TOWN OF AJAX

Community Climate Study

Stormwater and Overland Flooding (FINAL)

October 2018 –18-7286

The preparation of this study was carried out with assistance from the Government of Canada and the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors, and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them.

Table of Contents

Figures

Tables

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Appendices

1.0 Introduction

1.1 Background

The Town of Ajax (the Town) has been impacted by significant climatic events which, among other things, have caused property damage, disruptions to transportation and energy systems and resulted in economic and social impacts to the community.

The Town identified a need to better understand the threats and risks faced by the community as a result of changing trends associated to the following three climate variables: severe weather, temperature and precipitation. Three main community outlooks were identified of particular concern to the Town and included overland and stormwater flooding, threats to the natural environment, and impacts to emergency preparedness and response services. The purpose of the Town of Ajax Community Climate Study is to provide a GIS-based tool for the Town of Ajax to assist in identifying, analyzing, evaluating and ultimately managing climate change based risks as part of an overall Climate Change Adaptation Plan being developed by the Town.

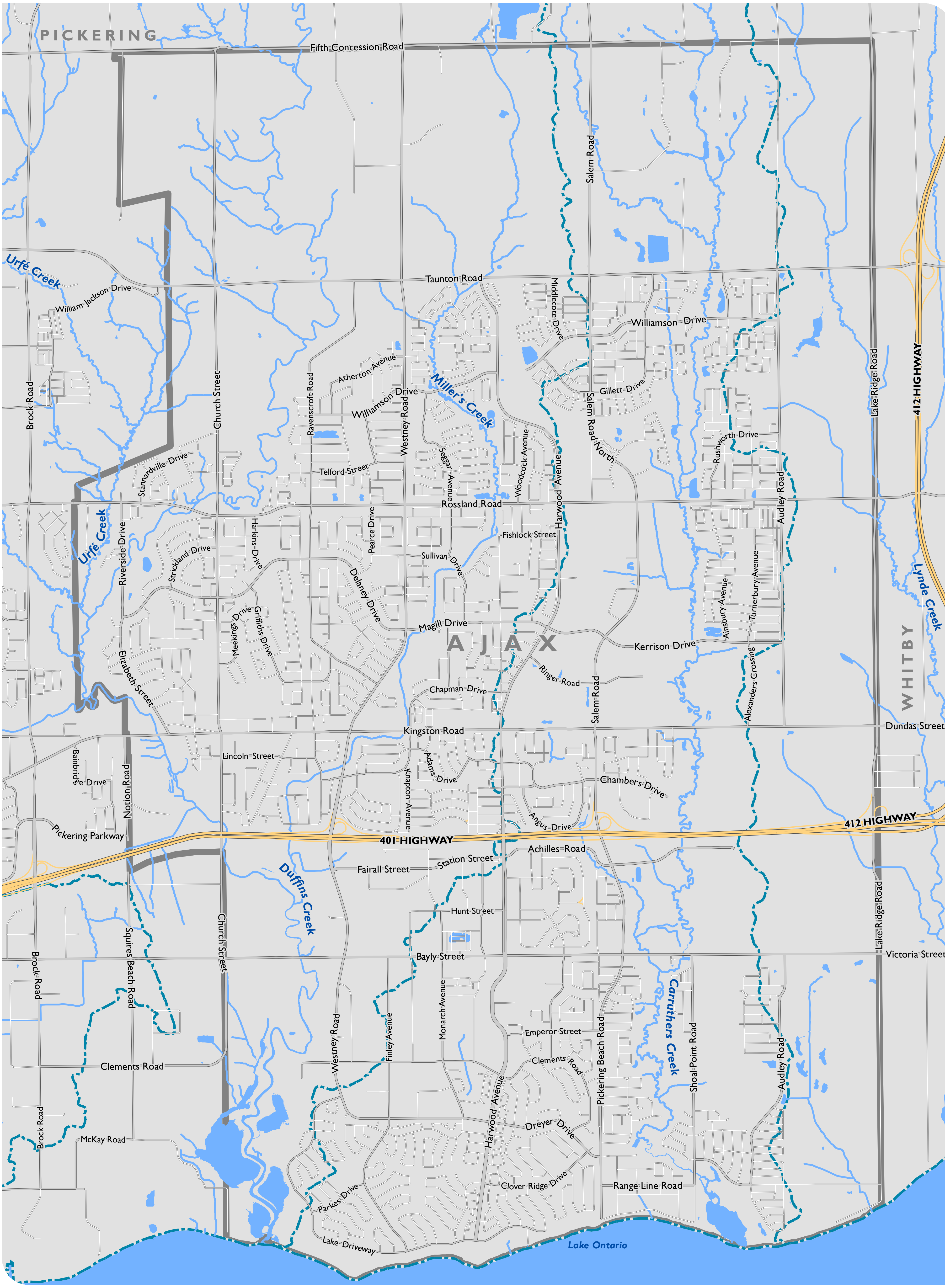
1.2 Study Area

The Town of Ajax is located east of the Greater Toronto Area within Durham Region. The Town is primarily situated between Duffins Creek and Carruthers Creek, and is bordered on the southern side by Lake Ontario. Minor tributaries of Lynde Creek fall within the eastern area of the Town, and Miller's Creek, a major tributary of Duffins Creek bisects the Town starting from north of Concession Road 5 to a number of kilometers south of Highway 401 (**Figure 1).**

The Town covers an area of 67km^2 and is a predominantly suburban area with areas of higher density urban, with greenbelt lands located to the east and north. According to the 2011 Census, Ajax is home to approximately 120,000 residents, the majority of which live within the west and south areas of the Town. Due to the presence of the two major creeks noted above that outlet to Lake Ontario, the Toronto Region and Conservation Authority (TRCA), and the Central Lake Ontario Conservation Authority (CLOCA) regulate, and have jurisdiction over development within the lands adjacent to the creeks.

1.3 Study Purpose

Understanding the threat of overland and Stormwater flooding was identified as a key area of interest for the Town, particularly concerning urban overland flow paths, undersized culverts and storm water infrastructure, and stream banks and shorelines susceptible to erosion. This study is mainly focused on the performance of the storm sewer system under minor and major storm events under current conditions and future climate change conditions. The study also highlights the impacts to the flooding extents for the three main creeks within the Town, under a climate change scenario. Overland flow paths are assessed for a sub-section of the study area to demonstrate the potential functionality of a completed hydraulic model.



Quaternary Watershed Boundary

TOWN OF AJAX
COMMUNITY CLIMATE STUDY

FIGURE 1
STUDY AREA

MAP DRAWING INFORMATION:
DATA PROVIDED BY MNR

MAP CREATED BY: GM
MAP CHECKED BY:
MAP PROJECTION: NAD 1983 UTM Zone 17N

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FILE LOCATION: I:\GIS\187286 - Town of Ajax Community Climate Study\mxd\Flooding\Figure 1 Overview of Waterbodies.mxd

2.0 Approach

Flooding from creeks and rivers, more commonly known as fluvial flooding, and overland flooding in urban areas (pluvial flooding) are two distinct types of threats of concern to the Town of Ajax. Dillon's approach was focused on identifying the areas of potential vulnerability based on the result of a developed hydrologic and hydraulic model for storm sewer surcharge and water surface flooding conditions.

Dillon's approach began with efforts to compile and develop an inventory of current and historical flooding areas in an effort to understand the Town's existing vulnerabilities. The Town of Ajax and the Region of Durham provided service call information, predominantly flood complaints records, which were summarized by Dillon and used to develop a geospatial map of potentially vulnerable areas within the Town (**Figure 2**).

Dillon engaged the Town Engineering staff to review the current and historical flood sites in view of causes and remedial measures already undertaken. Based on discussions with the Town, a number of particularly vulnerable areas were identified. Notably these included areas subject to overland flooding due to a combination of limited storm sewer infrastructure, existing capacity limitations with upstream culverts, proximity to, and locations within the Conservation Authority regulation limits and floodplains, in addition to varying levels of stormwater quantity and quality controls which correlated to the time period of development.

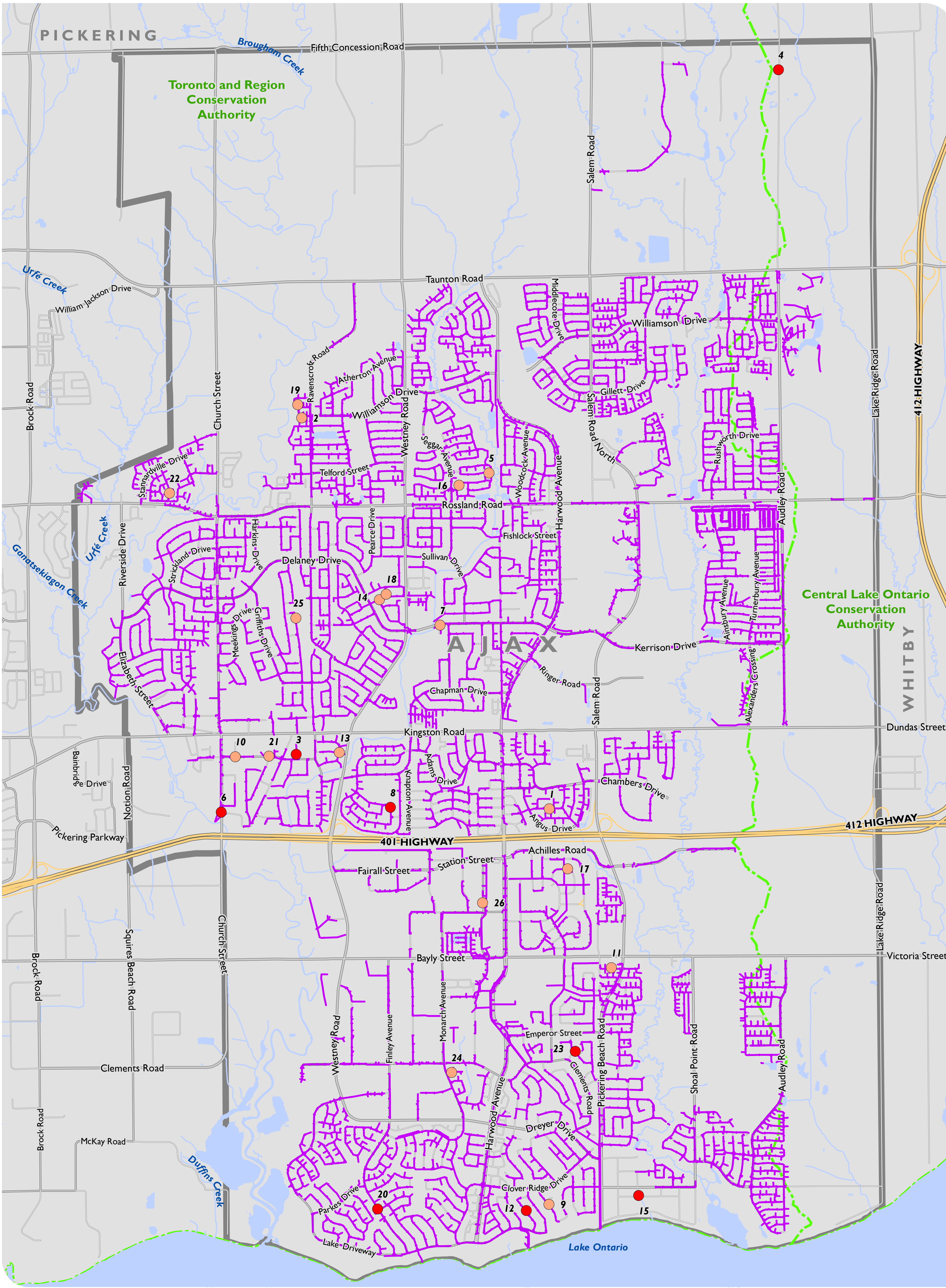
Once a qualitative assessment of current and historical flooding areas was complete, Dillon generated a topographic elevation map based on the 1m resolution Digital Elevation Model (DEM) surface and contours to show overall land relief, topographically low areas and depressions, natural and human-made storm water and floodplain storage areas, and to some extent, roadway sags **(Figure 3**).

The Town's GIS inventory including storm sewers, maintenance holes, catch basins, stormwater management ponds, culverts, bridges, major watercourses and their tributaries were reviewed in an effort to understand the drainage infrastructure network within the Town. Building envelopes were used to understand the land use within the area and allow for sub-catchment parametrization. Storm sub-catchments provided by the Town and storm sewer flow direction arrows were then used to develop a storm sewer skeleton based on the main trunk sewers within the Town (**Figure 4**).

To develop the input data for the screening level hydrologic model/tool for urban drainage or pluvial flooding, pre-processing of the GIS data was completed using ArcMap 10.3. The storm sewer skeleton, in addition to the neighbourhood scale subcatchments were used as the basis of a hydrologic and hydraulic model, which is detailed in Section 3.2.

The Toronto and Region Conservation Authority (TRCA) and Central Lake Ontario Conservation Authority (CLOCA) were also contacted and provided hydrologic and hydraulic models and reports, floodplain maps, and in the case of the TRCA, flood vulnerable buildings and roads within their jurisdiction. This data was used as the basis for the assessment of the impact of climate change on flooding extents of the creeks. The TRCA also provided details of restoration projects completed within the Town of Ajax to address erosion. This information was reviewed to highlight areas with higher vulnerability to erosion under a climate change scenario.

Two stakeholder consultation sessions were undertaken to allow for community feedback to be incorporated in the project. The first stakeholder session was held at the project outset and was a risk assessment workshop designed to outline and brainstorm the project approach to risk assessment. Attendees included staff from a range of Town departments and representatives from Dillon. Feedback from this session was incorporated into the project planning and formed the basis for how risk was assessed throughout the project. The second stakeholder session was held towards the end of the project and aimed at validating model results based on the collective experiences and expertise of the groups present. Attendees included representatives from the Town's Planning, Natural Capita, Engineering, Emergency Services and GIS departments, in addition to Conservation Authorities, Region of Durham Health Services and local community members. Feedback from this session was used to refine model results, generate additional datasets and finalize the project outcomes.



Flood Complaint (Storm > 25 mm)

Flood Complaint

Storm Sewer Pipe

Conservation Authority

TOWN OF AJAX
COMMUNITY CLIMATE STUDY

FIGURE 2
FLOOD COMPLAINTS

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MAP CREATED BY: GM
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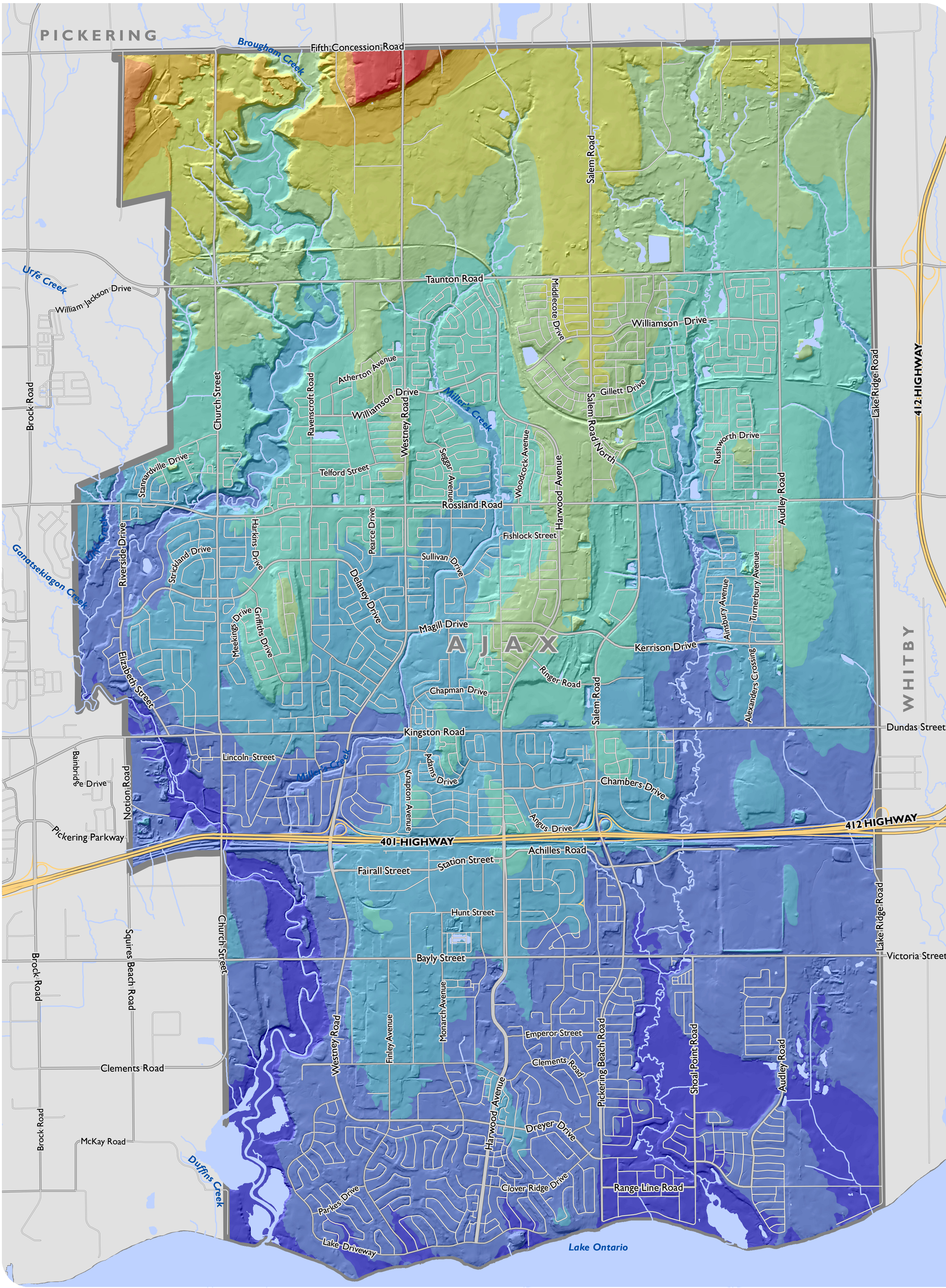
FILE LOCATION: I:\GIS\187286 - Town of Ajax Community Climate Study\mxd\Flooding\Figure 2 Flood Complaints.mxd



TOWN OF AJAX
COMMUNITY CLIMATE STUDY

FIGURE 3
BASE MAP WITH TOPOGRAPHY

Elevation (masl)

- 69.3 - 80.9
- 80.9 - 92.6
- 92.6 - 104.3
- 104.3 - 115.9
- 115.9 - 127.6
- 127.6 - 139.2
- 139.2 - 150.9
- 150.9 - 162.5
- 162.5 - 174.2

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2017 Breaklines, Contours, Drainage or DTM provided by © First Base Solutions

MAP CREATED BY: GM
MAP CHECKED BY:
MAP PROJECTION: NAD 1983 UTM Zone 17N

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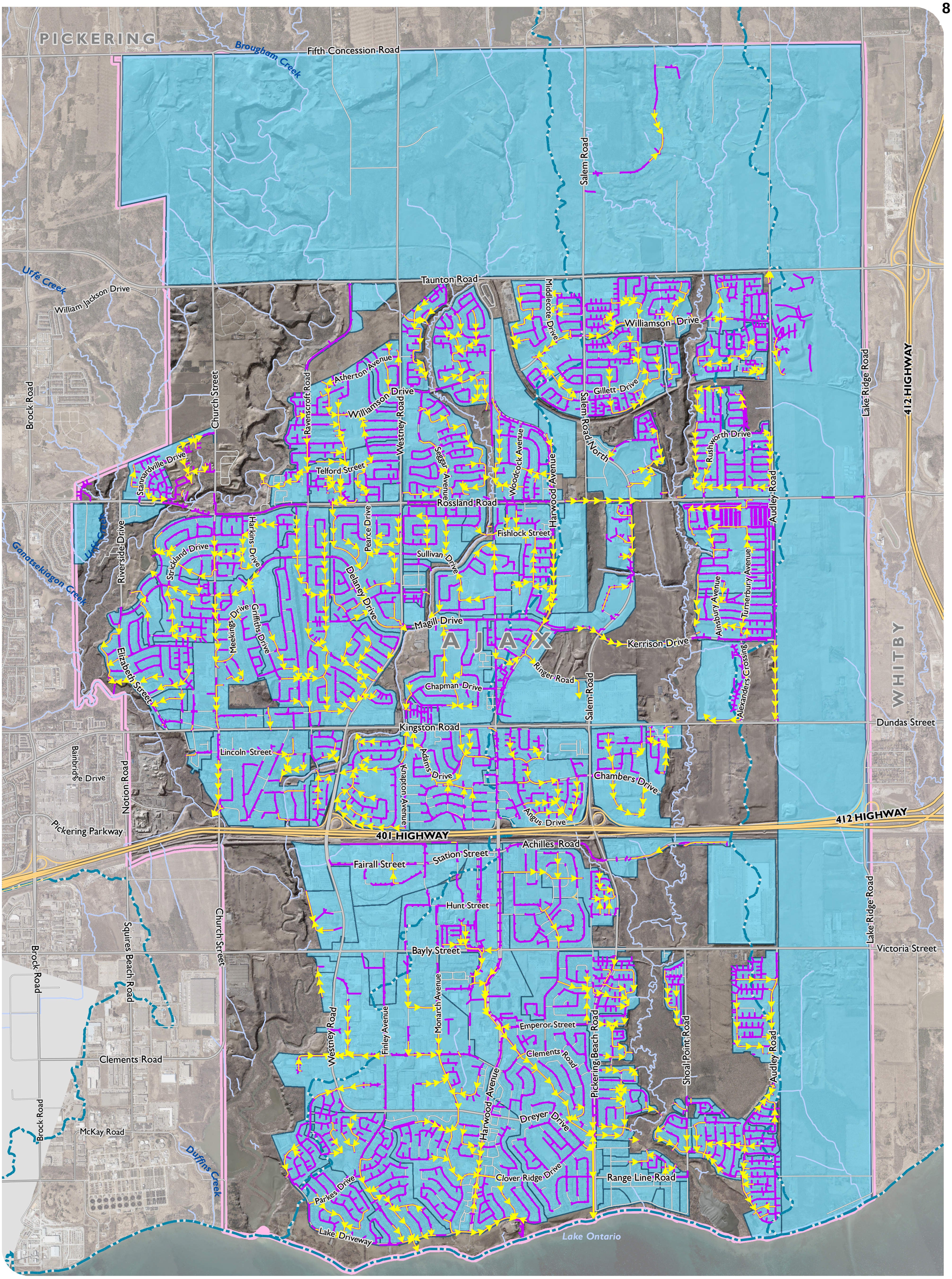
FILE LOCATION: I:\GIS\187286 - Town of Ajax Community Climate Study\mxd\Flooding\Figure 3 Base Map with Topography.mxd



TOWN OF AJAX
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FIGURE 4
DRAINAGE INFRASTRUCTURE

- Storm Sewer Skeleton Pipe (>600 mm)
- Storm Sewer Pipe
- Quaternary Watershed Boundary
- Major Drainage Area

2017 Breaklines, Contours, Drainage or DTM provided by © First Base Solutions
2017 Orthophotography provided by © First Base Solutions

MAP CREATED BY: GM
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FILE LOCATION: I:\GIS\187286 - Town of Ajax Community Climate Study\mxd\Flooding\Figure 4 Drainage Infrastructure.mxd

3.0 Hydrologic and Hydraulic Modelling

3.1 Fluvial Flooding

There are two main creeks within the Town of Ajax: Duffins Creek and Carruthers Creek. Tributaries of Lynde Creek also fall within the Town on the eastern side. Miller's Creek, a major tributary of Duffins Creek is also located within the Town. All creeks discharge to Lake Ontario and are somewhat influenced by lake levels, particularly on the downstream side. The HEC-RAS and/or VO2 models for all three creeks were provided by the respective Conservation Authorities (CAs). Floodplain mapping and Regulatory Limit data were also provided by both Conservation Authorities. The TRCA provided additional shapefiles for Regional Storm flood lines as well as geospatial data on Flood Vulnerable Assets (FVAs) that had been previously identified. CA Regulation Limits and TRCA FVAs (buildings and roads) are shown in Figure 5.

3.1.1 Hydrology

To assess the potential impacts of climate change on the water surface extents generated by the hydrologic and hydraulic models, Dillon examined the channel performances as a resulted in increased future flows anticipated for the 1:100-year storm for the major creek systems . The increase in flows was conservatively estimated to be approximately 25% based on a review of climate change literature, previous Dillon experience and an assessment of potential scenarios using the IDFCC tool. It was assumed that an increase of 25% in the 1:100-year rainfall intensity would conservatively translate into a corresponding increase of 25% in flows. Further discussion supporting the rationale for the assumed 25% increase in rainfall statistics under a future climate change condition is presented below in Section 3.1.1.1. While this is a conservative estimate, it yielded significantly less than the flows as compared to the Regional Storm estimates, which is a regulatory event (Hurricane Hazel) and within the Town represents an extreme anticipated riverine flooding extent. For the purposes of this assessment, this estimate and approach was deemed to be sufficient. The HEC-RAS models were re-run using the increased flows to determine the resulting water surface elevations and flooding extents.

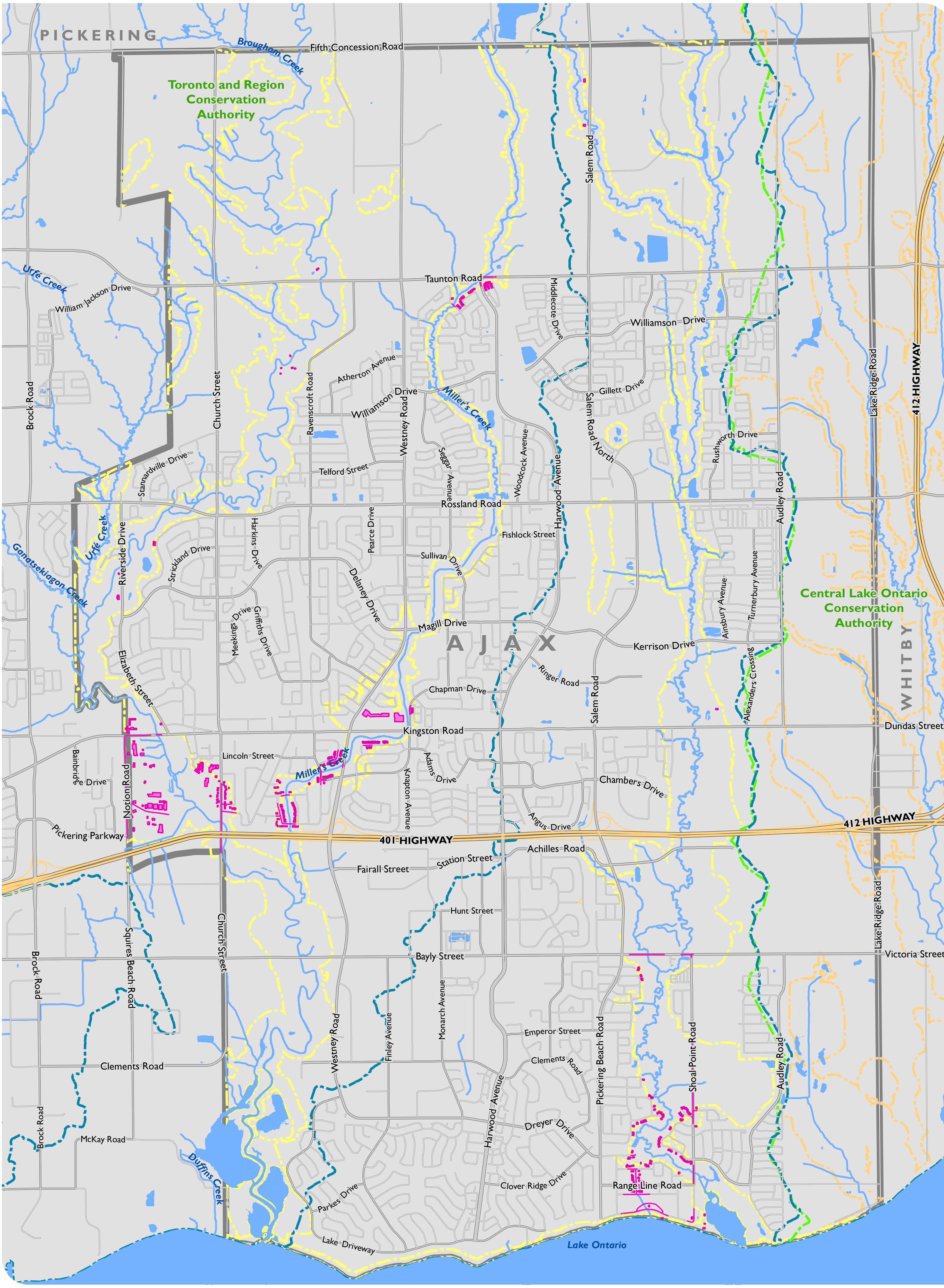
3.1.1.1 Climate Change Parameters

In 2014, SENES Consultants Ltd. completed an investigation examining future climate change conditions within Durham Region (Future Climate (2040-2049) – Durham Region). Notably the study identified changes in future precipitation amounts at key locations throughout the Region. Of particular importance, the study identified maximum daily rainfall amounts for the Town of Ajax would only increase by approximately 6.5% from 2000-2009 to 2040- 2049 (i.e., 79 mm to 84 mm daily maximum total) and that for the neighboring Town of Whitby the maximum daily rainfall amounts are projected to increase by approximately 48% (79 mm to 117 mm).

It is recognized that a 79 mm rainfall amount corresponds to approximately a 24-hour, 25-year return period storm based on the rainfall statistics for the Toronto Bloor (City) station which serves as the historical standard for the Town of Ajax. However, the study does not relate the maximum daily rainfall in the Town of Ajax to a return-period storm, or indicate how the increase in maximum rainfall translates into Intensity-Duration-Frequency (IDF) curve parameters for other storms (i.e. storms ranging from the 1:5 year to 1:100 year return period) at the Toronto Bloor Station which is required for input into the modelling of the storm drainage system.

The IDFCC tool from the University of Western Ontario was used as to generate the IDF statistics specifically for data from two stations within the Town (Toronto Bloor and TRCA Greenwood). A review of the projections demonstrated a range of increases over the current IDF statistics applied by the Town depending on the RCP scenario. Specifically the increase in IDF parameters ranged from approximately 35% to 45% for a 1:100-year 24-hr duration events under a RCP 2.6, 4.5, 8.5 scenarios, and between 15% to 25% for the 1:5-year 24-hour duration events.

For modelling purposes an aggregated estimate of 25% increase in precipitation was assumed and applied in the assessment of the future storm system and flooding vulnerabilities. Appendix A shows details of the IDFCC output for the different RCP scenarios to 2049.



TOWN OF AJAX
COMMUNITY CLIMATE STUDY

FIGURE 5
FLOOD VULNERABLE BUILDINGS AND ROADS

- Flood Vulnerable Road (TRCA)
- Flood Vulnerable Building (TRCA)
- Quaternary Watershed Boundary
- Conservation Authority
- Regulated Area (TRCA)
- Regulated Area (CLOCA)

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MAP DRAWING INFORMATION:
DATA PROVIDED BY MNR

MAP CREATED BY: GM
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MAP PROJECTION: NAD 1983 UTM Zone 17N

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PROJECT: 187286 STATUS: DRAFT DATE: 2018-10-12

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3.1.2 Hydraulics

Hydraulic models obtained from TRCA and CLOCA were predominantly unchanged except where it was necessary to modify reach extents to allow for data to be extracted. HEC-RAS v 5.0.3 was used in the analyses of all creeks. The Carruthers and Lynde Creek HEC-RAS models were spatially geo-referenced which allowed for simple extraction of model results once the climate change scenarios were run. The results from HEC-RAS were converted to an ESRI shapefile format to enable integration with the GIS model. Further details on how the model hydraulics were modified are detailed below.

3.1.2.1 Carruthers Creek and Lynde Creek

The creek geometries for Carruthers Creek and Lynde Creek were found to have a much larger extent than the 2017 DEM surface (i.e. a three-dimensional topographic terrain model). To address this spatial inconsistency, reach lines were edited to be contained within the Town of Ajax municipal boundary. Once the 1:100-year Climate Change scenario was simulated successfully without errors, the RAS Mapper tool in HECRAS was used to view water surface extents and hydraulic results such as depths and velocity. RAS Mapper is a HEC-RAS tool that allows the user to quickly view water surface extents without using another GIS or CADD software. For the purposes of this project, RAS Mapper was also used to create Flood Inundation polygons for the 1:100-year storm (both existing and climate change scenarios) and for the Regional Storm. **Figure 6** shows the 1:100-year climate change and Regional Storm flood lines. Due to the scale of the map and the minor difference in water levels, the existing 1:100-year flood lines are not shown on Figure 6, however this information is readily accessible through the HEC-RAS model.

3.1.2.2 Duffins Creek

The Duffins Creek hydraulic data was not spatially georeferenced and therefore the 1:100-year climate change flood line had to be estimated in GIS. The model results per reach and cross-section were extracted into a Microsoft Excel spreadsheet and the difference in top widths was calculated. The GIS buffer tool was used to estimate the corresponding reduction in water surface extents for the 100-year event from the Regional Storm flood line.

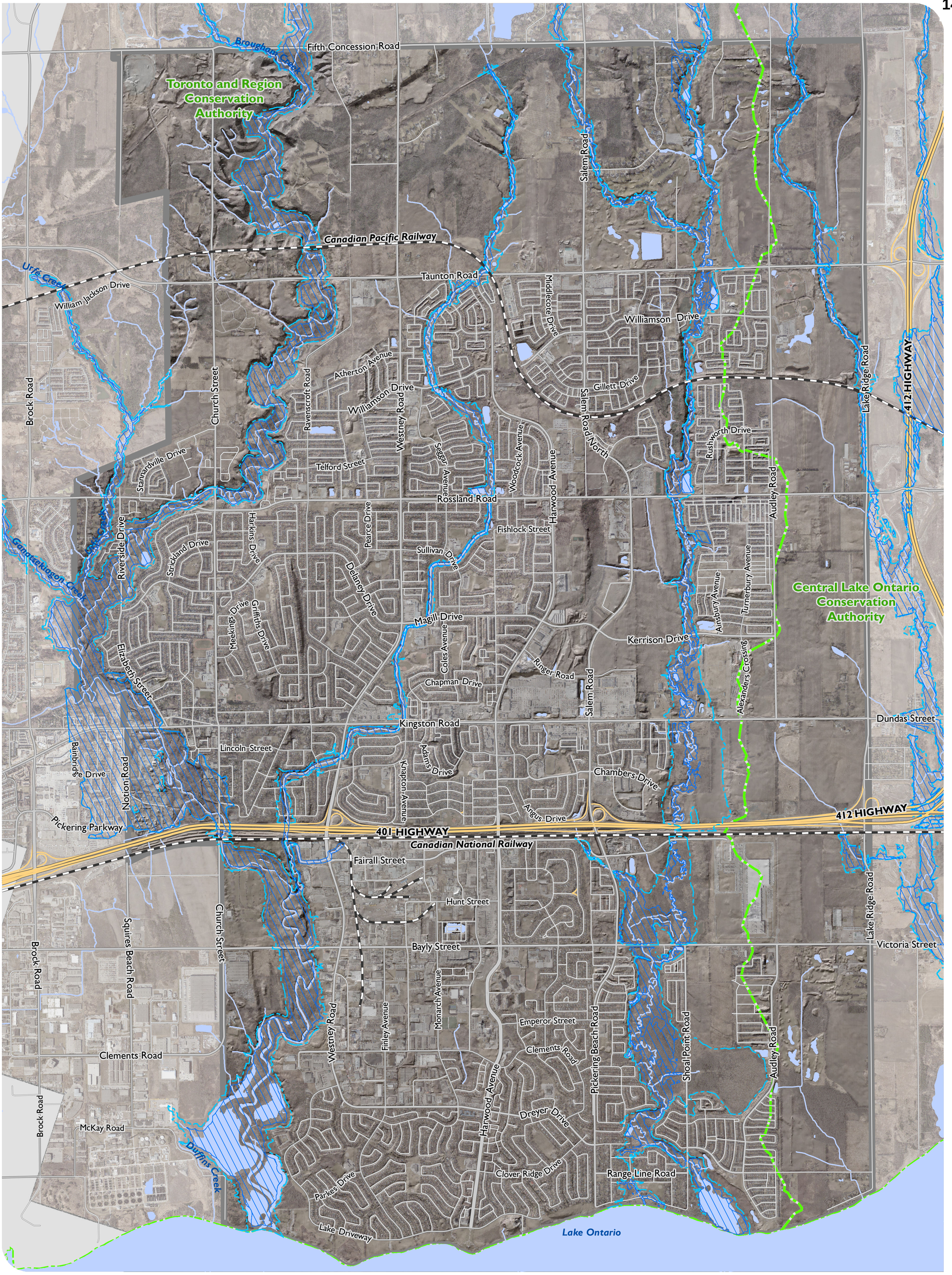
<u>Results</u>

Overall, the 1:100-year climate change scenario did not represent a significant increase from the existing 1:100-year flood extents for all of the three creeks. There were no instances where the 1:100-year flood line exceeded the Regional flood line; however, there were some instances where the difference between the two flood line extents was minimal. There were also marginal increases in velocity depending on the cross-section location. **Tables 1 – 6 in Appendix B** shows the model results for all creeks. This typically occurred in areas where the terrain was predominantly flat and where a minor increase in depth resulted in a much larger increase in spread. **Figure 7** shows an example of this. The majority of the lands inundated by both the 1:100-year storms and Regional storms were natural areas such as woodland and/or floodplains; however there were locations where the flood lines extend into the urban fabric and these are areas that are determined to be more vulnerable to flooding. **Figure 8** shows an example of this.

Lake Ontario

While not modelled, variation in Lake Ontario water levels is expected to have an impact on fluvial flooding, particularly for areas along the shoreline and at the outlets of the creeks. Variation in lake levels is not expected to be a climate change effect however, Plan 2014, a directive issued by International Joint Commission (IJC) outlining the acceptable range of water levels in the Great Lakes, allows for an increase in water levels to highs that exceed what has been experienced in the recent past. This potential increase in lake levels may have impacts to the Town as described below.

All three creeks within the Town discharge to the Lake and as such, during periods of high lake levels, there is limited capacity for the creek flows to discharge into the Lake. This can result in an increase in water levels further inland than is generally experienced and can result in an overflow into low-lying areas adjacent to the creeks. The Pickering Beach neighbourhood, in the south east section of the Town, is an example of an area that experiences significant flooding due to its proximity to the Lake and Carruthers Creek outlet. This scenario is further aggravated when creek levels are also high due to large rainfall events. The Town has experienced flooding along shoreline areas due to this combination of factors and it is expected that the predicted increase in rainfall due to climate change will further.



100 Year Climate Change Riverine Flooding
Railway
TRCA Regional Floodline
CLOCA Regional Floodline
Conservation Authority

TOWN OF AJAX
COMMUNITY CLIMATE STUDY

FIGURE 6
100 YEAR RIVERINE FLOODING AND REGIONAL FLOODLINES

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MAP DRAWING INFORMATION:
DATA PROVIDED BY AJAX

MAP CREATED BY: GM
MAP CHECKED BY:
MAP PROJECTION: NAD 1983 UTM Zone 17N

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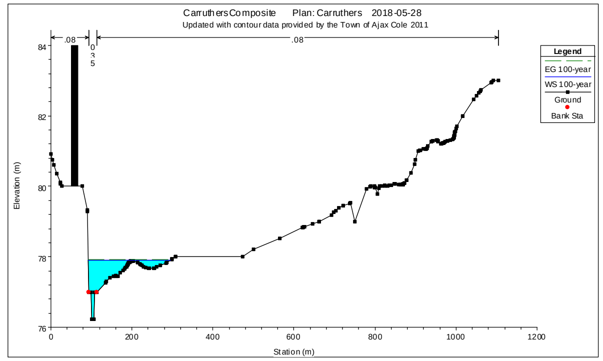
FILE LOCATION: I:\GIS\187286 - Town of Ajax Community Climate Study\mxd\Flooding\Figure 6 Riverine Flooding and Regional Floodlines.mxd

Riverine Flooding - Carruthers Example

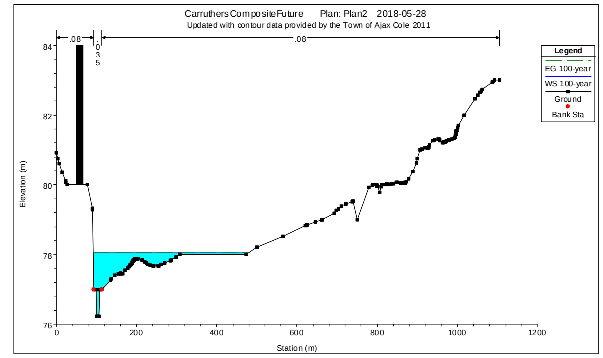
- Extents of flooding varies by cross-section, based on terrain

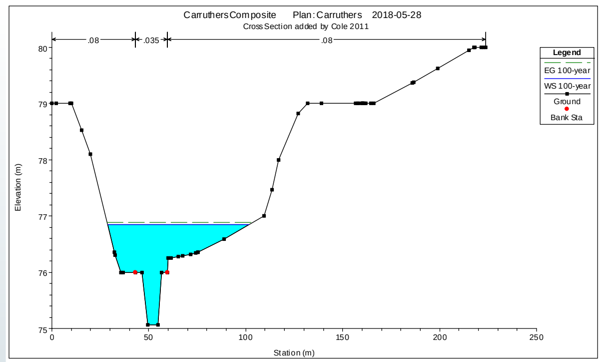
XS ID	Differences		
	WSEL (m)	Top Width (m)	Velocity
3.016	0.15	185.01	0.02
3.0103	0.13	7.86	0.07
3.002	0.02	0.33	0.01

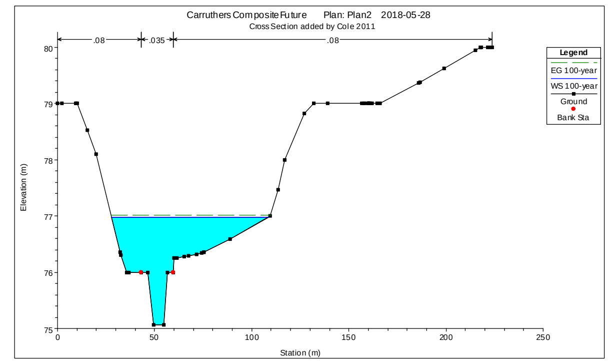
1:100 year

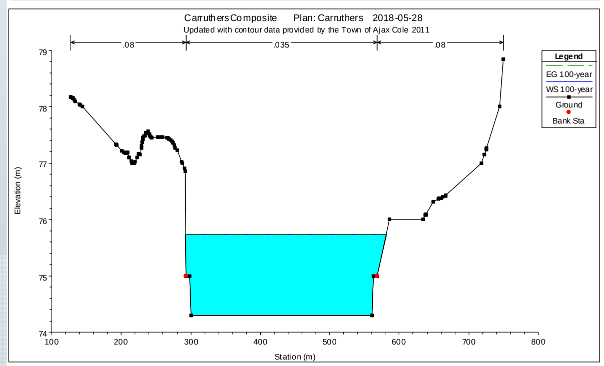


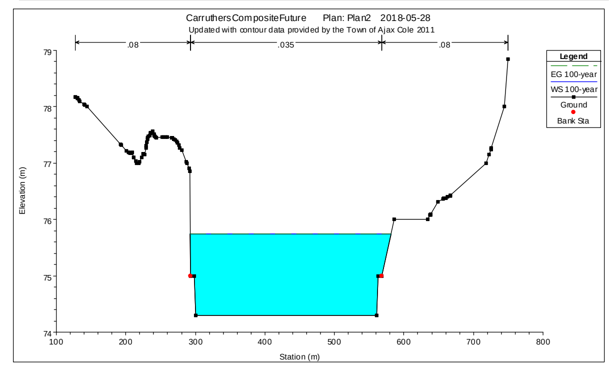
1:100 year Climate Change











100 Year Climate Change Riverine Flooding
TRCA_RegLimit
Building_Footprints
Railway
Regional Floodline

TOWN OF AJAX
COMMUNITY CLIMATE STUDY

FIGURE 8
EXAMPLE FLOODLINES IN URBAN FABRIC

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MAP DRAWING INFORMATION:
DATA PROVIDED BY AJAX

MAP CREATED BY: GM
MAP CHECKED BY:
MAP PROJECTION: NAD 1983 UTM Zone 17N

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PROJECT: 187286 STATUS: DRAFT DATE: 2018-06-04

FILE LOCATION: I:\GIS\187286 - Town of Ajax Community Climate Study\SWM\Mxd\Copy\Figure 12 Flood Vulnerability Map.mxd

3.1.3 Culverts

A high level assessment of culverts was completed to assess the performance of culverts identified as major culverts in the Town of Ajax geospatial data.

There are a total of 24 culverts identified within the Town's geospatial data; out of which 12 culverts were located in the HEC-RAS models provided by the TRCA. The remaining culverts were not modelled in HEC-RAS and were typically smaller road culverts. An additional 18 culverts were modelled in HEC-RAS but not included in the Town's geospatial data. This included culverts on large highways such as Highway 401, which are assumed to be owned by others such as the Region of Durham and/or the Ontario Ministry of Transportation (MTO), thus are not under the jurisdiction of the Town. Culvert locations are shown in **Figure 9**. **Table 1** below summarizes this detail.

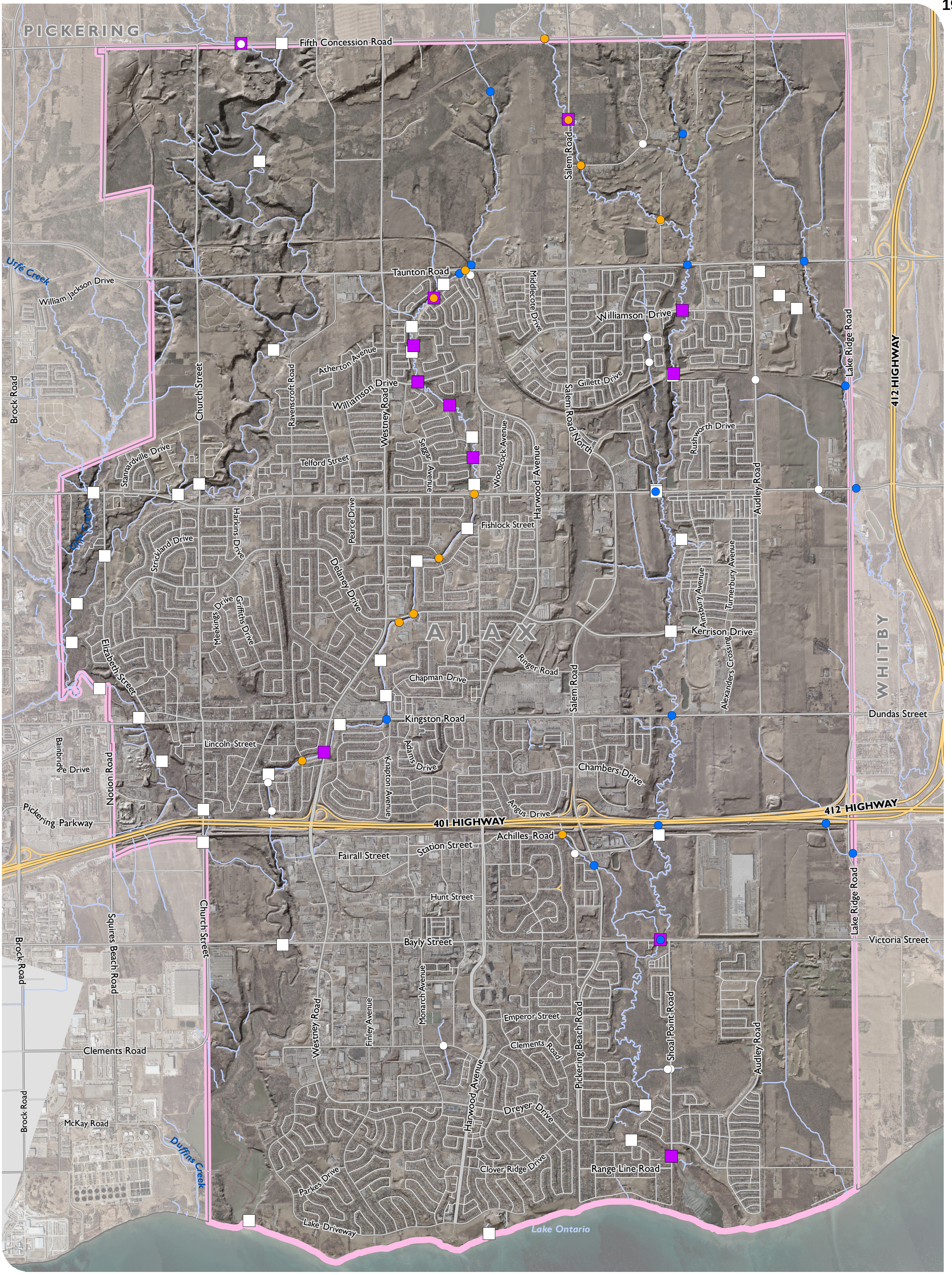
Table 1: Culvert Summary

Creek Name	Number of Culverts in Town GIS data	Number of Town Culverts modelled in HECRAS	Number of Town Culverts not modelled in HECRAS	Number of Culverts modelled in HEC-RAS and not included in Town GIS data
Carruthers Creek	12	5	7	7
Duffins Creek (Miller's Creek only)	10	7	3	4
Lynde Creek	2	0	2	7
Total	**24**	**12**	**12**	**18**

A comparison of culvert dimensions was completed to determine differences between the Town's data and the HEC-RAS model. While there was generally consistency between the two data sources, there were notable differences in culvert dimensions, particularly lengths, for some culverts. **Table 2** shows a summary of culvert dimensions for the culverts located in both data sources. Culvert sizes were not adjusted in HEC-RAS to reflect the Town's data; therefore the HEC-RAS results of culvert performance may require further fine-tuning. It is recommended that the TRCA models be updated with recent ground survey and cross-section data to establish flood lines that reflect existing conditions

To assess culvert performance, the Energy Grade Line (EGL) and Hydraulic Grade Line (HGL) were reviewed immediately upstream and downstream of the culverts for the 5-year and 100-year storms under existing conditions. These storms were selected for consistency with the overall modelling approach and to review existing culvert performance under minor and major storms; which is expected to be aggravated under climate change conditions. It is understood that the Town of Ajax culverts are generally designed and built to the 1:25-year storm so these results were also extracted in tabular format. Culvert performance for a range of return period storms, including the Regional Storm are included within the HEC-RAS models and can be extracted directly.

Overall, culvert performance is generally satisfactory under the 5-year, 25-year and 100-year storms; however a number of culverts on Carruthers Creek show EGLs/HGLs above the culvert obvert for the 1:100-year storm. HEC-RAS channel profiles showing all the Town's culverts are located in **Appendix C.** **Table 3** summarizes the HEC-RAS water surface elevation output for each of the 12 Town of Ajax culverts**.**



Culvert in both HEC-RAS and Town of Ajax Data

HEC-RAS Culvert

Town of Ajax Major Culvert

HEC-RAS Bridge

Town of Ajax Bridge

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FIGURE 9

CULVERTS AND BRIDGES WITHIN THE TOWN OF AJAX

2017 Breaklines, Contours, Drainage or DTM provided by © First Base Solutions
2017 Orthophotography provided by © First Base Solutions

MAP CREATED BY: GM
MAP CHECKED BY: YA
MAP PROJECTION: NAD 1983 UTM Zone 17N

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0 250 500 1,000 m

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PROJECT: 187286 STATUS: DRAFT DATE: 2018-10-12

FILE LOCATION: I:\GIS\187286 - Town of Ajax Community Climate Study\mxd\Flooding\Figure 9 Culverts and Bridges within the Town of Ajax.mxd

Table 2

CULVERT DIMENSION COMPARISON

MILLER'S CREEK (DUFFINS WATERSHED)

HEC-RAS Culverts					GIS shapefile_Major_Culverts						
REACH	HEC-RAS RIVER STATION	LENGTH (m)	HEIGHT/ DIAMETER (m)	SPAN/ WIDTH (m)	ASSET ID	LOCATION	LENGTH (m)	HEIGHT/ DIAMETER (m)	SPAN/ WIDTH (m)	SHAPE	MATERIAL
Reach 1- Millers Creek	27.747	33	1.9	2.83	1015	0.10 KM SOUTH OF TAUNTON ROAD	37.8	1.2	3.5	PA - Pipe Arch	CPS - Corr Plate Stl
Reach 1- Millers Creek	27.717	21	2.4	11.0	16	0.5 KM WEST OF HARWOOD AVENUE	30.9	2.4	11.1	FRR - Frames, Rigid	PCC - Precast Conc
Reach 1- Millers Creek	27.562	39.9	3	5.1	206	0.25 KM WEST OF WOODCOCK AVENUE	32.3	3.4	5.1	BOX - Box	CPR - Cast in Place
Reach 1- Millers Creek	27.502	22.2	2.47	5.1	205	0.1 KM NORTH OF BRAY STREET	22.2	2.4	5.2	BOX - Box	CPR - Cast in Place
Reach 1- Millers Creek	27.447	26.9	2.5	6.1	204	1.1 KM WEST OF SULLIVAN DRIVE	26	2.5	5.1	BOX - Box	CPR - Cast in Place
Reach 1- Millers Creek	27.417	15.1	3.85	5.1	208	0.02 KM SOUTH OF MAGILL DRIVE	14.4	4	5.1	BOX - Box	CPR - Cast in Place
Reach 1- Millers Creek	27.267	27.3	2.84	7.1	203	0.15 KM NORTH OF BRAMWELL DRIVE	31.7	3.6	7.3	PHE - Pipe Horiz	CPS - Corr Plate Stl

CARRUTHERS CREEK

HEC-RAS Culverts											
REACH	HEC-RAS RIVER STATION	LENGTH (m)	HEIGHT/ DIAMETER (m)	SPAN/ WIDTH (m)	ASSET ID	LOCATION	LENGTH (m)	HEIGHT/ DIAMETER (m)	SPAN/ WIDTH (m)	SHAPE	MATERIAL
Reach 8	2.0135	22.8	2.1 (dia)		1002	0.6 KM WEST OF SALEM ROAD	31.9	2.1	2.1	PR - Pipe Round	CST - Corr. Steel
Reach 11	4.0025	8.9	1.6	3.7	207	0.4 KM NORTH OF TAUNTON ROAD	12	1.7	3.8	OTH - Other	CPR - Cast in Place
Reach 11	4.0135	43	1.83	2.43	213	0.10 KM EAST OF SALEM ROAD	25	1.8	2.4	BOX - Box	PCC - Precast Conc
Reach 11	4.0185	6.5	1.23	4.9	1016	1.3 KM NORTH OF TAUNTON ROAD	6.9	1.2	5.8	FRA - Frames, Articulated	CPR - Cast in Place
Reach 11	4.0245	17.9	1.66	4.86	211	1.5 KM EAST OF WESTNEY ROAD	17.7	1.5	4.6	OTH - Other	CPR - Cast in Place

Table 3 - HEC RAS Culvert Output

DUFFINS - MILLER'S CREEK

HEC-RAS Culverts						5 YR				25 YR				100 YR			
Reach	Culvert River Station	SPAN/ WIDTH	HEIGHT/ DIAMETER	CULV LENGTH	UPSTREAM OBVERT	EGL (Upstream)	HGL (Upstream)	EGL (Downstream)	HGL (Downstream)	EGL (Upstream)	HGL (Upstream)	EGL (Downstream)	HGL (Downstream)	EGL (Upstream)	HGL (Upstream)	EGL (Downstream)	HGL (Downstream)
Reach 1- Millers Creek	27.747	2.83	1.9	33	111.71	110.67	110.64	110.82	110.79	110.95	111.16	110.9	111.12	111.19	111.14	111.48	111.44
Reach 1- Millers Creek	27.717	11.0	2.4	21	110.1	107.91	107.68	108.15	108.12	108.16	108.4	107.89	108.37	99	98.91	99.15	99.08
Reach 1- Millers Creek	27.562	5.1	3	39.9	101.08	98.62	98.58	98.71	98.67	98.86	98.97	98.79	98.91	99	98.88	99.15	99.08
Reach 1- Millers Creek	27.502	5.1	2.47	22.2	97.56	96.13	96.1	96.15	96.13	96.51	96.54	96.47	96.51	96.8	96.75	96.84	96.8
Reach 1- Millers Creek	27.447	6.1	2.5	26.9	95.26	93.48	93.44	93.53	93.48	93.82	93.88	93.75	93.82	94.15	94.08	94.23	94.15
Reach 1- Millers Creek	27.417	5.1	3.85	15.1	95.46	92.81	92.79	92.84	92.81	93.37	93.4	93.33	93.36	93.81	93.77	93.85	93.8
Reach 1- Millers Creek	27.267	7.1	2.84	27.3	87.26	86.87	86.77	87.18	87.09	86.71	86.92	86.63	86.86	87.01	86.89	87.41	87.31

CARRUTHERS CREEK

HEC-RAS Culverts						5 YR				25 YR				100 YR			
Reach	Culvert River Station	SPAN/WIDTH	HEIGHT/DIAMETER	CULVLENGTH	UPSTREAM OBVERT	EGL (Upstream)	HGL (Upstream)	EGL (Downstream)	HGL (Downstream)	EGL (Upstream)	HGL (Upstream)	EGL (Downstream)	HGL (Downstream)	EGL (Upstream)	HGL (Upstream)	EGL (Downstream)	HGL (Downstream)
Reach 11	4.0185	4.9	1.23	6.5	131.7	131.29	131.58	131.23	131.47	131.58	132.12	131.47	132	131.8	132.42	131.62	132.42
Reach 8	2.0135	N/A	2.1 (dia)	22.8	92.66	90.59	91.78	90.39	91.77	90.82	92.17	90.55	92.14	90.98	92.44	90.65	92.39
Reach 11	4.0025	3.7	1.6	8.9	112.44	111.82	112.23	111.496	112.15	112.24	112.85	111.78	112.75	112.6	113.66	112.02	113.56
Reach 11	4.0135	2.43	1.83	43	127.75	126.76	127.85	126.37	127.78	127.28	128.74	126.71	128.64	127.72	129.17	127.01	129.15
Reach 11	4.0245	4.86	1.66	17.9	137.24	136.33	136.69	136.24	136.64	136.65	137.08	136.5	137	136.92	137.46	136.72	137.36

3.1.4 Stream Bank Erosion Potential

A high level analysis of the stream bank erosion potential was undertaken using the results generated from HEC-RAS. The RAS Mapper tool was used to generate maps showing locations of high velocity and shear within the watercourse channels, particularly for Miller's Creek, Carruthers Creek and Lynde Creek. Due to RAS-Mappers GIS interface, the extents of Duffins Creek that were not geo-referenced in HEC-RAS were not able to be mapped.

Channel shear stress and channel velocity were selected as key indicators for erosion potential along the stream banks, and were assessed for both the 5-year and 100-year storms. The channel shear stress and channel velocity values were also extracted from HEC-RAS and a spreadsheet analysis was also completed to determine average, maximum and minimum values. This second level of assessment allowed for high level trends and patterns to be inferred from the model results, and served as a validation of the RAS Mapper output.

Overall, a number of trends were visible in both the results table and velocity/shear mapping. Higher velocities tended to occur immediately downstream of the modelled crossings; and around channel meanders. Shear stress also increased around channel meanders and in some cases; shear stresses on the left and right channel banks differed noticeable, highlighting locations of additional erosion potential. In some locations; there were higher shear stresses and velocities under the 5-year storm than the 100-year storm; indicating that higher levels of erosion may occur under more frequent return-period storms than under larger storms. Areas with notable levels of shear and velocity under existing conditions include the Kingston Road crossing at Miller's Creek, the CP Rail and Lakeridge Road crossing at Lynde Creek and the Rossland Road East and Kerrison Drive East crossings on Carruthers Creek.

Figures 10 and 11 show an example of the 5-year and 100-year shear and velocity mapping results for Lynde Creek with a number of the above patterns highlighted. Detailed results tables and the maps for Miller's and Carruthers Creek are also included in **Appendix D.** It is recommended that these results are cross-referenced with current locations where the Town has noticed erosion of stream banks to add another level of confirmation.

Erosion potential for the Lake Ontario shoreline was not completed as part of this exercise as none of the models included substantial assessment of the shoreline. However, a number of restoration and erosion control have been completed by various agencies, including the Town, the TRCA and the Ontario Federation of Anglers, Hunters and Trout Unlimited (OFAH). **Figure 12** shows the locations of these projects, a notable number of which are along the Lake Ontario shoreline. **Table 4** shows the type of work undertaken, the year of the work and the agency that completed the work. **Table 5** shows a list of restoration projects completed by the TRCA only, within the Town of Ajax. Project IDs in the tables can be cross-referenced with the numbers on **Figure 12.**

As these areas are currently experiencing erosion under existing conditions, it is expected that they will be more vulnerable to increased erosion under climate change conditions. This vulnerability may be aggravated by potentially higher lake levels resulting from the implementation of Plan 2014, and highly erodible soils along the shoreline. A more detailed shoreline analysis is recommended to fully understand shoreline vulnerability.

Table 4: Location of Erosion Control Projects within the Town of Ajax

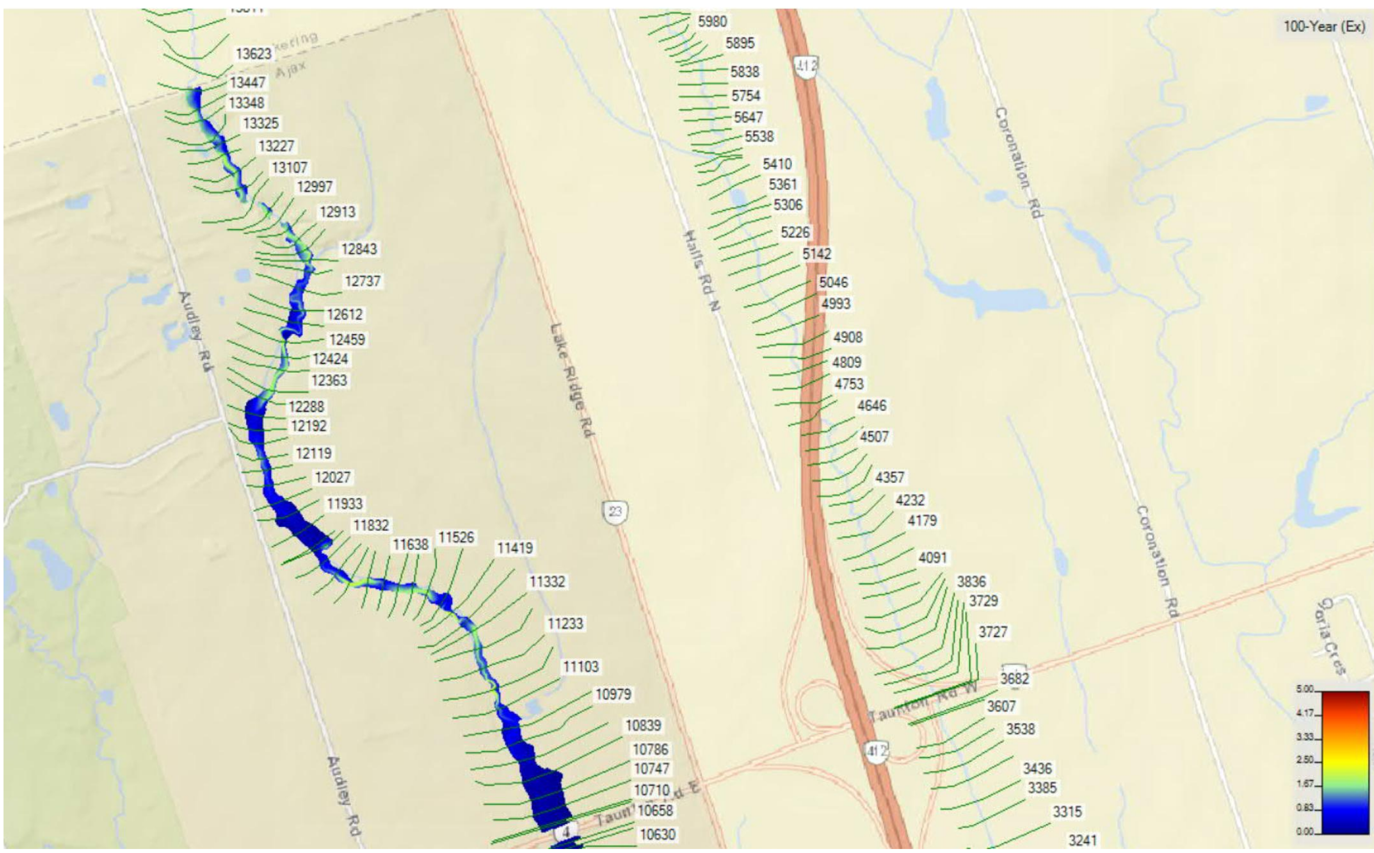
Location	Waterbody	Agency	Work Completed	Year
Wilkie Lane	Carruthers Creek	Private	Bank Stabilization	2015
Greenwood CA	Duffins Creek	OFAH, TRCA	Bank stabilization plus follow-up tree and shrub planting	2008
Greenwood CA	Duffins Creek	OFAH, TRCA	Bridge erosion mitigation project and planting	2009
Paulynn Park- south east of the walking bridge, next to parking lot	Duffins Creek	TRCA and Metro East Anglers	Bank Stabilization	2010
Greenwood CA	Duffins Creek	OFAH, TRCA	Failed bridge removal and bank stabilization	2010
Greenwood CA	Duffins Creek	OFAH, TRCA	GWCA Hydro Corridor Root Wad Placement Bank Stabilization	2010
Greenwood CA	Duffins Creek	TRCA and OFAH	Bank Stabilization	2011
Private Property	Duffins Creek	Trout Unlimited	Bank stabilization, tree planting	2012
Annie Crescent	Duffins Creek	Town (completed by TRCA) in partnership with OFAH and Trout Unlimited	Bank stabilization	2014
Greenwood CA	Duffins Creek	Trout Unlimited	Bank stabilization	2015
Ontoro Boulevard	Lake Ontario	Private	Sea Wall Installation	2016
Rotary Park Beach	Lake Ontario	TRCA	Bank Stabilization and native plantings	2011
Paradise Beach	Lake Ontario	TRCA	Sand dune installation	2015
Paradise Beach East	Lake Ontario	TRCA	Stone and grading of beach	2017
Waterfront	Lake Ontario	Town & TRCA	Primary & Secondary Erosion control	2017
Waterfront	Lake Ontario	Town	Headwall stabilization	2019 (pending budget approval)

Table 5: Location of TRCA Restoration Projects within the Town of Ajax

Project	Waterbody	Agency
Carruthers Creek Marsh Restoration	Carruthers Creek	TRCA
Carruthers Marsh – West Shore	Carruthers Creek	TRCA
Carruthers Splash Pad	Carruthers Creek	TRCA
Paulynn Park Stream Planting South	Duffins Creek	TRCA
Corner Marsh	Duffins Creek	TRCA
Deer Creek MTO Redside Dace Compensation	Duffins Creek	TRCA
Duffins Rotary Park Canoe Launch Shoreline Enhancement	Duffins Creek	TRCA
Duffins Marsh	Duffins Creek	TRCA
Duffins Marsh Northeast Lagoon	Duffins Creek	TRCA
Greenwood	Duffins Creek	TRCA
Lower Duffins Simcoe Point Lagoon	Duffins Creek	TRCA
Annie Crescent Streambak Stream Planting East	Duffins Creek	TRCA
Paulynn Park Stream Planting East	Duffins Creek	TRCA
Paradise Park Beach Restoration and Waterfront Trail	Lake Ontario	TRCA
Paradise Park Drainage Enhancement	Lake Ontario	TRCA
Simcoe Point Cemetery	Lake Ontario	TRCA

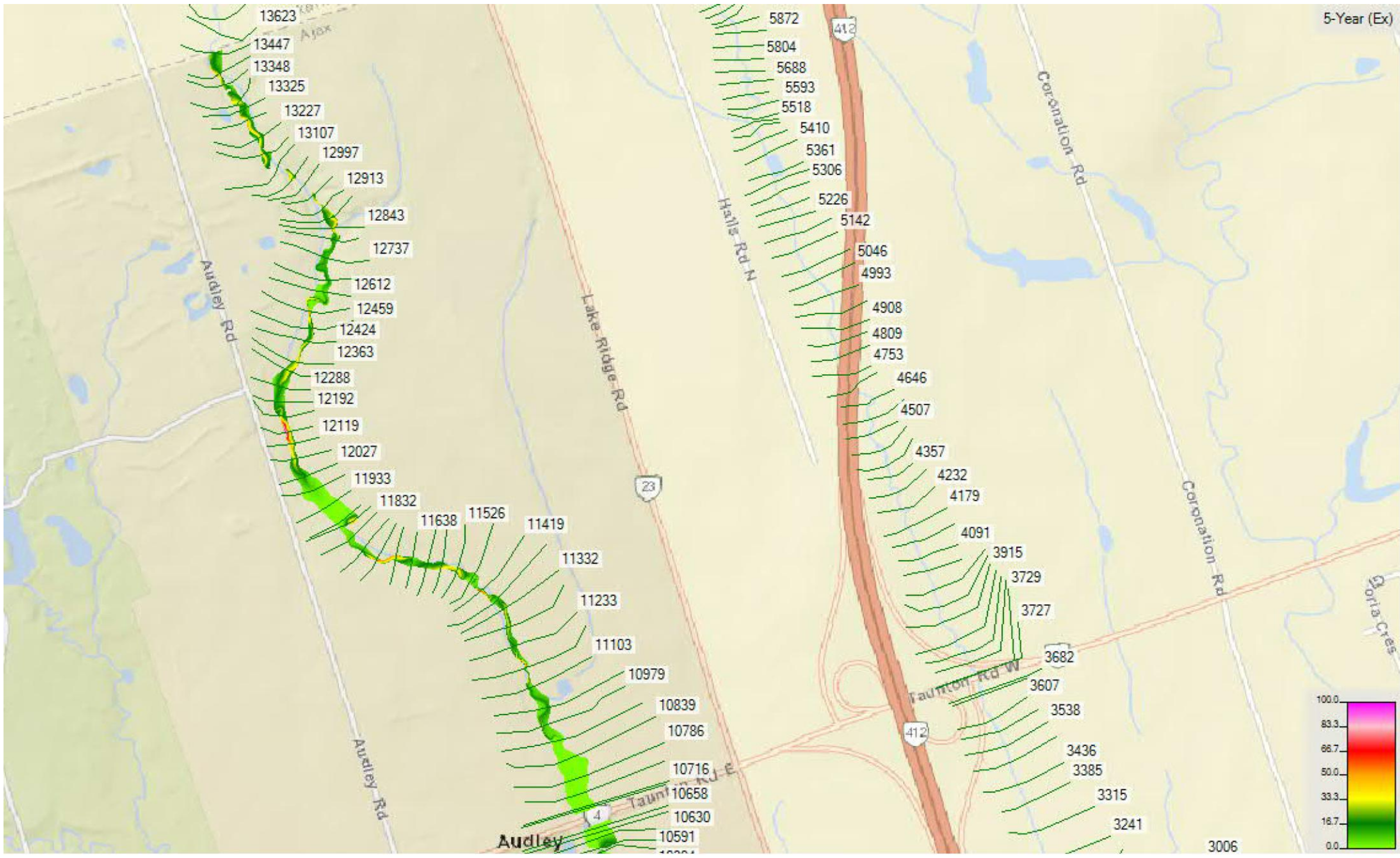
Figure 10: 5-year and 100-year Velocity Mapping Results - Lynde Creek Example

5-year

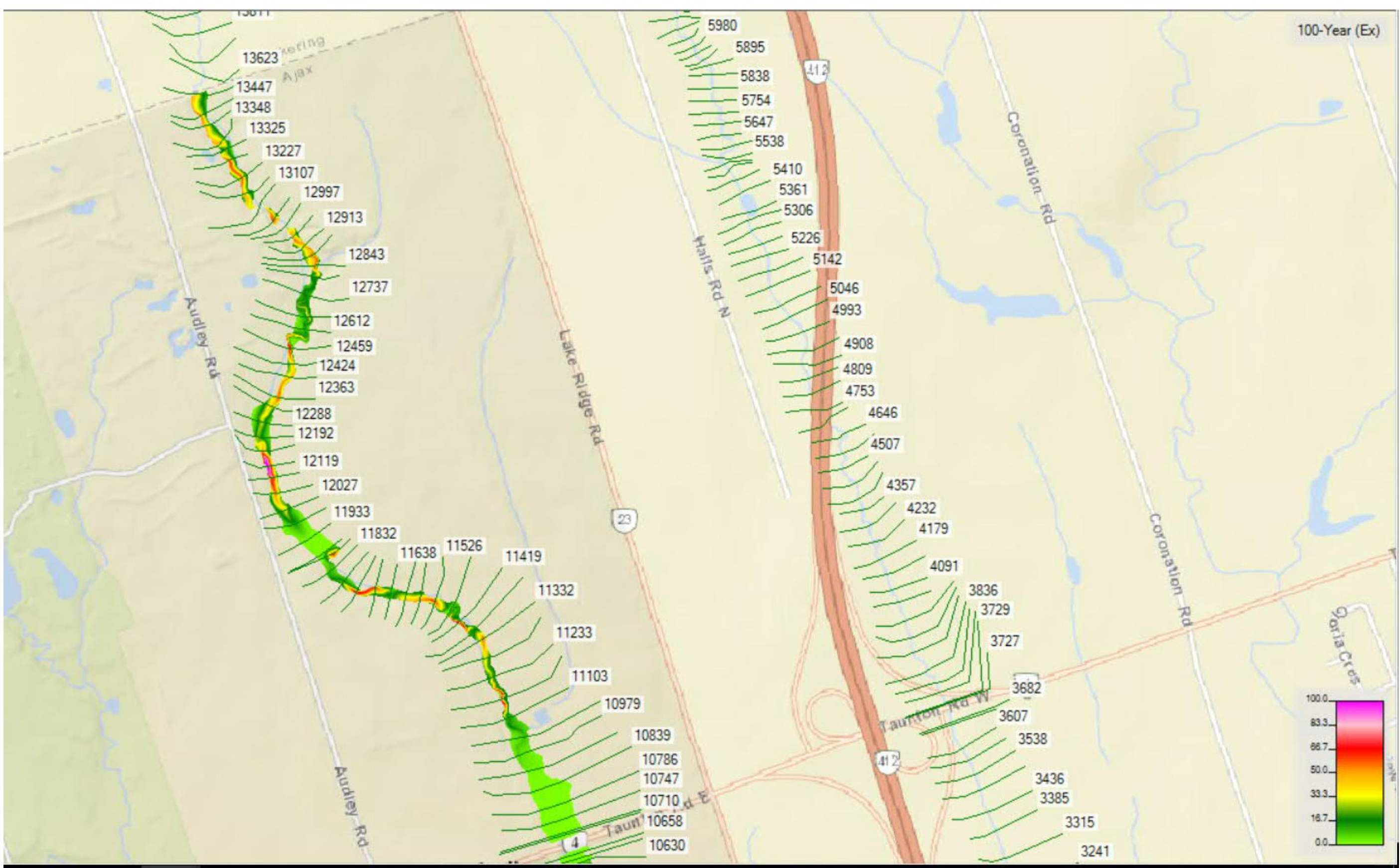


100-year

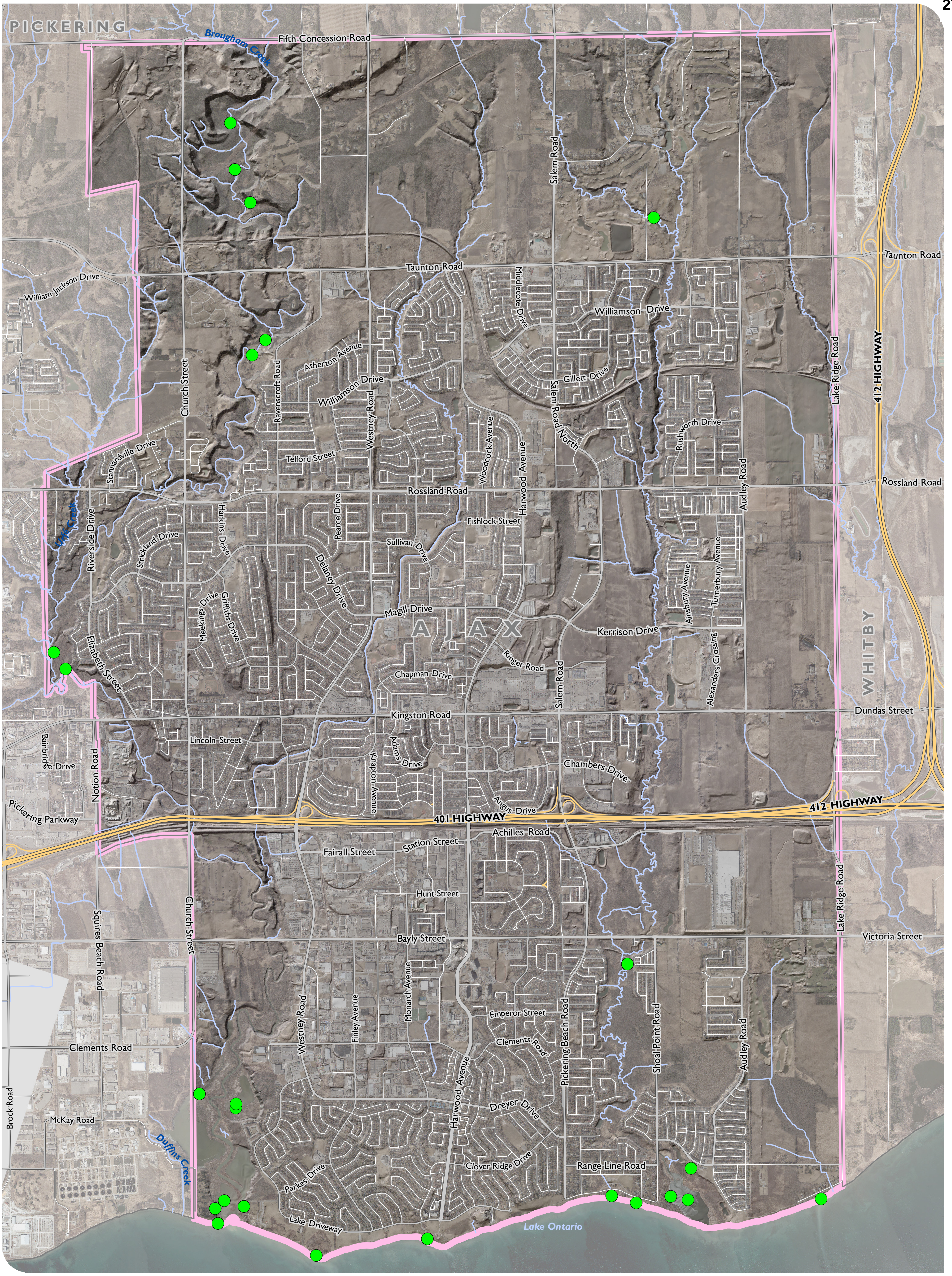
Figure 11: 5-year and 100-year Shear Mapping Results - Lynde Creek Example



5-year



100-year



Project Location

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FIGURE 12

EROSION CONTROL AND RESTORATION PROJECTS WITHIN THE TOWN OF AJAX

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2017 Breaklines, Contours, Drainage or DTM provided by © First Base Solutions
2017 Orthophotography provided by © First Base Solutions

MAP CREATED BY: GM
MAP CHECKED BY: YA
MAP PROJECTION: NAD 1983 UTM Zone 17N

1:32,000
0 250 500 1,000 m

PROJECT: 187286 STATUS: DRAFT DATE: 2018-10-12

FILE LOCATION: I:\GIS\187286 - Town of Ajax Community Climate Study\mxd\Flooding\Figure 12 Erosion Control and Restoration Projects within the Town of Ajax.mxd

3.2 Pluvial Flooding

The Town of Ajax has an extensive storm sewer network that reflects the main development hubs within the Town. Due to its proximity to a number of large watercourses, the storm sewer network tends to occur in clusters with multiple outlets directly to the creeks. There are no large or extensive storm sewers that run from north to Lake Ontario (south) along the entire length of the City; however there are several large trunk sewers in the central portion of the City that discharge to the Lake. There are numerous storm water management ponds within the Town, specifically within the central north-east area, reflecting the changes in stormwater quantity and quality requirements through the Town's development.

PCSWMM Professional 2017 was used to develop a screening level hydrologic model to represent stormwater and overland flooding within the urban fabric of the town. PCSWMM is highly compatible with the GIS platform and allows for easy transfer, querying, rendering and editing of GIS shapefiles.

3.2.1 Hydrology

The 1:5, 1:25 and 1:100-year, 24-hour Chicago Storm distributions were used to generate runoff within the PCSWMM model. The rainfall hyetograph was developed using IDF data from the Toronto City Station (previously Toronto Bloor), as per the Section C of the Town of Ajax Engineering Design Criteria Guidelines. Visual Otthymo version 2 (VO2) was used to generate the 24-hour storm distribution with a 10 minute time step.

As outlined in **Section 3.1.1.1**, a 25% increase in rainfall intensity was applied to the three design storms to represent the climate change scenario.

3.2.2 Hydraulics – Model Development

There were a number of data gaps in the GIS data provided by the Town, including limited to no invert information for all storm sewer pipes, storm sewer pipes with missing lengths or diameters; limited to no information on manholes, catch basins or SWM Ponds; and limited to no information on outfalls to the creeks. However, since the purpose of this model is to act as a screening-level tool to identify areas of potential vulnerability under climate change for further investigation, high-level assumptions were made to address these gaps and pre-processing of model input was completed before import to PCSWMM. The sections below outline some of the assumptions that were made to fill in the data gaps, as well as opportunities for further model development.

3.2.2.1 Storm Sewer Network

Top of manhole elevations were generated based on the LiDAR data provided by the Town. A GIS tool was used to extract the surface elevation at the manhole point. It was assumed that the top of manhole elevation generally reflected the topography of the land in the area. Storm sewer pipe inverts (both upstream and downstream) were assumed to be 3m below their respective top of manhole elevation, and consequently the slope of the storm sewers generally reflects the slope of the road.

Pipes with diameters greater than or equal to 600 mm were used to develop the storm sewer skeleton and these were manually traced from outlets to the most upstream pipes. A roughness coefficient of 0.013 was assumed for all pipes, and pipes with missing diameters were generally assumed to be the same diameter as upstream pipe flowing into it. Where possible, as-built drawings were reviewed to confirm general pipe characteristics, however pipe details in the Town-wide model were not updated to reflect the as-built data. The only location where as-built drawings were used to populate storm sewer infrastructure was in the detailed sub-model discussed in **Section 3.2.4.** Isolated pipes and orphan sewer networks are not considered in the model. A town-wide basin schematic was developed in the model and some reverse slope pipes were noticed based on terrain

It was assumed that all SWM pond inverts were at least 1m below the incoming pipes invert. All outfalls are assumed to be free outfalls with inverts approximately 10 m below the incoming pipes. Missing pipe lengths were auto-calculated in PCSWMM and missing manholes (upstream or downstream of storm sewer pipes) were manually added in to PCSWMM. **Table 6** below summarizes the modelling assumptions used to generate the storm sewer network.

Table 6: Modelling Assumptions

Parameter	Assumptions	Notes
Maintenance Hole (MH): Ground Elevation	Generated from 2017 LiDAR data	Missing MHs were manually added in PCSWMM and top of MH elevation estimated from 2017 contour data
Maintenance Hole (MH): Invert Elevation	MH Inverts assumed to be 3.0 m below top of MH elevations to correspond with storm sewer pipe inverts	-
Storm Sewers: Inverts	Storm sewer inverts assumed to be 3.0 m below top of MH elevations	-
Storm Sewers: Pipe Diameter	Pipe Diameter extracted from geospatial data provided by Town of Ajax for pipes greater than 600 mm	Where pipe diameters were missing from geospatial data, the pipe diameter immediately upstream was assumed to apply
Storm Sewers: Lengths	Pipe Lengths extracted from geospatial data provided by Town of Ajax	Where sewer lengths were missing from geospatial data, they were estimated using ArcGIS
SWM Ponds: Inverts	SWM Pond inverts assumed to be approximately 1.0 m below incoming pipe invert	-
SWM Ponds: Storage	Pond volumes based on assumed 3.5 to 5.0 m depths with the areas adjusted as necessary	Pond footprint area and depths were adjusted to ensure no surface ponding/flooding losses occurred at pond nodes in the model

Parameter	Assumptions	Notes
System Outfalls	Free outfalls into creeks were assumed; outfall inverts were assumed to be approximately 10 m below incoming pipe	-

3.2.2.2 Sub-catchments

The Town provided major urban drainage boundaries in CAD file format which were overlaid on building footprints and Town's storm sewer skeleton and used to determine sub-catchment boundaries. 107 drainage boundaries were provided by the Town which were further sub-divided into 915 sub-catchments based on a high-level manhole to manhole delineation approach. In open space areas, contour information was used to further delineate sub catchments. A generic subcatchment width of 75 m was assigned to all subcatchments and further refined in some areas.

Building envelopes and aerial photography were used to determine the land use of the sub catchments, and hydrologic parameters were determined using available soil classification data. The general land use types were determined to be approximately 65% residential, 30% commercial/industrial and 5% open space. Percent impervious values were selected based on land use type assuming 70% impervious for residential, 90% impervious for commercial/industrial and 25% impervious for open space areas. These values are generally consistent with the Runoff Coefficients outlined in the Town's Design Criteria for Stormwater Management and Storm Drainage (November 2016). A more refined level of detail for land use and percent impervious can be derived from building footprints and lot dimensions, and it is recommended that this be undertaken as part of future model development.

The study area consists of Hydrological Soil Group (HSG) B, C on the east of Audley Road; HSG A, B north of Taunton Road; HSG B,D on the west of Westney Road and south of Highway 401; and HSG A on the north of Highway 401, south of Taunton Road and west of Audley Road. Based on this classification, a Curve Number (CN) of 85 was assumed for west of Audley Road and south of Taunton Road and a CN of 60 was assumed for north of Taunton Road. **Table 7** summarizes the typical attributes for subcatchments within the model.

