SMART CITY SOLUTIONS

Civica Infrastructure

Drainage Capacity Management

Analysis of SWM Controls to Meet Multiple Drainage Criteria

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Introduction: MECP Regulation

- On August 14 2019, the Ontario Ministry of the Environment, Conservation and Parks, posted a notice in the Environmental Registry of Ontario about their decision to introduce a new regulation under the Environmental Protection Act (EPA).

- The new regulation is called “Environmental Compliance Regulation in Respect of Sewage Works” (Ontario Regulation 208/19).

- The regulation is to enable prescribed persons to make alterations to sanitary collection and stormwater systems.

Stormwater Management Criteria

- A new 'Design Criteria Document' is being developed, to be satisfied together with the conditions in the municipal wide consolidated permission for stormwater, sometimes called the Area-Wide Linear Infrastructure ECA.

- "Pre-authorized" projects will be removed from requiring ministry approval.

- Ministry also wants to provide some flexibility for retrofits and to promote the use of new Low-Impact-Development (LID) techniques.

Stormwater Management Criteria

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- As of August 2019, the new Design Criteria Document to be followed covers:
  - Water Balance
  - Water Quality
  - Erosion Control
  - Water Quantity
  - Flood Control
  - Construction Erosion & Sediment Control
  - Monitoring

Stormwater Management Criteria

- This presentation provides an example of how a municipality can plan and manage new and existing stormwater drainage infrastructure to meet stormwater management criteria, such as the new MECP criteria, and other Provincial and Conservation Authority regulations.

- Specifically, it presents the process and tools to manage new development areas and SWM controls.

Stormwater Management Criteria

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STEP 1: Technical Direction →
Relevant Policies, Studies, and Regulations

STEP 2: Characterization →
Physical Features and Functions

STEP 3: Identify Extents of Study Area →
Existing and Future Development Boundaries and Contributing Drainage

STEP 4: Define Area Drainage Features →
Discretized Catchments, Delineated Watercourse, SWM Controls, Future Land Use

STEP 5: Build the Model →
Model Parameterization

STEP 6: Input Modelling Data →
Design Storms, Climate Data, and Water Quality

STEP 7: Analysis of Existing Conditions →
Pre-Development Model

STEP 8: Analysis of Future Conditions →
Post-Development Models: With and Without Controls

STEP 9: Scenario Comparison →
Set Targets

STEP 10: Water Balance →
Manage the Recharge to Meet Pre-Development Conditions

STEP 11: Erosion Control →
As Per Water Balance Assessment Completed in Local Watershed Studies and Erosion Analysis

STEP 12: Water Quantity →
Control Post-Development Peak Flows to Pre-Development Levels for Design Storms up to and Including the 100-Year Storm

STEP 13: Water Quality →
Manage the 90th Percentile Storm and 80 % Suspended Solids Removal Over the Catchment

STEP 14: Construction Erosion & Sediment Control →
Develop an Effective ESC Plan According to CSA Erosion and Sediment Control Inspection and Monitoring Standard

STEP 15: Monitoring
Post-Development Monitoring and Asset/Infrastructure Management

Step 1: Technical Direction

Relevant Policies, Studies, and Regulatory Guidelines

- Provincial Plans
- Provincial and Conservation Authority Guidelines
- Official Plans
- Watershed/Subwatershed Plans
- Source Water Protection Programs
- Previously Completed Technical Studies

Step 2: Characterization

Physical Features and Functions

- Existing Drainage Infrastructure
- Natural Heritage
- Soil Conditions
- Geomorphology
- Groundwater Resources
- Surface Water Features and Systems

Step 3: Identify Extents of Study Area

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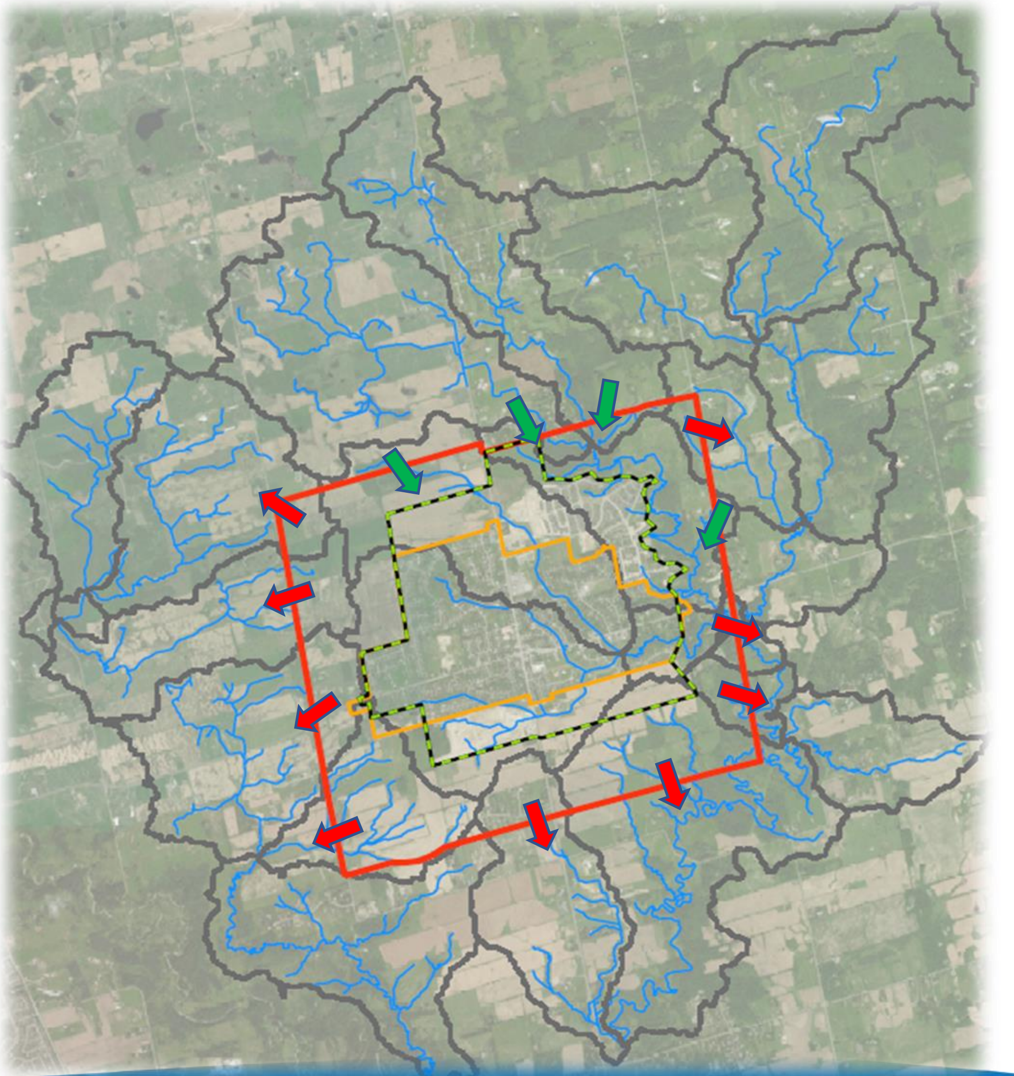
Study Area Includes:

- Existing Settlement Area
- Future Settlement Area Expansion
- Adjacent Lands Contributing Stormwater Drainage
- Permanent and Intermittent Streams

Legend

Settlement Area Reserve Boundary
Village Boundary
Built Boundary
Inflow
Stormwater Drainage Areas
Watercourse
Outflow



Step 4: Define Area Drainage Features

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Study Area Includes Existing:

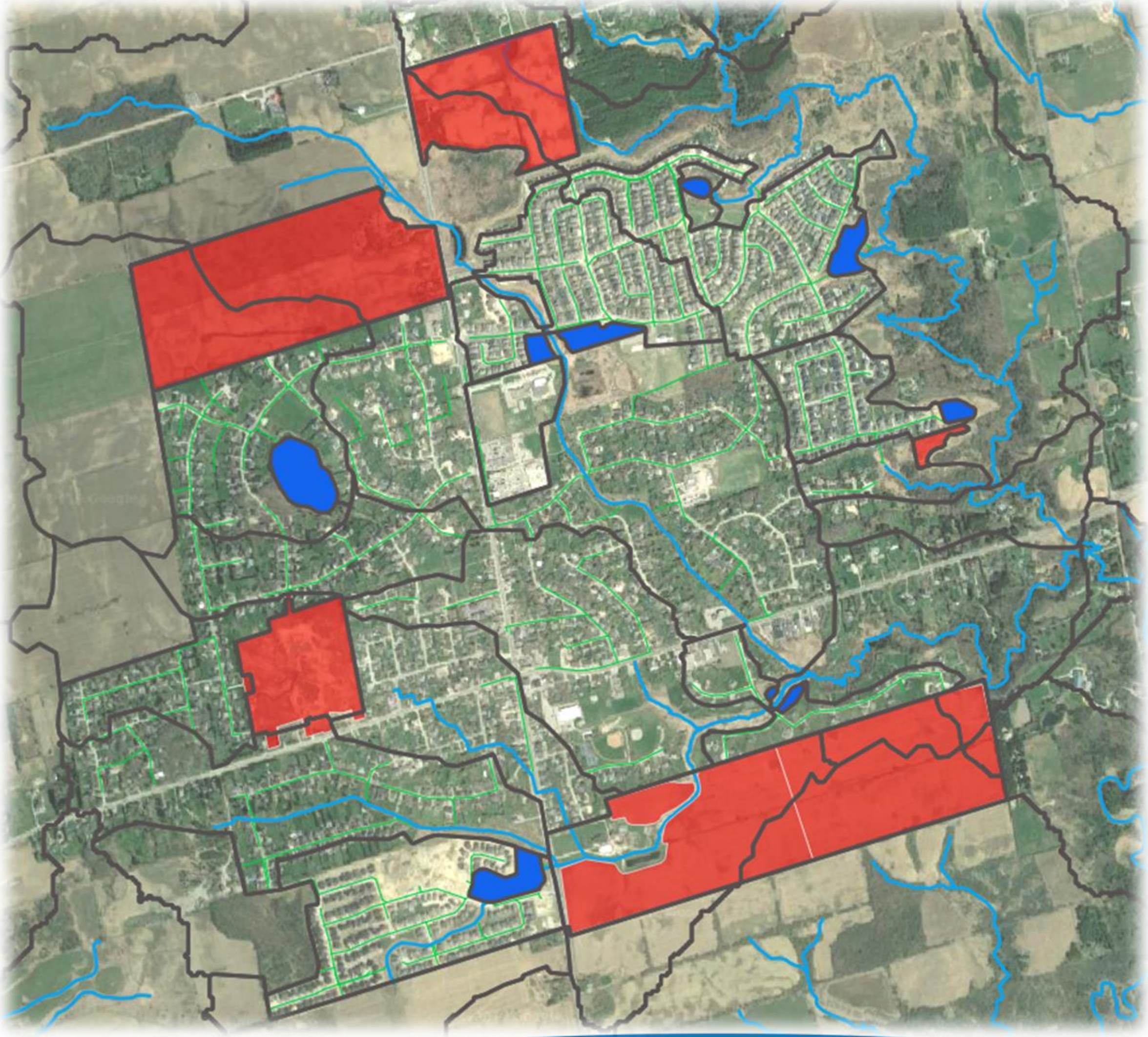
- Watercourses
- SWM Controls
- Subcatchments

