Markham Village & Unionville Flood Remediation Plan

Technical Memorandum #4:
Program Summary

Prepared for:

City of Markham

RVA 173838

May 7, 2021

R.V. Anderson Associates Limited
2001 Sheppard Avenue East Suite 300
Toronto Ontario M2J 4Z8 Canada
Tel 416 497 8600 Fax 855 833 4022
www.rvanderson.com

May 7, 2021 RVA 173858

Environmental Services Department
City of Markham
8100 Warden Avenue
Markham Ontario, L6G 1B4

Attention: **Ms. Kate Rothwell, M.Eng., P. Eng.,**
Senior Environmental Engineer, Stormwater

Dear Ms. Rothwell,

Re: Markham Village & Unionville Flood Remediation Plan
Technical Memorandum #4: Program Summary
RVA Project Number 173858

We are pleased to provide the final report summarizing the Markham Village and Unionville Flood Control Plan. The proposed sewer upgrades and construction estimates are as they were previously presented to the City.

This plan provides the City with a clear path forward for flood risk mitigation in the older built-up areas of Markham Village and Unionville.

We thank you for retaining our team with this work and look forward to serving the City further. Please feel free to contact either of the undersigned if you have any questions regarding the flood remediation plan.

Yours very truly,

R.V. ANDERSON ASSOCIATES LIMITED

E. André Poirier, P. Eng.
Project Manager, Municipal

Oliver Olberg, Dipl.-Ing.
Manager of Hydraulic Modeling

Markham Village & Unionville Flood Remediation Plan
Technical Memorandum #4: Program Summary
TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

EXECUTIVE SUMMARY

Background and Objectives

Urban storm drainage standards have undergone significant evolution since settlement in the City of Markham. Newer developments built after 1978 have been designed and built to a robust standard that provides a minor and major storm conveyance system providing a high-level of protection to buildings under significant storm events.

The City of Markham experienced three (3) significant storm events in June and July 2017 that resulted in 350 reports of flooding throughout the Markham Village and Unionville Areas.

In response to these storm events, the City has recognized the need for a comprehensive approach to mitigate the risks of flooding in the areas of Markham Village and Unionville (the study areas). The City of Markham retained R.V. Anderson Associates Limited (RVA) to evaluate the urban flooding dynamics in these study areas.

The objectives of this report are as follows:

1. Provide a clear planning document to allow for the implementation (financial planning, regulatory approvals, design and construction) of the flood remediation program in Markham Village and Unionville over the coming years; and
2. Document the study process and rationale for developing the program.

Markham Village is a 691 ha urban area that was evaluated as twenty-one (21) distinct subcatchments for the purpose of drainage infrastructure planning.

Unionville is a 304 ha urban area that was split into ten (10) subcatchments for the purpose of drainage infrastructure planning

Study Scope

The scope of the study includes:

Storm Drainage System

- Urban drainage system characterization with dual-drainage hydraulic models;
- Development of a standard criteria for identifying flood vulnerable properties and drainage infrastructure in the study areas;
- Development of a standard level of service criteria for remediating flood vulnerabilities identified in the study areas;
- Development of a standardized flood remediation program that meets the level of service for the flood vulnerable areas;
- Refinement of the flood remediation program;
- Prioritization of works in the program to service high risk areas; and
- Identify opportunities for incorporation of green infrastructure / LIDs into the flood remediation solutions.

Sanitary Collection System

- Sanitary collection system characterization through the validation of an existing sanitary system;
- Development of a standard level of service criteria for operating the sanitary sewer system; and
- Development of a sanitary sewer improvement program that meets the level of service.

The sanitary system evaluation is addressed in a separate report titled *Sanitary Modeling Report – Flood Remediation Study – Markham Village and Unionville (Cole Engineering February 2021)* included in Appendix C2.

Limitations

System characterization, flood vulnerability assessment, and system performance modelled through this study is subject to practical limitations some of which are highlighted in the report.

Study Area Description

Markham Village is subdivided into 21 subcatchments as follows:

	Size	Land Use	Year of Construction
Fincham	122 ha	Residential	1980
Paramount	11 ha	Residential, Schools, Parks, Worship, Commercial	before 1972
Church	19 ha	Residential, Schools, Parks, Worship, Commercial	before 1972
Main	40 ha	Residential, Commercial	before 1972
Tuclor East	54 ha	Residential, small commercial plaza, schools, parks	before 1978
Exhibition East	151 ha	Residential, schools, parks.	Before 1978, Mostly before 1972
Milne	11 ha	Low density residential, commercial near HWY7.	before 1972
Windridge	44 ha	Low density residential, commercial near HWY7.	before 1972
Willowgate	12 ha	Low density residential, commercial near HWY7 and on Bulllock Drive	before 1972
Rouge	11 ha	Low density residential.	before 1972
Christman Court	8 ha	Low density residential.	some before 1978, some from 1978-1983
Reeve	15 ha	Low Density Residential with a school, parkland and community facilities.	Phase 1: 1979 -1983; Phase 2: 1996-2004
John Lyons	5 ha	Residential	after 1980
Tuclor West	11 ha	Residential	before 1972
Edward / Washington	8 ha	Residential and commercial	before 1972
Anderson	20 ha	Commercial / Institutional	before 1985
Walkerton	14 ha	Residential and commercial.	before 1972
Friar Tuck	55 ha	Residential and commercial.	before 1972
Laidlaw	54 ha	Industrial, commercial.	before 1972
Drakefield	25 ha	Residential, School.	before 1972

Unionville is subdivided into 10 subcatchments as follows:

	Size	Land Use	Year of Construction
UV1	61 ha	Residential, Briarwood Park, portions of Carlton Park	1970-1978
UV2	31 ha	Residential, William Berczy Public School, portions of Carlton Park	1970-1995
UV3	69 ha	Residential, Blessed John XXIII School, Village Park.	1970-1995
UV4	22 ha	Residential, Toogood park.	1970-1995
UV5	19 ha	Residential	1965 - 1995
UV6	23 ha	Residential, Commercial, low lying wetland.	mid 1960's
UV7	49 ha	Residential, parts of Blessed John XXIII School property.	1970- 1995
UV8	10 ha	Residential	before 1970
UV9	17 ha	Residential, Commercial along HWY7	before 1970, some area in 1978
UV10	2.5 ha	Residential	1979 to 1983

Flood Records

The City of Markham experienced three (3) significant storm events in June and July 2017 that resulted in 350 reports of flooding throughout the Markham Village and Unionville Areas. Most of the flooding reports received for this time period were from the Markham Village area with some concentrated areas described as flood clusters in the following subcatchments:

- Exhibition East Subcatchment
- Fincham Subcatchment
- Friar Tuck Subcatchment
- Paramount Subcatchment

Hydraulic Model – Data Sources and Model Development

Hydraulic models were built for all subcatchments in Markham Village and Unionville. Data sources that were used to characterize the system in the hydraulic models included:

- GIS data on storm sewers, catchbasins and maintenance holes;
- As-constructed drawings
- Remote Sensing Data (LIDAR)
- Smoke Testing Surveys
- Flow monitoring data
- Close Circuit Television (CCTV) inspection records
- Toronto and Region Conservation Authority (TRCA) river and creek system hydraulic models
- Field Investigations

The Markham Village East and Unionville models were prepared by Cole Engineering and refined by RVA.

The Markham Village West model was prepared by the City and refined by RVA.

Existing Conditions Assessment

The urban drainage system characterization and flood records in Markham Village and Unionville indicate the following:

- Drainage infrastructure in Markham Village and Unionville was generally not constructed to current design standards and has operational deficiencies with regards to the configuration of the system such as locating trunk sewers on private properties, having developments enclosing creeks, not having well defined overland flow routes, and having some cross connections with the sanitary sewer system.

- The type of drainage infrastructure is not consistent amongst the subcatchments with some areas having a fully separated storm and sanitary sewer system with curb/gutter roadway, and other areas having roadside ditch systems that are connected to storm sewers.
- The percentage of foundation drains connected to the storm sewer system varies with older areas (built before 1970) typically not built with foundation drains connected to a storm sewer and newer areas having been built with foundation drains connected to storm sewers.
- System wide dual drainage modeling highlights areas that are under-serviced for various test levels (5-year AES conditions, 25-year AES conditions, 100-year AES Storm conditions).
- A recent high intensity storm event occurred in Markham Village in July 2017 and there were numerous floods calls in Markham Village with clusters of calls in the Exhibition East, Fincham, Paramount and Friar Tuck Subcatchments.
- There are several areas in Markham Village where flood records coincide with areas that the urban drainage system model indicates as deficient level of service.
- Unlike other areas in Markham such as Markham Village and West Thornhill, Unionville has not experienced a severe weather event in recent memory with which any modelled vulnerabilities can be validated.
- The Unionville receiving watercourse of Fonthill Creek traverses over 35 private properties and peak flows in this watercourse are affected by the upstream urban drainage system in UV3, UV4 and UV7 subcatchments.

Flood Control Plan Design Considerations

A framework for developing infrastructure improvements in the Markham Village and Unionville areas was established to address overall flood risk reduction. This includes the development of level of service objectives and performance metrics, in consideration of the City's current design criteria for new developments. In addition, the framework considered many practical sewer operational considerations that are associated with the limitations imposed by the existing built-up areas.

The design considerations are summarized as follows:

1. **Design Storm:** The 3-hour duration 100-year AES storm is applied to evaluate the system performance;
2. **Level of Service (LOS):** Residential dwellings, commercial and institutional buildings should not be exposed to flooding under the 100-year AES peak flow conditions. This is achieved by:
    a. Maintaining the hydraulic grade line in the minor system near residential dwellings is below 1.8 m below the road surface (below basement levels) under all storm conditions up to and including the 100-year AES storm;
    b. Maintaining the hydraulic grade line in the major storm system (overland flow) below 0.3 m under all storm conditions up to and including the 100-year AES storm; and
    c. Maintaining overland flow routes within the right of way with no spillage of flow from the road onto private property.
3. **Minor System / Major System Flow Balancing:** Flow balancing to limit capture in the minor storm system in extreme events and to utilize the major storm system as a means of limiting the need for storm sewer upgrades wherever possible. This is achieved by incorporating inlet control devices (ICDs) in the catch basins. This approach limits the entry of flow into the minor system during high flow events and maximizes the use of available overland flow capacity in the major storm (overland) system.
4. **City of Markham Property Rights:** Preference for pipe infrastructure to be maintained in the roadway or on City property rather than on easements through private property.
5. **Off-line Storage if warranted:** Use of off-line storage as a means of attenuating flow in order to limit the need for storm sewer upgrades where warranted.
6. **Impacts on Receiving Waters on Private Property or Near Buildings:** Consider mitigate or eliminate any impacts of increasing peak flows in receiving waters systems that are near buildings.
7. **Simplicity of Construction:** Wherever possible consider 1800 mm as the maximum size for typical urban storm sewers. Storm sewers should be laid out such that construction depths are less than 5 m deep.

Resilience to Climate Change

The City's flood control program is a significant component of the climate change resilience strategy. Upgrading storm drainage systems in the older areas, starting with the most flood vulnerable areas, and targeting a level of service with a built-in safety factor to service events that exceed those that have occurred in Markham to date.

The City's stormwater management guidelines select the use of an intensity-duration-frequency based on a dataset from Environment Canada's Atmospheric Environment Services (AES) Bloor Street Rain Gauge. The City's SWM guidelines indicate that this dataset produces short duration storm intensities that are 30% higher than those observed in the City's Buttonville Rain datasets. This synthetic storm event (100-year AES), though it has not been observed in the areas of Markham Village or Unionville, provides a robust standard for design.

The additional flexibility provided in this standard allows for some uncertainty associated with changes in rainfall patterns associated with climate change.

Development and Prioritization of a Flood Mitigation Program

Stage 1 Initial Program: An initial program that meets the desired level of service (all modelled vulnerabilities eliminated up to the 100 year AES storm event) was evaluated. This initial program was developed regardless of cost and other practical considerations and generally maintained the existing configuration of the urban drainage system.

Stage 2 Program Refinement: The program was then refined in consideration of practical realities that limit the ability to meet the desired performance and level of service everywhere in the subcatchment such as: ,

- in some cases, the City would need to exceed the maximum desired right of way pipe sizes (1800 mm diameter),
- in some cases, the cost of implementing the full level of service is high relative to the overall benefit provided, or
- in some cases, upstream improvements could transfer a problem further downstream, such as with Fonthill Creek, where properties along the receiving watercourse may be affected by increased peaks caused by drainage improvements upstream.

The program was also refined through the evaluation of opportunities to reconfigure the drainage system in some areas, including diversions and relief sewers where a significant overall improvement could be made.

Stage 3 Risk Prioritization: The refined program was then presented to the technical team and the City developed three (3) risk categories for the properties as follows:

High Risk Properties: Properties where the 10 - year or lesser AES storm hydraulic grade line in the storm sewer is at the street level.

Medium Risk Properties: Properties where the 25 - year or lesser AES storm hydraulic grade line in the storm sewer is at the street level.

Low Risk Properties: Properties where the 100 - year or lesser AES storm hydraulic grade line in the storm sewer is at the street level.

The recommended flood improvement program generally consists of the refined stage 2 program projects that service the areas that are categorized as high risk.

A Private Plumbing Protection Rebate program is being implemented in the City in locations where the desired level of service in the drainage system cannot be met economically. This report identifies properties that can be targeted for this program. Affected properties are recommended to implement back flow protection measures on both the sanitary and the storm systems.

Program Costs

Program costs are given in 2019 dollars. The Markham Village Recommended Program cost summary is given below:

	Construction Estimate	10% Engineering	40% Contingency	Total
Exhibition East Subcatchment	$21.7 M	$2.2 M	$8.7M	$32.6M
Fincham Subcatchment	$6.3 M	$0.6 M	$2.5 M	$9.4 M
Church, Paramount and Main Subcatchments	$8.5 M	$0.9 M	$3.4 M	$12.8M
Tuclor East Subcatchment	$16.3 M	$1.6 M	$6.5 M	$24.5M
Friar Tuck Subcatchment	$3.3 M	$0.3 M	$1.3 M	$4.9 M
Milne Subcatchment	$0.7 M	$0.1 M	$0.3 M	$1.0 M
Rouge Subcatchment	$1.8 M	$0.2 M	$0.7 M	$2.7 M
Willowgate Subcatchment	$0.0 M	$0.0 M	$0.0 M	$0.0 M
Christman Court Subcatchment	$0.0 M	$0.0 M	$0.0 M	$0.0 M
Reeve Drive Subcatchment	$0.0 M	$0.0 M	$0.0 M	$0.0 M
Walkerton Subcatchment	$0.0 M	$0.0 M	$0.0 M	$0.0 M
Windridge Subcatchment	$0.0 M	$0.0 M	$0.0 M	$0.0 M
John Lyons Subcatchment	$0.1 M	$0.0 M	$0.0 M	$0.1 M
Markham Village Storm Program	**$58.4M**	**$5.8M**	**$23.4M**	**$87.7M**

The Unionville Recommended Program Cost Summary is given below:

	Construction Estimate	10% Engineering	40% Contingency	Program Costs
UV1 Subcatchment	$0.0 M	$0.0 M	$0.0 M	$0.0 M
UV2 Subcatchment	$0.0 M	$0.0 M	$0.0 M	$0.0 M
UV3 Subcatchment	$3.5 M	$0.3 M	$1.4 M	$5.2 M
UV4 Subcatchment	$0.3 M	$0.0 M	$0.1 M	$0.5 M
UV5 Subcatchment	$5.1 M	$0.5 M	$2.1 M	$7.7 M
UV6 Subcatchment	$1.1 M	$0.1 M	$0.5 M	$1.7 M
UV7 Subcatchment	$0.0 M	$0.0 M	$0.0 M	$0.0 M
UV8 Subcatchment	$0.0 M	$0.0 M	$0.0 M	$0.0 M
UV9 Subcatchment	$1.7 M	$0.2 M	$0.7 M	$2.6 M
UV10 Subcatchment	$0.0 M	$0.0 M	$0.0 M	$0.0 M
Unionville Storm Program	$11.9M	$1.2M	$4.7M	$17.8M

The Markham Village and Unionville Sanitary Program cost summary is given below:

	Construction Estimate	10% Engineering	40% Contingency	Program Cost
Unionville Sanitary Improvements	$7.4 M	$0.7 M	$3.0 M	$11.1M
Markham Village Sanitary Improvements	$14.7 M	$1.5 M	$5.9 M	$22.1M
Total Sanitary Program	**$22.1M**	**$2.2M**	**$8.8M**	**$33.2M**

Summary of Recommendations

1. **Flood Control Program Implementation:** It is recommended that the City proceed with the Markham Village Recommended Storm Program, the Unionville Recommended Storm Program, and the Markham Village Unionville Sanitary Program.
2. **Flood Control Program Used as a Guide:** It is recommended that the Program Documents and Work Packages be considered as a guide for a multi-year implementation program that can continue to be refined through the detailed design process, and as new information comes to light.
3. **Implementation Timeframe:** The program can be implemented in a multi-year program over 7-20 years. The City can elect to implement on an accelerated schedule or extend it over a longer period.
4. **Program Cost Monitoring and Updating:** It is recommended that the costs provided herein be considered as the initial budget and that the costs be updated and monitored periodically throughout the implementation process to account for regulatory changes, construction cost changes, changes in the scope of the program work packages.
5. **Integrate with Other Community Infrastructure Projects:** It is recommended that the City consider integrating the Flood Remediation Program works with other community infrastructure projects where economies of scale can be identified. This includes life-cycle renewal of storm, sanitary and watermain infrastructure, asphalt renewal, streetscaping projects, Stormwater Quality or LID initiatives, and Parks and Open Space systems.
6. **Seeking Funding Partnerships:** It is recommended that the City seek funding partners to share in the cost of implementing the Flood Control Program noting that the flood control program is economically justifiable based on insurance claims reduction, improved public safety, improved resilience of community infrastructure.
7. **Continued Sanitary Inflow and Infiltration Monitoring:** It is recommended that the City continue with its Sanitary Inflow and Infiltration Program involving both I/I reduction efforts and performance monitoring (Sanitary Flow and Rainfall Monitoring).
8. **Promote Roof Downspout Discharge to Surface:** It is recommended that the City continue to support best practices of roof leader discharges to surface in Markham Village and Unionville through education efforts, and development

controls on infill developments or new building permits. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

9. **Targeted Backflow Prevention Monitoring:** It is recommended that the City encourage residents in identified risk areas to have their home's foundation drainage system evaluated and to implement backflow prevention if they are connected to the storm or sanitary system.

10. **On-Going Maintenance:** The flood control program does not include funding for on-going maintenance activities. It is recommended that the City maintain key elements of the drainage system such as driveway culvert inspections, maintenance at the Anderson Subcatchment Storm inlet, key storage facilities including those in Village Park, Mintleaf Park and Fincham Park, maintenance of key overland flow routes such as the one on John Lyons Drive.

1.0 INTRODUCTION

1.1 Background

Urban storm drainage standards have undergone significant evolution since settlement in the City of Markham. New developments built after the mid 1980's have been designed and built to a robust standard that provides a minor and major storm conveyance system providing a high level of protection to buildings under significant events.

The City of Markham experienced three (3) significant storm events in June and July 2017 that resulted in 350 reports of flooding throughout the Markham Village and Unionville Areas.

Drainage infrastructure varies within the study areas in many aspects such as:

- Roads a mix of rural (ditches) and urbanized (curb & gutter) cross-sections;
- Some rural sections also have storm sewers;
- Some roads have underground creeks encased in large shallow culverts running within the road right-of-way;
- Storm sewer outlets are not consistently at an elevation level sufficiently high to allow for free flow to the receiving waters;
- Major and minor drainage systems are sometimes insufficiently sized to convey design storms;
- Some homes have foundation drains connected to storm sewers, others to the sanitary sewers, and others are connected elsewhere;
- Trunk sewers are sometimes located on private property where the City has no easement or property rights to maintain;
- Some road systems have low points with no overland flow outlets; and
- A major creek system / urban drainage receiving system is situated in a series of backyards across multiple private properties.

1.2 Purpose

In response to the storm events, the City has recognized the need for a comprehensive approach to dealing with the risks of flooding in the areas of Markham Village and Unionville (the study areas). The City of Markham retained R.V. Anderson Associates

Ltd. (RVA) to evaluate the urban flooding dynamics in study areas. The study addresses flooding from the sanitary system and in the storm drainage system.

The objectives of this report are as follows:

1. Provide a clear planning document to allow for the implementation (financial planning, regulatory approvals, design and construction) of the flood remediation program in Markham Village and Unionville over the coming years; and
2. Document the study process and rationale for developing the program.

1.3 Scope of Study

Storm Drainage System

The scope of the study includes:

- Urban drainage system characterization through the development and validation of dual drainage storm system models for the study areas in partnership with the City;
- Development of a standard criteria for identifying flood vulnerable properties and infrastructure in the study areas;
- Development of a standard level of service criteria for remediating flood vulnerabilities identified in the study areas;
- Development of a standardized flood remediation program that meets the level of service for the flood vulnerable areas;
- Refinement of flood remediation program to optimize the infrastructure investment by evaluating major and minor system flow split opportunities, and storm sewer system re-configuration (rather than simple pipe upgrades);
- Prioritization of works in the program to service high risk areas as defined by the City; and
- Identify opportunities for incorporation of green infrastructure / LIDs into the flood remediation solutions.

Sanitary Collection System

The scope of the study includes:

- Sanitary Collection System Characterization through the validation of an existing sanitary system model for the study areas;

- Development of a standard level of service criteria for operating the sanitary sewer system; and
- Development of a sanitary sewer improvement program that meets the level of service.

1.4 Limitations

Hydraulic Models

The hydraulic models are an attempt at simulating a complex real-world scenario to evaluate the behaviour of rainfall, and run-off in the study areas and to identify flood vulnerabilities. The real-world scenario is not the same as what is in the model. It is not possible to simulate all the factors that would happen in a real-world meteorological and drainage response event that may lead to flooding. The drainage systems themselves are dynamic in nature as they change over time when roads get built, pipes get blocked, homes modify their plumbing/grading, etc.

A fully accurate calibration of the storm model is not reasonably possible. This would require the collection of site-specific data for multiple storm events in many locations. The data would need to be of sufficient quality to observe, quantify and relate actual rainfall distribution within each subcatchment and the flow response at various points in the system. Collection and analysis of the site-specific data can at best suggest a general validation of a modelled rainfall response. It does not provide an absolute representation of the physical system. The models developed in this study did not benefit from site specific flow data correlated with rainfall data for any events.

Design Storms and Performance Predictions

The system evaluation and level of service performance is based on design storms that are synthetic and developed by others. The synthetic design storms are generated by statistical regression type predictions. Recurrence interval terminology, for example “100-year AES storm”, is based on data for South Central Ontario and it is not specific to the subcatchments in the study areas. Actual rainfall events that occur in the study area will differ from the design storms. Actual storm intensity-durations may occur at greater or lesser intervals than implied by the name of the synthetic storm.

The model predicted performance / level of service is not an absolute solution to flood risks. The solutions provide practical means of reducing the overall risk, they do not eliminate all risks of flooding.

Program Cost Estimate

The program cost estimate is based on the conceptual improvements' configurations given in the work packages, as well as recent construction cost information for similar work in the Markham area. The construction costs are provided in 2019 dollars as a baseline year, actual costs may vary due to general inflation, seasonal variations, labour and construction material market fluctuations, government regulatory changes, changes from concept to implementation, etc.

Flood Report Data

Since 2002, the City of Markham has compiled historical flood reports into their GIS system to facilitate a temporal and spatial analysis of the data. This information is summarized in **Section** 3.0. These records have several limitations including the following:

- Not every property owner that has experienced flooding notified the City of Markham;
- The flood records do not necessarily identify the type of flooding (e.g. basement flooding, surface flooding);
- The flood records do not necessarily quantify the severity of flooding (e.g. the cost to repair property damage); and
- The flood records do not necessarily identify the cause of flooding (e.g. sanitary sewer back-up; storm sewer back-up; blockages in laterals, main sewer, catch basins or culverts; reverse grade driveway; poor grading around house; flooded window wells; cracked walls or floors in basement).

2.0 STUDY AREAS

2.1 Storm Drainage System Overview

The storm systems are split into two study areas known as Markham Village and Unionville.

Markham Village is a 691 ha urban area that is evaluated as twenty-one (21) distinct subcatchments for the purpose of drainage infrastructure planning.

Unionville is a 304 ha urban area that is split into ten (10) subcatchments for the purpose of drainage infrastructure planning.

An overview of the subcatchments and drainage areas is given in **Figure 2-1** and **Figure 2-2**.

2.2 Creeks

The entire area falls within the Rouge River Watershed and is within the jurisdiction of the Toronto Region Conservation Authority (TRCA). TRCA provides hydraulic models for the Creeks and Rivers. The hydrfigure

aulic information for the Creeks and Rivers provides the basis for establishing the receiving water levels for the urban drainage systems.

The following creek and river systems run through the study area.

Markham Village

- Mount Joy Creek;
- Milne Creek;
- Robinson Creek; and
- Rouge River.

Unionville

- Fonthill Creek;
- Bruce Creek;
- Berczy Creek; and
- Rouge River (Branch South of Unionville).

Creeks are shown in **Figure 2-1** and **Figure 2-2**..

