# PROGRESS REPORT #1 – FLOODPLAIN SPILL ASSESSMENT
# FLOOD EVALUATION STUDY
LITTLE ETOBICOKE CREEK

Report Prepared for:
**CITY OF MISSISSAUGA**

Prepared by:
**MATRIX SOLUTIONS INC.**

January 2018
Guelph, Ontario

Unit 7B, 650 Woodlawn Rd. West
Guelph, ON, Canada N1K 1B8
T 519.772.3777 F 226.314.1908
www.matrix-solutions.com

## PROGRESS REPORT #1 – FLOODPLAIN SPILL ASSESSMENT

## FLOOD EVALUATION STUDY

## LITTLE ETOBICOKE CREEK

Report prepared for City of Mississauga, January 2018


**Kelly Molnar, P.Eng.**
**Water Resources Engineer**

January 8, 2018

reviewed by
**Karen Hofbauer, M.A.Sc., P.Eng.**
**Water Resources Engineer**

January 8, 2018

reviewed by
**Stephen Braun, P.Eng.**
**Senior Water Resources Engineer**

January 8, 2018

# TABLE OF CONTENTS



# LIST OF FIGURES

## LIST OF TABLES



## MAP SET



## APPENDICES

# 1 INTRODUCTION

The Little Etobicoke Creek watershed has experienced flooding and erosion concerns recorded back to at least the 1970s. The recent large flood event on July 8, 2013, which corresponded approximately to a 350-year storm (MMM 2015), resulted in many reports of flooding-related incidents and damage, particularly in the Dixie Road and Dundas Street area in the City of Mississauga. The focus of this flood evaluation study of Little Etobicoke Creek, being conducted by Matrix Solutions Inc. for the City of Mississauga, is to characterize flooding and to define the extent of any spill into adjacent watersheds. Characterization of flooding is also provided for all simulated rainfall events.

The Little Etobicoke Creek Flood Evaluation Study is being conducted in two phases. Phase 1 expands on previous studies of the overland spill from Little Etobicoke Creek and is particularly focussed on the Dixie-Dundas Special Policy Area (SPA), where flood flows spill from Toronto and Region Conservation Authority (TRCA) jurisdiction lands into Credit Valley Conservation (CVC) jurisdiction lands. The purpose of Phase 1 is to further define and characterize the extents of overland spill from Little Etobicoke Creek during major storm events; lack of available data prevented previous studies from adequately defining this spill. Recommendations to CVC for incorporating the spill flows into their watershed are provided within this report. Phase 2 of the study will focus on the Little Etobicoke Creek watershed as a whole and include characterization of overland urban flood risk as well as development, assessment, and recommendations for flood mitigation measures.

## 1.1 Progress Report Purpose

This progress report encapsulates Phase 1 study results. As part of the Phase 1 study, a spill assessment was conducted for the Regional Storm event (both steady and unsteady states), the July 8, 2013 event and the following design storms:

- 100-year 24-hour Chicago event
- 50-year 24-hour Chicago event
- 25-year 24-hour Chicago event
- 100-year 12-hour AES event
- 50-year 12-hour AES event
- 25-year 12-hour AES event

The spill assessment aims to appropriately partition the spill flows for the July 8, 2013 and Regional Storm events between Little Etobicoke Creek, Applewood Creek, Serson Creek, and Cooksville Creek.

This progress report summarizes the background review and details of the MIKE FLOOD modelling used to assess the predicted extent of spill in response to these various storm events under existing conditions in the study area. The study limit of Phase 1 is indicated in Figure 1.

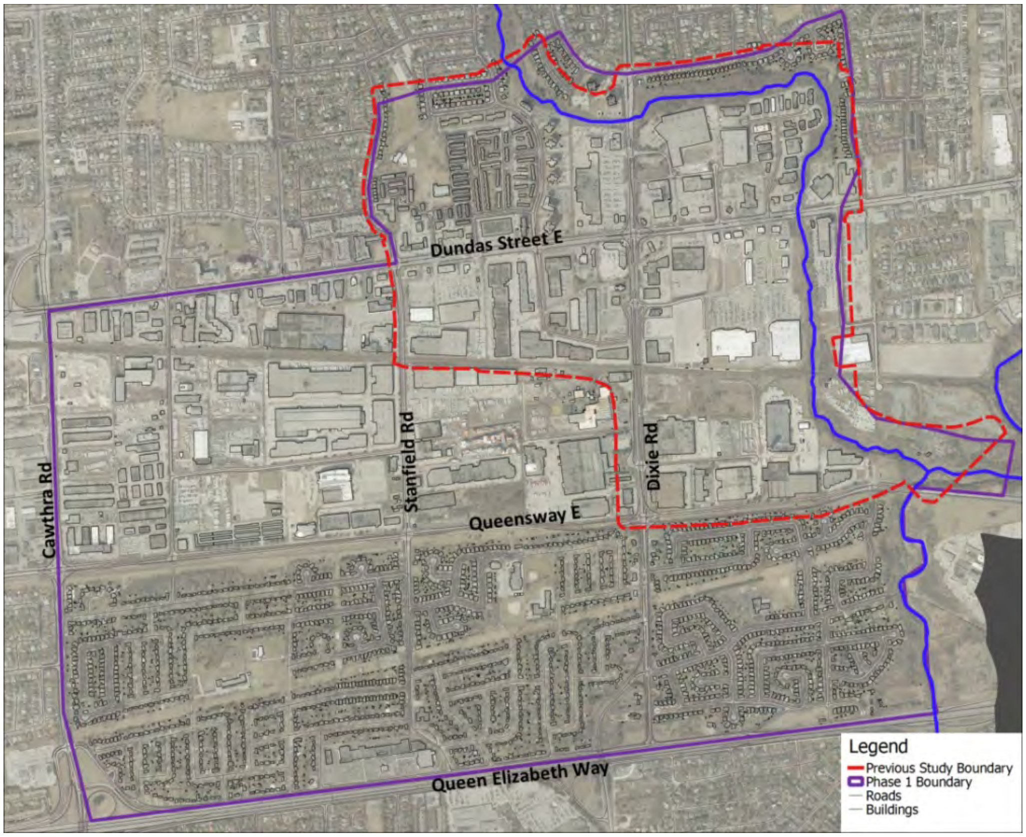


**Figure 1 Phase 1 Study Limit**

## 2 BACKGROUND REVIEW

At the outset of the project, background review was undertaken for both Phases 1 and 2. All data related to the study, including hydrologic and hydraulic models, previous study reports, historical flooding information (including July 8, 2013), aerial photography, LiDAR, and GIS layers were compiled and reviewed. Also included in the background review were personal communication and consultation with staff from the City of Mississauga, TRCA, CVC, Region of Peel, and from residents who had expressed a willingness to share information and contribute to the project. The historical flooding reports were a main component of the data used to identify flood cluster areas for Phase 2.

### 2.1 Review of Related Studies

#### 2.1.1 Etobicoke Creek Hydrology Update (MMM Group Ltd., April 2013)

The purpose of this study was to update the hydrologic model for the study area to reflect current drainage characteristics and watershed parameters. The original hydrologic modelling for the Etobicoke Creek watershed was first developed by Fred Schaeffer & Associated in 1996. The modelling was updated by Totten Sims Hubicki Associated in 2003 and 2007; however, these updates incorporated similar characteristics as contained in the 1996 study. Due to changes in land use, topography, reach delineation, etc. since 1996 as well as the presence of more current rainfall and streamflow data available for calibration, TRCA recognized that the modelling required a comprehensive update. The hydrologic modelling resulting from the Etobicoke Creek Hydrology Update completed by MMM Group Limited includes a calibrated Visual OTTHYMO v2.0 (VO) model of current land use and topographic conditions and also includes a stormwater quantity control strategy which will aid in mitigating flood risks that would result from further land use changes. The model simulations include 2-, 5-, 10-, 25-, 50-, 100-, and 350-year design storm events as well as the Regional Storm (Hurricane Hazel). Matrix has used this most recent hydrologic modelling in our analyses.

### 2.1.2 Floodplain Mapping in Applewood and Dundas / Dixie Special Policy Area (MMM Group Ltd., January 2015)

The 2015 MMM study produced a 2D hydraulic model of Little Etobicoke Creek and used this to define Regional Storm flood maps for flood conditions within the Dixie / Dundas SPA and Applewood SPA in the City of Mississauga. A 2D model was required to capture the complex nature of the overland flow patterns within the study area, which could not be definitively delineated using traditional 1D modelling techniques. Little Etobicoke Creek is known to overtop its banks during major flood events, which causes flooding throughout the urban neighbourhood downstream. The study identified and assessed a number of preliminary flood mitigation alternatives based on the 2D modelling results. The modelling was done in MIKE FLOOD and included the 5-, 25-, 50-, 100-, and 350-year design storm events, in addition to the Regional Storm (Hurricane Hazel) and also the July 8, 2013 major storm event. The model was validated using the July 8, 2013 flow event in coordination with anecdotal evidence.

### 2.1.3 DRAFT Special Policy Area and Flood Mitigation Review Dundas Street Transportation Master Plan (AECOM, June 2016)

The purpose of this portion of the Master Plan study is to review the existing boundaries of the various Special Policy Areas (SPAs) located in the vicinity of the Dundas Street corridor: Applewood SPA, Dixie District West Side SPA, and Dixie District East Side SPA. The goal of the study is to review potential flood mitigation measures and identify potential benefits in support of reducing or eliminating the current restrictions that the SPAs place on intensification or transportation improvements along the Dundas Street corridor. The Applewood SPA and Dixie District West Side SPA are impacted by the spill from Little Etobicoke Creek, thereby linking it to this present study where the spill has been analyzed and discussed extensively. The AECOM study identified that the flooding is caused by: undersized main channel and floodplain; undersized bridges and culverts; and large flows from upstream from a largely urbanized catchment (AECOM 2016). A long list of alternatives was developed and of these, five flood mitigation measures were carried forward for detailed modelling in MIKE FLOOD. General consensus of City, TRCA, and CVC staff and other project team members reached at a recent coordination meeting held at City of Mississauga offices on December 19, 2017, pointed towards an Environmental Assessment being the next likely step, with this also allowing integration of the recommendations of the AECOM study with the results of the present study.

# 3 PUBLIC CONSULTATION

Consistent with the Master Planning approach, this study requires effective stakeholder and public engagement throughout. As such, two Public Information Centres (PICs) were specified: one at the initiation of the study to ensure the scope and purpose of the study was understood by the public and other potential stakeholders; and the second one which will occur during Phase 2 to coincide with selection of the preferred set of alternatives.

## 3.1 Public Information Centre #1

The first PIC (PIC #1) was held on June 15, 2017 at the beginning stage of Phase 1 of the study. The purpose of PIC #1 was to provide an overview of the study and obtain public input regarding known flooding issues in the area. The presentation boards displayed at PIC #1 are provided in Appendix A. A single comment sheet was submitted at PIC #1; it is included at the end of Appendix A.

The second PIC will be held near the end of Phase 2 before the preparation of the Master Plan Report.

# 4 PHASE 1: SPILL ASSESSMENT (DIXIE-DUNDAS)

In short, the spill from the Little Etobicoke Creek floodplain into CVC jurisdiction lands needs to be quantified. The Phase 1 assessment was conducted using the previously developed MIKE FLOOD model (i.e. the previous Dixie-Dundas 2D Flood Modelling study; MMM 2015) as a base. The purpose of the original study was to provide accurate flood characterization within the SPA. As such, the model domain for the original study did not capture the full extent of the area impacted by spill from Little Etobicoke Creek; it was not extended further at that time due to project timelines, cost, and jurisdiction.

Modelling and anecdotal evidence indicate that a spill occurs at Queen Frederica Drive during high flows. This spill crosses the creek's regular watershed boundary which is maintained under normal flow conditions. The spilled flow is conveyed from the Little Etobicoke Creek watershed in TRCA jurisdiction into the Applewood Creek watershed which is within CVC jurisdiction. Note that runoff from within the Applewood Creek watershed was not considered in the analysis; only spill flow from Little Etobicoke Creek has been incorporated into the modelling.

## 4.1 MIKE FLOOD Model Setup

The existing MIKE FLOOD model (MMM 2015) was provided by TRCA. The existing MIKE FLOOD model consists of a 1D MIKE 11 model of Little Etobicoke Creek and a 2D MIKE 21 model of the adjacent floodplain area. The MIKE FLOOD model setup including boundary conditions, flood control structures, and noise barriers, discussed in detail below, is depicted in Figure 2.