& Proposed:

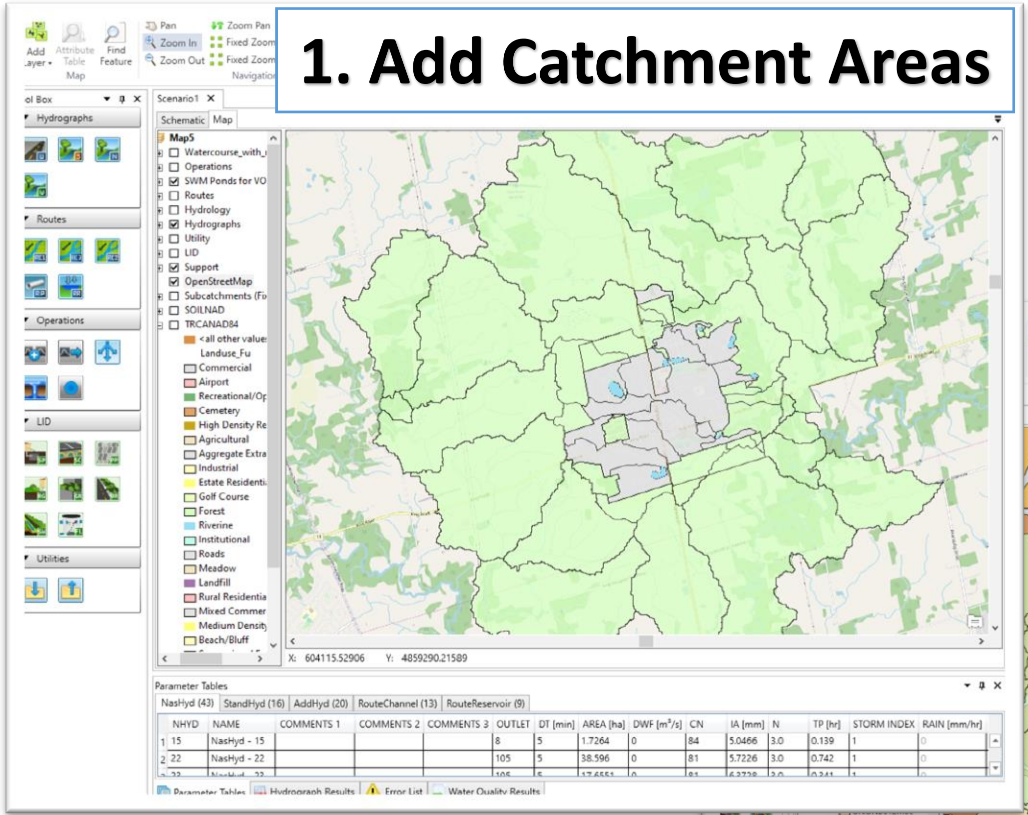
- Future Land Use Areas

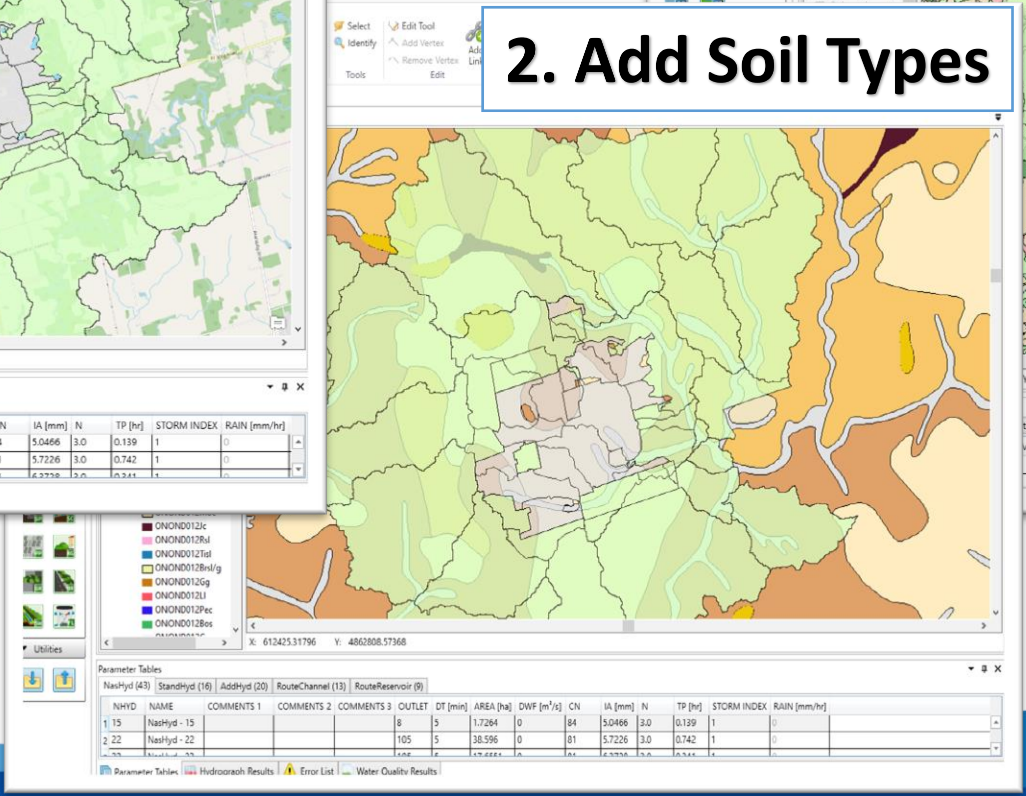
Legend

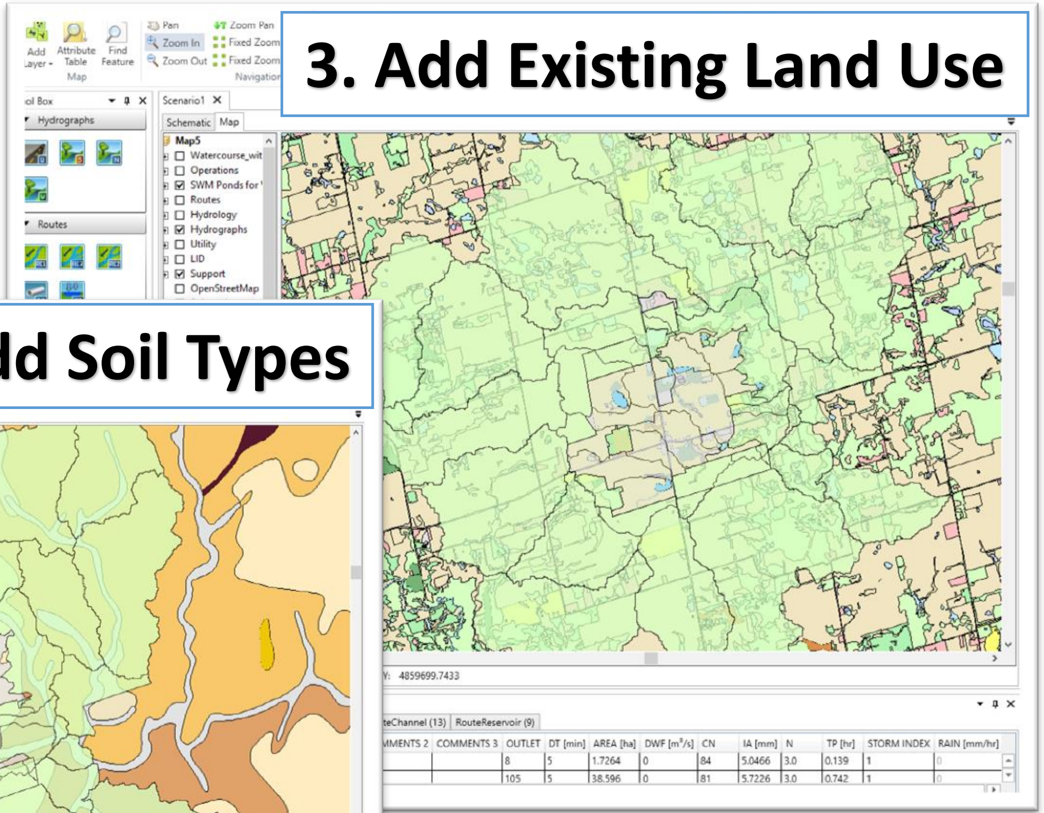
- Delineated Watercourse
- Stormwater Management Facilities
- Storm Sewer System
- Discretized Subcatchments
- Future Development



