston	2014	1	6	3	13	0.254
Kingston	2014	1	6	3	17	0.254
Kingston	2014	1	6	3	19	0.254
Kingston	2014	1	6	3	23	0.254
Kingston	2014	1	6	3	27	0.254
Kingston	2014	1	6	3	32	0.254
Kingston	2014	1	6	3	35	0.254
Kingston	2014	1	6	3	39	0.254
Kingston	2014	1	6	3	41	0.254

Kingston	2014	1	6	3	46	0.254
Kingston	2014	1	6	3	51	0.254
Kingston	2014	1	6	3	56	0.254
Kingston	2014	1	6	3	58	0.254
Kingston	2014	1	6	4	3	0.254
Kingston	2014	1	6	4	7	0.254
Kingston	2014	1	6	4	10	0.254
Kingston	2014	1	6	4	11	0.254
Kingston	2014	1	6	4	13	0.254
Kingston	2014	1	6	4	14	0.254
Kingston	2014	1	6	4	16	0.254
Kingston	2014	1	6	4	17	0.254
Kingston	2014	1	6	4	20	0.254
Kingston	2014	1	6	4	22	0.254
Kingston	2014	1	6	4	26	0.254
Kingston	2014	1	6	4	30	0.254
Kingston	2014	1	6	4	42	0.254
Kingston	2014	1	6	4	47	0.254
Kingston	2014	1	6	4	51	0.254
Kingston	2014	1	6	4	54	0.254
Kingston	2014	1	6	4	58	0.254
Kingston	2014	1	6	5	1	0.254
Kingston	2014	1	6	5	10	0.254
Kingston	2014	1	6	5	17	0.254
Kingston	2014	1	6	5	22	0.254
Kingston	2014	1	6	5	28	0.254
Kingston	2014	1	6	5	34	0.254
Kingston	2014	1	6	5	40	0.254
Kingston	2014	1	6	5	49	0.254
Kingston	2014	1	6	6	33	0.254
Kingston	2014	1	6	7	4	0.254
Kingston	2014	1	6	7	7	0.254
Kingston	2014	1	6	7	13	0.254
Kingston	2014	1	10	21	30	0.254
Kingston	2014	1	10	23	49	0.254
Kingston	2014	1	11	3	38	0.254
Kingston	2014	1	11	4	50	0.254
Kingston	2014	1	11	8	50	0.254
Kingston	2014	1	11	9	0	0.254
Kingston	2014	1	11	9	5	0.254
Kingston	2014	1	11	9	8	0.254
Kingston	2014	1	11	9	11	0.254
Kingston	2014	1	11	9	14	0.254
Kingston	2014	1	11	9	17	0.254
Kingston	2014	1	11	9	21	0.254
Kingston	2014	1	11	9	24	0.254
Kingston	2014	1	11	9	26	0.254
Kingston	2014	1	11	9	28	0.254
Kingston	2014	1	11	9	31	0.254
Kingston	2014	1	11	9	33	0.254
Kingston	2014	1	11	9	36	0.254
Kingston	2014	1	11	9	39	0.254
Kingston	2014	1	11	9	44	0.254
Kingston	2014	1	11	9	47	0.254
Kingston	2014	1	11	9	50	0.254
Kingston	2014	1	11	9	53	0.254
Kingston	2014	1	11	9	56	0.254
Kingston	2014	1	11	10	0	0.254
Kingston	2014	1	11	10	5	0.254
Kingston	2014	1	11	10	9	0.254
Kingston	2014	1	11	10	14	0.254
Kingston	2014	1	11	10	20	0.254
Kingston	2014	1	11	10	24	0.254

Kingston	2014	1	11	10	25	0.254
Kingston	2014	1	11	10	28	0.254
Kingston	2014	1	11	10	30	0.254
Kingston	2014	1	11	10	35	0.254
Kingston	2014	1	11	10	38	0.254
Kingston	2014	1	11	10	41	0.254
Kingston	2014	1	11	10	43	0.254
Kingston	2014	1	11	10	50	0.254
Kingston	2014	1	11	10	53	0.254
Kingston	2014	1	11	10	58	0.254
Kingston	2014	1	11	11	5	0.254
Kingston	2014	1	11	11	11	0.254
Kingston	2014	1	11	11	15	0.254
Kingston	2014	1	11	11	19	0.254
Kingston	2014	1	11	11	22	0.254
Kingston	2014	1	11	11	27	0.254
Kingston	2014	1	11	11	30	0.254
Kingston	2014	1	11	11	36	0.254
Kingston	2014	1	11	11	40	0.254
Kingston	2014	1	11	11	46	0.254
Kingston	2014	1	11	11	49	0.254
Kingston	2014	1	11	11	51	0.254
Kingston	2014	1	11	11	53	0.254
Kingston	2014	1	11	11	55	0.254
Kingston	2014	1	11	11	57	0.254
Kingston	2014	1	11	11	59	0.254
Kingston	2014	1	11	12	0	0.254
Kingston	2014	1	11	12	1	0.254
Kingston	2014	1	11	12	3	0.254
Kingston	2014	1	11	12	5	0.254
Kingston	2014	1	11	12	6	0.254
Kingston	2014	1	11	12	9	0.254
Kingston	2014	1	11	12	11	0.254
Kingston	2014	1	11	12	15	0.254
Kingston	2014	1	11	12	19	0.254
Kingston	2014	1	11	12	39	0.254
Kingston	2014	1	11	12	54	0.254
Kingston	2014	1	11	17	46	0.254
Kingston	2014	1	11	17	56	0.254
Kingston	2014	1	11	18	1	0.254
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Kingston	2014	8	16	16	13	0.254
Kingston	2014	8	16	16	17	0.254
Kingston	2014	8	16	16	19	0.254
Kingston	2014	8	16	16	22	0.254
Kingston	2014	8	16	16	24	0.254
Kingston	2014	8	16	16	26	0.254
Kingston	2014	8	16	16	28	0.254
Kingston	2014	8	16	16	30	0.254
Kingston	2014	8	16	16	33	0.254
Kingston	2014	8	16	16	36	0.254
Kingston	2014	8	16	16	38	0.254
Kingston	2014	8	16	16	40	0.254
Kingston	2014	8	16	16	43	0.254
Kingston	2014	8	16	16	45	0.254
Kingston	2014	8	16	16	49	0.254
Kingston	2014	8	16	17	37	0.254
Kingston	2014	8	16	17	38	0.254
Kingston	2014	8	16	17	39	0.254
Kingston	2014	8	16	17	40	0.254
Kingston	2014	8	16	17	40	0.254
Kingston	2014	8	16	17	41	0.254
Kingston	2014	8	16	17	42	0.254
Kingston	2014	8	16	17	44	0.254
Kingston	2014	8	16	17	46	0.254
Kingston	2014	8	16	17	47	0.254
Kingston	2014	8	16	17	51	0.254
Kingston	2014	8	16	20	17	0.254
Kingston	2014	8	20	18	13	0.254
Kingston	2014	8	20	18	55	0.254
Kingston	2014	8	20	19	12	0.254
Kingston	2014	8	20	19	25	0.254
Kingston	2014	8	20	19	39	0.254
Kingston	2014	8	21	1	38	0.254
Kingston	2014	8	22	17	17	0.254
Kingston	2014	8	22	17	17	0.508
Kingston	2014	8	22	17	18	0.254
Kingston	2014	8	22	17	18	0.254
Kingston	2014	8	22	17	19	0.254

Kingston	2014	8	22	17	19	0.254
Kingston	2014	8	22	17	20	0.254
Kingston	2014	8	22	17	21	0.254
Kingston	2014	8	22	17	22	0.254
Kingston	2014	8	22	17	22	0.254
Kingston	2014	8	22	17	22	0.254
Kingston	2014	8	22	17	23	0.254
Kingston	2014	8	22	17	23	0.254
Kingston	2014	8	22	17	24	0.254
Kingston	2014	8	22	17	24	0.508
Kingston	2014	8	22	17	25	0.254
Kingston	2014	8	22	17	27	1.016
Kingston	2014	8	22	17	27	0.254
Kingston	2014	8	22	17	28	0.254
Kingston	2014	8	22	17	28	0.254
Kingston	2014	8	22	17	29	0.254
Kingston	2014	8	22	17	31	0.508
Kingston	2014	8	22	17	32	0.254
Kingston	2014	8	22	17	33	0.254
Kingston	2014	8	22	17	34	0.254
Kingston	2014	8	22	17	35	0.254
Kingston	2014	8	22	17	37	0.254
Kingston	2014	8	22	17	40	0.254
Kingston	2014	8	22	17	51	0.254
Kingston	2014	8	30	19	27	0.254
Kingston	2014	8	30	19	30	0.254
Kingston	2014	8	30	19	30	0.254
Kingston	2014	8	30	19	31	0.254
Kingston	2014	8	30	19	32	0.254
Kingston	2014	8	30	19	33	0.254
Kingston	2014	8	30	19	34	0.254
Kingston	2014	8	30	19	35	0.254
Kingston	2014	8	30	19	38	0.254
Kingston	2014	8	30	19	41	0.254
Kingston	2014	8	30	22	30	0.254
Kingston	2014	8	30	22	30	0.254
Kingston	2014	8	30	22	31	0.508
Kingston	2014	8	30	22	31	0.508
Kingston	2014	8	30	22	32	0.508
Kingston	2014	8	30	22	32	0.508
Kingston	2014	8	30	22	32	0.508
Kingston	2014	8	30	22	33	0.254
Kingston	2014	8	30	22	33	0.254
Kingston	2014	8	30	23	30	0.254
Kingston	2014	8	31	0	16	0.254
Kingston	2014	8	31	9	57	0.254
Kingston	2014	8	31	10	4	0.254
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Kingston	2014	8	31	10	10	0.254
Kingston	2014	8	31	10	14	0.254
Kingston	2014	8	31	11	21	0.254
Kingston	2014	8	31	12	28	0.254
Kingston	2014	8	31	12	29	0.254
Kingston	2014	8	31	12	29	0.254
Kingston	2014	8	31	12	30	0.254
Kingston	2014	9	1	23	3	0.254
Kingston	2014	9	1	23	6	0.254
Kingston	2014	9	2	16	19	0.254
Kingston	2014	9	2	16	40	0.254
Kingston	2014	9	2	16	41	0.254
Kingston	2014	9	2	16	42	0.254
Kingston	2014	9	2	16	42	0.254

Kingston	2014	9	2	16	43	0.254
Kingston	2014	9	2	16	44	0.254
Kingston	2014	9	2	16	49	0.254
Kingston	2014	9	2	17	10	0.254
Kingston	2014	9	2	18	2	0.254
Kingston	2014	9	2	18	6	0.254
Kingston	2014	9	2	18	10	0.254
Kingston	2014	9	2	18	17	0.254
Kingston	2014	9	2	18	37	0.254
Kingston	2014	9	6	2	57	0.254
Kingston	2014	9	6	3	36	0.254
Kingston	2014	9	6	4	8	0.254
Kingston	2014	9	6	5	50	0.254
Kingston	2014	9	6	7	39	0.254
Kingston	2014	9	6	8	49	0.254
Kingston	2014	9	6	9	14	0.254
Kingston	2014	9	6	9	16	0.254
Kingston	2014	9	6	9	16	0.254
Kingston	2014	9	6	9	20	0.254
Kingston	2014	9	6	9	25	0.254
Kingston	2014	9	6	10	24	0.254
Kingston	2014	9	6	14	58	0.254
Kingston	2014	9	6	22	26	0.254
Kingston	2014	9	11	0	46	0.254
Kingston	2014	9	11	1	18	0.254
Kingston	2014	9	11	1	23	0.254
Kingston	2014	9	11	1	32	0.254
Kingston	2014	9	11	1	36	0.254
Kingston	2014	9	11	1	38	0.254
Kingston	2014	9	11	1	40	0.254
Kingston	2014	9	11	1	42	0.254
Kingston	2014	9	11	1	43	0.254
Kingston	2014	9	11	1	44	0.254
Kingston	2014	9	11	1	47	0.254
Kingston	2014	9	11	1	48	0.254
Kingston	2014	9	11	1	51	0.254
Kingston	2014	9	11	1	54	0.254
Kingston	2014	9	11	1	56	0.254
Kingston	2014	9	11	1	57	0.254
Kingston	2014	9	11	1	59	0.254
Kingston	2014	9	11	2	14	0.254
Kingston	2014	9	11	2	53	0.254
Kingston	2014	9	11	2	54	0.254
Kingston	2014	9	11	2	56	0.254
Kingston	2014	9	11	2	59	0.254
Kingston	2014	9	11	3	1	0.254
Kingston	2014	9	11	3	2	0.254
Kingston	2014	9	11	3	5	0.254
Kingston	2014	9	11	3	12	0.254
Kingston	2014	9	11	3	49	0.254
Kingston	2014	9	11	4	26	0.254
Kingston	2014	9	11	4	34	0.254
Kingston	2014	9	11	4	38	0.254
Kingston	2014	9	11	4	50	0.254
Kingston	2014	9	11	6	9	0.508
Kingston	2014	9	11	6	15	0.254
Kingston	2014	9	11	6	23	0.254
Kingston	2014	9	11	6	24	0.254
Kingston	2014	9	11	6	25	0.254
Kingston	2014	9	11	6	27	0.254
Kingston	2014	9	11	6	29	0.254
Kingston	2014	9	11	6	42	0.254
Kingston	2014	9	13	9	33	0.254

Kingston	2014	9	13	9	48	0.254
Kingston	2014	9	13	10	0	0.254
Kingston	2014	9	13	10	16	0.254
Kingston	2014	9	13	10	25	0.254
Kingston	2014	9	13	10	32	0.254
Kingston	2014	9	13	10	41	0.254
Kingston	2014	9	13	10	50	0.254
Kingston	2014	9	13	11	18	0.254
Kingston	2014	9	13	11	26	0.254
Kingston	2014	9	13	11	30	0.254
Kingston	2014	9	13	11	33	0.254
Kingston	2014	9	13	11	36	0.254
Kingston	2014	9	13	11	39	0.254
Kingston	2014	9	13	11	42	0.254
Kingston	2014	9	13	11	45	0.254
Kingston	2014	9	13	11	48	0.254
Kingston	2014	9	13	11	52	0.254
Kingston	2014	9	13	11	55	0.254
Kingston	2014	9	13	11	59	0.254
Kingston	2014	9	13	12	8	0.254
Kingston	2014	9	13	12	14	0.254
Kingston	2014	9	13	12	16	0.254
Kingston	2014	9	13	12	20	0.254
Kingston	2014	9	13	12	22	0.254
Kingston	2014	9	13	12	27	0.254
Kingston	2014	9	13	12	29	0.254
Kingston	2014	9	13	12	30	0.254
Kingston	2014	9	13	12	32	0.254
Kingston	2014	9	13	12	35	0.254
Kingston	2014	9	13	12	36	0.254
Kingston	2014	9	13	12	40	0.254
Kingston	2014	9	13	12	42	0.254
Kingston	2014	9	13	12	44	0.254
Kingston	2014	9	13	12	46	0.254
Kingston	2014	9	13	12	48	0.254
Kingston	2014	9	13	12	49	0.254
Kingston	2014	9	13	12	52	0.254
Kingston	2014	9	13	12	57	0.254
Kingston	2014	9	13	13	19	0.254
Kingston	2014	9	13	13	30	0.254
Kingston	2014	9	13	13	39	0.254
Kingston	2014	9	13	13	46	0.254
Kingston	2014	9	13	13	48	0.254
Kingston	2014	9	13	13	51	0.254
Kingston	2014	9	13	13	56	0.254
Kingston	2014	9	13	14	4	0.254
Kingston	2014	9	13	15	47	0.254
Kingston	2014	9	16	1	47	0.254
Kingston	2014	9	16	2	31	0.254
Kingston	2014	9	16	2	53	0.254
Kingston	2014	9	21	7	9	0.254
Kingston	2014	9	21	7	10	0.254
Kingston	2014	9	21	7	10	0.508
Kingston	2014	9	21	7	11	0.508
Kingston	2014	9	21	7	12	0.508
Kingston	2014	9	21	9	30	0.254
Kingston	2014	9	21	9	33	0.254
Kingston	2014	9	21	9	35	0.254
Kingston	2014	9	21	9	37	0.254
Kingston	2014	9	21	9	41	0.254
Kingston	2014	9	21	9	56	0.254
Kingston	2014	9	21	10	0	0.254
Kingston	2014	9	21	10	3	0.254

Kingston	2014	9	21	10	6	0.254
Kingston	2014	9	21	10	8	0.254
Kingston	2014	9	21	10	11	0.254
Kingston	2014	9	21	10	13	0.254
Kingston	2014	9	21	10	15	0.254
Kingston	2014	9	21	10	17	0.254
Kingston	2014	9	21	10	17	0.254
Kingston	2014	9	21	10	18	0.254
Kingston	2014	9	21	10	19	0.254
Kingston	2014	9	21	10	19	0.254
Kingston	2014	9	21	10	20	0.254
Kingston	2014	9	21	10	22	0.254
Kingston	2014	9	21	10	23	0.254
Kingston	2014	9	21	10	28	0.254
Kingston	2014	9	21	11	4	0.254
Kingston	2014	9	21	11	8	0.254
Kingston	2014	9	21	11	9	0.254
Kingston	2014	9	21	11	13	0.254
Kingston	2014	9	21	11	49	0.254
Kingston	2014	9	21	19	58	0.254
Kingston	2014	9	21	20	40	0.254
Kingston	2014	9	21	20	42	0.254
Kingston	2014	9	21	20	47	0.254
Kingston	2014	9	21	20	54	0.254
Kingston	2014	9	21	22	10	0.254
Kingston	2014	9	21	22	14	0.254
Kingston	2014	9	22	0	15	0.254
Kingston	2014	9	22	0	16	0.254
Kingston	2014	9	22	0	17	0.254
Kingston	2014	9	22	0	18	0.254
Kingston	2014	9	22	0	19	0.254
Kingston	2014	9	22	0	37	0.254
Kingston	2014	9	22	0	43	0.254
Kingston	2014	10	3	19	33	0.254
Kingston	2014	10	3	20	1	0.254
Kingston	2014	10	3	20	36	0.254
Kingston	2014	10	3	22	17	0.254
Kingston	2014	10	4	6	12	0.254
Kingston	2014	10	4	6	38	0.254
Kingston	2014	10	4	6	43	0.254
Kingston	2014	10	4	6	46	0.254
Kingston	2014	10	4	6	47	0.254
Kingston	2014	10	4	6	55	0.254
Kingston	2014	10	4	7	49	0.254
Kingston	2014	10	4	7	54	0.254
Kingston	2014	10	4	8	14	0.254
Kingston	2014	10	4	8	25	0.254
Kingston	2014	10	4	8	31	0.254
Kingston	2014	10	4	8	34	0.254
Kingston	2014	10	4	8	37	0.254
Kingston	2014	10	4	8	39	0.254
Kingston	2014	10	4	8	42	0.254
Kingston	2014	10	4	8	42	0.254
Kingston	2014	10	4	8	47	0.254
Kingston	2014	10	4	8	59	0.254
Kingston	2014	10	4	9	13	0.254
Kingston	2014	10	4	9	19	0.254
Kingston	2014	10	4	9	23	0.254
Kingston	2014	10	4	12	9	0.254
Kingston	2014	10	4	13	52	0.254
Kingston	2014	10	4	14	25	0.254
Kingston	2014	10	5	13	5	0.254
Kingston	2014	10	5	13	8	0.254

Kingston	2014	10	5	13	9	0.254
Kingston	2014	10	5	13	9	0.254
Kingston	2014	10	5	13	12	0.254
Kingston	2014	10	5	13	14	0.254
Kingston	2014	10	5	13	14	0.254
Kingston	2014	10	5	13	16	0.508
Kingston	2014	10	5	13	18	0.254
Kingston	2014	10	5	13	19	0.254
Kingston	2014	10	5	13	25	0.508
Kingston	2014	10	5	13	32	0.254
Kingston	2014	10	5	22	28	0.254
Kingston	2014	10	6	11	18	0.254
Kingston	2014	10	6	11	48	0.254
Kingston	2014	10	6	12	26	0.254
Kingston	2014	10	6	20	55	0.254
Kingston	2014	10	6	21	12	0.254
Kingston	2014	10	6	21	22	0.254
Kingston	2014	10	6	21	31	0.254
Kingston	2014	10	6	22	4	0.254
Kingston	2014	10	6	22	15	0.254
Kingston	2014	10	6	23	7	0.254
Kingston	2014	10	6	23	37	0.254
Kingston	2014	10	7	0	22	0.254
Kingston	2014	10	7	1	35	0.254
Kingston	2014	10	7	1	42	0.254
Kingston	2014	10	7	1	53	0.254
Kingston	2014	10	7	4	11	0.254
Kingston	2014	10	7	4	32	0.254
Kingston	2014	10	7	5	4	0.254
Kingston	2014	10	7	5	40	0.254
Kingston	2014	10	7	5	48	0.254
Kingston	2014	10	7	5	58	0.254
Kingston	2014	10	7	6	8	0.254
Kingston	2014	10	7	8	2	0.254
Kingston	2014	10	7	8	3	0.254
Kingston	2014	10	7	8	4	0.508
Kingston	2014	10	7	8	5	0.254
Kingston	2014	10	7	8	5	0.254
Kingston	2014	10	7	8	5	0.508
Kingston	2014	10	7	8	6	0.254
Kingston	2014	10	7	8	6	0.254
Kingston	2014	10	7	8	28	0.254
Kingston	2014	10	8	0	13	0.254
Kingston	2014	10	8	0	21	0.254
Kingston	2014	10	8	0	23	0.254
Kingston	2014	10	8	0	26	0.254
Kingston	2014	10	8	0	30	0.254
Kingston	2014	10	8	0	37	0.254
Kingston	2014	10	8	0	41	0.254
Kingston	2014	10	8	0	51	0.254
Kingston	2014	10	8	1	4	0.254
Kingston	2014	10	8	1	21	0.254
Kingston	2014	10	8	1	37	0.254
Kingston	2014	10	8	1	45	0.254
Kingston	2014	10	8	1	51	0.254
Kingston	2014	10	8	1	58	0.254
Kingston	2014	10	8	2	4	0.254
Kingston	2014	10	8	2	12	0.254
Kingston	2014	10	8	2	20	0.254
Kingston	2014	10	8	2	26	0.254
Kingston	2014	10	8	2	35	0.254
Kingston	2014	10	8	2	44	0.254
Kingston	2014	10	8	3	34	0.254

Kingston	2014	10	8	12	7	0.254
Kingston	2014	10	8	12	8	0.254
Kingston	2014	10	8	18	42	0.254
Kingston	2014	10	15	5	41	0.254
Kingston	2014	10	15	5	51	0.254
Kingston	2014	10	15	6	8	0.254
Kingston	2014	10	15	6	30	0.254
Kingston	2014	10	15	11	24	0.254
Kingston	2014	10	15	12	12	0.254
Kingston	2014	10	15	12	18	0.254
Kingston	2014	10	15	12	23	0.254
Kingston	2014	10	15	12	26	0.254
Kingston	2014	10	15	12	28	0.254
Kingston	2014	10	15	12	30	0.254
Kingston	2014	10	15	12	43	0.254
Kingston	2014	10	15	17	30	0.254
Kingston	2014	10	15	18	1	0.254
Kingston	2014	10	15	18	29	0.254
Kingston	2014	10	15	19	9	0.254
Kingston	2014	10	15	19	52	0.254
Kingston	2014	10	16	2	1	0.254
Kingston	2014	10	16	4	43	0.254
Kingston	2014	10	16	4	45	0.254
Kingston	2014	10	16	4	47	0.254
Kingston	2014	10	16	4	51	0.254
Kingston	2014	10	16	4	52	0.254
Kingston	2014	10	16	4	54	0.254
Kingston	2014	10	16	4	55	0.254
Kingston	2014	10	16	4	57	0.254
Kingston	2014	10	16	4	58	0.254
Kingston	2014	10	16	5	0	0.254
Kingston	2014	10	16	5	2	0.254
Kingston	2014	10	16	5	3	0.254
Kingston	2014	10	16	5	4	0.254
Kingston	2014	10	16	5	6	0.254
Kingston	2014	10	16	5	8	0.254
Kingston	2014	10	16	5	13	0.254
Kingston	2014	10	16	5	22	0.254
Kingston	2014	10	16	5	30	0.254
Kingston	2014	10	16	5	35	0.254
Kingston	2014	10	16	5	43	0.254
Kingston	2014	10	16	5	46	0.254
Kingston	2014	10	16	5	57	0.254
Kingston	2014	10	16	6	8	0.254
Kingston	2014	10	16	6	41	0.254
Kingston	2014	10	16	6	45	0.254
Kingston	2014	10	16	6	50	0.254
Kingston	2014	10	16	6	52	0.254
Kingston	2014	10	16	6	58	0.254
Kingston	2014	10	16	7	2	0.254
Kingston	2014	10	16	7	8	0.254
Kingston	2014	10	16	7	13	0.254
Kingston	2014	10	16	7	16	0.254
Kingston	2014	10	16	7	22	0.254
Kingston	2014	10	16	7	27	0.254
Kingston	2014	10	16	7	31	0.254
Kingston	2014	10	16	7	37	0.254
Kingston	2014	10	16	7	40	0.254
Kingston	2014	10	16	7	44	0.254
Kingston	2014	10	16	9	42	0.254
Kingston	2014	10	17	12	54	0.254
Kingston	2014	10	17	21	41	0.254
Kingston	2014	10	18	12	32	0.254

Kingston	2014	10	25	14	29	0.254
Kingston	2014	10	25	14	30	0.254
Kingston	2014	10	25	14	35	0.254
Kingston	2014	10	25	14	38	0.254
Kingston	2014	10	25	14	44	0.254
Kingston	2014	10	25	14	49	0.254
Kingston	2014	10	25	15	23	0.254
Kingston	2014	10	25	15	31	0.254
Kingston	2014	10	28	18	1	0.254
Kingston	2014	10	28	18	3	0.254
Kingston	2014	10	28	18	5	0.254
Kingston	2014	10	28	18	5	0.254
Kingston	2014	10	28	18	15	0.254
Kingston	2014	10	28	21	27	0.254
Kingston	2014	10	28	21	34	0.254
Kingston	2014	10	28	22	13	0.254

; KINGSTON, ONTARIO - AES 12-hour design storm

; Return period						2 years
;Station	Year	Month	Day	Hour	Min	Rain in mm
Kingston	2008	07	01	01	00	1.263
Kingston	2008	07	01	01	10	1.263
Kingston	2008	07	01	01	20	1.263
Kingston	2008	07	01	01	30	1.263
Kingston	2008	07	01	01	40	1.263
Kingston	2008	07	01	01	50	1.263
Kingston	2008	07	01	02	00	1.474
Kingston	2008	07	01	02	10	1.474
Kingston	2008	07	01	02	20	1.474
Kingston	2008	07	01	02	30	1.474
Kingston	2008	07	01	02	40	1.474
Kingston	2008	07	01	02	50	1.474
Kingston	2008	07	01	03	00	1.403
Kingston	2008	07	01	03	10	1.403
Kingston	2008	07	01	03	20	1.403
Kingston	2008	07	01	03	30	1.403
Kingston	2008	07	01	03	40	1.403
Kingston	2008	07	01	03	50	1.403
Kingston	2008	07	01	04	00	1.053
Kingston	2008	07	01	04	10	1.053
Kingston	2008	07	01	04	20	1.053
Kingston	2008	07	01	04	30	1.053
Kingston	2008	07	01	04	40	1.053
Kingston	2008	07	01	04	50	1.053
Kingston	2008	07	01	05	00	0.982
Kingston	2008	07	01	05	10	0.982
Kingston	2008	07	01	05	20	0.982
Kingston	2008	07	01	05	30	0.982
Kingston	2008	07	01	05	40	0.982
Kingston	2008	07	01	05	50	0.982
Kingston	2008	07	01	06	00	0.561
Kingston	2008	07	01	06	10	0.561
Kingston	2008	07	01	06	20	0.561
Kingston	2008	07	01	06	30	0.561
Kingston	2008	07	01	06	40	0.561
Kingston	2008	07	01	06	50	0.561
Kingston	2008	07	01	07	00	0.211
Kingston	2008	07	01	07	10	0.211
Kingston	2008	07	01	07	20	0.211
Kingston	2008	07	01	07	30	0.211
Kingston	2008	07	01	07	40	0.211
Kingston	2008	07	01	07	50	0.211
Kingston	2008	07	01	08	00	0.070
Kingston	2008	07	01	08	10	0.070
Kingston	2008	07	01	08	20	0.070
Kingston	2008	07	01	08	30	0.070
Kingston	2008	07	01	08	40	0.070
Kingston	2008	07	01	08	50	0.070

; KINGSTON, ONTARIO - AES 12-hour design storm

; Return period						5years
;Station	Year	Month	Day	Hour	Min	Rain in mm
Kingston	2008	07	01	01	00	1.716
Kingston	2008	07	01	01	10	1.716
Kingston	2008	07	01	01	20	1.716
Kingston	2008	07	01	01	30	1.716
Kingston	2008	07	01	01	40	1.716
Kingston	2008	07	01	01	50	1.716
Kingston	2008	07	01	02	00	2.002
Kingston	2008	07	01	02	10	2.002
Kingston	2008	07	01	02	20	2.002
Kingston	2008	07	01	02	30	2.002
Kingston	2008	07	01	02	40	2.002
Kingston	2008	07	01	02	50	2.002
Kingston	2008	07	01	03	00	1.907
Kingston	2008	07	01	03	10	1.907
Kingston	2008	07	01	03	20	1.907
Kingston	2008	07	01	03	30	1.907
Kingston	2008	07	01	03	40	1.907
Kingston	2008	07	01	03	50	1.907
Kingston	2008	07	01	04	00	1.430
Kingston	2008	07	01	04	10	1.430
Kingston	2008	07	01	04	20	1.430
Kingston	2008	07	01	04	30	1.430
Kingston	2008	07	01	04	40	1.430
Kingston	2008	07	01	04	50	1.430
Kingston	2008	07	01	05	00	1.335
Kingston	2008	07	01	05	10	1.335
Kingston	2008	07	01	05	20	1.335
Kingston	2008	07	01	05	30	1.335
Kingston	2008	07	01	05	40	1.335
Kingston	2008	07	01	05	50	1.335
Kingston	2008	07	01	06	00	0.763
Kingston	2008	07	01	06	10	0.763
Kingston	2008	07	01	06	20	0.763
Kingston	2008	07	01	06	30	0.763
Kingston	2008	07	01	06	40	0.763
Kingston	2008	07	01	06	50	0.763
Kingston	2008	07	01	07	00	0.286
Kingston	2008	07	01	07	10	0.286
Kingston	2008	07	01	07	20	0.286
Kingston	2008	07	01	07	30	0.286
Kingston	2008	07	01	07	40	0.286
Kingston	2008	07	01	07	50	0.286
Kingston	2008	07	01	08	00	0.095
Kingston	2008	07	01	08	10	0.095
Kingston	2008	07	01	08	20	0.095
Kingston	2008	07	01	08	30	0.095
Kingston	2008	07	01	08	40	0.095
Kingston	2008	07	01	08	50	0.095

; KINGSTON, ONTARIO - AES 12-hour design storm

; Return period 10 years

;Station	Year	Month	Day	Hour	Min	Rain in mm
Kingston	2008	07	01	01	00	2.016
Kingston	2008	07	01	01	10	2.016
Kingston	2008	07	01	01	20	2.016
Kingston	2008	07	01	01	30	2.016
Kingston	2008	07	01	01	40	2.016
Kingston	2008	07	01	01	50	2.016
Kingston	2008	07	01	02	00	2.352
Kingston	2008	07	01	02	10	2.352
Kingston	2008	07	01	02	20	2.352
Kingston	2008	07	01	02	30	2.352
Kingston	2008	07	01	02	40	2.352
Kingston	2008	07	01	02	50	2.352
Kingston	2008	07	01	03	00	2.240
Kingston	2008	07	01	03	10	2.240
Kingston	2008	07	01	03	20	2.240
Kingston	2008	07	01	03	30	2.240
Kingston	2008	07	01	03	40	2.240
Kingston	2008	07	01	03	50	2.240
Kingston	2008	07	01	04	00	1.680
Kingston	2008	07	01	04	10	1.680
Kingston	2008	07	01	04	20	1.680
Kingston	2008	07	01	04	30	1.680
Kingston	2008	07	01	04	40	1.680
Kingston	2008	07	01	04	50	1.680
Kingston	2008	07	01	05	00	1.568
Kingston	2008	07	01	05	10	1.568
Kingston	2008	07	01	05	20	1.568
Kingston	2008	07	01	05	30	1.568
Kingston	2008	07	01	05	40	1.568
Kingston	2008	07	01	05	50	1.568
Kingston	2008	07	01	06	00	0.896
Kingston	2008	07	01	06	10	0.896
Kingston	2008	07	01	06	20	0.896
Kingston	2008	07	01	06	30	0.896
Kingston	2008	07	01	06	40	0.896
Kingston	2008	07	01	06	50	0.896
Kingston	2008	07	01	07	00	0.336
Kingston	2008	07	01	07	10	0.336
Kingston	2008	07	01	07	20	0.336
Kingston	2008	07	01	07	30	0.336
Kingston	2008	07	01	07	40	0.336
Kingston	2008	07	01	07	50	0.336
Kingston	2008	07	01	08	00	0.112
Kingston	2008	07	01	08	10	0.112
Kingston	2008	07	01	08	20	0.112
Kingston	2008	07	01	08	30	0.112
Kingston	2008	07	01	08	40	0.112
Kingston	2008	07	01	08	50	0.112

; KINGSTON, ONTARIO - AES 12-hour design storm

; Return period						25 years
;Station	Year	Month	Day	Hour	Min	Rain in mm
Kingston	2008	07	01	01	00	2.394
Kingston	2008	07	01	01	10	2.394
Kingston	2008	07	01	01	20	2.394
Kingston	2008	07	01	01	30	2.394
Kingston	2008	07	01	01	40	2.394
Kingston	2008	07	01	01	50	2.394
Kingston	2008	07	01	02	00	2.793
Kingston	2008	07	01	02	10	2.793
Kingston	2008	07	01	02	20	2.793
Kingston	2008	07	01	02	30	2.793
Kingston	2008	07	01	02	40	2.793
Kingston	2008	07	01	02	50	2.793
Kingston	2008	07	01	03	00	2.660
Kingston	2008	07	01	03	10	2.660
Kingston	2008	07	01	03	20	2.660
Kingston	2008	07	01	03	30	2.660
Kingston	2008	07	01	03	40	2.660
Kingston	2008	07	01	03	50	2.660
Kingston	2008	07	01	04	00	1.995
Kingston	2008	07	01	04	10	1.995
Kingston	2008	07	01	04	20	1.995
Kingston	2008	07	01	04	30	1.995
Kingston	2008	07	01	04	40	1.995
Kingston	2008	07	01	04	50	1.995
Kingston	2008	07	01	05	00	1.862
Kingston	2008	07	01	05	10	1.862
Kingston	2008	07	01	05	20	1.862
Kingston	2008	07	01	05	30	1.862
Kingston	2008	07	01	05	40	1.862
Kingston	2008	07	01	05	50	1.862
Kingston	2008	07	01	06	00	1.064
Kingston	2008	07	01	06	10	1.064
Kingston	2008	07	01	06	20	1.064
Kingston	2008	07	01	06	30	1.064
Kingston	2008	07	01	06	40	1.064
Kingston	2008	07	01	06	50	1.064
Kingston	2008	07	01	07	00	0.399
Kingston	2008	07	01	07	10	0.399
Kingston	2008	07	01	07	20	0.399
Kingston	2008	07	01	07	30	0.399
Kingston	2008	07	01	07	40	0.399
Kingston	2008	07	01	07	50	0.399
Kingston	2008	07	01	08	00	0.133
Kingston	2008	07	01	08	10	0.133
Kingston	2008	07	01	08	20	0.133
Kingston	2008	07	01	08	30	0.133
Kingston	2008	07	01	08	40	0.133
Kingston	2008	07	01	08	50	0.133

; KINGSTON, ONTARIO - AES 12-hour design storm

; Return period						50 years
;Station	Year	Month	Day	Hour	Min	Rain in mm
Kingston	2008	07	01	01	00	2.673
Kingston	2008	07	01	01	10	2.673
Kingston	2008	07	01	01	20	2.673
Kingston	2008	07	01	01	30	2.673
Kingston	2008	07	01	01	40	2.673
Kingston	2008	07	01	01	50	2.673
Kingston	2008	07	01	02	00	3.119
Kingston	2008	07	01	02	10	3.119
Kingston	2008	07	01	02	20	3.119
Kingston	2008	07	01	02	30	3.119
Kingston	2008	07	01	02	40	3.119
Kingston	2008	07	01	02	50	3.119
Kingston	2008	07	01	03	00	2.970
Kingston	2008	07	01	03	10	2.970
Kingston	2008	07	01	03	20	2.970
Kingston	2008	07	01	03	30	2.970
Kingston	2008	07	01	03	40	2.970
Kingston	2008	07	01	03	50	2.970
Kingston	2008	07	01	04	00	2.228
Kingston	2008	07	01	04	10	2.228
Kingston	2008	07	01	04	20	2.228
Kingston	2008	07	01	04	30	2.228
Kingston	2008	07	01	04	40	2.228
Kingston	2008	07	01	04	50	2.228
Kingston	2008	07	01	05	00	2.079
Kingston	2008	07	01	05	10	2.079
Kingston	2008	07	01	05	20	2.079
Kingston	2008	07	01	05	30	2.079
Kingston	2008	07	01	05	40	2.079
Kingston	2008	07	01	05	50	2.079
Kingston	2008	07	01	06	00	1.188
Kingston	2008	07	01	06	10	1.188
Kingston	2008	07	01	06	20	1.188
Kingston	2008	07	01	06	30	1.188
Kingston	2008	07	01	06	40	1.188
Kingston	2008	07	01	06	50	1.188
Kingston	2008	07	01	07	00	0.446
Kingston	2008	07	01	07	10	0.446
Kingston	2008	07	01	07	20	0.446
Kingston	2008	07	01	07	30	0.446
Kingston	2008	07	01	07	40	0.446
Kingston	2008	07	01	07	50	0.446
Kingston	2008	07	01	08	00	0.149
Kingston	2008	07	01	08	10	0.149
Kingston	2008	07	01	08	20	0.149
Kingston	2008	07	01	08	30	0.149
Kingston	2008	07	01	08	40	0.149
Kingston	2008	07	01	08	50	0.149

; KINGSTON, ONTARIO - AES 12-hour design storm

; Return period 100 years

;Station	Year	Month	Day	Hour	Min	Rain in mm
Kingston	2008	07	01	01	00	2.952
Kingston	2008	07	01	01	10	2.952
Kingston	2008	07	01	01	20	2.952
Kingston	2008	07	01	01	30	2.952
Kingston	2008	07	01	01	40	2.952
Kingston	2008	07	01	01	50	2.952
Kingston	2008	07	01	02	00	3.444
Kingston	2008	07	01	02	10	3.444
Kingston	2008	07	01	02	20	3.444
Kingston	2008	07	01	02	30	3.444
Kingston	2008	07	01	02	40	3.444
Kingston	2008	07	01	02	50	3.444
Kingston	2008	07	01	03	00	3.280
Kingston	2008	07	01	03	10	3.280
Kingston	2008	07	01	03	20	3.280
Kingston	2008	07	01	03	30	3.280
Kingston	2008	07	01	03	40	3.280
Kingston	2008	07	01	03	50	3.280
Kingston	2008	07	01	04	00	2.460
Kingston	2008	07	01	04	10	2.460
Kingston	2008	07	01	04	20	2.460
Kingston	2008	07	01	04	30	2.460
Kingston	2008	07	01	04	40	2.460
Kingston	2008	07	01	04	50	2.460
Kingston	2008	07	01	05	00	2.296
Kingston	2008	07	01	05	10	2.296
Kingston	2008	07	01	05	20	2.296
Kingston	2008	07	01	05	30	2.296
Kingston	2008	07	01	05	40	2.296
Kingston	2008	07	01	05	50	2.296
Kingston	2008	07	01	06	00	1.312
Kingston	2008	07	01	06	10	1.312
Kingston	2008	07	01	06	20	1.312
Kingston	2008	07	01	06	30	1.312
Kingston	2008	07	01	06	40	1.312
Kingston	2008	07	01	06	50	1.312
Kingston	2008	07	01	07	00	0.492
Kingston	2008	07	01	07	10	0.492
Kingston	2008	07	01	07	20	0.492
Kingston	2008	07	01	07	30	0.492
Kingston	2008	07	01	07	40	0.492
Kingston	2008	07	01	07	50	0.492
Kingston	2008	07	01	08	00	0.164
Kingston	2008	07	01	08	10	0.164
Kingston	2008	07	01	08	20	0.164
Kingston	2008	07	01	08	30	0.164
Kingston	2008	07	01	08	40	0.164
Kingston	2008	07	01	08	50	0.164

Appendix D

FLOW DATA AND ANALYSIS SUMMARY

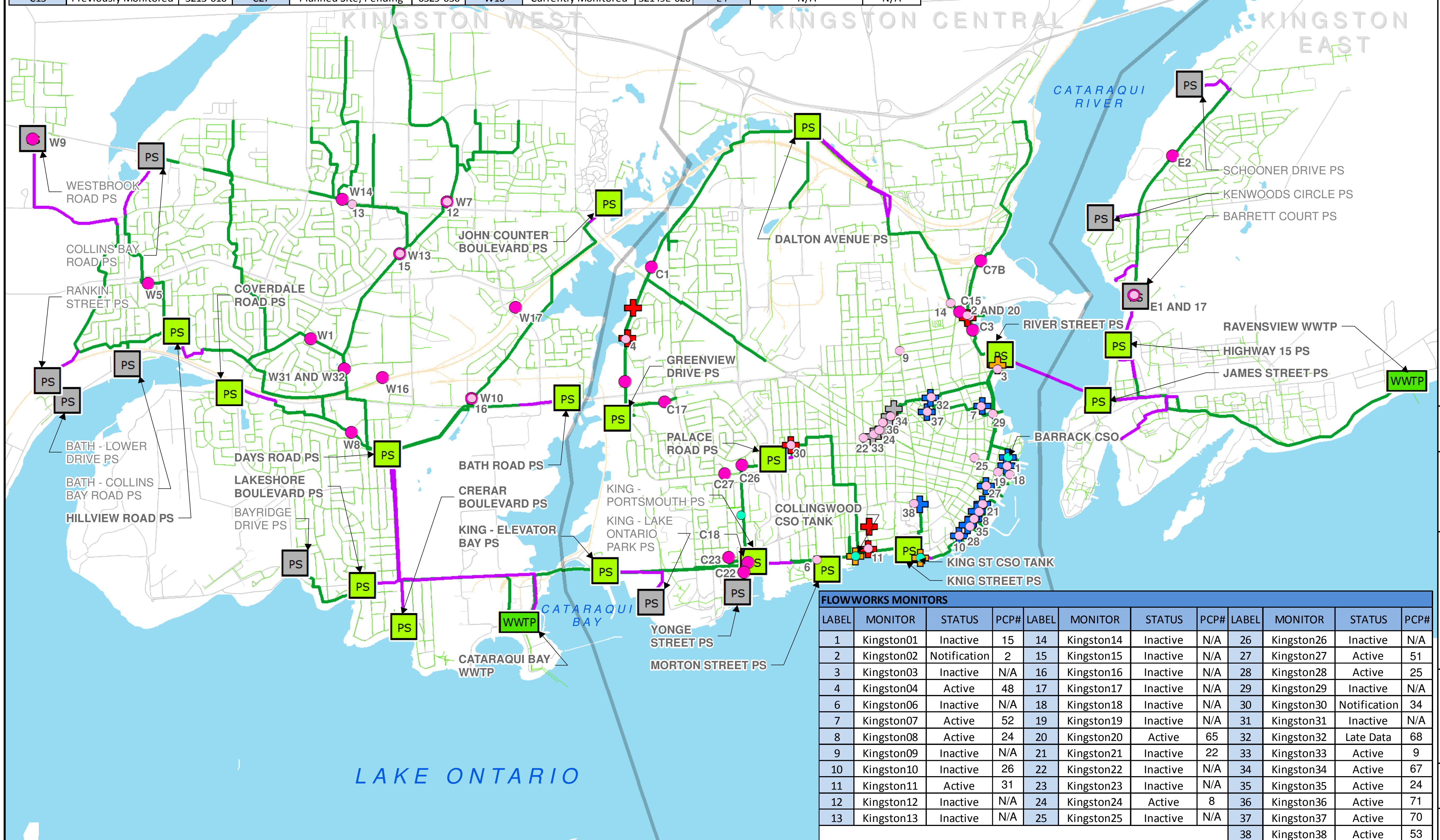
Appendix D – Contents

Figure D-1: Monitor Location Overview

Flow Data Review Summary

IN-LINE FLOW MONITORS

MONITOR	STATUS	MANHOLE	MONITOR	STATUS	MANHOLE	MONITOR	STATUS	MANHOLE	MONITOR	STATUS	MANHOLE
C1	Currently Monitored	2285-020	C14	Previously Monitored	7954-160	C28	N/A	N/A	W11	Previously Monitored	31325E-110
C2	Previously Monitored	5402-010	C15	Currently Monitored	9227E-070	C29	N/A	N/A	W12	Previously Monitored	0842-230
C3	Currently Monitored	9227E-010	C16	Currently Monitored	5405-030	C30	N/A	N/A	W13	Currently Monitored	0526-040
C4	Previously Monitored	7104-010	C17	Currently Monitored	3941E-050	W1	Currently Monitored	33240-020	W14	Currently Monitored	0842-060
C5	Previously Monitored	9903-110	C18	Currently Monitored	0048-030	W2	Previously Monitored	33024-010	W15	Currently Monitored	35511-040
C6	Currently Monitored	9729-010	C19	Currently Monitored	9231-030	W3	Previously Monitored	0346-210	W16	Currently Monitored	32321-020
C7	Previously Monitored	8554E-040	C20	To be determined	N/A	W4	Previously Monitored	33738-010	W17	Currently Monitored	0769E-230
- C7b	Currently Monitored	8554E-070	C21	Currently Monitored	8902-010	W5	Currently Monitored	33472-010	W18	N/A	N/A
C8	Currently Monitored	0004-010	C22	Currently Monitored	3204-020	W6	Previously Monitored	34023-020	W19	N/A	N/A
C9	N/A	N/A	C23	Currently Monitored	3406-100	W6b	Previously Monitored	34156-010	W20	N/A	N/A
C10	Previously Monitored	N/A	C24	Planned Site, Pending	3208-010	W7	Currently Monitored	0837E-020	E1	Currently Monitored	0630-020
C11	Currently Monitored	0828-010	C25	Planned Site, Pending	3210-010	W8	Currently Monitored	0345E-150	E2	Currently Monitored	0633-100
C12	Currently Monitored	2140-010	C26	Currently Monitored	0329E-050	W9	Currently Monitored	9853-010	E3	N/A	N/A
C13	Previously Monitored	3213-010	C27	Planned Site, Pending	0329-030	W10	Currently Monitored	32149E-020	E4	N/A	N/A



FLOWWORKS MONITORS

LABEL	MONITOR	STATUS	PCP#	LABEL	MONITOR	STATUS	PCP#	LABEL	MONITOR	STATUS	PCP#
1	Kingston01	Inactive	15	14	Kingston14	Inactive	N/A	26	Kingston26	Inactive	N/A
2	Kingston02	Notification	2	15	Kingston15	Inactive	N/A	27	Kingston27	Active	51
3	Kingston03	Inactive	N/A	16	Kingston16	Inactive	N/A	28	Kingston28	Active	25
4	Kingston04	Active	48	17	Kingston17	Inactive	N/A	29	Kingston29	Inactive	N/A
6	Kingston06	Inactive	N/A	18	Kingston18	Inactive	N/A	30	Kingston30	Notification	34
7	Kingston07	Active	52	19	Kingston19	Inactive	N/A	31	Kingston31	Inactive	N/A
8	Kingston08	Active	24	20	Kingston20	Active	65	32	Kingston32	Late Data	68
9	Kingston09	Inactive	N/A	21	Kingston21	Inactive	22	33	Kingston33	Active	9
10	Kingston10	Inactive	26	22	Kingston22	Inactive	N/A	34	Kingston34	Active	67
11	Kingston11	Active	31	23	Kingston23	Inactive	N/A	35	Kingston35	Active	24
12	Kingston12	Inactive	N/A	24	Kingston24	Active	8	36	Kingston36	Active	71
13	Kingston13	Inactive	N/A	25	Kingston25	Inactive	N/A	37	Kingston37	Active	70
								38	Kingston38	Active	53

WSP

1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

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
- EXISTING SANITARY SEWER
- SANITARY SEWER (MODELLED)
- FORCEMAIN
- IN-LINE SEWER MONITOR
- FLOWWORKS PCP 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:
0 300 600 1,200 Meters
1:47,500

Project:
Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title:
MONITOR LOCATION OVERVIEW

Project No.:	Date:
151-02944-00	MARCH, 2016

Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	WWM	D-1

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.6_Wastewater Model\Maps\Calibration Report Maps\D_FlowDataReview\151-02944-00_Monitor_Locations_Overview.mxd

Flow Data Tables and Analysis Summary

The following flow data review represents a summary of wastewater data used and reviewed for the 2015 Master Plan. It is to be noted that smaller timeframes and flow data from specific dates are used in calibration while trends observed with full year data is used for seasonal dry-weather variation calibration.

Table D- 1 Summary of historical daily flow to UK's West and Central/East sanitary catchment areas

	Cataraqui Bay WWTP Peak Rate **Flows** (m^3)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	1,221,668	983,099	1,246,999	1,059,776	970,696	1,103,776	987,284	894,581	966,654	1,172,844	1,170,533	1,320,544
2011	988,301	987,824	1,611,742	1,469,656	1,447,219	992,107	926,340	1,112,588	913,026	1,111,873	1,025,492	1,374,737
2012	1,122,442	1,014,223	1,223,387	964,566	1,102,569	961,317	897,336	907,519	1,150,365	1,050,690	950,441	1,116,207
2013	1,163,299	917,851	1,281,349	1,185,965	1,010,408	1,247,020	916,061	933,532	1,010,429	1,087,495	884,535	1,002,400
2014	1,244,814	989,427	1,189,341	1,635,356	1,186,571	1,093,746	950,649	985,191	0	0	0	0

	Ravensview WWTP Total Influent **Flows** (m^3)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	1,800,429	1,565,271	2,098,001	1,618,289	1,448,832	1,714,724	1,595,904	1,472,502	1,602,982	1,640,076	1,825,558	1,926,023
2011	1,388,596	1,502,761	2,707,510	2,651,146	2,775,129	1,840,983	1,808,908	1,641,863	1,385,778	1,636,981	1,452,498	2,053,322
2012	2,152,978	1,821,534	2,303,068	1,672,045	1,638,644	1,511,210	1,236,808	1,243,034	1,516,586	1,409,667	1,248,600	1,849,903
2013	2,055,967	1,558,692	2,241,567	2,052,079	1,703,776	2,388,171	1,766,152	1,560,931	1,534,453	1,615,051	1,612,579	1,512,181
2014	2,170,530	1,616,399	2,047,880	2,987,806	2,500,250	1,972,874	1,804,175	1,818,505	1,380,129	1,318,427	1,240,601	1,377,399

Source: UK WWTP Flow Summaries (Annual Reports)

Table D- 2 Summary of Pumping Station Flow data from SCADA Data Summaries.
(Note: Data shows long term averages for full year flow data as observed for comparison purposes. Smaller data sets and dates ranges are used for model calibration)

Pumping Station	Average Flow (l/s)		Peak Wet Weather Flow (l/s)		Peak Dry Weather Flow (l/s)	
	2013	2014	2013	2014	2013	2014
Barrett Ct.	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]
Bath-Collins Bay	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]
Bath-Lower Drive	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]
Bath Rd.	8.3	10.6	95.6	33.0	32.8	30.6
Bayridge Dr.	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]
Collins Bay Rd.	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]
Coverdale Dr.	48.7	51.6	133.1	133.1	133.1	133.1
Crerar Blvd.	15.1	18.5	58.6	54.6	40.7	40.7
Dalton Ave.	169.0	154.1	834.9	956.8	929.0	397.5
Days Rd.	292.0	259.0	790.3	610.8	438.0	560.3
Greenview Dr.	23.1	28.1	101.7	101.8	108.8	85.8
Hatter St.	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
Hillview Rd.	16.7	2.9	109.0	90.6	116.3	108.2
Hwy. 15	11.5	11.4	143.3	143.6	91.3	98.3
James St.	30.2	37.1	381.3	382.0	150.1	196.8
John Counter Blvd.	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]
Kenwood Circle	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]
King - Elevator Bay	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]	N/A[2]
King - Lake Ontario Park	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]
King - Portsmouth	73.0	78.2	396.8	310.5	174.0	195.7
King St.	255.3	283.0	755.2	482.6	640.2	474.4
Lakeshore Blvd. (Front Rd)	12.2	14.0	239.3	239.3	239.3	128.3
Morton St.	7.1	35.9	35.7	56.0	29.8	56.0
Notch Hill Rd.	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]
Palace Rd.	59.0	61.6	111.7	111.7	111.7	111.7
Rankin St.	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]
River St.	663.6	1033.8	1822.7	2986.5	1830.2	2414.8
Schooner Dr.	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]
Westbrook Rd.	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]
Yonge St.	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]	N/A[1]

[1]No or limited SCADA data

[2]Only level monitoring

Table D- 3 Table D- 4 Summary of Pumping Station Minimum, Maximum and Average Flow (2013-Dry-Weather)

2013 FLOW		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct
Ravensview WWTP	MAX	776.37	953.61	909.62	981.47	758.65	1896.47	884.93	1243.53	727.95	550.00
	MIN	397.21	418.10	513.05	569.38	485.51	105.71	318.72	74.69	244.34	0.00
	AVERAGE	599.12	591.23	707.54	763.53	599.98	1037.73	612.97	541.30	497.97	532.50
Cataraqui Bay WWTP	MAX	398.85	485.01	455.98	503.38	404.72	592.67	337.49	369.64	368.72	389.66
	MIN	0.00	24.99	179.31	198.78	61.54	234.24	13.41	0.18	0.00	0.00
	AVERAGE	275.38	236.85	301.92	324.41	253.75	403.69	222.29	235.09	252.80	189.51
Days Rd.	MAX	248.95	239.00	294.62	313.16	294.62	334.19	223.17	228.37	239.68	264.55
	MIN	106.95	82.98	117.80	126.40	28.04	136.57	0.00	0.00	48.16	0.00
	AVERAGE	174.15	152.83	198.24	204.66	156.28	239.99	136.70	150.06	155.20	95.11
Dalton Ave.	MAX	160.31	136.69	167.45	200.49	141.13	304.16	242.37	0.00	0.00	7.97
	MIN	66.23	0.00	0.02	0.03	0.00	0.02	0.05	0.00	0.00	0.00
	AVERAGE	125.04	64.63	53.00	102.26	41.48	140.81	80.38	0.00	N/A	1.88
King St.	MAX	471.38	399.07	473.54	481.60	480.01	647.93	467.32	474.77	0.00	269.68
	MIN	12.10	37.85	6.76	236.23	14.04	15.62	130.58	0.07	0.00	4.52
	AVERAGE	227.37	201.51	242.61	303.34	257.67	404.67	290.44	252.27	N/A	198.63
River St.	MAX	704.87	772.61	854.06	921.04	745.13	1709.29	755.32	1337.67	726.46	674.73
	MIN	419.77	378.30	474.52	542.21	447.99	0.00	410.08	0.00	88.45	374.84
	AVERAGE	566.79	530.46	627.71	706.32	571.66	994.31	603.10	546.87	466.31	546.80
Monitor C1	MAX	97.03	84.60	106.68	112.09	84.74	267.29	69.18	84.83	78.16	80.07
	MIN	58.99	45.09	60.44	65.92	43.44	84.87	36.53	38.75	35.39	41.54
	AVERAGE	80.06	65.75	86.36	87.19	63.57	126.80	53.82	56.38	54.16	62.36
Monitor C12	MAX	77.47	75.01	81.17	70.87	58.69	135.01	54.90	59.97	60.24	62.97
	MIN	53.01	43.34	54.40	45.29	32.68	52.53	33.62	31.49	33.91	37.95
	AVERAGE	66.19	61.01	67.97	57.43	44.76	74.62	45.10	44.70	46.19	51.48
Monitor E1	MAX	40.13	41.91	41.10	42.40	45.95	65.06	35.89	50.13	45.90	60.13
	MIN	5.40	4.42	7.20	6.65	7.52	13.82	6.75	7.54	7.80	8.48
	AVERAGE	15.86	16.47	20.02	19.77	21.71	29.49	18.31	21.20	22.77	23.26

Table D- 4 Summary of Pumping Station Minimum, Maximum and Average Flow (2014-Dry-Weather)

2014 FLOW		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct
Ravensview WWTP	MAX	778.59	1111.23	927.66	1034.32	1003.94	776.06	736.18	721.94	639.01	685.54
	MIN	408.29	495.32	532.99	607.36	543.11	477.92	418.73	383.91	306.37	328.21
	AVERAGE	615.85	691.14	758.81	786.53	669.64	607.47	561.00	531.85	470.17	511.30
Cataraqui Bay WWTP	MAX	376.80	404.72	677.54	481.89	385.99	349.98	370.00	334.18	362.84	394.25
	MIN	164.24	0.00	68.71	224.32	144.58	43.36	0.18	125.29	0.00	147.71
	AVERAGE	267.17	289.16	358.53	346.56	262.88	230.03	215.03	232.17	216.40	270.25
Days Rd.	MAX	284.45	251.89	383.94	337.13	245.10	234.48	227.47	199.66	290.78	254.83
	MIN	99.94	97.91	19.90	125.72	89.31	67.61	0.00	80.95	0.00	78.91
	AVERAGE	163.59	177.44	219.11	202.29	157.75	148.96	116.73	145.56	135.89	166.55
Dalton Ave.	MAX	4.04	205.48	351.11	211.97	177.45	151.61	121.54	119.56	121.06	142.07
	MIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02
	AVERAGE	0.18	79.74	95.95	96.92	39.53	36.68	48.81	37.05	32.25	57.17
King St.	MAX	473.16	483.99	615.50	474.00	470.07	454.02	442.80	466.87	259.32	262.34
	MIN	15.24	9.53	16.31	20.54	169.63	225.37	10.09	7.43	4.48	5.14
	AVERAGE	270.29	241.72	263.59	306.58	300.78	277.31	238.89	220.25	181.40	168.53
River St.	MAX	856.50	1070.26	822.75	933.22	1004.39	769.59	728.22	701.54	627.51	618.14
	MIN	474.97	466.23	447.65	575.52	515.74	476.47	403.41	355.48	150.01	259.78
	AVERAGE	626.37	645.54	682.75	733.46	656.14	619.40	562.42	506.99	428.76	454.03
Monitor C1	MAX	107.56	113.43	122.49	135.06	90.97	85.26	84.04	93.58	70.19	10.26
	MIN	64.46	70.42	81.76	72.65	52.01	47.85	45.10	40.31	31.61	10.26
	AVERAGE	83.81	93.47	100.89	103.30	71.49	66.92	62.52	61.35	50.40	10.26
Monitor C12	MAX	58.47	66.19	75.74	56.63	60.69	58.96	52.38	69.17	0.18	0.19
	MIN	36.31	42.49	47.49	55.41	33.29	32.34	31.31	32.41	0.06	0.06
	AVERAGE	48.54	55.91	62.09	55.41	48.44	45.76	44.21	44.58	0.16	0.15
Monitor E1	MAX	47.84	43.80	54.88	46.59	50.01	45.17	36.47	36.36	34.35	39.16
	MIN	6.61	8.14	10.87	7.43	6.39	5.89	5.19	5.31	4.21	5.58
	AVERAGE	18.59	19.13	23.79	24.45	19.89	19.24	15.72	15.93	15.04	16.80

Figure D-2 2013 Monthly Flow Data Summary - Ravensview WWTP

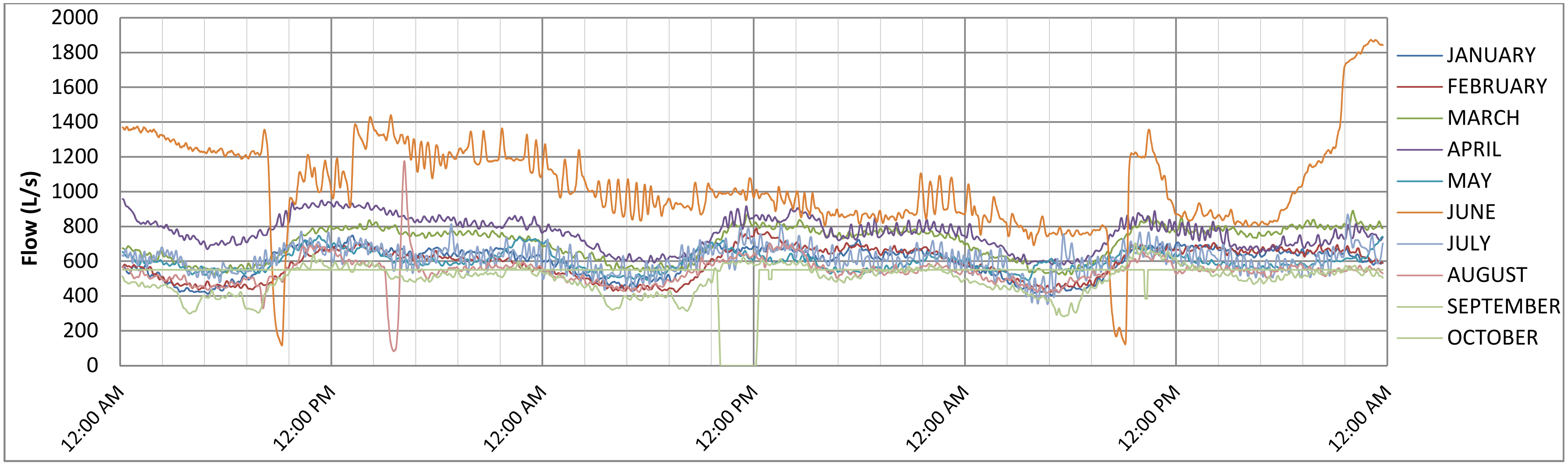


Figure D-3 2013 Monthly Flow Data Summary – Cataraqui Bay WWTP

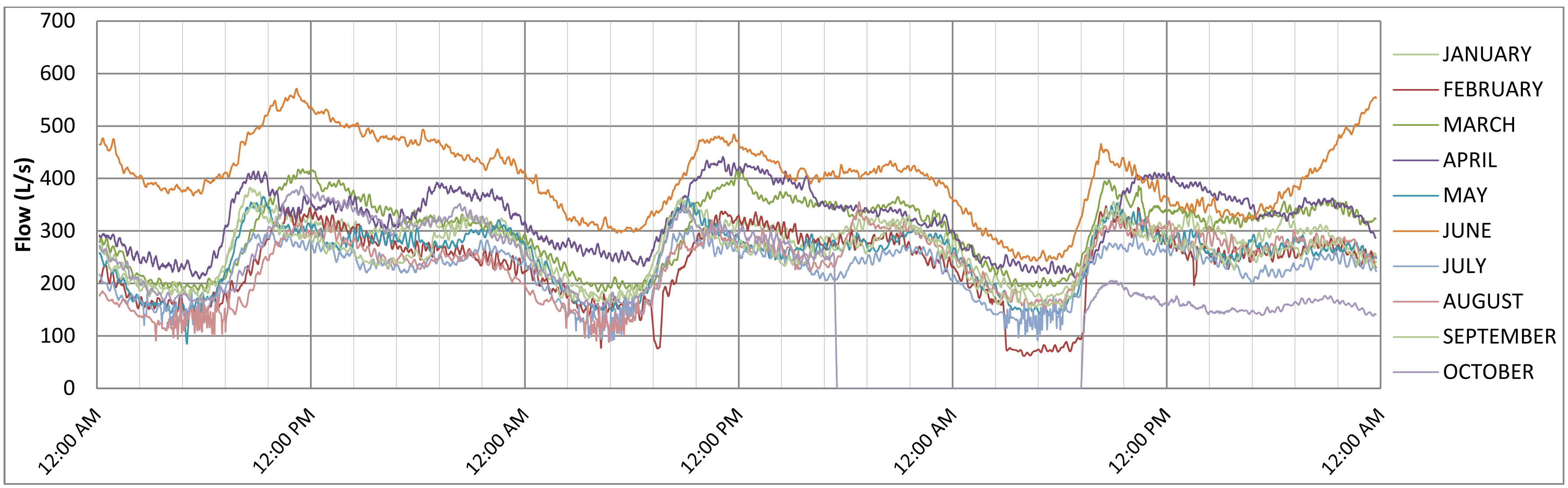


Figure D-4 2014 Monthly Flow Data Summary - Ravensview WWTP

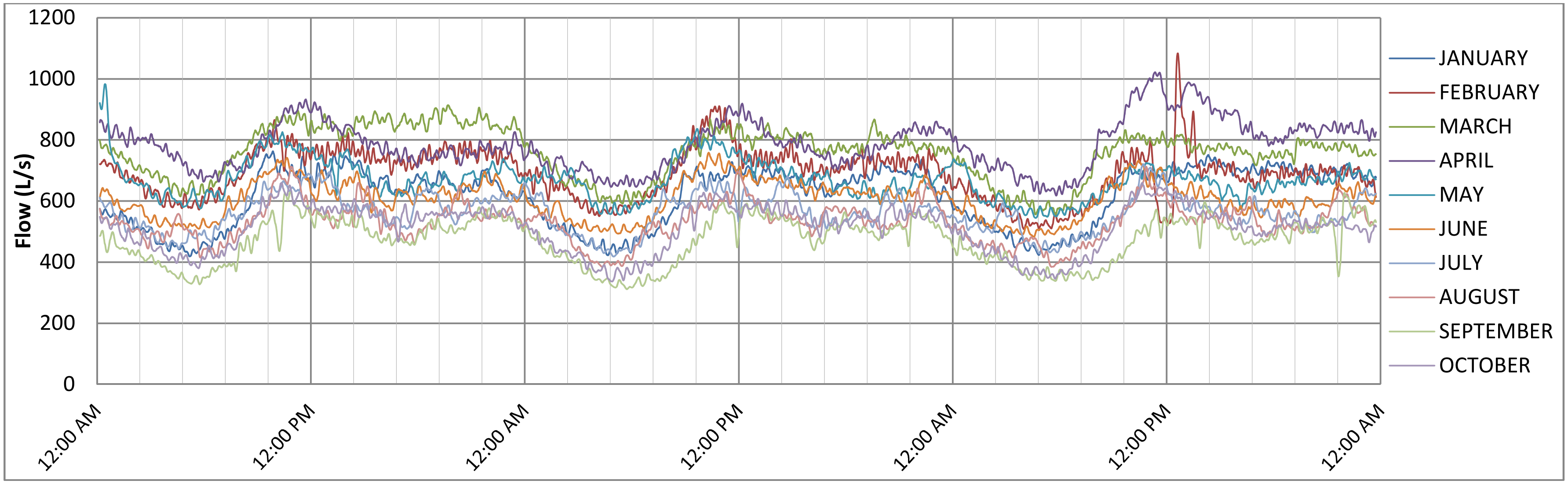
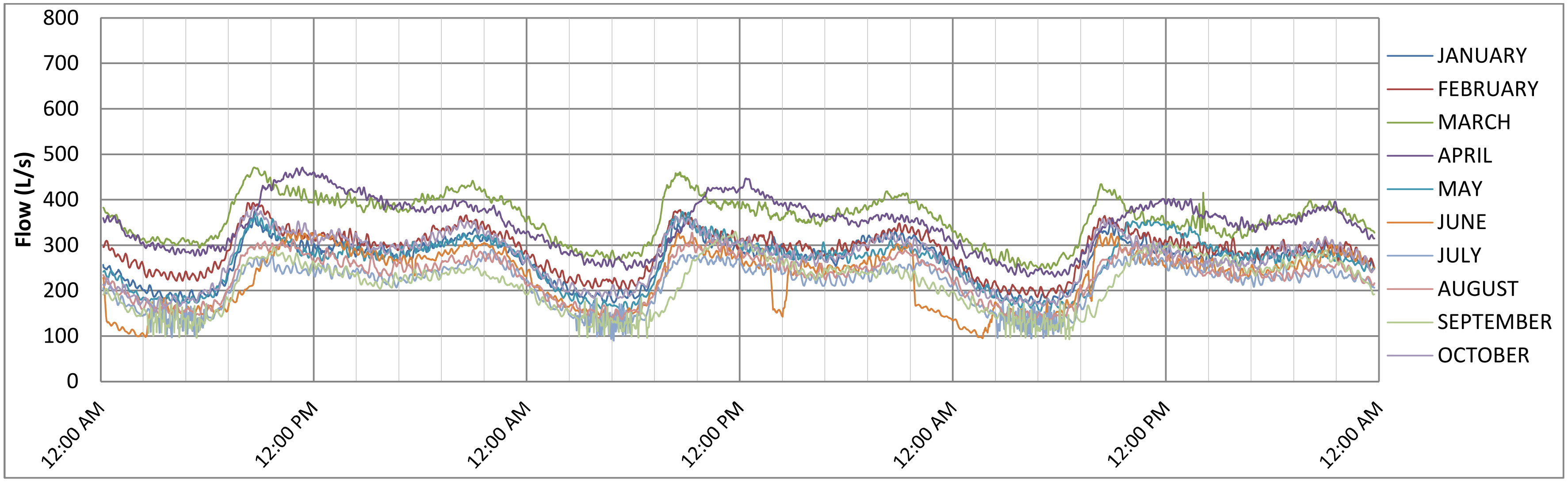


Figure D-5 2014 Monthly Flow Data Summary – Cataraqui Bay WWTP



Trend Data Observations for Flow vs. Rain Gage Information Comparison for Select Monitor Data

Figure D-6 2013 Monthly Flow vs Rainfall Data – Monitor C3 (Kingston Central/East)

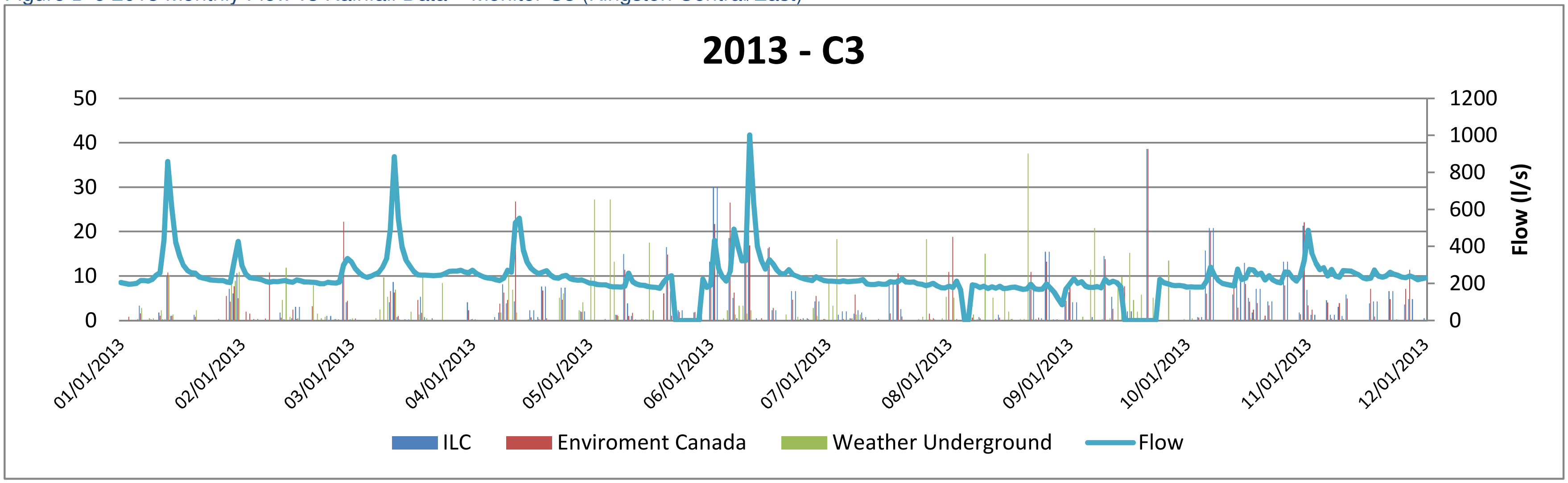


Figure D-7 2013 Monthly Flow vs Rainfall Data – Monitor W8 (Kingston West)

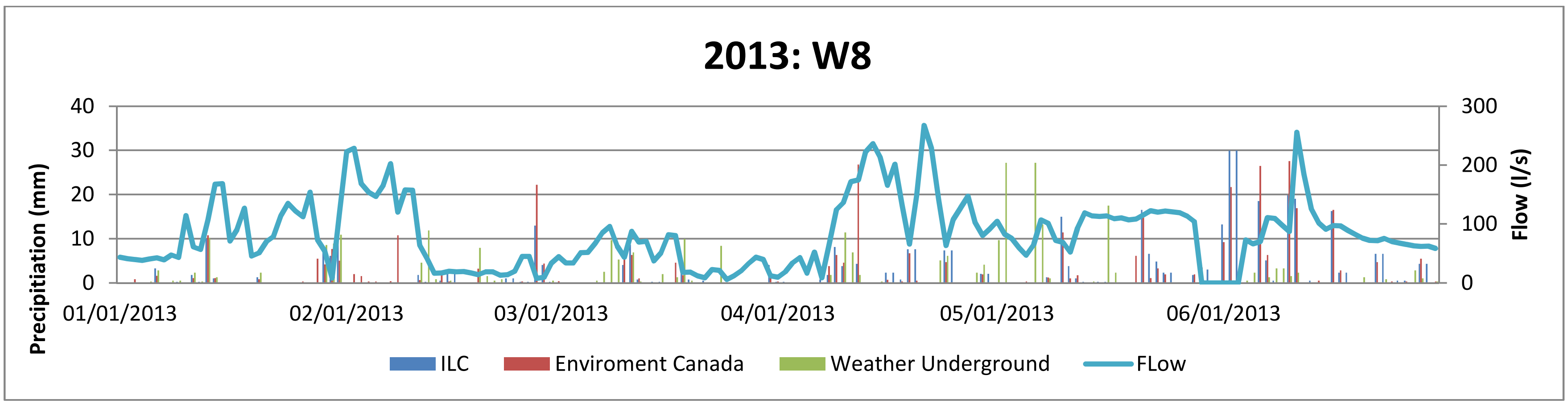


Figure D-8 2014 Monthly Flow vs Rainfall Data – Monitor C8 (Kingston West)

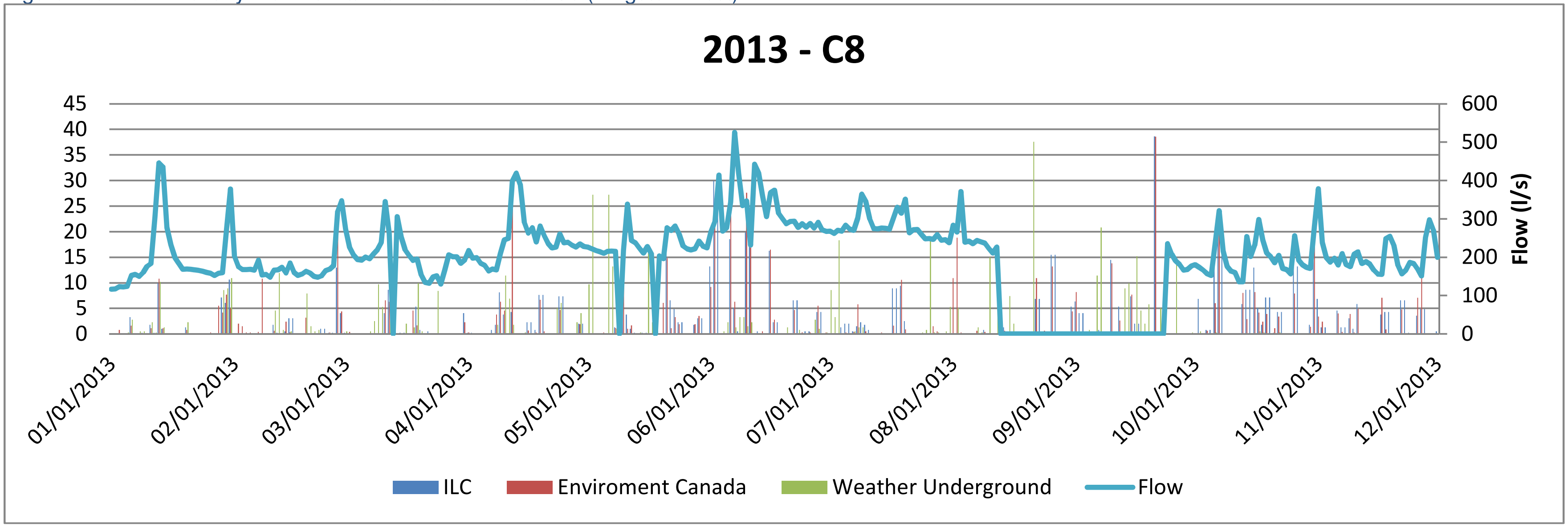
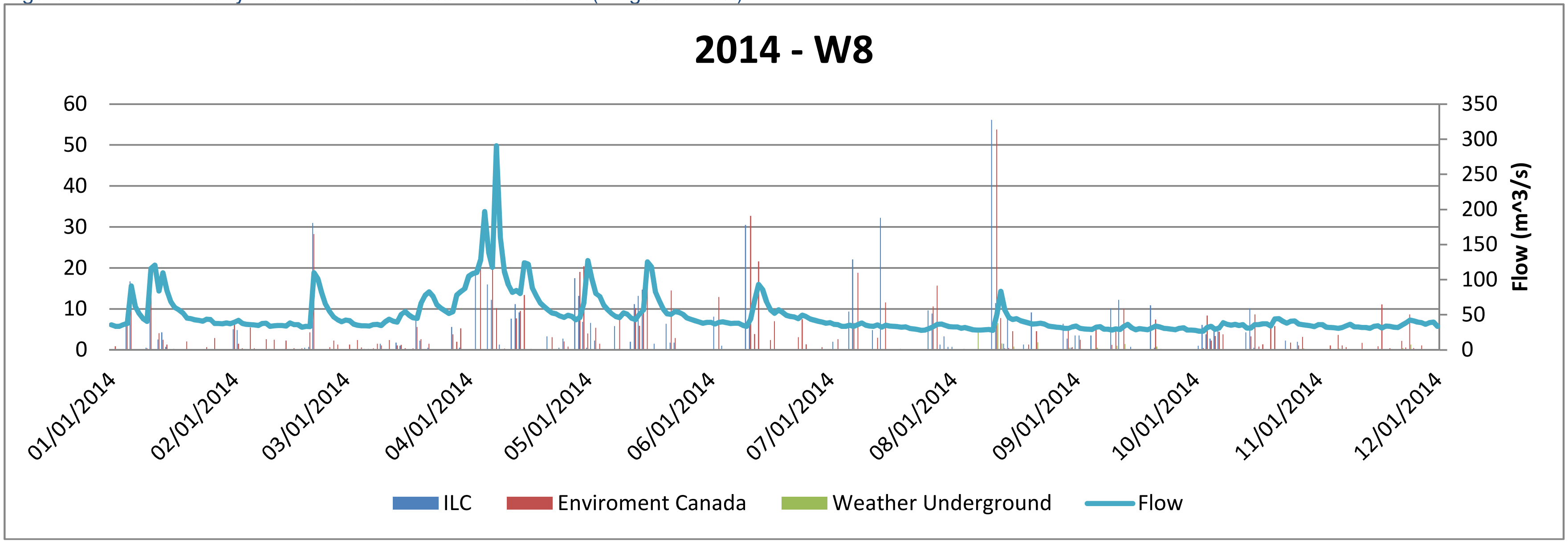


Figure D-9 2014 Monthly Flow vs Rainfall Data – Monitor W8 (Kingston West)



Appendix E

ADDITIONAL DATA SUMMARY

Appendix E – Contents

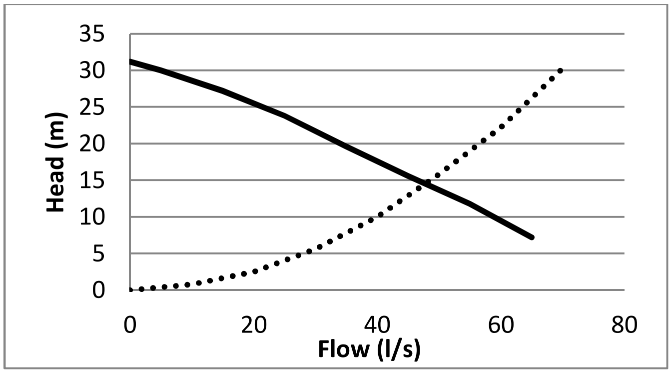
Researched Pump & System Curve Summary

SCADA Screenshots for Facilities

Pump Curves – Wastewater

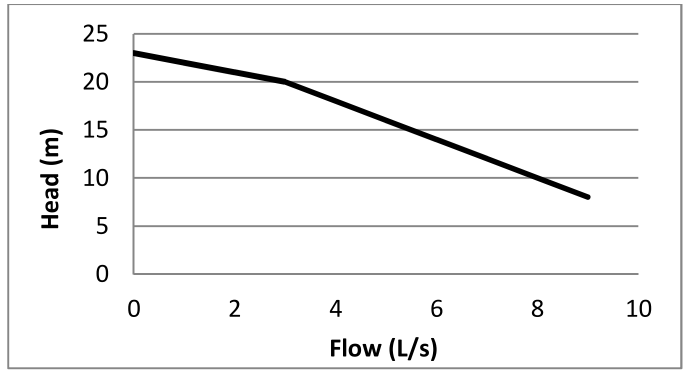
Pump Curve ······ System Head

Bath Road



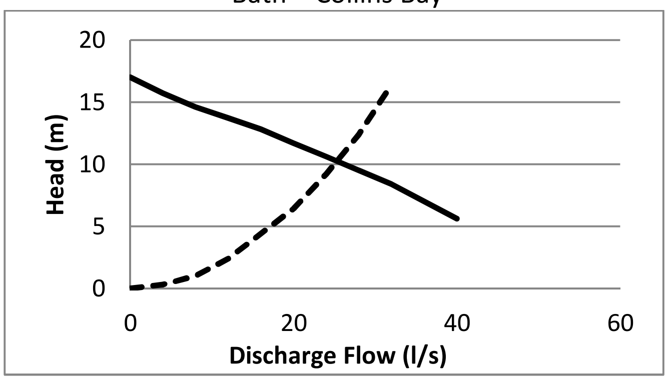
Lead and Lag, **Make**: FLYGT, **Model**: CP-3152 20Hp

Bath - Lower



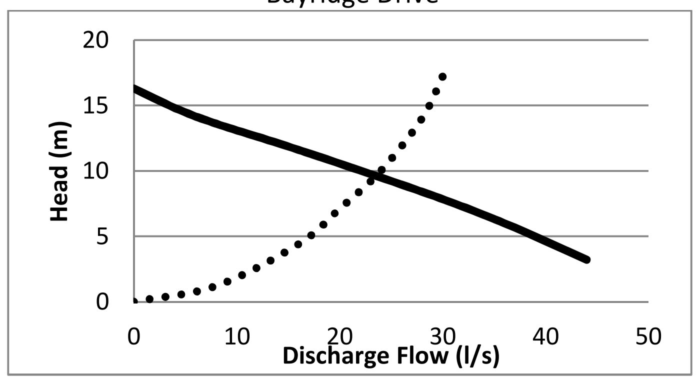
Lead and Lag, **Make:** Barnes, **Model(s):** DCP-2512 4SE-151 7.4 Hp

Bath – Collins Bay



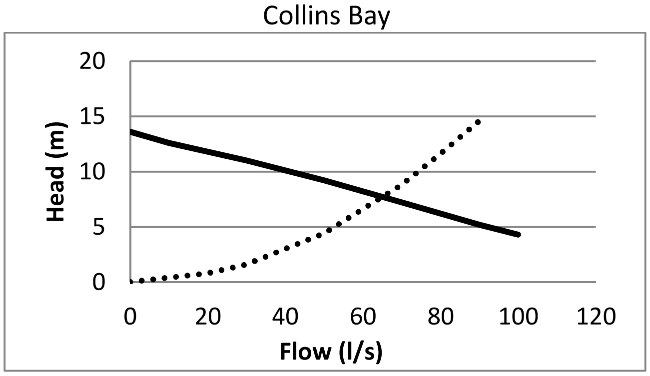
Lead and Lag, **Make:** FLYGT, **Model(s):** CP-3102 5Hp

Bayridge Drive



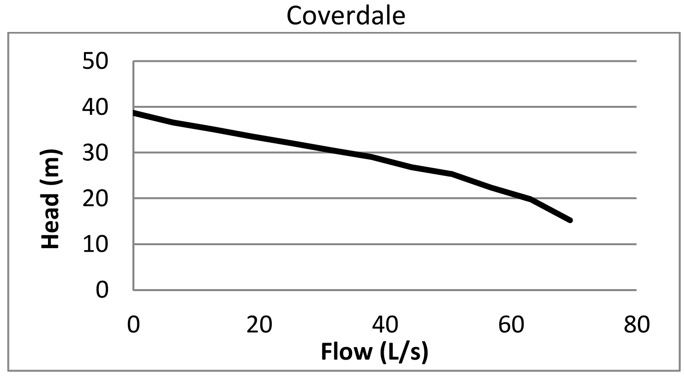
Lead and Lag, **Make:** FLYGT, **Model(s):** CP-3102

Collins Bay



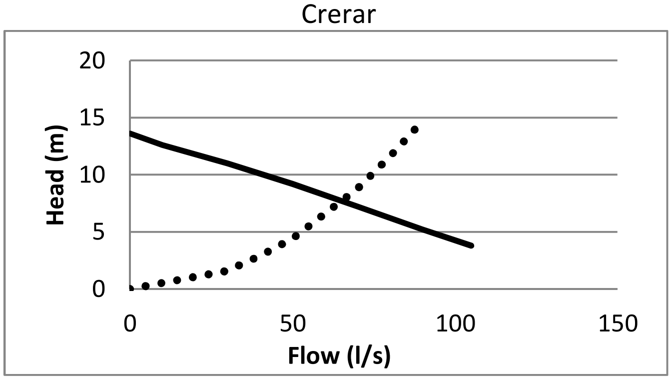
Lead and Lag, **Make:** FLYGT, **Model(s):** CP-3127 10Hp

Coverdale



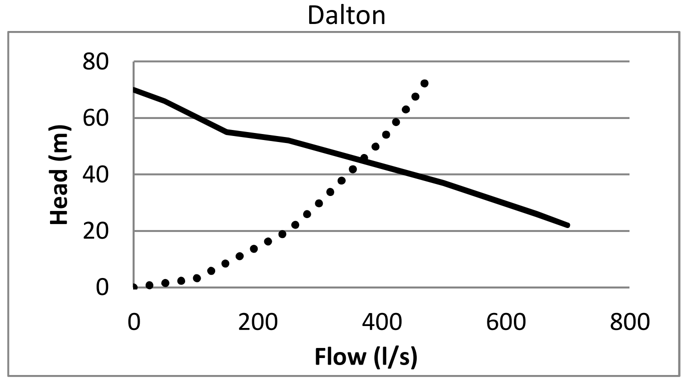
Lead and Lag, **Make:** Myers, **Model(s):** 14.00 0.38

Crerar



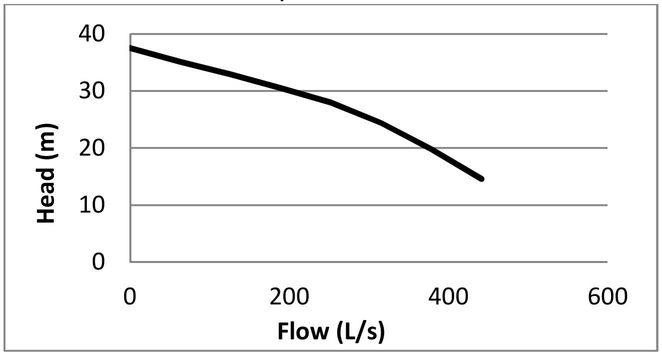
Lead and Lag, **Make:** FLYGT, **Model(s):** CP-3152 20Hp

Dalton



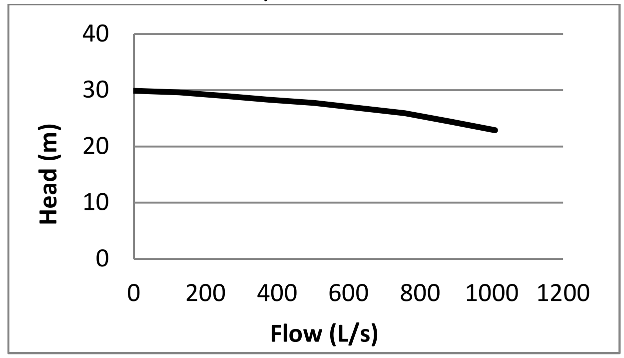
Lead and three lags, **Make:** FLYGT, **Model(s):** C3312, 835

Days – Curve 1



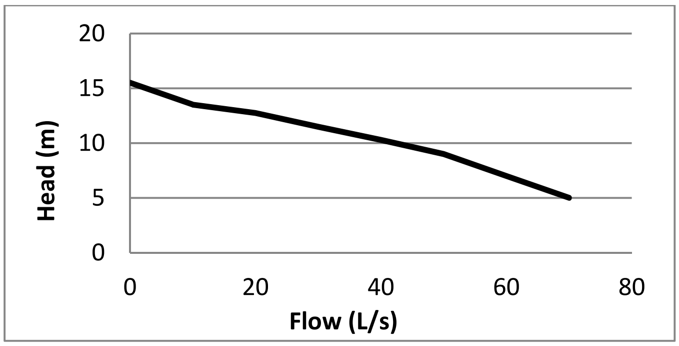
Lead and Lag, **Make:** N/A, **Model(s):** N/A

Days – Curve 2



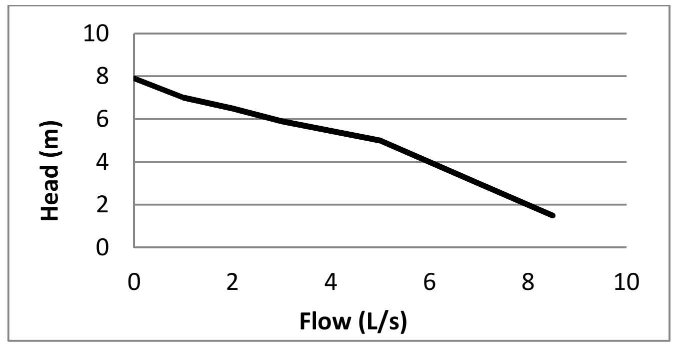
Lead and Lag, **Make:** N/A, **Model(s):** N/A

Greenview



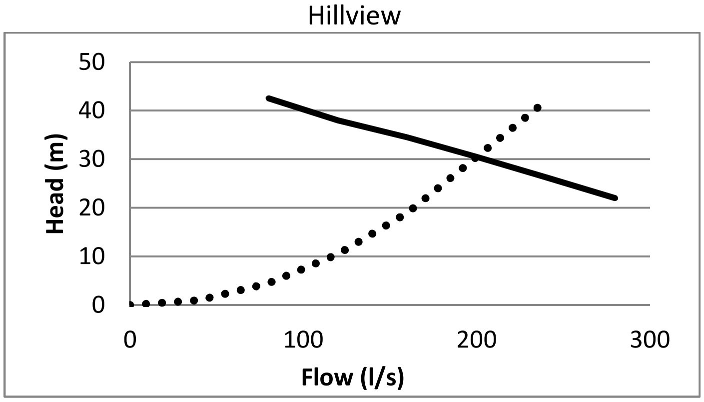
Lead and Lag, **Make:** Chicago Pumps, **Model(s):** 2-B-SO-61-08509-2A

Hatter



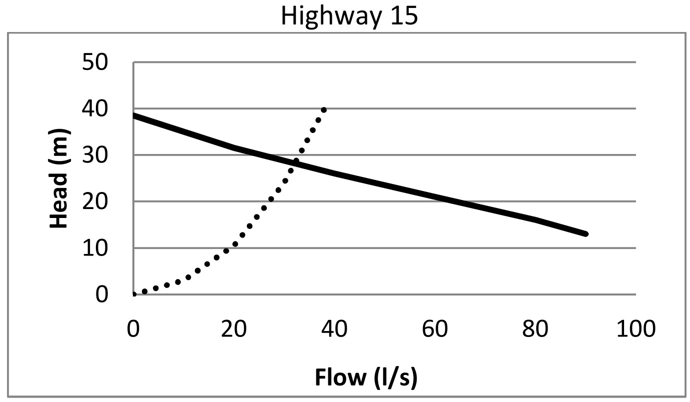
Lead and Lag, **Make:** Myers, **Model(s):** SRM4P-1 0.4Hp

Hillview



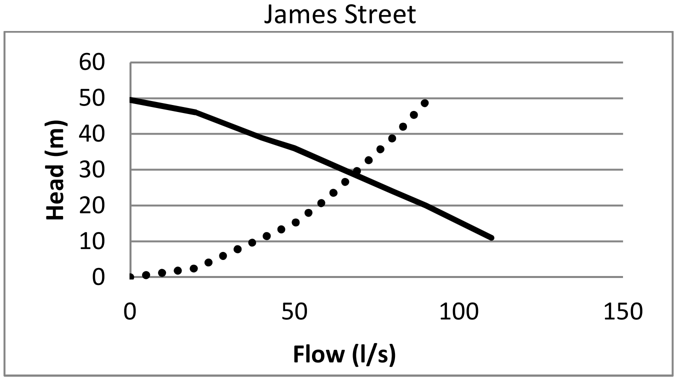
Lead and Lag, **Make:** FLYGT, **Model(s):** CP-3231 110Hp

Highway 15



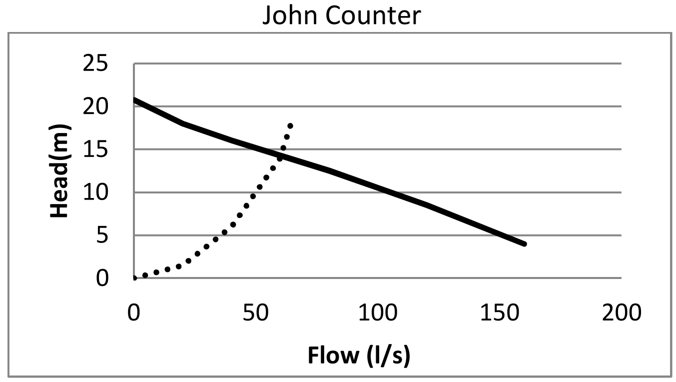
Lead and Lag, **Make:** FLYGT, **Model(s):** CT-3170 30Hp

James Street



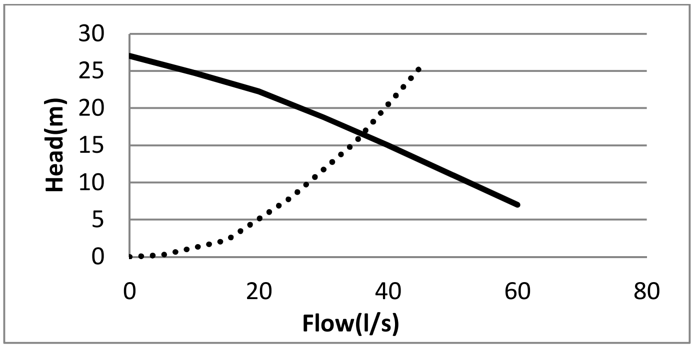
Lead and Lag, **Make:** FLYGT, **Model(s):** CT-3201

John Counter



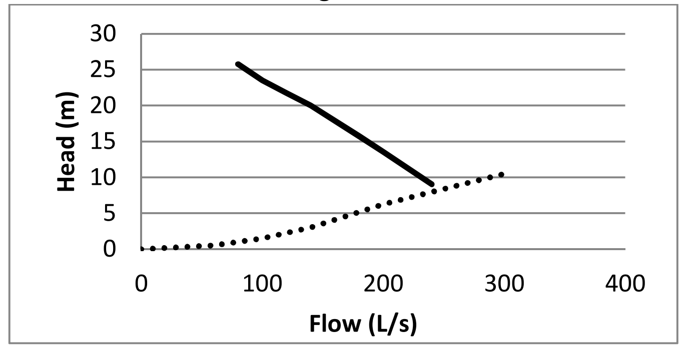
Lead and Lag, **Make:** FLYGT, **Model(s):** NP3153.181MT

Kenwood



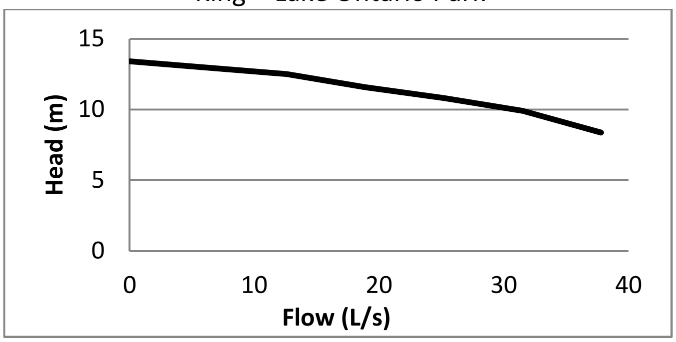
Lead and Lag, **Make:** FLYGT, **Model(s):** CP-3152 20Hp

King Street



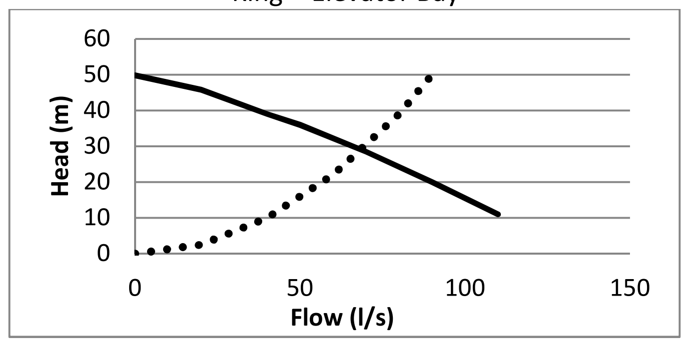
Lead and three Lags, **Make:** FLYGT, **Model(s):** 3202

