ECS Lunch and Learn

Supporting internal knowledge transfer within TRCA

November 10, 2020

Toronto and Region Conservation Authority

TRCA’s Recent Floodplain Mapping Updates

Wilfred Ho*, Christina Bright*, Mike Todd**

* Flood Risk Management, Development & Engineering Services
** Information Technology & Records Management

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Presentation Outline

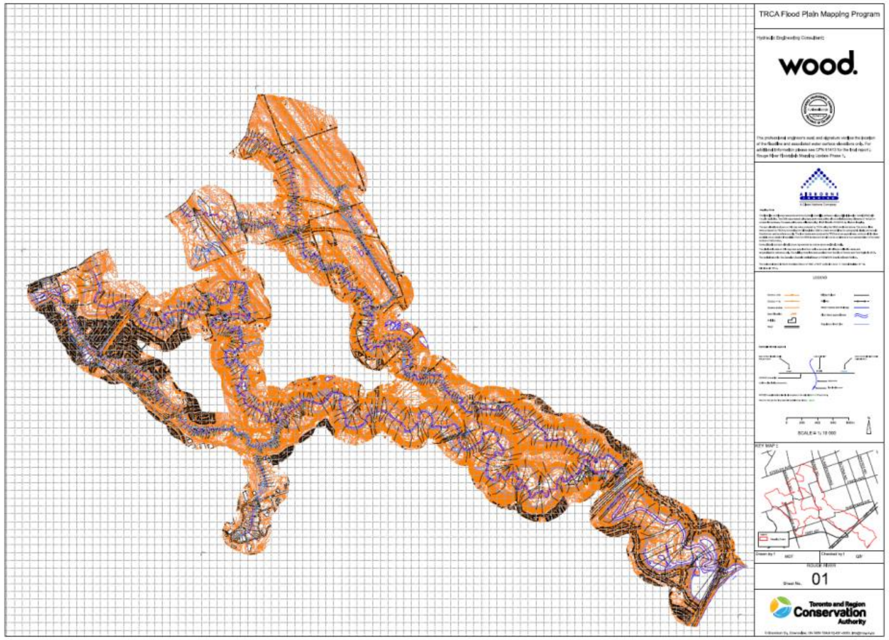
1. Floodplain Mapping (FPM) – What is it and why do we do it?

2. FPM – How do we do it?
    1. Hydrological Modelling
    2. Hydraulic Modelling
    3. Mapping

3. What have we done recently?

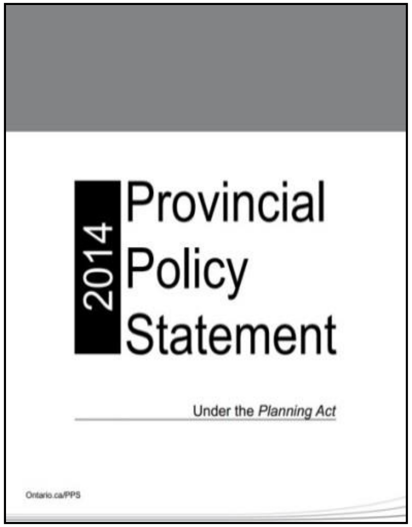
What is Floodplain Mapping?

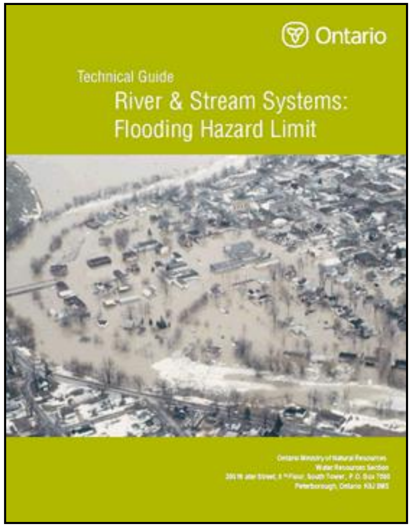
Floodplain Map: Riverine flood extents of a storm event – most commonly done for the Regulatory storm (greater of 100-yr storm or Regional storm (Hurricane Hazel)

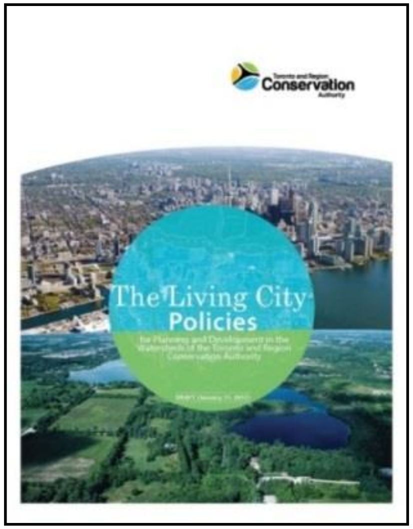


Why do we undertake FPM updates?

- Provincially delegated responsibility to represent the province interests on natural hazards which includes flood hazards
- Mapping and modelling must comply with standards established by the Province
- Determines regulatory flood hazard limits
- Informs municipal landuse, emergency management, and infrastructure planning





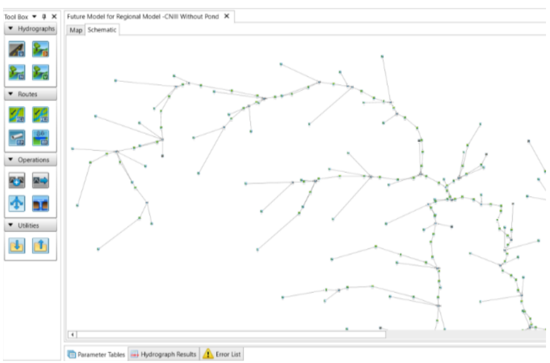


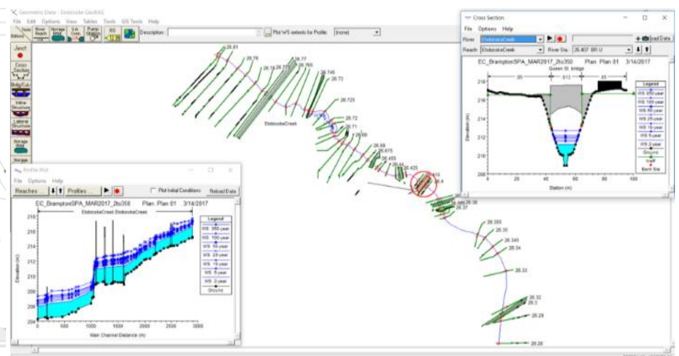
Recent FPM Updates

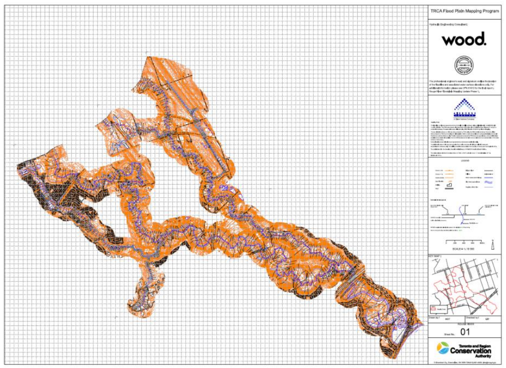
- Initiated in 2016 and further accelerated by National Disaster Mitigation Program (NDMP) Funding
- Mapping updates involved a multi-phased approach

MODELLING | MAPPING

Hydrologic Modeling → Hydraulic Modeling → Mapping Component







- These phases were undertaken over the last few years for many of TRCA's watersheds

Hydrology - Idealized Processes

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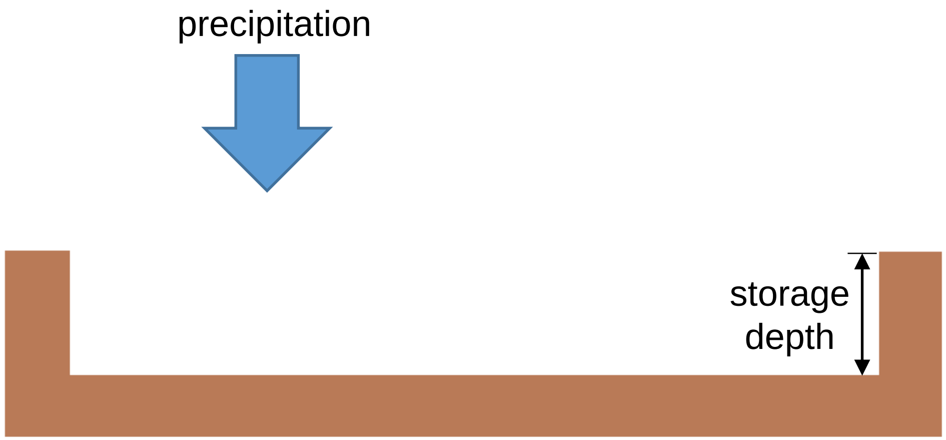
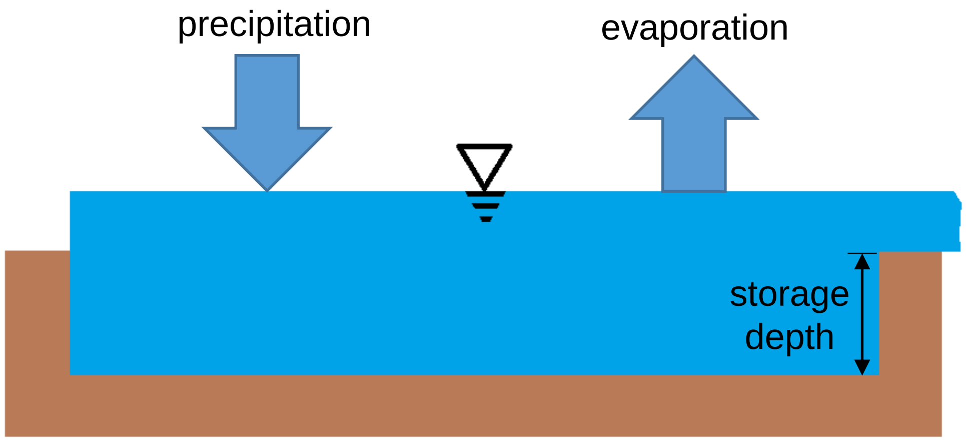
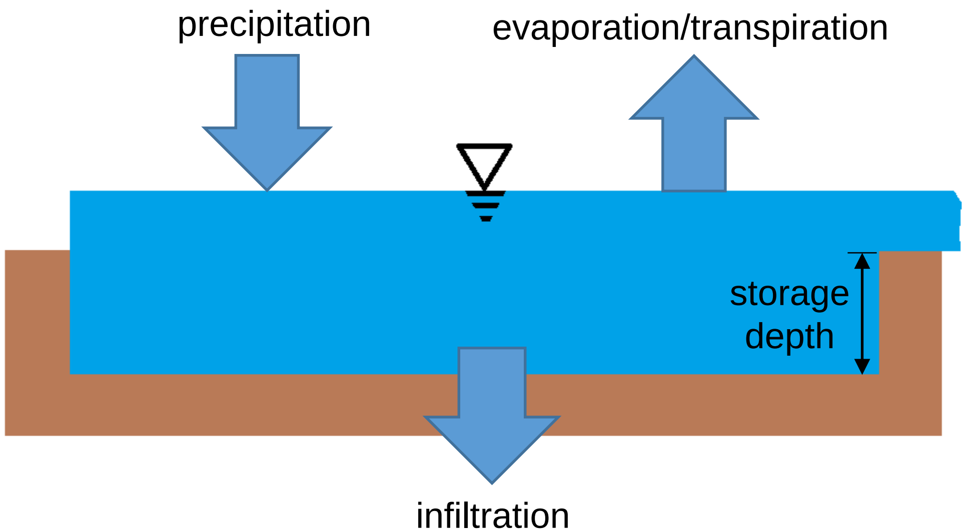