Table 7: Sub-catchment Attribute Assumptions

Parameter	Value
Width	75 m
Percent Imperviousness	Residential =70%, Commercial/Industrial =90%, Open Space =25%
Depression Storage-Impervious	1 mm
Depression Storage-Pervious	5 mm
Manning's N – Impervious	0.01
Manning's N – Pervious	0.2

3.2.3 Results

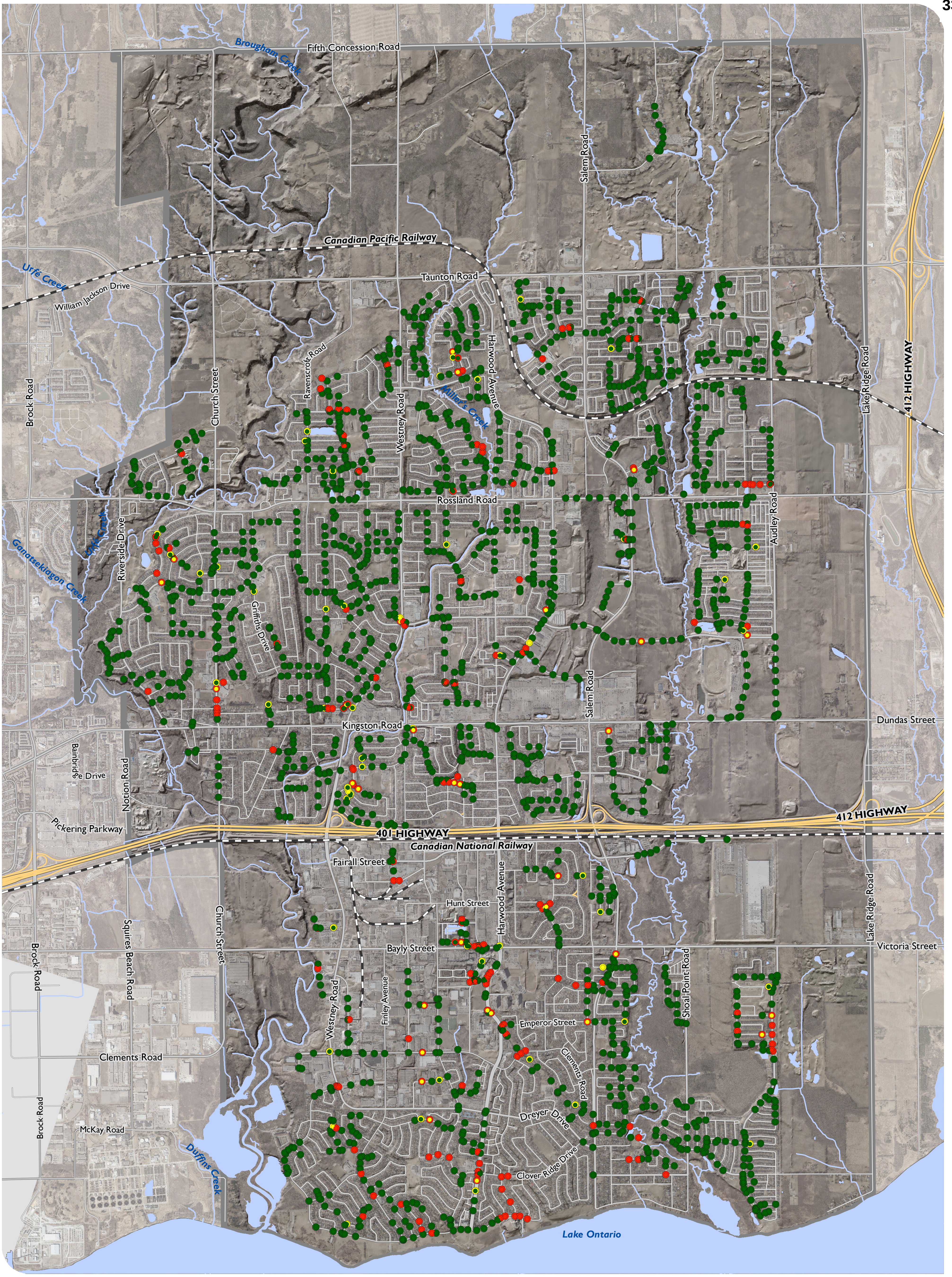
Model results show surcharged junctions in areas where the water surface elevation reached or exceeded the top of manhole elevation. The potential for surface ponding at manholes up to 0.1 ha was integrated into the model and the surcharged nodes for the 1:100-year Climate Change scenario (i.e., nodes with depths greater than 0.3 m) were converted to polygons to represent areas with the potential to be vulnerable to overland flooding.

Beta testing was undertaken using the 1:5 and 1:25-year storms under both existing and climate change scenarios. The 1:5-year storm was selected to review minor system performance; and the 1:25-year was included based on Town observations of the minor system surcharging to the road at approximately this return periods. Results for model simulations demonstrated the same trend of increases in the number of nodes surcharged under the climate change scenario, as compared to the existing conditions. As expected, the total number of nodes surcharged under the 1:100-year storm is much higher than the number of nodes surcharged under the 1:5 or 1:25-year storms. It is noted that there are some areas under the 1:5 and 1:25-year where node surcharge above 0.3 m occurs, which may indicate minor system capacity limitations. **Figures 13, 14, 15** illustrate the model results. Plans and profiles for three main sewer pipes are included in **Appendix E**as a representation of model output that can be generated from the PCSWMM model.

3.2.3.1 Urban Overland Flow Paths

Urban overland flow paths results were not generated from the PCSWMM model as a dual-drainage model for the entire Town was not undertaken. A detailed sub-model was created, including an overland flow path, as outlined in **Section 3.2.4.**

In order to visualize the general flow paths within the Town, RAS-Mapper was used to generate a topographic surface map of the entire Town and overlain with 0.5 m contours (**Figure 16**). Smaller scale maps were created by zooming in to sections of the Study Area and exported as screen-shots to pdf. All maps are included in **Appendix F**.



TOWN OF AJAX
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FIGURE 13
SURCHAGED NODES: 5 YEAR STORM

Existing Conditions (Max Ponded Depth)
- 0 - 0.3 m
- 0.3 - 0.5 m
- > 0.5 m

Climate Change Conditions (Max Ponded Depth)
- 0 - 0.3 m
- 0.3 - 0.5 m
- > 0.5 m
- Railway

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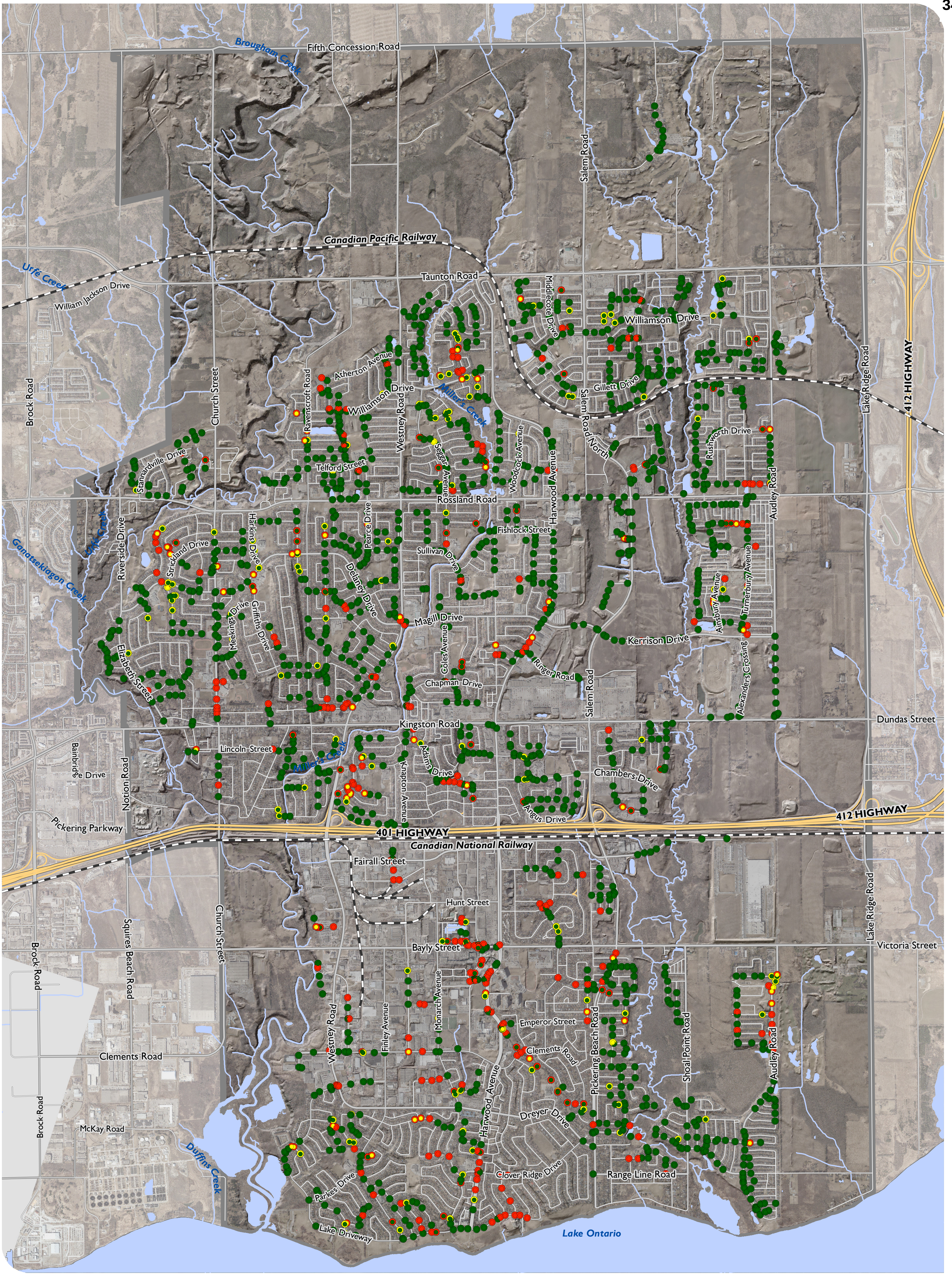
2017 Orthophotography provided by © First Base Solutions

1:32,000
0 250 500 1,000 m

MAP CREATED BY: GM
MAP CHECKED BY:
MAP PROJECTION: NAD 1983 UTM Zone 17N

PROJECT: 187286 STATUS: DRAFT DATE: 2018-10-12



TOWN OF AJAX

COMMUNITY CLIMATE STUDY

FIGURE 14

SURCHAGED NODES: 25 YEAR STORM

Existing Conditions (Max Ponded Depth)

- 0 - 0.3 m
- 0.3 - 0.5 m
- > 0.5 m

Climate Change Conditions (Max Ponded Depth)

- 0 - 0.3 m
- 0.3 - 0.5 m
- > 0.5 m
- Railway

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MAP CREATED BY: GM
MAP CHECKED BY:
MAP PROJECTION: NAD 1983 UTM Zone 17N

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0 250 500 1,000 m

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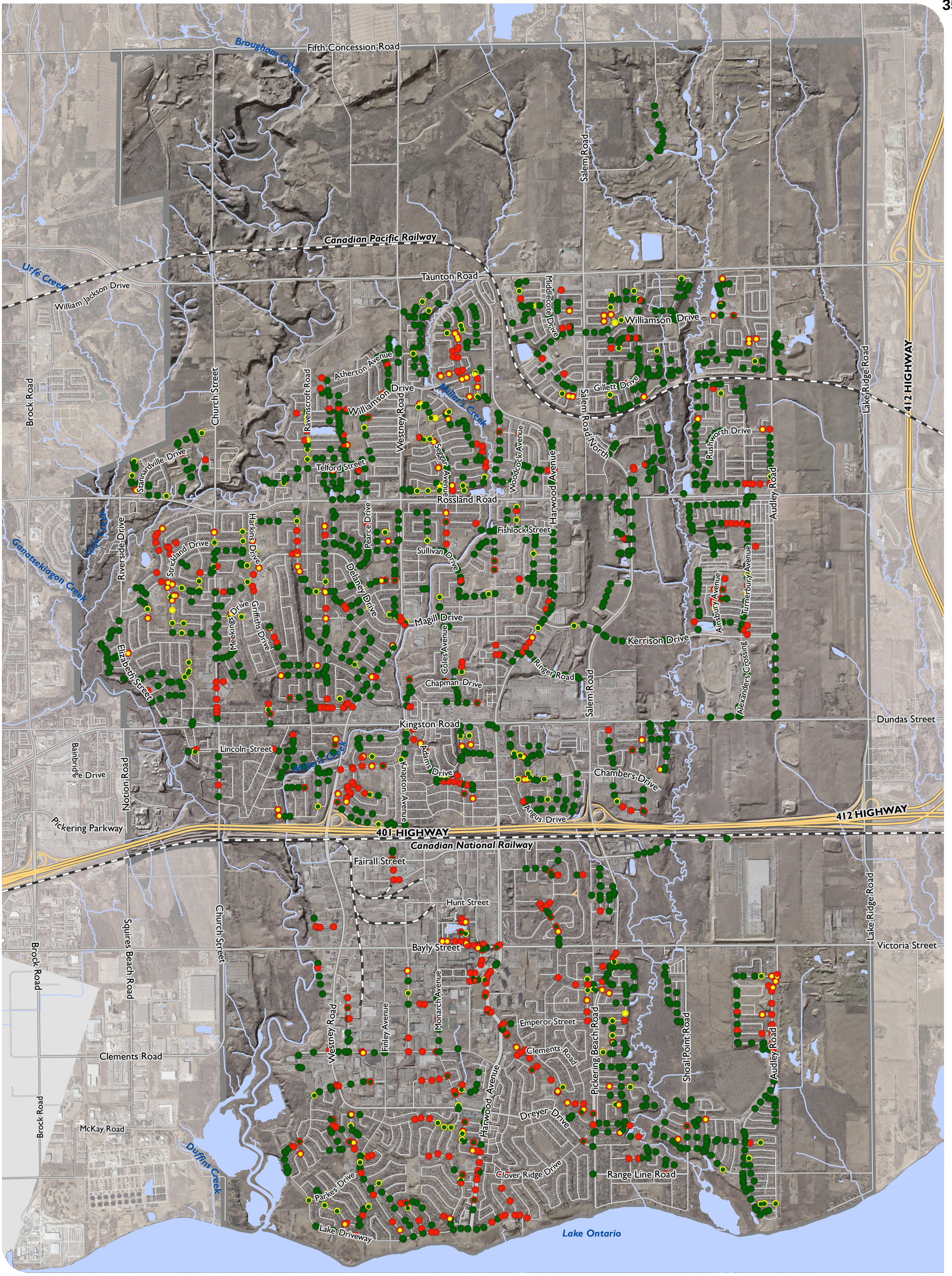
PROJECT: 187286 STATUS: DRAFT DATE: 2018-10-12

FILE LOCATION: I:\GIS\187286 - Town of Ajax Community Climate Study\mxd\Flooding\Figure 14 25 Year Flood Model Results.mxd



TOWN OF AJAX
COMMUNITY CLIMATE STUDY

FIGURE 15
SURCHAGED NODES: 100 YEAR STORM

Existing Conditions (Max Ponded Depth)

- 0 - 0.3 m
- 0.3 - 0.5 m
- > 0.5 m

Climate Change Conditions (Max Ponded Depth)

- 0 - 0.3 m
- 0.3 - 0.5 m
- > 0.5 m
- Railway

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MAP CREATED BY: GM
MAP CHECKED BY:
MAP PROJECTION: NAD 1983 UTM Zone 17N

1:32,000
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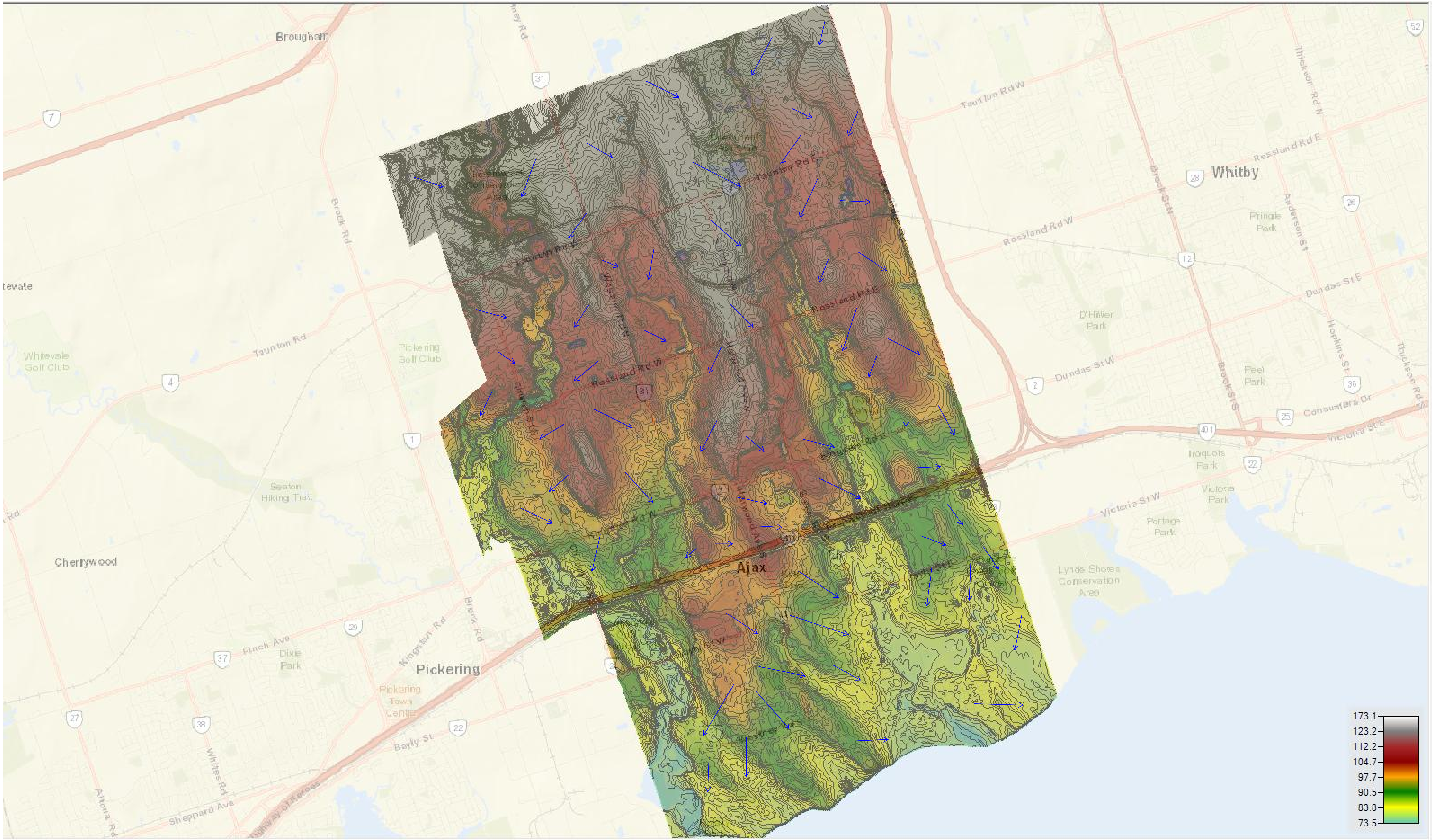
PROJECT: 187286 STATUS: DRAFT DATE: 2018-10-12

FILE LOCATION: I:\GIS\187286 - Town of Ajax Community Climate Study\mxd\Flooding\Figure 15 100 Year Flood Model Results.mxd

Figure 16 : Town-Wide Surface Flow Direction



3.2.4 Detailed Sub-Model

Due to the number of assumptions incorporated in the overall model, a mid-sized sewershed area was built-out in further detail based on as-built drawings provided by the Town. The sub-model was re-run in PCSWMM for both the 5-year and 100-year storms and model results compared to the model for the entire Town.

To demonstrate model capabilities, an overland flow system was also generated for the sub-model area. A generic road profile with an assumed width of 6.0 m and 0.45 m depth was used to represent the roadways; and was then connected to the minor system with a 0.25 m diameter orifice.

Due to the additional detail provided, pipes smaller than 600 mm were incorporated into the sub-model and the sub-catchment delineation was refined to allow smaller sub-catchments to discharge to the most upstream pipes. The addition of smaller pipes resulted in the re-routing of an additional catchment area to the sub-model outlet that was previously assumed to discharge into a separate system. This more refined level of detail is an example of the types of modifications that can be made to the model, as needed by the Town.

A comparison of HGLs between the sub-model and initial model results show that while there is variation in between the results, the initial model provides similar, and slightly more conservative results than the detailed mode (shown in **Figures 17 and 18**). In some instances, the 5-year HGL for the sub-model is higher than that of the original Town-wide model, and this is due to the additional sub-catchment being re-routed to the submodel outfall.

A further comparison was completed for the sub-model showing the difference in pipe HGL elevations with and without an overland flow path. As shown in **Figure 19**; there are minor differences for the 5-year HGL when an overland flow path is present; however the HGL is fairly similar in both models. The presence of an overland system results in some flow on the surface for the 5-year storm and in some cases, results in a lower HGL within the storm sewer pipes.

The overland flow path has the most benefits for the 100-year storm, as it distributes a flow over the width and depth of the roadway and identifies topographically low areas where runoff may pond during large storms, as shown in **Figure 20**. Additional plans and profiles are included in **Appendix G.**

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Figure 17 - 5-yr HGL Comparison: Sub-Model vs Town-Wide Model

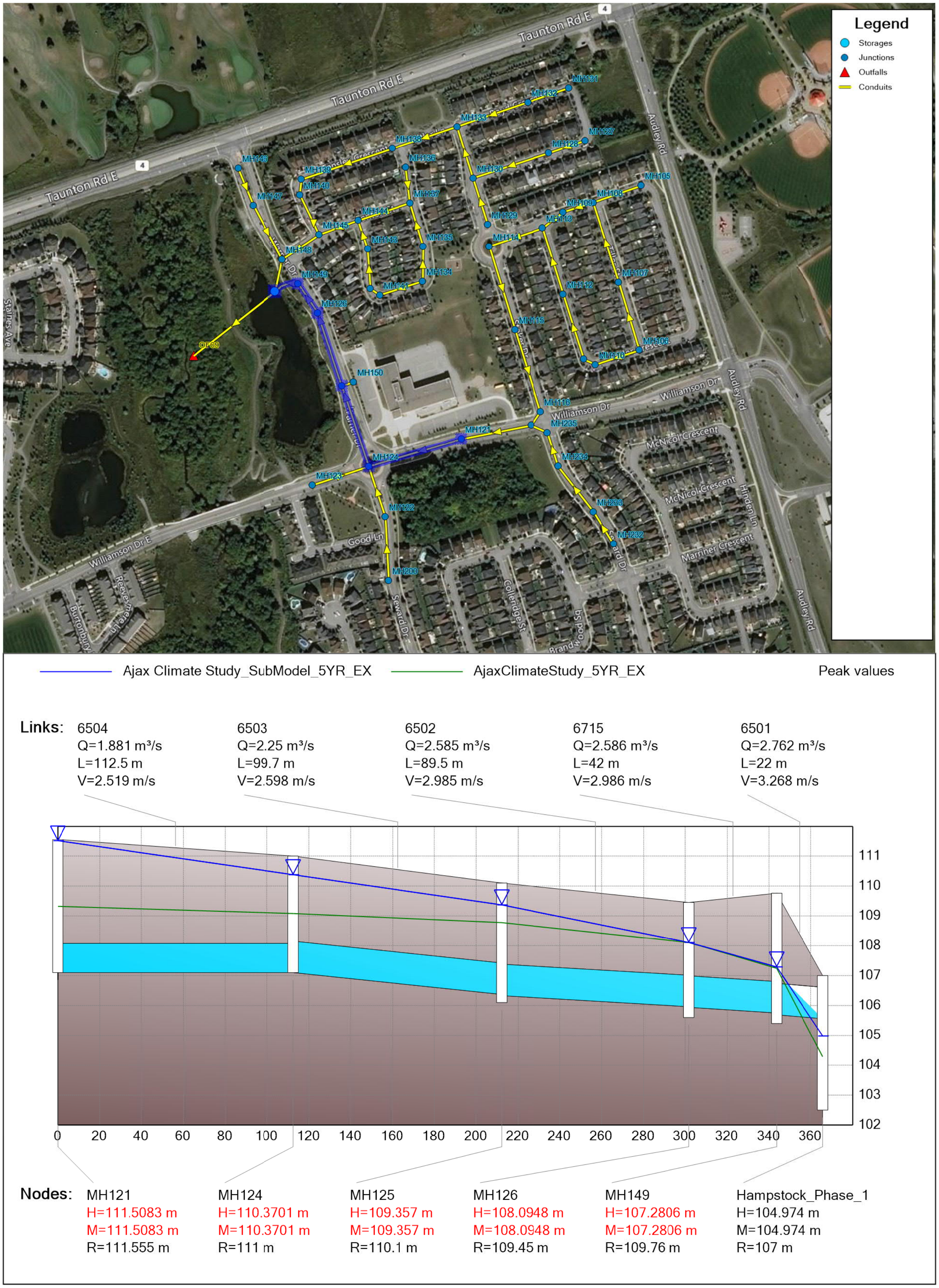


Figure 18 - 5-yr HGL Comparison: Sub-Model vs Town-Wide Model

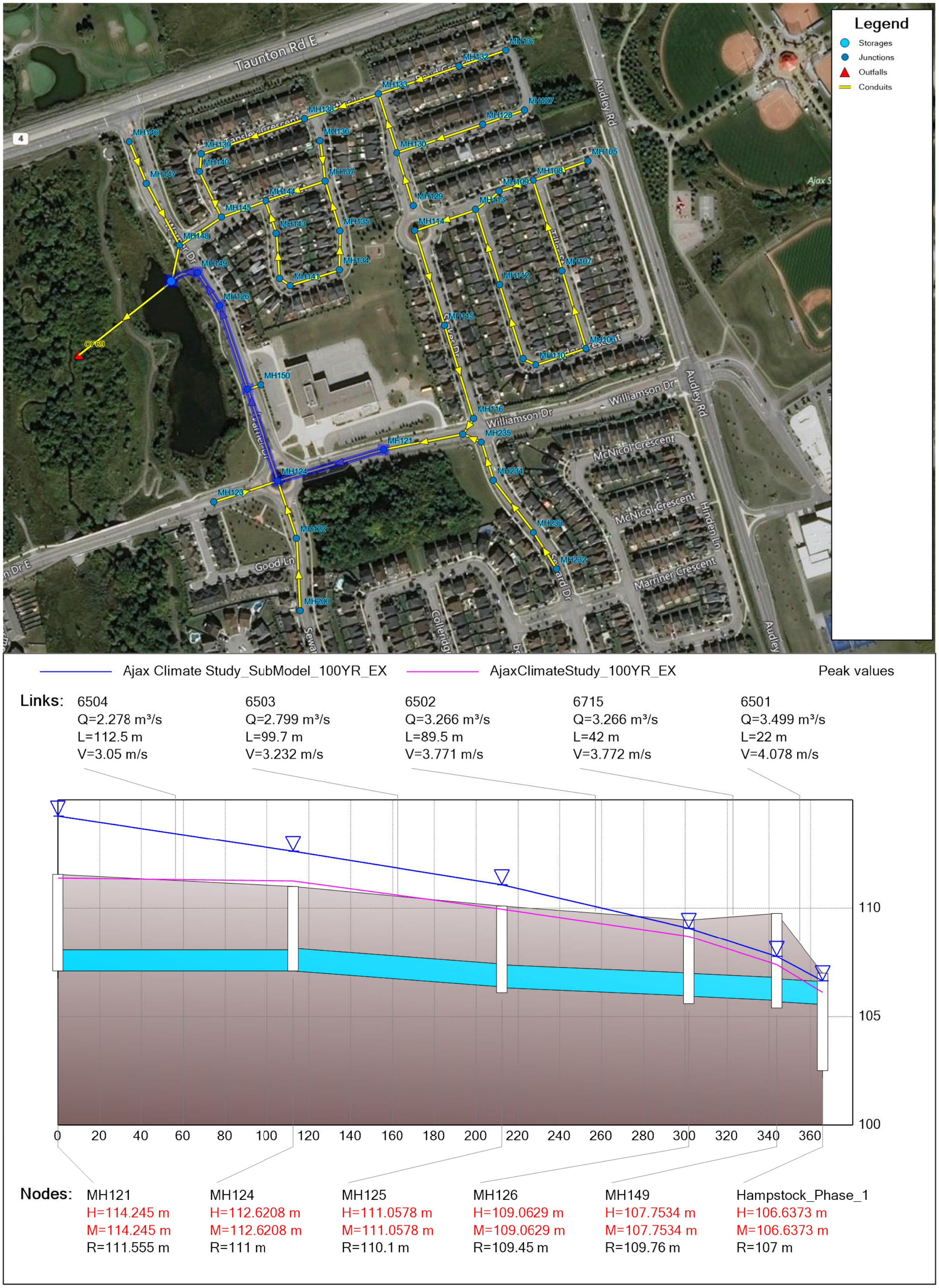


Figure 19 - Sub-Model 5-yr HGL Comparison: With and Without Overland Flow Component

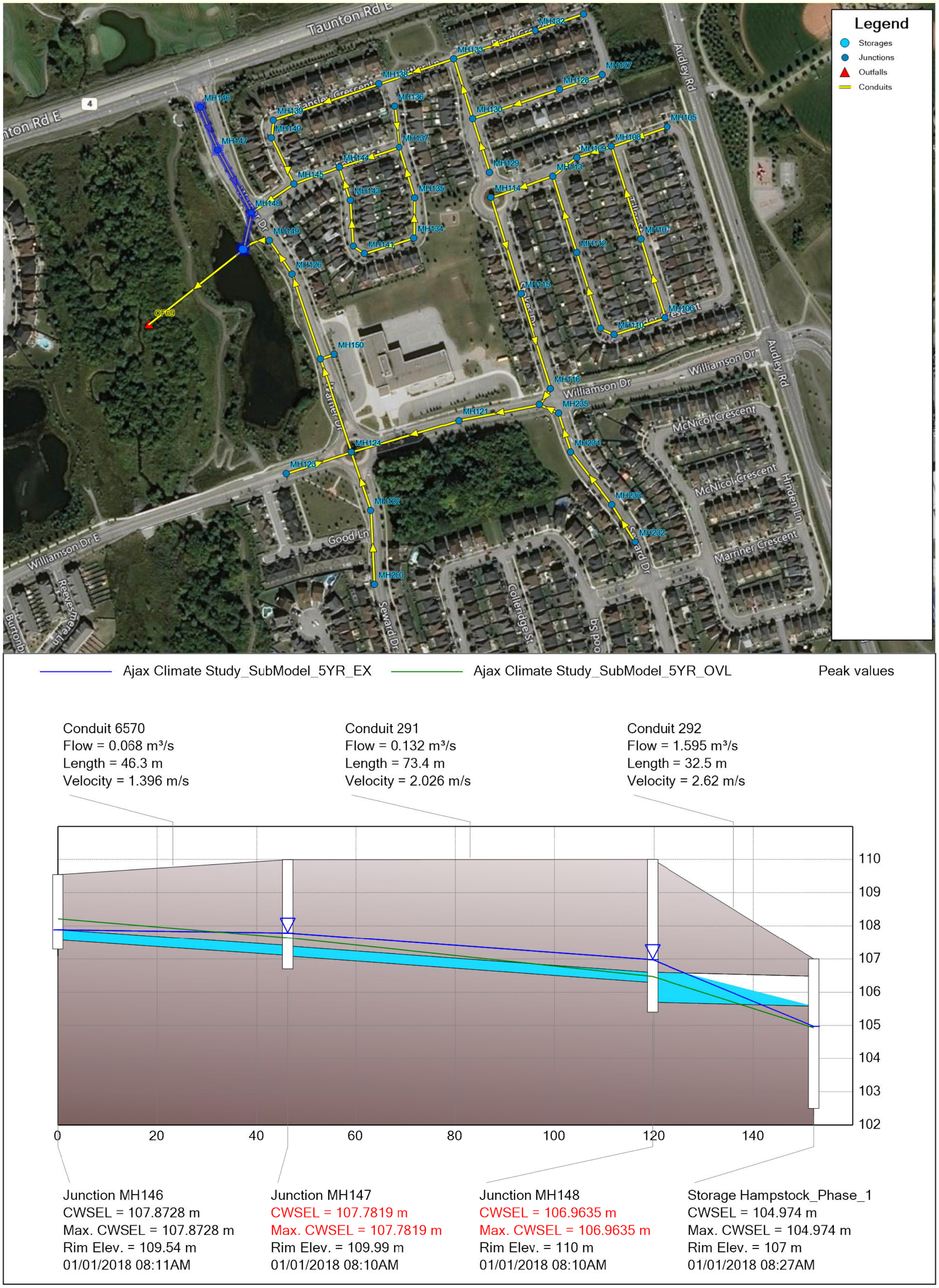


Figure 20 - Sub-Model 5-yr HGL Comparison: With and Without Overland Flow Component

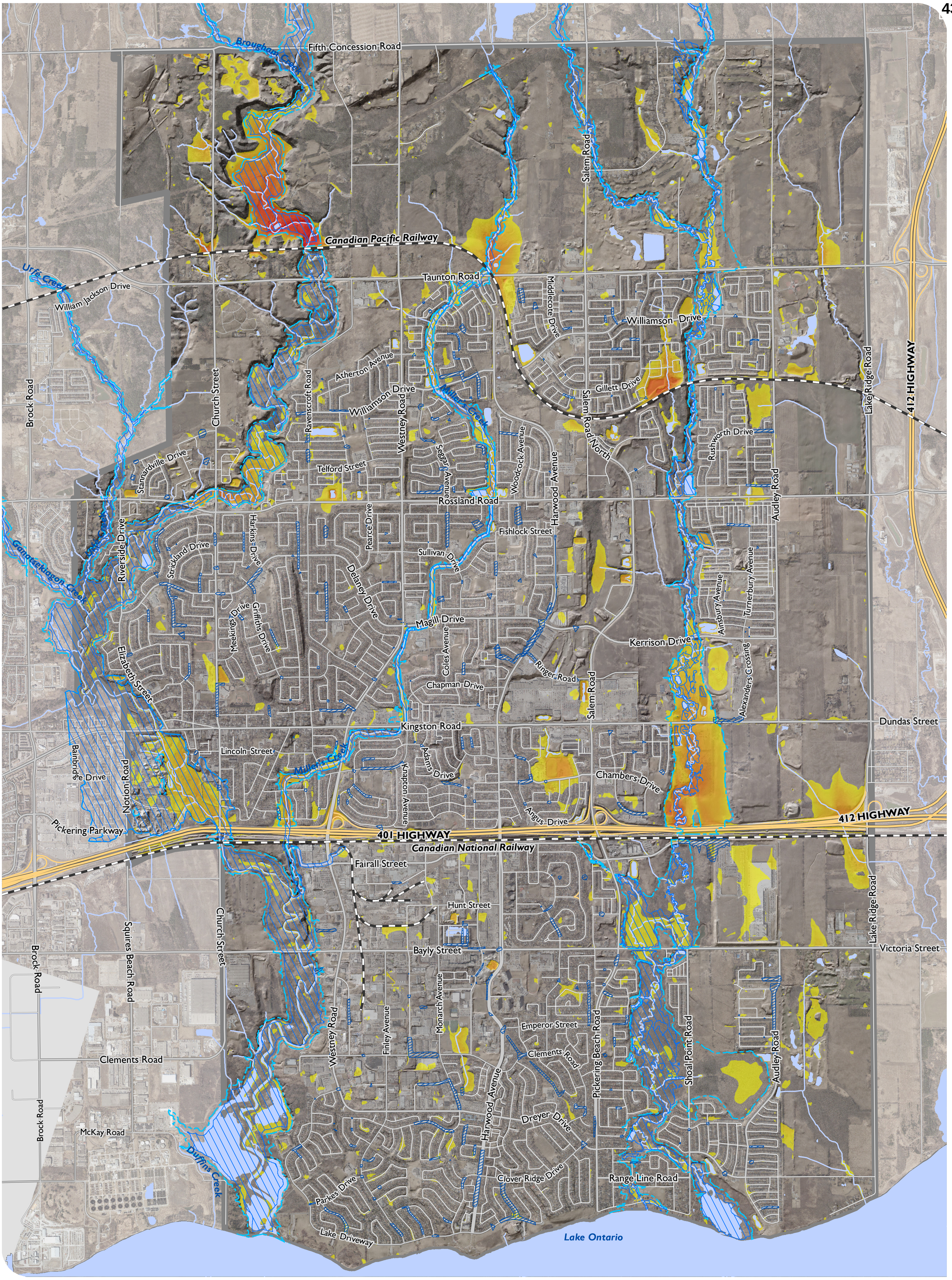
3.3 Flood Vulnerability Map

A flood vulnerability map was produced for the Town of Ajax showing the combined modelling results for fluvial and pluvial flooding. The map shows the extent of riverine flooding under the 1:100-year climate change scenario, as well as the Regional Storm flood lines. Based on the location of the surcharged nodes, the map also highlights areas within the urban fabric that have the potential for significant flooding under the 1:100-year climate change scenario. These are likely to be areas where the depth of ponding in the roadway exceeds the curb and may be especially noticeable within road sags and other low-lying areas. Surface depressions and stormwater management (SWM) ponds are also shown on the map to highlight areas of added depression storage in the system. It is assumed that under the 1:100-year climate change scenario, the depression areas will be areas of runoff accumulation and can therefore also serve to identify climate vulnerable areas **(Figure 21).**

3.4 Recommendations

The hydraulic models developed as part of this study are generally structurally sound and suitable for risk identification purposes; however a number of assumptions were made to mitigate the effects of missing data and it is recommended that additional model development be undertaken to validate and calibrate model results. It is specifically recommended that the minor system be further developed to reflect as-built sewer information, particularly inverts, and include pipes less than 600 mm in diameter.

Additional model development could include development of an overland system for the entire Town of Ajax based on top of manhole elevations and the inclusion of catch basin lead connections between the minor and major system. Further refinements can be made to the model including, developing a 2D mesh to more accurately determine overflow routes and areas of flow relief outside of road right of way and at the property/lot level.



TOWN OF AJAX
COMMUNITY CLIMATE STUDY

FIGURE 21

FLOOD VULNERABILITY MAP

100 Year Climate Change Overland Flooding Extent
100 Year Climate Change Riverine Flooding
Railway
Regional Floodline

Depression (m)
High : 0
Low : -8.87717

2017 Breaklines, Contours, Drainage or DTM provided by © First Base Solutions
2017 Orthophotography provided by © First Base Solutions

1:32,000
0 250 500 1,000 m

DILLON CONSULTING

MAP CREATED BY: GM
MAP CHECKED BY:
MAP PROJECTION: NAD 1983 UTM Zone 17N

PROJECT: 187286 STATUS: DRAFT DATE: 2018-10-12

FILE LOCATION: I:\GIS\187286 - Town of Ajax Community Climate Study\mxd\Flooding\Figure 21 Flood Vulnerability Map.mxd

4.0 Summary

Dillon has prepared this report to enable the Town of Ajax to better understand the threats and risks faced by the community as a result of changing climate trends, specifically to the storm sewer system and fluvial flooding from creeks. Dillon's approach was focused on understanding the areas of potential vulnerability resulting from two main types of flooding, fluvial and pluvial flooding. Dillon developed a hydraulic and hydrologic model using PCSWMM Professional 2017 for pluvial flooding; and updated hydraulic models provided by the TRCA and CLOCA in an effort to understand the impact of higher intensity rainfall on flood vulnerability.

A flood vulnerability map showing areas with the potential to experience significant flooding under climate change was developed to allow the Town to understand areas where a more detailed analyses may be necessary and to inform proposed measures under the Climate Adaptation Plan phase of this project. A summary of the report outcomes are outlined in **Table 8** below:

Table 8: Summary Stormwater Assessment Outcomes

Area of Assessment	Model Outcomes	Recommendations
Fluvial Flooding	**Water Surface Extents** • The 1:100-year climate change scenario did not represent a significant increase from the existing 1:100-year flood extents for all of the three creeks within the Town. • There were no instances where the 1:100-year flood line exceeded the Regional flood Line • The majority of the lands inundated by both the 1:100-year storms and Regional storms were natural areas such as woodland and/or floodplains • There were locations where the flood lines extend into the urban fabric and these are areas that are determined to be more vulnerable to flooding	• The TRCA Duffins Creek hydraulic model should be updated and georeferenced to allow ease of data extraction and compatibility with GIS tools.
	Culvert Performance: • 12 out of 24 culverts identified as "Major Culverts" were assessed. • Culvert performance is generally satisfactory under the 5-year. 25-year and 100-year storms. • A number of culverts on Carruthers Creek show EGLs/HGLs above the culvert obvert for the 1:100-year storm; however model results should be compared with in-field observations for further validation; • Notable differences in culvert dimensions between Town of Ajax and hydraulic model files.	• Culvert dimensions and cross-section data in TRCA models should be verified (by the TRCA or others) through field survey and updated to establish flood lines that reflect existing conditions
	Stream Bank Erosion Potential: • Higher velocities and shear stresses tended to occur immediately downstream of the modelled crossings; and around channel meanders • Areas with notable levels of shear and velocity include the Kingston Road crossing at Miller's Creek, the CP Rail and Lakeridge Road crossing at Lynde Creek and the Rossland Road East and Kerrison Drive East crossings on Carruthers Creek.	• Areas identified as locations with high erosion potential should be cross-referenced with locations where the Town has noticed erosion of stream banks. • A more detailed shoreline analysis should be completed to fully understand shoreline vulnerability and identify additional areas susceptible to erosion.

DILLON CONSULTING

Area of Assessment	Model Outcomes	Recommendations
	• Erosion control and restoration projects completed by various agencies identify areas within the Town of Ajax that currently experience erosion issues, which are likely to be aggravated under climate change conditions	
Stormwater Infrastructure	**5-year, 25-year, 100-year Storms: Existing vs Climate Change Conditions** • Model simulations demonstrated increases in the number of storm sewer nodes surcharged under the climate change scenario, as compared to the existing conditions • The total number of nodes surcharged under the 1:100-year storm is much higher than the number of nodes surcharged under the 1:5 or 1:25-year storms, as expected • In some cases, node surcharge depths above 0.3 m occur under the 1:5 and 1:25-year, which may indicate minor system capacity limitations	• The storm sewer network in the PCSWMM model should be further developed to reflect as-built sewer information, particularly inverts, and to include pipes less than 600 mm in diameter. • The PCSWMM model should be further refined by filling the data gaps in the GIS data provided by the Town, including maintenance hole, catch basin, stormwater pond and creek outfall details • A more refined level of detail for land use parameters and percent impervious can be derived from building footprints and lot dimensions and is recommended for future model development. • The development of an overland system for the entire Town of Ajax is also recommended for future model development
	Detailed Sub-Model Area: • There are some differences between results for Town-wide model versus sub-area model; however results are generally similar • There are minor differences to the 5-year hydraulic grade lines in storm sewers when an overland flow path is present due to some runoff temporarily stored on the surface • The overland flow path has the most benefits for the 100-year storm, as it distributes a flow over the width and depth of the roadway and identifies topographically low areas where runoff may pond during large storms	• At the sub-model scale, further refinements can be made to the model including, as needed, including developing a 2D mesh to more accurately determine overflow routes and areas of flow relief outside of road right of way and at the property/lot level.

Appendix A

IDFCC Future Climate Projections

IDF for: TORONTO CITY ID:6158355

Station Info | IDF historical data | IDF under climate change

GEV | Gumbel

Tables | Plots | Interpolation Equations

Total precipitation amounts are presented in mm and precipitation intensity rates are presented in mm/h for different return periods (T) presented in years

Total PPT (mm) Intensity rates (mm/h)

T (years)	2	5	10	25	50	100
5 min	9.10	12.66	15.01	17.98	20.19	22.38
10 min	12.68	16.93	19.75	23.30	25.94	28.56
15 min	15.42	21.26	25.13	30.01	33.64	37.24
30 min	19.54	27.30	32.44	38.93	43.74	48.52
1 h	23.77	32.62	38.48	45.89	51.38	56.83
2 h	27.95	37.37	43.60	51.48	57.33	63.13
6 h	34.49	45.78	53.25	62.69	69.69	76.64
12 h	41.07	53.23	61.28	71.44	78.99	86.48
24 h	45.91	58.97	67.62	78.55	86.65	94.70

Historical IDF - Toronto City Station

IDF for: TORONTO CITY ID:6158355

Station Info | IDF historical data | IDF under climate change

Climate Model Selection | Scenario RCP 2.6 | Scenario RCP 4.5 | Scenario RCP 8.5 | Comparison Graphs

Tables | Plots | Interpolation Equations | Box Plot - Uncertainty

Total precipitation amounts presented in mm and precipitation intensity rates presented in mm/h for different return periods (T) presented in years

Total PPT (mm) Intensity rates (mm/h)

T (years)	2	5	10	25	50	100
5 min	9.98	15.38	18.89	23.35	28.39	34.11
10 min	14.02	20.80	25.09	30.33	36.16	42.72
15 min	16.93	25.92	31.73	39.05	47.29	56.64
30 min	21.51	33.66	41.32	50.96	61.37	73.78
1 h	26.68	41.23	49.64	59.76	69.28	81.65
2 h	31.63	47.65	56.53	66.91	76.05	88.25
6 h	38.45	57.02	68.25	81.72	95.80	112.68
12 h	46.03	67.01	79.29	93.64	108.12	126.12
24 h	51.46	74.04	87.30	102.69	118.48	137.63

Future Climate IDF (RCP 2.6) - Toronto City Station

IDF for: TORONTO CITY ID:6158355

Station Info | IDF historical data | IDF under climate change

Climate Model Selection | Scenario RCP 2.6 | Scenario RCP 4.5 | Scenario RCP 8.5 | Comparison Graphs

Tables | Plots | Interpolation Equations | Box Plot - Uncertainty

Total precipitation amounts presented in mm and precipitation intensity rates presented in mm/h for different return periods (T) presented in years

Total PPT (mm) Intensity rates (mm/h)

T (years)	2	5	10	25	50	100
5 min	9.83	14.27	17.81	23.98	28.32	32.71
10 min	13.82	19.34	23.61	31.16	36.08	41.00
15 min	16.69	24.06	29.90	40.11	47.18	54.32
30 min	21.21	31.22	39.03	52.35	61.36	70.47
1 h	26.32	38.26	46.87	60.51	69.79	78.18
2 h	31.20	44.24	53.28	67.19	76.82	84.90
6 h	37.90	53.01	64.30	83.51	95.85	107.70
12 h	45.37	62.33	74.63	95.14	108.34	120.38
24 h	50.72	68.90	82.11	104.41	118.58	131.53

Future Climate IDF (RCP 4.5) - Toronto City Station

IDF for: TORONTO CITY ID:6158355

Station Info | IDF historical data | IDF under climate change

Climate Model Selection | Scenario RCP 2.6 | Scenario RCP 4.5 | Scenario RCP 8.5 | Comparison Graphs

Tables | Plots | Interpolation Equations | Box Plot - Uncertainty

Total precipitation amounts presented in mm and precipitation intensity rates presented in mm/h for different return periods (T) presented in years

Total PPT (mm) Intensity rates (mm/h)

T (years)	2	5	10	25	50	100
5 min	9.91	14.16	17.92	22.96	28.56	32.40
10 min	13.96	19.15	23.75	29.57	36.44	40.68
15 min	16.82	23.86	30.08	38.35	47.60	53.83
30 min	21.44	30.98	39.27	50.14	62.06	70.13
1 h	26.82	37.93	47.24	57.93	69.82	78.54
2 h	31.87	43.84	53.78	64.32	76.15	85.53
6 h	38.42	52.49	64.71	79.46	97.14	107.43
12 h	46.08	61.68	75.14	90.56	109.91	120.37
24 h	51.48	68.16	82.64	99.18	120.31	131.38

Future Climate IDF (RCP 8.5) - Toronto City Station

IDF for: GREENWOOD MTRCA ID:6153020

Station Info | IDF historical data | IDF under climate change

GEV | Gumbel

Tables | Plots | Interpolation Equations

Total precipitation amounts are presented in mm and precipitation intensity rates are presented in mm/h for different return periods (T) presented in years

◉ Total PPT (mm) ○ Intensity rates (mm/h)

T (years)	2	5	10	25	50	100
5 min	7.32	9.35	10.70	12.41	13.67	14.93
10 min	10.50	12.89	14.48	16.48	17.97	19.44
15 min	13.07	16.18	18.25	20.85	22.79	24.71
30 min	17.85	23.84	27.81	32.82	36.54	40.23
1 h	21.95	30.03	35.38	42.13	47.14	52.12
2 h	25.38	34.50	40.54	48.17	53.83	59.45
6 h	31.81	43.66	51.50	61.41	68.76	76.06
12 h	35.81	48.23	56.45	66.83	74.54	82.19
24 h	40.92	54.53	63.54	74.92	83.37	91.75

Historical IDF - TRCA Greenwood Station (Town of Ajax)

IDF for: GREENWOOD MTRCA ID:6153020

Station Info | IDF historical data | IDF under climate change

Climate Model Selection | Scenario RCP 2.6 | Scenario RCP 4.5 | Scenario RCP 8.5 | Comparison Graphs

Tables | Plots | Interpolation Equations | Box Plot - Uncertainty

Total precipitation amounts presented in mm and precipitation intensity rates presented in mm/h for different return periods (T) presented in years

◉ Total PPT (mm) ○ Intensity rates (mm/h)

T (years)	2	5	10	25	50	100
5 min	8.35	11.19	13.02	15.25	16.78	18.31
10 min	12.39	15.80	17.54	19.51	20.48	22.08
15 min	15.39	19.89	22.23	24.92	26.24	28.43
30 min	20.02	27.58	33.05	39.72	44.95	49.69
1 h	24.44	34.12	41.44	50.37	58.08	64.19
2 h	28.45	39.24	47.26	57.00	65.00	71.75
6 h	35.06	48.55	59.23	72.48	85.40	94.17
12 h	39.74	54.30	65.60	79.44	92.18	101.34
24 h	45.80	62.69	75.26	90.45	102.78	113.31

Future Climate IDF (RCP 2.6) - TRCA Greenwood Station

IDF for: GREENWOOD MTRCA ID:6153020

Station Info | IDF historical data | IDF under climate change

Climate Model Selection | Scenario RCP 2.6 | Scenario RCP 4.5 | Scenario RCP 8.5 | Comparison Graphs

Tables | Plots | Interpolation Equations | Box Plot - Uncertainty

Total precipitation amounts presented in mm and precipitation intensity rates presented in mm/h for different return periods (T) presented in years

◉ Total PPT (mm) ○ Intensity rates (mm/h)

T (years)	2	5	10	25	50	100
5 min	8.26	11.45	13.16	15.07	16.38	17.60
10 min	12.17	16.07	17.71	19.31	20.26	21.04
15 min	15.12	20.22	22.45	24.66	25.99	27.10
30 min	19.87	28.38	33.47	39.60	44.13	48.61
1 h	24.30	35.20	41.99	50.43	56.84	63.34
2 h	28.26	40.45	47.87	56.93	63.71	70.48
6 h	34.92	50.14	60.13	73.04	83.25	93.16
12 h	39.52	56.05	66.55	79.76	89.96	99.99
24 h	45.47	64.65	76.23	90.29	100.75	111.16

Future Climate IDF (RCP 4.5) - TRCA Greenwood Station

IDF for: GREENWOOD MTRCA ID:6153020

Station Info | IDF historical data | IDF under climate change

Climate Model Selection | Scenario RCP 2.6 | Scenario RCP 4.5 | Scenario RCP 8.5 | Comparison Graphs

Tables | Plots | Interpolation Equations | Box Plot - Uncertainty

Total precipitation amounts presented in mm and precipitation intensity rates presented in mm/h for different return periods (T) presented in years

◉ Total PPT (mm) ○ Intensity rates (mm/h)

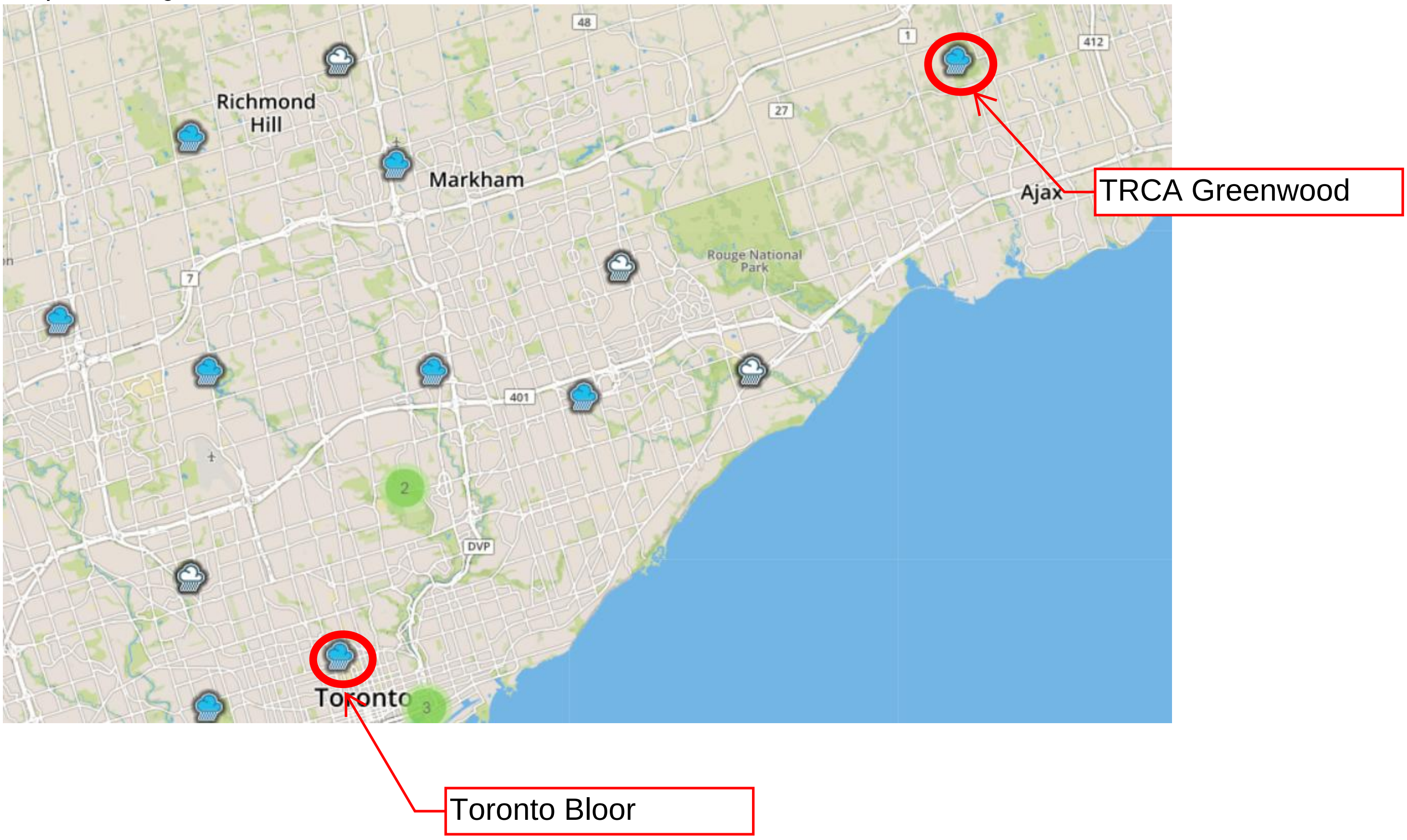
T (years)	2	5	10	25	50	100
5 min	8.48	11.05	12.77	14.87	16.26	18.01
10 min	12.54	15.49	17.14	18.93	20.07	20.96
15 min	15.57	19.50	21.73	24.18	25.77	27.01
30 min	20.35	27.36	32.49	39.03	44.65	50.40
1 h	24.85	33.92	40.69	49.65	57.71	66.01
2 h	28.91	38.99	46.41	56.08	64.59	73.28
6 h	35.64	48.25	58.10	71.77	84.97	98.90
12 h	40.38	53.97	64.31	78.44	91.60	105.32
24 h	46.53	62.31	73.86	88.94	102.11	115.55

Future Climate IDF (RCP 8.5) - TRCA Greenwood Station

Summary of Percent Difference in IDF Paratmeters for Existing and Future Climate Change Scenarios

	Toronto				TRCA Greenwood			
	Current	RCP	Future	%	Current	RCP	Future	%
100 yr 24 hr	mm		mm		mm		mm	
	94.7	2.6	137.63	45.3%	91.75	2.6	113.31	23.5%
		4.5	131.53	38.9%		4.5	111.16	21.2%
		8.5	131.38	38.7%		8.5	115.55	25.9%
10 yr 24 hr	67.62	2.6	87.3	29.1%	63.52	2.6	75.26	18.5%
		4.5	82.11	21.4%		4.5	76.23	20.0%
		8.5	82.64	22.2%		8.5	73.86	16.3%
5 yr 24 hr	58.97	2.6	74.04	22.3%	54.53	2.6	62.69	15.0%
		4.5	68.9	16.8%		4.5	64.65	18.6%
		8.5	68.16	15.6%		8.5	62.31	14.3%
				27.8%				19.2%
					Average	23.5%		

Map showing locations of Toronto Bloor and TRCA Greenwood Stations



Appendix B

HEC-RAS Results Tables

Table 1: Lynde Creek HEC-RAS model results for 1:100 year storm under existing conditions

HEC-RAS Plan: ex8 River: Kinsale Reach: 3 Profile: 100-Year (Ex)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
3	6222	100-Year (Ex)	41.69	86.71	88.68	87.84	88.68	0.000104	0.26	212.22	226.69	0.07
3	6176	100-Year (Ex)	41.69	86.55	88.68	87.77	88.68	0.000089	0.24	231.33	249.83	0.06
3	6130	100-Year (Ex)	41.69	86.49	88.68	87.64	88.68	0.000075	0.25	230.77	220.67	0.06
3	6084	100-Year (Ex)	41.69	86.33	88.67	87.55	88.68	0.000065	0.23	249.50	223.15	0.05
3	6035	100-Year (Ex)	41.69	86.33	88.67	87.39	88.67	0.000053	0.21	260.11	222.33	0.05
3	5994	100-Year (Ex)	41.69	86.33	88.67	87.37	88.67	0.000047	0.20	279.09	238.24	0.05
3	5962	100-Year (Ex)	41.69	86.33	88.67	87.39	88.67	0.000051	0.21	273.86	240.29	0.05
3	5936	100-Year (Ex)	41.69	86.23	88.67		88.67	0.000054	0.23	294.85	300.21	0.05
3	5893	100-Year (Ex)	41.69	86.09	88.67		88.67	0.000044	0.21	319.39	338.81	0.05
3	5847	100-Year (Ex)	41.69	85.95	88.67		88.67	0.000058	0.24	254.04	249.30	0.05
3	5845	100-Year (Ex)	41.69	85.90	88.64	88.48	88.67	0.001611	1.06	92.95	231.87	0.26
3	5833		Culvert									
3	5822	100-Year (Ex)	41.69	85.76	88.47	88.47	88.57	0.003440	2.00	57.90	203.27	0.46
3	5814	100-Year (Ex)	41.69	85.75	87.71	87.03	87.71	0.000883	0.54	112.38	156.50	0.13
3	5757	100-Year (Ex)	41.69	85.70	87.67	87.06	87.68	0.001193	0.50	100.10	124.05	0.14
3	5627	100-Year (Ex)	41.69	85.49	87.59	86.92	87.60	0.000861	0.47	111.08	118.64	0.13
3	5547	100-Year (Ex)	41.69	85.40	87.52	86.86	87.54	0.001691	0.71	75.54	75.49	0.18
3	5501	100-Year (Ex)	41.69	85.34	87.42	86.91	87.45	0.003710	1.03	52.80	56.22	0.27
3	5462	100-Year (Ex)	41.69	85.32	87.33	86.67	87.35	0.002144	0.73	70.23	77.32	0.20
3	5442	100-Year (Ex)	41.69	85.31	87.27	86.56	87.30	0.002847	0.87	55.97	51.81	0.23
3	5392	100-Year (Ex)	41.69	85.11	87.20	86.46	87.22	0.002014	0.76	66.70	63.49	0.20
3	5321	100-Year (Ex)	41.69	84.85	87.06	86.39	87.08	0.002575	0.86	58.84	56.63	0.22
3	5261	100-Year (Ex)	41.69	84.68	86.93		86.96	0.002852	1.01	57.90	61.31	0.24
3	5222	100-Year (Ex)	41.69	84.65	86.84		86.87	0.002758	0.88	59.71	69.74	0.23
3	5192	100-Year (Ex)	41.69	84.50	86.76		86.79	0.002802	0.95	57.34	60.51	0.23
3	5149	100-Year (Ex)	41.69	84.41	86.65		86.69	0.003963	1.14	47.85	46.43	0.28
3	5061	100-Year (Ex)	41.69	84.29	86.45		86.49	0.003840	1.09	50.77	52.74	0.27
3	4994	100-Year (Ex)	41.69	84.29	86.24		86.29	0.004760	1.21	46.36	52.52	0.31
3	4970	100-Year (Ex)	41.69	84.23	86.11		86.19	0.007227	1.44	38.03	44.70	0.38
3	4931	100-Year (Ex)	41.69	84.18	86.04		86.06	0.002586	0.85	63.85	69.38	0.23
3	4884	100-Year (Ex)	41.69	84.13	85.96		85.99	0.003641	0.94	54.81	60.63	0.26
3	4812	100-Year (Ex)	41.69	84.04	85.87		85.89	0.002494	0.84	61.19	60.13	0.22
3	4771	100-Year (Ex)	41.69	83.91	85.77		85.81	0.004328	1.07	54.80	79.35	0.29
3	4754	100-Year (Ex)	41.69	83.84	85.67		85.72	0.005304	1.19	47.32	72.15	0.32
3	4707	100-Year (Ex)	41.69	83.61	85.55		85.57	0.003001	0.91	66.19	90.47	0.24
3	4598	100-Year (Ex)	41.69	83.60	85.30		85.34	0.004203	0.99	50.32	72.16	0.28
3	4577	100-Year (Ex)	41.69	83.36	85.23		85.27	0.003760	0.99	44.66	54.74	0.27
3	4553	100-Year (Ex)	41.69	83.36	85.18		85.21	0.002556	0.79	51.73	62.13	0.22
3	4504	100-Year (Ex)	41.69	83.33	85.08		85.13	0.003533	1.50	42.79	55.47	0.40
3	4480	100-Year (Ex)	41.69	83.16	85.05		85.08	0.001498	1.01	61.78	76.66	0.26
3	4408	100-Year (Ex)	41.69	82.90	84.99		85.02	0.001358	0.98	59.07	69.48	0.25
3	4383	100-Year (Ex)	41.69	82.89	84.98		84.99	0.000707	0.73	77.21	82.92	0.18
3	4361	100-Year (Ex)	41.69	82.89	84.96		84.98	0.000652	0.71	82.41	88.69	0.18
3	4343	100-Year (Ex)	41.69	82.89	84.96		84.97	0.000528	0.63	86.57	83.74	0.16
3	4335	100-Year (Ex)	41.69	82.89	84.95		84.96	0.000449	0.59	91.59	84.73	0.15
3	4316	100-Year (Ex)	41.69	82.87	84.94		84.96	0.000508	0.62	88.88	86.25	0.15
3	4299	100-Year (Ex)	41.69	82.79	84.93		84.95	0.000479	0.62	93.64	99.14	0.15
3	4201	100-Year (Ex)	41.69	82.43	84.93		84.93	0.000144	0.37	139.83	101.92	0.08
3	4179	100-Year (Ex)	41.69	82.43	84.92		84.93	0.000204	0.46	143.37	99.64	0.10
3	4156	100-Year (Ex)	41.69	82.37	84.92		84.92	0.000197	0.44	152.44	106.41	0.10
3	4110	100-Year (Ex)	41.69	82.33	84.91		84.92	0.000468	0.49	116.36	87.70	0.10
3	4091	100-Year (Ex)	41.69	82.33	84.90		84.91	0.000368	0.43	120.58	80.13	0.09
3	4033	100-Year (Ex)	41.69	82.33	84.89		84.90	0.000291	0.38	137.56	91.03	0.08
3	4009	100-Year (Ex)	41.69	82.33	84.88		84.89	0.000350	0.41	131.47	93.77	0.09
3	3967	100-Year (Ex)	41.69	82.33	84.87		84.87	0.000432	0.47	116.50	86.32	0.10
3	3941	100-Year (Ex)	41.69	82.23	84.86		84.87	0.000153	0.28	184.83	120.43	0.06
3	3886	100-Year (Ex)	41.69	81.78	84.85	83.12	84.85	0.000336	0.44	107.34	55.49	0.09
3	3880	100-Year (Ex)	41.69	81.71	84.68	83.25	84.84	0.004556	1.73	24.04	56.34	0.33
3	3857		Culvert									
3	3834	100-Year (Ex)	41.69	81.26	83.67	82.87	83.69	0.001743	0.71	73.33	85.65	0.19
3	3820	100-Year (Ex)	41.69	81.23	83.66	83.00	83.67	0.000439	0.34	168.58	238.51	0.09
3	3806	100-Year (Ex)	41.69	81.21	83.63	82.93	83.65	0.002120	0.76	63.87	65.28	0.21
3	3778	100-Year (Ex)	41.69	81.20	83.57	82.67	83.59	0.002008	0.79	59.58	53.20	0.20
3	3750	100-Year (Ex)	41.69	81.19	83.52		83.54	0.001887	0.77	65.45	61.41	0.20
3	3725	100-Year (Ex)	41.69	81.18	83.49		83.50	0.001297	0.62	79.53	73.49	0.16
3	3704	100-Year (Ex)	41.69	81.17	83.44		83.47	0.003076	0.78	62.13	71.92	0.23
3	3680	100-Year (Ex)	41.69	81.16	83.36		83.38	0.003340	0.86	59.63	72.56	0.25
3	3638	100-Year (Ex)	41.69	81.15	83.27		83.29	0.001873	0.77	66.97	67.52	0.20
3	3599	100-Year (Ex)	41.69	81.14	83.20		83.22	0.002168	0.79	68.46	73.29	0.21
3	3578	100-Year (Ex)	41.69	81.14	83.16		83.18	0.002469	0.79	63.94	66.68	0.22
3	3549	100-Year (Ex)	41.69	81.14	83.11		83.13	0.002095	0.78	65.94	67.18	0.21
3	3528	100-Year (Ex)	41.69	81.10	83.02		83.06	0.004226	1.06	48.67	54.54	0.29
3	3504	100-Year (Ex)	41.69	80.98	82.93		82.98	0.004138	1.07	49.10	54.11	0.29
3	3483	100-Year (Ex)	41.69	80.97	82.84		82.89	0.004753	1.17	44.77	50.70	0.31
3	3466	100-Year (Ex)	41.69	80.96	82.77		82.82	0.003742	1.07	49.00	53.07	0.28
3	3445	100-Year (Ex)	41.69	80.95	82.64		82.72	0.007540	1.40	39.55	53.03	0.39
3	3427	100-Year (Ex)	41.69	80.87	82.56		82.62	0.005388	1.30	44.00	53.28	0.33
3	3399	100-Year (Ex)	41.69	80.80	82.46		82.51	0.003956	1.10	45.96	47.84	0.29
3	3373	100-Year (Ex)	41.69	80.74	82.38		82.42	0.002606	0.96	52.82	50.14	0.26
3	3346	100-Year (Ex)	41.69	80.34	82.34		82.37	0.001574	0.73	64.52	51.40	0.18
3	3320	100-Year (Ex)	41.69	80.34	82.31		82.33	0.001548	0.76	66.41	54.50	0.18
3	3300	100-Year (Ex)	41.69	80.25	82.28		82.30	0.001332	0.72	68.75	54.09	0.17
3	3273	100-Year (Ex)	41.69	80.24	82.22		82.25	0.002177	0.90	58.31	58.71	0.22
3	3258	100-Year (Ex)	41.69	80.22	82.17		82.21	0.002792	0.99	53.86	61.58	0.24
3	3238	100-Year (Ex)	41.69	80.22	82.05	81.46	82.13	0.005947	1.38	38.77	47.16	0.35

HEC-RAS Plan: ex8 River: Kinsale Reach: 3 Profile: 100-Year (Ex) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
3	3225	100-Year (Ex)	41.69	80.22	82.00	81.40	82.05	0.004645	1.12	45.12	55.30	0.31
3	3216	100-Year (Ex)	41.69	80.22	81.98	81.30	82.01	0.003033	0.93	56.41	68.93	0.25
3	3201	100-Year (Ex)	41.69	80.22	81.94		81.96	0.002586	0.84	60.73	71.84	0.23
3	3166	100-Year (Ex)	41.69	80.12	81.87		81.89	0.001693	0.68	70.68	74.44	0.18
3	3110	100-Year (Ex)	41.69	80.10	81.84	80.89	81.85	0.000690	0.45	104.85	89.13	0.12
3	3046	100-Year (Ex)	41.69	80.07	81.81		81.81	0.000605	0.43	119.23	130.76	0.11
3	3008	100-Year (Ex)	41.69	79.81	81.78		81.79	0.000879	0.52	104.19	128.54	0.13
3	2977	100-Year (Ex)	41.69	79.70	81.77		81.77	0.000507	0.35	142.21	190.73	0.10
3	2956	100-Year (Ex)	41.69	79.65	81.76		81.77	0.000314	0.26	173.72	219.41	0.08
3	2937	100-Year (Ex)	46.58	79.65	81.76		81.76	0.000242	0.25	210.85	247.16	0.07

Table 2: Lynde Creek HEC-RAS Model Results for 1:100 year Storm under Climate Change Conditions

HEC-RAS Plan: 8 River: Kinsale Reach: 3 Profile: 100-Year (CC)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
3	6222	100-Year (CC)	52.11	86.71	88.74	87.87	88.74	0.000136	0.31	224.84	228.93	0.08
3	6176	100-Year (CC)	52.11	86.55	88.73	87.81	88.73	0.000116	0.28	245.02	251.77	0.07
3	6130	100-Year (CC)	52.11	86.49	88.73	87.69	88.73	0.000101	0.29	242.65	222.38	0.07
3	6084	100-Year (CC)	52.11	86.33	88.73	87.59	88.73	0.000088	0.27	261.42	224.51	0.06
3	6035	100-Year (CC)	52.11	86.33	88.73	87.48	88.73	0.000072	0.25	271.92	223.98	0.06
3	5994	100-Year (CC)	52.11	86.33	88.73	87.41	88.73	0.000064	0.23	291.70	240.00	0.06
3	5962	100-Year (CC)	52.11	86.33	88.72	87.48	88.73	0.000070	0.25	286.45	242.06	0.06
3	5936	100-Year (CC)	52.11	86.23	88.72		88.72	0.000072	0.27	310.50	302.95	0.06
3	5893	100-Year (CC)	52.11	86.09	88.72		88.72	0.000059	0.25	336.90	341.99	0.05
3	5847	100-Year (CC)	52.11	85.95	88.72		88.72	0.000081	0.28	267.00	260.67	0.06
3	5845	100-Year (CC)	52.11	85.90	88.69	88.52	88.72	0.001832	1.15	104.17	235.21	0.28
3	5833		Culvert									
3	5822	100-Year (CC)	52.11	85.76	88.51	88.51	88.62	0.004015	2.19	65.70	205.22	0.50
3	5814	100-Year (CC)	52.11	85.75	87.85	87.13	87.86	0.000824	0.55	135.33	169.08	0.13
3	5757	100-Year (CC)	52.11	85.70	87.81	87.09	87.82	0.001119	0.52	118.37	131.84	0.14
3	5627	100-Year (CC)	52.11	85.49	87.74	86.95	87.74	0.000840	0.50	128.46	119.48	0.13
3	5547	100-Year (CC)	52.11	85.40	87.66	86.91	87.68	0.001715	0.76	86.55	76.39	0.19
3	5501	100-Year (CC)	52.11	85.34	87.56	86.97	87.60	0.003711	1.10	60.81	56.82	0.27
3	5462	100-Year (CC)	52.11	85.32	87.47	86.74	87.49	0.002088	0.77	81.58	78.80	0.20
3	5442	100-Year (CC)	52.11	85.31	87.41	86.63	87.45	0.003070	0.96	63.37	53.51	0.25
3	5392	100-Year (CC)	52.11	85.11	87.33	86.53	87.36	0.002165	0.84	75.41	64.88	0.21
3	5321	100-Year (CC)	52.11	84.85	87.20	86.46	87.22	0.002359	0.87	76.74	84.80	0.22
3	5261	100-Year (CC)	52.11	84.68	87.07		87.11	0.002936	1.08	66.74	63.01	0.25
3	5222	100-Year (CC)	52.11	84.65	86.99		87.02	0.002629	0.92	69.91	71.43	0.23
3	5192	100-Year (CC)	52.11	84.50	86.91		86.94	0.002789	1.00	66.24	62.01	0.24
3	5149	100-Year (CC)	52.11	84.41	86.79		86.84	0.004200	1.24	54.43	47.62	0.29
3	5061	100-Year (CC)	52.11	84.29	86.59		86.63	0.003979	1.17	57.94	53.62	0.28
3	4994	100-Year (CC)	52.11	84.29	86.37		86.42	0.004955	1.31	53.23	53.88	0.32
3	4970	100-Year (CC)	52.11	84.23	86.24		86.32	0.007579	1.56	43.61	45.78	0.40
3	4931	100-Year (CC)	52.11	84.18	86.17		86.20	0.002702	0.92	72.65	70.43	0.23
3	4884	100-Year (CC)	52.11	84.13	86.08		86.12	0.003789	1.02	62.24	61.25	0.27
3	4812	100-Year (CC)	52.11	84.04	85.98		86.01	0.002784	0.94	68.18	61.05	0.24
3	4771	100-Year (CC)	52.11	83.91	85.89		85.92	0.004291	1.12	63.93	80.62	0.29
3	4754	100-Year (CC)	52.11	83.84	85.79		85.84	0.005292	1.25	55.93	75.60	0.33
3	4707	100-Year (CC)	52.11	83.61	85.67		85.69	0.002893	0.94	77.21	91.70	0.24
3	4598	100-Year (CC)	52.11	83.60	85.43		85.48	0.003740	1.00	60.30	73.94	0.27
3	4577	100-Year (CC)	52.11	83.36	85.36		85.42	0.003599	1.03	52.37	56.54	0.27
3	4553	100-Year (CC)	52.11	83.36	85.32		85.36	0.002415	0.83	60.67	63.52	0.22
3	4504	100-Year (CC)	52.11	83.33	85.23		85.29	0.003171	1.52	51.36	56.63	0.38
3	4480	100-Year (CC)	52.11	83.16	85.21		85.24	0.001367	1.03	74.10	79.01	0.25
3	4408	100-Year (CC)	52.11	82.90	85.15		85.18	0.001305	1.03	70.93	76.14	0.25
3	4383	100-Year (CC)	52.11	82.89	85.14		85.16	0.000705	0.78	91.22	90.17	0.19
3	4361	100-Year (CC)	52.11	82.89	85.13		85.14	0.000636	0.74	97.37	93.82	0.18
3	4343	100-Year (CC)	52.11	82.89	85.12		85.13	0.000520	0.67	100.42	85.44	0.16
3	4335	100-Year (CC)	52.11	82.89	85.12		85.13	0.000450	0.63	105.58	86.28	0.15
3	4316	100-Year (CC)	52.11	82.87	85.11		85.12	0.000498	0.65	103.13	87.72	0.15
3	4299	100-Year (CC)	52.11	82.79	85.10		85.11	0.000459	0.65	110.12	101.33	0.15
3	4201	100-Year (CC)	52.11	82.43	85.09		85.10	0.000156	0.41	156.65	102.92	0.09
3	4179	100-Year (CC)	52.11	82.43	85.09		85.09	0.000227	0.51	159.77	100.65	0.11
3	4156	100-Year (CC)	52.11	82.37	85.08		85.09	0.000219	0.49	169.94	107.71	0.11
3	4110	100-Year (CC)	52.11	82.33	85.07		85.08	0.000517	0.54	130.77	90.11	0.11
3	4091	100-Year (CC)	52.11	82.33	85.06		85.07	0.000428	0.48	133.69	83.01	0.10
3	4033	100-Year (CC)	52.11	82.33	85.05		85.06	0.000337	0.43	152.28	93.78	0.09
3	4009	100-Year (CC)	52.11	82.33	85.04		85.05	0.000392	0.46	146.43	95.32	0.10
3	3967	100-Year (CC)	52.11	82.33	85.02		85.03	0.000485	0.52	130.10	87.64	0.11
3	3941	100-Year (CC)	52.11	82.23	85.02		85.02	0.000177	0.32	203.76	121.94	0.07
3	3886	100-Year (CC)	52.11	81.78	85.00	83.20	85.01	0.000418	0.51	115.84	56.56	0.10
3	3880	100-Year (CC)	52.11	81.71	85.00	83.46	85.01	0.000157	0.31	273.77	331.43	0.06
3	3857		Culvert									
3	3834	100-Year (CC)	52.11	81.26	83.83	83.07	83.83	0.000338	0.33	220.16	260.60	0.09
3	3820	100-Year (CC)	52.11	81.23	83.82	83.17	83.82	0.000406	0.35	207.69	260.01	0.09
3	3806	100-Year (CC)	52.11	81.21	83.78	83.01	83.81	0.002138	0.82	74.17	68.00	0.21
3	3778	100-Year (CC)	52.11	81.20	83.72	82.77	83.75	0.002181	0.87	67.71	55.65	0.22
3	3750	100-Year (CC)	52.11	81.19	83.66		83.69	0.002028	0.85	74.62	64.12	0.21
3	3725	100-Year (CC)	52.11	81.18	83.63		83.65	0.001391	0.68	90.37	76.10	0.17
3	3704	100-Year (CC)	52.11	81.17	83.59		83.61	0.002986	0.82	72.66	74.12	0.23
3	3680	100-Year (CC)	52.11	81.16	83.51		83.54	0.003090	0.90	70.53	73.90	0.24
3	3638	100-Year (CC)	52.11	81.15	83.42		83.45	0.001926	0.83	77.29	69.27	0.20
3	3599	100-Year (CC)	52.11	81.14	83.36		83.38	0.002106	0.83	79.68	74.61	0.21
3	3578	100-Year (CC)	52.11	81.14	83.31		83.33	0.002418	0.84	74.18	67.99	0.22
3	3549	100-Year (CC)	52.11	81.14	83.26		83.29	0.002113	0.84	76.34	69.23	0.21
3	3528	100-Year (CC)	52.11	81.10	83.17		83.22	0.004178	1.13	57.06	57.39	0.29
3	3504	100-Year (CC)	52.11	80.98	83.09		83.13	0.004064	1.14	57.48	56.26	0.29
3	3483	100-Year (CC)	52.11	80.97	82.99		83.05	0.004776	1.26	52.74	54.52	0.32
3	3466	100-Year (CC)	52.11	80.96	82.92		82.97	0.003928	1.17	57.29	58.34	0.29
3	3445	100-Year (CC)	52.11	80.95	82.80		82.87	0.007041	1.45	48.08	57.77	0.38
3	3427	100-Year (CC)	52.11	80.87	82.72		82.78	0.005217	1.36	52.90	58.19	0.33
3	3399	100-Year (CC)	52.11	80.80	82.62		82.67	0.004056	1.19	54.30	55.97	0.29
3	3373	100-Year (CC)	52.11	80.74	82.54		82.58	0.002654	1.04	60.95	52.13	0.27
3	3346	100-Year (CC)	52.11	80.34	82.50		82.53	0.001734	0.81	72.71	53.35	0.19
3	3320	100-Year (CC)	52.11	80.34	82.46		82.49	0.001714	0.85	74.90	56.72	0.20
3	3300	100-Year (CC)	52.11	80.25	82.43		82.45	0.001519	0.81	76.99	56.74	0.19
3	3273	100-Year (CC)	52.11	80.24	82.36		82.40	0.002423	1.00	67.13	65.46	0.23
3	3258	100-Year (CC)	52.11	80.22	82.31		82.36	0.002969	1.08	62.85	68.04	0.26
3	3238	100-Year (CC)	52.11	80.22	82.18	81.57	82.27	0.006505	1.52	44.89	51.49	0.37

HEC-RAS Plan: 8 River: Kinsale Reach: 3 Profile: 100-Year (CC) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
3	3225	100-Year (CC)	52.11	80.22	82.12	81.50	82.19	0.005044	1.23	52.12	60.64	0.32
3	3216	100-Year (CC)	52.11	80.22	82.10	81.42	82.14	0.003276	1.02	65.09	74.39	0.26
3	3201	100-Year (CC)	52.11	80.22	82.05		82.09	0.002853	0.93	69.39	76.72	0.24
3	3166	100-Year (CC)	52.11	80.12	81.98		82.00	0.001956	0.77	78.89	77.99	0.20
3	3110	100-Year (CC)	52.11	80.10	81.94	80.93	81.95	0.000831	0.52	113.98	90.37	0.13
3	3046	100-Year (CC)	52.11	80.07	81.90		81.91	0.000715	0.48	132.42	140.81	0.12
3	3008	100-Year (CC)	52.11	79.81	81.88		81.89	0.001088	0.60	116.88	150.19	0.15
3	2977	100-Year (CC)	52.11	79.70	81.86		81.86	0.000565	0.38	159.74	200.13	0.11
3	2956	100-Year (CC)	52.11	79.65	81.85		81.85	0.000356	0.29	193.63	228.46	0.08
3	2937	100-Year (CC)	58.23	79.65	81.85		81.85	0.000281	0.28	232.94	254.26	0.08