King – Lake Ontario Park



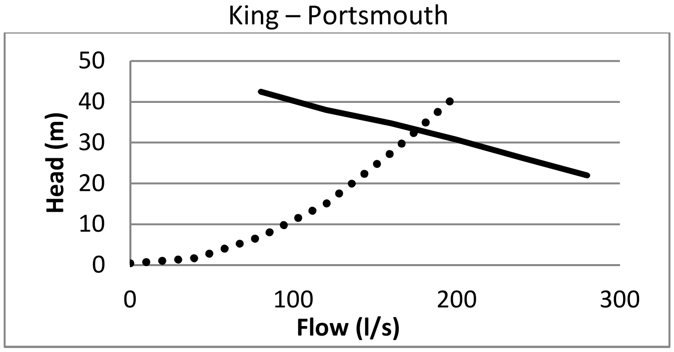
Lead and Lag, **Make:** Smith and Loveless, **Model(s):** 4B2A 15Hp

King – Elevator Bay



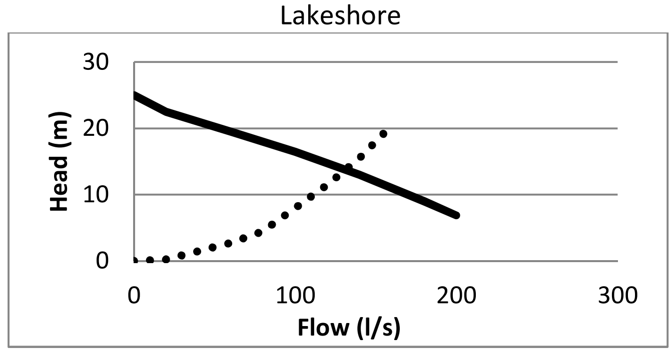
Lead and Lag, **Make:** FLYGT, **Model(s):** CP-3201 43Hp

King – Portsmouth



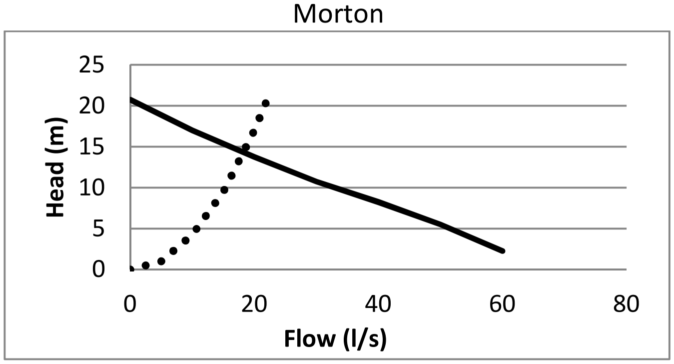
Lead and two lags, **Make:** FLYGT, **Model(s):** CP-3231 90Hp

Lakeshore



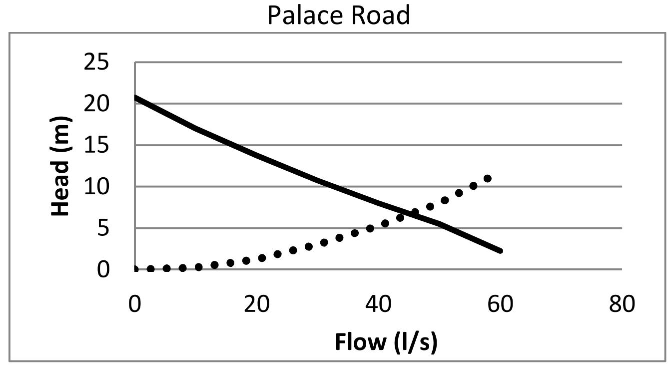
Lead and Lag, **Make:** FLYGT, **Model(s):** CP-3201 35Hp

Morton



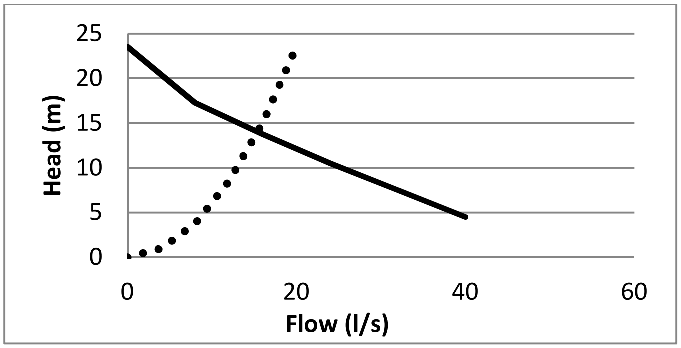
Lead and Lag, **Make:** FLYGT, **Model(s):** NT-3127 7.4Hp

Palace Road



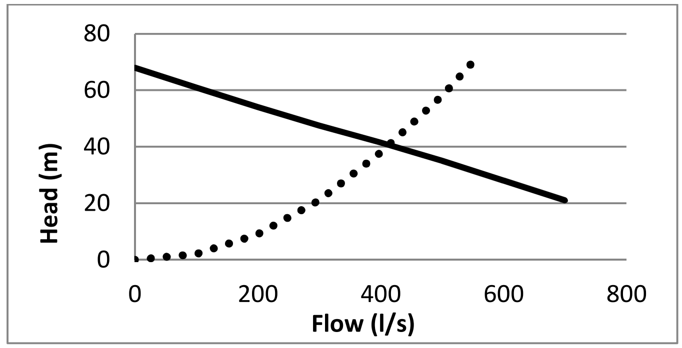
Lead and Lag, **Make:** FLYGT, **Model(s):** NP3127 7.5Hp

Rankin



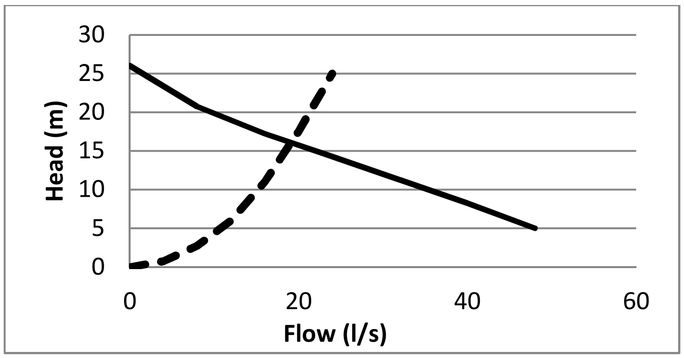
Lead and Lag, **Make:** FLYGT, **Model(s):** CP-3127 10Hp

River Street



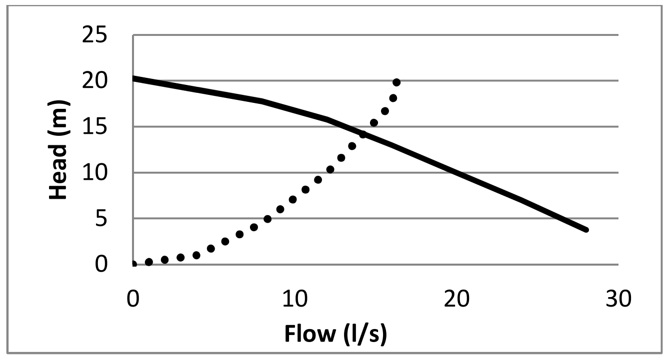
Lead and three Lags, **Make:** FLYGT, **Model(s):** Ct-3312

Schooner Drive

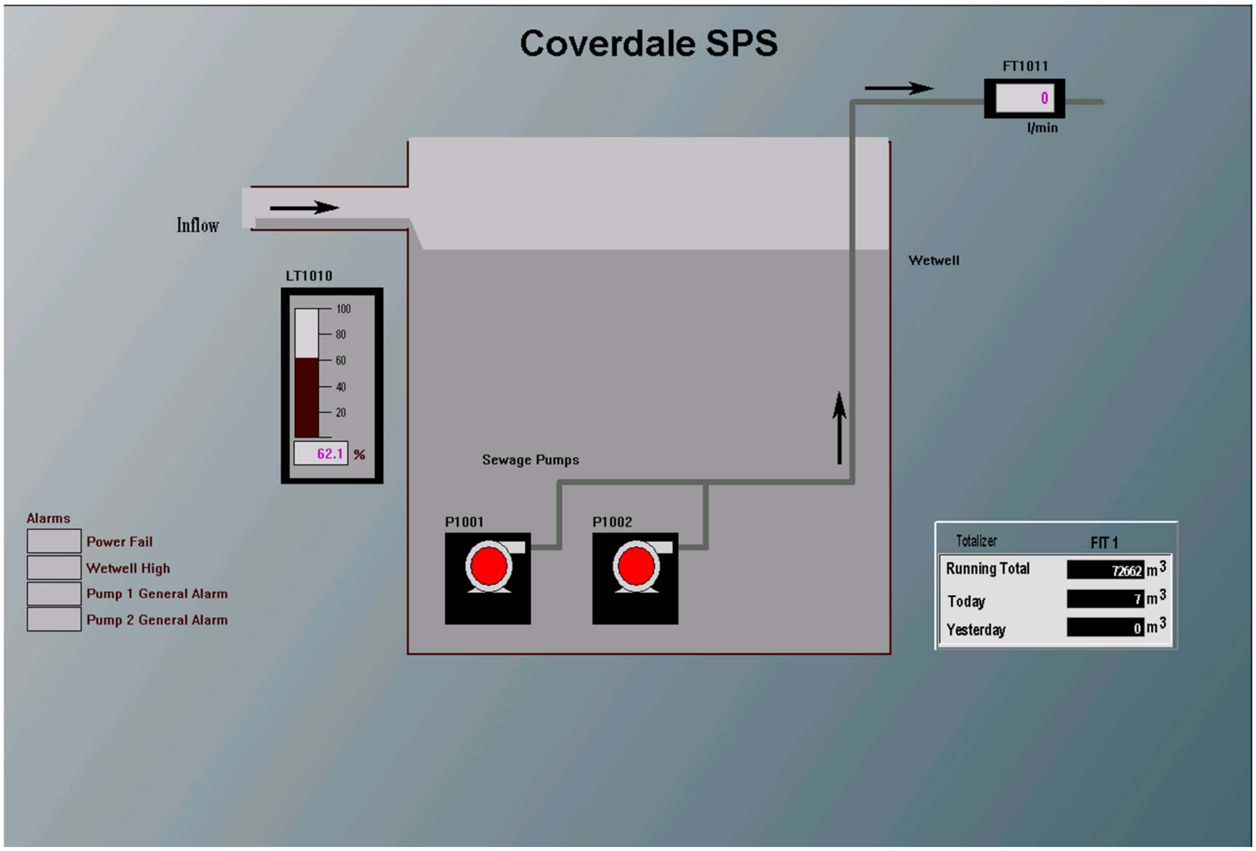


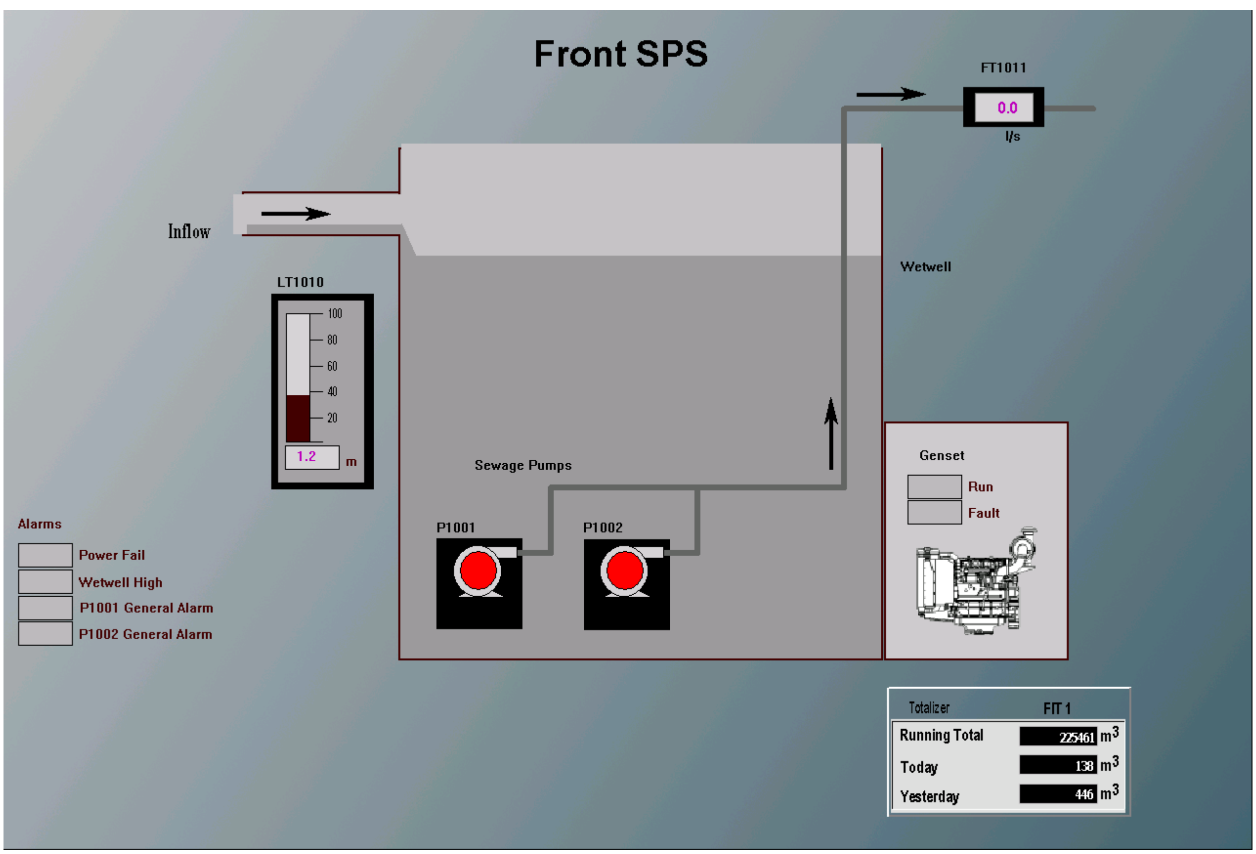
Lead and Lag, **Make:** FLYGT, **Model(s):** NP-3127 10Hp

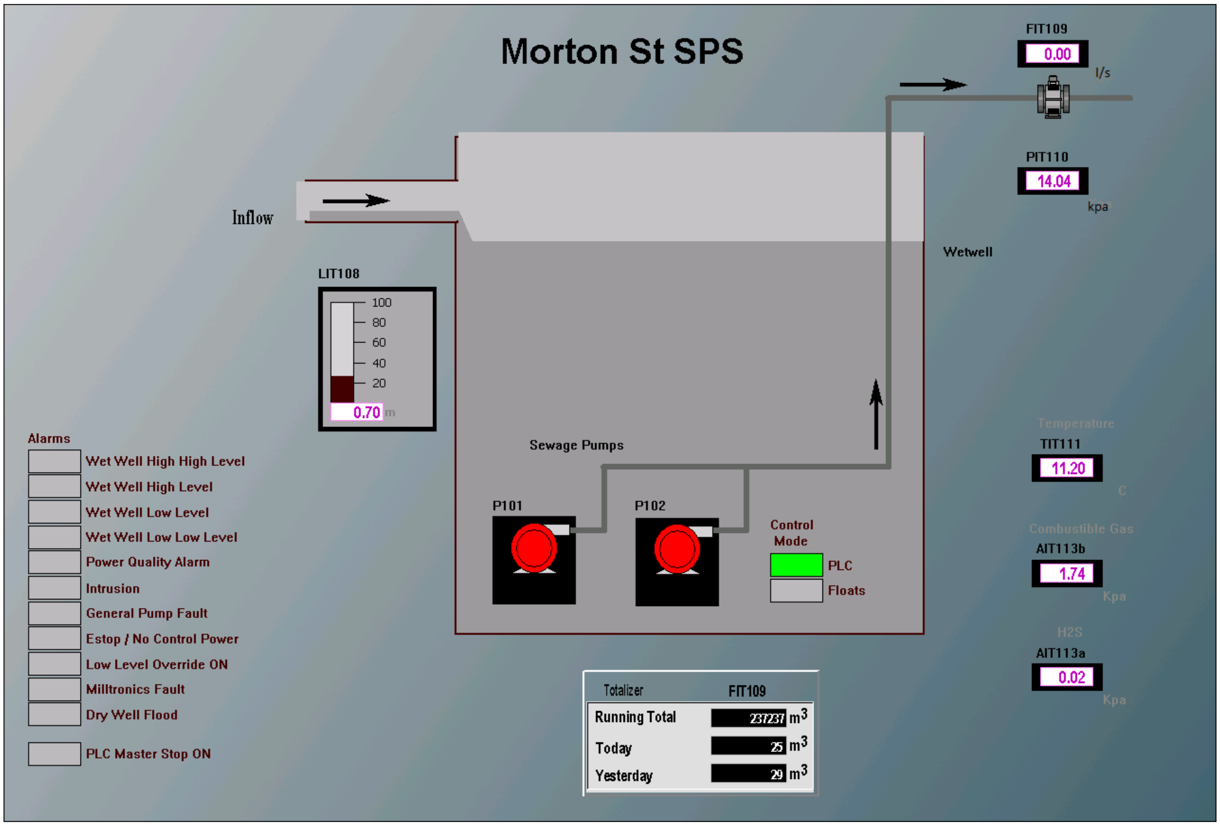
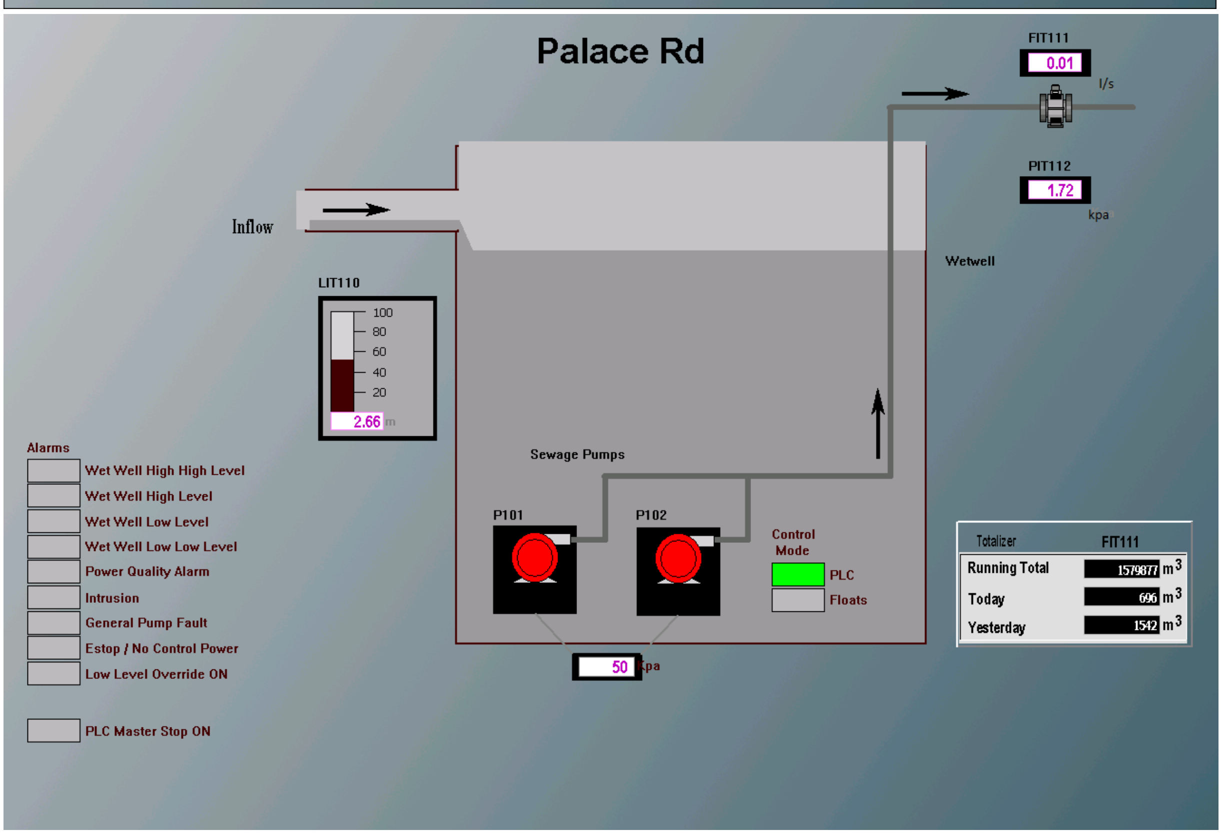
Westbrook

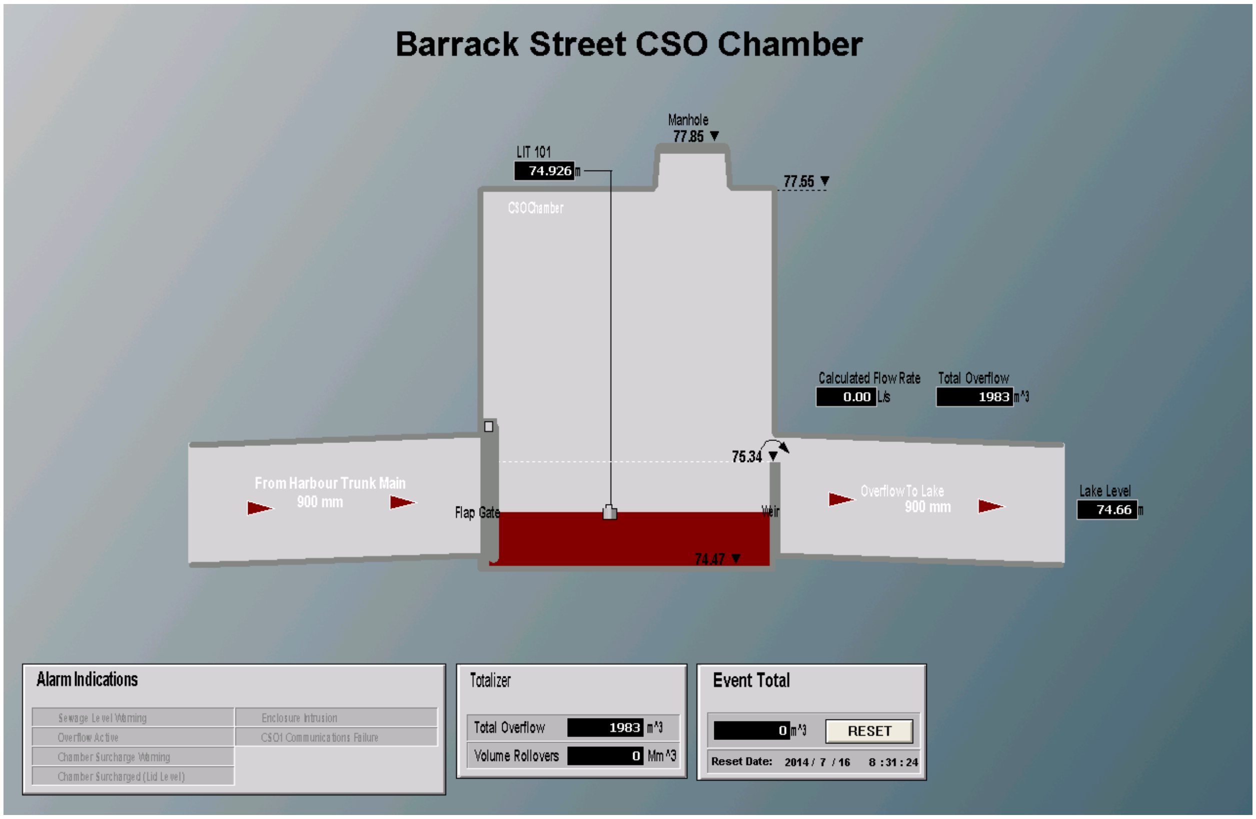


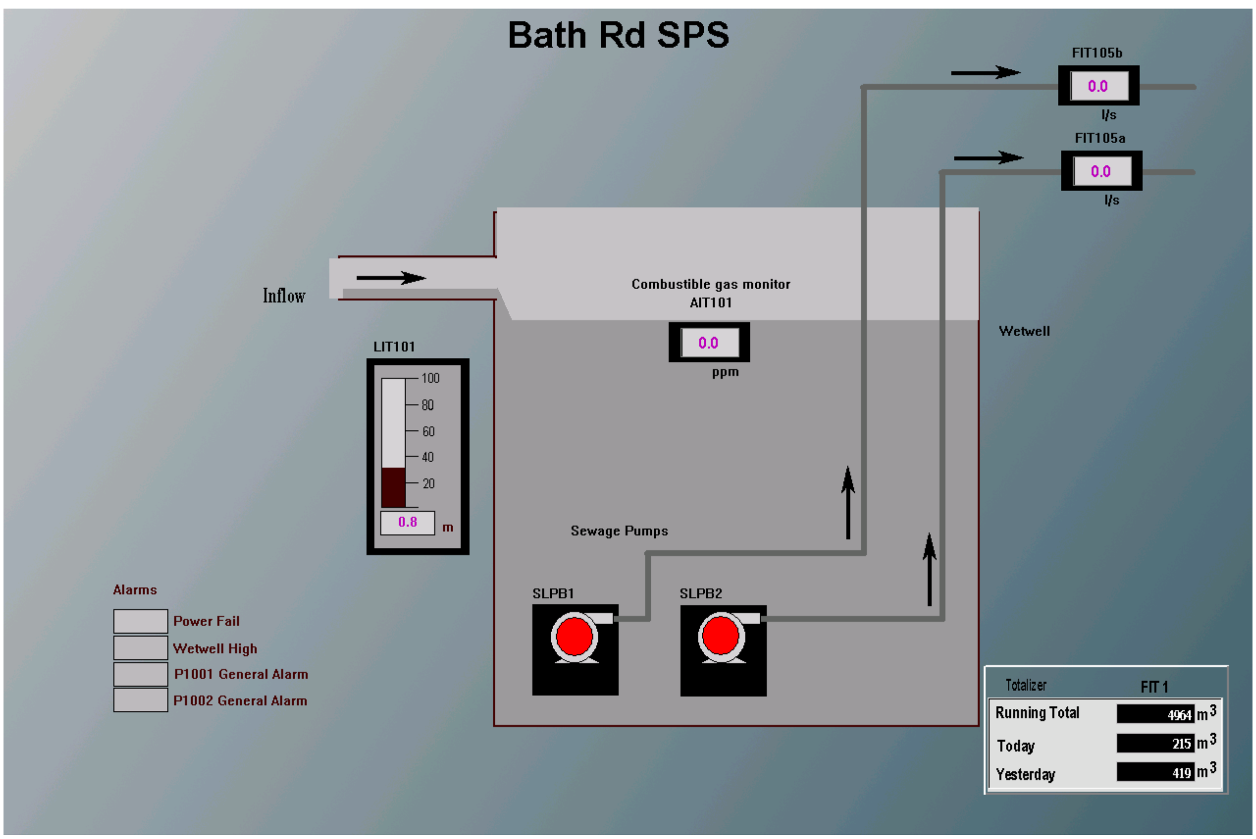
Lead and Lag, **Make:** FLYGT, **Model(s):** CP-3127 7.5Hp

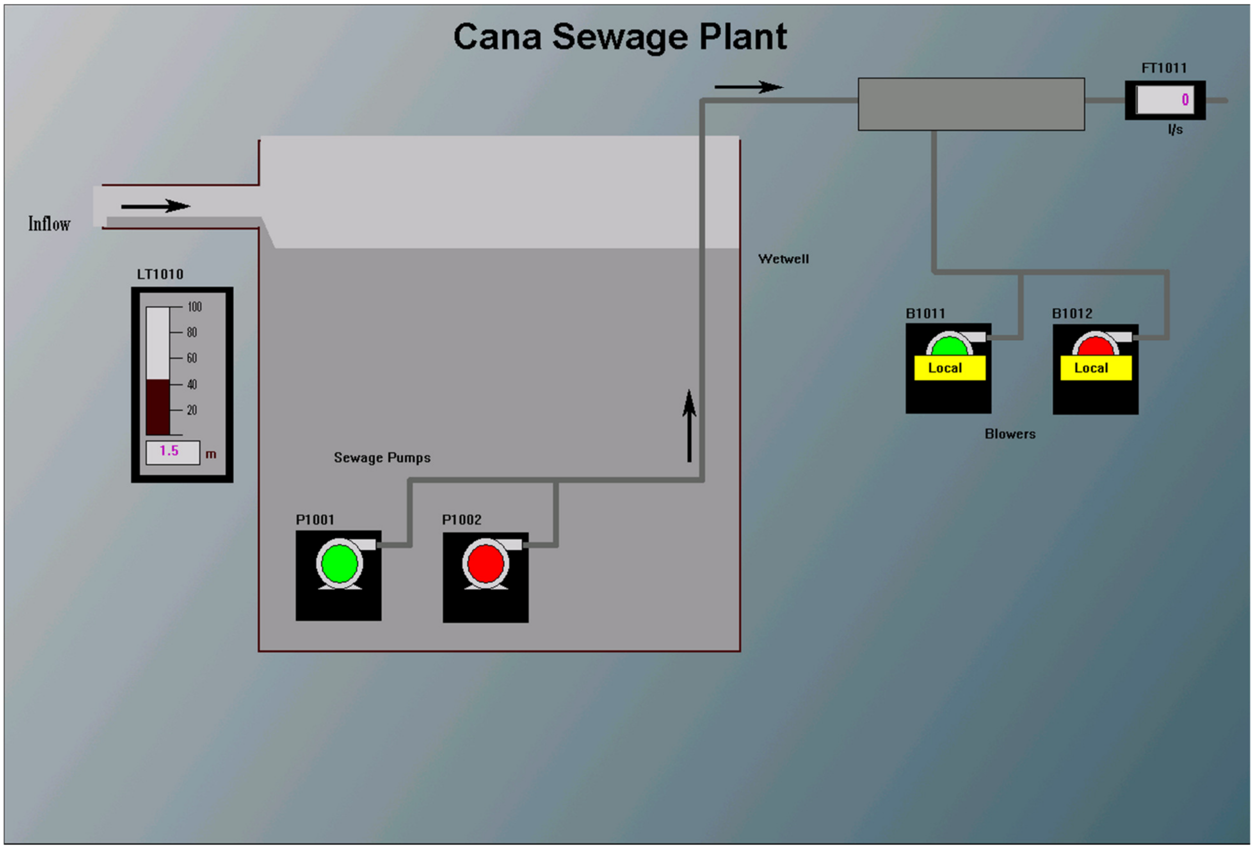

Coverdale SPS
FT1011
0
l/min
Inflow
Wetwell
LT1010
100
80
60
40
20
62.1 %
Sewage Pumps
P1001
P1002
Alarms
Power Fail
Wetwell High
Pump 1 General Alarm
Pump 2 General Alarm
Totalizer
FIT 1
Running Total 72662 m3
Today 7 m3
Yesterday 0 m3

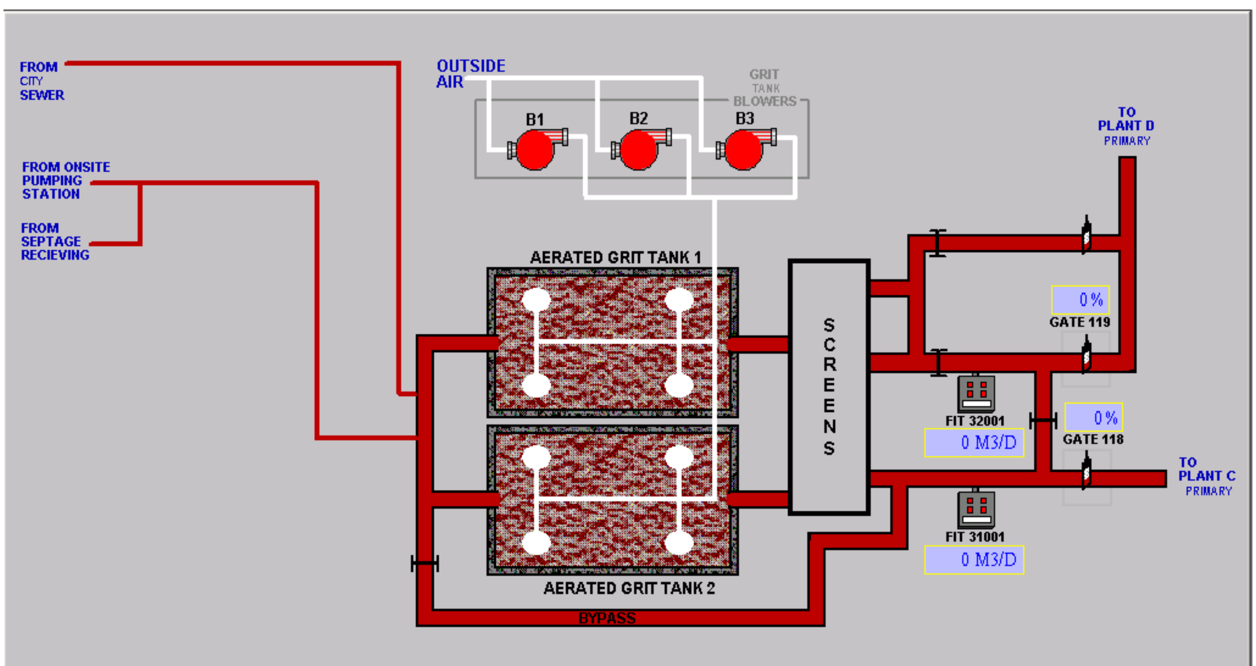

Front SPS
FT1011
0.0
l/s
Inflow
Wetwell
LT1010
100
80
60
40
20
1.2 m
Sewage Pumps
P1001
P1002
Genset
Run
Fault
Alarms
Power Fail
Wetwell High
P1001 General Alarm
P1002 General Alarm
Totalizer
FIT 1
Running Total 225461 m3
Today 138 m3
Yesterday 446 m3


Morton St SPS
FIT109
0.00
l/s
PIT110
14.04
kpa
Inflow
Wetwell
LIT108
100
80
60
40
20
0.70 m
Temperature
TIT111
11.20
C
Alarms
Wet Well High High Level
Wet Well High Level
Wet Well Low Level
Wet Well Low Low Level
Power Quality Alarm
Intrusion
General Pump Fault
Estop / No Control Power
Low Level Override ON
Milltronics Fault
Dry Well Flood
PLC Master Stop ON
Sewage Pumps
P101
P102
Control Mode
PLC
Floats
Combustible Gas
AIT113b
1.74
Kpa
H2S
AIT113a
0.02
Kpa
Totalizer
FIT109
Running Total 237237 m3
Today 25 m3
Yesterday 29 m3

Palace Rd
FIT111
0.01
l/s
PIT112
1.72
kpa
Inflow
Wetwell
LIT110
100
80
60
40
20
2.66 m
Alarms
Wet Well High High Level
Wet Well High Level
Wet Well Low Level
Wet Well Low Low Level
Power Quality Alarm
Intrusion
General Pump Fault
Estop / No Control Power
Low Level Override ON
PLC Master Stop ON
Sewage Pumps
P101
P102
Control Mode
PLC
Floats
50 kpa
Totalizer
FIT111
Running Total 1579877 m3
Today 696 m3
Yesterday 1542 m3


Barrack Street CSO Chamber
Manhole
77.85
LIT 101
74.926 m
77.55
CSO Chamber
Calculated Flow Rate
0.00 L/s
Total Overflow
1983 m^3
75.34
From Harbour Trunk Main
900 mm
Flap Gate
Weir
Overflow To Lake
900 mm
Lake Level
74.66 m
74.47
Alarm Indications
Sewage Level Warning
Enclosure Intrusion
Overflow Active
CSO1 Communications Failure
Chamber Surcharge Warning
Chamber Surcharged (Lid Level)
Totalizer
Total Overflow
1983 m^3
Volume Rollovers
0 Mm^3
Event Total
0 m^3
RESET
Reset Date: 2014 / 7 / 16 8 : 31 : 24

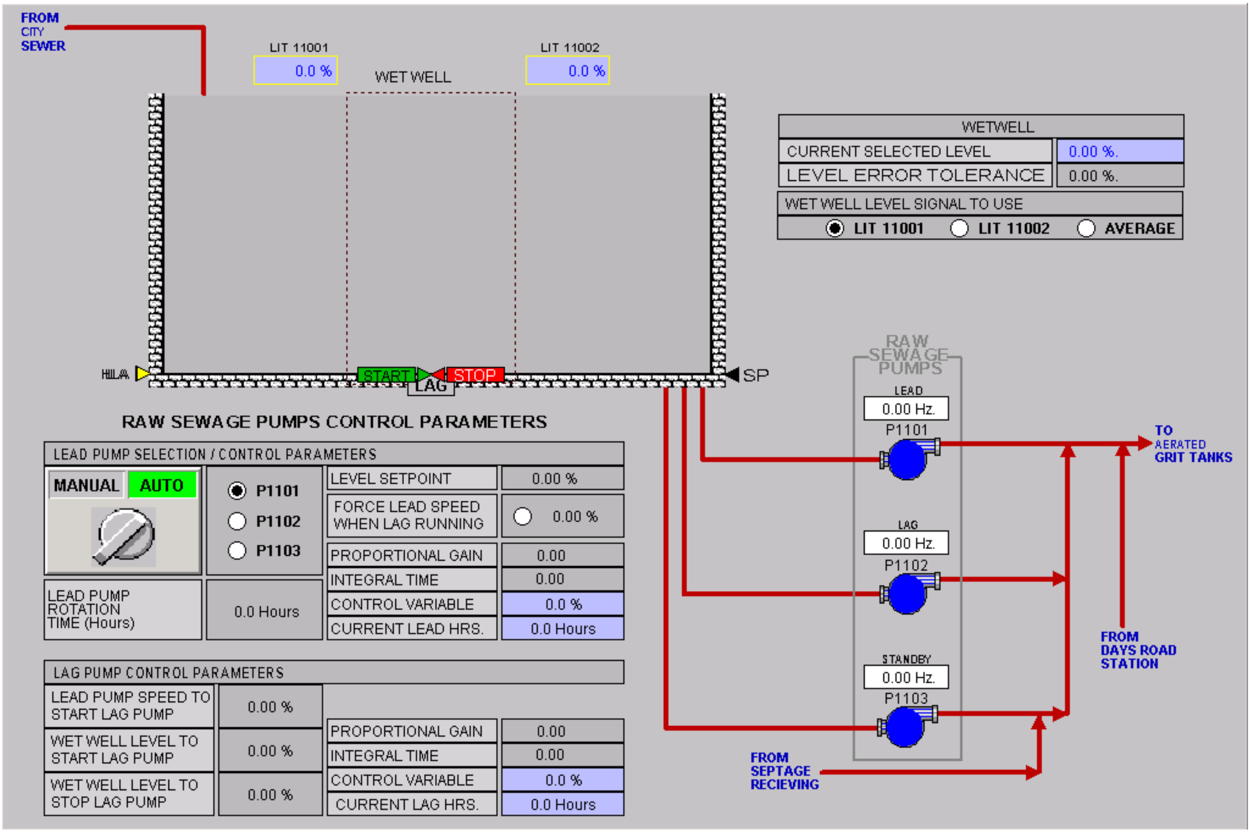

Bath Rd SPS
FIT105b
0.0
l/s
FIT105a
0.0
l/s
Inflow
Combustible gas monitor
AIT101
0.0
ppm
Wetwell
LIT101
100
80
60
40
20
0.8
m
Sewage Pumps
SLPB1
SLPB2
Alarms
Power Fail
Wetwell High
P1001 General Alarm
P1002 General Alarm
Totalizer
FIT 1
Running Total
4964 m3
Today
215 m3
Yesterday
419 m3

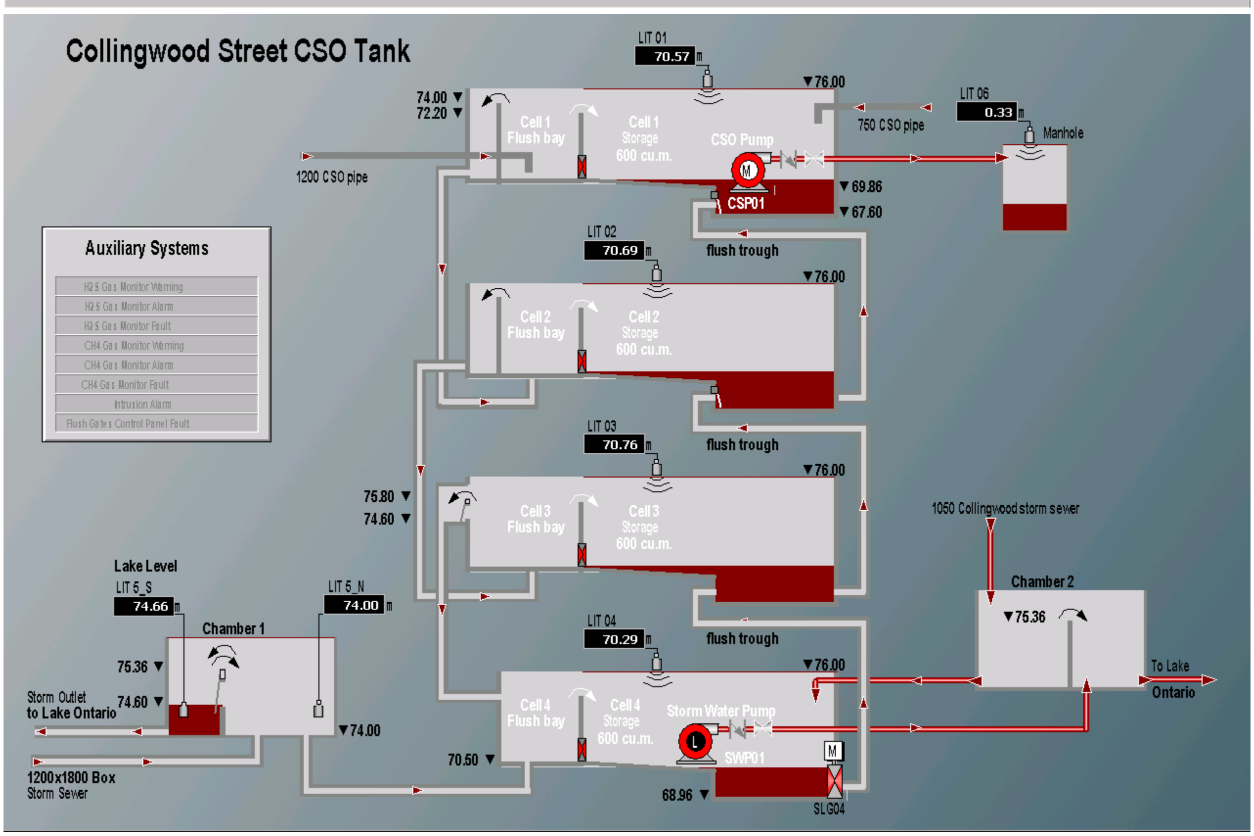


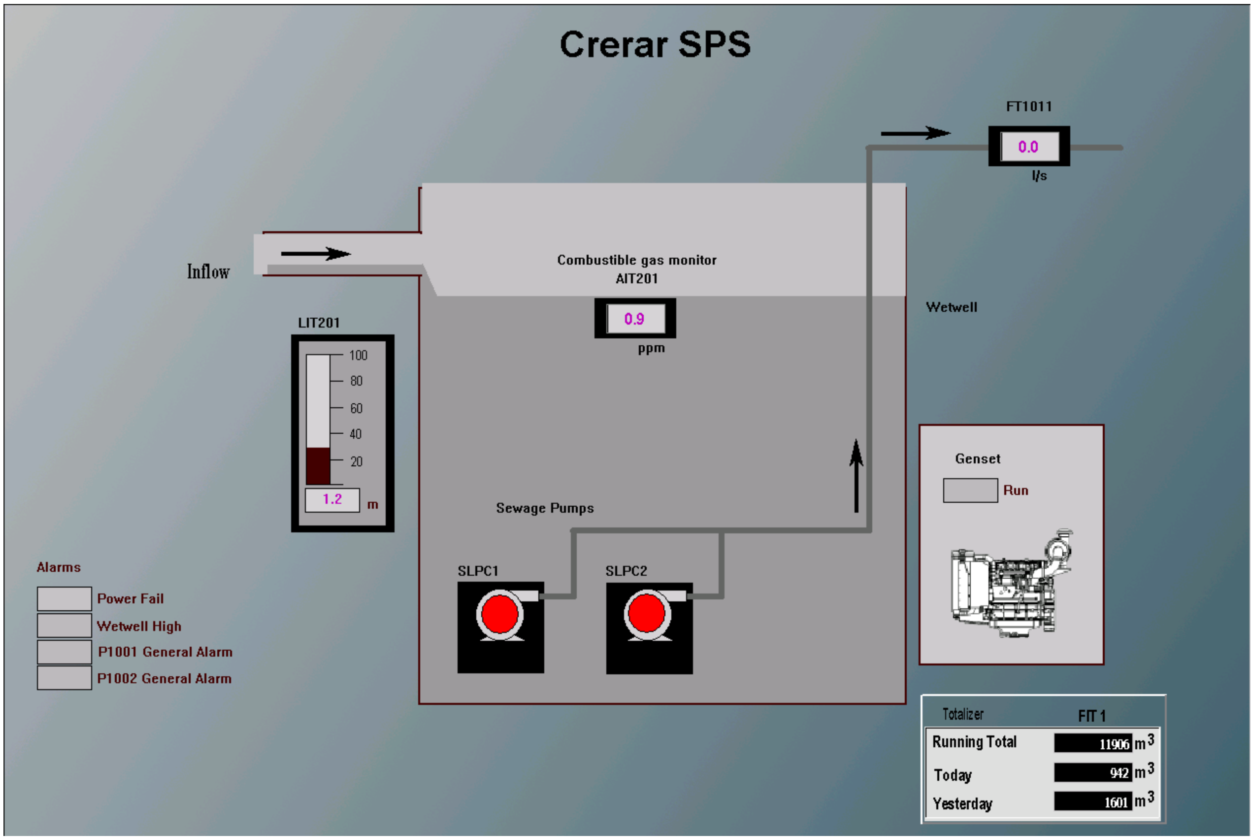


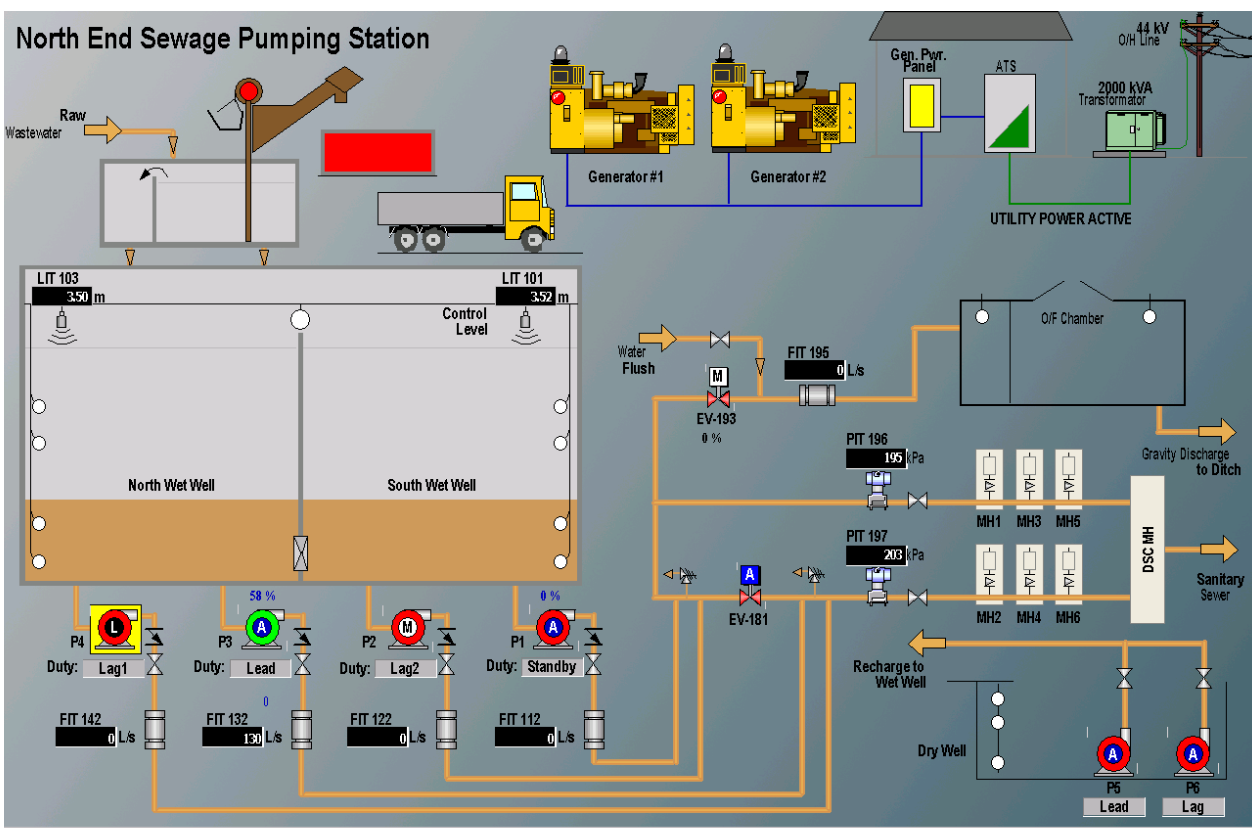
	Mode	Control	Command	
Gate No.118	Local	Manual	100	%
Gate No.119	Local	Manual	42	%

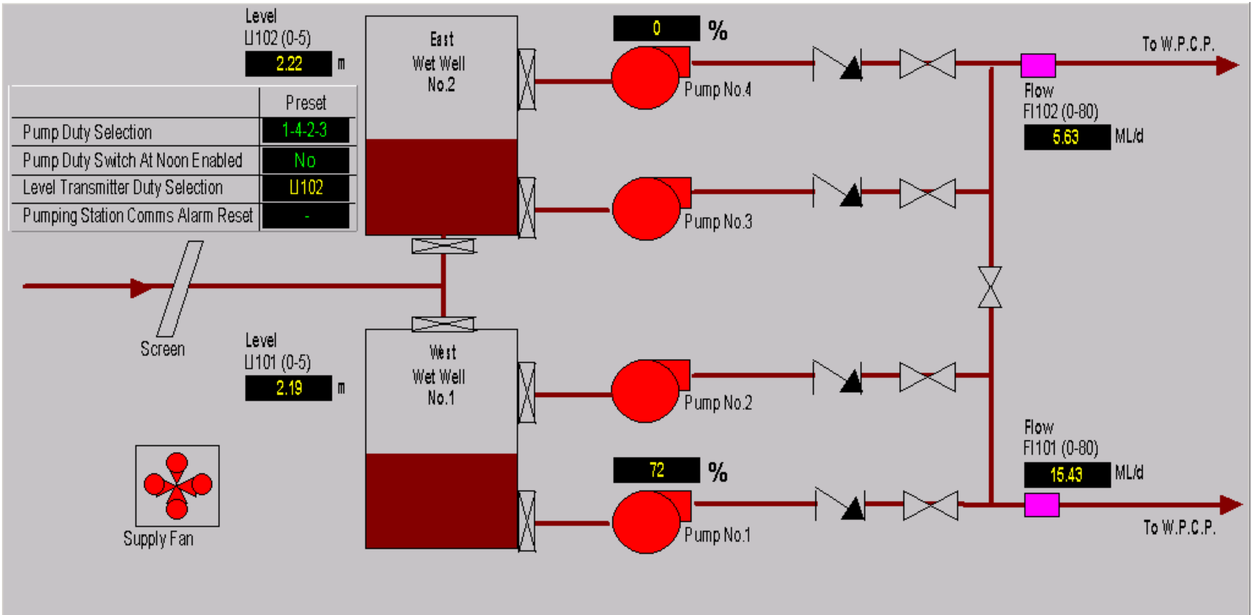
Cat Bay WWTP


FROM
CITY
SEWER
LIT 11001
0.0 %
WET WELL
LIT 11002
0.0 %
WETWELL
CURRENT SELECTED LEVEL
0.00 %.
LEVEL ERROR TOLERANCE
0.00 %.
WET WELL LEVEL SIGNAL TO USE
LIT 11001
LIT 11002
AVERAGE
HLA
START
LAG
STOP
SP
RAW SEWAGE PUMPS
LEAD
0.00 Hz.
P1101
LAG
0.00 Hz.
P1102
STANDBY
0.00 Hz.
P1103
TO AERATED GRIT TANKS
FROM DAYS ROAD STATION
FROM SEPTAGE RECIEVING
RAW SEWAGE PUMPS CONTROL PARAMETERS
LEAD PUMP SELECTION / CONTROL PARAMETERS
MANUAL
AUTO
P1101
P1102
P1103
LEVEL SETPOINT
0.00 %
FORCE LEAD SPEED WHEN LAG RUNNING
0.00 %
PROPORTIONAL GAIN
0.00
INTEGRAL TIME
0.00
CONTROL VARIABLE
0.0 %
CURRENT LEAD HRS.
0.0 Hours
LEAD PUMP ROTATION TIME (Hours)
0.0 Hours
LAG PUMP CONTROL PARAMETERS
LEAD PUMP SPEED TO START LAG PUMP
0.00 %
WET WELL LEVEL TO START LAG PUMP
0.00 %
WET WELL LEVEL TO STOP LAG PUMP
0.00 %
PROPORTIONAL GAIN
0.00
INTEGRAL TIME
0.00
CONTROL VARIABLE
0.0 %
CURRENT LAG HRS.
0.0 Hours


Collingwood Street CSO Tank
LIT 01
70.57
74.00
72.20
76.00
LIT 06
0.33
750 CSO pipe
Manhole
Cell 1 Flush bay
Cell 1 Storage 600 cu.m.
CSO Pump
CSP01
1200 CSO pipe
69.86
67.60
flush trough
LIT 02
70.69
76.00
Cell 2 Flush bay
Cell 2 Storage 600 cu.m.
Auxiliary Systems
H2S Gas Monitor Warning
H2S Gas Monitor Alarm
H2S Gas Monitor Fault
CH4 Gas Monitor Warning
CH4 Gas Monitor Alarm
CH4 Gas Monitor Fault
Intrusion Alarm
Flush Gates Control Panel Fault
LIT 03
70.76
flush trough
76.00
75.80
74.60
Cell 3 Flush bay
Cell 3 Storage 600 cu.m.
1050 Collingwood storm sewer
Chamber 2
75.36
Lake Level
LIT 5_S
74.66
LIT 5_N
74.00
Chamber 1
75.36
74.60
74.00
Storm Outlet to Lake Ontario
LIT 04
70.29
flush trough
76.00
Cell 4 Flush bay
Cell 4 Storage 600 cu.m.
Storm Water Pump
SWP01
SLG04
70.50
68.96
To Lake Ontario
1200x1800 Box Storm Sewer

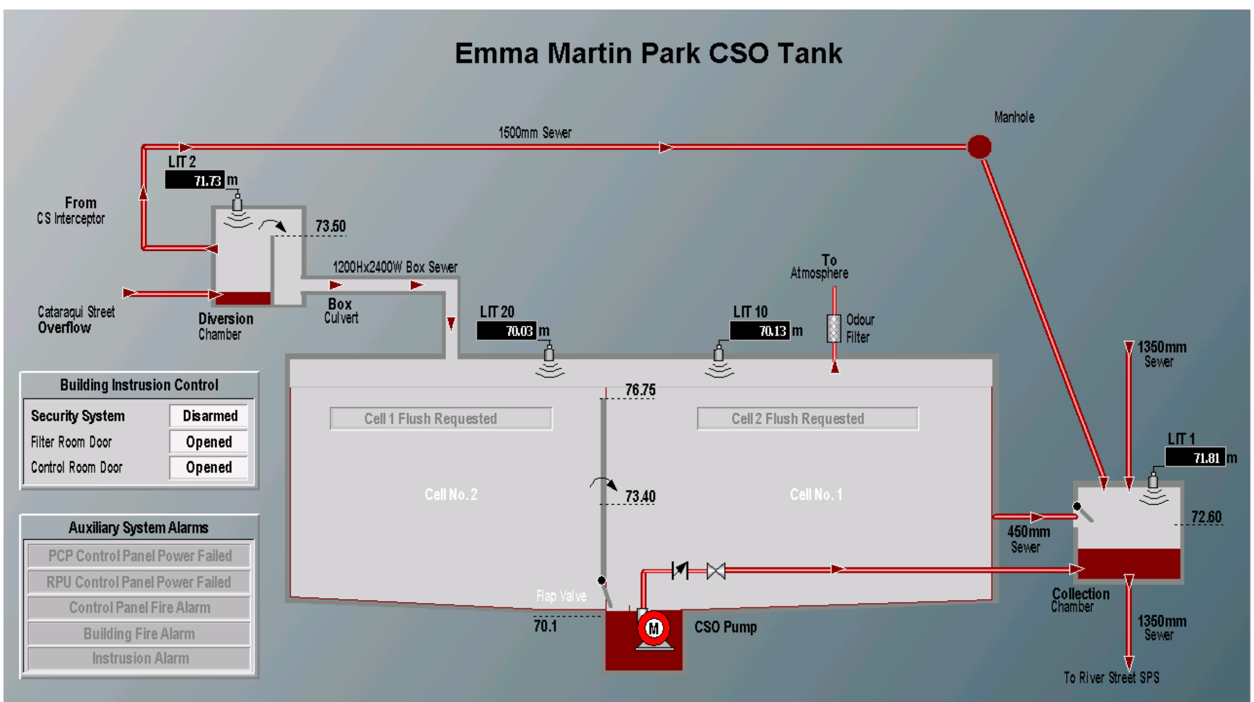

Crerar SPS
FT1011
0.0
l/s
Inflow
Combustible gas monitor
AIT201
0.9
ppm
Wetwell
LIT201
100
80
60
40
20
1.2
m
Sewage Pumps
Genset
Run
Alarms
SLPC1
SLPC2
Power Fail
Wetwell High
P1001 General Alarm
P1002 General Alarm
Totalizer
FIT 1
Running Total
11906 m3
Today
942 m3
Yesterday
1601 m3


North End Sewage Pumping Station
Raw
Wastewater
Generator #1
Generator #2
Gen. Pwr. Panel
ATS
44 KV O/H Line
2000 kVA Transformer
UTILITY POWER ACTIVE
LIT 103
3.50 m
LIT 101
3.52 m
Control Level
North Wet Well
South Wet Well
Water Flush
FIT 195
0 L/s
EV-193
0 %
O/F Chamber
Gravity Discharge to Ditch
PIT 196
195 kPa
MH1
MH3
MH5
DSC MH
PIT 197
203 kPa
MH2
MH4
MH6
Sanitary Sewer
EV-181
58 %
0 %
P4
P3
P2
P1
Duty: Lag1
Duty: Lead
Duty: Lag2
Duty: Standby
FIT 142
0 L/s
FIT 132
130 L/s
FIT 122
0 L/s
FIT 112
0 L/s
Recharge to Wet Well
Dry Well
P5
Lead
P6
Lag

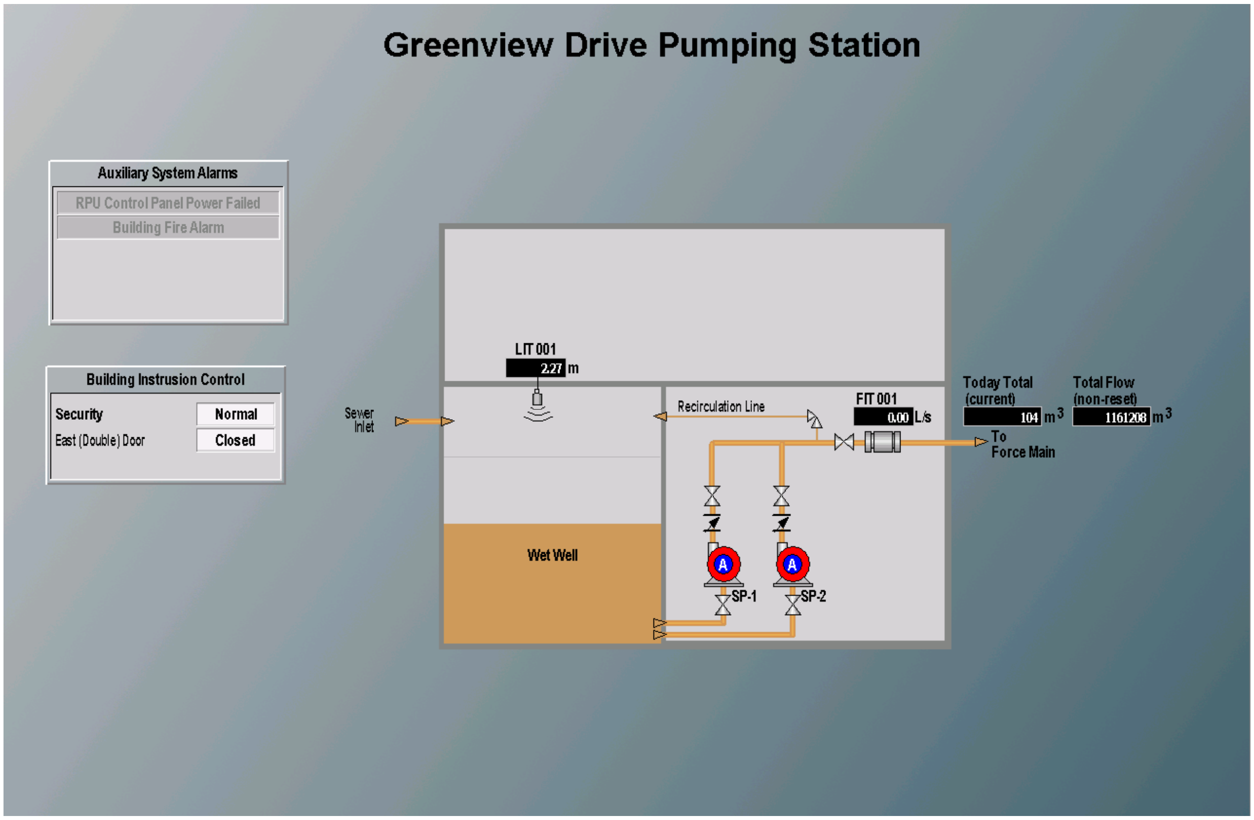


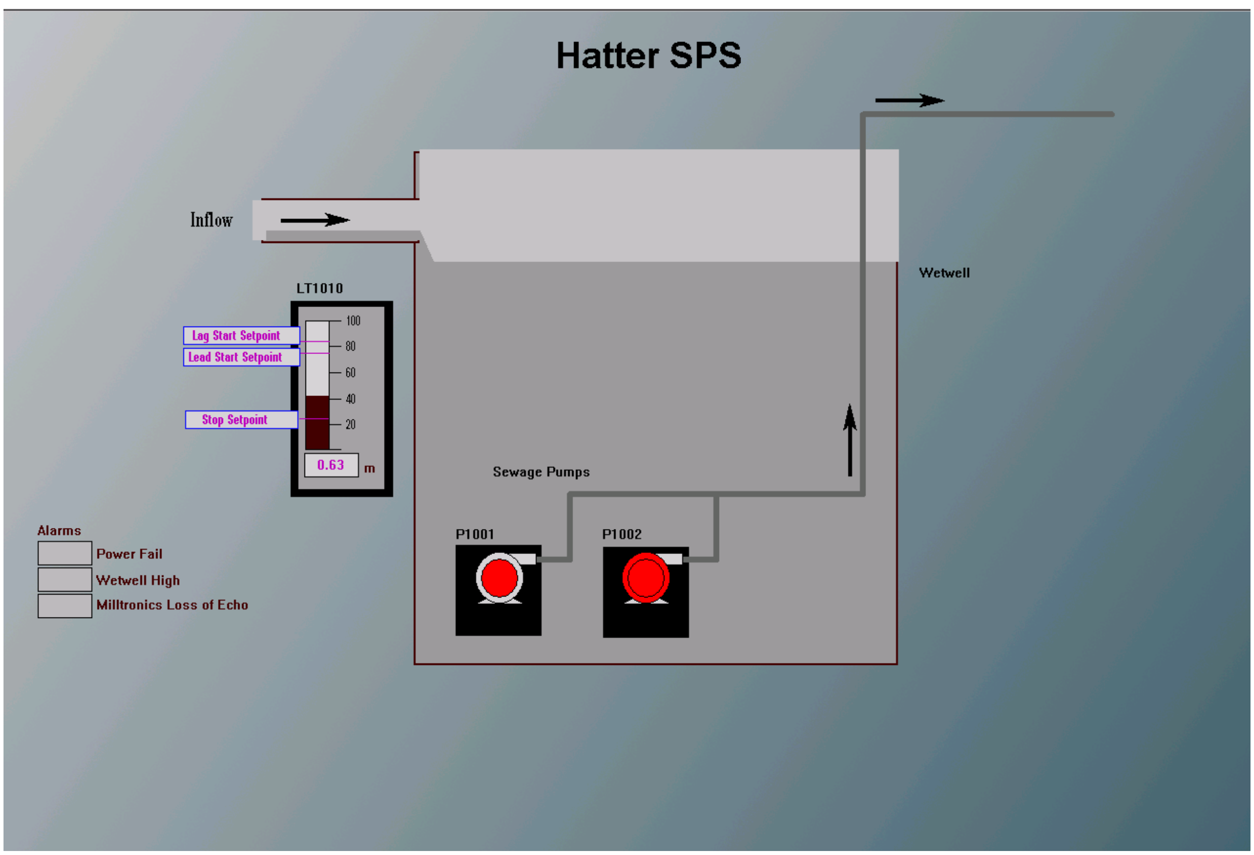
	Start Lvl (m)	Stop Lvl (m)	Min Speed %	Max Speed %	Min Spd Lvl	Max Spd Lvl
1 Pump	0.00	0.00	0	0	0.00	0.00
2 Pumps	0.00	0.00	0	0	0.00	0.00
3 Pumps	0.00	0.00	0	0	0.00	0.00
4 Pumps	0.00	0.00	0	0	0.00	0.00

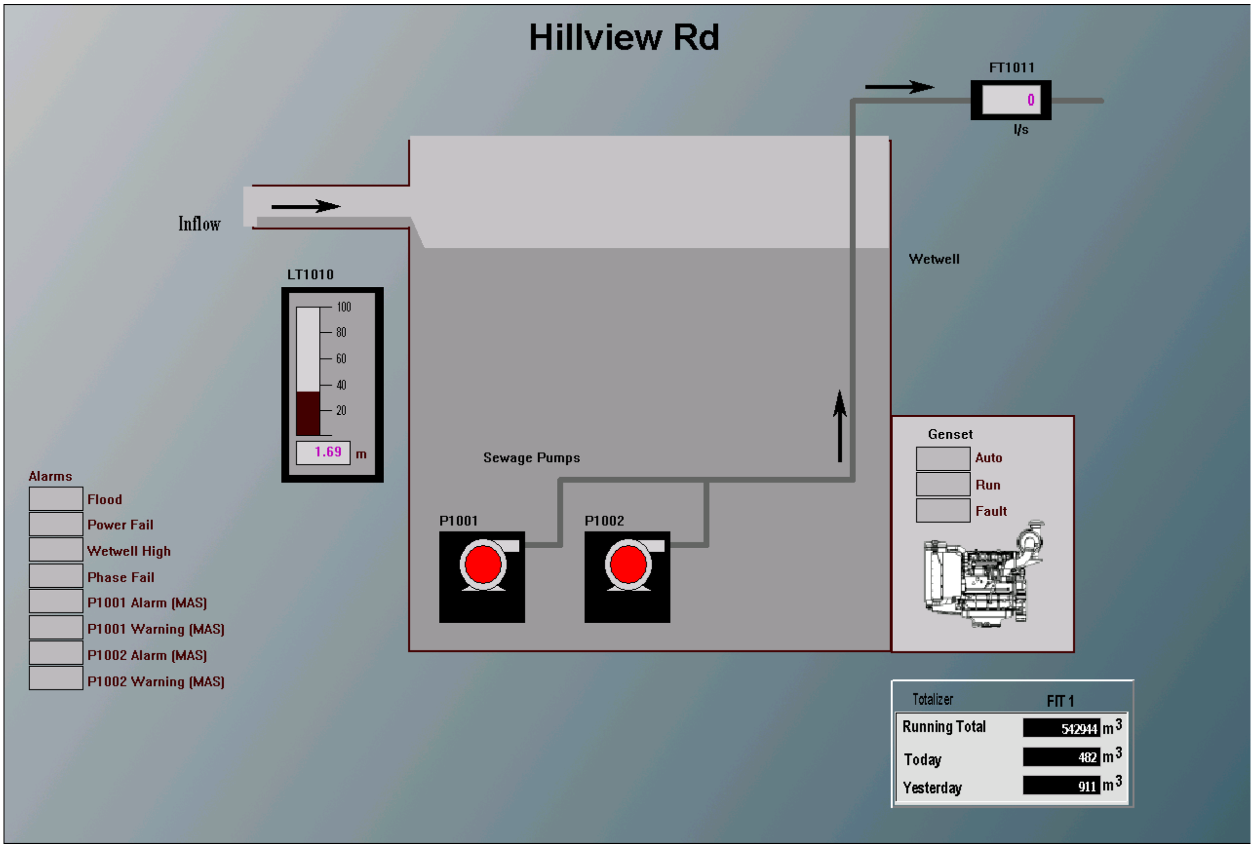
	Mode	Control	Command
Pump No.1 (On/Off)	Local	Auto	Stop
Pump No.1 VFD (Speed)	Local	Auto	13 %
Pump No.2	Remote	Auto	Stop
Pump No.3	Local	Auto	Stop
Pump No.4 (On/Off)	Local	Auto	Stop
Pump No.4 VFD (Speed)	Local	Auto	0 %

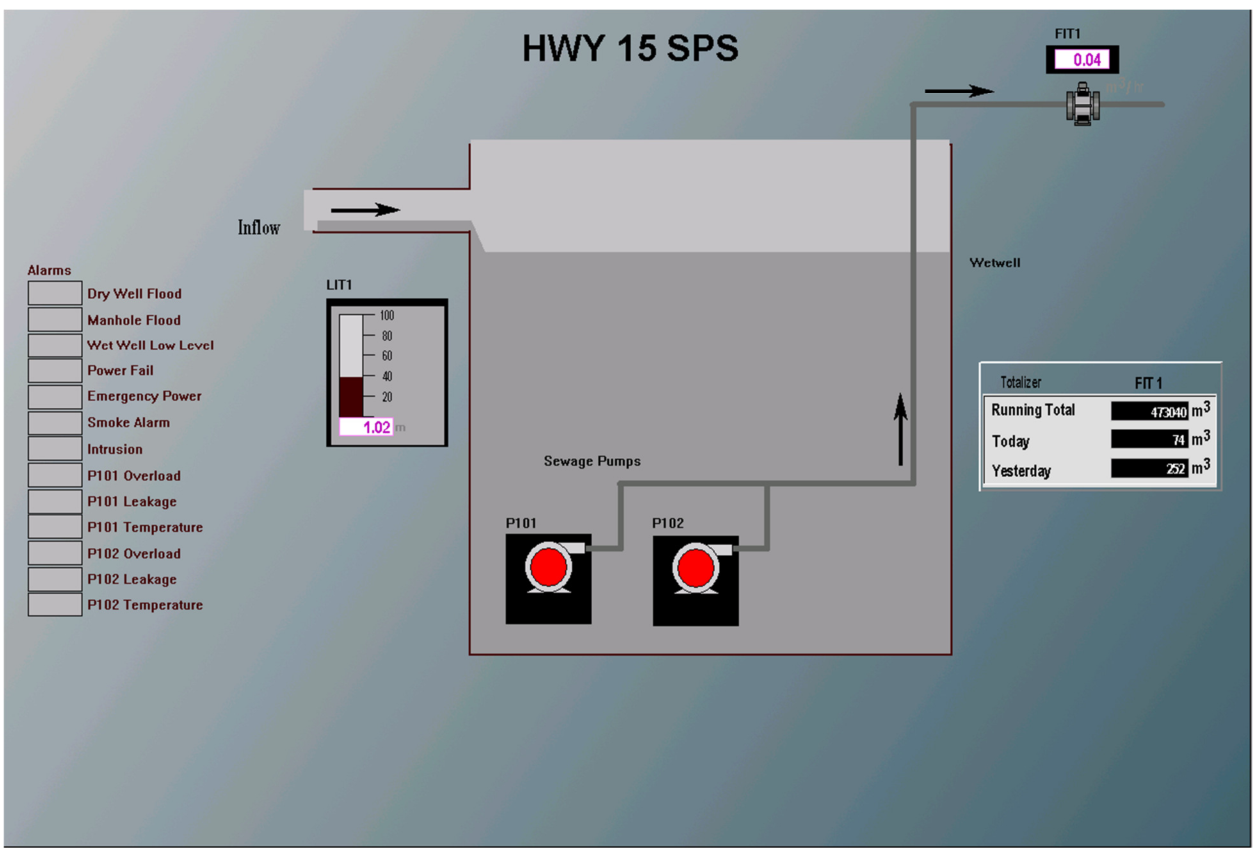


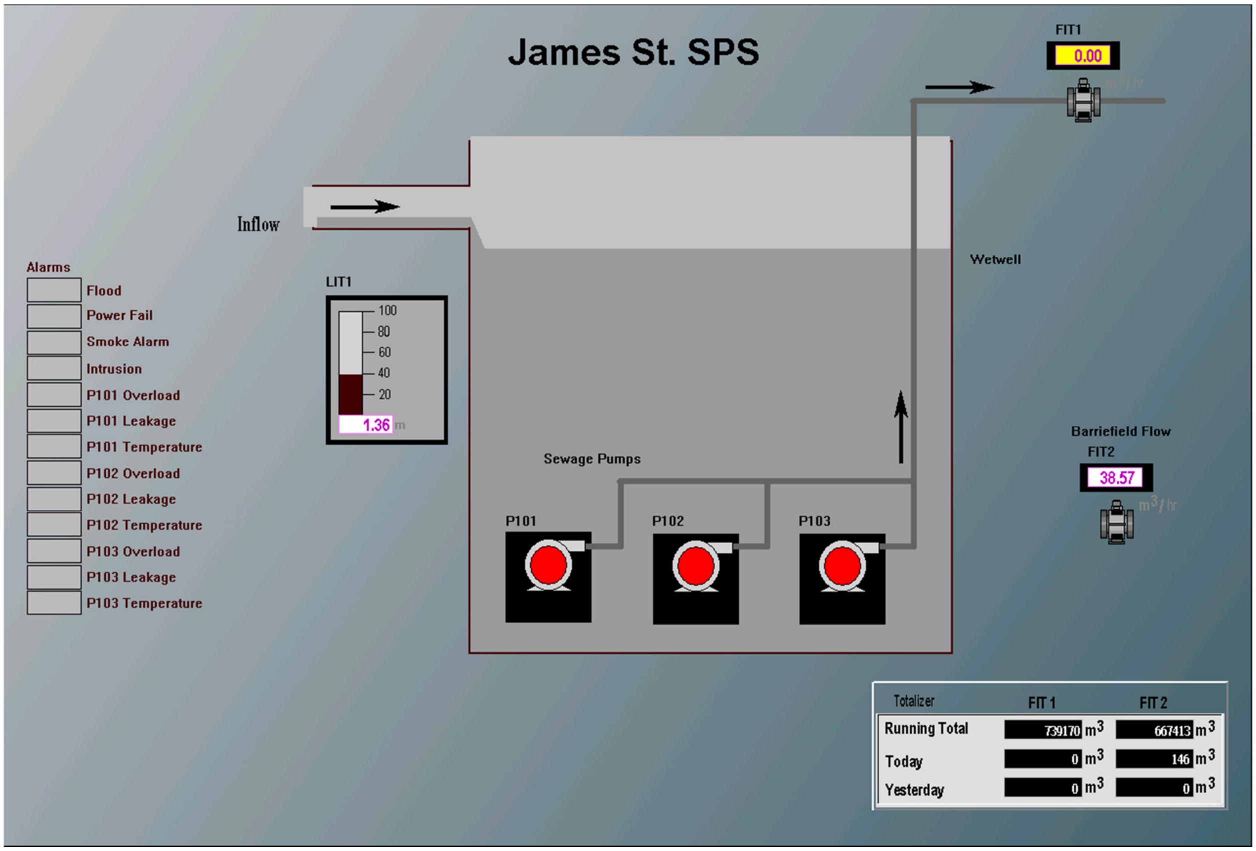
Cell No. 2						Cell No. 1					
Gate #1 Flushing	Gate #2 Flushing	Gate #3 Flushing	Gate #4 Flushing	Gate #5 Flushing	Gate #6 Flushing	Gate #1 Flushing	Gate #2 Flushing	Gate #3 Flushing	Gate #4 Flushing	Gate #5 Flushing	Gate #6 Flushing

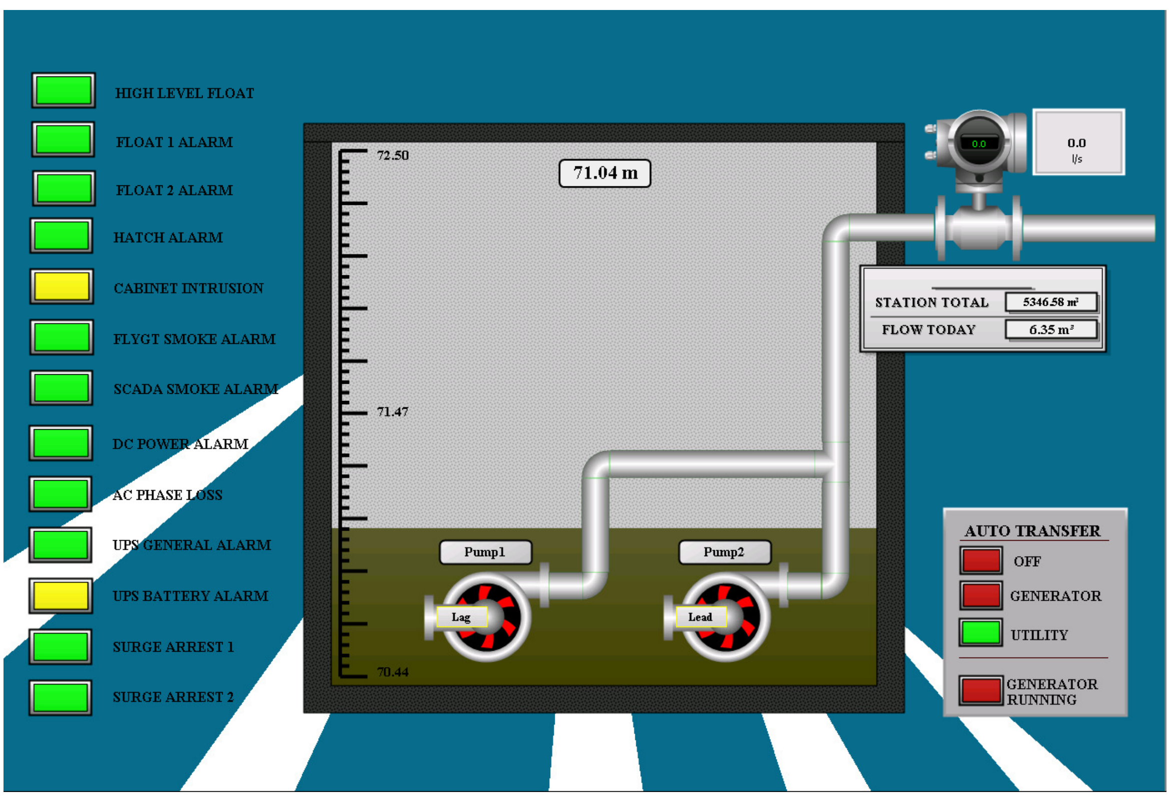

Greenview Drive Pumping Station
Auxiliary System Alarms
RPU Control Panel Power Failed
Building Fire Alarm
Building Instrusion Control
Security
Normal
East (Double) Door
Closed
Sewer Inlet
LIT 001
2.27 m
Wet Well
Recirculation Line
FIT 001
0.00 L/s
A
SP-1
A
SP-2
Today Total (current)
104 m3
Total Flow (non-reset)
1161208 m3
To Force Main


Hatter SPS
Inflow
Wetwell
LT1010
100
80
60
40
20
Lag Start Setpoint
Lead Start Setpoint
Stop Setpoint
0.63
m
Sewage Pumps
P1001
P1002
Alarms
Power Fail
Wetwell High
Milltronics Loss of Echo

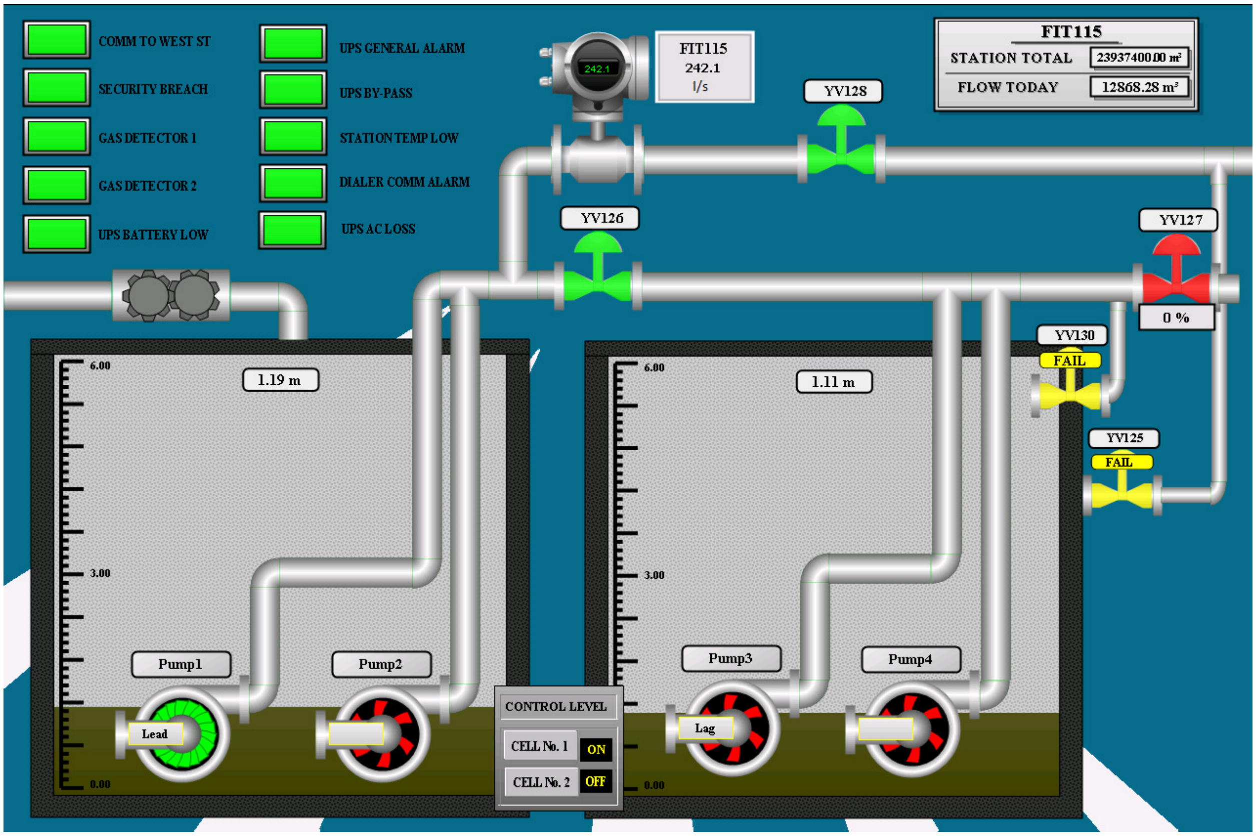

Hillview Rd
FT1011
0
l/s
Inflow
LT1010
100
80
60
40
20
1.69
m
Wetwell
Sewage Pumps
P1001
P1002
Genset
Auto
Run
Fault
Alarms
Flood
Power Fail
Wetwell High
Phase Fail
P1001 Alarm (MAS)
P1001 Warning (MAS)
P1002 Alarm (MAS)
P1002 Warning (MAS)
Totalizer
FIT 1
Running Total 542944 m3
Today 482 m3
Yesterday 911 m3


HWY 15 SPS
FIT1
0.04
Inflow
Alarms
Dry Well Flood
Manhole Flood
Wet Well Low Level
Power Fail
Emergency Power
Smoke Alarm
Intrusion
P101 Overload
P101 Leakage
P101 Temperature
P102 Overload
P102 Leakage
P102 Temperature
LIT1
100
80
60
40
20
1.02
m
Wetwell
Sewage Pumps
P101
P102
Totalizer
FIT 1
Running Total 473040 m3
Today 74 m3
Yesterday 252 m3



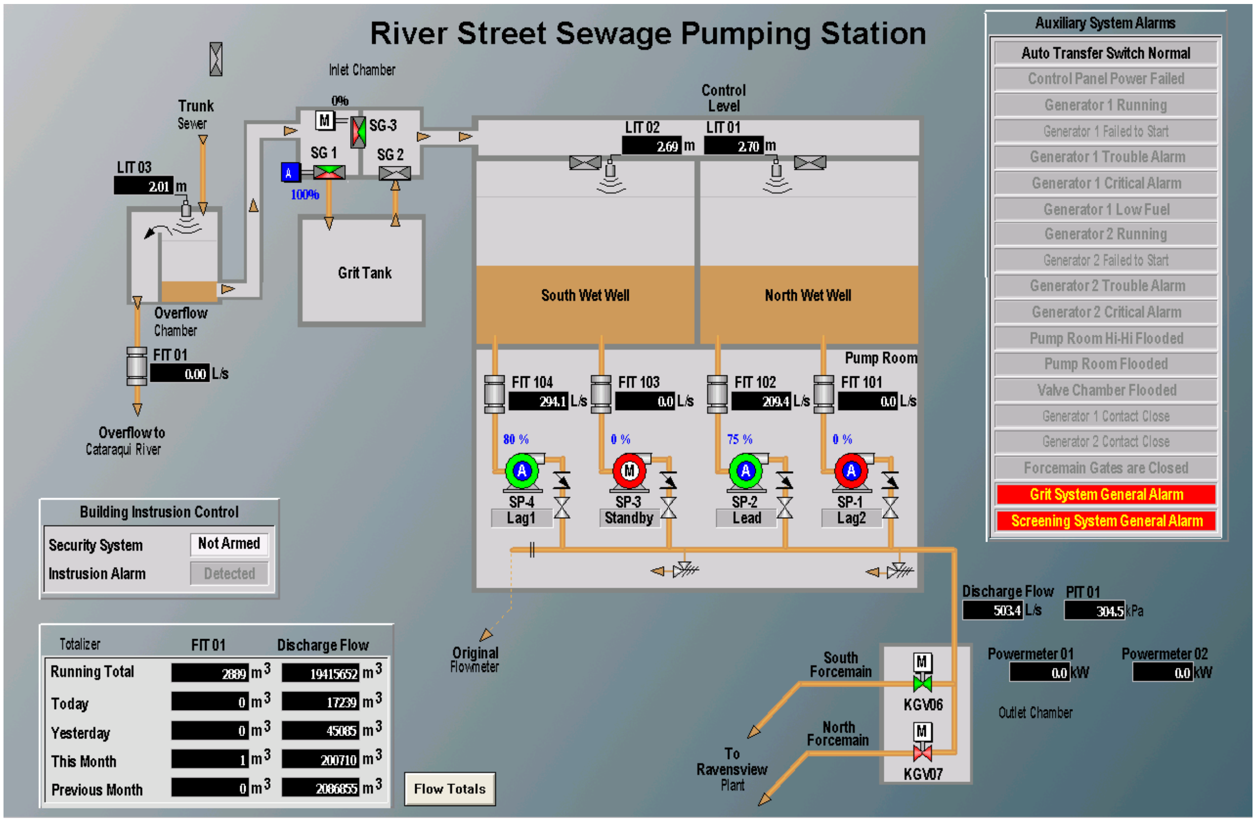


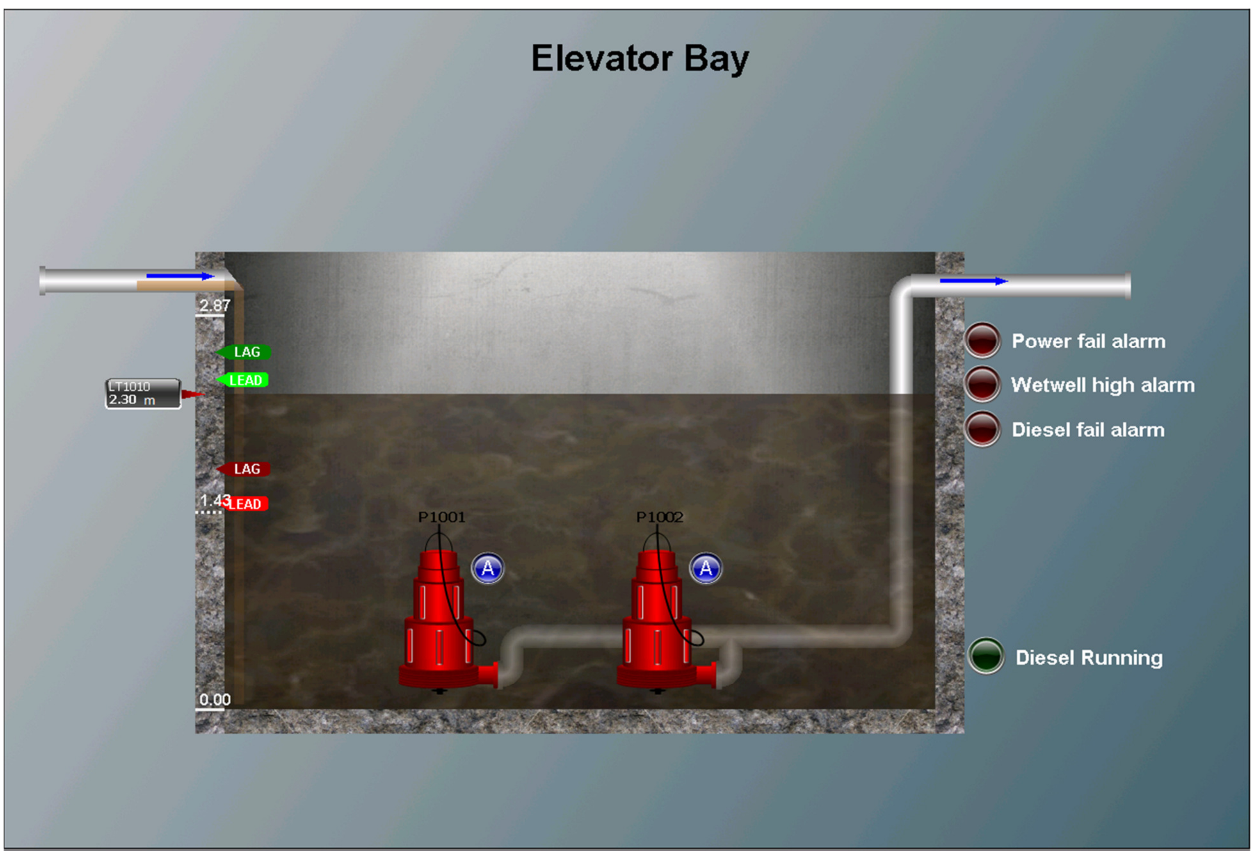
John Counter Blvd

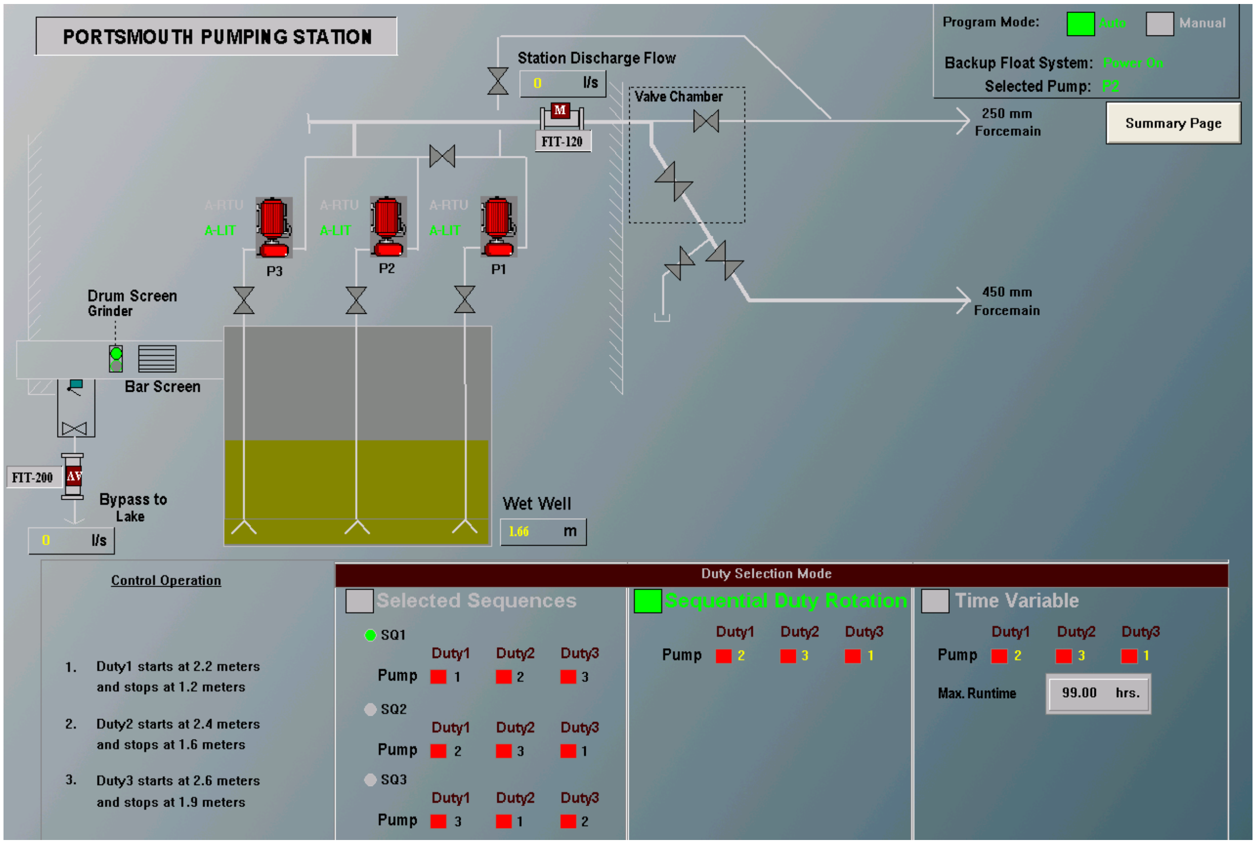


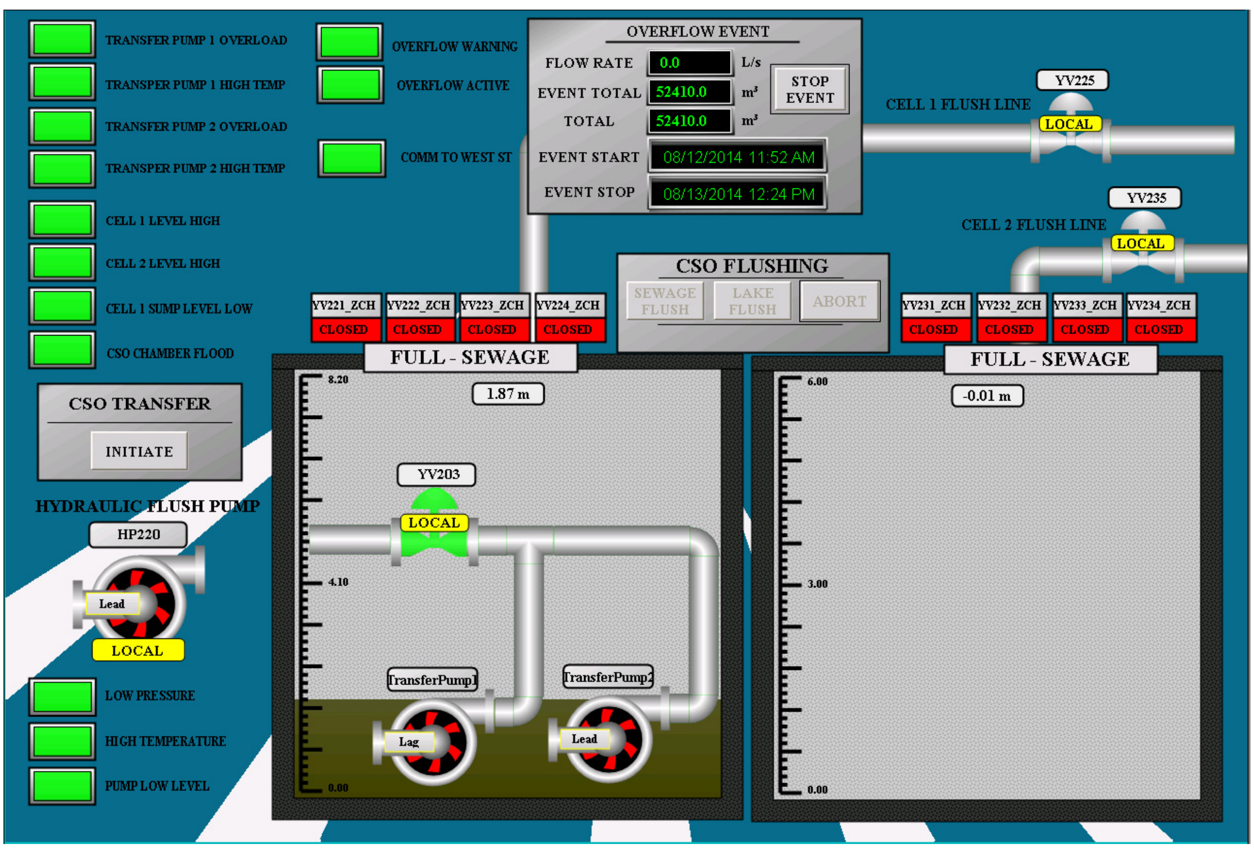
COMM TO WEST ST
SECURITY BREACH
GAS DETECTOR 1
GAS DETECTOR 2
UPS BATTERY LOW
UPS GENERAL ALARM
UPS BY-PASS
STATION TEMP LOW
DIALER COMM ALARM
UPS AC LOSS
FIT115
242.1
l/s
FIT115
STATION TOTAL
23937400.00 m³
FLOW TODAY
12868.28 m³
YV128
YV126
YV127
0 %
YV130
FAIL
YV125
FAIL
6.00
3.00
0.00
1.19 m
1.11 m
Pump1
Pump2
Pump3
Pump4
Lead
Lag
CONTROL LEVEL
CELL No. 1
ON
CELL No. 2
OFF

King St.

