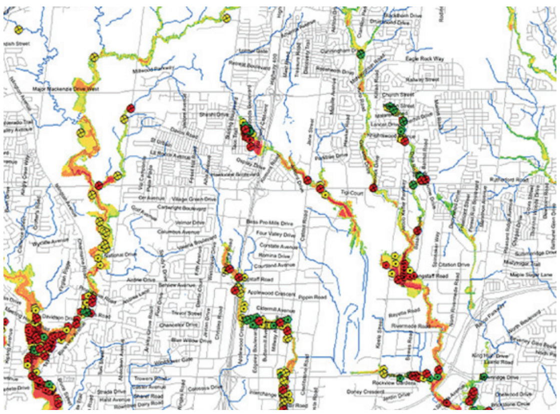
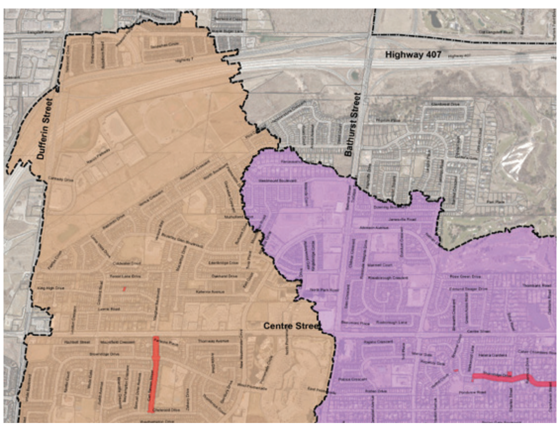
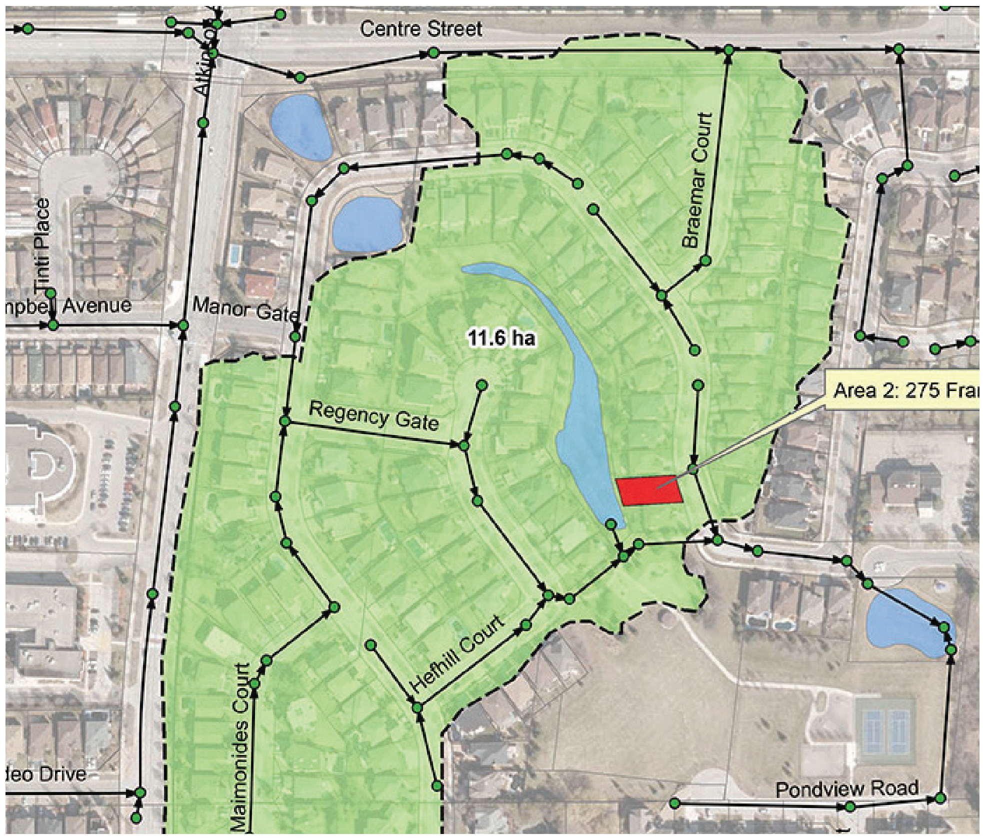
VAUGHAN CITY-WIDE DRAINAGE STUDY FLOOD VULNERABLE SITES REPORT

PHASE II

Project code: COL13-0005 / W11-251







CIVICA
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

CIVICA INFRASTRUCTURE INC.

71 Creditstone Road
Vaughan, ON CANADA L4K 1N3
T. 905.532.9011 **F.** 866.318.2465
www.civicainfrastructure.com

COLE ENGINEERING GROUP LTD.

70 Valleywood Drive
Markham, ON CANADA L3R 4T5
T. 905.940.6161 | 416.987.6161
F. 905.940.2064 | www.ColeEngineering.ca

MARCH, 2014

March 21, 2014
Our Ref: W11-251

Engineering Services
2141 Major Mackenzie Drive
Vaughan, ON L6A 1T1

Attention: Saad Yousaf
Storm Drainage Engineer

Dear Mr. Saad:

Re: Phase ll Drainage Study / Flood Vulnerable Sites
Submission of Final Report

We are happy to submit the Final Report for the City of Vaughan (the City) Phase ll Drainage Study / Flood Vulnerable Sites. This report has been updated to address the comments received in a letter dated May 22, 2013 and discussed in our meeting June 11, 2013. Further comments regarding some minor text edits were received on October 21st, 2013. These comments have been addressed as follows:

Comments dated May 22, 2013:

Comment 1 – *Inventory of stormwater control facilities owned by the City, not currently in the stormwater management (SWM) facility database. These include super-pipe flow control storages, oil-grit separators, on-site controls (roof, parking lots, underground):*

Discussion with the City staff concluded that the inventory of facilities owned by the City but not included in the SWM facility database should be integrated into a new expanded SWMsoft system. Latest discussion with the City indicated that the expansion may happen at a later date.

Comment 2 – *Inventory of other drainage facilities or infrastructure owned by other public agencies including quantity and quality control facilities, large sewers and channels, and onsite controls:*

Several attempts were made to collect information and some responses were received. However, similar to City's records, much of this information was not readily available. Through discussion with City staff it has been agreed that the City must develop a strategy to co-ordinate file and field investigations with agencies who have jurisdiction over SWM assets. This data should be collected, reviewed and entered into the expanded SWMSoft system once the data becomes available.

Comment 3 – *Refinements to the existing sewer data to verify directional information in sewer networks:*

This task was completed for all the areas where detailed modeling and analysis were required to evaluate the level of flood protection and develop flood remediation alternatives. It was recommended that the City should develop a City-wide Drainage Management system using VH SWMM, as such a system model would include QA and QC of all the service areas.

Comment 4 – *A final monitoring report is to be submitted at the end of the flow monitoring program:*

A copy of the monitoring report has been included in **Appendix E**.

Comment 5 – *The hydraulic model for site eight (8) must include the most recent hydraulic analysis for the 2 year event through the Regional storm event:*

The models provided to the City include these design events. It should be noted that although the Regional event was modeled as part of the analysis the 1 in 100 year event was the largest event for which flood remediation was required as part of this study.

Comment 6 – *The models are to be calibrated and validated using the 6 largest events measured during the monitoring program:*

All events modeled were used for model calibration and validation (>6 events). However, not all events showed consistent results, possibly due to debris accumulation at the flow monitoring weirs. This is discussed in section 7.2 of the report and is shown in the flow monitoring report found in **Appendix E**.

Comment 7 – *The proponent will also use the August 19th, 2005 storm event to assist with the model calibration:*

This storm event was included in the analysis and the model results were discussed in relation to reported flooding from this event. The results of this analysis are discussed in **Section 8.4** of the report.

Comment 8 – *It should be noted that the remediation plan must focus on storm drainage systems which may be susceptible to overloading leading to flooding under the City's level of service and not the August 19th storm event condition:*

Only the 1 to 100 year design storms have been considered for remediation when high flood potential has been identified

Comment 9 – *A series of graduated remediation options and the associated costs should be developed:*

Remediation measures for the seven (7) problem areas identified are described in **Section 10** and cost estimates are provided in **Table 10.2.**

Comments dated October 21st, 2013:

Minor text edits were identified in the report, these errors have been addressed as requested.

We trust that the above noted changes address all the comments pertaining to the City Phase ll Drainage Study / Flood Vulnerable Sites.

Yours truly,

COLE ENGINEERING GROUP LTD.

Geoff Masotti
Business Unit Leader, Water Resources

GM:jn

S:\2011 Projects\D-EE(E11)\WWF\W11-251 Vaughan City-Wide Drainage Study Phase II\Reports\20140128_Final Report\ReportText\DRAFT Final Report - Vfinal (Civica, Feb 10 2014).docx

PREPARED BY:

CIVICA INFRASTRUCTURE INC.

Edward Graham, M.A.Sc.Eng., P.Eng.
President

AUTHORIZED FOR ISSUE BY:

COLE ENGINEERING GROUP LTD.

Geoff Masotti, P.Eng.
Business Unit Leader, Water Resourses

Issues and Revisions Registry

Identification	Date	Description of issued and/or revision
Draft Report	Feb 22, 2012	For client review
Final Report	March 25, 2014	For client review

Statement of Conditions

This Report / Study (the "Work") has been prepared at the request of, and for the exclusive use of, the Owner / Client, and its affiliates (the "Intended User"). No one other than the Intended User has the right to use and rely on the Work without first obtaining the written authorization of Cole Engineering Group Ltd. and its Owner. Cole Engineering expressly excludes liability to any party except the intended User for any use of, and/or reliance upon, the work.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

APPENDICES

Executive Summary

Introduction and Background

On August 19th, 2005, approximately 85% of the City of Vaughan (the City) experienced a rainstorm event equivalent to the 1 in 100 year design storm condition or larger, with the greatest intensities concentrated in the central and southern areas of the City. This storm caused considerable flood damage to private and public properties. As a result of this event, City Council endorsed a staff recommendation to undertake a City-wide drainage study. In 2009, Clarifica Inc. completed Phase I of the City-Wide Drainage and Stormwater Management (SWM) Study for the City. The objectives of the Phase I Study included:

- To evaluate the existing storm drainage system data, primarily in the urbanized areas of the City; and,
- To develop a management strategy for flood susceptible areas through comprehensive mapping and evaluation of the City's existing drainage and SWM.

The primary recommendations from the study were:

- Fill in data gaps and improve the existing drainage data in order to develop a comprehensive drainage system inventory of the surface and sewer systems throughout the City using Geographic Information Systems (GIS); and,
- Preliminary assessment of 20 known flooding sites showed that a detailed drainage analysis was required to assess the level of flood protection and upgrades required to bring these to acceptable levels.

The Phase II investigations were initiated to improve the existing drainage data in the City and complete a detailed drainage analysis for seven (7) of the known flooding areas identified in the Phase I Drainage Study, in an effort to establish accurate levels of flood risk, leading to specific retrofit and/or remediation recommendations.

Objectives and Scope

The main objectives of the Phase ll Study are:

- Continue the development of a comprehensive GIS based drainage inventory of the City's drainage system by continuing to address key data gaps identified in the Phase I Drainage Study;
- Development of Data Standards for submissions by consultants, agencies or others providing new drainage infrastructure;
- Flood Emergency Response Planning (FERP) refinements using the new building envelope information to establish building's level of flood protection; and,
- Develop flood remediation plans for Sites 1 through 6 and 8 by evaluating the existing drainage performance in terms of the level of flood protection and by developing the best cost-effective solutions to upgrade the protection to match the City's standard. **Table 1** summarizes the flooding problems for each of these areas.

Table 1 – Summary of Flooding Problems

Site	Reported flooding	Description of Flooding problem
Area 1: 122 Thornridge Drive	Flooding reported in 2005	Surface flooding due to improper grading and high water levels in adjacent roadside ditches. Property was re-developed and re-graded in 2008.
Area 2: 275 Franklin Avenue	Flooding reported in 2005 and concerns of flooding in 2008	Surface flooding when the water levels in the pond exceed the backyards crest elevations of 187.70 m.
Area 3: 311 Franklin Avenue	Flooding reported in 2005	House located a low point with reverse slope driveway. Floods due to capacity problems for major system.
Area 4: 109 Brooke Street	Backyard flooding reported in 2005	House located a low point. Floods due to capacity problems for major and minor systems.
Area 5: Brooke Street to Yonge Street and Thornridge Drive	City has received several flooding reports in this area	Major and minor systems are not built to current standards, ditches, culverts and inlets are susceptible to blockages.
Area 6: Tanjo Court and Springfield Way	Flooding on the road around catchbasins and at the road sag	Major and minor systems are not built to current standards, ditches, culverts and inlets are susceptible to blockages.
Area 8: Charlton Avenue	Potential rear yard flooding	Limited channel and culvert capacity and capacity of the downstream system cause the engineered channel to overtop the road and flood properties adjacent to the channel.

Drainage System Inventory

As part of the Phase II Study field investigations recommended in Phase I were conducted to expanded the inventory of storm drainage infrastructure by identifying and inspecting culvert and bridge crossings at various locations in the City. These structures were identified from 2009 aerial photography and Digital Elevation Models (DEM) GIS analysis prior to field investigations. This information is necessary to assess flood potential due to restrictions at the crossings, and also for accurately delineating overland flow paths using a refined DEM.

In order to complete the City's drainage system inventory it is recommended that the City:

- Secure more accurate DEM data, such as from aerial and land-based LIDaR survey sources;
- Complete a GIS assessment including sink-fill analysis, data entry, cataloguing;
- Complete a file archive search for storm drainage area plans, plan and profile drawings, SWM reports; and,
- Invest in field verification where required.

Drainage Assessment of Areas 1 through 6 and 8

The drainage assessment of Areas 1 through 6 and 8 included:

- Data collection;
- Analysis of the sewer system data;
- Correcting existing data gaps;
- Field assessments;
- Flow monitoring; and,
- The setup of the micro-drainage model.

Data gaps and potential errors in the data were identified in the existing storm sewer GIS database sources. Missing manhole inverts, ground elevations, pipe diameter, pipe slope, and pipe length were consistently identified (e.g. zero diameter, zero length, etc.). Missing storm sewer segments and catchbasins where identified in most areas. Data gaps were addressed partially through additional data received from the City and through assumptions using engineering judgment. A thorough review was also conducted to identify potential errors in the data by assessing extreme values such as very steep or very shallow pipe slopes, and pipe dimensions that did not appear to be consistent with adjoining pipes. In addition to the existing drainage infrastructure, a review of the SWM facilities within the study area was conducted.

Field data collection was required for Areas 1 through 6 and 8 to capture the information required for the development of the detailed micro-drainage model upstream, within and downstream of the flood prone areas. There three (3) main components of the survey in Areas 1 through 6 and 8 included:

1. Confirm the type, location and size of storm sewer inlets located in public areas, primarily within the right of ways but also within parks and other publicly-accessed open spaces;
2. Inspection of the number of directly connected roof drains visible from public Right-Of-Ways. Directly connected roofs are a source of sewer inflow and are critical in assessing the existing drainage capacity; and,
3. Identifying the presence of reverse slope driveways. Identifying reverse slope driveways is critical in order to assess potential flood vulnerable areas:
    - The DEM is source information used in the development of overland flow route. The DEM is a good indicator of the direction of major overland flow path and is useful in delineating drainage areas. A raw DEM contains detailed surface elevation data but requires conditioning in order to accounts for culverts, road crossing and buildings. Once this conditioning has been completed the DEM can be used to generate overland flow paths used as the major system in micro-drainage modeling. This conditioning was completed for the existing City DEM, with additional focus on the seven (7) flooding areas to be analysed as part of this study; and,
    - Civica's VH SWMM modelling tool was used to create a detailed hydrodynamic Micro-Drainage model of the storm drainage system. A micro-drainage model combines GIS data in the form of detailed surface elevation data, sewer asset data, field verification, and modeling. The model was calibrated using the monitored rain and flow data and then used to analyze flood remediation solutions for Areas 1 through 6 and 8. **Table 2** summarizes the recommended solution for each of these areas.

Table 2 – Proposed Remediation Measures

Site	Proposed Remediation Measures	Cost Estimate
Area 1: 122 Thornridge Drive	Recommendation is that City collects improved DEM data such as through LIDaR and continue to improve the drainage management system to evaluate local drainage capacity in this and other areas of the City.	N/A
Area 2: 275 Franklin Avenue (Interim Solution)	Increase existing outlet from 200 mm to 350 mm.	$42,000
	Re-direct flows from three (3) existing catchbasins located at Franklin Avenue and Markwood Lane from the Franklin Avenue storm sewer to Pondview Pond.	
Area 2: 275 Franklin Avenue (Ultimate Solution)	Install a 180 m long 600 mm outlet sewer from the Franklin Avenue Pond to Pondview Pond.	$300,000
	Re-direct flows from three (3) existing catchbasins located at Franklin Avenue and Markwood Lane from the Frainklin Avenue storm sewer to Pondview Pond.	
	Increase the Pondview Pond storage by 1250 m^3 to 3050 m^3.	
	Increase outlet pipe size for Pondview Pond from existing 200 mm to 525 mm.	
	Raise Hillock Berm 0.6 m.	
Area 3: 311 Franklin Avenue	Issue will be addressed as part of the solution for Area 2. Interim solution would be to raise sidewalk elevations.	$4,500
Area 4: 109 Brooke Street	Retrofit of Gallanough Park Pond.	$1,675,000
	Redirect the 2100 mm storm sewer (which conveys flow from 150 ha west of the park) from the Brook Street storm sewer to the Gallanough Park Pond.	
	A 600 mm storm sewer inlet will convey runoff from 3.4 ha south of the pond.	
Area 5: Brooke Street to Yonge Street and Thornridge Drive	Sewer by-pass from Tributary 2 to the Brook Street Trunk sewer. This solution is contingent on the construction of the Gallanough Pond and the redirection of the Brook Street storm sewer in order to provide downstream capacity for the bypass.	
	Relief sewer along Arnold Avenue, east of Brooke Street, to reduce flows along the Brooke Street sewer. This is subject to the existing 1500 mm diameter trunk sewer being able to convey the additional flows without impacting the downstream drainage systems in Markham.	Additional Cost $780,000
Area 6: Tanjo Court and Springfield Way	Lower sidewalk on Springfield Way, adjacent to Gallanough Park, by approximately 0.37 m and re-grading within the park.	$15,000
Area 8: Charlton Avenue	No mitigation is recommended as modelling shows that the system provides a 1 in 100 year level of flood protection without the need for specific infrastructure enhancements.	N/A

Notes:
Cost estimate includes design and construction cost, estimate does not include applicable taxes.
The recommended solutions for remediating Flood Areas 2, 3, 4, 5, and 6 fall under the Municipal Class EA process, with Schedules to be confirmed at a later time.

General Recommendations

General recommendations are made in additional to the specific flood remedial recommendations made for each of the seven (7) flood vulnerable areas, these recommendations are summarized below:

1) Inventory and database:
    - The City should consider conducting a thorough QA / QC of their sewer infrastructure GIS data including missing pipe data and missing inlet data throughout the City by cross-referencing their existing GIS data with digital drawings and, more importantly, from on-going CCTV surveys work and air photography (for inlets);
    - As part of infilling data gaps the City should identify data gaps with respect to SWM ponds;
    - In order to complete the City's drainage system inventory it is recommended that the City:
        - Secure more accurate DEM data, such as from aerial and land-based LIDaR survey sources;
        - Complete a follow-up GIS assessment (e.g. sink-fill analysis, data entry, cataloguing);
        - Perform a file archive search for storm drainage area plans, plan and profile drawings, SWM reports;
        - Complete additional field verifications; and,
        - Develop a strategy to coordinate file and field investigations with agencies who have SWM asset jurisdiction.
2) Un-catalogued drainage structures should be assessed and included in the inventory;
3) SWM and Storm Drainage Infrastructure from other sources (i.e., Regional, MTO, etc.) as well as private SWM and infrastructure (subsurface / underground storage units, oil-grit separator units, etc.) should also be input into the City's SWMSoft database so that the City can keep an up to date inventory of all SWM facilities and drainage infrastructure within their Jurisdiction;
4) It is recommended that the City collects improved DEM data such as through LIDaR and continue to improve the Drainage Management System to evaluate the local drainage capacity in this and other areas of the City;
5) Further field investigations of existing road profiles within the City should be completed through field investigations and through cross-referencing locations using high resolution aerial photography or LIDaR technology;
6) The regular CCTV surveys, typically conducted for infrastructure condition assessment, should be specified such that accurate invert elevations of connecting pipes and ground elevations are simultaneously collected at the manholes. Sewer segments with significant sags should also be identified and included in the Drainage Management System database;
7) The City should consider expanding the building layer to include new development and re-development since 2007 using high resolution air photography;
8) It is recommended that where possible, the City update their database so that engineered channels can be represented in the overland flow path;
9) It is recommended that the city undertake a more detailed survey to get a better topographic representation of sag areas;

10) This information should be reviewed and filed into the SWMSoft database system. This inventory would be tied to the City's GIS system and would be used by staff as part of a City-Wide Drainage Management System involved in Master Planning, site development approvals, engineering, operations, parks, traffic, finance, etc., resulting in a co-ordinated and precise effort to inspect and maintain the inter-related drainage system;

11) The City may also decide to selectively share some of the drainage system information with residents (e.g. rain gauge data, flow analysis data, asset data, etc.) to increase awareness of the City's drainage management functions;

12) It is recommended that the City implement data standards for drainage infrastructure, specifically for culverts and bridges, which have been developed to ensure submissions from consultants, agencies or other proponents with respect to drainage infrastructure are consistent and can be easily incorporated into the City's SWMSoft database.; and,

13) Model Updates:

    - The model development required significant data infilling. The City should consider updating the model as part of the future studies and detailed design in areas proposed for remediation to further confirm the results and recommendations of this study;
    - Future improvements to the model inputs should be considered such as improvements to GIS data and DEM data;
    - It is recommended that the City surveys all inlets within the study area so that an accurate inlet capture curve can be input into the model, resulting in a more accurate analysis of the quantity of major overland flow entering the minor system;
    - In order to accurately represent the hydrological effect of AMC, It is recommended that future calibration of micro drainage models take into account AMC to accurately represent the rainfall-runoff relationship during the specific calibration / storm event; and,
    - Future monitoring should include rain gauge densities no greater than 1 per 200 ha or ground-corrected radar images (combination of rain gauges and Doppler radar data) in conjunction with self-cleaning flow measuring flumes.

14) General Recommendations:

    - It is recommended that the City implement a City-Wide Drainage Management System that includes a flooding reporting feature in combination with a public communication program that advises residents, tenants and property owners to report flooding during large storm events. Such a system would provide valuable information to the City allowing for more effective management of the drainage system;
    - It is recommended that the City update their criteria by providing oversized debris gratings with high debris control capacity in combination with either low-maintenance inlet control devices or inlet sizing that controls the flow;
    - The Class EA studies and detailed design that will be required for the implementation of some of the proposed remedial measures could be financed through a development charge. The City should consider implementing development charges for the proposed work if there is proposed development upstream of any of the flood vulnerable areas;
    - Although source control measures will not significantly reduce basement flooding by themselves during larger storm events, the City should consider these types of measures for infill and redevelopment areas as they are effective at reducing runoff volumes to receiving streams, mitigating erosion and improving water quality;

- It is recommended that the City consider implementing a downspout / roof leader disconnection program in an effort to reduce the amount of stormwater runoff in both the major and minor storm systems and reduce the risk of flooding;
- As a general overall improvement to the City's drainage infrastructure, the City should consider proceeding with the selection and installation of Inlet Control Devices (ICDs) and/or additional inlets to help optimize the used of the minor-major system capacity. Additionally, the City should consider the construction of new culverts and intake structures for improved capture of stormwater throughout the City; and,
- Due to the recurring issues with respect to surface drainage, it is recommended that the City conduct an analysis to determine the feasibility of implementing a minor storm sewer system along Thornridge Drive. The proposed storm sewer would start in the cul-de-sac on west side of Thornridge Drive and continue eastwards, eventually discharging to the Brooke Street Trunk Sewer. A capacity assessment on the Brooke Street Trunk Sewer at Thornridge Drive would also have to be undertaken to determine what the potential impacts are of connecting storm sewers along Thornridge Drive to the Brooke Street Trunk Sewer.

1.0 Introduction

On August 19th, 2005, approximately 85% of the City experienced a rainstorm event equivalent to the 1 in 100 year design storm condition or larger, with the greatest intensities concentrated in the central and southern areas of the City. This storm caused considerable flood damage to private and public properties. As a result of this event, City Council endorsed a staff recommendation to undertake a City-Wide Drainage Study. In 2009, Clarifica Inc. completed Phase I of a City-Wide Drainage and SWM Study for the City. The objective of Phase I Study included:

- To evaluate the existing storm drainage system data, primarily in the urbanized areas of the City; and,
- To develop a management strategy for flood susceptible areas through comprehensive mapping and evaluation of the City's existing drainage and SWM.

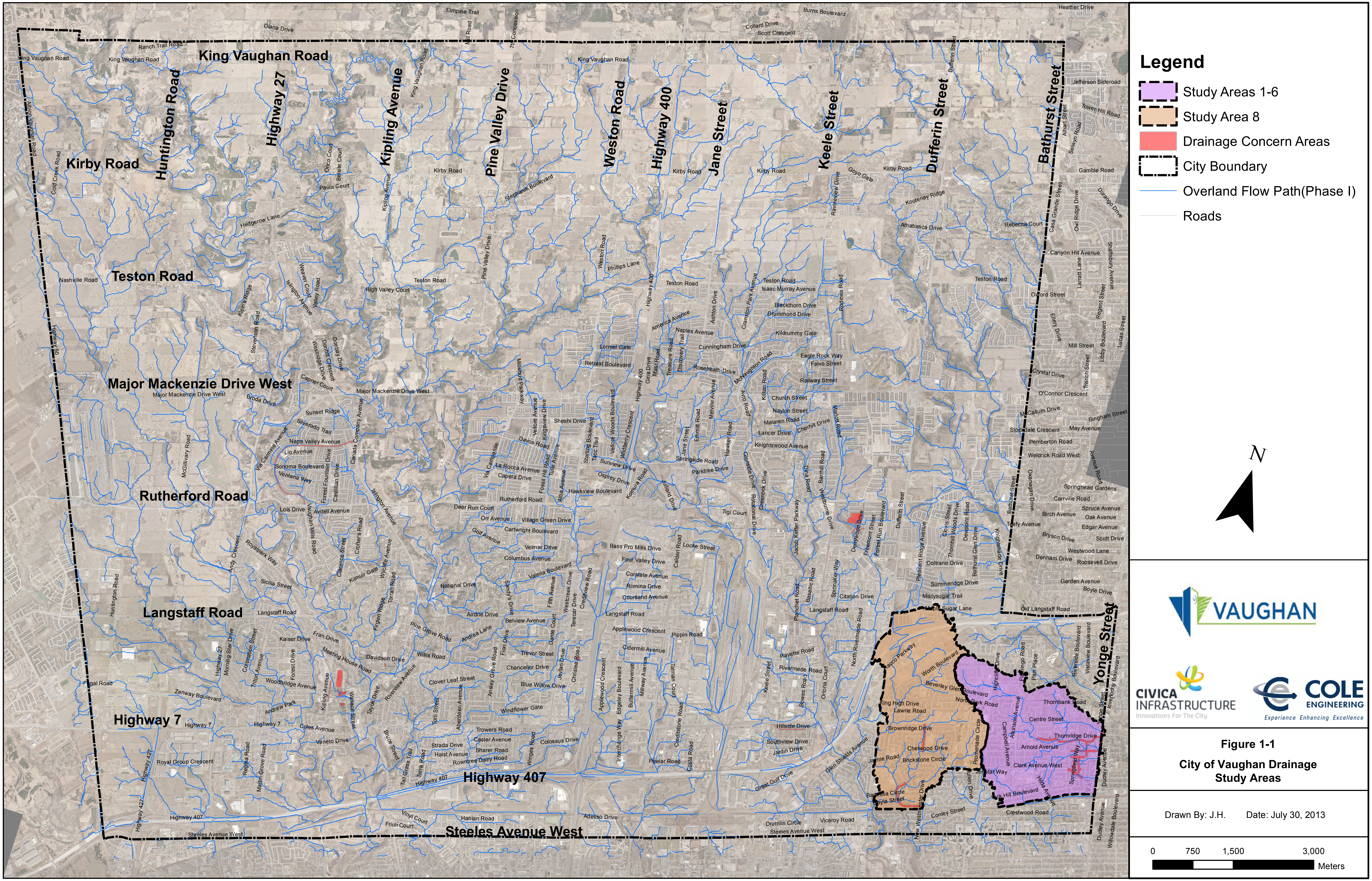
The primary recommendations from the study were:

- Fill in data gaps and improve the existing drainage data in order to develop a comprehensive drainage system inventory of the surface and sewer systems throughout the City using a GIS; and,
- Preliminary assessment of 20 known flooding sites showed that a detailed drainage analysis was required to assess the level of flood protection and upgrades required to bring these to acceptable levels.

Figure 1-1 illustrates the City's boundary and surface drainage areas with higher flood potential identified in the Phase I Drainage Study which would be subject to assessment in this Phase II Drainage Study.

The Phase II investigations were initiated to improve the existing drainage data in the City and complete a detailed drainage analysis for seven (7) of the known flooding areas identified in the Phase I Drainage Study, in an effort to establish accurate levels of flood risk, leading to specific retrofit and/or remediation recommendations. Thus, this Phase II Study filled-in some of the data gaps while assessing solutions at locations prioritized by the City with high flood potential. These locations are contained within Watershed Areas 1-6 and 8 as shown in **Figure 1-1.**

The detailed assessments produced as part of this study were completed using a new technique that uses rapid-model development methods to evaluate the surface and sewer capacities simultaneously. This technique is known as "micro-drainage", and it combines GIS data in the form of detailed surface elevation data, sewer asset data, field verification, and modeling. The approach increases accuracy and reliability and leads to improved flood protection while reducing implementation costs. This approach will allow for development of a comprehensive City-Wide Drainage Management System that integrates geographic and asset information (e.g. sewers, culverts, inlets, catch basins, SWM facilities, channels), analysis tools (e.g. models, condition assessment criteria, performance criteria), operational tools (reported flooding, sewer defects) useful for planning and managing growth and infrastructure maintenance and expansion works.



King Vaughan Road
Huntington Road
Highway 27
Kipling Avenue
Pine Valley Drive
Weston Road
Highway 400
Jane Street
Keele Street
Dufferin Street
Bathurst Street
Kirby Road
Teston Road
Major Mackenzie Drive West
Rutherford Road
Langstaff Road
Highway 7
Highway 407
Steeles Avenue West
Yonge Street
Legend
Study Areas 1-6
Study Area 8
Drainage Concern Areas
City Boundary
Overland Flow Path(Phase I)
Roads
N
VAUGHAN
CIVICA INFRASTRUCTURE
Innovations For The City
COLE ENGINEERING
Experience Enhancing Excellence
Figure 1-1
City of Vaughan Drainage Study Areas
Drawn By: J.H.
Date: July 30, 2013
0
750
1,500
3,000
Meters

1.1. Objectives and Scope

The main objectives of this Phase II study are:

1) Continue the development of a comprehensive GIS based drainage inventory of the City's drainage system by continuing to address key data gaps identified in the Phase I drainage study, including:
   - GIS building envelop layer based on recent aerial photography;
   - Culverts crossings;
   - Bridges and overpasses;
   - SWM facilities not currently in the City's database;
   - Drainage facilities and infrastructure owned by other public agencies (i.e., York Region, Province, Highway 407, Toronto and Region Conservation Authority (TRCA));
   - Refinements to existing sewer data in areas where drainage is analyzed in detail; and,
   - Refinements to existing DEM in areas where drainage is analyzed in detail.
2) Development of Data Standards for submissions by consultants, agencies or others providing new drainage infrastructure. The SWMSoft system will be used to create forms and specifications for data storage and presentation for different types of infrastructure components;
3) Flood Emergency Response Planning (FERP) refinements using the new building envelope information to establish building's level of flood protection; and,
4) Develop flood remediation plans for Sites 1-6 and 8 by evaluating the existing drainage performance in terms of the level of flood protection and by developing the best cost-effective solutions to upgrade the protection to match the City's standard. This work includes digital and on-site data collection and inspections and extensive GIS data processing to develop detailed models of the areas upstream, within, and downstream of the flood-prone area. Downstream conditions are necessary to assess potential backwater effects, while upstream conditions affect the flow contributions to the area. Initially four (4) of the areas modeled will be calibrated using rain and flow-data collected on-site. The remaining areas will be modeled with the parameters and the methodology from previous calibration. All sites will be evaluated for causes of flooding and level of flood protection, remediation options will be evaluated and recommended for each area. Preliminary design and cost estimates will be provided for the preferred alternatives for each site.

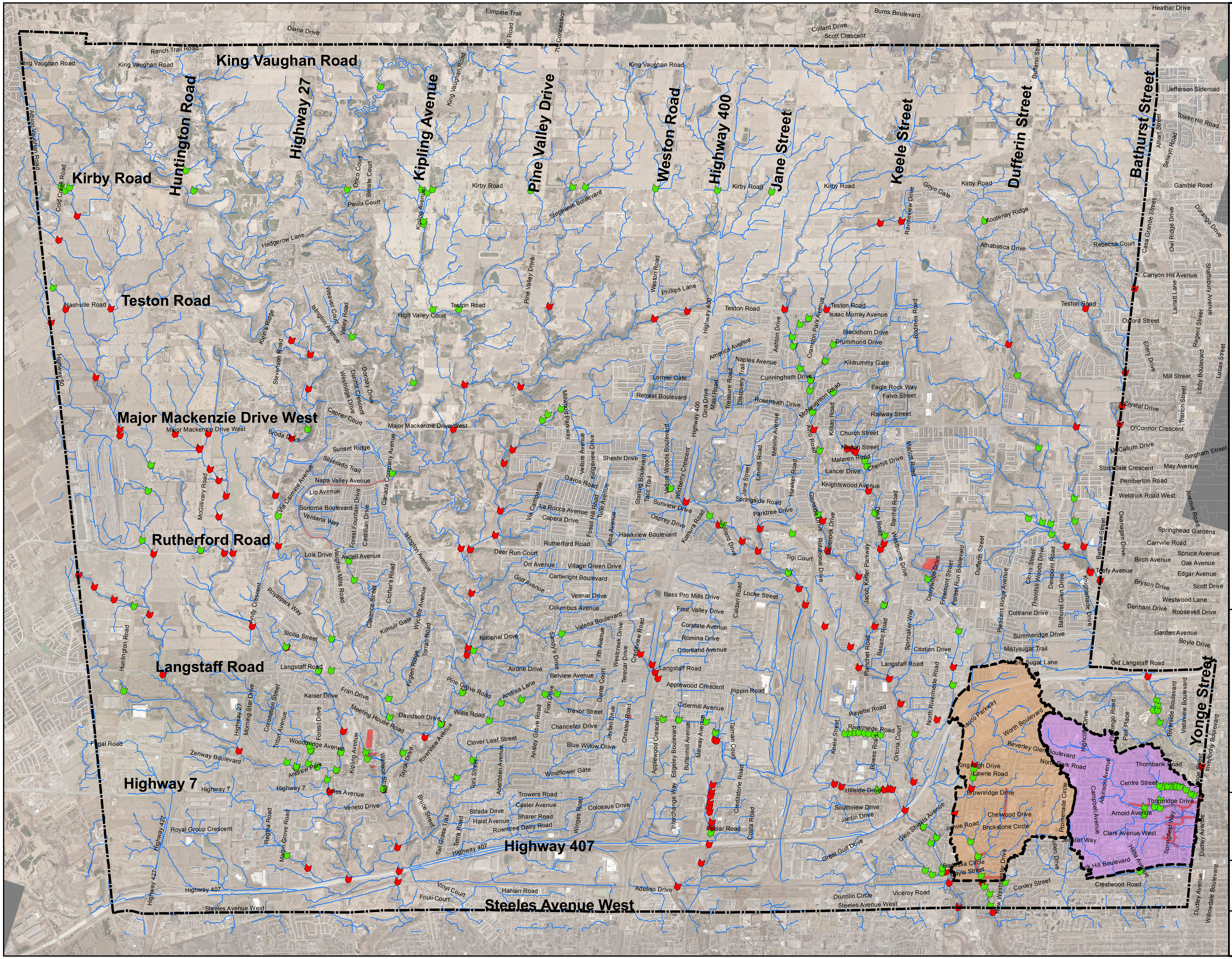
2.0 Drainage System Inventory

A recommendation of the Phase I Drainage Study was that the City should continue to expand the storm drainage system infrastructure database to allow for effective management of the City's drainage system. The following sections describe how various data gaps identified in Phase I have been targeted in this Phase II Study. Additionally, this section describes the catalogue of SWM infrastructure provided by other agencies which are not in the City's GIS database, this information includes culvert crossings, bridges and road overpass crossings.

2.1. Inventory of Existing Storm Drainage Infrastructure

Culvert crossings, bridge and road overpass crossings are key components of both the minor and major overland stormwater conveyance system. By creating a comprehensive inventory of these structures, the City will be able to plan inspections, assess their condition, conduct regular maintenance and repairs, evaluate their capacity, and upgrade or replace as necessary. The capacity assessment will tie into the flood protection evaluation and planning, including detailed modeling of hydrologic and hydraulic performance of the surface and sewer systems. This information is necessary to assess flood potential due to restrictions at the crossings, and also for accurately delineating overland flow paths using a refined DEM as described in **Section 3.1.7.**

One (1) source used to identify and fill in data gaps was a qualitative inventory of culverts and bridges completed in 2010 (GIS layer provided by the City via DVD on May 30, 2011). This inventory provided qualitative (visual) condition assessments and included the location, date of inspection, name of inspector and equipment used in the inspection. These inspections did not include testing or measurements. **Figure 2-1** shows the location of these "Municipal Structures". This inventory was useful as it identified City's assets for future planning and assessment. In addition to incorporating this data into the study, our team also identified existing culverts and bridges found in hydraulic models created and maintained by the TRCA for the purpose of flood mapping and flood management along valleys and streams corridors under their jurisdiction. These TRCA crossings are referred to as FVR in **Figure 1-1**. These structures are only a fraction of the existing culverts and bridges that make-up the City's drainage system. York Region also provided a list of regional bridges and culverts. Similar to the 2010 inventory by the City, this was only a qualitative assessment. **Figure 2-2** shows the regional culverts and bridges in the study area.



Legend

- Municipal Structures (161)
- FVR from Hec_Ras Model (176)
- Study Areas 1-6
- Study Area 8
- Drainage Concern Areas
- City Boundary
- Overland Flow Path(Phase I)
- Roads

N

VAUGHAN

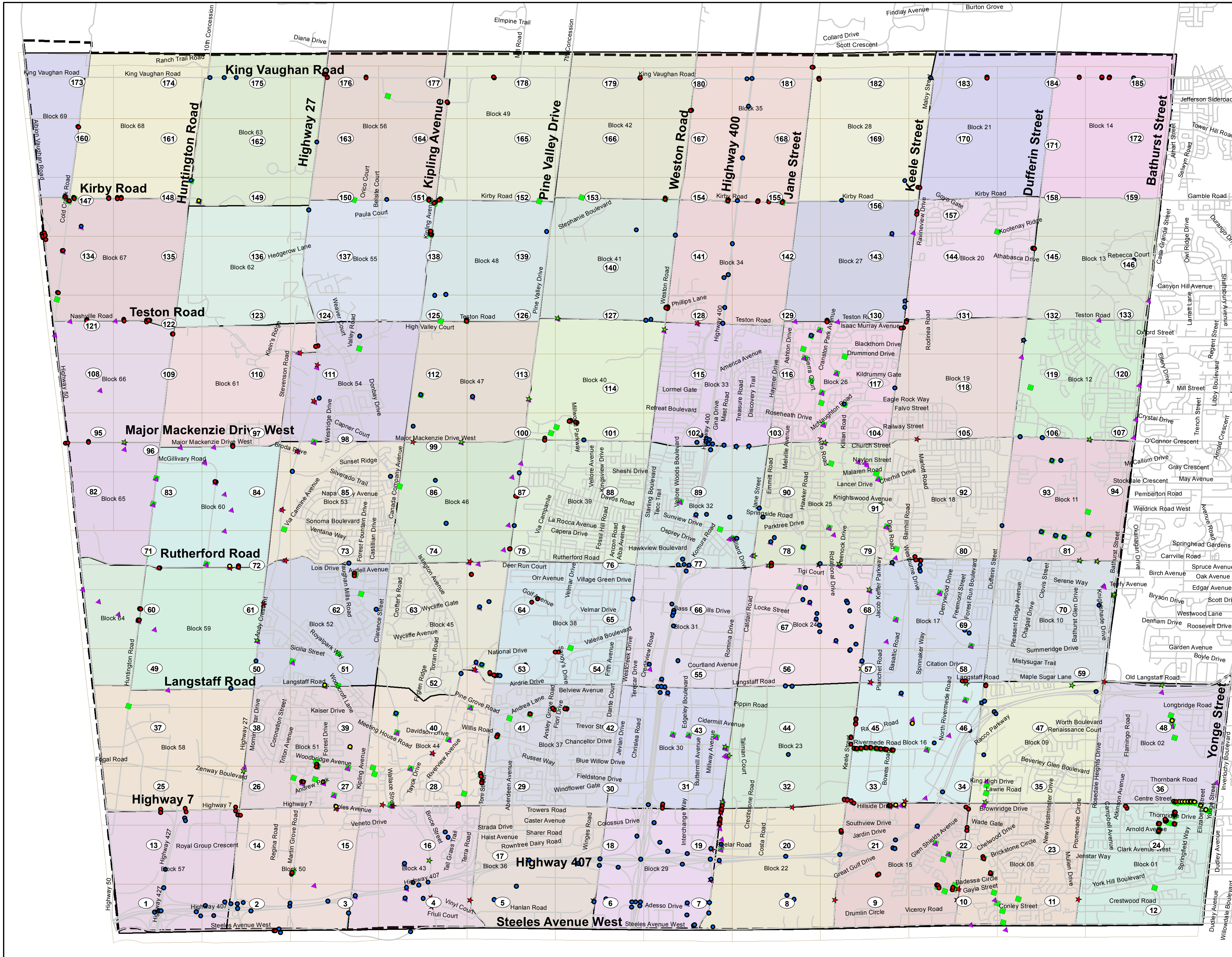
CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 2-1
Location of Municipal Structures

Drawn By: J.H. Date: July 30, 2013

0 750 1,500 3,000
Meters



Legend

- Culverts Surveyed (130)
- Bridges Surveyed (40)
- Inaccessible Culverts and Bridges (228)
- Bridges from York Region (36)
- Culverts from York Region (33)
- FVR from Hec_Ras (176)
- Municipal Structures(161)
- Roads
- Survey Zone Boundary
- City Boundary
- Block
- Survey Zone ID

VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

**Figure 2-2
Regional Culverts
and Bridges**

Drawn By: J.H. Date: Aug 1, 2013

0 500 1,000 2,000
Meters

2.2. Filed Inspection – City Wide Crossings

As part of the Phase II Study field investigations recommended in Phase I were conducted to expanded the inventory of storm drainage infrastructure by identifying and inspecting culvert and bridge crossings at various locations in the City. Significant locations were identified using the City's 2009 air photography and DEM GIS analysis prior to field investigations. Crossing locations where a watercourse / overland flow path crossed a road were identified as a potential bridge or culvert crossing. Field inspections were carried out at these locations to collect hydraulic information.

Figure 2-2 shows all the bridges and culverts surveyed during this study. During the inspection, each crossing was geo-referenced with GPS survey equipment and a Hydraulic Inventory form was completed. A sample of the Hydraulic Inventory Sheet can be found in **Appendix A**. Information compiled during the inspection includes:

- Structure type;
- Inverts of inlet and outlet structures;
- Material;
- Shape;
- Size / diameter and span / length of structure;
- Channel width;
- Emergency overland spillway;
- Vegetation; and,
- Presence of erosion, unsafe conditions, nuisance issues, encroachments, poor water quality, etc.

By creating an inventory of the entire culvert, bridge, and road overpass crossings the existing drainage network system can be evaluated with a higher level of confidence. This information is critical when using detailed modeling techniques to assess the performance of the major and minor system in areas where previous flooding has been reported. Through the survey, previously identified municipal and regional structures which only had qualitative information now had the hydraulic / quantitative information associated with that particular structure.

In addition to updating the SWM infrastructure inventory, the purpose of the hydraulic survey was to account for flow path breaches (i.e. crossings) identified in the Phase I Drainage Study. Breaches are openings along the surface flow path which occur at culvert and bridge crossings and road overpasses. These openings have been previously identified as blockages or 'dams' by the DEM which do not account for structures located underneath the existing ground surface. These existing structures allow flow to continue through the road crossing. This process of accurately defining the overland flow path and surface drainage system is known as DEM "conditioning." This is further described in **Section 3.1.7**.

Further refinement of existing road profile data within the City should be completed through field investigations and through cross-referencing locations using high resolution aerial photography or LIDaR technology.

There are still many un-catalogued drainage structures which should be assessed and included in the inventory. Undersized or damaged drainage structures can be a source of localized flooding resulting in complaints from residents, damages to residential and/or commercial property, disruptions to traffic flow and an increased risk to public safety.

In order to complete the City's drainage system inventory, it is recommended that the City:

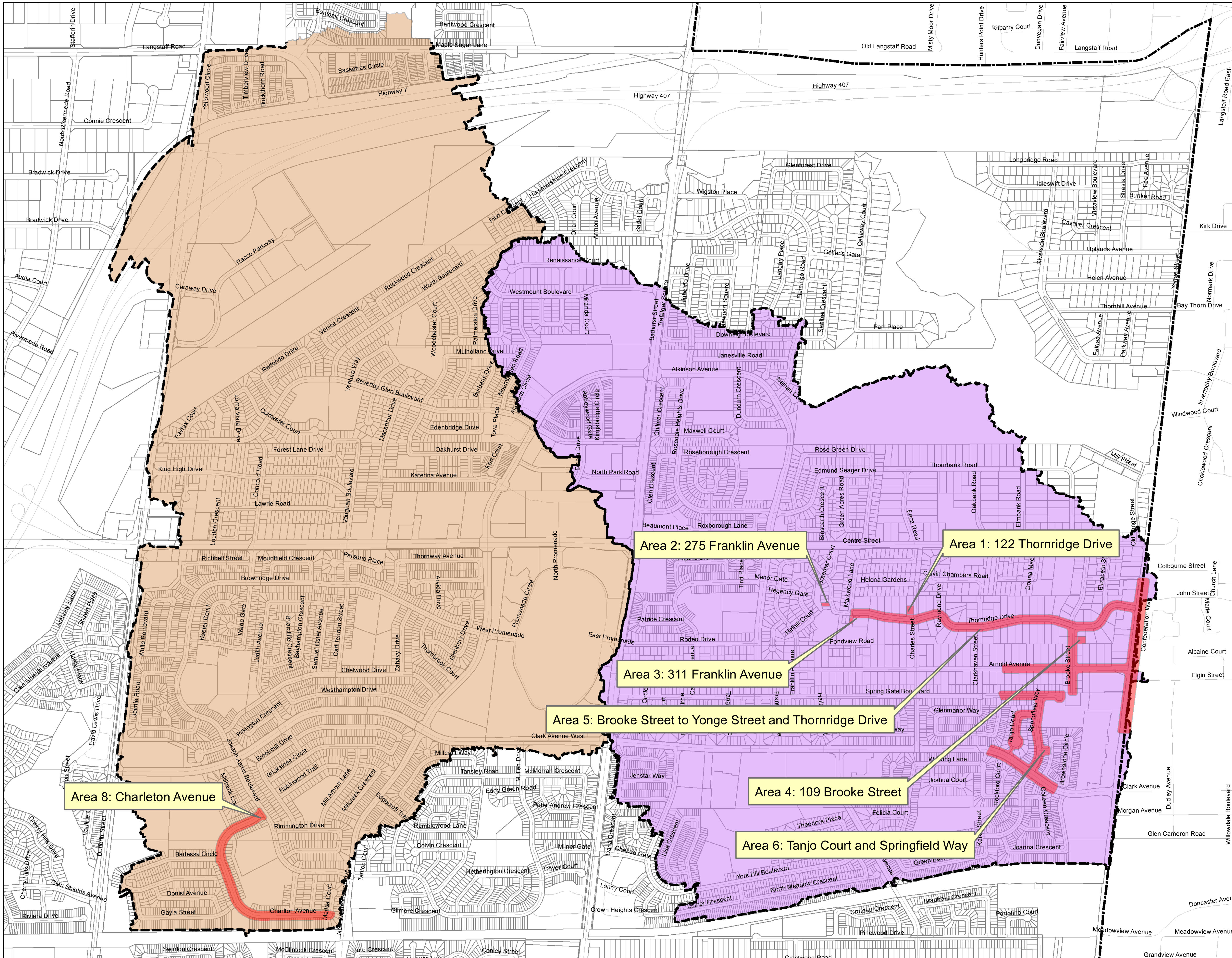
- Secure more accurate DEM data, such as from aerial and land-based LIDaR survey sources;
- Complete a GIS assessment including sink-fill analysis, data entry, and cataloguing;
- Complete a file archive search for storm drainage area plans, plan and profile drawings, SWM reports; and,
- Invest in field verification where required.

This inventory would be tied to the City's GIS system and would be used by staff as part of a City-Wide Drainage Management System involved in Master Planning, site development approvals, engineering, operations, parks, traffic, finance, etc. The City may also decide to selectively share some of the drainage system information with residents (e.g. rain gauge data, flow analysis data, asset data, etc.) to increase awareness of the City's drainage management functions

3.0 Assessing Existing Drainage Systems at Sites 1-6 and 8

An assessment of the existing drainage system was conducted at the reported flooding Sites 1 through 6 and 8 as shown in **Figure 3-1**. The existing storm drainage system / SWM for Areas 1 through 6 and 8 are shown on **Figure 3-2.**

The drainage assessment of Areas 1 through 6 and 8 included data collection, analysis of the sewer system data, correcting existing data gaps, field assessments, flow monitoring, and the setup of the Micro-Drainage Model.



Legend

- Study Areas 1-6
- Study Area 8
- Drainage Concern Areas
- Parcels
- City Boundary
- Roads

VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 3-1
Study Area
(Flooding Site 1-6 and 8)

Drawn By: J.H. Date: July 30, 2013

0 130 260 520 Meters

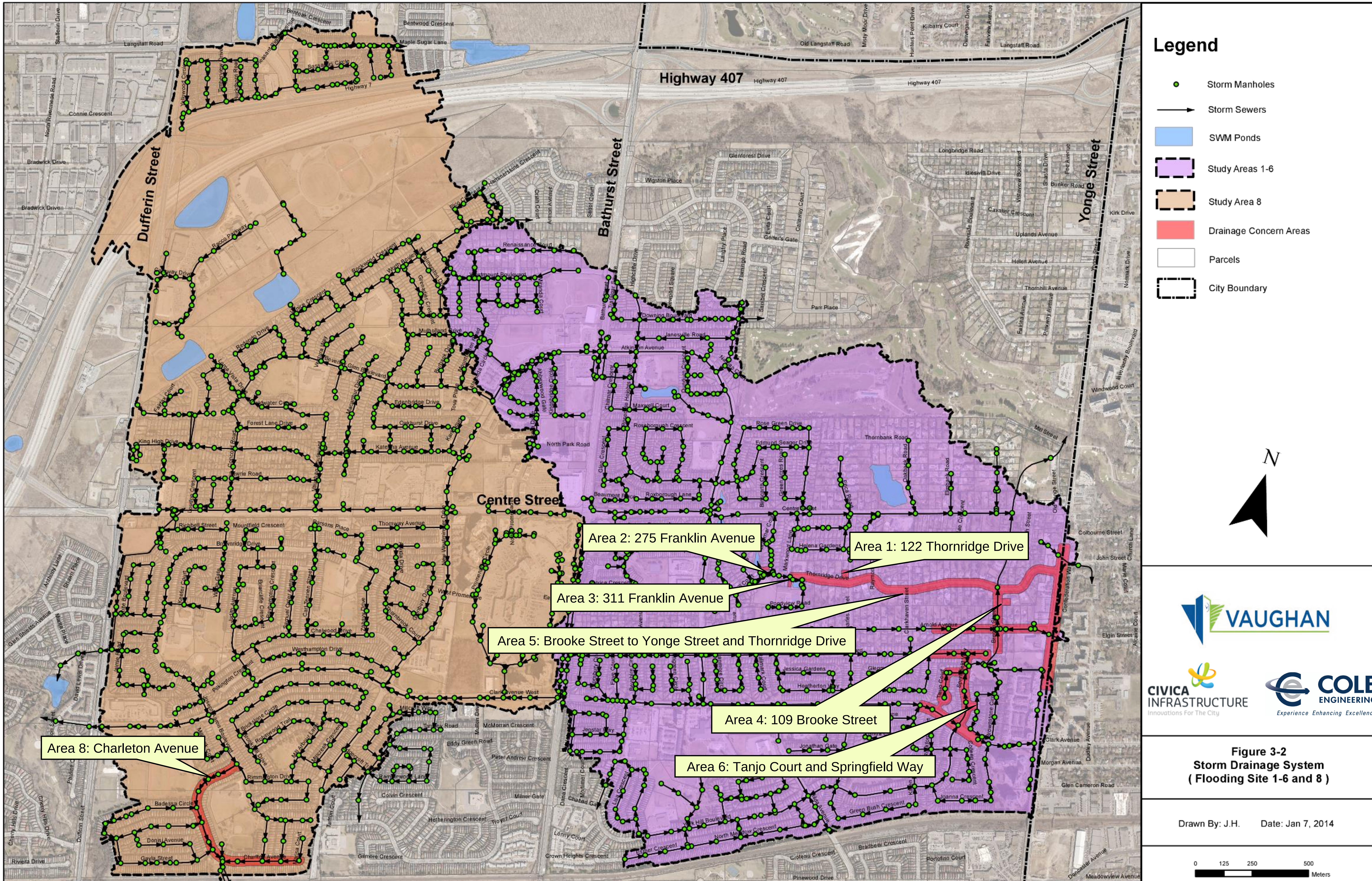


Figure 3-2
Storm Drainage System
(Flooding Site 1-6 and 8)

3.1. Data Collection

The following sections describe the results of the data collection, review and preliminary data processing. Analysis results are discussed later in the report.

The data collected, analyzed, and reviewed as part of this study includes:

- Digital sewer system data;
- DEM data;
- Orthophotography (2007 / 2009 / 2011);
- SWM facility information;
- Land-Use Data including zoning and lot fabric;
- Existing Soils;
- As-built and Plan-Profile drawings;
- Reported Flooding during August 19, 2005 storm event – Summary table;
- August 19 rainfall hyetograph; and,
- Individual SWM Reports for private developments.

3.1.1. Digital Sewer System Data

Development of the detailed Micro-Drainage Model depends on the availability and accuracy of the digital storm sewer information. The components of the storm sewer network include:

- Pipe Segments (polyline features), including both main sewers and catch basin inlet leads, and contain attribute data such as: pipe ID, pipe length, slope, upstream invert, downstream invert, width and height;
- Manholes (point features) which contain attribute data such as manhole ID, width, length, top elevation, and invert (possibly, the bottom of the manhole); and,
- Inlets / Catchbasins data (point features) containing attribute data such as inlet / catchbasin ID, width, length, top elevation, and invert (possibly, the bottom of inlet or catch basin structure).

Storm sewer infrastructure data specific to Areas 1 through 6 and 8 was reviewed to identify the data gaps and assess the general quality of the digital data. A list of data gaps was prepared and submitted to the City, listing missing information, reports, and drawings for SWM facilities including super-pipe flow control storages, oil-grit separators, and on-site controls. Aside from stormwater ponds owned by the City, most of the missing information was not immediately available. Actions have been recommended in **Section 11.0** of this report for the City's strategy to collect and review data for input to the expanded SWMSoft system.

3.1.2. Data Gaps and Data Errors

Data gaps and potential errors in the data were identified in the existing storm sewer GIS database sources, a complete list of data gaps and the associated corrections / assumptions can be found in **Appendix B**. As documented in the **Appendix B**, missing manhole inverts, ground elevations, pipe diameter, pipe slope, and pipe length were consistently identified (e.g. zero diameter, zero length, etc.). Missing storm sewer segments and catchbasins were identified in most areas. Data gaps were addressed partially through additional data received from the City and through assumptions using engineering judgment.

A thorough review was also conducted to identify potential errors in the data by assessing extreme values such as very steep or very shallow pipe slopes, and pipe dimensions that did not appear to be consistent with adjoining pipes.

The development of the detailed hydrodynamic model includes the delineation of drainage areas to each pipe segment. Since the model includes individual pipe segments and manholes, data infilling was necessary to ensure the model is capable of predicting flood potential within each node (manhole) and pipe segment.

Major system data gaps, as discussed previously, include the apparent blockages in the surface DEM due to apparent 'damming' of the flow at crossings. The process of DEM conditioning is necessary to represent the overland flow path by accounting for and allowing the flow to cross the dams. The analysis of the hydraulic capacity through the crossings, and potential flooding of the road and structures upstream of these crossings requires an accurate representation of the culvert and associated inlet and outlet configurations. The re-conditioned overland flow route must also account for partial blockages due to existing buildings not directly accounted in the DEM.

The City should consider conducting a thorough QA/QC of their sewer infrastructure GIS data including missing pipe data and missing inlet data throughout the City by cross-referencing their existing GIS data with digital drawings and, more importantly, from on-going CCTV surveys work and air photography (for inlets). The regular CCTV surveys, typically conducted for infrastructure condition assessment, should be specified such that accurate invert elevations of connecting pipes and ground elevations are simultaneously collected at the manholes. Sewer segments with significant sags should be identified in the Drainage Management System Database for future operation and maintenance inspection, flushing and planning sewer system upgrades, particularly when these are located downstream of new development or redevelopment areas. As indicated previously, the City should also consider LIDaR survey from air or ground based stations that provide significant added accuracy to the surface survey data.

3.1.3. Stormwater Management Ponds

In addition to the existing drainage infrastructure, a review of the SWM facilities within the study area was conducted. The last comprehensive inventory of SWM facilities within the City was conducted in 2004. A total of 53 facilities were surveyed at that time of which 25 are dry ponds and 28 are wet ponds, hybrid ponds or wetlands. A System Wide Maintenance Software (SWMSoft) was designed to provide easy access to all the drawings, reports, pictures, inspections and maintenance information about each facility and component.

Currently, the database contains SWM facility information such as (name, type, function, location, etc.) as well as data referring to its functionality (drainage area, slope, drainage length, etc.). Each of the facilities is included in the SWMSoft database which is used for operation and maintenance purposes.

Since 2004, the City has continued to update the SWM facility database adding new SWM facility information as it becomes available. However; there are a number of SWM facilities which do not have the required information for hydrologic and hydraulic analysis, such as facility size and peak discharge rate. DEM data and using sink-fill analysis has been utilized to update the sizing information.

3.1.4. Field Inspection / Surveys

In addition to the culvert and bridge crossings that were identified as part of the City-wide field inspection survey, field data collection was required for Areas 1 through 6 and 8 to capture the information required for the development of the detailed Micro-Drainage Model upstream, within and downstream of the flood prone areas. Downstream conditions are necessary to assess potential backwater effects, while upstream conditions affect the flow contributions to the area.

There three (3) main components of the survey in Areas 1 through 6 and 8 included:

1) Confirm the type, location and size of storm sewer inlets located in public areas, primarily within the right of ways but also within parks and other publicly-accessed open spaces;
2) Inspection of the number of directly connected roof drains visible from public Right-Of-Ways. Directly connected roofs are a source of sewer inflow and are critical in assessing the existing drainage capacity; and,
3) Identifying the presence of reverse slope driveways. Identifying reverse slope driveways is critical in order to assess potential flood vulnerable areas.

Figure 3-3 shows the locations of directly connected roofs, **Figure 3-4** shows locations where there are reversed slope driveways.

3.1.5. Digital Elevation Model Data

High resolution DEM is important for developing major system drainage paths and evaluating surface and dual drainage performance. The DEM can be used for establishing preliminary direction of flows and for drainage area (catchment) delineation. In the absence of surveyed or as-built / design drawings, the DEM can be used to identify the surface elevation of manholes, measure surface storage, locate sags, define spill levels, etc. The source data provided by the City were in the format of ground elevation data points (mass points). The data was then used to create a high definition 1x1 m DEM raster image used for major system flow path analysis. As is described is **Section 3.1.7**, further DEM refinement or “conditioning” was done in order to account for flow breaches.

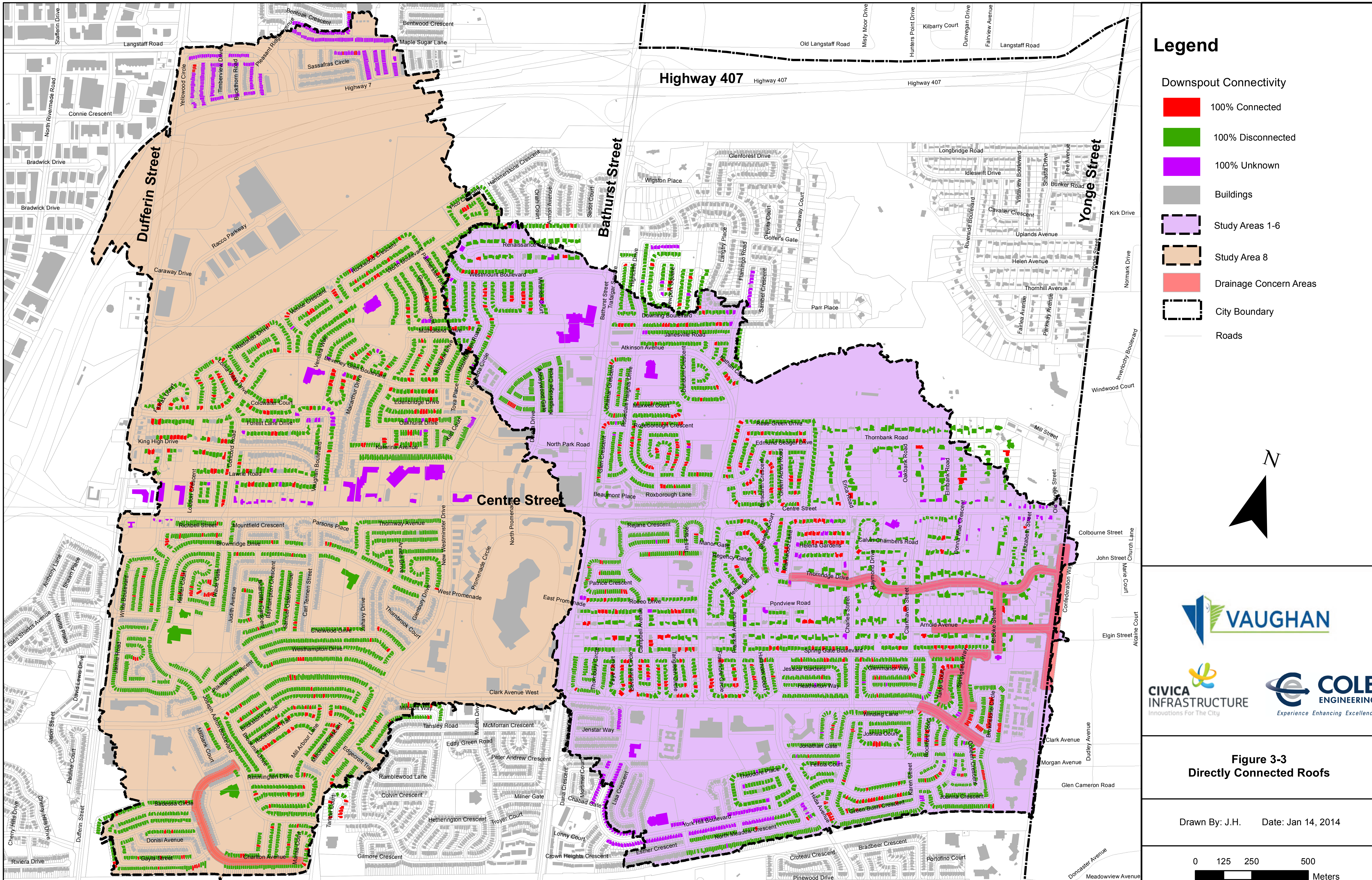
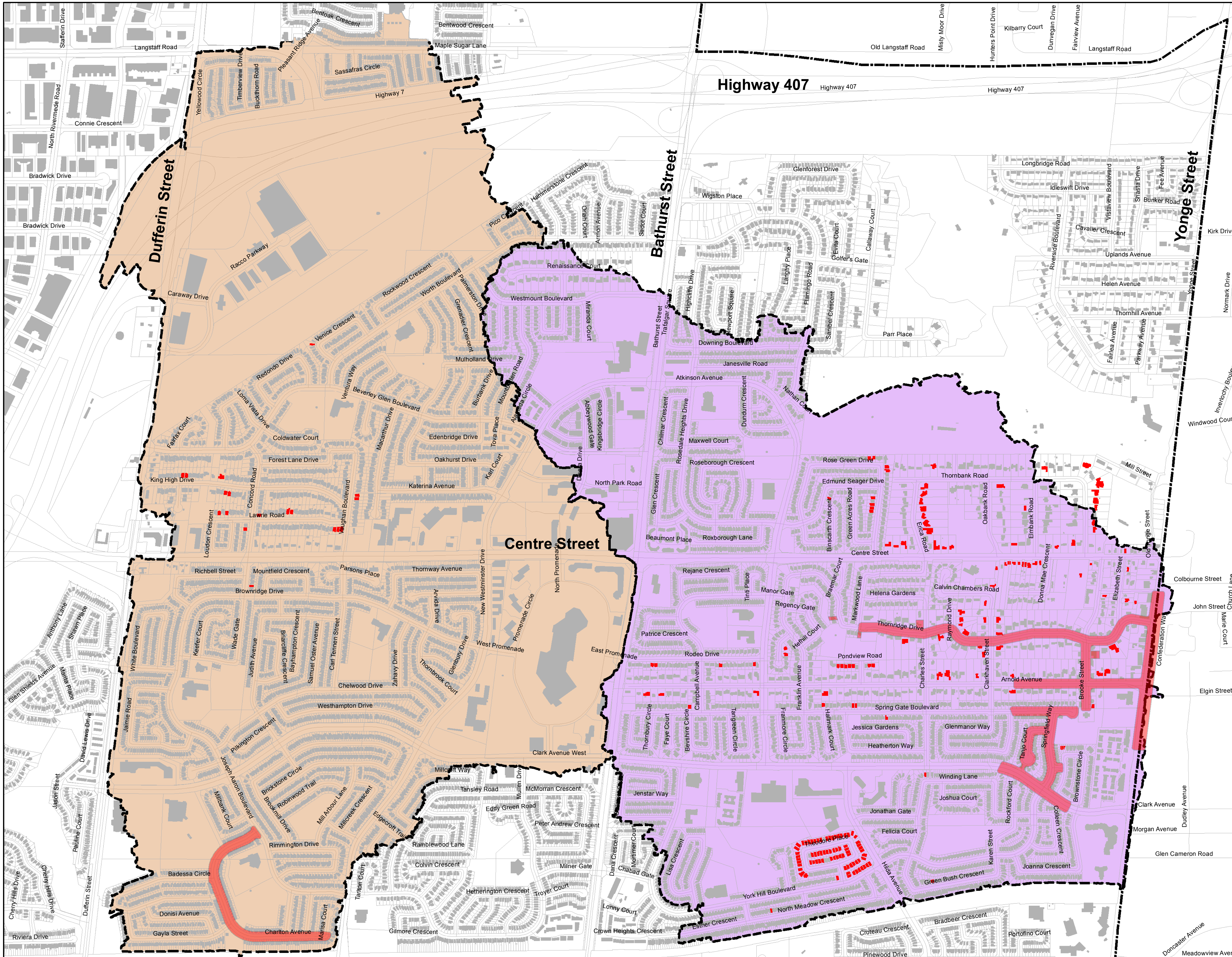


Figure 3-3
Directly Connected Roofs

Drawn By: J.H. Date: Jan 14, 2014



Legend

- Buildings with Reversed Slope Driveway
- Buildings
- Study Areas 1-6
- Study Area 8
- Drainage Concern Areas
- City Boundary
- Parcels
- Roads

N

VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 3-4
Reverse Sloped Driveway

Drawn By: J.H. Date: Jan 14, 2014

0 125 250 500 Meters

3.1.6. Building Layer

The Phase II work included development of a building envelope layer for all the buildings in the City (as of 2007). This was necessary, among other reasons, because the existing "unconditioned" surface model (DEM) is used to generate the overland flow path and in some instances, the flow path generated crosses existing building or structures and must be corrected. The flow path must be re-generated so that all overland flow occurs at the lowest point in "open" spaces between buildings. Contrary to the approach to remove culverts and bridges as blockages or breaches in the system, buildings should be added as obstructions so that the flow path does not go through these structures but rather through open spaces between or around structures.

The City had provided the regional aerial photography from 2007 and 2009. Upon review, it was decided that, because of higher resolution, the 2007 air photo would be used to create the building layer. Using this image, impervious areas represented primarily by rooftops were delineated throughout the City. Using the building layer the DEM was conditioned so that the buildings were now considered as blockages preventing the overland flow path from passing through buildings. **Figure 3-5** shows the building layer created.

It is recommended that the City consider expanding the building layer to include new development and re-development since 2007 using high resolution air photography as it becomes available.

3.1.7. DEM Conditioning

The DEM is source information used in the development of overland flow route. The DEM is a good indicator of the direction of major overland flow path and is useful in delineating drainage areas. The Phase I Drainage Study stated that a detailed major system flow path analysis would be required to condition the DEM such that the analysis would account for "breaches" or "blockages" in the system. Breaches included road crossings such as bridges and culverts as well as building envelopes. The process of adjusting the DEM to account for the breaches and improving the hydrologic and hydraulic functionality is known as "conditioning". This process modifies the DEM so that the overland flow path passes through culverts, bridges, and road overpasses and around buildings in standard surface elevation analysis.

Breaches in the system were accounted for through the City-wide and area specific field investigations that were conducted as well as the development of a building / roof layer. The information was used to condition the existing DEM, such that an accurate overland flow path was produced. **Figure 3-6** shows the reconditioned DEM.

Legend

- Buildings (79627)
- Study Areas 1-6
- Study Area 8
- Drainage Concern Areas
- City Boundary
- Roads

VAUGHAN

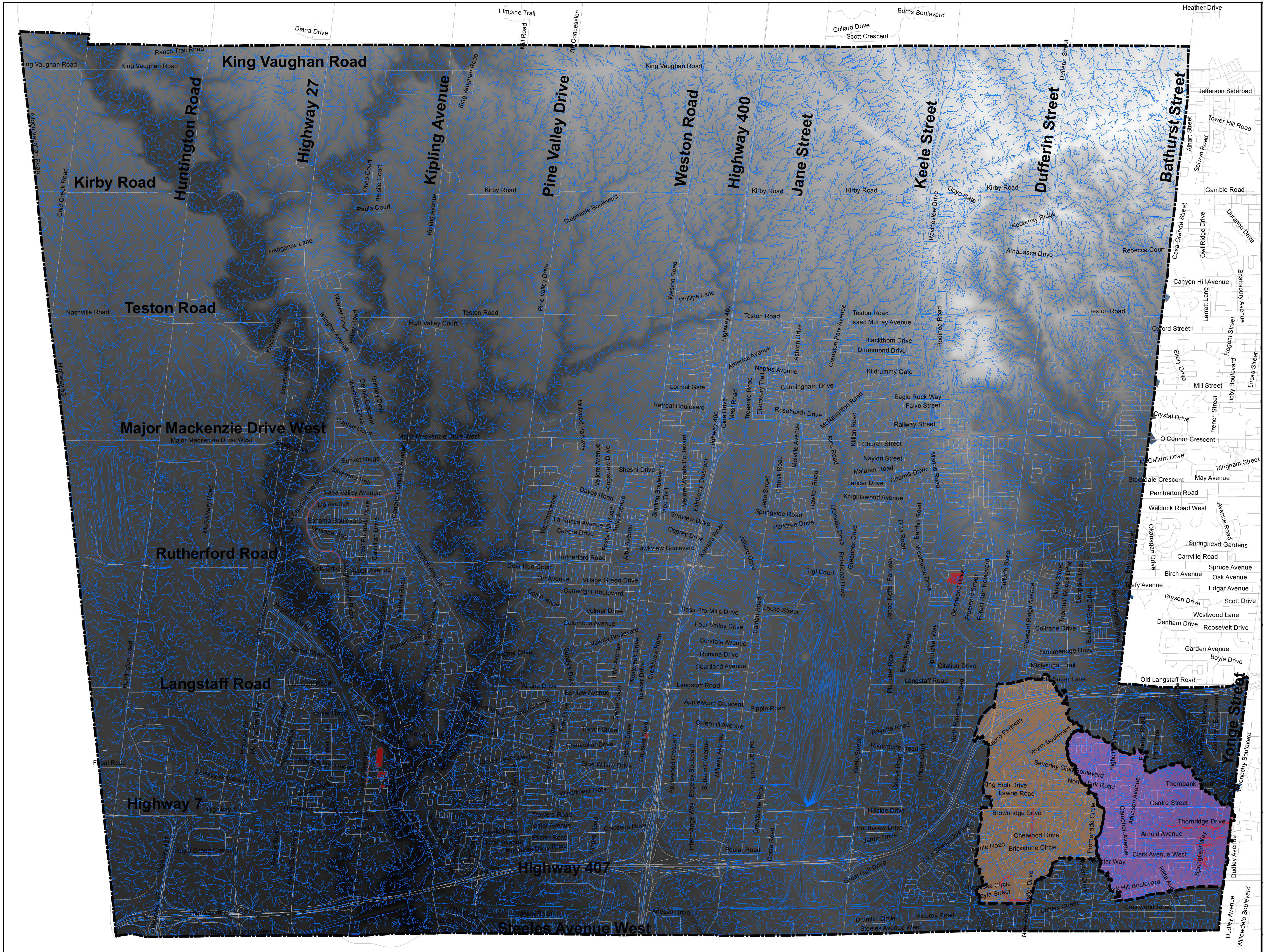
CIVICA INFRASTRUCTURE — Innovations For The City

COLE ENGINEERING — Experience Enhancing Excellence

Figure 3-5
Roof Layer of Buildings

Drawn By: J.H. Date: July 30, 2013

0 750 1,500 3,000 Meters



Legend

- Study Areas 1-6
- Study Area 8
- Drainage Concern Areas
- City Boundary
- Reconditioned Overland Flow Path
- Roads

VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 3-6
Reconditioned DEM

Drawn By: J.H. Date: July 30, 2013

0 750 1,500 3,000 Meters

4.0 Development of Data Standards for Submissions

As a part of the asset management plan for the City's SWM infrastructure, standards should be established for data produced and submitted by engineering consultants for new development areas. Developing data standards for submissions by consultants for new development applications will be important for future cost-effective management of the City's infrastructure assets. The City currently has data standards for SWM facility submissions. Using the existing template for SWM facility submission standards, the standards were expanded to include SWM drainage infrastructure such as culverts, bridges and other road crossings. **Appendix C** shows the template for data standards for SWM infrastructure submissions developed as part of this study.

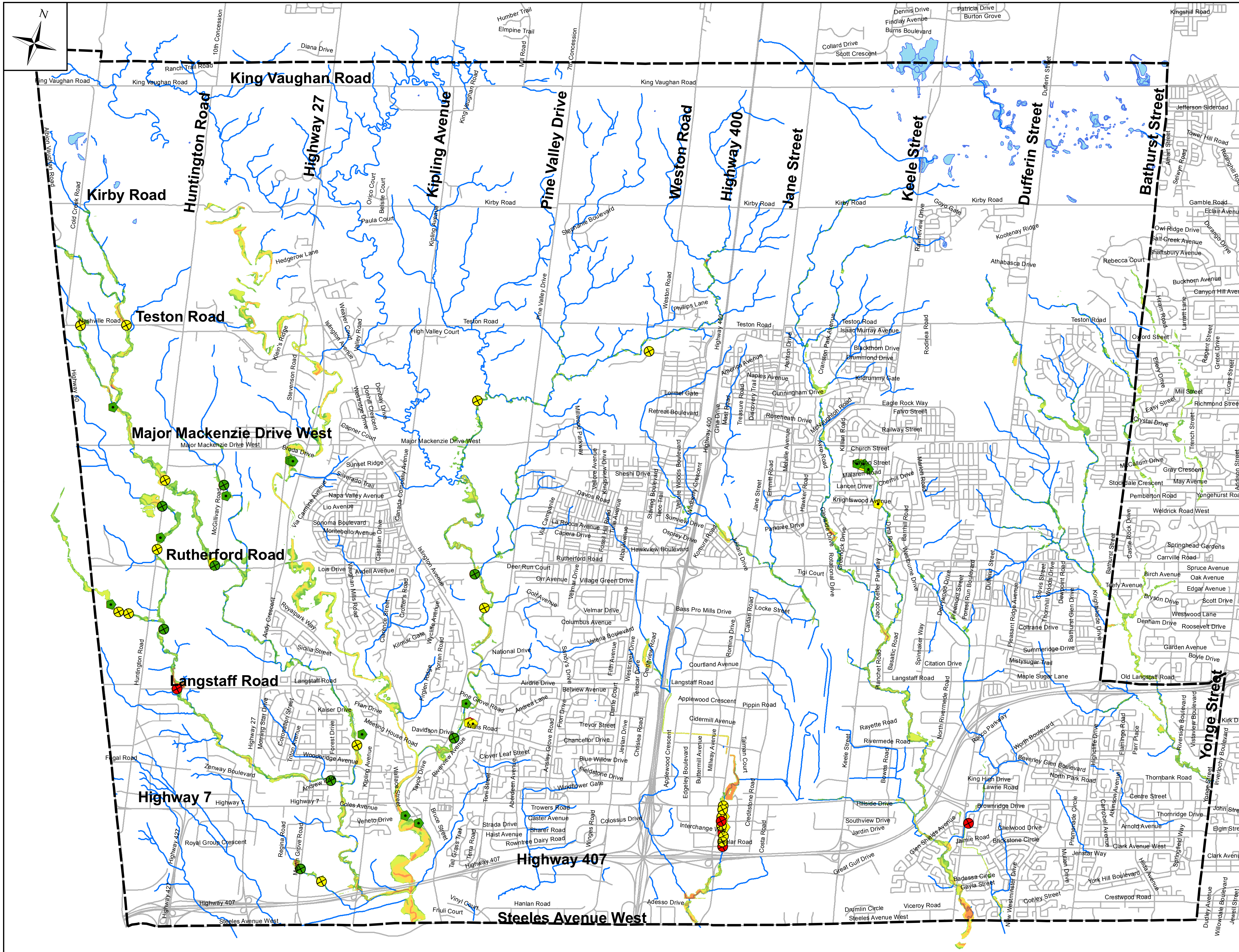
5.0 Flood Emergency Response Planning Refinements

The Phase I Drainage Study identified potential flood vulnerable sites and roads crossings affected by flooding along rivers and tributaries with the City under various design storms. A Flood Emergency Response Index (FERI) was developed which provided a flood classification system, based on a ranking of the highest priority sites. The FERI uses depth of flooding, type of building and land use such as residential, school, institutional, utilities (e.g. key municipal pumping stations for water and wastewater drainage, electrical utilities, etc.), commercial / industrial, parking lots, parks, and other uses to classify flood sites.

The initial river system base map from the Phase I Drainage Study had been prepared from lot fabric obtained from the City and hydraulic models from the TRCA. A thematic map had been developed by analyzing the computed water surface elevations at each of the hydraulic model cross section locations for each return period storm. In the absence of a building boundary GIS layer, property information (residential, commercial, and institutional) within the floodplain was used with the FERI to prioritize the severity of flooding. The maps also identify road crossings (bridges and culverts) susceptible to overtopping under the various return period events. Flood depths are identified for each overtopping location.

The building layer (building envelope) which was created to condition the DEM was used to update the FERP / FERI for the City. Previously, the flooding depth or water surface elevation had been associated with the lowest point on a particular parcel of land and not necessarily the building or structure associated with that particular parcel of land. With the inclusion of the building envelopes, flood depths / water surface elevations are now assessed at the building as opposed to the lowest point on a particular parcel where there may be a high flood depth.

Figure 5-1 through **Figure 5-5** show the updated FERP mapping based on the newly created building layer. The updated FERI tables associated with flood vulnerable properties can be found in **Appendix D**.



Legend

Vaughan Boundary

10 Year Event FERI for Flood Vulnerable Road (FVR)

- FERI < 50
- 50 < FERI < 75
- 75 < FERI < 100

10 Year Event FERI for Flood Vulnerable Area (FVA)

- FERI < 50
- 50 < FERI < 75
- 75 < FERI < 100

10 Year Event Flood Depth

- < 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1m - 2m
- 2m - 4m
- > 4m

Rivers

Lakes

VAUGHAN

CIVICA INFRASTRUCTURE Innovations For The City

COLE ENGINEERING Experience Enhancing Excellence

Figure 5-1: FERP 10-Year

Drawn By: J.H. Date: Aug 1, 2013

0 750 1,500 3,000 Meters

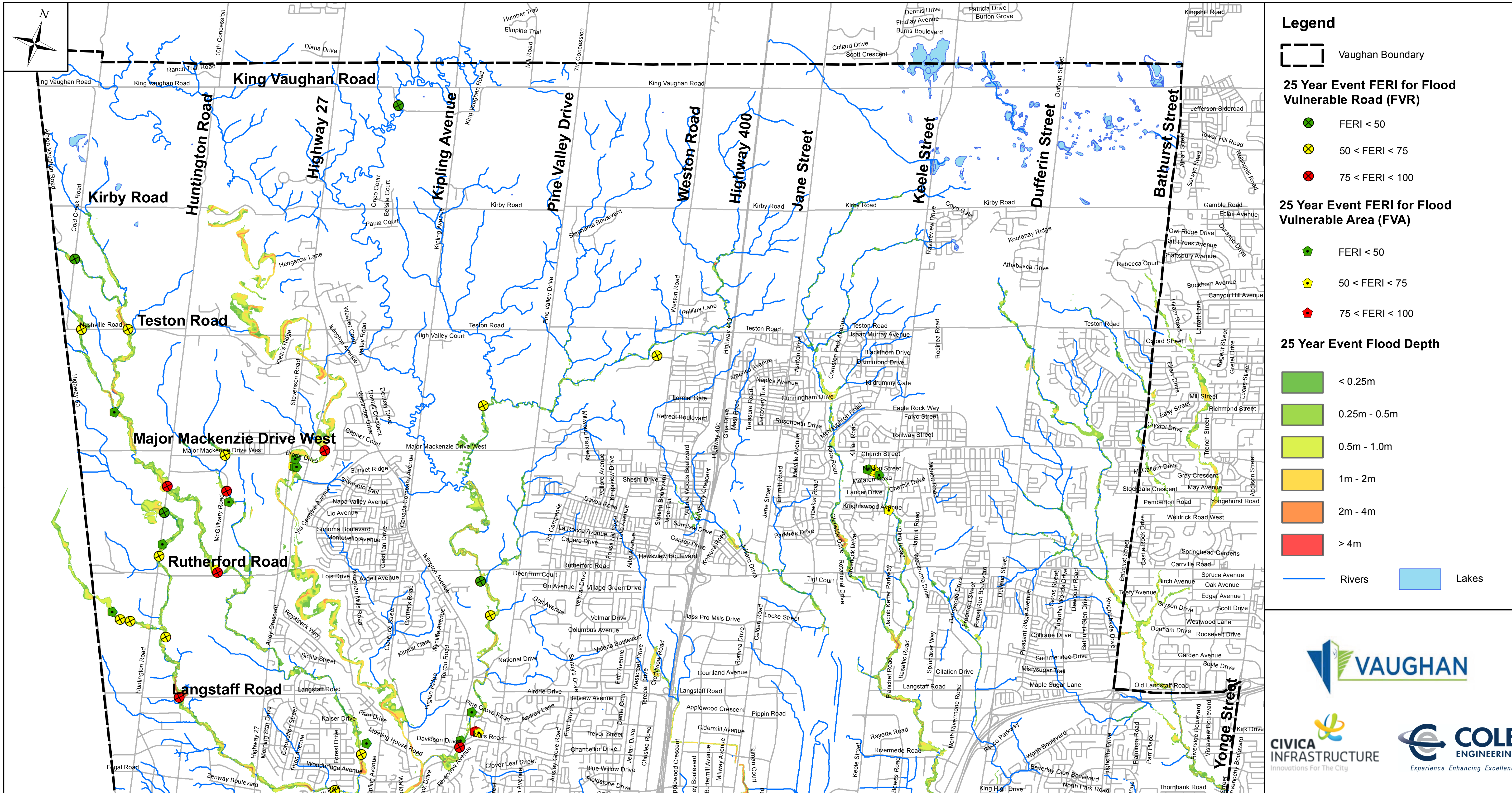
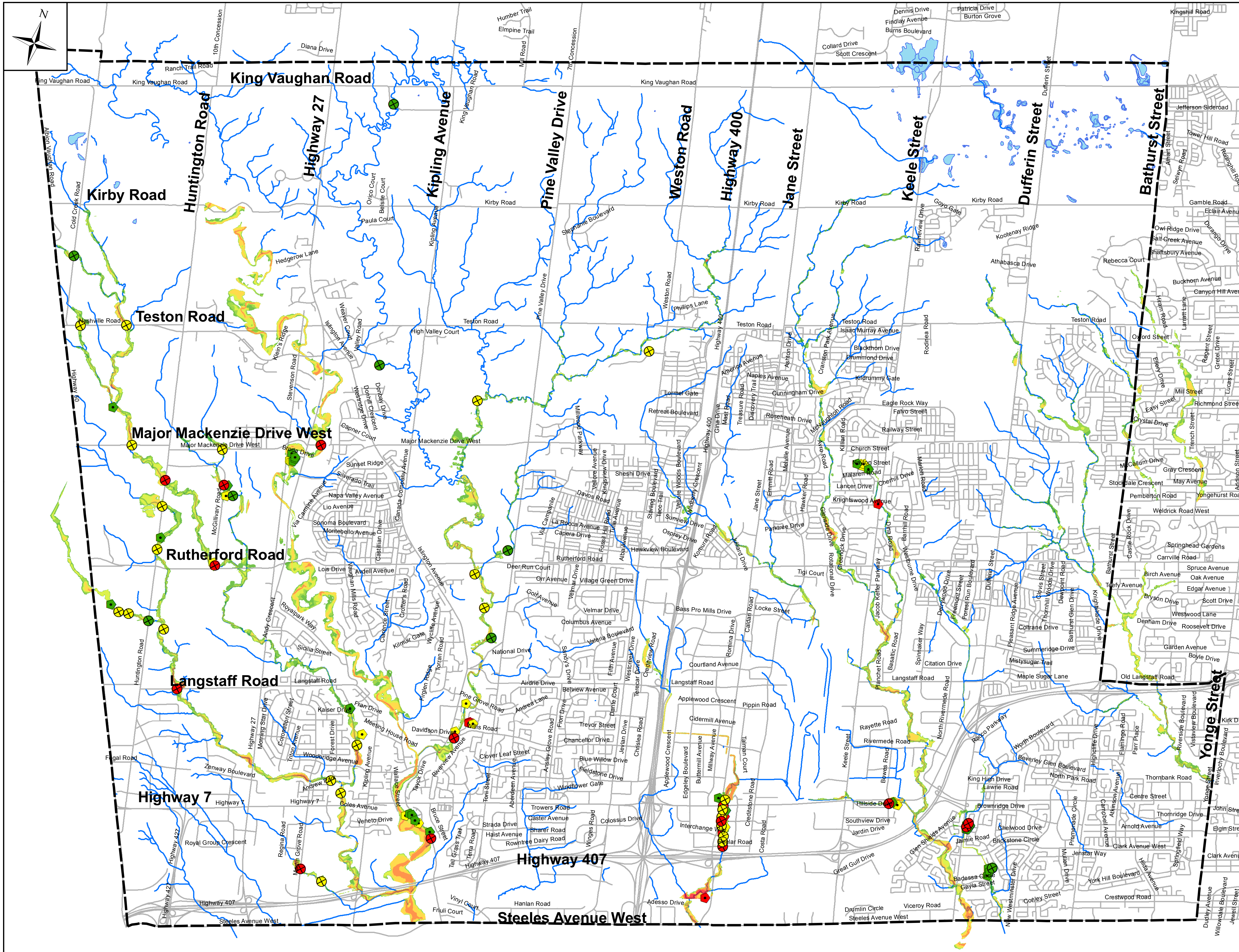


Figure 5-2: FERP 25 Year

Drawn By: J.H. Date: Aug 1, 2013



Legend

Vaughan Boundary

50 Year Event FERI for Flood Vulnerable Road (FVR)

- FERI < 50
- 50 < FERI < 75
- 75 < FERI < 100

50 Year Event FERI for Flood Vulnerable Area (FVA)

- FERI < 50
- 50 < FERI < 75
- 75 < FERI < 100

50 Year Event Flood Depth

- < 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1m - 2m
- 2m - 4m
- > 4m

Rivers

Lakes

VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 5-3: FERP 50 Year

Drawn By: J.H. Date: Aug 1, 2013

0 750 1,500 3,000
Meters

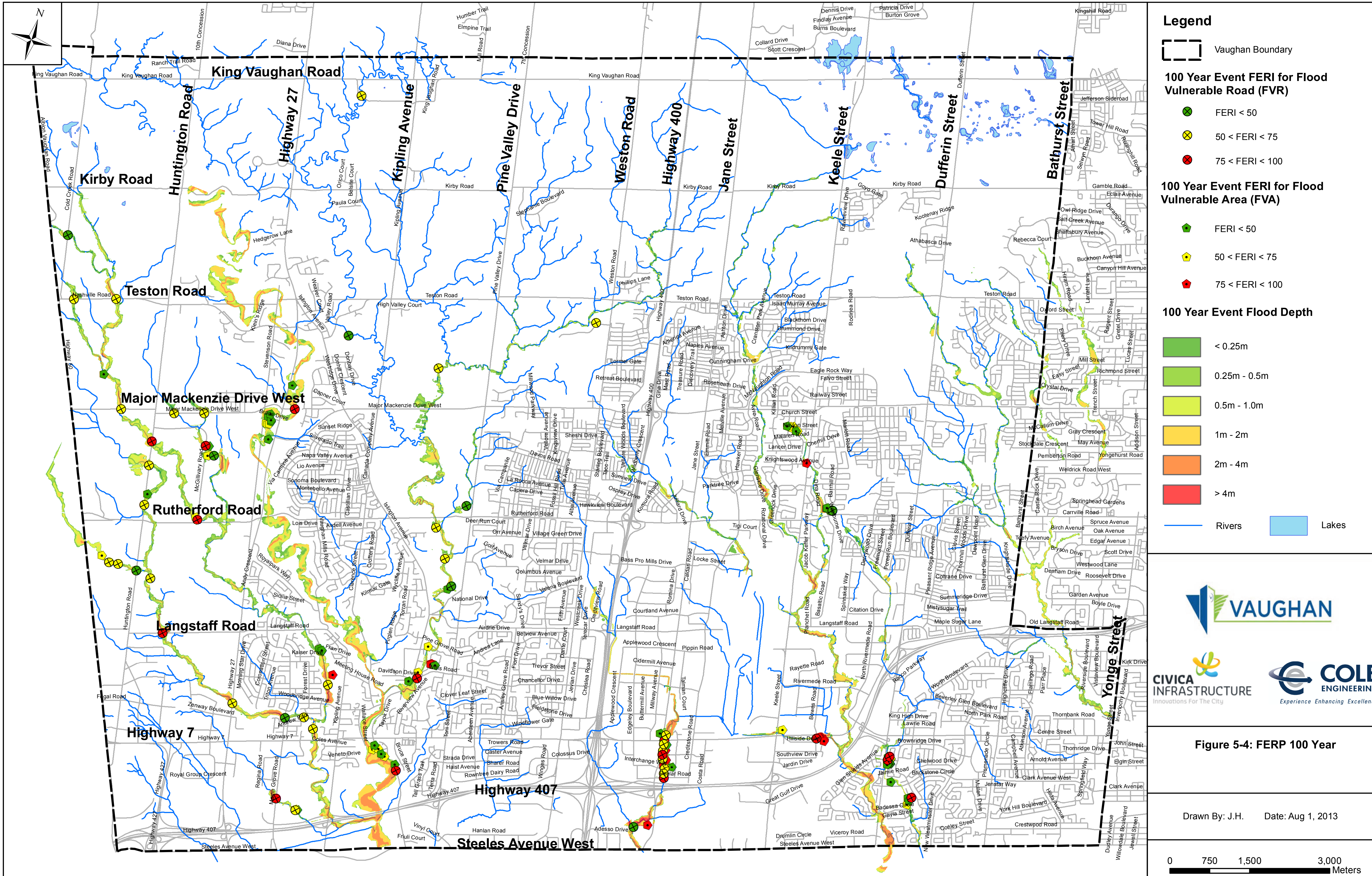


Figure 5-4: FERP 100 Year

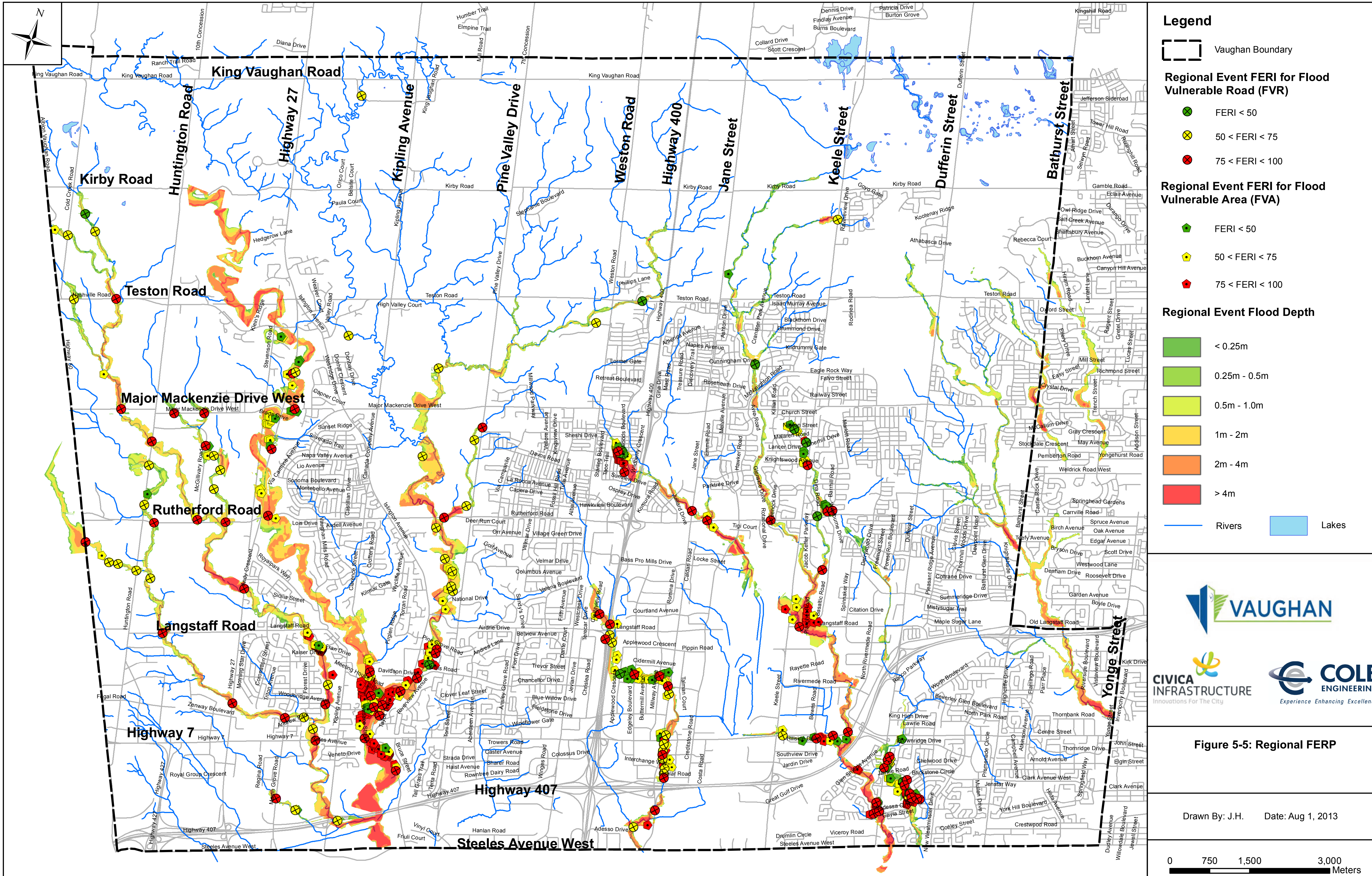


Figure 5-5: Regional FERP

6.0 Flow and Rainfall Monitoring

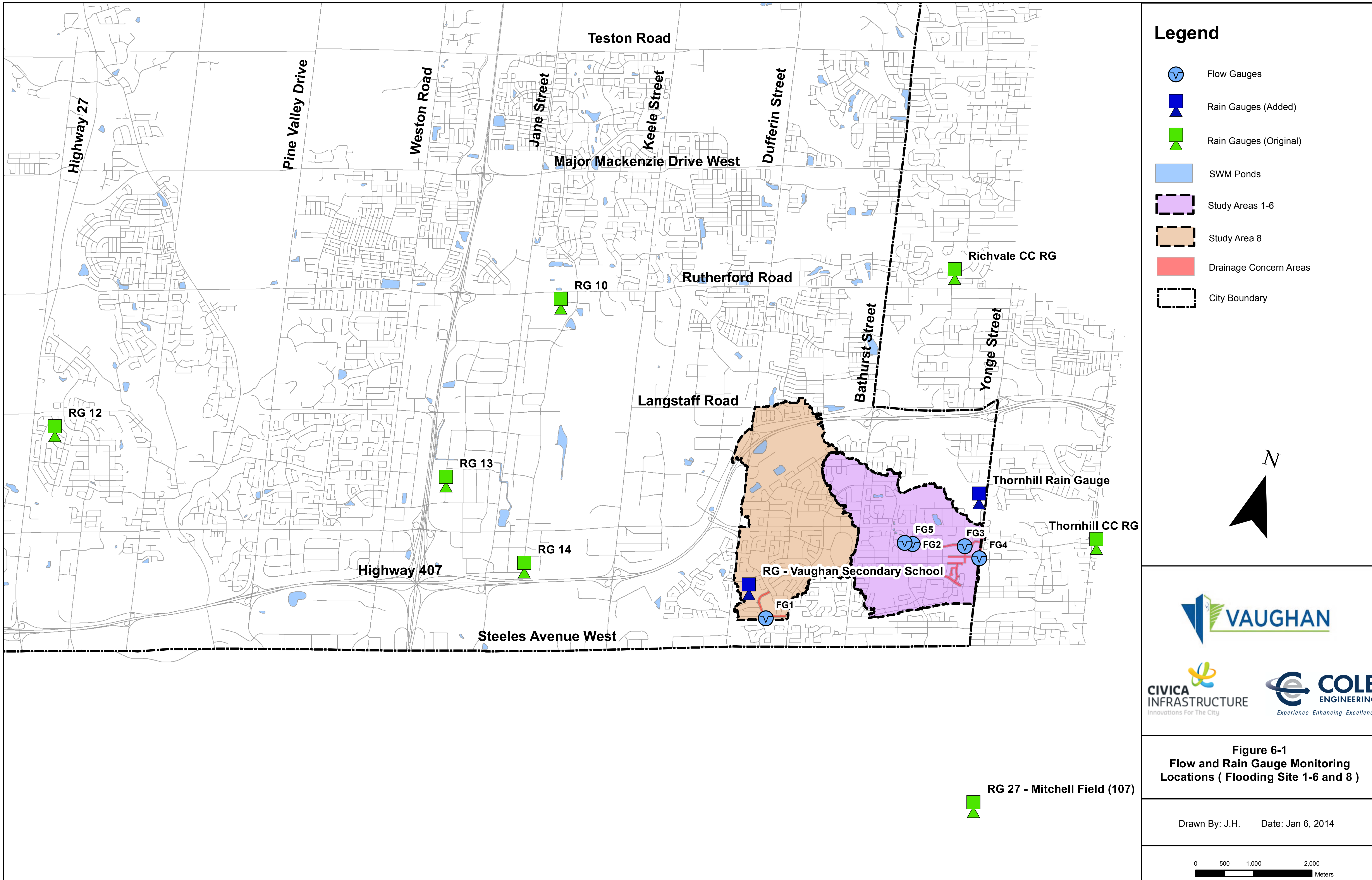
This Phase II Study involved the collection of precipitation and flow data from July 2011 to February 2012. The results of this study are detailed in the monitoring report prepared by Cole Engineering Group Ltd (Cole Engineering) in June 2013, a copy of this report is located in **Appendix E**. The data was used to quantify the rainfall-runoff response in five (5) sub-catchment areas encompassing all seven (7) flood susceptible areas. Rainfall and sewer flow monitoring is used to calibrate the model. Two (2) tipping bucket rain gauges and five (5) flow monitoring stations were installed as part of this study. Rainfall and flow monitoring locations are illustrated on **Figure 6-1**. **Table 6.1** below summarizes the drainage characteristics upstream of the stations. In all cases, area velocity meters with independent level sensors were used to capture flows as accurately as possible. As previously stated, the data was analyzed and used for calibrating the model to reduce the uncertainties of rainfall-runoff response.

Table 6.1 – Flow Monitoring Station Drainage Area Characteristics

Flow Gauge	General Location	Incremental Upstream Area (ha)	Imperviousness (%)	Roof Connectivity (%)	Reverse Sloped Driveways (%)	Average Slope (%)
FG1	Gayla Street / Charlton Avenue	557	71	5.7	0.4	1.7
FG2	Markwood Lane / Thornridge Drive	162	56	10.1	0.4	1.5
FG3	Thornridge Drive / Brooke Street	194	59	7.2	4.7	1.5
FG4	Arnold Avenue / Yonge Street	190	60	7.0	5.0	1.3
FG5	Hefhill Court / Franklin Avenue	152	61	10.0	0.3	1.6

6.1. Precipitation Data

The rainfall monitoring program coincides with the flow monitoring program from July 2011 to February 2012. Two (2) of the nine (9) rain gauges that were analyzed were specifically installed for the purposes of this study. The remaining six (6) rain gauges were installed by Cole Engineering as part of another study that is currently being undertaken. As these seven (7) gauges are located in the vicinity of the study area, the data from these devices were used in the analysis to complement the two (2) devices installed specifically for this study. Refer to **Figure 6-1** for the locations of the Rain gauges. A total of six (6) events were used in the rainfall analysis, a summary of these events is provided in **Table 6.2**



VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 6-1
Flow and Rain Gauge Monitoring Locations (Flooding Site 1-6 and 8)

Drawn By: J.H. Date: Jan 6, 2014

Table 6.2 – Rainfall Analysis

Event Date	Rainfall Volume (mm) and Peak Intensity (Brackets)																	
	Vaughan Secondary School RG		Mitchell RG		Richvale CC RG		Thornhill CC RG		Thornhill RG		RG10		RG12		RG13		RG14	
09/23/11	34	30	33	24	32	21	31	27	33	27	31	39	17	18	31	27	33	54
09/29/11	22	18	25	21	13	12	14	12	16	12	11	12	9	12	15	12	14	12
10/12/11	20	9	28	9	13	6	17	9	17	6	14	6	11	6	13	6	15	6
10/19/11	34	15	34	9	27	9	37	15	34	15	33	15	45	24	23	15	40	18
10/25/11	26	6	NA	NA	23	6	27	9	26	6	27	6	24	6	23	12	26	6
11/29/11	57	15	NA	NA	52	12	62	15	59	12	56	21	55	12	58	24	54	24

*Notes: NA denotes a Rain Gauges which was not operating during a specific event

Note that the rain volume data which is included shows the rainfall variability between stations. Rainfall variability is important when analysing the differences between the measured and modelled flow. Rainfall variability has been addressed through the distributed rainfall modelling technique (DRMT), which interpolates the rainfall into to each catchment used in the model from the rainfall measured at nearby stations.

6.2. Flow Data

The objective of the storm sewer flow monitoring program was to collect wet-weather flow to calibrate the Micro-Drainage Model. Below in **Table 6.3** summarizes the measured peak flow during six (6) key storm events at each of the stations used to calibrate the model.

Table 6.3 – Measured Peak Flows

Flow Gauge	Upstream Area (ha)	Imperviousness (%)	Storm Events Peak Flow (m3/s)					
			09/23/11	09/29/11	10/12/11	10/19/11	10/25/11	11/29/11
1	557	71	1.035	0.597	0.212	0.443	0.276	0.499
2	162	56	0.205	0.103	0.032	0.115	0.053	0.139
3	194	59	1.792	0.977	0.587	1.284	0.759	1.336
4	190	60	0.133	0.087	0.034	0.107	0.045	0.066
5	152	61	0.040	0.011	0.004	0.017	0.010	0.021

7.0 Model Development and Calibration

As discussed in **Section 3.0**, the existing drainage system was analyzed using a Micro-Drainage Modelling approach to establish the cause of flooding at Sites 1 through 6 and 8 and to identify remediation alternatives. The sites were presented in **Figure 3-1** and **Figure 3-2**.

The drainage assessment included data collection, analysis of the sewer system data, correcting existing data gaps, field assessments, flow monitoring, and the setup of the Micro-Drainage Model. This section describes the model development and calibration.

7.1. Model Development

Civica's VH SWMM modelling tool was used to create a detailed hydrodynamic Micro-Drainage Model of the storm drainage system. **Figure 7-1** and **Figure 7-2** shows the catchment areas and internal drainage boundaries used in the model. Both major and minor drainage system were evaluated in detail. Each catch basin connecting the surface drainage with the sewer system was analyzed and individual capture curves derived to connect the surface flow to the sewer system. SWM facilities were also coded in the model (e.g. Franklin Avenue Pond) to assess spill levels and effectiveness for attenuating peak flows. Please refer to **Appendix F** for the detailed physical system model data.

7.2. Model Calibration

Civica's VH SWMM model parameters were calculated and estimated as follows:

- Sub-Catchment Width:
  - Width = Area / length
  - Length = square root of (Area / 1.5)
  - Area = delineated from DEM;

- Sub-Catchment Slope was calculated using the DEM;
- Imperviousness was calculated from the roof, road, parking Lot, driveway, and sidewalk layers, and assumes 40% of the roof area, according to a sample area test;
- Impervious depression storage = 1.5 mm;
- Pervious depression storage = 5 mm; and,
- CN was calculated using the land use and soil layers.

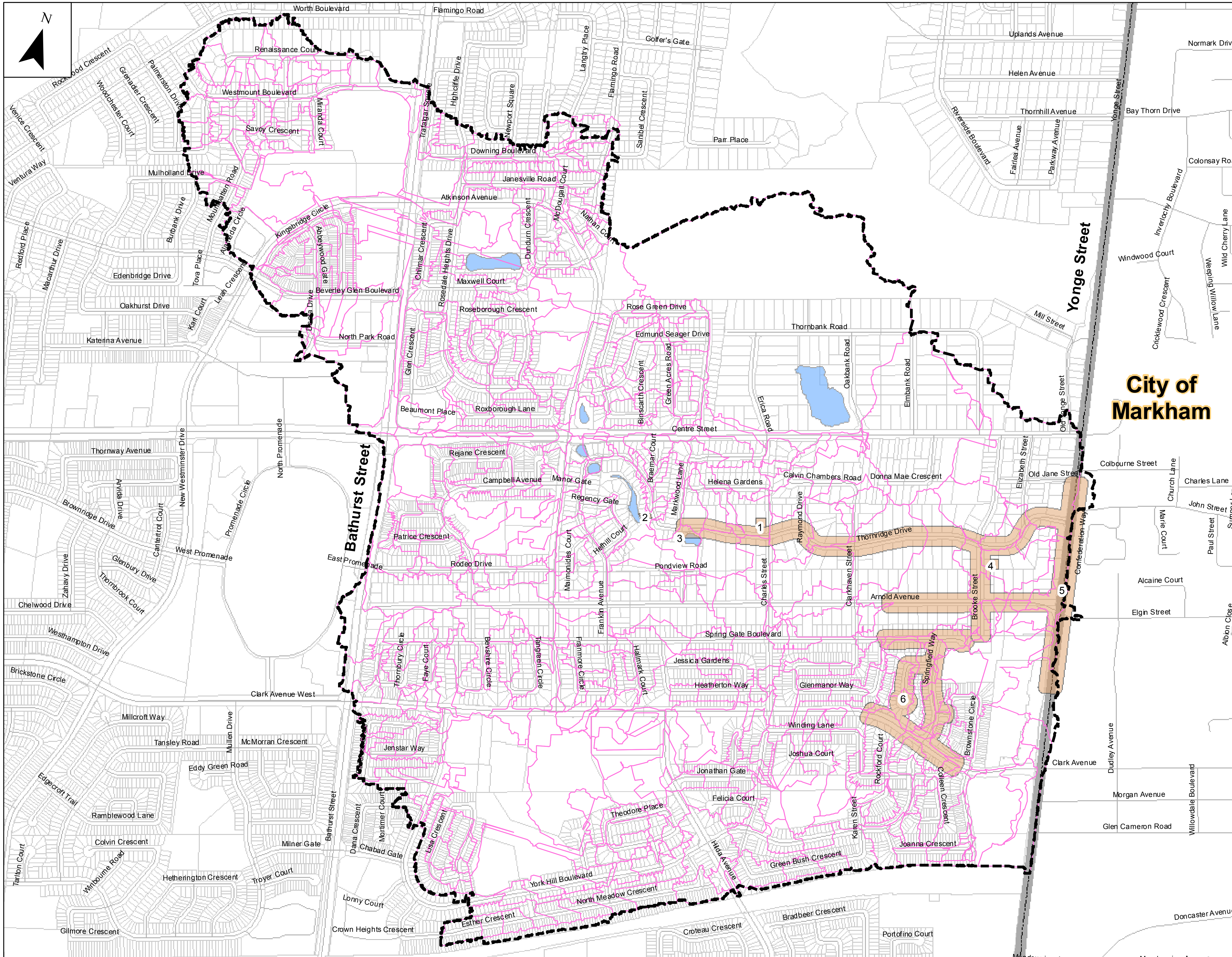
These calculated and estimated parameters were found to be accurate, and so the parameters were not adjusted in model calibration.

Hydrographs were generated for the six (6) largest rain events in each of the flow monitoring stations and the model results were compared to the measured hydrographs. The monitored rain and flow data used for this analysis is presented in **Section 6.0**. **Figure 7-3** to **Figure 7-7** illustrates the modeled and monitored results for these events (November 23, 2011).

As presented in **Appendix G**, the difference between measured and model hydrographs can vary significantly. In this case, depending on the event and the monitoring location, peak flow variability ranges from 60% to 282%.

This variability can be attributed to a combination of rainfall coverage plus debris accumulation at the monitoring station. Future recommendations include using rain gauge densities no greater than 1 per 200 hectares or ground-corrected radar images (combination of rain gauges and Doppler radar data) in conjunction with self-cleaning flow measuring flumes.

In most cases, the model values exceed the measured flow values after 'calibrating' the projected flooding to match the scope of the observed flooding during the August 19, 2005 storm event.



Legend

- Catchments
- Flooding Sites 1-6 Study Area Boundary
- Drainage Concern Areas
- Existing Ponds
- Parcels
- Municipality Boundary

VAUGHAN

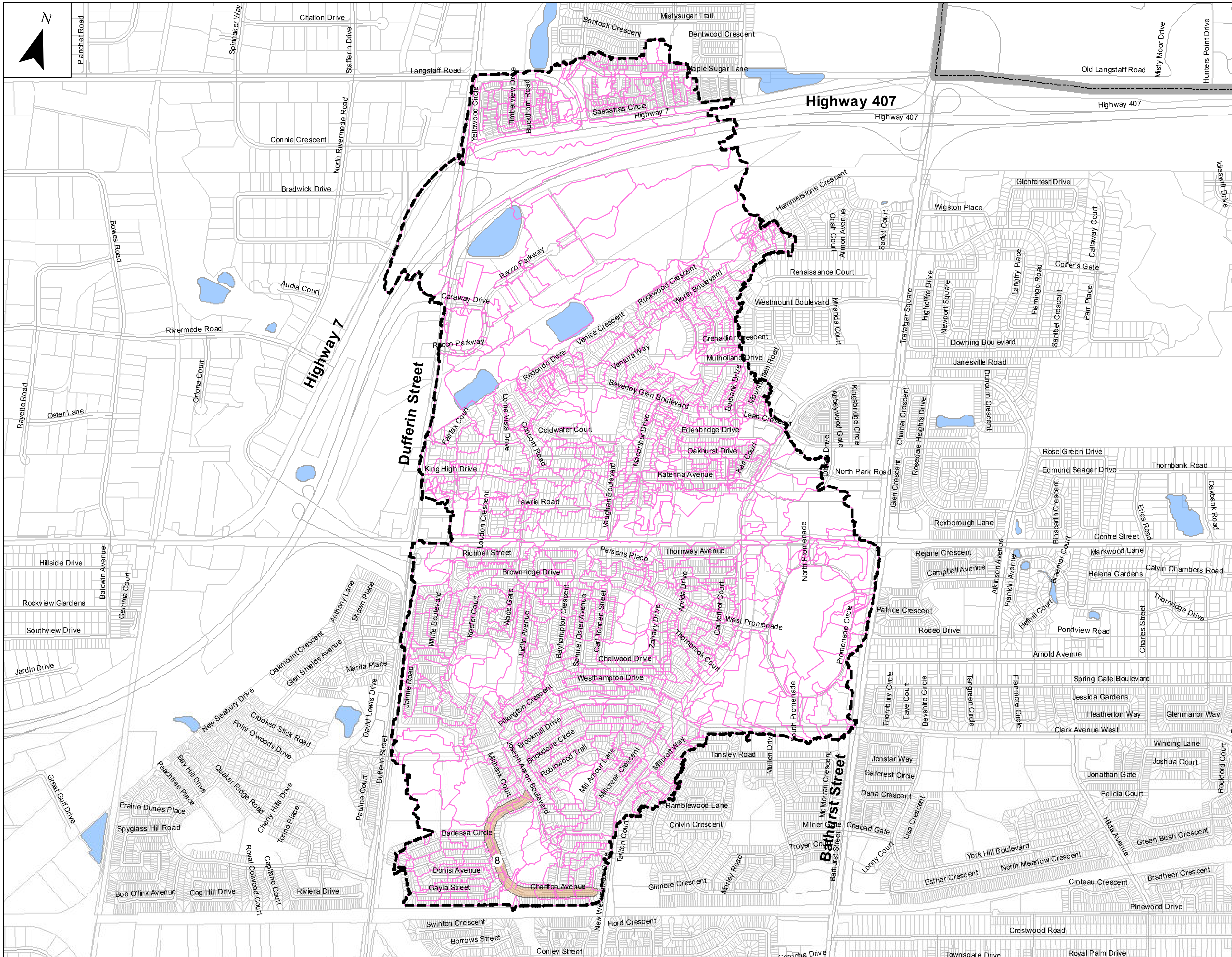
CIVICA INFRASTRUCTURE — Innovations For The City

COLE ENGINEERING — Experience Enhancing Excellence

Figure 7-1
Detailed Catchment Discretisation - Areas 1-6

Drawn By: J.H. Date: Oct 18, 2013

0 125 250 500 Meters



Legend

- Catchments
- Flooding Sites 8 Study Area Boundary
- Drainage Concern Areas
- Existing Ponds
- Parcels
- Municipality Boundary

VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 7-2
Detailed Catchment Discretisation - Area 8

Drawn By: J.H. Date: Oct 18, 2013

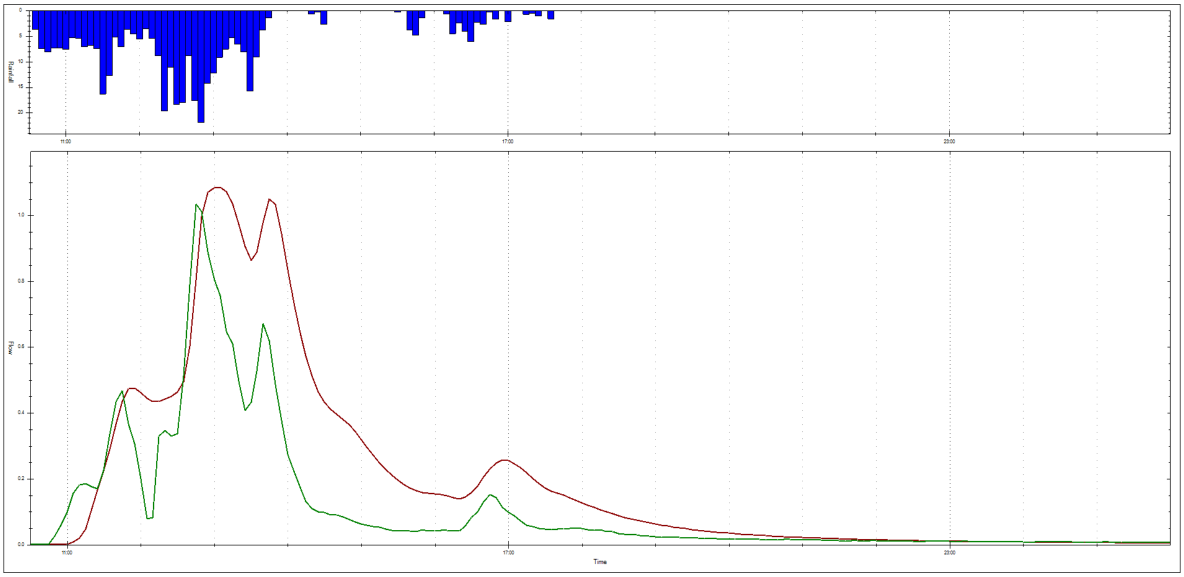


Figure 7-3 Flow Gauge 1 – Calibration Results – Nov 23, 2011 Storm Event

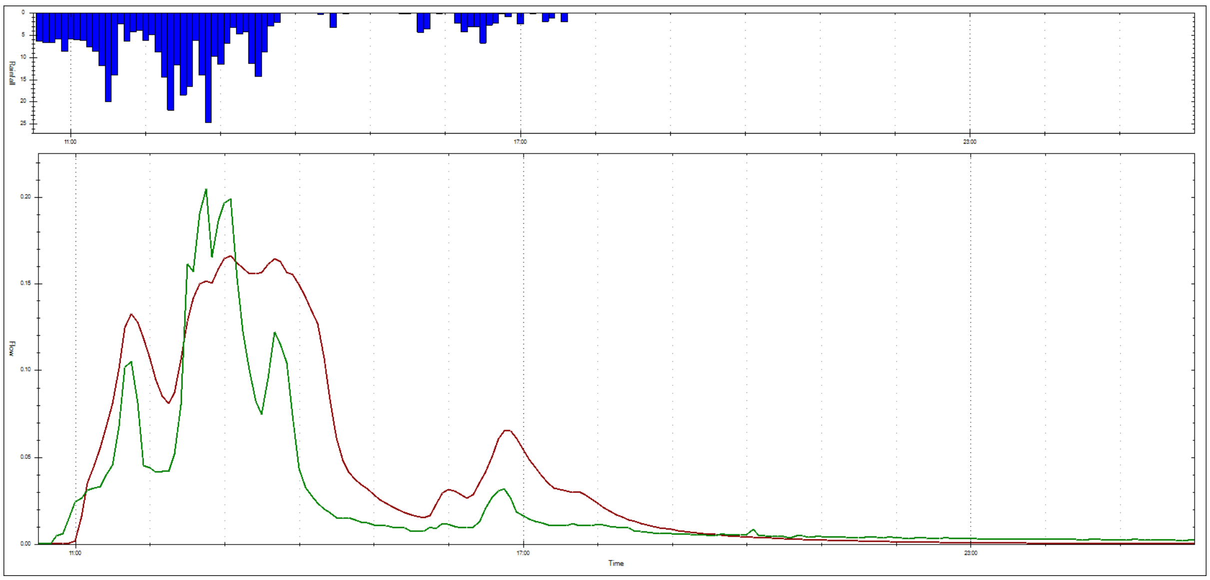


Figure 7-4 Flow Gauge 2 – Calibration Results – Nov 23, 2011 Storm Event

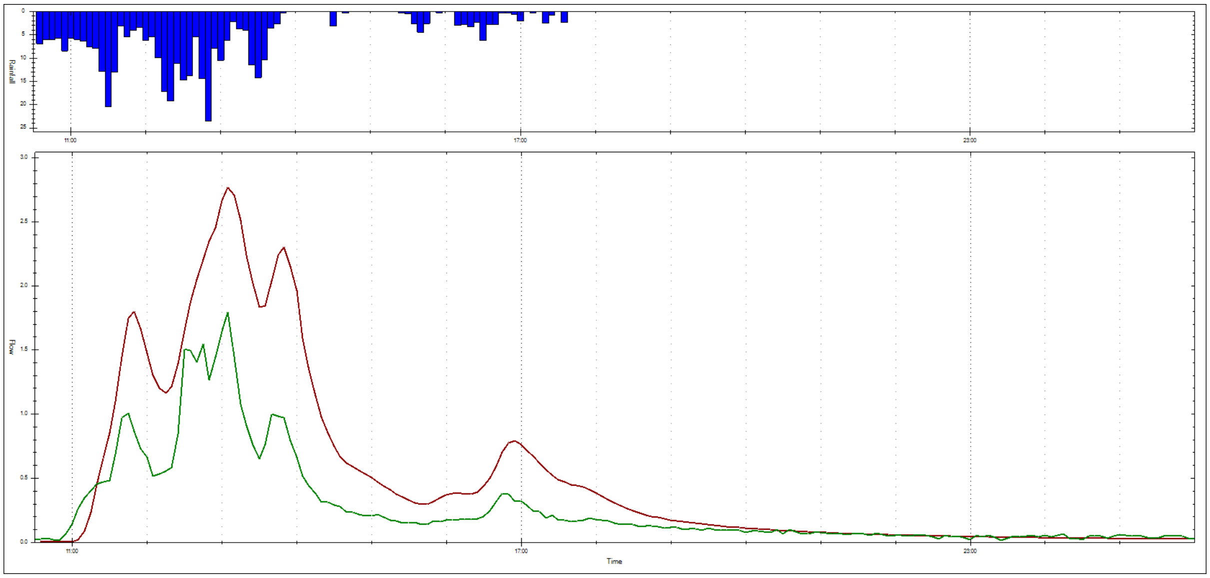


Figure 7-5 Flow Gauge 3 – Calibration Results – Nov 23, 2011 Storm Event

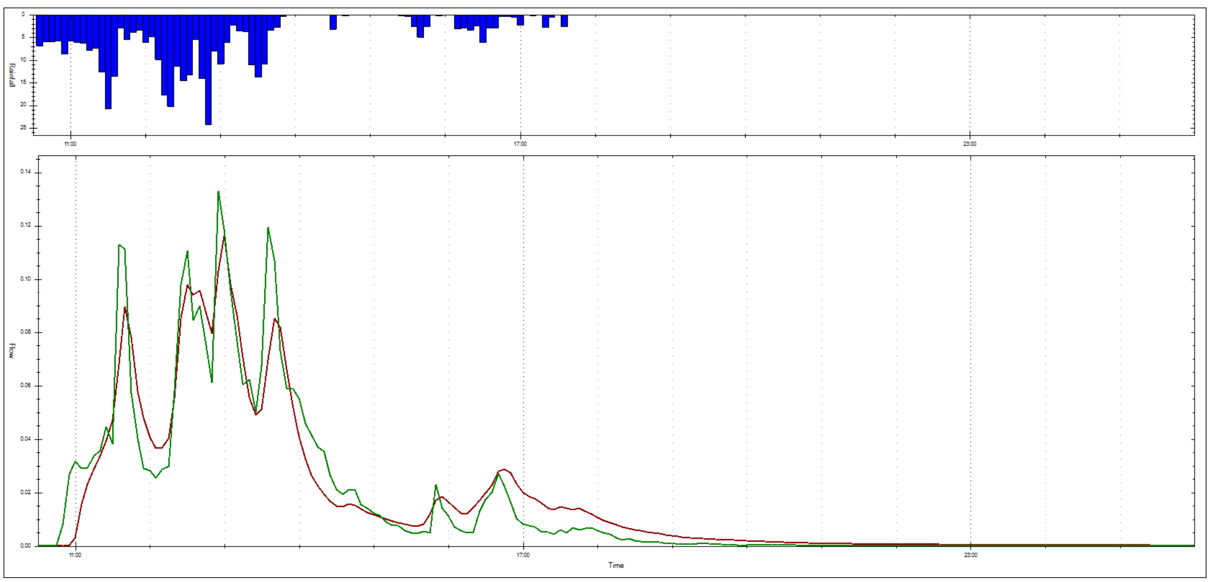


Figure 7-6 Flow Gauge 4 – Calibration Results – Nov 23, 2011 Storm Event

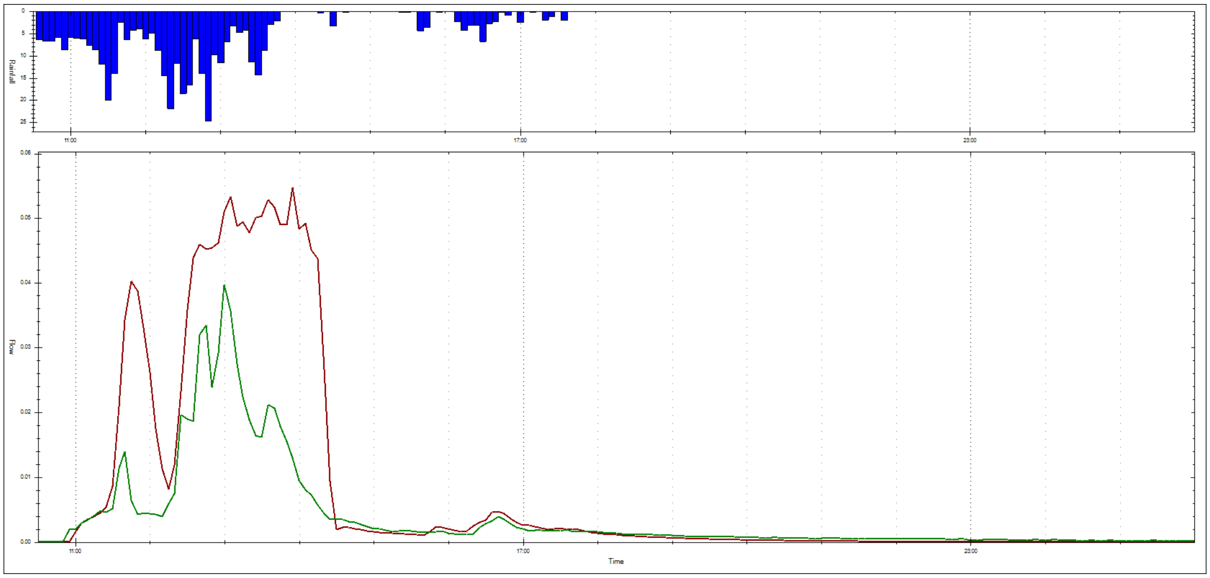


Figure 7-7 Flow Gauge 5 – Calibration Results – Nov 23, 2011 Storm Event

8.0 Existing Storm Drainage Flood Analysis

Preliminary assessment of 20 known flooding sites, which identified by the City after the August 19, 2005 storm event, showed that a detailed drainage analysis was required to assess the level of flood protection and upgrades required to bring these to acceptable levels. Of these 20 sites seven (7) of these sites were identified and prioritized by the City for the Phase II Study. These seven (7) sites where analyzed with a detailed Micro-Drainage Model for the area. The seven (7) sites are identified on **Figure 8-1**. As shown, the sites are located in two (2) drainage watershed locations. These watersheds total 1255 ha and include 9055 properties.

8.1. Prioritised Sites

8.1.1. Area 1: 122 Thornridge Drive

As shown in **Figure 8-2**, this site is located on the northwest corner of Charles Street and Thornridge Drive. The initial site visit, during the Phase I Study in 2008, revealed that the property was under re-development including lot regrading. A review of the topography around the property shows that the site receives surface sheet flow from adjacent lands to the northwest. Because of the changes in grading during re-development, it is believed that the original house could have flooded in 2005 due to poor local grading. Surface runoff may have reached the side of the house and enter through cracks in the foundation, window wells or other low-lying openings. Another possible cause of the flooding during the August 19th event may have been high water levels in adjacent local ditches along Thornridge Avenue.

8.1.2. Area 2: 275 Franklin Avenue

The property at 275 Franklin Avenue is located on the west side of the road. Please refer to **Figure 8-3** for an illustration of the drainage features near the site. Franklin Avenue slopes down south towards a low point located at the bend just north of Hefhill Park, south of the property. There is an in-line dry SWM pond (Franklin Avenue Pond) located behind the properties fronting the west side of Franklin Avenue.

Runoff enters the Franklin Avenue Pond from the adjacent lands as well as from a large sewer at the south end of the pond. The outflow from the pond discharges into the Franklin Avenue storm sewer through an inlet connected to a 1200 mm sewer segment. Under larger events (greater than 25 year storms), the pond overflows eastward through 275 Franklin Avenue and the adjacent lots and continues eastward along Franklin Avenue before entering a dry pond (Pondview Road Pond) located north east of Hefhill Park.

Design drawings also show that the overland flow from Hefhill Court is captured by oversized runoff intakes at the northeast entrance to Hefhill Park. The captured runoff is conveyed via the 1200 mm diameter storm sewer into the south end of the pond.

The pond outlet consists of a 200 mm diameter storm sewer, which increases to a 300 mm storm sewer. In periods of high flows, drainage can also be discharged overland towards the existing dry pond in Hefhill Park. The majority of the pond drainage discharges to a 750 mm diameter concrete storm sewer located underneath the existing sidewalk. The 750 mm diameter storm sewer travels eastwards towards the existing pond located in Hefhill Park.

A CCTV inspection from 2009 shows that there was an obstruction in the 200 mm diameter orifice from the pond. A similar obstruction may have contributed to the flooding during the August 2005 event. It is recommended that all inlets to the pond be retrofitted with grates, so that blockages and other obstructions can be prevented, thus allowing the pond to function as designed. The hydraulic details of this area specifically relating to the functioning of the Franklin Avenue Pond is not captured in the City's existing GIS database, therefore; it is recommended that the City's GIS database be updated to accurately represent the hydraulic details of the drainage system prior to detail design.

8.1.3. Area 3: 311 Franklin Avenue

As shown in **Figure 8-4** this property is located on the south east corner of Markwood Lane and Franklin Avenue and has a reverse sloped driveway. Markwood Lane slopes noticeably from north to south and Franklin Avenue slopes from west to east. The major system overland flow, which converges in front of 311 Franklin Avenue, should continue eastward towards Pondview Pond, which is located in Hefhill Park. The sewers underneath Franklin Avenue and Markwood Lane also converge near 311 Franklin Avenue and discharge into the creek east of Pondview Pond through an existing 950 mm storm sewer. Two (2) sets of double inlet catchbasins located at the intersection of Franklin Avenue and Markwood Lane capture overland flow and convey the drainage via a 600 mm diameter concrete storm sewer which outlets at the south end of the Pondview Pond.

Flooding was reported is 2005 due to insufficient capacity in the overland flow path and was exacerbated by the reverse sloped driveway.

8.1.4. Area 4: 109 Brooke Street

As shown in **Figure 8-5**, the site is located on the east side of Brooke Street, south of Thornridge Drive. Backyard flooding was reported on August 19, 2005. Brooke Street slopes down from north to south. The property is significantly lower than adjacent properties, at the opposite side of Brooke Street. Analysis of the DEM and overland flow path shows the drainage watercourse crossing Brooke Street, north of Arnold Avenue. Flooding is attributed to both major and minor system capacity constraints, poorly defined overland drainage routes, sewer backups, and ponding in the low lying areas.

8.1.5. Area 5: Brooke Street to Yonge Street and Thornridge Drive

As shown in **Figure 8-6**, the site is located:

- Along Brooke Street from Thornridge Drive to east Spring Gate Boulevard;
- Along Yonge Street from Old Jane Street to just south of Gallanough Park;
- Along Thornridge Drive from Markwood Lane to Yonge Street, and;
- Along Arnold Avenue from Yonge Street to slightly east of Clarkhaven Street.

The City has received several flooding reports in this area. Analysis of the DEM and overland flow path in the area shows that there is significant flow conveyed through the area. As this area is relatively old, major and minor drainage capacities in the area seem to be below current standards. It is known that ditches, culverts and inlets are susceptible to blockages.

8.1.6. Area 6: Tanjo Court and Springfield Way

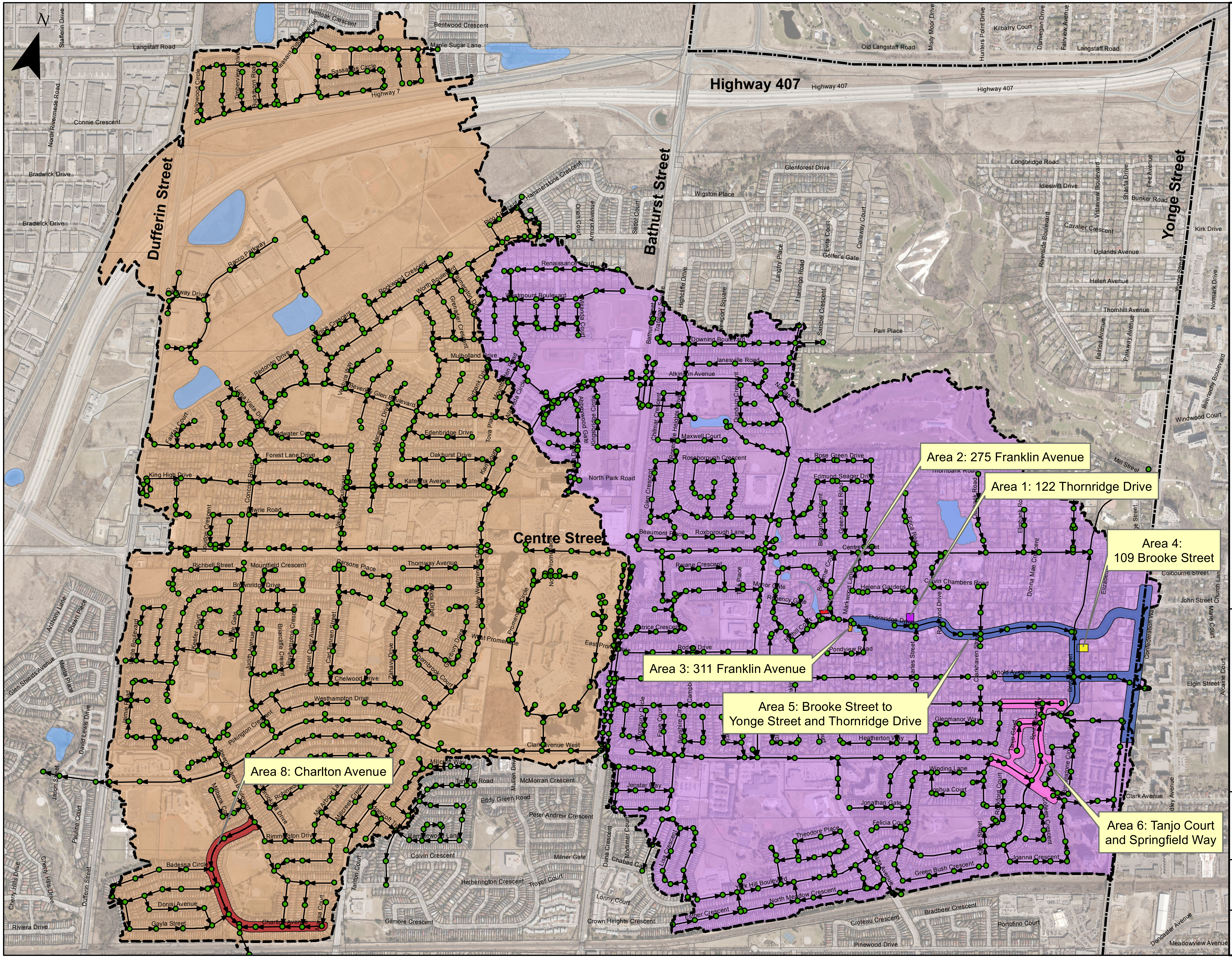
As shown in **Figure 8-7**, this site is located:

- Along Spring Gate Boulevard from Glenmanor Way to Brooke Street;
- Along Springfield Way from Spring Gate Boulevard to Clark Avenue West;
- Along Clark Avenue West from Winding Land to midway along Brownstone Circle, and;
- All of Tanjo Court.

Flooding has been reported on the road around catchbasins and at the road sag. Similar to Area 5, analysis of the DEM and overland flow path in the area shows that there are significant flows conveyed through this area. Surface and sewer drainage capacities in the area are below current standards. It is known that ditches, culverts and inlets are susceptible to blockages. It is also likely that catch basins are partially blocked with leaves and debris. Insufficient sewer capacity results in flow accumulating around catch basins in sag areas.

8.1.7. Area 8: Charlton Avenue

The Charlton Avenue flood site receives flow from a large (557 ha) upstream drainage area, as shown on **Figure 8-8**. The flood site is believed to start from the southwest side of Joseph-Aaron Boulevard and ends at the south of Marisa Court. A significant engineered channel conveys flows from south of Centre Street into this area. This channel flows south between the school and other properties fronting Millbank Court and crosses Charlton Avenue through twin 3 X 1.8 m box culverts. During larger events, due to limited channel and culvert capacity, overtopping occurs at the crossing. The properties backing onto the channel will also be subject to flooding. Moreover, the channel receives local surface runoff from lands to both the east and west. Topographic analysis of the area shows there is significant potential for ponding depending on the culvert intake conditions on the north side of the railroad tracks. Capacity within the downstream system may also cause backups in the area.



Legend

- Storm Manholes
- Storm Sewers
- SWM Ponds
- Study Areas 1-6
- Study Area 8
- Parcels
- City Boundary
- Roads

Flooding Areas:

- 1
- 2
- 3
- 4
- 5
- 6
- 8

VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-1
Flooding Areas (7 Sites)

Drawn By: J.H. Date: July 30, 2013

0 125 250 500 Meters

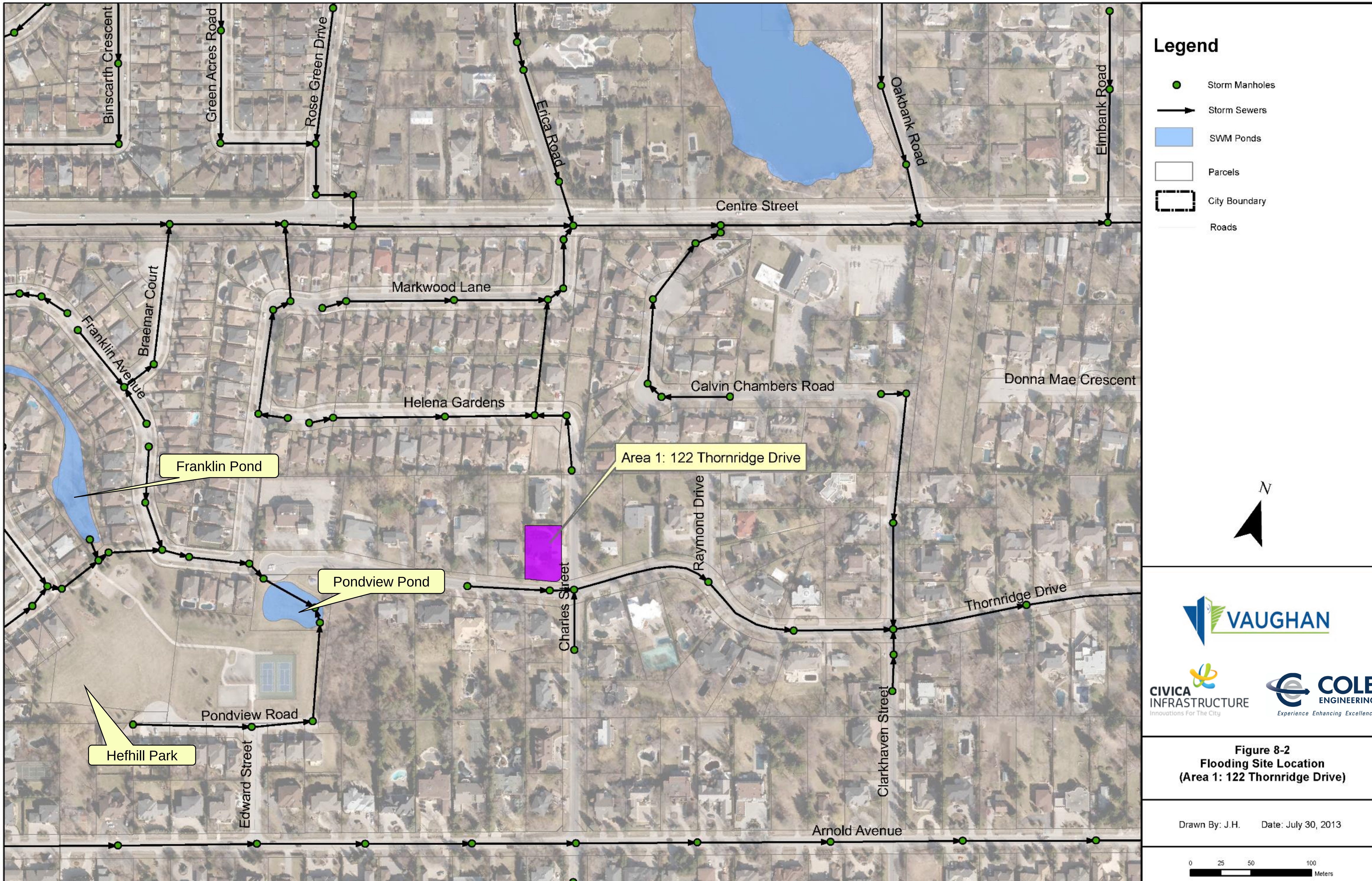


Figure 8-2
Flooding Site Location
(Area 1: 122 Thornridge Drive)

Drawn By: J.H. Date: July 30, 2013

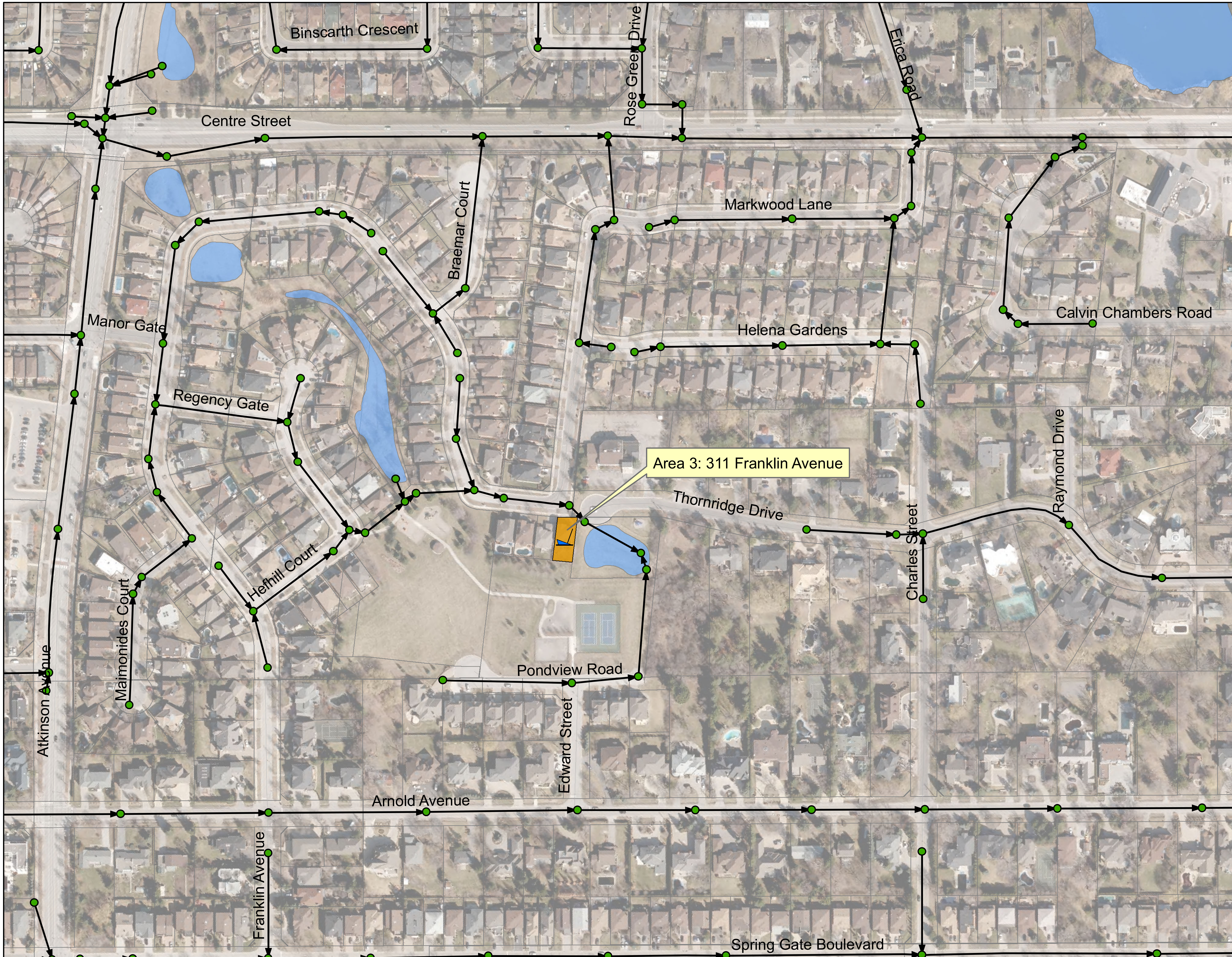
VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-3
Flooding Site Location
(Area 2: 275 Franklin Avenue)

Drawn By: J.H. Date: July 30, 2013



Legend

- Storm Manholes
- Storm Sewers
- Reversed Slope Driveway
- SWM Ponds
- Parcels
- City Boundary
- Roads

VAUGHAN

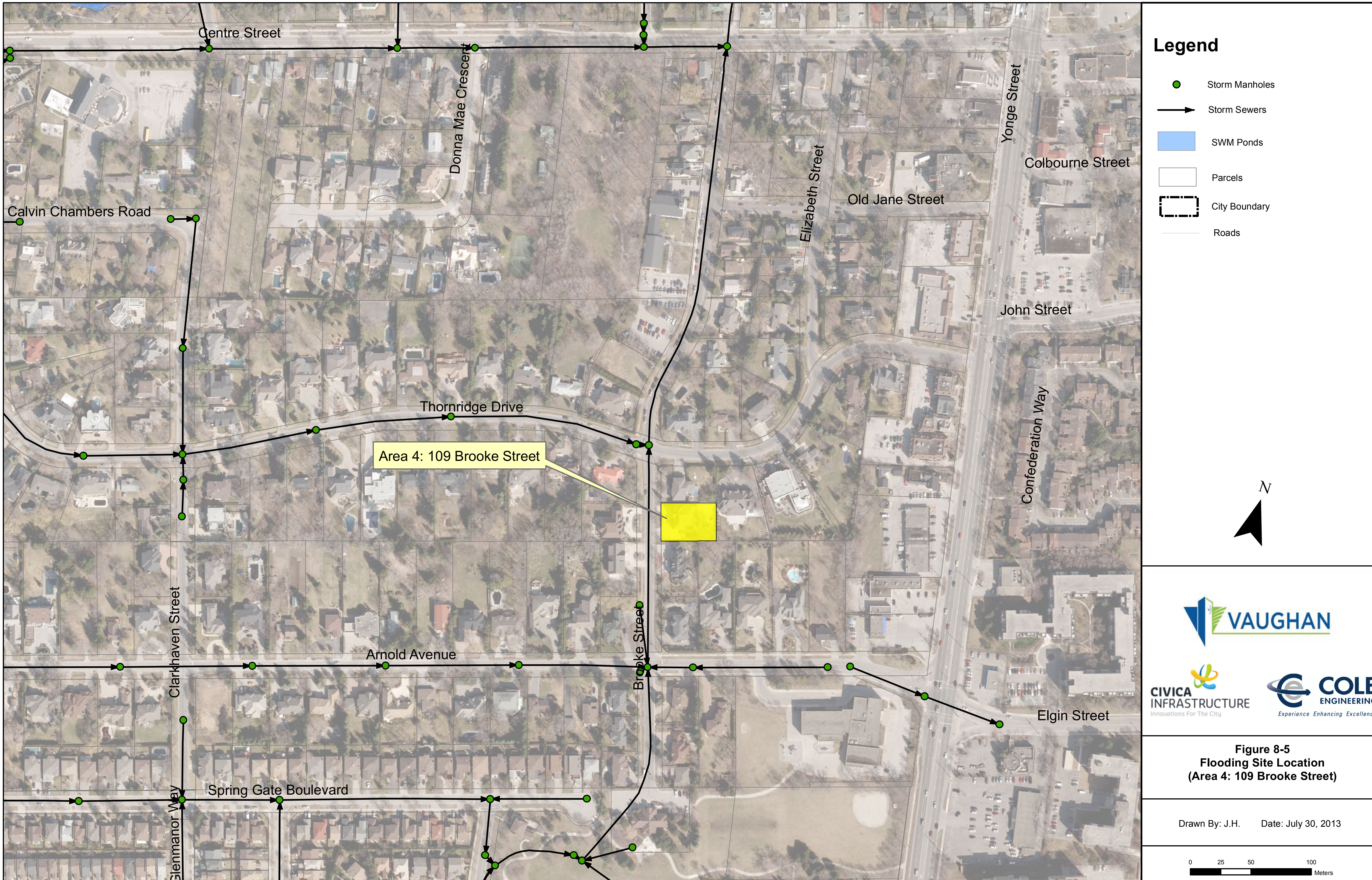
CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-4
Flooding Site Location
(Area 3: 311 Franklin Avenue)

Drawn By: J.H. Date: July 30, 2013

0 25 50 100
Meters



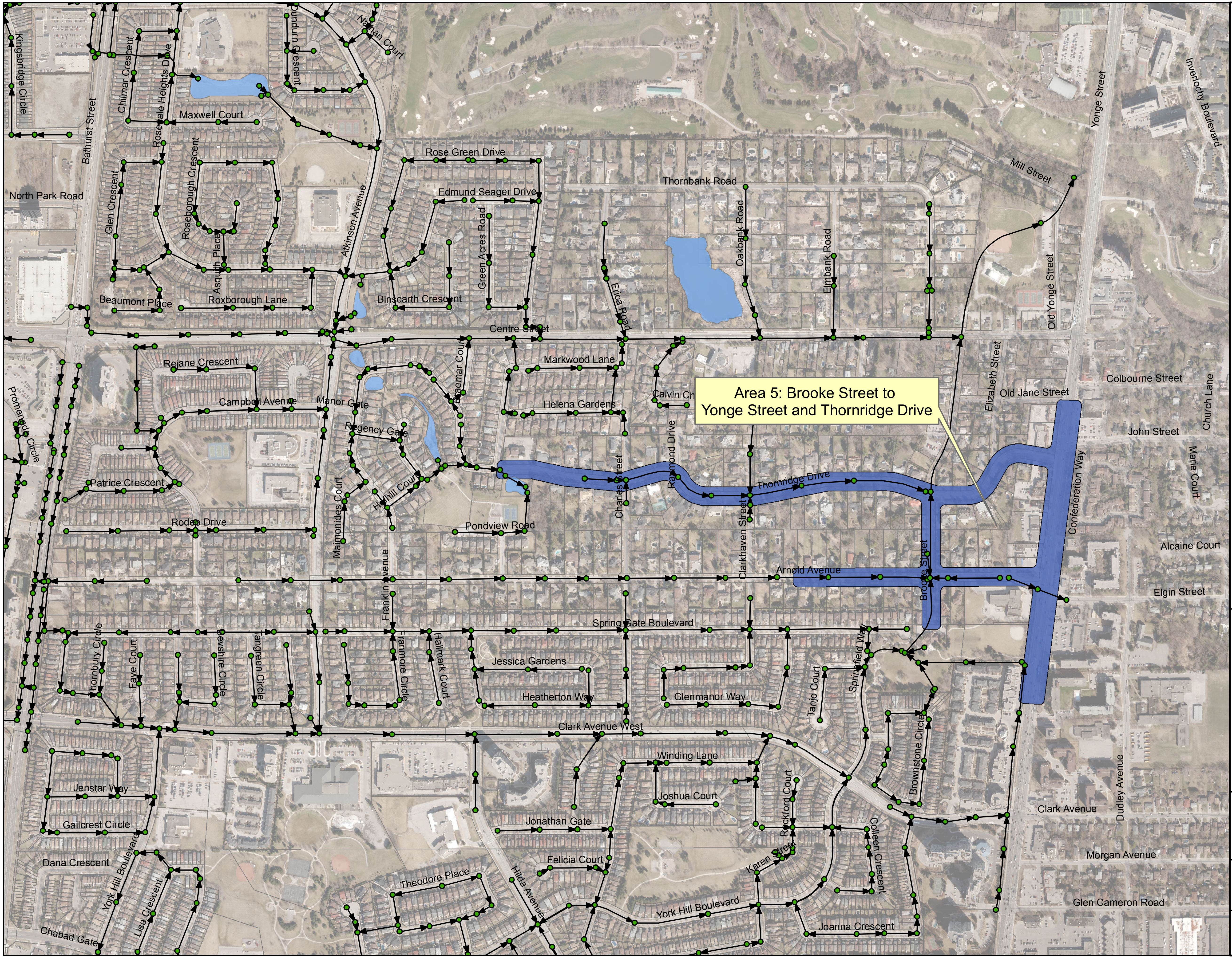
VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-5
Flooding Site Location
(Area 4: 109 Brooke Street)

Drawn By: J.H. Date: July 30, 2013



Legend

- Storm Manholes
- Storm Sewers
- SWM Ponds
- Parcels
- City Boundary
- Roads

N

VAUGHAN

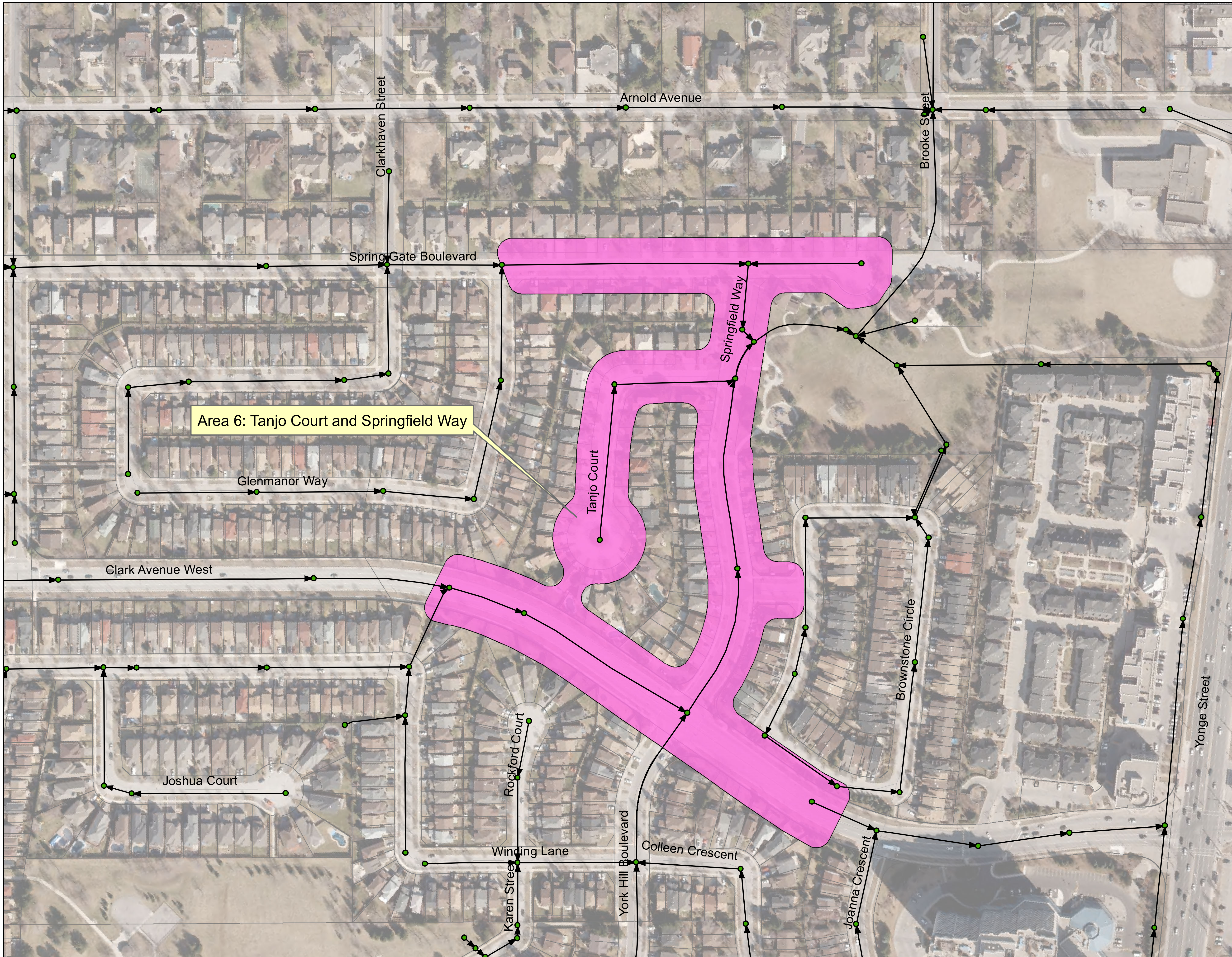
CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-6
Flooding Site Location
(Area 5: Brooke Street to
Yonge Street and Thornridge Drive)

Drawn By: J.H. Date: July 30, 2013

0 75 150 300 Meters



Legend

- Storm Manholes
- Storm Sewers
- SWM Ponds
- Parcels
- City Boundary
- Roads

N

VAUGHAN

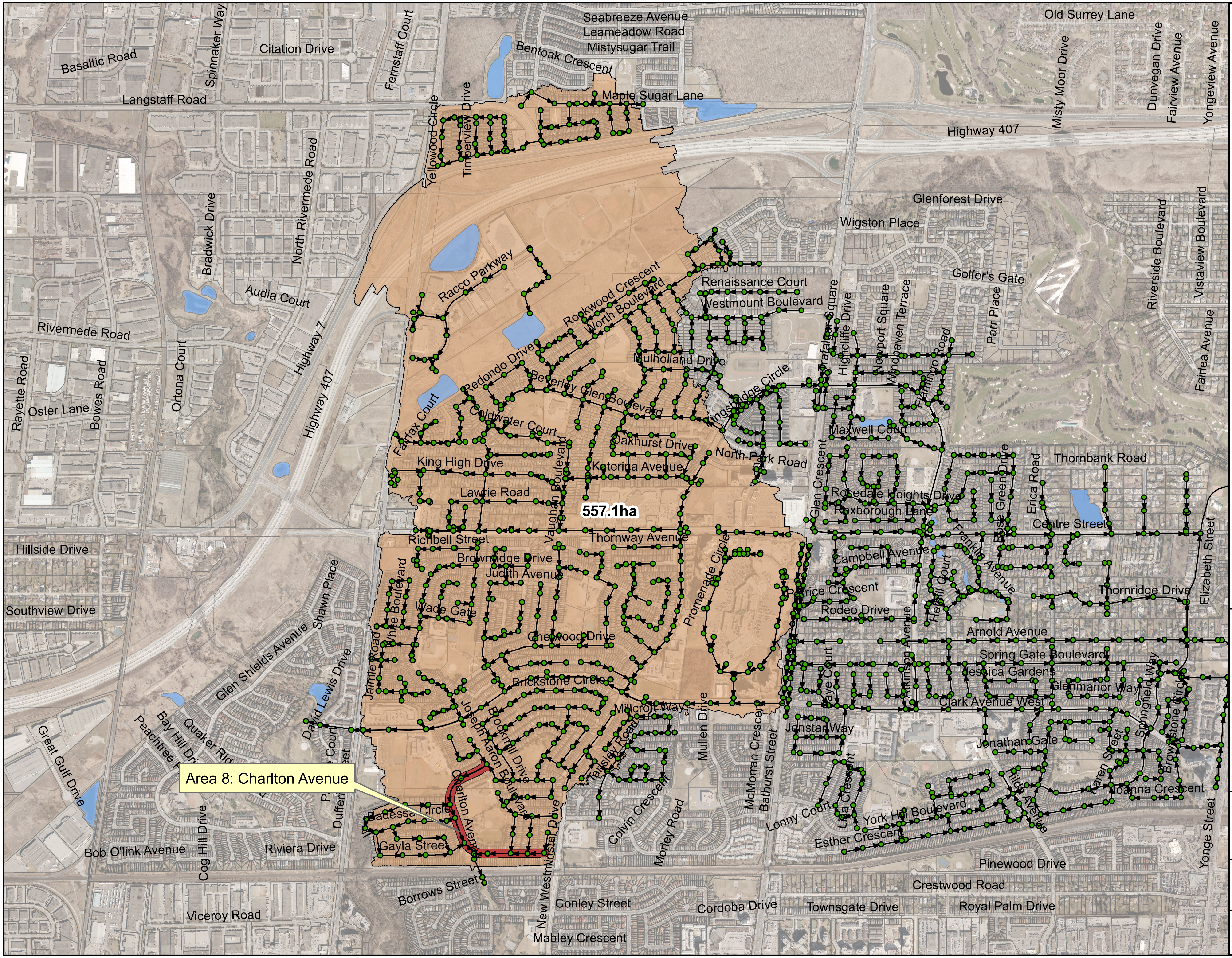
CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-7
Flooding Site Location
(Area 6: Tanjo Court and Springfield Way)

Drawn By: J.H. Date: July 30, 2013

0 25 50 100 Meters



Legend

- Storm Manholes
- Storm Sewers
- Major System Drainage Area
- SWM Ponds
- Parcels
- City Boundary
- Roads

VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-8
Flooding Site Location
(Area 8: Charlton Avenue)

Drawn By: J.H. Date: July 30, 2013

0 125 250 500 Meters

8.2. Flood Criteria

The objective of this study is to evaluate the drainage system performance, assess the existing level of flood protection, and develop alternatives to increase the service level to current standards. These standards are that the SWM system should be sized to safely convey runoff from both the 1 in 100 year, 24-hour Chicago storm and the Regional 48-hour Hazel storm. The study areas were modeled using Micro-Drainage software and the results of the model were be compared with the flood potential evaluation to assess where critical flooding is most likely to occur within the study area and develop remediation options.