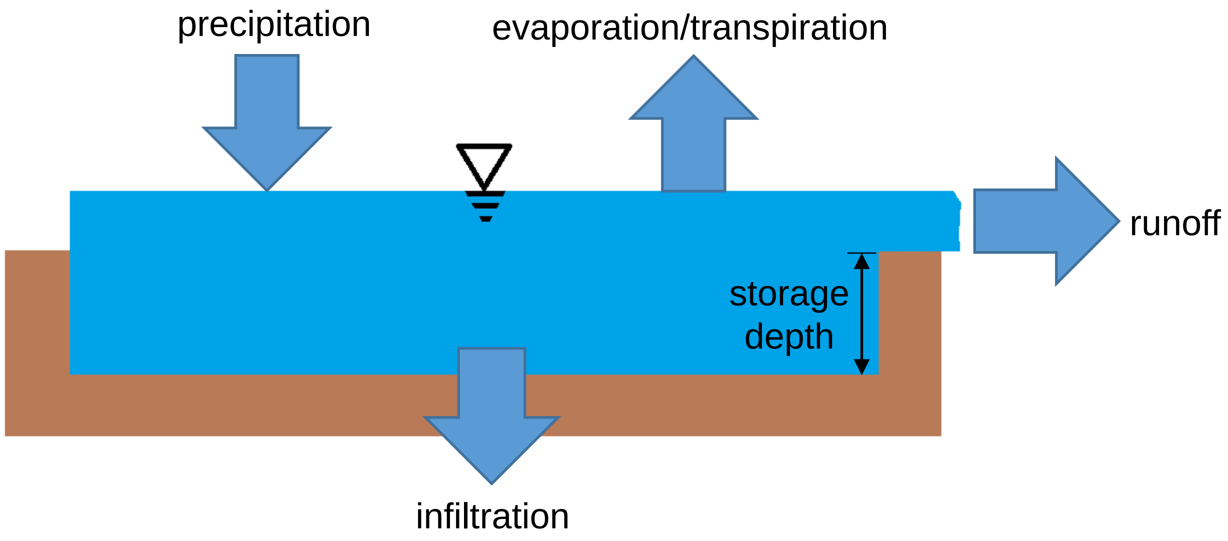
Hydrology - Idealized Processes



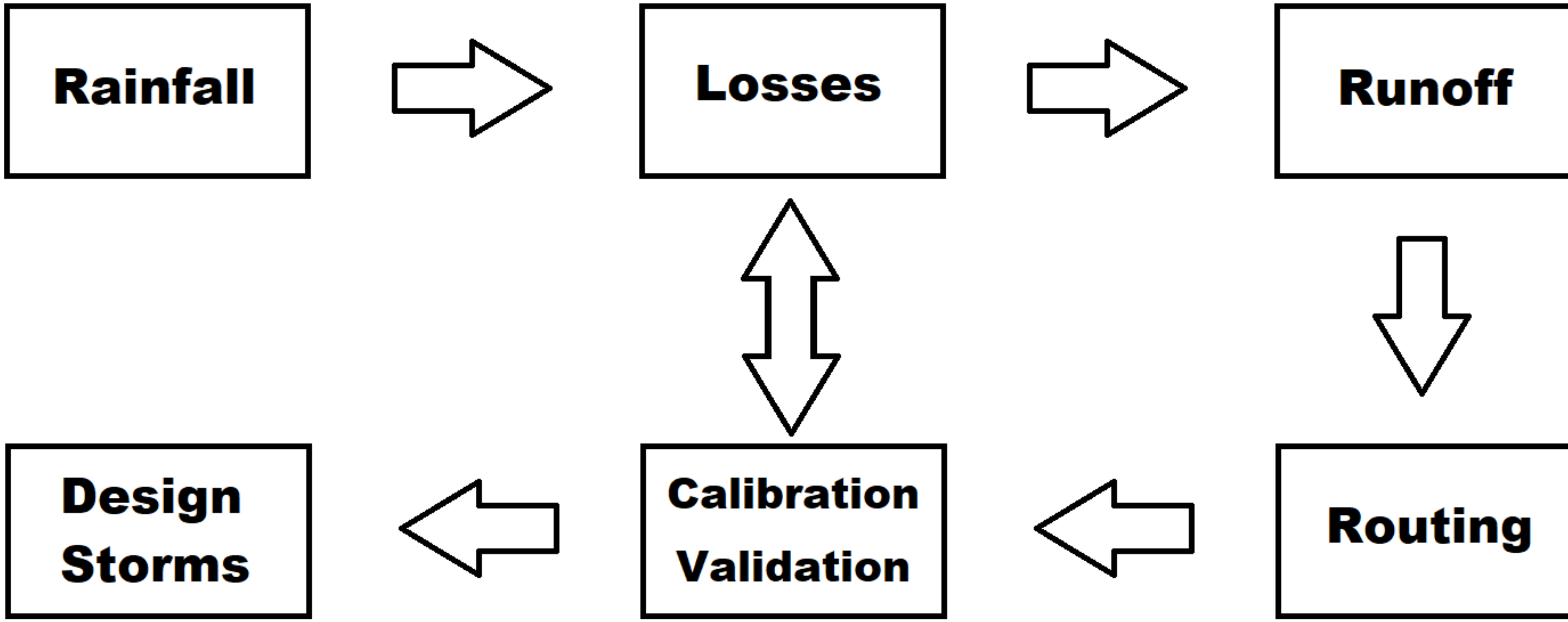
Hydrology - Idealized Processes



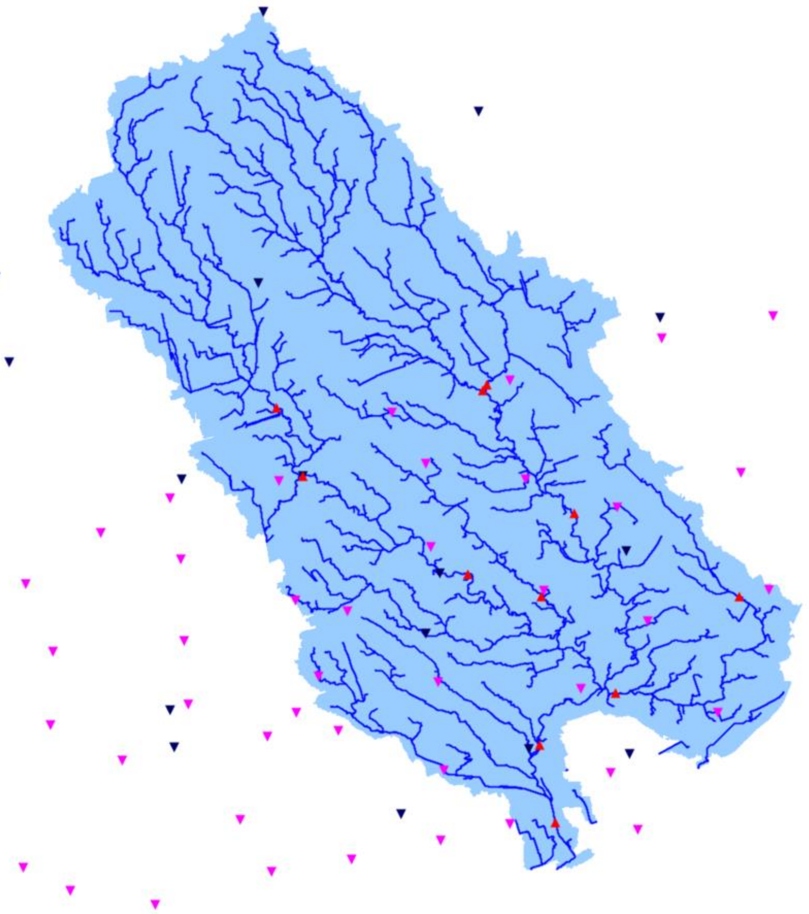
Hydrology - Idealized Processes



Basic workflow

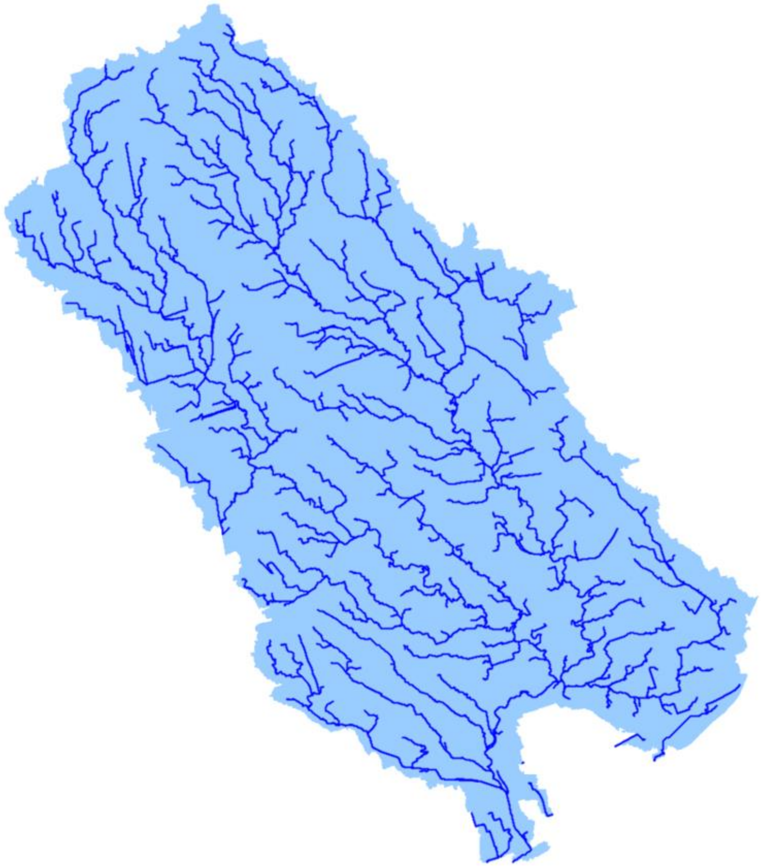


Event Data – Point Gauges

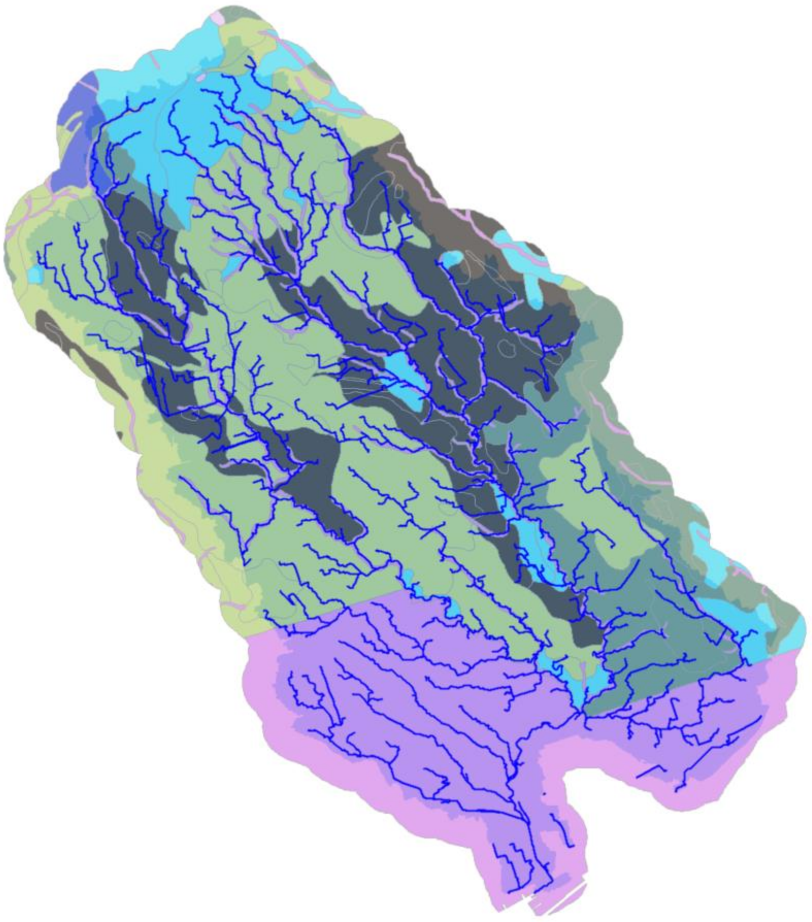


Terrain Data – LiDAR DEM

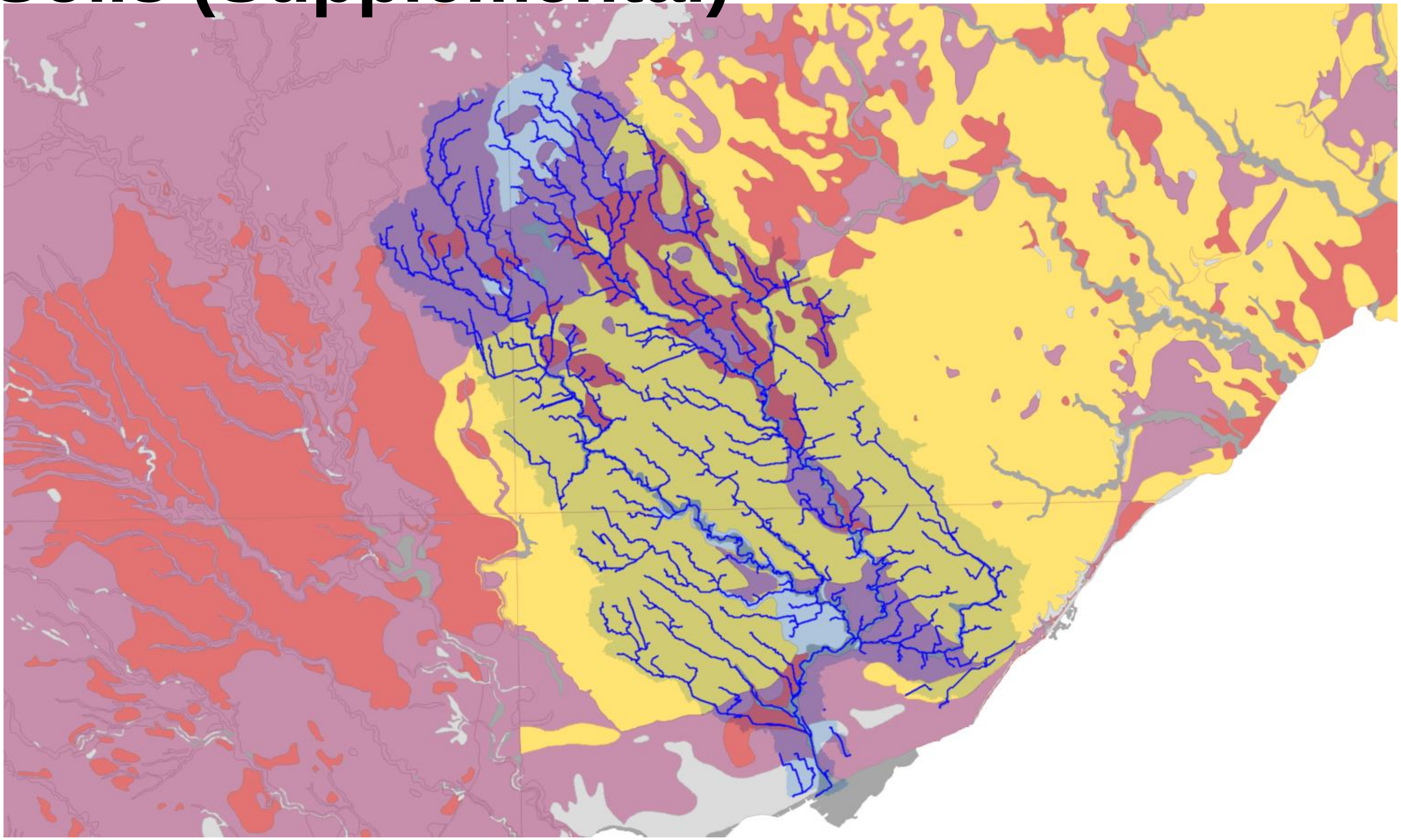
Catchments and Drainage Features



Soils



Soils (Supplemental)



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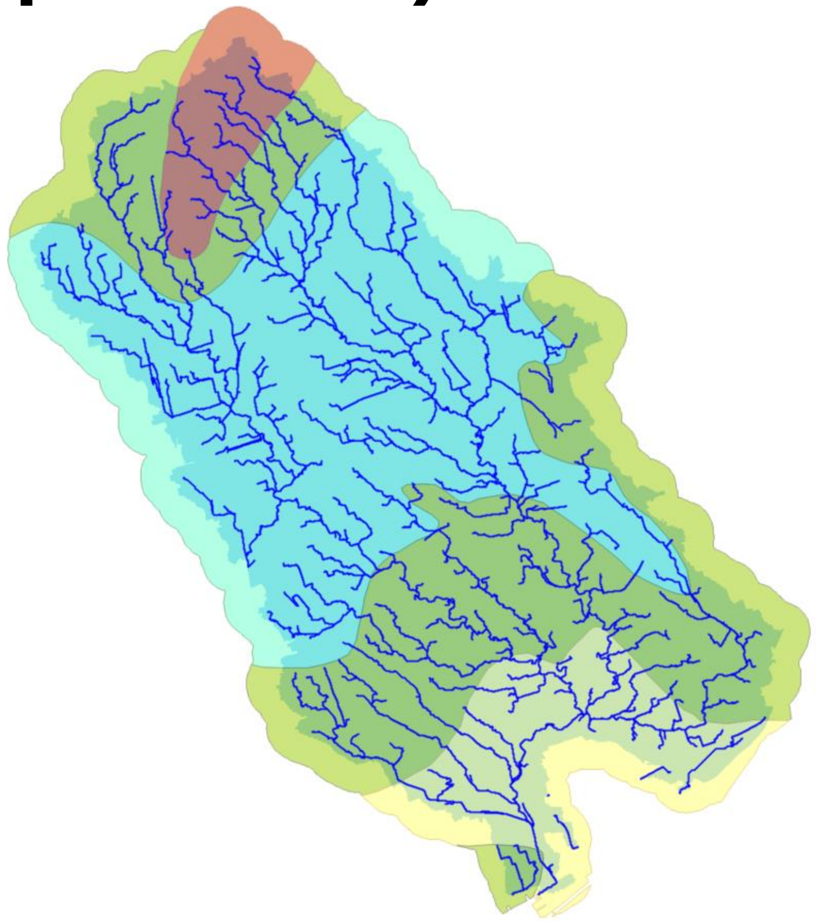
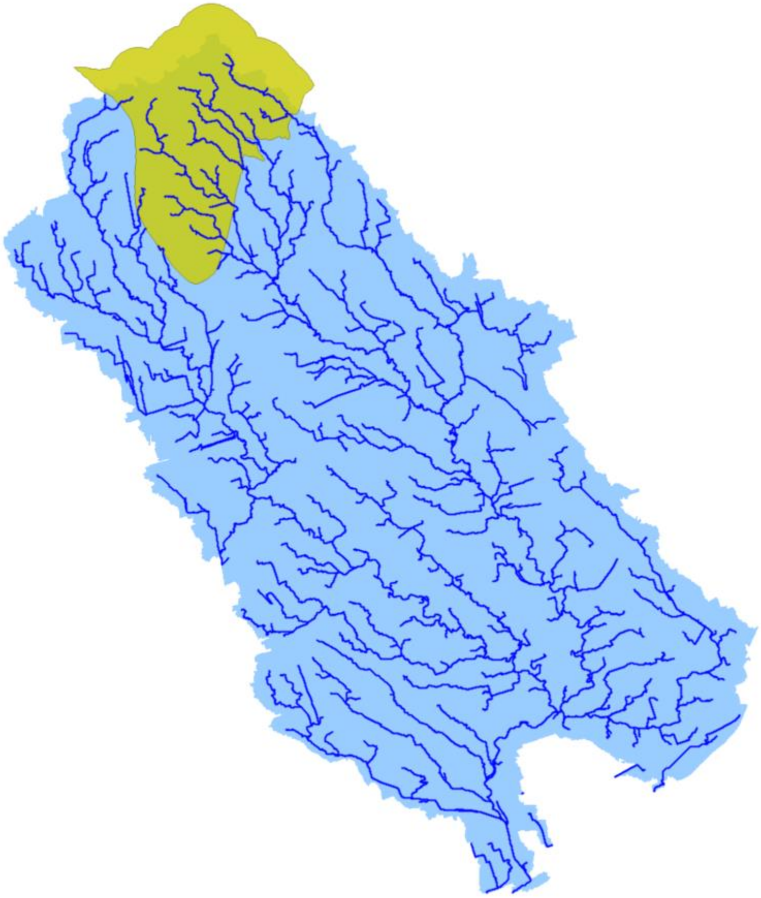


Geological Features



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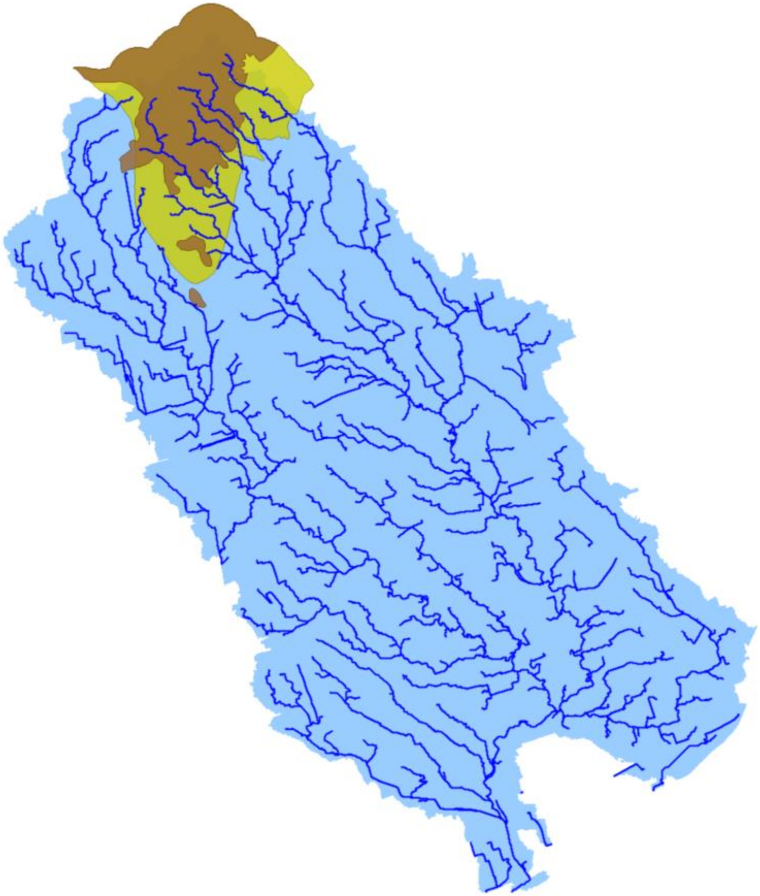
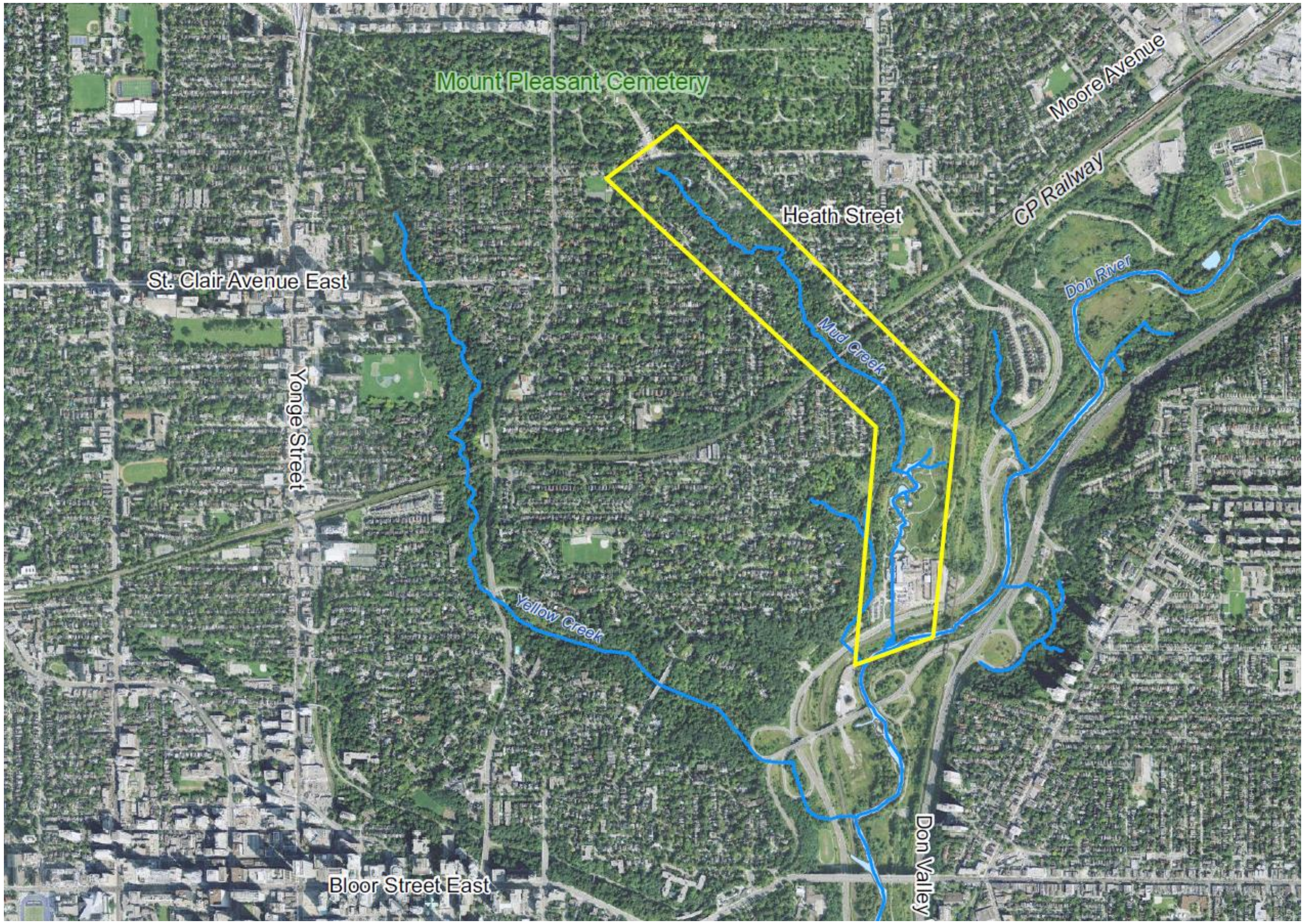
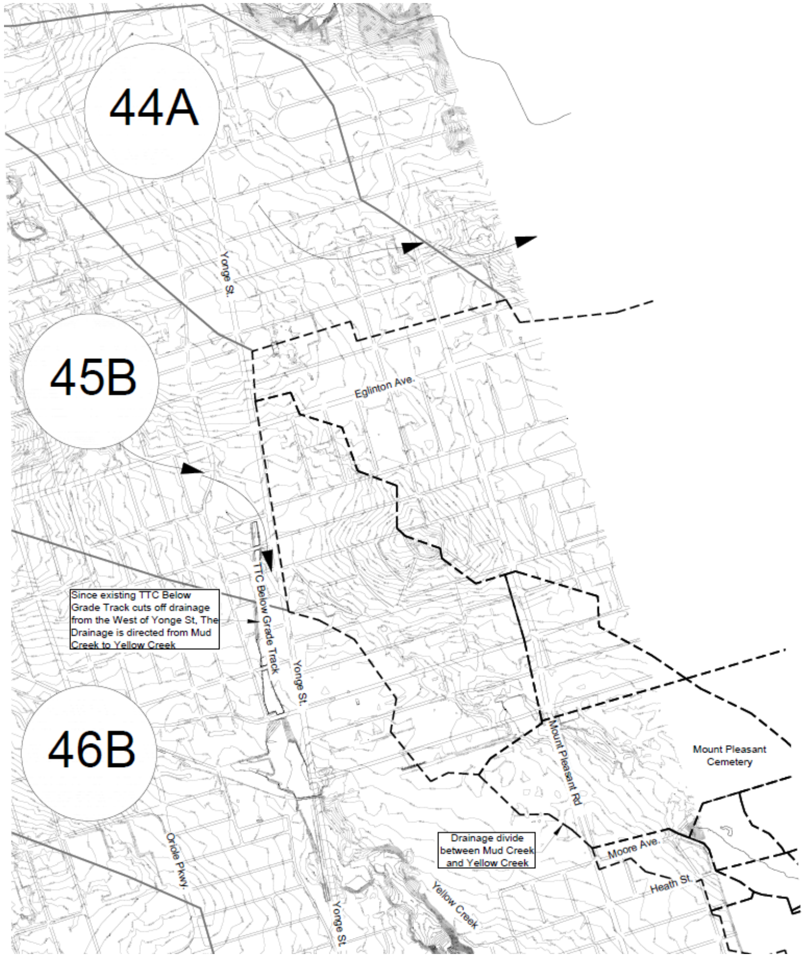