Figure 2-1 Markham Village Overview

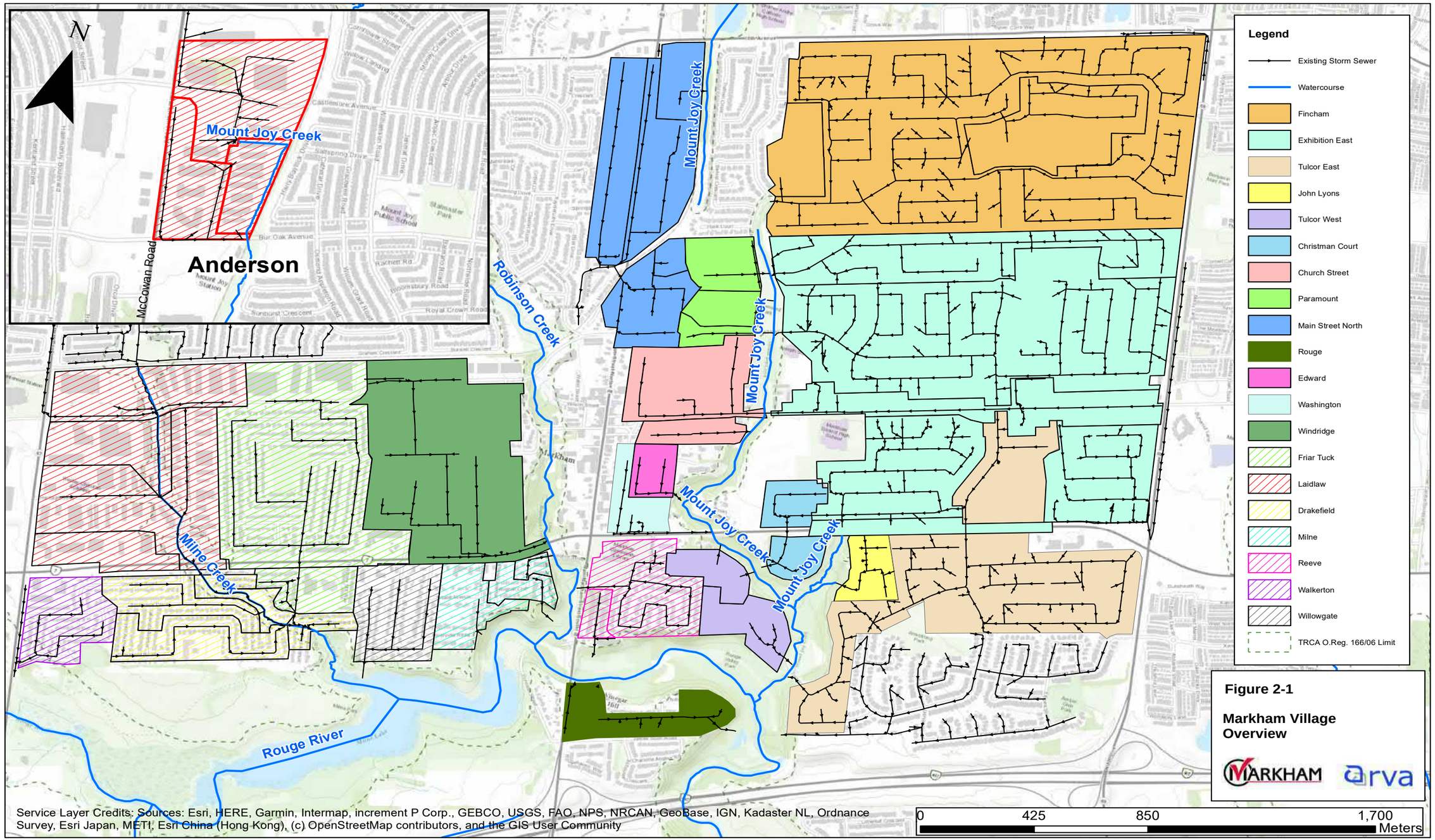
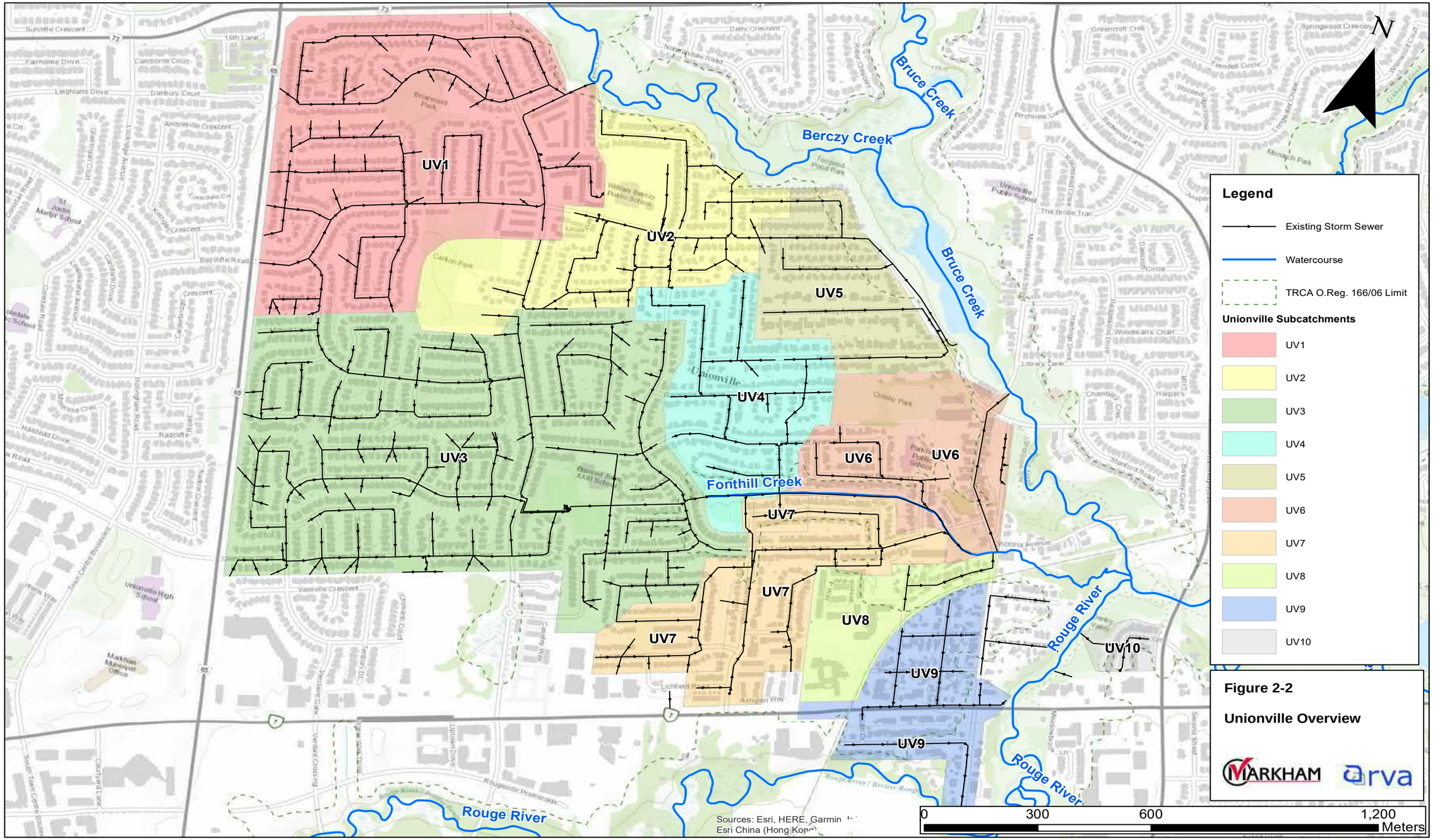


Figure 2-2 Unionville Overview



2.3 Markham Village and Unionville Sub-Catchments

General descriptions of the subcatchments are provided in **Table 2-1**, **Table 2-2**, and **Table 2-3**. Additional details on the existing conditions are provided in Section 4.0.

Two important factors in the dynamics of the urban drainage system affecting residential areas are:

- Roof drainage – Is roof drainage directed to the ground surface? Is it directed below ground to a house foundation drain?
- Foundation drainage – Is the house foundation drain connected directly to a sanitary sewer, a storm sewer or to a surface ditch, swale or ravine via gravity or pumping?

Accurate information of these two factors on a property-by-property basis is only partially complete and changing within MV and UV. For the purposes of developing the storm drainage model, multiple sources of information were provided including CCTV inspection reports/videos, roof downspout surveys and as-constructed drawings. The model development used the best available information to assign the percentage of roof downspouts in each local catchment that are directly connected to the storm sewer system.

The “existing conditions” model assumptions for roof connectivity and foundation drain connections for Markham Village East and Unionville are presented in *Model Development Process Summary (Cole Engineering 2019)* and in the *Unionville Roof Connectivity Assumption Figure – June 2019* both of which are included in **Appendix D** of this report.

Table 2-1 Markham VIllage East Subcatchments

Subcatchment	Size	Land Use	Year of Construction	Drainage System	Roof Downspout Connections	Storm Private Drain Connections
Fincham	122 ha	Residential	1980	Urban roads with curb and gutter, CB and STM sewers, Major flow controlled storage in City Parks	Survey indicates over 80% of roofs directed underground	More than 80% foundation drains connected
Paramount	11 ha	Residential, schools, parks, worship, commercial	Before 1972	Urban roads with curb and gutter, CB and STM sewers	Survey indicates a mix with different streets ranging from 8% to 77% of roofs directed underground	Foundation drain connections on Paramount Road only
Church	19 ha	Residential, schools, parks, worship, commercial	Before 1972	Urban roads with curb and gutter, CB and STM sewers	Survey indicates a mix with different streets ranging from 0% to 35% of roofs directed underground	Foundation drain connections on Elm Street only
Main	40 ha	Residential, commercial	Before 1972	Urban roads with curb and gutter, CB and STM sewers	Survey information provided only from partial information	Mostly not connected to STM sewers
Tuclor East	54 ha	Residential, small commercial plaza, schools, parks	Before 1978	Urban roads with curb and gutter, CB and STM sewers	Survey indicates a mix with different streets ranging from 0% to 100% of roofs directed underground	Majority of foundation drains connected to STM sewers.
Exhibition East	151 ha	Residential, schools, parks.	Before 1978, mostly before 1972	Urban roads with curb and gutter, CB and STM sewers	Survey indicates a mix with different streets ranging from 0% to 100% of roofs directed underground	As-constructed drawings show some connections to STM sewer.
Milne	11 ha	Low density residential, commercial near Highway #7 and Bullock Drive	Before 1972	Rural cross sections with ditches connected to STM sewers.	Survey indicates a mix with different streets ranging from 15% to 100% of roofs directed underground	Most roads serviced by ditches only
Windridge	44 ha	Low density residential, commercial near Highway #7	Before 1972	Rural cross sections with ditches connected to STM sewers.	Partial Survey Information available only less than 30% of area	Most roads serviced by ditches only
Willowgate	12 ha	Low density residential, commercial near Highway #7	Before 1972	Rural cross sections with ditches and ditch inlet CBs connected to STM sewers.	No Survey information available	Most roads serviced by ditches only - some foundations connected
Rouge	11 ha	Low density residential.	Before 1972	Urban roads with curb and gutter, CB and STM sewers	Survey indicates a mix with different streets ranging from 0% to 100% of roofs directed underground	Houses along south side of Rouge between Schouten & Magill have STM laterals
Christman Court	8 ha	Low density residential.	Some before 1978, Some from 1978-1983	Urban roads with curb and gutter, CB and STM sewers	Survey indicates a mix with different streets ranging from 0% to 100% of roofs directed underground	Storm connections on North side of Highway #7
Reeve	15 ha	Low density residential with a school, parkland and community facilities.	Phase 1: 1979 - 1983; Phase 2: 1996-2004	Urban roads with curb and gutter, CB and STM sewers	Survey indicates a mix with different streets ranging from 25% to 100% of roofs directed underground	Shared dual PDCs (one per two houses)

Subcatchment	Size	Land Use	Year of Construction	Drainage System	Roof Downspout Connections	Storm Private Drain Connections
John Lyons	5 ha	Residential	After 1980	Urban roads with curb and gutter, CB and STM sewers	Survey indicates a mix with different streets ranging from 0% to 53% of roofs directed underground	Properties have dual storm drainage laterals
Tuclor West	11 ha	Residential	Before 1972	Rural cross sections with ditches and ditch inlet CBs connected to STM sewers. Billy Joel Crescent and Tuclor Lane served by urban cross sections with curb and gutter.	Survey indicates a mix with different streets ranging from 0% to 47% of roofs directed underground	Most roads serviced by ditches only - some foundation drains connected
Edward / Washington	8 ha	Residential and commercial	Before 1972	Urban roads with curb and gutter, CB and STM sewers	Survey indicates a mix with different streets ranging from 0% to 53% of roofs directed underground	No Information
Anderson	20 ha	Commercial and institutional	Before 1985	Urban roads with curb and gutter, CB and STM sewers	No survey information	Commercial roofs drain to surface

Table 2-2 Markham Village West Subcatchments

Subcatchment	Size	Land Use	Year of Construction	Drainage System	Roof Downspout Connections	Storm Private Drain Connections
Walkerton	14 ha	Residential and commercial.	Before 1972	Urban roads with curb and gutter, CB and STM sewers	No survey Information	No connections
Friar Tuck	55 ha	Residential and commercial.	Before 1972	Urban roads with curb and gutter, CB and STM sewers	No survey information	Parts connected to STM sewers.
Laidlaw	54 ha	Industrial, commercial.	Before 1972	Urban roads with curb and gutter, CB and STM sewers	No survey information - Commercial area would not have deep basement foundations	Commercial roofs drain to ground surface
Drakefield	25 ha	Residential, school.	Before 1972	Urban roads with curb and gutter, CB and STM sewers	No survey information	No storm laterals

Table 2-3 Unionville Subcatchments

Subcatchment	Size	Land Use	Year of Construction	Drainage System	Roof Downspout Connections	Storm Private Drain Connections
UV1	61 ha	Residential, Briarwood Park, portions of Carlton Park	1970-1978	Urban roads with curb and gutter, CB and STM sewers	Mixed rate of 63% connection to STM sewers	All buildings have foundation drains connected to STM sewers
UV2	31 ha	Residential, William Berczy Public School, portions of Carlton Park	1970-1995	Urban roads with curb and gutter, CB and STM sewers	Mixed rate of 63% connection to STM sewers	All buildings have foundation drains connected to STM sewers
UV3	69 ha	Residential, Blessed John XXIII School property, Village Park.	1970-1995	Urban roads with curb and gutter, CB and STM sewers	Mixed rate between 0% to 100% connection to STM sewers	All buildings have foundation drains connected to STM sewers
UV4	22 ha	Residential, Toogood park.	1970-1995	Urban roads with curb and gutter, CB and STM sewers	Mixed rate between 0% to 100% connection to STM sewers	All buildings have foundation drains connected to STM sewers.
UV5	19 ha	Residential	1965 - 1995	Urban roads with curb and gutter, CB and STM sewers	Mixed rate of 63% connection to STM sewers	Some buildings have foundation drains connected to the STM sewers.
UV6	23 ha	Residential, commercial, low lying wetland	mid 1960's	Urban roads with curb and gutter, CB and STM sewers	Mixed rate of 63% connection to STM sewers	No storm drains present.
UV7	49 ha	Residential, parts of Blessed John XXIII School property	1970- 1995	Urban roads with curb and gutter, CB and STM sewers	Mixed rate between 0% to 100% connection to STM sewers	All buildings have foundation drains connected to STM sewers
UV8	10 ha	Residential	before 1970	Urban roads with curb and gutter, CB and STM sewers	Mixed rate of 63% connection to STM sewers	Likely that most foundation drains are connected to STM sewers.
UV9	17 ha	Residential, commercial along HWY7	before 1970, some area in 1978	Urban roads with curb and gutter, CB and STM sewers	Mixed rate of 63% connected, 2% south of HWY7	Little to no confirmed storm drains.
UV10	2.5 ha	Residential	1979 to 1983	Urban roads with curb and gutter, CB and STM sewers	0% connected	All buildings have foundation drains connected to STM sewers.

2.4 Sanitary Collection System

The sanitary collection system is described in a separate report, the *Sanitary Model Modelling Report (Cole Engineering, February 2021)* included in **Appendix C2**.

3.0 FLOOD RECORDS

Since 2002, the City of Markham has compiled historical flood reports into their GIS system to facilitate a temporal and spatial analysis of the data. A summary table of the Flood Records is provided in **Table F1** (**Appendix F**). Detailed maps showing the subcatchments with the highest concentration of flood calls are also provided in Figures **F1**, **F2**, **F3** and **F4** (**Appendix F**). Locations of the flood calls are also shown on the system performance figures in **Appendix A3** (Markham Village – System Performance Figures) and **Appendix B3** (Unionville – System Performance Figures)

There are 318 records for Markham Village and 53 records for Unionville for a total of 371 records from which the following observations are made:

- Over 50% of the records were related to the storm that occurred on July 16, 2017 – the rainfall intensity during this storm approached 100-year return period for durations ranging from 2 hours to 6 hours;
- There was only one property owner in Unionville that reported flooding in July 2017 as would be expected since the storm that occurred on July 16, 2017 was centred over Markham Village and not Unionville;
- Excluding the 2017 flood records, the annual number of records ranged from “0” in 2015 and 2016 to 29 in 2013 with an average of 11 records/year over this 15-year period;
- There were only 10 property owners that reported flooding on August 19, 2005 and this is not surprising since the centre of that storm generally traversed across the south end of Markham;
- Although there were 156 records for the period from 2002 to 2015 (excluding August 2005), this equates to an average of 11 records per year over this 14-year period and the records are distributed throughout the various sub-catchments. Apart from the storms on August 19, 2005 and July 16, 2017, Unionville was the only subcatchment that had multiple flood records with 20 properties reporting flooding during five (5) months between 2012 and 2017 (i.e. an average of four (4) records per month);

- One-third of the records dating back to 2002 were for properties within the Exhibition East Subcatchment. Over one-half of the records for July 2017 were from this same subcatchment;
- Four (4) other subcatchments included at least 10 records related to the storm on July 16, 2017, namely: Fincham, Friar Tuck, Tuclor East and Paramount;
- Six (6) of the subcatchments in Markham Village did not report any flooding on July 16, 2017 and four (4) other subcatchments had only one flood record each. In other words, one-half of the subcatchments in Markham Village had less than two (2) reports of flooding during this storm and considering the intensity of this storm, it can be concluded that the risk of flooding in these subcatchments is minimal; and
- Although there are only 53 records of flooding in Unionville, it should be noted that there has not been a major storm recorded over this area since 2002. If the storm that occurred on July 16, 2017 was centred over Unionville, it is possible that more flooding would have been reported in this area.

Noteworthy clusters of flooding are observed as follows:

Exhibition East

Clusters of flooding are apparent near the intersection of Ramona Boulevard and Brookfield Court; along Church Street; on Jack Court; on Judy Court; on Sir Lancelot Drive east of the intersection with Sir Pellias Terrace; and on Sir Lancelot Drive north of Merlin Gate – please refer to **Figure F1.**

There is a sag in the road profile of Sir Lancelot Drive at the intersection with Sir Pellias Terrace and this likely contributed to the flooding at this location.

Flood records from June and July 2017 indicated that virtually all of the calls were noted as “sewer backup” and that they were related to the July 16, 2017 rainfall event.

Fincham

It is noted that 10 houses along the West end of Daniel Court reported flooding – refer to **Figure F2**. A review of the as-built drawings suggests that any surcharging of the storm sewer on Enos Gate and Fincham Avenue (between Enos Gate and the outfall) would result in basement flooding in the houses located at the west end of Daniel Court.

Flood records from June and July 2017 indicated that virtually all of the calls were noted as “sewer backup” and that they were related to the July 16, 2017 rainfall event.

Friar Tuck

Twelve (12) houses reported flooding – refer to **Figure F3.** This flooding is likely attributed to an interconnection (referred to as a "jumper" pipe) between the storm sewer and sanitary sewer in the intersection of Robinson Street and Friar Tuck Road. When the storm sewers in this intersection surcharged sufficiently, stormwater overflowed into the sanitary sewer and this likely resulted in surcharging of the sanitary sewer to a level that resulted in basement flooding along Friar Tuck Road.

Following the storm on July 16, 2017, the City of Markham blocked the jumper pipe to prevent stormwater from overflowing into the sanitary sewer system.

Flood records from June and July 2017 indicated that virtually all of the calls were noted as "sewer backup" and that they were related to the July 16, 2017 rainfall event.

Paramount Road

Six (6) houses in the northerly portion of the subcatchment (i.e. along the west side of Paramount Road) reported flooding – refer to **Figure F4**.

Flood records from June and July 2017 indicated that virtually all of the calls were noted as "sewer backup" and that they were related to the July 16, 2017 rainfall event.

4.0 DESCRIPTION OF EXISTING DRAINAGE SYSTEMS

4.1 Storm Drainage Systems

Each of the storm drainage systems has its own characteristics in terms of governing topography, age, land use, receiving waters and surface imperviousness and overland flow path that is in many areas governed by the road network. The sub-sections below describe the critical parameters that made differences for providing flood protection solutions in the Markham Village and Unionville areas.

Refer to **Appendix A3-1** and **Appendix B3-1** for an overview of the simulated “existing conditions" system performance. The areas where deficient performance was identified are further assigned a risk level (High, Medium, Low) as described in **Section 9.4.** Please refer to the risk maps in **Appendix A4** and **Appendix B4**.

4.1.1 MV East – Fincham

The Fincham Subcatchment Area is a 122 ha subcatchment that was developed in the early 1980s. The land use is primarily residential with some parks and schools.

Drainage infrastructure in the Fincham subcatchment is generally within urban road cross sections (curb and gutter) with the minor system consisting of catchbasins and storm sewers.

Minor Storm Drainage System (Sewers)

This Subcatchment has a single storm sewer outlet to the upper reach of Mount Joy Creek at Fincham Avenue across from Fincham Park.

Major Storm Drainage System (Overland)

The overland flow system incorporates storage in Mintleaf Park and Fincham Park. This storage is incorporated in the existing conditions model. Overland flow in the Fincham subcatchment is generally continuous within the roadway with surface outlets to Mintleaf Park, Fincham Park and Mount Joy Creek. There are a few noteworthy low spots as follows:

- Daniel Court: Low spot at West end of cul-de-sac with no suitable overland flow route – note that an easement was secured between two homes in this location however an overland flow route does not exist within the existing grades;
- Fry Court: Low spot at east end of cul-de-sac with an overland flow route to Ninth Line;

- Celebrity Place: Low spot at west end of cul-de-sac with no suitable overland flow route;
- Heisy Drive (Near 8-10 Heisy Drive): Low spot in the road way with overland flow to Fincham Park via an existing walkway;
- Tilman Circle (Near 20-24 Tilman Drive): Low spot in the roadway with overland flow to Mintleaf Park via an existing overland flow route; and
- Eastwood Crescent (Near 65-67 Eastman Crescent): Low spot in the roadway with overland flow to Mintleaf Park via an existing overland walkway.

Overland flows may collect in these low spot locations and generate higher than desirable overland ponding depth that can cause flooding concerns and therefore were investigated further during the solution design stage. The model indicated that ponding in these areas typically does not significantly exceed a depth of 30 cm.

Roof Downspout Connectivity

The available information suggests that 80% of the roofs have direct connections to storm sewers.

Private Drain Connections (Foundation Drains)

The available information suggests that 80% of properties have foundation drains connected to storm sewers.

Existing Performance and Flood Risk

The Westerly portion of Daniel Court was particularly affected by the July 16, 2017 storm event as described in **Section** 3.0.

The Fincham Subcatchment “existing conditions” storm drainage model indicates system vulnerabilities throughout most of the area with exception of Lehman Crescent and Celebrity Place.

The risk prioritization (as described in section 9.4) identifies the following areas as high risk:

- Bryant Road (West Leg) and Hallam Road;
- Larkin Avenue (Westerly portion from 6-26 Larkin Avenue); and
- Fincham Avenue (Near Follett Court from 152-168 Fincham Avenue).

Due to the flooding records as discussed in **Section** 3.0, the area of Daniel Court West of Enos Gate is also considered a priority area despite meeting only the medium risk criteria.

4.1.2 MV East – Paramount/ Main Street North/ Church Street West

The Paramount, Main and Church Street West Subcatchments are three (3) subcatchments of 11 ha, 40 ha, and 19 ha that are described together as the solutions considered were interdependent. Land use in the three (3) subcatchments includes residential, schools, parks, places of worship and commercial areas. The entire area was developed prior to 1972.

Drainage infrastructure in the subcatchments are within urban road cross sections (curb and gutter) with the minor system consisting of catchbasins and storm sewers.

The Church and Paramount subcatchments encompass a large residential area between Markham Road/Main Street and Mount Joy Creek North of Highway 7 and South of 16th Avenue. The area also has some commercial and some institutional land-use.

Minor Storm Drainage System (Sewers)

Main Street North Subcatchment

The Main Street North subcatchment has two outlets as follows:

- Mount Joy Creek Outlet at Deer Park Lane; and
- Robinson Creek Valley outlet through a storm sewer in the rear yards of the homes on the East side of Snider Drive.

This area is serviced by a single storm sewer system that outlets to the Robinson Creek Valley. This storm sewer system is deficient from an operations perspective in terms of material and accessibility as it traverses private properties in back yards. Maintenance of this storm sewer requires coordination with over 20 property owners and access to many fenced-off areas.

Paramount and Church Subcatchments

The storm sewer systems in Paramount and Church Subcatchments have four (4) outlets to Mount Joy Creek as follows:

- Ramona Boulevard Mount Joy Creek Crossing storm sewer outlet;
- Storm sewer outlet to the East of the Strathroy and Paramount Intersection;
- Parkway Avenue and Mount Joy Creek Crossing storm sewer outlet; and
- Church Street and Mount Joy Creek Crossing storm sewer outlet.