Step 5: Build the Model





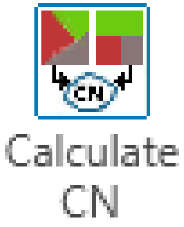


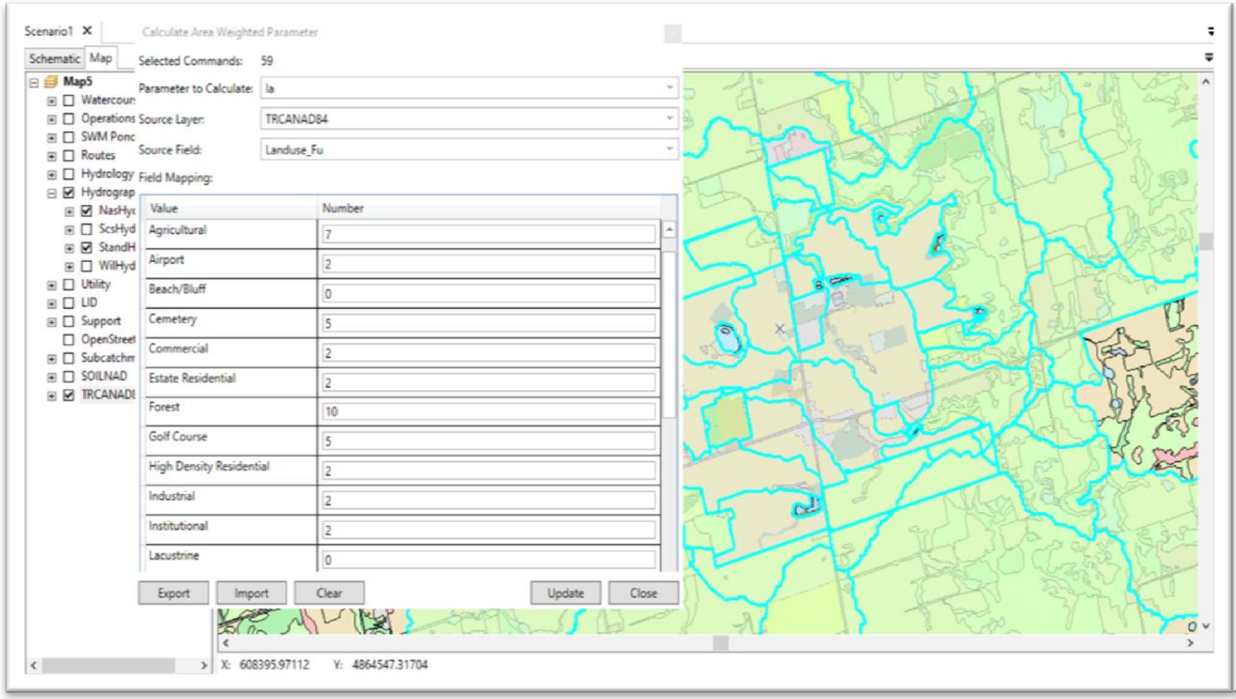
Step 5: Build the Model

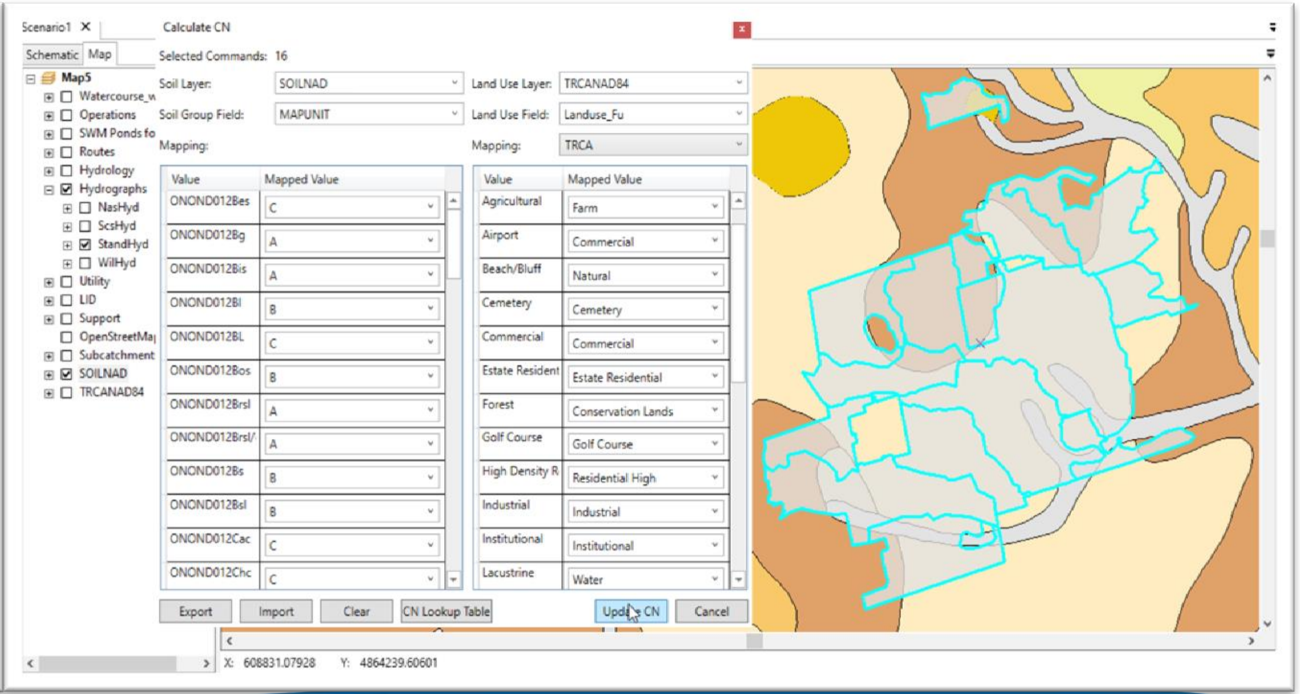
Model Parameterization

Infiltration Loss Method

- Modified SCS Curve Method (CN & IA)
- Horton's Equation Method (F_o, F_c, F, K)





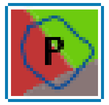


Step 5: Build the Model

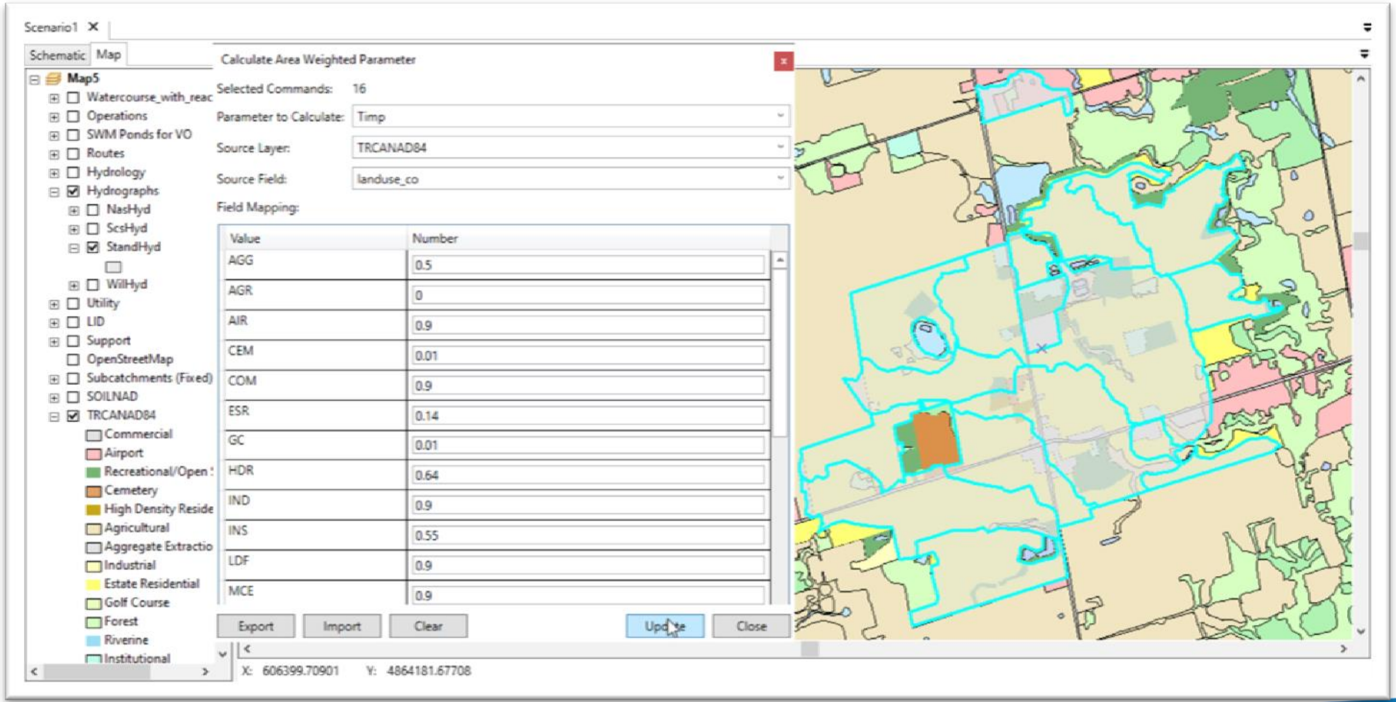
Model Parameterization

Percent Impervious

- Total Percent Impervious (TIMP)
- Directly Connected Percent Impervious (XIMP)



Calculate
Area Weighted



AREA [ha]	TIMP	XIMP
6.3237	0.5296	0.3423
22.6572	0.5323	0.3424
35.0615	0.5344	0.3433
10.2875	0.5778	0.5214
5.3475	0.4045	0.3744
8.0861	0.1388	0.0892
14.3166	0.5325	0.3424
32.6874	0.5316	0.344
9.8639	0.2686	0.2686
24.0767	0.4932	0.3204
18.391	0.5272	0.3355
51.653	0.4884	0.3581
48.864	0.5069	0.3362
29.904	0.5905	0.4205
98.95	0.4676	0.3152
28.8103	0.4897	0.3167

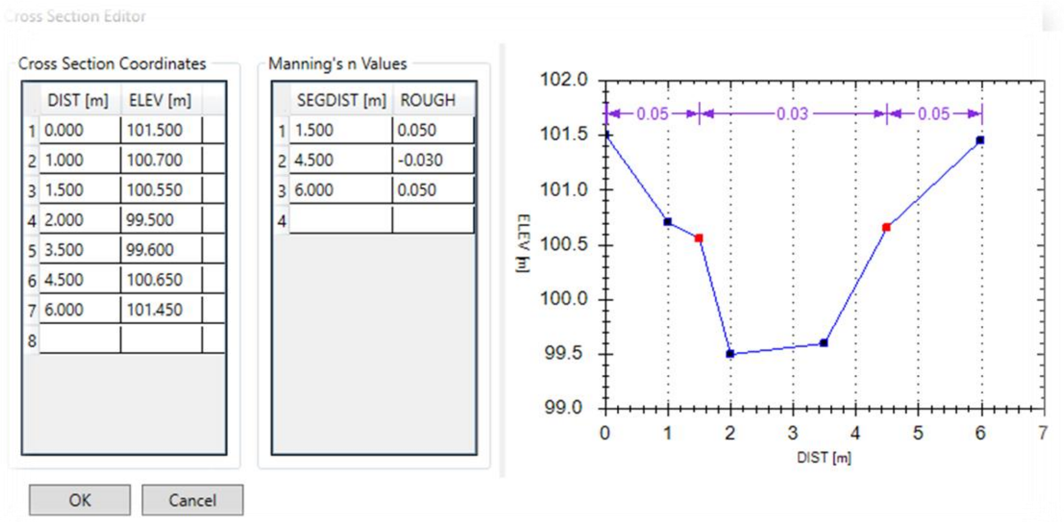
Step 5: Build the Model

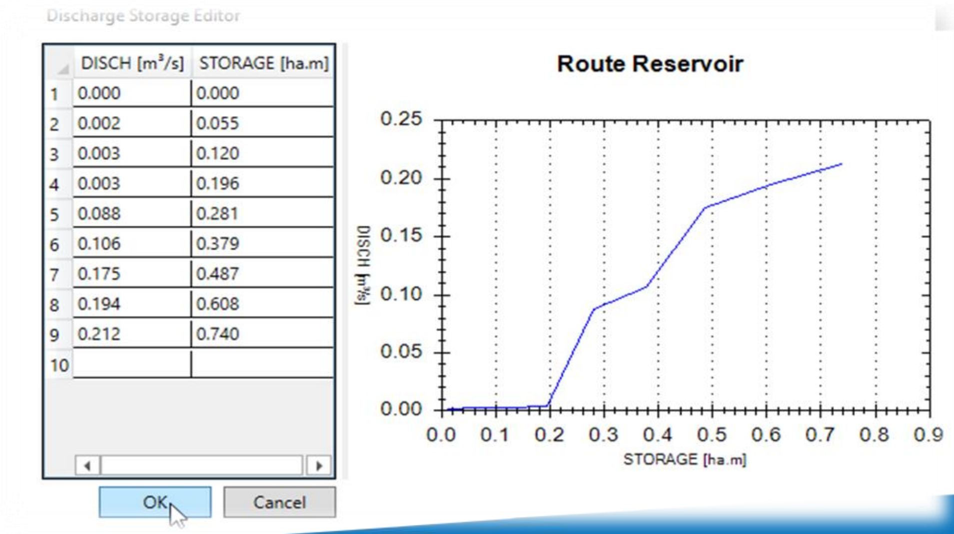
Model Parameterization

Time to Peak (TP)
- Upland's Method
- Airport Method (T_c), TP = $0.67xT_c$
- Bransby-William's (T_c)