The boundary condition for the 1D riverine portion of the model is consistent with the approved HEC-RAS model, as provided by TRCA in 2016, for Etobicoke Creek (of which Little Etobicoke Creek is a tributary) and has cross-sections spaced approximately every 50 m with cross-sections situated from left to right looking downstream. The existing MIKE 11 model extends from approximately 450 m south of Bloor Street downstream to the confluence with the main branch of Etobicoke Creek. The MIKE 11 model was not extended for the purpose of the Phase 1 study as its existing extents were sufficient to capture the spill from Little Etobicoke Creek into the Phase 1 study area. However the downstream boundary condition for the MIKE 11 model was reviewed and updated to match the appropriate water level from the Etobicoke Creek HEC-RAS model at the corresponding cross-section.

The existing MIKE 21 model is based on a 2 m × 2 m grid. To fully quantify the extent of flows, the extent of the 2D model domain was expanded to the west and south to capture all overland spill throughout the Phase 1 study area. The 2D domain was extended using 2012 LiDAR data provided by TRCA and CVC. While more current LiDAR is available from TRCA, it was decided that 2012 LiDAR data would be used as it would be consistent with the existing MIKE 21 model and also with data available from CVC. The extended model surface uses the same grid type and scale as the previous MIKE 21 model. Consistent with the previous model, the extended surface also incorporates building footprints as blocked obstructions (i.e., set as land value) to ensure water cannot flow through the buildings. The building footprints used to create the blocked obstructions within the extended 2D domain were based on shapefiles provided by the City during the background review.

Along the right bank of Little Etobicoke Creek between Queen Frederica Drive and Dixie Road, there is a flood control wall and a flood control berm (see Figure 2). For the purpose of design storm runs these flood control features were included in the model. These flood control features are not permanent and therefore are consistent with current Ministry of Natural Resources and Forestry (MNRF) practice, and should not be included in Regional Storm simulations. As such, the flood control features were removed from the Regional Storm models.

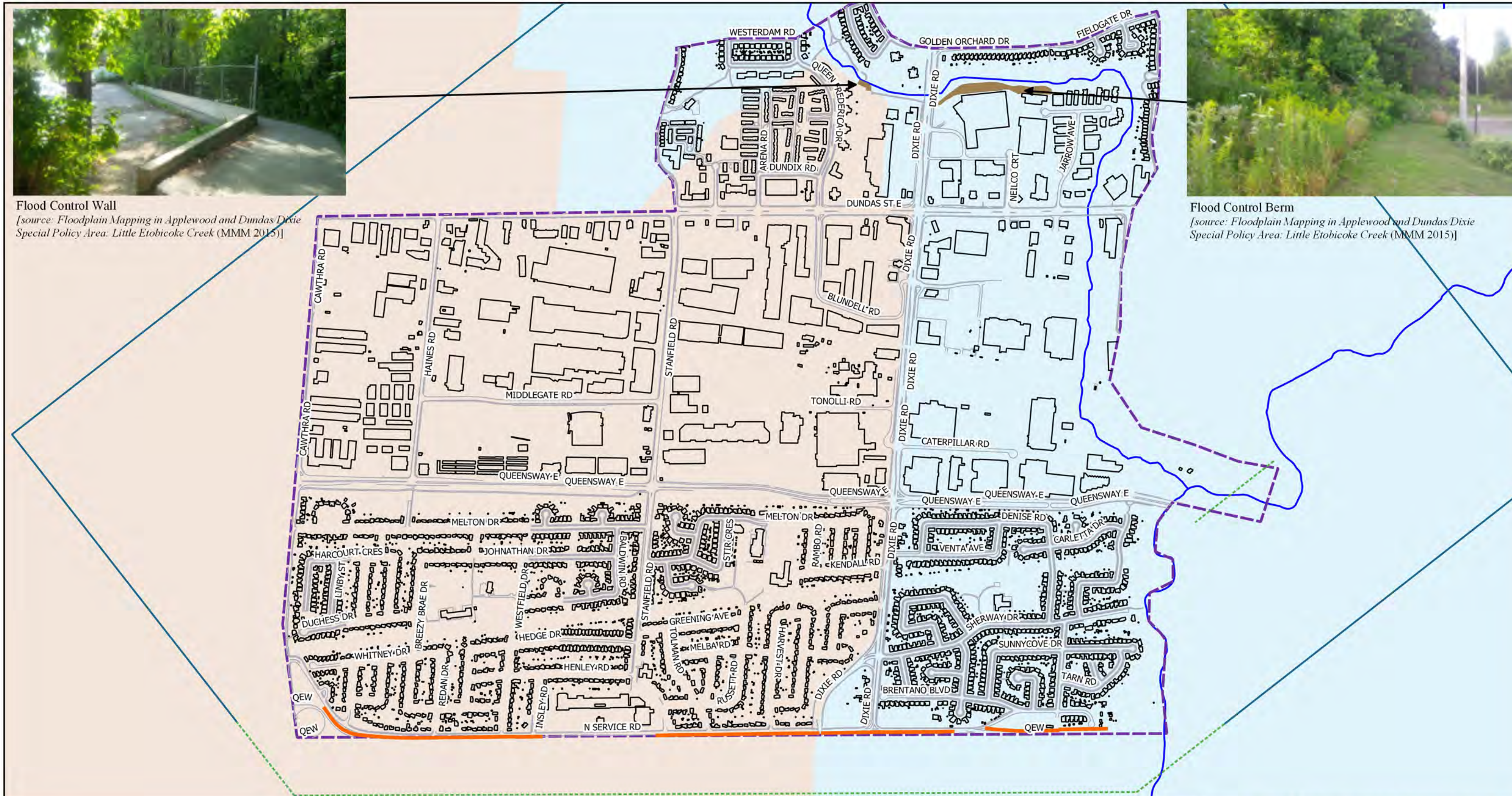
The expanded study area includes the QEW, along which there is a noise wall on the north side between North Service Road and the highway. The noise wall includes a concrete barrier extending from Cawthra Road easterly to the Applewood Village Plaza. There is no noise wall along the extent of the plaza. From the plaza easterly to Laughton Avenue, there is a noise wall with no concrete barrier. It is understood that the noise wall with concrete barrier and also the noise wall alone will create a significant blockage to overland flow and therefore they were included in the 2D model as blocked obstructions.

In addition to extending the model surface bathymetry, the 2D model resistance map (Manning's roughness) was extended to match the Phase 1 study limits (Figure 3). Standard TRCA Manning's values were applied in the expanded area based on land use data provided by TRCA and CVC. Table 1 provides a summary of the TRCA Manning's roughness values used in the model. The methodology for applying roughness in MIKE FLOOD modelling is to use Manning's M (the inverse of Manning's n).

**Table 1 Manning's Roughness Values**

| Land Use | Manning's n | Manning's M |
|---|---|---|
| Woods / Meadow / Cultivated Lands | 0.08 | 12.5 |
| Lawns | 0.05 | 20 |
| Impervious Areas | 0.025 | 40 |

The boundary conditions for the extended 2D model were assigned based on site conditions. The available options for assigning boundary condition options include either open or closed boundaries, wherein flow will be permitted to exit the system or be blocked, respectively. The majority of the 2D boundary edge is closed including all areas upstream of the MIKE 11 extent, the entire western edge, and the eastern edge up to the point where the MIKE 11 model outlets. The remaining areas are open, including the entire southern edge and the area encompassing the main branch of Etobicoke Creek downstream of its confluence with Little Etobicoke Creek. A boundary condition water level was applied to the open boundary locations consistent with site conditions and the results of the TRCA HEC-RAS model. The boundary conditions are shown on Figure 2.




Flood Control Wall
*[source: Floodplain Mapping in Applewood and Dundas/Dixie Special Policy Area: Little Etobicoke Creek* (MMM 2015)]

Flood Control Berm
*[source: Floodplain Mapping in Applewood and Dundas/Dixie Special Policy Area: Little Etobicoke Creek* (MMM 2015)]

- Watercourse
- Noise Wall
- Flood Control Wall
- Flood Control Berm
- Phase 1 Boundary

- TRCA Jurisdiction
- CVC Jurisdiction

MIKE FLOOD Boundary Conditions
- Closed
- Open

0 250 500 750 1000 m

1:12,500

Figure Date: December 1, 2017

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Little Etobicoke Creek Flood Evaluation Study
Progress Report #1

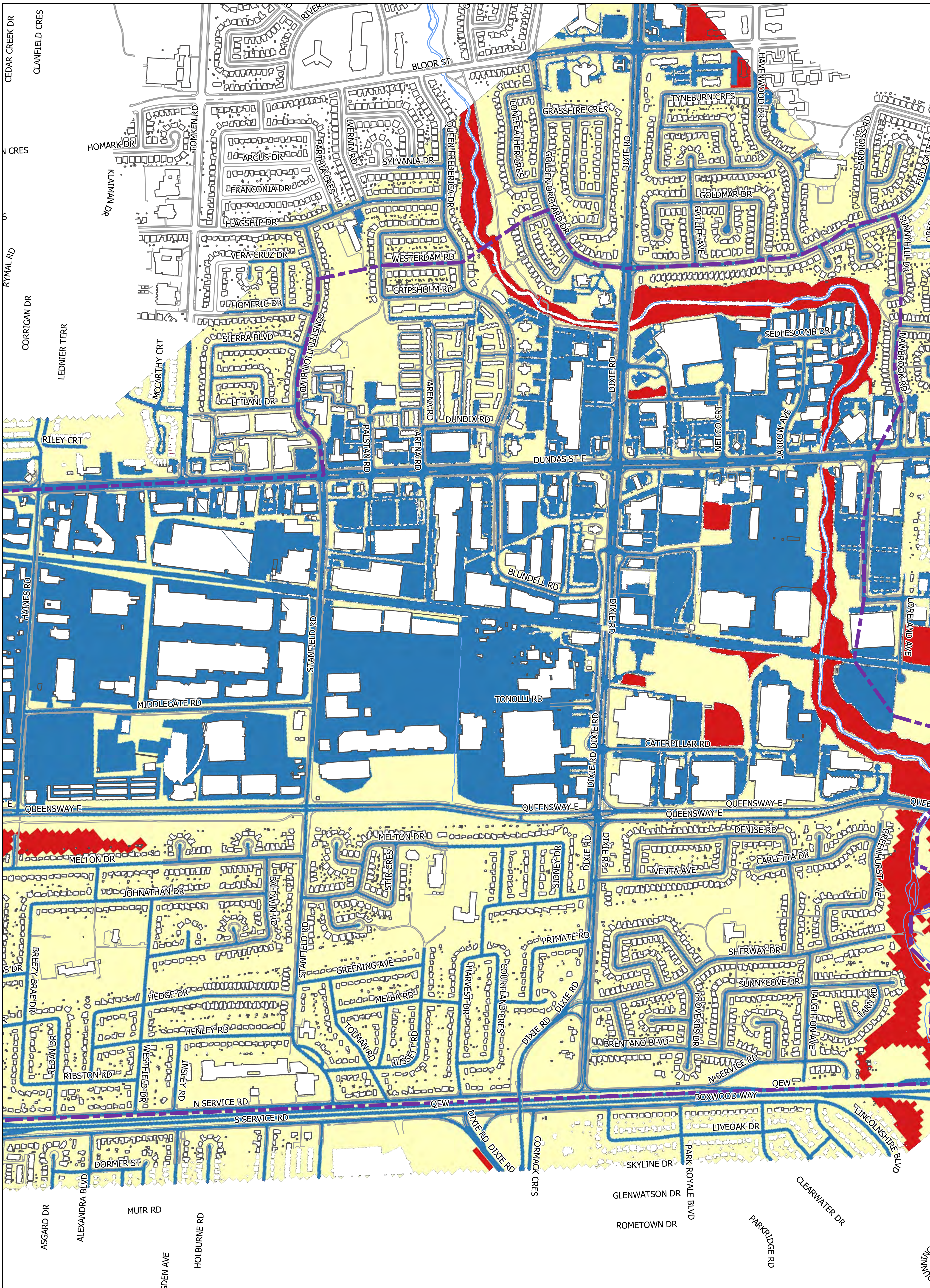
Project #24603

## MIKE FLOOD Model Setup



K. Molnar
K. Hofbauer

Figure 2




Phase 1 Study Area

Manning's M

- 12.5 (n=0.08)
- 20 (n=0.05)
- 40 (n=0.025)

0 100 200 300 400 500 m

1:10,000

N

Figure Date: October 2, 2017

**Matrix Solutions Inc.**
ENVIRONMENT & ENGINEERING

Little Etobicoke Creek Flood Evaluation Study
Progress Report #1

Project #24603

## Manning's Roughness Map

Disclaimer: The information contained herein may be compiled from numerous third party materials that are subject to periodic change without prior notification. While every effort has been made by Matrix Solutions Inc. to ensure the accuracy of the information presented at the time of publication, Matrix Solutions Inc. assumes no liability for any errors, omissions, or inaccuracies in the third party material.