It should be noted that high flooding potential from overloaded sewers or overloaded roadway drainage systems may or may not result in actual flooding. Actual flooding is site-specific and depends on site grading, building particulars and road construction for each area. For example, the analysis would predict flooding if the hydraulic grade lines (HGL) in the sewer rises above 1.8 m below the ground elevation regardless of whether a building or group of buildings have basements. Buildings without basements would not be flooded under this condition. Conversely, buildings with basement elevations below 1.8 m the elevation of the road will have a higher flood potential. Although these factors may be partially accounted for based on the building standards at the time of construction, changes after the initial construction also affect the actual flooding. Site-specific investigations would be required at the detailed design stage to assess specific flood susceptibility at a particular location.

A 'Flood Potential' criteria used in this Phase II Drainage Study was developed for evaluating the capacity of the major and minor systems prior to flood damage and flood hazards occurring in the area. The flood potential is based on surface depths and HGL elevation in the sewers. The flood potential quantifies the likeliness of flooding at specific locations in the study area based on whether or not a flood depth or HGL elevation trigger is reached. The model provides the best predictive tool based on assumed building elevations relative to sewer and street elevations. Potential flooding occurs when levels in overloaded sewers reach estimated basement elevations or ponding on the street reaches building elevations. The flood potential criteria assumed for this study is as follows:

High surface and/or basement flooding occurs if:

- Surface water level is above the surface elevation (gutter elevation) by more than 300 mm; and,
- Surcharge level in the storm sewer is higher than 1.8 m below the surface elevation, which should approximate the assumed basement elevations for homes with the basements directly connected to the combined / storm sewer.

Surface flood conditions are categorized based on predicted depth as:

- From gutter surface to 150 mm above surface, represents flow contained on the road between curbs. When reversed-slop driveways are present, depths in excess of 150 mm above gutter suggest potential surface flooding;
- Water depths between 150 mm to 300 mm results in water that is above the curb but is assumed to be contained within the street right-of-way; and,
- Water depths in excess of 300 mm above the gutter surface suggest potential surface flooding.

Basement flooding is evaluated by calculating the HGL through sewer system hydraulic analysis. Potential flooding is classified as:

- Sewer surcharges but the HGL elevation is below 1.8 m from surface (assumed basement elevation);
- Sewer surcharges and the HGL is within the surface elevation and 1.8 m below surface; and,
- The HGL is above surface elevation, which indicates that the pipe is surcharged up to the surface.

8.3. Precipitation Monitoring and Distributed Rainfall Modeling Technique

As previously discussed, several tipping bucket rain gauges and flow meters were used to assess the storm water response in the sewers and calibrate the detailed hydrodynamic model. The rain gauges were in place in July 2011 and remained in place until February 2012. Data from other rain gauges in operation during the study were also included to obtain a more accurate representation of rainfall over the area. The spatial distribution of rainfall was analyzed using GIS methods to create a "rainfall surface" for modeling the rainfall response. This is known as the Distributed Rainfall Modeling Technique.

8.4. Simulation of Historic and Design Storm Events

The model was used to simulate the August 19, 2005 storm event, which resulted in extensive flooding in the study area. The results of the sewers and overland drainage system analysis for this event were compared with flood reports received by the City soon after this storm. **Figure 8-9** and **Figure 8-10** illustrate the locations with high flood potential due to storm sewer surcharge and surface depth exceeding the flood criteria and the location of reported flooding. As shown, the model predicts high flood potential in areas where flooding was reported and in various other locations. These models are typically the best-available tools for predicting drainage system performance. Such models should not be forced to only match reported flooding locations unless there is measurable evidence of actual system performance because:

- Only a fraction of actual flooding is reported to the City by residents, tenants and property owners. Lack of engagement significantly reduces flooding reports during such events, which results in a tendency to underestimate the actual flooding areas. It is recommended that the City implement a City-Wide Drainage Management System that includes a flood reporting feature in combination with a public communication program that advises residents, tenants and property owners to report flooding during large storm events. Such a system would provide valuable information to the City allowing for more effective management of the drainage system;
- Potential flooding is an indicator of the likelihood of water reaching buildings or property lines where damages may occur. Sewer and surface flood criteria may be reached in locations where local conditions provide flood protection, such as in areas where local grading results in elevated homes and basements which protect homes from flood damage. In such cases, surface water elevations or HGL elevations in the sewer may approach but not reach the buildings;

- The Micro-Drainage approach of modelling makes the best use of the available data which at times originates from sources which require significant data infill and may have a significant margin of error. Future model improvements should be considered through improvements in GIS and DEM data. Increased accuracy can be achieved through the use of LIDaR-surveyed topographic data which can be collected rapidly with vehicle-mounted equipment and provide accurate topographic data. When combined with Micro-Drainage tools, this technique has shown to provide improved predictions of flood depth and flood potential; and,
- Differences in drainage system performance compared to models may be due to partial or complete conveyance system blockages. The likelihood of partial or complete blockages, especially of intake locations such as catch basins, culvert crossings, and pond outlets increases during large events due to the additional energy contained in the precipitation, wind, and flow produced during large storm events capable of dislodging and carrying debris. It is recommended that the City update their criteria to require oversized debris gratings with high debris control capacity in combination with either low-maintenance inlet control devices or inlet sizing that controls the flow. In other words, intake grating should be used to keep debris out of the sewers and culverts and not as a flow control measure. Inlet control should be achieved through intake sizing insuring that debris does not block the intakes.

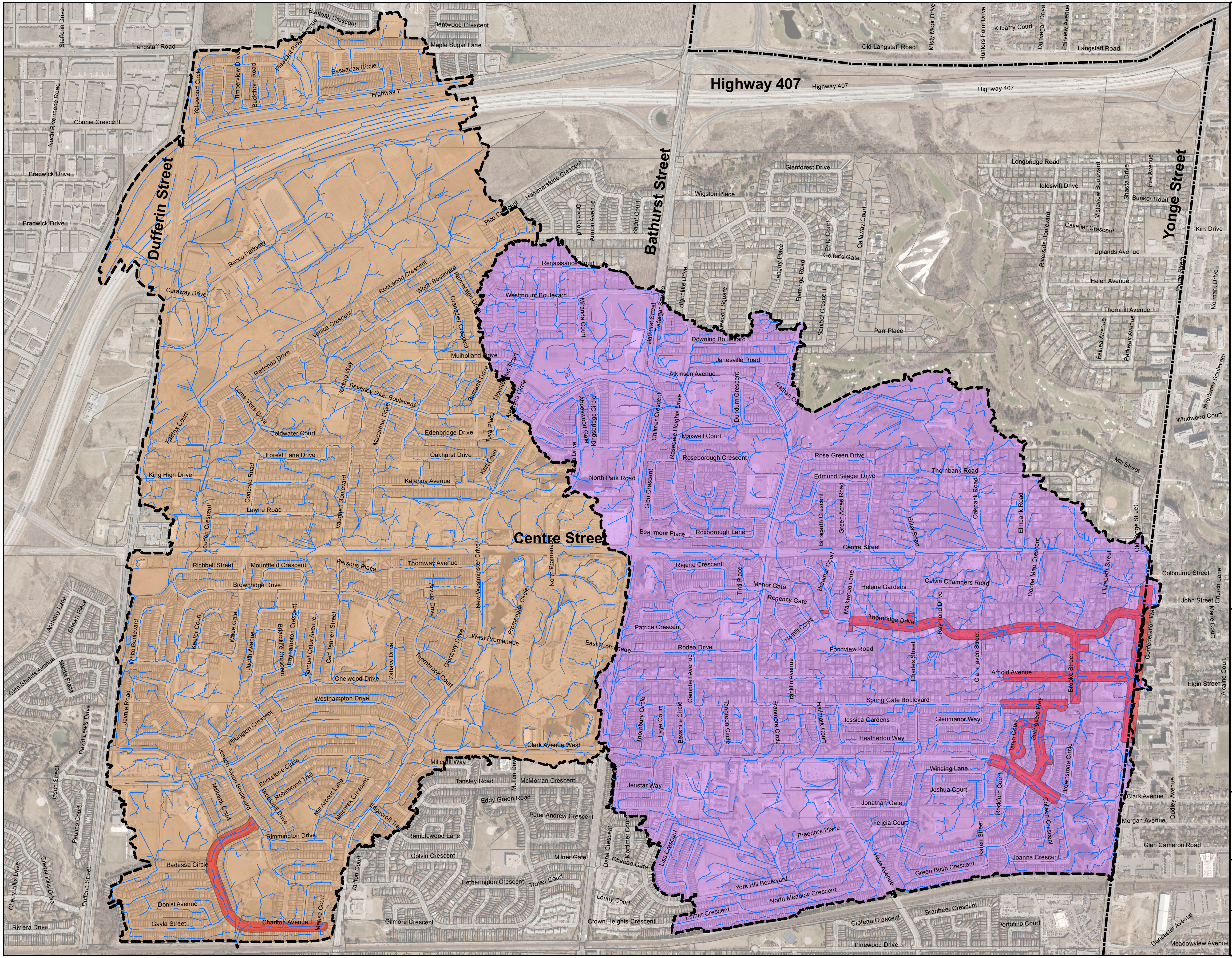
The model was used to predict the level of flood protection provided by the drainage system during 2, 5, 10, 25, 50, 100-year and Regional storms. The City's 24-hour Chicago design storm distribution (5 minute intervals) and the Regional 48-hour Hazel design storm distribution (15 minute intervals) were used in the analysis. The CN values were adjusted from AMC (II), used for the Chicago distribution, to AMC (III) for the Hurricane Hazel analysis. The results of the model simulation are shown for the surface and sewer systems from **Figure 8-11** to **Figure 8-42**. In general, reported flooding during the August 19, 2005 event agrees with the predicted flooding of the model during the same event, and flooding locations during the 1 in 100 year event are consistent with that of the August 19, 2005 storm event.

8.4.1. Factors Contributing to Flooding

The causes of flooding for the storm drainage system areas could be generally attributed to the following:

- Excess flow capture by sewer inlets or undersized pipes resulting in sewer overloading and high HGL;
- Accumulation of surface runoff in low-lying or sagged areas with poor or no overland flow routes downstream;
- Streets designed prior to the use of 'dual-drainage' principles where flow between sewers and surface capacity is not accounted resulting in surface depths exceeding the maximum depth criteria;
- Blocked catchbasins, insufficient catchbasin capacity, and/or catchbasins which are unable to capture flow due to overloaded sewer systems, particularly at and downstream end of sagged street locations;
- Reversed-sloped driveways allowing street flow into the basements;
- Poor lot grading resulting in local drainage towards the building;

- Depth of flow in channels reaching building openings; and,
- Flow into private properties without dedicated conveyance channels due to modifications by residents, owners and tenants.



Legend

- Study Areas 1-6
- Study Area 8
- Drainage Concern Areas
- Parcels
- City Boundary
- Reconditioned Overland Flow Path

N

VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-9
Reconditioned Overland Flow Path
(Flooding Site 1-6 and 8)

Drawn By: J.H. Date: Jan 7, 2014

0 125 250 500
Meters

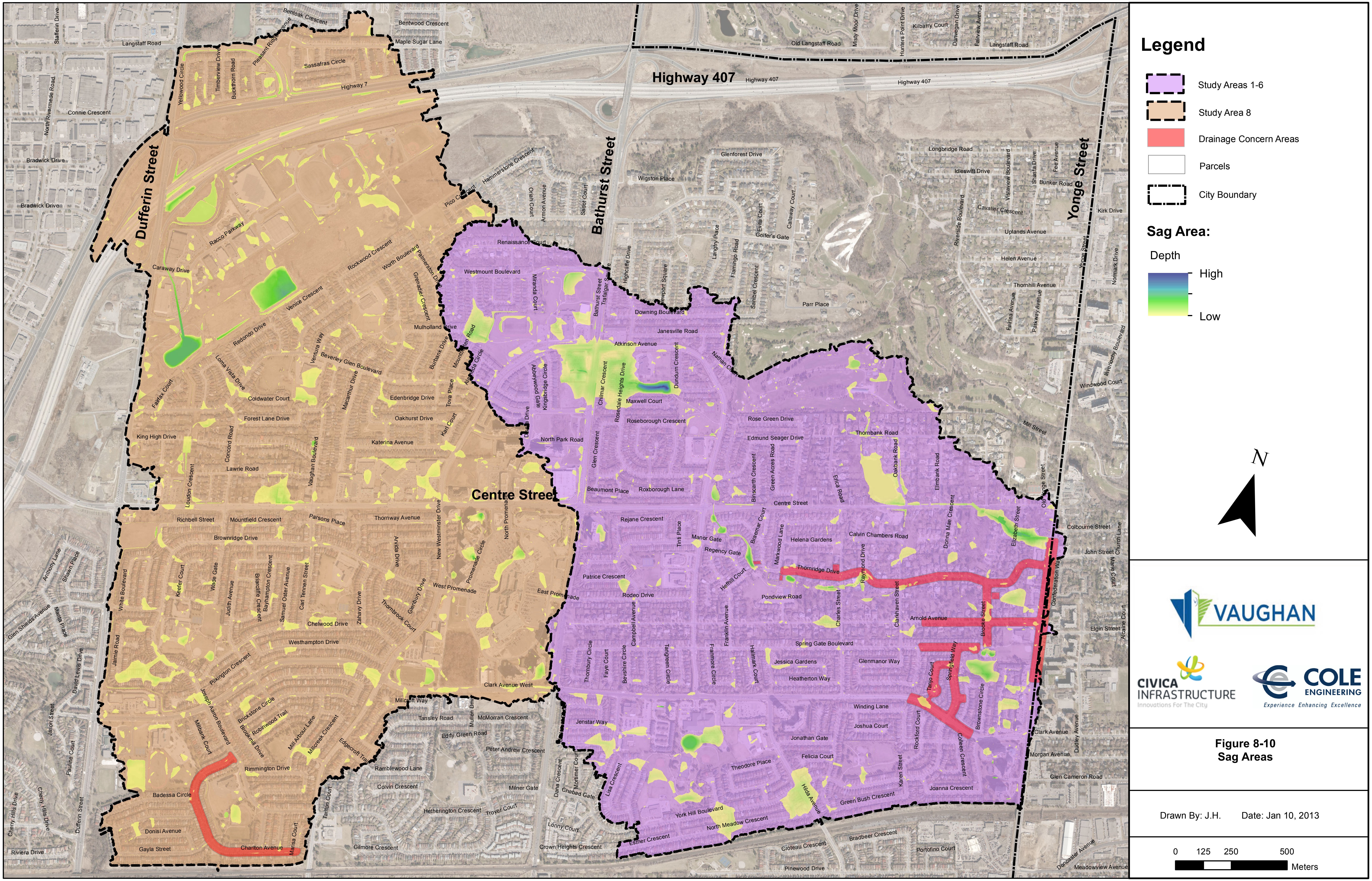


Figure 8-10
Sag Areas

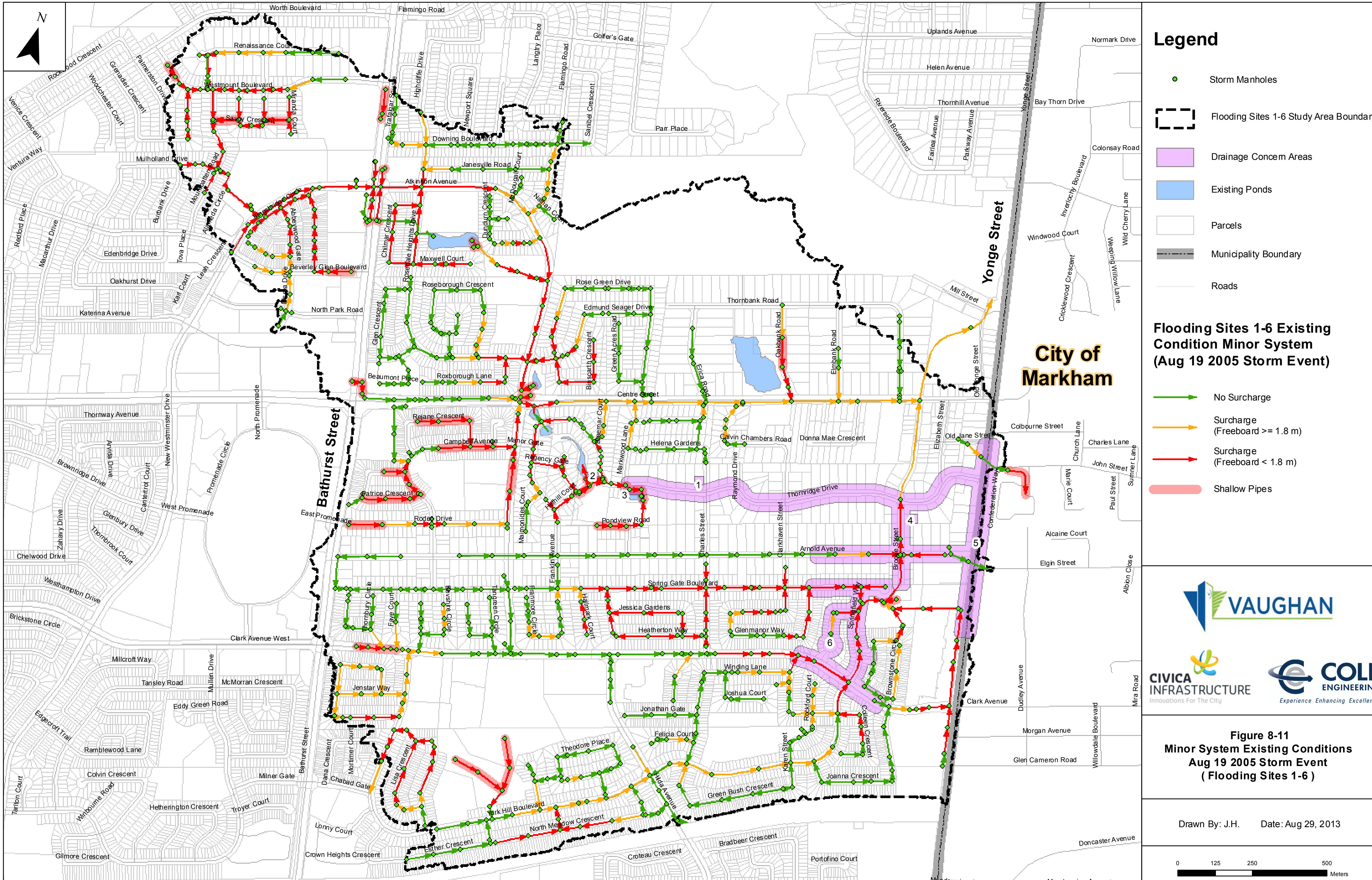
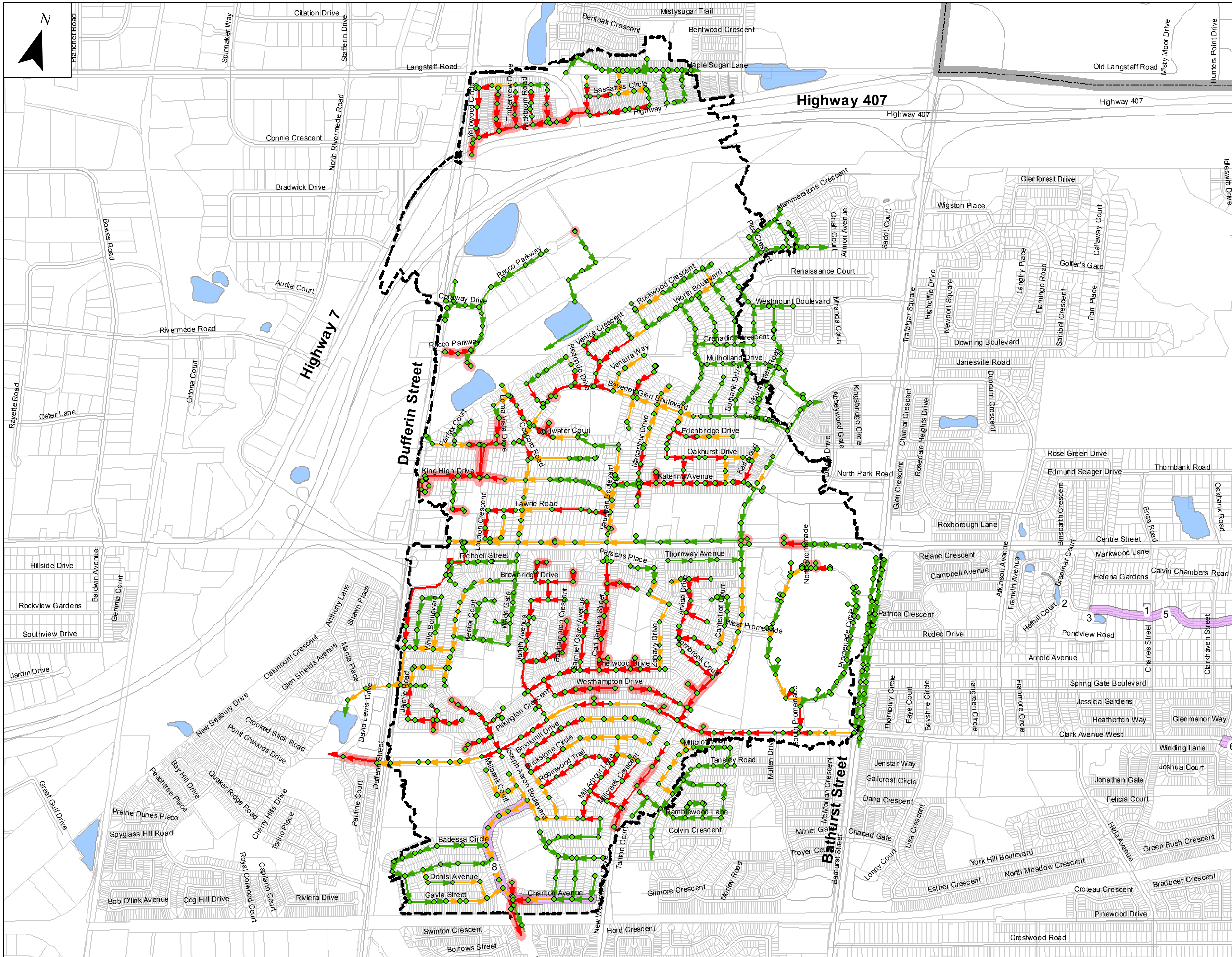


Figure 8-11
Minor System Existing Conditions
Aug 19 2005 Storm Event
(Flooding Sites 1-6)



Legend

- Storm Manholes
- Flooding Sites 1-6 Study Area Boundary
- Drainage Concern Areas
- Existing Ponds
- Parcels
- Municipality Boundary
- Roads

Flooding Site 8 Existing Condition Minor System (Aug 19 2005 Storm Event)

- No Surcharge
- Surcharge (Freeboard >= 1.8 m)
- Surcharge (Freeboard < 1.8 m)
- Shallow Pipes

VAUGHAN

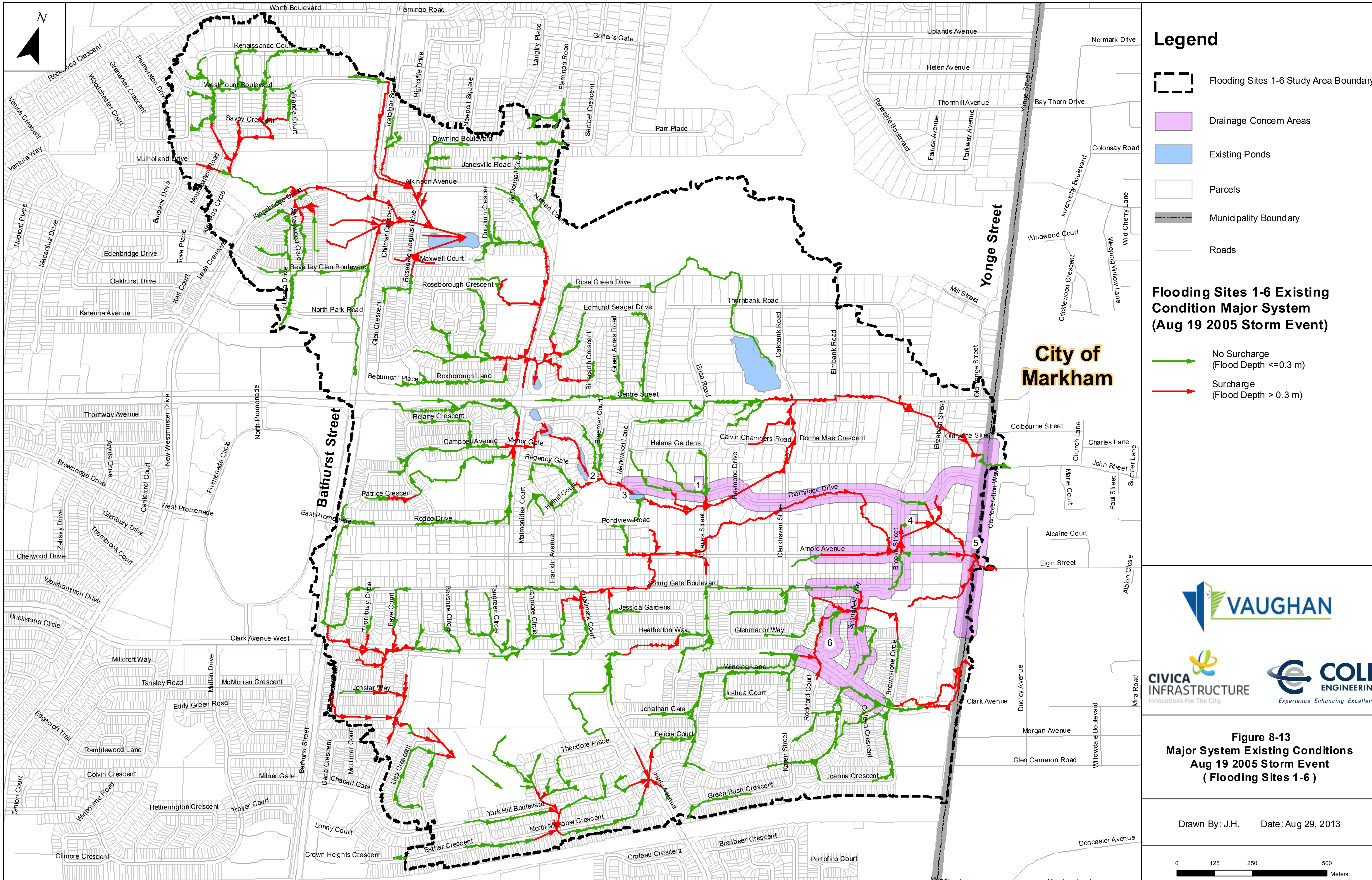
CIVICA INFRASTRUCTURE
Innovations For The City

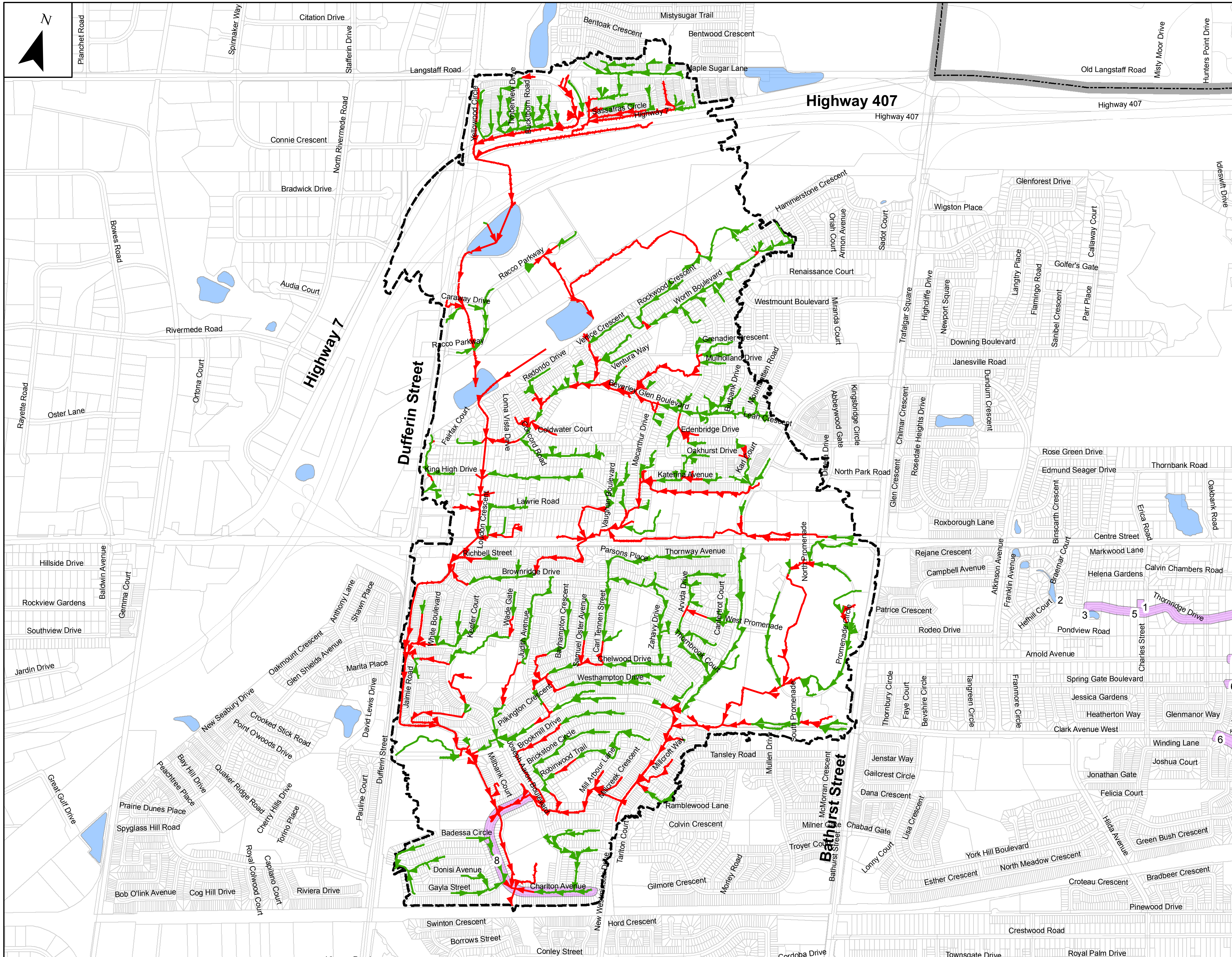
COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-12
Minor System Existing Conditions
Aug 19 2005 Storm Event
(Flooding Site 8)

Drawn By: J.H. Date: Aug 29, 2013

0 175 350 700 Meters


N
Legend
Flooding Sites 1-6 Study Area Boundary
Drainage Concern Areas
Existing Ponds
Parcels
Municipality Boundary
Roads
Flooding Sites 1-6 Existing Condition Major System (Aug 19 2005 Storm Event)
No Surcharge (Flood Depth <=0.3 m)
Surcharge (Flood Depth > 0.3 m)
City of Markham
Bathurst Street
Yonge Street
1
2
3
4
5
6
Worth Boulevard
Flamingo Road
Golfer's Gate
Renaissance Court
Westmount Boulevard
Savoy Crescent
Miranda Court
Trafalgar Square
Highcliffe Drive
Newport Square
Langtry Place
Sanibel Crescent
Parr Place
Downing Boulevard
Janesville Road
McDougall Court
Atkinson Avenue
Mulholland Drive
Kingsbridge Circle
Beverley Glen Boulevard
Maxwell Court
Roseborough Crescent
North Park Road
Glen Crescent
Beaumont Place
Roxborough Lane
Rose Green Drive
Edmund Seager Drive
Thornbank Road
Oakbank Road
Elmbank Road
Erica Road
Green Acres Road
Birchcroft Crescent
Centre Street
Rejane Crescent
Campbell Avenue
Manor Gate
Regency Gate
Helena Gardens
Calvin Chambers Road
Donna Mae Crescent
Thornridge Drive
Raymond Drive
Clarkhaven Street
Charles Street
Pondview Road
Arnold Avenue
Brooke Street
Confederation Way
Spring Gate Boulevard
Jessica Gardens
Heatherton Way
Glenmanor Way
Springfield Way
Winding Lane
Joshua Court
Jonathan Gate
Felicia Court
Theodore Place
Green Bush Crescent
Joanna Crescent
Colleen Crescent
Brownstone Circle
Rockford Court
Karen Street
Hilda Avenue
York Hill Boulevard
North Meadow Crescent
Esther Crescent
Croteau Crescent
Bradbeer Crescent
Portofino Court
Crown Heights Crescent
Lonny Court
Chabad Gate
Lisa Crescent
Jenstar Way
Patrice Crescent
Rodeo Drive
East Promenade
West Promenade
Clark Avenue West
Clark Avenue
Thornway Avenue
North Promenade
New Westminster Drive
Promenade Circle
Brownridge Drive
Glenbury Drive
Thornbrook Court
Chelwood Drive
Westhampton Drive
Brickstone Circle
Millcroft Way
Tansley Road
McMorran Crescent
Eddy Green Road
Edgecroft Trail
Ramblewood Lane
Colvin Crescent
Milner Gate
Hetherington Crescent
Troyer Court
Gilmore Crescent
Wimbourne Road
Tarlton Court
Oakhurst Drive
Katerina Avenue
Edenbridge Drive
Ventura Way
Venice Crescent
Rockwood Crescent
Uplands Avenue
Helen Avenue
Thornhill Avenue
Riverside Boulevard
Fairlea Avenue
Parkway Avenue
Normark Drive
Bay Thorn Drive
Colonsay Road
Inverlochy Boulevard
Windwood Court
Mill Street
Old Jane Street
Colbourne Street
Church Lane
Charles Lane
John Street
Elizabeth Street
Alcaine Court
Elgin Street
Dudley Avenue
Morgan Avenue
Glen Cameron Road
Doncaster Avenue
Meadowview Avenue
VAUGHAN
CIVICA INFRASTRUCTURE
Innovations For The City
COLE ENGINEERING
Experience Enhancing Excellence
Figure 8-13
Major System Existing Conditions
Aug 19 2005 Storm Event
(Flooding Sites 1-6)
Drawn By: J.H.
Date: Aug 29, 2013
0
125
250
500
Meters



Legend

Flooding Sites 1-6 Study Area Boundary

Drainage Concern Areas

Existing Ponds

Parcels

Municipality Boundary

Roads

Flooding Site 8 Existing Condition Major System (Aug 19 2005 Storm Event)

No Surcharge (Flood Depth <=0.3 m)

Surcharge (Flood Depth > 0.3 m)

VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-14
Major System Existing Conditions
Aug 19 2005 Storm Event
(Flooding Site 8)

Drawn By: J.H. Date: Aug 27, 2013

0 175 350 700 Meters

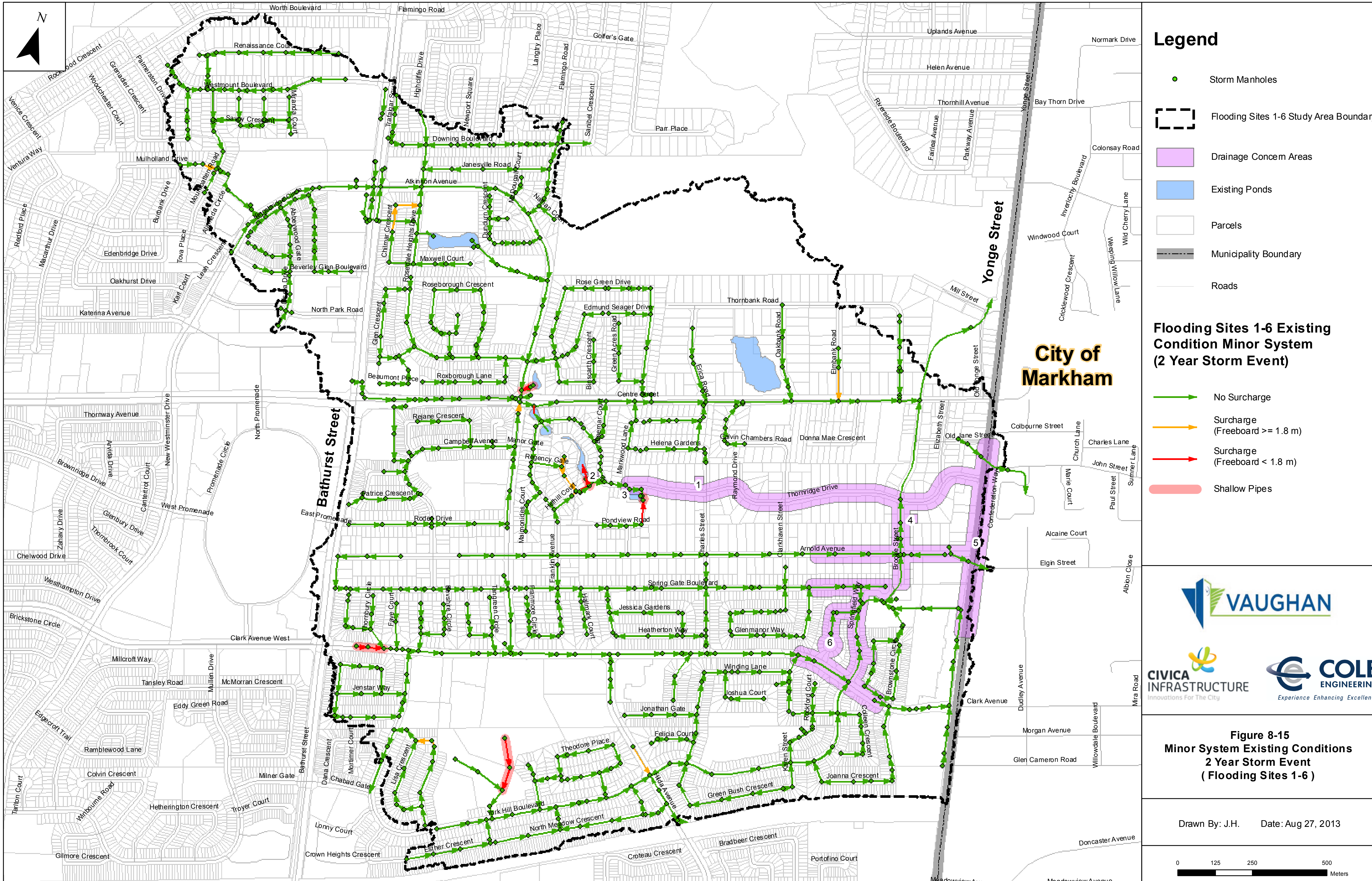
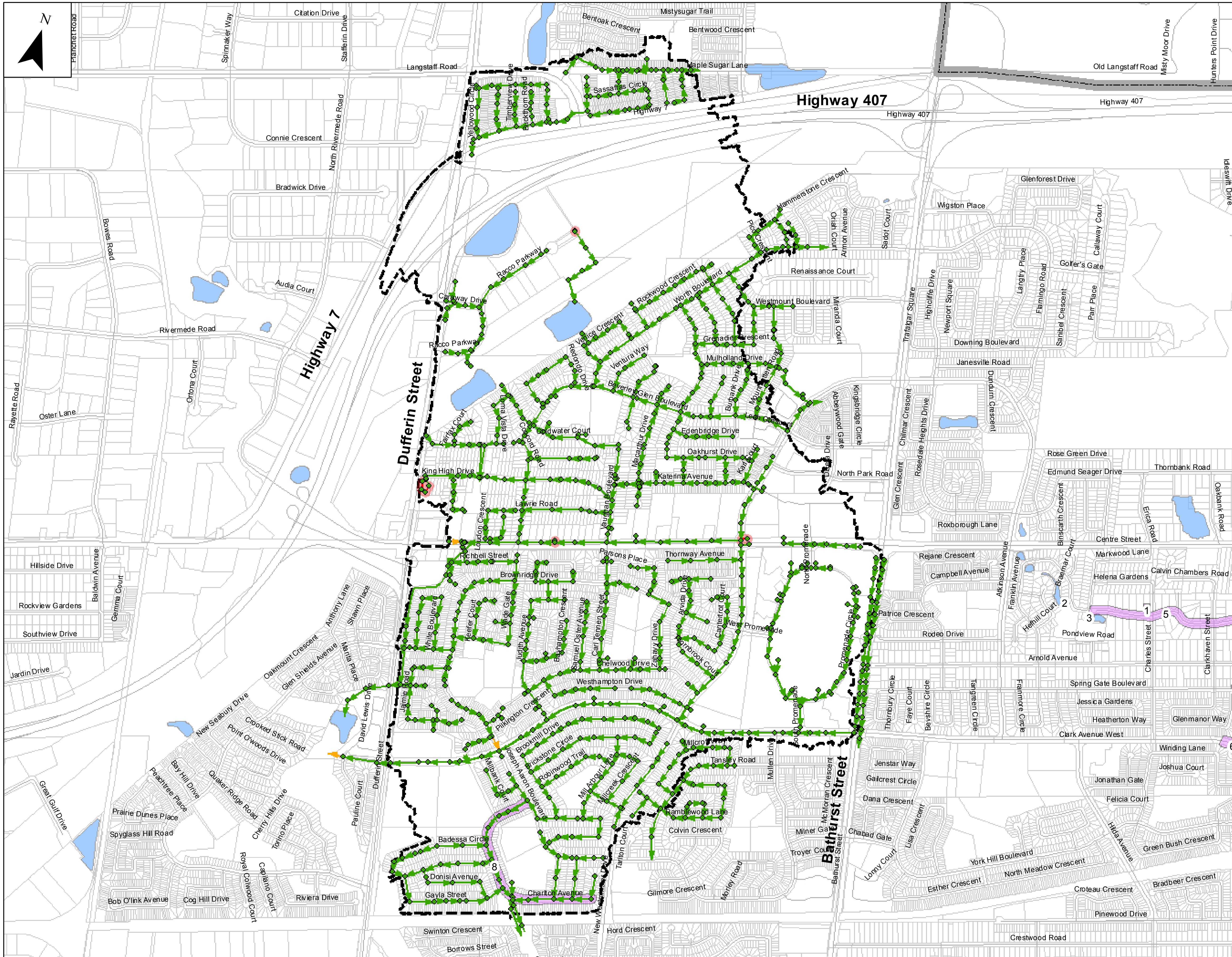


Figure 8-15
Minor System Existing Conditions
2 Year Storm Event
(Flooding Sites 1-6)



Legend

- Storm Manholes
- Flooding Sites 1-6 Study Area Boundary
- Drainage Concern Areas
- Existing Ponds
- Parcels
- Municipality Boundary
- Roads

Flooding Site 8 Existing Condition Minor System (2 Year Storm Event)

- No Surcharge
- Surcharge (Freeboard >= 1.8 m)
- Surcharge (Freeboard < 1.8 m)
- Shallow Pipes

VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-16
Minor System Existing Conditions
2 Year Storm Event
(Flooding Site 8)

Drawn By: J.H. Date: Aug 29, 2013

0 175 350 700
Meters

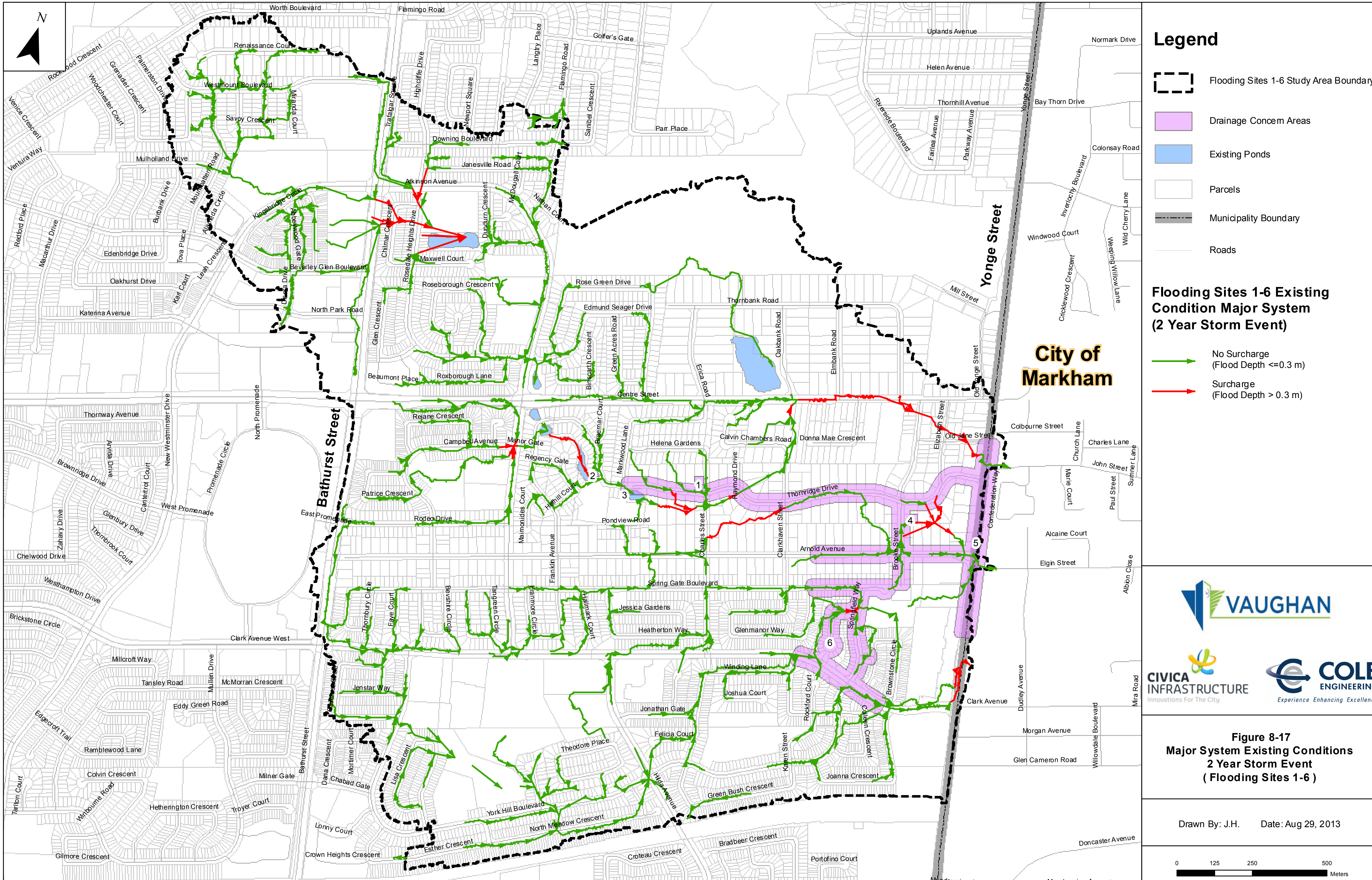
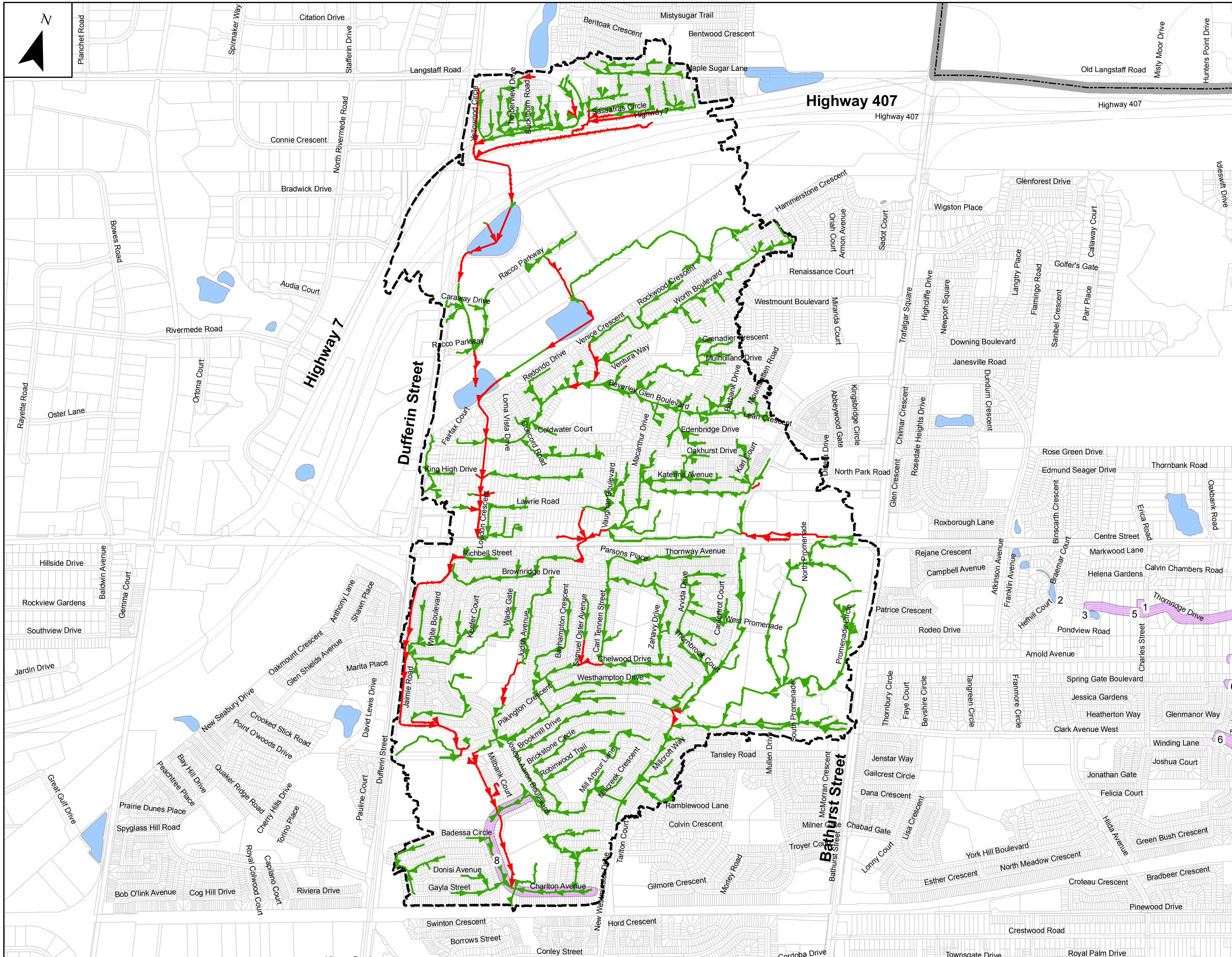


Figure 8-17
Major System Existing Conditions
2 Year Storm Event
(Flooding Sites 1-6)



Legend

- Flooding Sites 1-6 Study Area Boundary
- Drainage Concern Areas
- Existing Ponds
- Parcels
- Municipality Boundary
- Roads

Flooding Site 8 Existing Condition Major System (2 Year Storm Event)

- No Surcharge (Flood Depth <=0.3 m)
- Surcharge (Flood Depth > 0.3 m)

VAUGHAN

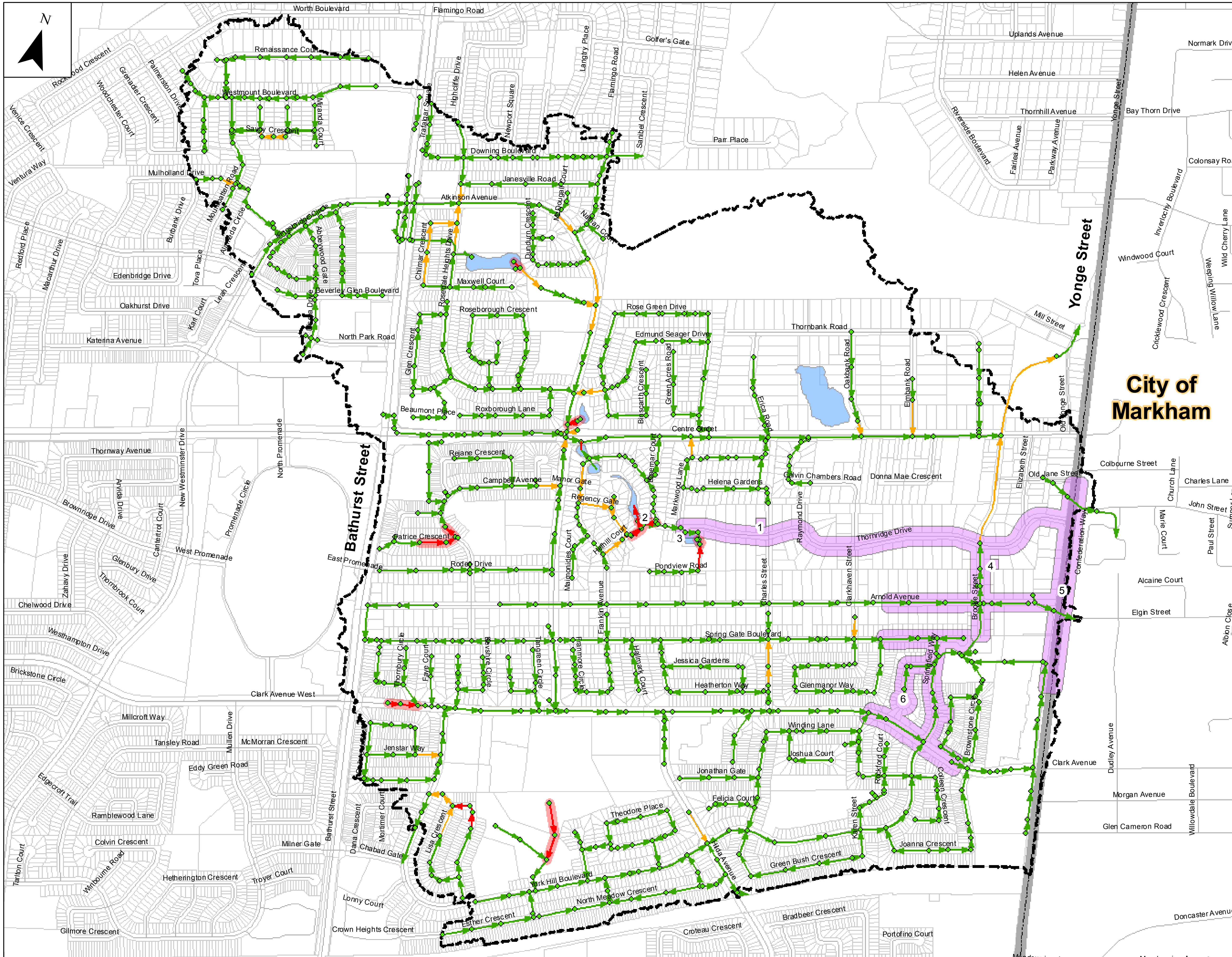
CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-18
Major System Existing Conditions
2 Year Storm Event
(Flooding Site 8)

Drawn By: J.H. Date: Aug 27, 2013

0 175 350 700
Meters



Legend

- Storm Manholes
- Flooding Sites 1-6 Study Area Boundary
- Drainage Concern Areas
- Existing Ponds
- Parcels
- Municipality Boundary
- Roads

Flooding Sites 1-6 Existing Condition Minor System (5 Year Storm Event)

- No Surcharge
- Surcharge (Freeboard >= 1.8 m)
- Surcharge (Freeboard < 1.8 m)
- Shallow Pipes

VAUGHAN

CIVICA INFRASTRUCTURE Innovations For The City

COLE ENGINEERING Experience Enhancing Excellence

Figure 8-19
Minor System Existing Conditions
5 Year Storm Event
(Flooding Sites 1-6)

Drawn By: J.H. Date: Aug 27, 2013

0 125 250 500 Meters

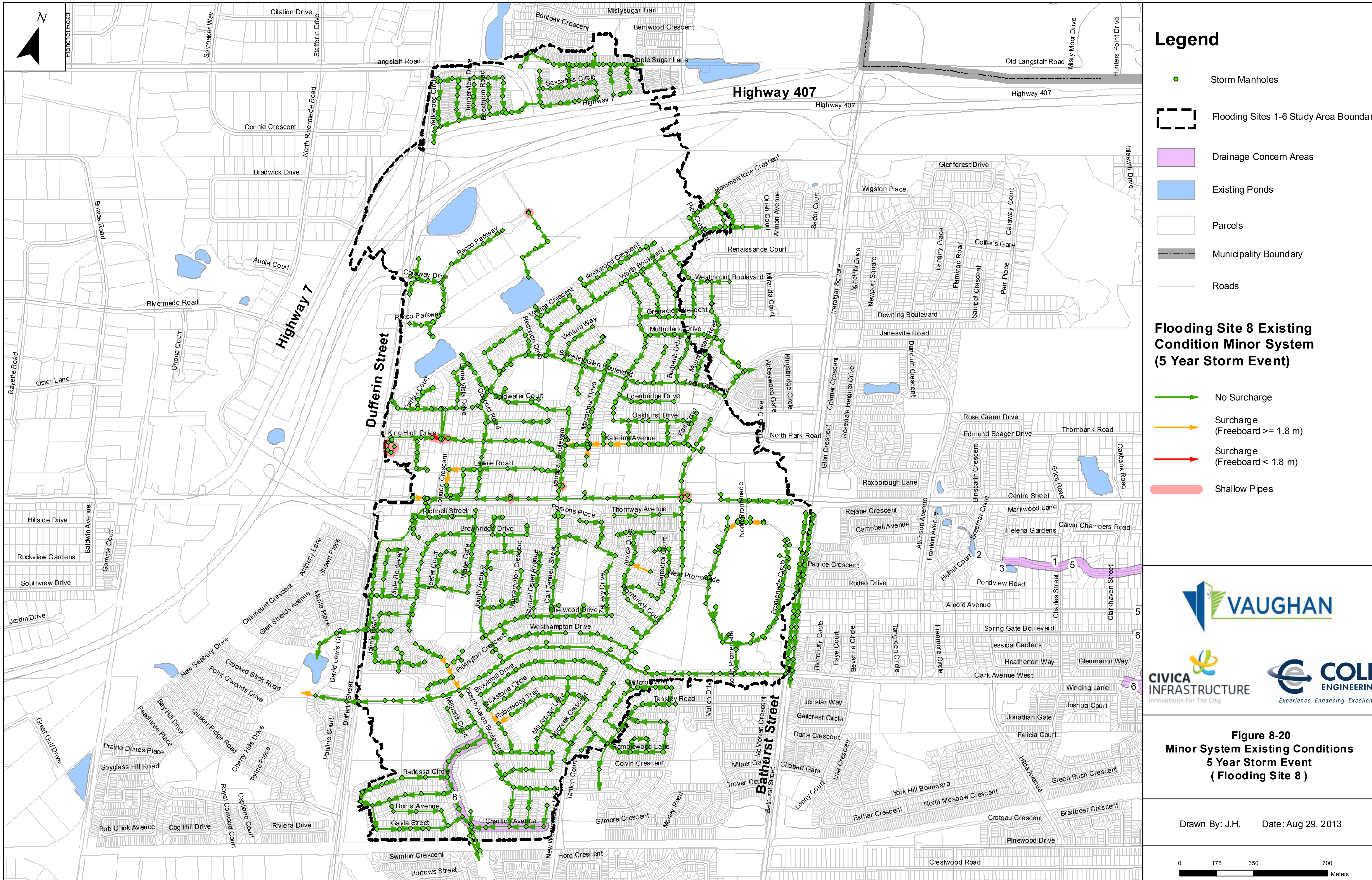
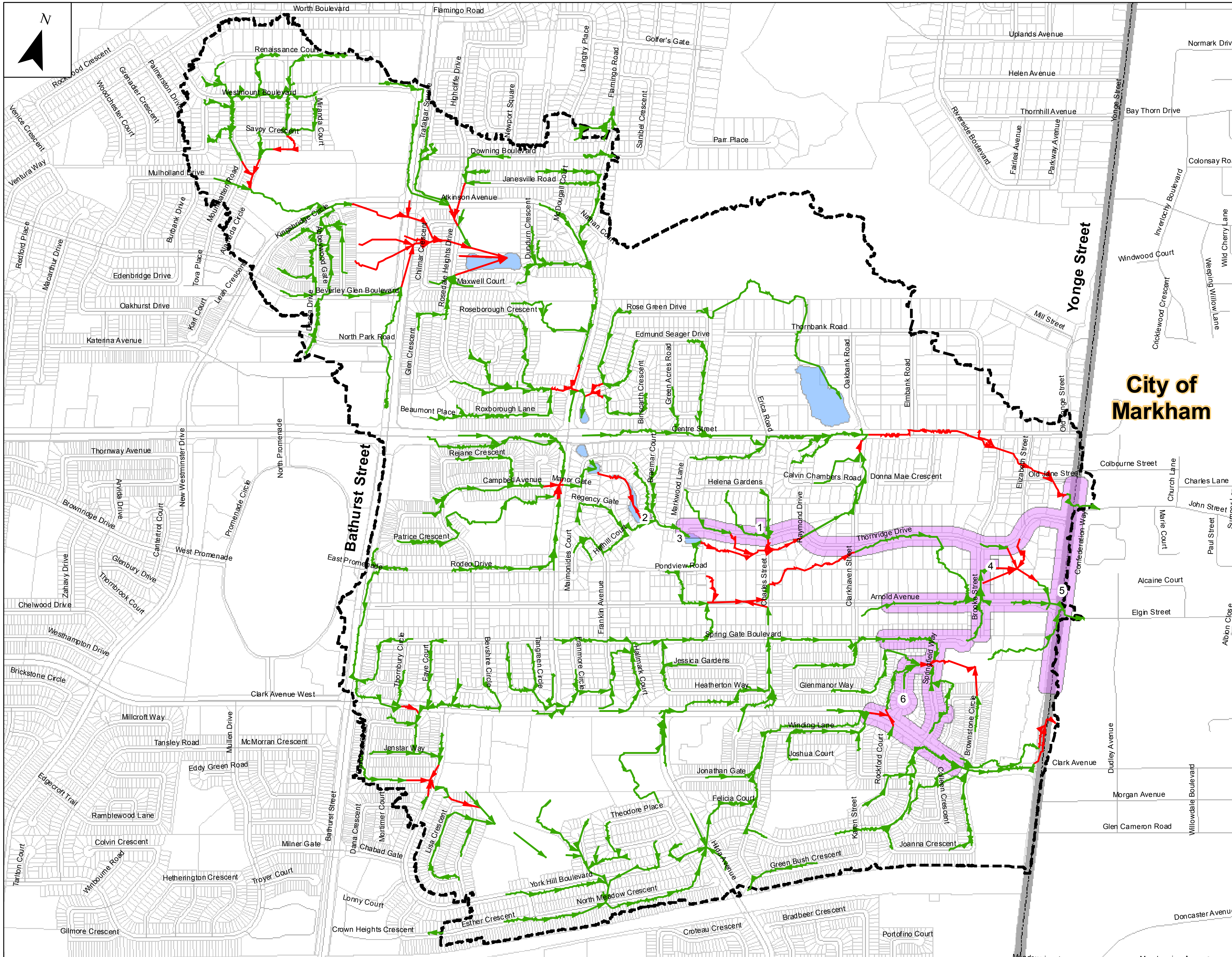


Figure 8-20
Minor System Existing Conditions
5 Year Storm Event
(Flooding Site 8)

Drawn By: J.H. Date: Aug 29, 2013



Legend

- Flooding Sites 1-6 Study Area Boundary
- Drainage Concern Areas
- Existing Ponds
- Parcels
- Municipality Boundary
- Roads

Flooding Sites 1-6 Existing Condition Major System (5 Year Storm Event)

- No Surcharge (Flood Depth <=0.3 m)
- Surcharge (Flood Depth > 0.3 m)

VAUGHAN

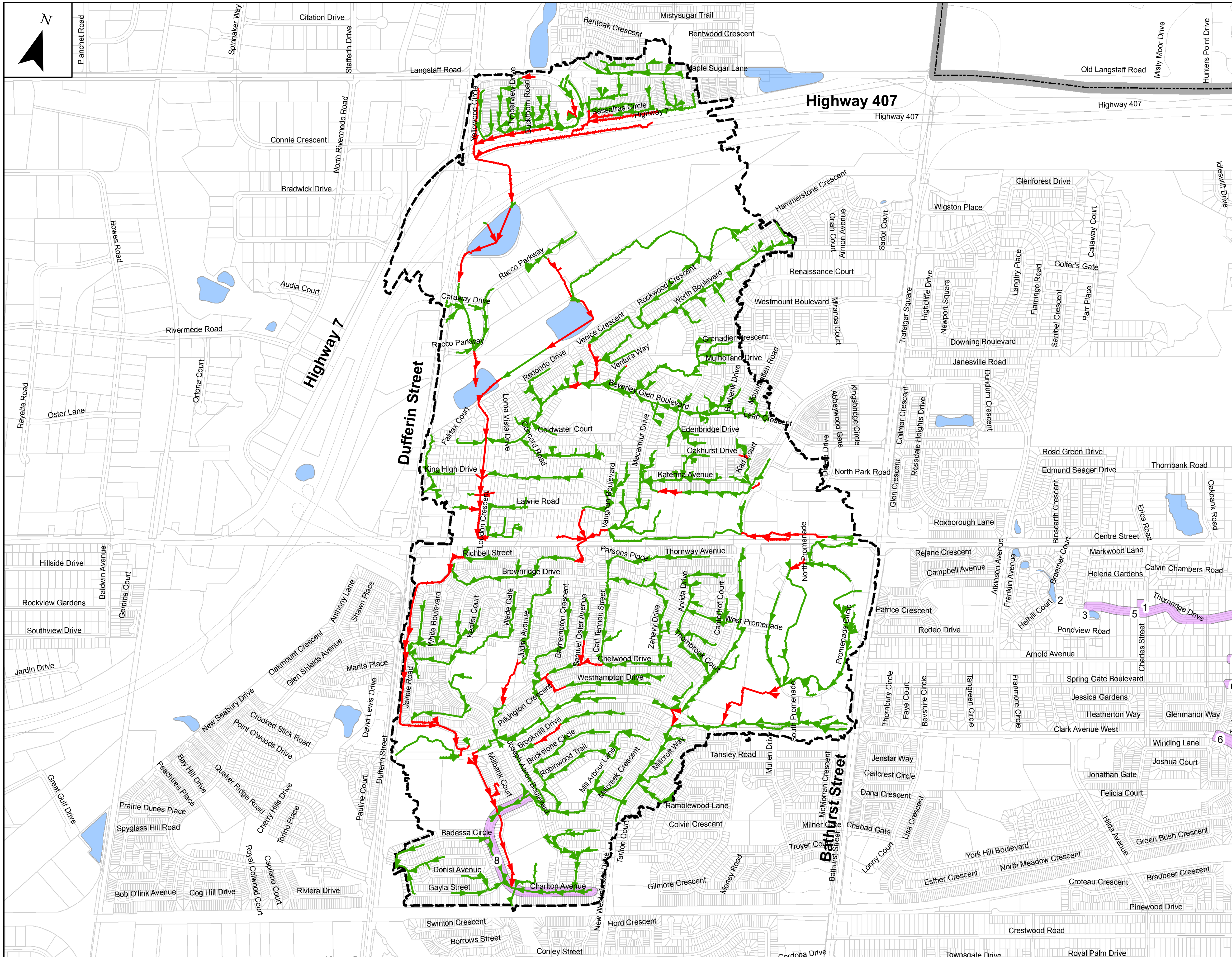
CIVICA INFRASTRUCTURE — Innovations For The City

COLE ENGINEERING — Experience Enhancing Excellence

Figure 8-21
Major System Existing Conditions
5 Year Storm Event
(Flooding Sites 1-6)

Drawn By: J.H. Date: Aug 29, 2013

0 125 250 500 Meters



Legend

Flooding Sites 1-6 Study Area Boundary

Drainage Concern Areas

Existing Ponds

Parcels

Municipality Boundary

Roads

Flooding Site 8 Existing Condition Major System (5 Year Storm Event)

No Surcharge (Flood Depth <=0.3 m)

Surcharge (Flood Depth > 0.3 m)

VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-22
Major System Existing Conditions
5 Year Storm Event
(Flooding Site 8)

Drawn By: J.H. Date: Aug 27, 2013

0 175 350 700 Meters

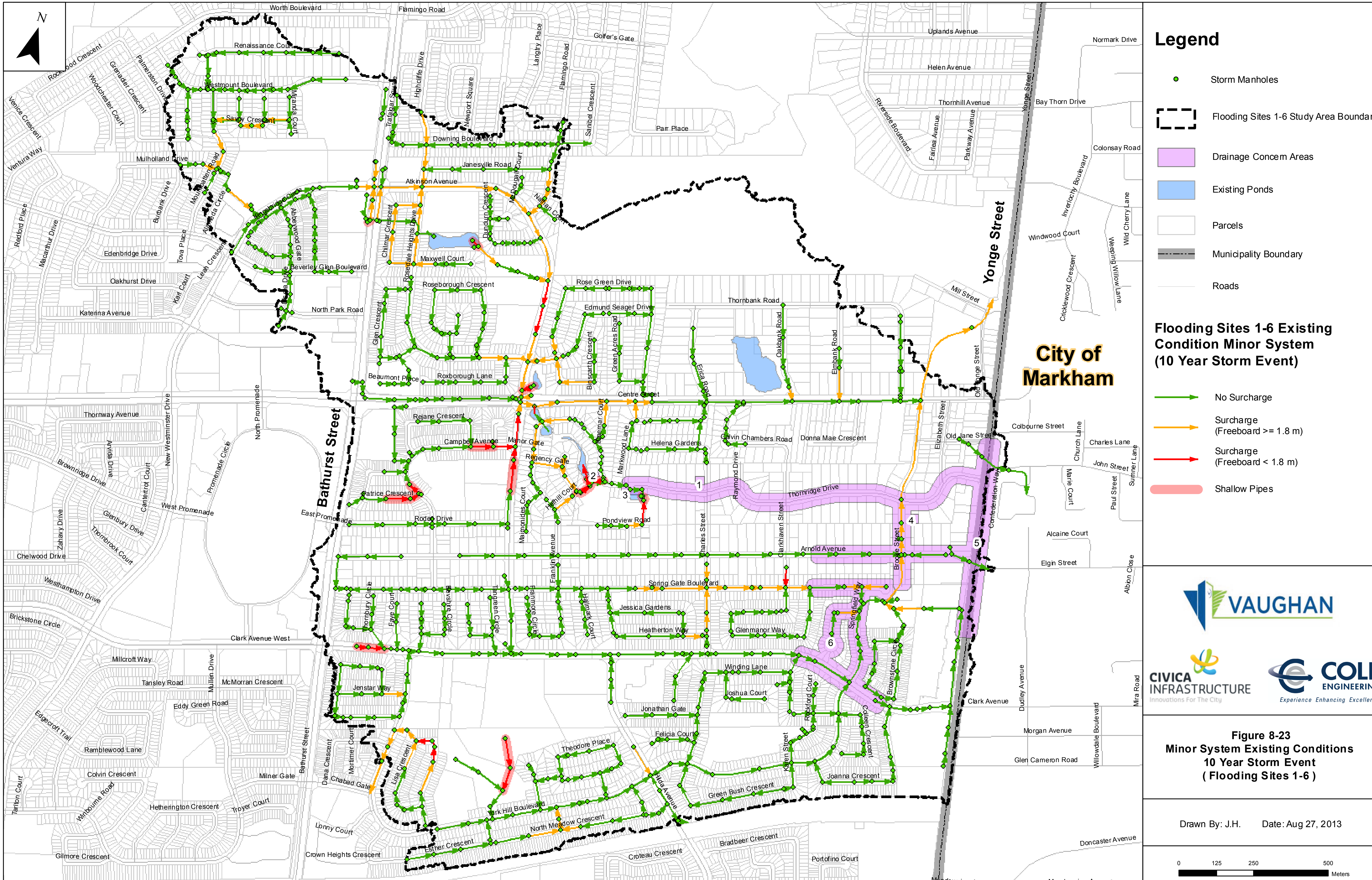
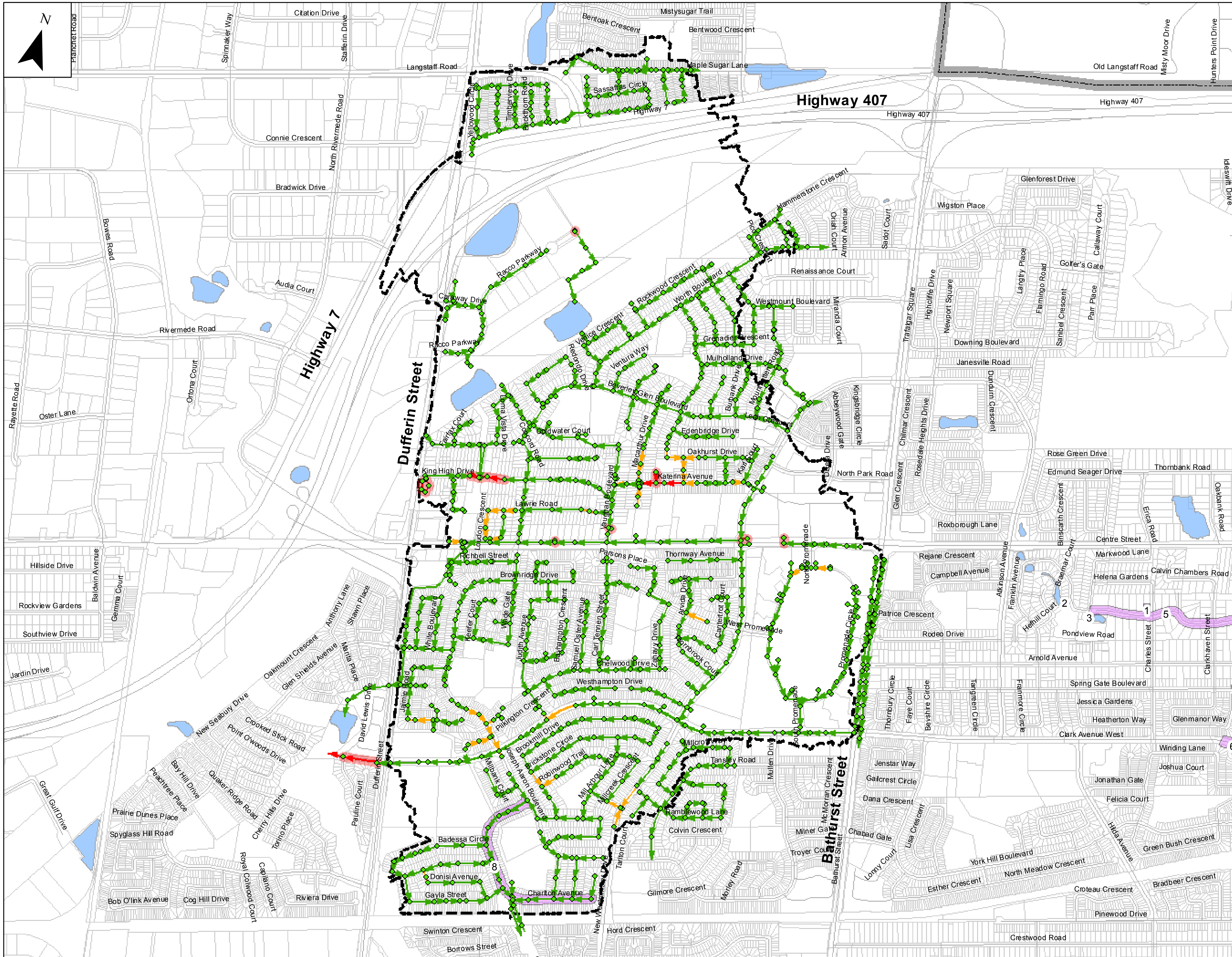


Figure 8-23
Minor System Existing Conditions
10 Year Storm Event
(Flooding Sites 1-6)

Drawn By: J.H. Date: Aug 27, 2013



Legend

- Storm Manholes
- Flooding Sites 1-6 Study Area Boundary
- Drainage Concern Areas
- Existing Ponds
- Parcels
- Municipality Boundary
- Roads

Flooding Site 8 Existing Condition Minor System (10 Year Storm Event)

- No Surcharge
- Surcharge (Freeboard >= 1.8 m)
- Surcharge (Freeboard < 1.8 m)
- Shallow Pipes

VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-24
Minor System Existing Conditions
10 Year Storm Event
(Flooding Site 8)

Drawn By: J.H. Date: Aug 29, 2013

0 175 350 700 Meters

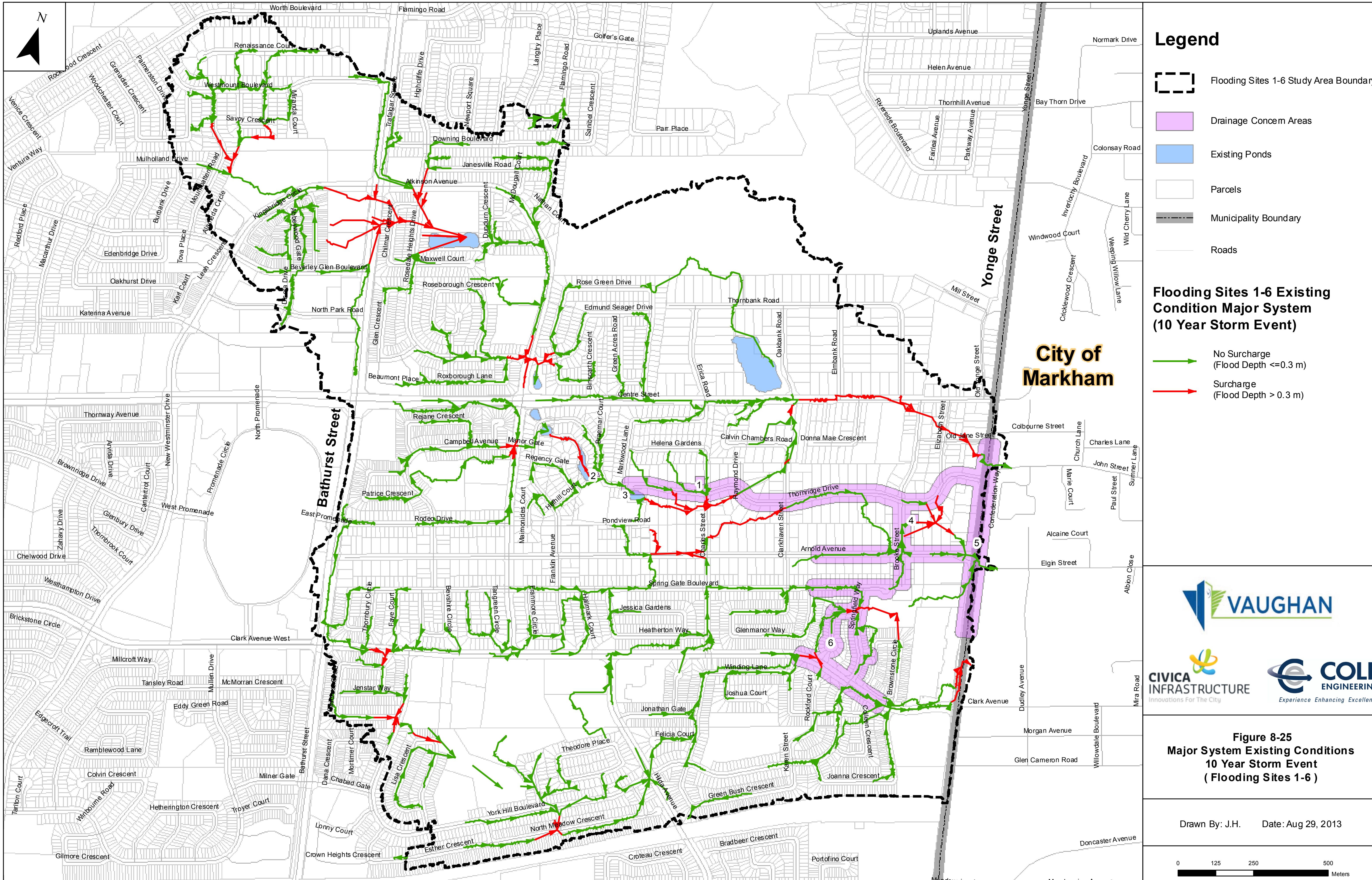
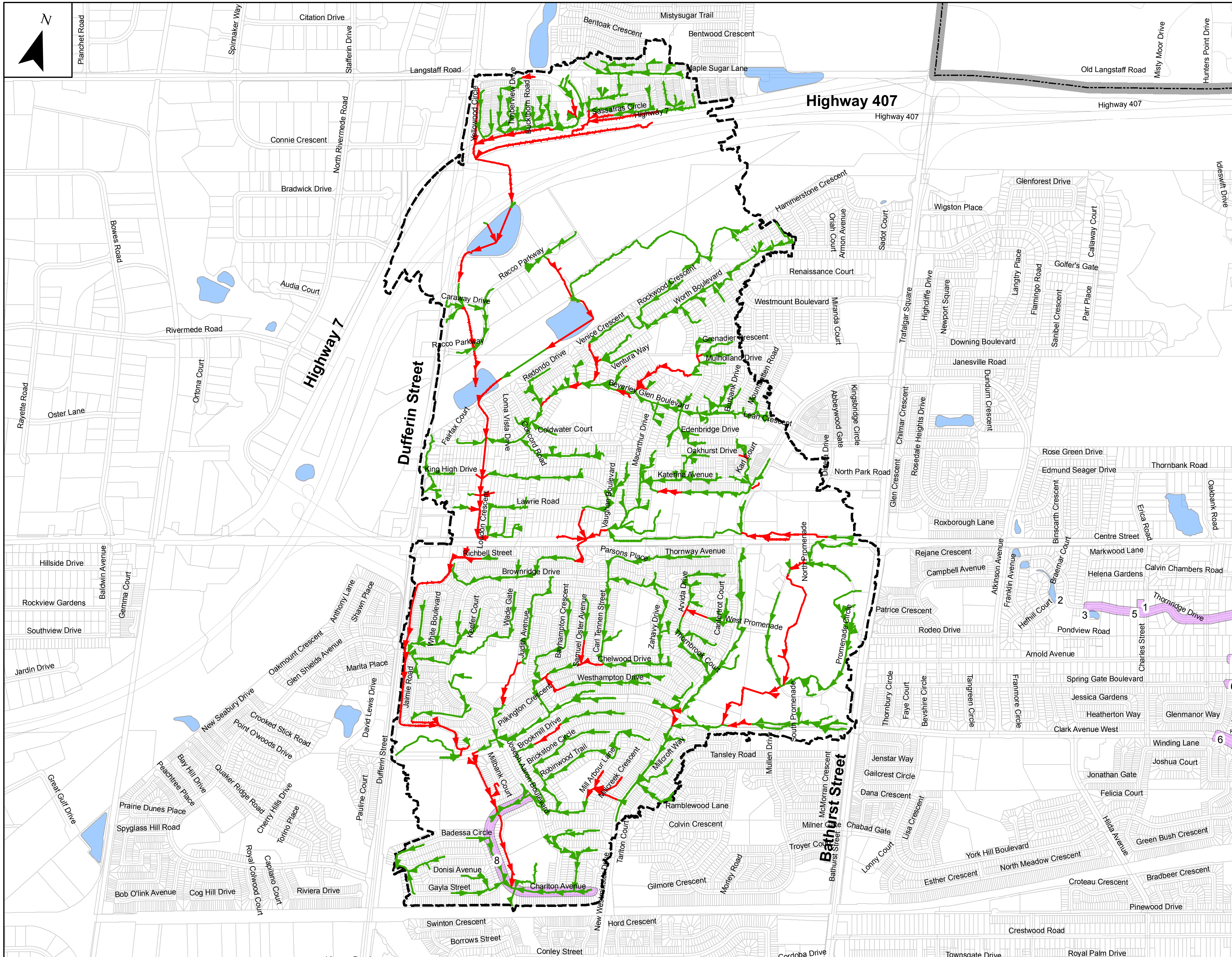


Figure 8-25
Major System Existing Conditions
10 Year Storm Event
(Flooding Sites 1-6)



Legend

- Flooding Sites 1-6 Study Area Boundary
- Drainage Concern Areas
- Existing Ponds
- Parcels
- Municipality Boundary
- Roads

Flooding Site 8 Existing Condition Major System (10 Year Storm Event)

- No Surcharge (Flood Depth <=0.3 m)
- Surcharge (Flood Depth > 0.3 m)

VAUGHAN

CIVICA INFRASTRUCTURE — Innovations For The City

COLE ENGINEERING — Experience Enhancing Excellence

Figure 8-26
Major System Existing Conditions
10 Year Storm Event
(Flooding Site 8)

Drawn By: J.H. Date: Aug 27, 2013

0 175 350 700 Meters

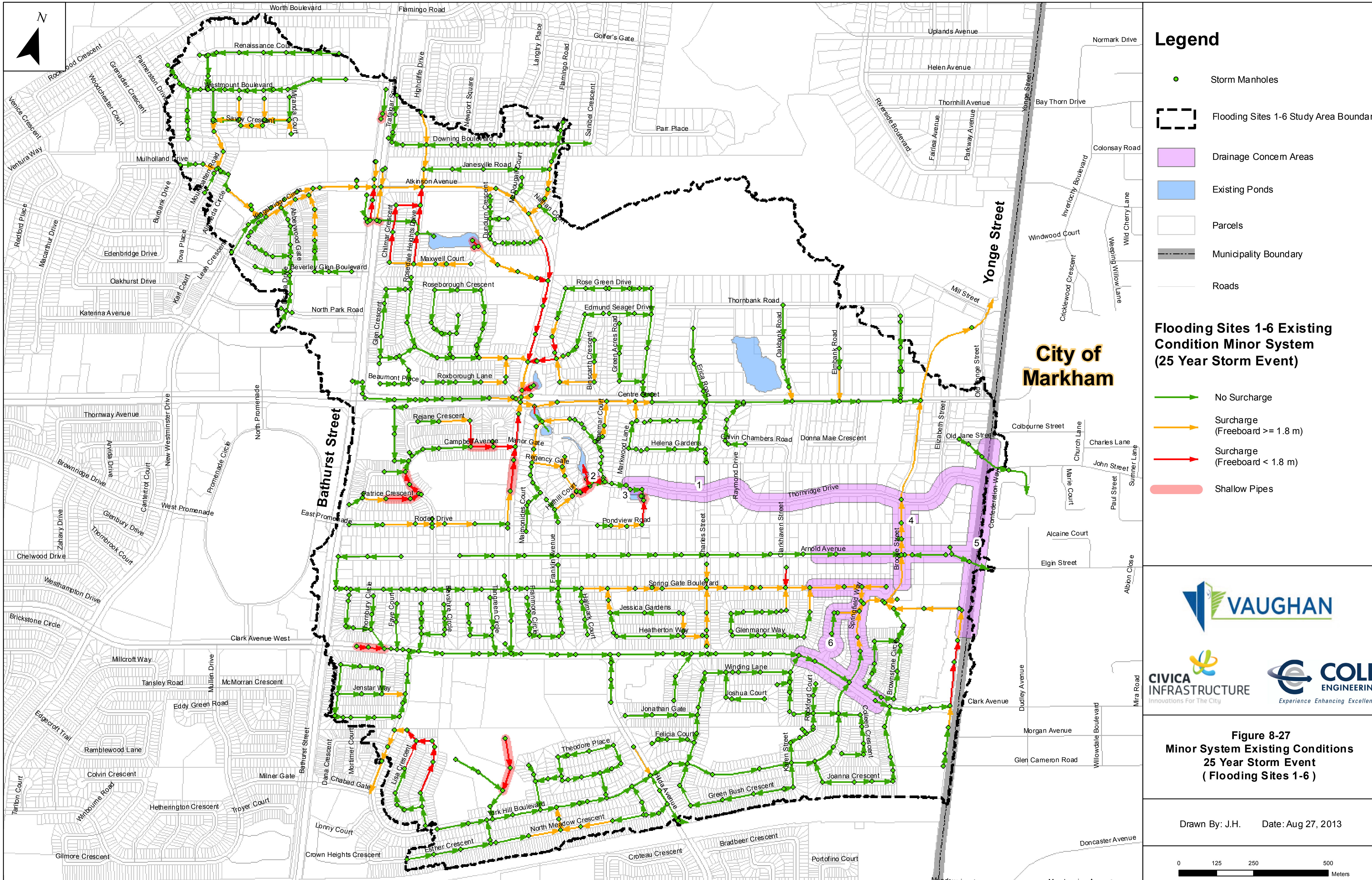


Figure 8-27
Minor System Existing Conditions
25 Year Storm Event
(Flooding Sites 1-6)

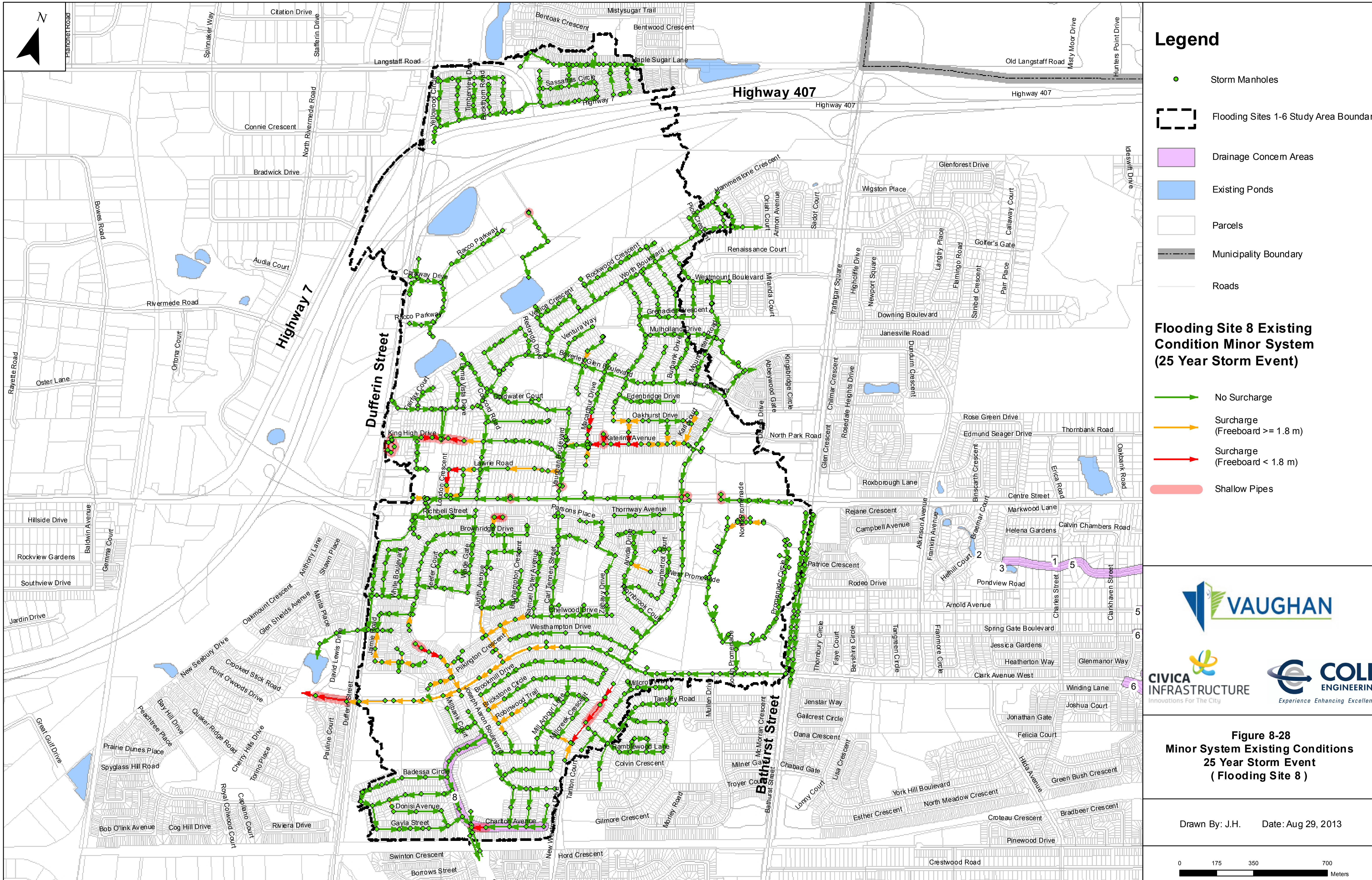
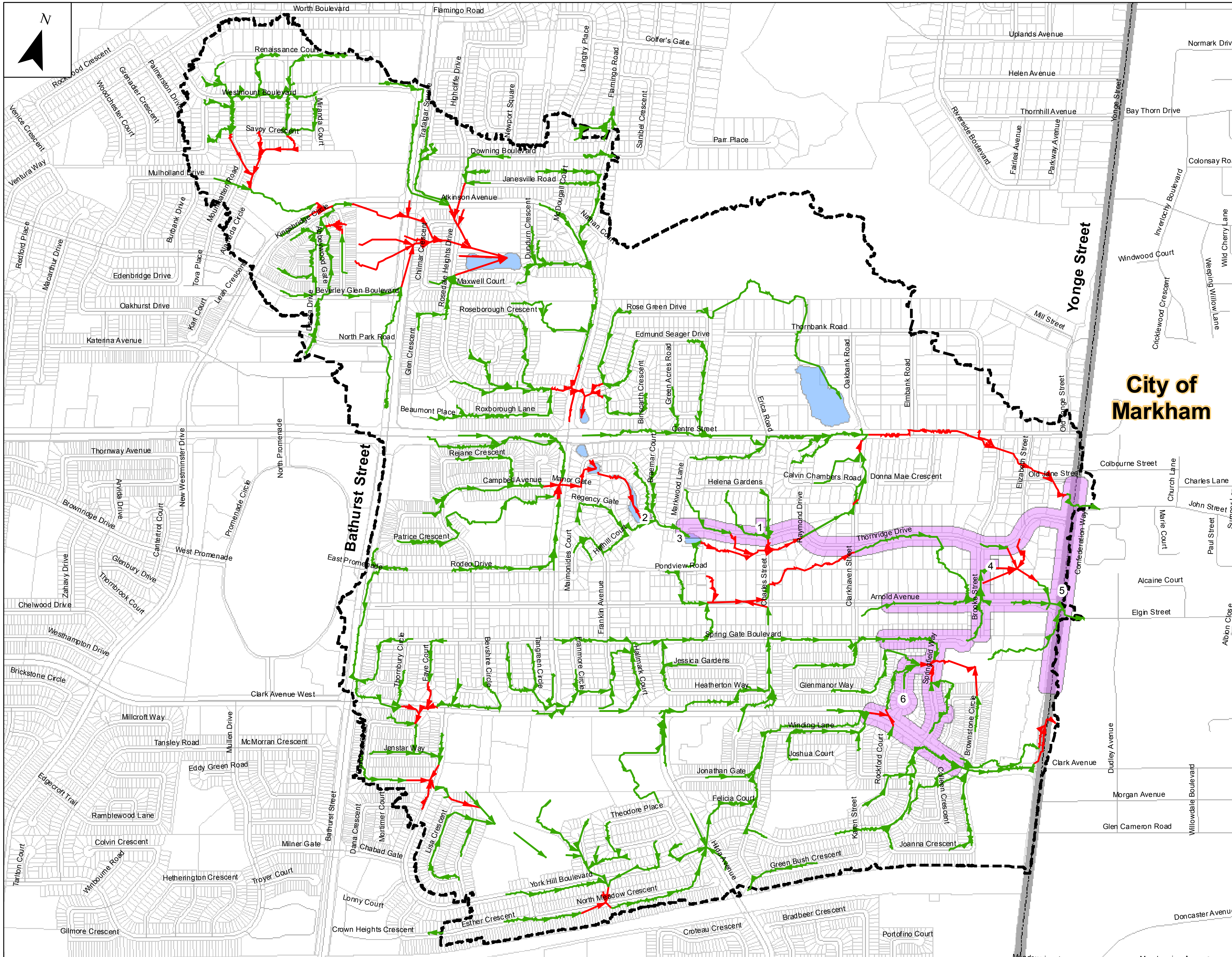


Figure 8-28
Minor System Existing Conditions
25 Year Storm Event
(Flooding Site 8)

Drawn By: J.H. Date: Aug 29, 2013



Legend

- Flooding Sites 1-6 Study Area Boundary
- Drainage Concern Areas
- Existing Ponds
- Parcels
- Municipality Boundary
- Roads

Flooding Sites 1-6 Existing Condition Major System (25 Year Storm Event)

- No Surcharge (Flood Depth <=0.3 m)
- Surcharge (Flood Depth > 0.3 m)

VAUGHAN

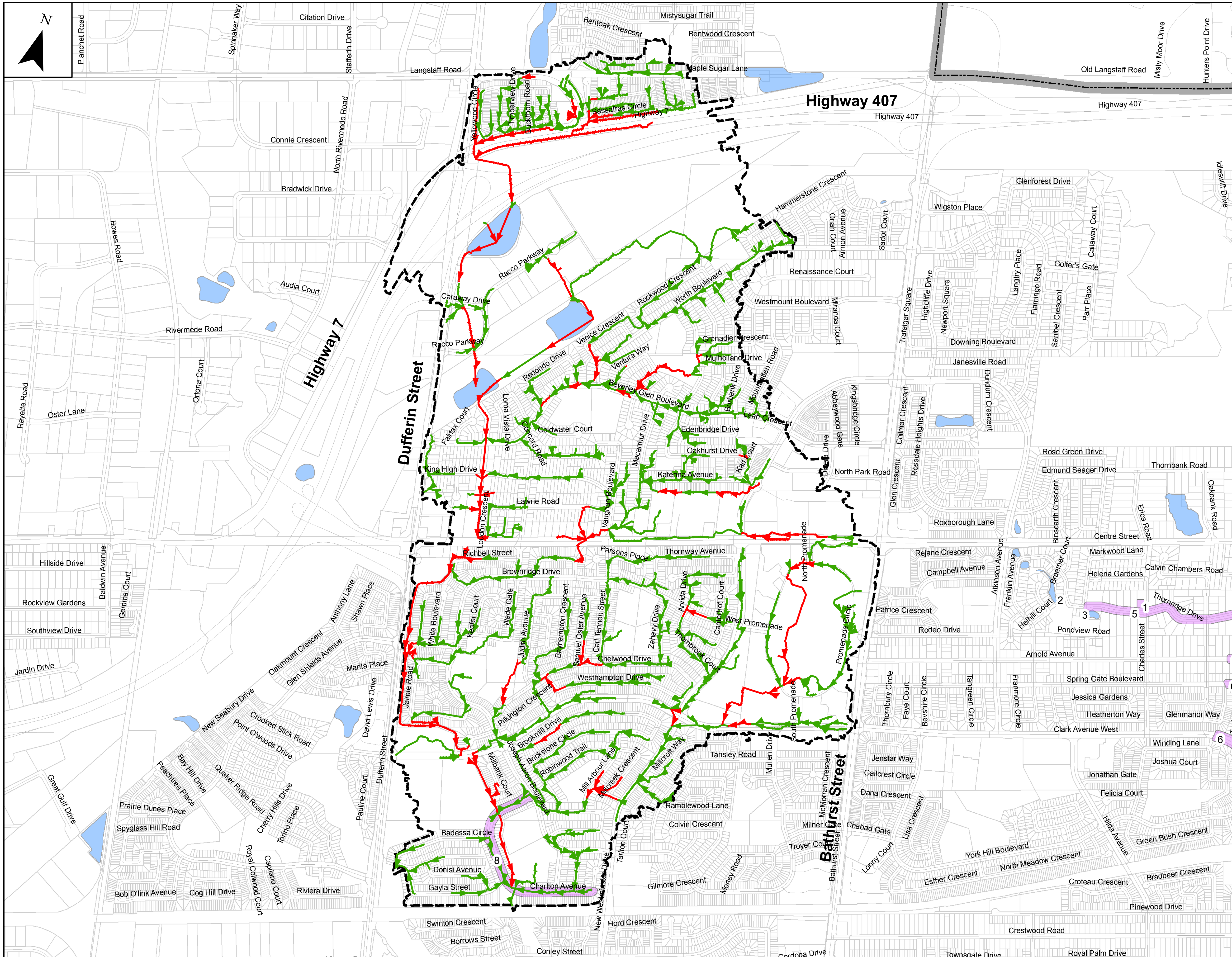
CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-29
Major System Existing Conditions
25 Year Storm Event
(Flooding Sites 1-6)

Drawn By: J.H. Date: Aug 29, 2013

0 125 250 500 Meters



Legend

Flooding Sites 1-6 Study Area Boundary

Drainage Concern Areas

Existing Ponds

Parcels

Municipality Boundary

Roads

Flooding Site 8 Existing Condition Major System (25 Year Storm Event)

No Surcharge (Flood Depth <=0.3 m)

Surcharge (Flood Depth > 0.3 m)

VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-30
Major System Existing Conditions
25 Year Storm Event
(Flooding Site 8)

Drawn By: J.H. Date: Aug 27, 2013

0 175 350 700
Meters

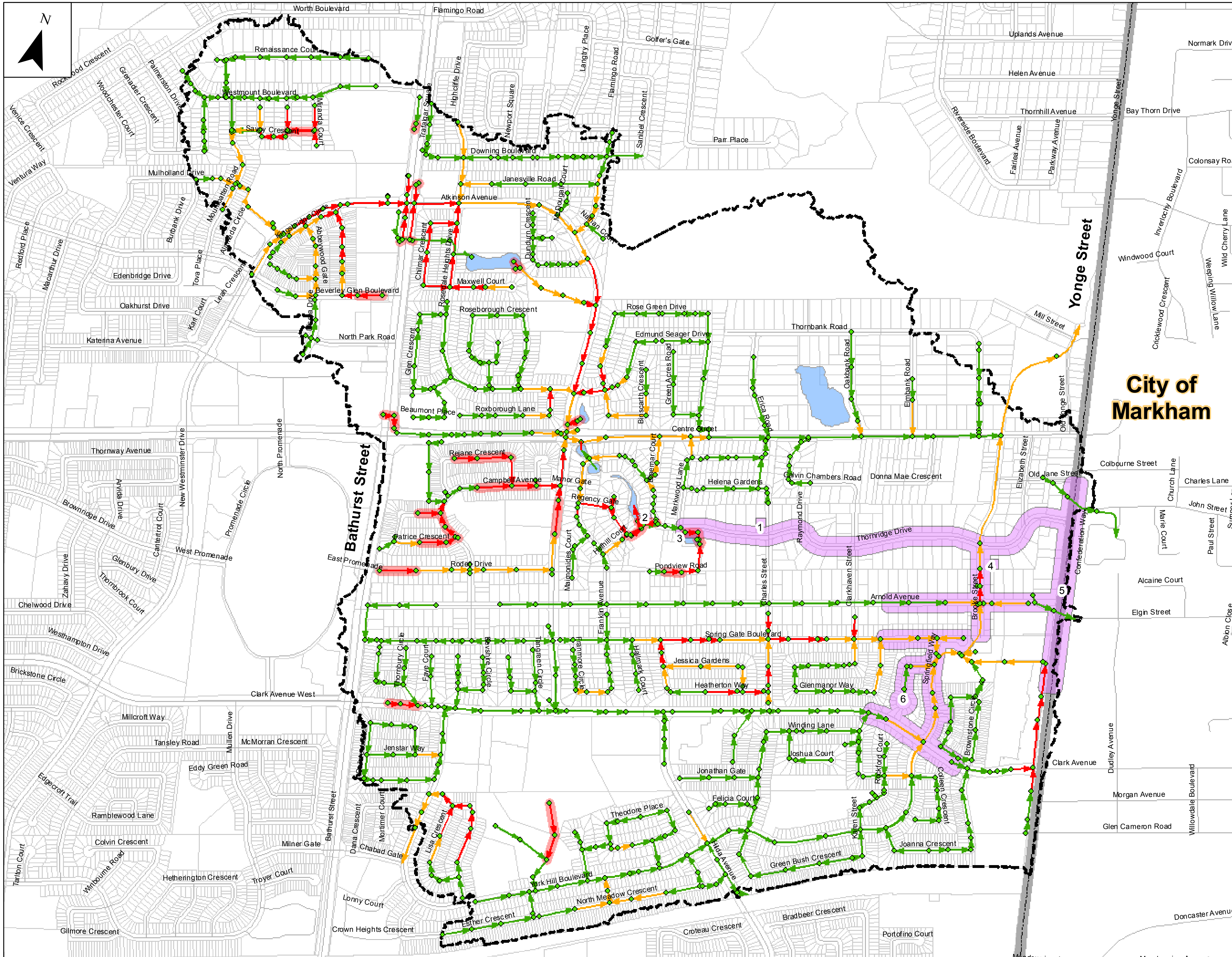
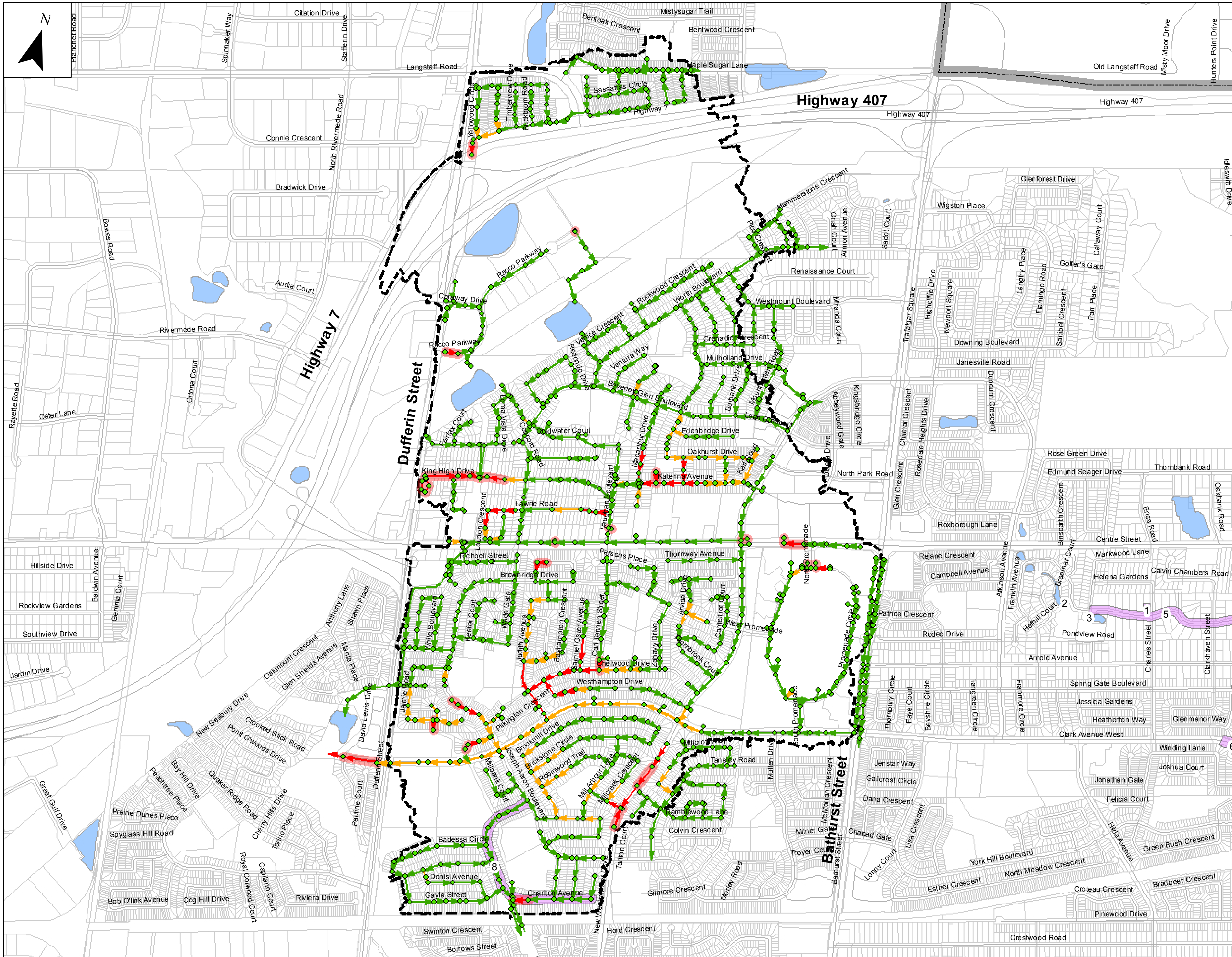


Figure 8-31
Minor System Existing Conditions
50 Year Storm Event
(Flooding Sites 1-6)

Drawn By: J.H. Date: Aug 27, 2013



Legend

- Storm Manholes
- Flooding Sites 1-6 Study Area Boundary
- Drainage Concern Areas
- Existing Ponds
- Parcels
- Municipality Boundary
- Roads

Flooding Site 8 Existing Condition Minor System (50 Year Storm Event)

- No Surcharge
- Surcharge (Freeboard >= 1.8 m)
- Surcharge (Freeboard < 1.8 m)
- Shallow Pipes

VAUGHAN

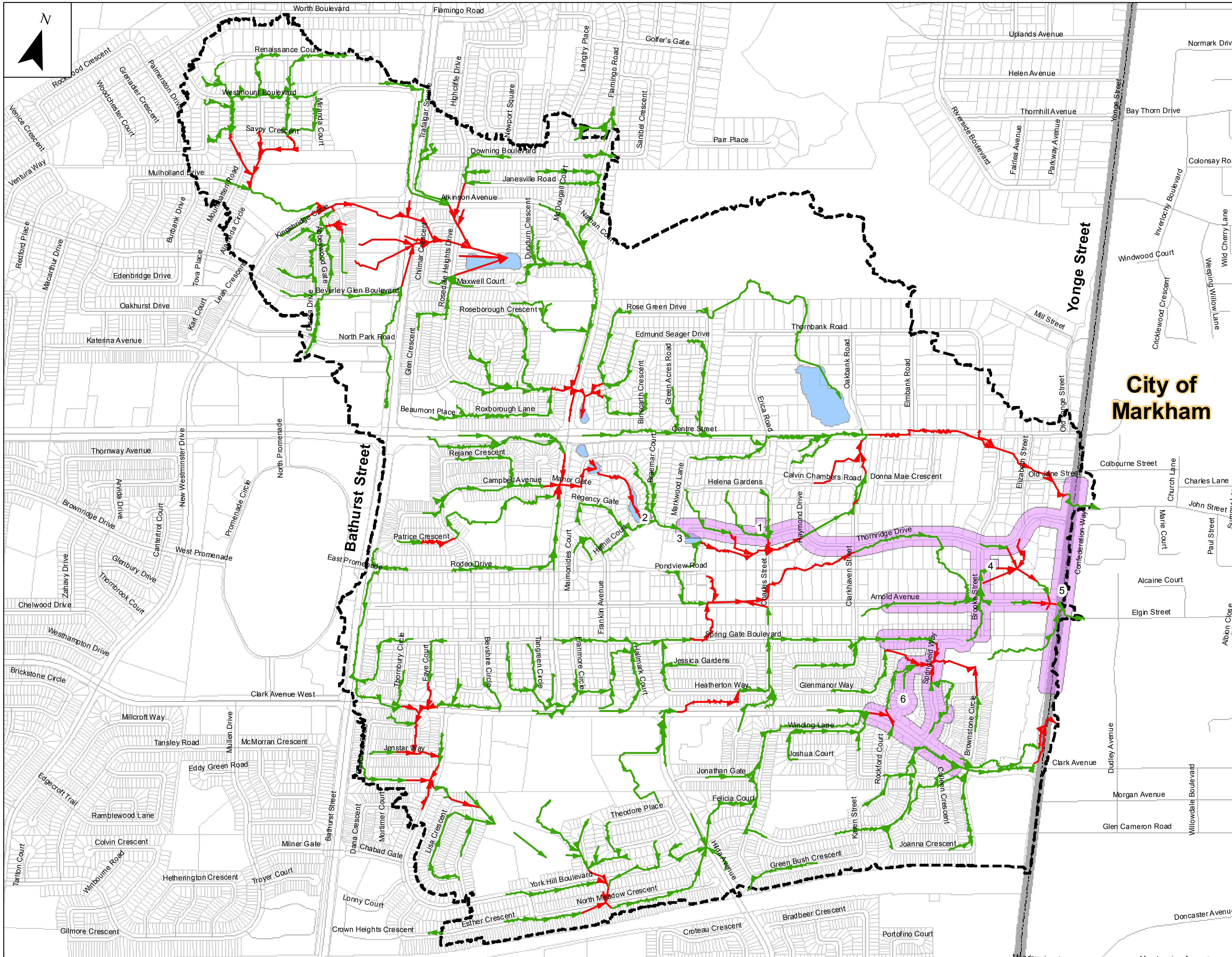
CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-32
Minor System Existing Conditions
50 Year Storm Event
(Flooding Site 8)

Drawn By: J.H. Date: Aug 29, 2013

0 175 350 700
Meters



Legend

- Flooding Sites 1-6 Study Area Boundary
- Drainage Concern Areas
- Existing Ponds
- Parcels
- Municipality Boundary
- Roads

Flooding Sites 1-6 Existing Condition Major System (50 Year Storm Event)

- No Surcharge (Flood Depth <=0.3 m)
- Surcharge (Flood Depth > 0.3 m)

VAUGHAN

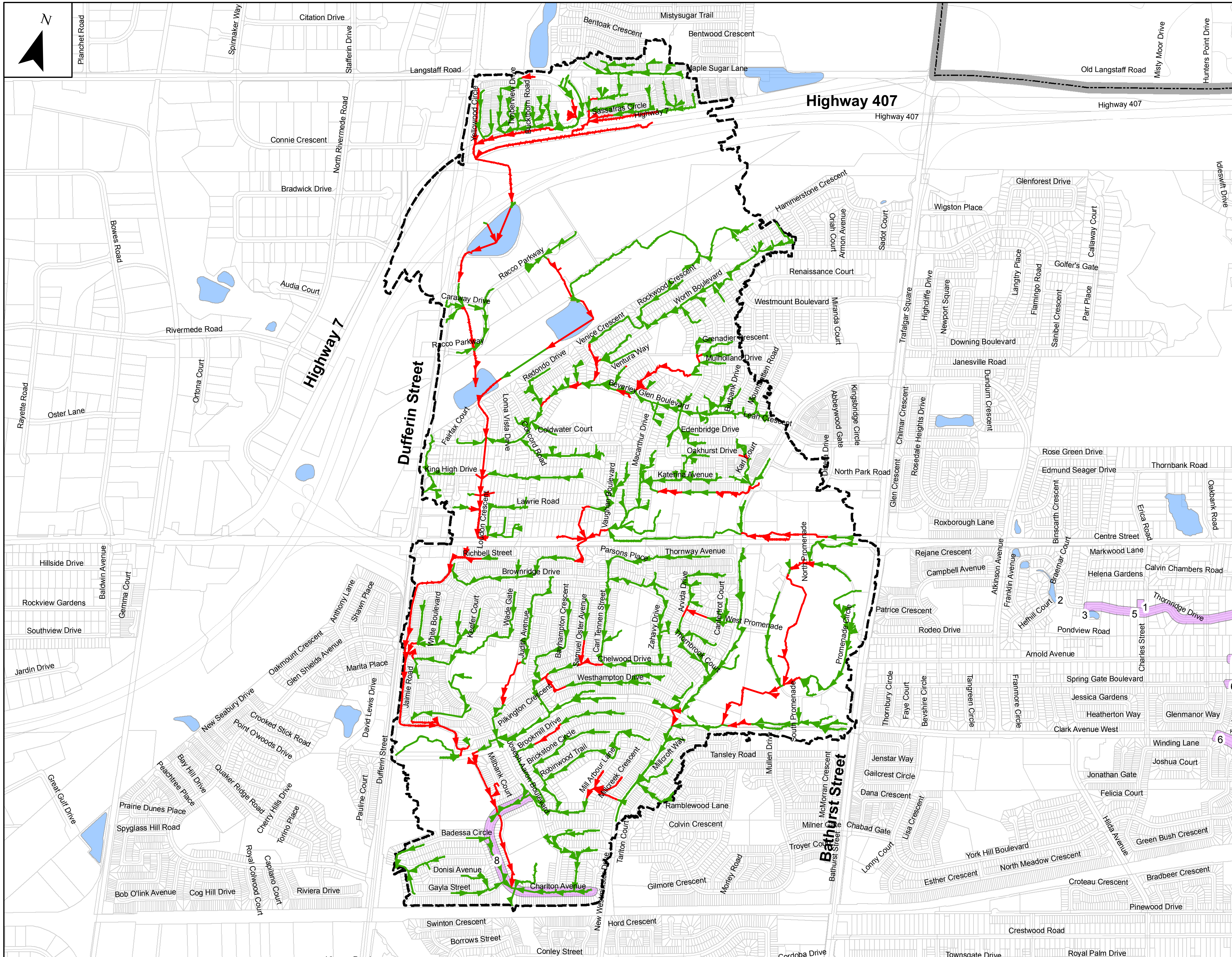
CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-33
Major System Existing Conditions
50 Year Storm Event
(Flooding Sites 1-6)

Drawn By: J.H. Date: Aug 29, 2013

0 125 250 500 Meters



Legend

- Flooding Sites 1-6 Study Area Boundary
- Drainage Concern Areas
- Existing Ponds
- Parcels
- Municipality Boundary
- Roads

Flooding Site 8 Existing Condition Major System (50 Year Storm Event)

- No Surcharge (Flood Depth <=0.3 m)
- Surcharge (Flood Depth > 0.3 m)

VAUGHAN

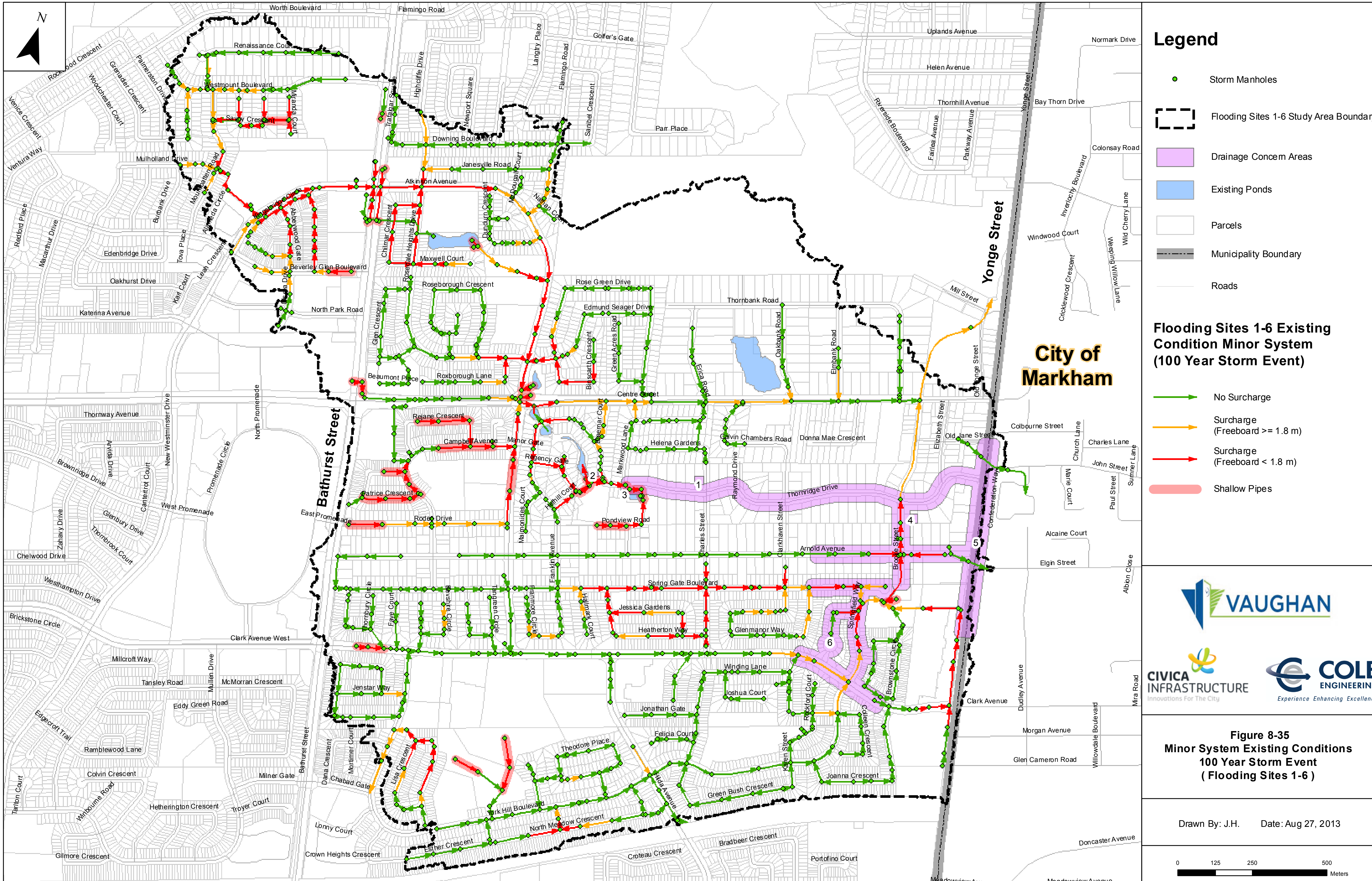
CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

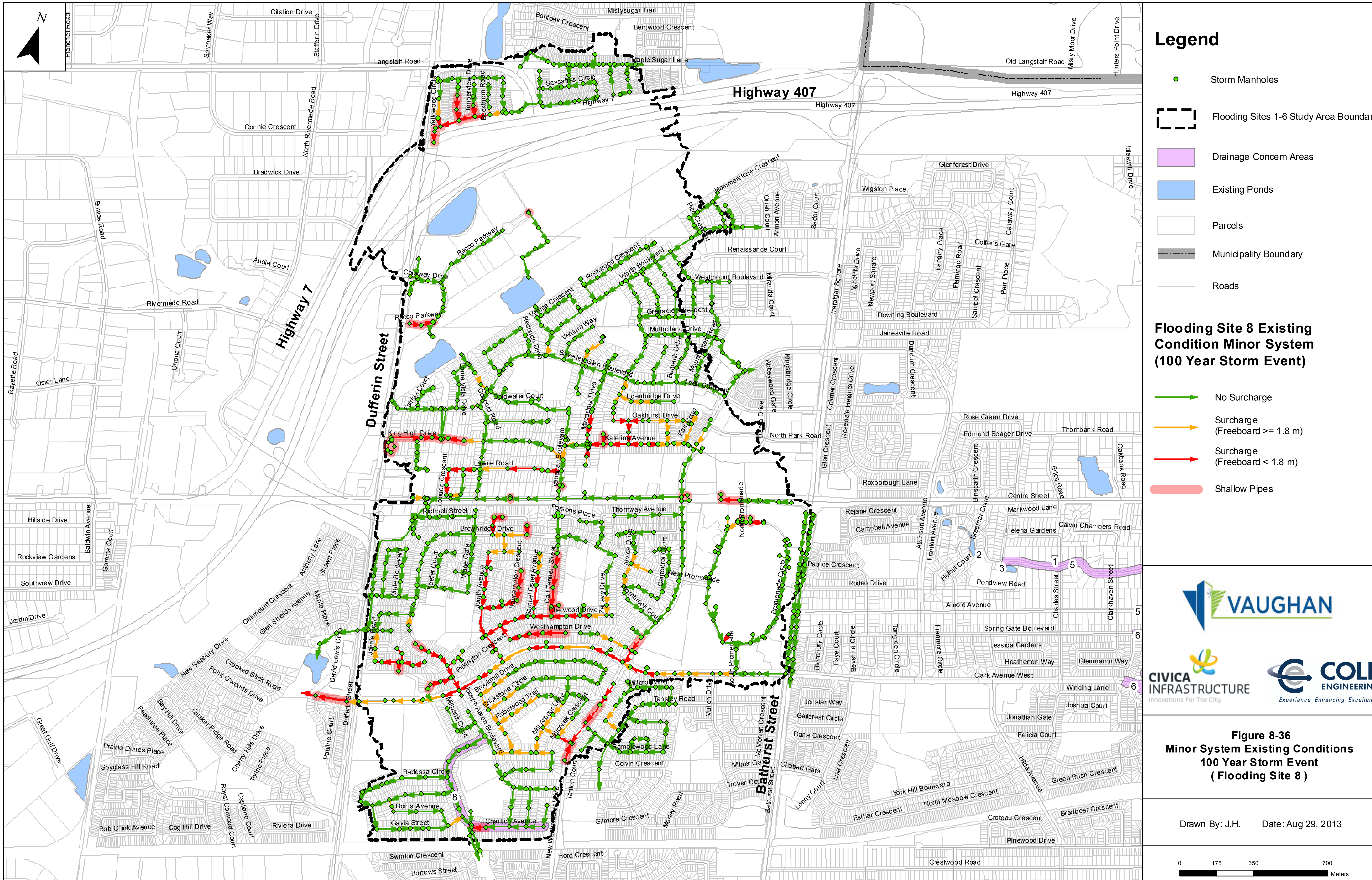
Figure 8-34
Major System Existing Conditions
50 Year Storm Event
(Flooding Site 8)

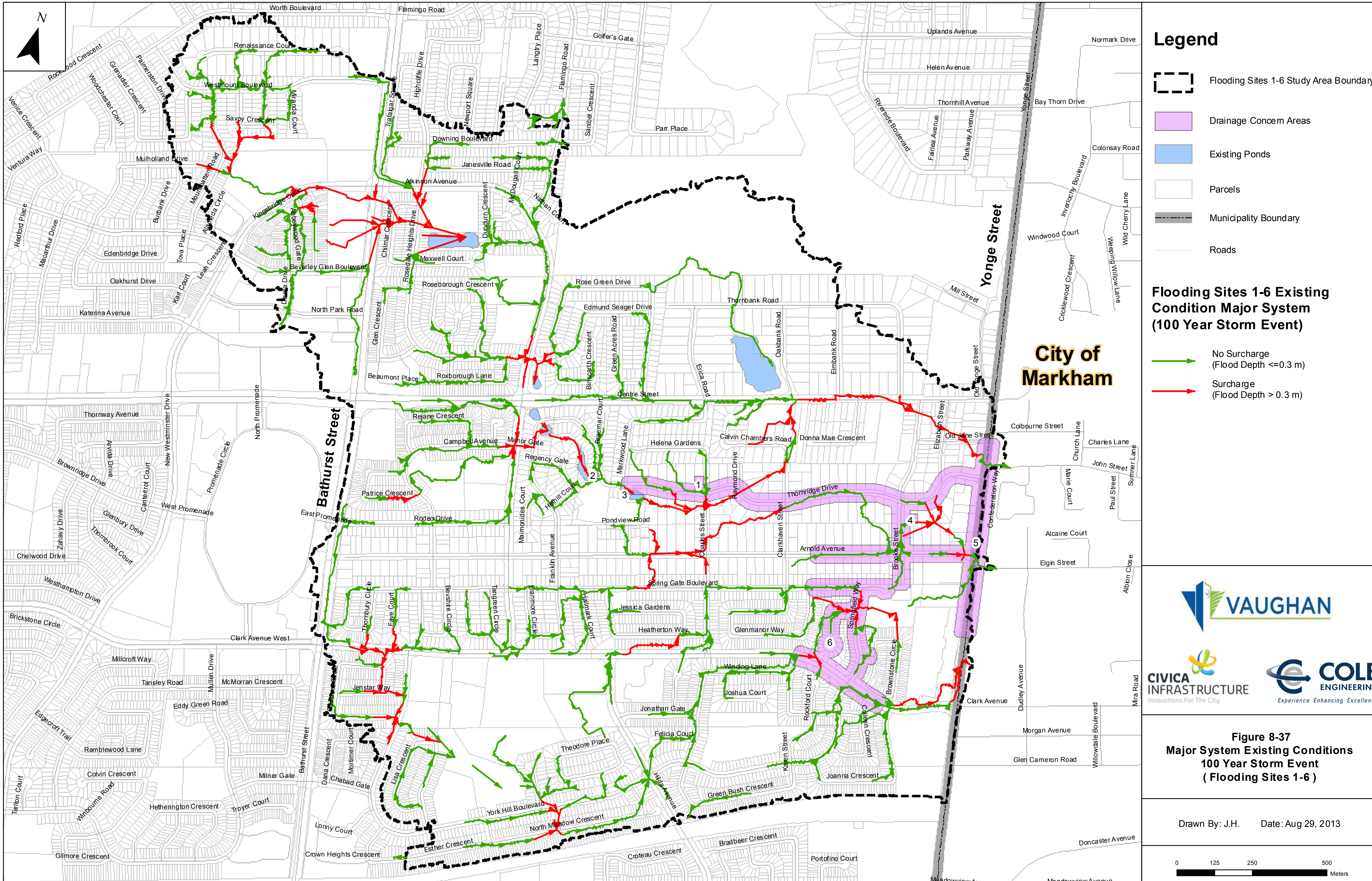
Drawn By: J.H. Date: Aug 27, 2013

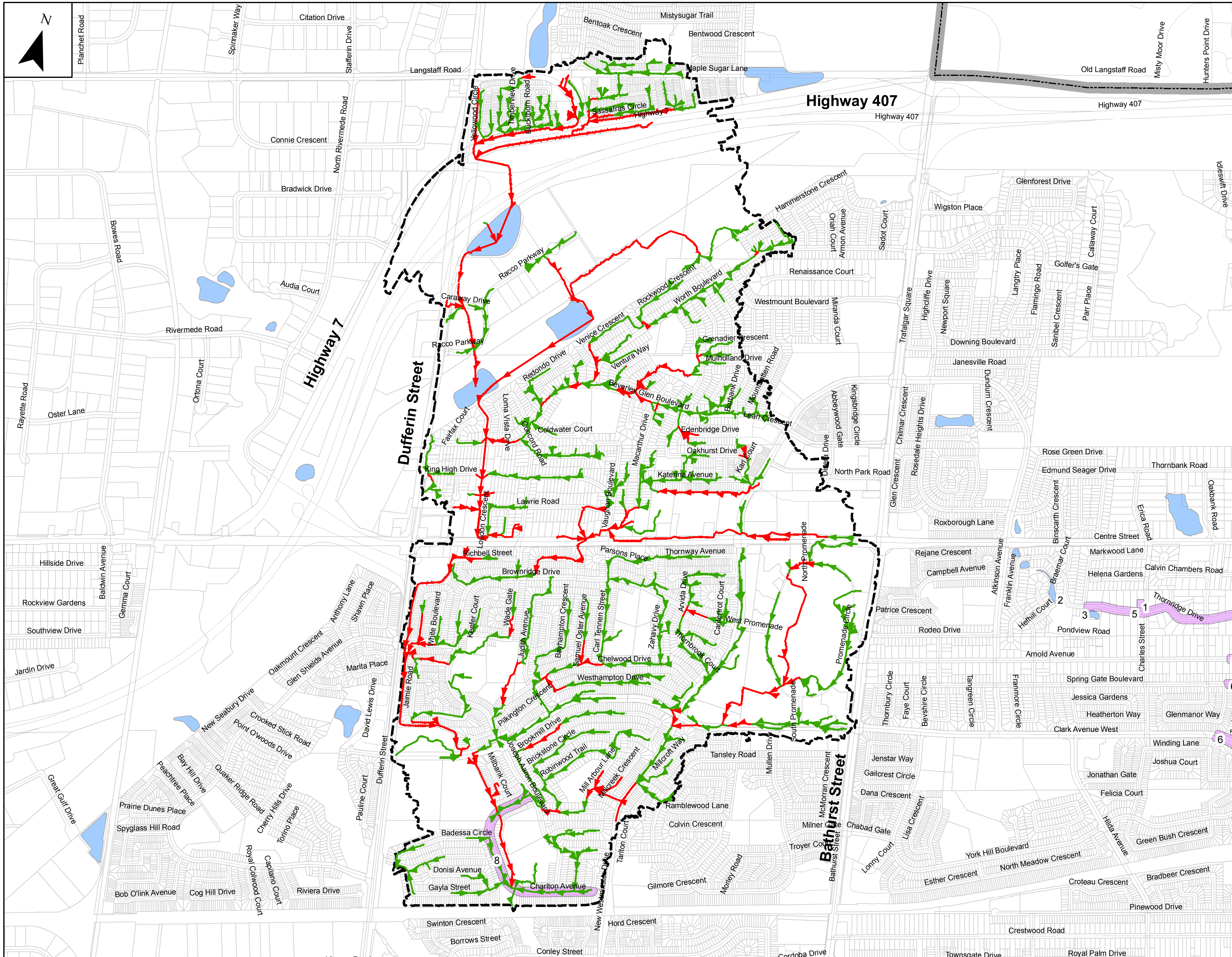
0 175 350 700
Meters



N
Legend
Storm Manholes
Flooding Sites 1-6 Study Area Boundary
Drainage Concern Areas
Existing Ponds
Parcels
Municipality Boundary
Roads
Flooding Sites 1-6 Existing Condition Minor System (100 Year Storm Event)
No Surcharge
Surcharge (Freeboard >= 1.8 m)
Surcharge (Freeboard < 1.8 m)
Shallow Pipes
VAUGHAN
CIVICA INFRASTRUCTURE
Innovations For The City
COLE ENGINEERING
Experience Enhancing Excellence
Figure 8-35
Minor System Existing Conditions
100 Year Storm Event
(Flooding Sites 1-6)
Drawn By: J.H.
Date: Aug 27, 2013
0
125
250
500
Meters
City of Markham
Yonge Street
Bathurst Street
Centre Street
Thornridge Drive
Arnold Avenue
Spring Gate Boulevard
Clark Avenue West
Atkinson Avenue
Beverley Glen Boulevard
Rose Green Drive
Thornbank Road
Confederation Way
Elgin Street
Clark Avenue
Worth Boulevard
Flamingo Road
1
2
3
4
5
6


N
Highway 407
Highway 7
Dufferin Street
Bathurst Street
Langstaff Road
Old Langstaff Road
Rivermede Road
Centre Street
Clark Avenue West
Legend
Storm Manholes
Flooding Sites 1-6 Study Area Boundary
Drainage Concern Areas
Existing Ponds
Parcels
Municipality Boundary
Roads
Flooding Site 8 Existing Condition Minor System (100 Year Storm Event)
No Surcharge
Surcharge (Freeboard >= 1.8 m)
Surcharge (Freeboard < 1.8 m)
Shallow Pipes
VAUGHAN
CIVICA INFRASTRUCTURE
Innovations For The City
COLE ENGINEERING
Experience Enhancing Excellence
Figure 8-36
Minor System Existing Conditions
100 Year Storm Event
(Flooding Site 8)
Drawn By: J.H.
Date: Aug 29, 2013
0
175
350
700
Meters


Legend
Flooding Sites 1-6 Study Area Boundary
Drainage Concern Areas
Existing Ponds
Parcels
Municipality Boundary
Roads
Flooding Sites 1-6 Existing Condition Major System (100 Year Storm Event)
No Surcharge (Flood Depth <=0.3 m)
Surcharge (Flood Depth > 0.3 m)
VAUGHAN
CIVICA INFRASTRUCTURE
Innovations For The City
COLE ENGINEERING
Experience Enhancing Excellence
Figure 8-37
Major System Existing Conditions
100 Year Storm Event
(Flooding Sites 1-6)
Drawn By: J.H.
Date: Aug 29, 2013
0
125
250
500
Meters
N
City of Markham
Bathurst Street
Yonge Street
Centre Street
Thornridge Drive
Spring Gate Boulevard
Clark Avenue West
Clark Avenue
Atkinson Avenue
Beverley Glen Boulevard
York Hill Boulevard
Worth Boulevard
Flamingo Road
Confederation Way
1
2
3
4
5
6



Legend

- Flooding Sites 1-6 Study Area Boundary
- Drainage Concern Areas
- Existing Ponds
- Parcels
- Municipality Boundary
- Roads

Flooding Site 8 Existing Condition Major System (100 Year Storm Event)

- No Surcharge (Flood Depth <=0.3 m)
- Surcharge (Flood Depth > 0.3 m)

VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-38
Major System Existing Conditions
100 Year Storm Event
(Flooding Site 8)

Drawn By: J.H. Date: Aug 27, 2013

0 175 350 700
Meters

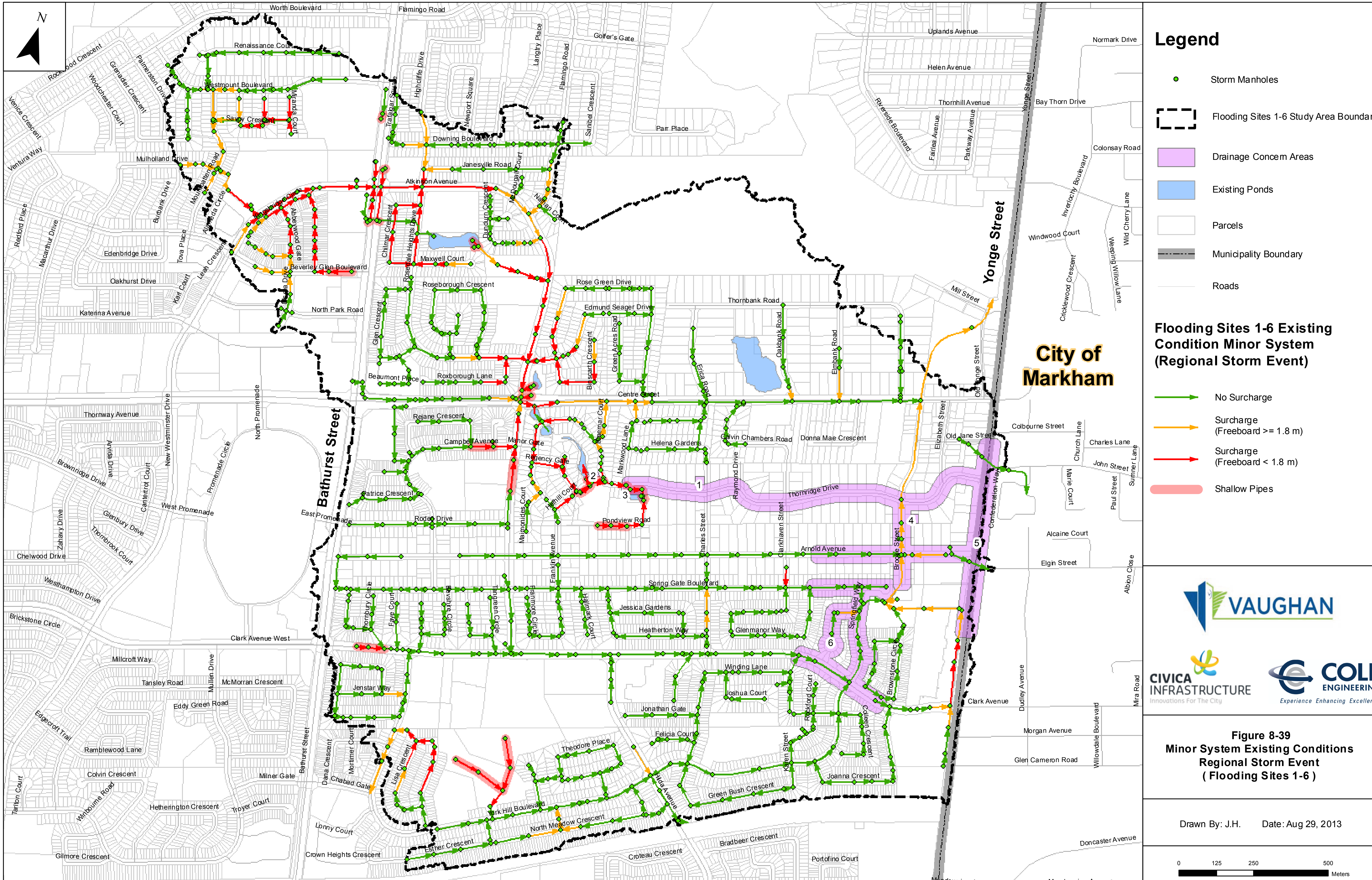
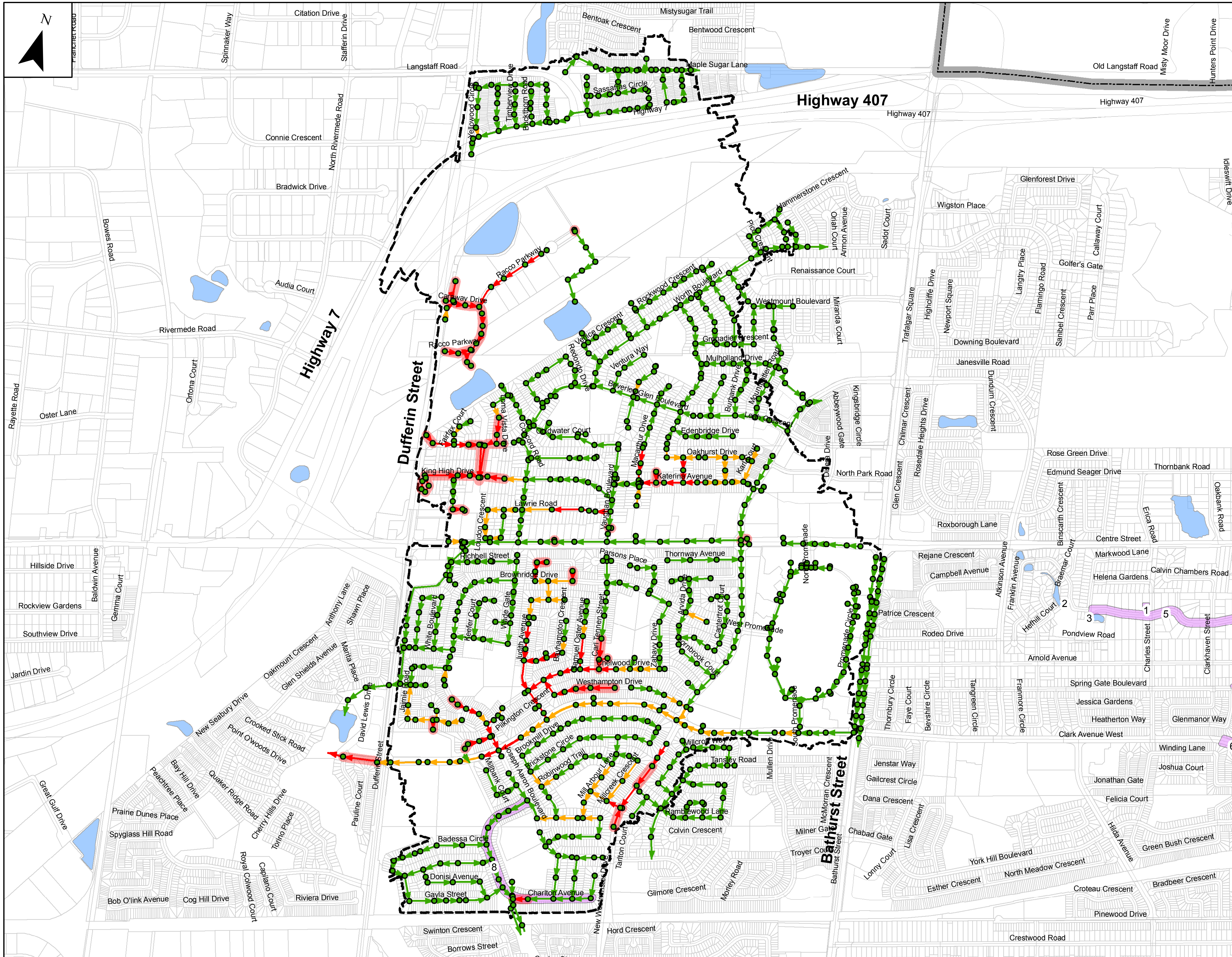


Figure 8-39
Minor System Existing Conditions
Regional Storm Event
(Flooding Sites 1-6)

Drawn By: J.H. Date: Aug 29, 2013



Legend

- Storm Manholes
- Flooding Sites 1-6 Study Area Boundary
- Drainage Concern Areas
- Existing Ponds
- Parcels
- Municipality Boundary
- Roads

Flooding Site 8 Existing Condition Minor System (Regional Storm Event)

- No Surcharge
- Surcharge (Freeboard >= 1.8 m)
- Surcharge (Freeboard < 1.8 m)
- Shallow Pipes

VAUGHAN

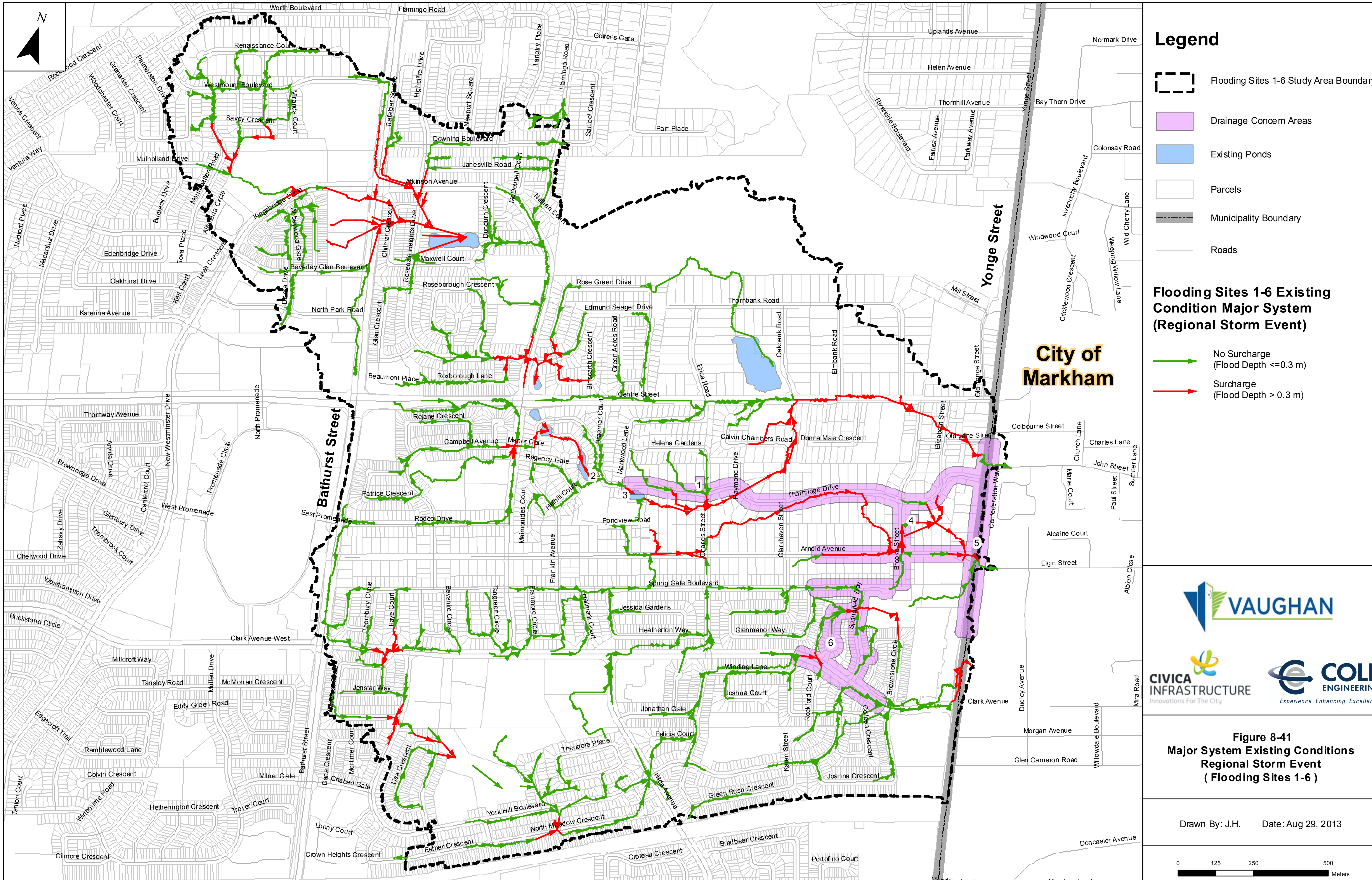
CIVICA INFRASTRUCTURE
Innovations For The City

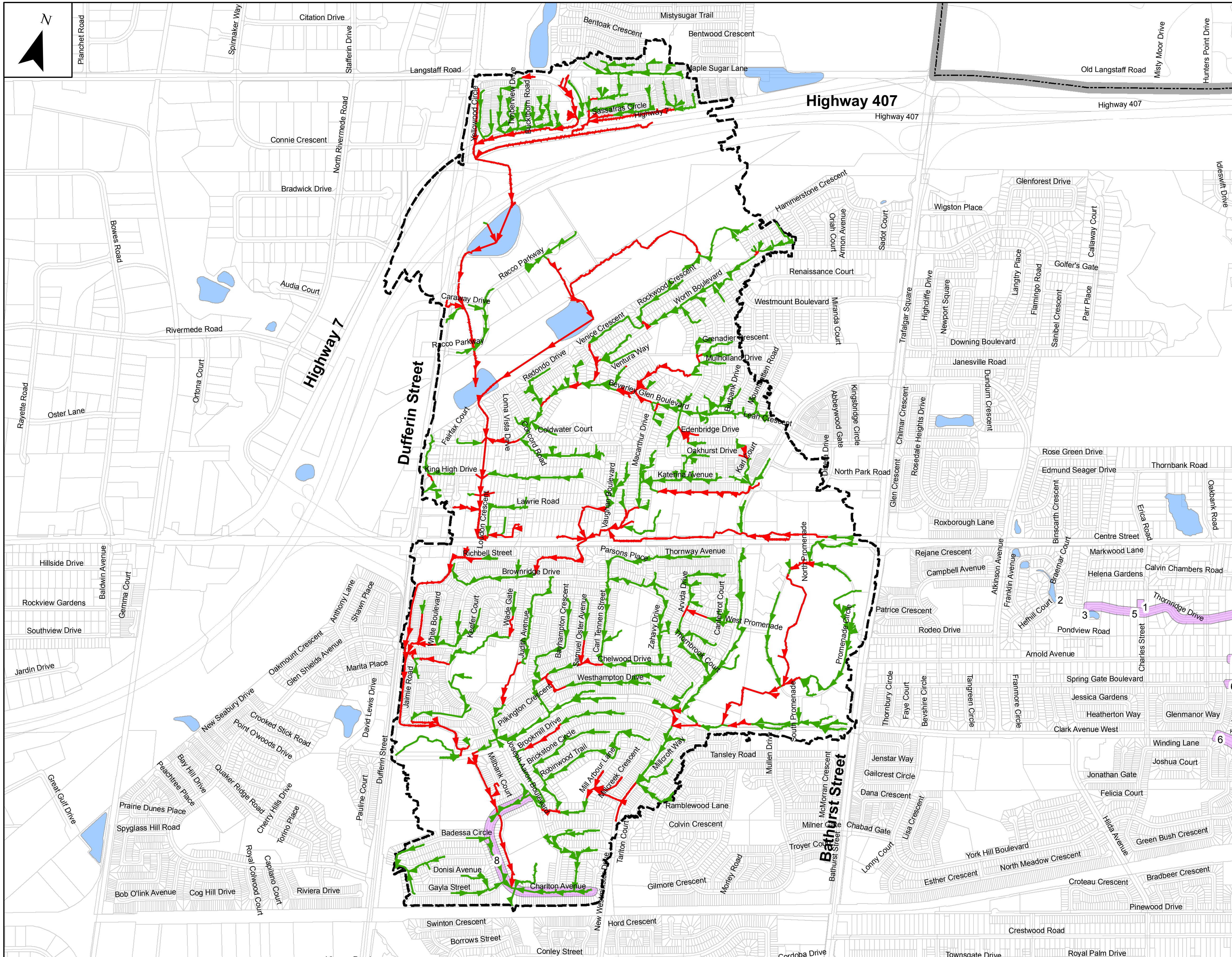
COLE ENGINEERING
Experience Enhancing Excellence

Figure 8-40
Minor System Existing Conditions
Regional Storm Event
(Flooding Site 8)

Drawn By: J.H. Date: Aug 29, 2013

0 175 350 700 Meters


N
Legend
Flooding Sites 1-6 Study Area Boundary
Drainage Concern Areas
Existing Ponds
Parcels
Municipality Boundary
Roads
Flooding Sites 1-6 Existing Condition Major System (Regional Storm Event)
No Surcharge (Flood Depth <=0.3 m)
Surcharge (Flood Depth > 0.3 m)
City of Markham
Bathurst Street
Yonge Street
1
2
3
4
5
6
VAUGHAN
CIVICA INFRASTRUCTURE
Innovations For The City
COLE ENGINEERING
Experience Enhancing Excellence
Figure 8-41
Major System Existing Conditions
Regional Storm Event
(Flooding Sites 1-6)
Drawn By: J.H.
Date: Aug 29, 2013
0
125
250
500
Meters



Legend

Flooding Sites 1-6 Study Area Boundary

Drainage Concern Areas

Existing Ponds

Parcels

Municipality Boundary

Roads

Flooding Site 8 Existing Condition Major System (Regional Storm Event)

No Surcharge (Flood Depth <=0.3 m)

Surcharge (Flood Depth > 0.3 m)

VAUGHAN

CIVICA INFRASTRUCTURE Innovations For The City

COLE ENGINEERING Experience Enhancing Excellence

Figure 8-42
Major System Existing Conditions
Regional Storm Event
(Flooding Site 8)

Drawn By: J.H. Date: Aug 29, 2013

0 175 350 700 Meters

9.0 Flood Control Alternatives

Flood control alternatives have been selected by the City for key locations that reported flooding during the August 19, 2005 storm event. Remedial measures are considered for high flood potential, confirmed through modelling and observations. It is possible that additional locations may be identified in the future, subject to improvements in digital elevation and sewer data.