Channel Properties
- Length
- Slope
- Roughness (n)
- Cross Section

Reservoir Properties
- Storage
- Discharge





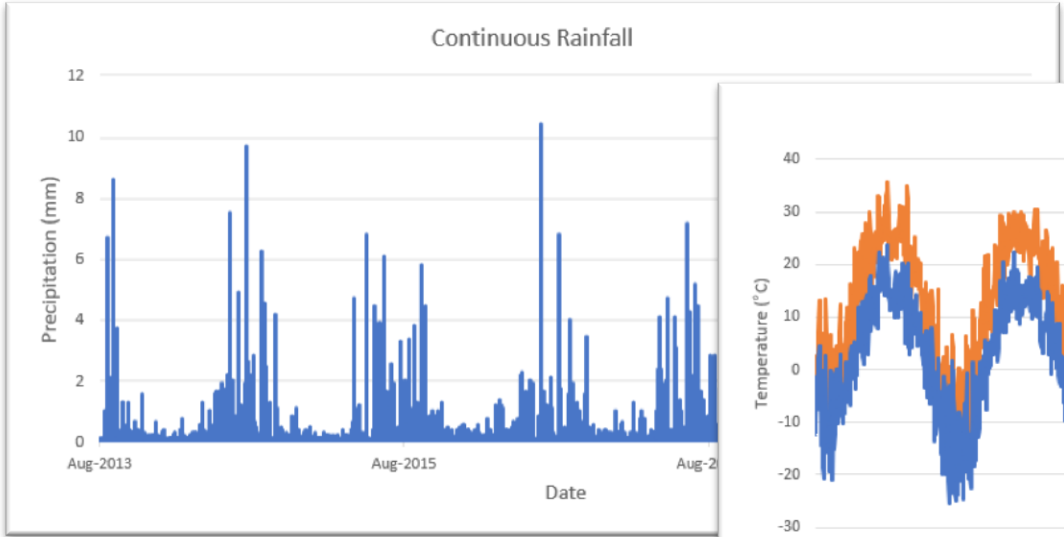
Step 6: Input Modelling Data

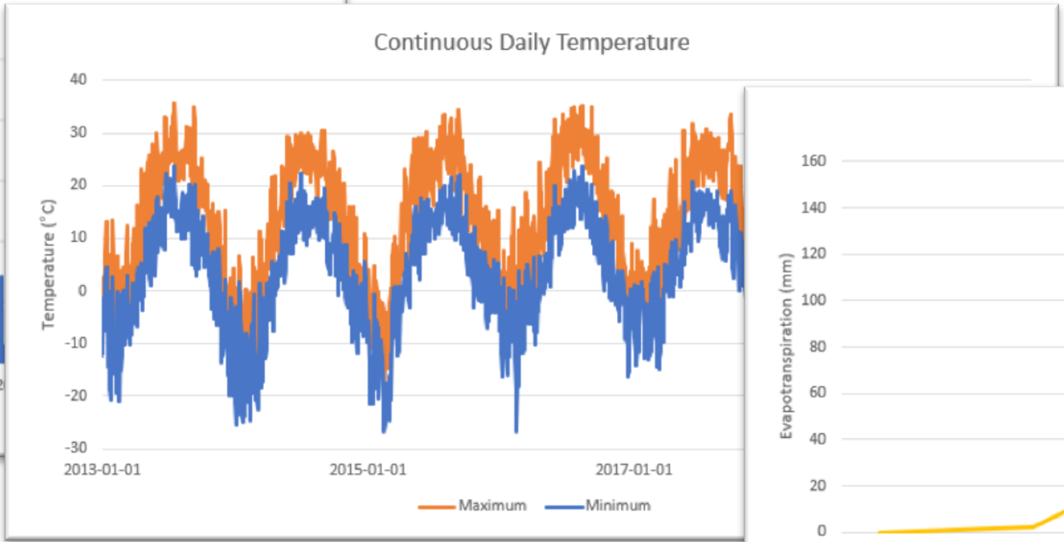
Continuous Climate Data

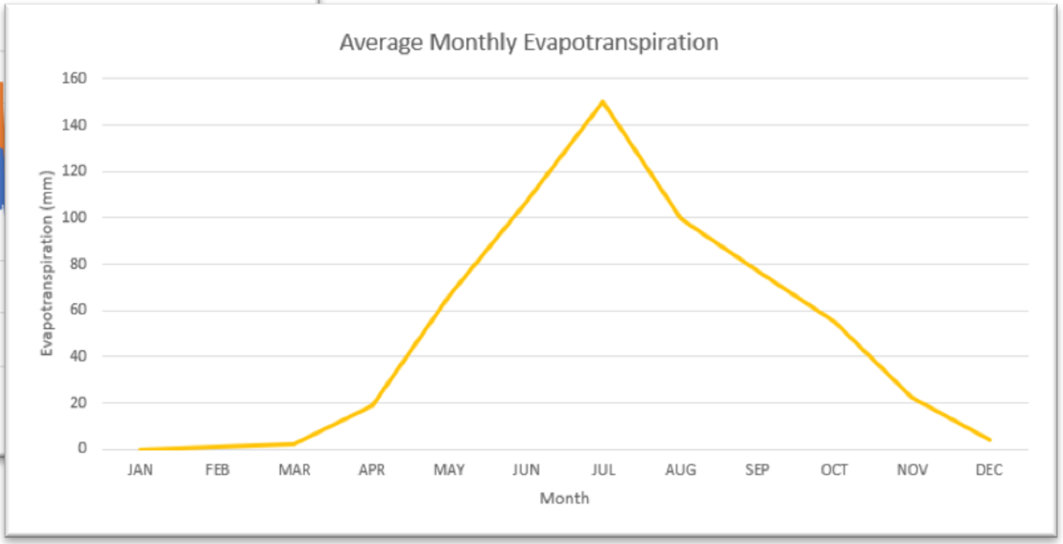
Precipitation

Temperature

Evapotranspiration







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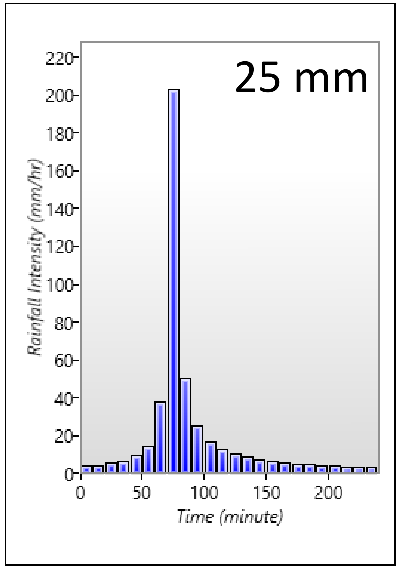
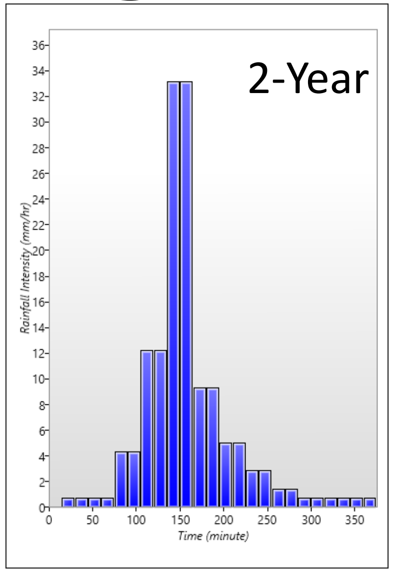
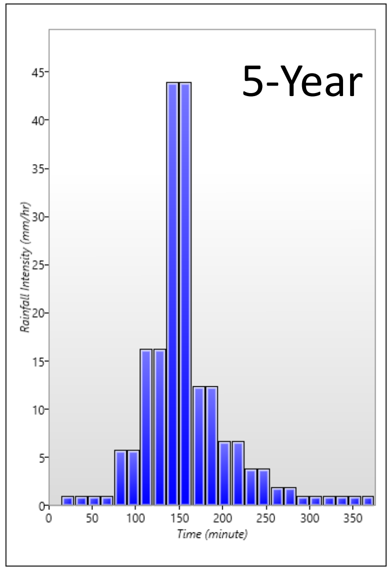
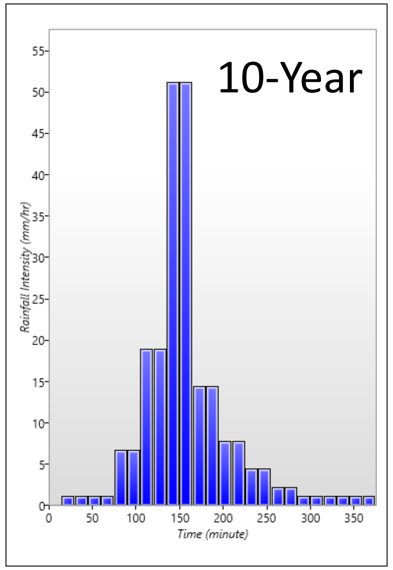
Step 6: Input Modelling Data

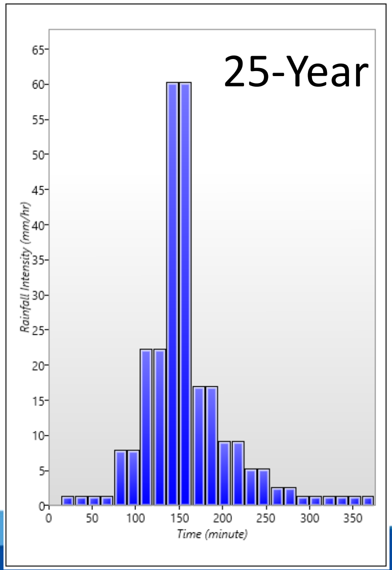
Design Storms

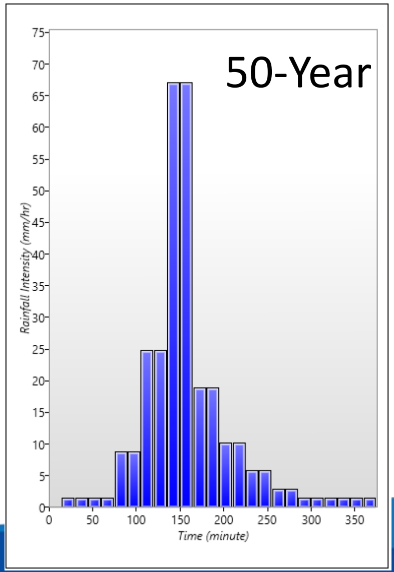


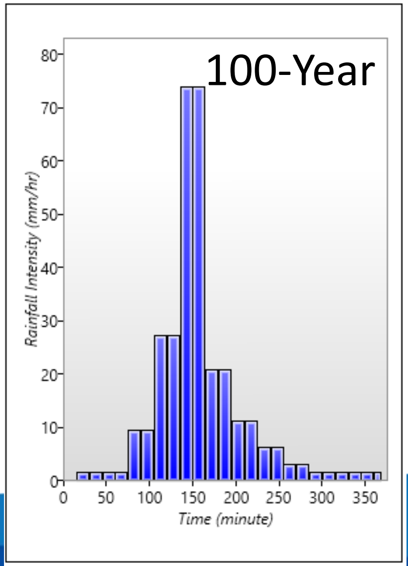


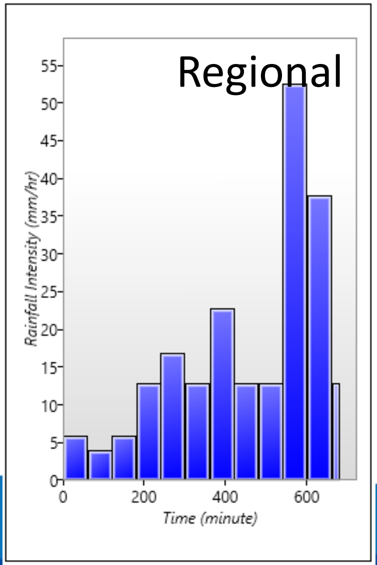












Step 6: Input Modelling Data

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Water Quality Modelling Data