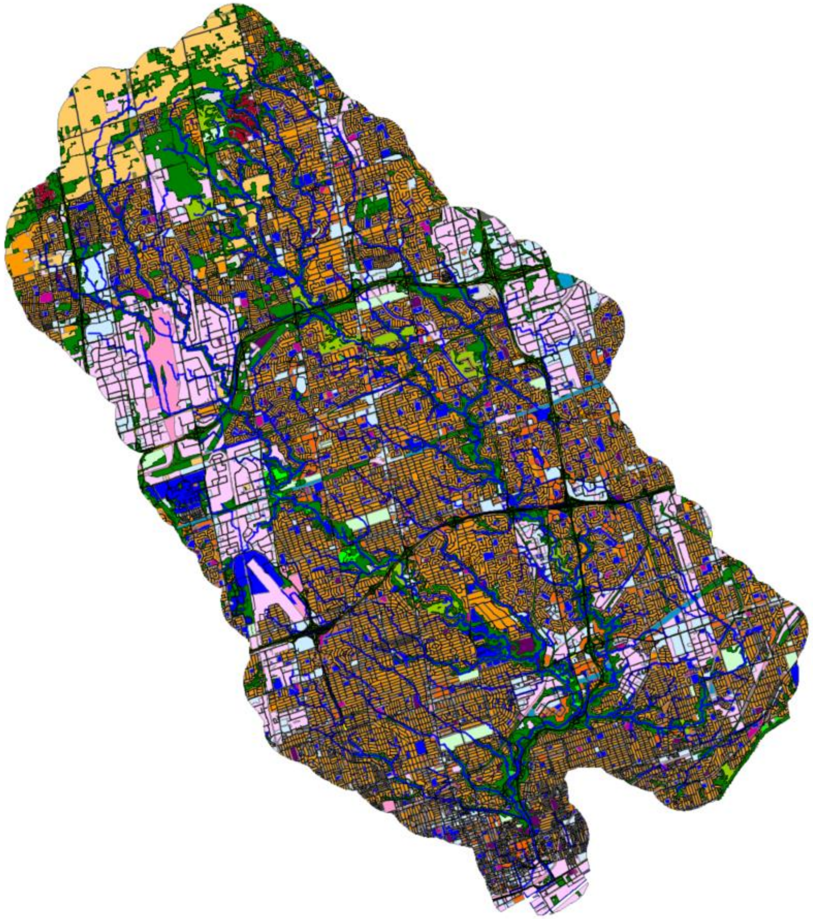
Anthropogenic Features



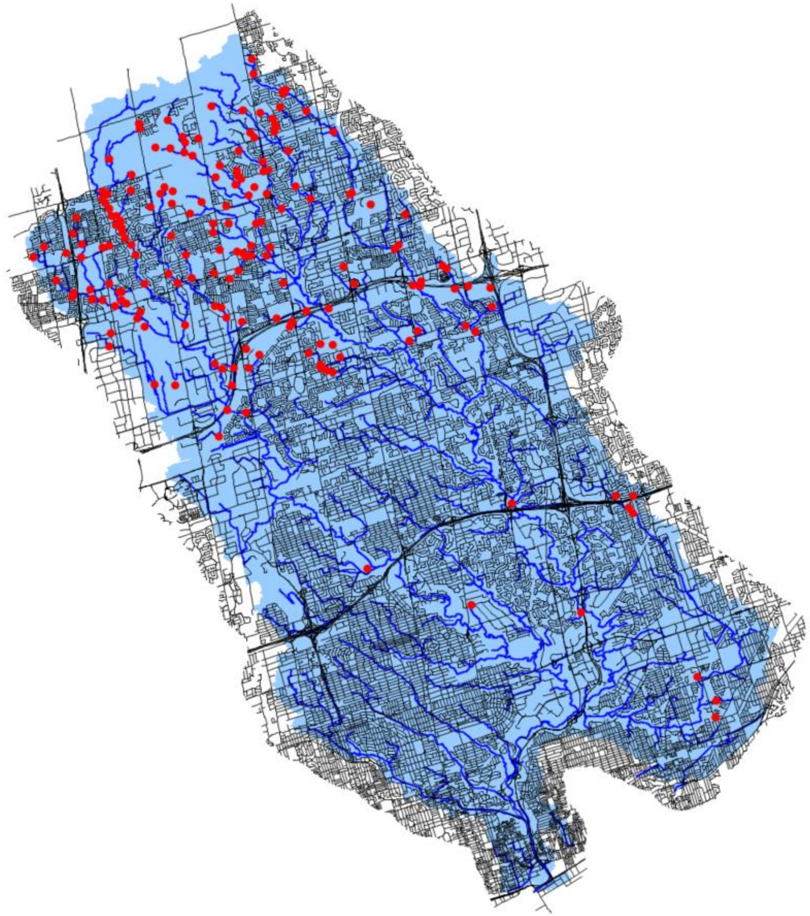
Anthropogenic Features



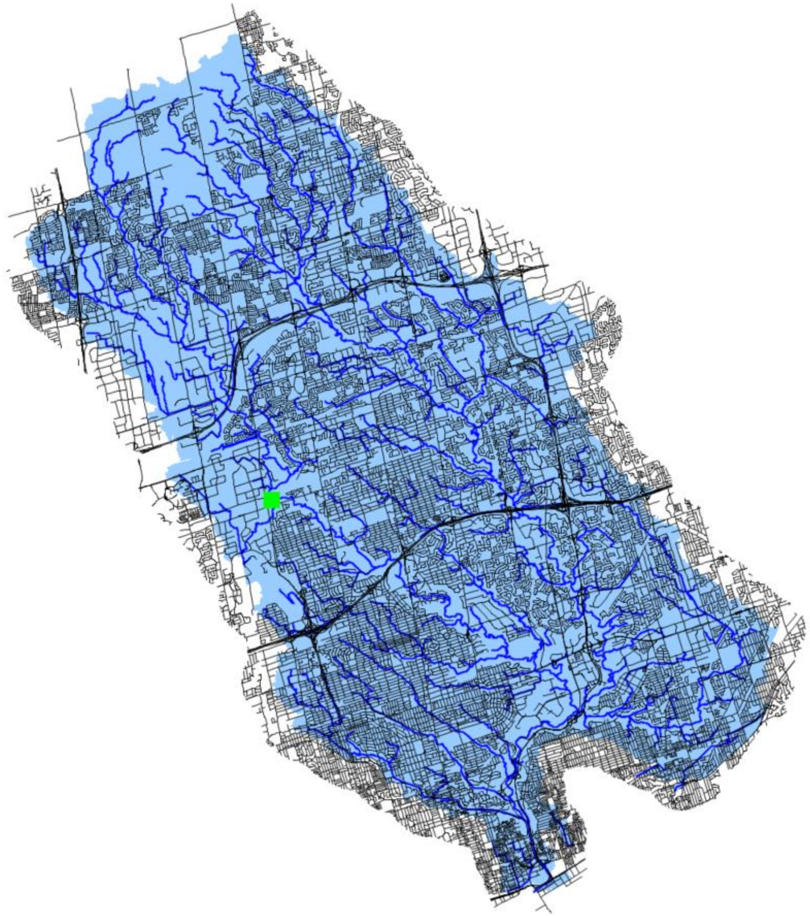
Land Use and Natural Cover



Artificial Reservoirs - SWM Ponds



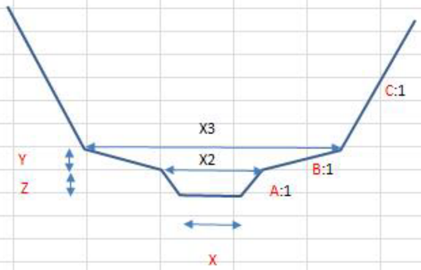
Artificial Reservoirs - Dams

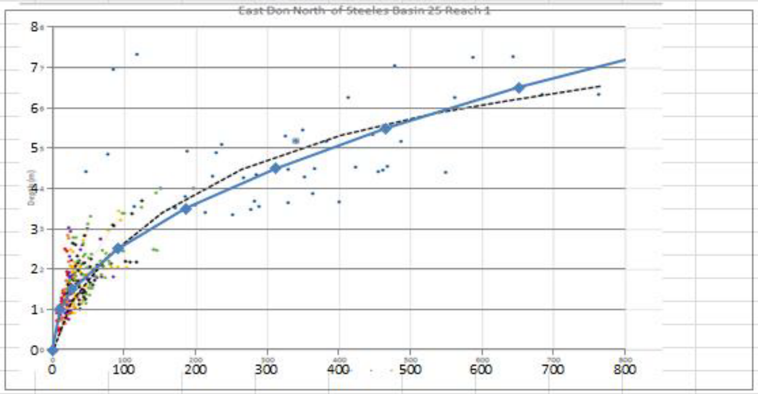


Conveyance Elements

X	5	X2	15
Y	0.5	X3	50
Z	1		
A	5		
B	35		
C	15		

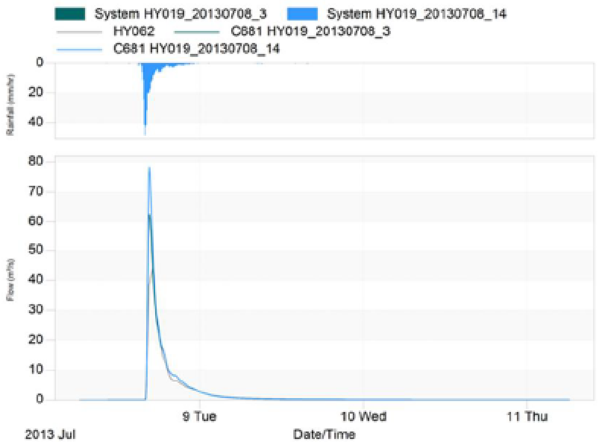
Depth	Top Width	Area
0	0	0
1	15	10
1.5	50	26.25
2.5	80	91.25
3.5	110	186.25
4.5	140	311.25
5.5	170	466.25
6.5	200	651.25
7.5	230	866.25

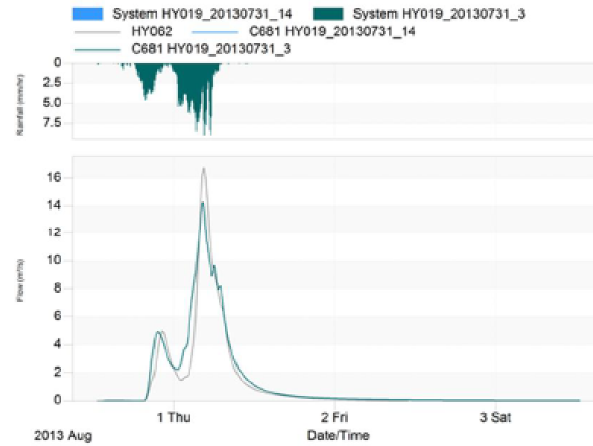


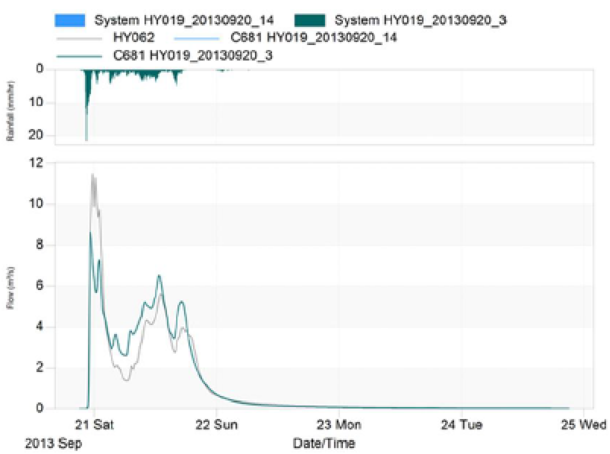


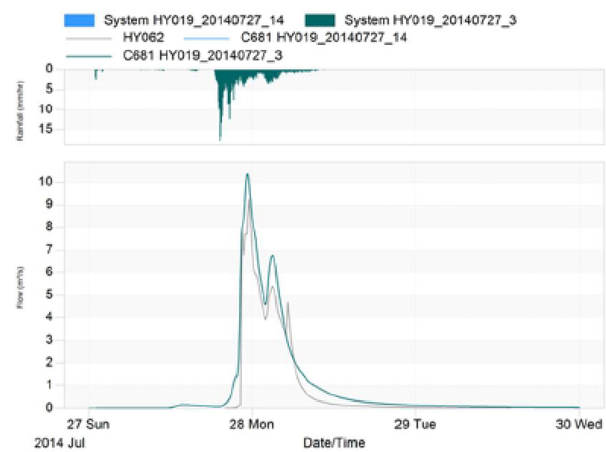
Model Build

Calibration

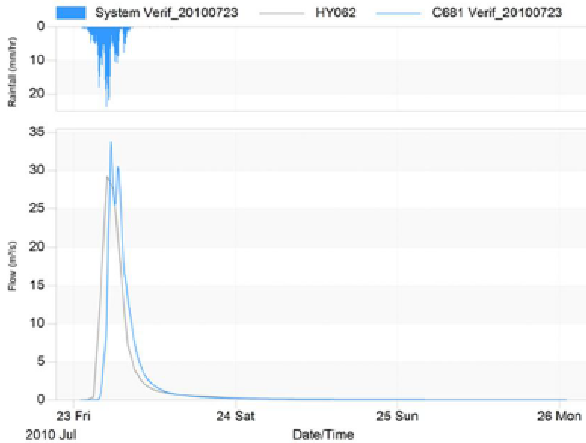








Validation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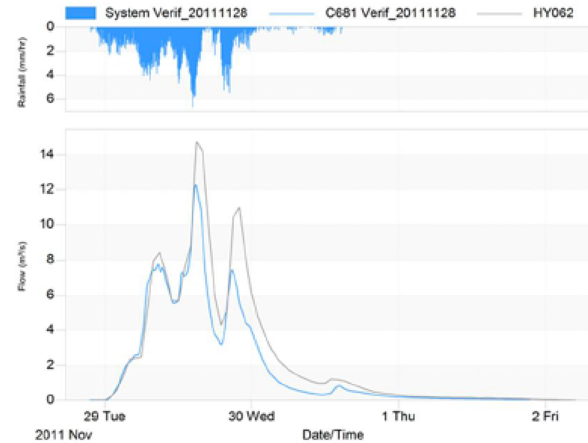
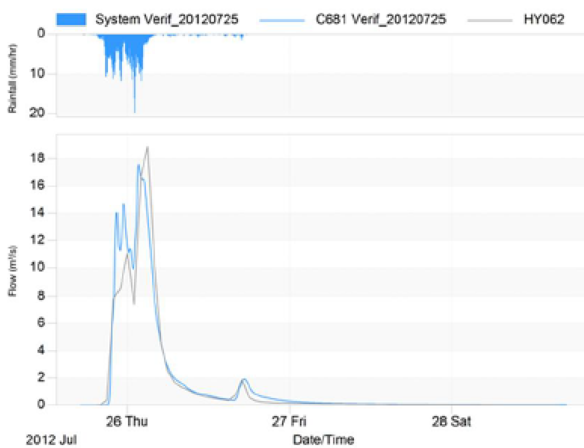
HY062
C681 Verif_20100723
Rainfall (mm/hr)
Flow (m³/s)
23 Fri
24 Sat
25 Sun
26 Mon
2010 Jul
Date/Time


System Verif_20111128
C681 Verif_20111128
HY062
Rainfall (mm/hr)
Flow (m³/s)
29 Tue
30 Wed
1 Thu
2 Fri
2011 Nov
Date/Time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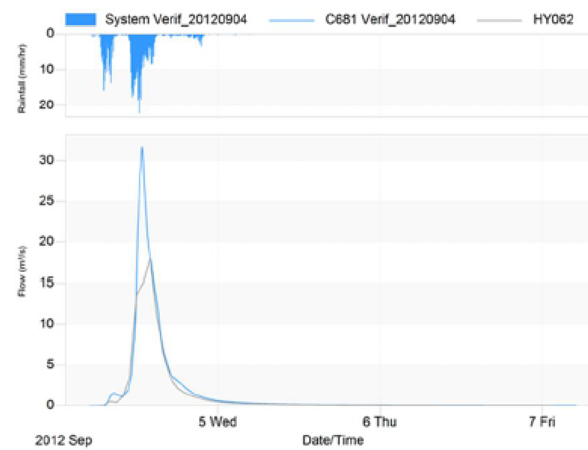
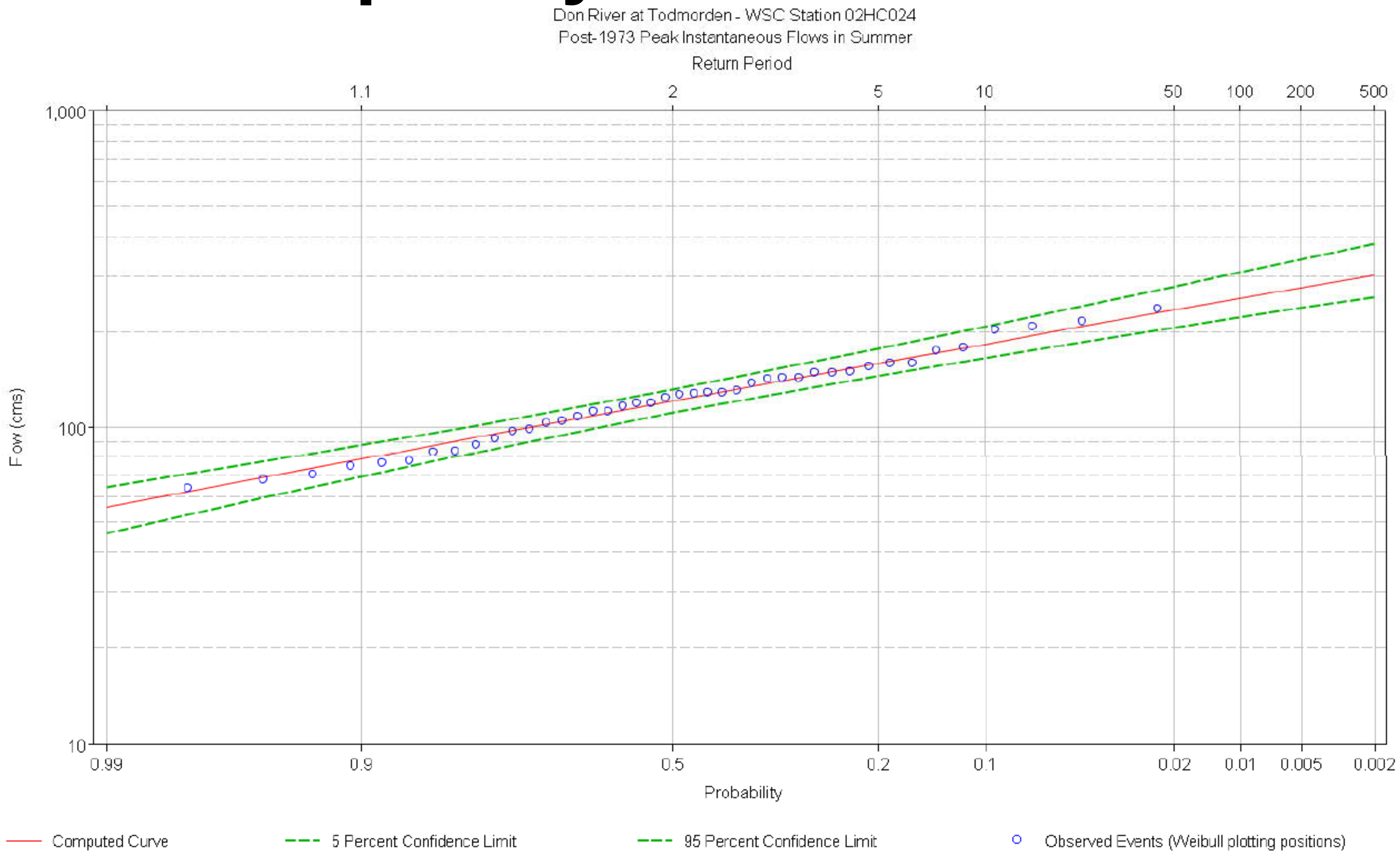
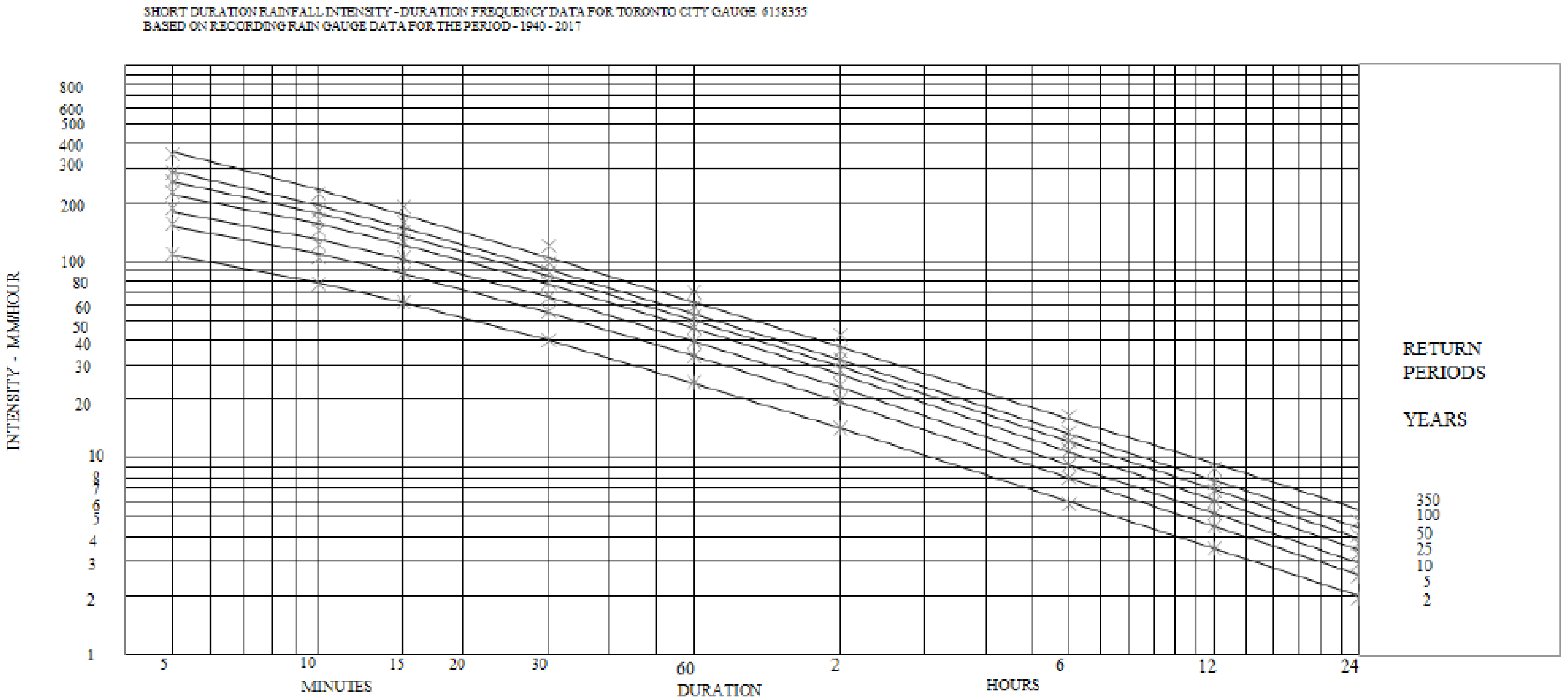
C681 Verif_20120725
HY062
Rainfall (mm/hr)
Flow (m³/s)
26 Thu
27 Fri
28 Sat
2012 Jul
Date/Time