K. Molnar
K. Hofbauer

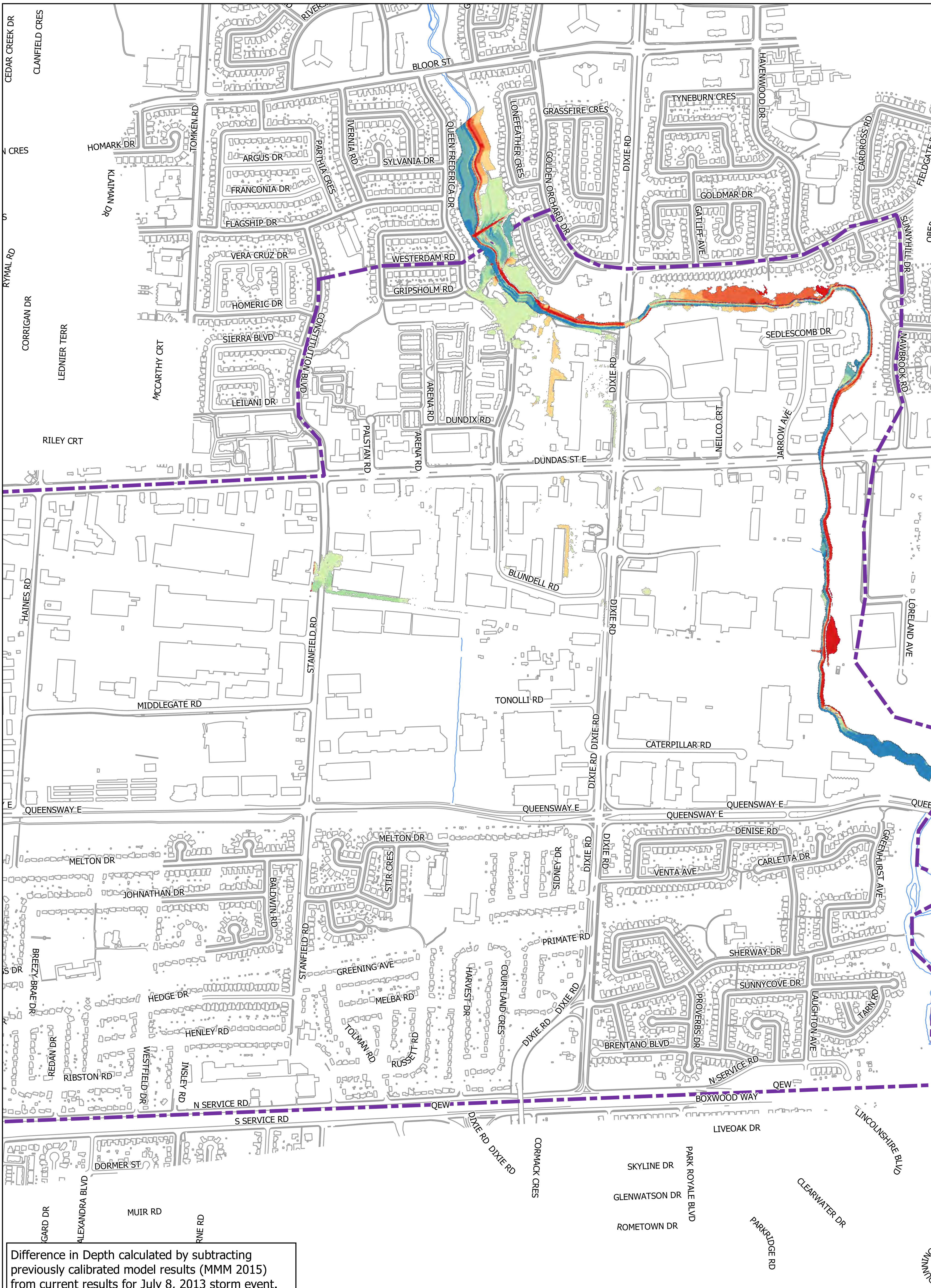
Figure 3

T:\24603 - Little EtobicokeCr_Flood\531\05 Analysis\GIS

## 4.2 Model Validation

The MIKE FLOOD model was first simulated using the July 8, 2013 rainfall event based on hydrologic output from the existing VO model. The validation process was consistent with the MMM 2015 study in which anecdotal information (video and photographs posted to social media by residents) was compared to model results at a number of locations. The validation was required to ensure that the extension of the 2D boundary and re-evaluation of boundary conditions did not result in any significant changes to the model results.

The results of the expanded model were compared to that of the previous model. The comparison revealed very minimal difference between the results. A comparison of the water level differences are shown in Figure 4 in which the previous model results were subtracted from the current results with the expanded model domain. The average difference in water level is less than 1 cm (note that differences between -0.01 m and 0.01 m are not shown). Larger differences are noted along the river banks due to the updated MIKE 11 boundary conditions, as discussed in Section 4.1. A small increase in spill adjacent to Queen Frederica Drive is also noted; however, this can also be attributed to the riverine water elevations and does not propagate through the surface model.




Difference in Depth calculated by subtracting previously calibrated model results (MMM 2015) from current results for July 8, 2013 storm event.

**Difference in Depth (m)**

- <= -0.20
- -0.20 - -0.10
- -0.10 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.10
- 0.10 - 0.2
- > 0.2
- Phase 1 Study Area

0 100 200 300 400 500 m

1:10,000

N

Run Date: September 17, 2017
Figure Date: October 2, 2017

**Matrix Solutions Inc.**
ENVIRONMENT & ENGINEERING

Little Etobicoke Creek Flood Evaluation Study
Phase 1: MIKE FLOOD Results

Project #24603

# Water Level Comparison to Previous Model July 8, 2013 Storm Event



K. Molnar
K. Hofbauer

Figure 4

T:\24603 - Little EtobicokeCr_Flood\531\05 Analysis\GIS

## 4.3 Design Storm Runs

The validated model was run under a variety of rainfall distributions and design rainfall event hydrographs to assess existing flood risk and spill conditions, as summarized in Table 2. The run numbers correlate with the risk mapping which are displayed in Maps 1 to 9.

The steady state Regional Storm run was required for mapping the flood extent of the Regional Storm in line current provincial standards. While the aim of this study is not to produce regulatory mapping, the use of steady state results is standard practice for Regional Storm flood mapping. The unsteady Regional Storm and design storm runs were used for the spill assessment.

At the request of the City, both 24-hour Chicago and 12-hour AES design storm runs were completed for the 25-year to 100-year design storm events. Peak flows based on the 24-hour Chicago rainfall distribution were used for the design storm modelling as this rainfall distribution is typically used in urban areas where the peak flow is largely influenced by rainfall intensity as opposed to rainfall depth. The 12-hour AES was also considered as it was found to be the most conservative estimate of peak flows in the MMM 2013 study and was therefore recommended for establishing peak flows within the Etobicoke Creek watershed. The 12-hour AES rainfall distribution is also used by TRCA is other urban watersheds.

**Table 2 Existing Condition Model Runs**

| Run No. | Storm Event | Rainfall Distribution | Flow Condition |
|---|---|---|---|
| 1 | Regional | n/a | Steady |
| 2 | Regional | n/a | Unsteady |
| 3 | 100-year | 24-hour Chicago | Unsteady |
| 4 | 50-year | 24-hour Chicago | Unsteady |
| 5 | 25-year | 24-hour Chicago | Unsteady |
| 6 | 100-year | 12-hour AES | Unsteady |
| 7 | 50-year | 12-hour AES | Unsteady |
| 8 | 25-year | 12-hour AES | Unsteady |
| 9 | July 8, 2013 | n/a | Unsteady |

## 4.4 Subwatershed Spill Assessment

A detailed review of the Regional Storm, design storms, and July 8, 2013 historical storm model output was conducted to quantify spill from Little Etobicoke Creek. To develop hydrographs of the spill the dynamic unsteady results were reviewed. The output file from the dynamic modelling includes a time series of flooding in the 2D domain including depth and velocity. A number of cross-sections along the spill path were generated using GIS as shown on Figure 6. Locations 2 and 5 were used for the spill assessment into CVC jurisdiction as they all contribute flow across the TRCA / CVC watershed boundary based on review of the dynamic results. Using a post-processing tool in MIKE Zero, a time series of discharge values was generated from the 1D and 2D result files along the selected cross-sections for each modelled storm event (25-year through 100-year and Regional Storm) was generated.

To confirm the results, the calculated total spill hydrograph from the MIKE 21 model was compared to the lateral spill hydrograph along the right bank from the MIKE 11 model (see Figure 5). The difference in spill between the MIKE 21 results (purple line) and the right bank lateral spill (light blue dashed line) represents the storage on the surface in the model domain between these points. The purple line indicates the 2D spill from the river in the vicinity of Queen Frederica Drive, which represents the flow spilling from TRCA's Little Etobicoke Creek watershed into CVC jurisdiction.

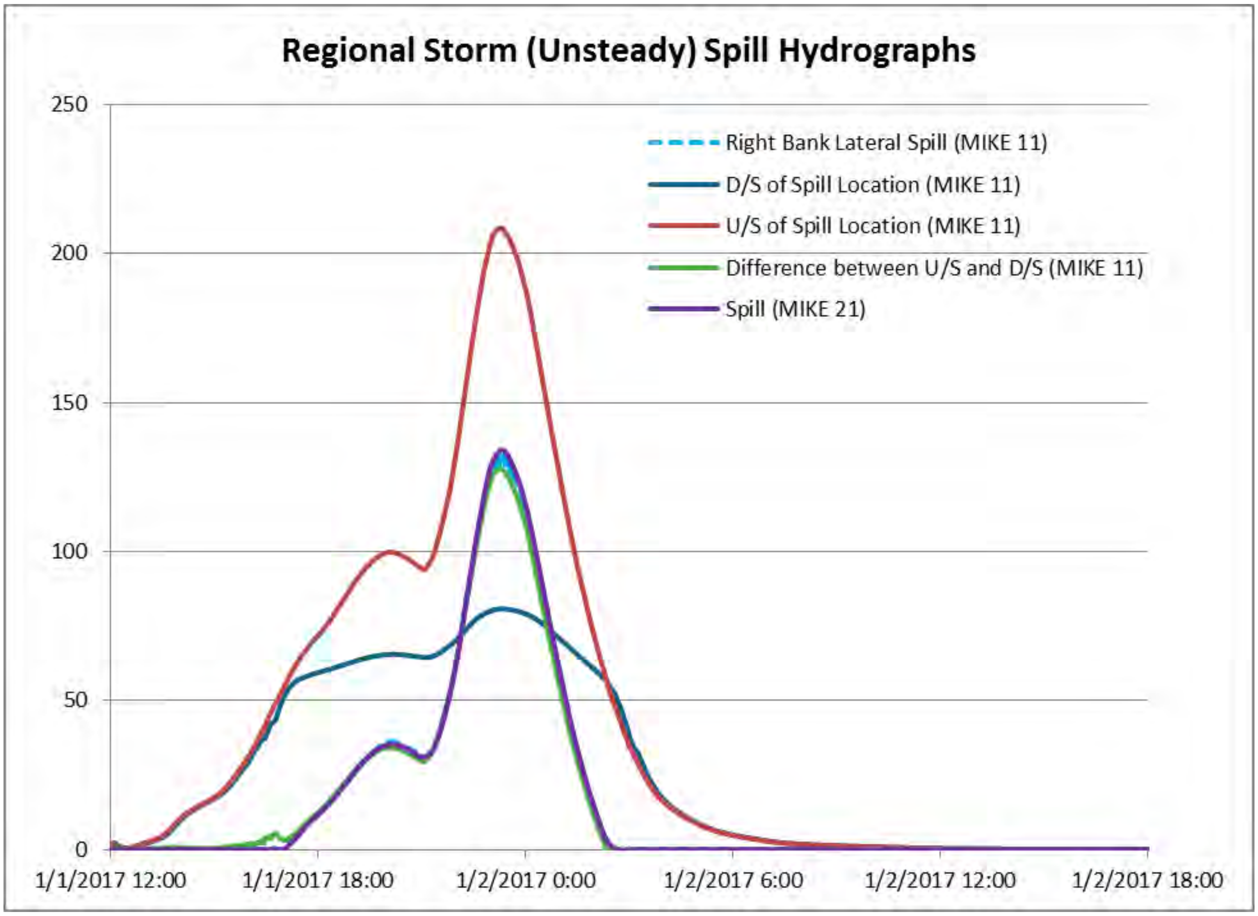



**Figure 5 Regional Storm Spill Hydrographs (Unsteady State)**

Further confirmation of flow results are summarized in the flow balance provided in Table 3. The flow balance locations are indicated on Figure 6. This method has also been used to confirm flow balance and develop spill hydrographs from the river for all design storms which are provided in Appendix B.