Major Storm Drainage System (Overland)

The Main Street North Subcatchment is roughly divided by the Metrolinx corridor with overland flow concentrating at local low spots as follows:

- Beech Street; and
- Main Street and Ramona Boulevard.

Any overland flow that cannot be captured by the storm sewer at Beech Street runs along Marmill Way, a private property condominium driveway. Overland flow from Main Street and Ramona Boulevard spills to Robinson Creek via the GO Station lands and the railway corridor via a ditch system along the railway.

The Northern portion of the Main Street North subcatchment drains to Mount Joy Creek via overland flow and a storm sewer system with an outlet at the easterly terminus of Deer Park Lane. Overland flow is continuous within the right ‘of’ way to this point.

Paramount and Church

Overland flow for the Church and Paramount subcatchment road rights ‘of’ ways is generally continuous and directed overland to Mount Joy Creek in a similar alignment as the storm sewer system with outlets as follows:

- Ramona Boulevard Mount Joy Creek Crossing storm sewer outlet;
- Storm sewer outlet to the East of the Strathroy and Paramount Intersection;
- Parkway Avenue and Mount Joy Creek Crossing storm sewer outlet; and
- Church Street and Mount Joy Creek Crossing storm sewer outlet.

An additional overland flow route runs to Mount Joy Creek through a low spot on private property between 3 Elm Street and 65 Joseph Street.

Roof Downspout Connectivity

Available information indicates some of the homes have surface drainage directed underground however most homes to not have foundation drains.

Private Drain Connections (Foundation Drains)

The available information indicates that homes on Paramount Road and Elm Street have foundation drain connections to the storm sewer system.

Existing Performance and Flood Risk

Main Street Subcatchment

The “existing conditions” storm drainage model indicates system vulnerabilities throughout much of the Main Street North Subcatchment as follows:

- **Peter Street** (from Old 16th Avenue to Beech Street);
- **Beech Street** (from Main Street to Peter Street);
- **Main Street** (from Gleason Avenue to the Railway);
- **Wales Avenue** (from approximately 90 m South of Deer Park Lane to the southerly terminus / cul-de-sac of Wales Avenue); and
- **South Side of Railway – Main Street, Parkway Avenue, George Street, Ramona Boulevard and Orchard Street.**

The risk prioritization (as described in section 9.4) identifies most of these areas as "high risk" except for a portion of Wales Avenue.

Church and Paramount Subcatchments

The "existing conditions" storm drainage model indicates system vulnerabilities as follows:

- **Paramount Road** (from Talisman Crescent to Parkway Avenue).

The Paramount Road area was also particularly affected by the July 16, 2017 storm event as described in **Section 3.0**.

The "existing conditions" model also indicates a deficient level of service in other areas as follows, although these areas have limited foundation drain connections to the storm sewer system:

- **Parkway Avenue** (from Orchard Street to Paramount Road);
- **George Street** (from Church Street to North of Franklin Street); and
- **Church Street West** (from Maple Street to George Street).

The City's risk assignment system identified the following areas as "high risk":

- **Paramount Avenue:** Two (2) properties to the South of Ramona Boulevard; and
- **Parkway Avenue** from Strathroy Crescent to Orchard Street.

4.1.3 MV East – Tuclor East

The Tuclor East Subcatchment is a 54 ha subcatchment that was developed prior to 1978. The land use is primarily residential with some small commercial plazas, parks and schools.

The "existing conditions" model includes an external area labeled as "Tuclor South", this area was added to the model to allow the development of a solution to Tuclor East that is integrated with the Tuclor South drainage system.

Minor Storm Drainage System (Sewers)

Drainage infrastructure in the Tuclor East Subcatchment is within urban road cross sections (curb and gutter) with the minor system consisting of catchbasins and storm sewers. This subcatchment has a single storm sewer outlet to the Rouge / Mount Joy Creek at Tuclor Lane.

Major Storm Drainage System (Overland)

Overland flow in Exhibition East is generally continuous within the roadway with the following exceptions / low spots as follows:

- Wooten Way (North of Major Buttons Drive): There is a low spot in the road near 15 Wooten Way South with overland flow that spills over in the roadway at Major Buttons Drive;
- Henry Corson Place near Sherwood Forest Park: There is a low spot in the road with overland flow spilling over into the Sherwood Forest Park low ground;
- John Dexter Place (near 40-42 John Dexter Place): Low spot in the road with spill over through swale on lot line of 39-41 Dexter Place;
- Senator Reesor's Drive (South Leg near 144-116 Senator Reesor's Drive): Low spot in the road with spill over through Senator Reesor's Drive at Cosgrove Road through walkway to Standish Crescent; and
- Senator Reesor's Drive (East Leg near 88-90 Senator Reesor's Drive): Low spot in the road with spill over into private properties – note that this low spot is on the upstream end of the storm sewer system.

Roof Downspout Connectivity

The available information including CCTV inspection conducted in June 2020 indicates that most of the area's roofs have direct connections to storm sewers.

Private Drain Connections (Foundation Drains)

The available information including CCTV inspection conducted in June 2020 indicates that most of the area's buildings have foundation drains connected to storm sewers.

Existing Performance and Flood Risk

The Tuclor East subcatchment Existing Conditions storm drainage model indicates system vulnerabilities throughout most of the Tuclor East subcatchment.

The risk prioritization (as described in section 9.4) identified the areas in the upstream portion of the subwatershed as high risk including the Reesorville Road, John Dexter

Place and Henry Corson Place sewers as well as the James Speight and Captain Armstrong Lane area.

The grades of Senator Reesor's drive are such that land grade is opposite the storm sewer grade.

Despite meeting the high-risk criteria, the area has only 6 flood complaint records from the July 2017 events.

Given that the hydraulic model predicts significant surcharge in the sewer system for low return period frequencies such as the 2-year storm event, further investigations such as verification through flow surveys may be considered to confirm the hydraulic model.

4.1.4 MV East – Exhibition East

The Exhibition East Area is a 151 ha subcatchment. The entire area was developed prior to 1978 while some of the area was developed prior to 1972. The land use is primarily residential with some parks and schools.

Minor Storm Drainage System (Sewers)

This subcatchment has multiple storm sewer systems and outlets as follows:

- Ramona Boulevard Storm Sewer System which outlets to Mount Joy Creek;
- Parkway Drive Storm Sewer System which outlets to Mount Joy Creek;
- Church Street East Storm Sewer System which outlets to Mount Joy Creek;
- Reesorville Storm Sewer System which outlets to Mount Joy Creek via a 1200 mm storm sewer system crossing Highway #7; and
- Rose Way Storm Sewer System which outlets to the York Region Storm Sewer System at 9th Line and Highway #7.

Major Storm Drainage System (Overland)

Overland flow in Exhibition East is generally continuous within the roadway with the following exceptions / low spots as follows:

- Jack Court: Low spot at south end of cul-de-sac with overland flow through private properties towards Reesorville Road;
- Judy Court: Low spot at south end of cul-de-sac with overland flow through private properties towards Reesorville Road;
- Jill Court: Low spot at south end of cul-de-sac with overland flow through private properties towards Reesorville Road;

- Sir Lancelot Drive (corner of Sir Pellias Terrace): Low on Sir Lancelot Drive with overland flow spill-over westerly in Sir Lancelot Drive;
- Church Street East (near 242-248 Church Street East): Low on Sir Lancelot Drive with overland flow spill-over southerly through private property into Rose Way Drainage System;
- Ramona Boulevard (near 162-166 Ramona Boulevard): Low spot in the roadway with spill-over into Reesor Park to the south; and
- Woodside Court: Low spot on the West end of cul-de-sac with no suitable overland flow outlet.

Overland flows may collect in these low spot locations and generate greater than desirable overland ponding depth that can cause flooding concerns and therefore were investigated further during the solution design stage. The model indicated that ponding in these areas typically does not significantly exceed a depth of 30 cm.

Roof Downspout Connectivity

The available information suggests that 80% of the roofs have direct connections to storm sewers.

Private Drain Connections (Foundation Drains)

The available information suggests that 80% of the properties have foundation drains connected to storm sewers.

Existing Performance and Flood Risk

The area was also particularly affected by the July 16th 2017 storm event as described in **Section** 3.0.

Drainage infrastructure in the Exhibition East subcatchment has generally urban road cross sections (curb and gutter) with the minor system consisting of catchbasins and storm sewers.

The Exhibition East Existing Conditions storm drainage model indicates system vulnerability in all four storm sewer subsystems. This includes significant surcharging along the Church Street Sewer, in the Jill Court, Jack Court and Judy Court sewers, the upper portions of the Reesorville storm system, as well as the upper portion of Rose Way.

The risk prioritization (as described in section 9.4) identified the following areas as “high risk”:

- Church Street East;
- Jack Court;
- Jill Court;
- Judy Court;
- King Arthurs Court area Church Street East;
- Sir Lancelot Drive near Sir Pelllias Intersection;
- Sir Pellias Drive;
- Sir Gawaine Place;
- Sir Constantine Place (only 4 properties identified); and
- Rose Way (North section near intersection with Church Street East).

4.1.5 MV East – Milne Lane

The Milne Ssubcatchment is an 11 ha subcatchment that was developed prior to 1972. The land use is primarily low density residential with some commercial land uses on fronting on to Highway #7.

Minor Storm Drainage System (Sewers)

Drainage infrastructure in the Milne subcatchment is based on rural cross sections(ditches) that are connected to storm sewer system outlets with ditch inlet catchbasins. The subcatchment is connected to Robinson Creek in three storm sewer systems as follows:

Milne Lane System: Outlets to Robinson Creek at the corner of Milne Lane and Riverview Road.

Sarah Jane Court System: Outlets to Robinson Creek at the end of the cul-de-sac (South side).

Old Wellington Street: Outlets to Robinson Creek at the Old Old Wellington Street / Robinson Creek Crossing.

Major Storm Drainage System (Overland)

Overland flow follows the alignment of the three storm sewer systems. Overland flow is generally continuous through the right of way with the following exceptions:

- Rear yard drainage for the homes on the North side of Erlane Avenue and commercial properties on the South side of Highway #1; and
- Overland flow in the Milne Lane System at McPhillips Avenue can spill across private property in the southwest quadrant of Milne Lane and McPhillips Avenue.

Roof Downspout Connectivity

Survey indicates a mix with different streets ranging from 15% to 100% of roofs directed underground.

Private Drain Connections (Foundation Drains)

The majority ofMost roads are serviced by ditch systems only.

Existing Performance and Flood Risk

The area has a limited history of flood calls.

The “existing conditions” storm drainage model indicates system vulnerability Milne Lane storm sewer system.

The risk prioritization (as described in section 9.4) identified the following areas as “high risk”, all of which are tributary to the Milne Lane storm sewer:

- Millne Lane;
- Erlane Avenue; and
- Riverview Drive.

4.1.6 MV East – Windridge

The Windridge Subcatchment is an 44 ha subcatchment that was developed prior to 1972. The land use is primarily low density residential with some commercial land uses on fronting on to Highway #7 as well as in the North on Bullock Drive.

Minor Storm Drainage System (Sewers)

Drainage infrastructure in the Windridge Subcatchment has a combination of:

- Rural cross sections (ditches) that are connected to storm sewer system outlets with ditch inlet catchbasins; and
- Urban cross sections.

Storm sewers exist in a portion of Windridge, Hawkridge Avenue, Abercorn Road, Grenfell Crescent and Honeybourne Crescent (Nnorth portion only) do not have any storm sewers they are serviced by ditches that connect to a storm capture system within the Windridge subcatchment.

The Windridge storm sewer system outlets into the York Region system on Highway #7.

Major Storm Drainage System (Overland)

The overland flow system is generally continuous in the ditch systems in the right of way. The overland flow system relies on driveway culverts which require maintenance.

Overland flow from Windridge generally flows to Highway # 7.

Roof Downspout Connectivity

Partial Survey Information was available for this area and shows that only less than 30% of the downspouts are connected to the storm sewer.

Private Drain Connections (Foundation Drains)

Available information indicates that private drain connections to the storm sewers were not initially implemented and that any private drain connections would be an exception rather than the rule.

Existing Performance and Flood Risk.

The existing storm system indicates surcharging under the design storm conditions. Under intense storm conditions it would be expected that the overland flow system (road and ditches) provide a significant portion of the flow.

Storm sewer surcharging could also affect the sanitary sewer system if there were significant cross connections. As described in the sanitary system analysis, a cross connection between the sanitary sewer system and the storm system at Jonquil Crescent and Vanderbilt Road was recently eliminated.

The risk prioritization (as described in section 9.4) has identified many of the areas as “high risk” based on the storm sewer performance. However, as these areas are not known to have foundation drain connections, the risks to buildings may be limited.

4.1.7 MV East – Willowgate

The Willowgate Subcatchment is a 12 ha subcatchment that was developed prior to 1972. The land use is primarily low density residential with some commercial and apartment building land uses on fronting on to Highway #7.

Minor Storm Drainage System (Sewers)

Drainage infrastructure in the Willowgate subcatchment is based on rural cross sections that (ditches) that are connected to storm sewer system outlets with ditch inlet catchbasins.

The subcatchment drains to the Rouge River via a storm sewer system at the end of Willowgate Drive.

Major Storm Drainage System (Overland)

The overland system in this subcatchment follows the roadside ditch system.

Roof Downspout Connectivity

No survey information is available.

Private Drain Connections (Foundation Drains)

Available information suggests very few homes have foundation drain connections.

Existing Performance and Flood Risk

The “existing conditions” storm drainage model indicates system vulnerability on the section of Willowgate Drive to the North of Riverview Avenue.

Although the risk prioritization (as described in section 9.4) identified this area as “high risk” due to the hydraulic grade lines in the storm sewer, very few homes in this area have direct foundation drain connections to the storm sewer system.

4.1.8 MV East – Rouge

The Rouge Subcatchment is an 11 ha subcatchment that was developed prior to 1972. The land use is low density residential.

Rouge Street is on a high ridge that is surrounded by the Rouge River Valley.

Minor Storm Drainage System (Sewers)

Drainage infrastructure in the Rouge subcatchment is based on an urban (curb and gutter) system that is serviced by catchbasins and storm sewers.

The system drains to the Rouge River through a single outlet that includes a corrugated metal pipe (CMP) storm sewer and a concrete headwall.

Major Storm Drainage System (Overland)

The overland flow system on Rouge Street does not have a continuous slope and has three (3) shallow low spots along its Easterly section.

Roof Downspout Connectivity

Survey indicates that a mix with different streets ranging from 0% to 100% of roofs directed underground are being present in the area.

Private Drain Connections (Foundation Drains)

Survey data have indicated that properties along the South side of Rouge between Schouten & Magill have foundation drains connected to storm laterals.

Existing Performance and Flood Risk

The existing conditions storm drainage model indicates system vulnerability on the mid-section of Rouge Street (near the intersection with Schouten Crescent). This area is also categorized as “high risk” by the risk prioritization (as described in section 9.4).

4.1.9 MV East – Christman Court

The Christman Court Subcatchment is an 8 ha subcatchment that includes a subdivision on the North side of Highway #7 developed before 1978, and a subdivision on the South side of Highway #7 developed between 1978 and 1983. Land use in the subcatchment is low density residential.

Minor Storm Drainage System (Sewers)

Drainage infrastructure in the Christman Court subcatchment is based on an urban (curb and gutter) system that is serviced by catchbasins and storm sewers.

Major Storm Drainage System (Overland)

Overland flow in the subdivision to the North of Highway #7 stays within the roadway and concentrates at a low spot on Pringle Avenue (near 9-11 Pringle Avenue) where there are two catchbasins. Any excess overland flow spills over towards Highway #7 via a swale between these two residential dwellings.

Overland flow in the subdivision to the South of Highway #7 concentrates at a low spot on Christman Court (near 25-27 Christman Court). The “existing conditions” drainage model indicates that overland flow ponds in this area at a level greater than 0.30 m.

Roof Downspout Connectivity

Survey indicates a mix of different streets ranging from 0% to 100% of roofs directed below ground.

Private Drain Connections (Foundation Drains)

Storm Connections with foundation drains were surveyed along the north side of Highway #7.

Existing Performance and Flood Risk

The “existing conditions” model does not indicate any vulnerabilities in the minor storm system under a 100 - year AES storm. This area is also not categorized as “high risk" by the risk prioritization (as described in section 9.4).

4.1.10 MV East – Reeve

The Reeve Subcatchment is a 15 ha subcatchment that was developed in two phases. An initial phase East of Torrance Road was constructed between 1979-1983 and a second phase including James Walker Court was constructed between 1996-2004. Houses are generally serviced by shared dual foundation drains (one lateral for two properties).

Minor Storm Drainage System (Sewers)

Drainage infrastructure in the Reeve Subcatchment is based on an urban (curb and gutter) system that is serviced by catchbasins and storm sewers.

The subcatchment has two storm drainage outlets as follows:

Park Outlet: A 900 mm storm sewer that crosses Markham Road via municipal park lands and enters the Rouge Creek Valley.

James Walker Court Outlet: a storm sewer system enters the Rouge Creek Valley via a 450 mm storm sewer at James Walker Court.

Major Storm Drainage System (Overland)

Overland flow in the Reeve Drive Subcatchment is generally continuous and flows through the Road Right-of-Way to an outlet at the South end of James Walker Court where it exits the court towards Markham Road via a walkway.

Roof Downspout Connectivity

As-built information showed that shared dual foundation drains (one per two houses) are present in this subcatchment.

Private Drain Connections (Foundation Drains)

The subcatchment is characterized by shared foundation drains where one sewer connection serves two homes.

Existing Performance and Flood Risk

The “existing conditions” model does not indicate any vulnerabilities in the minor storm system under a 100 - year AES storm. This area is also not categorized as “high risk" by the risk prioritization (as described in section 9.4).

4.1.11 MV East – John Lyons

The John Lyons Drive subcatchment is a 5 ha subcatchment that includes residential homes that were built after 1980.

Minor Storm Drainage System (Sewers)

Drainage infrastructure in the John Lyons Court Subcatchment is based on an urban (curb and gutter) system that is serviced by catchbasins and storm sewers. The storm sewer system outlets to Mount Joy Creek in the same alignment as the John Lyons overland flow route.

Major Storm Drainage System (Overland)

There are two overland flow systems and outlets to Mount Joy Creek as follows:

Captain Armstrong Lane Overland Flow Route: Graded Overland Flow route located between 45 and 47 Captain Armstrong Lane.

John Lyons Road Overland Flow Outlet: At the West Terminus of John Lyons Road, overland flow spills over towards the Creek Valley.

Roof Downspout Connectivity

Survey indicates a mix with different streets ranging from 0% to 53% of roofs directed underground.

Private Drain Connections (Foundation Drains)

Properties in this subcatchment have dual storm laterals, i.e. a single storm lateral is connected to the foundation drains of two homes.

Existing Performance and Flood Risk

The “existing conditions” model indicates some system vulnerabilities in the minor system along Captain Armstrong Drive and along John Lyons Drive. The areas were not categorized as “high risk” risk prioritization (as described in section 9.4).

4.1.12 MV East – Tuclor West

The Tuclor West Subcatchment is an 11 ha subcatchment that includes residential homes that were built before 1972.

Minor Storm Drainage System (Sewers)

Tuclor West is serviced by rural cross-sections (roads and ditches) in a portion of the area (Rougecrest Drive, Paradise Avenue, and Fredericton Road) and by curb gutter and storm sewers in the remainder of the area (Billy Joel Crescent and Tuclor Lane)

The ditch section connects to the storm sewers via ditch inlet catchbasins in 3 locations as follows:

- Rougecrest Outlet #1 - Ditch inlet catchbasin near 20 Rougecrest Drive – connects to 250 mm storm sewer that outlets to Mount Joy Creek;
- Rougecrest Outlet #2 – Ditch inlet catchbasin near #30 Rougecrest Drive – connects to a 600 mm storm sewer that outlets to Mount Joy Creek; and
- Billy Joel Crescent Storm Sewer system DICB Ditch inlet catchbasin at the intersection of Billy Joel Crescent and Fredericton Road that connects to the storm sewer system outletting into Mount Joy Creek at the Tuclor Lane Creek Crossing.

Major Storm Drainage System (Overland)

Overland flow in the Rougecrest Drive ditch system flows to a low spot near 30 Rougecrest Drive. There are two intended easements on either side of the residential building on 30 Rougecrest Drive with overland flow routes connecting to Mount Joy Creek.

Overland flow in the Billy Joel Crescent system flows in the right-of-way curb and gutter to outlet into Mount Joy Creek at the Tuclor Lane Creek Crossing.

Roof Downspout Connectivity

Survey indicates a mix of different streets ranging from 0% to 47% of roofs directed below ground.

Private Drain Connections (Foundation Drains)

Most roads in this subcatchment are serviced by ditches only with some foundation drains connected.

Existing Performance and Flood Risk

The “existing conditions” model does not indicate any vulnerabilities in the minor storm system under a 100 year AES storm. This area is also not categorized as “high risk” by the risk prioritization (as described in section 9.4).

4.1.13 MV East – Edward/ Washington

The Edward and Washington subcatchments are an 8 ha size area that includes residential and commercial homes that were built before 1972.

Minor Storm Drainage System (Sewers)

Drainage infrastructure in the Edward/Washington subcatchments is arranged in an urban cross section with a major system in the road connected to a minor system consisting of catchbasins and storm sewers.

The Edward Street Storm Sewer outlets directly to the Mount Joy Creek Valley. The Washington Street storm system outlets directly to the Highway #7 storm system.

Major Storm Drainage System (Overland)

Overland Flow generally flows North to South in the area outletting to the Highway #7 Right of Way (owned by York Region). There is a minor overland flow outlet through Houghton Boulevard.

Rear Yard Drainage between Albert Street and Jerman Street Homes has no catchbasin system to collect and is understood to outlet via surface at three points as follows:

- Albert Street Right of Way (ROW) near #30-32 Albert Street;
- Jerman Street Right of Way near #23-25 Jerman Street and; and
- Highway #7 Right of Way via the commercial properties at 6060 Highway #7.

Flow in the right of way is continuous to Highway #7.

Roof Downspout Connectivity

Survey indicates a mix of different streets ranging from 0% to 53% of roofs directed below ground.

Private Drain Connections (Foundation Drains)

Information available suggests that there are no foundation drain connections to storm sewers.

Existing Performance and Flood Risk

The existing conditions model indicates some system vulnerabilities in the minor system throughout the subcatchments.

The following areas categorized as high risk as per the risk prioritization (as described in section 9.4).:

- Jerman Street; and
- Washington Street.

4.1.14 MV East – Anderson

The Anderson Subcatchment is approximately 26 ha in size and consists mainly of Industrial, Commercial and Institutional (ICI) properties with large paved surfaces.

The area was developed prior to 1985.

To the north of the developed subcatchment is a rural catchment that also drains into Anderson's storm sewer system. The external area includes a smaller area to the south of Major Mackenzie Drive East and a larger area to the north of this road, totalling approximately 88 ha in size to bring in external inflows. The area is largely located within the regional floodplain.

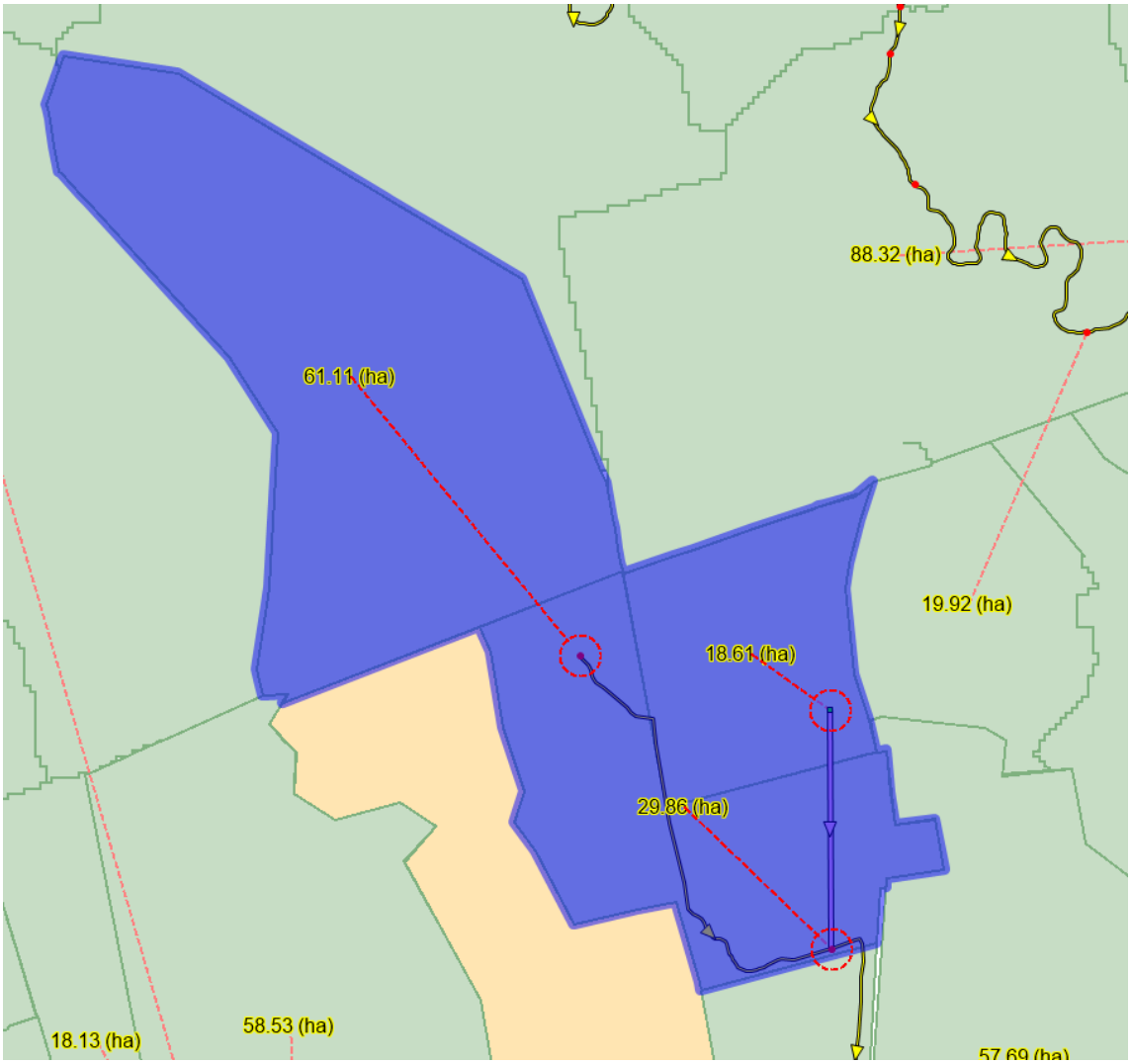


Figure 4-1 External Drainage Area from PCSWMM model - Anderson Subcatchment

Minor Storm Drainage System (Sewers)

To the north of Anderson Avenue, a small watercourse exists that is fed by the external catchment area. An open channel at the downstream end of the watercourse provides some storage capacity to buffer peak flows from the catchment. The model represented the available storage with a storage node from which the piped model starts and into which the external area drains. The watercourse is culverted into twin 1500 mm diameter sewers and runs south along Anderson Avenue.