Calculate GIS Land Use Percentage for Each Subcatchment
Assign Standard TSS and TP EMC Values to Each Land Use

Calculate LandUse Percentage

Land Use

Name :

Land Cover	Percent	Area(ha)
Aggregate Extra	0.000	0.000
Agricultural	0.000	0.000
Airport	0.000	0.000
Beach/Bluff	0.000	0.000
Cemetery	0.000	0.000
Commercial	1.700	1.682
Estate Residenti:	0.881	0.871
Forest	2.204	2.181
Golf Course	0.000	0.000
High Density Re:	0.000	0.000
Industrial	0.000	0.000
Institutional	4.315	4.270
Lacustrine	0.518	0.513
Landfill	0.000	0.000
Meadow	5.493	5.436
Medium Density	70.549	69.809
Mixed Commerc	0.000	0.000
Railway	0.000	0.000
Recreational/Op	11.436	11.316
Riverine	0.000	0.000
Roads	1.642	1.624
Rural Residentia	0.916	0.907
Successional For	0.000	0.000
Vacant Land	0.000	0.000
Wetland	0.346	0.343
Total	100	98.95

OK Cancel

Water Quality

Land Cover	TSS (mg/l)	TP (mg/l)
Aggregate Extraction	177	0.33
Agricultural	100	0.23
Airport	201	0.25
Beach/Bluff	0	0
Cemetery	176	0.13
Commercial	201	0.25
Estate Residential	132	0.4
Forest	55	0.23
Golf Course	100	0.32
High Density Residential	132	0.4
Industrial	177	0.33
Institutional	91	0.21
Lacustrine	0	0
Landfill	177	0.33
Meadow	55	0.23
Medium Density Residential	132	0.4
Mixed Commercial Entertainment	201	0.25
Railway	114	0.43
Recreational/Open Space	27	0.2
Riverine	0	0
Roads	90	0.23
Rural Residential	132	0.4
Successional Forest	55	0.23
Vacant Land	27	0.2
Wetland	13	0.81

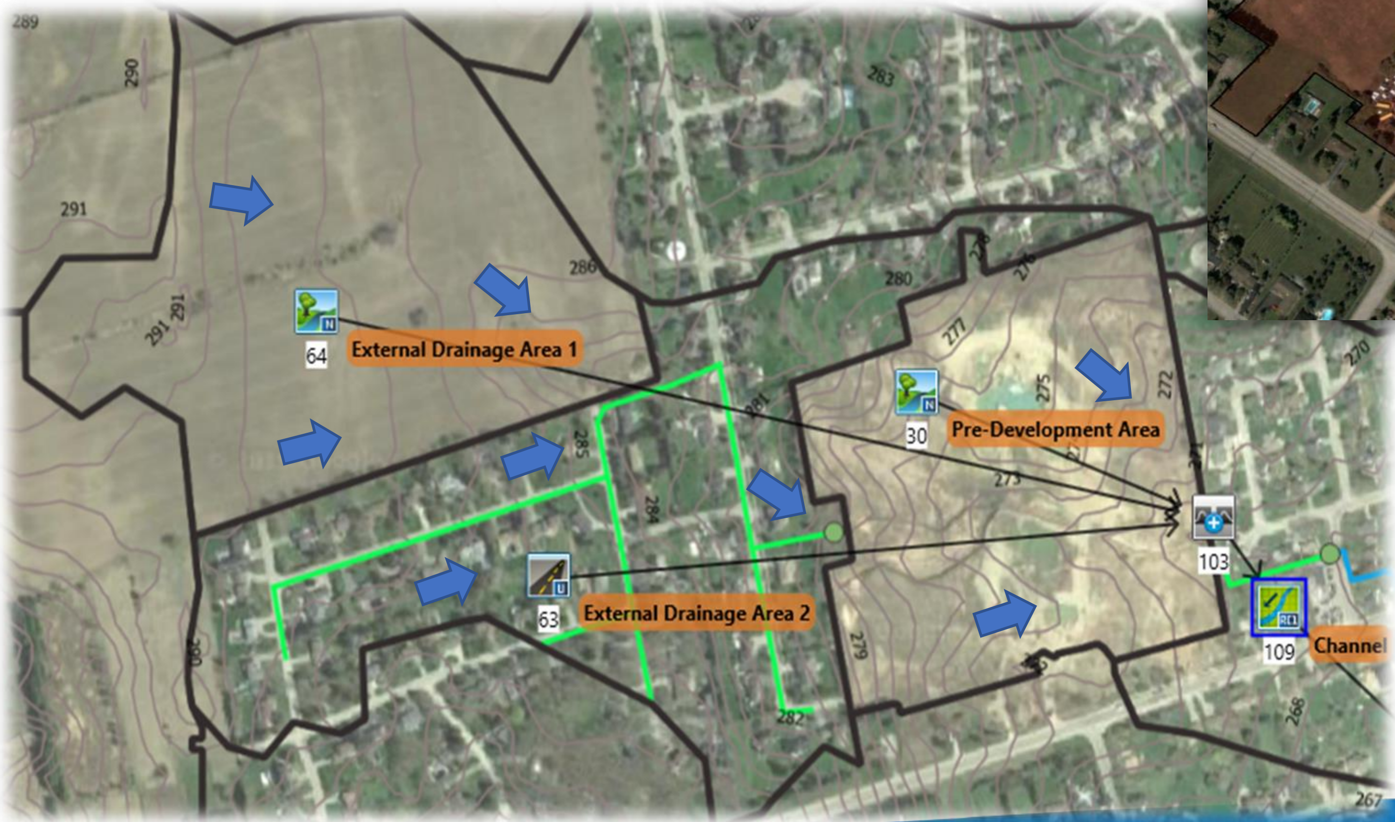
Step 7: Analysis of Existing Conditions

Pre-Development

External Drainage Area 1:
Area: 17.12 ha
Land Use: Agriculture

External Drainage Area 2:
Area: 18.39 ha
Land Use: Medium Density Residential

Pre-Development Area:
Area: 12.95 ha
Land Use: Vacant Land/ Open Space

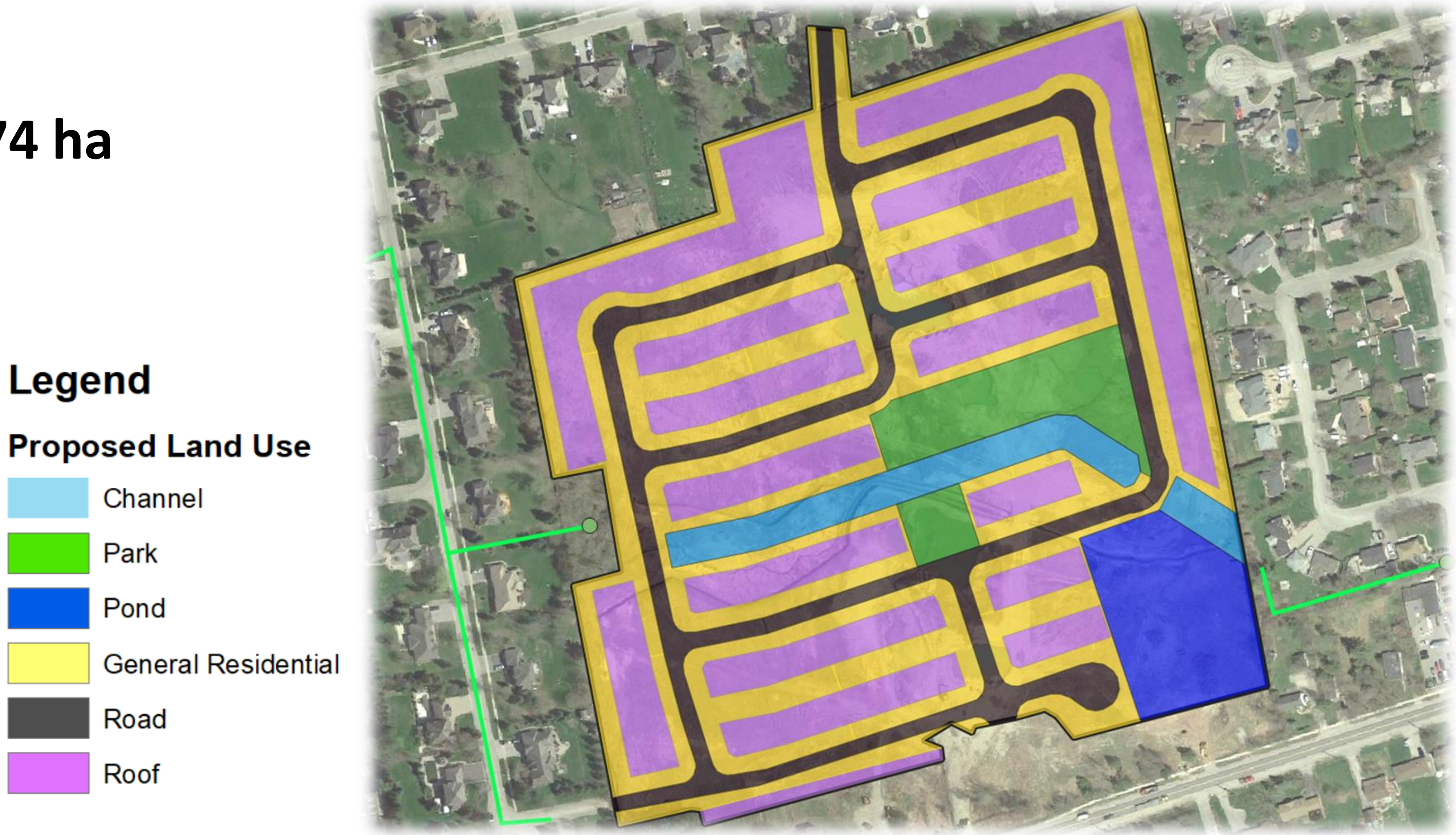


Step 8: Analysis of Future Conditions

Post-Development

General Residential = 4.74 ha
Roofs = 4.28 ha
Roads = 1.76 ha
Park = 0.74 ha
Channel = 0.63 ha
Pond Block = 0.80 ha