System Verif_20120904
C681 Verif_20120904
HY062
Rainfall (mm/hr)
Flow (m³/s)
5 Wed
6 Thu
7 Fri
2012 Sep
Date/Time

Flood Frequency



Design Storm Selection

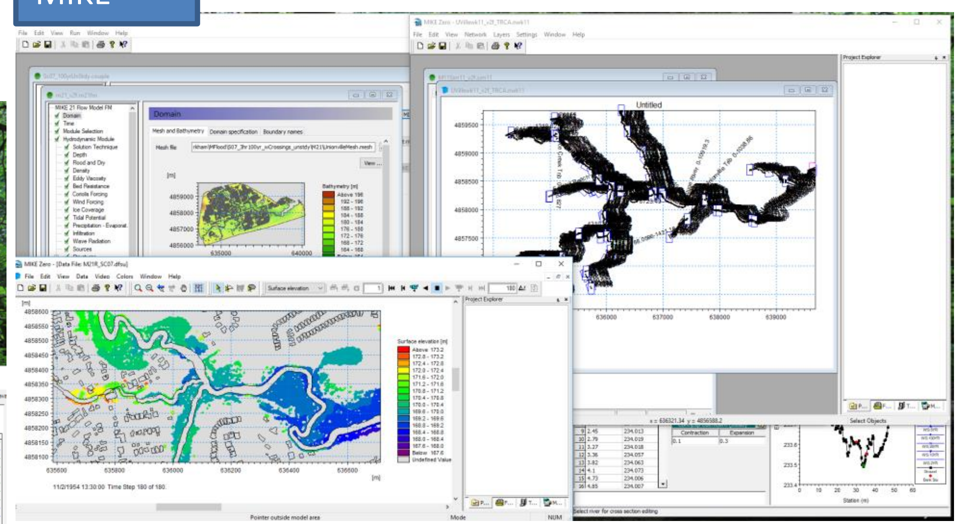


Updated IDF Curve for Toronto City Gauge 6158355

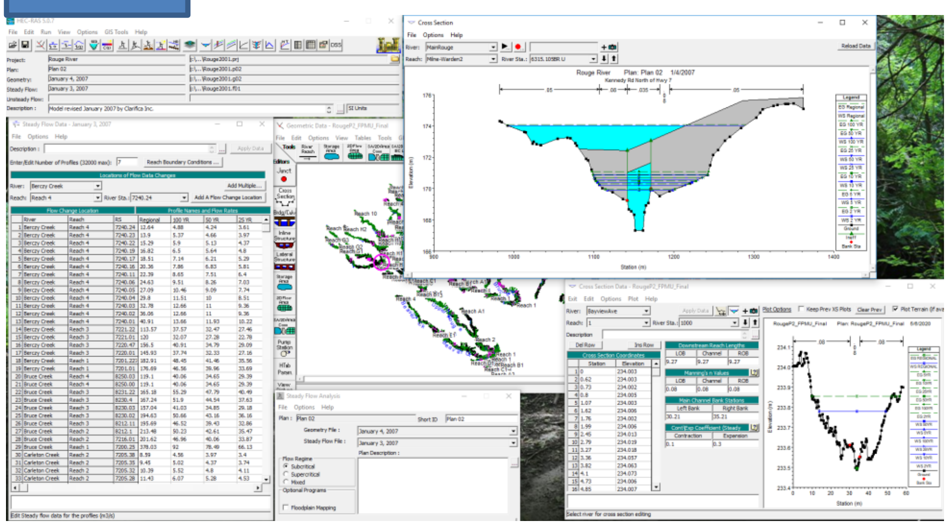
Hydraulic Modelling

- Simulates the flow of water through a stream corridor & associated floodplain
- Representation of the physical characteristics of the stream corridor
- Provides water surface elevations for the various flows modelled

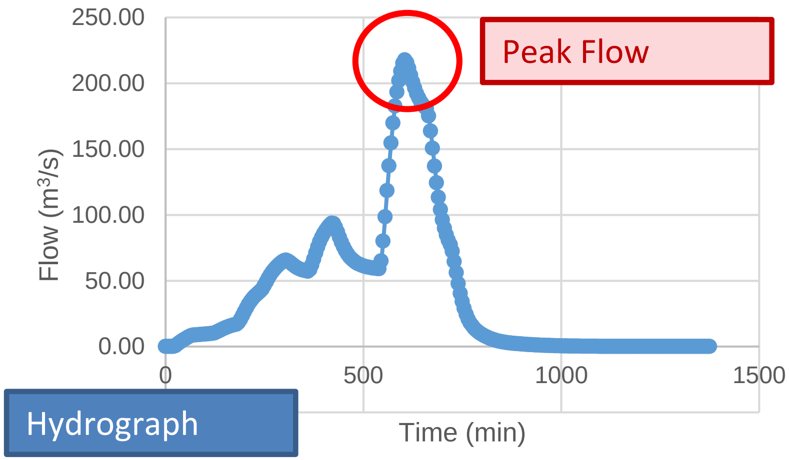
MIKE



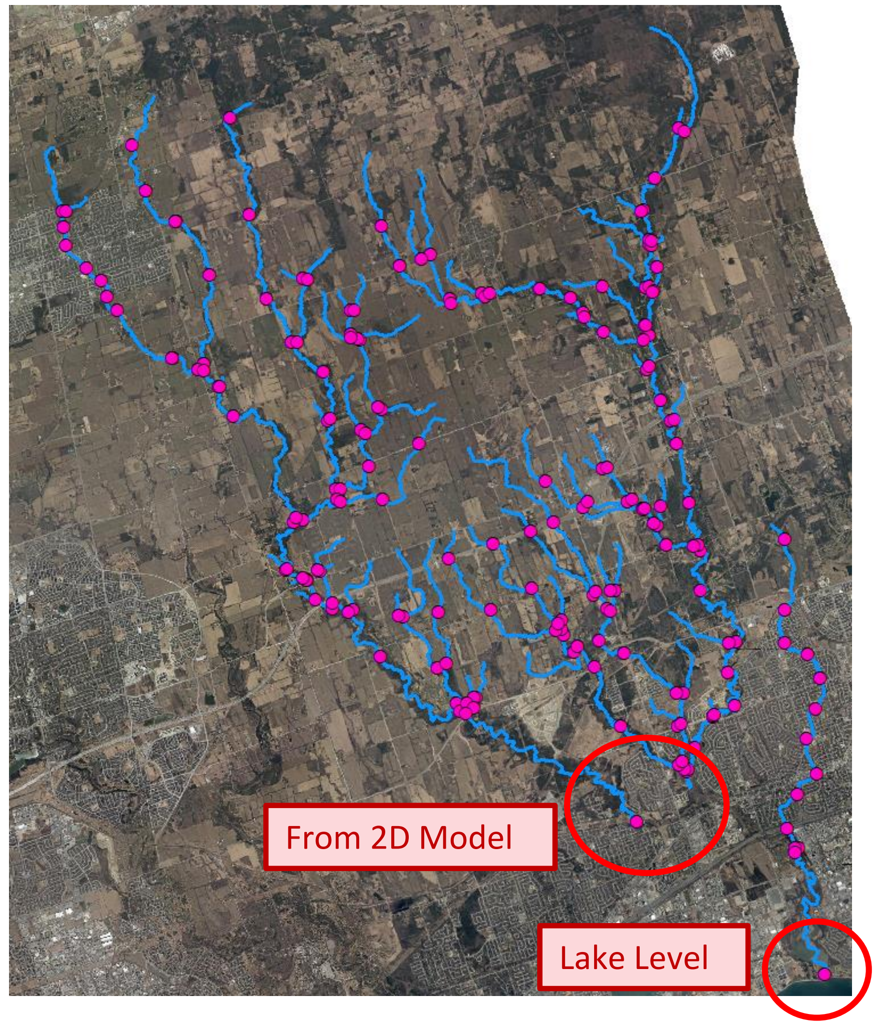
HEC-RAS



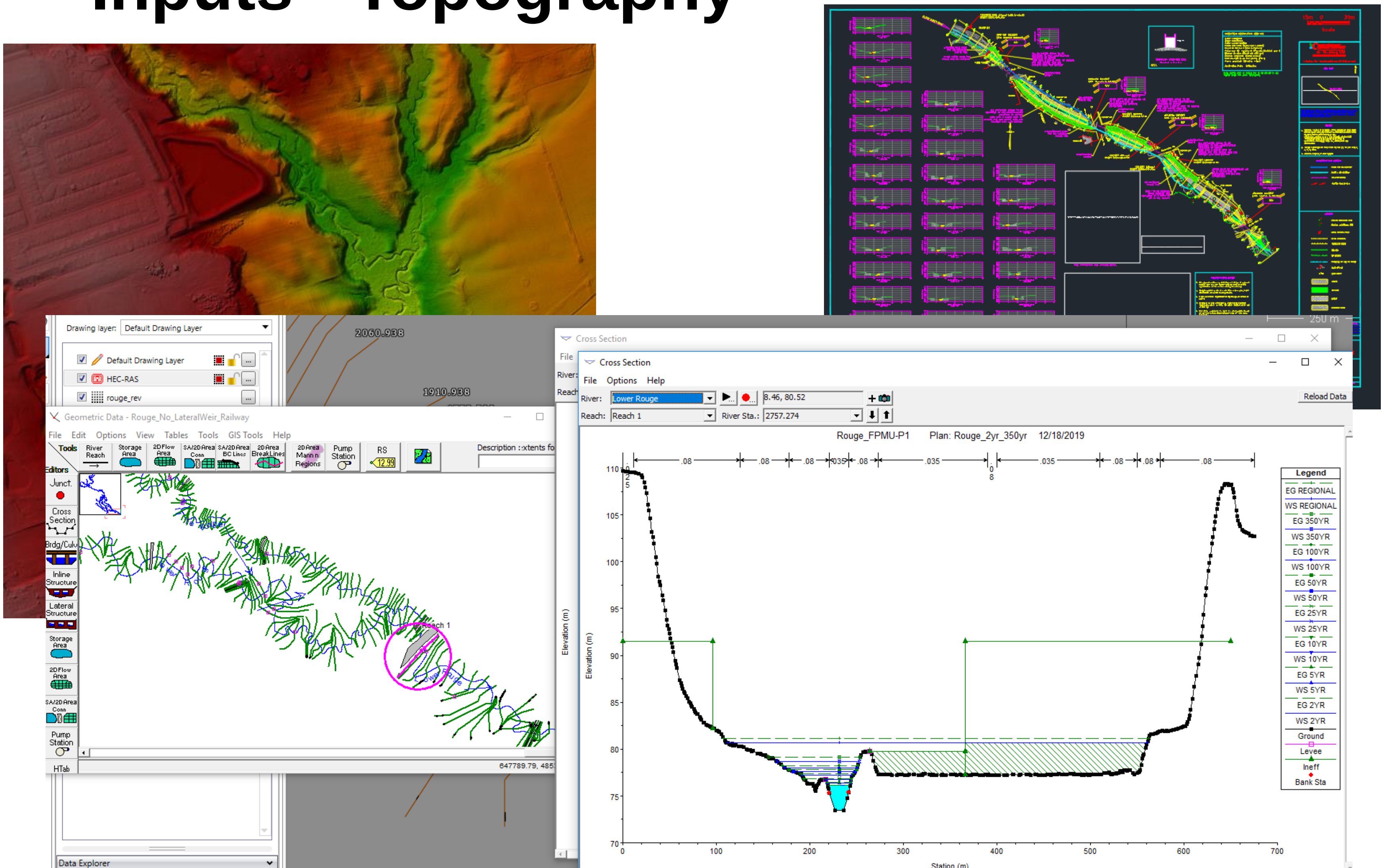
Inputs - Flows & Boundary Conditions



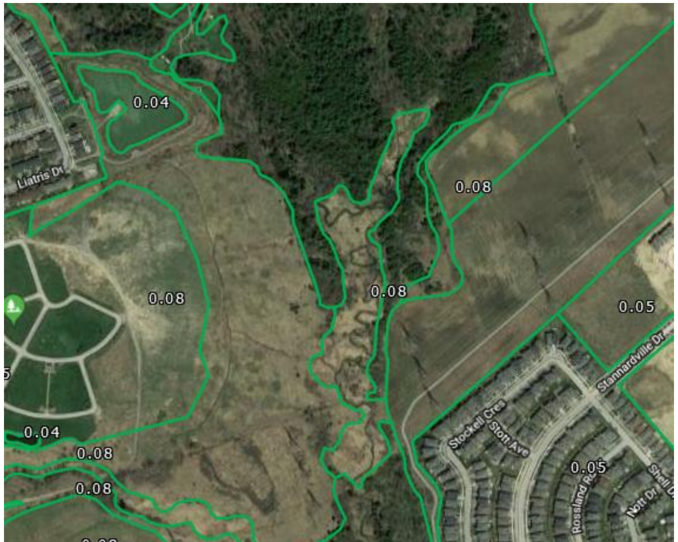
	Flow Change Location			Profile Names and Flow Rates						
	River	Reach	RS	REG	100Y	50Y	25Y	10Y	5Y	2Y
1	Brougham Creek	Reach 4	5024.9	12.97	2.64	2.27	1.92	1.48	1.17	0.73
2	Brougham Creek	Reach 4	3303.71	18.43	3.75	3.22	2.73	2.1	1.66	1.03
3	Brougham Creek	Reach 4	2020.84	21.18	4.31	3.7	3.14	2.41	1.9	1.18
4	Brougham Creek	Reach 3	61.92	36.52	7.43	6.39	5.41	4.16	3.28	2.04
5	Brougham Creek	Reach 2	580.4	48.76	9.91	8.53	7.22	5.56	4.38	2.73
6	Brougham Creek	Reach 1	1645.81	72.04	15.88	13.67	11.59	8.94	7.06	4.4
7	Brougham Creek	Reach 1	990.45	75.38	16.61	14.3	12.13	9.36	7.39	4.6
8	Brougham Trib A	Trib A1	2159.01	29.11	6.74	5.82	4.94	3.82	3.02	1.89
9	Brougham Trib A	Trib A1	1840.34	29.11	6.74	5.82	4.94	3.82	3.02	1.89
10	Brougham Trib A	Trib A1	770.82	29.56	6.7	5.78	4.91	3.8	3	1.87
11	Brougham Trib B	Trib B1	417.48	1.45	0.29	0.25	0.21	0.17	0.13	0.08
12	E Duffins Trib A	East A1	515.88	1.48	0.3	0.26	0.22	0.17	0.13	0.08
13	E Duffins Trib B	East B1	1888.94	2.41	0.49	0.42	0.35	0.27	0.21	0.13
14	E Duffins Trib C	East C1	1364.13	3.72	0.78	0.67	0.57	0.43	0.34	0.21
15	E Duffins Trib D	East D1	647.41	0.77	0.16	0.14	0.12	0.09	0.07	0.04
16	E Duffins Trib D	East D1	282.59	1.18	0.25	0.21	0.18	0.14	0.11	0.07
17	E Duffins Trib E	East E1	3170.84	6.92	1.36	1.19	1	0.76	0.6	0.37
18	E Duffins Trib E	East E1	1947.71	8.97	1.76	1.54	1.3	0.99	0.77	0.48
19	E Duffins Trib F	East F1	955.93	1.12	0.22	0.19	0.16	0.12	0.1	0.06
20	E Duffins Trib F	East F1	669.16	2.14	0.42	0.37	0.31	0.24	0.18	0.11
21	E Duffins Trib G	East G1	2020.55	6.28	1.23	1.08	0.91	0.69	0.54	0.34
22	E Duffins Trib H	East H1	2726.99	33.25	6.54	5.6	4.73	3.61	2.83	1.74
23	E Duffins Trib I	East I1	516.74	8.98	1.74	1.5	1.26	0.97	0.76	0.47
24	E Duffins Trib J	East J1	1004.76	16.96	3.29	2.83	2.39	1.83	1.44	0.88