9.1. Development and Analysis of Alternative Remedial Measures

Table 9.1 lists the source, conveyance and end-of-pipe measures considered and describes the advantages, disadvantages and applicability of each

9.1.1. Source Control Measures

The main advantages of source control measures are that they encourage storm water infiltration, reduce requirements for additional sewer system capacity, and can often be more affordable compared to other alternatives. The main disadvantage is that, in most cases, implementing does not provide a complete solution for the required level of flood protection; in this case, the 1 in 100 year and Regional design storms. In addition, lot level control measures are subject to the homeowner's initiative, and their success is subject to their implementation and maintenance by the homeowners. These measures are not considered in the analysis; however, implementation of source control measures is recommended for consideration over the entire study area. Implementation of source control measures will reduce the storm flows to the sewer system resulting in a further reduction of water levels in both the major and minor systems than the levels calculated through the analysis of the implementation of other relief measures. Roof leader disconnection, for example, could be applied throughout the study area as this is a cost-effective control measure which requires little or no disruption.

9.1.2. Conveyance Measures

The sewer twinning, diversion and channelization options have been considered under the 1 in 100 year and Regional events. Note that, because the cost of replacing sewers is higher than adding to the existing sewers, sewer replacement would only be considered in areas without adequate space to add a new sewer. "Flow balancing" through ICDs or providing additional inlets can be more cost effective than constructing new sewers and channels. It is critical when providing conveyance alternatives that the downstream drainage system is assessed to ensure that the potential increase in peak flows with the proposed solution does not increase the risk of flooding downstream.

9.1.2.1 Conveyance and Flow Balancing

Flow balancing refers to the improvement of drainage system performance by utilizing available surface drainage system capacity to alleviate sewer system overload, and vice-versa. This is achieved by introducing ICDs upstream of overloaded storm sewers or new inlets to reduce surface overloading.

Table 9.1 – Remedial Measures

Control Type	Control Measure	Advantage	Disadvantage	Applicability
Source Control	Roof leader disconnection	Diverts roof runoff from storm sewers thereby reducing the peak flows and volume of runoff.	Requires proper soil conditions (sandy) and proper grading to be effective.	Applicable in areas where suitable soil conditions exist. To be assessed on a sewershed basis.
	Soak away pits	Effective in reducing stormwater volume entering the stormwater system by redirecting roof drainage to an underground infiltration trench.	Implementation costs for retrofit would be high due to disruption, restoration of property.	Difficult to implement in already developed areas. Limited effectiveness for basement flood remediation for large storm events.
	Porous pavement	Effective in reducing stormwater runoff by promoting infiltration. Significantly reduces surface runoff contaminant load.	Requires the initiative of private property owners.	This control measure is feasible since the study area consists of mainly asphalt driveways. A government incentive program may increase the interest of private property owners. Limited effectiveness for basement flood remediation for large storm events.
	ICD in large paved areas	Highly effective in reducing downstream flow rates by maintaining runoff as surface flow in areas where storm pipes are undersized.	Total runoff or volume not reduced as flow occurs at a controlled rate over a longer time period. Ponding cannot exceed 300 mm depth under most conditions.	Difficult to implement for retrofit or improvement projects due to existing site constraints (ownership). A government incentive program may increase the interest of private property owners. Will work only if there is surface flow outlet with adequate capacity and no sags in the street.
	Backflow prevention with sump pump	Effective in preventing stormwater from foundation drains and roof leader from entering the storm system.	Implementation costs for retrofit will be high due to disruption, damage and restoration of property.	Applied in situations where basement flooding exists. Would be responsibility of property owner. A government incentive program may increase interest of homeowners.

Table 9.1 – Remedial Measures (Continued)

Control Type	Control Measure	Advantage	Disadvantage	Applicability
	Sump pump for foundation drains	Effective in reducing inflow into the storm sewer from foundation drains.	Implementation costs for retrofit will be high due to disruption, restoration of property.	Applied in situations where basement flooding exists. A government incentive program may increase interest of homeowners
	Lot grading	Effective in reducing storm runoff by promoting recharge and natural infiltration.	Difficult to implement for retrofit.	This control measure is not feasible for this project since the study area is fully developed and lot regarding will be very costly. Would be the responsibility of property owner.
	Rain barrel	Effective in reducing storm runoff by promoting re-use of roof runoff	In order for it to operate effectively proper installation and modification must be made. Requires the initiative of homeowners.	Applied in situation where basement flooding exists due to local grading deficiencies. Would be the responsibility of the property owner. A government incentive program may increase the interest of homeowners
Conveyance	Increase inlet capacity by adding catchbasins, inlets or trench drains	Effective in rapidly conveying runoff from the surface into the storm sewer system.	High capital costs and potential construction constraints.	Applied where the sewer system has extra capacity and overland flow causes flooding. Reduces overland flow depth.
	ICDs	Effective in controlling the stormwater entering the storm system.	Water ponding will occur in open areas.	Applied in situations where sewer surcharge causes basement flooding and the major drainage system has adequate outlet capacity and there are no road sags.

Table 9.1 – Remedial Measures (Continued)

Control Type	Control Measure	Advantage	Disadvantage	Applicability
	System storage (in-line / off-line sewers)	Effective in regulating / moderating peak flows in locations where the capacity of a sewer is inadequate.	Costs can vary significantly depending on sewer depth and the presence of bedrock.	Applied in situations where head and space in the street are available. Most effective if the downstream sewer system does not have adequate capacity to convey the peak flow. Land / space requirements can limit the application of in-line / off-line storage.
	Storm relief sewers	Effective in preventing surcharge of existing storm sewer system.	High capital cost due to construction constraints.	Applied in situations where storm sewer is undersized.
	Diversion of the major overland flow through channelization	Effective in reducing the inflow of runoff into the storm sewer by re-directing runoff into channels / swales.	Difficult to implement in urbanized areas due the limited availability of open / grassed areas.	Applied in situations where overland flow route or natural areas are available.
End-of-Pipe	Provide SWM facilities	Effective in controlling stormwater downstream by releasing runoff at a controlled rate. Lower cost than subsurface tanks.	The footprints of SWM facilities occupy a significant amount of space.	SWM facilities are applicable for this project in areas with available open space.
	Underground storage tanks	Effective in controlling stormwater downstream by releasing runoff at a controlled rate.	Potentially high costs associated with excavation and construction.	Underground / subsurface tanks are applicable in areas where there is limited availability of above ground storage space.

9.1.2.2 Storm Sewer Twinning and Improved Channelization

Sewer twinning refers to the installation of additional new storm sewers of equal or greater size to the existing, so as to eliminate high flood potential due to minor system overloading. Optimization of the storm sewer size will occur at the detailed design stage. In many cases, the new twin sewer is up-sized compared with the existing storm sewer to relieve the overloaded condition. In this analysis, the new proposed sewer is interconnected with the existing sewer at manholes; hence, the flow is balanced and the water level or HGL is the same in the two (2) sewers. The main advantage of this alternative is that it provides the most effective and reliable measure to eliminate basement flooding. Some of the disadvantages include the increase in the flows and the potential impact on the downstream receiving systems, requirement of available space in existing streets (which are crowded with utilities and services in some areas), the inconvenience to the residents' due to construction activities in the roads, and the relatively high costs.

Similar to how storm sewer twinning can reduce the flood risk potential in the minor system, the diversion of the major overland flow through channelization can help alleviate major system flooding potential. The major overland flows in the study area can be controlled by redirection towards an overland flow diversion / channel / swale. This can be effective for reducing the amount of runoff into the storm sewer system by providing an alternate overland flow route. The difficulty with implementing overland flow routes through engineered channels is the availability of open space.

9.1.3. End-of-Pipe Measures

This alternative provides system storage in key locations within the major and minor storm water system. Storage facilities attenuate flows by holding and releasing at a reduced rate, alleviating pressure on the downstream conveyance system. Storage is provided online or offline in subsurface tanks or conduits or above ground through the use of SWM ponds. Surface ponding is generally less expensive than subsurface facilities, but requires open space, which is normally provided in park settings. Dry ponds serving as overflow / storage facilities have the advantage of being utilized as multi-use facilities.

The main advantage of this alternative is that it provides basement flooding protection and reduces flow rates downstream. It is most effective in cases where the downstream system does not have conveyance capacity and space is readily available. A disadvantage of this alternative includes difficulty in acquiring land in existing built up urban environments and the costs associated with building and maintaining ponds or storage facilities. Storage alternatives, both subsurface and SWM ponds, typically require relatively more expensive capital and operation / maintenance costs compared to other alternatives. Due to the lack of readily available space for surface storage, these types of solutions were identified conceptually and would be subject to further evaluation at the pre-design stage considering the area and property ownership constraints and opportunities at that time.

9.1.3.1 Analysis of Stormwater Management Pond and Other Storage

The analysis approach for storage solutions uses the available data from the GIS database plus additional data processing during this study to evaluate the system performance and identify the best approach to address drainage system deficiencies. It is assumed that a more detailed analysis will be carried-out prior to the detailed design stage in order to:

- Optimize the type, sizing and location of ICDs and sizing and allocation of new inlets into the minor system and their connection to existing or new sewer segments;
- Confirm sewer system invert elevations from plan and profile drawings or field surveys for those locations where invert interpolation was required during the study;
- Confirm conveyance alignment and method i.e., via sewer or overland flow; and,
- Optimization of size and method of storage (underground / surface or SWM pond).

9.2. Previous Studies

Other studies have been conducted in the Thornhill area which provided specific flood remediation recommendations. These recommendations have been considered when determining the remedial measures for the flood susceptible areas, which are the focus of this study.

9.2.1. Thornridge Drive

There have been a number of studies, summarized below, which assessed the recurring surface flooding problems in this area. Refer to **Figure 9-1** for drainage features in this area.

The storm water on Thornridge Drive enters from the roadside ditch on the south side of Arnold Avenue east of Atkinson Avenue. This ditch is also referred as Tributary 2 and is subject to flood regulation by the TRCA under Ontario Regulation 166/06. Tributary 2 crosses Arnold Avenue through a culvert on the west side of Charles Street and connects to the private backyards. Drainage flows east of Clarkhaven into the ditch on the south side of Thornridge Drive and continues 150 m along the ditch to the west of Brooke Street. The flow travels south between private residential properties and across backyards to Brooke Street just north of Arnold Avenue.

The existing ditch inlet at Brooke Street just north of Arnold Avenue, captures overland flow and conveys it to the Brooke Street Trunk Sewer. Flows in excess of the inlet capacity flow eastwards through backyards to an inlet in an easement approximately 75 m west of Yonge Street. A 1200 mm diameter storm sewer conveys the storm drainage to the existing 1500 mm diameter storm trunk sewer on Arnold Avenue towards Markham.

9.2.1.1 Thornhill Storm Drainage Improvement Study

The City undertook the Thornhill Storm Drainage Improvement Study (Genivar, 2008) to determine the causes of flooding and recommend potential solutions. The recommendations of the study included:

- Replacement of deficient culverts;
- Construction of a new SWM facility in Gallanough Park to reduce peak flows to the Brooke Street Trunk Sewer;
- Construction of a storm sewer bypass along Thornridge Drive to divert flow from the existing tributary to the Brooke Street Trunk Sewer;
- Removal of the twin culverts crossing Brooke Street just north of Arnold Avenue;
- Replacement of deficient catch basins and ditch inlets, and,
- Improvement of existing ditches.

The proposed pond has an important role in the overall drainage improvement in the area as the storage provided will attenuate peak flows during large storm events, thus reducing the surcharging experienced in the Brooke Street Trunk Sewer. The additional capacity created by the reduction in peak flows will allow the trunk sewer to accept flows from the proposed Thornridge relief / bypass sewer.

9.2.1.2 Thornhill Area Road Reconstruction

This SWM Study (W.G. Clarke, 2009) was prepared in support of the Thornhill area road design and to alleviate the flooding problems in the area. Key recommendations from that study include:

- The implementation of the Thornridge Drive storm sewer by-pass as recommended in the Thornhill Drainage Improvement Study; and,
- A relief sewer along Arnold Avenue east of Brooke Street from Brooke Street to Yonge Street. This is based on the ability of the existing 1500 mm diameter trunk sewer to convey the additional flows across Yonge Street into Markham. Therefore, this option requires further review under the EA process.

9.2.2. Gallanough Park Municipal Class EA

The Gallanough Park SWM facility was proposed in this 2010 study (Clarifica, 2010) to alleviate the flooding north of the park. The study evaluated design options and concluded that flood mitigation could be achieved with a 10,000 m^3 dry pond in Gallanough Park.

9.2.2.1 Gallanough Park Pond Preliminary Design

The objective of the SWM facility in the park is to alleviate flooding north of the park. The pond would detain runoff and regulate the discharge into the 2100 mm diameter storm sewer, which runs along the west side of Gallanough Park. This sewer, which conveys storm water runoff from approximately 150 ha west of Gallanough Park, increases to 3000 mm as it leaves the park to flow north along Brooke Street. The Gallanough Park Pond would free up capacity in the Brooke Street trunk sewer allowing the areas to the north to discharge the local runoff into the sewer. The study proposed re-directing the flow from the areas west of Brooke Street into the new SWM pond. An additional 600 mm diameter storm sewer would also be constructed to convey runoff from a 3.4 ha area south of the pond. Two (2) outlet pipes, a 2100 mm diameter storm pipe and a 600 mm diameter storm pipe, as well as flow control headwalls, are proposed to control the discharge to the Brooke Street Trunk Sewer from the SWM pond.

9.2.2.2 Proposed Thornridge By-pass

The Gallanough Park EA recommended a sewer by-pass from Tributary 2 to the Brooke Street Trunk Sewer (refer to **Figure 9-2**). The by-pass will reduce the overland flow through the rear lots south of Thornridge Drive abutting Tributary 2. With the construction of the Gallanough Park Pond, the Brooke Street Trunk Sewer would have capacity to accept flows from the by-pass relief sewer. The design includes a new 600 mm culvert replacing the existing culvert under Clarkhaven Street to convey the base flow from Tributary 2. Major storm flows from Tributary 2 will be conveyed to a 1000 mm diameter relief sewer originating on Clarkhaven Street just south of Thornridge Drive through a new 1050 mm culvert. The 1050 mm culvert is offset by approximately 0.15 m from the 600 mm low flow (base flow) culvert so that only flows in excess of base flow conditions are conveyed to the relief sewer. The relief sewer will continue east along Thornridge the Brooke Street Trunk Sewer. An additional inlet is proposed on the Thornridge Drive east of Brooke Street so that overland flow from the east is captured and conveyed to the Brooke Street Trunk Sewer through a 500 mm diameter storm pipe.

The Gallanough Park EA considered the relief sewer proposed on Arnold Avenue east of Brooke Street as part of the overall solution reiterating that this would be possible subject to the ability of the existing 1500 mm diameter trunk sewer to convey the additional flows into Markham without impacting the downstream drainage systems. This option represents a significant change to the approved EA report for the Thornhill Drainage Improvement Study. Therefore, this option requires further review.

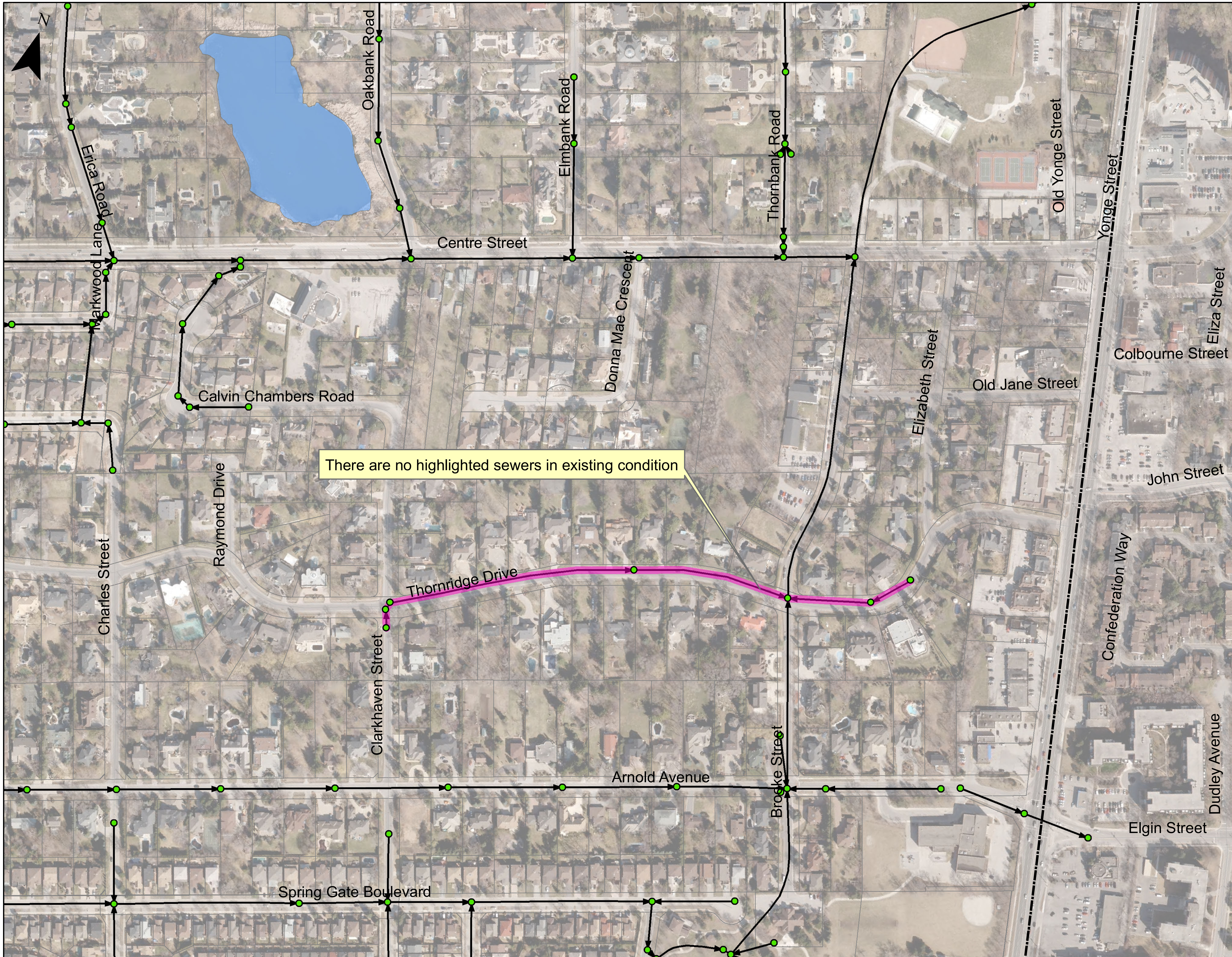
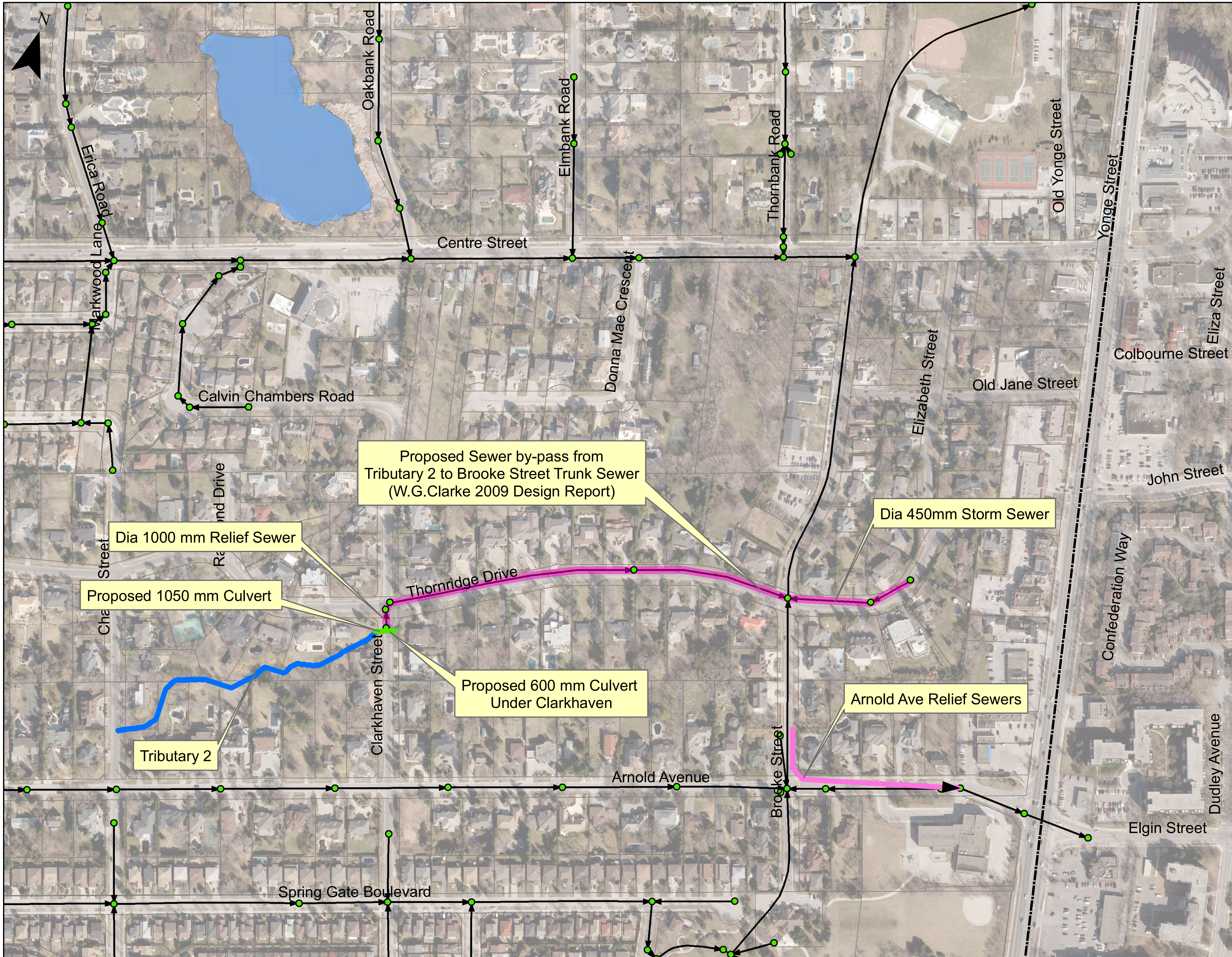


Figure 8-1
Drainage Features on Thornridge Drive

Drawn By: J.H. Date: Jan 7, 2014



Legend

- Storm Manholes
- Storm Sewers
- SWM Ponds
- Parcels
- City Boundary
- Roads

VAUGHAN

CIVICA INFRASTRUCTURE Innovations For The City

COLE ENGINEERING Experience Enhancing Excellence

Figure 9-2
Thornridge Drive
Proposed Sewer By-Pass

Drawn By: J.H. Date: Jan 7, 2014

0 25 50 100 Meters

10.0 Flood Remediation Measures

The following describes proposed flood remediation measures for each of the seven (7) sites identified by the City. In all cases, the goal is to provide flood protection for the 1 in 100 year design event.

10.1. Area 1: Thornridge Drive

The property was re-developed and re-graded in 2008. The existing conditions model does not predict external flow affecting the property. Local drainage, improper grading and high levels in adjacent roadside ditches appear to be potential causes of the previously reported flooding from 2005. It is recommended that the City collects improved DEM data such as through LIDaR and continue to improve the Drainage Management System to evaluate the local drainage capacity in this and other areas of the City.

10.2. Area 2: 275 Franklin Avenue

As shown in **Figure 10-1** the Franklin Avenue Pond discharges through a 200 mm diameter orifice into the 750 mm diameter storm sewer under Franklin Avenue. This sewer continues east and eventually outlets into Tributary 1 downstream of the Pondview Pond in Hefhill Park. The properties abutting the Franklin Avenue Pond, at the south end, have been flooded when the water level in the pond exceeded their backyard 'crest' elevation of approximately 187.70 mm as determined by the City's DEM. Upon reaching the crest, the water spills between the houses onto Franklin Avenue. The spill also occurs at the south end of the pond onto the trail on Hefhill Park before reaching Franklin Avenue. The 2005 storm flooded 275 Franklin Avenue and the adjacent properties through the backyard. The 2008 storm also caused concerns as the level came close to flooding 275 Franklin Avenue.

Based on the existing model, 275 Franklin Avenue is subject to flooding approximately every 50 years, provided the 200 mm diameter outlet is not partially blocked during the storm. During the 1 in 50 year storm event, with the outlet operating without blockage, the water level reaches 187.91 m, which exceeds the approximate crest elevation of 187.70 m. During the 1 in 100 year design storm, the water level in the pond is approximately 188.01 m.

10.2.1. Remediation Alternatives

Several alternatives have been investigated and feasible ones are presented below. **Figure 10-2** shows the proposed flood remediation measures at 275 Franklin Avenue during the 1 in 50 year storm event.

The first short-term flood remediation measure will alleviate flooding by increasing the size of the outlet pipe from 200 mm diameter to 450 mm. A 350 mm orifice plate would be installed at the head-wall, with proper debris grating. The flow will continue to discharge into the Franklin Avenue sewer which outlets downstream of the Pondview Pond located at the northeast corner of Hefhill Park.

Without additional controls, the increased outlet size will increase the peak flows in the Franklin Avenue storm sewer and downstream, in Tributary 1. To compensate for the increased flow from the Franklin Avenue Pond, the flow from the three (3) existing catchbasins at Franklin Avenue and Markwood Lane, which are connected to the Franklin Avenue storm sewer, will be re-directed to Pondview Pond.

The Pondview Pond maximum storage is 1800 m^3. This volume will be increased as a condition of development approvals for other areas to the south and east of Hefhill Park. As part of the SWM plan for the proposed development, the existing Pondview Pond will be expanded by approximately 400 m^3, which would result in a total pond volume of 2,200 m^3. The expansion provides additional capacity to accommodate and attenuate the diversion of the catchbasins from the Franklin Avenue storm sewer.

Through the increase in size to the existing outlet pipe from the Franklin Avenue Pond, the diversion of the three (3) basins to the Pondview Pond and increased storage, the 1 in 50 year water surface elevation in the Franklin Avenue Pond will be 187.67 m.

Additional measures are necessary to increase the level of protection to 1 in 100 years. The following conveyance and storage alternatives have been considered.

Figure 10-3 shows the 1 in 100 year flood remediation measures. One (1) alternative is to install a new 450 mm outlet sewer from the Franklin Avenue Pond at an elevation of approximately 185.70 m. The sewer (or an equivalent open channel or swale), can be accommodated within Hefhill Park to the south, with an approximate alignment as shown in **Figure 10-3**. The length of the channel would be approximately 180 m. It is recommended that the alignment of this storm sewer or swale be similar to that of the existing path. The exact configuration and alignment of this conveyance route should be defined at the detailed design stage.

The new outlet from Franklin Avenue Pond will increase the peak flow downstream in Tributary 1. To compensate for the increased flow from the Franklin Avenue Pond, the Pondview Pond storage should be further increased from the currently-proposed 2,200 m^3 to 3050 m^3 and the outlet be increased to allow for flow to discharge at the existing 1 in 100 year flow rate. This would regulate the water surface elevation in the Pondview Pond and prevent backwater on the Franklin Avenue storm sewer. Increasing the Pondview Pond outlet from existing 352 mm to 400 mm diameter will allow to the pond to discharge at its existing flow.

As a result of the peak flow attenuation provided by the Franklin Avenue Pond and the expansion to the Pondview Pond, the downstream peak flows to Tributary 1 will decrease from 1.12 m^3/s under current conditions to 1.10 m^3/s.

An additional alternative to be considered at the detailed design stage would be the expansion of the Franklin Avenue Pond by re-grading within the existing pond block. In this case, additional storage may be achieved by increasing side-slopes and deepening the facility. Impacts to existing vegetation and slopes should be considered during the evaluation of this alternative.

It is recommended that the City conduct a detailed survey of the Franklin Avenue Pond and the surrounding area to capture critical elevations, hydraulic information, and grading details of the pond and surrounding area. It is also recommended that all the inlets to the pond be retrofitted with grates so that blockages and other obstructions can be prevented, allowing the pond to function as designed. The hydraulic details of this area, specifically as it relates to drainage to the pond and subsequent discharge from the pond, are not captured in the City's existing GIS database; therefore, it is recommended that the City's GIS database is updated to accurately represent the hydraulic details of the drainage system prior to detail design.

Additionally it is recommended that basement elevations along Franklin Avenue near Markwood Lane be surveyed to accurately capture basement elevations in the area. This will give a better indication of the existing level of service for these properties.

10.3. Area 3: 311 Franklin Avenue

The property at 311 Franklin Avenue is susceptible to flooding because of the reversed-slope driveway and location at the junction of Markwood Lane and Franklin Avenue. The 1 in 100 year depth of flow is estimated at 0.183 m. Thus, the currently level of flood protection has been estimated at 1 in 50 years, based on the flood depth on the road exceeding 0.15 m. However, the flooding on this property is also related to the effectiveness of the operation of the Franklin Avenue Pond, located upstream of the property, and the pond outlet, which may be susceptible to blockage.

The model shows that Franklin Avenue storm sewer surcharges during the 1 in 100 year event. Preliminary grading analysis shows that the distance from the HGL to the top of the road is approximately 1.45 m, which does not meet the estimated 1.8 m minimum criteria to protect against basement flooding.

The alternative bypass outlet from the Franklin Avenue Pond (refer to Area 2 solutions) through the storm sewer / overland flow swale will reduce the flow to this storm sewer resulting in significantly reduced flood potential. However, as an interim measure prior to the implementation of the 1 in 100 year solution for Area 2, elevating the sidewalk at 311 Franklin Avenue will also provide protection against surface flooding. This would have to be discussed and agreed upon by the resident as this alternative will increase the driveway slope. Detailed design stage will require detailed survey.

10.4. Areas 4, 5, 6: Brooke Street to Yonge Street, Thornridge Drive, Tanjo Court, and Springfield Way

Refer to **Figure 10-4** for the proposed drainage improvements in this area. Due to their relative proximity the 1 in 100 year solution will address flooding concerns at all these locations. The preferred remediation strategy involves the following measures.

10.4.1. Gallanough Park Stormwater Management Pond

The proposed SWM facility in Gallanough Park will reduce flows into the Brooke Street storm sewer to free-up capacity for the areas north of Gallanough Park and for the by-pass along Thornridge Drive to be captured and conveyed through the existing 3000 mm diameter trunk sewer. The Gallanough Pond should provide 10,000 m^3 of storage. The 2100 mm diameter storm sewer that conveys flow from approximately 150 ha west of Gallanough Park currently discharges directly into the Brooke Street sewer. It is proposed to have this storm sewer redirected and discharge into the new pond. An additional 600 mm diameter storm inlet to the facility will be provided which conveys approximately 3.4 ha of storm runoff south of the pond. Two (2) outlet pipes, a 2100 mm diameter storm pipe and a 600 mm diameter storm pipe, as well as flow control headwalls will control the discharge from the pond.

10.4.2. Proposed Thornridge By-Pass

The Thornridge By-Pass will convey flow from Tributary 2 to the Brooke Street storm trunk. This will reduce flooding in the rear lots on Tributary 2 south of Thornridge Drive. The Brooke Street sewer will have the capacity to accept flows from the by-pass relief sewer once the Gallanough Park Pond has been expanded. The by-pass, as illustrated in **Figure 9-2**, includes a new 600 mm culvert, which will replace the existing culvert underneath Clarkhaven Street, to convey base flow from Tributary 2. Major storm flows from Tributary 2 will be conveyed to a 1000 mm diameter relief sewer originating on Clarkhaven Street just south of Thornridge Drive through a new 1050 mm culvert. The 1050 mm culvert is offset by approximately 0.15 m from the 600 mm low flow (base flow) culvert, so that only flows in excess of base flow conditions are conveyed to the relief sewer. The relief sewer will continue along Thornridge Drive, eventually discharging to the Brooke Street Trunk Sewer. An additional inlet is proposed on the Thornridge Drive east of Brooke Street so that overland flow from the east is captured and conveyed to the Brooke Street Trunk Sewer through a 525 mm diameter pipe.

10.4.3. Arnold Avenue Relief Sewer

The relief sewer along Arnold Avenue, east of Brooke Street, will reduce flows along the Brooke Street sewer. This is subject to the existing 1500 mm diameter trunk sewer being able to convey the additional flows without impacting the downstream drainage systems in Markham. This option represents a significant change to the approved EA report for the Thornhill Drainage Improvement Study. Therefore, this option requires further review under the EA process.

These by-passes, in addition to the proposed pond, are key components as part of the overall remedial measures proposed to solve flooding problems in the Thornhill area.

10.4.4. Tanjo Court and Springfield Way

Refer to **Figure 10-4** for the proposed flood remediation in Area 6 – Tanjo Court and Springfield Way. The drainage system in this area provides a 2-year level of flood protection against overland flooding at the intersection of Tanjo Court and Springfield Way. The depths exceed 0.3 metres and model results shows sewer surcharging starting with the 2-year storm event.

In an effort to reduce the occurrence of surface flooding it is recommended to lower the sidewalk on Springfield Way adjacent to Gallanough Park and convey the overland flow into the proposed Gallanough Pond. The overland flow path will be created by lowering the sidewalk by approximately 0.38 m and re-grading within the park. Alternatively, a shallow sewer can be installed connecting the intersection to the pond. This would result in the major overland flow depth at the intersection of Tanjo Court and Springfield Way being reduced to 0.23 m during the 1 in 100 year event.

It is noted that the proposed remedial measures in Areas 4, 5 and 6 are contingent on the construction of the Gallanough Park SWM Facility and associated drainage improvements as recommended in the Gallanough Park EA completed in 2010. The following recommendations accompany the solutions for Areas 4, 5, and 6.

- Detailed design of the Gallanough Park Pond should minimize backwater effects on the storm sewer on Springfield Way;
- An assessment and discussion with Markham staff is necessary for the proposed Arnold Avenue sewer by-pass, east of Brooke Street; and,
- A detailed survey of the tributary crossing Brooke Street as well as a survey of the surrounding areas should be conducted. It is suspected that there is an existing inlet north of Arnold Avenue and east of Brooke Street. A site visit showed that the area in the vicinity of the inlet is currently being re-developed and site access is limited; therefore confirmation of the inlet's existence was not possible.

10.5. Area 8: Charlton Avenue

As described previously, the Charlton Avenue flood area (Area 8) receives the runoff from a large tributary area upstream. **Figure 10-5** illustrates the drainage area. The flood site starts at the south side of Joseph-Aaron Boulevard and ends south of Marisa Court. A significant engineered channel conveys flows from south of Centre Street into this area. This channel flows south between the school and other properties fronting Millbank Court and crosses Charlton Avenue through twin 3 X 1.8 m box culverts. Limited channel and culvert capacity causes overtopping at the crossing. The properties backing onto the channel are subject to flooding. The channel also receives flow from adjacent lands to both east and west. Topographic analysis of the area shows there is also significant potential ponding depending on the culvert intake conditions on the north side of the railroad tracks. Capacity within the downstream system may also cause backup in the area.

The existing drainage system at Area 8 provides sufficient protection against flooding during the 1 in 100 year storm and therefore, no additional work, beyond regular operation and maintenance of the drainage infrastructure, including culvert crossings and grates, is recommended.

Table 10.1 below summaries the recommended remedial solution for each of the seven (7) flooding areas, and summarizes the projected cost estimate for these flood remediation measures.

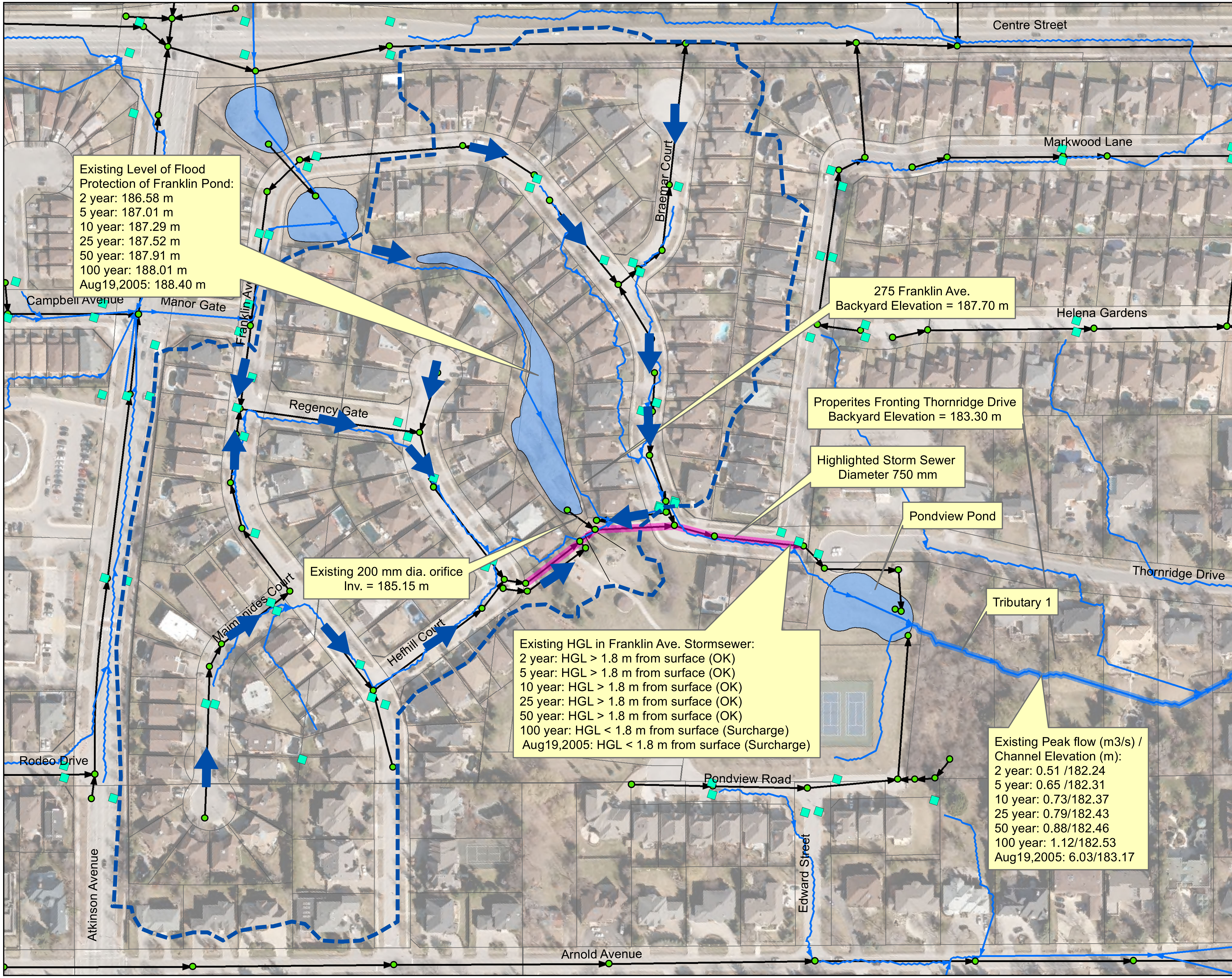
Table 10.1 – Recommended Remedial Solutions

Site	Causes of Flooding	Recommended Solution
Area 1: 122 Thornridge Drive	Poor local grading	Improved DEM data
Area 2: 275 Franklin Avenue	Pond overtopping	Increase outlet pipe size, increase pond capacity, new pond outlet, re-grading
Area 3: 311 Franklin Avenue	Reversed slope driveway, storm sewer surcharge	Alternate by-pass outlet, elevate sidewalk
Area 4: 109 Brooke Street	Capacity restraints, poorly defined overland flow routes, backups, ponding, blockages	SWM pond, Thornridge By-Pass, relief sewer, sidewalk re-grading
Area 5: Brooke Street to Yonge Street and Thornridge Drive	Capacity restraints, poorly defined overland flow routes, backups, ponding, blockages	SWM pond, Thornridge By-Pass, relief sewer, sidewalk re-grading
Area 6: Tanjo Court and Springfield Way	Capacity restraints, poorly defined overland flow routes, backups, ponding, blockages	SWM pond, Thornridge By-Pass, relief sewer, sidewalk re-grading
Area 8: Charlton Avenue	Runoff	No additional work

Table 10.2 – Cost Estimate

SITE ID	Description of Area	Reported Flooding	Description of Flooding Problem	Proposed Remediation Measures	Cost Estimate			
Area 1	122 Thornridge Drive	Flooding reported in 2005	Surface flooding due to improper grading and high water levels in adjacent roadside ditches. Property was re-developed and re-graded in 2008.	Recommendation is that city collect improved DEM data such as through LIDaR and continue to improve the drainage management system to evaluate local drainage capacity in this and other areas of the city.	N/A			
Area 2 (Interim)	275 Franklin Avenue and adjacent properties	Flooding reported in 2005 and concerns of flooding in 2008	Surface flooding when the water levels in the pond exceed the backyards crest elevations of 187.70 m.	Increase existing outlet from 200 mm to 350 mm	Construction Estimate	$35,000		
				Re-direct flows from three (3) existing catchbasins located at Franklin Avenue and Markwood Lane from the Franklin Avenue storm sewer to Pondview Pond.	Design Estimate	$7,000		
					Total (Excluding Applicable Taxes)	**$42,000**		
Area 2 (Ultimate)	275 Franklin Avenue and adjacent properties	Flooding reported in 2005 and concerns of flooding in 2008	Surface flooding when the water levels in the pond exceed the backyards crest elevations of 187.70 m.	Install a 180 m long 450 mm outlet sewer from the Franklin Avenue Pond to Pondview Pond	Construction Estimate	$250,000		
				Re-direct flows from three (3) existing catchbasins located at Franklin Avenue and Markwood Lane from the Franklin Avenue storm sewer to Pondview Pond.	Design Estimate	$50,000		
				Increase the Pondview Pond storage by 1250 m^3 to 3050 m^3	**Total (Excluding Applicable Taxes)**	**$300,000**		
				Increase outlet pipe size for Pondview Pond from existing 200 mm to 450 mm with 350 mm orifice				
				Raise Hillock Berm 0.6 m				
Area 3	311 Franklin Avenue	Flooding reported in 2005	House located a low point with reverse slope driveway. Floods due to capacity problems for major system.	Issue will be addressed as part of the solution for Area 2. Interim solution would be to raise sidewalk elevations.	Construction Estimate	$3,000		
					Design Estimate	$1,500		
					Total (Excluding Applicable Taxes)	**$4,500**		
Area 4	109 Brooke Street	Backyard flooding reported in 2005	House located a low point. Floods due to capacity problems for major and minor systems.	Retrofit of Gallanough Park Pond	Alternative 1 – Thornridge By-Pass*		Alternative 2 - Arnold Avenue By-Pass*	
				Redirect the 2100 mm storm sewer (which conveys flow from 150 ha west of the park) from the Brook Street storm sewer to the Gallanough Park Pond	Construction Estimate	$1,145,000	Construction Estimate	$480,000
				A 600 mm storm sewer inlet will convey runoff from 3.4 ha south of the pond.	Design Estimate	$230,000	Design Estimate	$100,000
Area 5	Brooke Street to Yonge Street and Thornridge Drive	City has received several flooding reports in this area	Major and minor systems are not built to current standards, ditches, culverts and inlets are susceptible to blockages.	Sewer by-pass from Tributary 2 to the Brook Street Trunk Sewer. This solution is contingent on the construction of the Gallanough Pond and the redirection of the Brook Street storm sewer in order to provide downstream capacity for the bypass.	Environmental Assessment Allowance	$300,000	Environmental Assessment Allowance	$200,000
					Total (Excluding Applicable Taxes)	**$1,675,000**	**Total (Excluding Applicable Taxes)**	**$780,000**
Area 6	Tanjo Court and Springfield Way	Flooding on the road around catchbasins and at the road sag	Major and minor systems are not built to current standards, ditches, culverts and inlets are susceptible to blockages.	Lower sidewalk on Springfield Way, adjacent to Gallanough Park, by approximately 0.38 m and re-grading within the park	Construction Cost	$12,000		
					Design Cost	$3,000		
					Total (Does not Included Taxes)	**$15,000**		
Area 8	Charlton Avenue	Potential rear yard flooding	Limited channel and culvert capacity and capacity of the downstream system cause the engineered channel to overtop the road and flood properties adjacent to the channel.	No mitigation recommended	N/A			

* Estimates based on the alternative designs presented by W.G Clarke in the report "Thornhill Area Road Reconstruction, City of Vaughan, SWM Final Report, May 27, 2009



Legend

- Existing Catchbasins
- Existing Storm Manholes
- Existing Storm Sewers
- Overland Flow Path
- Existing Drainage Pattern
- Existing Major System Drainage Area (11.6 ha)
- Existing SWM Ponds
- Parcels

N

VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 10-1
Franklin Avenue Existing

Drawn By: J.H. Date: Jan 20, 2014

0 25 50 100 Meters

Figure 10-2 - Franklin Avenue Proposed Remedial Measures (1:50 year Design Storm Event)

Drawn By: J.H. Date: Jan 23, 2014

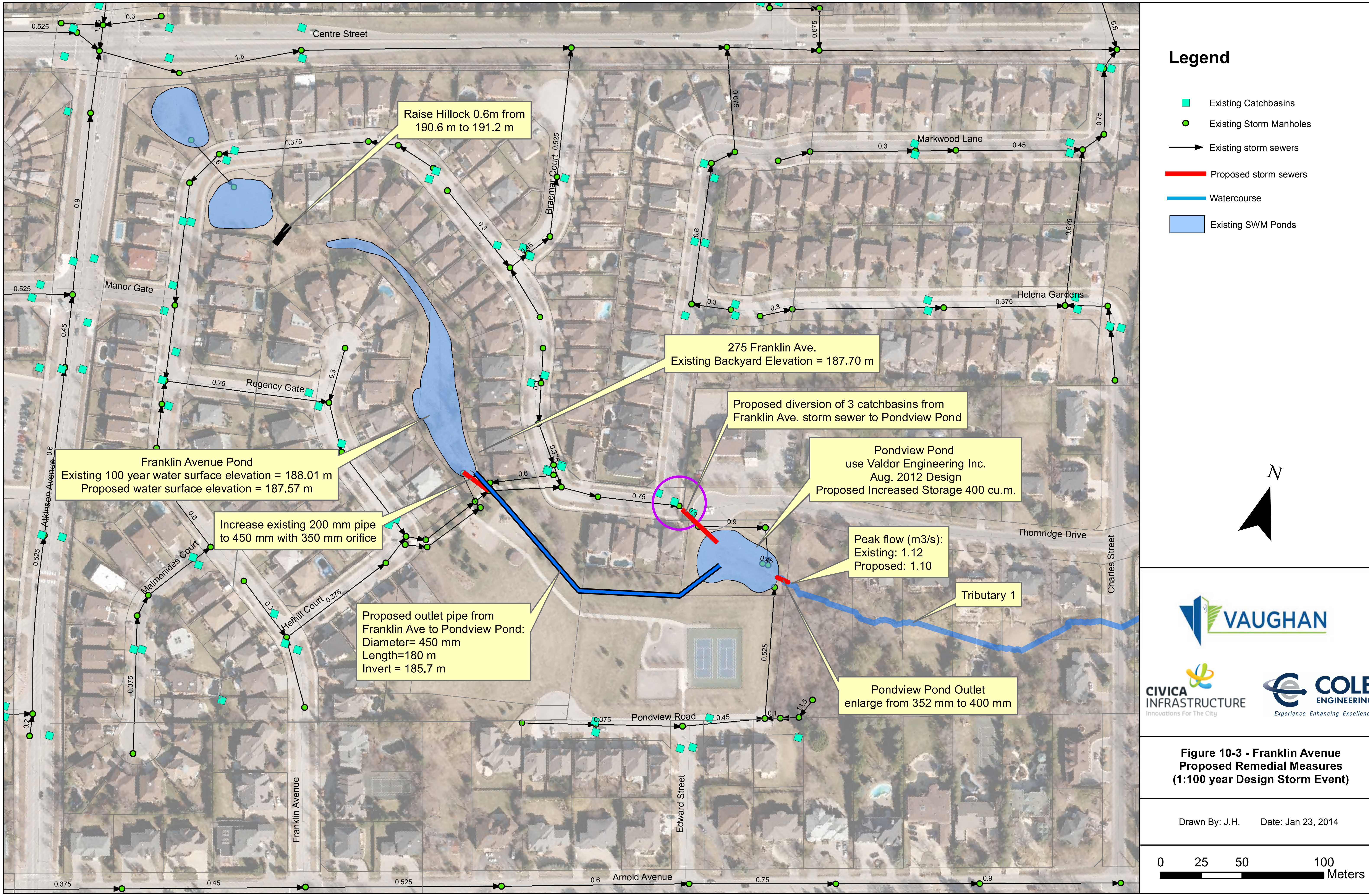
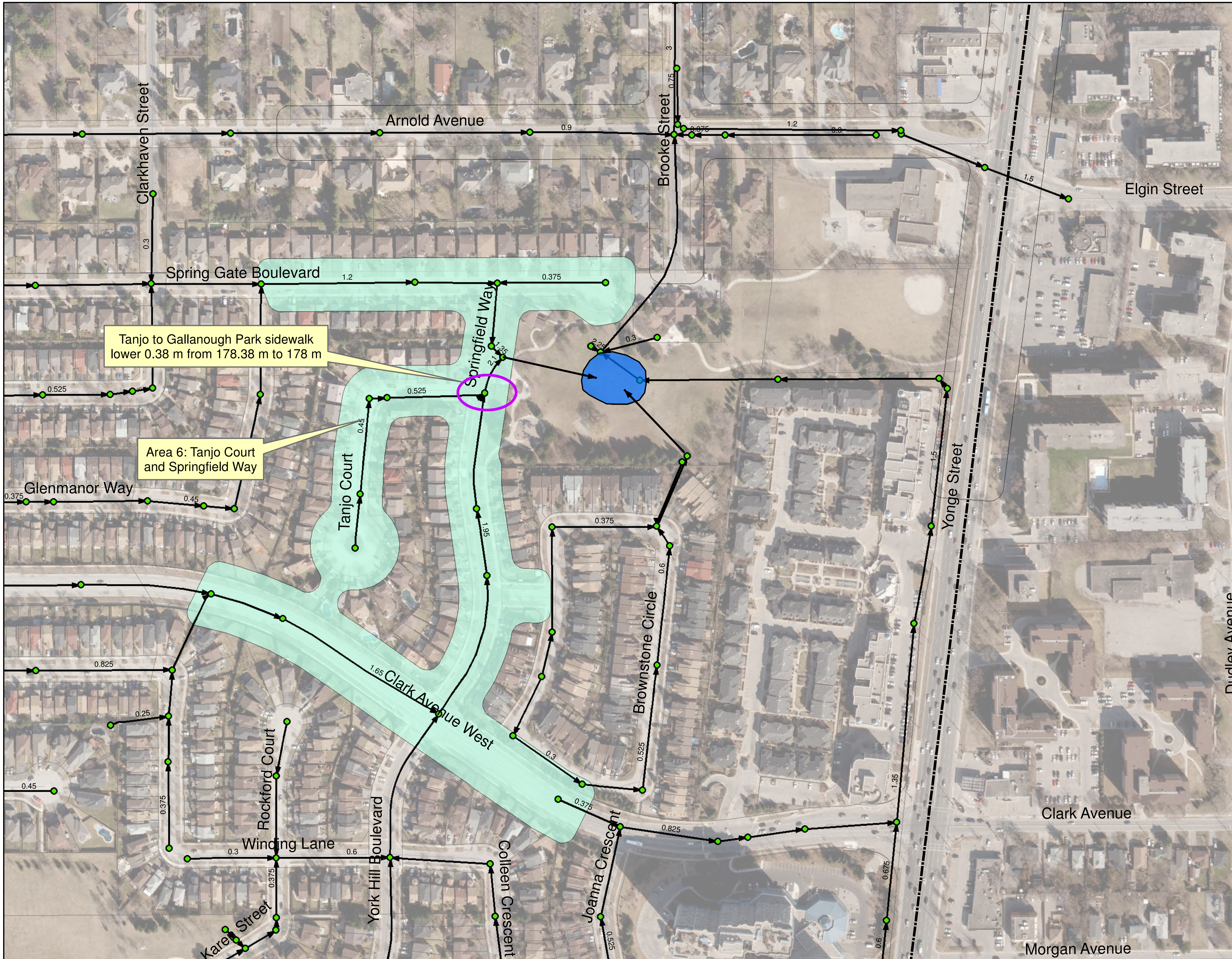


Figure 10-3 - Franklin Avenue Proposed Remedial Measures (1:100 year Design Storm Event)



Legend

- Storm Manholes
- Storm Sewers
- Parcels
- City Boundary
- Roads

N

VAUGHAN

CIVICA INFRASTRUCTURE
Innovations For The City

COLE ENGINEERING
Experience Enhancing Excellence

Figure 10-4
Proposed Drainage Improvements to Yonge Street, Thornridge Drive, Tanjo Court, and Springfield Way

Drawn By: J.H. Date: July 30, 2013

0 25 50 100 Meters

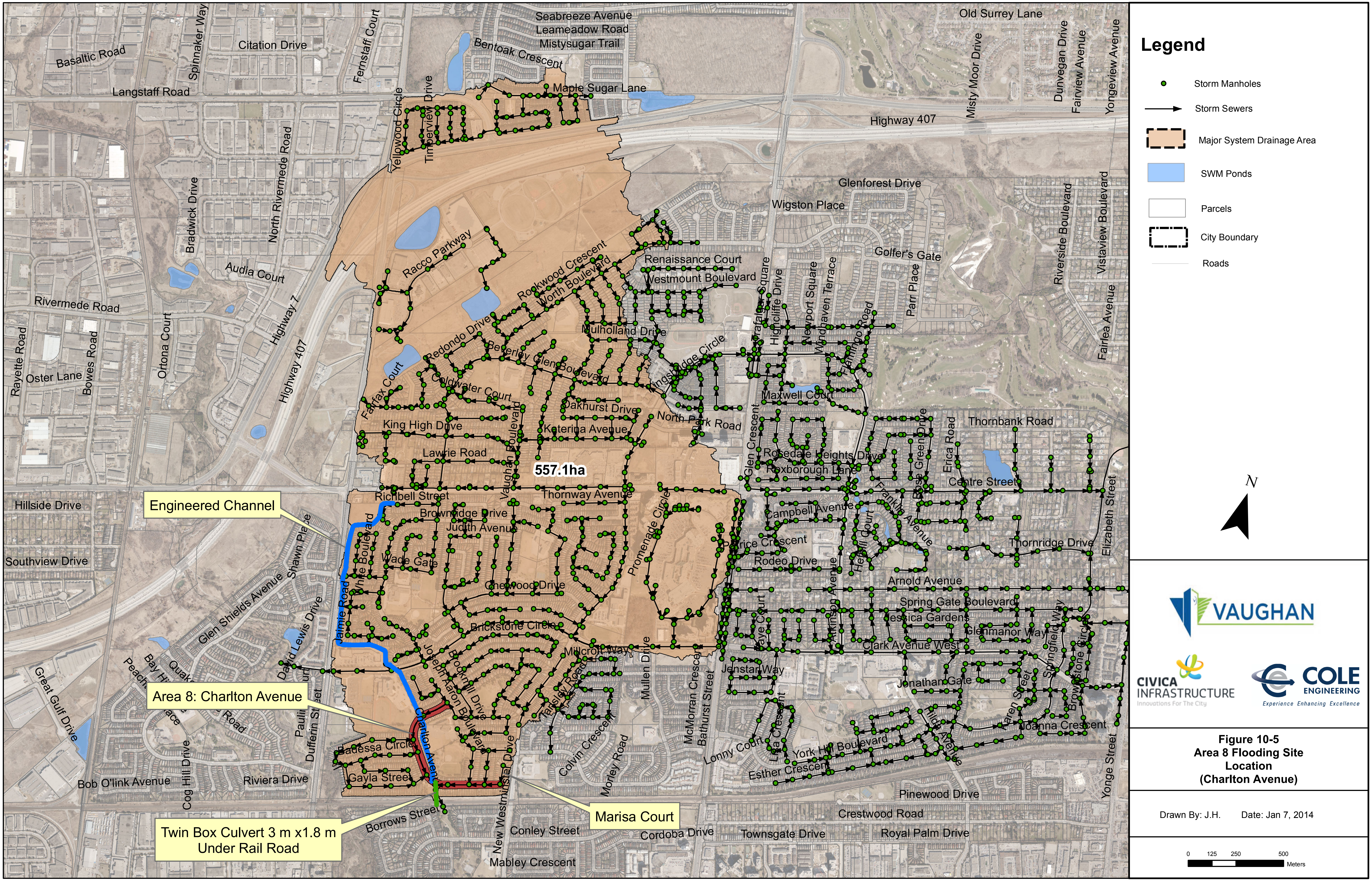


Figure 10-5
Area 8 Flooding Site Location (Charlton Avenue)

Drawn By: J.H. Date: Jan 7, 2014

11.0 Conclusions

The following conclusions can be drawn from this Phase II City-Wide Drainage Study:

- The Phase II Drainage Study / Vulnerable Sites report has advanced the City's goal is to develop a City-wide understanding of the storm drainage system condition and performance so as to manage the system to provide acceptable and consistent level of flood protection. Specific deliverables achieved from this study include:
  - Update to the City's GIS drainage data by providing an initial building layers based on buildings present at the time the 2007 air photo was produced; and,
  - Starting and populating an inventory and GIS layer of culvert crossings owned and operated by the City and other agencies which are part of the overall drainage system.
- The City GIS sewer database contains significant data gaps. Many of these data gaps can be filled-in by entering the data from available digitized plan and profile and storm drainage area design drawings. It is important to update and maintain this information for use by engineering planning, operations, and other department staff in the City;
- An inventory of the City's storm drainage infrastructure, specifically with respect to bridges and culverts, has been developed to address previously identified data gaps. The inventory includes culvert crossings, bridges, overpasses, the development of a building layer based on the City's aerial photography, and the refinements to the City's DEM based on the newly collected drainage infrastructure information;
- Data standards for drainage infrastructure, specifically for culverts and bridges, has been developed to ensure submissions from consultants, agencies or other proponents with respect to drainage infrastructure are consistent and can be easily incorporated into the City's SWMSoft database;
- The City's existing FERP has been updated according to the newly created building layer based on the City's aerial photography. Previously, specific lots had been identified to be a potential risk of flooding, however; this did not indicate if a particular structure located on a lot was at a flooding risk. As the newly created roof layer identifies the building envelop and the location of the structure on the property, the FERP was updated to reflect if a particular structure was susceptible to flood risk as opposed to a parcel of land, regardless if there was a structure present or not;
- An assessment was conducted of seven (7) sites in the Thornhill area which have experienced recurring flooding issues. The assessment included the development of a detailed dual drainage model of the areas, using a technique known as Micro-Drainage. The model was used to assess the existing drainage conditions in the area and used to reproduce historical flooding events. Remediation measures have been proposed for six (6) flood locations including conveyance and end of pipe alternatives. Previous studies which have investigated flooding in the area have developed recommendations to help alleviate flooding in the area. These measures have been carried forwarded and included in the remediation measures recommended as part of this study. The seventh site (Area 8) was shown to have sufficient flood protection for a 1:100 event and no remedial measures were recommended beyond the regular maintenance required for the City's entire storm infrastructure;
- The recommended solutions for remediating flood areas 2, 3, 4, 5, and 6 fall under the Municipal Class EA process, with schedules to be confirmed at a later time; and,

- Analysis of the Area 8 flood site showed that the site flooded during the August 19, 2005 storm event. The extent of flooding resulted in road overtopping and flooded structures along Charlton Avenue. Modelling shows that the same system would provide a 1 in 100 year level of flood protection without the need for specific infrastructure enhancements.

12.0 Recommendations

The following general recommendations are made in additional to the specific flood remedial recommendations made for each of the seven (7) flood vulnerable areas:

- There are still many un-catalogued drainage structures which should be assessed and included in the inventory. Undersized, badly configured or damaged drainage structures can be a source of localized flooding resulting in complaints from residents, damages to residential and/or commercial property, disruptions to traffic flow and an increased risk to public safety.
- In order to complete the City's drainage system inventory it is recommended that the City:
  - Secure more accurate DEM data, such as from aerial and land-based LIDaR survey sources;
  - Complete a follow-up GIS assessment (e.g. sink-fill analysis, data entry, cataloguing);
  - Perform a file archive search for storm drainage area plans, plan and profile drawings, SWM reports;
  - Complete additional field verifications; and,
  - Develop a strategy to co-ordinate file and field investigations with agencies who have SWM asset jurisdiction.
- This information should be reviewed and filed into the SWMSoft database system. This inventory would be tied to the City's GIS system and would be used by staff as part of a City-Wide Drainage Management System involved in Master Planning, site development approvals, engineering, operations, parks, traffic, finance, etc., resulting in a co-ordinated and precise effort to inspect and maintain the inter-related drainage system;
- The City may also decide to selectively share some of the drainage system information with residents (e.g. rain gauge data, flow analysis data, asset data, etc.) to increase awareness of the City's drainage management functions;
- Further field investigations of existing road profiles within the City should be completed through field investigations and through cross-referencing locations using high resolution aerial photography or LIDaR technology;
- The City should consider conducting a thorough QA / QC of their sewer infrastructure GIS data including missing pipe data and missing inlet data throughout the City by cross-referencing their existing GIS data with digital drawings and, more importantly, from on-going CCTV surveys work and air photography (for inlets). The regular CCTV surveys, typically conducted for infrastructure condition assessment, should be specified such that accurate invert elevations of connecting pipes and ground elevations are simultaneously collected at the manholes. Sewer segments with significant sags should also be identified and included in the Drainage Management System Database for future operation and maintenance inspection, flushing and planning sewer system upgrades, particularly when these are located downstream of new development or redevelopment areas. As indicated previously, the City should also consider LIDaR survey from air or ground based stations that provide significant added accuracy to the surface survey data;

- The City should consider expanding the building layer to include new development and re-development since 2007 using high resolution air photography;
- It is recommended that the City implement a City-Wide Drainage Management System that includes a flooding reporting feature in combination with a public communication program that advises residents, tenants and property owners to report flooding during large storm events. Such a system would provide valuable information to the City allowing for more effective management of the drainage system;
- Future improvements to the model inputs should be considered such as improvements to GIS data and DEM data. The use of LIDaR-surveyed topographic data which can be collected rapidly with vehicle-mounted equipment and provide accurate localized topographic data is recommended. When combined with Micro-Drainage tools, this technique been has shown to provide improved localized predictions of flood depth and flood potential;
- It is recommended that the City update their criteria by providing oversized debris gratings with high debris control capacity in combination with either low-maintenance inlet control devices or inlet sizing that controls the flow. In other words, intake grating should be used to keep debris out of the sewers and culverts and not as a flow control measure. Inlet control should be achieved through intake sizing insuring that debris does not block the intakes;
- It is recommended that the City collects improved DEM data such as through LIDaR and continue to improve the Drainage Management System to evaluate the local drainage capacity in this and other areas of the City;
- It is recommended that the City conduct a detailed survey of the Franklin Avenue Pond and the surrounding area to capture critical elevations, hydraulic information, and grading details. It is also recommended that all inlets to the pond be retrofitted with grates so that blockages and other obstructions can be prevented, allowing the pond to function as designed. The hydraulic details of this area, specifically as it relates to drainage into the pond and subsequent discharge from the pond, are not captured in the City's existing GIS database; therefore, it is recommended that the City's GIS database be updated to accurately represent the hydraulic details of the drainage system prior to detail design;
- It is recommended that basement elevations along Franklin Avenue near Markwood Lane be surveyed to accurately capture basement elevations in the area. This will provide a better indication of the existing level of service at these properties;
- It is recommended that the City consider developing a Drainage Management System that stores, organizes and updates the drainage data and also uses the data for capacity analysis, condition assessment, growth planning, etc.;
- The Class EA studies and detailed design that will be required for the implementation of some of the proposed remedial measures could be financed through a Development Charge. The City should consider implementing Development Charges for the proposed work if there is proposed development upstream of any of the flood vulnerable areas;
- The model development required significant data infilling for which a complete list can be found in **Appendix B**. For example, the model redevelopment required the interpolation of sewer and manhole inverts based on a limited number of known inverts and pipe slopes at some locations. The City should consider updating the model as part of the future studies and detailed design in areas proposed for remediation to further confirm the results and recommendations of this study;

- Although source control measures will not significantly reduce basement flooding by themselves during larger storm events, the City should consider these types of measures for infill and redevelopment areas as they are effective at reducing runoff volumes to receiving streams, mitigating erosion and improving water quality;
- A number of missing catchbasin inlets along Thornridge Drive and Arnold Avenue were identified. It is recommended that a survey be conducted to identify all inlet locations within the study area;
- Contained within the City's GIS database are a number of inlets such as catchbasins, culverts, intake grates, etc. For the purposes of this study, assumptions were made as to the capture capacity of each of the inlets based on the "grate type" contained within the GIS database or their dimensions based on aerial photography and other mapping / drawings. It is recommended that the City surveys all inlets within the study area so that an accurate inlet capture curve can be input into the model, resulting in a more accurate analysis of the quantity of major overland flow entering the minor system;
- As part of this study, field surveys were conducted to develop a comprehensive GIS inventory of all the bridges and culverts. Potential locations of culverts and bridges were based on 2009 aerial photography and the existing GIS information from the City and Region. The method of identifying bridge and culvert locations based on aerial photography is not an exact science and it is recommended that additional surveys be conducted to identify all the bridges and culverts within the City so that proper drainage routes can be defined. LIDaR and/or high resolution aerial photography is recommended to help capture previously unidentified culverts, bridges and road overpasses;
- Currently, the City maintains an inventory of all their SWM ponds in a centralized database known as SWMSoft. As part of the scope of this study, culverts and bridges will also be added to the SWMSoft database. It is recommended that the City includes all SWM ponds and storm drainage infrastructure (culverts and bridges) into the SWMSoft database as the information becomes available so that the information is stored in a centralized database and is easily accessible;
- SWM and Storm Drainage Infrastructure from other sources (i.e., Regional, MTO, etc.) as well as private SWM and infrastructure (subsurface / underground storage units, oil- grit separator units, etc.) should also be input into the City's SWMSoft database so that the City can keep an up to date inventory of all SWM facilities and drainage infrastructure within their jurisdiction;
- Some roof leaders and downspouts within the City are connected to storm sewers, leading to increased and fast responding runoff from roofs into the receiving system. It is recommended that downspouts be disconnected and directed towards landscaped areas, this would promote infiltration and also reduce overall surface runoff to the receiving system. The City currently does not have a downspout / roof leader disconnection program. Although site surveys in the Thornhill area showed that only 10% of roof leaders were connected, it is recommended that the City consider implementing a downspout / roof leader disconnection program in an effort to reduce the amount of stormwater runoff in both the major and minor storm systems and reduce the risk of flooding;

- As a general overall improvement to the City's drainage infrastructure, the City should consider proceeding with the selection and installation of ICDs and/or additional inlets to help optimize the used of the minor-major system capacity. Additionally, the City should consider the construction of new culverts and intake structures for improved capture of stormwater throughout the City;
- As part of infilling data gaps the City should identify data gaps with respect to SWM ponds. Knowledge of the upstream drainage area, pond volume, release rates, etc., for SWM ponds is critical in assessing downstream impacts, particularly during major storm events. There are a total of seven (7) ponds located in the study area. In cases where there was insufficient hydraulic information, assumptions were necessary to accurately represent the hydraulics on the facility. For example, the bottom elevation of pond 120 differs between surveyed information and the City's DEM. Due to the elevation differences, an adjustment had to made so that hydraulic routing affects could be modelled, otherwise, flow would have accumulated in the pond with no discharge;
- The existing model has been calibrated according to average Antecedent Moisture Conditions (AMC); however, soil moisture conditions can vary throughout the year. In order to accurately represent the hydrological effect of AMC, It is recommended that future calibration of Micro Drainage models take into account AMC to accurately represent the rainfall-runoff relationship during the specific calibration / storm event;
- The relief sewer along Arnold Avenue, east of Brooke Street, will reduce flows along the Brooke Street sewer. This solution is dependent on the ability of the existing 1500 mm diameter trunk sewer to convey the additional flows without impacting the downstream drainage systems. As the downstream drainage system is in Markham an agreement would have to be reached regarding increasing flows to the trunk sewer prior to proceeding with this portion of the design. This option represents a significant change to the approved EA report for the Thornhill Drainage Improvement Study. Therefore, this option requires further review under the EA process;
- Overland flow channels can be engineered or naturally occur as conveyance routes. For the purpose of this study, the conveyance capacity of all overland flow routes have been determined by cross sections calculated using the City's DEM, with the exception of roads where pre-defined cross sections have been assigned using existing cross-section data. Similar to roads, engineered channels would have a unique cross-section which would indicate the conveyance capacity. It is recommended that where possible, the City update their database so that engineered channels can be represented in the overland flow path;
- Sag areas were defined in the model using the elevations from the DEM, which is relatively coarse, resulting in modeled flow accumulating in certain sag areas and not discharge downstream due to overestimation of the available storage volume. In certain instances, sag areas are engineered to store / pond surface flow (i.e., parking lots). However, in most instances water should not pond and remain stagnant in sage areas; it should continue to flow downstream. It is recommended that the City undertake a more detailed survey to get a better topographic representation of sag areas;

- A more detailed topographical representation of the study area would be useful in determining critical surface elevations related to the City's existing DEM. One (1) possible way to achieve this could be through the use of LIDaR technology. LIDaR is an optical remote sensing technology which is used to measure the properties of light, determining the distance to a particular object or surface. Similar to radar technology, the distance to an object is obtained by measuring the time lag between the transmission of a pulse and the subsequent detection of the signal. LIDaR technology would be much more efficient than a manual topographic survey;
- Due to the recurring issues with respect to surface drainage, it is recommended that the City conduct an analysis to determine the feasibility of implementing a minor storm sewer system along Thornridge Drive. The proposed storm sewer would start in the cul-de-sac on west side of Thornridge Drive and continue eastwards, eventually discharging to the Brooke Street Trunk Sewer. A capacity assessment on the Brooke Street Trunk Sewer at Thornridge Drive would also have to be undertaken to determine what the potential impacts are of connecting storm sewers along Thornridge Drive to the Brooke Street Trunk Sewer; and,
- Future monitoring should include rain gauge densities no greater than 1 per 200 ha or ground-corrected radar images (combination of rain gauges and doppler radar data) in conjunction with self-cleaning flow measuring flumes.

APPENDIX A
Hydraulic Inventory Sheet

APPENDIX B
Data Gaps

STORM SEWER LINK DATA GAPS
Vaughan Site 1 – 6 and 8

Pipe	Problem	Correction	Notes
STMMH16236→STMMH16249 Highcliffe Drive	Reversed Flow Direction Wrong d/s invert = 194.866	From Drawing d/s invert = 194.509	EngineeringImages/Block 02/P-00681-05.tif, d/s inv = 194.866 is a mistake
STMMH15052→Dummy_MH_001 Mulholland Drive	Missing Sewer	From Drawing	EngineeringImages/Block 09/P-01038-02.tif
STMMH14900→ STMMH15123 Beverley Glen Blvd / New Westminster Drive	Reversed Flow Direction	From Drawing	EngineeringImages/Block 09/P-00507-07.tif
STMMH14900→ STMMH15123 Beverley Glen Blvd / New Westminster Drive	To be abandoned	From Drawing	EngineeringImages/Block 09/T94-0047-02.tif
STMMH15126→STMMH15132 New Westminster Drive / Bathurst Street	Wrong Length = 78 m Wrong u/s invert = 196.62 Wrong d/s invert = 196.13	From Drawing Length = 121.2 m u/s invert = 195.98 d/s invert = 195.62	EngineeringImages/Block 09/P-00507-10.tif, P-00507-09.tif
STMMH15082→MissingMH22 New Westminster Drive / Kingsbridge Circle	Missing d/s MH Missing d/s invert	From Drawing d/s invert = 196.356	EngineeringImages/Block 09/19T-90009-13.tif
STMMH11787→STMMH17201 Centre Street / Atkinson Ave	Wrong Length = 0 m Wrong u/s invert = 189.752 Wrong d/s invert = 189	From Drawing Length = 45.7 m u/s invert = 187.387 d/s invert = 187.028	EngineeringImages/C-81-015-06.tif
STMMH17201→STMMH17181 Centre Street	Wrong Length = 0 m Wrong u/s invert = 189 Wrong d/s invert = 186.3	From Drawing Length = 73.95 m u/s invert = 186.943 d/s invert = 186.471	EngineeringImages/C-81-015-06.tif, C-81-015-05.tif
STMMH17181→STMMH12100 Centre Street	Wrong Length = 0 m Wrong u/s invert = 186.3 Wrong d/s invert = 185.29	From Drawing Length = 169.45 m u/s invert = 186.419 d/s invert = 185.207	EngineeringImages/C-81-015-05.tif
STMMH12100→ STMMH17180 Centre Street	Wrong Length = 0 m Wrong u/s invert = 185.26 Wrong d/s invert = 184.17	From Drawing Length = 152.3 m u/s invert = 185.023 d/s invert = 184.089	EngineeringImages/C-81-015-05.tif, C-81-015-04.tif
STMMH12100→Dummy_MH1004 Centre Street		Length = 95.6 m u/s invert = 185.023 d/s invert = 184.437	Split Pipe STMMH12100→ STMMH17180 Centre Street
Dummy_MH1004→ STMMH17180 Centre Street		Length = 56.7 m u/s invert = 184.437 d/s invert = 184.089	Split Pipe STMMH12100→ STMMH17180 Centre Street
STMMH12233→ Dummy_MH1004 Centre Street	Wrong d/s invert = 0	d/s invert = 185.37	Interpolated invert using GIS slope 0.8% and u/s inv
STMMH17180→ STMMH12238 Centre Street	Wrong Length = 0 m Wrong u/s invert = 184.12 Wrong d/s invert = 181.94	From Drawing Length = 182.2 m u/s invert = 183.957 d/s invert = 181.98	EngineeringImages/C-81-015-04.tif

STMMH12238→ STMMH12252 Centre Street	Reversed Flow Direction Wrong Length = 0 m Wrong u/s invert = 178.32	From Drawing Length = 119.9 m u/s invert = 178.265	EngineeringImages/C-81-015-04.tif, C-81-015-03.tif
STMMH12252→ STMMH18064 Centre Street	Reversed Flow Direction Wrong Length = 0 m Wrong u/s invert = 176.65 Wrong d/s invert = 171.7	From Drawing Length = 166.1 m u/s invert = 173.661 d/s invert = 171.771	EngineeringImages/C-81-015-03.tif
STMMH18064→ STMMH16451 Centre Street	Wrong Length = 0 m Wrong u/s invert = 171.4 Wrong d/s invert = 170.5	From Drawing Length = 154.7 m u/s invert = 171.465 d/s invert = 170.604	EngineeringImages/C-81-015-03.tif, C-81-015-02.tif
STMMH16451→ STMMH17198 Centre Street	Wrong Length = 0 m Wrong u/s invert = 170.47 Wrong d/s invert = 170.1	From Drawing Length = 66.5 m u/s invert = 170.581 d/s invert = 170.217	EngineeringImages/C-81-015-02.tif
STMMH17198→ STMMH17199 Centre Street	Wrong Length = 0 m Wrong u/s invert = 171.15 Wrong d/s invert = 169.27	From Drawing Length = 139.5 m u/s invert = 170.217 d/s invert = 169.281	EngineeringImages/C-81-015-02.tif
STMMH17199→ STMMH12457 Centre Street / Brooke Street	Wrong Length = 0 m Wrong u/s invert = 0 Wrong d/s invert = 0	From Drawing Length = 62.9 m u/s invert = 169.236 d/s invert = 168.819	EngineeringImages/C-81-015-02.tif
STMMH17375→ STMMH17374 ? / Maple Sugar Lane	Wrong d/s invert = 0	d/s invert = 209.044	EngineeringImages/19T-97V20-50.tif Interpolated d/s invert using 1.7% slope from Drawing
STMMH15108→STMMH15172 Racco Parkway	Wrong u/s invert = 197.3	u/s invert = 195.67	Interpolated invert using up stream segment d/s inv d/s inv = 195.19 Length = 171.6 m Diameter = 2250 mm
STMMH15108→Dummy_MH1008 Racco Parkway		u/s invert = 195.67 d/s invert = 195.349 Length = 114.9 m Diameter = 2250 mm	Split pipe STMMH15108→STMMH15172 Racco Parkway
Dummy_MH1008→STMMH15172 Racco Parkway		u/s invert = 195.349 d/s invert = 195.19 Length = 56.7 m Diameter = 2250 mm	Split pipe STMMH15108→STMMH15172 Racco Parkway
STMMH14963→STMSJ326 Rockwood Crescent	Wrong u/s invert = 0	u/s invert = 199.743	Interpolated invert using GIS slope 0.5% and d/s inv
STMSJ325→STMMH14954 Venice Crescent	Wrong u/s invert = 0	u/s invert = 195.239	Interpolated invert using GIS slope 0.2% and d/s inv
STMMH15072→STMMH14893	Wrong u/s invert = 194.808	u/s invert = 194.793	Interpolated invert using up stream segment d/s inv

STMMH14930→STMMH14895 Beverley Glen Boulevard	STMMH14930→STMSJ323 Wrong d/s invert = 0	d/s invert = 192.954	Interpolated invert using GIS slope 0.5% and u/s inv, assume STMMH14930 connect to STMMH14895
STMSJ324→STMMH14895 Beverley Glen Boulevard	STMSJ324→STMSJ323		assume STMSJ324 connect to STMMH14895
STMMH14895→STMMH14889 Beverley Glen Boulevard	Wrong connection	u/s node connect to STMSJ323	Assume STMNH14895→STMMH14889
STMMH14927→STMSJ321 Beverley Glen Boulevard	Wrong connection Wrong d/s invert=193.867	d/s node connect to STMMH14889 d/s invert=193.81	Assume STMMH14927→STMMH14889
STMMH14889→STMMH14891 Beverley Glen Boulevard	Wrong d/s invert=191	d/s invert=191.8	EngineeringImages/p-01023-3.tif
STMMH14923→STMSJ320 Beverley Glen Boulevard	Wrong connection	d/s node connect to STMMH14891	Assume STMMH14923→STMMH14891
STMMH14884→STMSJ317 Concord Road	Wrong connection	d/s node connect to STMMH15096	Assume STMMH14884→STMMH15096
STMMH18042→STMMH18041 Concord Road	Wrong u/s invert=0 Wrong d/s invert=0	u/s invert=192.321 d/s invert=192.251 d/s node connect to STMMH18041	Interpolated invert using GIS slope 0.5% and d/s segment obvert match and assume d/s node connect to STMMH18041
STMMH15097→STMMH15090 King High Drive/Concord Road	Reversed Flow Direction	From Drawing STMMH15090→STMMH15097	EngineeringImages/p-00299-052.tif
STMMH15090→STMMH15089 King High Drive/Concord Road	Wrong u/s invert=192.384 Wrong d/s invert=192.735	From Drawing u/s invert=192.735 d/s invert=192.384	EngineeringImages/p-00297-052.tif
STMMH15171→STMMH15170 King High Drive/Belfield Court	Wrong d/s invert=192.527	From Drawing Pipe profile d/s invert=192.537	EngineeringImages/p-00297-051.tif
STMMH15170→IO319 King High Drive/Belfield Court	Wrong u/s invert=192.537	From Drawing Pipe profile u/s invert=192.527	EngineeringImages/p-00297-051.tif
STMMH14877→STMMH14876 Belfield Court	Wrong u/s invert=0 Wrong d/s invert=0	From Drawing u/s invert=192.828 d/s invert=192.705	EngineeringImages/ 19t-89107-911P.TIF
STMMH35070→STMMH35071	Wrong u/s invert=193.49	u/s invert=193.459	Interpolated invert using GIS slope and d/s invert
STMMH15004→Dummy_MH1019 Forest lane Drive	Wrong d/s invert=0 Missing d/s node	d/s invert=193.72 Assumption d/s node connect to Dummy_MH1019	EngineeringImages/ P-01196-00.TIF Interpolated invert using GIS slope 0.8% and u/s invert
STMMH17191→ Dummy_MH1001 Centre Street / Vaughan Boulevard	Wrong u/s invert = 0 Wrong d/s invert = 0 Wrong Diameter=1500 mm	From Drawing u/s invert = 193.208 d/s invert = 192.751 Diameter=1350 mm	EngineeringImages/P-011-5A.tif and P-011-3A.tif

Dummy_MH1001→ STMMH15007 Centre Street / Vaughan Boulevard	Missing pipe	From Drawing u/s invert = 192.726 d/s invert = 191.774 Diameter=1350 mm Length=127.2 m Slope=0.77%	EngineeringImages/P-00011-5A.tif
STMMH15007→ STMMH17194 Centre Street / Vaughan Boulevard	Wrong u/s invert = 0 Wrong d/s invert = 0	From Drawing u/s invert = 191.764 d/s invert = 190.924	EngineeringImages/P-00011-6A.tif
STMMH17193→ STMMH17195 Centre Street / Concord Road	Wrong u/s invert = 0 Wrong d/s invert = 0	From Drawing u/s invert = 190.285 d/s invert = 189.764	EngineeringImages/P-00011-6A.tif And P-00011-052.tif
STMMH17195→ STMMH17185 Centre Street / Concord Road	Wrong u/s invert = 188.159 Wrong d/s invert = 187.634 Wrong Length=107.5m Wrong Slope=0.49%	From Drawing u/s invert = 189.364 d/s invert = 188.159 Length=122.05 m Slope=0.99%	EngineeringImages P-00011-052.tif
STMMH17185→ STMMH17206 Centre Street / Concord Road	Wrong u/s invert = 188.159	From Drawing u/s invert = 188.154	EngineeringImages/ P-00011-052.tif
STMMH17206→ STMSJ418 Centre Street / Concord Road	Wrong u/s invert = 188.159 Wrong d/s invert = 187.634 Wrong Length = 107.45 Wrong Slope=0.49%	u/s invert = 187.584(from drawing) d/s invert = 187.549 Length = 7 m	EngineeringImages/ P-00011-052.tif Interpolated invert d/s inv using assume slope 0.5% and u/s inv ,assume length=7 m
STMMH17196→ STMSJ418 Centre Street / Concord Road	Wrong u/s invert = 188.159 Wrong d/s invert = 187.634 Wrong Length = 107.45 Wrong Diameter = 2250 mm Wrong Slope=0.49% Missing d/s node	From Drawing u/s invert = 188.021 Length = 7 m Diameter = 450 mm Slope=0.3% d/s invert = 188.0	EngineeringImages/ P-00011-052.tif Assumption: d/s node connect to STMSJ418
STMMH17197→ STMMH17196 Centre Street / Concord Road	Wrong u/s invert =0 Wrong d/s invert =0	u/s invert = 188.36 d/s invert = 188.021	Interpolated invert using GIS slope and d/s segment u/s inv
STMSJ418→ STMSJ417 Centre Street / Concord Road	Wrong u/s invert = 188.159 Wrong d/s invert = 187.634 Wrong Length = 107.45 Wrong Slope=0.49%	u/s invert =187.549 d/s invert = 187.517 Length = 6.5 m	Interpolated invert using assume slope 0.5% and u/s segment d/s inv and GIS length
STMSJ417→ STMSJ416 Centre Street / Concord Road	Wrong u/s invert = 188.159 Wrong d/s invert = 187.634 Wrong Slope=0.49%	u/s invert = 187.517 d/s invert = 187.227	Interpolated invert using assume slope 0.5% and u/s segment d/s inv

STMSJ416→ Dummy_MHOut1 Centre Street / Concord Road	Missing d/s node Wrong u/s invert = 188.159 Wrong d/s invert = 187.634 Wrong Length = 107.45 Wrong Slope=0.49%	u/s invert = 187.227 d/s invert = 187.19 Length = 7.5 m	Interpolated invert using assume slope 0.5% and u/s segment d/s inv and GIS length Assumption: d/s node connect to Dummy_MHOut1
STMMH17190→STMMH17189 Centre Street / Concord Road	Wrong u/s invert =0 Wrong d/s invert =0	u/s invert = 194.402 d/s invert = 193.823	EngineeringImages/ P-011-5.tif
STMMH14865→STMMH14866 New Westminster Drive / Katerina Avenue	Wrong d/s invert =0	d/s invert = 197.51	Interpolated invert using d/s segment obvert match
STMMH15151→STMMH15150 New Westminster Drive / Katerina Avenue	Wrong u/s invert =197.08	d/s invert = 197.04	Interpolated invert using u/s segment d/s inv
STMSJ343→STMMH15129 New Westminster Drive / Beverley Glen Boulevard	Wrong u/s invert =197.837	u/s invert = 197.485	Interpolated invert using u/s segment STMSJ341→STMSJ343 obvert match
STMSJ340→STMSJ341 New Westminster Drive / Beverley Glen Boulevard	Wrong u/s invert =0 Wrong d/s invert =0	u/s invert = 198.489 d/s invert = 198.379	Interpolated invert using GIS slope 1% and u/s segment STMSJ341→STMSJ343 obvert match
STMSJ233→STMMH12791 New Westminster Drive / Centre Street	Wrong u/s invert =0	u/s invert = 196.75	Interpolated invert using GIS slope 1% and d/s segment u/s inv
STMMH12641→STMMH12640 Thornway Avenue / Arvida Drive	Wrong u/s invert =195.39 Wrong d/s invert =195.08 Wrong Length = 41.5m Wrong Diameter= 300 mm Wrong slope = 0.94%	u/s invert = 194.86 d/s invert = 194.61 Length = 35.5 m Diameter = 525 mm Slope = 0.7%	EngineeringImages/ P-1010-09.tif
STMMH12733→STMMH12790 New Westminster Drive / Clark Avenue	Wrong u/s invert =189.38 Wrong d/s invert =189.06 Wrong slope = 0.41%	From Drawing u/s invert = 190.24 d/s invert = 189.93 Slope = 0.39%	EngineeringImages/ P-507-4.tif
STMSJ232→STMMH12790 New Westminster Drive / Clark Avenue	Wrong u/s invert =0 Wrong d/s invert =0	u/s invert = 190.405 d/s invert = 190.18	Interpolated invert using assume slope 1% and d/s segment obvert match
STMMH12704→STMMH12914 Brookmill Drive / Robinwood Trail	Wrong u/s invert =188.451	u/s invert = 186.451	Interpolated invert using GIS slope 0.46% and d/s inv
STMMH12105→STMMH12104 Joseph Aaron Boulevard / Millbank Court	Wrong u/s invert =185.855 Wrong d/s invert =185.146	u/s invert = 186.858 From Drawing d/s invert = 186.405	EngineeringImages/ P-00795-30.tif Interpolated u/s invert using slope 0.73% and d/s inv from drawing
STMMH12329→STMMH12337 Clark Avenue West / York Hill Boulevard	Wrong u/s invert =192.61 Wrong d/s invert =191.85	From Drawing u/s invert = 192.08	EngineeringImages/ P-00524-02.tif

STMMH12333→STMMH12338 Clark Avenue West / York Hill Boulevard	Wrong u/s invert =188.63 Wrong d/s invert =188.52	From Drawing u/s invert = 188.38 d/s invert = 188.01	EngineeringImages/ P-00524-03.tif
STMMH12326→STMMH12329 Clark Avenue West / York Hill Boulevard	Wrong u/s invert =191.73 Wrong d/s invert =191.49	From Drawing u/s invert = 192.36 d/s invert = 192.12	EngineeringImages/ P-00524-02.tif
STMMH12884→STMMH12285 Clark Avenue West / Winding Lane	Wrong u/s invert =179.8	u/s invert = 179.53	Interpolated invert using u/s segment STMMH12283→STMMH12284 d/s inv
STMMH12569→STMMH12284 Clark Avenue West / Winding Lane	Wrong u/s invert =0 Wrong d/s invert =0	u/s invert = 182.25 d/s invert = 181.013	Interpolated invert using GIS slope 2.98% and u/s segment STMMH12570→STMMH12569 obvert match
STMMH12452→STMSJ227 Kalen Street	Wrong d/s invert =0	d/s invert = 186.91	Interpolated invert using GIS slope 0.91% and u/s inv
STMMH12449→STMMH12450 Kalen Street			Original data from GIS: u/s invert = 189.304 d/s invert = 185.042 Length = 87.5 m Diameter = 375 mm Slope = 4.87%
STMMH12449→Dummy_MH1020 Kalen Street		u/s invert = 189.304 d/s invert = 186.284 Length = 62 m Diameter = 375 mm Slope = 4.87%	Split pipe STMMH12449→STMMH12450 Kalen Street
Dummy_MH1020→STMMH12450 Kalen Street		u/s invert = 186.284 d/s invert = 185.042 Length = 25.5 m Diameter = 375 mm Slope = 4.87%	Split pipe STMMH12449→STMMH12450 Kalen Street
STMSJ227→Dummy_MH1020 Kalen Street	Wrong u/s invert =0 Wrong d/s invert =0	u/s invert = 186.91 d/s invert = 186.63	Assumption: D/S connect to Dummy_MH1020 and Interpolated invert using u/s segment d/s inv and GIS slope 2.8%
STMMH12453→STMMH12563 Winding Lane / Kalen Street	Wrong u/s invert =0 Wrong d/s invert =0 Wrong Length = 24 m	From Drawing u/s invert = 180.73 d/s invert = 179.23 Length = 83.9 m Slope = 1.78%	EngineeringImages/ P-526-3.tif
STMMH12572→STMMH12453 Winding Lane / Kalen Street	Wrong u/s invert =180.75 Wrong d/s invert =179.23 Wrong Length = 83.9m Wrong Diameter = 600 mm Wrong Slope=1.78%	From Drawing u/s invert = 185.07 d/s invert = 182.72 Length = 65.4 m Slope = 3.59% Diameter = 300 mm	EngineeringImages/ P-526-3.tif
STMMH12558→STMMH12555 Green Bush Crescent	Wrong d/s invert =0	From Drawing d/s invert = 191.811	EngineeringImages/ P-00586-1.tif EngineeringImages/ P-00586-2.tif

STMMH12562→STMMH11948 York Hill Boulevard / Green Bush Crescent	Wrong d/s invert =0	d/s invert = 183.782	Interpolated invert using GIS slope 0.52% and u/s inv
STMMH11953→STMMH11954 Joanna Crescent	Wrong d/s invert =0	d/s invert = 182.544	Interpolated invert using GIS slope 4.24% and u/s inv
STMMH12301→STMMH12302 Joanna Crescent	Wrong u/s invert =178.46	u/s invert = 175.886	Interpolated invert using GIS slope 2.37% and d/s inv
STMMH12444→STMMH12456 Arnold Avenue / Brooke Street	Wrong u/s invert =174.107 Wrong d/s invert =166.047	u/s invert = 173.272 d/s invert = 171.382	Interpolated invert using u/s segment d/s inv
STMMH12304→STMMH17165 Yonge Street / Clark Avenue West	Wrong u/s invert =170.01 Wrong d/s invert =169.349	From Drawing u/s invert = 170.10 d/s invert = 169.68	EngineeringImages/ E-090-1.tif
STMMH17167→STMMH12304 Yonge Street / Clark Avenue West	Wrong d/s invert =170.043	d/s invert = 170.567	Interpolated invert using GIS slope and u/s inv
STMMH17165→STMMH17106 Yonge Street / Clark Avenue West	Wrong u/s invert =0 Wrong d/s invert =0	From Drawing u/s invert = 169.65 d/s invert = 169.46	EngineeringImages/ E-090-1.tif And E-090-2.tif
STMMH17106→STMMH17107 Yonge Street / Clark Avenue West	Wrong u/s invert =169.46 Wrong d/s invert =168.94	From Drawing u/s invert = 169.35 d/s invert = 169.01	EngineeringImages/ E-090-2.tif
STMMH17107→STMMH17108 Yonge Street / Clark Avenue West	Wrong u/s invert =169.01 Wrong d/s invert =168.86	From Drawing u/s invert = 168.94 d/s invert = 168.88	EngineeringImages/ E-090-2.tif
STMMH17108→STMMH17110 Yonge Street / Clark Avenue West	Wrong u/s invert =0 Wrong d/s invert =0	From Drawing u/s invert = 168.86 d/s invert = 168.48	EngineeringImages/ E-090-2.tif and E-090-3.tif
STMMH17110→STMMH17109 Yonge Street / Clark Avenue West	Wrong d/s invert =167.87	From Drawing d/s invert = 168.10	EngineeringImages/ E-090-3.tif
STMMH17109→STMMH12458 Yonge Street / Clark Avenue West	Wrong u/s invert =0 Wrong length = 0 m Wrong slope = 0	From Drawing u/s invert = 167.87 Length = 32.14 m Slope = 0.75%	EngineeringImages/ E-090-3.tif
STMMH12417→STMMH12458 Yonge Street	Wrong d/s invert =167.83	From Drawing d/s invert = 167.90	EngineeringImages/ E-090-3.tif
STMMH12417→STMMH12458 Brooke Street / Arnold Avenue	Wrong d/s invert =166.047	d/s invert = 166.059	Interpolated invert using d/s segment STMMH12456→STMMH27063 u/s invert
STMMH12456→STMMH27063 Brooke Street / Arnold Avenue	Wrong d/s invert =164.466	From Drawing d/s invert = 165.522 Slope = 0.299%	EngineeringImages/ E-99000-15.tif
STMMH127063→STMMH12457 Brooke Street / Arnold Avenue	Wrong u/s invert =166.059 Wrong d/s invert =164.466	u/s invert = 165.522 From Drawing d/s invert = 164.29	EngineeringImages/ P-00244-02.tif Interpolated u/s invert using u/s segment d/s inv
STMMH12457→STMMH16253 Brooke Street / Centre Street	Wrong d/s invert =0 Wrong Slope = 0	d/s invert = 163.357	Interpolated u/s invert using Assume slope 0.338% and u/s inv

STMMH16253→IO378 Brooke Street / Centre Street	Wrong u/s invert =164.466 Wrong d/s invert =0	u/s invert = 163.357 d/s invert = 163.041	Interpolated invert using GIS slope 0.338% and u/s inv
STMMH17167→STMMH12304 Yonge Street / Clark Avenue West	Wrong d/s invert =170.043	d/s invert = 170.567	Interpolated invert using GIS slope 1.21% and u/s inv
STMMH17166→STMMH17167 Yonge Street / Clark Avenue West	Wrong u/s invert =176.68	u/s invert = 176.451	Interpolated invert using GIS slope 4.73% and d/s inv
STMSJ415→STMMH17166 Yonge Street / Clark Avenue West	Wrong u/s invert =0 Wrong d/s invert =176.455	u/s invert = 177.551 d/s invert = 176.53	Interpolated invert using GIS slope 2.43% and d/s segment obvert match
STMMH12420→STMSJ214 Springfield Way / Tanjo Court	Wrong u/s invert =0 Wrong d/s invert =0	u/s invert = 174.43 d/s invert = 174.08	Interpolated invert using segment STMMH12419→STMMH12420 d/s inv and STMMH12420→STMSJ214 u/s inv
STMMH12303→STMMH12304 Clark Avenue West / Yonge Street	Wrong u/s invert =171.48 Wrong d/s invert =170.11	From Drawing u/s invert = 172.2 d/s invert = 170.69	EngineeringImages/ P-00524-10.tif
STMMH12268→STMMH12270 Campbell Avenue / Rejane Crescent	Wrong u/s invert =197.32 Wrong d/s invert =194.652	From Drawing u/s invert = 194.374 d/s invert = 192.500	EngineeringImages/ P-00290-4.tif (Drawing is not clear)
STMMH12266→STMMH12267 Campbell Avenue / Rejane Crescent	Wrong u/s invert =0 Wrong d/s invert =0	From Drawing u/s invert = 197.849 d/s invert = 197.579	EngineeringImages/ P-00290-3.tif (Drawing is not clear)
STMMH12264→STMMH12266 Campbell Avenue / Rejane Crescent	Wrong u/s invert =0 Wrong d/s invert =0	u/s invert = 198.11 d/s invert = 197.90	Interpolated invert using u/s segment invert and slope 0.5%
STMMH12262→STMMH12261 Campbell Avenue / Rejane Crescent	Wrong length = 43.7 m Wrong slope = 0.348%	From Drawing Length = 45.0 m Slope = 0.707%	EngineeringImages/ P-00290-2.tif (Drawing is not clear)
STMMH12261→STMMH12263 Campbell Avenue / Patrice Crescent	Wrong u/s invert =0 Wrong d/s invert =0 Wrong slope = 0.232%	u/s invert = 199.483 d/s invert = 199.197 From Drawing Slope = 0.654%	EngineeringImages/ P-00290-2.tif (Drawing is not clear) Interpolated invert using slope 0.654% and u/s segment STMMH12059→STMMH12261 obvert match
STMMH12263→STMMH12264 Campbell Avenue / Patrice Crescent	Wrong u/s invert =0 Wrong d/s invert =0	u/s invert = 198.168 d/s invert = 198.11	EngineeringImages/ P-00290-3.tif (Drawing is not clear) Interpolated d/s invert using slope 0.232%
STMMH11947→STMMH12551 Gailcrest Circle / York Hill Boulevard	Wrong u/s invert =190.13 Wrong d/s invert =189.7	u/s invert = 190.61 d/s invert = 190.3	EngineeringImages/ P-00545-03.tif
STMMH11944→STMMH11941 Gailcrest Circle / Jenstar way	Wrong d/s invert =191.75	From Drawing d/s invert = 192.38	EngineeringImages/ P-00545-01.tif
STMMH11941→STMMH11942 Gailcrest Circle / Jenstar way	Wrong u/s invert =191.7 Wrong d/s invert =191.26	From Drawing u/s invert = 192.30 d/s invert = 191.85	EngineeringImages/ P-00545-01.tif

STMMH12477→STMMH12475 Theodore Place	Wrong u/s invert = 0 Wrong d/s invert = 0	u/s invert = 190.92 From Drawing d/s invert = 190.64 Length = 38 m slope=0.9%	EngineeringImages/ P-01148-04.tif and P-01148-01.tif Interpolated u/s invert using u/s segment d/s inv 190.92
STMMH12475→STMMH_Cole102 Theodore Place	Wrong u/s invert = 0 Wrong d/s invert = 0 Wrong length = 0	u/s invert = 189.86 d/s invert = 189.5 Length = 9.5 m	EngineeringImages/ P-01148-01.tif and P-00495-02.tif
STMMH12482→STMMH12295 Theodore Place	Wrong u/s invert = 0 Wrong d/s invert = 0 Wrong length = 0	u/s invert = 190.54 d/s invert = 190.21 Length = 88.7 m	EngineeringImages/ P-01148-00.tif and P-00523-00.tif Interpolated length using measured GIS length 88.6 m
STMMH12544→STMMH12537 York Hill Boulevard	Wrong u/s invert = 0	u/s invert = 191.74	Interpolated u/s invert using GIS slope 1.63% and d/s inv
Dummy_MH1035→ STMMH12538 York Hill Boulevard	Wrong u/s invert = 0	u/s invert = 190.798	Assumption: connect to Dummy_MH1035 Interpolated u/s invert using GIS slope 0.39% and d/s inv
STMMH12538→Dummy_MH1002 York Hill Boulevard	Wrong d/s invert = 0	d/s invert = 190.4	Assumption: connect to Dummy_MH1002 Interpolated u/s invert using GIS slope 0.3% and u/s inv
STMMH12537→Dummy_MH1002 York Hill Boulevard		u/s invert = 190.385 d/s invert = 190.22 Length = 20 m	Split segment STMMH12537→ STMMH12536
Dummy_MH1002→STMMH12536 York Hill Boulevard		u/s invert = 190.22 d/s invert = 189.668 Length = 67.7 m	Split segment STMMH12537→ STMMH12536
STMMH11929→STMMH11930 Michael Court	Wrong length = 0	Length = 36.4 m	Interpolated length using GIS length
STMMH11930→STMMH12295 Michael Court	Wrong length = 0	Length = 22.2 m	Interpolated length using GIS length
STMMH12295→STMMH12567 Michael Court	Wrong length = 0	Length = 98.3 m	Interpolated length using GIS length
STMMH12537→STMMH12286 North Meadow Crescent / York Hill Boulevard	Wrong Flow Direction Wong u/s invert = 190.68 Wrong d/s invert = 0	From Drawing STMMH12286→ STMMH12537 u/s invert = 191.412 d/s invert = 190.698	EngineeringImages/ P-00495-1A.tif Interpolated u/s invert using GIS slope 1.02% and d/s inv 190.698 from drawing
STMMH12561→STMMH12286 North Meadow Crescent / York Hill Boulevard	Wrong d/s invert = 0	d/s invert = 191.412	Interpolated d/s invert using segment STMMH12286→ STMMH12537 u/s inv
STMMH12286→STMMH12560 North Meadow Crescent / York Hill Boulevard	Wrong d/s invert = 19.041	d/s invert = 191.041	Interpolated invert using GIS slope 1.68% and u/s inv
STMMH12525→STMMH12528 Hilda Avenue / York Hill Boulevard	Wrong d/s invert = 0	d/s invert = 191.005	EngineeringImages/ P-00537-06.tif

STMMH12526→STMMH12525 Hilda Avenue / York Hill Boulevard	Missing Pipe	u/s invert = 192.00 d/s invert = 191.766 diameter = 375 mm length = 40.52 m slope = 0.58%	EngineeringImages/ P-00537-05.tif Interpolated u/s invert using slope 0.58% and d/s inv 191.766
STMMH12564→STMMH12528 Hilda Avenue / York Hill Boulevard	Wrong u/s invert = 0 Wrong d/s invert = 0	u/s invert = 186.24 d/s invert = 186.07	EngineeringImages/ P-00537-06.tif Interpolated u/s invert using slope 0.24% and d/s inv from drawing
STMMH12053→STMMH12052 Hefhill Court / Regency Gate	Wrong d/s invert = 185.848	From Drawing d/s invert = 186.248	EngineeringImages/ P-00952-00.tif
STMMH12052→STMMH12051 Hefhill Court / Regency Gate	Wrong u/s invert = 186.248 Wrong d/s invert = 185.61	From Drawing u/s invert = 185.848 d/s invert = 185.68	EngineeringImages/ P-00952-00.tif
STMMH12051→STMMH12047 Hefhill Court / Regency Gate	Wrong u/s invert = 185.68 Wrong d/s invert = 185.128	From Drawing u/s invert = 185.61 d/s invert = 185.358	EngineeringImages/ P-00952-00.tif
STMMH12046→STMMH12047 Hefhill Court / Regency Gate	Wrong d/s invert = 185.258	From Drawing u/s invert = 185.528	EngineeringImages/ P-00952-00.tif
STMMH12047→STMMH12048 Hefhill Court / Regency Gate	Wrong u/s invert = 0 Wrong d/s invert = 0	From Drawing u/s invert = 185.128	EngineeringImages/ P-00952-00.tif
STMMH12213→STMMH12212 Franklin Avenue / Manor Gate	Wrong d/s invert = 187.223	From Drawing d/s invert = 187.273	EngineeringImages/ P-00292-5.tif
STMMH12212→STMMH12211 Franklin Avenue / Manor Gate	Wrong u/s invert = 187.273 Wrong d/s invert = 187.073	From Drawing u/s invert = 187.223 d/s invert = 187.048	EngineeringImages/ P-00292-5.tif
STMMH12211→STMMH12054 Franklin Avenue / Manor Gate	Wrong u/s invert = 187.073	From Drawing u/s invert = 187.048	EngineeringImages/ P-00292-5.tif
STMMH12576→STMMH12055 Franklin Avenue / Braemar Court	Wrong u/s invert = 0 Wrong d/s invert = 0	u/s invert =187.434 d/s invert = 187.197	EngineeringImages/ P-00960-1A.tif Interpolated u/s invert using slope 0.7% and d/s inv from drawing
STMMH12575→STMMH12055 Franklin Avenue / Braemar Court	Wrong u/s invert = 0 Wrong d/s invert = 0	u/s invert = 188.835 d/s invert = 188.352	EngineeringImages/ P-00960-1A.tif Interpolated u/s invert using slope 0.77% and d/s inv from drawing
STMMH12047→STMMH12048 Hefhill Court / Franklin Avenue	Wrong u/s invert = 0 Wrong d/s invert = 0	u/s invert = 185.128 d/s invert = 184.689 length = 10.7 m slope = 4.1%	EngineeringImages/ P-00952-00.tif and 65M-2581-02[1].tif Interpolated d/s invert using slope 4.1% and u/s inv from drawing
STMMH12048→STMMH12049 Hefhill Court / Franklin Avenue	Wrong u/s invert = 0 Wrong d/s invert = 0	u/s invert = 184.689 d/s invert = 184.565 slope = 0.326%	65M-2581-02[1].tif Interpolated invert using slope 0.326% from drawing and u/s segment d/s inv
STMMH12049→STMMH12050 Hefhill Court / Franklin Avenue	Wrong u/s invert = 0 Wrong d/s invert = 0 Wrong length = 0.8 m Diameter = 200 mm Slope = 1%	u/s invert = 184.565 d/s invert = 184.530 length = 10.7 m diameter = 750 mm slope = 0.326%	65M-2581-02[1].tif Interpolated invert using slope 0.326% from drawing and u/s segment d/s inv

STMMH12050→STMMH12424 Hefhill Court / Franklin Avenue	Wrong u/s invert = 0 Wrong d/s invert = 0 Wrong length = 0.8 m Diameter = 200 mm Slope = 1%	u/s invert = 184.530 d/s invert = 182.741 length = 42.0 m diameter = 750 mm slope = 4.26%	65M-2581-02[1].tif Interpolated invert using slope 4.26% from drawing and u/s segment d/s inv
STMMH12049→ IO295 Hefhill Court / Franklin Avenue	Wrong Flow Direction Wrong u/s invert = 0 Wrong d/s invert = 0 Wrong length = 19 m Diameter = 1200 mm Slope = 1%	IO295→ STMMH12049 u/s invert = 185.149 d/s invert = 185.015 length = 17.3 m diameter = 300 mm slope = 0.773%	65M-2581-02[1].tif Interpolated invert using slope 0.773% from drawing and d/s segment obvert match
STMMH12424→STMMH12227 Franklin Avenue	Wrong u/s invert = 0 Wrong d/s invert = 0	u/s invert = 182.741 d/s invert = 182.680	65M-2581-02[1].tif Interpolated invert using slope 0.24% from drawing and u/s segment STMMH12050→STMMH12424 d/s inv
STMMH12227→STMMH12228 Franklin Avenue	Wrong u/s invert = 0 Wrong d/s invert = 0 Wrong length = 0	u/s invert = 182.680 d/s invert = 182.43 length = 50.1 m	Interpolated invert using assume slope 0.5% and u/s segment d/s inv
STMMH12227→STMMH12228 Franklin Avenue	Wrong u/s invert = 0 Wrong d/s invert = 0	u/s invert = 182.28 d/s invert = 182.235	Interpolated invert using GIS slope 0.26% and u/s segment obvert match
STMMH12423→STMMH12424 Franklin Avenue	Wrong u/s invert = 0 Wrong d/s invert = 0	u/s invert = 183.634 d/s invert = 183.116	Interpolated invert using GIS slope 1.28% and d/s segment obvert match
STMMH12422→STMMH12423 Franklin Avenue	Wrong u/s invert = 0 Wrong d/s invert = 0	u/s invert = 185.361 d/s invert = 183.709	Interpolated invert using GIS slope 3.53% and d/s segment obvert match
STMMH16458→STMMH11787 Atkinson Avenue / Rosedale Heights Drive	Wrong u/s invert = 189.924	u/s invert = 188.924	EngineeringImages/ P-00681-1A.tif
STMMH16458→Dummy_MH1012 Atkinson Avenue / Rosedale Heights Drive		u/s invert = 188.924 d/s invert = 188.258 Length = 95.7 m Diameter = 1650 mm Slope = 0.7%	Split pipe STMMH16458→STMMH11787 Atkinson Avenue / Rosedale Heights Drive
Dummy_MH1012→STMMH11787 Atkinson Avenue / Rosedale Heights Drive		u/s invert = 188.258 d/s invert = 187.98 Length = 40 m Diameter = 1650 mm Slope = 0.7%	Split pipe STMMH16458→STMMH11787 Atkinson Avenue / Rosedale Heights Drive
IO395→Dummy_MH1012 Atkinson Avenue / Rosedale Heights Drive			Assume IO395 connect to Dummy_MH1012
STMMH16371→STMMH16458 Atkinson Avenue / Rosedale Heights Drive	Wrong length = 0	Length = 398.125 m	Interpolated length using GIS slope 0.64% and u/s inv and d/s inv
STMMH16371→STMMH16732 Atkinson Avenue / Rosedale Heights Drive		u/s invert = 191.645 d/s invert = 190.76 Length = 138.3 m Diameter = 1500 mm Slope = 0.64%	Split original pipe STMMH16371→STMMH16458
STMMH16732→STMMH16458 Atkinson Avenue / Rosedale Heights Drive		u/s invert = 190.76 d/s invert = 189.097 Length = 259.8 m Diameter = 1500 mm Slope = 0.64%	Split original pipe STMMH16371→STMMH16458

STMMH16379→STMMH16732 Atkinson Avenue / Rosedale Heights Drive	Missing d/s manhole	STMMH16379→ STMMH16732	Assume d/s connect to STMMH16732
IO376→STMMH16377 Dundurn Crescent / Atkinson Avenue	Wrong u/s invert = 0	u/s invert = 194.755	Interpolated length using GIS slope 0.59% and d/s inv
STMMH12231→STMMH12230 Helena Gardens / Markwood Lane	Wrong u/s invert = 0 Wrong d/s invert = 0 Wrong length = 0 Wrong slope = 0	From Drawing u/s invert =186.905 d/s invert = 186.664 length = 24.4 m slope = 0.99%	EngineeringImages/ P-00847-01.tif
STMMH12230→STMMH12232 Helena Gardens / Markwood Lane	Wrong u/s invert = 186.664	From Drawing u/s invert =186.544	EngineeringImages/ P-00847-01.tif
STMMH27064→STMMH12247 Calvin Chambers Road	Wrong u/s invert = 0	u/s invert = 178.067	Interpolated invert using GIS slope 1.28% and d/s inv
STMMH4560→STMMH12748 Ramblewood Lane	Wrong Flow Direction	From Drawing STMMH12748 → STMMH4560	EngineeringImages/ P-00748-02.tif
STMMH_Cole1001→Dummy_MH1003 Thornridge Drive / Charles Street	Missing Pipe	u/s invert =182.0 d/s invert =180.965 length = 69 m Diameter = 300 mm slope =1.5%	EngineeringImages/ C083-023-24.tif Interpolated invert using slope 1.5% and u/s inv from drawing
Dummy_MH1003→Dummy_MH1004 Thornridge Drive / Charles Street	Missing Pipe	u/s invert =180.8 d/s invert =180.5 length = 20 m Diameter = 450 mm slope =1.5%	EngineeringImages/ C083-023-24.tif Interpolated invert using slope 1.5% and d/s inv from drawing
Dummy_MH1004→Dummy_MH1005 Thornridge Drive / Raymond Drive	Missing Pipe	From drawing u/s invert =178.6 d/s invert =177.910 length = 115 m Diameter = 600 mm slope = 0.85%	EngineeringImages/ C083-023-24.tif
Dummy_MH1005→Dummy_MH1006 Thornridge Drive / Raymond Drive	Missing Pipe	From drawing u/s invert =177.835 d/s invert =177.218 length = 85 m Diameter = 675 mm slope = 0.65%	EngineeringImages/ C083-023-24.tif
Dummy_MH1006→Dummy_MH1007 Thornridge Drive / Clarkhaven Street	Missing Pipe	From drawing u/s invert =177.188 d/s invert =176.520 length = 89 m Diameter = 675 mm slope = 0.75%	EngineeringImages/ C083-023-23.tif
Dummy_MH1007→Dummy_MH1008 Thornridge Drive / Clarkhaven Street	Missing Pipe	From drawing u/s invert =174.693 d/s invert =173.349 length = 112 m Diameter = 825 mm slope = 1.2%	EngineeringImages/ C083-023-23.tif
Dummy_MH1008→Dummy_MH1009 Thornridge Drive / Clarkhaven Street	Missing Pipe	From drawing u/s invert =173.274 d/s invert =172.339 length = 110 m Diameter = 900 mm slope = 0.85%	EngineeringImages/ C083-023-23.tif

Dummy_MH1009→Dummy_MH1010 Thornridge Drive / Brooke Street	Missing Pipe	From drawing u/s invert =172.264 d/s invert =170.946 length = 155 m Diameter = 975 mm slope = 0.85%	EngineeringImages/ C083-023-22.tif
STMMH_Cole1010→STMMH27063 Thornridge Drive / Brooke Street	Missing Pipe	From drawing u/s invert =170.917 d/s invert =170.367 length = 10 m Diameter = 975 mm slope = 2.5%	EngineeringImages/ C083-023-22.tif
STMMH_Cole1015→STMMH_Cole1014 Erica Road / Centre Street	Missing Pipe	From drawing u/s invert =184.65 d/s invert =184 length = 93 m Diameter = 375 mm slope = 0.70%	EngineeringImages/ P-00286-01.tif
STMMH_Cole1014→STMMH_Cole1013 Erica Road / Centre Street	Missing Pipe	From drawing u/s invert = 183.92 d/s invert = 183.84 length = 22 m Diameter = 450 mm slope = 0.50%	EngineeringImages/ P-00286-01.tif
STMMH_Cole1013→STMMH_Cole1012 Erica Road / Centre Street	Missing Pipe	From drawing u/s invert = 183.46 d/s invert = 182.5 length = 96 m Diameter = 450 mm slope = 1%	EngineeringImages/ P-00286-02.tif
STMMH_Cole1012→STMMH12238 Erica Road / Centre Street	Missing Pipe	From drawing u/s invert = 182.35 d/s invert = 182.15 length = 39 m Diameter = 600 mm slope = 0.51%	EngineeringImages/ P-00286-02.tif
STMMH_Cole1016→STMMH_Cole1017 Oakbank Road / Centre Street	Missing Pipe	From drawing u/s invert = 174.454 d/s invert = 173.794 length = 110 m Diameter = 525 mm slope = 0.6%	EngineeringImages/ P-00269-2A.tif
STMMH_Cole1017→STMMH_Cole1018 Oakbank Road / Centre Street	Missing Pipe	From drawing u/s invert = 173.719 d/s invert = 173.082 length = 98 m Diameter = 1000 mm slope = 0.65%	EngineeringImages/ P-00269-2A.tif and P-00269-1.tif
STMMH_Cole1018→STMMH_Cole1019 Oakbank Road / Centre Street	Missing Pipe	From drawing u/s invert = 173.082 d/s invert = 172.402 length = 68 m Diameter = 1000 mm slope = 1%	EngineeringImages/ P-00269-1.tif
STMMH_Cole1019→STMMH18064 Oakbank Road / Centre Street	Missing Pipe	From drawing u/s invert = 172.402 d/s invert = 171.922 length = 40 m Diameter = 1000 mm slope = 1.28%	EngineeringImages/ P-00269-1.tif

STMMH_Cole1020→STMMH_Cole 1021 Thornbank Road / Centre Street	Missing Pipe	From drawing u/s invert = 178.74 d/s invert = 178.54 length = 19 m Diameter = 375 mm slope = 1%	EngineeringImages/ T00-0054-26.tif
STMMH_Cole1021→STMMH_Cole 1022 Thornbank Road / Centre Street	Missing Pipe	From drawing u/s invert = 178.49 d/s invert = 177.66 length = 84 m Diameter = 375 mm slope = 1%	EngineeringImages/ T00-0054-26.tif
STMMH_Cole1022→STMMH_Cole 1023 Thornbank Road / Centre Street	Missing Pipe	From drawing u/s invert = 177.61 d/s invert = 176.14 length = 69 m Diameter = 375 mm slope = 2.1%	EngineeringImages/ T00-0054-26.tif
STMMH_Cole1023→STMMH_Cole 1024 Thornbank Road / Centre Street	Missing Pipe	u/s invert = 176.09 d/s invert = 173.39 length = 90 m Diameter = 375 mm slope = 3%	EngineeringImages/ T00-0054-26.tif Interpolated d/s invert using slope 3% and u/s inv from drawing
STMMH_Cole1024→STMMH_Cole 1025 Thornbank Road / Centre Street	Missing Pipe	u/s invert = 173.39 d/s invert = 172.763 length = 9.5 m Diameter = 375 mm slope = 6.6%	EngineeringImages/ T00-0054-26.tif Interpolated slope=(170.67-170.039)/9.5 from drawing , u/s invert using u/s segment d/s inv , d/s inv using u/s inv and slope 6.6%
STMMH_Cole1025→STMMH17199 Thornbank Road / Centre Street	Missing Pipe	u/s invert = 172.763 d/s invert = 172.103 length = 10 m Diameter = 375 mm slope = 6.6%	EngineeringImages/ T00-0054-26.tif Interpolated Invert using u/s segment d/s inv and u/s segment slope 6.6% and estimated length 10m
STMMH_Cole1028→STMMH_Cole 1029 Clarkhaven Street / Thornridge Drive	Missing Pipe	u/s invert = 178.345 d/s invert = 177.595 length = 30 m Diameter = 250 mm slope = 2.5%	EngineeringImages/ C083-023-26.tif Interpolated d/s Invert using u/s inv and slope 2.5% from drawing
STMMH_Cole1029→STMMH_Cole 1007 Clarkhaven Street / Thornridge Drive	Missing Pipe	u/s invert = 177.045 d/s invert = 176.52 length = 21 m Diameter = 525 mm slope = 2.5%	EngineeringImages/ C083-023-26.tif Interpolated u/s Invert using d/s inv and slope 2.5% from drawing
STMMH_Cole1026→STMMH_Cole 1027 Clarkhaven Street / Thornridge Drive	Missing Pipe	From drawing u/s invert = 176.055 d/s invert = 175.395 length = 110 m Diameter = 675 mm slope = 0.6%	EngineeringImages/ C083-023-26.tif
STMMH_Cole1027→STMMH_Cole 1007 Clarkhaven Street / Thornridge Drive	Missing Pipe	From drawing u/s invert = 175.365 d/s invert = 174.843 length = 87 m Diameter = 675 mm slope = 0.6%	EngineeringImages/ C083-023-26.tif

STMMH_Cole1030→STMMH_Cole 1026 Donna Mae Crescent / Clarkhaven Street	Missing Pipe	From drawing u/s invert = 176.58 d/s invert = 176.355 length = 21 m Diameter = 375 mm slope = 2.5%	EngineeringImages/ P-00248-01.tif
STMMH12404→STMMH12081 Charles Street / Spring Gate Boulevard	Wrong u/s invert = 188.77 Wrong d/s invert = 187.94 Wrong length = 77.9 m Wrong slope = 1.07%	From drawing u/s invert = 181.54 d/s invert = 180.50 length = 89.7 m slope = 1.16%	EngineeringImages/ P-00294-01.tif
STMMH_Cole1031→STMMH_Cole 1004 Charles Street / Thornridge Drive	Missing Pipe	u/s invert = 180.0 d/s invert = 179.5 length = 50 m diameter = 375 mm slope = 1%	EngineeringImages/ P-00294-03.tif
Dummy_MH1007→Dummy_MH100 6Caraway Drive	Missing u/s,d/s manholes	Add Dummy manhole Dummy_MH1007 Dummy_MH1006	
STMMH17552→Dummy_MH1005 Caraway Drive	Missing d/s manhole	Add Dummy manhole Dummy_MH1005	
IO473→Dummy_MH1006 Caraway Drive		u/s invert = 198.04 d/s invert = 197.329 length = 86.5 m	Split pipe IO473→STMMH15008
Dummy_MH1006→Dummy_MH100 5 Caraway Drive		u/s invert = 197.329 d/s invert = 197.262 length = 8.2 m	Split pipe IO473→STMMH15008
Dummy_MH1005→STMMH15008 Caraway Drive		u/s invert = 197.262 d/s invert = 196.342 length = 111.9 m	Split pipe IO473→STMMH15008
STMMH15172→IO320 Racco Parkway		u/s invert = 195.19 d/s invert = 194.958 length = 23.2 m Diameter = 2250 mm	Assumption new pipe to pond Assumption all data
STMMH15020→STMMH15019 Racco Parkway			Original data from GIS: u/s invert = 202.439 d/s invert = 202.117 length = 67.1 m Diameter = 525 mm Slope = 0.5%
STMMH15020→Dummy_MH1009 Racco Parkway		u/s invert = 202.439 d/s invert = 202.132 length = 64 m Diameter = 525 mm Slope = 0.5%	Split from pipe STMMH15020→STMMH1 5019 Racco Parkway
Dummy_MH1009→ STMMH15019 Racco Parkway		u/s invert = 202.132 d/s invert = 202.117 length = 3.1 m Diameter = 525 mm Slope = 0.5%	Split from pipe STMMH15020→STMMH1 5019 Racco Parkway
IO307→ Dummy_MH1009 Westmount Boulevard	Wrong u/s invert = 0 Wrong d/s invert = 0 Wrong length = 0	u/s invert = 202.467 d/s invert = 202.407 length = 6 m Diameter = 250 mm Slope = 1%	Interpolated Invert using d/s segment obvert match and assume slope 1%

STMMH15045→ STMMH15046 Savoy Crescent			Original data from GIS: u/s invert = 201.31 d/s invert = 201.195 length = 22 m Diameter = 525 mm Slope = 0.52%
STMMH15045→ Dummy_MH1010 Savoy Crescent		u/s invert = 201.31 d/s invert = 201.294 length = 3 m Diameter = 525 mm Slope = 0.52%	Split from pipe STMMH15045→ STMMH15046 Savoy Crescent
Dummy_MH1010→ STMMH15046 Savoy Crescent		u/s invert = 201.294 d/s invert = 201.195 length = 19 m Diameter = 525 mm Slope = 0.52%	Split from pipe STMMH15045→ STMMH15046 Savoy Crescent
IO308→ Dummy_MH1010 Savoy Crescent	Wrong u/s invert = 0 Wrong d/s invert = 0 Wrong length = 0	u/s invert = 201.346 d/s invert = 201.294 length = 5.2 m Diameter = 750 mm Slope = 1%	Interpolated Invert using d/s segment u/s inv ,assume slope 1% and estimated length
STMMH15051→ STMMH15050 Savoy Crescent			Original data from GIS: u/s invert = 199.693 d/s invert = 199.461 length = 38.8 m Diameter = 975 mm Slope = 0.598%
STMMH15051→ Dummy_MH1011 Savoy Crescent		u/s invert = 199.693 d/s invert = 199.668 length = 4.2 m Diameter = 975 mm Slope = 0.598%	Split from pipe STMMH15051→ STMMH15050 Savoy Crescent
Dummy_MH1011→ STMMH15050 Savoy Crescent		u/s invert = 199.668 d/s invert = 199.461 length = 34.6 m Diameter = 975 mm Slope = 0.598%	Split from pipe STMMH15051→ STMMH15050 Savoy Crescent
IO309→ Dummy_MH1011 Savoy Crescent	Wrong u/s invert = 0 Wrong d/s invert = 0	u/s invert = 200.056 d/s invert = 199.668	Interpolated Invert using d/s segment u/s inv and GIS slope 0.5%
STMMH12334→ STMMH12441 Brownstone Circle		Assume STMMH12334 connect to STMMH12441	EngineeringImages/ P- 00992-03.tif STMMH12334 is a CBMH , a lead from STMMH12334 connect to 2 CBs in drawing
STMMH12192→ STMMH12579 Judith Avenue / Clark Avenue west			Original data from GIS: u/s invert = 188.345 d/s invert = 187.889 Length = 117.4 m Diameter = 1500 mm Slope = 0.39%
STMMH12192→ Dummy_MH1013 Judith Avenue / Clark Avenue west		u/s invert = 188.345 d/s invert = 188.034 Length = 80 m Diameter = 1500 mm Slope = 0.39%	Split pipe STMMH12192→ STMMH12579 Judith Avenue / Clark Avenue west

Dummy_MH1013→ STMMH12579 Judith Avenue / Clark Avenue west		u/s invert = 188.034 d/s invert = 187.889 Length = 37.4 m Diameter = 1500 mm Slope = 0.39%	Split pipe STMMH12192→ STMMH12579 Judith Avenue / Clark Avenue west
STMMH12669→ Dummy_MH1013 Judith Avenue / Clark Avenue west		Assumption: connect to Dummy_MH1013	
STMMH13113→ ? Pondview Road	No outlet		Original data from GIS: u/s invert = 183.047 d/s invert = 182.966 Diameter = 300 mm Length = 3 m Slope = 2.7%
STMMH13113→ Dummy_MH1014 Pondview Road	Wrong length = 3 m Wrong outlet	Assumption: u/s invert = 183.047 d/s invert = 182.696 Length = 13 m Diameter = 300 mm Slope = 2.7%	Assumption: connect to Dummy_MH1014 Follow original pipe diameter,slope and u/s invert. Interpolated d/s invert using updated pipe length from GIS and slope 2.7%
STMMH12229→ Dummy_MH1014 Pondview Road	Missing Pipe	Assumption: u/s invert = 182.235 d/s invert = 182.108 Length = 49 m Diameter = 900 mm Slope = 0.26%	Assumption: New Pipe Interpolated data using u/s segment d/s inv, slope 0.26%, diameter and GIS length
STMMH14879→ Dummy_MH1015 Beverley Glen Boulevard	Missing d/s node (outlet)		Assumption: STMMH14879 connect to Dummy_MH1015
STMMH14887→ Dummy_MH1016 Beverley Glen Boulevard	Missing d/s node (outlet)		Assumption: STMMH14887 connect to Dummy_MH1016
STMMH14966→ STMMH14940 Rockwood Crescent			Original data from GIS: u/s invert = 203.246 d/s invert = 202.403 length = 84.7 m Diameter = 450 mm Slope = 0.5%
STMMH14966→ Dummy_MH1017 Rockwood Crescent		u/s invert = 203.246 d/s invert = 203.149 length = 9.7 m Diameter = 450 mm Slope = 0.5%	Split Pipe STMMH14966→ STMMH14940 Rockwood Crescent
Dummy_MH1017→ STMMH14940 Rockwood Crescent		u/s invert = 203.149 d/s invert = 202.403 length = 75 m Diameter = 450 mm Slope = 0.5%	Split Pipe STMMH14966→ STMMH14940 Rockwood Crescent
STMMH14965→ Dummy_MH1017 Rockwood Crescent	Missing d/s node Wrong u/s invert = 0 Wrong d/s invert = 0	u/s invert = 203.567 d/s invert =203.349	Assumption: STMMH14965 connect to Dummy_MH1017, Interpolated invert using GIS slope 0.5% and d/s segment Dummy_MH1017→STMMH14940 Obvert match

STMMH_Cole1032→ STMMH15001 Forest Lane Drive	Missing Pipe	u/s invert =197.151 d/s invert = 195.681 Length = 105 m Diameter = 375 mm Slope = 1.4%	EngineeringImages/ P-1196-01.tif Interpolated invert using d/s segment obvert match and length,slope,diameter from drawing
STMMH14915→ STMMH14916 Coldwater Court	Wrong u/s invert = 0 Wrong d/s invert = 0 Wrong length = 32 m	u/s invert = 195.689 d/s invert = 195.147 Length = 12.6 m	Interpolated invert using d/s segment STMMH14916→ STMMH14917 obvert match, GIS slope 4.3% and estimated length from GIS
STMMH14914→ STMMH14915 Coldwater Court	Wrong u/s invert = 0 Wrong d/s invert = 0	u/s invert = 197.065 d/s invert = 195.689	Interpolated invert using d/s segment u/s inv and GIS slope 4.3%
STMMH15096→ Dummy_MH1018 Concord Road	Missing d/s node	Assume connect to d/s node Dummy_MH1018	
Dummy_MH1018→ STMMH18041 Concord Road	Missing u/s node and d/s node	Assume u/s node connect to Dummy_MH1018 and d/s node connect to STMMH18041	
Dummy_MH1019→ STMMH18042 Forest Lane Drive / Concord Road	Missing Pipe	Assumption: Dummy_MH1019 connect to STMMH1019 u/s invert = 193.42 d/s invert = 192.321 Length = 166.8 m Diameter = 825 mm	Interpolated u/s invert using u/s segment obvert match, Interpolated d/s invert using d/s segment u/s inv, Interpolated diameter using d/s segment diameter and estimated GIS length
STMMH35074→ STMMH15171 King High Drive	Missing d/s node Wrong u/s invert = 193.3	Assumption: d/s node connect to STMMH15171 u/s invert = 193.28	Interpolated u/s invert using u/s segment d/s invert
STMMSJ20610→ STMMH35074 King High Drive	Wrong u/s invert = 0 Wrong d/s invert = 0 Length = 0 Diameter = 75 mm	deleted	Length = 0.2 m in GIS
STMMH35071→ STMSJ20610 King High Drive			u/s inv = 193.32 d/s inv = 193.28 Length = 2.5 m Diameter = 600 mm Slope = 0.3%
STMMH35071→ STMMH35074 King High Drive		Assumption: d/s node connect to STMMH35074 u/s inv = 193.32 d/s inv = 193.28 Length = 2.5 m Diameter = 600 mm Slope = 0.3%	
STMMH12416→ STMSJ214 Springfield Way	Wrong u/s invert = 174.08 Wrong d/s invert = 0 Wrong length = 0	u/s invert = 174.79 d/s invert = 174.738 Length = 12 m	Interpolated invert using u/s segment d/s inv and slope 0.43%, and estimated GIS length
STMMH12095→ Outfall_Site_5 Elgin Street	Wrong u/s invert = 0 Wrong d/s invert = 0 Wrong length = 0	u/s invert = 168.05 d/s invert = 167.734 Length = 63.2 m	Interpolated invert using u/s segment d/s inv and assume slope 0.5%, and estimated GIS length

STMMH12157→ IO2760 Haley Court	Wrong d/s invert = 0 Wrong length = 0 Wrong slope = 0	d/s invert = 184.878 Length = 38.25 m Slope = 1.6%	EngineeringImages/ P-00739-01.tif Interpolated invert using u/s inv and 1.6% from drawing
STMMH12431→ STMMH12432 Carl Tennen Street	Wrong d/s invert = 0	d/s invert = 190.916	Interpolated invert using u/s inv and 0.361%
STMMH12587→ STMMH12588 Carl Tennen Street	Wrong d/s invert = 0	d/s invert = 190.378	Interpolated invert using u/s inv and 0.48% GIS
STMSJ14524→ STMMH25104 North Park Road	Wrong u/s invert = 0 Wrong d/s invert = 0	u/s invert = 202.535 d/s invert = 202.135	Interpolated invert using d/s segment STMMH25104→ STMMH25103 Obvert match and GIS slope 2%
STMSJ14525→ STMMH25104 North Park Road	Wrong u/s invert = 0 Wrong d/s invert = 0	u/s invert = 202.535 d/s invert = 202.135	Interpolated invert using d/s segment STMMH25104→ STMMH25103 Obvert match and GIS slope 2%
STMMH15323→ STMMH16416 New Westminster Drive / Bathurst Street	Wrong d/s invert = 0	d/s invert = 196.651	Interpolated invert using u/s inv and 0.43%
STMMH16416→ IO375 New Westminster Drive / Bathurst Street	Wrong u/s invert = 0 Wrong d/s invert = 0	u/s invert = 196.651 d/s invert = 195.722	Interpolated invert using u/s segment d/s inv and 0.43% from GIS
STMMH16351→ STMMH16348 Trafalgar Square	Wrong u/s invert = 0	u/s invert = 200.699	Interpolated invert using d/s inv and 0.89% from GIS
STMMH24497→ STMSJ14371 Macarthur Drive / Katerina Avenue	Wrong d/s invert = 0	d/s invert = 195.325	Interpolated invert using u/s inv and average slope from STMMH24497→ STMMH24496
STMSJ14371→ STMMH24496 Macarthur Drive / Katerina Avenue	Wrong u/s invert = 0	u/s invert = 195.325	Interpolated invert using d/s inv and average slope from STMMH24497→ STMMH24496
STMMH16933→ STMMH16932 Bathurst Street / Atkinson Avenue	Wrong flow direction Wrong length = 0	STMMH16932→ STMMH16933 Length = 58.4 m	Estimated length from GIS
STMMH16934→ STMMH16933 Bathurst Street / Atkinson Avenue	Wrong u/s invert = 0 Wrong d/s invert = 0 Wrong length = 0	u/s invert = 196.8 d/s invert = 196.236 Length = 112.9 m	Assumed u/s invert and slope 0.5%, estimated GIS length
STMMH15105→ STMMH17185 Loudon Crescent	Wrong d/s invert = 0	d/s invert = 190.189	Interpolated invert using u/s invert and GIS slope 0.7%
STMMH14919→ STMMH14918 Coldwater Court	Wrong u/s invert = 0	u/s invert = 194.049	Interpolated invert using d/s invert and GIS slope 0.96%
STMMH12524→ STMMH12527 Hilda Avenue	Wrong d/s invert = 0	d/s invert = 192.207	Interpolated invert using u/s invert and GIS slope 0.17%
STMMH12352→ STMMH12353 Winding Lane	Wrong length = 0	Length = 23.5 m	Estimated length from GIS
STMMH12437→ STMMH12438 Winding Lane	Wrong length = 0	Length = 62.5 m	Estimated length from GIS
STMMH14941→ STMMH14972 Worth Boulevard	Wrong length = 0	Length = 23.8 m	Estimated length from GIS

STMMH14972→ STMMH14948 Worth Boulevard	Wrong d/s Invert = 202.31 m Wrong length = 0	d/s invert = 203.41 m Length = 35.8 m	Interpolated invert using u/s invert and estimated length from GIS
STMSJ229→ STMMH12116 Jaimie Road	Wrong d/s invert = 186.325 Wrong length = 0 Wrong diameter = 0	d/s invert = 186.579 Length = 15 m Diameter = 600 mm Slope = 1%	EngineeringImages/ P-00738-03.tif
STMMH15519→ STMMH15520 Bentoak Crescent	Wrong length = 0	Length = 58 m	EngineeringImages/ 19T-97V20-35.tif
STMMH32885→ STMMH17109 Brownstone Circle	Wrong u/s invert = 174.95	u/s invert = 173.817	Interpolated invert using d/s invert and GIS slope 1.018%
STMMH14999→ STMMH15000 Loudon Crescent	Wrong d/s invert = 190.265	d/s invert = 191.265	EngineeringImages/ P-00387-02.tif
STMMH12645→ STMMH12644 Cantertrot Court	Wrong d/s invert = 194.73	d/s invert = 195.73	EngineeringImages/ P-01058-00.tif
STMMH15183→ STMMH15184 Yellowood Circle	Wrong u/s invert = 204.128 Wrong d/s invert = 203.32	u/s invert = 204.56 d/s invert = 204.253	EngineeringImages/ P-01355-03.tif
STMMH12156→ STMMH12136 Wade Gate / Richbell Street	Wrong u/s invert = 189.476 Wrong d/s invert = 188.513	u/s invert = 189.513 d/s invert = 189.476	EngineeringImages/ P-00742-01.tif Interpolated u/s invert using d/s invert and slope 0.13% from drawing (u/s invert 188.513 in drawing is wrong)
STMMH15155→ STMMH15156 Oakhurst Drive / Edenbridge Drive	Wrong u/s invert = 197.71 Wrong d/s invert = 197.21 Length = 27.7 m Slope = 1.81%	From Drawing: u/s invert = 197.080 d/s invert = 196.64 Length = 40.1 m Slope = 1.1%	EngineeringImages/ P-01040-01.tif
STMMH15034→ STMMH15033 Palmerston Drive / Grenadier Crescent	Wrong u/s invert = 203.174	u/s invert = 202.69	EngineeringImages/ P-01040-02.tif u/s Invert = 203.174 in drawing may be wrong , so Interpolated invert using u/s segment obvert match
STMMH12171→ STMMH12170 Havenbrook Court / Brownridge Drive	Wrong u/s invert = 187.06 Wrong d/s invert = 186.905 Wrong length = 13.6 m Wrong slope = 0.39%	From Drawing: u/s invert = 187.27 d/s invert = 187.08 Length = 48.3 m Slope = 0.39%	EngineeringImages/ P-00893-01.tif
STMMH12170→ STMMH12108 Havenbrook Court / Brownridge Drive	Wrong u/s invert = 187.27 Wrong d/s invert = 187.08 Wrong length = 48.3 m Wrong slope = 0.39%	From Drawing: u/s invert = 187.06 d/s invert = 186.905 Length = 13.6 m Slope = 1.14%	EngineeringImages/ P-00893-01.tif
Dummy_MH1021→ STMMH12172 Havenbrook Court / Brownridge Drive	Missing Pipe	From Drawing: u/s invert = 188.83 d/s invert = 188.01 Length = 30.3 m Diameter = 300 mm Slope = 2.7%	EngineeringImages/ P-00893-01.tif

STMMH15054→ Dummy_MH_001 Mountbatten Road / Mulholland Drive	Wrong u/s invert = 199.386	From Drawing: u/s invert = 198.911	EngineeringImages/ P-01043-03.tif
STMMH15031→ STMMH14940 Palmerston Drive / Worth Boulevard	Wrong d/s invert = 202.723	From Drawing: d/s invert = 202.773	EngineeringImages/ P-01026-04.tif
STMMH15031→ STMMH14940 Worth Boulevard / Palmerston Drive	Wrong u/s invert = 202.723	u/s invert = 202.403	EngineeringImages/ P-01026-04.tif u/s invert = 202.723 in drawing may be wrong, Interpolated u/s invert using u/s segment Dummy_MH1017→ STMMH14940 d/s inv
STMMH12566→ STMMH12565 York Hill Boulevard / North Meadow Gate	Wrong u/s invert = 188.762	u/s invert = 188.125	Interpolated u/s invert using d/s inv and GIS slope 0.45%
STMMH12165→ STMMH12166 Jaimie Road / Haley Court	Wrong u/s invert = 185.765 Wrong d/s invert = 185.52	u/s invert = 185.890 d/s invert = 185.805	EngineeringImages/ P-00738-03.tif
STMMH12166→ STMMH12157 Jaimie Road / Haley Court	Wrong length = 72.8 m	Length = 71.5 m	EngineeringImages/ P-00738-03.tif
STMMH12580→ STMMH12192 Judith Avenue / Bayhampton Crescent	Wrong u/s invert =189.84	u/s invert = 189.443	Interpolated u/s invert using d/s inv and GIS slope 0.4%
STMMH12138→ STMMH12139 Richbell Street / Brownridge Drive	Wrong u/s invert =188.621 Wrong d/s invert =188.518	u/s invert = 188.968 d/s invert = 188.771	EngineeringImages/ P-00741-03.tif
STMMH16380→ STMMH16381 Maxwell Court / Rosedale Heights Drive	Wrong d/s invert =197.306	d/s invert = 197.394	EngineeringImages/ P-00835-00.tif, Interpolated d/s invert using W:197.394
STMMH16381→ STMMH16375 Maxwell Court / Rosedale Heights Drive	Wrong u/s invert =197.394	u/s invert = 197.306	EngineeringImages/ P-00835-00.tif, Interpolated u/s invert using E:197.306
STMMH14904→ STMMH14905 Fairfax Court / Beverley Glen Boulevard	Wrong d/s invert =193.676	d/s invert = 193.756	EngineeringImages/ P-01029-00.tif, Interpolated u/s invert using S:193.756
STMMH14905→ STMMH14880 Fairfax Court / Beverley Glen Boulevard	Wrong u/s invert =193.756	u/s invert = 193.676	EngineeringImages/ P-01029-00.tif, Interpolated u/s invert using S:193.676
STMMH15084→ STMMH15085 Kingsbridge Circle / Abbeywood Gate	Wrong d/s invert =200.207	d/s invert = 200.282	EngineeringImages/19T-90009-14.tif, Interpolated u/s invert using E:200.282
STMMH15085→ STMMH15083 Kingsbridge Circle / Abbeywood Gate	Wrong u/s invert =200.282	u/s invert = 200.207	EngineeringImages/19T-90009-14.tif, Interpolated u/s invert using W:200.207

STMMH12176→ STMMH17474 Clark Avenue West / Dufferin Street	Wrong d/s invert =183.666 Shape = “CIRC” Conduit Weight = 3600 mm Conduit Height = 3600 mm	d/s invert = 183.740 Shape = “BOX” Conduit Weight = 3660 mm Conduit Height = 2440 mm	EngineeringImages/ P-00524-053.tif, Interpolated u/s invert using W:183.740
STMMH17474→ STMMH14510 Clark Avenue West / Dufferin Street	Wrong u/s invert =183.74 Shape = “CIRC” Conduit Weight = 2400 mm	u/s invert = 183.666 Shape = “BOX” Conduit Weight = 3000 mm	EngineeringImages/ P-00524-053.tif, Interpolated u/s invert using W:183.666
STMMH14510→ IO314 Clark Avenue West / Dufferin Street	Shape = “CIRC” Conduit Weight = 1535 mm Conduit Height = 1535 mm	Shape = “BOX” Conduit Weight = 1200 mm Conduit Height = 1000 mm	EngineeringImages/ P-00524-053.tif
STMMH12706→ STMMH12707 Brookmill Drive / Robinwood Trail	d/s invert = 186.853	d/s invert = 186.921	EngineeringImages/ P-00812-02.tif, Interpolated d/s invert using SE:186.921
STMMH12707→ STMMH12704 Brookmill Drive / Robinwood Trail	u/s invert = 186.921	u/s invert = 186.853	EngineeringImages/ P-00812-02.tif, Interpolated d/s invert using NE:186.853
STMMH29907→ STMMH29906 Daniel Reaman Crescent / Maple Sugar Lane	u/s invert = 206.885	u/s invert = 206.825	Interpolated u/s invert using u/s segment d/s invert
STMMH12388→ STMMH12387 Franmore Circle	u/s invert = 188.87	u/s invert = 188.71	Interpolated u/s invert using d/s invert and GIS slope 0.87%
STMMH12923→ STMMH11791 White Boulevard	d/s invert = 187.922	d/s invert = 188.004	Interpolated d/s invert using u/s invert and GIS slope 0.75%
STMMH11796→ STMMH11795 Joseph Aaron Boulevard / Ferne-Rachel Road	u/s invert = 185.524	u/s invert = 185.514	Interpolated u/s invert using u/s segment STMMH12682→ STMMH11796 d/s invert
STMMH12064→ STMMH12065 Rodeo Drive / Atkinson Avenue	u/s invert = 197.169	u/s invert = 197.086	Interpolated u/s invert using u/s segment obvert match
STMMH12062→ STMMH12063 Rodeo Drive / Campbell Avenue	u/s invert = 198.124	u/s invert = 198.044	Interpolated u/s invert using u/s segment obvert match
STMMH12595→ STMMH12737 Gayla Street / Donisi Avenue	u/s invert = 183.909	u/s invert = 183.829	Interpolated u/s invert using u/s segment obvert match
STMMH12276→ STMMH12277 Rejane Crescent / Campbell Avenue	d/s invert = 196.279	From Drawing d/s invert = 196.283	EngineeringImages/ P-00624-01.tif
STMMH12277→ STMMH12278 Rejane Crescent / Campbell Avenue	u/s invert = 196.283	From Drawing u/s invert = 196.279	EngineeringImages/ P-00624-01.tif
STMMH15016→ STMMH15021 Westmount Boulevard / Grenadier Crescent	d/s invert = 202.989	d/s invert = 202.99	Interpolated d/s invert using u/s invert and GIS slope 1.097%
STMMH15021→ STMMH15020 Westmount Boulevard / Grenadier Crescent	u/s invert = 202.99	u/s invert = 202.989	Interpolated u/s invert using d/s invert and GIS slope 0.98%
STMMH15141→ STMMH15142 Macarthur Drive / Katerina Avenue	d/s invert = 195.8	d/s invert = 195.671	Interpolated d/s invert using u/s invert and GIS slope 0.78%

STMMH15112→ Dummy_MH1008 Racco Parkway	d/s invert = 197.3	d/s invert = 197.235	Interpolated d/s invert using u/s invert and GIS slope 1.5%
STMMH12393→ STMMH12392 Heather Way / Spring Gate Boulevard	d/s invert = 182	d/s invert = 182.692	Interpolated d/s invert using u/s invert, d/s segment d/s invert and average slope
STMMH12392→ STMMH12078 Heather Way / Spring Gate Boulevard	u/s invert = 182	u/s invert = 182.692	Interpolated u/s invert using d/s invert and u/s segment u/s invert and average slope
STMMH_Cole101→ STMMH13112 Charlton Avenue / Conley Street	Wrong d/s invert = 180.486	d/s invert = 181.517	Interpolated d/s invert using u/s invert ,GIS slope 0.48% and length
STMMH13112→ OutfallSite8 Charlton Avenue / Conley Street	Wrong d/s invert = 0	d/s invert = 181.07	Interpolated d/s invert using u/s invert GIS slope
STMMH16343→ STMMH16339	u/s invert = 194.62 d/s invert = 197.89	u/s invert = 197.89 d/s invert = 194.62	u/s invert and d/s invert upside down
STMMH17924→ STMMH17930 10 segments on HWY #7	Missing all of inverts and stop on the road	deleted	Delete these segments because flow direction the same as major system and only one CB drain to the sewer
STMMH34749→ IO5321 5 segments on North of Pond 9	Missing all of inverts, length and ground elevation	Assumed slope=0.5%	STMMH34749 to IO5321,5 segments,outlet invert=198.8 from Pond 9 drawing Site003.tif, assumed slope=0.5%, Length and ground elev. from DEM
STMMH17202→ IO437 5 segments on Centre St.	Missing all of inverts, length and ground elevation	Assumed slope=0.5%	STMMH17202→ IO437, 5 segments,outlet invert=199.7 and ground elev. from DEM, assumed slope=0.5%, Length from GIS
Dummy_MH1022→ STMMH14913	Missing u/s invert	u/s invert = 193.539	Calculated u/s invert using d/s invert=193.436 and GIS slope 0.2%
Dummy_MH1023→ STMMH12859	Missing u/s invert	u/s invert = 193.231	Calculated u/s invert using d/s invert=192.687 and GIS slope 0.4%
Dummy_MH1024→ STMMH12858	Missing u/s invert	u/s invert = 193.733	Calculated u/s invert using d/s invert=192.875 and GIS slope 1%
Dummy_MH1025→ STMMH12868	Missing u/s invert	u/s invert = 194.607	Calculated u/s invert using d/s invert=194.152 and GIS slope 0.7%
Dummy_MH1026→ STMMH12869	Missing u/s invert	u/s invert = 195.005	Calculated u/s invert using d/s invert=194.954 and GIS measured length=10.1,slope 0.5%
STMMH12868→ STMMH12847	Missing u/s invert	u/s invert = 193.527	Using u/s segment invert=193.527
STMSL28666: STMMH15145 → STMMH15146	Missing d/s invert Missing d/s MH	d/s invert = 195.848 Assumed slope=1% Assumed connected to STMMH15146	Calculated d/s invert using u/s invert=195.9 and assumed slope 1%
STMSL22285: STMMH12542 → STMMH12485	Wrong u/s invert=0	u/s invert = 194.575	Calculated u/s invert using d/s invert=193.729 and GIS slope 1.33%

STMSL24333: STMMH12485 → STMMH12488	Wrong d/s invert=0	d/s invert = 193.067	Calculated u/s invert using u/s invert=193.487 and GIS slope 0.92%
STMMH12433→ STMMH12195	Wrong u/s invert = 190.906 m Wrong d/s invert = 190.539 m Wrong length = 92.1 m	From drawing: u/s invert = 190.489 d/s invert = 190.317 Length = 43.0 m	EngineeringImages/ P-00660-03.tif
STMMH12432→ STMMH12433	Wrong u/s invert = 190.489 m Wrong d/s invert = 190.317 m Wrong length = 43.0 m	From drawing: u/s invert = 190.906 d/s invert = 190.539 Length = 92.10 m	EngineeringImages/ P-00660-03.tif
STMMH16966→ STMMH16959	Wrong d/s invert = 0 m Wrong length = 0 m	d/s invert = 196.703 Length = 83.6 m	Interpolated d/s invert using d/s segment STMMH16959→ STMMH16958 obvert match and assume length 83.6 from GIS
STMMH16966→ STMMH16959	Wrong d/s invert = 0 m Wrong length = 0 m	d/s invert = 196.703 Length = 83.6 m	Interpolated d/s invert using d/s segment STMMH16959→ STMMH16958 obvert match and estimated length 83.6 from GIS
STMMH16945→ STMMH16938	Wrong length = 0 m	Length = 123.8 m	Estimated length 123.8 from GIS
STMMH16943→ STMMH12926	Wrong d/s invert = 192.2 m Wrong length = 0 m	d/s invert = 192.325 m Length = 26.8 m	Interpolated d/s invert using d/s segment STMMH12926→ STMMH12924 obvert match, Estimated length 26.8 m from GIS
STMMH12487→ STMMH12491	Wrong u/s invert =0 m	u/s invert = 192.511 m	Interpolated u/s invert using d/s invert and GIS slope 0.15%
STMMH16967→ STMMH16960	Wrong d/s invert = 203.04 m	d/s invert = 203.10 m	Interpolated d/s invert using u/s invert and GIS slope 0.8%
STMMH16960→ STMMH16961	Wrong u/s invert = 203.82 m Wrong length = 0 m	u/s invert = 203.10 length = 16.8 m	Interpolated u/s invert using u/s segment d/s invert , Estimated length 16.8 m from GIS
Dummy_MH1033→ STMMH12867	Wrong direction: STMMH12867→ ? Wrong u/s invert = 198.443 m	u/s invert = 198.59 m d/s invert = 198.443 m	Interpolated u/s invert using d/s invert 198.443 , GIS length 42m and slope 0.35%
STMMH14882→ STMMH14883		Assume STMMH14882 connect to STMMH14883	
STMMH14883→ STMMH15096		Assume STMMH15096 connect to STMMH14883	
STMMH18041→STMMH15090	STMSJ315→STMMH15090	Assume STMMH15090 connect to STMMH18041	

Dummy_MH1036→ STMMH12845	Wrong u/s invert = 0 m	u/s invert = 195.968	Interpolated u/s invert using d/s invert and GIS slope 0.5%
Dummy_MH1037→ STMMH12863	Missing u/s node	Assume STMMH12863 connect to Dummy_MH1037	
Dummy_MH1038→ STMMH12861	Missing u/s node	Assume STMMH12861 connect to Dummy_MH1038	
Dummy_MH1039→ STMMH12864	Missing u/s node	Assume STMMH12861 connect to Dummy_MH1038	
STMMH24496→ STMMH15143	STMMH24496→ STMMH24495	Assume STMMH24496 connect to STMMH15143	
STMMH16939→ STMMH16952	Wrong d/s invert = 194.794 m	d/s invert = 195.04	Interpolated d/s invert using d/s segment u/s invert
STMMH12545→ STMMH12546	Wrong u/s invert = 190.343	u/s invert = 190.193	Interpolated d/s invert using d/s segment obvert match
CB38416→ STMMH34749	Missing u/s Inv. Missing d/s Inv.	u/s invert = 201.711 d/s invert = 201.638	Assumed u/s MH depth 1.5 m and slope 1%
CB10589→ Dummy_MH1040	Missing u/s Inv. Missing d/s Inv.	u/s invert = 191.95 d/s invert = 191.698	u/s MH invert, measured length and assumed slope 1%
CB10589→ Dummy_MH1041	Missing u/s Inv. Missing d/s Inv.	u/s invert = 191.62 d/s invert = 191.346	u/s MH invert, measured length and assumed slope 1%
CB10577→ Dummy_MH1042	Missing u/s Inv. Missing d/s Inv.	u/s invert = 190.7 d/s invert = 190.459	u/s MH invert, measured length and assumed slope 1%
CB10601→ STMMH12178	Missing u/s Inv. Missing d/s Inv.	u/s invert = 187 d/s invert = 186.82	Assumed u/s MH depth 1.0 m
STMMH12159→ STMMH12160	Missing Pipe	u/s invert = 187.404 d/s invert = 187.127 diameter=375	Assumed diameter and slope the same as d/s segment
CB13741→ STMMH14881	Missing u/s Inv. Missing d/s Inv.	u/s invert = 194.71 d/s invert = 194.362	use u/s inv. and LED length, slope
CB17211→ Dummy_MH1044	Missing u/s Inv. Missing d/s Inv.	u/s invert = 194 d/s invert = 193.9	Assumed u/s MH depth 2.0 m and slope 1%
CB14272→ Dummy_MH1045	Missing u/s Inv. Missing d/s Inv.	u/s invert = 195 d/s invert = 194.93	Assumed u/s MH depth 2.0 m and LED slope
CB14267→ Dummy_MH1046	Missing u/s Inv. Missing d/s Inv.	u/s invert = 197 d/s invert = 196.909	Assumed u/s MH depth 2.0 m, slope 1% and measured length
CB13863→ STMMH15075	Missing u/s Inv. Missing d/s Inv.	u/s invert = 197.91 d/s invert = 197.81	u/s MH invert and LED slope 5%
STMMH15075→ STMMH15074	Missing Pipe	u/s invert = 196.058 d/s invert = 195.945 diameter=525	Use u/s MH inv. And assumed the diameter and slope the same as d/s segment
CB16491→ STMMH16349	Missing u/s Inv. Missing d/s Inv.	u/s invert = 200 d/s invert = 199.982	Assumed u/s MH depth 1.0 m and LED slope 0.2%
CB14112→ STMMH15133	Missing u/s Inv. Missing d/s Inv.	u/s invert = 197.13 d/s invert = 197	u/s MH invert and LED slope 4.48%
STMMH15133→ STMMH15132	Missing Pipe	u/s invert = 197 d/s invert = 196.618 diameter=750	Use u/s MH inv. And assumed the diameter and slope

CB14453→ STMMH15326	Missing d/s invert	d/s invert = 197.16	Calculated d/s invert using u/s invert and LED slope
CB17110→ STMMH16932	Missing length Missing u/s Inv. Missing d/s Inv.	Length = 8.169 u/s invert = 198.016 d/s invert = 197.853	u/s MH invert, assumed GIS length and slope 2%
CB17111→ STMMH16934	Missing length Missing u/s Inv. Missing d/s Inv.	Length = 7.652 u/s invert = 197.093 d/s invert = 197.016	u/s MH invert, assumed GIS length and slope 1%
CB14450→ STMMH15324	Missing d/s invert	d/s invert = 196.9	Calculated d/s invert using u/s invert and LED slope 1%
CB16317→ Dummy_MH1047	Missing u/s Inv. Missing d/s Inv.	u/s invert = 195.5 d/s invert = 195.2	Assumed u/s MH depth 1.5 m and LED slope 1%
CB9076→ STMMH12844	Missing u/s Inv. Missing d/s Inv.	u/s invert = 195.73 d/s invert = 195.628	u/s MH invert and LED slope 0.6%
STMMH12843→ CB9076	Missing u/s Inv. Missing d/s Inv.	u/s invert = 195.97 d/s invert = 195.73	Use d/s MH inv. And assumed slope 0.6% the same as d/s segment
CB9390→ Dummy_MH1048	Missing u/s Inv. Missing d/s Inv.	u/s invert = 197.204 d/s invert = 196.596	u/s MH invert and assumed LED slope 3.2%
CB9391→ Dummy_MH1049	Missing length Missing u/s Inv. Missing d/s Inv.	Length = 19.571 u/s invert = 199 d/s invert = 198.021	Assumed u/s MH depth 2.0 m and GIS length and slope 5%
CB9700→ Dummy_MH1050	Missing u/s Inv. Missing d/s Inv.	u/s invert = 196.104 d/s invert = 195.159	Use u/s MH inv. And LED slope 6.75%
CB9697→ STMMH12862	Missing u/s Inv. Missing d/s Inv.	u/s invert = 194.904 d/s invert = 194.596	Assumed u/s MH depth 1.0 m and LED slope 2.2%
CB9706→ Dummy_MH1051	Missing u/s Inv. Missing d/s Inv.	u/s invert = 198.465 d/s invert = 198.4	Use u/s MH inv. And LED slope 0.5%
CB9703→ Dummy_MH1052	Missing u/s Inv. Missing d/s Inv.	u/s invert = 200.5 d/s invert = 199.65	Use u/s MH inv. And LED slope 5.15%
CB14093→ STMMH15119	Missing length Missing u/s Inv. Missing d/s Inv.	Length = 26.512 u/s invert = 198.81 d/s invert = 197.484	Use u/s MH inv. GIS Length, assumed LED slope 5%
CB9040→ STMMH12073	Missing d/s Inv.	d/s invert = 197.356	Use u/s MH inv. and LED slope 2%
CB9044→ STMMH12339	Missing length Missing d/s Inv.	Length = 19.158 d/s invert = 193.142	Use u/s MH inv. and GIS length, assumed LED slope 5%
CB10549→ STMMH12570	Missing u/s Inv. Missing d/s Inv.	u/s invert = 185.48 d/s invert = 183.723	Use u/s MH inv. and LED slope 4.04%
CB10534→ STMMH12458	Missing length Missing u/s Inv. Missing d/s Inv.	Length = 43.058 u/s invert = 173.086 d/s invert = 170.933	Use GIS Length, assumed u/s MH depth 2.0 m and LED slope 5%
CB10533→ STMMH12456	Missing length Missing u/s Inv. Missing d/s Inv.	Length = 6.9 u/s invert = 172 d/s invert = 171.655	Use GIS Length, assumed u/s MH depth 2.0 m and LED slope 5%
CB29748→ STMMH12456	Missing intake lead	Length = 10 u/s invert = 170.9 d/s invert = 170.4	Use u/s MH inv. assumed length 10m, diameter 450mm and slope 5%
CB38100→ STMMH_Cole1023	Missing intake lead	Length = 10 u/s invert = 176.5 d/s invert = 176.4	Assumed u/s MH inv. length 10m, diameter 250mm and slope 1%
CB38101→ STMMH_Cole1023	Missing intake lead	Length = 10 u/s invert = 176.5 d/s invert = 176.4	Assumed u/s MH inv. length 10m, diameter 250mm and slope 1%
CB17198→ CB17197	Missing length	Length = 34.5	Use GIS length
CB17197→ STMMH17186	Wrong u/s inv.	u/s invert = 176.5	Use u/s segment inv.