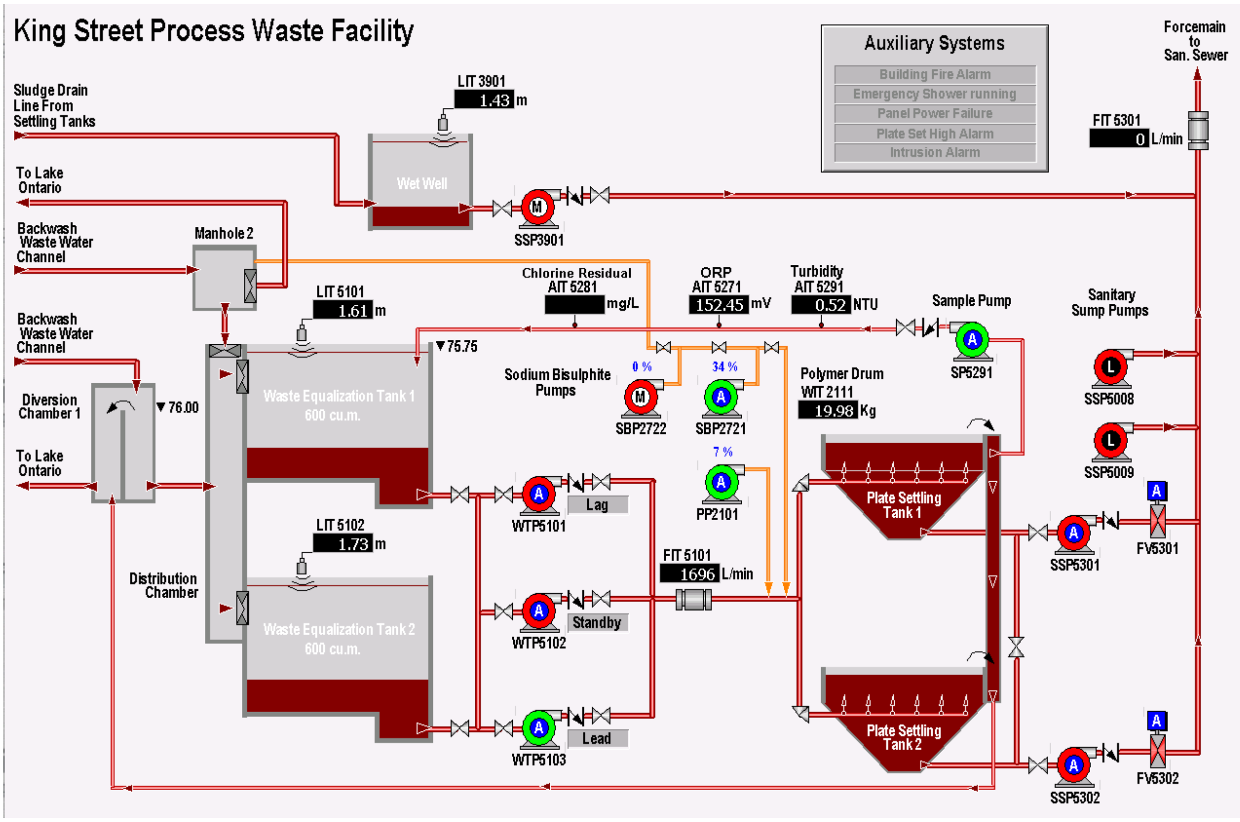

River Street Sewage Pumping Station
Inlet Chamber
Trunk Sewer
LIT 03 2.01 m
0%
SG-3
SG 1
SG 2
100%
Grit Tank
Control Level
LIT 02 2.69 m
LIT 01 2.70 m
South Wet Well
North Wet Well
Pump Room
Overflow Chamber
FIT 01 0.00 L/s
Overflow to Cataraqui River
FIT 104 294.1 L/s
FIT 103 0.0 L/s
FIT 102 209.4 L/s
FIT 101 0.0 L/s
80 %
0 %
75 %
0 %
SP-4 Lag1
SP-3 Standby
SP-2 Lead
SP-1 Lag2
Auxiliary System Alarms
Auto Transfer Switch Normal
Control Panel Power Failed
Generator 1 Running
Generator 1 Failed to Start
Generator 1 Trouble Alarm
Generator 1 Critical Alarm
Generator 1 Low Fuel
Generator 2 Running
Generator 2 Failed to Start
Generator 2 Trouble Alarm
Generator 2 Critical Alarm
Pump Room Hi-Hi Flooded
Pump Room Flooded
Valve Chamber Flooded
Generator 1 Contact Close
Generator 2 Contact Close
Forcemain Gates are Closed
Grit System General Alarm
Screening System General Alarm
Building Instrusion Control
Security System Not Armed
Instrusion Alarm Detected
Discharge Flow 503.4 L/s
PIT 01 304.5 kPa
Powermeter 01 0.0 kW
Powermeter 02 0.0 kW
Outlet Chamber
South Forcemain
KGV06
North Forcemain
KGV07
To Ravensview Plant
Original Flowmeter
Totalizer FIT 01 Discharge Flow
Running Total 2889 m3 19415652 m3
Today 0 m3 17239 m3
Yesterday 0 m3 45085 m3
This Month 1 m3 200710 m3
Previous Month 0 m3 2086855 m3
Flow Totals

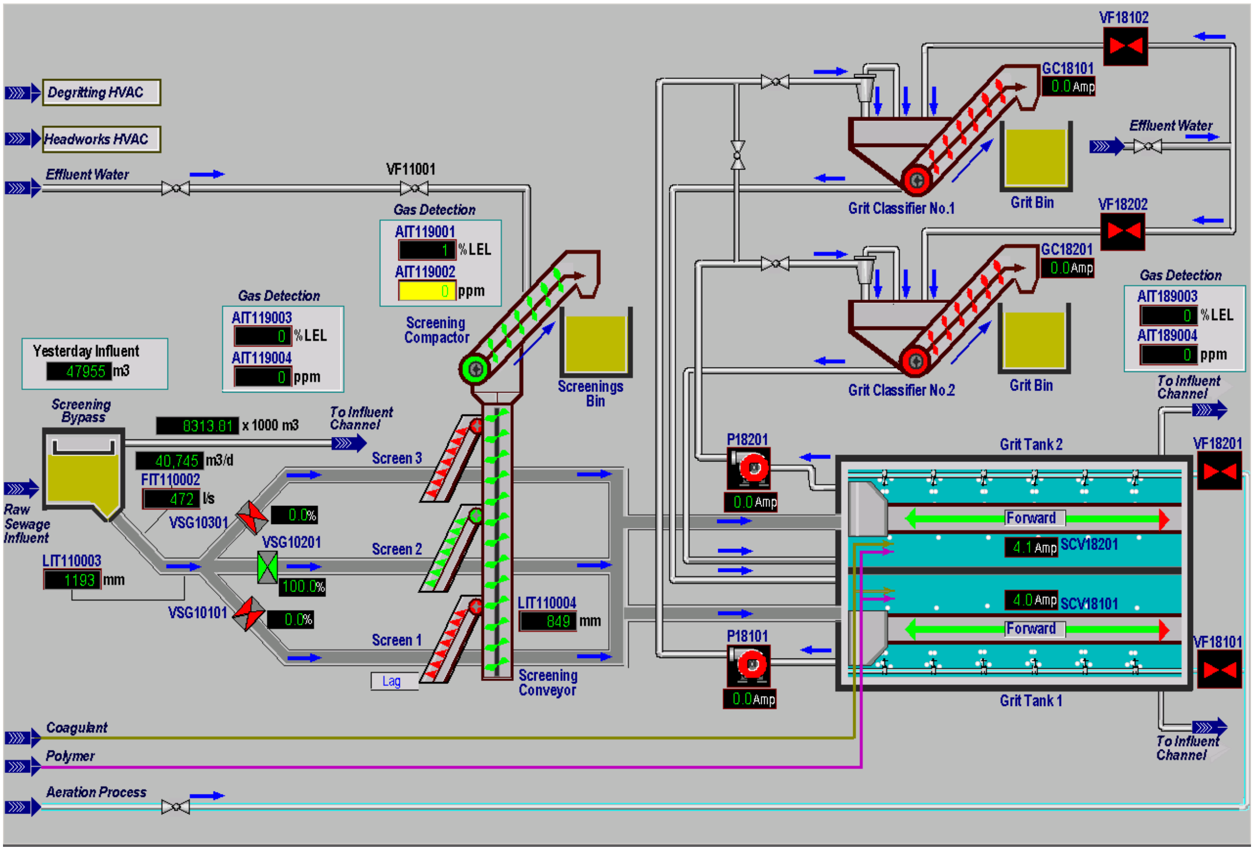

Elevator Bay
2.87
LAG
LEAD
LT1010 2.30 m
LAG
1.43
LEAD
P1001
P1002
0.00
Power fail alarm
Wetwell high alarm
Diesel fail alarm
Diesel Running


PORTSMOUTH PUMPING STATION
Program Mode:
Auto
Manual
Backup Float System:
Power On
Selected Pump:
P2
Station Discharge Flow
0
l/s
Valve Chamber
FIT-120
250 mm
Forcemain
Summary Page
P3
P2
P1
A-RTU
A-LIT
450 mm
Forcemain
Drum Screen
Grinder
Bar Screen
FIT-200
Bypass to
Lake
0
l/s
Wet Well
1.66
m
Control Operation
1. Duty1 starts at 2.2 meters and stops at 1.2 meters
2. Duty2 starts at 2.4 meters and stops at 1.6 meters
3. Duty3 starts at 2.6 meters and stops at 1.9 meters
Duty Selection Mode
Selected Sequences
Sequential Duty Rotation
Time Variable
SQ1
Duty1
Duty2
Duty3
Pump
1
2
3
SQ2
Pump
2
3
1
SQ3
Pump
3
1
2
Max. Runtime
99.00
hrs.

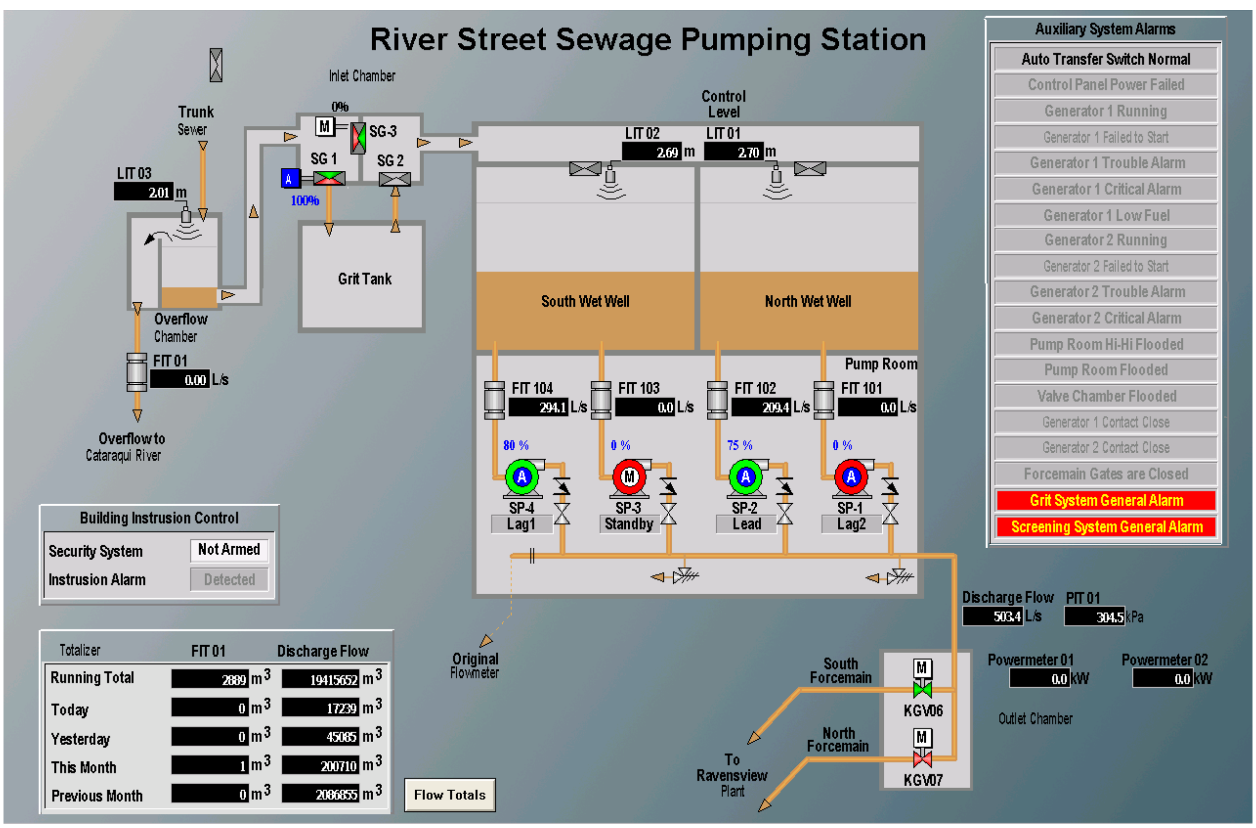

TRANSFER PUMP 1 OVERLOAD
TRANSFER PUMP 1 HIGH TEMP
TRANSFER PUMP 2 OVERLOAD
TRANSFER PUMP 2 HIGH TEMP
CELL 1 LEVEL HIGH
CELL 2 LEVEL HIGH
CELL 1 SUMP LEVEL LOW
CSO CHAMBER FLOOD
OVERFLOW WARNING
OVERFLOW ACTIVE
COMM TO WEST ST
OVERFLOW EVENT
FLOW RATE
0.0
L/s
EVENT TOTAL
52410.0
m³
TOTAL
52410.0
m³
STOP EVENT
EVENT START
08/12/2014 11:52 AM
EVENT STOP
08/13/2014 12:24 PM
CELL 1 FLUSH LINE
YV225
LOCAL
CELL 2 FLUSH LINE
YV235
LOCAL
CSO FLUSHING
SEWAGE FLUSH
LAKE FLUSH
ABORT
YV221_ZCH
YV222_ZCH
YV223_ZCH
YV224_ZCH
CLOSED
YV231_ZCH
YV232_ZCH
YV233_ZCH
YV234_ZCH
CLOSED
FULL - SEWAGE
1.87 m
-0.01 m
YV203
LOCAL
TransferPump1
TransferPump2
Lag
Lead
CSO TRANSFER
INITIATE
HYDRAULIC FLUSH PUMP
HP220
Lead
LOCAL
LOW PRESSURE
HIGH TEMPERATURE
PUMP LOW LEVEL

O'KILL PS


King Street Process Waste Facility
Auxiliary Systems
Building Fire Alarm
Emergency Shower running
Panel Power Failure
Plate Set High Alarm
Intrusion Alarm
Forcemain to San. Sewer
Sludge Drain Line From Settling Tanks
LIT 3901
1.43 m
Wet Well
SSP3901
FIT 5301
0 L/min
To Lake Ontario
Backwash Waste Water Channel
Manhole 2
Chlorine Residual AIT 5281
mg/L
ORP AIT 5271
152.45 mV
Turbidity AIT 5291
0.52 NTU
Sample Pump
SP5291
Sanitary Sump Pumps
SSP5008
SSP5009
LIT 5101
1.61 m
▼75.75
Backwash Waste Water Channel
Sodium Bisulphite Pumps
0 %
34 %
SBP2722
SBP2721
Polymer Drum WIT 2111
19.98 Kg
Diversion Chamber 1
▼76.00
Waste Equalization Tank 1 600 cu.m.
To Lake Ontario
7 %
PP2101
WTP5101
Lag
Plate Settling Tank 1
SSP5301
FV5301
LIT 5102
1.73 m
Distribution Chamber
FIT 5101
1696 L/min
Waste Equalization Tank 2 600 cu.m.
WTP5102
Standby
WTP5103
Lead
Plate Settling Tank 2
SSP5302
FV5302


Degritting HVAC
Headworks HVAC
Effluent Water
VF11001
Gas Detection
AIT119001
%LEL
AIT119002
ppm
Screening Compactor
Screenings Bin
Gas Detection
AIT119003
%LEL
AIT119004
ppm
Yesterday Influent
47955 m3
Screening Bypass
8313.81 x 1000 m3
To Influent Channel
40,745 m3/d
FIT110002
472 l/s
Raw Sewage Influent
VSG10301
VSG10201
VSG10101
LIT110003
1193 mm
Screen 3
Screen 2
Screen 1
Lag
LIT110004
849 mm
Screening Conveyor
VF18102
GC18101
0.0 Amp
Effluent Water
Grit Classifier No.1
Grit Bin
VF18202
GC18201
0.0 Amp
Grit Classifier No.2
Grit Bin
Gas Detection
AIT189003
%LEL
AIT189004
ppm
To Influent Channel
P18201
0.0 Amp
Grit Tank 2
VF18201
Forward
4.1 Amp
SCV18201
4.0 Amp
SCV18101
Forward
P18101
0.0 Amp
Grit Tank 1
VF18101
To Influent Channel
Coagulant
Polymer
Aeration Process

Ravensview


River Street Sewage Pumping Station
Inlet Chamber
Trunk Sewer
LIT 03
2.01 m
SG 1
SG 2
SG 3
100%
Grit Tank
Overflow Chamber
FIT 01
0.00 L/s
Overflow to Cataraqui River
Control Level
LIT 02
2.69 m
LIT 01
2.70 m
South Wet Well
North Wet Well
Pump Room
FIT 104
294.1 L/s
FIT 103
0.0 L/s
FIT 102
209.4 L/s
FIT 101
0.0 L/s
80 %
0 %
75 %
0 %
SP-4 Lag1
SP-3 Standby
SP-2 Lead
SP-1 Lag2
Auxiliary System Alarms
Auto Transfer Switch Normal
Control Panel Power Failed
Generator 1 Running
Generator 1 Failed to Start
Generator 1 Trouble Alarm
Generator 1 Critical Alarm
Generator 1 Low Fuel
Generator 2 Running
Generator 2 Failed to Start
Generator 2 Trouble Alarm
Generator 2 Critical Alarm
Pump Room Hi-Hi Flooded
Pump Room Flooded
Valve Chamber Flooded
Generator 1 Contact Close
Generator 2 Contact Close
Forcemain Gates are Closed
Grit System General Alarm
Screening System General Alarm
Building Instrusion Control
Security System
Not Armed
Instrusion Alarm
Detected
Totalizer
FIT 01
Discharge Flow
Running Total
2889 m3
19415652 m3
Today
0 m3
17239 m3
Yesterday
0 m3
45085 m3
This Month
1 m3
200710 m3
Previous Month
0 m3
2086855 m3
Flow Totals
Original Flowmeter
Discharge Flow
503.4 L/s
PIT 01
304.5 kPa
Powermeter 01
0.0 kW
Powermeter 02
0.0 kW
South Forcemain
North Forcemain
KGV06
KGV07
Outlet Chamber
To Ravensview Plant

Appendix F

WATER DEMAND ADJUSTMENT AND MODEL LOADING SUMMARY

Appendix F – Contents

Trunk Sewer Model Loading Procedure and Demand Adjustment Methodology

Figure F-1: InfoSWMM Loading Example

Trunk Sewer Model Loading Procedure and Demand Adjustment Methodology

The following steps and assumptions were made for the loading phase of the 2015 Master Plan Trunk Sewer Model update using the InfoSWMM dry-weather flow allocation tool suite.

Arrangement of GIS data using the provided Billed Water Consumption layers supplied by Utilities Kingston for the years of 2013 and 2014.

1. For sanitary sewer loading (SAN), remove water meter records from areas which do not contribute to a sanitary sewer. For water model loading (WTR), all meter records are loaded into the model and no distinction is made for well or surface water source(s).

2. The following table shows the description categories used for both sewer (SAN) and water (WTR) system loading of Residential water users based on the City of Kingston official land use designation layers as supplied by Utilities Kingston. When loading the water model, no "Demand Adjustment" is applied to the metered USAGE. For sanitary sewer loading (SAN), use only 60-80% of total billed water consumption/summed usage per residential property (Assumed amount entering sanitary, (Briere F. G., 2014)). This is to include residential, multi-unit residences located in 'Mixed Use Commercial' land types from identified properties.

Table F-1: Residential Demand Adjustment for Trunk Sewer Model

<table>
<tr><th>Zone Type</th><th>Description</th><th>By-Law Reference</th><th>Demand Adjustment</th><th>Demand Adjustment for Model</th></tr>
<tr><td>ZONE</td><td>ZONETYDESC</td><td>- 8499: City of Kingston restricted area
- 96-259: Downtown and Harbour restricted area
- 76-26: Kingston Township restricted area
- 97-102: Cataraqui North
- 32-74: Pittsburgh Township restricted area</td><td>USAGE x Adjustment = USAGE_SAN</td><td>USAGE x Adjustment = USAGE_SAN</td></tr>
<tr><td>A</td><td>Residential</td><td>- One-Family Dwelling and Two-Family Dwelling (8499)</td><td>80%</td><td rowspan="6">80%</td></tr>
<tr><td>A1</td><td>Residential</td><td>- One-Family Dwelling (8499)
- Restricted Agricultural Zone (76-26)
- Restricted Rural Zone (32-74)</td><td>75%</td></tr>
<tr><td>A2</td><td>Residential</td><td>- One-Family Dwelling (8499)
- General Agricultural Zone (76-26)
- General Rural Zone (32-74)</td><td>70%</td></tr>
<tr><td>A3</td><td>Residential</td><td>- One-Family and Two-Family Dwelling (8499)
- Proposed Airport Restricted Zone (76-26)</td><td>70%</td></tr>
<tr><td>A4</td><td>Residential</td><td>- One-Family and Two-Family Dwelling (8499)</td><td>80%</td></tr>
<tr><td>A5</td><td>Residential</td><td>- One-Family and Two-Family</td><td>80%</td></tr>
</table>

		Dwelling (8499)		
A6	Residential	- Mobile Home Residential (8499)	60%	
A7	Residential	- One-Family, Semi-Detached & Row Dwelling (8499)	80%	
A8	Residential	- Single Detached, Semi-Detached & Row Dwelling (8499)	80%	
B	Residential	- Three-Family Dwelling (8499)	80%	
B1	Residential	- Multiple Family Dwelling (8499)	80%	
B2	Residential	- Multiple Family Dwelling (Unified Ownership) (8499)	80%	
B3	Residential	- Multiple Family Dwelling (8499)	80%	
E	Residential	- Special Educational and Medical Uses (8499)	80%	
ER	Residential	- Estate Residential Zone (32-74)	80%	
LDR	Residential	- Low Density Residential (76-26)	75%	
LSR	Residential	- Limited Service Residential (32-74)	70%	
MDR	Residential	- Medium Density Residential (97-102)	75%	
R1	Residential	- Residential Type 1 Zone (32-74 & 76-26)	80%	
R2	Residential	- Residential Type 2 Zone (32-74 & 76-26)	80%	
R3	Residential	- Residential Type 3 Zone (32-74 & 76-26)	80%	
R4	Residential	- Residential Type 4 Zone (32-74 & 76-26)	80%	
R5	Residential	- Residential Type 5 Zone (32-74 & 76-26)	80%	
R6	Residential	- Residential Type 6 Zone (32-74)	80%	
R7	Residential	- Residential Type 7 Zone (32-74)	80%	
R8	Residential	- Residential Type 8 Zone (32-74)	80%	
RR	Residential	- Rural Residential	60%	
A1	Rural	- One-Family Dwelling (8499) - Restricted Agricultural Zone (76-26) - Restricted Rural Zone (32-74)	60%	
A2	Rural	- One-Family Dwelling (8499) - General Agricultural Zone (76-26) - General Rural Zone (32-74)	60%	

Based on review of residential land use types, 80% demand adjustment to residential water meters is to be applied to the dry-weather loading shapefile using InfoSWMM's Dry-Weather Allocator Tool.

3. The following tables shows the description categories used for both sewer (SAN) and water (WTR) system loading of Industrial, Commercial and Institutional (ICI) water users; plus Open Space water usage for parks, etc... When loading the water model, no "Demand Adjustment" is applied to the metered USAGE. For ICI properties: Downtown, Regional Centre (Commercial) properties use 50-80% of billed water consumption. Heavy Industrial, General Industrial and Institutional use 50-80% of billed water consumption. Parks & Open Space Area's with billed water consumption is assumed at 10-50% based on site usage description. The following tables show the description categories summaries and assumptions.

Table F-2: Commercial Demand Adjustment for Trunk Sewer Model

<table>
<tr><th>Zone Type</th><th>Description</th><th>By-Law Reference</th><th>Demand Adjustment</th><th>Demand Adjustment for Model</th></tr>
<tr><td>ZONE</td><td>ZONETYDESC</td><td>- 8499: City of Kingston restricted area
- 96-259: Downtown and Harbour restricted area
- 76-26: Kingston Township restricted area
- 97-102: Cataraqui North
- 32-74: Pittsburgh Township restricted area</td><td>USAGE x Adjustment = USAGE_SAN</td><td>USAGE x Adjustment = USAGE_SAN</td></tr>
<tr><td>C</td><td>Commercial</td><td>- Commercial Uses - Central Business District and Upper Princess Street (8499)</td><td>80%</td><td rowspan="15">80%</td></tr>
<tr><td>C1</td><td>Commercial</td><td>- Neighbourhood Commercial (8499)
- Local Commercial Zone (76-26)
- Central Business System Zone (96-259)</td><td>70%</td></tr>
<tr><td>C2</td><td>Commercial</td><td>- Arterial Commercial (8499)
- General Commercial (76-26)</td><td>75%</td></tr>
<tr><td>C3</td><td>Commercial</td><td>- Shopping Centre Commercial (8499)
- Highway Commercial Zone (76-26)</td><td>80%</td></tr>
<tr><td>C4</td><td>Commercial</td><td>- Williams Street Commercial Zone (8499)
- Marine commercial Zone (76-26)</td><td>75%</td></tr>
<tr><td>C5</td><td>Commercial</td><td>- General Shopping Centre Commercial Zone (76-26)</td><td>80%</td></tr>
<tr><td>C6</td><td>Commercial</td><td>- Regional Shopping Centre Commercial Zone (76-26)</td><td>70%</td></tr>
<tr><td>C7</td><td>Commercial</td><td>- Industrial Commercial Zone (76-26)</td><td>80%</td></tr>
<tr><td>CH</td><td>Commercial</td><td>- Highway Commercial Zone (32-74)</td><td>80%</td></tr>
<tr><td>CL</td><td>Commercial</td><td>- Local Commercial Zone (32-74)</td><td>75%</td></tr>
<tr><td>CMS</td><td>Commercial</td><td>- Market Square Commercial Zone (96-259)</td><td>70%</td></tr>
<tr><td>CT</td><td>Commercial</td><td>- Tourist Commercial Zone (32-74)</td><td>70%</td></tr>
<tr><td>MU</td><td>Commercial</td><td>- Mixed Use (97-102)</td><td>75%</td></tr>
<tr><td>MVC</td><td>Commercial</td><td>- Mixed Village Centre (32-74)</td><td>70%</td></tr>
<tr><td>NC</td><td>Commercial</td><td>- Neighbourhood Commercial Zone (97-102)</td><td>75%</td></tr>
</table>

Based on the review of commercial land use types an 80% demand adjustment to water meters is to be applied.

Table F-3: Industrial Demand Adjustment for Trunk Sewer Model

Zone Type	Description	By-Law Reference	Demand Adjustment	Demand Adjustment for Model
ZONE	ZONETYDESC	- 8499: City of Kingston restricted area - 96-259: Downtown and Harbour restricted area - 76-26: Kingston Township restricted area - 97-102: Cataraqui North - 32-74: Pittsburgh Township restricted area	USAGE x Adjustment = USAGE_SAN	USAGE x Adjustment = USAGE_SAN
AP	Industrial	- Airport Zone (76-26)	70%	75%
M	Industrial	- Industrial Zone (8499)	60%	
M1	Industrial	- Industrial (8499) - Restricted Industrial Zone (32-74) - General Industrial Zone (76-26)	70%	
M2	Industrial	- Industrial (8499) - General Industrial Zone (32-74) - Light Industrial Zone (76-26)	75%	
M3	Industrial	- Industrial (8499) - Service Industrial Zone (76-26)	75%	
M4	Industrial	- Industrial (8499) - Disposal Industrial Zone (76-26)	60%	
M5	Industrial	- Waterfront Industrial (8499) - Extractive Industrial Zone (76-26)	60%	
M6	Industrial	- Industrial (8499) - Restricted General Industrial Zone (76-26)	70%	
M7	Industrial	- Industrial (8499)	70%	
M9	Industrial	- Business Park Zone (8499)	80%	
MD	Industrial	- Disposal Zone (32-74)	60%	
MX	Industrial	- Extractive Zone (32-74)	60%	
BP-1	Business Park	- Business Park Zone	80%	
BP-2	Business Park	- Business Park Zone	80%	
BP-3	Business Park	- Business Park Zone	75%	
BP4	Business Park	- Business Park Zone	75%	
HR	Harbour Area	- Harbour Zone	60%	

Based on the review of industrial land use types a 75% demand adjustment to water meters is to be applied.

Table F-4: Institutional and Development Area Demand Adjustment for Trunk Sewer Model

Zone Type	Description	By-Law Reference	Demand Adjustment	Demand Adjustment for Model
ZONE	ZONETYDESC	- 8499: City of Kingston restricted area - 96-259: Downtown and Harbour restricted area - 76-26: Kingston Township restricted area - 97-102: Cataraqui North - 32-74: Pittsburgh Township restricted area	USAGE x Adjustment = USAGE_SAN	USAGE x Adjustment = USAGE_SAN
E	Institutional	- Special education and Medical Uses (8499)	80%	80%
E1	Institutional	- Special education and Medical Uses (8499)	80%	
E2	Institutional	- Special education and Medical Uses (8499)	80%	
I	Institutional	- Institutional Zone (76-26 & 32-74)	80%	
ZONE	ZONETYDESC	- 76-26: Kingston Township restricted area	USAGE x Adjustment = USAGE_SAN	USAGE x Adjustment = USAGE_SAN
D	Development Area	- Development Zone (76-26)	80%	80%
D4	Development Area	- Development Zone (76-26)	80%	

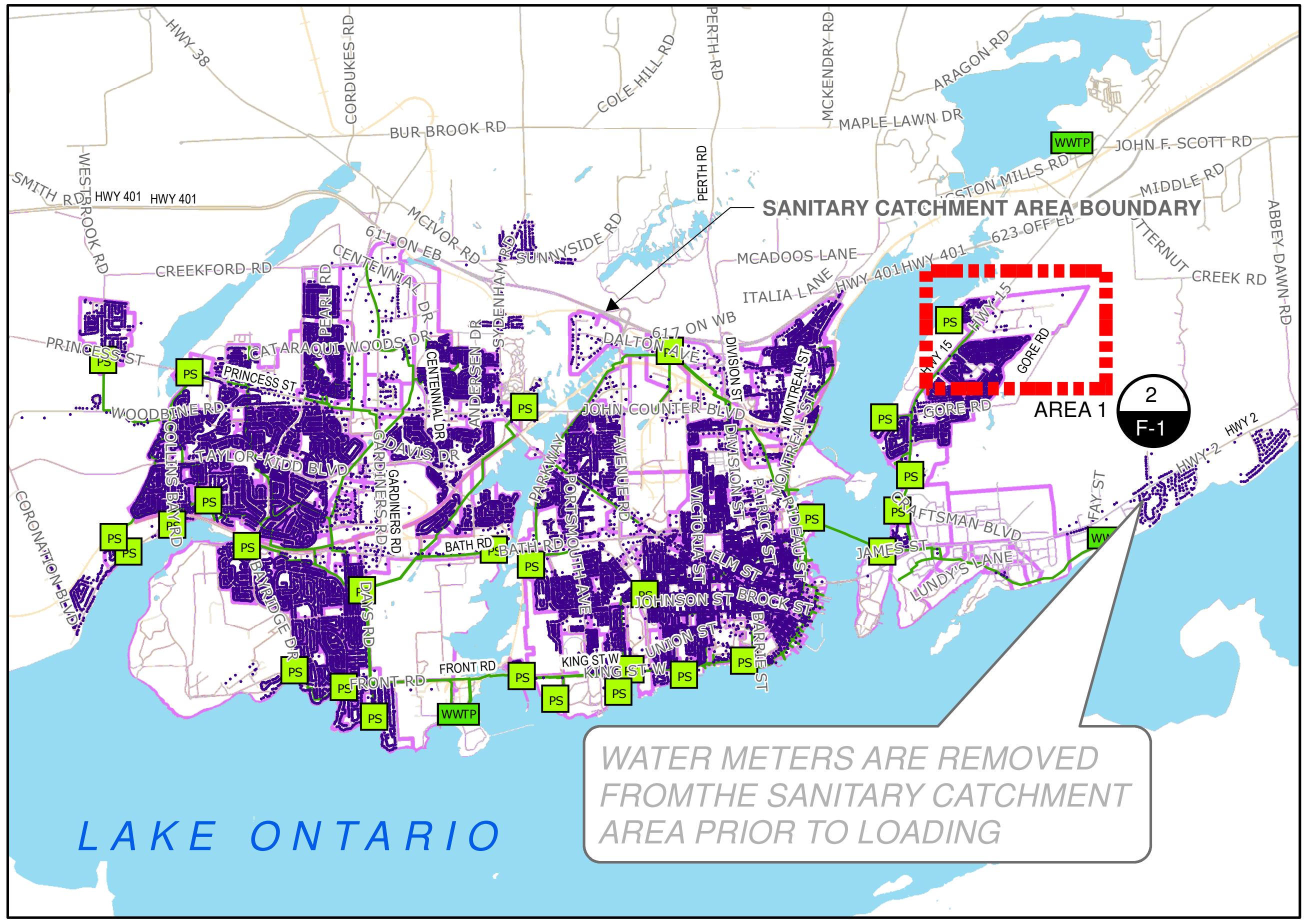
Based on the review of institutional and development area land use types an 80% demand adjustment to water meters is to be applied.

Table F-5: Open Space Property Demand Adjustment for Trunk Sewer Model

<table>
<tr><th>Zone Type</th><th>Description</th><th>By-Law Reference</th><th>Demand Adjustment</th><th>Demand Adjustment for Model</th></tr>
<tr><td>ZONE</td><td>ZONETYDESC</td><td>- 8499: City of Kingston restricted area
- 76-26: Kingston Township restricted area
- 97-102: Cataraqui North
- 32-74: Pittsburgh Township restricted area</td><td>USAGE x Adjustment = USAGE_SAN</td><td>USAGE x Adjustment = USAGE_SAN</td></tr>
<tr><td>OS</td><td>Open Space/ Park</td><td>- General Open Space Zone (76-26)
- Open Space Zone (32-74)</td><td>30%</td><td rowspan="9">25%</td></tr>
<tr><td>OS1</td><td>Open Space/ Park</td><td>- Public Open Space (8499)
- Open Space One Zone (97-102)</td><td>25%</td></tr>
<tr><td>OS2</td><td>Open Space/ Park</td><td>- Private Open Space (8499)</td><td>25%</td></tr>
<tr><td>OS3</td><td>Open Space/ Park</td><td>- Harbour Open Space (8499)</td><td>25%</td></tr>
<tr><td>P</td><td>Open Space/ Park</td><td>- General Recreation Park (8499)</td><td>30%</td></tr>
<tr><td>P1</td><td>Open Space/ Park</td><td>- Recreational Building (8499)</td><td>60%</td></tr>
<tr><td>P2</td><td>Open Space/ Park</td><td>- Water-Area (8499)</td><td>10%</td></tr>
<tr><td>EPA</td><td>Environmental Protection Area</td><td>- Environmental Protection Area (8499)</td><td>5%</td></tr>
<tr><td>FP</td><td>Environmental Protection Area</td><td>- Flood Plain Zone (32-74)</td><td>5%</td></tr>
</table>

Based on the review of open space land use types a 25% demand adjustment to water meters is to be applied.

4. Load each land use type separately using the InfoSWMM DWF Allocator Tool by the ‘meter summation’ method. Meters are to be distributed to nodes by catchment area shapefile for model junctions associated. Each junction meter allocation is designated its Land Type. (e.g. Residential, 2021_Residentail, Industrial, etc…)



1 F-1 OVERVIEW
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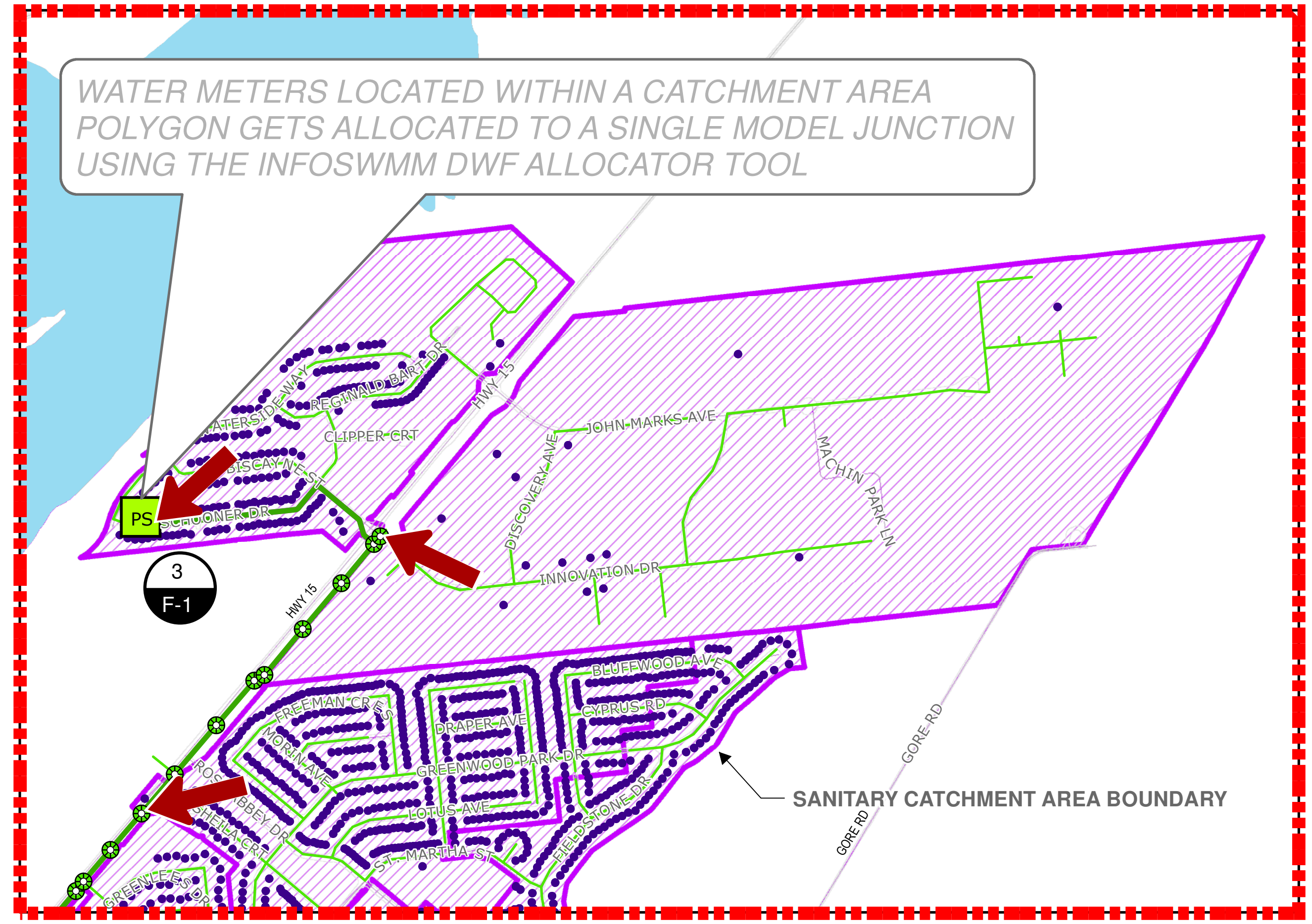

2 F-1 AREA 1
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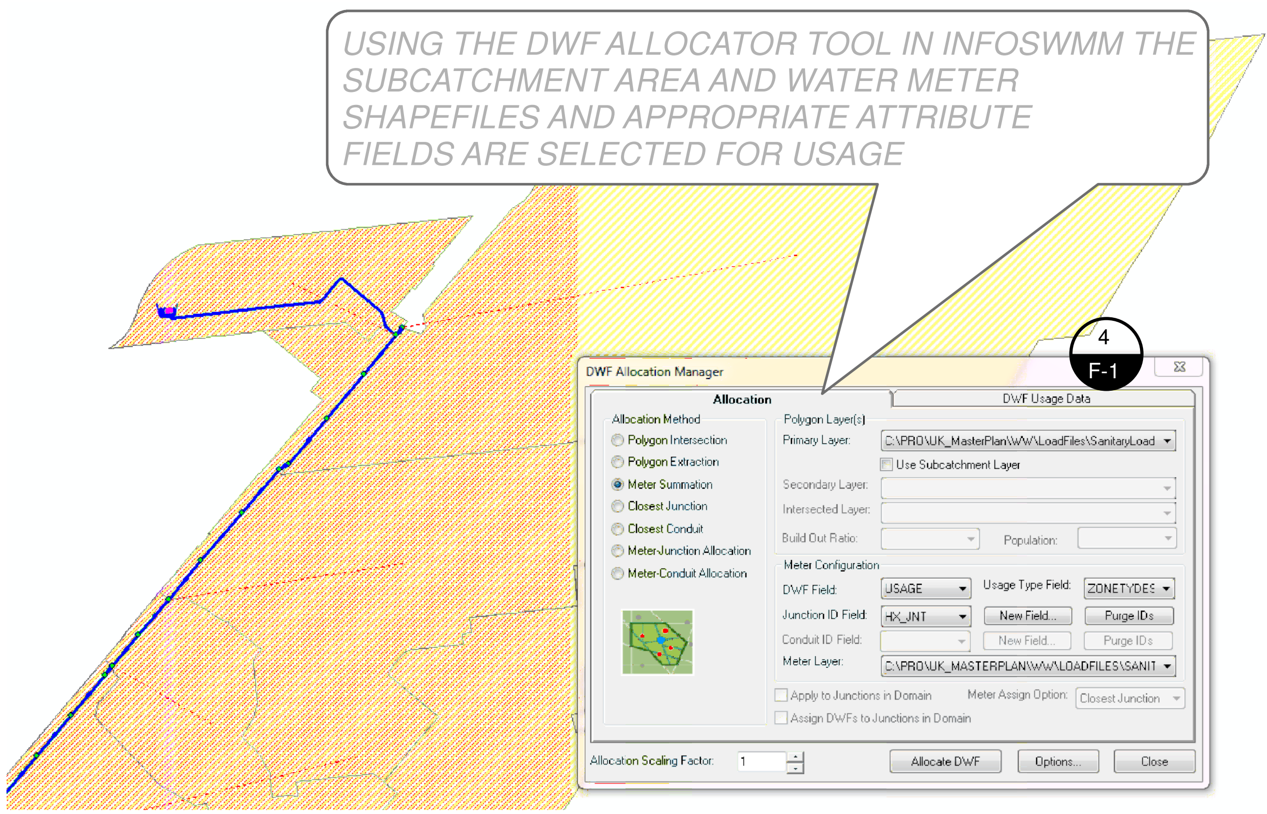
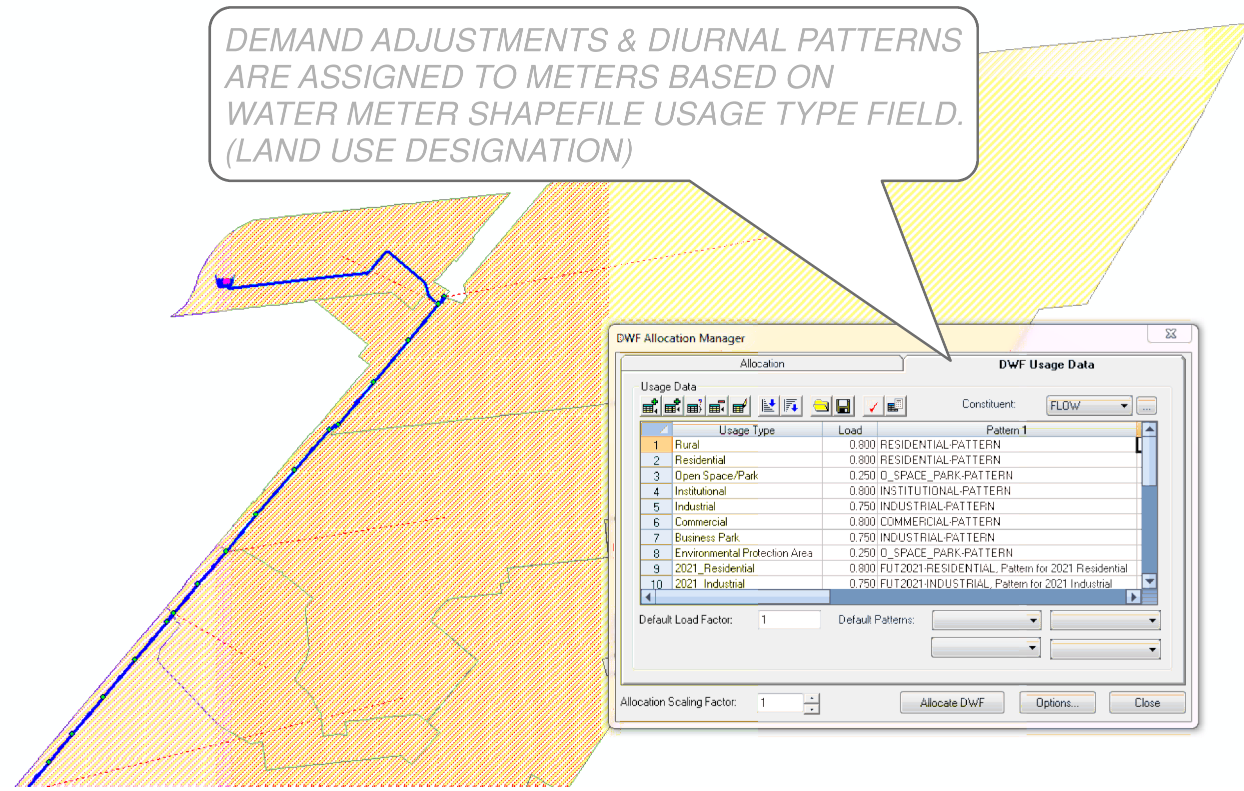


3 F-1 DWF ALLOCATOR AND METER SUMMATION



4 F-1 DEMAND ADJUSTMENT AND DIURNAL PATTERN ALLOCATION

WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

PS SANITARY PUMPING STATION

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

Scale:
0 850 1,700 3,400 Meters
1:122,500

Project:
Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title:
LOADING EXAMPLE OVERVIEW

Project No.:	Date:		
151-02944-00	MARCH, 2016		
Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	WWM	F-1

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.6_Wastewater Model\Maps\Calibration Report Maps\F_DemandAdjustment\V10_3_151-02944-00_Loading_Example_Map_4_Quads.mxd

Appendix G

DIURNAL PATTERN DEVELOPMENT SUMMARY

Diurnal Pattern Development for Water and Wastewater Model

The following data review represents the analysis of water and wastewater flow data and provides a summary of Diurnal Pattern development for use in the 2015 Master Plan.

KINGSTON HISTORICAL MONTHLY WATER USAGE

The historic daily flow record in the three water distribution zones in Kingston is analyzed. Figure G- 1 shows the 5-year historic and year 2014 daily average flow trends from Point Pleasant WTP (West Zone). Table G- 1 is the summary of the historical daily flow to UK's three water distribution zones. It is noticed that 2013 data is close to the 5 year's average trend for West and Central zones. Due to East Zone has small water demand, the fluctuation of the demand trend is not surprise. It is suggested that 2013 data to be used for water usage patterns creation.

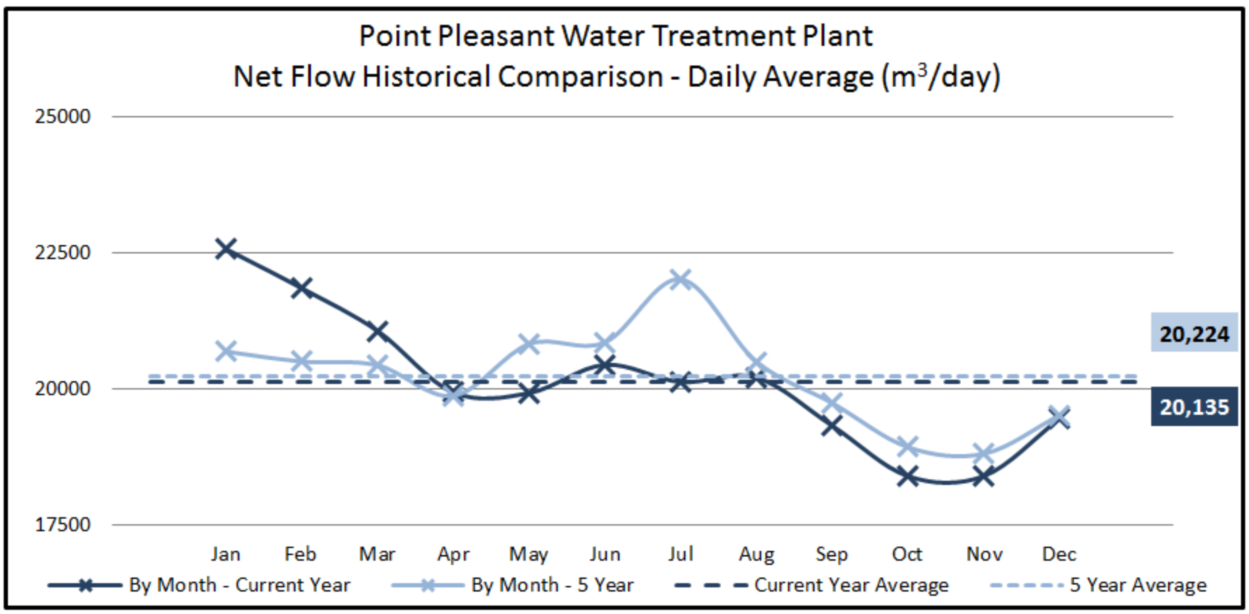


Figure G- 1 Point Pleasant Water Treatment Plant historic

Table G- 1 Summary of historical daily flow to UK’s three water distribution zones

	King St. Water Treatment Plant - **Net to Central Distribution System** (Monthly total)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	1,552,586	1,447,609	1,569,390	1,402,721	1,394,225	1,280,839	1,336,613	1,302,149	1,272,852	1,262,316	1,231,909	1,293,245
2011	1,437,020	1,341,122	1,503,635	1,423,423	1,380,548	1,346,025	1,424,409	1,338,465	1,313,944	1,325,410	1,301,617	1,268,295
2012	1,414,293	1,398,765	1,430,981	1,315,448	1,289,904	1,265,657	1,402,138	1,326,464	1,293,582	1,259,802	1,225,870	1,318,971
2013	1,518,903	1,442,011	1,555,195	1,453,273	1,371,263	1,263,092	1,352,530	1,290,199	1,289,898	1,294,992	1,214,837	1,354,056
2014	1,644,084	1,448,306	1,571,373	1,328,117	1,222,040	1,190,309	1,213,599	1,191,847	1,205,509	1,215,704	1,165,921	1,175,035

	Kingston St. Water Treatment Plant - to **East Distribution System** Flows (Monthly total)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	172,912	167,004	182,457	168,973	157,712	126,654	130,795	114,635	100,344	104,535	108,272	123,018
2011	135,492	110,292	117,413	111,454	116,453	123,776	150,894	124,533	120,493	116,150	114,282	109,181
2012	119,130	122,564	132,967	127,967	145,693	142,309	181,447	155,641	140,037	134,734	135,946	140,946
2013	161,095	158,974	171,448	165,640	173,165	152,712	165,590	164,378	140,340	136,552	197,233	208,171
2014	157,560	143,976	185,941	190,032	166,701	154,783	164,832	161,045	157,964	158,722	164,529	177,154

	Point Pleasant Water Treatment Plant - Net to **West Distribution System** (Monthly total)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	630,258	570,871	615,739	590,564	670,914	596,760	644,033	620,571	576,528	563,492	539,421	574,140
2011	590,388	555,989	599,599	581,823	608,383	631,949	697,443	627,244	581,212	593,545	565,548	622,821
2012	644,274	586,294	650,994	612,789	639,277	624,237	754,004	658,305	585,195	581,148	574,893	635,229
2013	716,967	654,763	660,370	641,869	692,403	684,514	754,263	730,601	681,393	661,268	686,520	655,783
2014	699,797	611,854	653,099	598,043	617,629	613,280	623,951	626,437	579,674	570,259	551,984	603,119

1.1.1 AVERAGE WEEK AND MAXIMUM WEEK DETERMINATION

Daily flow data during year 2010 to 2014 from King Street WTP that supplies water to Central Zone and East Zone, and Point Pleasant WTP that supplies water to West Zone is provided by UK. Based on the historical water demand data, 2013 and 2014 data is analyzed for average and maximum week calculation for demand pattern creation.

The steps to determine weekly average daily and weekly maximum flows are:

1. Determine the annual daily average flow, see Table G- 1.
2. Determine the average weekly daily flow in the whole year 2013.
3. Determine the average week daily flow for demand pattern by removing the month(s) with extreme high flows that could be caused by pipe brakes due to land movement during spring draw duration, mostly in March, and comparing the average week daily flow and the annual average daily flow, and
4. Determine the maximum week daily flow by only considering the months between May and November to avoid spring thaw and early frost pipe break impact.
5. Uniform the calculated average week and maximum week in three zones to one representative week by comparing the weekly water flows.

After the flow data analysis Table G- 2 shows that the average week and maximum week water demand periods.

Table G- 2 Average week and maximum week water demand

System	All Zone except Third Ave. Res.	Third Ave. Res.
Average Week	September 9 – 15, 2013	December 9 - 15, 2013
Maximum Week	July 15 – 21, 2013	

However, it is found that there is no data in September 2013 for Third Ave Reservoir. Dec 9 - 15, 2013 SCADA data (real average week before the unification) for Third Ave Reservoir water level is used for the curve plotting.

AVERAGE WEEK AND MAXIMUM WEEK SCADA DATA

The SCADA data of these weeks for all Kingston water facility has been plotted and analysed. The water flow and storage tank water level curves and the curve tag descriptions can be found in figures below.

WEST ZONE

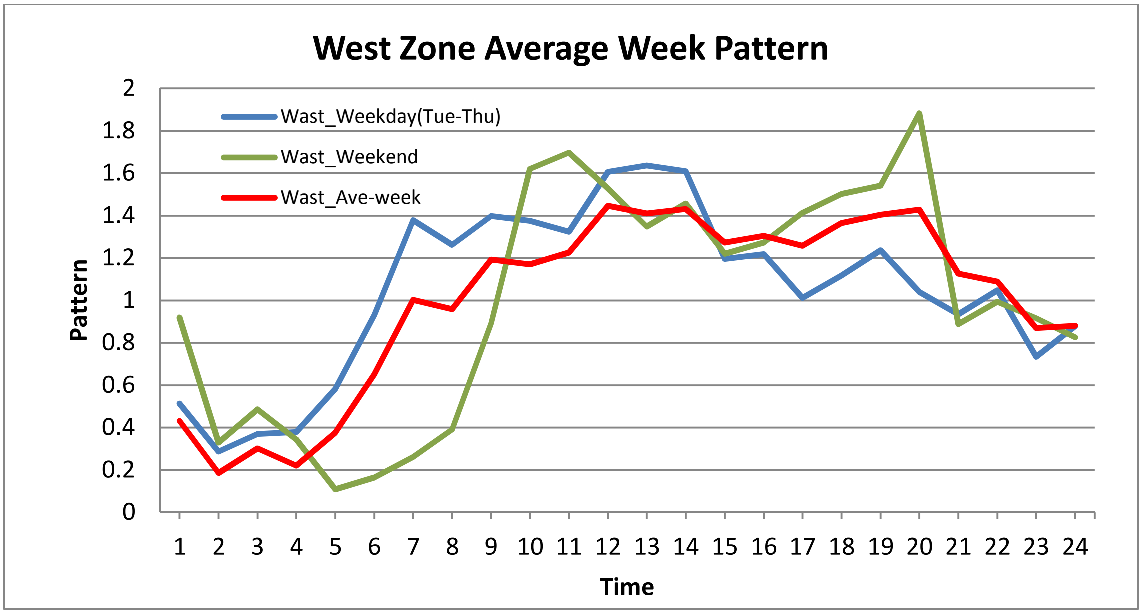


Figure G- 2 West Zone average week pattern

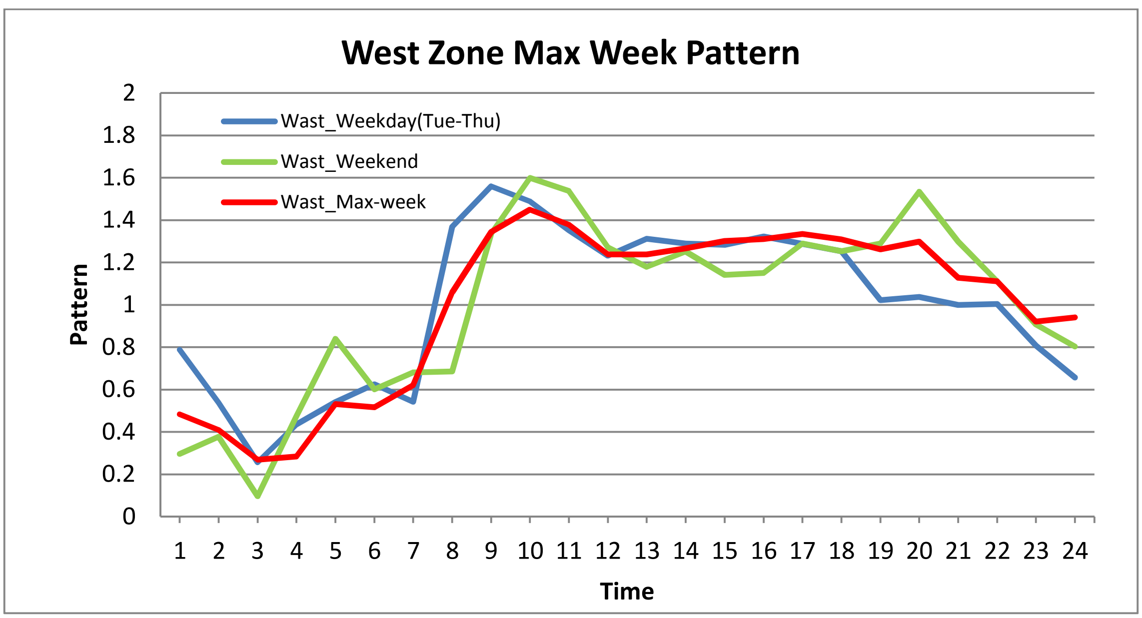


Figure G- 3 West Zone maximum week pattern

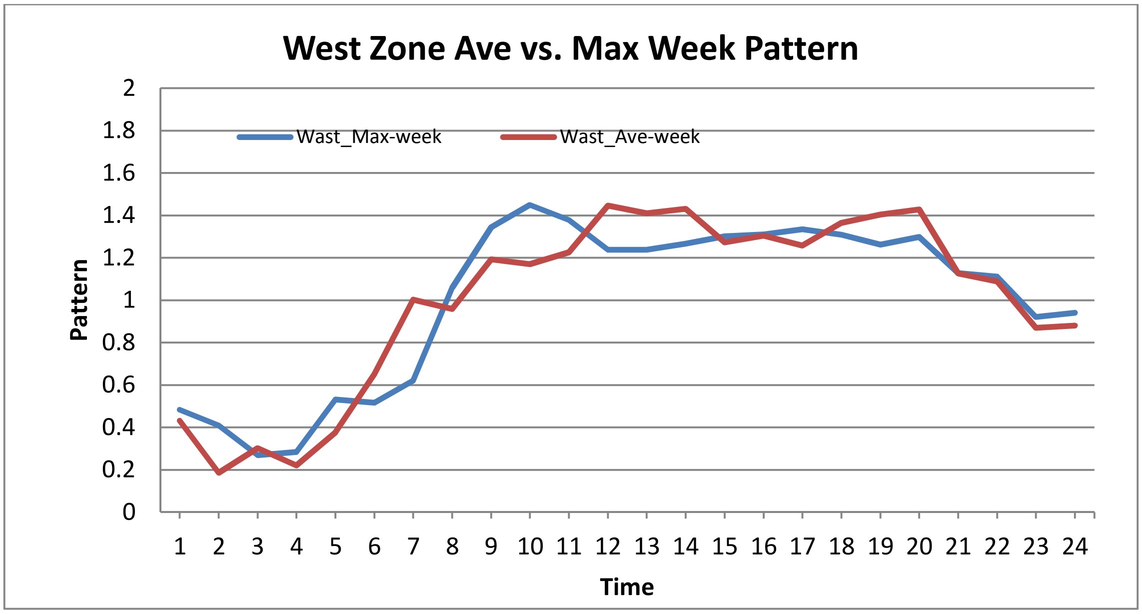


Figure G- 4 Comparison of West Zone average and maximum week patterns

CENTRAL ZONE

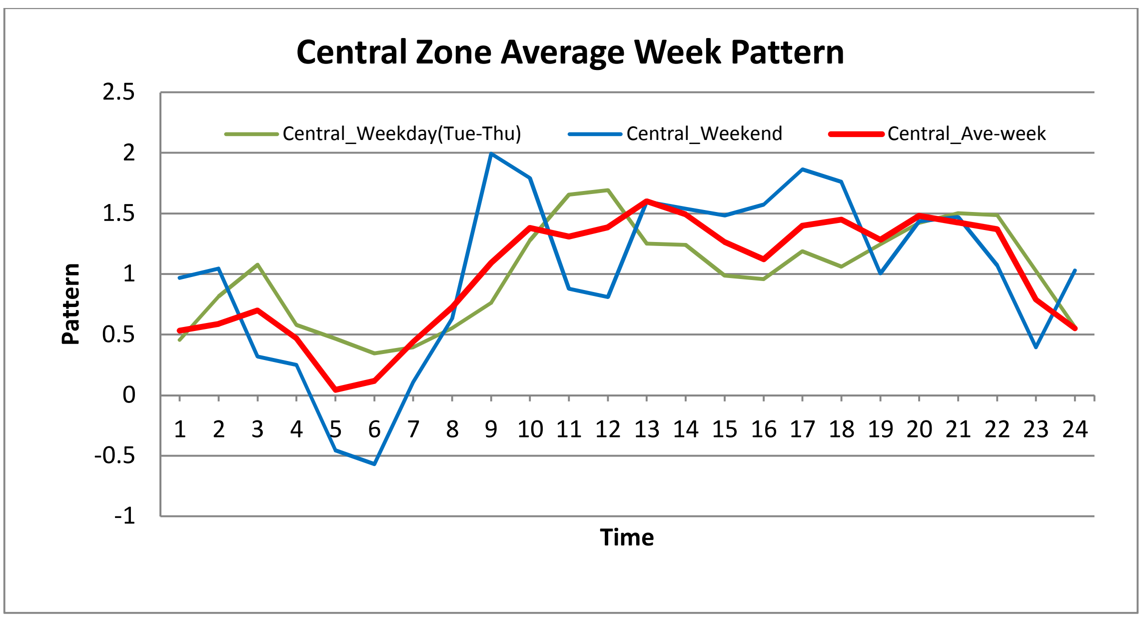


Figure G- 5 Central Zone average week pattern

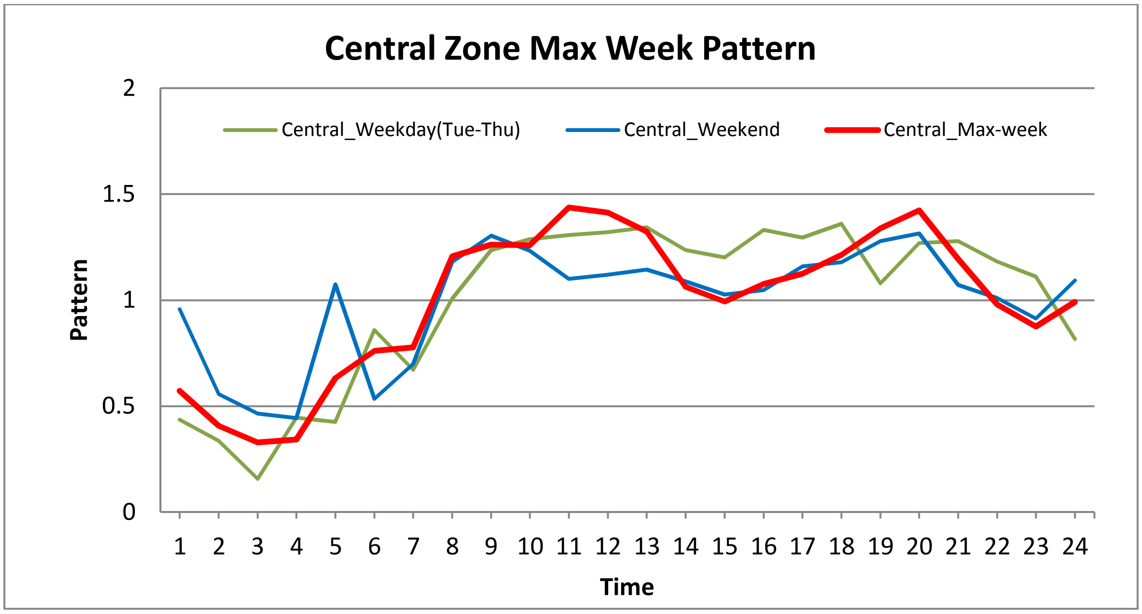


Figure G- 6 Central Zone maximum week pattern

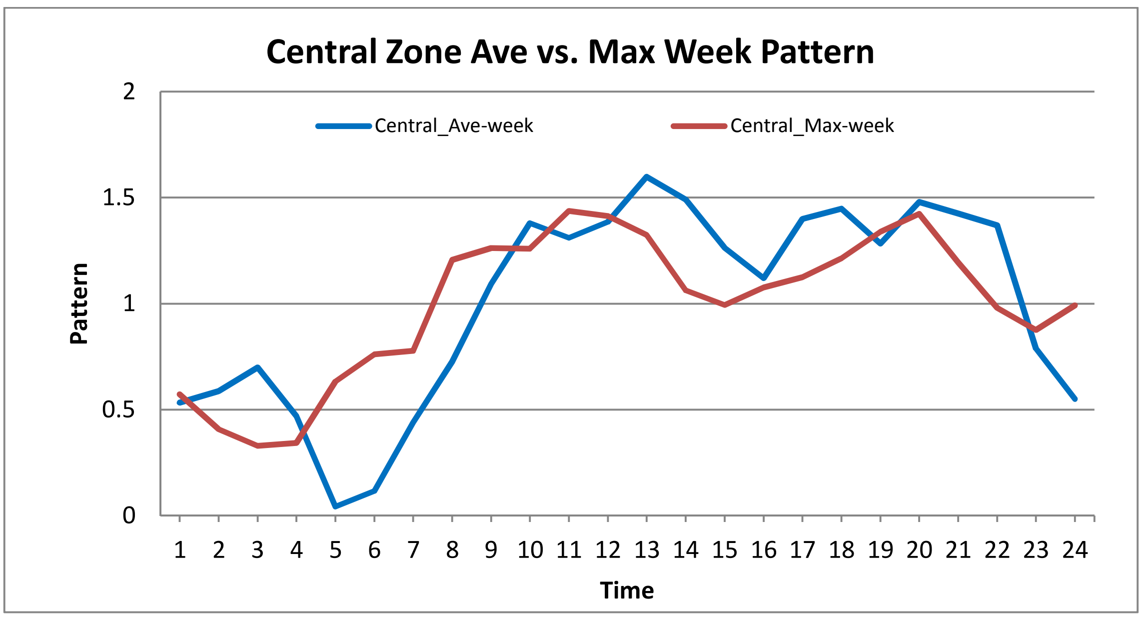


Figure G- 7 Comparison of Central Zone average and maximum week patterns

EAST ZONE

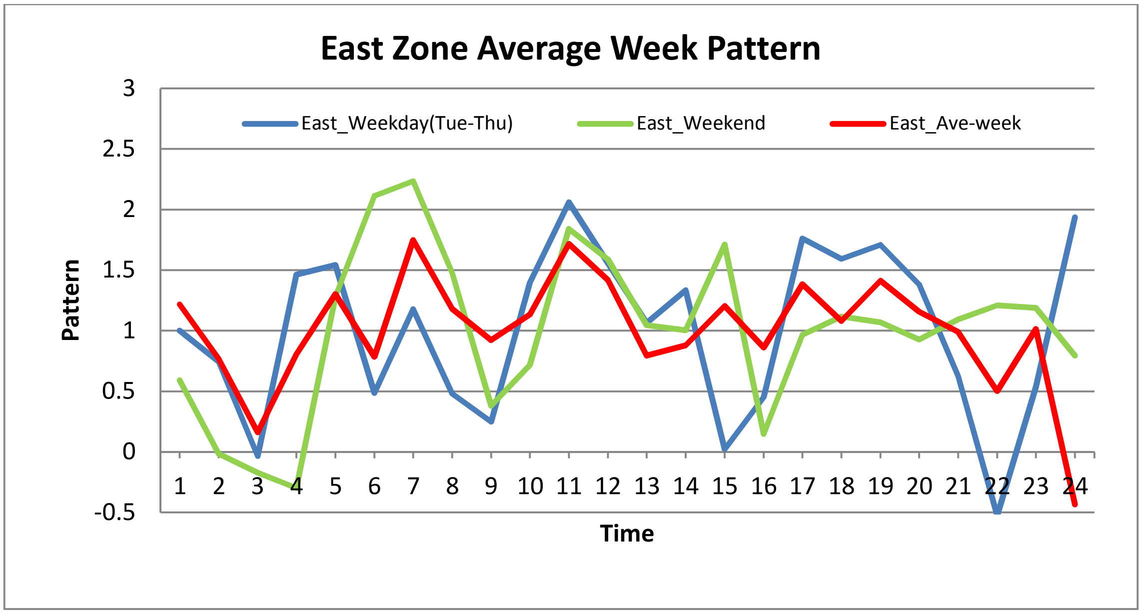


Figure G- 8 East Zone average week pattern

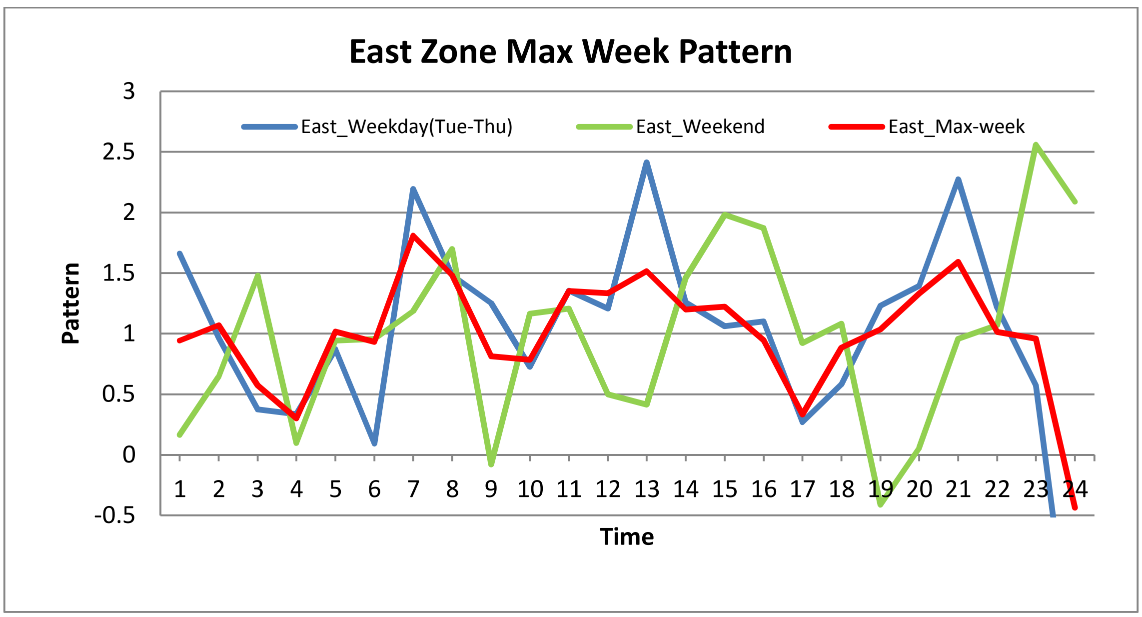


Figure G- 9 East Zone maximum week pattern

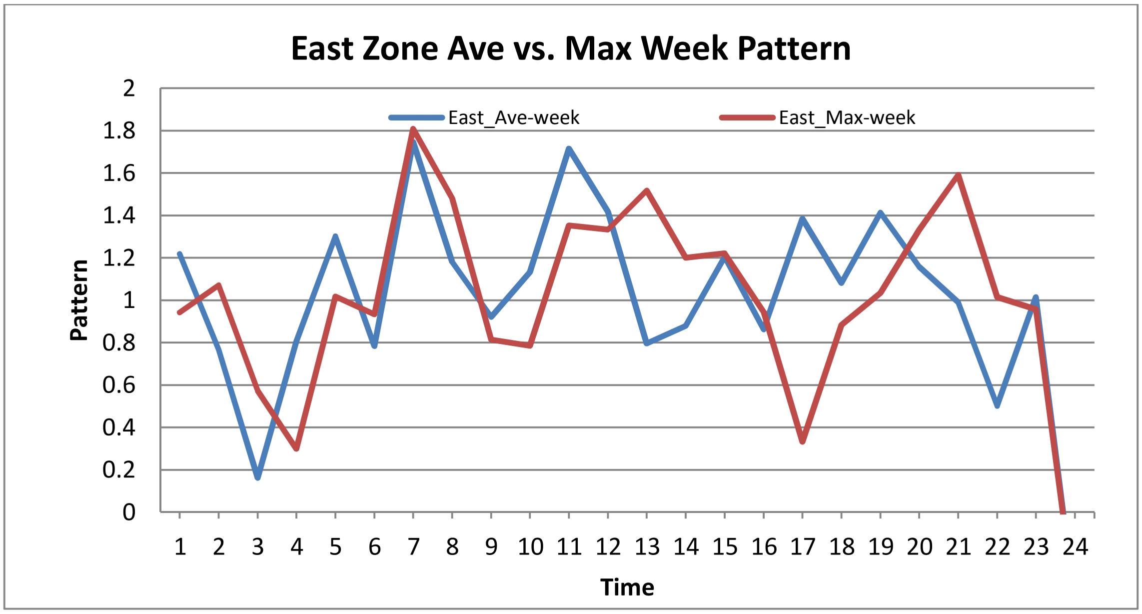


Figure G- 10 Comparison of East Zone average and maximum week patterns

Water Demand Diurnal Pattern for Distribution Zones in Kingston

The daily water demand patterns were created based on the 2013 average and maximum week SCADA data. The explanation of the date used can be found in the previous section. The preliminary diurnal patterns and a note are shown in the previous section. However, the East Zone SCADA data was not able to provide a consistent pattern. It is worth noting that these curves are the combination of residential and other variations land use water demands.

WESTBROOK FOUR WEEK HYDROGRAPH

This hydrograph displays flow monitor data from Westbrook, a residential area recorded over a four week period during June 14 to July 11, 2015. Note that a repeatable daily or *diurnal* pattern is observed.

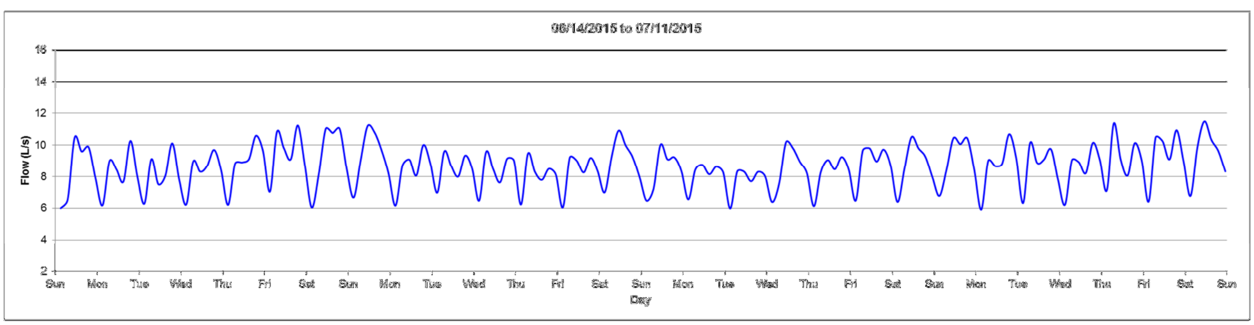


Figure G- 11 Westbrook Four Week Water Demand Pattern

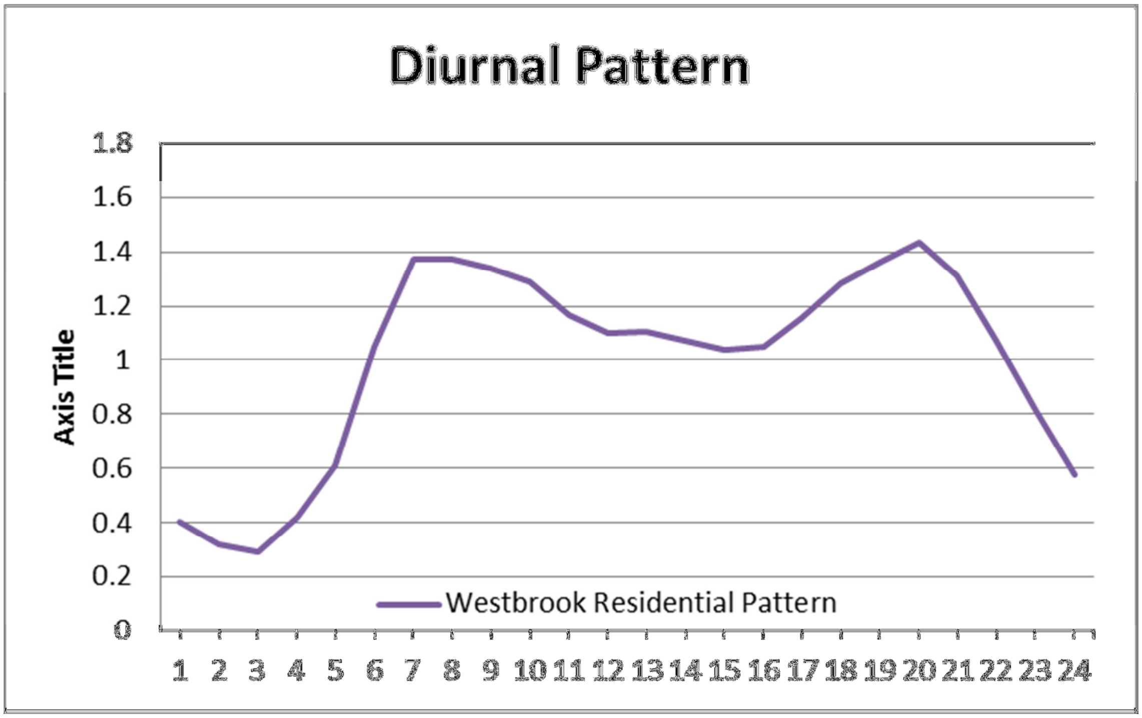


Figure G- 12 Westbrook 2015 residential pattern

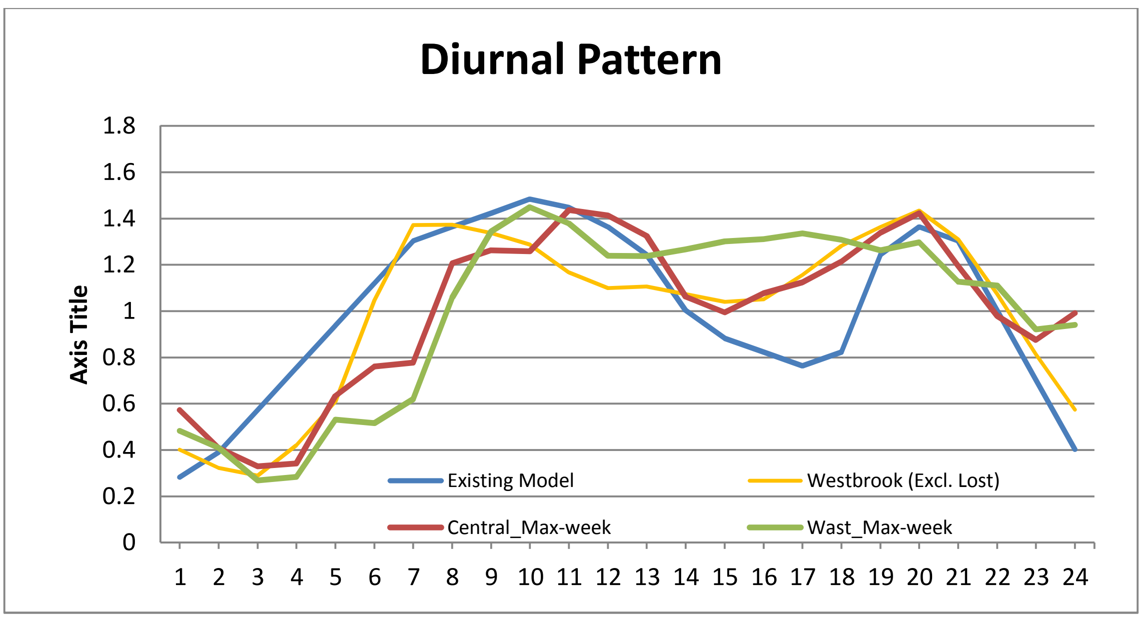


Figure G- 13 Comparison of existing patterns in UK existing model, Westbrook area and maximum week patterns

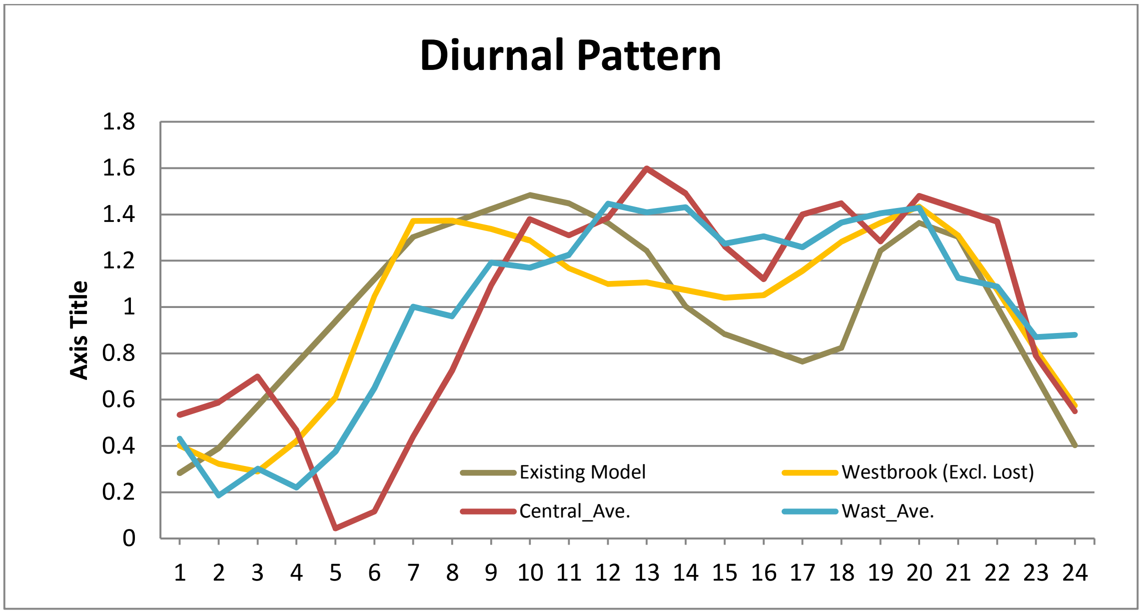


Figure G- 14 Comparison of existing patterns in UK existing model, Westbrook area and average week patterns

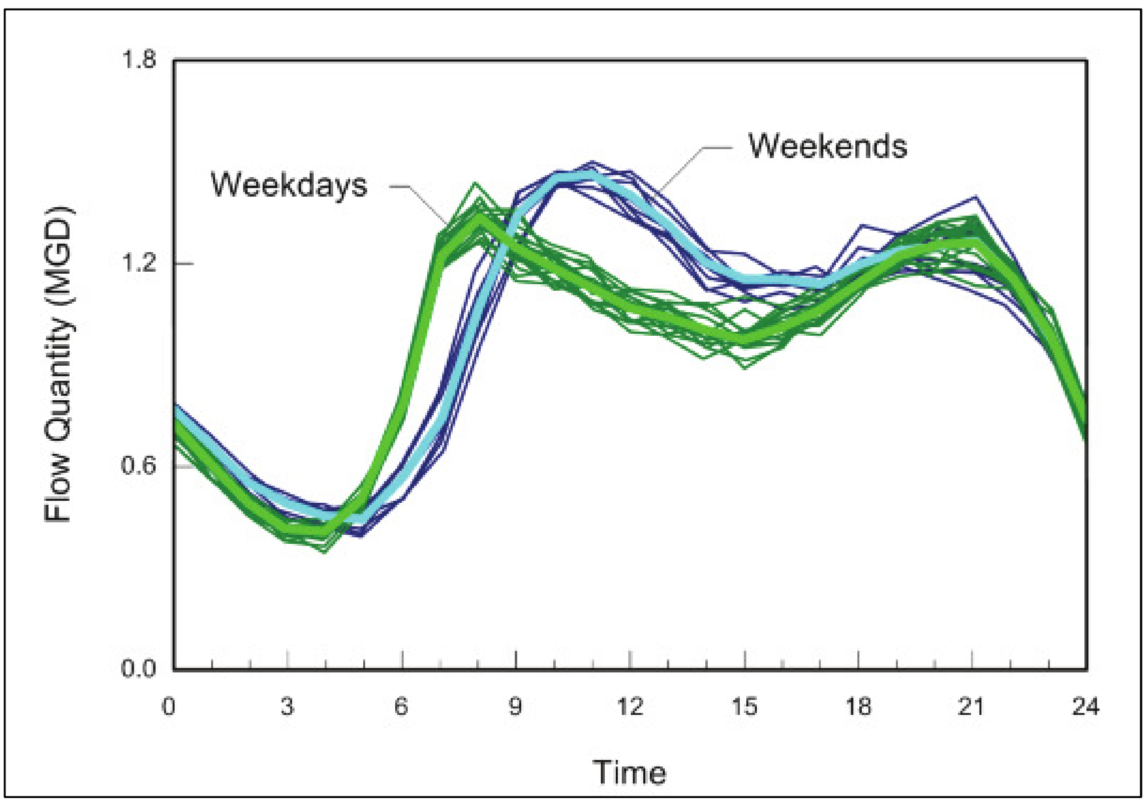


Figure G- 15 Published typical residential diurnal pattern

Land Use Diurnal Pattern Example

Land use within a particular area can impact the shape of the diurnal pattern. Since there is no operational SCADA data for various land use in Kingston area, the examples below represent typical dry weather sewer diurnal patterns from six different land use areas. The residential pattern is the most common. Combinations and variations of these patterns are often observed in mixed land use areas. Industrial patterns are industry specific and come in many varieties.

TYPICAL INDUSTRICAL WATER DEMAND PATTERNS

The industrial example provided here is from an automobile assembly plant that runs production during the first shift (7AM - 3PM).

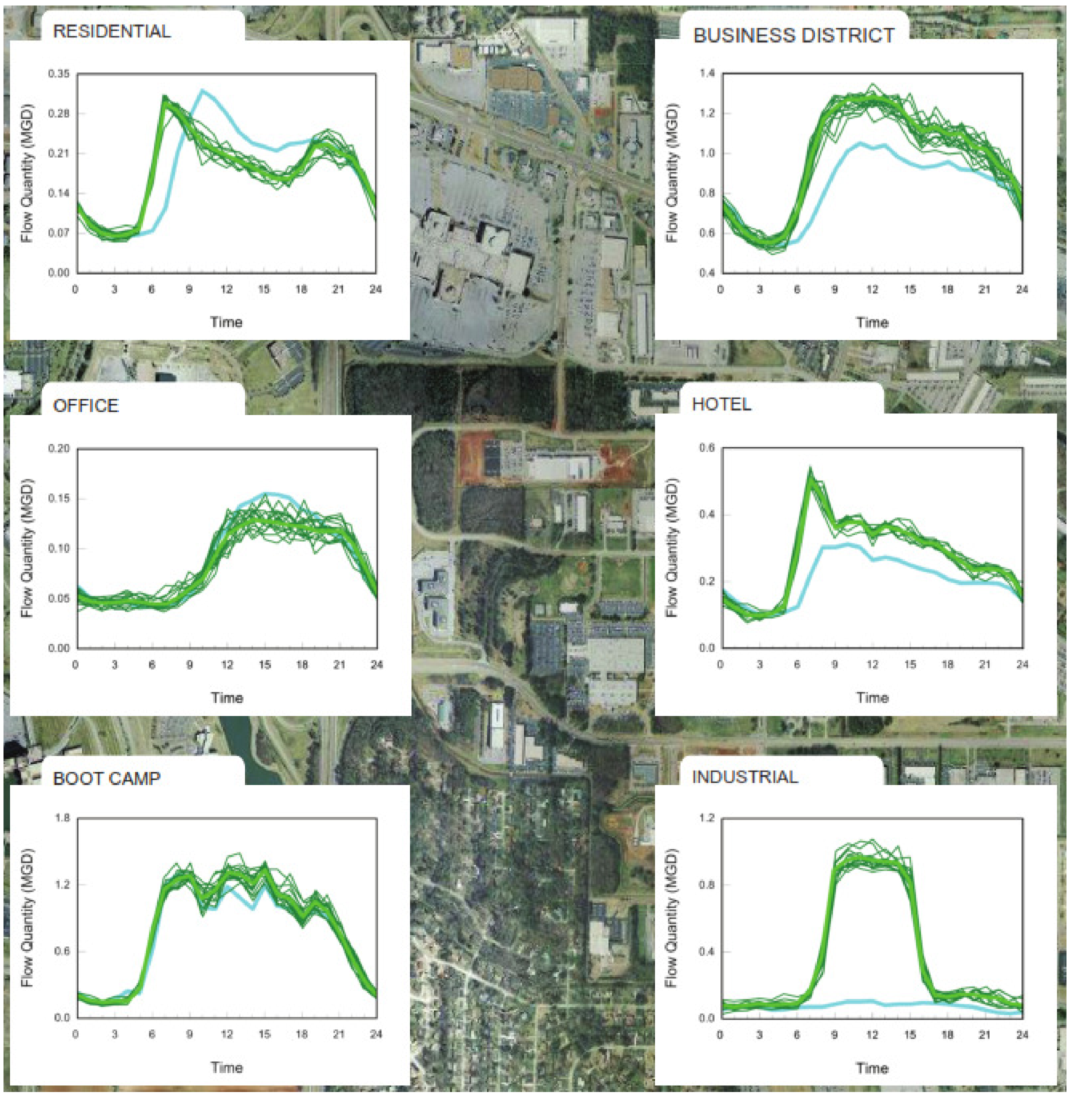


Figure G- 16 Typical water Demand Patterns for Residential and ICI

ICI WATER DEMAND PATTERN FOR KINGSTON

The ICI pattern creation was based on the combination of the typical business district, office, boot camp and industrial patterns shown in Figure G- 16 above. Figure G- 17 shows the ICI pattern to be used in the WSP model.

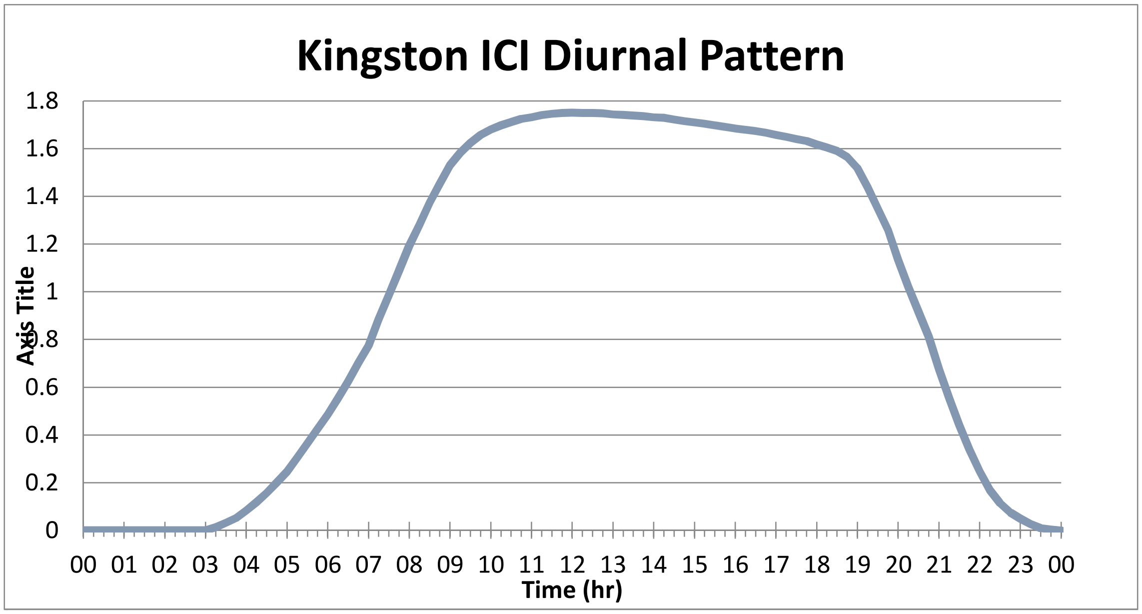


Figure G- 17 Kingston ICI Diurnal Pattern

DIURNAL PATTERNS COMBINATION

Residential and ICI combined patterns for each water supply zone are used for all future scenarios when the land use is not specified. The patterns were developed based on the land-use percentage for each zone. The water demand based on ultimate land-use information provided by UK is applied to determine the residential and ICI water use weight. Table G - 3 and Figure G- 18 show the water use percentage between residential and ICI and the combined diurnal patterns developed based on the Land-use feature for each zone.

Table G - 3 Land-use Percentage for each Water Supply Zone

		West Zone	Central Zone	East Zone
Water Demand	Res (L/s)	102.9	134.4	26.4
	ICI (L/s)	31.4	97.3	10.4
Ratio	Res	77%	58%	72%
	ICI	23%	42%	28%

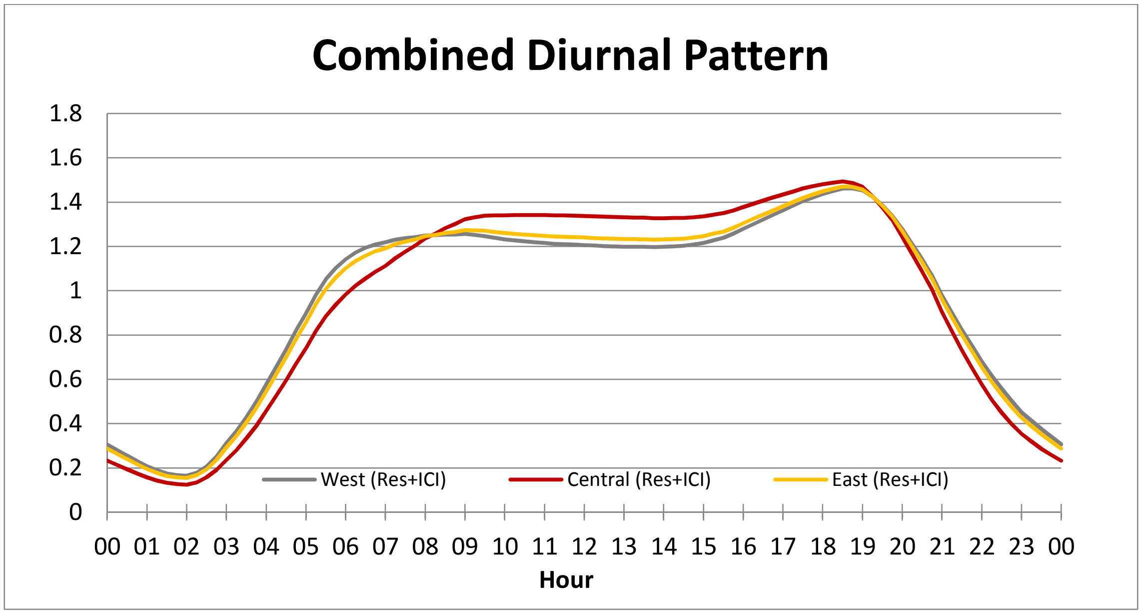


Figure G- 18 Residential and ICI Combined Water Demand Diurnal Pattern Development in this Study

DIURNAL CURVES FROM FLOW DATA PATTERNS - WASTEWATER

The patterns developed for individual meters presented the closet calibration fit for dry-weather representation of the Kingston sanitary sewer system. Prior to this determination WSP conducted a review of Diurnal Curve Data for 2013 and 2014 flow data to determine the representative area curves by pump station catchment areas. The following summary and figures show the representative area curves and their 2013 and 2014 comparison.