**Table 3 Regional Storm Flow Balance (Unsteady State)**

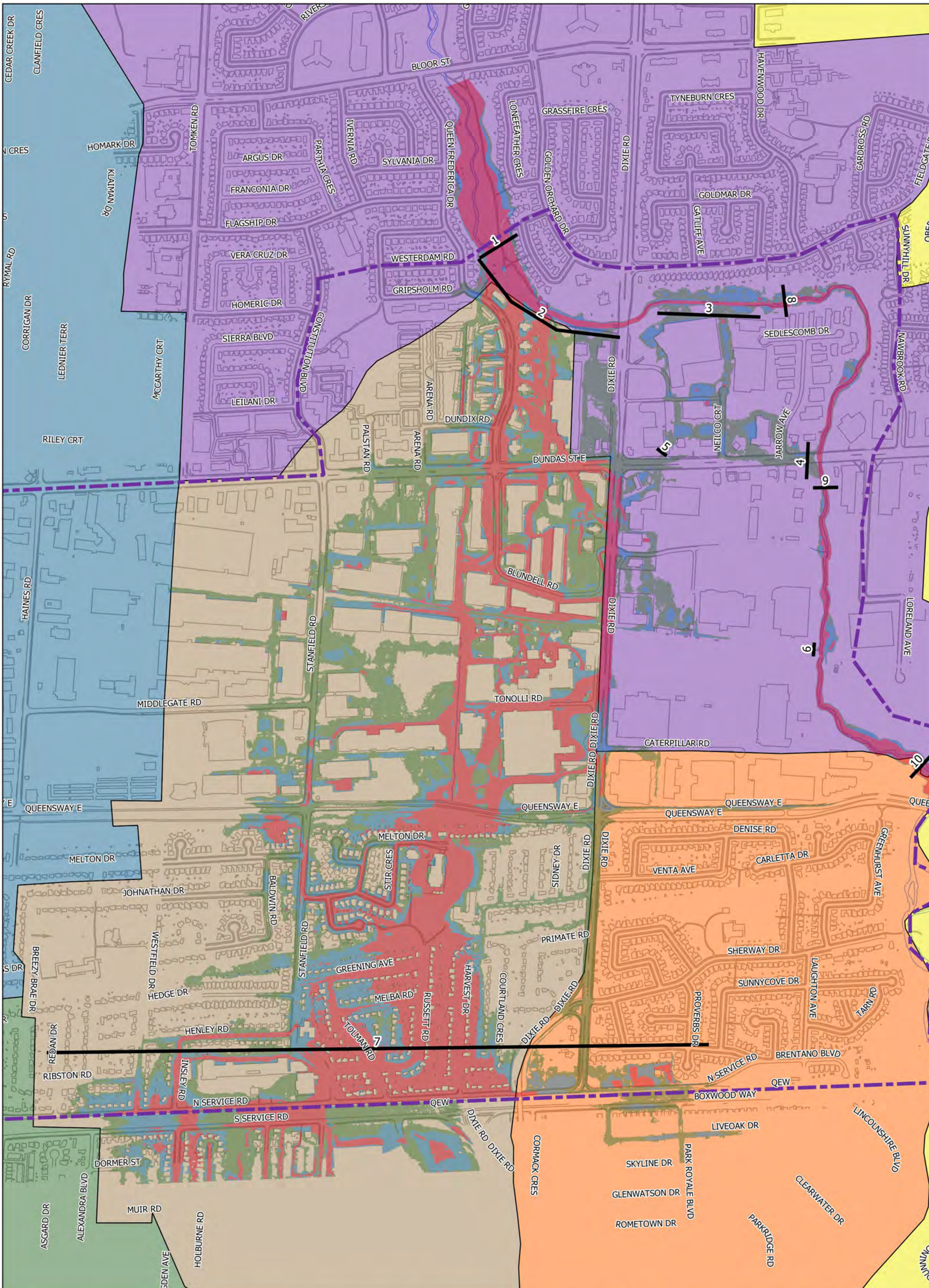
| Location | Flow ($m^3/s$) |
|---|---|
| 1 | 205.0 |
| 2 | 134.1 |
| 3 | 3.1 |
| 4 | 3.8 |
| 5 | 0.1 |
| 6 | 0.0 |
| 7 | 127.7 |
| 8 | 73.9 |
| 9 | 79.0 |
| 10 | 80.4 |

### 4.4.1 CVC Hydrology Recommendations

During major storm events flow from Little Etobicoke Creek spills from TRCA into CVC jurisdiction. Based on review of the subwatershed boundaries within the City of Mississauga (Figure 6), the flow spills from the Little Etobicoke Creek subwatershed into the Applewood Creek subwatershed; no spill into the Cooksville Creek or Serson Creek subwatersheds is observed based on the model results. While there is some spill directed to TRCA's Etobicoke Lakeshore subcatchment in the vicinity of Dixie Road and the QEW, the vast majority of this flow will be conveyed back into Applewood Creek along the QEW noise barrier.

To account for the spill from TRCA into CVC jurisdiction, it is recommended that the spill hydrographs provided in Appendix B be incorporated into the Applewood Creek hydrology model at the most upstream flow node in the Applewood Creek watershed (VO ID 1018, Queen Frederica Drive from the Applewood Visual OTTHYMO Model (Civica Infrastructure 2015) provided by CVC at the outset of the project).

Under steady state flow conditions a very small amount of flow (approximately 0.05 $m^3/s$) is observed spilling from the Applewood Creek subwatershed into the Cooksville Creek subwatershed near Middlegate Road east of Haines Road (see Figure 8). However, flows do not spill to Cooksville Creek under the unsteady state simulation, and therefore no inflow should be incorporated into the Cooksville Creek hydrology model.




Mississauga Watersheds

- Etobicoke Creek (TRCA)
- Etobicoke Lakeshore (TRCA)
- Little Etobicoke Creek (TRCA)
- Applewood Creek (CVC)
- Cooksville Creek (CVC)
- Serson Creek (CVC)

Flow Balance Locations

Phase 1 Study Area

Risk (Regional Unsteady)

- Low
- Medium
- High

0 100 200 300 400 500 m

1:10,000

Figure Date: December 19, 2017

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Little Etobicoke Creek Flood Evaluation Study
Phase 1: MIKE FLOOD Results

Project #24603

Mississauga Watersheds
Spill Assessment

Disclaimer: The information contained herein may be compiled from numerous third party materials that are subject to periodic change without prior notification. While every effort has been made by Matrix Solutions Inc. to ensure the accuracy of the information presented at the time of publication, Matrix Solutions Inc. assumes no liability for any errors, omissions, or inaccuracies in the third party material.

K. Molnar
K. Hofbauer

Figure 6

T:\24603 - Little EtobicokeCr_Flood\531\05 Analysis\GIS

## 4.5 Risk Assessment

A risk assessment was completed for the design storm runs with consideration of three risk factors: depth, velocity, and depth-velocity product. In accordance with current MNRF practices, the following risk mapping criteria apply (Table 4). Low risk includes areas that are inundated but where vehicular and pedestrian ingress and egress are still feasible. Medium risk areas do not permit vehicular ingress and egress, but pedestrian ingress and egress is possible. High risk areas do not facilitate safe land access of any kind. These flood risk criteria were used to develop the flood risk mapping presented as Sheet 4 in each of Maps 1 through 9.

**Table 4 Flood Risk Criteria**

| Risk Level | Low | Medium | High * |
|---|---|---|---|
| Depth | ≤ 0.3 m | > 0.3 m and ≤ 0.8 m | > 0.8 m |
| Velocity | ≤ 1.7 m/s | ≤ 1.7 m/s | > 1.7 m/s |
| Depth-Velocity Product | ≤ 0.37 $m^2/s$ | ≤ 0.37 $m^2/s$ | > 0.37 $m^2/s$ |

* Exceedance of any one of the criteria results in high risk.

## 4.6 Regional Storm Mapping

In addition to the risk assessment, the graphical mapping produced by the steady state Regional Storm event was reviewed to determine where spill is contained within municipal rights of way, as requested by the City (Figure 7).

In order to determine Regional Storm flood extents, current provincial standards stipulate the hydraulic model be run in steady state. Additionally, also consistent with current standards, the flood control features (flood wall and flood control berm) in the vicinity of the spill area from Little Etobicoke Creek were not included in the Regional Storm run of the model.

Regional Storm flood extents mapping has been developed as part of the final tasks of Phase 1 based on the steady state model results (refer to Figure 8).


Phase 1 Study Area

Right-of-Way Assessment

Spill within ROW

Spill on Private Property

0 100 200 300 400 500 m

1:10,000

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Little Etobicoke Creek Flood Evaluation Study
Phase 1: MIKE FLOOD Results

Project #24603

## Right-of-Way and Private Land Areas Spill Assessment

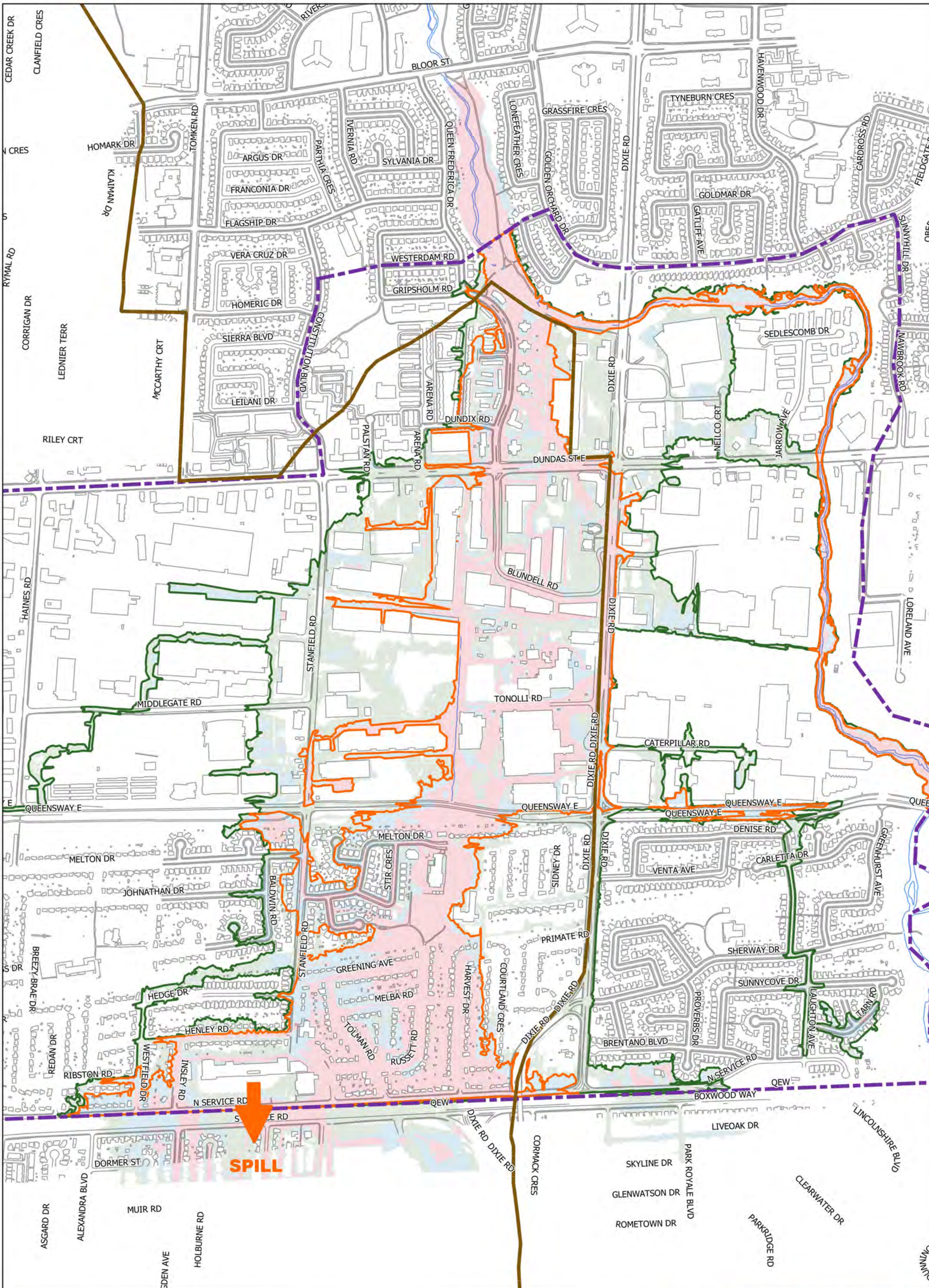
Disclaimer: The information contained herein may be compiled from numerous third party materials that are subject to periodic change without prior notification. While every effort has been made by Matrix Solutions Inc. to ensure the accuracy of the information presented at the time of publication, Matrix Solutions Inc. assumes no liability for any errors, omissions, or inaccuracies in the third party material.