IO379→ IO380	Missing u/s Inv. Missing d/s Inv.	u/s invert = 192.12 d/s invert = 191.04	Use d/s MH inv. and LED slope 6%
STMMH11789→ STMMH12065	Missing length Missing u/s Inv. Missing d/s Inv.	Length = 13.838 u/s invert = 197.065 d/s invert = 196.927	Use GIS Length and d/s obvert, assumed slope 1%
STMMH12574→ STMMH12260	Missing length Missing u/s Inv. Missing d/s Inv.	Length = 10.631 u/s invert = 200.601 d/s invert = 200.495	Use GIS Length and d/s obvert, assumed slope 1%
STMMH12269→ STMMH12270	Missing length Missing u/s Inv. Missing d/s Inv.	Length = 17.326 u/s invert = 194.374 d/s invert = 193.508	Use GIS Length and u/s MH inv. assumed slope 5%
STMMH12265→ STMMH12264	Missing length Missing u/s Inv. Missing d/s Inv.	Length = 13.659 u/s invert = 198.922 d/s invert = 198.785	Use GIS Length and d/s obvert, assumed slope 1%
STMMH12259→ Dummy_MH1054	Missing length Missing u/s Inv. Missing d/s Inv.	Length = 16.811 u/s invert = 199.2 d/s invert = 198.359	Use GIS Length and u/s MH inv. assumed slope 5%
STMMH12258→ Dummy_MH1054	Missing length Missing u/s Inv. Missing d/s Inv.	Length = 11.232 u/s invert = 199.2 d/s invert = 198.638	Use GIS Length and u/s MH inv. assumed slope 5%
STMMH12842→ STMMH12854	Missing length Missing u/s Inv. Missing d/s Inv.	Length = 7.65 u/s invert = 189.266 d/s invert = 188.883	Use GIS Length and d/s obvert, assumed slope 5%
STMMH12058→ STMMH12057	Missing diameter Missing length Missing u/s Inv. Missing d/s Inv.	Diameter = 200 Length = 13.487 u/s invert = 202.337 d/s invert = 201.663	Use GIS Length and d/s obvert, assumed slope 5%, diameter=200mm
Dummy_MH1055→ STMMH12057	Missing length Missing u/s Inv. Missing d/s Inv.	Length = 51.293 u/s invert = 201.919 d/s invert = 201.663	Use GIS Length LED slope 0.5% and d/s obvert
STMMH12106→ STMMH12107	Missing Pipe	u/s invert = 187.544 d/s invert = 186.982 diameter=450	Use u/s MH inv. And assumed the diameter and slope 5%
STMMH12884→ STMMH12196	Missing u/s Inv. Missing d/s Inv.	u/s invert = 192.74 d/s invert = 192.013	Use u/s MH inv. and LED slope 1.5%
STMMH14890→ Dummy_MH1056	Missing u/s Inv. Missing d/s Inv.	u/s invert = 194.084 d/s invert = 193.769	Use u/s MH inv. and LED slope 1.5%
STMMH15147→ Dummy_MH1057	Missing u/s Inv. Missing d/s Inv.	u/s invert = 197.14 d/s invert = 196.925	Use u/s MH inv. and LED slope 0.5%
STMMH15219→ STMMH15220	Wrong u/s Inv.=208.91	u/s invert = 205.91	Calculated from d/s inv. And slope 0.81%

STORM SEWER NODE DATA GAPS
Vaughan Site 1 – 6 and 8

MH	Problem	Correction	Notes
STMMH11787	Wrong ground elev. = 195 m	From Drawing MH Cover = 194.94 m	EngineeringImages/C-81-015-06.tif
STMMH17201	Wrong ground elev. = 195.3 m	From Drawing MH Cover = 192.065	EngineeringImages/C-81-015-06.tif
STMMH17181	Wrong ground elev. = 194.5 m	From Drawing MH Cover = 194.421	EngineeringImages/C-81-015-05.tif
STMMH12100	Wrong ground elev. = 193.92 m	From Drawing MH Cover = 193.632	EngineeringImages/C-81-015-05.tif
STMMH17180	Wrong ground elev. = 191.5 m Wrong Bottom elev. = 184 m	From Drawing MH Cover = 191.408 Bottom elev. = 183.957m	EngineeringImages/C-81-015-04.tif Interpolated Bottom Elevation using STMMH17180→ STMMH12238 u/s invert
STMMH12238	Wrong ground elev. = 186.24 m	From Drawing MH Cover = 185.885	EngineeringImages/C-81-015-04.tif
STMMH12252	Wrong ground elev. = 180.48 m	From Drawing MH Cover = 180.672	EngineeringImages/C-81-015-03.tif
STMMH14895		Move to STMSJ323	EngineeringImages/P-1023-4.tif
STMMH17192	Duplicated as STMMH15007 and Wrong Bottom Elevation=193	Deleted STMMH17192 And Keep STMMH15007	EngineeringImages/P-011-5A.tif
STMMH15098	Duplicated as STMMH17195	Deleted STMMH15098 And Keep STMMH17195	EngineeringImages/P-011-2.tif
Dummy_MH1002			New added
STMMH16451	Wrong Bottom elev. = 170.986 m	Bottom elev. = 170.581 m	Interpolated Bottom Elevation using STMMH16451→STMMH17198 u/s invert
STMMH4560	Wrong Bottom elev. = 217.747 m	Bottom elev. = 189.345 m	Interpolated Bottom Elevation using STMMH4560→STMMH12753 u/s invert
STMMH4557	Wrong Bottom elev. = 222.305 m	Bottom elev. = 189.416 m	Interpolated Bottom Elevation using STMMH4557→STMMH12745 u/s invert
STMMH4559	Wrong Bottom elev. = 217.119 m	Bottom elev. = 188.45 m	Interpolated Bottom Elevation using STMMH4559→STMMH12598 u/s invert
STMMH32885	Wrong Bottom elev. = 174.95 m	Bottom elev. = 173.817 m	Interpolated Bottom Elevation using STMMH32885→STMMH17109 u/s invert
STMMH17206	Wrong Bottom elev. = 187.634 m	Bottom elev. = 187.584 m	Interpolated Bottom Elevation using STMMH17206→STMSJ418 u/s invert

STMMH17197	Wrong Bottom elev. = 191.8 m	Bottom elev. = 188.36 m	Interpolated Bottom Elevation using STMMH17197→STMMH17196 u/s invert
STMMH17194	Wrong Bottom elev. = 192.7 m	Bottom elev. = 190.914 m	Interpolated Bottom Elevation using STMMH17194→STMMH17193 u/s invert
STMMH17193	Wrong Bottom elev. = 191.8 m	Bottom elev. = 190.285 m	Interpolated Bottom Elevation using STMMH17193→STMMH17195 u/s invert
STMMH17474	Wrong Bottom elev. = 183.83 m	Bottom elev. = 183.666 m	Interpolated Bottom Elevation using STMMH17474→STMMH14510 u/s invert
STMMH17189	Wrong Bottom elev. = 195.5 m	Bottom elev. = 193.823m	Interpolated Bottom Elevation using STMMH17189→STMMH17191 u/s invert
STMMH17191	Wrong Bottom elev. = 194.5 m	Bottom elev. = 193.208m	Interpolated Bottom Elevation using STMMH17191→Dummy_MH1001 u/s invert
Dummy_MH1001	Missing MH	MH Cover = 197.613m Bottom elev. = 192.726m	EngineeringImages/P-011-5A.tif Interpolated Ground Elevation from DEM, Interpolated Bottom Elevation using Dummy_MH1001→STMMH15007 u/s invert
STMMH17185	Wrong Bottom elev. = 188.755 m	Bottom elev. = 188.154m	Interpolated Bottom Elevation using STMMH17185→ STMMH17206 u/s invert
STMMH17165	Wrong Bottom elev. = 172 m	Bottom elev. = 169.65m	Interpolated Bottom Elevation using STMMH17165→ STMMH17106 u/s invert
STMMH17106	Wrong Bottom elev. = 170.5 m	Bottom elev. = 169.35m	Interpolated Bottom Elevation using STMMH17106→ STMMH17107 u/s invert
STMMH17107	Wrong Bottom elev. = 170.5 m	Bottom elev. = 168.94m	Interpolated Bottom Elevation using STMMH17107→ STMMH17108 u/s invert
STMMH17110	Wrong Bottom elev. = 170 m	Bottom elev. = 168.48m	Interpolated Bottom Elevation using STMMH17110→ STMMH17109 u/s invert
STMMH17109	Wrong Bottom elev. = 169.8 m	Bottom elev. = 167.87m	Interpolated Bottom Elevation using STMMH17109→ STMMH12458 u/s invert
STMMH12085	Wrong Bottom elev. = 175.87 m	Bottom elev. = 174.98m	Interpolated Bottom Elevation using STMMH12085→ STMMH12416 u/s invert

STMMH16952	Wrong Bottom elev. = 195.04 m	Bottom elev. = 194.794m	Interpolated Bottom Elevation using STMMH16939→ STMMH16952 d/s invert
STMMH16938	Wrong Bottom elev. = 197.04 m	Bottom elev. = 196.97m	Interpolated Bottom Elevation using STMMH16938→ STMMH16959 u/s invert
STMMH16458	Wrong Bottom elev. = 189.097 m	Bottom elev. = 188.924m	Interpolated Bottom Elevation using STMMH16458→ Dummy_MH1012 u/s invert
STMMH16386	Wrong Bottom elev. = 197.299 m	Bottom elev. = 196.974m	Interpolated Bottom Elevation using STMMH16386→ STMMH16387 u/s invert
STMMH16351	Wrong Bottom elev. = 200.7 m	Bottom elev. = 200.699m	Interpolated Bottom Elevation using STMMH16351→ STMMH16348 u/s invert
STMMH16343	Wrong Bottom elev. = 198.09 m	Bottom elev. = 197.89m	Interpolated Bottom Elevation using STMMH16343→ STMMH16339 u/s invert
STMMH16249	Wrong Bottom elev. = 194.526 m	Bottom elev. = 194.509m	Interpolated Bottom Elevation using STMMH16236→ STMMH16249 u/s invert
STMMH16225	Wrong Bottom elev. = 198.6 m	Bottom elev. = 198.55m	Interpolated Bottom Elevation using STMMH16225→ STMMH16343 u/s invert
STMMH15324	Wrong Bottom elev. = 197.58 m	Bottom elev. = 196.646m	Interpolated Bottom Elevation using STMMH15324→ STMMH15130 u/s invert
STMMH15172	Wrong Bottom elev. = 195.206 m	Bottom elev. = 195.19m	Interpolated Bottom Elevation using STMMH15172→ IO320 u/s invert
STMMH15125	Wrong Bottom elev. = 199.357 m	Bottom elev. = 198.061m	Interpolated Bottom Elevation using STMMH15125→STMSJ343 u/s invert
STMMH15119	Wrong Bottom elev. = 195.04 m	Bottom elev. = 195.034m	Interpolated Bottom Elevation using STMMH15119→STMMH17190 u/s invert
STMMH15107	Wrong Bottom elev. = 195.705 m	Bottom elev. = 195.67m	Interpolated Bottom Elevation using STMMH15008→STMMH15107 d/s invert
STMMH15110	Wrong Bottom elev. = 198.86 m	Bottom elev. = 198.78m	Interpolated Bottom Elevation using STMMH15110→STMMH15111 u/s invert
STMMH15097	Wrong Bottom elev. = 190.914 m	Bottom elev. = 189.827m	Interpolated Bottom Elevation using STMMH15097→STMMH17195 u/s invert

STMMH14866	Wrong Bottom elev. = 197.61 m	Bottom elev. = 196.91m	Interpolated Bottom Elevation using STMMH14866→STMMH15122 u/s invert
STMMH14905	Wrong Bottom elev. = 193.756 m	Bottom elev. = 193.676m	Interpolated Bottom Elevation using STMMH14905→STMMH14880 u/s invert
STMMH14915	Wrong Bottom elev. = 195.897 m	Bottom elev. = 195.689m	Interpolated Bottom Elevation using STMMH14914→STMMH14915 d/s invert
STMMH14914	Wrong Bottom elev. = 197.843 m	Bottom elev. = 197.065m	Interpolated Bottom Elevation using STMMH14914→STMMH14915 u/s invert
STMMH15072	Wrong Bottom elev. = 194.808 m	Bottom elev. = 194.793m	Interpolated Bottom Elevation using STMMH15071→STMMH15702 d/s invert
STMMH12764	Wrong Bottom elev. = 189.101 m	Bottom elev. = 188.83m	Interpolated Bottom Elevation using STMMH12764→STMMH14559 u/s invert
STMMH15054	Wrong Bottom elev. = 199.01 m	Bottom elev. = 198.911m	Interpolated Bottom Elevation using STMMH15054→Dummy_MH_001 u/s invert
STMMH12714	Wrong Bottom elev. = 190.93 m	Bottom elev. = 190.7m	Interpolated Bottom Elevation using STMMH12714→ STMMH12713 u/s invert
STMMH15052	Wrong Bottom elev. = 199.355 m	Bottom elev. = 199.33m	Interpolated Bottom Elevation using STMMH15052→ Dummy_MH_001 u/s invert
STMMH15032	Wrong Bottom elev. = 201.85 m	Bottom elev. = 201.829m	Interpolated Bottom Elevation using STMMH15032→ STMMH15038 u/s invert
STMMH15026	Wrong Bottom elev. = 200.345 m	Bottom elev. = 200.31m	Interpolated Bottom Elevation using STMMH15026→ STMMH15060 u/s invert
STMMH15011	Wrong Bottom elev. = 197.251 m	Bottom elev. = 197.21m	Interpolated Bottom Elevation using STMMH15011→ STMMH15010 u/s invert
STMMH15010	Wrong Bottom elev. = 196.768 m	Bottom elev. = 196.7m	Interpolated Bottom Elevation using STMMH15010→ STMMH15008 u/s invert
STMMH15009	Wrong Bottom elev. = 197.841 m	Bottom elev. = 197.78m	Interpolated Bottom Elevation using STMMH15009→ STMMH15011 u/s invert

STMMH14970	Wrong Bottom elev. = 205.64 m	Bottom elev. = 205.62m	Interpolated Bottom Elevation using STMMH14970→ STMMH14969 u/s invert
STMMH14965	Wrong Bottom elev. = 203.63 m	Bottom elev. = 203.567m	Interpolated Bottom Elevation using STMMH14965→ Dummy_MH1017 u/s invert
STMMH14962	Wrong Bottom elev. = 199.291 m	Bottom elev. = 199.241m	Interpolated Bottom Elevation using STMMH14962→ STMMH14932 u/s invert
STMMH14940	Wrong Bottom elev. = 202.403 m	Bottom elev. = 202.043m	Interpolated Bottom Elevation using STMMH14940→ STMMH14935 u/s invert
STMMH14922	Wrong Bottom elev. = 194.73 m	Bottom elev. = 193.575m	Interpolated Bottom Elevation using STMMH14922→ STMMH14923 u/s invert
STMMH14920	Wrong Bottom elev. = 193.239 m	Bottom elev. = 192.95m	Interpolated Bottom Elevation using STMMH14920→ STMMH14882 u/s invert
STMMH14919	Wrong Bottom elev. = 194.05 m	Bottom elev. = 194.049m	Interpolated Bottom Elevation using STMMH14919→ STMMH14918 u/s invert
STMMH14510	Wrong Bottom elev. = 183.15 m	Bottom elev. = 182.855m	Interpolated Bottom Elevation using STMMH14510→ IO314 u/s invert
STMMH12176	Wrong Bottom elev. = 184.05 m	Bottom elev. = 183.79m	Interpolated Bottom Elevation using STMMH12176→ STMMH17474 u/s invert
STMMH12922	Wrong Bottom elev. = 188.069 m	Bottom elev. = 187.819m	Interpolated Bottom Elevation using STMMH12922→ STMMH12921 u/s invert
STMMH12859	Wrong Bottom elev. = 192.537 m	Bottom elev. = 192.534m	Interpolated Bottom Elevation using STMMH12922→ STMMH12921 u/s invert
STMMH12854	Wrong Bottom elev. = 188.224 m	Bottom elev. = 188.208m	Interpolated Bottom Elevation using STMMH12854→ STMMH12677 u/s invert
STMMH12762	Wrong Bottom elev. = 189.389 m	Bottom elev. = 189.101m	Interpolated Bottom Elevation using STMMH12762→ STMMH12764 u/s invert
STMMH12742	Wrong Bottom elev. = 216.07 m	Bottom elev. = 189.465m	Interpolated Bottom Elevation using STMMH12742→ STMMH12743 u/s invert

STMMH12595	Wrong Bottom elev. = 183.904 m	Bottom elev. = 183.829m	Interpolated Bottom Elevation using STMMH12595→ STMMH12737 u/s invert
STMMH12580	Wrong Bottom elev. = 189.444 m	Bottom elev. = 189.443m	Interpolated Bottom Elevation using STMMH12580→ STMMH12192 u/s invert
STMMH12567	Wrong Bottom elev. = 189.091 m	Bottom elev. = 188.926m	Interpolated Bottom Elevation using STMMH12567→ STMMH12566 u/s invert
STMMH12553	Wrong Bottom elev. = 190.716 m	Bottom elev. = 190.236m	Interpolated Bottom Elevation using STMMH12553→ STMMH12532 u/s invert
STMMH12551	Wrong Bottom elev. = 190.06 m	Bottom elev. = 190.03m	Interpolated Bottom Elevation using STMMH12551→ STMMH12552 u/s invert
STMMH12544	Wrong Bottom elev. = 191.743 m	Bottom elev. = 191.74m	Interpolated Bottom Elevation using STMMH12544→ STMMH12537 u/s invert
STMMH12542	Wrong Bottom elev. = 194.893 m	Bottom elev. = 194.575m	Interpolated Bottom Elevation using STMMH12542→ STMMH12485 u/s invert
STMMH12526	Wrong Bottom elev. = 192.003 m	Bottom elev. = 192 m	Interpolated Bottom Elevation using STMMH12526→ STMMH12525 u/s invert
STMMH12490	Wrong Bottom elev. = 191.242 m	Bottom elev. = 191.227 m	Interpolated Bottom Elevation using STMMH12490→ STMMH12294 u/s invert
STMMH12453	Wrong Bottom elev. = 181.24 m	Bottom elev. = 180.73 m	Interpolated Bottom Elevation using STMMH12453→ STMMH12563 u/s invert
STMMH12442	Wrong Bottom elev. = 175.51 m	Bottom elev. = 174.79 m	Interpolated Bottom Elevation using STMMH12442→ STMMH12441 u/s invert
STMMH12441	Wrong Bottom elev. = 174.73 m	Bottom elev. = 174.6 m	Interpolated Bottom Elevation using STMMH12441→ STMMH32885 u/s invert
STMMH12196	Wrong Bottom elev. = 190.596 m	Bottom elev. = 190.559 m	Interpolated Bottom Elevation using STMMH12196→ STMMH12195 u/s invert
STMMH12404	Wrong Bottom elev. = 188.77 m	Bottom elev. = 181.54 m	Interpolated Bottom Elevation using STMMH12404→ STMMH12081 u/s invert

STMMH12398	Wrong Bottom elev. = 182.94 m	Bottom elev. = 182.85 m	Interpolated Bottom Elevation using STMMH12398→ STMMH12403 u/s invert
STMMH12380	Wrong Bottom elev. = 192.47 m	Bottom elev. = 187.12 m	Interpolated Bottom Elevation using STMMH12380→ STMMH12339 u/s invert
STMMH12379	Wrong Bottom elev. = 193.33 m	Bottom elev. = 193.31 m	Interpolated Bottom Elevation using STMMH12379→ STMMH12380 u/s invert
STMMH12354	Wrong Bottom elev. = 185.78 m	Bottom elev. = 185.76 m	Interpolated Bottom Elevation using STMMH12354→ STMMH12355 u/s invert
STMMH12353	Wrong Bottom elev. = 184.91 m	Bottom elev. = 184.564 m	Interpolated Bottom Elevation using STMMH12353→ STMMH12568 u/s invert
STMMH12333	Wrong Bottom elev. = 192.74 m	Bottom elev. = 188.38 m	Interpolated Bottom Elevation using STMMH12333→ STMMH12338 u/s invert
STMMH11955	Wrong Bottom elev. = 177.474 m	Bottom elev. = 177.395 m	Interpolated Bottom Elevation using STMMH11955→ STMMH12301 u/s invert
STMMH12027	Wrong Bottom elev. = 198.52 m	Bottom elev. = 193.3 m	Interpolated Bottom Elevation using STMMH12027→ STMMH12652 u/s invert
STMMH12055	Wrong Bottom elev. = 187.197 m	Bottom elev. = 187.187 m	Interpolated Bottom Elevation using STMMH12055→ STMMH12056 u/s invert
STMMH12064	Wrong Bottom elev. = 197.169 m	Bottom elev. = 197.086 m	Interpolated Bottom Elevation using STMMH12064→ STMMH12065 u/s invert
STMSJ343	Wrong Bottom elev. = 197.635 m	Bottom elev. = 197.485 m	Interpolated Bottom Elevation using STMSJ→ STMMH15129 u/s invert
STMMH12301	Wrong Bottom elev. = 175.89 m	Bottom elev. = 195.886 m	Interpolated Bottom Elevation using STMMH12301→ STMMH12302 u/s invert
STMMH12300	Wrong Bottom elev. = 179.46 m	Bottom elev. = 178.46 m	Interpolated Bottom Elevation using STMMH12300→ STMMH12301 u/s invert
STMMH_Cole1004	Wrong Bottom elev. = 181.8 m	Bottom elev. = 178.6 m	Interpolated Bottom Elevation using STMMH_Cole1004→ STMMH_Cole1005 u/s invert

STMMH17190	Wrong Bottom elev. = 194.403 m	Bottom elev. = 194.402 m	Interpolated Bottom Elevation using STMMH17190→ STMMH17189 u/s invert
STMMH17182	Wrong Bottom elev. = 196.8 m	Bottom elev. = 196.725 m	Interpolated Bottom Elevation using STMMH17182→ STMMH17183 u/s invert
STMMH12332	Wrong Bottom elev. = 193.47 m	Bottom elev. = 193.4 m	Interpolated Bottom Elevation using STMMH12332→ STMMH12333 u/s invert
STMMH12329	Wrong Bottom elev. = 192.61 m	Bottom elev. = 192.08 m	Interpolated Bottom Elevation using STMMH12329→ STMMH12337 u/s invert
STMMH12241	Wrong Bottom elev. = 185.681 m	Bottom elev. = 183.65 m	Interpolated Bottom Elevation using STMMH12241→ STMMH12225 u/s invert
STMMH12262	Wrong Bottom elev. = 199.897 m	Bottom elev. = 189.89 m	Interpolated Bottom Elevation using STMMH12262→ STMMH12261 u/s invert
STMMH15081	Wrong Bottom elev. = 197.365 m	Bottom elev. = 197.05 m	Interpolated Bottom Elevation using STMMH15081→ STMMH15082 u/s invert
STMMH12223	Wrong Bottom elev. = 180.72 m	Bottom elev. = 180.44 m	Interpolated Bottom Elevation using STMMH12223→ STMMH12237 u/s invert
STMMH12225	Wrong Bottom elev. = 181.56 m	Bottom elev. = 181.015 m	Interpolated Bottom Elevation using STMMH12225→ STMMH12224 u/s invert
STMMH12238	Wrong Bottom elev. = 179.17 m	Bottom elev. = 178.265 m	Interpolated Bottom Elevation using STMMH12238→ STMMH12252 u/s invert
STMMH15034	Wrong Bottom elev. = 202.765 m	Bottom elev. = 202.69 m	Interpolated Bottom Elevation using STMMH15034→ STMMH15033 u/s invert
STMMH15124	Wrong Bottom elev. = 199.357 m	Bottom elev. = 199.292 m	Interpolated Bottom Elevation using STMMH15124→ STMMH15125 u/s invert
STMMH12569	Wrong Bottom elev. = 182.5 m	Bottom elev. = 182.25 m	Interpolated Bottom Elevation using STMMH12569→ STMMH12284 u/s invert
STMMH12401	Wrong Bottom elev. = 184.36 m	Bottom elev. = 184.34 m	Interpolated Bottom Elevation using STMMH12401→ STMMH12397 u/s invert

STMMH12284	Wrong Bottom elev. = 179.8 m	Bottom elev. = 179.53 m	Interpolated Bottom Elevation using STMMH12284→ STMMH12285 u/s invert
STMMH12304	Wrong Bottom elev. = 170.69 m	Bottom elev. = 170.1 m	Interpolated Bottom Elevation using STMMH12304→ STMMH17165 u/s invert
STMMH11938	Wrong Bottom elev. = 190.8 m	Bottom elev. = 190.07 m	Interpolated Bottom Elevation using STMMH11938→ STMMH12552 u/s invert
STMMH11948	Wrong Bottom elev. = 183.7 m	Bottom elev. = 183.639 m	Interpolated Bottom Elevation using STMMH11948→ STMMH12299 u/s invert
STMMH12072	Wrong Bottom elev. = 198.08 m	Bottom elev. = 196.66 m	Interpolated Bottom Elevation using STMMH12072→ STMMH12073 u/s invert
STMMH12073	Wrong Bottom elev. = 195.75 m	Bottom elev. = 195.58 m	Interpolated Bottom Elevation using STMMH12073→ STMMH11790 u/s invert
STMMH12119	Wrong Bottom elev. = 186.639 m	Bottom elev. = 186.557 m	Interpolated Bottom Elevation using STMMH12119→ STMMH12118 u/s invert
STMMH12267	Wrong Bottom elev. = 197.8 m	Bottom elev. = 197.32 m	Interpolated Bottom Elevation using STMMH12267→ STMMH12268 u/s invert
STMMH12263	Wrong Bottom elev. = 199.131 m	Bottom elev. = 198.168 m	Interpolated Bottom Elevation using STMMH12263→ STMMH12264 u/s invert
STMMH12271	Wrong Bottom elev. = 190.18 m	Bottom elev. = 189.68 m	Interpolated Bottom Elevation using STMMH12271→ STMMH11786 u/s invert
STMMH12326	Wrong Bottom elev. = 192.43 m	Bottom elev. = 192.36 m	Interpolated Bottom Elevation using STMMH12326→ STMMH12329 u/s invert
STMMH12322	Wrong Bottom elev. = 193.45 m	Bottom elev. = 193.32 m	Interpolated Bottom Elevation using STMMH12322→ STMMH12325 u/s invert
STMMH12325	Wrong Bottom elev. = 193.03 m	Bottom elev. = 192.95 m	Interpolated Bottom Elevation using STMMH12325→ STMMH12326 u/s invert
STMMH12231	Wrong Bottom elev. = 186.907 m	Bottom elev. = 186.905 m	Interpolated Bottom Elevation using STMMH12231→ STMMH12230 u/s invert

STMMH12157	Wrong Bottom elev. = 185.52 m	Bottom elev. = 185.49 m	Interpolated Bottom Elevation using STMMH12157→ IO2760 u/s invert
STMMH12144	Wrong Bottom elev. = 191.1 m	Bottom elev. = 190.759 m	Interpolated Bottom Elevation using STMMH12144→ STMMH12142 u/s invert
STMMH12140	Wrong Bottom elev. = 188.038 m	Bottom elev. = 188.036 m	Interpolated Bottom Elevation using STMMH12140→ OutfallSite8B u/s invert
STMMH16405	Wrong Bottom elev. = 197.353 m	Bottom elev. = 196.774 m	Interpolated Bottom Elevation using STMMH16405→ STMMH16404 u/s invert
STMMH12125	Wrong Bottom elev. = 191.676 m	Bottom elev. = 191.279 m	Interpolated Bottom Elevation using STMMH12125→ STMMH12578 u/s invert
STMMH12100	Wrong Bottom elev. = 185.152 m	Bottom elev. = 185.023 m	Interpolated Bottom Elevation using STMMH12100→ Dummy_MH1004 u/s invert
STMMH12099	Wrong Bottom elev. = 181.542 m	Bottom elev. = 180.475 m	Interpolated Bottom Elevation using STMMH12099→ STMMH12319 u/s invert
STMMH12074	Wrong Bottom elev. = 195.74 m	Bottom elev. = 195.47 m	Interpolated Bottom Elevation using STMMH12074→ STMMH12075 u/s invert
STMMH12132	Wrong Bottom elev. = 192.248 m	Bottom elev. = 192.245 m	Interpolated Bottom Elevation using STMMH12132→ STMMH12668 u/s invert
STMSJ340	Wrong ground elev. = 0.45 m	ground elev. = 203.014 m	Interpolated Ground elevation from DEM
Dummy_MH1033		ground elev. = 201.55 m Bottom elev.= 198.59 m	Interpolated Ground elevation from DEM, Bottom Elevation using u/s invert
Dummy_MH1034		ground elev. = 202.7 m Bottom elev.=199.269 m	Interpolated Ground elevation from DEM, Bottom Elevation using u/s invert
STMSJ415		ground elev. = 183.32 m Bottom elev.=177.551 m	Interpolated Ground elevation from DEM, Bottom Elevation using u/s invert
Dummy_MH1035		ground elev. = 193.46 m Bottom elev. =190.798 m	Interpolated Ground elevation from DEM, Bottom Elevation using u/s invert

Dummy_MH1036		ground elev. = 198.785 m Bottom elev.= 195.968 m	Interpolated Ground elevation from DEM, Bottom Elevation using u/s invert
Dummy_MH1037		ground elev. = 201.778 m Bottom elev.= 198.662 m	Interpolated Ground elevation from DEM, Bottom Elevation using u/s invert
Dummy_MH1038		ground elev. = 198.235 m Bottom elev.= 195.015 m	Interpolated Ground elevation from DEM, Bottom Elevation using u/s invert
Dummy_MH1039		ground elev. = 202.759 m Bottom elev.= 200.04 m	Interpolated Ground elevation from DEM, Bottom Elevation using u/s invert
STMSJ233		ground elev. = 200.15 m Bottom elev.= 196.75 m	Interpolated Ground elevation from DEM, Bottom Elevation using u/s invert
STMMH12545	Wrong Bottom elev. = 190.268 m	Bottom elev. = 190.193 m	Interpolated Bottom Elevation using STMMH12545→ STMMH12546 u/s invert
CB38416	Missing ground Elevation	Ground elev. = 203.211 m	Ditch Inlet, Ground Elev. from DEM
Dummy_MH1040		ground elev. = 192.882 bottom elev. = 188.774	Split STMSL21602, ground elevation from DEM
Dummy_MH1041		ground elev. = 192.695 bottom elev. = 188.384	Split STMSL23057, ground elevation from DEM
Dummy_MH1042		ground elev. = 192.201 bottom elev. = 187.206	Split STMSL22249, ground elevation from DEM
IO2760	Missing ground elevation	Ground elev. = 188.619	Ground elev. from DEM
Dummy_MH1043		ground elev. = 189.642	Ground elev. from DEM
IO265	Missing ground elevation	Ground elev. = 188.6	Assumed Ground elev. = MH Invert + Diameter
IO314	Missing ground elevation	Ground elev. = 183.8	Assumed Ground elev. = MH Invert + Diameter
Dummy_MH1044		ground elev. = 195.797 bottom elev. = 190.574	Split STMSL35820, ground elev. from DEM
Dummy_MH1045		ground elev. = 196.255 bottom elev. = 192.408	Split STMSL28982, ground elev. from DEM

Dummy_MH1046		ground elev. = 198.41 bottom elev. = 194.24	Split STMSL28667, ground elev. from DEM
STMMH16933			Split STMSL34202
IO376	Intake, missing ground and bottom elevation	Ground elev. = 195.3 Bottom elev. = 194.755	Using sewer u/s invert, assumed Ground elev. = MH Invert + Diameter
Dummy_MH1047		ground elev. = 200 m bottom elev. = 194.6	Split STMSL34342, ground elev. from DEM
Dummy_MH1048		ground elev. = 199.197 bottom elev. = 196.45	Split STMSL22905, ground elev. from DEM
Dummy_MH1049		ground elev. = 200.088 bottom elev. = 197.111	Split STMSL22904, ground elev. from DEM
Dummy_MH1050		ground elev. = 198.369 bottom elev. = 195.061	Split STMSL23374, ground elev. from DEM
Dummy_MH1051		ground elev. = 201.696 bottom elev. = 198.118	Split STMSL23377, ground elev. from DEM
Dummy_MH1052		ground elev. = 202.583 bottom elev. = 199.597	Split STMSL21781, ground elev. from DEM
IO378	Missing ground elevation	Ground elev. = 166.1	Assumed Ground elev. = MH Invert + Diameter
IO379	Intake missing ground elevation, bottom elevation	Ground elev. = 193.02 Bottom elev. = 192.12	Ground elev. From DEM, bottom elev. Calculated using d/s MH inv. And slope 6%
IO380	Outfall missing ground elevation, bottom elevation	Ground elev. = 191.7 Bottom elev. = 191.04	Bottom elev. From DEM and assumed Ground elev. = Bottom elev. + Diameter
IO395	Intake missing ground elevation	Ground elev. = 189.8	Ground elev. = pipe d/s inv. + Diameter
IO395	Intake wrong ground elevation=191.34	Ground elev. = 191.64	Ground elev. = pipe d/s inv. + Diameter
Dummy_MH1053		ground elev. = 194.342 bottom elev. = 188.089	Split from pipe STMMH16458->STMMH11787, ground elev. from DEM
STMMH12425	STM service MH		delete
STMMH12685	STM service MH		delete
STMMH12794	STM service MH		delete

Dummy_MH1054		ground elev. = 201.507 bottom elev. = 197.852	Split STMSL22254, ground elev. from DEM
Dummy_MH1055		ground elev. = 201.507 bottom elev. = 197.852	Split STMSL22254, ground elev. from DEM
STMMH12101	STM service MH		delete
STMMH12130	STM service MH		delete
STMMH12143	Outside of model MH		delete
STMMH12145	STM service MH		delete
STMMH14888	STM service MH		delete
Dummy_MH1056		ground elev. = 196.591 bottom elev. = 192.018	Split STMSL29997, ground elev. from DEM
STMMH14894	STM service MH		delete
STMMH14933	STM service MH		delete
STMMH14939	STM service MH		delete
STMMH14942	STM service MH		delete
STMMH15108	STM service MH		delete
STMMH15109	STM service MH		delete
Dummy_MH1057		ground elev. = 199.032 bottom elev. = 196.158	Split STMSL30487, ground elev. from DEM
STMMH16415	Isolated MH		delete
STMMH16731	Isolated MH		delete
STMMH16733	Isolated MH		delete
STMMH16734	Isolated MH		delete
STMMH16736	Isolated MH		delete
STMMH24495	Isolated MH		delete
IO473	Intake missing ground elevation	Ground elev. = 200	Ground elev. = pipe inv. + Diameter
STMMH14875	Missing ground elevation	Ground elev. = 193.02	Ground elev. = pipe inv. + Diameter
IO305	Outfall missing ground elevation	Ground elev. = 192.925	Ground elev. = pipe inv. + Diameter
STMMH14974	Wrong ground elevation = 204.02	Ground elev. = 208.144	Ground elev. From DEM
IO319	Outfall missing ground elevation	Ground elev. = 192.6	Ground elev. = pipe inv. + Diameter
IO375	Outfall missing ground elevation	Ground elev. = 198.032	Ground elev. = pipe inv. + Diameter
IO295	Intake missing ground elevation, Bottom elevation	Ground elev. = 186.563 Bottom elev. = 185.149	Ground elev. from DEM, bottom elev. use pipe inv.
CBsurvey1	Site Visit find CB at Franklin Ave.	CB type 713B	Increase a CB, type 713B
CBsurvey2	Site Visit find CB at Franklin Ave.	CB type 713B	Increase a CB, type 713B

CBsurvey3	Site Visit find CB at Franklin Ave.	CB type 713B	Increase a CB, type 713B
CBsurvey4	Site Visit find CB at Franklin Ave.	CB type KWC	Increase a CB, type KWC

APPENDIX C

Data Standards Submission

Storm Water Management Facility SWMSoft Data Requirements for Completion Approval

Development/Transportation Engineering Department, City of Vaughan

1. SUBMISSION REQUIREMENTS

The following information shall be submitted in digital format on a <u>CD-ROM or DVD disk</u> with the final or as-constructed subdivision submission:
Submissions shall contain all material indicated in this document and shall be submitted in well organized digital folders, named and numbered according to this document.
Submissions that do not comply with these requirements will be considered incomplete.
Only complete submissions that comply with these requirements will be accepted.
Please do not submit extraneous material.

1.1 New Facility Information

Fill out the "General Facility Information Survey" contained in Section 2.2 of this document. Scan the filled form and include in the disk submission.

1.2 Drawings

Provide a complete scanned set of both the approved and the as-constructed technical drawings. The drawings should be signed and sealed by the qualified Professional Engineer. The drawings will include, but not necessarily be limited to, the following types:

a. Storm sewer drainage area plans (internal & external)
b. Overland flow drawings
c. All drawings related to proposed SWM facilities including section & details of facility, inlet/outlet structures, etc.
d. All major & minor system design sheets
e. An original bathymetric/topographic survey of the as-built SWM pond conditions sealed by a qualified Ontario Land Surveyor

<u>Format</u>: Scanned into "Tagged Image File Format" – TIFF Group 4 (*.TIF).

- Quality of Scans must be such that all line types can be easily differentiated with a minimum scan resolution of 400 dots per inch (DPI).
- The maximum file size of each image file must not exceed 5MB. A file size of approximately 1MB is preferable.
- Image size must be at 1:1 scale with original record and printed items must maintain original drawing scale.
- Orientation of the Title Block and/or Descriptive Text must be horizontal.
- Drawing text of 5 point or higher must be legible and all characters easily differentiated on scanned image.
- Full size scanners must be used.
- Scanners must contain adaptive area thresholding ability.
- Image must not be skewed, where an acceptable skew is limited to 0.5 degrees.
- Minimum of 25.4mm (1 inch) white space border provided around image, where image is defined as the area within the drawing neat-line.

1.3 SWM Design & Facility Operation/Maintenance Report

Provide a final SWM report signed and sealed by the qualified Professional Engineer. Include all the attachments/appendicies.

Format: "Portable Document Format" (*.PDF)

1.4 Digital Photos of SWM Facility

Photographs of constructed SWM facility just prior to assumption shall be provided. These photos should include all significant components such as inlets, outlets, weirs, etc. Refer to "SWMSoft Legend" (Section 2.1) of this document for common element types.

Format: "Joint Photographic Experts Group" image file format (*.JPG) – High resolution.

Naming convention to be followed for each image file:

a. Brief description of photo's subject
b. Date photo was taken (YYYY-MMM-DD)

Example filename: **Access_Road_2008-Jul-21.jpg**

1.6 GIS Shapefile (if available)

Provide GIS shapefiles tracing the outline of the 100 year water level and the permanent pool (normal water) level of the pond properly geo-referenced. All property lines associated with pond block in question should be included. Significant features of the pond should be indicated as per the "SWMSoft Legend" (Section 2.1) of this document.

Format: ESRI shapefile or feature class compatible with ArcMap 9.1.

- All data to be geo-referenced to real world coordinates using a Projection/Coordinate System Universal Transverse Mercator, North American Datum (NAD83) Zone 17N and also to be referenced to legal property/parcel fabric.
- Deliver Feature Class data neatly organized in an ESRI Personal Geodatabase.
- Attribute values within any Feature Class to be standardized and coded whenever possible using Coded Value Domains and must confirm to M.I.D.S. Standard 1.95 whenever possible.
- Full Metadata, conforming to City requirements, for each object is to be created.
- All alpha characters to be upper case.

It is noted that design drawings are typically provided in CAD (.dwg) format. If GIS shapfiles are not available, design drawings which are in CAD or another format should be scanned as outlined in Section 1.2 or exported to shapefiles.

2. DATA DETAILS

2.1 SWMSoft Legend

Component symbology can be customized based on users preference.

2.2 General Facility Information Survey

1	**Facility Name**	
2	**Type**	☐Wet Pond ☐Dry Pond ☐Wetland ☐Hybrid ☐Oil/Grit Separator ☐Infiltration Basin ☐Infiltration Trench ☐Porous Pavement
3	**Function**	☐Flood Control ☐Quality Control ☐Quantity Control ☐Erosion Control ☐Quality/Quantity Control ☐Quality/Quantity/Erosion Control
4	**Pond Type**	☐Offline ☐Online
5	**General Description**	
6	**Location Description**	
7	**Nearest Major Intersection**	
8	**Municipal Address**	
9	**Easting**	
10	**Northing**	
11	**Access**	
12	**Driveway**	☐Yes ☐No
13	**Driveway Material**	
14	**Vehicle Turnaround**	☐Yes ☐No
15	**Gate Present**	☐Yes ☐No
16	**Lock Present**	☐Yes ☐No
17	**Adjacent Land Use**	☐Residential ☐Commercial ☐Industrial ☐Rural
18	**Block Number**	
19	**Comments**	

Storm Drainage Infrastructure: Culverts and Bridges
SWMSoft Data Requirements
for Completion Approval

Development/Transportation Engineering Department, City of Vaughan

---

1. SUBMISSION REQUIREMENTS

The following information shall be submitted in digital format on a <u>CD-ROM or DVD disk</u> with the final or as-constructed subdivision submission:
Submissions shall contain all material indicated in this document and shall be submitted in well organized digital folders, named and numbered according to this document.
Submissions that do not comply with these requirements will be considered incomplete.
Only complete submissions that comply with these requirements will be accepted.
Please do not submit extraneous material.

1.1 New Drainage Infrastructure Information

Fill out the "General Drainage Infrastructure Information Survey" contained in Section 2.2 of this document. Scan the filled form and include in the disk submission.

1.2 Drawings

Provide a complete scanned set of both the approved and the as-constructed technical drawings. The drawings should be signed and sealed by the qualified Professional Engineer. The drawings will include, but not necessarily be limited to, the following types:

a. General Plan
b. Erosion & Sediment Control Plan
c. Erosion & Sediment Control Plan Detail
d. Floodplain Mapping – Plan View
e. Floodplain Mapping – Cross Section Details
f. Traffic Control Plan
g. Pedestrian Enhancement Plan
h. Access Plan

<u>Format</u>: Scanned into "Tagged Image File Format" – TIFF Group 4 (*.TIF).

- Quality of Scans must be such that all line types can be easily differentiated with a minimum scan resolution of 400 dots per inch (DPI).
- The maximum file size of each image file must not exceed 5MB. A file size of approximately 1MB is preferable.
- Image size must be at 1:1 scale with original record and printed items must maintain original drawing scale.
- Orientation of the Title Block and/or Descriptive Text must be horizontal.
- Drawing text of 5 point or higher must be legible and all characters easily differentiated on scanned image.
- Full size scanners must be used.
- Scanners must contain adaptive area thresholding ability.
- Image must not be skewed, where an acceptable skew is limited to 0.5 degrees.

- Minimum of 25.4mm (1 inch) white space border provided around image, where image is defined as the area within the drawing neat-line.

1.3 Storm Drainage Infrastructure Design Report

Provide a final report signed and sealed by the qualified Professional Engineer. Include all the attachments/appendices.

Format: "Portable Document Format" (*.PDF)

1.4 Digital Photos of Storm Drainage Infrastructure

Photographs of constructed drainage infrastructure shall be provided. These photos should include all significant components such as inlets, outlets, etc. Refer to "SWMSoft Legend" (Section 2.1) of this document for common element types.

Format: "Joint Photographic Experts Group" image file format (*.JPG) – High resolution.

Naming convention to be followed for each image file:

a. Brief description of photo's subject
b. Date photo was taken (YYYY-MMM-DD)

Example filename: **Access_Road_2008-Jul-21.jpg**

1.6 GIS Shapefile (if available)

Provide GIS shapefiles tracing the outline of the 100 year water level and the permanent pool (normal water) level of the pond properly geo-referenced. All property lines associated with pond block in question should be included. Significant features of the pond should be indicated as per the "SWMSoft Legend" (Section 2.1) of this document.

Format: ESRI shapefile or feature class compatible with ArcMap 9.1.

- All data to be geo-referenced to real world coordinates using a Projection/Coordinate System Universal Transverse Mercator, North American Datum (NAD83) Zone 17N and also to be referenced to legal property/parcel fabric.
- Deliver Feature Class data neatly organized in an ESRI Personal Geodatabase.
- Attribute values within any Feature Class to be standardized and coded whenever possible using Coded Value Domains and must confirm to M.I.D.S. Standard 1.95 whenever possible.
- Full Metadata, conforming to City requirements, for each object is to be created.
- All alpha characters to be upper case.

It is noted that design drawings are typically provided in CAD (.dwg) format. If GIS shapfiles are not available, design drawings which are in CAD or another format should be scanned as outlined in Section 1.2 or exported to shapefiles.

2. DATA DETAILS

2.1 SWMSoft Legend

Component symbology can be customized based on users preference.

2.2 General Drainage Structure Information Survey

1	**Facility Name**	
2	**Type**	☐Bridge ☐Pedestrian ☐Rail ☐Road Transportation ☐Culvert ☐Circular ☐Box ☐Pipe Arch ☐Ellipse ☐Arch ☐Semi-circle ☐Low Arch ☐High Arch ☐Conspan Arch ☐Open Bottom
3	**General Description**	
4	**Location Description**	
5	**Nearest Major Intersection**	
6	**Municipal Address**	
7	**Easting**	
8	**Northing**	
9	**Access**	
10	**Driveway**	☐Yes ☐No
11	**Driveway Material**	
12	**Vehicle Turnaround**	☐Yes ☐No
13	**Gate Present**	☐Yes ☐No
14	**Lock Present**	☐Yes ☐No
15	**Adjacent Land Use**	☐Residential ☐Commercial ☐Industrial ☐Rural
16	**Block Number**	
17	**Comments**	

APPENDIX D
Flood Emergency Response Index (FERI)

Vaughan's Parameters:

Land use	
Commercial	75
Industrial	75
Other	50
Park	50
Residential	100

Vehicle Access		
Max flood depth > = 0.3 m	PV+	100
Maximum flood depth < 0.3 m	PV-	0

Pedestrian (adult access)		
Maximum flood depth >= 0.8 m	AA+	100
Maximum flood depth < 0.8 m	AA-	0

Road Classification	
Access Road	50
Arterial Road	100
Collector Road	75
Freeway	100
Private Road	50
Proposed Road	50
Railway	50
Regional Road	100
Rural Road	50
Urban Road	75
Vehicle Bridge	50
Vehicle Access	50

Overtopping Depth	
Depth >= 0.3 m	100
Depth < 0.3 m	0

Flood Vulnerable Area (FVA) for 10 Year Event :

Rank	Building ID	Address	Zones	Land Use	Centroid_X	Centroid_Y	10yr Max. Depth (m)	FERI
1	B308	14 NATTRESS STREET	R3	Residential	614150.35	4850131.30	1.864	100
2	B1076	111 RIVERSIDE DR	R3	Residential	614126.26	4850138.80	1.337	94
3	B309	18 NATTRESS STREET	R3	Residential	614164.67	4850131.15	0.925	90
4	B310	22 NATTRESS STREET	R3	Residential	614181.12	4850130.80	0.837	89
5	B372	7581 JANE STREET	EM1	Industrial	618850.30	4849634.36	1.192	83
6	B449	9290 MCGILLVRAY ROAD	OS1	Park	609094.17	4851433.61	0.937	70
7	B1077	105 RIVERSIDE DRIVE	R3	Residential	614123.47	4850122.95	0.626	67
8	B1099	9652 KEELE STREET	R1	Residential	619710.00	4855841.16	0.539	66
9	B311	28 NATTRESS STREET	R3	Residential	614196.25	4850131.15	0.391	64
10	B346	23 GRAM ST	RIV	Residential	619206.63	4856405.02	0.344	64
11	B348	26 NAYLON ST	RIV	Residential	619255.76	4856386.87	0.335	64
12	B373	7683 JANE ST	EM1	Industrial	618807.56	4849912.07	0.790	58
13	B371	7601 JANE ST	EM1	Industrial	618871.53	4849745.74	0.534	56
14	B457	BRODA	OS1	Park	609821.88	4853512.83	0.623	47
15	B2	7601 MARTIN GROVE ROAD	PB1	Other	612522.01	4846772.15	0.540	46
16	B447	8966 HUNTINGTON ROAD	OS2	Park	607632.72	4850222.76	0.498	45
17	B482	8966 HUNTINGTON ROAD	OS2	Park	607632.72	4850222.76	0.498	45
18	B477	BRODA	OS1	Park	609850.95	4853505.29	0.382	44
19	B467	9751 MC GILLIVRAY RD	A	Other	608961.79	4852599.22	0.369	44
20	B347	12 OLDFIELD ST	RIV	Residential	619264.85	4856424.71	0.295	43
21	B345	20 GRAM ST	RIV	Residential	619155.95	4856392.69	0.126	41
22	B11	60 LEGION COURT ROAD	R1	Residential	613562.35	4848273.95	0.100	41
23	B355	19 NAYLON ST	RIV	Residential	619373.27	4856366.17	0.099	41
24	B28	KIPLING	M2	Industrial	612429.43	4849384.93	0.022	30
25	B305	PINE GROVE	EM1	Industrial	613979.43	4850433.67	0.003	30
26	B12	7618 SLINGTON Ave	PB1	Other	613817.30	4848221.66	0.195	22
27	B448	10223 HIGHWAY 50	A	Other	606646.40	4853472.32	0.136	21
28	B476	BRODA	OS1	Park	609881.95	4853520.05	0.135	21
29	B450	9441 HUNTINGTON ROAD	A	Other	608103.80	4851573.71	0.018	20

Flood Vulnerable Area (FVA) for 25 Year Event :

Rank	Building ID	Address	Zones	Land Use	Centroid_X	Centroid_Y	25yr Max. Depth (m)	FERI
1	B308	14 NATTRESS STREET	R3	Residential	614150.35	4850131.30	2.096	100
2	B1076	111 RIVERSIDE DR	R3	Residential	614126.26	4850138.80	1.570	95
3	B309	18 NATTRESS STREET	R3	Residential	614164.67	4850131.15	1.157	91
4	B310	22 NATTRESS STREET	R3	Residential	614181.12	4850130.80	1.070	90
5	B1077	105 RIVERSIDE DRIVE	R3	Residential	614123.47	4850122.95	0.855	88
6	B372	7581 JANE STREET	EM1	Industrial	618850.30	4849634.36	1.334	83
7	B373	7683 JANE ST	EM1	Industrial	618807.56	4849912.07	0.953	79
8	B449	9290 MCGILLVRAY ROAD	OS1	Park	609094.17	4851433.61	1.022	70
9	B457	BRODA	OS1	Park	609821.88	4853512.83	0.935	69
10	B1099	9652 KEELE STREET	R1	Residential	619710.00	4855841.16	0.769	67
11	B311	28 NATTRESS STREET	R3	Residential	614196.25	4850131.15	0.624	66
12	B346	23 GRAM ST	RIV	Residential	619206.63	4856405.02	0.409	64
13	B348	26 NAYLON ST	RIV	Residential	619255.76	4856386.87	0.383	64
14	B11	60 LEGION COURT ROAD	R1	Residential	613562.35	4848273.95	0.373	64
15	B347	12 OLDFIELD ST	RIV	Residential	619264.85	4856424.71	0.332	63
16	B371	7601 JANE ST	EM1	Industrial	618871.53	4849745.74	0.681	56
17	B477	BRODA	OS1	Park	609850.95	4853505.29	0.695	47
18	B2	7601 MARTIN GROVE ROAD	PB1	Other	612522.01	4846772.15	0.659	46
19	B447	8966 HUNTINGTON ROAD	OS2	Park	607632.72	4850222.76	0.612	46
20	B482	8966 HUNTINGTON ROAD	OS2	Park	607632.72	4850222.76	0.612	46
21	B12	7618 SLINGTON Ave	PB1	Other	613817.30	4848221.66	0.600	46
22	B467	9751 MC GILLIVRAY RD	A	Other	608961.79	4852599.22	0.445	44
23	B476	BRODA	OS1	Park	609881.95	4853520.05	0.442	44
24	B1074	8201 ISLINGTON AVE	RA2	Residential	613941.02	4849908.39	0.215	42
25	B355	19 NAYLON ST	RIV	Residential	619373.27	4856366.17	0.183	42
26	B345	20 GRAM ST	RIV	Residential	619155.95	4856392.69	0.173	42
27	B129	5 WHITE BLVD	R5	Residential	622881.10	4851026.92	0.046	40
28	B1058	3 WHITE BOULEVARD	R5	Residential	622883.42	4851020.15	0.016	40
29	B130	7 WHITE BOULEVARD	R5	Residential	622880.52	4851035.37	0.011	40
30	B28	KIPLING	M2	Industrial	612429.43	4849384.93	0.237	32
31	B305	PINE GROVE	EM1	Industrial	613979.43	4850433.67	0.213	32
32	B5	7694 ISLINGTON AVE	C1	Commercial	613623.87	4848329.67	0.118	31
33	B6	7676 ISLINGTON AVE	C1	Commercial	613669.02	4848320.27	0.028	30
34	B448	10223 HIGHWAY 50	A	Other	606646.40	4853472.32	0.267	23
35	B450	9441 HUNTINGTON ROAD	A	Other	608103.80	4851573.71	0.125	21
36	B465	62 BRODA DR	OS1	Park	609820.15	4853641.87	0.040	20
37	B4	7642 ISLINGTON Ave	PB1	Other	613744.01	4848249.13	0.001	20

Flood Vulnerable Area (FVA) for 50 Year Event :

Rank	Building ID	Address	Zones	Land Use	Centroid_X	Centroid_Y	50yr Max. Depth (m)	FERI
1	B308	14 NATTRESS STREET	R3	Residential	614150.35	4850131.30	2.266	100
2	B1076	111 RIVERSIDE DR	R3	Residential	614126.26	4850138.80	1.740	95
3	B309	18 NATTRESS STREET	R3	Residential	614164.67	4850131.15	1.327	92
4	B310	22 NATTRESS STREET	R3	Residential	614181.12	4850130.80	1.240	91
5	B374	7230 JANE STREET	R	Residential	618909.39	4848477.89	1.084	90
6	B1099	9652 KEELE STREET	R1	Residential	619710.00	4855841.16	1.050	89
7	B1077	105 RIVERSIDE DRIVE	R3	Residential	614123.47	4850122.95	1.024	89
8	B372	7581 JANE STREET	EM1	Industrial	618850.30	4849634.36	1.438	83
9	B373	7683 JANE ST	EM1	Industrial	618807.56	4849912.07	1.076	79
10	B457	BRODA	OS1	Park	609821.88	4853512.83	1.140	70
11	B449	9290 MCGILLVRAY ROAD	OS1	Park	609094.17	4851433.61	1.085	70
12	B467	9751 MC GILLIVRAY RD	A	Other	608961.79	4852599.22	1.011	69
13	B477	BRODA	OS1	Park	609850.95	4853505.29	0.901	68
14	B12	7618 SLINGTON Ave	PB1	Other	613817.30	4848221.66	0.895	68
15	B311	28 NATTRESS STREET	R3	Residential	614196.25	4850131.15	0.794	67
16	B11	60 LEGION COURT ROAD	R1	Residential	613562.35	4848273.95	0.552	65
17	B346	23 GRAM ST	RIV	Residential	619206.63	4856405.02	0.528	65
18	B348	26 NAYLON ST	RIV	Residential	619255.76	4856386.87	0.461	64
19	B1074	8201 ISLINGTON AVE	RA2	Residential	613941.02	4849908.39	0.392	63
20	B347	12 OLDFIELD ST	RIV	Residential	619264.85	4856424.71	0.381	63
21	B371	7601 JANE ST	EM1	Industrial	618871.53	4849745.74	0.789	57
22	B364	1949 HIGHWAY 7	C1	Commercial	621512.79	4851019.37	0.645	56
23	B363	1955 HIGHWAY 7	C1	Commercial	621495.10	4851019.47	0.642	56
24	B28	KIPLING	M2	Industrial	612429.43	4849384.93	0.522	55
25	B365	1929 HIGHWAY 7	EM1	Industrial	621585.03	4850996.06	0.472	54
26	B305	PINE GROVE	EM1	Industrial	613979.43	4850433.67	0.368	53
27	B2	7601 MARTIN GROVE ROAD	PB1	Other	612522.01	4846772.15	0.759	47
28	B447	8966 HUNTINGTON ROAD	OS2	Park	607632.72	4850222.76	0.736	46
29	B482	8966 HUNTINGTON ROAD	OS2	Park	607632.72	4850222.76	0.736	46
30	B476	BRODA	OS1	Park	609881.95	4853520.05	0.644	46
31	B448	10223 HIGHWAY 50	A	Other	606646.40	4853472.32	0.352	43
32	B355	19 NAYLON ST	RIV	Residential	619373.27	4856366.17	0.268	42
33	B129	5 WHITE BLVD	R5	Residential	622881.10	4851026.92	0.256	42
34	B130	7 WHITE BOULEVARD	R5	Residential	622880.52	4851035.37	0.226	42
35	B1058	3 WHITE BOULEVARD	R5	Residential	622883.42	4851020.15	0.222	42
36	B345	20 GRAM ST	RIV	Residential	619155.95	4856392.69	0.206	42
37	B131	9 WHITE BOULEVARD	R5	Residential	622877.67	4851042.13	0.166	41
38	B103	139 CHARLTON AV	R3	Residential	623431.95	4850305.28	0.165	41
39	B84	72 CHARLTON AVENUE	R4	Residential	623409.72	4850423.58	0.106	41
40	B56	159 WOODCROFT LANE	R4	Residential	612096.67	4849742.58	0.087	41
41	B125	6 WHITE BOULEVARD	R5	Residential	622833.76	4851016.08	0.082	41
42	B126	8 WHITE BOULEVARD	R5	Residential	622832.82	4851024.42	0.056	40
43	B123	9 DRAPER BOULEVARD	R5	Residential	622852.86	4850963.55	0.037	40
44	B1057	4 WHITE BLVD	R5	Residential	622834.63	4851008.27	0.035	40
45	B124	7 DRAPER BOULEVARD	R5	Residential	622842.82	4850959.47	0.031	40
46	B127	10 WHITE BOULEVARD	R5	Residential	622831.37	4851031.44	0.030	40
47	B57	155 WOODCROFT LANE	R4	Residential	612099.83	4849752.77	0.030	40
48	B99	75 CHARLTON AV	R4	Residential	623444.85	4850381.64	0.019	40
49	B122	11 DRAPER BOULEVARD	R5	Residential	622861.63	4850965.81	0.002	40
50	B5	7694 ISLINGTON AVE	C1	Commercial	613623.87	4848329.67	0.273	32
51	B6	7676 ISLINGTON AVE	C1	Commercial	613669.02	4848320.27	0.216	32
52	B1105	1955 HIGHWAY 7	C1	Commercial	621490.04	4851010.24	0.203	32
53	B1129	7725 JANE STREET	C8	Commercial	618797.39	4850020.26	0.088	31
54	B480	7800 JANE ST	C7	Commercial	618616.08	4850182.24	0.068	31
55	B4	7642 ISLINGTON Ave	PB1	Other	613744.01	4848249.13	0.275	22
56	B450	9441 HUNTINGTON ROAD	A	Other	608103.80	4851573.71	0.218	22
57	B465	62 BRODA DR	OS1	Park	609820.15	4853641.87	0.205	22
58	B458	43 BRODA DR	OS1	Park	609903.46	4853569.02	0.181	22
59	B14	7553 ISLINGTON AV	OS1	Park	614046.29	4848137.01	0.139	21
60	B466	9751 MC GILLIVRAY RD	A	Other	608931.44	4852780.76	0.047	20
61	B459	43 BRODA DR	OS1	Park	609894.84	4853594.32	0.023	20

Flood Vulnerable Area (FVA) for 100 Year Event :

Rank	Building ID	Address	Zones	Land Use	Centroid_X	Centroid_Y	100yr Max. Depth (m)	FERI
1	B308	14 NATTRESS STREET	R3	Residential	614150.35	4850131.30	2.425	100
2	B1076	111 RIVERSIDE DR	R3	Residential	614126.26	4850138.80	1.899	96
3	B309	18 NATTRESS STREET	R3	Residential	614164.67	4850131.15	1.485	92
4	B310	22 NATTRESS STREET	R3	Residential	614181.12	4850130.80	1.399	92
5	B1099	9652 KEELE STREET	R1	Residential	619710.00	4855841.16	1.289	91
6	B374	7230 JANE STREET	R	Residential	618909.39	4848477.89	1.189	90
7	B1077	105 RIVERSIDE DRIVE	R3	Residential	614123.47	4850122.95	1.181	90
8	B311	28 NATTRESS STREET	R3	Residential	614196.25	4850131.15	0.953	88
9	B364	1949 HIGHWAY 7	C1	Commercial	621512.79	4851019.37	1.861	85
10	B363	1955 HIGHWAY 7	C1	Commercial	621495.10	4851019.47	1.860	85
11	B365	1929 HIGHWAY 7	EM1	Industrial	621585.03	4850996.06	1.685	84
12	B372	7581 JANE STREET	EM1	Industrial	618850.30	4849634.36	1.502	82
13	B1105	1955 HIGHWAY 7	C1	Commercial	621490.04	4851010.24	1.426	82
14	B28	KIPLING	M2	Industrial	612429.43	4849384.93	1.264	80
15	B362	1965 HIGHWAY 7	C1	Commercial	621475.21	4851007.66	1.185	80
16	B373	7683 JANE ST	EM1	Industrial	618807.56	4849912.07	1.165	80
17	B366	1929 HIGHWAY 7	EM1	Industrial	621590.00	4850969.46	1.094	79
18	B371	7601 JANE ST	EM1	Industrial	618871.53	4849745.74	0.856	77
19	B457	BRODA	OS1	Park	609821.88	4853512.83	1.330	71
20	B467	9751 MC GILLIVRAY RD	A	Other	608961.79	4852599.22	1.242	70
21	B12	7618 SLINGTON Ave	PB1	Other	613817.30	4848221.66	1.179	70
22	B449	9290 MCGILLVRAY ROAD	OS1	Park	609094.17	4851433.61	1.134	69
23	B477	BRODA	OS1	Park	609850.95	4853505.29	1.092	69
24	B2	7601 MARTIN GROVE ROAD	PB1	Other	612522.01	4846772.15	0.857	67
25	B447	8966 HUNTINGTON ROAD	OS2	Park	607632.72	4850222.76	0.845	67
26	B482	8966 HUNTINGTON ROAD	OS2	Park	607632.72	4850222.76	0.845	67
27	B476	BRODA	OS1	Park	609881.95	4853520.05	0.831	67
28	B11	60 LEGION COURT ROAD	R1	Residential	613562.35	4848273.95	0.733	66
29	B346	23 GRAM ST	RIV	Residential	619206.63	4856405.02	0.605	65
30	B1074	8201 ISLINGTON AVE	RA2	Residential	613941.02	4849908.39	0.568	65
31	B348	26 NAYLON ST	RIV	Residential	619255.76	4856386.87	0.505	64
32	B129	5 WHITE BLVD	R5	Residential	622881.10	4851026.92	0.429	64
33	B130	7 WHITE BOULEVARD	R5	Residential	622880.52	4851035.37	0.404	63
34	B347	12 OLDFIELD ST	RIV	Residential	619264.85	4856424.71	0.402	63
35	B1058	3 WHITE BOULEVARD	R5	Residential	622883.42	4851020.15	0.391	63
36	B131	9 WHITE BOULEVARD	R5	Residential	622877.67	4851042.13	0.338	63
37	B355	19 NAYLON ST	RIV	Residential	619373.27	4856366.17	0.335	63
38	B56	159 WOODCROFT LANE	R4	Residential	612096.67	4849742.58	0.327	63
39	B103	139 CHARLTON AV	R3	Residential	623431.95	4850305.28	0.310	63
40	B1120	KEELE STREET / HIGHWAY 7	EM1	Industrial	620787.43	4850939.91	0.531	54
41	B305	PINE GROVE	EM1	Industrial	613979.43	4850433.67	0.517	54
42	B5	7694 ISLINGTON AVE	C1	Commercial	613623.87	4848329.67	0.432	54
43	B6	7676 ISLINGTON AVE	C1	Commercial	613669.02	4848320.27	0.405	53
44	B4	7642 ISLINGTON Ave	PB1	Other	613744.01	4848249.13	0.543	44
45	B448	10223 HIGHWAY 50	A	Other	606646.40	4853472.32	0.436	44
46	B14	7553 ISLINGTON AV	OS1	Park	614046.29	4848137.01	0.432	44
47	B465	62 BRODA DR	OS1	Park	609820.15	4853641.87	0.361	43
48	B458	43 BRODA DR	OS1	Park	609903.46	4853569.02	0.355	43
49	B57	155 WOODCROFT LANE	R4	Residential	612099.83	4849752.77	0.270	42
50	B125	6 WHITE BOULEVARD	R5	Residential	622833.76	4851016.08	0.251	42
51	B299	10 WAKELIN CT	R2	Residential	613823.40	4849700.26	0.242	42
52	B126	8 WHITE BOULEVARD	R5	Residential	622832.82	4851024.42	0.233	42
53	B345	20 GRAM ST	RIV	Residential	619155.95	4856392.69	0.227	42
54	B1057	4 WHITE BLVD	R5	Residential	622834.63	4851008.27	0.204	42
55	B84	72 CHARLTON AVENUE	R4	Residential	623409.72	4850423.58	0.203	42
56	B127	10 WHITE BOULEVARD	R5	Residential	622831.37	4851031.44	0.202	42
57	B123	9 DRAPER BOULEVARD	R5	Residential	622852.86	4850963.55	0.173	41
58	B124	7 DRAPER BOULEVARD	R5	Residential	622842.82	4850959.47	0.166	41
59	B29	144 WOODCROFT LANE	R4	Residential	612044.25	4849777.22	0.136	41
60	B122	11 DRAPER BOULEVARD	R5	Residential	622861.63	4850965.81	0.133	41
61	B99	75 CHARLTON AV	R4	Residential	623444.85	4850381.64	0.128	41
62	B343	597 BARRHILL RD	R3	Residential	620328.36	4855145.33	0.097	41
63	B54	153 WOODCROFT LANE	R4	Residential	612101.74	4849762.91	0.096	41
64	B1056	15 DRAPER BOULEVARD	R5	Residential	622869.03	4850968.06	0.082	41
65	B336	17 PATNA CRESCENT	R4	Residential	620416.24	4855125.78	0.077	41
66	B335	15 PATNA CRESCENT	R4	Residential	620408.75	4855138.00	0.068	41
67	B354	21 NAYLON STREEET	RIV	Residential	619343.96	4856355.28	0.068	41
68	B342	593 BARRHILL RD	R3	Residential	620330.07	4855157.92	0.053	40
69	B121	34 JAIMIE RD	R5	Residential	622899.34	4850945.30	0.043	40
70	B119	40 JAIMIE RD	R5	Residential	622884.55	4850941.42	0.042	40
71	B118	42 JAIMIE ROAD	R5	Residential	622876.45	4850939.43	0.041	40
72	B120	38 JAIMIE RD	R5	Residential	622891.44	4850943.06	0.041	40
73	B117	44 JAIMIE RD	R5	Residential	622867.60	4850935.39	0.040	40
74	B116	46 JAIMIE ROAD	R5	Residential	622859.31	4850931.23	0.036	40
75	B312	32 NATTRESS AVENUE	R3	Residential	614211.56	4850131.40	0.035	40
76	B115	48 JAIMIE RD	R5	Residential	622851.94	4850922.79	0.027	40
77	B128	12 WHITE BOULEVARD	R5	Residential	622828.64	4851038.14	0.020	40
78	B114	50 JAIMIE RD	R5	Residential	622852.57	4850909.08	0.002	40
79	B480	7800 JANE ST	C7	Commercial	618616.08	4850182.24	0.190	32
80	B1129	7725 JANE STREET	C8	Commercial	618797.39	4850020.26	0.179	31
81	B105	1450 CLARK AVENUE WEST	C4	Commercial	623013.98	4850617.19	0.138	31
82	B1128	7551 JANE ST	EM1	Industrial	619015.17	4849650.89	0.042	30
83	B7	7710 ISLINGTON AVENUE	C1	Commercial	613579.65	4848361.18	0.034	30
84	B450	9441 HUNTINGTON ROAD	A	Other	608103.80	4851573.71	0.297	22
85	B466	9751 MC GILLIVRAY RD	A	Other	608931.44	4852780.76	0.279	22
86	B459	43 BRODA DR	OS1	Park	609894.84	4853594.32	0.191	22
87	B3	7601 MARTIN GROVE ROAD	PB1	Other	612558.73	4846771.54	0.126	21
88	B464	54 BRODA DR	OS1	Park	609851.07	4853699.69	0.099	21
89	B357	10165 HIGHWAY 27	OS1	Park	610079.96	4854335.40	0.060	20
90	B455	9770 HIGHWAY 27	OS1	Park	609953.29	4853237.57	0.025	20
91	B442	8739 ISLINGTON AVENUE	OS1	Park	614007.88	4851568.73	0.020	20

Flood Vulnerable Area (FVA) for Regional Event :

Rank	Building ID	Address	Zones	Land Use	Centroid_X	Centroid_Y	Regional Max. Depth (m)	FERI
1	B308	14 NATTRESS STREET	R3	Residential	614150.35	4850131.30	4.257	97
2	B11	60 LEGION COURT ROAD	R1	Residential	613562.35	4848273.95	4.255	97
3	B1076	111 RIVERSIDE DR	R3	Residential	614126.26	4850138.80	3.719	95
4	B251	7983 ISLINGTON AVE	R3	Residential	613597.70	4849190.69	3.532	94
5	B152	53 WOODBRIDGE AVENUE	RA1	Residential	613419.76	4849026.88	3.358	94
6	B286	129 CLARENCE ST	R3	Residential	613206.28	4849379.98	3.345	94
7	B136	95 WALLACE ST	R3	Residential	613198.05	4848653.44	3.328	94
8	B309	18 NATTRESS STREET	R3	Residential	614164.67	4850131.15	3.314	94
9	B1061	81 WALLACE STREET	RM2	Residential	613193.74	4848670.32	3.311	94
10	B310	22 NATTRESS STREET	R3	Residential	614181.12	4850130.80	3.216	93
11	B287	133 CLARENCE STREET	R3	Residential	613199.43	4849395.70	3.161	93
12	B21	31 PIONEER LANE	R3	Residential	613885.75	4848244.76	3.099	93
13	B277	26 PARK DR	R3	Residential	613304.41	4849268.20	3.089	93
14	B1077	105 RIVERSIDE DRIVE	R3	Residential	614123.47	4850122.95	3.070	93
15	B159	43 CLARENCE ST	R3	Residential	613314.41	4849153.98	3.046	92
16	B165	31 PARK DR	R3	Residential	613336.09	4849227.47	3.005	92
17	B255	8050 ISLINGTON AVENUE	RM2	Residential	613564.94	4849421.60	2.989	92
18	B278	16 PARK DRIVE	R3	Residential	613274.05	4849256.35	2.988	92
19	B253	8050 ISLINGTON AVENUE	RM2	Residential	613537.86	4849395.72	2.972	92
20	B160	31 PARK DR	R3	Residential	613364.90	4849191.01	2.946	92
21	B164	25 PARK DR	R3	Residential	613322.19	4849222.59	2.928	92
22	B474	7961 ISLINGTON AVENUE	R3	Residential	613580.05	4849127.29	2.902	92
23	B250	7973 ISLINGTON AVE	R3	Residential	613591.27	4849165.26	2.871	92
24	B163	21 PARK DR	R3	Residential	613309.26	4849215.28	2.847	92
25	B142	WOODBRIDGE 27	RA2	Residential	613289.30	4848878.73	2.831	92
26	B276	30 PARK DR	R3	Residential	613318.36	4849273.09	2.796	91
27	B1074	8201 ISLINGTON AVE	RA2	Residential	613941.02	4849908.39	2.788	91
28	B203	66 CLARENCE ST	R3	Residential	613216.94	4849190.18	2.786	91
29	B311	28 NATTRESS STREET	R3	Residential	614196.25	4850131.15	2.768	91
30	B161	51 CLARENCE ST	R3	Residential	613288.34	4849171.49	2.731	91

31	B18	40 PIONEER LANE	R3	Residential	613829.34	4848284.39	2.707	91
32	B264	41 PARK DRIVE	R3	Residential	613365.36	4849247.71	2.700	91
33	B261	51 PARK DRIVE	R3	Residential	613407.36	4849236.28	2.698	91
34	B202	15 ROSEBURY LANE	R3	Residential	613194.42	4849185.54	2.694	91
35	B103	139 CHARLTON AV	R3	Residential	623431.95	4850305.28	2.684	91
36	B171	22 ROSEBURY LANE	R3	Residential	613192.93	4849130.32	2.643	91
37	B285	117 CLARENCE ST	R3	Residential	613190.59	4849348.28	2.640	91
38	B252	8013 ISLINGTON AVE	R3	Residential	613594.60	4849272.63	2.635	91
39	B201	19 ROSEBURY LANE	R3	Residential	613185.47	4849182.50	2.618	91
40	B254	8050 ISLINGTON AVENUE	RM2	Residential	613543.23	4849360.73	2.613	91
41	B172	26 ROSEBURY LANE	R3	Residential	613181.80	4849128.44	2.565	91
42	B200	23 ROSEBURY LANE	R3	Residential	613176.95	4849179.55	2.559	90
43	B141	EMERALD 7	RA2	Residential	613238.77	4848863.03	2.552	90
44	B199	27 ROSEBURY LANE	R3	Residential	613167.53	4849177.74	2.545	90
45	B166	57 CLARENCE STREET	R3	Residential	613282.20	4849185.66	2.538	90
46	B56	159 WOODCROFT LANE	R4	Residential	612096.67	4849742.58	2.538	90
47	B1099	9652 KEELE STREET	R1	Residential	619710.00	4855841.16	2.522	90
48	B170	18 ROSEBURY LANE	R3	Residential	613204.33	4849133.64	2.513	90
49	B57	155 WOODCROFT LANE	R4	Residential	612099.83	4849752.77	2.479	90
50	B488	69 CLARENCE ST	R3	Residential	613262.60	4849212.65	2.464	90
51	B280	83 CLARENCE ST	R3	Residential	613240.66	4849258.49	2.453	90
52	B179	54 ROSEBURY LANE	R3	Residential	613111.54	4849192.06	2.442	90
53	B204	70 CLARENCE STREET	R3	Residential	613217.37	4849209.51	2.433	90
54	B184	15 ROSEWOOD COURT	R3	Residential	613084.91	4849202.04	2.409	90
55	B183	11 ROSEWOOD CT	R3	Residential	613091.78	4849207.96	2.406	90
56	B182	9 ROSEWOOD CT	R3	Residential	613101.01	4849212.18	2.396	90
57	B260	49 PARK DRIVE	R3	Residential	613396.99	4849232.07	2.393	90
58	B263	43 PARK DRIVE	R3	Residential	613370.25	4849236.02	2.387	90
59	B162	61 CLARENCE ST	R3	Residential	613269.59	4849199.43	2.382	90
60	B180	50 ROSEBURY LANE	R3	Residential	613115.48	4849184.26	2.375	90
61	B169	14 ROSEBURY LANE	R3	Residential	613215.77	4849137.82	2.371	90
62	B22	35 PIONEER LANE	R3	Residential	613893.32	4848265.23	2.338	90

63	B181	60 ROSEBURY LANE	R3	Residential	613110.41	4849216.99	2.335	90
64	B205	47 ROSEBURY LANE	R3	Residential	613166.54	4849202.89	2.324	90
65	B185	19 ROSEWOOD CT	R3	Residential	613076.76	4849194.53	2.322	90
66	B208	78 CLARENCE ST	R3	Residential	613205.50	4849221.14	2.320	90
67	B29	144 WOODCROFT LANE	R4	Residential	612044.25	4849777.22	2.315	89
68	B176	48 ROSEBURY LANE	R3	Residential	613118.43	4849174.38	2.311	89
69	B54	153 WOODCROFT LANE	R4	Residential	612101.74	4849762.91	2.304	89
70	B258	45 PARK DRIVE	R3	Residential	613374.37	4849222.45	2.296	89
71	B279	77 CLARENCE ST	R3	Residential	613242.23	4849243.30	2.292	89
72	B288	141 CLARENCE ST	R3	Residential	613166.98	4849405.82	2.277	89
73	B206	51 ROSEBURY LANE	R3	Residential	613161.89	4849211.30	2.259	89
74	B139	57 WALLACE ST	R3	Residential	613170.83	4848744.37	2.257	89
75	B173	30 ROSEBURY LANE	R3	Residential	613167.63	4849124.00	2.252	89
76	B289	153 CLARENCE ST	R3	Residential	613162.00	4849443.94	2.251	89
77	B281	89 CLARENCE ST	R3	Residential	613232.42	4849273.87	2.246	89
78	B177	44 ROSEBURY LANE	R3	Residential	613122.25	4849164.86	2.235	89
79	B186	23 ROSEWOOD CT	R3	Residential	613067.00	4849190.76	2.227	89
80	B55	151 WOODCROFT LANE	R4	Residential	612099.54	4849773.38	2.194	89
81	B17	48 PIONEER LANE	R3	Residential	613827.32	4848300.30	2.193	89
82	B282	93 CLARENCE STREET	R3	Residential	613223.45	4849286.70	2.187	89
83	B214	55 ROSEBURY LANE	R3	Residential	613157.69	4849221.15	2.178	89
84	B222	85 ROSEBURY LANE	R3	Residential	613125.90	4849296.80	2.175	89
85	B221	81 ROSEBURY LANE	R3	Residential	613130.37	4849286.56	2.174	89
86	B178	40 ROSEBURY LANE	R3	Residential	613126.20	4849155.08	2.159	89
87	B283	97 CLARENCE ST	R3	Residential	613215.49	4849302.80	2.153	89
88	B275	38 PARK DRIVE	R3	Residential	613351.35	4849270.45	2.141	89
89	B15	7 PIONEER LANE	R3	Residential	613792.12	4848319.57	2.136	89
90	B207	80 CLARENCE STREET	R3	Residential	613200.01	4849233.31	2.134	89
91	B294	181 CLARENCE ST	R3	Residential	613127.81	4849529.37	2.121	89
92	B215	59 ROSEBURY LANE	R3	Residential	613153.63	4849230.04	2.117	89
93	B220	79 ROSEBURY LANE	R3	Residential	613133.90	4849277.32	2.116	89
94	B271	48 PARK DRIVE	R3	Residential	613344.97	4849328.40	2.113	89

95	B231	132 CLARENCE STREET	R3	Residential	613129.52	4849385.36	2.093	89
96	B189	12 ROSEWOOD CT	R3	Residential	613072.48	4849254.39	2.091	89
97	B190	8 ROSEWOOD CT	R3	Residential	613081.72	4849258.66	2.091	89
98	B188	16 ROSEWOOD COURT	R3	Residential	613062.37	4849255.61	2.090	89
99	B191	4 ROSEWOOD COURT	R3	Residential	613091.52	4849262.81	2.090	89
100	B295	187 CLARENCE ST	R3	Residential	613119.03	4849546.06	2.090	89
101	B284	109 CLARENCE ST	R3	Residential	613207.96	4849321.97	2.088	89
102	B274	40 PARK DRIVE	R3	Residential	613341.68	4849279.39	2.085	89
103	B230	128 CLARENCE STREET	R3	Residential	613135.59	4849363.61	2.084	89
104	B216	63 ROSEBURY LANE	R3	Residential	613150.59	4849239.73	2.083	89
105	B223	91 ROSEBURY LANE	R3	Residential	613121.98	4849307.26	2.083	89
106	B473	116 CLARENCE ST	R3	Residential	613160.28	4849326.08	2.082	89
107	B224	95 ROSEBURY LANE	R3	Residential	613117.71	4849317.06	2.080	89
108	B229	124 CLARENCE STREET	R3	Residential	613153.13	4849346.90	2.079	89
109	B225	97 ROSEBURY LANE	R3	Residential	613113.51	4849326.78	2.078	89
110	B226	101 ROSEBURY LANE	R3	Residential	613110.08	4849336.54	2.076	89
111	B99	75 CHARLTON AV	R4	Residential	623444.85	4850381.64	2.074	89
112	B219	75 ROSEBURY LANE	R3	Residential	613137.81	4849267.90	2.065	88
113	B292	169 CLARENCE ST	R3	Residential	613141.44	4849494.01	2.064	88
114	B174	36 ROSEBURY LANE	R3	Residential	613130.23	4849145.00	2.057	88
115	B291	163 CLARENCE STREET	R3	Residential	613147.18	4849475.63	2.056	88
116	B209	84 CLARENCE STREET	R3	Residential	613202.58	4849249.15	2.055	88
117	B256	8050 ISLINGTON AVENUE	RM2	Residential	613603.00	4849416.00	2.052	88
118	B138	73 WALLACE STREET	R3	Residential	613183.67	4848701.18	2.051	88
119	B227	103 ROSEBURY LANE	R3	Residential	613104.33	4849346.14	2.051	88
120	B290	159 CLARENCE ST	R3	Residential	613146.64	4849460.27	2.050	88
121	B293	175 CLARENCE ST	R3	Residential	613125.21	4849512.84	2.049	88
122	B53	149 WOODCROFT LANE	R4	Residential	612099.12	4849783.66	2.043	88
123	B193	88 ROSEBURY LANE	R3	Residential	613075.41	4849280.94	2.033	88
124	B1155	5 CORMORANT CRESCENT	RV4(WS)	Residential	616456.83	4854952.96	2.031	88
125	B415	9 CORMORANT CRESCENT	RV4(WS)	Residential	616445.81	4854949.47	2.031	88
126	B416	15 CORMORANT CRESCENT	RV4(WS)	Residential	616432.85	4854945.82	2.031	88

127	B417	19 CORMORANT CRESCENT	RV4(WS)	Residential	616420.99	4854942.57	2.031	88
128	B437	86 ROYVIEW CRESCENT	RV3(WS)	Residential	616410.36	4854843.14	2.029	88
129	B438	90 ROYVIEW CRESCENT	RV3(WS)	Residential	616426.66	4854835.54	2.028	88
130	B217	67 ROSEBURY LANE	R3	Residential	613145.97	4849249.71	2.027	88
131	B167	50 CLARENCE AVE	R3	Residential	613243.82	4849157.66	2.019	88
132	B218	71 ROSEBURY LANE	R3	Residential	613142.07	4849258.86	2.018	88
133	B187	20 ROSEWOOD CT	R3	Residential	613051.38	4849253.81	2.014	88
134	B232	105 ROSEBURY LANE	R3	Residential	613097.31	4849357.06	2.011	88
135	B228	110 CLARENCE STREET	R3	Residential	613164.48	4849309.80	2.002	88
136	B192	92 ROSEBURY LANE	R3	Residential	613070.74	4849289.27	2.001	88
137	B194	100 ROSEBURY LANE	R3	Residential	613071.09	4849307.14	1.992	88
138	B233	107 ROSEBURY LANE	R3	Residential	613082.05	4849359.46	1.973	88
139	B210	92 CLARENCE STREET	R3	Residential	613190.24	4849256.07	1.967	88
140	B175	32 ROSEBURY LANE	R3	Residential	613141.24	4849128.64	1.963	88
141	B234	109 ROSEBURY LANE	R3	Residential	613071.22	4849361.60	1.939	88
142	B249	240 CLARENCE ST	R2	Residential	613055.80	4849702.02	1.936	88
143	B168	44 CLARENCE STREET	R3	Residential	613249.88	4849143.71	1.935	88
144	B243	11 MEETING HOUSE ROAD	R3	Residential	613101.07	4849402.56	1.931	88
145	B213	102 CLARENCE STREET	R3	Residential	613173.41	4849299.05	1.913	88
146	B23	39 PIONEER LANE	R3	Residential	613888.25	4848286.26	1.906	88
147	B102	133 CHARLTON AV	R3	Residential	623429.84	4850316.77	1.904	88
148	B16	56 PIONEER LANE	R3	Residential	613821.32	4848314.12	1.904	88
149	B24	45 PIONEER LANE	R3	Residential	613879.38	4848301.31	1.896	88
150	B242	17 MEETING HOUSE ROAD	R3	Residential	613081.86	4849402.10	1.883	88
151	B211	CLARENCE	R3	Residential	613181.66	4849269.27	1.872	88
152	B212	98 CLARENCE STREET	R3	Residential	613180.34	4849282.64	1.872	88
153	B30	140 WOODCROFT LANE	R4	Residential	612043.17	4849790.47	1.872	88
154	B299	10 WAKELIN CT	R2	Residential	613823.40	4849700.26	1.868	88
155	B235	111 ROSEBURY LANE	R3	Residential	613059.51	4849364.11	1.859	88
156	B312	32 NATTRESS AVENUE	R3	Residential	614211.56	4850131.40	1.857	88
157	B52	147 WOODCROFT LANE	R4	Residential	612100.20	4849794.51	1.827	87
158	B419	55 CORMORANT CRESCENT	RV4(WS)	Residential	616305.19	4854912.73	1.810	87

159	B259	47 PARK DRIVE	R3	Residential	613387.65	4849227.92	1.805	87
160	B100	125 CHARLTON AV	R3	Residential	623428.73	4850344.02	1.797	87
161	B472	23 MEETING HOUSE ROAD	R3	Residential	613067.49	4849407.66	1.796	87
162	B140	39 WALLACE STREET	RA3	Residential	613179.65	4848838.59	1.781	87
163	B420	59 CORMORANT CRESCENT	RV4(WS)	Residential	616289.36	4854920.32	1.778	87
164	B137	81 WALLACE STREET	RM2	Residential	613187.88	4848683.75	1.777	87
165	B236	113 ROSEBURY LANE	R3	Residential	613050.10	4849366.12	1.776	87
166	B262	53 PARK DRIVE	R3	Residential	613415.84	4849243.71	1.748	87
167	B84	72 CHARLTON AVENUE	R4	Residential	623409.72	4850423.58	1.737	87
168	B421	67 CORMORANT CRESCENT	RV4(WS)	Residential	616274.95	4854944.75	1.719	87
169	B422	71 CORMORANT CRESCENT	RV4(WS)	Residential	616269.87	4854955.18	1.712	87
170	B195	110 ROSEBURY LANE	R3	Residential	613054.50	4849309.56	1.702	87
171	B323	1 PAULINE CT	RM2	Residential	622882.13	4850125.01	1.698	87
172	B237	117 ROSEBURY LANE	R3	Residential	613041.97	4849367.18	1.687	87
173	B304	15 HARTMAN AVE	R2	Residential	613970.66	4850091.26	1.673	87
174	B51	143 WOODCROFT LANE	R4	Residential	612097.31	4849804.29	1.651	87
175	B423	79 CORMORANT CRESCENT	RV4(WS)	Residential	616258.04	4854978.82	1.647	87
176	B374	7230 JANE STREET	R	Residential	618909.39	4848477.89	1.646	87
177	B245	29 MEETING HOUSE ROAD	R3	Residential	613049.53	4849411.28	1.642	87
178	B31	136 WOODCROFT LANE	R4	Residential	612036.56	4849797.23	1.627	87
179	B418	39 CORMORANT CRESCENT	RV4(WS)	Residential	616359.45	4854925.29	1.622	87
180	B238	121 ROSEBURY LANE	R3	Residential	613030.71	4849370.05	1.584	86
181	B101	129 CHARLTON AV	R3	Residential	623428.88	4850329.59	1.550	86
182	B98	69 CHARLTON AVENUE	R4	Residential	623451.06	4850388.67	1.550	86
183	B196	114 ROSEBURY LANE	R3	Residential	613045.00	4849311.29	1.534	86
184	B26	6 PIONEER LANE	R3	Residential	613743.90	4848353.31	1.528	86
185	B33	9 BLOSSOM COURT	R4	Residential	611989.54	4849798.23	1.522	86
186	B244	151 ROSEBURY LANE	R3	Residential	613035.63	4849414.26	1.521	86
187	B5	7694 ISLINGTON AVE	C1	Commercial	613623.87	4848329.67	3.937	86
188	B6	7676 ISLINGTON AVE	C1	Commercial	613669.02	4848320.27	3.934	86
189	B424	91 CORMORANT CRESCENT	RV4(WS)	Residential	616241.17	4855013.32	1.492	86
190	B19	15 PIONEER LANE	R3	Residential	613803.54	4848332.71	1.482	86

191	B266	58 PARK DRIVE	R3	Residential	613379.91	4849280.32	1.482	86
192	B156	15 CLARENCE STREET	R3	Residential	613366.31	4849100.48	1.440	86
193	B425	95 CORMORANT CRESCENT	RV4(WS)	Residential	616236.13	4855024.47	1.404	86
194	B38	11 BLOSSOM CRT	R4	Residential	611976.82	4849797.85	1.394	86
195	B265	55 PARK DRIVE	R3	Residential	613416.79	4849256.64	1.369	86
196	B32	132 WOODCROFT LANE	R4	Residential	612029.76	4849803.39	1.368	86
197	B197	118 ROSEBURY LANE	R3	Residential	613035.86	4849313.56	1.349	86
198	B97	63 CHARLTON AV	R4	Residential	623456.99	4850394.51	1.335	85
199	B272	46 PARK DRIVE	R3	Residential	613338.60	4849315.46	1.328	85
200	B151	36 CLARENCE STREET	R2	Residential	613263.25	4849114.75	1.313	85
201	B300	20 WAKELIN CT	R2	Residential	613802.58	4849705.46	1.306	85
202	B44	20 WOODCROFT LANE	R4	Residential	611774.56	4849947.10	1.263	85
203	B324	3 PAULINE COURT	RM2	Residential	622892.53	4850130.75	1.261	85
204	B426	99 CORMORANT CRESCENT	RV4(WS)	Residential	616229.71	4855036.46	1.254	85
205	B43	18 WOODCROFT LANE	R4	Residential	611765.34	4849954.00	1.250	85
206	B322	25 GLEN SHIELDS AVE	R3	Residential	622836.51	4849920.87	1.236	85
207	B27	10 PIONEER LANE	R3	Residential	613756.76	4848361.72	1.231	85
208	B241	146 ROSEBURY LANE	R3	Residential	612988.43	4849394.07	1.228	85
209	B39	15 BLOSSOM CRT	R4	Residential	611964.26	4849802.61	1.226	85
210	B49	12 WOODCROFT LANE	R4	Residential	611751.05	4849975.60	1.220	85
211	B68	31 MILLBANK CRT	R4	Residential	623380.88	4850469.80	1.220	85
212	B1063	49 WALLACE STREET	R3	Residential	613169.45	4848770.68	1.216	85
213	B143	131 WOODBRIDGE AVENUE	RA2	Residential	613278.51	4848931.56	1.216	85
214	B240	140 ROSEBURY LANE	R3	Residential	612986.43	4849384.24	1.213	85
215	B198	122 ROSEBURY LANE	R3	Residential	613025.96	4849315.16	1.196	85
216	B42	16 WOODCROFT LANE	R4	Residential	611756.91	4849961.82	1.196	85
217	B96	57 CHARLTON AV	R4	Residential	623463.86	4850400.99	1.196	85
218	B95	51 CHARLTON AVENUE	R4	Residential	623470.37	4850407.20	1.187	85
219	B246	41 MEETING HOUSE ROAD	R3	Residential	612997.34	4849420.09	1.175	85
220	B28	KIPLING	M2	Industrial	612429.43	4849384.93	3.603	85
221	B25	49 PIONEER LANE	R3	Residential	613874.92	4848315.86	1.157	85
222	B247	47 MEETING HOUSE ROAD	R3	Residential	612980.59	4849425.03	1.149	85

223	B360	6 OAKMOUNT CR	R3	Residential	622360.04	4850648.54	1.147	85
224	B20	21 PIONEER LANE	R3	Residential	613816.43	4848341.16	1.139	85
225	B50	141 WOODCROFT LANE	R4	Residential	612093.18	4849815.62	1.132	85
226	B239	134 ROSEBURY LANE	R3	Residential	612985.14	4849371.69	1.127	85
227	B316	160 RIVERSIDE DR	R3	Residential	614037.32	4850293.01	1.098	85
228	B93	39 CHARLTON AVENUE	R4	Residential	623483.91	4850418.75	1.097	84
229	B34	7 BLOSSOM CRT	R4	Residential	611999.43	4849804.47	1.088	84
230	B427	103 CORMORANT CRESCENT	RV4(WS)	Residential	616224.72	4855048.61	1.068	84
231	B45	22 WOODCROFT LANE	R4	Residential	611786.21	4849945.54	1.068	84
232	B94	45 CHARLTON AV	R4	Residential	623477.31	4850412.47	1.066	84
233	B1062	65 WALLACE STREET	R3	Residential	613177.46	4848720.41	1.061	84
234	B67	33 MILLBANK COURT	R4	Residential	623373.06	4850477.98	1.034	84
235	B66	35 MILLBANK CRT	R4	Residential	623366.08	4850485.85	1.033	84
236	B432	66 ROYVIEW CRESCENT	RV3	Residential	616335.41	4854834.90	1.032	84
237	B433	70 ROYVIEW CRESCENT	RV3	Residential	616351.51	4854835.97	1.031	84
238	B434	74 ROYVIEW CRESCENT	RV3	Residential	616365.52	4854836.03	1.031	84
239	B435	78 ROYVIEW CRESCENT	RV3	Residential	616379.08	4854838.08	1.030	84
240	B436	82 ROYVIEW CRESCENT	RV3(WS)	Residential	616393.86	4854842.32	1.030	84
241	B439	94 ROYVIEW CRESCENT	RV3	Residential	616436.06	4854816.96	1.027	84
242	B440	98 ROYVIEW CRESCENT	RV3	Residential	616439.62	4854802.84	1.027	84
243	B85	159 JOSEPH AARON BLVD	R4	Residential	623531.11	4850474.46	1.025	84
244	B92	33 CHARLTON AV	R4	Residential	623491.74	4850425.12	1.025	84
245	B86	155 JOSEPH AARON BLVD	R4	Residential	623539.59	4850467.78	1.024	84
246	B83	68 CHARLTON AVE	R4	Residential	623415.36	4850428.77	1.015	84
247	B411	58 CORMORANT CRESCENT	RV4(WS)	Residential	616316.56	4854951.48	1.014	84
248	B479	121 JOSEPH AARON BOULEVARD	R4	Residential	623541.94	4850386.10	1.013	84
249	B65	37 MILLBANK CRT	R4	Residential	623360.43	4850492.07	1.006	84
250	B349	9654 KEELE ST	R1	Residential	619697.96	4855860.99	1.003	84
251	B64	39 MILLBANK COURT	R4	Residential	623354.31	4850499.09	0.990	84
252	B91	25 CHARLTON AVENUE	R4	Residential	623499.50	4850431.37	0.982	84
253	B359	4 OAKMOUNT CR	R3	Residential	622372.76	4850645.19	0.980	84
254	B82	62 CHARLTON AVENUE	R4	Residential	623421.34	4850434.81	0.980	84

255	B46	2 WOODCROFT LANE	R4	Residential	611740.03	4850006.67	0.979	84
256	B1039	49 MILLBANK COURT	R4	Residential	623337.58	4850518.46	0.960	84
257	B412	62 CORMORANT CRESCENT	RV4(WS)	Residential	616311.74	4854961.75	0.946	84
258	B89	11 CHARLTON AV	R4	Residential	623515.78	4850446.69	0.934	84
259	B90	19 CHARLTON AV	R4	Residential	623507.83	4850438.06	0.933	84
260	B428	107 CORMORANT CRESCENT	RV4(WS)	Residential	616219.36	4855060.30	0.930	84
261	B7	7710 ISLINGTON AVENUE	C1	Commercial	613579.65	4848361.18	3.368	84
262	B63	41 MILLBANK COURT	R4	Residential	623348.65	4850505.71	0.928	84
263	B62	45 MILLBANK CRT	R4	Residential	623342.35	4850512.72	0.926	84
264	B40	14 BLOSSOM CRT	R4	Residential	611953.76	4849810.70	0.925	84
265	B1026	24 WOODCROFT LANE	R4	Residential	611798.52	4849947.02	0.904	84
266	B268	54 PARK DRIVE	R3	Residential	613375.01	4849301.60	0.898	84
267	B81	56 CHARLTON AVE	R4	Residential	623428.12	4850440.80	0.893	84
268	B88	7 CHARLTON AV	R4	Residential	623523.71	4850454.21	0.891	84
269	B1080	27 GLEN SHIELDS AVE	R3	Residential	622824.94	4849921.93	0.881	84
270	B267	56 PARK DRIVE	R3	Residential	613375.58	4849290.08	0.875	84
271	B413	66 CORMORANT CRESCENT	RV4(WS)	Residential	616306.73	4854971.24	0.874	84
272	B80	50 CHARLTON AVENUE	R4	Residential	623434.24	4850446.56	0.871	84
273	B69	29 MILLBANK CRT	R4	Residential	623397.38	4850463.63	0.862	84
274	B76	26 CHARLTON AVENUE	R4	Residential	623462.57	4850469.89	0.848	83
275	B361	8 OAKMOUNT CR	R3	Residential	622345.05	4850651.94	0.845	83
276	B79	44 CHARLTON AVENUE	R4	Residential	623441.58	4850452.45	0.837	83
277	B410	44 CORMORANT CRESCENT	RV4(WS)	Residential	616335.90	4854960.50	0.836	83
278	B35	5 BLOSSOM CRT	R4	Residential	612008.46	4849813.26	0.827	83
279	B1098	8 MERINO ROAD	RIV	Residential	619554.50	4856233.88	0.826	83
280	B325	5 PAULINE CT	RM2	Residential	622900.68	4850139.24	0.826	83
281	B481	111 CORMORANT CRESCENT	RV4(WS)	Residential	616214.66	4855072.00	0.823	83
282	B48	10 WOODCROFT LANE	R4	Residential	611749.10	4849986.42	0.815	83
283	B73	10 CHARLTON AVENUE	R4	Residential	623483.66	4850491.80	0.810	83
284	B314	132 RIVERSIDE DRIVE	R3	Residential	614065.58	4850200.65	0.807	83
285	B78	38 CHARLTON AVENUE	R4	Residential	623448.95	4850458.20	0.801	83
286	B154	83 WOODBRIDGE AVE	C1	Commercial	613354.59	4848995.67	2.900	82

287	B145	93 WOODBRIDGE AVE	C1	Commercial	613350.65	4848964.23	2.888	82
288	B491	10 PLANCHET ROAD	EM1	Industrial	620593.61	4853012.12	2.821	82
289	B384	10 PLANCHET ROAD	EM1	Industrial	620615.81	4852969.60	2.820	82
290	B305	PINE GROVE	EM1	Industrial	613979.43	4850433.67	2.785	81
291	B8	7720 ISLINGTON AVE	C1	Commercial	613560.09	4848377.72	2.702	81
292	B9	7730 ISLINGTON AVENUE	C1	Commercial	613493.76	4848397.71	2.584	81
293	B12	7618 SLINGTON Ave	PB1	Other	613817.30	4848221.66	4.878	80
294	B298	8086 ISLINGTON AVE	C1	Commercial	613703.14	4849474.45	2.362	80
295	B364	1949 HIGHWAY 7	C1	Commercial	621512.79	4851019.37	2.162	79
296	B363	1955 HIGHWAY 7	C1	Commercial	621495.10	4851019.47	2.161	79
297	B385	50 PLANCHET ROAD	EM1	Industrial	620588.18	4853067.74	2.141	79
298	B386	70 PLANCHET ROAD	EM1	Industrial	620567.20	4853124.21	2.018	78
299	B153	75 WOODBRIDGE AVE	C1	Commercial	613361.65	4849018.01	2.003	78
300	B297	8074 ISLINGTON AVE	C1	Commercial	613678.83	4849455.47	1.988	78
301	B365	1929 HIGHWAY 7	EM1	Industrial	621585.03	4850996.06	1.987	78
302	B391	120 PLANCHET ROAD	EM1	Industrial	620547.75	4853271.60	1.856	78
303	B372	7581 JANE STREET	EM1	Industrial	618850.30	4849634.36	1.838	78
304	B389	96 PLANCHET ROAD	EM1	Industrial	620553.62	4853197.51	1.829	77
305	B387	25 PLANCHET ROAD	EM1	Industrial	620739.42	4853036.21	1.821	77
306	B368	8600 KEELE STREET	EM2	Industrial	620154.36	4853109.84	1.818	77
307	B14	7553 ISLINGTON AV	OS1	Park	614046.29	4848137.01	4.241	77
308	B1105	1955 HIGHWAY 7	C1	Commercial	621490.04	4851010.24	1.725	77
309	B4	7642 ISLINGTON Ave	PB1	Other	613744.01	4848249.13	4.162	77
310	B373	7683 JANE ST	EM1	Industrial	618807.56	4849912.07	1.599	77
311	B362	1965 HIGHWAY 7	C1	Commercial	621475.21	4851007.66	1.482	76
312	B390	43 BASALTIC ROAD	EM1	Industrial	620817.88	4853068.91	1.424	76
313	B10	7720 ISLINGTON AVE	C1	Commercial	613557.29	4848396.38	1.411	76
314	B366	1929 HIGHWAY 7	EM1	Industrial	621590.00	4850969.46	1.396	76
315	B257	8077 ISLINGTON AVENUE	C1	Commercial	613743.16	4849378.44	1.336	75
316	B369	1853 HIGHWAY 7	EM1	Industrial	621769.23	4851069.44	1.293	75
317	B489	8641 KEELE ST	EM1	Industrial	620349.24	4853207.72	1.256	75
318	B371	7601 JANE ST	EM1	Industrial	618871.53	4849745.74	1.224	75

319	B144	97 WOODBRIDGE AVE	C1	Commercial	613320.34	4848964.04	1.105	75
320	B478	1889 CENTRE STREET	EM1	Industrial	621695.91	4851007.47	1.049	74
321	B367	8575 KEELE STREET	C7	Commercial	620339.70	4852970.56	1.023	74
322	B105	1450 CLARK AVENUE WEST	C4	Commercial	623013.98	4850617.19	0.992	74
323	B1120	KEELE STREET / HIGHWAY 7	EM1	Industrial	620787.43	4850939.91	0.991	74
324	B13	7519 ISLINGTON AV	A	Other	614093.76	4848094.85	3.333	74
325	B150	30 CLARENCE STREET	C4	Commercial	613276.10	4849091.21	0.871	74
326	B388	18 BASALTIC RD	EM1	Industrial	620698.26	4853157.83	0.825	73
327	B457	BRODA	OS1	Park	609821.88	4853512.83	3.255	73
328	B134	BURWICK	OS2	Park	613429.73	4848539.05	3.249	73
329	B155	WOODBRIDGE	OS2	Park	613440.30	4849076.28	3.163	73
330	B477	BRODA	OS1	Park	609850.95	4853505.29	3.025	72
331	B476	BRODA	OS1	Park	609881.95	4853520.05	2.743	71
332	B1174	4630 LANGSTAFF RD	OS1	Park	614078.61	4851197.89	2.692	71
333	B318	180 PINE GROVE RD	OS1	Park	614125.43	4850506.82	2.602	71
334	B319	142 PINE GROVE ROAD	OS1	Park	614106.23	4850470.84	2.554	70
335	B296	DAVIDSON	OS1	Park	613126.30	4849582.55	2.411	70
336	B135	95 WALLACE ST	OS1	Park	613203.82	4848624.54	2.309	69
337	B307	155 PINE GROVE RD	OS1	Park	614073.76	4850432.55	2.307	69
338	B487	2920 RUTHERFORD RD	OS1	Park	618237.37	4854333.93	2.280	69
339	B485	2839 RUTHERFORD RD	OS1	Park	618411.65	4854165.70	2.274	69
340	B441	8739 ISLINGTON AVENUE	OS1	Park	613984.13	4851329.49	2.232	69
341	B458	43 BRODA DR	OS1	Park	609903.46	4853569.02	2.216	69
342	B465	62 BRODA DR	OS1	Park	609820.15	4853641.87	2.166	69
343	B306	161 PINE GROVE ROAD	OS1	Park	614050.38	4850437.83	2.147	69
344	B455	9770 HIGHWAY 27	OS1	Park	609953.29	4853237.57	2.094	69
345	B459	43 BRODA DR	OS1	Park	609894.84	4853594.32	2.027	68
346	B464	54 BRODA DR	OS1	Park	609851.07	4853699.69	2.024	68
347	B486	2920 RUTHERFORD RD	OS1	Park	618231.67	4854341.21	1.983	68
348	B356	10240 HIGHWAY 27	A	Other	609919.47	4854506.24	1.929	68
349	B456	9770 HIGHWAY 27	OS1	Park	609991.61	4853232.49	1.897	68
350	B248	SANREMO	OS1	Park	613082.69	4849552.47	1.801	67

351	B449	9290 MCGILLVRAY ROAD	OS1	Park	609094.17	4851433.61	1.704	67
352	B357	10165 HIGHWAY 27	OS1	Park	610079.96	4854335.40	1.700	67
353	B447	8966 HUNTINGTON ROAD	OS2	Park	607632.72	4850222.76	1.667	67
354	B482	8966 HUNTINGTON ROAD	OS2	Park	607632.72	4850222.76	1.667	67
355	B301	IMPALA	OS1	Park	612970.20	4849841.32	1.647	67
356	B462	42 BRODA DRIVE	OS1	Park	609892.69	4853643.56	1.634	67
357	B467	9751 MC GILLIVRAY RD	A	Other	608961.79	4852599.22	1.546	66
358	B320	170 PINE GROVE RD	OS1	Park	614034.30	4850490.09	1.535	66
359	B460	35 BRODA DR	OS1	Park	609918.98	4853592.04	1.518	66
360	B463	54 BRODA DR	OS1	Park	609847.55	4853646.78	1.510	66
361	B453	9450 HIGHWAY 27	OS1	Park	610100.68	4852311.39	1.479	66
362	B442	8739 ISLINGTON AVENUE	OS1	Park	614007.88	4851568.73	1.474	66
363	B452	9450 HIGHWAY 27	OS1	Park	610086.70	4852281.58	1.372	66
364	B469	5821 HUMBER BRIDGE TRAIL	OS1	Park	610210.95	4853876.49	1.348	66
365	B451	9400 HIGHWAY 27	OS1	Park	610135.05	4852228.42	1.291	65
366	B446	8739 ISLINGTON AVENUE	OS1	Park	613947.94	4851904.50	1.266	65
367	B461	36 BRODA DR	OS1	Park	609916.45	4853644.43	1.244	65
368	B315	136 RIVERSIDE DR	OS1	Park	614043.05	4850228.83	1.182	65
369	B445	8739 ISLINGTON AVENUE	OS1	Park	613884.87	4851954.26	1.151	65
370	B358	245 NASHVILLE ROAD	OS1	Park	609635.18	4855136.63	1.149	65
371	B302	IMPALA	OS1	Park	612983.62	4849877.66	1.139	65
372	B448	10223 HIGHWAY 50	A	Other	606646.40	4853472.32	1.118	65
373	B2	7601 MARTIN GROVE ROAD	PB1	Other	612522.01	4846772.15	1.104	65
374	B303	IMPALA	OS1	Park	613014.00	4849836.75	1.084	64
375	B443	8739 ISLINGTON AVENUE	OS1	Park	614006.87	4851844.26	1.074	64
376	B444	8739 ISLINGTON AVENUE	OS1	Park	613931.98	4851941.70	1.074	64
377	B321	DOLORES	OS1	Park	610531.13	4851868.53	0.970	64
378	B75	20 CHARLTON AVENUE	R4	Residential	623468.95	4850476.42	0.793	63
379	B346	23 GRAM ST	RIV	Residential	619206.63	4856405.02	0.790	63
380	B74	14 CHARLTON AVENUE	R4	Residential	623476.23	4850483.28	0.783	63
381	B72	6 CHARLTON AVE	R4	Residential	623491.05	4850500.20	0.779	63
382	B1056	15 DRAPER BOULEVARD	R5	Residential	622869.03	4850968.06	0.777	63

383	B122	11 DRAPER BOULEVARD	R5	Residential	622861.63	4850965.81	0.777	63
384	B123	9 DRAPER BOULEVARD	R5	Residential	622852.86	4850963.55	0.777	63
385	B124	7 DRAPER BOULEVARD	R5	Residential	622842.82	4850959.47	0.777	63
386	B77	32 CHARLTON AVENUE	R4	Residential	623455.30	4850464.47	0.774	63
387	B158	31 CLARENCE ST	R3	Residential	613321.50	4849124.46	0.773	63
388	B119	40 JAIMIE RD	R5	Residential	622884.55	4850941.42	0.764	63
389	B121	34 JAIMIE RD	R5	Residential	622899.34	4850945.30	0.764	63
390	B118	42 JAIMIE ROAD	R5	Residential	622876.45	4850939.43	0.763	63
391	B117	44 JAIMIE RD	R5	Residential	622867.60	4850935.39	0.762	63
392	B120	38 JAIMIE RD	R5	Residential	622891.44	4850943.06	0.762	63
393	B87	151 JOSEPH AARON BLVD	R4	Residential	623548.22	4850460.09	0.761	63
394	B116	46 JAIMIE ROAD	R5	Residential	622859.31	4850931.23	0.759	63
395	B414	70 CORMORANT CRESCENT	RV4(WS)	Residential	616302.51	4854981.48	0.758	63
396	B1185	139 WOODCROFT LANE	R4	Residential	612085.95	4849823.10	0.757	63
397	B115	48 JAIMIE RD	R5	Residential	622851.94	4850922.79	0.751	63
398	B129	5 WHITE BLVD	R5	Residential	622881.10	4851026.92	0.751	63
399	B114	50 JAIMIE RD	R5	Residential	622852.57	4850909.08	0.731	63
400	B130	7 WHITE BOULEVARD	R5	Residential	622880.52	4851035.37	0.730	63
401	B59	60 HAVENBROOK CT	R4	Residential	623179.70	4850621.86	0.727	63
402	B157	23 CLARENCE STREET	R3	Residential	613336.60	4849111.07	0.723	63
403	B113	52 JAIMIE RD	R5	Residential	622853.23	4850901.11	0.720	63
404	B269	52 PARK DRIVE	R3	Residential	613368.85	4849312.36	0.719	63
405	B471	14 PIONEER LANE	R3	Residential	613768.43	4848371.48	0.715	63
406	B1058	3 WHITE BOULEVARD	R5	Residential	622883.42	4851020.15	0.713	63
407	B112	54 JAIMIE RD	R5	Residential	622855.93	4850892.78	0.711	63
408	B326	7 PAULINE COURT	RM2	Residential	622904.36	4850151.97	0.704	63
409	B36	3 BLOSSOM CRT	R4	Residential	612014.21	4849820.32	0.703	63
410	B111	56 JAIMIE ROAD	R5	Residential	622857.25	4850885.92	0.702	63
411	B273	42 PARK DRIVE	R3	Residential	613334.31	4849288.22	0.696	63
412	B110	58 JAIMIE ROAD	R5	Residential	622858.58	4850877.84	0.693	63
413	B71	2 CHARLTON AVENUE	R4	Residential	623496.94	4850509.72	0.687	63
414	B47	6 WOODCROFT LANE	R4	Residential	611745.58	4849997.07	0.681	63

415	B355	19 NAYLON ST	RIV	Residential	619373.27	4856366.17	0.670	63
416	B429	115 CORMORANT CRESCENT	RV4(WS)	Residential	616209.73	4855084.32	0.667	63
417	B131	9 WHITE BOULEVARD	R5	Residential	622877.67	4851042.13	0.658	63
418	B327	11 PAULINE COURT	RM2	Residential	622900.21	4850171.73	0.654	63
419	B70	27 MILLBANK CT	R4	Residential	623409.54	4850467.37	0.651	63
420	B348	26 NAYLON ST	RIV	Residential	619255.76	4856386.87	0.639	63
421	B409	42 CORMORANT CRESCENT	RV4(WS)	Residential	616349.07	4854964.47	0.638	63
422	B350	9656 KEELE ST	R1	Residential	619691.90	4855881.64	0.626	63
423	B1092	11 CROMARTY PL	R2	Residential	619650.12	4855839.32	0.588	62
424	B328	15 PAULINE CT	RM2	Residential	622894.65	4850179.93	0.588	62
425	B125	6 WHITE BOULEVARD	R5	Residential	622833.76	4851016.08	0.570	62
426	B58	58 HAVENBROOK CT	R4	Residential	623173.11	4850631.29	0.562	62
427	B430	119 CORMORANT CRESCENT	RV4(WS)	Residential	616204.74	4855095.57	0.561	62
428	B126	8 WHITE BOULEVARD	R5	Residential	622832.82	4851024.42	0.557	62
429	B1154	1 CORMORANT CRESCENT	RV4(WS)	Residential	616470.43	4854956.51	0.547	62
430	B132	68 RICHBELL STREET	R4	Residential	622951.80	4851443.90	0.537	62
431	B408	34 CORMORANT CRESCENT	RV4(WS)	Residential	616361.34	4854968.05	0.536	62
432	B1057	4 WHITE BLVD	R5	Residential	622834.63	4851008.27	0.527	62
433	B127	10 WHITE BOULEVARD	R5	Residential	622831.37	4851031.44	0.520	62
434	B396	80 CORMORANT CRESCENT	RV4(WS)	Residential	616288.48	4855009.95	0.520	62
435	B1024	55 PIONEER LANE	R3	Residential	613871.69	4848331.02	0.514	62
436	B343	597 BARRHILL RD	R3	Residential	620328.36	4855145.33	0.512	62
437	B406	43 SCARLETT TRAIL	RV4(WS)	Residential	616323.66	4854986.54	0.508	62
438	B347	12 OLDFIELD ST	RIV	Residential	619264.85	4856424.71	0.501	62
439	B336	17 PATNA CRESCENT	R4	Residential	620416.24	4855125.78	0.491	62
440	B431	123 CORMORANT CRESCENT	RV4(WS)	Residential	616199.58	4855107.76	0.488	62
441	B1068	8142 ISLINGTON AVE	R2	Residential	613795.90	4849615.75	0.486	62
442	B335	15 PATNA CRESCENT	R4	Residential	620408.75	4855138.00	0.483	62
443	B1156	127 CORMORANT CRESCENT	RV4(WS)	Residential	616194.16	4855119.03	0.477	62
444	B342	593 BARRHILL RD	R3	Residential	620330.07	4855157.92	0.467	62
445	B1157	131 CORMORANT CRESCENT	RV4(WS)	Residential	616189.41	4855131.18	0.414	62
446	B337	21 PATNA CR	R4	Residential	620423.57	4855112.33	0.412	62

447	B345	20 GRAM ST	RIV	Residential	619155.95	4856392.69	0.412	62
448	B332	598 BARRHILL ROAD	R2	Residential	620381.37	4855128.71	0.408	62
449	B317	164 RIVERSIDE DR	R3	Residential	614040.44	4850334.14	0.404	62
450	B352	21 RYDER ROAD	RIV	Residential	619602.56	4856010.13	0.402	62
451	B354	21 NAYLON STREEET	RIV	Residential	619343.96	4856355.28	0.400	62
452	B331	604 BARRHILL ROAD	R2	Residential	620382.04	4855113.39	0.399	62
453	B333	590 BARRHILL RD	R2	Residential	620386.34	4855143.51	0.390	62
454	B133	66 RICHBELL STREET	R4	Residential	622958.43	4851446.30	0.388	62
455	B351	19 RYDER ROAD	RIV	Residential	619595.61	4856028.52	0.388	62
456	B41	12 BLOSSOM CRT	R4	Residential	611947.34	4849821.82	0.388	62
457	B341	589 BARRHILL RD	R3	Residential	620333.38	4855169.81	0.384	62
458	B104	1401 CLARK AVENUE WEST	R3	Residential	623188.65	4850488.58	0.375	62
459	B334	584 BARRHILL ROAD	R2	Residential	620389.74	4855157.01	0.370	62
460	B1093	15 CROMARTY PL	R2	Residential	619637.68	4855851.14	0.357	61
461	B109	60 JAIMIE RD	R5	Residential	622859.65	4850870.72	0.349	61
462	B128	12 WHITE BOULEVARD	R5	Residential	622828.64	4851038.14	0.332	61
463	B395	86 CORMORANT CRESCENT	RV4(WS)	Residential	616282.72	4855022.11	0.323	61
464	B405	39 SCARLETT TRAIL	RV4(WS)	Residential	616337.42	4854988.88	0.319	61
465	B394	90 CORMORANT CRESCENT	RV4(WS)	Residential	616277.36	4855031.96	0.314	61
466	B108	128 JAIMIE RD	R4	Residential	622948.17	4850668.00	0.301	61
467	B1091	7 CROMARTY PL	R2	Residential	619659.23	4855823.61	0.301	61
468	B1136	178 PENNSYLVANIA AVENUE	EM1	Industrial	617978.40	4851048.93	0.794	53
469	B1116	8711 KEELE STREET	EM1	Industrial	620290.37	4853357.20	0.792	53
470	B378	178 PENNSYLVANIA AVENUE	EM1	Industrial	618041.59	4851066.53	0.786	53
471	B1143	360 APPLEWOOD CRESCENT	EM1	Industrial	617405.35	4851343.70	0.761	53
472	B1142	388 APPLEWOOD CRESCENT	EM1	Industrial	617417.30	4851257.82	0.726	53
473	B383	460 APPLEWOOD CRESCENT	EM1	Industrial	617453.33	4851060.37	0.667	53
474	B392	70 CREDITVIEW ROAD	EM1	Industrial	616793.72	4851920.08	0.665	53
475	B1135	391EDGELEY BOULEVARD	EM1	Industrial	617904.80	4851032.66	0.657	53
476	B1145	345 COURTLAND AVENUE	EM1	Industrial	617233.36	4851903.03	0.643	53
477	B1137	130 PENNSYLVANIA AVENUE	EM1	Industrial	618106.98	4851083.24	0.625	53
478	B1129	7725 JANE STREET	C8	Commercial	618797.39	4850020.26	0.621	53

479	B379	390 MILLWAY AV	EM1	Industrial	618233.65	4851141.83	0.591	52
480	B490	8060 JANE STREET	EM1	Industrial	618527.50	4850893.95	0.556	52
481	B382	30 PENNSYLVANIA AVENUE	EM1	Industrial	618417.79	4851141.83	0.546	52
482	B380	445 EDGELEY BOULEVARD	EM1	Industrial	617884.42	4851160.05	0.522	52
483	B381	56 PENNSYLVANIA AVENUE	EM1	Industrial	618358.24	4851138.04	0.509	52
484	B480	7800 JANE ST	C7	Commercial	618616.08	4850182.24	0.490	52
485	B1128	7551 JANE ST	EM1	Industrial	619015.17	4849650.89	0.407	52
486	B1127	215 DOUGHTON ROAD	EM1	Industrial	618934.91	4849776.78	0.326	51
487	B1065	WOODBRIDGE AVENUE	C4	Commercial	613182.09	4849038.08	0.311	51
488	B1	11221 HIGHWAY 50	C2	Commercial	604957.12	4855778.77	0.304	51
489	B313	104 RIVERSIDE DR	OS1	Park	614063.01	4850122.52	0.799	43
490	B475	5789 OLD MAJOR MACKENZIE DRIVE	OS1	Park	610309.62	4853893.74	0.708	43
491	B1102	245 NASHVILLE ROAD	OS1	Park	609600.60	4855141.81	0.608	42
492	B466	9751 MC GILLIVRAY RD	A	Other	608931.44	4852780.76	0.576	42
493	B3	7601 MARTIN GROVE ROAD	PB1	Other	612558.73	4846771.54	0.556	42
494	B454	9732 HIGHWAY 27	OS1	Park	610020.11	4853135.49	0.546	42
495	B450	9441 HUNTINGTON ROAD	A	Other	608103.80	4851573.71	0.542	42
496	B470	5821 HUMBER BRIDGE TRAIL	OS1	Park	610191.36	4853871.86	0.526	42
497	B1176	14 BRODA DRIVE	A	Other	609958.05	4853646.01	0.515	42
498	B468	10343 HWY 27	A	Other	610070.65	4854823.63	0.428	42
499	B37	1 BLOSSOM CRT	R4	Residential	612016.92	4849832.04	0.288	41
500	B329	19 PAULINE CT	RM2	Residential	622890.45	4850189.09	0.276	41
501	B107	138 JAIMIE RD	R4	Residential	622982.94	4850678.50	0.262	41
502	B106	142 JAIMIE RD	R4	Residential	622991.23	4850681.72	0.256	41
503	B340	583 BARRHILL RD	R3	Residential	620337.50	4855182.60	0.255	41
504	B397	46 SCARLETT TRAIL	RV4(WS)	Residential	616305.76	4855022.63	0.254	41
505	B344	22 LARGO CR	R3	Residential	620289.06	4855190.62	0.217	41
506	B338	28 LARGO CR	R3	Residential	620266.77	4855207.28	0.216	41
507	B1115	30 HILLSIDE AVE	RIV	Residential	621205.19	4850854.03	0.212	41
508	B339	26 LARGO CR	R3	Residential	620276.92	4855199.05	0.200	41
509	B1089	18 LARGO CR	R3	Residential	620300.78	4855184.93	0.184	41
510	B353	17 RYDER ROAD	RIV	Residential	619594.33	4856048.76	0.181	41

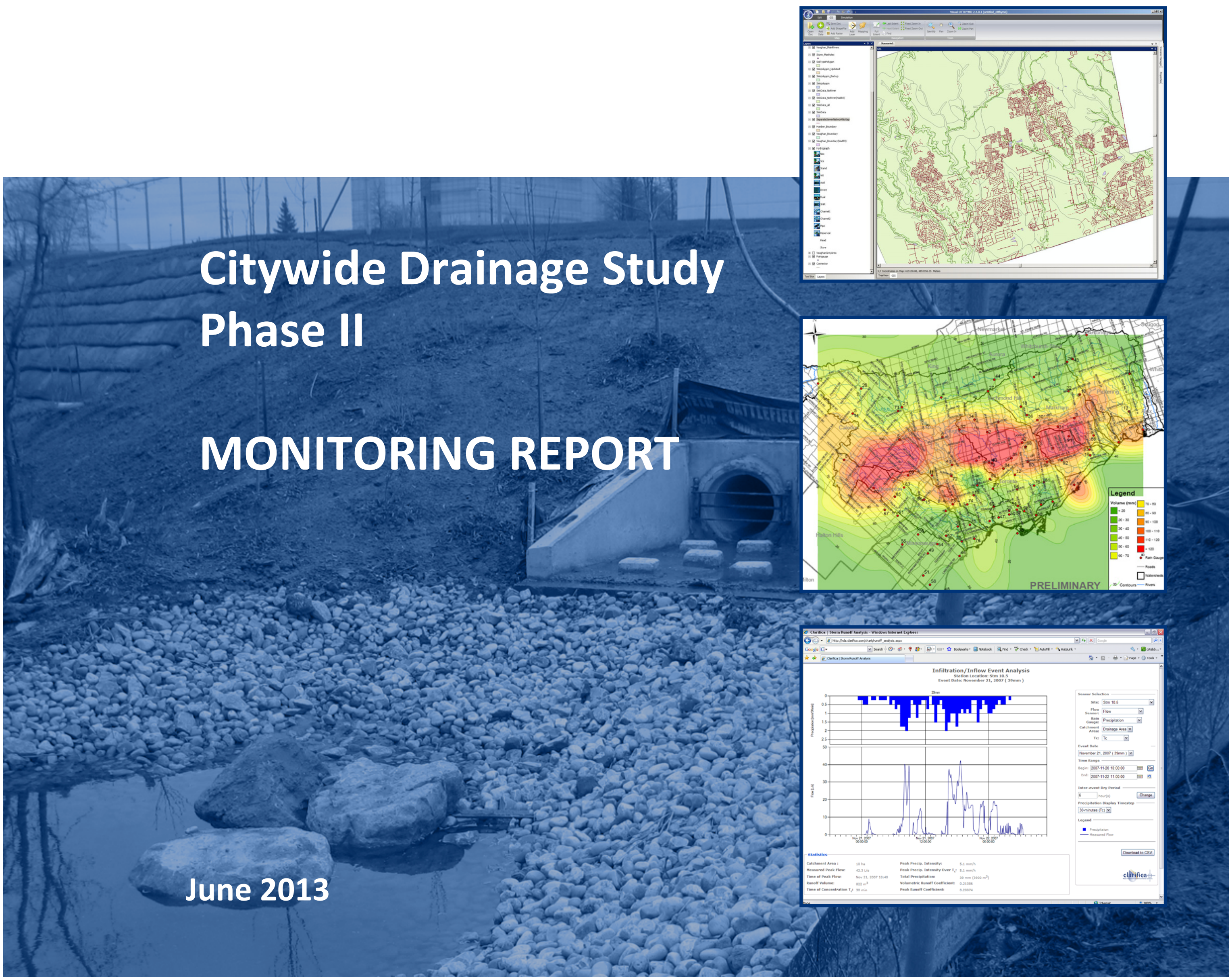
511	B1109	1997 HIGHWAY 7	RIV	Residential	621392.99	4850981.94	0.177	41
512	B393	94 CORMORANT CRESCENT	RV4(WS)	Residential	616272.95	4855042.98	0.176	41
513	B1096	21 GRAM STREET	RIV	Residential	619201.71	4856437.84	0.175	41
514	B1032	172 JOSEPH AARON BOULEVARD	R3	Residential	623532.87	4850542.38	0.154	41
515	B61	24 MILLBANK COURT	R4	Residential	623394.08	4850519.97	0.152	41
516	B1100	23 RYDER ROAD	RIV	Residential	619604.57	4855992.94	0.151	41
517	B398	42 SCARLETT TRAIL	RV4(WS)	Residential	616318.51	4855026.19	0.149	41
518	B1050	62 JAIMIE RD	R5	Residential	622861.67	4850862.74	0.148	41
519	B404	35 SCARLETT TRAIL	RV4(WS)	Residential	616348.83	4854992.55	0.144	41
520	B1090	14 LARGO CR	R3	Residential	620313.25	4855182.11	0.142	41
521	B270	50 PARK DRIVE	R3	Residential	613359.43	4849322.91	0.142	41
522	B1081	610 BARRHILL RD	R2	Residential	620386.24	4855098.53	0.130	41
523	B330	21 PAULINE CT	RM2	Residential	622889.78	4850197.17	0.130	41
524	B407	30 CORMORANT CRESCENT	RV4(WS)	Residential	616372.71	4854970.37	0.109	40
525	B1025	80 PIONEER LANE	R3	Residential	613791.75	4848382.61	0.091	40
526	B1033	176 JOSEPH AARON BLVD	R3	Residential	623522.39	4850550.09	0.081	40
527	B1059	62 RICHBELL ST	R4	Residential	622967.48	4851446.87	0.081	40
528	B399	38 SCARLETT TRAIL	RV4(WS)	Residential	616330.76	4855029.51	0.064	40
529	B1147	102 CORMORANT CRESCENT	RV4(WS)	Residential	616259.43	4855072.04	0.057	40
530	B1060	60 RICHBELL ST	R4	Residential	622975.68	4851452.43	0.054	40
531	B1047	68 JAIMIE RD	R5	Residential	622866.35	4850840.25	0.052	40
532	B1038	44 MILLBANK CRT	R4	Residential	623387.28	4850539.61	0.044	40
533	B60	20 MILLBANK CRT	R4	Residential	623400.62	4850525.72	0.040	40
534	B1037	16 MILLBANK CRT	R4	Residential	623408.11	4850530.95	0.038	40
535	B1148	30 SCARLETT TRAIL	RV4(WS)	Residential	616355.02	4855035.70	0.038	40
536	B400	34 SCARLETT TRAIL	RV4(WS)	Residential	616343.94	4855033.14	0.035	40
537	B402	27 SCARLETT TRAIL	RV4(WS)	Residential	616374.32	4854999.79	0.034	40
538	B403	31 SCARLETT TRAIL	RV4(WS)	Residential	616362.40	4854996.36	0.034	40
539	B1153	22 CORMORANT CRESCENT	RV4(WS)	Residential	616397.52	4854978.21	0.032	40
540	B401	26 CORMORANT CRESCENT	RV4(WS)	Residential	616385.78	4854974.50	0.032	40
541	B1138	112 PENNSYLVANIA AVENUE	EM1	Industrial	618173.39	4851097.40	0.283	31
542	B1140	425 MILLWAY AVENUE	EM1	Industrial	618335.97	4851269.53	0.248	31

543	B492	92 WOODBRIDGE Ave	C4	Commercial	613293.69	4848996.30	0.182	31
544	B377	440 EDGELEY BOULEVARD	EM1	Industrial	617756.86	4851118.63	0.162	31
545	B149	86 WOODBRIDGE AVE	C4	Commercial	613317.46	4849034.60	0.158	31
546	B148	108 WOODBRIDGE AVE	C4	Commercial	613270.70	4849004.84	0.143	31
547	B146	166 WOODBRIDGE AVENUE	C4	Commercial	613224.06	4848998.54	0.123	31
548	B147	112 WOODBRIDGE AVENUE	C4	Commercial	613254.43	4848971.78	0.121	30
549	B1132	463 APPLEWOOD CRESCENT	EM1	Industrial	617637.58	4851092.29	0.119	30
550	B1133	458 EDGELEY BOULEVARD	EM1	Industrial	617746.65	4851167.52	0.099	30
551	B376	PURCELL 13	EM1	Industrial	617786.19	4850998.77	0.099	30
552	B1131	270 PENNSYLVANIA AVENUE	EM1	Industrial	617723.70	4850977.92	0.079	30
553	B1141	11 CIDERMILL AVENUE	EM1	Industrial	618424.71	4851323.12	0.042	30
554	B375	7800 JANE ST	C7	Commercial	618652.14	4850104.28	0.035	30
555	B1117	1801 HIGHWAY 7	A	Other	621977.52	4851132.69	0.203	21
556	B370	1841 HIGHWAY 7	A	Other	621832.27	4851046.99	0.202	21
557	B1007	10945 JANE ST	A	Other	617248.30	4858784.66	0.161	21
558	B1181	10343 HWY 27	A	Other	610058.83	4854790.71	0.071	20

APPENDIX E
Flow and Precipitation Monitoring

City of Vaughan

W11-251



Citywide Drainage Study Phase II

MONITORING REPORT

June 2013

Table of Contents

LIST OF FIGURES

LIST OF TABLES

APPENDICES

1.0 Flow and Precipitation Monitoring

One (1) component of the Phase II Drainage Study involved the collection of precipitation and flow data roughly from the beginning of July 2011 to February 2012 to quantify the rainfall-runoff response in five (5) subcatchment areas encompassing all seven (7) flood susceptible areas. Rainfall and sewer flow monitoring will be used to calibrate the model as is later described. A total of two (2) tipping bucket rain gauges and five (5) flow monitoring stations were installed as part of this study. Rainfall and flow monitoring locations are illustrated below in **Figure 1-1**.

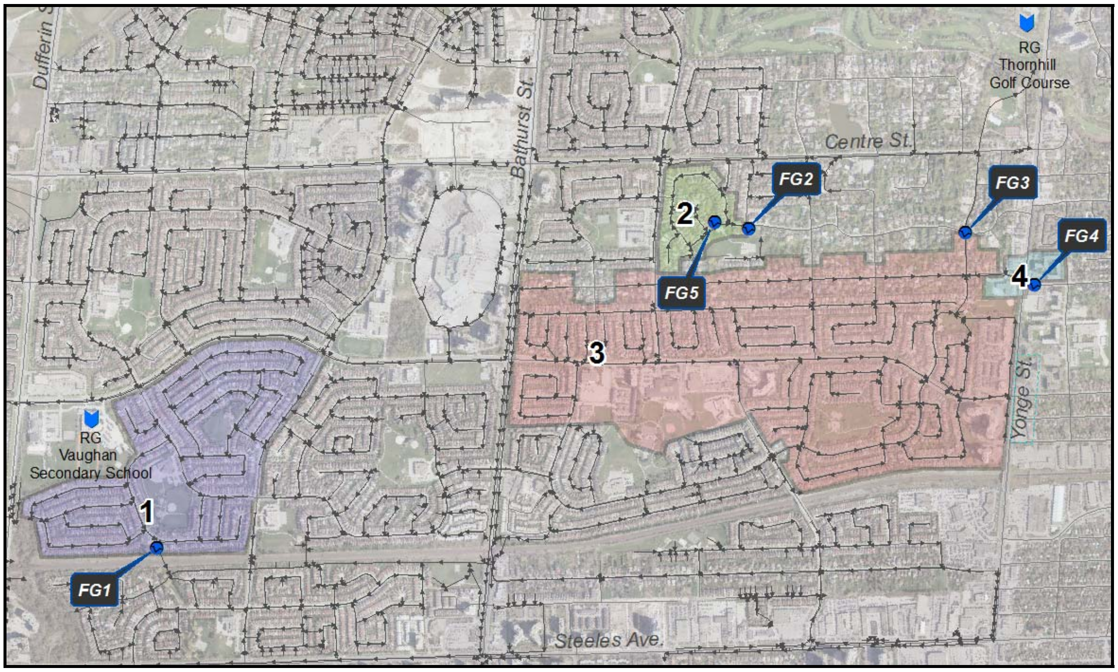


Figure 1-1 Rain Gauge and Flow Monitoring Location Map

Table 1-1 below summarizes the drainage characteristics upstream of the stations. In all cases, area velocity meters with independent level sensors were used to capture flows as accurately as possible. As previously stated and further explained in following sections, the data was analyzed and used for calibrating the model to reduce the uncertainties of rainfall-runoff response.

Table 1-1 – Flow Gauge Drainage Area Characteristics

Flow Gauge	General Location	Incremental Upstream Area (ha)	Imperviousness (%)	Roof Connectivity (%)	Reverse Sloped Driveways (%)	Average Slope (%)
FG1	Gayla Street / Charlton Avenue	557	71	5.7	0.4	1.7
FG2	Markwood Lane / Thornridge Drive	162	56	10.1	0.4	1.5
FG3	Thornridge Drive / Brooke Street	194	59	7.2	4.7	1.5
FG4	Arnold Avenue / Yonge Street	190	60	7.0	5.0	1.3
FG5	Franklin Avenue/Hefhill Ct	152	61	10.0	0.3	1.6

2.0 Precipitation Monitoring

2.1. Precipitation Data

The rainfall monitoring program coincides with the flow monitoring program from July 2011 to February 2012. Two (2) of the nine (9) rain gauges that were analyzed were specifically installed for the purposes of this study. The remaining seven (7) rain gauges were existing gauges previously installed by Cole Engineering. As these seven (7) gauges are located in the vicinity of the study area (**Figure 2-1**), the data from these devices were used in the analysis to complement the two (2) devices installed specifically for this study.

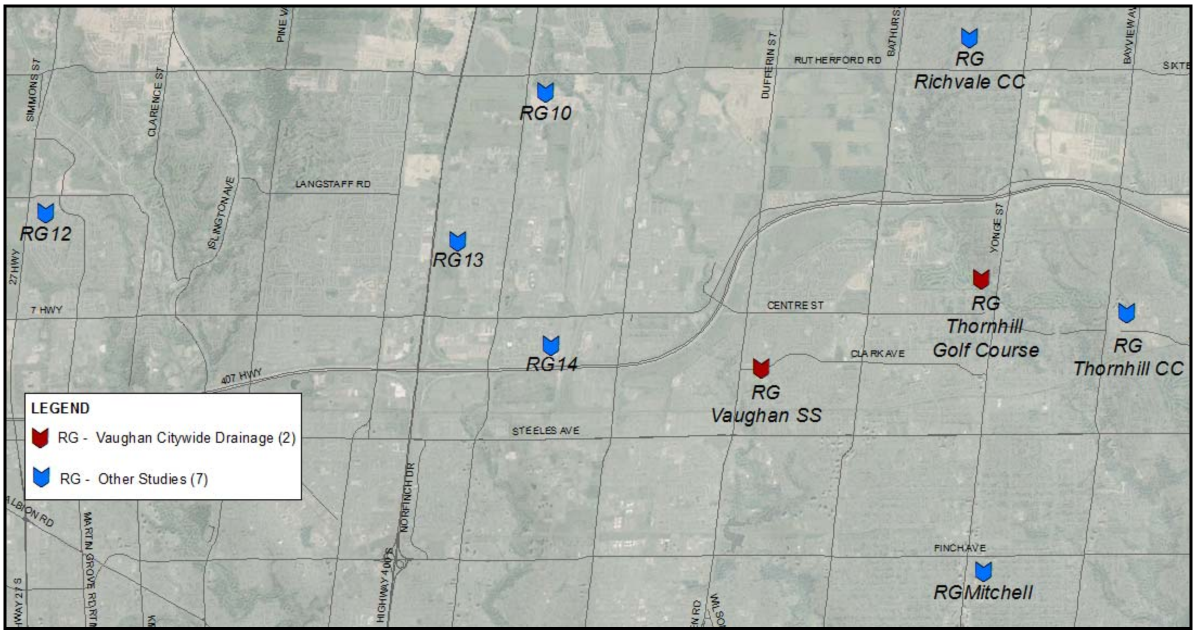


Figure 2-1 Rain Gauge Location Map

A total of six (6) events were used in the rainfall analysis and a summary of these events is provided below in **Table 2-1** to **Table 2-9** where, for the purpose of initial comparative analysis, an average Time of Concentration value (Tc) of 10 minutes was assigned to each rain gauge. All rain gauge data collected throughout the duration of this study has been compiled into monthly reports and provided in **Appendix A**. Note that all nine (9) gauges were not operational during all six storm events used for analysis. Mitchell RG was not operational for the storm events in October and November, 2011.

Table 2-1 – Vaughan Secondary RG - Peak Intensity over Minute Timestep

Storm Event Date	Total Volume (mm)	Peak Intensity Over Minute Timestep (mm/h)					
		5 min	10 min	15 min	20 min	30 min	60 min
09/23/11	34	33	28.5	23	21.8	19	14.2
09/29/11	18	24	18	17	14.2	13.5	10.8
10/12/11	20	9	7.5	7	6.8	6	5.5
10/19/11	32	21	13.5	10	8.2	8	6.2
10/25/11	27	9	7.5	6	6	5	4.2
11/29/11	57	18	15	13	10.5	7.5	6.5

Table 2-2 – Mitchell RG - Peak Intensity over Minute Timestep

Storm Event Date	Total Volume (mm)	Peak Intensity Over Minute Timestep (mm/h)					
		5 min	10 min	15 min	20 min	30 min	60 min
09/23/11	33	36.6	24.4	19.3	16.8	13.2	11.2
09/29/11	25	24.4	19.8	17.3	17.5	17.3	11.4
10/12/11	29	12.2	9.1	8.1	8.4	7.6	7.4
10/19/11	37	12.2	9.1	9.1	8.4	7.6	5.8
10/25/11	NA	NA	NA	NA	NA	NA	NA
11/29/11	NA	NA	NA	NA	NA	NA	NA

Table 2-3 – Richvale CC RG - Peak Intensity over Minute Timestep

Storm Event Date	Total Volume (mm)	Peak Intensity Over Minute Timestep (mm/h)					
		5 min	10 min	15 min	20 min	30 min	60 min
09/23/11	32	21.3	19.8	18.3	17.5	16.8	13.7
09/29/11	13	12.2	12.2	11.2	10.7	9.7	8.1
10/12/11	14	6.1	6.1	6.1	5.3	4.6	4.1
10/19/11	28	12.2	10.7	9.1	8.4	6.6	5.1
10/25/11	24	6.1	4.6	5.1	4.6	4.6	4.1
11/29/11	54	15.2	12.2	9.1	8.4	8.1	6.6

Table 2-4 – Thornhill CC RG - Peak Intensity over Minute Timestep

Storm Event Date	Total Volume (mm)	Peak Intensity Over Minute Timestep (mm/h)					
		5 min	10 min	15 min	20 min	30 min	60 min
09/23/11	31	27.4	18.3	16.3	13.7	12.2	10.9
09/29/11	14	15.2	13.7	12.2	12.2	11.7	8.6
10/12/11	18	9.1	7.6	7.1	6.1	5.6	5.1
10/19/11	37	21.3	16.8	14.2	13	11.7	8.1
10/25/11	28	9.1	6.1	6.1	6.1	5.1	4.6
11/29/11	63	18.3	13.7	10.2	9.9	9.7	7.9

Table 2-5 - Thornhill Golf Course RG - Peak Intensity over Minute Timestep

Storm Event Date	Total Volume (mm)	Peak Intensity Over Minute Timestep (mm/h)					
		5 min	10 min	15 min	20 min	30 min	60 min
09/23/11	33	27	22.5	19	17.2	15.5	13.5
09/29/11	15	18	13.5	12	12	11.5	9
10/12/11	18	6	6	6	6	5.5	5
10/19/11	36	21	15	13	12	10.5	8.2
10/25/11	28	9	7.5	6	6	5	4.2
11/29/11	60	12	12	10	9	8.5	7.2

Table 2-6 – RG 10 - Peak Intensity over Minute Timestep

Storm Event Date	Total Volume (mm)	Peak Intensity Over Minute Timestep (mm/h)					
		5 min	10 min	15 min	20 min	30 min	60 min
09/23/11	30	45	27	22	18.8	18.5	14
09/29/11	14	18	12	10	9.8	9	7
10/12/11	14	9	6	6	5.2	4.5	4
10/19/11	33	18	13.5	10	8.2	6.5	6
10/25/11	28	9	7.5	7	6.8	5.5	4.5
11/29/11	58	27	19.5	17	14.2	11	7

Table 2-7 – RG 12 - Peak Intensity over Minute Timestep

Storm Event Date	Total Volume (mm)	Peak Intensity Over Minute Timestep (mm/h)					
		5 min	10 min	15 min	20 min	30 min	60 min
09/23/11	19	18	12	10	9.8	8	5.8
09/29/11	8	18	12	9	9	8	6
10/12/11	11	6	4.5	4	3.8	3.5	3.2
10/19/11	45	27	19.5	17	15	11.5	9.8
10/25/11	26	6	6	5	4.5	4	3.8
11/29/11	57	18	12	10	9.8	8.5	6.8

Table 2-8 – RG 13 - Peak Intensity over Minute Timestep

Storm Event Date	Total Volume (mm)	Peak Intensity Over Minute Timestep (mm/h)					
		5 min	10 min	15 min	20 min	30 min	60 min
09/23/11	31	27	25.5	20	18	18	15.5
09/29/11	14	21	13.5	12	12	11	8.8
10/12/11	13	6	6	5	4.5	4.5	3.8
10/19/11	23	15	12	10	9	7.5	6
10/25/11	24	12	9	7	6	5.5	4.8
11/29/11	60	30	21	16	12.8	10.5	7

Table 2-9 – RG 14 - Peak Intensity over Minute Timestep

Storm Event Date	Total Volume (mm)	Peak Intensity Over Minute Timestep (mm/h)					
		5 min	10 min	15 min	20 min	30 min	60 min
09/23/11	33	54	36	29	25.5	22	15.5
09/29/11	14	15	12	12	10.5	9.5	8.2
10/12/11	15	6	6	6	5.2	5	4.5
10/19/11	42	21	16.5	16	15	13.5	9
10/25/11	27	9	6	6	5.2	5	4.5
11/29/11	56	27	19.5	15	13.5	11.5	7

Based on precipitation data collected from the nine (9) rain gauges used for this study, the highest total volume of precipitation occurred in the storm event on November 29, 2011 which displays precipitation levels close to the City's 1:2 year IDF curve after storm duration of between 16 and 22 hours.

At the majority of the rain gauge locations, the storm event on September 23, 2011 displays the highest peak intensities over a 60 minute time period. Refer to **Appendix B** for IDF curves and analysis for all six (6) key storm events used for this study, as well as the full range of timestep peak intensity data (24 hrs).

The precipitation data presented above shows the rainfall variability between stations. Rainfall variability is important when analysing the differences between the measured and modelled flow. For the purpose of this study, rainfall variability has been addressed through the distributed rainfall modelling technique (DRMT) which interpolates the measured rain between stations in to each catchment used in the model. As such, it should be noted that values presented above are subject to change when implementing a DRMT analysis methodology to aid in model accuracy.