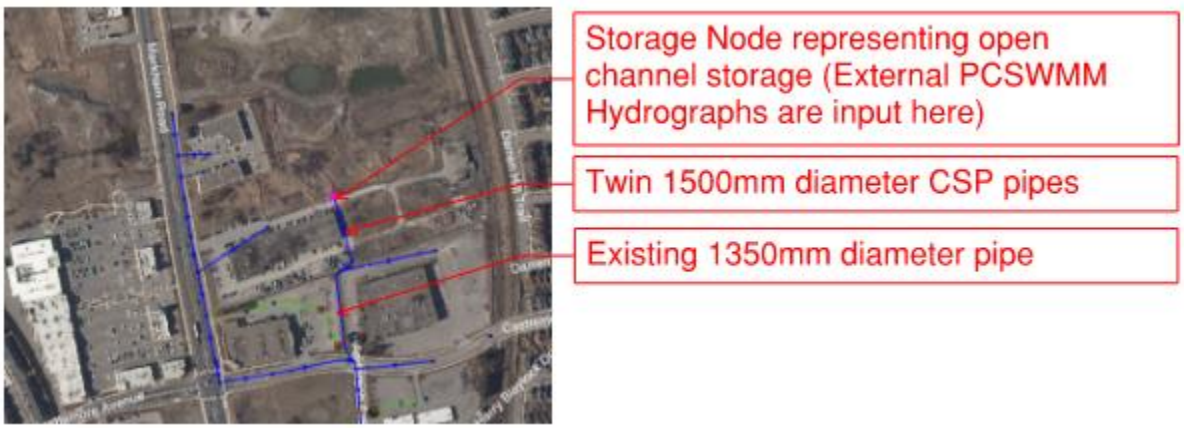


Figure 4-2 Anderson Subcatchment Elements

There are two major outlets to Mount Joy Creek. One outlet is located near property #155 Anderson Avenue where twin 1500 mm diameter CSP sewers outlet into a short ditch section that is overgrown and then inlet through a trash rack into a 1350 mm diameter RCP that further leads to the southeast of the catchment towards the rail line crossing.

The second discharge location is at the Northwest corner of Bur Oak Avenue and a rail line crossing where an 825 mm diameter sewer discharges into a culvert that crosses beneath the rail line.

Major Storm Drainage System (Overland)

The overland system within the Anderson subcatchment follows the roads and the storm sewer system. As discussed in the minor system section, the watercourse has been culverted from north of Anderson Avenue and runs south through the catchment area in pipes.

Roof Downspout Connectivity

Due to the size of the large paved ICI lots, it is assumed that these properties are connected to the storm sewer system.

Private Drain Connections (Foundation Drains)

Based on the type of properties, it is unlikely that there are any basements.

Existing Performance and Flood Risk

External flows were provided from a PCSWMM model (from TRCA) and the main Anderson subcatchment was evaluated as an InfoWorks model. The external inflows into the main Anderson subcatchment were taken from hydrographs from the PCSWMM model. During this process some uncertainties were discovered since the PCSWMM model was provided externally and did not contain initialization files to simulate the soil wetness conditions. Therefore, estimates had to be made that might have introduced a level of uncertainty for the prediction of external inflows to this subcatchment, based on uncertain catchment wetness conditions.

Based on the above information, the “existing conditions” model indicates some system vulnerabilities in the minor system in the following locations:

- Markham Road north of Bur Oak Avenue;
- Markham Road north of Castlemore Avenue;
- Anderson Avenue north of Bur Oak Avenue; and
- Bur Oak Avenue towards outlet at rail line.

The external area drains into a storage node that represents the available storage from an open channel and functions to smooth out some of the peak inflows from the external area. The model shows that in some areas of Markham Road and Anderson Avenue, the overland conveyance system runs at carrying capacity and might flood into areas that are outside of the public ROW such as parking lots and paved private property areas.

The area shows evidence of flooding risk. However, since this area is predominantly industrial and commercial with buildings constructed at above ground elevation without basements, the flood impact is reduced.

Due to the highlighted uncertainties in flows from the hydraulic model, it is recommended that current flooding conditions should be looked at in further detail during future development studies.

4.1.15 MV West – Walkerton

The Walkerton Subcatchment is a 14 ha urban area with residential land use with some commercial use. The area was developed prior to 1972.

Minor Storm Drainage System (Sewers)

Walkerton's storm sewer discharges to a 975 mm storm sewer on McCowan Road via a 600 mm pipe through an easement between 61 and 63 Walkerton Drive.

Major Storm Drainage System (Overland)

Overland flow in the Walkerton subcatchment is continuous within the roadway and concentrates at a low-point in the South-West corner of Walkerton Drive (near houses 61 and 63) where overland flow ponds and eventually enters the storm sewer system via two double catchbasins.

Roof Downspout Connectivity

Available information does not indicate that residential dwellings have storm laterals in the Walkerton subcatchment.

Private Drain Connections (Foundation Drains)

Available information does not indicate that residential dwellings have storm laterals in the Walkerton subcatchment.

Existing Performance and Flood Risk

The "existing conditions" model indicates some system vulnerabilities in the minor system in the following locations:

- Walkerton Drive (from approximately 51-79 Walkerton Drive);
- Southdale Drive (from approximately 85-100 Southdale Drive); and
- Gladiator Road (from approximately 37-41 Gladiator Road).

4.1.16 MV West – Friar Tuck

The Friar Tuck Subcatchment is a 55 ha area. The subcatchment encompasses a large residential and commercial area North of Highway 7 and a smaller residential area South of Highway 7. The residential area North of the highway was developed prior to 1972.

Minor Storm Drainage System (Sewers)

Friar Tuck is serviced by a single storm sewer system, which crosses Highway 7 at Robinson Road. The sewer picks up the storm flow from the Highway. South of the highway, the storm sewer and runs through an easement through the Jolyn Court rear yards and follows the pedestrian walkway to Drakefield Road where it discharges to Milne Creek.

There was a jumper connection between the storm sewer and sanitary sewer at the intersection of Robinson Road and Friar Tuck Road, which was disconnected in 2018.

Major Storm Drainage System (Overland)

Overland flow on the North side of Highway 7 generally flows South, outleting to the Highway 7 right of' way via Robinson Street and via a pedestrian walkway at the south-westerly corner of King Richard Court.

There is a low point near 78 Lincoln Green Drive where stormwater ponds over two double catchbasins. There is no clear overland flow route by which stormwater can escape. Ponding is not expected to exceed 300 mm depth.

There is a low point on Highway 7 and Robinson Street and excess overland flow at this location is expected to spill over into the St. Patrick School parking lot and into rear yard ditches on Jolyn Court, eventually outletting to Drakefield Road via a pedestrian walkway.

South of Highway 7, overland flow within the Bakerdale-Jolyn subdivision flows via the roadways and outlets to Drakefield Road via a pedestrian walkway between 9 and 16 Jolyn Court. Overland flow on Drakefield Road outlets to Milne Creek.

Private Drain Connections (Foundation Drains)

Available information indicates that these homes generally do not have foundation drain connections. The subdivision South of Highway 7 (Bakerdale Road - Jolyn Court) was registered in 1977 and has foundation drain connections to the storm sewer system.

Existing Performance and Flood Risk

The existing conditions model indicates some system vulnerabilities in the minor system in the following locations:

- Robinson Street;
- Friar Tuck Road; and
- Lincoln Green Drive.

Friar Tuck Road was particularly affected by the July 16, 2017 storm event as described in **Section** 3.0.

4.1.17 MV West – Laidlaw

The Laidlaw Subcatchment is a 54 ha size urban area with industrial land use.

The Laidlaw sub-catchment is entirely commercial and industrial land-use with buildings at grade and no basements. Buildings' roof downspouts discharge to the ground – typically to the parking lot, which drains to the storm sewer via catchbasins on private property. Some of the lots have been serviced with flow controls.

There is an overland flow system along the rear lots of properties between Highway #7 and Heritage Road.

Minor Storm Drainage System (Sewers)

Milne Creek is buried in a 1800 mm to 2400 mm diameter concrete pipe from North-West of the Heritage Road and Laidlaw Boulevard intersection, and again South of Highway 7 in the Drakefield subcatchment. The creek was buried during the development of the properties fronting on the West side of Laidlaw Boulevard between Highway 7 and Heritage Road.

Major Storm Drainage System (Overland)

Overland flow on Bullock Drive concentrates at a low point in the roadway near the open portion of Milne Creek where it would spill over into the Creek.

Overland flow on Laidlaw Boulevard concentrates at a low point in the roadway over the buried portion of Milne Creek where it is connected by two double catchbasins and a ditch inlet catchbasin.

The properties on the East side of Laidlaw Boulevard (2-4 Laidlaw) are lower than Laidlaw boulevard itself and have an overland flow outlet to the buried Creek located in a ditch along the 1 Laidlaw / Highway #7 right 'of' way property line.

Roof Downspout Connectivity

Commercial Buildings with slab on grade in this area are assumed to have downspouts connected to the surface.

Private Drain Connections (Foundation Drains)

The commercial buildings do not have basements as such they are not typically subject to sewer backup.

Existing Performance and Flood Risk

The existing conditions model indicates some system vulnerabilities in the following locations:

- Laidlaw Boulevard; and
- Bullock Drive.

As the buildings have no basements and are typically on site plans with drainage directed away from buildings, surcharging of the storm sewer and flow within major overland flow routes have limited potential to cause flooding.

4.1.18 MV West – Drakefield

The Drakefield Subcatchment is a 25 ha urban area with residential land use as well as a public school. The area was developed prior to 1972.

Minor Storm Drainage System (Sewers)

Milne Creek is buried and runs under Drakefield Road for approximately 100 m near Banfield Avenue where it runs through a 2100 mm diameter concrete pipe.

The storm sewer system has four (4) outlets to Milne Creek as follows:

- Easement at 19-21 Bakerdale Road - 300 mm diameter storm sewer which drains to an open section of Milne Creek;
- Drakefield Road – West of Banfield Road - 675 mm diameter storm sewer on Drakefield Road connects to the underground section of Milne Creek.
- Easement at 16-18 Southdale Drive - 525 mm diameter storm sewer drains to an open section of Milne Creek;
- Drakefield Road, East of Banfield Avenue - 525mm diameter storm sewer drains to an open section of Milne Creek.

Major Storm Drainage System (Overland)

Overland flow in the Drakefield subcatchment outlets to Milne Creek at two locations:

- Bakerdale Road Low Point (near 24 Bakerdale Road) - Overland flow ponds over two double catchbasins and eventually leaves the right ’of’ way, discharging to Milne Creek via an overland flow route between 21 and 23 Bakerdale Road.
- Drakefield Road Low Point (East of Banfield Avenue) - Overland flow ponds over two double catchbasins and an inset curb allows for spill into the Milne Creek Valley with minimal attenuation.

Some overland flow outlets to Cosburn Park Woods at the Westernmost point of Drakefield Road. There are two double catchbasins at this location and excess flow spills into Cosburn Park.

Roof Downspout Connectivity

Available information does not indicate that residential dwellings have storm laterals in Drakefield Subcatchment.

Private Drain Connections (Foundation Drains)

Available information indicates that residential dwellings do not have storm laterals in Drakefield Subcatchment.

Existing Performance and Flood Risk

The "existing conditions" model indicates some system vulnerabilities in the following locations:

- Drakefield Road;
- Southdale Boulevard; and
- Gladiator Road.

Despite the modelled flood vulnerabilities, there are relatively few records of flood calls in Drakefield Subcatchment.

4.1.19 Unionville – UV1

The Unionville – UV1 Subcatchment is a 61 ha urban area with residential land use and it includes Briarwood Park and portions of Carlton Park. The subdivisions within this subcatchment were registered between 1970 and 1978. There are approximately 522 residential dwellings in the subcatchment.

Minor Storm Drainage System (Sewers)

The subcatchment consists of storm sewers that follow the road alignments and range in size from 250 mm diameter to 1350 mm diameter. The general catchment drainage direction is to the Northeast boundary of the subcatchment.

The primary storm sewer drainage outlet for UV1 is a 1350 mm diameter storm sewer that runs through a walkway between the rear lots on Rae Crescent and a Townhouse property at #653 Carlton Road. This sewer outlets flows into Berczy Creek.

Major Storm Drainage System (Overland)

The overland flow system is generally continuous draining to three (3) isolated low points within the road right 'of' way as follows:

- Carlton Road low point near # 63/65 Carlton Road – This is a low point that is remote from the subcatchment outlet;
- Briarwood Road low point near # 81/83 Briarwood Road – This is a low point that is remote from the subcatchment outlet; and

- Rae Crescent near #27 Rae Crescent – There is a 900 mm dia. outlet pipe from this low point through an easement that connects to the Berczy Creek outlet. There is no suitable overland flow route in this easement that provides positive drainage from the road to the Creek.

The rear lots of Foxglove Court drain overland to the William Berczy Public School in the UV2 subwatershed. There are catchbasins in the low spot along the lot line of the school and the court intended to receive this drainage.

Roof Downspout Connectivity

Downspout connectivity is assumed to be mixed and was assigned an average of 63% "directly connected" to the storm sewer system in the model.

Private Drain Connections (Foundation Drains)

As-constructed drawings in UV1 indicate foundation drains on all buildings with their connections to storm sewers.

Existing Performance and Flood Risk

The "existing conditions" drainage model indicates that the storm sewer system is surcharged above basement floor elevations (i.e. approx. 1.8 m below ground) under a 25 - year AES storm throughout UV1 with a few exceptions. In fact, the storm sewer system is surcharged to road level in much of UV1.

Furthermore, the model indicates that the storm sewer system surcharges to road level under a 100 - year AES storm throughout UV1 with a few exceptions.

The model indicates that the maximum HGL in the storm sewer system is generally below basement floor levels during a 5 - year AES storm with a few exceptions.

The "existing conditions" model indicates some system vulnerabilities in the minor system throughout the subcatchments.

The following flood risk areas are categorized as either low or medium risk under the risk prioritization (as described in section 9.4) and shown in the risk maps in Appendix B4:

- Briarwood Road;
- Rae Crescent;
- Carlton Road;
- Webber Crescent;
- Braithwaite Road/ Liebeck Crescent;

- Village Parkway; and
- Foxglove Court.

4.1.20 Unionville – UV2

The Unionville – UV2 Subcatchment is a 31 ha urban area with residential land use and it includes the William Berczy Public School as well as portions of Carlton Park.

The subdivisions in this subcatchment were registered between 1970 and 1995. There are 228 residential dwellings in the subcatchment.

Minor Storm Drainage System (Sewers)

The storm sewer system ranges in size from 250 mm diameter to 1050 mm diameter and drains in the North to North-Western direction into Berczy Creek. Whilst the majority of storm sewers follow the road alignments, some cross through private easement properties from cul-de sacs into neighboring streets. The storm sewer in Pennock Crescent has a local high pipe invert near the mid-section of the road with one portion draining into the UV2 subcatchment and the other portion draining into the UV5 subcatchment. High sewer surcharge levels can therefore lead to a flow transfer from one subcatchment to another subcatchment and create an “interconnectivity” that needed to be considered when developing flooding solutions.

Storm drainage is collected in the storm sewer system via two (2) trunk sewers outletting through Pennock Crescent and Goodmills Court and draining into a common outfall (1050 mm diameter sewer) to Berczy Creek.

Major Storm Drainage System (Overland)

The right ‘of’ way overland flow system is generally continuous; draining to five (5) low points within the road right ‘of’ way as follows:

- Chant Crescent near #70 and 72 – isolated low point with no outlet;
- Trumpour Court – isolated low point with no outlet;
- Pennock Crescent and Carlton Road – isolated low point with no outlet;
- Goodmills Court – low point with overland flow to Berczy Creek; and
- Millstone Court – low point with overland flow to Berczy Creek.

The external overland flow drainage from Carlton Park drains via a storm sewer in the parking lot of property #600 Village Parkway (a church) into the storm sewer in Village Parkway. This parking lot is also a local low spot.

Roof Downspout Connectivity

Downspout connectivity is assumed to be mixed and was assigned an average of 63% "directly connected" to the storm sewer system in the model.

Private Drain Connections (Foundation Drains)

As-constructed drawings in UV2 indicate foundation drains on all buildings and their connections to storm sewers.

Existing Performance and Flood Risk

The model indicates that the maximum HGL in the storm sewer system is generally below basement floor levels during a 5 - year AES storm with a few exceptions.

The model indicates that the storm sewer system is surcharged above basement floor levels during a 25 - year AES storm throughout UV2 with a few exceptions.

The model indicates that the storm sewer system surcharges to road level under a 100 - year AES storm throughout UV2 with a few exceptions.

The "existing conditions" model indicates some system vulnerabilities in the minor system throughout the subcatchment.

The following flood risk areas are categorized as either low or medium risk under the risk prioritization (as described in section 9.4).::

- Village Parkway;
- Padget Place;
- Chant Crescent;
- Millstone Court;
- Goodmills Court;
- Fred Varley Drive; and
- Trumpour Court.

4.1.21 Unionville – UV3

The Unionville – UV3 Subcatchment is a 92 ha urban area with residential land use and it includes the Blessed John XXIII School as well as the adjacent Village Park.

The subdivisions in this subcatchment were registered between 1970 and 1995. There are 1005 residential dwellings in the UV3 subcatchment.

Minor Storm Drainage System (Sewers)

The UV 3 subcatchment drains to Fonthill Creek via a complex trunk system in what was once the original Creek bed now enclosed to accommodate urban development. This trunk system includes:

- A storage system with twin 3000 mm W x 1800 mm H concrete box system that is approximately 163 m long in Village Park as well as depression storage that is available within the park (for further details, please see Note1 below);
- A 106 m long, 975 mm diameter trunk storm sewer that runs through easements on the Blessed John XXIII School grounds;
- A 187 m long section of the trunk system with 2134 mm W x 1549 mm H CSP elliptical pipe that runs along the rear lot line of 18 homes between Markhaven Road and Tuscay Court; and
- A 53 m long 1200 mm diameter storm sewer that runs through an easement between two (2) homes at #111 and 113 Fred Varley Drive where it enters Toogood Park and discharges into Fonthill Creek.

The twin box culverts act as storage system that are each fed individually by a sewer system from Village Parkway and Buchanan Drive. The downstream ends of both box culverts are interconnected and includes an above ground outlet structure that can provide surcharge relief by spilling stormwater over a 2.7 m long weir into a soccer field in Village Park that acts as temporary above ground storage. It was noted that the weir dimensions limit the spill capacity of the current weir/outlet structure. The floodwater can drain back into the sewer system through existing catchbasins that are also located close to the relief structure.

Major Storm Drainage System (Overland)

The urbanization of UV3 subcatchment did not allow for continuous major flow systems within the right ‘of’ way to a surface outlet. There are several overland flow routes through walkways, parks and private property as follows:

- Guildwood Circle, Turnberry Crescent and Brittany Crescent have a continuous overland flow route in the road right ‘of’ way that is connected by two (2) walkways;
- Glencove Drive, Braeside Square (South side) and Landmark Court have a continuous overland flow route in the road right ‘of’ way that is connected by two (2) walkways;

- Braeside Square (North East Side) to Buchanan Drive has a walkway that receives overland flow from the two (2) roadways into a low spot in the middle of the walkway at rear yard property lines in between Braeside Square and Buchanan Drive; and
- Overland flow route from Amberwood Court that enters Village Park.
- Overland flow route from Krieghoff Avenue (120 m East of Village Parkway) that enters a walkway on the West side of the Blessed John XXIII school grounds, draining to Village Park into the enclosed section of Fonthill Creek; and
- Overland flow route from Krieghoff Avenue (70m East of Fred Varley Drive) that enters a walkway between two (2) homes draining to Toogood Park and ultimately Fonthill Creek.

There are a number of localized lows spots where overland flow drains to as follows:

- Low spot in walkway between Braeside Square and Buchanan Drive;
- Low spot on Champion Road between Emmeloord Drive and Fittzgerald Avenue;
- Low spot on Fred Varley Drive near intersection with Markhaven Drive;
- Two (2) low spots on Krieghoff Avenue draining to walkways;
- Additional low spot on Krieghoff Avenue 30 m west of Fred Varley Drive; and
- Low spot on Tuscay Court.

Roof Downspout Connectivity

Roof downspout connectivity in the hydraulic model is assigned 0% to 100% “directly connected” to the foundation drains. This is based on smoke testing information available at the time of model development. For areas that had no information, downspout connectivity is assumed based on the age of the subdivision and the respective construction practice at the time.

Subsequent to the model development, supplemental smoke testing results were provided along with a report. The report confirms that the previously assumed connection rate is sufficiently accurate for the purposes of this planning study. Since flooding solutions target further downspout disconnection marketing and the use of backflow preventers, this connection rate will further reduce with time and will only increase local on-street (overland) flows after any current spare catchbasin inlet capacity has been used up. Many of the topographic low spots in the catchment break the continuity of the overland flow path and therefore creating local low spots where flows accumulate and drain into the storm sewer system. The assumed level of downspout

connectivity has been validated through sample surveys. Due to the topography as described above, it is less sensitive to future changes or deviations and therefore impacts to the identified flood risks and the developed flood solutions.

Private Drain Connections (Foundation Drains)

The Unionville subcatchments were constructed with storm sewer connections to the foundation drains of homes. As-constructed drawings in UV3 indicate foundation drains on all buildings with their connections to storm sewers.

Existing Performance and Flood Risk

The model indicates that the UV3 subcatchment storm sewer system is surcharged above basement floor levels under a 5 - year AES storm in many areas due to back-up conditions in the trunk system as well as limited pipe capacity in upper areas including Fenwick Drive and Webber Crescent.

The model indicates that the UV3 Subcatchment storm sewer system is surcharged above basement floor levels and to the road throughout the subcatchment under 25 - year AES and 100 - year AES storms.

The model indicates that the overland flow system functions at or near acceptable levels (less than 0.3 m overland flood depth within road right of way) under 100 - year AES conditions and that buildings can be protected from overland flow levels or ponding.

There are a few locations in excess of 0.3 m overland flood depth. However, these areas have positive drainage away from homes.

The “existing conditions” model indicates some system vulnerabilities in the minor system throughout the subcatchment.

Under the risk prioritization (as described in section 9.4) there are some “high flood risk” areas in UV3 as follows:

- Fitzgerald Avenue;
- Fred Varley Drive to the west of Sciberras Road;
- Portions of Markhaven Road; and
- Tuscay Court.

The following flood risk areas are either categorized as low or medium risk under the risk prioritization (as described in section 9.4):

- Fenwick Crescent;
- Buchanan Drive;
- Landmark Court;
- Amberwood Court;
- Easement between Glencove Drive and Braeside Square;
- Webber Crescent;
- Brittany Cresecent;
- Village Parkway;
- Emmeloord Crescent;
- Fred Varley Drive (west of Sciberras Road and north of Markhaven Road); and
- Markhaven Road.

4.1.22 Unionville – UV4

The Unionville – UV4 Subcatchment is a 22 ha urban area with residential land use and it includes Toogood Park. The subdivisions within this subcatchment were registered between 1970 and 1995. There are approx. 201 residential dwellings in the UV 4 subcatchment.

Minor Storm Drainage System (Sewers)

The UV4 subcatchment drains south towards Fonthill Creek and outlets via an existing 900 mm diameter storm sewer connection at Rycroft Road where the creek crosses the road via a 2,336 mm diameter corrugated steel pipe. An overland flow route in the road right-of-way also outlets to this location. There are two sewer branches that connect East-West aligned streets to the South through private property sewer easements. The subcatchment contains a higher number of Cul-de sac locations that either represent end of pipe situations or a sewer connection through a private property easement.

Major Storm Drainage System (Overland)

The overland flow route within the right ‘of’way is continuous with the following exceptions:

- Pomander Avenue which has two (2) low points within the right-of-way;

- Gainsville Avenue which has one (1) low spot in the right-of-way to the East of Spicer Circle; and
- Krieghoff Avenue on the western boundary which has a low spot near a walkway intersection.

Overland flows also outlet at the Eastern end of Gainsville Avenue into Crosby Park where flows are typically absorbed by the large size grassed surface. For extreme storm events, these flows would eventually flow in southwestern direction through the park towards Fonthill Creek.