Inputs - Topography



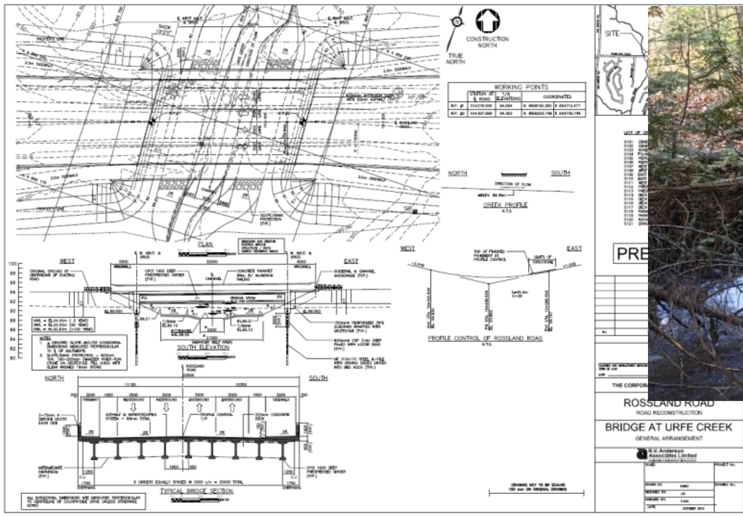
Inputs - Channel Resistance

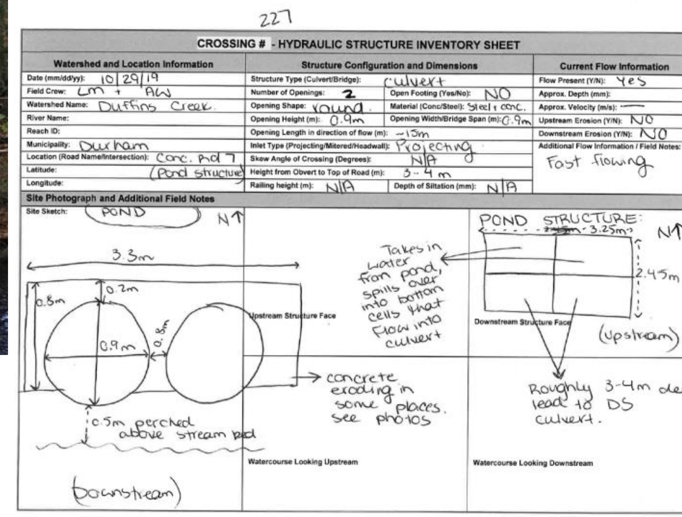


Standard Manning's Roughness Coefficients for TRCA Watershed Hydraulic Modelling		
Land Use	Description and Conditions	"n" Value [1]
Channel Component		
Watercourse/ Channel	• low flow channel • extends typically from bank to bank	0.035
Hydraulic Structures	• culvert crossings (e.g., corregated metal, concrete open/closed footing etc.) • bridge crossings	Variable [2]
Floodplain Component		
Urban Uses (Impervious)	• Road crossings, existing parking lots or any large impervious surfaces etc. • typically located within valley and stream corridors • Does not include structures or buildings (to be modelled using available ineffective flow area options)[2]	0.025
Urban Uses (Pervious)	• Existing uses including municipal parks, playing fields, golf courses etc. • typically located within valley and stream corridors • Regular maintenance of area is required	0.050
Natural Areas	• Pasture, meadow, agricultural, riparian vegetation, brush and forest • located within urban and/or rural land use setting • typically located within valley and stream corridors • Not subject to regular maintenance • Assumes regeneration of open space type uses including pasture, meadow and agricultural uses within floodplain areas (Consistent with TRCA's VSCMP and Natural Heritage Strategies)	0.080
Flood Control Channels	• Flood control channels and associated works designed specifically for flood flow conveyance (eg., trapezoidal lined and un-lined channels etc.) • "n" value based on original design or maximum allowable value determined through a sensitivity analysis • Regular maintenance of area is required	Variable [2]

Notes: 1. Manning's "n" values represent average values based on literature data assuming flooding conditions.
2. Refer to HEC-2 and/or HEC-Ras User's Manual for further details.

Inputs - Hydraulic Constraints

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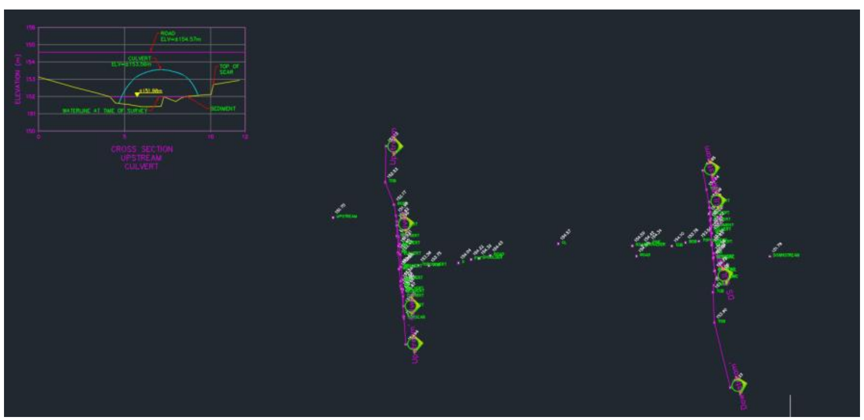
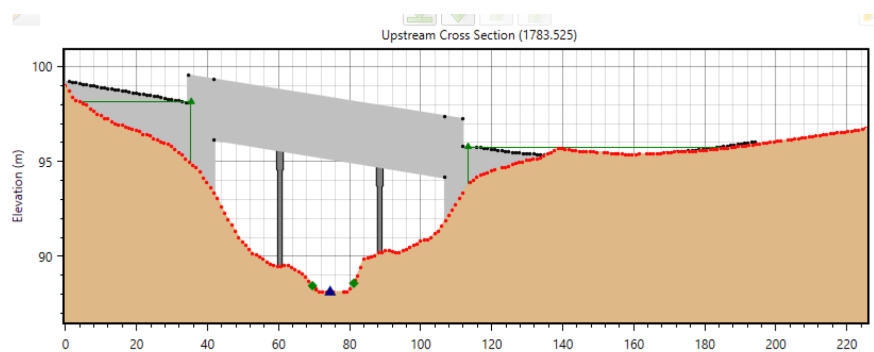
CROSSING # - HYDRAULIC STRUCTURE INVENTORY SHEET

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 10/29/19	Structure Type (Culvert/Bridge): culvert	Flow Present (Y/N): Yes
Field Crew: LM + AW	Number of Openings: 2 / Open Footing (Yes/No): NO	Approx. Depth (mm):
Watershed Name: Duffins Creek	Opening Shape: round / Material (Conc/Steel): Steel + conc.	Approx. Velocity (m/s): —
River Name:	Opening Height (m): 0.9m / Opening Width/Bridge Span (m): 0.9m	Upstream Erosion (Y/N): NO
Reach ID:	Opening Length in direction of flow (m): ~15m	Downstream Erosion (Y/N): NO
Municipality: Durham	Inlet Type (Projecting/Mitered/Headwall): Projecting	Additional Flow Information / Field Notes:
Location (Road Name/Intersection): Conc. Rd 7 (Pond structure)	Skew Angle of Crossing (Degrees): N/A	Fast flowing
Latitude:	Height from Obvert to Top of Road (m): 3-4 m	
Longitude:	Railing height (m): N/A / Depth of Siltation (mm): N/A	

Site Photograph and Additional Field Notes

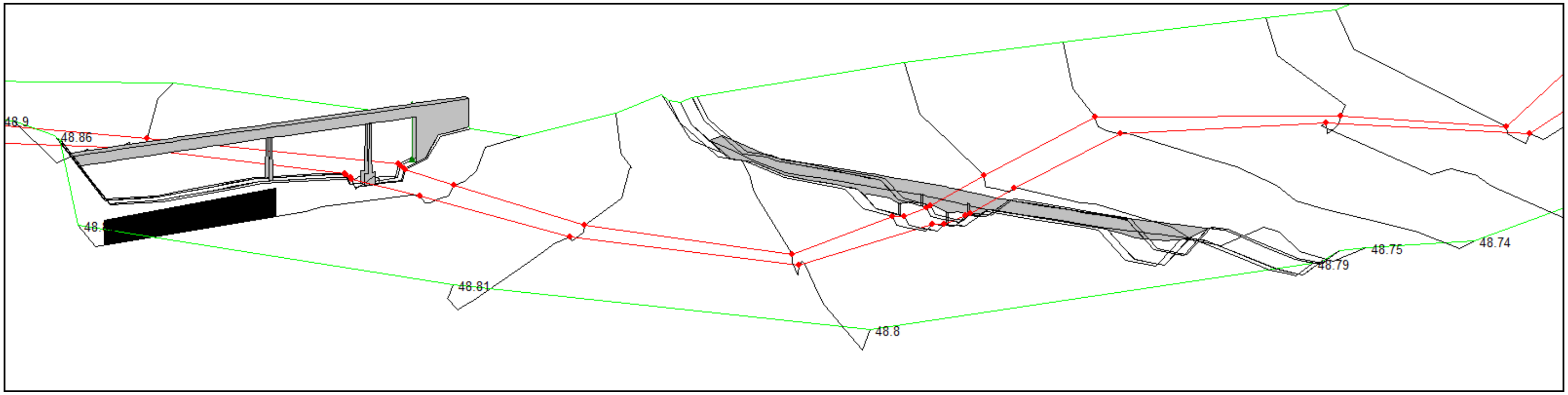
Site Sketch: POND N
3.3m
0.8m
0.2m
0.9m
0.3m
0.5m perched above stream bed
(Downstream)
Upstream Structure Face
Takes in water from pond, spills over into bottom cells that flow into culvert
concrete eroding in some places. See photos
Watercourse Looking Upstream
POND STRUCTURE 3.25m N
2.45m
Downstream Structure Face
(Upstream)
Roughly 3-4m deep lead to DS culvert.
Watercourse Looking Downstream



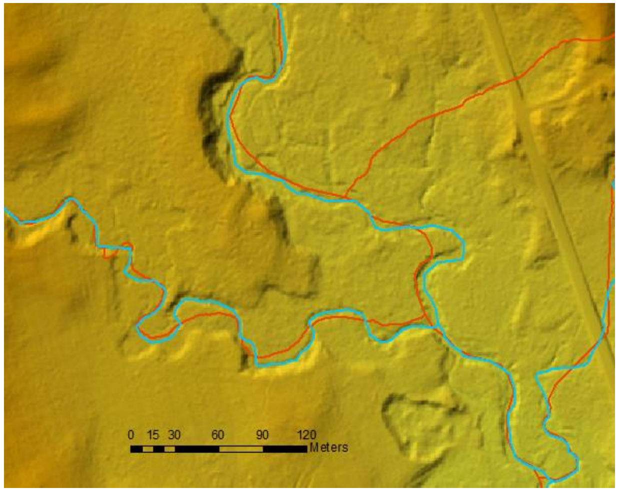


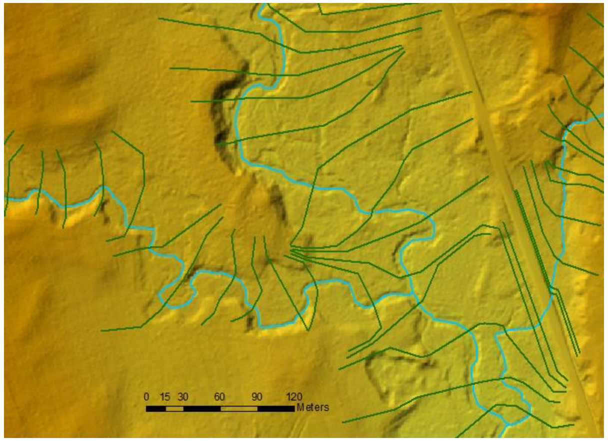
Hydraulic Modelling – 1D Models

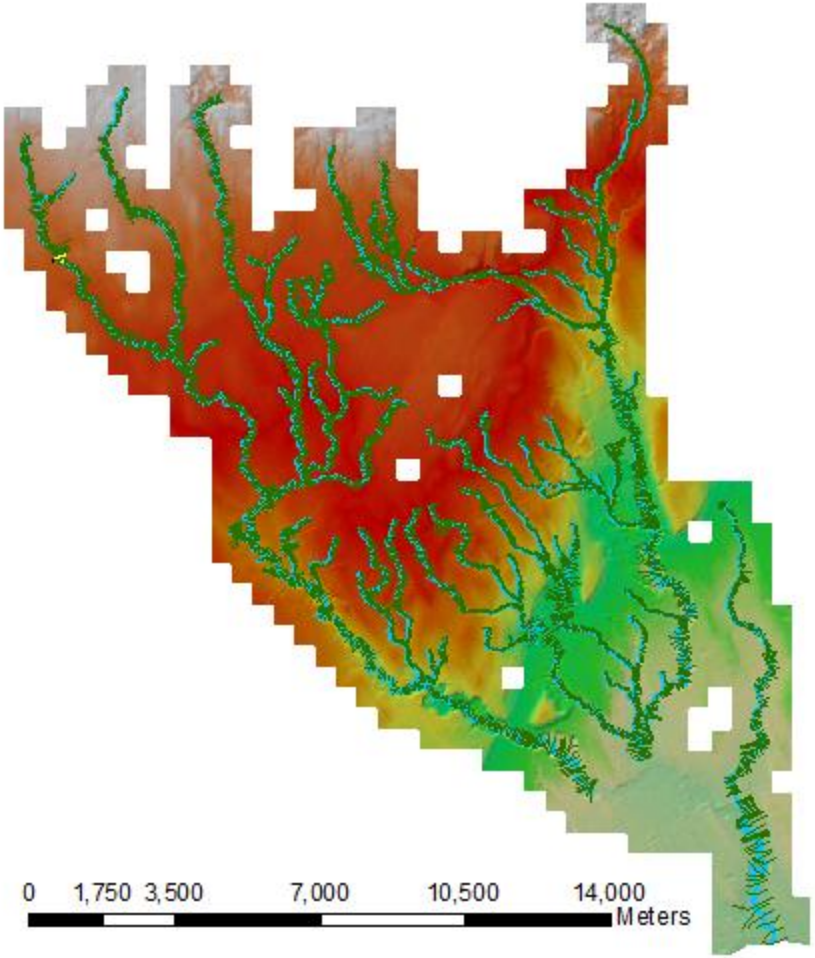
- Flow is one-dimensional
- Utilizes cross-sections to represent ground and structures
- Fast and relatively straight forward
- Vast majority of TRCA floodplain mapping done in 1D