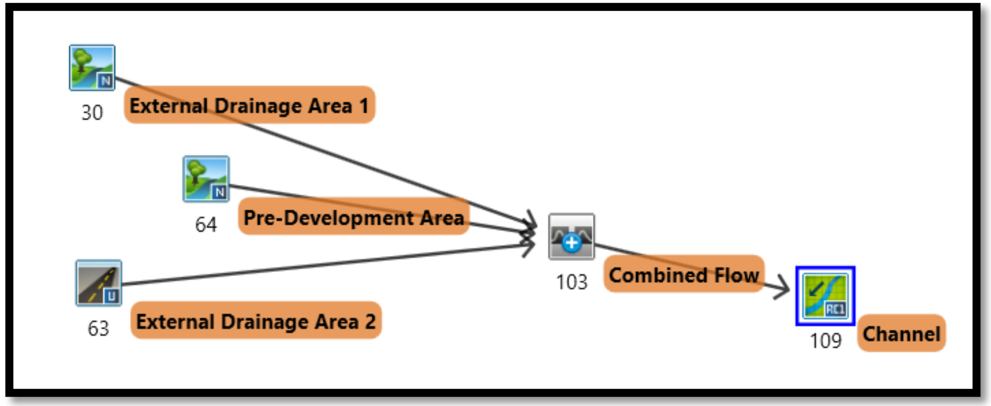
174 Proposed Houses



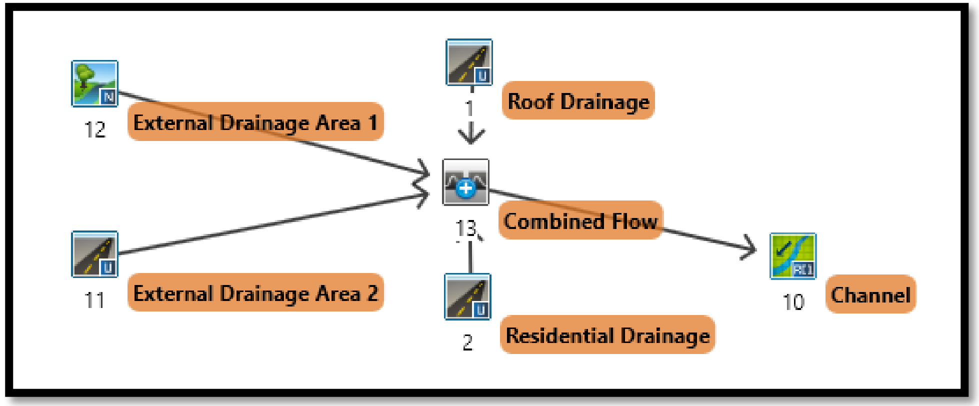
Step 9: Scenario Comparison

Three Models Required for Further Analysis

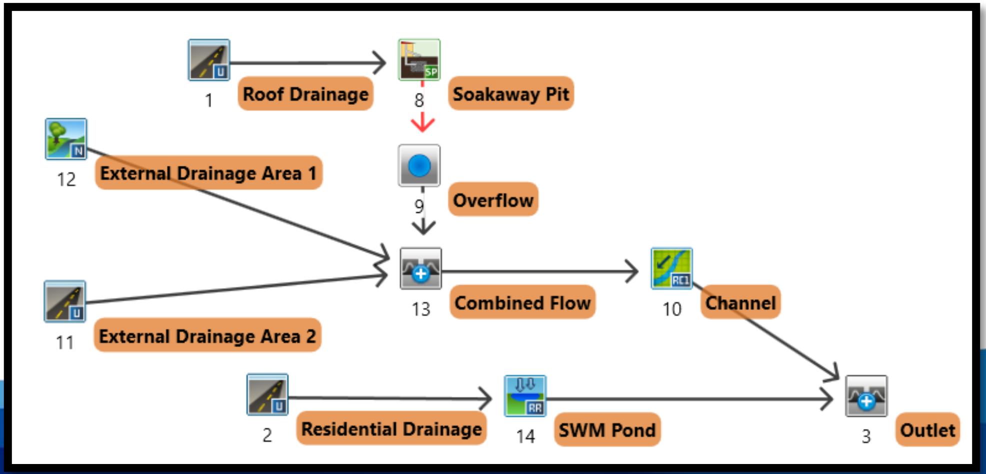
1. Pre-Development (Existing Conditions)



2. Post-Development (Without Controls)



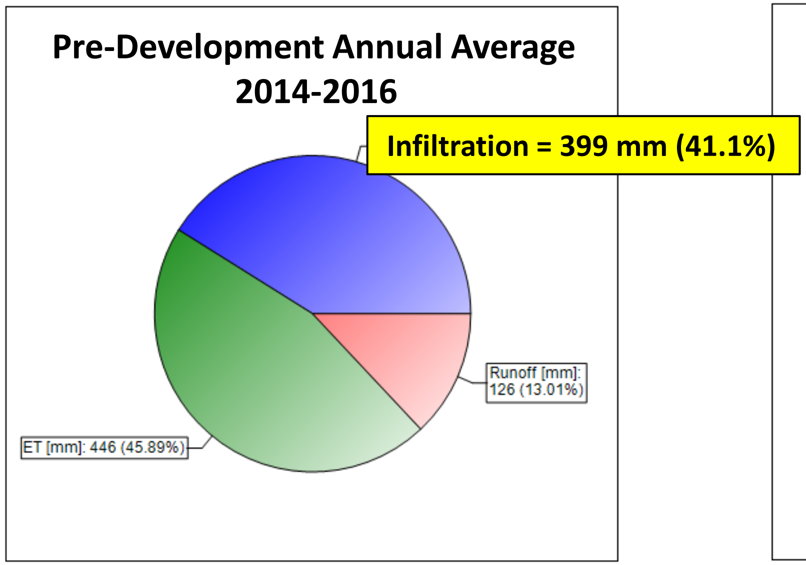
3. Post-Development (With Controls)

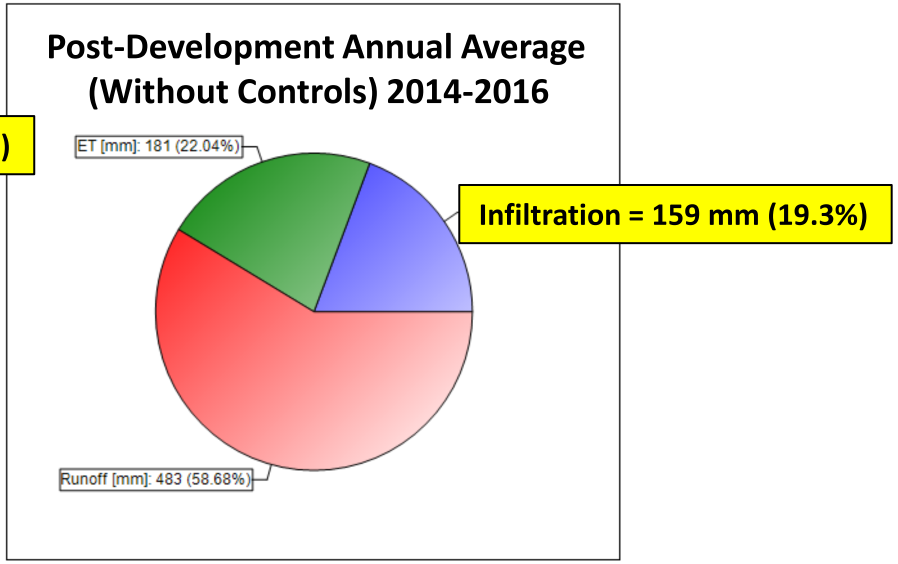


Step 10: Water Balance

Continuous Simulation of Existing and Future Conditions Models

Manage the Recharge to Meet Predevelopment Conditions





Water Balance Targets

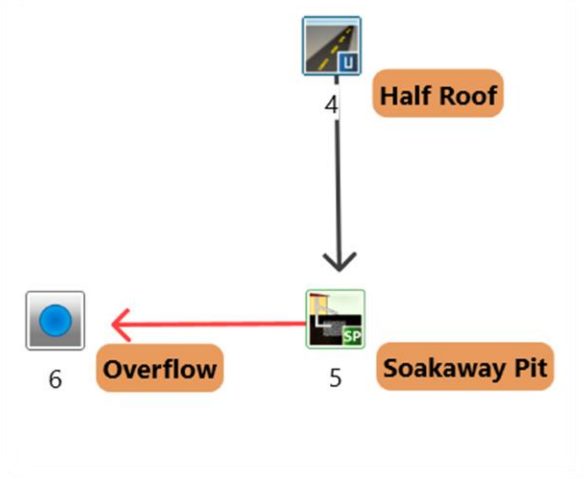
Groundwater Recharge			
Year	Pre-Development (m^3)	Post- Development (m^3)	Target (m^3)
2014	19035	7510	11525
2015	19165	6475	12690
2016	24862	8028	16834
Average	21021	7338	13683