2.2. Rain Gauge Maintenance and Calibration

The rain gauges at Thornhill Golf Course and Vaughan Secondary School and were successfully installed between August 16, 2011 and August 18, 2011. After initial installation, no maintenance visits were required at either rain gauge location throughout the duration of the study. The tipping bucket style rain gauges were calibrated to 0.25 mm prior to being installed. No further calibration was necessary throughout the duration of this study. A complete summary of rain gauge installation, maintenance and calibration activities is provided in **Appendix C**.

3.0 Flow Monitoring

3.1. Flow Gauge Data

The objective of the storm sewer flow monitoring program was to collect wet-weather flow to calibrate a Micro-drainage model. **Table 3-1** below summarises the measured peak flow during six (6) key storm events at each station which were used to calibrate the model. All flow gauge data collected throughout the duration of this study has been provided in **Appendix D**.

Table 3-1 – Measured Peak Flows

Flow Gauge	Storm Events Peak Flow (m^3/s)					
	09/23/11	09/29/11	10/12/11	10/19/11	10/25/11	11/29/11
FG1	1.035	0.597	0.212	0.443	0.276	0.499
FG2	0.205	0.103	0.032	0.115	0.053	0.139
FG3	1.792	0.977	0.587	1.284	0.759	1.336
FG4	0.133	0.087	0.034	0.107	0.045	0.066
FG5	0.040	0.011	0.004	0.017	0.010	0.021

The highest peak flows at each flow gauge were recorded during the storm event on September 23, 2011. During this event, Flow gauge 1 and flow gauge 3 recorded the highest peak flows of 1.792 m^3/s and 1.035 m^3/s respectively. Flow gauge 5 recorded the lowest peak flow of 0.040 m^3/s. The differences in peak flow values can be most likely be attributed to drainage area size and imperviousness as described above in **Table 1-1**.

The volumetric and peak runoff coefficients during all six (6) key storm events analyzed at the five (5) flow gauge locations are summarized below in **Table 3-2.**

Table 3-2 – Volumetric and Peak Runoff Coefficients

Flow Gauge	Volumetric (VRC) and Peak (PRC) Runoff Coefficient											
	09/23/11		09/29/11		10/12/11		10/19/11		10/25/11		11/29/11	
	VRC	PRC	VRC	PRC	VRC	PRC	VRC	PRC	VRC	PRC	VRC	PRC
FG1	0.033	0.032	0.032	0.028	0.025	0.022	0.041	0.030	0.044	0.034	0.054	0.024
FG2	0.025	0.021	0.021	0.021	0.013	0.013	0.023	0.020	0.030	0.021	0.001	0.034
FG3	0.230	0.211	0.235	0.161	0.272	0.207	0.339	0.211	0.419	0.268	0.461	0.276
FG4	0.015	0.006	0.012	0.005	0.008	0.004	0.125	0.007	0.010	0.006	0.0176	0.008
FG5	0.004	0.004	0.003	0.020	0.002	0.002	0.004	0.002	0.004	0.004	0.009	0.004

The measured runoff volumes during all six (6) key storm events analyzed at the five (5) flow gauge locations are summarized below in **Table 3-3.**

Table 3-3 – Measured Runoff Volumes

Flow Gauge	Storm Events Runoff Volume (m^3)					
	09/23/11	09/29/11	10/12/11	10/19/11	10/25/11	11/29/11
FG1	6,340	3,158	2,721	7,394	6,661	17,247
FG2	1,368	509	386	1,290	1,324	4,199
FG3	14,908	6,849	9,479	24,144	22,549	55,983
FG4	944	326	268	828	527	2,003
FG5	214	72	46	224	184	839

In addition to the information provided in the tables above, storm flow Reports have been prepared for each storm event which occurred throughout the duration of the study. The storm flow reports for each flow gauge location are provided in **Appendix E**.

3.2. Flow Gauge Maintenance and Calibration

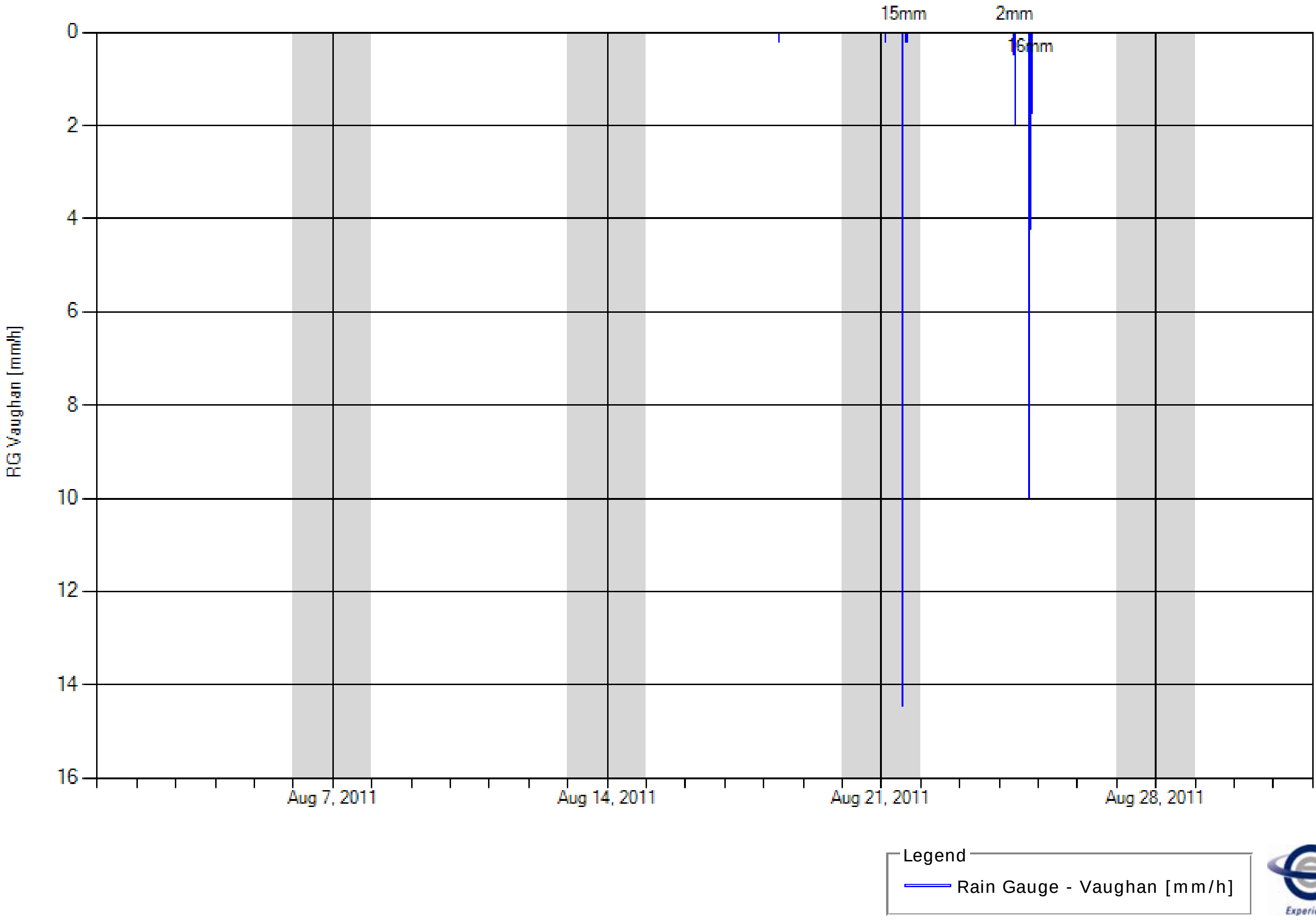
The five (5) flow gauges within the study area were successfully installed between July 11, 2011 and September 21, 2011. Flow gauge 5 (FG5) was installed later than other flow gauges as a way to quantify the inflow of a drainage creek which becomes active during rain events. After initial installation, ongoing maintenance visits were required for all flow gauge locations throughout the duration of the study. The maintenance addressed issues with telemetry, battery replacement, desiccant replacement, data downloads and subsequent re-launching of the unit.

Although calibrated prior to being installed, flow gauge sensors required periodic calibration throughout the study duration in order to ensure accurate results. A complete summary of flow gauge installation, maintenance, calibration and removal activities is provided in **Appendix F.**

APPENDIX A
Rain Gauge Monthly Reports

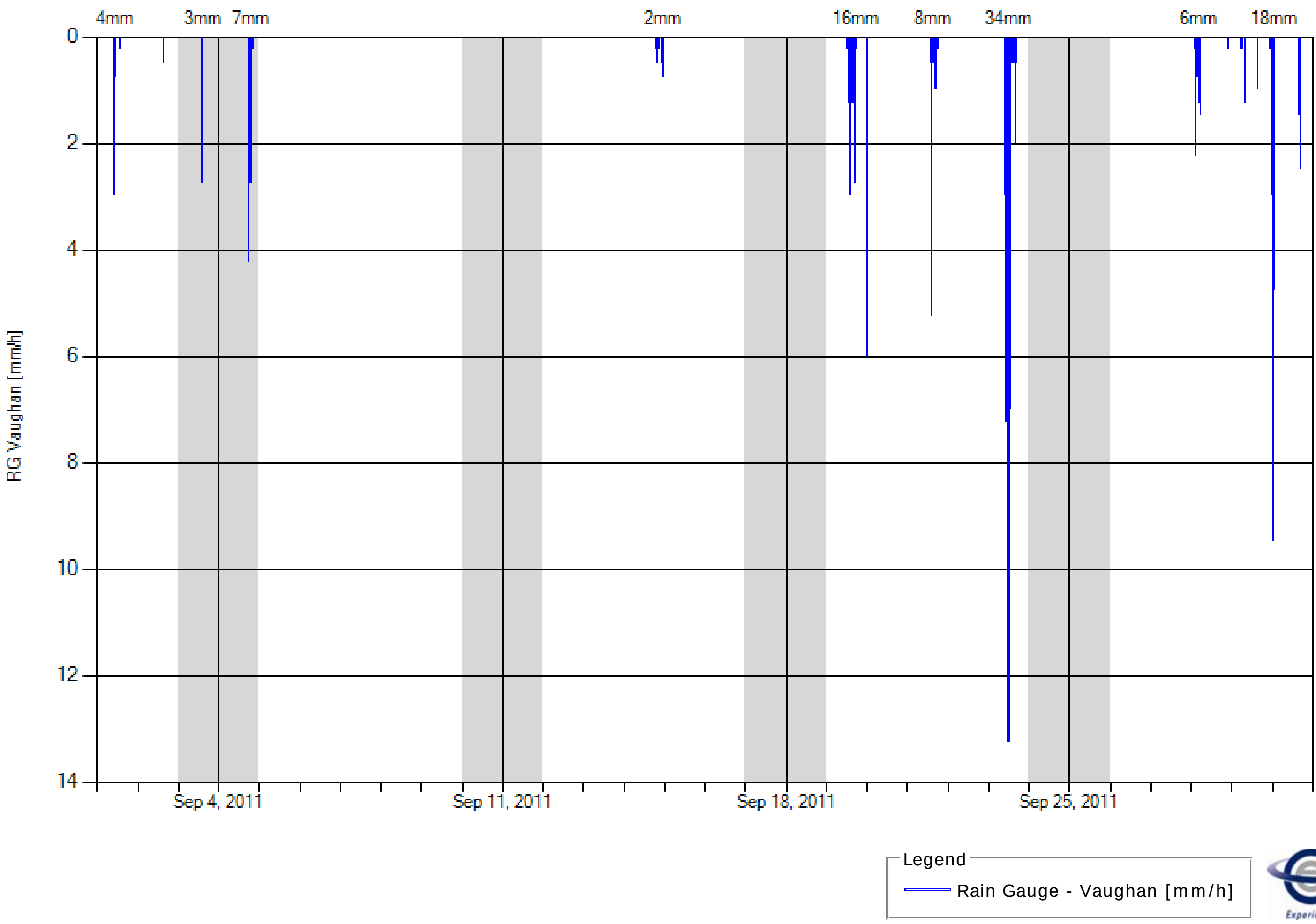
Vaughan City Wide Drainage Study Phase II RG - Vaughan Secondary School

Aug 1, 2011 - Sep 1, 2011



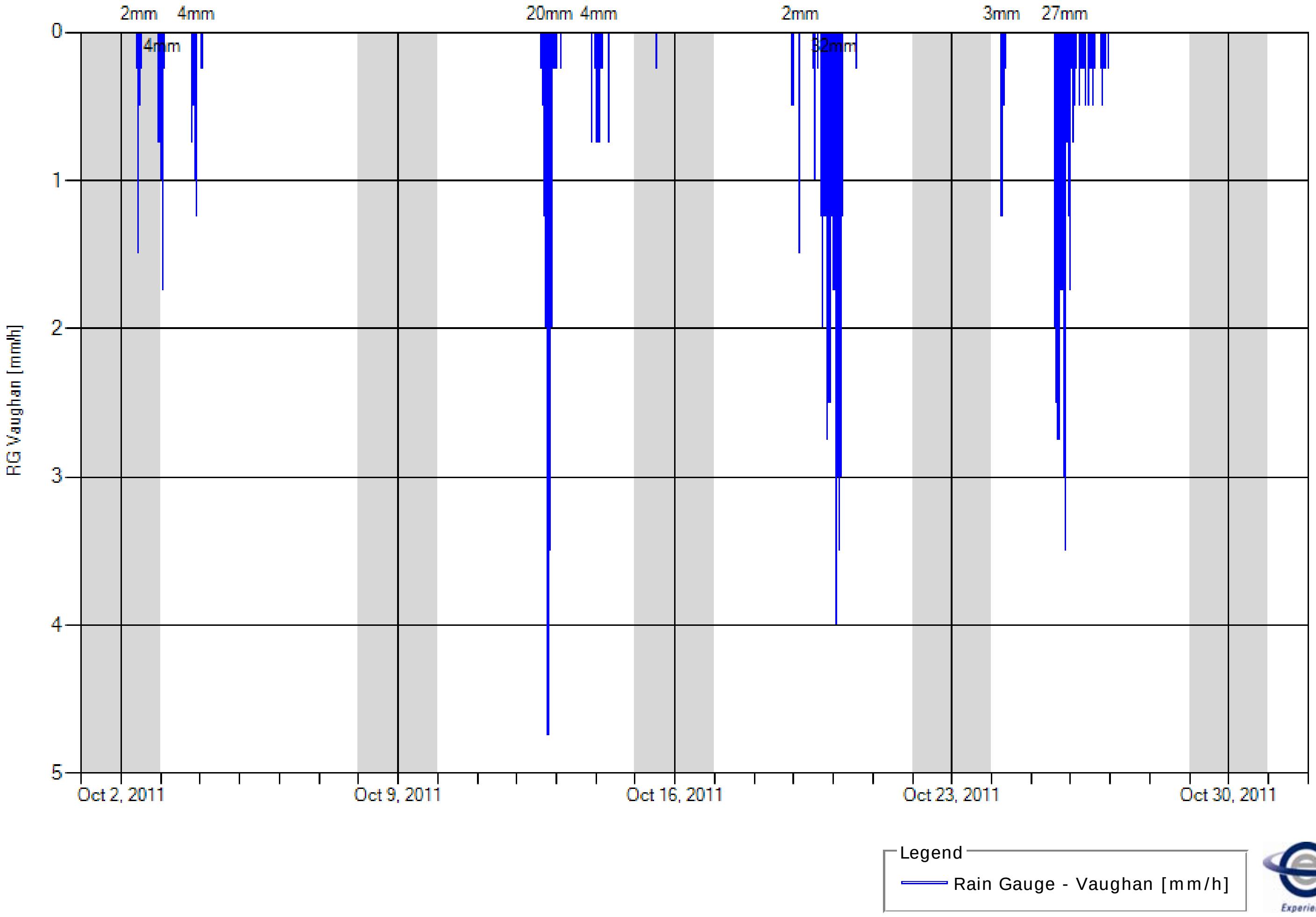
Vaughan City Wide Drainage Study Phase II RG - Vaughan Secondary School

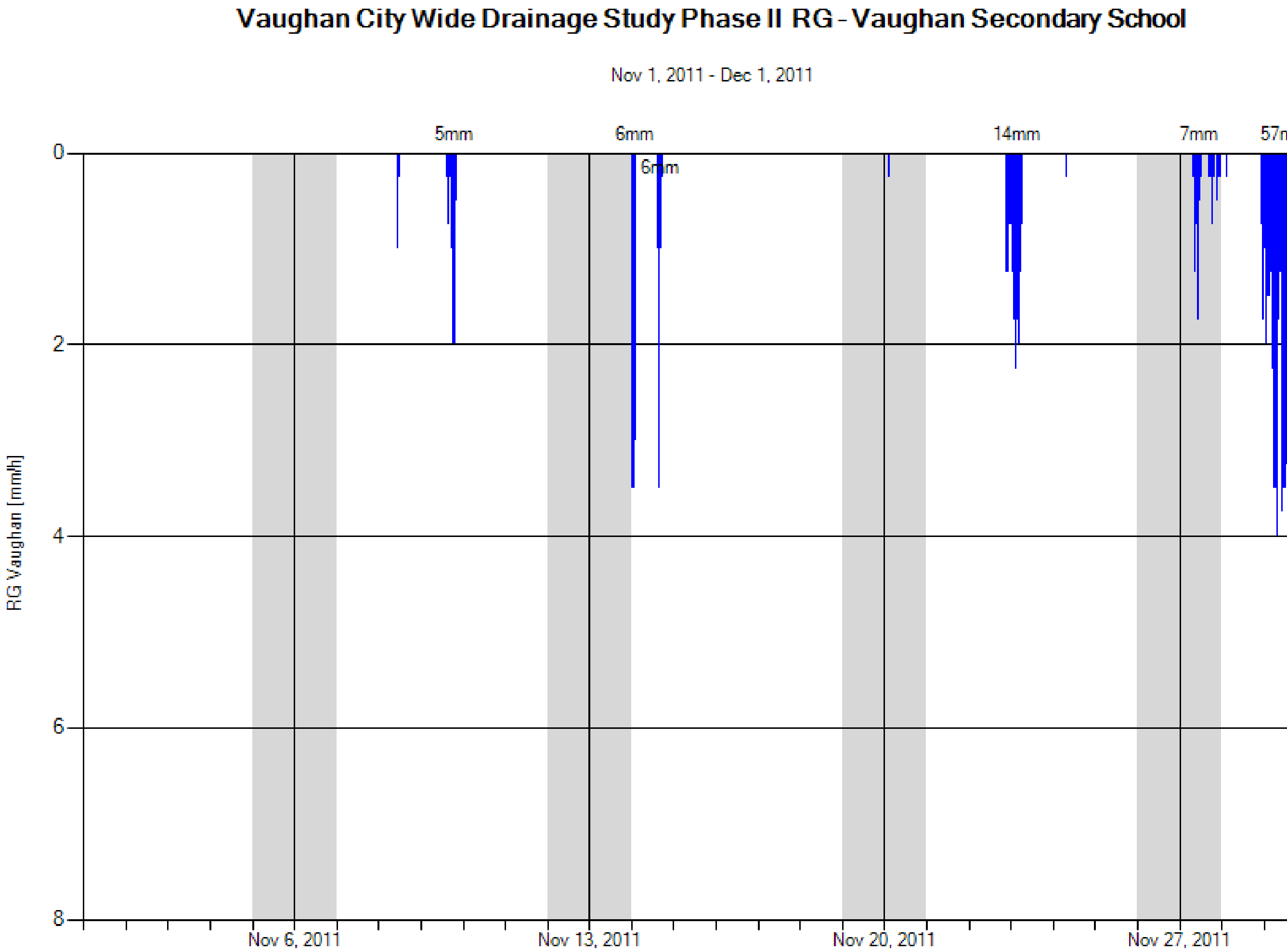
Sep 1, 2011 - Oct 1, 2011

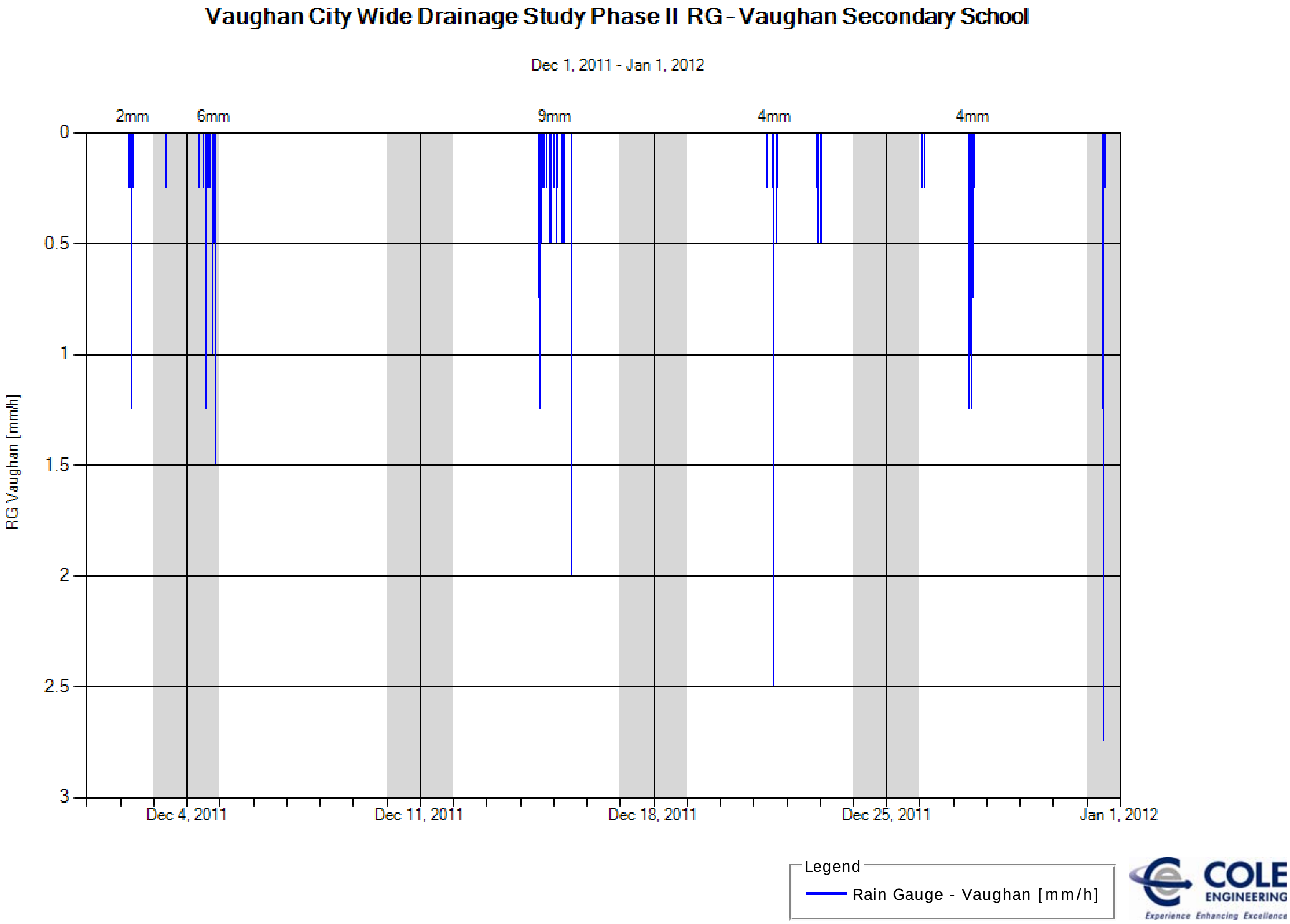


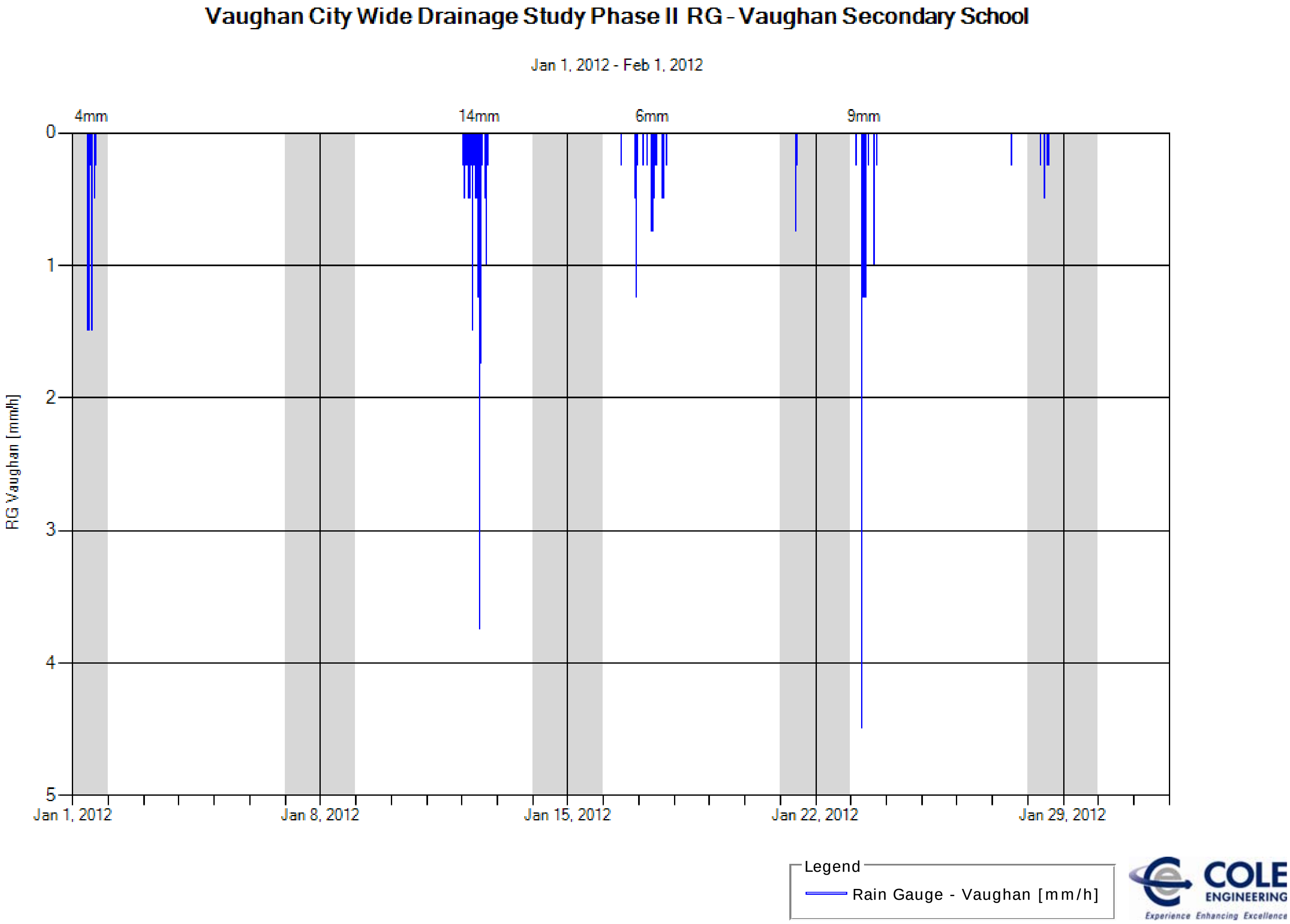
Vaughan City Wide Drainage Study Phase II RG - Vaughan Secondary School

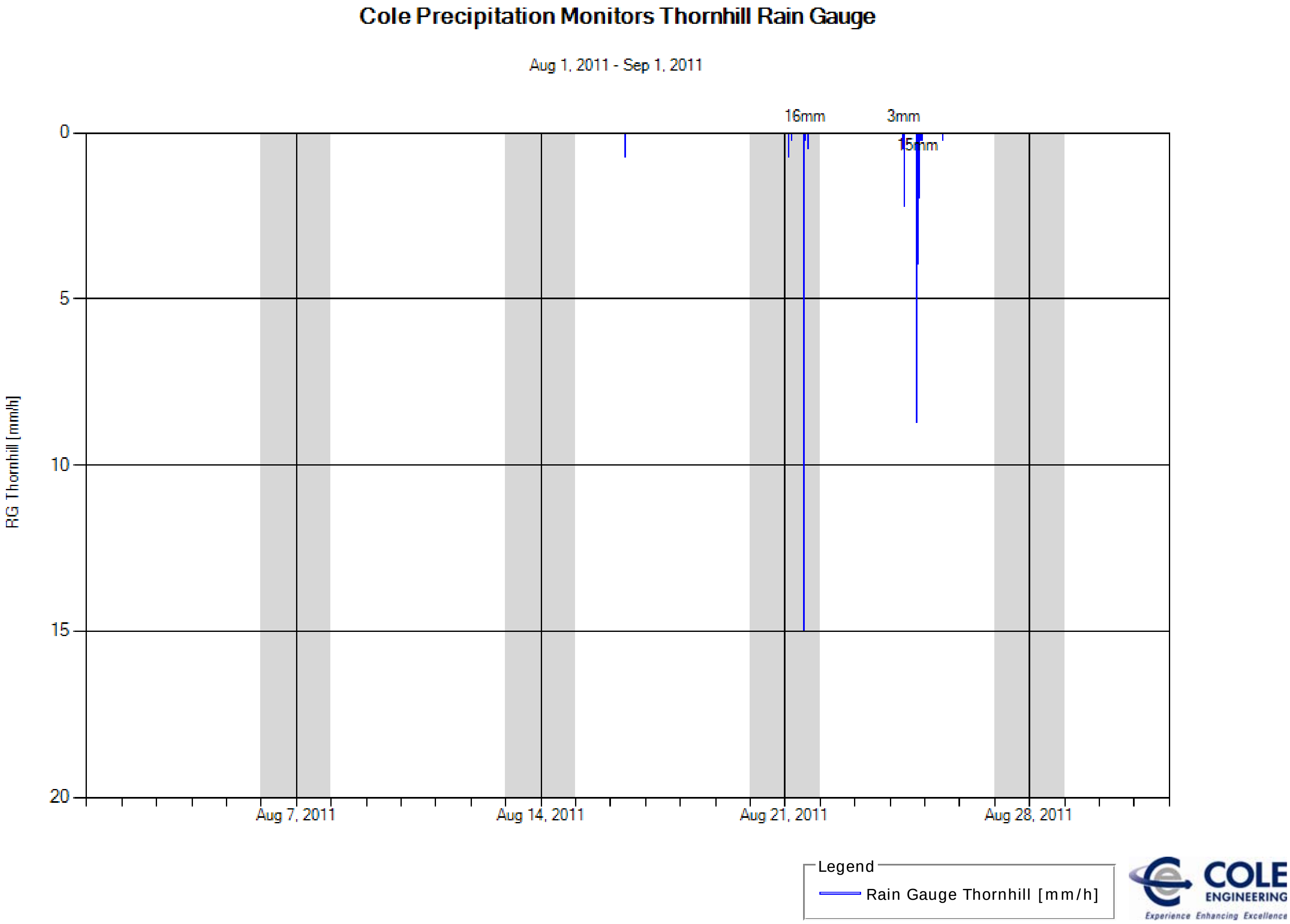
Oct 1, 2011 - Nov 1, 2011



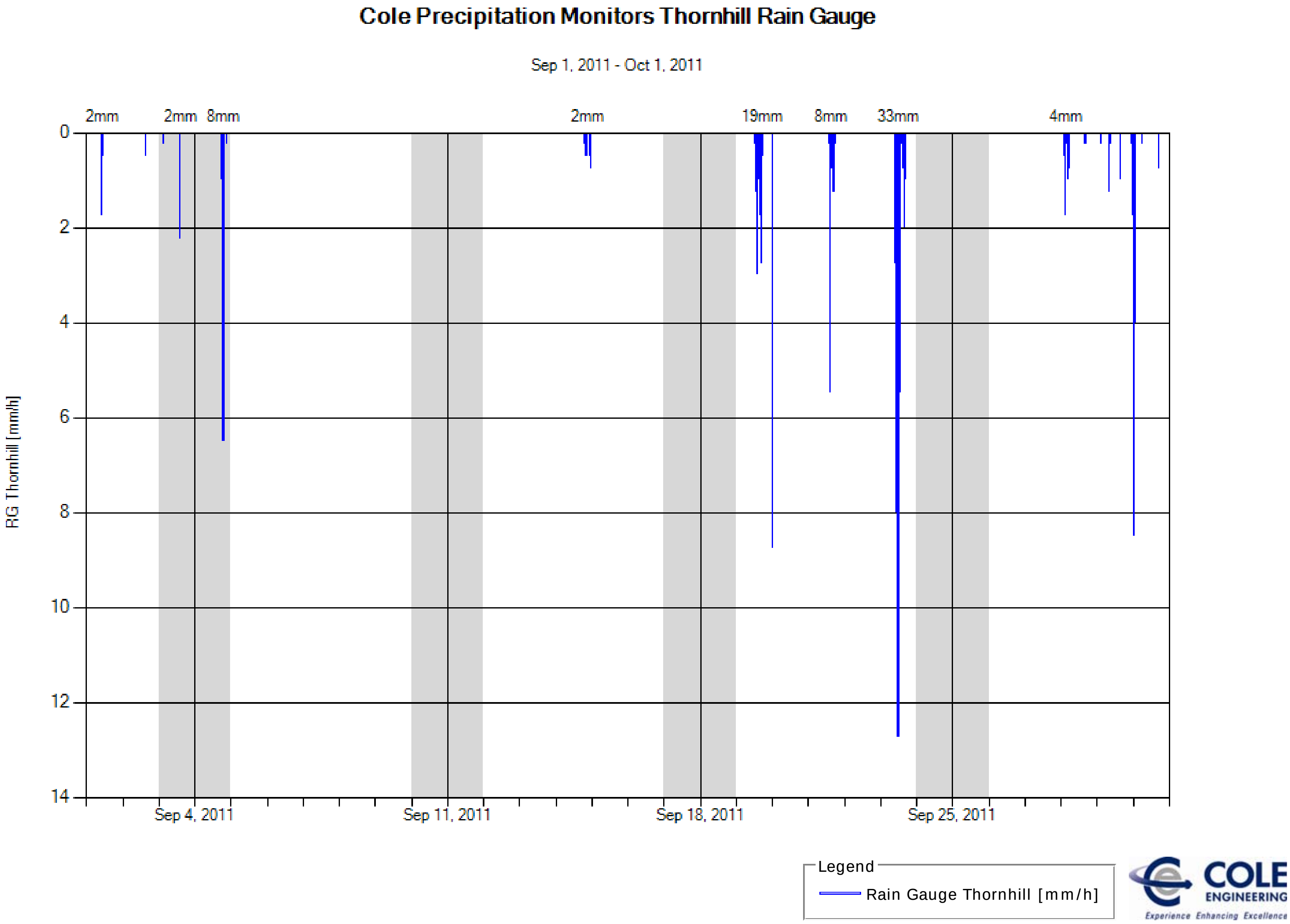

Vaughan City Wide Drainage Study Phase II RG - Vaughan Secondary School
Nov 1, 2011 - Dec 1, 2011
5mm
6mm
6mm
14mm
7mm
57mm
0
2
4
6
8
RG Vaughan [mm/h]
Nov 6, 2011
Nov 13, 2011
Nov 20, 2011
Nov 27, 2011
Legend
Rain Gauge - Vaughan [mm/h]

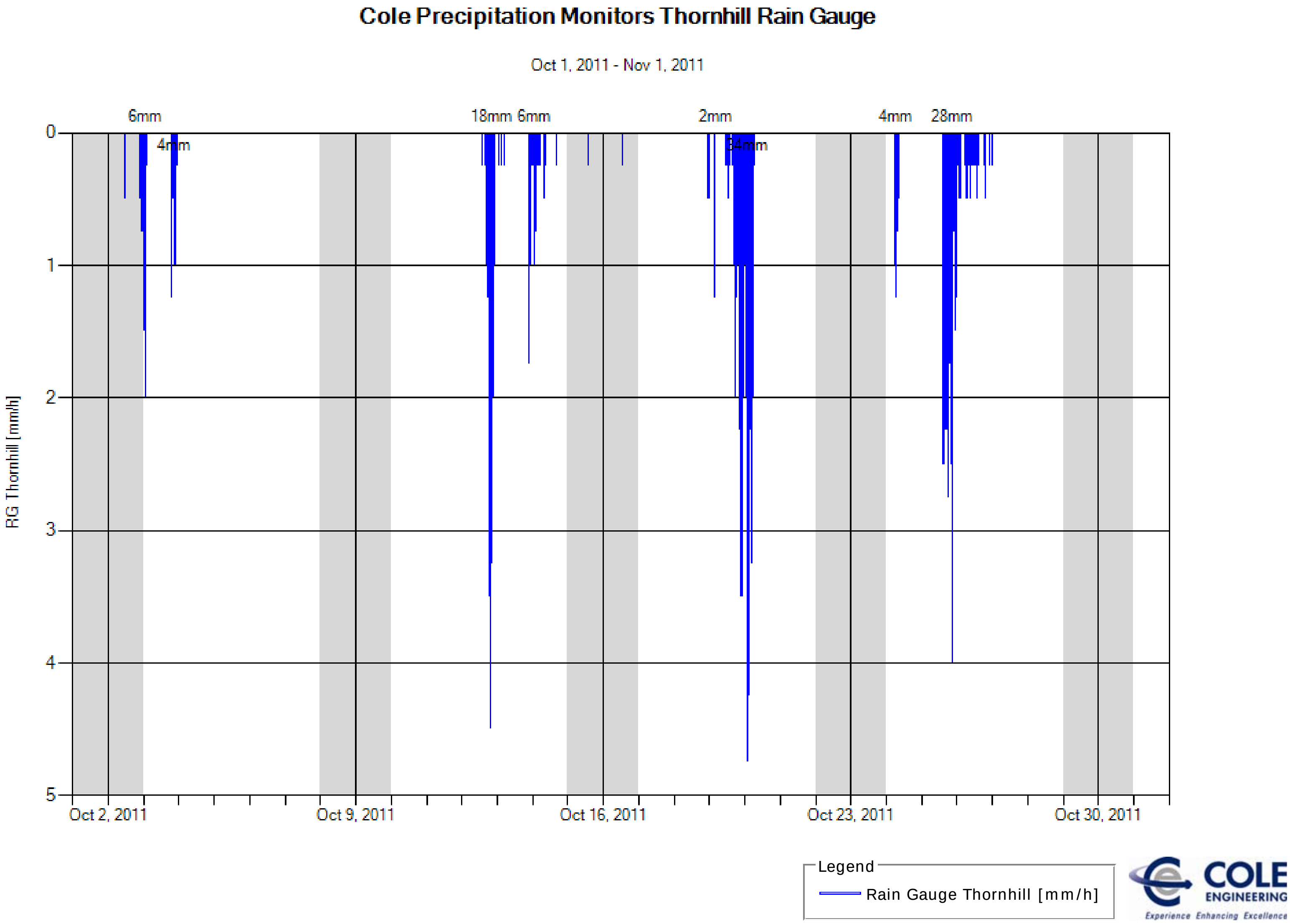

Vaughan City Wide Drainage Study Phase II RG - Vaughan Secondary School
Dec 1, 2011 - Jan 1, 2012
2mm
6mm
9mm
4mm
4mm
RG Vaughan [mm/h]
0
0.5
1
1.5
2
2.5
3
Dec 4, 2011
Dec 11, 2011
Dec 18, 2011
Dec 25, 2011
Jan 1, 2012
Legend
Rain Gauge - Vaughan [mm/h]
COLE ENGINEERING
Experience Enhancing Excellence

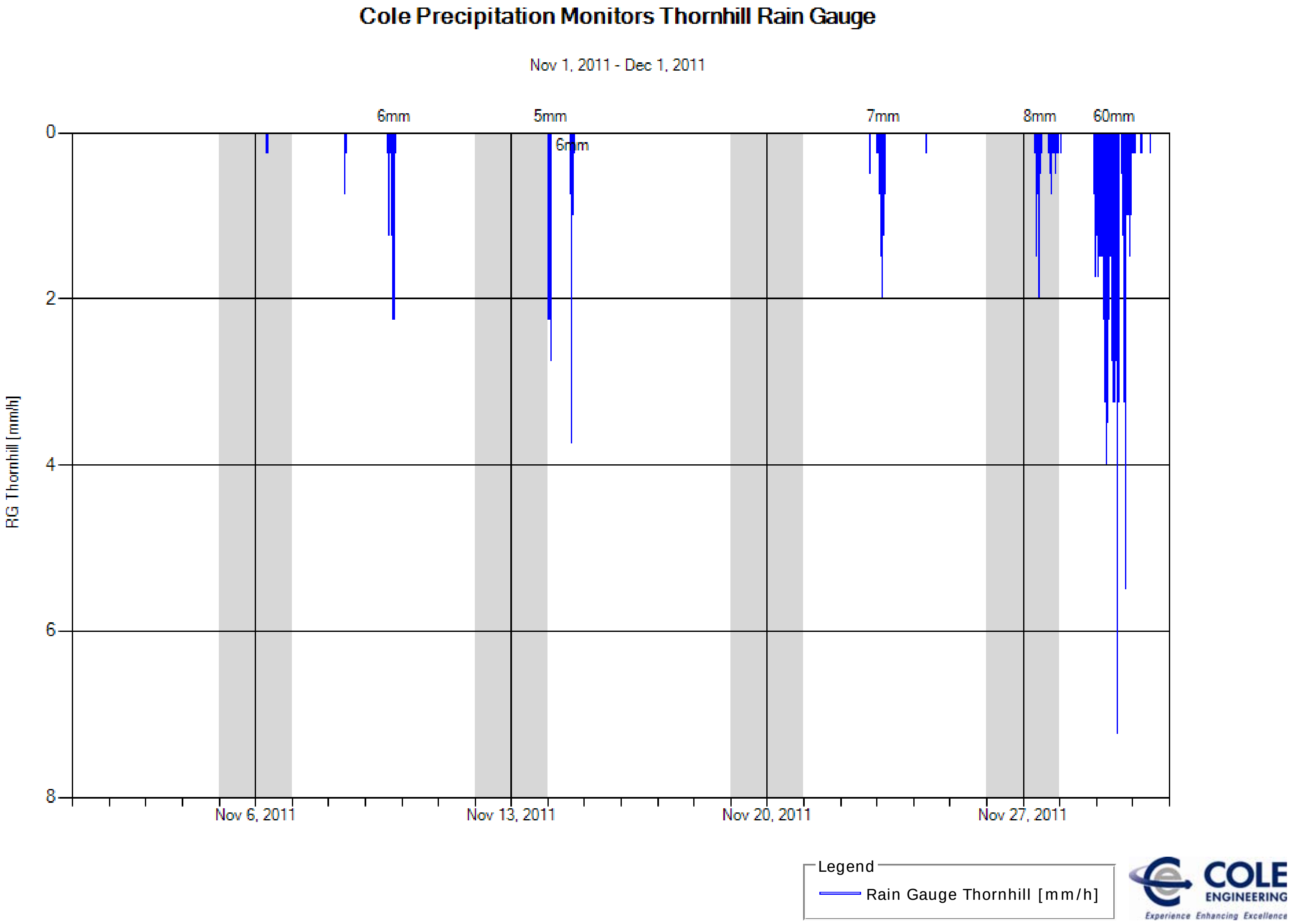

Vaughan City Wide Drainage Study Phase II RG - Vaughan Secondary School
Jan 1, 2012 - Feb 1, 2012
4mm
14mm
6mm
9mm
RG Vaughan [mm/h]
0
1
2
3
4
5
Jan 1, 2012
Jan 8, 2012
Jan 15, 2012
Jan 22, 2012
Jan 29, 2012
Legend
Rain Gauge - Vaughan [mm/h]

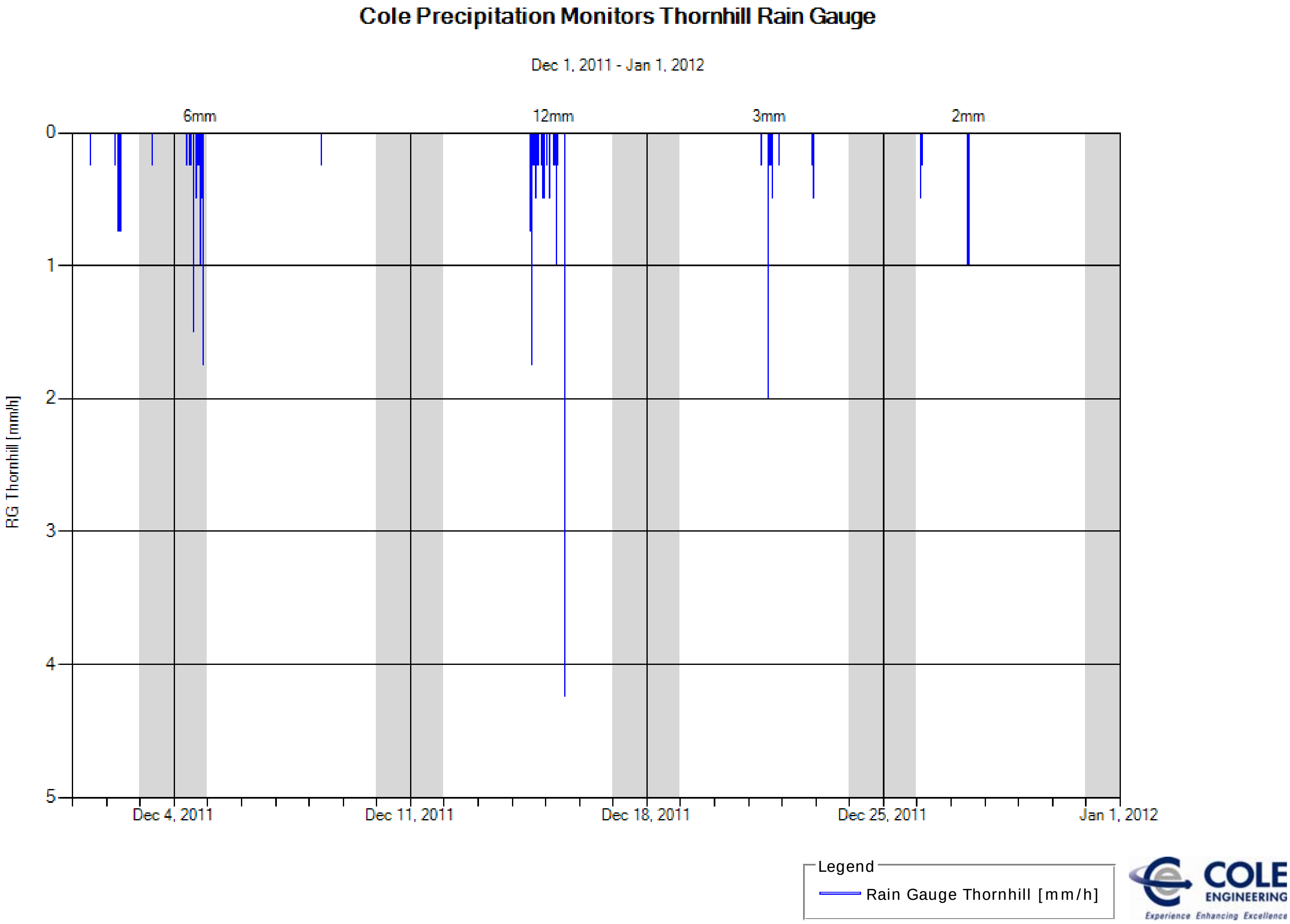


Cole Precipitation Monitors Thornhill Rain Gauge
Aug 1, 2011 - Sep 1, 2011
16mm
3mm
15mm
0
5
10
15
20
RG Thornhill [mm/h]
Aug 7, 2011
Aug 14, 2011
Aug 21, 2011
Aug 28, 2011
Legend
Rain Gauge Thornhill [mm/h]


Cole Precipitation Monitors Thornhill Rain Gauge
Sep 1, 2011 - Oct 1, 2011
2mm
2mm
8mm
2mm
19mm
8mm
33mm
4mm
0
2
4
6
8
10
12
14
RG Thornhill [mm/h]
Sep 4, 2011
Sep 11, 2011
Sep 18, 2011
Sep 25, 2011
Legend
Rain Gauge Thornhill [mm/h]
COLE ENGINEERING
Experience Enhancing Excellence

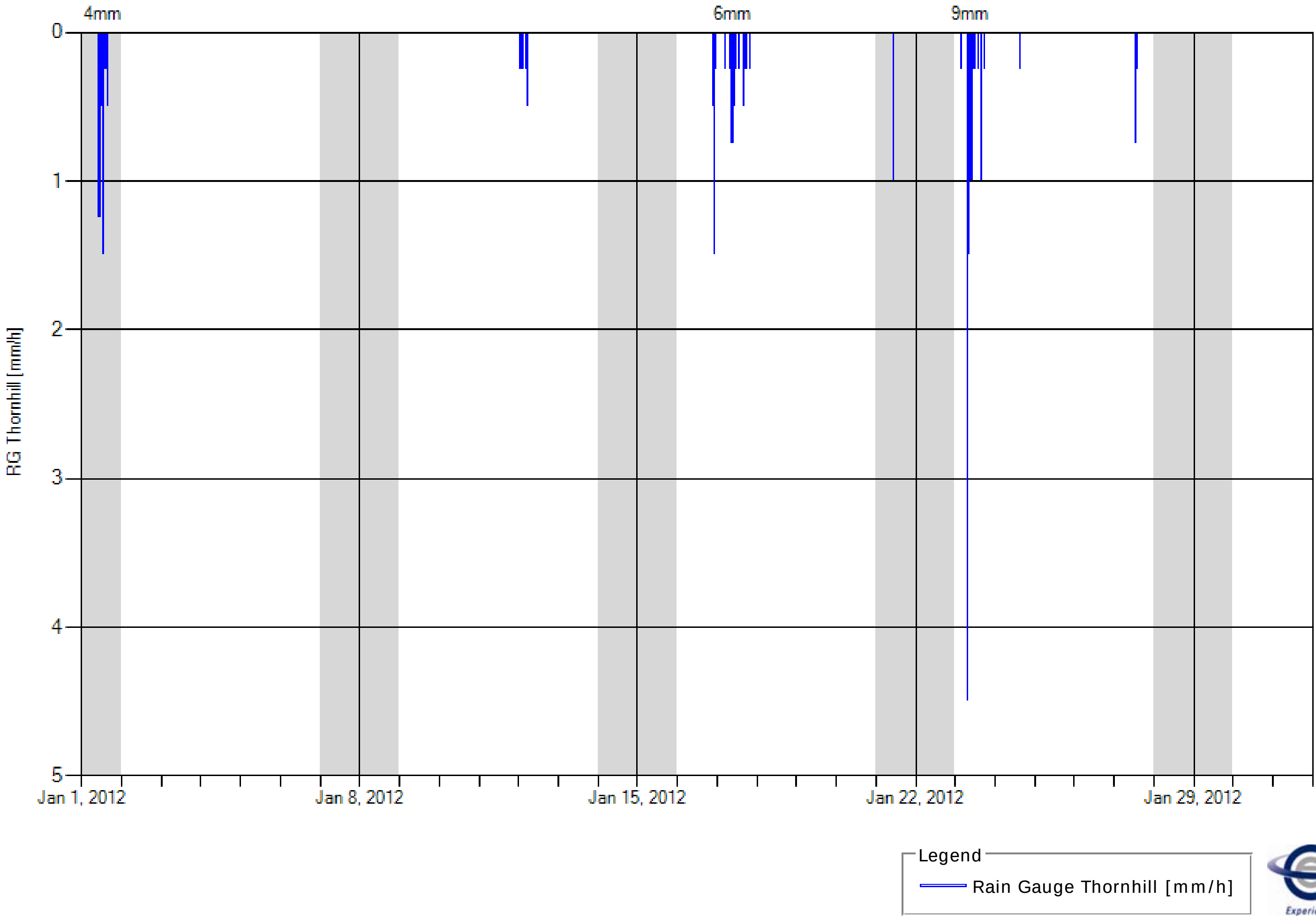

Cole Precipitation Monitors Thornhill Rain Gauge
Oct 1, 2011 - Nov 1, 2011
6mm
4mm
18mm
6mm
2mm
34mm
4mm
28mm
0
1
2
3
4
5
RG Thornhill [mm/h]
Oct 2, 2011
Oct 9, 2011
Oct 16, 2011
Oct 23, 2011
Oct 30, 2011
Legend
Rain Gauge Thornhill [mm/h]
COLE ENGINEERING
Experience Enhancing Excellence

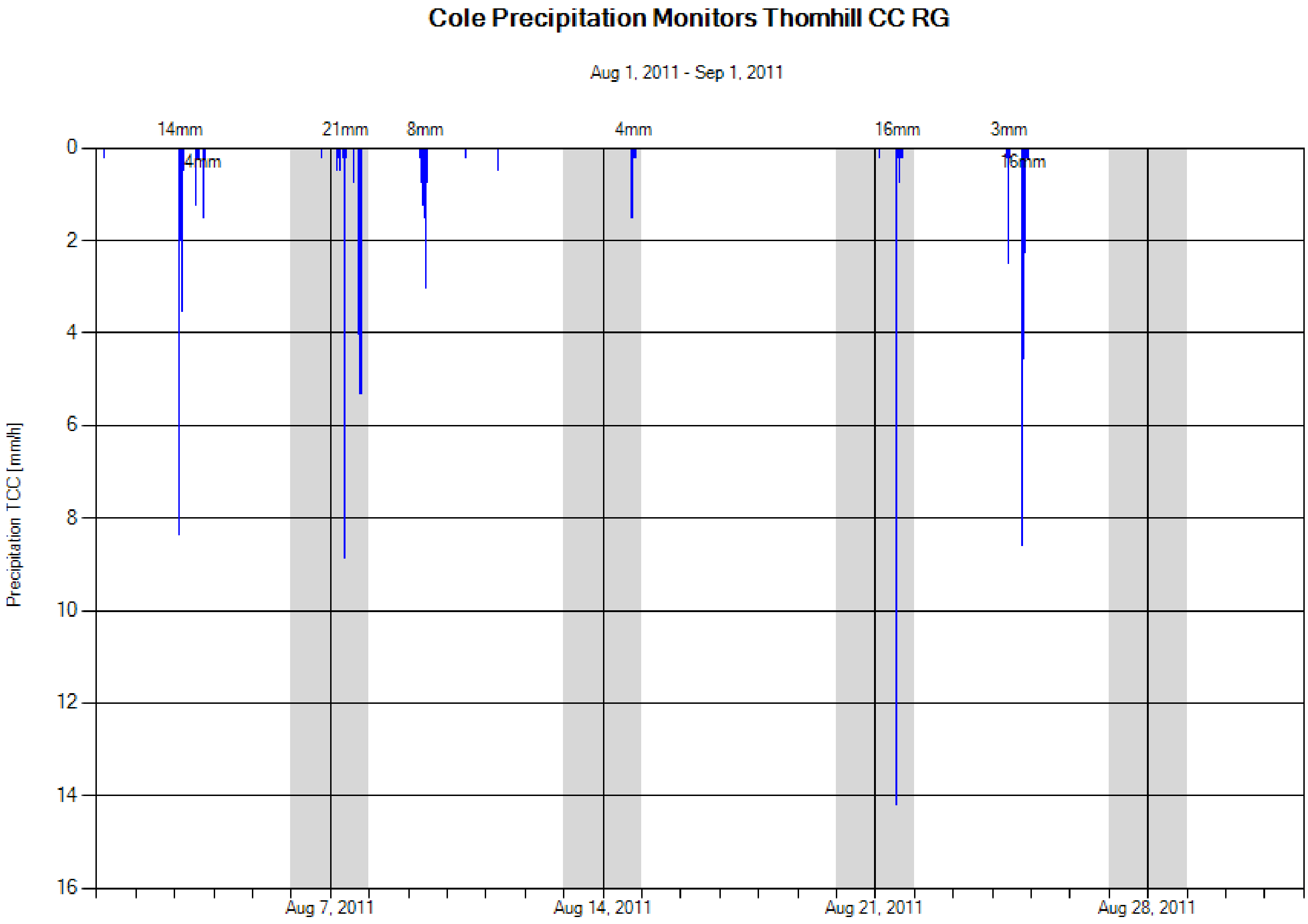

Cole Precipitation Monitors Thornhill Rain Gauge
Nov 1, 2011 - Dec 1, 2011
6mm
5mm
6mm
7mm
8mm
60mm
RG Thornhill [mm/h]
0
2
4
6
8
Nov 6, 2011
Nov 13, 2011
Nov 20, 2011
Nov 27, 2011
Legend
Rain Gauge Thornhill [mm/h]
COLE ENGINEERING
Experience Enhancing Excellence

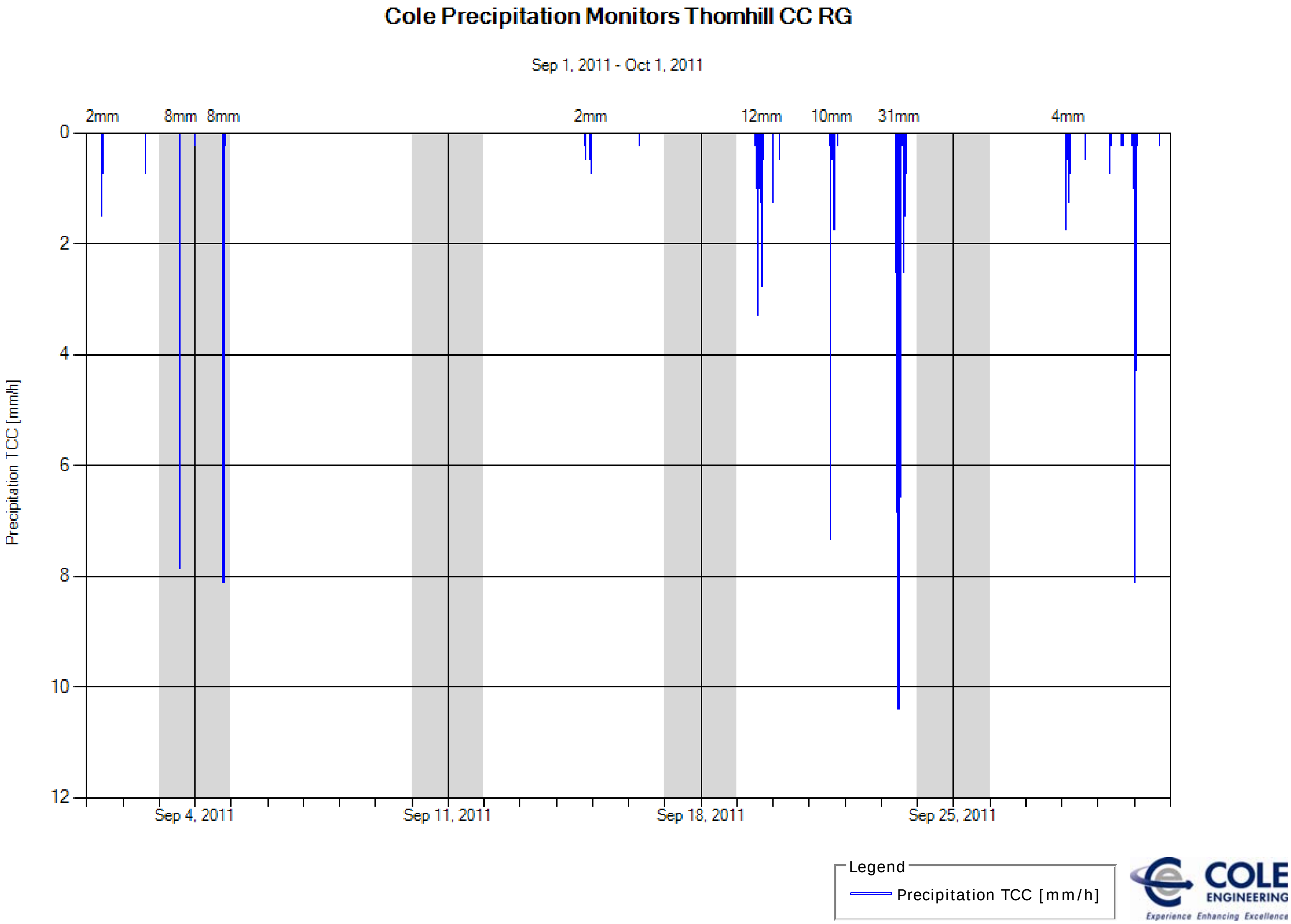

Cole Precipitation Monitors Thornhill Rain Gauge
Dec 1, 2011 - Jan 1, 2012
6mm
12mm
3mm
2mm
RG Thornhill [mm/h]
0
1
2
3
4
5
Dec 4, 2011
Dec 11, 2011
Dec 18, 2011
Dec 25, 2011
Jan 1, 2012
Legend
Rain Gauge Thornhill [mm/h]
COLE ENGINEERING
Experience Enhancing Excellence

Cole Precipitation Monitors Thornhill Rain Gauge

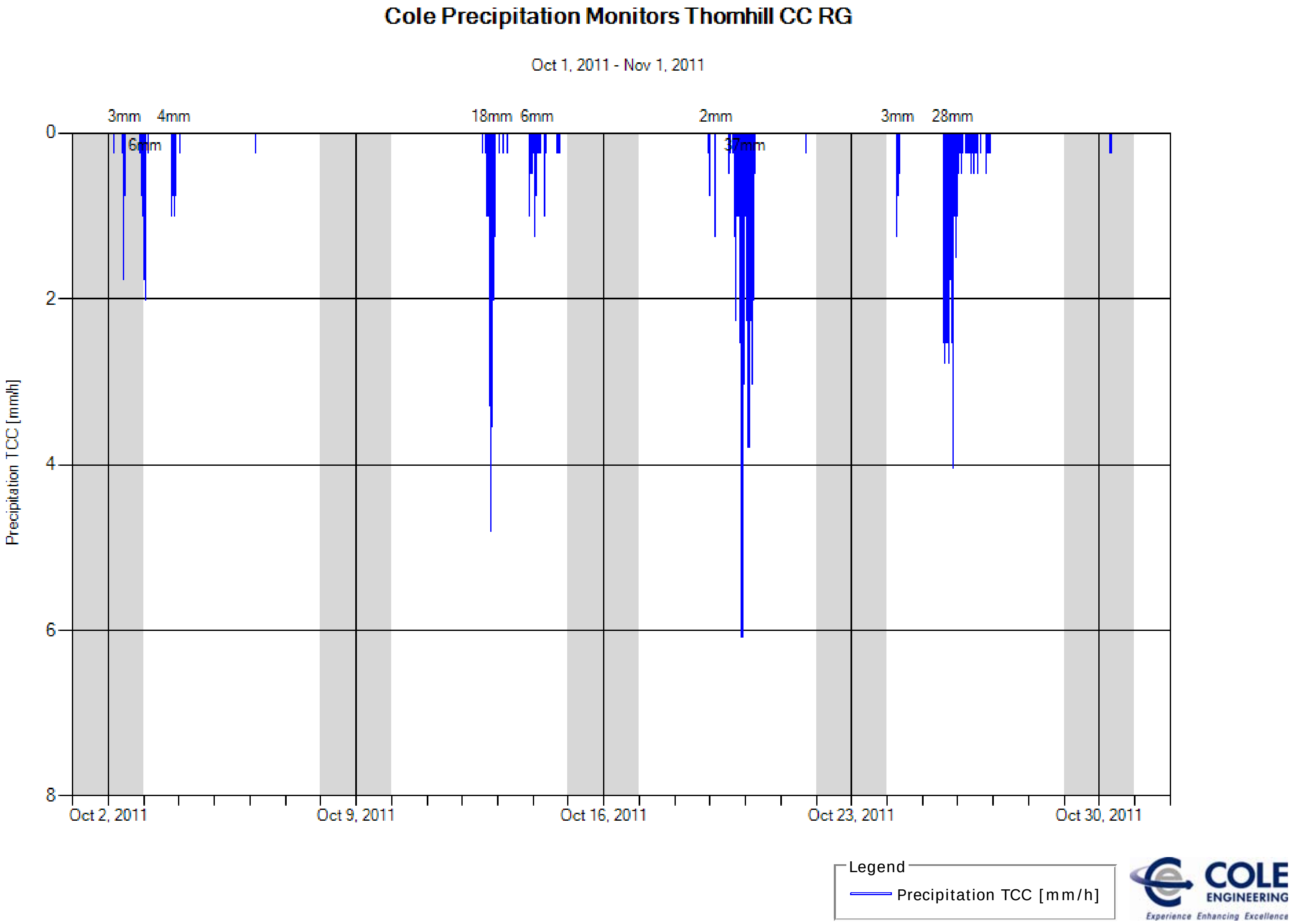
Jan 1, 2012 - Feb 1, 2012

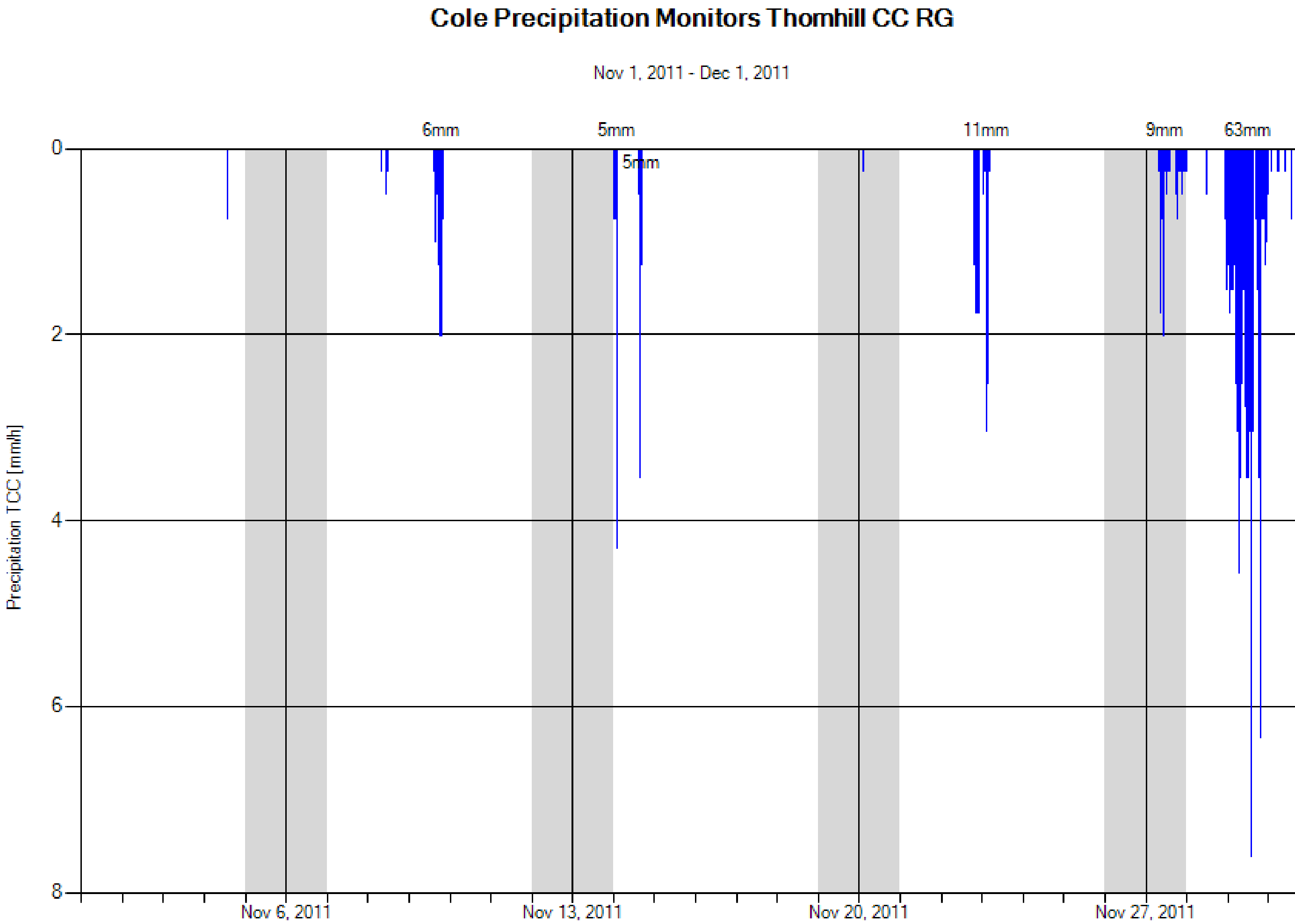



Cole Precipitation Monitors Thornhill CC RG
Aug 1, 2011 - Sep 1, 2011
14mm
4mm
21mm
8mm
4mm
16mm
3mm
16mm
Precipitation TCC [mm/h]
0
2
4
6
8
10
12
14
16
Aug 7, 2011
Aug 14, 2011
Aug 21, 2011
Aug 28, 2011
Legend
Precipitation TCC [mm/h]

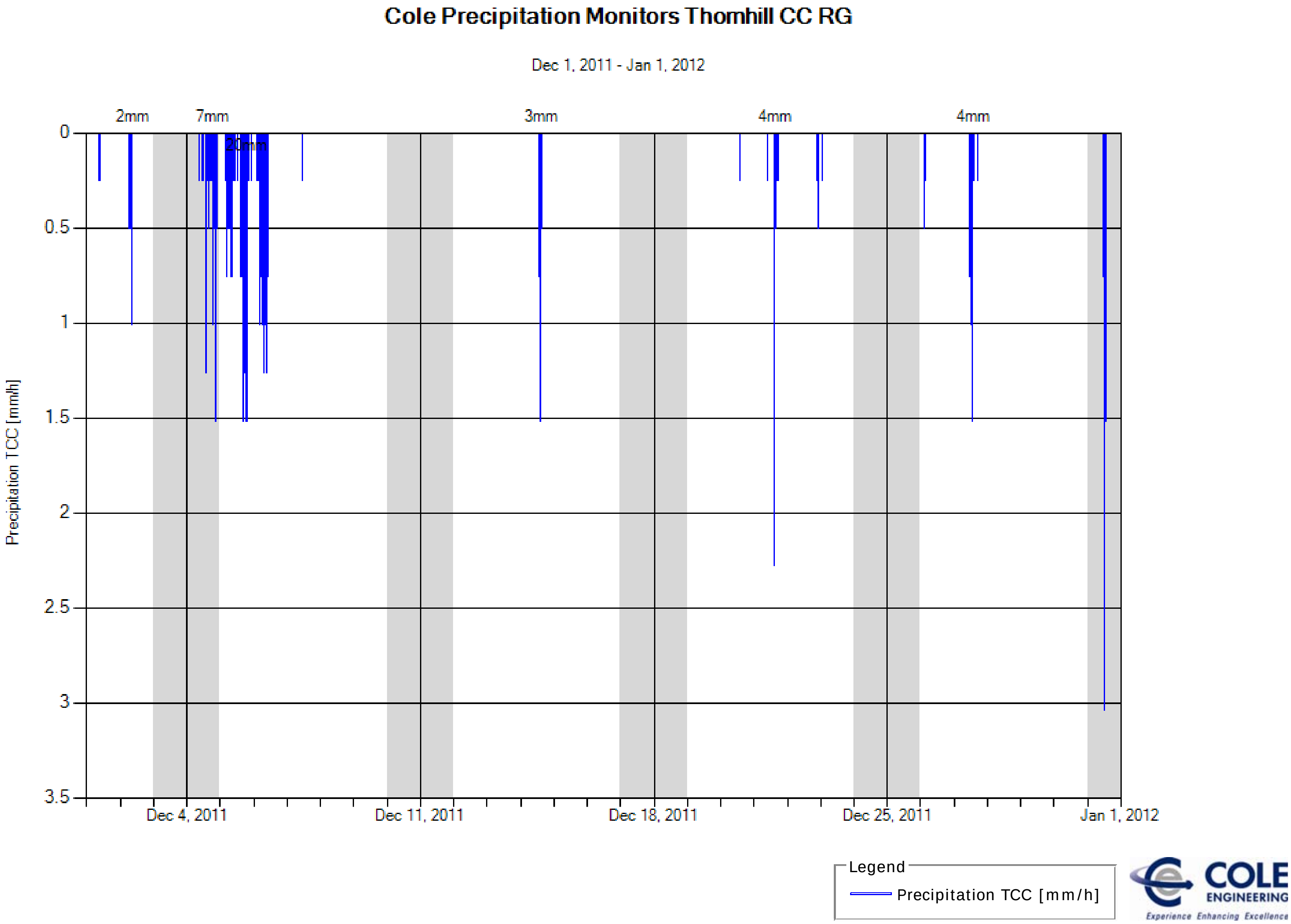


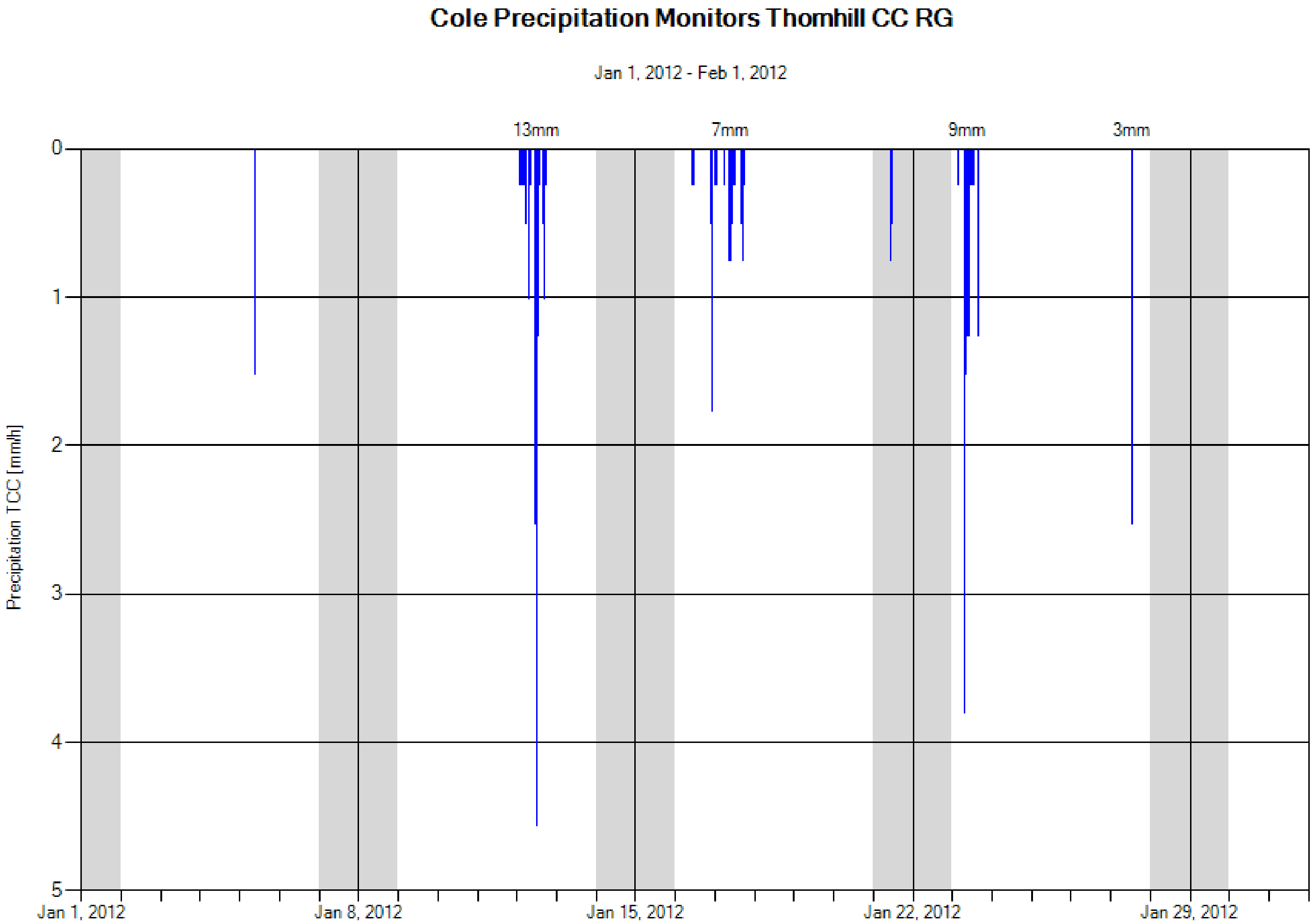
Cole Precipitation Monitors Thornhill CC RG
Sep 1, 2011 - Oct 1, 2011
2mm
8mm
8mm
2mm
12mm
10mm
31mm
4mm
0
2
4
6
8
10
12
Precipitation TCC [mm/h]
Sep 4, 2011
Sep 11, 2011
Sep 18, 2011
Sep 25, 2011
Legend
Precipitation TCC [mm/h]
COLE ENGINEERING
Experience Enhancing Excellence

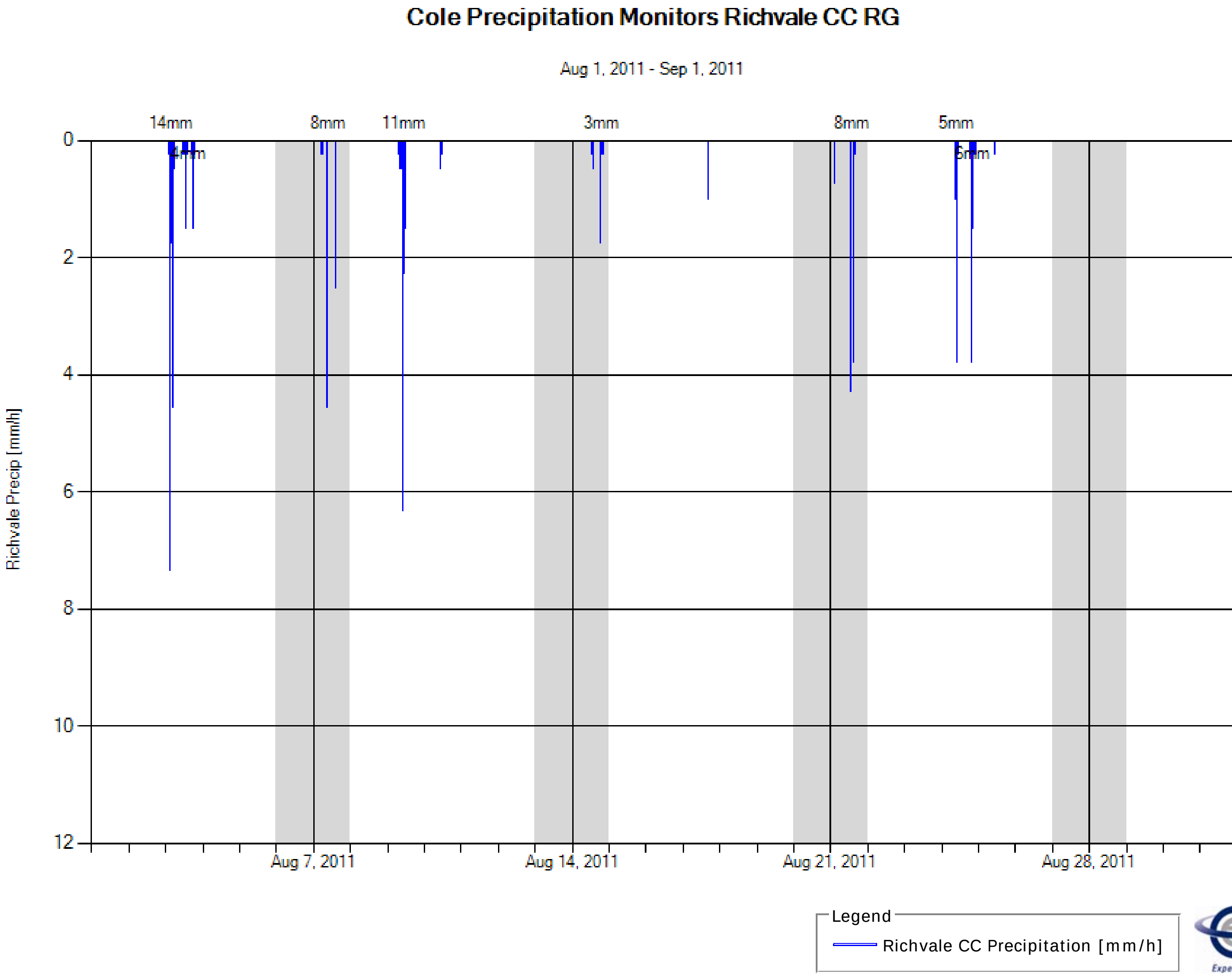

Cole Precipitation Monitors Thornhill CC RG
Oct 1, 2011 - Nov 1, 2011
Precipitation TCC [mm/h]
3mm
4mm
6mm
18mm
6mm
2mm
37mm
3mm
28mm
0
2
4
6
8
Oct 2, 2011
Oct 9, 2011
Oct 16, 2011
Oct 23, 2011
Oct 30, 2011
Legend
Precipitation TCC [mm/h]



Cole Precipitation Monitors Thornhill CC RG
Nov 1, 2011 - Dec 1, 2011
6mm
5mm
5mm
11mm
9mm
63mm
0
2
4
6
8
Precipitation TCC [mm/h]
Nov 6, 2011
Nov 13, 2011
Nov 20, 2011
Nov 27, 2011
Legend
Precipitation TCC [mm/h]

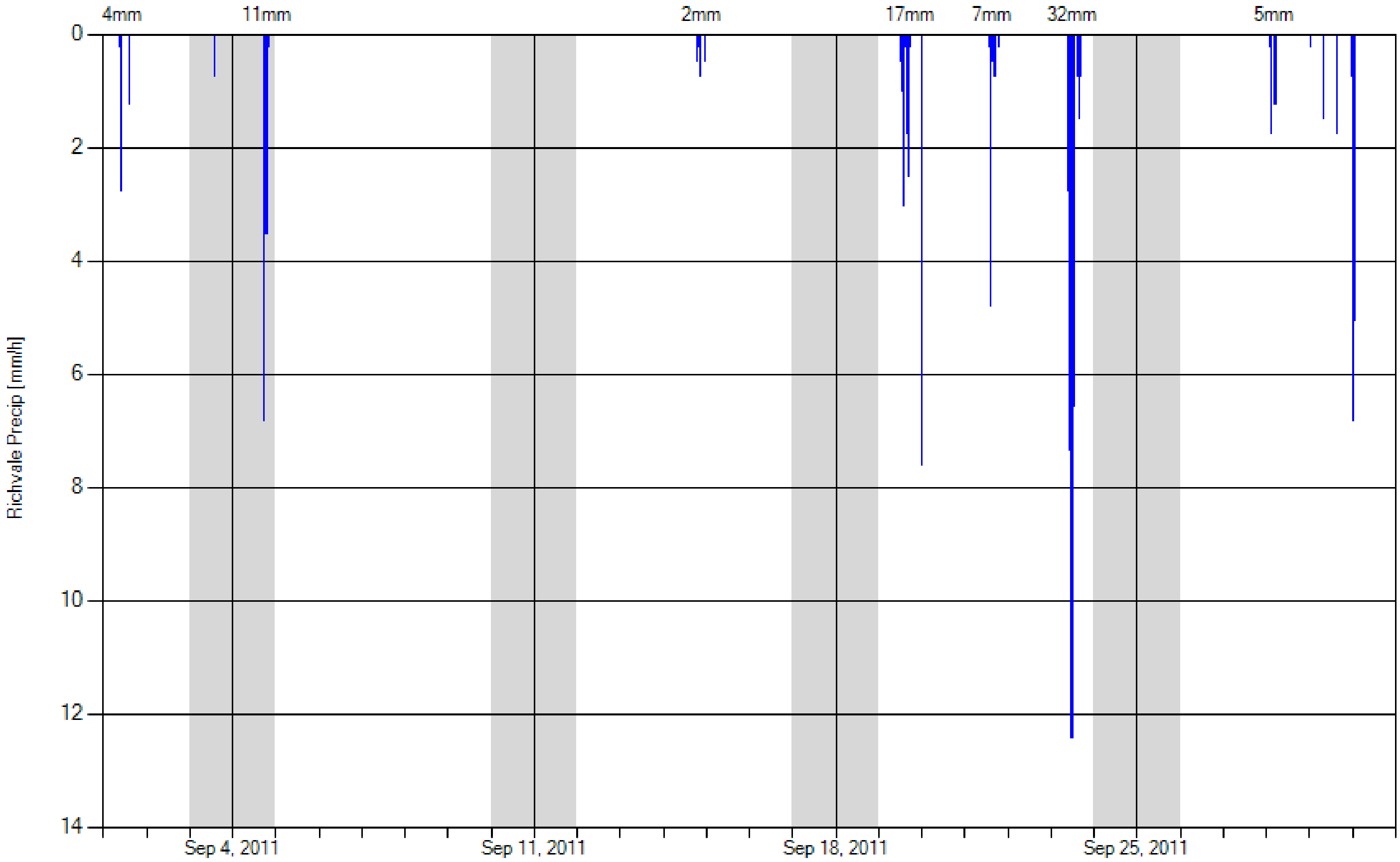

Cole Precipitation Monitors Thornhill CC RG
Dec 1, 2011 - Jan 1, 2012
2mm
7mm
20mm
3mm
4mm
4mm
0
0.5
1
1.5
2
2.5
3
3.5
Precipitation TCC [mm/h]
Dec 4, 2011
Dec 11, 2011
Dec 18, 2011
Dec 25, 2011
Jan 1, 2012
Legend
Precipitation TCC [mm/h]


Cole Precipitation Monitors Thornhill CC RG
Jan 1, 2012 - Feb 1, 2012
13mm
7mm
9mm
3mm
Precipitation TCC [mm/h]
0
1
2
3
4
5
Jan 1, 2012
Jan 8, 2012
Jan 15, 2012
Jan 22, 2012
Jan 29, 2012
Legend
Precipitation TCC [mm/h]


Cole Precipitation Monitors Richvale CC RG
Aug 1, 2011 - Sep 1, 2011
14mm
4mm
8mm
11mm
3mm
8mm
5mm
6mm
Richvale Precip [mm/h]
0
2
4
6
8
10
12
Aug 7, 2011
Aug 14, 2011
Aug 21, 2011
Aug 28, 2011
Legend
Richvale CC Precipitation [mm/h]

Cole Precipitation Monitors Richvale CC RG

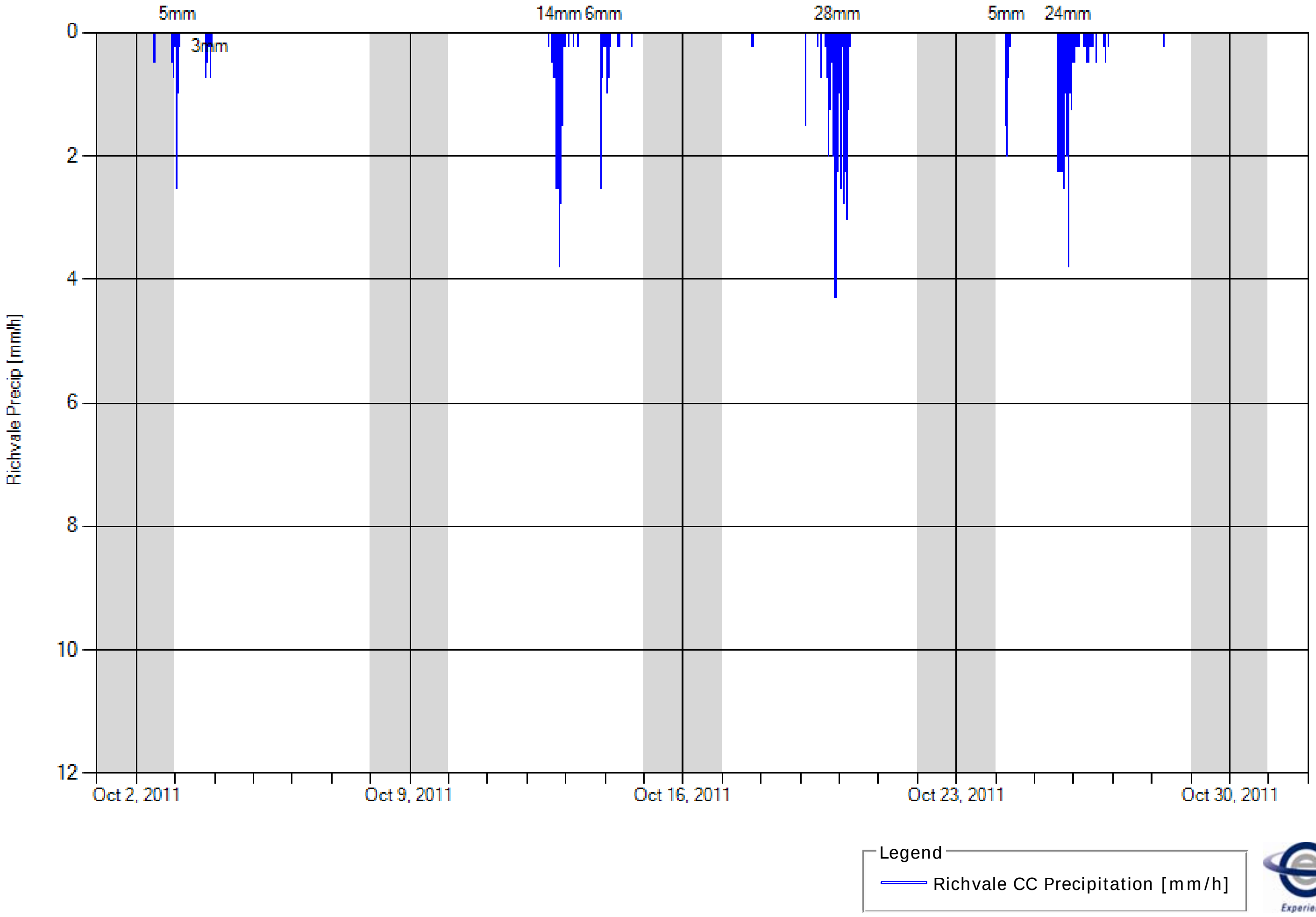
Sep 1, 2011 - Oct 1, 2011

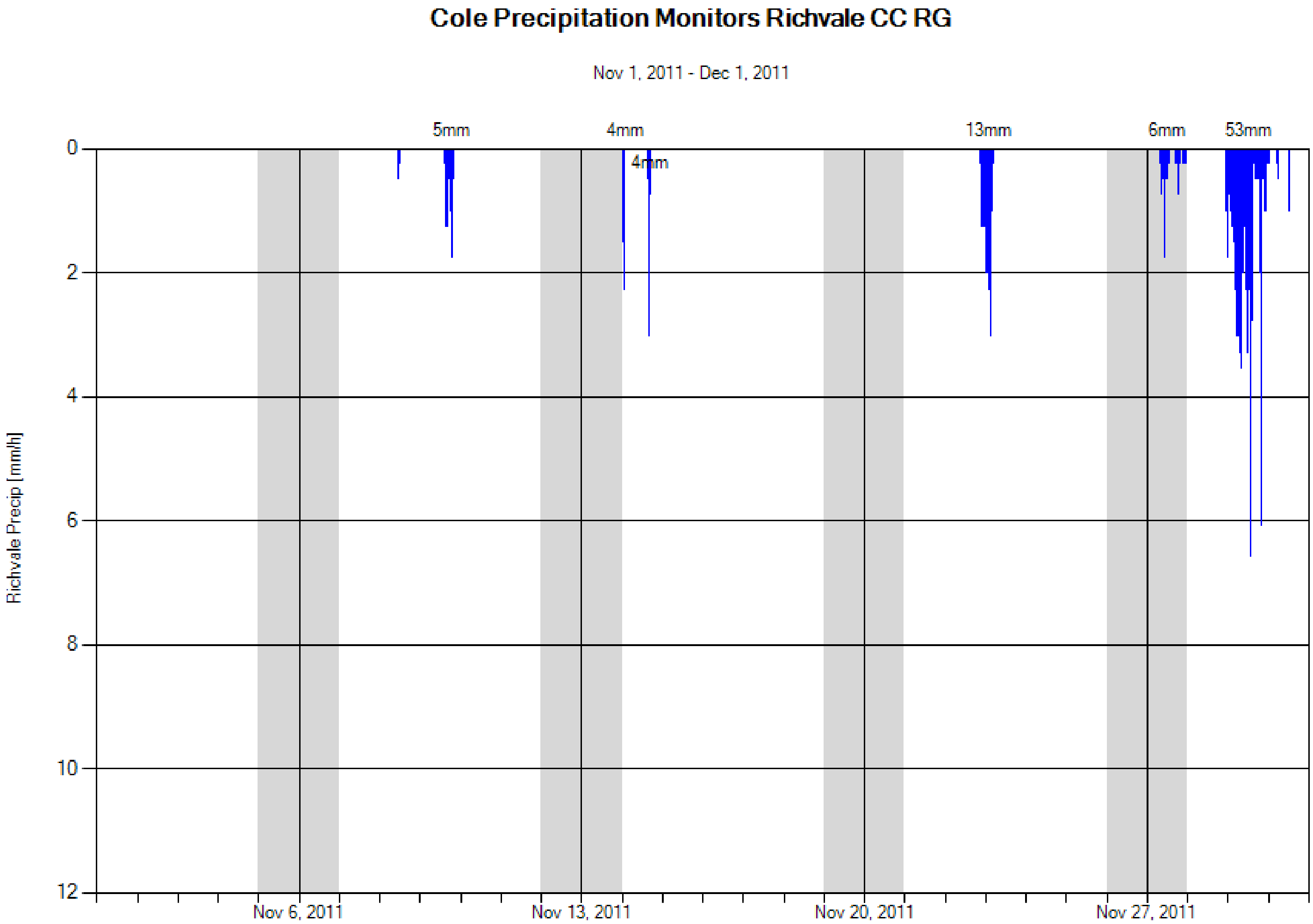


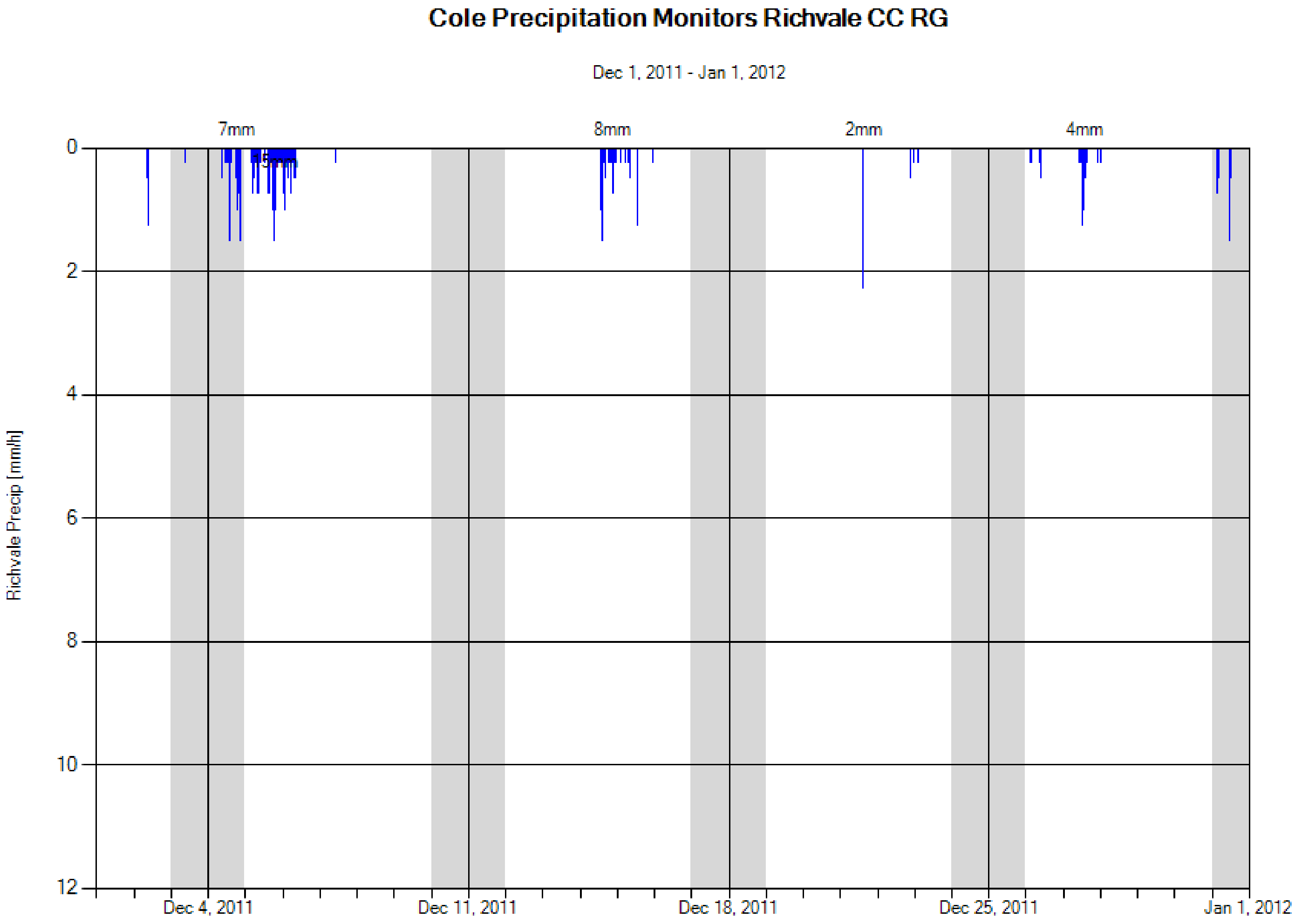
Legend
Richvale CC Precipitation [mm/h]

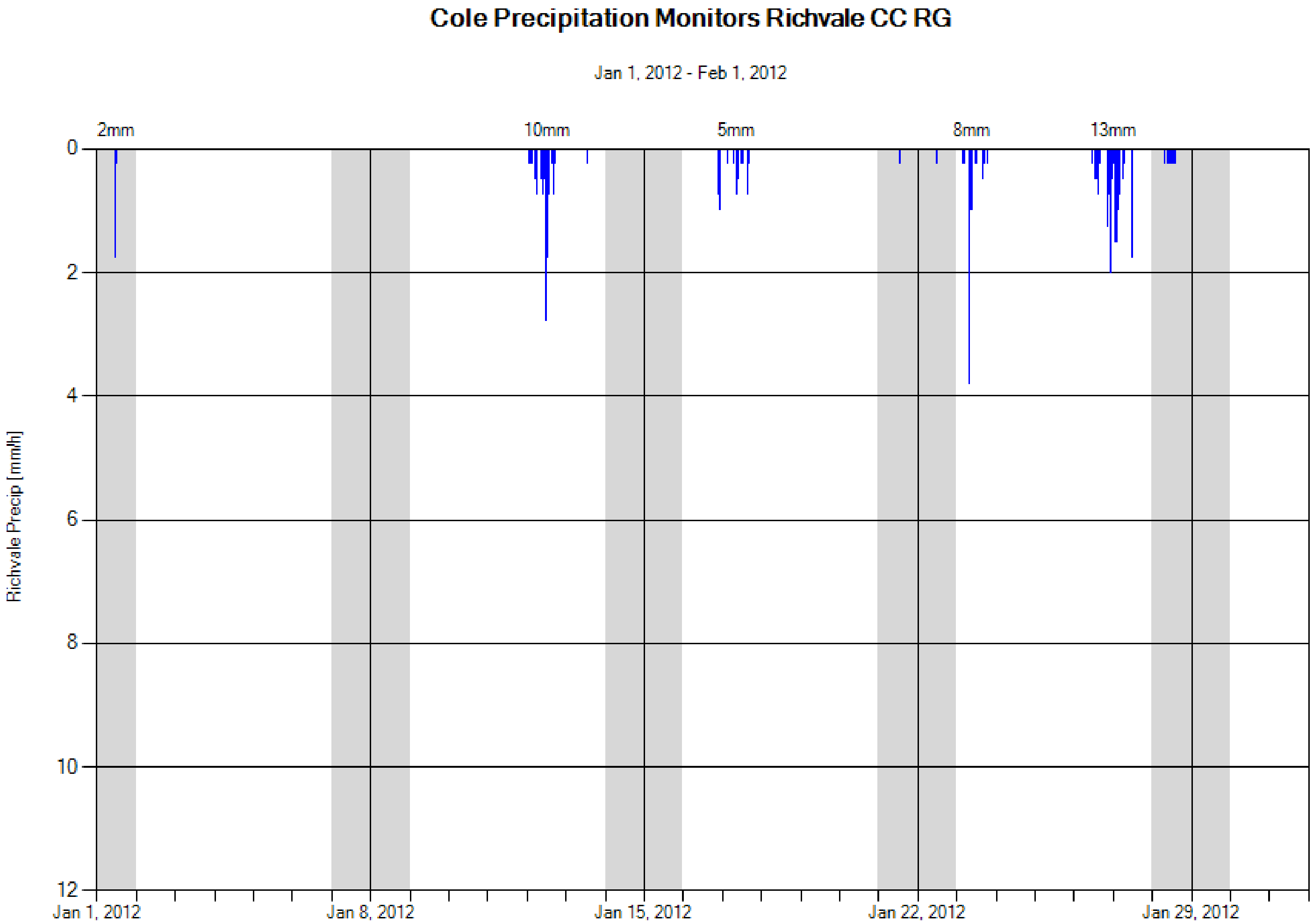
Cole Precipitation Monitors Richvale CC RG

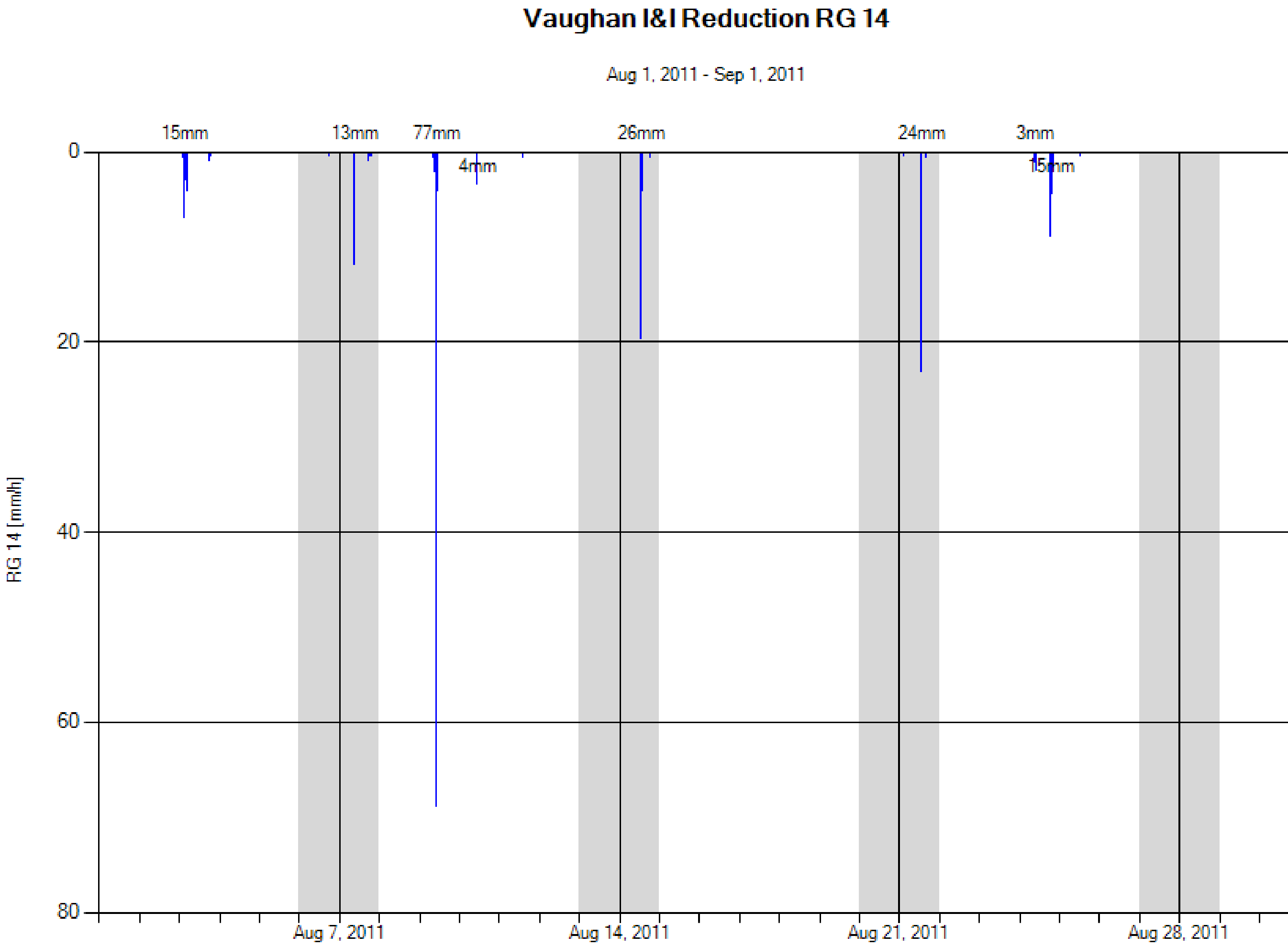
Oct 1, 2011 - Nov 1, 2011

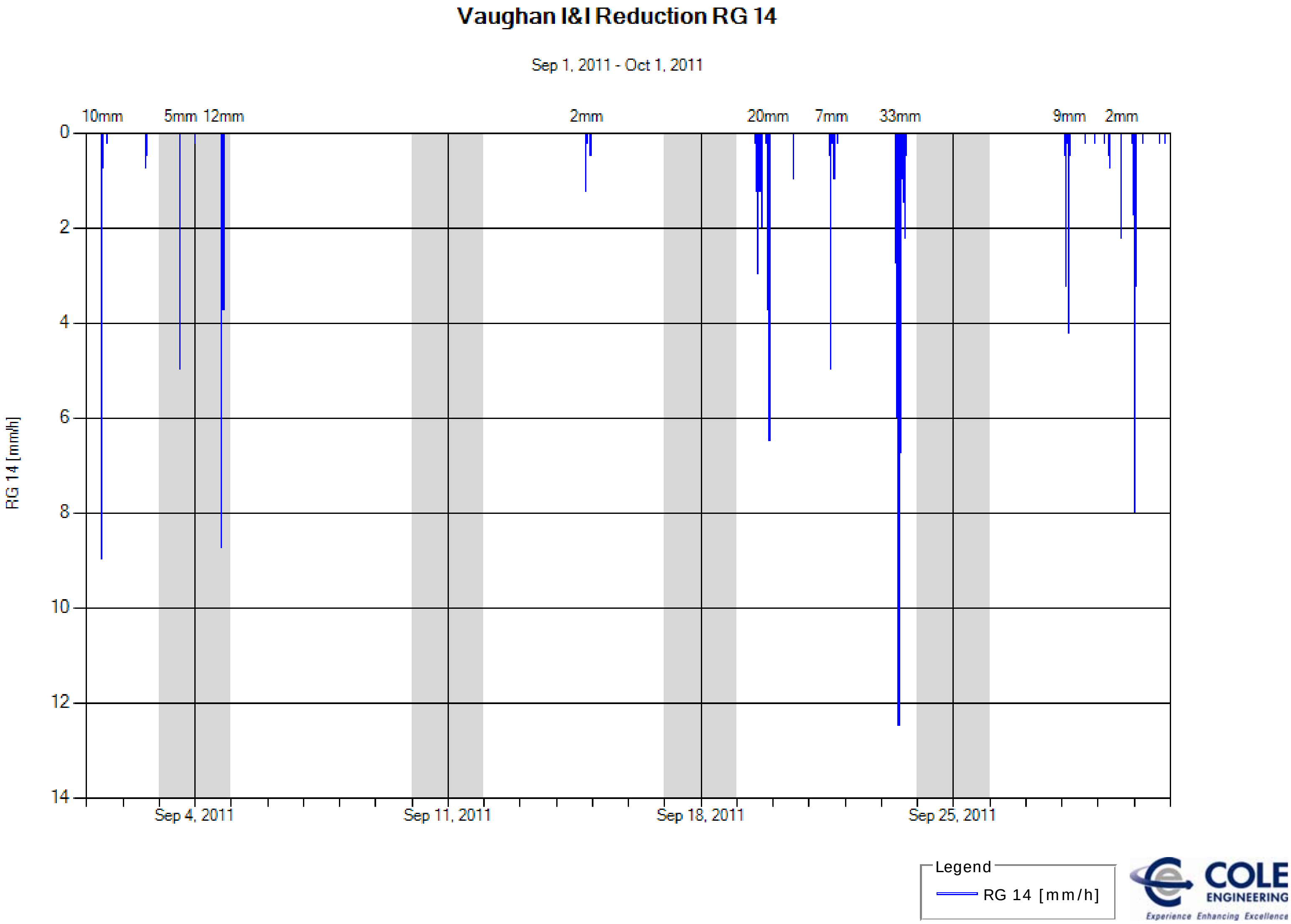


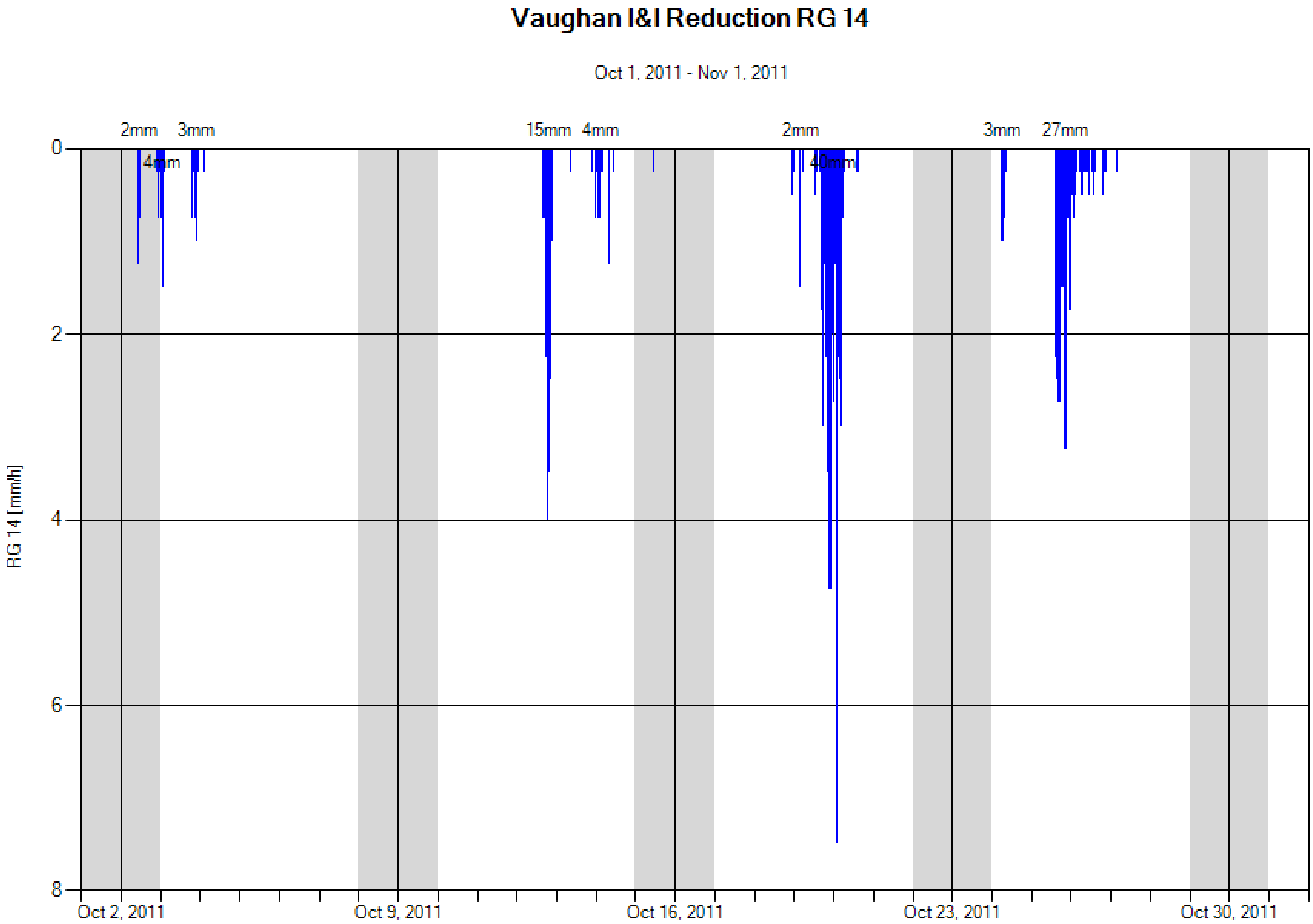

Cole Precipitation Monitors Richvale CC RG
Nov 1, 2011 - Dec 1, 2011
5mm
4mm
4mm
13mm
6mm
53mm
Richvale Precip [mm/h]
0
2
4
6
8
10
12
Nov 6, 2011
Nov 13, 2011
Nov 20, 2011
Nov 27, 2011
Legend
Richvale CC Precipitation [mm/h]


Cole Precipitation Monitors Richvale CC RG
Dec 1, 2011 - Jan 1, 2012
7mm
8mm
2mm
4mm
Richvale Precip [mm/h]
0
2
4
6
8
10
12
Dec 4, 2011
Dec 11, 2011
Dec 18, 2011
Dec 25, 2011
Jan 1, 2012
Legend
Richvale CC Precipitation [mm/h]


Cole Precipitation Monitors Richvale CC RG
Jan 1, 2012 - Feb 1, 2012
2mm
10mm
5mm
8mm
13mm
Richvale Precip [mm/h]
0
2
4
6
8
10
12
Jan 1, 2012
Jan 8, 2012
Jan 15, 2012
Jan 22, 2012
Jan 29, 2012
Legend
Richvale CC Precipitation [mm/h]

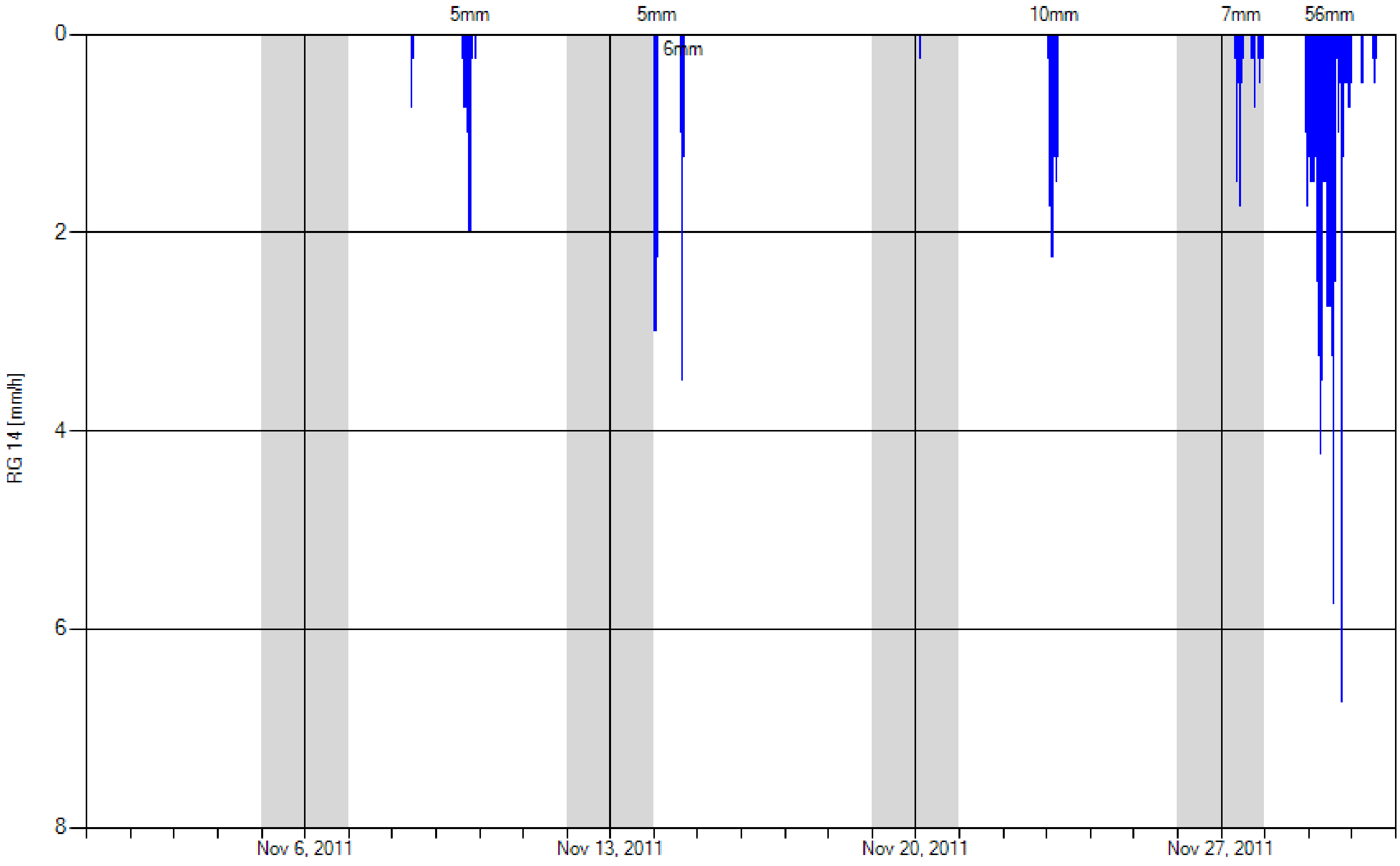

Vaughan I&I Reduction RG 14
Aug 1, 2011 - Sep 1, 2011
15mm
13mm
77mm
4mm
26mm
24mm
3mm
15mm
0
20
40
60
80
RG 14 [mm/h]
Aug 7, 2011
Aug 14, 2011
Aug 21, 2011
Aug 28, 2011
Legend
RG 14 [mm/h]


Vaughan I&I Reduction RG 14
Sep 1, 2011 - Oct 1, 2011
10mm
5mm
12mm
2mm
20mm
7mm
33mm
9mm
2mm
0
2
4
6
8
10
12
14
RG 14 [mm/h]
Sep 4, 2011
Sep 11, 2011
Sep 18, 2011
Sep 25, 2011
Legend
RG 14 [mm/h]
COLE ENGINEERING
Experience Enhancing Excellence


Vaughan I&I Reduction RG 14
Oct 1, 2011 - Nov 1, 2011
2mm
4mm
3mm
15mm
4mm
2mm
40mm
3mm
27mm
0
2
4
6
8
RG 14 [mm/h]
Oct 2, 2011
Oct 9, 2011
Oct 16, 2011
Oct 23, 2011
Oct 30, 2011
Legend
RG 14 [mm/h]

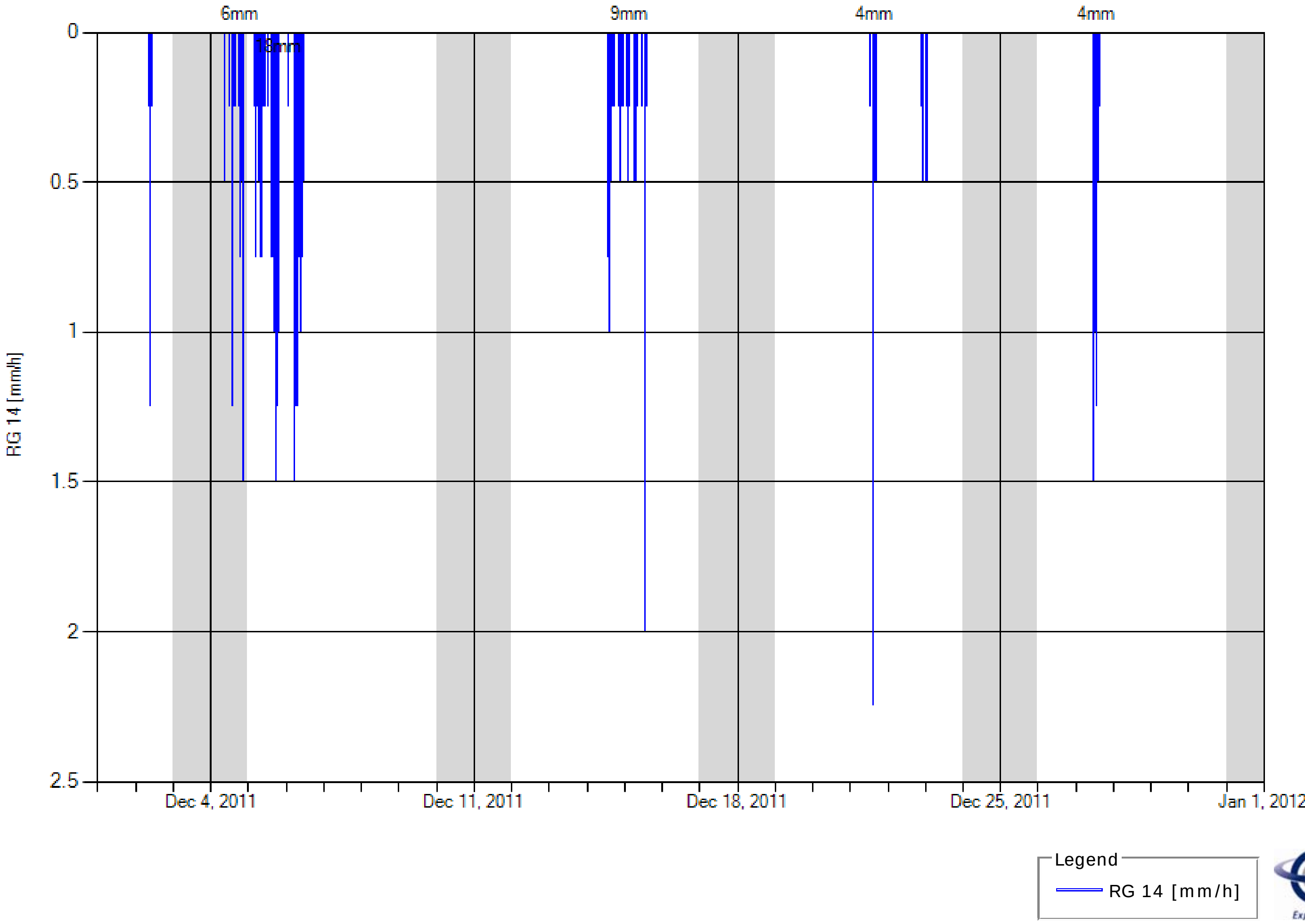
Vaughan I&I Reduction RG 14

Nov 1, 2011 - Dec 1, 2011



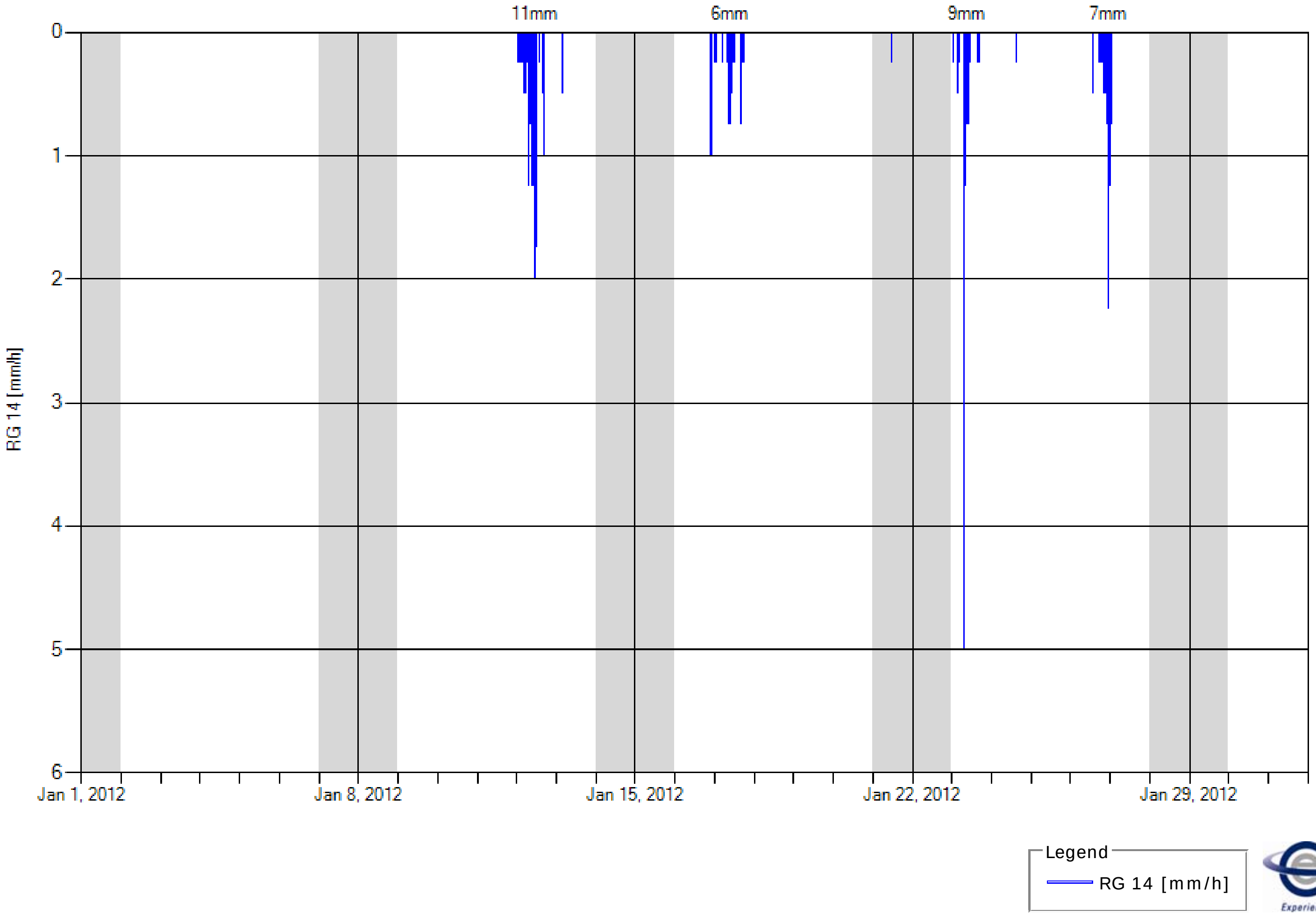
Vaughan I&I Reduction RG 14

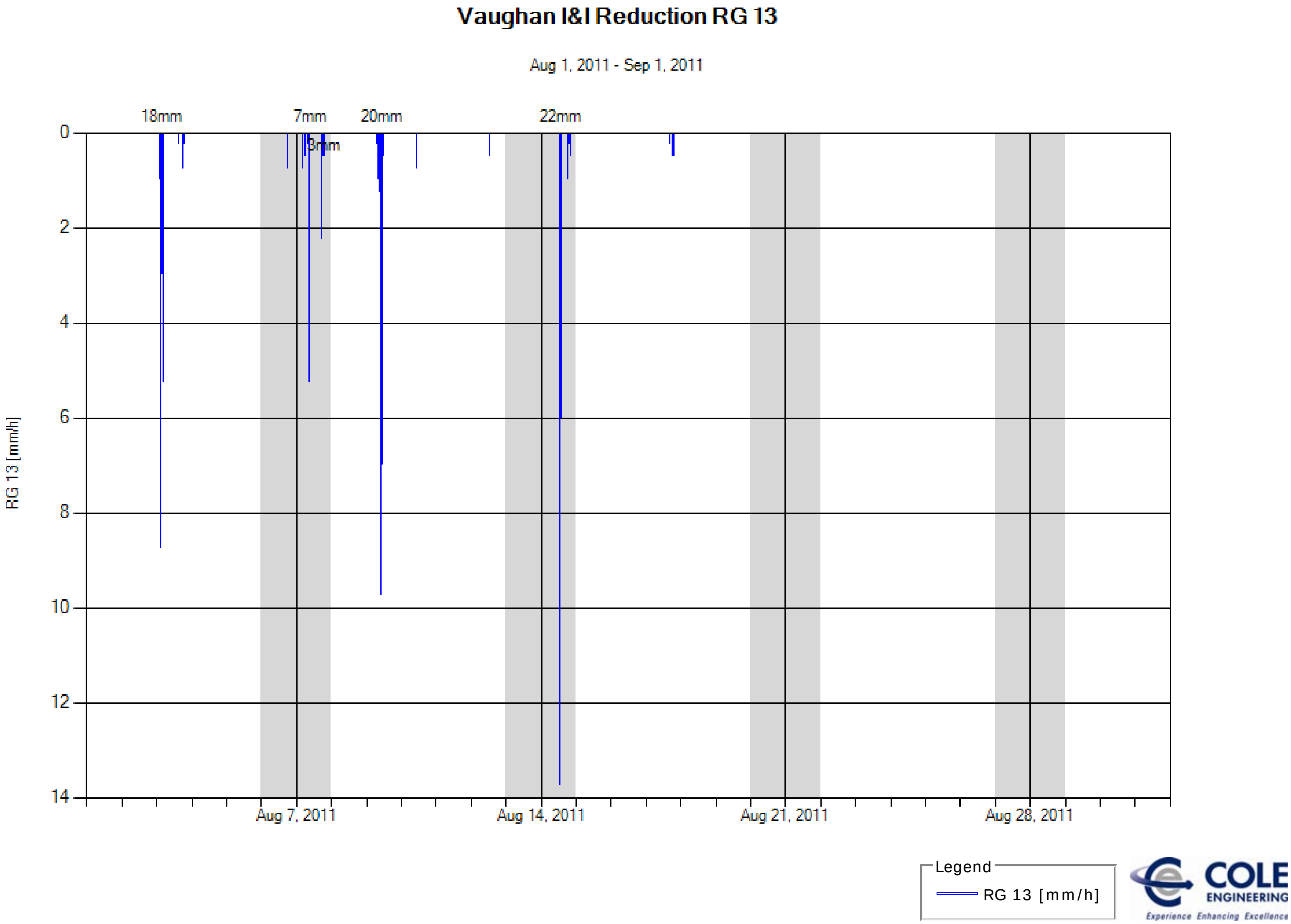
Dec 1, 2011 - Jan 1, 2012

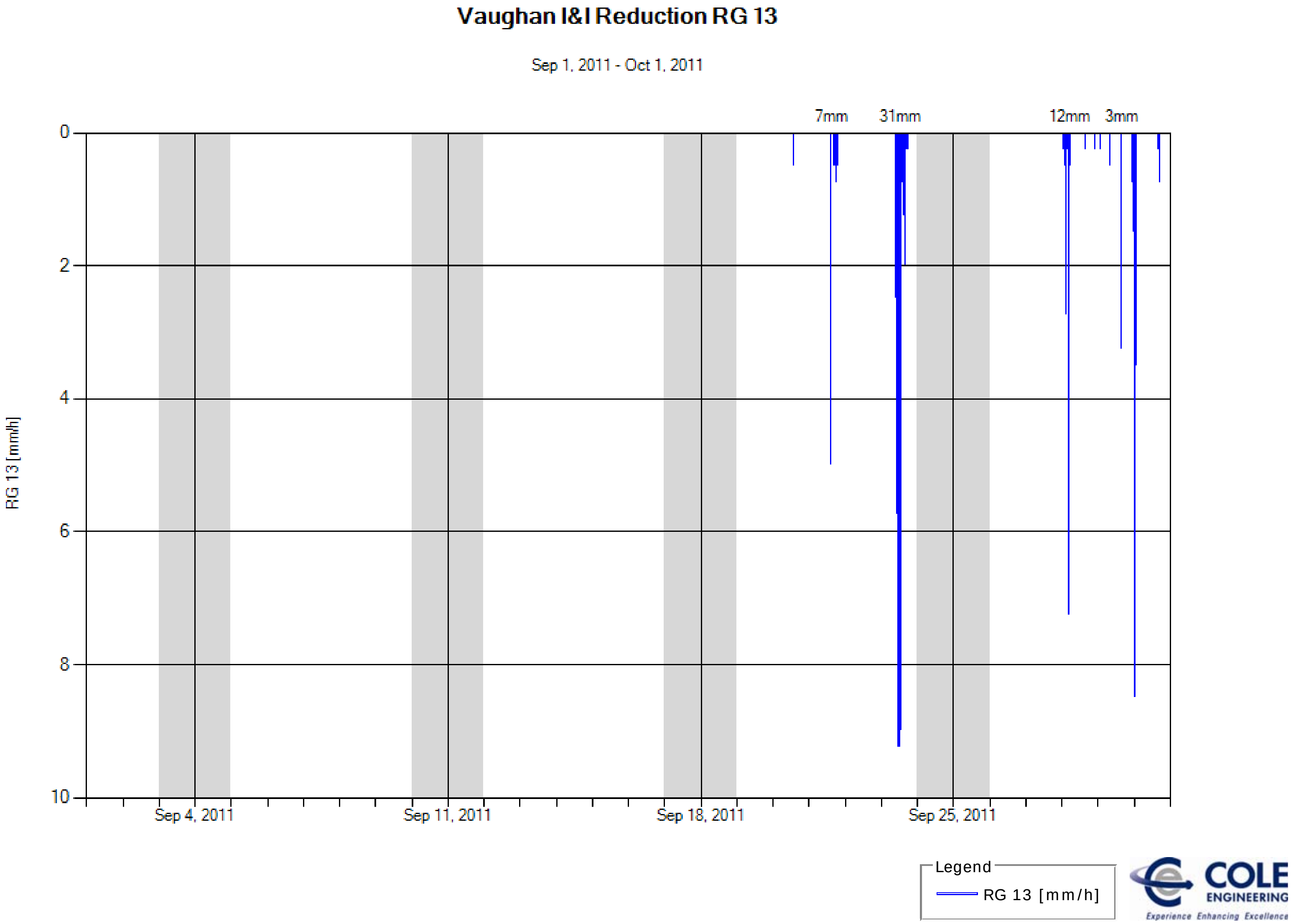


Vaughan I&I Reduction RG 14

Jan 1, 2012 - Feb 1, 2012

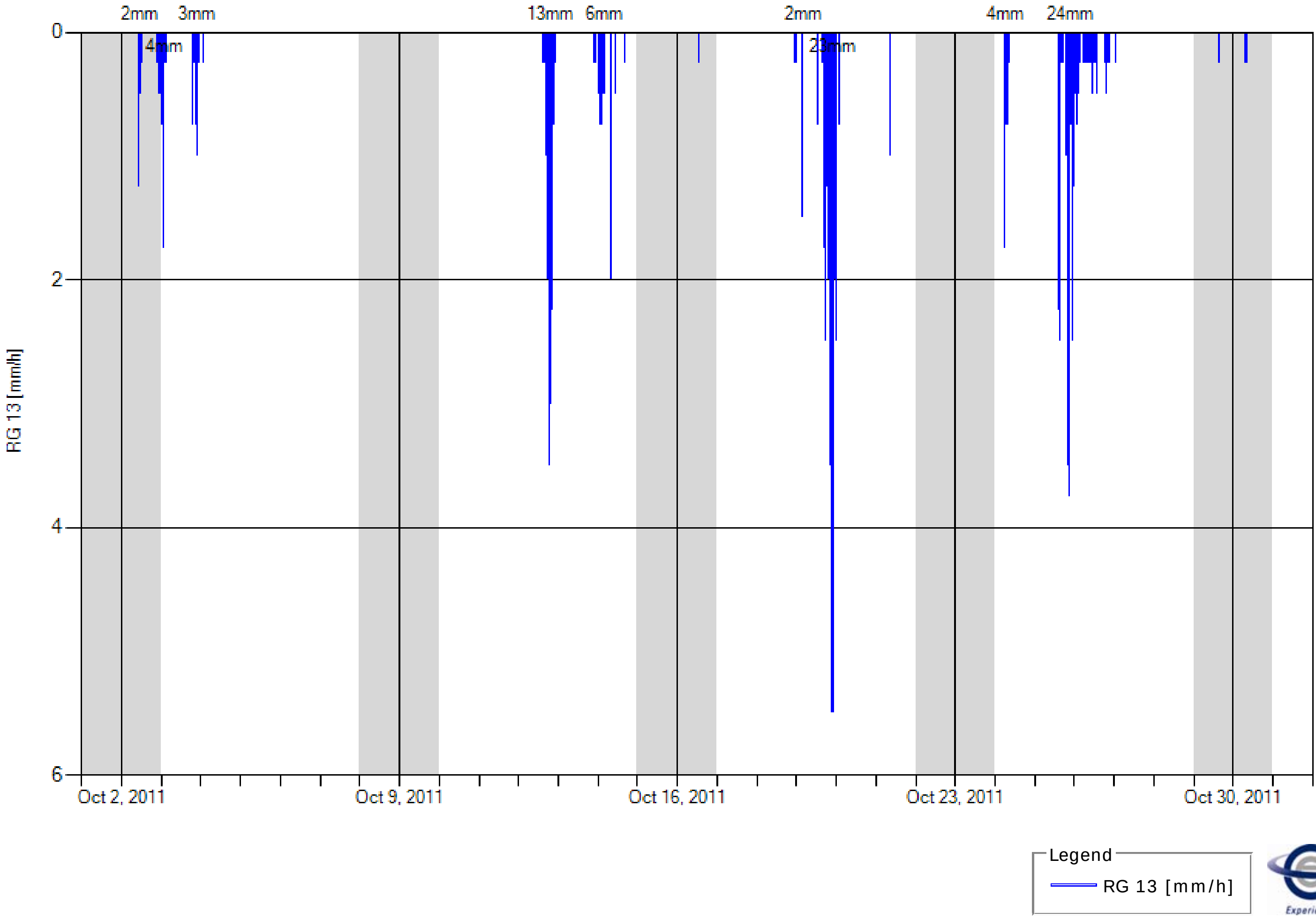


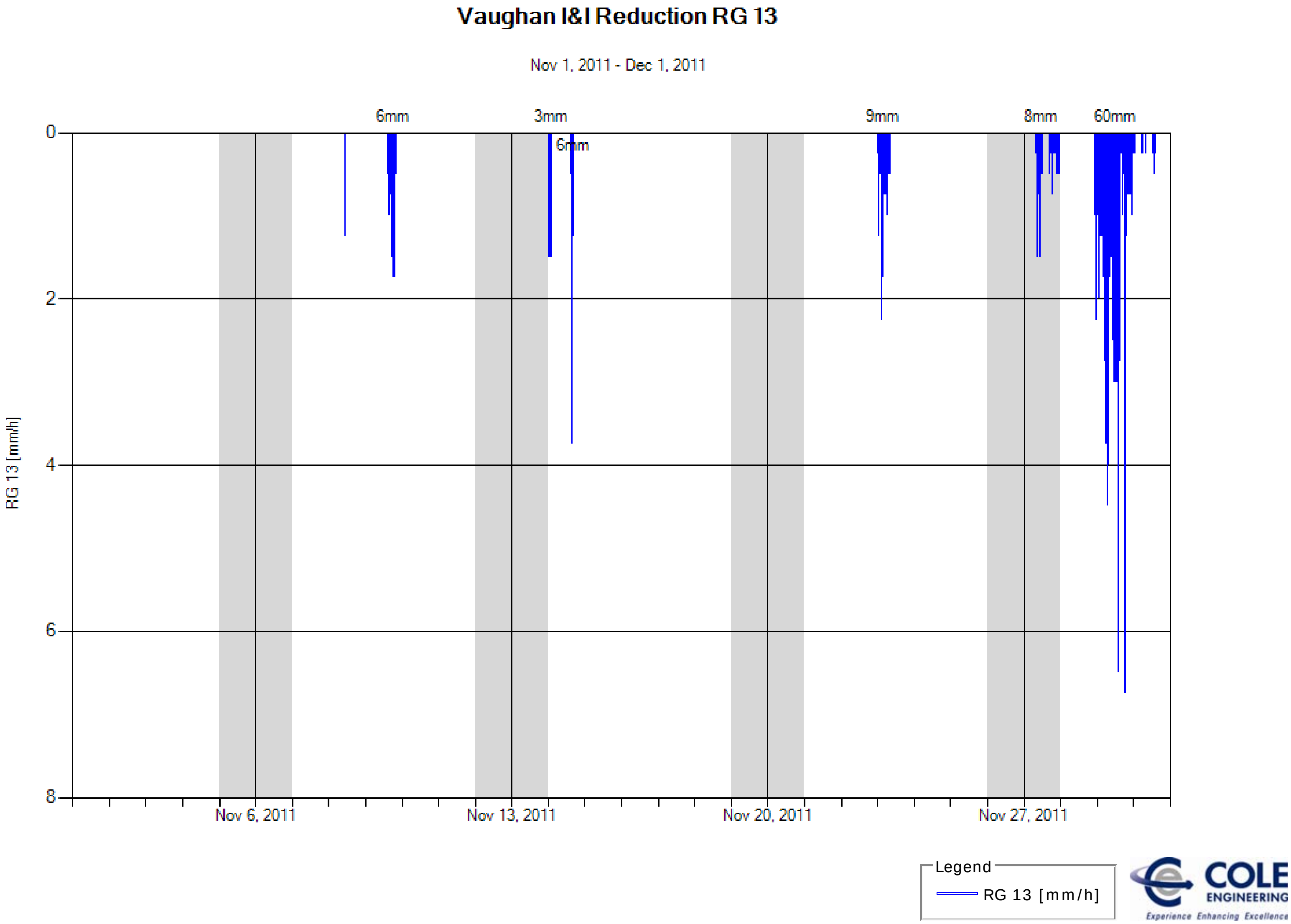

Vaughan I&I Reduction RG 13
Aug 1, 2011 - Sep 1, 2011
18mm
7mm
3mm
20mm
22mm
RG 13 [mm/h]
0
2
4
6
8
10
12
14
Aug 7, 2011
Aug 14, 2011
Aug 21, 2011
Aug 28, 2011
Legend
RG 13 [mm/h]


Vaughan I&I Reduction RG 13
Sep 1, 2011 - Oct 1, 2011
7mm
31mm
12mm
3mm
0
2
4
6
8
10
RG 13 [mm/h]
Sep 4, 2011
Sep 11, 2011
Sep 18, 2011
Sep 25, 2011
Legend
RG 13 [mm/h]
COLE ENGINEERING
Experience Enhancing Excellence

Vaughan I&I Reduction RG 13

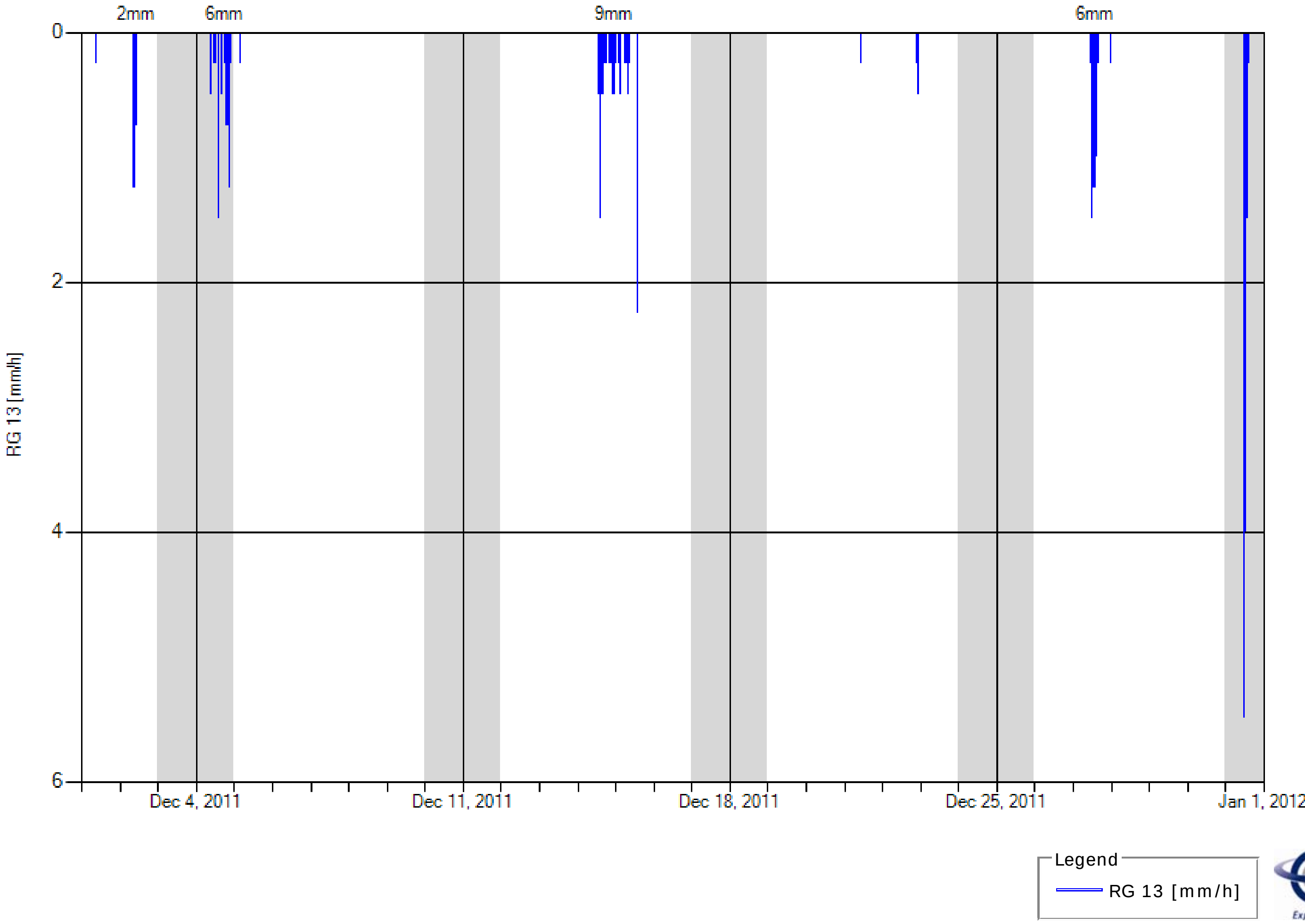
Oct 1, 2011 - Nov 1, 2011

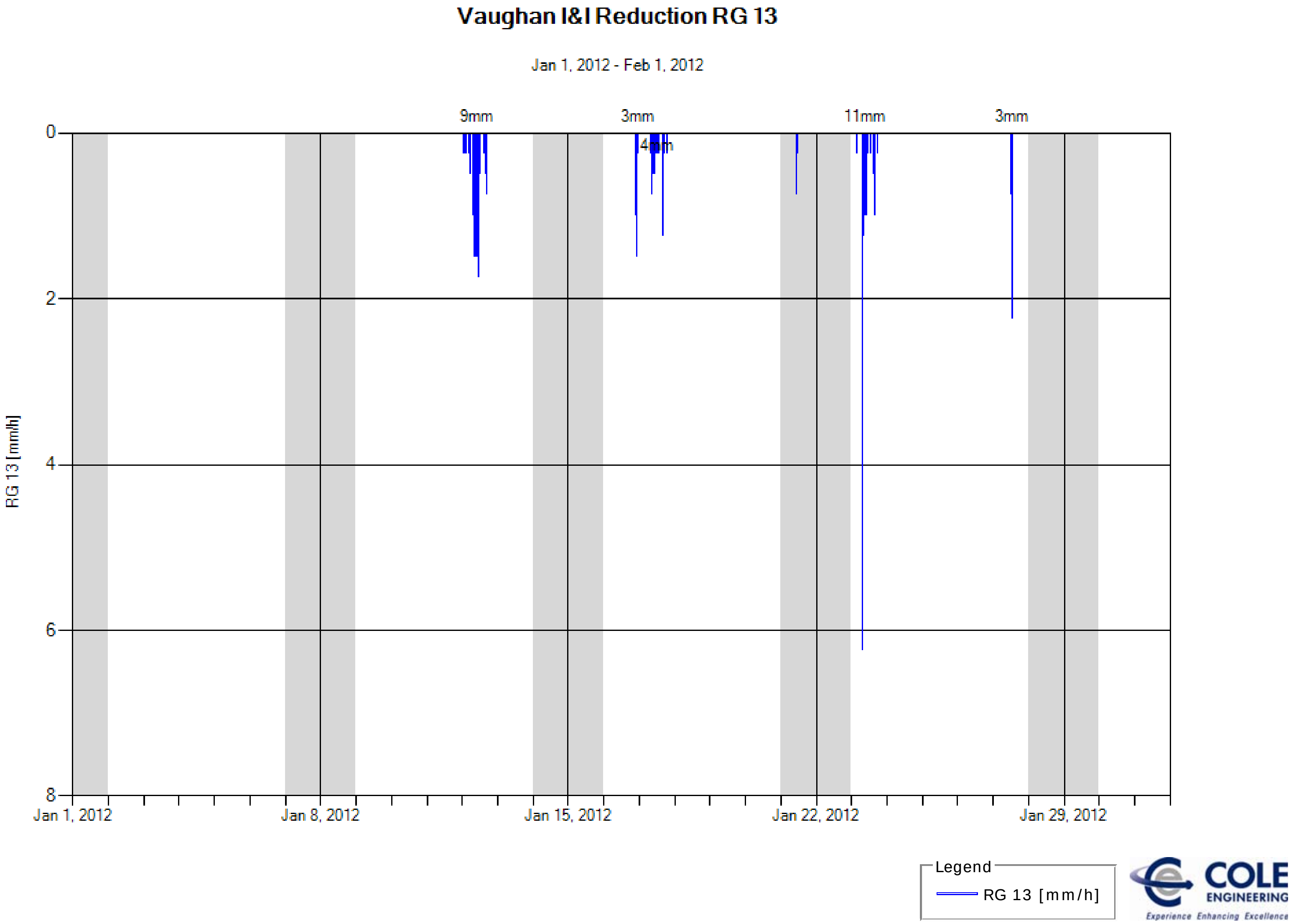



Vaughan I&I Reduction RG 13
Nov 1, 2011 - Dec 1, 2011
6mm
3mm
6mm
9mm
8mm
60mm
0
2
4
6
8
RG 13 [mm/h]
Nov 6, 2011
Nov 13, 2011
Nov 20, 2011
Nov 27, 2011
Legend
RG 13 [mm/h]
COLE ENGINEERING
Experience Enhancing Excellence