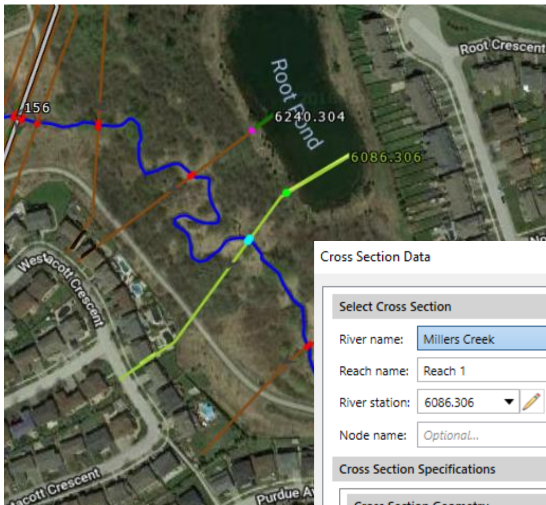
Building the Model Skeleton

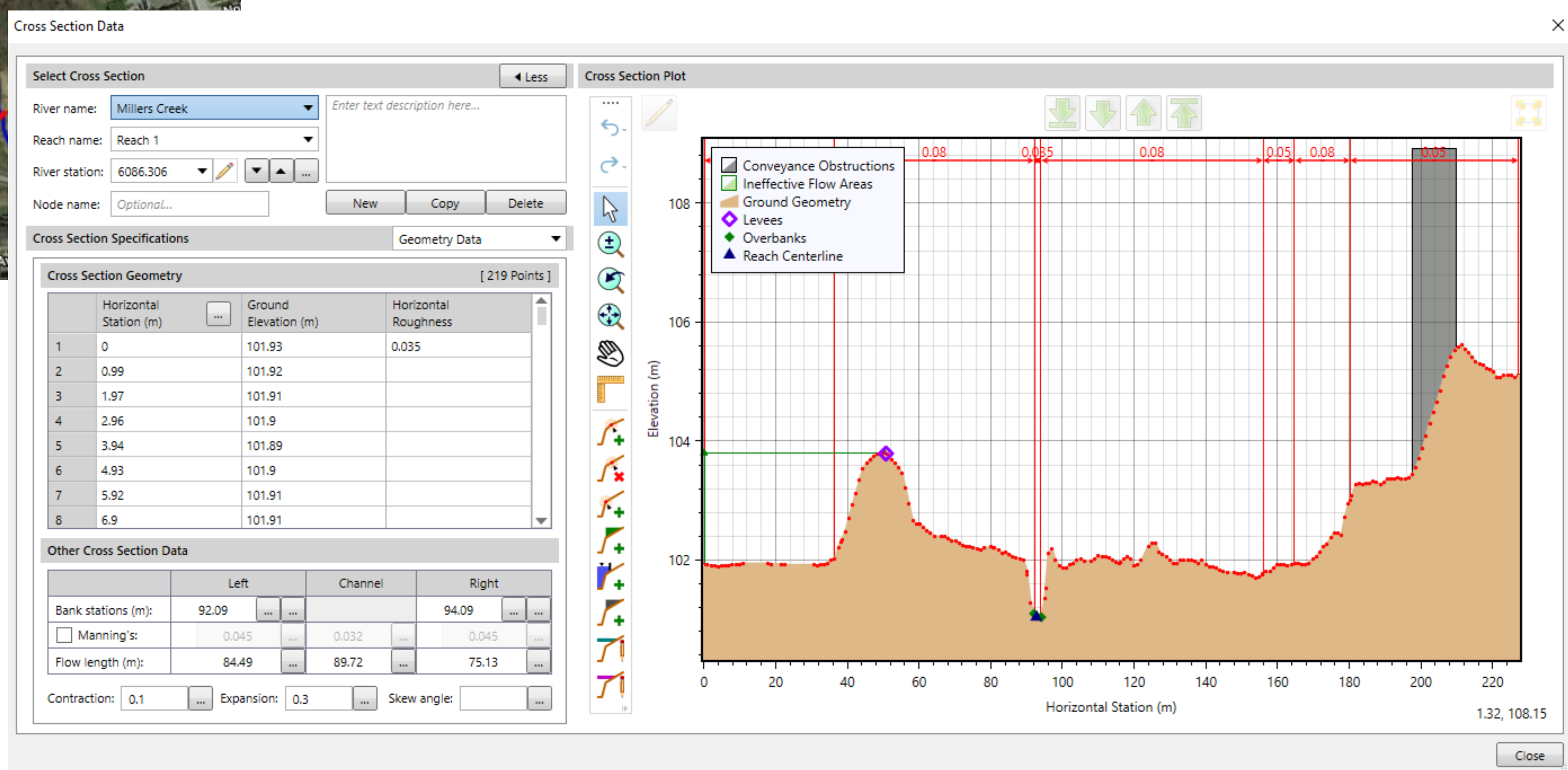




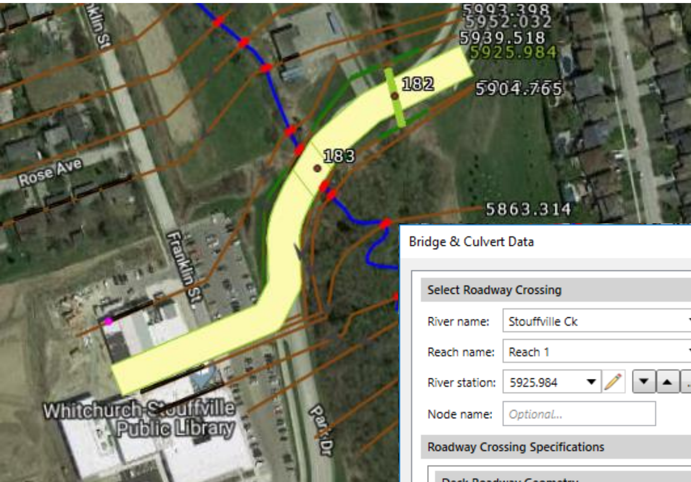


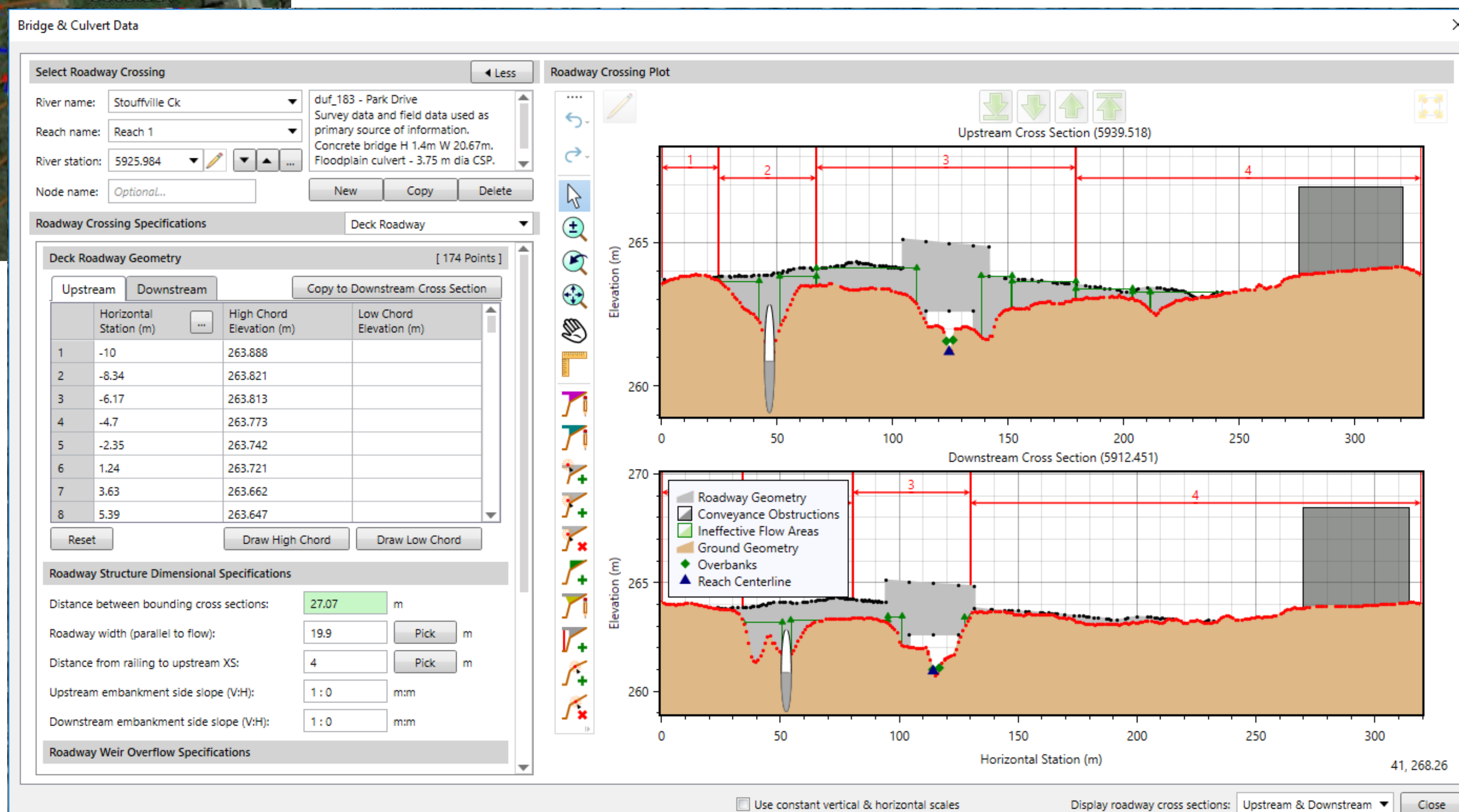
Adding Cross Section Details



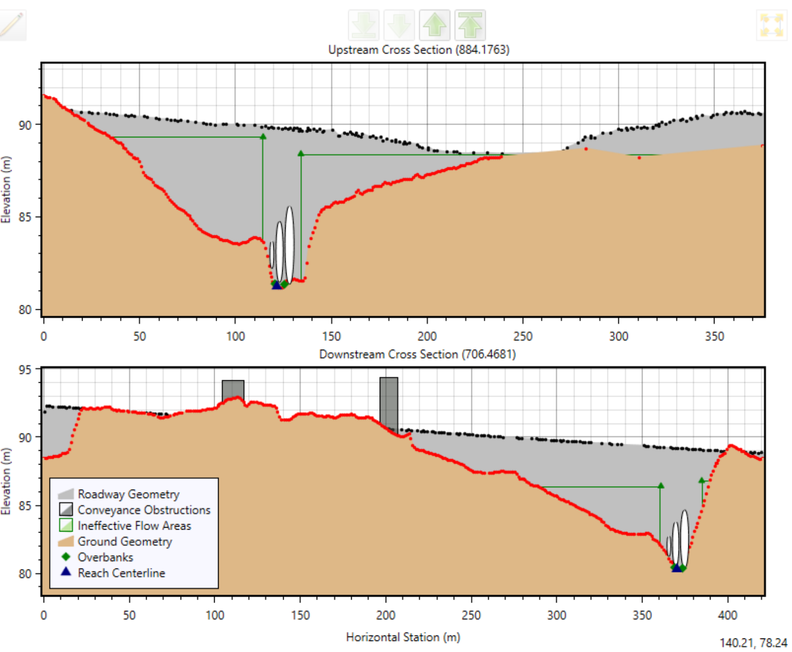


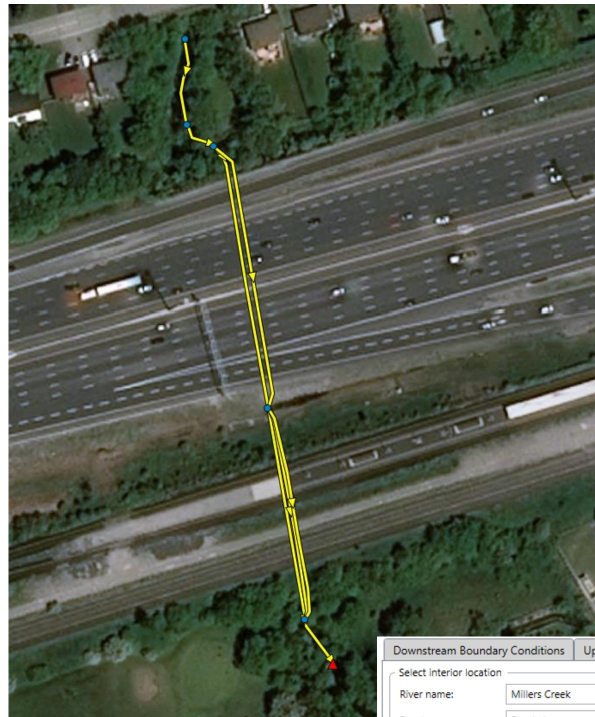
Adding Structures

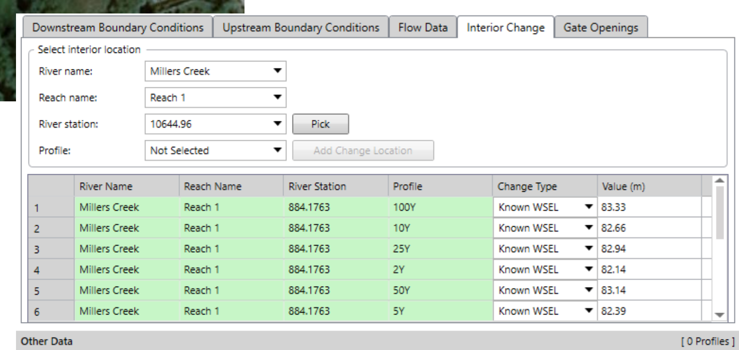




Special Cases – Complex Structures PCSWMM







Special Cases – Routing & PCSWMM

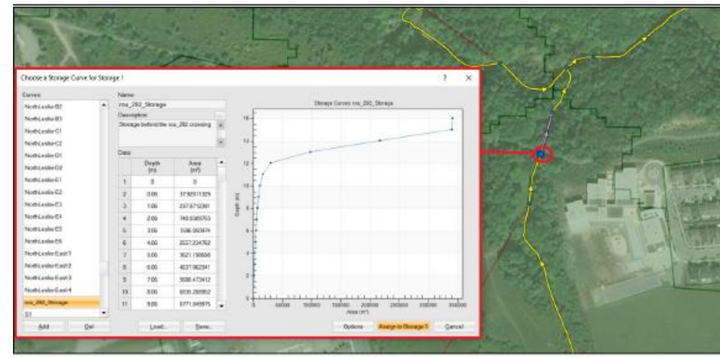


Figure 2-3 Storage Feature coded into Rouge River hydrology model

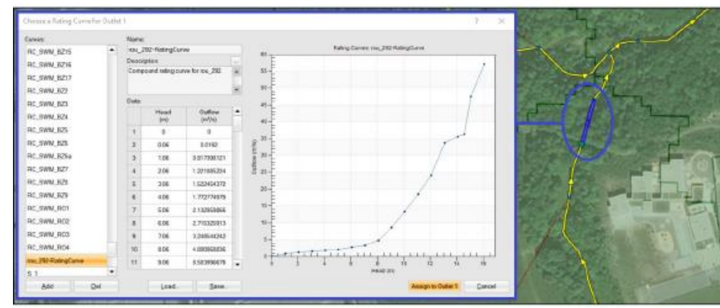
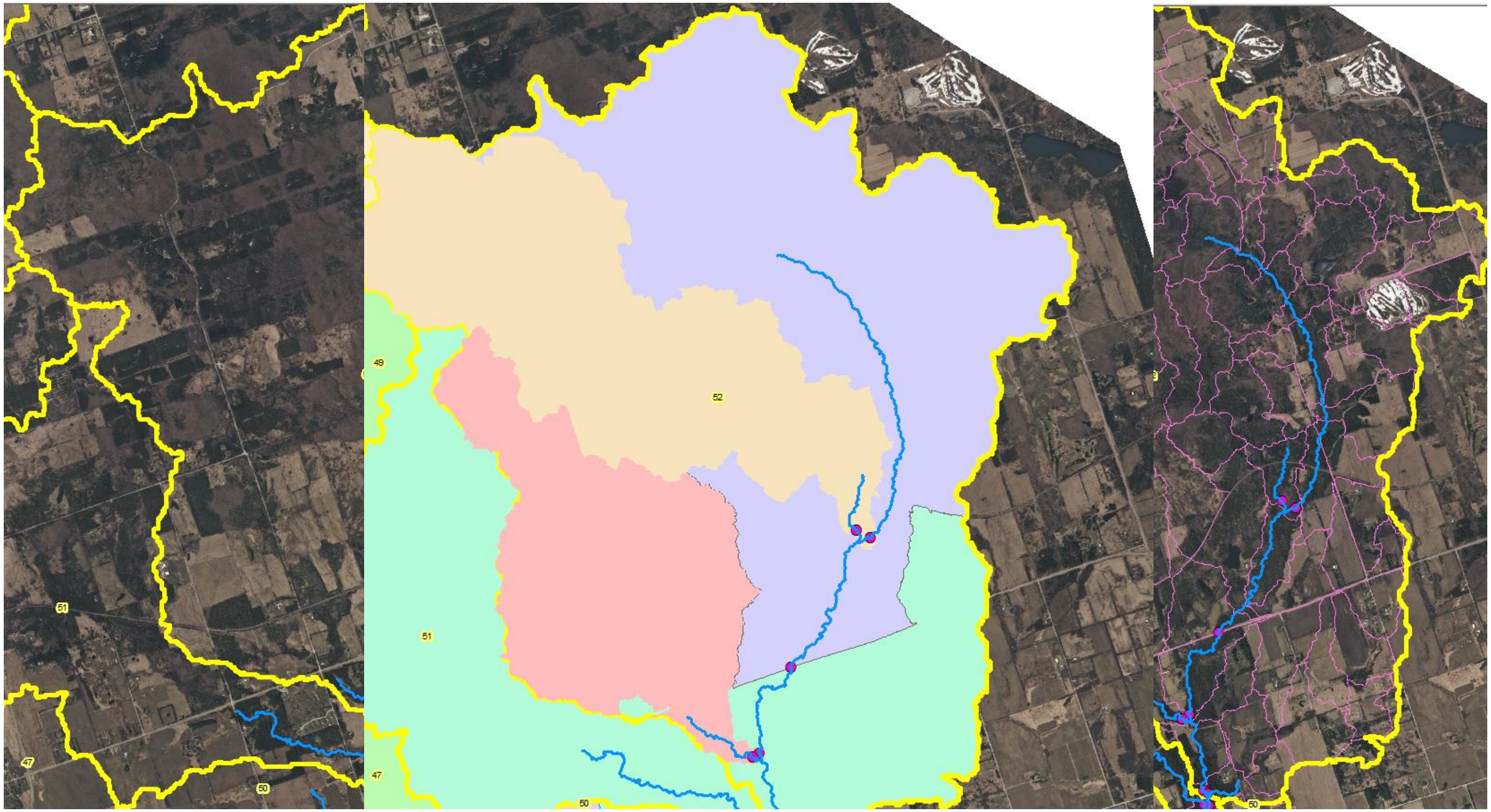
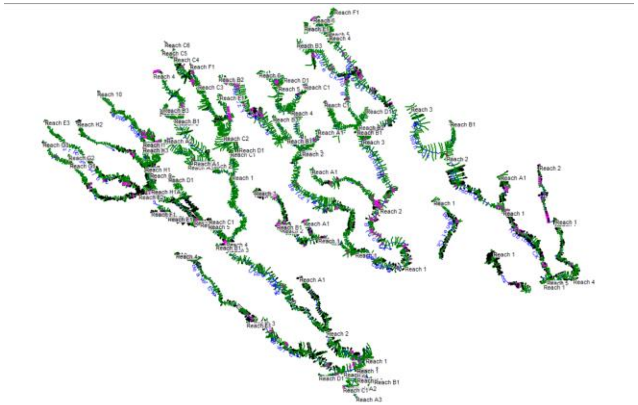


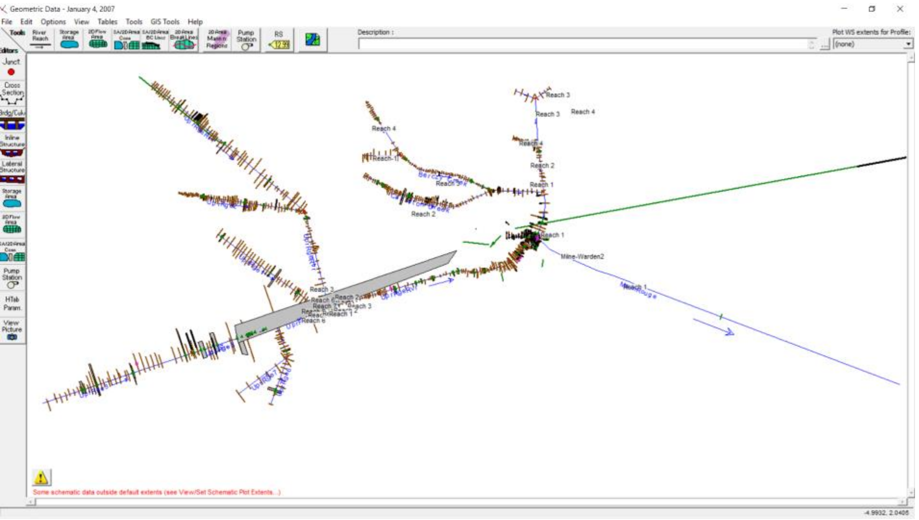
Figure 2-4 Outlet Feature coded into Rouge River hydrology model

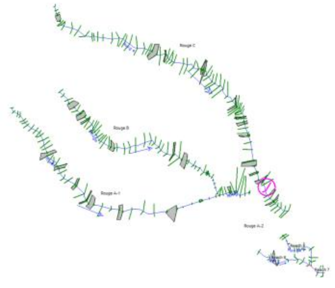
Adding Flows

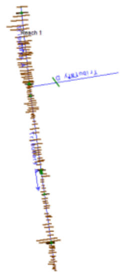


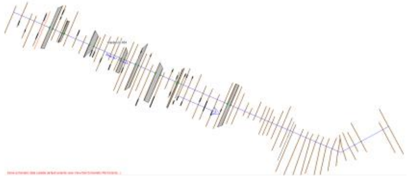
Example: Rouge Update

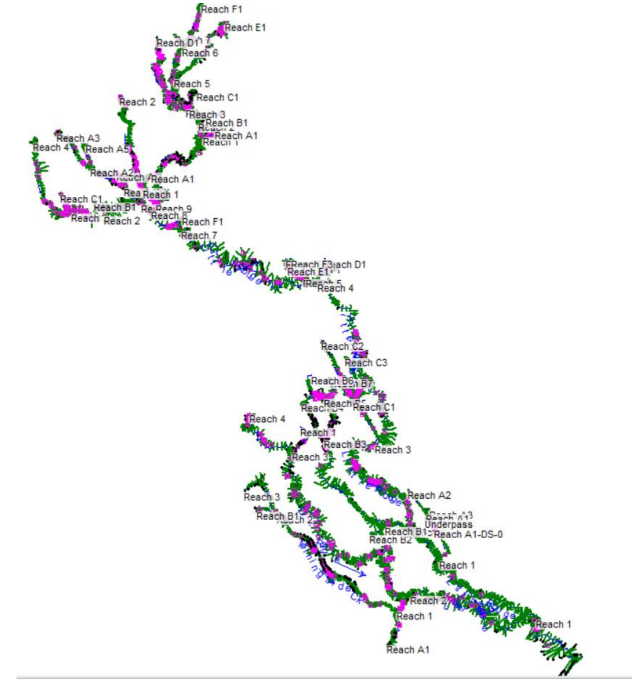






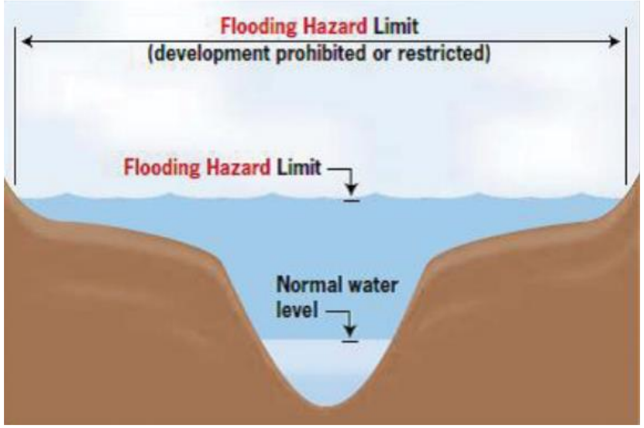


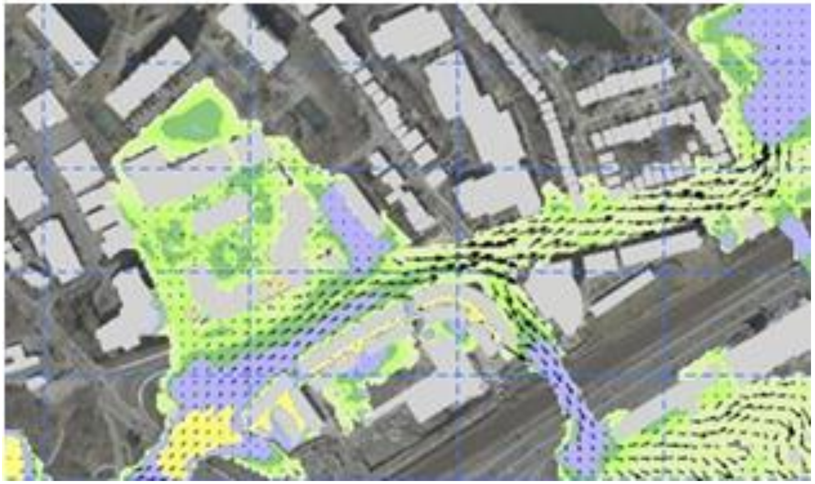




Hydraulic Modelling - Outputs

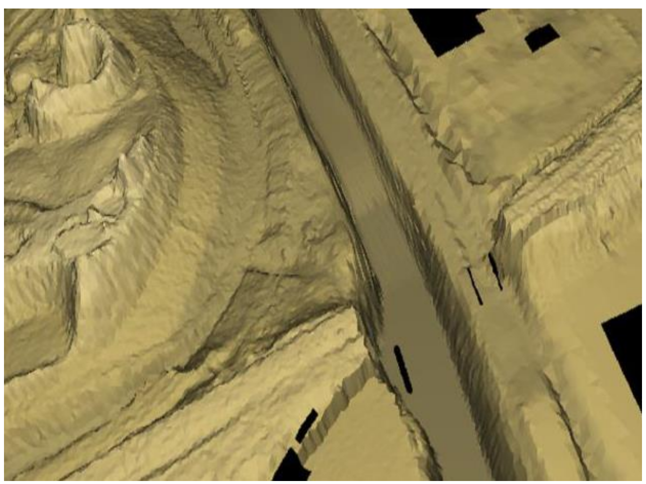
- Expected elevation of the river at various points
- Water depth, velocity, other hydraulic outputs
- This gets mapped to determine the extent of flooding