Table G - 4 Pumping Station Nominal Diurnal Patterns Derived from Wastewater SCADA Flow Data (1 of 2)

Time	Bath Rd.	Coverdale	Crerar	Dalton	Days Rd	Front Rd	Greenview	Hillview
12:00 AM	0.883	0.780	0.896	0.956	0.883	0.761	0.906	0.924
1:00 AM	0.796	0.776	0.884	0.903	0.796	0.683	0.848	0.728
2:00 AM	0.735	0.870	0.944	0.861	0.735	0.547	0.789	0.677
3:00 AM	0.710	0.819	0.928	0.841	0.710	0.730	0.803	0.585
4:00 AM	0.699	0.899	0.916	0.839	0.699	0.776	0.782	0.618
5:00 AM	0.698	0.909	0.900	0.834	0.698	0.784	0.891	0.685
6:00 AM	0.744	1.053	0.886	0.850	0.744	0.857	0.980	0.796
7:00 AM	0.923	1.101	0.916	0.897	0.923	0.906	1.035	1.135
8:00 AM	1.132	1.120	0.972	1.006	1.132	1.193	1.037	1.331
9:00 AM	1.153	1.144	1.022	1.093	1.153	1.228	1.078	1.163
10:00 AM	1.143	1.187	1.065	1.125	1.143	1.273	1.047	1.295
11:00 AM	1.152	1.179	1.077	1.129	1.152	1.293	1.076	1.217
12:00 PM	1.140	1.068	1.113	1.124	1.140	1.183	1.062	1.073
1:00 PM	1.116	1.056	1.113	1.092	1.116	1.182	1.039	1.107
2:00 PM	1.091	0.987	1.138	1.079	1.091	1.025	1.013	1.040
3:00 PM	1.063	1.021	1.089	1.049	1.063	1.084	1.087	0.996
4:00 PM	1.065	1.008	1.071	1.053	1.065	0.993	1.076	1.034
5:00 PM	1.081	1.008	1.010	1.042	1.081	1.026	1.122	1.023
6:00 PM	1.106	1.029	1.007	1.042	1.106	1.092	1.137	1.091
7:00 PM	1.137	1.083	1.028	1.054	1.137	1.198	1.100	1.187
8:00 PM	1.169	1.051	1.059	1.069	1.169	1.215	1.043	1.161
9:00 PM	1.155	1.015	1.047	1.068	1.155	1.075	1.038	1.128
10:00 PM	1.089	0.946	0.995	1.022	1.089	1.038	1.039	1.052
11:00 PM	1.020	0.889	0.923	0.972	1.020	0.856	0.973	0.955

Table G - 5 Pumping Station Nominal Diurnal Patterns Derived from Wastewater SCADA Flow Data (2 of 2)

Time	Hwy 15	James	King-Portsmouth	King St.	River	Average	Absolute max
12:00 AM	0.887	0.862	0.937	0.968	0.974	0.894	0.761
1:00 AM	0.990	0.753	0.885	0.977	0.955	0.844	0.683
2:00 AM	0.863	0.708	0.869	0.871	0.896	0.797	0.547
3:00 AM	0.883	0.692	0.840	0.835	0.839	0.786	0.585
4:00 AM	0.853	0.714	0.819	0.861	0.820	0.792	0.618
5:00 AM	0.886	0.700	0.824	0.903	0.828	0.811	0.685
6:00 AM	0.931	0.964	0.881	0.856	0.847	0.876	0.744
7:00 AM	1.066	1.243	0.972	0.922	0.869	0.993	1.243
8:00 AM	1.044	1.293	1.081	1.074	0.965	1.106	1.331
9:00 AM	1.079	1.236	1.092	1.143	1.078	1.128	1.236
10:00 AM	1.069	1.146	1.090	1.094	1.077	1.135	1.295
11:00 AM	1.048	1.126	1.094	1.082	1.101	1.133	1.293
12:00 PM	1.010	1.113	1.076	1.099	1.099	1.100	1.183
1:00 PM	1.049	1.108	1.075	1.116	1.111	1.099	1.039
2:00 PM	0.979	1.056	1.066	1.050	1.136	1.058	0.979
3:00 PM	1.081	0.987	1.053	0.999	1.072	1.049	0.987
4:00 PM	1.055	0.995	1.039	1.038	1.033	1.040	0.993
5:00 PM	1.044	1.040	1.059	1.063	1.046	1.050	1.122
6:00 PM	1.032	1.118	1.063	1.009	1.058	1.068	1.137
7:00 PM	1.037	1.094	1.059	0.995	1.039	1.088	1.198
8:00 PM	1.059	1.100	1.061	1.040	1.037	1.095	1.215
9:00 PM	1.004	1.052	1.063	1.054	1.056	1.070	1.155
10:00 PM	1.009	0.984	1.024	0.986	1.046	1.025	0.946
11:00 PM	1.043	0.915	0.977	0.967	1.017	0.964	0.856

Figures G-19 to G- 33 Wastewater Nominal Diurnal Patterns by Area

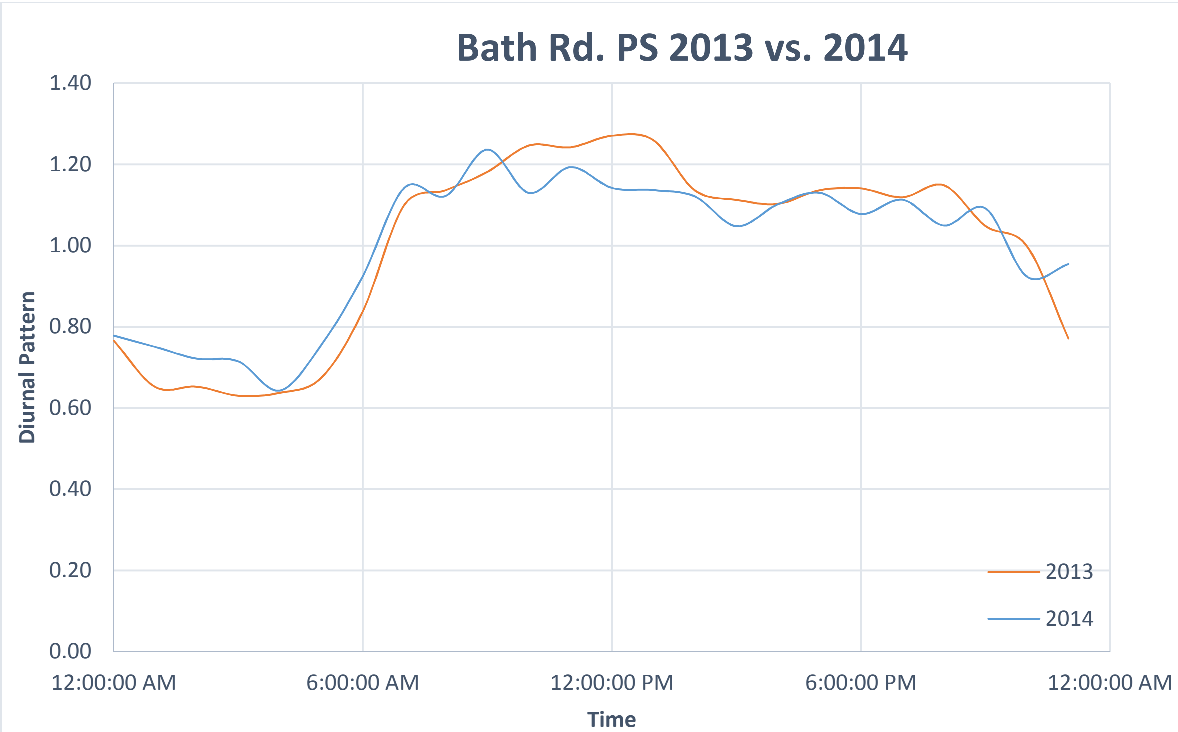


Figure G- 199

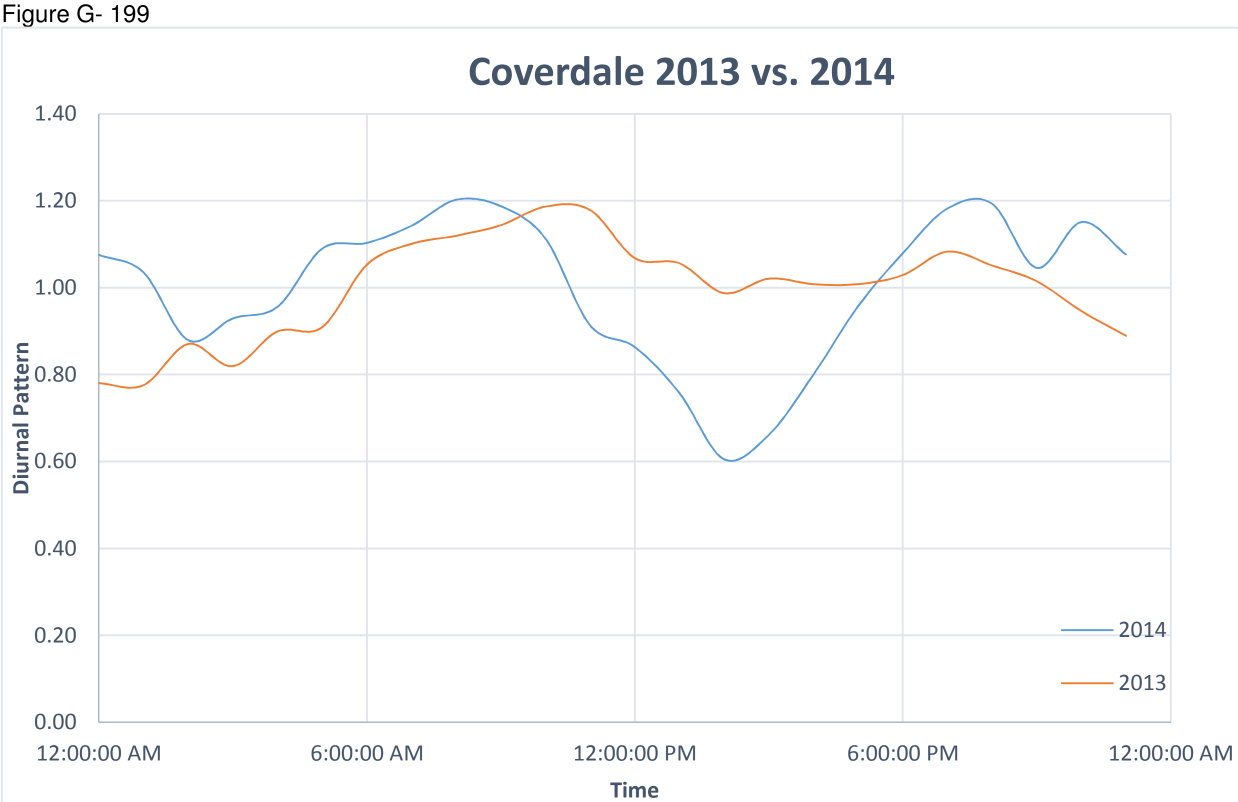


Figure G- 20

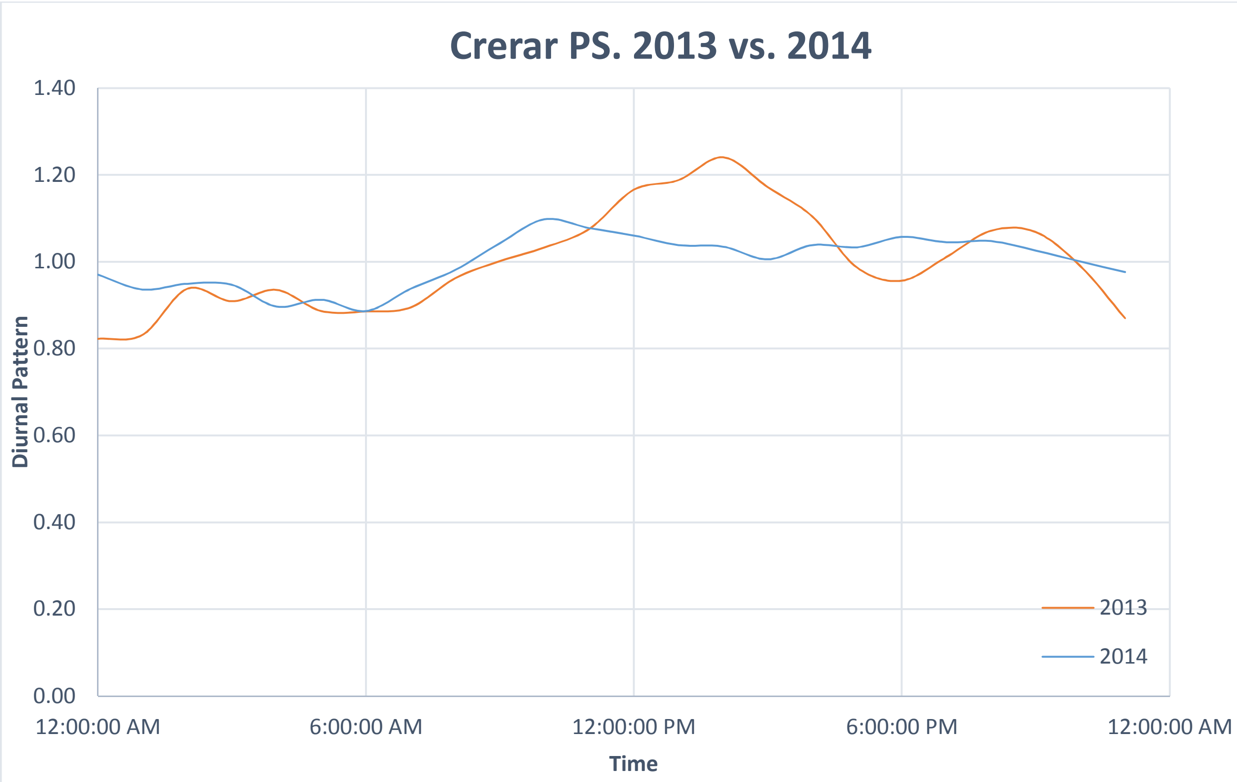


Figure G- 21

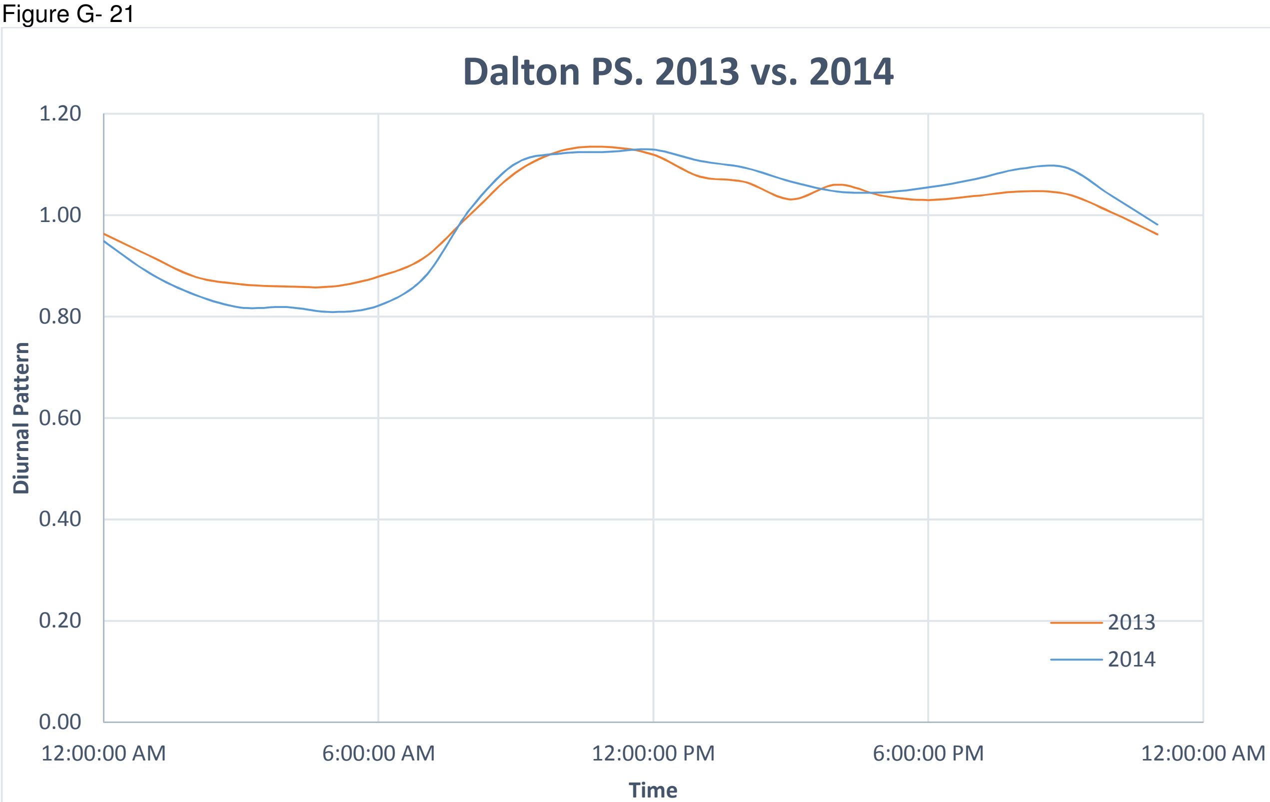


Figure G- 22

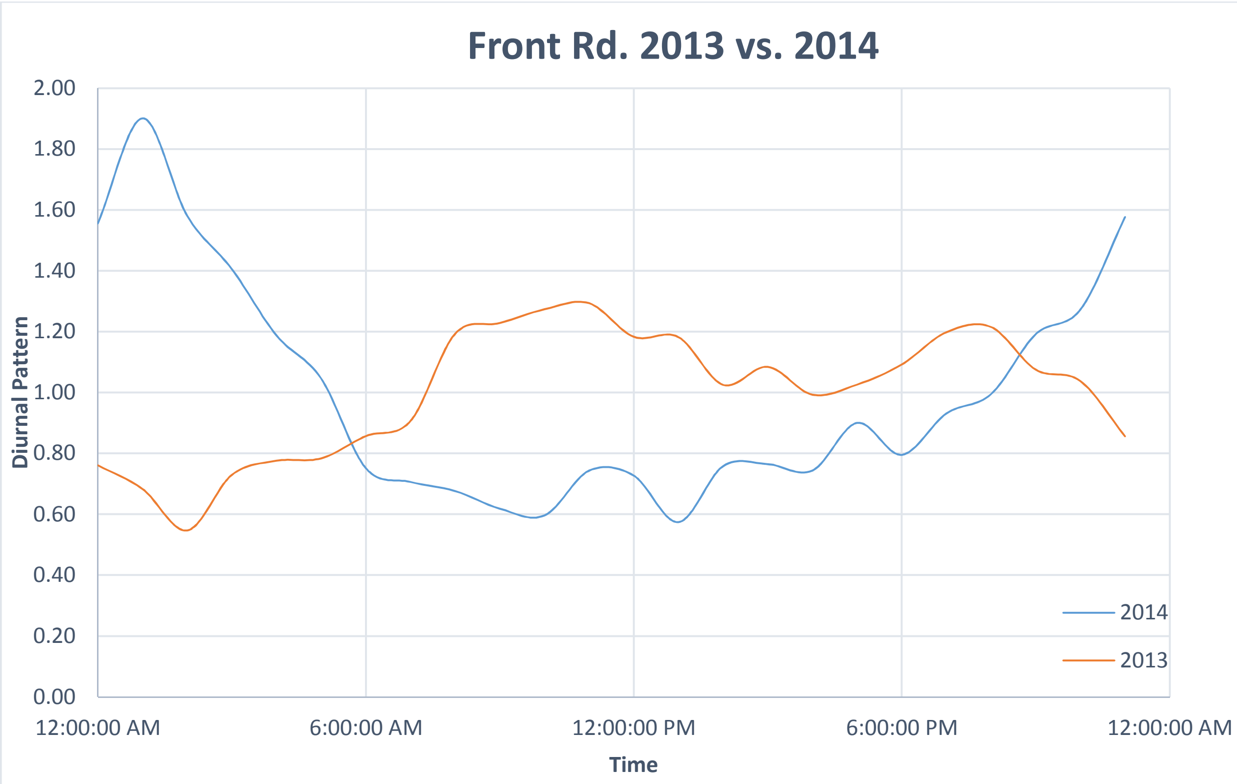


Figure G- 23

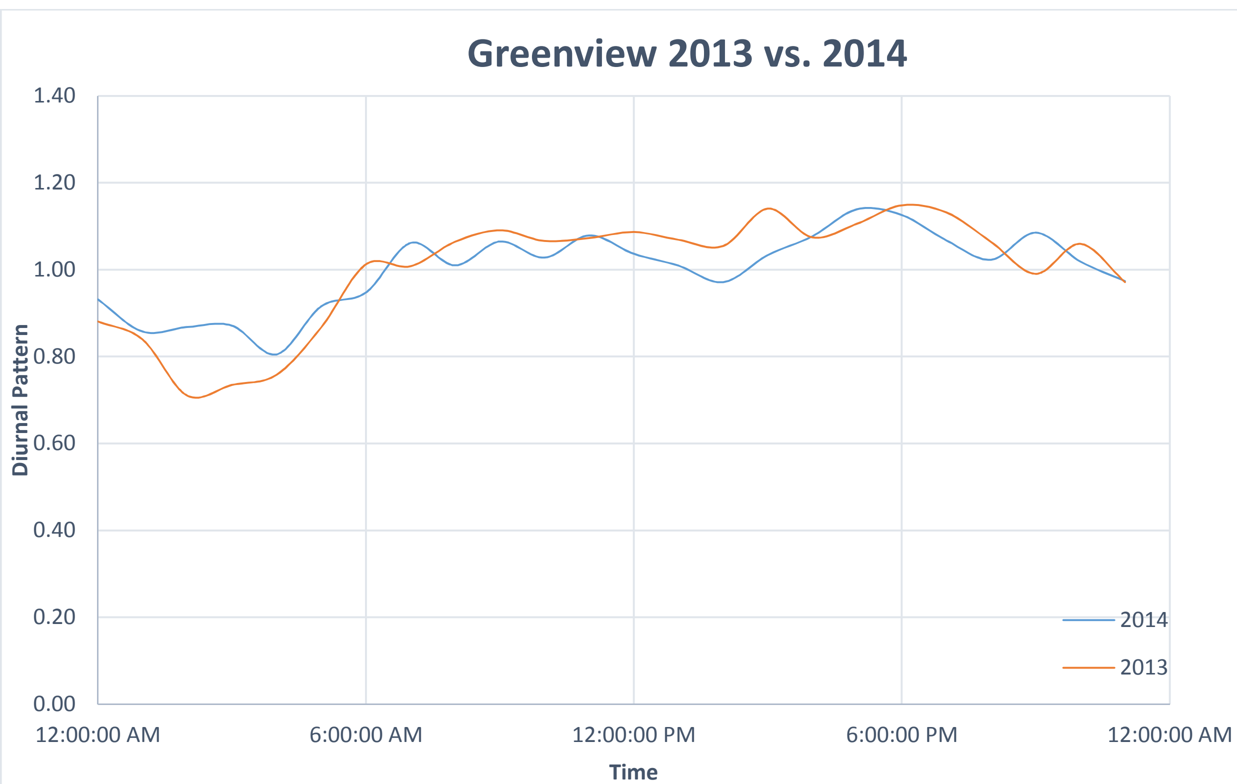


Figure G- 24

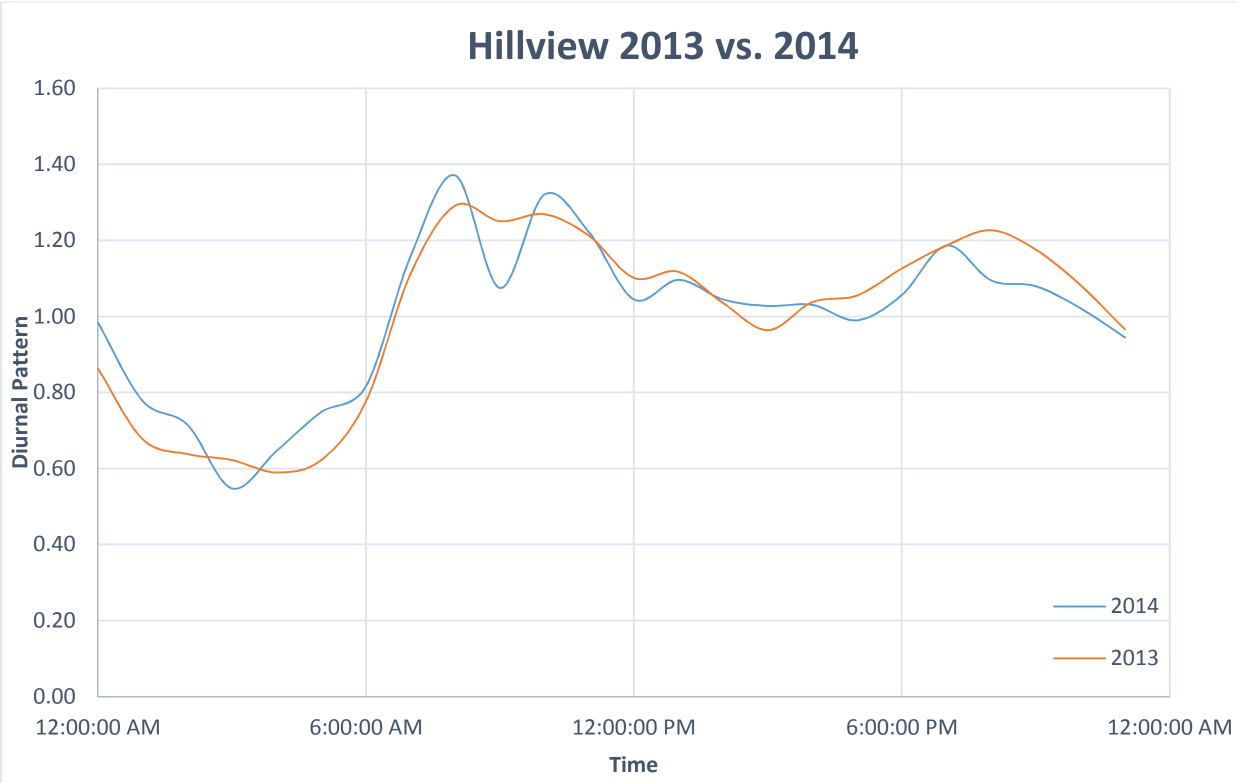


Figure G- 25

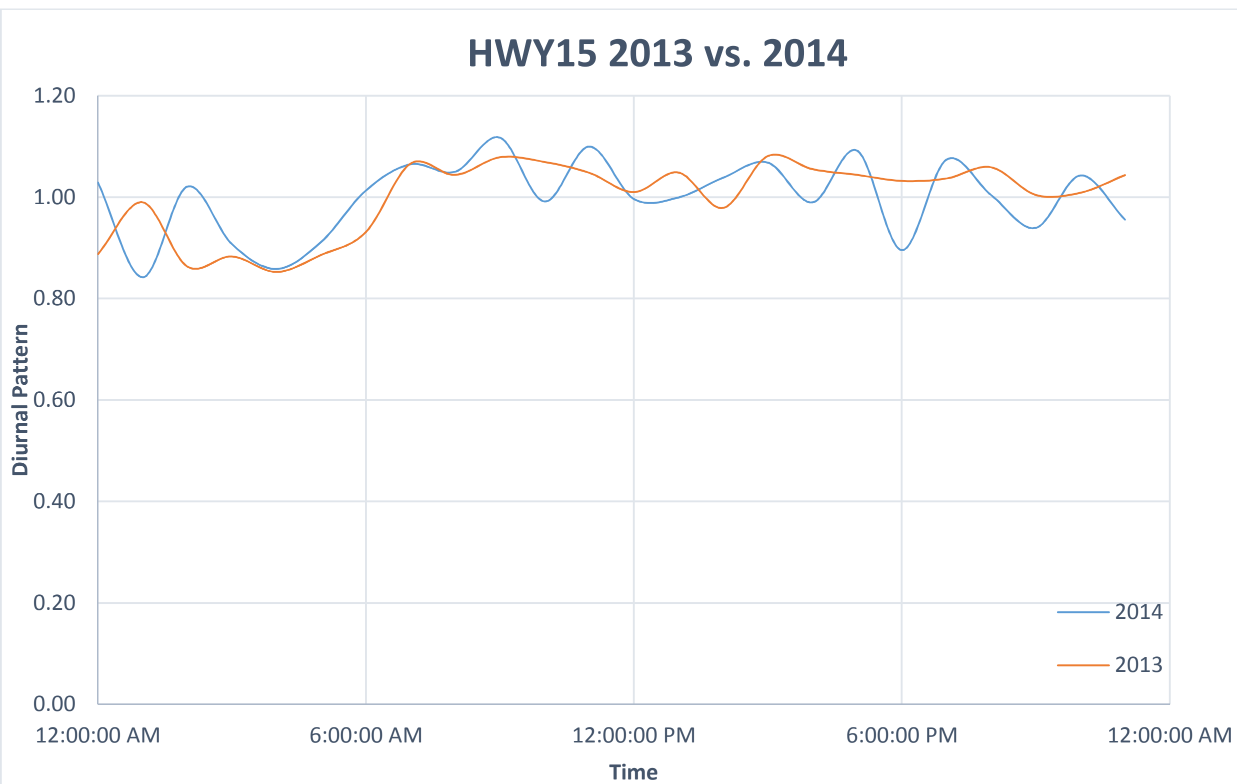


Figure G- 26

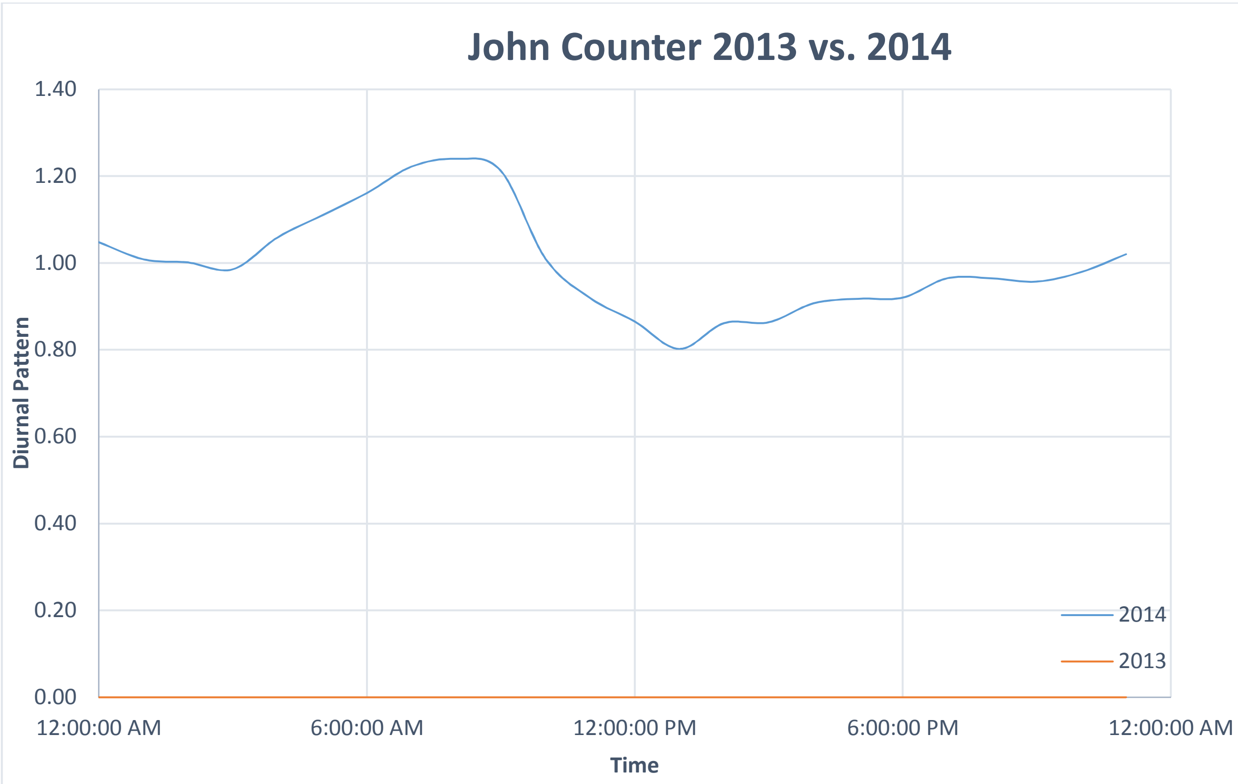


Figure G- 27

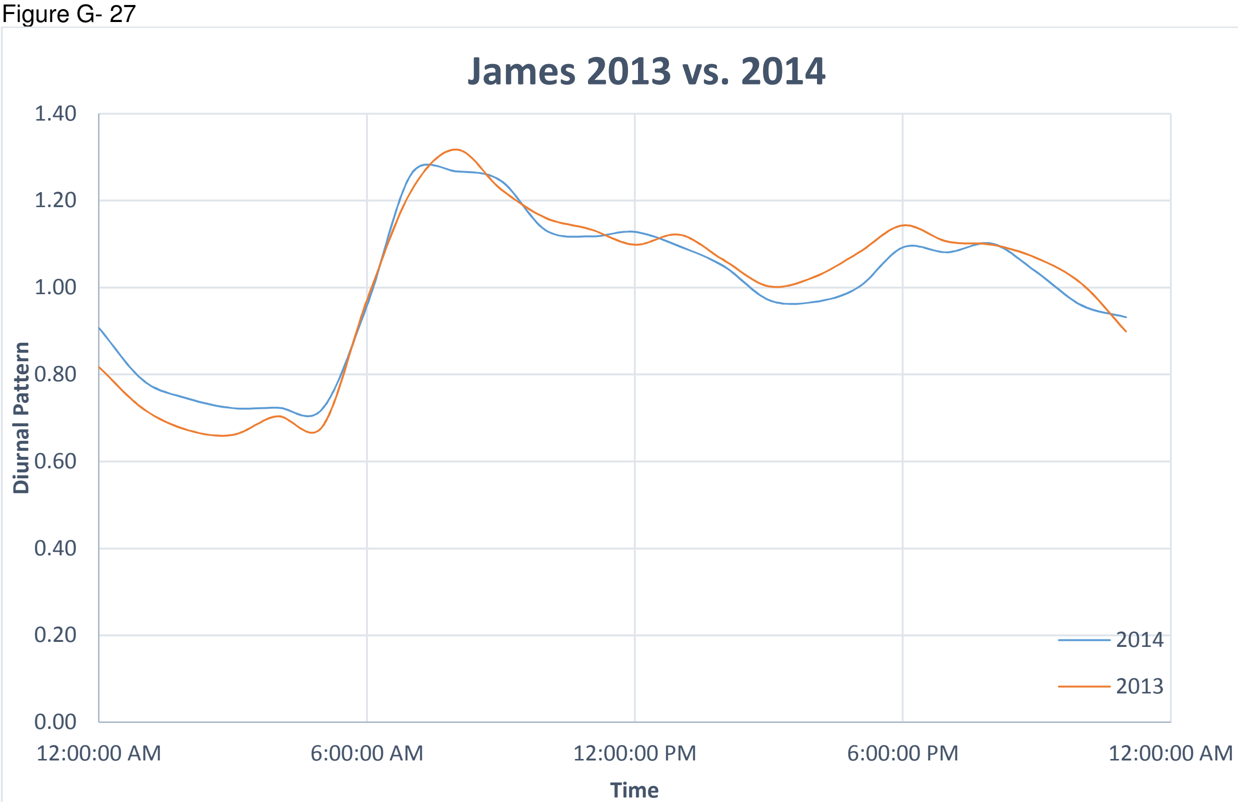


Figure G- 28

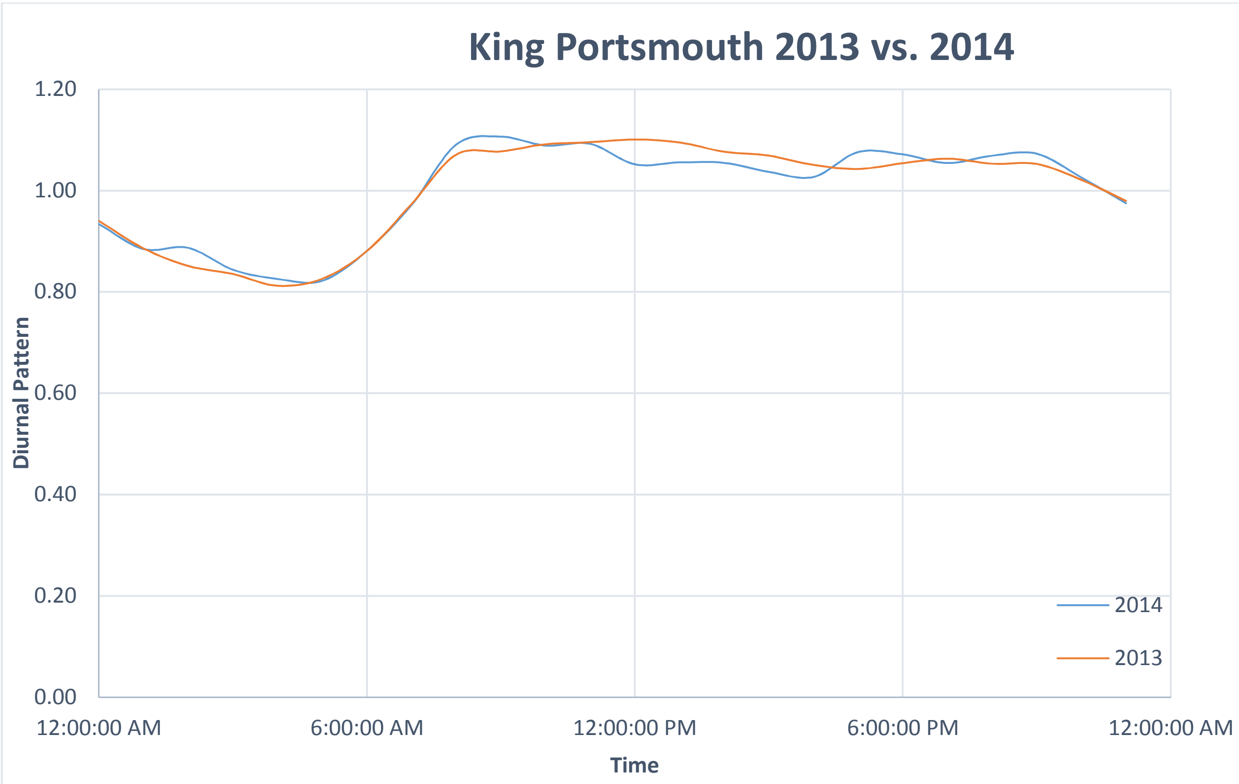


Figure G- 29

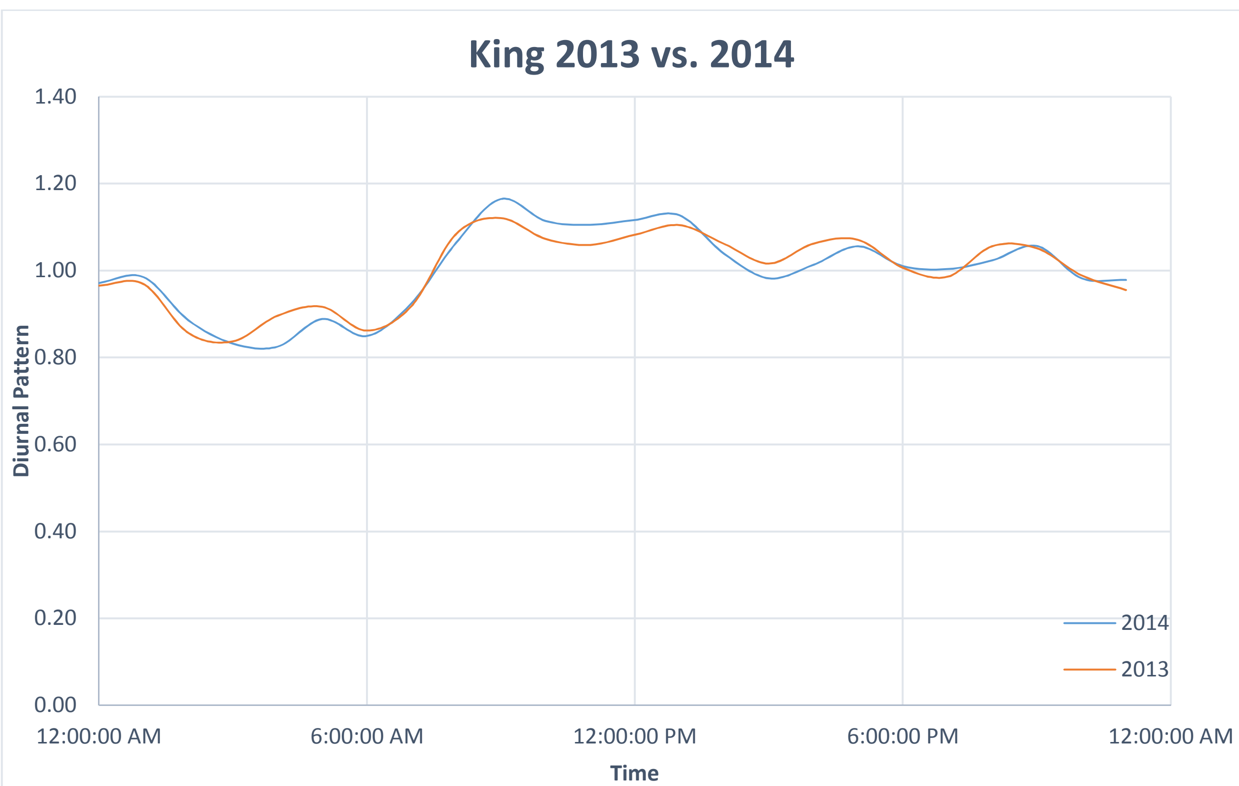


Figure G- 30

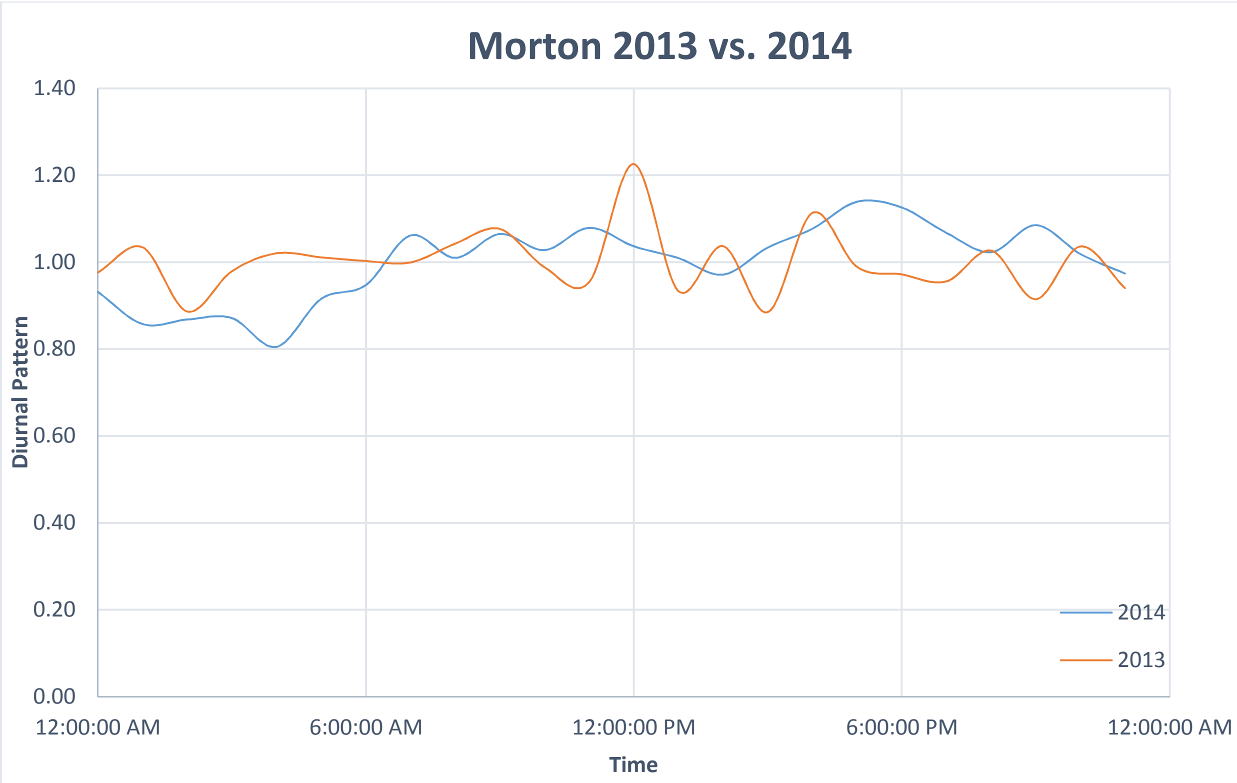


Figure G- 31

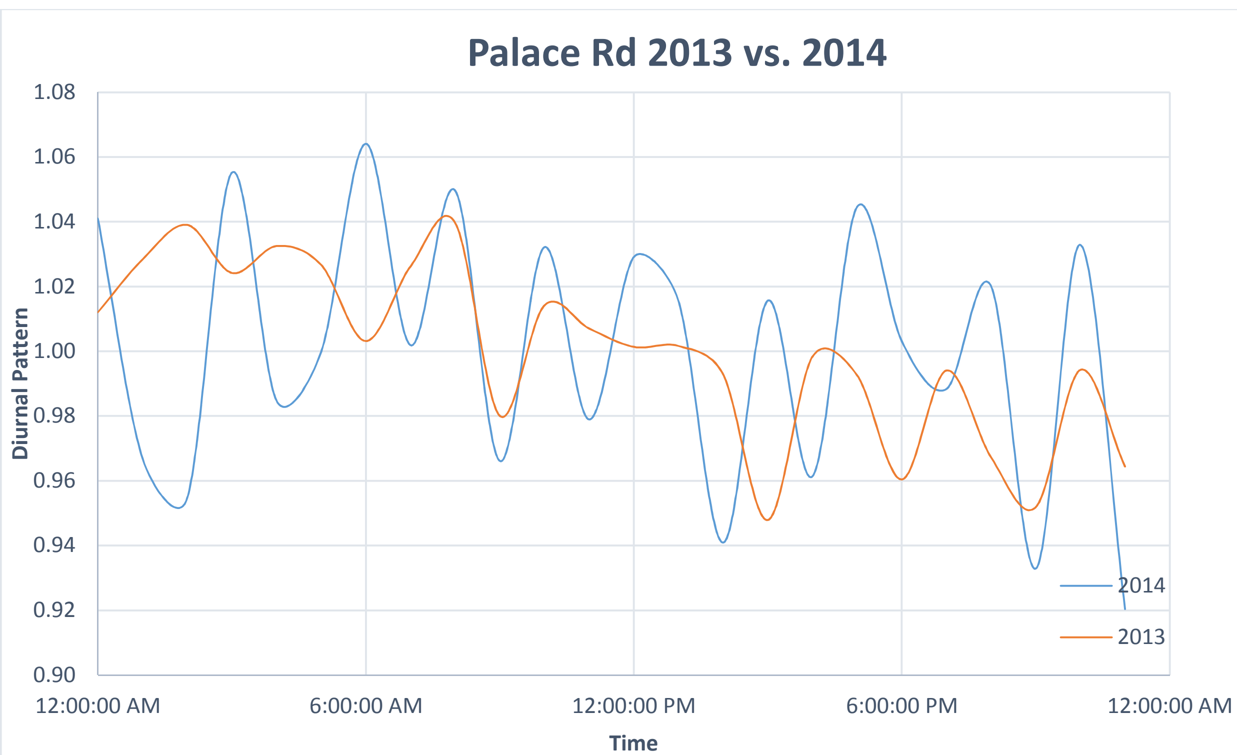


Figure G- 32

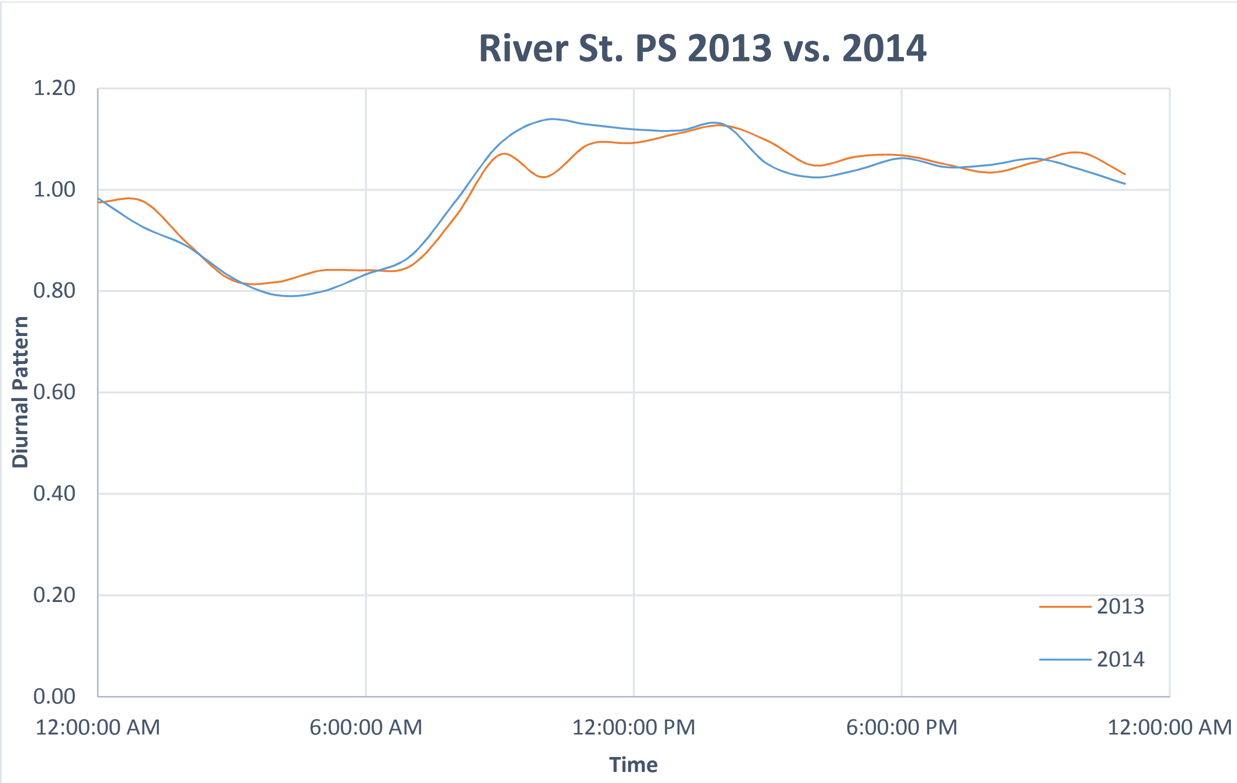


Figure G- 33

Combining the diurnal pattern graphs shows for Kingston areas show the pattern trends where the absolute max case is determined to represent the general pattern of the City of Kingston wastewater system as shown in Figures G-34 & G-35

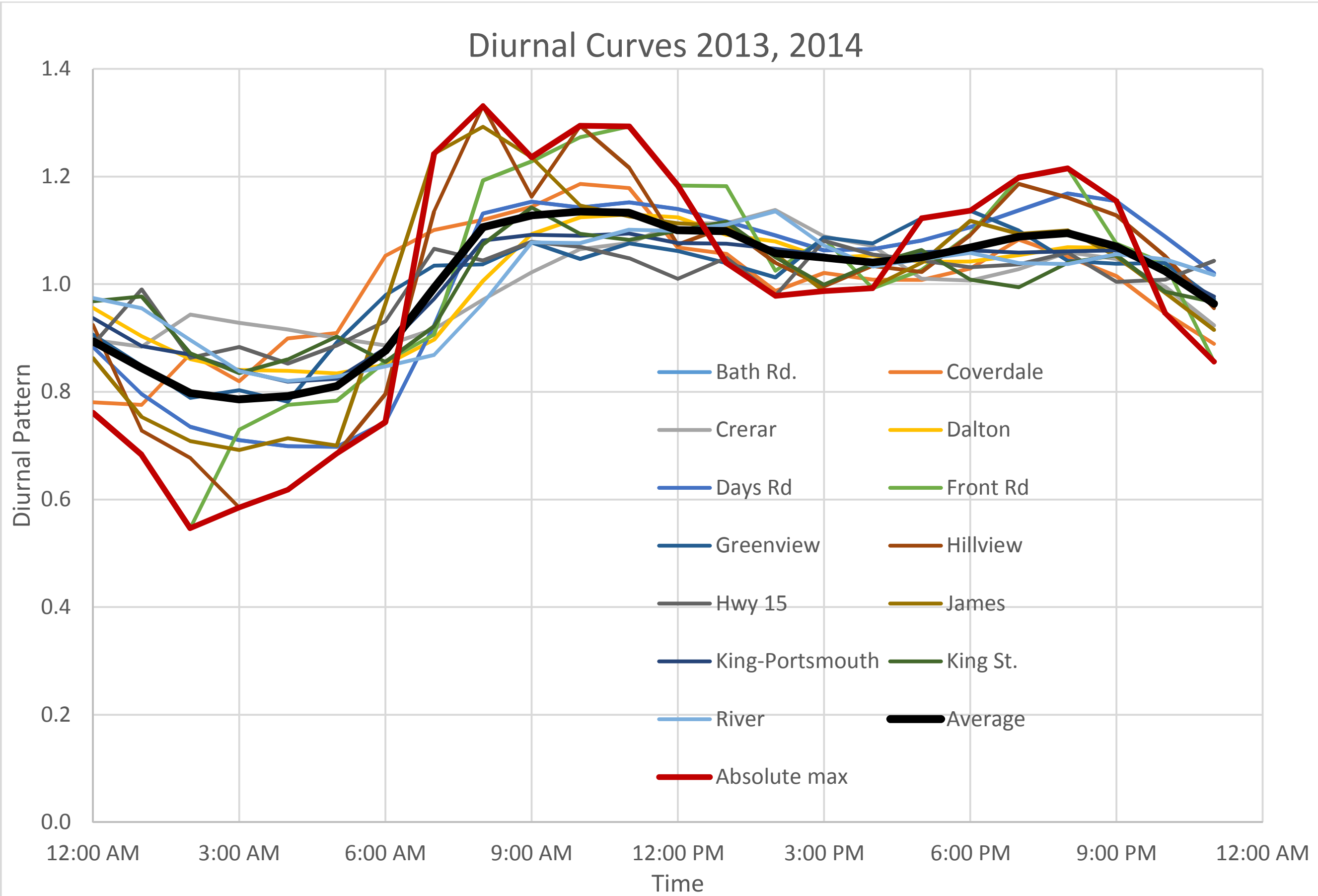


Figure G-34 Kingston Average Diurnal Patterns for all Pump Station Areas

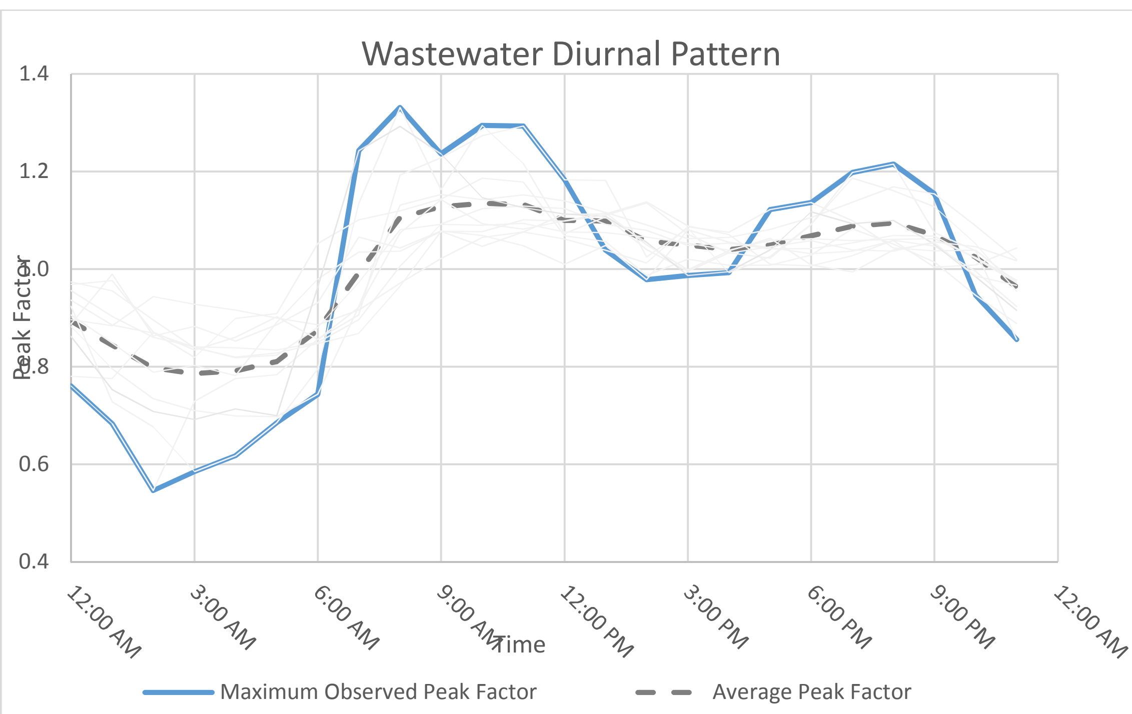


Figure G- 35 Kingston Average Peak Diurnal Patterns for All Pump Station Areas

While the application of area patterns were used for model inputs initially, the patterns developed from water demand inputs showed the most accurate representation of dry-weather sanitary flow when using demand adjusted water meters for loading. The final combined diurnal patterns are showing in Figure G-36

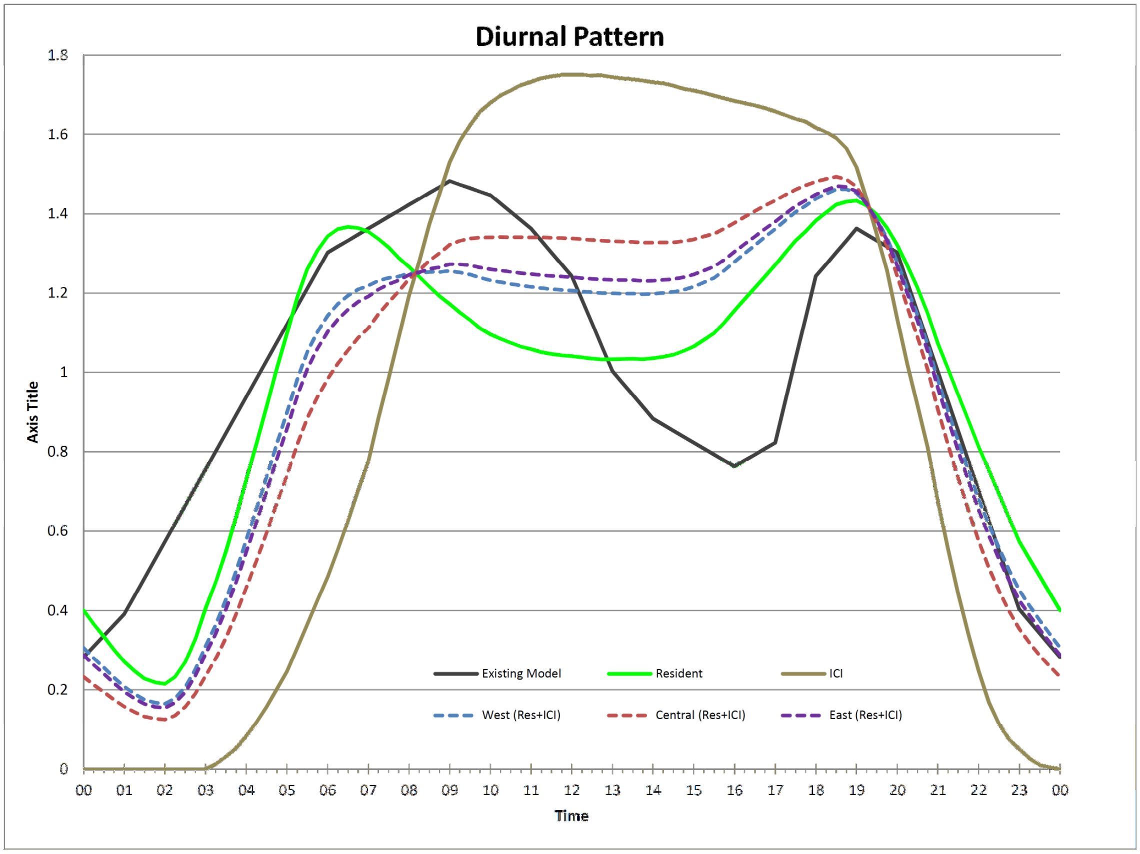


Figure G- 36 Combined Diurnal Patterns for Dry-Weather Calibration

Appendix H

CALIBRATION PROGRAM SUMMARY

2015 WASTEWATER MASTER PLAN - TRUNK MODEL CALIBRATION PROGRAM: InfoSWMM				
Phase	**Task ID**	**Task Name**	**Sub-Task**	**Sub-Task Name**
	MODEL INPUT & PREPARATION TASKS			
1	1	Past Model Review/Data Transfer	1.1	Receive Data from Utilties Kingston (UK)
			1.2	Review Data for Use
	2	Model Updates	2.1	Transfer/update provided model information to trunk model
			2.2	Add as-built/GIS information not already incorporated
			2.3	Set-up initial model scenario's and alternatives for review
	3	Input Lift Station Operation Details	3.1	Input into model and documentation of any assumptions
			3.2	Input and review of relative pump curves
			3.3	Final checks prior to reporting for scenario runs
	4	Sanitary Catchment Updates and Inputs	4.1	Generate sub-catchments using latest provided information.
			4.2	Input using 'Sub-Catchment Manager'
2	5	Sanitary Loading	5.1	Water consumption data processing (Coordinated with water modelling)
			5.2	Preliminary wastewater balance (Coordinated with water modelling)
			5.3	Sanitary loading from water demand adjustments
			5.4	Shape files preparation for sanitary loading
	6	Future Sanitary Loading	6.1	Processing of shape files (in conjunction with sanitary loading
			6.2	Model alternative creation in conjunction with projected infrastructure
			6.3	Mapping review with growth scenario projections
			6.4	Model inputting done in conjunction with water modelling
3	7	Dry-Weather, Wet-Weather and Infiltration (RDII) Calculation/Checks	7.1	Review and data processing of flow/rain information
			7.2	Calculation of infiltration from water balance and comparison of infiltration rate with documented/recorded information/studies
			7.3	RDII Calculations and Development within the model
			7.4	Development of scenarios and alternatives for dry-weather and wet-weather events for all simulation years
	8	Existing/Missing Model Feature Checks	8.1	Review of as-built/GIS information inputted with preliminary results
			8.2	Finalization of pump curve details, System curve analysis and generation (in Model)
			8.3	Review of field checks completed by WSP staff (Coordinated through the condition assessment)
			8.4	Model updates for error checks and documentation of assumptions
			8.5	Final checks prior to reporting for scenario runs
	9	Model Calibration Check	9.1	Calibrate catchment areas for trunk model by comparing to flow monitoring data
			9.2	Development of diurnal patterns and assignment
			9.3	Creation of model profiles for reporting and validation
			9.4	Documentation of assumptions
4	10	Model Comparison/Validation and Simulation	10.1	Review of UK's original trunk wastewater model with initial settings for comparison of results
			10.2	Compare the output results from UK's and WSP's models on flow, CSO's...Identify the causes of the difference and address themt to ensure current model scenario reflect the real system response
			10.3	Complete final model checks and finalize for report simulations

Appendix I

DRY-WEATHER CALIBRATION RESULTS AND SUMMARY

Appendix I – Contents

Wastewater Balance and Initial Base I&I Calculation

Figure I-1: Sanitary Pipe Overview: Age and Material

Figure I-2: Pipe Groups: Pipe Age <35 Years

Figure I-3: Pipe Groups: Pipe Age 35-75 Years

Figure I-4: Pipe Groups: Pipe Age >75 Years

Figure I-5: Dry Weather Calibration Summary – Kingston West June 23-26, 2014

Figure I-6: Dry Weather Calibration Summary – Kingston Central & East – June 23-26, 2014

Dry-Weather Calibration Results

Seasonal Variation Dry-Weather Results Summary

Ravensview Wastewater Balance and Initial Base I&I Calculation

Wastewater Balance using Demand Adjusted 2014 Billed Water Meter Data

WWTP	Historical Average Day Flow (2014 Flow Data) (m^3/day)	Historical Average Max Day Flow (2014 Flow Data) (m^3/day)	Total Metered Flow (No I/I using total of USAGE_SAN*) (m^3/day)	% Total Metered Flow vs Historical Average Day	Simulated Dry Weather Flow from Model (With I/I from 5. for intial balance) (m^3/day)	% Simulated Dry Weather Flow vs. Historical Average Day
	A	B	C	D = C / B	E	F = E / A
Ravensview	60916	185620.0	19420.85	32%	61955.3	102%

WWTP flow from Annual Reports provided by Utilties Kingston

*from UK Water Consumption GIS Attribute Data

I&I Calculation

Initial Base Infiltration is calculated for model input based on the

Note: The results from steps 5. are inputted into the Trunk Sewer model for initial dry-weather calibraiton only. The water balance is finalized for the selected dry-weather period after area model nodes and elements are updated with I/I based on pipe group designation ranges.

1. Average of Average Daily Flows through 2012

Average WWTP flow from Annual Reports provided by UK

60916	m3/d

2. Billing Data Total

Sum of all Meter records from USAGE_SAN divided by 365

24472	m3/day

3. Base (Dry Weather) I/I

Average Average Daily WWTP Flow Minus Metered Flow

36444	m3/d, or

4. Total Trunk Model Nodes

Sum all active pipes in the model for Kingston Central/East

560	Nodes

5. Base I/I per Trunk Model Node

*Base *Dry Weather) I/I divided by Total Pipe Length*

65.079	m3/m/d
65079	L/m/d
0.75323	L/m/s

Cataraqui Bay WWTP Wastewater Balance and Base I&I Calculation

Wastewater Balance using Demand Adjusted 2014 Billed Water Meter Data

WWTP	**Historical Average Day Flow** (2014 Flow Data) **(m^3/day)**	**Historical Average Max Day Flow** (2014 Flow Data) **(m3/day)**	**Total Metered Flow** (No I/I using total of USAGE_SAN) **(m3/day)**	**% Total Metered Flow vs Historical Average Day**	**Simulated Dry Weather Flow from Model** (With I/I from 5.) **(m3/day)**	**% Simulated Dry Weather Flow vs. Historical Average Day**
	A	**B**	**C**	**D = C / A**	**E**	**F = E / A**
Cataraqui Bay	27145	90801.0	**8946.65**	**33%**	**26959.8**	**99%**

WWTP flow from Annual Reports provided by Utilties Kingston

*from UK Water Consumption GIS Attribute Data

I&I Calculation

Infiltration is calculated for model input based on the water balance results. Total Flow = Metered Flow + I/I Flow

1. Average of Average Daily Flows through 2014

Average WWTP flow from Annual Reports provided by UK

27145	**m3/d**

2. Billing Data Total

Sum of all Meter records from USAGE_SAN divided by 365

11178	**m3/day**

3. Base (Dry Weather) I/I

Average Average Daily WWTP Flow Minus Metered Flow

15967	**m3/d, or**

4. Total Trunk Model Nodes

Sum all nodes in the model for service area

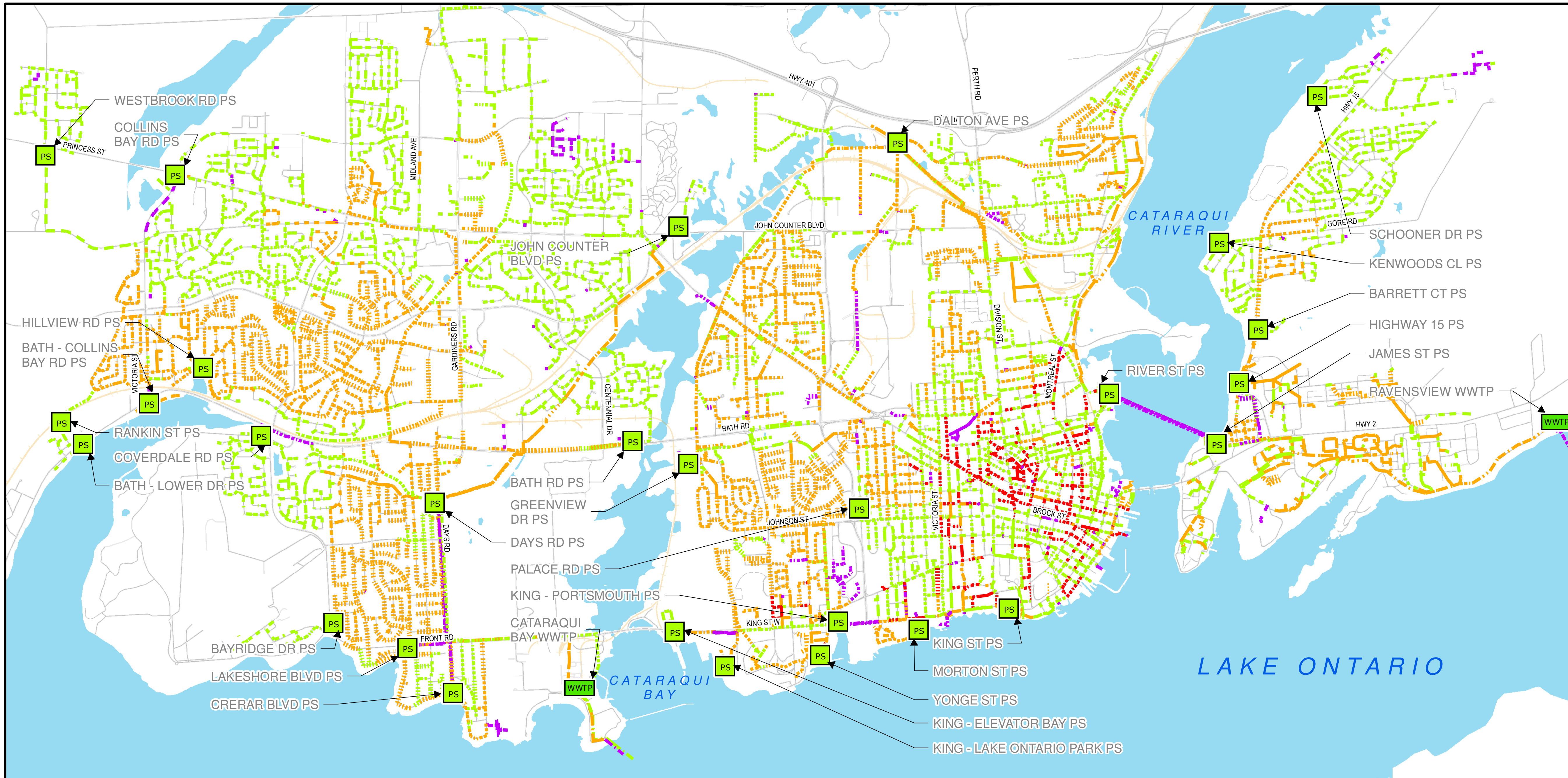
497	**Nodes**

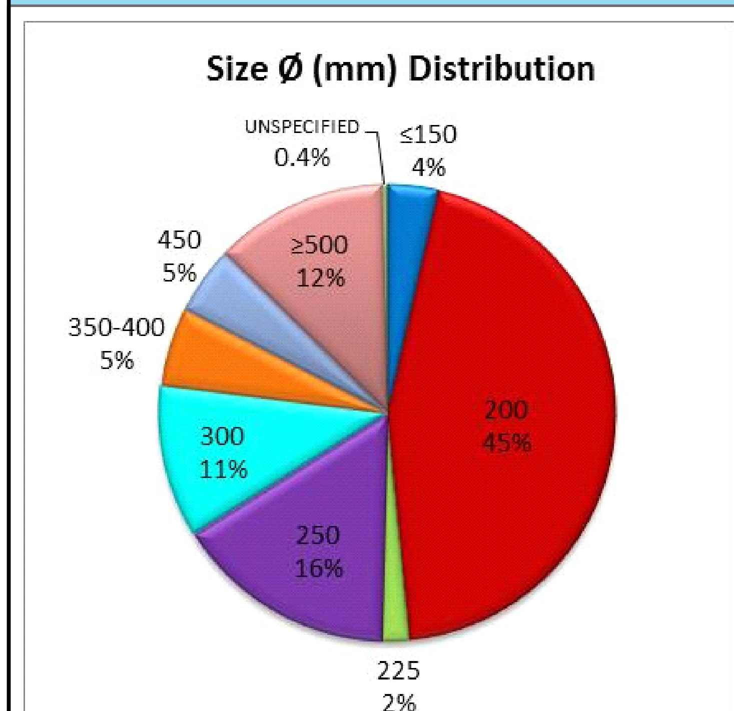
5. Base I/I per Trunk Model Node

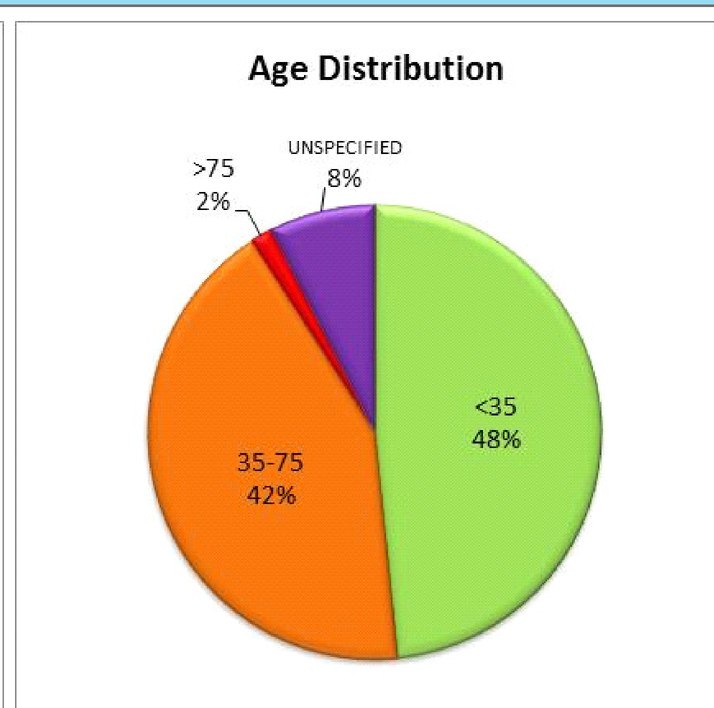
*Base *Dry Weather) I/I divided by Total Trunk Model Nodes*

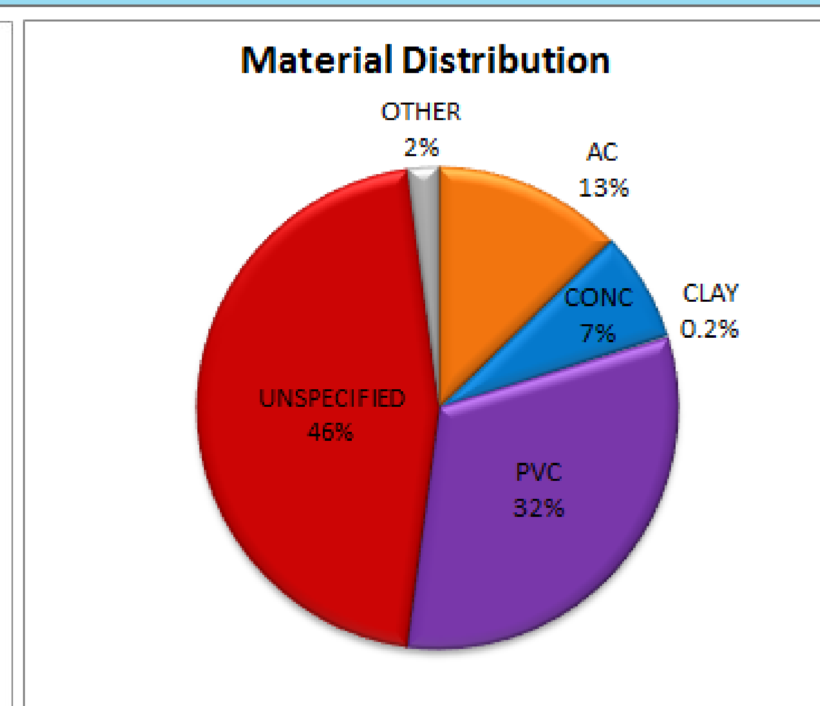
32.127	**m3/node/d**
32127	**L/node/d**
0.37184	**L/node/s**

Note: The results from steps 5. are inputted into the Trunk Sewer model for initial dry-weather calibraiton only. The water balance is finalized for the selected dry-weather period after area model nodes and elements are updated with I/I based on pipe group designation ranges.









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Legend

- WWTP — WASTEWATER TREATMENT PLANT
- PS — SANITARY PUMPING STATION

SANITARY PIPES - MATERIAL, AGE

<Null>, < 35	CLAY, 35 - 75
<Null>, 35 - 75	CLAY, > 75
<Null>, > 75	CLAY, <Null>
<Null>, <Null>	CONC, < 35
AC, < 35	CONC, 35 - 75
AC, 35 - 75	CONC, > 75
AC, > 75	CONC, <Null>
AC, <Null>	HDPE, < 35
CI, 35 - 75	PVC, < 35
CIPP, < 35	PVC, 35 - 75
CIPP, 35 - 75	PVC, > 75
CIPP, > 75	PVC, <Null>
CLAY TILE, < 35	STONE, < 35
CLAY TILE, 35 - 75	STONE, 35 - 75
CLAY TILE, > 75	STONE, > 75
CLAY TILE, <Null>	STONE, <Null>
CLAY, < 35	

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

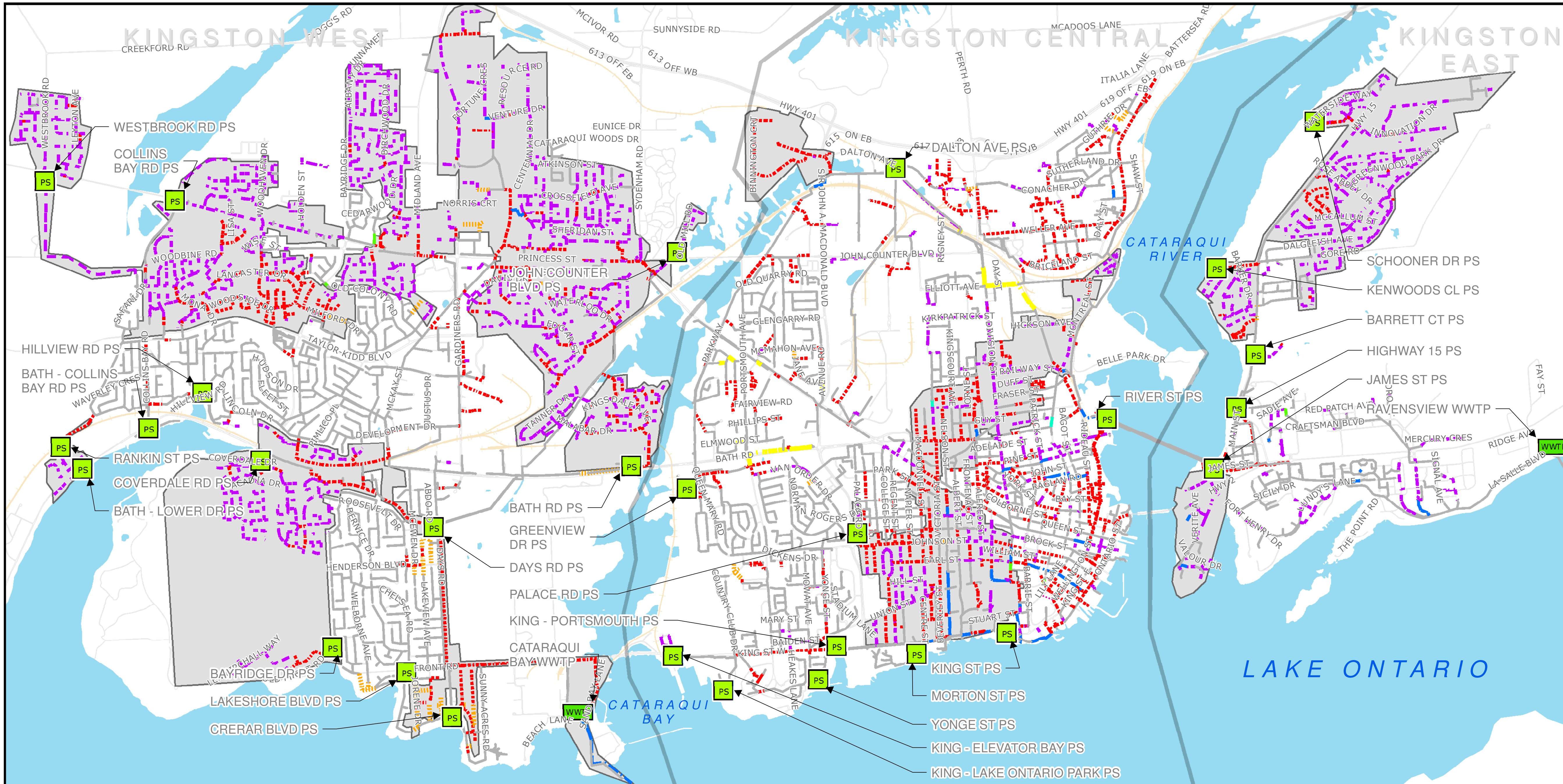
Project:
Water and Wastewater Master Plan Updates

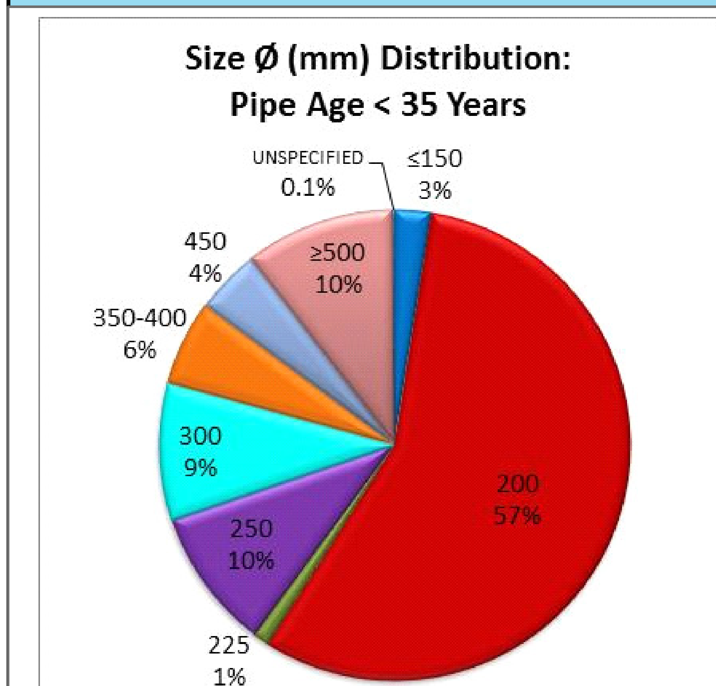
City of Kingston, Ontario

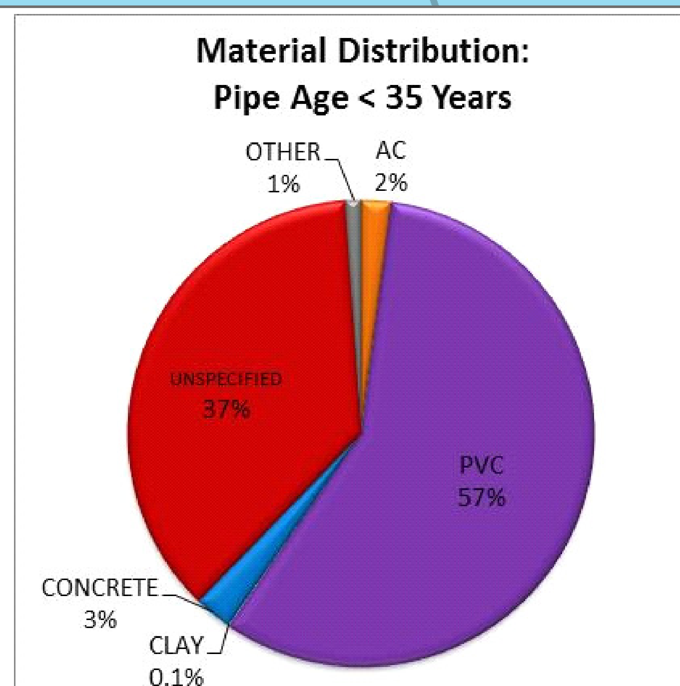
Title:
SANITARY PIPE OVERVIEW: AGE AND MATERIAL

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

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.6_Wastewater Model\Maps\Calibration Report Maps\I_DryWeatherCalb\151-02944-00_WWM_FigI-1_Pipe_Age_and_Material.mxd







GENERAL NOTES:

1. CONCRETE MATERIAL GROUP TO APPLY 0.05-0.5 L/S/NODE I&I RATE. INCLUDES ASBESTOS PIPE, CLAY TILE, CONCRETE AND STONE MATERIAL DESIGNATIONS.
2. PLASTIC MATERIAL GROUP TO APPLY 0.0-0.4 L/S/NODE I&I RATE. INCLUDES PVC, CIPP AND HDPE MATERIAL DESIGNATIONS.
3. 'OTHER' MATERIAL GROUP TO APPLY 0.05-0.5 L/S/NODE I&I RATE. INCLUDES UNKNOWN OR <NULL> MATERIAL DESIGNATIONS.

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Legend

- WWTP — WASTEWATER TREATMENT PLANT
- PS — SANITARY PUMPING STATION
- PIPES > 35
- <Null>, < 35
- AC, < 35
- CIPP, < 35
- CLAY TILE, < 35
- CLAY, < 35
- CONC, < 35
- HDPE, < 35
- PVC, < 35
- STONE, < 35
- PIPES <35

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

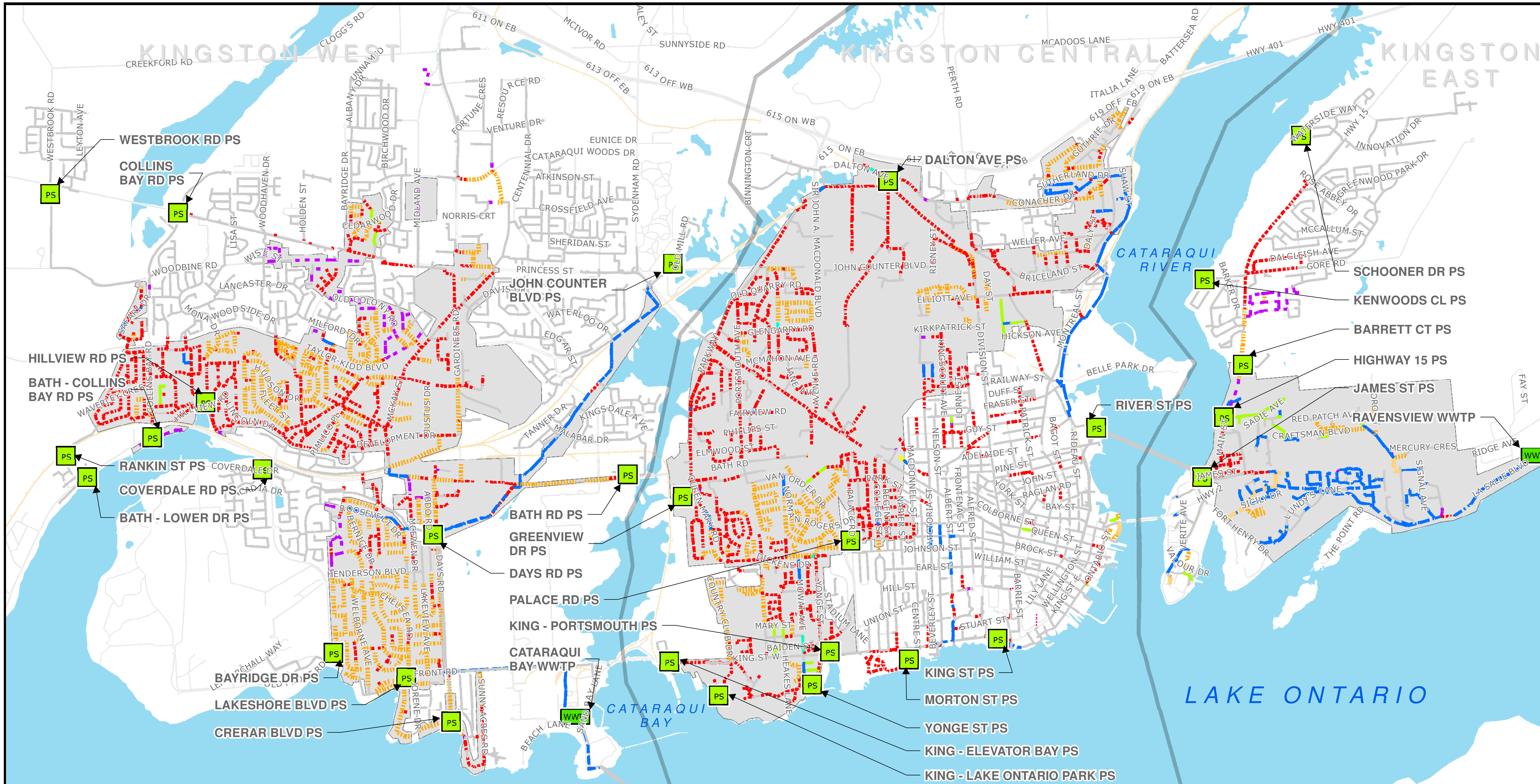
Scale: 0 300 600 1,200 Meters
1:47,500

Project:
Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title:
PIPE GROUPS:
PIPE AGE < 35 YEARS

Project No.:	Date:		
151-02944-00	DECEMBER 2016		
Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	WWM	I-2



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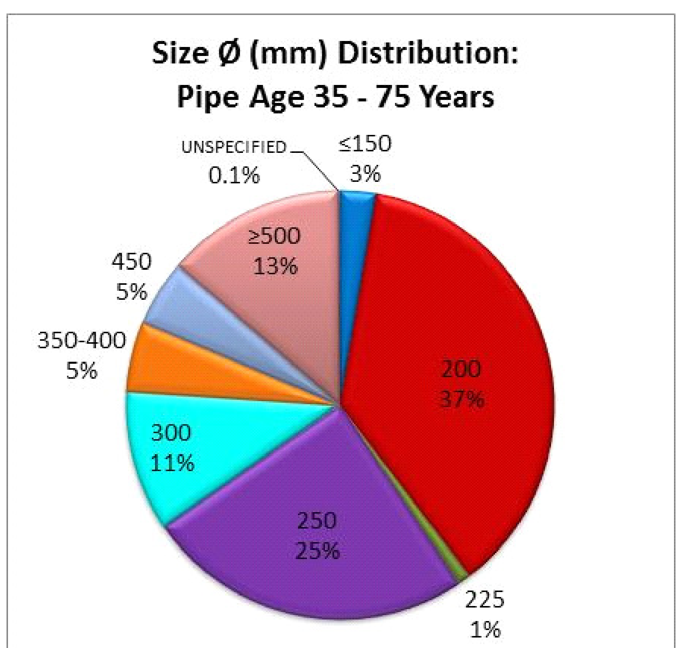
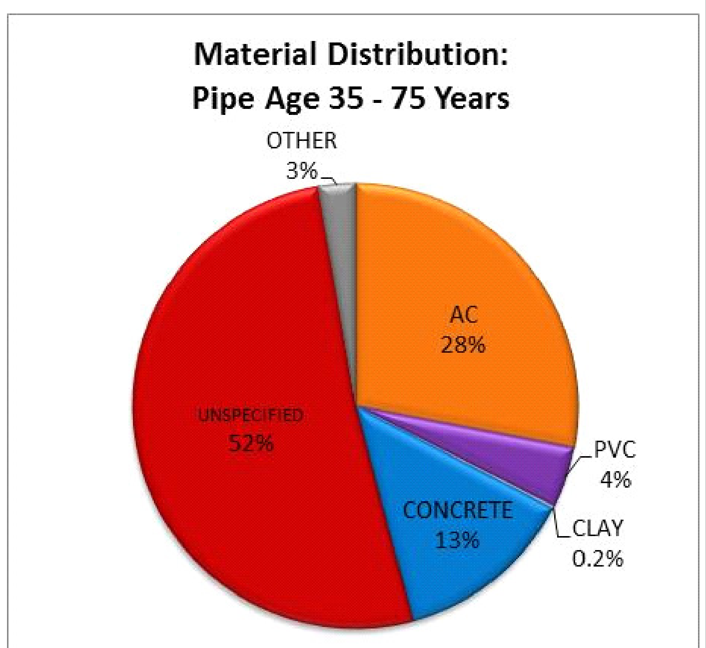
Legend

WWTP	WASTEWATER TREATMENT PLANT
PS	SANITARY PUMPING STATION
	PIPES > 75 AND < 35
	<Null>, 35 - 75
	AC, 35 - 75
	CI, 35 - 75
	CIPP, 35 - 75
	CLAY TILE, 35 - 75
	CLAY, 35 - 75
	CONC, 35 - 75
	PVC, 35 - 75
	STONE, 35 - 75
	PIPES 35-75 YEARS

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





GENERAL NOTES:

1. CONCRETE MATERIAL GROUP TO APPLY 0.2-1 L/S/NODE I&I RATE.
   INCLUDES ASBESTOS PIPE, CLAY TILE, CONCRETE AND STONE MATERIAL DESIGNATIONS.
2. PLASTIC MATERIAL GROUP TO APPLY 0.1-0.5 L/S/NODE I&I RATE.
   INCLUDES PVC, CIPP AND HDPE MATERIAL DESIGNATIONS.
3. 'OTHER' MATERIAL GROUP TO APPLY 0.1-1 L/S/NODE I&I RATE.
   INCLUDES UNKNOWN OR <NULL> MATERIAL DESIGNATIONS.

Project:
Water and Wastewater Master Plan Updates

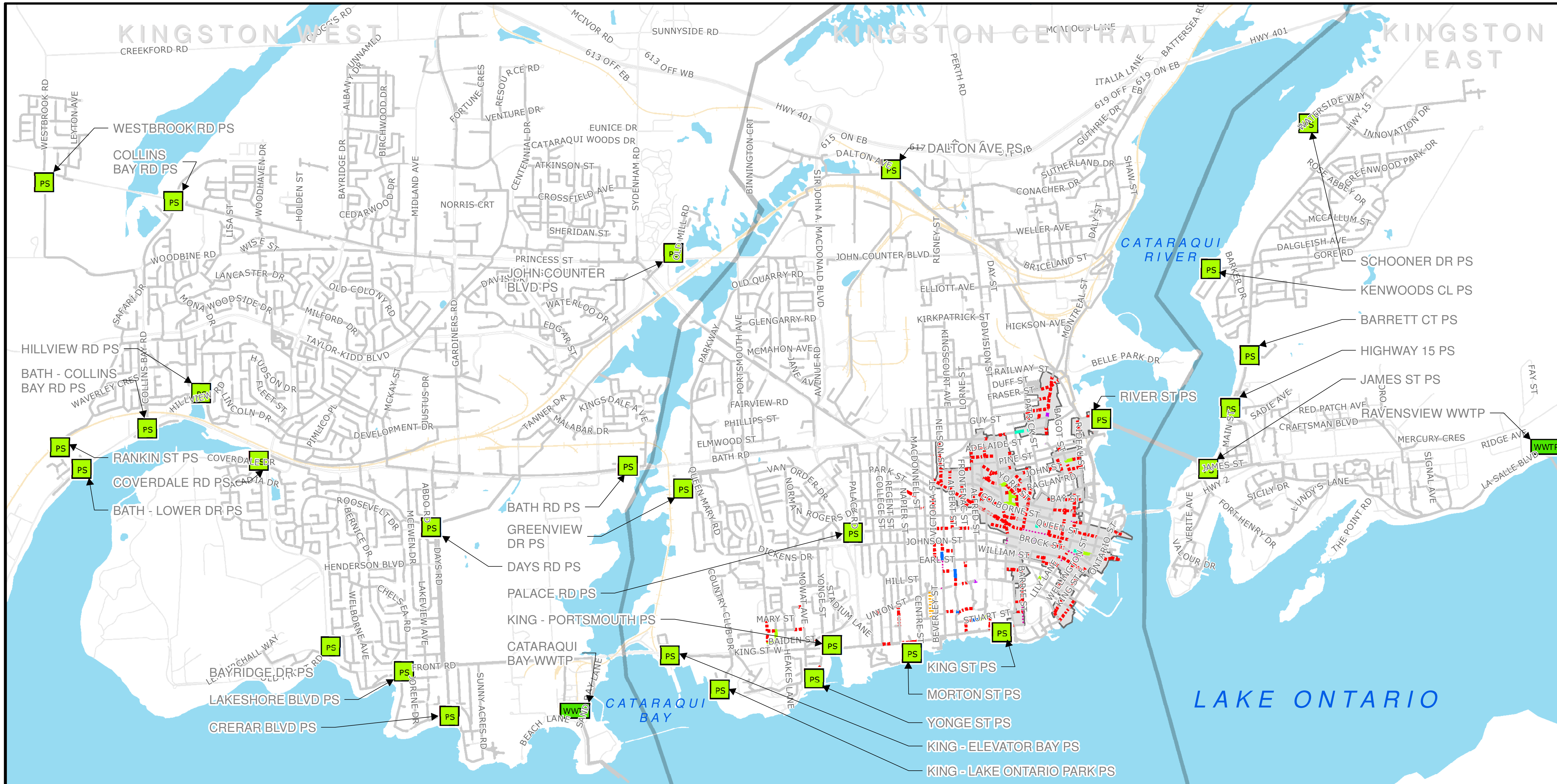
City of Kingston, Ontario

Title:
PIPE GROUPS:
PIPE AGE 35-75 YEARS

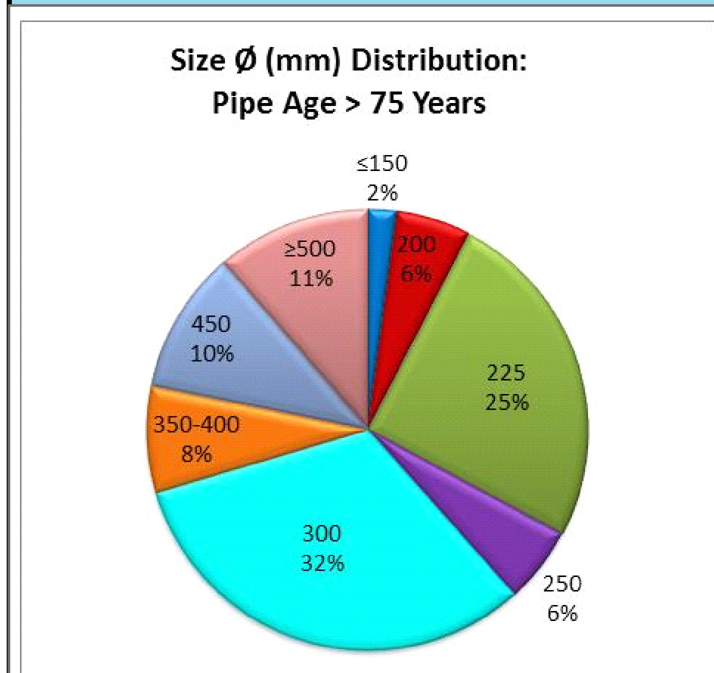
Project No.:	Date:
151-02944-00	DECEMBER 2016

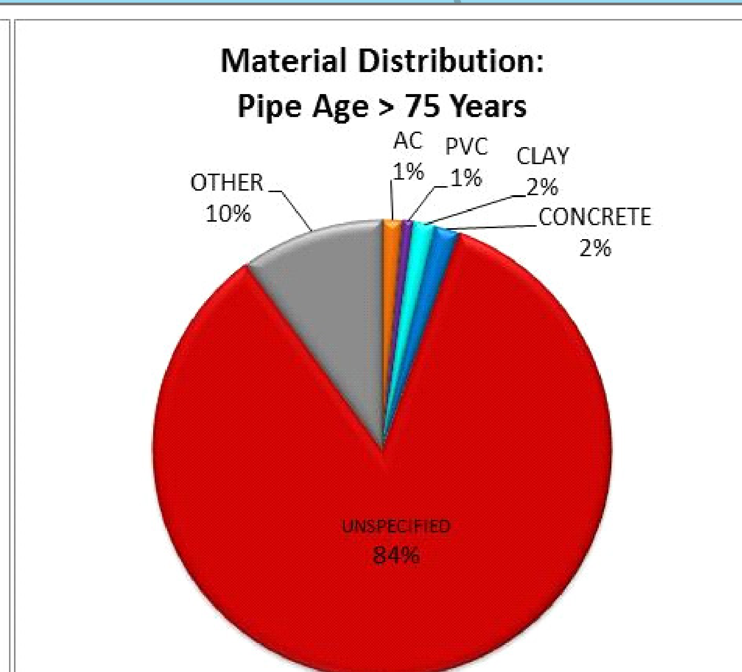
Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	WWM	I-3

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.6_Wastewater Model\Maps\Calibration Report Maps\I_DryWeatherCalb\151-02944-00_WWM_FigI-3_35-75YearOld_Pipe_Material.mxd



Legend	
	West_Central_East
WWTP	WASTEWATER TREATMENT PLANT
PS	PUMPING STATION
	PIPES <75
	<Null>, > 75
	AC, > 75
	CIPP, > 75
	CLAY TILE, > 75
	CLAY, > 75
	CONC, > 75
	PVC, > 75
	STONE, > 75
	PIPES >75
	<all other values>
	COK_RAIL
	COK_ROAD_ELEMENT





GENERAL NOTES:

1. CONCRETE MATERIAL GROUP TO APPLY 0.2-2 L/S/NODE I&I RATE. INCLUDES ASBESTOS PIPE, CLAY TILE, CONCRETE AND STONE MATERIAL DESIGNATIONS.
2. PLASTIC MATERIAL GROUP TO APPLY 0.1-2 L/S/NODE I&I RATE. INCLUDES PVC, CIPP AND HDPE MATERIAL DESIGNATIONS.
3. 'OTHER' MATERIAL GROUP TO APPLY 0.2-2 L/S/NODE I&I RATE. INCLUDES UNKNOWN OR <NULL> MATERIAL DESIGNATIONS.