Table 3: Lynde Creek HEC-RAS Model Results for Regional Storm

HEC-RAS Plan: ex8 River: Kinsale Reach: 3 Profile: Future Regional

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
3	6222	Future Regional	134.46	86.71	89.05	88.06	89.06	0.000377	0.58	299.59	245.43	0.14
3	6176	Future Regional	134.46	86.55	89.04	88.02	89.05	0.000320	0.53	325.14	265.83	0.12
3	6130	Future Regional	134.46	86.49	89.03	87.91	89.04	0.000311	0.56	311.99	236.26	0.12
3	6084	Future Regional	134.46	86.33	89.02	87.80	89.03	0.000287	0.54	330.73	237.15	0.12
3	6035	Future Regional	134.46	86.33	89.02	87.71	89.03	0.000247	0.51	340.77	237.64	0.11
3	5994	Future Regional	134.46	86.33	89.02	87.68	89.02	0.000220	0.48	365.40	254.14	0.11
3	5962	Future Regional	134.46	86.33	89.01	87.72	89.02	0.000239	0.52	360.15	257.02	0.11
3	5936	Future Regional	134.46	86.23	89.01		89.01	0.000233	0.53	398.49	317.66	0.11
3	5893	Future Regional	134.46	86.09	89.00		89.01	0.000188	0.48	434.86	357.69	0.10
3	5847	Future Regional	134.46	85.95	88.99		89.00	0.000297	0.59	340.03	273.10	0.12
3	5845	Future Regional	134.46	85.90	88.95	88.70	88.99	0.003103	1.64	169.28	262.69	0.37
3	5833		Culvert									
3	5822	Future Regional	134.46	85.76	88.72	88.72	88.89	0.007228	3.14	110.24	222.70	0.69
3	5814	Future Regional	134.46	85.75	88.70	87.42	88.71	0.000582	0.60	303.07	228.26	0.12
3	5757	Future Regional	134.46	85.70	88.67	87.34	88.68	0.000903	0.64	247.06	175.92	0.14
3	5627	Future Regional	134.46	85.49	88.59	87.18	88.61	0.000819	0.66	232.83	124.14	0.13
3	5547	Future Regional	134.46	85.40	88.51	87.23	88.55	0.001888	1.04	153.04	81.56	0.21
3	5501	Future Regional	134.46	85.34	88.37	87.36	88.45	0.003976	1.48	108.41	60.21	0.30
3	5462	Future Regional	134.46	85.32	88.30	87.10	88.34	0.002050	1.03	148.61	83.45	0.21
3	5442	Future Regional	134.46	85.31	88.24	87.07	88.29	0.003591	1.38	143.51	135.50	0.29
3	5392	Future Regional	134.46	85.11	88.16	86.93	88.20	0.002186	1.10	167.20	126.78	0.22
3	5321	Future Regional	134.46	84.85	88.04	86.86	88.08	0.002030	1.07	154.83	101.21	0.22
3	5261	Future Regional	134.46	84.68	87.90		87.97	0.003005	1.40	123.84	77.08	0.27
3	5222	Future Regional	134.46	84.65	87.83		87.88	0.002298	1.13	134.43	81.95	0.23
3	5192	Future Regional	134.46	84.50	87.75		87.81	0.002801	1.29	122.18	72.46	0.25
3	5149	Future Regional	134.46	84.41	87.61		87.70	0.004751	1.69	104.40	78.67	0.33
3	5061	Future Regional	134.46	84.29	87.40		87.49	0.004395	1.59	103.68	59.05	0.32
3	4994	Future Regional	134.46	84.29	87.20		87.29	0.004651	1.66	107.24	83.24	0.33
3	4970	Future Regional	134.46	84.23	87.05		87.20	0.007328	2.02	83.74	52.38	0.42
3	4931	Future Regional	134.46	84.18	87.02		87.07	0.002618	1.21	135.80	78.03	0.25
3	4884	Future Regional	134.46	84.13	86.93		87.00	0.003475	1.33	116.13	65.58	0.28
3	4812	Future Regional	134.46	84.04	86.84		86.90	0.002995	1.30	123.45	67.90	0.27
3	4771	Future Regional	134.46	83.91	86.78		86.83	0.002539	1.18	140.83	91.46	0.24
3	4754	Future Regional	134.46	83.84	86.73		86.79	0.002711	1.24	134.32	92.60	0.25
3	4707	Future Regional	134.46	83.61	86.68		86.71	0.001440	0.93	175.57	102.44	0.18
3	4598	Future Regional	134.46	83.60	86.60		86.63	0.001094	0.81	185.02	124.68	0.16
3	4577	Future Regional	134.46	83.36	86.57		86.61	0.001542	1.00	154.92	117.25	0.19
3	4553	Future Regional	134.46	83.36	86.55		86.58	0.001050	0.82	180.83	131.14	0.16
3	4504	Future Regional	134.46	83.33	86.52		86.56	0.001045	1.29	173.50	128.47	0.24
3	4480	Future Regional	134.46	83.16	86.52		86.54	0.000461	0.87	233.68	149.61	0.16
3	4408	Future Regional	134.46	82.90	86.51		86.53	0.000429	0.87	227.08	142.14	0.16
3	4383	Future Regional	134.46	82.89	86.50		86.52	0.000295	0.73	255.83	144.59	0.13
3	4361	Future Regional	134.46	82.89	86.50		86.51	0.000295	0.74	250.35	131.55	0.13
3	4343	Future Regional	134.46	82.89	86.49		86.51	0.000291	0.73	227.17	101.55	0.13
3	4335	Future Regional	134.46	82.89	86.49		86.50	0.000262	0.69	232.59	99.14	0.12
3	4316	Future Regional	134.46	82.87	86.48		86.50	0.000270	0.70	234.16	106.83	0.13
3	4299	Future Regional	134.46	82.79	86.48		86.49	0.000223	0.65	262.91	120.69	0.11
3	4201	Future Regional	134.46	82.43	86.47		86.48	0.000135	0.53	310.84	125.15	0.09
3	4179	Future Regional	134.46	82.43	86.47		86.48	0.000207	0.67	306.49	115.52	0.11
3	4156	Future Regional	134.46	82.37	86.47		86.48	0.000196	0.65	334.64	150.38	0.11
3	4110	Future Regional	134.46	82.33	86.46		86.47	0.000393	0.64	279.17	158.07	0.10
3	4091	Future Regional	134.46	82.33	86.45		86.46	0.000389	0.63	275.42	148.51	0.10
3	4033	Future Regional	134.46	82.33	86.44		86.45	0.000309	0.56	303.34	134.04	0.09
3	4009	Future Regional	134.46	82.33	86.43		86.44	0.000306	0.55	298.54	131.99	0.09
3	3967	Future Regional	134.46	82.33	86.41		86.43	0.000403	0.64	262.95	107.29	0.11
3	3941	Future Regional	134.46	82.23	86.41		86.42	0.000187	0.44	396.17	164.78	0.07
3	3886	Future Regional	134.46	81.78	86.41	83.67	86.41	0.000052	0.24	809.06	451.14	0.04
3	3880	Future Regional	134.46	81.71	84.81	84.81	86.27	0.040946	5.35	25.12	57.84	1.01
3	3857		Culvert									
3	3834	Future Regional	134.46	81.26	84.59	83.70	84.59	0.000292	0.41	434.74	298.56	0.08
3	3820	Future Regional	134.46	81.23	84.59	83.54	84.59	0.000324	0.42	425.09	295.33	0.09
3	3806	Future Regional	134.46	81.21	84.58	83.41	84.59	0.000282	0.39	442.09	305.97	0.08
3	3778	Future Regional	134.46	81.20	84.57	83.31	84.58	0.000241	0.38	463.96	322.24	0.08
3	3750	Future Regional	134.46	81.19	84.50		84.56	0.002568	1.24	136.00	83.37	0.25
3	3725	Future Regional	134.46	81.18	84.47		84.51	0.001758	1.00	160.13	90.94	0.20
3	3704	Future Regional	134.46	81.17	84.42		84.47	0.002684	1.08	138.23	82.68	0.24
3	3680	Future Regional	134.46	81.16	84.35		84.40	0.002643	1.14	136.90	83.65	0.25
3	3638	Future Regional	134.46	81.15	84.26		84.31	0.002224	1.16	139.61	78.99	0.23
3	3599	Future Regional	134.46	81.14	84.19		84.24	0.002160	1.11	145.51	82.51	0.23
3	3578	Future Regional	134.46	81.14	84.14		84.19	0.002578	1.16	133.72	76.48	0.24
3	3549	Future Regional	134.46	81.14	84.09		84.14	0.002414	1.18	138.18	80.16	0.24
3	3528	Future Regional	134.46	81.10	83.98		84.07	0.004323	1.53	109.27	70.41	0.32
3	3504	Future Regional	134.46	80.98	83.89		83.98	0.004397	1.56	108.10	70.22	0.32
3	3483	Future Regional	134.46	80.97	83.78		83.88	0.005130	1.70	103.66	72.64	0.35
3	3466	Future Regional	134.46	80.96	83.71		83.80	0.004317	1.59	113.07	79.41	0.32
3	3445	Future Regional	134.46	80.95	83.61		83.71	0.005788	1.76	102.23	74.64	0.37
3	3427	Future Regional	134.46	80.87	83.54		83.63	0.004831	1.71	108.38	75.13	0.34
3	3399	Future Regional	134.46	80.80	83.45		83.54	0.003909	1.53	111.05	77.00	0.31
3	3373	Future Regional	134.46	80.74	83.36		83.45	0.003423	1.57	109.78	72.69	0.33
3	3346	Future Regional	134.46	80.34	83.30		83.37	0.002787	1.32	118.92	62.92	0.26
3	3320	Future Regional	134.46	80.34	83.22		83.29	0.002984	1.40	124.00	77.02	0.27
3	3300	Future Regional	134.46	80.25	83.17		83.24	0.002596	1.32	132.02	87.61	0.26
3	3273	Future Regional	134.46	80.24	83.08		83.15	0.003398	1.47	122.91	89.48	0.29
3	3258	Future Regional	134.46	80.22	83.02		83.10	0.003647	1.49	122.67	98.97	0.30
3	3238	Future Regional	134.46	80.22	82.81	82.30	82.98	0.009140	2.23	83.90	70.97	0.47

HEC-RAS Plan: ex8 River: Kinsale Reach: 3 Profile: Future Regional (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
3	3225	Future Regional	134.46	80.22	82.74	82.08	82.86	0.006997	1.83	95.14	78.32	0.40
3	3216	Future Regional	134.46	80.22	82.71	81.91	82.80	0.004545	1.50	116.44	91.35	0.33
3	3201	Future Regional	134.46	80.22	82.65		82.72	0.004246	1.42	120.68	93.16	0.31
3	3166	Future Regional	134.46	80.12	82.52		82.59	0.003636	1.29	125.12	91.70	0.29
3	3110	Future Regional	134.46	80.10	82.44	81.25	82.47	0.001927	0.95	160.60	96.96	0.21
3	3046	Future Regional	134.46	80.07	82.37		82.39	0.001477	0.83	202.94	162.77	0.18
3	3008	Future Regional	134.46	79.81	82.31		82.34	0.001913	0.93	191.75	197.02	0.21
3	2977	Future Regional	134.46	79.70	82.29		82.30	0.001019	0.62	251.27	231.15	0.15
3	2956	Future Regional	134.46	79.65	82.27		82.28	0.000700	0.50	295.05	260.17	0.12
3	2937	Future Regional	145.33	79.65	82.26		82.27	0.000563	0.47	345.50	290.34	0.11

Table 4: Carruthers Creek HEC-RAS Model Results for 1:100 year Storm under Existing Conditions

HEC-RAS Plan: ex8 River: Kinsale Reach: 3 Profile: 100-Year (Ex)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
3	6222	100-Year (Ex)	41.69	86.71	88.68	87.84	88.68	0.000104	0.26	212.22	226.69	0.07
3	6176	100-Year (Ex)	41.69	86.55	88.68	87.77	88.68	0.000089	0.24	231.33	249.83	0.06
3	6130	100-Year (Ex)	41.69	86.49	88.68	87.64	88.68	0.000075	0.25	230.77	220.67	0.06
3	6084	100-Year (Ex)	41.69	86.33	88.67	87.55	88.68	0.000065	0.23	249.50	223.15	0.05
3	6035	100-Year (Ex)	41.69	86.33	88.67	87.39	88.67	0.000053	0.21	260.11	222.33	0.05
3	5994	100-Year (Ex)	41.69	86.33	88.67	87.37	88.67	0.000047	0.20	279.09	238.24	0.05
3	5962	100-Year (Ex)	41.69	86.33	88.67	87.39	88.67	0.000051	0.21	273.86	240.29	0.05
3	5936	100-Year (Ex)	41.69	86.23	88.67		88.67	0.000054	0.23	294.85	300.21	0.05
3	5893	100-Year (Ex)	41.69	86.09	88.67		88.67	0.000044	0.21	319.39	338.81	0.05
3	5847	100-Year (Ex)	41.69	85.95	88.67		88.67	0.000058	0.24	254.04	249.30	0.05
3	5845	100-Year (Ex)	41.69	85.90	88.64	88.48	88.67	0.001611	1.06	92.95	231.87	0.26
3	5833		Culvert									
3	5822	100-Year (Ex)	41.69	85.76	88.47	88.47	88.57	0.003440	2.00	57.90	203.27	0.46
3	5814	100-Year (Ex)	41.69	85.75	87.71	87.03	87.71	0.000883	0.54	112.38	156.50	0.13
3	5757	100-Year (Ex)	41.69	85.70	87.67	87.06	87.68	0.001193	0.50	100.10	124.05	0.14
3	5627	100-Year (Ex)	41.69	85.49	87.59	86.92	87.60	0.000861	0.47	111.08	118.64	0.13
3	5547	100-Year (Ex)	41.69	85.40	87.52	86.86	87.54	0.001691	0.71	75.54	75.49	0.18
3	5501	100-Year (Ex)	41.69	85.34	87.42	86.91	87.45	0.003710	1.03	52.80	56.22	0.27
3	5462	100-Year (Ex)	41.69	85.32	87.33	86.67	87.35	0.002144	0.73	70.23	77.32	0.20
3	5442	100-Year (Ex)	41.69	85.31	87.27	86.56	87.30	0.002847	0.87	55.97	51.81	0.23
3	5392	100-Year (Ex)	41.69	85.11	87.20	86.46	87.22	0.002014	0.76	66.70	63.49	0.20
3	5321	100-Year (Ex)	41.69	84.85	87.06	86.39	87.08	0.002575	0.86	58.84	56.63	0.22
3	5261	100-Year (Ex)	41.69	84.68	86.93		86.96	0.002852	1.01	57.90	61.31	0.24
3	5222	100-Year (Ex)	41.69	84.65	86.84		86.87	0.002758	0.88	59.71	69.74	0.23
3	5192	100-Year (Ex)	41.69	84.50	86.76		86.79	0.002802	0.95	57.34	60.51	0.23
3	5149	100-Year (Ex)	41.69	84.41	86.65		86.69	0.003963	1.14	47.85	46.43	0.28
3	5061	100-Year (Ex)	41.69	84.29	86.45		86.49	0.003840	1.09	50.77	52.74	0.27
3	4994	100-Year (Ex)	41.69	84.29	86.24		86.29	0.004760	1.21	46.36	52.52	0.31
3	4970	100-Year (Ex)	41.69	84.23	86.11		86.19	0.007227	1.44	38.03	44.70	0.38
3	4931	100-Year (Ex)	41.69	84.18	86.04		86.06	0.002586	0.85	63.85	69.38	0.23
3	4884	100-Year (Ex)	41.69	84.13	85.96		85.99	0.003641	0.94	54.81	60.63	0.26
3	4812	100-Year (Ex)	41.69	84.04	85.87		85.89	0.002494	0.84	61.19	60.13	0.22
3	4771	100-Year (Ex)	41.69	83.91	85.77		85.81	0.004328	1.07	54.80	79.35	0.29
3	4754	100-Year (Ex)	41.69	83.84	85.67		85.72	0.005304	1.19	47.32	72.15	0.32
3	4707	100-Year (Ex)	41.69	83.61	85.55		85.57	0.003001	0.91	66.19	90.47	0.24
3	4598	100-Year (Ex)	41.69	83.60	85.30		85.34	0.004203	0.99	50.32	72.16	0.28
3	4577	100-Year (Ex)	41.69	83.36	85.23		85.27	0.003760	0.99	44.66	54.74	0.27
3	4553	100-Year (Ex)	41.69	83.36	85.18		85.21	0.002556	0.79	51.73	62.13	0.22
3	4504	100-Year (Ex)	41.69	83.33	85.08		85.13	0.003533	1.50	42.79	55.47	0.40
3	4480	100-Year (Ex)	41.69	83.16	85.05		85.08	0.001498	1.01	61.78	76.66	0.26
3	4408	100-Year (Ex)	41.69	82.90	84.99		85.02	0.001358	0.98	59.07	69.48	0.25
3	4383	100-Year (Ex)	41.69	82.89	84.98		84.99	0.000707	0.73	77.21	82.92	0.18
3	4361	100-Year (Ex)	41.69	82.89	84.96		84.98	0.000652	0.71	82.41	88.69	0.18
3	4343	100-Year (Ex)	41.69	82.89	84.96		84.97	0.000528	0.63	86.57	83.74	0.16
3	4335	100-Year (Ex)	41.69	82.89	84.95		84.96	0.000449	0.59	91.59	84.73	0.15
3	4316	100-Year (Ex)	41.69	82.87	84.94		84.96	0.000508	0.62	88.88	86.25	0.15
3	4299	100-Year (Ex)	41.69	82.79	84.93		84.95	0.000479	0.62	93.64	99.14	0.15
3	4201	100-Year (Ex)	41.69	82.43	84.93		84.93	0.000144	0.37	139.83	101.92	0.08
3	4179	100-Year (Ex)	41.69	82.43	84.92		84.93	0.000204	0.46	143.37	99.64	0.10
3	4156	100-Year (Ex)	41.69	82.37	84.92		84.92	0.000197	0.44	152.44	106.41	0.10
3	4110	100-Year (Ex)	41.69	82.33	84.91		84.92	0.000468	0.49	116.36	87.70	0.10
3	4091	100-Year (Ex)	41.69	82.33	84.90		84.91	0.000368	0.43	120.58	80.13	0.09
3	4033	100-Year (Ex)	41.69	82.33	84.89		84.90	0.000291	0.38	137.56	91.03	0.08
3	4009	100-Year (Ex)	41.69	82.33	84.88		84.89	0.000350	0.41	131.47	93.77	0.09
3	3967	100-Year (Ex)	41.69	82.33	84.87		84.87	0.000432	0.47	116.50	86.32	0.10
3	3941	100-Year (Ex)	41.69	82.23	84.86		84.87	0.000153	0.28	184.83	120.43	0.06
3	3886	100-Year (Ex)	41.69	81.78	84.85	83.12	84.85	0.000336	0.44	107.34	55.49	0.09
3	3880	100-Year (Ex)	41.69	81.71	84.68	83.25	84.84	0.004556	1.73	24.04	56.34	0.33
3	3857		Culvert									
3	3834	100-Year (Ex)	41.69	81.26	83.67	82.87	83.69	0.001743	0.71	73.33	85.65	0.19
3	3820	100-Year (Ex)	41.69	81.23	83.66	83.00	83.67	0.000439	0.34	168.58	238.51	0.09
3	3806	100-Year (Ex)	41.69	81.21	83.63	82.93	83.65	0.002120	0.76	63.87	65.28	0.21
3	3778	100-Year (Ex)	41.69	81.20	83.57	82.67	83.59	0.002008	0.79	59.58	53.20	0.20
3	3750	100-Year (Ex)	41.69	81.19	83.52		83.54	0.001887	0.77	65.45	61.41	0.20
3	3725	100-Year (Ex)	41.69	81.18	83.49		83.50	0.001297	0.62	79.53	73.49	0.16
3	3704	100-Year (Ex)	41.69	81.17	83.44		83.47	0.003076	0.78	62.13	71.92	0.23
3	3680	100-Year (Ex)	41.69	81.16	83.36		83.38	0.003340	0.86	59.63	72.56	0.25
3	3638	100-Year (Ex)	41.69	81.15	83.27		83.29	0.001873	0.77	66.97	67.52	0.20
3	3599	100-Year (Ex)	41.69	81.14	83.20		83.22	0.002168	0.79	68.46	73.29	0.21
3	3578	100-Year (Ex)	41.69	81.14	83.16		83.18	0.002469	0.79	63.94	66.68	0.22
3	3549	100-Year (Ex)	41.69	81.14	83.11		83.13	0.002095	0.78	65.94	67.18	0.21
3	3528	100-Year (Ex)	41.69	81.10	83.02		83.06	0.004226	1.06	48.67	54.54	0.29
3	3504	100-Year (Ex)	41.69	80.98	82.93		82.98	0.004138	1.07	49.10	54.11	0.29
3	3483	100-Year (Ex)	41.69	80.97	82.84		82.89	0.004753	1.17	44.77	50.70	0.31
3	3466	100-Year (Ex)	41.69	80.96	82.77		82.82	0.003742	1.07	49.00	53.07	0.28
3	3445	100-Year (Ex)	41.69	80.95	82.64		82.72	0.007540	1.40	39.55	53.03	0.39
3	3427	100-Year (Ex)	41.69	80.87	82.56		82.62	0.005388	1.30	44.00	53.28	0.33

HEC-RAS Plan: ex8 River: Kinsale Reach: 3 Profile: 100-Year (Ex) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
3	3399	100-Year (Ex)	41.69	80.80	82.46		82.51	0.003956	1.10	45.96	47.84	0.29
3	3373	100-Year (Ex)	41.69	80.74	82.38		82.42	0.002606	0.96	52.82	50.14	0.26
3	3346	100-Year (Ex)	41.69	80.34	82.34		82.37	0.001574	0.73	64.52	51.40	0.18
3	3320	100-Year (Ex)	41.69	80.34	82.31		82.33	0.001548	0.76	66.41	54.50	0.18
3	3300	100-Year (Ex)	41.69	80.25	82.28		82.30	0.001332	0.72	68.75	54.09	0.17
3	3273	100-Year (Ex)	41.69	80.24	82.22		82.25	0.002177	0.90	58.31	58.71	0.22
3	3258	100-Year (Ex)	41.69	80.22	82.17		82.21	0.002792	0.99	53.86	61.58	0.24
3	3238	100-Year (Ex)	41.69	80.22	82.05	81.46	82.13	0.005947	1.38	38.77	47.16	0.35
3	3225	100-Year (Ex)	41.69	80.22	82.00	81.40	82.05	0.004645	1.12	45.12	55.30	0.31
3	3216	100-Year (Ex)	41.69	80.22	81.98	81.30	82.01	0.003033	0.93	56.41	68.93	0.25
3	3201	100-Year (Ex)	41.69	80.22	81.94		81.96	0.002586	0.84	60.73	71.84	0.23
3	3166	100-Year (Ex)	41.69	80.12	81.87		81.89	0.001693	0.68	70.68	74.44	0.18
3	3110	100-Year (Ex)	41.69	80.10	81.84	80.89	81.85	0.000690	0.45	104.85	89.13	0.12
3	3046	100-Year (Ex)	41.69	80.07	81.81		81.81	0.000605	0.43	119.23	130.76	0.11
3	3008	100-Year (Ex)	41.69	79.81	81.78		81.79	0.000879	0.52	104.19	128.54	0.13
3	2977	100-Year (Ex)	41.69	79.70	81.77		81.77	0.000507	0.35	142.21	190.73	0.10
3	2956	100-Year (Ex)	41.69	79.65	81.76		81.77	0.000314	0.26	173.72	219.41	0.08
3	2937	100-Year (Ex)	46.58	79.65	81.76		81.76	0.000242	0.25	210.85	247.16	0.07

Table 5: Carruthers Creek HEC-RAS Model Results for 1:100 year Storm under Climate Change Conditions

HEC-RAS Plan: plan2 River: Carruthers Creek Reach: Reach 11 Profile: 100-year

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach 11	4.033	100-year	6.48	145.20	146.10	145.97	146.11	0.000765	0.40	41.95	251.99	0.21
Reach 11	4.032	100-year	6.48	144.60	145.80	145.42	145.85	0.002165	0.93	6.94	11.54	0.38
Reach 11	4.031	100-year	6.48	144.00	144.78	144.71	144.91	0.010475	1.59	4.38	31.11	0.80
Reach 11	4.03	100-year	6.48	143.00	144.21		144.23	0.000579	0.48	13.96	28.53	0.20
Reach 11	4.029	100-year	20.60	142.00	143.15	143.15	143.44	0.012259	2.37	9.24	21.49	0.93
Reach 11	4.028	100-year	20.60	140.00	141.28		141.32	0.001734	0.90	28.01	75.87	0.35
Reach 11	4.027	100-year	20.60	139.50	140.79	140.76	140.95	0.011156	2.91	21.93	51.98	0.91
Reach 11	4.026	100-year	20.60	138.00	139.40	139.40	139.60	0.007119	2.21	18.69	64.07	0.74
Reach 11	4.025	100-year	20.60	135.58	137.70	136.55	137.80	0.000909	1.42	14.51	12.82	0.31
Reach 11	4.0245		Culvert									
Reach 11	4.024	100-year	20.60	135.51	136.87	136.48	137.12	0.003935	2.20	9.35	36.76	0.60
Reach 11	4.023	100-year	20.60	134.27	135.33	135.33	135.70	0.010990	2.76	8.69	16.61	0.92
Reach 11	4.022	100-year	20.60	133.35	134.85		134.93	0.002180	1.58	32.60	63.67	0.43
Reach 11	4.021	100-year	20.60	132.47	134.32	134.21	134.41	0.005721	1.43	21.59	65.84	0.61
Reach 11	4.02	100-year	20.60	131.65	133.24	133.24	133.37	0.009873	1.94	22.52	84.32	0.81
Reach 11	4.019	100-year	20.60	130.19	132.46	131.79	132.46	0.000119	0.46	175.69	274.63	0.10
Reach 11	4.0185		Bridge									
Reach 11	4.018	100-year	20.60	130.25	131.73	131.30	131.96	0.003693	2.13	9.68	21.47	0.57
Reach 11	4.017	100-year	20.60	129.30	130.78		130.91	0.004494	2.03	24.42	52.39	0.61
Reach 11	4.016	100-year	22.90	128.50	130.14	130.00	130.36	0.006209	2.72	19.70	30.16	0.74
Reach 11	4.015	100-year	22.90	128.00	129.21	129.21	129.54	0.012903	2.56	9.48	18.37	0.97
Reach 11	4.014	100-year	22.90	125.92	129.23	127.58	129.24	0.000173	0.66	58.70	62.61	0.13
Reach 11	4.0135		Culvert									
Reach 11	4.013	100-year	22.90	125.58	127.23	127.23	128.06	0.010148	4.03	5.69	29.40	1.00
Reach 11	4.012	100-year	22.90	124.21	125.24	125.21	125.49	0.012641	2.20	10.53	19.25	0.92
Reach 11	4.011	100-year	22.90	123.17	124.15	124.04	124.43	0.008510	2.33	10.09	15.49	0.80
Reach 11	4.01	100-year	22.90	121.70	122.66	122.66	122.84	0.014826	2.69	15.53	41.94	1.03
Reach 11	4.009	100-year	22.90	120.72	121.33	121.33	121.48	0.021585	2.10	15.22	54.47	1.12
Reach 11	4.008	100-year	22.90	117.43	118.75	118.75	118.94	0.011253	2.93	16.26	38.74	0.92
Reach 11	4.007	100-year	22.90	115.75	116.53		116.64	0.005519	1.73	20.63	55.52	0.64
Reach 11	4.006	100-year	22.90	113.82	115.56	115.56	115.74	0.008834	3.50	18.79	48.34	0.87
Reach 11	4.005	100-year	22.90	112.50	114.52		114.52	0.000099	0.41	111.65	112.48	0.10
Reach 11	4.004	100-year	22.90	111.50	114.52		114.52	0.000009	0.17	185.70	86.82	0.03
Reach 11	4.003	100-year	22.90	110.84	114.39	112.18	114.49	0.000426	1.37	16.69	81.93	0.23
Reach 11	4.0025		Culvert									
Reach 11	4.002	100-year	22.90	110.86	112.20	112.20	112.87	0.010863	3.63	6.32	25.13	1.00
Reach 11	4.001	100-year	22.90	109.80	111.45		111.53	0.005013	1.59	22.15	48.37	0.59
Reach 11	4	100-year	25.44	108.59	110.21	110.21	110.35	0.013310	1.99	19.58	71.84	0.91

Table 6: Carruthers Creek HEC-RAS Model Results for Regional Storm

HEC-RAS Plan: Carruthers River: Carruthers Creek Reach: Reach 11 Profile: Regional

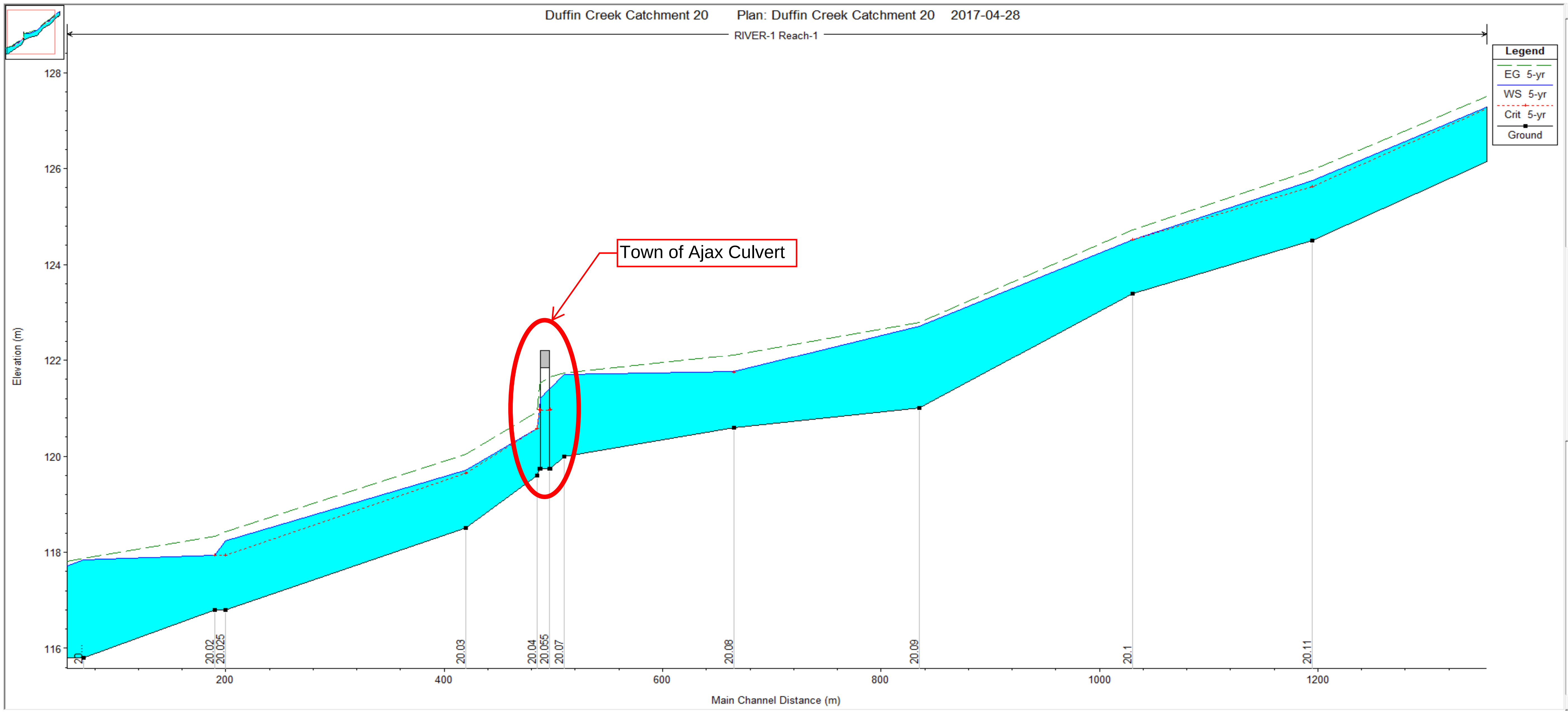
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach 11	4.033	Regional	20.49	145.20	146.36		146.36	0.000507	0.47	109.86	278.69	0.19
Reach 11	4.032	Regional	20.49	144.60	146.03	146.03	146.12	0.004009	1.54	41.41	315.89	0.55
Reach 11	4.031	Regional	20.49	144.00	145.18		145.20	0.001713	1.02	62.10	195.42	0.36
Reach 11	4.03	Regional	20.49	143.00	144.42		144.48	0.001995	1.09	20.49	34.21	0.39
Reach 11	4.029	Regional	25.43	142.00	143.27	143.27	143.56	0.010447	2.43	11.98	27.53	0.89
Reach 11	4.028	Regional	25.43	140.00	141.36		141.41	0.001734	0.97	34.38	87.58	0.36
Reach 11	4.027	Regional	25.43	139.50	140.86	140.82	141.03	0.011738	3.11	25.62	56.28	0.94
Reach 11	4.026	Regional	25.43	138.00	139.48	139.48	139.69	0.006888	2.30	24.49	75.60	0.74
Reach 11	4.025	Regional	25.43	135.58	138.42	136.70	138.51	0.000518	1.30	19.50	55.03	0.25
Reach 11	4.0245		Culvert									
Reach 11	4.024	Regional	25.43	135.51	137.00	136.63	137.31	0.004477	2.49	10.21	39.50	0.65
Reach 11	4.023	Regional	25.43	134.27	135.47	135.47	135.87	0.009810	2.87	11.33	20.42	0.89
Reach 11	4.022	Regional	25.43	133.35	134.94		135.03	0.002380	1.72	38.33	69.49	0.46
Reach 11	4.021	Regional	25.43	132.47	134.38	134.26	134.48	0.005647	1.52	26.02	71.60	0.62
Reach 11	4.02	Regional	25.43	131.65	133.28	133.28	133.43	0.010593	2.10	26.16	87.08	0.84
Reach 11	4.019	Regional	25.43	130.19	132.48	131.96	132.48	0.000168	0.55	180.67	275.86	0.12
Reach 11	4.0185		Bridge									
Reach 11	4.018	Regional	25.43	130.25	131.84	131.44	132.14	0.004438	2.45	10.40	23.40	0.64
Reach 11	4.017	Regional	25.43	129.30	130.90		131.03	0.004010	2.06	31.40	59.89	0.59
Reach 11	4.016	Regional	28.26	128.50	130.25	130.13	130.50	0.006544	2.94	23.25	33.14	0.77
Reach 11	4.015	Regional	28.26	128.00	129.32	129.32	129.69	0.011730	2.69	11.73	21.53	0.95
Reach 11	4.014	Regional	28.26	125.92	129.29	127.82	129.31	0.000237	0.79	62.64	66.10	0.15
Reach 11	4.0135		Culvert									
Reach 11	4.013	Regional	28.26	125.58	127.48	127.48	128.43	0.009659	4.31	6.55	31.03	1.00
Reach 11	4.012	Regional	28.26	124.21	125.34	125.30	125.62	0.011306	2.32	12.48	19.82	0.90
Reach 11	4.011	Regional	28.26	123.17	124.25	124.17	124.58	0.008938	2.57	11.70	18.08	0.84
Reach 11	4.01	Regional	28.26	121.70	122.72	122.72	122.92	0.015216	2.88	18.14	45.34	1.05
Reach 11	4.009	Regional	28.26	120.72	121.38	121.38	121.54	0.021046	2.24	17.76	57.12	1.13
Reach 11	4.008	Regional	28.26	117.43	118.82	118.82	119.03	0.011692	3.12	19.03	42.05	0.95
Reach 11	4.007	Regional	28.26	115.75	116.60		116.72	0.005632	1.85	24.53	60.98	0.66
Reach 11	4.006	Regional	28.26	113.82	115.63	115.63	115.82	0.009297	3.68	22.21	53.39	0.90
Reach 11	4.005	Regional	28.26	112.50	114.93		114.93	0.000051	0.33	158.87	118.09	0.07
Reach 11	4.004	Regional	28.26	111.50	114.93		114.93	0.000008	0.18	221.69	88.88	0.03
Reach 11	4.003	Regional	28.26	110.84	114.93	112.38	114.93	0.000010	0.21	210.38	89.79	0.04
Reach 11	4.0025		Culvert									
Reach 11	4.002	Regional	28.26	110.86	112.41	112.41	113.18	0.010343	3.89	7.27	34.68	1.00
Reach 11	4.001	Regional	28.26	109.80	111.51		111.60	0.005364	1.74	25.11	49.83	0.62
Reach 11	4	Regional	31.04	108.59	110.26	110.26	110.40	0.012975	2.09	22.77	72.28	0.91

Appendix C

HEC-RAS Channel and Culvert Profiles

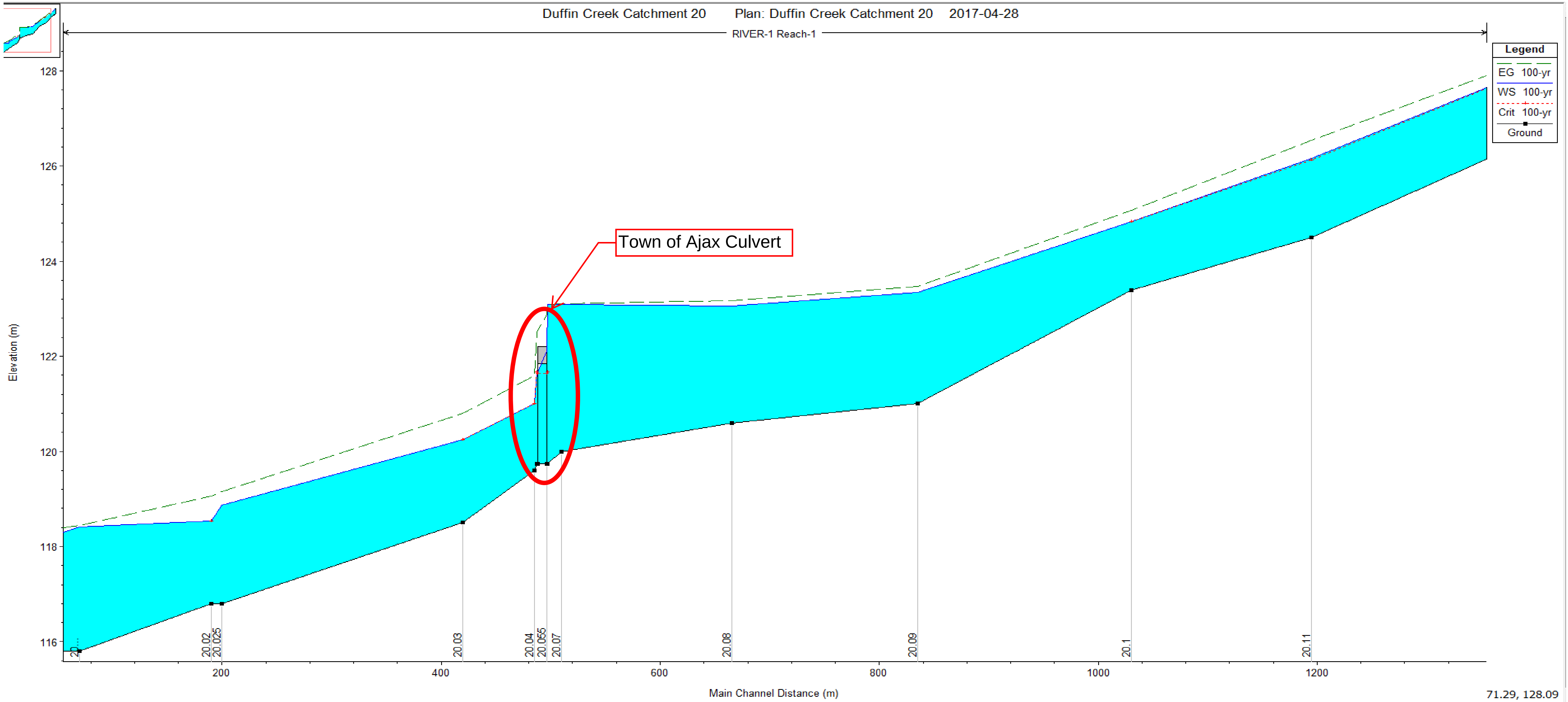
HEC RAS Channel Profile - Miller's Creek

1: 5-year Storm



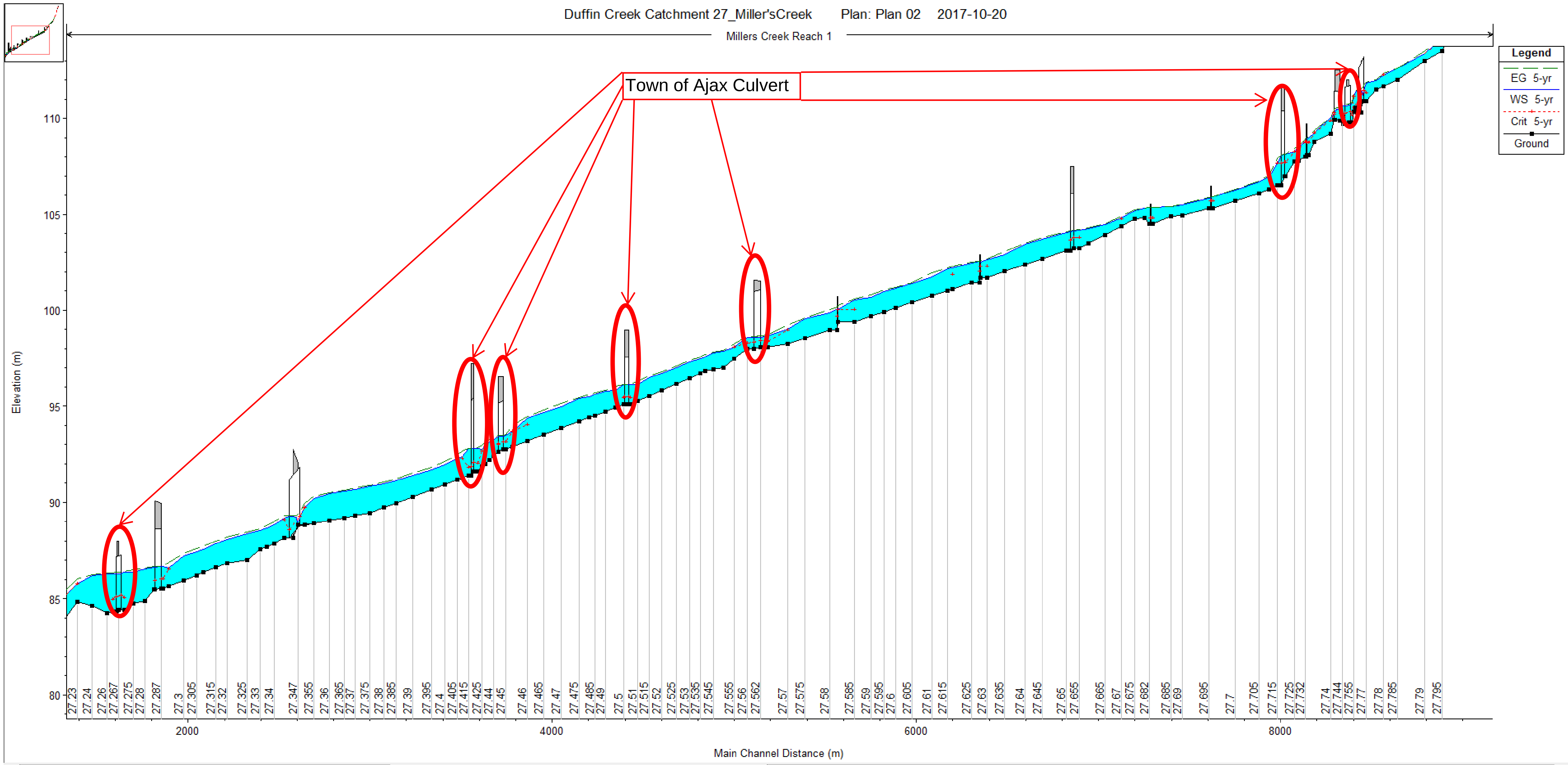
HEC RAS Channel Profile - Miller's Creek

1: 100-year Storm



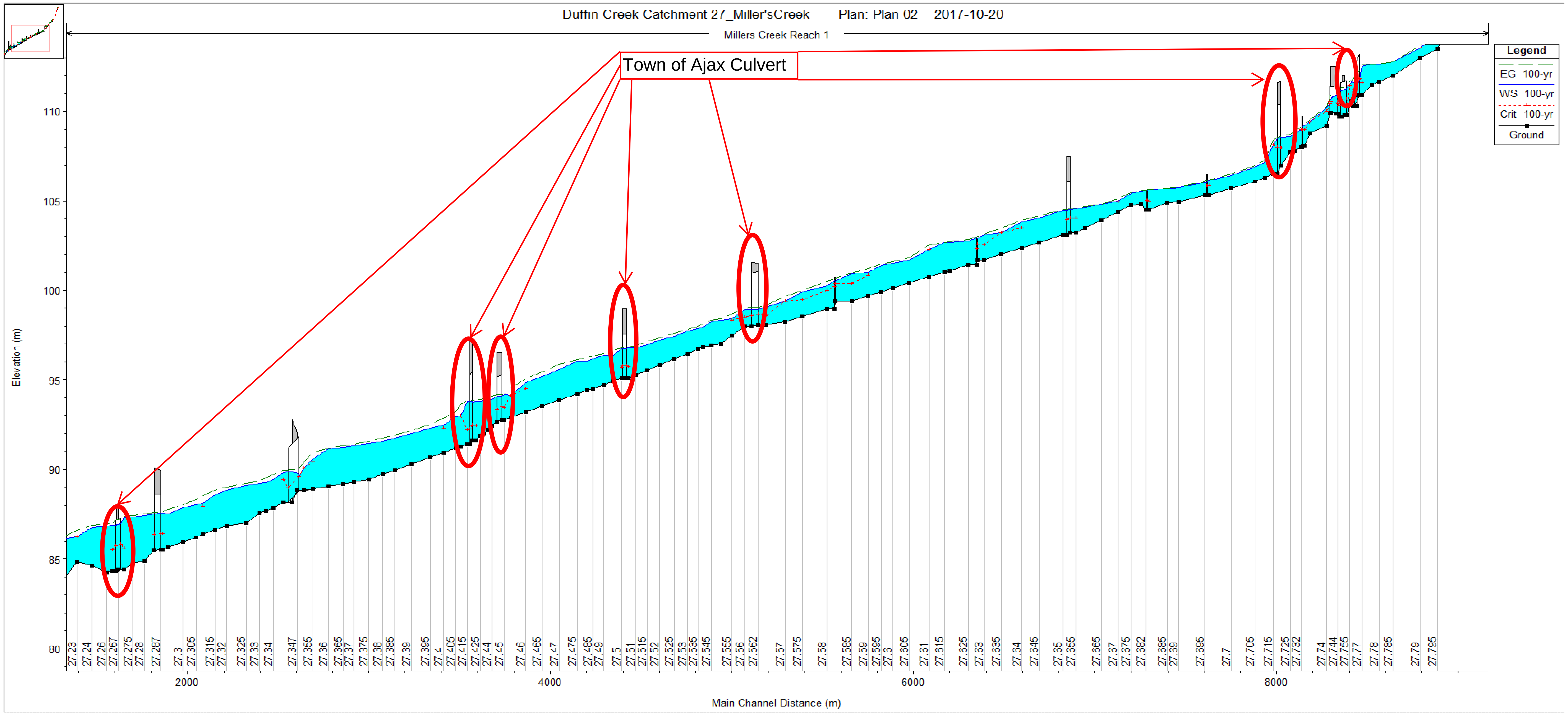
HEC RAS Channel Profile - Miller's Creek

1: 5-year Storm



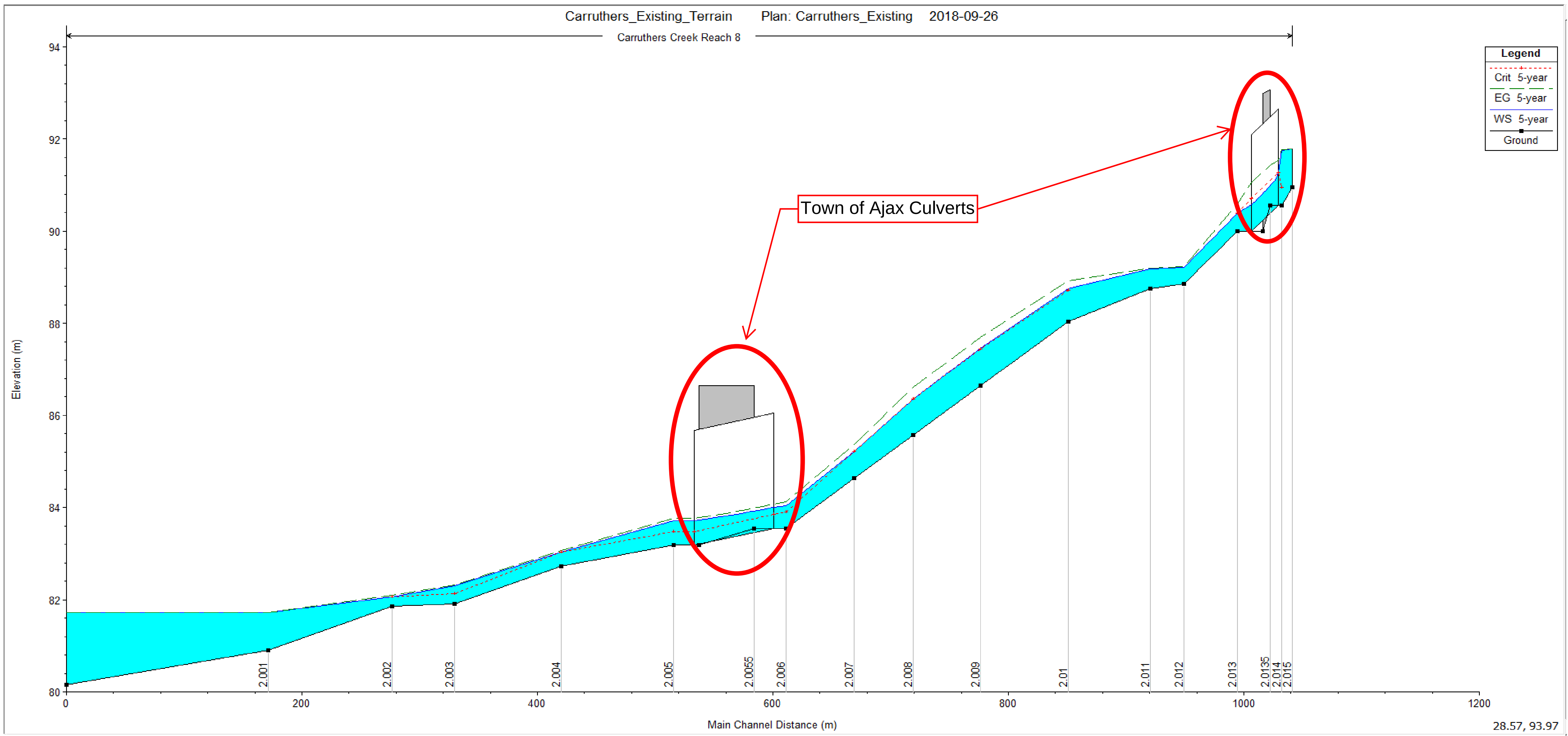
HEC RAS Channel Profile - Miller's Creek

1: 100-year Storm



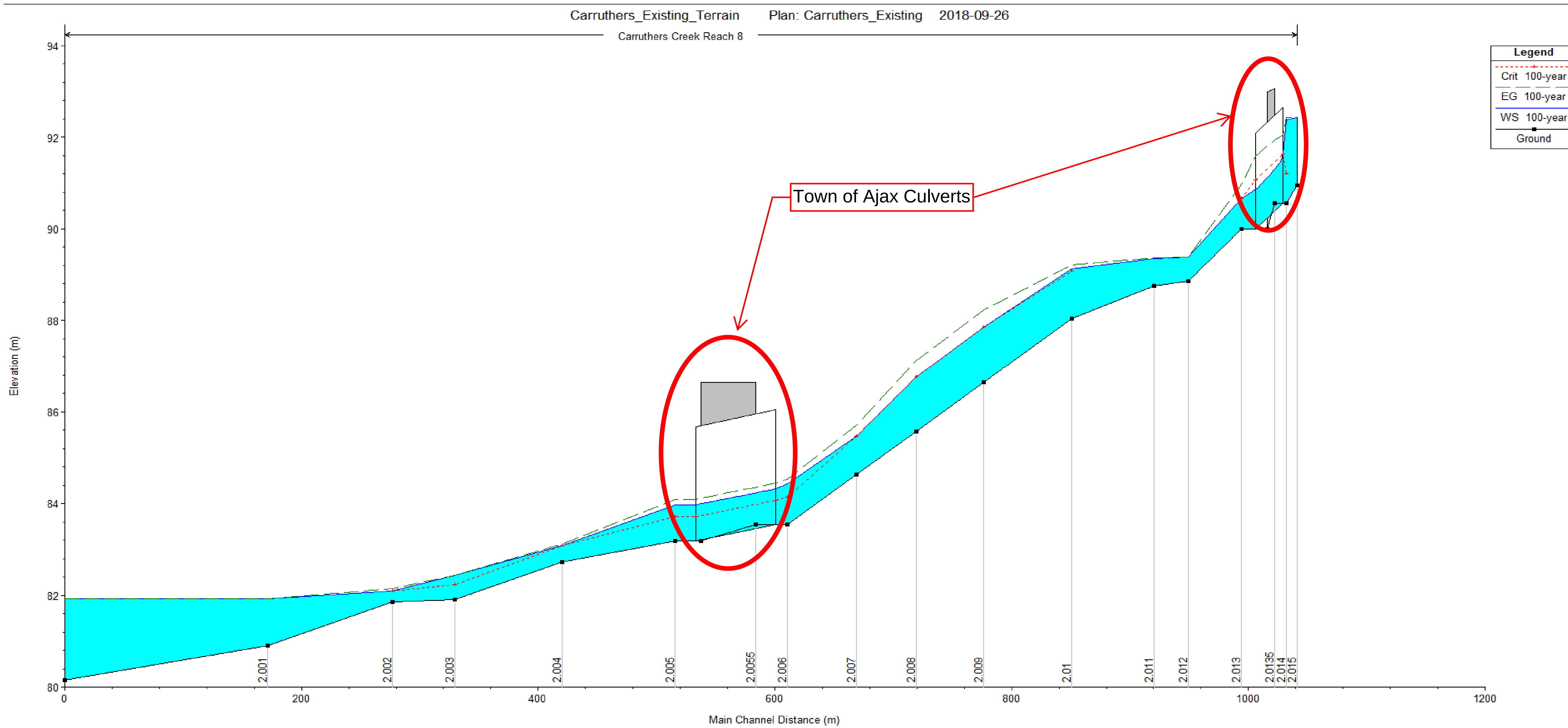
HEC RAS Channel Profile - Carruthers Creek

1: 5-year Storm



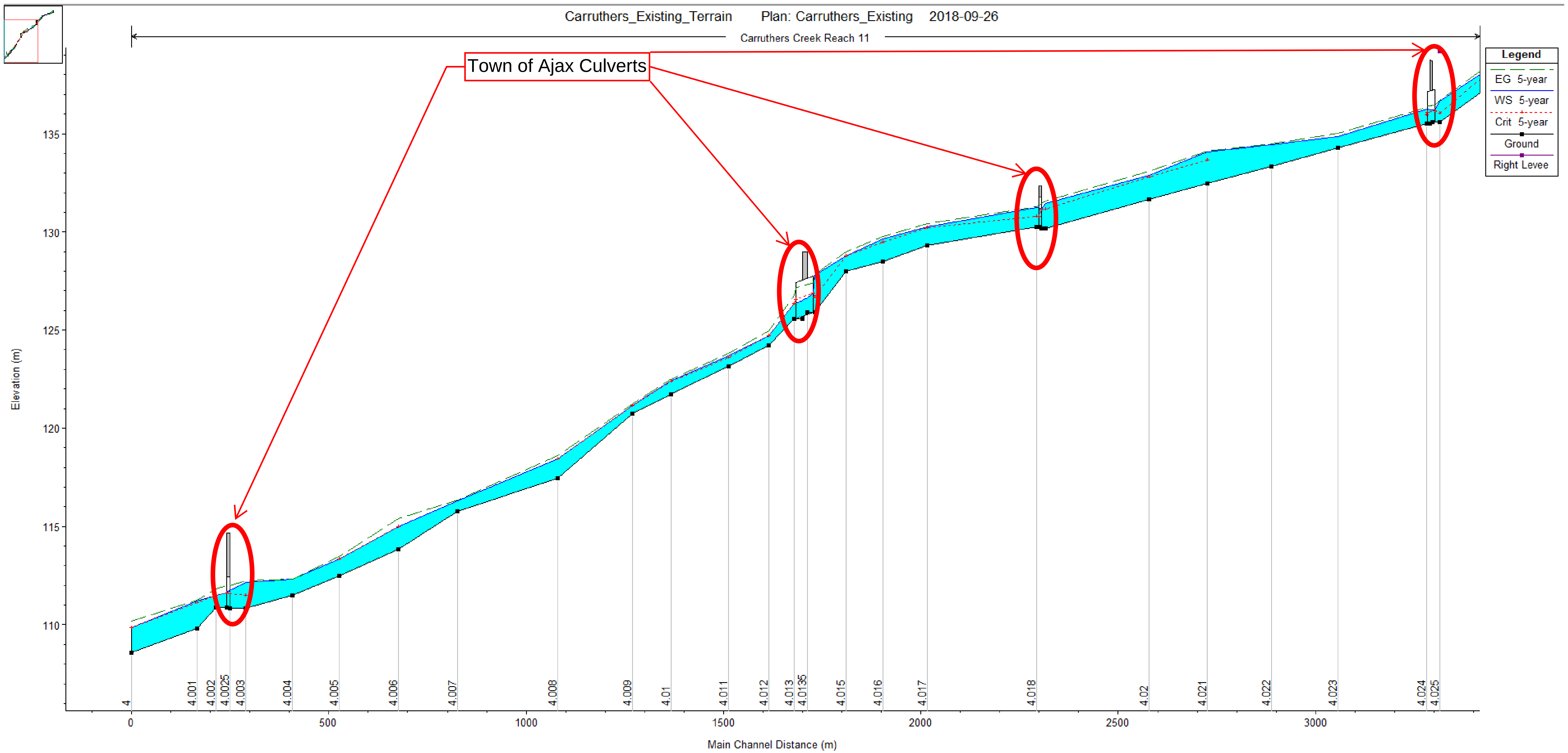
HEC RAS Channel Profile - Carruthers Creek

1: 100-year Storm



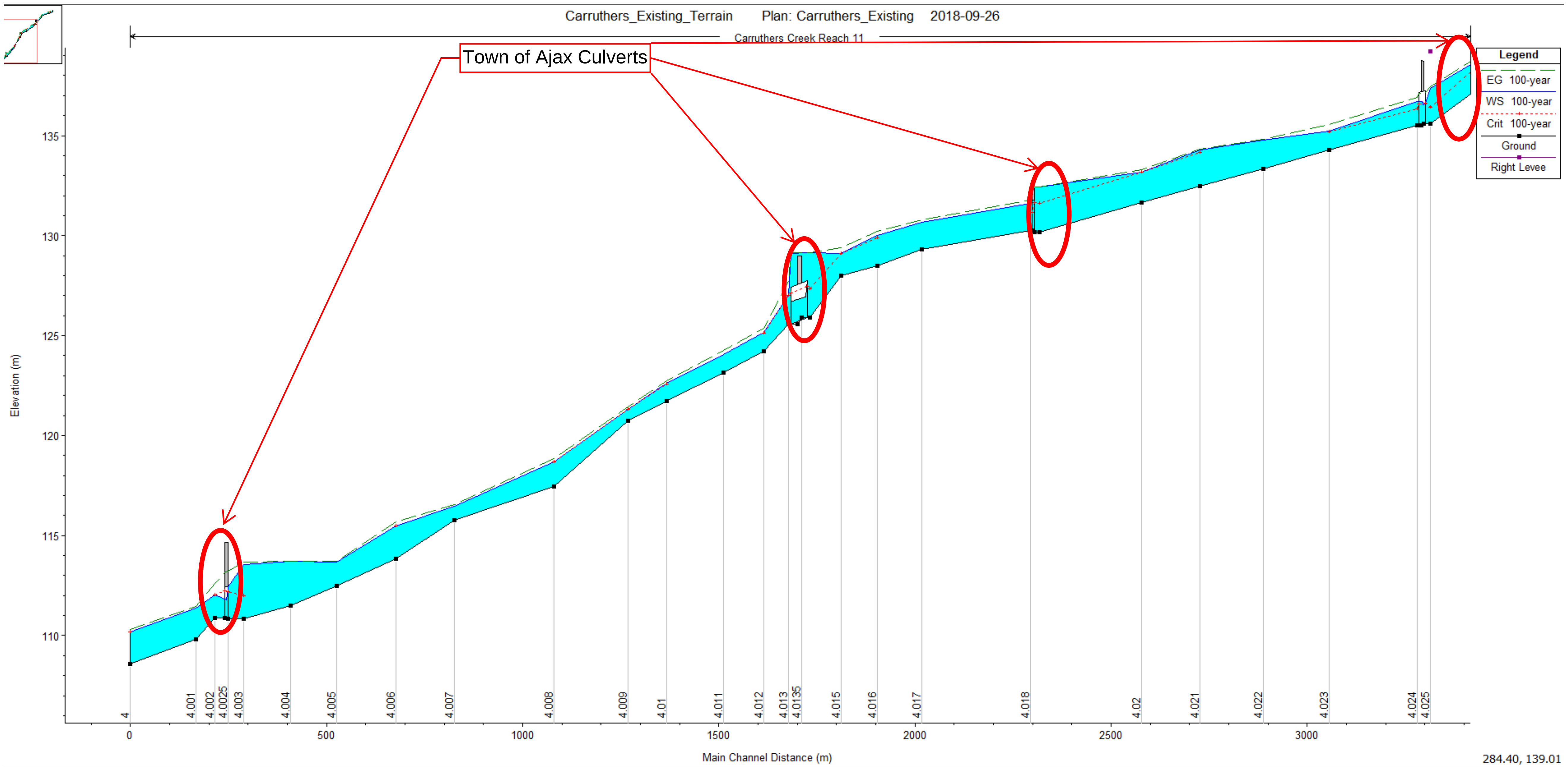
HEC RAS Channel Profile - Carruthers Creek

1: 5-year Storm



HEC RAS Channel Profile - Carruthers Creek

1: 100-year Storm



Appendix D

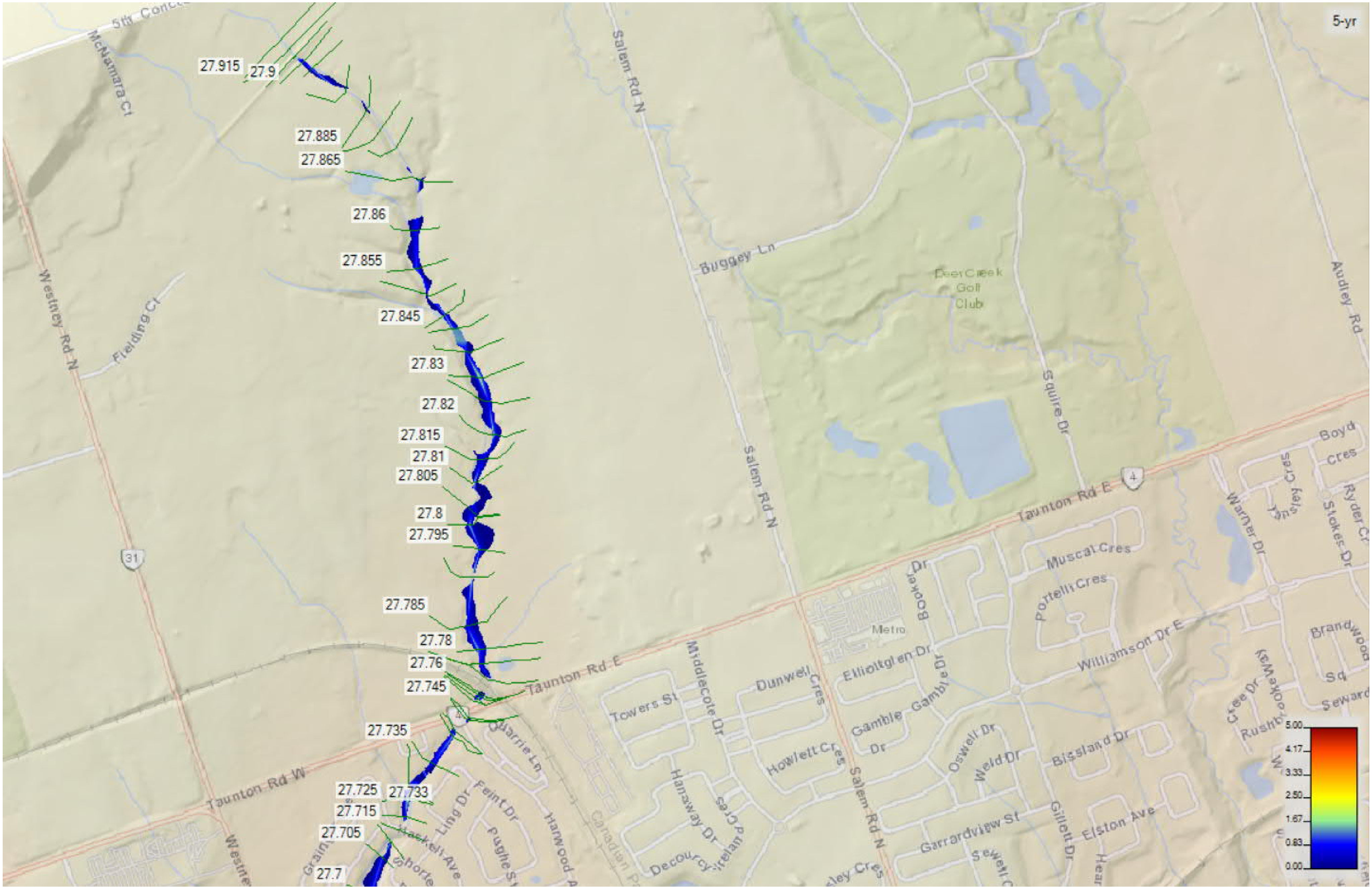
Shear and Velocity Results Mapping

Velocity & Shear Profiles

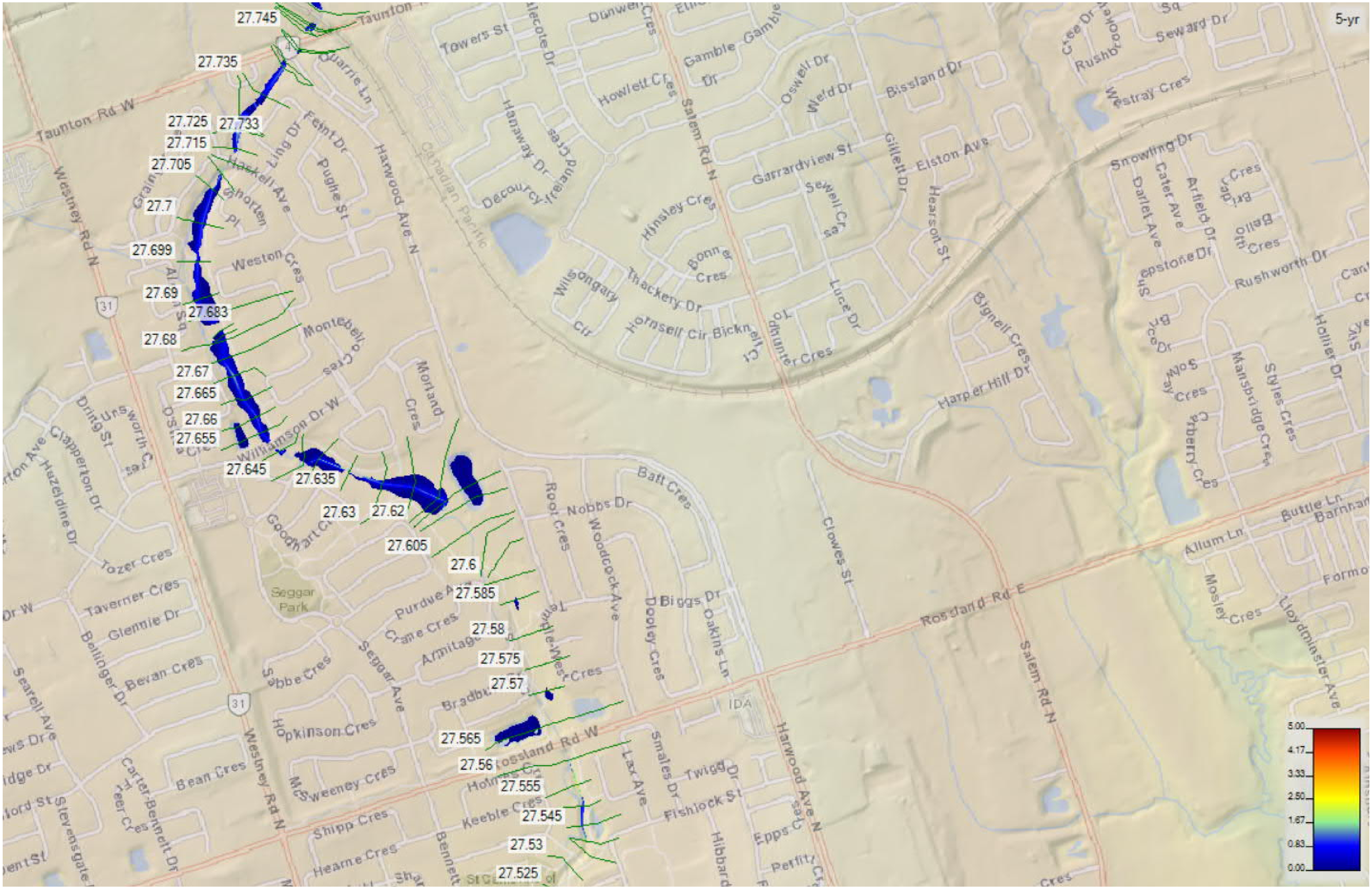
Miller's Creek

5yr & 100yr

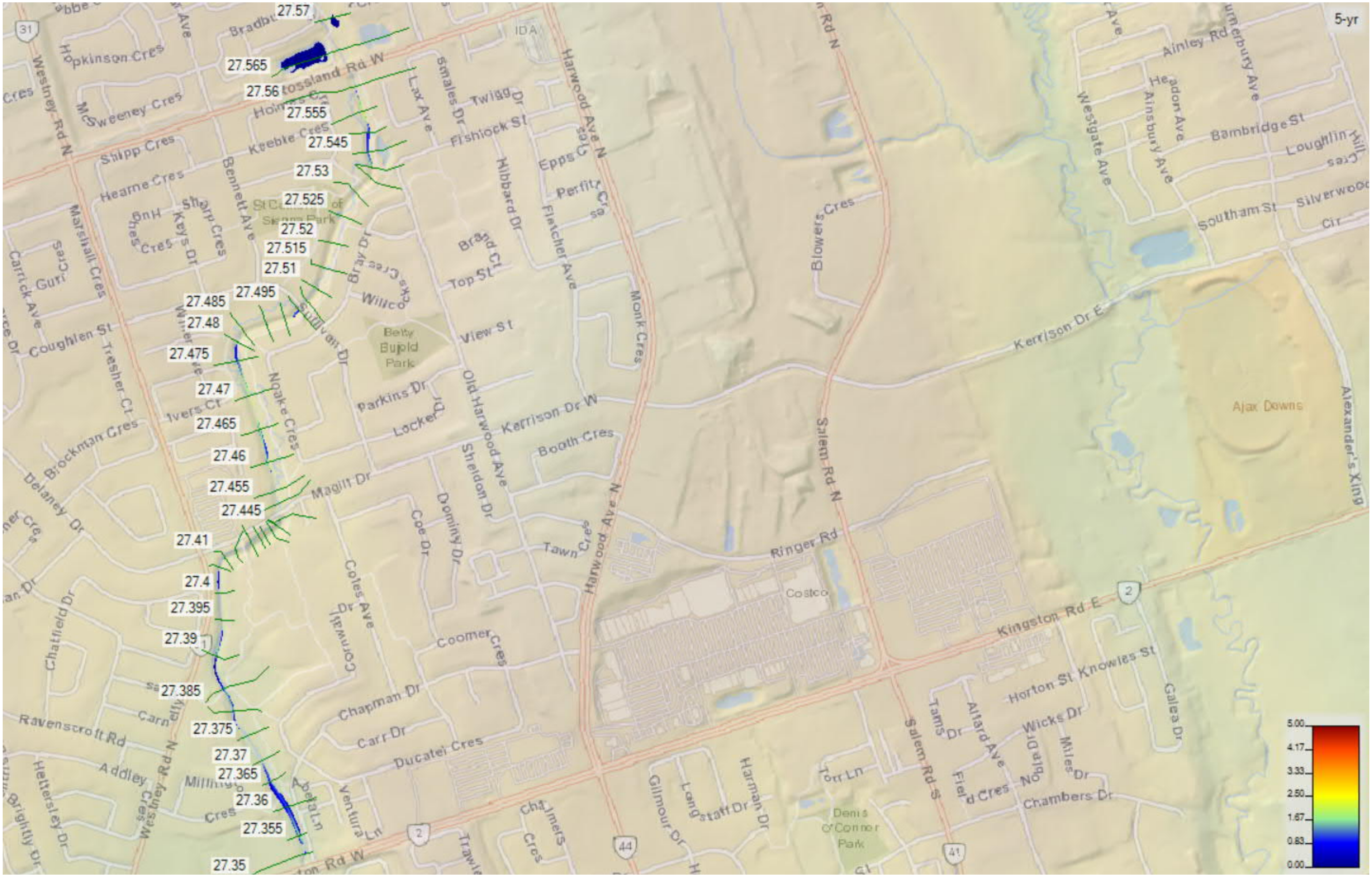
Velocity



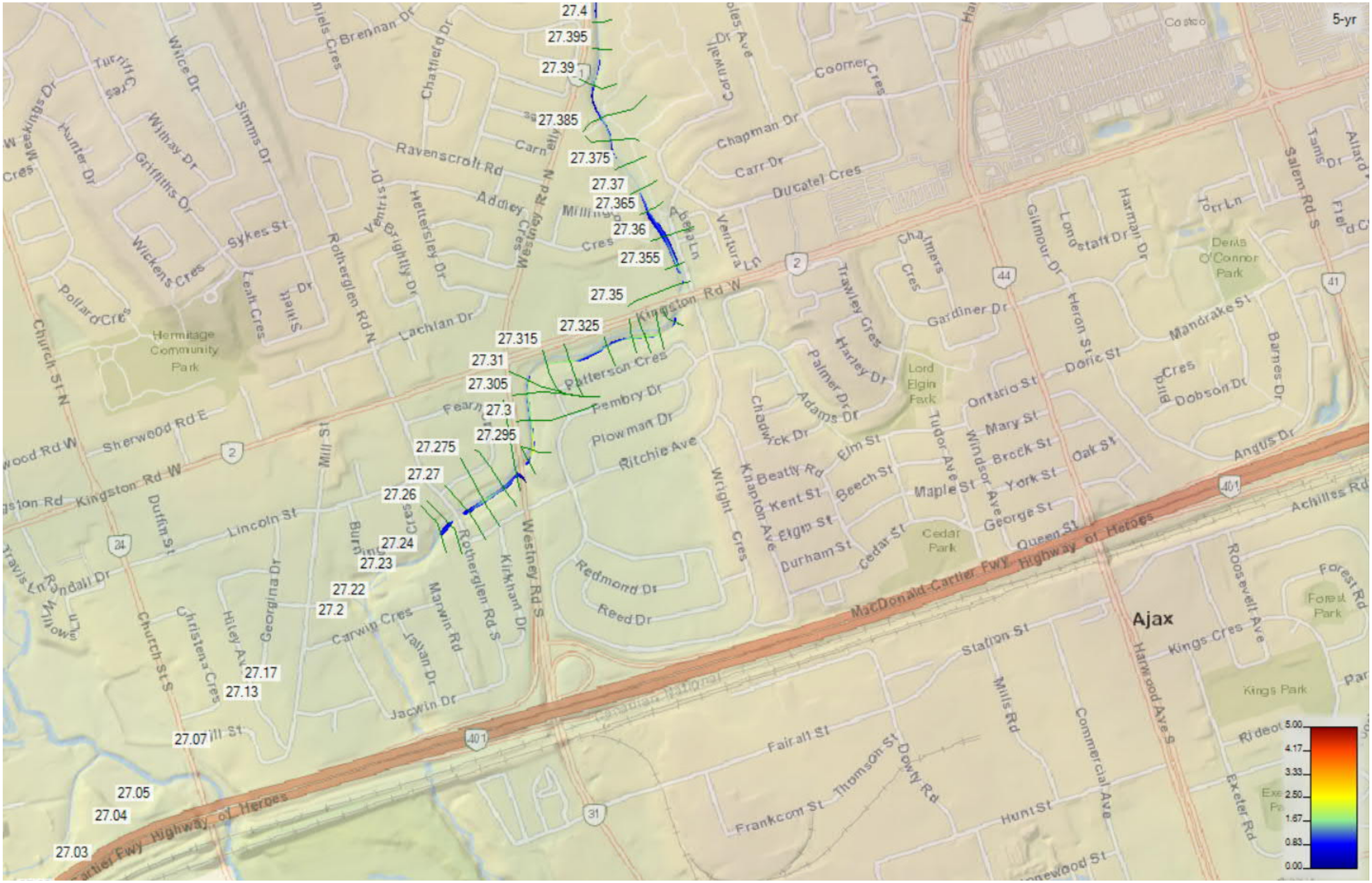
5-year velocity mapping - Miller Creek - Section 1



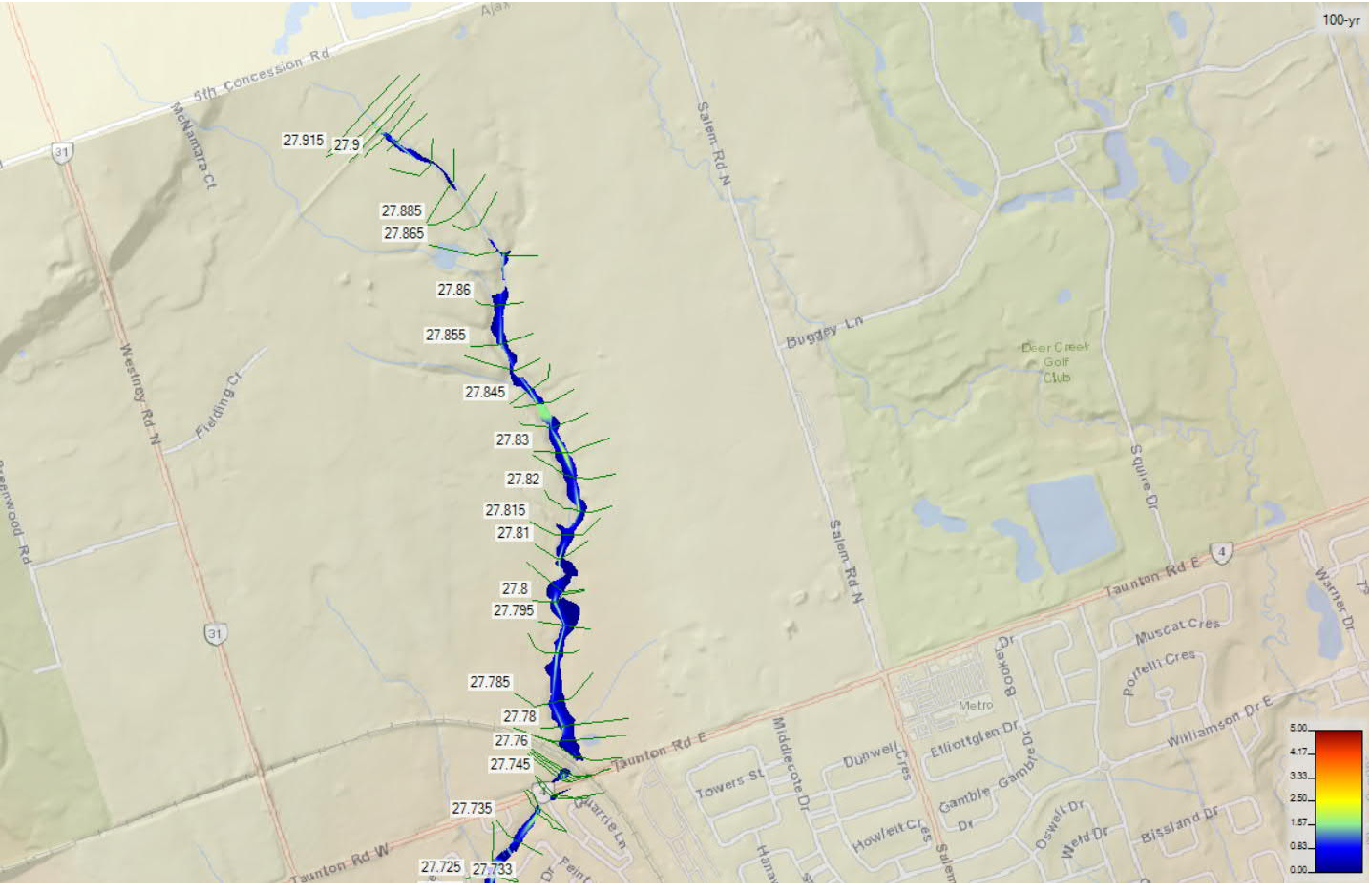
5-year velocity mapping - Miller Creek - Section 2



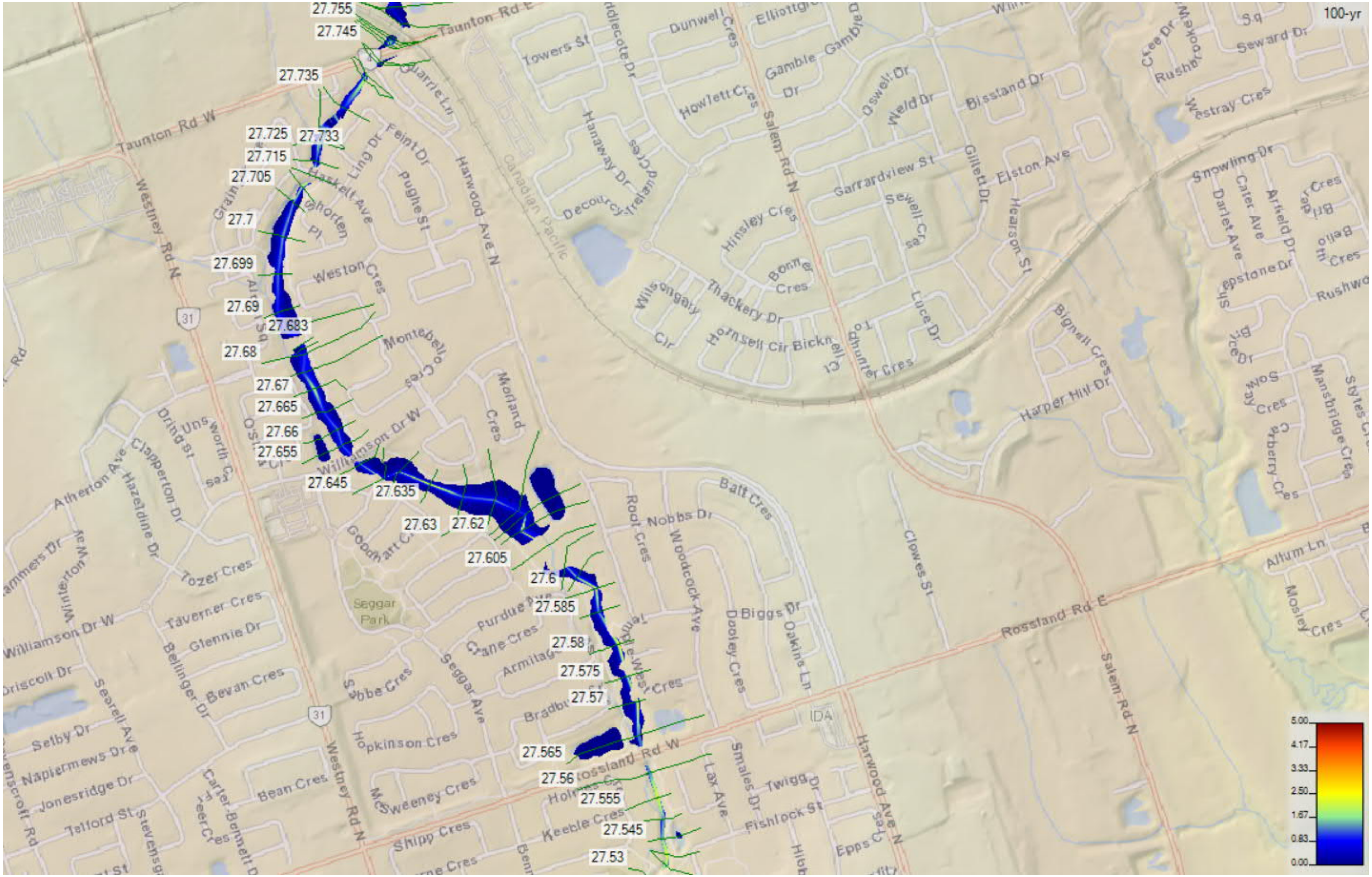
5-year velocity mapping - Miller Creek - Section 3



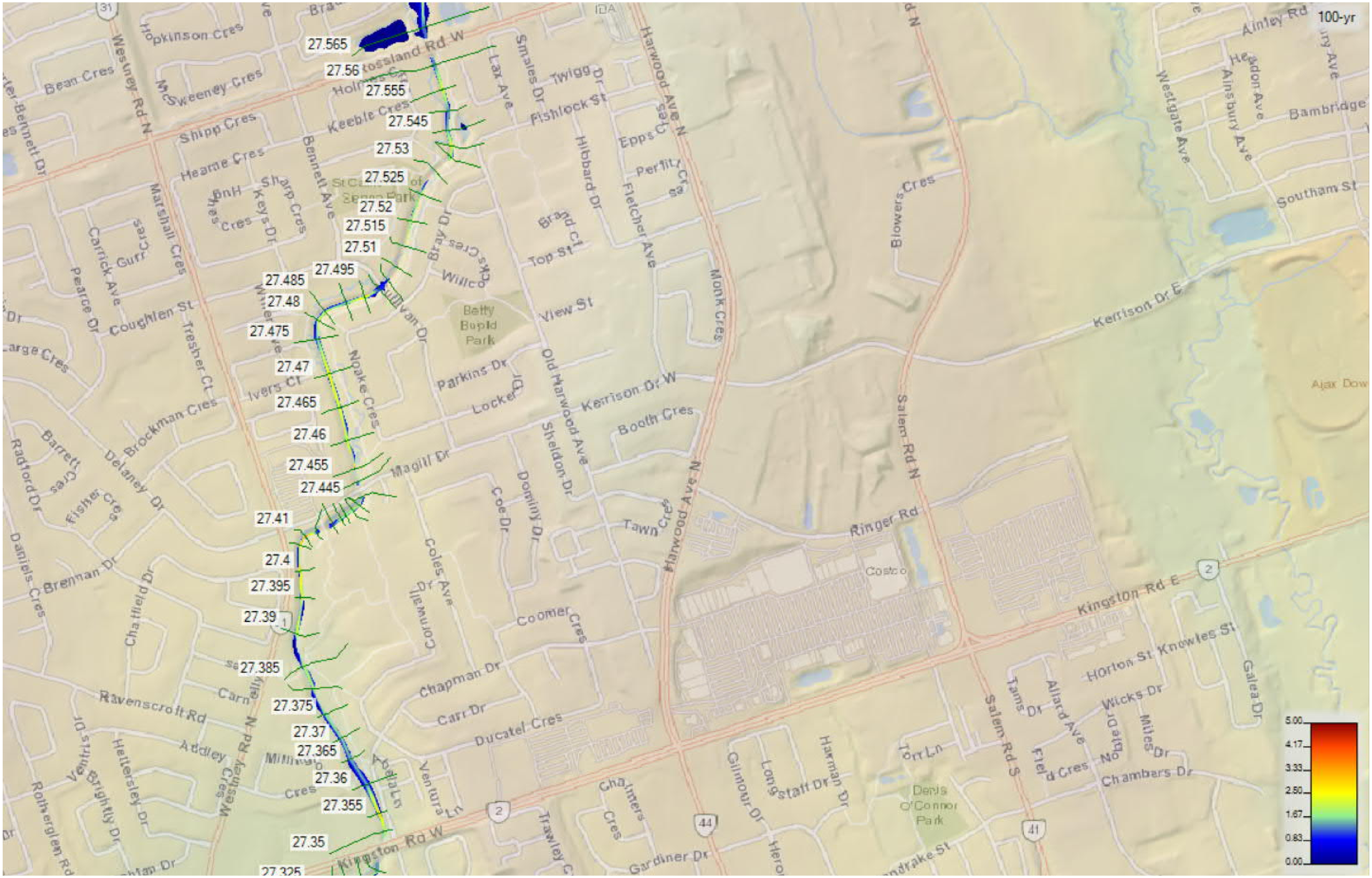
5-year velocity mapping - Miller Creek - Section 4