Roof Downspout Connectivity

Roof downspout connectivity in the hydraulic model is assigned a value ranging from 0% to 100% “directly connected” to the storm sewer system. This is based on smoke testing information available at the time of model development. For areas that had no information – downspout connectivity is assumed based on the age of the subdivision and the respective construction practice at the time.

Subsequent to the model development, supplemental smoke testing results were provided along with a report. The report confirms that the previously assumed connection rate is sufficiently accurate for the purposes of the planning study. Since flooding solutions target further downspout disconnection marketing and the use of backflow preventers, this connection rate will further reduce with time and will only increase local on-street (overland) flows after any current spare catchbasin inlet capacity has been used up. Many of the topographic low spots in the catchment break the continuity of the overland flow path and therefore creating local low spots where flows accumulate and drain into the storm sewer system. The assumed level of downspout connectivity has been validated through sample surveys. Due to the topography as described above, it is less sensitive to future changes or deviations and therefore impacts to the identified flood risks and the developed flood solutions.

Private Drain Connections (Foundation Drains)

As-constructed drawings in UV4 indicate foundation drains on all buildings. The Unionville subcatchments were constructed with storm sewer connections to the foundation drains of homes.

Existing Performance and Flood Risk

The model indicates that the UV4 Subcatchment storm sewer system is surcharged above basement floor levels and to the road level under a 5-year AES storm in some areas including Sciberras Road, Ferrah Street, and Litchfield Crescent.

The model indicates that the UV4 Subcatchment storm sewer system is surcharged above basement floor levels and to the road throughout the subcatchment under 25-year AES and 100-year AES storms.

The model indicates that the overland flow system generally functions within acceptable levels (less than 0.3 m within road right of way) under 100-year AES storm and that buildings can be protected from overland flow levels or ponding. There are a few locations in excess of 0.3 m overland flood depth. However, these areas have positive drainage away from homes.

The “existing conditions” model indicates some system vulnerabilities in the minor system throughout the subcatchment.

Under the risk prioritization (as described in section 9.4) there are some “high flood risk” areas in UV4 as follows:

- Emily Carr Street;
- Portions of Gainsville Avenue;
- Shadbolt Court; and
- Pomander Road.

Additional flood risk areas are categorized as either low or medium risk under the risk prioritization (as described in section 9.4):

- Jeremy Drive;
- Callahan Road;
- Krieghoff Avenue;
- Callahan Road; and
- Worsley Court.

4.1.23 Unionville – UV5

The Unionville – UV5 Subcatchment is a 19 ha urban area with residential land use.

The subdivisions were registered between 1965 and 1995. There are approximately 145 residential dwellings in the subcatchment.

Minor Storm Drainage System (Sewers)

Storm sewers in UV5 follow the road alignment and drain towards south east to discharge downstream of the pond outlet into Bruce Creek via an 825 mm diameter storm sewer outlet. The sewer sizes range from 300 mm diameter to 825 mm diameter.

Major Storm Drainage System (Overland)

Overland flow and storm drainage in UV5 flows towards Toogood Pond and outlets downstream of the pond outlet into Bruce Creek via an 825 mm diameter storm sewer.

The right ‘of’ way overland flow system is continuous and drains to five (5) low points within the road right ‘of’ way as follows:

- Near #54 Pennock Crescent - low point in the road ROW;
- Carlton Road Intersection with Pennock Crescent - low point in the road ROW;
- Near #11 Mckay Crescent - low point in the road ROW;
- Near # 45 Wembley Avenue - low point in the road ROW;
- Near #56 Pomander Road - low point in the road ROW; and
- Carlton Road near Pomander Road - overland flow spills to Toogood Pond / Creek system – with no defined overland flow route. Further investigations were completed and the “base model was subsequently refined with a defined overland flow route at the road intersection and towards a parking lot to the East of Carlton Road than then spills into Bruce Creek.

Overland flow contributions from subcatchment UV4 on Pomander Road add to flows in the UV5 subcatchment.

Overland contributions from subcatchment UV2 on Pennock Crescent add to flows in the UV5 subcatchment.

Roof Downspout Connectivity

Downspout connectivity is assumed to be mixed and was assigned an average of 63% “directly connected” to the storm sewer system in the model.

Private Drain Connections (Foundation Drains)

As-constructed drawings in UV5 indicate foundation drains on some of the buildings.

Existing Performance and Flood Risk

The model indicates that under a 5-year AES storm the storm sewer system is surcharged to road levels on Pomander and Wembley Avenue, and surcharged above basement flow levels for a portion of Pennock Crescent.

The model indicates that under 25-year AES and 100-year AES storms the storm sewer system is surcharged to road levels or above basement floor levels throughout the UV5 subcatchment.

The “existing conditions” model indicates some system vulnerabilities in the minor system throughout the subcatchments.

Under the risk prioritization (as described in section 9.4) there are some “high flood risk” areas in UV5 as follows:

- Wembley Avenue; and
- Pomander Road.

Additional flood risk areas are categorized as either low or medium risk under the risk prioritization (as described in section 9.4):

- McKay Crescent;
- Carlton Road; and
- Pennock Crescent.

4.1.24 Unionville – UV6

The Unionville – UV6 Subcatchment is a 23 ha urban area. It has three (3) distinct drainage areas including the area of Fonthill Boulevard (residential), Main Street Unionville (commercial) and, lower alley rear of properties on Main Street Unionville (mostly parking lot near a low-lying wetland). The Fonthill Boulevard area was constructed in the mid 1960’s. There are approximately 110 residential dwellings in the subcatchment.

Minor Storm Drainage System (Sewers)

The Fonthill Boulevard area comprises of storm sewers from 250 mm diameter to 900 mm diameter. The subcatchment drains to the Southeast and outlets via a 900 mm diameter sewer into Fonthill Creek.

The Main Street sewershed comprises of storm sewers ranging from 300 mm diameter to 375 mm diameter. Near the mid-section of Main Street is a topographic high point that also separates the flows for the minor (and major) system with one sewer branch

draining North to outlet into Bruce Creek and the other sewer branch draining South to outlet into Fonthill Creek.

The low-lying area to the east of Main Street comprises of sewer sections of 300 mm diameter to 375 mm diameter sewers and ditch sections that drain a parking lot and outlet into Bruce Creek. The area is lower than any residential buildings and therefore does not propose a flooding risk to buildings or properties.

Major Storm Drainage System (Overland)

Overland flow and storm drainage in the Fonthill Boulevard area drains towards Fonthill Creek via a 900 mm dia. outlet near property #10 Fonthill Boulevard.

Main Street is oriented in north/ south direction and overland flows follow the road from a high point at mid road section to drain to both directions,

- south to Fonthill Creek and
- north to Bruce Creek.

Overland flow from the lower alley of Main Street drains towards the roadway and outlets to the low-lying area via a 900 mm dia. storm sewer into Bruce Creek.

The right ‘of’ way overland flow system is generally continuous, there is one (1) low spot in the Fonthill Boulevard near property #38 Fonthill Boulevard.

Roof Downspout Connectivity

Downspout connectivity is assumed to be mixed and was assigned an average of 63% “directly connected” to the storm sewer system in the model.

Private Drain Connections (Foundation Drains)

Drawings from the mid 1960’s do not indicate foundation drain connections.

It is possible that homes on the South side of Fonthill Boulevard may have foundation drains directly connected to a surface system outletting to Fonthill Creek through their back yards.

The area of Main Street is one of the oldest areas of Markham and infrastructure along this road was built in stages. It is currently serviced by a storm sewer system. Commercial properties consist of former residential homes and have some basements that may be connected to the storm sewer system.

Existing Performance and Flood Risk

The model indicates that under a 5-year AES storm the storm sewer system meets flood criteria in the Fonthill Boulevard area and on Main Street and it is surcharged to the road level in the lower alley area.

The model indicates that under a 25-year AES storm the storm sewer system is surcharged above basement levels in the Fonthill Boulevard area and on Main Street. It is surcharged to the road level in the lower alley area.

The model indicates that under a 100-year AES storm, the storm sewer system is surcharged above basement levels or to road level in the Fonthill Boulevard area and on Main Street and it is surcharged to the road level in the lower alley area.

Since the lower alley area is well below the building elevations, flooding at road level does not pose a risk to basements.

The “existing conditions” model indicates some system vulnerabilities in the minor system throughout the subcatchment.

Under the the risk prioritization (as described in section 9.4) there is one “high flood risk” areas in UV6 as follows:

- Main Street.

An additional flood risk area is categorized as either low or medium risk under the risk prioritization (as described in section 9.4):

- Fonthill Boulevard; and
- Low lying area to the east of Main Street.

4.1.25 Unionville – UV7

The Unionville – UV7 Subcatchment is a 26 ha urban area with residential land use. The subdivisions were registered between 1970 and 1995. There are approx. 250 residential dwellings in the UV7 subcatchment.

Minor Storm Drainage System (Sewers)

The UV7 subcatchment drains to Fonthill Creek via three (3) trunk sewer systems as follows:

- An existing 900 mm diameter trunk storm sewer that runs north from Sciberras Road (West portion of Sciberras Road);

- An existing 400 mm diameter storm sewer connection to Fonthill Creek at Rycroft Road where the creek crosses the road via a 2,336 mm diameter corrugated steel pipe; and
- A trunk storm sewer system on Fred Varley Drive that drains to the East outletting into Fonthill Creek via a 1350 mm diameter trunk storm sewer.

The Sciberras Road right ‘of’way in the area immediately to South of Fred Varley Drive has two (2) storm sewers each going in different directions – one storm sewer connects to the Fred Varley Drive East storm system outletting via Fred Varley Drive, while the other storm sewer is directed to the outlet at Toogood Park.

Major Storm Drainage System (Overland)

The above mentioned three outlets also serve as overland flow outlets to Fonthill Creek.

The overland flow route within the right ‘of’ way is generally continuous with the exception of a low spot at Sciberras Road and Ferrah Street. There are two (2) overland flow routes through walkways, parks and private property as follows:

- Connection from the end of the Greentree Road cul-de sac to the backyards of properties south of Fred Varley Drive; and
- Connection in private easement between properties #38 and 40 Fred Varley Drive, backyards to Fred Varley Drive.

Roof Downspout Connectivity

Roof downspout connectivity in the hydraulic model is assigned a value ranging from 0% to 100% directly connected to the storm sewers. This is based on smoke testing information available at the time of model development. For areas that had no information downspout connectivity is assumed based on the age of the subdivision and the respective construction practice at the time.

Subsequent to the model development, supplemental smoke testing results were provided along with a report. The report confirms that the previously assumed connection rate is sufficiently accurate for the purposes of this planning study. Since flooding solutions target further downspout disconnection marketing and the use of backflow preventers, this connection rate will further reduce with time and will only increase local on-street (overland) flows after any current spare catchbasin inlet capacity has been used. Since many of the topographic low spots in the subcatchment break the overland flow path, the previously assumed level of connectivity is suitable for this study for the purposes of identifying the inherent flood vulnerabilities and in developing general network flood solutions.

Private Drain Connections (Foundation Drains)

The UV7 Subcatchment was constructed with storm sewer laterals to the foundation drains of homes. The subdivisions were registered between 1970 and 1995 and as-constructed drawings in UV7 indicate foundation drains on all buildings.

Existing Performance and Flood Risk

The model indicates that the UV7 Subcatchment storm sewer system is surcharged above basement floor levels under a 5-year AES storm in some areas including Sciberras Road, Ferrah Street, and Litchfield Crescent.

The model indicates that the UV7 subcatchment storm sewer system is surcharged above basement floor levels and to the road throughout the subcatchment under 25 - year AES and 100 - year AES storms with the exception of the eastern portion of Fred Varley Drive.

The existing conditions model indicates some system vulnerabilities in the minor system throughout the subcatchment.

Under the risk prioritization (as described in section 9.4).:there are “high flood risk” areas in UV7 as follows:

- Southern portion of Sciberras Road/ Woodglen Way/ Lichfield Road; and
- Fred Varley Drive to the east of Sciberras Road.

Additional flood risk areas are categorized as either low or medium risk under the risk prioritization (as described in section 9.4).:

- Emmeloord Crescent;
- Other portions of Fred Varley Drive (west of Sciberras Road and north of Markhaven Road);
- Markhaven Road;
- Ferrah Street; and
- Sciberras Road (other than high risk).

4.1.26 Unionville – UV8

The Unionville – UV8 Subcatchment is a 10 ha urban area with residential land use.

UV8 areas of Station Street and Eureka Street are old developments built before 1970.

There are approximately 20 single residential dwellings in the subcatchment as well as the Heritage Village condominium development.

Minor Storm Drainage System (Sewers)

The minor storm sewer system follows the road alignment and drains North-East towards Fonthill Creek. Sewer sizes range from 300 mm diameter to 525 mm diameter. At the upstream part of the public drainage network at the road intersection of Eureka Street and Anna Russel Way, there are private residences with their independent drainage network that discharges into the 300 mm diameter storm sewer in Eureka Street.

Major Storm Drainage System (Overland)

Overland flow and storm drainage in the Eureka Street / Station Lane area drains towards Fonthill Creek via a 525 mm diameter storm sewer outlet at Main Street.

Overland flow is generally continuous within the road right ‘of’ way with a local low spot at Eureka Street and Anna Russell Way and one at the north end of Eureka Street.

Roof Downspout Connectivity

Downspout connectivity is assumed to be mixed and was assigned an average of 63% “directly connected” to the storm sewer system in the model.

Private Drain Connections (Foundation Drains)

Station Street and Eureka Street are currently serviced by storm sewers that service old residential properties that may have foundation drains connected directly to the storm sewer.

Existing Performance and Flood Risk

The model indicates that under a 5-year AES storm the storm sewer system is surcharged above basement floor levels on Station Lane and to the road level on Eureka Street.

The model indicates that under a 25-year AES storm the storm sewer system is surcharged above basement floor levels on Station Lane and to road level on Eureka Street.

The model indicates that under a 100-year AES storm the storm sewer system is surcharged above basement floor levels on Station Lane and to the road level on Eureka Street.

Under the risk prioritization (as described in section 9.4): there is a “high flood risk” area in UV8 along Station Lane.

No other areas are highlighted as medium or low floor risk.

4.1.27 Unionville – UV9

The Unionville – UV9 Subcatchment is a 17 ha urban area with residential land use along East Drive and Main Street. Highway 7 intersects the catchment area and whilst the northern portion of the catchment is residential, some properties along Highway 7 are commercial. Most UV9 developments were built prior to 1970 with some areas north of HWY7 being built around 1978. There are approximately 130 residential dwellings in the subcatchment.

Minor Storm Drainage System (Sewers)

Storm water runoff in UV9 flows into the Rouge River branch via three (3) outlets including a 1350 mm diameter outlet at Highway #7; a 525 mm diameter storm sewer outlet on Main Street south at the low point of the street; and a 600 mm diameter sewer at Eckardt Avenue.

Highway 7 drainage outlets to UV9 and drains to the Rouge River.

The right ‘of’ way overland flow system is generally continuous, draining to three (3) low points within the road right ‘of’ way as follows:

- Main Street at East Drive – low point in the road ROW;
- Near #15 Pavillion Street - low point in the road ROW; and
- Near #4 Pavillion Street - low point in the road ROW.

Major Storm Drainage System (Overland)

The major storm drainage system is continuous and follows the road alignment. Flows outlet at the same locations as the minor storm sewers.

There are three (3) overland low spots, one south of HWY 7 at road intersection East Drive and Main Street, and one north of HYW 7 at the northern end of Union Street near the rail line. A further low spot is in a parking lot of a commercial property south of HWY 7 on South Drive.

Roof Downspout Connectivity

Downspout connectivity is assumed to be mixed and was assigned an average of 63% “directly connected” to the storm sewer system in the model in the areas North of Highway #7 and 2% in the areas South of Highway #7.

Downspout survey information indicates very little confirmed downspout connections to storm sewer, and many downspouts discharge to ground or with an unknown outlet.

Private Drain Connections (Foundation Drains)

The area to the South of Highway #7 was originally serviced by a sanitary sewer and the storm sewer was constructed after the original servicing. No drawings are available for this storm sewer system. To the North of Highway #7, the storm sewers were built around 1978 and drawings show some foundation drain connections.

Properties along Highway #7 are commercial properties with no basements.

Existing Performance and Flood Risk

Under the risk prioritization (as described in section 9.4) there is a “high flood risk” area in UV9 along East Street and five (5) additional properties on Main Street South of the intersection with East Street.

Some additional areas are highlighted as “low flood risk” or “medium flood risk” under the risk prioritization (as described in section 9.4):

- Main Street Unionville between Eckardt Avenue and Highway 7;
- Main Street Unionville (north of East Street); and
- Maple Lane.

4.1.28 Unionville – UV10

The Unionville – UV10 Subcatchment is a 2.5 ha urban area with residential land use along Denby Court. UV10 residential units were developed between 1979 to 1983.

Minor Storm Drainage System (Sewers)

There are only two sewer branches of 375 mm diamater sewers that merge into a 525 mm diameter sewer. The small catchment area outlets via a 525 mm diameter sewer in western direction to the Rouge River.

Major Storm Drainage System (Overland)

The overland system follows the road alignment of Denby Court but slopes in north and east direction and spills onto Kennedy Road rather than the minor sewer outfall location.

Roof Downspout Connectivity

Downspout connectivity is assumed to be 0%, based on surrounding area profiles, of “directly connected” to the storm sewer system in the model.

Private Drain Connections (Foundation Drains)

All buildings have foundation drains connected to STM sewers.

Existing Performance and Flood Risk

Tere are no “high flood risk” areas being identified in UV10 in the risk prioritization (as described in section 9.4).

4.2 Sanitary Collection Systems

A description of the sanitary collection system is provided in the *Sanitary Modeling Report – Flood Remediation Study – Markham Village and Unionville (Cole Engineering February 2021)* included in **Appendix C2**.

5.0 SOURCES OF INFORMATION

Information that was used for the technical evaluation of the urban drainage system is described below. The process of building and validating the storm hydraulic model is described separately, in Appendix D Storm Drainage Modeling Guidelines.

The sources of information used for the sanitary sewer system evaluation is described in **Appendix C2**.

5.1 GIS Data

GIS shapefiles of the storm drainage system were provided. The shapefiles are a geospatial database that provides georeferenced elements with the following information:

- Maintenance hole locations, and IDs, and rim elevation; and
- Pipe locations, sizes, and inverts.

The City's GIS was generally reliable in regard to circular pipe sewer infrastructure. The GIS available for this project did not include information on catchbasins and catchbasin leads or any eccentric pipe systems (elliptical / box culverts), creek systems, underground storage or flow control systems. As such, it is important that the model build incorporate the hydraulic details that are not in GIS but from other sources. Refer to Appendix D for details on the model build process.

5.2 As-Constructed Drawings

The City maintains record drawings for civil construction projects including storm sewer construction, grading plans, storm water management plans androad construction. The quality of information varies significantly from one place to the next due to the era of construction, reliability of construction inspection and other factors. The City's record drawings are generally reliable for information such as storm sewer size, location, inverts, road profiles, etc. Details on stormwater management structures, flow control systems are not consistently available.

5.3 Light Detection and Ranging (LIDAR) Mapping

Light Detection and Ranging (LIDAR) data is used to generate topographic surfaces. The United States Geological Survey suggests that LIDAR "is a technology similar to

RADAR that can be used to create high-resolution digital elevation models (DEMs) with vertical accuracy as good as 10 cm."[1]

LIDAR data was used to evaluate depressions, depression storage and determine overland flow spill over routes. The use of LIDAR for this has some practical limitations as follows:

- LIDAR does not account for any man-made changes that can be made to a flow route through landscaping construction or other; and
- Identifying minor overland flow routes between homes and in forested areas is not practical as LIDAR may consider the roofs of the homes, tops of trees, or other objects as the ground surface.

5.4 Smoke Testing Surveys

Smoke Testing is a method used to determine where a pipe connection leads to. It can be used to determine if an item such as a weeping tile is connected to a storm sewer. The City has numerous smoke testing reports for Markham Village and Unionville. This information was used to assist in the understanding of which buildings have their foundation drains connected to the sanitary or the storm sewer system.

5.5 Flow Monitoring Data

Flow monitoring in the storm sewers can be used to confirm the system response to a rainfall event. It requires that rainfall in the subcatchment be monitored at the same time as flow monitoring. No storm flow monitoring was available for this project. Practical limitations of calibrating a storm pipe model are discussed in **Section** 1.4,**Hydraulic Models**.

5.6 Close Circuit Television (CCTV) Inspection Records

CCTV inspection involves the placement of a camera into the pipe system and recording the condition, connections, breaks, etc. CCTV inspection records were provided for some parts of the system where the connectivity of residential dwellings was in doubt.

[1] United States Geological Survey Website usgs.gov

5.7 Toronto Region Conservation Authority (TRCA) Flood Line Mapping / HEC-RAS models

Flood line mapping and hydraulic models are maintained by TRCA for river and creek systems in the TRCA jurisdiction area.

For cases where the Creek system interacts with the Urban Drainage system such as in the Anderson Subcatchment, external flows from the TRCA model were taken and integrated with the InfoWorks model built by RVA.

5.8 Field Investigations

Field investigations were conducted to confirm details that were not clear from other sources as described above. This includes pipe inspections, Park/Stormwater Management Facility inspections, etc.

6.0 DESIGN STANDARDS – STORM SYSTEM

6.1 Historical Design Standards – Storm Drainage

Development in the oldest portions of study areas dates as far back to the mid 1800s. Markham Village and Unionville were separate municipal entities until 1970 when the Town of Markham (now the City of Markham) was formed into its current geographical unit.

Markham's stormwater management guidelines summarize the history of the design standards as follows:

Pre 1978: Minor system designed to a 2-year event with no major system design criteria.

1978-1983: Minor system designed to a 2-year event and major system designed to a 100-year event.

1983-1995: Minor system designed to a 2 and 5-year event and major system designed to a 100-year event.

1995-Current: Minor system designed to a 5-year event and major system designed to a 100-year event.

The design guidelines are typically applied to new construction and developments. The application and enforcement is ensured through City development controls and other methods.

6.2 Current Design Criteria - Storm Drainage

The City of Markham's design criteria for storm drainage is publicly available on the City's website as *Engineering Design Criteria – Section E Storm Drainage and Stormwater Management* . Key standards in this document include:

- Storm sewers (minor system) shall be designed to accommodate a 5-Year design flow and shall operate without surcharge;
- For Greenfield developments, the basement slab elevations shall be set minimum 0.5 m above the 100- Year (HGL);
- For Infill developments, where HGL information is not readily available or determined, then the HGL shall be estimated to be minimum 1.8 m below the road centreline elevation, provided the municipal sewer is located at the standard 2.5 m depth. Therefore, the minimum basement slab elevation shall be set at maximum 1.3 m depth from the road centreline elevation. Sump pump shall be

installed if the basement elevation is lower than 1.3 m from the centreline elevation of the road;

- Inlet control devices (ICDs) shall only be used to control flow into the sewer to reduce 100-Year HGL
- Maximum depth of flow in overland flow routes shall be 250 mm in accordance
- Where super catchbasins are to be installed to capture the major overland flow, the catchbasin inlet capacity shall be designed considering 50% blockage

6.3 Flood Control Plan Design Considerations

The design standards and approaches applied to the proposed improvements in this Flood Remediation Program were based on the City of Markham's drainage criteria, as well as practical operations considerations to work within the limitations imposed by the need to improve storm drainage systems in existing built-up areas. They are summarized as follows:

8. **Design Storm:** The 3-hour duration 100-year AES Storm (described in section 6.3) is applied to evaluate the system performance.
9. **Level of Service (LOS):** Residential dwellings, commercial and institutional buildings should not be exposed to flooding under the 100-year AES peak flow conditions. This is achieved by:
    a. Maintaining the hydraulic grade line in the minor system near residential dwellings is below 1.8 m below the road surface (below basement levels) under all storm conditions up to and including the 100-year AES storm;
    b. Maintaining the hydraulic grade line in the major storm system (overland flow) below 0.3 m under all storm conditions up to and including the 100-year storm; and
    c. Maintaining overland flow routes within the right of way with no spillage of flow from the road onto private property.
10. **Minor System / Major System Flow Balancing:** Flow balancing to limit capture in the minor storm system in extreme events and utilize the major storm system as a means of limiting the need for storm sewer upgrades wherever possible. Flow balancing is achieved by incorporating inlet control devices (ICDs) in catchbasins. ICDs limit the entry of flow into the minor system during high flow events and maximize the use of available overland flow capacity in the major storm (overland) system.

11. **City of Markham Property Rights:** Ownership of the right 'of' way or easements in which critical drainage infrastructure is built. Preference is for pipe infrastructure to be maintained in the roadway or on City property rather than on easements through private property. Preference is also for new infrastructure to be in City right of way / property and where possible and infrastructure in complex easements to be re-aligned.
12. **Off-Line Storage if warranted:** Use of off-line storage as a means of attenuating flow in order to limit the need for storm sewer upgrades where there is a significant reduction in the proposed downstream upgrades.
13. **Impacts on Receiving Waters on Private Property or Near Buildings:** Consider, mitigate or eliminate any impacts of increasing peak flows in receiving waters systems that are located near buildings.
14. **Simplicity of Construction:** Wherever possible consider 1800 mm as the maximum size for typical urban storm sewers. Storm sewers should be laid out such that construction depths are less than 5 m deep.

6.4 Design Storm Considerations

The design storm utilized for the project is described in **Appendix D.**

The City's stormwater management guidelines select the use of an intensity-duration-frequency based on a dataset from Environment Canada's Atmospheric Environment Services (AES) Bloor Street Rain Gauge. The City's SWM guidelines indicate that this dataset produces short duration storm intensities that are 30% higher than those observed in the City's Buttonville Rain datasets.

This dataset is also used by the City of Toronto and is updated periodically.