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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:
PIPE GROUPS:
PIPE AGE > 75 YEARS

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

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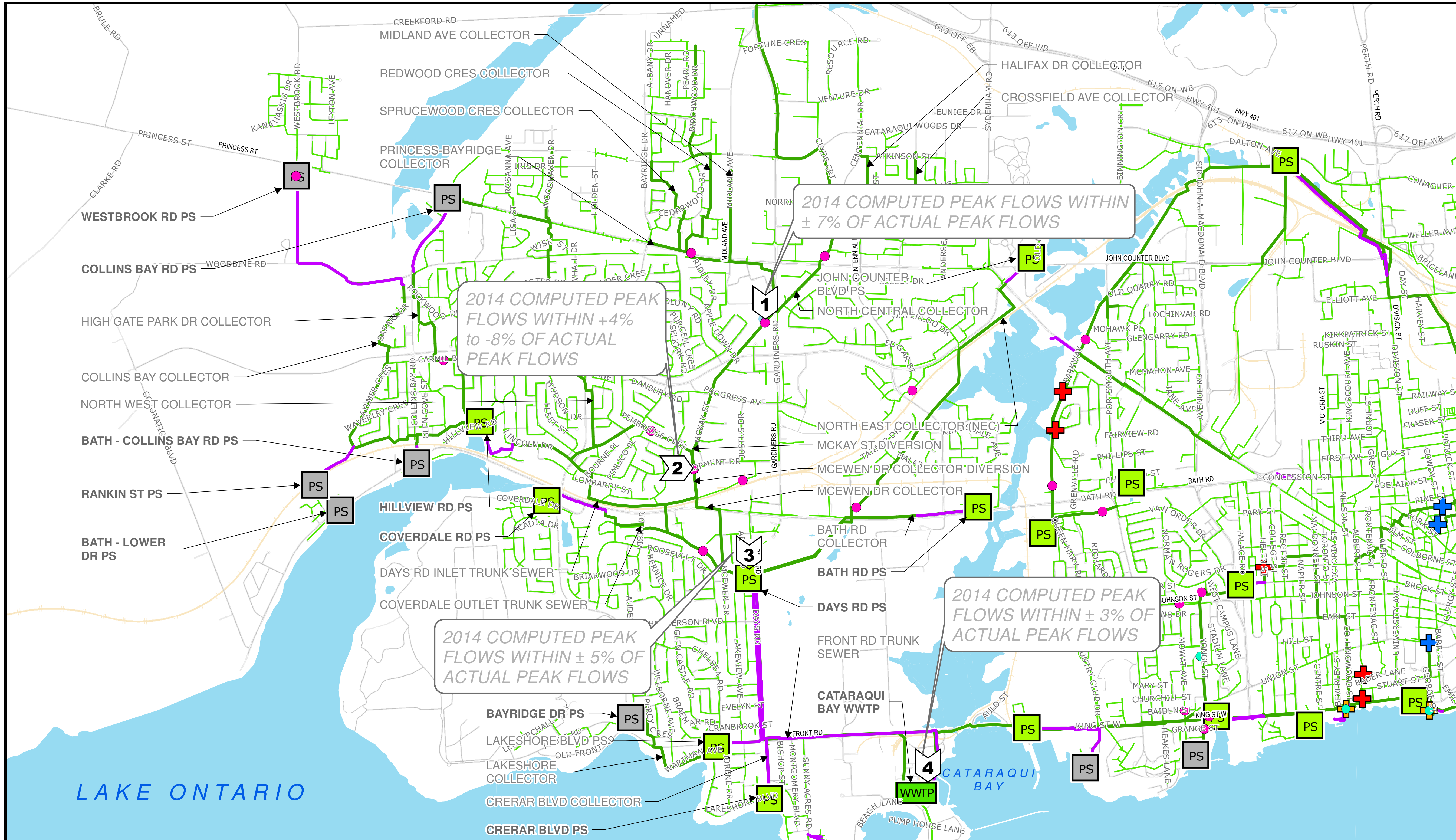
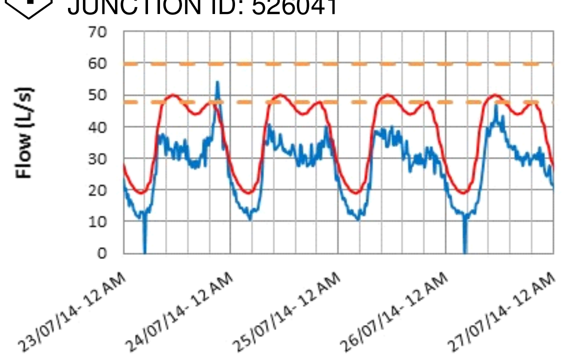
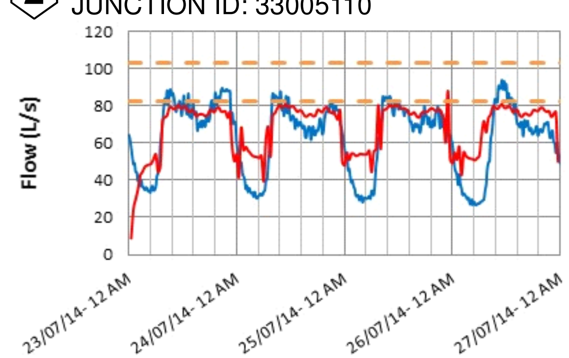


CALIBRATION RESULTS:

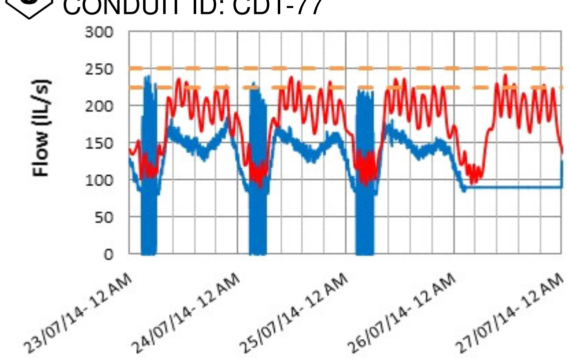
1 STATION W13 INFLOW
JUNCTION ID: 526041



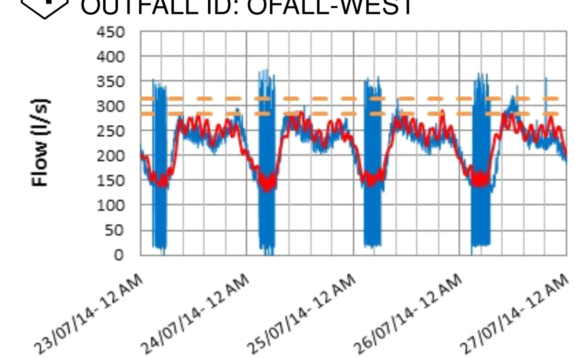
2 STATION W31 INFLOW
JUNCTION ID: 33005110



3 DAYS RD PS DISCHARGE
CONDUIT ID: CDT-77



4 CATARAQUI BAY WWTP INFLOW
OUTFALL ID: OFALL-WEST



- CALIBRATION TARGET RANGE
- COMPUTED (2014)
- ACTUAL

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Legend

- WWTP — WASTEWATER TREATMENT PLANT WITH SCADA MONITOR
- WWTP — WASTEWATER TREATMENT PLANT
- PS — SANITARY PUMPING STATION WITH SCADA MONITOR
- PS — SANITARY PUMPING STATION
- COMBINED SEWER OVERFLOW (CSO)
- CSO CAPTURED BY TANK
- TANK OVERFLOW (TO)
- SANITARY SEWER OVERFLOW (SSO)
- FORCEMAIN
- EXISTING SANITARY SEWER
- MODEL CONDUIT
- IN-LINE SEWER MONITOR
- 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:
0 250 500 1,000 Meters
1:38,000

Project:
Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title:
DRY WEATHER CALIBRATION SUMMARY - KINGSTON WEST JULY 23-26, 2014

Project No.:	Date:		
151-02944-00	DECEMBER 2016		
Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	WWM	I-5

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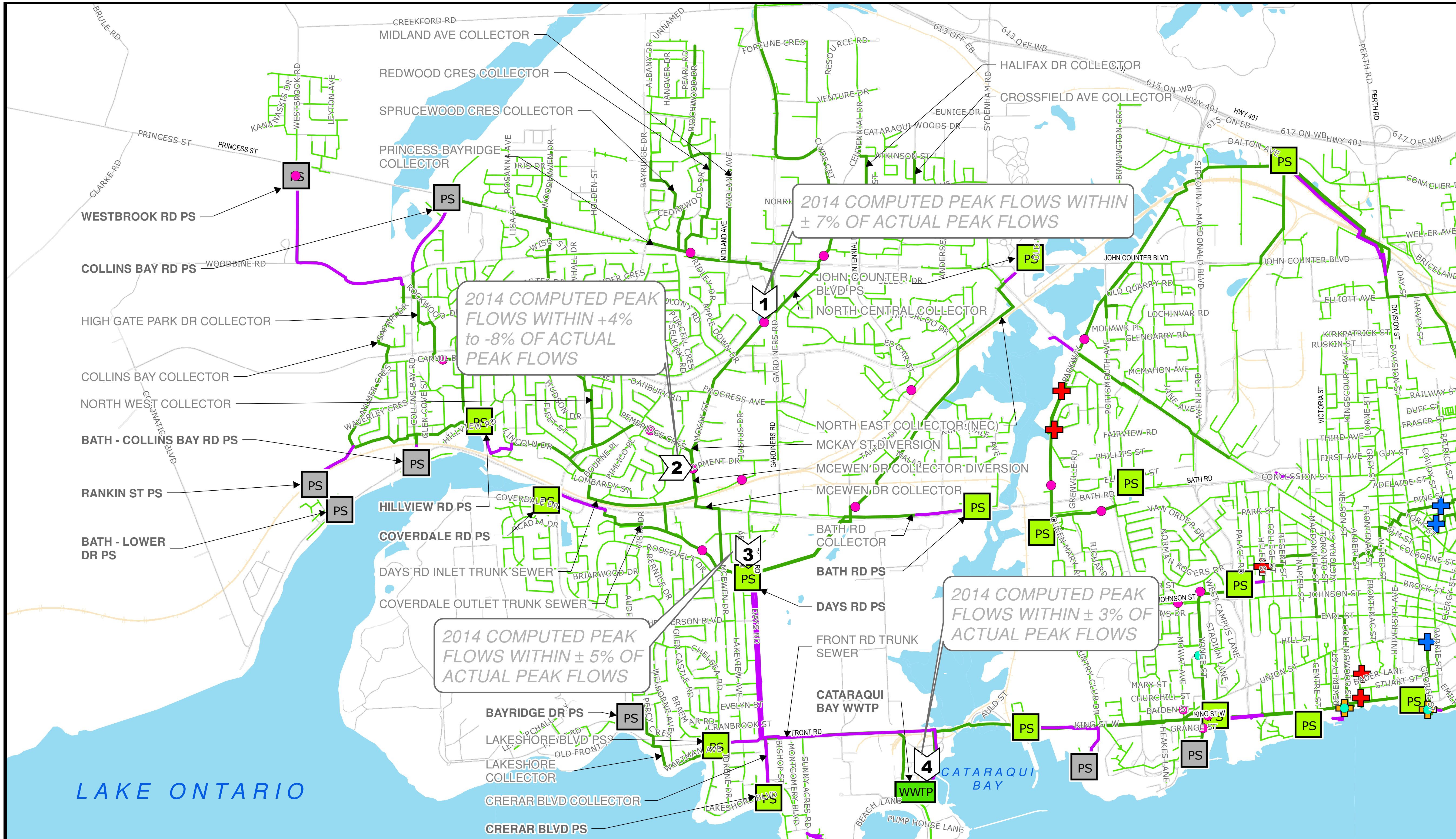

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- SANITARY SEWER OVERFLOW (SSO)
- FORCEMAIN
- EXISTING SANITARY SEWER
- MODEL CONDUIT
- IN-LINE SEWER MONITOR
- SCADA MONITOR

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

Scale: 0 250 500 1,000 Meters
1:38,000

Project:
Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title:
DRY WEATHER CALIBRATION SUMMARY - KINGSTON WEST JULY 23-26, 2014

Project No.:		Date:	
151-02944-00		DECEMBER 2016	
Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	WWM	I-5

CALIBRATION RESULTS:

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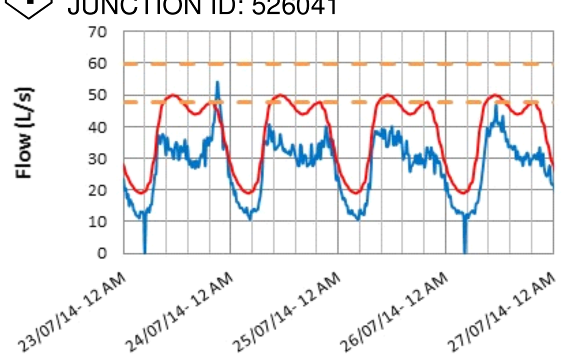
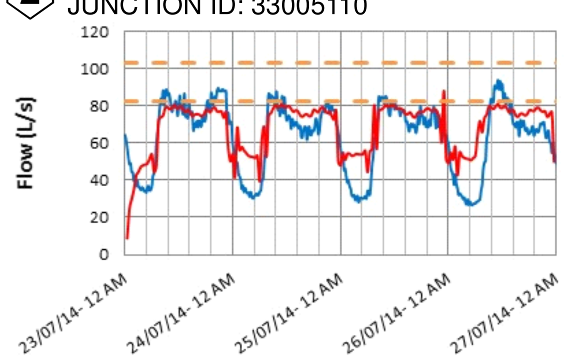
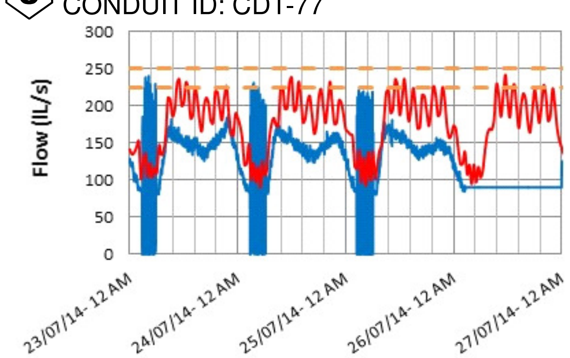
JUNCTION ID: 526041



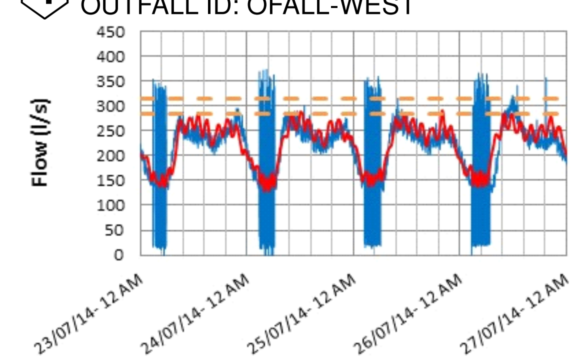
2 STATION W31 INFLOW
JUNCTION ID: 33005110



3 DAYS RD PS DISCHARGE
CONDUIT ID: CDT-77



4 CATARAQUI BAY WWTP INFLOW
OUTFALL ID: OFALL-WEST



- CALIBRATION TARGET RANGE
- COMPUTED (2014)
- ACTUAL

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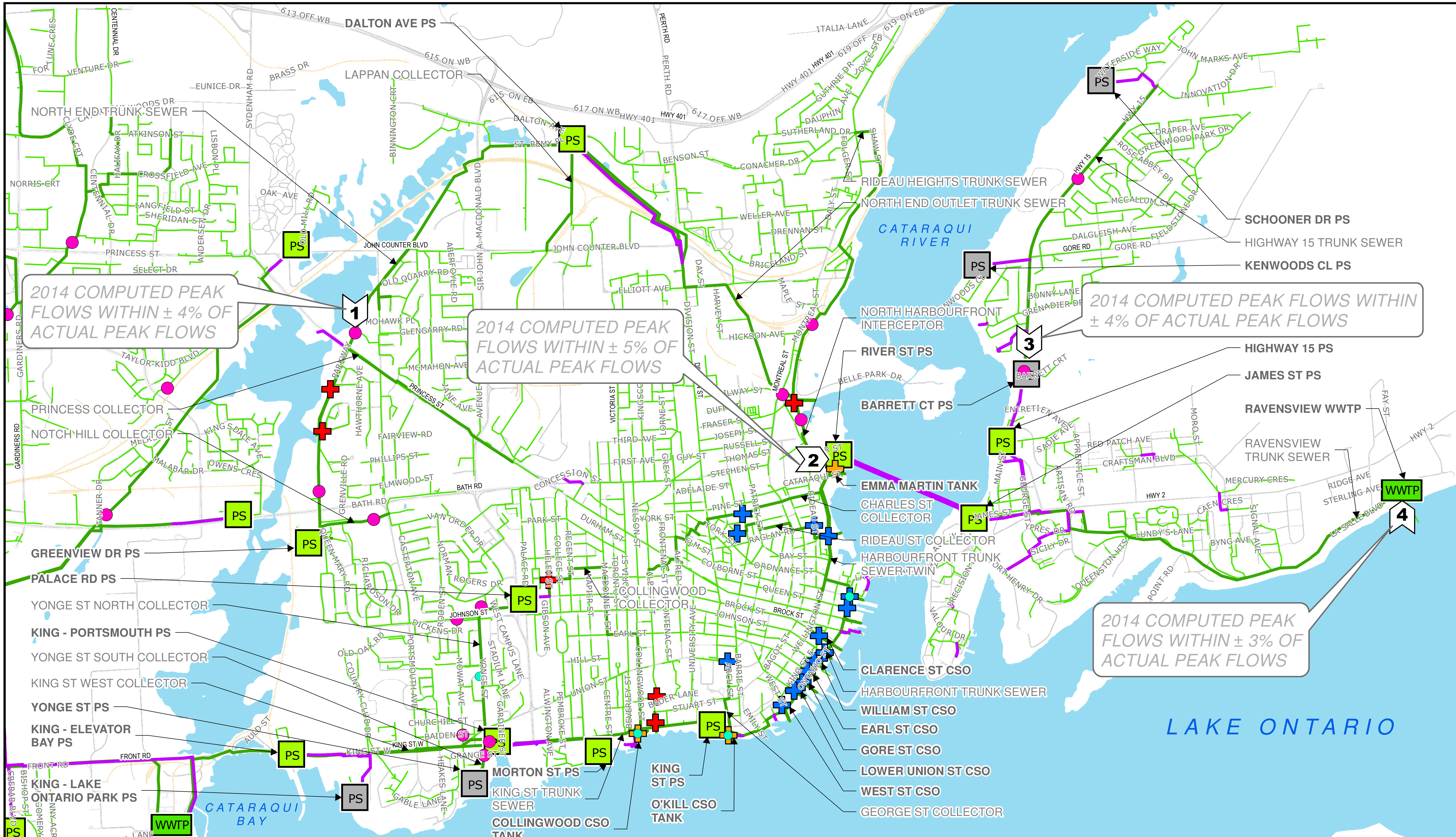

CALIBRATION RESULTS:

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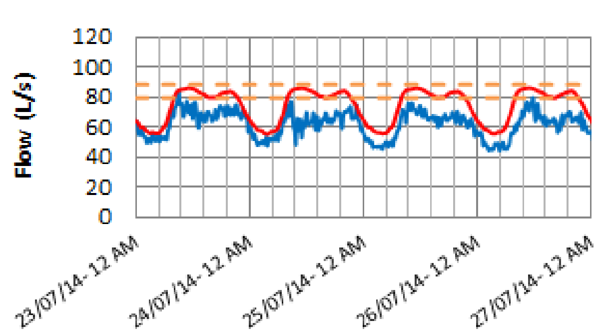
JUNCTION ID: 2285020



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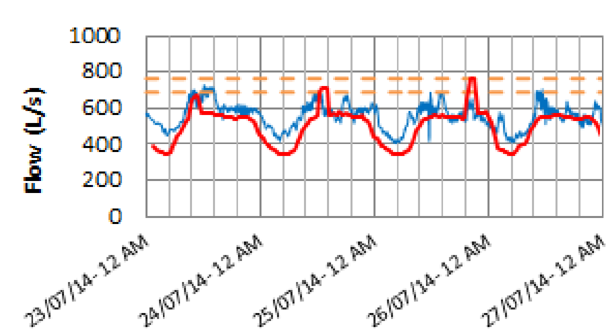
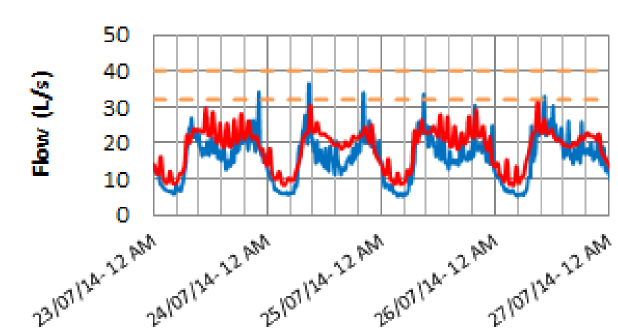
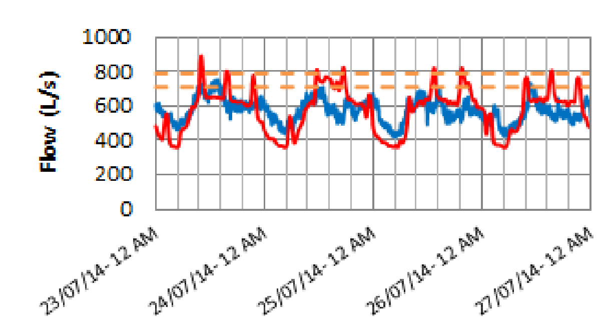
CONDUIT ID: CDT-39



3 STATION E1 INFLOW
JUNCTION ID: 630020



4 RAVENSVIEW WWTP INFLOW
OUTFALL ID: 01



- CALIBRATION TARGET RANGE
- COMPUTED (2014)
- ACTUAL

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Legend

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- WWTP — WASTEWATER TREATMENT PLANT
- PS — SANITARY PUMPING STATION WITH SCADA MONITOR
- PS — SANITARY PUMPING STATION
- COMBINED SEWER OVERFLOW (CSO)
- CSO CAPTURED BY TANK
- TANK OVERFLOW (TO)
- SANITARY SEWER OVERFLOW (SSO)
- FORCEMAIN
- EXISTING SANITARY SEWER
- MODEL CONDUIT
- IN-LINE SEWER MONITOR
- 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: 0 250 500 1,000 Meters
1:35,000

Project:
Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title: DRY WEATHER CALIBRATION SUMMARY - KINGSTON CENTRAL & EAST - JUNE 23-26, 2014

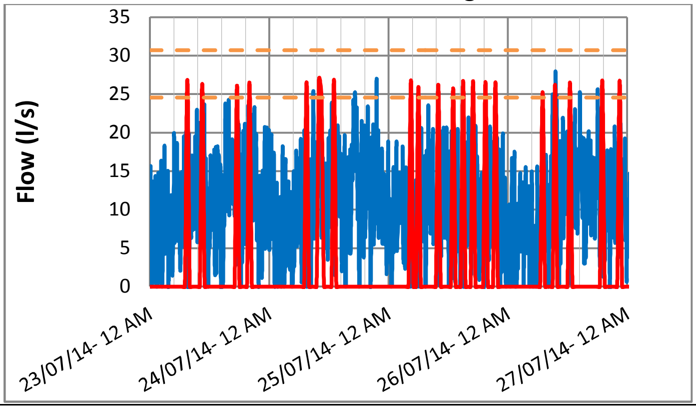
Project No.:		Date:	
151-02944-00		DECEMBER 2016	
Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	WWM	I-6

July 23-27, 2014 Event – Dry-Weather Events

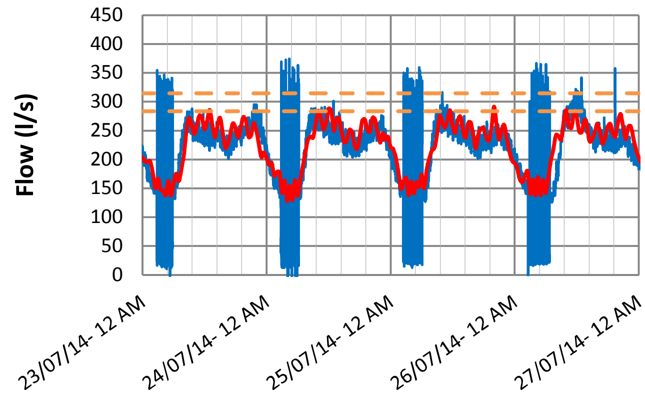
Actual   2014 Simulated   Calibration Range

Kingston West

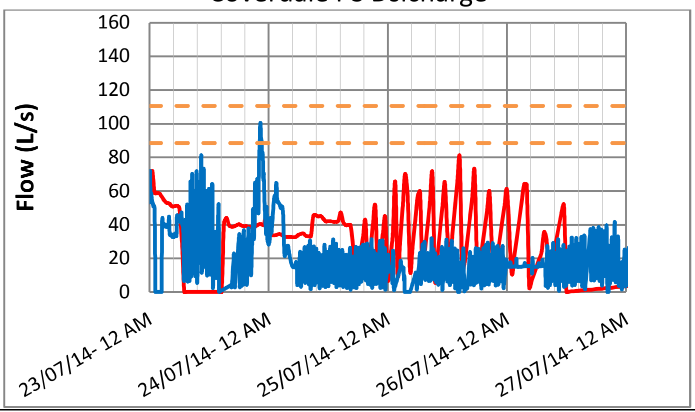
Bath Road PS Discharge



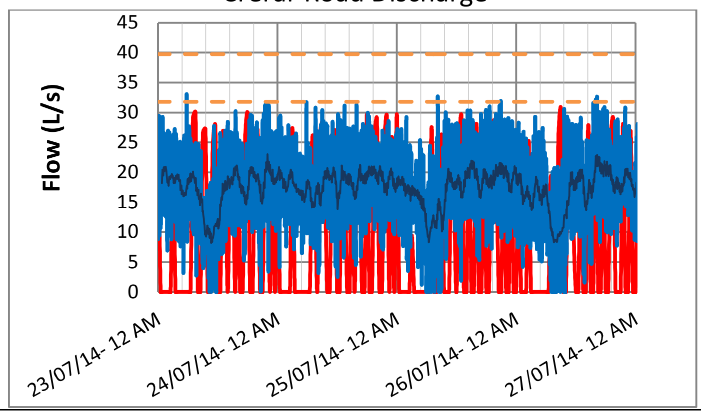
Cataraqui Bay WWTP Inflow



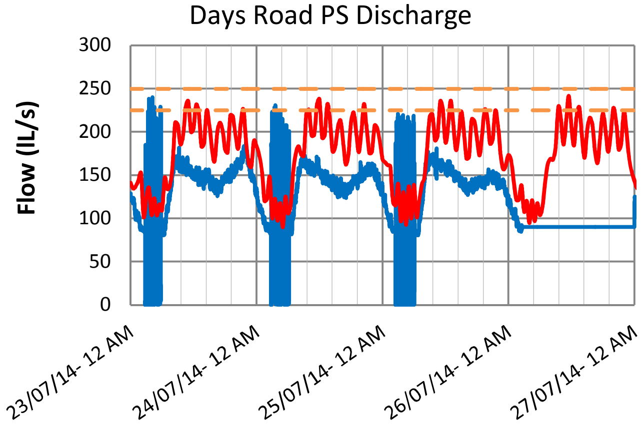
Coverdale PS Dsicharge



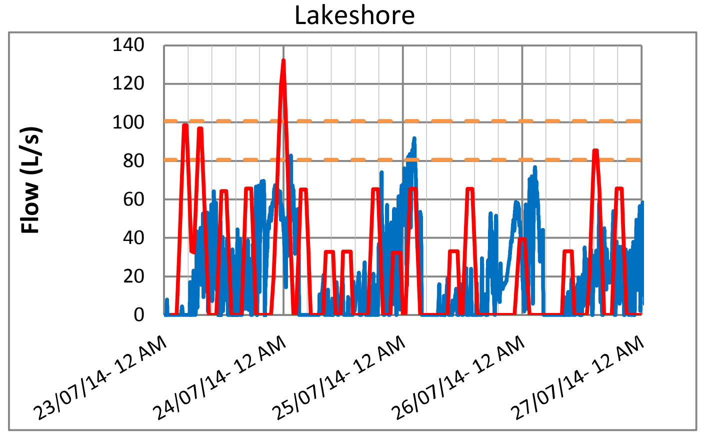
Crerar Road Discharge



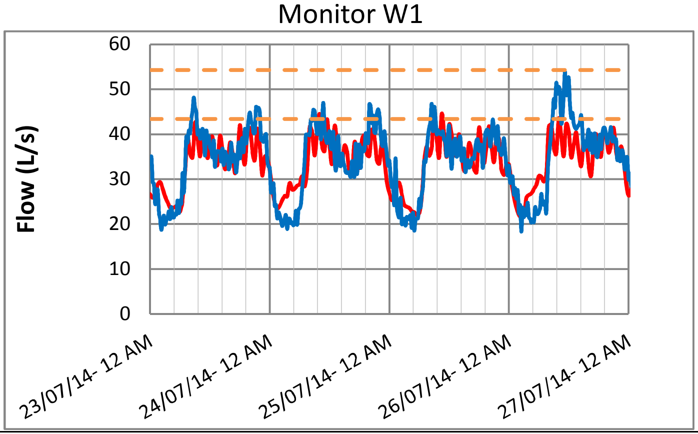
Days Road PS Discharge



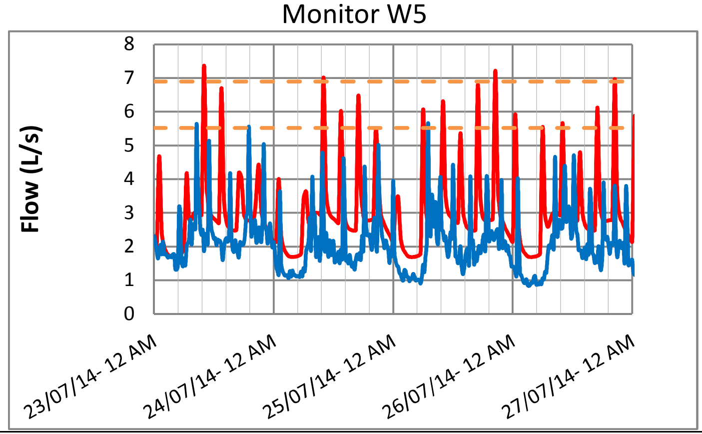
Lakeshore

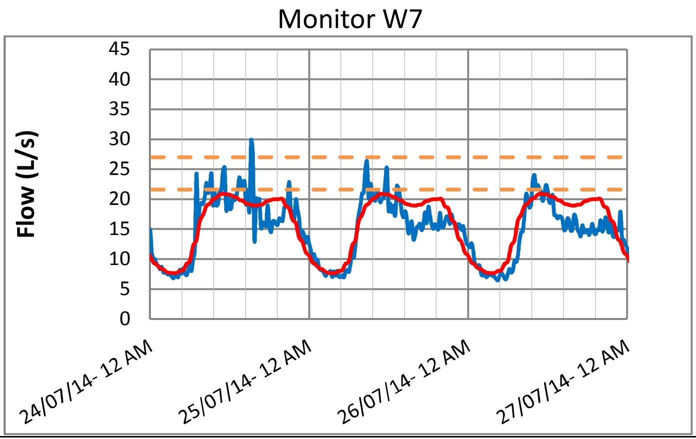


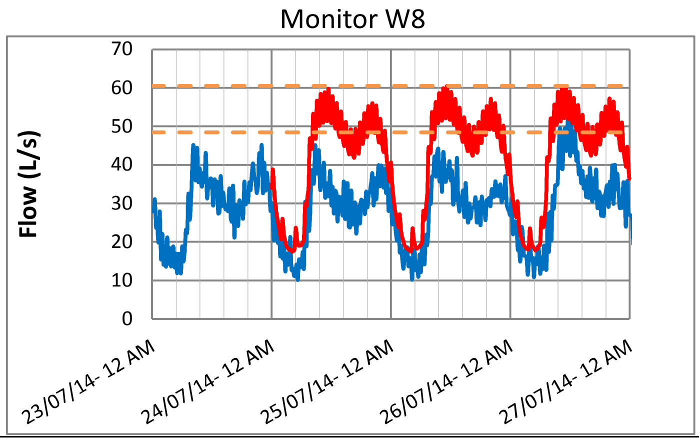
Monitor W1

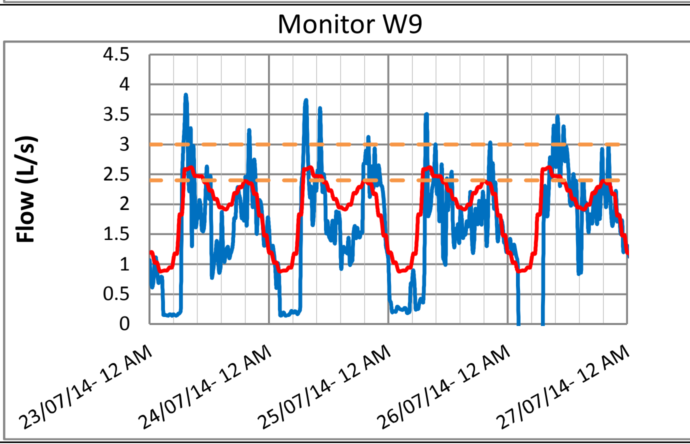


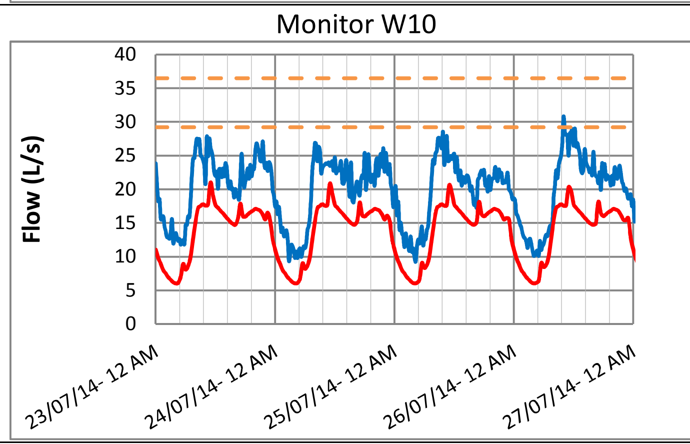
Monitor W5

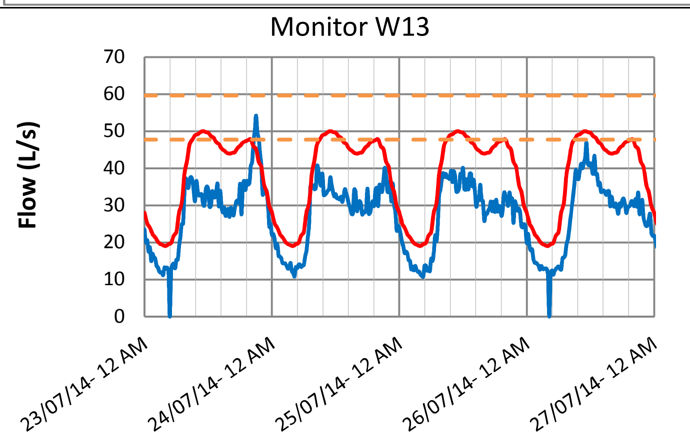


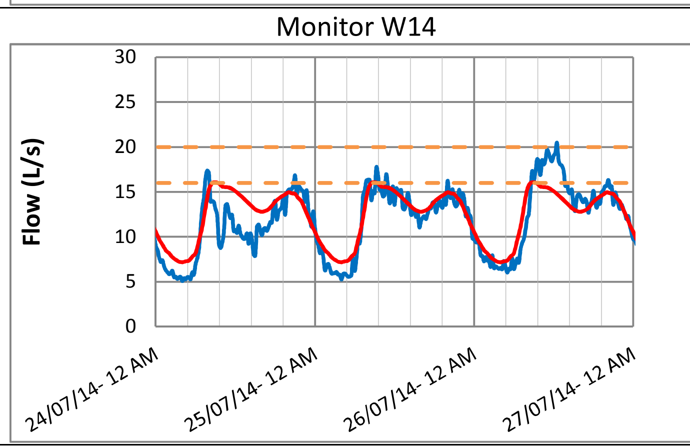

Monitor W7
Flow (L/s)
45
40
35
30
25
20
15
10
5
0
24/07/14- 12 AM
25/07/14- 12 AM
26/07/14- 12 AM
27/07/14- 12 AM

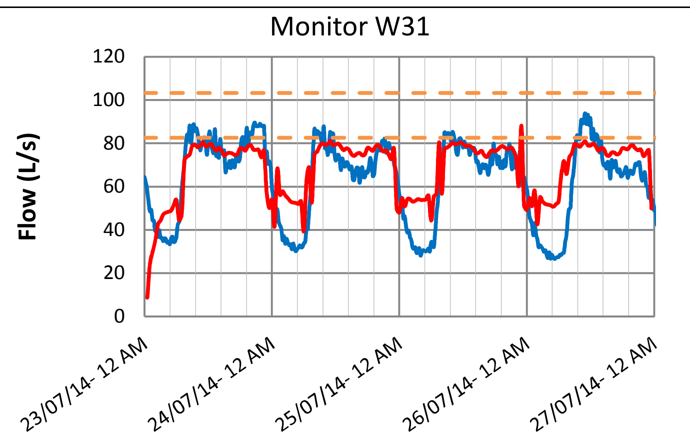

Monitor W8
Flow (L/s)
70
60
50
40
30
20
10
0
23/07/14- 12 AM
24/07/14- 12 AM
25/07/14- 12 AM
26/07/14- 12 AM
27/07/14- 12 AM

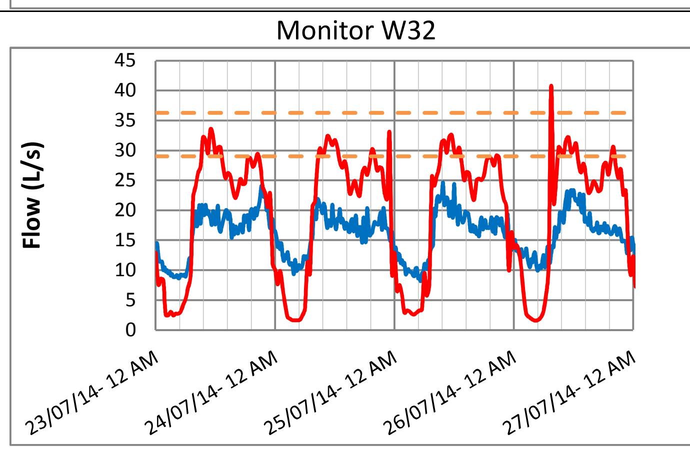

Monitor W9
Flow (L/s)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23/07/14- 12 AM
24/07/14- 12 AM
25/07/14- 12 AM
26/07/14- 12 AM
27/07/14- 12 AM


Monitor W10
Flow (L/s)
40
35
30
25
20
15
10
5
0
23/07/14- 12 AM
24/07/14- 12 AM
25/07/14- 12 AM
26/07/14- 12 AM
27/07/14- 12 AM


Monitor W13
Flow (L/s)
70
60
50
40
30
20
10
0
23/07/14- 12 AM
24/07/14- 12 AM
25/07/14- 12 AM
26/07/14- 12 AM
27/07/14- 12 AM

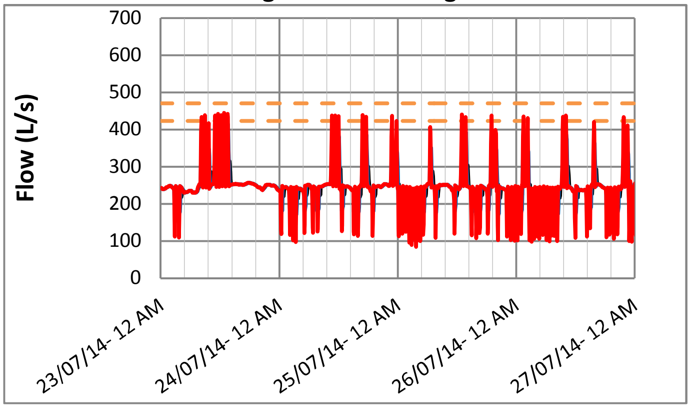

Monitor W14
Flow (L/s)
30
25
20
15
10
5
0
24/07/14- 12 AM
25/07/14- 12 AM
26/07/14- 12 AM
27/07/14- 12 AM


Monitor W31
Flow (L/s)
120
100
80
60
40
20
0
23/07/14- 12 AM
24/07/14- 12 AM
25/07/14- 12 AM
26/07/14- 12 AM
27/07/14- 12 AM

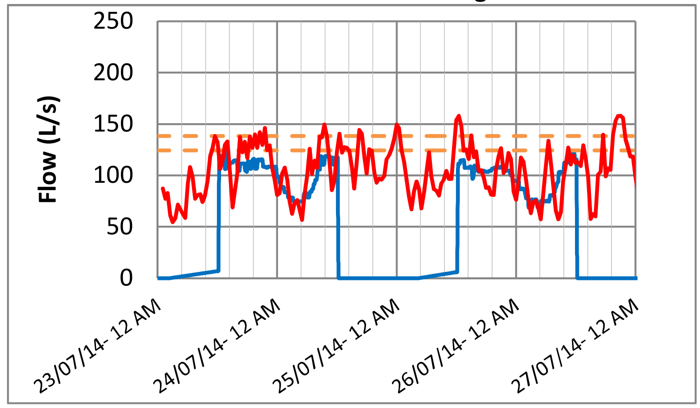

Monitor W32
Flow (L/s)
45
40
35
30
25
20
15
10
5
0
23/07/14- 12 AM
24/07/14- 12 AM
25/07/14- 12 AM
26/07/14- 12 AM
27/07/14- 12 AM

Kingston Central/East

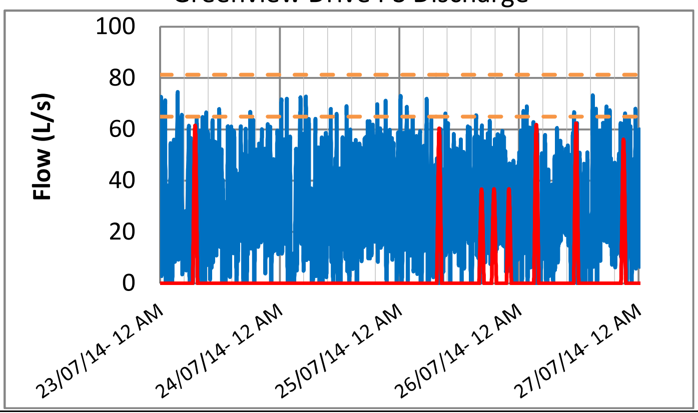
King St. PS Discharge



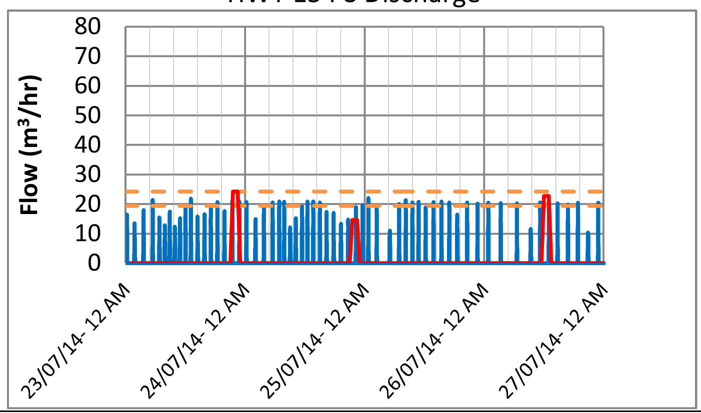
Dalton Ave. PS Discharge



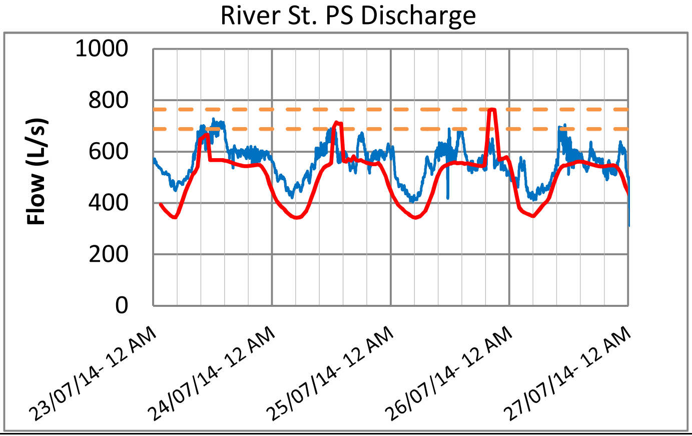
Greenview Drive PS Discharge



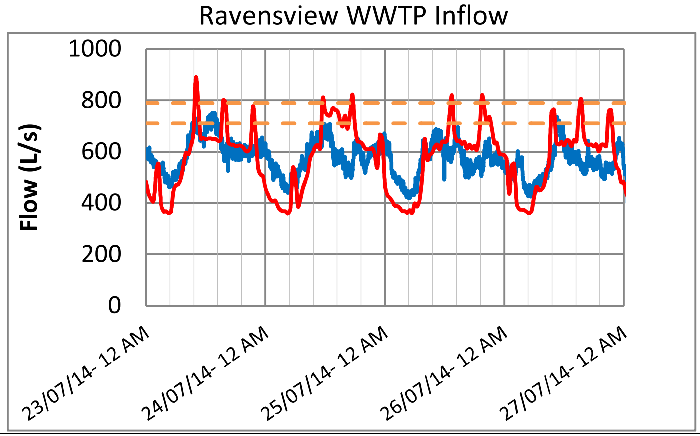
HWY 15 PS Discharge



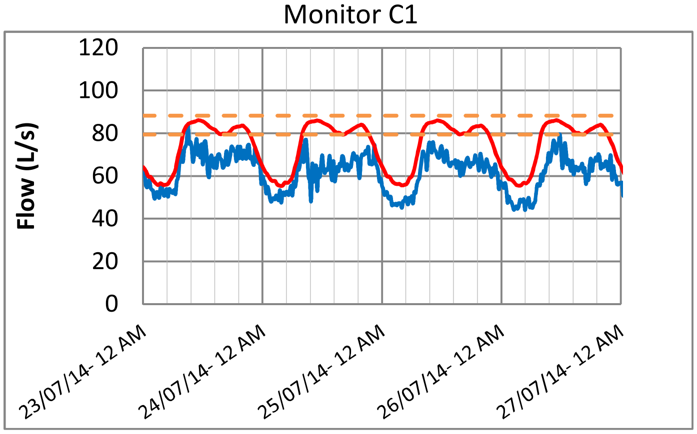
River St. PS Discharge



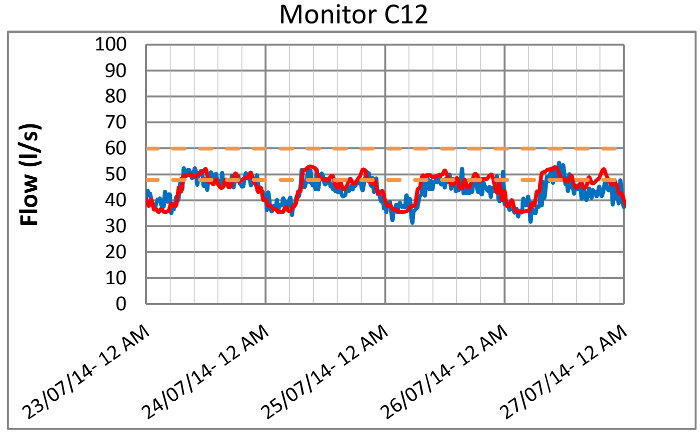
Ravensview WWTP Inflow

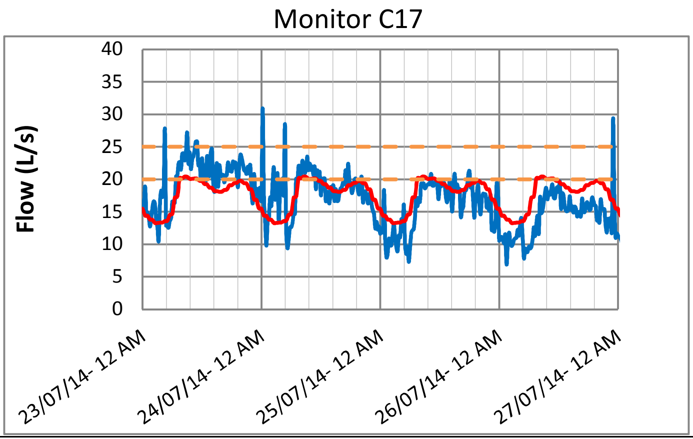


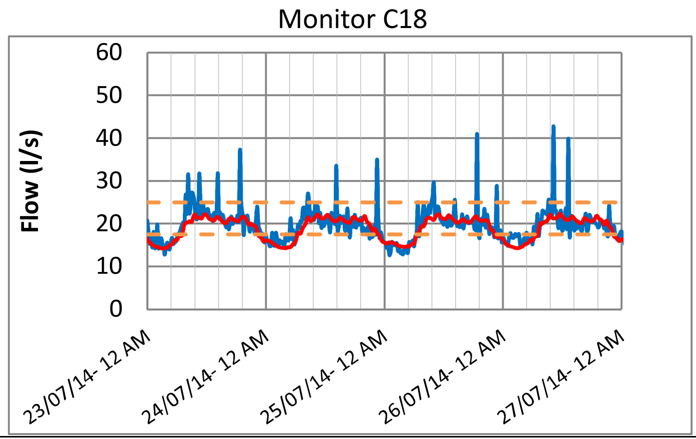
Monitor C1

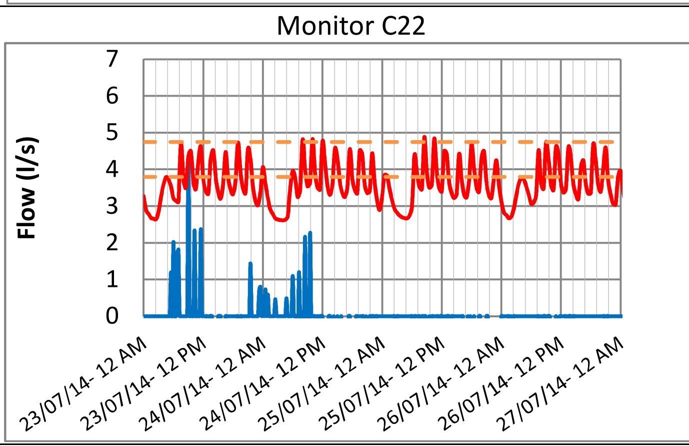


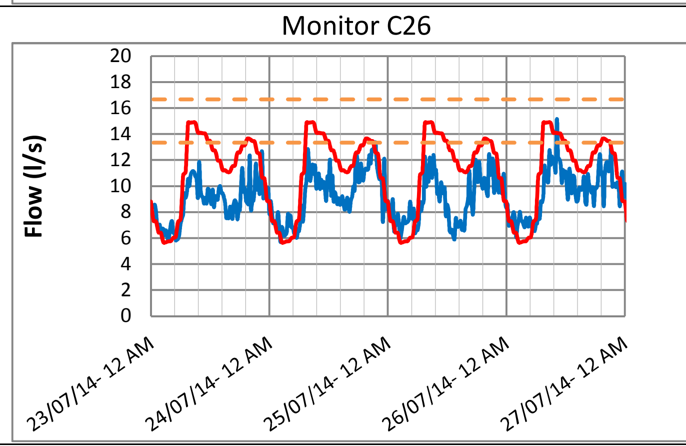
Monitor C12

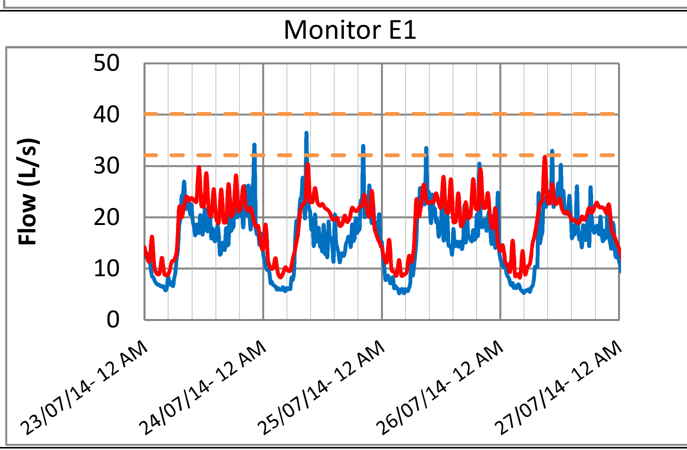


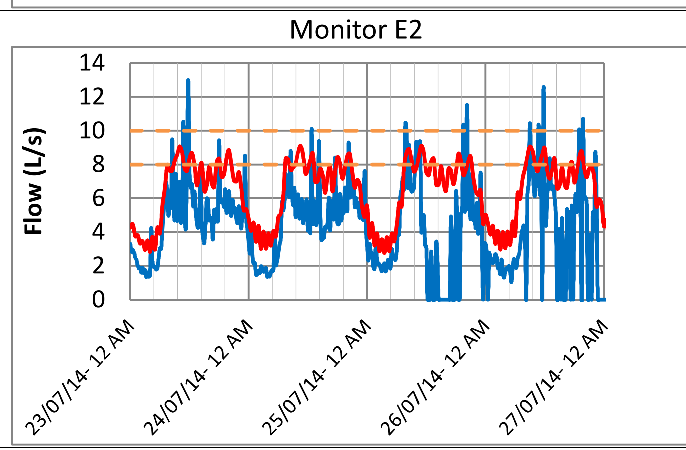

Monitor C17
Flow (L/s)
0
5
10
15
20
25
30
35
40
23/07/14- 12 AM
24/07/14- 12 AM
25/07/14- 12 AM
26/07/14- 12 AM
27/07/14- 12 AM

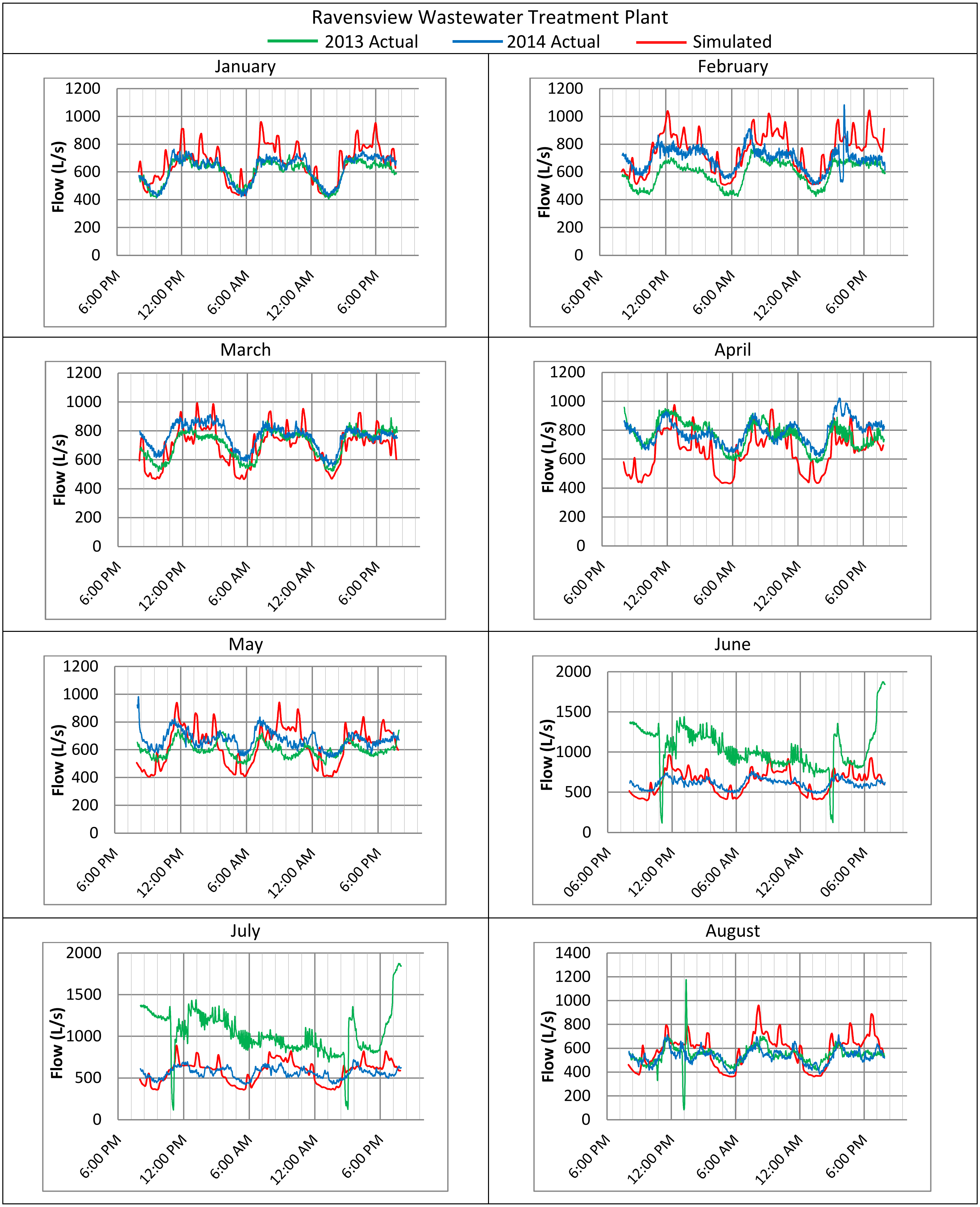

Monitor C18
Flow (l/s)
0
10
20
30
40
50
60
23/07/14- 12 AM
24/07/14- 12 AM
25/07/14- 12 AM
26/07/14- 12 AM
27/07/14- 12 AM

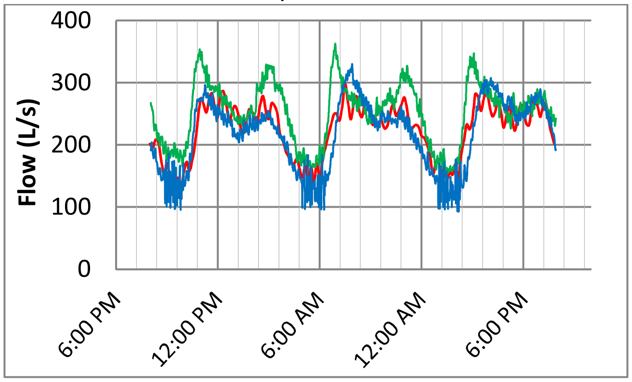

Monitor C22
Flow (l/s)
0
1
2
3
4
5
6
7
23/07/14- 12 AM
23/07/14- 12 PM
24/07/14- 12 AM
24/07/14- 12 PM
25/07/14- 12 AM
25/07/14- 12 PM
26/07/14- 12 AM
26/07/14- 12 PM
27/07/14- 12 AM

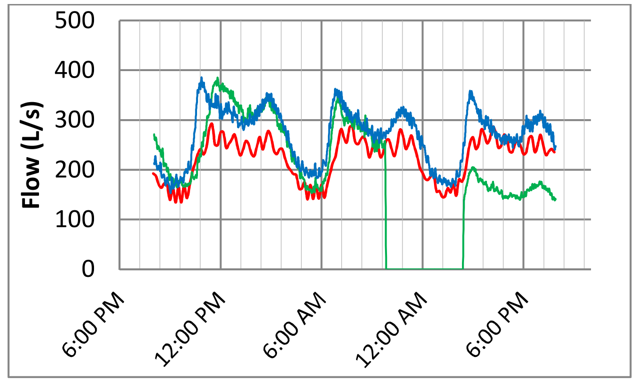

Monitor C26
Flow (l/s)
0
2
4
6
8
10
12
14
16
18
20
23/07/14- 12 AM
24/07/14- 12 AM
25/07/14- 12 AM
26/07/14- 12 AM
27/07/14- 12 AM

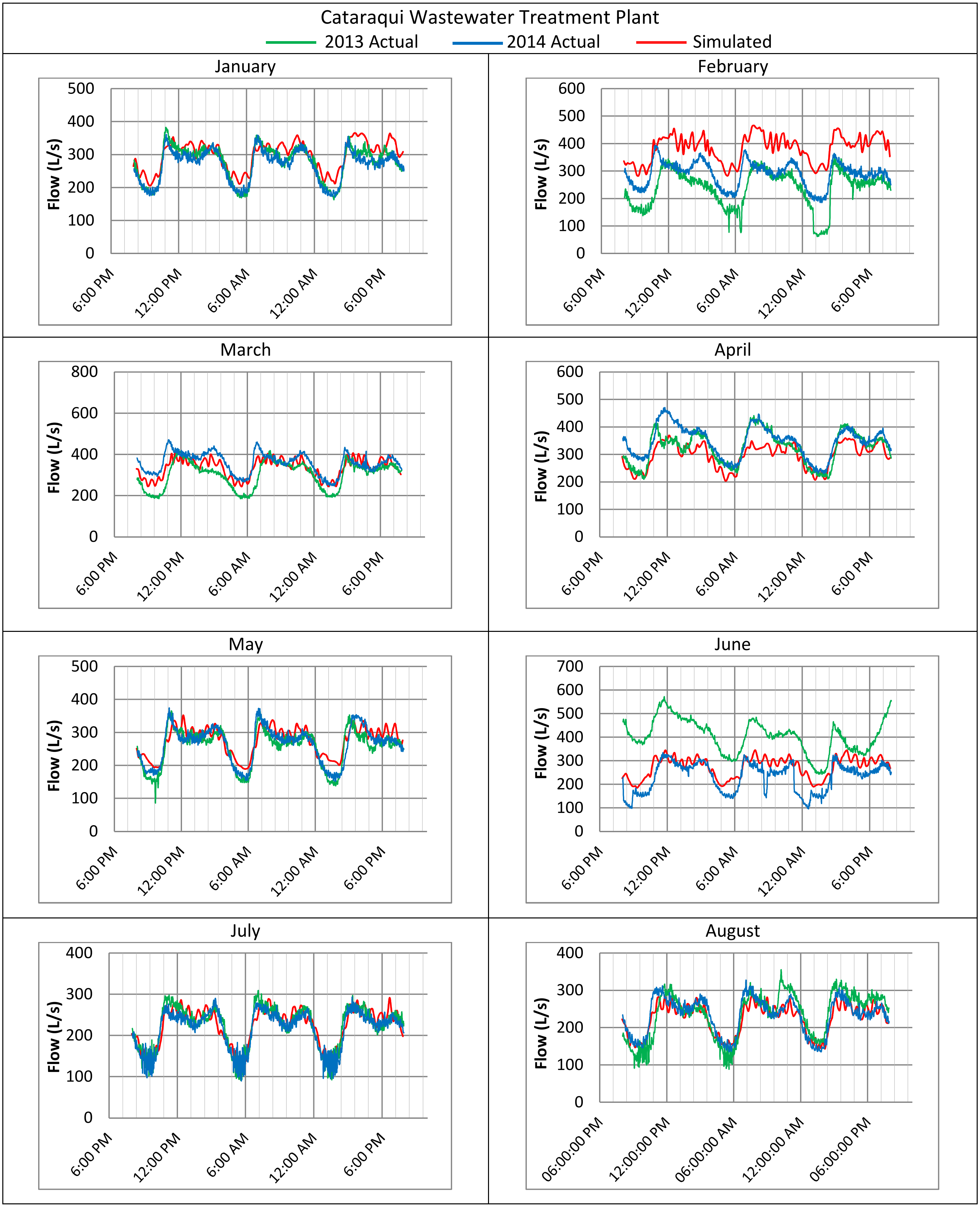

Monitor E1
Flow (L/s)
0
10
20
30
40
50
23/07/14- 12 AM
24/07/14- 12 AM
25/07/14- 12 AM
26/07/14- 12 AM
27/07/14- 12 AM

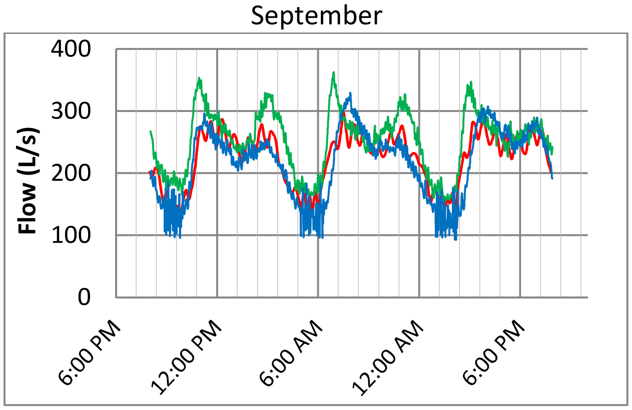

Monitor E2
Flow (L/s)
0
2
4
6
8
10
12
14
23/07/14- 12 AM
24/07/14- 12 AM
25/07/14- 12 AM
26/07/14- 12 AM
27/07/14- 12 AM

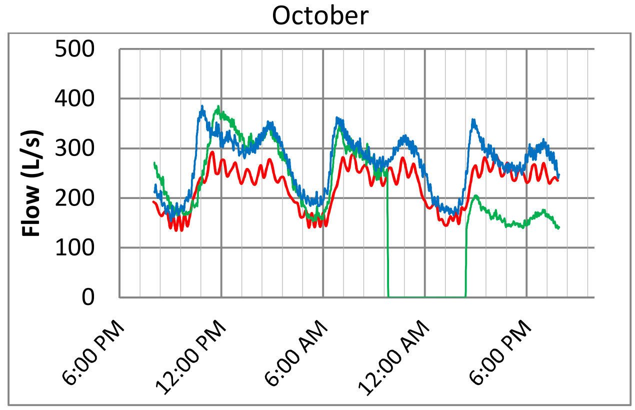

Ravensview Wastewater Treatment Plant
2013 Actual
2014 Actual
Simulated
January
February
March
April
May
June
July
August
Flow (L/s)
6:00 PM
12:00 PM
6:00 AM
12:00 AM
06:00 PM
06:00 AM
0
200
400
600
800
1000
1200
1400
500
1500
2000


September
Flow (L/s)
400
300
200
100
0
6:00 PM
12:00 PM
6:00 AM
12:00 AM
6:00 PM


October
Flow (L/s)
500
400
300
200
100
0
6:00 PM
12:00 PM
6:00 AM
12:00 AM
6:00 PM


Cataraqui Wastewater Treatment Plant
2013 Actual
2014 Actual
Simulated
January
February
March
April
May
June
July
August
Flow (L/s)
6:00 PM
12:00 PM
6:00 AM
12:00 AM
06:00:00 PM
12:00:00 PM
06:00:00 AM
12:00:00 AM


September
Flow (L/s)
400
300
200
100
0
6:00 PM
12:00 PM
6:00 AM
12:00 AM
6:00 PM


October
Flow (L/s)
500
400
300
200
100
0
6:00 PM
12:00 PM
6:00 AM
12:00 AM
6:00 PM

Appendix J

WET-WEATHER CALIBRATION RESULTS AND SUMMARY

Appendix J – Contents

Combined Sewer Catchment Area Update

RDII R-T-K Plot Summaries for Input into InfoSWMM

J-1 Wet Weather Calibration Summary – Kingston West
August 9-16, 2014

J-2 Wet Weather Calibration Summary – Kingston Central/East
August 9-16, 2014

J-3 CSO Calibration Summary – August 10-16, 2014

Wet-Weather Calibration Period Data Summary and Result Graphs

Subcatch ID	OUTLET	AREA (hc) 2014	AREA (hc) 2015	AREA (hc) 2021	AREA (hc) 2026	AREA (hc) 2036	AREA (hc) Build-Out	AREA (hc) Ultimate	IMPERV	WIDTH (m)
COM_COKL10	4803002	3.577	3.577	3.577	0	0	0	0	33.284	120
COM_COKL09	4602010	10.989	10.989	10.989	10.389	10.389	0	0	41.918	250
COM_COKL08	42020	6.931	6.931	6.931	6.23	0	0	0	55	110
COM_COKL07	41020	0.573	0.573	0.573	0	0	0	0	62.5	75
COM_COKL05	39130	2.278	2.278	0	0	0	0	0	25.4	140
COM_COKL04B	9502030	1.31	1.31	1.31	1.31	1.31	0	0	58.728	90
COM_COKL04	9502030	12.486	12.486	12.486	11.179	6.45	0	0	55.673	250
COM_COKL02	34050	0.928	0.928	0.928	0	0	0	0	62.46	100
COM_COKL01L	5002010	1.119	1.119	0	0	0	0	0	95	100
COM_COKL01J	5052100	2.472	2.472	0	0	0	0	0	50	100
COM_COKL01I	5004010	0.62	0.62	0	0	0	0	0	25	100
COM_COKL01H	9802010	0.935	0.935	0.935	0.935	0.935	0	0	71.433	100
COM_COKL01G	9802010	1.034	1.034	1.034	1.034	0	0	0	45.296	100
COM_COKL01F	9802030	1.219	1.219	1.219	1.219	0	0	0	63.044	100
COM_COKL01E	5004030	1.499	1.499	0	0	0	0	0	90	100
COM_COKL01D	9802030	21.236	0	0	0	0	0	0	75	100
COM_COKL01C	5003030	22.119	22.119	5.818	2.71	2.713	0	0	65	100
COM_COKL01B	5052100	2.468	2.468	2.468	2.468	0	0	0	46.149	100
COM_COKL01	34030	3.058	0	0	0	0	0	0	90	100
COM_CNEO02C	9227020	4.865	4.865	0	0	0	0	0	37.4	90
COM_CNEO02B	9227020	0.142	0.142	0.142	0	0	0	0	25	25
COM_CNEO02A	9227020	9.83	9.83	0	0	0	0	0	41.935	320
COM_CHRB23	6051031	0.286	0.286	0.286	0.286	0.286	0	0	56.52	60
COM_CHRB22	6052020	8.517	8.517	8.517	8.517	8.517	0	0	19.065	270
COM_CHRB20	6151050	4.141	4.141	4.141	4.141	4.141	0	0	19.222	140
COM_CHRB19	6251040	6.439	6.439	6.439	6.439	6.439	0	0	53.342	100
COM_CHRB18	6351020	3.452	3.452	0	0	0	0	0	75.687	100
COM_CHRB17	6451050	6.259	6.259	6.259	6.259	6.259	0	0	47.432	100
COM_CHRB16	6551030	8.125	8.125	8.125	8.125	0	0	0	66.268	120
COM_CHRB15	1010	0.934	0.934	0.934	2	0	0	0	50.179	110

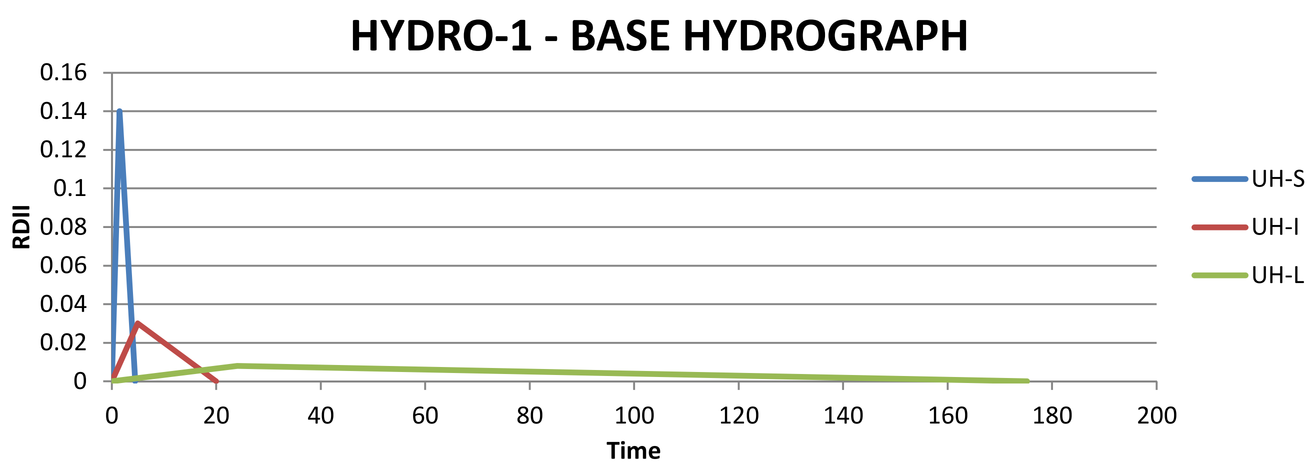
Subcatch ID	OUTLET	AREA (hc) 2014	AREA (hc) 2015	AREA (hc) 2021	AREA (hc) 2026	AREA (hc) 2036	AREA (hc) Build-Out	AREA (hc) Ultimate	IMPERV	WIDTH (m)
COM_CHRB14	6752020	6	6	1.603	1.603	0	0	0	98.741	120
COM_CHRB13	4010	1.589	1.589	0	0	0	0	0	94.008	80
COM_CHRB12	5010	0.304	0.304	0.304	0.304	0	0	0	92.965	100
COM_CHRB11	9101010	1.564	1.564	0	0	0	0	0	90	70
COM_CHRB05	7105020	4.896	4.896	4.896	4.896	0	0	0	54.349	130
COM_CHRB03D	7455035	1.125	1.125	1.125	1.125	1.125	0	0	72.25	100
COM_CHRB03C	7456-015	3.985	3.985	3.985	3.985	3.985	0	0	62.5	100
COM_CHRB03B	7558025	1.763	1.763	1.763	1.763	1.763	0	0	62.5	100
COM_CHRB03	7608010	0.68	0.68	0.68	0	0	0	0	46.381	150
COM_CHRB02B	9916020	0.701	0.701	0.701	0	0	0	0	44.5	100
COM_CHRB02	9413020	2.212	2.212	2.212	2.212	0	0	0	59.747	200
COM_CHRB01	7954110	2.007	2.007	2.007	0	0	0	0	40.363	150
COM_CHBT03	7101110	10.702	10.702	4.828	0.583	0	0	0	68.559	150
COM_CHBT02B	7102110	0.294	0.294	0	0	0	0	0	0.9	100
COM_CHBT02A	7102110	0.643	0.643	0	0	0	0	0	41.202	20
COM_CHBT02	7102110	0.643	0.643	0	0	0	0	0	41.2	20
COM_CHBT01	7054110	2.175	2.175	2.175	0	0	0	0	90	130
COM_CCOL07	5259010	2.338	2.338	2.338	0	0	0	0	36.995	210
COM_CCOL06	5259010	0.149	0.149	0.149	0	0	0	0	57.592	40
COM_CCOL05	5405020	1.256	1.256	1.256	0	0	0	0	88.482	120
COM_CCOL04	5404050	2.519	2.519	2.519	0	0	0	0	45.92	120
COM_CCOL03	5404010	1.08	1.08	1.08	0	0	0	0	45.295	100

Unit Hydrograph Selection

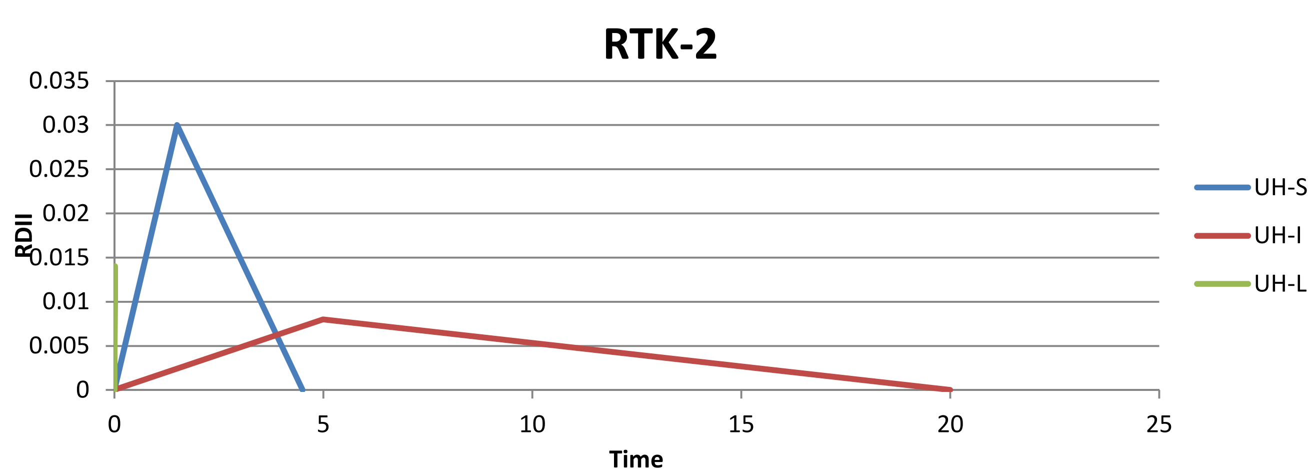
Definitions	
R	the fraction of rainfall volume that enters the sewer system
T	the time from the onset of rainfall to the peak of the unit hydrograph (UH) in hours
K	the ratio of time to recession of the UH to the time to peak

Unit Hydrograph Selection

HYDRO-1: Base Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.14	R_M =	0.03	R_L =	0.008
T_S =	1.5	T_M =	5	T_L =	24
K_S =	2	K_M =	3	K_L =	6.3
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

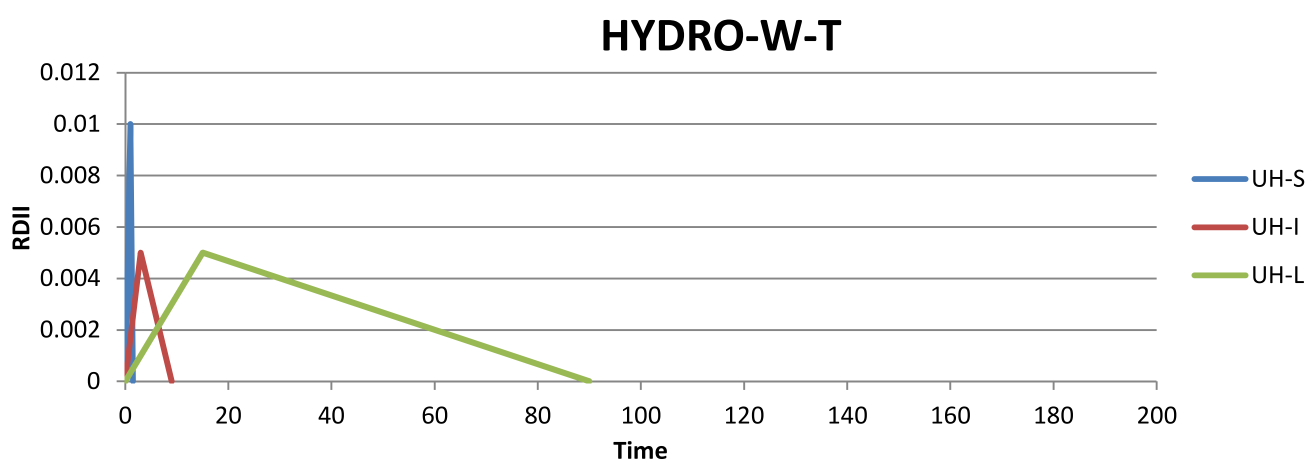


RTK-2: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.03	R_M =	0.008	R_L =	0.014
T_S =	1.5	T_M =	5	T_L =	24
K_S =	2	K_M =	3	K_L =	6.3
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	

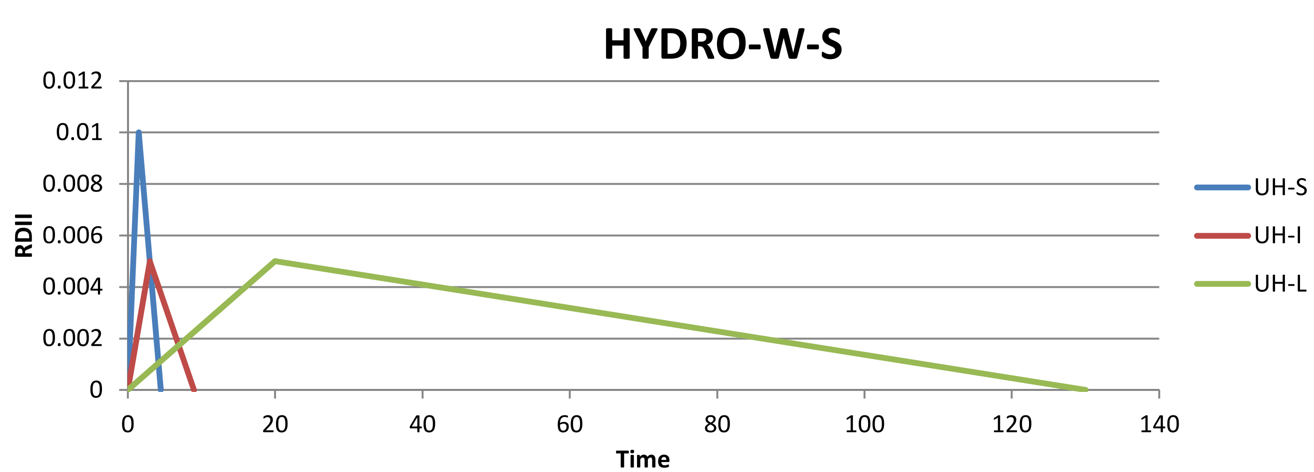


Unit Hydrograph Selection

HYDRO-W-T: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.01	R_M =	0.005	R_L =	0.005
T_S =	1	T_M =	3	T_L =	15
K_S =	1.5	K_M =	2	K_L =	5
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

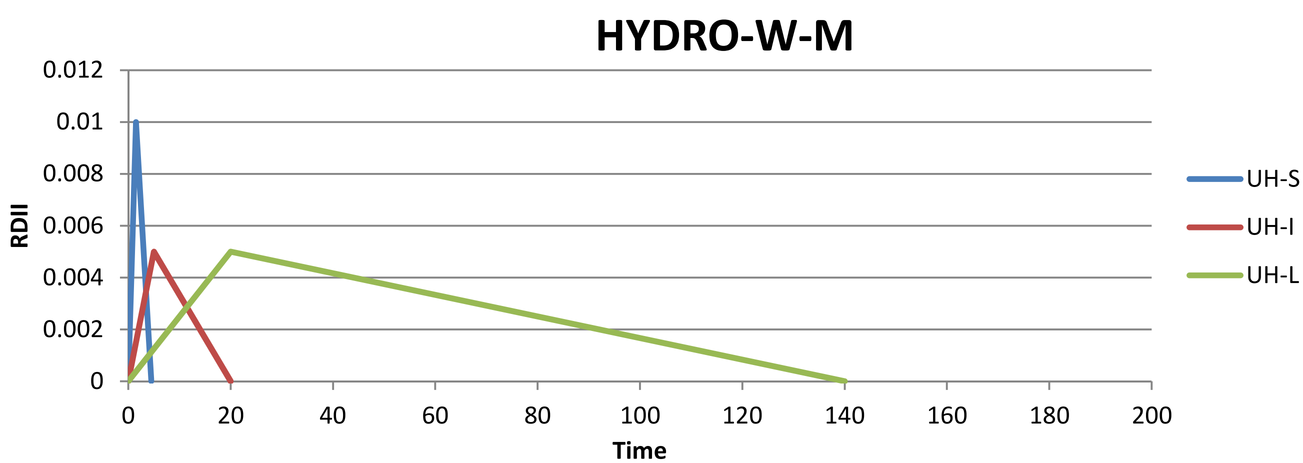


HYDRO-W-S: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.01	R_M =	0.005	R_L =	0.005
T_S =	1.5	T_M =	3	T_L =	20
K_S =	2	K_M =	2	K_L =	5.5
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

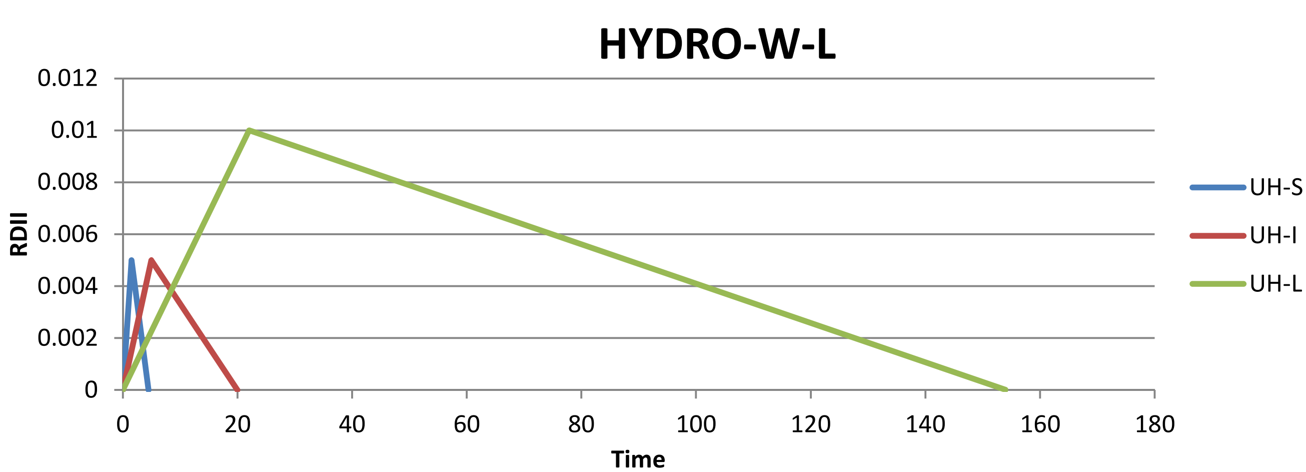


Unit Hydrograph Selection

HYDRO-W-M: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.01	R_M =	0.005	R_L =	0.005
T_S =	1.5	T_M =	5	T_L =	20
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

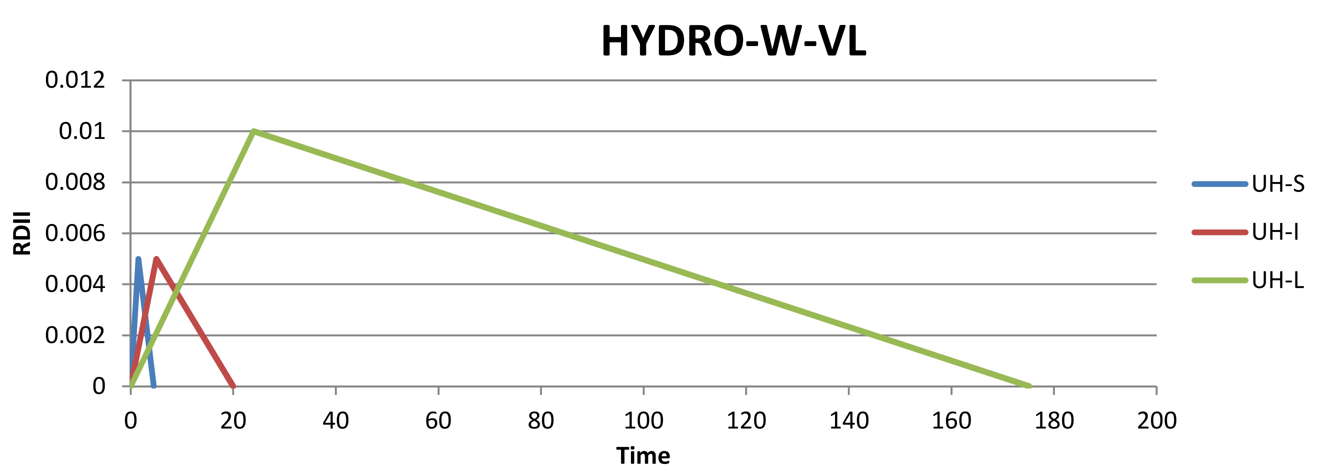


HYDRO-W-L: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.005	R_M =	0.005	R_L =	0.01
T_S =	1.5	T_M =	5	T_L =	22
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

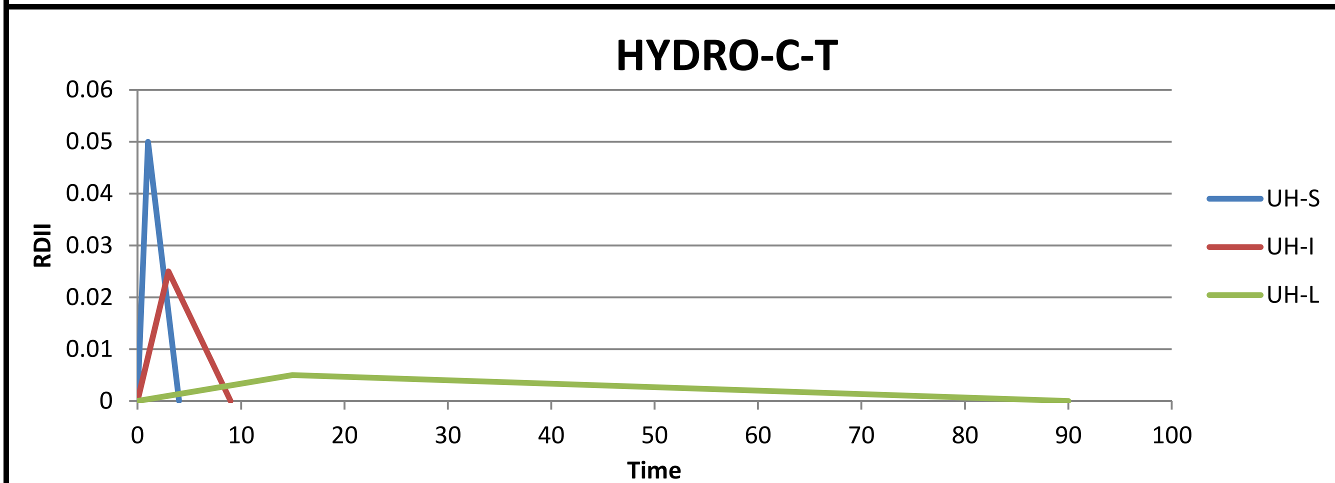


Unit Hydrograph Selection

HYDRO-W-VL: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.005	R_M =	0.005	R_L =	0.01
T_S =	1.5	T_M =	5	T_L =	24
K_S =	2	K_M =	3	K_L =	6.3
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

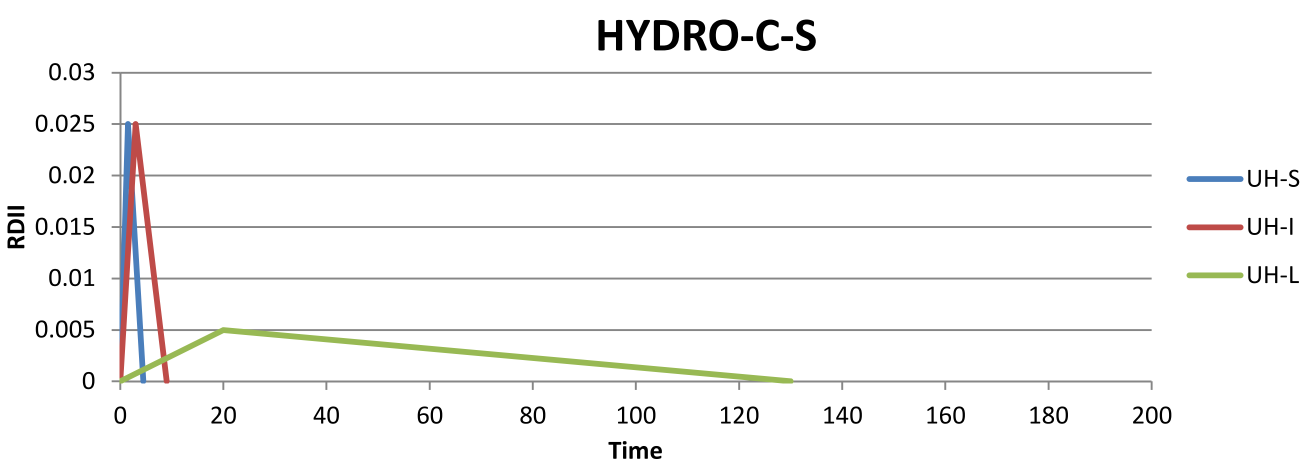


HYDRO-C-T1: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.05	R_M =	0.025	R_L =	0.005
T_S =	1	T_M =	3	T_L =	15
K_S =	3	K_M =	2	K_L =	5
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

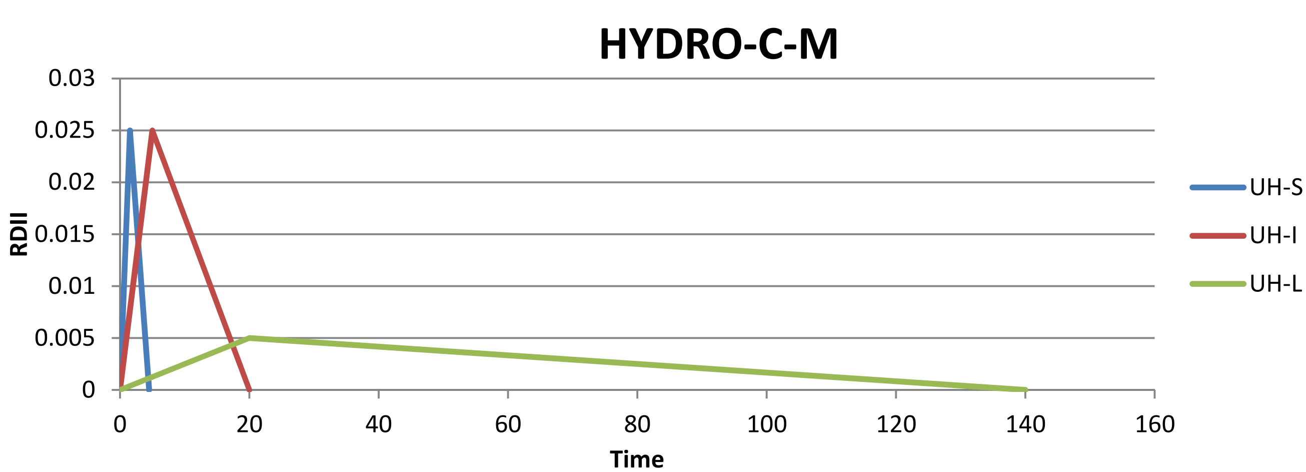


Unit Hydrograph Selection

HYDRO-W-S: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.025	R_M =	0.025	R_L =	0.005
T_S =	1.5	T_M =	3	T_L =	20
K_S =	2	K_M =	2	K_L =	5.5
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