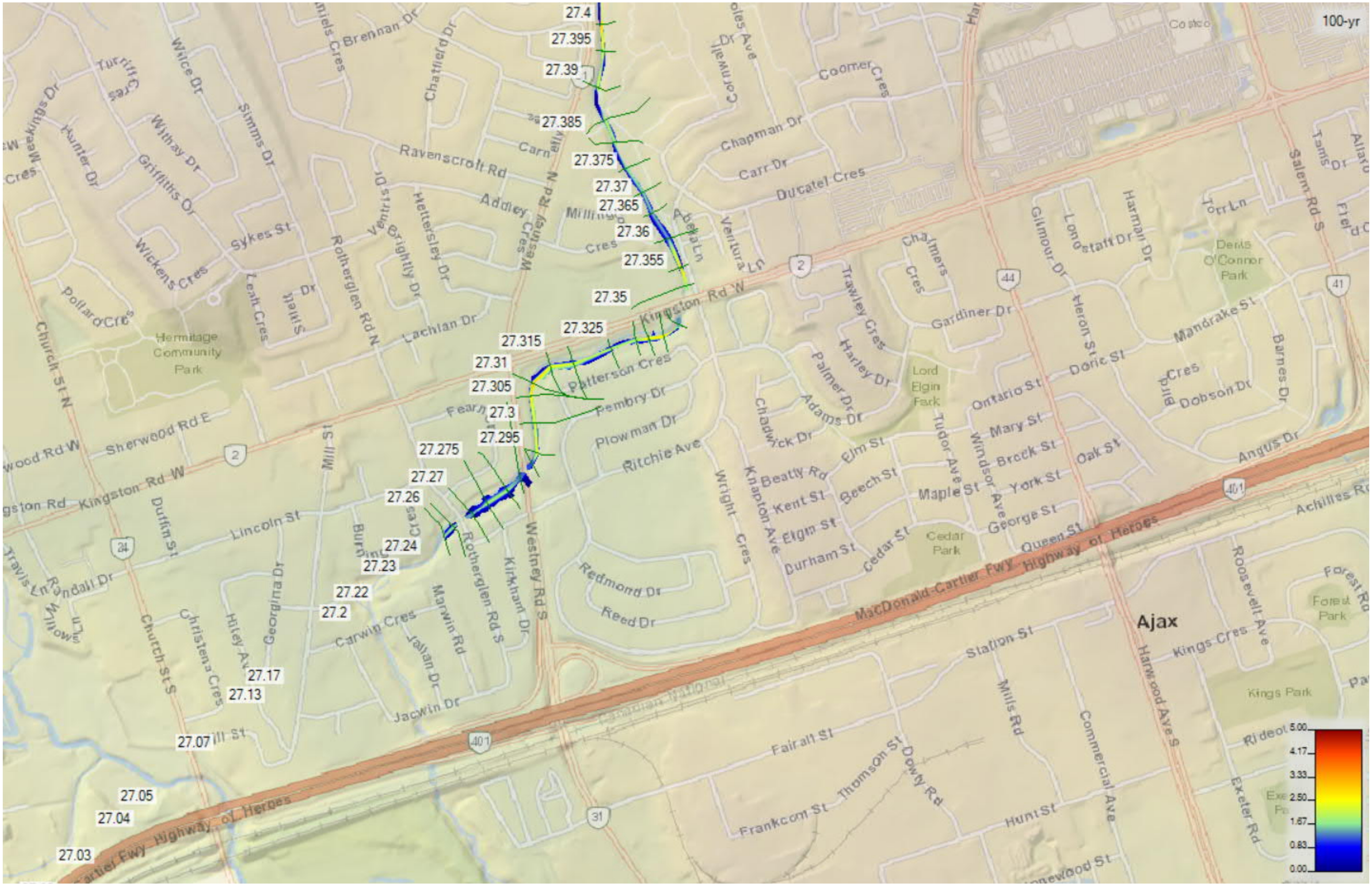
100-year velocity mapping - Miller Creek - Section 1



100-year velocity mapping - Miller Creek - Section 2

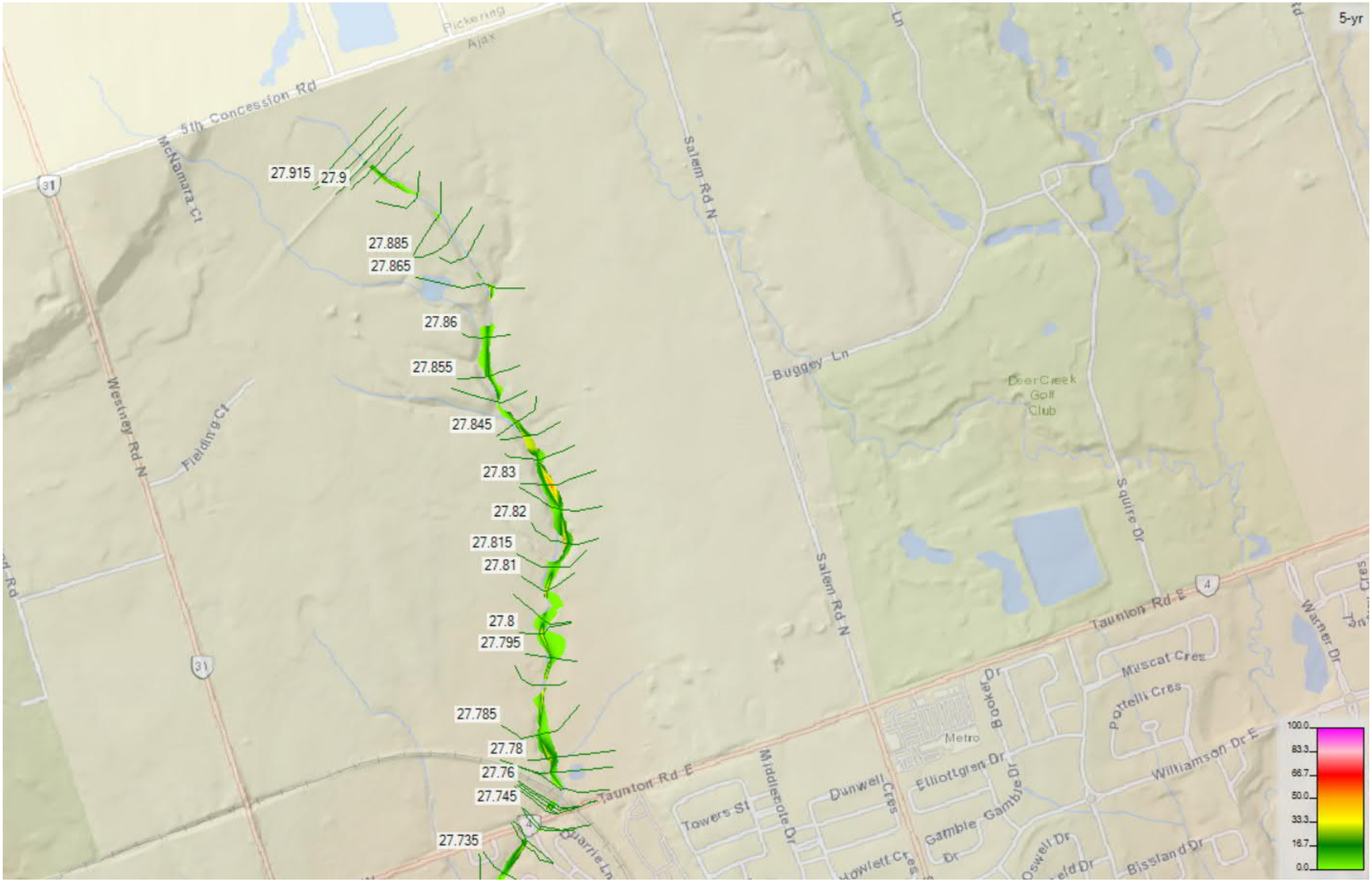


100-year velocity mapping - Miller Creek - Section 3

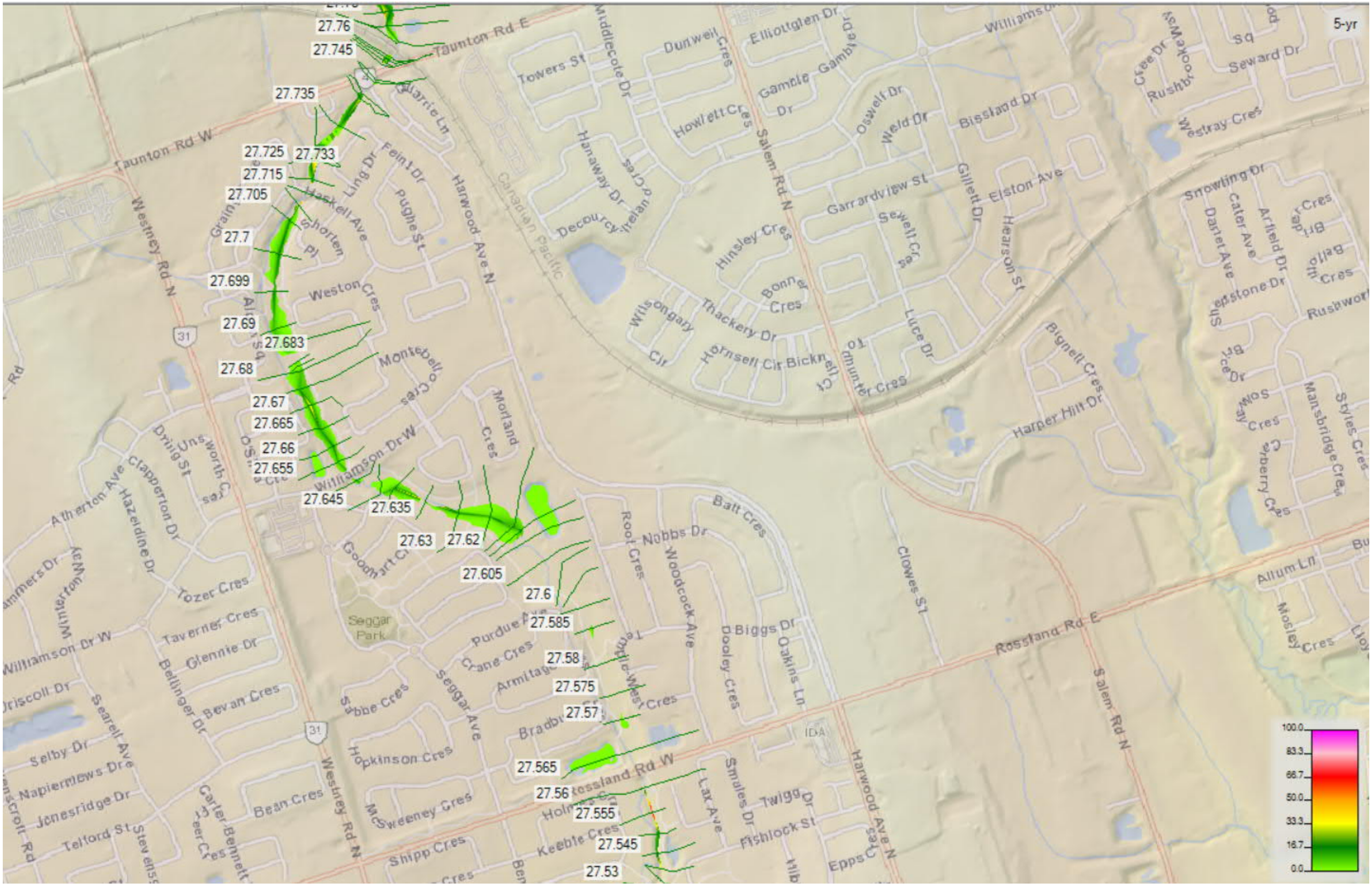


100-year velocity mapping - Miller Creek - Section 4

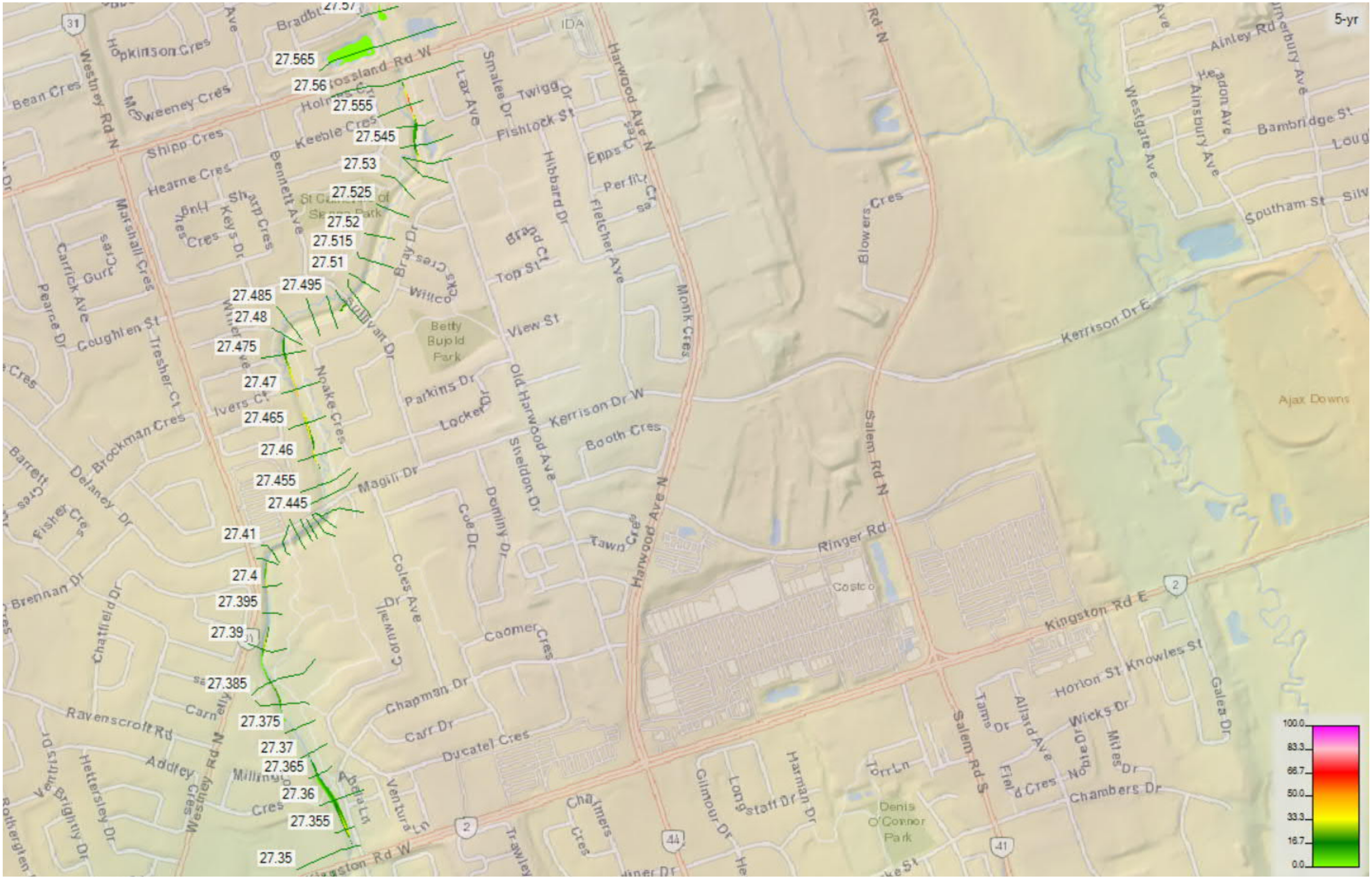
Shear



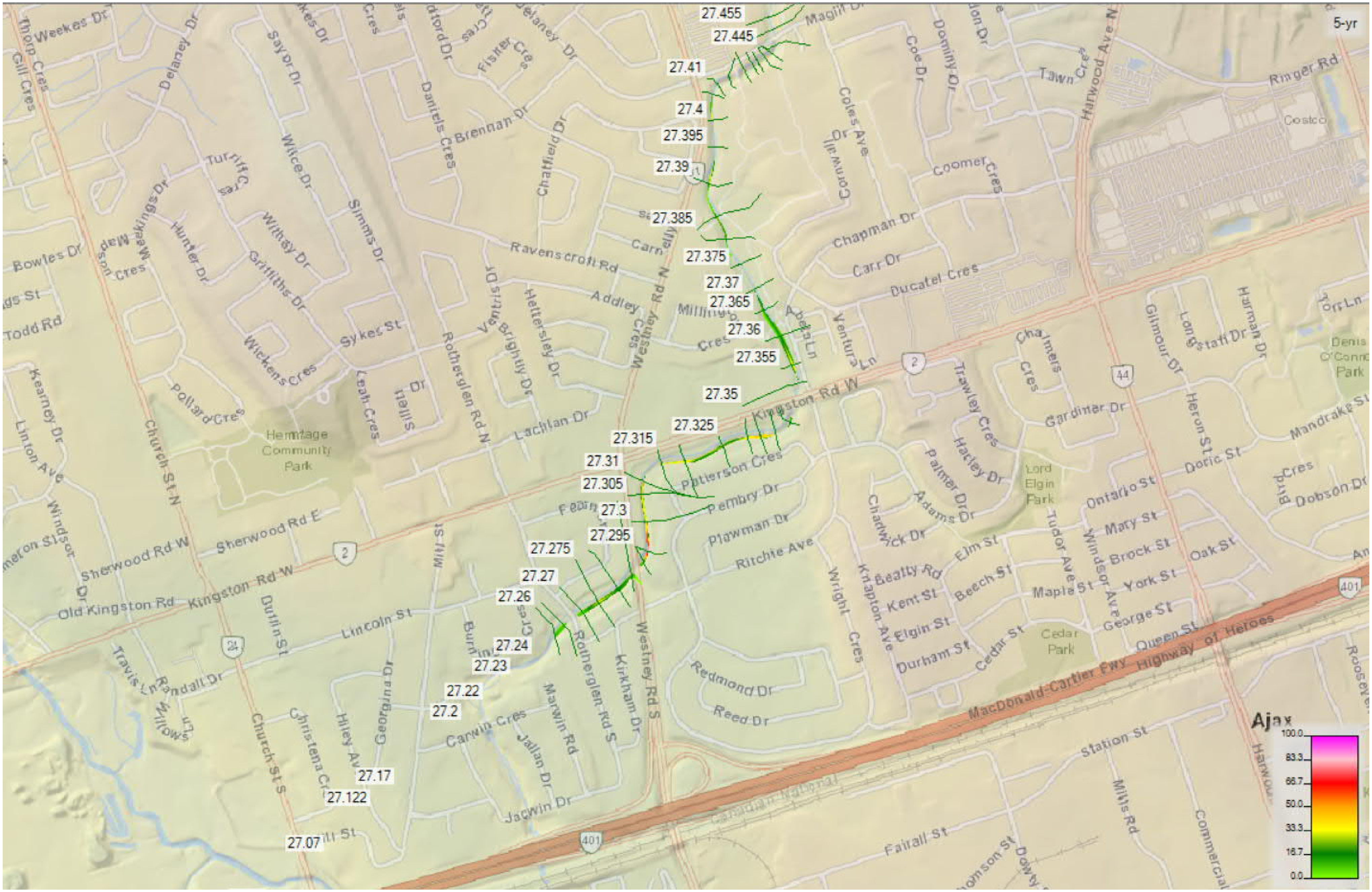
5-year shear mapping - Miller Creek - Section 1



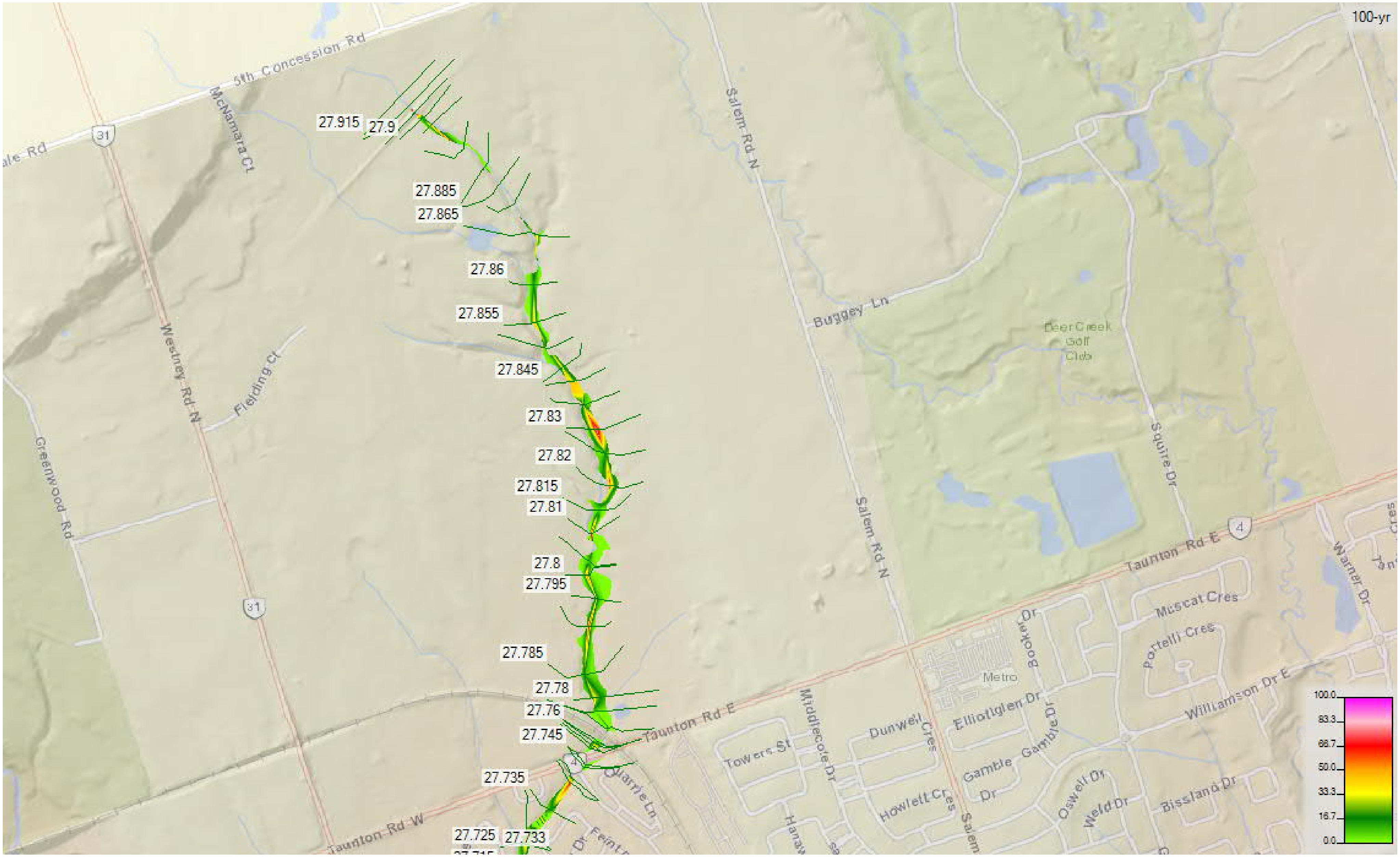
5-year shear mapping - Miller Creek - Section 2



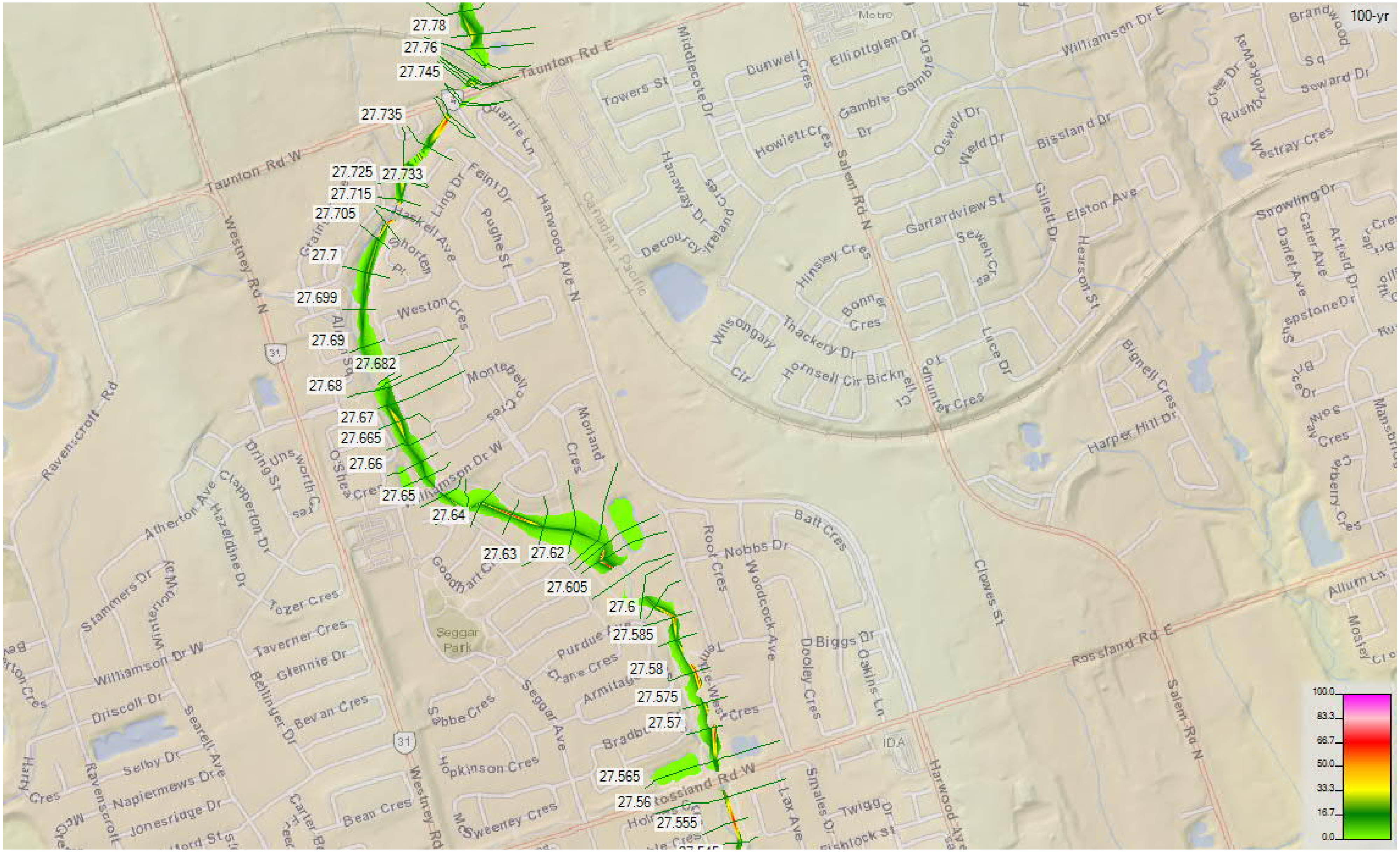
5-year shear mapping - Miller Creek - Section 3



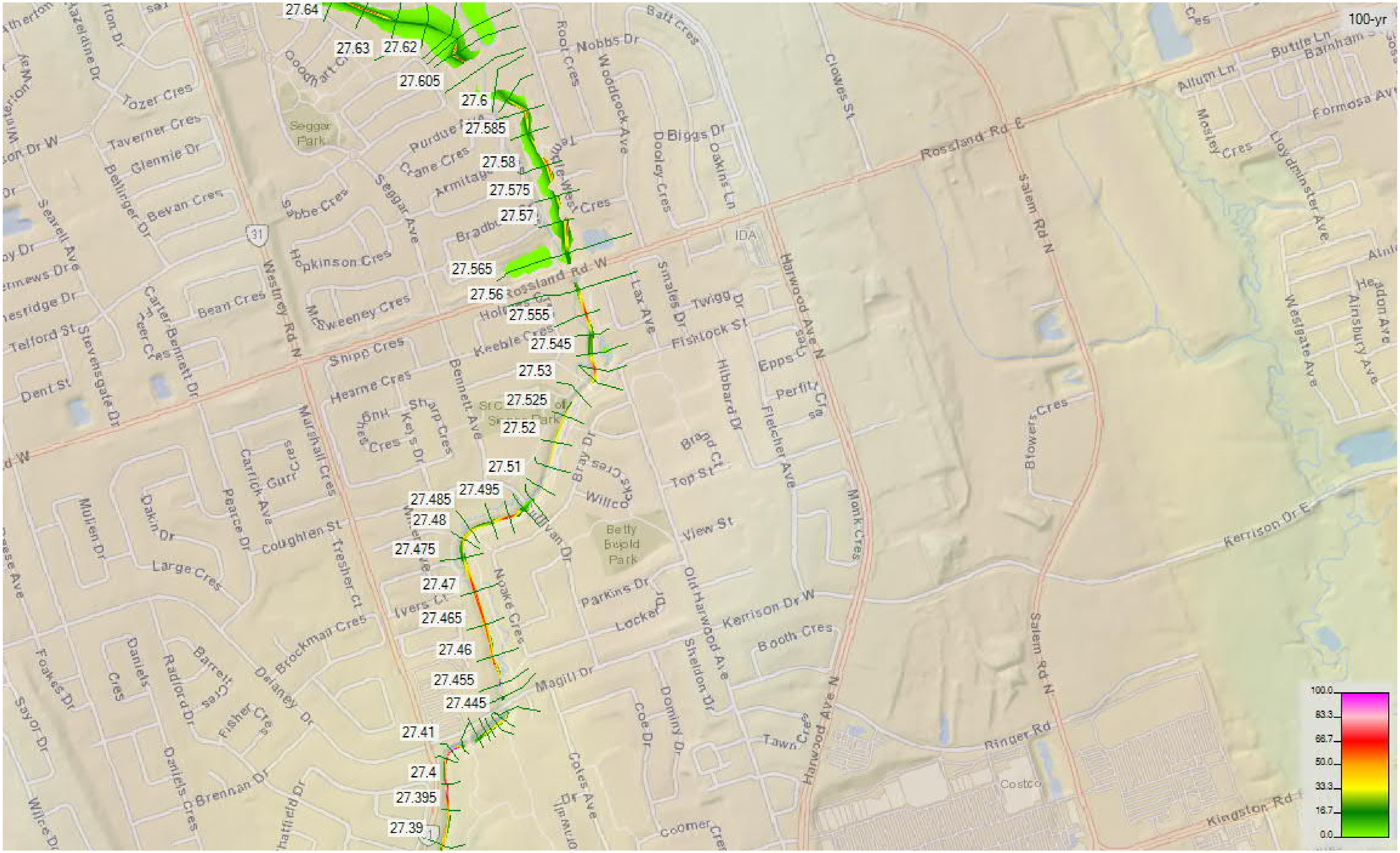
5-year shear mapping - Miller Creek - Section 4



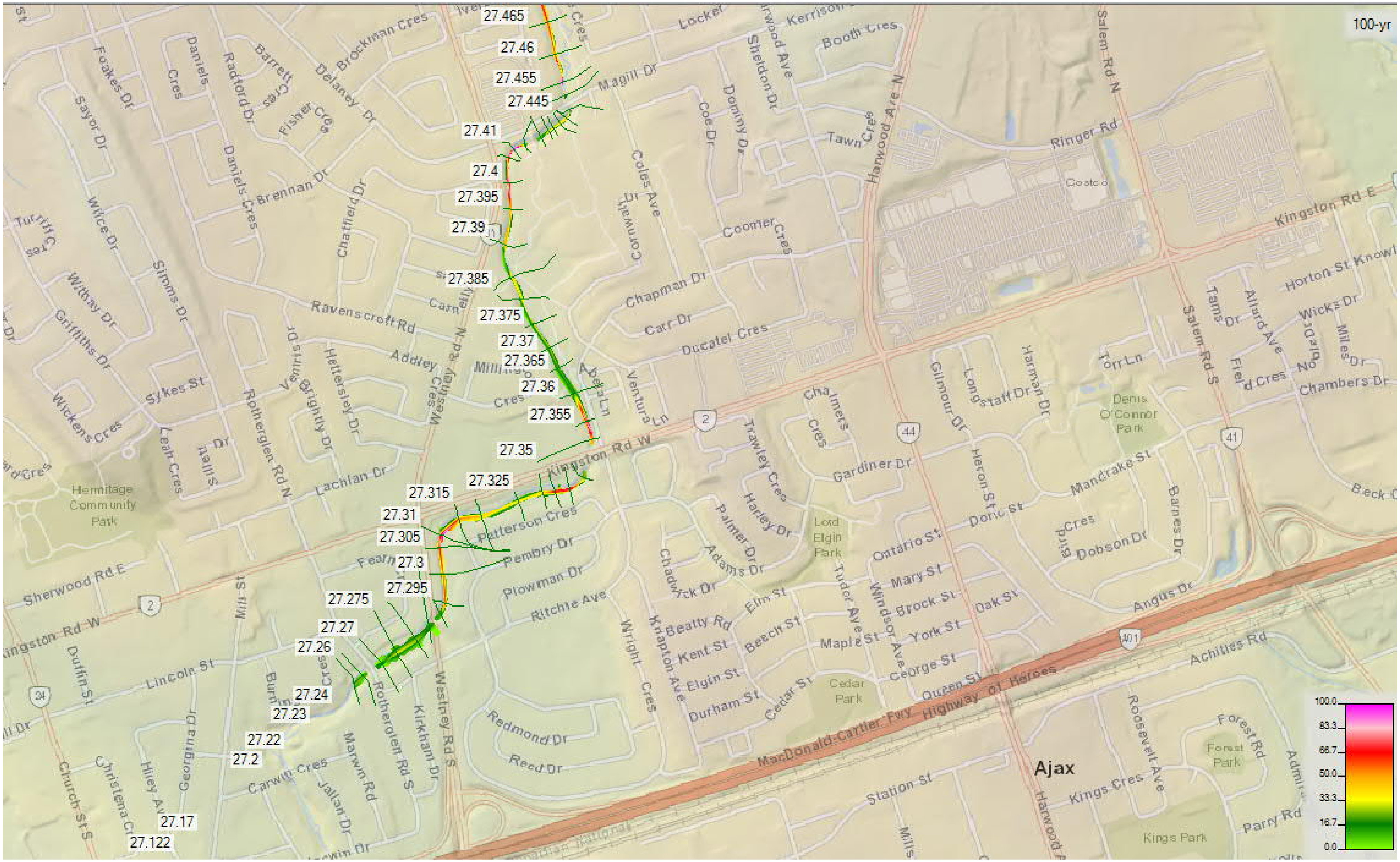
100-year shear mapping - Miller Creek - Section 1



100-year shear mapping - Miller Creek - Section 2



100-year shear mapping - Miller Creek - Section 3



100-year shear mapping - Miller Creek - Section 4

DUFFINS (MILLER'S) CREEK - 5YR

River	Reach	River Sta	Vel Chnl	Shear Chan	Shear LOB	Shear ROB	
			(m/s)	(N/m2)	(N/m2)	(N/m2)	
Millers Creek	Reach 1	27.915	1.15	28.44			
Millers Creek	Reach 1	27.91	1.35	36.76	9.11	9.12	
Millers Creek	Reach 1	27.905	1.84	57.26	21.8	22.76	
Millers Creek	Reach 1	27.9	0.5	4.76	1.36	1.37	
Millers Creek	Reach 1	27.895	0.99	22.06			
Millers Creek	Reach 1	27.89	1.42	41.87			
Millers Creek	Reach 1	27.885	0.58	4.46			
Millers Creek	Reach 1	27.88					
Millers Creek	Reach 1	27.875	1.64	49.68			
Millers Creek	Reach 1	27.87	1.5	36.98	13.25	12.19	
Millers Creek	Reach 1	27.865	1.19	32.59			
Millers Creek	Reach 1	27.86	0.61	8.2			
Millers Creek	Reach 1	27.855	0.96	21.32			
Millers Creek	Reach 1	27.85	0.71	11.41			
Millers Creek	Reach 1	27.845	1.13	24.34			
Millers Creek	Reach 1	27.84	1.59	38.24	15.19	16.06	
Millers Creek	Reach 1	27.835	0.84	11.71	0.77	0.8	
Millers Creek	Reach 1	27.83	2.06	66.23	28.82	28.14	
Millers Creek	Reach 1	27.825	0.62	7.13			
Millers Creek	Reach 1	27.82	1.59	45.26	12.64	12.7	
Millers Creek	Reach 1	27.815	0.3	1.76			
Millers Creek	Reach 1	27.81	1.54	46.48			
Millers Creek	Reach 1	27.805	0.4	3.35	0.6	0.6	
Millers Creek	Reach 1	27.8	1.27	35.78			
Millers Creek	Reach 1	27.795	0.98	15.43	3.06	3.14	
Millers Creek	Reach 1	27.79	1.4	40.69			
Millers Creek	Reach 1	27.785	0.59	5.97	0.87	0.87	
Millers Creek	Reach 1	27.78	1.64	43.42	13.64	13.66	
Millers Creek	Reach 1	27.775	0.52	5.33			
Millers Creek	Reach 1	27.77	0.93	10.61			
Millers Creek	Reach 1	27.767					
Millers Creek	Reach 1	27.765	0.8	7.36			
Millers Creek	Reach 1	27.76	1.2	20.87	6.77	6.72	
Millers Creek	Reach 1	27.755	1.94	58.77	11.09	11.05	
Millers Creek	Reach 1	27.75	0.72	6.22			
Millers Creek	Reach 1	27.747					
Millers Creek	Reach 1	27.745	0.76	7.19			
Millers Creek	Reach 1	27.744	0.75	7.35			
Millers Creek	Reach 1	27.742					
Millers Creek	Reach 1	27.741	1.79	56			
Millers Creek	Reach 1	27.74	0.8	11.34	0.52	0.51	
Millers Creek	Reach 1	27.735	1.37	39.81			
Millers Creek	Reach 1	27.733	0.85	11.87			

Table 1 - Summary

		Channel Velocity (m/s)			Shear Stress (N/m2)		
	Reach	Min	Max	Avg	Min	Max	Avg
Millers Creek	Reach 1	0.3	3.08	1.30	1.3	110.1	27.6
River 1	Reach 1	0.95	3.1	2.16	9.6	136.8	64.8

Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

DUFFINS (MILLER'S) CREEK - 5YR

River	Reach	River Sta	Vel Chnl	Shear Chan	Shear LOB	Shear ROB	
			(m/s)	(N/m2)	(N/m2)	(N/m2)	
Millers Creek	Reach 1	27.7325					
Millers Creek	Reach 1	27.732	1.69	53.02			
Millers Creek	Reach 1	27.73	0.99	15.84	0.45	0.45	
Millers Creek	Reach 1	27.725	1.81	53.58	18.44	18.48	
Millers Creek	Reach 1	27.72	0.72	7.41	0.75	0.75	
Millers Creek	Reach 1	27.717					
Millers Creek	Reach 1	27.715	2.61	96.64	44.67	53.1	
Millers Creek	Reach 1	27.71	1.21	26.32			
Millers Creek	Reach 1	27.705	0.96	14.55	3.11	3.11	
Millers Creek	Reach 1	27.7	0.95	14.53	4.12	4.12	
Millers Creek	Reach 1	27.699	0.69	8.19			
Millers Creek	Reach 1	27.6975					
Millers Creek	Reach 1	27.695	0.88	14.07			
Millers Creek	Reach 1	27.69	0.71	7.57	3.52	3.55	
Millers Creek	Reach 1	27.685	0.65	6.51	2.83	2.84	
Millers Creek	Reach 1	27.683	0.39	2.08	0.54	0.37	
Millers Creek	Reach 1	27.6825					
Millers Creek	Reach 1	27.682	0.4	2.19	0.55	0.4	
Millers Creek	Reach 1	27.68	0.66	6.83	2.51	2.37	
Millers Creek	Reach 1	27.675	0.73	8.9	2.47	5.67	
Millers Creek	Reach 1	27.67	1.28	30.67	1.05	1.05	
Millers Creek	Reach 1	27.665	0.89	11.78	5.29	5.29	
Millers Creek	Reach 1	27.66	0.98	13.82	3.09	3.09	
Millers Creek	Reach 1	27.655	0.78	8.45	1.22	1.22	
Millers Creek	Reach 1	27.652					
Millers Creek	Reach 1	27.65	0.86	10.7	0.47	0.47	
Millers Creek	Reach 1	27.645	1.15	18.34			
Millers Creek	Reach 1	27.64	1.3	21.85	5.85	5.59	
Millers Creek	Reach 1	27.635	1.65	39.55			
Millers Creek	Reach 1	27.63	0.87	11.18			
Millers Creek	Reach 1	27.6275					
Millers Creek	Reach 1	27.625	0.77	8.51			
Millers Creek	Reach 1	27.62	1.32	23.05	3.42	3.42	
Millers Creek	Reach 1	27.615	0.95	11.93	1.43	1.43	
Millers Creek	Reach 1	27.61	1.99	56.53			
Millers Creek	Reach 1	27.605	0.97	13.57			
Millers Creek	Reach 1	27.6	1.15	18.11	1.83	1.83	
Millers Creek	Reach 1	27.595	1.04	15.07			
Millers Creek	Reach 1	27.59	1.5	30.28	4.1	3.98	
Millers Creek	Reach 1	27.585	0.82	9.12	0.3	0.3	
Millers Creek	Reach 1	27.5825					
Millers Creek	Reach 1	27.58	1.73	39.9	10.23	8.71	

Table 1 - Summary

		Channel Velocity (m/s)			Shear Stress (N/m2)		
	Reach	Min	Max	Avg	Min	Max	Avg
Millers Creek	Reach 1	0.3	3.08	1.30	1.3	110.1	27.6
River 1	Reach 1	0.95	3.1	2.16	9.6	136.8	64.8

Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

DUFFINS (MILLER'S) CREEK - 5YR

River	Reach	River Sta	Vel Chnl	Shear Chan	Shear LOB	Shear ROB	
			(m/s)	(N/m2)	(N/m2)	(N/m2)	
Millers Creek	Reach 1	27.575	1.06	14.26	2.2	3.35	
Millers Creek	Reach 1	27.57	2.1	66.07	1.61	1.6	
Millers Creek	Reach 1	27.565	0.91	11.97			
Millers Creek	Reach 1	27.562					
Millers Creek	Reach 1	27.56	0.91	11.73			
Millers Creek	Reach 1	27.555	1.9	60.97	5.28	5.28	
Millers Creek	Reach 1	27.55	0.98	12.2	4.46	4.29	
Millers Creek	Reach 1	27.545	1.03	13.83	4.01	4.14	
Millers Creek	Reach 1	27.54	1.62	35.84	14.33	14.44	
Millers Creek	Reach 1	27.535	1.23	21.04	7.48	7.44	
Millers Creek	Reach 1	27.53	1.05	15.42	3.84	3.82	
Millers Creek	Reach 1	27.525	1.43	30.95			
Millers Creek	Reach 1	27.52	1.28	20.99	8.86	8.86	
Millers Creek	Reach 1	27.515	1.36	24.15	7.32	7.35	
Millers Creek	Reach 1	27.51	1.83	48.78	4.81	4.78	
Millers Creek	Reach 1	27.505	0.65	5.04			
Millers Creek	Reach 1	27.502					
Millers Creek	Reach 1	27.5	0.66	5.2			
Millers Creek	Reach 1	27.495	2.11	55.38	25.19	24.39	
Millers Creek	Reach 1	27.49	1.08	14.4	5.74	5.81	
Millers Creek	Reach 1	27.485	1.45	26.13	8.25	8.45	
Millers Creek	Reach 1	27.48	1.58	31.62	8.5	8.55	
Millers Creek	Reach 1	27.475	1.09	15.19	3.33	3.38	
Millers Creek	Reach 1	27.47	2.02	47.34	20.19	20.57	
Millers Creek	Reach 1	27.465	1.63	32.34	10.63	10.84	
Millers Creek	Reach 1	27.46	1.45	26.32	5.52	5.64	
Millers Creek	Reach 1	27.455	2.26	77.48			
Millers Creek	Reach 1	27.45	0.97	12.72			
Millers Creek	Reach 1	27.447					
Millers Creek	Reach 1	27.445	0.9	10.52			
Millers Creek	Reach 1	27.44	1.64	38.09	7.03	7.03	
Millers Creek	Reach 1	27.435	1.48	30.65	3.15	3.22	
Millers Creek	Reach 1	27.43	1.6	36.32			
Millers Creek	Reach 1	27.425	2.15	67			
Millers Creek	Reach 1	27.42	0.75	6.31			
Millers Creek	Reach 1	27.417					
Millers Creek	Reach 1	27.415	0.64	4.44			
Millers Creek	Reach 1	27.41	2.5	79.57	15.31	16.5	
Millers Creek	Reach 1	27.405	1.75	39.09	6.9	6.75	
Millers Creek	Reach 1	27.4	2	48.12	20.89	21.58	
Millers Creek	Reach 1	27.395	1.49	27.37	10.1	10.17	
Millers Creek	Reach 1	27.39	1.42	25.38	6.03	6.01	
Millers Creek	Reach 1	27.385	1.26	20.77	2.09	2.06	
Millers Creek	Reach 1	27.38	1.2	19.05			
Millers Creek	Reach 1	27.375	1.07	14.91			
Millers Creek	Reach 1	27.37	1.03	13.72			
Millers Creek	Reach 1	27.365	0.95	11.76			
Millers Creek	Reach 1	27.36	0.92	10.86			
Millers Creek	Reach 1	27.355	1.58	31.44	3.65	3.54	

Table 1 - Summary

		Channel Velocity (m/s)			Shear Stress (N/m2)		
	Reach	Min	Max	Avg	Min	Max	Avg
Millers Creek	Reach 1	0.3	3.08	1.30	1.3	110.1	27.6
River 1	Reach 1	0.95	3.1	2.16	9.6	136.8	64.8

Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

DUFFINS (MILLER'S) CREEK - 5YR

River	Reach	River Sta	Vel Chnl	Shear Chan	Shear LOB	Shear ROB	
			(m/s)	(N/m2)	(N/m2)	(N/m2)	
Millers Creek	Reach 1	27.35	1.9	61.54			
Millers Creek	Reach 1	27.347					
Millers Creek	Reach 1	27.345	1.59	40.47			
Millers Creek	Reach 1	27.34	1.71	35.69	15.1	15.04	
Millers Creek	Reach 1	27.335	1.83	42.55	15.31	16.32	
Millers Creek	Reach 1	27.33	1.57	31.81	10.03	10.3	
Millers Creek	Reach 1	27.325	1.42	21.98	8.96	4.28	
Millers Creek	Reach 1	27.32	1.77	35.94	13.34	9.47	
Millers Creek	Reach 1	27.315	1.68	32.25	11.95	11.1	
Millers Creek	Reach 1	27.31	2.02	48.91	13.23	13.52	
Millers Creek	Reach 1	27.305	1.66	33.53	7.03	7.77	
Millers Creek	Reach 1	27.3	1.47	26.8	3.1	3.4	
Millers Creek	Reach 1	27.295	2.36	77.92			
Millers Creek	Reach 1	27.29	0.85	8.45	3.12	3.23	
Millers Creek	Reach 1	27.287					
Millers Creek	Reach 1	27.285	0.9	9.41	3.25	3.32	
Millers Creek	Reach 1	27.28	1.28	16.74	6.48	4.36	
Millers Creek	Reach 1	27.275	1.72	30.5	9.36	7.44	
Millers Creek	Reach 1	27.27	0.83	6.64			
Millers Creek	Reach 1	27.267					
Millers Creek	Reach 1	27.265	0.83	6.65			
Millers Creek	Reach 1	27.26	0.94	8.93	2.75	2.15	
Millers Creek	Reach 1	27.24	1.07	12.69	4.6	4.34	
Millers Creek	Reach 1	27.23	2.68	90.42	43.16	36.73	
Millers Creek	Reach 1	27.22	2.59	80.03	12.55	30.39	
Millers Creek	Reach 1	27.21	1.47	24.33	5.82	5.32	
Millers Creek	Reach 1	27.2	1.41	23.93	5.4		
Millers Creek	Reach 1	27.195					
Millers Creek	Reach 1	27.19	1.74	38.65			
Millers Creek	Reach 1	27.18	1.13	14.96		2.26	
Millers Creek	Reach 1	27.17	1.15	14.56	4.97	5.74	
Millers Creek	Reach 1	27.16	1.27	16.48			
Millers Creek	Reach 1	27.155					
Millers Creek	Reach 1	27.15	1.57	28.05			
Millers Creek	Reach 1	27.14	1.57	26.71	13.11	9.61	
Millers Creek	Reach 1	27.13	1.72	35.64	8.02	15.86	
Millers Creek	Reach 1	27.122	1.34	21.15			
Millers Creek	Reach 1	27.1					
Millers Creek	Reach 1	27.07	1.09	13.22			
Millers Creek	Reach 1	27.06	1.08	12.44	6.07	3.57	
Millers Creek	Reach 1	27.05	2.26	58.94	21.34	30.46	
Millers Creek	Reach 1	27.04	2.24	57.65	22.08	20.9	
Millers Creek	Reach 1	27.03	3.08	110.11	32.56	30.94	
Millers Creek	Reach 1	27.02	3.03	105.42	29.78	25.42	
Millers Creek	Reach 1	27.01	2.05	42.42	19.4	18.17	
Millers Creek	Reach 1	27	0.4	1.32	0.04	0.09	

Table 1 - Summary

		Channel Velocity (m/s)			Shear Stress (N/m2)		
	Reach	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**
Millers Creek	Reach 1	0.3	3.08	1.30	1.3	110.1	27.6
River 1	Reach 1	0.95	3.1	2.16	9.6	136.8	64.8

Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

DUFFINS (MILLER'S) CREEK - 5YR

River	Reach	River Sta	Vel Chnl	Shear Chan	Shear LOB	Shear ROB	
			(m/s)	(N/m2)	(N/m2)	(N/m2)	
River 1	Reach-1	20.13	1.74	37.99	8.83	13.12	
River 1	Reach-1	20.12	2.31	69.66	18.82	18.87	
River 1	Reach-1	20.11	2.18	59.24	18.26	17.8	
River 1	Reach-1	20.1	2.23	65.01	17.57	17.58	
River 1	Reach-1	20.09	1.39	21.86	8.95	9.79	
River 1	Reach-1	20.08	2.67	94.26	21.76	21.76	
River 1	Reach-1	20.07	0.96	9.93	2.91	4.34	
River 1	Reach-1	20.06	2.12	56.04			
River 1	Reach-1	20.055					
River 1	Reach-1	20.05	3.1	136.79			
River 1	Reach-1	20.04	2.69	93.56	31.93	31.93	
River 1	Reach-1	20.03	2.57	85.92	18.07	20.82	
River 1	Reach-1	20.025	2.01	48.69	13.15	14.03	
River 1	Reach-1	20.02	2.79	103.58	22.09	22.09	
River 1	Reach-1	20.01	0.95	9.56	3.45	2.85	
River 1	Reach-1	20	2.64	79.26	21.07	20.51	

Table 1 - Summary

		Channel Velocity (m/s)			Shear Stress (N/m2)		
	Reach	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**
Millers Creek	Reach 1	0.3	3.08	1.30	1.3	110.1	27.6
River 1	Reach 1	0.95	3.1	2.16	9.6	136.8	64.8

Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

DUFFINS (MILLER'S) CREEK - 100YR

	Reach	River Station	Vel Chnl	Shear Stress in Main Channel	Shear LOB	Shear ROB
			(m/s)	(N/m2)	(N/m2)	(N/m2)
Millers Creek	Reach 1	27.915	1.5	44.75		
Millers Creek	Reach 1	27.91	1.65	47.03	16.21	16.22
Millers Creek	Reach 1	27.905	2.33	78.25	31.31	32.67
Millers Creek	Reach 1	27.9	0.69	7.92	2.84	2.86
Millers Creek	Reach 1	27.895	1.32	34.74	3.79	3.78
Millers Creek	Reach 1	27.89	1.7	52.6	4.31	4.31
Millers Creek	Reach 1	27.885	0.8	7.07		
Millers Creek	Reach 1	27.88				
Millers Creek	Reach 1	27.875	2.15	71.35		
Millers Creek	Reach 1	27.87	1.94	56.14	22.5	20.7
Millers Creek	Reach 1	27.865	1.4	40.67		
Millers Creek	Reach 1	27.86	0.7	9.72		
Millers Creek	Reach 1	27.855	1.33	37.91		
Millers Creek	Reach 1	27.85	0.78	12.45		
Millers Creek	Reach 1	27.845	1.48	36.75	5.03	5.19
Millers Creek	Reach 1	27.84	1.94	50.97	21.68	22.92
Millers Creek	Reach 1	27.835	1.13	18.69	4.03	4.16
Millers Creek	Reach 1	27.83	2.61	96.74	45.57	44.51
Millers Creek	Reach 1	27.825	0.78	10.02	1.97	0.97
Millers Creek	Reach 1	27.82	1.96	59.17	21.34	21.45
Millers Creek	Reach 1	27.815	0.36	2.09	0.35	0.35
Millers Creek	Reach 1	27.81	1.8	57.28		
Millers Creek	Reach 1	27.805	0.52	4.83	1.47	1.47
Millers Creek	Reach 1	27.8	1.48	43.87		
Millers Creek	Reach 1	27.795	1.34	25.68	7.44	7.63
Millers Creek	Reach 1	27.79	1.66	50.76	1.92	1.92
Millers Creek	Reach 1	27.785	0.84	10.64	2.71	2.71
Millers Creek	Reach 1	27.78	0.9	10.7	4.41	4.42
Millers Creek	Reach 1	27.775	0.26	0.88	0.31	0.32
Millers Creek	Reach 1	27.77	1.19	14.33		
Millers Creek	Reach 1	27.767				
Millers Creek	Reach 1	27.765	1.45	22.98		
Millers Creek	Reach 1	27.76	1.43	26.11	10.08	10.01
Millers Creek	Reach 1	27.755	2.23	67.25	21.52	21.44
Millers Creek	Reach 1	27.75	0.95	9.13		
Millers Creek	Reach 1	27.747				
Millers Creek	Reach 1	27.745	1.08	12.48		
Millers Creek	Reach 1	27.744	0.99	10.78		
Millers Creek	Reach 1	27.742				
Millers Creek	Reach 1	27.741	2.31	78.29		
Millers Creek	Reach 1	27.74	1.12	19.36	4.05	3.99
Millers Creek	Reach 1	27.735	1.58	48.35		
Millers Creek	Reach 1	27.733	1.21	20.74	3.38	3.6

Table 1 - Summary

	Channel Velocity (m/s)			Shear Stress (N/m2)		
Reach	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**
Reach 1	0.26	3.96	1.65	0.9	149.9	37.4
River 1	0.45	4.06	2.43	1.9	195.2	78.4

Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

DUFFINS (MILLER'S) CREEK - 100YR

	Reach	River Station	Vel Chnl (m/s)	Shear Stress in Main Channel (N/m2)	Shear LOB (N/m2)	Shear ROB (N/m2)
Millers Creek	Reach 1	27.7325				
Millers Creek	Reach 1	27.732	1.9	61.44		
Millers Creek	Reach 1	27.73	1.36	26.23	5.18	5.17
Millers Creek	Reach 1	27.725	1.77	41.85	17.4	17.44
Millers Creek	Reach 1	27.72	0.86	8.95	4.04	4.21
Millers Creek	Reach 1	27.717				
Millers Creek	Reach 1	27.715	2.98	110.5	33.79	62.9
Millers Creek	Reach 1	27.71	1.57	38.16	5.57	5.8
Millers Creek	Reach 1	27.705	1.27	22.09	6.83	6.84
Millers Creek	Reach 1	27.7	1.29	23.28	8.24	8.24
Millers Creek	Reach 1	27.699	0.86	11.13	1.42	1.42
Millers Creek	Reach 1	27.6975				
Millers Creek	Reach 1	27.695	1.06	17.88	0.83	0.83
Millers Creek	Reach 1	27.69	0.91	10.93	5.19	5.23
Millers Creek	Reach 1	27.685	0.83	9.16	4.19	4.2
Millers Creek	Reach 1	27.683	0.6	4.37	1.46	1.17
Millers Creek	Reach 1	27.6825				
Millers Creek	Reach 1	27.682	0.63	4.94	1.55	1.2
Millers Creek	Reach 1	27.68	0.92	11.91	4.88	4.62
Millers Creek	Reach 1	27.675	0.98	13.88	4.89	9.71
Millers Creek	Reach 1	27.67	1.66	44.1	9.42	9.42
Millers Creek	Reach 1	27.665	0.99	12.53	5.86	5.87
Millers Creek	Reach 1	27.66	1.15	16.19	5.37	5.37
Millers Creek	Reach 1	27.655	0.98	11.48	3.2	3.21
Millers Creek	Reach 1	27.652				
Millers Creek	Reach 1	27.65	1.03	12.71	2.95	2.95
Millers Creek	Reach 1	27.645	1.67	35.52	0.8	1.05
Millers Creek	Reach 1	27.64	1.47	24.96	9.01	4.06
Millers Creek	Reach 1	27.635	2.27	66.27	9.47	9.46
Millers Creek	Reach 1	27.63	0.95	11.27	1.84	2.2
Millers Creek	Reach 1	27.6275				
Millers Creek	Reach 1	27.625	1.11	15.84	1.69	1.69
Millers Creek	Reach 1	27.62	0.95	10.38	3.11	3.43
Millers Creek	Reach 1	27.615	0.89	8.83	2.39	2.65
Millers Creek	Reach 1	27.61	2.37	69.96	10.66	10.64
Millers Creek	Reach 1	27.605	1.35	24.04		
Millers Creek	Reach 1	27.6	1.26	18.83	5.03	4.69
Millers Creek	Reach 1	27.595	1.32	20.85	4.02	4.03
Millers Creek	Reach 1	27.59	2.12	54.09	13.31	12.66
Millers Creek	Reach 1	27.585	1.09	14.14	2.84	2.84
Millers Creek	Reach 1	27.5825				
Millers Creek	Reach 1	27.58	2.37	66.1	10.77	13.09

Table 1 - Summary

	Channel Velocity (m/s)			Shear Stress (N/m2)		
Reach	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**
Reach 1	0.26	3.96	1.65	0.9	149.9	37.4
River 1	0.45	4.06	2.43	1.9	195.2	78.4

Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

DUFFINS (MILLER'S) CREEK - 100YR

	Reach	River Station	Vel Chnl	Shear Stress in Main Channel	Shear LOB	Shear ROB
			(m/s)	(N/m2)	(N/m2)	(N/m2)
Millers Creek	Reach 1	27.575	1.5	25.57	5.08	6.19
Millers Creek	Reach 1	27.57	2.34	68.58	16.15	16.06
Millers Creek	Reach 1	27.565	1.22	17.8		
Millers Creek	Reach 1	27.562				
Millers Creek	Reach 1	27.56	1.31	21.18		
Millers Creek	Reach 1	27.555	2.14	61.13	17.51	17.51
Millers Creek	Reach 1	27.55	1.35	19.96	8.99	7.76
Millers Creek	Reach 1	27.545	1.44	23.39	8.13	8.73
Millers Creek	Reach 1	27.54	2.32	64.12	27.28	27.5
Millers Creek	Reach 1	27.535	1.7	33.97	13.76	13.69
Millers Creek	Reach 1	27.53	1.46	25.15	8.51	8.48
Millers Creek	Reach 1	27.525	1.74	37.09	8.64	8.73
Millers Creek	Reach 1	27.52	1.73	32.69	15.04	14.51
Millers Creek	Reach 1	27.515	1.9	39.96	14.87	14.92
Millers Creek	Reach 1	27.51	1.86	38.96	12.32	12.24
Millers Creek	Reach 1	27.505	0.93	8.69		
Millers Creek	Reach 1	27.502				
Millers Creek	Reach 1	27.5	0.95	9.15		
Millers Creek	Reach 1	27.495	2.71	77.83	39.06	34.2
Millers Creek	Reach 1	27.49	1.45	21.91	9.21	9.85
Millers Creek	Reach 1	27.485	1.94	39.76	14.87	15.82
Millers Creek	Reach 1	27.48	2.1	47.23	16.79	16.95
Millers Creek	Reach 1	27.475	1.4	20.55	6.94	7.03
Millers Creek	Reach 1	27.47	2.79	78.71	33.5	26.31
Millers Creek	Reach 1	27.465	2.34	57.77	22	20.83
Millers Creek	Reach 1	27.46	2.11	48.4	15.14	15.49
Millers Creek	Reach 1	27.455	2.76	99.55	8.78	8.99
Millers Creek	Reach 1	27.45	1.23	16.33		
Millers Creek	Reach 1	27.447				
Millers Creek	Reach 1	27.445	1.2	15.45		
Millers Creek	Reach 1	27.44	1.88	39.3	13.11	13.09
Millers Creek	Reach 1	27.435	1.63	28.8	8.64	8.82
Millers Creek	Reach 1	27.43	1.64	28.94	7.82	8.05
Millers Creek	Reach 1	27.425	1.68	30.02	7.72	7.54
Millers Creek	Reach 1	27.42	1.01	9.38		
Millers Creek	Reach 1	27.417				
Millers Creek	Reach 1	27.415	0.93	7.83		
Millers Creek	Reach 1	27.41	3.64	142.88	43.3	46.67
Millers Creek	Reach 1	27.405	2.39	60.75	19.01	18.61
Millers Creek	Reach 1	27.4	2.96	91.4	39.9	42.49
Millers Creek	Reach 1	27.395	2.1	46.08	19.58	19.84
Millers Creek	Reach 1	27.39	2	43.05	14.63	14.59
Millers Creek	Reach 1	27.385	1.79	35	9.34	9.18
Millers Creek	Reach 1	27.38	1.65	29.8	6.5	6.42
Millers Creek	Reach 1	27.375	1.47	23.74	3.86	3.94
Millers Creek	Reach 1	27.37	1.35	20.23	2.57	2.55
Millers Creek	Reach 1	27.365	1.24	17.3	1.63	1.65
Millers Creek	Reach 1	27.36	1.18	15.71	0.85	0.85
Millers Creek	Reach 1	27.355	2.75	85.42	19.73	19.16

Table 1 - Summary

	Channel Velocity (m/s)			Shear Stress (N/m2)		
Reach	Min	Max	Avg	Min	Max	Avg
Reach 1	0.26	3.96	1.65	0.9	149.9	37.4
River 1	0.45	4.06	2.43	1.9	195.2	78.4

Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

DUFFINS (MILLER'S) CREEK - 100YR

	Reach	River Station	Vel Chnl	Shear Stress in Main Channel	Shear LOB	Shear ROB
			(m/s)	(N/m2)	(N/m2)	(N/m2)
Millers Creek	Reach 1	27.35	2.59	92.6		
Millers Creek	Reach 1	27.347				
Millers Creek	Reach 1	27.345	1.61	30.74		
Millers Creek	Reach 1	27.34	2.59	69.84	30.83	32.65
Millers Creek	Reach 1	27.335	2.49	66.11	26.79	27.21
Millers Creek	Reach 1	27.33	1.81	34.32	10.06	15.09
Millers Creek	Reach 1	27.325	1.86	32.76	13.15	10.24
Millers Creek	Reach 1	27.32	2.11	42.65	13.16	10.96
Millers Creek	Reach 1	27.315	2.38	55.1	20.36	13.1
Millers Creek	Reach 1	27.31	3.01	94.44	31.82	25.93
Millers Creek	Reach 1	27.305	2.47	63.38	18.11	20.18
Millers Creek	Reach 1	27.3	2.02	42.83	11.1	12.16
Millers Creek	Reach 1	27.295	2.2	52.68	9.68	10.12
Millers Creek	Reach 1	27.29	1.07	10.87	4.58	4.74
Millers Creek	Reach 1	27.287				
Millers Creek	Reach 1	27.285	1.22	14.25	5.6	5.66
Millers Creek	Reach 1	27.28	1.73	26.45	8.58	7.85
Millers Creek	Reach 1	27.275	1.86	30.63	9.78	10.62
Millers Creek	Reach 1	27.27	1.39	16.4		
Millers Creek	Reach 1	27.267				
Millers Creek	Reach 1	27.265	1.58	21.81		
Millers Creek	Reach 1	27.26	1.62	23.99	7.89	6.45
Millers Creek	Reach 1	27.24	1.71	28.97	11.07	12.93
Millers Creek	Reach 1	27.23	3.53	137.65	78.49	56.05
Millers Creek	Reach 1	27.22	1.26	14.45	7.17	6.02
Millers Creek	Reach 1	27.21	1.33	15.12	5.85	5.97
Millers Creek	Reach 1	27.2	1.38	16.97	12.9	
Millers Creek	Reach 1	27.195				
Millers Creek	Reach 1	27.19	1.38	19.22	3	1.11
Millers Creek	Reach 1	27.18	1.19	12.7	3.59	4.76
Millers Creek	Reach 1	27.17	1.01	8.52	3.51	4.14
Millers Creek	Reach 1	27.16	1.58	20.16		
Millers Creek	Reach 1	27.155				
Millers Creek	Reach 1	27.15	2.39	57.49		
Millers Creek	Reach 1	27.14	1.97	36.92	24.37	12.96
Millers Creek	Reach 1	27.13	1.79	31.13	10.92	13.18
Millers Creek	Reach 1	27.122	1.8	31.55		
Millers Creek	Reach 1	27.1				
Millers Creek	Reach 1	27.07	1.79	31.11		
Millers Creek	Reach 1	27.06	1.79	30.05	14.31	8.37
Millers Creek	Reach 1	27.05	2.89	85.68	39.4	51.1
Millers Creek	Reach 1	27.04	2.86	83.95	46.52	41.29
Millers Creek	Reach 1	27.03	3.47	119.07	34.95	48.98
Millers Creek	Reach 1	27.02	3.49	119.68	43.88	40.09
Millers Creek	Reach 1	27.01	3.96	149.87	71.2	35.27
Millers Creek	Reach 1	27	0.61	2.92	0.5	0.49

Table 1 - Summary

	Channel Velocity (m/s)			Shear Stress (N/m2)		
Reach	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**
Reach 1	0.26	3.96	1.65	0.9	149.9	37.4
River 1	0.45	4.06	2.43	1.9	195.2	78.4

Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

DUFFINS (MILLER'S) CREEK - 100YR

	Reach	River Station	Vel Chnl	Shear Stress in Main Channel	Shear LOB	Shear ROB
			(m/s)	(N/m2)	(N/m2)	(N/m2)
River-1	Reach-1	20.13	2.09	50.18	15.31	21.38
River-1	Reach-1	20.12	2.75	88.37	31.56	31.66
River-1	Reach-1	20.11	3.07	105.57	39.94	34.96
River-1	Reach-1	20.1	2.77	90.86	31.69	31.71
River-1	Reach-1	20.09	1.89	35.54	16.31	17.8
River-1	Reach-1	20.08	1.73	29.33	4.31	9.98
River-1	Reach-1	20.07	0.51	2.22	0.92	0.99
River-1	Reach-1	20.06	0.45	1.92	1.12	1.19
River-1	Reach-1	20.055				
River-1	Reach-1	20.05	4.06	195.22		
River-1	Reach-1	20.04	3.67	151.84	58.57	59.84
River-1	Reach-1	20.03	3.43	131.58	30.98	49.47
River-1	Reach-1	20.025	2.57	69.08	25.15	26.16
River-1	Reach-1	20.02	3.36	126.6	40.82	43.09
River-1	Reach-1	20.01	1.18	13.36	5.06	4.3
River-1	Reach-1	20	2.91	84	43.54	30.85

Table 1 - Summary

	Channel Velocity (m/s)			Shear Stress (N/m2)		
Reach	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**
Reach 1	0.26	3.96	1.65	0.9	149.9	37.4
River 1	0.45	4.06	2.43	1.9	195.2	78.4

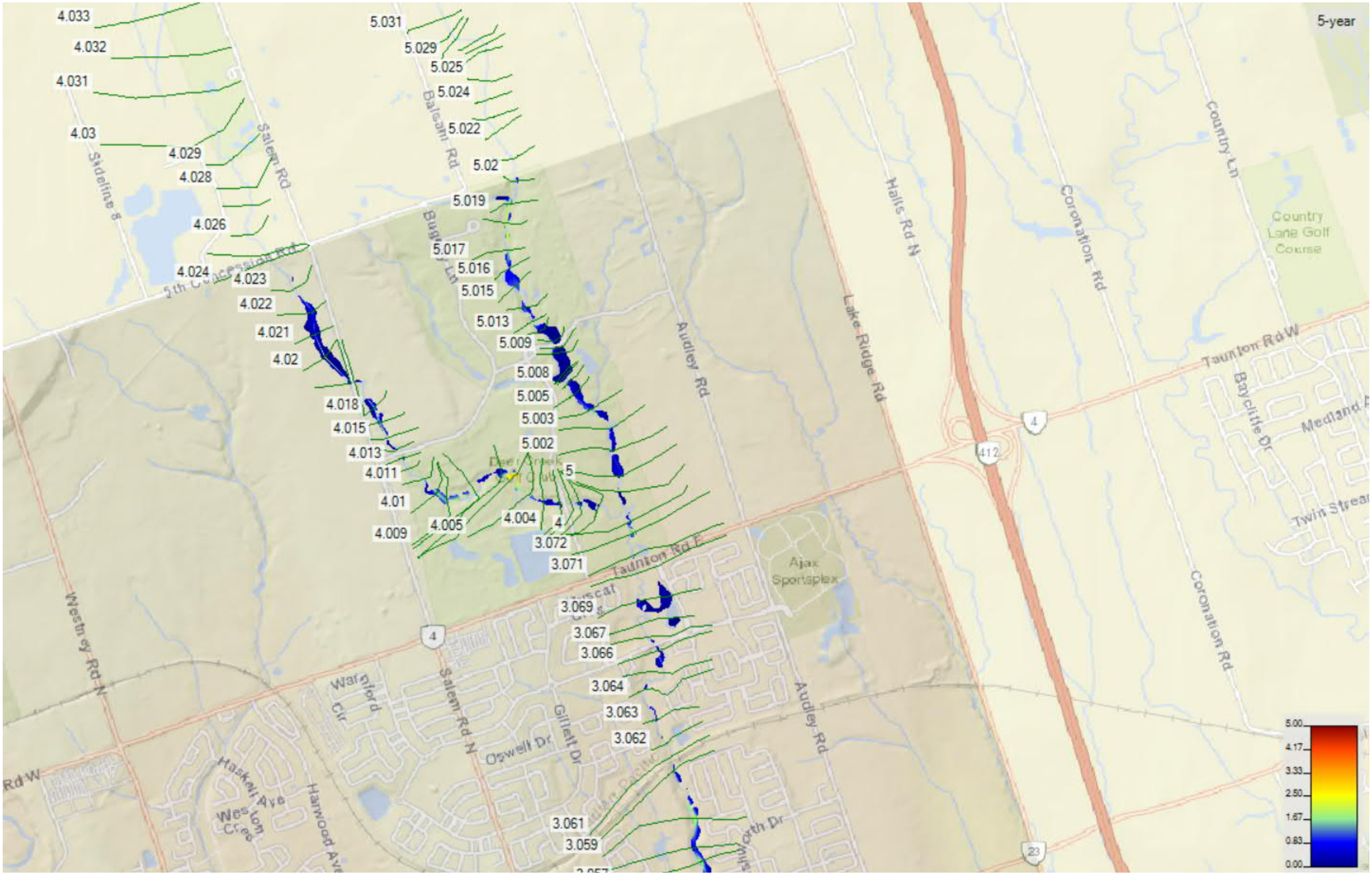
Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

Velocity & Shear Profiles

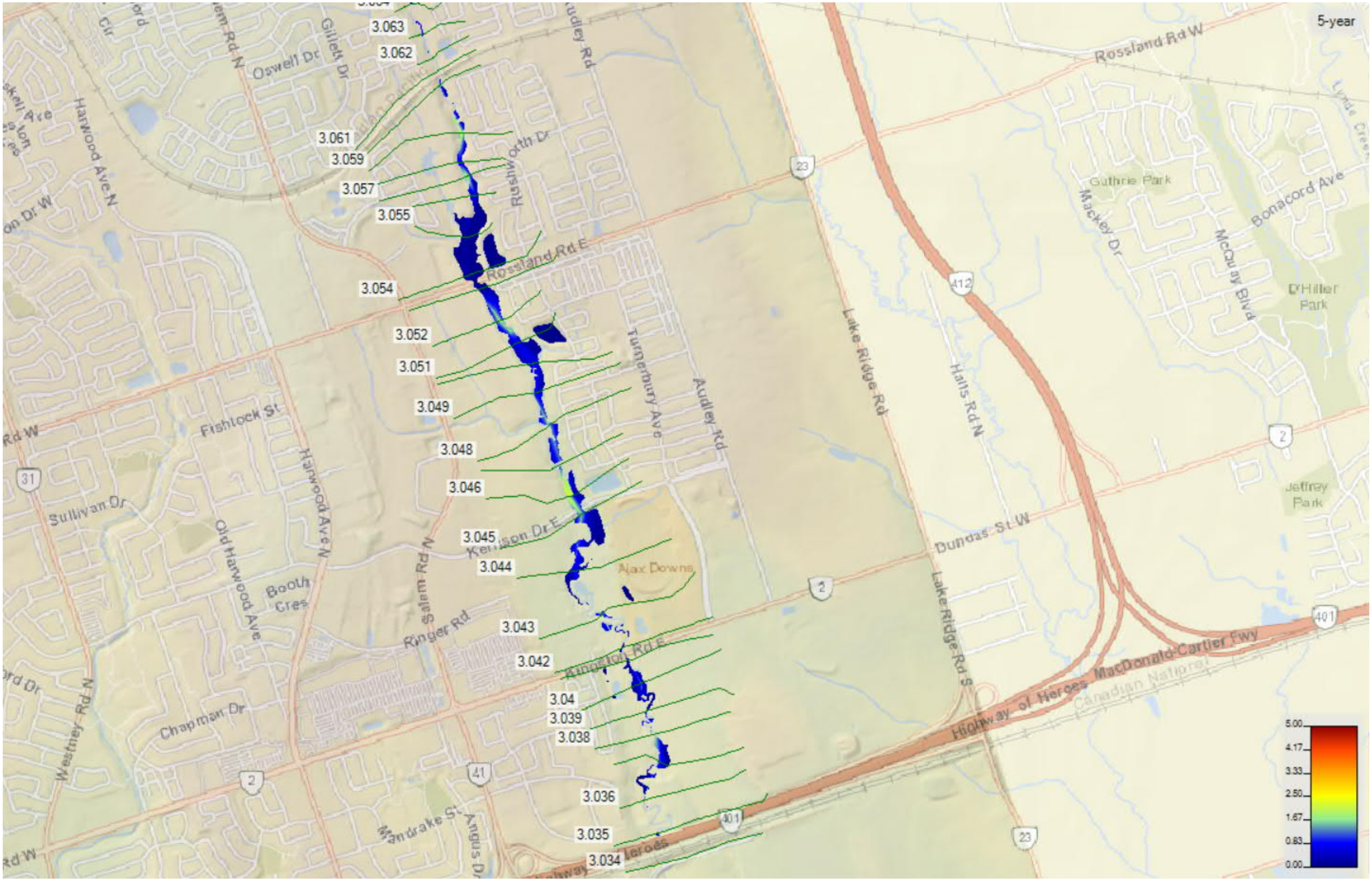
Carruthers' Creek

5yr & 100yr

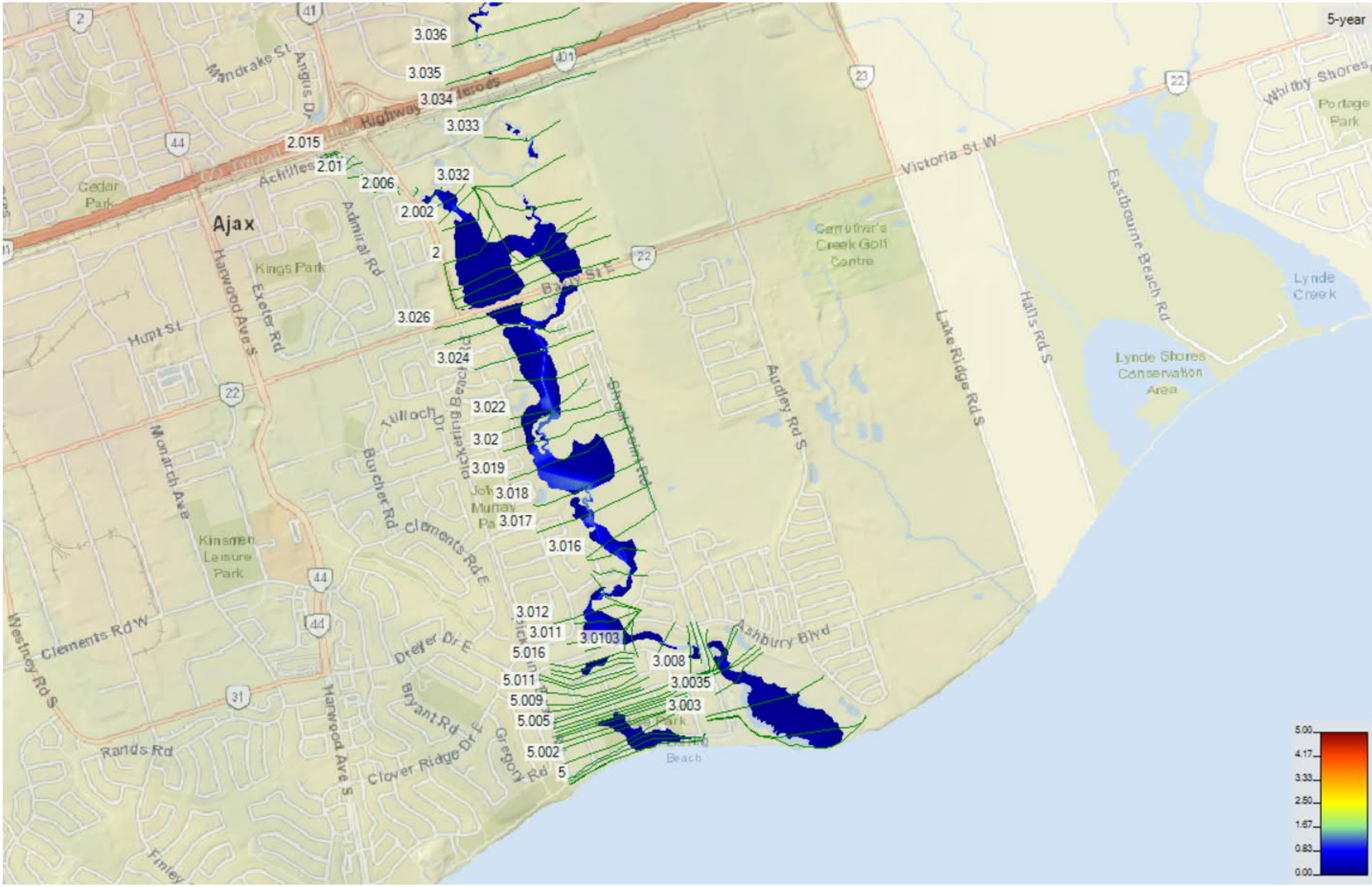
Velocity



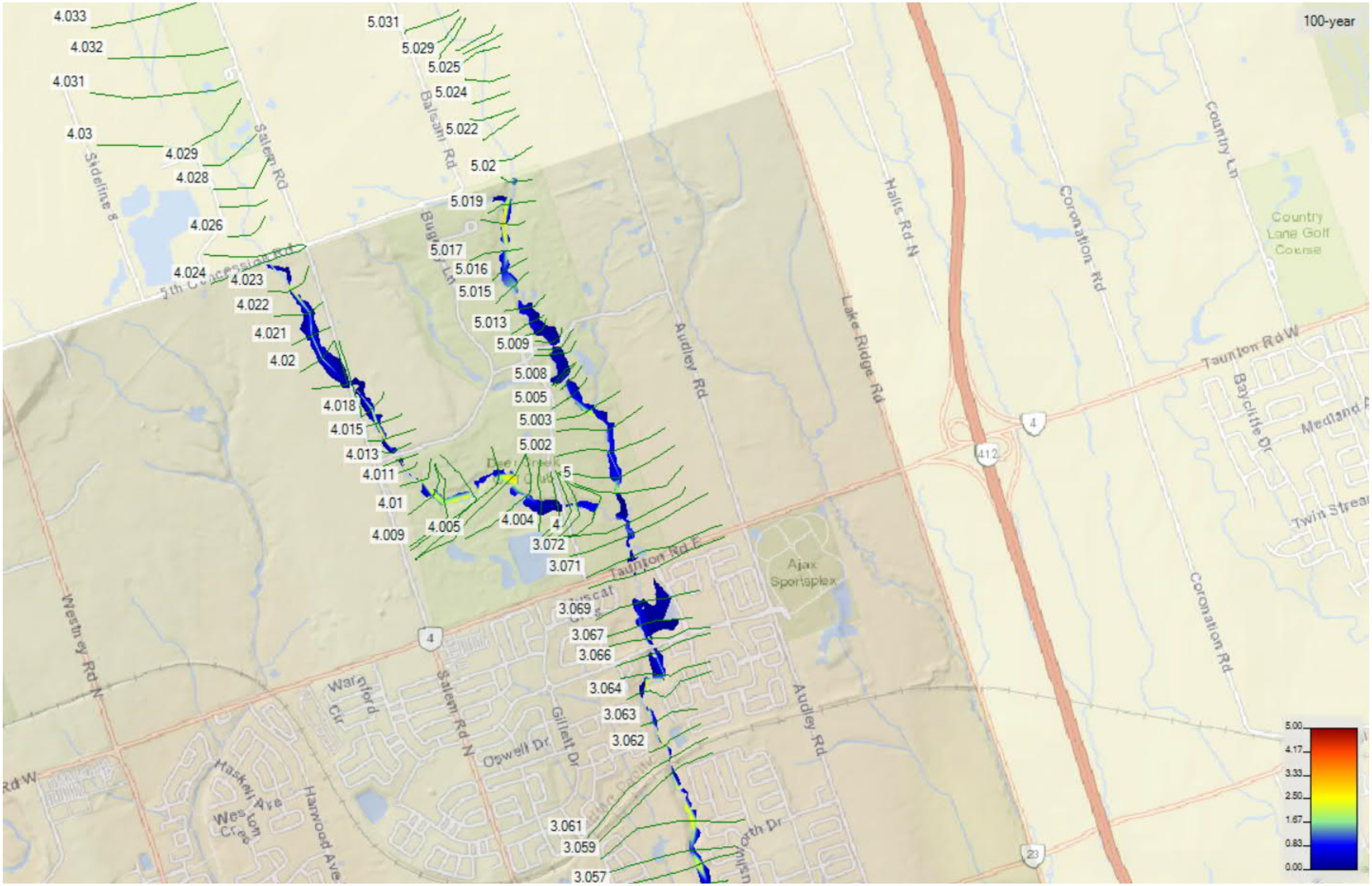
5-year velocity mapping - Carruthers Creek - Section 1



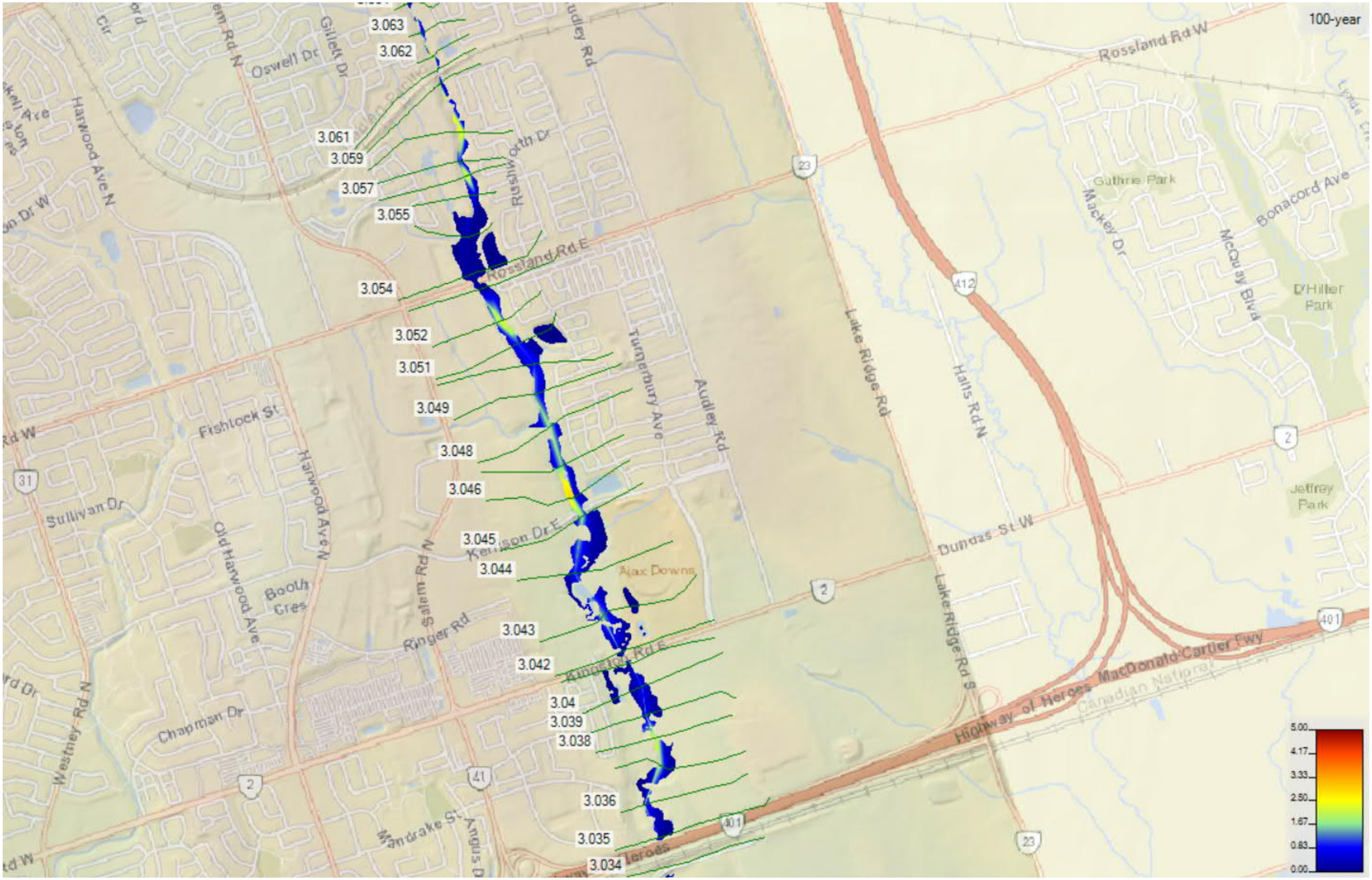
5-year velocity mapping - Carruthers Creek - Section 2