K. Molnar
K. Hofbauer

Figure Date: October 12, 2017

Figure 7

T:\24603 - Little EtobicokeCr_Flood\531\05 Analysis\GIS




Phase 1 Study Area
TRCA/CVC Boundary

Preliminary Floodlines

Floodway
Flood Fringe

Modelled Flood Risk

Low
Medium
High

0 100 200 300 400 500 m

1:10,000

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Little Etobicoke Creek Flood Evaluation Study
Phase 1: MIKE FLOOD Results

Project #24603

Regional Storm - Steady State
Flood Extents

Disclaimer: The information contained herein may be compiled from numerous third party materials that are subject to periodic change without prior notification. While every effort has been made by Matrix Solutions Inc. to ensure the accuracy of the information presented at the time of publication, Matrix Solutions Inc. assumes no liability for any errors, omissions, or inaccuracies in the third party material.

K. Molnar
K. Hofbauer

Figure 8

Run Date: December 16, 2017
Figure Date: December 19, 2017

T:\24603 - Little EtobicokeCr_Flood\531\05 Analysis\GIS

# 5 NEXT STEPS

With the validated MIKE FLOOD model and completion of design storm runs, this report finalizes Phase 1 of the study. Following completion of Phase 1, Matrix is proceeding with Phase 2 including preparation of the integrated PCSWMM model.

# 6 REFERENCES

AECOM. 2016. *DRAFT Special Policy Area and Flood Mitigation Review Dundas Street Transportation Master Plan*. Mississauga, Ontario. June 2016.

Civica Infrastructure Inc. (Civica Infrastructure). 2015. *Applewood Hydrology Regional Storm Visual OTTHYMO (VO) v3.0 Model,* Vaughan, Ontario. 2015.

MMM Group Limited. 2015. *Floodplain Mapping in Applewood and Dundas / Dixie Special Policy Area: Little Etobicoke Creek*. Toronto and Region Conservation Authority. Mississauga, Ontario. January 2015.

MMM Group Limited. 2013. *Draft Final Report Etobicoke Creek Hydrology Update*. Toronto and Region Conservation Authority. Mississauga, Ontario. April 2013.

# APPENDIX A
# Public Information Centre #1 Material

# Welcome

Welcome to Public Information Centre #1 for the

## Little Etobicoke Creek
## Flood Evaluation Study and Master Plan

The purpose of this evening's Public Information Centre is to

**Provide an overview of the proposed study**
**Obtain public input regarding known flooding issues to inform the study**

**Please sign in if you would like to be included on the project mailing list**

Visual information presented this evening is available on
the City of Mississauga's website:
**http://www.mississauga.ca/portal/stormwater/flooding**

# Last Comprehensive Flood Study

1985

2017

The last comprehensive flood study of Little Etobicoke Creek watershed was completed in 1988:

**A Preliminary Engineering Study for Flood and Erosion Control – Little Etobicoke Creek**

The outcomes from that study included:

- Identification of 7 flood hazard areas within the watershed where a significant flood hazard exists
- Identification of existing erosion problem areas and protective channel works
- Proposed flood mitigation schemes

**Significant changes have occurred within the watershed since the 1988 study:**

- Development in headwaters (east of 403/410)
- New roads (Eastgate Parkway)
- Increased impervious areas
- Climate change

# Project History - Recent Flooding

There have been several large flood events in the GTA in recent years:

- This shows an increase in frequency and intensity of extreme events
- May be an indication of climate change

Recent Flooding events include:

**August 19th, 2005 Flooding**

- Rainfall in excess if 100 mm recorded
- Produced estimated 25 year return period flow

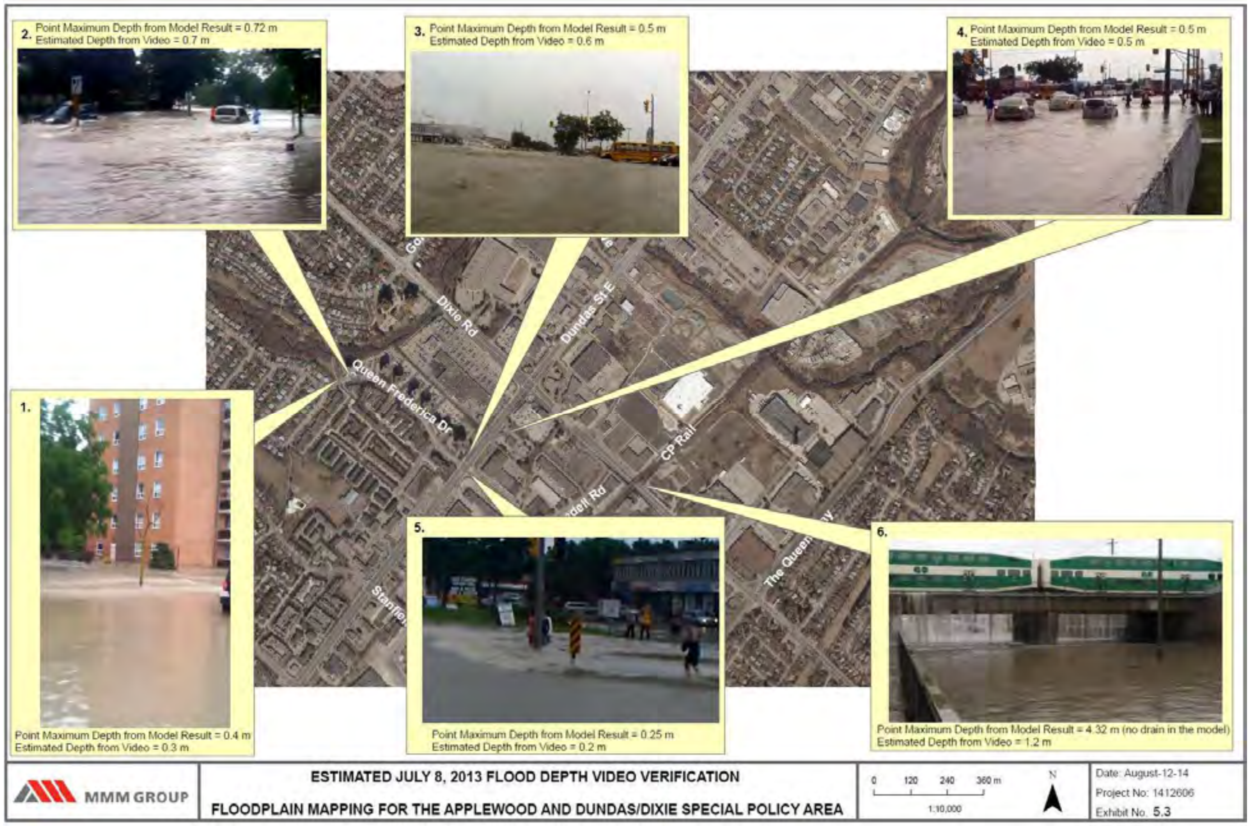
**July 8th, 2013 Flooding**

- Largest flood on record for Etobicoke Creek
- Estimated 350-year peak flow in Little Etobicoke near Dixie Road

Dixie Road and Dundas Street

Cawthra Road and North Service Road

Map and photos of July 8th, 2013 flooding in Dundas/Dixie special policy area



# Project History - Recent Studies

Recent flooding spurred new studies focused on flood prone areas:

**Floodplain Mapping in Applewood and Dundas / Dixie Special Policy Area (MMM Group, 2015)**

- Develop updated flood hazard mapping for Little Etobicoke Creek through the Dundas / Dixie and Applewood SPAs
- Develop 1D and 2D hydraulic models to estimate flood elevations
- Complete preliminary assessment of alternatives to reduce flood risk

**DRAFT Special Policy Area and Flood Mitigation Review Dundas Street Transportation Master Plan (AECOM, 2016)**

- Review of existing Special Policy Areas subject to flooding (Applewood SPA, Dixie District SPA)
- Review boundaries and restrictions
- Review potential flood mitigation measures that may reduce restrictions on intensification and transit along Dundas Street
- It should be noted that the SPA update process is at a preliminary stage, and results to date may be subject to significant changes

**Dundas Connects (City of Mississauga, in progress)**

- Master Plan for the Dundas Corridor focusing on changes to land-use, transit and public realm
- Mitigation measures being considered for flood constraints in Dixie Dundas area

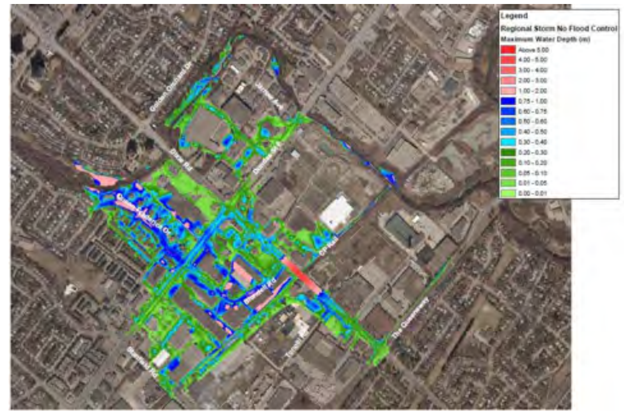


Image: Regional Flood Depth Map (MMM, 2015)


Images: Applewood and Dixie Special Policy Areas (AECOM, 2016)

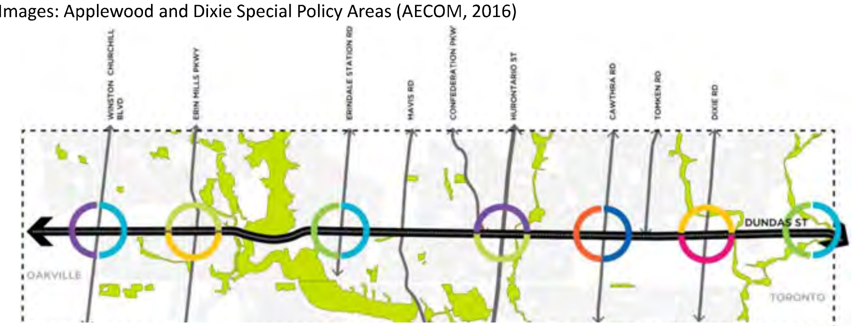



Image: Dundas Corridor (Mississauga, 2017)

# Study Overview

Following the recent focused studies, the current project will be completed as a comprehensive watershed scale study.

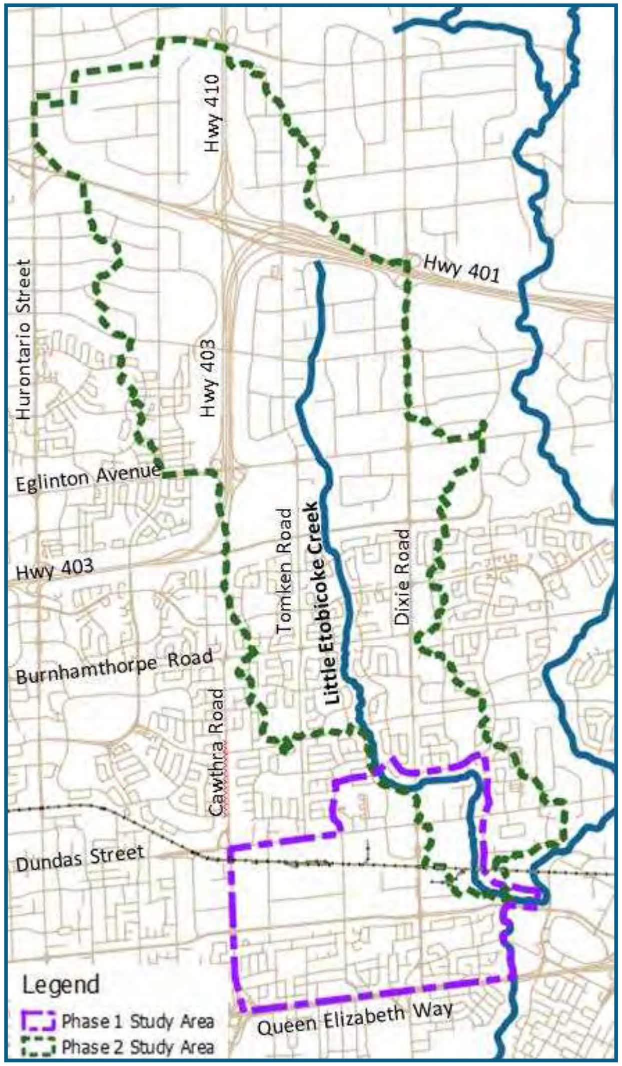
**The study will be completed as two phases:**

- Phase 1 will expand upon previous studies of the overland spill from Little Etobicoke Creek, particularly in the Dixie Road and Dundas Street area, during high flow conditions.
- Phase 2 will identify overland urban flooding risk throughout the Little Etobicoke Creek subwatershed and develop, assess and recommend remediation measures.