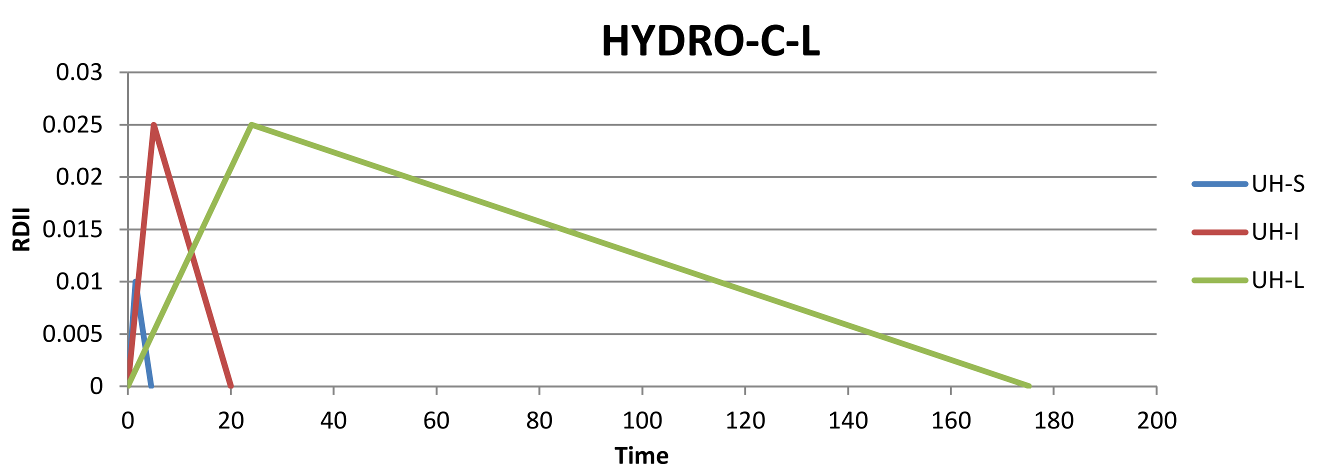


HYDRO-C-M: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.025	R_M =	0.025	R_L =	0.005
T_S =	1.5	T_M =	5	T_L =	20
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

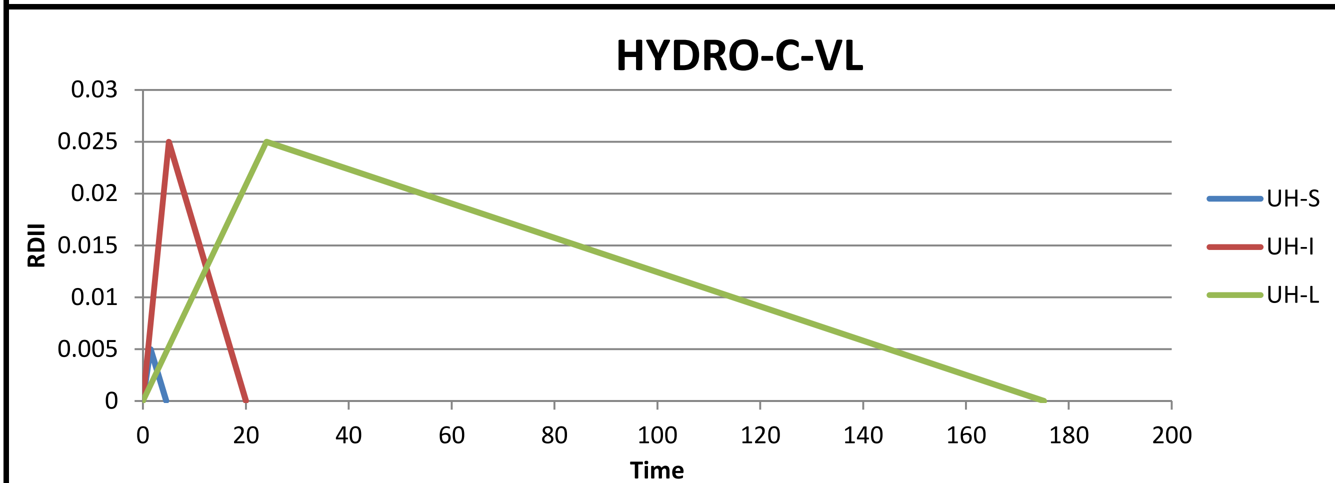


Unit Hydrograph Selection

HYDRO-W-L: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.01	R_M =	0.025	R_L =	0.025
T_S =	1.5	T_M =	5	T_L =	24
K_S =	2	K_M =	3	K_L =	6.3
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

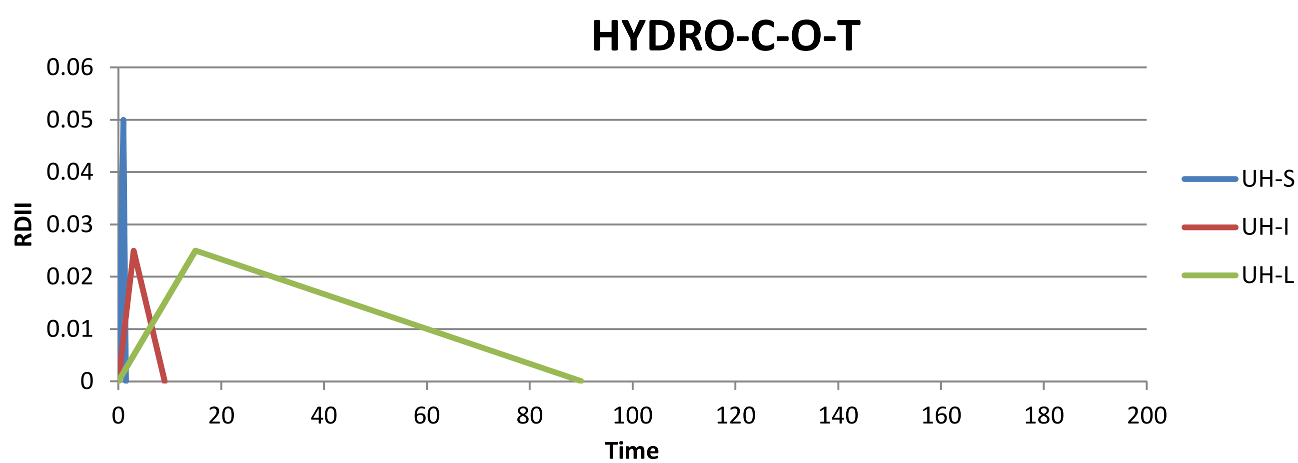


HYDRO-C-VL: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.005	R_M =	0.025	R_L =	0.025
T_S =	1.5	T_M =	5	T_L =	24
K_S =	2	K_M =	3	K_L =	6.3
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

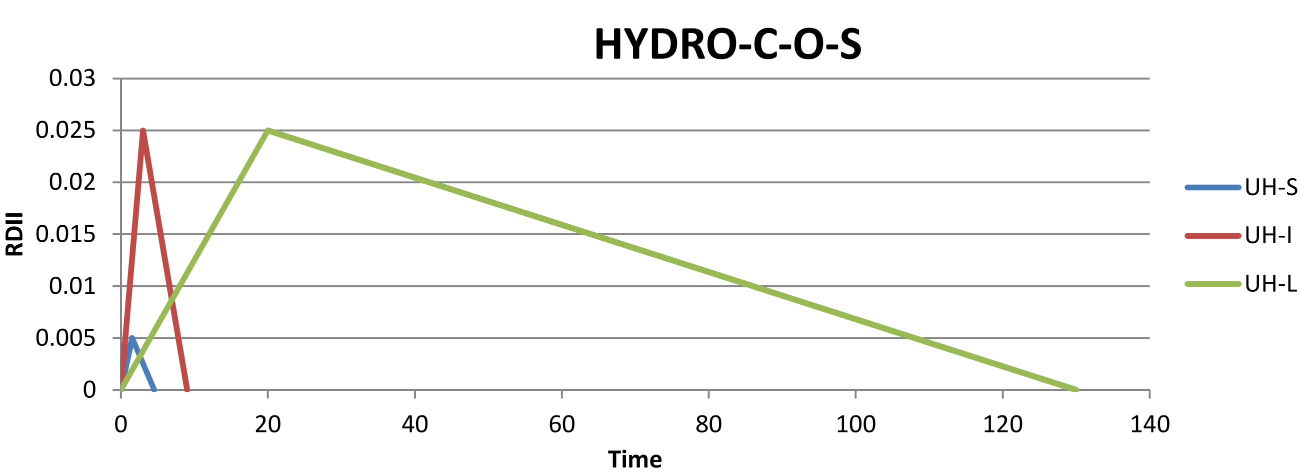


Unit Hydrograph Selection

HYDRO-C-O-T: Unit Hydrograph					
UH-S: Short-Term		**UH-I: Intermediate-Term**		**UH-L: Long-Term**	
R_S =	0.05	R_M =	0.025	R_L =	0.025
T_S =	1	T_M =	3	T_L =	15
K_S =	1.5	K_M =	2	K_L =	5
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

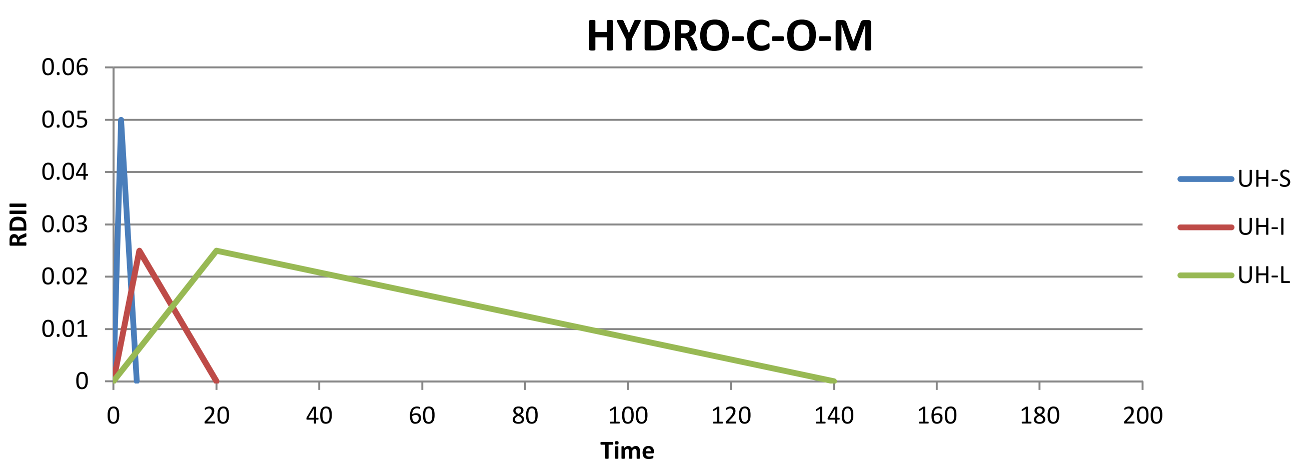


HYDRO-C-O-S: Unit Hydrograph					
UH1: Short-Term		**UH2: Medium-Term**		**UH3: Long-Term**	
R_S =	0.005	R_M =	0.025	R_L =	0.025
T_S =	1.5	T_M =	3	T_L =	20
K_S =	2	K_M =	2	K_L =	5.5
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

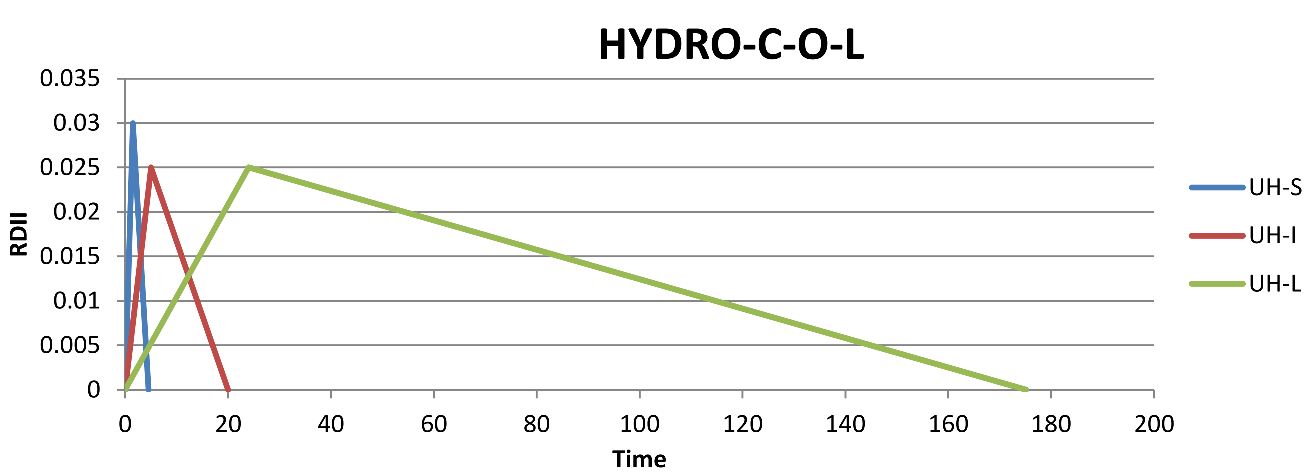


Unit Hydrograph Selection

HYDRO-C-O-M: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.05	R_M =	0.025	R_L =	0.025
T_S =	1.5	T_M =	5	T_L =	20
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

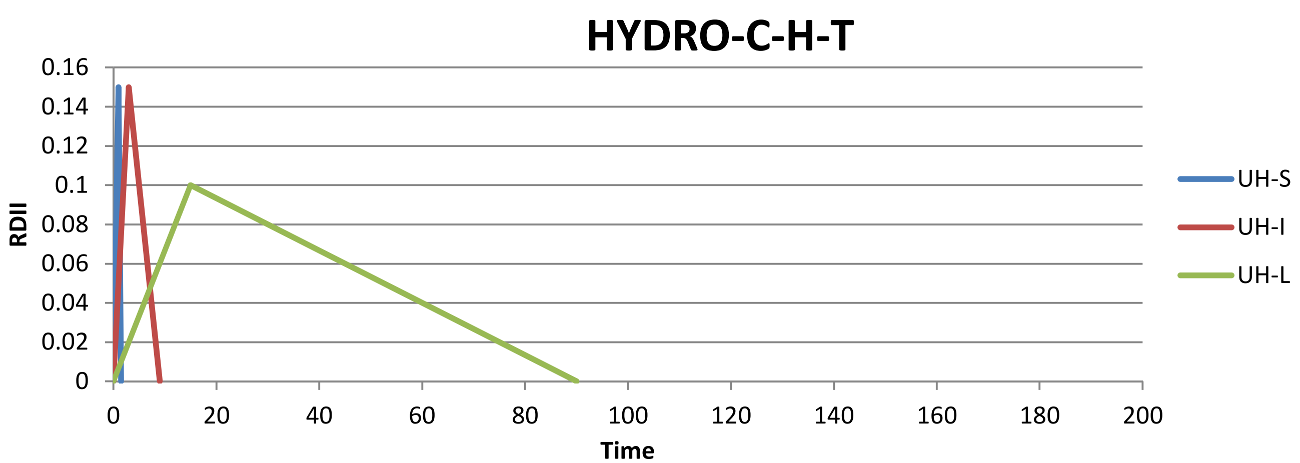


HYDRO-C-O-L: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.03	R_M =	0.025	R_L =	0.025
T_S =	1.5	T_M =	5	T_L =	24
K_S =	2	K_M =	3	K_L =	6.3
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

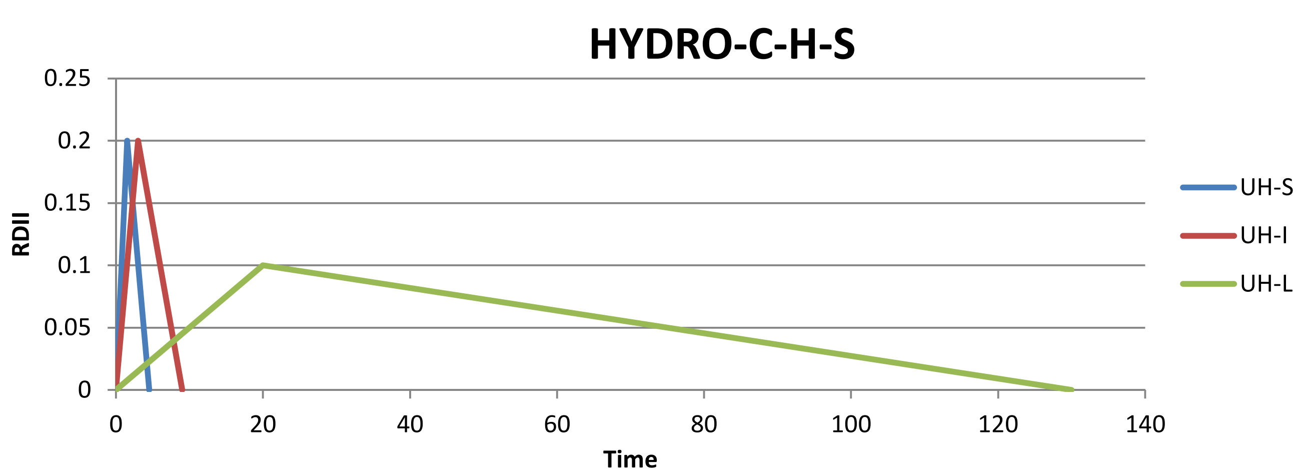


Unit Hydrograph Selection

HYDRO-C-H-T: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.15	R_M =	0.15	R_L =	0.1
T_S =	1	T_M =	3	T_L =	15
K_S =	1.5	K_M =	2	K_L =	5
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

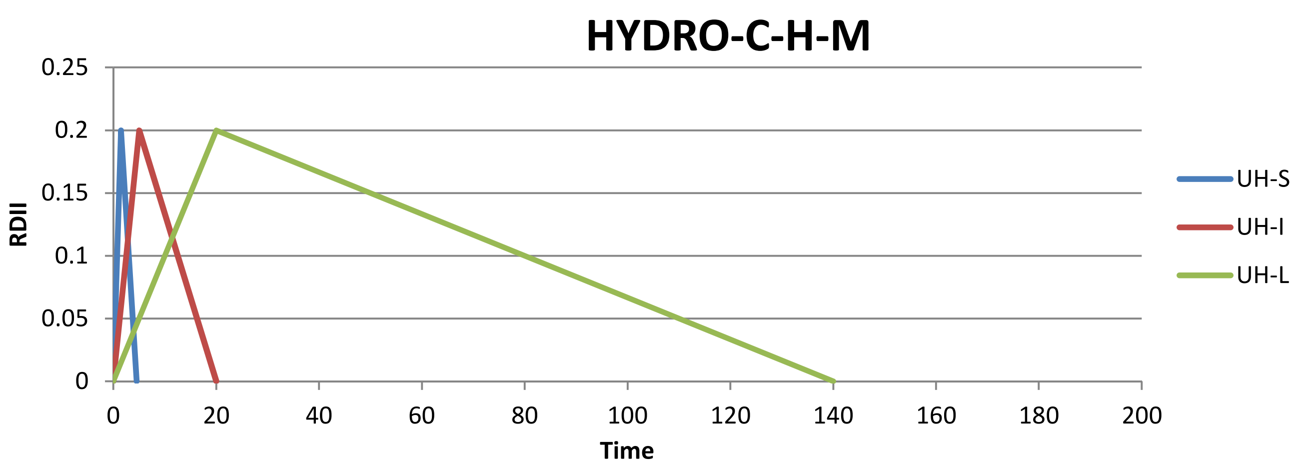


HYDRO-C-H-S: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.2	R_M =	0.2	R_L =	0.1
T_S =	1.5	T_M =	3	T_L =	20
K_S =	2	K_M =	2	K_L =	5.5
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

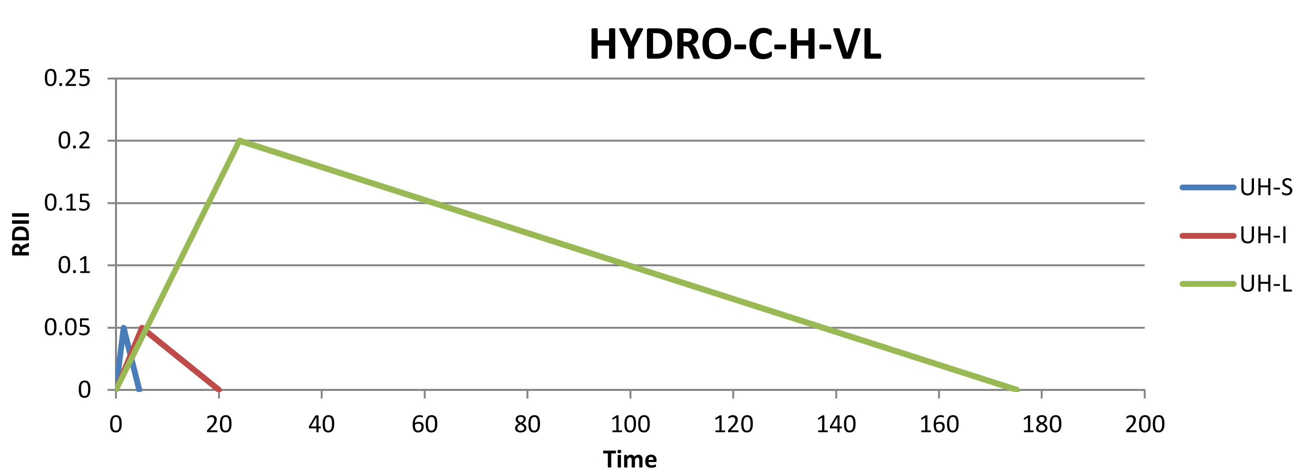


Unit Hydrograph Selection

HYDRO-C-H-M: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.2	R_M =	0.2	R_L =	0.2
T_S =	1.5	T_M =	5	T_L =	20
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

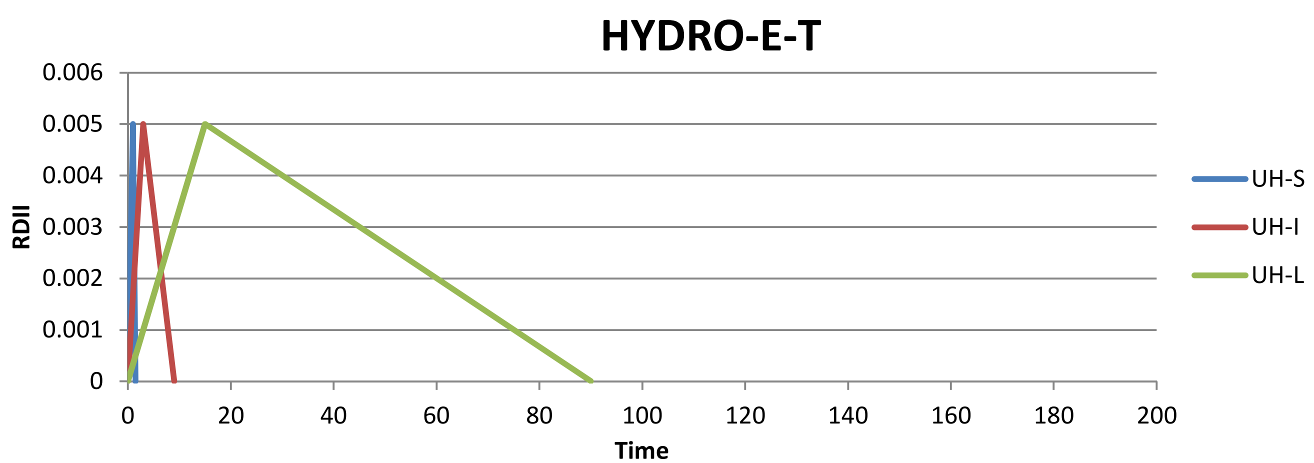


HYDRO-C-H-VL: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.05	R_M =	0.05	R_L =	0.2
T_S =	1.5	T_M =	5	T_L =	24
K_S =	2	K_M =	3	K_L =	6.3
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

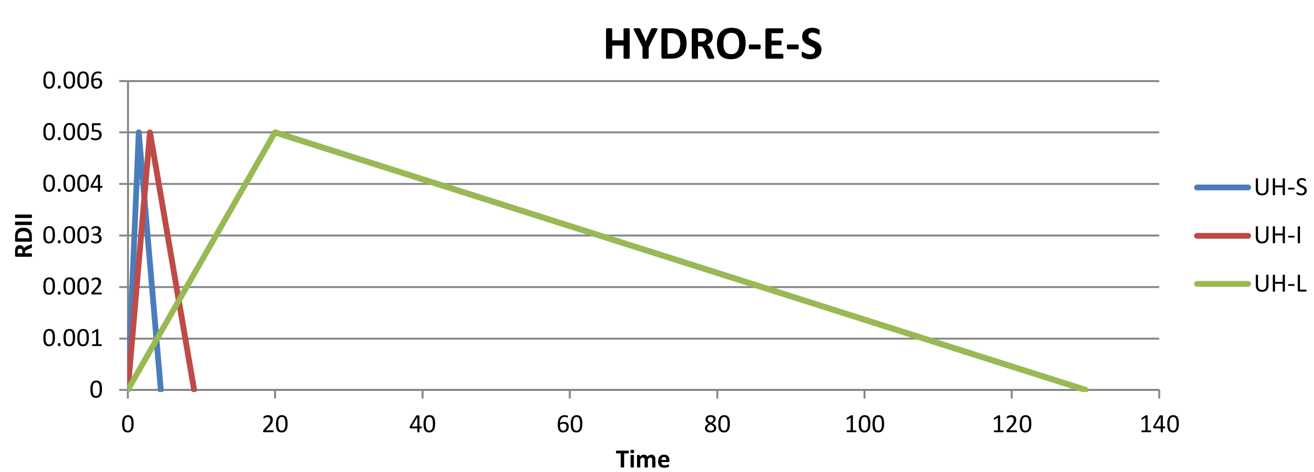


Unit Hydrograph Selection

HYDRO-E-T: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.005	R_M =	0.005	R_L =	0.005
T_S =	1	T_M =	3	T_L =	15
K_S =	1.5	K_M =	2	K_L =	5
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

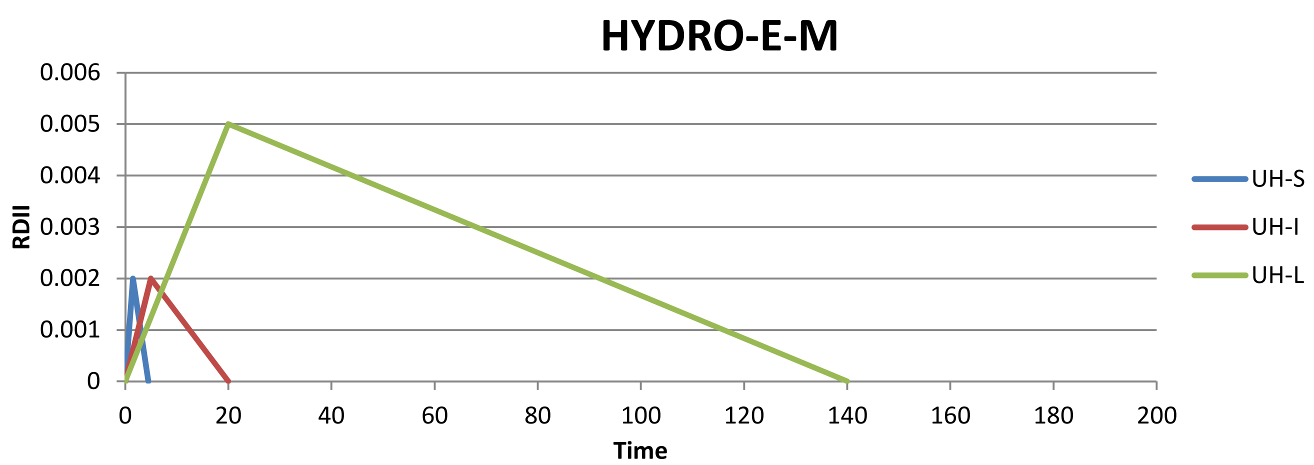


HYDRO-E-S: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.005	R_M =	0.005	R_L =	0.005
T_S =	1.5	T_M =	3	T_L =	20
K_S =	2	K_M =	2	K_L =	5.5
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

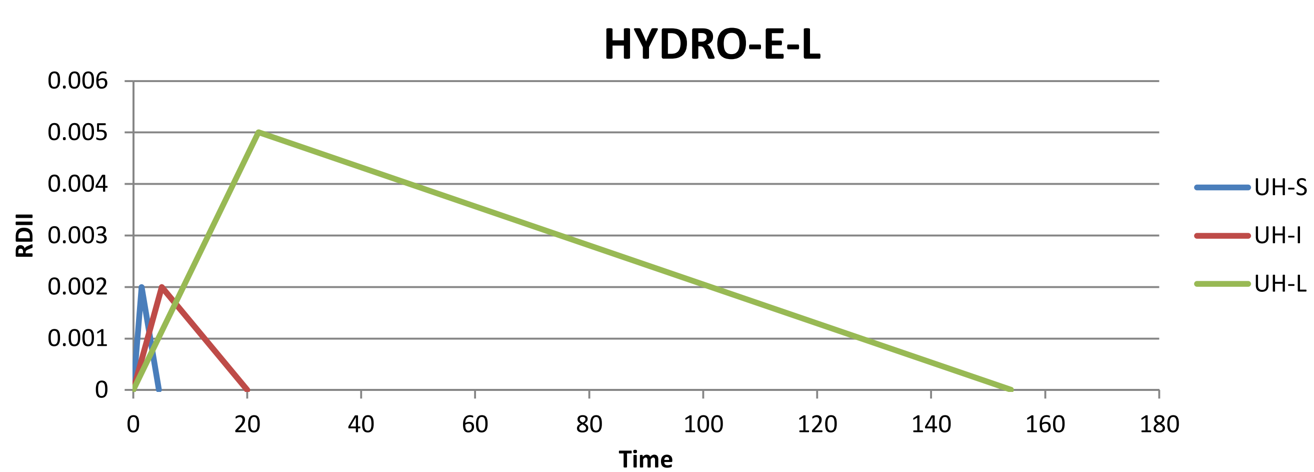


Unit Hydrograph Selection

HYDRO-E-M: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.002	R_M =	0.002	R_L =	0.005
T_S =	1.5	T_M =	5	T_L =	20
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

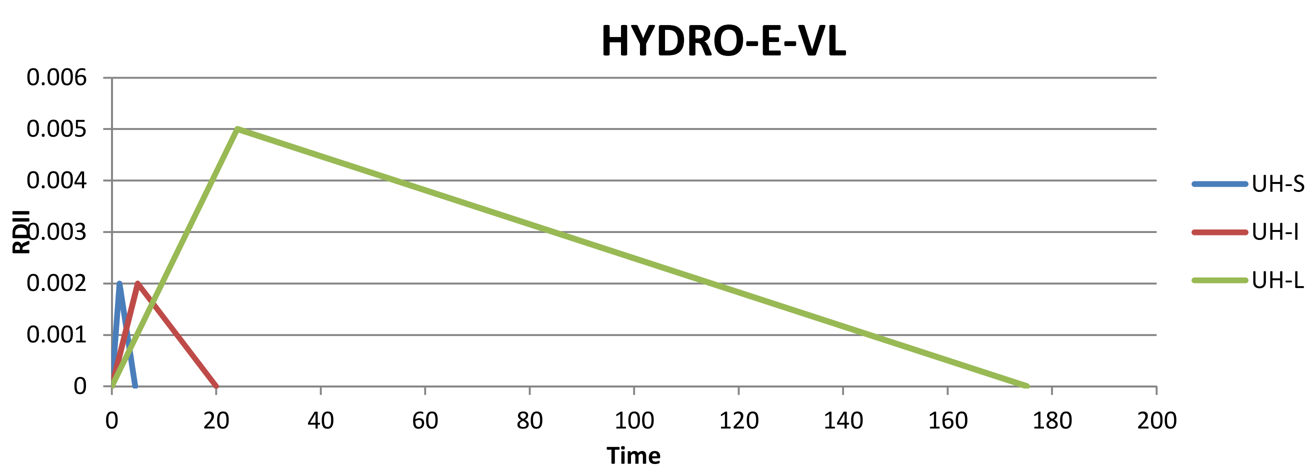


HYDRO-E-L: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.002	R_M =	0.002	R_L =	0.005
T_S =	1.5	T_M =	5	T_L =	22
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

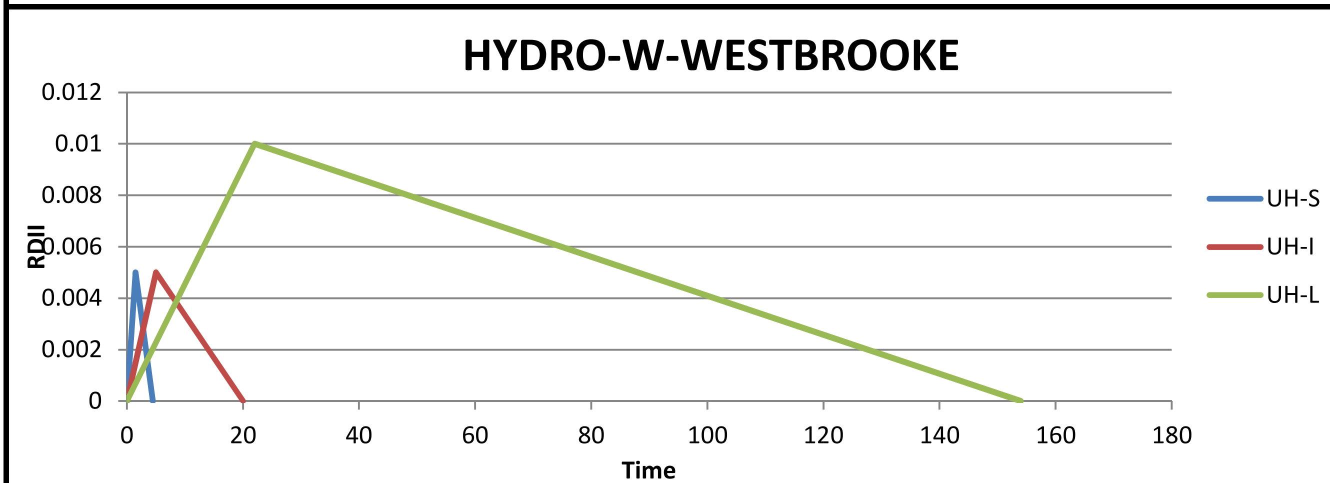


Unit Hydrograph Selection

HYDRO-E-VL: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.002	R_M =	0.002	R_L =	0.005
T_S =	1.5	T_M =	5	T_L =	24
K_S =	2	K_M =	3	K_L =	6.3
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

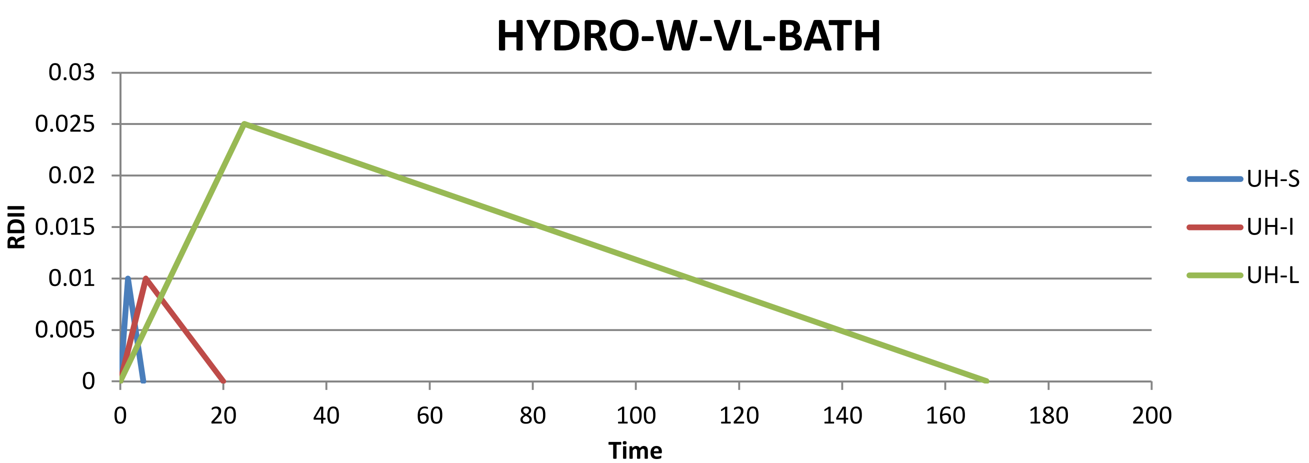


HYDRO-W-WESTBROOKE-: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.005	R_M =	0.005	R_L =	0.01
T_S =	1.5	T_M =	5	T_L =	22
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

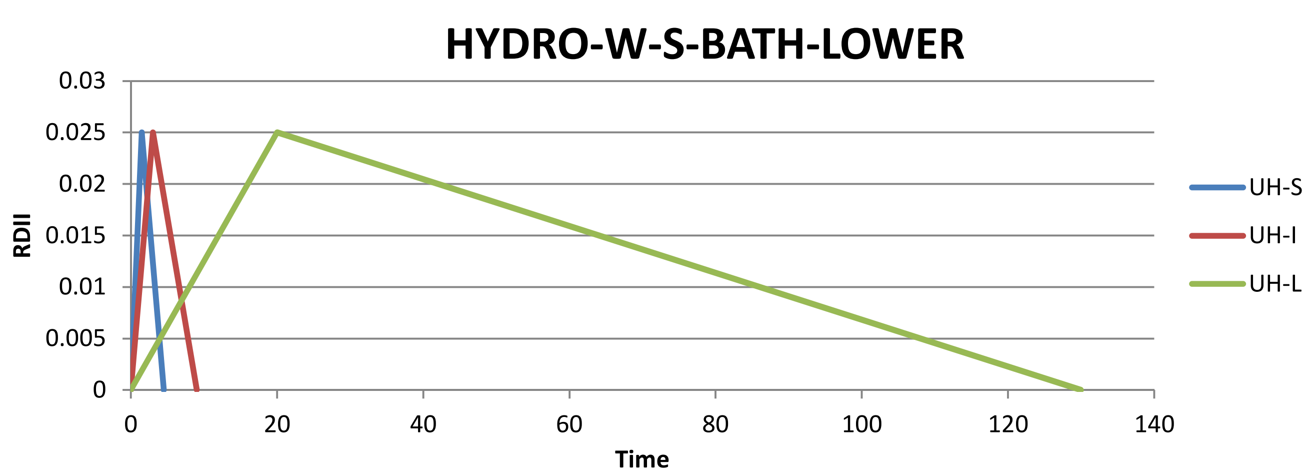


Unit Hydrograph Selection

HYDRO-W-VL-BATH: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.01	R_M =	0.01	R_L =	0.025
T_S =	1.5	T_M =	5	T_L =	24
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

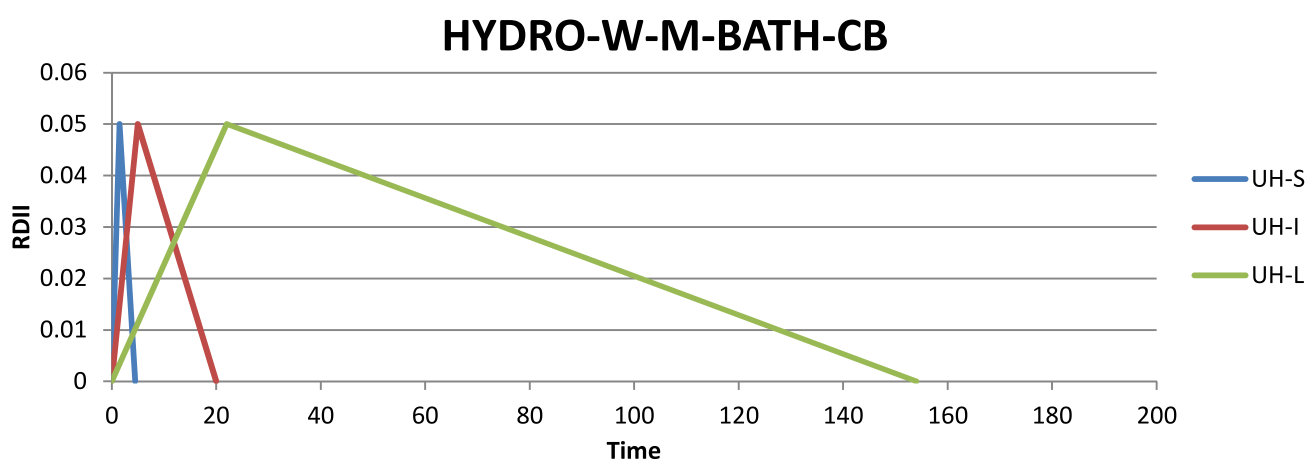


HYDRO-W-BATH-LOWER-: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.025	R_M =	0.025	R_L =	0.025
T_S =	1.5	T_M =	3	T_L =	20
K_S =	2	K_M =	2	K_L =	5.5
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

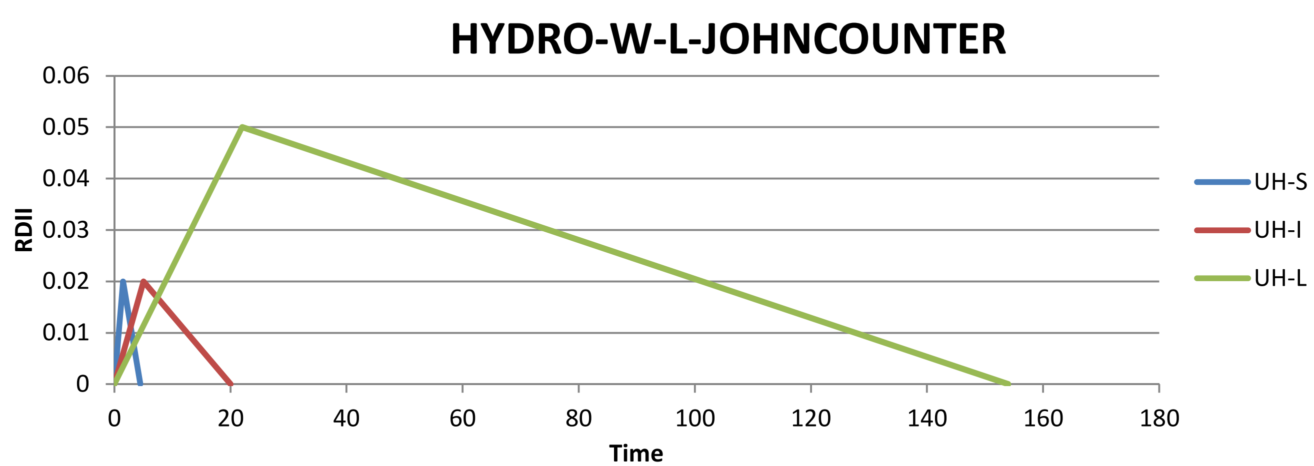


Unit Hydrograph Selection

HYDRO-W-M-BATH-CB: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.05	R_M =	0.05	R_L =	0.05
T_S =	1.5	T_M =	5	T_L =	22
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

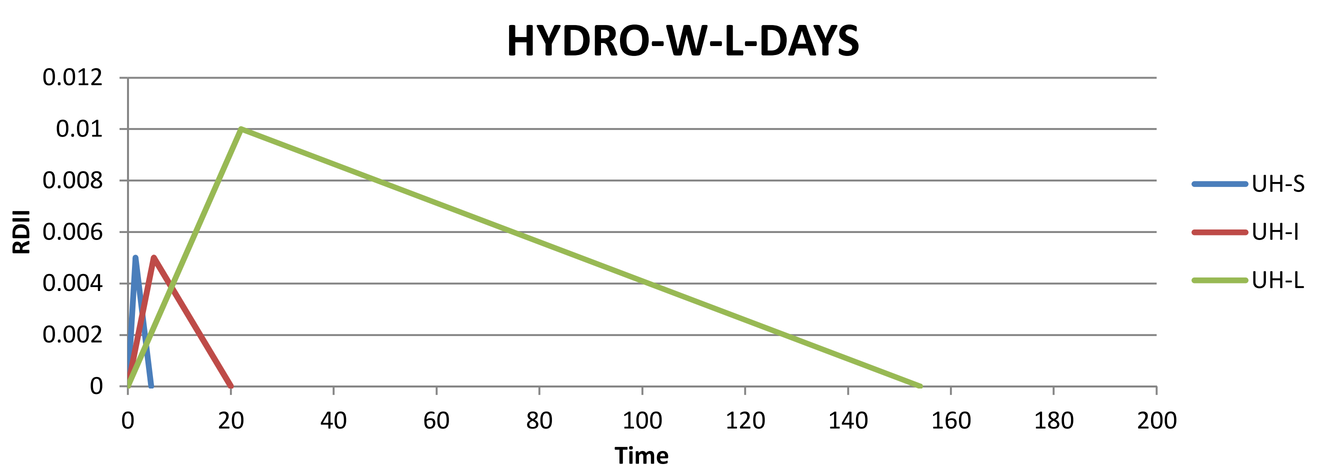


HYDRO-W-L-JOHNCOUNTER-: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.02	R_M =	0.02	R_L =	0.05
T_S =	1.5	T_M =	5	T_L =	22
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

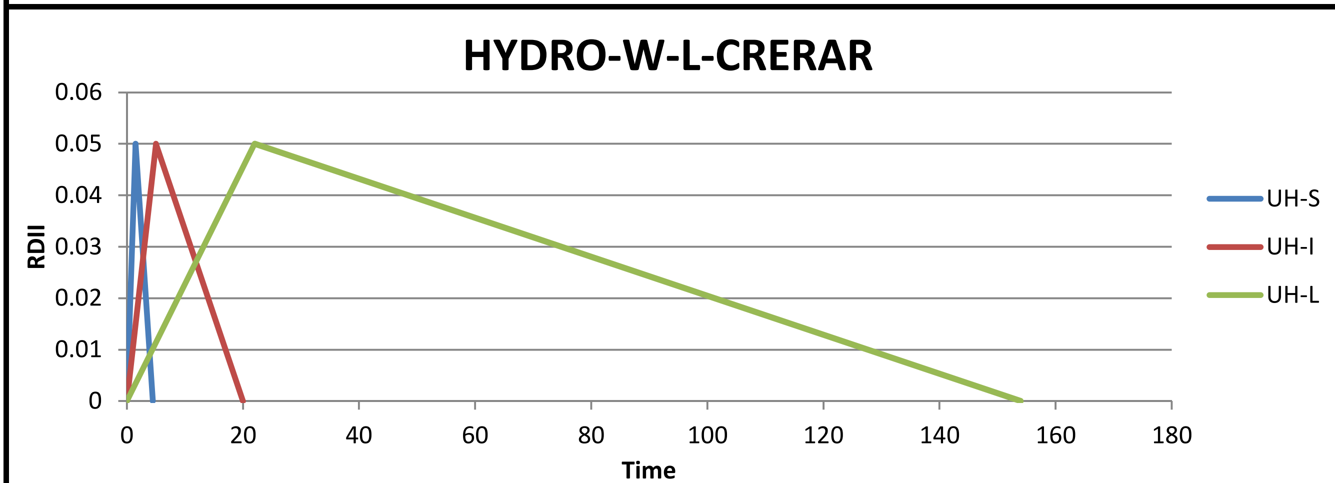


Unit Hydrograph Selection

HYDRO-W-L-DAYS: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.005	R_M =	0.005	R_L =	0.01
T_S =	1.5	T_M =	5	T_L =	22
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

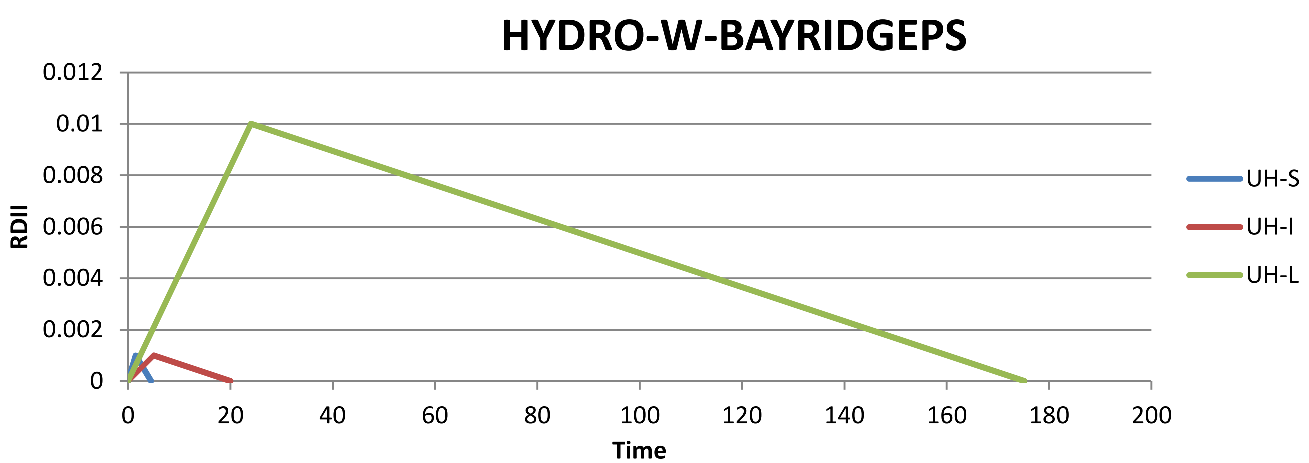


HYDRO-W-L-CRERAR: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.05	R_M =	0.05	R_L =	0.05
T_S =	1.5	T_M =	5	T_L =	22
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

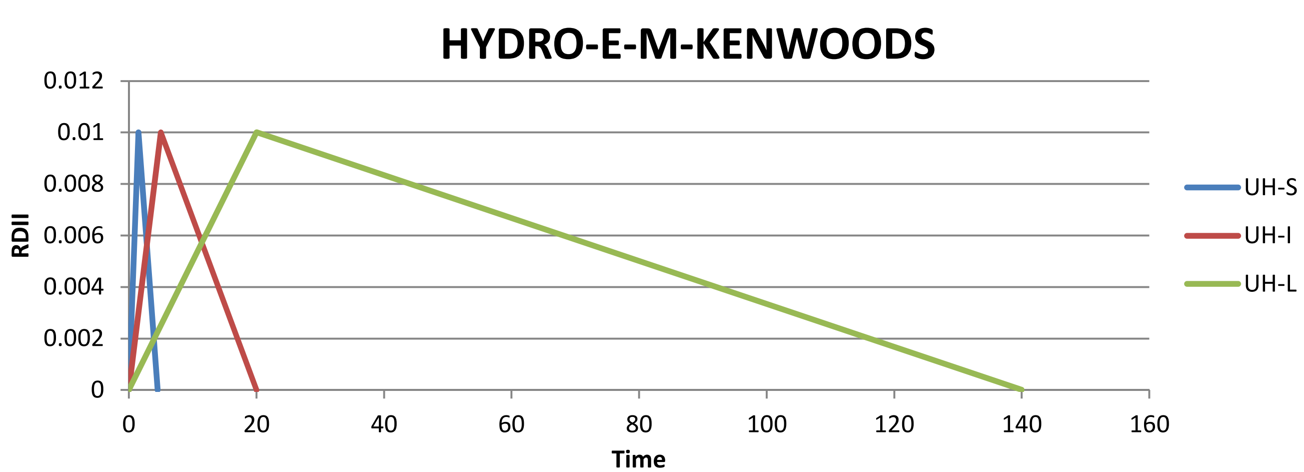


Unit Hydrograph Selection

HYDRO-W-L-BAYRIDGEPS: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.001	R_M =	0.001	R_L =	0.01
T_S =	1.5	T_M =	5	T_L =	24
K_S =	2	K_M =	3	K_L =	6.3
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

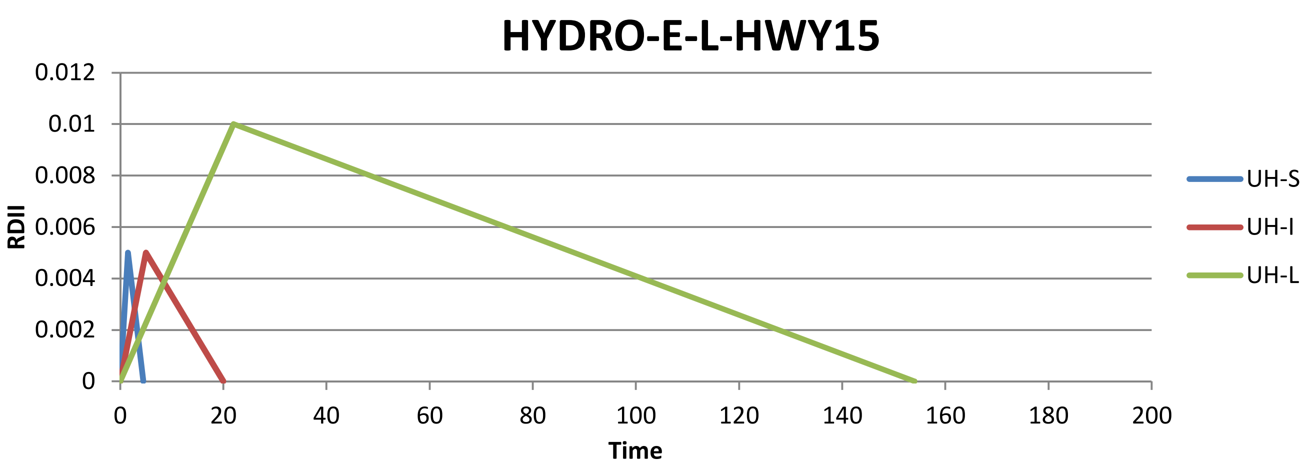


HYDRO-E-M-KENWODOS: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.01	R_M =	0.01	R_L =	0.01
T_S =	1.5	T_M =	5	T_L =	20
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1



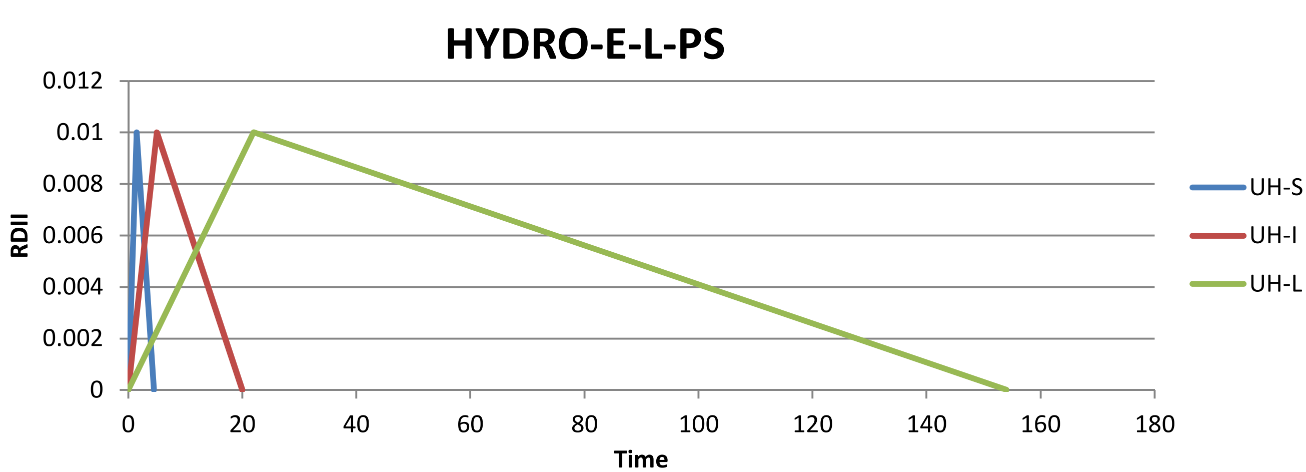
Unit Hydrograph Selection

HYDRO-E-L-HWY15: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.005	R_M =	0.005	R_L =	0.01
T_S =	1.5	T_M =	5	T_L =	22
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1



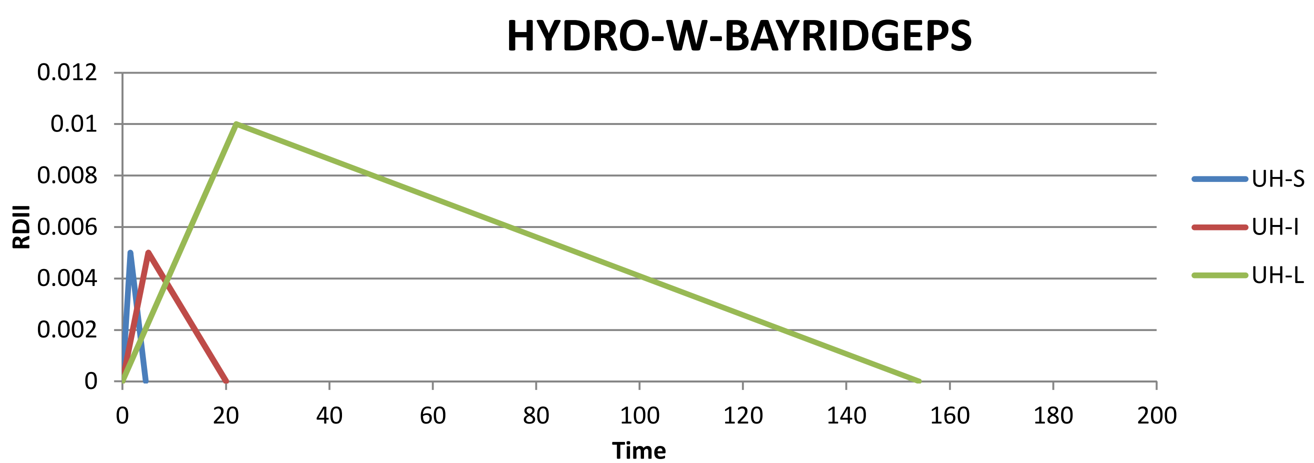
HYDRO-E-L-PS: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.01	R_M =	0.01	R_L =	0.01
T_S =	1.5	T_M =	5	T_L =	22
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

*General Kingston East PS Hyodrograph



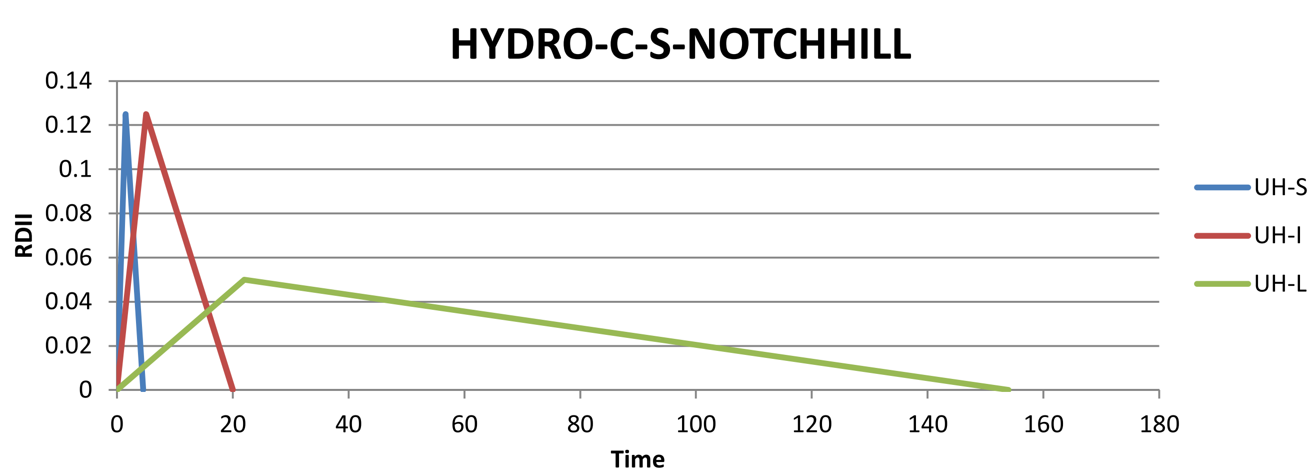
Unit Hydrograph Selection

HYDRO-C-T-YONGE: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.005	R_M =	0.005	R_L =	0.01
T_S =	1.5	T_M =	5	T_L =	22
K_S =	2	K_M =	3	K_L =	6
Max Depth$_S$ =	0.05	Max Depth$_M$ =	0.06	Max Depth$_L$ =	0.04
Recovery$_S$ =	0.2	Recovery$_M$ =	0.2	Recovery$_L$ =	0.2
Int. Depth$_S$ =	0.1	Int. Depth$_M$ =	0.1	Int. Depth$_L$ =	0.1



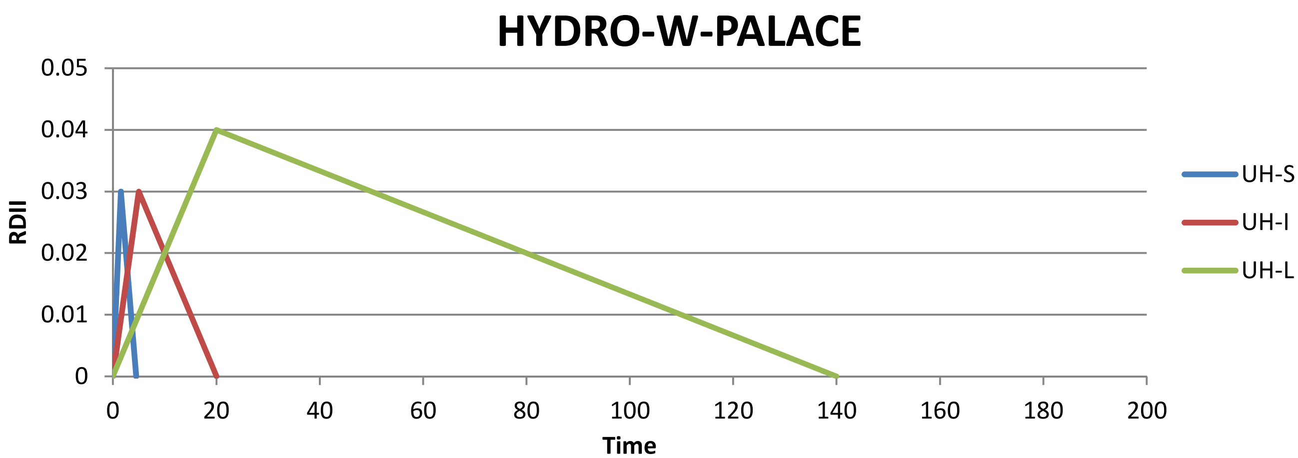
HYDRO-C-S-NOTCHHILL: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.125	R_M =	0.125	R_L =	0.05
T_S =	1.5	T_M =	5	T_L =	22
K_S =	2	K_M =	3	K_L =	6
Max Depth$_S$ =	0.05	Max Depth$_M$ =	0.06	Max Depth$_L$ =	0.04
Recovery$_S$ =	0.2	Recovery$_M$ =	0.2	Recovery$_L$ =	0.2
Int. Depth$_S$ =	0.1	Int. Depth$_M$ =	0.1	Int. Depth$_L$ =	0.1

*Used for areas surrounding Notch Hill PS

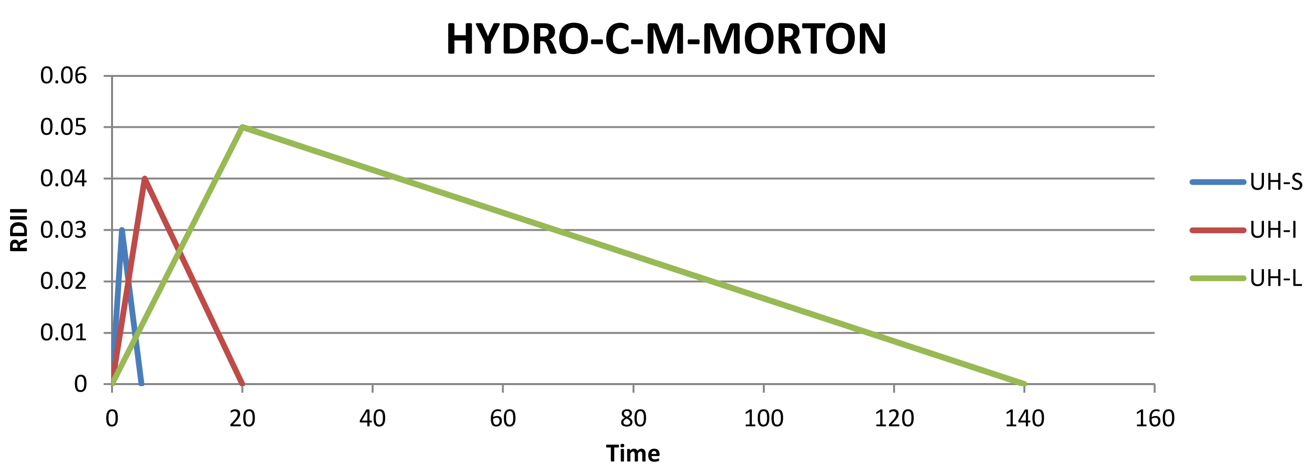


Unit Hydrograph Selection

HYDRO-C-M-PALACE: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.03	R_M =	0.03	R_L =	0.04
T_S =	1.5	T_M =	5	T_L =	20
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1



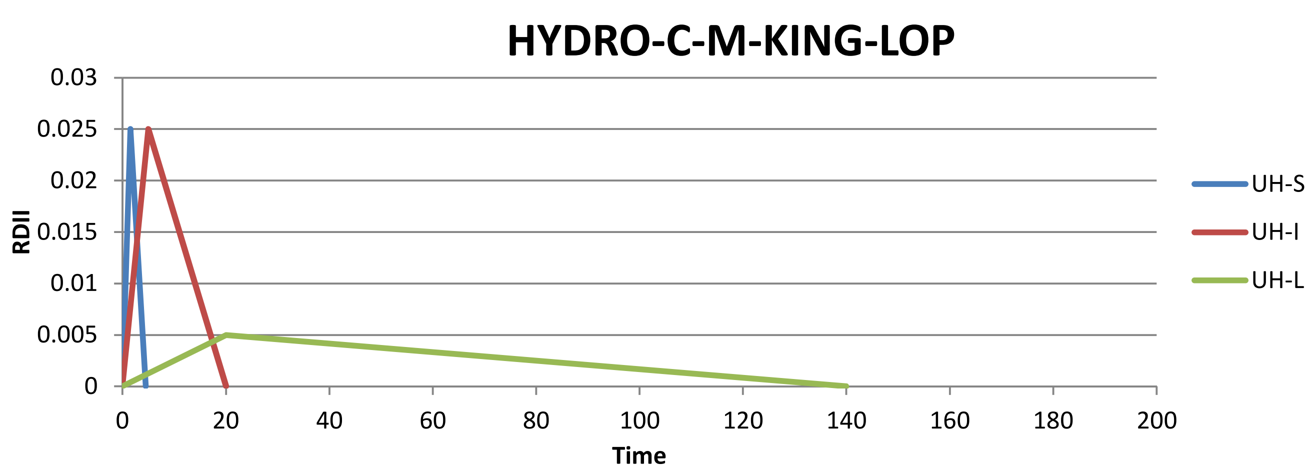
HYDRO-C-M-MORTON: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.03	R_M =	0.04	R_L =	0.05
T_S =	1.5	T_M =	5	T_L =	20
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1



Unit Hydrograph Selection

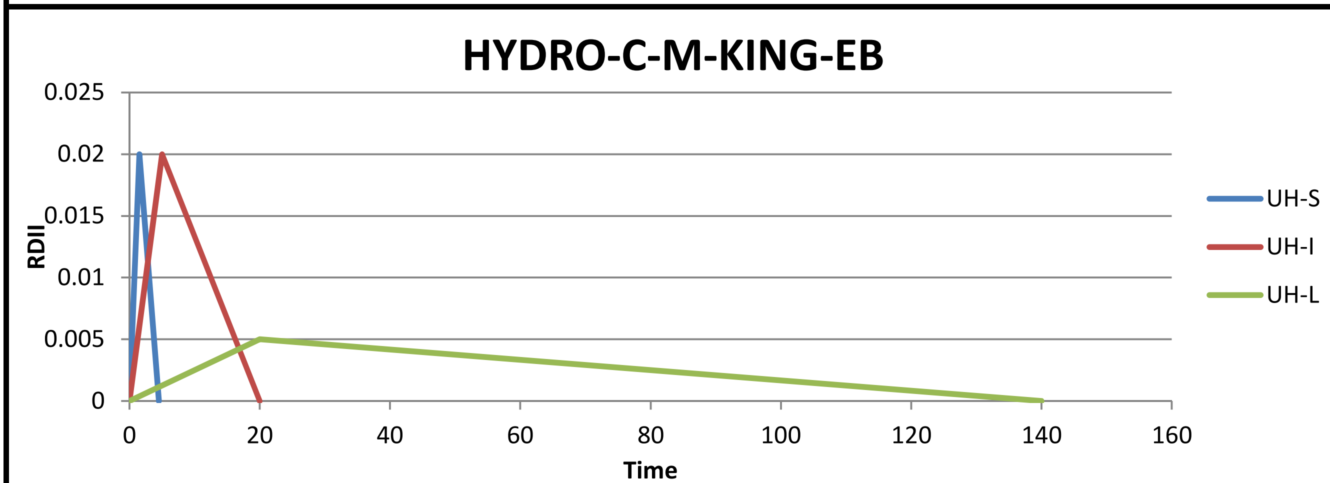
HYDRO-C-M-KING-LOP: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.025	R_M =	0.025	R_L =	0.005
T_S =	1.5	T_M =	5	T_L =	20
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

*Lake Ontario Park



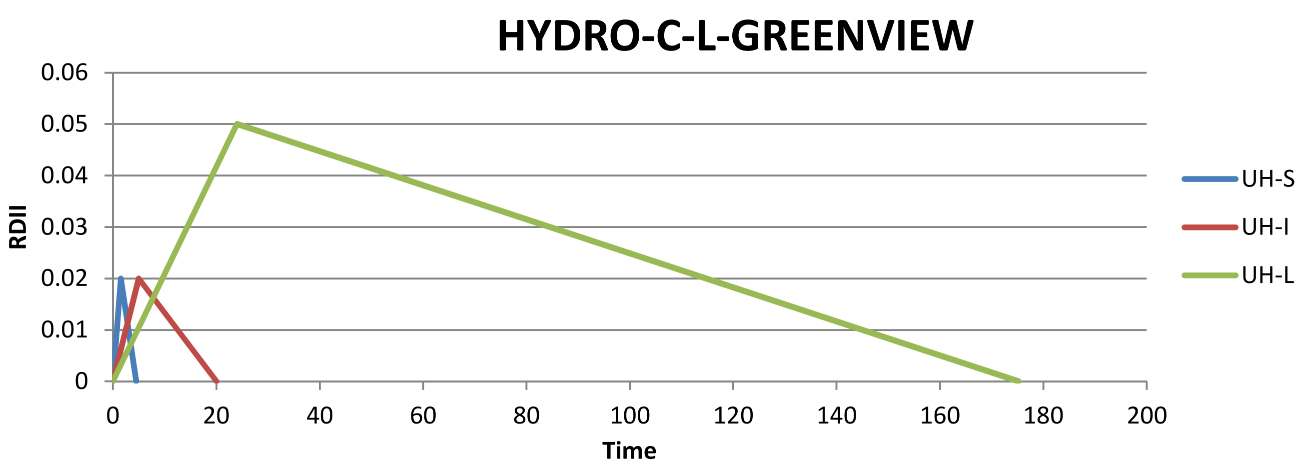
HYDRO-C-M-MORTON: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =	0.02	R_M =	0.02	R_L =	0.005
T_S =	1.5	T_M =	5	T_L =	20
K_S =	2	K_M =	3	K_L =	6
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1

*Elevator Bay

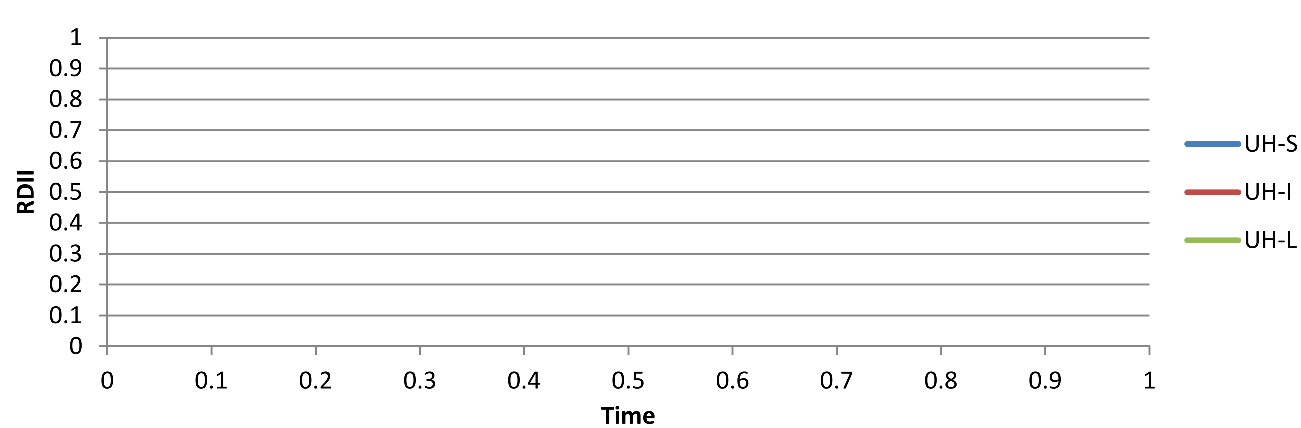


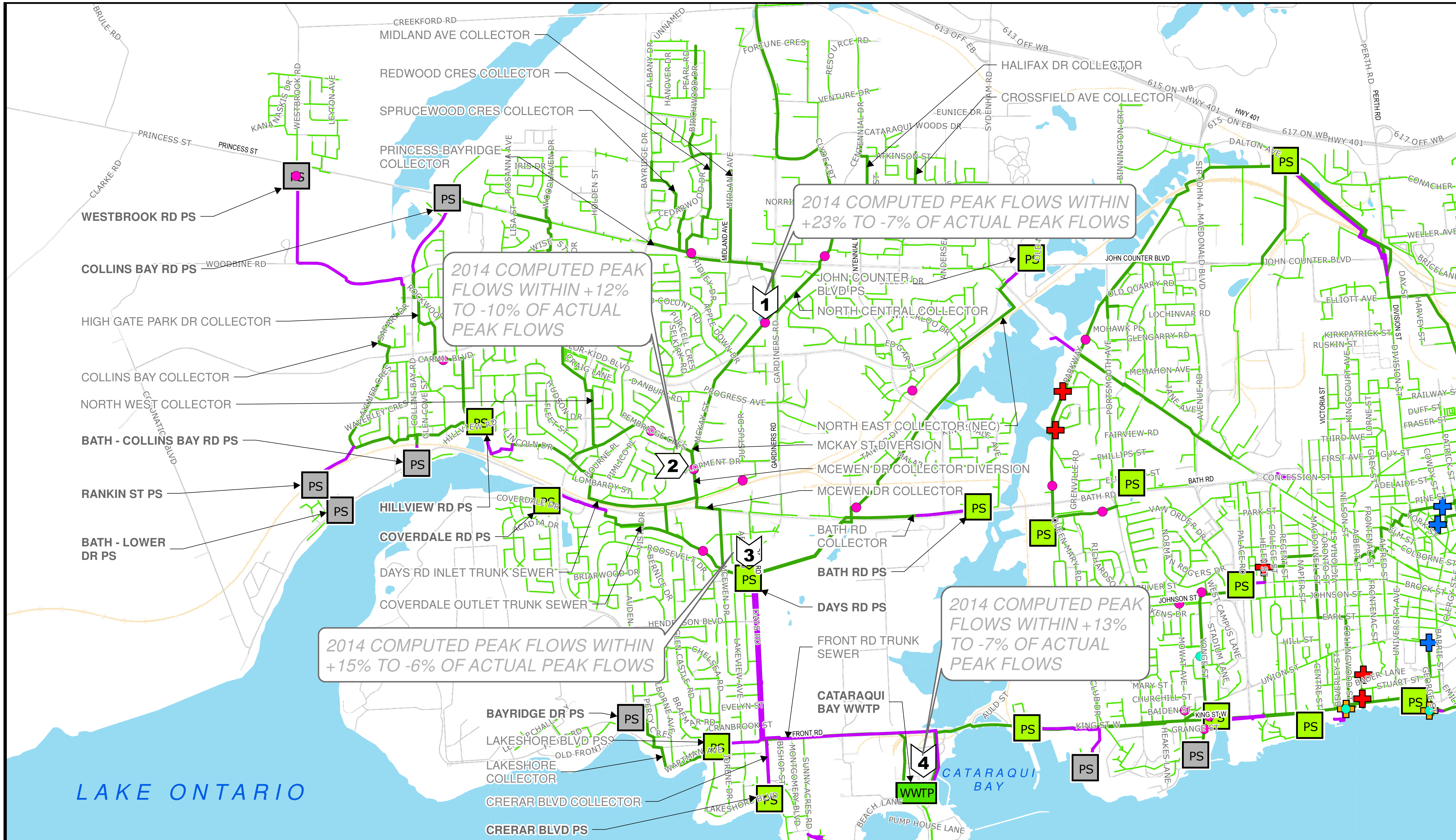
Unit Hydrograph Selection

HYDRO-C-L-GREENVIEW: Unit Hydrograph					
UH-S: Short-Term		UH-I: Intermediate-Term		UH-L: Long-Term	
R_S =	0.02	R_M =	0.02	R_L =	0.05
T_S =	1.5	T_M =	5	T_L =	24
K_S =	2	K_M =	3	K_L =	6.3
Max $Depth_S$ =	0.05	Max $Depth_M$ =	0.06	Max $Depth_L$ =	0.04
$Recovery_S$ =	0.2	$Recovery_M$ =	0.2	$Recovery_L$ =	0.2
Int. $Depth_S$ =	0.1	Int. $Depth_M$ =	0.1	Int. $Depth_L$ =	0.1



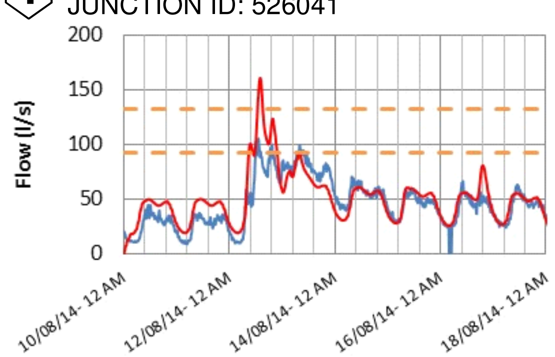
: Unit Hydrograph					
UH1: Short-Term		UH2: Medium-Term		UH3: Long-Term	
R_S =		R_M =		R_L =	
T_S =		T_M =		T_L =	
K_S =		K_M =		K_L =	
Max $Depth_S$ =		Max $Depth_M$ =		Max $Depth_L$ =	
$Recovery_S$ =		$Recovery_M$ =		$Recovery_L$ =	
Int. $Depth_S$ =		Int. $Depth_M$ =		Int. $Depth_L$ =	



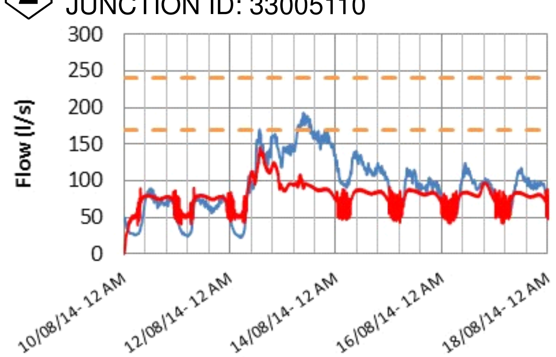


CALIBRATION RESULTS:

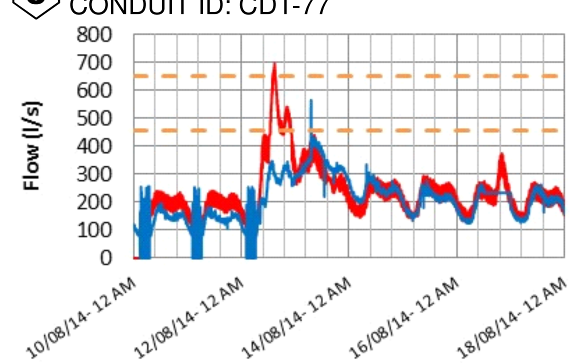
1 STATION W13 INFLOW
JUNCTION ID: 526041



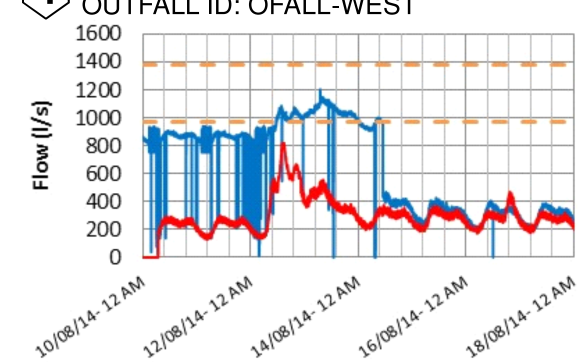
2 STATION W31 INFLOW
JUNCTION ID: 33005110



3 DAYS RD PS DISCHARGE
CONDUIT ID: CDT-77



4 CATARAQUI BAY WWTP INFLOW
OUTFALL ID: OFALL-WEST



- CALIBRATION TARGET RANGE
- COMPUTED (2014)
- ACTUAL

WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WWTP — WASTEWATER TREATMENT PLANT WITH SCADA MONITOR
- WWTP — WASTEWATER TREATMENT PLANT
- PS — SANITARY PUMPING STATION WITH SCADA MONITOR
- PS — SANITARY PUMPING STATION
- COMBINED SEWER OVERFLOW (CSO)
- CSO CAPTURED BY TANK
- TANK OVERFLOW (TO)
- SANITARY SEWER OVERFLOW (SSO)
- FORCEMAIN
- EXISTING SANITARY SEWER
- MODEL CONDUIT
- IN-LINE SEWER MONITOR
- 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:
0 250 500 1,000 Meters
1:38,000

Project:
Water and Wastewater Master Plan Updates

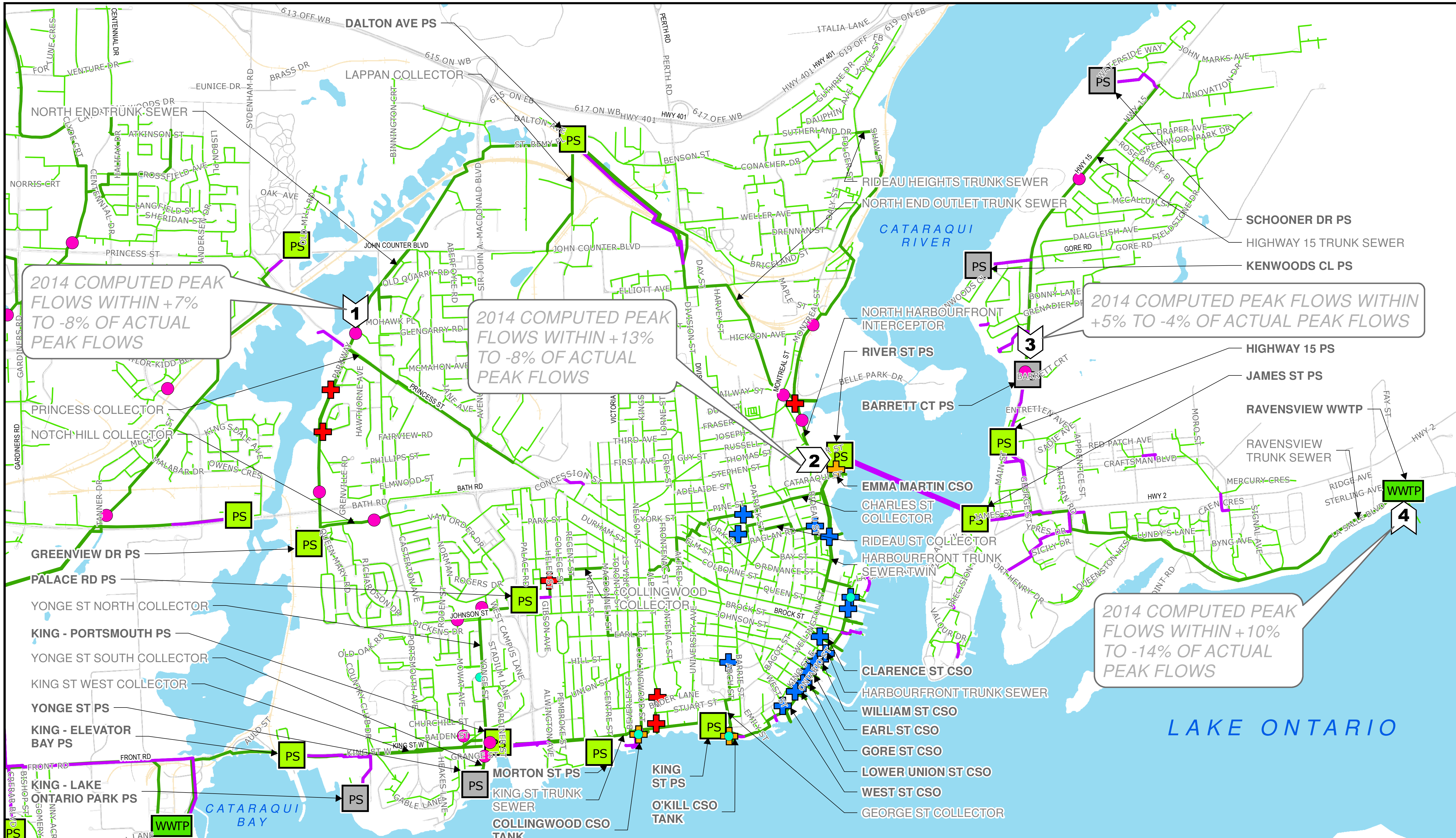
City of Kingston, Ontario

Title:
WET WEATHER CALIBRATION SUMMARY - KINGSTON WEST AUGUST 9-16, 2014

Project No.:	Date:
151-02944-00	DECEMBER 2016

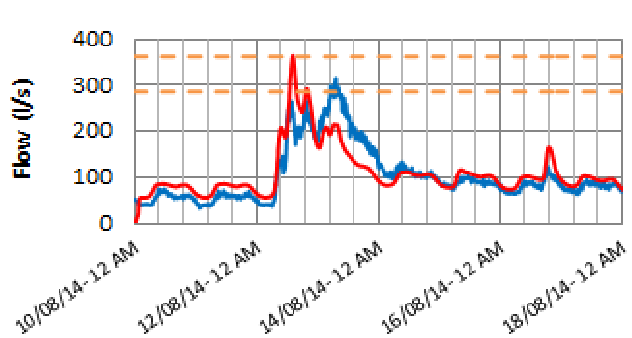
Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	WWM	J-1

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.6_Wastewater Model\Maps\Calibration Report Maps\J_WetWeatherCalb\151-02944-00_WWM_FigJ-1_WET_Calibration_Summary_West.mxd

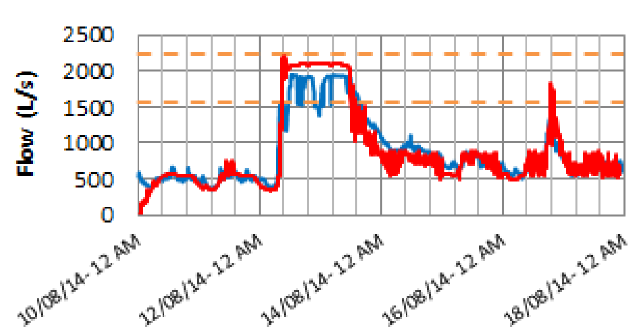


CALIBRATION RESULTS:

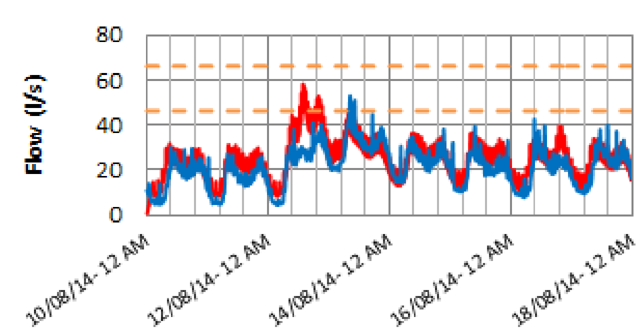
1 STATION C1 INFLOW
JUNCTION ID: 2285020



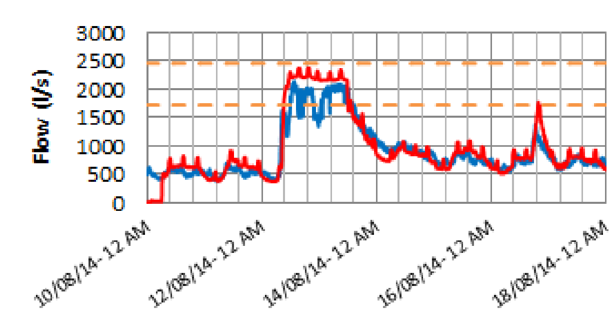
2 RIVER ST DISCHARGE
CONDUIT ID: CDT-39



3 STATION E1 INFLOW
JUNCTION ID: 630020



4 RAVENSVIEW WWTP INFLOW
OUTFALL ID: 01



- CALIBRATION TARGET RANGE
- COMPUTED (2014)
- ACTUAL

WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

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

Legend

- WWTP — WASTEWATER TREATMENT PLANT WITH SCADA MONITOR
- WWTP — WASTEWATER TREATMENT PLANT
- PS — SANITARY PUMPING STATION WITH SCADA MONITOR
- PS — SANITARY PUMPING STATION
- COMBINED SEWER OVERFLOW (CSO)
- CSO CAPTURED BY TANK
- TANK OVERFLOW (TO)
- SANITARY SEWER OVERFLOW (SSO)
- FORCEMAIN
- EXISTING SANITARY SEWER
- MODEL CONDUIT
- IN-LINE SEWER MONITOR
- 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:
0 250 500 1,000 Meters
1:35,000

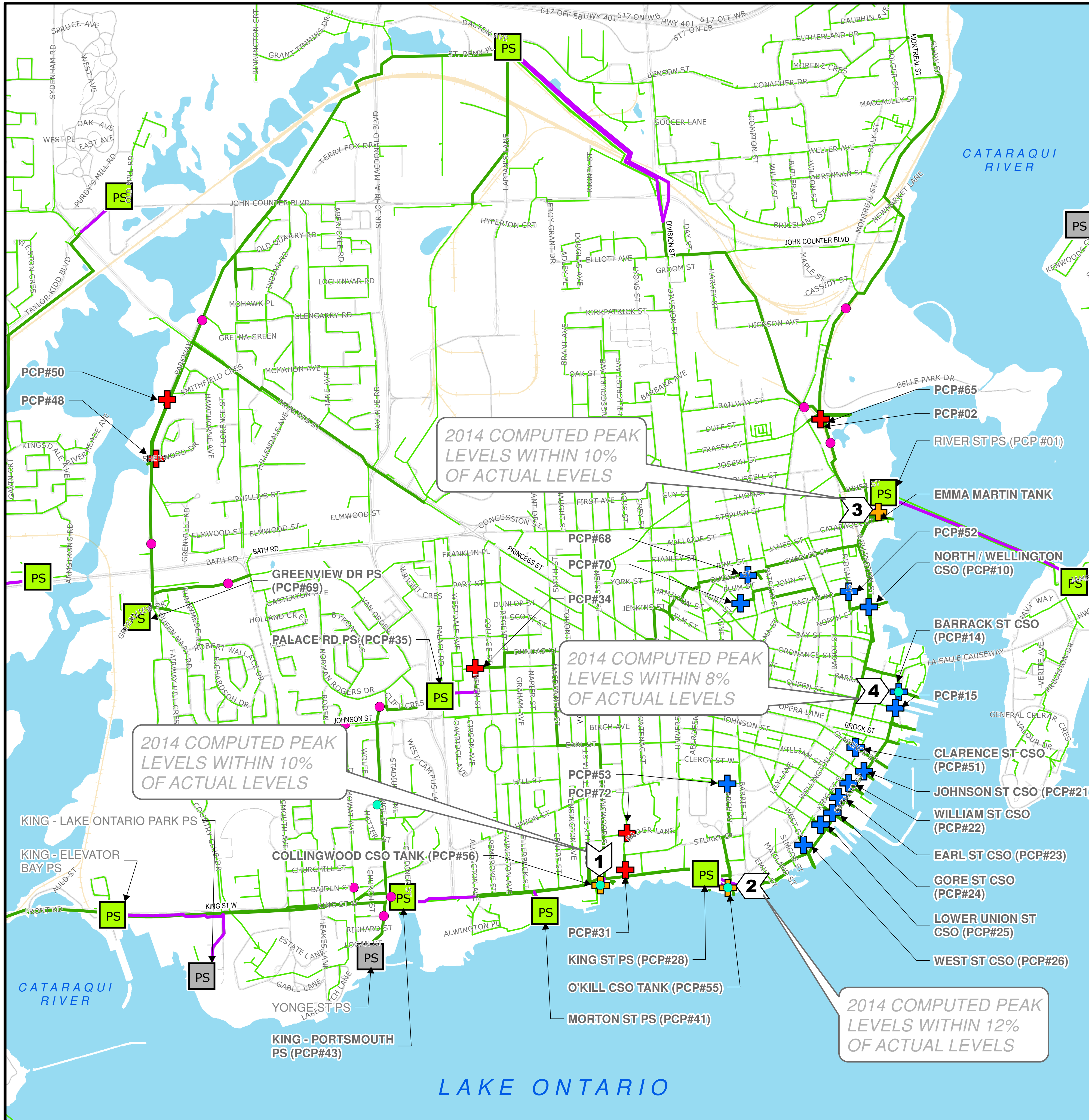
Project:
Water and Wastewater Master Plan Updates

City of Kingston, Ontario

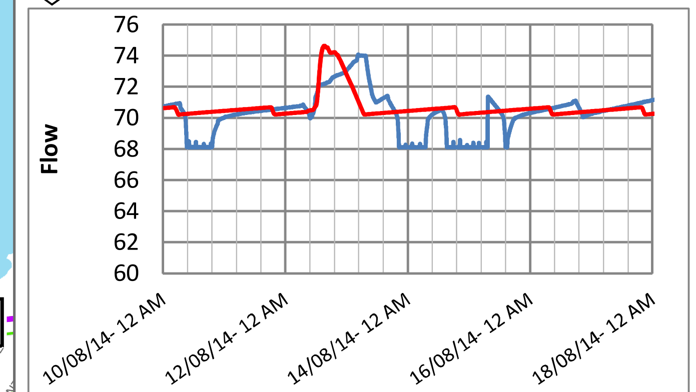
Title:
WET WEATHER CALIBRATION SUMMARY - KINGSTON CENTRAL & EAST - AUGUST 10-16, 2014

Project No.:		Date:	
151-02944-00		DECEMBER 2016	
Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	WWM	J-2

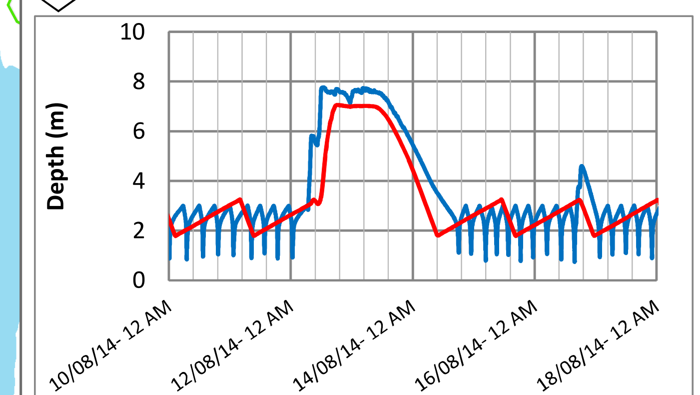
File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.6_Wastewater Model\Maps\Calibration Report Maps\J_WetWeatherCalb\151-02944-00_WWM_FigJ-2_WET_Calibration_Summary_CentralandEast.mxd



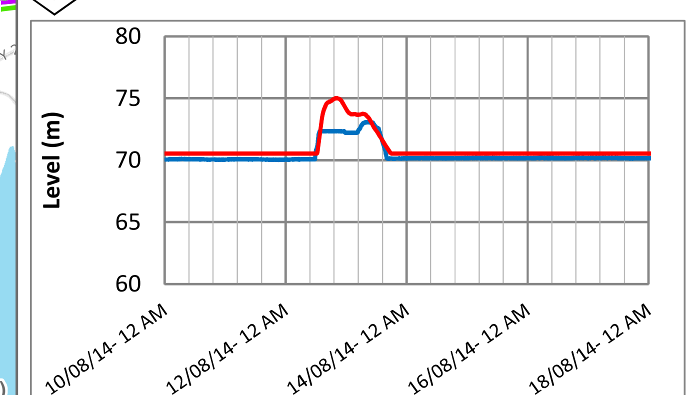
1 COLLINGWOOD CSO TANK (PCP#56)



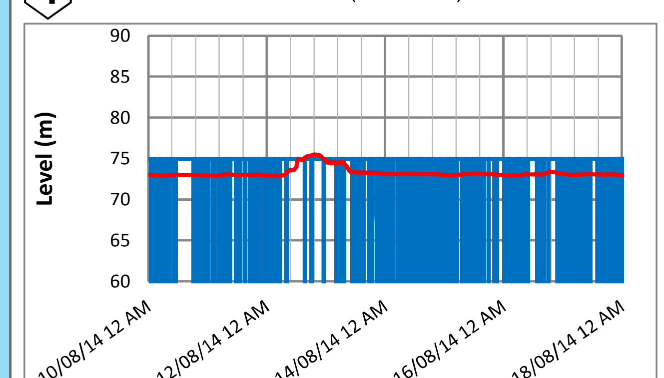
2 O'KILL CSO TANK (PCP#55)



3 EMMA MARTIN CSO TANK (PCP#01)



4 BARRACK ST. CSO (PCP#14)



- COMPUTED (2014)
- ACTUAL

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1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston

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

Legend

- WWTP — WASTEWATER TREATMENT PLANT WITH SCADA MONITOR
- WWTP — WASTEWATER TREATMENT PLANT
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- PS — SANITARY PUMPING STATION
- COMBINED SEWER OVERFLOW (CSO)
- CSO CAPTURED BY TANK
- TANK OVERFLOW (TO)
- SANITARY SEWER OVERFLOW (SSO)
- FORCEMAIN
- EXISTING SANITARY SEWER
- MODEL CONDUIT
- IN-LINE SEWER MONITOR
- 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:
0 150 300 600 Meters
1:25,000

N E S W

Project:
Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title:
CSO CALIBRATION SUMMARY - AUGUST 10-16, 2014