Vaughan I&I Reduction RG 13

Dec 1, 2011 - Jan 1, 2012

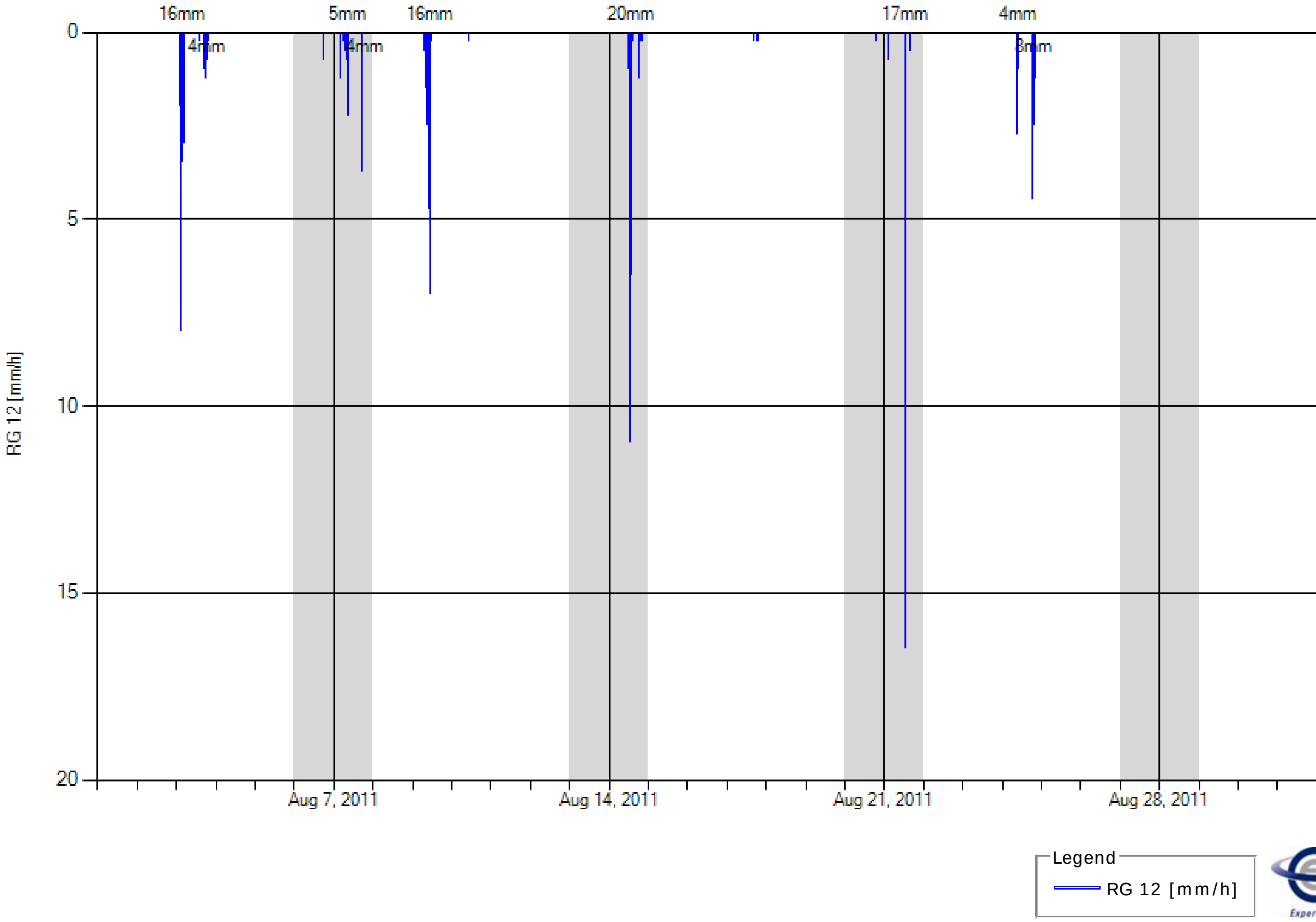


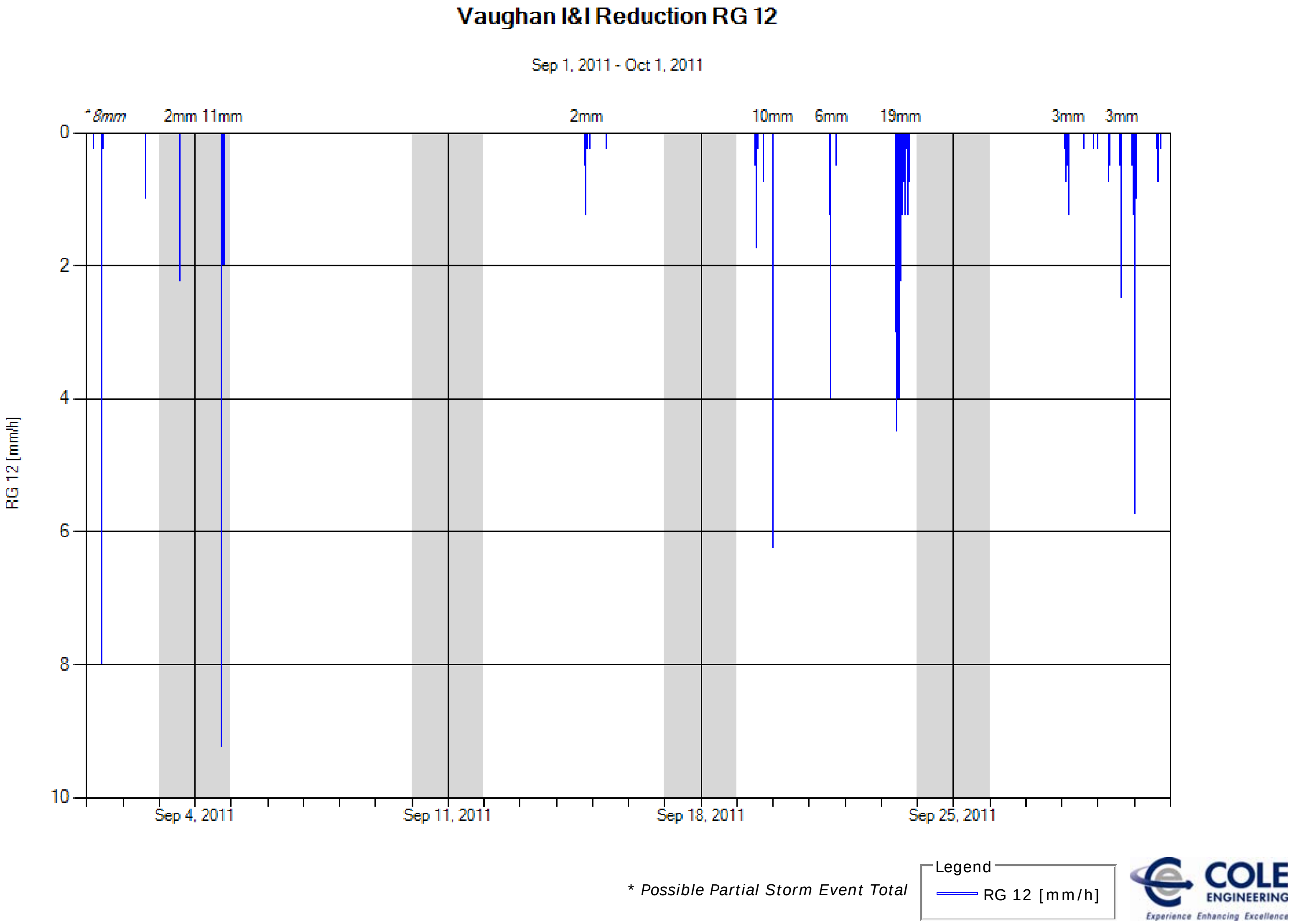


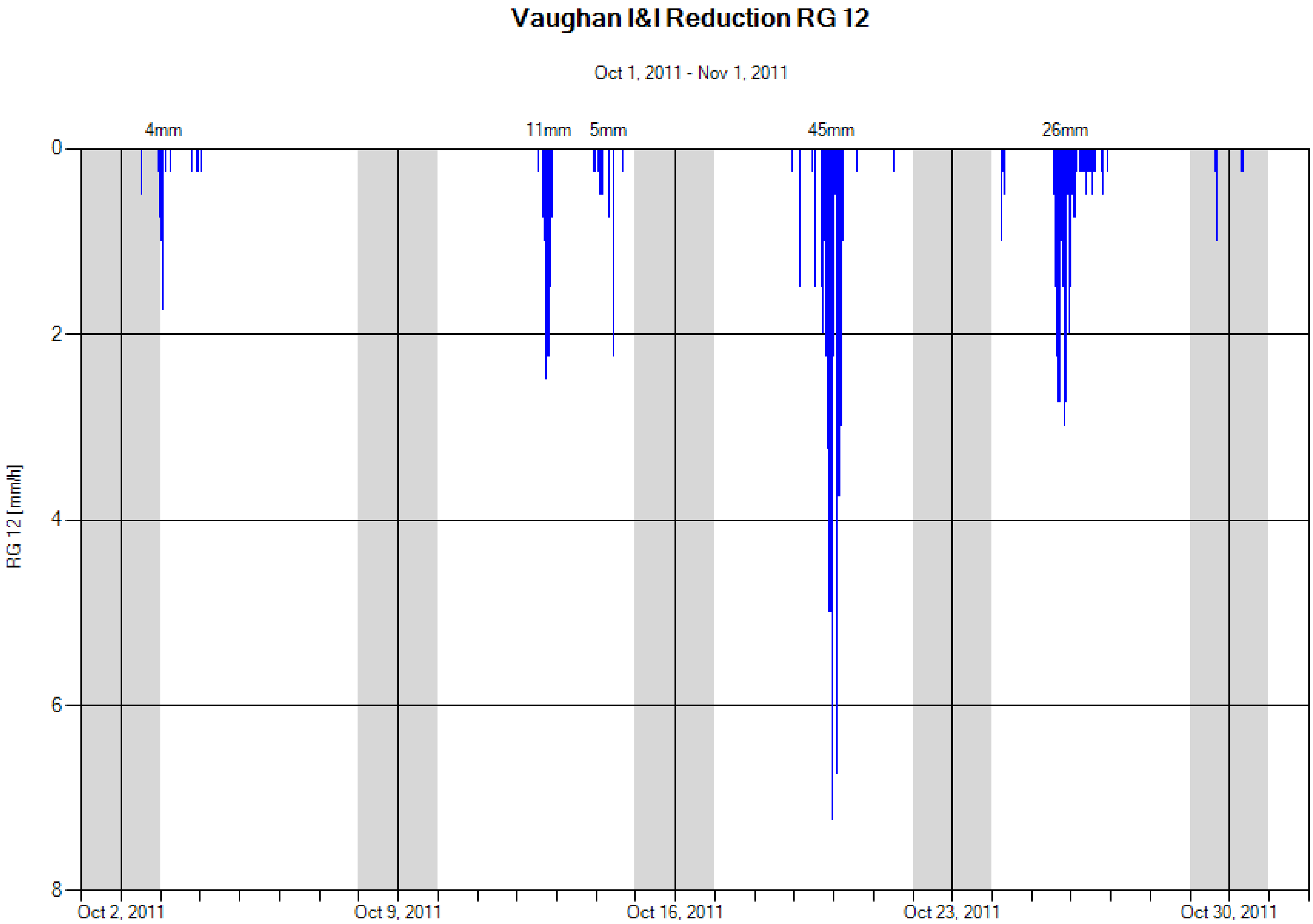
Vaughan I&I Reduction RG 13
Jan 1, 2012 - Feb 1, 2012
9mm
3mm
4mm
11mm
3mm
RG 13 [mm/h]
0
2
4
6
8
Jan 1, 2012
Jan 8, 2012
Jan 15, 2012
Jan 22, 2012
Jan 29, 2012
Legend
RG 13 [mm/h]
COLE ENGINEERING
Experience Enhancing Excellence

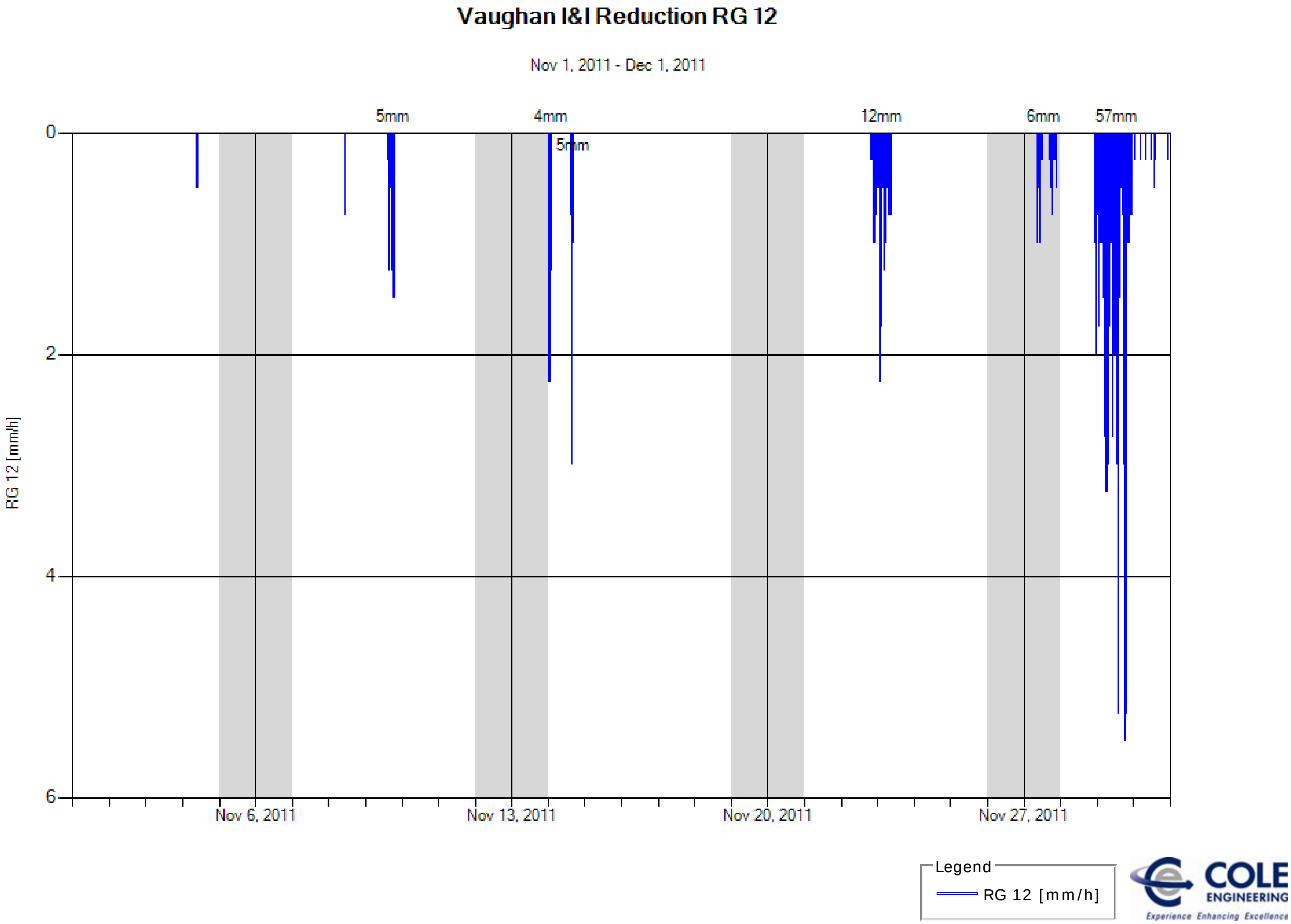
Vaughan I&I Reduction RG 12

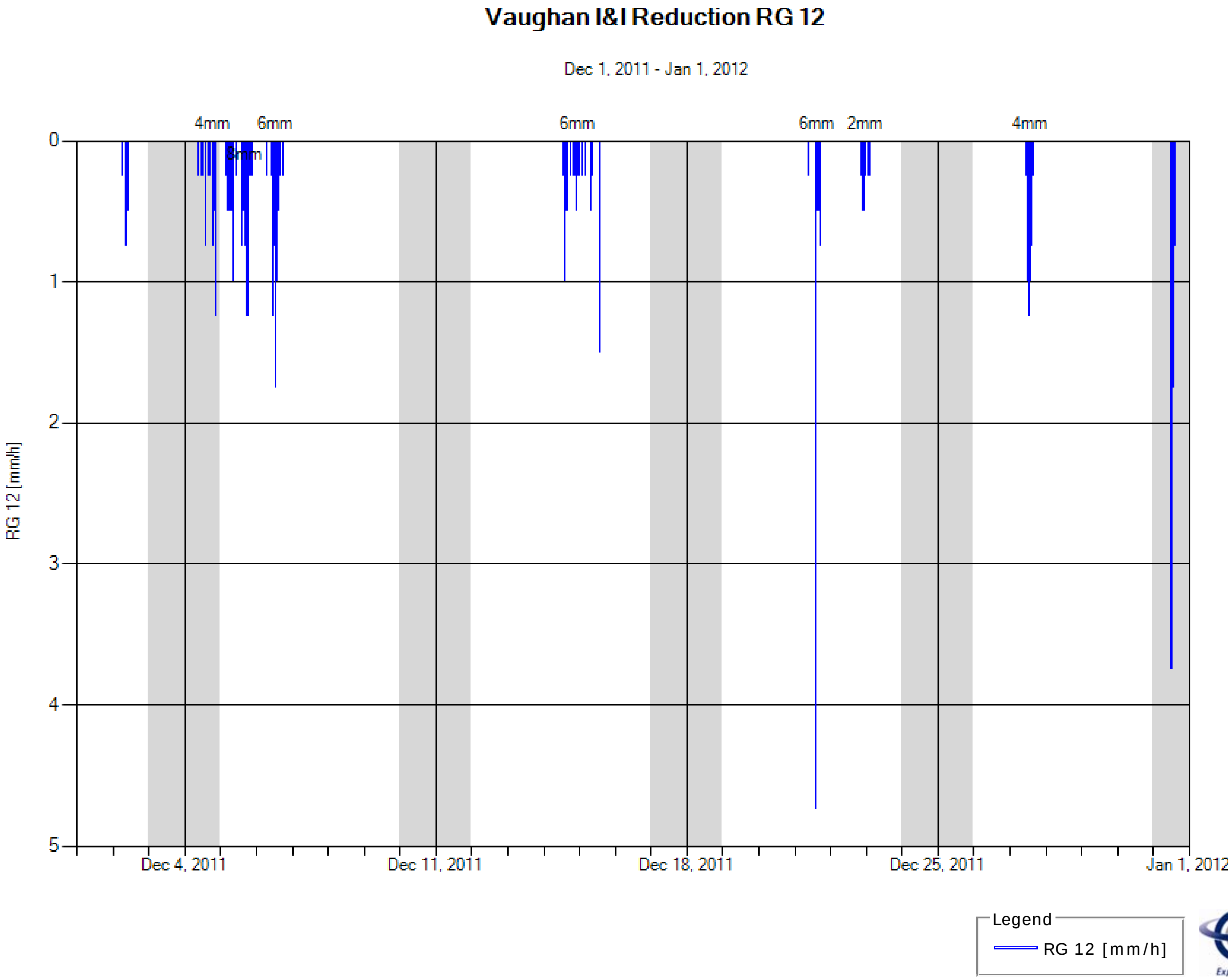
Aug 1, 2011 - Sep 1, 2011

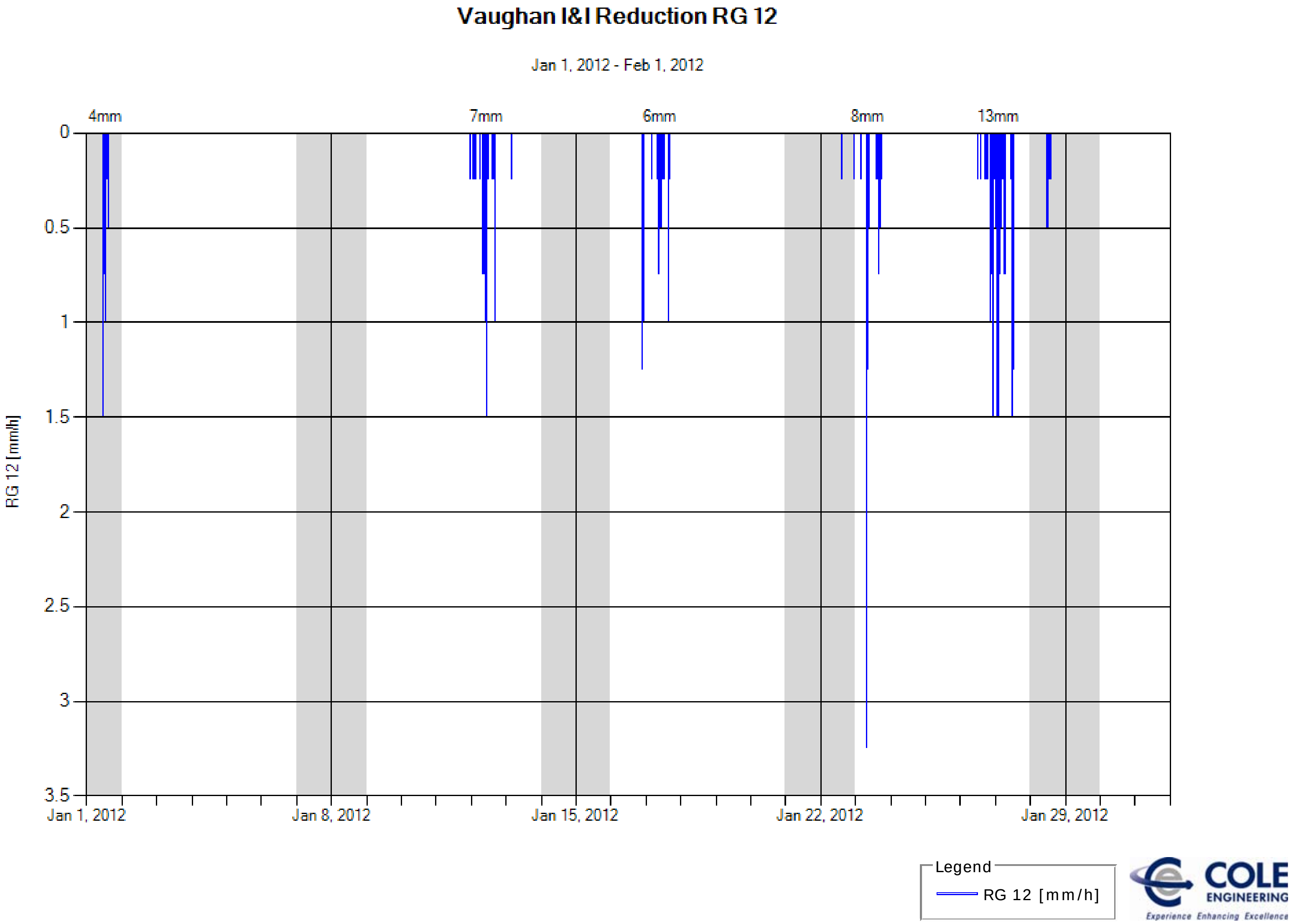


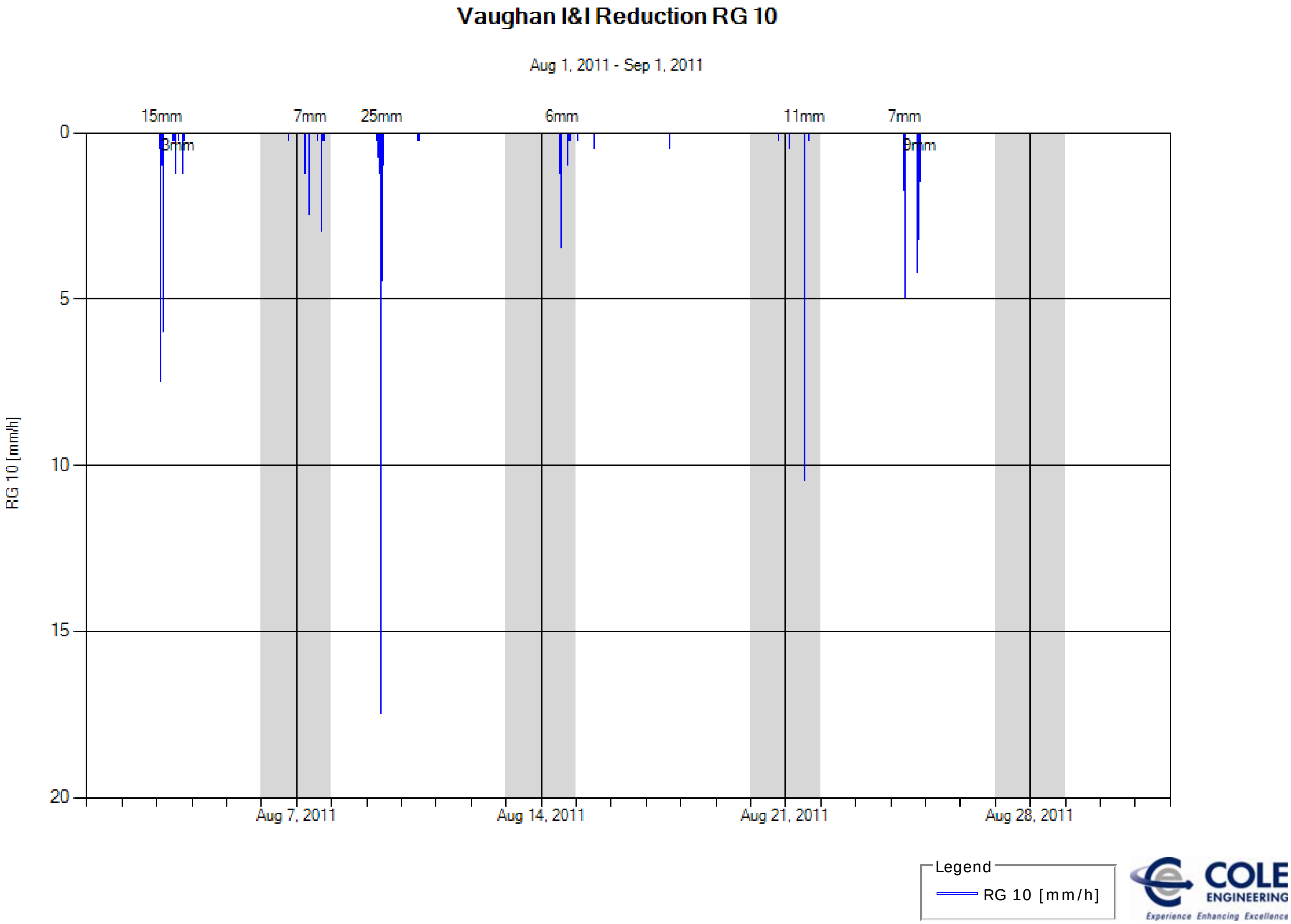

Vaughan I&I Reduction RG 12
Sep 1, 2011 - Oct 1, 2011
* 8mm
2mm 11mm
2mm
10mm
6mm
19mm
3mm
3mm
0
2
4
6
8
10
RG 12 [mm/h]
Sep 4, 2011
Sep 11, 2011
Sep 18, 2011
Sep 25, 2011
* Possible Partial Storm Event Total
Legend
RG 12 [mm/h]
COLE ENGINEERING
Experience Enhancing Excellence

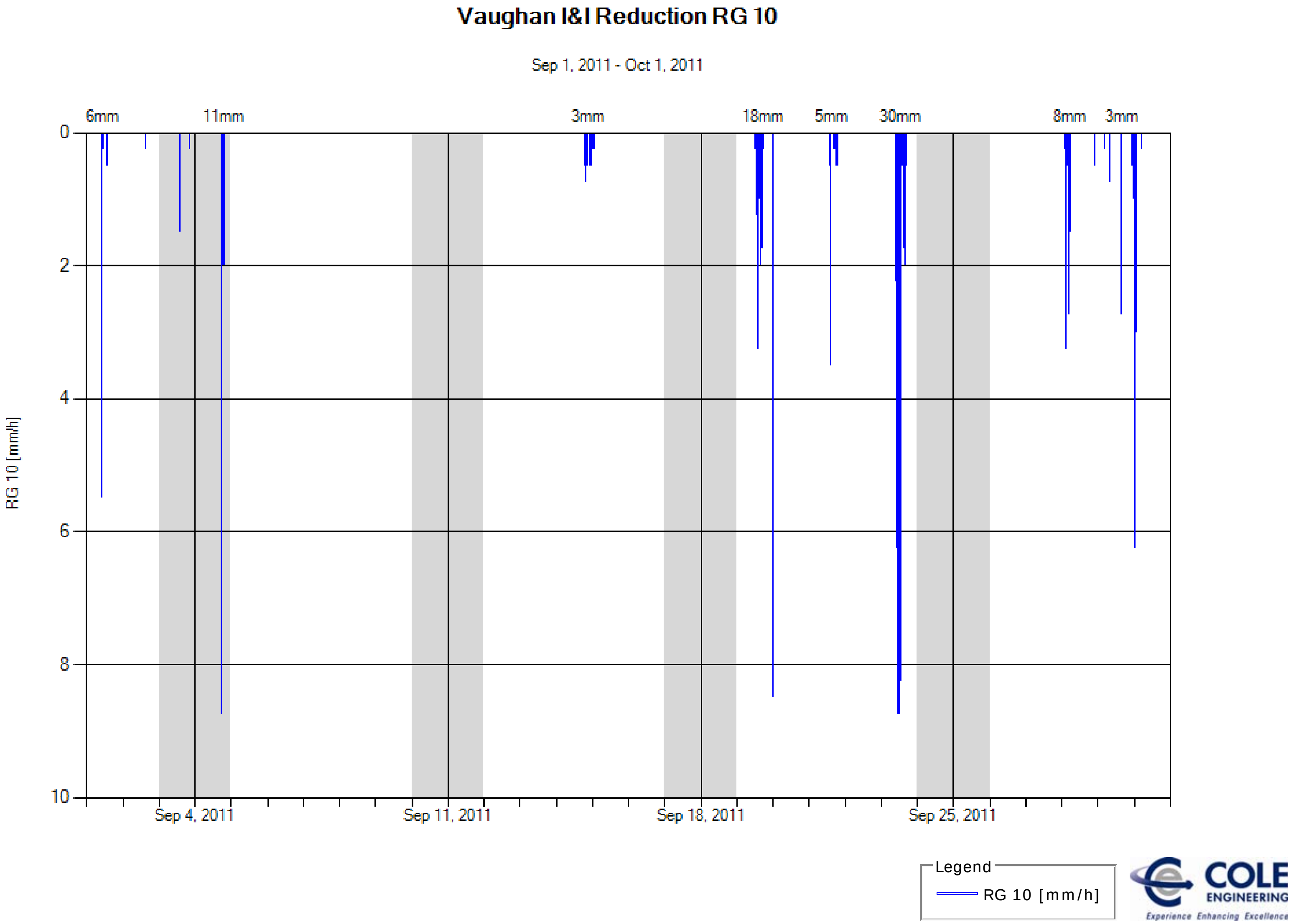

Vaughan I&I Reduction RG 12
Oct 1, 2011 - Nov 1, 2011
4mm
11mm
5mm
45mm
26mm
0
2
4
6
8
RG 12 [mm/h]
Oct 2, 2011
Oct 9, 2011
Oct 16, 2011
Oct 23, 2011
Oct 30, 2011
Legend
RG 12 [mm/h]

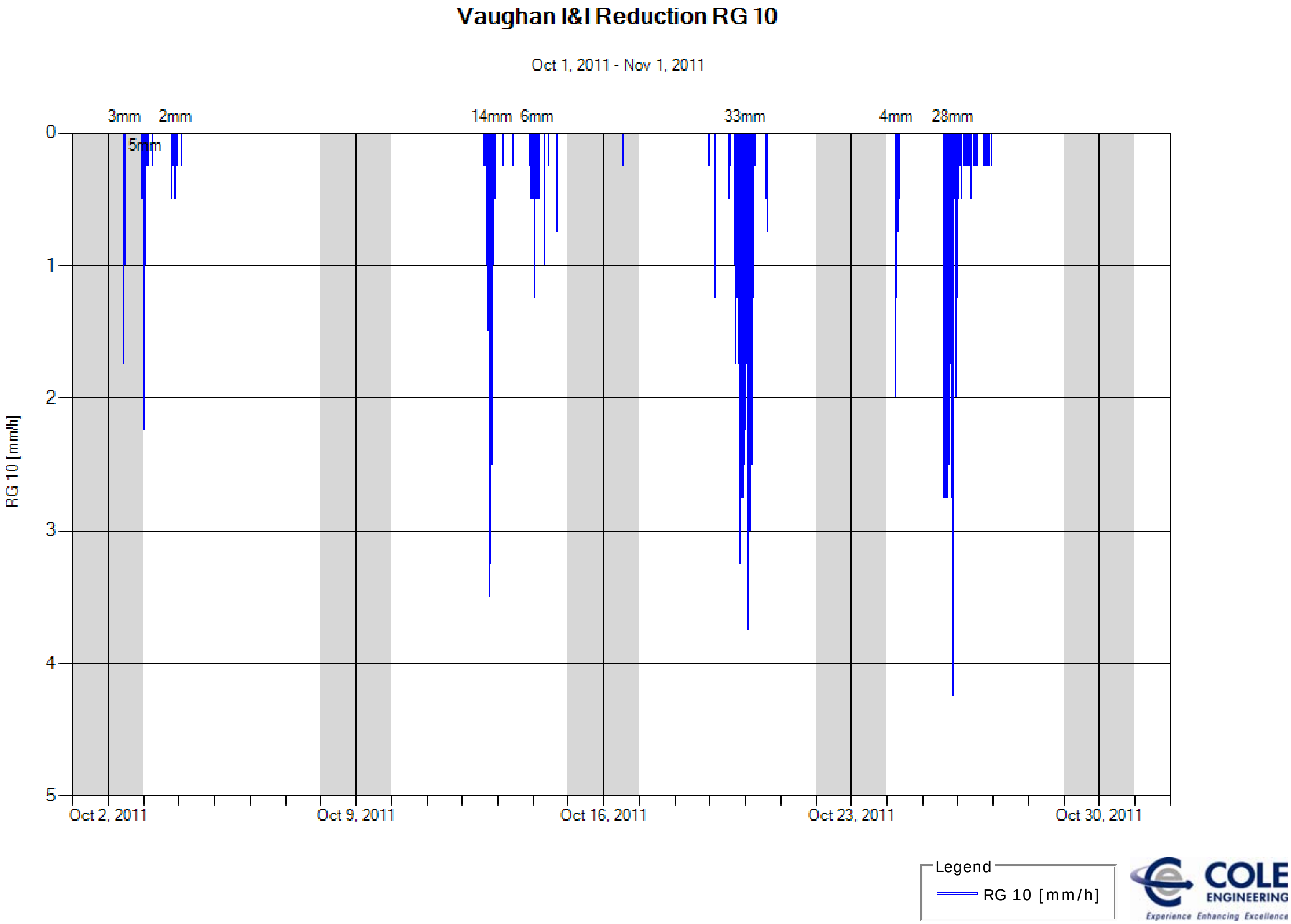

Vaughan I&I Reduction RG 12
Nov 1, 2011 - Dec 1, 2011
5mm
4mm
5mm
12mm
6mm
57mm
0
2
4
6
RG 12 [mm/h]
Nov 6, 2011
Nov 13, 2011
Nov 20, 2011
Nov 27, 2011
Legend
RG 12 [mm/h]
COLE ENGINEERING
Experience Enhancing Excellence

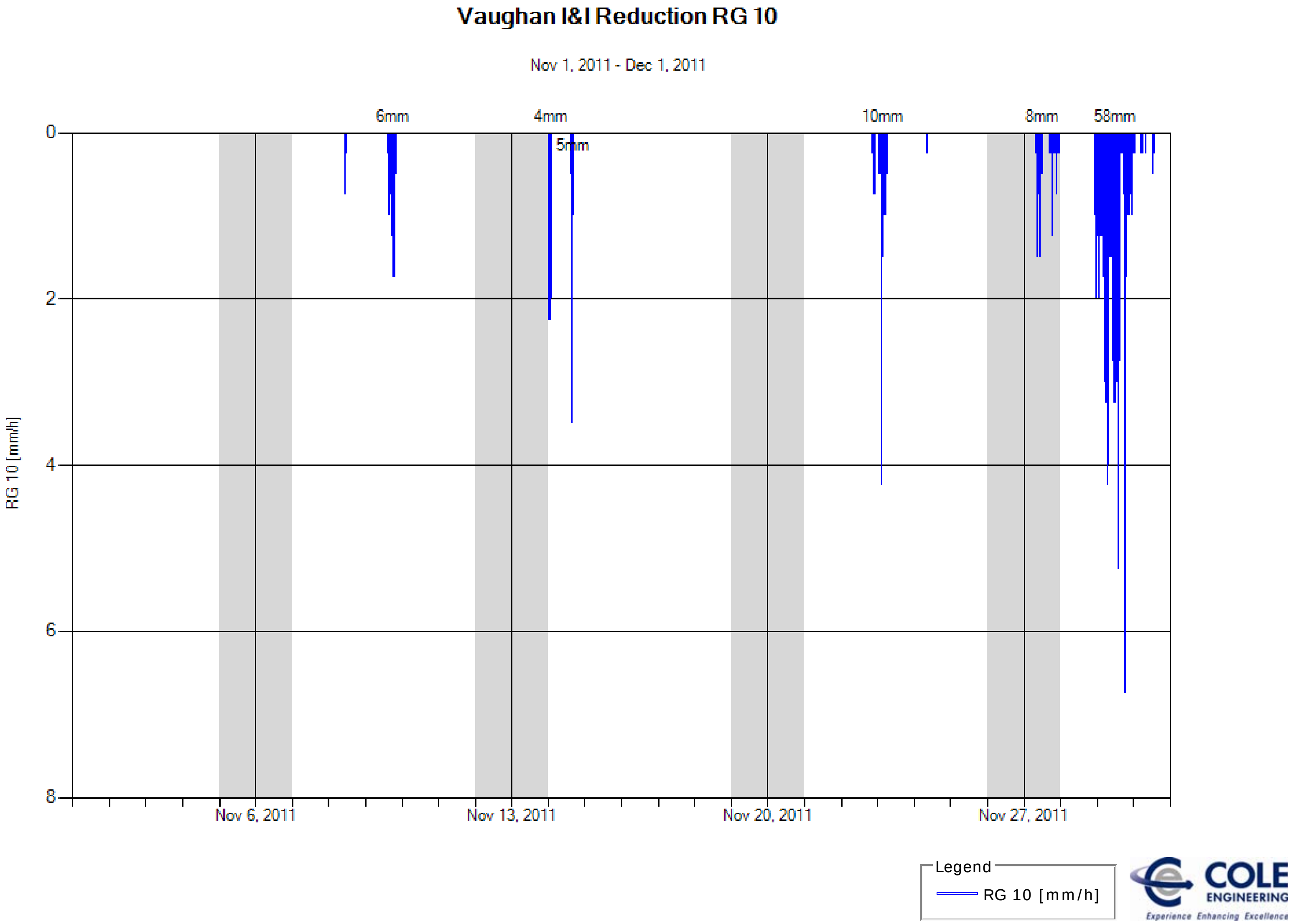

Vaughan I&I Reduction RG 12
Dec 1, 2011 - Jan 1, 2012
4mm
6mm
6mm
6mm
2mm
4mm
RG 12 [mm/h]
0
1
2
3
4
5
Dec 4, 2011
Dec 11, 2011
Dec 18, 2011
Dec 25, 2011
Jan 1, 2012
Legend
RG 12 [mm/h]


Vaughan I&I Reduction RG 12
Jan 1, 2012 - Feb 1, 2012
4mm
7mm
6mm
8mm
13mm
RG 12 [mm/h]
0
0.5
1
1.5
2
2.5
3
3.5
Jan 1, 2012
Jan 8, 2012
Jan 15, 2012
Jan 22, 2012
Jan 29, 2012
Legend
RG 12 [mm/h]


Vaughan I&I Reduction RG 10
Aug 1, 2011 - Sep 1, 2011
15mm
3mm
7mm
25mm
6mm
11mm
7mm
9mm
0
5
10
15
20
RG 10 [mm/h]
Aug 7, 2011
Aug 14, 2011
Aug 21, 2011
Aug 28, 2011
Legend
RG 10 [mm/h]
COLE ENGINEERING
Experience Enhancing Excellence

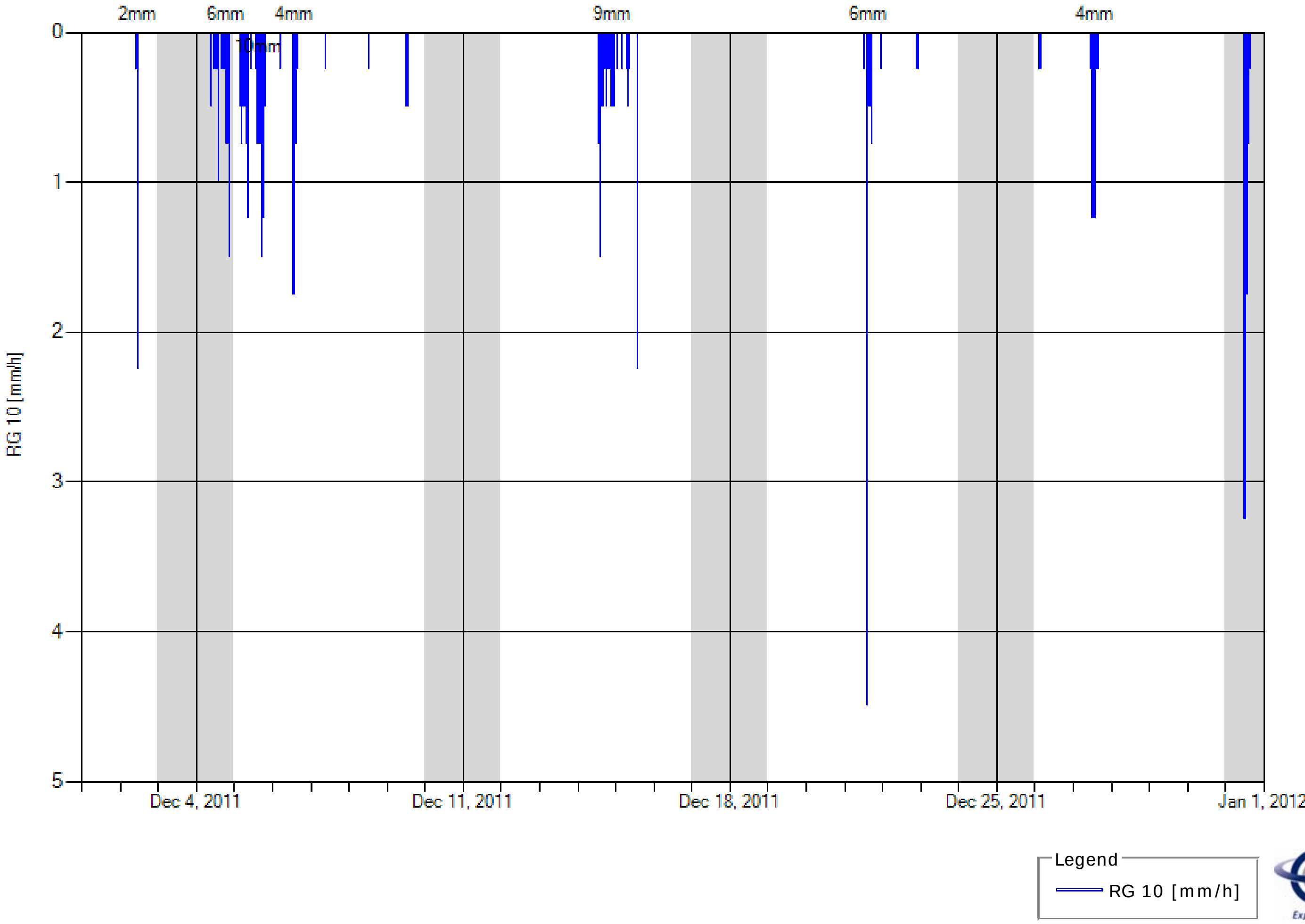

Vaughan I&I Reduction RG 10
Sep 1, 2011 - Oct 1, 2011
6mm
11mm
3mm
18mm
5mm
30mm
8mm
3mm
RG 10 [mm/h]
0
2
4
6
8
10
Sep 4, 2011
Sep 11, 2011
Sep 18, 2011
Sep 25, 2011
Legend
RG 10 [mm/h]
COLE ENGINEERING
Experience Enhancing Excellence

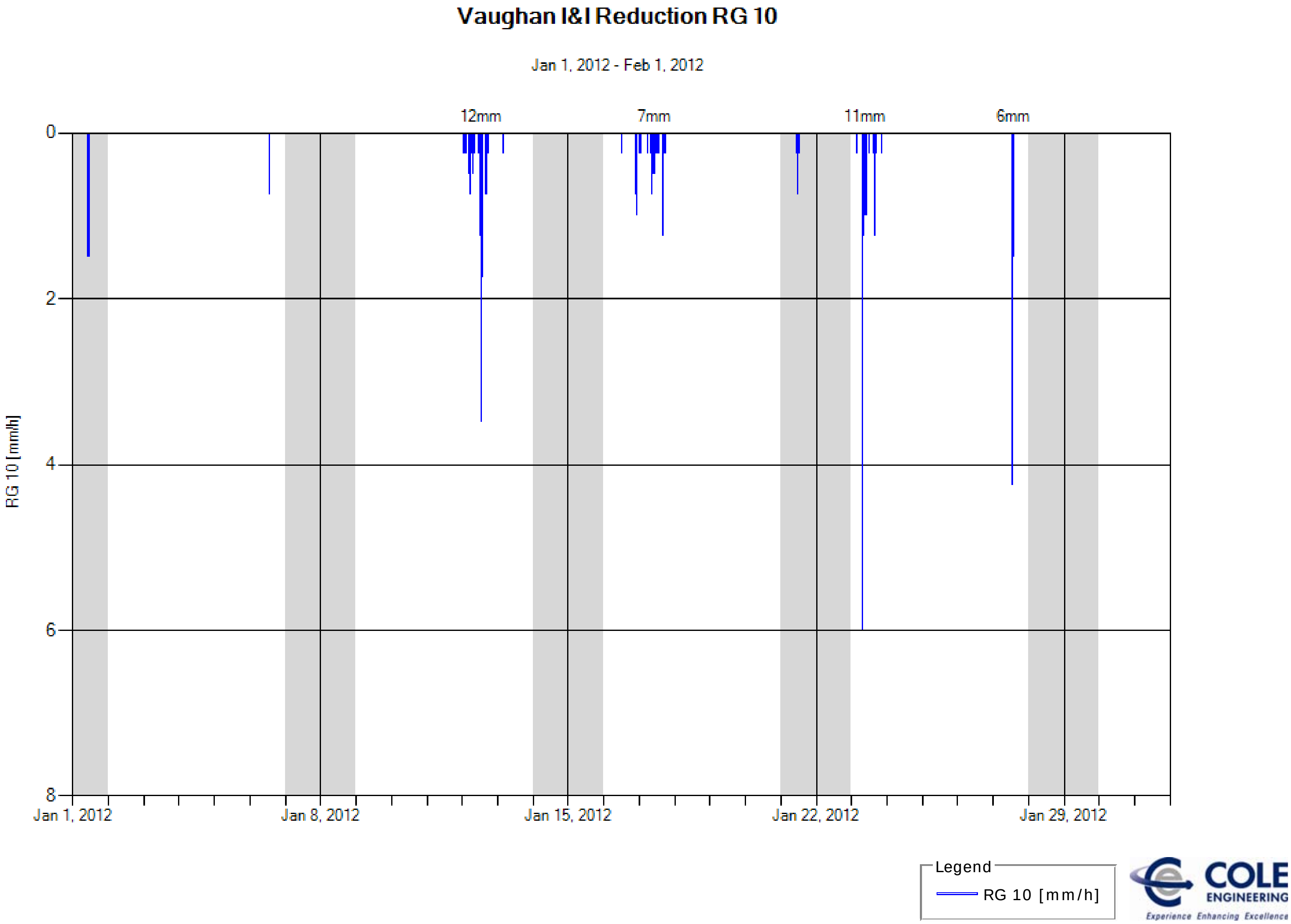

Vaughan I&I Reduction RG 10
Oct 1, 2011 - Nov 1, 2011
RG 10 [mm/h]
0
1
2
3
4
5
3mm
5mm
2mm
14mm
6mm
33mm
4mm
28mm
Oct 2, 2011
Oct 9, 2011
Oct 16, 2011
Oct 23, 2011
Oct 30, 2011
Legend
RG 10 [mm/h]
COLE ENGINEERING
Experience Enhancing Excellence


Vaughan I&I Reduction RG 10
Nov 1, 2011 - Dec 1, 2011
6mm
4mm
5mm
10mm
8mm
58mm
RG 10 [mm/h]
0
2
4
6
8
Nov 6, 2011
Nov 13, 2011
Nov 20, 2011
Nov 27, 2011
Legend
RG 10 [mm/h]
COLE ENGINEERING
Experience Enhancing Excellence

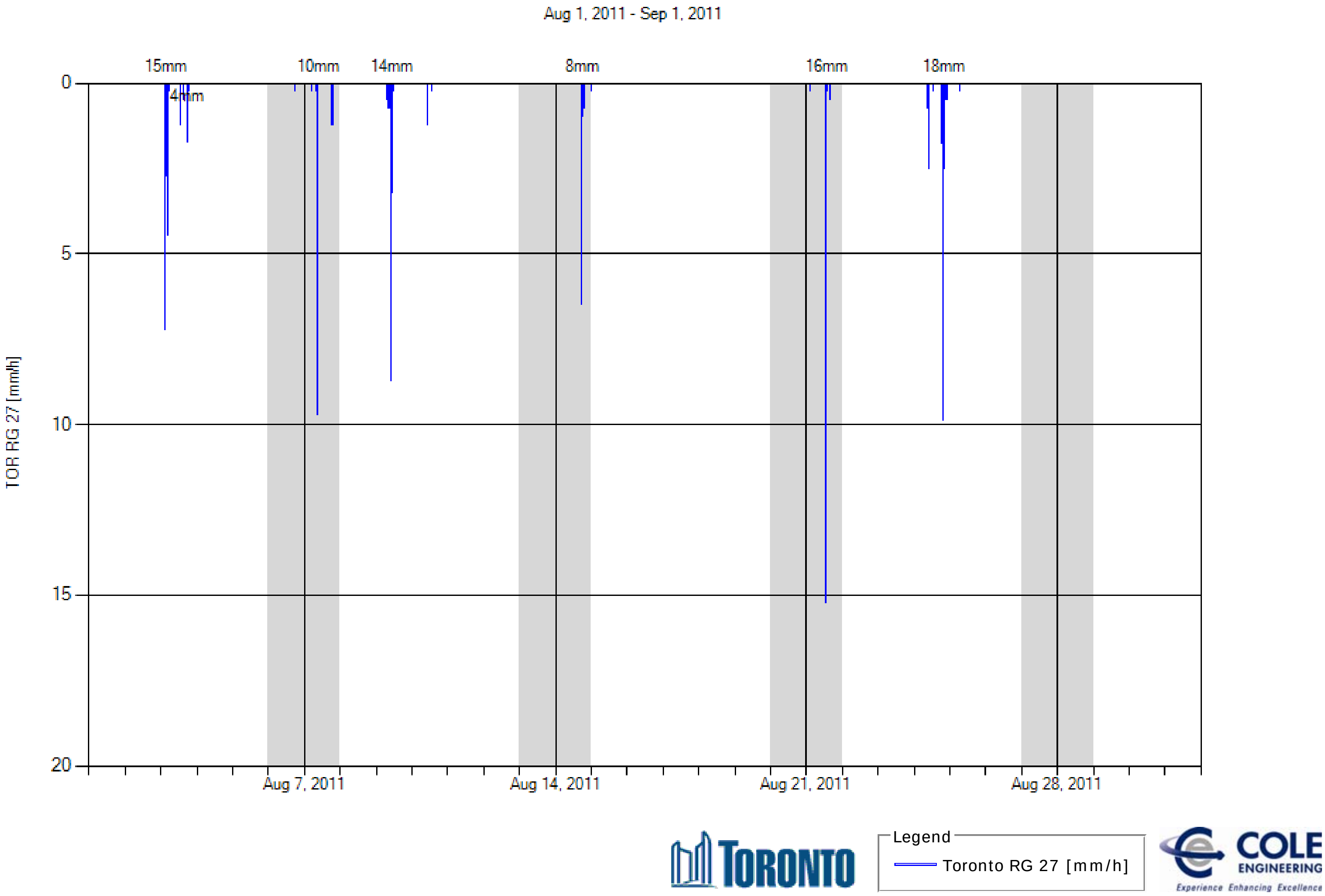
Vaughan I&I Reduction RG 10

Dec 1, 2011 - Jan 1, 2012



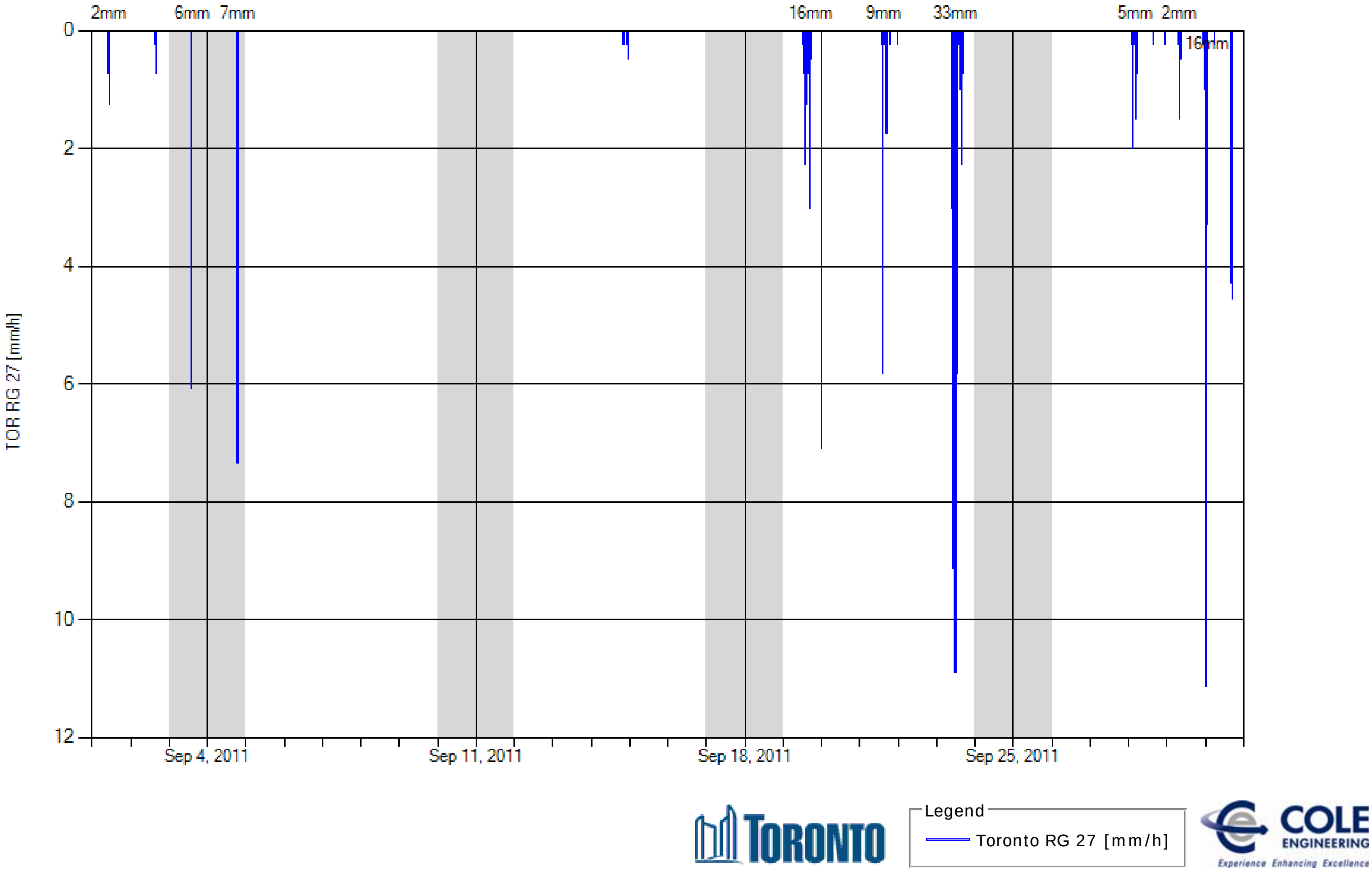

Vaughan I&I Reduction RG 10
Jan 1, 2012 - Feb 1, 2012
12mm
7mm
11mm
6mm
0
2
4
6
8
RG 10 [mm/h]
Jan 1, 2012
Jan 8, 2012
Jan 15, 2012
Jan 22, 2012
Jan 29, 2012
Legend
RG 10 [mm/h]
COLE ENGINEERING
Experience Enhancing Excellence

2012 and 2013 Precipitation Monitoring RG-027 Mitchell Field



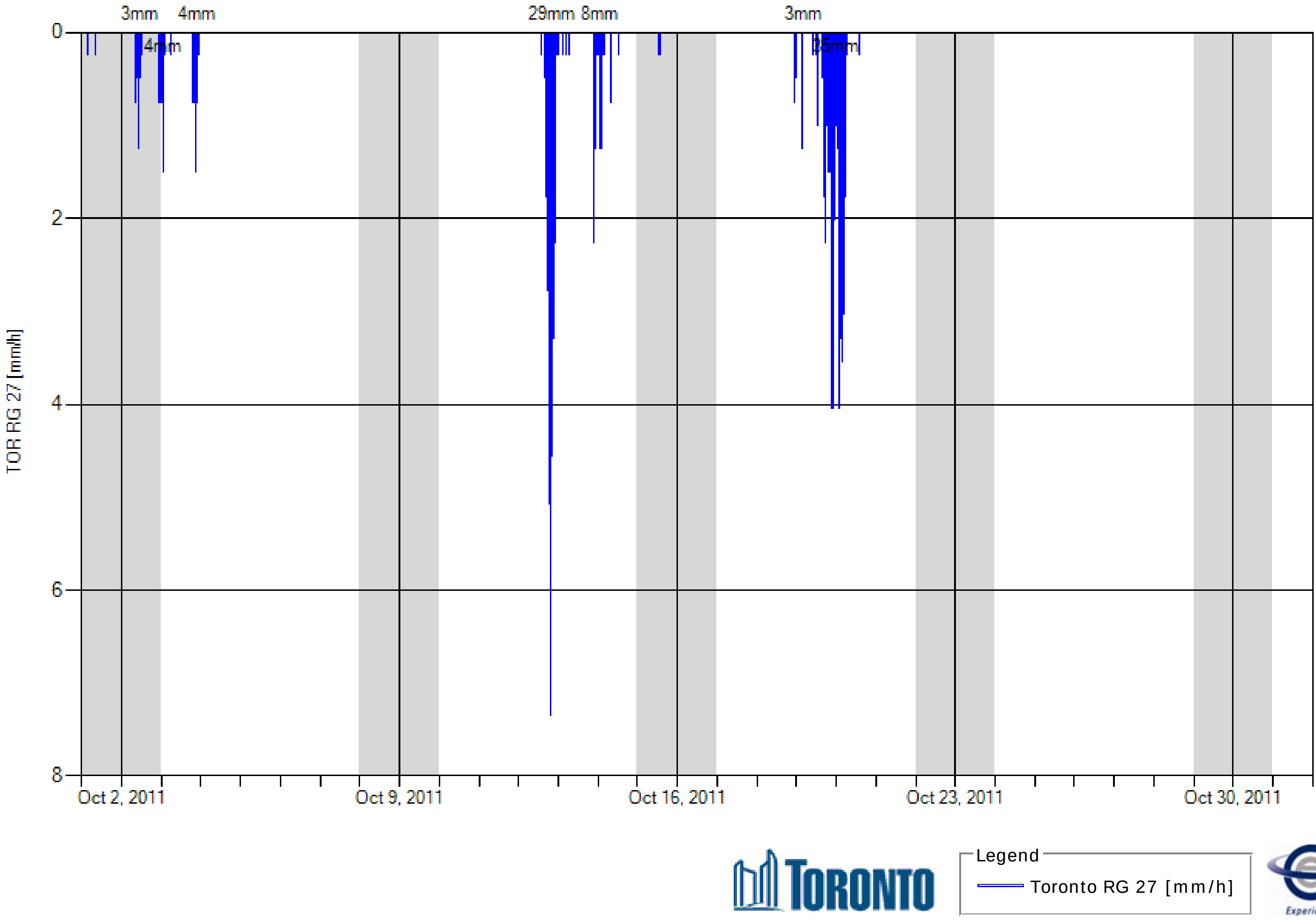
2012 and 2013 Precipitation Monitoring RG-027 Mitchell Field

Sep 1, 2011 - Oct 1, 2011



2012 and 2013 Precipitation Monitoring RG-027 Mitchell Field

Oct 1, 2011 - Nov 1, 2011



No Data Exists For This Date Range.

Nov 1, 2011 - Dec 1, 2011

No Data Exists For This Date Range.

Dec 1, 2011 - Jan 1, 2012

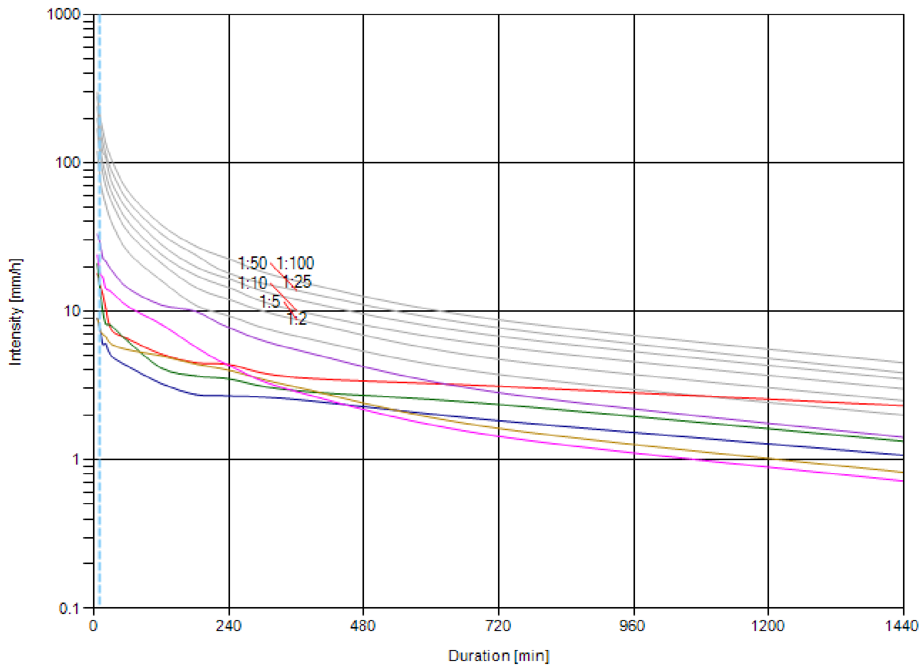
No Data Exists For This Date Range.

Jan 1, 2012 - Feb 1, 2012

APPENDIX B
Rain Gauge IDF Curves And Analyses

IDF Return Period Analysis

RG - Vaughan Secondary Sch...



Project: Vaughan City Wide Drainag...

Site: RG - Vaughan Secondary Sch...

Rain Gauge: RG Vaughan

IDF Source: Vaughan

Tc: -- Enter Tc -- - 10 min

☑ Show ?

Event Selection

Minimum storm size: 14 mm

Inter-event dry period: 6 hour(s) ?

◉ Date Range ○ All Storms

From 2011-09-21

To 2011-12-30

Refresh Events

Event List

November 28, 2011 (57 mm)
October 25, 2011 (27 mm)
October 19, 2011 (32 mm)
October 12, 2011 (20 mm)
September 30, 2011 (18 mm)
September 23, 2011 (34 mm)

** max 8 selections*

Display Options

☑ Show design storms in summary table

☐ Set maximum duration: 360 min Go

Design Storms

Source: City of Vaughan - IDF Curve

☑ 1:2 year ☑ 1:25 year

☑ 1:5 year ☑ 1:50 year

☑ 1:10 year ☑ 1:100 year

Legend

Tc
November 28, 2011
October 25, 2011
October 19, 2011
October 12, 2011
September 30, 2011
September 23, 2011

Storm Return Period Over Time Of Concentration

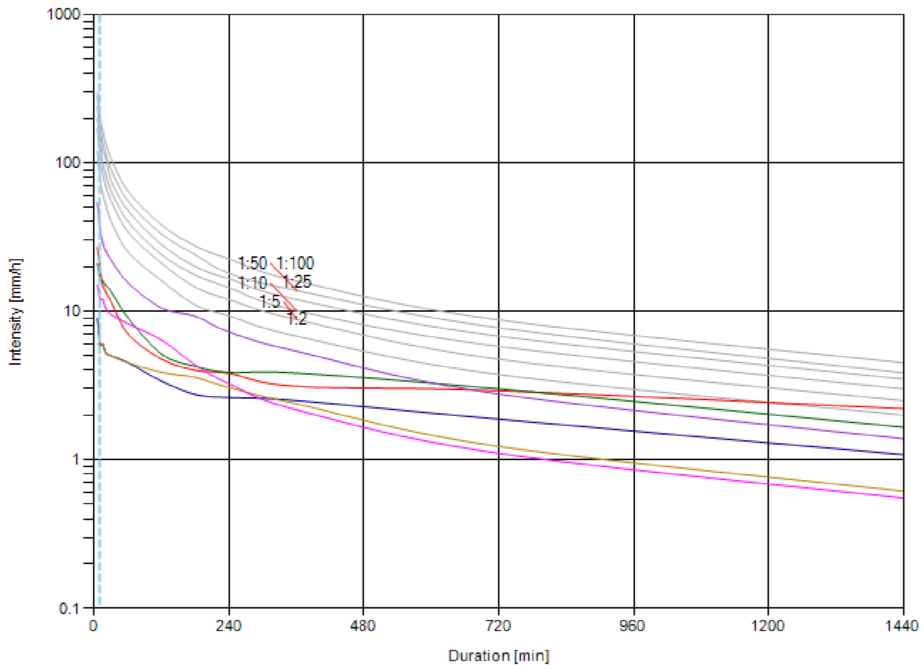
Storm Date	Time of Concentration T_c (min)	Return Period over T_c
Nov 28, 2011	10	< 2 yr
Oct 25, 2011	10	< 2 yr
Oct 19, 2011	10	< 2 yr
Oct 12, 2011	10	< 2 yr
Sep 30, 2011	10	< 2 yr
Sep 23, 2011	10	< 2 yr

Storm Date	Total Volume (mm)	Peak Intensity over Minute Timestep (mm/h)											
		5	10	15	20	30	60	120	180	240	360	720	1440
2 Year Storm	N/A	120	77.5	62	52.5	40	25	16	11	9.3	6.8	3.8	2
5 Year Storm	N/A	170	109	85	70	55	34	21	14.5	12	8.8	4.8	2.5
10 Year Storm	N/A	200	130	100	84	64	40	24	17.5	14.4	10.1	5.8	3
25 Year Storm	N/A	240	155	118	109	75	47.5	28	20	16.5	12	6.8	3.5
50 Year Storm	N/A	280	180	138	115	89	55	33	24	18	13.8	7.8	3.8
100 Year Storm	N/A	300	206	166	135	106	64	38	27.5	22.5	16	8.8	4.5
Nov 28, 2011	57	18	15	13	10.5	7.5	6.5	5.1	4.5	4.4	3.6	3.1	2.3
Oct 25, 2011	27	9	7.5	6	6	5	4.2	3.2	2.8	2.7	2.5	1.8	1.1
Oct 19, 2011	32	21	13.5	10	8.2	8	6.2	4.1	3.7	3.5	2.9	2.4	1.3
Oct 12, 2011	20	9	7.5	7	6.8	6	5.5	5	4.4	4	3.1	1.6	0.8
Sep 30, 2011	18	24	18	17	14.2	13.5	10.8	8.1	5.8	4.3	2.9	1.4	0.7
Sep 23, 2011	34	33	28.5	23	21.8	19	14.2	11	10	7.8	5.5	2.8	1.4

Export Peak Intensity Table

IDF Return Period Analysis

RG 14



Project: Vaughan I&I Reduction

Site: RG 14

Rain Gauge: RG 14

IDF Source: Vaughan

Tc: -- Enter Tc -- - 10 min

Show ?

Event Selection

Minimum storm size: 12 mm

Inter-event dry period: 6 hour(s) ?

Date Range All Storms

From 2011-09-21

To 2011-12-30

Refresh Events

Event List

December 05, 2011 (18 mm)
November 28, 2011 (56 mm)
October 25, 2011 (27 mm)
October 19, 2011 (42 mm)
October 12, 2011 (15 mm)
September 30, 2011 (14 mm)
September 23, 2011 (33 mm)

** max 8 selections*

Display Options

Show design storms in summary table

Set maximum duration: 360 min Go

Design Storms

Source: City of Vaughan - IDF Curve

1:2 year 1:25 year
1:5 year 1:50 year
1:10 year 1:100 year

Legend

Tc
November 28, 2011
October 25, 2011
October 19, 2011
October 12, 2011
September 30, 2011
September 23, 2011

Storm Return Period Over Time Of Concentration

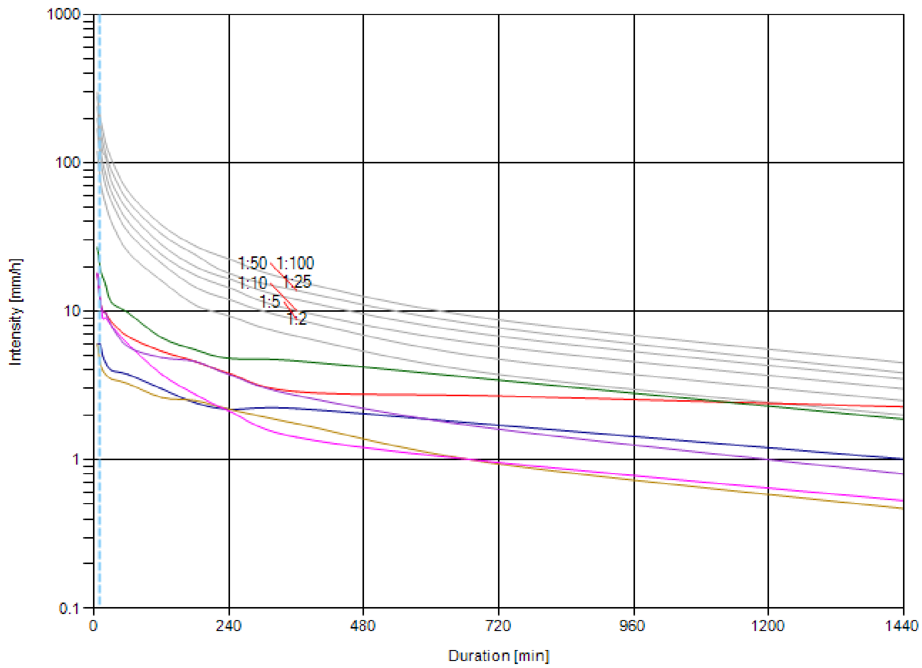
Storm Date	Time of Concentration T_c (min)	Return Period over T_c
Nov 28, 2011	10	< 2 yr
Oct 25, 2011	10	< 2 yr
Oct 19, 2011	10	< 2 yr
Oct 12, 2011	10	< 2 yr
Sep 30, 2011	10	< 2 yr
Sep 23, 2011	10	< 2 yr

Storm Date	Total Volume (mm)	Peak Intensity over Minute Timestep (mm/h)											
		5	10	15	20	30	60	120	180	240	360	720	1440
Nov 28, 2011	56	27	19.5	15	13.5	11.5	7	4.8	4	3.8	3.1	2.9	2.2
Oct 25, 2011	27	9	6	6	5.2	5	4.5	3.4	2.8	2.6	2.5	1.9	1.1
Oct 19, 2011	42	21	16.5	16	15	13.5	9	5.1	4.2	3.9	3.8	3	1.7
Oct 12, 2011	15	6	6	6	5.2	5	4.5	3.9	3.6	3.1	2.4	1.2	0.6
Sep 30, 2011	14	15	12	12	10.5	9.5	8.2	6.4	4.3	3.2	2.2	1.1	0.6
Sep 23, 2011	33	54	36	29	25.5	22	15.5	10.5	9.2	7.2	5.4	2.8	1.4

Export Peak Intensity Table

IDF Return Period Analysis

RG 12



Project: Vaughan I&I Reduction

Site: RG 12

Rain Gauge: RG 12

IDF Source: Vaughan

Tc: -- Enter Tc -- - 10 min

Show ?

Event Selection

Minimum storm size: 8 mm

Inter-event dry period: 6 hour(s) ?

Date Range   All Storms

From 2011-09-21

To 2011-12-30

Refresh Events

Event List

December 05, 2011 (8 mm)
November 28, 2011 (57 mm)
November 22, 2011 (12 mm)
October 25, 2011 (26 mm)
October 19, 2011 (45 mm)
October 12, 2011 (11 mm)
September 29, 2011 (8 mm)
September 23, 2011 (19 mm)

* *max 8 selections*

Display Options

Show design storms in summary table

Set maximum duration: 360 min Go

Design Storms

Source: City of Vaughan - IDF Curve

1:2 year   1:25 year
1:5 year   1:50 year
1:10 year   1:100 year

Legend

Tc
November 28, 2011
October 25, 2011
October 19, 2011
October 12, 2011
September 29, 2011
September 23, 2011

Storm Return Period Over Time Of Concentration

Storm Date	Time of Concentration T_c (min)	Return Period over T_c
Nov 28, 2011	10	< 2 yr
Oct 25, 2011	10	< 2 yr
Oct 19, 2011	10	< 2 yr
Oct 12, 2011	10	< 2 yr
Sep 29, 2011	10	< 2 yr
Sep 23, 2011	10	< 2 yr

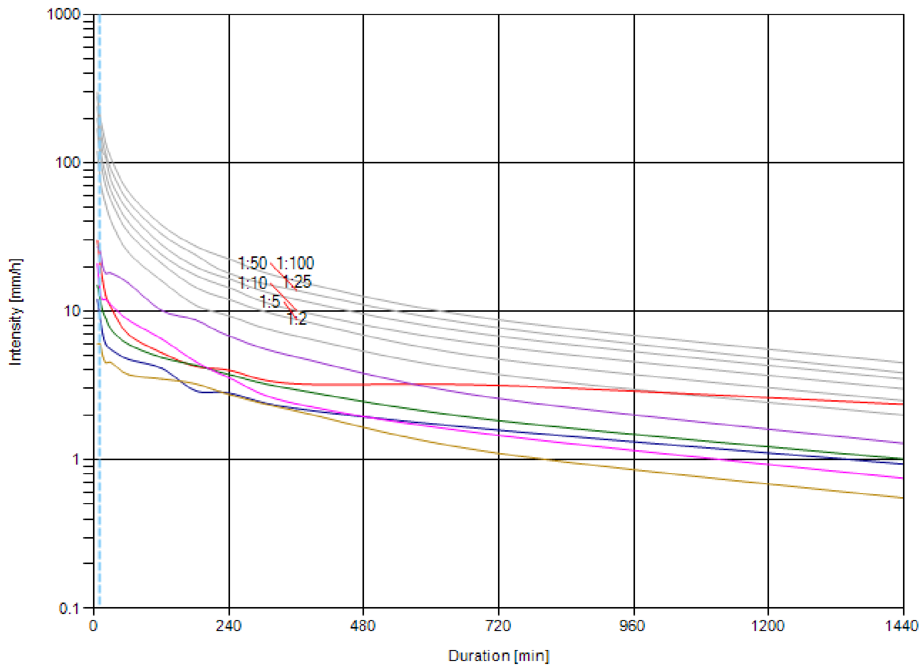
Map data ©2013 Google Imagery ©2013 Cnes/Spot Image, DigitalGlobe, First Base Solutions

Storm Date	Total Volume (mm)	Peak Intensity over Minute Timestep (mm/h)											
		5	10	15	20	30	60	120	180	240	360	720	1440
Nov 28, 2011	57	18	12	10	9.8	8.5	6.8	5.4	4.6	3.8	2.9	2.7	2.3
Oct 25, 2011	26	6	6	5	4.5	4	3.8	3	2.4	2.2	2.2	1.7	1
Oct 19, 2011	45	27	19.5	17	15	11.5	9.8	6.6	5.5	4.8	4.6	3.4	1.9
Oct 12, 2011	11	6	4.5	4	3.8	3.5	3.2	2.6	2.5	2.2	1.8	0.9	0.5
Sep 29, 2011	8	18	12	9	9	8	6	3.8	2.8	2.1	1.4	1	0.5
Sep 23, 2011	19	18	12	10	9.8	8	5.8	4.9	4.6	3.8	2.7	1.6	0.8

Export Peak Intensity Table

IDF Return Period Analysis

RG 13



Project: Vaughan I&I Reduction

Site: RG 13

Rain Gauge: RG 13

IDF Source: Vaughan

Tc: -- Enter Tc -- - 10 min

☑ Show ?

Event Selection

Minimum storm size: 12 mm

Inter-event dry period: 6 hour(s) ?

◉ Date Range ○ All Storms

From 2011-09-21

To 2011-12-30

Refresh Events

Event List

November 28, 2011 (60 mm)
October 25, 2011 (24 mm)
October 19, 2011 (23 mm)
October 12, 2011 (13 mm)
September 29, 2011 (14 mm)
September 23, 2011 (31 mm)

* *max 8 selections*

Display Options

☐ Show design storms in summary table

☐ Set maximum duration: 360 min Go

Design Storms

Source: City of Vaughan - IDF Curve

☑ 1:2 year ☑ 1:25 year

☑ 1:5 year ☑ 1:50 year

☑ 1:10 year ☑ 1:100 year

Legend

Tc
November 28, 2011
October 25, 2011
October 19, 2011
October 12, 2011
September 29, 2011
September 23, 2011

Storm Return Period Over Time Of Concentration

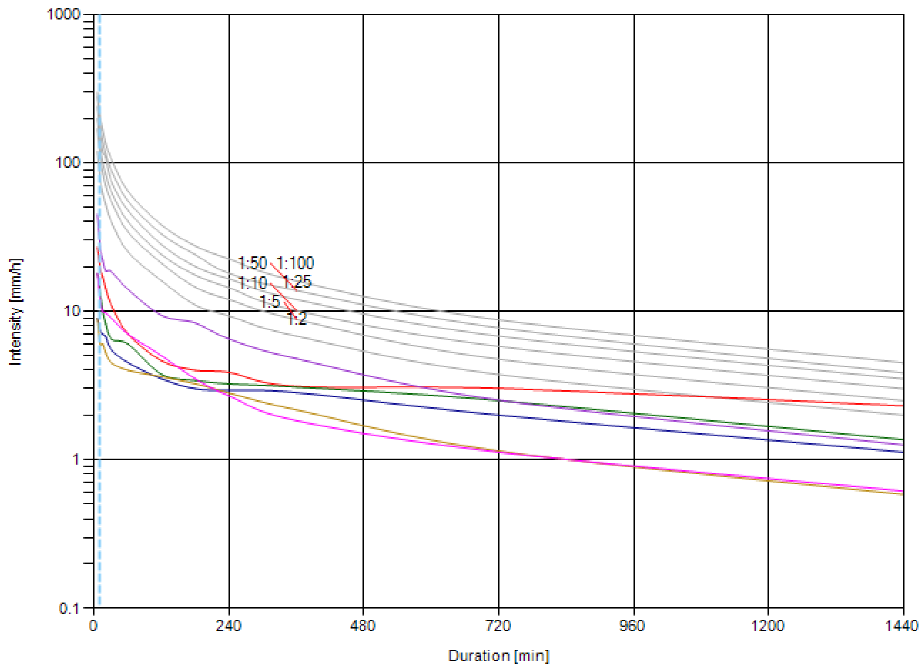
Storm Date	Time of Concentration T_c (min)	Return Period over T_c
Nov 28, 2011	10	< 2 yr
Oct 25, 2011	10	< 2 yr
Oct 19, 2011	10	< 2 yr
Oct 12, 2011	10	< 2 yr
Sep 29, 2011	10	< 2 yr
Sep 23, 2011	10	< 2 yr

Storm Date	Total Volume (mm)	Peak Intensity over Minute Timestep (mm/h)											
		5	10	15	20	30	60	120	180	240	360	720	1440
Nov 28, 2011	60	30	21	16	12.8	10.5	7	5.2	4.2	4	3.2	3.2	2.4
Oct 25, 2011	24	12	9	7	6	5.5	4.8	4.1	2.9	2.8	2.2	1.6	0.9
Oct 19, 2011	23	15	12	10	9	7.5	6	4.9	4.3	3.8	3	1.8	1
Oct 12, 2011	13	6	6	5	4.5	4.5	3.8	3.5	3.2	2.8	2.1	1.1	0.6
Sep 29, 2011	14	21	13.5	12	12	11	8.8	6.5	4.6	3.6	2.4	1.5	0.8
Sep 23, 2011	31	27	25.5	20	18	18	15.5	10.1	8.8	6.8	4.9	2.6	1.3

Export Peak Intensity Table

IDF Return Period Analysis

RG 10



Project: Vaughan I&I Reduction

Site: RG 10

Rain Gauge: RG 10

IDF Source: Vaughan

Tc: -- Enter Tc -- - 10 min

☑ Show

Event Selection

Minimum storm size: 13 mm

Inter-event dry period: 6 hour(s)

◉ Date Range ○ All Storms

From 2011-09-21

To 2011-12-30

Refresh Events

Event List

- December 04, 2011 (16 mm)
- November 28, 2011 (58 mm)
- October 25, 2011 (28 mm)
- October 19, 2011 (33 mm)
- October 12, 2011 (14 mm)
- September 29, 2011 (14 mm)
- September 23, 2011 (30 mm)

* *max 8 selections*

Display Options

☐ Show design storms in summary table

☐ Set maximum duration: 360 min Go

Design Storms

Source: City of Vaughan - IDF Curve

☑ 1:2 year ☑ 1:25 year

☑ 1:5 year ☑ 1:50 year

☑ 1:10 year ☑ 1:100 year

Legend

- Tc
- November 28, 2011
- October 25, 2011
- October 19, 2011
- October 12, 2011
- September 29, 2011
- September 23, 2011

Storm Return Period Over Time Of Concentration

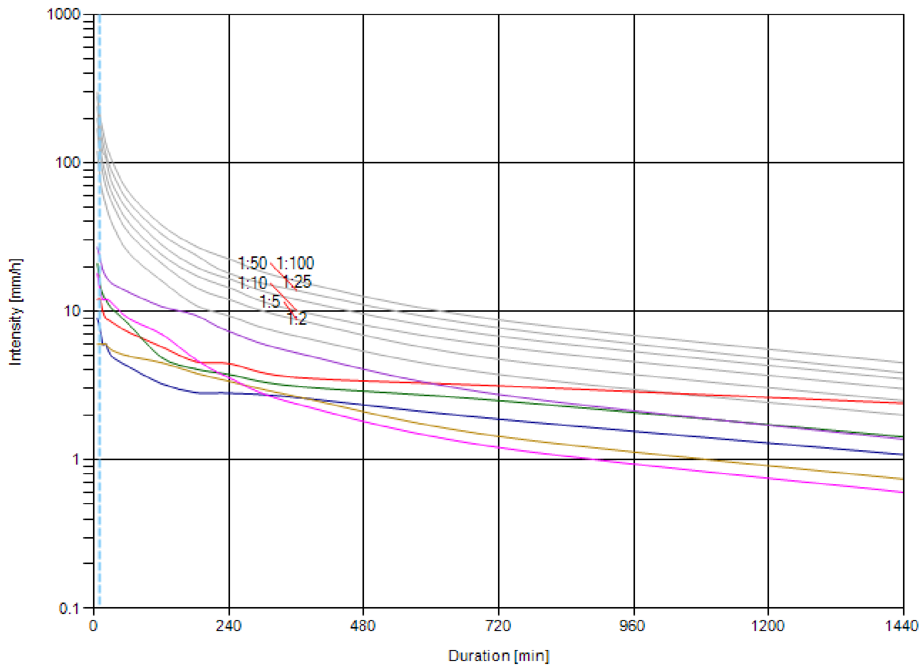
Storm Date	Time of Concentration T_c (min)	Return Period over T_c
Nov 28, 2011	10	< 2 yr
Oct 25, 2011	10	< 2 yr
Oct 19, 2011	10	< 2 yr
Oct 12, 2011	10	< 2 yr
Sep 29, 2011	10	< 2 yr
Sep 23, 2011	10	< 2 yr

Storm Date	Total Volume (mm)	Peak Intensity over Minute Timestep (mm/h)											
		5	10	15	20	30	60	120	180	240	360	720	1440
Nov 28, 2011	58	27	19.5	17	14.2	11	7	4.6	4	3.9	3.1	3	2.3
Oct 25, 2011	28	9	7.5	7	6.8	5.5	4.5	3.5	3	2.9	2.8	2	1.1
Oct 19, 2011	33	18	13.5	10	8.2	6.5	6	3.8	3.4	3.2	3.1	2.5	1.4
Oct 12, 2011	14	9	6	6	5.2	4.5	4	3.6	3.2	2.8	2.2	1.1	0.6
Sep 29, 2011	14	18	12	10	9.8	9	7	5	3.5	2.7	1.8	1.1	0.6
Sep 23, 2011	30	45	27	22	18.8	18.5	14	9.4	8.3	6.5	4.8	2.5	1.3

Export Peak Intensity Table

IDF Return Period Analysis

Thornhill Rain Gauge



Project: Cole Precipitation Monito...

Site: Thornhill Rain Gauge

Rain Gauge: RG Thornhill

IDF Source: Vaughan

Tc: -- Enter Tc -- - 10 min

☑ Show ?

Event Selection

Minimum storm size: 12 mm

Inter-event dry period: 6 hour(s) ?

◉ Date Range ○ All Storms

From 2011-09-21

To 2011-12-30

Refresh Events

Event List

November 28, 2011 (60 mm)
October 25, 2011 (28 mm)
October 19, 2011 (36 mm)
October 12, 2011 (18 mm)
September 30, 2011 (15 mm)
September 23, 2011 (33 mm)

* *max 8 selections*

Display Options

☐ Show design storms in summary table

☐ Set maximum duration: 360 min Go

Design Storms

Source: City of Vaughan - IDF Curve

☑ 1:2 year ☑ 1:25 year
☑ 1:5 year ☑ 1:50 year
☑ 1:10 year ☑ 1:100 year

Legend

Tc
November 28, 2011
October 25, 2011
October 19, 2011
October 12, 2011
September 30, 2011
September 23, 2011

Storm Return Period Over Time Of Concentration

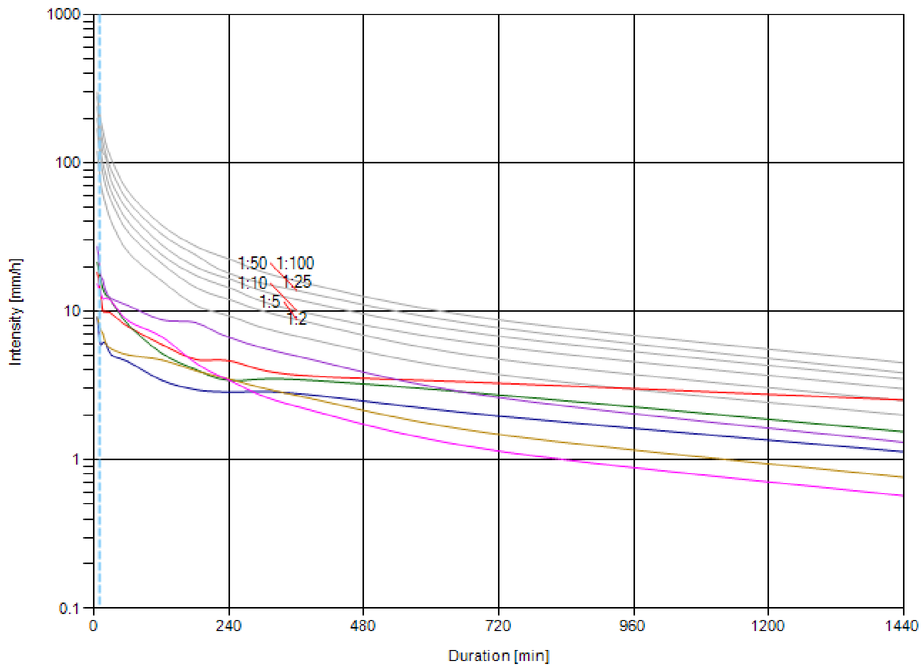
Storm Date	Time of Concentration T_c (min)	Return Period over T_c
Nov 28, 2011	10	< 2 yr
Oct 25, 2011	10	< 2 yr
Oct 19, 2011	10	< 2 yr
Oct 12, 2011	10	< 2 yr
Sep 30, 2011	10	< 2 yr
Sep 23, 2011	10	< 2 yr

Storm Date	Total Volume (mm)	Peak Intensity over Minute Timestep (mm/h)											
		5	10	15	20	30	60	120	180	240	360	720	1440
Nov 28, 2011	60	12	12	10	9	8.5	7.2	5.8	4.6	4.4	3.6	3.1	2.4
Oct 25, 2011	28	9	7.5	6	6	5	4.2	3.2	2.8	2.8	2.6	1.9	1.1
Oct 19, 2011	36	21	15	13	12	10.5	8.2	4.9	4.1	3.8	3.1	2.5	1.4
Oct 12, 2011	18	6	6	6	6	5.5	5	4.5	3.8	3.4	2.7	1.4	0.7
Sep 30, 2011	15	18	13.5	12	12	11.5	9	7	4.8	3.6	2.4	1.2	0.6
Sep 23, 2011	33	27	22.5	19	17.2	15.5	13.5	10.8	9.4	7.3	5.2	2.8	1.4

Export Peak Intensity Table

IDF Return Period Analysis

Thornhill CC RG



Project: Cole Precipitation Monito...

Site: Thornhill CC RG

Rain Gauge: Precipitation TCC

IDF Source: Vaughan

Tc: -- Enter Tc -- - 10 min

☑ Show

Event Selection

Minimum storm size: 12 mm

Inter-event dry period: 6 hour(s)

◉ Date Range ○ All Storms

From 2011-09-21

To 2011-12-30

Refresh Events

Event List

December 04, 2011 (27 mm)
November 28, 2011 (63 mm)
October 25, 2011 (28 mm)
October 19, 2011 (37 mm)
October 12, 2011 (18 mm)
September 30, 2011 (14 mm)
September 23, 2011 (31 mm)

** max 8 selections*

Display Options

☐ Show design storms in summary table

☐ Set maximum duration: 360 min Go

Design Storms

Source: City of Vaughan - IDF Curve

☑ 1:2 year ☑ 1:25 year

☑ 1:5 year ☑ 1:50 year

☑ 1:10 year ☑ 1:100 year

Legend

- Tc
- November 28, 2011
- October 25, 2011
- October 19, 2011
- October 12, 2011
- September 30, 2011
- September 23, 2011

Storm Return Period Over Time Of Concentration

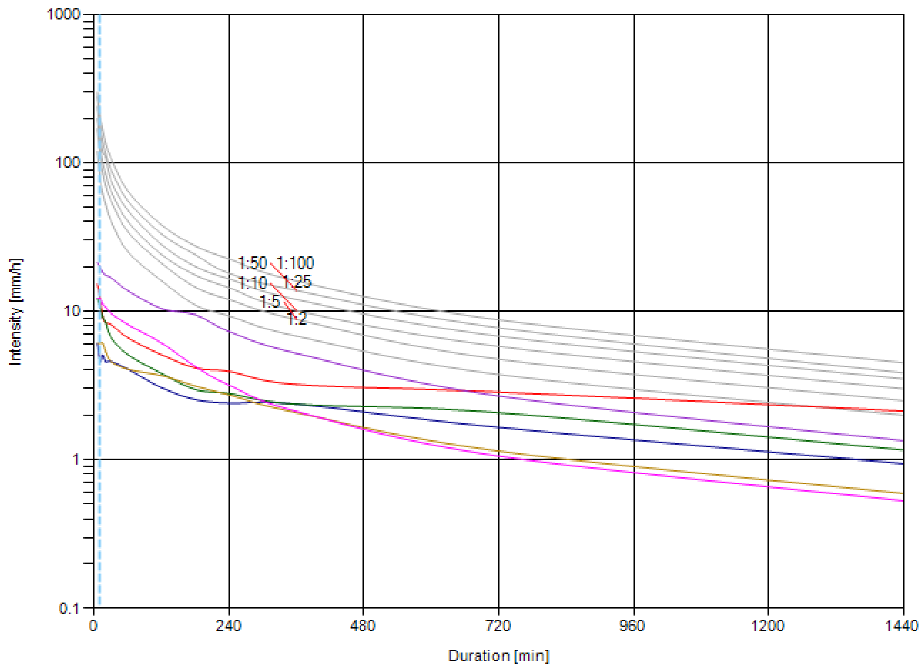
Storm Date	Time of Concentration T_c (min)	Return Period over T_c
Nov 28, 2011	10	< 2 yr
Oct 25, 2011	10	< 2 yr
Oct 19, 2011	10	< 2 yr
Oct 12, 2011	10	< 2 yr
Sep 30, 2011	10	< 2 yr
Sep 23, 2011	10	< 2 yr

Storm Date	Total Volume (mm)	Peak Intensity over Minute Timestep (mm/h)											
		5	10	15	20	30	60	120	180	240	360	720	1440
Nov 28, 2011	63	18.3	13.7	10.2	9.9	9.7	7.9	6	4.7	4.6	3.7	3.3	2.5
Oct 25, 2011	28	9.1	6.1	6.1	6.1	5.1	4.6	3.4	3	2.9	2.8	2	1.1
Oct 19, 2011	37	21.3	16.8	14.2	13	11.7	8.1	5.2	4.1	3.4	3.5	2.7	1.5
Oct 12, 2011	18	9.1	7.6	7.1	6.1	5.6	5.1	4.7	4	3.5	2.7	1.5	0.8
Sep 30, 2011	14	15.2	13.7	12.2	12.2	11.7	8.6	6.7	4.5	3.4	2.3	1.1	0.6
Sep 23, 2011	31	27.4	18.3	16.3	13.7	12.2	10.9	8.8	8.4	6.7	5	2.6	1.3

Export Peak Intensity Table

IDF Return Period Analysis

Richvale CC RG



Project: Cole Precipitation Monito...

Site: Richvale CC RG

Rain Gauge: Richvale Precip

IDF Source: Vaughan

Tc: -- Enter Tc -- - 10 min

Show ?

Event Selection

Minimum storm size: 12 mm

Inter-event dry period: 6 hour(s) ?

Date Range All Storms

From 2011-09-21

To 2011-12-30

Refresh Events

Event List

December 04, 2011 (22 mm)
November 28, 2011 (54 mm)
November 22, 2011 (13 mm)
October 25, 2011 (24 mm)
October 19, 2011 (28 mm)
October 12, 2011 (14 mm)
September 30, 2011 (13 mm)
September 23, 2011 (32 mm)

* *max 8 selections*

Display Options

Show design storms in summary table

Set maximum duration: 360 min Go

Design Storms

Source: City of Vaughan - IDF Curve

1:2 year 1:25 year
1:5 year 1:50 year
1:10 year 1:100 year

Legend

Tc
November 28, 2011
October 25, 2011
October 19, 2011
October 12, 2011
September 30, 2011
September 23, 2011

Storm Return Period Over Time Of Concentration

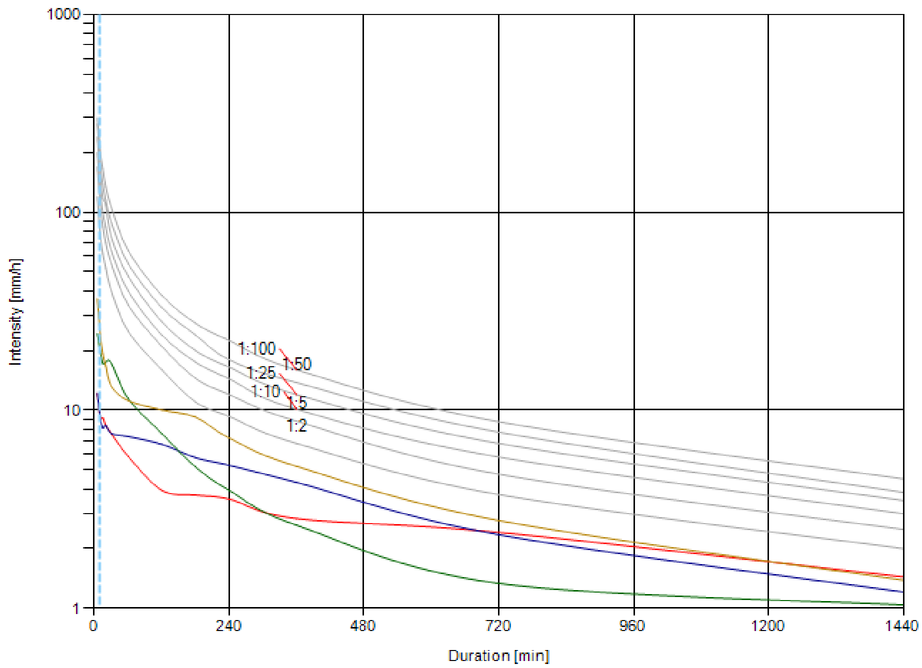
Storm Date	Time of Concentration T_c (min)	Return Period over T_c
Nov 28, 2011	10	< 2 yr
Oct 25, 2011	10	< 2 yr
Oct 19, 2011	10	< 2 yr
Oct 12, 2011	10	< 2 yr
Sep 30, 2011	10	< 2 yr
Sep 23, 2011	10	< 2 yr

Storm Date	Total Volume (mm)	Peak Intensity over Minute Timestep (mm/h)											
		5	10	15	20	30	60	120	180	240	360	720	1440
Nov 28, 2011	54	15.2	12.2	9.1	8.4	8.1	6.6	5.1	4.1	3.9	3.2	2.9	2.1
Oct 25, 2011	24	6.1	4.6	5.1	4.6	4.6	4.1	3	2.5	2.4	2.4	1.7	0.9
Oct 19, 2011	28	12.2	10.7	9.1	8.4	6.6	5.1	3.8	3	2.8	2.4	2.1	1.2
Oct 12, 2011	14	6.1	6.1	6.1	5.3	4.6	4.1	3.7	3.1	2.7	2.1	1.1	0.6
Sep 30, 2011	13	12.2	12.2	11.2	10.7	9.7	8.1	6.1	4.2	3.2	2.1	1.1	0.5
Sep 23, 2011	32	21.3	19.8	18.3	17.5	16.8	13.7	10.4	9.5	7.3	5.2	2.7	1.3

Export Peak Intensity Table

IDF Return Period Analysis

RG-027 Mitchell Field



Project: 2012 and 2013 Precipitati...

Site: RG-027 Mitchell Field

Rain Gauge: TOR RG 27

IDF Source: Vaughan

Tc: -- Enter Tc -- - 10 min

Show

Event Selection

Minimum storm size: 15 mm

Inter-event dry period: 12 hour(s)

Date Range All Storms

From 2011-09-21

To 2011-12-30

Refresh Events

Event List

October 19, 2011 (37 mm)
October 12, 2011 (29 mm)
September 29, 2011 (25 mm)
September 23, 2011 (33 mm)

** max 8 selections*

Display Options

Show design storms in summary table

Set maximum duration: 360 min Go

Design Storms

Source: City of Vaughan - IDF Curve

1:2 year
1:25 year
1:5 year
1:50 year
1:10 year
1:100 year

Legend

Tc
October 19, 2011
October 12, 2011
September 29, 2011
September 23, 2011

Storm Return Period Over Time Of Concentration

Storm Date	Time of Concentration T_c (min)	Return Period over T_c
Oct 19, 2011	10	< 2 yr
Oct 12, 2011	10	< 2 yr
Sep 29, 2011	10	< 2 yr
Sep 23, 2011	10	< 2 yr

Storm Date	Total Volume (mm)	Peak Intensity over Minute Timestep (mm/h)											
		5	10	15	20	30	60	120	180	240	360	720	1440
Oct 19, 2011	37	12.2	9.1	9.1	8.4	7.6	5.8	3.9	3.7	3.6	2.8	2.4	1.4
Oct 12, 2011	29	12.2	9.1	8.1	8.4	7.6	7.4	6.7	5.8	5.3	4.3	2.3	1.2
Sep 29, 2011	25	24.4	19.8	17.3	17.5	17.3	11.4	7.6	5.2	3.9	2.6	1.3	1
Sep 23, 2011	33	36.6	24.4	19.3	16.8	13.2	11.2	10	9.2	7.2	5.2	2.8	1.4

Export Peak Intensity Table

APPENDIX C
Rain Gauge Installation, Maintenance and Calibration Logs

Site:	RG - Vaughan Secondary School
Date:	2011-08-18 08:30:00 **EST**
Staff:	Randall Huizingh
Purpose of Visit:	Installation of RG
Location:	1401 Clark Avenue West, Thornhill
GPS Coordinates:	Longitude:-79.46909219026565 Latitude: 43.7974562557332
Equipment:	1675,1283,1511,1672,1674
Comments:	Rain gauge was successfully installed on Vaughan Secondary School. Unit was tested with tips and is online.

Site:	Thornhill Rain Gauge
Date:	2011-08-16 12:59:00 **EST**
Staff:	Randall Huizingh
Purpose of Visit:	Installation of RG
Location:	7994 Yonge Street , Thornhill
GPS Coordinates:	Longitude:-79.42734897136688 Latitude: 43.82105136465289
Equipment:	1694,1693,1695,1282
Comments:	rain gauge installation was successful. Please check in with the office before maintenance.

Site:	Thornhill Rain Gauge
Date:	2012-05-15 11:30:00 **EST**
Staff:	Jordan Webb
Purpose of Visit:	maintenance
Action Taken:	rewired black box and solar panel, recalibrated RG
Results:	online and logging
Additional Actions:	
Probable Root Cause:	
Comments:	

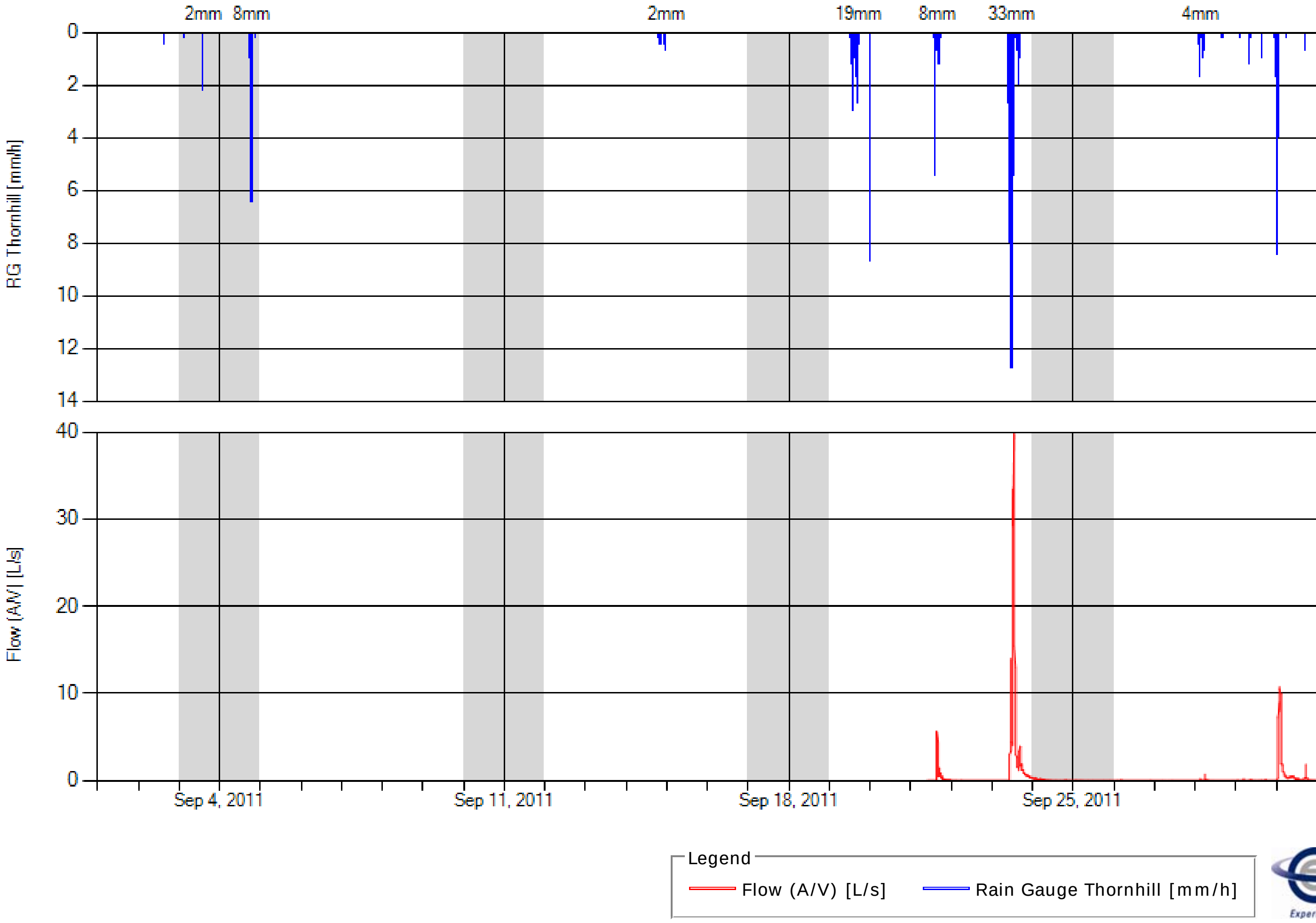
Site:	Thornhill Rain Gauge
Date:	2012-10-23 12:30:00 **EST**
Staff:	Jordan Webb
Purpose of Visit:	maintenance
Action Taken:	download
Results:	online and logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Thornhill Rain Gauge
Date:	2012-10-23 12:30:00 **EST**
Staff:	Jordan Webb
Purpose of Visit:	maintenance

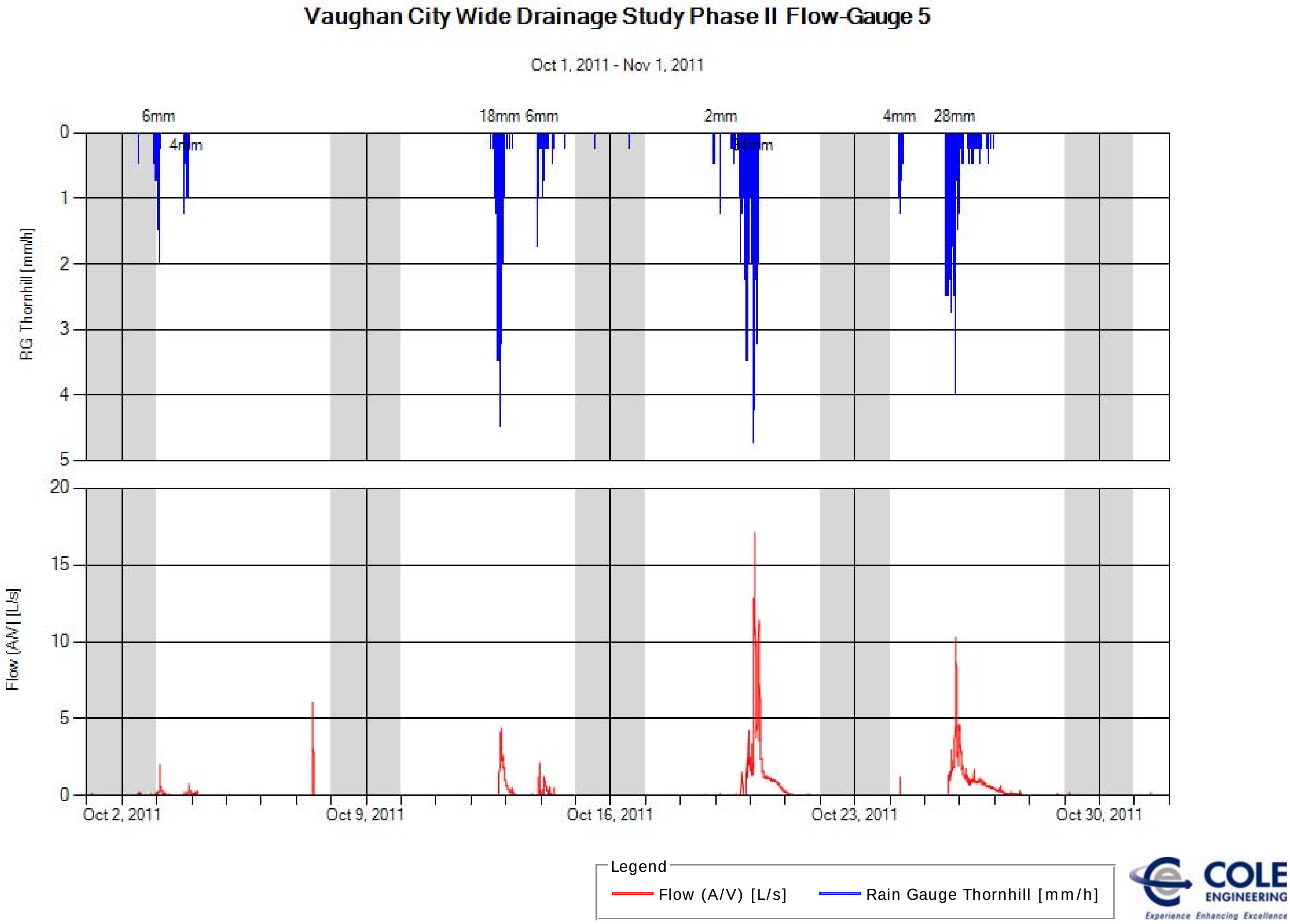
APPENDIX D
Flow Gauge Monthly Reports

Vaughan City Wide Drainage Study Phase II Flow-Gauge 5

Sep 1, 2011 - Oct 1, 2011

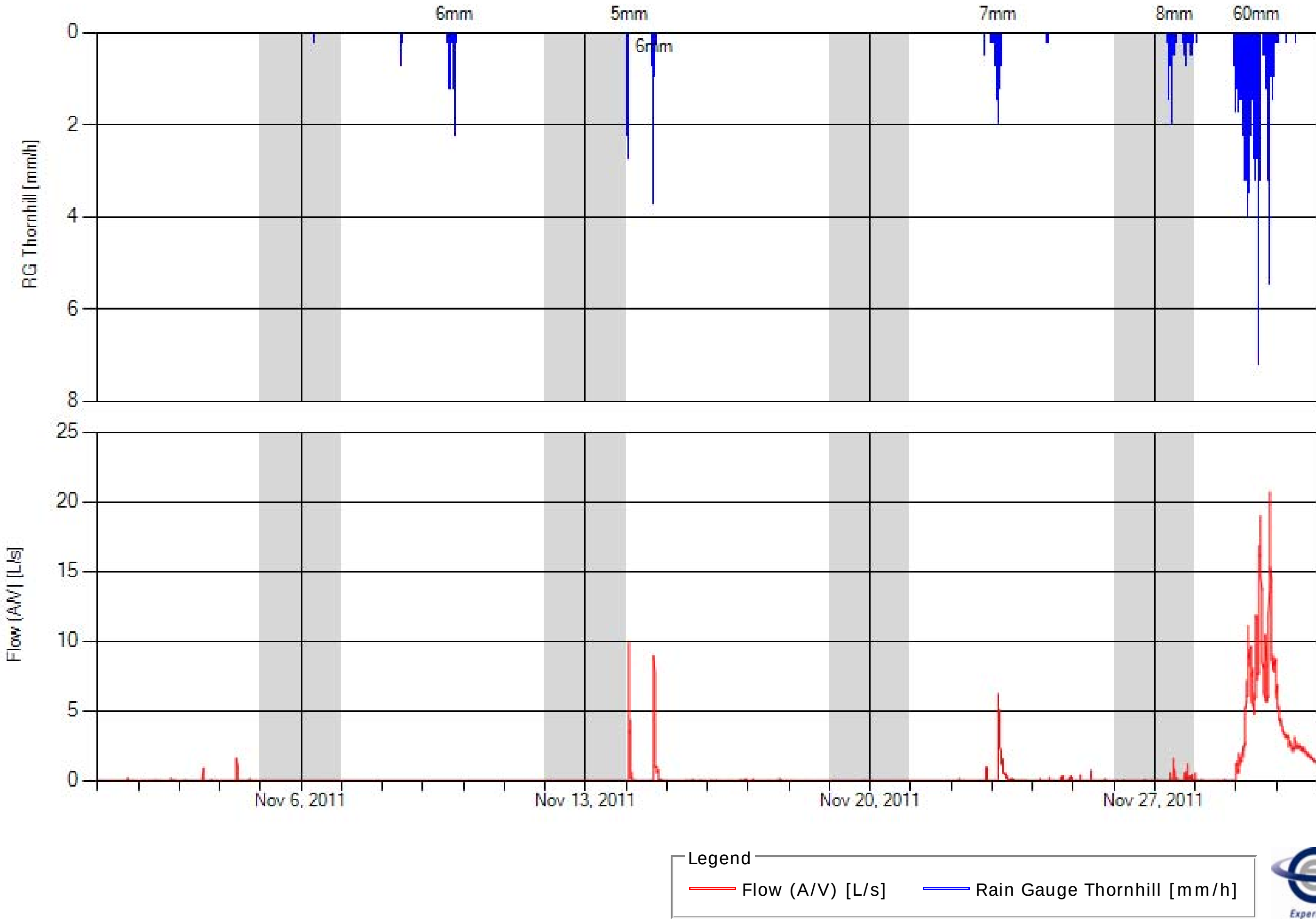


COLE ENGINEERING
Experience Enhancing Excellence


Vaughan City Wide Drainage Study Phase II Flow-Gauge 5
Oct 1, 2011 - Nov 1, 2011
6mm
4mm
18mm 6mm
2mm
4mm
28mm
RG Thornhill [mm/h]
Flow (A/V) [L/s]
Oct 2, 2011
Oct 9, 2011
Oct 16, 2011
Oct 23, 2011
Oct 30, 2011
Legend
Flow (A/V) [L/s]
Rain Gauge Thornhill [mm/h]

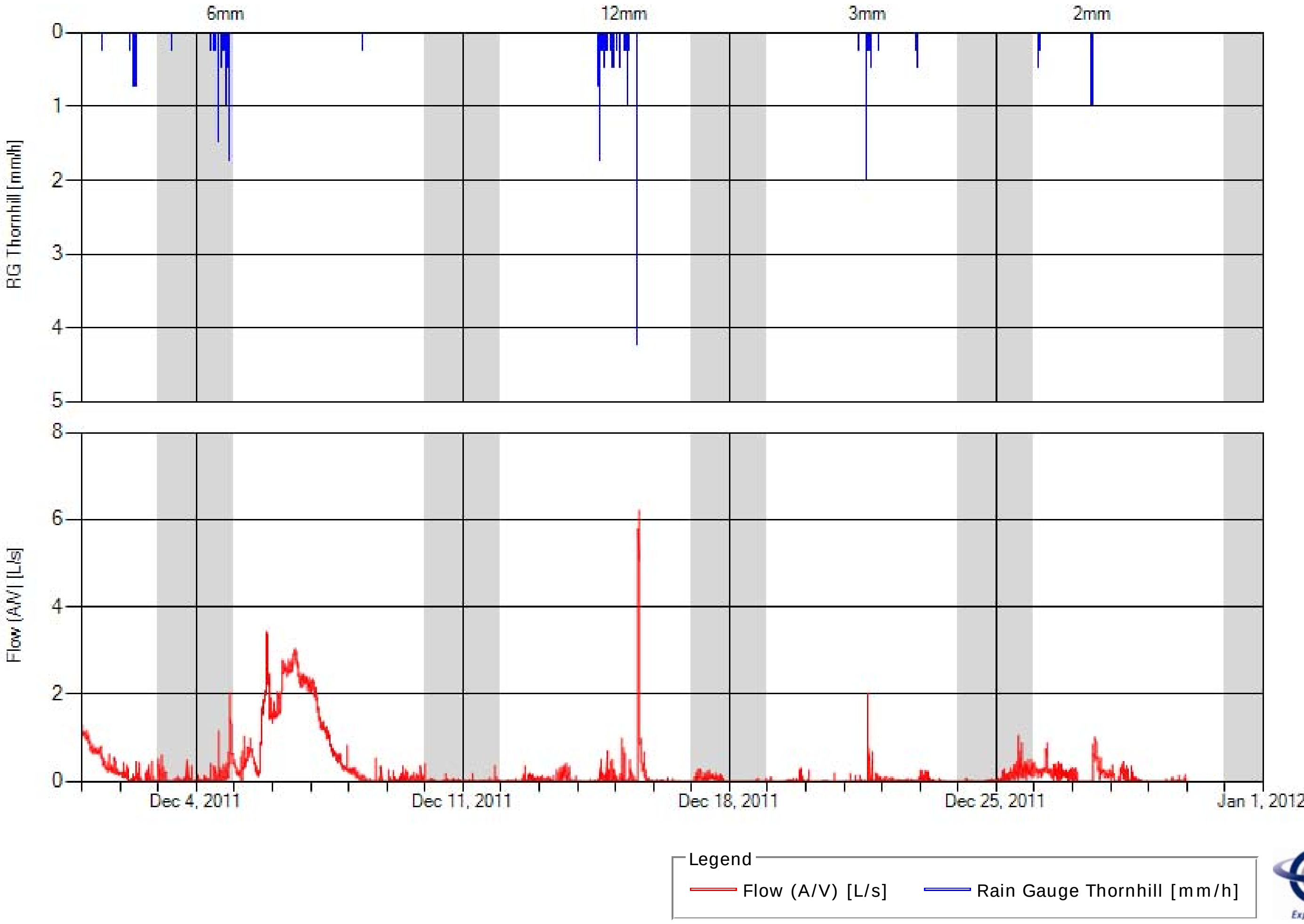
Vaughan City Wide Drainage Study Phase II Flow-Gauge 5

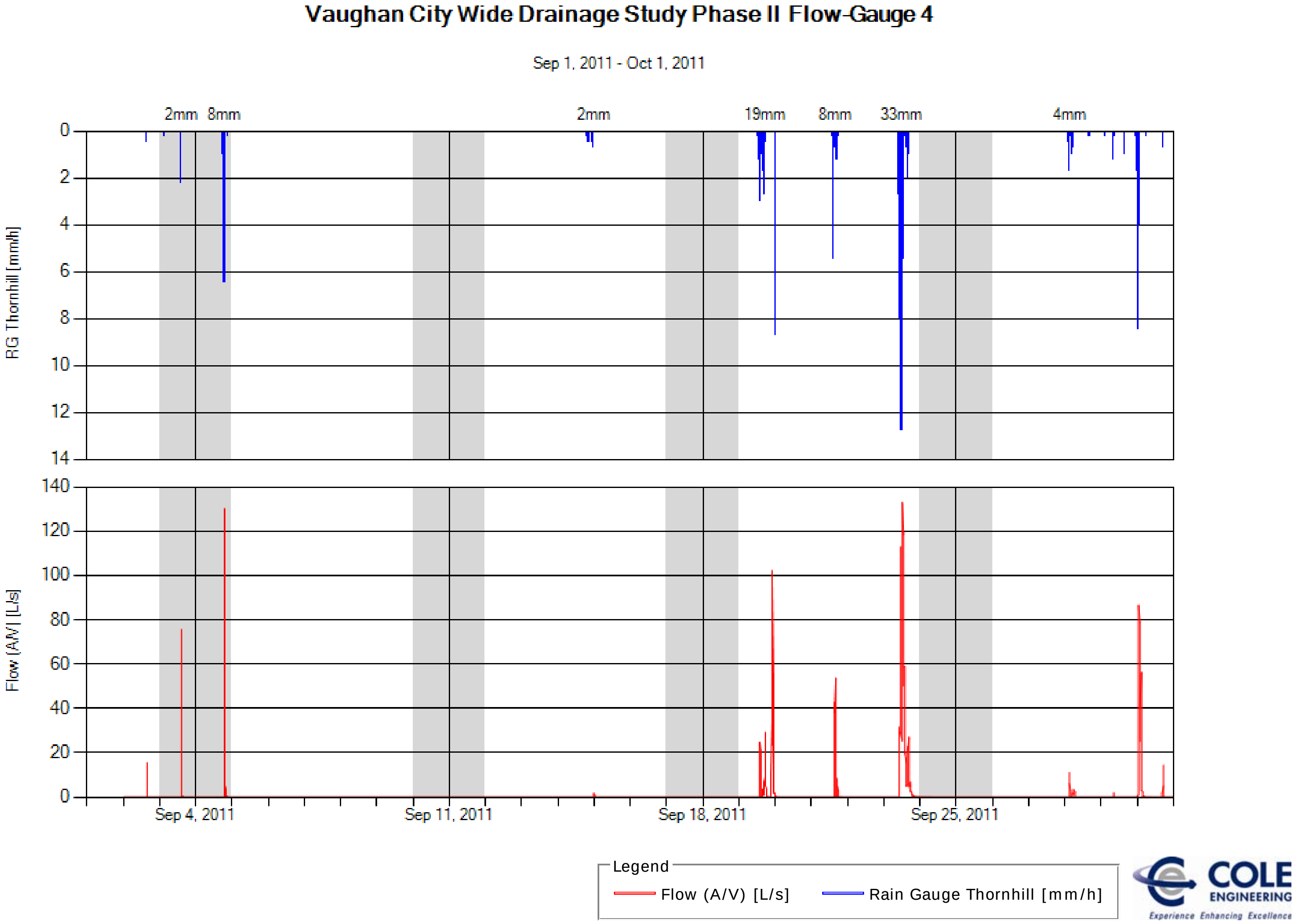
Nov 1, 2011 - Dec 1, 2011

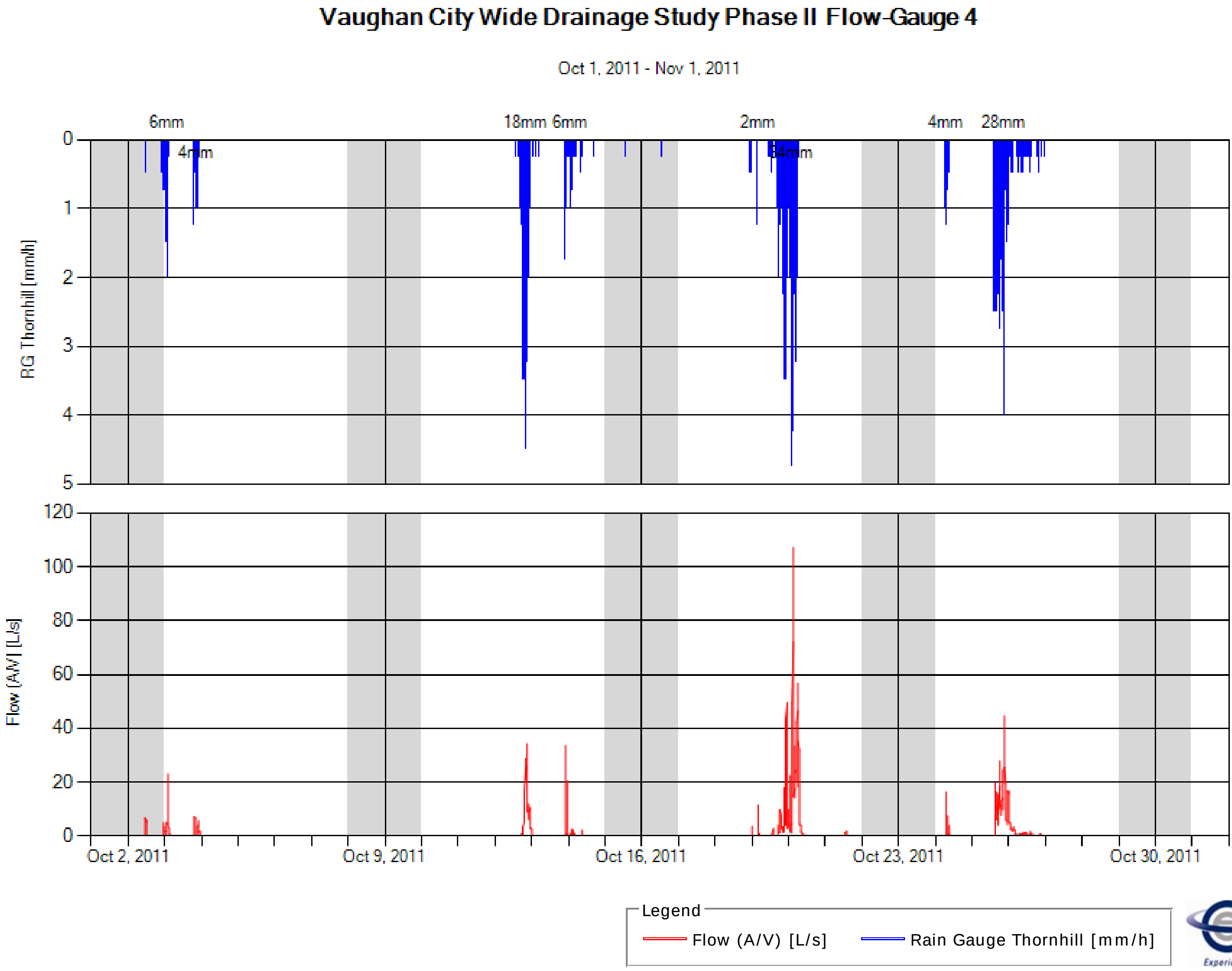


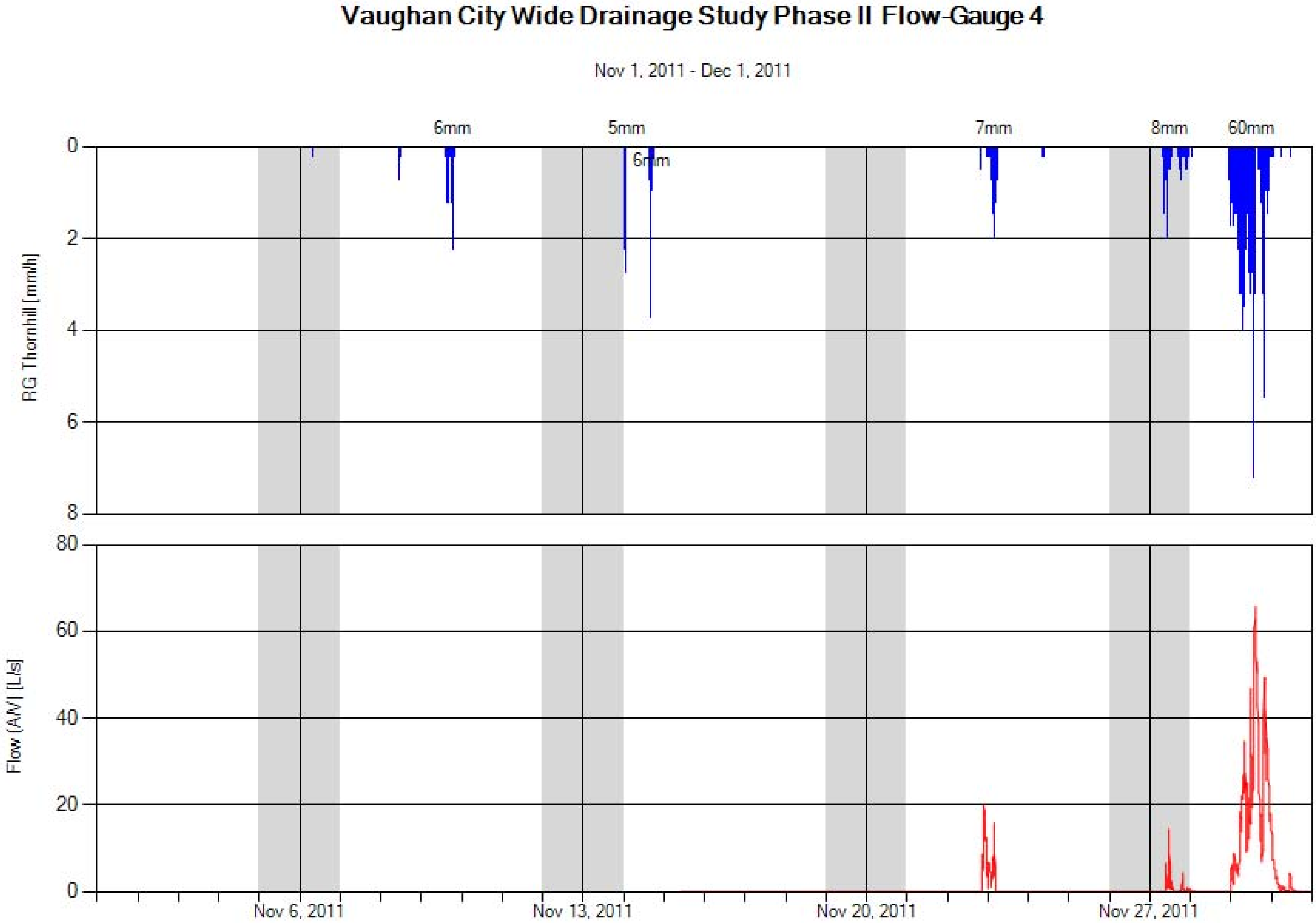
Vaughan City Wide Drainage Study Phase II Flow-Gauge 5

Dec 1, 2011 - Jan 1, 2012



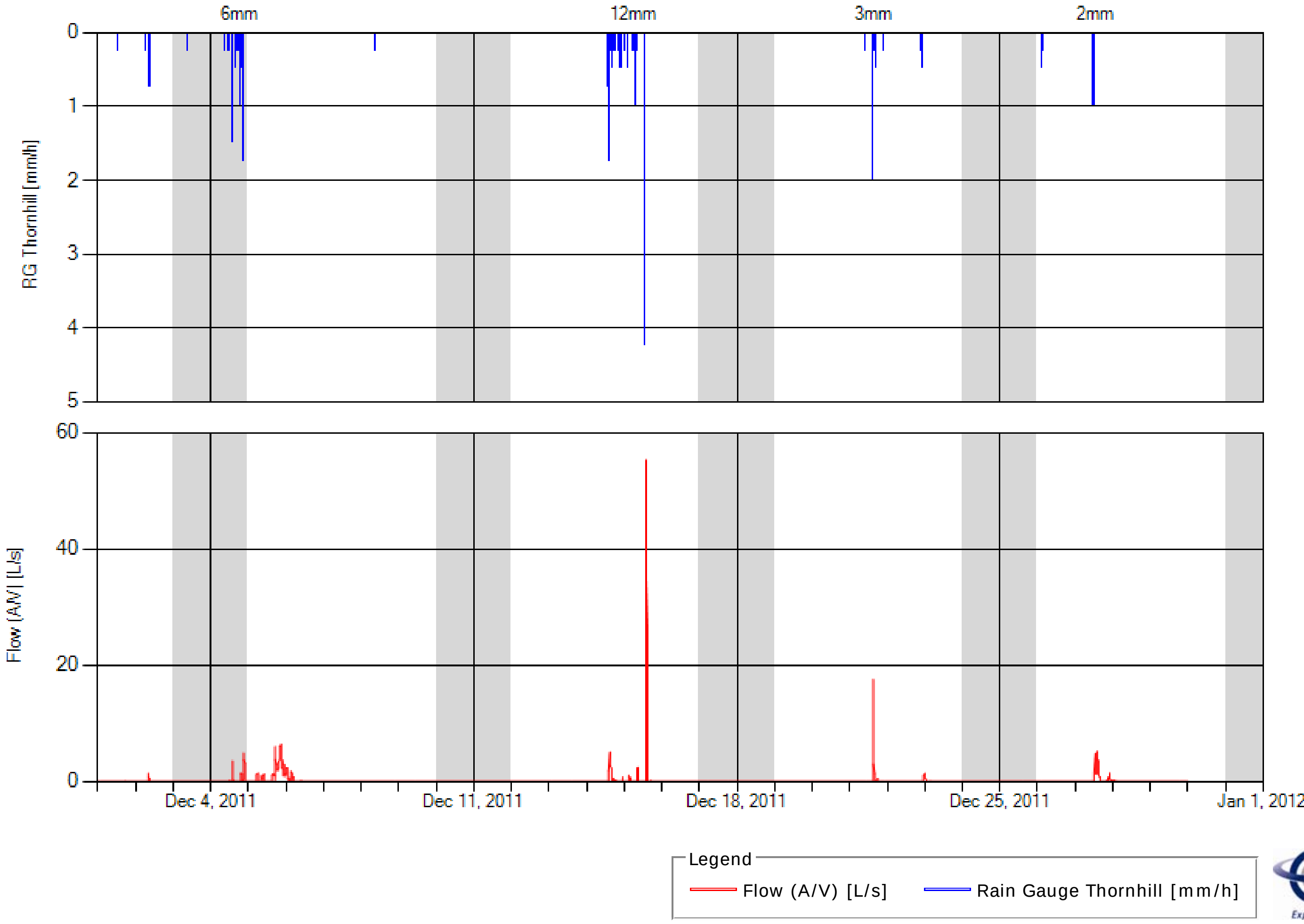

Vaughan City Wide Drainage Study Phase II Flow-Gauge 4
Sep 1, 2011 - Oct 1, 2011
2mm
8mm
2mm
19mm
8mm
33mm
4mm
RG Thornhill [mm/h]
0
2
4
6
8
10
12
14
Flow (A/V) [L/s]
140
120
100
80
60
40
20
0
Sep 4, 2011
Sep 11, 2011
Sep 18, 2011
Sep 25, 2011
Legend
Flow (A/V) [L/s]
Rain Gauge Thornhill [mm/h]

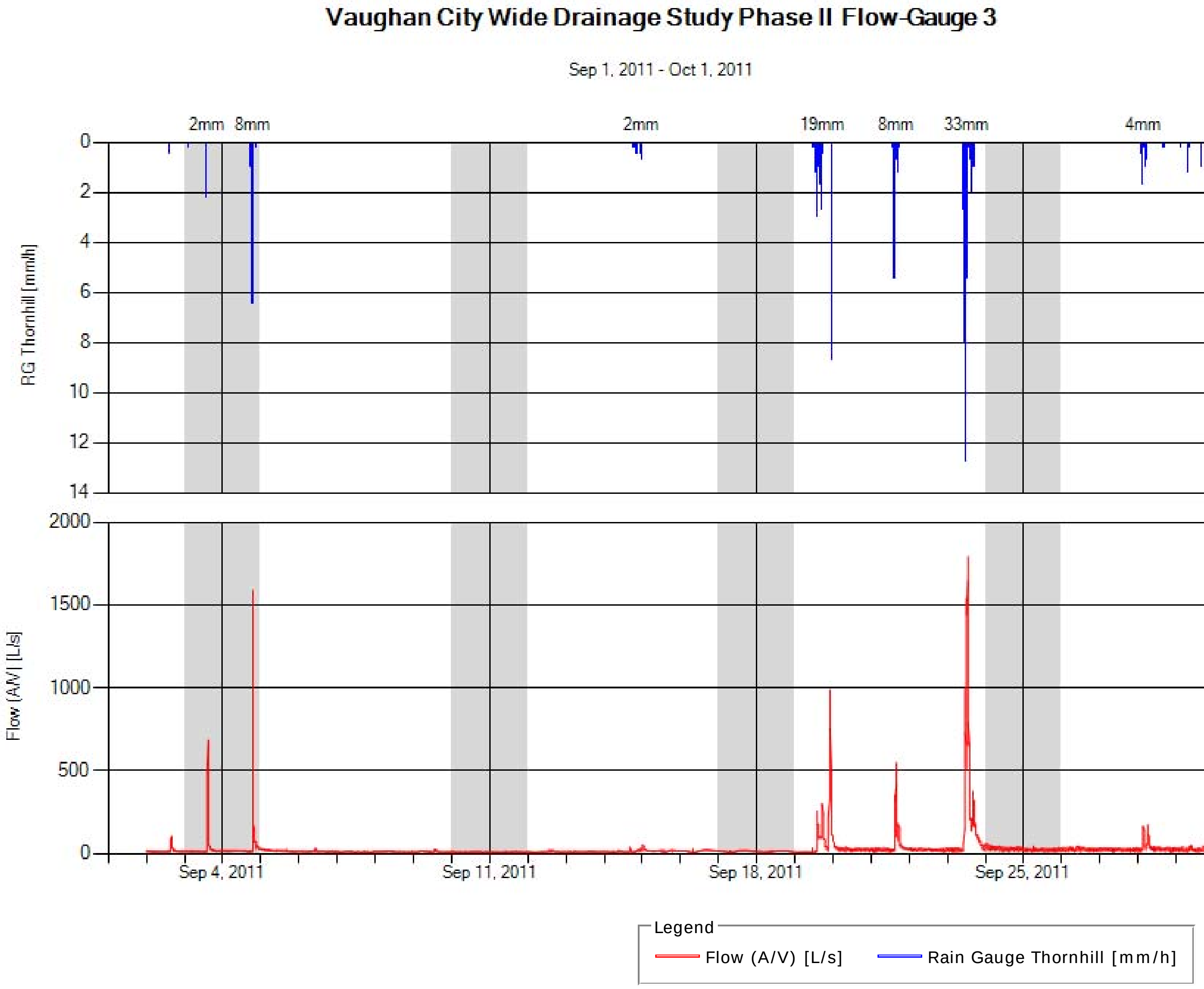

Vaughan City Wide Drainage Study Phase II Flow-Gauge 4
Oct 1, 2011 - Nov 1, 2011
6mm
4mm
18mm
6mm
2mm
54mm
4mm
28mm
RG Thornhill [mm/h]
0
1
2
3
4
5
Flow (A/V) [L/s]
120
100
80
60
40
20
0
Oct 2, 2011
Oct 9, 2011
Oct 16, 2011
Oct 23, 2011
Oct 30, 2011
Legend
Flow (A/V) [L/s]
Rain Gauge Thornhill [mm/h]


Vaughan City Wide Drainage Study Phase II Flow-Gauge 4
Nov 1, 2011 - Dec 1, 2011
6mm
5mm
6mm
7mm
8mm
60mm
RG Thornhill [mm/h]
0
2
4
6
8
80
60
40
20
0
Flow (A/V) [L/s]
Nov 6, 2011
Nov 13, 2011
Nov 20, 2011
Nov 27, 2011
Legend
Flow (A/V) [L/s]
Rain Gauge Thornhill [mm/h]

Vaughan City Wide Drainage Study Phase II Flow-Gauge 4

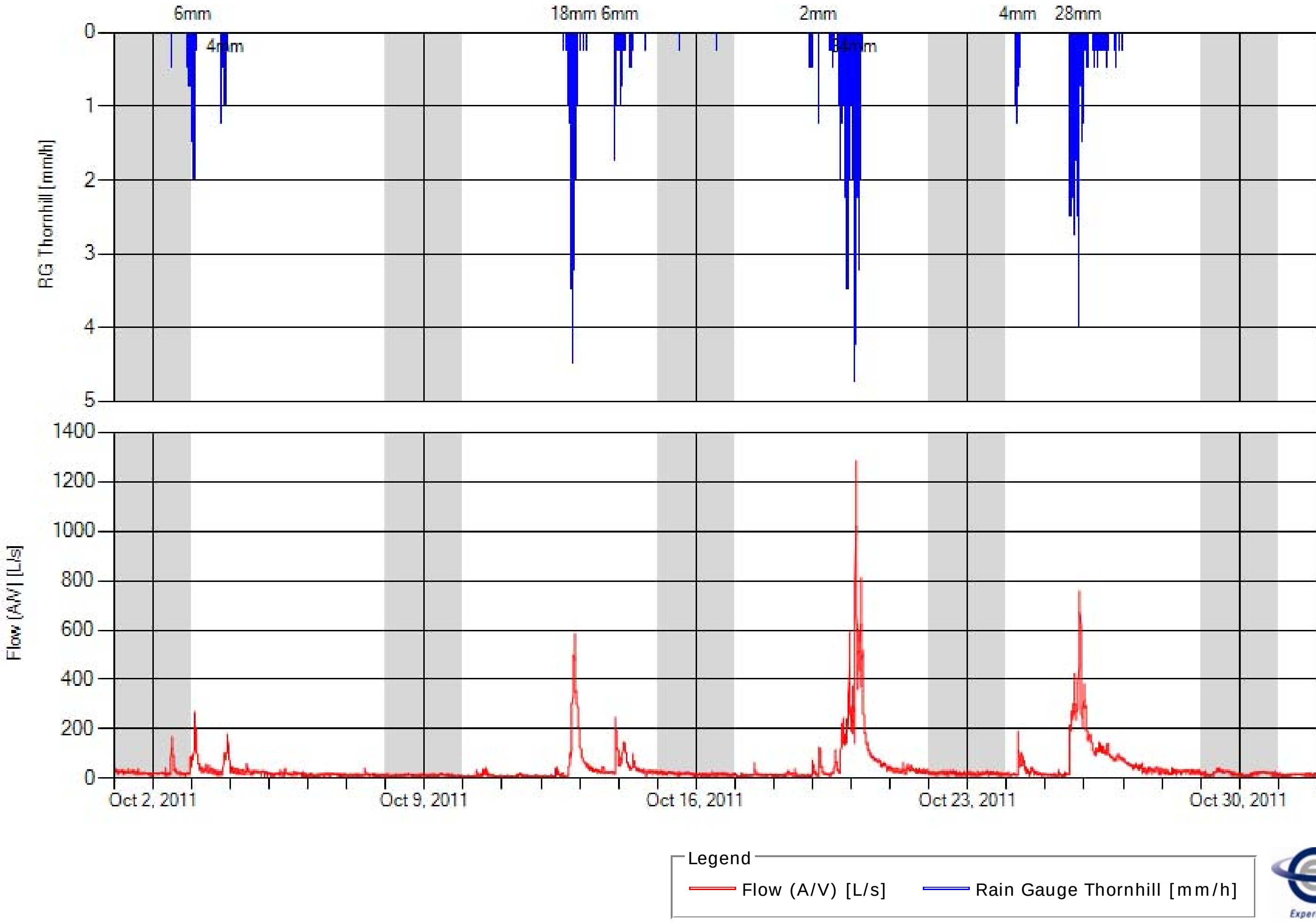
Dec 1, 2011 - Jan 1, 2012

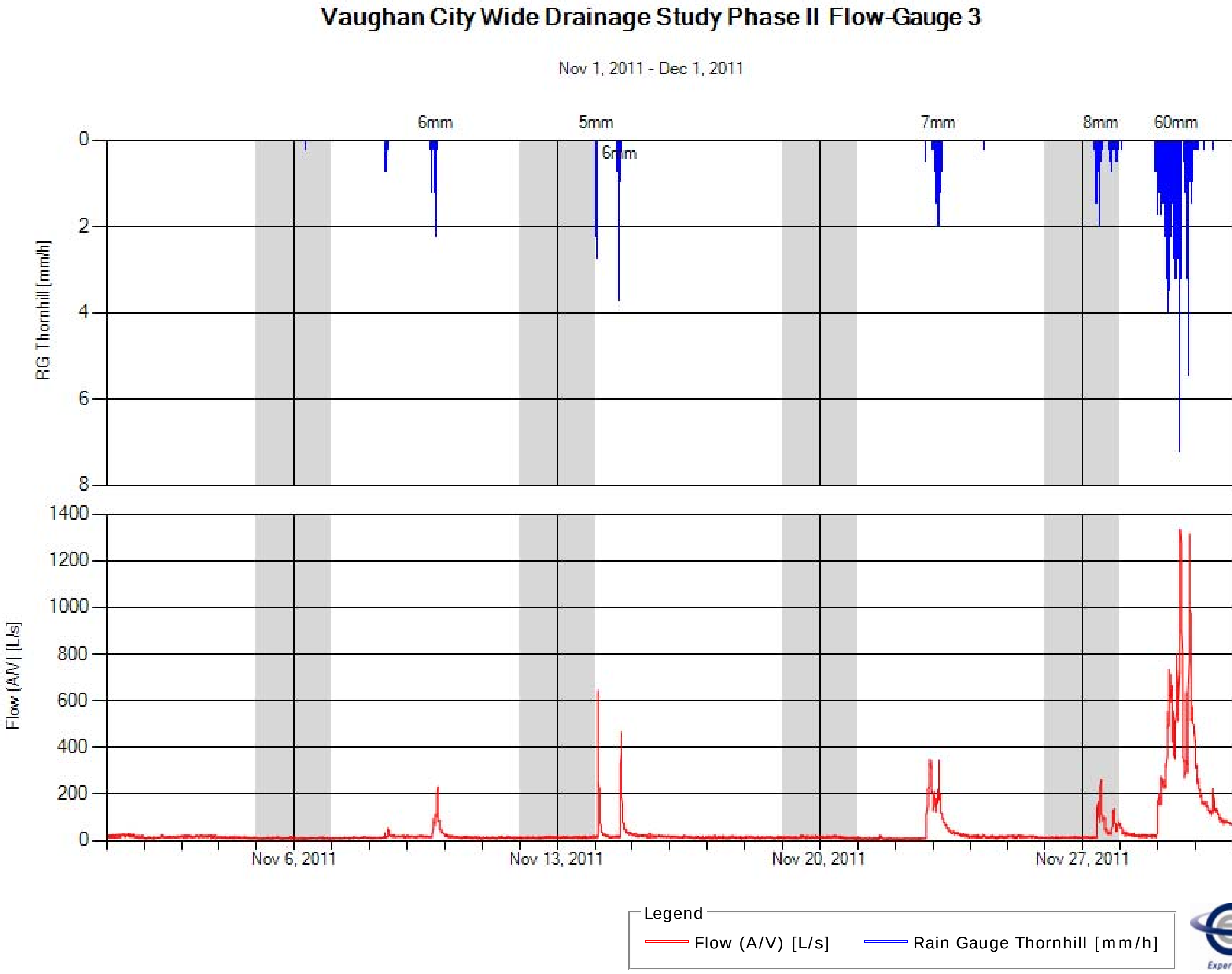



Vaughan City Wide Drainage Study Phase II Flow-Gauge 3
Sep 1, 2011 - Oct 1, 2011
2mm 8mm 2mm 19mm 8mm 33mm 4mm
RG Thornhill [mm/h]
0 2 4 6 8 10 12 14
Flow (A/V) [L/s]
2000 1500 1000 500 0
Sep 4, 2011
Sep 11, 2011
Sep 18, 2011
Sep 25, 2011
Legend
Flow (A/V) [L/s]
Rain Gauge Thornhill [mm/h]

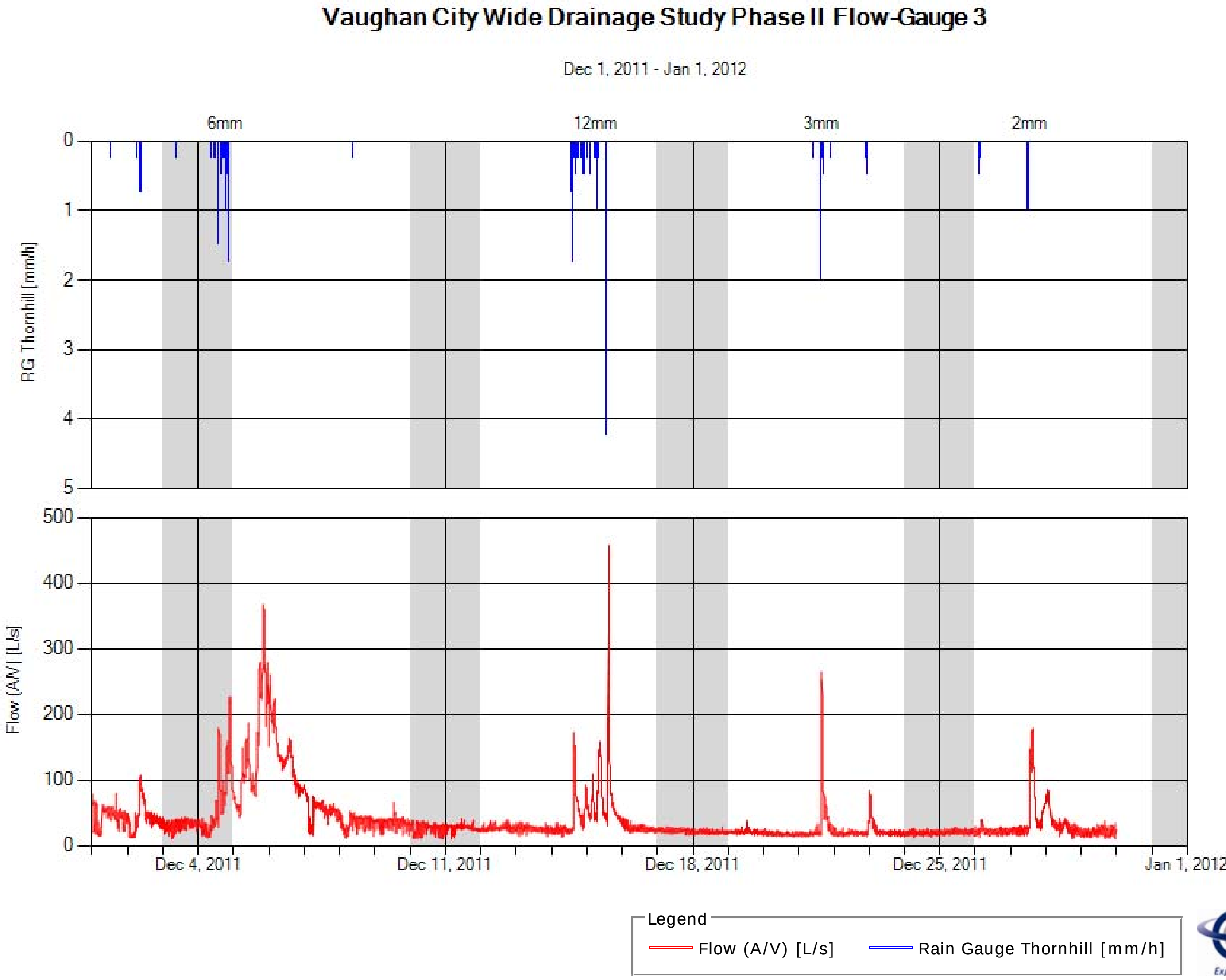
Vaughan City Wide Drainage Study Phase II Flow-Gauge 3

Oct 1, 2011 - Nov 1, 2011



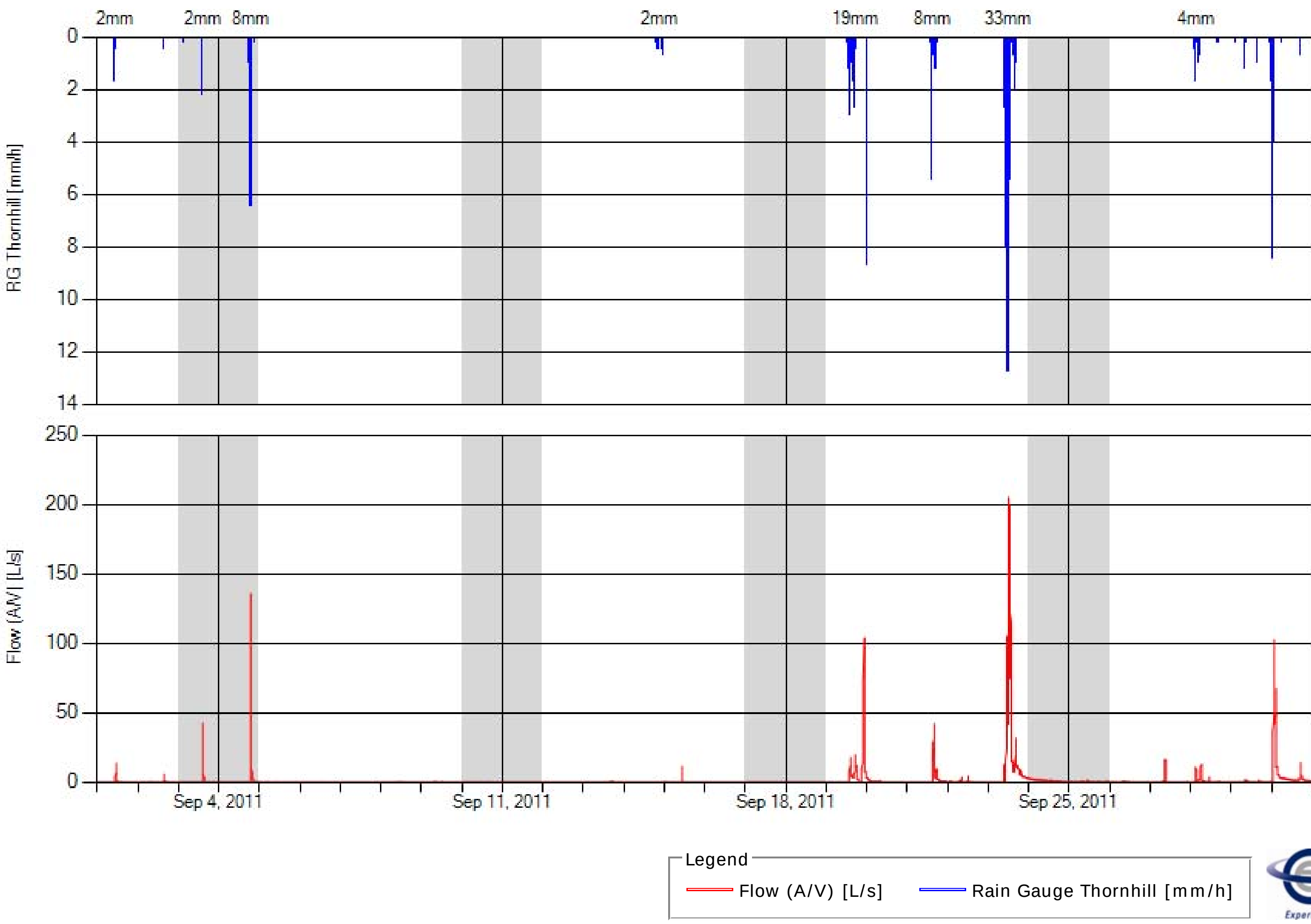


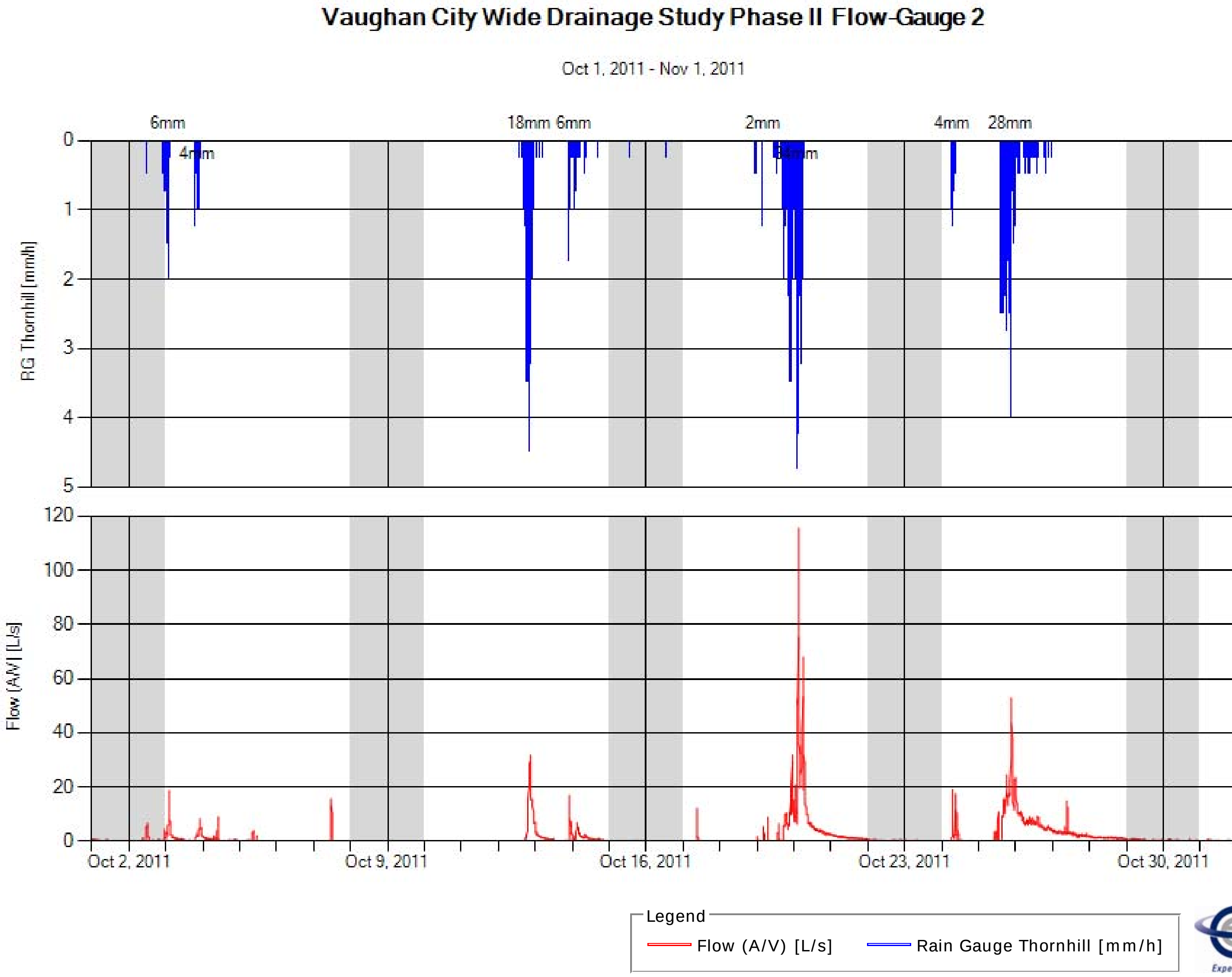
COLE ENGINEERING
Experience Enhancing Excellence


Vaughan City Wide Drainage Study Phase II Flow-Gauge 3
Dec 1, 2011 - Jan 1, 2012
6mm
12mm
3mm
2mm
RG Thornhill [mm/h]
0
1
2
3
4
5
Flow (A/V) [L/s]
500
400
300
200
100
0
Dec 4, 2011
Dec 11, 2011
Dec 18, 2011
Dec 25, 2011
Jan 1, 2012
Legend
Flow (A/V) [L/s]
Rain Gauge Thornhill [mm/h]