6.5 Climate Change Considerations

It is commonly understood that climate change will lead to more severe weather events globally. However, with respect to rainfall patterns in Markham, there is no conclusive data to date indicating an upward trend in the frequency of high intensity storms. A 2018 study[2] conducted a review of Canada's most recent engineering climate datasets and

[2] Robert J Muir, *Evidence Based Policy Gaps in Water Resources: Thinking Fast and Slow on Floods and Flow,* Journal of Hydrologic and Water Management Modeling – Computational Hydraulics International, 2018

found that climate stations with long term records show as many decreasing trends as increasing trends.

Another commonly held notion is that when flooding occurs in old urban areas it is due to a climate change induced increased frequency of high intensity rainfall events. Urbanized areas that have been constructed to a lower urban drainage design standard are inherently more vulnerable to flooding than urbanized areas that have been designed to a higher standard. In other words, it is practical and possible to implement urban drainage systems to accommodate higher flows, and in urban areas where this is done, infrastructure is more resilient to changes in rainfall patterns.

Regarding the design storm selection in consideration of climate change, the City's stormwater management guidelines select the use of an intensity-duration-frequency based on a dataset from Environment Canada's Atmospheric Environment Services (AES) Bloor Street Rain Gauge. The City's SWM guidelines indicate that this dataset produces short duration storm intensities that are 30% higher than those observed in the City's Buttonville Rain datasets.

This synthetic storm event (100-year AES) provides a robust standard for design. Bringing a given system improvement up to the 100-year AES from a lesser standard should represent a minor incremental cost to a given improvement project.

While there is inherent uncertainty in predicting how rainfall intensity-frequency patterns will change in the future, the approach taken by the City in this Flood Remediation Plan provides a practical method of targeting the highest risk areas at a reasonable cost.

The additional flexibility provided in this standard allows for some uncertainty associated with changes in rainfall patterns associated with climate change. The targeting of the most vulnerable areas provides a resilience approach.

6.6 Solution Development, Evaluation and Refinement Process

Once developed, the hydraulic models provide the primary tool for identifying vulnerabilities. The development of an optimized program of solutions was through an iterative process that was applied for each subcatchment.

The process involved three stages as follows:

Stage 1 Initial Program: An initial program that meets the desired level of service (all modelled vulnerabilities eliminated up to the 100 year AES storm event) was evaluated. This initial program was developed regardless of cost and other practical considerations and generally maintained the existing configuration of the urban drainage system.

The initial program work packages was undertaken with the following steps.

- **Step #1** Identify storm sewer flood vulnerabilities based on LOS deficiencies.
- **Step #2** Simulate the installation of inlet control devices (ICDs) in catchbasins in the roadways upstream of deficient pipe systems and verify the impact on storm LOS deficiencies.
- **Step #3** Increase minor storm system capacity in the existing or desired (refer to property rights in **Section** 6.2) configuration until storm LOS deficiencies are sufficiently mitigated.
- **Step #4** Review overland flow system and identify LOS deficiencies (depth of ponding in excess of 0.30 m). If there are deficiencies, increase the inlet capture by adding catchbasins or removing ICDs and repeat Steps #3 and #4 as requried.
- **Step #5** Estimate the cost for the proposed sewer upgrades in the existing configuration. If the cost to benefit ratio is excessive, examine alternative configurations such as storage, new outlets, or diversions into other existing or proposed storm sewer systems.

Stage 2 Program Refinement: The program was then refined in consideration of practical realities that limit the ability to meet the desired performance and level of service everywhere in the subcatchment such as: ,

- in some cases, the City would need to exceed the maximum desired right of way pipe sizes (1800 mm diameter),
- in some cases, the cost of implementing the full level of service is high relative to the overall benefit provided, or
- in some cases, upstream improvements could transfer a problem further downstream, such as with Fonthill Creek, where properties along the receiving watercourse may be affected by increased peaks caused by drainage improvements upstream.

The program was also refined through the evaluation of opportunities to reconfigure the drainage system in some areas, including diversions and relief sewers where a significant overall improvement could be made.

Stage 3 Risk Prioritization: The refined program was then presented to the technical team and the City developed three (3) risk categories as described in **Section 9.4.**

The storm sewer system solutions are mostly in areas where there is basement flooding risk (residential). Specific approaches for non-residential areas such as Laidlaw and Anderson are discussed in **Section 8.0.**

6.7 Considerations for Infill and Redevelopment

Infill and redevelopment projects provide an opportunity to bring the roof drainage and foundation drains up to current standard. It is recommended that the City implement development controls for infill and redevelopment that ensure the following:

- Maintain any existing overland flow routes on the property;
- Require roof drainage to be directed to the ground surface with grading to allow overland flow and mitigate the risk of flooding adjacent properties;
- Provide foundation drainage to the storm sewer system with a backflow prevention device for each infill/redeveloped property; and
- Provide a sanitary sewer backflow prevention device for each infill/redeveloped property.
- For commercial / industrial or high density residential infil applications the City can consider adopting a site specific requirement for land use applications in Laidlaw subcatchment for on-site controls for new infill re-development. A requirement similar to the City of Toronto's requirement in the wet weather flow management guidelines (100 year storm on-site with slow release pre-development 2 year flow rate) can be applied in areas where it is suitable such as Laidlaw subcatchment.

6.8 Private Plumbing Protection Rebate Program

The City of Markham has implemented a private plumbing protection rebate plan which offers homeowners the opportunity to get subsidies for the installation of backflow prevention devices on the storm foundation drain laterals and on the sanitary sewer laterals. Mapping is provided for the areas where it is recommended that such protection is warranted. The mapping generally identifies areas where the modelled level of service is deficient, and where no minor and major system upgrades are proposed in the flood control plan. The Mapping is provided in Appendix A5 and in Appendix B5.

7.0 EVALUATION OF SANITARY SEWER SYSTEMS

7.1 Wastewater Master Plan

The sanitary flood remediation program builds on the City's latest Wastewater Master Plan. An existing condition model was developed for the Wastewater Management Plan and this model was updated for the Markham Village and Unionville areas.

7.2 Validate Computer Model

The City's model was validated through the review of rainfall and flow monitoring data. Details of the validation process are provided in the *Sanitary Modeling Report – Flood Remediation Study – Markham Village and Unionville (Cole Engineering February 2021)* included in **Appendix C2**.

7.3 Analysis of Existing Systems

The existing systems analysis is provided in the *Sanitary Modeling Report – Flood Remediation Study – Markham Village and Unionville (Cole Engineering February 2021)* included in **Appendix C2**.

7.4 Recommended Upgrades to Sanitary Sewer Systems

Recommended upgrades to the sanitary sewer system are described in the *Sanitary Modelling Report – Flood Control Remediation Study Markham Village Unionville (Cole Engineering February 2021)* attached in **Appendix C2** of this report. Details of the recommended improvements are shown in **Figures 29** through **Figure 38** of this report.

Note that work package SA-1 can be modified in preliminary design to include a re-alignment of the sewer in the rear yard easement of Jolyn Court to a new alignment through the Jolyn Court right-of-way in parallel with the alignment of the storm sewer in work package FT-3.

7.5 Estimated Construction Costs

Estimated construction costs are provided in **Section 10.1** with detailed breakdowns provided in **Appendix C1** of this report.

7.6 Ongoing Inflow and Infiltration Reduction Program

Ongoing inflow and infiltration (I&I) reduction and monitoring is recommended. This includes:

- Identification and removal of significant sources of inflow such as cross-connections and surface inlets;
- Roof downspout disconnection programs;
- Requiring any infill developments to have foundation drainage directed to storm sewer systems;
- Asset management including pipe condition assessments and targeted life-cycle renewal to minimize extraneous flows as much as practical; and
- Continuous flow monitoring and rainfall data collection to understand the system dynamics and the reduction in I&I over time.

8.0 EVALUATION OF STORM DRAINAGE SYSTEMS

8.1 Dual Drainage (Hydraulic and Hydrologic) Model Development

Models were developed for the study area as follows.

Markham Village – InfoWorks Platform

An Infoworks 1D model was initially developed by Cole Engineering as described in **Appendix D**. The City's dual drainage model was based on the information provided in City's GIS for pipes and manholes. Manhole lid elevations were taken as the surface elevation for the major drainage system in the roadway. Overland flow routes outside the roadway including those through walkways, swales etc. were input manually.

The model was refined in further detail in the system characterization stage using as-constructed drawings, field investigations and LIDAR mapping review. Local 3D surface models were developed using the LIDAR mapping to understand how the ponding and overflows function in the low spots within the urban drainage system.

The subcatchments that are represented in the InfoWorks Model developed by Cole and refined by RVA are as follows:

- Fincham subcatchment
- Paramount Subcatchment
- Main Street Subcatchment
- Church Street West Subcatchment
- Tuclor East Subcatchment
- Exhibition East Subcatchment
- Milne Lane Subcatchment
- Windridge Subcatchment
- Willowgate Subcatchment
- Rouge Subcatchment
- Christman Court Subcatchment
- Reeve Subcatchment
- John Lyons Subcatchment

- Tuclor West Subcatchment
- Edward Subcatchment
- Washington Subcatchment
- Anderson Subcatchment

Markham Village – PC-SWMM Platform

A PCSWMM model was initially developed by the City of Markham as described in **Appendix D**. The City's standard dual drainage model was based on the information provided in the City's GIS for pipes and manholes. Maintenance hole lid elevations were taken as the surface elevation for the major storm system in the roadway. Overland flow routes outside the roadway including those through walkways, swales etc. were input manually.

The model was refined in further detail in the system characterization stage using as-constructed drawings, field investigations and LIDAR mapping reviews. Local 3D surface models were developed using the LIDAR mapping to understand how the ponding and overflows function in the low spots within the urban drainage system.

The subcatchments that are represented in the PC-SWMM Model developed by the City and refined by RVA are as follows:

- Walkerton Subcatchment
- Friar Tuck Subcatchment
- Laidlaw Subcatchment
- Drakefield Subcatchment

Unionville – Info Works

An InfoWorks 1D base model was initially developed by Cole Engineering as described in **Appendix D**. The City's dual drainage runoff model was based on the information provided in the City's GIS for pipes and manholes. Manhole lid elevations were taken as the surface elevation for the major storm system in the roadway. Overland flow routes outside the roadway including those through walkways, swales etc. were input manually.

The model was refined in further detail in the system characterization stage using as-constructed drawings, field investigations and LIDAR mapping review. Local 3D surface models were developed using the LIDAR mapping to understand how the ponding and overflows function in the low spots within the urban drainage system. Significant refinements beyond the GIS information for the Unionville model included:

Village Park – Underground and above ground storage system and configuration.

Elliptical Pipes – Many pipes entered as circular pipes in GIS are in fact elliptical pipes.

Fonthill Creek – A section of Fonthill Creek was added in the InfoWorks ICM model as this creek is the receiving waters for the UV3, UV4 and UV7 subcatchments and its outfalls are in multiple locations along the section of the creek.

All Unionville subcatchments are represented in an InfoWorks model developed by Cole and refined by RVA.

8.2 Performance Analysis of Existing Systems

The InfoWorks ICM and PCSWMM models allow for the design storm scenarios to be evaluated. A summary of existing system performance is given in **Appendix A3** and **Appendix B3** for all of the subcatchments in MV and UV, respectively.

Performance analysis for the existing systems showing the 100-year AES storm conditions is given in **Appendix A3** and **Appendix B3** for each of the subcatchments in MV and UV, respectively. Each condition is represented with two (2) figures, one for the overland system and the other for the storm sewer system.

The overland flow system has colour coded nodes representing the depth of overland flow. Green and yellow nodes indicate overland flow in the system that is within LOS limits (less than 0.30 m). Red nodes indicate water depths in excess of 0.30 m which exceeds than the LOS criterion.

The storm sewer system also has colour coded nodes representing the hydraulic grade line in the storm sewer system. The hydraulic grade line is the level at which water would rise to if an open-ended pipe or manhole were connected to the system at that point. Red nodes indicate a hydraulic grade line above the ground surface, yellow nodes indicate a hydraulic grade line between the road surface and the basement floor level (i.e. 1.8 m below the ground surface). Red and yellow nodes indicate that surcharging exceeds the LOS criterion of 1.8 m below the ground.

Modelled storm vulnerabilities are described as areas where the LOS is not met and where there are buildings or infrastructure are at risk of flooding.

Risk categorization is shown in maps that are included in **Appendix A4** and **Appendix B4** for MV and UV, respectively.

8.3 Flood Program Development – Initial Iteration – Full Level of Service

The initial program described as full level of service (Full LOS) targets meeting the hydraulic level of service requirements under the 100 year AES storm conditions.

The following areas have practical limitations where meeting the 100 year LOS is not achieved, in these areas the LOS is achieved for a lesser storm (25 year AES storm or 5 year):

- Reesorville Road in Tuclor East; and
- Portions of UV3, UV4 and UV7 upstream of Fonthill Creek.

8.4 Recommended Flood Program Development

8.4.1 High Risk Area Prioritization

The risk prioritization as described in **Section** 9.4. was used to finalize the recommended flood program. The flood program includes all of the work packages that are required to service the areas that are classified as "high flood risk".

8.4.2 Operational Considerations

Other works included in the program are for operations improvements such as the re-location of difficult to access sewers that are located outside City right 'of' ways. This includes a proposed outlet to Bullock Drive (Work Package CPM-1A) and the Jolyn Court Diversion (Work Package FT-3).

8.5 Markham Village Storm Drainage Alternatives

The Markham Village Program is a result of the application of the design criteria, evaluation and solution development process described in **Sections** 6.2 and 6.6.

The following subsection provides a high-level overview of the alternatives that were considered in each subcatchment as well as the rationale for the recommended upgrade. Descriptions of the work packages are provided in **Appendix A2** and the cost estimates are provided in **Appendix A1**. The proposed locations for catchbasin Inlet Control Devices (ICD's) are identified in the InfoWorks ICM models.

8.5.1 **Markham Village** - *Fincham Subcatchment (FNC)*

Minor and Major Storm System Flow Balancing

The provision of catchbasin inlet control devices (ICDs) is proposed for approximately 60 catchbasins in the subcatchment. This measure helps to balance overland flows and their interaction with the minor (sewer) system. Where ICDs are proposed, the peak inflow into the storm system can be reduced so that storm sewer capacity can be freed up and flood vulnerabilities throughout the subcatchment can be reduced at a relatively low cost. This measure better utilizes the available overland storage and conveyance capacity that exists in the road right 'of' ways.

Storm water which collects at a low spot in Larkin Avenue on the North side of Fincham Park is reduced by providing additional catchbasin inlet capacity to reduce the ponding in the roadway.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Recommended Program

Targeted upgrades to the storm sewer system are provided to target the high-risk areas and the Daniel Court flood cluster.

Upgrades were initially identified in the existing configuration.

Work Package FNC-1 Storm Sewer Upgrades to Daniel Court and Enos Gate provides additional conveyance capacity to lower the hydraulic grade line in the storm sewer system in the Daniel Court Flood Cluster. This upgrade is designed to function with the FNC-2 upgrades (Fincham Park Relief Sewer)

Work Package FNC-2 Fincham Park Relief Sewer provides trunk sewer capacity at the downstream end of the Fincham subcatchment up to the critical areas identified as “high flood risk”. The relief sewer concept was identified as an alternative to upgrading the existing storm sewer through Heisey Drive and McCarty Crescent as this sewer runs through private property. The relief sewer configuration provides operational flexibility, resilience and is less costly than the replacement of the existing storm sewer.

Work Package FNC-3 Hallam Road, Larkin Avenue, Bryant Road provides additional storm sewer capacity to lower the hydraulic grade line in the designated high flood risk area at Hallam Road and Bryant Road.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider private plumbing protection like i.e. the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for PPP systems is provided in **Appendix A5**.

8.5.2 Markham Village - *Paramount, Main Street North and Church Street West Subcatchments (CPM)*

Minor and Major Storm System Flow Balancing

The use of ICDs was reviewed in Paramount, Church and Main Street and are not implemented for the following reasons:

- The major system is already overloaded at the low areas of the Main Street subcatchment (Main Street, Beech Street) and overland flow may spill over onto private property; and

- The implementation of ICDs in Paramount and Church subcatchments would require the addition of catchbasins further downstream and would not reduce the cost for the proposed storm sewer upgrades.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the sub-catchment.

Storm Sewer Upgrades – Recommended Program

Storm sewer upgrades are provided to address the operational deficiencies associated with the existing Snider Drive trunk sewer outlet in the Main Street Subcatchment; target the areas that are identified as high-risk and that have basement flooding vulnerability, and target the flood cluster on Paramount Road.

Work Package CPM-1A - New Storm Sewer Outlet from Bullock Drive provides an alternate route for the Snider Drive Trunk Sewer. This sewer system crosses the railway tracks and would require a permit from Metrolinx.

Work Package CPM-1B - Peter Street Storm Sewer Upgrade provides additional capture and the required minor storm capacity to remediate the overland flow system at Peter Street and Beech Street.

Work Package CPM-2 - Parkway Avenue Storm Sewer Upgrade lowers the hydraulic grade line in the Elm Street storm sewer to reduce the risk of basement flooding in this area.

Work Package CPM-3 - Church Street West lowers the hydraulic grade line in the Elm Street storm sewer to reduce the risk of basement flooding in this area.

Work Package CPM-4 - Elm Street Overflow pipe into Parkway Avenue Storm Sewer lowers the hydraulic grade line in the Elm Street system to reduce the risk of basement flooding.

Work Package CPM-5 - Upgrade Ramona Storm Sewer Outlet lowers the hydraulic grade line in the Paramount Road system to reduce the risk of basement flooding.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protection such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for PPP systems is provided in Appendix A5.

8.5.3 Markham Village – *Tuclor East Subcatchment (TE)*

Minor and Major Storm System Flow Balancing

The provision of catchbasin ICDs is proposed for approximately 24 catchbasins in the subcatchment. This program reduces the risk of flooding throughout the subcatchment at a relatively low cost.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the sub-catchment.

Storm Sewer Upgrades – Recommended Program

An extensive program for Tuclor East is driven by the fact that the high flood risk areas are located in the upper section of the subwatershed. Several alternative configurations were evaluated in order to provide trunk capacity up to the Senator Reesor's area of Tuclor East, including:

- Upgrading the storm sewer for the entire length of the storm system from Tuclor Lane NorthEast to Senator Reesor's drive via Squire Baker's Lane, Major Button's Drive and Wooten Way South;
- Diverson of flow out of the Major Button's Drive trunk sewer by a southerly route along Wooten Way South;
- Diversion of flow into Wooten Way South from North of Highway #7 through Hamilton Hall Drive;
- Diversion of flow out of the Senator Reesor's Drive catchment to Ninth Line via Berczy Gate; and
- Construction of an off-line stormwater storage system in William Armstrong Park (the preferred solution).

The Armstrong Park solution is selected as a practical alternative that minimizes the extent of trunk sewer upgrades along Major Button's Drive and Squire Bakers Lane.

The following work packages are included in the program:

Work Package TE-1 - William Armstrong Park Storage includes a 2,400 m^3 storage system to be constructed in Armstrong Park as well as the trunk sewer upgrades on Major Button's Drive from Wooten Way to the Park access point to the west of William Armstrong Public School. The storage system can be constructed in the City owned Park Lands and located underground allowing for park facilities to be maintained on top of the storage system. The storage will function with a weir control from Major Button's Drive that is triggered when the Major Button's Drive system exceeds the capacity of the downstream system. The flow is controlled by an orifice and re-inters the City's storm sewer system with a slow-release rate through the storm sewer at the Dewitt Court Walkway.

Work Package TE-2 - John Dexter Pl and Senator Reesor's Drive increases the storm sewer capacity in the high flood risk area at Senator Reesor's Drive and John Dexter Place. It requires the implementation of Work Packages TE-1, TE-4, TE7 as well as the proposed ICD implementation to achieve the desired performance.

Work Package TE-3 - Senator Reesor's Drive (East Area) increases the storm sewer capacity in the high flood risk area at Senator Reesor's Drive East and North of John Dexter Drive. It requires the implementation of Work Packages TE-1, TE-4, TE7 as well as the proposed ICD implementation to achieve the desired performance. Note that due to the existing grades, the storm sewer in this section does not meet the full LOS level of 1.8 m below road surface. The storm sewer configuration and grades are such that the road grade is opposite the storm sewer grade and receiving sewers downstream cannot provide a sufficiently low hydraulic grade line to meet the LOS under 100-year AES storm conditions.

Work Package TE-4 - Wooten Way (from Senator Reesor's Drive North Branch to Senator Reesor's Drive South Branch) increases the capacity in the trunk system leading to Major Button's Drive.

Work Package TE-5 – James Speight Road increases the storm sewer capacity to the high flood risk area of James Speight Road and Captain Armstrong Lane. It requires the implementation of Work Packages TE-1 and TE7 as well as the proposed ICD implementation to achieve the desired performance.

Work Package TE-6 - Senator Reesor's Drive (NorthEast area) increases the storm sewer capacity in the high flood risk area at Senator Reesor's Drive and Henry Corson Place. It requires the implementation of Work PackagesTE-1, TE-4 and TE7 as well as the proposed ICD implementation to achieve the desired performance.

Work Package TE-7 – Major Buttons Drive increases the storm sewer capacity in the trunk system. It is required to support the area in achieving the overall performance.

Work Package TE-8 – Squire Bakers Lane South Branch increases the storm sewer capacity in Squire Baker's Lane to achieve the desired level of service.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protection such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix A5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.5.4 Markham Village – *Exhibition East Subcatchment (EE)*

Minor and Major Storm System Flow Balancing

The provision of ICDs is proposed for approximatley 100 catchbasins in the subcatchment. This program reduces the flood risk throughout the subcatchment at a relatively low cost.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere through out the subcatchment.

Storm Sewer Upgrades – Recommended Program

An extensive program for Exhibition East is proposed to address the high floodrisk areas and flood report clusters in the subcatchment. Alternative approaches were evaluated as follows:

Diversion of Flow from Sir Lancelot out of the Parkway Drive Storm Sewer

- Work Packages EE-11 and EE-3 provide a diversion of the flow from Sir Lancelot Drive to a proposed storm sewer upgrade on Church Street – this provides additional outlet capacity for the storm sewer system on Sir Lancelot Drive and it reduces the peak flow in the existing Parkway Drive storm sewer allowing for lower flood risk along Parkway Avenue.
- An alternative approach, involving a capacity upgrade to storm sewer systems on both Parkway Avenue and Church Street, was also considered. This approach was discarded in favour of the diversion to Church Street as the benefit cost ratio would be higher with the Church Street diversion.

Rose Way Service Area Diversion

- Work Package EE-13 diverts the existing upstream portion of the Rose Way storm sewer system into the proposed Church Street storm sewer upgrade (Work Package EE-2)
- An alternative approach involving the upgrade of the storm sewer system in the existing configuration, ie. The entire trunk system that drains from Northwest to Southeast along Rose Way from Oak Leas Circle to Ninth Line. This approach was discarded in favour of the diversion to the new Church Street sewer as the overall value and return on investment is better.

Jack Court, Judy Court and Jill Court Diversions

- Work Packages EE-5, EE-7 and EE-8 divert the flow from these courts on the South side of Church Street out of the Reesorville storm sewer system to the south. This approach utilizes the capacity in the upgraded Church Street sewer (Work Package EE-1) to service these courts and it eliminates the need to upgrade storm sewers in the existing Reesorville storm sewer system to the South. This approach also reduces the flow in the system to the South which is not recommended for upgrades.
- An alternative approach was also evaluated involving the upgrade of the Reesorville storm sewer system from the courts via backyard easements to Reesorville Road and then continuing downstream to Hamilton Hall Drive. This approach would require the upgrading of many storm sewers through private property easements including large diameter (1200 – 1500 mm diameter) sewers

between homes from Pringle Avenue to Hamilton Hall Drive and from Hamilton Hall Drive to Highway #7 . This approach was discarded in favour of the diversion to the upgraded Church Street sewer as the benefit cost ratio would be higher.

Sir Galahad Gate / Sir Isaac Gate Diversion

- Work Package EE-9 diverts the flow from Sir Isaac Gate and Sir Galahad out of the Parkway storm sewer system and into the upgraded Church Street storm sewer. This approach utilizes the upgraded Church Street sewer (Work Package EE-1) to service this area and reduces flow in the Parkway storm sewer system.
- An alternative approach involving the upgrade of the Sir Galahad Gate storm sewer system in the same configuration as existing from Sir Isaac Gate to the Parkway Storm sewer was considered. This approach was discarded in favour of the diversion to the new Church Street sewer as the benefit-cost ratio would be higher.

The following work packages are included in the program:

Work Package EE-1 - Church Street (Wooten Way to Mount Joy Creek) upgrades the storm sewer system on Church Streetaccomodate the diversion flow from Sir Lancelot, Rose Way, Jack Court, Judy Court, Jill Court and Sir Isaac Gate and achieve the LOS objectives.

Work Package EE-2 - Church Street (Wooten Way to 450 m East of Wooten Way) upgrades the storm sewer system on Church Street providing sufficient capacity to address the high flood risk area of Church Street between Wooten Way and Ninth Line. Itrequires implementation of EE-1.

Work Package EE-3 - Wooten Way, Sir Lancelot Drive, Sir Gawaine Place Areas upgrades the storm sewer system on Sir Lancelot Drive providing sufficient capacity to meet the high flood risk areas on Sir Lancelot Drive and Sir Gawaine Place. It requires implementation of EE-1.

Work Package EE-4 Wooten Way – Sir Tristram Place upgrades the storm sewer system on Wooten Way and on Sir Tristam Place providing sufficient capacity to meet the medium flood risk area of Sir Tristam Place.