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	WWM	J-3

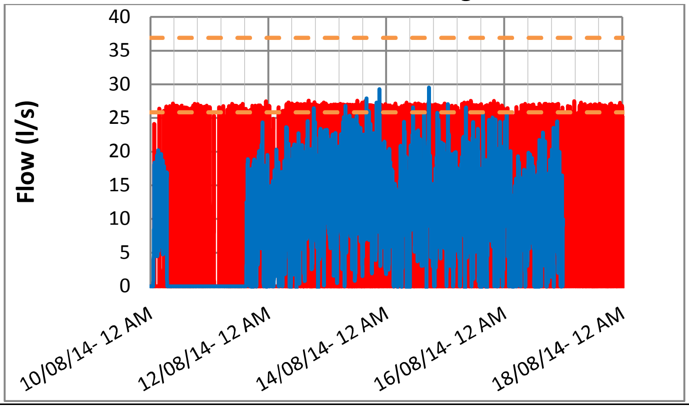
File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.6_Wastewater Model\Maps\Calibration Report Maps\J_WetWeatherCalib\151-02944-00_WWM_FigJ-3_CSO_Calibration_Summary.mxd

August 10-16, 2014 Event – Wet-Weather Events

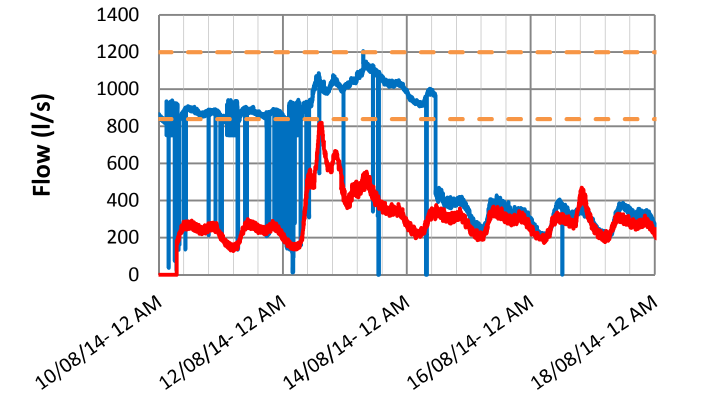
Actual — 2014 Simulated — Calibration Range

Kingston West

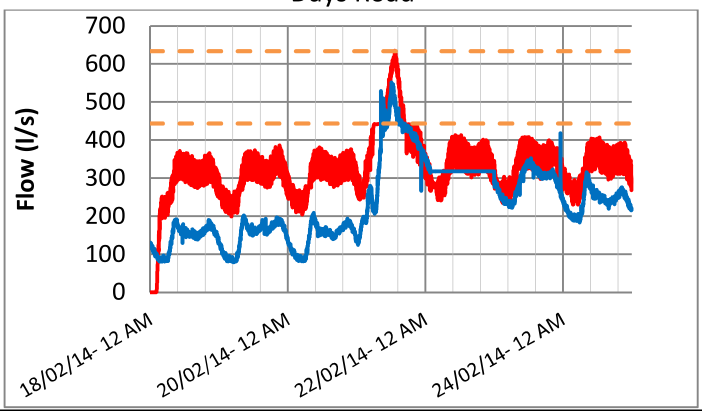
Bath Road PS Discharge



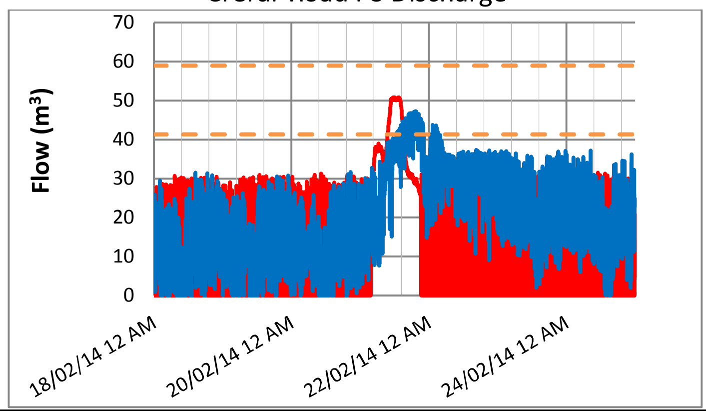
Cataraqui Bay WWTP



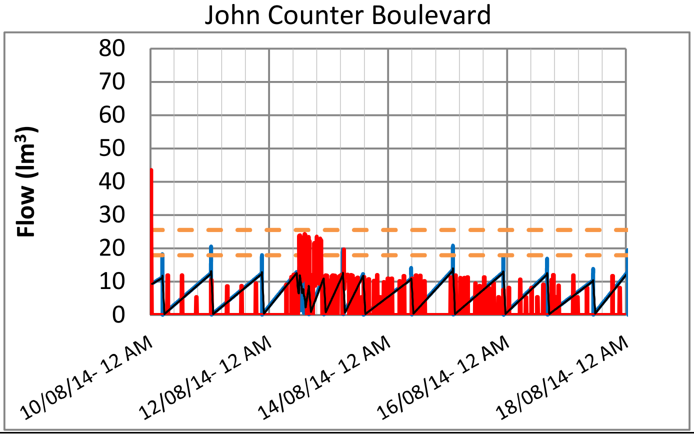
Days Road



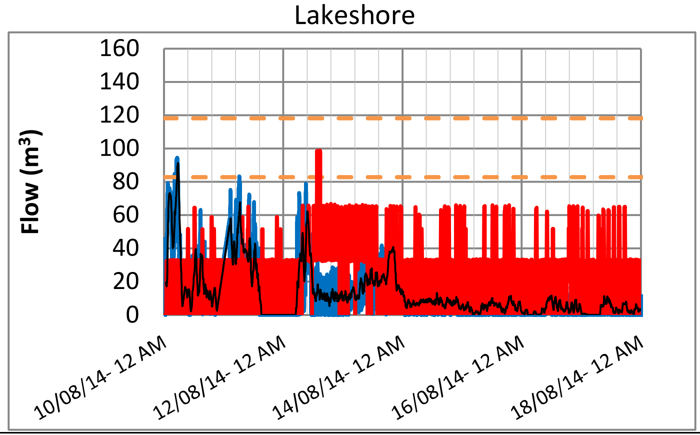
Crerar Road PS Discharge



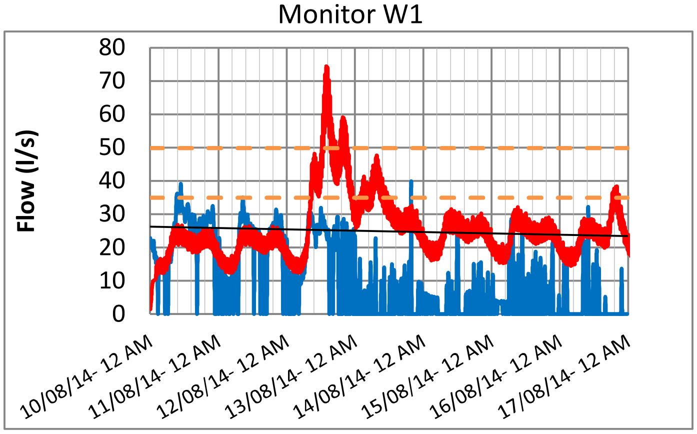
John Counter Boulevard



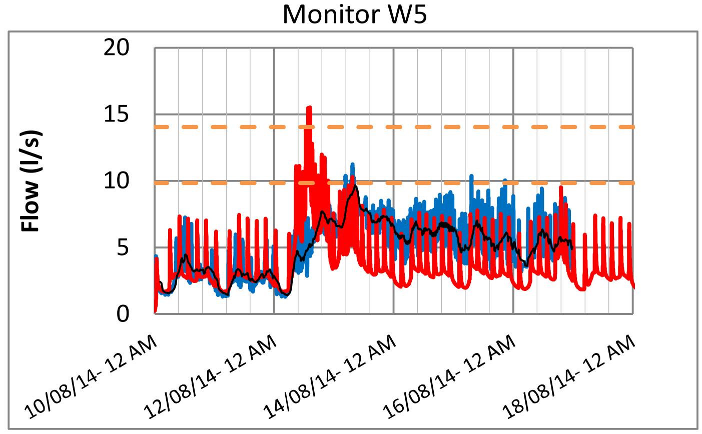
Lakeshore

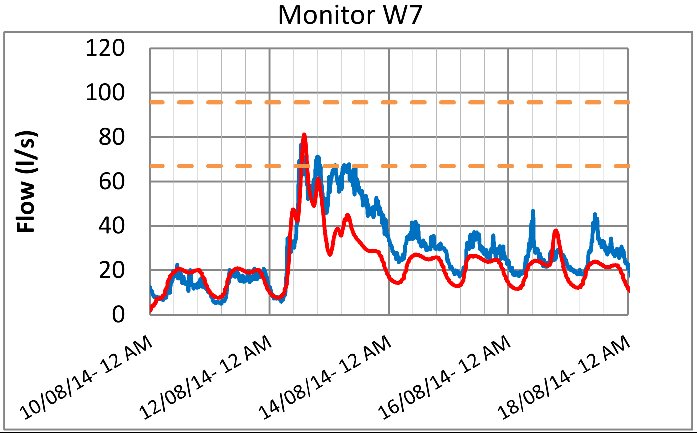


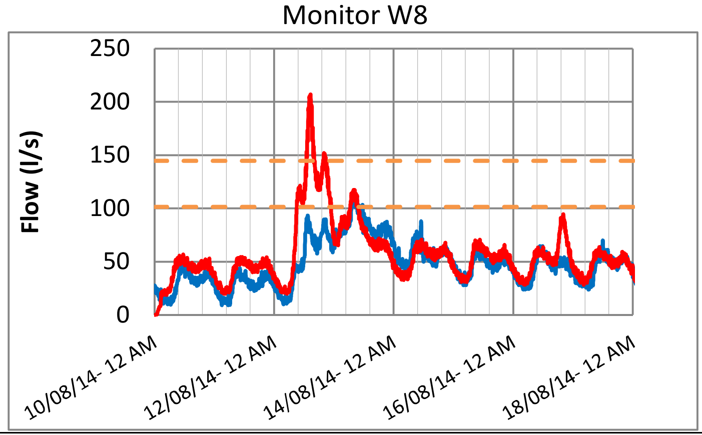
Monitor W1

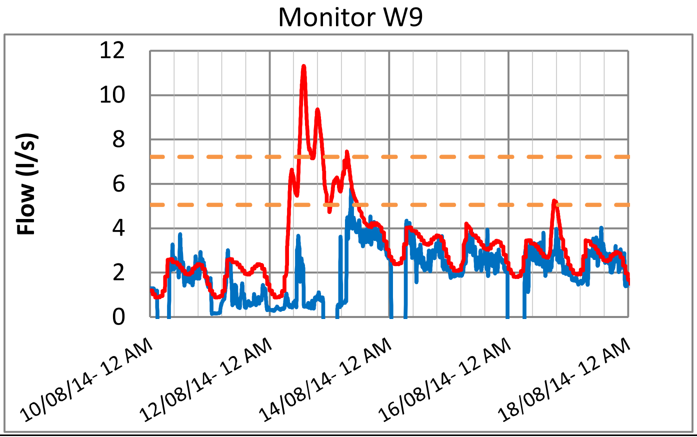


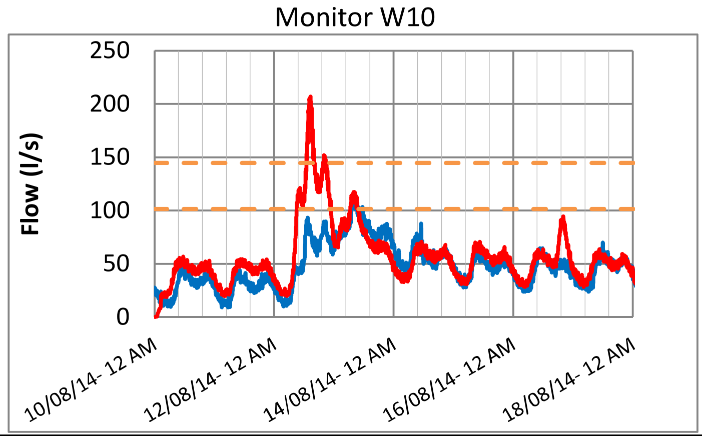
Monitor W5

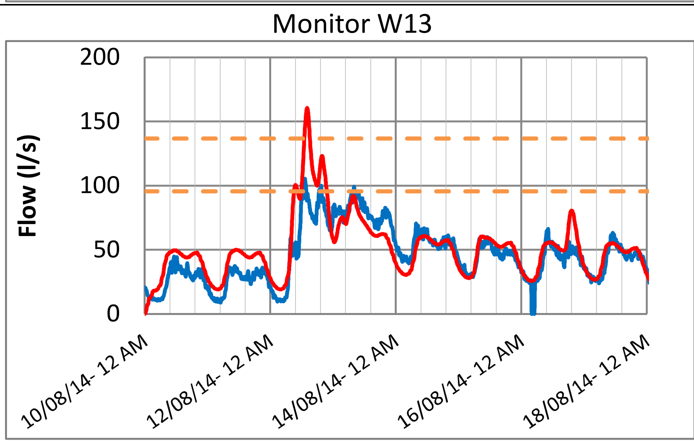


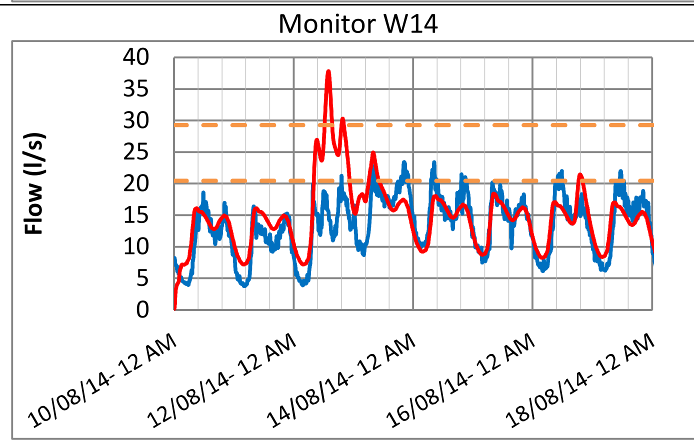

Monitor W7
Flow (l/s)
120
100
80
60
40
20
0
10/08/14- 12 AM
12/08/14- 12 AM
14/08/14- 12 AM
16/08/14- 12 AM
18/08/14- 12 AM

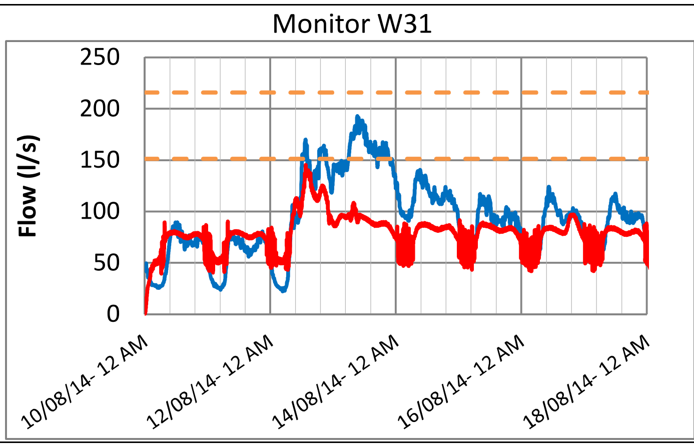

Monitor W8
Flow (l/s)
250
200
150
100
50
0
10/08/14- 12 AM
12/08/14- 12 AM
14/08/14- 12 AM
16/08/14- 12 AM
18/08/14- 12 AM


Monitor W9
Flow (l/s)
12
10
8
6
4
2
0
10/08/14- 12 AM
12/08/14- 12 AM
14/08/14- 12 AM
16/08/14- 12 AM
18/08/14- 12 AM


Monitor W10
Flow (l/s)
250
200
150
100
50
0
10/08/14- 12 AM
12/08/14- 12 AM
14/08/14- 12 AM
16/08/14- 12 AM
18/08/14- 12 AM

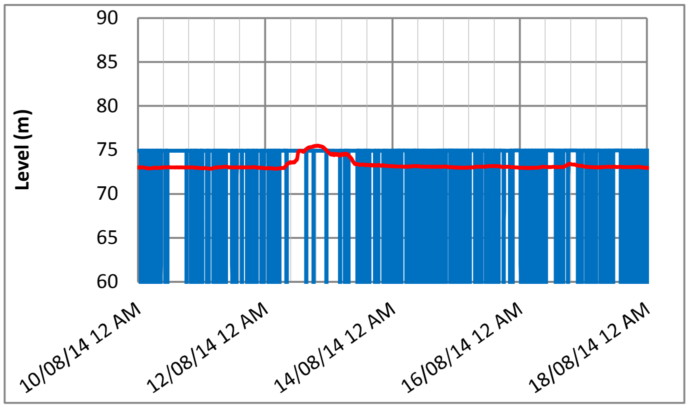

Monitor W13
Flow (l/s)
200
150
100
50
0
10/08/14- 12 AM
12/08/14- 12 AM
14/08/14- 12 AM
16/08/14- 12 AM
18/08/14- 12 AM


Monitor W14
Flow (l/s)
40
35
30
25
20
15
10
5
0
10/08/14- 12 AM
12/08/14- 12 AM
14/08/14- 12 AM
16/08/14- 12 AM
18/08/14- 12 AM

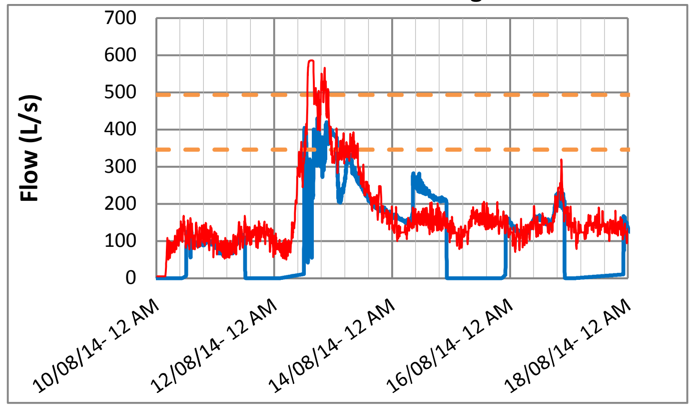

Monitor W31
Flow (l/s)
250
200
150
100
50
0
10/08/14- 12 AM
12/08/14- 12 AM
14/08/14- 12 AM
16/08/14- 12 AM
18/08/14- 12 AM

Kingston Central/East

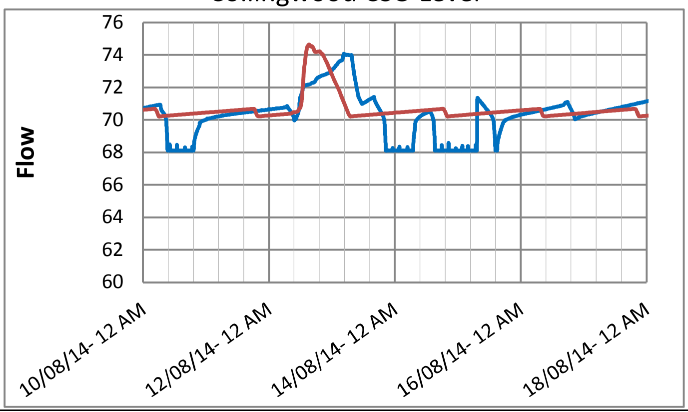
Barrack Street CSO Level



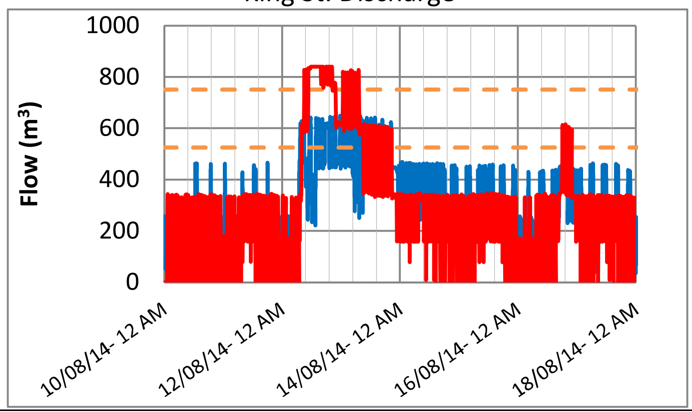
Dalton Ave. PS Discharge



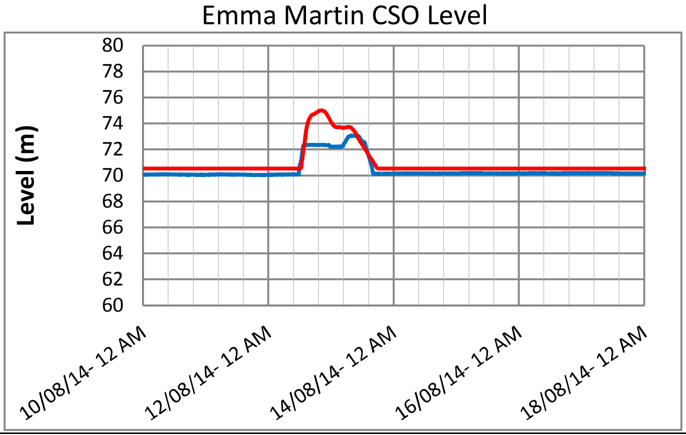
Collingwood CSO Level



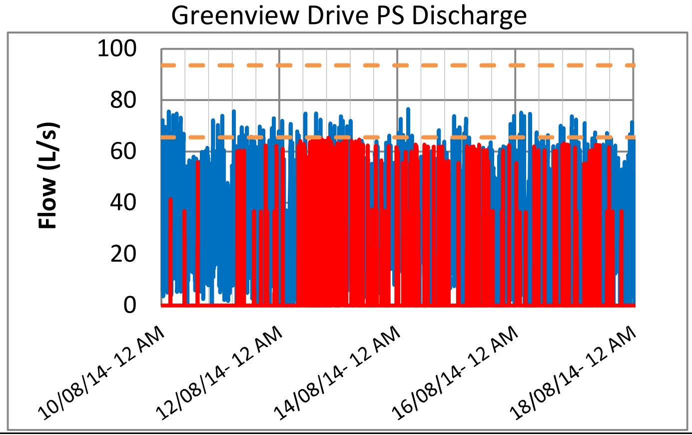
King St. Discharge



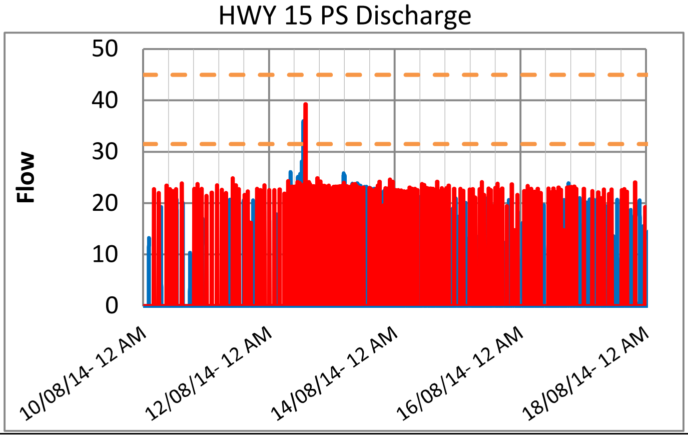
Emma Martin CSO Level



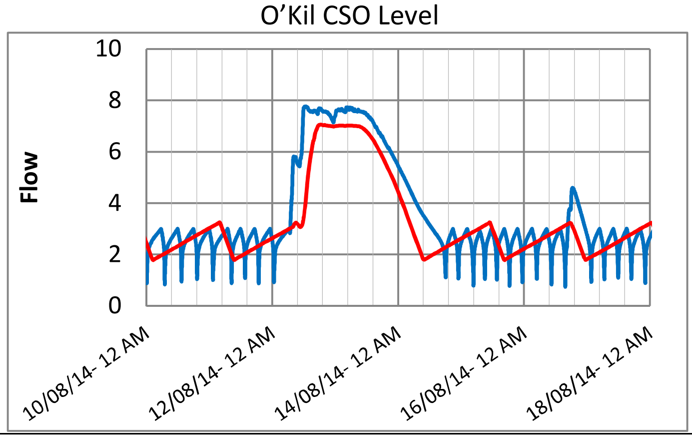
Greenview Drive PS Discharge

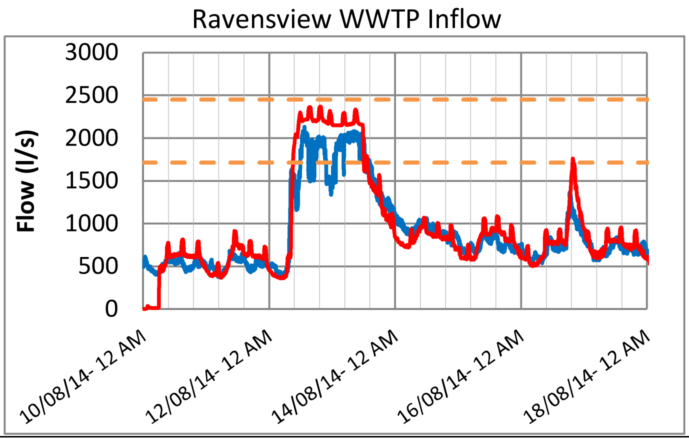


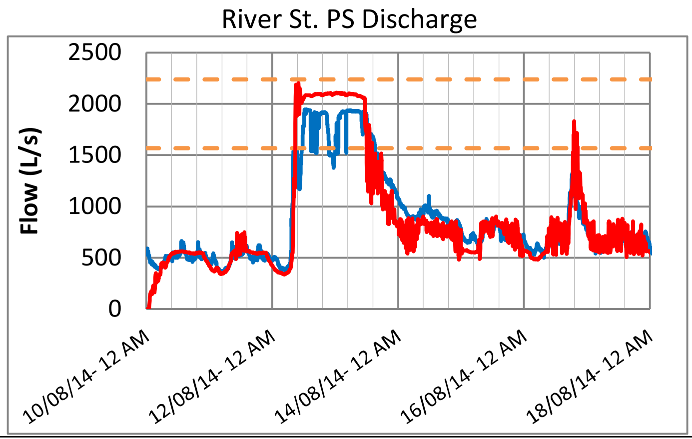
HWY 15 PS Discharge

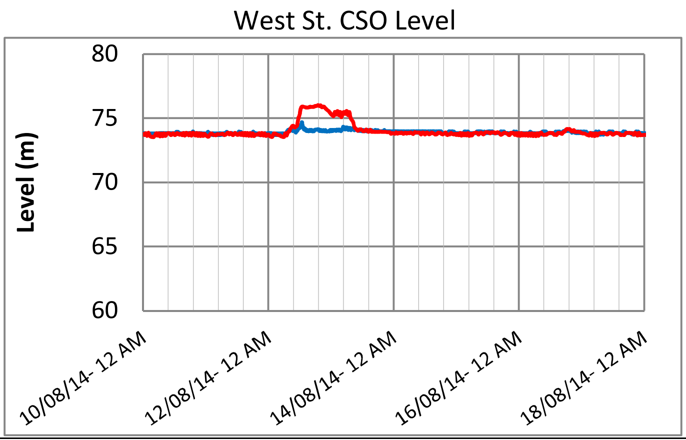


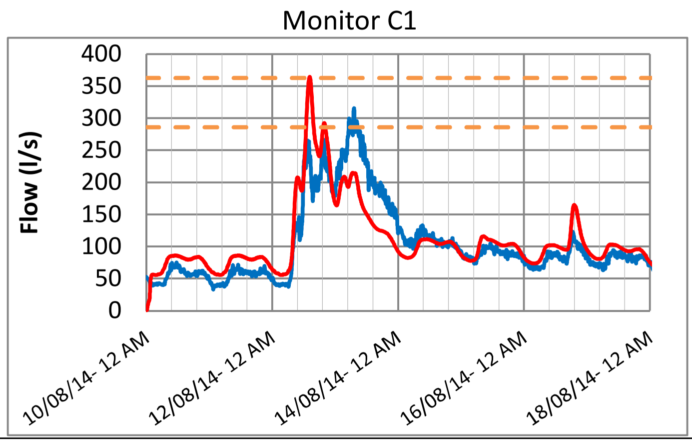
O'Kil CSO Level

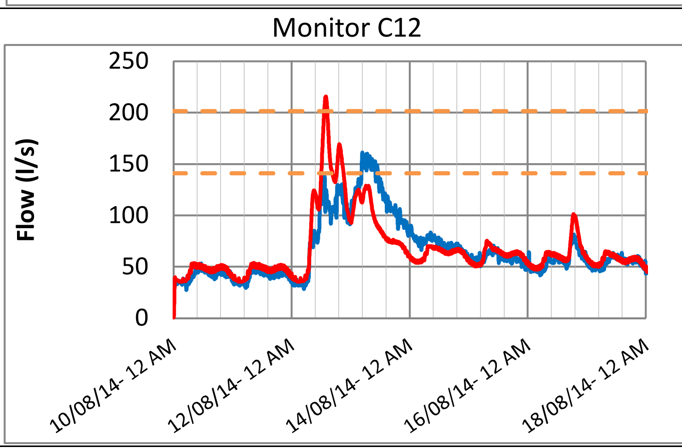


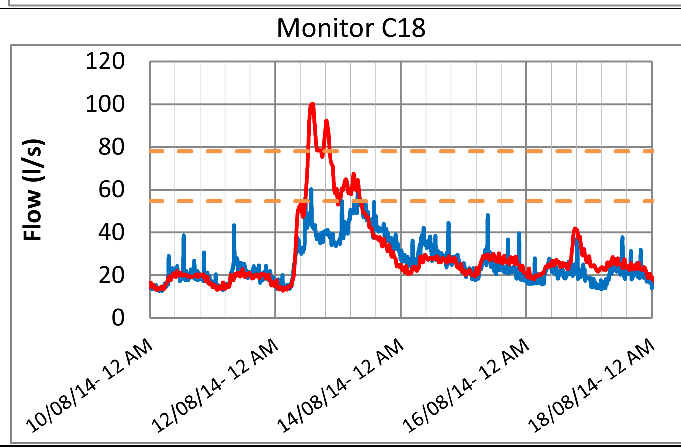

Ravensview WWTP Inflow
Flow (l/s)
3000
2500
2000
1500
1000
500
0
10/08/14- 12 AM
12/08/14- 12 AM
14/08/14- 12 AM
16/08/14- 12 AM
18/08/14- 12 AM

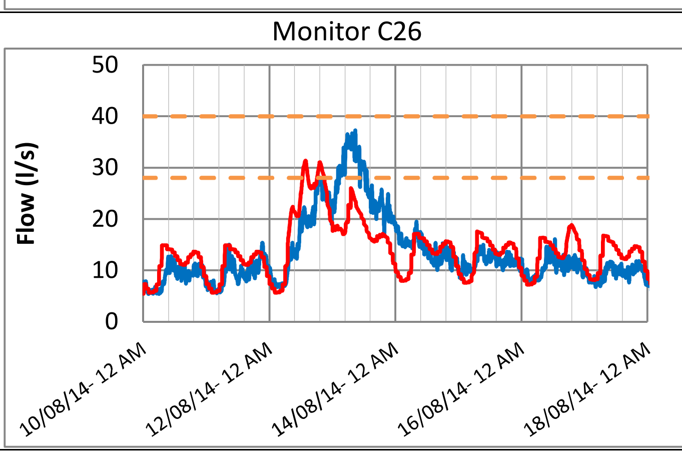

River St. PS Discharge
Flow (L/s)
2500
2000
1500
1000
500
0
10/08/14- 12 AM
12/08/14- 12 AM
14/08/14- 12 AM
16/08/14- 12 AM
18/08/14- 12 AM

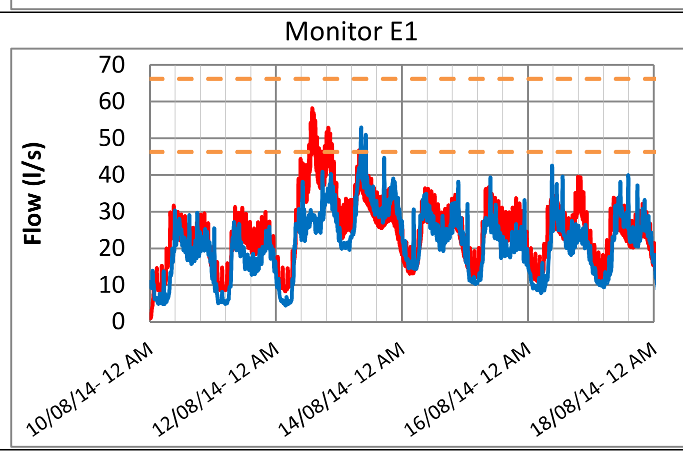

West St. CSO Level
Level (m)
80
75
70
65
60
10/08/14- 12 AM
12/08/14- 12 AM
14/08/14- 12 AM
16/08/14- 12 AM
18/08/14- 12 AM

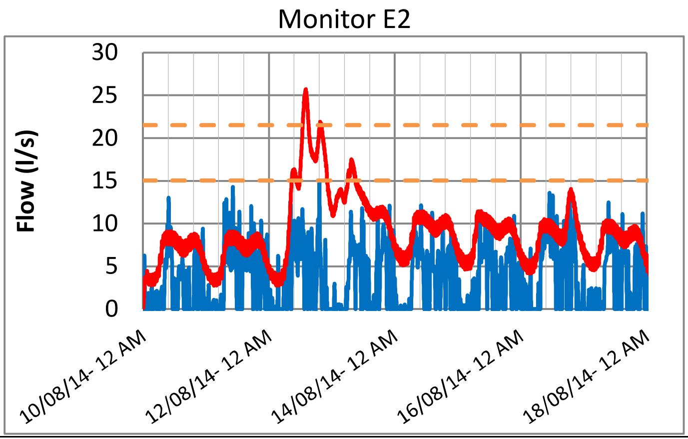

Monitor C1
Flow (l/s)
400
350
300
250
200
150
100
50
0
10/08/14- 12 AM
12/08/14- 12 AM
14/08/14- 12 AM
16/08/14- 12 AM
18/08/14- 12 AM


Monitor C12
Flow (l/s)
250
200
150
100
50
0
10/08/14- 12 AM
12/08/14- 12 AM
14/08/14- 12 AM
16/08/14- 12 AM
18/08/14- 12 AM


Monitor C18
Flow (l/s)
120
100
80
60
40
20
0
10/08/14- 12 AM
12/08/14- 12 AM
14/08/14- 12 AM
16/08/14- 12 AM
18/08/14- 12 AM


Monitor C26
Flow (l/s)
50
40
30
20
10
0
10/08/14- 12 AM
12/08/14- 12 AM
14/08/14- 12 AM
16/08/14- 12 AM
18/08/14- 12 AM


Monitor E1
Flow (l/s)
70
60
50
40
30
20
10
0
10/08/14- 12 AM
12/08/14- 12 AM
14/08/14- 12 AM
16/08/14- 12 AM
18/08/14- 12 AM

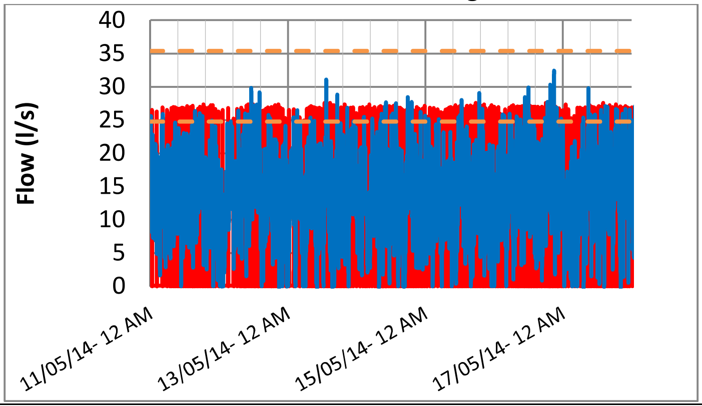

Monitor E2
Flow (l/s)
30
25
20
15
10
5
0
10/08/14- 12 AM
12/08/14- 12 AM
14/08/14- 12 AM
16/08/14- 12 AM
18/08/14- 12 AM

May 11-16, 2014 Event – Wet-Weather Events

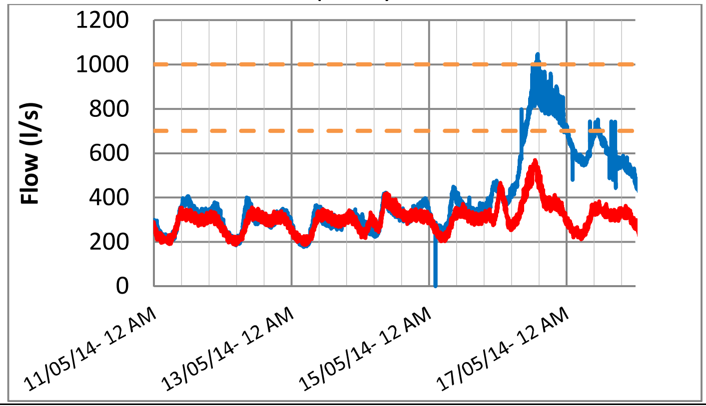
Actual   2014 Simulated   Calibration Range

Kingston West

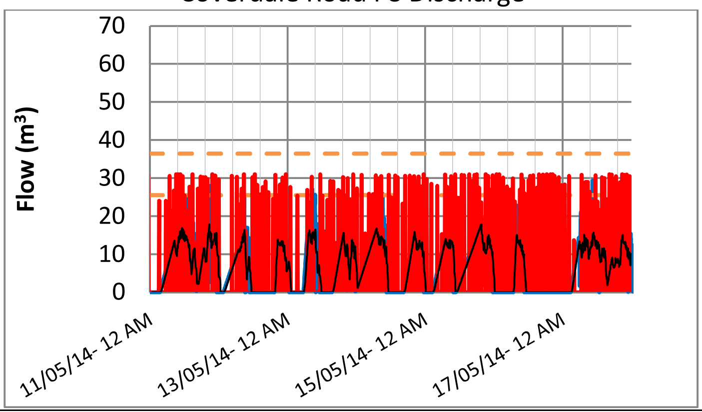
Bath Road PS Discharge



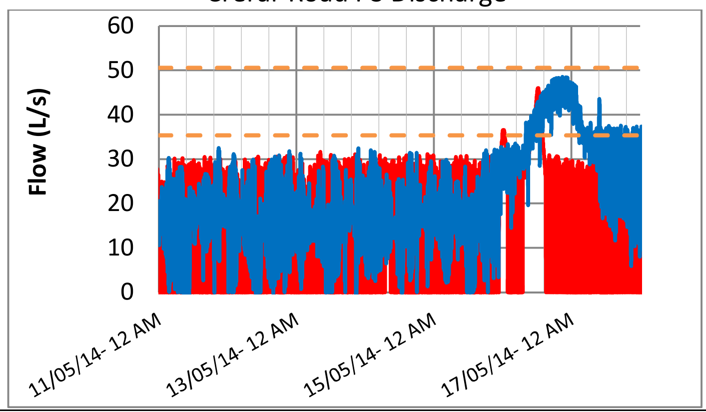
Cataraqui Bay WWTP



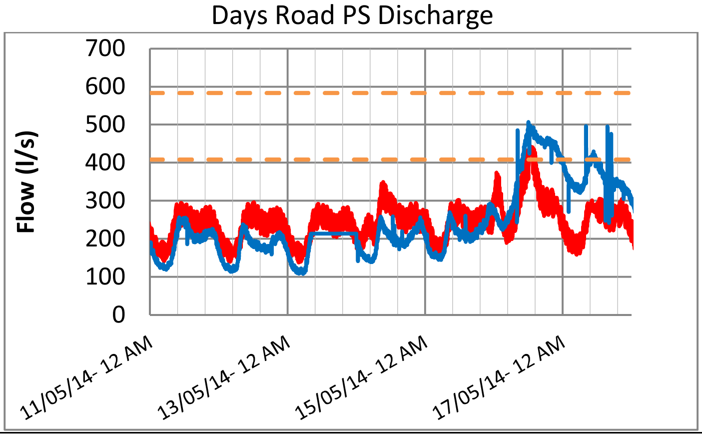
Coverdale Road PS Discharge



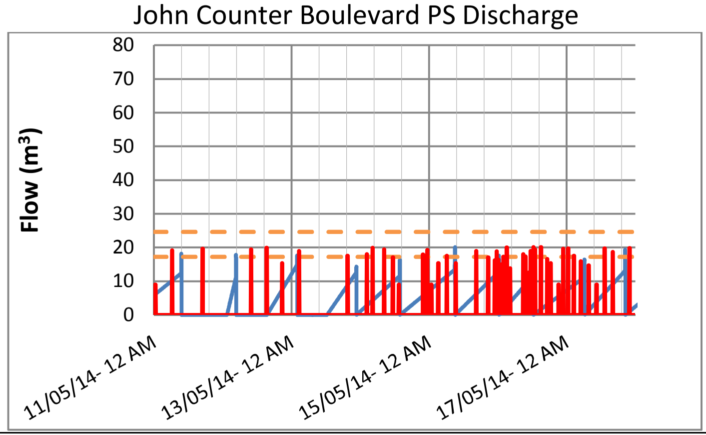
Crerar Road PS Discharge



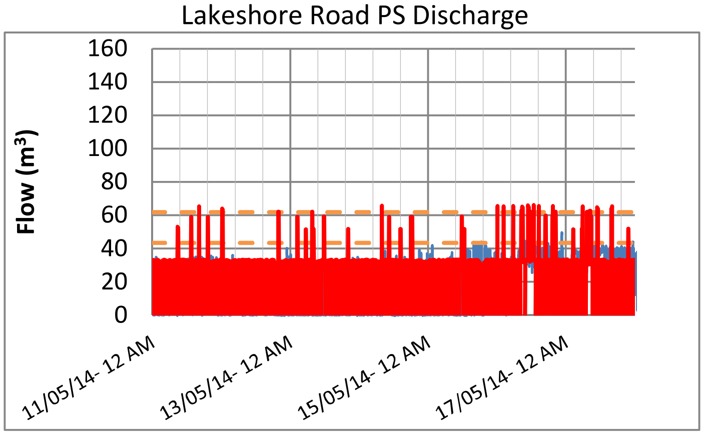
Days Road PS Discharge



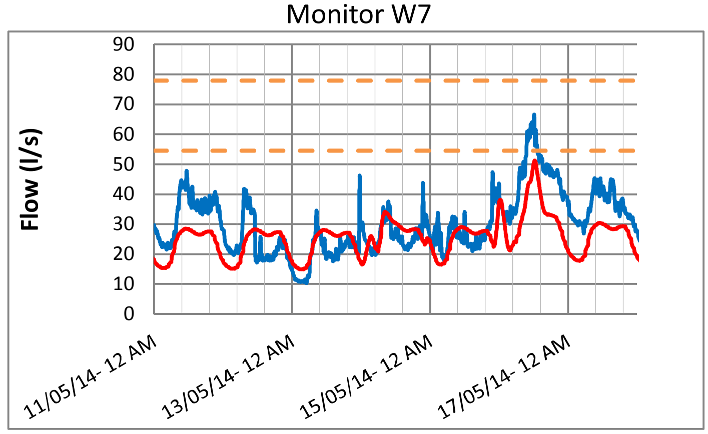
John Counter Boulevard PS Discharge



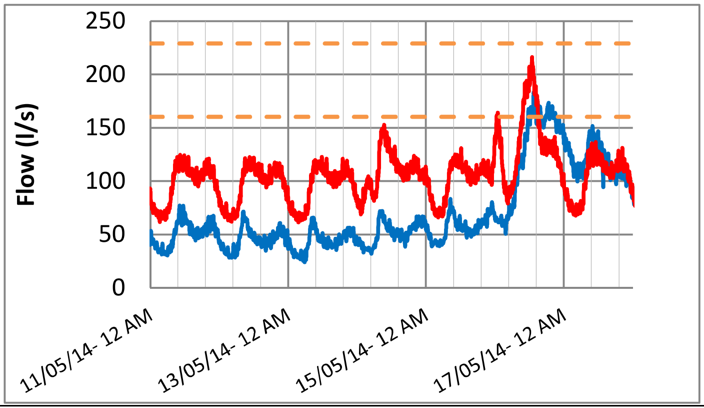
Lakeshore Road PS Discharge



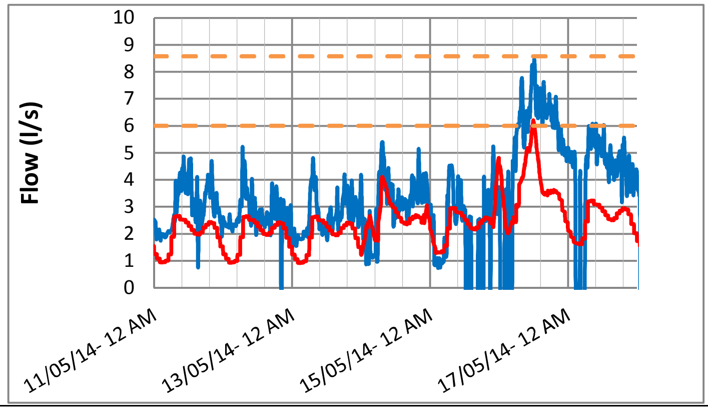
Monitor W7



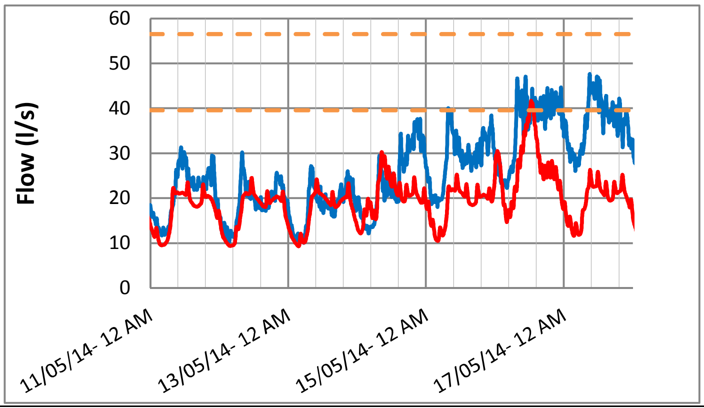
Monitor W8



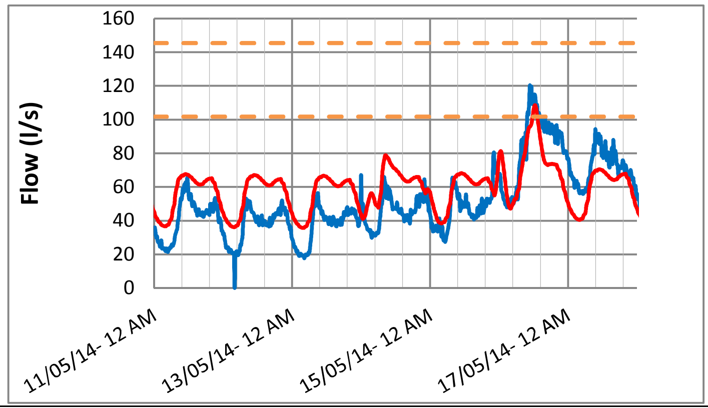
Monitor W9



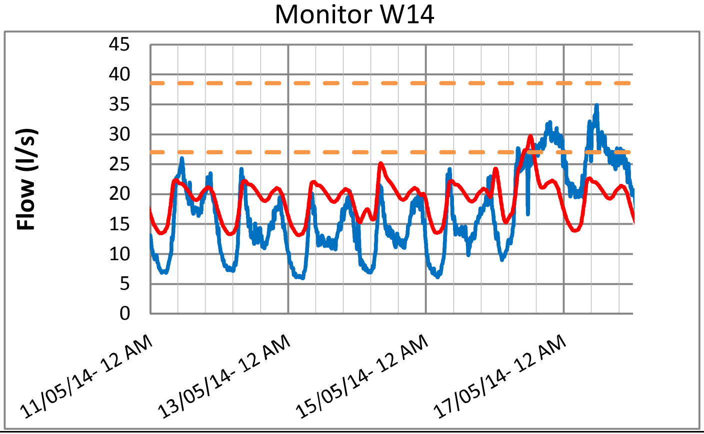
Monitor W10



Monitor W13

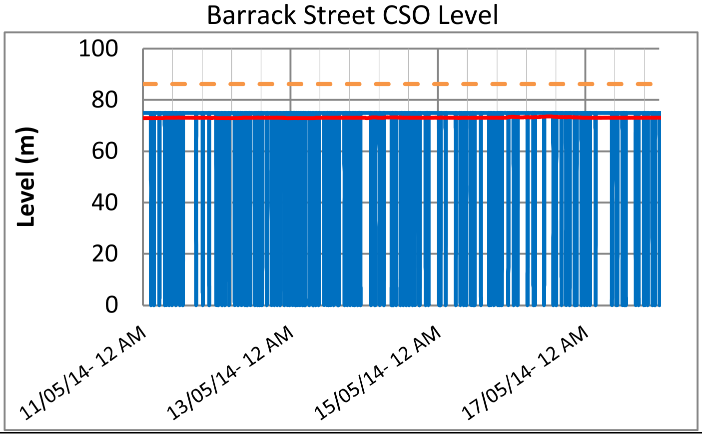


Monitor W14

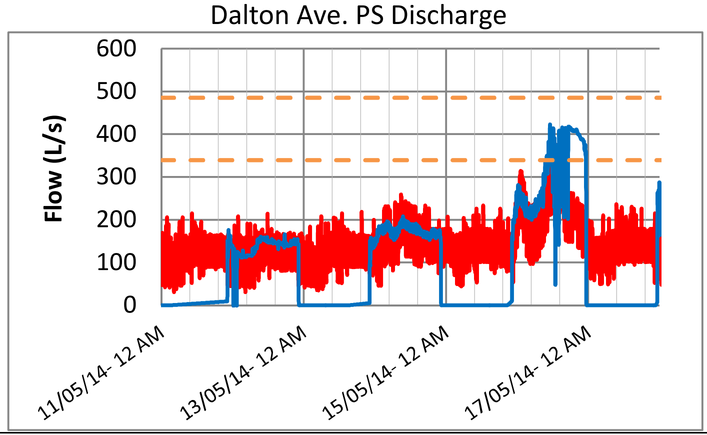


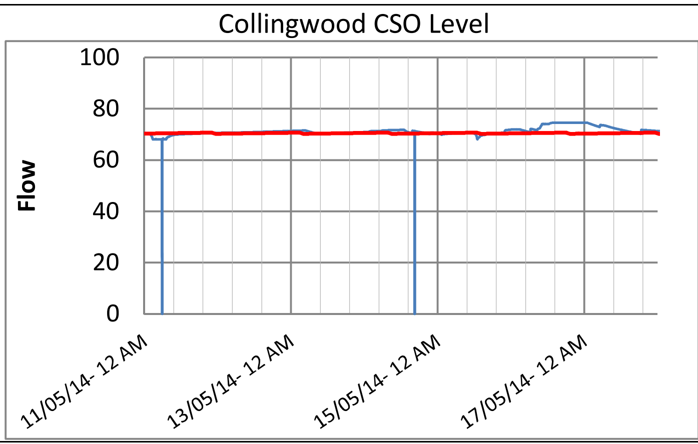
Kingston Central/East

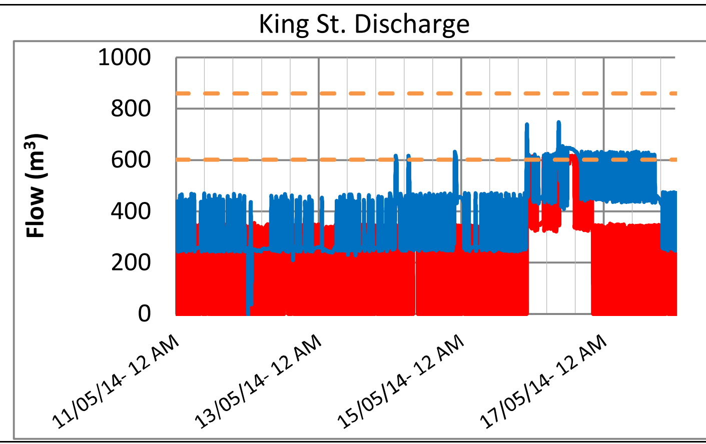
Barrack Street CSO Level

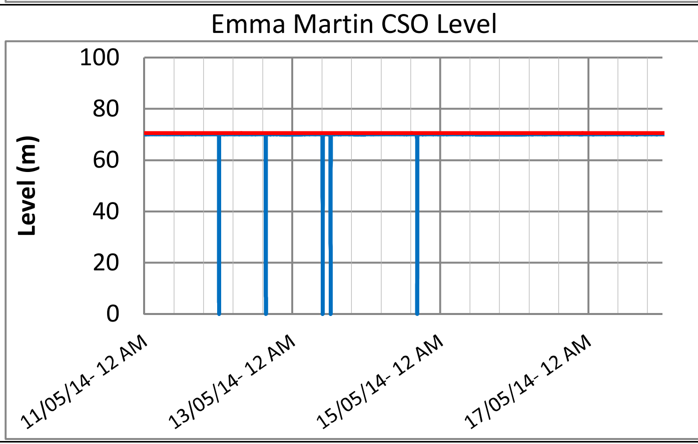


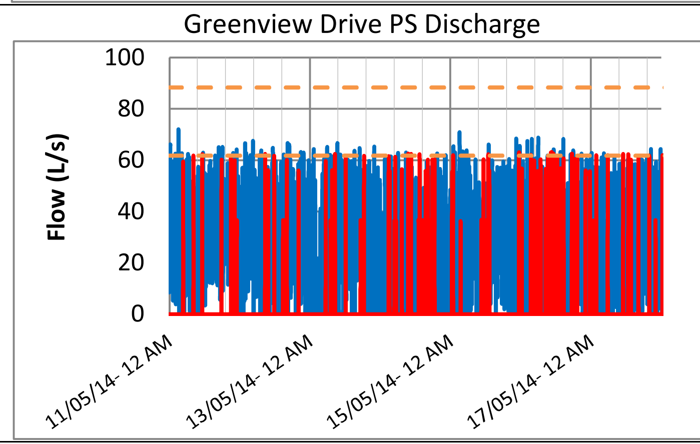
Dalton Ave. PS Discharge

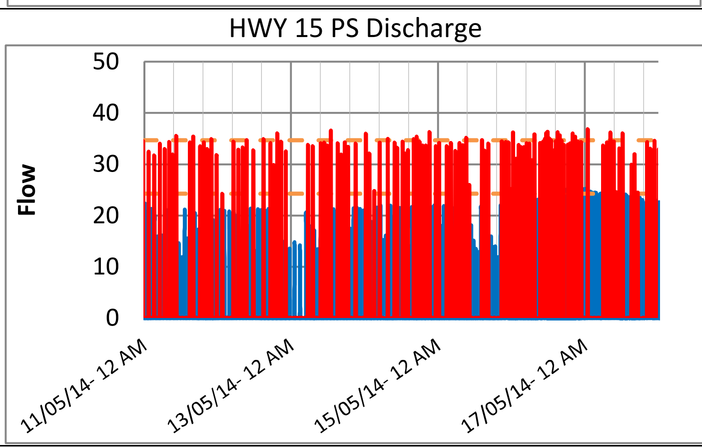


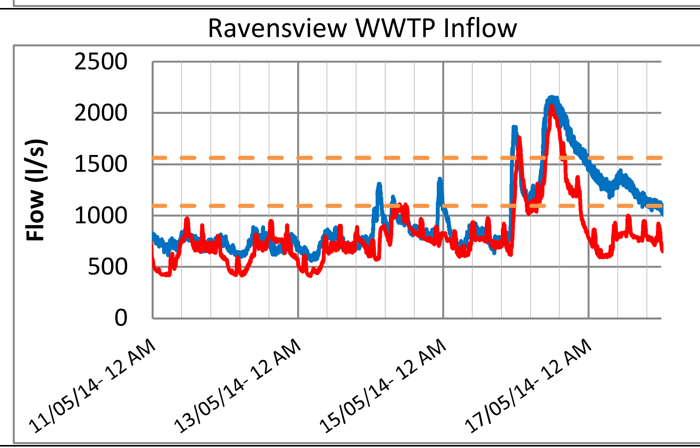

Collingwood CSO Level
Flow
100
80
60
40
20
0
11/05/14- 12 AM
13/05/14- 12 AM
15/05/14- 12 AM
17/05/14- 12 AM

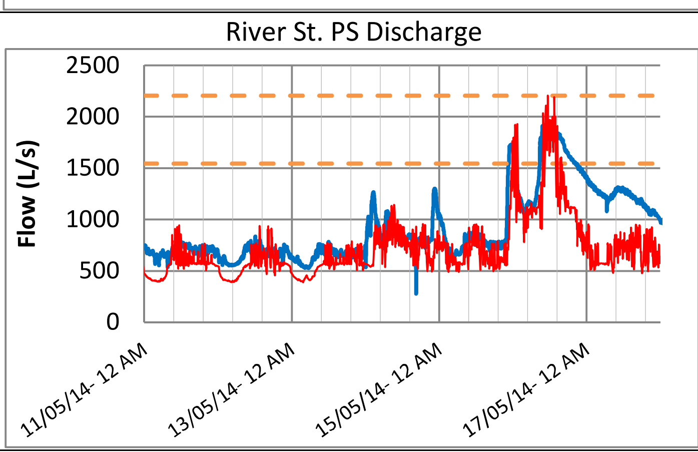

King St. Discharge
Flow (m³)
1000
800
600
400
200
0
11/05/14- 12 AM
13/05/14- 12 AM
15/05/14- 12 AM
17/05/14- 12 AM


Emma Martin CSO Level
Level (m)
100
80
60
40
20
0
11/05/14- 12 AM
13/05/14- 12 AM
15/05/14- 12 AM
17/05/14- 12 AM


Greenview Drive PS Discharge
Flow (L/s)
100
80
60
40
20
0
11/05/14- 12 AM
13/05/14- 12 AM
15/05/14- 12 AM
17/05/14- 12 AM


HWY 15 PS Discharge
Flow
50
40
30
20
10
0
11/05/14- 12 AM
13/05/14- 12 AM
15/05/14- 12 AM
17/05/14- 12 AM


Ravensview WWTP Inflow
Flow (l/s)
2500
2000
1500
1000
500
0
11/05/14- 12 AM
13/05/14- 12 AM
15/05/14- 12 AM
17/05/14- 12 AM

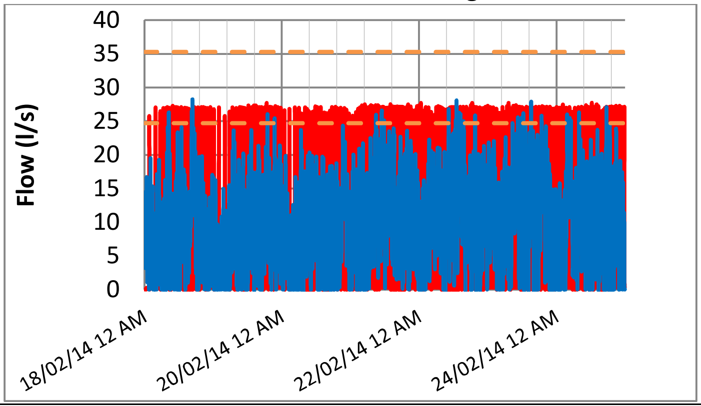

River St. PS Discharge
Flow (L/s)
2500
2000
1500
1000
500
0
11/05/14- 12 AM
13/05/14- 12 AM
15/05/14- 12 AM
17/05/14- 12 AM

February 18-22, 2014 Event – Wet-Weather Events

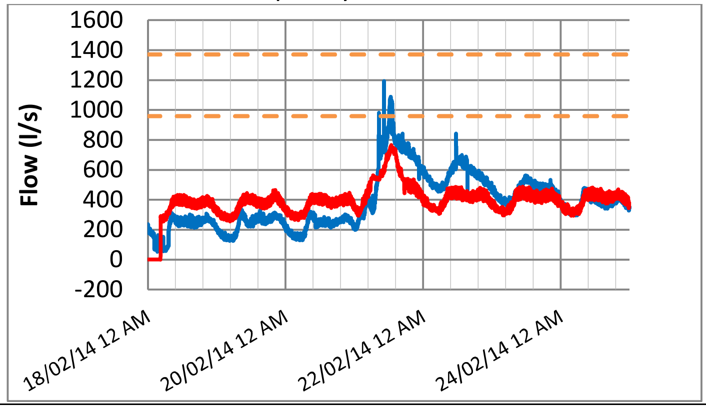
Actual 2014 Simulated Calibration Range

Kingston West

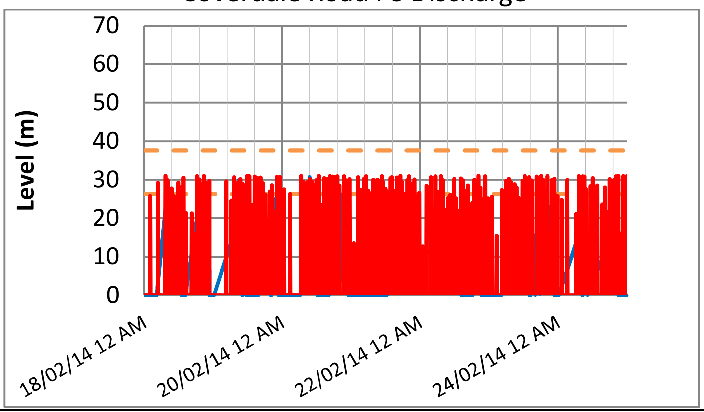
Bath Road PS Discharge



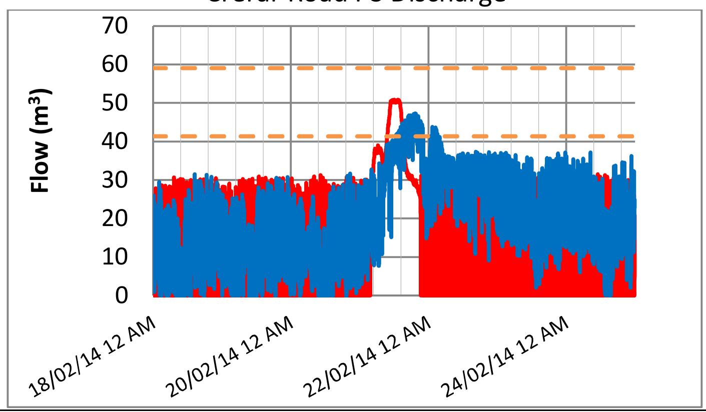
Cataraqui Bay WWTP Inflow



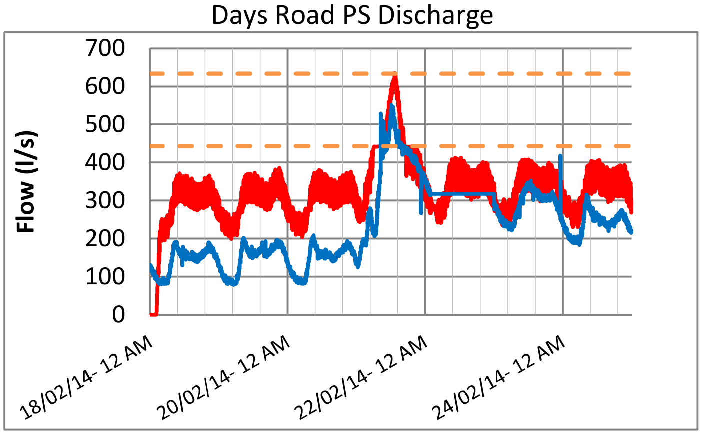
Coverdale Road PS Discharge



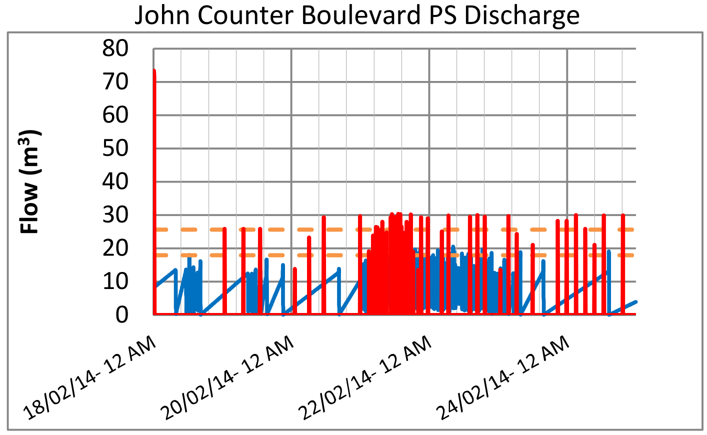
Crerar Road PS Discharge



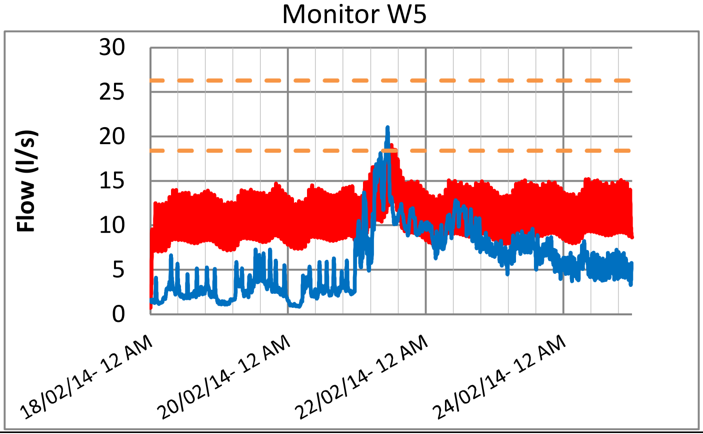
Days Road PS Discharge



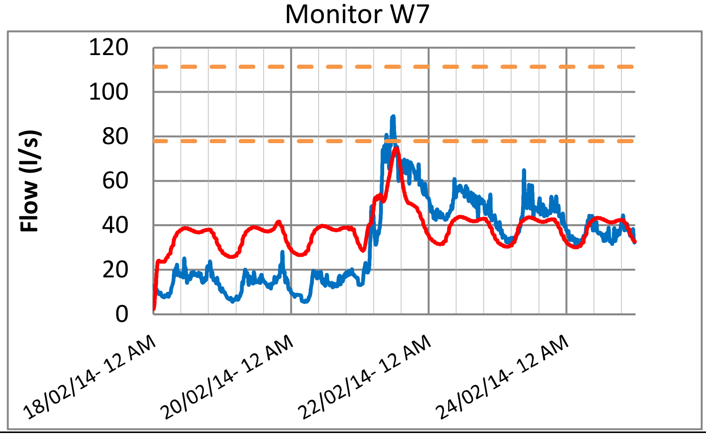
John Counter Boulevard PS Discharge



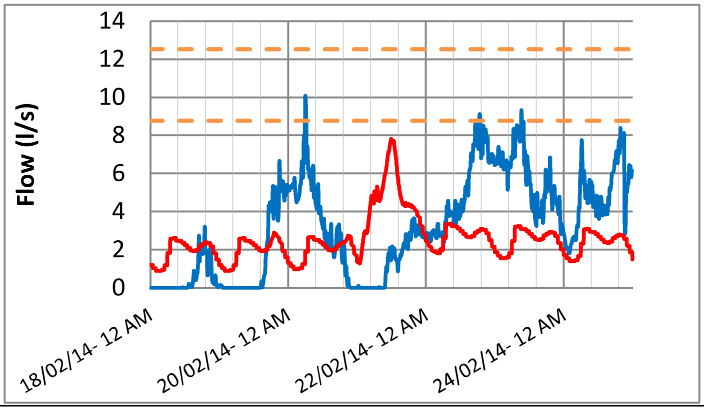
Monitor W5



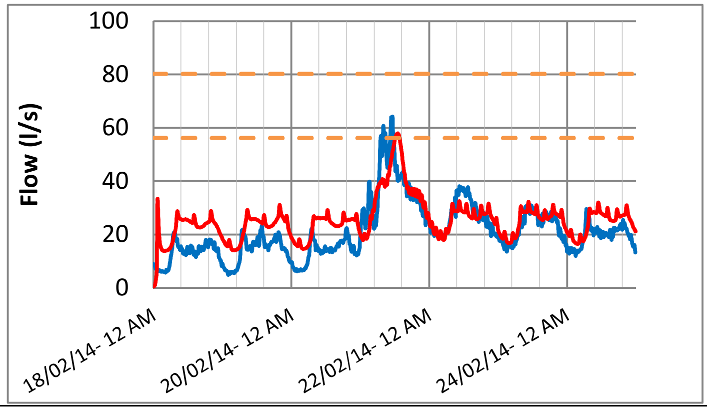
Monitor W7



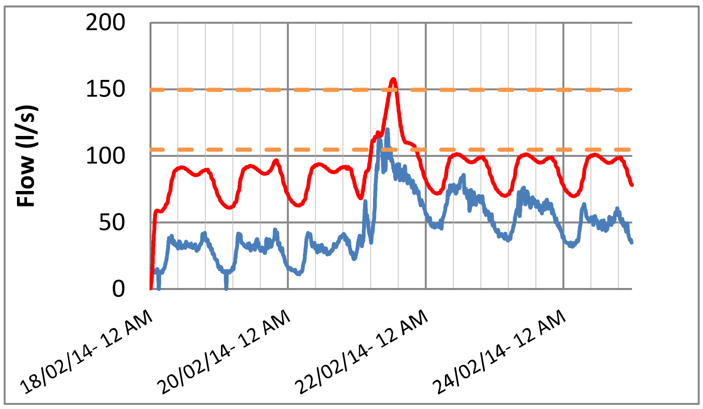
Monitor W9



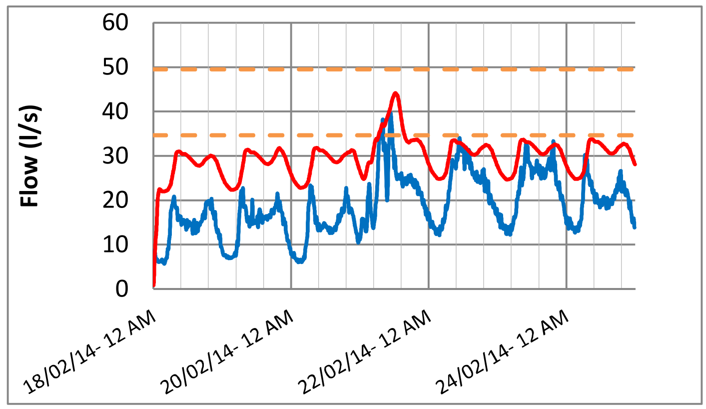
Monitor W10



Monitor W13

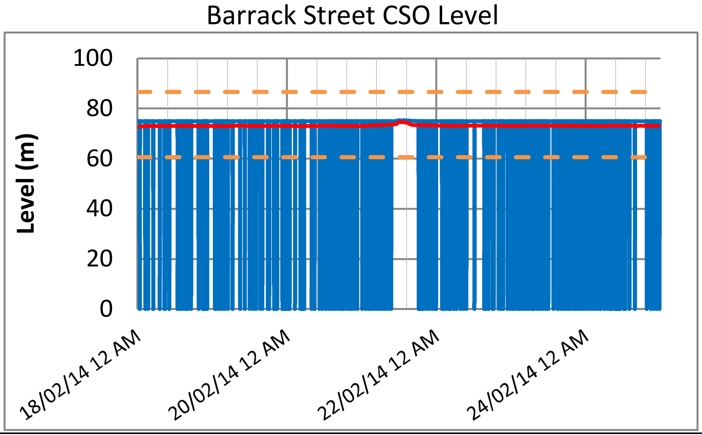


Monitor W14

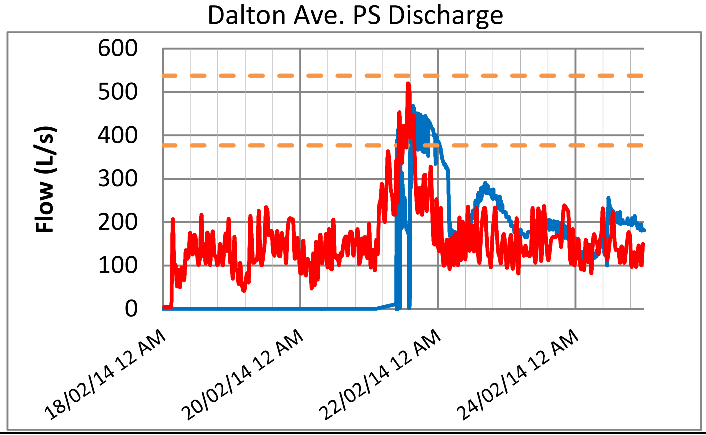


Kingston Central/East

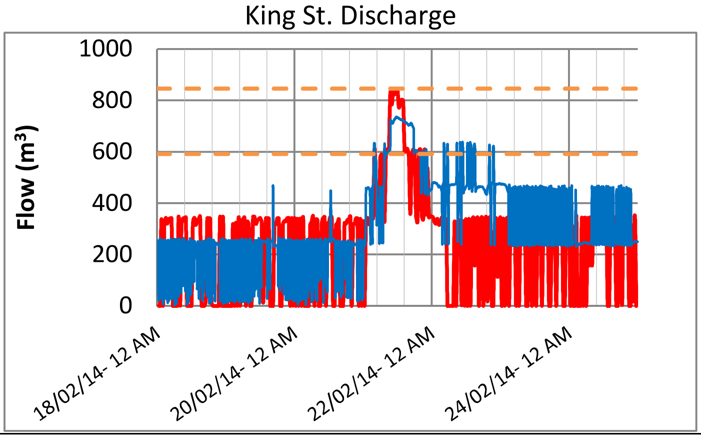
Barrack Street CSO Level



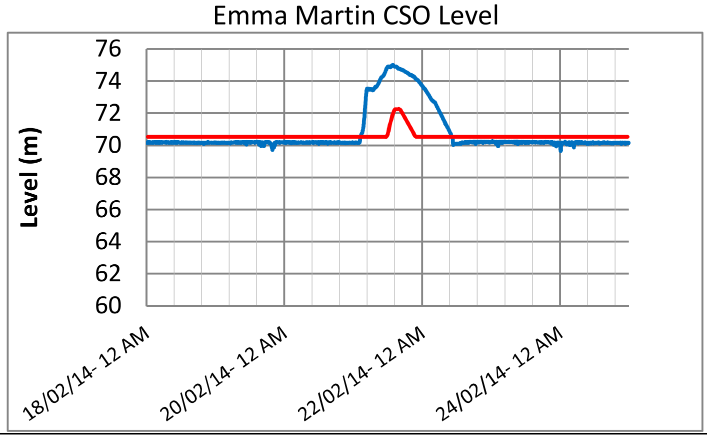
Dalton Ave. PS Discharge

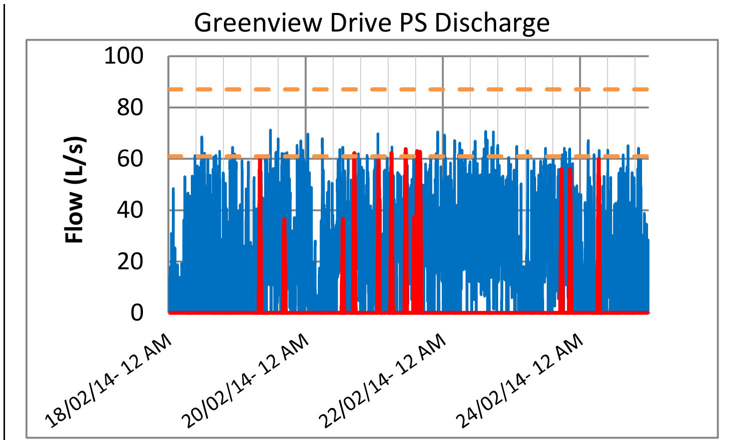


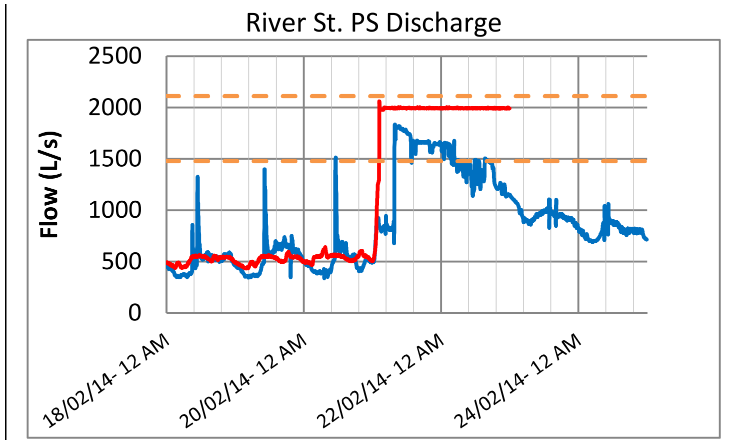
King St. Discharge

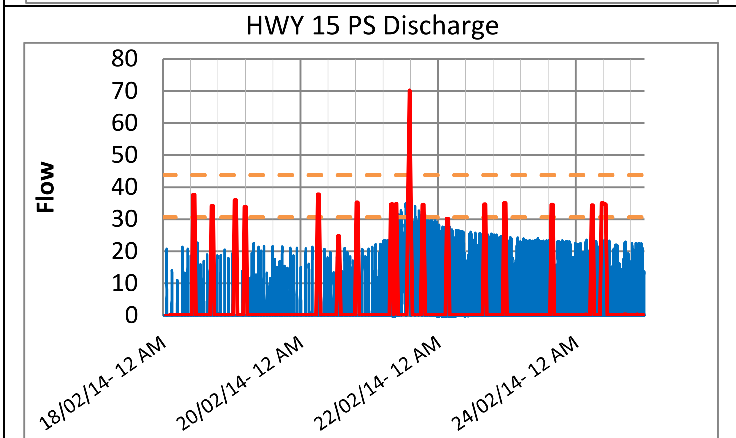


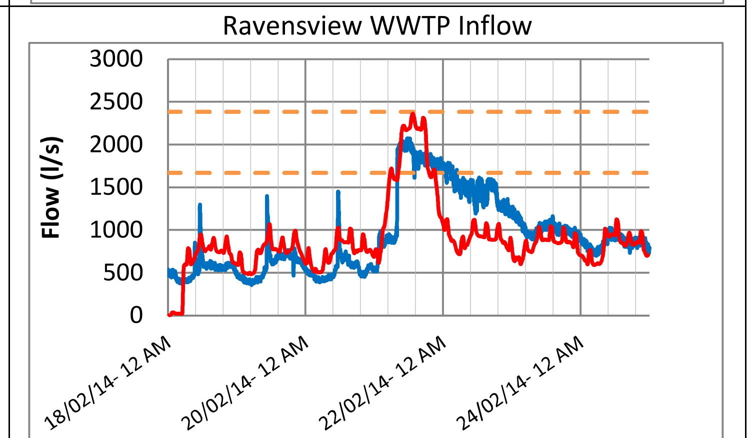
Emma Martin CSO Level

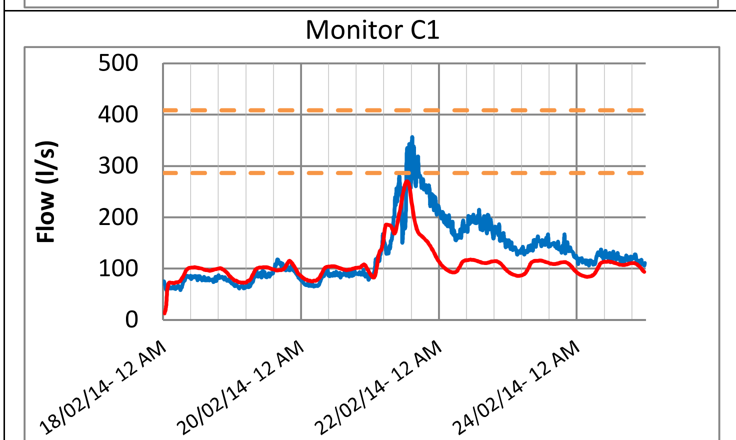


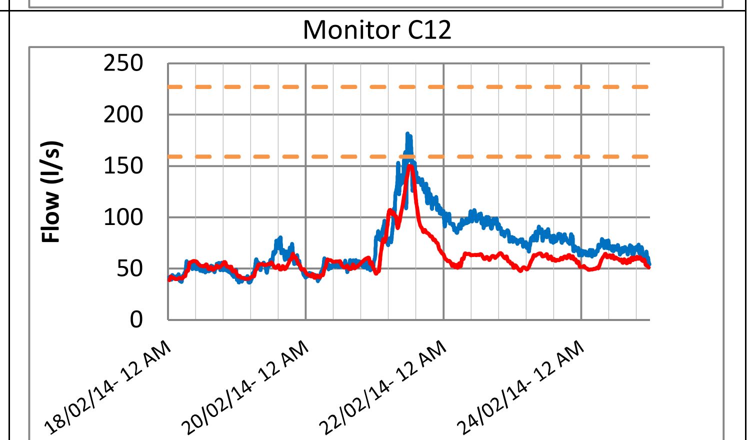

Greenview Drive PS Discharge
Flow (L/s)
100
80
60
40
20
0
18/02/14- 12 AM
20/02/14- 12 AM
22/02/14- 12 AM
24/02/14- 12 AM

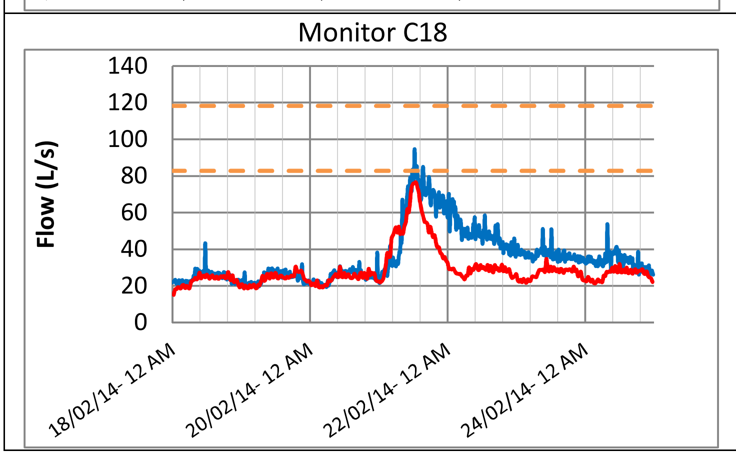

River St. PS Discharge
Flow (L/s)
2500
2000
1500
1000
500
0
18/02/14- 12 AM
20/02/14- 12 AM
22/02/14- 12 AM
24/02/14- 12 AM

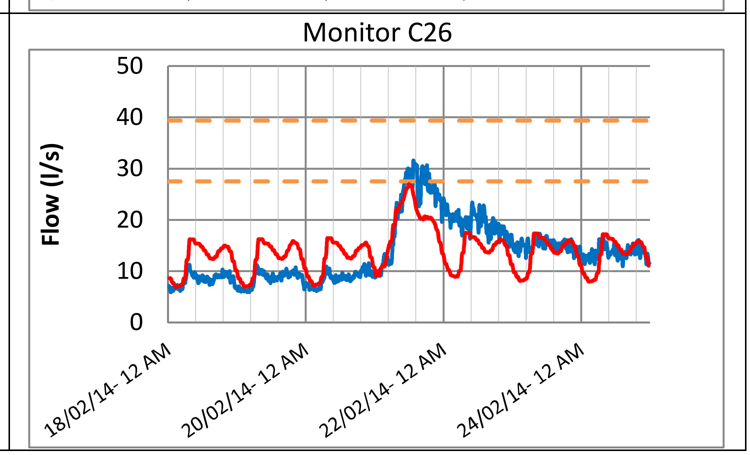

HWY 15 PS Discharge
Flow
80
70
60
50
40
30
20
10
0
18/02/14- 12 AM
20/02/14- 12 AM
22/02/14- 12 AM
24/02/14- 12 AM

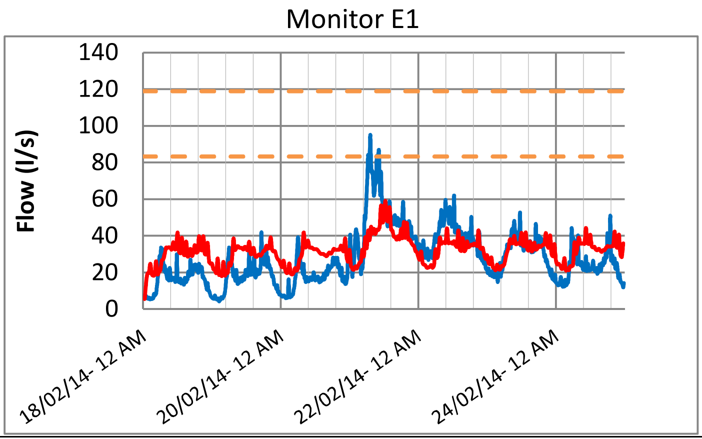

Ravensview WWTP Inflow
Flow (l/s)
3000
2500
2000
1500
1000
500
0
18/02/14- 12 AM
20/02/14- 12 AM
22/02/14- 12 AM
24/02/14- 12 AM

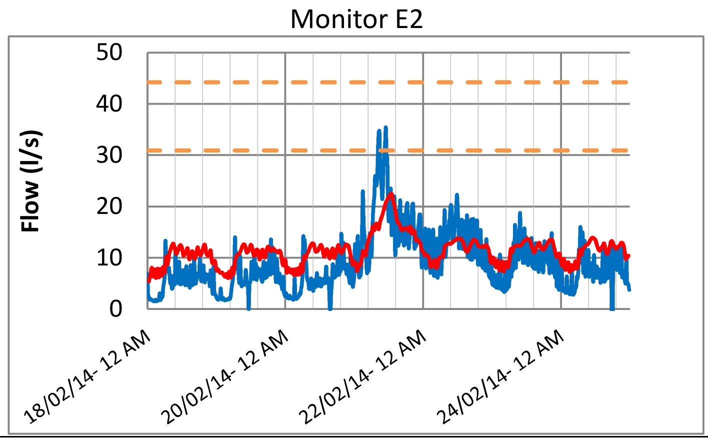

Monitor C1
Flow (l/s)
500
400
300
200
100
0
18/02/14- 12 AM
20/02/14- 12 AM
22/02/14- 12 AM
24/02/14- 12 AM


Monitor C12
Flow (l/s)
250
200
150
100
50
0
18/02/14- 12 AM
20/02/14- 12 AM
22/02/14- 12 AM
24/02/14- 12 AM


Monitor C18
Flow (L/s)
140
120
100
80
60
40
20
0
18/02/14- 12 AM
20/02/14- 12 AM
22/02/14- 12 AM
24/02/14- 12 AM


Monitor C26
Flow (l/s)
50
40
30
20
10
0
18/02/14- 12 AM
20/02/14- 12 AM
22/02/14- 12 AM
24/02/14- 12 AM


Monitor E1
Flow (l/s)
140
120
100
80
60
40
20
0
18/02/14- 12 AM
20/02/14- 12 AM
22/02/14- 12 AM
24/02/14- 12 AM


Monitor E2
Flow (l/s)
50
40
30
20
10
0
18/02/14- 12 AM
20/02/14- 12 AM
22/02/14- 12 AM
24/02/14- 12 AM

Appendix K

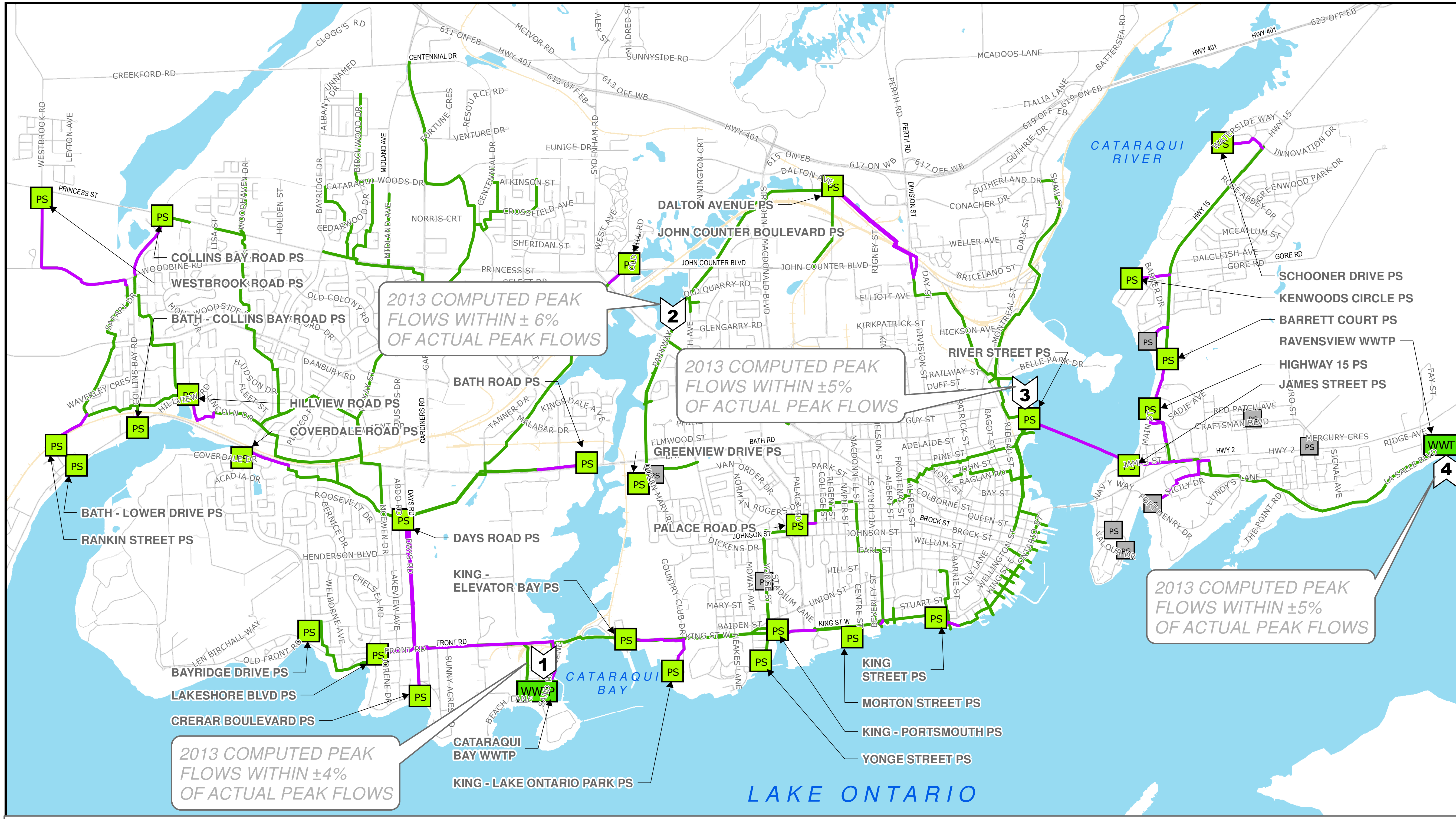
MODEL VALIDATION SUMMARY

Appendix K – Contents

Figure K-1 Model Validation: Dry Weather – March 24-30, 2013

Figure K-2: Model Validation: Wet Weather – May 19-25, 2013

Validation Results Summary Graphs



WSP

1224 GARDINERS RD, SUITE 201
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Utilities Kingston

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

Legend

- WWTP — WASTEWATER TREATMENT PLANT
- PS — SANITARY PUMPING STATION
- PS — SANITARY PUMPING STATION (NOT MODELLED)
- FORCEMAIN
- MODEL CONDUIT
- WATERBODY

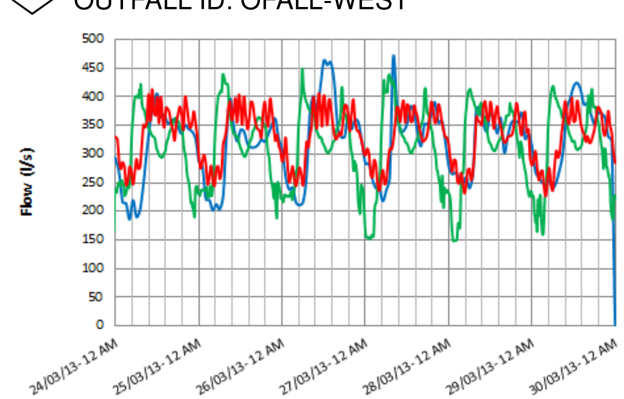
Data Source: Ontario Base Mapping, Ministry of Natural Resources, August 2013. Water and Waste Water Systems, Utilities Kingston, April 2015, City of Kingston.

Scale: 0 300 600 1,200 Meters

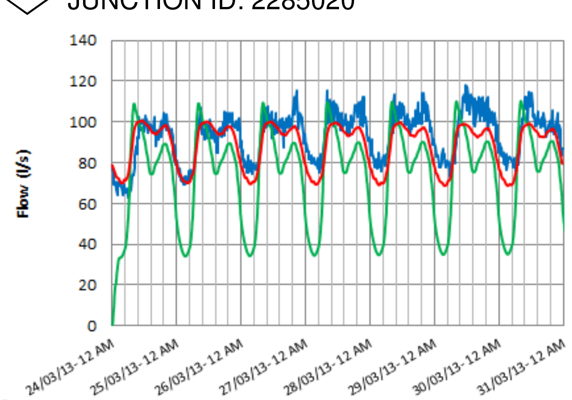
1:47,500

VALIDATION RESULTS:

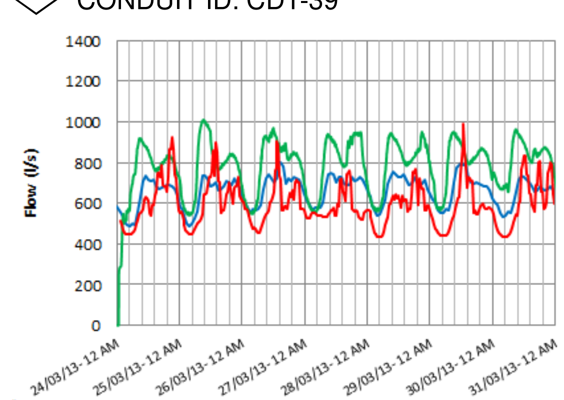
1 CATARAQUI BAY WWTP INFLOW
OUTFALL ID: OFALL-WEST



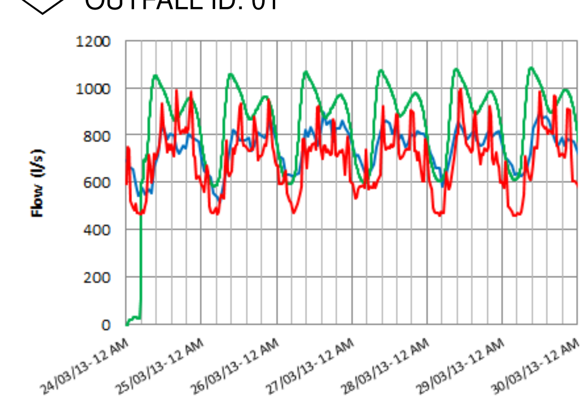
2 MONITOR C1 INFLOW
JUNCTION ID: 2285020



3 RIVER ST PS DISCHARGE
CONDUIT ID: CDT-39



4 RAVENSVIEW WWTP INFLOW
OUTFALL ID: 01



- 2013 PRE-CALIBRATION RESULTS — - COMPUTED (2014) — - ACTUAL

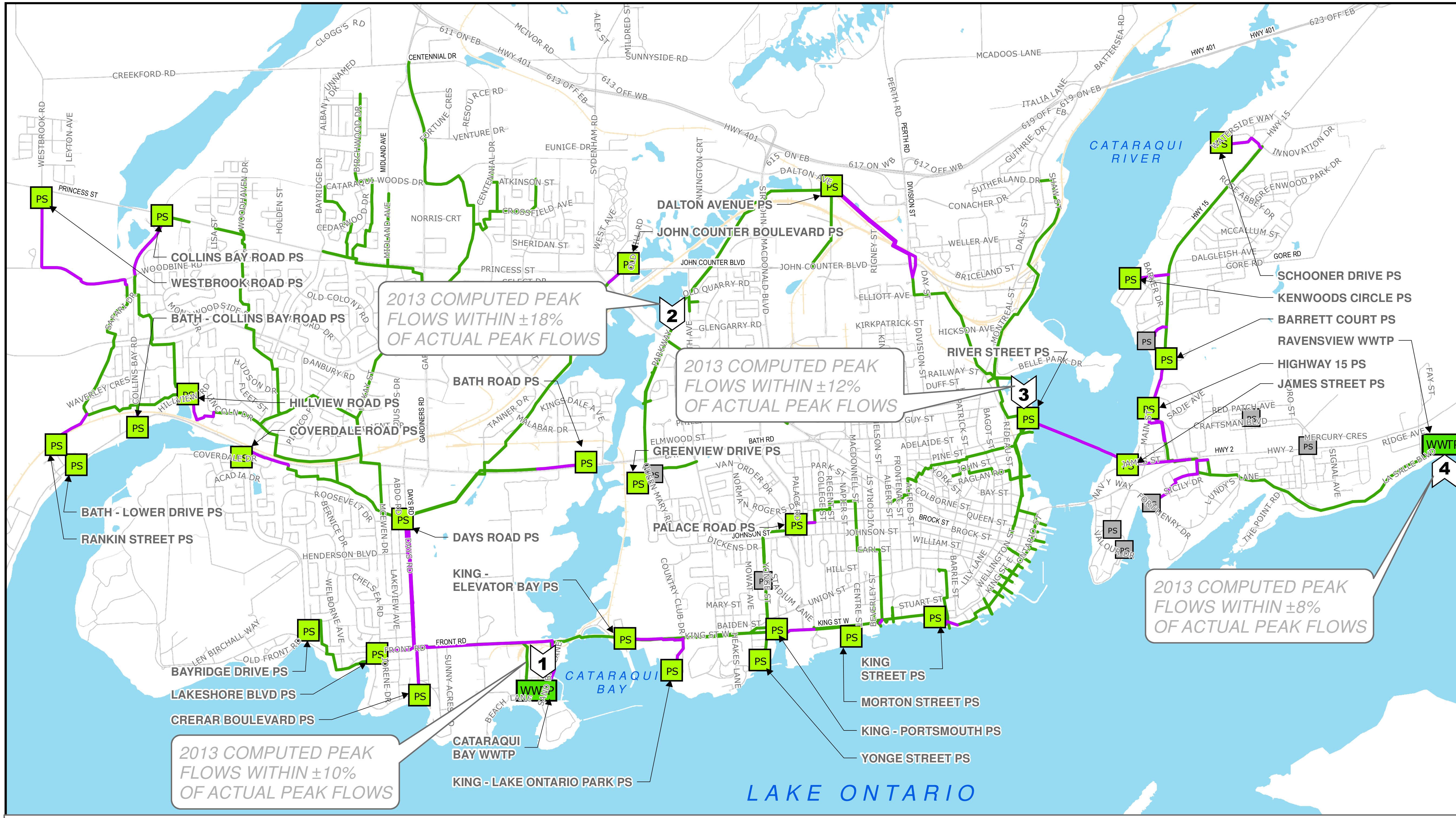
Project:
Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title:
MODEL VALIDATION: DRY WEATHER - MARCH 24-30, 2013

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

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.6_Wastewater Model\Maps\Calibration Report Maps\K_ModelValidation\151-02944-00_WWM_FigK-1_Model_Validation_Map-Dry_Weather.mxd



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CANADA, K7P 0G2
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P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WWTP — WASTEWATER TREATMENT PLANT
- PS — SANITARY PUMPING STATION
- PS — SANITARY PUMPING STATION (NOT MODELLED)
- FORCEMAIN
- MODEL CONDUIT
- WATERBODY

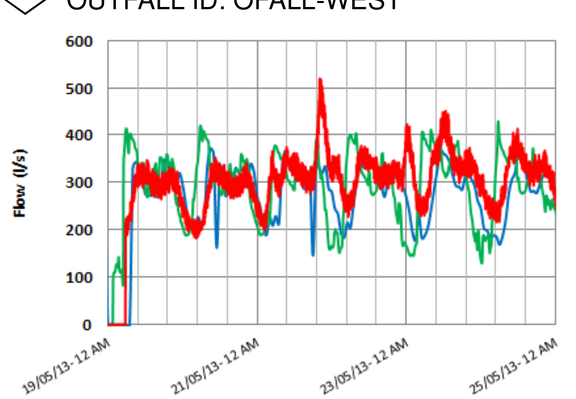
Data Source: Ontario Base Mapping, Ministry of Natural Resources, August 2013. Water and Waste Water Systems, Utilities Kingston, April 2015, City of Kingston.