Vaughan City Wide Drainage Study Phase II Flow-Gauge 2

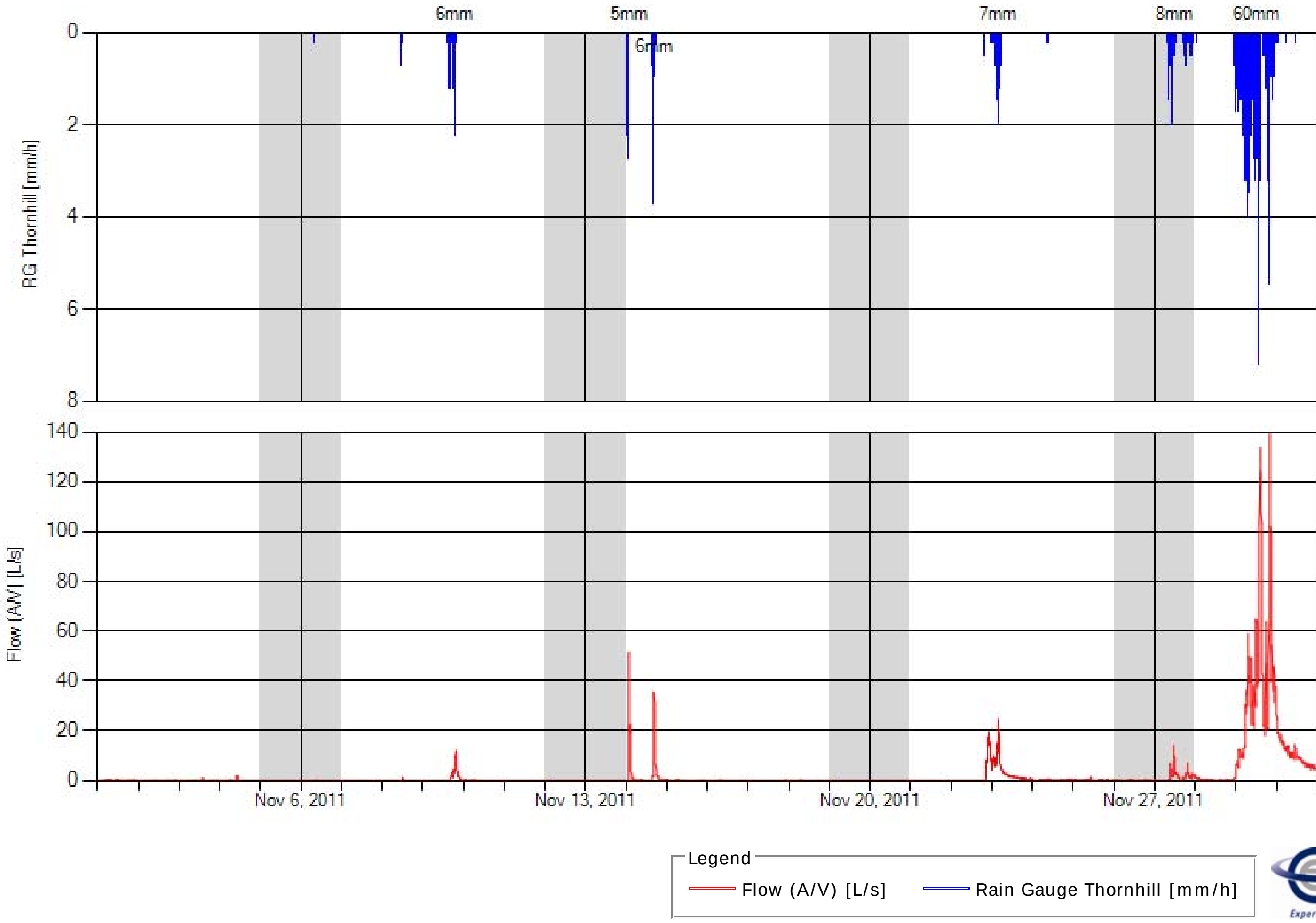
Sep 1, 2011 - Oct 1, 2011




Vaughan City Wide Drainage Study Phase II Flow-Gauge 2
Oct 1, 2011 - Nov 1, 2011
6mm
4mm
18mm 6mm
2mm
4mm
28mm
RG Thornhill [mm/h]
Flow [A/V] [L/s]
Oct 2, 2011
Oct 9, 2011
Oct 16, 2011
Oct 23, 2011
Oct 30, 2011
Legend
Flow (A/V) [L/s]
Rain Gauge Thornhill [mm/h]

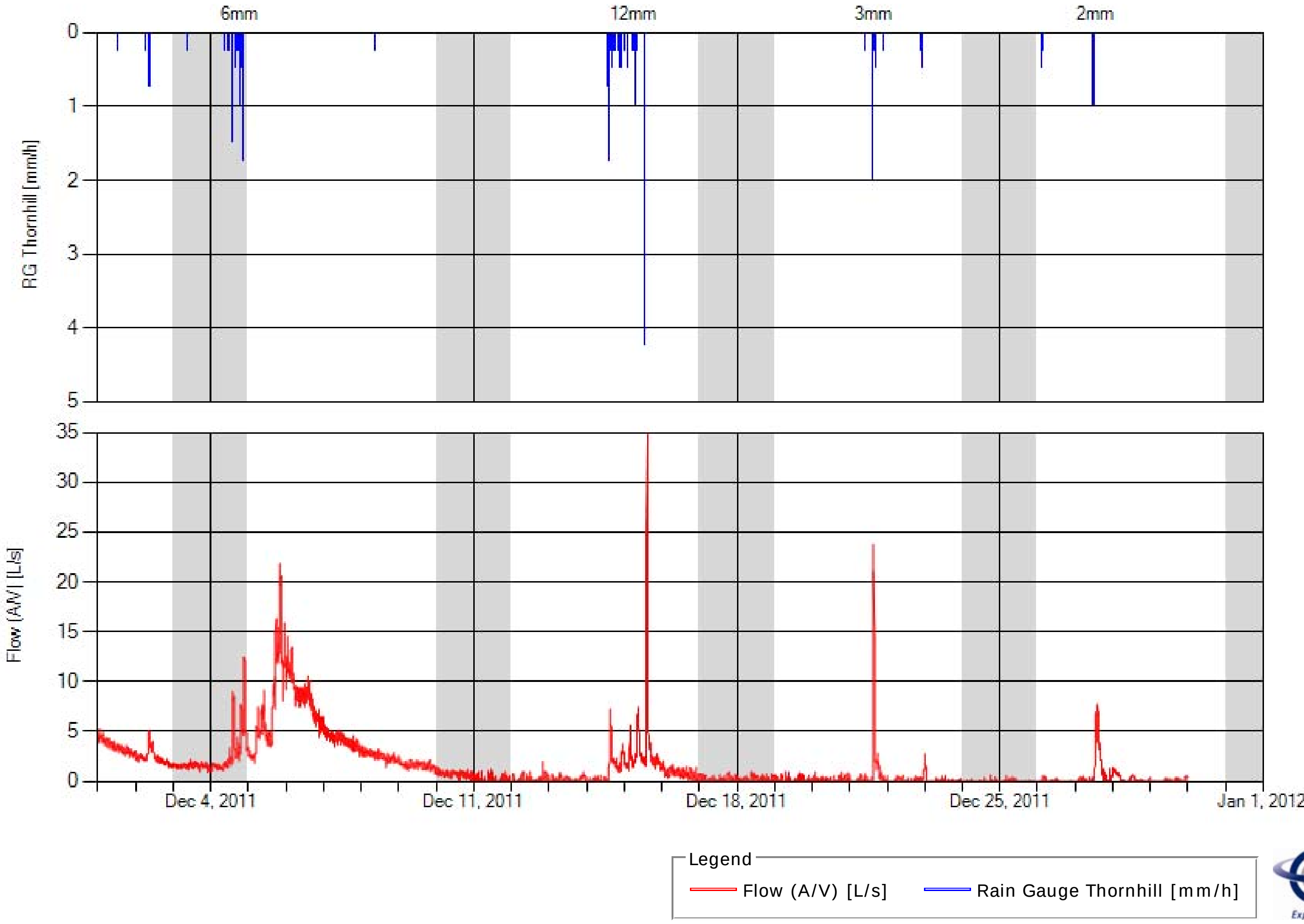
Vaughan City Wide Drainage Study Phase II Flow-Gauge 2

Nov 1, 2011 - Dec 1, 2011



Vaughan City Wide Drainage Study Phase II Flow-Gauge 2

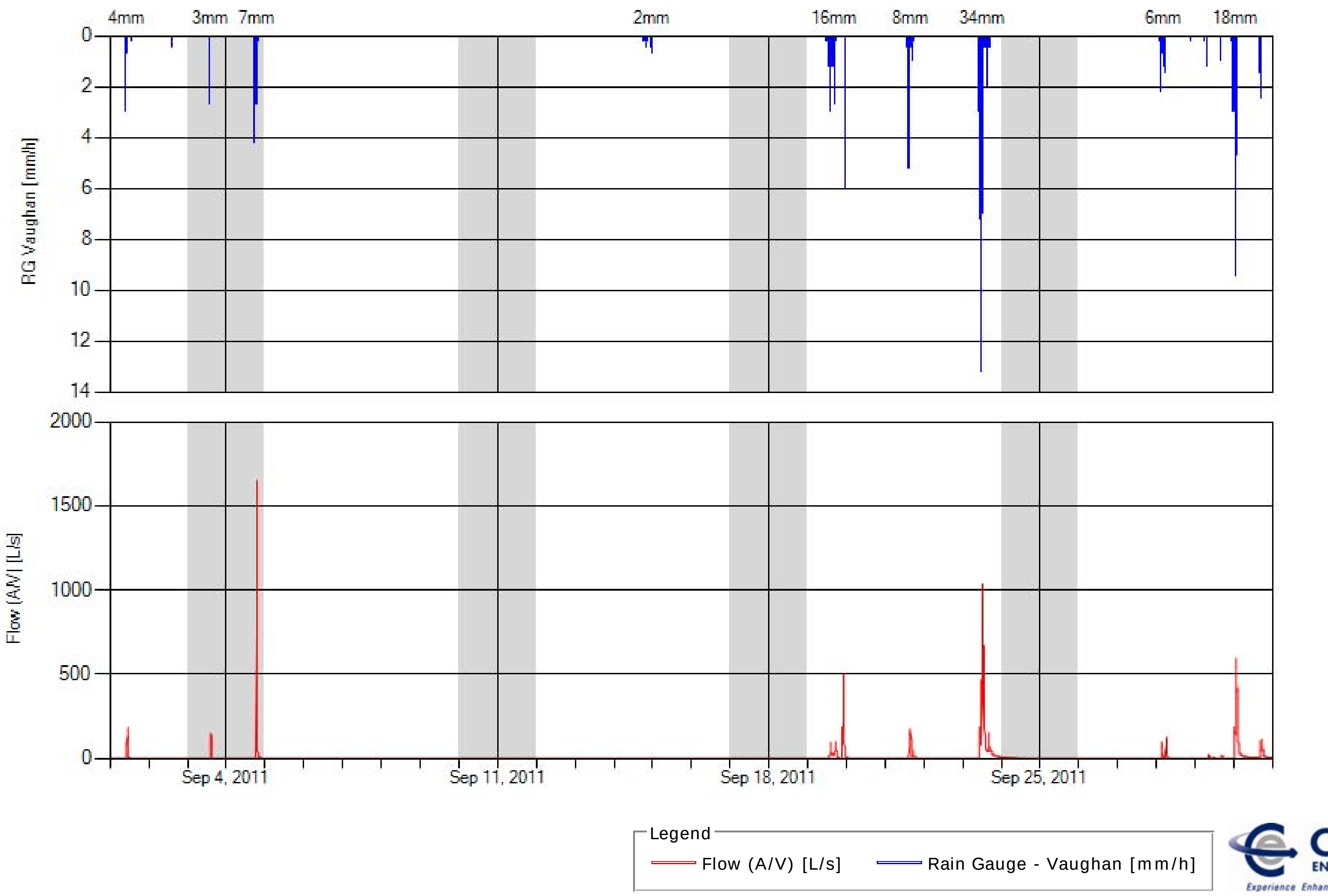
Dec 1, 2011 - Jan 1, 2012



COLE ENGINEERING
Experience Enhancing Excellence

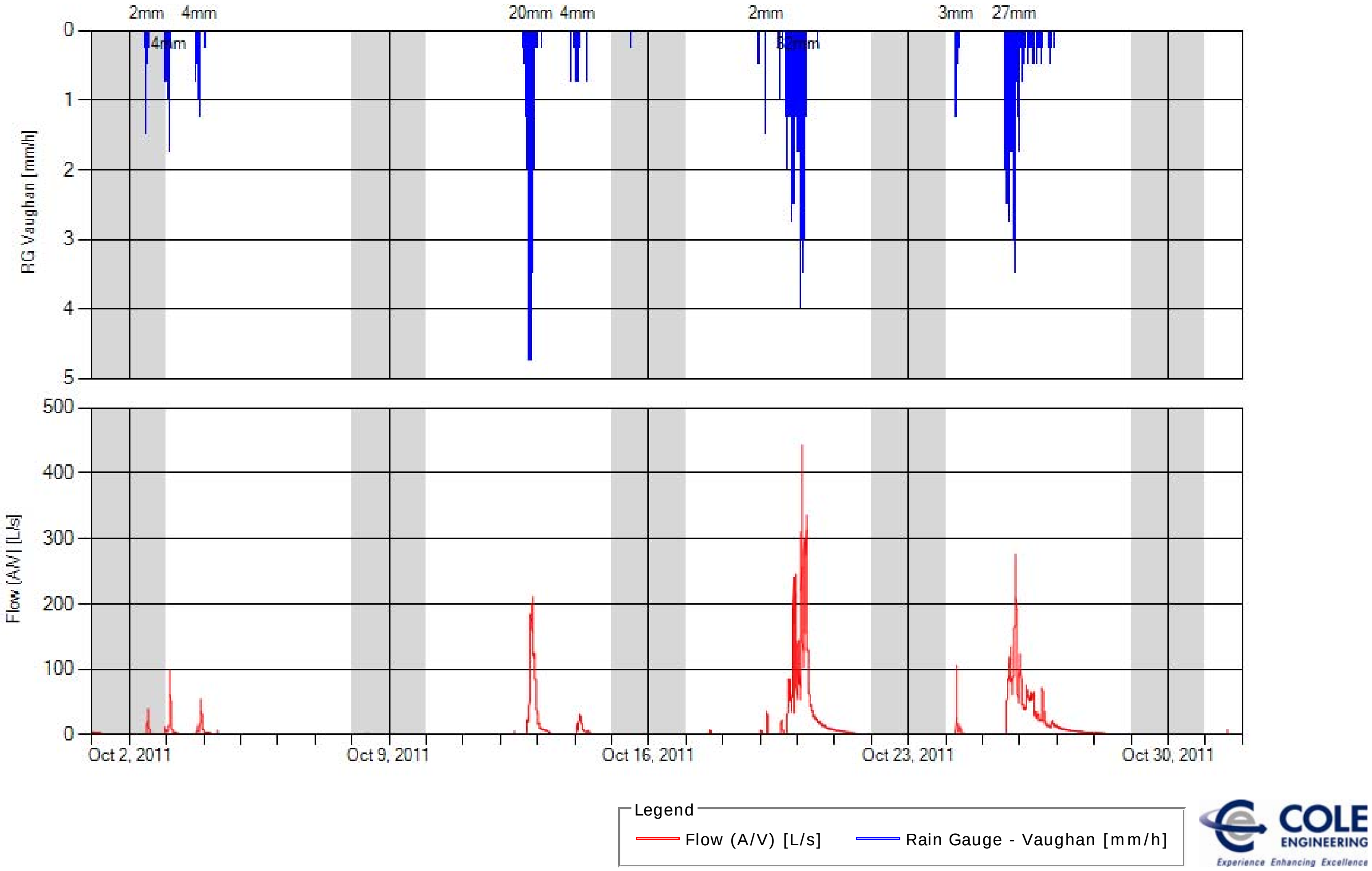
Vaughan City Wide Drainage Study Phase II Flow-Gauge 1

Sep 1, 2011 - Oct 1, 2011



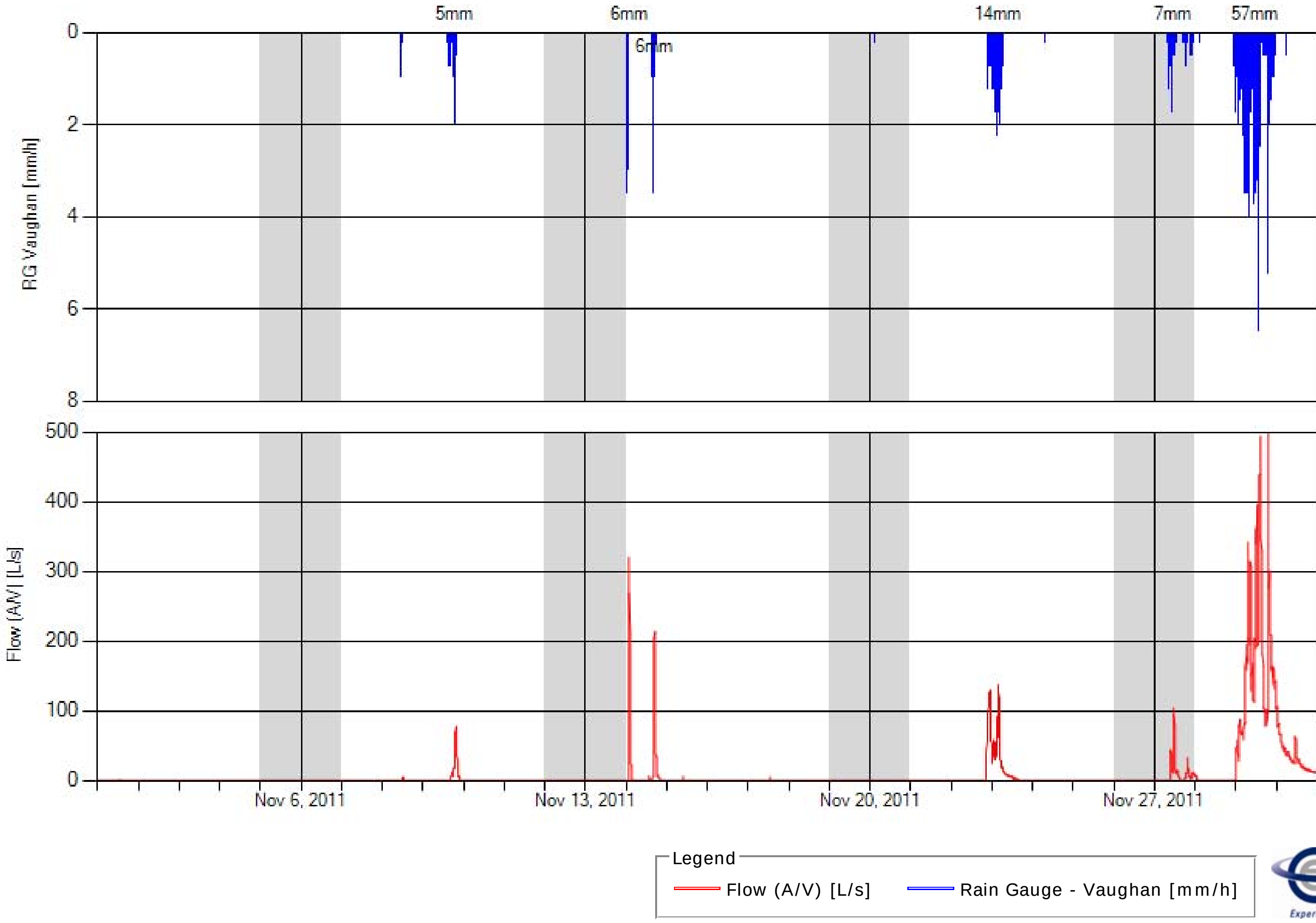
Vaughan City Wide Drainage Study Phase II Flow-Gauge 1

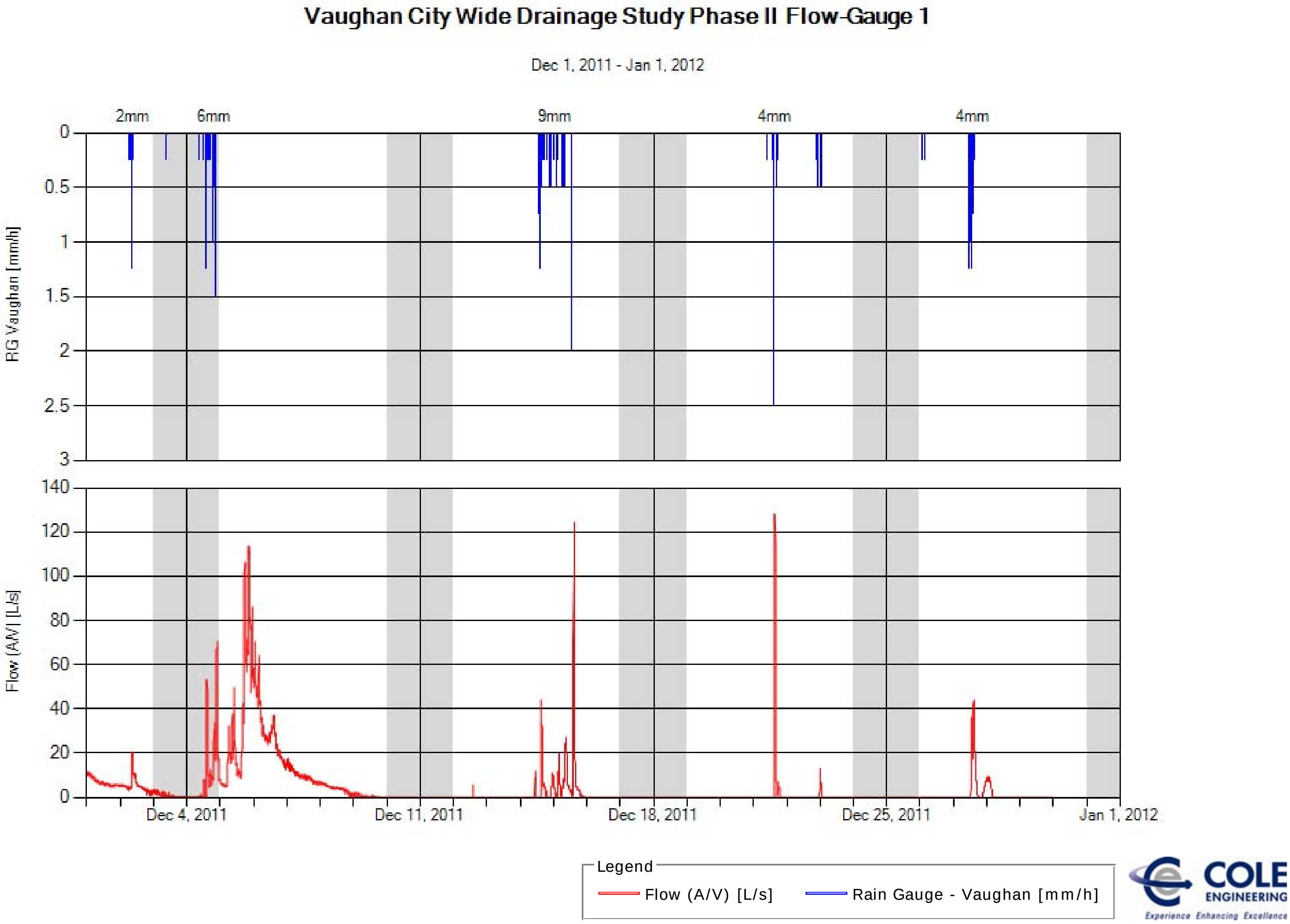
Oct 1, 2011 - Nov 1, 2011



Vaughan City Wide Drainage Study Phase II Flow-Gauge 1

Nov 1, 2011 - Dec 1, 2011




Vaughan City Wide Drainage Study Phase II Flow-Gauge 1
Dec 1, 2011 - Jan 1, 2012
2mm
6mm
9mm
4mm
4mm
RG Vaughan [mm/h]
0
0.5
1
1.5
2
2.5
3
Flow (A/V) [L/s]
140
120
100
80
60
40
20
0
Dec 4, 2011
Dec 11, 2011
Dec 18, 2011
Dec 25, 2011
Jan 1, 2012
Legend
Flow (A/V) [L/s]
Rain Gauge - Vaughan [mm/h]
COLE ENGINEERING
Experience Enhancing Excellence

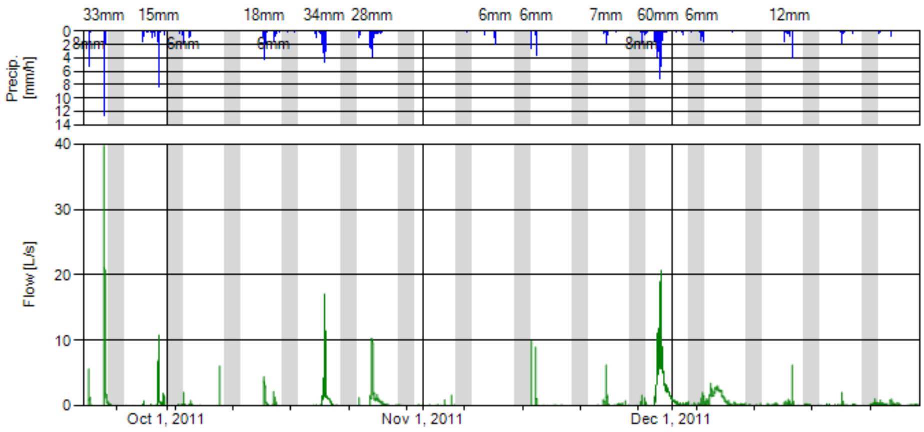
APPENDIX E
Storm Flow Reports

Storm Flow Analysis Report

Automated Analysis System

Project: Vaughan City Wide Drainage Study Phase II
Site: Flow-Gauge 5
Start: 2011-Sep-21 00:00:00
End: 2011-Dec-30 23:59:59

Measured Flow and Precipitation



Event Statistics

Drainage Area: 152.0 ha

Tc: 5 min

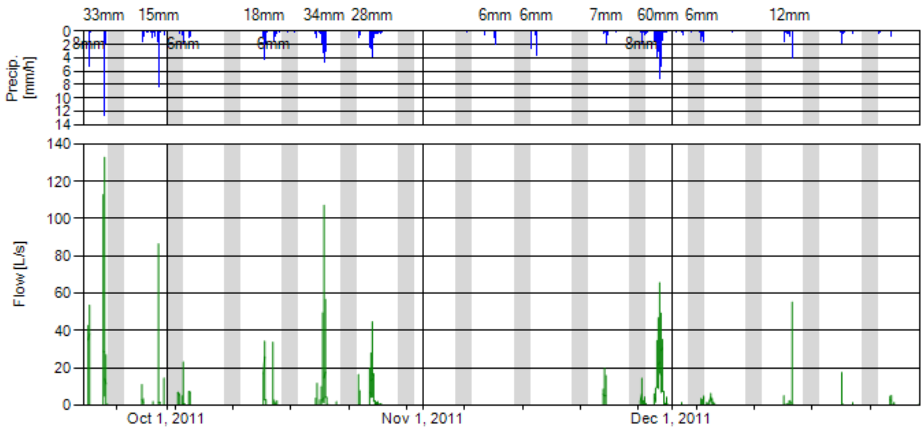
Event Date	Total Precipitation [mm]	Peak Precip. Intensity [mm/h]	Peak Precip. Intensity over Tc [mm/h]	Measured Peak Flow [L/s]	Time of Peak Flow	Peak Runoff Rate [L/s/ha]	Runoff Volume [m³]	Volumetric Runoff Coefficient	Peak Runoff Coefficient	
2011-Sep-21	8	3.5	9.8	5.6	2011-Sep-21 16:00:00	0.037	17	0.00136	0.00136	
2011-Sep-23	33	10.3	26.1	39.8	2011-Sep-23 13:00:00	0.262	214	0.00427	0.00361	
2011-Sep-29	15	8.0	13.0	10.8	2011-Sep-30 01:55:00	0.071	72	0.00319	0.00196	
2011-Oct-02	6	2.5	6.5	2.0	2011-Oct-03 02:25:00	0.013	8	0.00095	0.00074	
2011-Oct-12	18	4.5	6.5	4.4	2011-Oct-12 21:25:00	0.029	46	0.00170	0.00160	
2011-Oct-13	6	1.5	9.8	2.2	2011-Oct-13 23:30:00	0.014	12	0.00122	0.00052	
2011-Oct-18	37	8.0	19.6	17.1	2011-Oct-20 03:35:00	0.113	224	0.00403	0.00207	
2011-Oct-25	28	3.3	6.5	10.3	2011-Oct-25 21:40:00	0.068	184	0.00439	0.00374	
2011-Nov-09	6	1.5	3.3	-	-	-	-	-	-	- - -
2011-Nov-14	5	4.5	26.1	9.9	2011-Nov-14 02:05:00	0.065	13	0.00173	0.00090	
2011-Nov-14	6	3.0	9.8	9.0	2011-Nov-14 17:00:00	0.059	17	0.00191	0.00217	
2011-Nov-22	7	2.8	9.8	6.2	2011-Nov-23 04:20:00	0.041	32	0.00290	0.00151	
2011-Nov-27	8	1.5	6.5	1.6	2011-Nov-27 11:45:00	0.010	9	0.00072	0.00058	
2011-Nov-28	60	6.3	13.0	20.7	2011-Nov-29 20:30:00	0.136	839	0.00924	0.00376	
2011-Dec-04	7	1.3	3.3	2.0	2011-Dec-04 21:40:00	0.013	19	0.00196	0.00148	
2011-Dec-14	12	4.0	19.6	6.2	2011-Dec-15 15:10:00	0.041	23	0.00127	0.00075	

Storm Flow Analysis Report

Automated Analysis System

Project: Vaughan City Wide Drainage Study Phase II
Site: Flow-Gauge 4
Start: 2011-Sep-21 00:00:00
End: 2011-Dec-30 23:59:59

Measured Flow and Precipitation



Event Statistics

Drainage Area: 190.0 ha

Tc: 1 min

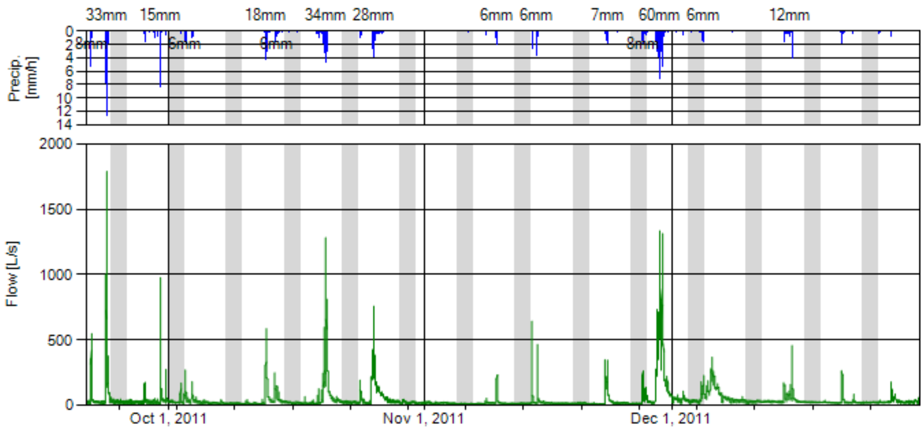
Event Date	Total Precipitation [mm]	Peak Precip. Intensity [mm/h]	Peak Precip. Intensity over Tc [mm/h]	Measured Peak Flow [L/s]	Time of Peak Flow	Peak Runoff Rate [L/s/ha]	Runoff Volume [m^3]	Volumetric Runoff Coefficient	Peak Runoff Coefficient	
2011-Sep-21	8	3.5	15.0	53.6	2011-Sep-21 16:05:00	0.282	126	0.00828	0.00678	
2011-Sep-23	33	10.3	45.0	133.0	2011-Sep-23 12:55:00	0.700	944	0.01505	0.00560	
2011-Sep-29	15	8.0	30.0	86.6	2011-Sep-30 01:40:00	0.456	326	0.01164	0.00547	
2011-Oct-02	6	2.5	15.0	23.2	2011-Oct-03 02:20:00	0.122	62	0.00571	0.00293	
2011-Oct-12	18	4.5	15.0	34.3	2011-Oct-12 21:25:00	0.181	268	0.00795	0.00434	
2011-Oct-13	6	1.5	15.0	33.8	2011-Oct-13 22:35:00	0.178	45	0.00377	0.00427	
2011-Oct-18	37	8.0	30.0	107.2	2011-Oct-20 03:05:00	0.564	828	0.01193	0.00677	
2011-Oct-25	28	3.3	15.0	44.8	2011-Oct-25 21:45:00	0.236	527	0.01008	0.00566	
2011-Nov-09	6	1.5	15.0	-	-	-	-	-	-	- - -
2011-Nov-14	5	4.5	45.0	-	-	-	-	-	-	- - -
2011-Nov-14	6	3.0	15.0	-	-	-	-	-	-	- - -
2011-Nov-22	7	2.8	15.0	19.9	2011-Nov-22 22:00:00	0.105	213	0.01543	0.00251	
2011-Nov-27	8	1.5	15.0	14.4	2011-Nov-27 11:45:00	0.076	74	0.00469	0.00182	
2011-Nov-28	60	6.3	15.0	65.7	2011-Nov-29 14:45:00	0.346	2,003	0.01765	0.00830	
2011-Dec-04	7	1.3	15.0	4.9	2011-Dec-04 21:45:00	0.026	21	0.00171	0.00062	
2011-Dec-14	12	4.0	30.0	55.3	2011-Dec-15 14:45:00	0.291	96	0.00430	0.00349	

Storm Flow Analysis Report

Automated Analysis System

Project: Vaughan City Wide Drainage Study Phase II
Site: Flow-Gauge 3
Start: 2011-Sep-21 00:00:00
End: 2011-Dec-30 23:59:59

Measured Flow and Precipitation



Event Statistics

Drainage Area: 194.0 ha

Tc: 20 min

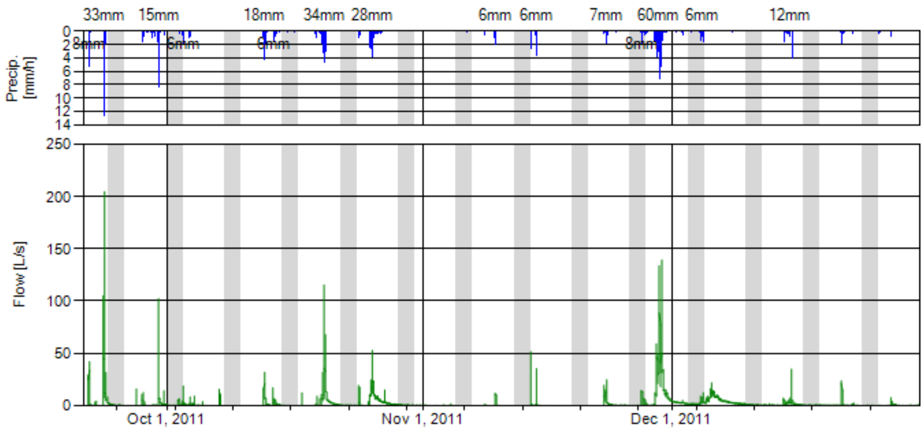
Event Date	Total Precipitation [mm]	Peak Precip. Intensity [mm/h]	Peak Precip. Intensity over Tc [mm/h]	Measured Peak Flow [L/s]	Time of Peak Flow	Peak Runoff Rate [L/s/ha]	Runoff Volume [m^3]	Volumetric Runoff Coefficient	Peak Runoff Coefficient
2011-Sep-21	8	3.5	6.8	548.5	2011-Sep-21 16:10:00	2.827	3,159	0.20355	0.15080
2011-Sep-23	33	10.3	15.8	1,792.0	2011-Sep-23 13:05:00	9.237	14,908	0.23286	0.21114
2011-Sep-29	15	8.0	11.3	977.4	2011-Sep-30 02:00:00	5.038	6,849	0.23934	0.16122
2011-Oct-02	6	2.5	3.0	270.1	2011-Oct-03 02:35:00	1.392	3,181	0.28517	0.16710
2011-Oct-12	18	4.5	5.3	586.6	2011-Oct-12 21:25:00	3.024	9,479	0.27528	0.20733
2011-Oct-13	6	1.5	4.5	248.0	2011-Oct-13 22:45:00	1.278	4,606	0.37988	0.10227
2011-Oct-18	37	8.0	11.3	1,284.4	2011-Oct-20 03:15:00	6.620	24,144	0.34097	0.21185
2011-Oct-25	28	3.3	5.3	758.7	2011-Oct-25 21:50:00	3.911	22,549	0.42267	0.26816
2011-Nov-09	6	1.5	3.0	231.5	2011-Nov-09 20:00:00	1.193	2,415	0.22631	0.14320
2011-Nov-14	5	4.5	9.8	643.7	2011-Nov-14 02:15:00	3.318	2,343	0.24157	0.12252
2011-Nov-14	6	3.0	3.8	465.9	2011-Nov-14 17:10:00	2.401	3,080	0.27607	0.23054
2011-Nov-22	7	2.8	6.0	348.8	2011-Nov-22 22:45:00	1.798	8,491	0.60372	0.10786
2011-Nov-27	8	1.5	3.0	260.5	2011-Nov-27 12:00:00	1.343	5,210	0.32553	0.16113
2011-Nov-28	60	6.3	9.0	1,336.5	2011-Nov-29 14:55:00	6.889	55,983	0.48296	0.27556
2011-Dec-04	7	1.3	2.3	227.4	2011-Dec-04 22:15:00	1.172	5,880	0.46628	0.18751
2011-Dec-14	12	4.0	6.8	457.4	2011-Dec-15 15:10:00	2.358	8,282	0.36332	0.12574

Storm Flow Analysis Report

Automated Analysis System

Project: Vaughan City Wide Drainage Study Phase II
Site: Flow-Gauge 2
Start: 2011-Sep-21 00:00:00
End: 2011-Dec-30 23:59:59

Measured Flow and Precipitation



Event Statistics

Drainage Area: 162.0 ha   **Tc:** 8 min

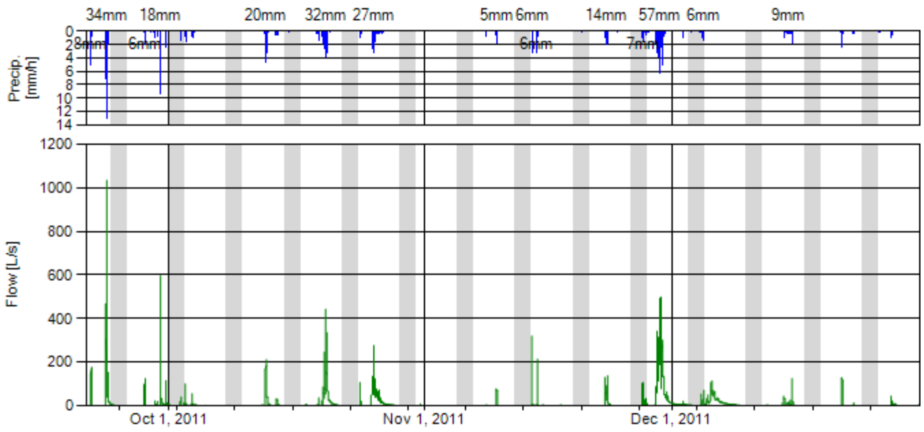
Event Date	Total Precipitation [mm]	Peak Precip. Intensity [mm/h]	Peak Precip. Intensity over Tc [mm/h]	Measured Peak Flow [L/s]	Time of Peak Flow	Peak Runoff Rate [L/s/ha]	Runoff Volume [m^3]	Volumetric Runoff Coefficient	Peak Runoff Coefficient
2011-Sep-21	8	3.5	9.1	42.1	2011-Sep-21 16:05:00	0.260	147	0.01136	0.01023
2011-Sep-23	33	10.3	22.0	204.8	2011-Sep-23 12:45:00	1.264	1,368	0.02559	0.02074
2011-Sep-29	15	8.0	11.0	102.5	2011-Sep-30 01:55:00	0.633	509	0.02130	0.02076
2011-Oct-02	6	2.5	3.7	18.9	2011-Oct-03 02:30:00	0.116	107	0.01153	0.01145
2011-Oct-12	18	4.5	5.5	31.9	2011-Oct-12 21:25:00	0.197	386	0.01344	0.01293
2011-Oct-13	6	1.5	9.1	17.1	2011-Oct-13 22:40:00	0.106	138	0.01365	0.00415
2011-Oct-18	37	8.0	14.6	115.5	2011-Oct-20 03:15:00	0.713	1,290	0.02182	0.01754
2011-Oct-25	28	3.3	5.5	52.9	2011-Oct-25 21:40:00	0.327	1,324	0.02973	0.02144
2011-Nov-09	6	1.5	3.7	12.0	2011-Nov-09 19:45:00	0.074	70	0.00780	0.00730
2011-Nov-14	5	4.5	14.6	51.7	2011-Nov-14 02:10:00	0.319	94	0.01165	0.00786
2011-Nov-14	6	3.0	5.5	35.5	2011-Nov-14 17:00:00	0.219	122	0.01315	0.01437
2011-Nov-22	7	2.8	7.3	24.8	2011-Nov-23 04:15:00	0.153	416	0.03538	0.00754
2011-Nov-27	8	1.5	3.7	14.1	2011-Nov-27 11:50:00	0.087	146	0.01090	0.00857
2011-Nov-28	60	6.3	9.1	139.4	2011-Nov-29 20:25:00	0.861	4,199	0.04338	0.03387
2011-Dec-04	7	1.3	3.7	12.5	2011-Dec-04 21:55:00	0.077	261	0.02481	0.00757
2011-Dec-14	12	4.0	12.8	35.0	2011-Dec-15 15:00:00	0.216	344	0.01807	0.00607

Storm Flow Analysis Report

Automated Analysis System

Project: Vaughan City Wide Drainage Study Phase II
Site: Flow-Gauge 1
Start: 2011-Sep-21 00:00:00
End: 2011-Dec-30 23:59:59

Measured Flow and Precipitation



Event Statistics

Drainage Area: 557.0 ha

Tc: 14 min

Event Date	Total Precipitation [mm]	Peak Precip. Intensity [mm/h]	Peak Precip. Intensity over Tc [mm/h]	Measured Peak Flow [L/s]	Time of Peak Flow	Peak Runoff Rate [L/s/ha]	Runoff Volume [m^3]	Volumetric Runoff Coefficient	Peak Runoff Coefficient
2011-Sep-21	8	3.3	8.4	176.4	2011-Sep-21 16:05:00	0.317	723	0.01732	0.01363
2011-Sep-23	34	14.0	20.9	1,035.4	2011-Sep-23 12:45:00	1.859	6,340	0.03348	0.03201
2011-Sep-28	6	2.5	5.2	124.6	2011-Sep-28 06:30:00	0.224	494	0.01478	0.01541
2011-Sep-29	18	8.8	13.6	597.0	2011-Sep-30 01:45:00	1.072	3,158	0.03240	0.02839
2011-Oct-12	20	5.5	6.3	211.6	2011-Oct-12 21:20:00	0.380	2,721	0.02474	0.02181
2011-Oct-19	32	6.3	9.4	443.0	2011-Oct-20 03:20:00	0.795	7,394	0.04148	0.03043
2011-Oct-25	27	3.8	5.2	276.2	2011-Oct-25 21:45:00	0.496	6,661	0.04388	0.03416
2011-Nov-14	7	6.3	17.8	320.0	2011-Nov-14 02:15:00	0.574	640	0.01767	0.01164
2011-Nov-14	6	3.0	5.2	213.6	2011-Nov-14 17:05:00	0.383	773	0.02412	0.02641
2011-Nov-22	14	2.5	3.1	137.7	2011-Nov-23 04:20:00	0.247	2,352	0.03070	0.02838
2011-Nov-27	7	1.3	3.1	104.4	2011-Nov-27 12:00:00	0.187	734	0.01818	0.02151
2011-Nov-28	57	5.0	13.6	499.2	2011-Nov-29 19:35:00	0.896	17,247	0.05432	0.02374
2011-Dec-04	6	1.3	2.1	70.7	2011-Dec-04 22:05:00	0.127	845	0.02758	0.02185
2011-Dec-14	9	1.8	5.2	124.5	2011-Dec-15 15:10:00	0.224	937	0.01923	0.01540

APPENDIX F

Flow Gauge Installation, Maintenance and Calibration Logs

Site:	Flow-Gauge 5
Date:	2011-09-21 17:43:00 **EST**
Staff:	Jordan Wiedrick
Purpose of Visit:	install flow monitor
Location:	on walking path behind 279 Franklin ave
GPS Coordinates:	Longitude:-79.439608 Latitude: 43.810492
Equipment:	794,1765,1764,1763
Comments:	Unit was installed in the 300mm upstream pipe coming from the river. The other upstream pipe is 750mm and the downstream pipe is 750mm

---

Site:	Flow-Gauge 5
Date:	2011-09-30 14:50:00 **EST**
Staff:	Michael Heifetz, Steven Kamenar
Purpose of Visit:	Maintenance
Action Taken:	Downloaded
Results:	Online and logging
Additional Actions:	
Probable Root Cause:	
Comments:	Reviewed data

Site:	Flow-Gauge 5
Date:	2011-10-18 14:29:00 **EST**
Staff:	Jordan Wiedrick
Purpose of Visit:	maintenance
Action Taken:	collect data
Results:	online and logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 5
Date:	2011-10-31 14:07:00 **EST**

Staff:	Michael Heifetz, Sebastian Aristizabal
Purpose of Visit:	Maintenance
Action Taken:	Downloaded
Results:	Online and logging
Additional Actions:	
Probable Root Cause:	
Comments:	Reviewed data

Site:	Flow-Gauge 5
Date:	2011-11-15 15:46:00 **EST**
Staff:	Josh Wagemaker
Purpose of Visit:	Maintenance
Action Taken:	Data download. Battery change.
Results:	Online and logging.
Additional Actions:	
Probable Root Cause:	
Comments:	Data shows spikes during storm events. Battery at full voltage.

Site:	Flow-Gauge 5
Date:	2011-12-20 07:59:00 **EST**
Staff:	Sebastian Aristizabal
Purpose of Visit:	Maintenance
Action Taken:	Download
Results:	Online and Logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 5
Sensor:	Velocity
Staff:	Jordan Wiedrick and Gordon McCready

Purpose of Measurement:	Calibration
Value:	0.31
Nearest Sensor Value:	0.38 (0.308)
Date:	2012-01-12 14:05:00 **EST**

Site:	Flow-Gauge 5
Sensor:	Depth (Pressure)
Staff:	Jordan Wiedrick and Gordon McCready
Purpose of Measurement:	Calibration
Value:	0.03
Nearest Sensor Value:	0.038 (0.035)
Date:	2012-01-12 14:05:00 **EST**

Site:	Flow-Gauge 5
Date:	2012-01-12 16:05:00 **EST**
Staff:	Jordan Wiedrick
Purpose of Visit:	maintenance
Action Taken:	collect data and CSE for manual measurement and sensor clean
Results:	online and logging
Additional Actions:	
Probable Root Cause:	
Comments:	unit was stopped and restarted

Site:	Flow-Gauge 5
Sensor:	Depth (Pressure)
Staff:	Sebastian Aristizabal and Jordan Weidrick
Purpose of Measurement:	Calibration
Value:	0.01
Nearest Sensor Value:	0.015 (0.017)
Date:	2012-01-30 14:15:00 **EST**

Site:	Flow-Gauge 5
Date:	2012-01-30 15:36:00 **EST**
Staff:	Sebastian Aristizabal
Purpose of Visit:	Maintenance
Action Taken:	Download, mm measurements.
Results:	Online and Logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 5
Date:	2012-02-06 08:17:00 **EST**
Staff:	Gordon McCready, Mike Heifetz
Purpose of Visit:	ongoing maintenance
Action Taken:	download
Results:	online and logging
Additional Actions:	
Probable Root Cause:	
Comments:	Data downloaded and reviewed

Site:	Flow-Gauge 5
Sensor:	Depth (Pressure)
Staff:	Joshua Wagemaker
Purpose of Measurement:	Calibration
Value:	0.02
Nearest Sensor Value:	0.014 (0.014)
Date:	2012-02-14 10:10:00 **EST**

Site:	Flow-Gauge 5
Date:	2012-02-14 15:05:00 **EST**
Staff:	Josh Wagemaker
Purpose of	Removal

Visit:	
Location:	On path near Franklin Ave and Markwood Ln
Comments:	Data collected upon removal. Battery @ 11.7V Manual measurement: 2cm Device reading: 1.4cm @10:10am EST Unit removed successfully.

Site:	Flow-Gauge 4
Date:	2011-07-13 15:14:00 **EST**
Staff:	Steven Kamenar
Purpose of Visit:	Installation
Location:	Yonge St. and Elgin St. Just east of Yonge in right lane
GPS Coordinates:	Longitude:-79.42341 Latitude: 43.81146
Equipment:	120
Comments:	Monitor was successfully installed.

Site:	Flow-Gauge 4
Date:	2011-08-02 15:00:00 **EST**
Staff:	Gordon McCready, Steven Kamenar
Purpose of Visit:	ongoing maintenance
Action Taken:	download, battery change, desiccant change
Results:	logging
Additional Actions:	
Probable Root Cause:	
Comments:	Data downloaded and reviewed

Site:	Flow-Gauge 4
Date:	2011-08-11 14:00:00 **EST**
Staff:	Gordon McCready, Jordan Wiedrick
Purpose of Visit:	ongoing maintenance
Action Taken:	maintenance
Results:	Logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 4
Date:	2011-08-26 15:00:00 **EST**
Staff:	Gordon McCready, Jordan Wiedrick

Purpose of Visit:	ongoing maintenance
Action Taken:	Data Download, Battery Change
Results:	Online and Logging
Additional Actions:	
Probable Root Cause:	
Comments:	Data downloaded and reviewed

Site:	Flow-Gauge 4
Date:	2011-09-09 06:22:00 **EST**
Staff:	Randall Huizingh
Purpose of Visit:	Maintenance
Action Taken:	Data download
Results:	logging
Additional Actions:	
Probable Root Cause:	
Comments:	Downloaded sigma. Battery voltage was 5.5-5.7v

Site:	Flow-Gauge 4
Date:	2011-09-15 15:32:00 **EST**
Staff:	Sebastian Aristizabal
Purpose of Visit:	Maintenance
Action Taken:	Download
Results:	Logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 4
Date:	2011-09-20 06:30:00 **EST**
Staff:	Jordan Wiedrick
Purpose of	maintenance

Visit:	
Action Taken:	collect data and change 6v battery
Results:	logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 4
Date:	2011-09-30 14:49:00 **EST**
Staff:	Michael Heifetz, Steven Kamenar
Purpose of Visit:	Maintenance
Action Taken:	Downloaded
Results:	Logging
Additional Actions:	
Probable Root Cause:	
Comments:	Reviewed data

Site:	Flow-Gauge 4
Date:	2011-10-18 10:30:00 **EST**
Staff:	Jordan Wiedrick
Purpose of Visit:	maintenance
Action Taken:	collect data and change battery
Results:	logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 4
Date:	2011-10-31 14:05:00 **EST**
Staff:	Michael Heifetz, Sebastian Aristizabal
Purpose of Visit:	Maintenance

Action Taken:	Downloaded, changed desiccant
Results:	Logging
Additional Actions:	
Probable Root Cause:	
Comments:	Reviewed data

Site:	Flow-Gauge 4
Date:	2011-11-15 15:44:00 **EST**
Staff:	Josh Wagemaker
Purpose of Visit:	Maintenance
Action Taken:	Changed 6V battery. Downloaded data.
Results:	Logging.
Additional Actions:	
Probable Root Cause:	
Comments:	Device was set to imperial units. Changed to metric. 6V battery at full charge.

Site:	Flow-Gauge 4
Date:	2011-12-20 07:58:00 **EST**
Staff:	Sebastian Aristizabal
Purpose of Visit:	Maintenance
Action Taken:	Download
Results:	Online and Logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 4
Date:	2012-01-04 15:33:00 **EST**
Staff:	Sebastian Aristizabal
Purpose of Visit:	Maintenance

Action Taken:	Download
Results:	Online and Logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 4
Date:	2012-01-13 17:51:00 **EST**
Staff:	Jordan Wiedrick
Purpose of Visit:	maintenance
Action Taken:	collect data and change battery
Results:	logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 4
Date:	2012-01-30 15:32:00 **EST**
Staff:	Sebastian Aristizabal and Jordan Weidrick
Purpose of Visit:	Maintenance
Action Taken:	Download, mm measurements.
Results:	Logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 4
Date:	2012-02-06 15:37:00 **EST**
Staff:	Gordon McCready, Mike Heifetz
Purpose of Visit:	ongoing maintenance
Action Taken:	connected to unit

Results:	logging
Additional Actions:	
Probable Root Cause:	
Comments:	Data reviewed

Site:	Flow-Gauge 4
Sensor:	Depth (Pressure)
Staff:	Joshua Wagemaker
Purpose of Measurement:	Calibration
Value:	.005
Nearest Sensor Value:	0.0 (0)
Date:	2012-02-14 11:00:00 **EST**

Site:	Flow-Gauge 4
Date:	2012-02-14 14:58:00 **EST**
Staff:	Josh Wagemaker
Purpose of Visit:	Removal
Location:	Intersection of Elgin St and Yonge St
Comments:	Data collected from unit upon removal. Manual measurement: .5cm Device reading: 0cm @ 11:00am EST Unit removed successfully.

Site:	Flow-Gauge 3
Date:	2011-07-20 07:10:00 **EST**
Staff:	Steven Kamenar
Purpose of Visit:	Installation
Location:	intersection of Brooke st and Thornridge ave
GPS Coordinates:	Longitude:-79.427066 Latitude: 43.812598
Equipment:	403,342,293
Comments:	

Site:	Flow-Gauge 3
Date:	2011-08-11 08:03:00 **EST**
Staff:	Jordan Wiedrick
Purpose of Visit:	collect data
Action Taken:	CSE to connect serial cable to flow monitor and collect data
Results:	logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 3
Date:	2011-08-26 14:00:00 **EST**
Staff:	Gordon McCready, Jordan Wiedrick
Purpose of Visit:	ongoing maintenance
Action Taken:	download, data send
Results:	Online and Logging
Additional Actions:	
Probable Root Cause:	
Comments:	Data downloaded and reviewed

Site:	Flow-Gauge 3
Date:	2011-09-09 06:21:00 **EST**
Staff:	Randall Huizingh
Purpose of Visit:	Maintenance
Action Taken:	Data download

Results:	logging
Additional Actions:	
Probable Root Cause:	
Comments:	Reviewed data

Site:	Flow-Gauge 3
Date:	2011-09-15 15:31:00 **EST**
Staff:	Sebastian Aristizabal
Purpose of Visit:	Maintenance
Action Taken:	Download
Results:	Logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 3
Date:	2011-09-20 06:30:00 **EST**
Staff:	Jordan Wiedrick
Purpose of Visit:	maintenance
Action Taken:	collect data
Results:	logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 3
Date:	2011-09-30 14:47:00 **EST**
Staff:	Michael Heifetz, Steven Kamenar
Purpose of Visit:	Maintenance
Action Taken:	Downloaded
Results:	Logging
Additional Actions:	

Probable Root Cause:	
Comments:	Reviewed data

Site:	Flow-Gauge 3
Date:	2011-10-18 09:40:00 **EST**
Staff:	Jordan Wiedrick
Purpose of Visit:	maintenance
Action Taken:	collect data
Results:	logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 3
Date:	2011-10-31 14:04:00 **EST**
Staff:	Michael Heifetz, Sebastian Aristizabal
Purpose of Visit:	Maintenance
Action Taken:	Downloaded
Results:	Logging
Additional Actions:	
Probable Root Cause:	
Comments:	Reviewed data

Site:	Flow-Gauge 3
Date:	2011-11-15 15:43:00 **EST**
Staff:	Josh Wagemaker
Purpose of Visit:	Maintenance
Action Taken:	Data download.
Results:	Logging.
Additional Actions:	
Probable Root Cause:	
Comments:	Battery at 7.7V. Data shows spikes during rain events.

Site:	Flow-Gauge 3
Date:	2011-12-20 07:57:00 **EST**
Staff:	Sebastian Aristizabal
Purpose of Visit:	Maintenance
Action Taken:	Download
Results:	Online and Logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 3
Date:	2012-01-04 15:32:00 **EST**
Staff:	Sebastian Aristizabal
Purpose of Visit:	Maintenance
Action Taken:	Download
Results:	Online and Logging
Additional Actions:	
Probable Root Cause:	
Comments:	CSE for download

Site:	Flow-Gauge 3
Date:	2012-01-13 17:51:00 **EST**
Staff:	Jordan Wiedrick
Purpose of Visit:	maintenance
Action Taken:	collect data
Results:	logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 3
Date:	2012-01-30 15:27:00 **EST**

Staff:	Jordan Wiedrick
Purpose of Visit:	maintenance
Action Taken:	collect data
Results:	logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 3
Date:	2012-02-06 08:15:00 **EST**
Staff:	Gordon McCready, Mike Heifetz
Purpose of Visit:	ongoing maintenance
Action Taken:	download
Results:	logging
Additional Actions:	
Probable Root Cause:	
Comments:	Data downloaded and reviewed

Site:	Flow-Gauge 3
Date:	2012-02-14 14:52:00 **EST**
Staff:	Josh Wagemaker
Purpose of Visit:	Removal
Location:	Intersection of Thornridge Dr and Brooke St
Comments:	Unit successfully removed. Manual Measurement: 4cm @ 12:15pm EST

Site:	Flow-Gauge 2
Date:	2011-08-11 12:00:00 **EST**
Staff:	Gordon McCready, Jordan Wiedrick
Purpose of Visit:	Installation
Location:	Thornbridge Rd. Across from Zahany Family Education Center
GPS Coordinates:	Longitude:-79.437945 Latitude: 43.810705
Equipment:	
Comments:	

Site:	Flow-Gauge 2
Date:	2011-08-11 12:00:00 **EST**
Staff:	Gordon McCready, Jordan Wiedrick
Purpose of Visit:	Installation of detectronic flow monitor
Location:	Thornbridge Rd. Across from Zahany Family Education Center
GPS Coordinates:	Longitude:-79.437923 Latitude: 43.81067
Equipment:	1682,1681
Comments:	- Detectronic Flow monitor successfully installed in the upstream of Thornbridge Rd. storm sewer. - Pipe size upstream = 900mm - Pipe size downstream = 900mm - PMAC ID = 1048

Site:	Flow-Gauge 2
Date:	2011-08-25 13:30:00 **EST**
Staff:	Gordon McCready, Jordan Wiedrick
Purpose of Visit:	ongoing maintenance
Action Taken:	download, data send
Results:	online and logging
Additional Actions:	
Probable Root Cause:	
Comments:	Data downloaded and reviewed

Site:	Flow-Gauge 2
Date:	2011-09-09 06:21:00 **EST**
Staff:	Randall Huizingh

Purpose of Visit:	Maintenance
Action Taken:	Data download
Results:	logging
Additional Actions:	
Probable Root Cause:	
Comments:	reviewed data

Site:	Flow-Gauge 2
Date:	2011-09-15 15:30:00 **EST**
Staff:	Sebastian Aristizabal
Purpose of Visit:	Maintenance
Action Taken:	Download
Results:	Online and logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 2
Date:	2011-09-20 06:29:00 **EST**
Staff:	Jordan Wiedrick
Purpose of Visit:	maintenance
Action Taken:	collect data
Results:	online and logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 2
Date:	2011-09-30 14:44:00 **EST**
Staff:	Michael Heifetz, Steven Kamenar
Purpose of	Maintenance

Visit:	
Action Taken:	Downloaded
Results:	Online and logging
Additional Actions:	
Probable Root Cause:	
Comments:	Reviewed data

Site:	Flow-Gauge 2
Date:	2011-10-18 09:20:00 **EST**
Staff:	Jordan Wiedrick
Purpose of Visit:	maintenance
Action Taken:	collect data
Results:	online and logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 2
Date:	2011-10-31 14:01:00 **EST**
Staff:	Michael Heifetz, Sebastian Aristizabal
Purpose of Visit:	Maintenance
Action Taken:	Downloaded
Results:	Online and logging
Additional Actions:	
Probable Root Cause:	
Comments:	Reviewed data

Site:	Flow-Gauge 2
Date:	2011-11-15 15:42:00 **EST**
Staff:	Josh Wagemaker
Purpose of Visit:	Maintenance

Action Taken:	Data download. Battery change.
Results:	Online and logging.
Additional Actions:	
Probable Root Cause:	
Comments:	Battery at full voltage. Data shows spikes during rain events.

Site:	Flow-Gauge 2
Date:	2011-12-20 07:56:00 **EST**
Staff:	Sebastian Aristizabal
Purpose of Visit:	Maintenance
Action Taken:	Download
Results:	Online and Logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 2
Date:	2012-01-04 15:31:00 **EST**
Staff:	Sebastian Aristizabal
Purpose of Visit:	Maintenance
Action Taken:	Download
Results:	Online and Logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 2
Date:	2012-01-12 16:04:00 **EST**
Staff:	Jordan Wiedrick
Purpose of Visit:	maintenance
Action Taken:	collect data and check telemetry

Results:	online and logging
Additional Actions:	
Probable Root Cause:	
Comments:	unit was stopped and restarted

Site:	Flow-Gauge 2
Sensor:	Depth (Pressure)
Staff:	Sebastian Aristizabal and Jordan Weidrick
Purpose of Measurement:	Calibration
Value:	0.03
Nearest Sensor Value:	0.02 (0.024)
Date:	2012-01-30 12:45:00 **EST**

Site:	Flow-Gauge 2
Date:	2012-01-30 15:26:00 **EST**
Staff:	Sebastian Aristizabal and Jordan Weidrick
Purpose of Visit:	Maintenance
Action Taken:	Download, mm measurements.
Results:	Online and Logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 2
Date:	2012-02-06 08:14:00 **EST**
Staff:	Gordon McCready, Mike Heifetz
Purpose of Visit:	ongoing maintenance
Action Taken:	download
Results:	online and logging
Additional Actions:	
Probable Root	

Cause:	
Comments:	Data downloaded and reviewed

Site:	Flow-Gauge 2
Sensor:	Depth (Pressure)
Staff:	Joshua Wagemaker
Purpose of Measurement:	Calibration
Value:	0.015
Nearest Sensor Value:	0.016 (0.016)
Date:	2012-02-14 11:30:00 **EST**

Site:	Flow-Gauge 2
Date:	2012-02-14 14:47:00 **EST**
Staff:	Josh Wagemaker
Purpose of Visit:	Removal
Location:	At end of Thornridge Dr
Comments:	Device downloaded upon removal. Battery @ 11.6V Manual measurement: 1.5cm Device reading: 1.6cm @ 11:30am EST Unit removed successfully.

Site:	Flow-Gauge 1
Date:	2011-08-11 07:50:00 **EST**
Staff:	Jordan Wiedrick
Purpose of Visit:	install flow monitor
Location:	beside 236 Charlton ave
GPS Coordinates:	Longitude:-79.463598 Latitude: 43.793178
Equipment:	1631,1649,1640
Comments:	pipe size upstream 1680mm circular, downstream semi circular 2280mm by 1380mm, PMAC 1047

Site:	Flow-Gauge 1
Date:	2011-08-25 13:00:00 **EST**
Staff:	Gordon McCready, Jordan Wiedrick
Purpose of Visit:	ongoing maintenance
Action Taken:	download, data send
Results:	Online and Logging
Additional Actions:	
Probable Root Cause:	
Comments:	Data downloaded and reviewed

Site:	Flow-Gauge 1
Date:	2011-09-09 06:15:00 **EST**
Staff:	Randall Huizingh
Purpose of Visit:	Maintenance
Action Taken:	Data download
Results:	logging
Additional Actions:	
Probable Root Cause:	
Comments:	Unit was downloaded. Y and X axis is not correct. Detec was called to trouble shot, nobody was available to help. Unit may need to be swapped out to trouble shoot in-house.

Site:	Flow-Gauge 1
Date:	2011-09-15 15:28:00 **EST**
Staff:	Sebastian Aristizabal

Purpose of Visit: Maintenance
Action Taken: Download
Results: Online and logging
Additional Actions:
Probable Root Cause:
Comments:

Site: Flow-Gauge 1
Date: 2011-09-20 06:25:00 **EST**
Staff: Jordan Wiedrick
Purpose of Visit: collect data
Action Taken: data collect and sent using cello
Results: online and logging
Additional Actions:
Probable Root Cause:
Comments:

Site: Flow-Gauge 1
Date: 2011-09-30 14:42:00 **EST**
Staff: Michael Heifetz, Steven Kamenar
Purpose of Visit: Maintenance
Action Taken: Downloaded
Results: Online and logging
Additional Actions:
Probable Root Cause:
Comments: Reviewed data

Site: Flow-Gauge 1
Date: 2011-10-06 15:42:00 **EST**
Staff: Jordan Wiedrick
Purpose of Visit: maintenance
Action Taken: collect and send data, reconfigure detec and restart unit
Results: online and logging

Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 1
Date:	2011-10-18 09:00:00 **EST**
Staff:	Jordan Wiedrick
Purpose of Visit:	maintenance
Action Taken:	collect data
Results:	online and logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 1
Date:	2011-10-31 13:59:00 **EST**
Staff:	Michael Heifetz, Sebastian Aristizabal
Purpose of Visit:	Maintenance
Action Taken:	Downloaded
Results:	Online and logging
Additional Actions:	
Probable Root Cause:	
Comments:	Reviewed data

Site:	Flow-Gauge 1
Date:	2011-11-15 15:33:00 **EST**
Staff:	Josh Wagemaker
Purpose of Visit:	Maintenance
Action Taken:	Data download. Battery change. Dessicant change.
Results:	Online and logging.
Additional Actions:	
Probable Root Cause:	

Comments:	Battery at full voltage. Dessicant OK. Data shows spikes during rain events.

Site:	Flow-Gauge 1
Date:	2011-12-20 07:55:00 **EST**
Staff:	Sebastian Aristizabal
Purpose of Visit:	Maintenance
Action Taken:	Download
Results:	Online and Logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 1
Date:	2012-01-04 15:27:00 **EST**
Staff:	Sebastian Aristizabal
Purpose of Visit:	Maintenance
Action Taken:	Download
Results:	Online and Logging
Additional Actions:	
Probable Root Cause:	
Comments:	

Site:	Flow-Gauge 1
Date:	2012-01-12 16:00:00 **EST**
Staff:	Jordan Wiedrick
Purpose of Visit:	maintenance
Action Taken:	collect data and check telemetry
Results:	online and logging
Additional Actions:	
Probable Root Cause:	
Comments:	unit was stopped and restarted

Site:	Flow-Gauge 1
Sensor:	Velocity
Staff:	Jordan Wiedrick and Sebastian Aristizabal
Purpose of Measurement:	Calibration
Value:	0.29
Nearest Sensor Value:	0.00 (0)
Date:	2012-01-30 11:55:00 **EST**

Site:	Flow-Gauge 1
Sensor:	depth primary
Staff:	Jordan Wiedrick and Sebastian Aristizabal
Purpose of Measurement:	Calibration
Value:	0.03
Nearest Sensor Value:	0.01 (0.025)
Date:	2012-01-30 11:55:00 **EST**

Site:	Flow-Gauge 1
Date:	2012-01-30 15:17:00 **EST**
Staff:	Jordan Wiedrick
Purpose of Visit:	maintenance
Action Taken:	collect data and CSE for manual measurement
Results:	online and logging
Additional Actions:	
Probable Root Cause:	
Comments:	data sent and checked with internal staff. unit was stopped and restarted.

Site:	Flow-Gauge 1
Date:	2012-02-06 08:12:00 **EST**
Staff:	Gordon McCready, Mike Heifetz
Purpose of Visit:	ongoing maintenance
Action Taken:	download
Results:	online and logging

Additional Actions:	
Probable Root Cause:	
Comments:	Data downloaded and reviewed

Site:	Flow-Gauge 1
Sensor:	depth primary
Staff:	Joshua Wagemaker
Purpose of Measurement:	Calibration
Value:	0.035
Nearest Sensor Value:	0.016 (0.031)
Date:	2012-02-14 09:30:00 **EST**

Site:	Flow-Gauge 1
Date:	2012-02-14 14:43:00 **EST**
Staff:	Josh Wagemaker
Purpose of Visit:	Removal
Location:	Intersection of Charlton Ave and Gayla St
Comments:	Data collected from unit. Battery @ 11.7V upon removal. Manual measurement: 3.5cm Device reading: 1.6cm @9:30am EST

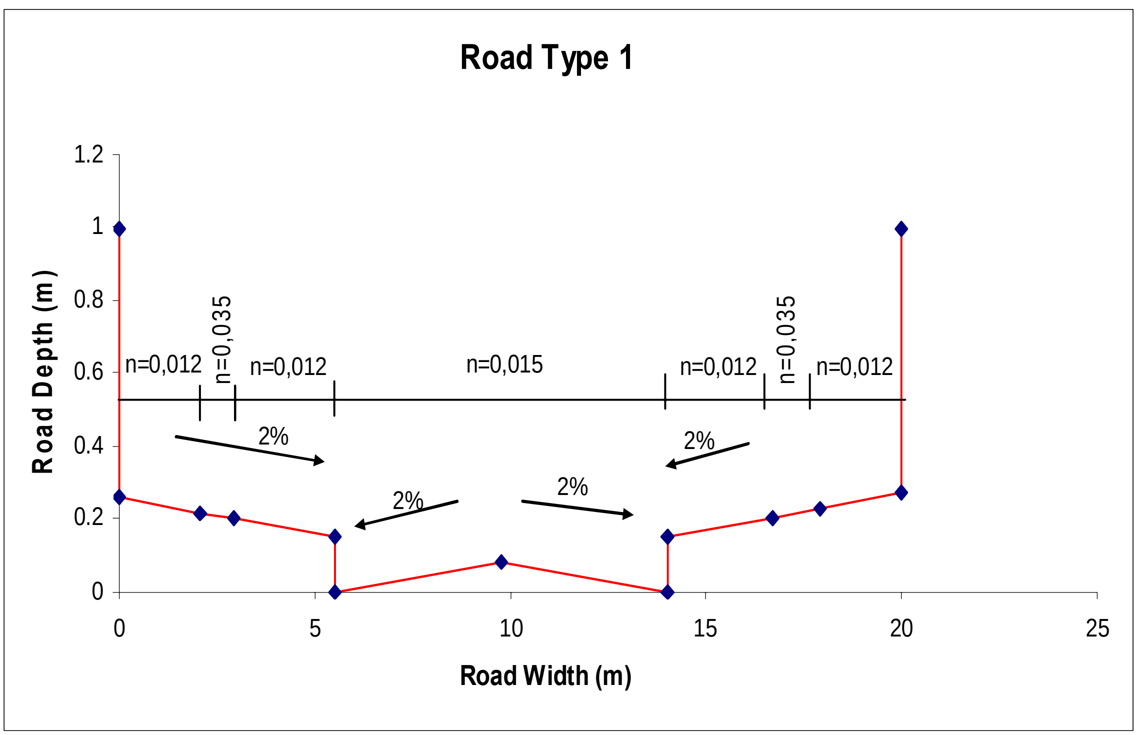
APPENDIX F
Capture Curves and Road Cross Sections

Appendix F.1

Typical Street Cross-Sections

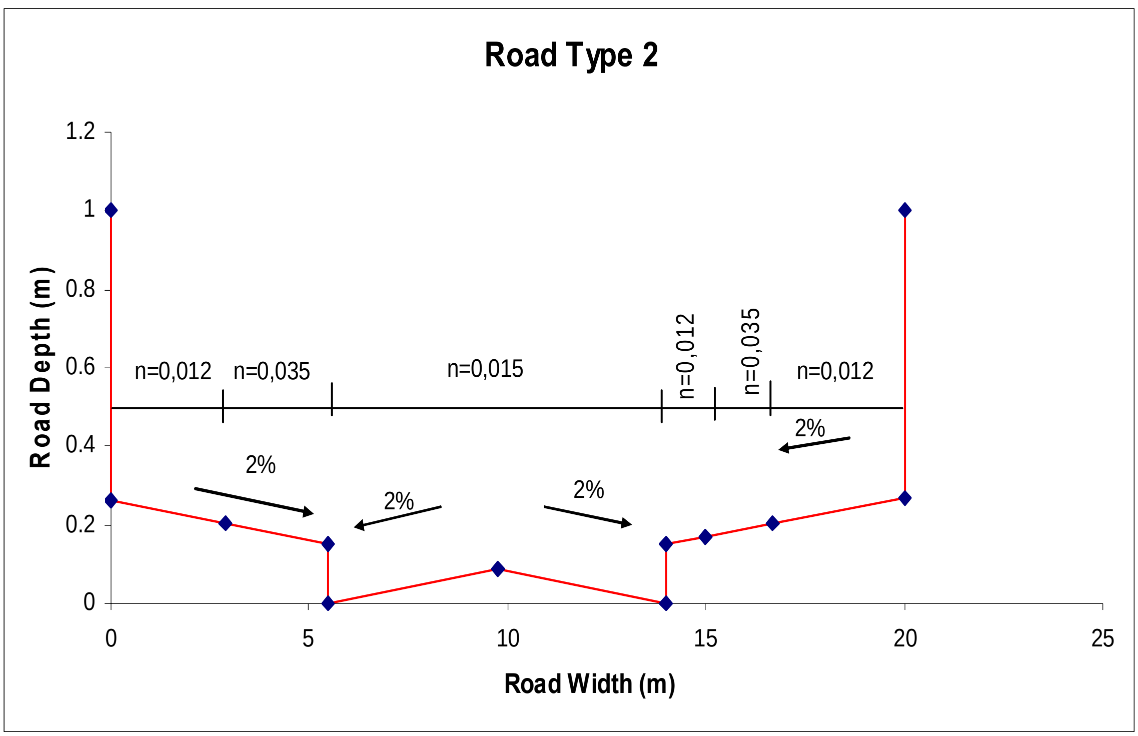
Standard Road Type 1:
Major Local Street 20.0m ROW, 8.5m pavement

X (m)	Y-Depth (m)	Maning's n	New Panel
0	1	0.012	1
0	0.26	0.012	0
2.05	0.219	0.035	1
2.95	0.201	0.035	0
5.5	0.15	0.012	1
5.5	0	0.015	1
9.75	0.085	0.015	0
14	0	0.015	0
14	0.15	0.012	1
16.7	0.204	0.035	1
17.9	0.228	0.035	0
20	0.27	0.012	1
20	1	0.012	0



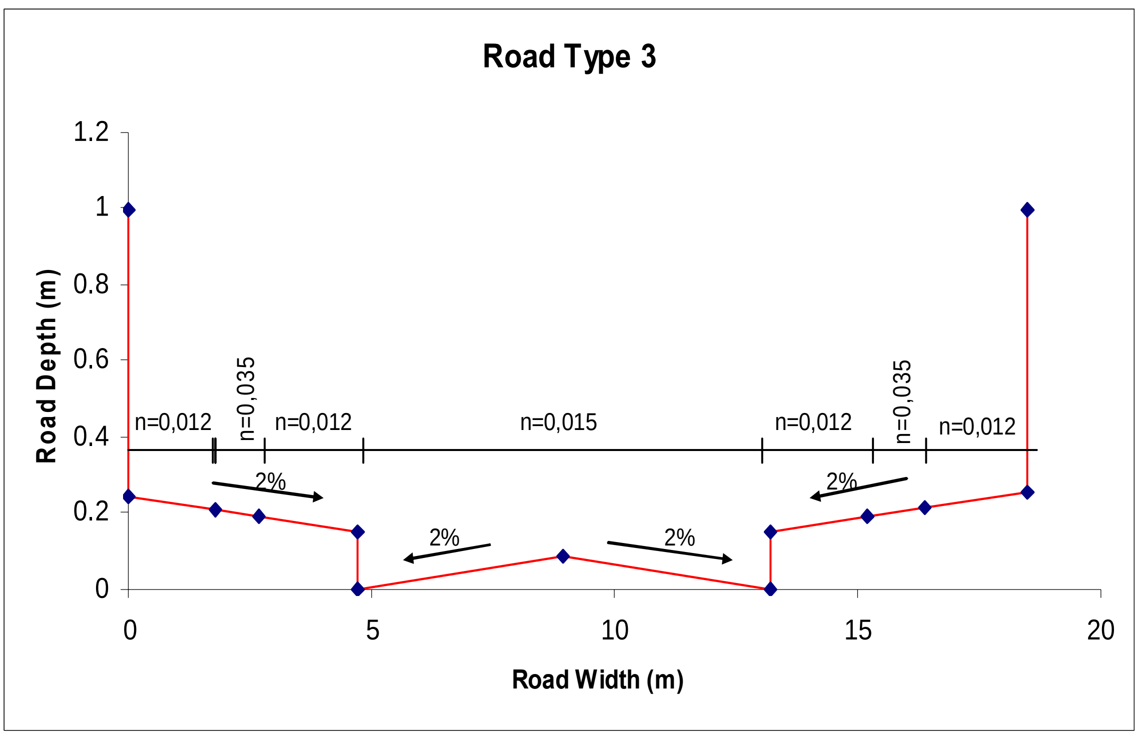
Standard Road Type 2:
Major Local Street 20.0m ROW, 8.5m pavement

X (m)	Y-Depth (m)	Maning's n	New Panel
0	1	0.012	1
0	0.26	0.012	0
2.9	0.202	0.035	1
5.5	0.15	0.035	0
5.5	0	0.015	1
9.75	0.085	0.015	0
14	0	0.015	0
14	0.15	0.012	1
15	0.17	0.035	1
16.7	0.204	0.035	0
20	0.27	0.012	1
20	1	0.012	0



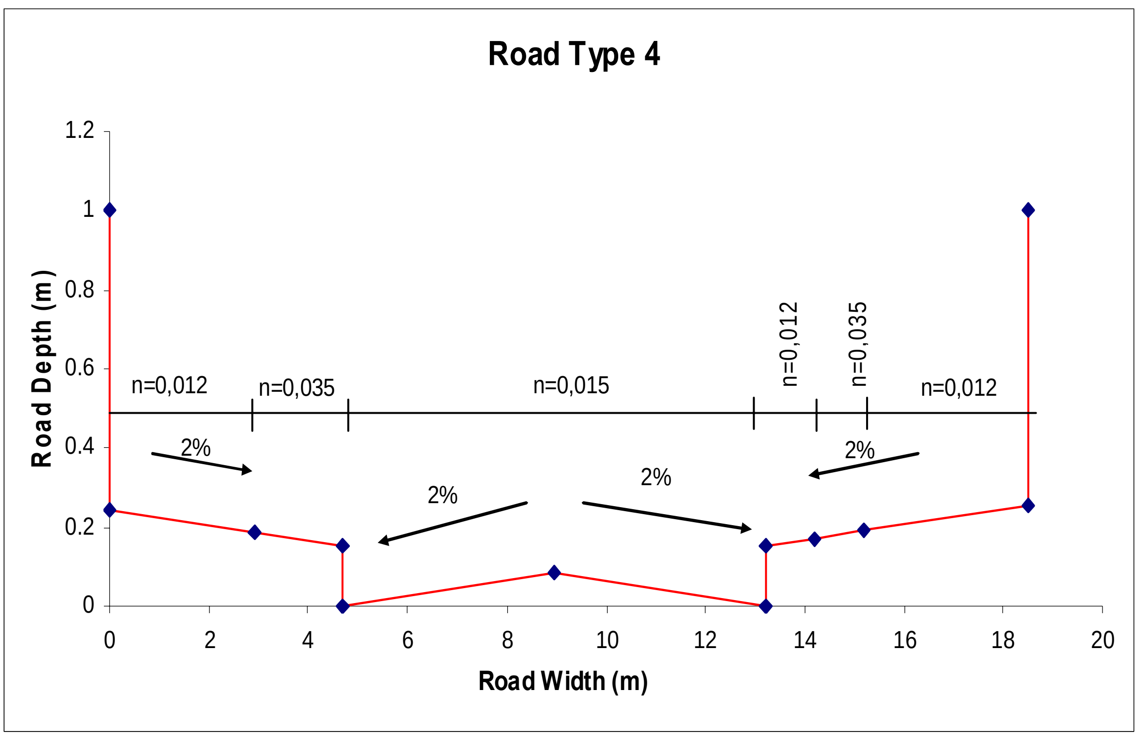
Standard Road Type 3:
Intermediate Local Residential Street, 18.5 ROW, 8.5m pavement

X (m)	Y-Depth (m)	Maning's n	New Panel
0	1	0.012	1
0	0.244	0.012	0
1.8	0.208	0.035	1
2.7	0.19	0.035	0
4.7	0.15	0.012	1
4.7	0	0.015	1
8.95	0.085	0.015	0
13.2	0	0.015	0
13.2	0.15	0.012	1
15.2	0.19	0.035	1
16.4	0.214	0.035	0
18.5	0.256	0.012	1
18.5	1	0.012	0



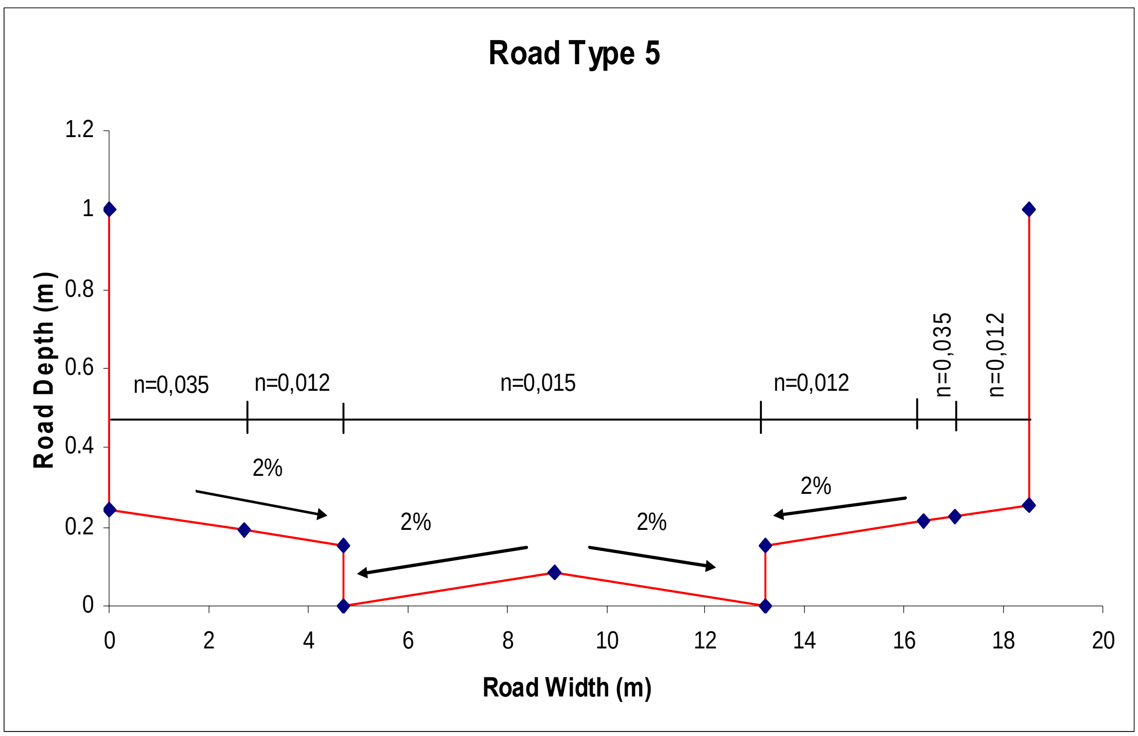
Standard Road Type 4:
Intermediate Local Residential Street, 18.5 ROW, 8.5m pavement

X (m)	Y-Depth (m)	Maning's n	New Panel
0	1	0.012	1
0	0.244	0.012	0
2.9	0.186	0.035	1
4.7	0.15	0.035	0
4.7	0	0.015	1
8.95	0.085	0.015	0
13.2	0	0.015	0
13.2	0.15	0.012	1
14.2	0.17	0.012	0
15.2	0.19	0.035	1
18.5	0.256	0.035	0
18.5	1	0.012	0



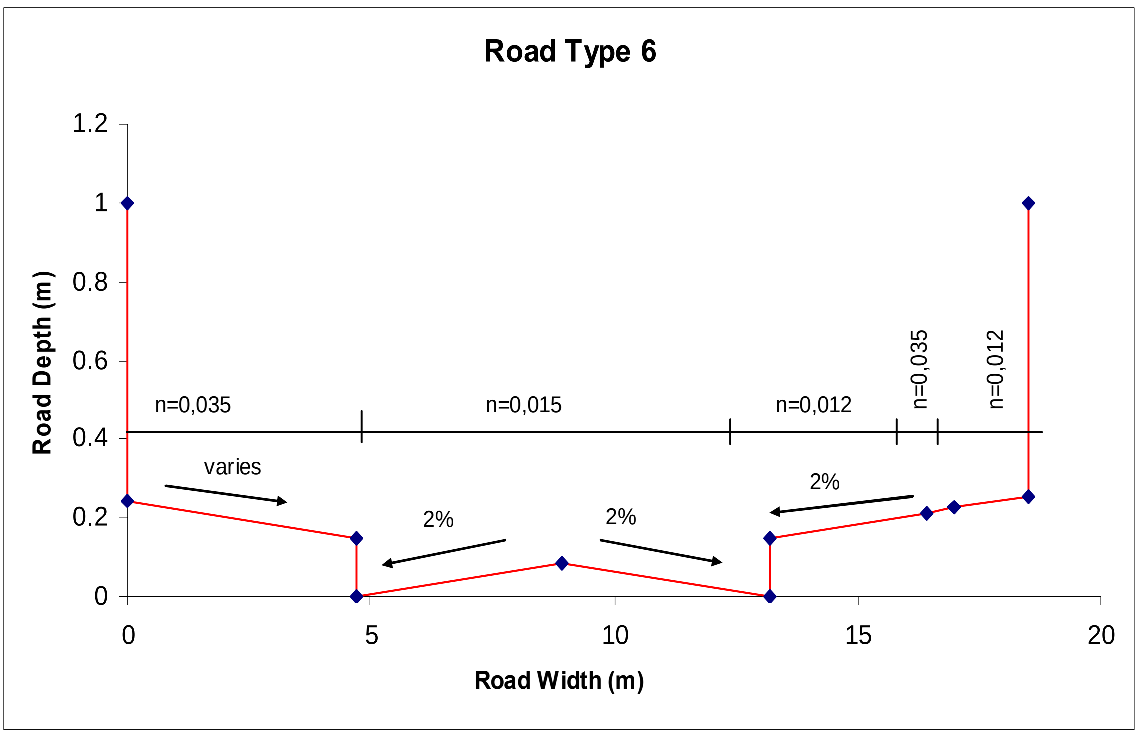
Standard Road Type 5:
Minor Local Residential Street, 18.5 ROW, 8.5m pavement

X (m)	Y-Depth (m)	Maning's n	New Panel
0	1	0.012	1
0	0.244	0.035	1
2.7	0.19	0.012	1
4.7	0.15	0.015	1
4.7	0	0.015	0
8.95	0.085	0.015	0
13.2	0	0.012	1
13.2	0.15	0.012	0
16.4	0.214	0.035	1
17	0.226	0.035	0
18.5	0.256	0.035	0
18.5	1	0.012	1



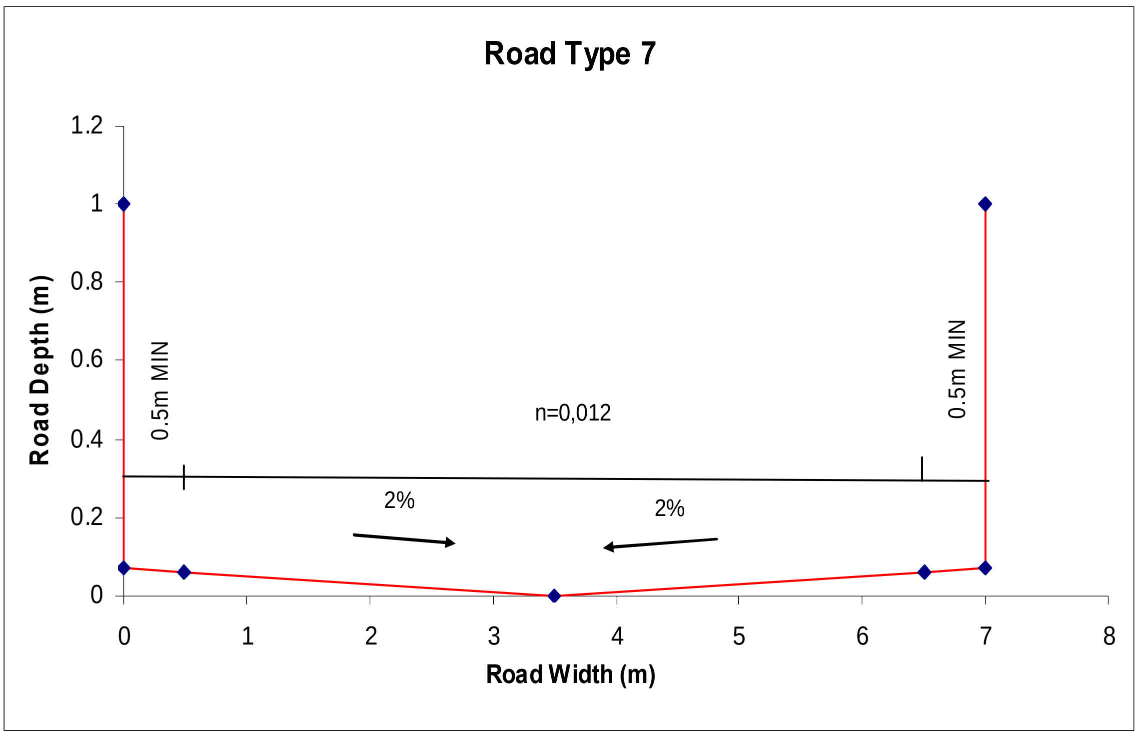
Standard Road Type 6:
Minor Local Residential Street, 18.5 ROW, 8.5m pavement

X (m)	Y-Depth (m)	Maning's n	New Panel
0	1	0.012	1
0	0.244	0.035	1
4.7	0.15	0.035	0
4.7	0	0.012	1
8.95	0.085	0.015	1
13.2	0	0.015	0
13.2	0.15	0.012	1
16.4	0.214	0.012	0
17	0.226	0.035	1
18.5	0.256	0.035	0
18.5	1	0.012	1



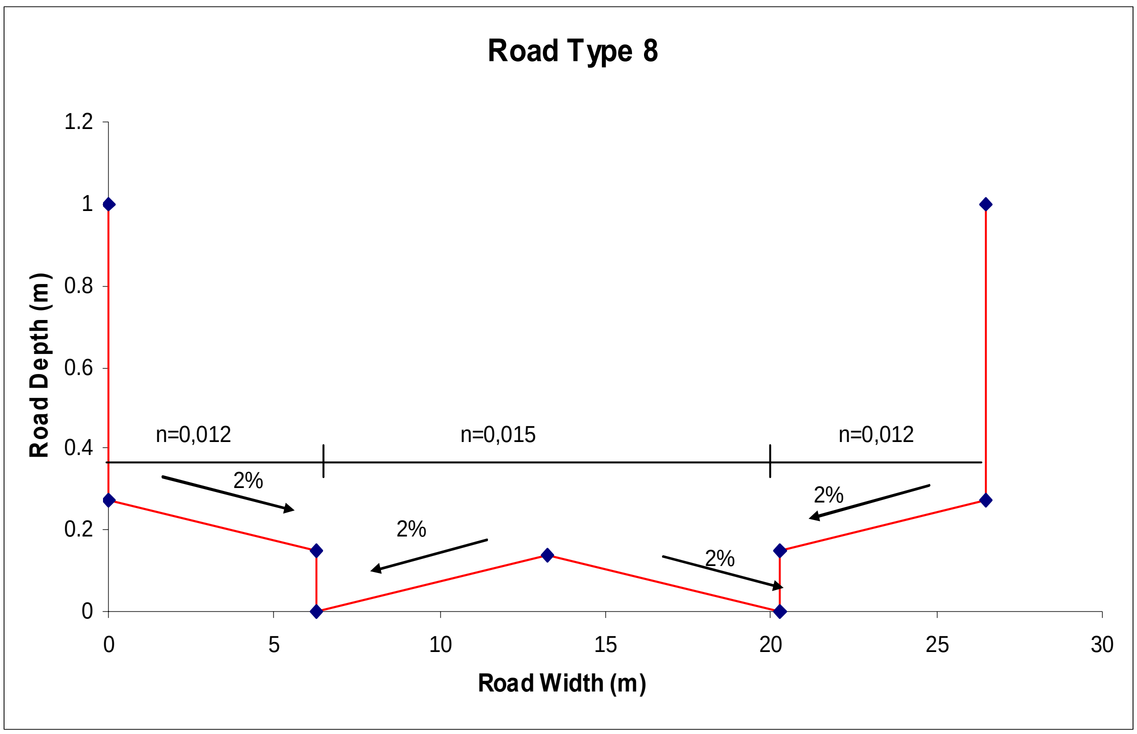
Standard Road Type 7:
Rear Lane 6.0 ROW

X (m)	Y-Depth (m)	Maning's n	New Panel
0	1	0.012	1
0	0.07	0.012	0
0.5	0.06	0.012	0
3.5	0	0.012	0
6.5	0.06	0.012	0
7	0.07	0.012	0
7	1	0.012	0



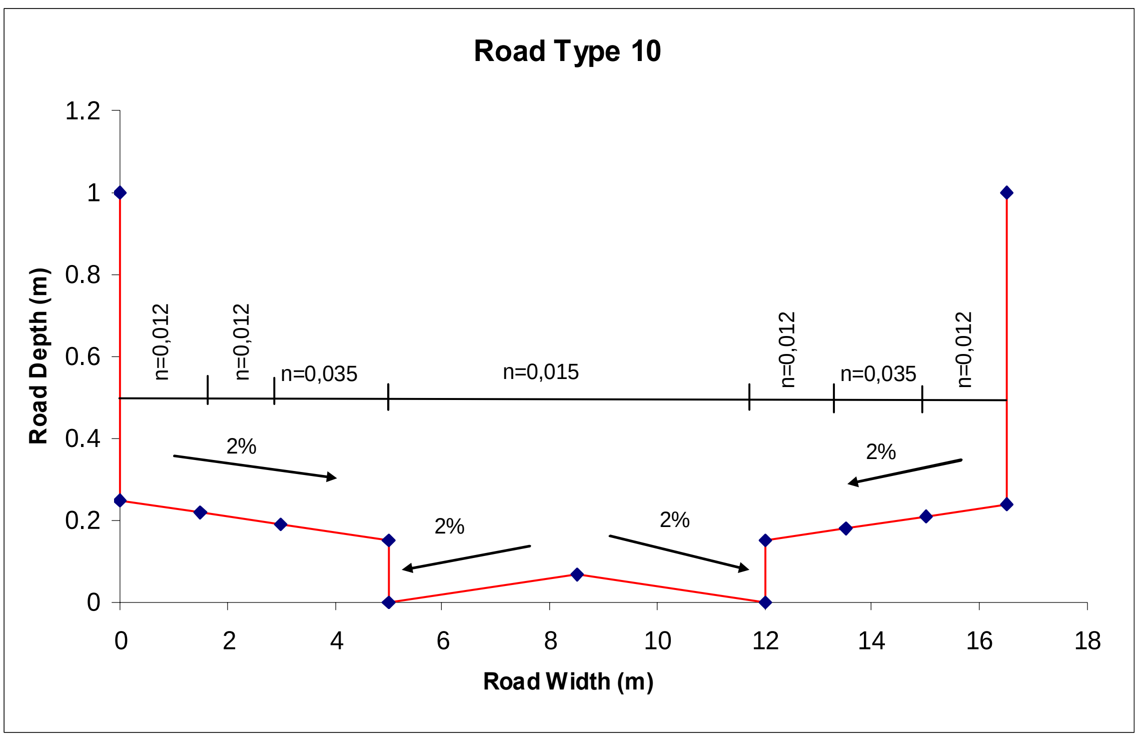
Standard Road Type 8:
Major Arterials

X (m)	Y-Depth (m)	Maning's n	New Panel
0	1	0.012	1
0	0.275	0.012	0
6.25	0.15	0.012	0
6.25	0	0.015	1
13.25	0.14	0.015	0
20.25	0	0.015	0
20.25	0.15	0.015	0
26.5	0.275	0.012	1
26.5	1	0.012	0



Standard Road Type 10:
Minor Local Residential Street

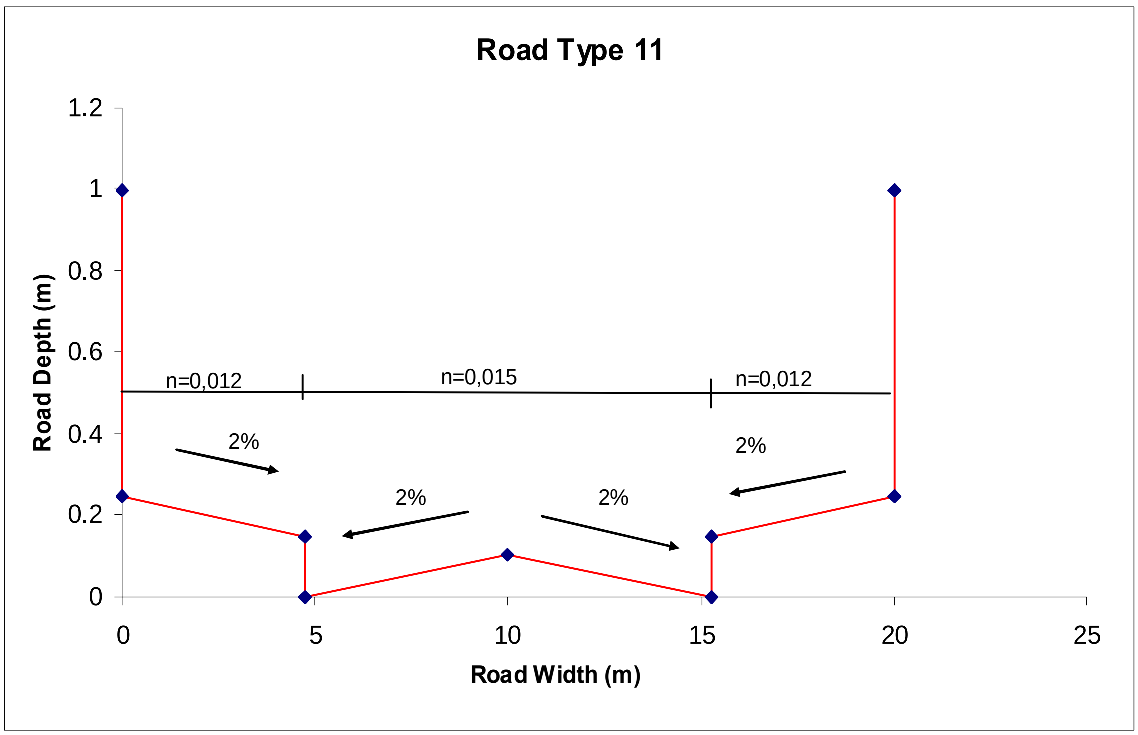
X (m)	Y-Depth (m)	Maning's n	New Panel
0	1	0.012	1
0	0.25	0.012	0
1.5	0.22	0.012	0
3	0.19	0.035	1
5	0.15	0.035	0
5	0	0.015	1
8.5	0.07	0.015	0
12	0	0.015	0
12	0.15	0.012	1
13.5	0.18	0.035	1
15	0.21	0.035	0
16.5	0.24	0.012	1
16.5	1	0.012	0



Standard Road Type 11:

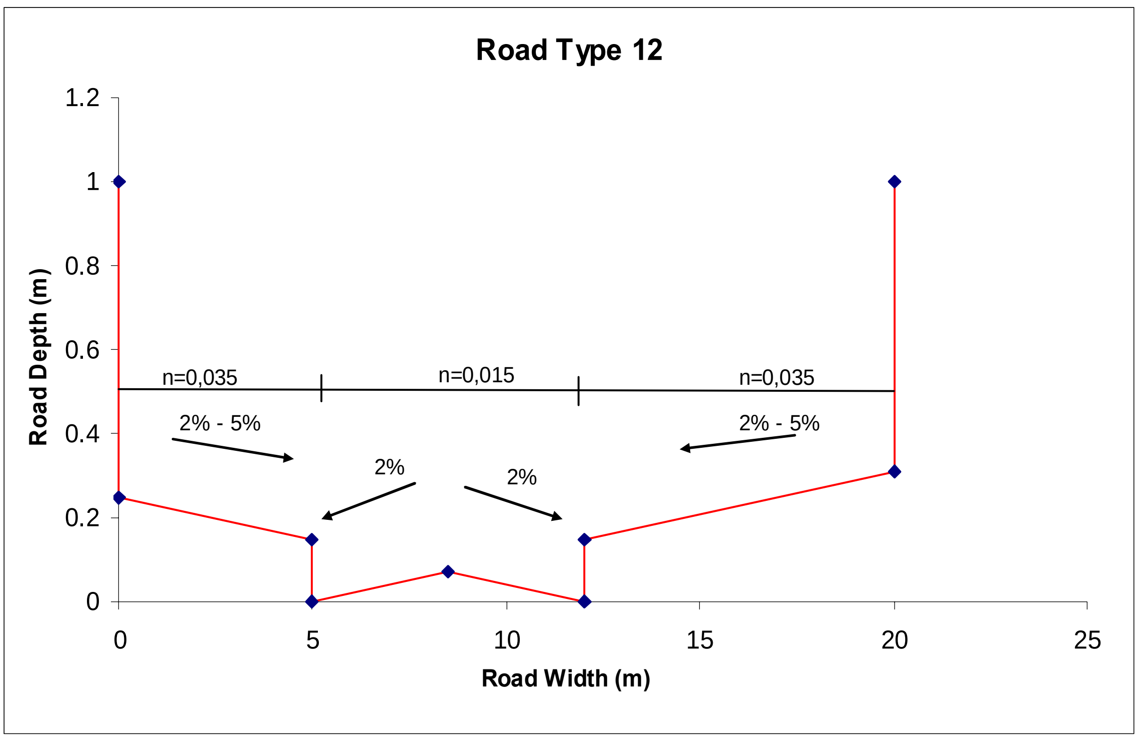
Minor Arterial 20m (Rogers RD, Marlee Avenue, Oakwood Avenue, Vaughan RD)

X (m)	Y-Depth (m)	Maning's n	New Panel
0	1	0.012	1
0	0.245	0.012	0
4.75	0.15	0.012	0
4.75	0	0.015	1
10	0.105	0.015	0
15.25	0	0.015	0
15.25	0.15	0.012	1
20	0.245	0.012	0
20	1	0.012	0



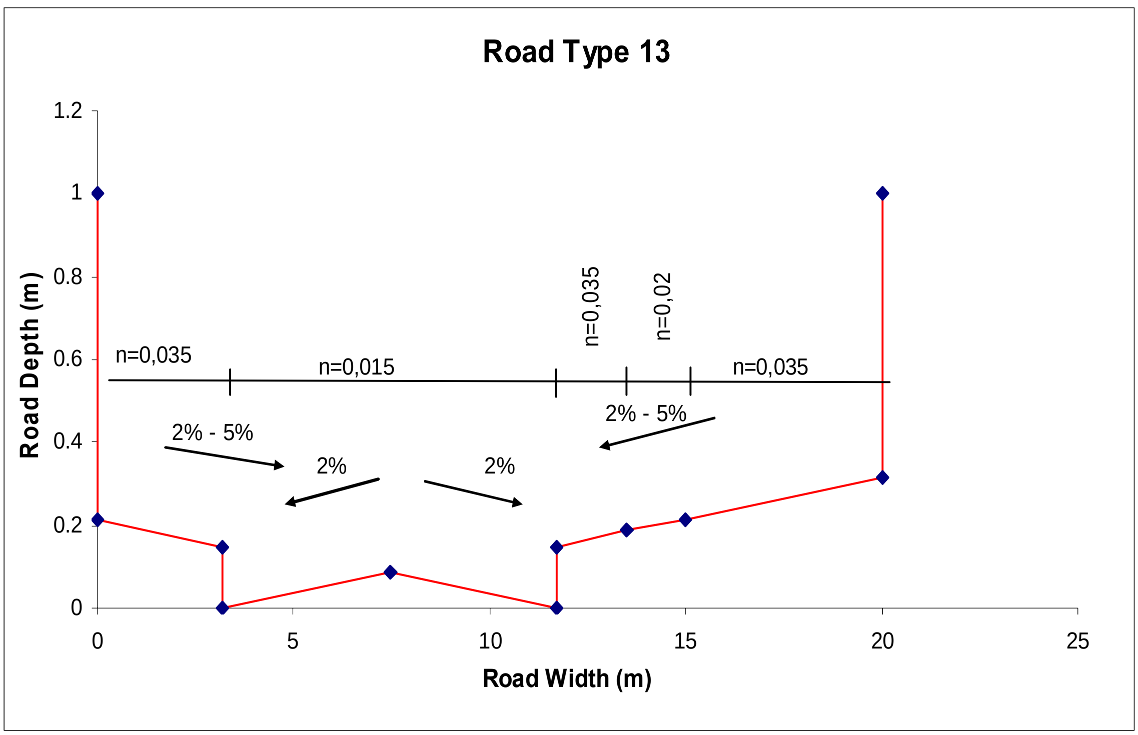
Standard Road Type 12:
Local Residential Street

X (m)	Y-Depth (m)	Maning's n	New Panel
0	1	0.035	1
0	0.25	0.035	0
5	0.15	0.035	0
5	0	0.015	1
8.5	0.07	0.015	0
12	0	0.015	0
12	0.15	0.035	1
20	0.31	0.035	0
20	1	0.035	0



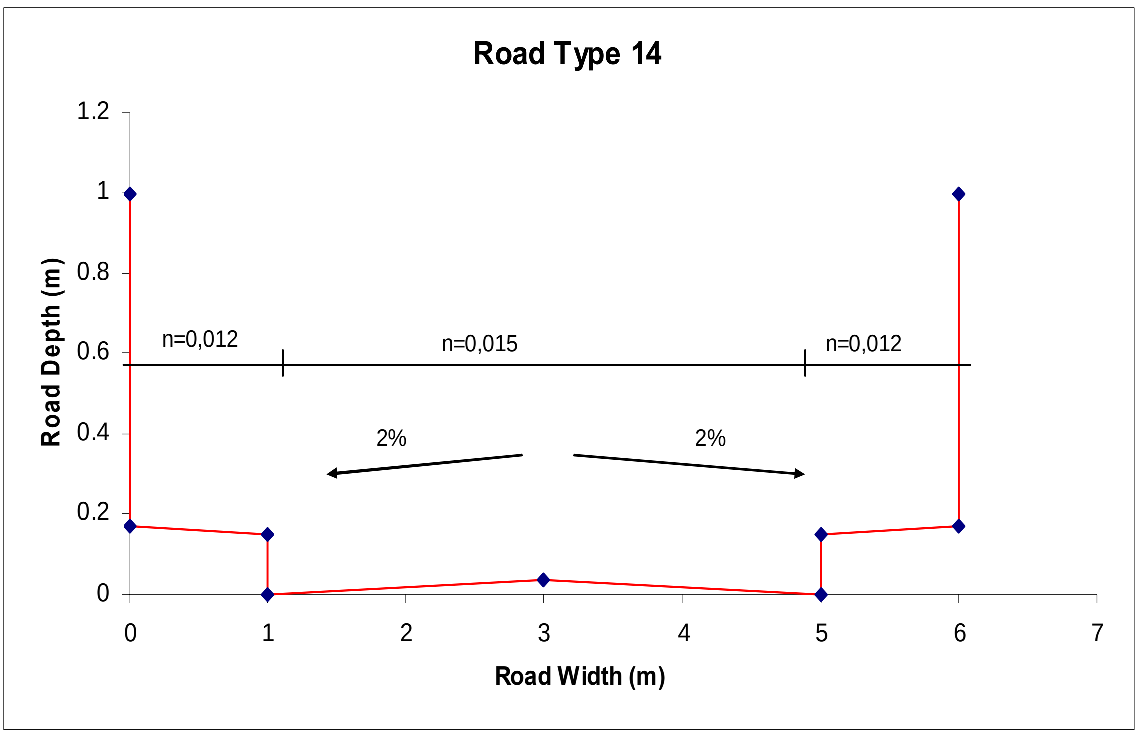
Standard Road Type 13:
Local Residential Street 20 ROW

X (m)	Y-Depth (m)	Maning's n	New Panel
0	1	0.035	1
0	0.214	0.035	0
3.2	0.15	0.035	0
3.2	0	0.015	1
7.45	0.085	0.015	0
11.7	0	0.015	0
11.7	0.15	0.035	1
13.5	0.186	0.035	0
15	0.216	0.012	1
20	0.316	0.035	1
20	1	0.012	1



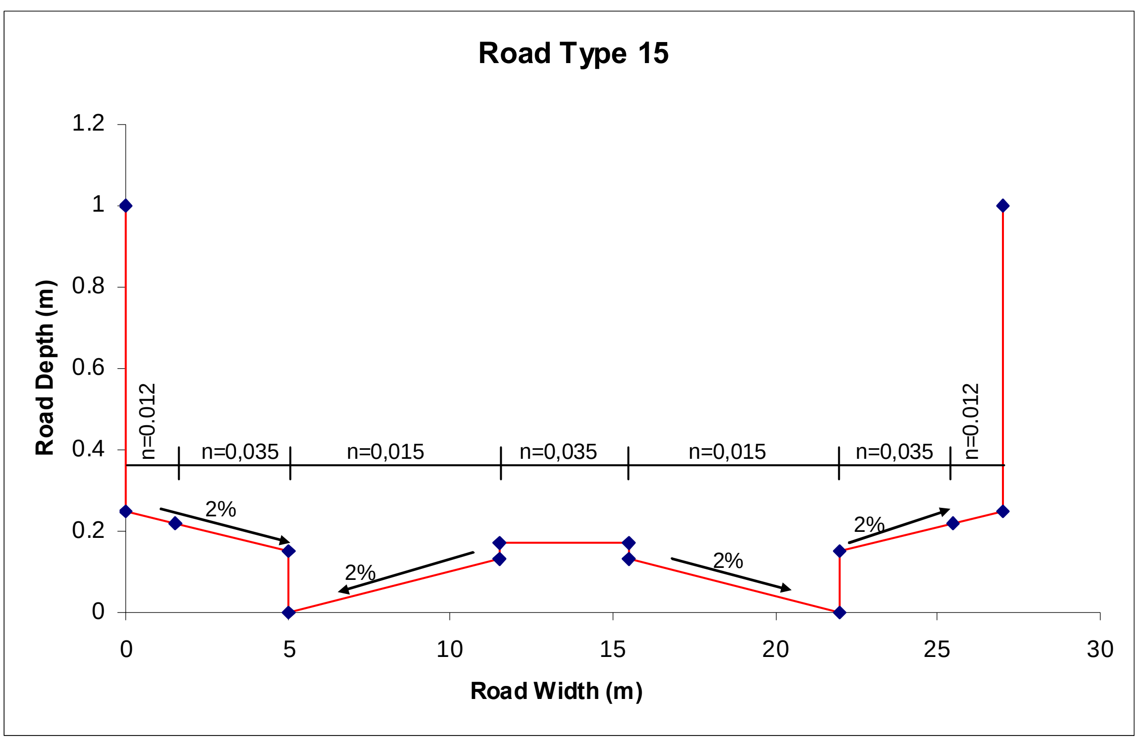
Standard Road Type 14:
Local Residential Street 20 ROW

X (m)	Y-Depth (m)	Maning's n	New Panel
0	1	0.035	1
0	0.17	0.035	0
1	0.15	0.035	0
1	0	0.015	1
3	0.04	0.015	0
5	0	0.015	0
5	0.15	0.035	1
6	0.17	0.035	0
6	1	0.012	1



Standard Road Type 15:
27 m collector road , 11 m pavement with central media

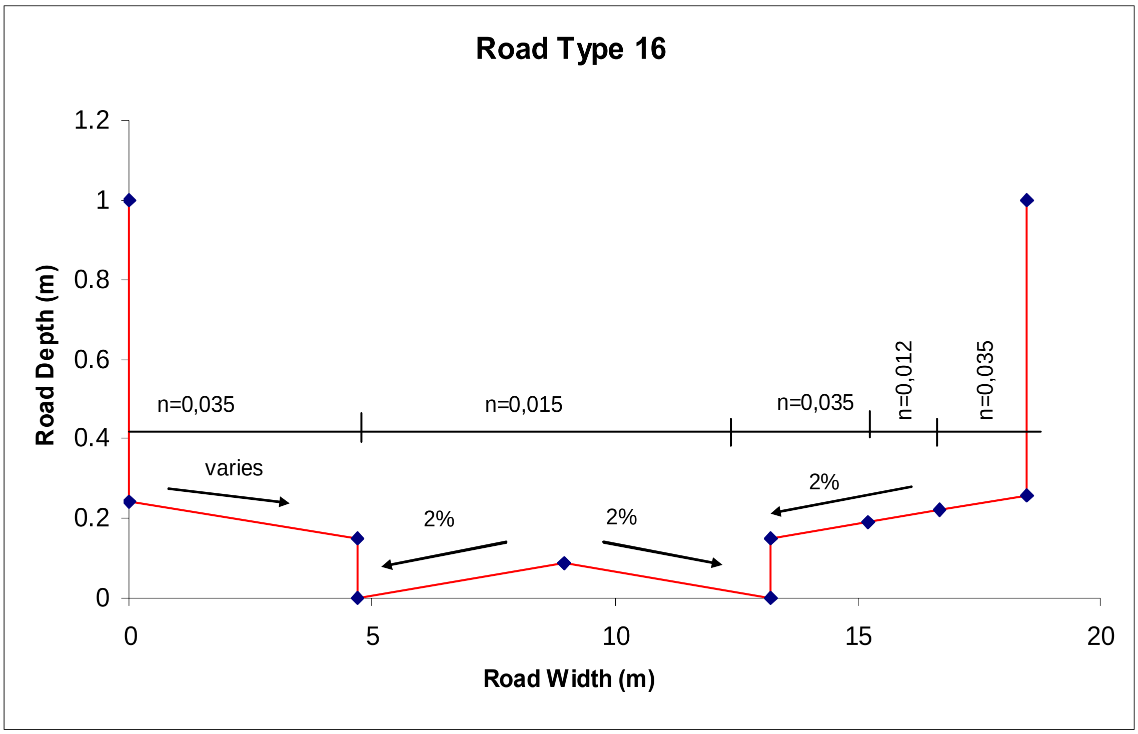
X (m)	Y-Depth (m)	Maning's n	New Panel
0	1	0.012	1
0	0.25	0.012	1
1.5	0.22	0.035	1
5	0.15	0.012	1
5	0	0.015	1
11.5	0.13	0.012	1
11.5	0.17	0.035	1
15.5	0.17	0.035	0
15.5	0.13	0.015	1
22	0	0.012	1
22	0.15	0.035	1
25.5	0.22	0.012	1
27	0.25	0.035	1
27	1	0.012	1



Standard Road Type 16:

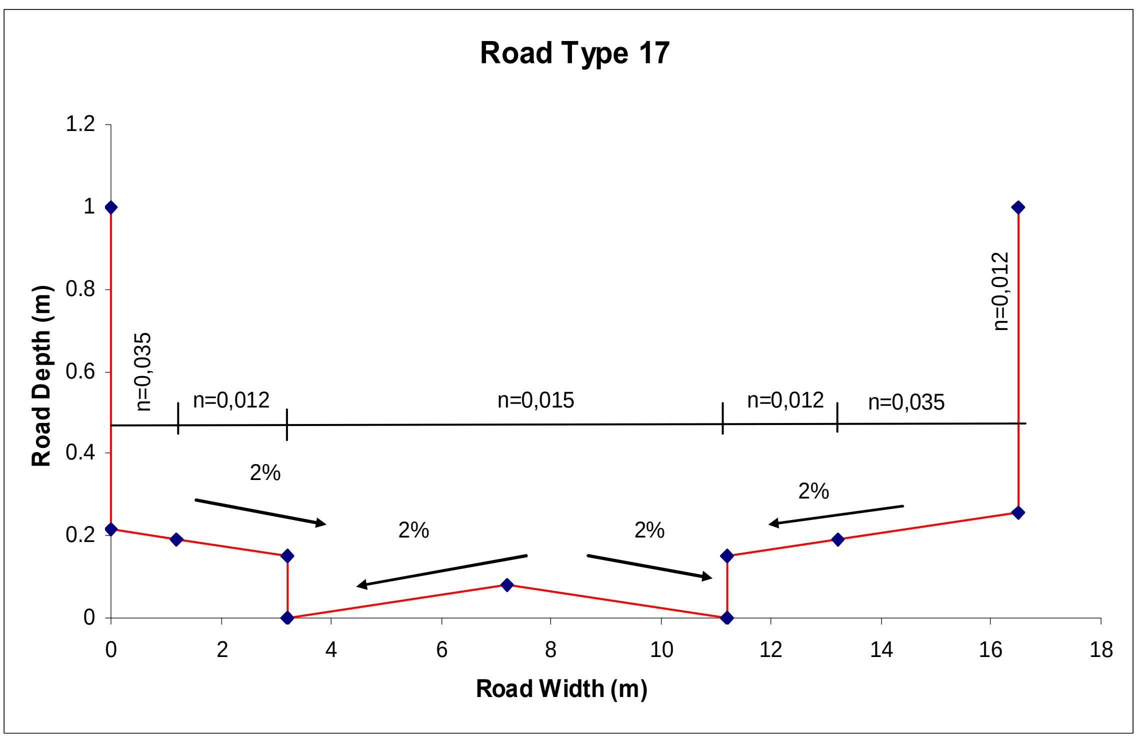
Local Residential Street, 18.5 ROW, 8.5m pavement for Pinewood avenue, Heathdale Rd.

X (m)	Y-Depth (m)	Maning's n	New Panel
0	1	0.012	1
0	0.244	0.035	1
4.7	0.15	0.035	0
4.7	0	0.012	1
8.95	0.085	0.015	1
13.2	0	0.015	0
13.2	0.15	0.012	1
15.2	0.19	0.012	0
16.7	0.22	0.035	1
18.5	0.256	0.035	0
18.5	1	0.012	1



Standard Road Type 17:
Minor Local Residential Street, 16.5 ROW, 8m pavement

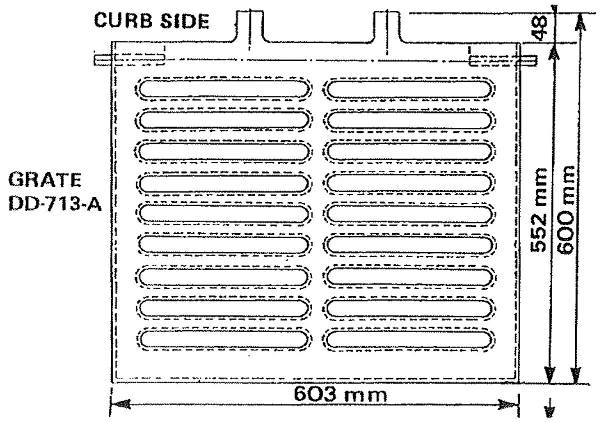
X (m)	Y-Depth (m)	Maning's n	New Panel
0	1	0.012	1
0	0.214	0.035	1
1.2	0.19	0.012	1
3.2	0.15	0.015	1
3.2	0	0.015	0
7.2	0.08	0.015	0
11.2	0	0.012	1
11.2	0.15	0.012	0
13.2	0.19	0.035	1
16.5	0.256	0.035	0
16.5	1	0.012	1



Appendix F.2

Standard Inlet Capture Curve

Grate DD - 713A Inlet Capacity Evaluation



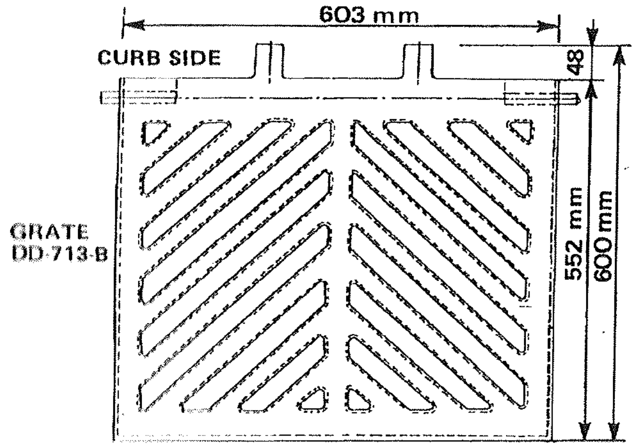
Inlet Capture Rate Q (m^3/s) for Grate DD-713A Inlet (on Grade) and Curb and Gutter Type B

Crossfall (m/m)	Flow Depth (m)	Longitudinal Slope				
		0.003 (m/m)	0.01 (m/m)	0.02 (m/m)	0.04 (m/m)	0.1 (m/m)
0.02	0	0	0	0	0	0
	0.06	0.0055	0.0076	0.0094	0.0114	0.0122
	0.065	0.0083	0.0125	0.0160	0.0191	0.0185
	0.07	0.0112	0.0166	0.0207	0.0249	0.0242
	0.08	0.0150	0.0250	0.0308	0.0356	0.0350
	0.09	0.0249	0.0377	0.0434	0.0487	0.0459
	0.10	0.0387	0.0501	0.0556	0.0599	0.0555
	0.104	0.0410	0.0555	0.0592	0.0625	0.0581
	0.11	0.0462	0.0615	0.0654	0.0678	0.0627
	0.12	0.0554	0.0715	0.0749	0.0773	0.0707
	0.13	0.0635	0.0807	0.0836	0.0854	0.0777
	0.14	0.0710	0.0893	0.0917	0.0929	0.0842
	0.15	0.0780	0.0973	0.0992	0.0999	0.0902
	0.20	0.1071	0.1306	0.1306	0.1291	0.1153
	0.25	0.1297	0.1564	0.1550	0.1517	0.1348
	0.30	0.1482	0.1775	0.1748	0.1702	0.1507
	0.35	0.1638	0.1953	0.1917	0.1858	0.1642
	0.40	0.1773	0.2108	0.2062	0.1994	0.1758
	0.45	0.1892	0.2244	0.2191	0.2113	0.1861
	0.50	0.1999	0.2366	0.2306	0.2220	0.1953
	0.55	0.2095	0.2476	0.2410	0.2317	0.2036
	0.60	0.2183	0.2577	0.2505	0.2405	0.2112
	0.65	0.2264	0.2670	0.2592	0.2486	0.2182
	0.70	0.2339	0.2755	0.2673	0.2561	0.2247
	0.75	0.2409	0.2835	0.2748	0.2631	0.2307
	0.80	0.2474	0.2910	0.2819	0.2697	0.2363
	0.85	0.2536	0.2980	0.2885	0.2758	0.2416
	0.90	0.2593	0.3046	0.2947	0.2816	0.2466
	0.95	0.2648	0.3109	0.3006	0.2871	0.2513
	1	0.2700	0.3168	0.3062	0.2923	0.2558

Notes: For flow depth less than or equal to 0.11 m, capture rates derived from laboratory testing of full experimental roadway; for flow depth greater than 0.11 m, capture rates extrapolated by using experimental data.

clarifica

Grate DD - 713B Inlet Capacity Evaluation

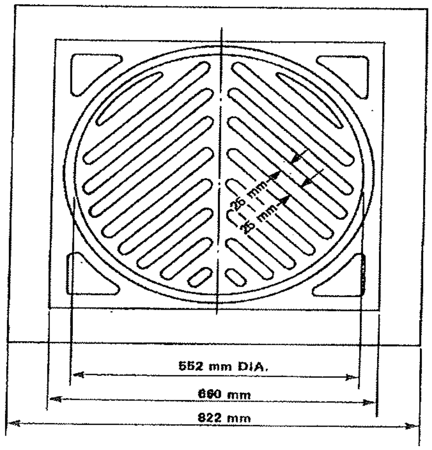


Inlet Capture Rate Q (m^3/s) for Grate DD-713B Inlet (on Grade) and Curb and Gutter Type B

Crossfall (m/m)	Flow Depth (m)	Longitudinal Slope				
		0.003 (m/m)	0.01 (m/m)	0.02 (m/m)	0.04 (m/m)	0.1 (m/m)
0.02	0	0	0	0	0	0
	0.06	0.0047	0.0073	0.0097	0.0116	0.0122
	0.065	0.0079	0.0115	0.0142	0.0177	0.0173
	0.07	0.0103	0.0143	0.0182	0.0223	0.0218
	0.08	0.0131	0.0226	0.0285	0.0334	0.0321
	0.09	0.0229	0.0354	0.0401	0.0439	0.0410
	0.10	0.0342	0.0461	0.0520	0.0543	0.0494
	0.104	0.0364	0.0500	0.0558	0.0577	0.0522
	0.11	0.0420	0.0549	0.0605	0.0618	0.0571
	0.12	0.0499	0.0644	0.0701	0.0703	0.0637
	0.13	0.0572	0.0726	0.0783	0.0775	0.0700
	0.14	0.0640	0.0802	0.0859	0.0843	0.0757
	0.15	0.0703	0.0872	0.0929	0.0906	0.0811
	0.20	0.0967	0.1165	0.1224	0.1167	0.1036
	0.25	0.1171	0.1393	0.1453	0.1370	0.1210
	0.30	0.1338	0.1579	0.1640	0.1536	0.1353
	0.35	0.1479	0.1736	0.1798	0.1676	0.1473
	0.40	0.1602	0.1872	0.1935	0.1797	0.1577
	0.45	0.1710	0.1993	0.2056	0.1904	0.1669
	0.50	0.1806	0.2100	0.2164	0.2000	0.1752
	0.55	0.1893	0.2197	0.2261	0.2087	0.1826
	0.60	0.1973	0.2286	0.2350	0.2166	0.1894
	0.65	0.2046	0.2368	0.2432	0.2238	0.1957
	0.70	0.2114	0.2443	0.2508	0.2306	0.2014
	0.75	0.2177	0.2514	0.2579	0.2368	0.2068
	0.80	0.2237	0.2579	0.2645	0.2427	0.2119
	0.85	0.2292	0.2641	0.2707	0.2482	0.2166
	0.90	0.2344	0.2700	0.2766	0.2534	0.2211
	0.95	0.2394	0.2755	0.2821	0.2583	0.2253
	1	0.2441	0.2807	0.2874	0.2630	0.2293

Notes: For flow depth less than or equal to 0.11 m, capture rates derived from laboratory testing of full experimental roadway; for flow depth greater than 0.11 m, capture rates extrapolated by using experimental data.

Grate Round Frame Inlet Capacity Evaluation



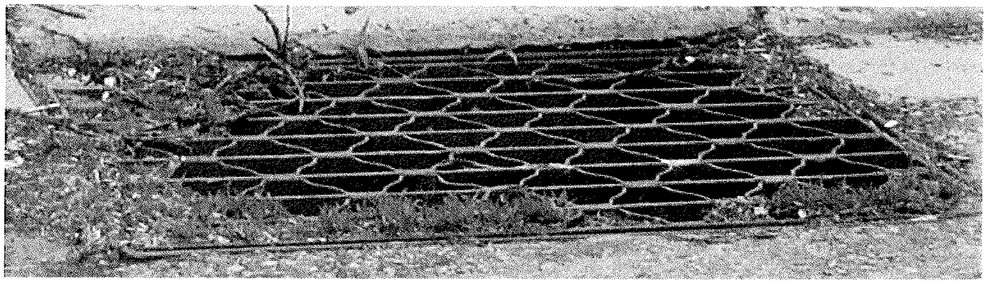
Inlet Capture Rate Q (m^3/s) for Grate Round Frame Inlet (on Grade) and Curb and Gutter Type B

Crossfall (m/m)	Flow Depth (m)	Longitudinal Slope				
		0.003 (m/m)	0.01 (m/m)	0.02 (m/m)	0.04 (m/m)	0.1 (m/m)
0.02	0	0	0	0	0	0
	0.06	0.0042	0.0062	0.0078	0.0081	0.0067
	0.065	0.0071	0.0098	0.0114	0.0124	0.0095
	0.07	0.0093	0.0122	0.0146	0.0156	0.0120
	0.08	0.0118	0.0192	0.0228	0.0234	0.0177
	0.09	0.0206	0.0301	0.0321	0.0307	0.0226
	0.10	0.0308	0.0392	0.0416	0.0380	0.0272
	0.104	0.0328	0.0425	0.0446	0.0404	0.0287
	0.11	0.0378	0.0467	0.0484	0.0433	0.0314
	0.12	0.0450	0.0548	0.0560	0.0493	0.0349
	0.13	0.0516	0.0617	0.0626	0.0543	0.0384
	0.14	0.0577	0.0681	0.0687	0.0591	0.0416
	0.15	0.0634	0.0741	0.0743	0.0634	0.0445
	0.20	0.0871	0.0991	0.0979	0.0817	0.0569
	0.25	0.1055	0.1184	0.1162	0.0959	0.0665
	0.30	0.1205	0.1342	0.1312	0.1075	0.0743
	0.35	0.1332	0.1476	0.1438	0.1173	0.0810
	0.40	0.1442	0.1592	0.1548	0.1258	0.0867
	0.45	0.1539	0.1694	0.1644	0.1333	0.0918
	0.50	0.1626	0.1785	0.1731	0.1400	0.0963
	0.55	0.1704	0.1868	0.1809	0.1461	0.1004
	0.60	0.1776	0.1943	0.1880	0.1516	0.1041
	0.65	0.1842	0.2013	0.1946	0.1567	0.1076
	0.70	0.1903	0.2077	0.2007	0.1614	0.1108
	0.75	0.1960	0.2137	0.2063	0.1658	0.1137
	0.80	0.2013	0.2193	0.2116	0.1699	0.1165
	0.85	0.2063	0.2245	0.2166	0.1738	0.1191
	0.90	0.2110	0.2295	0.2213	0.1774	0.1216
	0.95	0.2155	0.2342	0.2257	0.1808	0.1239
	1	0.2197	0.2386	0.2299	0.1841	0.1261

Notes: Capture Rate Qi = Ks x Capture rates of DD-713B on grade. Ks from 0.9 to 0.55 , varing along longitudinal slope.

clarifica

Grate Honeycomb Inlet Capacity Evaluation



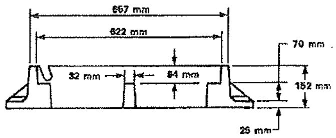
Size: 0.84m x 0.66m

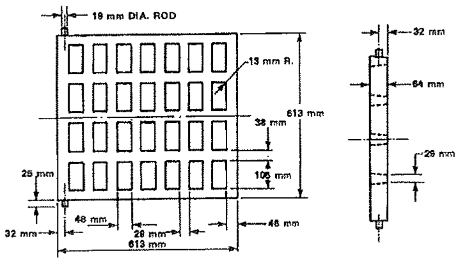
Inlet Capture Rate Q (m^3/s) for Grate Honeycomb Inlet (on Grade) and Curb and Gutter Type B

Crossfall (m/m)	Flow Depth (m)	Longitudinal Slope				
		0.003 (m/m)	0.01 (m/m)	0.02 (m/m)	0.04 (m/m)	0.1 (m/m)
0.02	0	0	0	0	0	0
	0.065	0.0095	0.0099	0.0048	0.0000	0.0000
	0.07	0.0123	0.0180	0.0164	0.0000	0.0000
	0.08	0.0177	0.0304	0.0335	0.0299	0.0002
	0.09	0.0247	0.0423	0.0496	0.0513	0.0059
	0.10	0.0334	0.0555	0.0667	0.0676	0.0229
	0.104	0.0374	0.0614	0.0735	0.0746	0.0254
	0.11	0.0439	0.0709	0.0845	0.0855	0.0293
	0.12	0.0493	0.0799	0.0968	0.0998	0.0387
	0.13	0.0558	0.0899	0.1095	0.1135	0.0467
	0.14	0.0619	0.0993	0.1213	0.1262	0.0541
	0.15	0.0675	0.1079	0.1323	0.1381	0.0609
	0.20	0.0909	0.1441	0.1780	0.1874	0.0896
	0.25	0.1091	0.1721	0.2135	0.2257	0.1118
	0.30	0.1239	0.1950	0.2425	0.2570	0.1299
	0.35	0.1364	0.2143	0.2671	0.2835	0.1452
	0.40	0.1473	0.2311	0.2883	0.3064	0.1585
	0.45	0.1569	0.2459	0.3071	0.3266	0.1702
	0.50	0.1655	0.2591	0.3238	0.3447	0.1807
	0.55	0.1732	0.2711	0.3390	0.3610	0.1902
	0.60	0.1803	0.2820	0.3528	0.3759	0.1989
	0.65	0.1868	0.2921	0.3656	0.3897	0.2068
	0.70	0.1929	0.3014	0.3774	0.4024	0.2142
	0.75	0.1985	0.3101	0.3883	0.4142	0.2211
	0.80	0.2037	0.3182	0.3986	0.4253	0.2275
	0.85	0.2087	0.3258	0.4082	0.4357	0.2335
	0.90	0.2133	0.3330	0.4173	0.4455	0.2392
	0.95	0.2177	0.3398	0.4259	0.4548	0.2446
	1	0.2219	0.3462	0.4341	0.4636	0.2497

Notes: Capture rates derived from formula: Qi = Q(RfE0+Rs(1-E0). Here Q is gutter flow, Rf is the frontal-flow interception efficiency, Rs is a side- flow ration and E0 is the frontal-flow ration for a straight cross-slope.

Grate KWC Inlet Capacity Evaluation





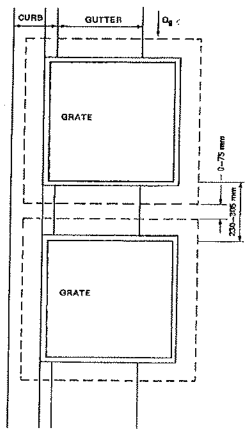
Inlet Capture Rate Q (m^3/s) for Grate KWC Inlet (on Grade) and Curb and Gutter Type B

Crossfall (m/m)	Flow Depth (m)	Longitudinal Slope				
		0.003 (m/m)	0.01 (m/m)	0.02 (m/m)	0.04 (m/m)	0.1 (m/m)
0.02	0	0	0	0	0	0
	0.06	0.0033	0.0069	0.0092	0.0098	0.0047
	0.065	0.0057	0.0096	0.0124	0.0129	0.0073
	0.07	0.0081	0.0122	0.0153	0.0159	0.0106
	0.08	0.0121	0.0174	0.0213	0.0230	0.0169
	0.09	0.0191	0.0254	0.0303	0.0337	0.0266
	0.10	0.0268	0.0343	0.0391	0.0413	0.0316
	0.104	0.0330	0.0398	0.0440	0.0458	0.0356
	0.11	0.0392	0.0472	0.0513	0.0523	0.0401
	0.12	0.0446	0.0531	0.0574	0.0589	0.0458
	0.13	0.0513	0.0604	0.0648	0.0660	0.0514
	0.14	0.0575	0.0672	0.0716	0.0726	0.0566
	0.15	0.0633	0.0735	0.0780	0.0788	0.0614
	0.20	0.0875	0.0999	0.1044	0.1044	0.0816
	0.25	0.1062	0.1204	0.1250	0.1243	0.0973
	0.30	0.1215	0.1371	0.1417	0.1406	0.1101
	0.35	0.1344	0.1512	0.1559	0.1544	0.1209
	0.40	0.1456	0.1635	0.1682	0.1663	0.1303
	0.45	0.1555	0.1743	0.1790	0.1768	0.1385
	0.50	0.1643	0.1839	0.1887	0.1862	0.1459
	0.55	0.1723	0.1927	0.1975	0.1947	0.1526
	0.60	0.1796	0.2007	0.2055	0.2024	0.1587
	0.65	0.1864	0.2080	0.2129	0.2096	0.1644
	0.70	0.1926	0.2148	0.2197	0.2162	0.1696
	0.75	0.1984	0.2211	0.2260	0.2223	0.1744
	0.80	0.2038	0.2270	0.2320	0.2281	0.1789
	0.85	0.2089	0.2326	0.2375	0.2335	0.1832
	0.90	0.2137	0.2378	0.2428	0.2386	0.1872
	0.95	0.2182	0.2428	0.2478	0.2434	0.1910
	1	0.2225	0.2475	0.2525	0.2480	0.1946

Notes: For flow depth less than or equal to 0.11 m, capture rates derived from laboratory testing of full experimental roadway; for flow depth greater than 0.11 m, capture rates extrapolated by using experimental data.

clarifica

Twin Grate DD - 713A Inlets Capacity Evaluation

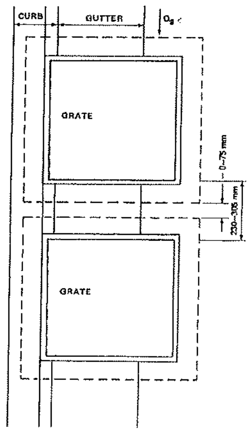


Inlet Capture Rate Q (m^3/s) for Twin Grate DD-713A Inlets (on Grade) and Curb and Gutter Type B

Crossfall (m/m)	Flow Depth (m)	Longitudinal Slope				
		0.003 (m/m)	0.01 (m/m)	0.02 (m/m)	0.04 (m/m)	0.1 (m/m)
0.02	0	0	0	0	0	0
	0.06	0.0056	0.0077	0.0096	0.0116	0.0124
	0.065	0.0085	0.0129	0.0165	0.0201	0.0196
	0.07	0.0115	0.0173	0.0217	0.0266	0.0261
	0.08	0.0156	0.0265	0.0333	0.0399	0.0406
	0.09	0.0264	0.0411	0.0486	0.0580	0.0578
	0.10	0.0418	0.0561	0.0651	0.0749	0.0749
	0.104	0.0447	0.0627	0.0704	0.0800	0.0819
	0.11	0.0513	0.0713	0.0798	0.0909	0.0922
	0.12	0.0614	0.0827	0.0918	0.1037	0.1052
	0.13	0.0706	0.0939	0.1035	0.1163	0.1181
	0.14	0.0791	0.1044	0.1144	0.1281	0.1301
	0.15	0.0870	0.1141	0.1244	0.1390	0.1412
	0.20	0.1201	0.1546	0.1665	0.1845	0.1876
	0.25	0.1457	0.1861	0.1991	0.2198	0.2236
	0.30	0.1667	0.2118	0.2257	0.2486	0.2530
	0.35	0.1844	0.2335	0.2482	0.2730	0.2779
	0.40	0.1997	0.2523	0.2677	0.2941	0.2994
	0.45	0.2133	0.2689	0.2849	0.3128	0.3184
	0.50	0.2254	0.2837	0.3003	0.3294	0.3354
	0.55	0.2363	0.2972	0.3143	0.3445	0.3508
	0.60	0.2463	0.3094	0.3270	0.3583	0.3648
	0.65	0.2555	0.3207	0.3387	0.3710	0.3777
	0.70	0.2640	0.3311	0.3495	0.3827	0.3897
	0.75	0.2719	0.3409	0.3596	0.3936	0.4008
	0.80	0.2794	0.3500	0.3690	0.4038	0.4112
	0.85	0.2863	0.3585	0.3779	0.4134	0.4210
	0.90	0.2929	0.3666	0.3862	0.4224	0.4302
	0.95	0.2991	0.3742	0.3941	0.4310	0.4389
	1	0.3050	0.3814	0.4016	0.4391	0.4472

Notes: For flow depth less than or equal to 0.11 m, capture rates derived from laboratory testing of full experimental roadway; for flow depth greater than 0.11 m, capture rates extrapolated by using experimental data.

Twin Grate DD - 713B Inlets Capacity Evaluation



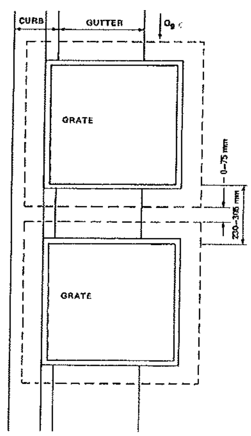
Inlet Capture Rate Q (m^3/s) for Twin Grate DD-713B Inlets (on Grade) and Curb and Gutter Type B

Crossfall (m/m)	Flow Depth (m)	Longitudinal Slope				
		0.003 (m/m)	0.01 (m/m)	0.02 (m/m)	0.04 (m/m)	0.1 (m/m)
0.02	0	0	0	0	0	0
	0.06	0.0056	0.0077	0.0096	0.0116	0.0124
	0.065	0.0085	0.0129	0.0165	0.0201	0.0196
	0.07	0.0115	0.0173	0.0217	0.0266	0.0261
	0.08	0.0156	0.0265	0.0333	0.0399	0.0406
	0.09	0.0264	0.0411	0.0486	0.0580	0.0578
	0.10	0.0418	0.0561	0.0651	0.0749	0.0749
	0.104	0.0447	0.0627	0.0704	0.0800	0.0819
	0.11	0.0513	0.0713	0.0798	0.0909	0.0922
	0.12	0.0614	0.0827	0.0918	0.1037	0.1052
	0.13	0.0706	0.0939	0.1035	0.1163	0.1181
	0.14	0.0791	0.1044	0.1144	0.1281	0.1301
	0.15	0.0870	0.1141	0.1244	0.1390	0.1412
	0.20	0.1201	0.1546	0.1665	0.1845	0.1876
	0.25	0.1457	0.1861	0.1991	0.2198	0.2236
	0.30	0.1667	0.2118	0.2257	0.2486	0.2530
	0.35	0.1844	0.2335	0.2482	0.2730	0.2779
	0.40	0.1997	0.2523	0.2677	0.2941	0.2994
	0.45	0.2133	0.2689	0.2849	0.3128	0.3184
	0.50	0.2254	0.2837	0.3003	0.3294	0.3354
	0.55	0.2363	0.2972	0.3143	0.3445	0.3508
	0.60	0.2463	0.3094	0.3270	0.3583	0.3648
	0.65	0.2555	0.3207	0.3387	0.3710	0.3777
	0.70	0.2640	0.3311	0.3495	0.3827	0.3897
	0.75	0.2719	0.3409	0.3596	0.3936	0.4008
	0.80	0.2794	0.3500	0.3690	0.4038	0.4112
	0.85	0.2863	0.3585	0.3779	0.4134	0.4210
	0.90	0.2929	0.3666	0.3862	0.4224	0.4302
	0.95	0.2991	0.3742	0.3941	0.4310	0.4389
	1	0.3050	0.3814	0.4016	0.4391	0.4472

Notes: For flow depth less than or equal to 0.11 m, capture rates derived from laboratory testing of full experimental roadway; for flow depth greater than 0.11 m, capture rates extrapolated by using experimental data.

clarifica

Twin Grate Honeycomb Inlets Capacity Evaluation



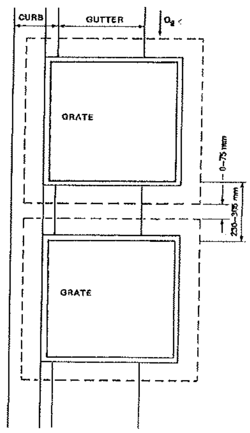
Inlet Capture Rate Q (m^3/s) for Twin Grate Honeycomb Inlets (on Grade) and Curb and Gutter Type B

Crossfall (m/m)	Flow Depth (m)	Longitudinal Slope				
		0.003 (m/m)	0.01 (m/m)	0.02 (m/m)	0.04 (m/m)	0.1 (m/m)
	0	0	0	0	0	0
	0.065	0.0095	0.0100	0.0049	0.0000	0.0000
	0.07	0.0123	0.0181	0.0167	0.0000	0.0000
	0.08	0.0177	0.0306	0.0342	0.0313	0.0003
	0.09	0.0249	0.0431	0.0514	0.0550	0.0070
	0.10	0.0340	0.0576	0.0710	0.0756	0.0291
	0.104	0.0382	0.0643	0.0793	0.0852	0.0334
	0.11	0.0452	0.0753	0.0933	0.1010	0.0408
	0.12	0.0507	0.0848	0.1065	0.1169	0.0522
	0.13	0.0575	0.0958	0.1211	0.1340	0.0630
	0.14	0.0638	0.1061	0.1347	0.1498	0.0731
	0.15	0.0696	0.1156	0.1473	0.1646	0.0825
	0.20	0.0941	0.1553	0.2001	0.2261	0.1216
	0.25	0.1131	0.1861	0.2409	0.2738	0.1519
0.02	0.30	0.1286	0.2113	0.2743	0.3128	0.1767
	0.35	0.1417	0.2325	0.3026	0.3457	0.1976
	0.40	0.1530	0.2510	0.3270	0.3743	0.2158
	0.45	0.1630	0.2672	0.3486	0.3995	0.2318
	0.50	0.1720	0.2817	0.3679	0.4220	0.2461
	0.55	0.1801	0.2949	0.3854	0.4424	0.2591
	0.60	0.1875	0.3069	0.4013	0.4610	0.2709
	0.65	0.1943	0.3180	0.4160	0.4781	0.2818
	0.70	0.2006	0.3282	0.4296	0.4939	0.2918
	0.75	0.2064	0.3377	0.4422	0.5087	0.3012
	0.80	0.2119	0.3466	0.4540	0.5225	0.3100
	0.85	0.2171	0.3550	0.4651	0.5355	0.3182
	0.90	0.2219	0.3629	0.4756	0.5477	0.3260
	0.95	0.2265	0.3703	0.4855	0.5592	0.3333
	1	0.2309	0.3774	0.4949	0.5702	0.3403

Notes: Capture rates derived from formula: $Qi = (E(1+Qg-Qi1)) \times Qi1$, $E=Qi1/Qg$, $Qi1$= single Inlet capture rate, Qg=gutter flow

clarifica

Twin Grate Roundframe Inlets Capacity Evaluation

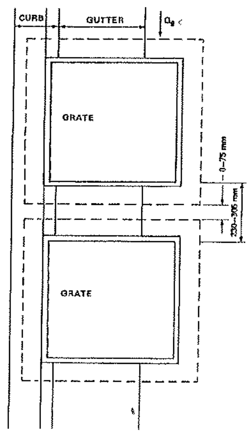


Inlet Capture Rate Q (m^3/s) for Twin Grate Roundframe Inlets (on Grade) and Curb and Gutter Type B

Crossfall (m/m)	Flow Depth (m)	Longitudinal Slope				
		0.003 (m/m)	0.01 (m/m)	0.02 (m/m)	0.04 (m/m)	0.1 (m/m)
0.02	0	0	0	0	0	0
	0.06	0.0050	0.0065	0.0077	0.0081	0.0068
	0.065	0.0076	0.0109	0.0132	0.0140	0.0108
	0.07	0.0104	0.0147	0.0174	0.0187	0.0144
	0.08	0.0140	0.0225	0.0266	0.0279	0.0223
	0.09	0.0238	0.0349	0.0389	0.0406	0.0318
	0.10	0.0376	0.0477	0.0520	0.0524	0.0412
	0.104	0.0402	0.0533	0.0564	0.0560	0.0451
	0.11	0.0462	0.0606	0.0638	0.0636	0.0507
	0.12	0.0553	0.0702	0.0734	0.0726	0.0579
	0.13	0.0635	0.0798	0.0828	0.0814	0.0650
	0.14	0.0712	0.0887	0.0915	0.0897	0.0716
	0.15	0.0783	0.0969	0.0995	0.0973	0.0777
	0.20	0.1081	0.1314	0.1332	0.1291	0.1032
	0.25	0.1312	0.1581	0.1592	0.1538	0.1230
	0.30	0.1500	0.1800	0.1806	0.1740	0.1392
	0.35	0.1659	0.1984	0.1986	0.1911	0.1529
	0.40	0.1798	0.2144	0.2142	0.2059	0.1647
	0.45	0.1919	0.2285	0.2280	0.2189	0.1752
	0.50	0.2028	0.2412	0.2403	0.2306	0.1845
	0.55	0.2127	0.2526	0.2514	0.2411	0.1930
	0.60	0.2217	0.2630	0.2616	0.2508	0.2007
	0.65	0.2300	0.2726	0.2709	0.2596	0.2078
	0.70	0.2376	0.2815	0.2796	0.2678	0.2144
	0.75	0.2448	0.2897	0.2877	0.2755	0.2205
	0.80	0.2514	0.2975	0.2952	0.2826	0.2262
	0.85	0.2577	0.3047	0.3023	0.2893	0.2316
	0.90	0.2636	0.3116	0.3090	0.2956	0.2367
	0.95	0.2692	0.3181	0.3153	0.3016	0.2415
	1	0.2745	0.3242	0.3213	0.3073	0.2460

Notes: Capture Rate Qi = Ks x Capture rates of Twin DD-713B on grade. Ks from 0.9 to 0.55 , varing along longitudinal slope.

Twin Grate KWC Inlets Capacity Evaluation

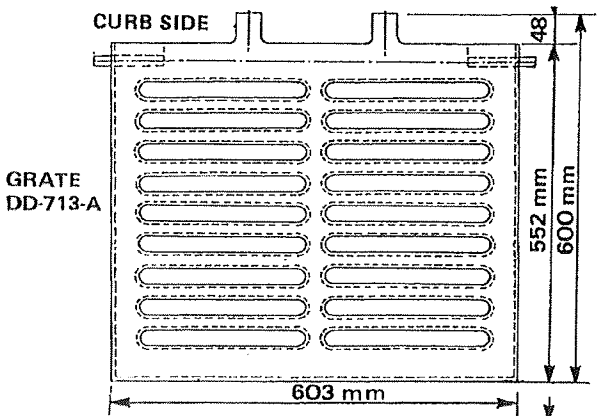


Inlet Capture Rate Q (m^3/s) for Twin Grate KWC Inlets (on Grade) and Curb and Gutter Type B

Crossfall (m/m)	Flow Depth (m)	Longitudinal Slope				
		0.003 (m/m)	0.01 (m/m)	0.02 (m/m)	0.04 (m/m)	0.1 (m/m)
0.02	0	0	0	0	0	0
	0.06	0.0033	0.0069	0.0093	0.0100	0.0049
	0.065	0.0057	0.0097	0.0126	0.0132	0.0077
	0.07	0.0081	0.0123	0.0156	0.0164	0.0113
	0.08	0.0122	0.0178	0.0220	0.0243	0.0187
	0.09	0.0194	0.0263	0.0320	0.0367	0.0311
	0.10	0.0274	0.0363	0.0427	0.0473	0.0399
	0.104	0.0339	0.0425	0.0488	0.0536	0.0465
	0.11	0.0405	0.0513	0.0584	0.0635	0.0554
	0.12	0.0461	0.0575	0.0653	0.0714	0.0628
	0.13	0.0531	0.0658	0.0741	0.0809	0.0716
	0.14	0.0596	0.0734	0.0824	0.0897	0.0799
	0.15	0.0656	0.0805	0.0900	0.0979	0.0875
	0.20	0.0908	0.1100	0.1219	0.1322	0.1194
	0.25	0.1103	0.1329	0.1467	0.1587	0.1441
	0.30	0.1263	0.1517	0.1669	0.1804	0.1643
	0.35	0.1397	0.1675	0.1840	0.1988	0.1814
	0.40	0.1514	0.1812	0.1988	0.2147	0.1962
	0.45	0.1617	0.1933	0.2118	0.2287	0.2092
	0.50	0.1709	0.2041	0.2235	0.2412	0.2209
	0.55	0.1793	0.2139	0.2341	0.2526	0.2315
	0.60	0.1869	0.2228	0.2437	0.2629	0.2411
	0.65	0.1939	0.2311	0.2526	0.2724	0.2500
	0.70	0.2004	0.2387	0.2608	0.2813	0.2582
	0.75	0.2064	0.2458	0.2685	0.2895	0.2658
	0.80	0.2121	0.2524	0.2757	0.2971	0.2730
	0.85	0.2174	0.2586	0.2824	0.3044	0.2797
	0.90	0.2224	0.2645	0.2887	0.3112	0.2860
	0.95	0.2271	0.2700	0.2947	0.3176	0.2920
	1	0.2316	0.2753	0.3004	0.3237	0.2977

Notes: Capture rates derived from formula: $Qi = (E(1+Qg-Qi1)) \times Qi1$, $E=Qi1/Qg$, Qi1= single Inlet capture rate, Qg= gutter flow.

Grate DD-713A Inlet Capacity Evaluation

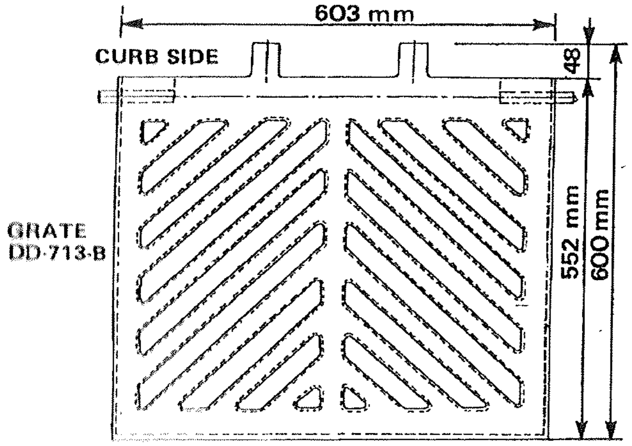


Inlet Capture Rate (m^3/s) for Grate DD-713A inlet (on Sag) and Curb and Gutter Type B

Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0004
0.02	0.0017
0.03	0.0040
0.04	0.0070
0.05	0.0110
0.06	0.0171
0.07	0.0250
0.08	0.0347
0.09	0.0464
0.1	0.0600
0.11	0.0726
0.12	0.0853
0.13	0.0971
0.14	0.1082
0.15	0.1184
0.2	0.1569
0.25	0.1811
0.3	0.2027
0.35	0.2260
0.4	0.2434
0.45	0.2589
0.5	0.2726
0.55	0.2851
0.6	0.2965
0.65	0.3070
0.7	0.3166
0.75	0.3257
0.8	0.3341
0.85	0.3420
0.9	0.3495
0.95	0.3566
1	0.3633

Notes: For flow depth less than or equal to 0.3 m, capture rates derived from laboratory testing of full experimental roadway;
for flow depth greater than 0.3 m, capture rates extrapolated by using experimental data.