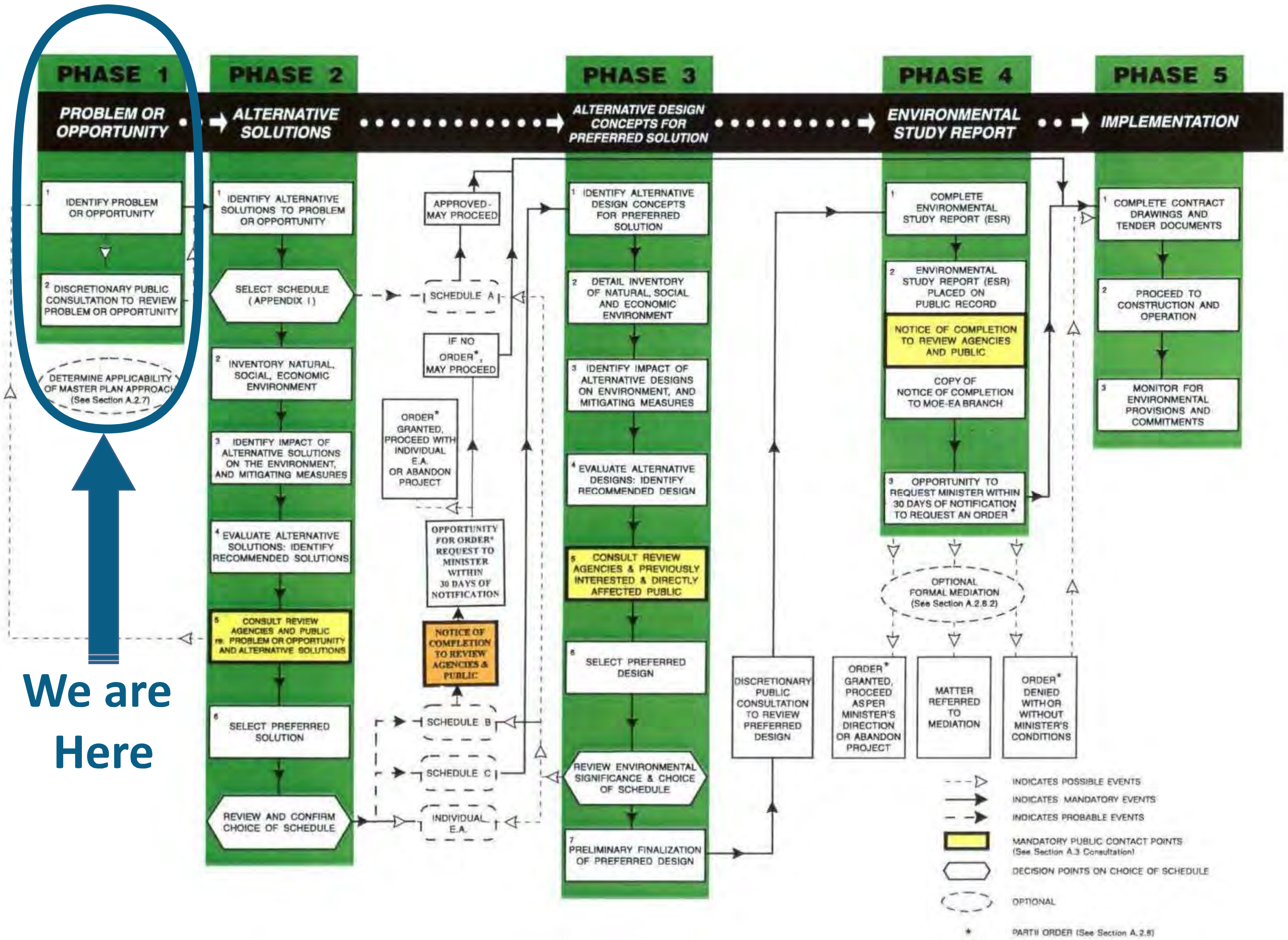
**Objectives of the Little Etobicoke Creek Flood Evaluation study:**

- To recognize and account for the flow entering other subwatersheds as a result of spill originating near Dixie Road and Dundas Street
- To identify areas at risk of riverine and urban flooding
- To develop a plan to mitigate risks to people, property and infrastructure

**At the end of the study, a Master Plan Report documenting the entire study will be available for public review.**



# Master Plan and EA Process




The study will be completed as a Master Plan under the Municipal Class Environmental Assessment ("EA") process.

The study will follow Approach 2 of the Municipal Class EA Master Planning process which includes completion of Phases 1 and 2 of the EA process.

This method will fulfill planning, technical, and public input requirements for any future Class EA Schedule B projects undertaken by the City.

# Phase 1- Study Description

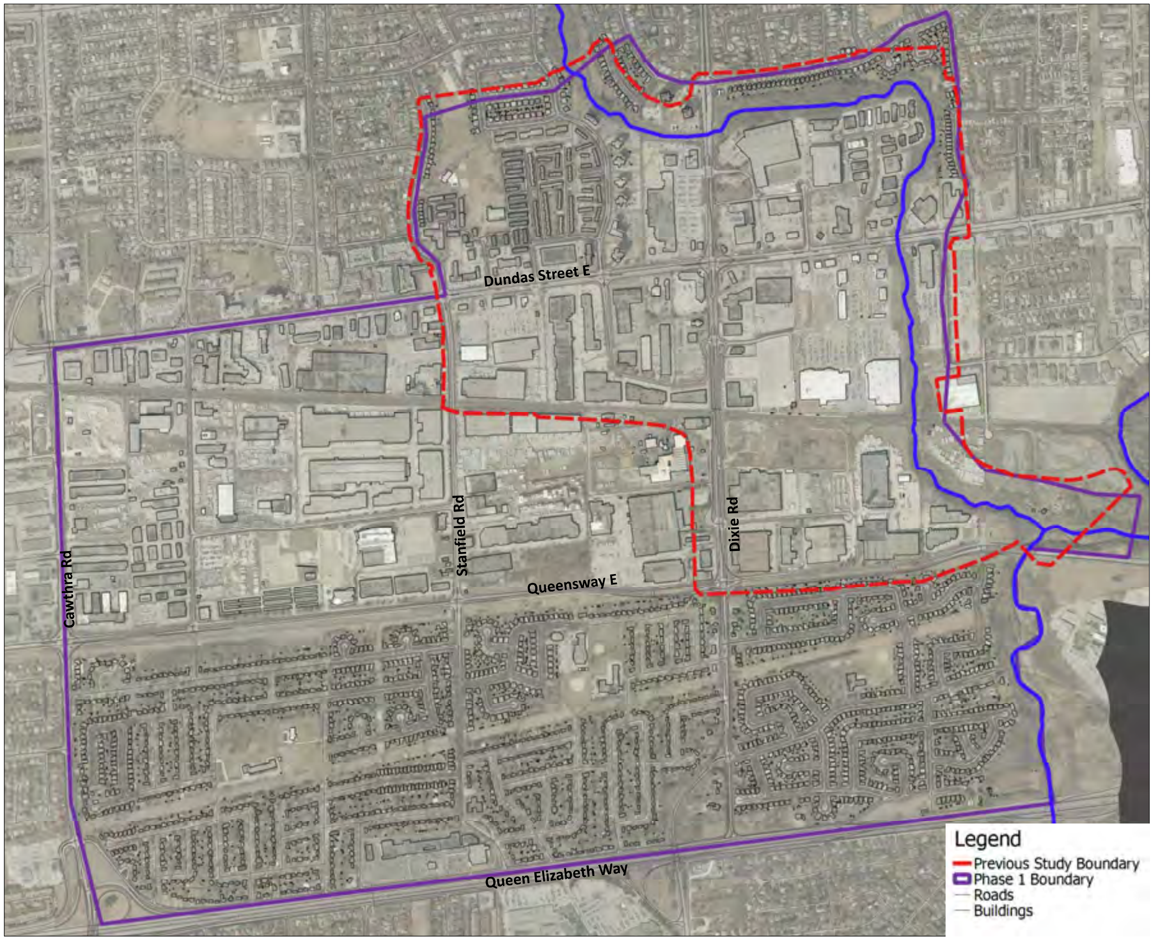
Phase 1 expands upon previous studies which identified that under high flow conditions Little Etobicoke Creek (TRCA jurisdiction) spills to an adjacent watershed (CVC jurisdiction).

**Phase 1 objectives are to:**

- Identify the extents of flooding resulting from the spill
- Determine the quantity of flow entering other watersheds
- Develop regulatory flood hazard mapping of the spill area

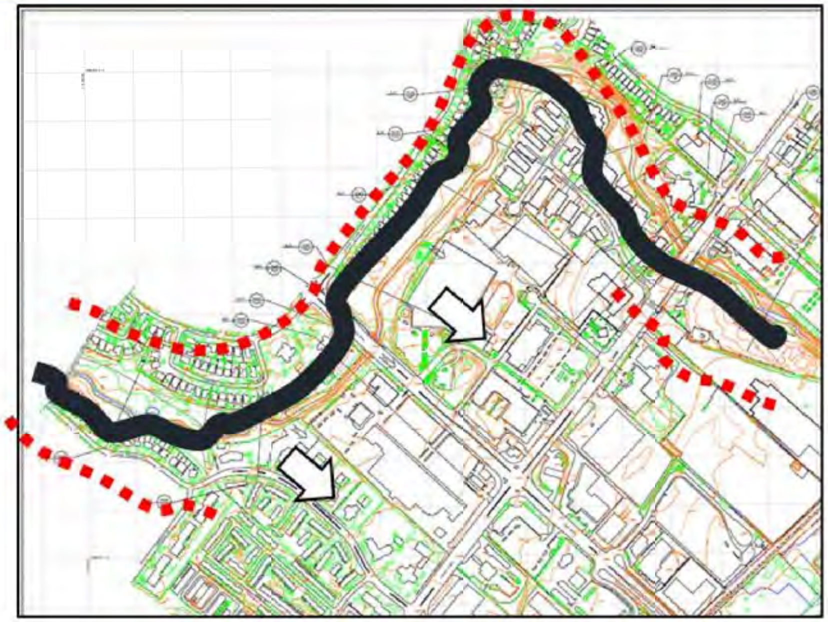
Phase 1 technical assessment includes expanding the existing model to allow for additional spill assessment of the July 8, 2013 and Regional storm events.

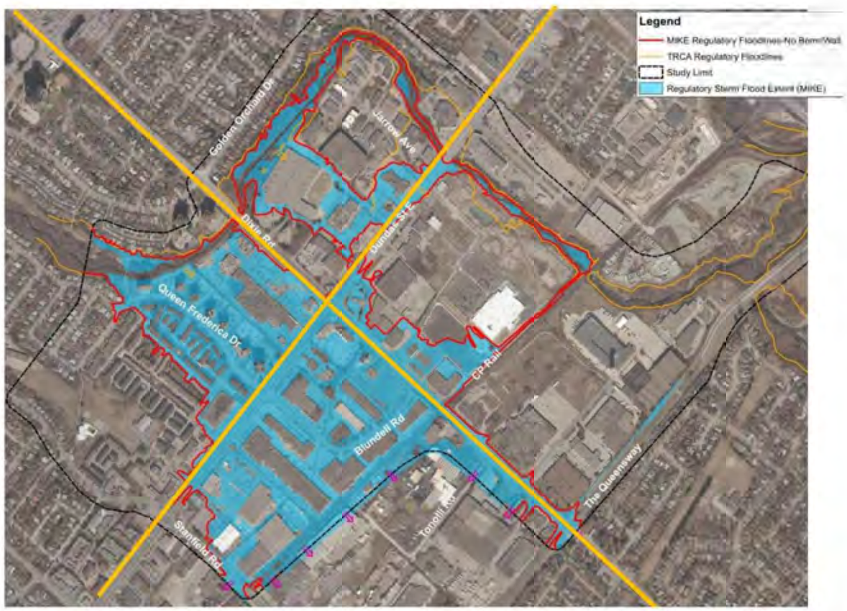
**Results will be used by both TRCA and CVC to update their respective hydrologic and hydraulic models.**



# Phase 1 – Floodplain Spills

- Spills occur when water from the channel leaves the floodplain as a result of high flows.
- Water from spills flows overland in a direction not in line with the channel.
- Spill flow typically rejoins the channel somewhere downstream.
- In this case spilled flow leaves the Etobicoke Creek watershed and flows into Applewood Creek and Serson Creek subwatersheds.