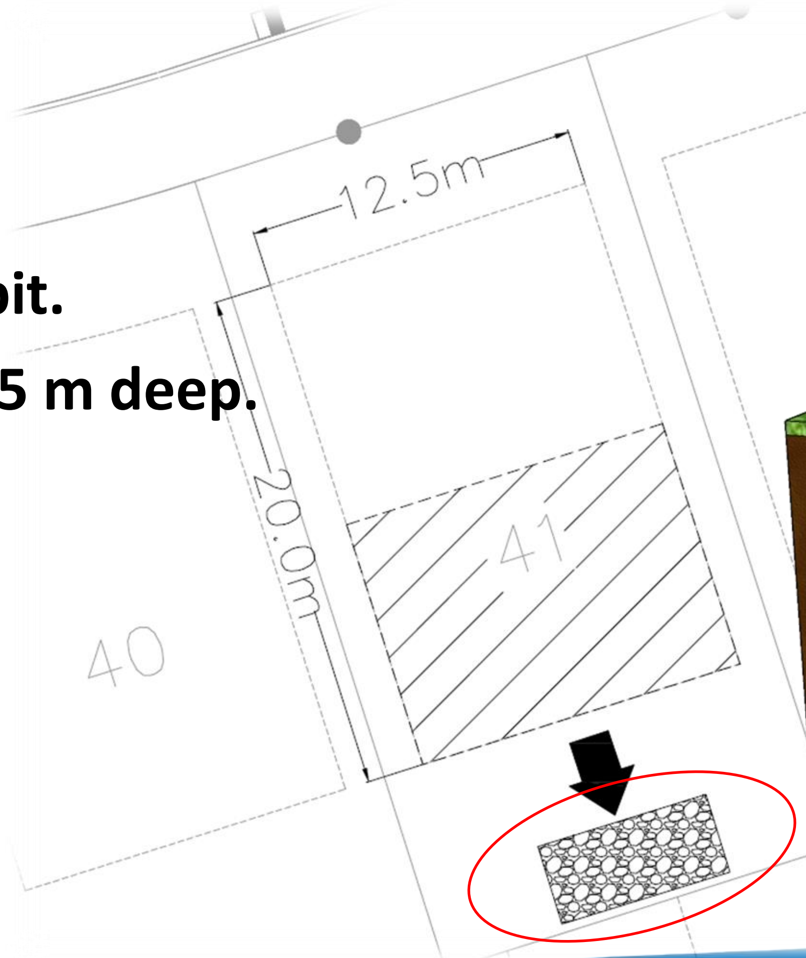
Step 10: Water Balance

Develop Mitigation Strategy

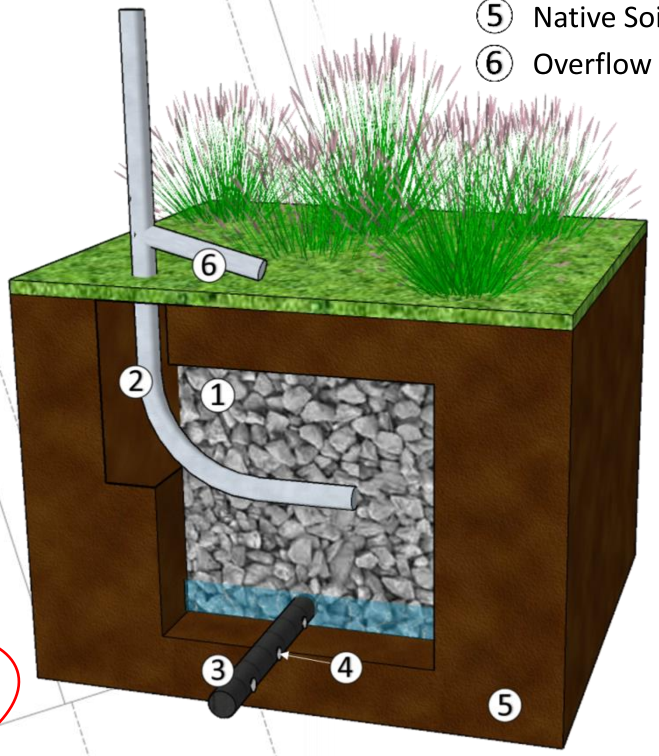
Assumptions:

1. Each roof is approximately 250 m^2.
2. Half of roof is routed to soakaway pit.
3. Each soakaway pit is 19.5 m^2 and 0.5 m deep.





Soakaway Pit



Step 10: Water Balance

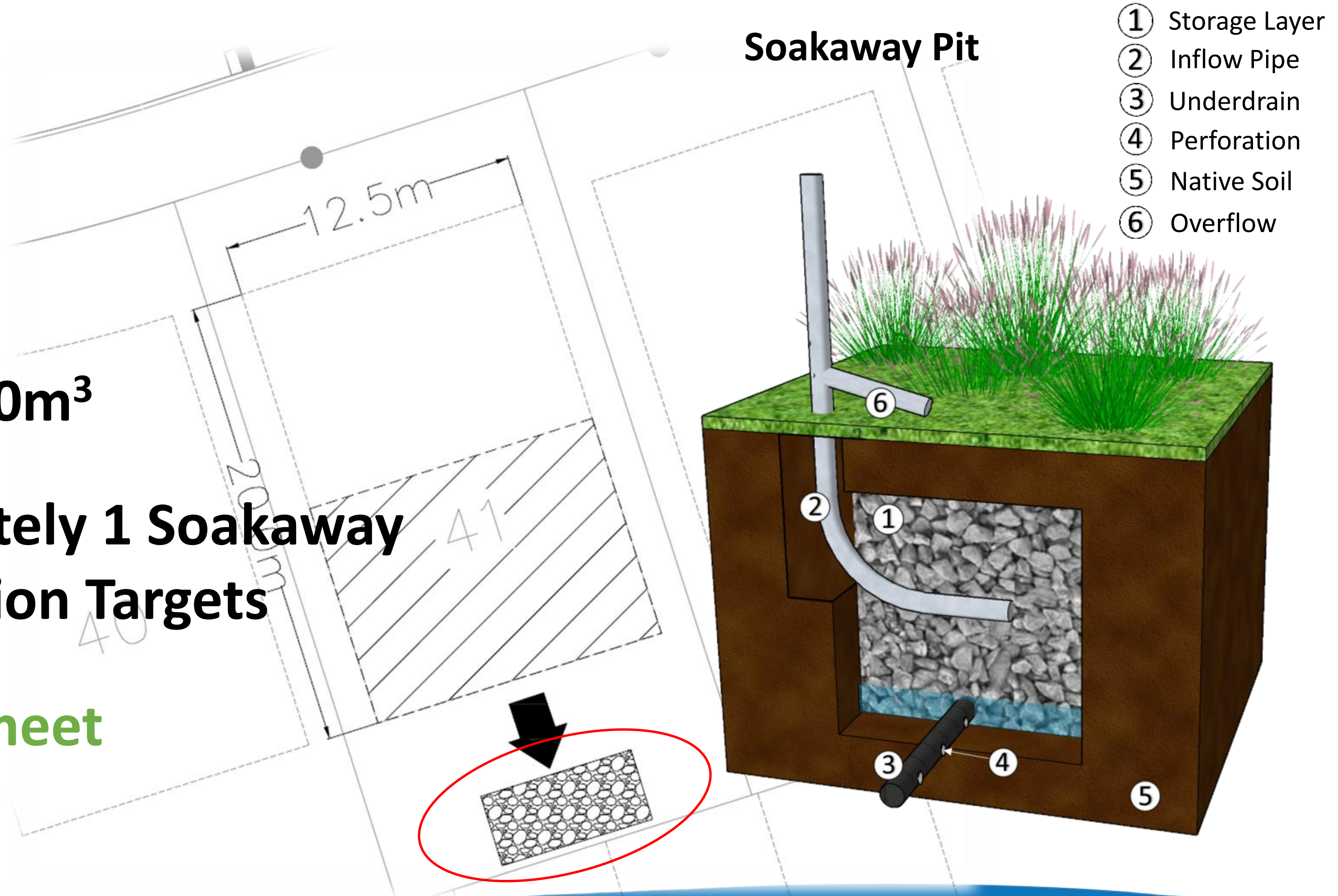
Implement Mitigation

Results:

Infiltration/Soakaway Pit = 80 m^3
Target = 13,683 m^3
# of Soakaway Pits = 13,683m^3/80m^3

171 Soakaway Pits or Approximately 1 Soakaway Pit Per House to Achieve Infiltration Targets

Recharge has been managed to meet predevelopment conditions.



Step 11: Erosion Control

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Single Event Simulation and Continuous Simulation

Follow the water balance assessments completed in local watershed studies, MESPs, Class EAs, and geomorphological erosion assessments; ✓

OR

Manage the 90th percentile storm (25 mm);

OR

Detain 25 mm over 24 to 48 hours.

Step 11: Erosion Control

Watercourse Erosion Analysis – Geomorphic Assessment

Threshold analysis establishes a depth, velocity, and discharge at which sediment of a particular size may potentially be entrained.

Two Phase Process:

- Phase I – Characterization
- Phase II – Erosion Analysis

Step 11: Erosion Control

Phase I – Characterization

- **Conducted by P.Eng or P.Geo**

- **The purpose of erosion threshold analysis is to determine the flow rate required to entrain and transport channel/bank material.**

Step 11: Erosion Control

Phase II – Erosion Analysis

A hydrologic model to assess in-stream erosion potential was created:

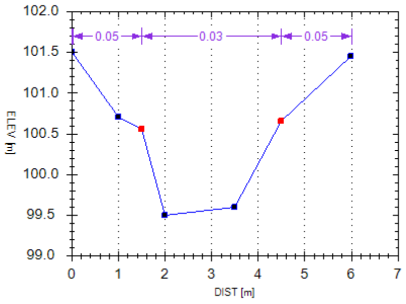
- **Run existing conditions scenario to obtain targets**
- **Run future scenario with and without SWM controls**
- **Determine necessary LIDs and attenuation to maintain existing erosion potential**
- **A critical discharge rate of 0.07 m^3/s was calculated based on the critical shear stress obtained from geomorphic assessment**

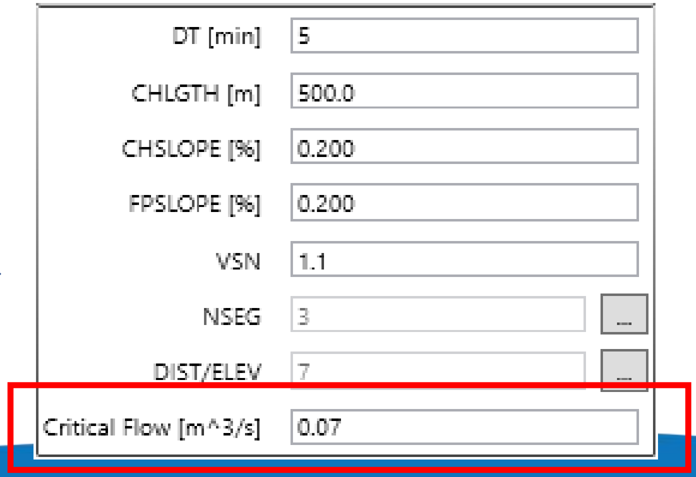
Cross Section Coordinates

	DIST [m]	ELEV [m]
1	0.000	101.500
2	1.000	100.700
3	1.500	100.550
4	2.000	99.500
5	3.500	99.600
6	4.500	100.650
7	6.000	101.450
8		