Grate DD-713B Inlet Capacity Evaluation



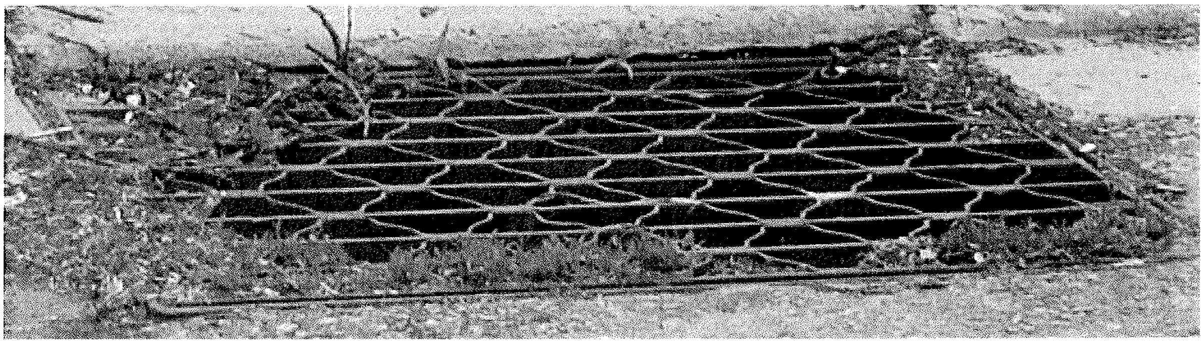
Inlet Capture Rate (m^3/s) for Grate DD-713B inlet (on Sag) and Curb and Gutter Type B

Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0004
0.02	0.0017
0.03	0.0040
0.04	0.0070
0.05	0.0110
0.06	0.0171
0.07	0.0250
0.08	0.0347
0.09	0.0464
0.1	0.0600
0.11	0.0726
0.12	0.0853
0.13	0.0971
0.14	0.1082
0.15	0.1184
0.2	0.1569
0.25	0.1811
0.3	0.2027
0.35	0.2260
0.4	0.2434
0.45	0.2589
0.5	0.2726
0.55	0.2851
0.6	0.2965
0.65	0.3070
0.7	0.3166
0.75	0.3257
0.8	0.3341
0.85	0.3420
0.9	0.3495
0.95	0.3566
1	0.3633

Notes: For flow depth less than or equal to 0.3 m, capture rates derived from laboratory testing of full experimental roadway; for flow depth greater than 0.3 m, capture rates extrapolated by using experimental data.

clarifica

Grate Honeycomb Inlet Capacity Evaluation



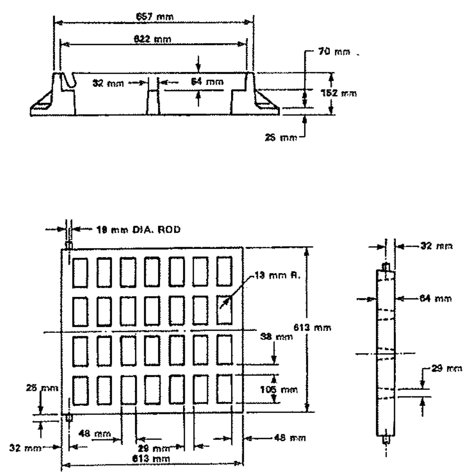
Size: 0.84m x 0.66m

Inlet Capture Rate (m^3/s) for Grate Honeycomb inlet (on Sag) and Curb and Gutter Type B

Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0036
0.02	0.0101
0.03	0.0186
0.04	0.0287
0.05	0.0401
0.06	0.0527
0.07	0.0664
0.08	0.0811
0.09	0.0968
0.1	0.1134
0.11	0.1308
0.12	0.1491
0.13	0.1681
0.14	0.1878
0.15	0.2083
0.2	0.3207
0.25	0.4495
0.3	0.4837
0.35	0.5397
0.4	0.5882
0.45	0.6310
0.5	0.6693
0.55	0.7039
0.6	0.7355
0.65	0.7646
0.7	0.7915
0.75	0.8166
0.8	0.8400
0.85	0.8621
0.9	0.8828
0.95	0.9025
1	0.9211

Notes: For flow depth less than 0.3 m, Capture rates derived from formula: $Qi = CPd^{1.5}$; for flow depth equal to or greater than 0.3 m, capture rates extrapolated by using calculation data.

Grate KWC Inlet Capacity Evaluation



Inlet Capture Rate (m^3/s) for Grate KWC inlet (on Sag) and Curb and Gutter Type B

Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0004
0.02	0.0017
0.03	0.0040
0.04	0.0070
0.05	0.0110
0.06	0.1710
0.07	0.0250
0.08	0.0347
0.09	0.0464
0.1	0.0600
0.11	0.0726
0.12	0.0855
0.13	0.0975
0.14	0.1090
0.15	0.1220
0.2	0.1725
0.25	0.2082
0.3	0.2340
0.35	0.2571
0.4	0.2780
0.45	0.2965
0.5	0.3130
0.55	0.3279
0.6	0.3416
0.65	0.3541
0.7	0.3657
0.75	0.3765
0.8	0.3866
0.85	0.3961
0.9	0.4051
0.95	0.4136
1	0.4216

Notes: For flow depth less than or equal to 0.3 m, capture rates derived from laboratory testing of full experimental roadway; for flow depth greater than 0.3 m, capture rates extrapolated by using experimental data.

clarifica

Grate Round-Arc-Frame Inlet Capacity Evaluation

Size: 0.60m x 0.60m

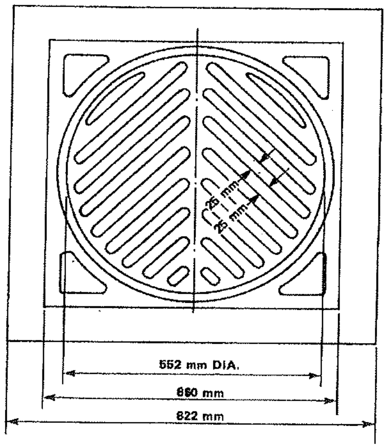
Inlet Capture Rate (m^3/s) for Grate Round-Arc-Frame inlet (on Sag) and Curb and Gutter Type B

Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0018
0.02	0.0051
0.03	0.0093
0.04	0.0143
0.05	0.0200
0.06	0.0263
0.07	0.0332
0.08	0.0406
0.09	0.0484
0.1	0.0567
0.11	0.0654
0.12	0.0745
0.13	0.0840
0.14	0.0939
0.15	0.1042
0.2	0.1604
0.25	0.1868
0.3	0.2048
0.35	0.2254
0.4	0.2433
0.45	0.2592
0.5	0.2733
0.55	0.2861
0.6	0.2978
0.65	0.3085
0.7	0.3185
0.75	0.3278
0.8	0.3364
0.85	0.3446
0.9	0.3523
0.95	0.3595
1	0.3664

Notes: For flow depth equal to or less than 0.3 m, Capture rates derived from formula: $Qi = CPd^{1.5}$ and $Qi=C_0A(2gd)^{0.5}$,
for flow depth greater than 0.3 m, capture rates extrapolated by using calculation data.

clarifica

Grate Round Frame Inlet Capacity Evaluation



Inlet Capture Rate (m^3/s) for Grate Round Frame inlet (on Sag) and Curb and Gutter Type B

Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0004
0.02	0.0016
0.03	0.0038
0.04	0.0066
0.05	0.0103
0.06	0.0161
0.07	0.0235
0.08	0.0326
0.09	0.0436
0.1	0.0564
0.11	0.0682
0.12	0.0802
0.13	0.0913
0.14	0.1017
0.15	0.1113
0.2	0.1475
0.25	0.1702
0.3	0.1905
0.35	0.2124
0.4	0.2288
0.45	0.2433
0.5	0.2563
0.55	0.2680
0.6	0.2787
0.65	0.2885
0.7	0.2976
0.75	0.3061
0.8	0.3141
0.85	0.3215
0.9	0.3285
0.95	0.3352
1	0.3415

Notes: For flow depth less than or equal to 0.3 m, Qi = Ks x Capture rates of DD-713-B, which derived from laboratory testing of full experimental roadway; for flow depth greater than 0.3 m, capture rates extrapolated by using experimental data. Ks=0.94

clarifica

Grate Small Grid Inlet Capacity Evaluation

Size: 0.25m x 0.25m

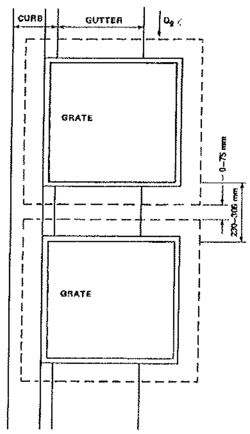
Inlet Capture Rate (m^3/s) for Grate Small Grid inlet (on Sag) and Curb and Gutter Type B

Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0001
0.02	0.0003
0.03	0.0007
0.04	0.0012
0.05	0.0018
0.06	0.0284
0.07	0.0042
0.08	0.0058
0.09	0.0077
0.1	0.0100
0.11	0.0121
0.12	0.0142
0.13	0.0162
0.14	0.0181
0.15	0.0203
0.2	0.0286
0.25	0.0346
0.3	0.0388
0.35	0.0427
0.4	0.0462
0.45	0.0492
0.5	0.0520
0.55	0.0544
0.6	0.0567
0.65	0.0588
0.7	0.0607
0.75	0.0625
0.8	0.0642
0.85	0.0658
0.9	0.0672
0.95	0.0687
1	0.0700

Notes: For flow depth less than or equal to 0.3 m, Qi = Ks x Capture rates of KWC, which derived from laboratory testing of full experimental roadway; for flow depth greater than 0.3 m, capture rates extrapolated by using experimental data. Ks=0.166

clarifica

Grate Twin DD-713A Inlet Capacity Evaluation

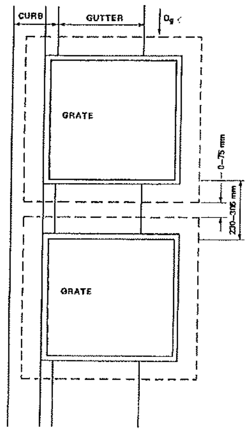


Inlet Capture Rate (m^3/s) for Grate Twin DD-713A inlet (on Sag) and Curb and Gutter Type B

Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0012
0.02	0.0028
0.03	0.0050
0.04	0.0098
0.05	0.0158
0.06	0.0256
0.07	0.0365
0.08	0.0530
0.09	0.0709
0.1	0.0908
0.11	0.1083
0.12	0.1256
0.13	0.1415
0.14	0.1548
0.15	0.1683
0.2	0.2440
0.25	0.3235
0.3	0.4054
0.35	0.4219
0.4	0.4592
0.45	0.4921
0.5	0.5215
0.55	0.5481
0.6	0.5724
0.65	0.5948
0.7	0.6155
0.75	0.6348
0.8	0.6528
0.85	0.6697
0.9	0.6857
0.95	0.7008
1	0.7151

Notes: For flow depth less than or equal to 0.3 m, capture rates derived from laboratory testing of full experimental roadway;
for flow depth greater than 0.3 m, capture rates extrapolated by using experimental data.

Grate Twin DD-713B Inlet Capacity Evaluation

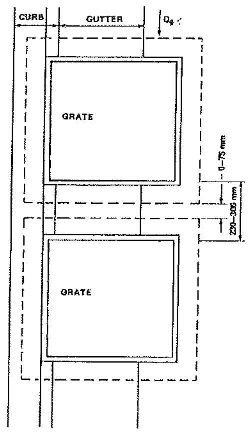


Inlet Capture Rate (m^3/s) for Grate Twin DD-713B inlet (on Sag) and Curb and Gutter Type B

Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0012
0.02	0.0028
0.03	0.0050
0.04	0.0098
0.05	0.0158
0.06	0.0256
0.07	0.0365
0.08	0.0530
0.09	0.0709
0.1	0.0908
0.11	0.1083
0.12	0.1256
0.13	0.1415
0.14	0.1548
0.15	0.1683
0.2	0.2440
0.25	0.3235
0.3	0.4054
0.35	0.4219
0.4	0.4592
0.45	0.4921
0.5	0.5215
0.55	0.5481
0.6	0.5724
0.65	0.5948
0.7	0.6155
0.75	0.6348
0.8	0.6528
0.85	0.6697
0.9	0.6857
0.95	0.7008
1	0.7151

Notes: For flow depth less than or equal to 0.3 m, capture rates derived from laboratory testing of full experimental roadway;
for flow depth greater than 0.3 m, capture rates extrapolated by using experimental data.

Grate Twin Honeycomb Inlet Capacity Evaluation



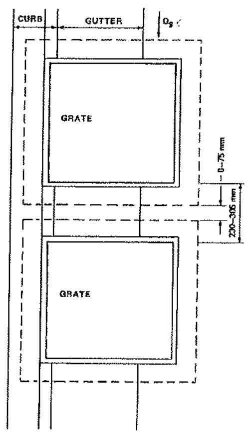
Inlet Capture Rate (m^3/s) for Grate Twin Honeycomb inlet (on Sag) and Curb and Gutter Type B

Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0108
0.02	0.0167
0.03	0.0233
0.04	0.0402
0.05	0.0576
0.06	0.0789
0.07	0.0970
0.08	0.1239
0.09	0.1479
0.1	0.1716
0.11	0.1951
0.12	0.2195
0.13	0.2449
0.14	0.2687
0.15	0.2961
0.2	0.4987
0.25	0.8029
0.3	0.9674
0.35	1.0076
0.4	1.1095
0.45	1.1995
0.5	1.2802
0.55	1.3533
0.6	1.4201
0.65	1.4816
0.7	1.5385
0.75	1.5916
0.8	1.6412
0.85	1.6879
0.9	1.7319
0.95	1.7735
1	1.8130

Notes: Capture Rate Qi = Ks x Capture rates of single Honeycomb inlet on sag

Ks=Twin capture rate/single capture rate of other grates, which capture rates derived from laboratory testing.

Grate Twin KWC Inlet Capacity Evaluation



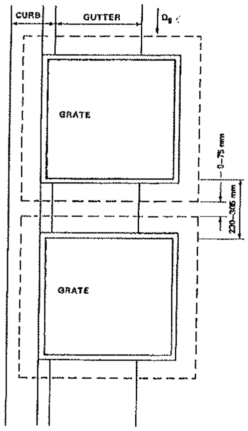
Inlet Capture Rate (m^3/s) for Grate Twin KWC inlet (on Sag) and Curb and Gutter Type B

Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0012
0.02	0.0028
0.03	0.0050
0.04	0.0098
0.05	0.0158
0.06	0.2560
0.07	0.0365
0.08	0.0530
0.09	0.0709
0.1	0.0908
0.11	0.1083
0.12	0.1259
0.13	0.1421
0.14	0.1559
0.15	0.1734
0.2	0.2683
0.25	0.3719
0.3	0.4680
0.35	0.4800
0.4	0.5244
0.45	0.5636
0.5	0.5987
0.55	0.6304
0.6	0.6594
0.65	0.6861
0.7	0.7108
0.75	0.7339
0.8	0.7554
0.85	0.7756
0.9	0.7947
0.95	0.8127
1	0.8299

Notes: Capture Rate Qi = Ks x Capture rates of single KWC on sag.

Ks=Twin capture rate/single capture rate of other grates, which capture rates derived from laboratory testing.

Grate Twin Round Frame Inlet Capacity Evaluation



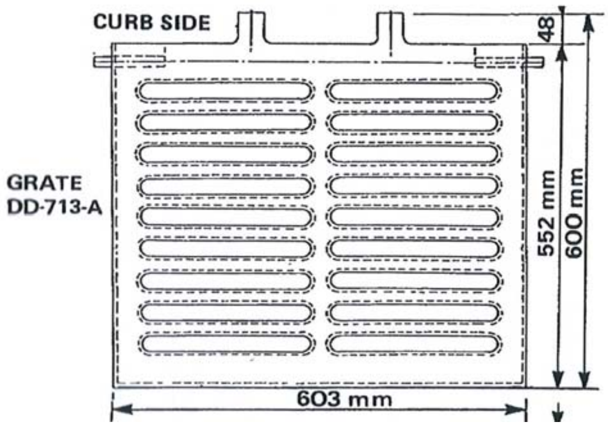
Inlet Capture Rate (m^3/s) for Grate Twin Round Frame inlet (on Sag) and Curb and Gutter Type B

Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0011
0.02	0.0026
0.03	0.0047
0.04	0.0092
0.05	0.0149
0.06	0.0241
0.07	0.0343
0.08	0.0498
0.09	0.0666
0.1	0.0854
0.11	0.1018
0.12	0.1181
0.13	0.1330
0.14	0.1455
0.15	0.1582
0.2	0.2294
0.25	0.3041
0.3	0.3811
0.35	0.3966
0.4	0.4316
0.45	0.4626
0.5	0.4902
0.55	0.5152
0.6	0.5381
0.65	0.5591
0.7	0.5786
0.75	0.5967
0.8	0.6136
0.85	0.6295
0.9	0.6445
0.95	0.6587
1	0.6722

Notes: Capture Rate Qi = Ks x Capture rates of Twin DD-713A on sag.
Ks=0.94.

Grate DD -713 A Inlet Capacity Evaluation

Curb & Gutter: Type B



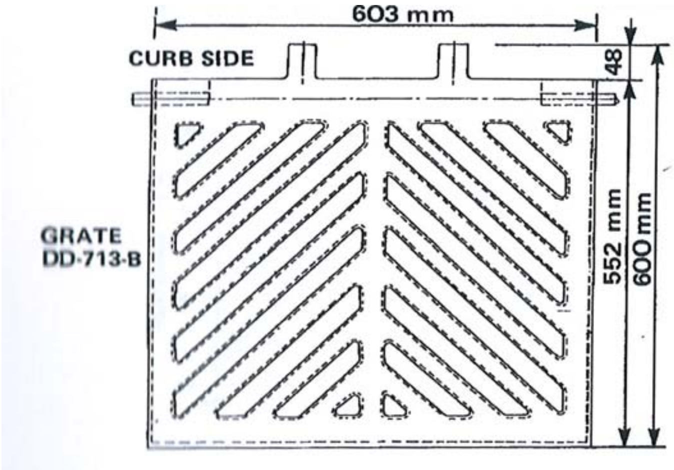
Data for Grate DD- 713-A inlet Capacity Curves (on Grade)

Crossfall (m/m)	Flow Depth (m)	Inlet Capture Flow Rate Q (m^3/s) Longitudinal Slopes (m/m)							
		0.003	0.01	0.02	0.03	0.04	0.06	0.08	0.1
0.02	0.06	0.0055	0.0076	0.0094	0.0106	0.0114	0.0126	0.0129	0.0122
	0.065	0.0083	0.0125	0.016	0.0177	0.0191	0.0202	0.0204	0.0185
	0.07	0.0112	0.0166	0.0207	0.0232	0.0249	0.0263	0.0257	0.0242
	0.08	0.015	0.025	0.0308	0.0339	0.0356	0.0367	0.0363	0.035
	0.09	0.0249	0.0377	0.0434	0.0475	0.0487	0.0488	0.0474	0.0459
	0.1	0.0387	0.0501	0.0556	0.059	0.0599	0.0586	0.0568	0.0555
	0.104	0.041	0.0555	0.0592	0.062	0.0625	0.0621	0.0607	0.0581
	0.11	0.0462	0.0615	0.0654	0.0676	0.0678	0.0671	0.0645	0.0627
0.04	0.07	0.0085	0.013	0.0169	0.0203	0.022	0.0239	0.0237	0.0224
	0.08	0.0126	0.0209	0.0286	0.0324	0.0347	0.0368	0.0356	0.032
	0.09	0.0169	0.0288	0.0379	0.0425	0.0444	0.046	0.0445	0.0424
	0.11	0.0303	0.0477	0.0572	0.06	0.0611	0.0608	0.0583	0.0559
	0.13	0.0469	0.07	0.0749	0.0767	0.0768	0.075	0.0724	0.0681
	0.15	0.0624	0.0805	0.0872	0.0896	0.0887	0.0864	0.082	0.0785
0.06	0.08	0.0093	0.0165	0.0227	0.0266	0.0293	0.0328	0.0341	0.0342
	0.095	0.0211	0.0302	0.0356	0.0392	0.0419	0.046	0.0477	0.0471
	0.11	0.0335	0.045	0.0518	0.0568	0.0592	0.0625	0.061	0.0576
	0.14	0.0526	0.0729	0.0803	0.0842	0.0848	0.0836	0.0803	0.0754
0.08	0.09	0.0163	0.0255	0.0324	0.0363	0.0384	0.0425	0.0444	0.046
	0.11	0.028	0.0372	0.0443	0.0492	0.0511	0.0557	0.059	0.0634
	0.13	0.0395	0.0496	0.0561	0.0602	0.0628	0.0672	0.0704	0.0744

Notes: Capture rates derived from laboratory testing of full experimental roadway at the National Water Research Institute Canada Centre for Inland Waters

Grate DD -713 B Inlet Capacity Evaluation

Curb & Gutter: Type B



Data for Grate DD- 713-B inlet Capacity Curves (on Grade)

Crossfall (m/m)	Flow Depth (m)	Inlet Capture Flow Rate Q (m^3/s)							
		Longitudinal Slopes (m/m)							
		0.003	0.01	0.02	0.03	0.04	0.06	0.08	0.1
0.02	0.06	0.0047	0.0073	0.0097	0.011	0.0116	0.0125	0.0126	0.0122
	0.065	0.0079	0.0115	0.0142	0.0166	0.0177	0.0188	0.0193	0.0173
	0.07	0.0103	0.0143	0.0182	0.0209	0.0223	0.0233	0.0235	0.0218
	0.08	0.0131	0.0226	0.0285	0.0315	0.0334	0.0345	0.0343	0.0321
	0.09	0.0229	0.0354	0.0401	0.0433	0.0439	0.0437	0.0427	0.041
	0.1	0.0342	0.0461	0.052	0.0542	0.0543	0.0536	0.0519	0.0494
	0.104	0.0364	0.05	0.0558	0.0575	0.0577	0.0572	0.0555	0.0522
	0.11	0.042	0.0549	0.0605	0.0619	0.0618	0.0605	0.0591	0.0571
0.04	0.07	0.0069	0.0126	0.017	0.0194	0.0215	0.0239	0.0236	0.0212
	0.08	0.0121	0.021	0.0272	0.0304	0.0315	0.0324	0.031	0.0281
	0.09	0.0156	0.0271	0.0345	0.0384	0.0399	0.0417	0.0403	0.0379
	0.11	0.0275	0.0461	0.0537	0.0568	0.0576	0.056	0.0529	0.05
	0.13	0.042	0.0642	0.0697	0.0708	0.0709	0.0698	0.0677	0.0636
	0.15	0.0575	0.0777	0.0806	0.0807	0.0797	0.0765	0.0733	0.072
0.06	0.08	0.0095	0.0154	0.021	0.0242	0.0264	0.028	0.0303	0.0301
	0.095	0.0186	0.028	0.0328	0.036	0.0393	0.0425	0.0444	0.0433
	0.11	0.0302	0.0421	0.0479	0.0517	0.0539	0.0556	0.0549	0.0509
	0.14	0.0479	0.0621	0.0687	0.0712	0.0725	0.0713	0.0678	0.0625
0.08	0.09	0.0131	0.023	0.0295	0.0322	0.035	0.0376	0.0383	0.038
	0.11	0.0271	0.0375	0.0422	0.0456	0.0489	0.0535	0.0565	0.0573
	0.13	0.0379	0.0504	0.0468	0.0609	0.0633	0.0681	0.0722	0.0743

Notes: Capture rates derived from laboratory testing of full experimental roadway at the National Water Research Institute Canada Centre for Inland Waters

clarifica

Grate Honeycomb Inlet Capacity Evaluation

Curb & Gutter: Type B

Size: 0.84m x 0.66m

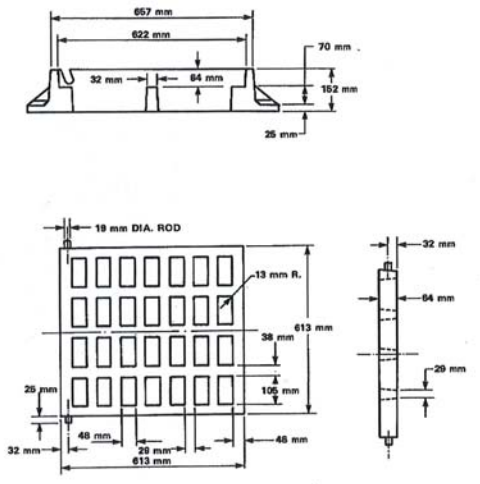
Data for Grate Honeycomb inlet Capacity Curves (on Grade)

Crossfall (m/m)	Flow Depth (m)	Inlet Capture Flow Rate Q (m^3/s)							
		Longitudinal Slopes (m/m)							
		0.003	0.01	0.02	0.03	0.04	0.06	0.08	0.1
0.02	0.065	0.0095	0.0099	0.0048	0.0000	0.0000	0.0000	0.0000	0.0000
	0.07	0.0123	0.0180	0.0164	0.0120	0.0000	0.0000	0.0000	0.0000
	0.08	0.0177	0.0304	0.0335	0.0323	0.0299	0.0199	0.0035	0.0002
	0.09	0.0247	0.0423	0.0496	0.0511	0.0513	0.0406	0.0272	0.0059
	0.1	0.0334	0.0555	0.0667	0.0689	0.0676	0.0578	0.0399	0.0229
	0.104	0.0374	0.0614	0.0735	0.0763	0.0746	0.0637	0.0440	0.0254
	0.11	0.0439	0.0709	0.0845	0.0874	0.0855	0.0730	0.0505	0.0293
0.04	0.08	0.0179	0.0199	0.0125	0.0000	0.0000	0.0000	0.0000	0.0000
	0.09	0.0252	0.0350	0.0317	0.0214	0.0001	0.0001	0.0001	0.0001
	0.11	0.0430	0.0676	0.0662	0.0575	0.0425	0.0010	0.0009	0.0008
	0.13	0.0659	0.1016	0.1009	0.0906	0.0738	0.0121	0.0027	0.0024
	0.15	0.0941	0.1395	0.1373	0.1225	0.0905	0.0059	0.0053	0.0048
0.06	0.095	0.0281	0.0308	0.0174	0.0000	0.0000	0.0000	0.0000	0.0000
	0.11	0.0422	0.0536	0.0433	0.0161	0.0003	0.0002	0.0002	0.0002
	0.14	0.0773	0.1039	0.0925	0.0597	0.0023	0.0020	0.0018	0.0016
0.08	0.11	0.0384	0.0398	0.0146	0.0000	0.0000	0.0000	0.0000	0.0000
	0.13	0.0627	0.0684	0.0420	0.0005	0.0004	0.0004	0.0003	0.0003

Notes: Capture rates derived from formula: Qi = Q(RfE0+Rs(1-E0). Here Q is gutter flow, Rf is the frontal-flow interception efficiency, Rs is a side- flow ration and E0 is the frontal-flow ration for a straight cross-slope

Grate KWC Inlet Capacity Evaluation

Curb & Gutter: Type B



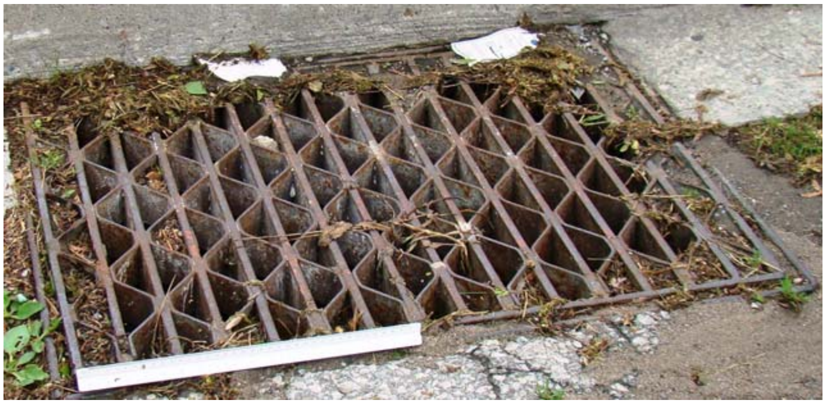
Data for Grate KWC inlet Capacity Curves (on Grade)

Crossfall (m/m)	Flow Depth (m)	Inlet Capture Flow Rate Q (m^3/s)							
		Longitudinal Slopes (m/m)							
		0.003	0.01	0.02	0.03	0.04	0.06	0.08	0.1
0.02	0.06	0.0033	0.0069	0.0092	0.0101	0.0098	0.0083	0.0067	0.0047
	0.065	0.0057	0.0096	0.0124	0.013	0.0129	0.0117	0.0098	0.0073
	0.07	0.0081	0.0122	0.0153	0.0162	0.0159	0.0147	0.0128	0.0106
	0.08	0.0121	0.0174	0.0213	0.0227	0.023	0.0222	0.0203	0.0169
	0.09	0.0191	0.0254	0.0303	0.0328	0.0337	0.0334	0.0309	0.0266
	0.1	0.0268	0.0343	0.0391	0.041	0.0413	0.0398	0.0364	0.0316
	0.104	0.033	0.0398	0.044	0.0454	0.0458	0.0436	0.04	0.0356
	0.11	0.0392	0.0472	0.0513	0.0523	0.0523	0.0489	0.0447	0.0401
0.04	0.07	0.0066	0.0124	0.0167	0.0188	0.0201	0.0198	0.0174	0.0136
	0.08	0.011	0.0178	0.0231	0.0257	0.0269	0.0269	0.0248	0.0211
	0.09	0.0153	0.0241	0.0294	0.0323	0.0336	0.0338	0.0322	0.0286
	0.11	0.0274	0.0365	0.0421	0.0451	0.0471	0.0478	0.0456	0.0411
	0.13	0.0461	0.0537	0.0587	0.0608	0.061	0.0599	0.0566	0.0517
	0.15	0.0658	0.0737	0.076	0.0751	0.0738	0.0702	0.0656	0.0597
0.06	0.08	0.0125	0.0174	0.0211	0.0231	0.024	0.0238	0.0216	0.0177
	0.095	0.0175	0.0251	0.0306	0.0331	0.0343	0.0337	0.0306	0.0254
	0.11	0.0254	0.0355	0.0413	0.0438	0.0451	0.043	0.0388	0.0331
	0.14	0.043	0.0537	0.0597	0.0621	0.0622	0.0588	0.0527	0.0448
0.08	0.09	0.0141	0.0214	0.0262	0.0278	0.028	0.0274	0.0263	0.0186
	0.11	0.0232	0.0322	0.0384	0.0411	0.0417	0.0398	0.0354	0.0291
	0.13	0.0348	0.0453	0.0522	0.0556	0.0561	0.0522	0.0464	0.0388

Notes: Capture rates derived from laboratory testing of full experimental roadway at the National Water Research Institute Canada Centre for Inland Waters

Grate New Honeycomb Inlet Capacity Evaluation

Curb & Gutter: Type B



Size: 0.69m x 0.61m

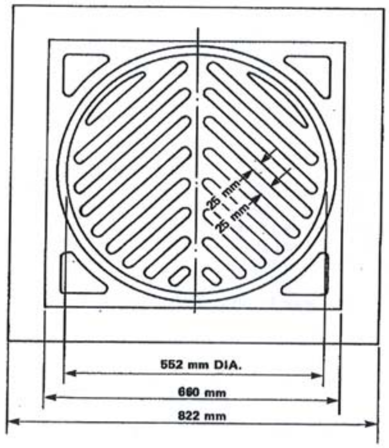
Data for Grate New Honeycomb inlet Capacity Curves (on Grade)

Crossfall (m/m)	Flow Depth (m)	Inlet Capture Flow Rate Q (m^3/s)							
		Longitudinal Slopes (m/m)							
		0.003	0.01	0.02	0.03	0.04	0.06	0.08	0.1
0.02	0.065	0.0087	0.0082	0.0020	0.0000	0.0000	0.0000	0.0000	0.0000
	0.07	0.0120	0.0157	0.0129	0.0083	0.0005	0.0001	0.0001	0.0001
	0.08	0.0174	0.0272	0.0294	0.0271	0.0241	0.0120	0.0036	0.0004
	0.09	0.0248	0.0397	0.0434	0.0426	0.0402	0.0298	0.0144	0.0062
	0.1	0.0343	0.0532	0.0593	0.0591	0.0550	0.0439	0.0284	0.0048
	0.104	0.0386	0.0591	0.0657	0.0656	0.0613	0.0491	0.0318	0.0062
	0.11	0.0457	0.0686	0.0757	0.0753	0.0701	0.0563	0.0366	0.0077
0.04	0.08	0.0166	0.0179	0.0092	0.0000	0.0000	0.0000	0.0000	0.0000
	0.09	0.0249	0.0308	0.0261	0.0134	0.0003	0.0002	0.0002	0.0002
	0.11	0.0428	0.0597	0.0565	0.0463	0.0286	0.0018	0.0016	0.0015
	0.13	0.0667	0.0903	0.0874	0.0729	0.0503	0.0051	0.0046	0.0042
	0.15	0.0968	0.1267	0.1191	0.0973	0.0657	0.0098	0.0088	0.0081
0.06	0.095	0.0252	0.0265	0.0094	0.0000	0.0000	0.0000	0.0000	0.0000
	0.11	0.0405	0.0468	0.0321	0.0034	0.0006	0.0005	0.0004	0.0004
	0.14	0.0770	0.0921	0.0729	0.0351	0.0041	0.0036	0.0032	0.0030
0.08	0.11	0.0354	0.0323	0.0026	0.0001	0.0001	0.0001	0.0001	0.0000
	0.13	0.0566	0.0597	0.0431	0.0010	0.0009	0.0008	0.0007	0.0007

Notes: Capture rates derived from formula: Qi = Q(RfE0+Rs(1-E0). Here Q is gutter flow, Rf is the frontal-flow interception efficiency, Rs is a side- flow ration and E0 is the frontal-flow ration for a straight cross-slope

Grate Round Frame Inlet Capacity Evaluation

Curb & Gutter: Type B



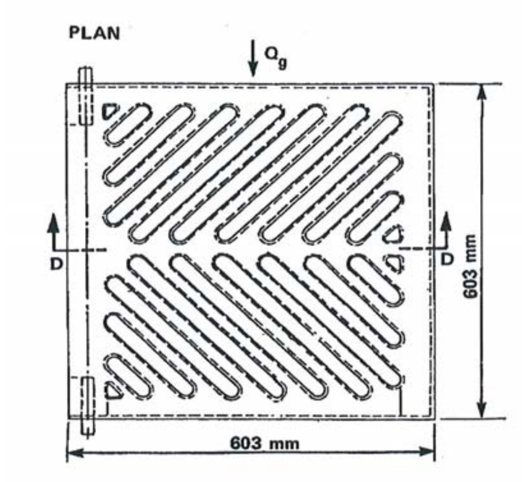
Data for Grate Round Frame inlet Capacity Curves (on Grade)

Crossfall (m/m)	Flow Depth (m)	Inlet Capture Flow Rate Q (m^3/s)							
		Longitudinal Slopes (m/m)							
		0.003	0.01	0.02	0.03	0.04	0.06	0.08	0.1
0.02	0.06	0.0042	0.0062	0.0078	0.0083	0.0081	0.0081	0.0076	0.0067
	0.065	0.0071	0.0098	0.0114	0.0125	0.0124	0.0122	0.0116	0.0095
	0.07	0.0093	0.0122	0.0146	0.0157	0.0156	0.0151	0.0141	0.0120
	0.08	0.0118	0.0192	0.0228	0.0236	0.0234	0.0224	0.0206	0.0177
	0.09	0.0206	0.0301	0.0321	0.0325	0.0307	0.0284	0.0256	0.0226
	0.1	0.0308	0.0392	0.0416	0.0407	0.0380	0.0348	0.0311	0.0272
	0.104	0.0328	0.0425	0.0446	0.0431	0.0404	0.0372	0.0333	0.0287
	0.11	0.0378	0.0467	0.0484	0.0464	0.0433	0.0393	0.0355	0.0314
0.04	0.07	0.0062	0.0107	0.0136	0.0146	0.0151	0.0155	0.0142	0.0117
	0.08	0.0109	0.0179	0.0218	0.0228	0.0221	0.0211	0.0186	0.0155
	0.09	0.0140	0.0230	0.0276	0.0288	0.0279	0.0271	0.0242	0.0208
	0.11	0.0248	0.0392	0.0430	0.0426	0.0403	0.0364	0.0317	0.0275
	0.13	0.0378	0.0546	0.0558	0.0531	0.0496	0.0454	0.0406	0.0350
	0.15	0.0518	0.0660	0.0645	0.0605	0.0558	0.0497	0.0440	0.0396
0.06	0.08	0.0086	0.0131	0.0168	0.0182	0.0185	0.0182	0.0182	0.0166
	0.095	0.0167	0.0238	0.0262	0.0270	0.0275	0.0276	0.0266	0.0238
	0.11	0.0272	0.0358	0.0383	0.0388	0.0377	0.0361	0.0329	0.0280
	0.14	0.0431	0.0528	0.0550	0.0534	0.0508	0.0463	0.0407	0.0344
0.08	0.09	0.0118	0.0196	0.0236	0.0242	0.0245	0.0244	0.0230	0.0209
	0.11	0.0244	0.0319	0.0338	0.0342	0.0342	0.0348	0.0339	0.0315
	0.13	0.0341	0.0428	0.0374	0.0457	0.0443	0.0443	0.0433	0.0409

Notes: Capture rates derived from laboratory testing of full experimental roadway at the National Water Research Institute Canada Centre for Inland Waters

Grate DD-705 Inlet Capacity Evaluation

Curb & Gutter: Type B



Data for Grate DD-705 inlet Capacity Curves (on Sag)

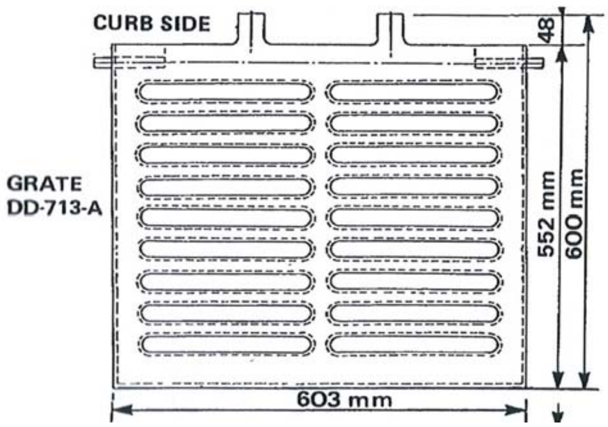
Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0004
0.02	0.0017
0.03	0.004
0.04	0.007
0.05	0.011
0.06	0.0171
0.07	0.025
0.08	0.0347
0.09	0.0464
0.1	0.06
0.11	0.0726
0.12	0.0853
0.13	0.0971
0.14	0.1082
0.15	0.1184
0.16	0.1278
0.17	0.1363
0.18	0.1441
0.19	0.151
0.2	0.1569
0.22	0.1671
0.24	0.1768
0.26	0.186
0.28	0.1946
0.3	0.2027

Notes: Capture rates derived from laboratory testing of full experimental roadway at the National Water Research Institute

Canada Centre for Inland Waters

Grate DD-713-A Inlet Capacity Evaluation

Curb & Gutter: Type B



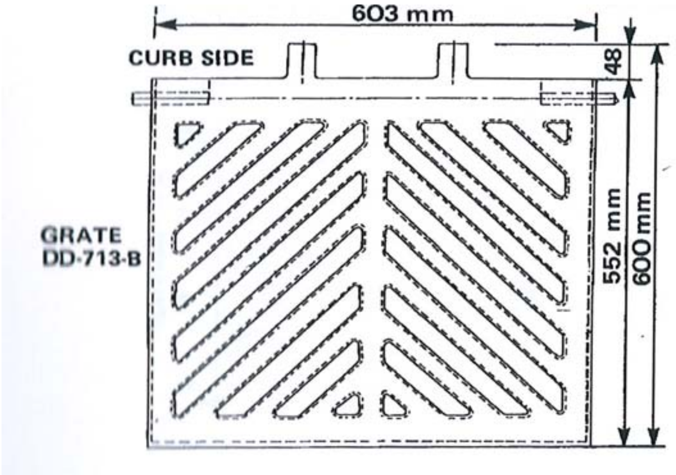
Data for Grate DD-713-A inlet Capacity Curves (on Sag)

Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0004
0.02	0.0017
0.03	0.004
0.04	0.007
0.05	0.011
0.06	0.0171
0.07	0.025
0.08	0.0347
0.09	0.0464
0.1	0.06
0.11	0.0726
0.12	0.0853
0.13	0.0971
0.14	0.1082
0.15	0.1184
0.16	0.1278
0.17	0.1363
0.18	0.1441
0.19	0.151
0.2	0.1569
0.22	0.1671
0.24	0.1768
0.26	0.186
0.28	0.1946
0.3	0.2027

Notes: Capture rates derived from laboratory testing of full experimental roadway at the National Water Research Institute
Canada Centre for Inland Waters

Grate DD-713-B Inlet Capacity Evaluation

Curb & Gutter: Type B



Data for Grate DD-713-B inlet Capacity Curves (on Sag)

Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0004
0.02	0.0017
0.03	0.004
0.04	0.007
0.05	0.011
0.06	0.0171
0.07	0.025
0.08	0.0347
0.09	0.0464
0.1	0.06
0.11	0.0726
0.12	0.0853
0.13	0.0971
0.14	0.1082
0.15	0.1184
0.16	0.1278
0.17	0.1363
0.18	0.1441
0.19	0.151
0.2	0.1569
0.22	0.1671
0.24	0.1768
0.26	0.186
0.28	0.1946
0.3	0.2027

Notes: Capture rates derived from laboratory testing of full experimental roadway at the National Water Research Institute

Canada Centre for Inland Waters

Grate Honeycomb Inlet Capacity Evaluation

Curb & Gutter: Type B

Size: 0.84m x 0.66m

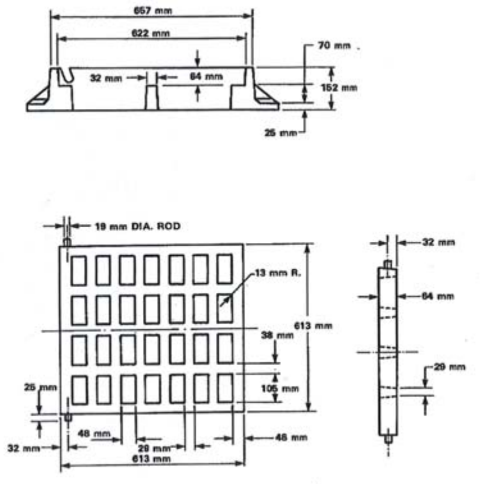
Data for Grate Honeycomb inlet Capacity Curves (on Sag)

Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0036
0.02	0.0101
0.03	0.0186
0.04	0.0287
0.05	0.0401
0.06	0.0527
0.07	0.0664
0.08	0.0811
0.09	0.0968
0.1	0.1134
0.11	0.1308
0.12	0.1491
0.13	0.1681
0.14	0.1878
0.15	0.2083
0.16	0.2295
0.17	0.2513
0.18	0.2738
0.19	0.2970
0.2	0.3207
0.22	0.3700
0.24	0.4216
0.26	0.4754
0.28	0.5312
0.3	0.5892

Notes: Capture rates derived from formula: Qi =CPd1.5 . Here Qi is inlete capture rate, C is the weir coefficient, P is grate perimeter, and d is the depth of water over the inlet.

Grate KWC Inlet Capacity Evaluation

Curb & Gutter: Type B



Data for Grate KWC inlet Capacity Curves (on Sag)

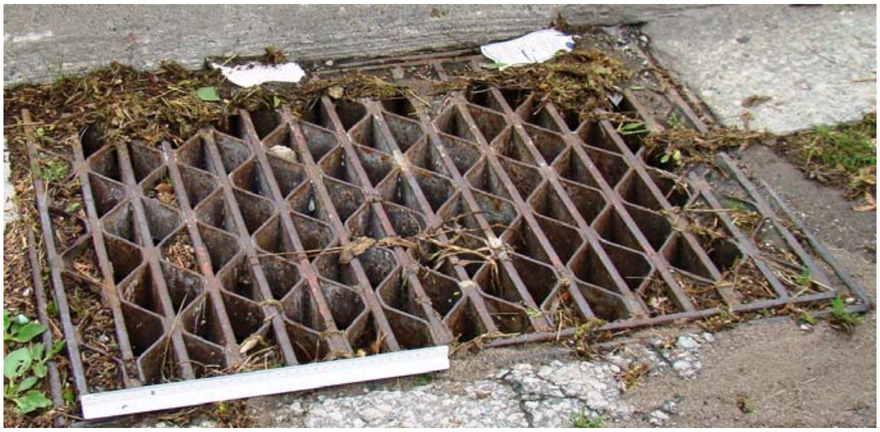
Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0004
0.02	0.0017
0.03	0.004
0.04	0.007
0.05	0.011
0.06	0.0171
0.07	0.025
0.08	0.0347
0.09	0.0464
0.1	0.06
0.11	0.0726
0.12	0.0855
0.13	0.0975
0.14	0.109
0.15	0.122
0.16	0.1337
0.17	0.1444
0.18	0.1544
0.19	0.1638
0.2	0.1725
0.22	0.1891
0.24	0.2031
0.26	0.2151
0.28	0.2255
0.3	0.234

Notes: Capture rates derived from laboratory testing of full experimental roadway at the National Water Research Institute

Canada Centre for Inland Waters

Grate New Honeycomb Inlet Capacity Evaluation

Curb & Gutter: Type B



Size: 0.69m x 0.61m

Data for Grate New Honeycomb inlet Capacity Curves (on Sag)

Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0032
0.02	0.0090
0.03	0.0165
0.04	0.0254
0.05	0.0354
0.06	0.0466
0.07	0.0587
0.08	0.0717
0.09	0.0856
0.1	0.1003
0.11	0.1157
0.12	0.1318
0.13	0.1486
0.14	0.1661
0.15	0.1842
0.16	0.2029
0.17	0.2222
0.18	0.2421
0.19	0.2626
0.2	0.2836
0.22	0.3272
0.24	0.3728
0.26	0.4203
0.28	0.4698
0.3	0.5210

Notes: Capture rates derived from formula: $Qi = CPd^{1.5}$. Here Qi is inlete capture rate, C is the weir coefficient, P is grate perimeter, and d is the depth of water over the inlet.

Grate Round - Arc- Frame Inlet Capacity Evaluation

Curb & Gutter: Type B

Size: 0.60m x 0.60m

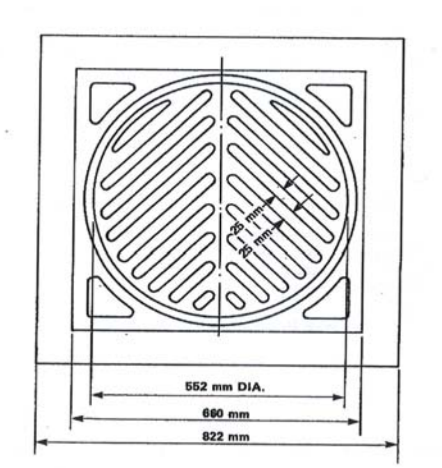
Data for Round- Arc Frame inlet Capacity Curves (on Sag)

Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0374
0.02	0.0529
0.03	0.0648
0.04	0.0748
0.05	0.0836
0.06	0.0916
0.07	0.0989
0.08	0.1058
0.09	0.1122
0.1	0.1182
0.11	0.1240
0.12	0.1295
0.13	0.1348
0.14	0.1399
0.15	0.1448
0.16	0.1496
0.17	0.1542
0.18	0.1586
0.19	0.1630
0.2	0.1672
0.22	0.1754
0.24	0.1832
0.26	0.1907
0.28	0.1979
0.3	0.2048

Notes: Qcapture = C_0 A $(2gd)^{0.5}$, Here, C0= 1.66, A=0.126(opening area), g=9.81m3/s, d= depth of water

Grate Round Frame Inlet Capacity Evaluation

Curb & Gutter: Type B



Data for Grate Round Frame inlet Capacity Curves (on Sag)

Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0004
0.02	0.0016
0.03	0.0038
0.04	0.0066
0.05	0.0103
0.06	0.0161
0.07	0.0235
0.08	0.0326
0.09	0.0436
0.1	0.0564
0.11	0.0682
0.12	0.0802
0.13	0.0913
0.14	0.1017
0.15	0.1113
0.16	0.1201
0.17	0.1281
0.18	0.1355
0.19	0.1419
0.2	0.1475
0.22	0.1571
0.24	0.1662
0.26	0.1748
0.28	0.1829
0.3	0.1905

Notes: Qcapture = Ks x Capture rates of DD-713-B, which derived from laboratory testing of full experimental roadway at the National Water Research Institute Canada Centre for Inland Waters. Ks = 0.94

Grate Small Grid Inlet Capacity Evaluation

Curb & Gutter: Type B

Size: 0.25m x 0.25m

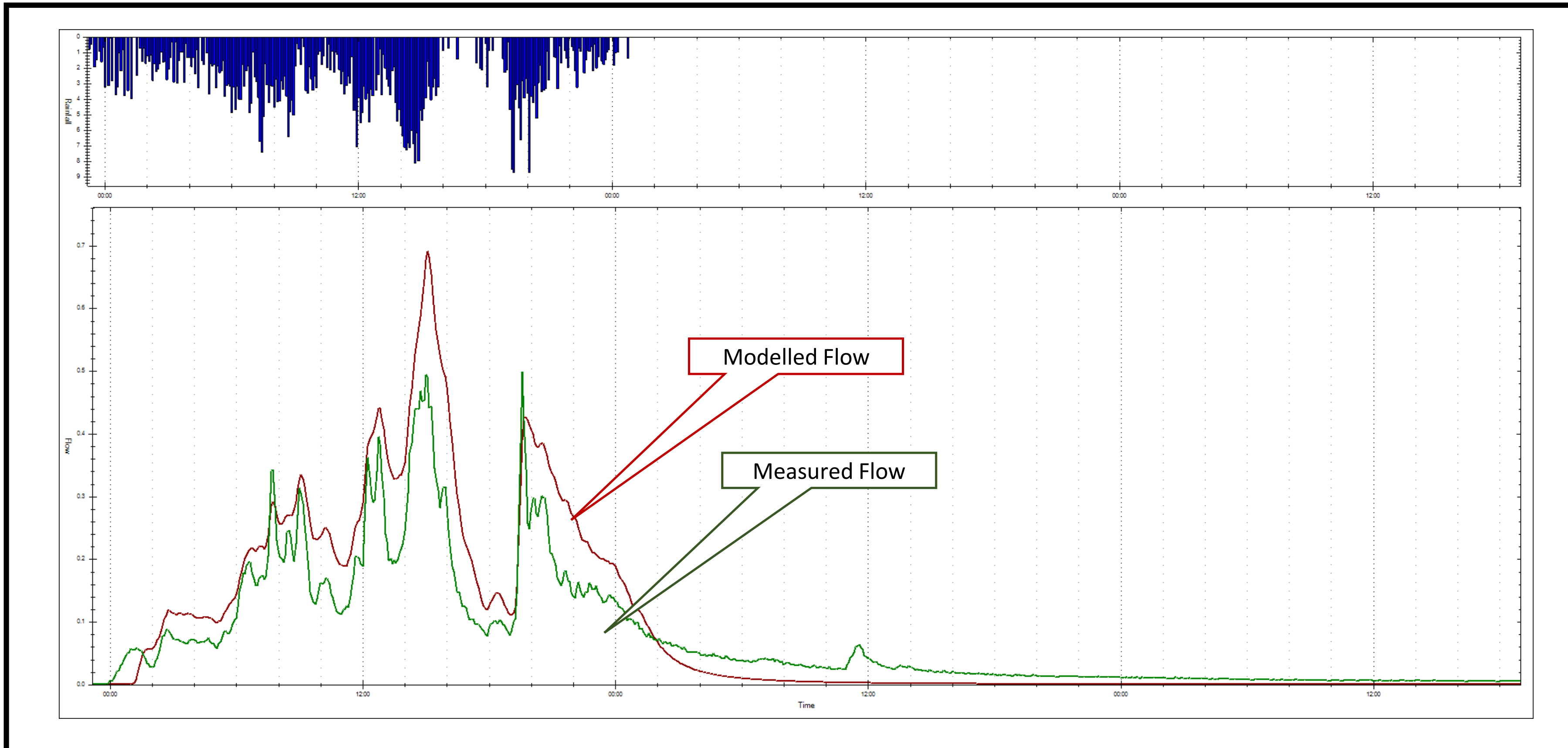
Data for Small Grid inlet Capacity Curves (on Sag)

Depth of Ponding (m)	Inlet Capacity (m^3/s)
0	0
0.01	0.0001
0.02	0.0003
0.03	0.0007
0.04	0.0012
0.05	0.0018
0.06	0.0284
0.07	0.0042
0.08	0.0058
0.09	0.0077
0.1	0.0100
0.11	0.0121
0.12	0.0142
0.13	0.0162
0.14	0.0181
0.15	0.0203
0.16	0.0222
0.17	0.0240
0.18	0.0256
0.19	0.0272
0.2	0.0286
0.22	0.0314
0.24	0.0337
0.26	0.0357
0.28	0.0374
0.3	0.0388

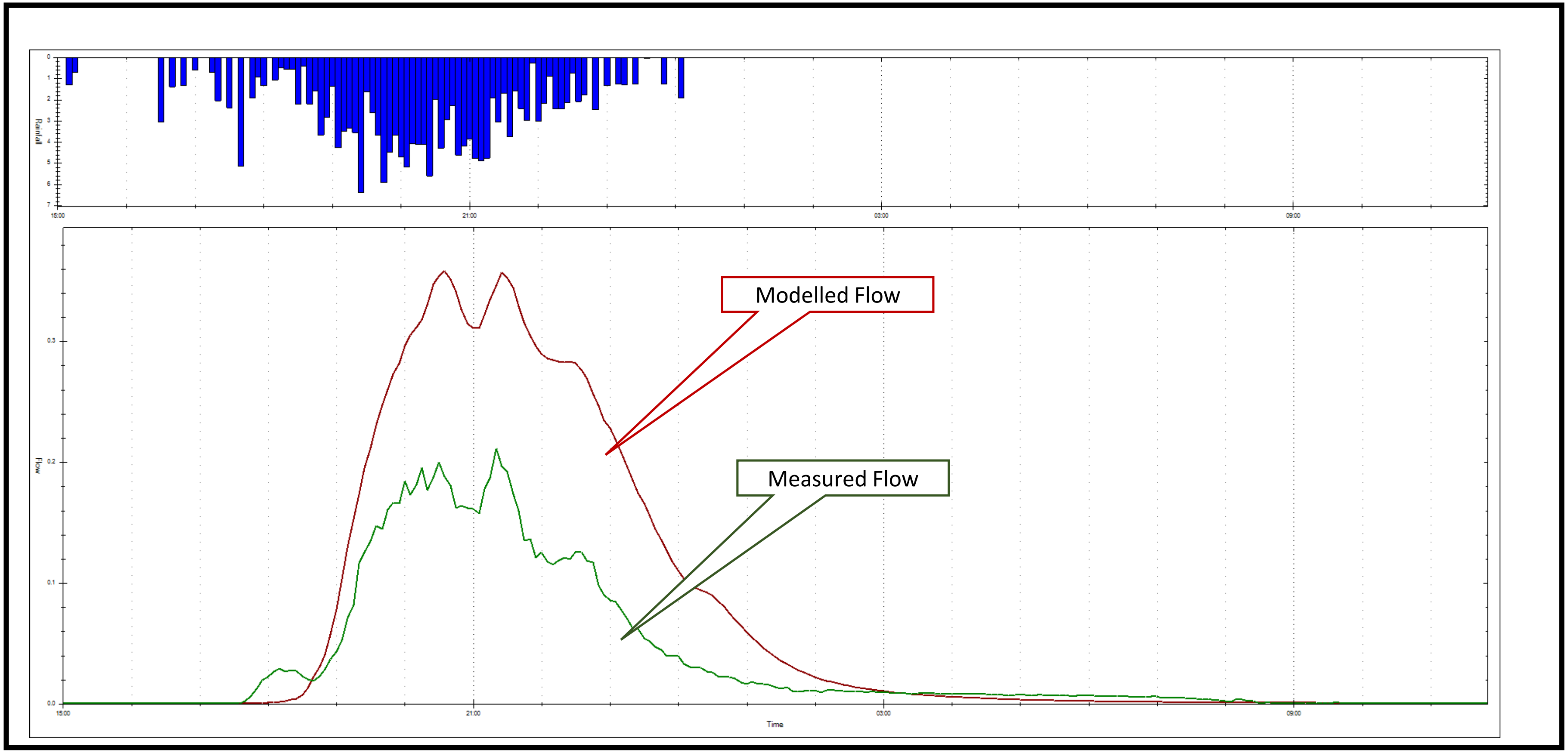
Notes: Qcapture = Ks x Capture rates of KWC, which derived from laboratory testing of full experimental roadway at the National Water Research Institute Canada Centre for Inland Waters. Ks = 0.166

APPENDIX G
Model Calibration

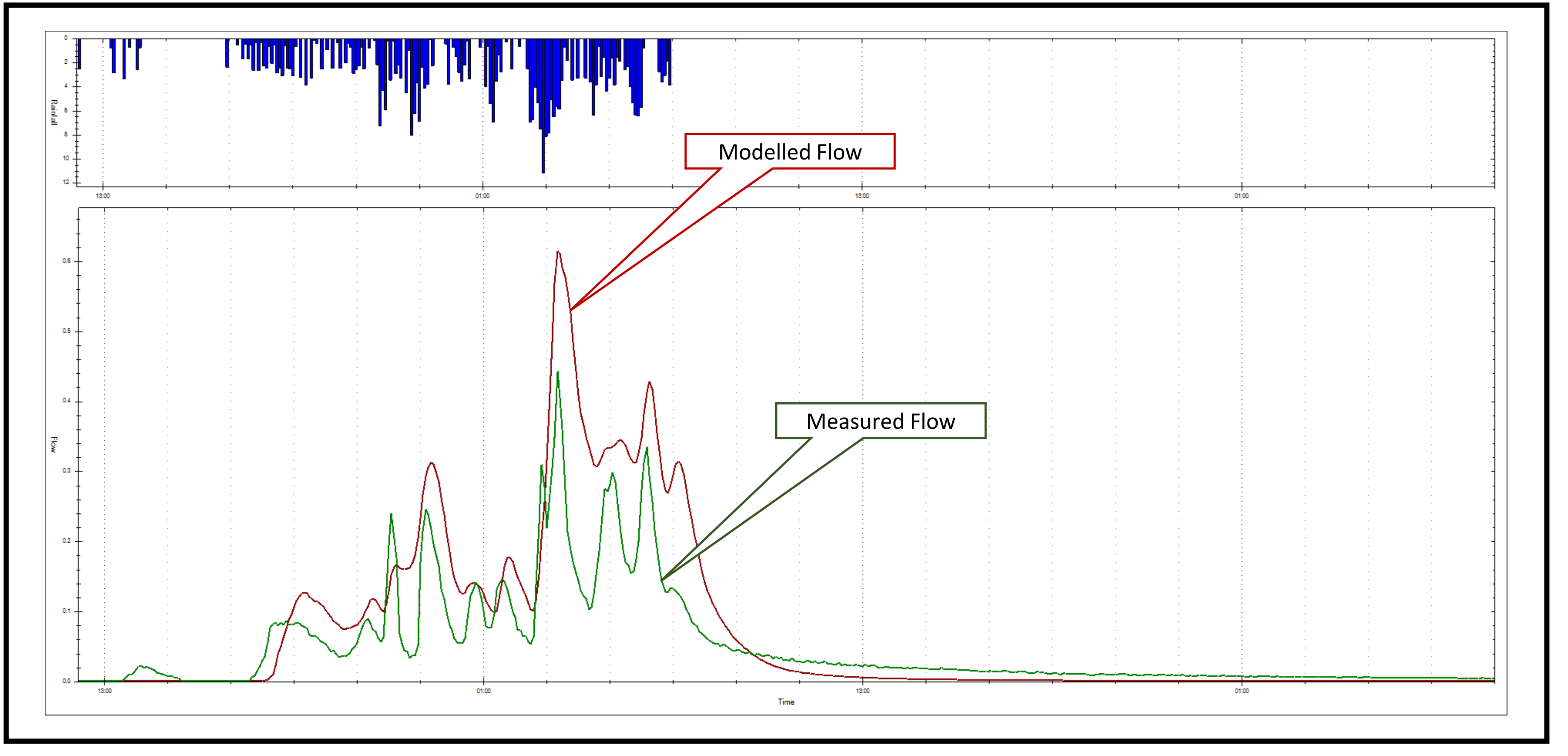
Flow Gauge 1: November 29, 2011



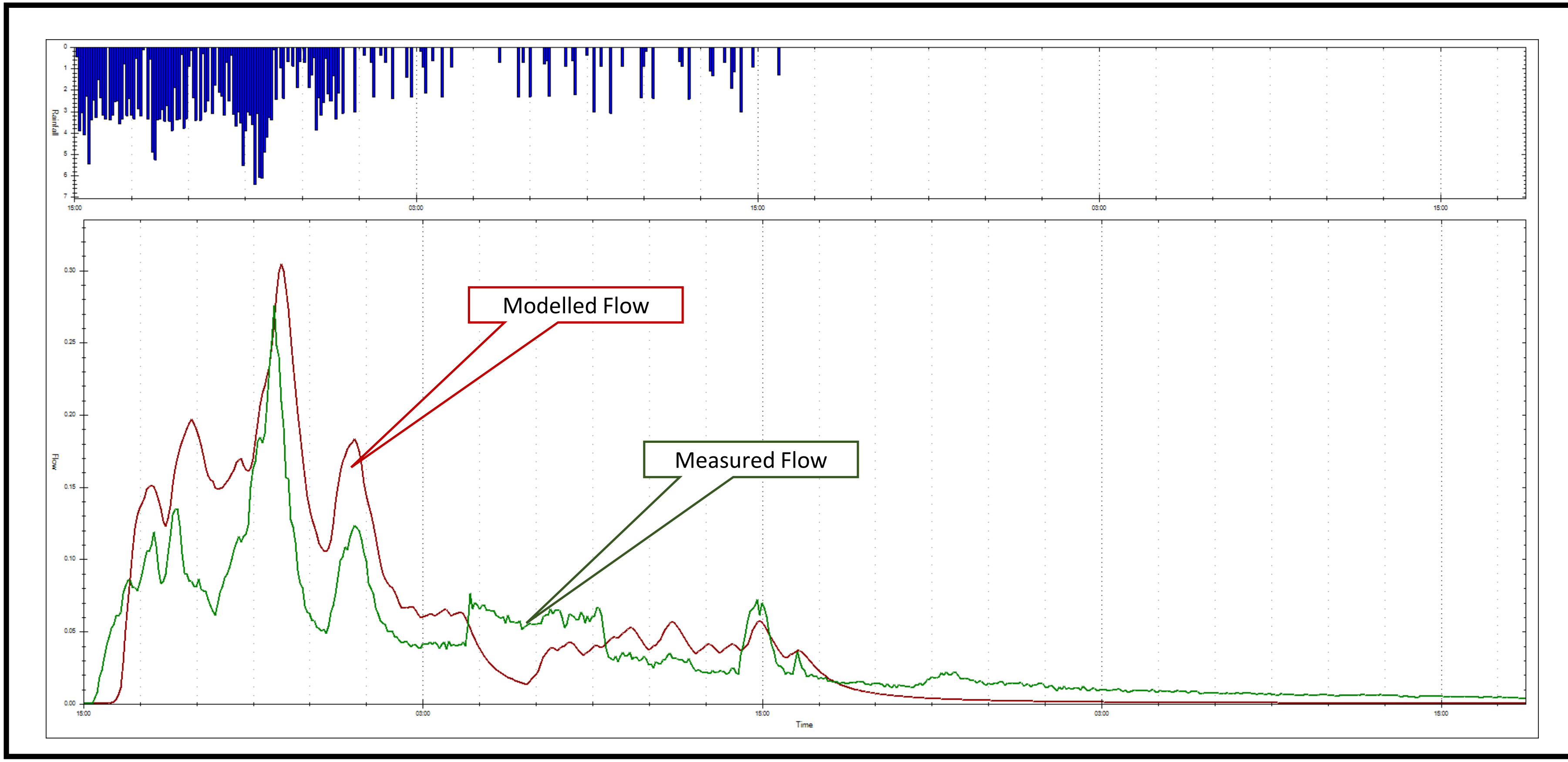
Flow Gauge 1: October 12, 2011



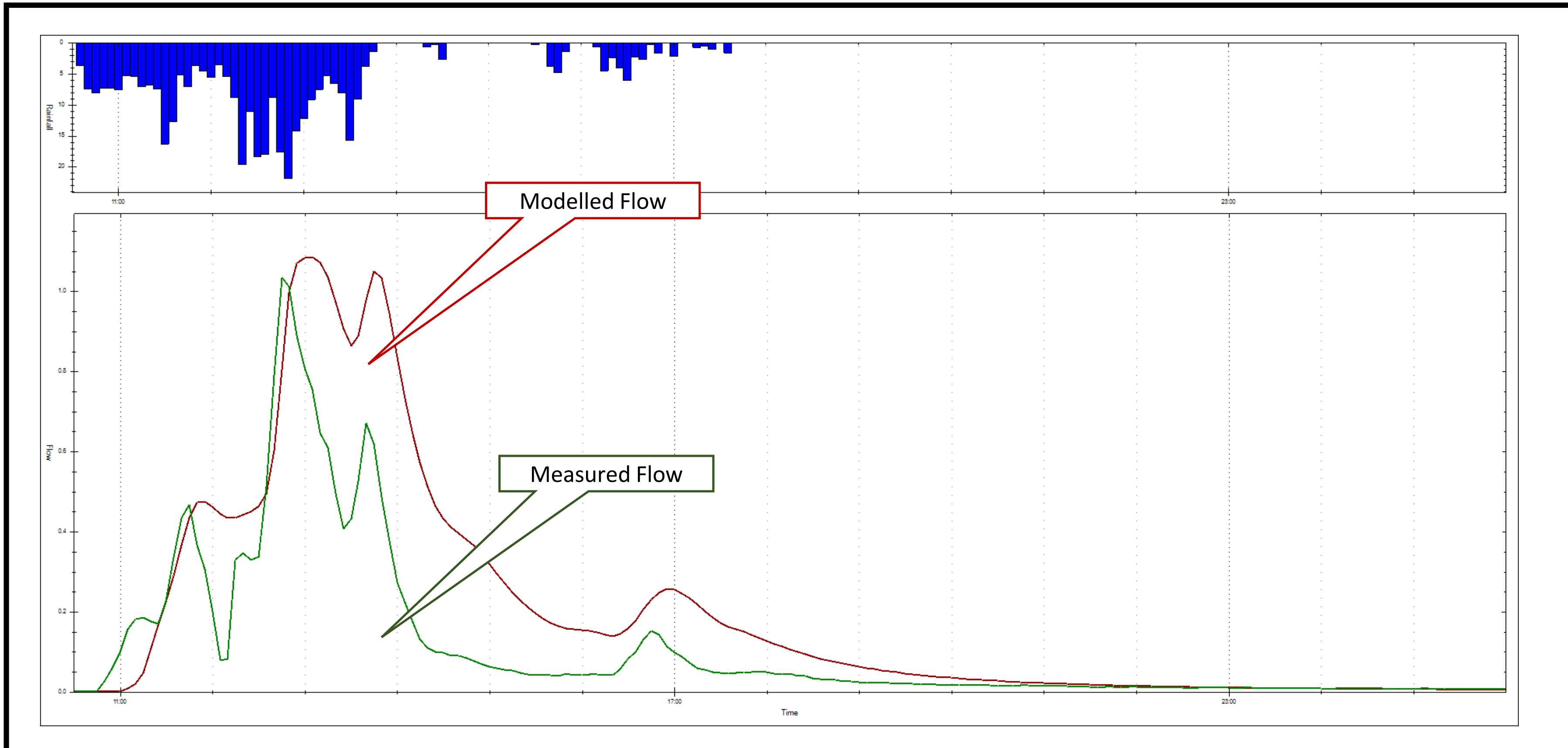
Flow Gauge 1: October 19, 2011



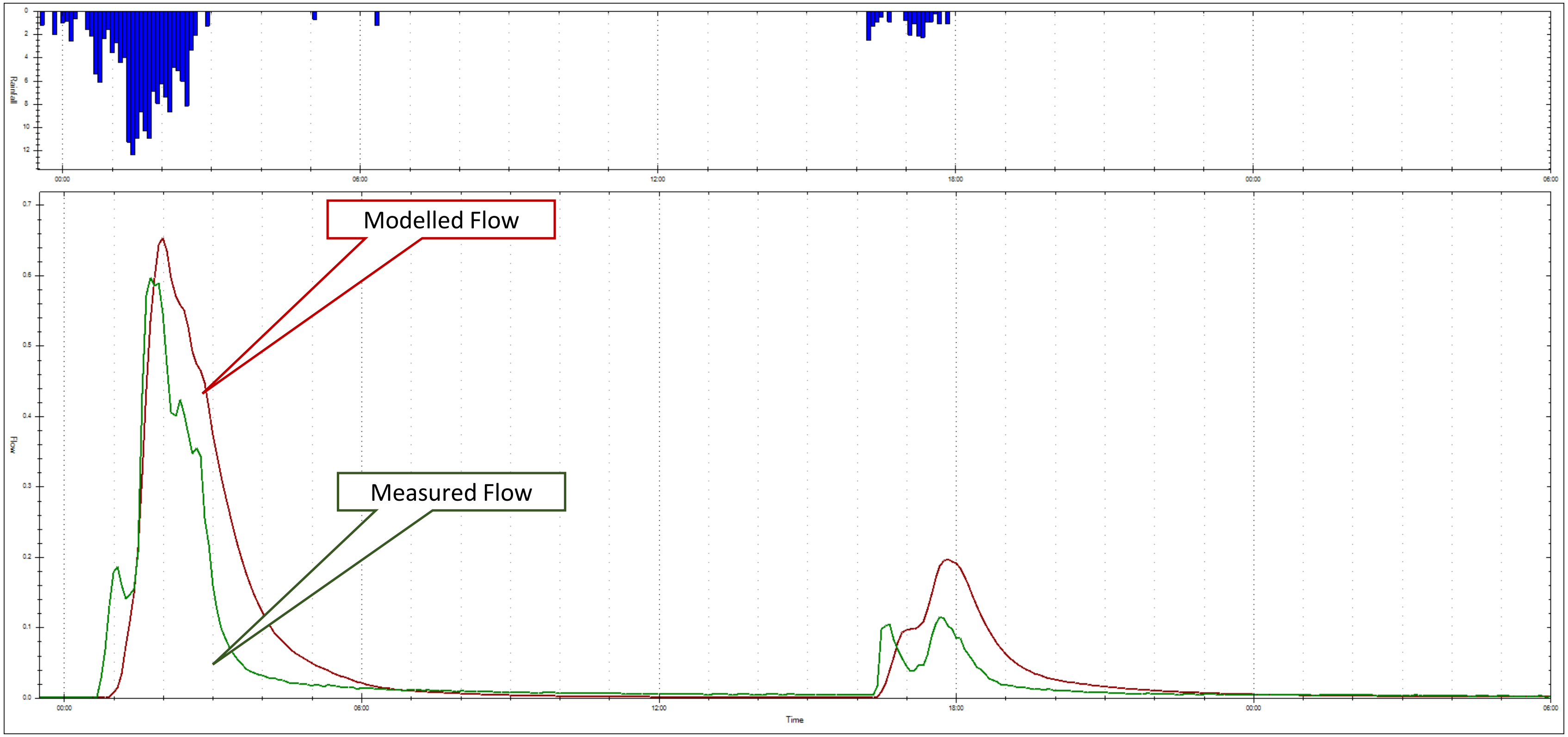
Flow Gauge 1: October 25, 2011



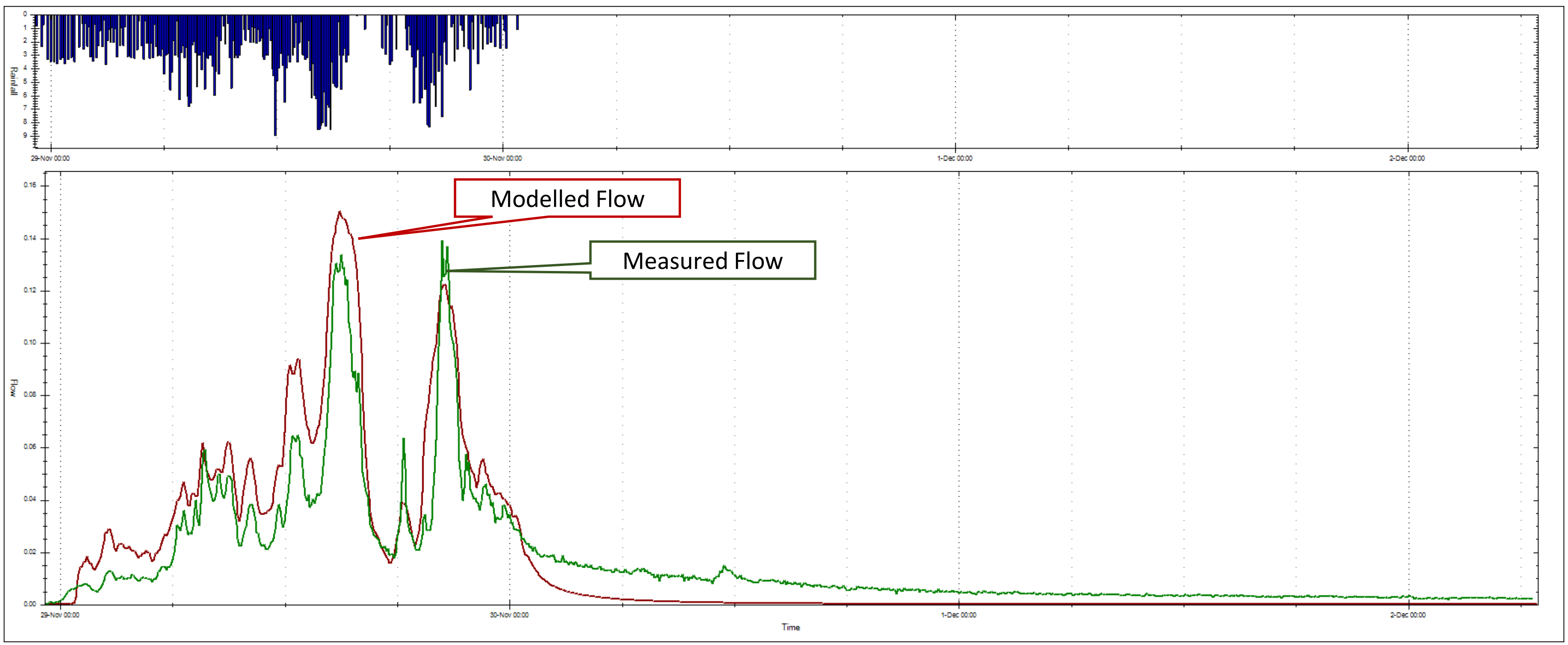
Flow Gauge 1: September 23, 2011



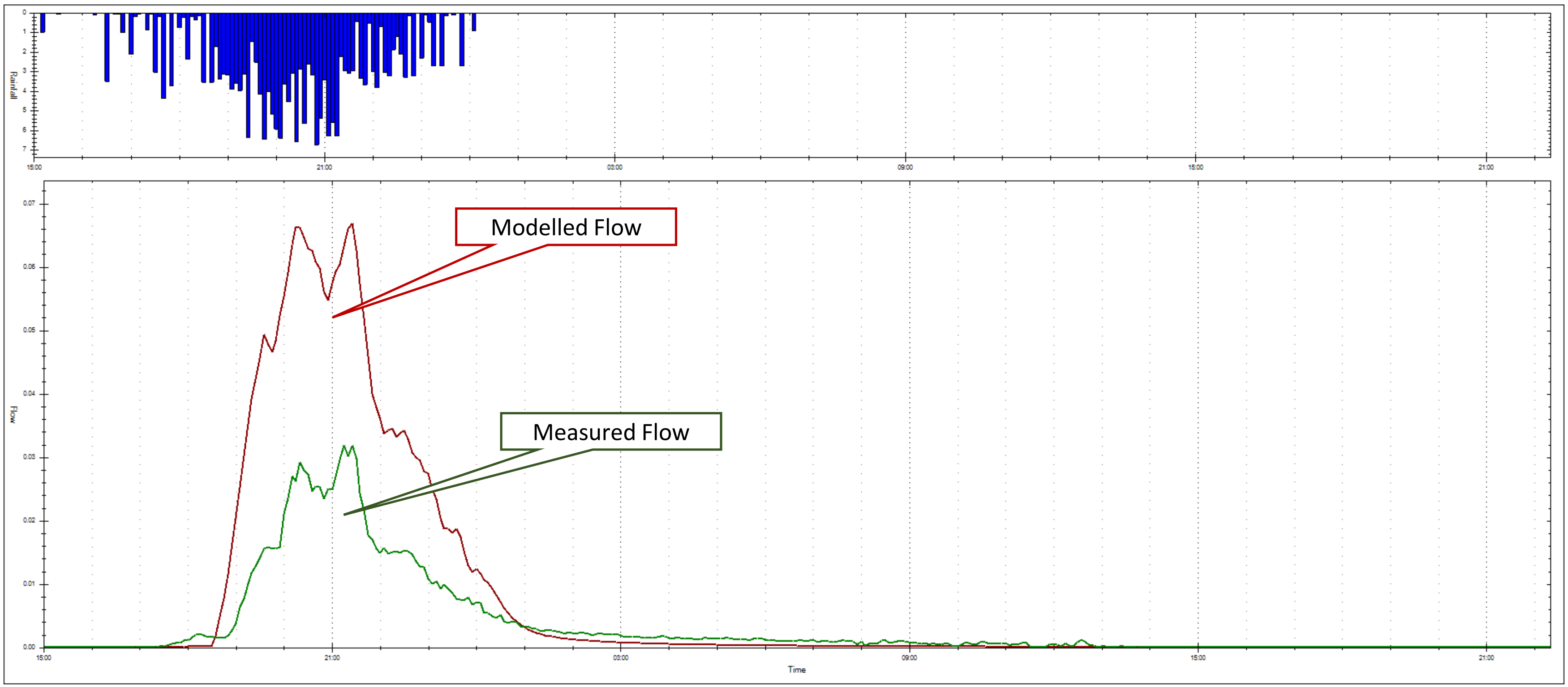
Flow Gauge 1: September 29, 2011



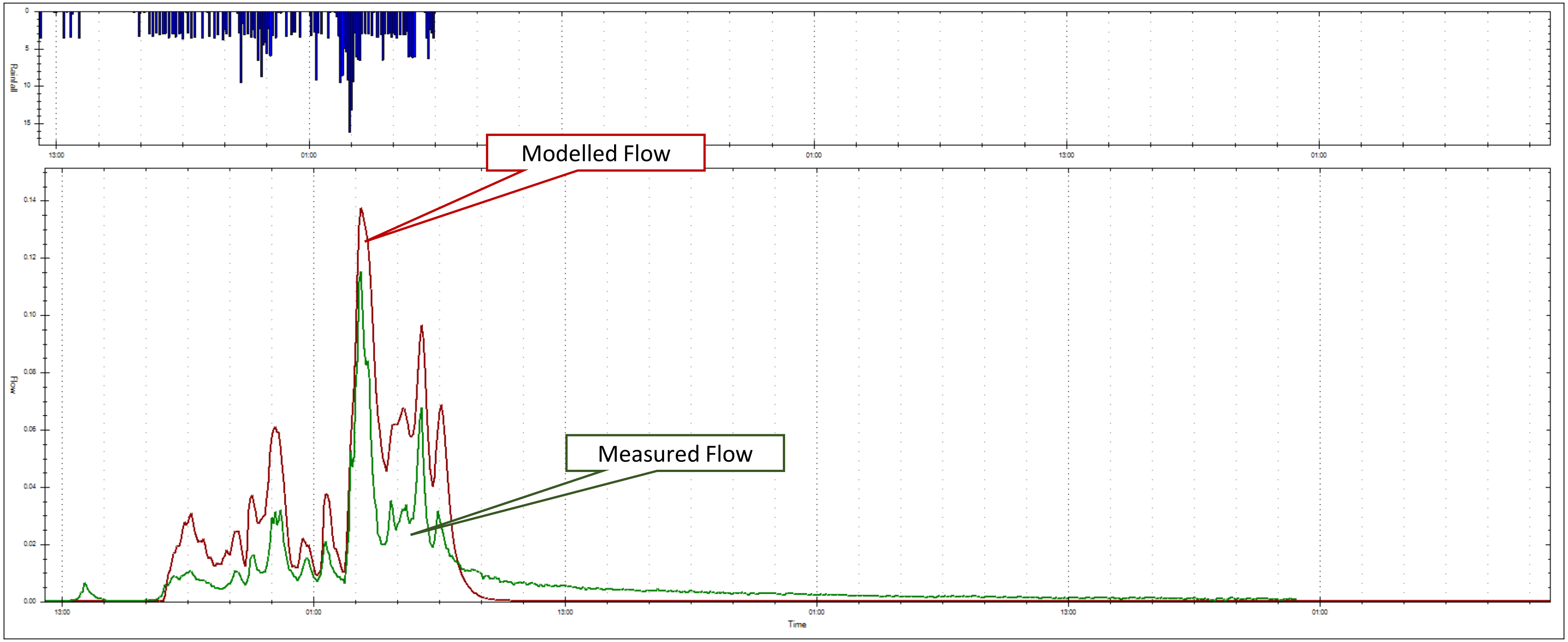
Flow Gauge 2: November 29, 2011



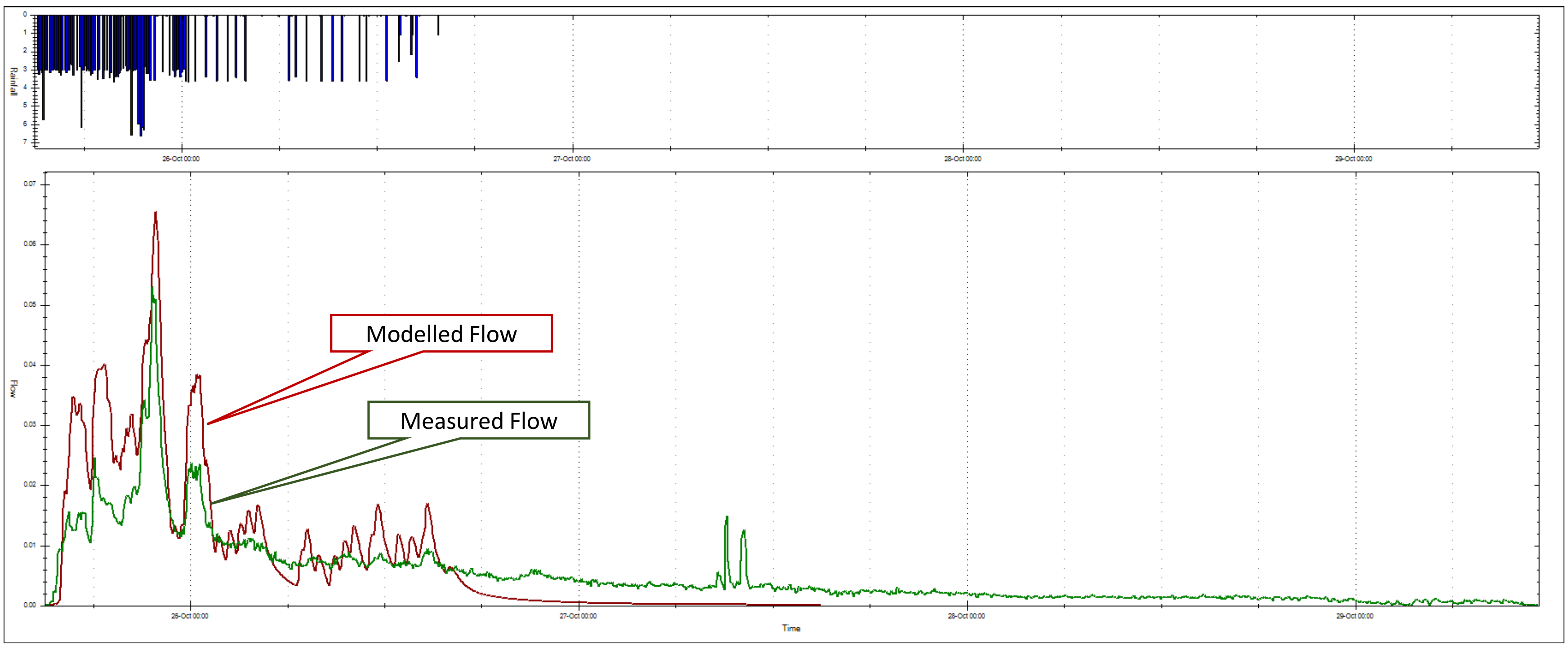
Flow Gauge 2: October 12, 2011



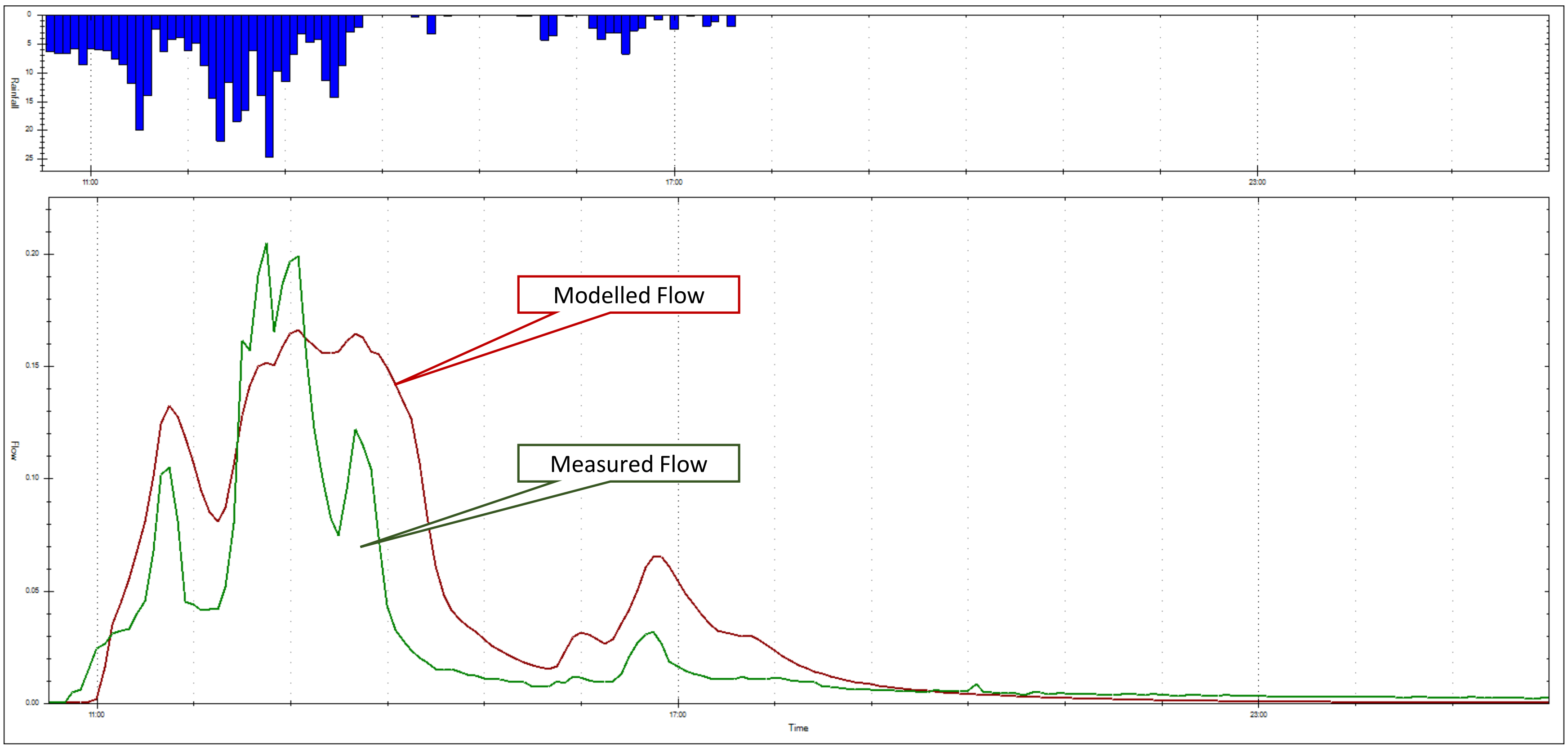
Flow Gauge 2: October 19, 2011



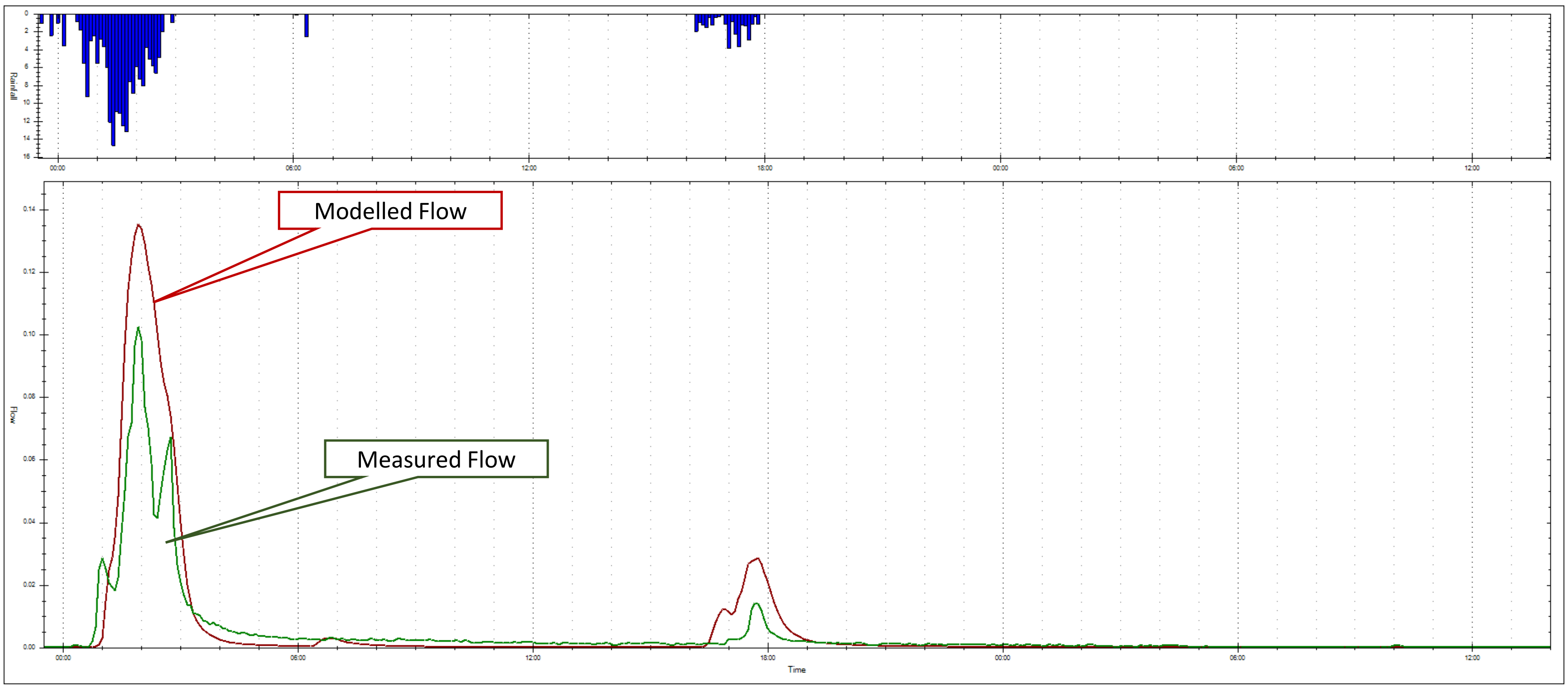
Flow Gauge 2: October 25, 2011



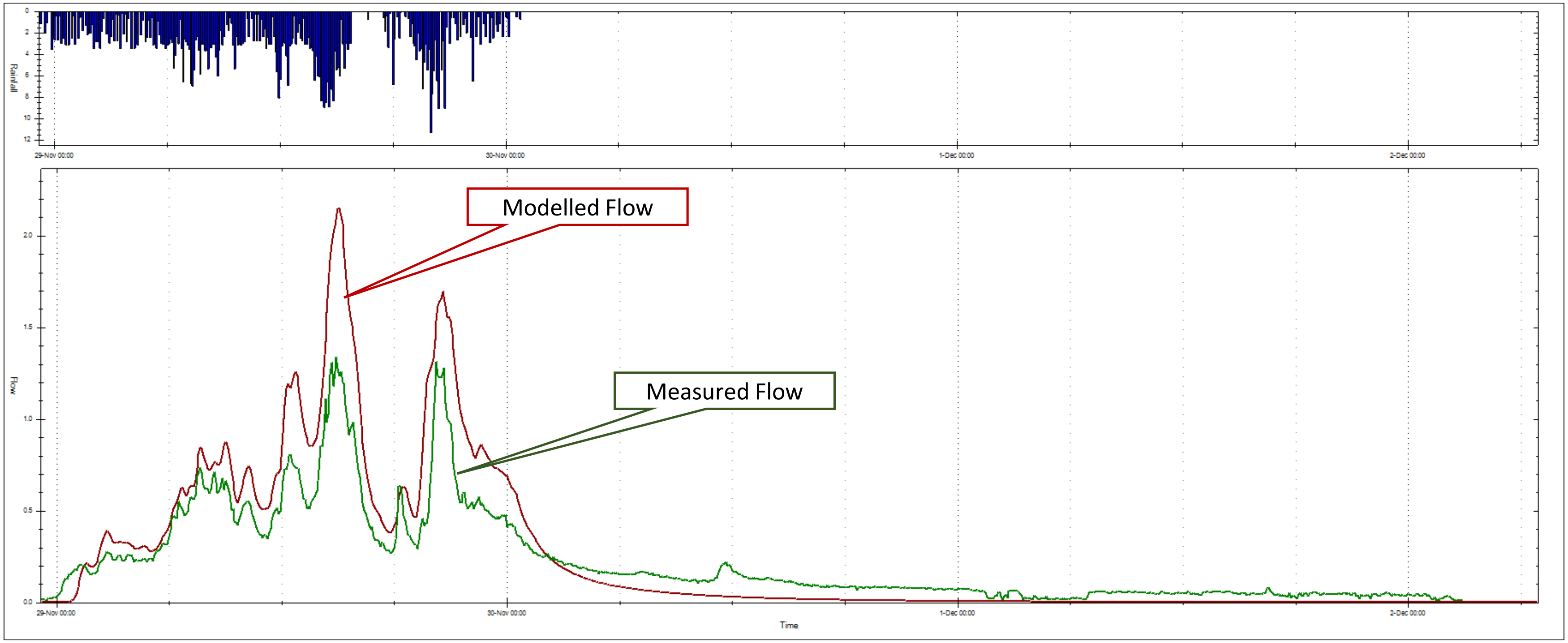
Flow Gauge 2: September 23, 2011



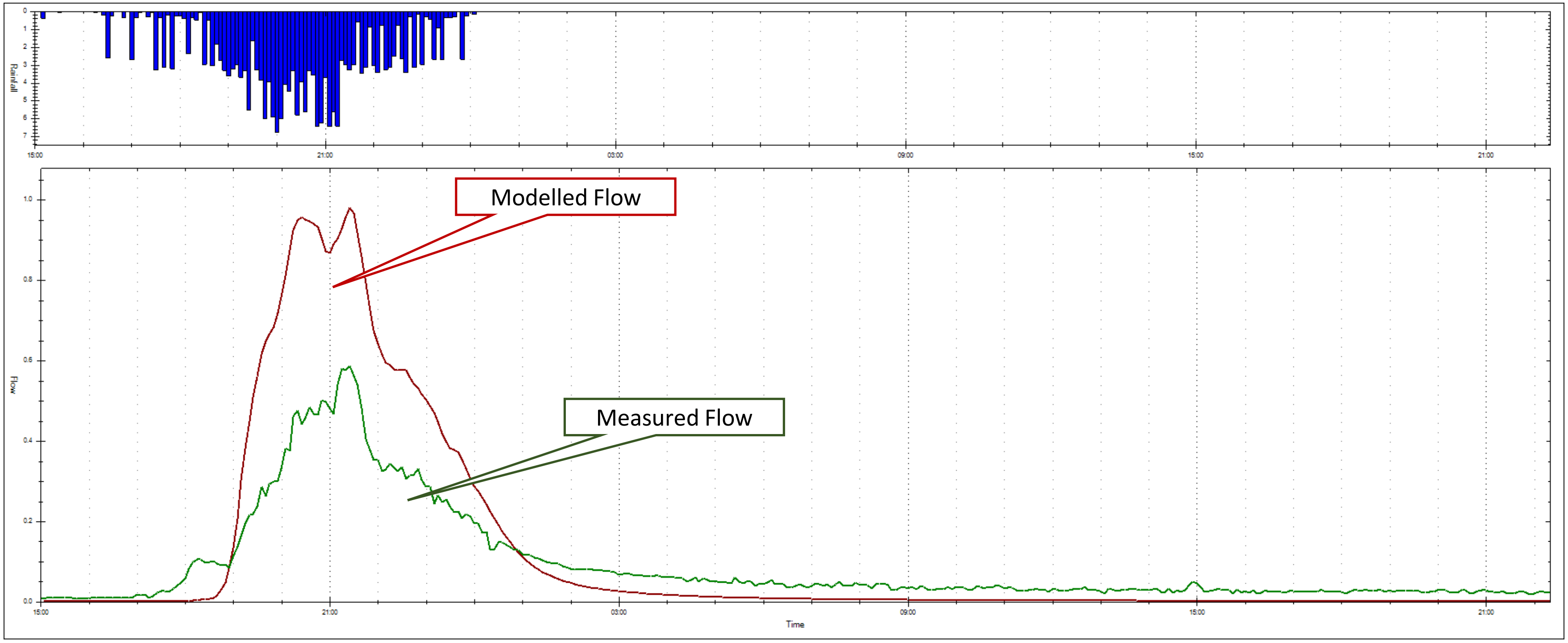
Flow Gauge 2: September 29, 2011



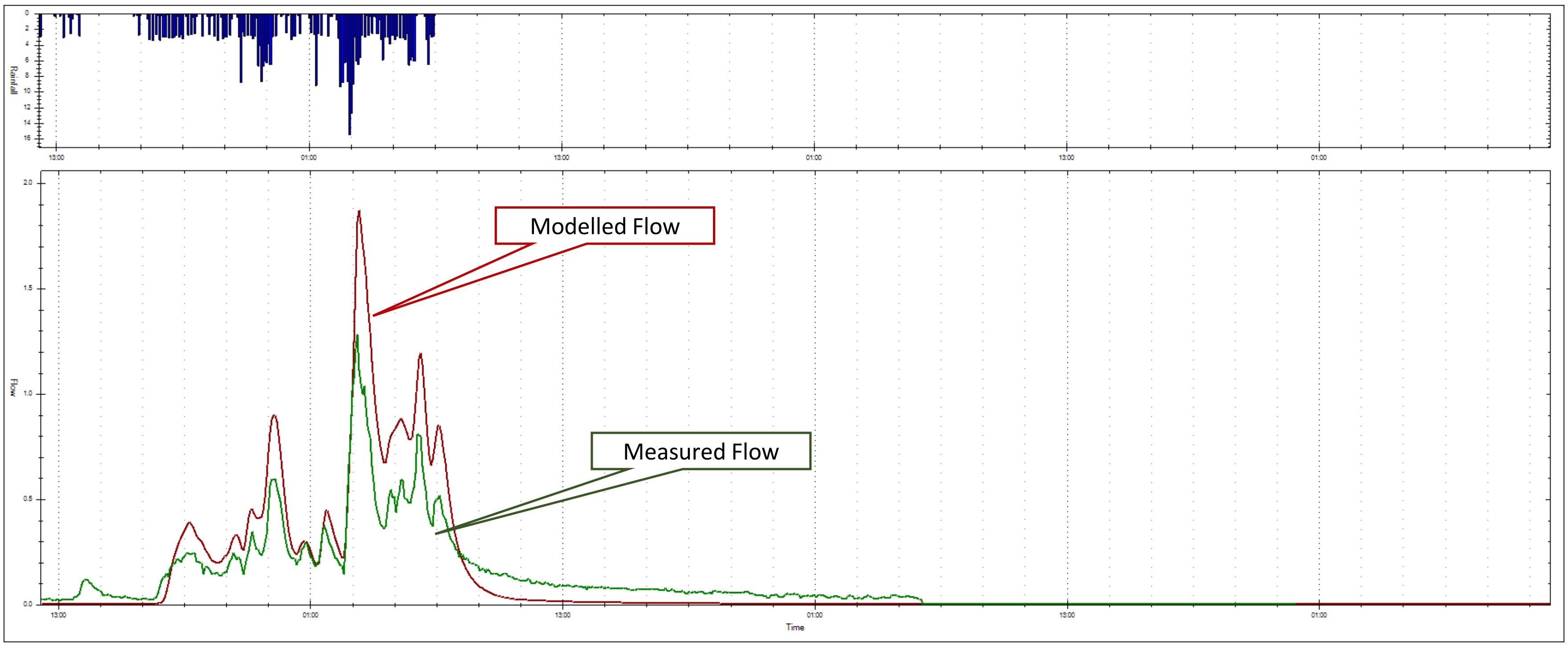
Flow Gauge 3: November 29, 2011



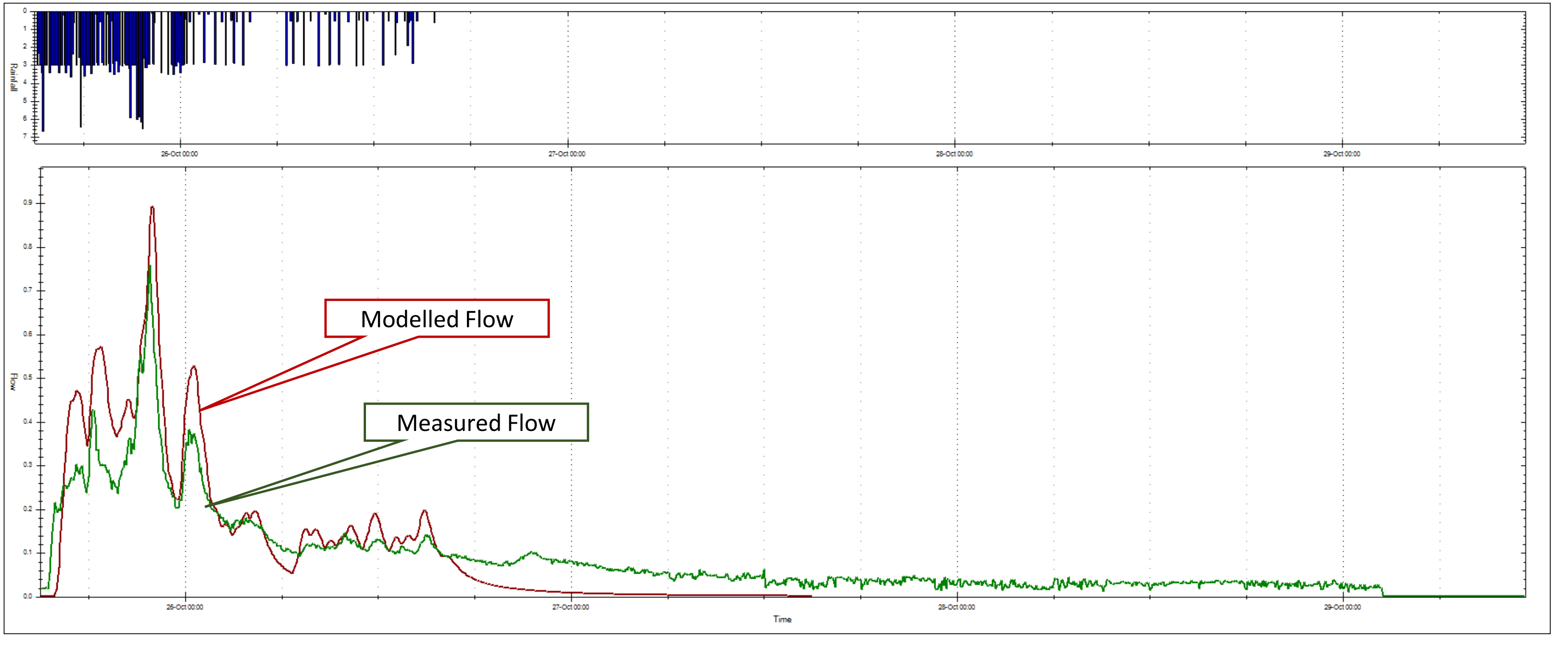
Flow Gauge 3: October 12, 2011



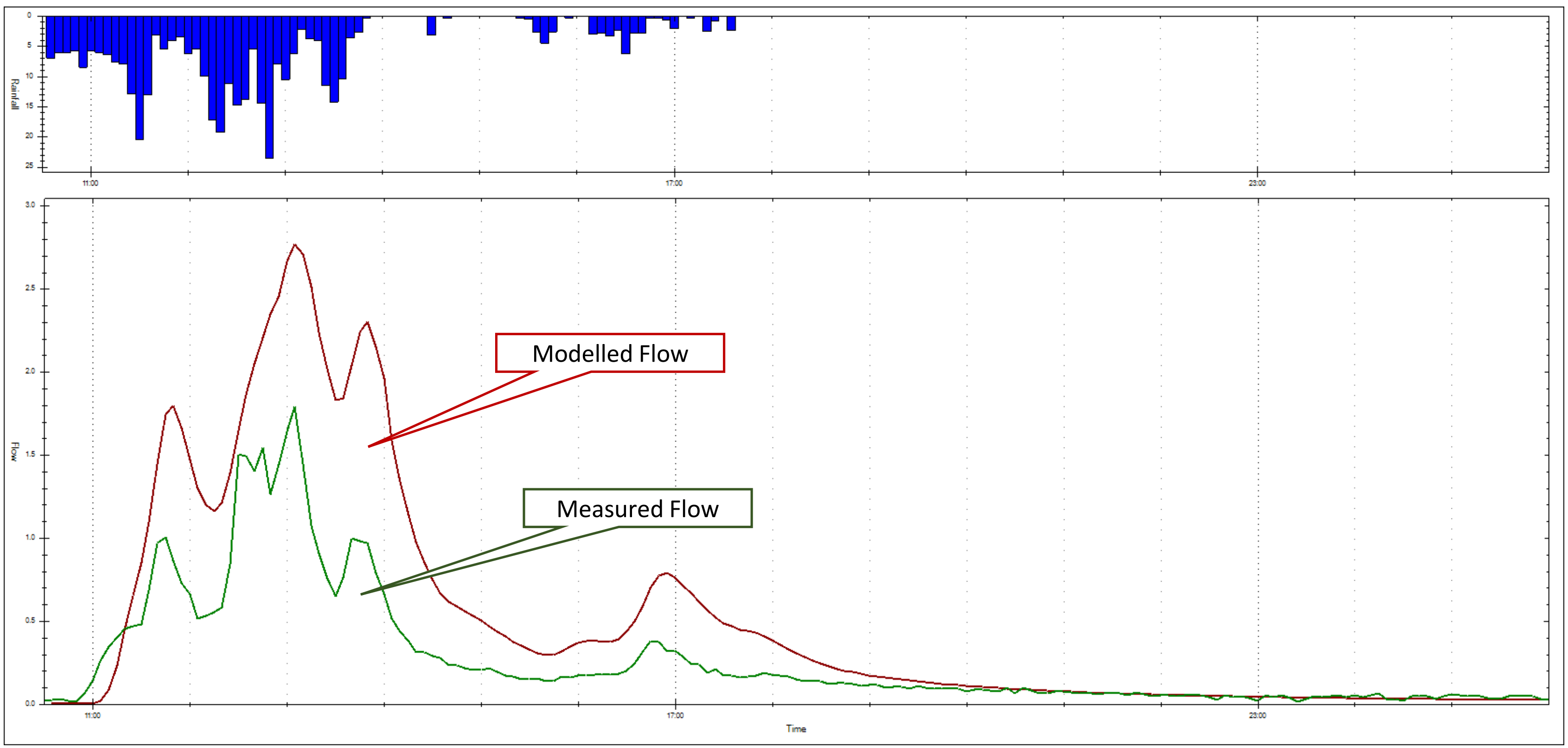
Flow Gauge 3: October 19, 2011



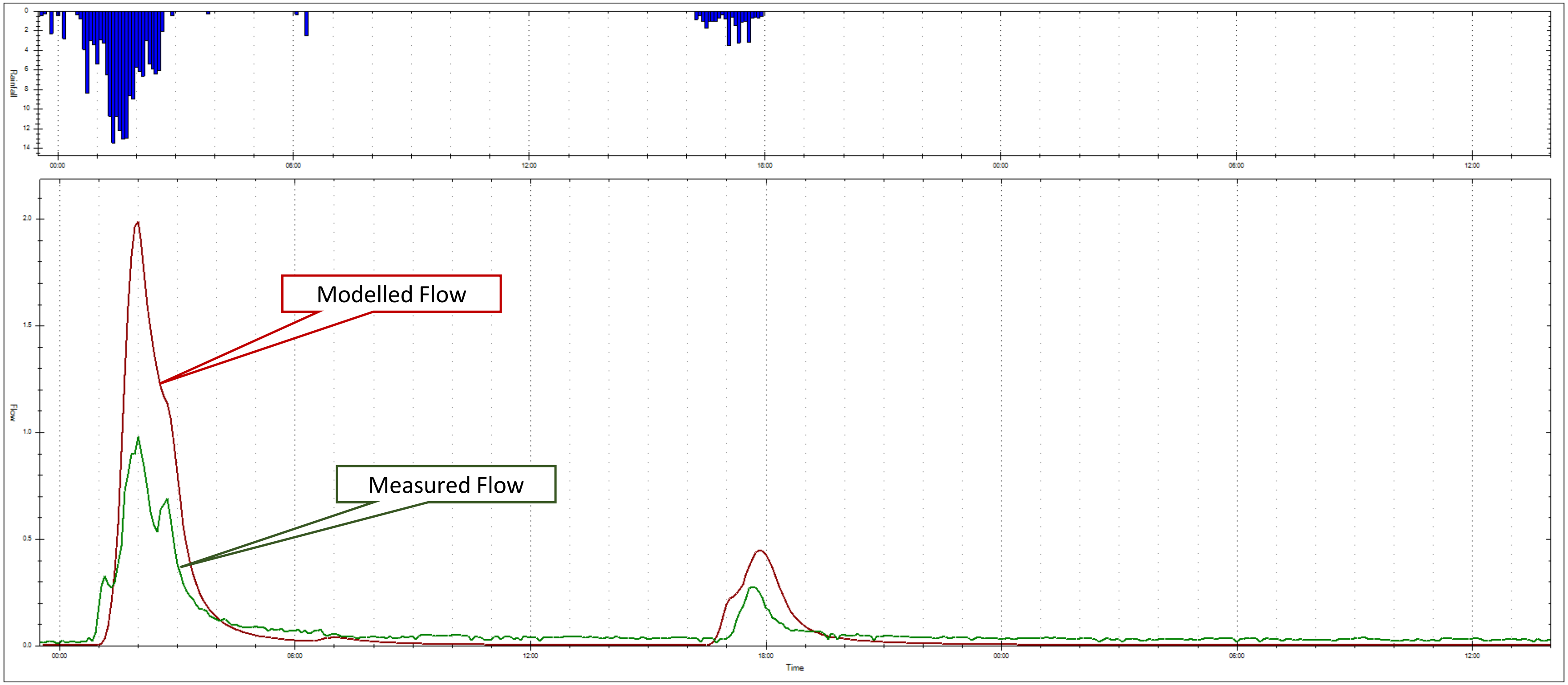
Flow Gauge 3: October 25, 2011



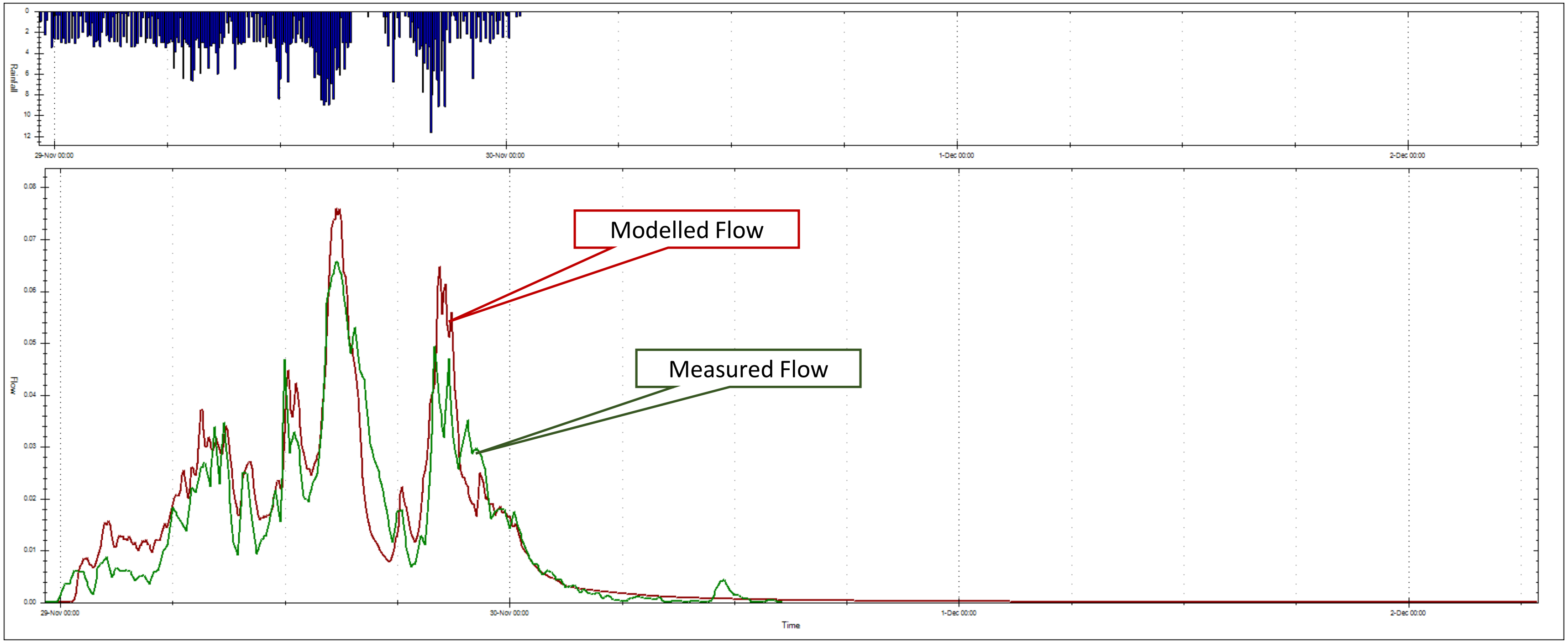
Flow Gauge 3: September 23, 2011



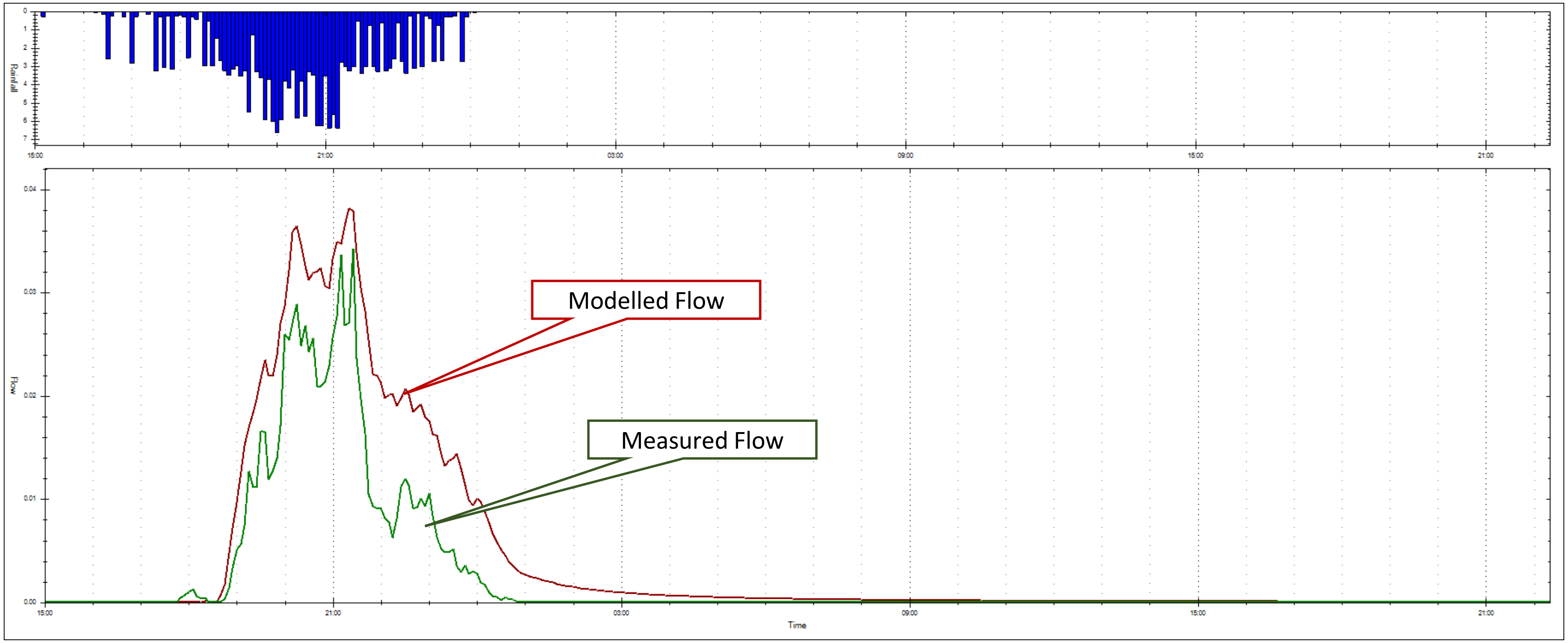
Flow Gauge 3: September 29, 2011



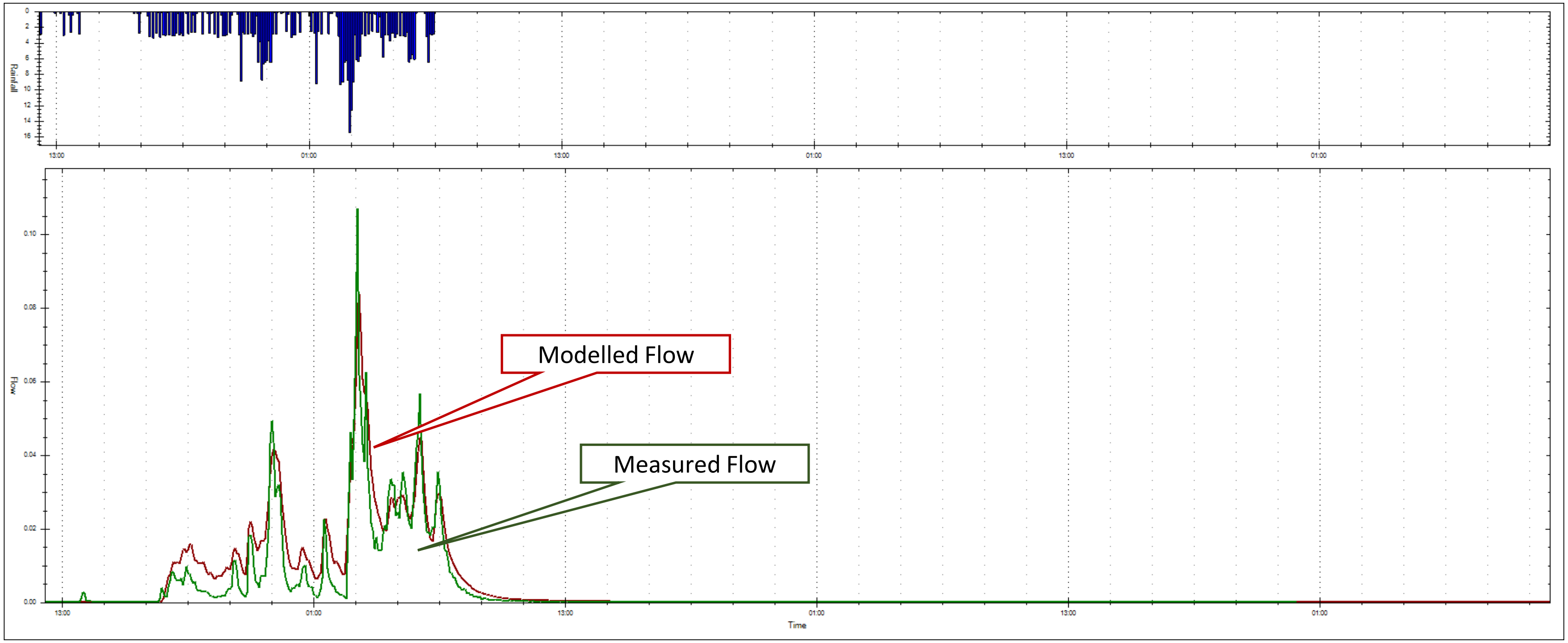
Flow Gauge 4: November 29, 2011



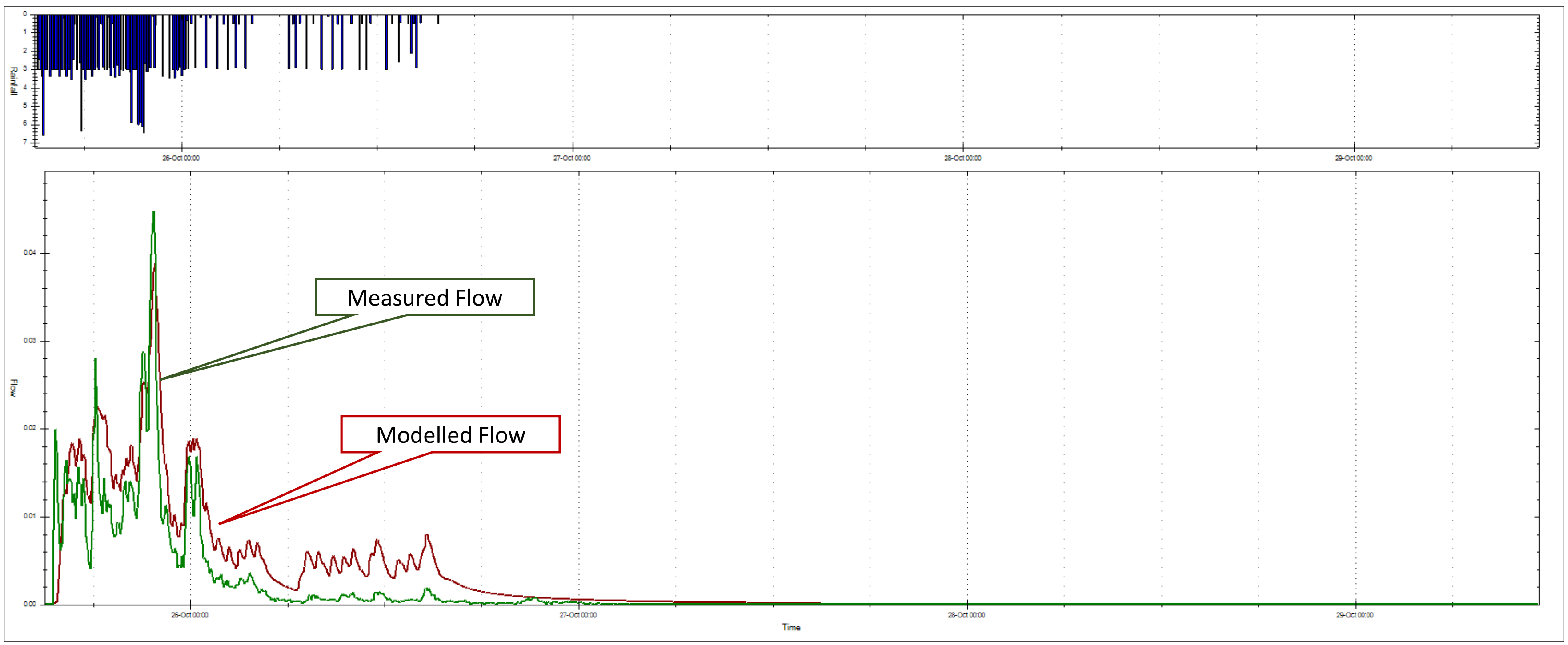
Flow Gauge 4: October 12, 2011



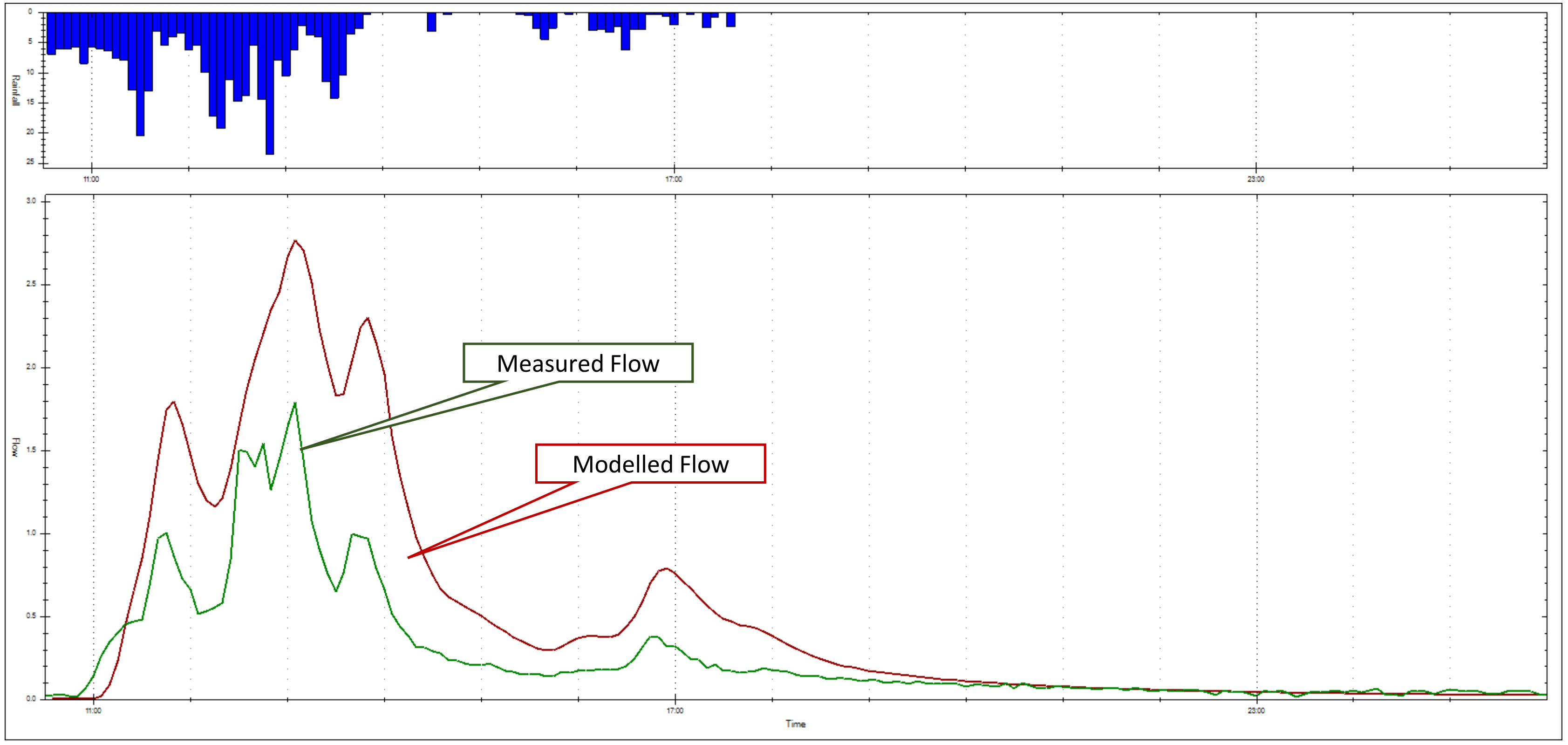
Flow Gauge 4: October 19, 2011



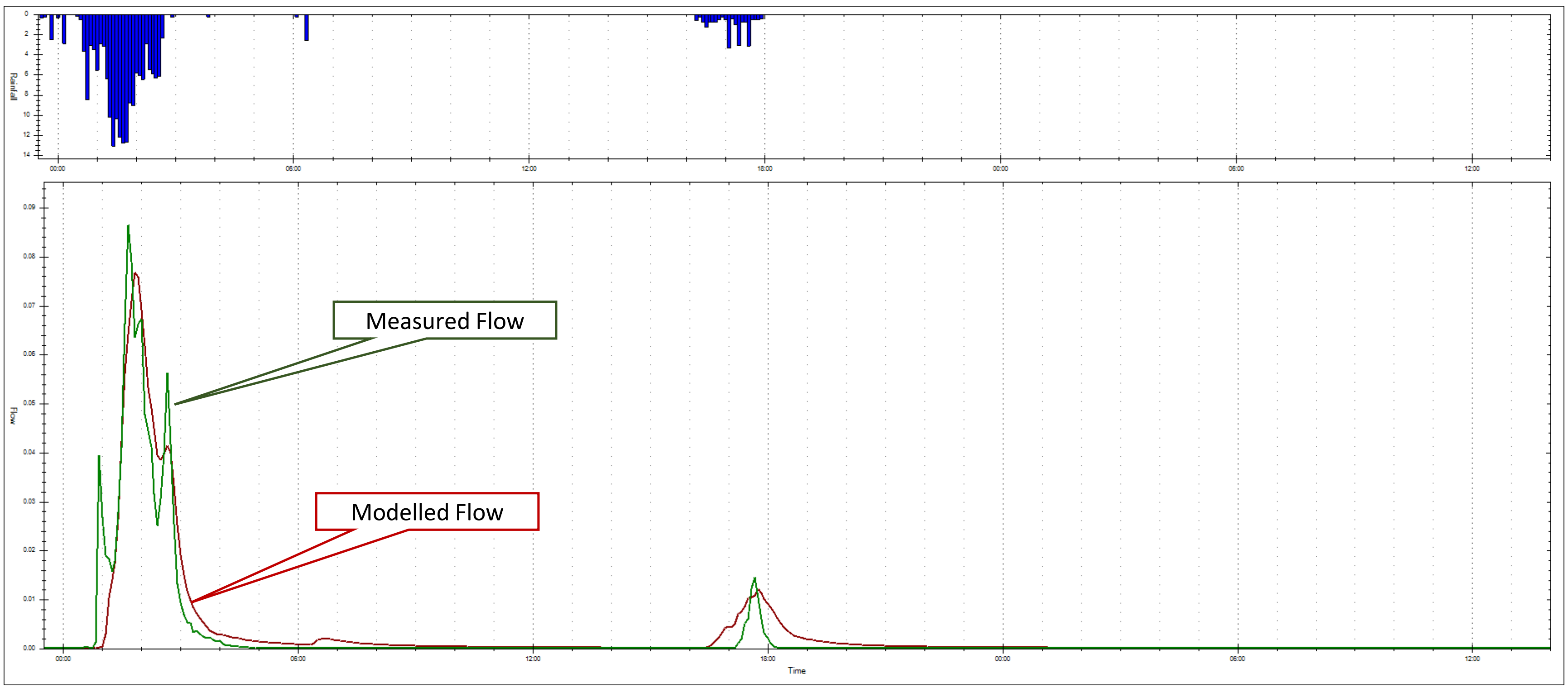
Flow Gauge 4: October 25, 2011



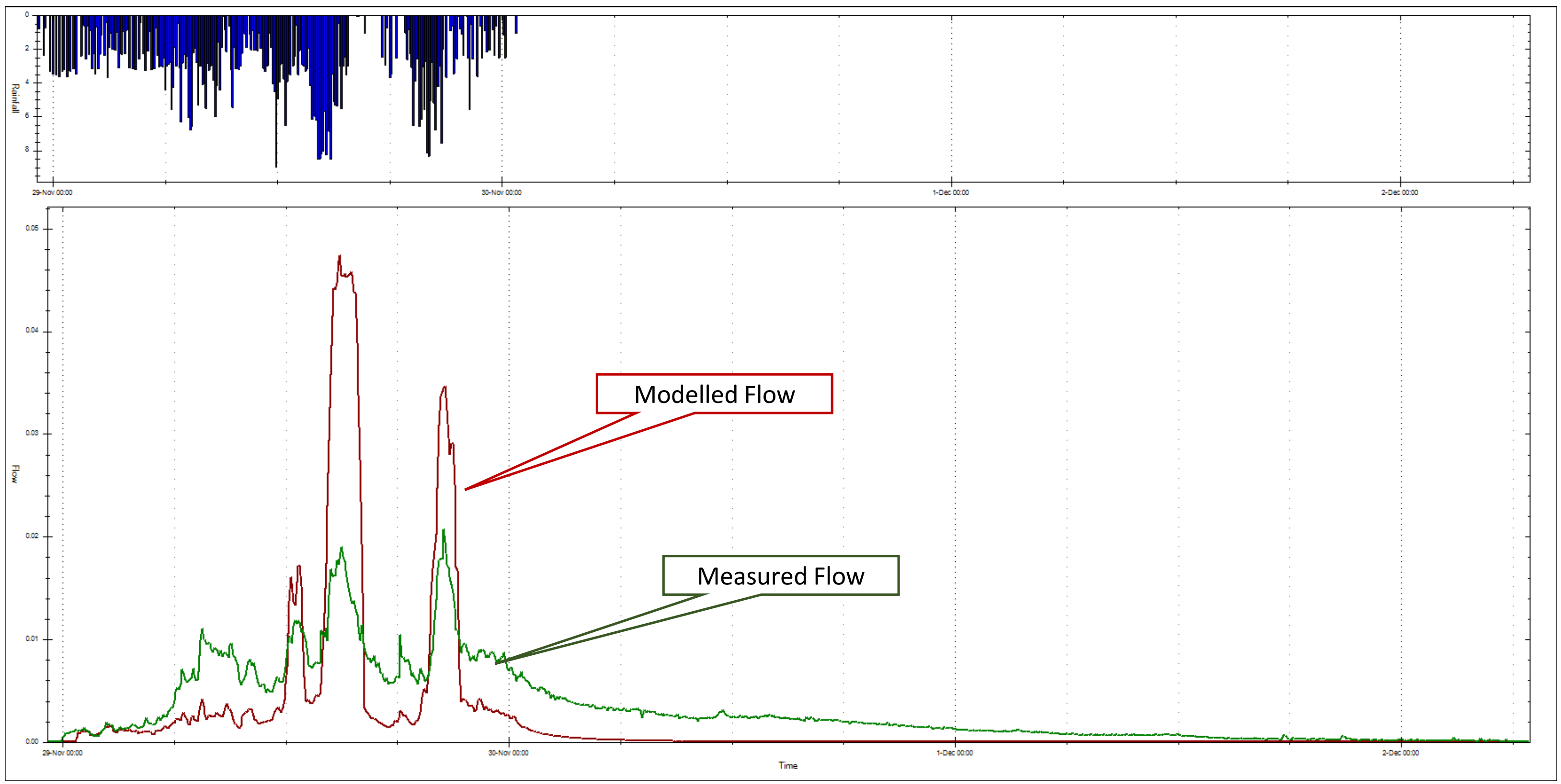
Flow Gauge 4: September 23, 2011



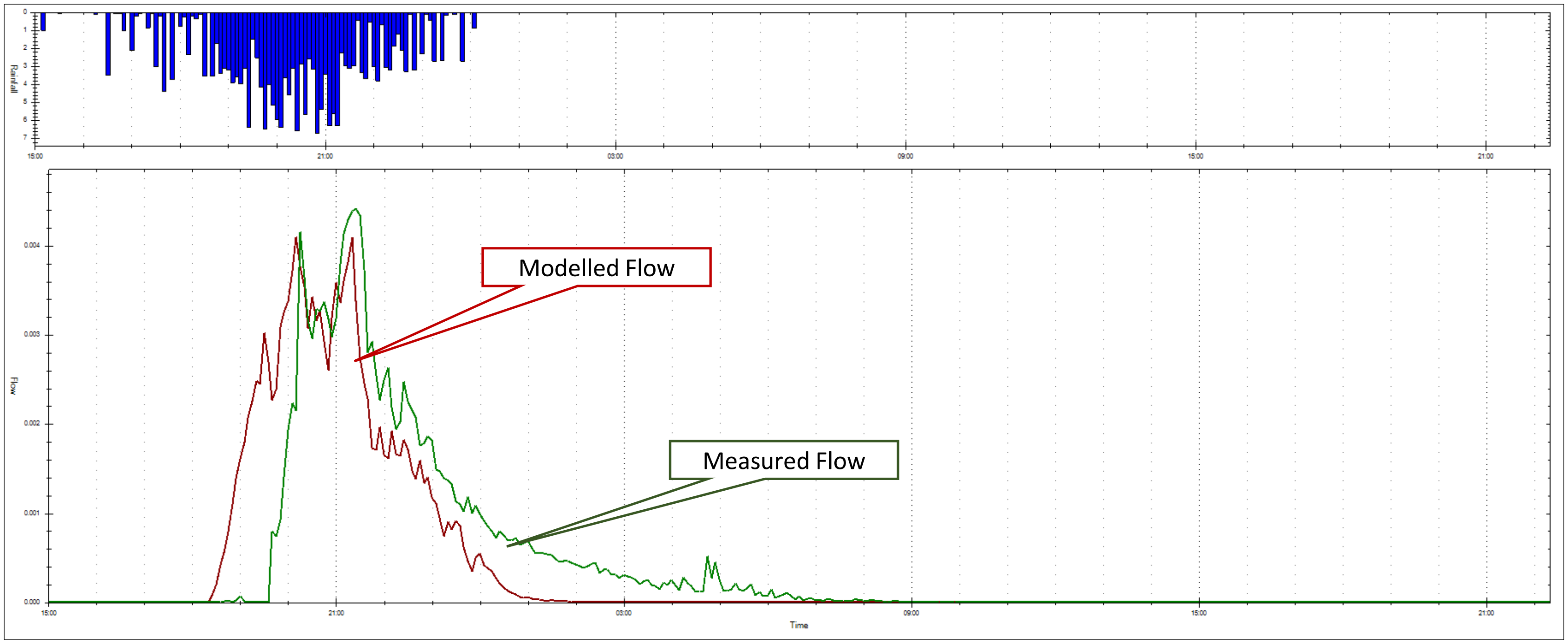
Flow Gauge 4: September 29, 2011



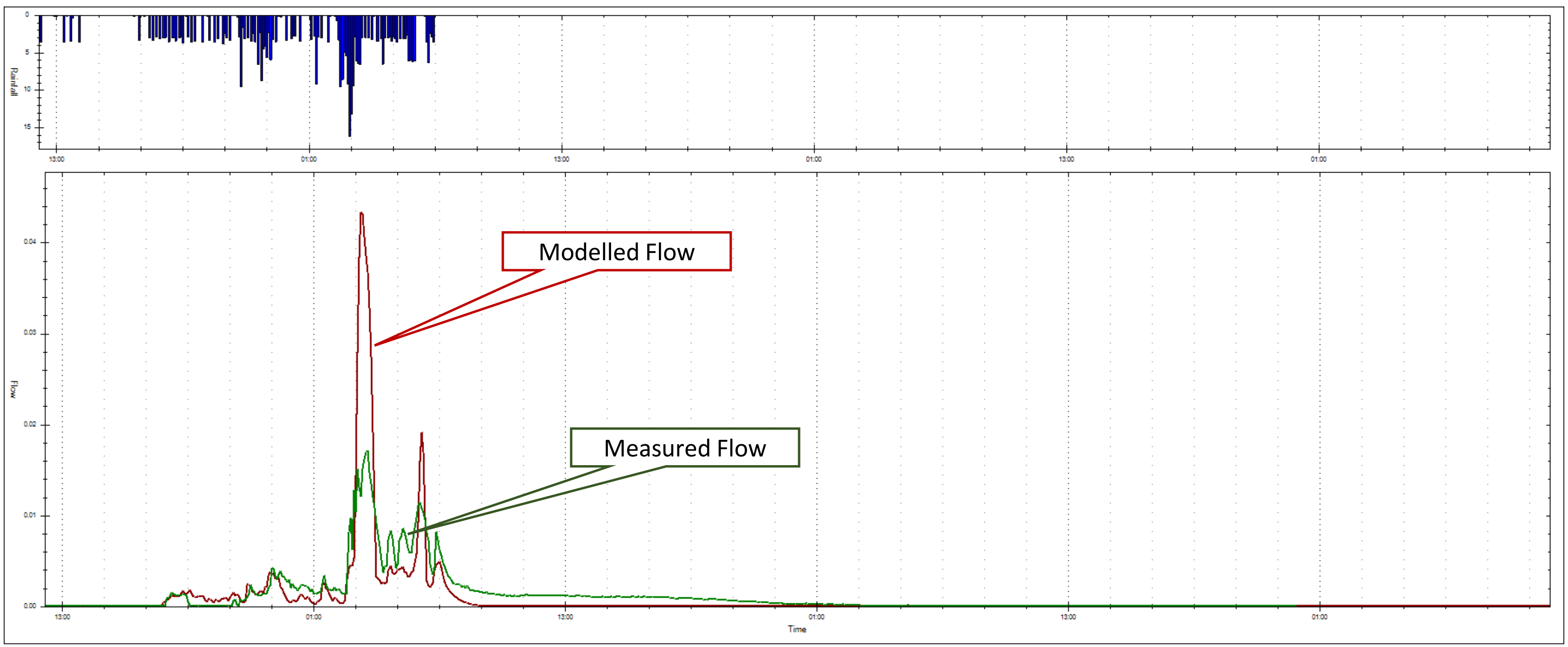
Flow Gauge 5: November 29, 2011



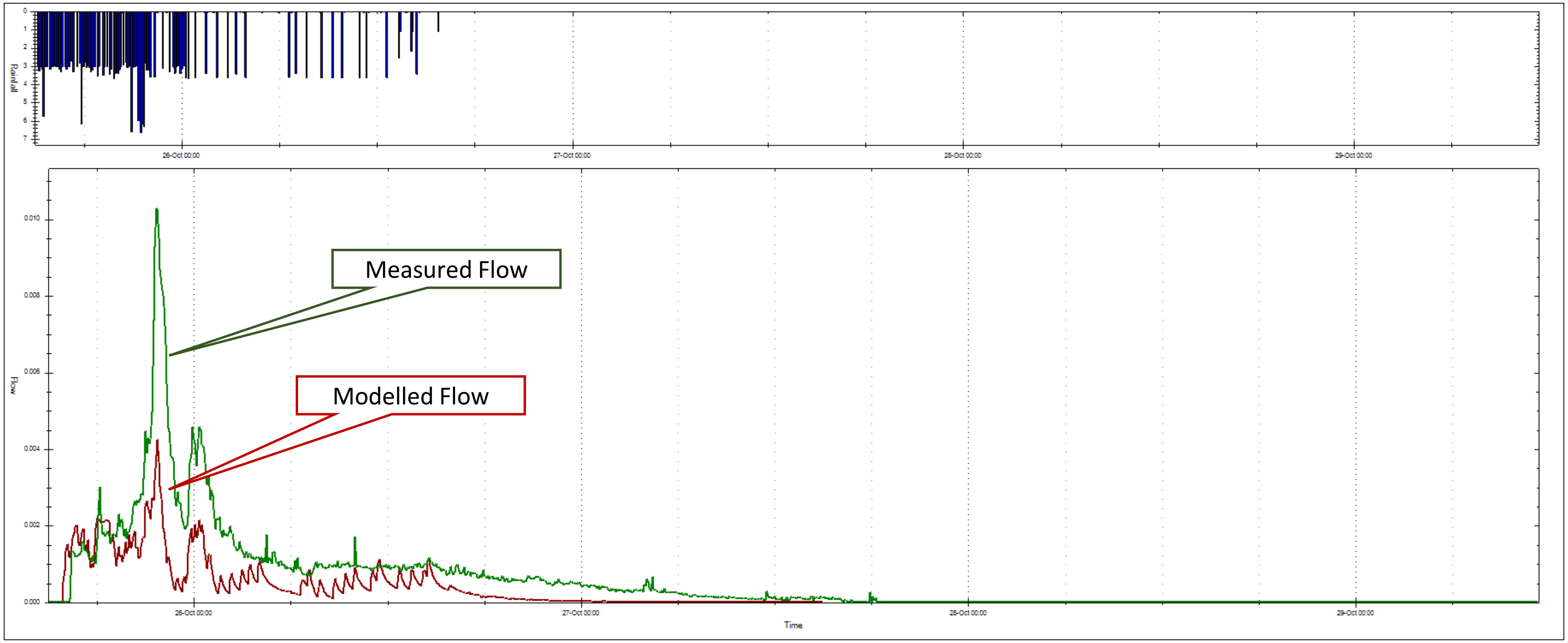
Flow Gauge 5: October 12, 2011



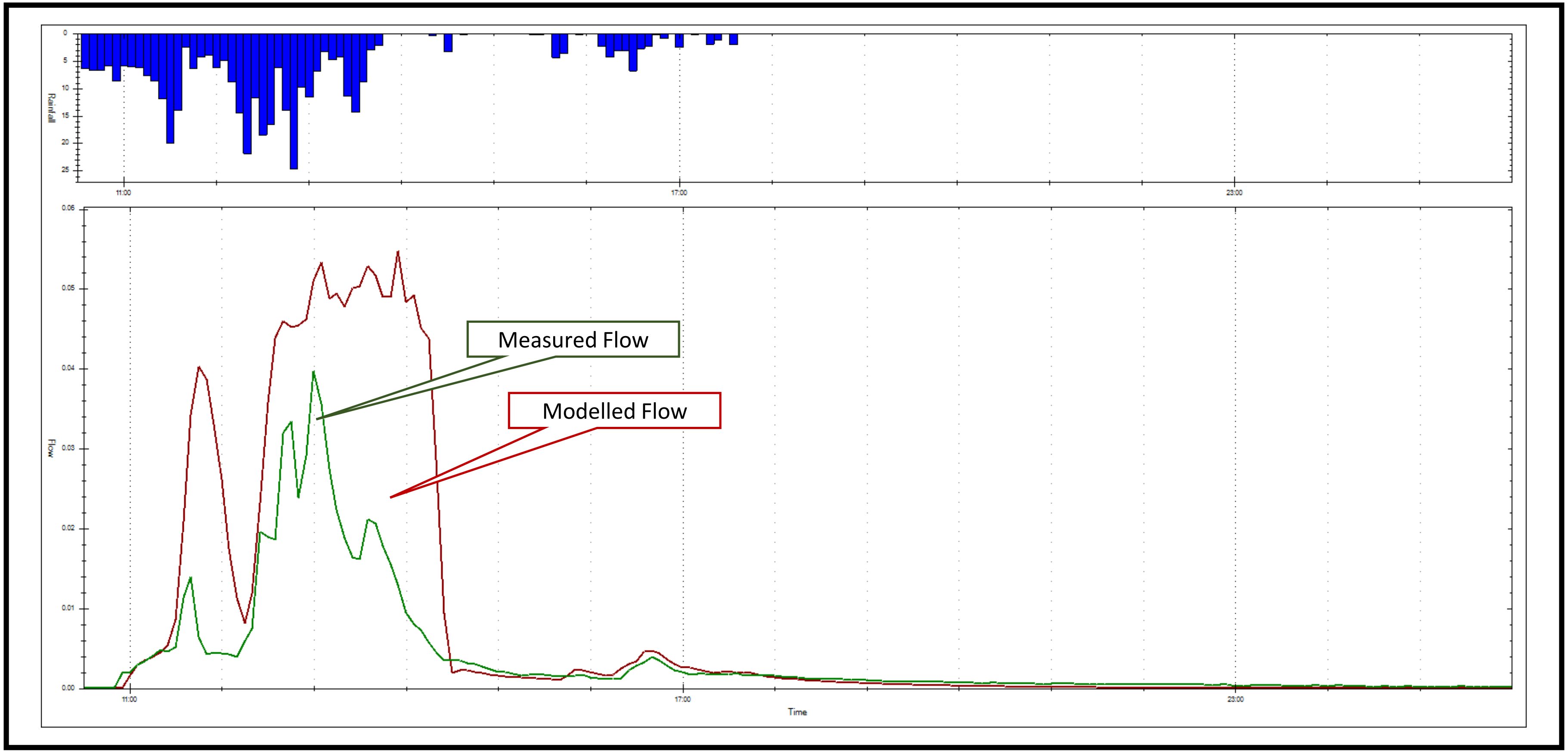
Flow Gauge 5: October 19, 2011



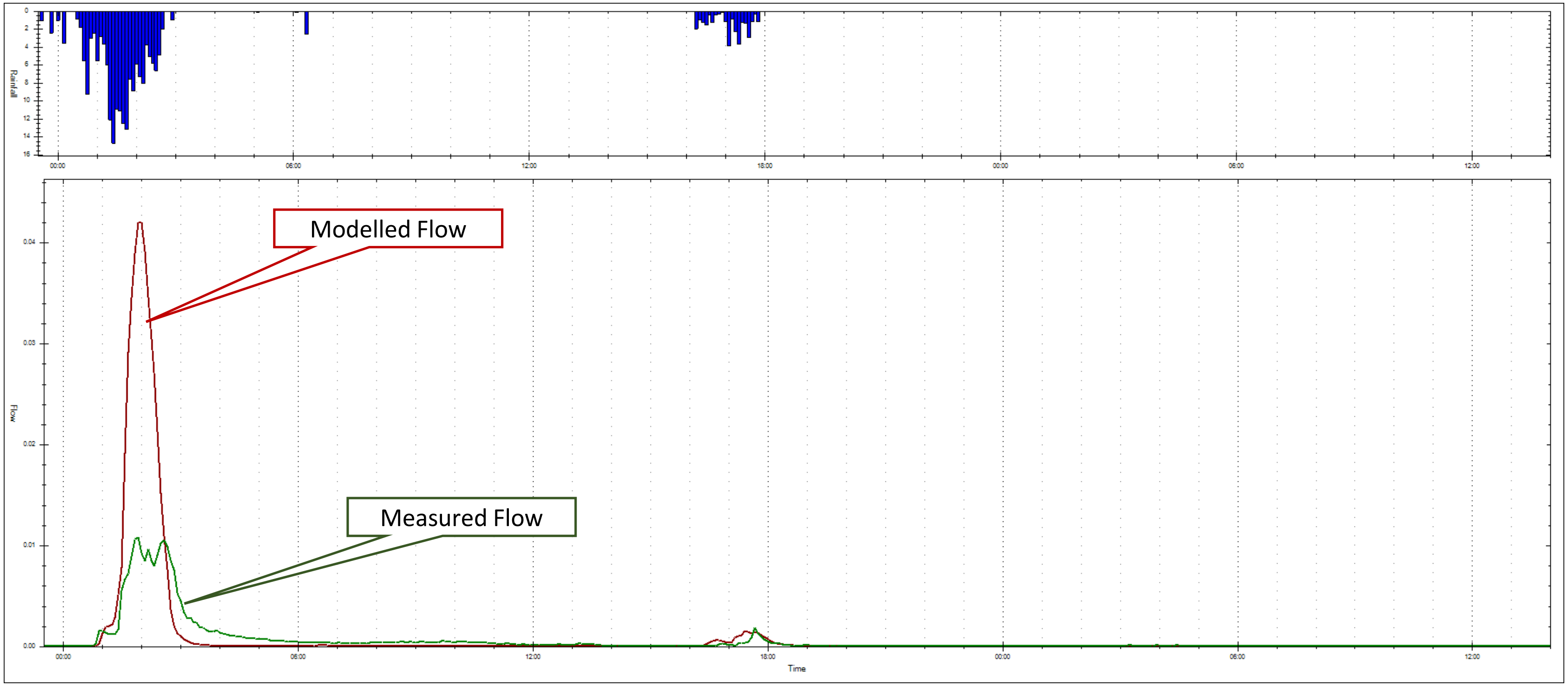
Flow Gauge 5: October 25, 2011



Flow Gauge 5: September 23, 2011



Flow Gauge 5: September 29, 2011



APPENDIX H
Statement of Limiting Conditions and Assumptions

Statement of Limiting Conditions and Assumptions

1. This Report/Study (the "Work") has been prepared at the request of, and for the exclusive use of, the Owner, and its affiliates (the "Intended Users"). No one other than the Intended Users has the right to use and rely on the Work without first obtaining the written authorization of Cole Engineering Group Ltd. (Cole Engineering) and its Owner.

2. Cole Engineering expressly excludes liability to any party except the Intended Users for any use of, and/or reliance upon, the Work.

3. Cole Engineering notes that the following assumptions were made in completing the Work:

   a) the land use description(s) supplied to us are correct;
   b) the surveys and data supplied to Cole Engineering by the Owner are accurate;
   c) market timing, approval delivery and secondary source information is within the control of Parties other than Cole Engineering; and
   d) there are no encroachments, leases, covenants, binding agreements, restrictions, pledges, charges, liens or special assessments outstanding, or encumbrances which would significantly affect the use or servicing.

   Investigations have not been carried out to verify these assumptions. Cole Engineering deems the sources of data and statistical information contained herein to be reliable, but we extend no guarantee of accuracy in these respects.

4. Cole Engineering accepts no responsibility for legal interpretations, questions of survey, opinion of title, hidden or inconspicuous conditions of the property, toxic wastes or contaminated materials, soil or sub-soil conditions, environmental, engineering or other factual and technical matters disclosed by the Owner, the Client, or any public agency, which by their nature, may change the outcome of the Work. Such factors, beyond the scope of this Work, could affect the findings, conclusions and opinions rendered in the Work. We have made disclosure of related potential problems that have come to our attention. Responsibility for diligence with respect to all matters of fact reported herein rests with the Intended Users.

5. Cole Engineering practices engineering in the general areas of infrastructure and transportation. It is not qualified to and is not providing legal or planning advice in this Work.

6. The legal description of the property and the area of the site were based upon surveys and data supplied to us by the Owner. The plans, photographs, and sketches contained in this report are included solely to aide in visualizing the location of the property, the configuration and boundaries of the site, and the relative position of the improvements on the said lands.

7. We have made investigations from secondary sources as documented in the Work, but we have not checked for compliance with by-laws, codes, agency and governmental regulations, etc., unless specifically noted in the Work.

8. Because conditions, including capacity, allocation, economic, social, and political factors change rapidly and, on occasion, without notice or warning, the findings of the Work expressed herein, are as of the date of the Work and cannot necessarily be relied upon as of any other date without subsequent advice from Cole Engineering.

9. The value of proposed improvements should be applied only with regard to the purpose and function of the Work, as outlined in the body of this Work. Any cost estimates set out in the Work are based on construction averages and subject to change.

10. Neither possession of the Work, nor a copy of it, carries the right of publication. All copyright in the Work is reserved to Cole Engineering. The Work shall not be disclosed, produced or reproduced, quoted from, or referred to, in whole or in part, or published in any manner, without the express written consent of Cole Engineering and the Owner.

11. The Work is only valid if it bears the professional engineer's seal and original signature of the author, and if considered in its entirety. Responsibility for unauthorized alteration to the Work is denied.