5-year velocity mapping - Carruthers Creek - Section 3



100-year velocity mapping - Carruthers Creek - Section 1



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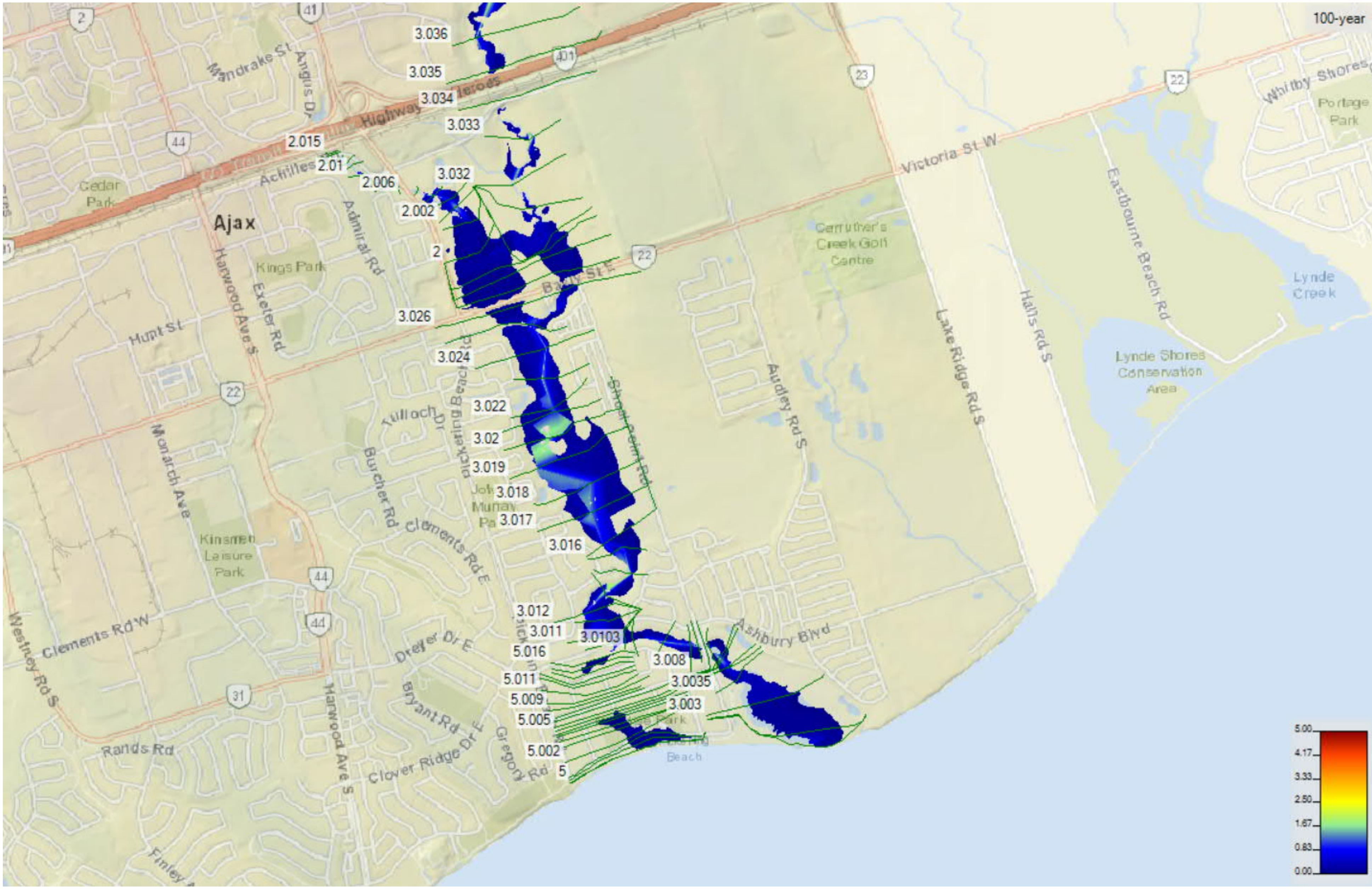
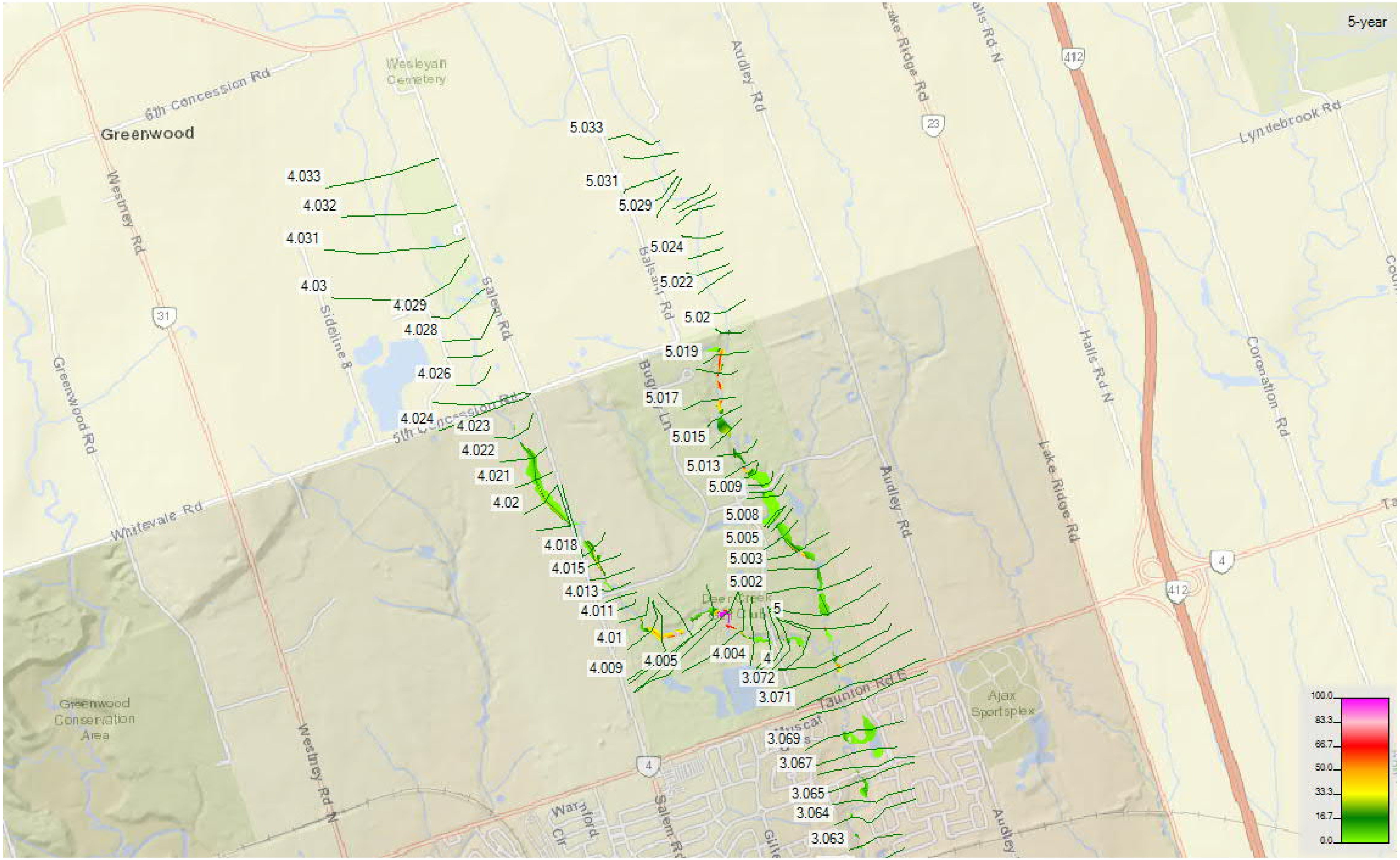
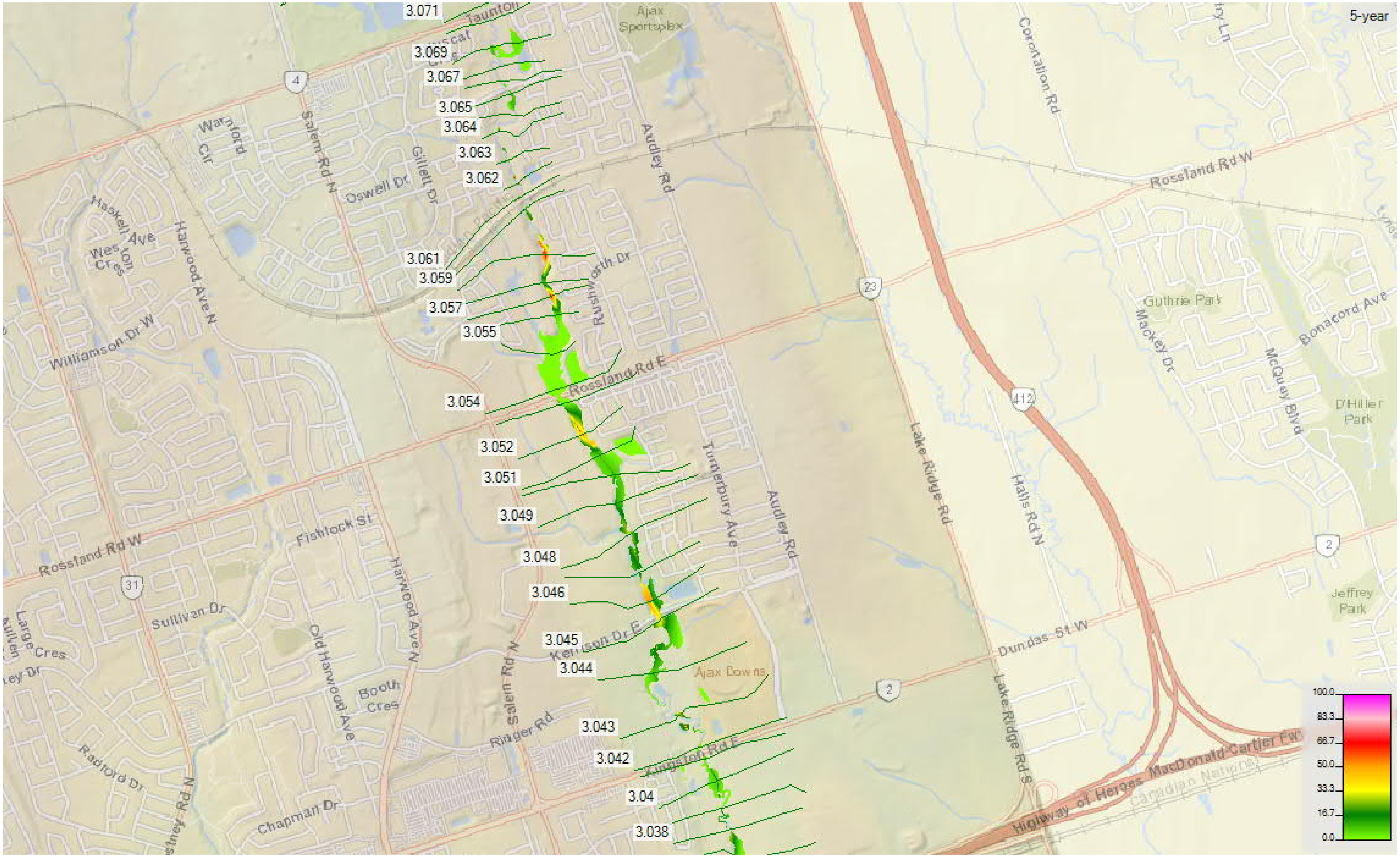


100-year velocity mapping - Carruthers Creek - Section 3

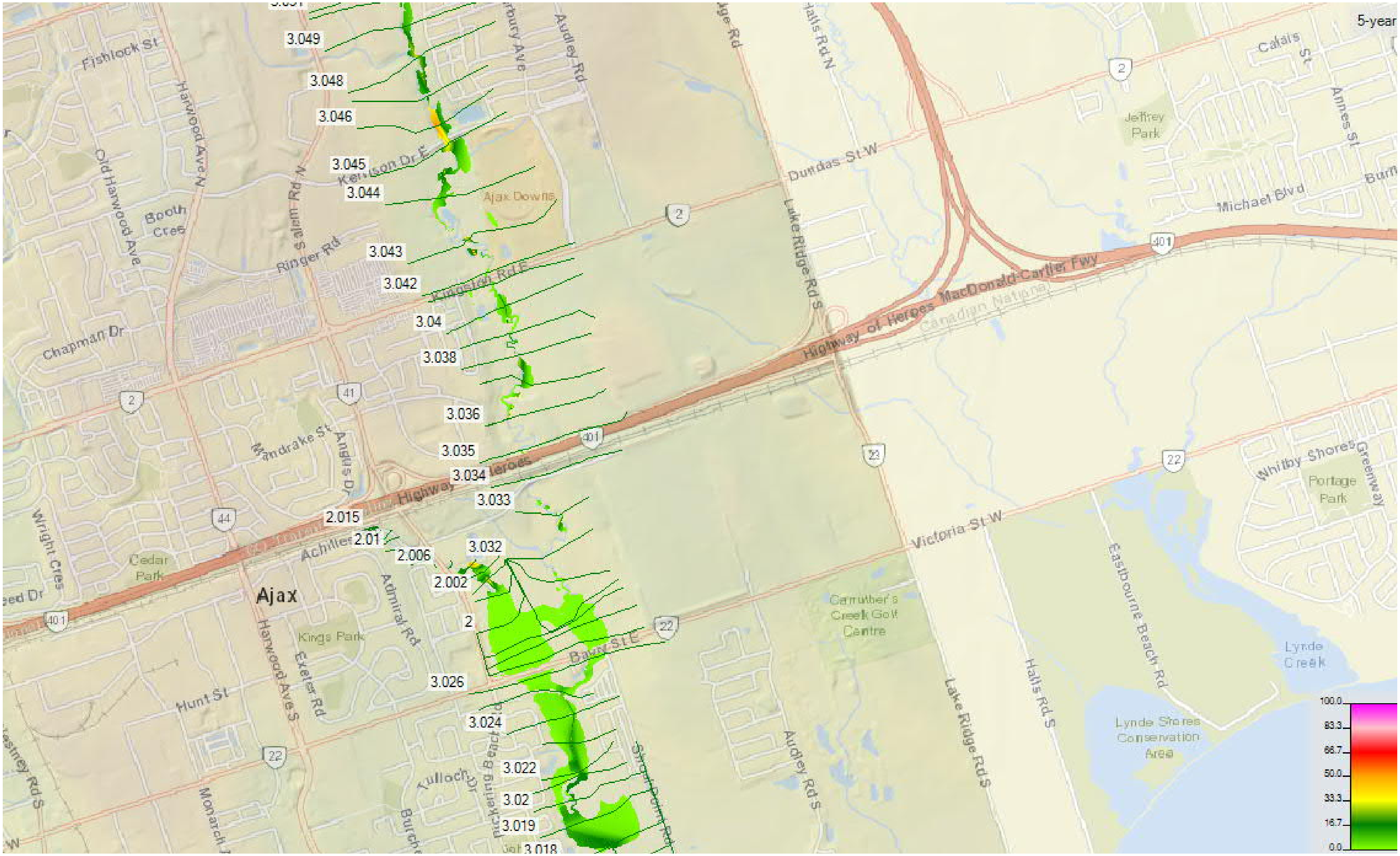
Shear



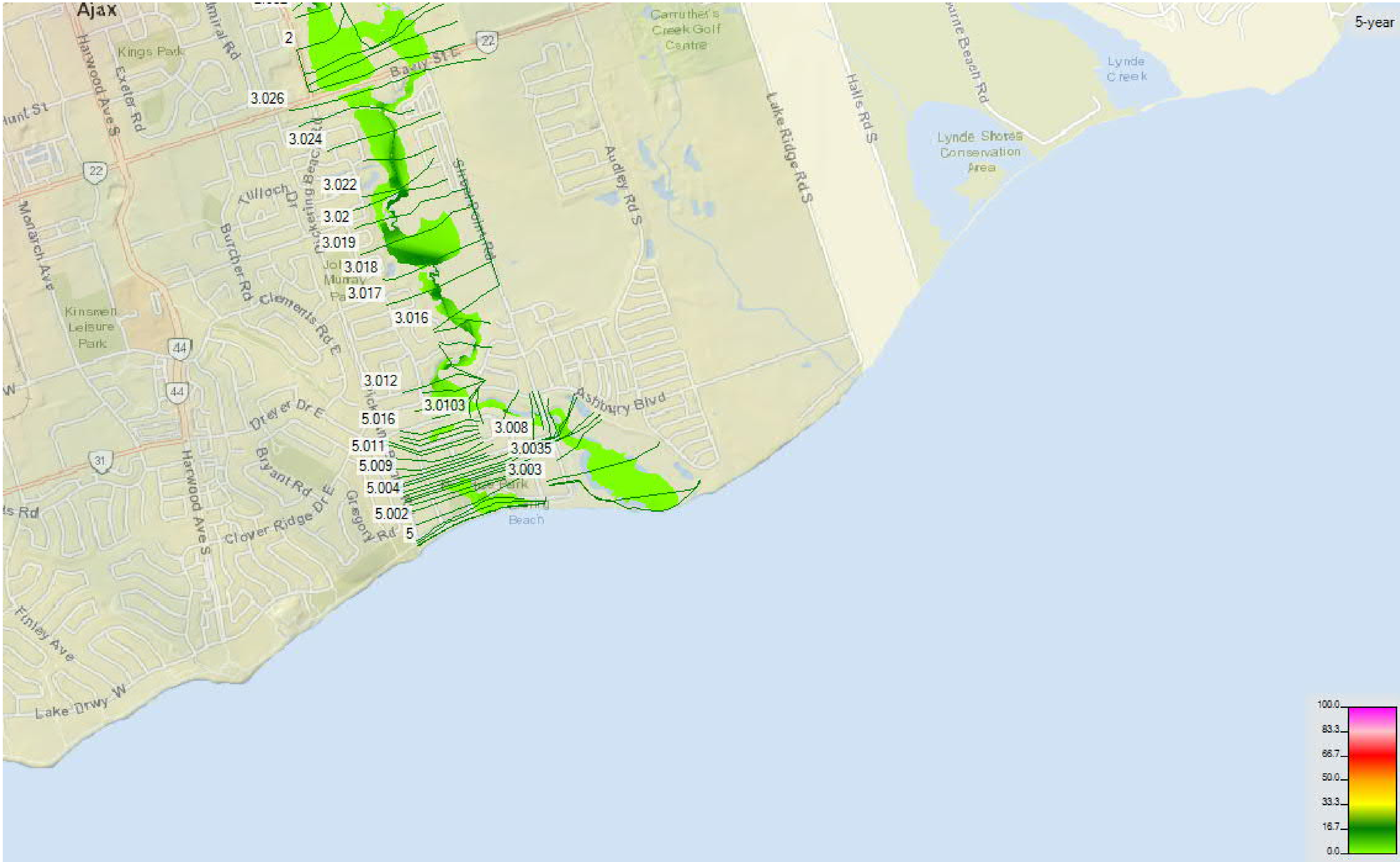
5-year shear mapping - Carruthers Creek - Section 1



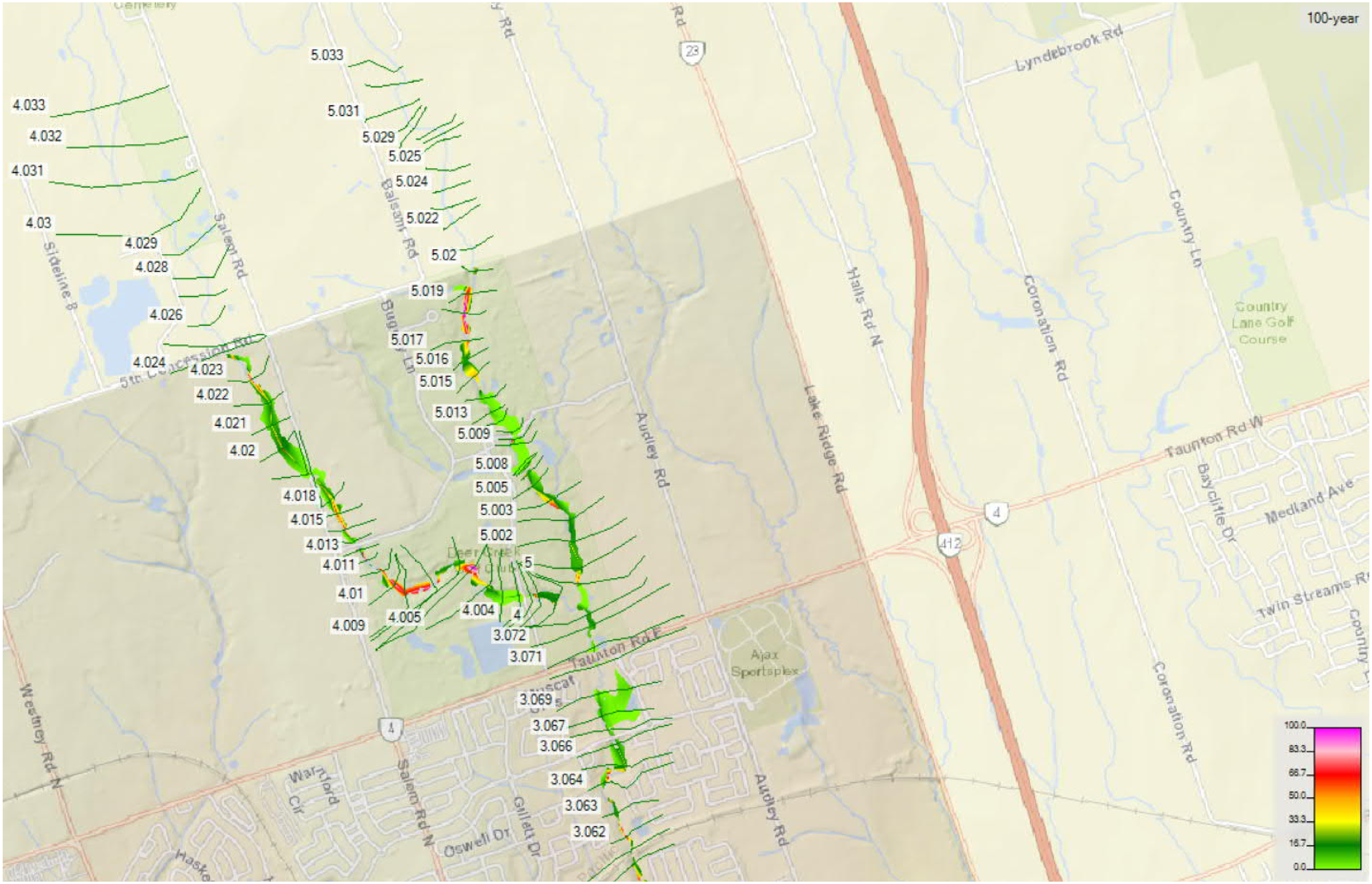
5-year shear mapping - Carruthers Creek - Section 2



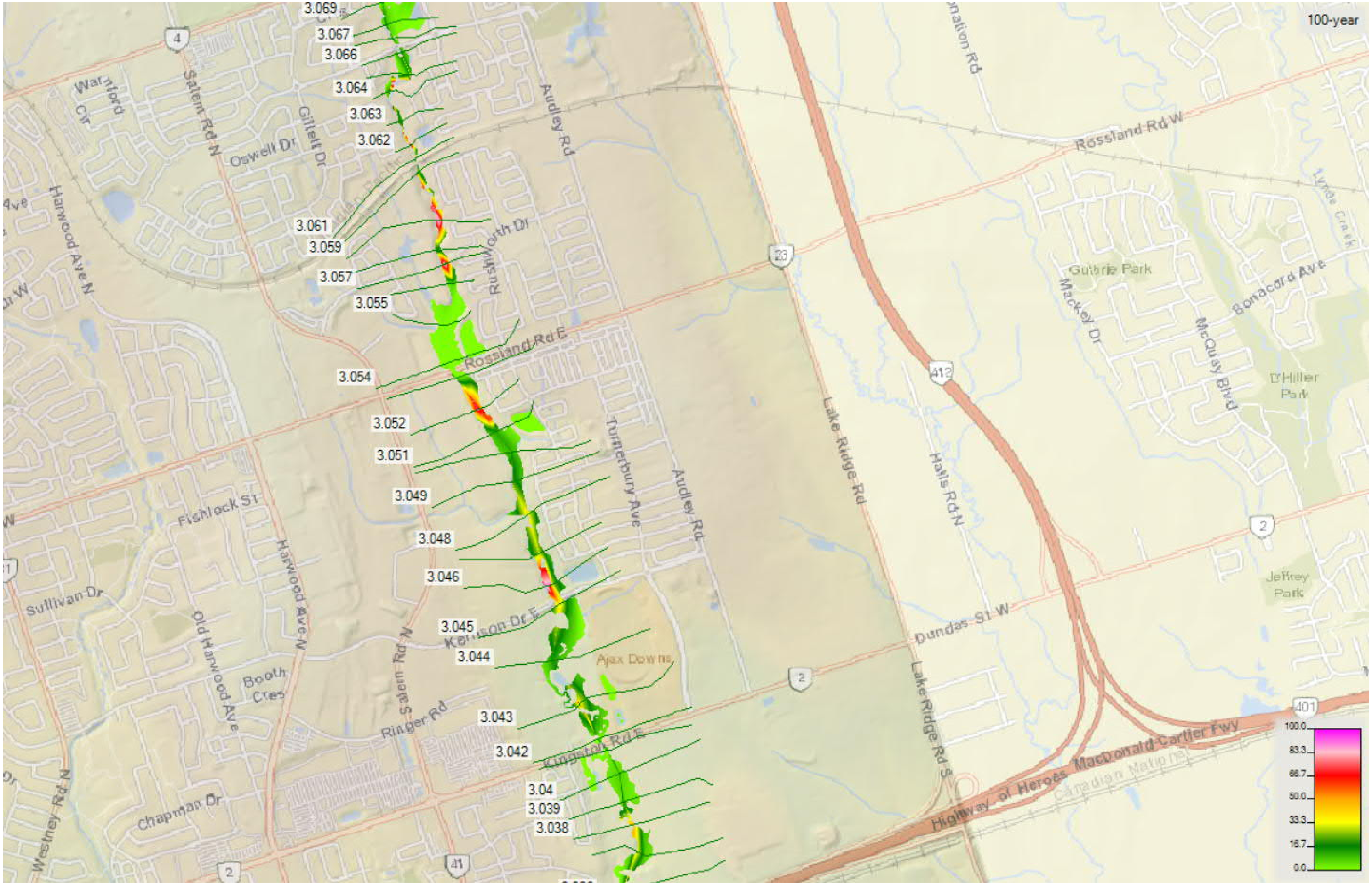
5-year shear mapping - Carruthers Creek - Section 3



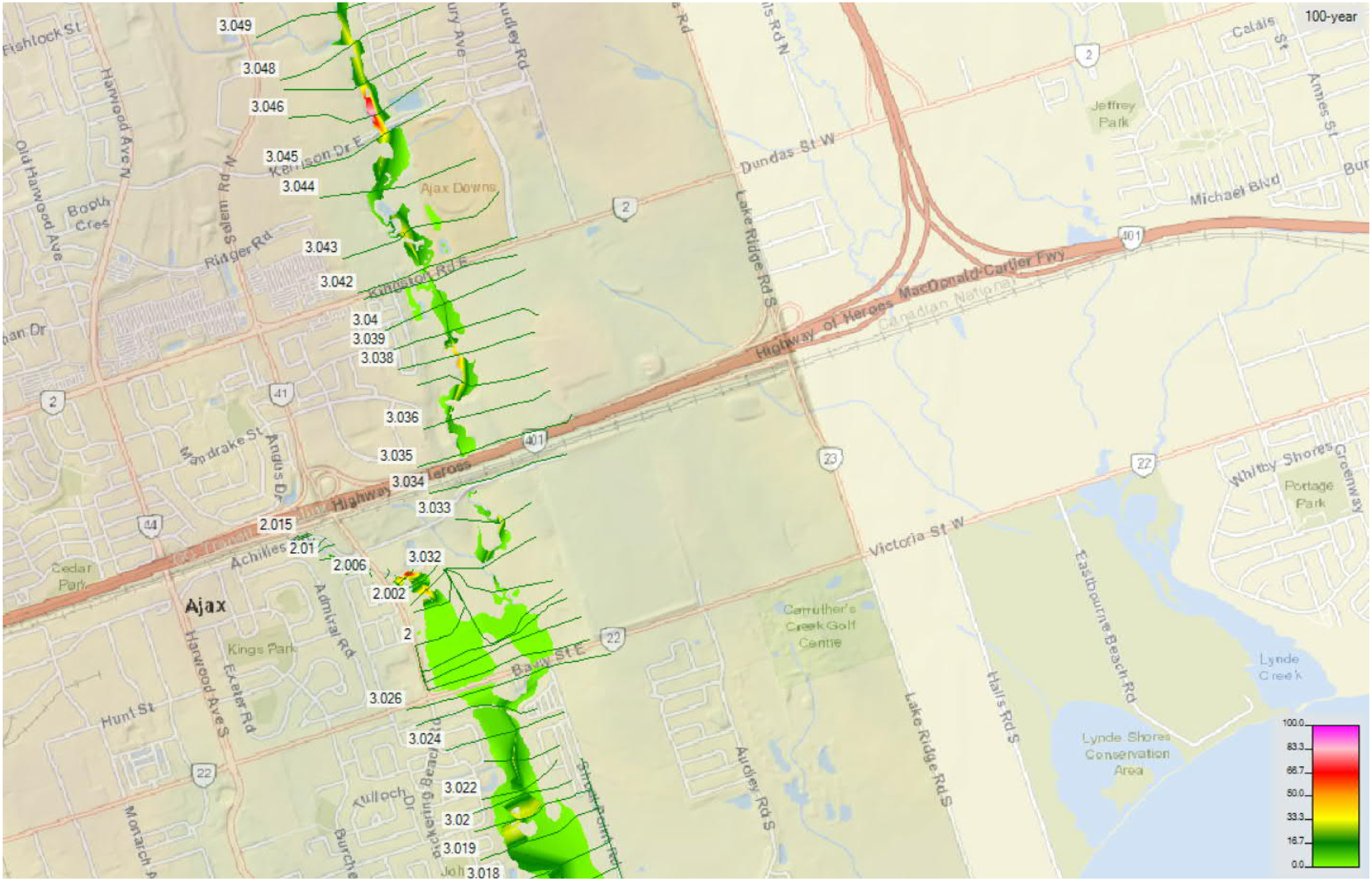
5-year shear mapping - Carruthers Creek - Section 4



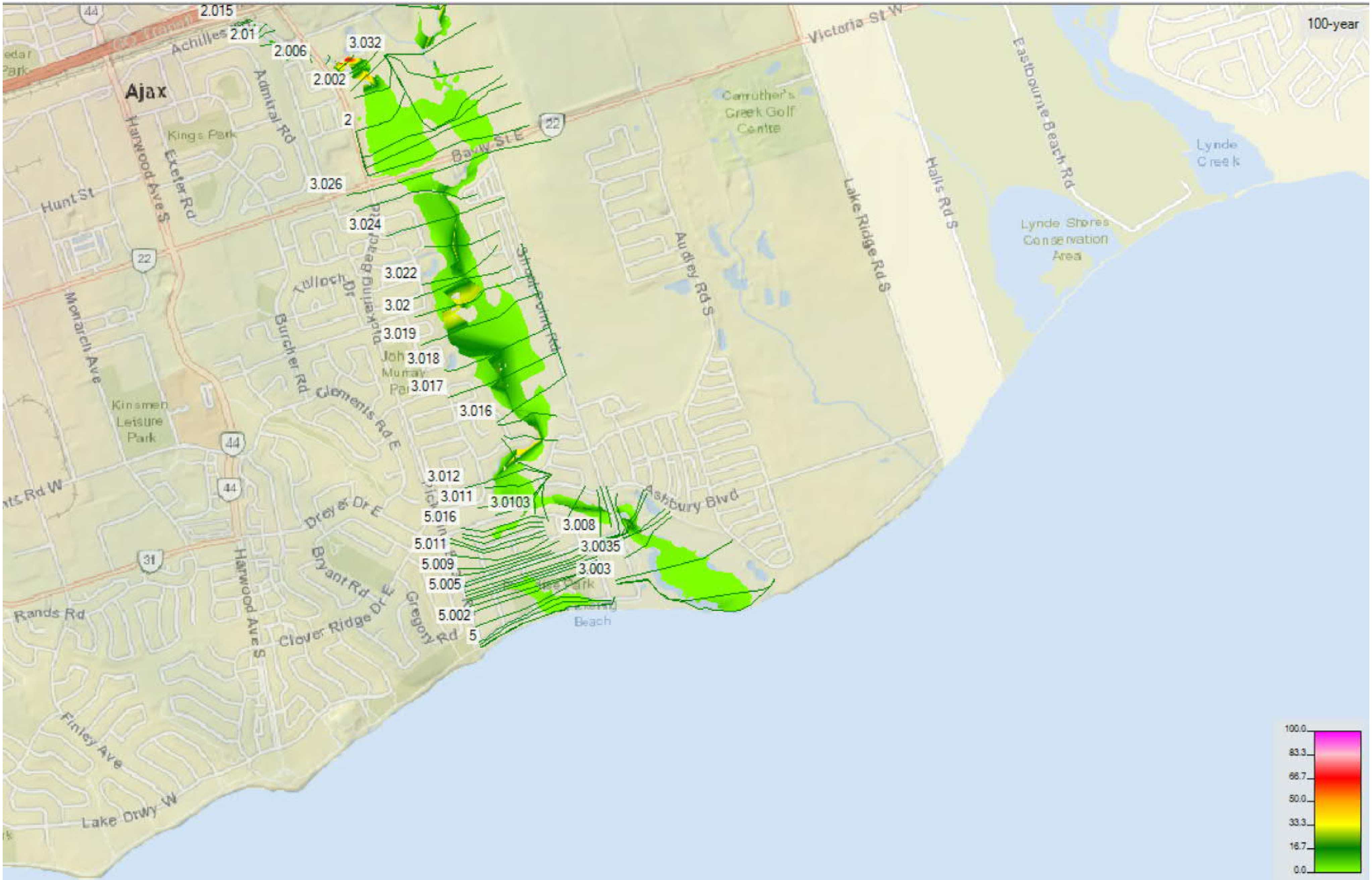
100-year shear mapping - Carruthers Creek - Section 1



100-year shear mapping - Carruthers Creek - Section 2



100-year shear mapping - Carruthers Creek - Section 3



100-year shear mapping - Carruthers Creek - Section 4

CARRUTHERS CREEK - 5YEAR

River	Reach	River Station	Channel Velocity	Shear Stress in Main Channel	Shear LOB	Shear ROB
			(m/s)	(N/m2)	(N/m2)	(N/m2)
Carruthers Spill	Carruthers Spill	5.016	0	0	0	0
Carruthers Spill	Carruthers Spill	5.015	0.01	0.01	0.01	0.01
Carruthers Spill	Carruthers Spill	5.014	0.15	3.42		
Carruthers Spill	Carruthers Spill	5.013	0.77	95.11		
Carruthers Spill	Carruthers Spill	5.012	0.27	8.4		
Carruthers Spill	Carruthers Spill	5.011	0.27	9.44		
Carruthers Spill	Carruthers Spill	5.01	0.1	1.31		
Carruthers Spill	Carruthers Spill	5.009	0.06	0.4		
Carruthers Spill	Carruthers Spill	5.008	0.46	47.83		
Carruthers Spill	Carruthers Spill	5.007	0.21	5.57		
Carruthers Spill	Carruthers Spill	5.006	0.09	0.88		
Carruthers Spill	Carruthers Spill	5.005	0.02	0.07		
Carruthers Spill	Carruthers Spill	5.004	0.01	0.01		
Carruthers Spill	Carruthers Spill	5.0035	0.01	0.01		
Carruthers Spill	Carruthers Spill	5.003	0.02	0.03		
Carruthers Spill	Carruthers Spill	5.0025	0.04	0.12		
Carruthers Spill	Carruthers Spill	5.002	0.21	3.68		
Carruthers Spill	Carruthers Spill	5.001	0.02	0.02		
Carruthers Spill	Carruthers Spill	5.0005	0.02	0.04		
Carruthers Spill	Carruthers Spill	5	0.08	0.95		
Carruthers Spill	Carruthers Spill	0.2	0.03	0.05		
Carruthers Spill	Carruthers Spill	0.1	0	0	0	0

Table 1 - Summary

	Channel Velocity (m/s)			Shear Stress (N/m2)		
Reach	Min	Max	Avg	Min	Max	Avg
Carruthers Spill	0	0.77	0.13	0.0	95.1	8.1
Reach 11	0.42	3.92	1.56	2.8	187.0	42.4
Reach 2	0.06	2.55	1.28	0.0	80.5	31.7
Reach 8	0.05	2.24	1.04	0.0	81.1	28.5
Reach 9	0.11	2.29	1.19	0.1	74.3	23.9
Reach 1	0.03	1.43	0.69	0.0	26.6	7.8

Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

CARRUTHERS CREEK - 5YEAR

River	Reach	River Station	Channel Velocity	Shear Stress in Main Channel	Shear LOB	Shear ROB
			(m/s)	(N/m2)	(N/m2)	(N/m2)
Carruthers Creek	Reach 11	4.033	0.51	5.34	0.59	0.59
Carruthers Creek	Reach 11	4.032	0.69	7.65		
Carruthers Creek	Reach 11	4.031	1.25	29.04		
Carruthers Creek	Reach 11	4.03	0.42	2.82		
Carruthers Creek	Reach 11	4.029	1.92	62.23		
Carruthers Creek	Reach 11	4.028	0.7	7.11		
Carruthers Creek	Reach 11	4.027	1.79	43.06	16.1	16.09
Carruthers Creek	Reach 11	4.026	2.1	70.61		
Carruthers Creek	Reach 11	4.025	0.92	10.01		
Carruthers Creek	Reach 11	4.0245				
Carruthers Creek	Reach 11	4.024	1.35	24.24		
Carruthers Creek	Reach 11	4.023	1.86	53.19		
Carruthers Creek	Reach 11	4.022	0.99	12.1	3.06	2.87
Carruthers Creek	Reach 11	4.021	0.9	14.32	2.07	3.69
Carruthers Creek	Reach 11	4.02	2.06	61.83		
Carruthers Creek	Reach 11	4.019	1.58	31.13	14.39	15.64
Carruthers Creek	Reach 11	4.0185				
Carruthers Creek	Reach 11	4.018	1.08	14.62		
Carruthers Creek	Reach 11	4.017	1.78	45.03	10.31	10.3
Carruthers Creek	Reach 11	4.016	1.81	41.67	15.37	15.59
Carruthers Creek	Reach 11	4.015	1.98	64.79		
Carruthers Creek	Reach 11	4.014	1.17	13.42		
Carruthers Creek	Reach 11	4.0135				
Carruthers Creek	Reach 11	4.013	2.77	100		
Carruthers Creek	Reach 11	4.012	2.03	64.79		
Carruthers Creek	Reach 11	4.011	1.53	36.31		
Carruthers Creek	Reach 11	4.01	1.74	47.47	22.34	22.35
Carruthers Creek	Reach 11	4.009	1.51	48.55	21.09	37.64
Carruthers Creek	Reach 11	4.008	2.13	62.1	20.03	20.6
Carruthers Creek	Reach 11	4.007	0.98	14.38	4.3	4.3
Carruthers Creek	Reach 11	4.006	3.92	186.97	80.58	92.13
Carruthers Creek	Reach 11	4.005	1.92	51.24	14.16	14.15
Carruthers Creek	Reach 11	4.004	0.46	2.94	0.77	0.77
Carruthers Creek	Reach 11	4.003	1.21	16.19		
Carruthers Creek	Reach 11	4.0025				
Carruthers Creek	Reach 11	4.002	2.5	87.55		
Carruthers Creek	Reach 11	4.001	1	15.47	6.73	5.86
Carruthers Creek	Reach 11	4	2.52	92.34		

Table 1 - Summary

	Channel Velocity (m/s)			Shear Stress (N/m2)		
Reach	Min	Max	Avg	Min	Max	Avg
Carruthers Spill	0	0.77	0.13	0.0	95.1	8.1
Reach 11	0.42	3.92	1.56	2.8	187.0	42.4
Reach 2	0.06	2.55	1.28	0.0	80.5	31.7
Reach 8	0.05	2.24	1.04	0.0	81.1	28.5
Reach 9	0.11	2.29	1.19	0.1	74.3	23.9
Reach 1	0.03	1.43	0.69	0.0	26.6	7.8

Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

CARRUTHERS CREEK - 5YEAR

River	Reach	River Station	Channel Velocity	Shear Stress in Main Channel	Shear LOB	Shear ROB
			(m/s)	(N/m2)	(N/m2)	(N/m2)
Carruthers Creek	Reach 2	5.033	1.54	41.23	11.53	11.42
Carruthers Creek	Reach 2	5.032	1.25	27.52	7.76	7.84
Carruthers Creek	Reach 2	5.031	0.45	3.32	1.73	1.71
Carruthers Creek	Reach 2	5.03	1.15	16.12	7.82	8.11
Carruthers Creek	Reach 2	5.029	2.47	80.48	28.41	30.71
Carruthers Creek	Reach 2	5.028	0.78	6.27		
Carruthers Creek	Reach 2	5.0275				
Carruthers Creek	Reach 2	5.027	2.31	78.68		
Carruthers Creek	Reach 2	5.026	1.46	41.59	17.93	18.1
Carruthers Creek	Reach 2	5.025	1.6	48.01	23.76	23.78
Carruthers Creek	Reach 2	5.024	1.12	20.5	10.03	9.95
Carruthers Creek	Reach 2	5.023	1.85	57.63	28.27	28.03
Carruthers Creek	Reach 2	5.022	0.86	13.06	6.4	6.42
Carruthers Creek	Reach 2	5.021	2.08	69.67	32.78	32.73
Carruthers Creek	Reach 2	5.02	0.79	9.58	1.21	1.14
Carruthers Creek	Reach 2	5.019	1.88	58.79	27.98	28.66
Carruthers Creek	Reach 2	5.018	2.55	75.45	32.68	24.52
Carruthers Creek	Reach 2	5.017	1.99	68.35	34.05	33.58
Carruthers Creek	Reach 2	5.016	0.52	4.2		
Carruthers Creek	Reach 2	5.015	1.14	30.54		
Carruthers Creek	Reach 2	5.014	1.05	16.54	6.86	6.87
Carruthers Creek	Reach 2	5.013	2.26	67.47	31.68	32.24
Carruthers Creek	Reach 2	5.012	0.12	0.14	0.05	0.05
Carruthers Creek	Reach 2	5.011	1.28	18.03		
Carruthers Creek	Reach 2	5.0105				
Carruthers Creek	Reach 2	5.01	1.42	23.05		
Carruthers Creek	Reach 2	5.009	0.1	0.11	0.03	0.03
Carruthers Creek	Reach 2	5.008	0.06	0.04	0.01	0.01
Carruthers Creek	Reach 2	5.007	0.09	0.11		
Carruthers Creek	Reach 2	5.0065				
Carruthers Creek	Reach 2	5.006	1.25	21.69	5.26	5.29
Carruthers Creek	Reach 2	5.005	1.02	14.65	1.55	3.05
Carruthers Creek	Reach 2	5.004	2.14	64.98	9.12	9.2
Carruthers Creek	Reach 2	5.003	1.1	17.42	8.11	8.59
Carruthers Creek	Reach 2	5.002	0.96	15.56	2.2	4.12
Carruthers Creek	Reach 2	5.001	0.89	15.26	7.18	3.62
Carruthers Creek	Reach 2	5	1.93	50.36	10.24	10.24

Table 1 - Summary

	Channel Velocity (m/s)			Shear Stress (N/m2)		
Reach	Min	Max	Avg	Min	Max	Avg
Carruthers Spill	0	0.77	0.13	0.0	95.1	8.1
Reach 11	0.42	3.92	1.56	2.8	187.0	42.4
Reach 2	0.06	2.55	1.28	0.0	80.5	31.7
Reach 8	0.05	2.24	1.04	0.0	81.1	28.5
Reach 9	0.11	2.29	1.19	0.1	74.3	23.9
Reach 1	0.03	1.43	0.69	0.0	26.6	7.8

Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

CARRUTHERS CREEK - 5YEAR

River	Reach	River Station	Channel Velocity	Shear Stress in Main Channel	Shear LOB	Shear ROB
			(m/s)	(N/m2)	(N/m2)	(N/m2)
Carruthers Creek	Reach 8	2.015	0.33	1.41	0.66	0.68
Carruthers Creek	Reach 8	2.014	0.64	4.64		
Carruthers Creek	Reach 8	2.0135				
Carruthers Creek	Reach 8	2.013	1.96	63.23		
Carruthers Creek	Reach 8	2.012	0.31	1.84	0.78	1.74
Carruthers Creek	Reach 8	2.011	0.36	2.73	2.45	2.51
Carruthers Creek	Reach 8	2.01	1.88	58.13		
Carruthers Creek	Reach 8	2.009	2.13	72.97		
Carruthers Creek	Reach 8	2.008	2.24	81.05		
Carruthers Creek	Reach 8	2.007	1.8	57.41		
Carruthers Creek	Reach 8	2.006	1.19	22.68		
Carruthers Creek	Reach 8	2.0055				
Carruthers Creek	Reach 8	2.005	0.95	13.45		
Carruthers Creek	Reach 8	2.004	1.15	39.72	20.02	43.16
Carruthers Creek	Reach 8	2.003	0.45	3.51	1.69	1.69
Carruthers Creek	Reach 8	2.002	1.06	32.47	26.08	13.13
Carruthers Creek	Reach 8	2.001	0.09	0.11	0.09	0.04
Carruthers Creek	Reach 8	2	0.05	0.04	0.02	0.02

Table 1 - Summary

	Channel Velocity (m/s)			Shear Stress (N/m2)		
Reach	Min	Max	Avg	Min	Max	Avg
Carruthers Spill	0	0.77	0.13	0.0	95.1	8.1
Reach 11	0.42	3.92	1.56	2.8	187.0	42.4
Reach 2	0.06	2.55	1.28	0.0	80.5	31.7
Reach 8	0.05	2.24	1.04	0.0	81.1	28.5
Reach 9	0.11	2.29	1.19	0.1	74.3	23.9
Reach 1	0.03	1.43	0.69	0.0	26.6	7.8

Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

CARRUTHERS CREEK - 5YEAR

River	Reach	River Station	Channel Velocity	Shear Stress in Main Channel	Shear LOB	Shear ROB
			(m/s)	(N/m2)	(N/m2)	(N/m2)
Carruthers Creek	Reach 9	3.073	0.91	10.68	4.58	4.58
Carruthers Creek	Reach 9	3.072	2.02	57.62	17.5	17.39
Carruthers Creek	Reach 9	3.071	0.9	9.81		
Carruthers Creek	Reach 9	3.0705				
Carruthers Creek	Reach 9	3.07	1.35	25.17		
Carruthers Creek	Reach 9	3.069	0.83	9.94		3.65
Carruthers Creek	Reach 9	3.068	0.91	10.87		
Carruthers Creek	Reach 9	3.067	1.01	13.45		
Carruthers Creek	Reach 9	3.0665				
Carruthers Creek	Reach 9	3.066	1.36	25.24	9.45	8.61
Carruthers Creek	Reach 9	3.065	1.3	22.13		
Carruthers Creek	Reach 9	3.064	2.01	55.77		
Carruthers Creek	Reach 9	3.063	1.15	17.34	1.22	1.24
Carruthers Creek	Reach 9	3.062	2.01	65.05	15.41	16.13
Carruthers Creek	Reach 9	3.061	1.1	16.82	3.59	
Carruthers Creek	Reach 9	3.0605				
Carruthers Creek	Reach 9	3.06	1.29	22.14		3.23
Carruthers Creek	Reach 9	3.059	2.02	64.7	30.9	30.74
Carruthers Creek	Reach 9	3.058	0.68	6.14	2.97	3
Carruthers Creek	Reach 9	3.057	1.97	63.3	29.72	29.3
Carruthers Creek	Reach 9	3.056	0.63	4.7	1.96	1.94
Carruthers Creek	Reach 9	3.055	0.14	0.16	0.05	0.08
Carruthers Creek	Reach 9	3.054	0.11	0.1		
Carruthers Creek	Reach 9	3.0535				
Carruthers Creek	Reach 9	3.053	0.88	11.97		
Carruthers Creek	Reach 9	3.052	2.01	61.24	24.3	24.29
Carruthers Creek	Reach 9	3.051	0.71	6.58	3.27	3.27
Carruthers Creek	Reach 9	3.05	0.65	8.04	3.22	3.04
Carruthers Creek	Reach 9	3.049	1.22	18.87	5.16	5.26
Carruthers Creek	Reach 9	3.048	1.69	35.6	13.88	13.9
Carruthers Creek	Reach 9	3.047	1.24	17.44	7.08	6.84
Carruthers Creek	Reach 9	3.046	2.26	55.9	22.69	12.84
Carruthers Creek	Reach 9	3.045	1.72	42.69	17.46	17.54
Carruthers Creek	Reach 9	3.044	0.8	8.46	3.4	3.4
Carruthers Creek	Reach 9	3.043	2.29	74.33	5.85	5.86
Carruthers Creek	Reach 9	3.042	0.83	7.01		
Carruthers Creek	Reach 9	3.0415				
Carruthers Creek	Reach 9	3.041	0.96	9.83		
Carruthers Creek	Reach 9	3.04	1.07	14.89	3.12	1.72
Carruthers Creek	Reach 9	3.039	0.91	10.1		
Carruthers Creek	Reach 9	3.038	1.65	29.06	10.68	4.05
Carruthers Creek	Reach 9	3.037	1.21	15.61	2.71	1.47
Carruthers Creek	Reach 9	3.036	1.82	53.5		
Carruthers Creek	Reach 9	3.035	0.6	3.85		
Carruthers Creek	Reach 9	3.0345				
Carruthers Creek	Reach 9	3.034	0.53	2.9		
Carruthers Creek	Reach 9	3.033	2.11	51.23	12.58	21.92
Carruthers Creek	Reach 9	3.032	0.97	11.01	3.55	2.32
Carruthers Creek	Reach 9	3.031	0.2	0.42	0.15	0.21
Carruthers Creek	Reach 9	3.03	0.18	0.33	0.12	0.07

Table 1 - Summary

	Channel Velocity (m/s)			Shear Stress (N/m2)		
Reach	Min	Max	Avg	Min	Max	Avg
Carruthers Spill	0	0.77	0.13	0.0	95.1	8.1
Reach 11	0.42	3.92	1.56	2.8	187.0	42.4
Reach 2	0.06	2.55	1.28	0.0	80.5	31.7
Reach 8	0.05	2.24	1.04	0.0	81.1	28.5
Reach 9	0.11	2.29	1.19	0.1	74.3	23.9
Reach 1	0.03	1.43	0.69	0.0	26.6	7.8

Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

CARRUTHERS CREEK - 5YEAR

River	Reach	River Station	Channel Velocity	Shear Stress in Main Channel	Shear LOB	Shear ROB
			(m/s)	(N/m2)	(N/m2)	(N/m2)
Carruthers Creek	Reach 1	3.029	0.05	0.04	0.04	0.02
Carruthers Creek	Reach 1	3.028	0.08	0.06	0.03	0.02
Carruthers Creek	Reach 1	3.027	0.05	0.03	0.02	0.01
Carruthers Creek	Reach 1	3.0265				
Carruthers Creek	Reach 1	3.026	0.11	0.16	0.13	0.04
Carruthers Creek	Reach 1	3.025	0.94	10.18	1.86	2.69
Carruthers Creek	Reach 1	3.024	0.9	10.43	1.7	0.55
Carruthers Creek	Reach 1	3.023	1.41	25.36	6.38	6.73
Carruthers Creek	Reach 1	3.022	1.03	11.71	0.72	0.69
Carruthers Creek	Reach 1	3.021	1.26	17.73	0.44	3.18
Carruthers Creek	Reach 1	3.02	1.07	13.2	4.21	2.38
Carruthers Creek	Reach 1	3.019	0.86	8.72	1.39	1.66
Carruthers Creek	Reach 1	3.018	1.28	18.23	1.17	2.91
Carruthers Creek	Reach 1	3.017	1.17	16.16	3.65	1.98
Carruthers Creek	Reach 1	3.016	0.68	6.16	1.6	1.47
Carruthers Creek	Reach 1	3.015	0.85	8.77	2.89	1.64
Carruthers Creek	Reach 1	3.014	1.3	19.28	7.54	7.4
Carruthers Creek	Reach 1	3.013	1.17	16.9	5.72	7.85
Carruthers Creek	Reach 1	3.012	0.75	7.13	0.37	2.92
Carruthers Creek	Reach 1	3.0115	0.41	2.06	0.97	0.72
Carruthers Creek	Reach 1	3.011	0.6	4.08	0.45	1.16
Carruthers Creek	Reach 1	3.0107	0.72	6	1.02	1.37
Carruthers Creek	Reach 1	3.0105				
Carruthers Creek	Reach 1	3.0103	0.72	6.61	2.78	0.88
Carruthers Creek	Reach 1	3.01	0.79	8.12	1.64	1.87
Carruthers Creek	Reach 1	3.009	1.43	26.55		
Carruthers Creek	Reach 1	3.008	0.7	5.74	2.2	2.12
Carruthers Creek	Reach 1	3.007	0.9	9.36		
Carruthers Creek	Reach 1	3.00675				
Carruthers Creek	Reach 1	3.0065	1.04	12.62	7.17	1.1
Carruthers Creek	Reach 1	3.006	0.55	3.41	0.09	1.08
Carruthers Creek	Reach 1	3.0055	0.66	4.83	1.3	1.37
Carruthers Creek	Reach 1	3.005	0.65	4.63	1.25	1.28
Carruthers Creek	Reach 1	3.0043	0.32	1.14	0.3	0.29
Carruthers Creek	Reach 1	3.004	0.28	0.85	0.23	0.22
Carruthers Creek	Reach 1	3.0035	0.15	0.25	0.07	0.06
Carruthers Creek	Reach 1	3.003	0.11	0.13	0.03	0.03
Carruthers Creek	Reach 1	3.002	0.03	0.01	0	0
Carruthers Creek	Reach 1	3.001	0.03	0.01	0	0
Carruthers Creek	Reach 1	3	0.42	1.99	0.57	0.59

Table 1 - Summary

	Channel Velocity (m/s)			Shear Stress (N/m2)		
Reach	Min	Max	Avg	Min	Max	Avg
Carruthers Spill	0	0.77	0.13	0.0	95.1	8.1
Reach 11	0.42	3.92	1.56	2.8	187.0	42.4
Reach 2	0.06	2.55	1.28	0.0	80.5	31.7
Reach 8	0.05	2.24	1.04	0.0	81.1	28.5
Reach 9	0.11	2.29	1.19	0.1	74.3	23.9
Reach 1	0.03	1.43	0.69	0.0	26.6	7.8

Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

CARRUTHERS CREEK - 100YEAR

River	Reach	River Station	Velocity Channel	Shear Channel	Shear LOB	Shear ROB
			(m/s)	(N/m2)	(N/m2)	(N/m2)
Carruthers Spill	Carruthers Spill	5.016	0	0	0	0
Carruthers Spill	Carruthers Spill	5.015	0.01	0.01	0.01	0.01
Carruthers Spill	Carruthers Spill	5.014	0.15	3.42		
Carruthers Spill	Carruthers Spill	5.013	0.77	95.11		
Carruthers Spill	Carruthers Spill	5.012	0.27	8.4		
Carruthers Spill	Carruthers Spill	5.011	0.27	9.44		
Carruthers Spill	Carruthers Spill	5.01	0.1	1.31		
Carruthers Spill	Carruthers Spill	5.009	0.06	0.4		
Carruthers Spill	Carruthers Spill	5.008	0.46	47.83		
Carruthers Spill	Carruthers Spill	5.007	0.21	5.57		
Carruthers Spill	Carruthers Spill	5.006	0.09	0.88		
Carruthers Spill	Carruthers Spill	5.005	0.02	0.07		
Carruthers Spill	Carruthers Spill	5.004	0.01	0.01		
Carruthers Spill	Carruthers Spill	5.0035	0.01	0.01		
Carruthers Spill	Carruthers Spill	5.003	0.02	0.03		
Carruthers Spill	Carruthers Spill	5.0025	0.04	0.12		
Carruthers Spill	Carruthers Spill	5.002	0.21	3.68		
Carruthers Spill	Carruthers Spill	5.001	0.02	0.02		
Carruthers Spill	Carruthers Spill	5.0005	0.02	0.04		
Carruthers Spill	Carruthers Spill	5	0.08	0.95		
Carruthers Spill	Carruthers Spill	0.2	0.03	0.05		
Carruthers Spill	Carruthers Spill	0.1	0	0	0	0

Table 1 - Summary

	Channel Velocity (m/s)			Shear Stress (N/m2)		
Reach	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**
Carruthers Spill	0	0.77	0.13	0.0	95.1	8.1
Reach 11	0.22	3.73	1.80	0.5	148.7	50.6
Reach 2	0.13	3.51	1.52	0.2	131.6	41.5
Reach 8	0.09	2.7	1.25	0.1	105.5	36.4
Reach 9	0.13	3	1.48	0.1	93.9	31.3
Reach 1	0.07	2.07	0.95	0.1	47.8	13.2

Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

CARRUTHERS CREEK - 100YEAR

River	Reach	River Station	Velocity Channel	Shear Channel	Shear LOB	Shear ROB
			(m/s)	(N/m2)	(N/m2)	(N/m2)
Carruthers Creek	Reach 11	4.033	0.43	3.27	1.11	1.04
Carruthers Creek	Reach 11	4.032	0.87	11.04		
Carruthers Creek	Reach 11	4.031	1.5	38.3		
Carruthers Creek	Reach 11	4.03	0.44	2.89	0.4	0.4
Carruthers Creek	Reach 11	4.029	2.29	77.28	3.41	3.37
Carruthers Creek	Reach 11	4.028	0.83	9.99	1.77	1.77
Carruthers Creek	Reach 11	4.027	2.67	89	36.37	36.35
Carruthers Creek	Reach 11	4.026	2.13	59.27	11.66	11.67
Carruthers Creek	Reach 11	4.025	1.35	17.97		
Carruthers Creek	Reach 11	4.0245				
Carruthers Creek	Reach 11	4.024	1.99	44.75		
Carruthers Creek	Reach 11	4.023	2.53	83.32	11.77	11.64
Carruthers Creek	Reach 11	4.022	1.45	23.79	7.58	7.1
Carruthers Creek	Reach 11	4.021	1.29	25.55	7.01	10.89
Carruthers Creek	Reach 11	4.02	1.86	51.82	15.6	18.07
Carruthers Creek	Reach 11	4.019	0.4	1.57	0.42	0.68
Carruthers Creek	Reach 11	4.0185				
Carruthers Creek	Reach 11	4.018	1.85	38.03		
Carruthers Creek	Reach 11	4.017	2	48.61	16.39	16.38
Carruthers Creek	Reach 11	4.016	2.51	71.01	29	29.63
Carruthers Creek	Reach 11	4.015	2.4	82.18	7.47	7.36
Carruthers Creek	Reach 11	4.014	0.55	2.81	0.56	0.73
Carruthers Creek	Reach 11	4.0135				
Carruthers Creek	Reach 11	4.013	3.73	148.69		
Carruthers Creek	Reach 11	4.012	2.1	67.44	10.16	10.19
Carruthers Creek	Reach 11	4.011	2.11	59.24	2.27	2.27
Carruthers Creek	Reach 11	4.01	2.49	87.32	42.14	42.17
Carruthers Creek	Reach 11	4.009	1.94	66.79	30.97	51.49
Carruthers Creek	Reach 11	4.008	2.79	97.63	36.32	37.35
Carruthers Creek	Reach 11	4.007	1.63	36.43	12.57	12.57
Carruthers Creek	Reach 11	4.006	3.26	113.68	22.16	65.01
Carruthers Creek	Reach 11	4.005	1.62	32.17	11.63	11.62
Carruthers Creek	Reach 11	4.004	0.22	0.48	0.28	0.27
Carruthers Creek	Reach 11	4.003	1.43	17.72		
Carruthers Creek	Reach 11	4.0025				
Carruthers Creek	Reach 11	4.002	3.37	129.86		
Carruthers Creek	Reach 11	4.001	1.56	34.13	19.44	15.87
Carruthers Creek	Reach 11	4	1.73	46.61	9.76	19.67

Table 1 - Summary

	Channel Velocity (m/s)			Shear Stress (N/m2)		
Reach	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**
Carruthers Spill	0	0.77	0.13	0.0	95.1	8.1
Reach 11	0.22	3.73	1.80	0.5	148.7	50.6
Reach 2	0.13	3.51	1.52	0.2	131.6	41.5
Reach 8	0.09	2.7	1.25	0.1	105.5	36.4
Reach 9	0.13	3	1.48	0.1	93.9	31.3
Reach 1	0.07	2.07	0.95	0.1	47.8	13.2

Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

CARRUTHERS CREEK - 100YEAR

River	Reach	River Station	Velocity Channel	Shear Channel	Shear LOB	Shear ROB
			(m/s)	(N/m2)	(N/m2)	(N/m2)
Carruthers Creek	Reach 2	5.033	2.08	64.36	23.68	23.45
Carruthers Creek	Reach 2	5.032	1.73	48.76	20.22	21.3
Carruthers Creek	Reach 2	5.031	0.26	0.8	0.63	0.6
Carruthers Creek	Reach 2	5.03	0.92	8.61	2.09	4.73
Carruthers Creek	Reach 2	5.029	1.51	22.95	10.38	7.82
Carruthers Creek	Reach 2	5.028	1.11	10.63		
Carruthers Creek	Reach 2	5.0275				
Carruthers Creek	Reach 2	5.027	3.12	118.51		
Carruthers Creek	Reach 2	5.026	1.92	60.23	27.8	28.06
Carruthers Creek	Reach 2	5.025	2.08	67.8	33.77	33.78
Carruthers Creek	Reach 2	5.024	1.52	32.35	16.03	15.9
Carruthers Creek	Reach 2	5.023	2.41	83.44	41.46	41.11
Carruthers Creek	Reach 2	5.022	1.19	21.57	10.66	10.7
Carruthers Creek	Reach 2	5.021	2.67	101.09	49.12	49.05
Carruthers Creek	Reach 2	5.02	1.15	17.47	4.7	4.43
Carruthers Creek	Reach 2	5.019	2.27	71.66	34.67	35.52
Carruthers Creek	Reach 2	5.018	3.51	130.16	49.73	35.54
Carruthers Creek	Reach 2	5.017	2.05	61.08	30.65	30.23
Carruthers Creek	Reach 2	5.016	0.83	9.44	1.29	1.29
Carruthers Creek	Reach 2	5.015	1.53	45.64		
Carruthers Creek	Reach 2	5.014	0.62	4.48	2.18	2.19
Carruthers Creek	Reach 2	5.013	0.95	8.63	2.87	2.46
Carruthers Creek	Reach 2	5.012	0.13	0.15	0.08	0.09
Carruthers Creek	Reach 2	5.011	0.26	0.59		0.35
Carruthers Creek	Reach 2	5.0105				
Carruthers Creek	Reach 2	5.01	3.4	131.64		
Carruthers Creek	Reach 2	5.009	0.22	0.57	0.16	0.17
Carruthers Creek	Reach 2	5.008	0.14	0.23	0.05	0.06
Carruthers Creek	Reach 2	5.007	0.22	0.57		
Carruthers Creek	Reach 2	5.0065				
Carruthers Creek	Reach 2	5.006	1.91	45.66	14.39	14.47
Carruthers Creek	Reach 2	5.005	1.24	19.48	4.32	8.19
Carruthers Creek	Reach 2	5.004	2.48	74.64	21.49	21.65
Carruthers Creek	Reach 2	5.003	1.41	25.22	11.9	12.6
Carruthers Creek	Reach 2	5.002	1.49	34.22	8.22	14.34
Carruthers Creek	Reach 2	5.001	1.02	17.15	11.52	5.86
Carruthers Creek	Reach 2	5	2.42	71.42	21.08	21.08

Table 1 - Summary

	Channel Velocity (m/s)			Shear Stress (N/m2)		
Reach	Min	Max	Avg	Min	Max	Avg
Carruthers Spill	0	0.77	0.13	0.0	95.1	8.1
Reach 11	0.22	3.73	1.80	0.5	148.7	50.6
Reach 2	0.13	3.51	1.52	0.2	131.6	41.5
Reach 8	0.09	2.7	1.25	0.1	105.5	36.4
Reach 9	0.13	3	1.48	0.1	93.9	31.3
Reach 1	0.07	2.07	0.95	0.1	47.8	13.2

Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

CARRUTHERS CREEK - 100YEAR

River	Reach	River Station	Velocity Channel	Shear Channel	Shear LOB	Shear ROB
			(m/s)	(N/m2)	(N/m2)	(N/m2)
Carruthers Creek	Reach 8	2.015	0.35	1.26	0.59	0.5
Carruthers Creek	Reach 8	2.014	0.9	7.95		
Carruthers Creek	Reach 8	2.0135				
Carruthers Creek	Reach 8	2.013	2.52	87.73		
Carruthers Creek	Reach 8	2.012	0.39	2.45	1.06	2.34
Carruthers Creek	Reach 8	2.011	0.41	2.87	2.61	2.72
Carruthers Creek	Reach 8	2.01	1.16	24.99	5.8	6
Carruthers Creek	Reach 8	2.009	2.7	105.54		
Carruthers Creek	Reach 8	2.008	2.68	104.32		
Carruthers Creek	Reach 8	2.007	2.14	72.31		
Carruthers Creek	Reach 8	2.006	1.47	27.95		
Carruthers Creek	Reach 8	2.0055				
Carruthers Creek	Reach 8	2.005	1.51	29.61		
Carruthers Creek	Reach 8	2.004	1.52	58.45	40.97	61.52
Carruthers Creek	Reach 8	2.003	0.65	6.64	3.24	3.24
Carruthers Creek	Reach 8	2.002	1.41	49.32	42.94	21.73
Carruthers Creek	Reach 8	2.001	0.16	0.31	0.27	0.13
Carruthers Creek	Reach 8	2	0.09	0.1	0.05	0.05

Table 1 - Summary

	Channel Velocity (m/s)			Shear Stress (N/m2)		
Reach	Min	Max	Avg	Min	Max	Avg
Carruthers Spill	0	0.77	0.13	0.0	95.1	8.1
Reach 11	0.22	3.73	1.80	0.5	148.7	50.6
Reach 2	0.13	3.51	1.52	0.2	131.6	41.5
Reach 8	0.09	2.7	1.25	0.1	105.5	36.4
Reach 9	0.13	3	1.48	0.1	93.9	31.3
Reach 1	0.07	2.07	0.95	0.1	47.8	13.2

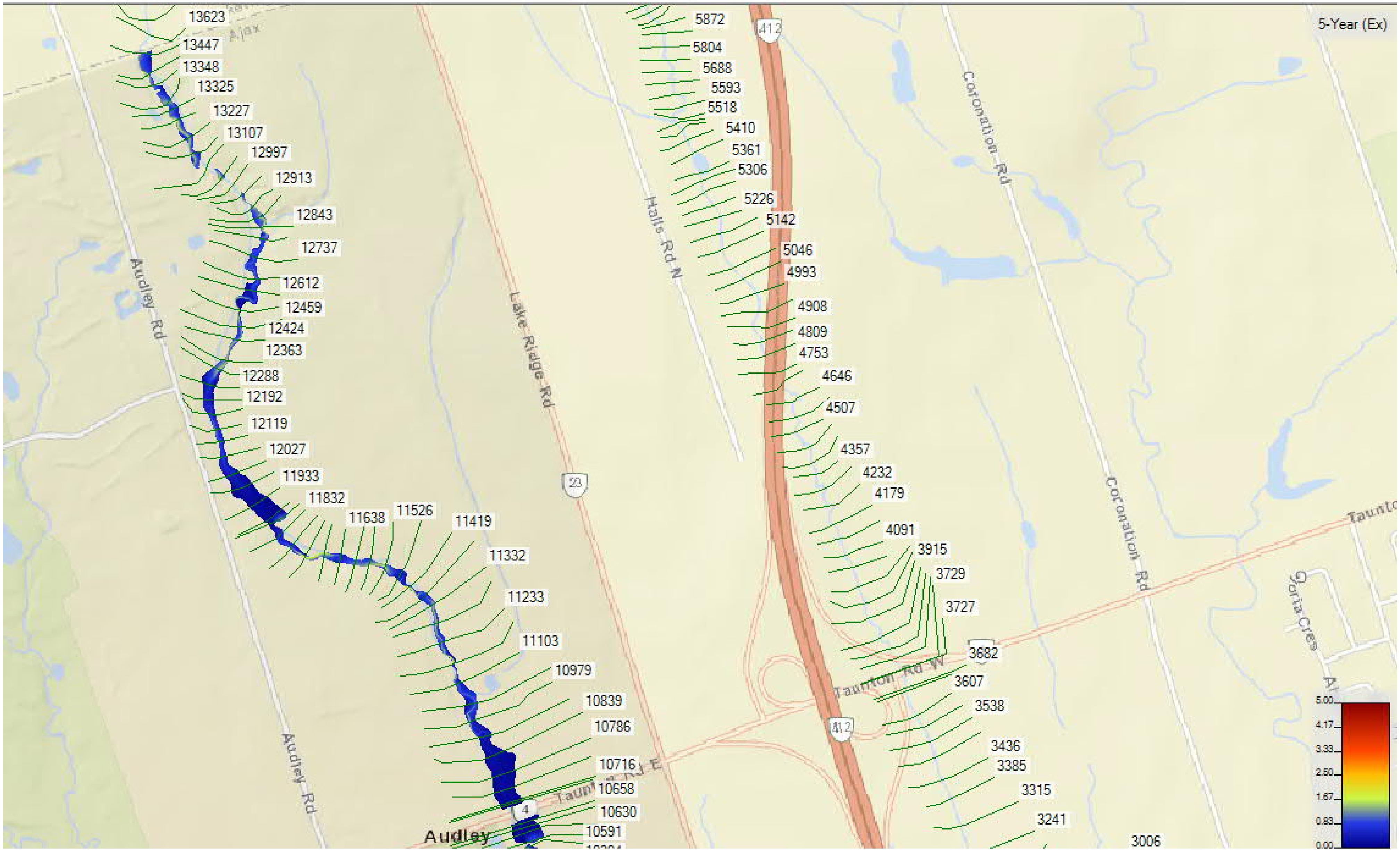
Cell Value > Average shear or Average velocity for the Reach (as per Table 1)

Velocity & Shear Profiles

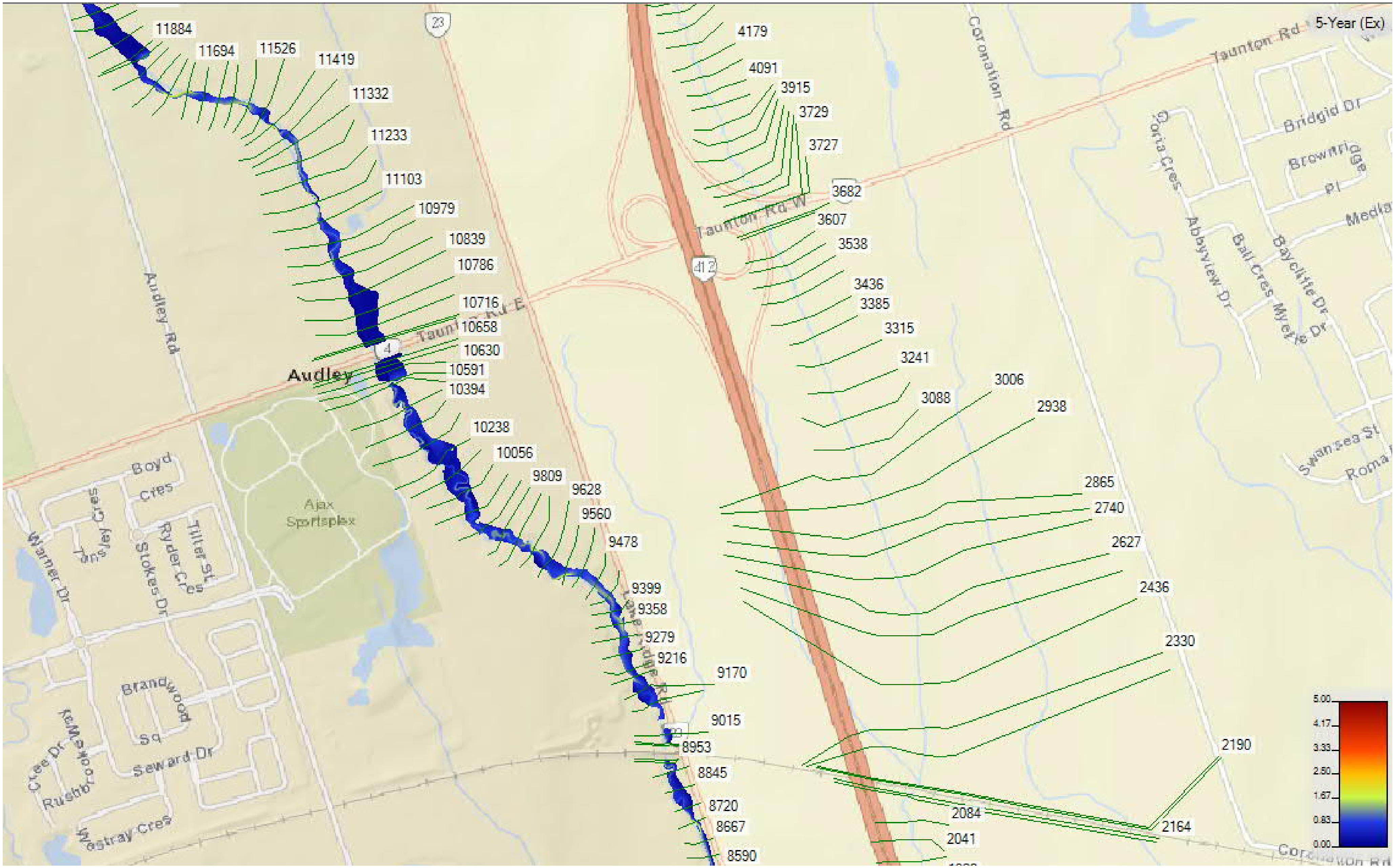
Lynde Creek

5yr & 100yr

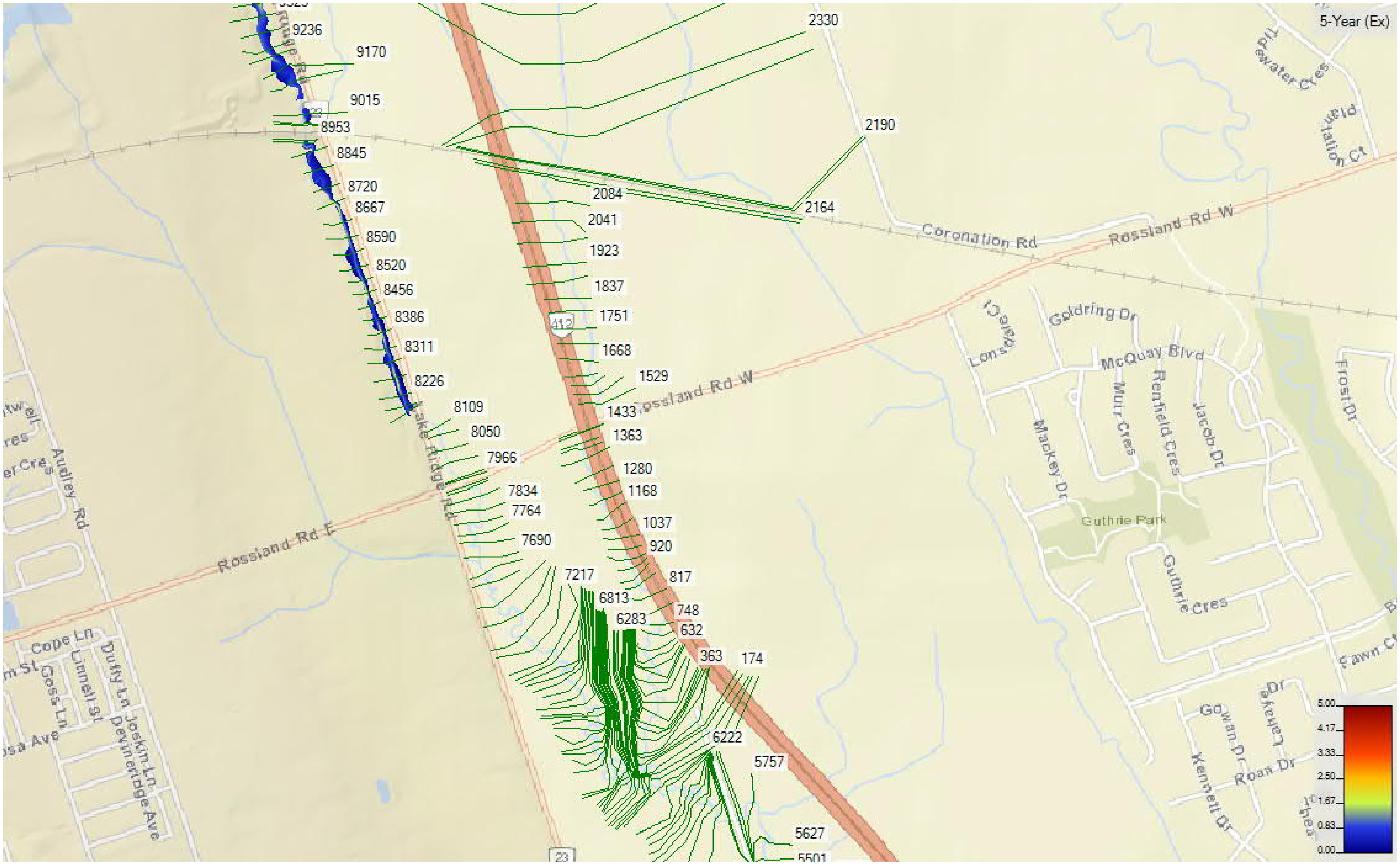
Velocity



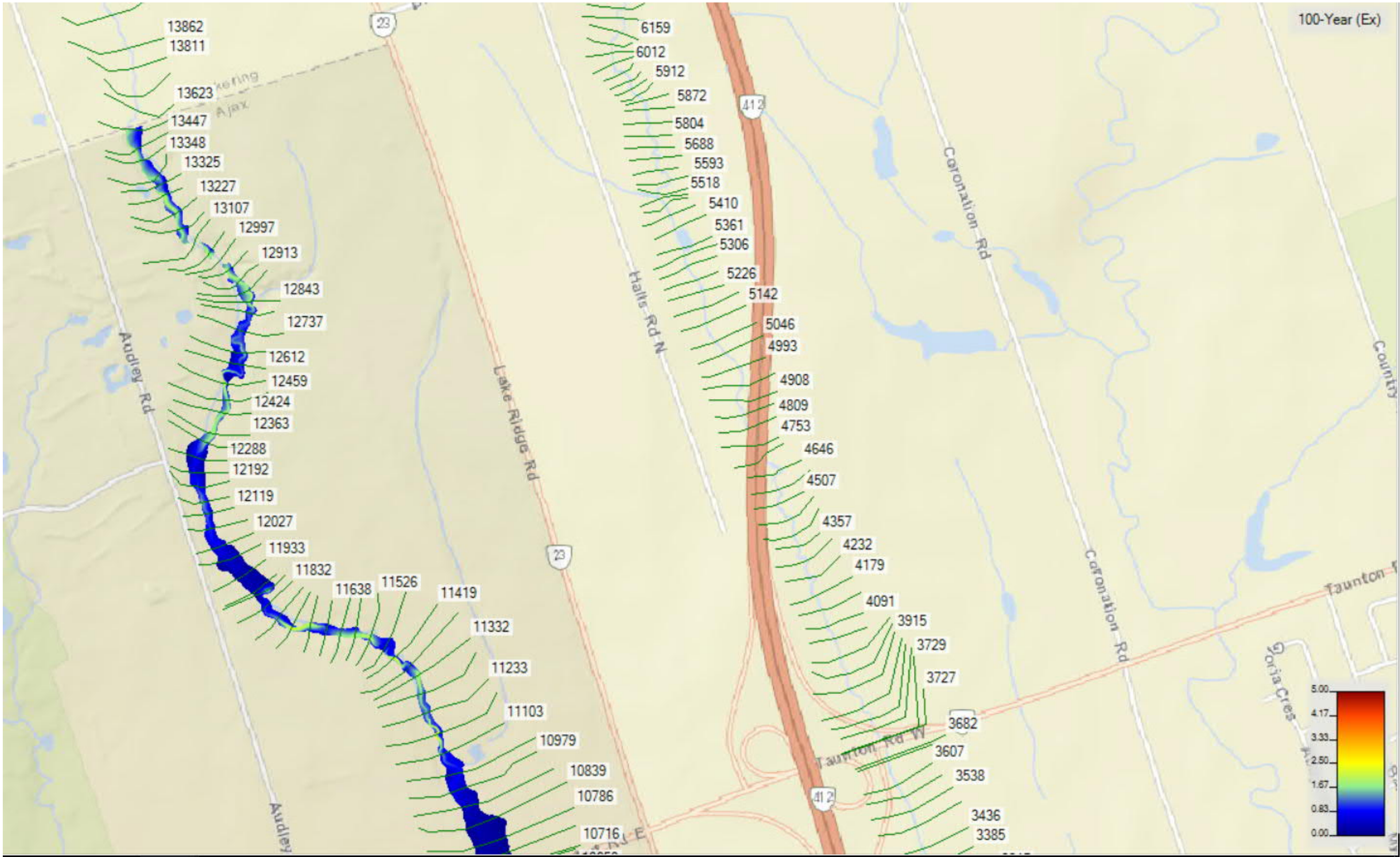
5-year velocity mapping - Lynde Creek - Section 1



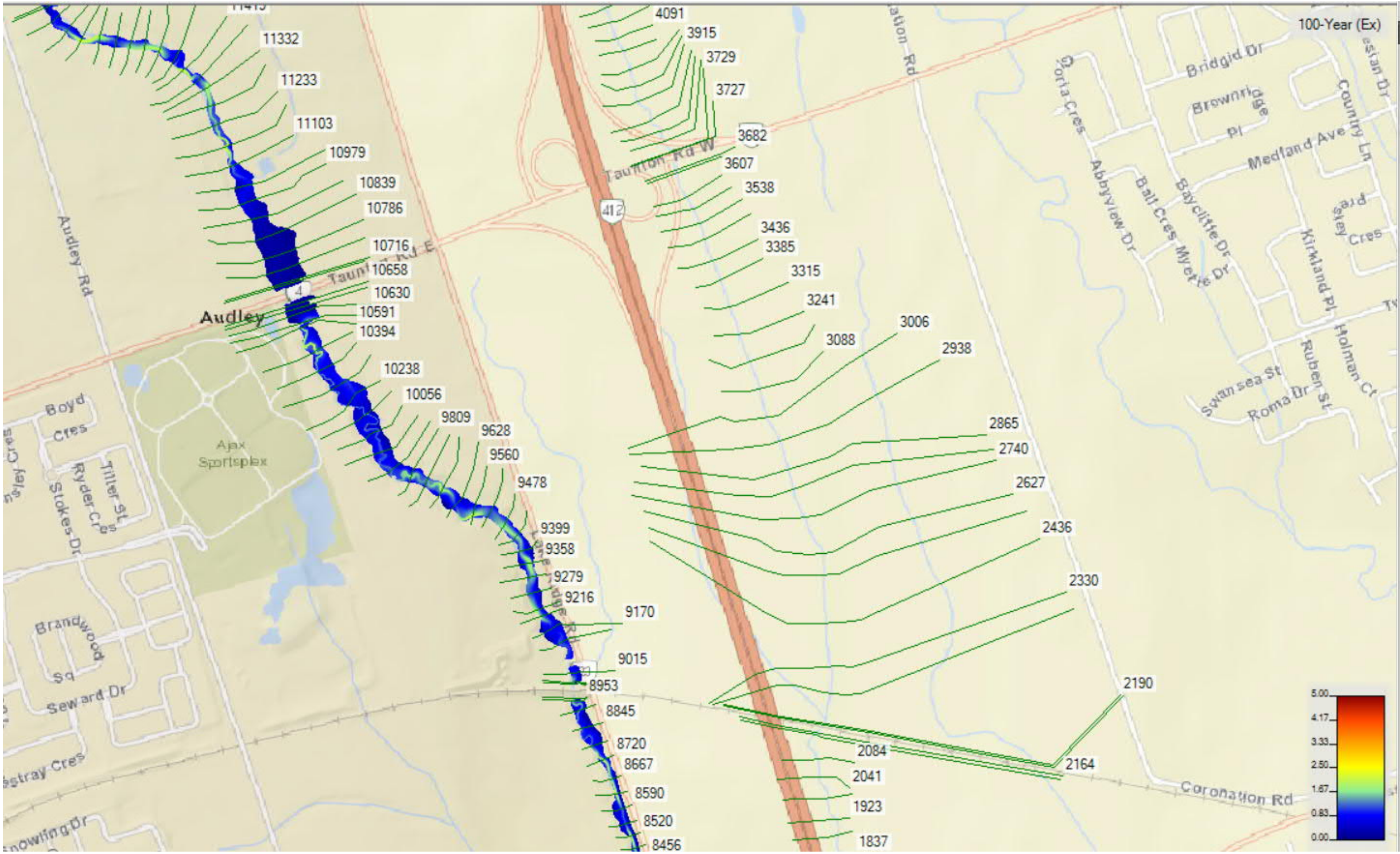
5-year velocity mapping - Lynde Creek - Section 2