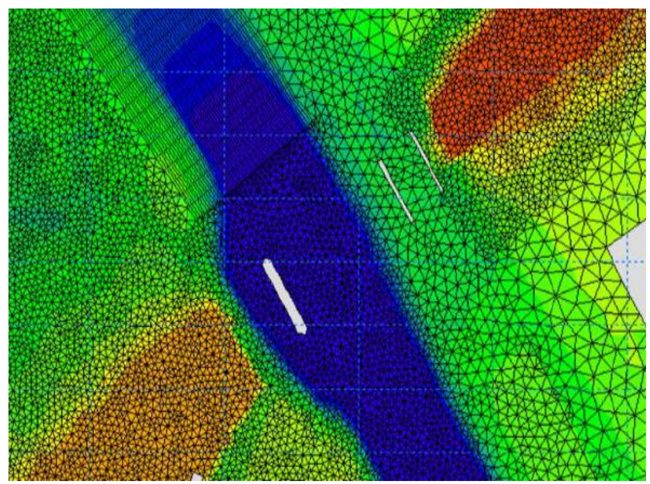


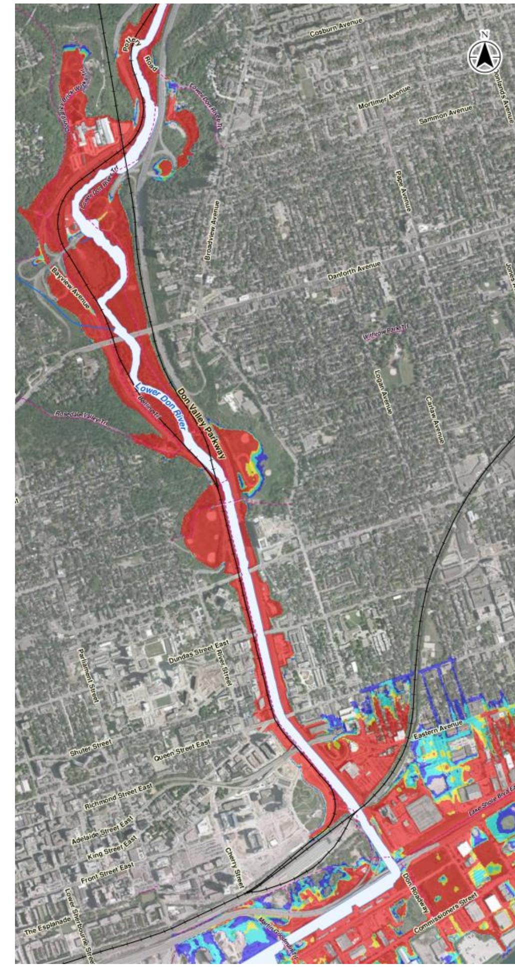


Hydraulic Modelling – 2D Models

- Flow is 2D and is fully hydrodynamic
- Dense network of grid or mesh describes ground
- User does not dictate flow direction
- Long run times, can be unstable
- Niche skillset to setup and modify models

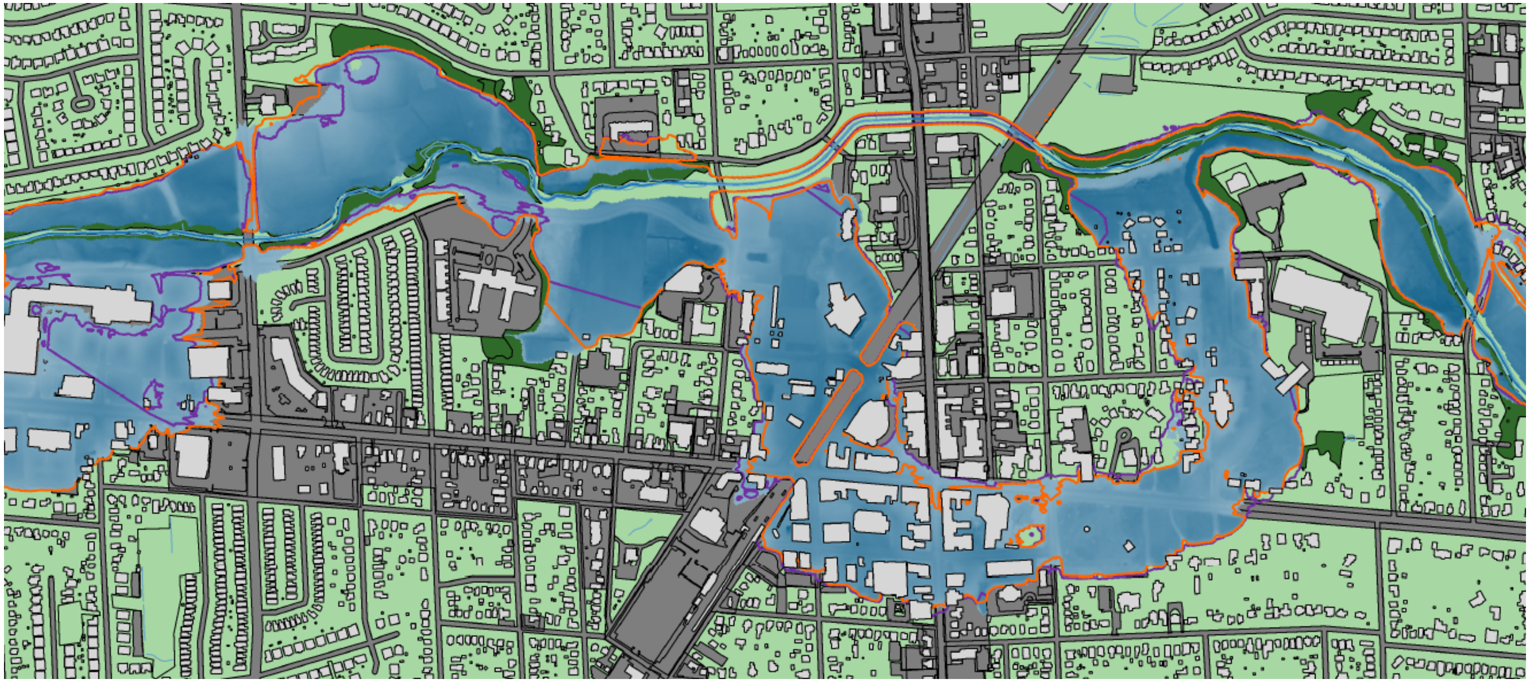






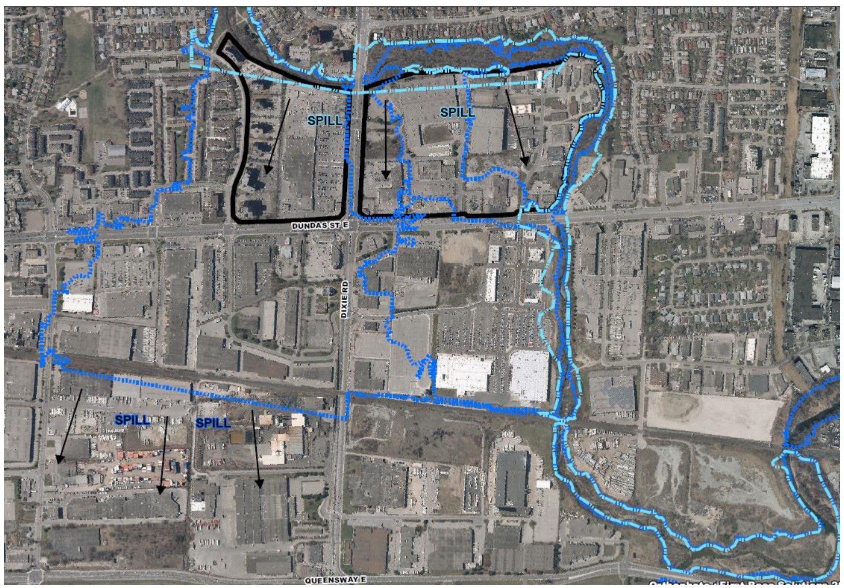
Hydraulic Modelling – 1D vs 2D

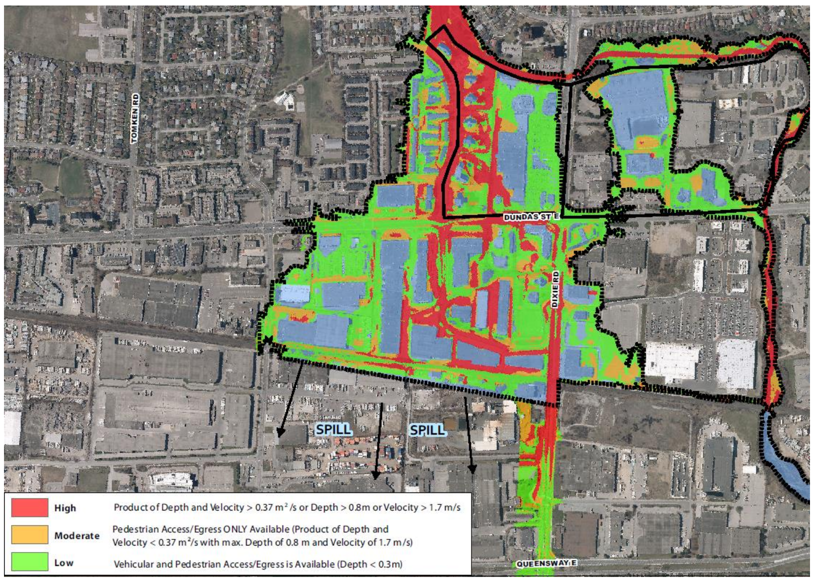
- 1D appropriate in most cases
- 2D good for: Situations where flow direction is unknown, complex interactions, flood characterization and visualization
- 2D also good for: enhanced risk characterization for Special Policy Areas (SPAs)



Some Example Outputs

1D & 2D modelling





Production of Flood Plain Maps

3 main components of map production

- Create base mapping
- Delineate flood line
- Create flood plain map

Create Base Mapping

- Main elements of base mapping
  - ground elevation data
  - planimetric features (buildings, roads, watercourse, railway, etc.)

- Ground Elevation data
  - Digital Elevation Model (DEM) – 2014/2015 LiDAR dataset
    - Use classified bare earth returns to create a DEM with 1m grid resolution
    - Acquisition of elevation data captured by LiDAR in 2019 allowed creation of custom DEM to incorporate changes in the landscape from 2015
  - Contours and spot elevation points

- Planimetric features (buildings, curbed roads, watercourse, railway)
  - These datasets can be acquired from regional or municipal partners or purchased from mapping vendor
  - Can be a challenge since our watersheds can span over multiple jurisdictions (municipal, regional) making datasets inconsistent, with regards to collection dates, method of capture, data quality and sometimes no collection at all.

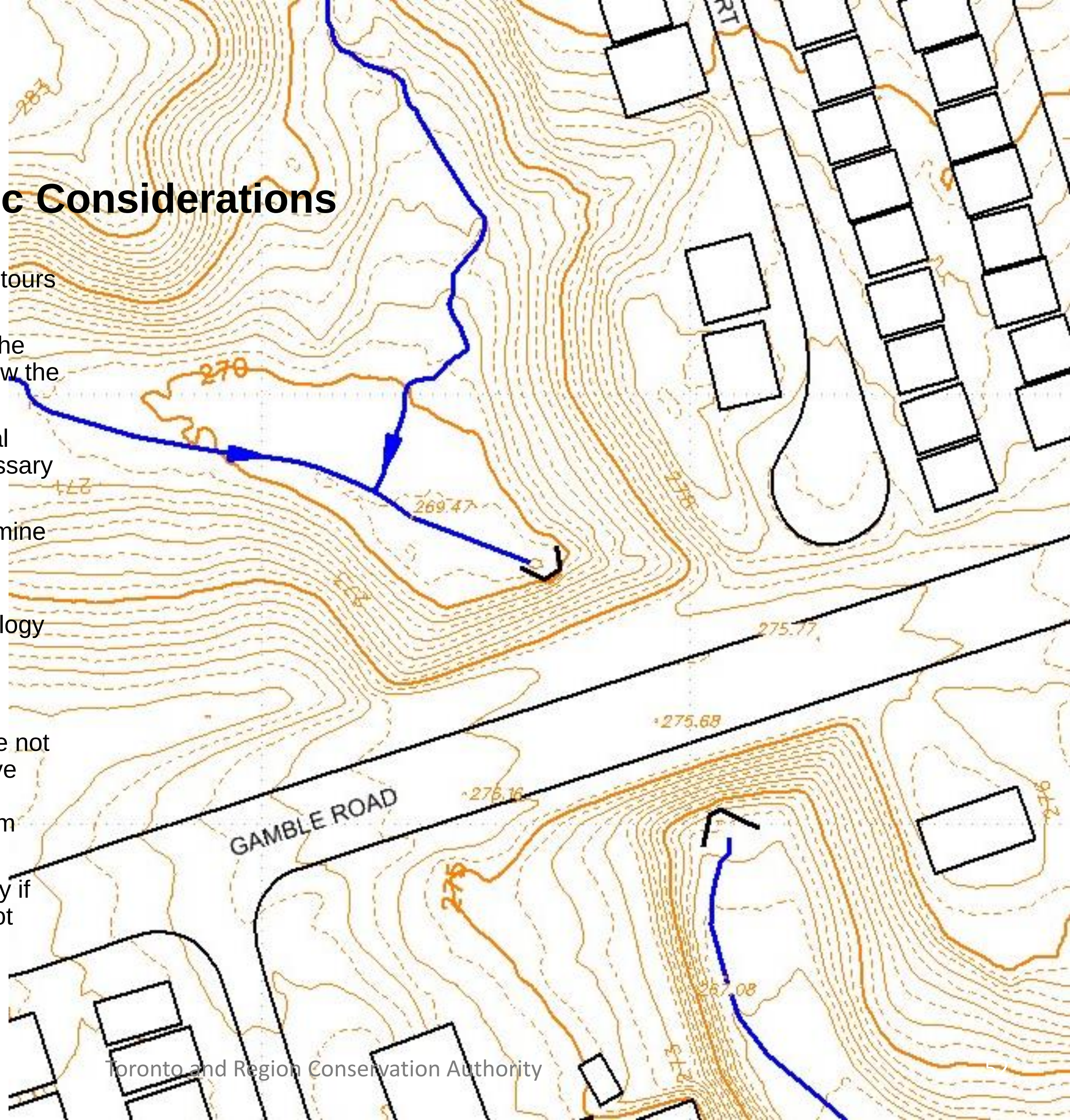
Conditioning of Ground Data

- Contours generated from points collected by LiDAR are messy and are smoothed for cartographic representation
- Contours need to be trimmed at bridges to ensure correct deck elevation
- Spot elevations placed at appropriate location

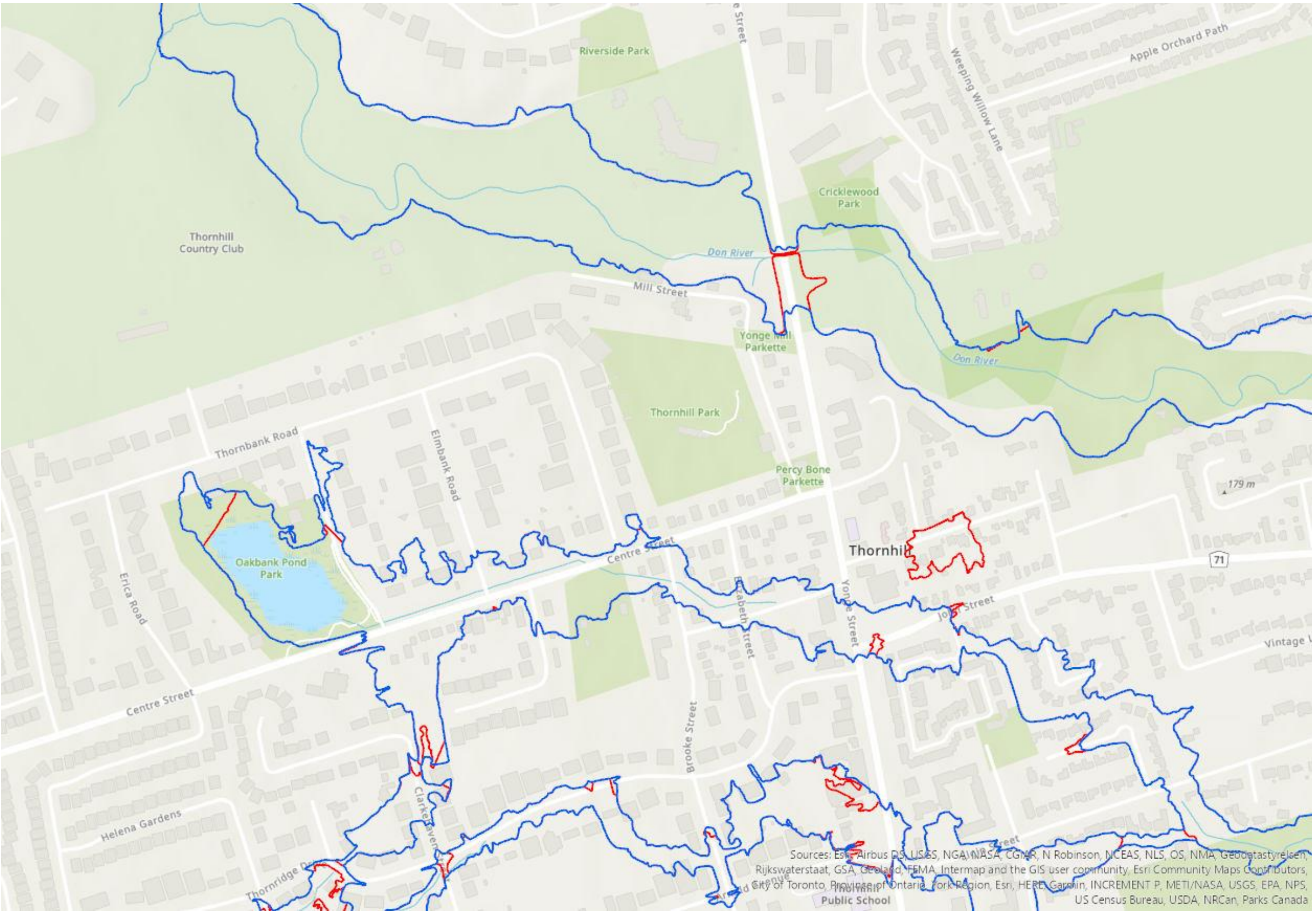
Other Cartographic Considerations

- Watercourse aligns with contours
  - Ensure that the watercourse follows the contours, should follow the lowest point
  - Need to make manual adjustments as necessary
  - Measure the width of watercourse to determine single or double symbology
  - Flow direction symbology

- Roads –curb line
  - Roads in mapping are not a centre line, and have width. These are not always up to date from municipality.
  - Digitizing is necessary if this type of layer is not available



Delineation of Flood line



- Flood line output from modelling software is not acceptable as is
- Must undergo QA/QC process to ensure correct delineation of flood line, human interpolation is required
- More discussion for standardizing this process is required

Final Map Production

Once the hydraulic model has been finalized and the flood line delineation has been reviewed by the sealing engineer, final map production can commence.