### Traditional Floodplain Mapping - ABOVE ↑

Traditional floodplain modelling could not represent spills well. As a result regulation mapping often includes arrows to indicate a spill, but the severity and impacts of the spill are ambiguous.

### ← Modern Analysis Techniques - LEFT

Modern hydraulic models are able to characterize flow depths and velocities in multiple dimensions. As a result spill extents and flood risk can be mapped more accurately.

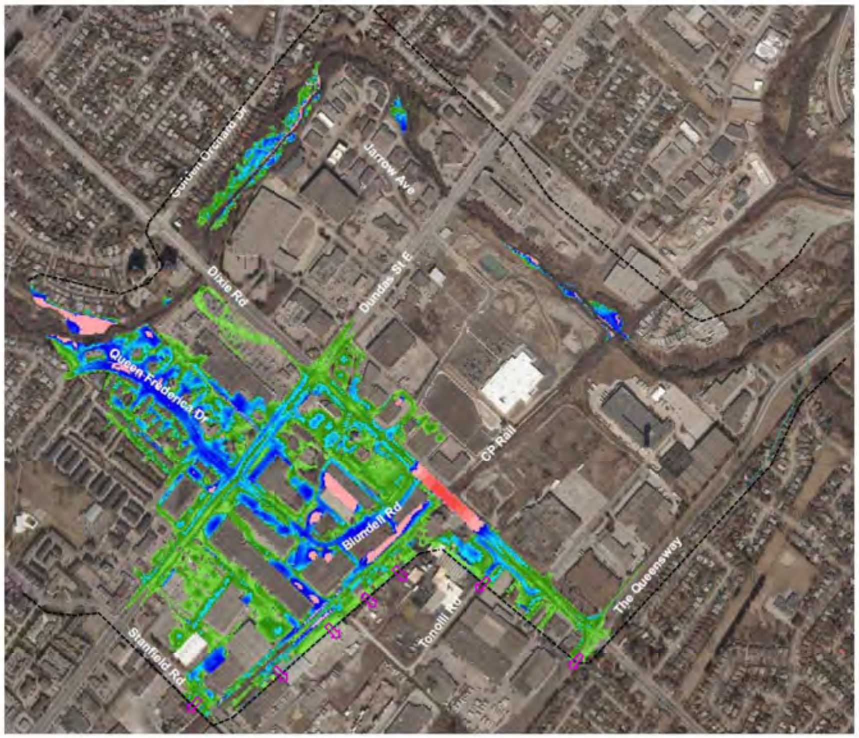
Images: Floodplain Mapping in Applewood and Dundas / Dixie Special Policy Area (MMM, 2015)

# Phase 1 – Previous Study Results

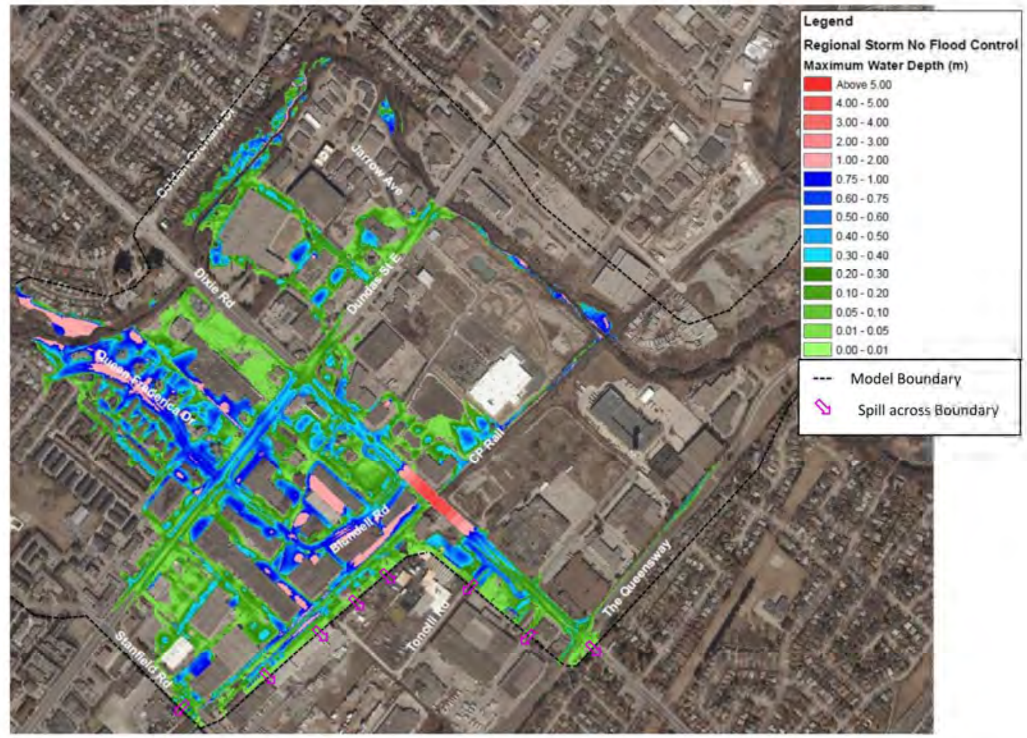
MISSISSAUGA

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

## Modelled depth of flooding from previous study.




July 8, 2013




Hurricane Hazel (Regulatory Storm)

Images: Floodplain Mapping in Applewood and Dundas / Dixie Special Policy Area (MMM, 2015)

# Phase 2 – Study Description

The Phase 2 study area includes the entire Little Etobicoke Creek subwatershed (map on next panel).

## Phase 2 objectives include:

- Identify existing preliminary flood cluster areas that are at risk of riverine and urban flooding
- Determine cause of flooding and contributing factors
- Develop and assess flood remediation works
- Prepare flood remediation plan

## Methodology:

1. Data Collection
2. Site Investigations
3. Develop Integrated Drainage Model
4. Identify Problems and Flood Cluster Areas
5. Complete Flood Characterization
6. Develop Potential Remedial Measures for Flood Cluster Areas
7. Investigate the Upstream and Downstream Effects of Potential Remedial Measures
8. Evaluate and Screen Options
9. Recommend Appropriate Remedial Measures
10. Complete Master Plan Report

# Phase 2 – Study Area



The Phase 2 study area includes the entire Little Etobicoke Creek subwatershed as shown below.

# Agency Roles and Responsibilities

There are multiple government agencies working together to regulate flood risk and maintain drainage infrastructure within the City of Mississauga. The roles and responsibilities of each are summarized below. These agencies have come together in order to complete this comprehensive Master Plan study.

| City of Mississauga | Region of Peel | Conservation Authorities (TRCA and CVC) |
|---|---|---|
| ▪ Road Drainage<br>▪ Storm Sewers<br>▪ Parks<br>▪ Greenbelts<br>▪ Trails<br>▪ City Trees<br>▪ Creek Erosion and Flow Management | ▪ Regional Roads<br>▪ Sanitary Sewers | ▪ Regulation of the Flood Plain<br>▪ Flood Warnings |

# Flooding Information

Your local knowledge and input are valuable to the success of this project.
If you are aware of past flooding please indicate such on your comment sheet and/or at the discussion tables.
Some information is provided below to assist you with this process.

## Types of Flooding

| |  **Riverine (also called Fluvial)** |  **Urban (also called Pluvial)** |
|---|---|---|
| Major System (Overland Flow) | This is significant flooding from the river corridor. This is a natural feature of the river system, however historic development may have occurred within the floodplain.<br>Includes:<br>- High water levels from creeks and rivers<br>- Standing water in floodplains<br>- Fast moving water in channel corridors | Occurs when the roadways and other surface flow paths cannot contain major flows.<br>Includes:<br>- Flooding onto private property from the public right of ways.<br>- Ponding in low areas (e.g. road sags and underpasses)<br>- Basement flooding via windows or doors |
| Minor System (Storm Sewers) | Occurs when culverts or ditches cannot convey flows from a certain storm event.<br>Includes:<br>- Backwater pool upstream of a road crossing<br>- Flow spilling from ditches | Occurs when the storm sewer system does not have capacity to convey a certain storm event.<br>Includes:<br>- Basement flooding via floor drains<br>- Flow coming out of catch basins (perhaps at reverse sloped driveways) |

# Phase 2 – Possible Study Outcomes

## Flood Risk Characterization:

- Identify flood mechanisms and areas of high flood risk based on:
  - Frequency of flooding
  - Depth of flooding
  - Velocity of overland flow
  - Product of depth and velocity
- Identify flooding characteristics in high risk land use areas
- Recommend  and assess potential mitigation measures to reduce flooding.

| Potential Causes of Flooding | Possible Solution Options |
|---|---|
| **Undersized channels (i.e., constrictions, low points in banks)** | • Channel and floodplain improvements<br>• Bank improvements<br>• Flood protection landforms |
| **Undersized structures (culverts, bridges)** | • Structure upgrades |
| **Insufficient minor drainage system (i.e. storm sewers)** | • Sewer improvements<br>• Inlet improvements<br>• Stormwater management facilities |
| **Insufficient conveyance in the right-of-way** | • Road regrading (i.e. road profile or cross section changes)<br>• Raised curbs or sidewalks |
| **Poorly defined overland flow paths and topographic low points (on private or public lands)** | • Recommendations to private land owners<br>• Regrading in public areas |
| **Poor lot drainage** | • Recommendations to private land owners |

## Climate Change:

- Increased storm frequency and intensities resulting from climate change can worsen the effect of any of the above flood types.  This will increase flood risks.

# Contact Information

Comments from this evening's PIC #1 will be received until

**June 30 2017**

Further ongoing study information is available at:

**http://www.mississauga.ca/portal/stormwater/flooding**

If you would like to be included on the project mailing list please sign the sheet at the Welcome Table.

**Thank you for attending!**

**For questions and additional information, please contact:**


**Louie Jakupi, P.Eng.**
Project Manager
City of Mississauga
louie.jakupi@mississauga.ca
Phone: 905.615.3200 x 3321
Fax: 905.615.4081

**Stephen Braun, P.Eng.**
Project Manager
Matrix Solutions Inc.
sbraun@matrix-solutions.com
Phone: 905.877.9531 x 228
Fax: 519.648.3168

## Little Etobicoke Creek Flood Evaluation Study and Master Plan
## Comment and Feedback Sheet – PIC #1 – June 15, 2017

MISSISSAUGA
Matrix Solutions Inc.

Your comments are appreciated. Please use this form to provide comments on any aspect of the project that you consider important. Please return your completed form to the front desk, or send by July 15, 2017 to:


**Louie Jakupi, P.Eng.**
Project Manager
City of Mississauga
louie.jakupi@mississauga.ca
Phone: 905.615.3200 x 3321
Fax: 905.615.4081

**Stephen Braun, P.Eng.**
Project Manager
Matrix Solutions Inc.
sbraun@matrix-solutions.com
Phone: 905.877.9531 x 228
Fax: 519.648.3168


Please describe any storm drainage problems (e.g. storm sewer backup, street flooding) and provide specific dates and locations if possible.

Storm sewer backup IN 2013

Please provide any additional comment on the study or information that may be useful for the study team.