Work Package EE-5 Jack Court; Work Package EE-7 Judy Court; Work Package EE-8 Jill Court divert the flow from these courts on the South Sside of Church Street out of the Reesorville storm sewer system to the south. These work packages require implementation of EE-1.

Work Package EE-9 - Sir Isaac Gate (Sir Galahad Place to Church Street) diverts the flow from Sir Isaac Gate and Sir Galahad into the proposed Church Street sewer. These work packages require the implementation of EE-1.

Work Package EE-11 - Brookfield Court, Ramona Blvd, Sir Constantine Drive provides additional capacity to service the high flood risk area on Sir Constantine Drive and the flood report cluster on Brookfield Court.

Work Package EE-13 - Rose Way Diversion to Church Street diverts the existing upstream portion of the Rose Way storm sewer system into the proposed Church Street sewer. It requires the implementation of EE-1 and EE-2.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full level of service (LOS) consider plumbing protection such as the installation of storm backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix A5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.5.5 Markham Village – *Milne Subcatchment (MLN)*

Minor and Major Storm System Flow Balancing

The area is serviced by road side ditches to storm sewer that are connected via ditch inlet catchbasins. Increased storm sewer capacity in the Erlane Road area and the Milne Lane / McPhillips Avenue intersection area would allow for more capture into the storm system and reduce the depth of ponding on the road.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the sub-catchment.

Storm Sewer Upgrades – Recommended Program

An improvement to the Milne Lane storm sewer outlet (Work Package MLN-1) is proposed to increase the flow capture from the ditch system thereby minimizing overland flow through private properties.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix A5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.5.6 Markham Village – Windridge Subcatchment

Minor and Major Storm System Flow Balancing

A flow balancing solution with active use of ICDs is not warranted as the system currently has limited surface inlets and makes significant use of the overland flow system.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Not Recommended

As private drain connections are not known to be consistent in Windridge subcatchment, piped upgrades are not warranted. A storm sewer upgrade in the trunk system was considered in order to increase the conveyance capacity from Vanderbilt Court and Jonquil Court to the outlet. This improvement is not recommended as the investment in additional pipe capacity will bring more flow into the minor system but does not provide significant protection to the residences.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protection such as like the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix A5. This can be supported by the City's Private Plumbing Protection Rebate Program.

Windridge has experienced several isolated flood calls in areas that cannot be described as flood clusters. Should flood calls persist, local improvements could be considered including:

- Ditch and driveway culvert improvements (where localized ponding is a concern);
- Local inflow into sanitary sewer system investigations (where sanitary sewer back-up calls occur during wet weather); and
- Extension of other storm sewers such as the Robinson Street system to the East of the Windridge subcatchment for the Hawkridge Drive and Robinson Street area.

8.5.7 Markham Village – *Willowgate Subcatchment (WLG)*

Minor and Major Storm System Flow Balancing

An ICD type flow balancing solution is not incorporated in Willowgate Subcatchment due to the flood risk category assignment as described in **Section 9.4**.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Not Recommended

Storm sewer upgrades are not recommended in Willowgate Subcatchment due to the flood risk category assignment as described in **Section 9.4**.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix A5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.5.8 Markham Village – *Rouge Subcatchment*

Minor and Major Storm System Flow Balancing

ICDs are not included in the Rouge Subcatchment program due to the existence of low points in the road system where ponding could exceed the desired levels.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Recommended Program

A storm sewer upgrade along Rouge Street (Work Package Rouge-1) is recommended to improve the service in the designated high flood risk area.

The proposed solution involves an upgrading the storm sewer all the way to the outlet including through the portion that goes down the ravine.

An alternative solution that maintained the existing outlet storm sewer and relied on inline storage in the Rouge Street sewer was considered and discarded based on operation simplicity considerations.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix A5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.5.9 Markham Village – *Christman Court Subcatchment (CC)*

Minor and Major Storm System Flow Balancing – Not Recommended

A flow balancing solution is not recommended in the Christman Court Subcatchment due to the flood risk category assignment as described in **Section 9.4**.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Not Recommended

Storm sewer upgrades is not recommended in Christman Court Subcatchment due to the flood risk category assignment as described in **Section 9.4**.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix A5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.5.10 Markham Village – *Reeve Subcatchment (RV)*

Minor and Major Storm System Flow Balancing – Not Recommended

A flow balancing solution is not included in Reeve Drive Subcatchment due to the risk category assignment as described in **Section 9.4**.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Not Recommended

Storm sewer upgrades are not recommended in Reeve Drive Subcatchment due to the flood risk category assignment as described in **Section 9.4**.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix A5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.5.11 Markham Village – *John Lyons Subcatchment (JL)*

Minor and Major Storm System Flow Balancing

The existing defined overland flow routes allow for the John Lyons subcatchment to make use of the ICDs to improve the system performance in the existing minor system. An ICD implementation program is proposed for the John Lyons subcatchment.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Not Recommended

Storm sewer upgrades were considered as a means of achieving a full 100-year LOS performance. The use of storm sewers was discarded as the area is not classified as high risk. Flow balancing provides a significant performance improvement for a relatively low cost.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix A5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.5.12 Markham Village – *Tuclor West Subcatchment (TW)*

Minor and Major Storm System Flow Balancing

The existing system performance and configuration does not require or lend itself to any minor / major flow balancing.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Not Recommended

Storm sewer upgrades are not required in this subcatchment due to the flood risk category assignment as described in **Section 9.4**.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix A5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.5.13 Markham Village– *Edward/Washington Subcatchments*

Minor and Major Storm System Flow Balancing

The existing system performance and configuration does not require or lend itself to any minor / major flow balancing.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Not Recommended

The City's risk management system has identified many of the areas as high flood risk based on the storm sewer performance. However, as these areas are not known to have foundation drain connections, the risk of basement flooding would be limited.

As such storm sewer upgrades are not recommended.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix A5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.5.14 Markham Village – *Anderson Subcatchment*

RVA has created a hydrologic / hydraulic model, which is based on a PC-SWMM model for the external area provided by others and the main drainage area being built in InfoWorks. The area shows evidence of surface flooding risk. Given that this is an industrial area, and that there are no basements, no storm sewer upgrades are recommended. Maintenance recommendations are provided below as well as the recommendation to have flood mitigation measures coordinated with the secondary plan implementation.

It is noted that Mount Joy Creek has been enclosed with storm sewers between the north side of 9833 Markham Road (Long & McQuade and several other businesses are located in this commercial building) and the northwest corner of 155 Anderson Avenue – see the area encircled with a red line in the figure below. TRCA floodline mapping indicates that this section of stream enclosure falls within an area that is regulated by the TRCA.

Figure 8-1 Location of enclosed portion of Mount Joy Creek

From site investigations, several operational improvements and maintenance activities are recommended for a short section of open channel at the southeast corner of 9833 Markham Road. This short section of open channel runs between the outlets of twin 1500 mm diameter CSP storm sewers (draining from the north along the east side of the building at 9833 Markham Road) and a ditch inlet structure with a bar screen connected to a 1350 mm diameter RCP storm sewer. The 1350 mm diameter storm sewer drains southerly along the east side of 9809 Markham Road (The Brick store) to Castlemore Avenue via an easement and then the storm sewer continues southerly along Anderson Avenue where it outlets to Mount Joy Creek at the northwest corner of 155 Anderson Avenue.

The ongoing Secondary Plan for this area focuses on remediating flooding in this area where the LOS required for the Secondary Plan is the Regional storm, due to the development aspect. Given that this higher LOS will be addressed through the Secondary Plan, the City did not pursue looking at upgrades of this area through the Flood Control Plan or this Markham Village Unionville Flood Study. It should also be noted that, given the slab-on grade nature of this commercial development/ area, there are no concerns regarding surcharges to the storm sewer and/or basement flooding (i.e. there are only reports of road flooding in this area, not building flooding).

The recommendations for the short section of open channel at the southeast corner of 9833 Markham Road include:

- Remove weeds along the to facilitate access to the outlet/ inlet location;
- Add armour stones and filter cloth to avoid regrowth of vegetation;
- inspect twin 1500 mm diameter CSP pipes to assess debris level and schedule maintenance if required; and
- Construct a gate and chain-link fence for better access for inspection and maintenance and to discourage illegal dumping of garbage and debris that could block the inlet structure.

The twin 1500 mm diameter CSP storm sewers extend to the north side of 9833 Markham Road with inlet structures that drain Mount Joy Creek - channel improvements have been completed along the section of the creek between Markham Road and these inlet structures. However, access to these inlet structures is challenging for the City of Markham operations staff due to trees, bushes and steep grades. Additional information on the locations of this infrastructure is provided in Appendix A6.

8.5.15 Markham Village – *Walkerton Subcatchment*

Minor and Major Storm System Flow Balancing

A flow balancing ICD program was considered and could provide some improvement to the storm system performance. However, it would require an upgrade of the trunk sewer downstream of where the overland flow collects at 61-63 Walkerton Drive.

Therefore, no flow balancing is recommended in the Walkerton Subcatchment.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Not Recommended

A storm sewer improvement was considered involving the upgrading of the trunk system in the easement from Walkerton Drive to McCowan Road (i.e. between 61 and 63 Walkerton Drive). An alternative solution involves a new trunk sewer through Milne Park along the walkway between 43-45 Walkerton Drive.

Storm sewer upgrades are not recommended in the Walkerton Subcatchment due to the limited risk of basement flooding associated with foundation drain connections to the storm sewer, the complexity (private property sewers) and cost of upgrades, and the fewness of flood complaints.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix A5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.5.16 Markham Village – *Friar Tuck Subcatchment*

Minor and Major Storm System Flow Balancing

The existing well defined overland flow routes allow for Friar Tuck Subcatchment to make use of the ICDs to improve the system performance in the minor system and limit the need for storm sewer upgrades.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Recommended Program

Storm sewer upgrades are included in the program in order to provide additional trunk sewer capacity to the areas that have experienced flooding along Friar Tuck Road. These areas would fit the high flood risk[6] definition as discussed in **Section** 9.4.

In order to improve operations, the improvements would divert the existing storm sewer that is in an easement through the backyards of Jolyn Court with a sewer that is re-aligned in the City's right 'of' ways (road and walkway).

The following work packages are included in the program:

Work Package FT-1 - Friar Tuck Road and Alanadale Avenue Storm Sewer Improvements upgrades the storm sewer system on Friar Tuck Road and provides the full LOS required for the Friar Tuck and Alanadale Avenue storm systems. This work package requires Work Package FT-2 and FT-3 to achieve the desired performance.

Work Package FT-2 - Robinson Street Storm Sewer Improvements provides additional trunk capacity to the storm sewer crossing Highway #7. This improves the storm sewer system performance on Robinson Street as well as King Richard Court.

Work Package FT-3 – Jolyn Court Diversion this replaces the existing 1500 mm diameter storm sewer in the rear yards of the homes on Jolyn Court with a new storm

[6] No Risk Map was provided for Markham VIillage West Subcatchments. Risk categorization is based on the Performance at different design storms (5 yr AES, 25 yr AES, 100 yr AES)

sewer in the Jolyn Court right ‘of’ way. This work package also requires the replacement of a storm sewer in the walkway between 9-11 Jolyn Court.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix A5. This can be supported by the City’s Private Plumbing Protection Rebate Program.

8.5.17 Markham Village – *Laidlaw Subcatchment*

Minor and Major Storm System Flow Balancing

A flow balancing ICD program is not warranted as this is a commercial area with no basements or foundation drains.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Not Recommended

In order to protect the low properties in the North East quadrant of Laidlaw Boulevard and Highway #7, the construction of additional catchbasins on Laidlaw Boulevard near the low spot over the buried portion of Milne Creek was considered. The hydraulic model, however indicates that the flow through the buried portion is high during the design storm events such that new catchbasins would be restricted by the capacity of the 2,400 mm diameter underground creek conduit. As such, pipe upgrades are not recommended

Infil / Redevelopment Controls

It is recommended that the City consider adopting a site specific requirement for land use applications in Laidlaw subcatchment for on-site controls for new infill re-development. A requirement similar to the City of Toronto’s requirement in the wet weather flow management guidelines (100 year storm on-site with slow release pre-development 2 year flow rate) will provide some mitigation of the flows through the underground Milne Creek Bottleneck.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix A5. This can be supported by the City’s Private Plumbing Protection Rebate Program.

8.5.18 Markham Village – *Drakefield Subcatchment*

Minor and Major Storm System Flow Balancing

A flow balancing ICD program is not warranted as there is limited number of foundation drains connected to the storm sewers in this area.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Not Recommended

Storm sewer upgrades are not recommended in the Drakefield Subcatchment due to the limited risk of basement flooding associated with little or no foundation drain connections to the storm sewer, and the fewness of flood complaint records.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix A5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.5.19 Low Impact Development and Water Quality Considerations in Markham Village

Low Impact Development (LID) techniques help improve the storm water quality by filtering pollutants out. They also provide a benefit in reducing the overall runoff volume with the highest impact on smaller return period storms. Due to the large volume and longer duration of the 100-year design storm that is used to performance test the system, the impacts of small-scale LID techniques applied on the roadside have an negligible impact on overall runoff volumes. Studies that were overseen by members of our team to test large scale catchment wide LID applications such as green roofs on every industrial flat roof have shown a peak flow reduction of 20-25% for the 100-year design storms in Basement flooding model studies, when compared to the original models without LID applications. However, such large-scale use of LID application has not been realized and is not feasible if only inside ROW construction projects are being proposed. For the set of projects that are part of this study, an opportunistic approach can be taken to apply LID features where space is available and feasible to construct to provide water quality benefits. Several LID techniques have been considered for potential use in Markham Village and Unionville, including:

- Pervious pavement;
- Roadside trees;
- Bioswales;
- Ponds;
- Trench drains;
- Perforated pipes/ arch profiles;

Additional water quality measures can also be considered as follows:

- Catchbasin filters; and
  Oil Grit Separators (OGSs)

Each of these techniques require suitable soil conditions or available space along the roadside and sufficient elevation head to work as a gravity system. The practicality of LIDs within the right of way can be further evaluated for implementation during the detailed design stage.

The flood control program in this study is for reducing flood risk.

Stormwater quality improvements can be integrated with the flood control program. The cost of these stormwater quality improvement measures is not included in the flood control program.

The use of roadside trees that intercept some of the runoff from the urban drainage system can be considered in most of the right ‘of’ ways in the subcatchments. When considering this technique, road type, traffic count and winter salt loading should be considered in the evaluation.

A bio-swale / ditch in Reesor Park (in Exhibition East subcatchment) provides an opportunity for flood control in the full LOS program (Work Package EE-15 Woodside Court Relief System). This work package is not included in the flood control program due to the risk prioritization.

8.6 Unionville Storm Drainage Upgrades

The Unionville program is a result of the application of the design criteria, evaluation and solution development process described in **Section** 6.2 and 6.6. The following section provides a high-level overview of the alternatives that were considered in each subcatchment as well as the rationale for the recommendation. Descriptions of the work packages are provided in **Appendix B2** and the cost estimates are provided in **Appendix B1**.

8.6.1 Unionville – UV1

Minor and Major Storm System Flow Balancing – Not Recommended

Flow balancing solutions are not recommended for the UV1 subcatchment based on the flood risk category assignment being low or medium as described in **Section 9.4**.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Not Recommended

A storm sewer improvement program was prepared in the initial full LOS program. Storm sewer upgrades are not recommended in the UV1 subcatchment due to the flood risk category assignment being low or medium as described in **Section 9.4**.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix B5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.6.2 Unionville – UV2

Minor and Major Storm System Flow Balancing

Flow balancing solutions are not recommended for the UV2 subcatchment based on the flood risk category assignment being low or medium as described in **Section 9.4**.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment.

Storm Sewer Upgrades – Not Recommended

A storm sewer improvement program was prepared in the initial full LOS program. Storm sewer upgrades are not recommended in the UV2 subcatchment due to the flood risk category assignment being low or medium as described in **Section 9.4**.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix B5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.6.3 Unionville – UV3

Minor and Major Storm System Flow Balancing

The provision of ICDs is proposed for approximately 23 catchbasins in the subcatchment. This program reduces the risk of basement flooding throughout the subcatchment at a relatively low cost.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Recommended Program

Work Package UV4-4 Tuscay Court Improvements (100 AES storm) includes storm sewer upgrades from 300 mm diameter to 525 mm diameter. Tuscany Court consists of two sewer sections that connect into a 675 mm diameter trunk sewer on Fred Varley Drive (see further downstream sewer upgrades at UV4-5). A local overland low spot at Tuscay Court shows overland ponding depth above 300 mm. The increase of the outlet pipe to 525 mm diameter increases the conveyance capacity to reduce the hydraulic gradeline (HGL) on Tuscay Court. In addition to the proposed pipe upgrade, there are two ICD's proposed at the upstream end of Tuscay Court.

An alternative solution to provide in-line storage in Tuscay Court instead of increased flow release was explored but discarded due to cost, downstream surcharge conditions and operational issues associated with box-culvert storage elements in the City right of way.

Work Package UV4-5 Fred Varley Drive (Tuscay Court to Easement) includes storm sewer upgrades from the original sewer size of 675 mm diameter to 975 mm diameter (50 m length) and 1050 mm diameter (30 m length). The sewer upgrades increase flow conveyance capacity from the sewer intersection at Tuscay Court (see UV4-4) towards the main storm outfall pipe into Fonthill Creek in Toogood Park.

Work Package UV7-1 Markhaven Road (5 AES storm) proposes to upgrade the most upstream sewer in Markhaven Road. This 63 m long section of sewer is currently 250 mm in diameter and will be upgraded to 300 mm diameter to meet current standards. In addition to the sewer upgrade, ICD's are proposed to be installed around three maintenance holes to also reduce overland inflows. The upgrade will improve conveyance capacity and reduce the HGL to 1.5 m below ground elevation for the 5-year AES storm event. For the 100-year AES storm event, basement flooding criteria cannot be achieved due to downstream HGL levels being high.

The HGL for the upgraded sewer remains below ground elevation for the 100-year AES storm conditions.

Because the flood risk can only marginally be reduced for the 100-year AES storm event,targeted promotion of the Private Plumbing Protection Rebate Program in this area is recommended.

Alternative solutions such as upgrading the entire storm sewer network up to the discharge point into Fonthill Creek were explored and modelled, but such actions would increase the peak flows in Fonthill Creek and increase flood risks for properties along Fonthill Creek. Because of these risks, the alternative solution was discarded.

Work Package UV7-2 Fitzgerald (5 AES storm) proposes to upgrade the first two sewer sections on Fitzgerald Avenue. The first 67 m section of sewer is currently 250 mm in diameter and will be upgraded to 375 mm diameter and the following 92msection will be upgraded from 300 mm diameter to 375 mm diameter for a total of 159 m of sewer upgrades. In addition, seven (7) ICD's will be installed to reduce peak inflows to the sewer. The proposed upgrades reduce the HGL for the 100-year AES storm event to be below ground elevation but cannot satisfy the minimum freeboard at 1.8m due to downstream HGL restrictions. The HGL for the 5-year AES storm event remains within the pipe but since the existing sewers do not have 1.8 m of cover, they cannot achieve 1.8 m of freeboard.

Because the flood risk can only marginally be reduced for the 100-year AES storm event, the targeted promotion of the P3 program in this area is recommended.

Alternative solutions such as upgrading the entire storm sewer network up to the discharge point into Fonthill Creek were explored and modelled, but such actions would increase the peak flows in Fonthill Creek and increase flood risks for properties along Fonthill Creek. Because of these risks, the alternative solution was discarded.

Work Package UV7-3 Fred Varley Drive Relief System Upstream of Sciberras Road (25 AES storm) proposes to reverse the direction of flow in thesewer section on Fred

Varley Drive East of Sciberras Road. The current flow direction is to the west towards Fitzgerald Avenue and drains further away from the main outlet into Fonthill Creek.

The existing 300 mm diameter (71 m length) sewer is being upgraded to 450 mm diameter and reversed in flow direction, whilst remaining also connected to the West side sewer branch. In addition, 27 m of 525mm diameter sewer need to be constructed to connect this sewer into the existing 900 mm diameter sewer at Fred Varley Drive / Sciberras Road intersection. This existing outfall pipe showed spare conveyance capacity and a lower HGL than the current sewer profile. Full compliance with the 100-year AES storm event cannot be achieved but the HGL was significantly reduced to 0.85 m freeboard at a local road low spot and the former start of the sewer system. Under 25-year AES storm conditions, the upgraded sewer achieves the 1.8 m freeboard criteria. Due to the reversed sewer still being connected to the original sewer branch to the west, the new sewer draws flows from the sewer branch west of Fred Varley Drive and therefore provides indirect flooding relief to sewer branches under work packages UV7-1 and UV7-2.

Because the flood risk cannot be adequatley mitigated for the 100-year AES storm event, targeted promotion of the Private Plumbing Protection Rebate Program in this area is recommended.

Since, as described for UV7-2 and UV7-1, the HGL shows a high elevation that comes from a flow restriction into Fonthill Creek, any attempt to increase the sewer sizes show limited to no reduction in HGL for this sewer section. Therefore, any such modelled options led to no reduction in the flood risk.

Work Package UV7-4 Fred Varley Drive – Markhaven Road to Easement proposes to upgrade 116 m of storm sewers from 750 mm diameter to 36.5 m of 900 mm diameter, 36.4 m of 975 mm diameter and 43 m of 1050 mm diameter sewers. The sewer upgrades provide extra flow capacity towards the easement pipe at the Fonthill Creek outlet and reduce the HGL in the sewer system significantly below ground elevation (0.85 m freeboard at a local road low spot). The installation of one additional catchbasin is also proposed at this local road low spot (MH D450).

Because the flood risk cannot be adequately mitigated for the 100-year AES storm event, targeted promotion of the Private Plumbing Protection Rebate Program in this area is recommended.

Work Package UV7-5 Easement to Fonthill Creek – Fred Varley Drive to Toogood Park proposes to upgrade 70 m of storm sewers consisting of three pipe sections from 1200 mm diameter to 1350 mm diameter. The existing 1200 mm diameter sewer

currently represents a hydraulic bottleneck with a larger CMP arch culvert of 2134 mm W x 1549 mm H draining into the upstream end of this pipe.

The first pipe section of 10 m length has a radius incorporated and enters Fred Varley Drive from a private property easement. The second sewer section of 7 m length crosses Fred Varley Drive. Large diameter sewers are proposed to be connected to this on the North and South sides (Work Packages UV7-4 and UV4-5).

The third sewer section of 53 m length runs through a private property easement towards the outfall into Fonthill Creek. Whilst the first two sewer sections can be constructed by open cut methods, the last sewer section will require trenchless methods such as jack and bore or micro tunnelling.

At the outlet into Fonthill Creek, a new 1,350 mm diameter pipe headwall is proposed.

Because the flood risk cannot be adequately mitigated for the 100-year AES storm event, targeted promotion of the Private Plumbing Protection Rebate Program in this area is recommended.

Alternatives with different pipe sizes and pipe roughnesses were simulated but it was found that the selected sewer size provides an optimum between flow release rate into Fonthill Creek, whilst reducing HGL levels that were previously shown to ground elevation, and still fully utilizing the original designed storage elements in Village Park.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix B5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.6.4 Unionville - UV4

Minor and Major Storm System Flow Balancing

The provision of ICDs is proposed for approximately 21 catchbasins in the subcatchment. This program reduces the risk of basement flooding throughout the subcatchment at a relatively low cost.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Recommended Program

Work Package UV4-2 Gainsville Avenue Improvements increases the size of a first sewer length (87m) from 300 mm diameter to 450 mm diameter. The end section of that sewer is a local low spot that shows greater than 300 mm depth of ponding. The increase in sewer size reduces the ponding depth without installing additional CB capacity up to the 25–year storm event. However, during the 100-year storm event, the hydraulic gradeline in the storm sewer system is governed by the capacity restrictions in the downstream pipes and cannot achieve the full performance criteria but shows an improvement in ponding depth and a reduction in surcharging when compared with the existing model scenario.

Alternative sewer upgrades to fully protect against a 100-year storm would involve several hundred meters of large diameter sewer upgrades through Gainsville Avenue, Callahan Road, Krieghoff Avenue and Rycroft Drive to the outlet to Fonthill Creek. This cost would become unreasonably high when compared to the small number of flood risk properties at the west end of Gainsville Avenue.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix B5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.6.5 Unionville – UV5

Minor and Major Storm System Flow Balancing

The provision of ICDs is proposed for approximately 12 catchbasins in the subcatchment. This program reduces the risk of basement flooding throughout the subcatchment at a relatively low cost.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Recommended Program

Work Package UV5-4 Wembley Avenue Improvements proposes to upgrade 305 m of storm sewers and build a new 12 m long sewer connection. The existing three (3) sewer sections on Wembley Avenue are 375 mm and 450 mm in size and they are proposed to

be upgraded to 600 mm, 675 mm and 750 mm diameter. A new 600 mm diameter sewer connection that crosses Carlton Road to the east side to connect to an existing 825 mm diameter storm sewer provides additional discharge capacity (i.e. in addition to the existing 450 mm diameter sewer that currently drains the Wembley storm sewer Southwards). Under 100-year AES storm conditions, the HGL has been significantly reduced to provide a minimum of 1.06 m freeboard. Due to discharge conditions in the downstream sewers, it is not possible to reduce the HGL level further.

Alternative solutions such as on-line box-culvert being placed in the road showed a similar HGL reduction as the proposed solution but at a higher cost and therefore was discarded.