Scale: 0 300 600 1,200 Meters

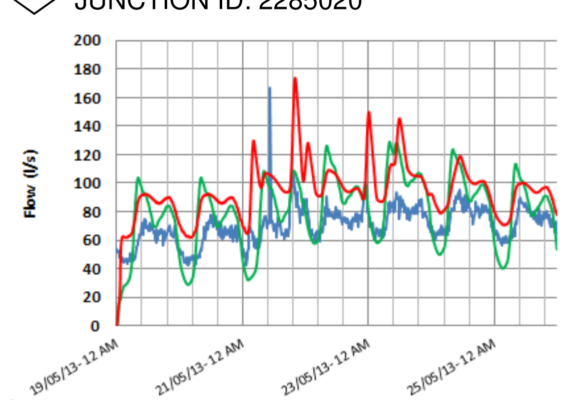
1:47,500

VALIDATION RESULTS:

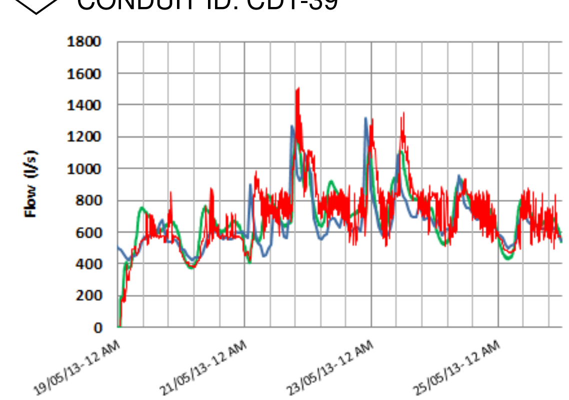
1 CATARAQUI BAY WWTP INFLOW
OUTFALL ID: OFALL-WEST



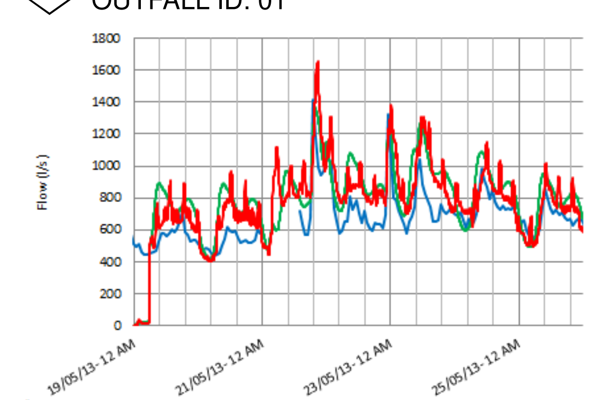
2 MONITOR C1 INFLOW
JUNCTION ID: 2285020



3 RIVER ST PS DISCHARGE
CONDUIT ID: CDT-39



4 RAVENSVIEW WWTP INFLOW
OUTFALL ID: 01



- 2013 PRE-CALIBRATION RESULTS - COMPUTED (2014) - ACTUAL

Project:
Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title:
MODEL VALIDATION: WET WEATHER - MAY 19-25, 2013

Project No.:	Date:
151-02944-00	DECEMBER 2016

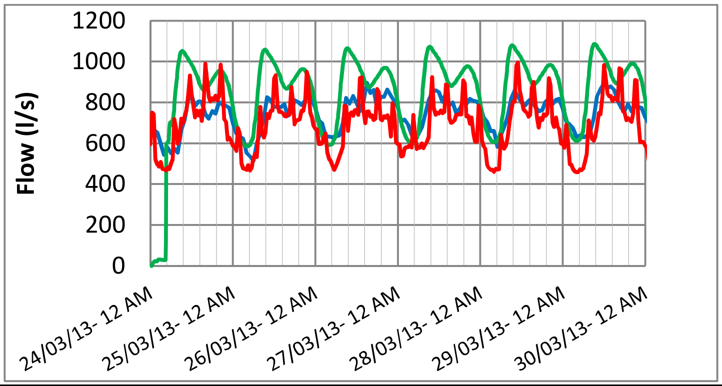
Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	WWM	K-2

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.6_Wastewater Model\Maps\Calibration Report Maps\K_ModelValidation\151-02944-00_WWM_FigK-2_Model_Validation_Map-Wet_Weather.mxd

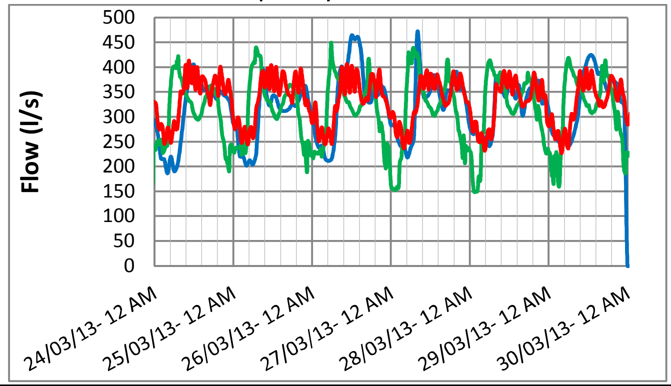
March 24-30, 2013 Event – Dry-Weather

2013 Actual — 2013 (Pre-Calibration) Computed — 2014 Computed

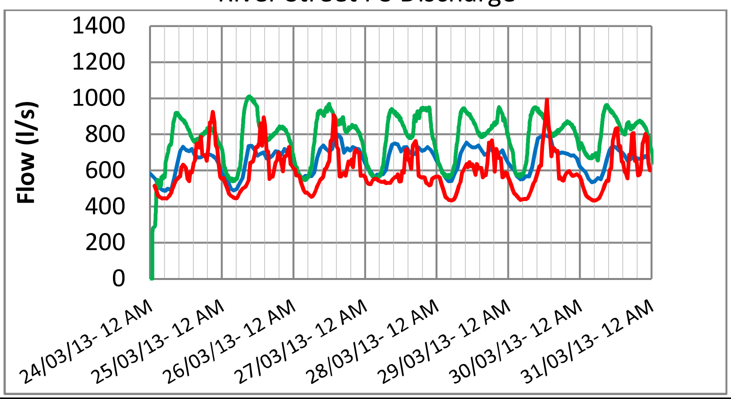
Ravensview WWTP Inflow



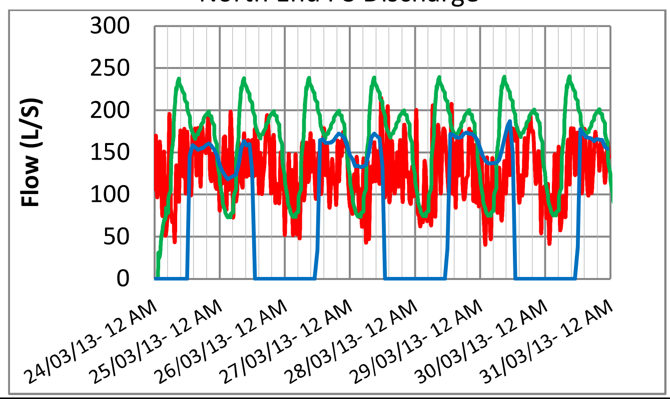
Cataraqui Bay WWTP Inflow



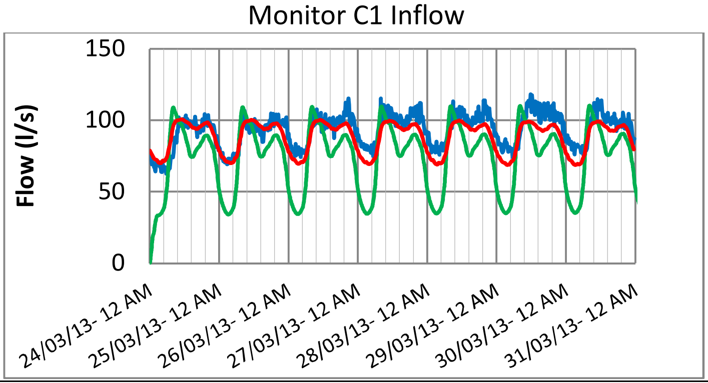
River Street PS Discharge



North End PS Discharge



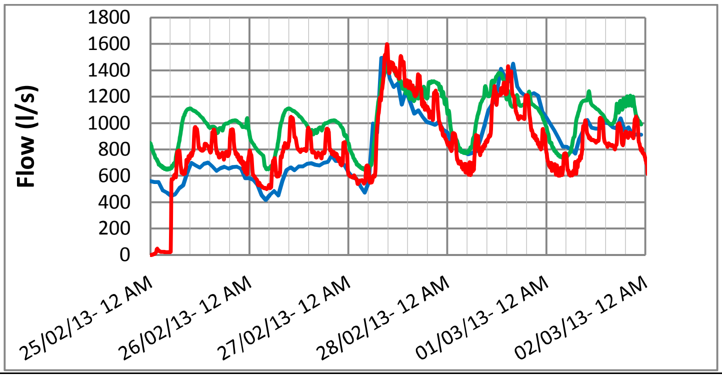
Monitor C1 Inflow



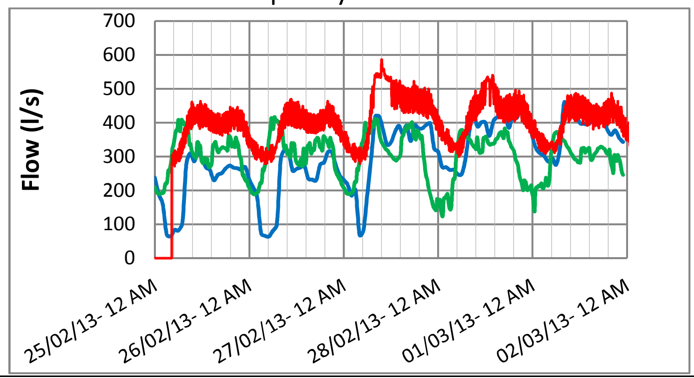
February 26-28, 2013 Event – Wet-Weather

2013 Actual **2013 (Pre-Calibration) Computed** **2014 Computed**

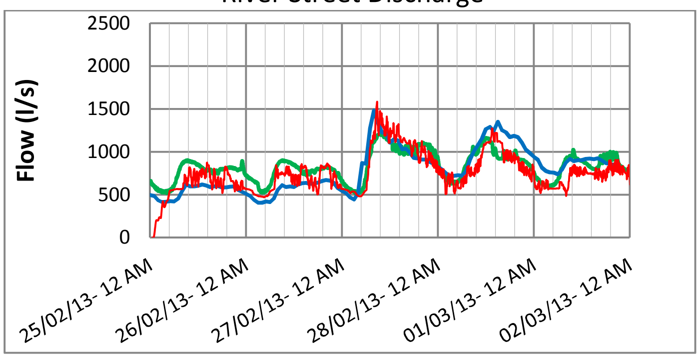
Ravensview WWTP Inflow



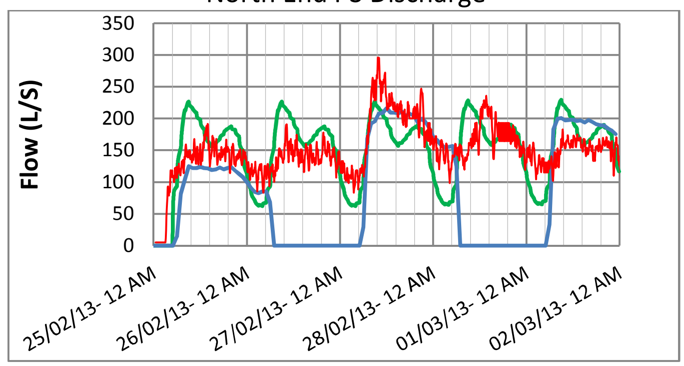
Cataraqui Bay WWTP Inflow



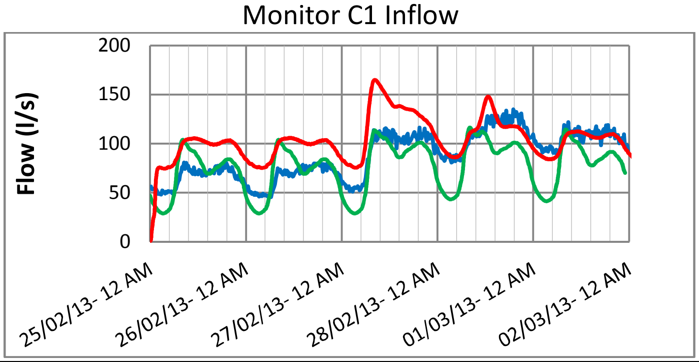
River Street Discharge



North End PS Discharge

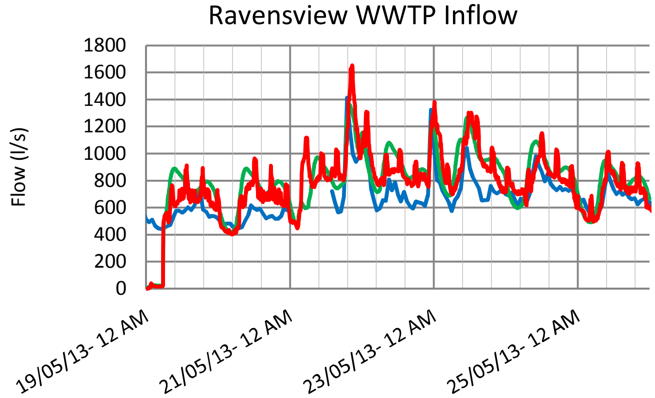


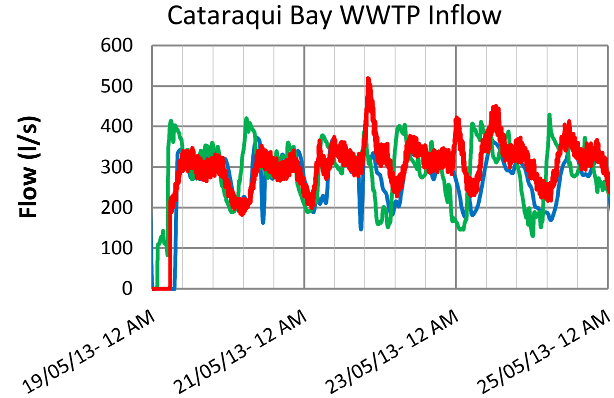
Monitor C1 Inflow

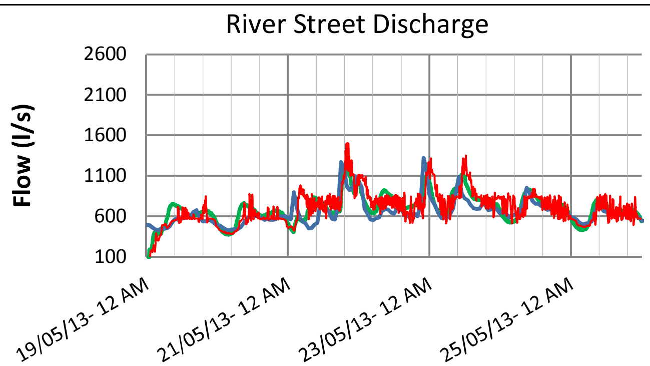


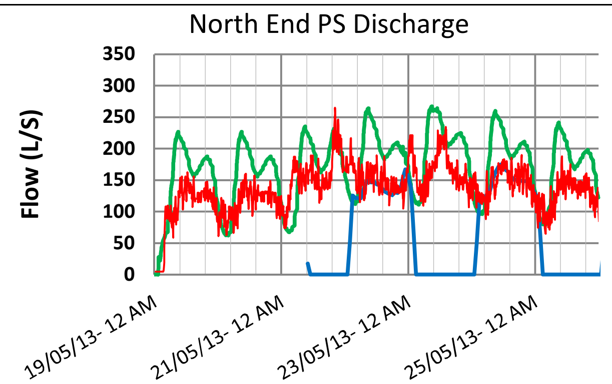
May 19-25, 2013 Event – Wet-Weather

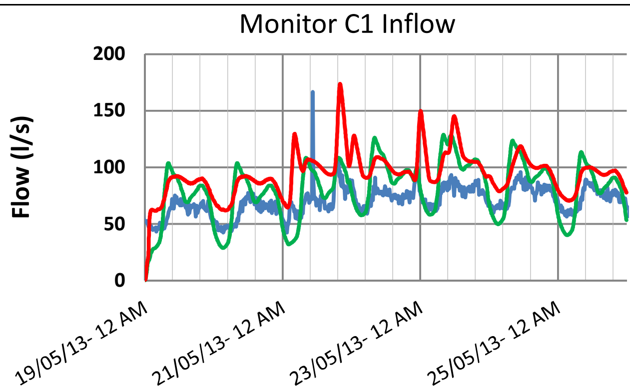
2013 Actual — 2013 (Pre-Calibration) Computed — 2014 Computed



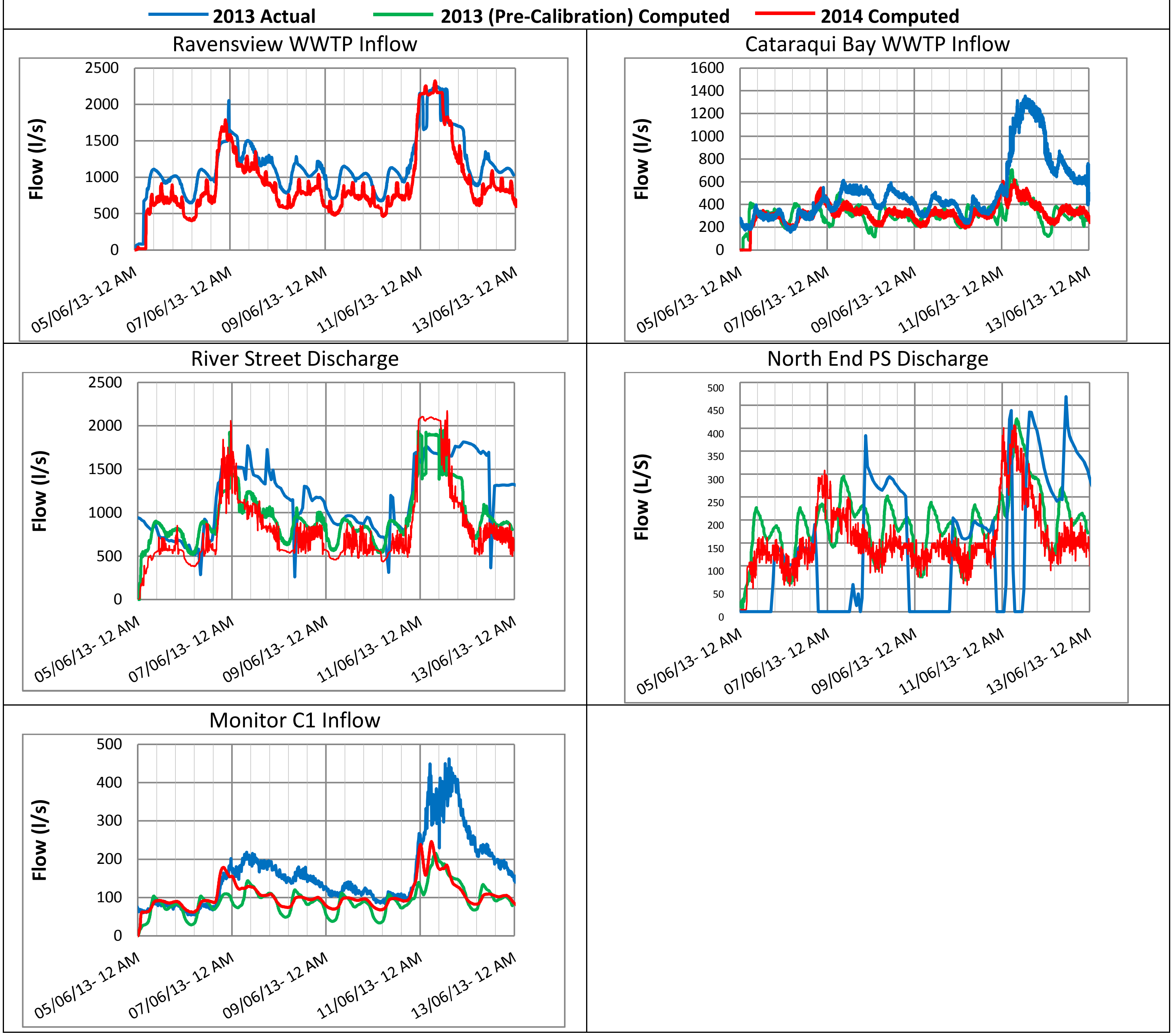








June 5-12, 2013 Event – Wet-Weather



Appendix L

MODEL SCENARIO DEVELOPMENT SUMMARY

Appendix L – Contents

Figure L-1: Combined Sewer Overview

Figure L-2: Growth Development Overview

Figure L-3: Future Growth Area RDII Allocation in Model

Figure L-4: Model Simulation: Existing Conditions

Figure L-5: Model Simulation: 2021 Conditions

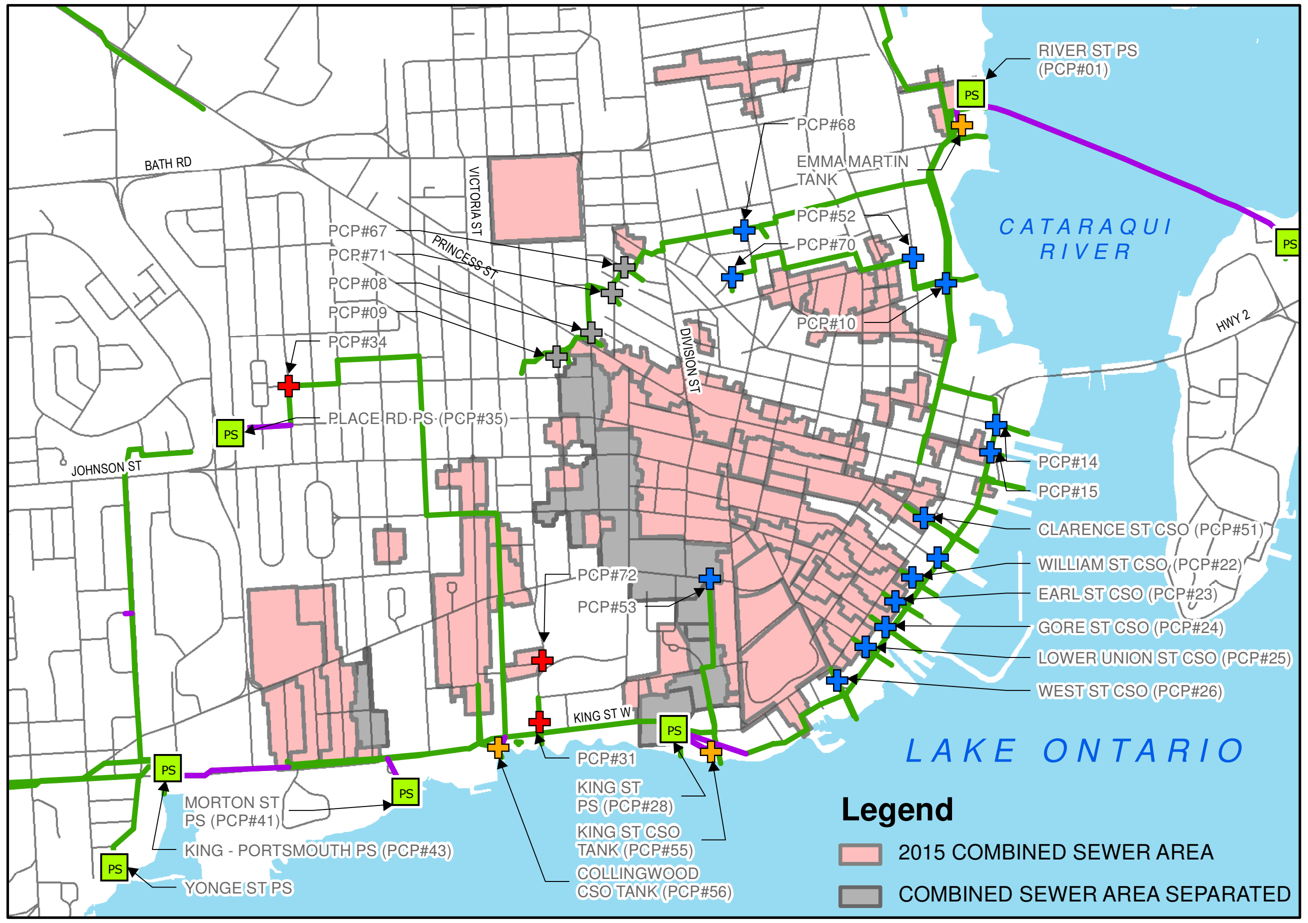
Figure L-6: Model Simulation: 2026 Conditions

Figure L-7: Model Simulation: 2036 Conditions

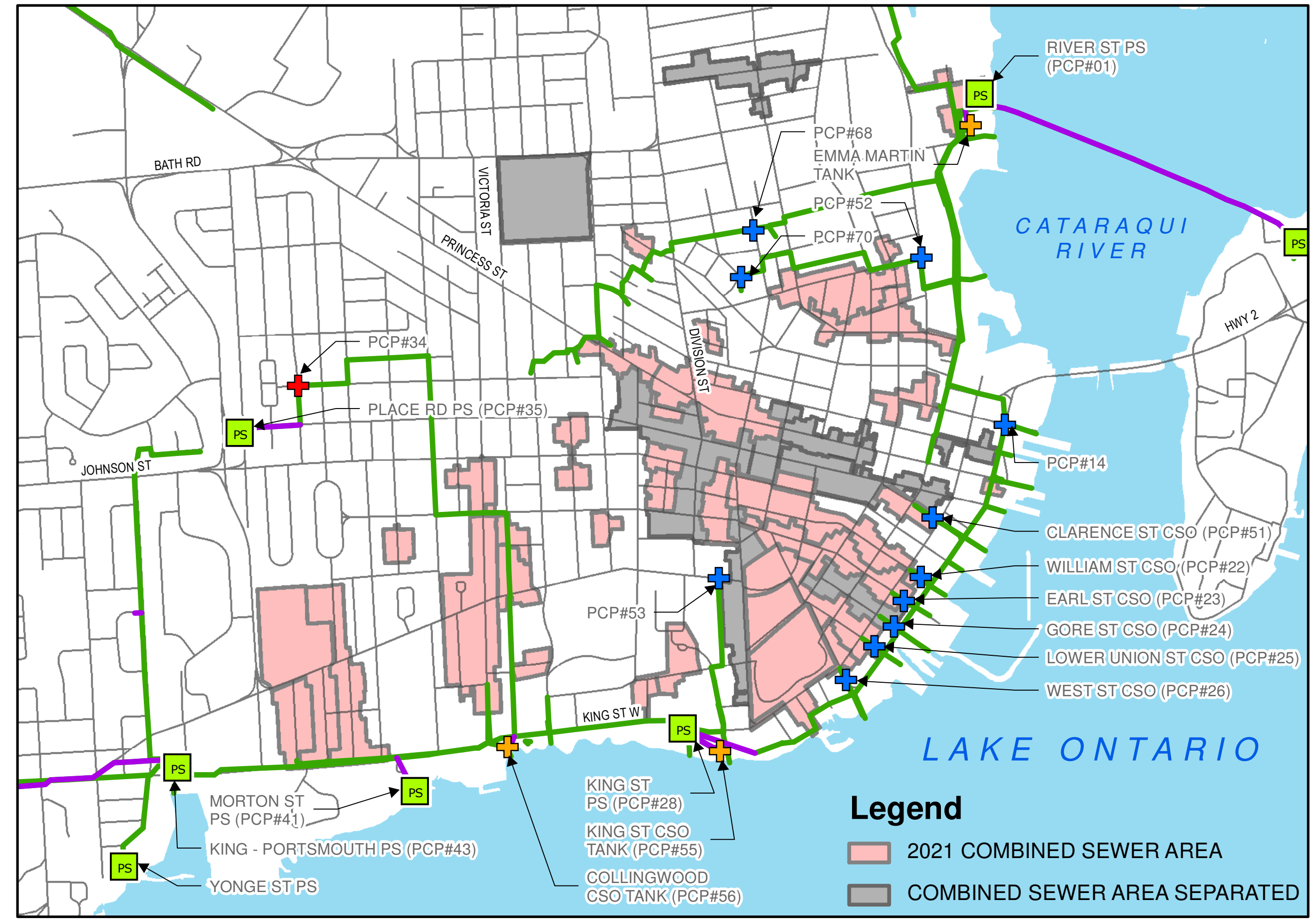
Figure L-8: Model Simulation: Full Buildout Conditions

Figure L-9: Model Simulation: Ultimate Conditions

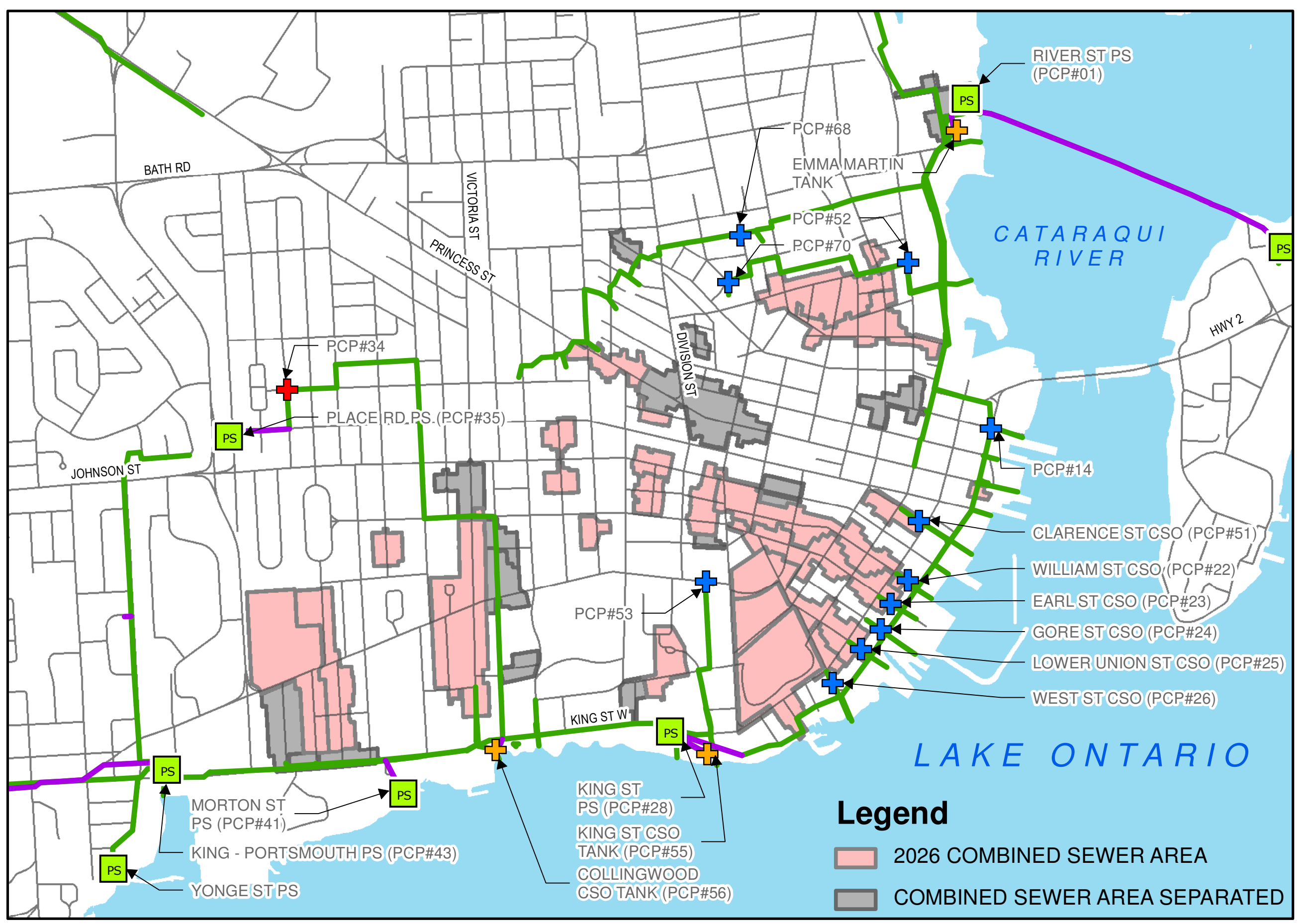
GAP and Alternative Scenario Development Summary



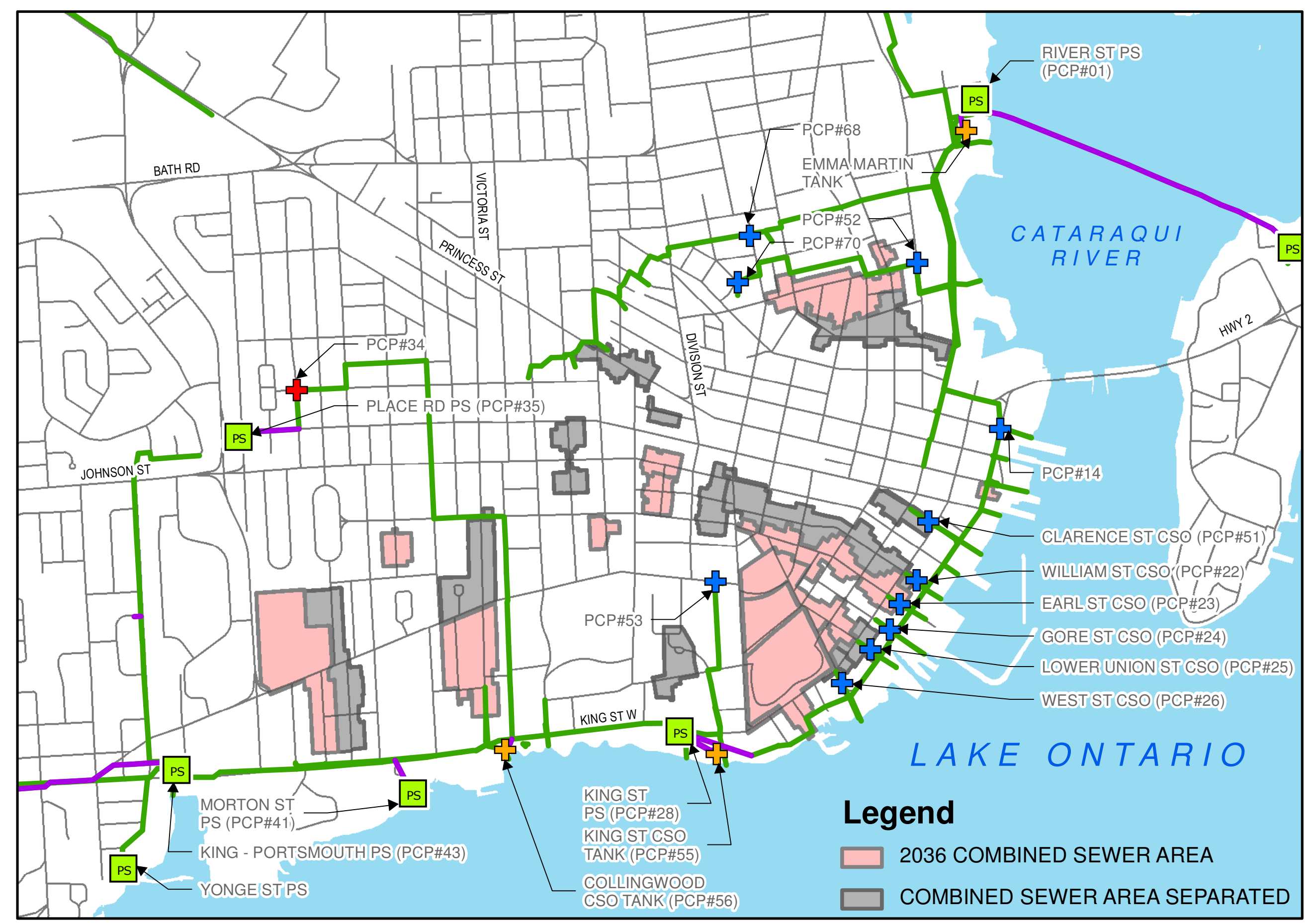
1 L-1 2015 COMBINED SEWER AREA
1:27,500



2 L-1 2021 COMBINED SEWER AREA
1:27,500



3 L-1 2026 COMBINED SEWER AREA
1:27,500



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

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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

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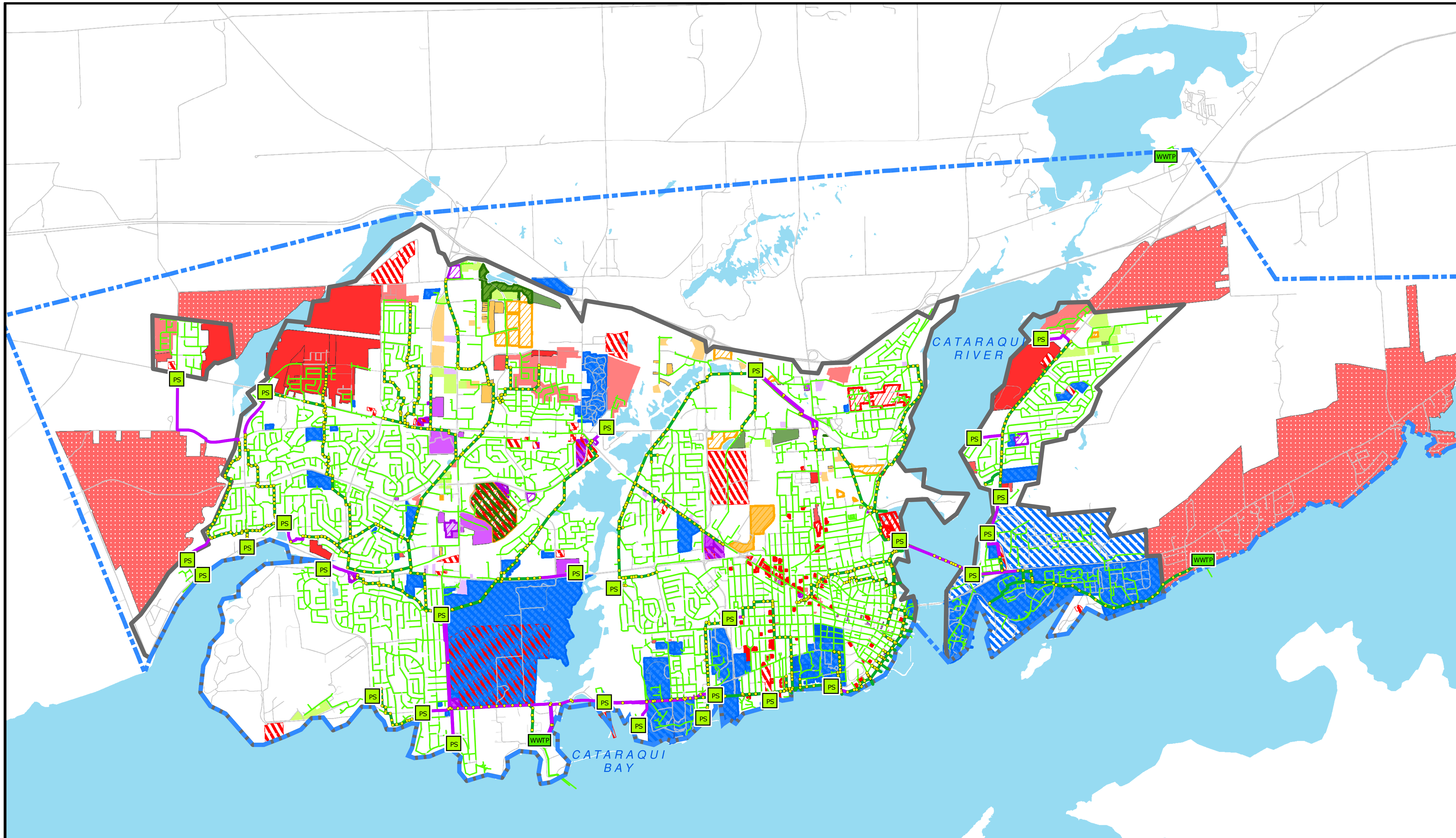
Project:
Water and Wastewater Master Plan Updates

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	WWM	L-1

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.6_Wastewater Model\Maps\Calibration Report Maps\L_ModelScenarioSum\151-02944-00_WWM_FigL-1_Combined_Sewer_Overview.mxd



GENERAL NOTES:

1. GROWTH DEVELOPMENT LOCATIONS AND FLOW PROJECTIONS IN ACCORDANCE WITH GROWTH DEVELOPMENT REPORT (2015 MASTER PLAN, WSP).
2. MODEL ALOCATION OF PROJECTION FLOWS COMPLETED USING INFO SWMM DWF ALLOCATOR TOOL USING 'METER SUMMATION' METHOD. MODEL JUNCTION ASSIGNMENT BASED ON SANITARY CATCHMENT AREAS USED FOR CALIBRATION.
3. DIURNAL PATTERNS DEVELOPED FOR THE RESPECTIVE LAND USE DESIGNATIONS APPLIED TO ALL PROJECTION FLOWS.

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Legend

- STUDY AREA
- URBAN BOUNDARY
- JUNCTION (MODELLED)
- WASTEWATER TREATMENT PLANT
- SANITARY PUMPING STATION
- FORCEMAIN
- SANITARY SEWER (MODELLED)
- SANITARY SEWER

GROWTH SCENARIO LAND USE

JUNCTION (MODELLED)

ULTIMATE
- RESIDENTIAL

2026
- COMMERCIAL
- INDUSTRIAL
- INSTITUTIONAL
- RESIDENTIAL

2026
- COMMERCIAL
- INDUSTRIAL
- GENERAL INDUSTRIAL
- INSTITUTIONAL
- RESIDENTIAL

2026
- COMMERCIAL
- INDUSTRIAL
- GENERAL INDUSTRIAL
- INSTITUTIONAL
- RESIDENTIAL

2026
- COMMERCIAL
- INDUSTRIAL
- GENERAL INDUSTRIAL
- INSTITUTIONAL
- RESIDENTIAL

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

Scale:
0 450 900 1,800 Meters
1:65,000

N W E S

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City of Kingston, Ontario

Title:
GROWTH DEVELOPMENT OVERVIEW

Project No.:		Date:	
151-02944-00		DECEMBER 2016	
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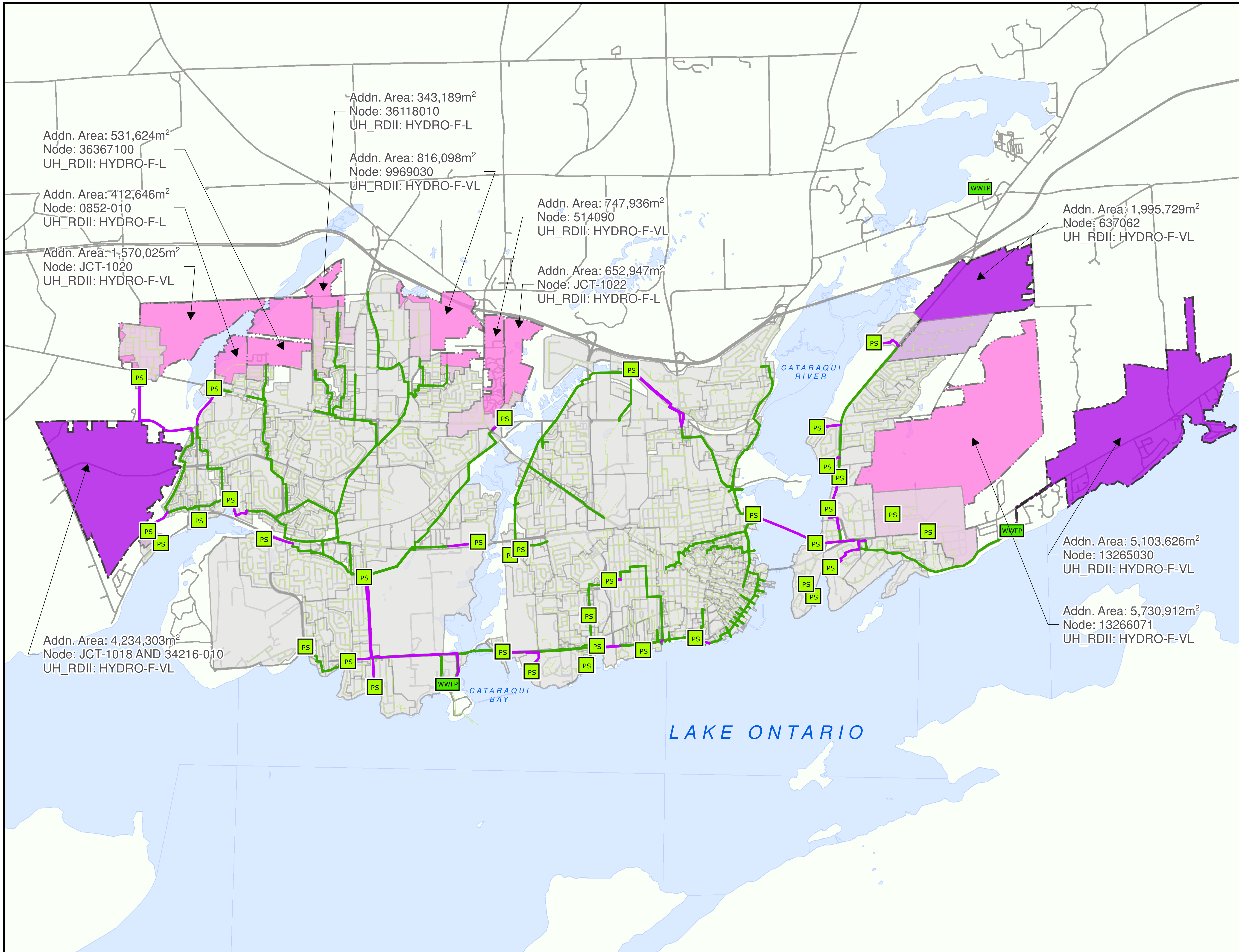
CM	MF	WWM	L-2



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Legend

- EXISTING SUBCATCHMENTS
- GROWTH DEVELOPMENT - OTHER YEARS
- GROWTH DEVELOPMENT - ULTIMATE
- FORCEMAIN
- EXISTING SANITARY SEWER
- MODEL CONDUIT
- PS SANITARY PUMPING STATION
- WWTP WASTEWATER TREATMENT PLANT

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

Scale:
0 450 900 1,800 Meters
1:65,000

Project:

Water and Wastewater Master Plan Updates

City of Kingston, Ontario

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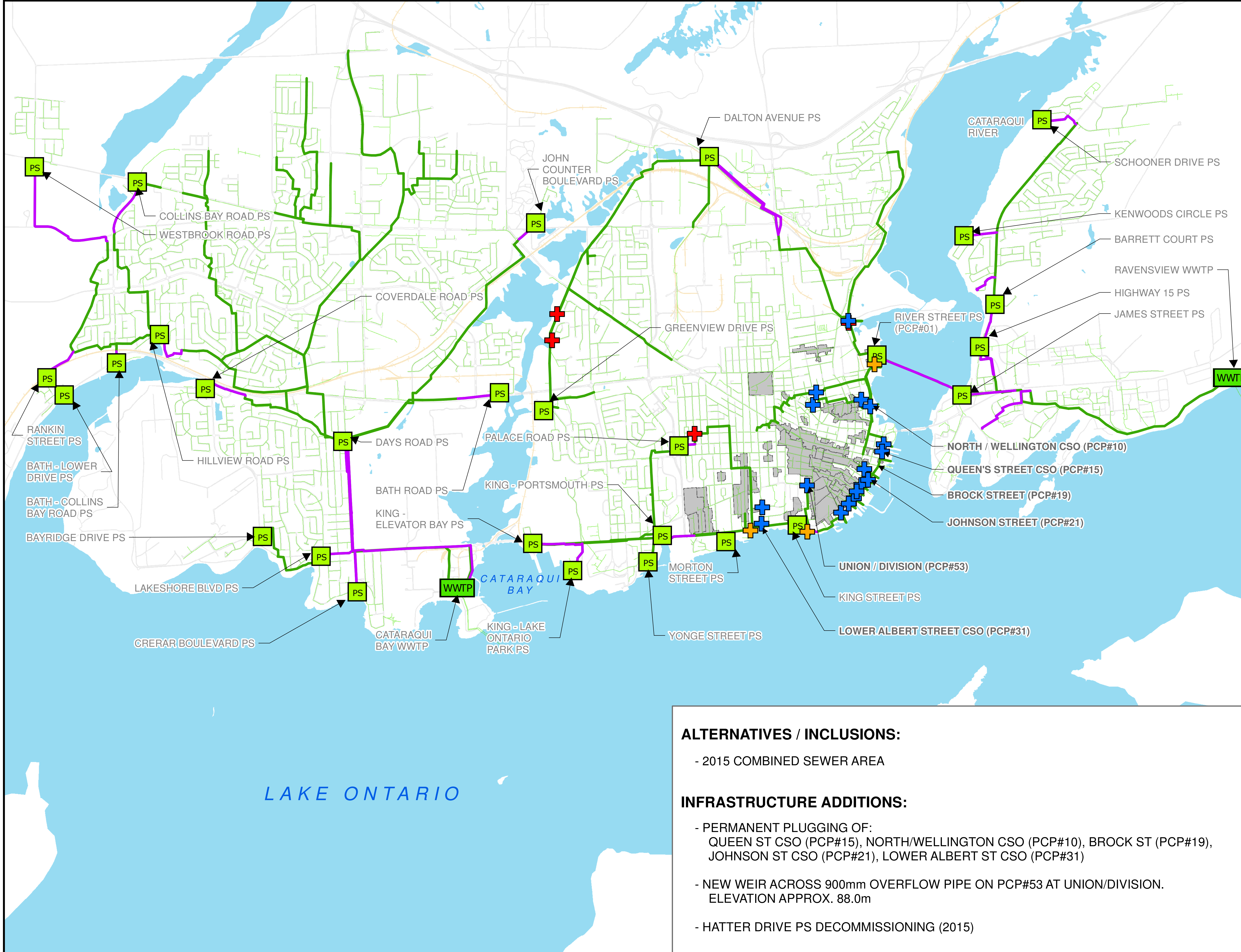
FUTURE GROWTH AREA RDII ALLOCATION IN MODEL

151-02944-00	Date: DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	MP	L-3



ALTERNATIVES / INCLUSIONS:

- 2015 COMBINED SEWER AREA

INFRASTRUCTURE ADDITIONS:

- PERMANENT PLUGGING OF:
  QUEEN ST CSO (PCP#15), NORTH/WELLINGTON CSO (PCP#10), BROCK ST (PCP#19), JOHNSON ST CSO (PCP#21), LOWER ALBERT ST CSO (PCP#31)
- NEW WEIR ACROSS 900mm OVERFLOW PIPE ON PCP#53 AT UNION/DIVISION. ELEVATION APPROX. 88.0m
- HATTER DRIVE PS DECOMMISSIONING (2015)

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- WWTP — WASTEWATER TREATMENT PLANT
- PS — SANITARY PUMPING STATION
- PS — SANITARY PUMPING STATION UPDATES
- COMBINED SEWER OVERFLOW (CSO)
- CSO CAPTURED BY TANK
- TANK OVERFLOW (TO)
- SANITARY SEWER OVERFLOW (SSO)
- FORCEMAIN
- EXISTING SANITARY SEWER
- MODEL CONDUIT
- 2015 COMBINED SEWER AREA
- WATERBODY

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

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Project:
Water and Wastewater Master Plan Updates

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Title:
MODEL SIMULATION: EXISTING CONDITIONS

Project No.:		Date:	
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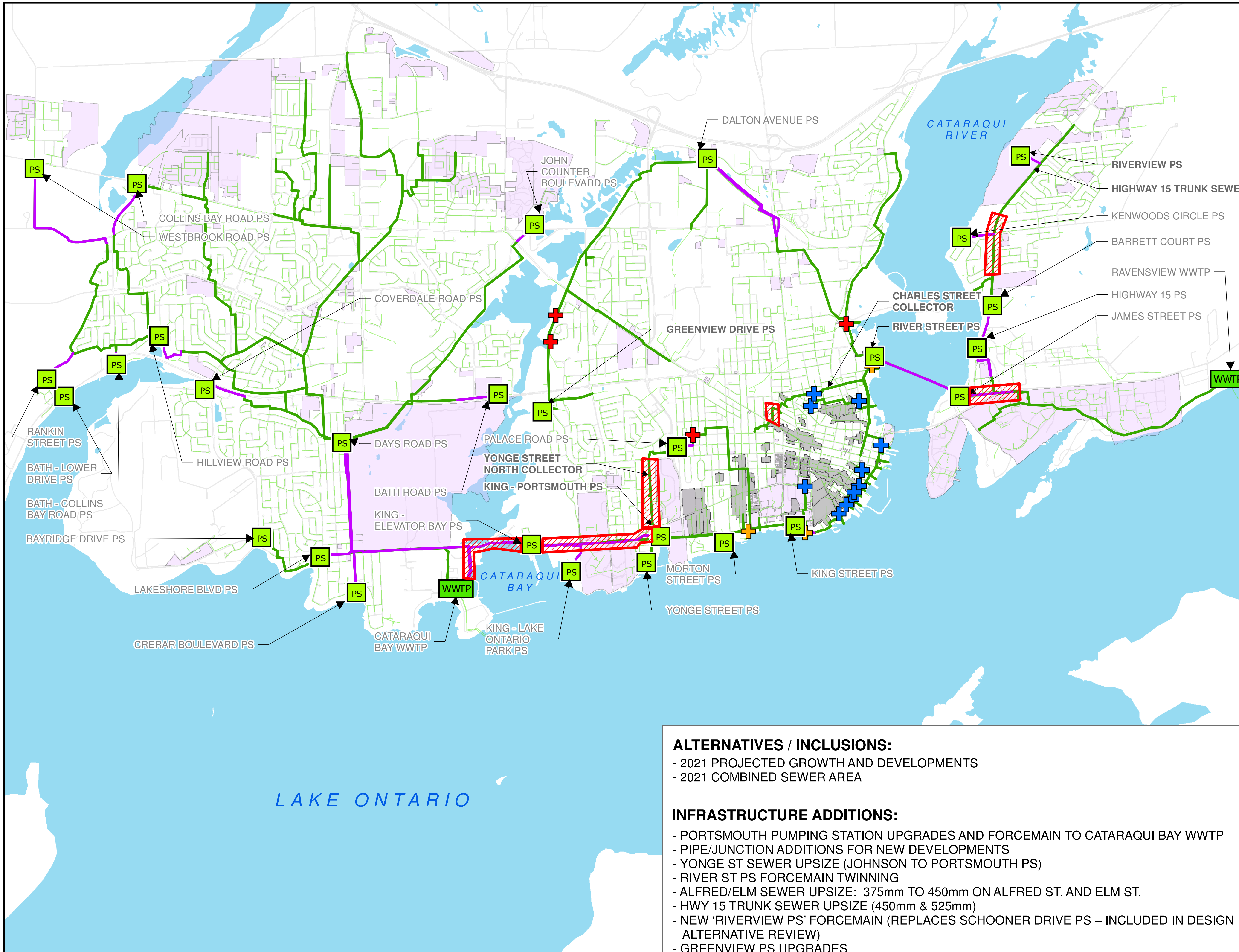
Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	WWM	L-4

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.6_Wastewater Model\Maps\Calibration Report Maps\L_ModelScenarioSum\151-02944-00_WWM_FigL-4_Model_Scenario_Simulation_Existing.mxd



ALTERNATIVES / INCLUSIONS:

- 2021 PROJECTED GROWTH AND DEVELOPMENTS
- 2021 COMBINED SEWER AREA

INFRASTRUCTURE ADDITIONS:

- PORTSMOUTH PUMPING STATION UPGRADES AND FORCEMAIN TO CATARAQUI BAY WWTP
- PIPE/JUNCTION ADDITIONS FOR NEW DEVELOPMENTS
- YONGE ST SEWER UPSIZE (JOHNSON TO PORTSMOUTH PS)
- RIVER ST PS FORCEMAIN TWINNING
- ALFRED/ELM SEWER UPSIZE: 375mm TO 450mm ON ALFRED ST. AND ELM ST.
- HWY 15 TRUNK SEWER UPSIZE (450mm & 525mm)
- NEW 'RIVERVIEW PS' FORCEMAIN (REPLACES SCHOONER DRIVE PS – INCLUDED IN DESIGN ALTERNATIVE REVIEW)
- GREENVIEW PS UPGRADES

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- CSO CAPTURED BY TANK
- TANK OVERFLOW (TO)
- SANITARY SEWER OVERFLOW (SSO)
- FORCEMAIN
- EXISTING SANITARY SEWER
- MODEL CONDUIT
- 2021 COMBINED SEWER AREA
- 2021 LAND DEVELOPMENT
- WATERBODY
- FUTURE PIPE UPGRADES

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

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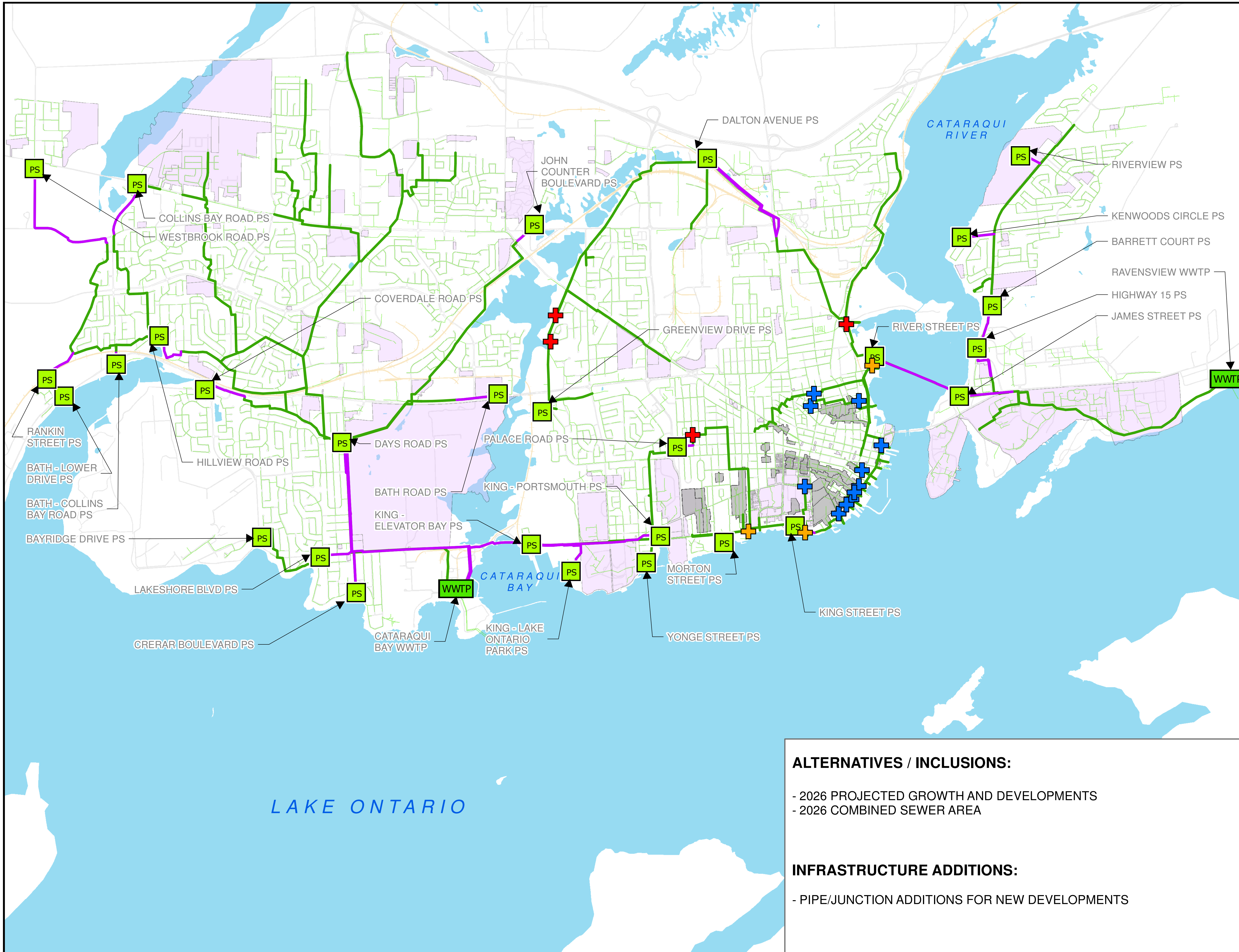
Project:
Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title:
MODEL SIMULATION: 2021 CONDITIONS

Project No.:	Date:		
151-02944-00	DECEMBER 2016		
Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	WWM	L-5



ALTERNATIVES / INCLUSIONS:

- 2026 PROJECTED GROWTH AND DEVELOPMENTS
- 2026 COMBINED SEWER AREA

INFRASTRUCTURE ADDITIONS:

- PIPE/JUNCTION ADDITIONS FOR NEW DEVELOPMENTS

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- CSO CAPTURED BY TANK
- TANK OVERFLOW (TO)
- SANITARY SEWER OVERFLOW (SSO)
- FORCEMAIN
- EXISTING SANITARY SEWER
- MODEL CONDUIT
- 2026 COMBINED SEWER AREA
- 2026 LAND DEVELOPMENT
- WATERBODY

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

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MODEL SIMULATION: 2026 CONDITIONS

Project No.:		Date:	
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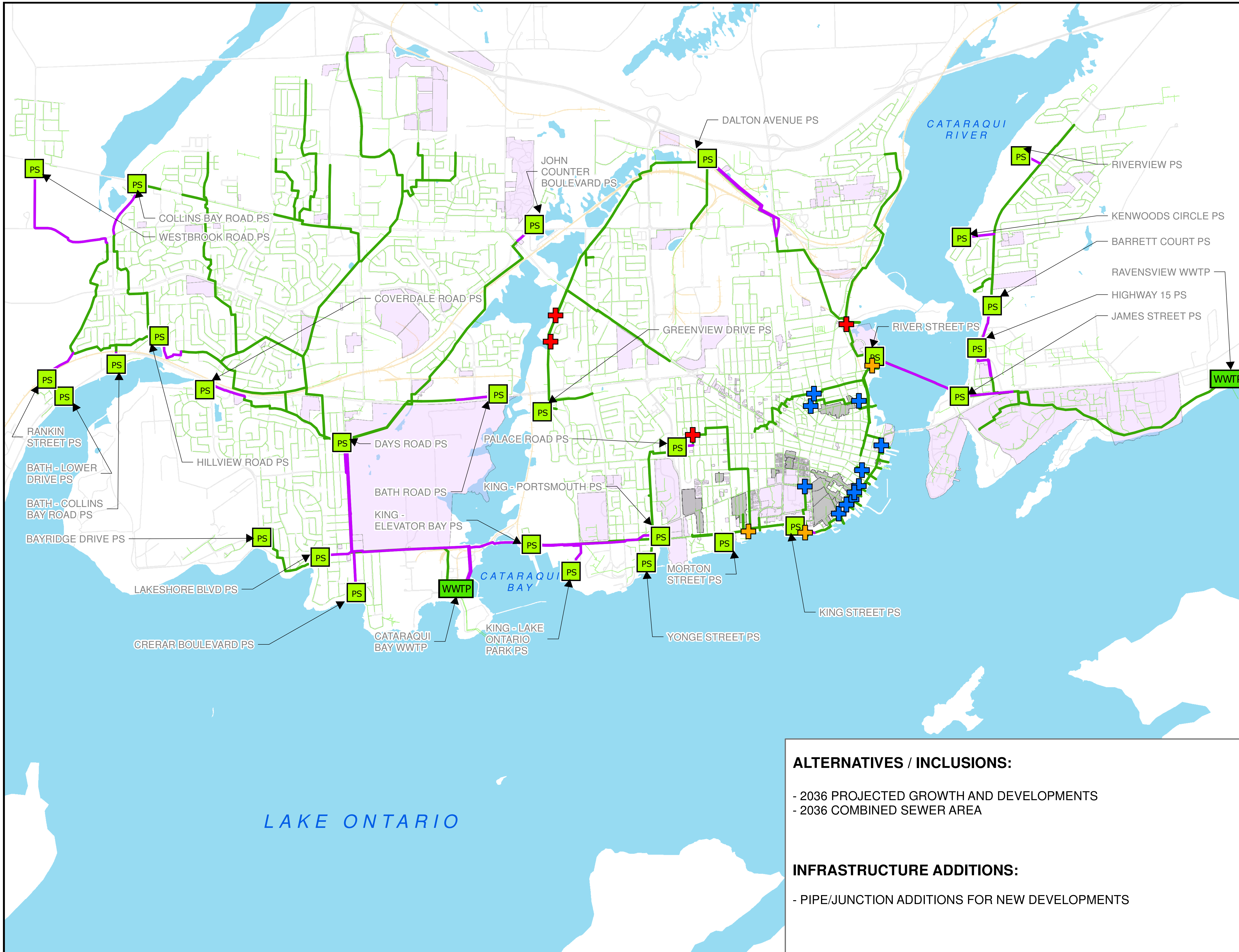
Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	WWM	L-6

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.6_Wastewater Model\Maps\Calibration Report Maps\L_ModelScenarioSum\151-02944-00_WWM_FigL-6_Model_Scenario_Simulation_2026.mxd



ALTERNATIVES / INCLUSIONS:

- 2036 PROJECTED GROWTH AND DEVELOPMENTS
- 2036 COMBINED SEWER AREA

INFRASTRUCTURE ADDITIONS:

- PIPE/JUNCTION ADDITIONS FOR NEW DEVELOPMENTS

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Legend

WWTP	WASTEWATER TREATMENT PLANT
PS	SANITARY PUMPING STATION
PS	SANITARY PUMPING STATION UPDATES
	COMBINED SEWER OVERFLOW (CSO)
	CSO CAPTURED BY TANK
	TANK OVERFLOW (TO)
	SANITARY SEWER OVERFLOW (SSO)
	FORCEMAIN
	EXISTING SANITARY SEWER
	MODEL CONDUIT
	2036 COMBINED SEWER AREA
	2036 LAND DEVELOPMENT
	WATERBODY

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
N E S W

Project:
Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title:
MODEL SIMULATION: 2036 CONDITIONS

Project No.:	Date:		
151-02944-00	DECEMBER 2016		
Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	WWM	L-7

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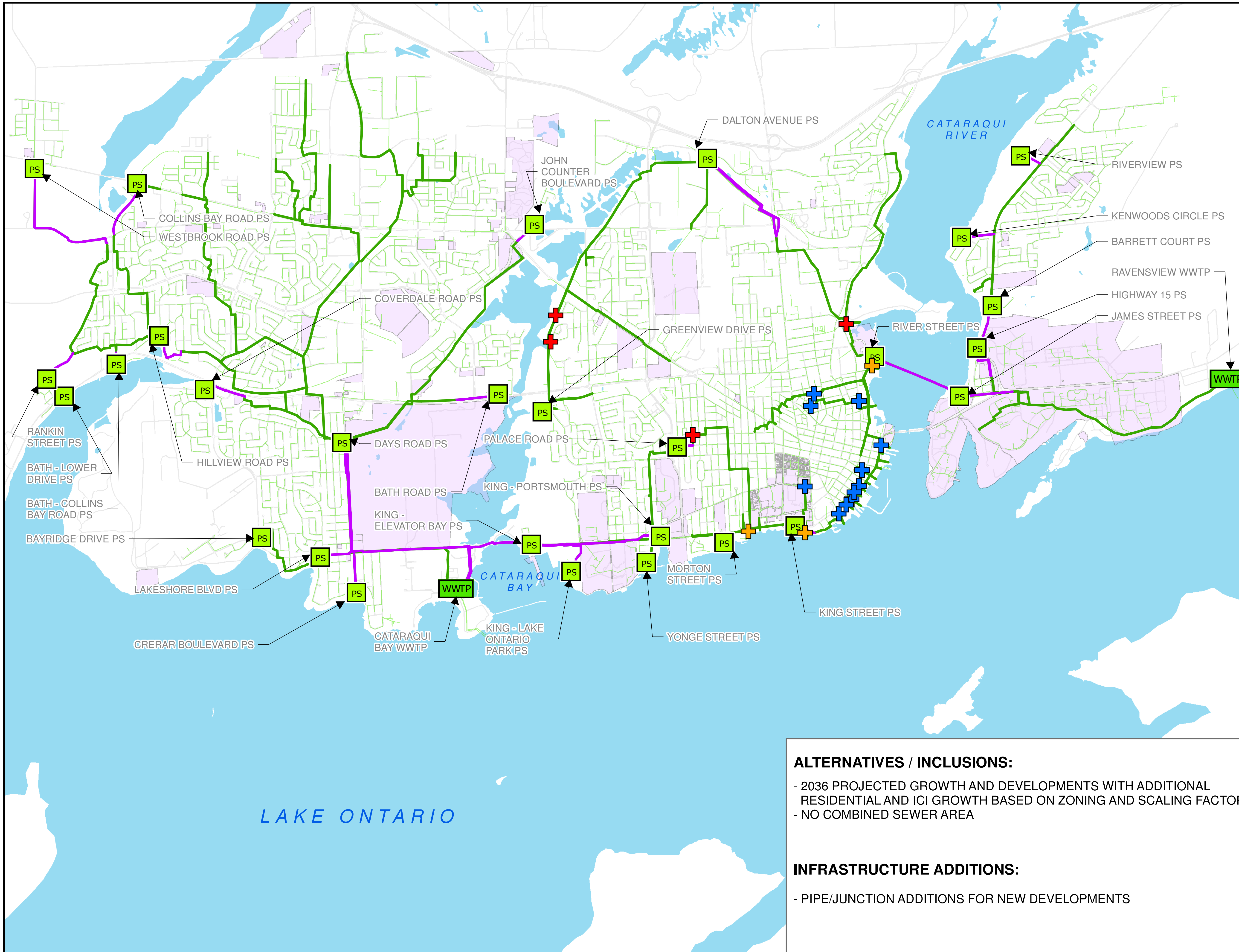

ALTERNATIVES / INCLUSIONS:

- 2036 PROJECTED GROWTH AND DEVELOPMENTS WITH ADDITIONAL RESIDENTIAL AND ICI GROWTH BASED ON ZONING AND SCALING FACTOR
- NO COMBINED SEWER AREA

INFRASTRUCTURE ADDITIONS:

- PIPE/JUNCTION ADDITIONS FOR NEW DEVELOPMENTS

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- PS — SANITARY PUMPING STATION UPDATES
- COMBINED SEWER OVERFLOW (CSO)
- CSO CAPTURED BY TANK
- TANK OVERFLOW (TO)
- SANITARY SEWER OVERFLOW (SSO)
- FORCEMAIN
- EXISTING SANITARY SEWER
- MODEL CONDUIT
- FULL BUILDOUT DEVELOPMENT
- WATERBODY

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

N E S W

Project:

Water and Wastewater Master Plan Updates

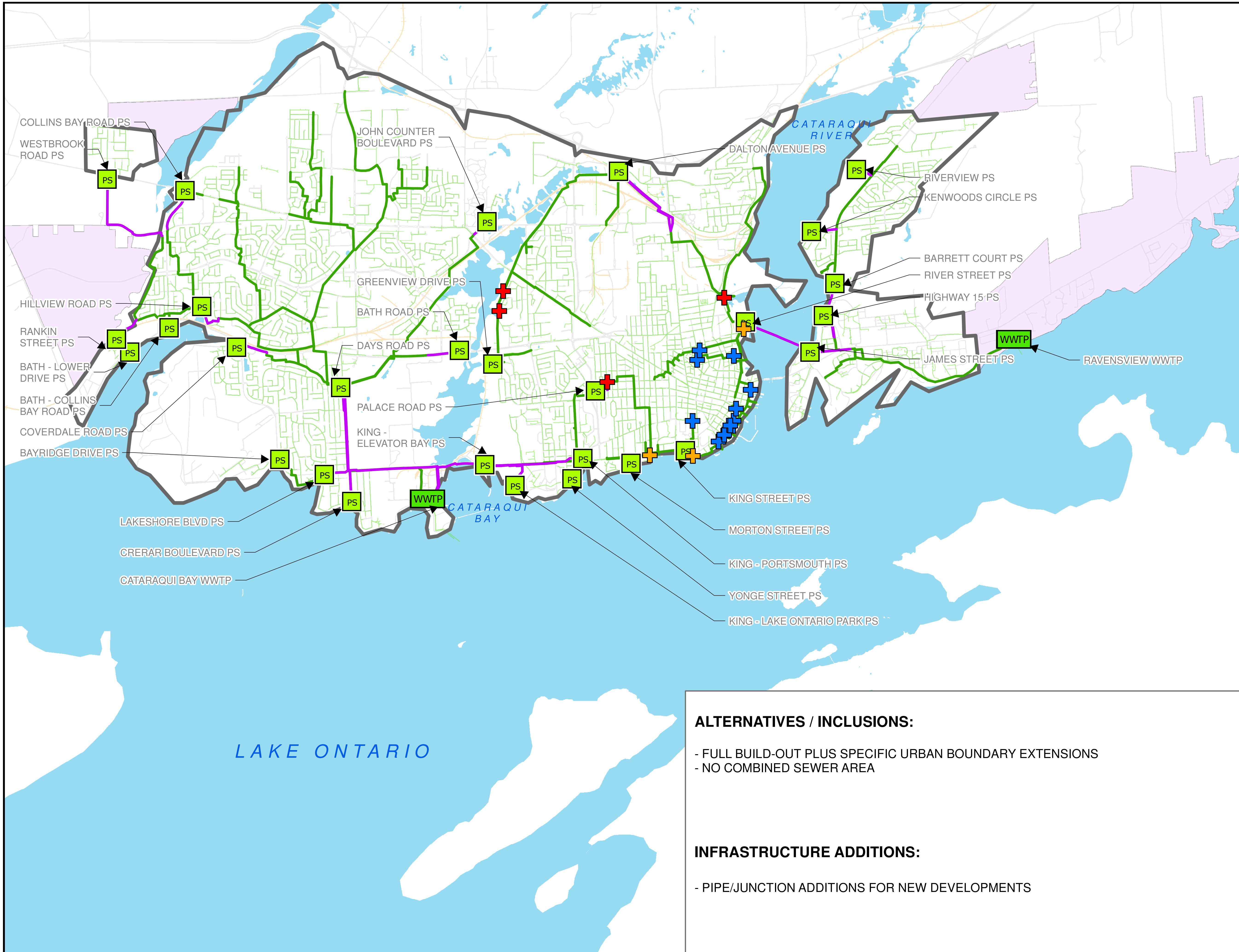
City of Kingston, Ontario

Title:

MODEL SIMULATION: FULL BUILDOUT CONDITIONS

Project No.:	Date:		
151-02944-00	DECEMBER 2016		
Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	WWM	L-8

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.6_Wastewater Model\Maps\Calibration Report Maps\L_ModelScenarioSum\151-02944-00_WWM_FigL-8_Model_Scenario_Simulation_BO.mxd



ALTERNATIVES / INCLUSIONS:

- FULL BUILD-OUT PLUS SPECIFIC URBAN BOUNDARY EXTENSIONS
- NO COMBINED SEWER AREA

INFRASTRUCTURE ADDITIONS:

- PIPE/JUNCTION ADDITIONS FOR NEW DEVELOPMENTS

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Legend

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- PS — SANITARY PUMPING STATION
- PS — SANITARY PUMPING STATION UPDATES
- COMBINED SEWER OVERFLOW (CSO)
- CSO CAPTURED BY TANK
- TANK OVERFLOW (TO)
- SANITARY SEWER OVERFLOW (SSO)
- FORCEMAIN
- EXISTING SANITARY SEWER
- MODEL CONDUIT
- ULTIMATE DEVELOPMENT
- WATERBODY
- URBAN BOUNDARY

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

Scale:
0 400 800 1,600 Meters
1:62,500

N W E S

Project:
Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title:
MODEL SIMULATION: ULTIMATE CONDITIONS

Project No.: 151-02944-00	Date: DECEMBER 2016		
Drawn By: CM	Checked By: MF	Code: WWM	Figure No.: L-9

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.6_Wastewater Model\Maps\Calibration Report Maps\L_ModelScenarioSum\151-02944-00_WWM_FigL-9_Model_Scenario_Simulation_ULT.mxd

GAP AND ALTERNATIVES SCENARIO DEVELOPMENT SUMMARY

1 GAP REPORTING SCENARIOS AND DEVELOPMENT

The wastewater model allows for simulations that can predict system responses to events under a wide range of conditions. Simulations conducted in the gap analysis include dry-weather and wet-weather design storm analysis (for 1:2, 1:5, 1:10, 1:25, 1:50 and 1:100 year design storm events for Kingston) and an extended-period CSO simulation analysis where a typical year of rainfall (2014 rainfall) and wetter-then-average year of rainfall (2008 rainfall) was simulated for the months of April-October. The design storm analysis is used to evaluate the firm/peak capacities of pumping stations and the capacities of pipes including gravity sewers and forcemains. The CSO analysis is carried out to determine the severity of CSO's and SSO's as well as the total volumes of by-passes, the number of by-pass events and the duration of these by-pass events.

1.1 DESIGN STORM ANALYSIS AND LEVEL OF SERVICE (LOS)

The level of service being provided by the infrastructure was evaluated for both dry and wet weather events. There are two considerations when assigning the overall level of service; the hydraulic condition occurring in the infrastructure and the scenario during which this hydraulic condition occurs. Hydraulic conditions experienced by the infrastructure were evaluated with consideration for the scenario during which they were experienced. Given the different flow characteristics during wet weather and dry weather as well as the corresponding probability of these events, they were evaluated against different benchmarks.

1.2 GRAVITY SEWERS

Sanitary sewer systems should be designed with the objective of conveying all the flows to be treated at the sewage treatment plant. Overflows within the sanitary sewer systems should be designed for emergency and unavoidable conditions only (MOECC, 2008). The MOECC also recommends that gravity sewers be designed to less than 100% full under normal conditions. During large rain events, trunk sewers may become surcharged. Allowing these sewers to surcharge provides storage capacity reducing the by-pass volume. However, this increase in the elevation of the hydraulic grade line in the sewer may have adverse effects depending on site-specific factors. The increase in the elevation of the hydraulic grade line is a result of capacity limitations resulting in bottlenecks and backup of the system. The two primary considerations are the amount of surcharging (elevation of hydraulic grade line) and the elevation of hydraulic grade line relative to adjacent basement elevations. The identified level of service below is based on satisfying MOECC's design guidelines for gravity sewers and maximizing storage capacity while minimizing the risk of basement flooding.

Table 1-1 Gravity Sewers Hydraulic Condition

FLOW CONDITION	HYDRAULIC CONDITION OF SEWERS		
	FAIR	MODERATE	SEVERE
Dry Weather	Flow < 85% of pipe capacity	Flow > 85% of pipe capacity	Flow > 85% of pipe capacity
Wet Weather (up to and including 100yr return event)	HGL < 0.3m above pipe obvert and > 2 m below finished ground	HGL > 0.3 m above pipe obvert and > 2 m below finished ground	HGL within 2 m of finished ground

Table 1-2 Gravity Sewers Level of Service

	LEVEL OF SERVICE OF SEWERS		
	GOOD	REVIEW	GAP
Facility Level of Service	Hydraulic grade line (HGL) from the 100yr storm is more than 2 m below the finished ground Dry weather flow is less than the sewer capacity	Hydraulic grade line (HGL) from the 25yr storm flows and larger, is within 2 m of the finished ground HGL from the 10yr storm flows and larger, is between 0.3m of the obvert of the pipe and 2m of the finished ground Dry weather flows > 85% of the sewer capacity but < 99% of the sewer capacity	HGL from the 10yrs storm flows and smaller, is within 2 m of the finished ground Cannot convey the dry weather flows without surcharging.

1.3 PUMPING STATIONS AND FORCEMAINS

The MOECC requires that sanitary sewer systems be able to pump the design peak instantaneous flow. Pumping stations that service combined sewer systems are required to have a capacity sufficient to pump all of the dry weather flow plus 90% of the volume resulting from the design wet weather flow for an average year flow. As the MOECC does not specify a specific design storm, a review of other Master Plans was completed.

Table 1-3 Sanitary Pumping Station Design Storm Review

MUNICIPALITY	DESIGN STORM
Kingston Master Plan (2007)	1:10yr
Cambridge	1:25yr
Region of Peel	1:5yr
Sudbury	1:2yr
Guelph	1:25yr

Based on this review the 10yr storm was selected as this is consistent with the previous Master Plan, recent upgrades completed in Kingston and is within the range used by other municipalities. Additionally, based on a typical year, the 10yr storm would be sufficient to satisfy the MOECC requirements regarding wet weather flows.

The flows experienced at sanitary pump stations and in the respective forcemains during both the existing and future flow conditions are evaluated. The purpose of this evaluation was to identify where capacity limitations are causing bottlenecks and backup of the system.

Multiple flow conditions were applied to each growth scenario using the hydraulic model. The flow conditions analyzed included the dry weather as well as multiple return periods for wet weather events ranging from the 2yr to 100yr design storm.

The recommended level of service is outlined in Table below:

Table 1-4 Sanitary Pump Stations Hydraulic Condition

WEATHER SCENARIO	HYDRAULIC CONDITION OF PUMP STATION		
	FAIR	MODERATE	SEVERE
Dry Weather and Wet Weather (up to and including 10yr return event)	Measured flow < 85% of firm capacity	Measured flow > 85% of firm capacity and < 100% of firm capacity	Measured flow > 100% of firm capacity
Wet Weather (above 10yr up to 100yr return event)	Measured flow < peak capacity and no bypass at the station	Measured flow > peak capacity and bypass at the station	Measured flow > peak capacity and local flooding

Table 1-5 Pump Station Recommended Level of Service

	LEVEL OF SERVICE OF PUMP STATION		
	GOOD	REVIEW	GAP
Facility Level of Service	Dry weather flows & 10yr storm flows are less than the pumping stations firm capacity	10yr storm flows are greater than the firm but less than the peak capacity	10yr storm flows are greater than the pumping station peak capacity

In addition to the pumping requirements, the MOECC also provides design standards for forcemains. At design pumping rates, a cleansing velocity of at least 0.6 m/s should be maintained. At peak flow, the maximum velocity should be limited to 3 m/s. Consideration also needs to be made for air/vacuum relief valves as well as the operating pressure in the forcemain.

The recommended criteria for evaluating the level of service was limited to the velocity in the forcemain. Considering operating pressures and requirements for air and vacuum relief valves require further hydraulic analysis beyond the scope of this assignment.

Table 1-6 Sanitary Forcemain Hydraulic Condition

	HYDRAULIC CONDITION OF FORCEMAIN		
	FAIR	MODERATE	SEVERE
All Scenarios	Velocity < 3 m/s	Velocity > 2 m/s	Velocity > 3 m/s

Table 1-7 Sanitary Forcemain Level of Service

	LEVEL OF SERVICE FORCEMAIN		
	GOOD	MONITOR	GAP
Forcemain Level of Service	Velocity in pipe is less than 2 m/s	Velocity in pipe is greater than 2 m/s and less than 3 m/s	Velocity in pipe is greater than 3 m/s

1.4 COMBINED SEWER OVERFLOW (CSO) ANALYSIS

Sections of the central sewer catchment area are still serviced by combined sewers. The MOECC has issued Procedure F-5-5 to regulate these by-pass events. Procedure F-5-5 provides a guideline regarding the quality, quantity, and frequency of overflows. Required mitigation measures are also identified to address the potential adverse effects of the sewer overflows.

While Procedure F-5-5 applies to all CSOs, more stringent requirements are also prescribed for swimming and bathing beaches. The majority of Kingston's CSO locations are situated in areas that meet the guideline's definition of a beach area.

> *Swimming and bathing beach is defined as 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.*

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

- 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.
- Controlling overflow to not more than 2 events per season (June 1 – September 30) for an average year.
- Combined total duration of CSO events at any one CSO location shall not exceed 48hrs.
- 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 for the CSOs is to satisfy these requirements and continue to reduce the volume of by-pass events during an average year. Additionally, based on discussions with UK, the long-term goal is to "virtually eliminate" combined sewer overflows based on a wetter than average year, which is intended to mean containment of all Combined Sewer Flows under a Wet Year Conditions, with overflows occurring only under less frequent storm events.

An extended-period CSO simulation analysis is conducted using the InfoSWMM model using each of the projection years completed under model development. In these scenarios both a typical year of rainfall (2014 rainfall) and wetter-then-average year of rainfall (2008 rainfall) was simulated for the months of April-October. The CSO analysis is carried out to determine the severity of CSO's and SSO's as well as the total volumes of overflows, the number of overflow events and the duration of these overflow events.

1.5 WASTEWATER TREATMENT PLANTS

The MOECC requires that treatment process unit at wastewater plants be sized based on various design parameters. The table below details the process design basis required by the MOECC.

Table 1-8 MOECC WWTP Design Basis Requirements

Treatment Unit	Design Basis
Sewage Pumping Stations	Design Peak Instantaneous Flow
Screening	Design Peak Instantaneous Flow
Grit Removal	Design Peak Hourly Flow Peak Hourly Grit Loading
Primary Sedimentation	Design Peak Daily Flow
Aeration (without nitrification)	Average Daily BOD5 Loading (based on Design Average Daily Flow)
Aeration (with nitrification)	Average Daily BOD5 loading (Design Average Daily Flow) Peak Daily TKN Loading (Design Peak Daily Flow)
Secondary Sedimentation	Design Peak Hourly Flow Peak Daily Solids Loading
Sludge Return for Activated Sludge	50 to 200 % of Design Average Daily Flow
Disinfection	Design Peak Hourly Flow
Effluent Filtration	Design Peak Hourly Flow
Outfall Sewer	Design Peak Instantaneous Flow
Sludge Treatment (digestion and dewatering.)	Maximum Monthly Mass Loading and Flow Rates

From the table above it can be seen that all of the processes are based on either the average daily flow or a peak flow rate.

The MOECC indicates a sewage treatment plant should be able to treat the flows of sewage generated within buildings serviced by the sewer system exclusive of any extraneous flows (i.e. the average daily flow).

The guidelines (MOECC, 2008) also indicate that "*during wet weather, the minimum level of treatment required for flows above the dry weather flows from combined sewer system is primary treatment.*"

Therefore, based on the above the MOECC criteria, the recommended level of service for treatment plants is to provide full treatment to all average daily flow.

Additionally, based on the MOECC criteria indicated above, procedure F-5-5 (i.e. 90% of the wet weather flow) the level of service for wet weather flows is to provide primary treatment (min) up to and including the 10yr storm.

The InfoSWMM model is used to simulate the wet weather conditions at the Ravensview and Cataraqui bay WWTP for all developed model scenarios for the Gap Analysis.

2 ALTERNATIVES REPORTING SCENARIOS AND DEVELOPMENT

The main tool used to evaluate alternative solutions is the InfoSWMM wastewater model which was uses the same projection year scenarios developed for and used for the GAP Analysis. This model was updated with new scenarios representing conditions with future and upgraded infrastructure to demonstrate how the flow conveyance is possible to meet a desired LOS.

2.1.1 SEWER INFRASTRUCTURE ANALYSIS

In the trunk model alternatives for sewer infrastructure upgrades are typically simulated by either upsizing pipe diameters or by twinning pipes of similar dimensions until the capacity of the sewer is adequate to resolve the identified gap for the 100yr (Sewer LOS) design storm to meet the LOS. Redirection or new sewer infrastructure along alternate routes was generally not considered where an existing servicing strategy exists. These were not considered viable sewer alternatives due to the implications caused when considering land acquisition, land disturbance and maintenance of multiple infrastructure components.

The alternative analysis is limited to collector and trunk sewers. These sewers represent the primary conveyance infrastructure for City’s collection systems. Sewers which are tributary to primary conveyance sewers are represented in the model through the calibration process. The recommended alternative solutions modeled may be assumed to improve tributary sewers through the improvements of downstream conveyance capacity and relief of “flow bottlenecks” in the collection system. The hydraulic profiles of the existing and upgraded conditions for the sewer alternatives are included in Appendix A.

2.1.2 PUMPING STATION AND SEWER INFRASTRUCTURE ANALYSIS

Both primary and secondary pumping stations are represented in the trunk sewer model, and alternative solutions were modeled based on meeting LOS criteria for the 10yr design storm. The 10yr storm was used since most stations have wet-weather controls able to alleviate surges in flow during major storms through local bypasses before causing flooding or sewer back-ups. The increased flow resulting from sewer conveyance capacity increases are represented in the model and pump station capacity is increased until a there is adequate capacity to convey the 10yr design storm peak wet-weather flow resulting in the required firm capacity upgrade. Given that the model is calibrated to simulate pump stations running at firm and peak conditions the model results are also reviewed for the number of pumps running in a given simulation to account for the dynamic relationship between the pumps, forcemain, and wet well storage. Alternative solution recommendations are derived based on the review of the pumping stations theoretical capacity and ability to convey flow through their forcemain(s).

Review of solutions included a review of forcemain upsizing/twinning or redirection or redirection where applicable.

2.1.3 COMBINED SEWER SYSTEM – INFRASTRUCTURE ANALYSIS

The combined sewer system was analyzed separately as there are controls and infrastructure in place to regulate the levels in the system that directly influence the different components (i.e. sewer & pumping station) and act a single system. The combined sewer system was reviewed based on two main criteria using InfoSWMM:

Objective 1. MOECC F-5-5 Guidelines & "Virtual Elimination" of CSOs

Objective 2. Long Term Goals – Level of Service

While source control was identified in previous studies and master plan as the most effective means of CSO reduction for the Kingston Central Collection system, this analysis was revisited to ensure that under current conditions and regulations it is still the most effective means. Once this is determined, a more detailed analysis of the preferred method is completed to provide guidance and recommendations to meet Objective 1.

In order to provide additional guidance and options for the combined sewer system, a long term goal was developed with the assumption that Objective 1 is achieved. This strategy was developed by comparing the combined sewer system to a LOS analysis to determine what upgrades would be required in the future for the sewers, pumping stations, and treatment plants. In order to review realistic and reasonable upgrades for the system, some of LOS criteria were reduced. The following table presents this long term LOS criteria:

Table 2-1 Level of Service to be met for Evaluated Alternative Solutions

COLLECTION SYSTEM TYPE	SEWERS LOS	PUMPING STATION LOS	WWTP LOS
Combined Sewer System	10yr Design Storm Flows	10yr Design Storm Flows	10yr Design Storm Flows

2.1.4 SUMMARY OF ALTERNATIVE SCENARIOS

Upon completion of the Alternatives review of the sewer collection systems using the wastewater trunk model the following scenarios were developed in the model to represent the new infrastructure recommended as shown in Table 2-2.

Table 2-2 Recommended Alternatives – Model Scenario Development

SCENARIO NAME & MODEL LABEL(S)	RECOMMENDED INFRASTRUCTURE – MODEL ADDITIONS*
2021 (MP-F-2021-A1)	→ Days Road. PS Capacity Increase → Hillview Raod PS – Forcemain Upsize → King St. Collector - Upsize → North end Trunk Sewer – Twinning Phase 1 → Princess St. Collector – Upsize Phase 1 → Westbrook PS – Flow Redirect
2026 (MP-F-2026-A1)	→ Collingwood St. Collector – Upsize → North West Collector between Lincoln dr. to Pembridge Cres. – Upsize → Notch Hill Collector – Upsize → Princess St. Collector – Upsize Phase 2 → King St. PS – Twin Forcemain
2036 ((MP-F-2036-A1)	→ North End Trunk Sewer – Twinning Phase 2 → Princess St. Collector – Upsize Phase 3 → Harbourfront Trunk Sewer – Twinning (River St PS Inlet Sewer) → Rideau St. Collector – Upsize → Ravensview Trunk Sewer – Twinning

*= Table excludes previously included imminent projects added during model scenario development for 2015, 2021, 2026, 2036, build-Out and Ultimate projections.

Additional details pertaining to the recommended alternatives are detailed in the Alternatives Report for the Master Plan.

Appendix M

MODEL RESOURCES

Name	Description
	West Sewer System
W_ALL_JUNCTIONS	West Sewer System Junctions
W_ALL_CONDUITS	West Sewer System Conduits
W_ALL_PUMPS	West Sewer System Pumps
W_ALL_SUBCATCH	West Sewer System Subcatchments
W_ALL_STORAGE	West Sewer System Storage Nodes
W_ALL_OUTFALLS	West Sewer System Outfalls
W_ALL_2015	Existing 2015 Elements in West Sewer System
	Central Sewer System
C_ALL_JUNCTIONS	Central Sewer System Junctions
C_ALL_CONDUITS	Central Sewer System Conduits
C_ALL_PUMPS	Central Sewer System Pumps
C_ALL_SUBCATCH	Central Sewer System Subcatchments
C_ALL_STORAGE	Central Sewer System Storage Nodes
C_ALL_OUTFALLS	Central Sewer System Outfalls
C_ALL_2015	Existing 2015 Elements in Central Sewer System
C_COM_SEWER_SUBCATCH	
C_COM_SEWER_ALL	
	East Sewer System
E_ALL_JUNCTIONS	East Sewer System Juctions
E_ALL_CONDUITS	East Sewer System Conduits
E_ALL_PUMPS	East Sewer System Pumps
E_ALL_SUBCATCH	East Sewer System Subcatchments
E_ALL_STORAGE	East Sewer System Storage Nodes
E_ALL_OUTFALLS	East Sewer System Outfalls
E_ALL_2015	Existing 2015 Elements in East Sewer System
	All Sewer Systems
2015_ALL_FM	All Existing Sewer System Forcemains
1_NORTH_END	North End Trunk Sewer
1_NORTH_END_OUT	North End Outlet Trunk Sewer
1_RIDEAU_HEIGHTS	Rideau Heights Trunk Sewer
1_NORTH_HARBOURFRONT	North Harbourfront Interceptor Trunk Sewer
1_DAYS_RD_IN	Days Road Inlet Trunk Sewer
1_FRONT_RD	Front Road Trunk Sewer
1_HARBOURFRONT	Harbourfront Trunk Sewer
1_KING_ST	King Street Trunk Sewer
1_HWY_15	Highway 15 Trunk Sewer
1_RAVENSVIEW	Ravensview Trunk Sewer

Name	Description
	Sewer/Forcemain Profiles
2_PRINCESS_ST	Princess Street Collector
2_NOTCHHILL_RD	Notch Hill Road Collector
2_CHAMPLAIN_AVE	Champlain Avenue Collector
2_LAPPENS_LN	Lappens Lane Collector
2_YONGE_ST	Yonge Street Collector
2_COLLINGWOOD_ST	Collingwood Street Collector
2_GEORGE_ST	George Street Collector
2_WELLINGTON_ST	Wellington Street Collector
2_MARKLAND_ST	Markland Street Collector
2_CHARLES_ST	Charles Street Collector
3_BARRET_CT	Barret Court Forcemain
3_BATH_RD	Bath Road PS Forcemain
3_BATH-COLLINSBAY_RD	Bath-Collings Bay Rd PS Forcemain
3_BATH-LOWER_DR	Bath-Lower Dr PS Forcemain
3_BAYRIDGE_DR	Bayridge Drive PS Forcemain
3_COLLINSBAY_RD	Collins Bay Road PS Forcemain
3_COVERDALE_RD	Coverdale Road PS Forcemain
3_CRERAR_BLVD	Crerar Blvd PS Forcemain
3_DALTON_AVE	Dalton Ave. PS Forcemain
3_DAYS_RD	Days Road PS Forcemain
3_GREENVIEW_DR	Greenview Drive PS Forcemain
3_HATTER_ST	Hatter Street PS Forcemain
3_HILLVIEW_RD	Hillview Road PS Forcemain
3_HWY15	Highway 15 PS Forcemain
3_JAMES_ST	
3_JOHNCOUNTER_BLVD	John-Counter Blvd. PS Forcemain
3_KENWOODS_CIRCLE	Kenwoods Circle PS Forcemain
3_KING_ST	King Street PS Forcemain
3_KING-ELEVATORBAY	King-Elevator Bay PS Forcemain
3_KING-LAKEONTARIOPARK	King-Lake Ontario Park PS Forcemain
3_KING-PORTSMOUTH	King-Portsmouth PS Forcemain
3_LAKESHORE_BLVD	Lakeshore Blvd PS Forcemain
3_MORTON_ST	Morton Street PS Forcemain
3_NOTCHHILL_RD	
3_PALACE_RD	Palace Road PS Forcemain
3_RANKIN_ST	Ranking Street PS Forcemain
3_RIVER_ST	River Street PS Forcemain
3_SCHOONER_DR	Schooner Drive PS Forcemain
3_WESTBROOK_RD	Westbrook Road PS Forcemain
3_YONGE_ST	Yonge Street Forcemain