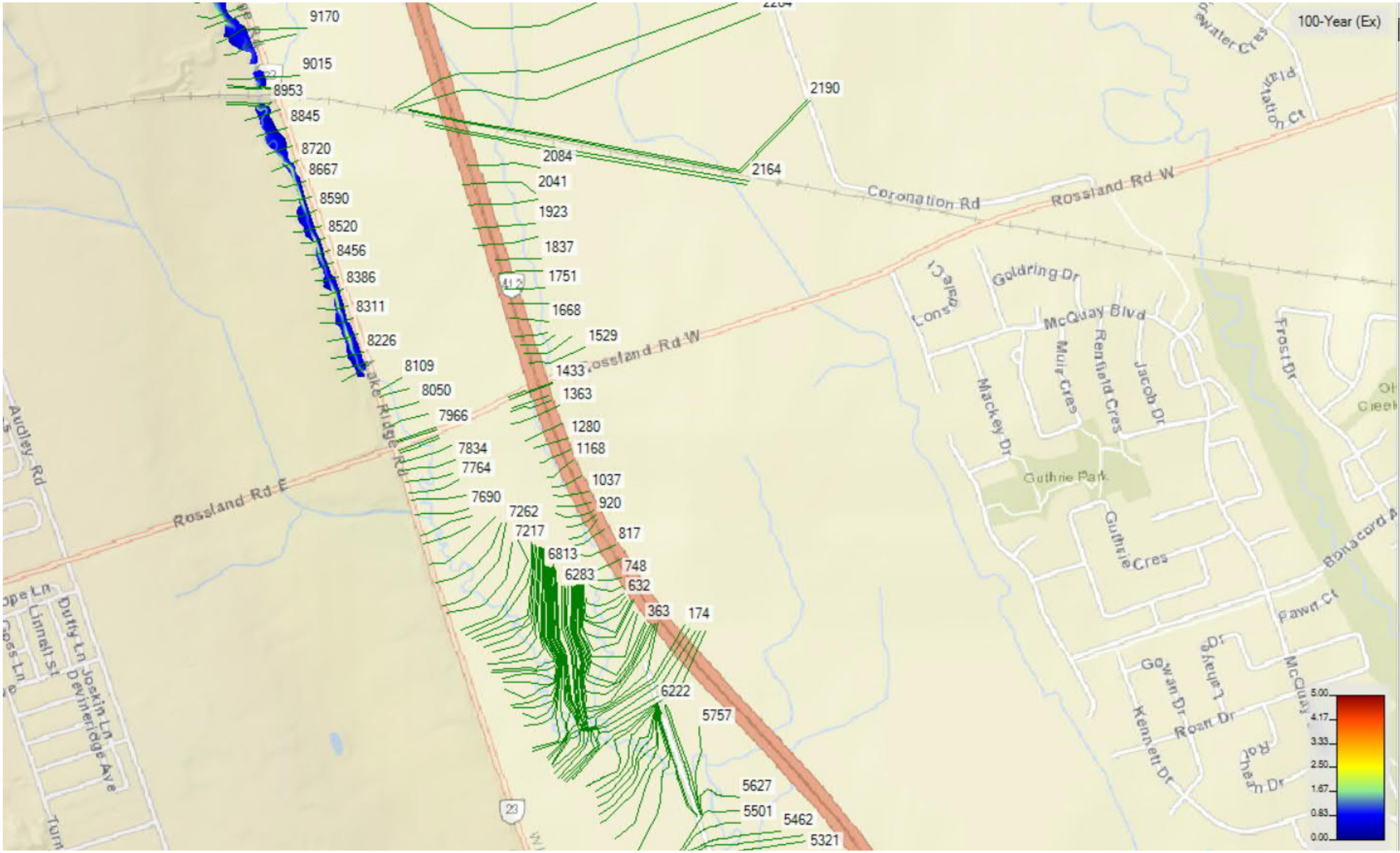
5-year velocity mapping - Lynde Creek - Section 3



100-year velocity mapping - Lynde Creek - Section 1

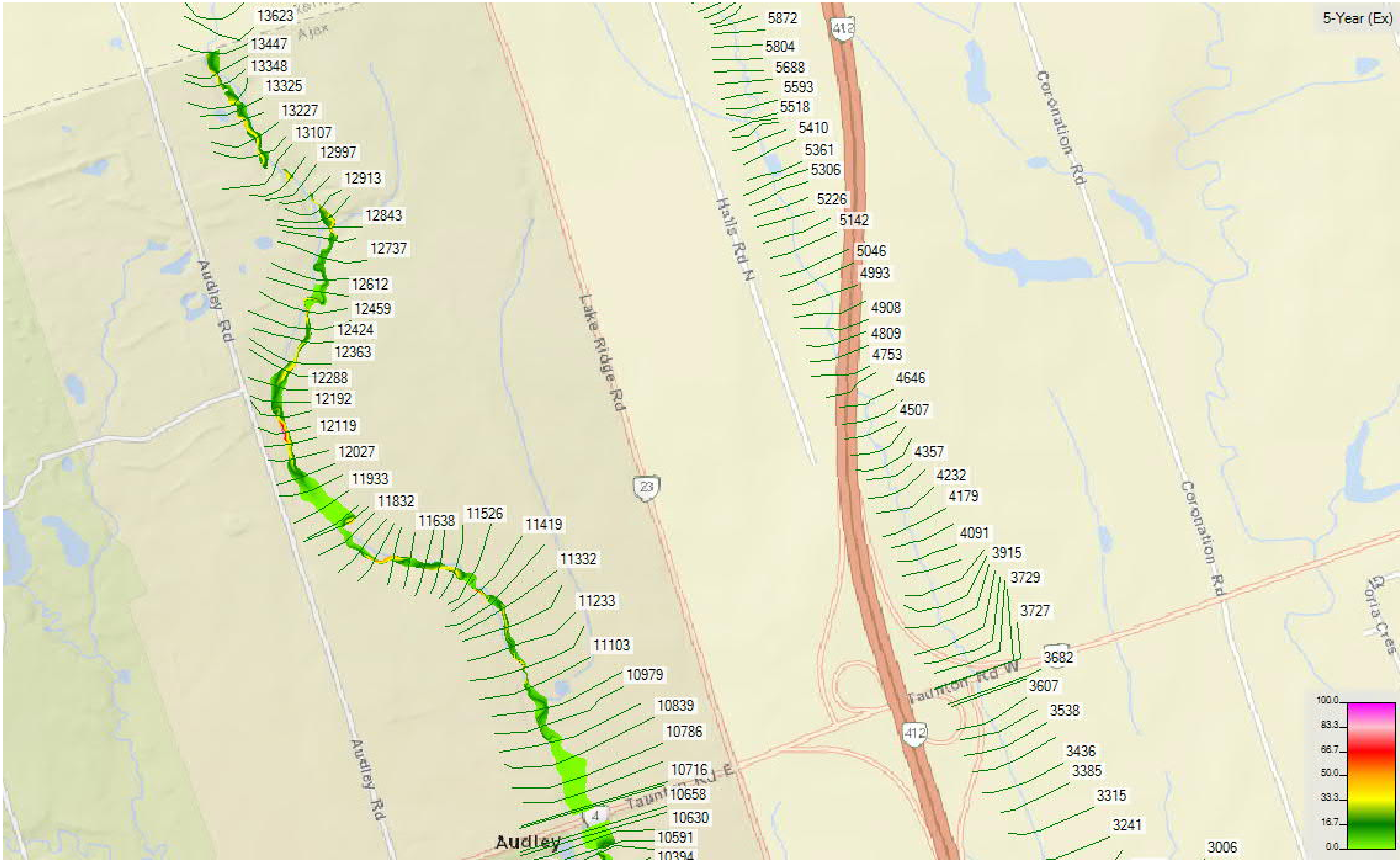


100-year velocity mapping - Lynde Creek - Section 2

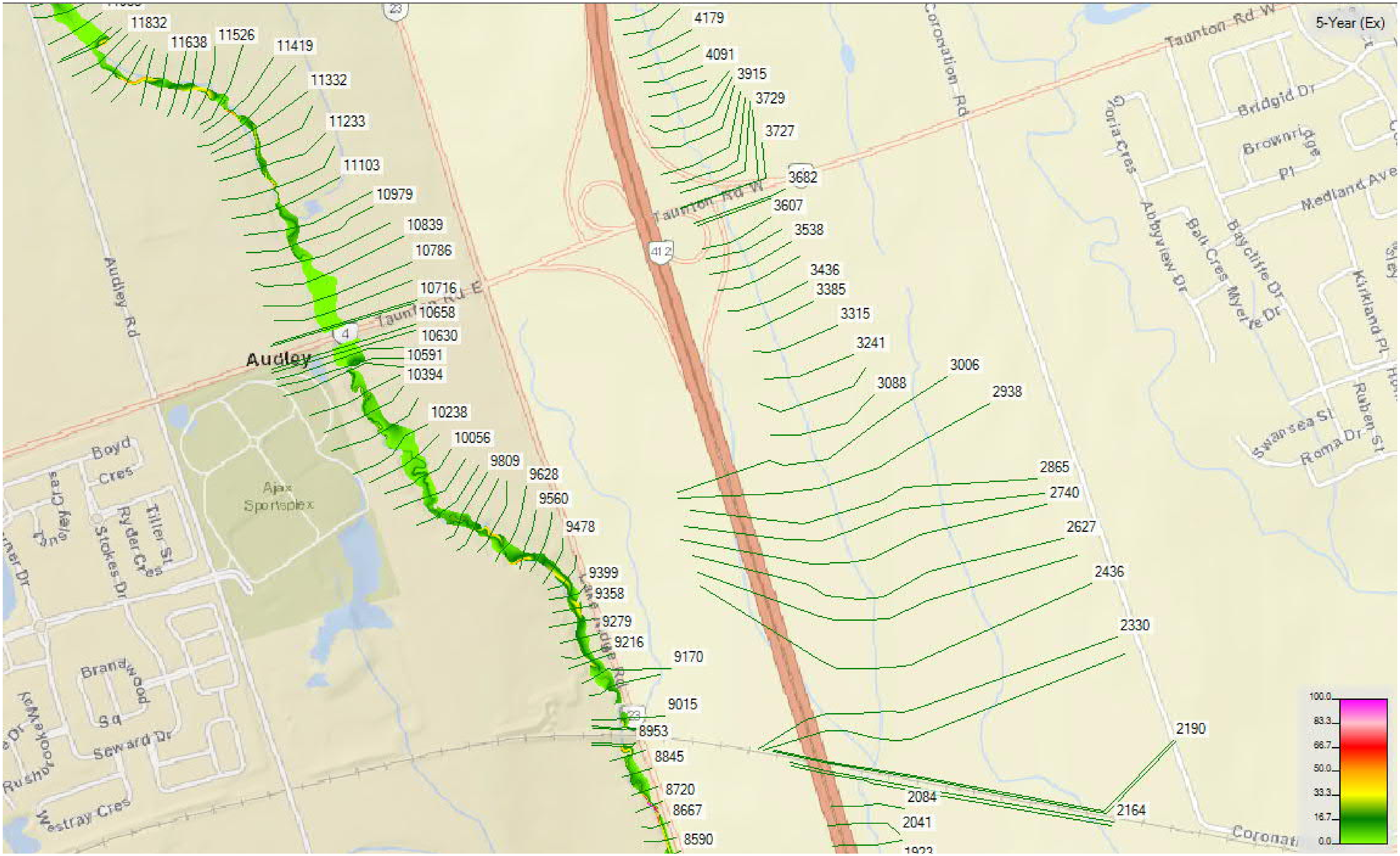


100-year velocity mapping - Lynde Creek - Section 3

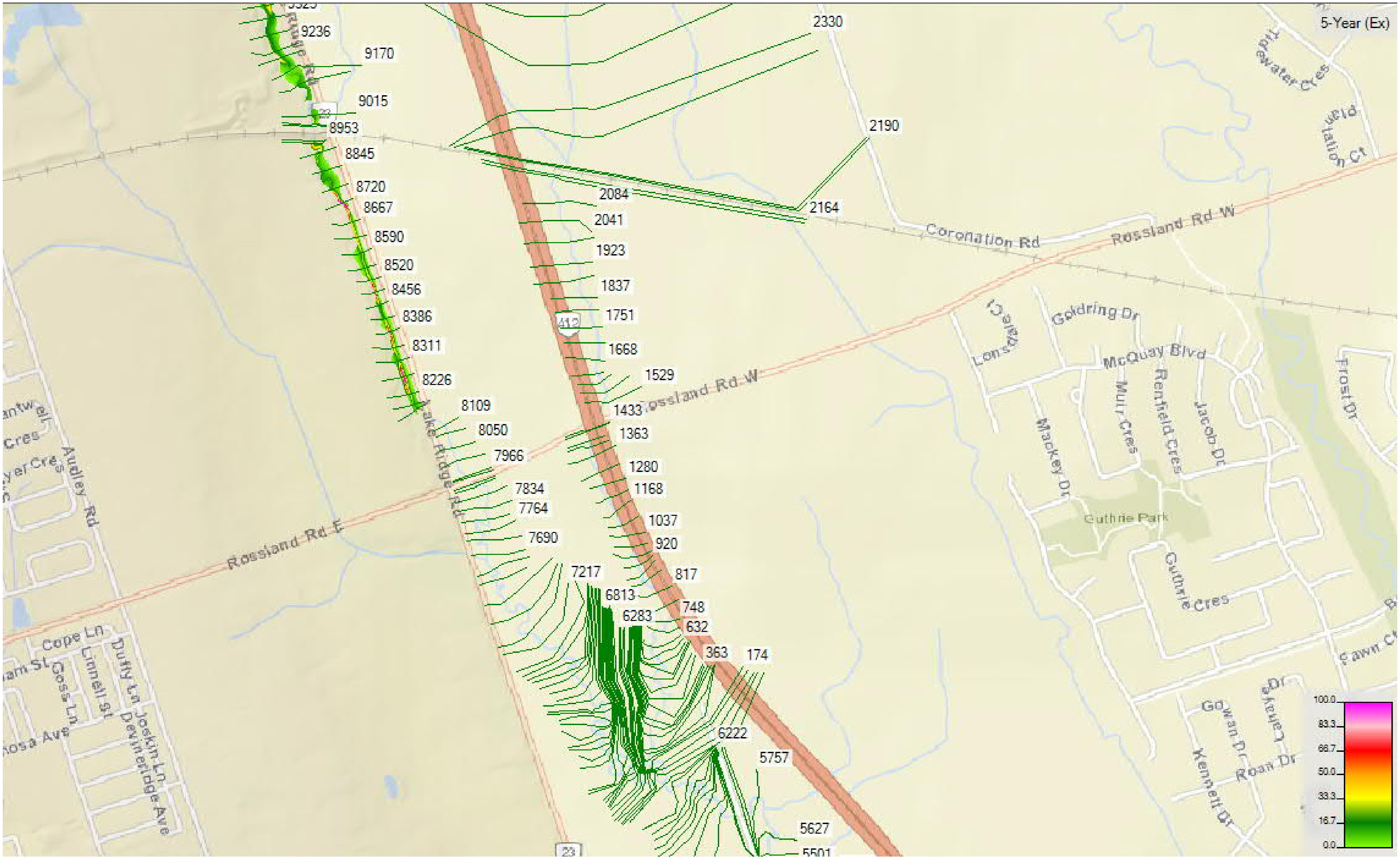
Shear



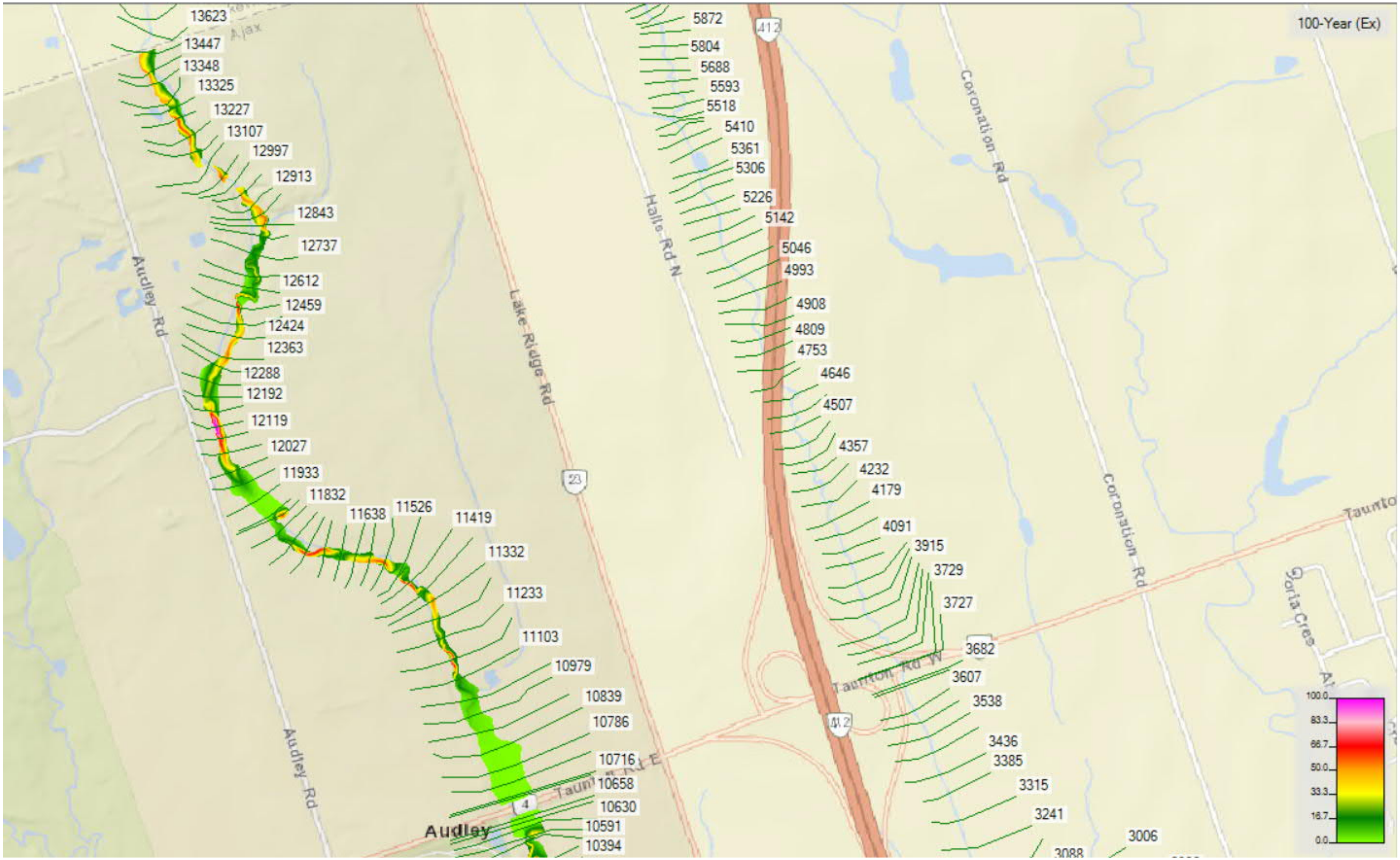
5-year shear mapping - Lynde Creek - Section 1



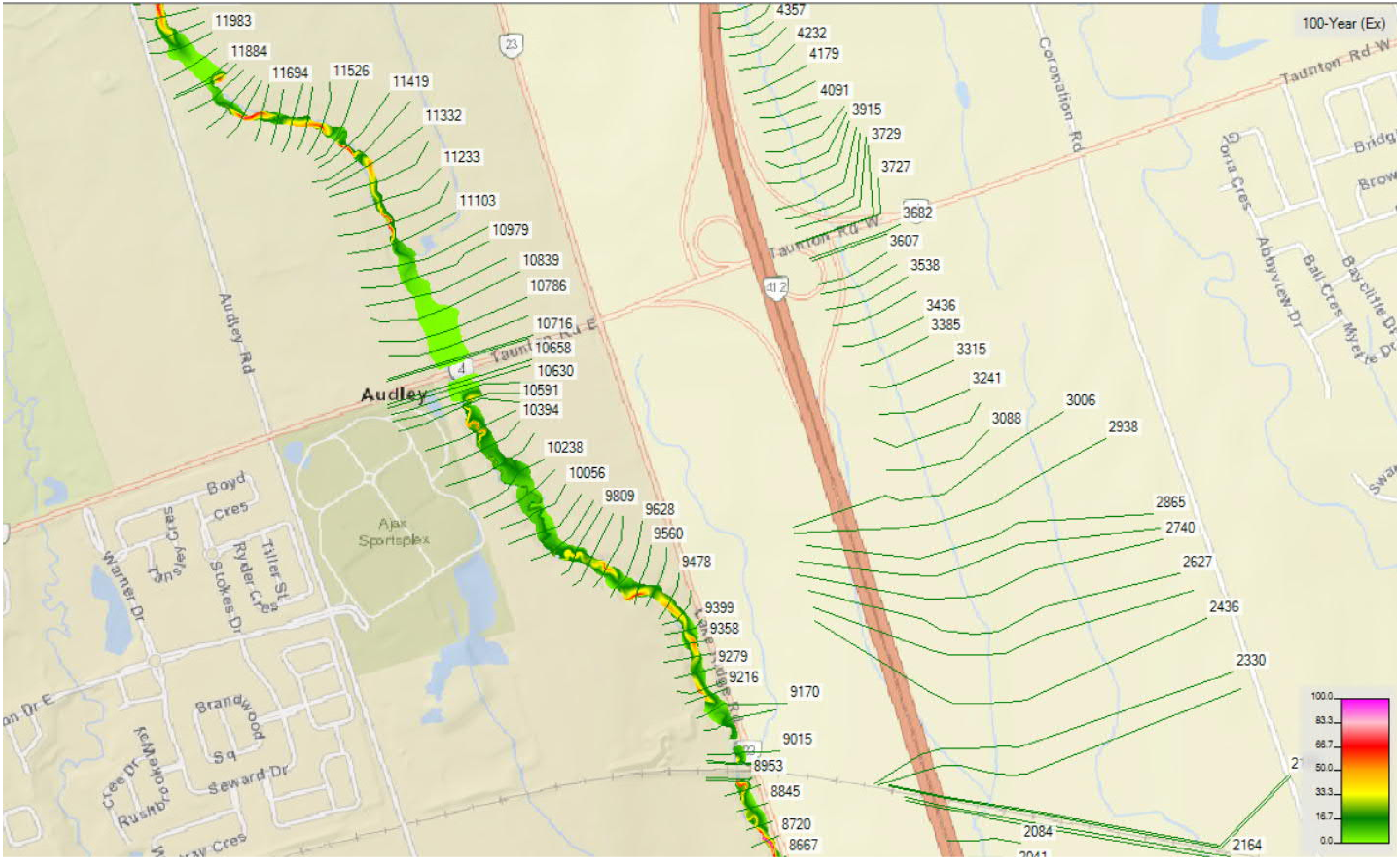
5-year shear mapping - Lynde Creek - Section 2



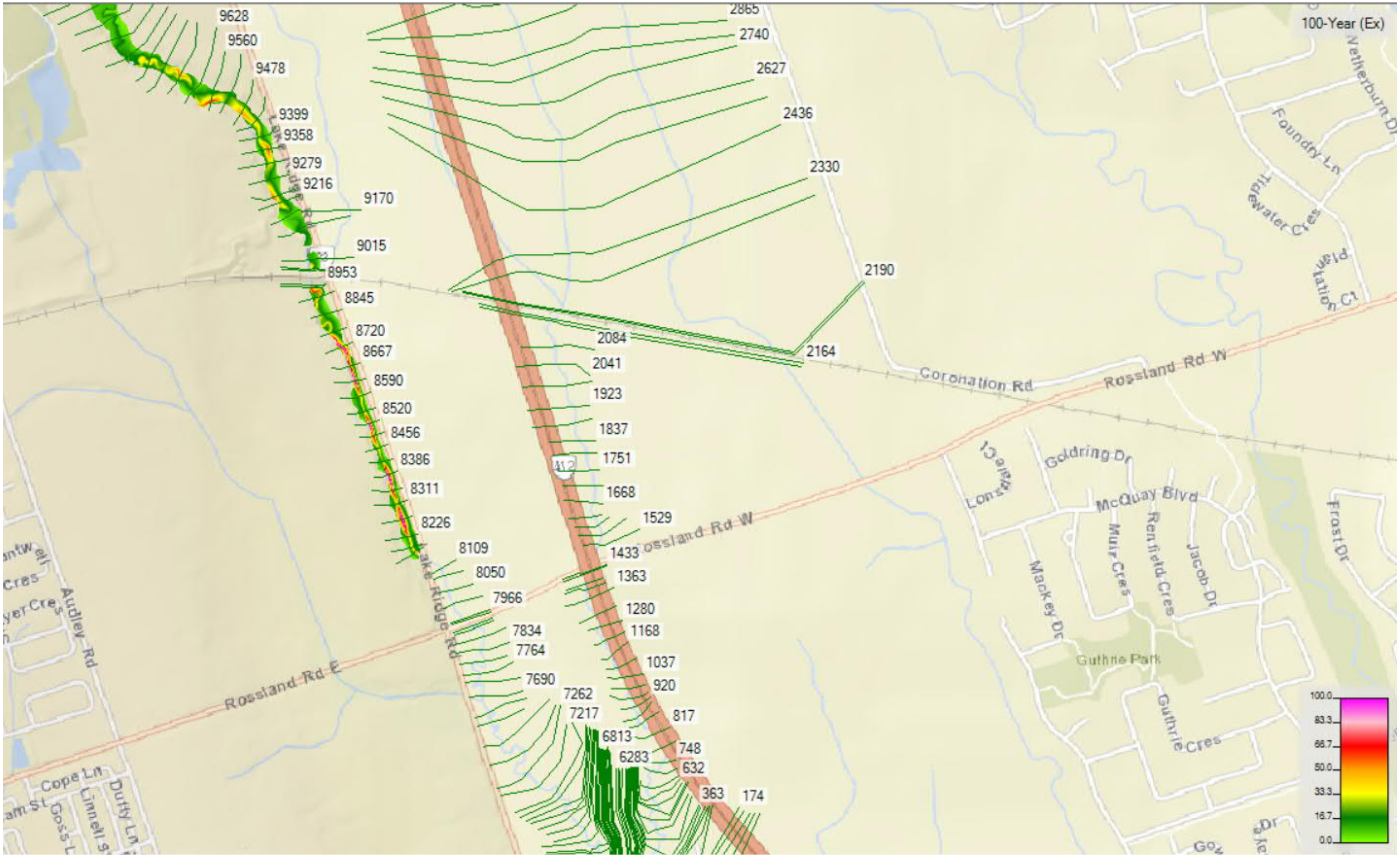
5-year shear mapping - Lynde Creek - Section 3



100-year shear mapping - Lynde Creek - Section 1



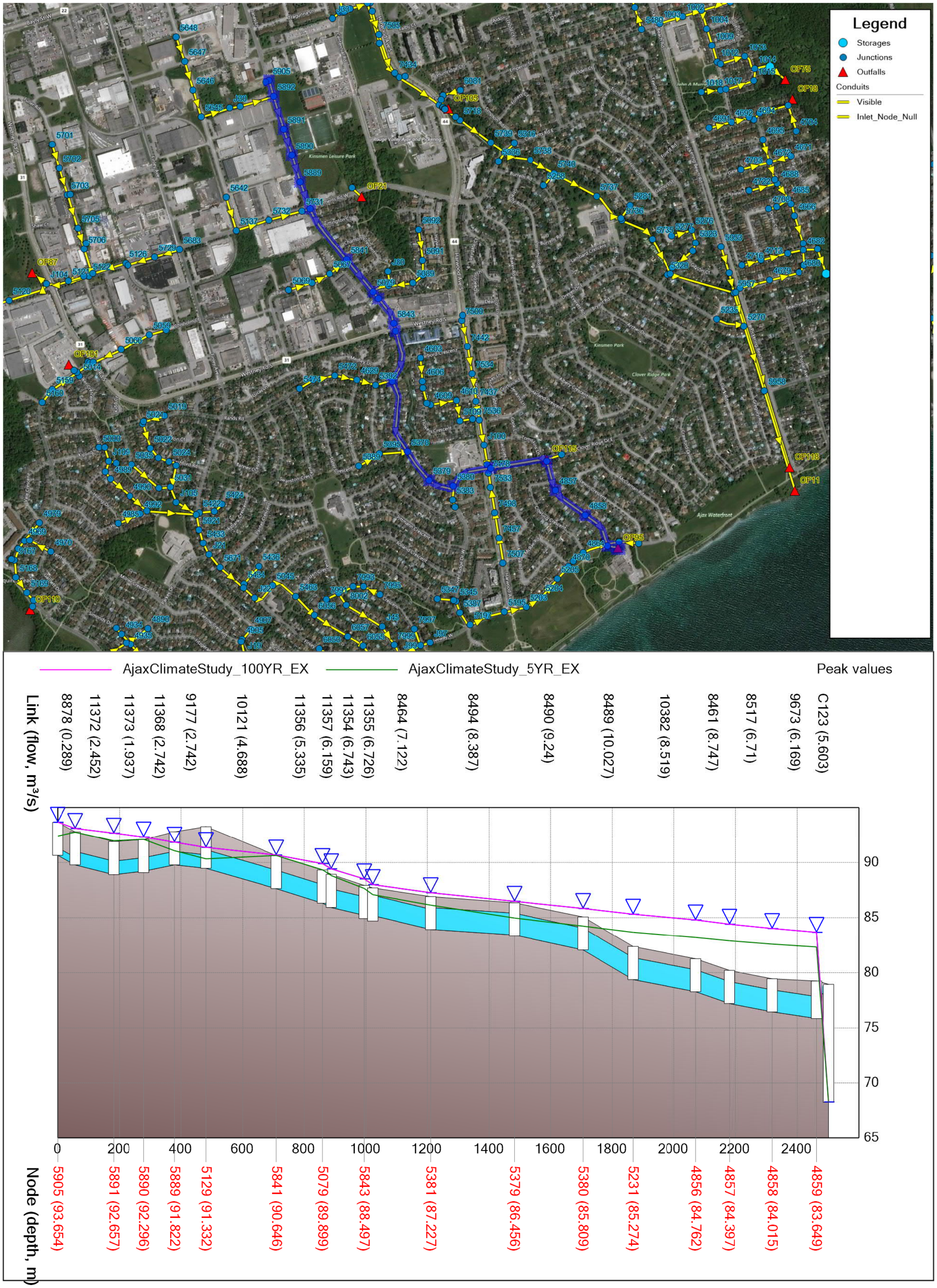
100-year shear mapping - Lynde Creek - Section 2

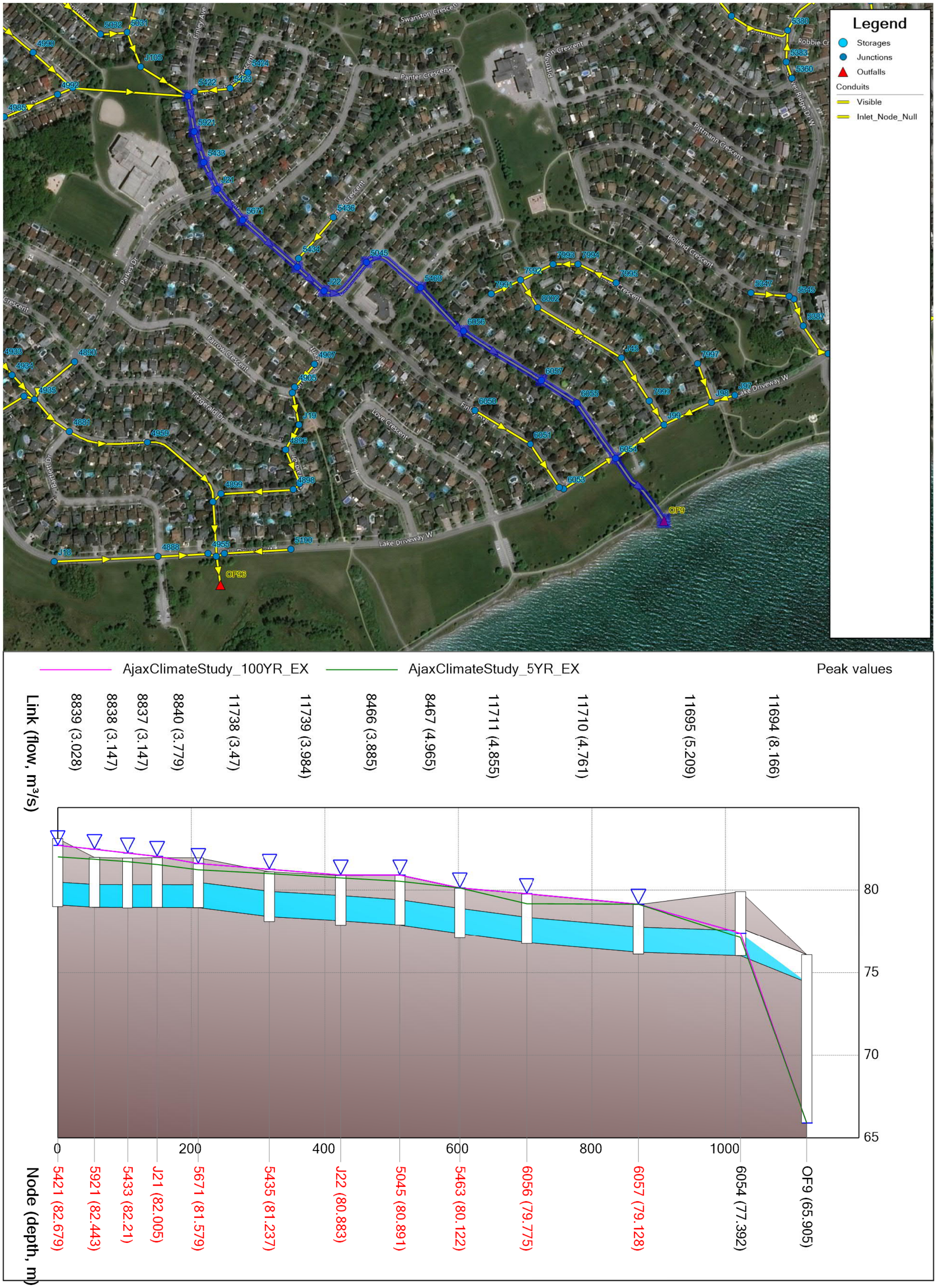


100-year shear mapping - Lynde Creek - Section 3

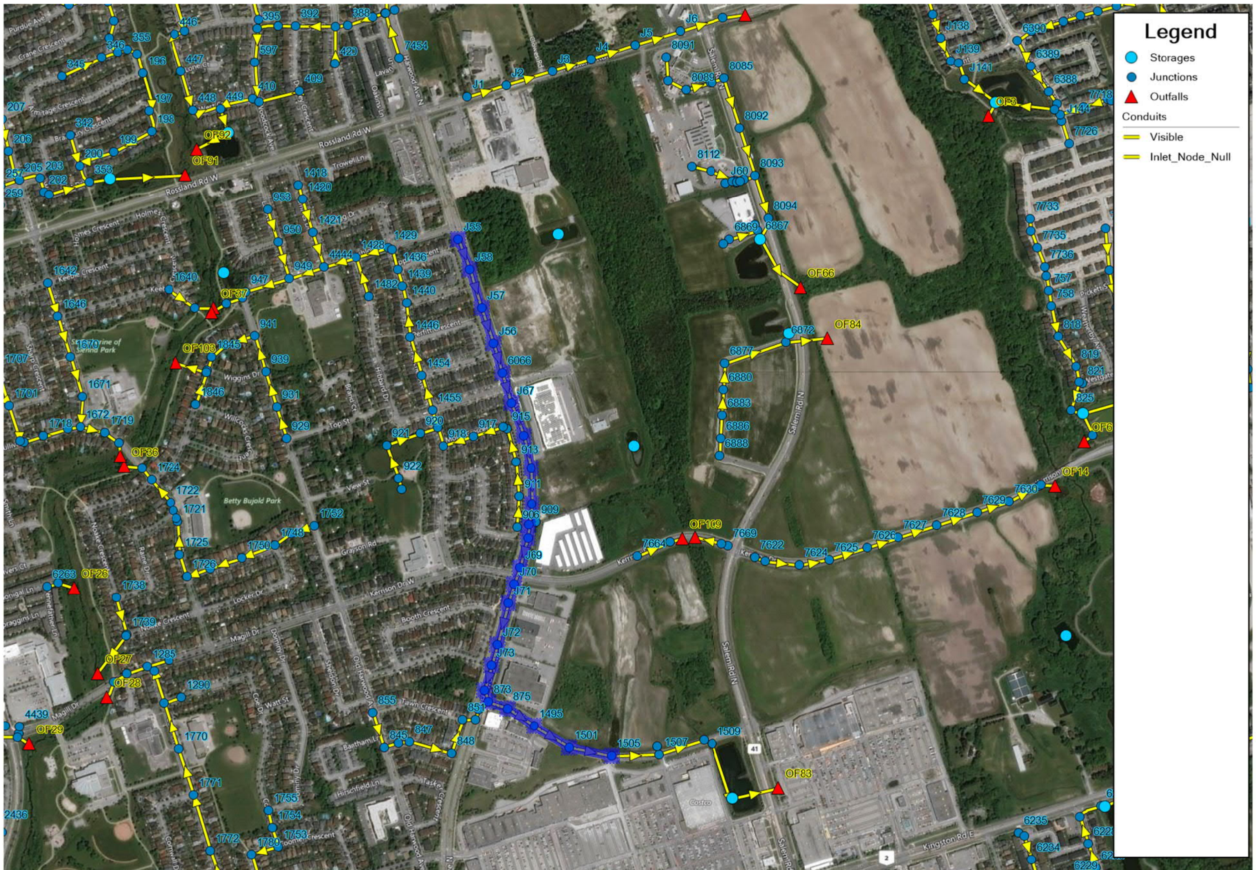
Appendix E

PCSWMM Plans and Profiles: Major Trunk Sewers

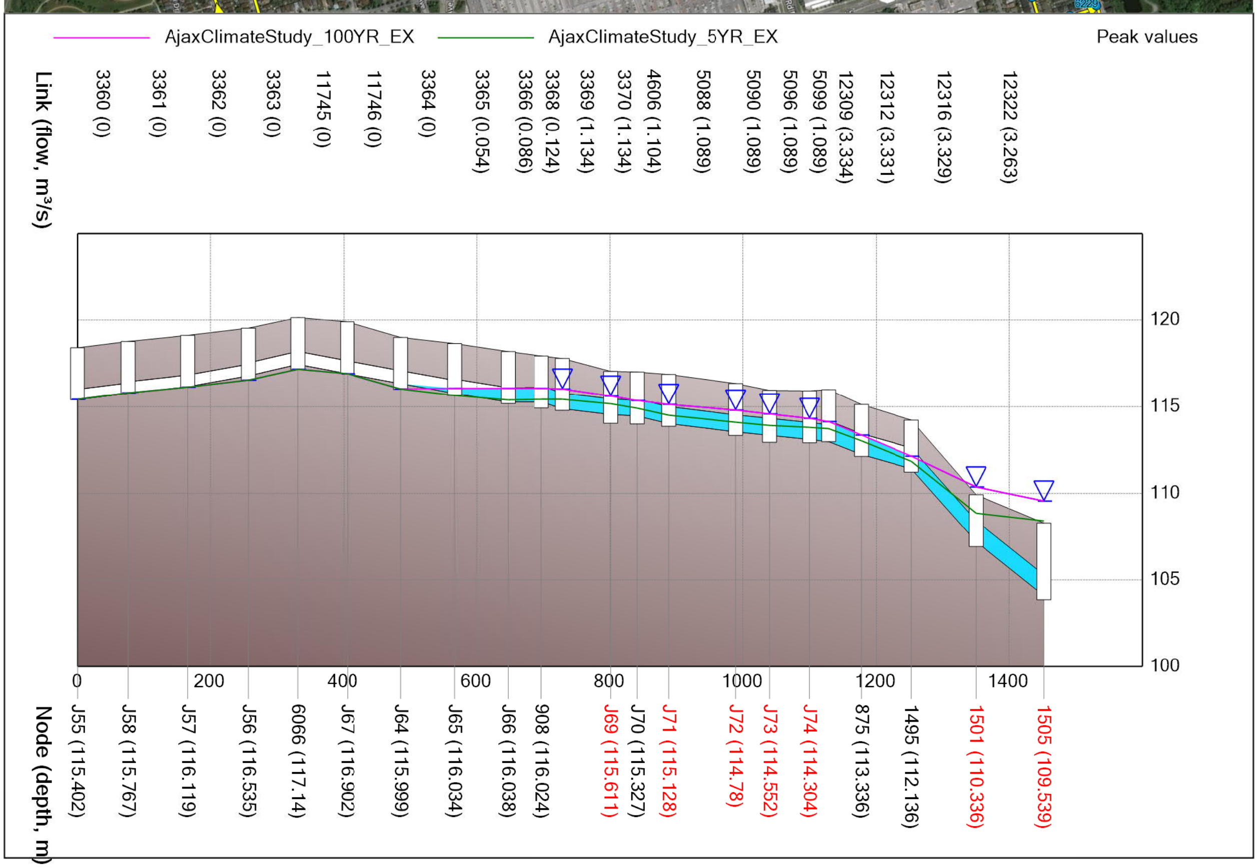

Legend
Storages
Junctions
Outfalls
Conduits
Visible
Inlet_Node_Null
AjaxClimateStudy_100YR_EX
AjaxClimateStudy_5YR_EX
Peak values
Link (flow, m³/s)
8878 (0.289)
11372 (2.452)
11373 (1.937)
11368 (2.742)
9177 (2.742)
10121 (4.688)
11356 (5.335)
11357 (6.159)
11354 (6.743)
11355 (6.726)
8464 (7.122)
8494 (8.387)
8490 (9.24)
8489 (10.027)
10382 (8.519)
8461 (8.747)
8517 (6.71)
9673 (6.169)
C123 (5.603)
90
85
80
75
70
65
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
Node (depth, m)
5905 (93.654)
5891 (92.657)
5890 (92.296)
5889 (91.822)
5129 (91.332)
5841 (90.646)
5079 (89.899)
5843 (88.497)
5381 (87.227)
5379 (86.456)
5380 (85.809)
5231 (85.274)
4856 (84.762)
4857 (84.397)
4858 (84.015)
4859 (83.649)



Legend
Storages
Junctions
Outfalls
Conduits
Visible
Inlet_Node_Null
AjaxClimateStudy_100YR_EX
AjaxClimateStudy_5YR_EX
Peak values
Link (flow, m³/s)
8839 (3.028)
8838 (3.147)
8837 (3.147)
8840 (3.779)
11738 (3.47)
11739 (3.984)
8466 (3.885)
8467 (4.965)
11711 (4.855)
11710 (4.761)
11695 (5.209)
11694 (8.166)
80
75
70
65
0
200
400
600
800
1000
Node (depth, m)
5421 (82.679)
5921 (82.443)
5433 (82.21)
J21 (82.005)
5671 (81.579)
5435 (81.237)
J22 (80.883)
5045 (80.891)
5463 (80.122)
6056 (79.775)
6057 (79.128)
6054 (77.392)
OF9 (65.905)

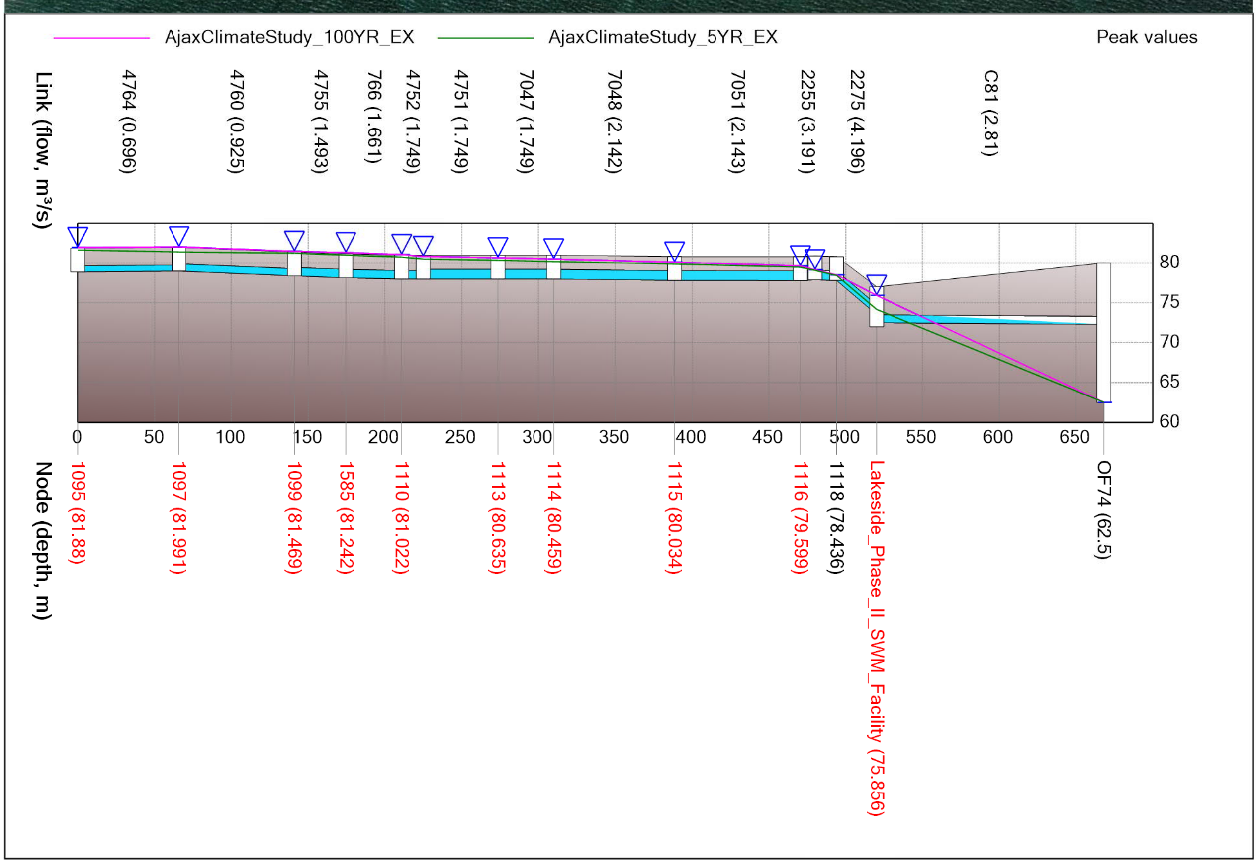


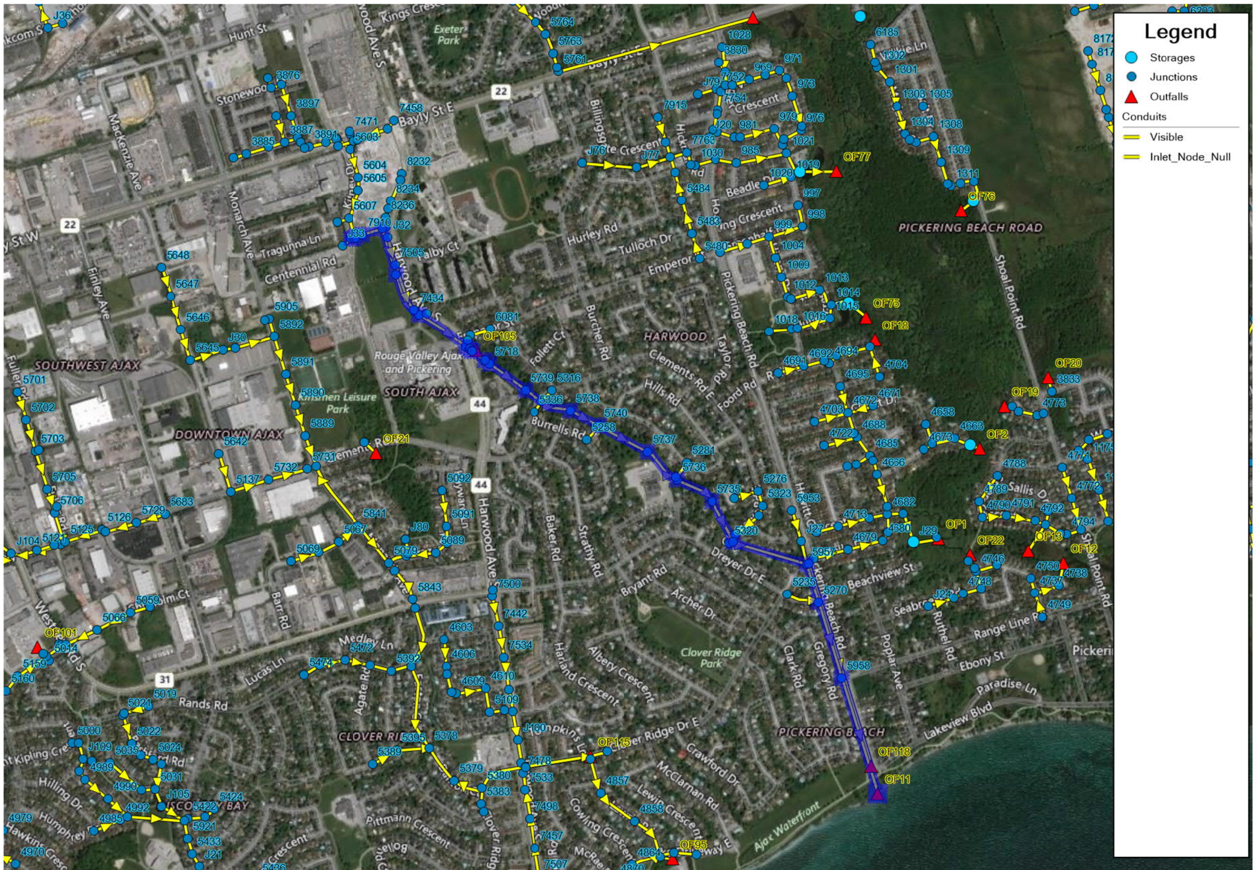
Legend
Storages
Junctions
Outfalls
Conduits
Visible
Inlet_Node_Null

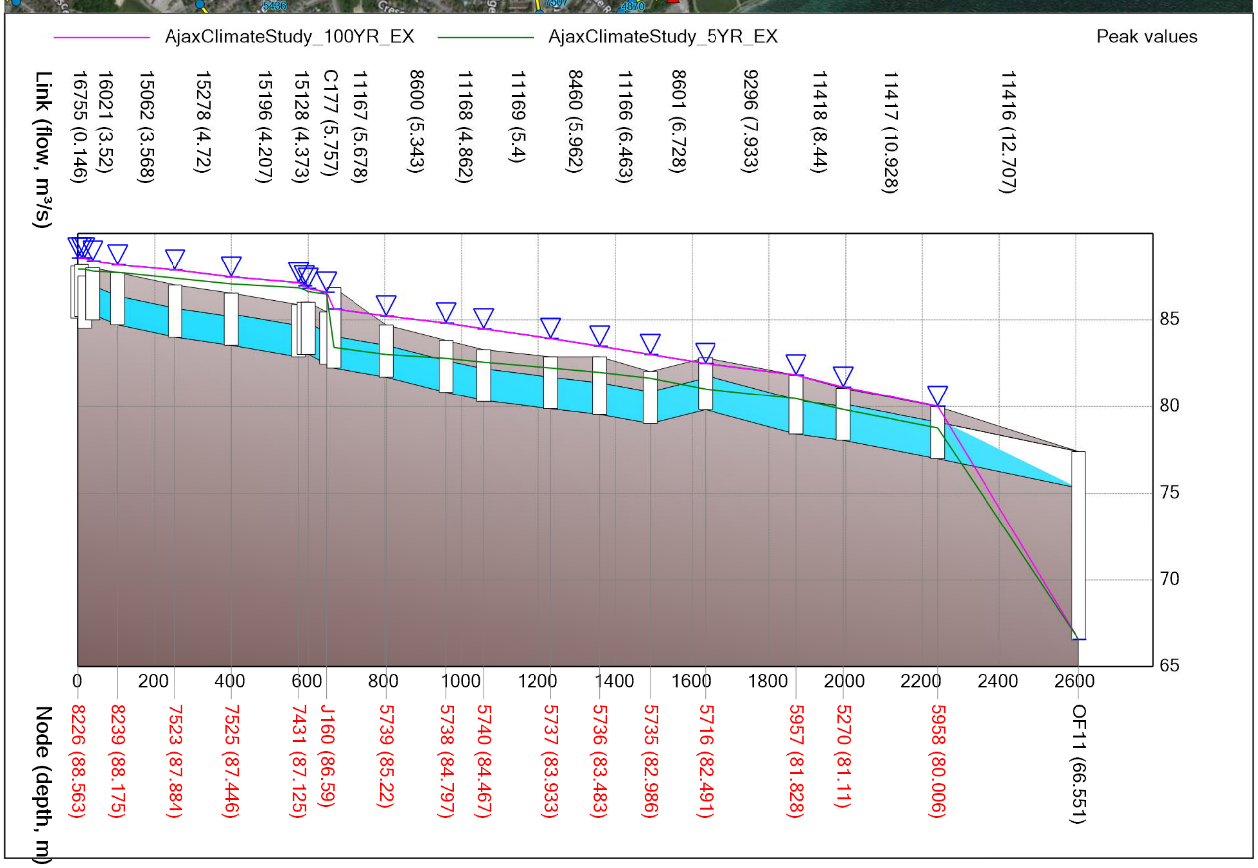


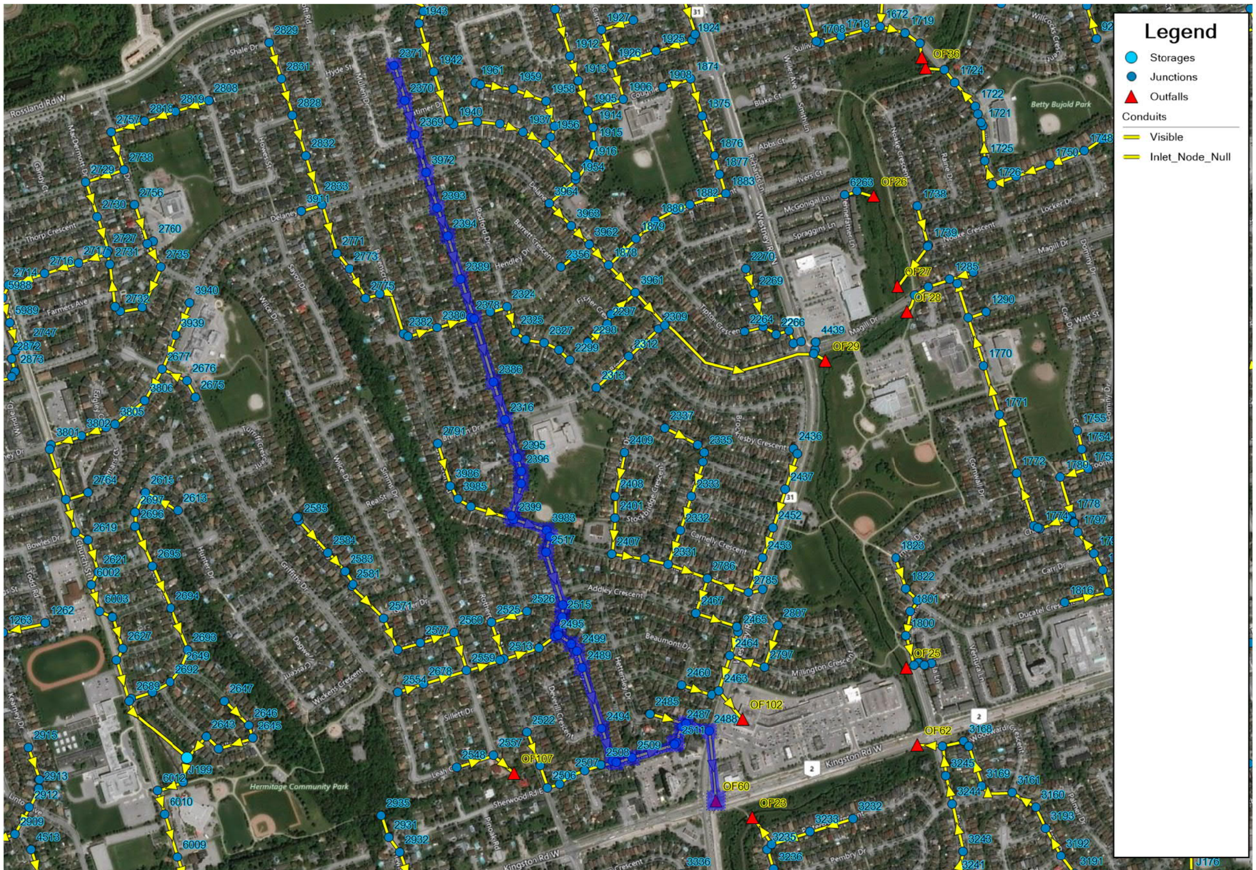
AjaxClimateStudy_100YR_EX
AjaxClimateStudy_5YR_EX
Peak values
Link (flow, m³/s)
3360 (0)
3361 (0)
3362 (0)
3363 (0)
11745 (0)
11746 (0)
3364 (0)
3365 (0.054)
3366 (0.086)
3368 (0.124)
3369 (1.134)
3370 (1.134)
4606 (1.104)
5088 (1.089)
5090 (1.089)
5096 (1.089)
5099 (1.089)
12309 (3.334)
12312 (3.331)
12316 (3.329)
12322 (3.263)
120
115
110
105
100
0
200
400
600
800
1000
1200
1400
Node (depth, m)
J55 (115.402)
J58 (115.767)
J57 (116.119)
J56 (116.535)
6066 (117.14)
J67 (116.902)
J64 (115.999)
J65 (116.034)
J66 (116.038)
908 (116.024)
J69 (115.611)
J70 (115.327)
J71 (115.128)
J72 (114.78)
J73 (114.552)
J74 (114.304)
875 (113.336)
1495 (112.136)
1501 (110.336)
1505 (109.539)

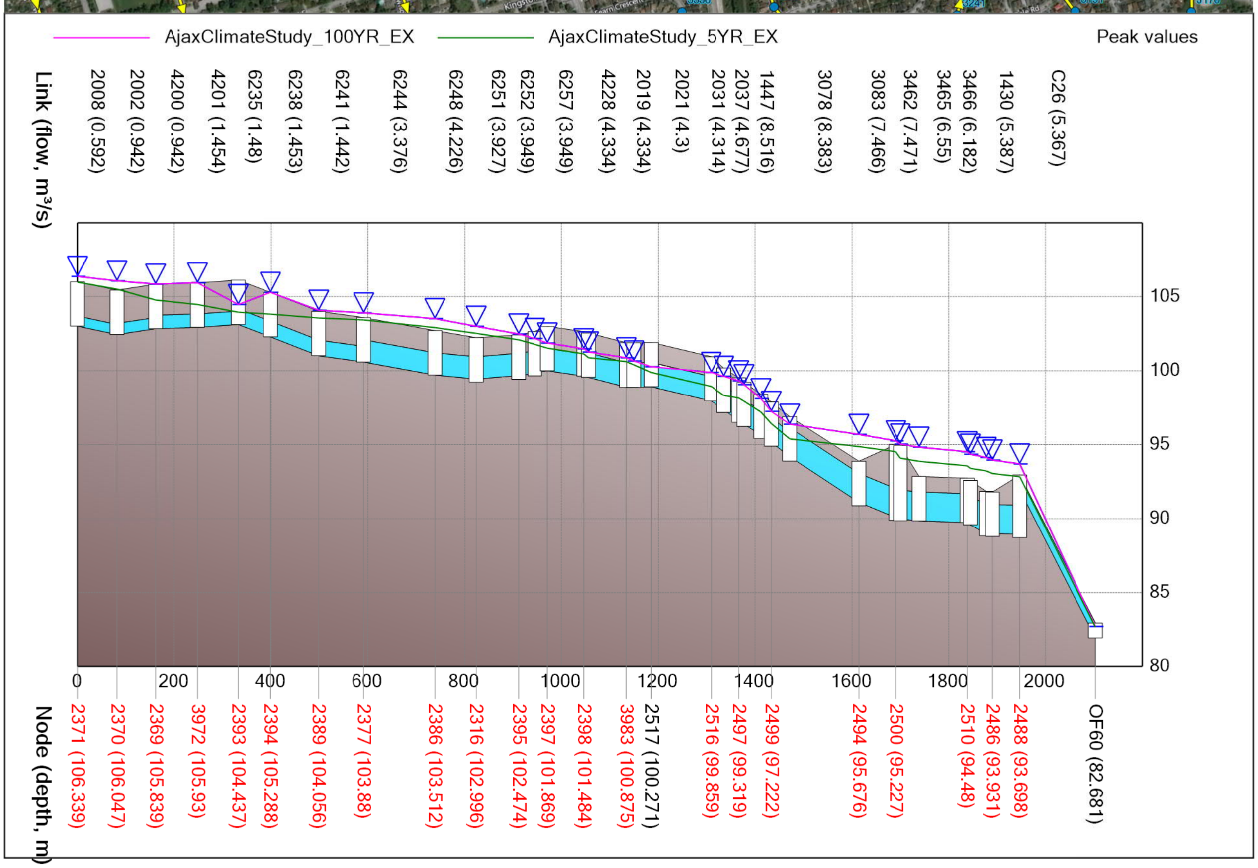

Legend
Storages
Junctions
Outfalls
Conduits
Visible
Inlet_Node_Null
Pickering Beach
Paradise Park
Lakeview Blvd
Range Rd
Warwick Ave
Handley Crescent
Kingham Ave
Upchurch Ave
OF74


AjaxClimateStudy_100YR_EX
AjaxClimateStudy_5YR_EX
Peak values
Link (flow, m³/s)
4764 (0.696)
4760 (0.925)
4755 (1.493)
766 (1.661)
4752 (1.749)
4751 (1.749)
7047 (1.749)
7048 (2.142)
7051 (2.143)
2255 (3.191)
2275 (4.196)
C81 (2.81)
80
75
70
65
60
0
50
100
150
200
250
300
350
400
450
500
550
600
650
Node (depth, m)
1095 (81.88)
1097 (81.991)
1099 (81.469)
1585 (81.242)
1110 (81.022)
1113 (80.635)
1114 (80.459)
1115 (80.034)
1116 (79.599)
1118 (78.436)
Lakeside_Phase_II_SWM_Facility (75.856)
OF74 (62.5)


Legend
Storages
Junctions
Outfalls
Conduits
Visible
Inlet_Node_Null
PICKERING BEACH ROAD
HARWOOD
SOUTHWEST AJAX
DOWNTOWN AJAX
SOUTH AJAX
PICKERING BEACH
Clover Ridge Park
Ajax Waterfront
OF11


AjaxClimateStudy_100YR_EX
AjaxClimateStudy_5YR_EX
Peak values
Link (flow, m³/s)
16755 (0.146)
16021 (3.52)
15062 (3.568)
15278 (4.72)
15196 (4.207)
15128 (4.373)
C177 (5.757)
11167 (5.678)
8600 (5.343)
11168 (4.862)
11169 (5.4)
8460 (5.962)
11166 (6.463)
8601 (6.728)
9296 (7.933)
11418 (8.44)
11417 (10.928)
11416 (12.707)
85
80
75
70
65
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
Node (depth, m)
8226 (88.563)
8239 (88.175)
7523 (87.884)
7525 (87.446)
7431 (87.125)
J160 (86.59)
5739 (85.22)
5738 (84.797)
5740 (84.467)
5737 (83.933)
5736 (83.483)
5735 (82.986)
5716 (82.491)
5957 (81.828)
5270 (81.11)
5958 (80.006)
OF11 (66.551)

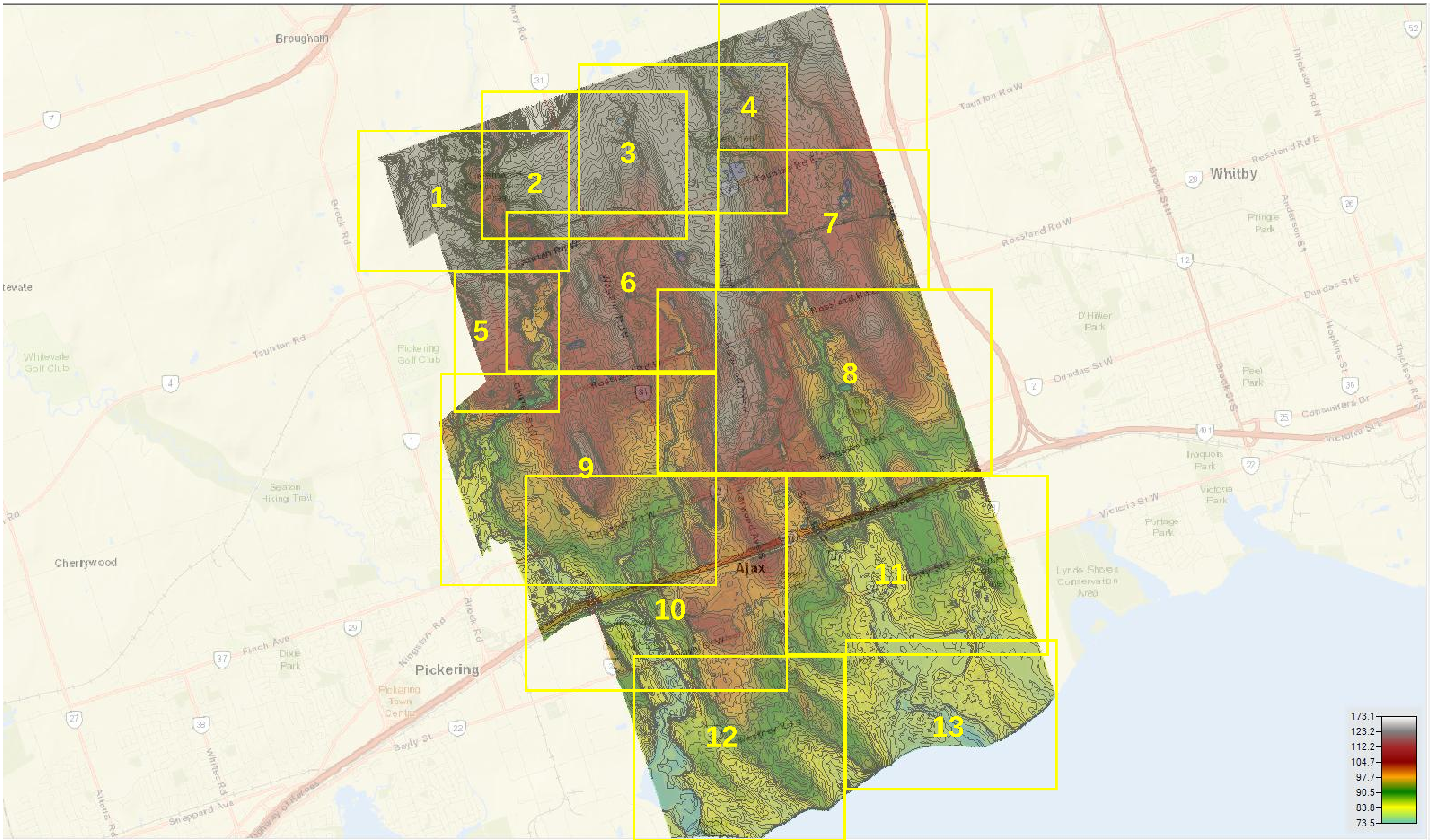

Legend
Storages
Junctions
Outfalls
Conduits
Visible
Inlet_Node_Null


AjaxClimateStudy_100YR_EX
AjaxClimateStudy_5YR_EX
Peak values
Link (flow, m³/s)
2008 (0.592)
2002 (0.942)
4200 (0.942)
4201 (1.454)
6235 (1.48)
6238 (1.453)
6241 (1.442)
6244 (3.376)
6248 (4.226)
6251 (3.927)
6252 (3.949)
6257 (3.949)
4228 (4.334)
2019 (4.334)
2021 (4.3)
2031 (4.314)
2037 (4.677)
1447 (8.516)
3078 (8.383)
3083 (7.466)
3462 (7.471)
3465 (6.55)
3466 (6.182)
1430 (5.387)
C26 (5.367)
105
100
95
90
85
80
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Node (depth, m)
2371 (106.339)
2370 (106.047)
2369 (105.839)
3972 (105.93)
2393 (104.437)
2394 (105.288)
2389 (104.056)
2377 (103.88)
2386 (103.512)
2316 (102.996)
2395 (102.474)
2397 (101.869)
2398 (101.484)
3983 (100.875)
2517 (100.271)
2516 (99.859)
2497 (99.319)
2499 (97.222)
2494 (95.676)
2500 (95.227)
2510 (94.48)
2486 (93.931)
2488 (93.698)
OF60 (82.681)

Appendix F

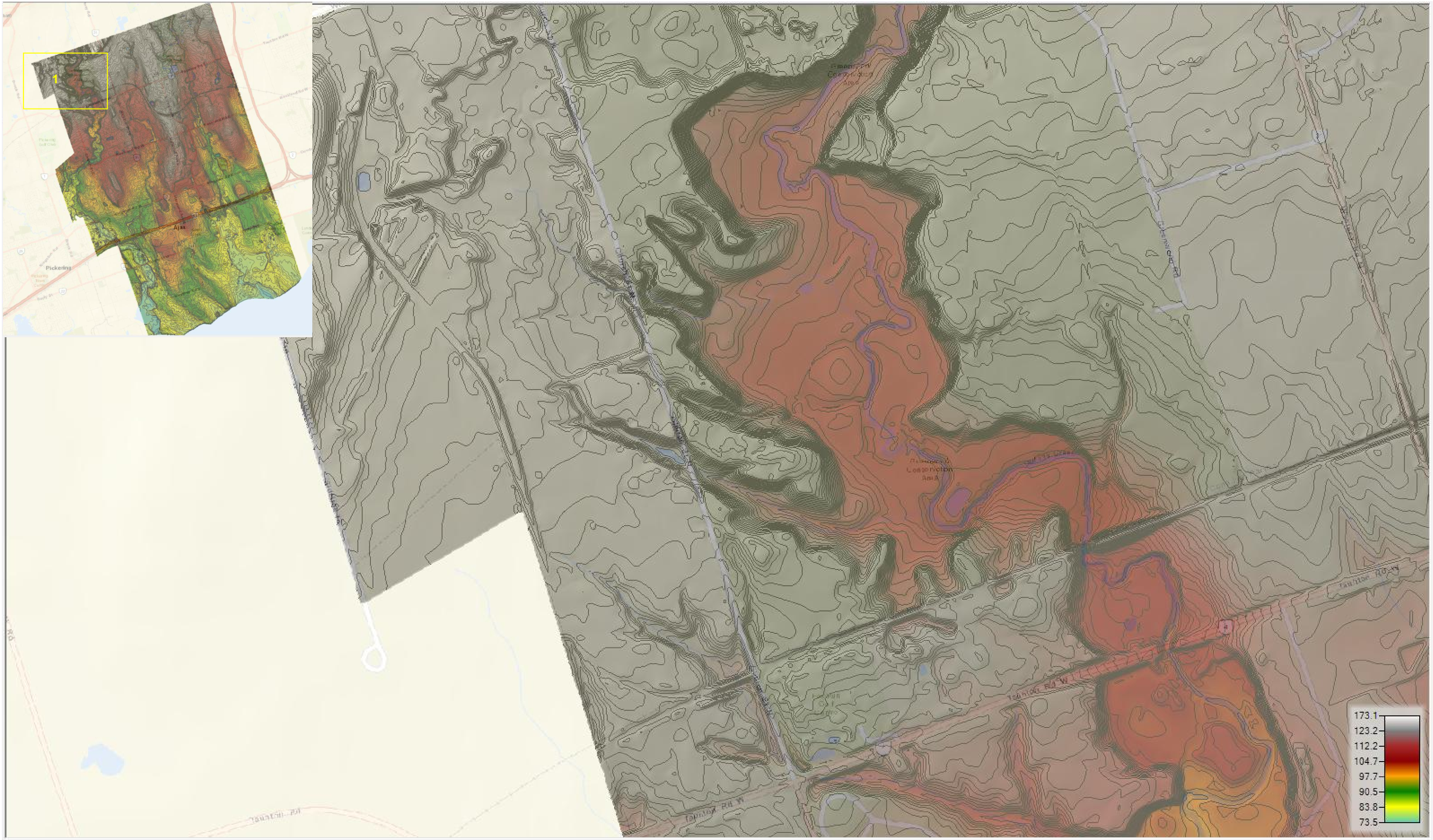
HEC-RAS Mapper Topographic Maps

DILLON CONSULTING



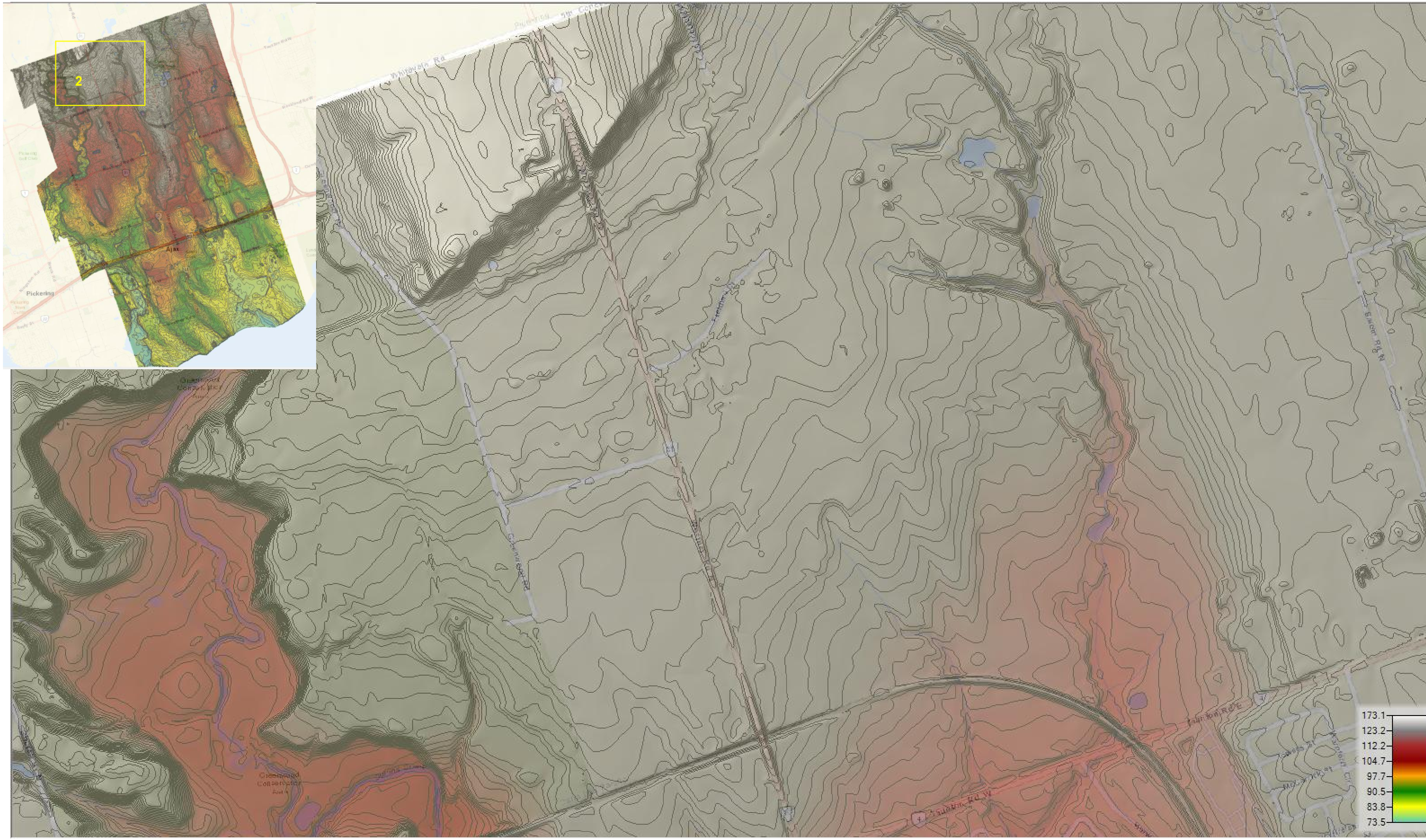
1
2
3
4
5
6
7
8
9
10
11
12
13
Brougham
Whitby
Ajax
Pickering
Cherrywood
Whitevale Golf Club
Pickering Golf Club
Seaton Hiking Trail
Taunton Rd W
Rossland Rd W
Dundas St W
Victoria St W
Brock Rd
Finch Ave
Kingston Rd
Bayly St
Sheppard Ave
Altona Rd
Lynde Shores Conservation Area
173.1
123.2
112.2
104.7
97.7
90.5
83.8
73.5

MAP 1

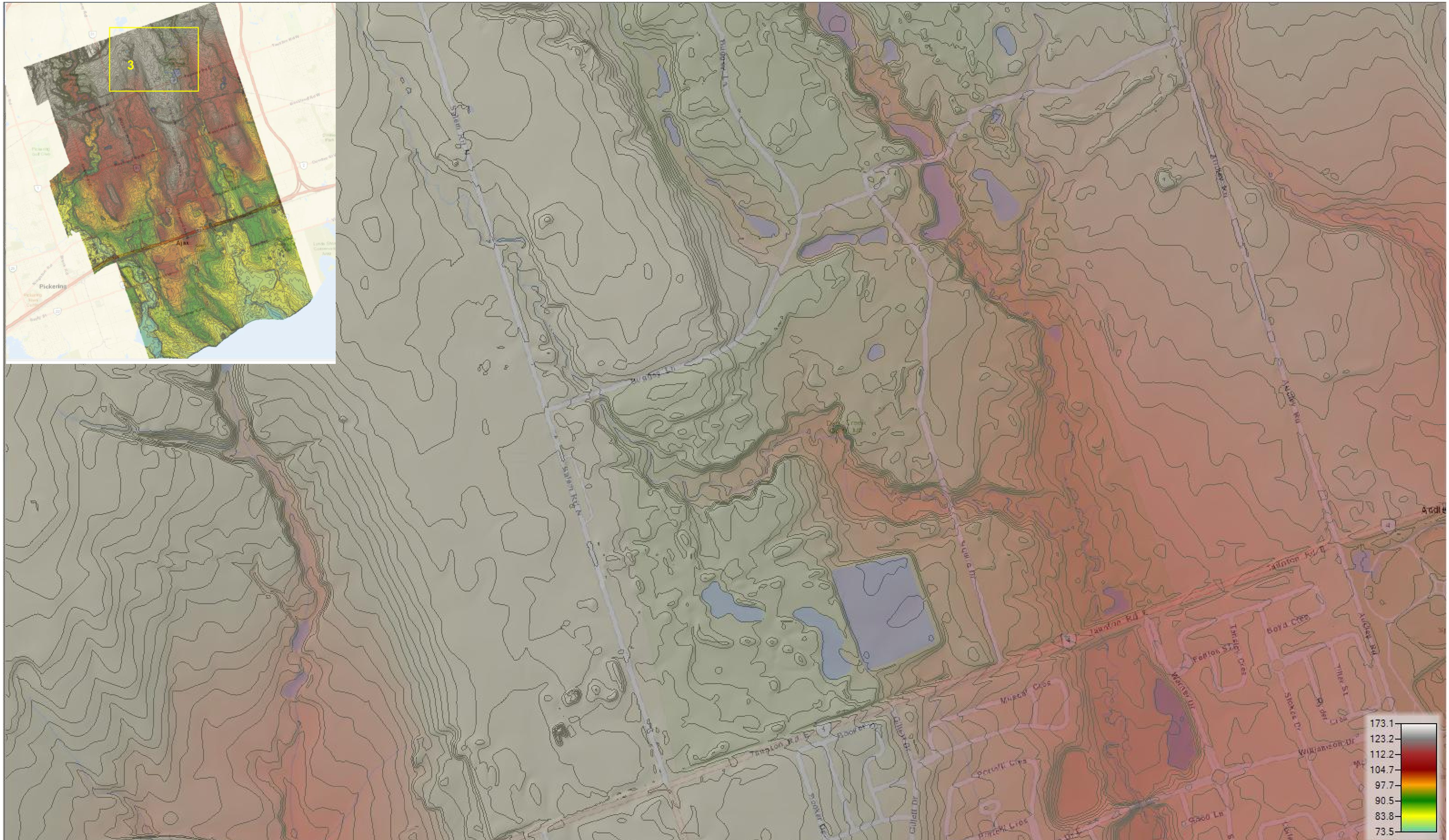


1
Pickering
Ajax
Taunton Rd W
Taunton Rd
173.1
123.2
112.2
104.7
97.7
90.5
83.8
73.5

MAP 2

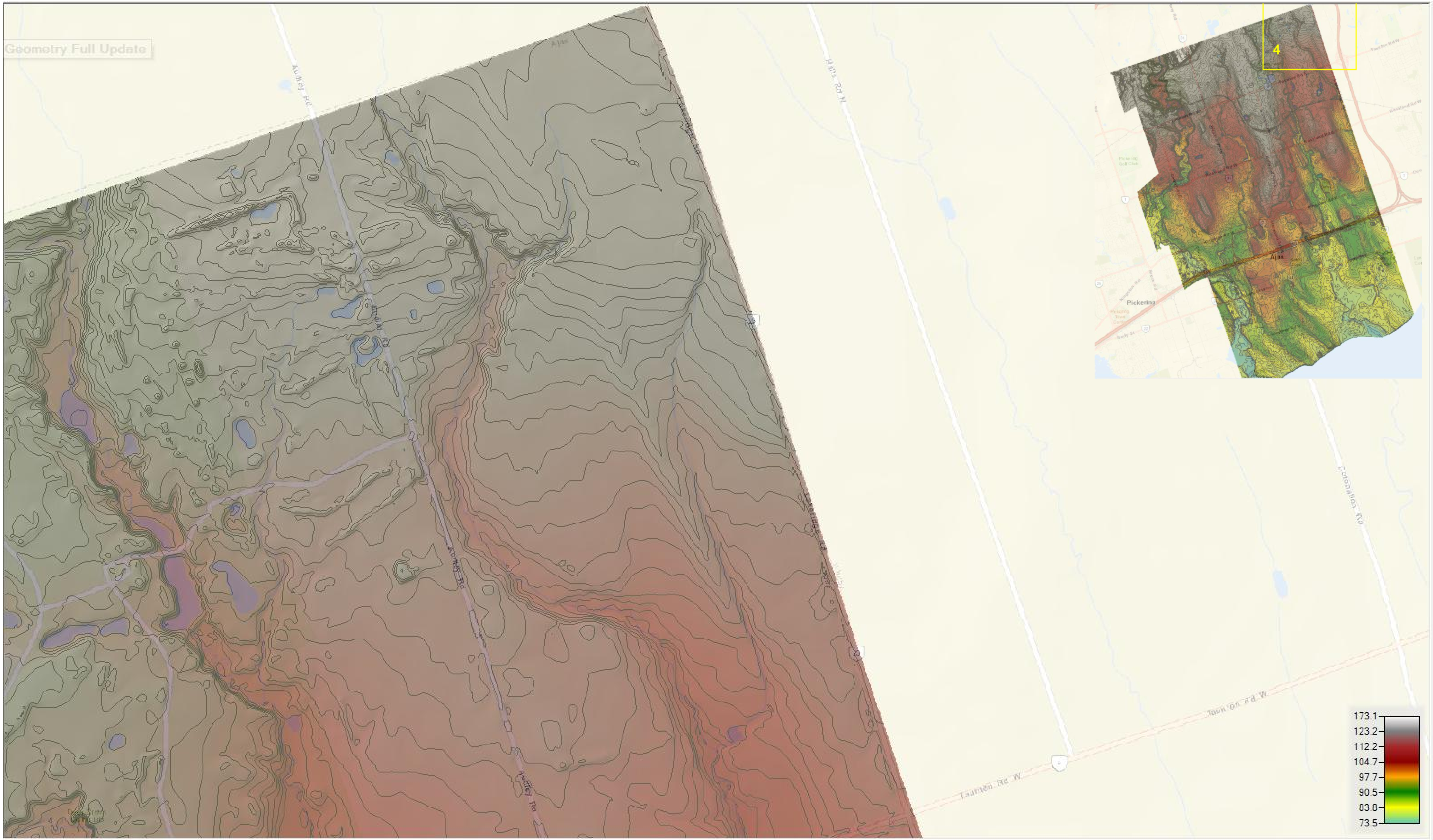


MAP 3



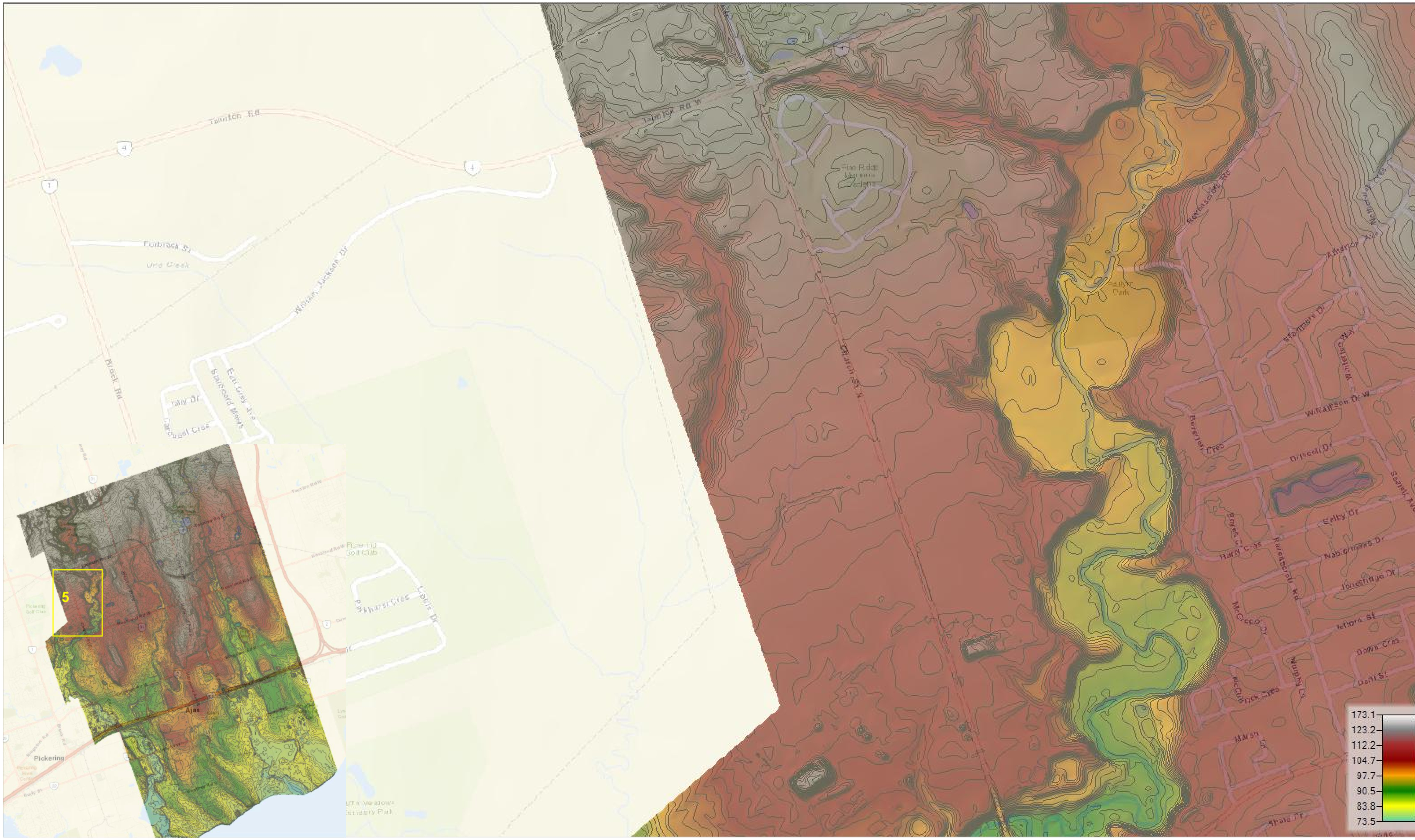
173.1
123.2
112.2
104.7
97.7
90.5
83.8
73.5
Taunton Rd E
Salem Rd N
Audley Rd