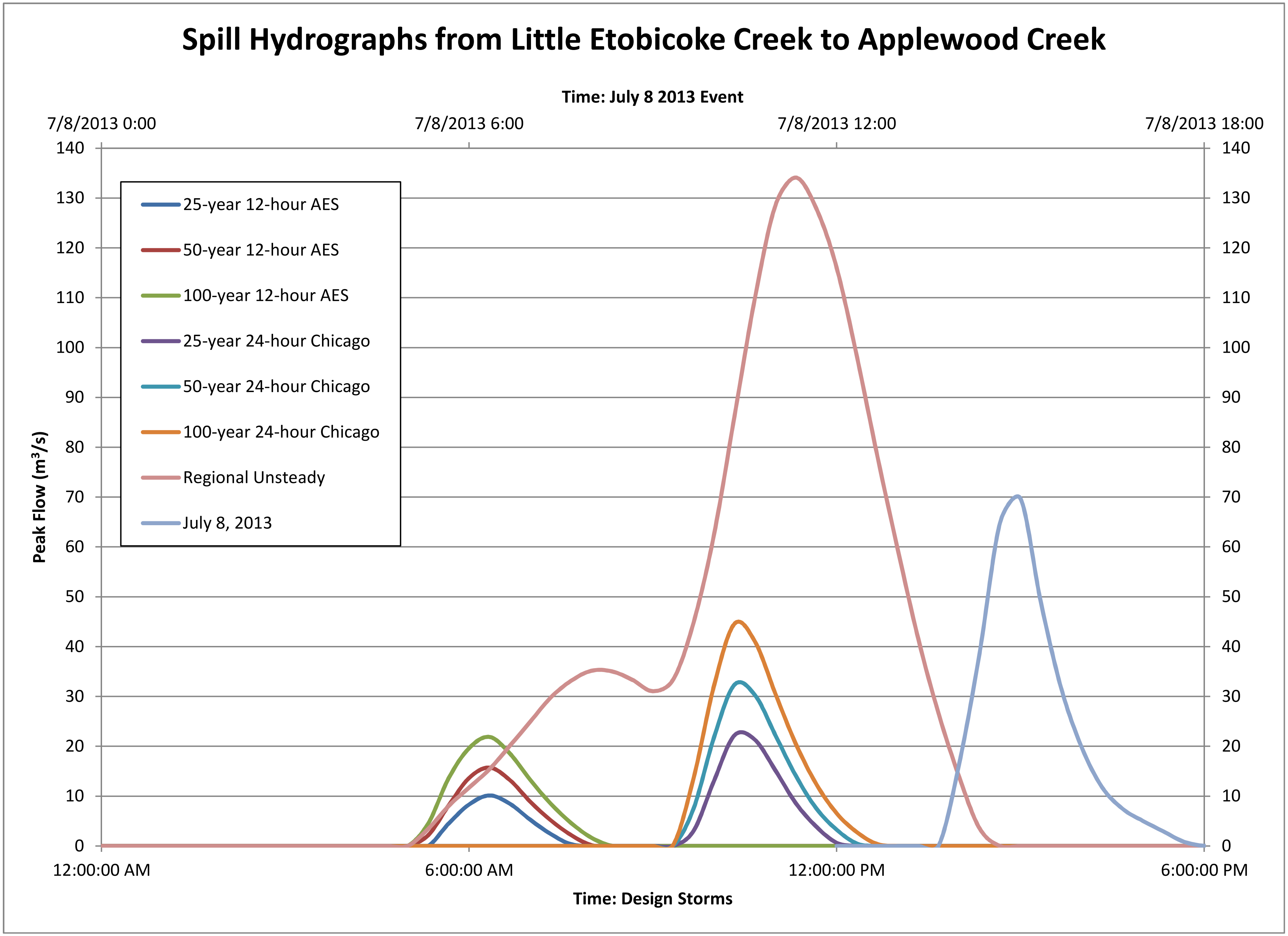
May we contact you to discuss the problems and/or information? Yes ☑ No ☐

*Note: With the exception of personal information, all comments will become part of the public record and a copy of this document may be attached to future reports.*

# APPENDIX B
# Spill Hydrographs to Applewood Creek

## Appendix B: Spill Hydrographs from Little Etobicoke Creek to Applewood Creek

| Time: Design Storms | Flow | | | | | | | Time: July 8, 2013 | Flow |
|---|---|---|---|---|---|---|---|---|---|
| | 25-year | 50-year | 100-year | 25-year | 50-year | 100-year | Regional | | July 8, 2013 |
| | 12-hour AES | | | 24-hour Chicago | | | Unsteady | | |
| 1/1/2017 0:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/8/2013 12:00 | 0.00 |
| 1/1/2017 0:20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/8/2013 12:20 | 0.00 |
| 1/1/2017 0:40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/8/2013 12:40 | 0.00 |
| 1/1/2017 1:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/8/2013 13:00 | 0.00 |
| 1/1/2017 1:20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/8/2013 13:20 | 0.00 |
| 1/1/2017 1:40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/8/2013 13:40 | 0.11 |
| 1/1/2017 2:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/8/2013 14:00 | 16.44 |
| 1/1/2017 2:20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/8/2013 14:20 | 38.67 |
| 1/1/2017 2:40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/8/2013 14:40 | 64.81 |
| 1/1/2017 3:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/8/2013 15:00 | 69.74 |
| 1/1/2017 3:20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/8/2013 15:20 | 48.94 |
| 1/1/2017 3:40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/8/2013 15:40 | 31.62 |
| 1/1/2017 4:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/8/2013 16:00 | 19.80 |
| 1/1/2017 4:20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/8/2013 16:20 | 11.79 |
| 1/1/2017 4:40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/8/2013 16:40 | 7.48 |
| 1/1/2017 5:00 | 0.00 | 0.05 | 0.01 | 0.00 | 0.00 | 0.00 | 0.02 | 7/8/2013 17:00 | 5.03 |
| 1/1/2017 5:20 | 0.04 | 2.16 | 4.50 | 0.00 | 0.00 | 0.00 | 3.43 | 7/8/2013 17:20 | 2.92 |
| 1/1/2017 5:40 | 4.49 | 8.12 | 13.58 | 0.00 | 0.00 | 0.00 | 8.01 | 7/8/2013 17:40 | 0.86 |
| 1/1/2017 6:00 | 8.31 | 13.63 | 19.63 | 0.00 | 0.00 | 0.00 | 11.70 | 7/8/2013 18:00 | 0.02 |
| 1/1/2017 6:20 | 10.14 | 15.73 | 21.88 | 0.00 | 0.00 | 0.00 | 15.40 | 7/8/2013 18:20 | 0.01 |
| 1/1/2017 6:40 | 8.46 | 13.21 | 18.55 | 0.00 | 0.00 | 0.00 | 20.10 | 7/8/2013 18:40 | 0.00 |
| 1/1/2017 7:00 | 5.26 | 8.88 | 13.26 | 0.00 | 0.00 | 0.00 | 24.94 | 7/8/2013 19:00 | 0.00 |
| 1/1/2017 7:20 | 2.40 | 5.17 | 8.48 | 0.00 | 0.00 | 0.00 | 29.78 | 7/8/2013 19:20 | 0.00 |
| 1/1/2017 7:40 | 0.36 | 2.18 | 4.61 | 0.00 | 0.00 | 0.00 | 33.15 | 7/8/2013 19:40 | 0.00 |
| 1/1/2017 8:00 | 0.01 | 0.16 | 1.64 | 0.00 | 0.00 | 0.00 | 35.16 | 7/8/2013 20:00 | 0.00 |
| 1/1/2017 8:20 | 0.00 | 0.01 | 0.04 | 0.00 | 0.00 | 0.00 | 35.03 | 7/8/2013 20:20 | 0.00 |
| 1/1/2017 8:40 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 33.33 | 7/8/2013 20:40 | 0.00 |
| 1/1/2017 9:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 31.07 | 7/8/2013 21:00 | 0.00 |
| 1/1/2017 9:20 | 0.00 | 0.00 | 0.00 | 0.03 | 0.02 | 0.21 | 33.41 | 7/8/2013 21:20 | 0.00 |
| 1/1/2017 9:40 | 0.00 | 0.00 | 0.00 | 3.07 | 7.57 | 13.66 | 44.88 | 7/8/2013 21:40 | 0.00 |
| 1/1/2017 10:00 | 0.00 | 0.00 | 0.00 | 13.10 | 21.82 | 32.19 | 62.55 | 7/8/2013 22:00 | 0.00 |
| 1/1/2017 10:20 | 0.00 | 0.00 | 0.00 | 22.21 | 32.36 | 44.58 | 86.26 | 7/8/2013 22:20 | 0.00 |
| 1/1/2017 10:40 | 0.00 | 0.00 | 0.00 | 21.30 | 30.29 | 41.02 | 109.95 | 7/8/2013 22:40 | 0.00 |
| 1/1/2017 11:00 | 0.00 | 0.00 | 0.00 | 15.18 | 22.25 | 30.57 | 128.48 | 7/8/2013 23:00 | 0.00 |
| 1/1/2017 11:20 | 0.00 | 0.00 | 0.00 | 8.60 | 14.11 | 20.51 | 134.10 | 7/8/2013 23:20 | 0.00 |
| 1/1/2017 11:40 | 0.00 | 0.00 | 0.00 | 3.90 | 7.57 | 12.46 | 127.96 | 7/8/2013 23:40 | 0.00 |
| 1/1/2017 12:00 | 0.00 | 0.00 | 0.00 | 0.65 | 3.27 | 6.56 | 116.07 | 7/9/2013 0:00 | 0.00 |
| 1/1/2017 12:20 | 0.00 | 0.00 | 0.00 | 0.02 | 0.47 | 2.74 | 98.07 | 7/9/2013 0:20 | 0.00 |
| 1/1/2017 12:40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.37 | 78.13 | 7/9/2013 0:40 | 0.00 |
| 1/1/2017 13:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 59.40 | 7/9/2013 1:00 | 0.00 |
| 1/1/2017 13:20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 41.55 | 7/9/2013 1:20 | 0.00 |
| 1/1/2017 13:40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 26.49 | 7/9/2013 1:40 | 0.00 |
| 1/1/2017 14:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 13.89 | 7/9/2013 2:00 | 0.00 |
| 1/1/2017 14:20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.53 | 7/9/2013 2:20 | 0.00 |
| 1/1/2017 14:40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 7/9/2013 2:40 | 0.00 |
| 1/1/2017 15:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 3:00 | 0.00 |
| 1/1/2017 15:20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 3:20 | 0.00 |
| 1/1/2017 15:40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 3:40 | 0.00 |
| 1/1/2017 16:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 4:00 | 0.00 |
| 1/1/2017 16:20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 4:20 | 0.00 |
| 1/1/2017 16:40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 4:40 | 0.00 |
| 1/1/2017 17:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 5:00 | 0.00 |
| 1/1/2017 17:20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 5:20 | 0.00 |
| 1/1/2017 17:40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 5:40 | 0.00 |
| 1/1/2017 18:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 6:00 | 0.00 |
| 1/1/2017 18:20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 6:20 | 0.00 |
| 1/1/2017 18:40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 6:40 | 0.00 |
| 1/1/2017 19:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 7:00 | 0.00 |
| 1/1/2017 19:20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 7:20 | 0.00 |
| 1/1/2017 19:40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 7:40 | 0.00 |
| 1/1/2017 20:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 8:00 | 0.00 |
| 1/1/2017 20:20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 8:20 | 0.00 |
| 1/1/2017 20:40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 8:40 | 0.00 |
| 1/1/2017 21:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 9:00 | 0.00 |
| 1/1/2017 21:20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 9:20 | 0.00 |
| 1/1/2017 21:40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 9:40 | 0.00 |
| 1/1/2017 22:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 10:00 | 0.00 |
| 1/1/2017 22:20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 10:20 | 0.00 |
| 1/1/2017 22:40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 10:40 | 0.00 |
| 1/1/2017 23:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 11:00 | 0.00 |
| 1/1/2017 23:20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 11:20 | 0.00 |
| 1/1/2017 23:40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 11:40 | 0.00 |
| 1/2/2017 0:00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7/9/2013 12:00 | 0.00 |



Spill Hydrographs from Little Etobicoke Creek to Applewood Creek
Time: July 8 2013 Event
7/8/2013 0:00
7/8/2013 6:00
7/8/2013 12:00
7/8/2013 18:00
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Peak Flow (m³/s)
25-year 12-hour AES
50-year 12-hour AES
100-year 12-hour AES
25-year 24-hour Chicago
50-year 24-hour Chicago
100-year 24-hour Chicago
Regional Unsteady
July 8, 2013
12:00:00 AM
6:00:00 AM
12:00:00 PM
6:00:00 PM
Time: Design Storms

## Spill Hydrographs - Flow Balance

| Location | Flow ($m^3/s$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Regional US | Regional SS | 100yr 24hr Chi | 50yr 24hr Chi | 25yr 24hr Chi | 100yr 12hr AES | 50yr 12hr AES | 25yr 12hr AES |
| 1 | 205.0 | 200.0 | 125.3 | 111.1 | 97.9 | 97.2 | 87.9 | 78.8 |
| 2 | 134.1 | 129.3 | 55.1 | 42.0 | 30.4 | 31.1 | 23.4 | 16.4 |
| 3 | 3.1 | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 4 | 3.8 | 3.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 5 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 6 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 7 | 127.7 | 134.1 | 23.9 | 19.1 | 11.2 | 13.5 | 7.2 | 3.9 |
| 8 | 73.9 | 73.6 | 71.6 | 69.8 | 67.7 | 64.2 | 62.5 | 60.6 |
| 9 | 79.0 | 78.8 | 74.0 | 71.8 | 69.3 | 68.6 | 66.5 | 64.1 |
| 10 | 80.4 | 80.6 | 74.0 | 71.8 | 69.3 | 68.6 | 66.5 | 64.1 |