Work Package UV5-5 Pomander Road proposes to upgrade 598 m of storm sewers along Pomander Road starting from Emily Carr Street and draining Eastwards to an upgraded storm outlet with a 1050 mm diameter sewer outlet into Bruce Creek downstream of Toogood Pond. The existing sewers are 300 mm to 450 mm in size and the proposed sewer sizes range from 675 mm diameter to 1050 mm diameter. For the majority of the upgraded sewer section, the HGL would be reduced to below 1.8 m freeboard for the 100-year AES storm event. Where minimum freeboards of 1.61 m have remained, the HGL is kept within the pipe. Further to the sewer upgrades, the installation of four (4) additional CBs is proposed at road low spots to capture the increased overland flow without causing ponding in excess of 300 mm. The installation of eight (8) ICDs is also proposed at various locations for flow balancing purposes.

At the road intersection with Emily Carr Street, the storm sewers would be disconnected from the UV4 subwatershed at node G315 and flows would be directed Eastwards on Pomander Road. The existing storm sewers along Pomander Road are not continuous and there are two (2) sewer sections that drain south through an easement pipe. These sewers are proposed to be disconnected from the easement sewer at node D485 and flows diverted Eastwards along Pomander Road. At the intersection of Pomander Road and Carlton Road, a new 1050 mm diameter sewer road crossing is proposed that will connect to a proposed 1050 mm diameter outlet pipe.

Work Package UV5-6 Gainsville Avenue Diversion through Crosby Park proposes to create a new sewer connection between the east end of Gainsville Avenue towards the upgraded sewer in Pomander Road (UV5-5). The purpose of this sewer connection is to mitigate flood risk in Shadbolt Court. The sewer between this high flood risk area and along the east end of Gainsville Avenue shows high levels of surcharge due to an undersized easement sewer between two (2) houses running south.

The most Eastern sewer section in Gainsville Avenue is proposed to be upsized to 750 mm diameter and have its flow direction reversed towards Crosby Park. A new 750 mm

diameter sewer connection is proposed through Crosby Park in Easterly direction and further turning north to connect to the proposed storm sewer on Pomander Road. The sewer alignment can be adjusted to avoid mature park trees and the existing soccer field.

The 100-year AES storm scenario shows HGL freeboards that meet the basement flooding criteria with an exception at Towne Court and Gainsville Avenue where the freeboard is only 1.65 m and the HGL has remained at / below the pipe obvert.

Alternative solutions were investigated that involved upgrading the existing sewers including the easement sewer running south towards Krieghoff Avenue. However, these were discarded due to feasibility concerns with upsizing the sewer within easements, the high cost associated with upsizing sewers further downstream all the way to the Ryecroft Drive outlet, and the risk of discharging higher peak flows in Fonthill Creek.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix B5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.6.6 Unionville – UV6

Minor and Major Storm System Flow Balancing

The provision of ICDs is proposed for approximatley 17 catchbasins in the subcatchment. This program reduces the risk of basement flooding throughout the subcatchment at a relatively low cost.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Recommended Program

Work Package UV6-2 Main Street Improvements – Main Street sewers drain towards the south and the north, with a high point approximately at the mid-point of Main Street. The proposed upgrades of the existing storm sewers to the south involve two (2) sewer sections with a total length of 199 m to be upsized to 450 mm diameter. To the north, the most downstream sewer section with 79 m length is to be upsized to 600 mm diameter.

Together with the outlet pipe upgrades, two (2) new headwall structures are proposed for the 450 mm and 600 mm sewers.

At node G755, the addition of 3 new sag-type catchbasins are also proposed to capture the additional overland flow and maintain the flow depth to acceptable levels (less than 0.3m).

The City inquired that in the event of a re-profiling of Main Street, would the road carry overland flow? As many of the buildings on Main street have the entrance at street level, the future road profile is unknown the storm sewer upgrades on Main Street are recommended to be included in the flood control program. If an eventual road profile modification is implemented overland flow system can be re-evaluated with a new profile.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix B5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.6.7 Unionville – UV7

Minor and Major Storm System Flow Balancing

The provision of ICDs is proposed for approximately 13 catchbasins in the subcatchment. This program reduces the risk of basement flooding throughout the subcatchment at a relatively low cost.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Recommended Program

Storm sewer upgrades are ruled out in the UV8 subcatchment due to the flood risk category assignment being low or medium as described in **Section 9.4**.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full level of service (LOS) consider plumbing protections like the installation of storm backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix B5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.6.8 Unionville – UV8

Minor and Major Storm System Flow Balancing – Not Recommended

Flow balancing solutions are not recommended for the UV8 subcatchment based on the flood risk category assignment being low or medium as described in **Section 9.4**.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Not Recommended

Storm sewer upgrades are not recommended in the UV8 subcatchment due to the flood risk category assignment being low or medium as described in **Section 9.4**.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix B5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.6.9 Unionville – UV9

Minor and Major Storm System Flow Balancing

The provision of ICDs is proposed for three (3) catchbasins in the subcatchment. This program reduces the risk of basement flooding throughout the subcatchment at a relatively low cost.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Recommended Program

Work Package UV9-1 East Drive, Main Street Improvements proposes to upgrade 367 m of existing sewers and to construct 93 m of new storm sewer outfall into the Rouge River. The proposed outfall sewer would be constructed in an existing sanitary sewer easement. The existing storm sewer ranges in size from 300 mm diameter to 525 mm diameter and are proposed as 188 m of 600 mm diameter; 75 m of 675 mm diameter; 104 m of 825 mm diameter; and 93 m of 750 mm diameter for the outfall pipe. The existing pipe connection to the downstream 525 mm diameter sewer and the existing outfall to the south will be kept in place. Flows between the existing (525 mm diameter) outfall and the proposed (750 mm diameter) outfall will be split, with a flow preference towards the 750 mm diameter outfall.

The solution also proposes to install three (3) ICDs at the west end of East Drive and six (6) additional catchbasins to be installed at the local road low spot (East Drive / Main Street). The solution achieves the 100-year AES storm event flooding criteria with an exception around the road low spot (East Drive / Main Street) where only 1.75 m freeboard is achieved but the HGL would be below the pipe obvert. Despite increasing the CB inlet capacity, the overland ponding depth at this low spot remains slightly above 300 mm with simulated ponding depth of 333 mm shown. Investigations were made through Lidar mapping to prove that no property flooding will occur, and the spill path of water would be between houses towards the Rouge River ravine.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix B5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.6.10 Unionville – UV10

Minor and Major Storm System Flow Balancing

Flow balancing solutions are not recommended for the UV10 subcatchment based on the flood risk category assignment being low or medium as described in **Section 9.4**.

Roof Downspout Disconnection

Roof downspout disconnection is recommended as a best management practice everywhere in the subcatchment. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

Storm Sewer Upgrades – Recommended Program

Storm sewer upgrades are not recommended in the UV10 subcatchment due to the flood risk category assignment being low or medium as described in **Section 9.4**.

Private Plumbing Protection Rebate Program

It is recommended that all areas that do not meet the full LOS consider plumbing protections such as the installation of backflow prevention devices on the storm laterals.

A map of suggested properties to target for backflow prevention systems is provided in Appendix B5. This can be supported by the City's Private Plumbing Protection Rebate Program.

8.6.11 Low Impact Development and Water Quality Considerations in Unionville

Low Impact Development (LID) techniques help improve the storm water quality by filtering pollutants out. They also provide a benefit in reducing the overall runoff volume with the highest impact on smaller return period storms. Due to the large volume and longer duration of the 100-year design storm that is used to performance test the system, the impacts of small scale LID techniques applied on the roadside have an negligible impact on overall runoff volumes. Studies that were overseen by members of our team to test large scale catchment wide LID applications such a green roofs on every industrial flat roof have shown a peak flow reduction of 20-25% for the 100-year design storms in Basement flooding model studies, when compared to the original models without LID applications. However such large scale use of LID application has not been realized and is not feasible if only inside ROW construction projects are being proposed. For the set of projects that are part of this study, an opportunistic approach can be taken to apply LID features where space is available and feasible to construct to provide water quality benefits. Several LID techniques have been considered for potential use in Markham Village and Unionville, including:

- Pervious pavement;
- Roadside trees;
- Bioswales;
- Ponds;
- Trench drains;
- Perforated pipes/ arch profiles;

Additional water quality measures can also be considered as follows:

- Catchbasin filters; and
  Oil Grit Separators (OGSs)

Each of these techniques require suitable soil conditions or available space along the roadside and sufficient elevation head to work as a gravity system. The practicality of LIDs within the right of way can be further evaluated for implementation during the detailed design stage.

Stormwater quality improvements can be integrated with the flood control program. The cost of these stormwater quality improvement measures is not included in the flood control program.

The use of roadside trees that intercept some of the runoff from the urban drainage system can be considered in most of the right ‘of’ ways in the subcatchments. When considering this technique, road type, traffic count and winter salt loading should be considered in the evaluation.

Pipe upgrades for work package UV5-6 are proposed to run through Crosby Park. The evaluation to use perforated pipes or open bottom arch profiles could be explored during the preliminary design. The full LOS solution considers an off-line storage system in Toogood Park in work package UV7-9. Open arch profiles that promote infiltration can be used for such a storage system. Similar approaches could be taken for the full LOS options in UV1-1 Briarwood Park Storage and UV1-3 Carlton Park storage pipes.

The Unionville subcatchments already have a number of existing stormwater ponds that are being used to store overland flow before outletting the water in a controlled manner back into the sewer system. Examples are an existing pond between Braeside Square and Landmark Court in the UV3 catchment.

The implementation of Bioswales/ Roadside trees/ Bioretention boxes could be considered in subcatchments such as UV3 for roads where green boulevards exists. An example would be Buchanan Drive, where green space is available beside the road.

Catchbasin Filters and Oil Grit Separators (OGSs) can be implemented along with any pipe upgrade solutions.

9.0 PROPOSED FLOOD REMEDIATION PLAN

9.1 Summary of Recommended Upgrades to Sanitary Sewer System

The proposed upgrades to the sanitary system are described in the *Sanitary Modelling Report – Flood Control Remediation Study Markham Village Unionville (Cole Engineering February 2021)* attached in **Appendix C2** of this report. Details of the recommended improvements are shown in **Figures 29** through **Figure 38** of this report.

The program cost is summarized in **Table 9-1**.

Table 9-1 - Sanitary Program Cost Summary

	Construction Cost Estimate	10% Engineering	40% Contingency	Program Cost
Unionville Sanitary Sewer Improvements	$7.4 M	$0.7 M	$3.0 M	$11.1M
Markham Village Sanitary Sewer Improvements	$14.7 M	$1.5 M	$5.9 M	$22.1M
Total Sanitary Program	**$22.1M**	**$2.2M**	**$8.8M**	**$33.2M**

A detailed breakdown showing all the work packages is provided in **Appendix C1** of this report. The cost of the sanitary program is based on coordination with the storm program i.e. the projects are to be designed and constructed together.

9.2 Summary of Recommended Upgrades to Storm Drainage System

A description of recommended improvements is provided in **Section 8.4**. Details for each proposed work package are provided in **Appendix A2** (Markham Village) and **Appendix B2** (Unionville). Initially, a full LOS program was developed targeting all areas of Markham Village and Unionville to perform to the desired level of service under 100-year AES storm conditions. Work packages that were developed but ultimately discarded are provided in this **Appendix A2** and **Appendix B2** in a subsection called “Full LOS” solution.

The Markham Village Program cost is summarized in **Table 9-2**.

Table 9-2 - Markham VIllage Storm Program Cost Summary – High Flood Risk

	Construction Estimate	10% Engineering	40% Contingency	Total
Exhibition East Subcatchment	$21.7 M	$2.2 M	$8.7 M	$32.6M
Fincham Subcatchment	$6.3 M	$0.6 M	$2.5 M	$9.4 M
Church, Paramount and Main Subcatchments	$8.3 M	$0.8 M	$3.3 M	$12.5 M
Tuclor East Subcatchment	$16.3 M	$1.6 M	$6.5 M	$24.5M
Friar Tuck Subcatchment	$3.4 M	$0.3 M	$1.3 M	$5.0 M
Milne Subcatchment	$0.7 M	$0.1 M	$0.3 M	$1.0 M
Rouge Subcatchment	$1.8 M	$0.2 M	$0.7 M	$2.7 M
Willowgate Subcatchment	$0.0 M	$0.0 M	$0.0 M	$0.0 M
Christman Court Subcatchment	$0.0 M	$0.0 M	$0.0 M	$0.0 M
Reeve Drive Subcatchment	$0.0 M	$0.0 M	$0.0 M	$0.0 M
Walkerton Subcatchment	$0.0 M	$0.0 M	$0.0 M	$0.0 M
Windridge Subcatchment	$0.0 M	$0.0 M	$0.0 M	$0.0 M
John Lyons Subcatchment	$0.1 M	$0.0 M	$0.0 M	$0.1 M
Markham Village Storm Program	**$58.5M**	**$5.9M**	**$23.4M**	**$87.7M**

The Unionville Program cost is summarized in Table 9-3.

Table 9-3 - Unionville Program Summary – High Flood Risk

	Construction Estimate	10% Engineering	40% Contingency	Program Costs
UV1 Subcatchment	$0.0 M	$0.0 M	$0.0 M	$0.0 M
UV2 Subcatchment	$0.0 M	$0.0 M	$0.0 M	$0.0 M
UV3 Subcatchment	$3.5 M	$0.3 M	$1.4 M	$5.2 M
UV4 Subcatchment	$0.3 M	$0.0 M	$0.1 M	$0.5 M
UV5 Subcatchment	$5.1 M	$0.5 M	$2.1 M	$7.7 M
UV6 Subcatchment	$1.1 M	$0.1 M	$0.5 M	$1.7 M
UV7 Subcatchment	$0.0 M	$0.0 M	$0.0 M	$0.0 M
UV8 Subcatchment	$0.0 M	$0.0 M	$0.0 M	$0.0 M
UV9 Subcatchment	$1.7 M	$0.2 M	$0.7 M	$2.6 M
UV10 Subcatchment				
Unionville Storm Program	$11.9M	$1.2M	$4.7M	$17.8M

A detailed breakdown showing all of the work packages is provided in **Appendix A1** (Markham Village) and Appendix B1 (Unionville). Initially a full level of service program was developed targeting servicing all areas of Markham and Unionville to perform to the desired level of service under 100-year AES storm conditions. The cost estimate for this level of program is included in **Appendix A1** and **Appendix B1** in a subsection called “Full LOS” solution.

9.3 Coordination with Other Infrastructure Improvement Programs

Upgrades to storm and sanitary sewers should be coordinated with other municipal assets that reside in the same right of way. There are opportunities to improve other assets as follows:

- Watermains;
- Road resurfacing / reconstruction;
- Parks and open spaces;

- Upgrading of utilities (e.g. gas, hydro, telephone, cable TV, telecommunication); and
- Other community infrastructure.

While each of these improvements require separate funding, there is potential for economies of scale when these projects are completed at the same time and would also minimize impacts on traffic, local residents and businesses as well as the natural environment.

9.4 Priorities - High Risk/ Low Risk Flooding Areas

The existing performance maps (Refer to **Appendix A4** and **Appendix B4**) indicated where system deficiencies are manifest under the 100 - year AES storm conditions. In order to prioritize the system improvements, the City developed Risk Maps (Refer to Appendix A4 and B4) that identify where properties are at risk under storms of lesser intensity. The City developed 3 risk categories for the properties as follows:

High Risk Properties: Properties where the 10 - year or lesser AES storm hydraulic grade line in the storm sewer is flooding at the road level.

Medium Risk Properties: Properties where the 25 - year or lesser AES storm hydraulic grade line in the storm sewer is above the flooding at the road level.

Low Risk Properties: Properties where the 100 - year or lesser AES storm hydraulic grade line in the storm sewer is above the flooding at the road level.

The full level of service program was initially developed to target all areas where the 100-year AES storm. A refined program, that completes the system improvements up to and including the high-risk properties was subsequently developed. The Flood remediation program is based on solutions that can service the high-risk properties.

9.5 Funding Requirements

The recommended flood remediation program provides economic value to the current and future residents of the City of Markham due to its pro-active elimination of ongoing flood risk.

Pro-active asset management and life-cycle renewal of sewer systems is an economic necessity for the wellbeing of the current and future residents of the City of Markham.

The flood remediation program targets the highest flood risk areas in a manner that provides the best return on investment based on known conditions. Areas that have low storm sewer capacity, and that have homes and infrastructure that is vulnerable to flooding as a result, are identified for system improvements.

A business case to support funding can be made to partners with regards to:

- Insurance claims reduction,
- Improved public safety; and
- Community infrastructure resilience.

9.6 Approvals and Permits

Approvals Permits and Property Considerations

Most of the proposed new storm sewer improvements are located in existing road right of ways or on City owned property. It is recommended that such upgrades be considered a Schedule A or Schedule A+ undertaking under the Municipal Class Environmental Assessment (Municipal Class EA) process.

The proposed storm outlet upgrades to receiving waters involve an existing outlet that is to be replaced with a larger diameter outlet on existing properties. It is recommended that such upgrades be considered a Schedule A or Schedule A+ undertaking under the Municipal Class EA process. It should also be noted that outlets to receiving waters in Markham typically are within the area regulated by the Toronto Region Conservation Authority (TRCA) and will require a permit from the TRCA for construction.

Work Package FNC-2 requires property acquisition from the York Region District School Board. It is recommended that this upgrade be considered a Schedule A or Schedule A+ undertaking under the Municipal Class EA process.

Work Package CPM-1A requires the construction of a new outlet to Robinson Creek and the structure may need to be partly outside the Bullock Drive Right of Way. A TRCA permit will be required for this outlet. Department of Fisheries and Oceans and MECP species at risk protocols may also apply for the construction of the outlet to Robinson Creek. It is recommended that, at the preliminary design stage, the City consider whether an approval beyond schedule A+ is appropriate in consideration of property requirements, impacts on the woodlot and species at risk.

Work Package CPM-1A crosses the Metrolinx corridor, this will require a crossing permit from the railway and a trenchless construction approach is recommended for the railway crossing.

10.0 CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

Markham Village Storm System

The Markham Village urban drainage system characterization and flood records indicate the following:

- Drainage infrastructure is generally not constructed to current standards and has operational deficiencies in the configuration of the system such as locating trunk sewers on private properties, with creek systems being enclosed underground, occasional cross connections with the sanitary sewer system, as well as poorly defined overland flow routes.
- The type of drainage infrastructure is not consistent across MV with some areas having a fully separated storm and sanitary sewer system with curb/gutter roadway, and other areas having roadside ditch systems that connect to storm sewers.
- The foundation drainage connection to the storm sewer system varies in Markham Village with older areas (built before 1970) typically not built with foundation drains connected to storm sewers and newer areas having been built with foundation drains connected to storm sewers.
- System wide dual drainage modeling highlights areas that are under-serviced for various test levels (5-year AES storm conditions, 25-year AES storm conditions, 100-year AES storm conditions).
- A recent high intensity storm event occurred in Markham Village in July 2017 and there were numerous flood calls in Markham Village with clusters of calls in the Exhibition East, Fincham, Paramount and Friar Tuck subcatchments.
- There are several areas where flood records coincide with areas that urban drainage system model indicates a deficient level of service
- Flood mitigation criteria and objectives were established as a means of overall risk reduction including the development of level of service objectives and performance metrics (**Section** 6.0).
- There are practical realities that limit the ability to meet the desired performance and level of service everywhere in Markham Village, in some cases receiving water systems cannot meet the desired level of service without exceeding the maximum desired practical sewer sizes (1800 mm diameter), or the cost of

implementing the full level of service is high relative to the overall benefit provided.

- Private Plumbing Protection is an added risk management measure that can be implemented in residential areas where achieving the full level of service is not economically or practically achievable. Affected properties are recommended to implement back flow protection measures on both the sanitary and the storm systems.
- Minor system / major system flow balancing can provide some benefit to existing drainage systems (reduce the depth of ponding on the roads or reduce the slope of storm sewer upgrades) and improve the performance of storm sewer system upgrades in some instances.
- A program that would target the full level of service everywhere in Markham Village would be costly. An initial program was developed with an estimated cost of $107.7 million, while this program targeted full LOS under 100-year AES storm conditions it still did not meet it in all of the areas in Markham Village.
- A prioritization process was developed based on frequency of exceedance of level of service; proximity to buildings with basements; coincidence of vulnerabilities with actual flood records; and operational improvements.
- A prioritized program was developed with an estimated implementation cost of $87.7 million as described in **Section** 9.2.
- Mapping of the areas where private plumbing protection is recommended is provided.
- Given that the hydraulic model predicts significant surcharge in the Tuclor East sewer system for low return period frequencies such as the 2-year storm event, further investigations such as verification through flow surveys may be considered to confirm the hydraulic model.

Unionville Storm System

The Unionville urban drainage system characterization and flood records indicate the following:

- Drainage infrastructure is generally not constructed to current standards and has operational deficiencies in the configuration of the system such as locating trunk sewers on private properties.
- The receiving watercourse of Fonthill Creek traverses over 35 private properties and peak flows in this watercourse can increase with the implementation of

improvements to the urban drainage systems upstream in UV3, UV4 and UV7 subcatchments.

- The foundation drainage connection to the storm sewer system varies in Unionville with older areas (built before 1970) typically not built with foundation drains connected to storm sewers and newer areas having been built with foundation drains connected to storm sewers.
- System wide dual-drainage modeling highlights areas that are under-serviced for various test levels (5 year AES storm conditions, 25-year AES storm conditions, 100-year AES storm conditions).
- Unlike other areas in Markham such as Markham Village and West Thornhill, Unionville has not experienced a severe weather event in recent years with which modelled vulnerabilities could be validated.
- Flood mitigation criteria and objectives were established as a means of overall risk reduction including the development of level of service objectives and performance metrics (**Section** 6.0).
- There are practical realities that limit the ability to meet the desired performance and level of service everywhere in Unionville, in some cases receiving water systems cannot meet the desired level of service without exceeding the maximum practical service sizes (1800 mm diameter); or the cost of implementing the full level of service is high relative to the overall benefit provided; or increasing risk to properties affected by increased flows in receiving waters in the case of Fonthill Creek.
- Private Plumbing Protection is an added risk management measure that can be implemented in residential areas where achieving the full level of service is not economically or practically achievable. Affected properties are recommended to implement back flow protection measures on both the sanitary and the storm systems.
- Minor system / major system flow balancing can provide some benefit to existing drainage systems and improve the performance of storm sewer system upgrades in some instances.
- A program that would target the full level of service and performance everywhere in Unionville would be costly. An initial program was developed with an estimated cost of $63.2 million, while this program targeted full LOS under 100-year AES storm conditions it did still not meet it in all of the areas in Unionville.

- A prioritization process was developed based on frequency of exceedance of level of service; proximity to buildings with basements; coincidence of vulnerabilities with actual flood records; operational improvements; and the need to avoid introducing new risks such as increased peak flows in Fonthill Creek.
- A prioritized program was developed with an estimated implementation cost of $17.7 million as described in **Section** 9.2.
- Mapping of the areas where private plumbing protection is recommended is provided.

Sanitary Program

A sanitary improvements program was developed through the refinement of the model as described in the *Sanitary Modeling Report – Flood Remediation Study – Markham Village and Unionville (Cole Engineering February 2021)* included in **Appendix C2**.

Program implementation costs are estimated to be $33.2 million as described in **Section** 9.2.

10.2 Recommendations

The following recommendations are provided:

1. **Flood Control Program Implementation:** It is recommended that the City proceed with the Flood Control Programs described in the **Section** 9.0.
2. **Flood Control Program to Be Used as a Guide:** It is recommended that the Program Documents and Work Packages be considered as a guide for a multi-year implementation program that can continue to be refined through the detailed design process, and as new information comes to light.
3. **Implementation Timeframe:** The program can be implemented in a multi-year program over 10-20 years. The City can choose to implement on an accelerated schedule or extend it over a longer period depending upon funding and tolerance of flood risk.
4. **Program Cost Monitoring and Updating:** It is recommended that the costs provided herein be considered as an initial budget and that the costs be updated and monitored periodically throughout the implementation process to account for regulatory changes, construction cost changes, changes in the scope of the program work packages, etc.
5. **Integrate with Other Municipal Infrastructure Projects:** It is recommended that the City consider integrating the Flood Remediation Program works with

other municipal infrastructure projects where economies of scale can be identified. This includes life-cycle renewal of storm, sanitary and watermain infrastructure, road resurfacing / reconstruction, streetscaping projects, stormwater quality or LID initiatives, and parks and open space systems.

6. **Seeking Funding:** It is recommended that the City seek funding from provincial and regional governments to share in the cost of implementing the Flood Control Program noting that the flood control program is economically justifiable based on insurance claims reduction, improved public safety, improved resilience of community infrastructure.

7. **Continued Sanitary Inflow and Infiltration Monitoring:** It is recommended that the City continue with its Sanitary Inflow and Infiltration Program involving both I/I reduction efforts and performance monitoring (sanitary flow and rainfall monitoring).

8. **Promote Roof Downspout Discharge to Ground Surface:** It is recommended that the City continue to support best practices of roof downspout discharges to the ground surface in Markham Village and Unionville through education efforts, and development controls on infill developments or redevelopments. Note that roof downspout disconnection should not be done on properties where there is no clear overland flow route to a municipal right of way, or where nuisance ponding could occur.

9. **Targeted Backflow Prevention Monitoring:** It is recommended that the City encourage residents in identified flood risk areas (see Appendix A5 and Appendix B5) to have their home's foundation drainage system evaluated and to implement backflow prevention if they are connected to the storm or sanitary system.

10. **On-Going Maintenance:** The flood control program does not include funding for on-going maintenance activities. It is recommended that the City maintain key elements of the drainage system such as driveway culvert inspections; maintenance at the Anderson Subcatchment Storm Inlet (described in **Section** 8.5.14); key storage facilities including those in Village Park, Mintleaf Park and Fincham Park; and maintenance of key overland flow routes such as the one on John Lyons Drive.