MAP 4



Geometry Full Update
Taunton Rd W
Pickering
Ajax
4
173.1
123.2
112.2
104.7
97.7
90.5
83.8
73.5

MAP 5



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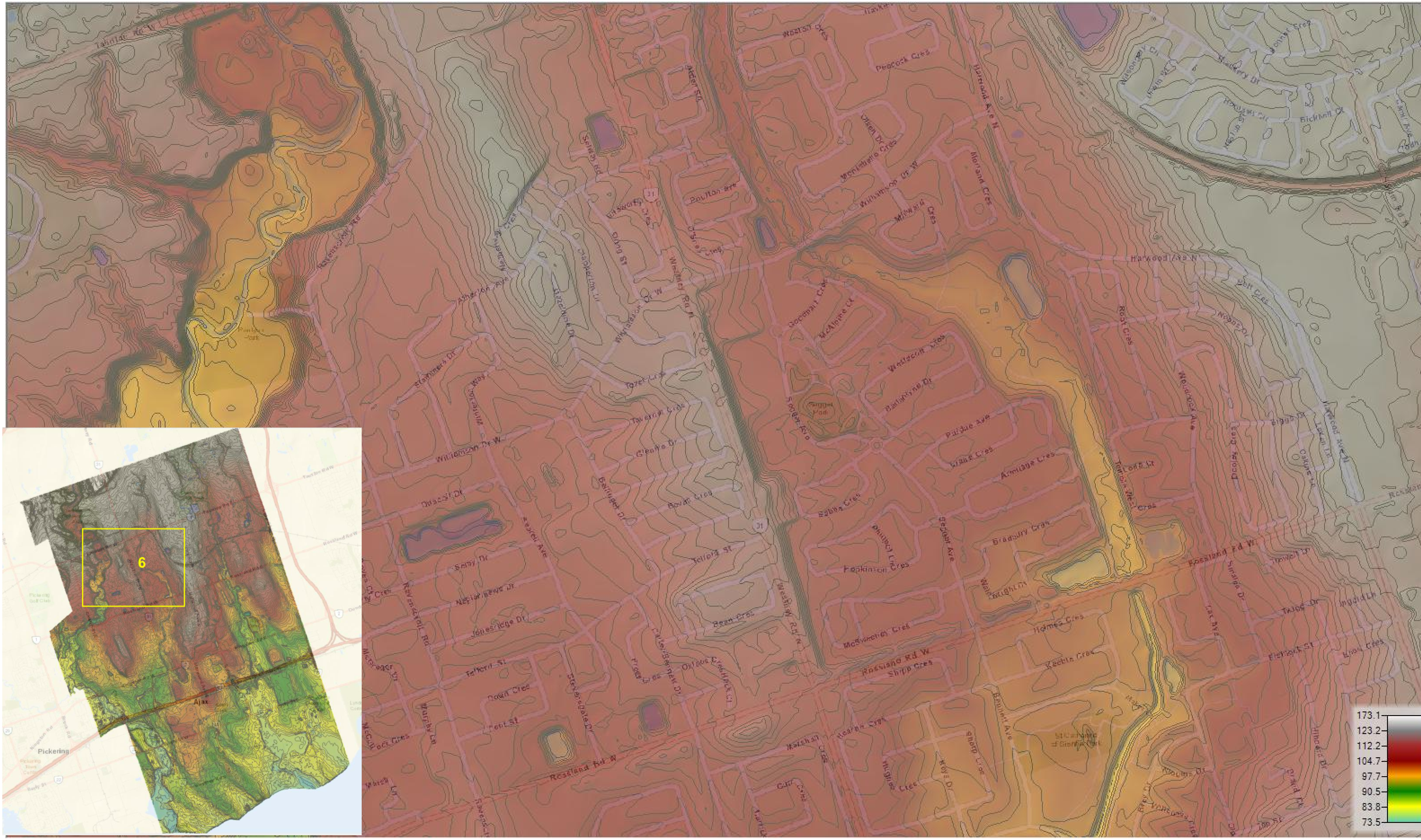
6
Pickering
Ajax
173.1
123.2
112.2
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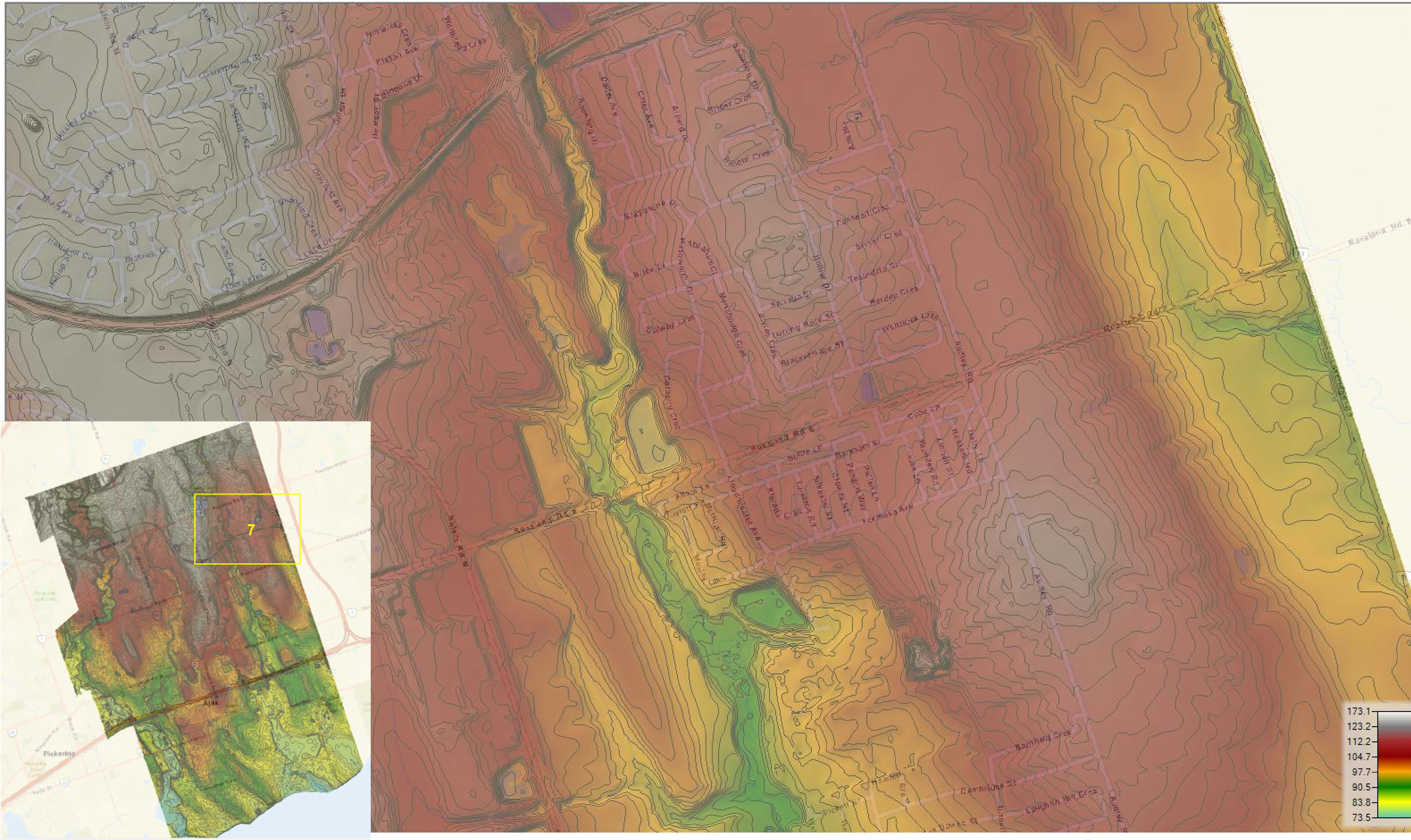
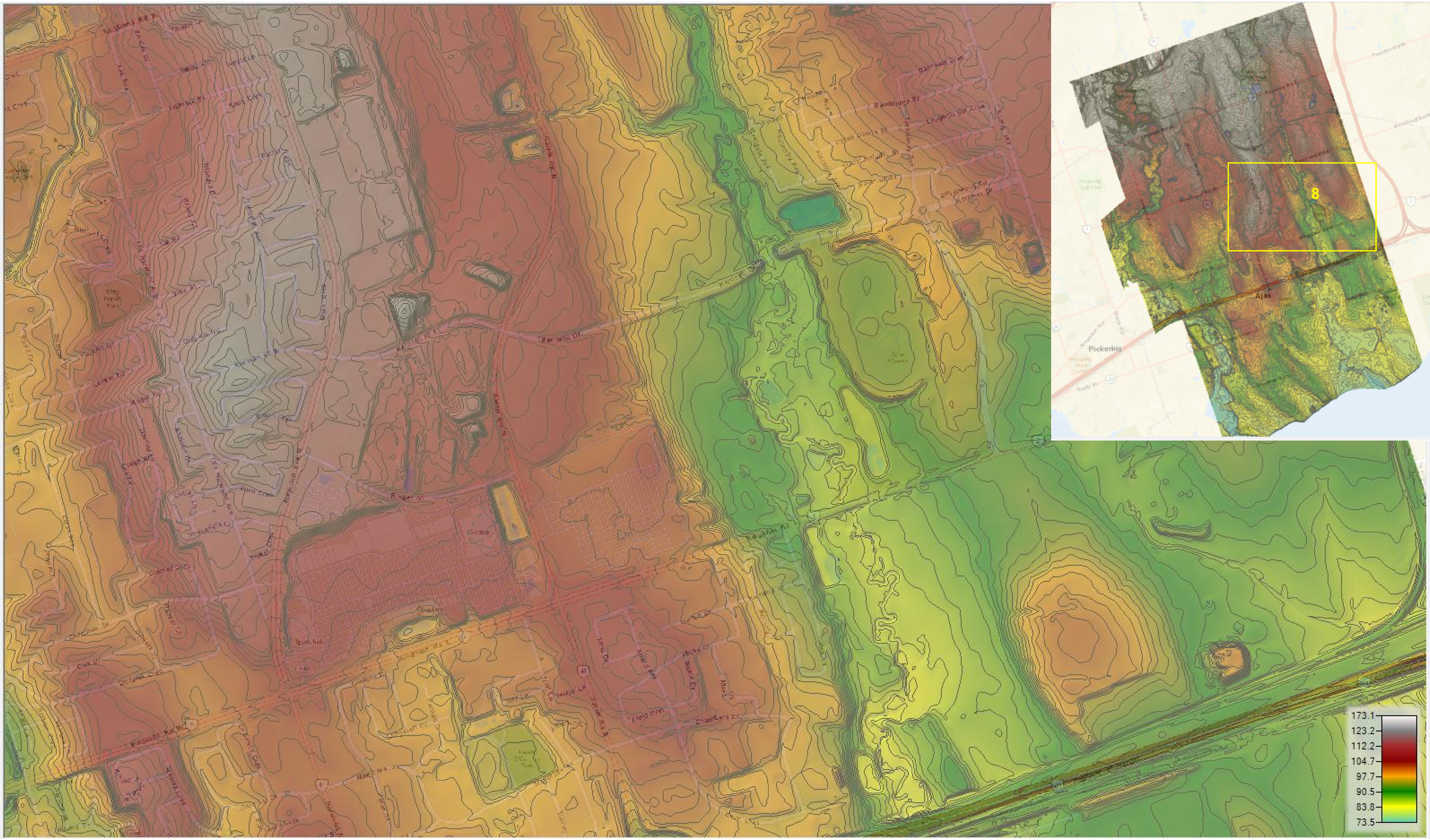
83.8
73.5
Rossland Rd W
Williamson Dr W
Harwood Ave N
Westney Rd N

MAP 7



Rossland Rd E
Rossland Rd W
Salem Rd N
Audley Rd
173.1
123.2
112.2
104.7
97.7
90.5
83.8
73.5
7
Ajax
Pickering

MAP 8



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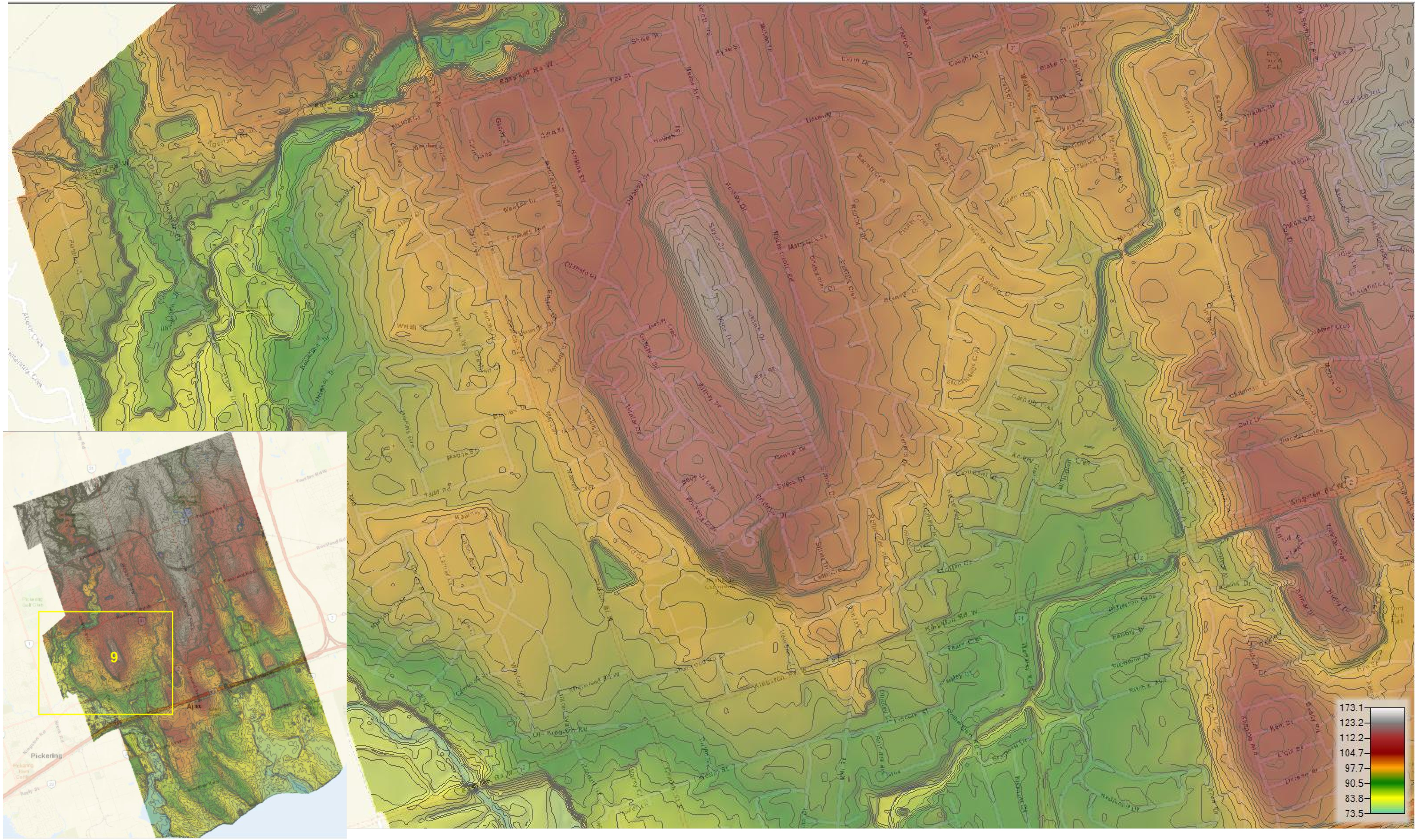

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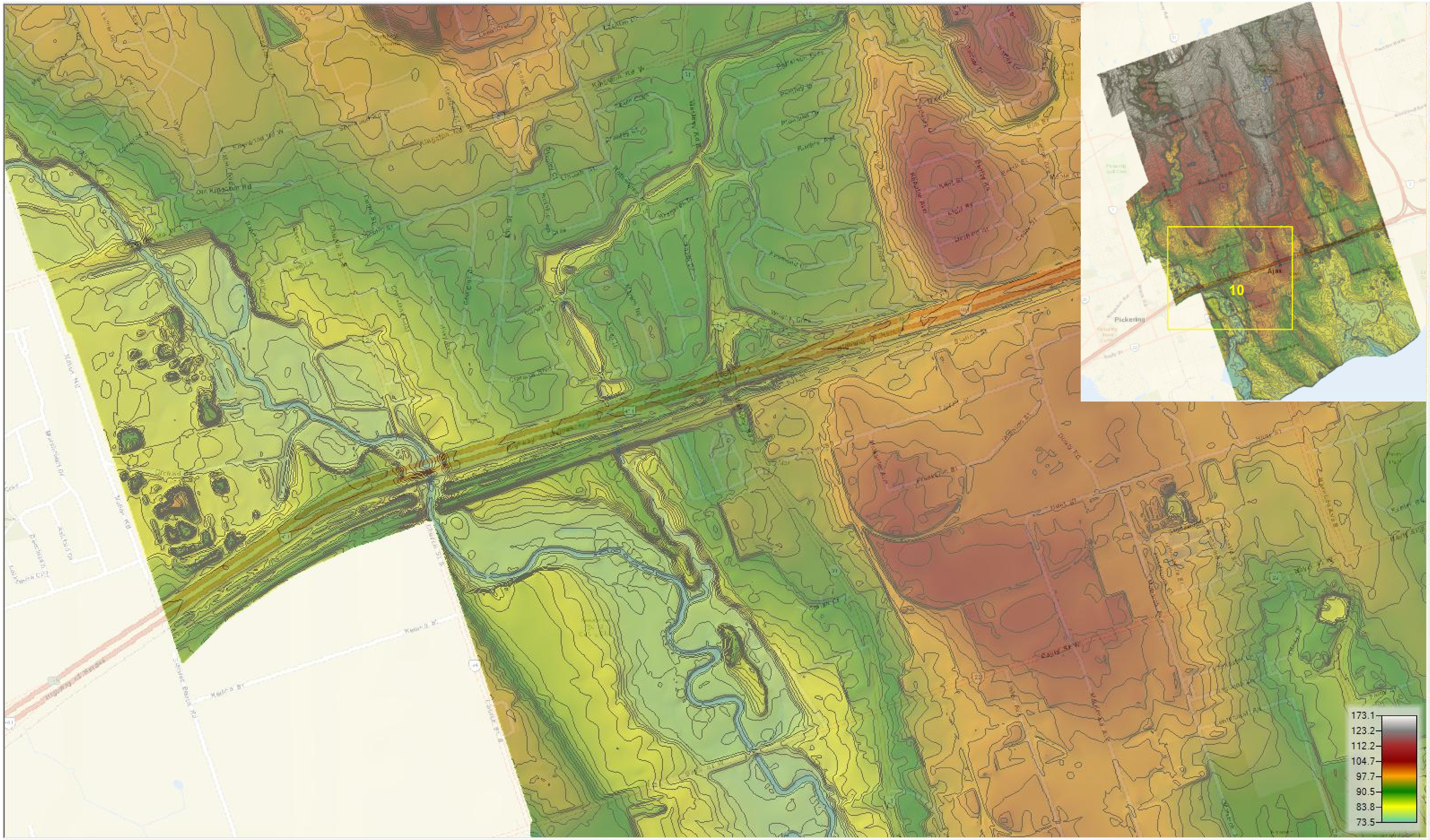
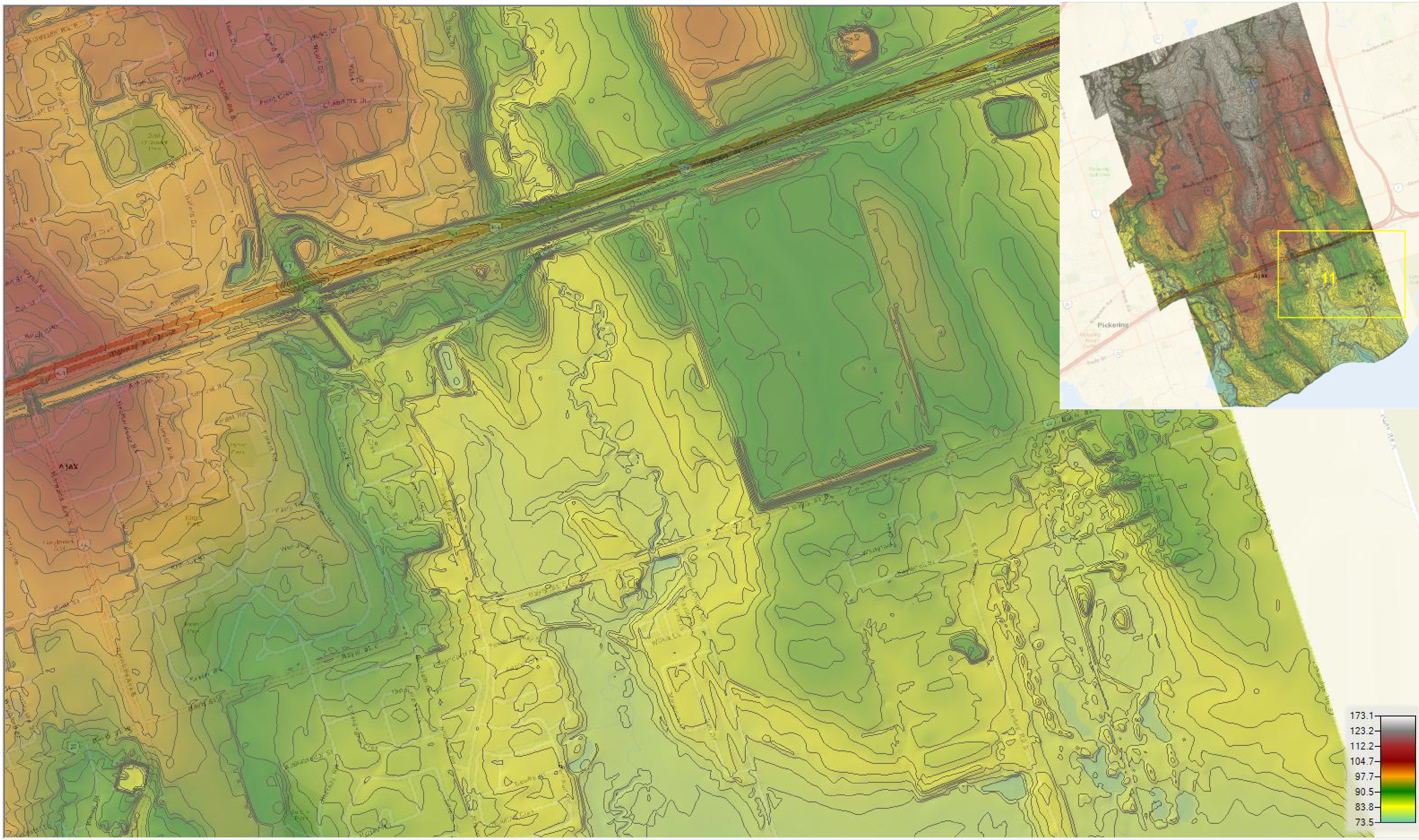


MAP 11



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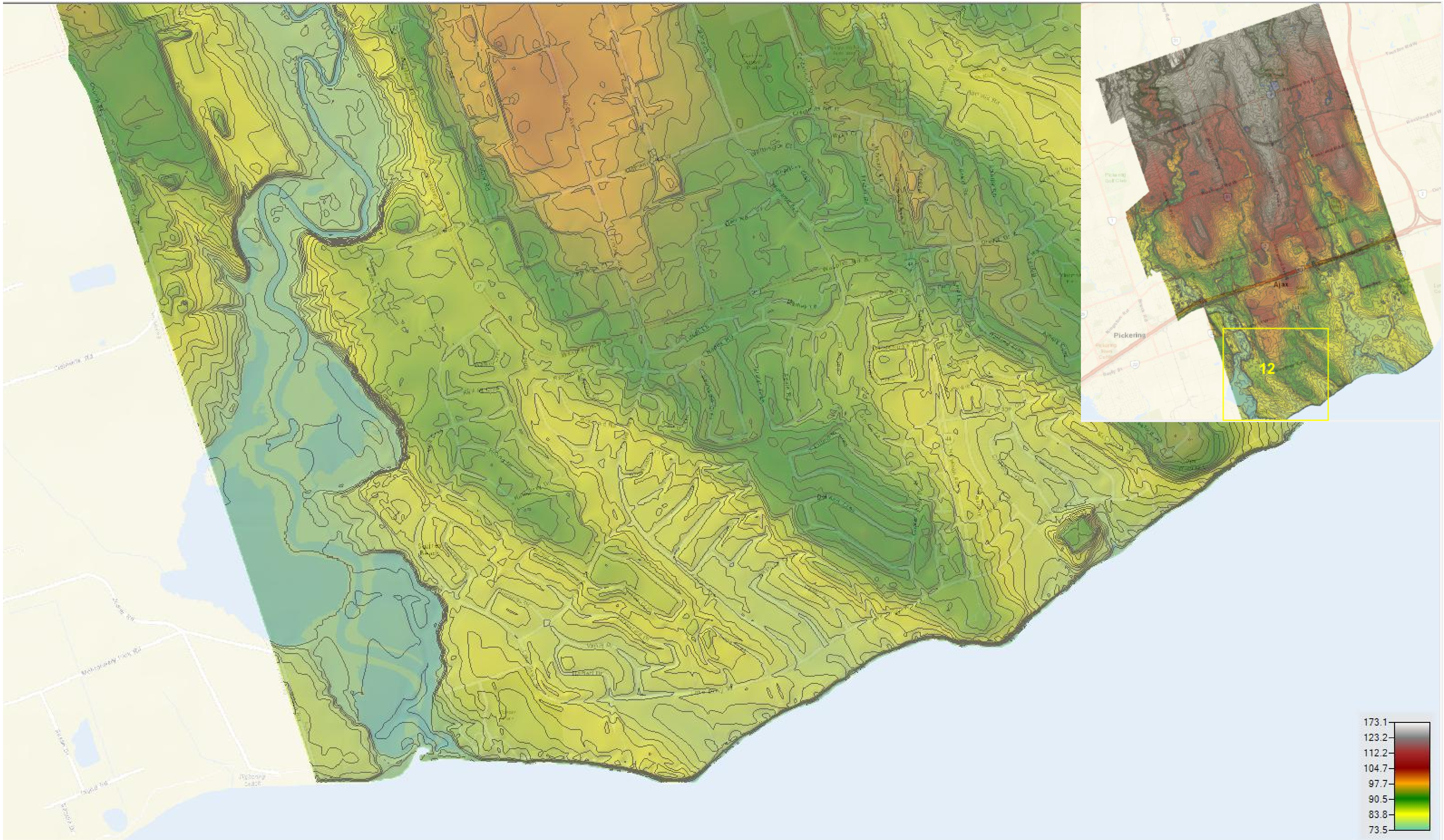

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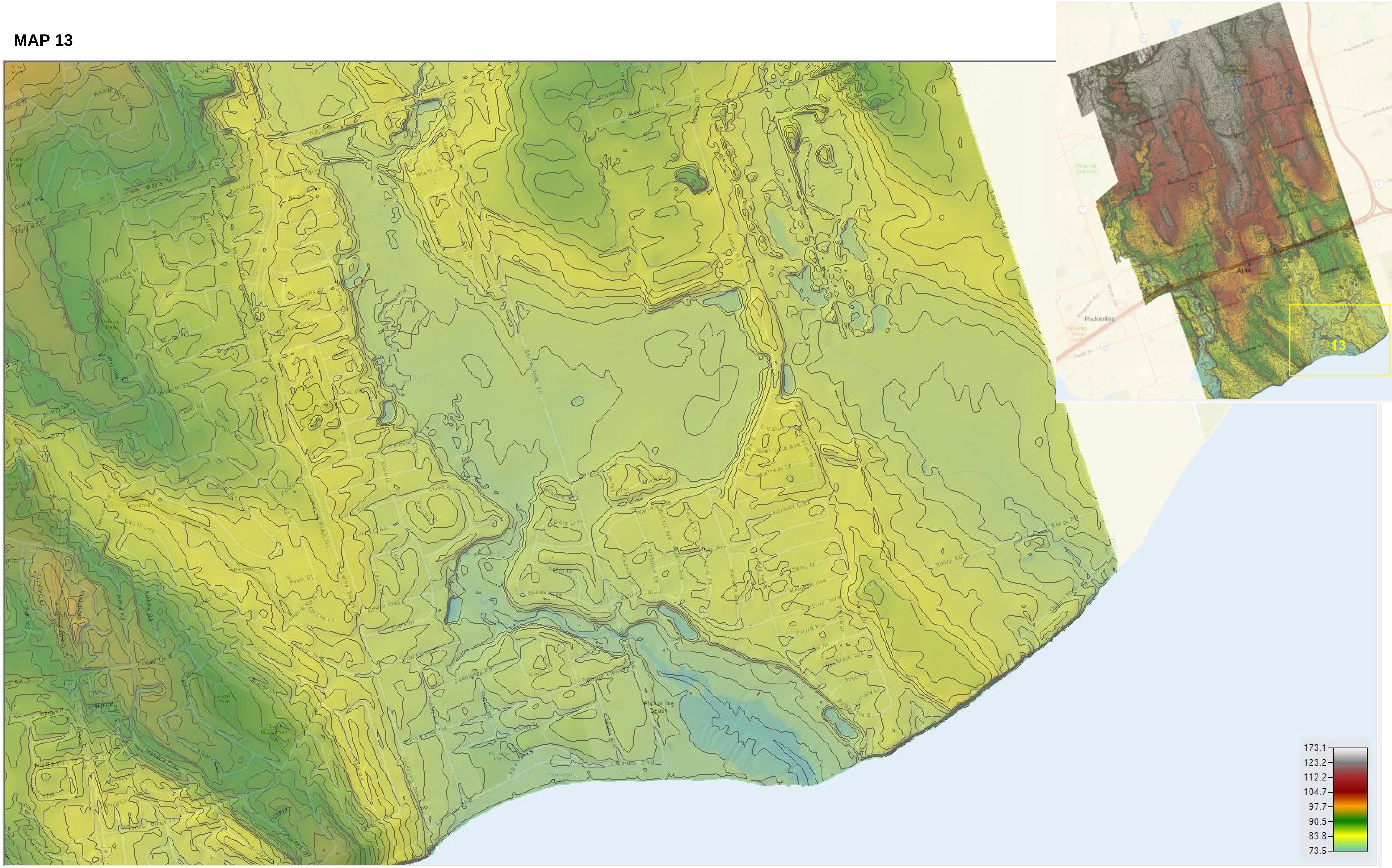
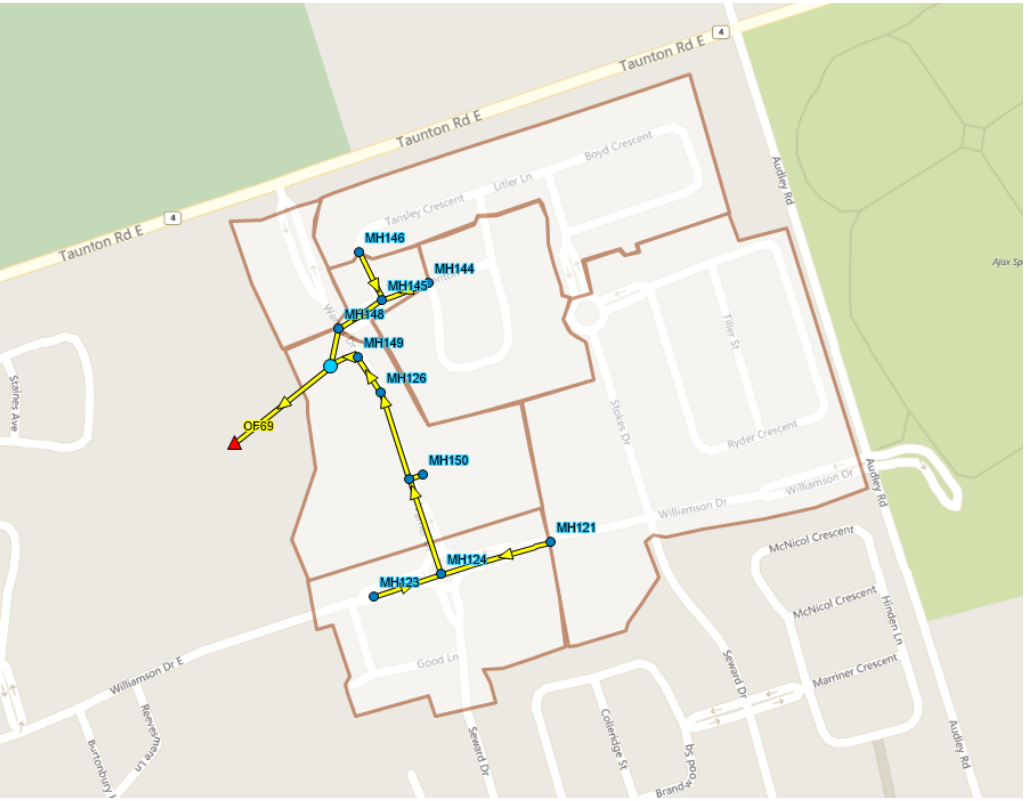


Appendix G

PCSWMM Plans and Profiles: Detailed Sub-model

DILLON CONSULTING

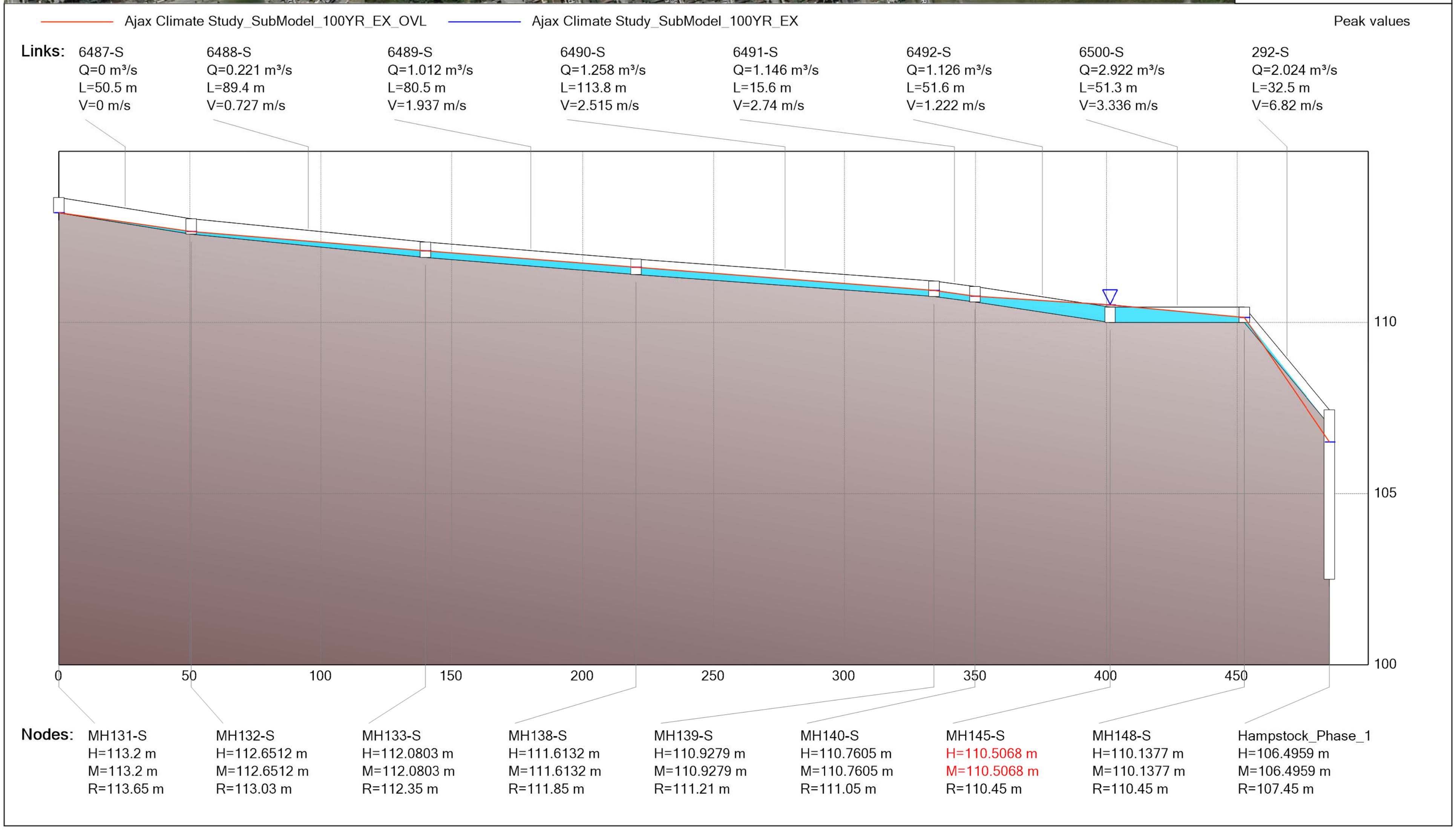
Key Plan showing Town-Wide Model and Detailed Sub-Model

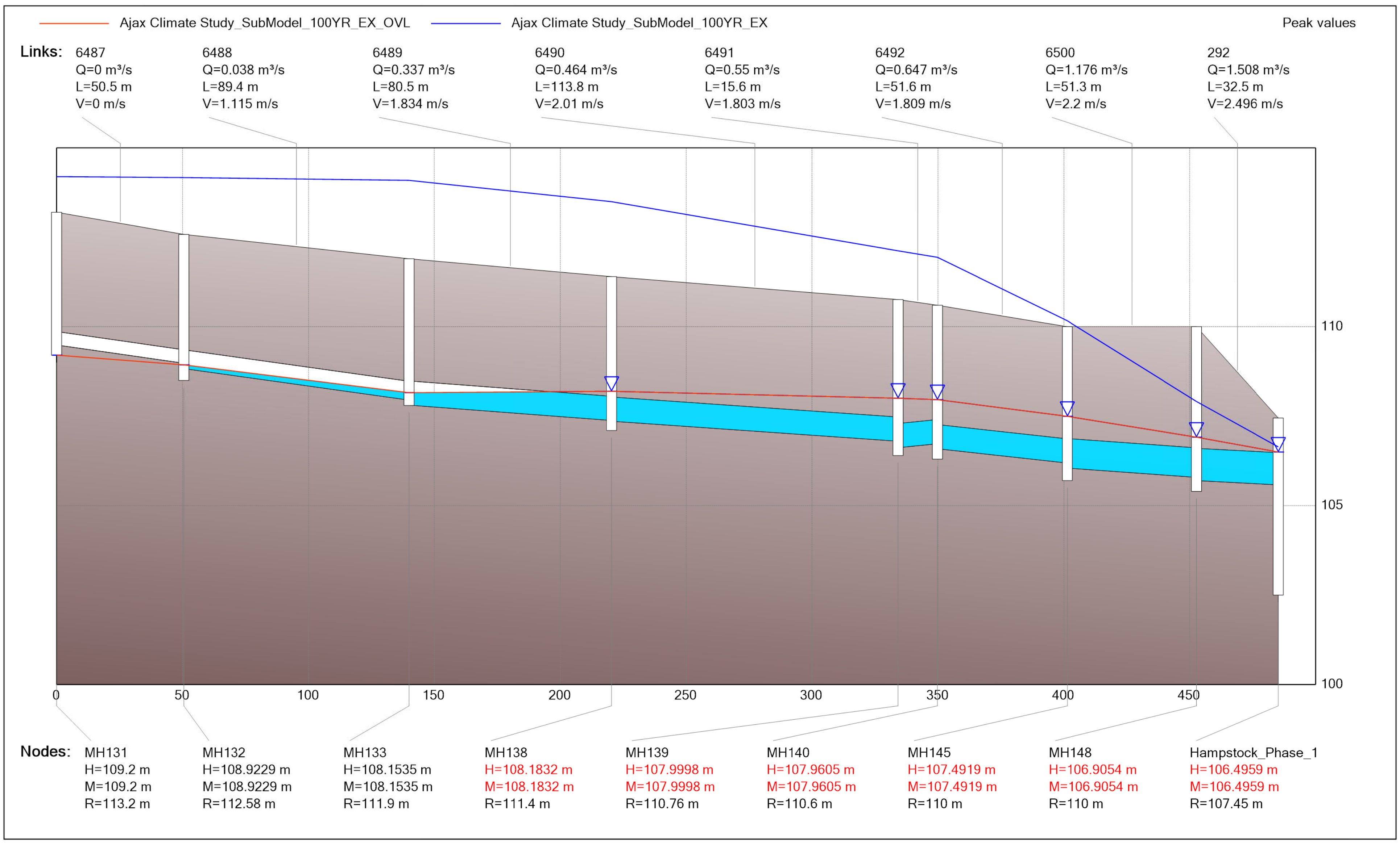


Town-Wide Model

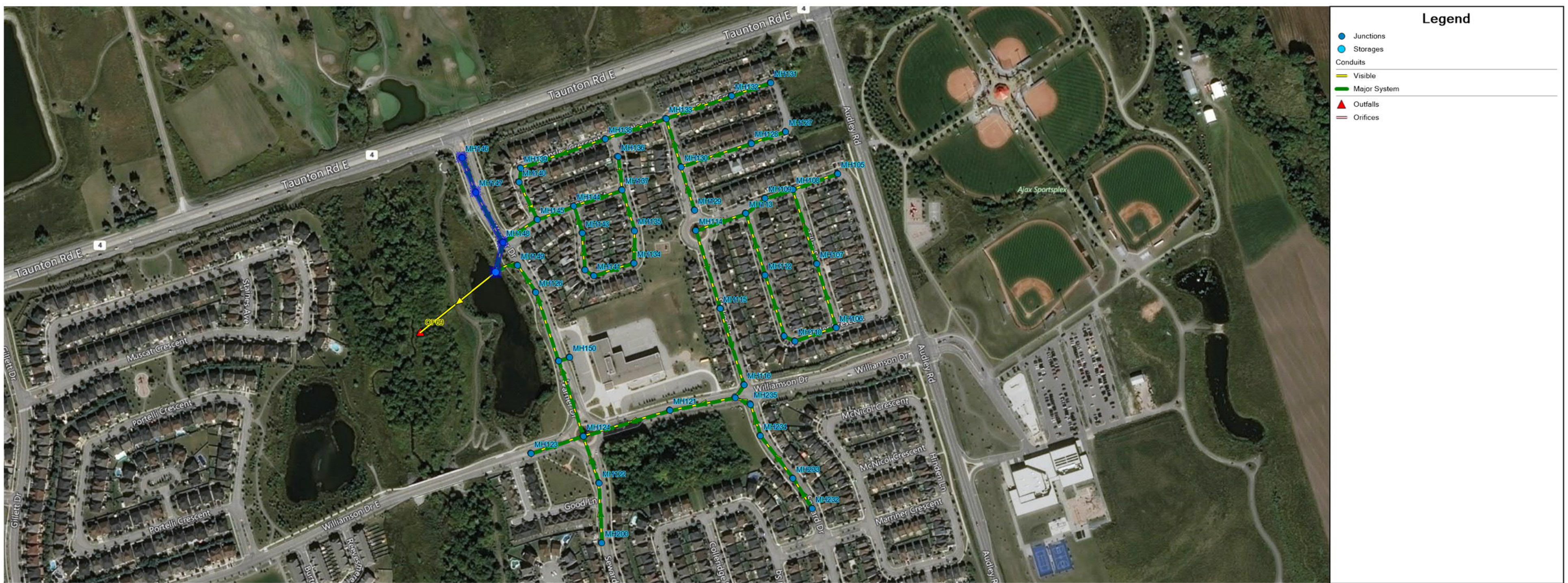
Detailed Sub-Model

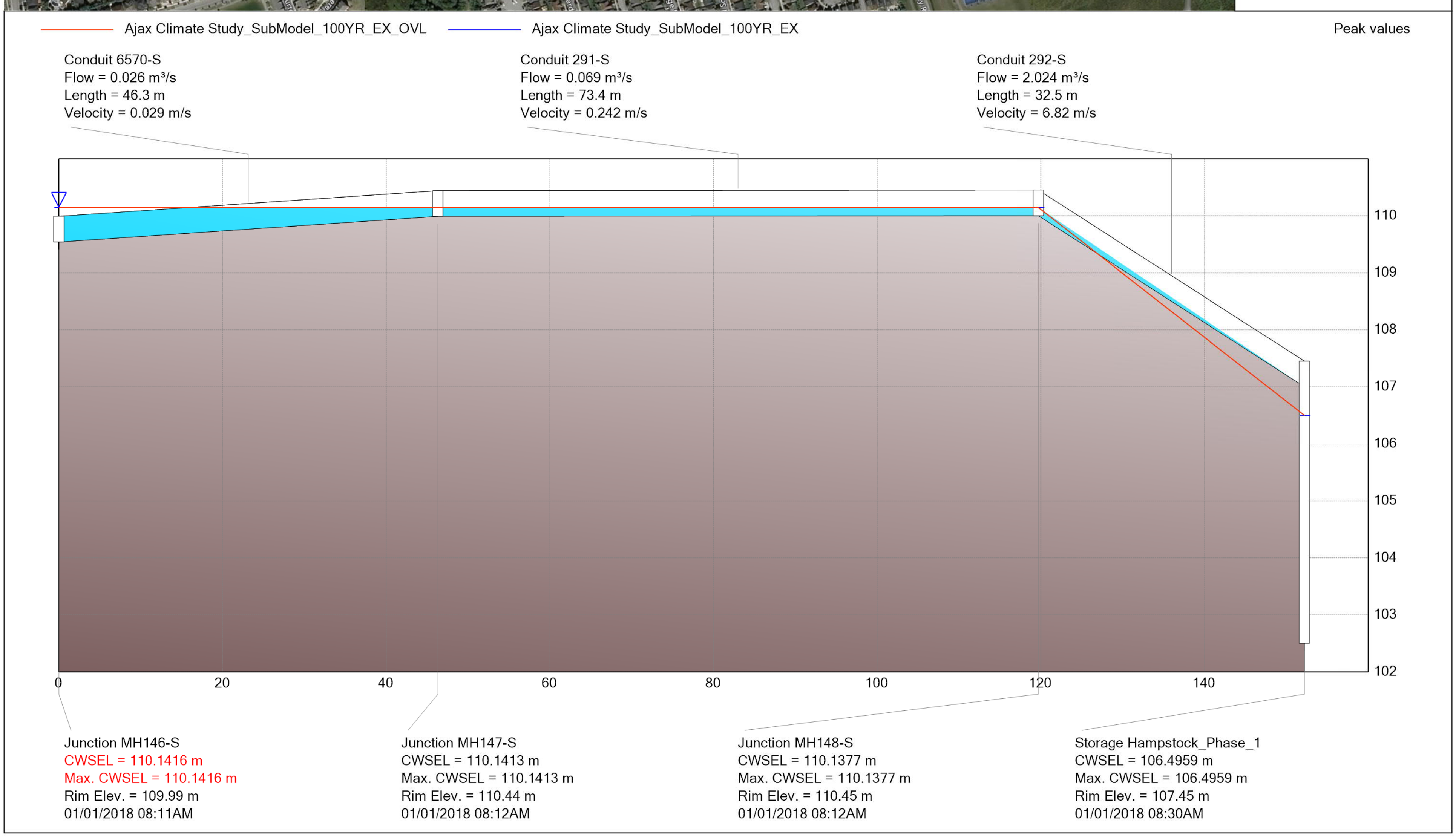
Sub-Model 100-yr HGL Comparison: With and Without Overland Flow Path

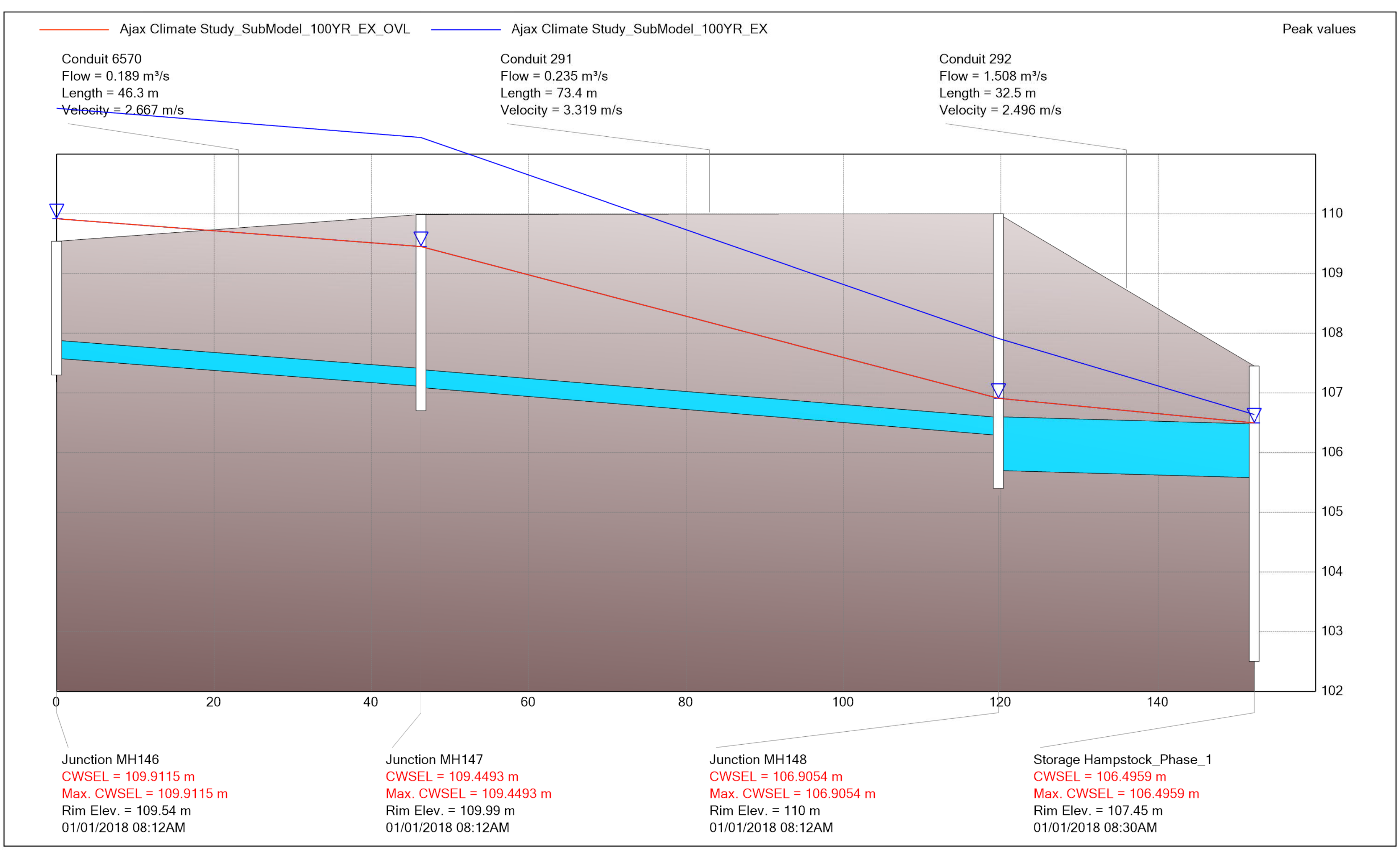




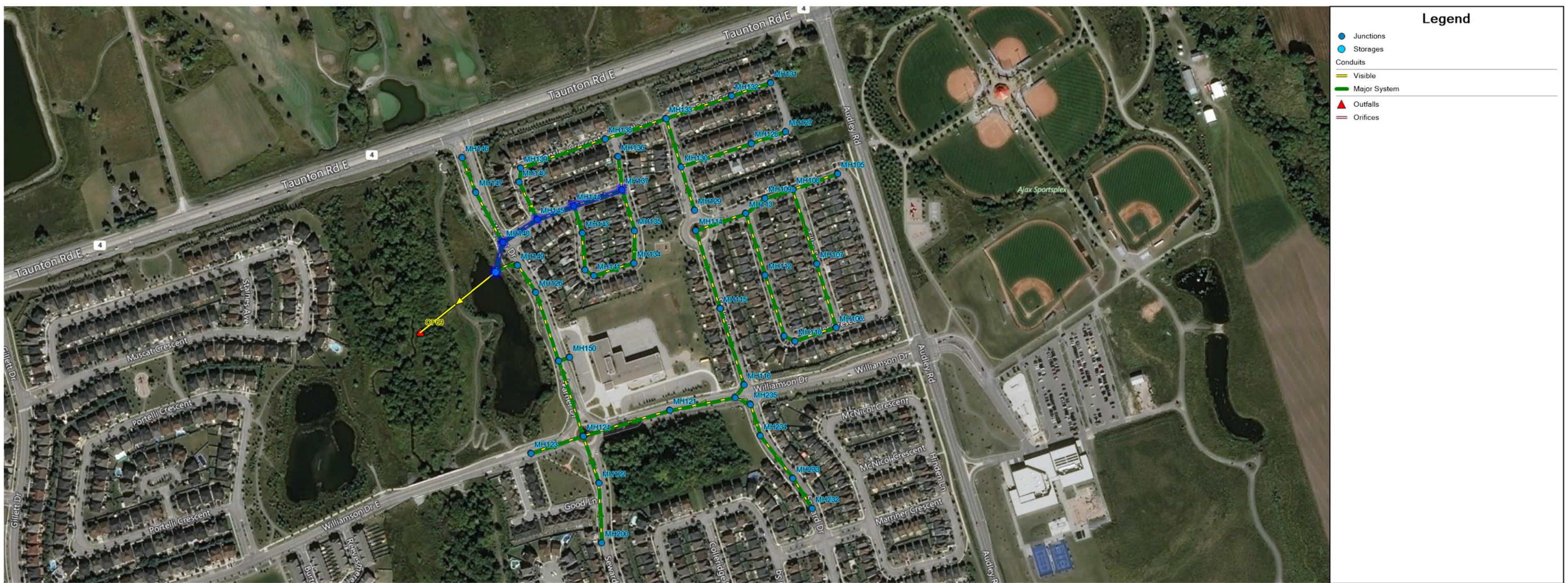
Sub-Model 100-yr HGL Comparison: With and Without Overland Flow Path

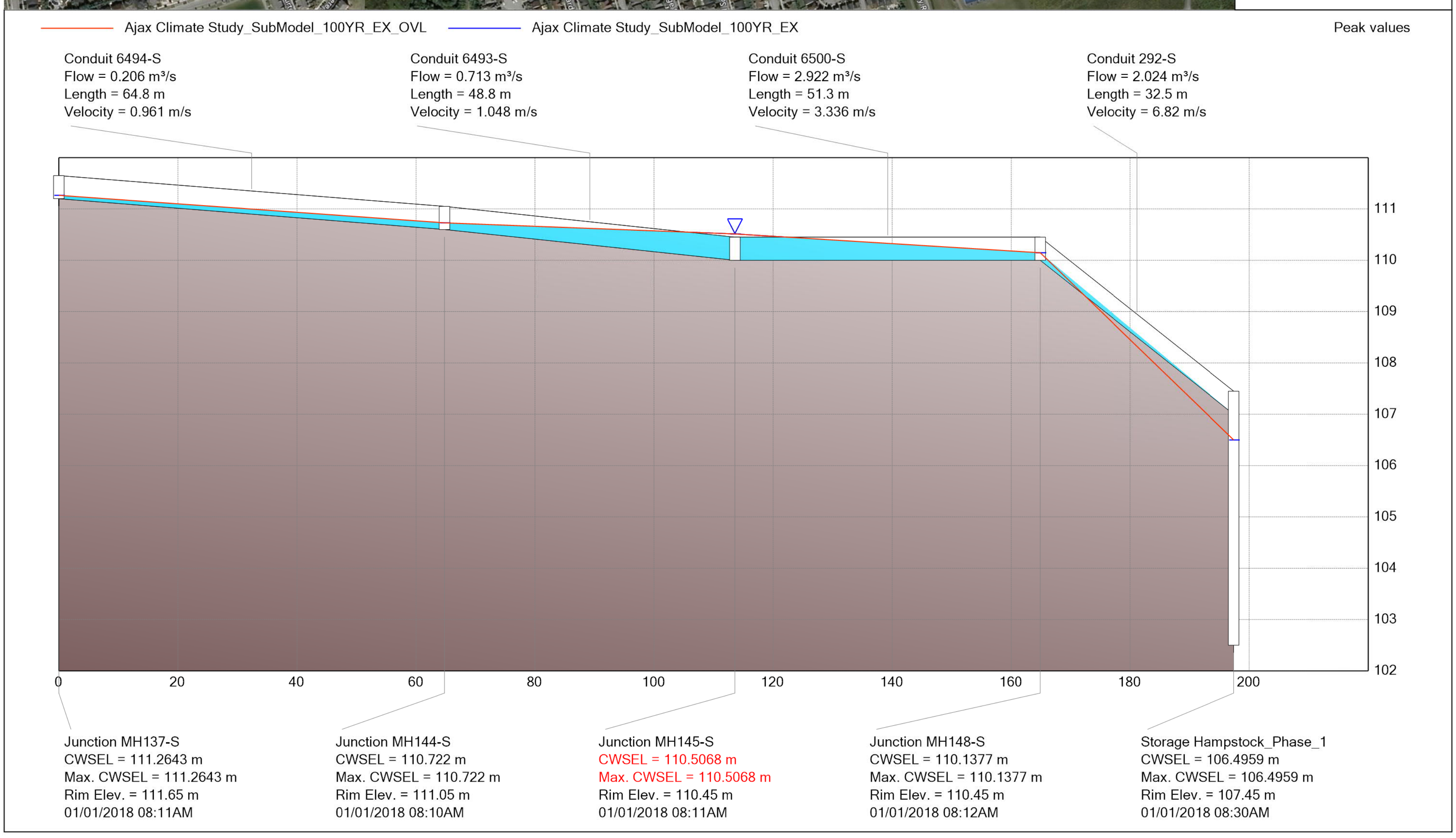


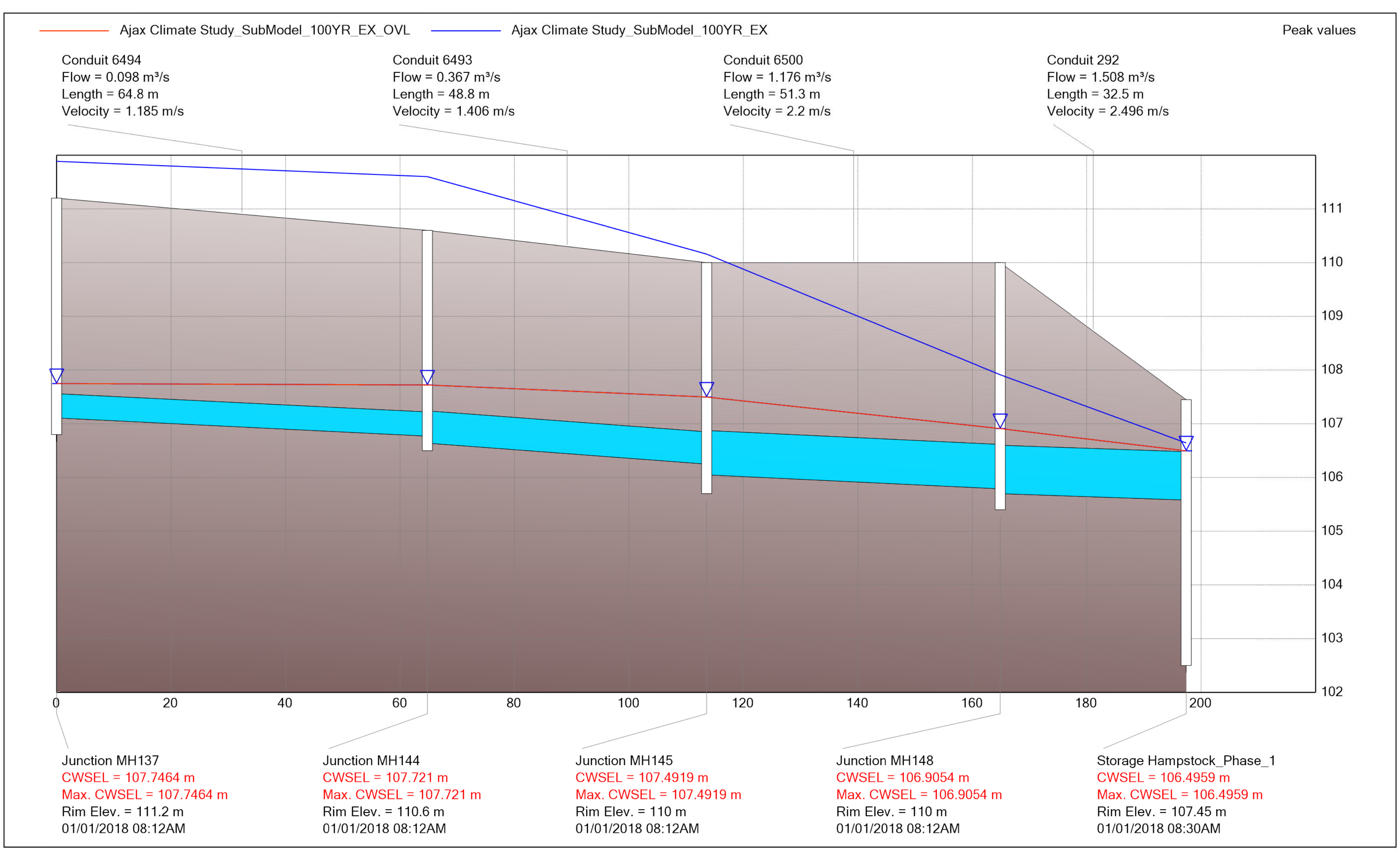




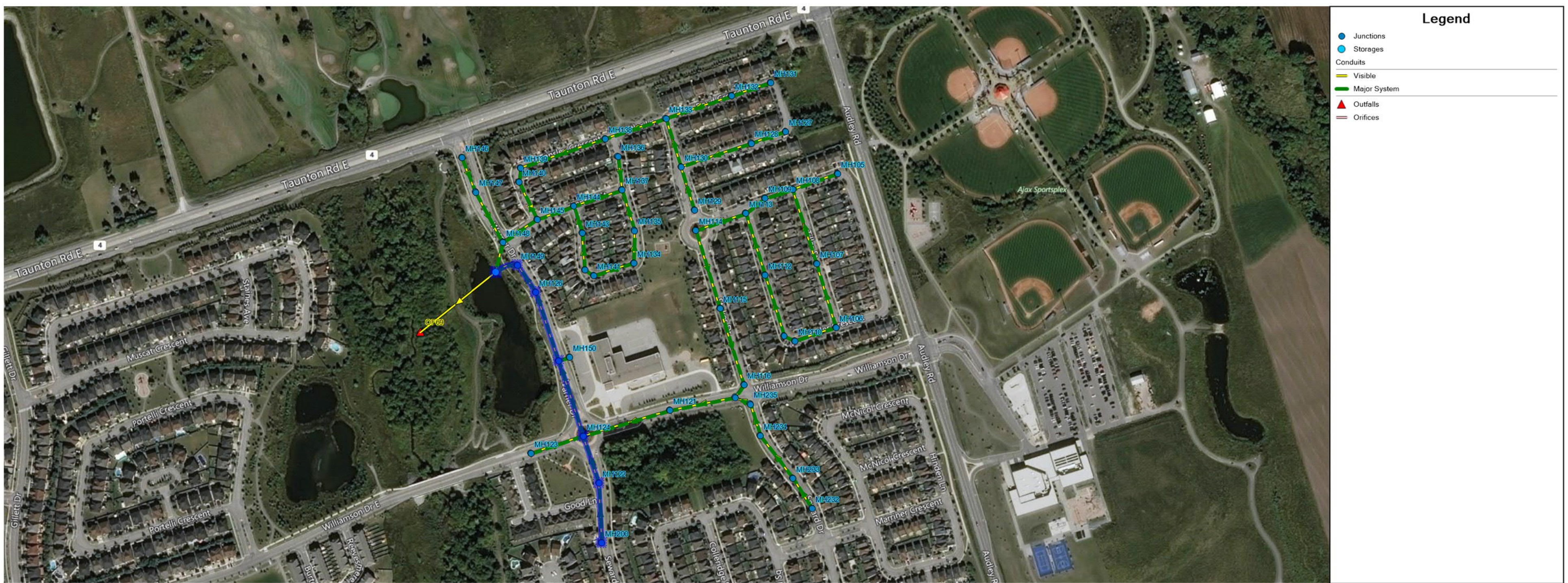
Sub-Model 100-yr HGL Comparison: With and Without Overland Flow Path

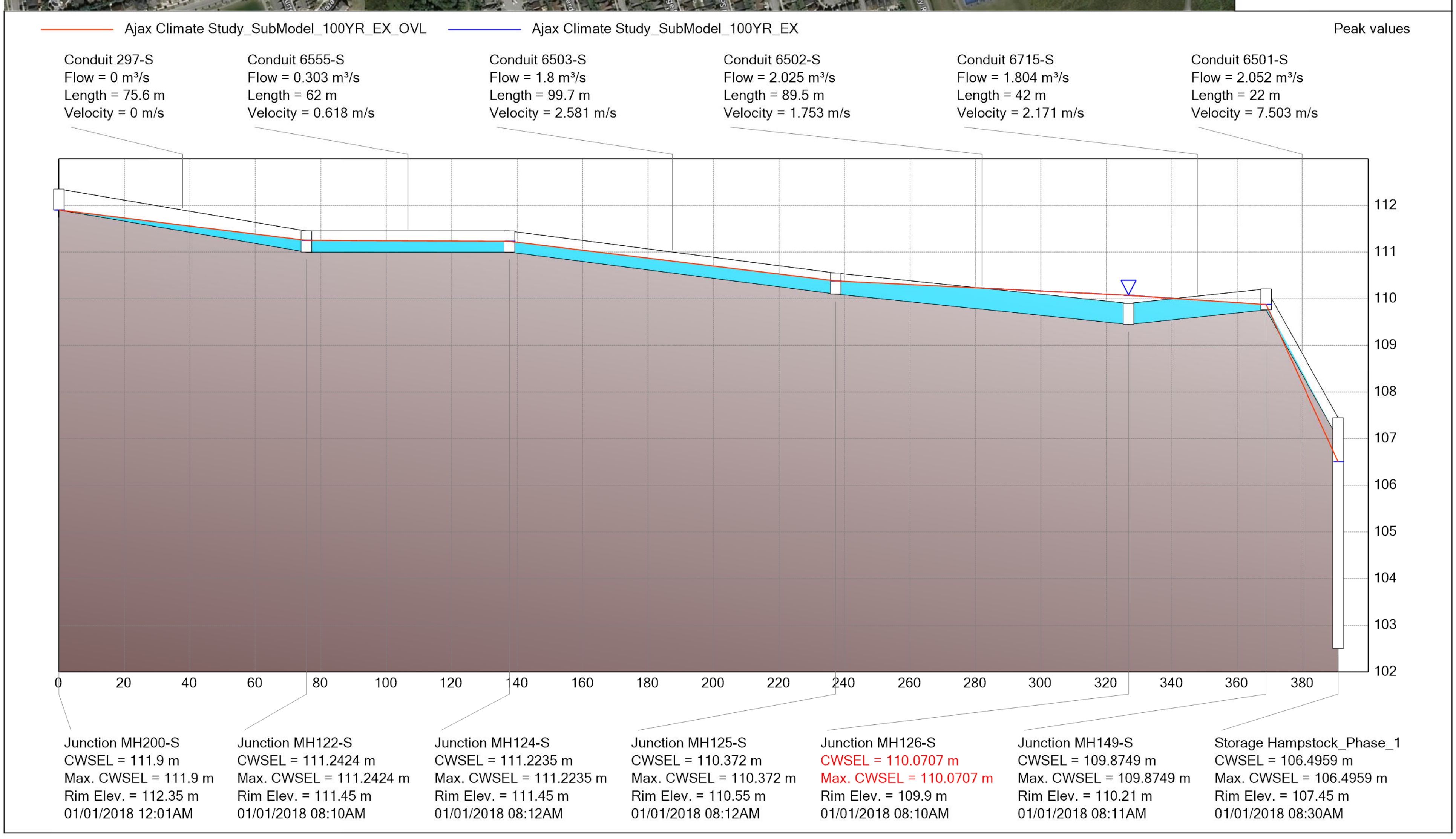


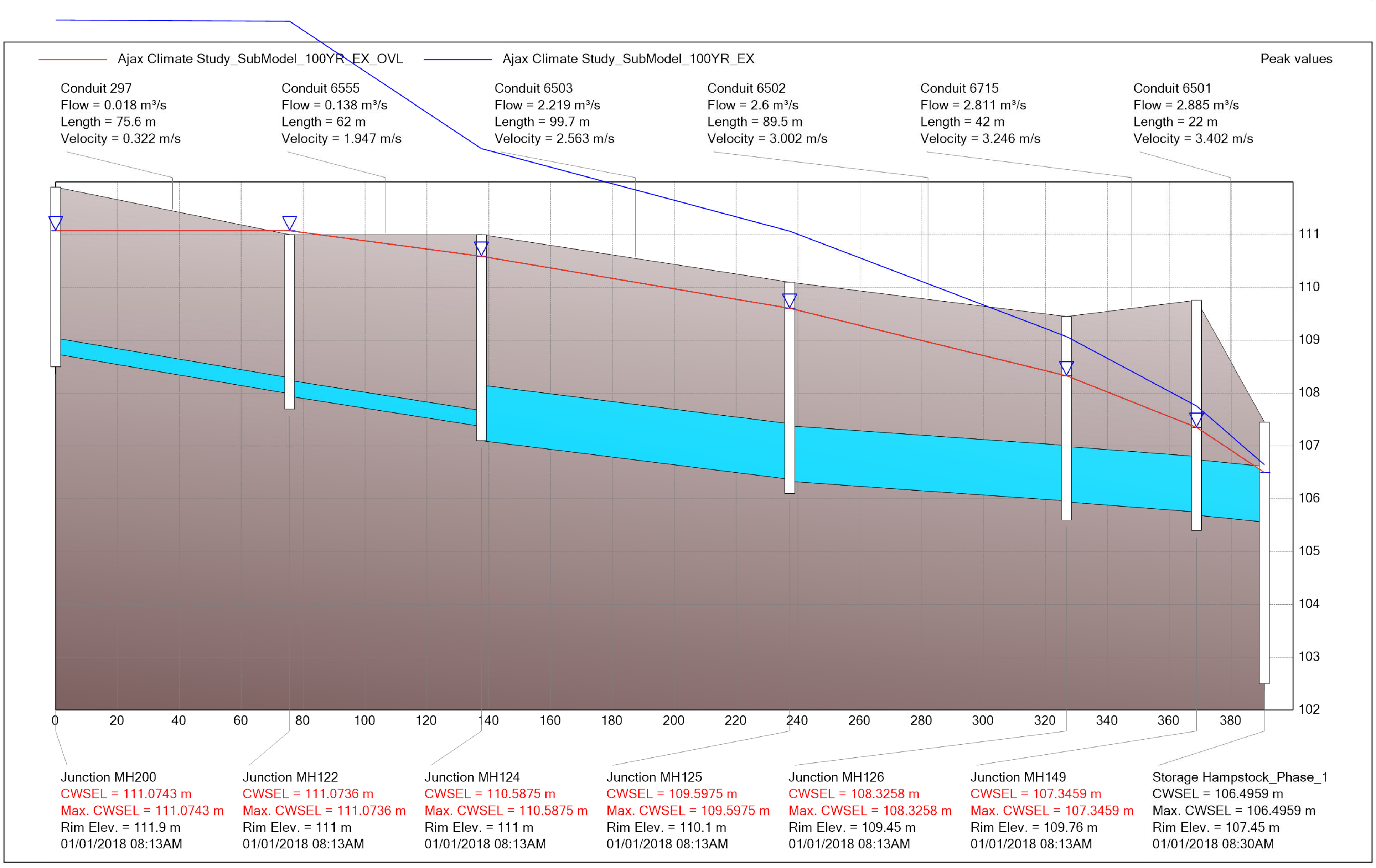




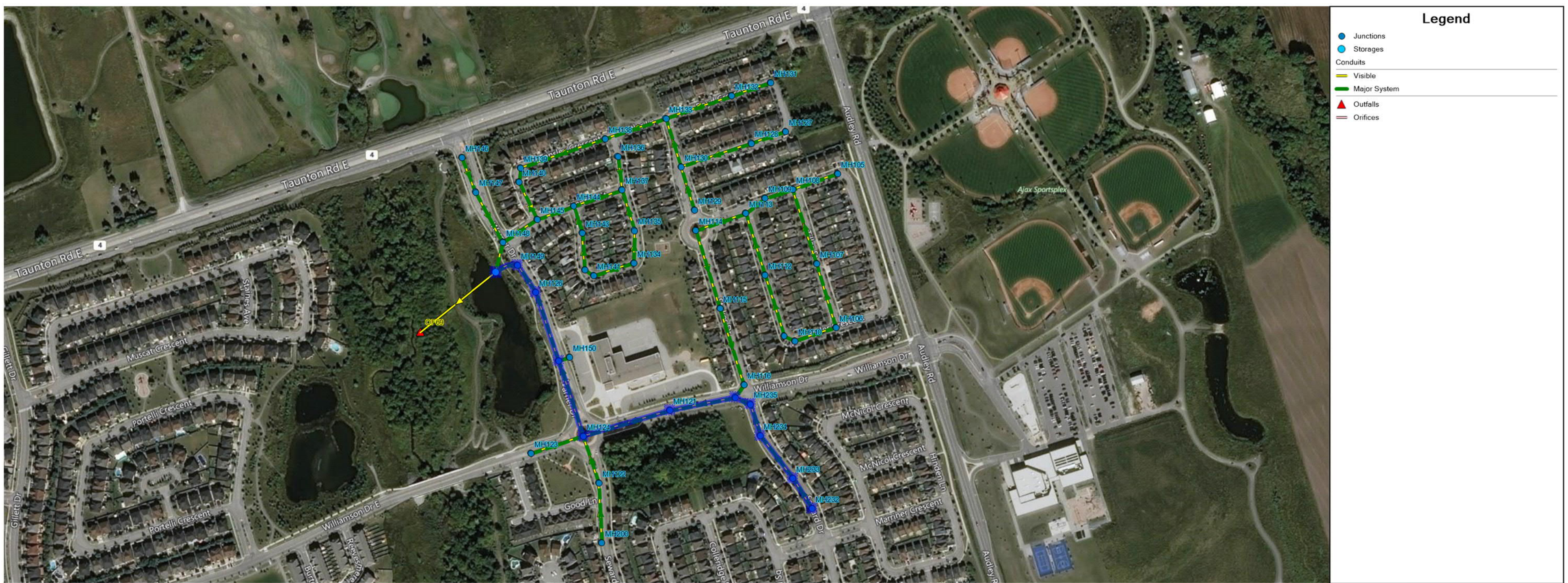
Sub-Model 100-yr HGL Comparison: With and Without Overland Flow Path

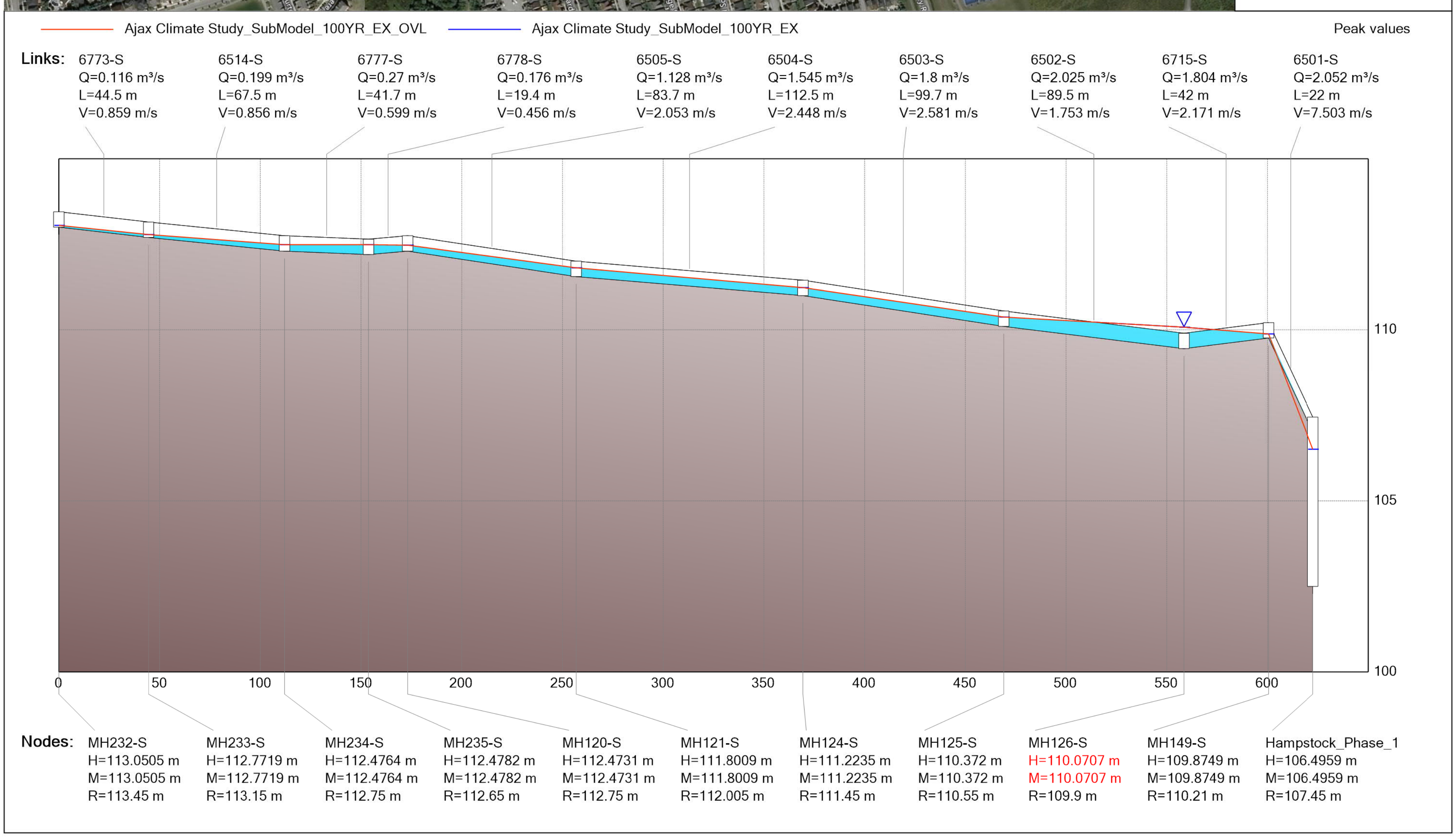


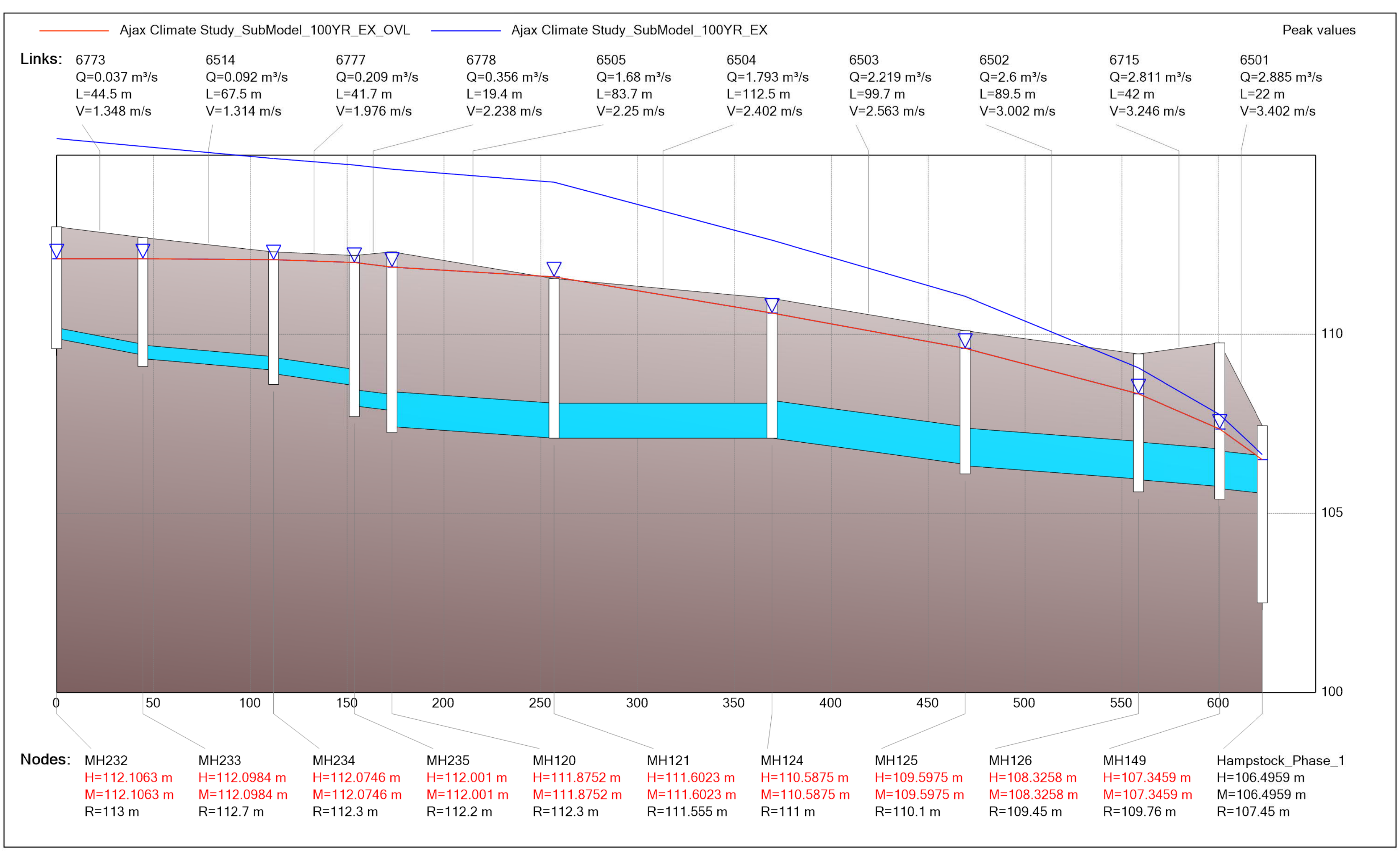




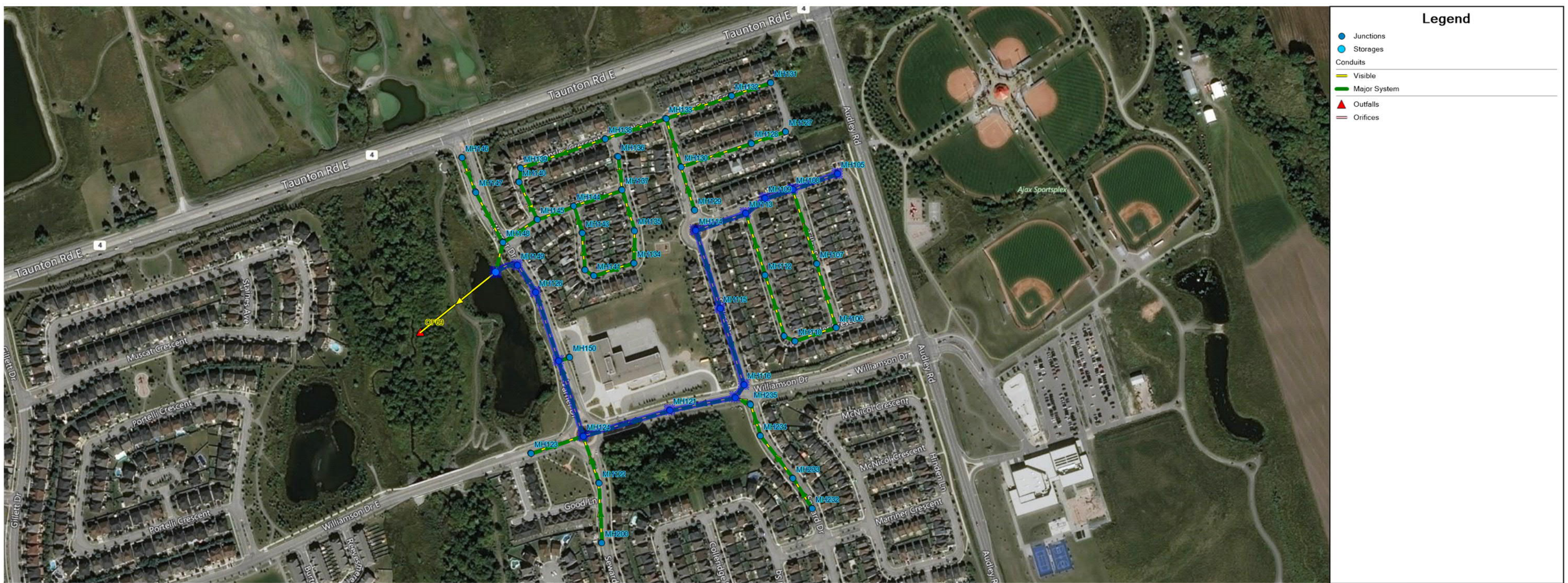
Sub-Model 100-yr HGL Comparison: With and Without Overland Flow Path