- Export cross section features from model and extract the necessary information for mapping: section ID and water surface elevations

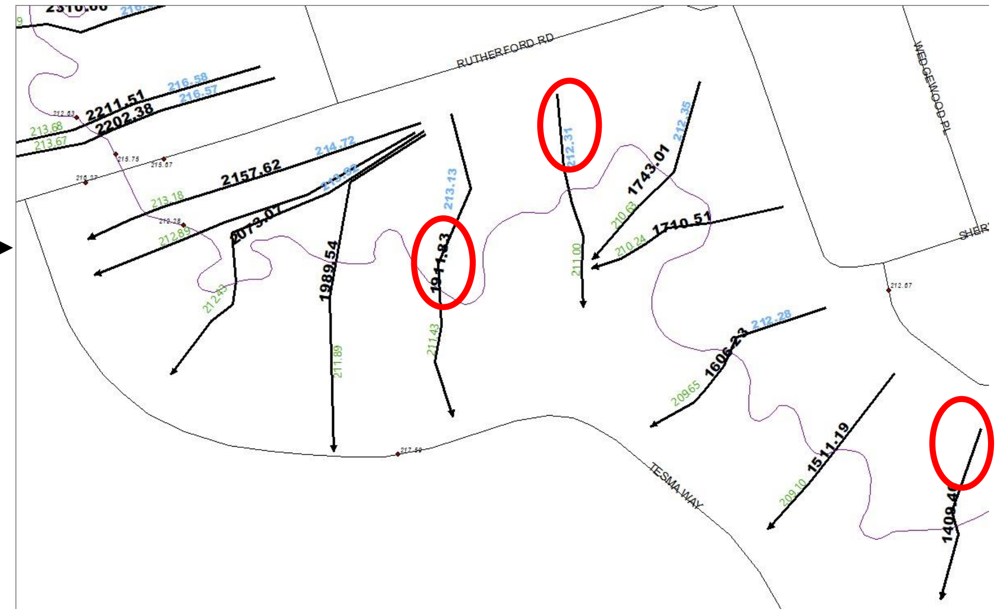
- Create labels for all features
  - Creating labels is an automated process, however, this does not produce a fully complete result. Manual adjustment is required

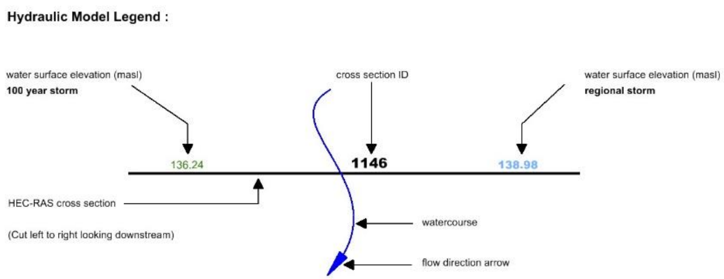
- Create title block with metadata

- Final mapping to Engineer for digital seal

- Approval of flood plain map
  - Administer mapping to network and 3rd party resellers
  - Create layers for web maps
  - Update data on website

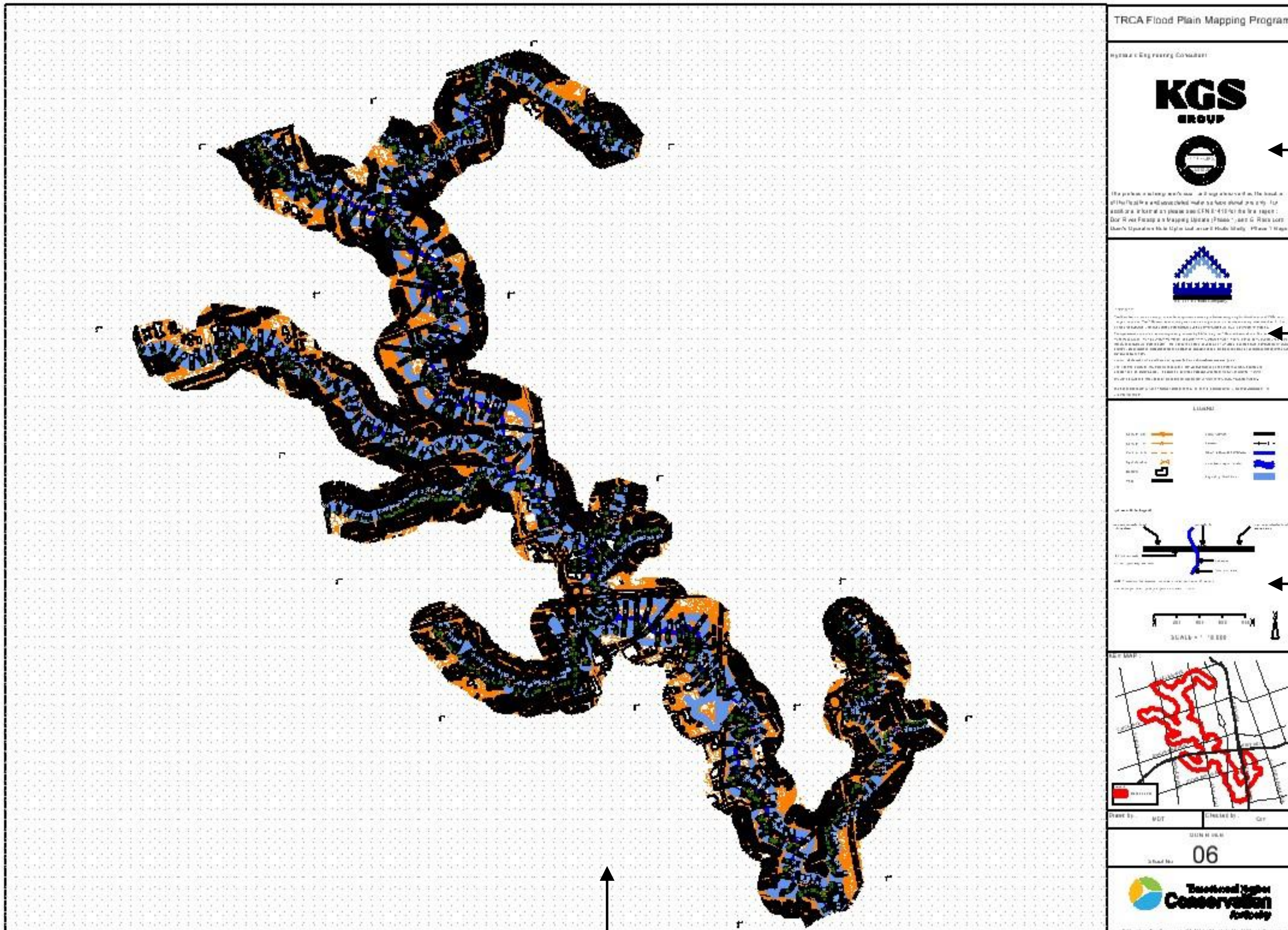
Automated cross section label

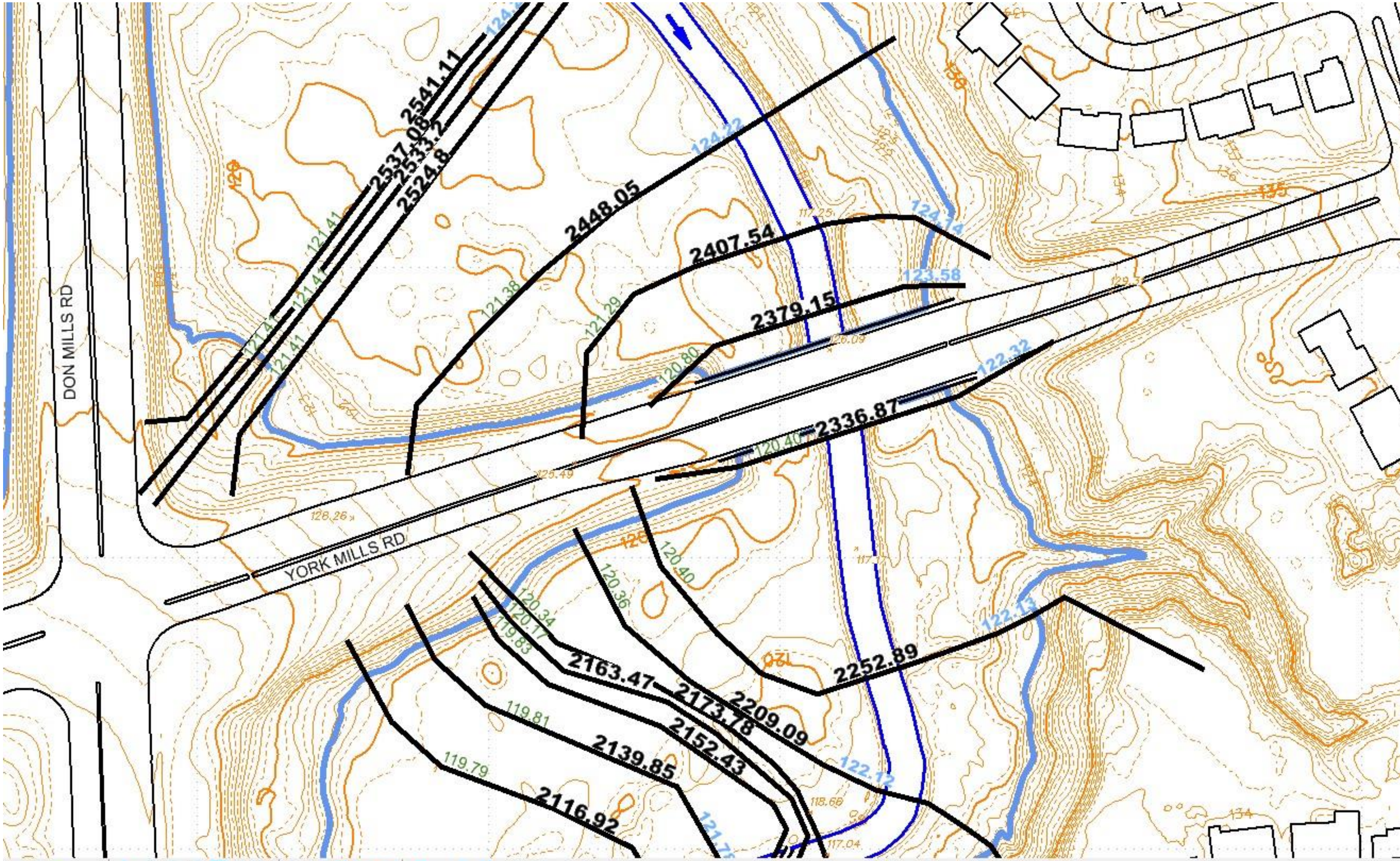




Automated cross section label with manual adjustment

Final Flood Plain Map




DON MILLS RD
YORK MILLS RD
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2537.08
2533.2
2524.8
2448.05
2407.54
2379.15
2336.87
2252.89
2209.09
2173.78
2163.47
2152.43
2139.85
2116.92
124.22
124.14
123.58
122.32
122.13
122.12
120.80
120.40
121.41
121.38
121.29
120.36
120.34
120.17
119.83
119.81
119.79

Flood Plain Mapping Updates 2016-2020

- ✓ 8/10 watersheds updated
- ✓ Modelled ~**1700 km** of watercourse
- ✓ **24 514** HECRAS cross sections produced
- ✓ **~15 000 ha** of flood plain mapped
- ✓ **~45000 ha** mapping produced

Recent (2016-2020) FPM Updates

Watersheds	Hydrology Model Updated?	Hydraulic Model Updated?	Mapping Updated ?	Notes:
Etobicoke Creek	No	Partial	Partial	Spring Creek extension – 2D Model;
Mimico Creek	Yes*	Yes	Yes	-
Humber River	Yes	Yes	Yes	Albion Creek 2D; Caledon East 2D; Rockliffe SPA 2D
Don River	Yes	Yes	Yes	Lower Don 2D;
Highland Creek	Yes	Yes	Yes	-
Rouge River	Yes	Yes	Yes	Unionville SPA 2D
Petticoat Creek	Yes	No	No	-
Frenchman's Bay	No	No	No	-
Duffins Creek	No	Yes	Yes	Pickering Ajax SPA 2D Study
Carruthers Creek	No	Yes	Yes	Lower Carruthers 2D

* Although hydrology was updated, this information was not used in the hydraulic model update

Recent FPM Updates – 2016 to 2018

Project Title	Date	NDMP Project	Hydraulic Modelling Approach	Notes:
Etobicoke Creek Floodplain Mapping Update	2016	No	1D	
Yonge St. and Elgin Mills Road Floodplain Mapping Update	2016	No	2D	Significant cost savings by leveraging modelling work completed by the City of Richmond Hill for Yonge and Elgin Mills Flood Remediation Environmental Assessment
Downtown Brampton Floodplain Mapping Update	2017	No	1D	
Lower Humber River 2D Modelling Study	2015 / 2017	No	2D	Revised in 2017
Pickering and Ajax SPA 2D Modelling Study	2018	Yes	2D	
Black Creek at Rockcliffe SPA 2D Modelling Study	2018	Yes	2D	
Humber River in Peel Region Floodplain Mapping Update	2018	No	1D and 2D	2D MIKE Flood model was developed for Caledon East.
Humber River in the City of Toronto Floodplain Mapping Update	2018	Yes	1D and 2D	2D MIKE Flood model was developed for Albion Creek.

Recent FPM Updates – 2019 to 2020

Project Title	Date	NDMP Project	Hydraulic Modelling Approach	Notes:
Spring Creek 2D Model Extension and Floodplain Mapping Update	2019	Yes	2D	
Carruthers Creek Floodplain Mapping Update	2019	Yes	1D and 2D	First comprehensive floodplain mapping update completed in-house. 2D MIKE Flood model developed for the Lower Carruthers Creek through the Pickering Beach Community.
Humber River in York Floodplain Mapping Update	2019	Yes	1D	
Unionville SPA 2D Modelling and Floodplain Mapping Update	2019	Yes	2D	Communicated to the Board at meeting #5/19, on Friday, May 24, 2019
Highland Creek Floodplain Map	2020	Yes	1D	
Don River Floodplain Mapping Update – Phase 1	2020	Yes	1D	
Rouge River Floodplain Mapping Update – Phase 1	2020	Yes	1D	
Don River Floodplain Mapping Update – Phase 2	2020	Yes	1D	
Rouge River Floodplain Mapping Update – Phase 2	2020	Yes	1D	
Duffins Creek Floodplain Mapping Update	2020	Yes	1D	

Where can you find this information?

1. TRCA Board Report – Sep 25, 2020 Meeting Item 8.4 (https://pub-trca.escribemeetings.com/FileStream.ashx?DocumentId=6164)
2. Maps
   a. On the GIS servers
   b. On the Viewer

   https://arcgis02.trca.local/engineering%20services/

   https://arcgis02.trca.local/plandev/

3. Models & Associated Reports
   a. Contact ES staff
   b. Some reports can be found here:

   https://trca.ca/conservation/flood-risk-management/modeling-references-section/

Future Work

1. FPM Extension Updates in Peel (2020-2021)
    1. Etobicoke
    2. Humber
2. FPM Extension Updates in York (2021-2022)
    1. Humber
    2. Rouge

Acknowledgements

Development and Engineering Services staff

- Flood Risk Management Staff
- Water Resources Staff
- Development Planning and Permits
- Infrastructure Planning and Permits

GIS staff

NDMP Funding

- Federal and provincial governments
- Our municipal partners

"All models are wrong, some are useful"
Quote by George Box (British Statistician)

wilfred.ho@trca.ca
christina.bright@trca.ca
mike.todd@trca.ca

www.trca.ca

Toronto and Region Conservation Authority

Upcoming Lunch and Learns

Tuesday, November 17
11:30am-12:30pm

Working with Indigenous Communities

By Tony Morris
(and Kathryn Brown)

Tuesday, December 8
11:00am-12:00pm

Green Infrastructure Asset Management

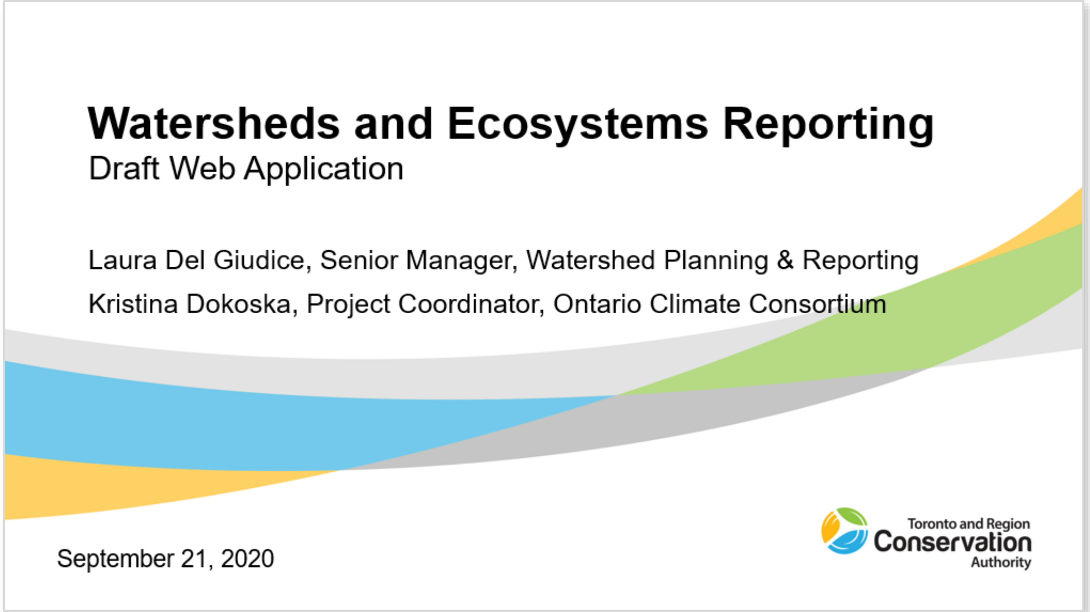
By Michelle Sawka and
Tracy Timmins

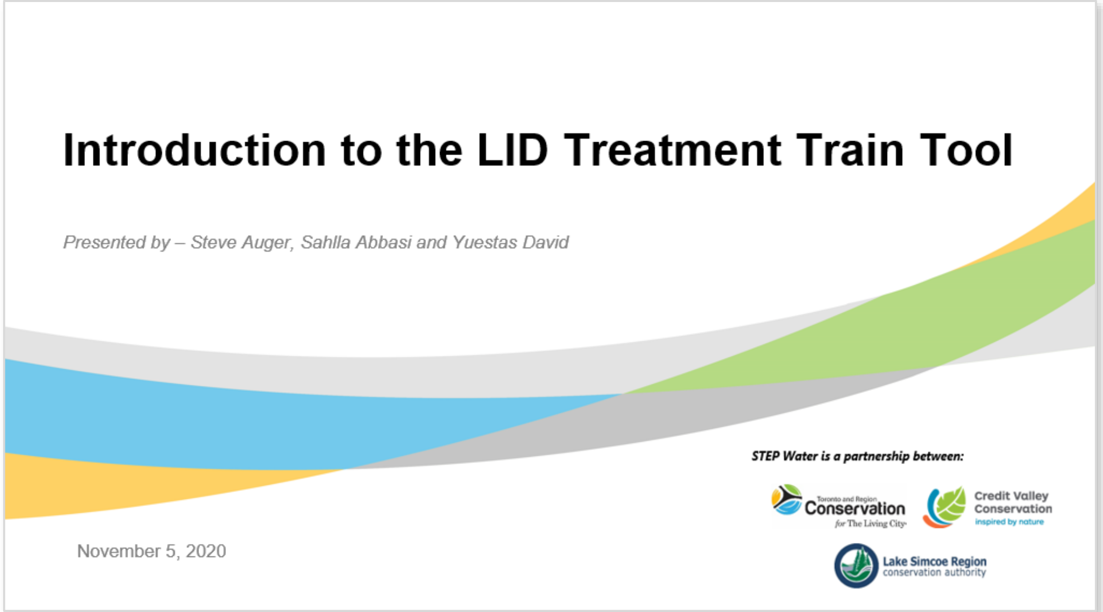
Wednesday, December 16
11:30am-12:30pm

Terrestrial Environmental Monitoring and Evaluation

By Paul Prior and
Gavin Miller

Past Recordings





Thank you

For questions about the ECS Lunch and Learn Series, please contact:

Sharon Lam
sharon.lam@trca.ca