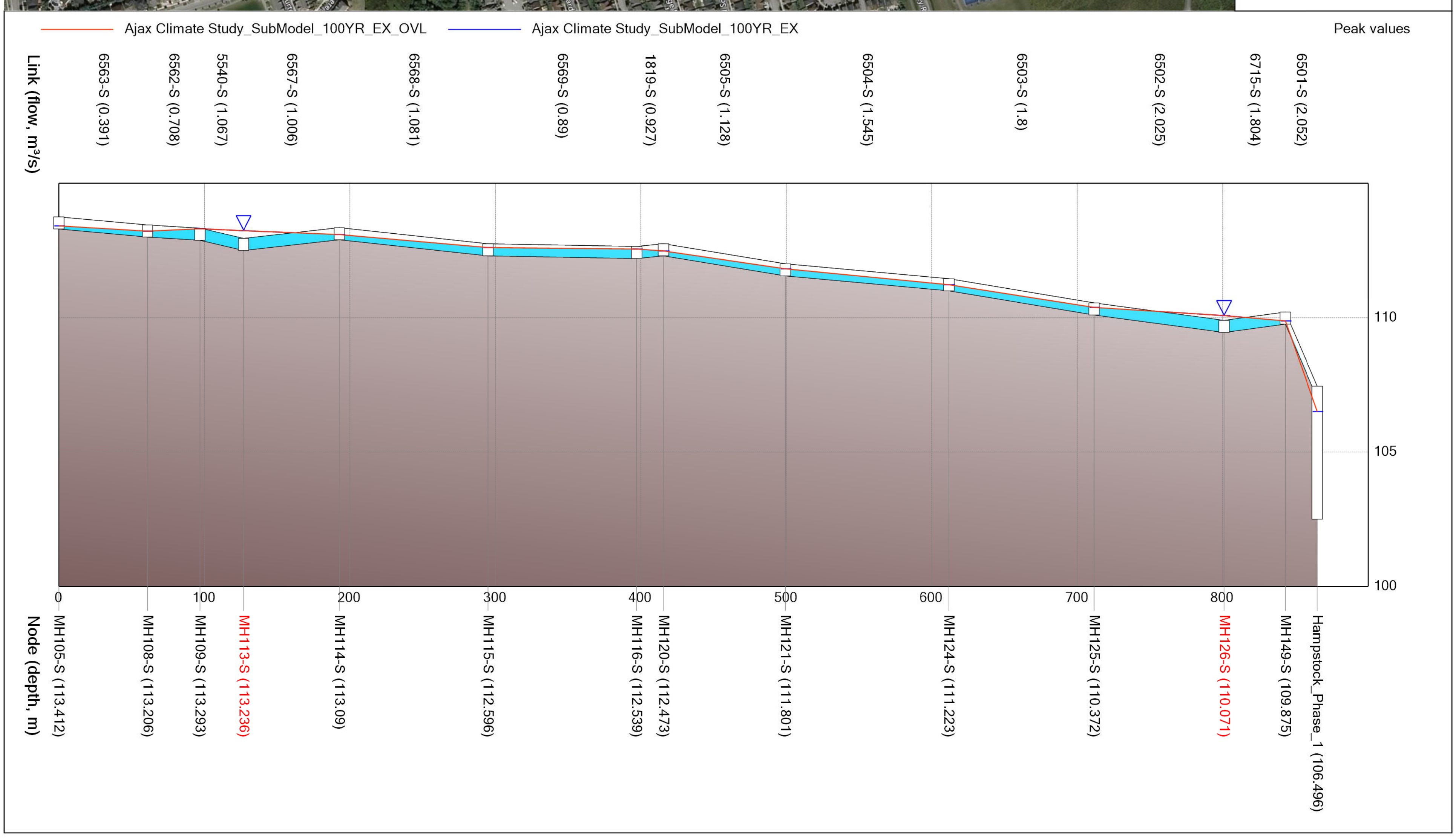


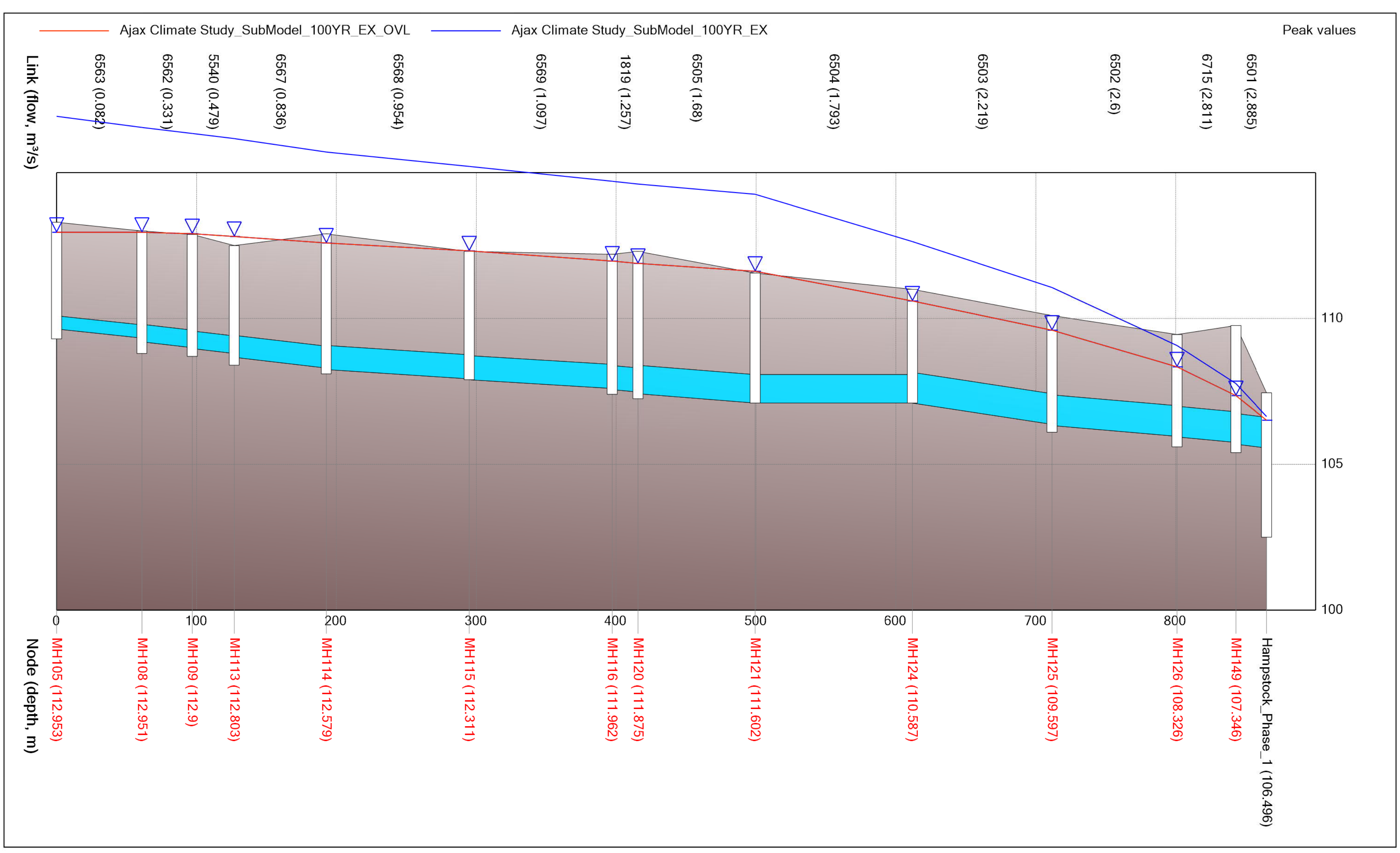




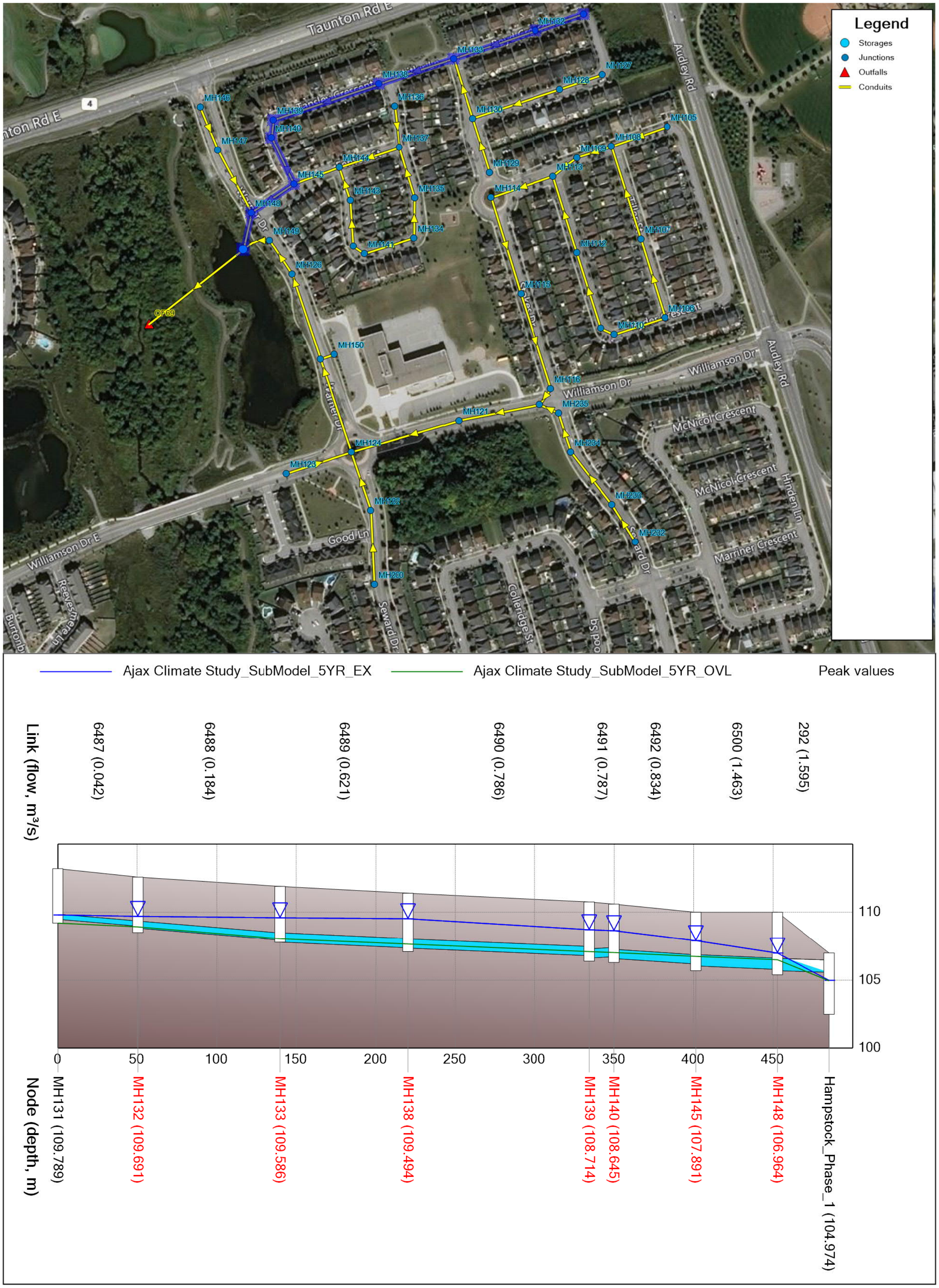
Sub-Model 100-yr HGL Comparison: With and Without Overland Flow Path



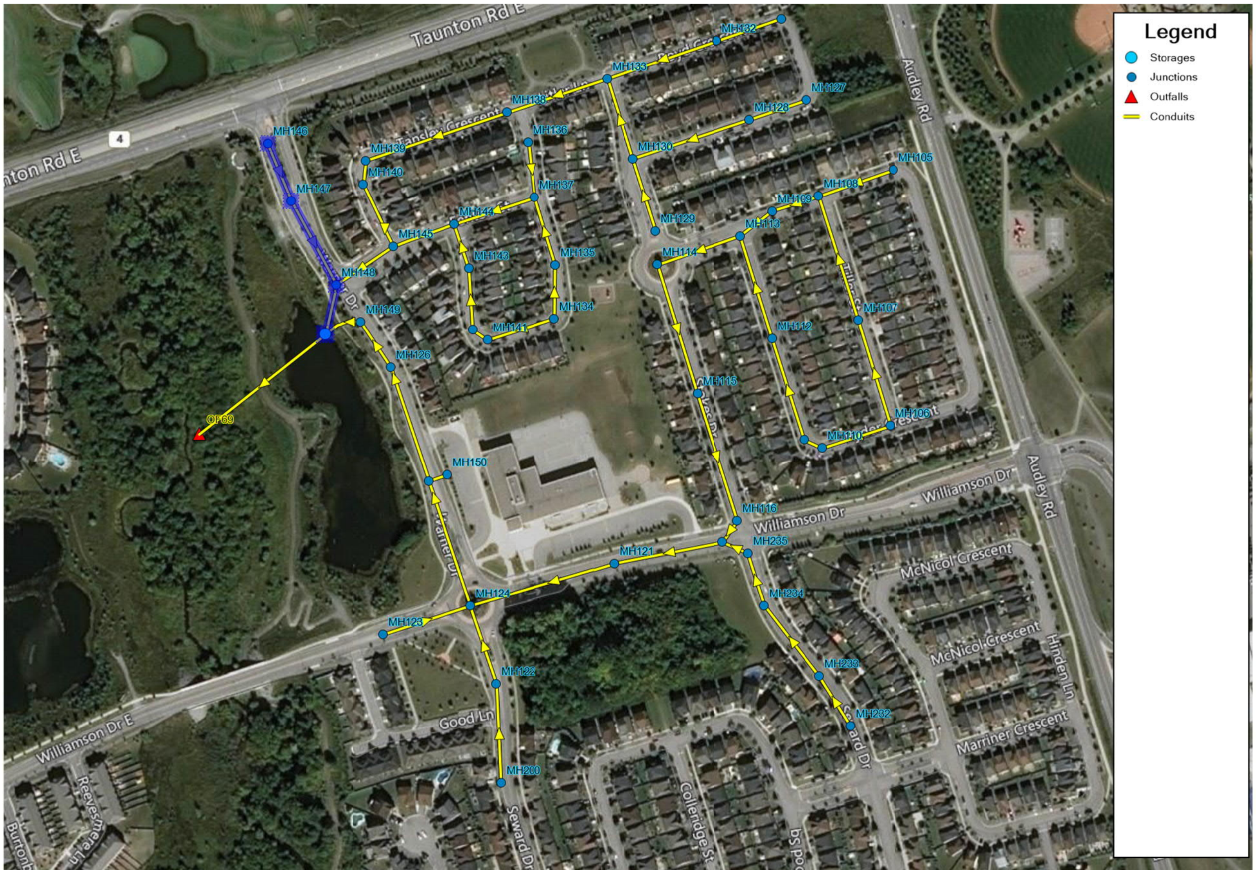


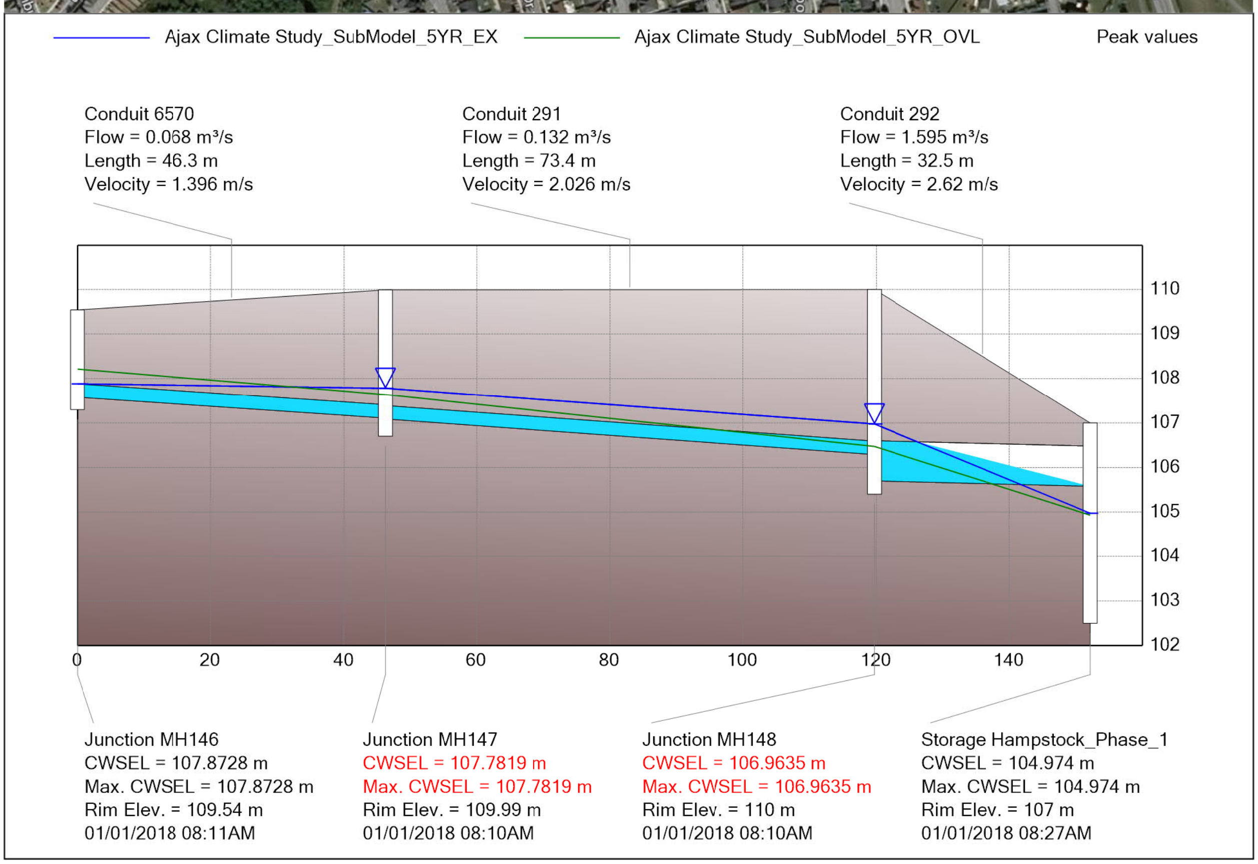


Sub-Model 5-yr HGL Comparison: With and Without Overland Flow Path

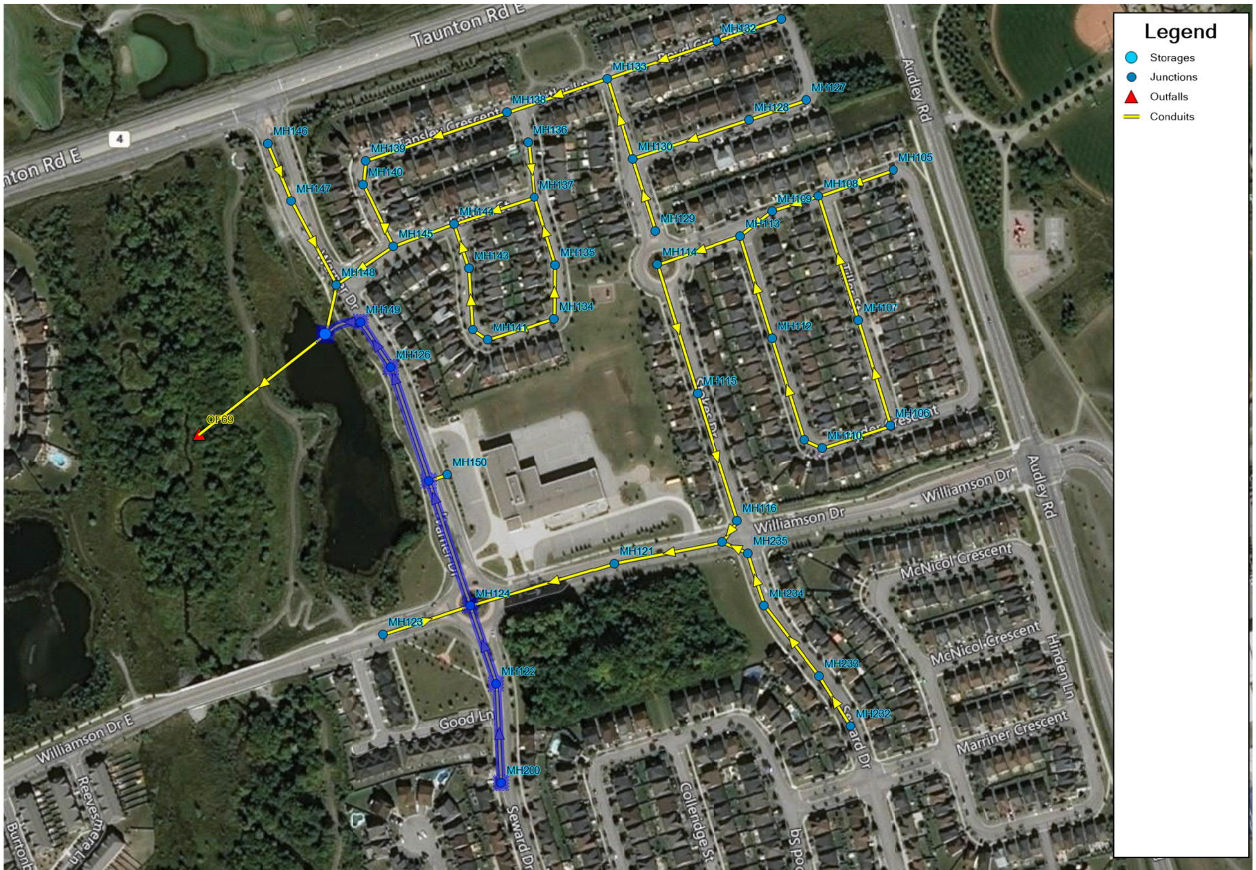


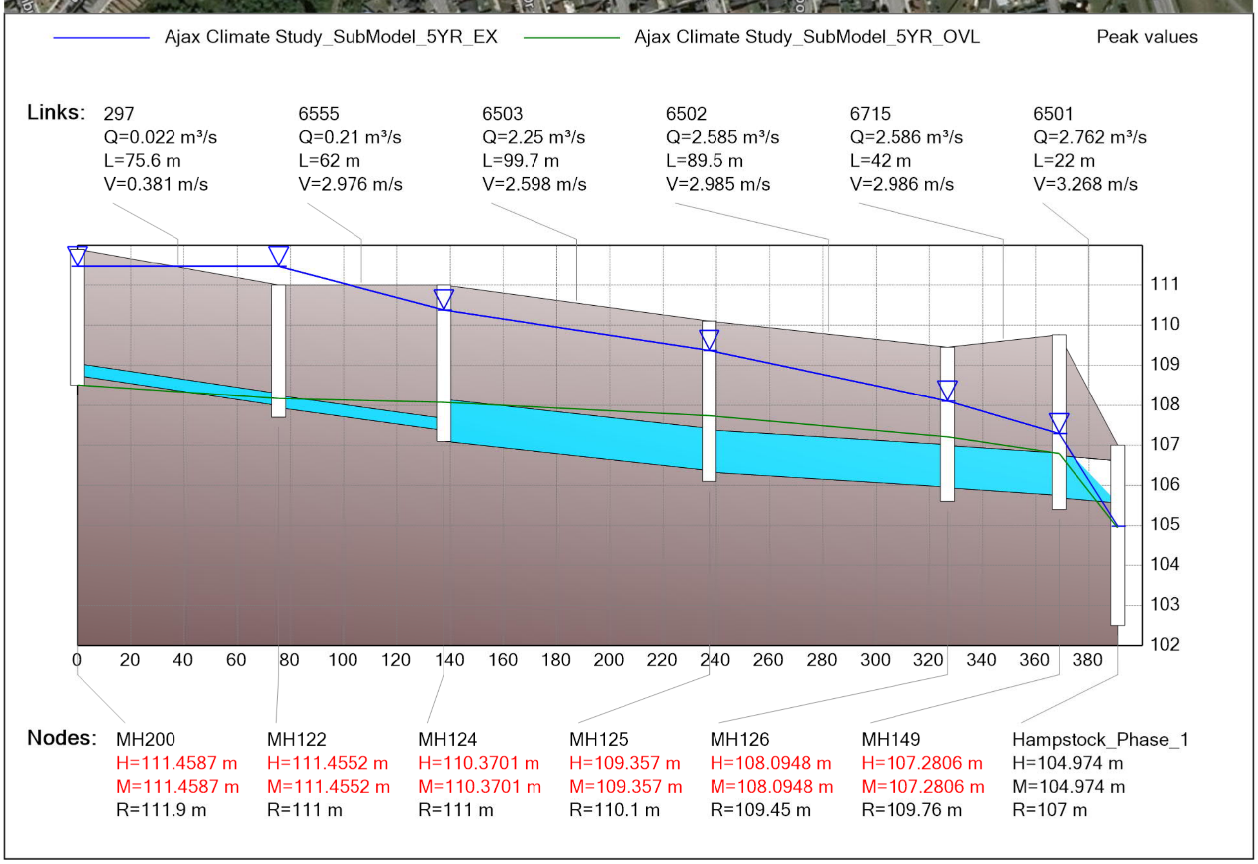
Sub-Model 5-yr HGL Comparison: With and Without Overland Flow Path



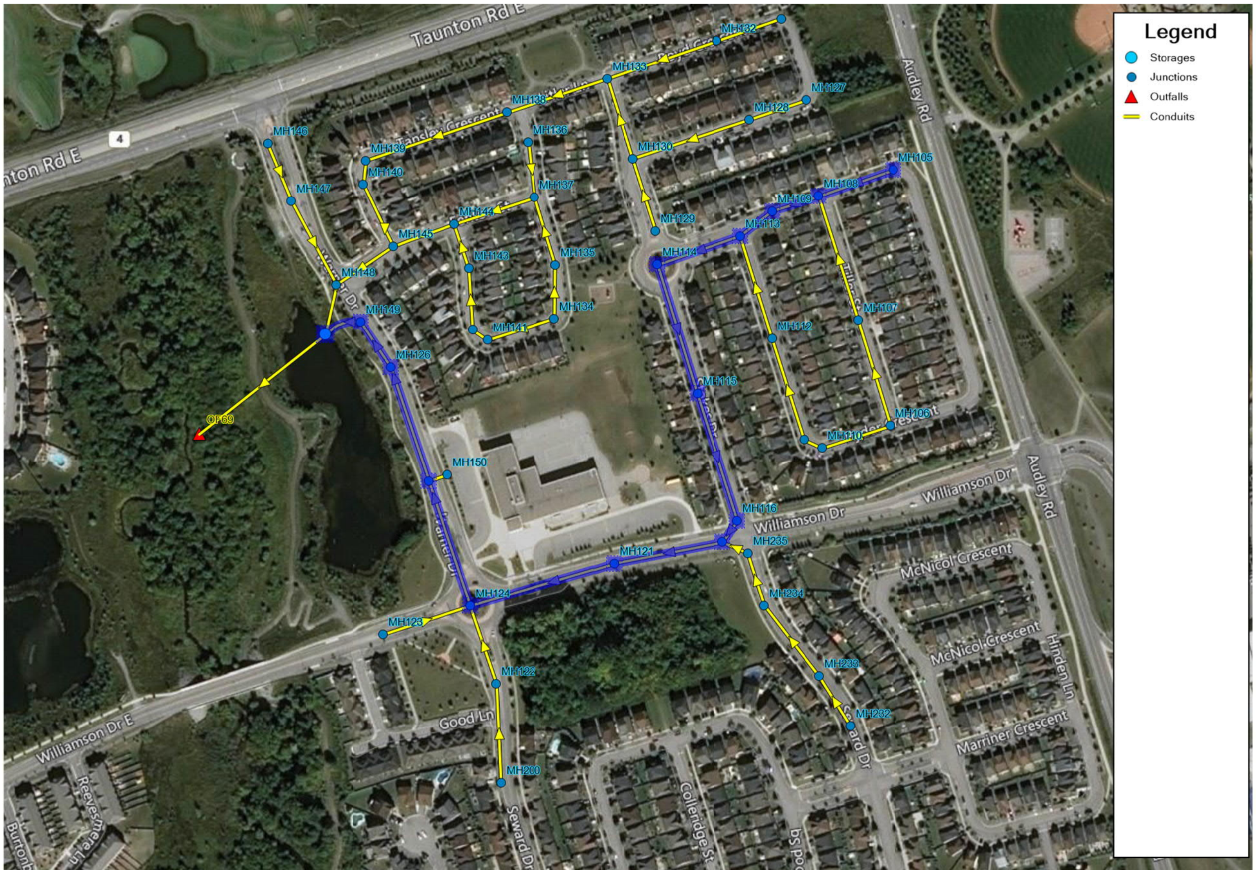


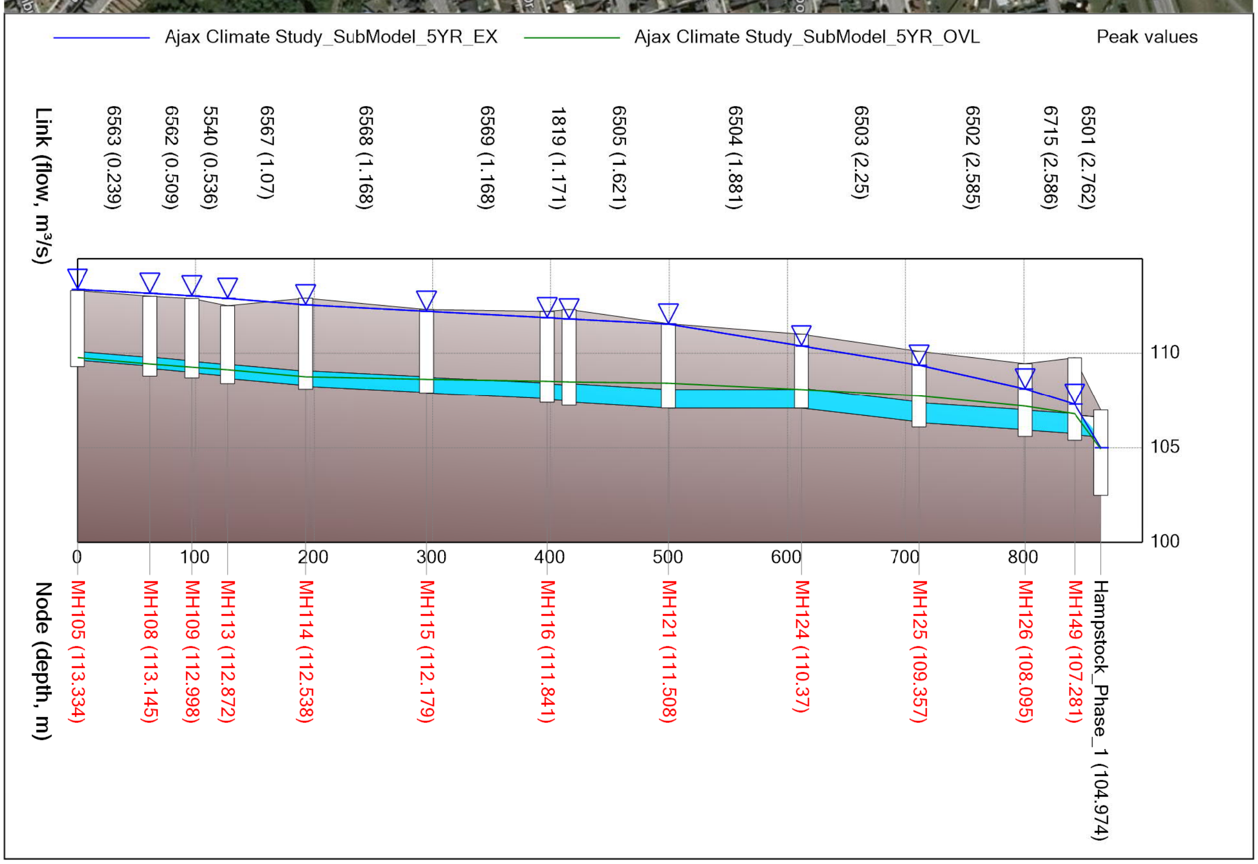
Sub-Model 5-yr HGL Comparison: With and Without Overland Flow Path





Sub-Model 5-yr HGL Comparison: With and Without Overland Flow Path





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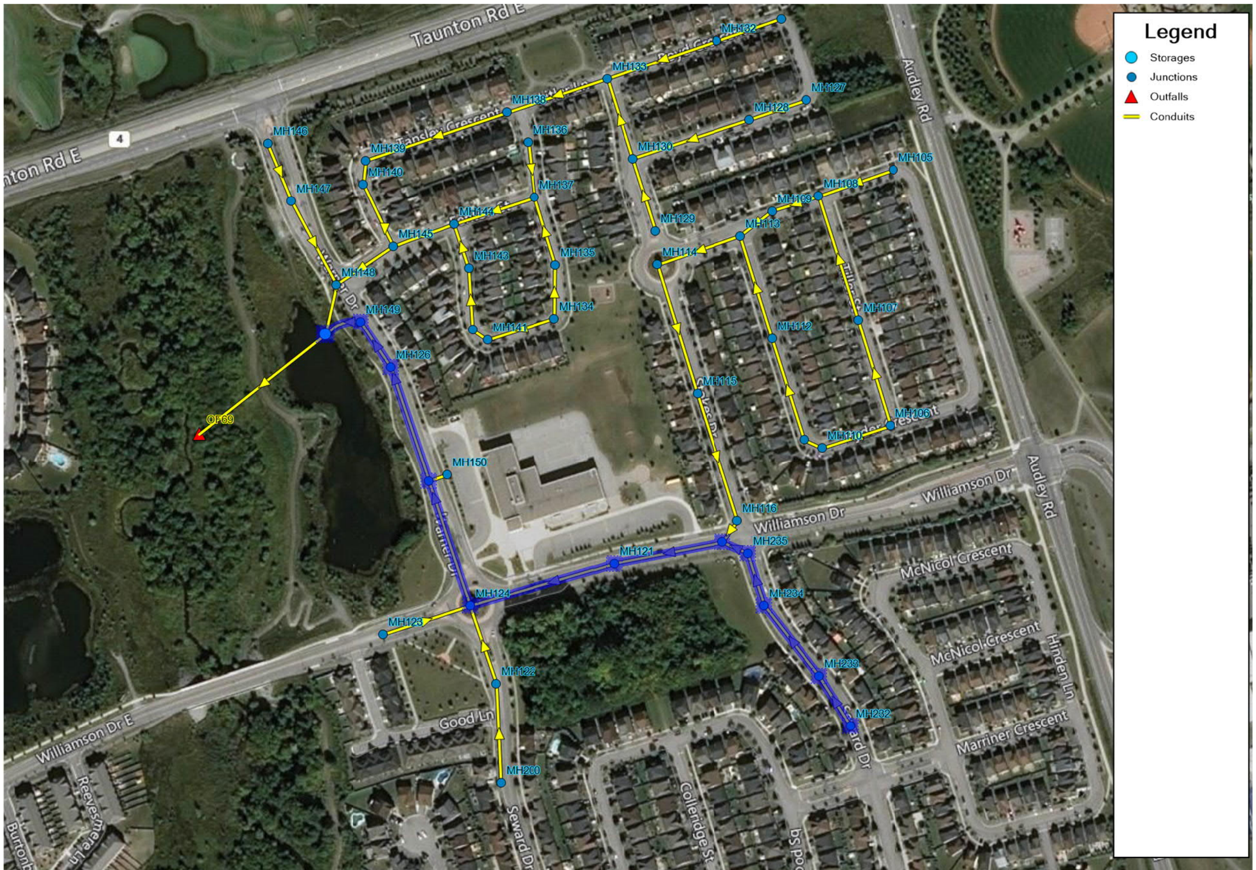
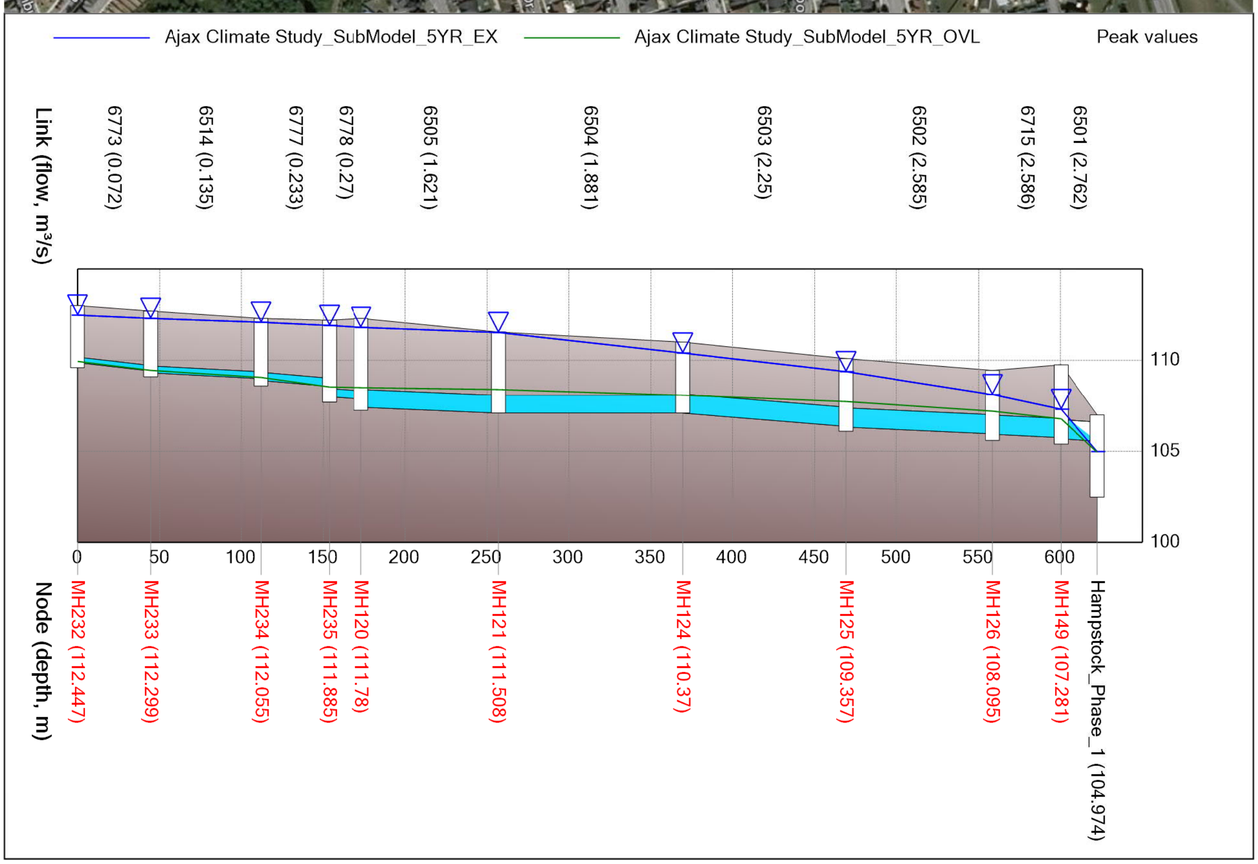
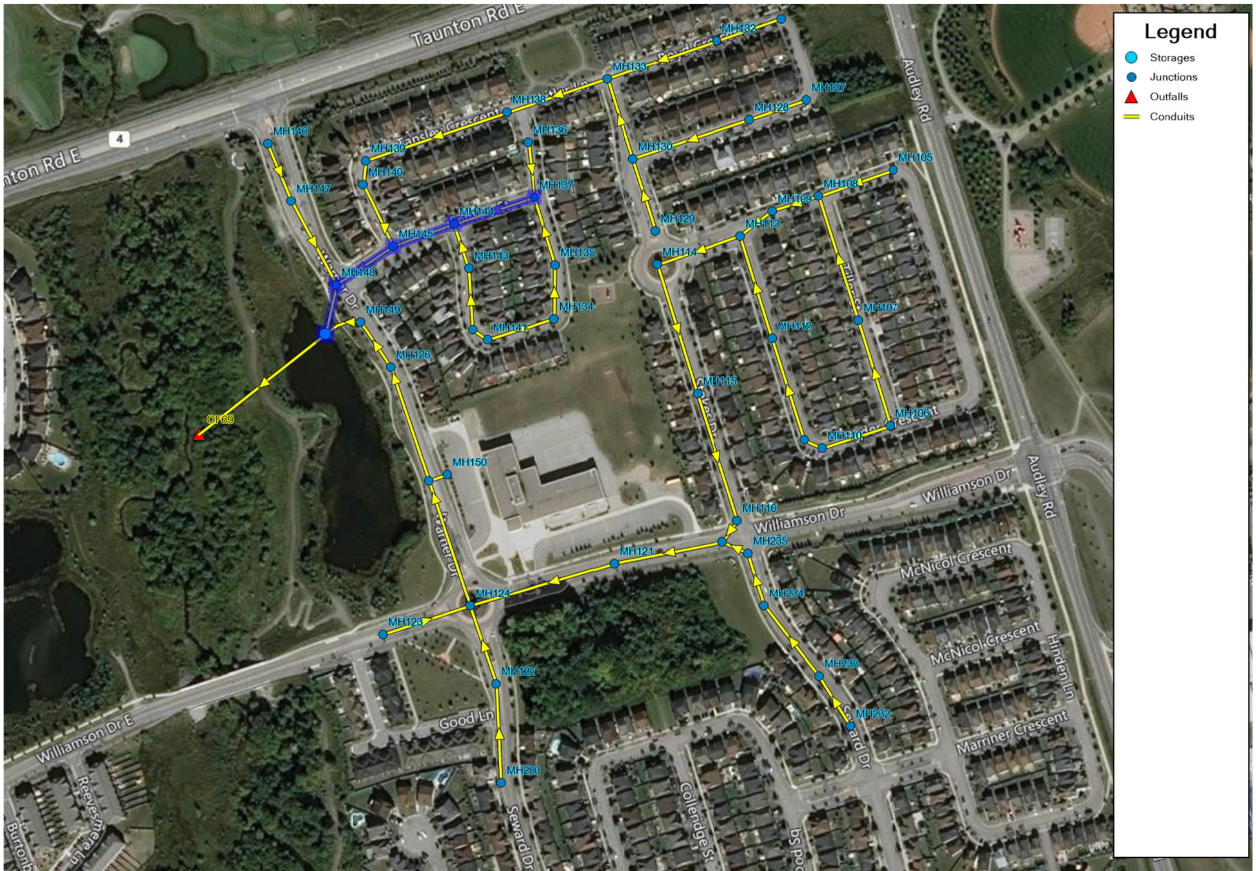
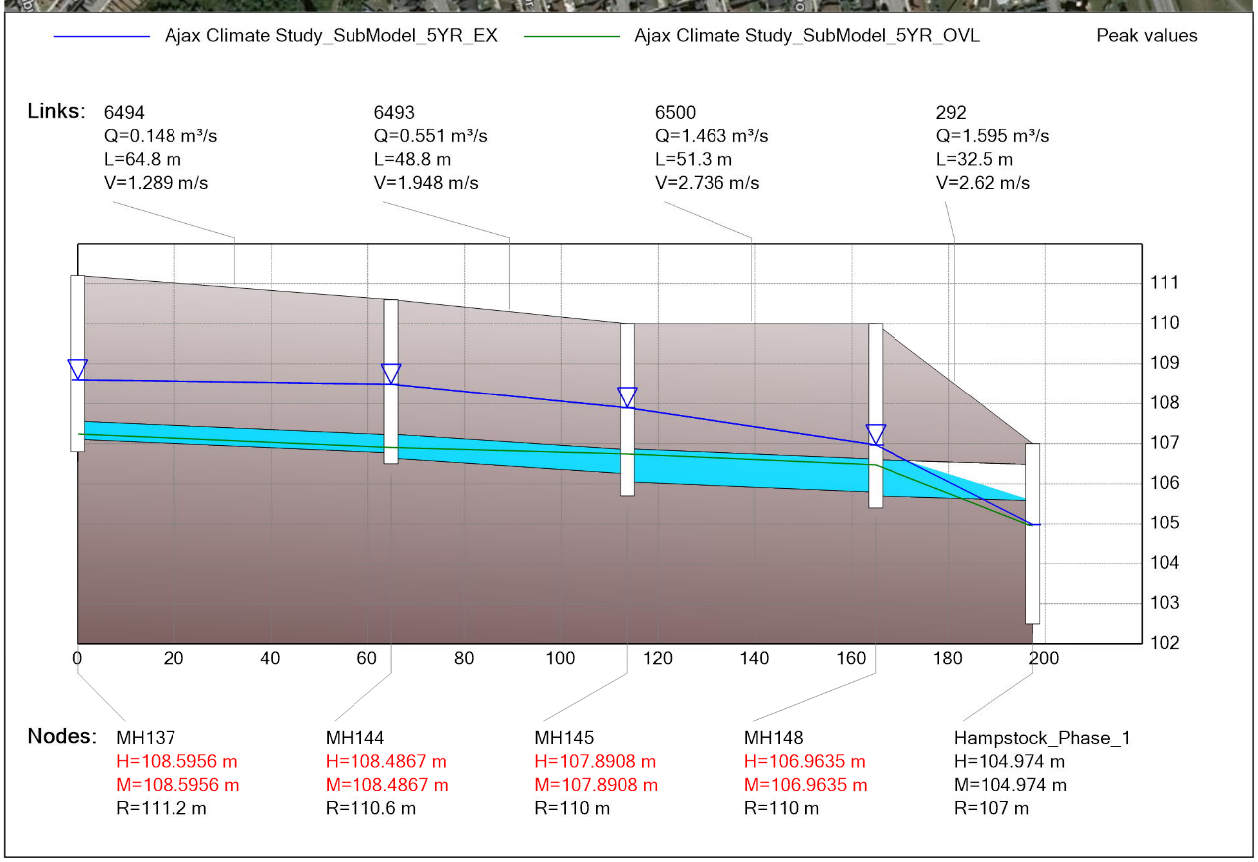


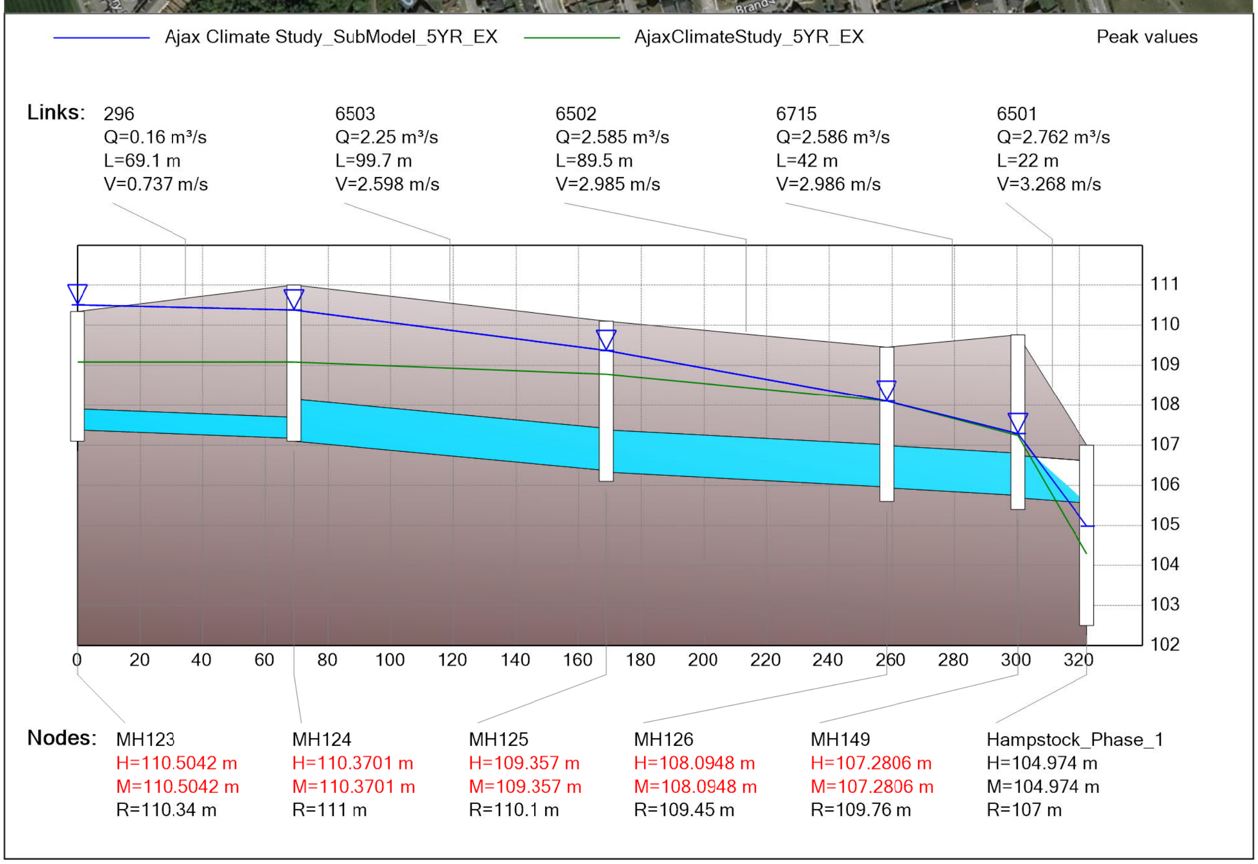


Sub-Model 5-yr HGL Comparison: With and Without Overland Flow Path

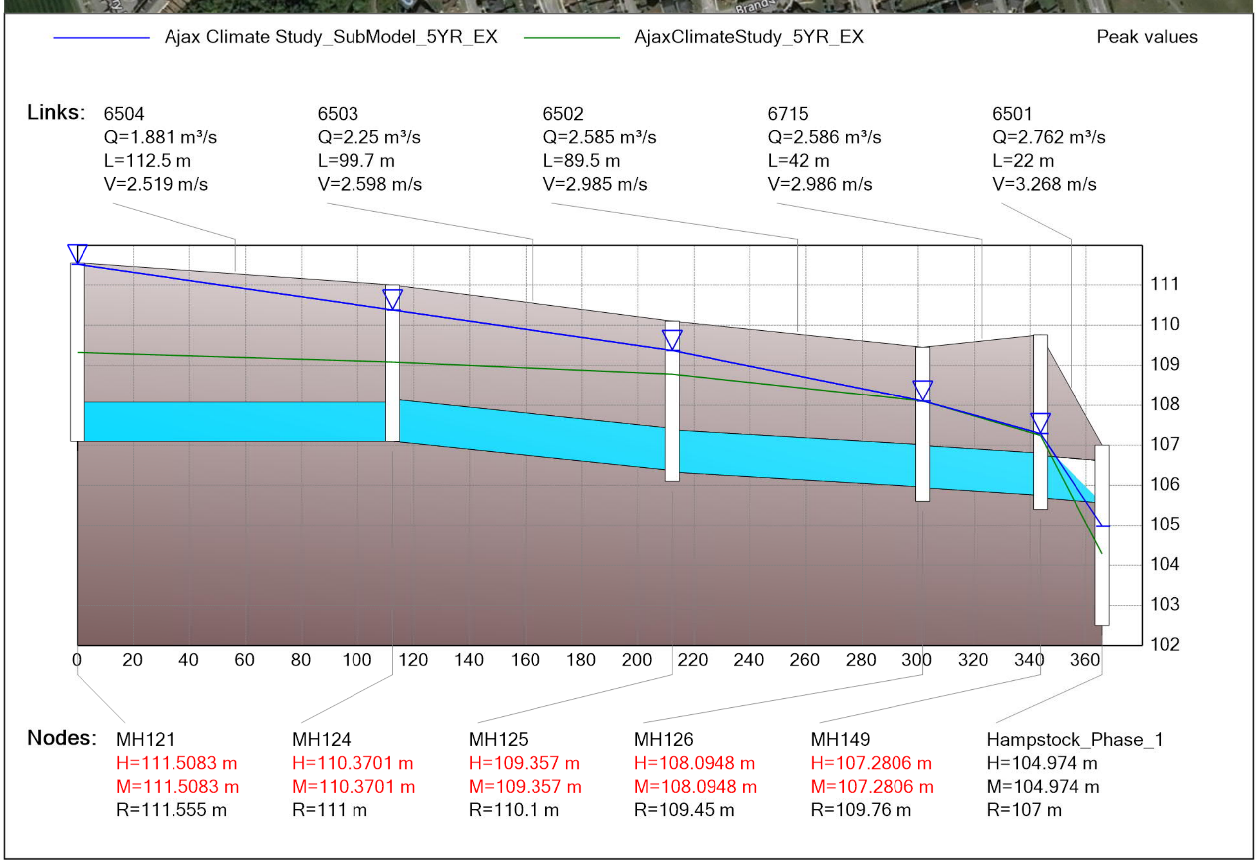




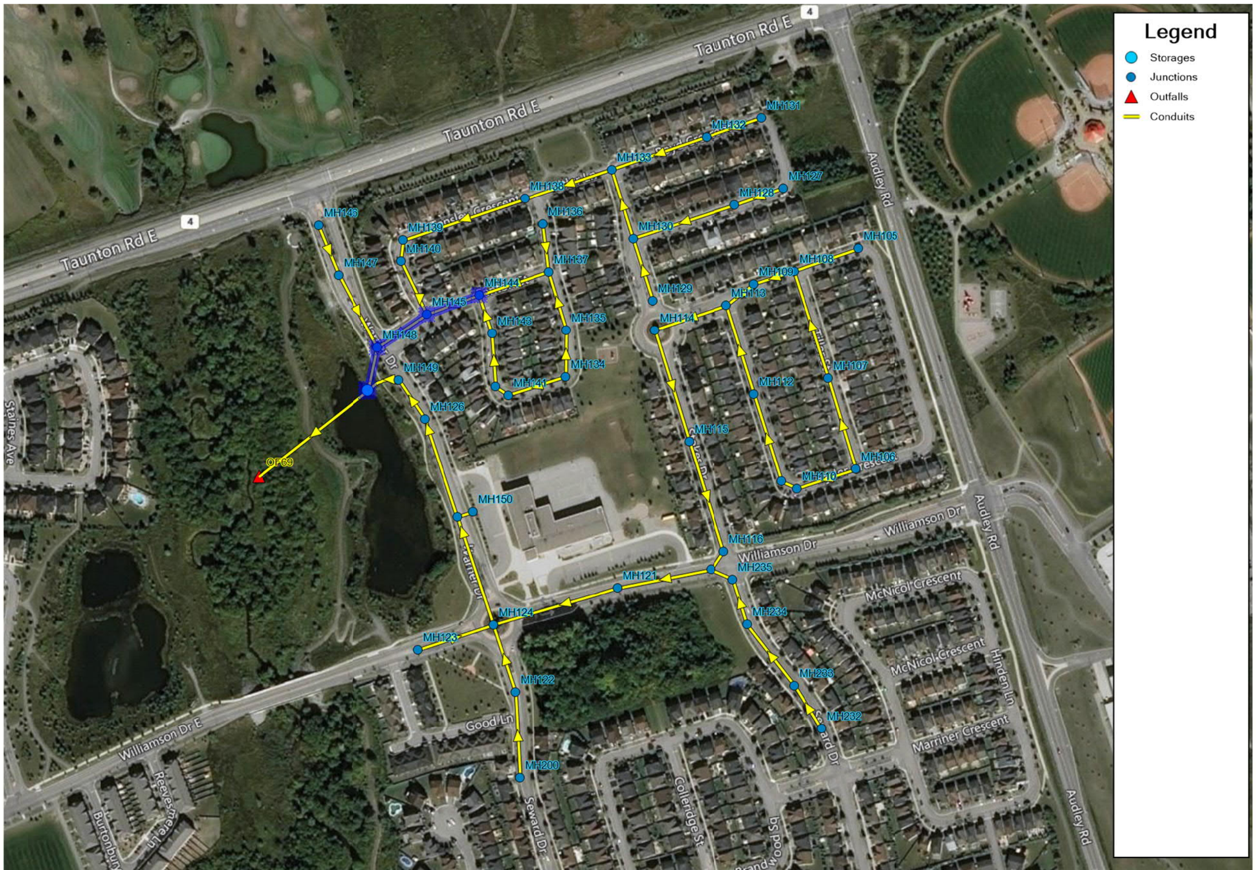
5-yr HGL Comparison: Sub-Model vs Town-Wide Model

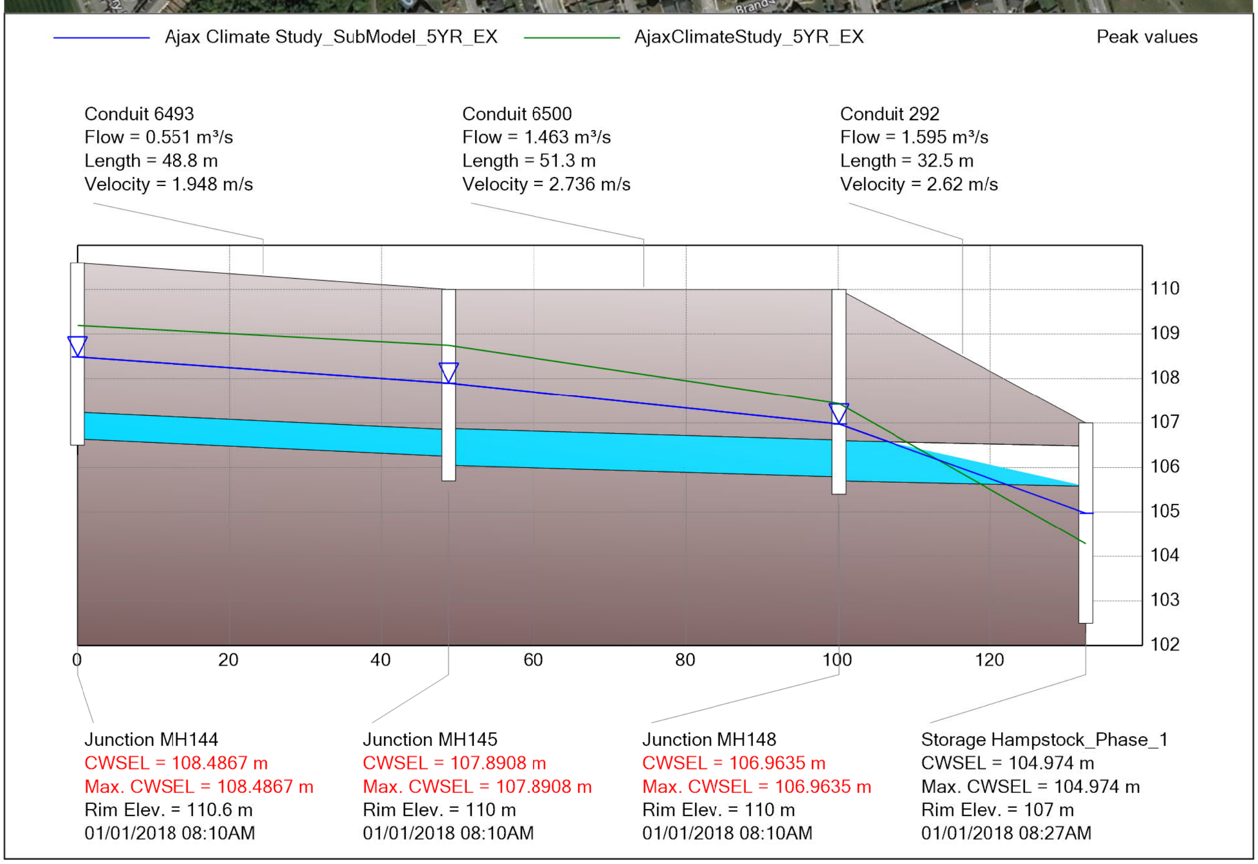


5-yr HGL Comparison: Sub-Model vs Town-Wide Model



5-yr HGL Comparison: Sub-Model vs Town-Wide Model





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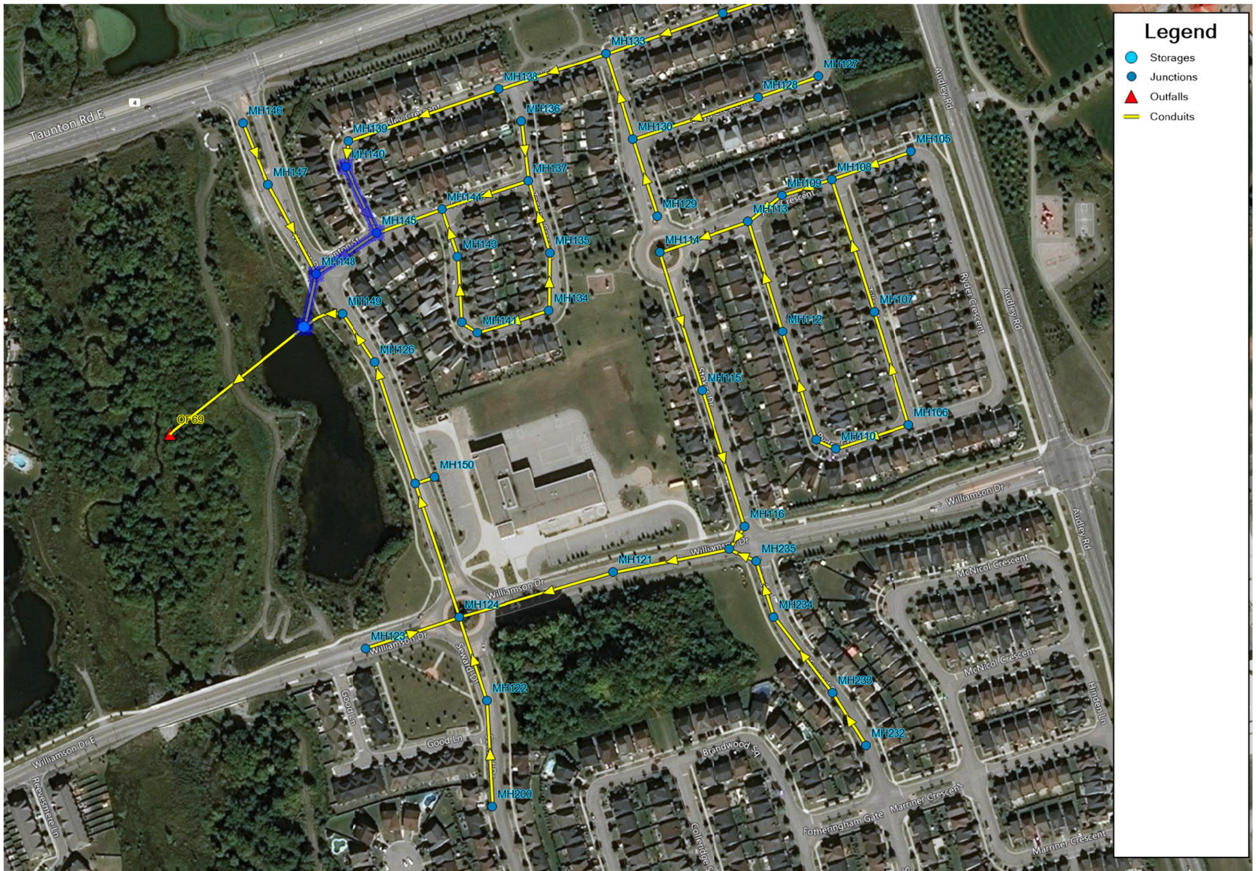
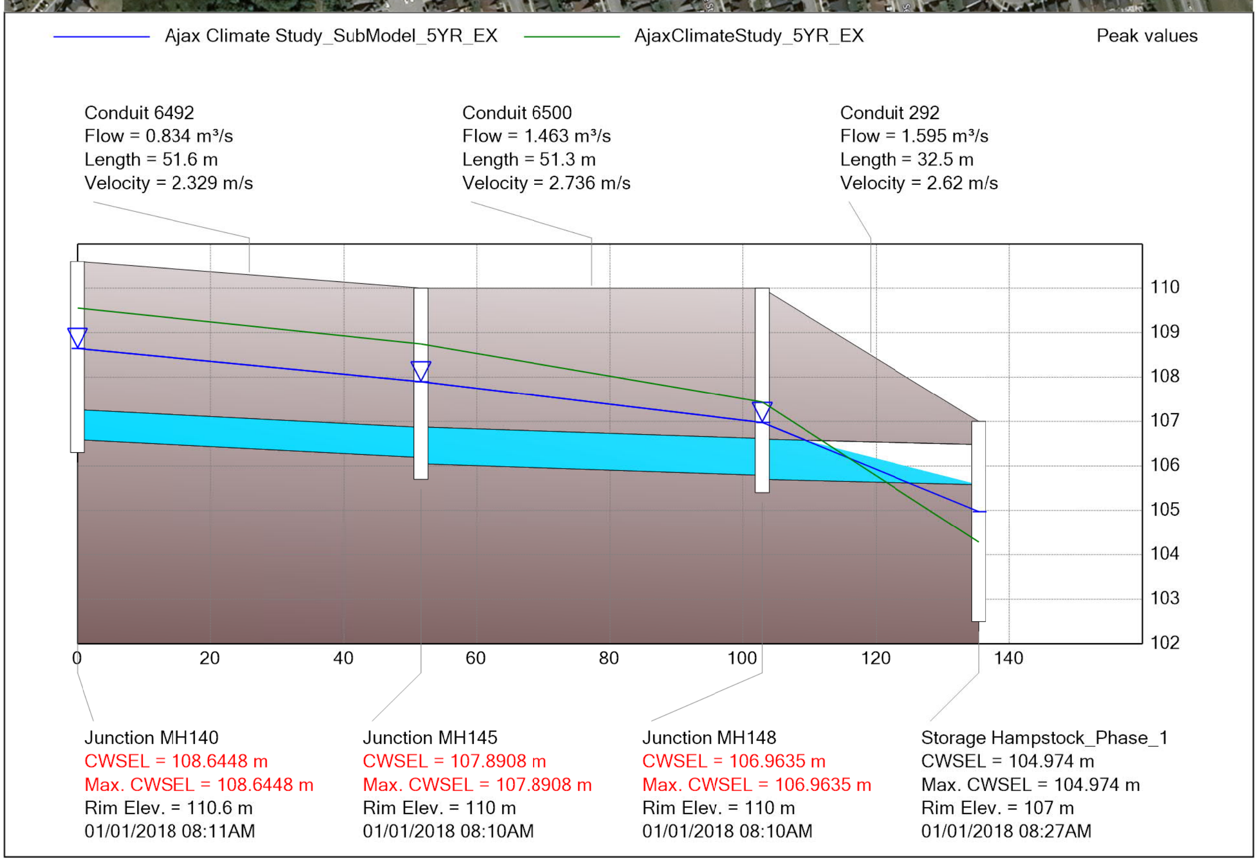
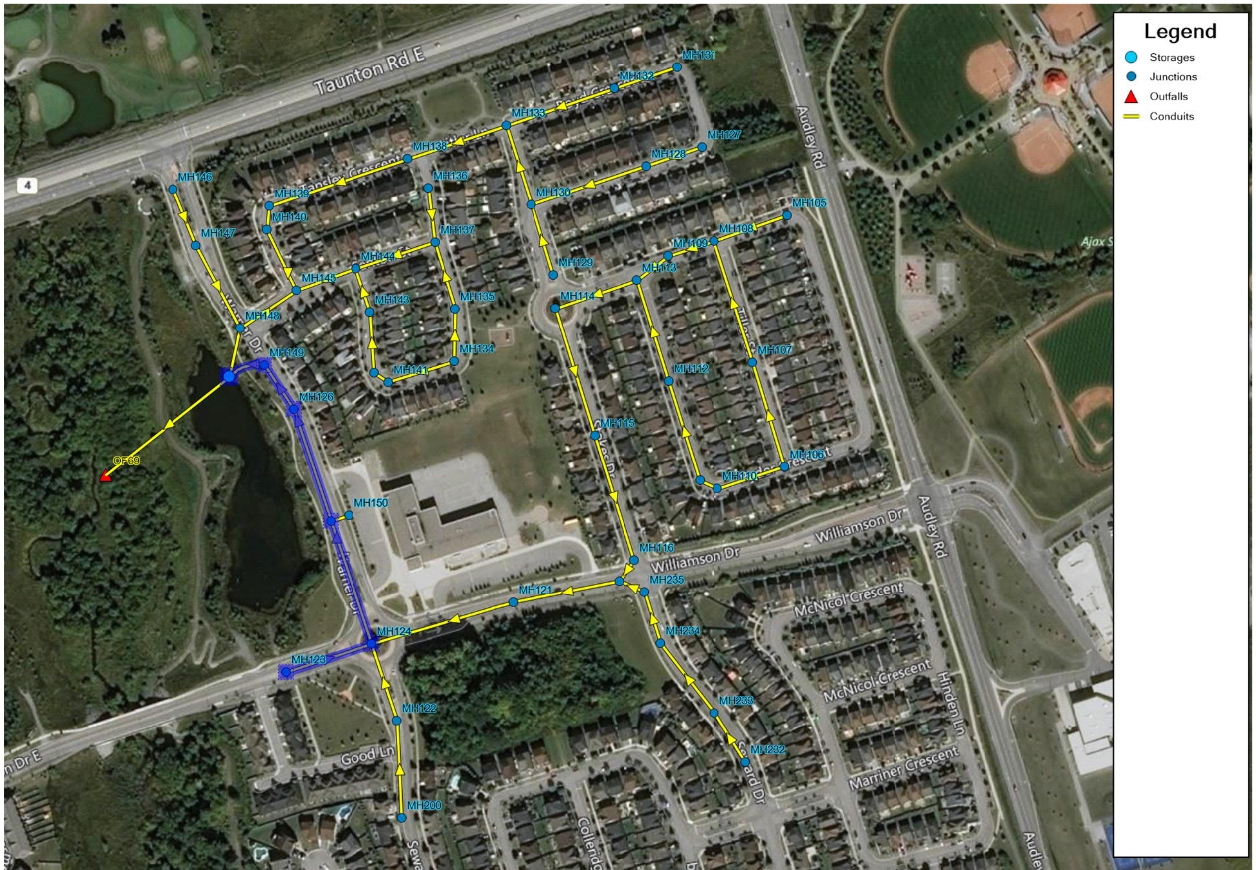
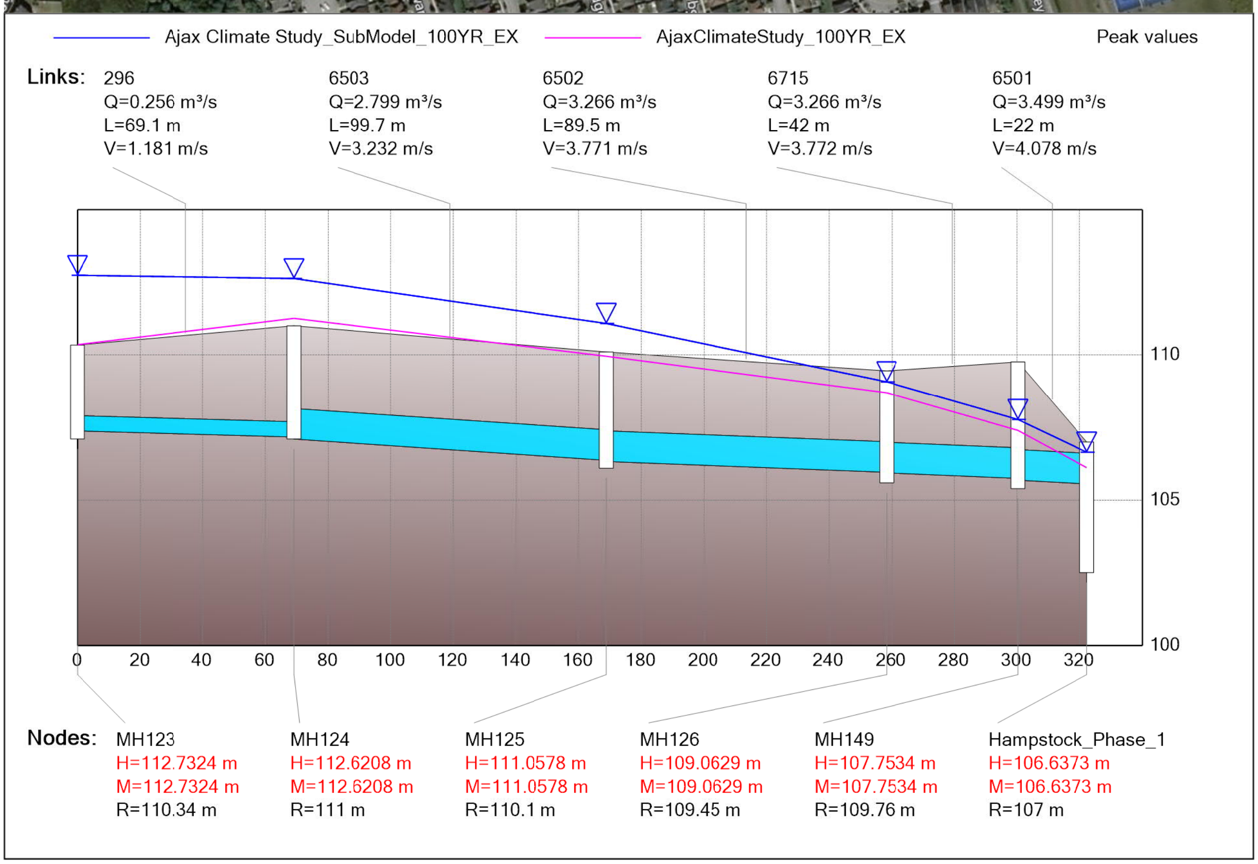


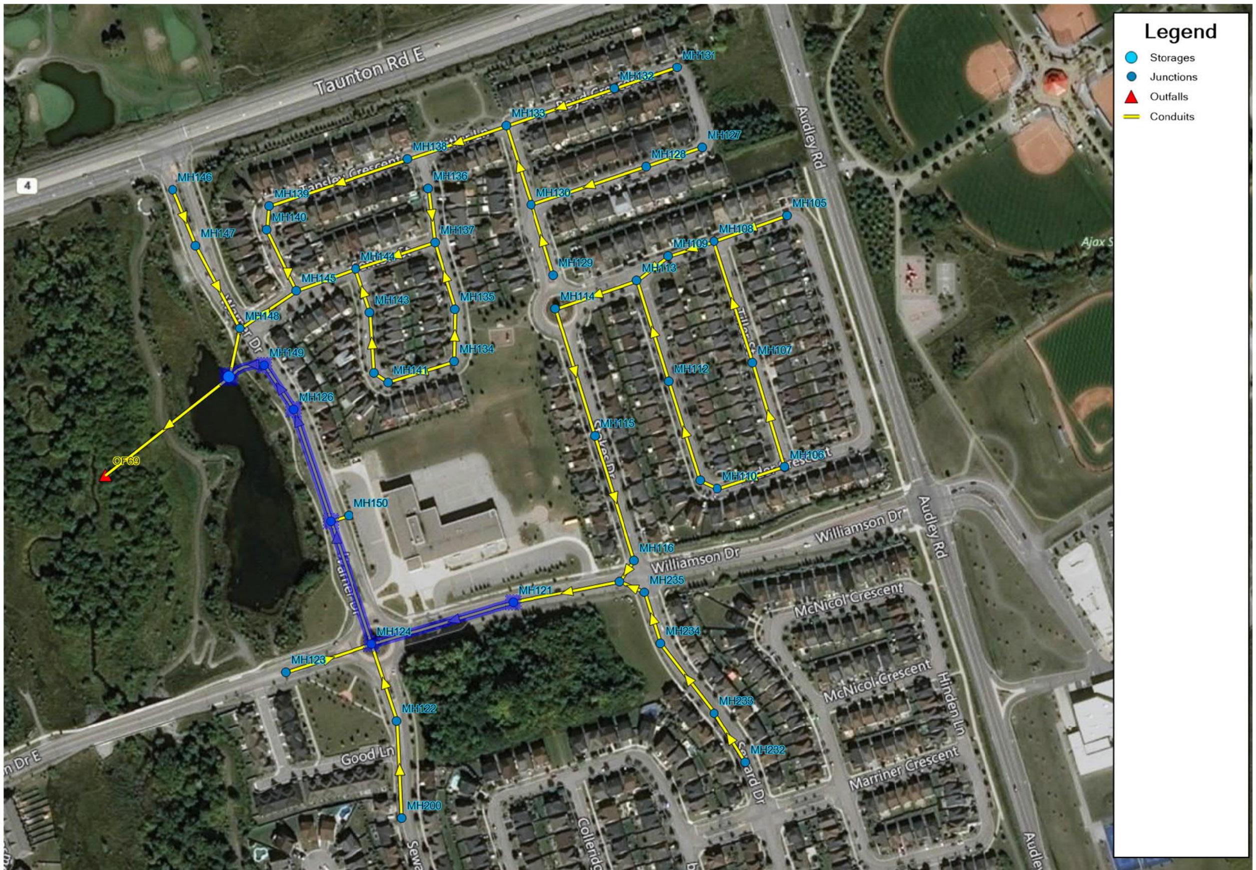


100-yr HGL Comparison: Sub-Model vs Town-Wide Model



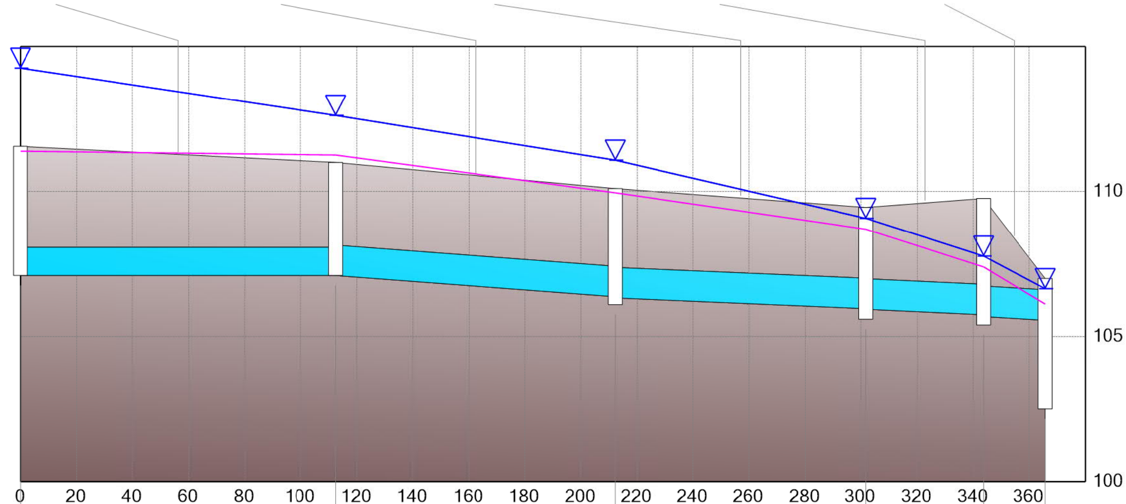


100-yr HGL Comparison: Sub-Model vs Town-Wide Model



Ajax Climate Study_SubModel_100YR_EX — AjaxClimateStudy_100YR_EX — Peak values

Links:	6504	6503	6502	6715	6501
	Q=2.278 m³/s	Q=2.799 m³/s	Q=3.266 m³/s	Q=3.266 m³/s	Q=3.499 m³/s
	L=112.5 m	L=99.7 m	L=89.5 m	L=42 m	L=22 m
	V=3.05 m/s	V=3.232 m/s	V=3.771 m/s	V=3.772 m/s	V=4.078 m/s



Nodes:	MH121	MH124	MH125	MH126	MH149	Hampstock_Phase_1
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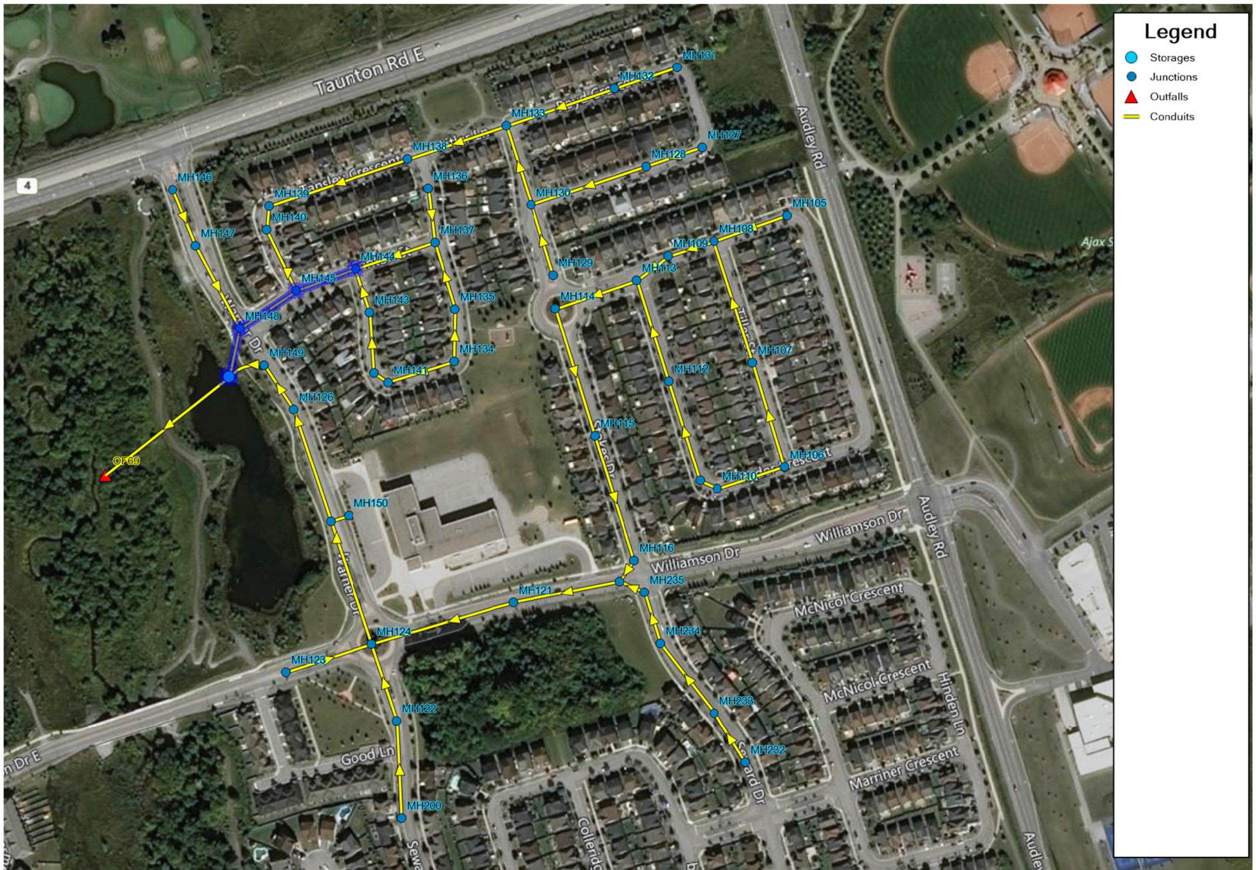
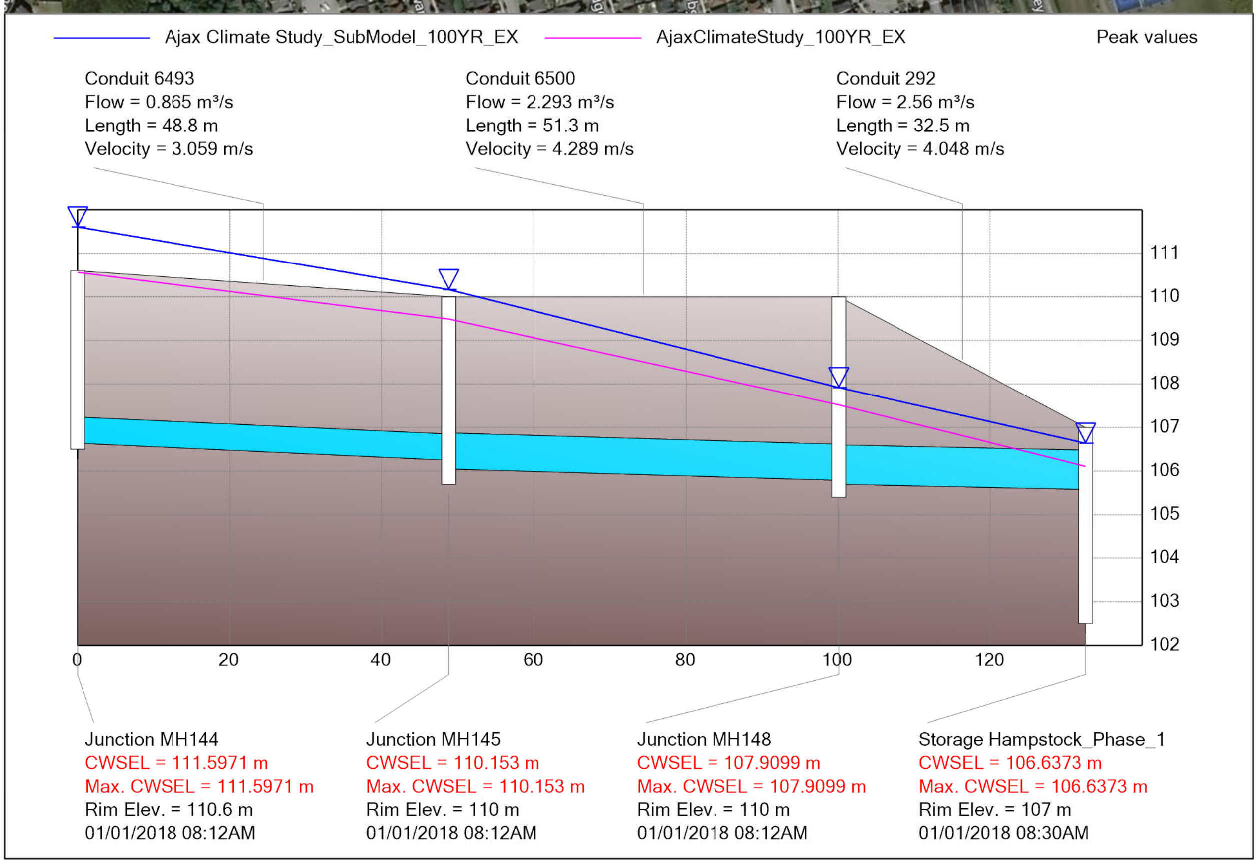
	M=114.245 m	M=112.6208 m	M=111.0578 m	M=109.0629 m	M=107.7534 m	M=106.6373 m
	R=111.555 m	R=111 m	R=110.1 m	R=109.45 m	R=109.76 m	R=107 m

100-yr HGL Comparison: Sub-Model vs Town-Wide Model





100-yr HGL Comparison: Sub-Model vs Town-Wide Model