Manning's n Values

	SEGDIST [m]	ROUGH
1	1.500	0.050
2	4.500	-0.030
3	6.000	0.050
4		



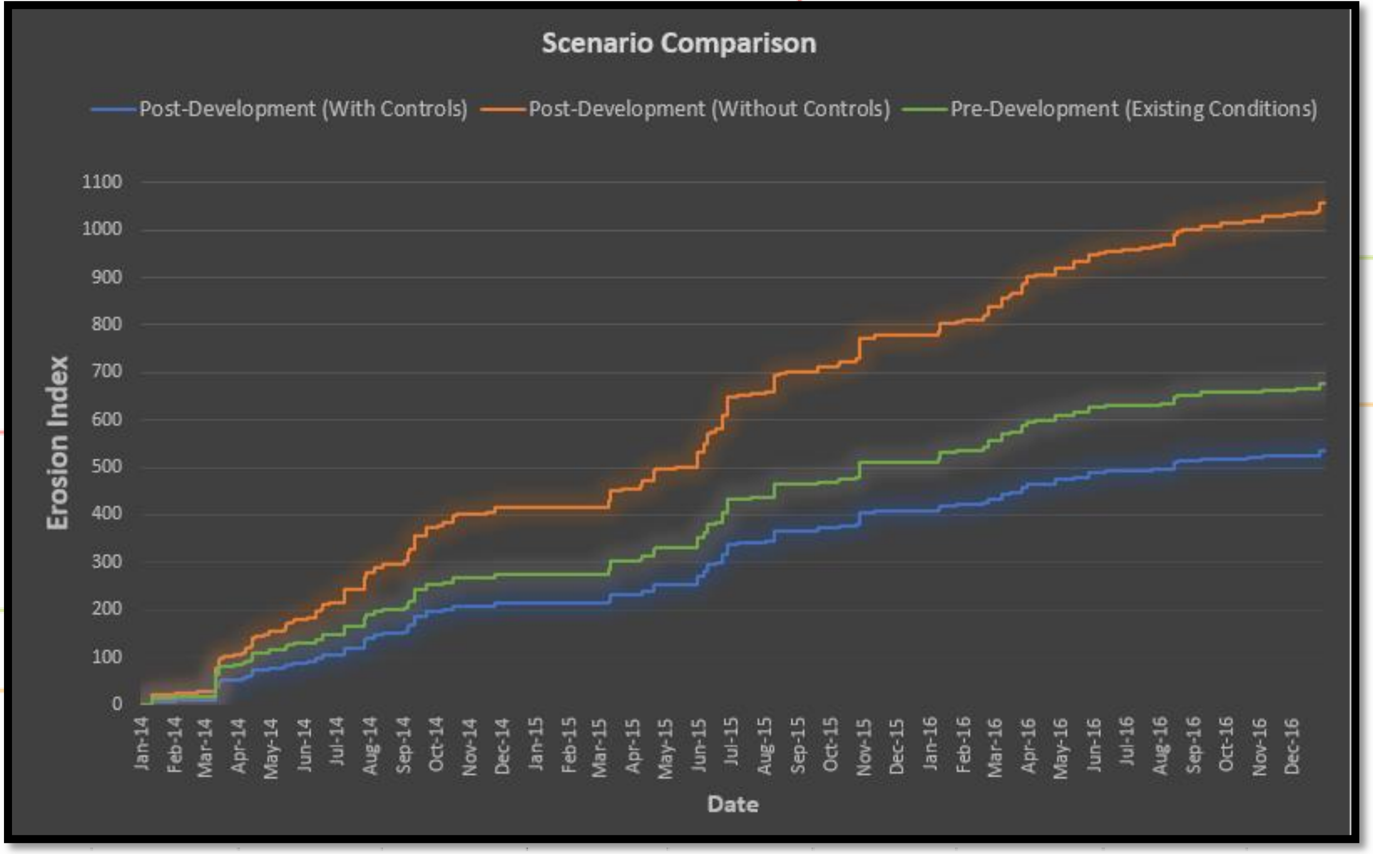


Step 11: Erosion Control

Erosion Threshold Analysis Continuous Simulation

Erosion Index Results

Scenario	Maximum Erosion Index	Average Erosion Index
Post-Development (Without Controls)	1056.54	588.94
Post-Development (With Controls)	533.94	303.34
Pre-Development (Existing Conditions)	677.87	389.16



Step 12: Water Quantity

Single Event Simulation

Control post-development peak flows to pre-development levels for all storms up to and including the 100-year storm (i.e. 2, 5, 10, 50, and 100-year). ✓

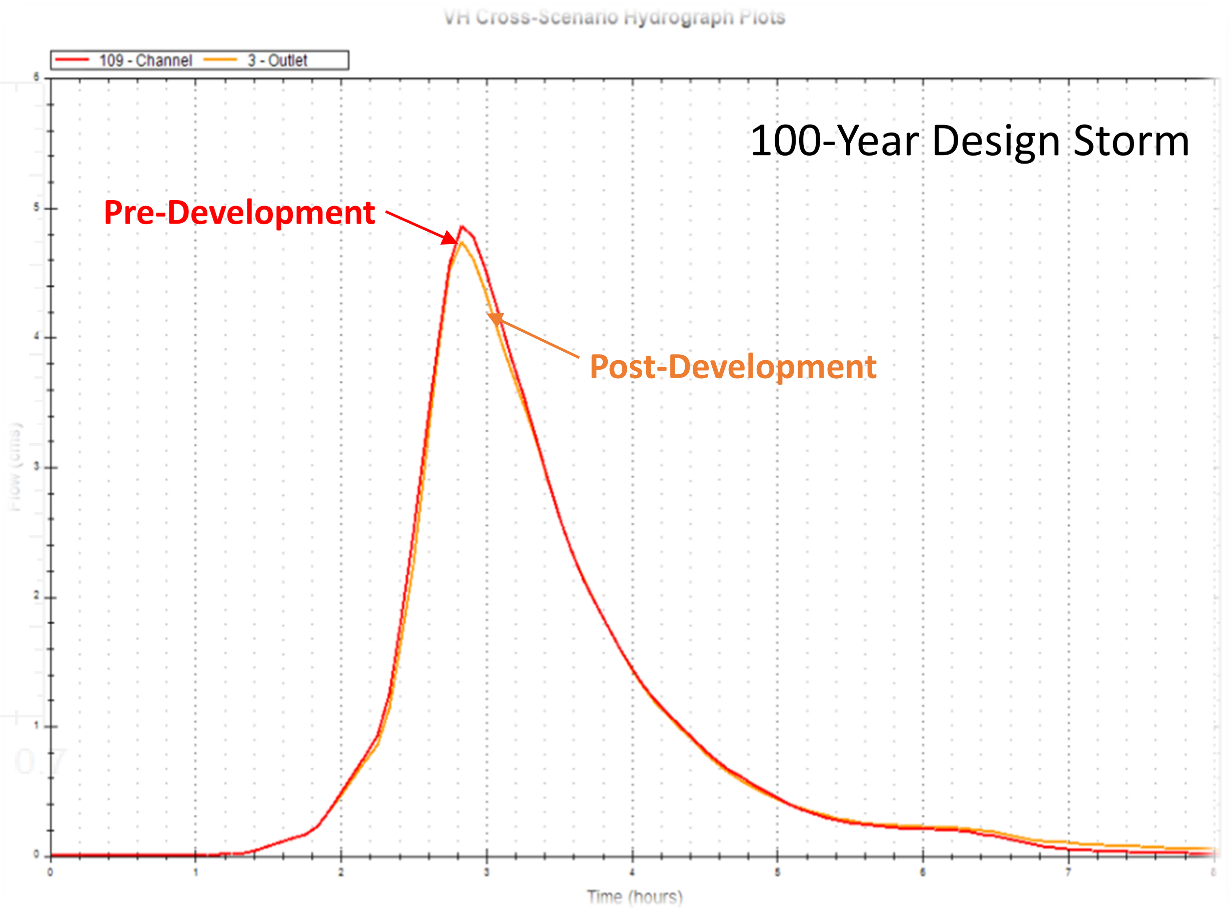
OR

Development outside of the approved urban boundary when the hydrology study was finalized may require Regional storm protection, proponents should consult with the local conservation authority to confirm.

Step 12: Water Quantity

Sizing of Stormwater Management Pond

- SWM pond discharge-storage curve was iterated until the outlet hydrographs from existing and future conditions models were matched.
- This process was completed for all design storms.
- Water quantity targets were achieved for each design storm including the 25 mm event.

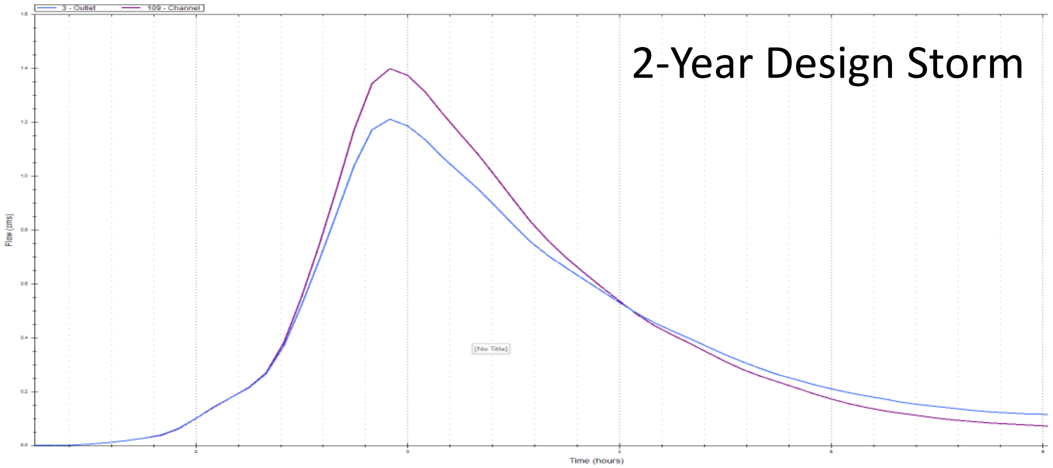


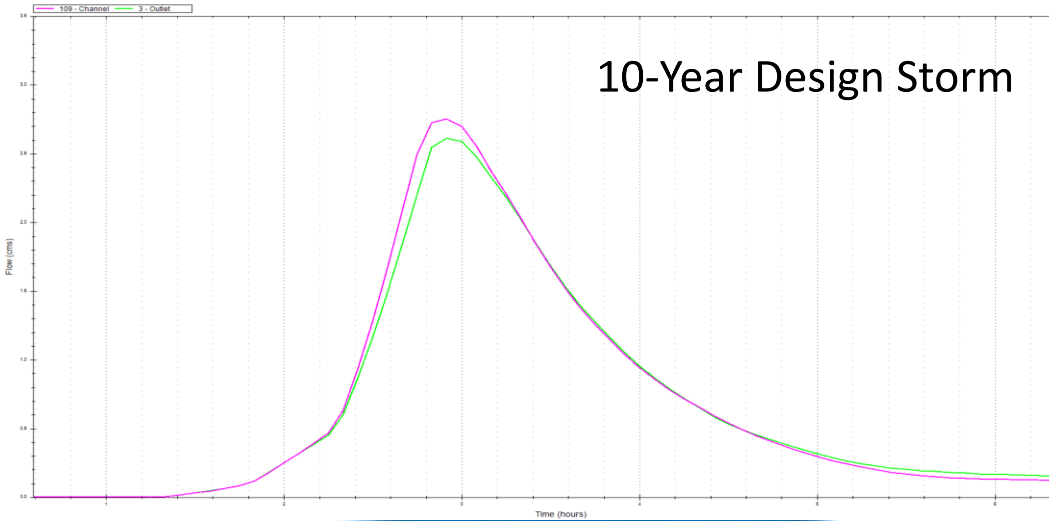
Step 12: Water Quantity

Single Event Analysis of Design Storms

Single-Event Analysis of Peak Flows

Design Storm	Existing Conditions Target Peak Flow (m^3/s)	Future Conditions Achieved Peak Flow (m^3/s)	% Difference
25 mm	0.91	0.84	5.49
2-Year	1.40	1.30	4.83
5-Year	2.24	2.11	3.94
10-Year	2.75	2.61	3.52
25-Year	3.61	3.52	1.66
50-Year	4.23	4.19	0.60
100-Year	4.86	4.76	1.31





Step 13: Water Quality

Single Event & Continuous Simulations

- Manage the 90th percentile storm (25 mm) and 80% Total Suspended Solids removal over the catchment as per Environmental Technology Verification (ETV) particle size distribution.

- Evaluate the anticipated changes in phosphorous loadings (TP) between existing and future conditions (analysis of pre-development versus post-development without controls).

- Demonstrate how post-development TP will be minimized. Target of 80% TP removal for major development.

Step 13: Water Quality

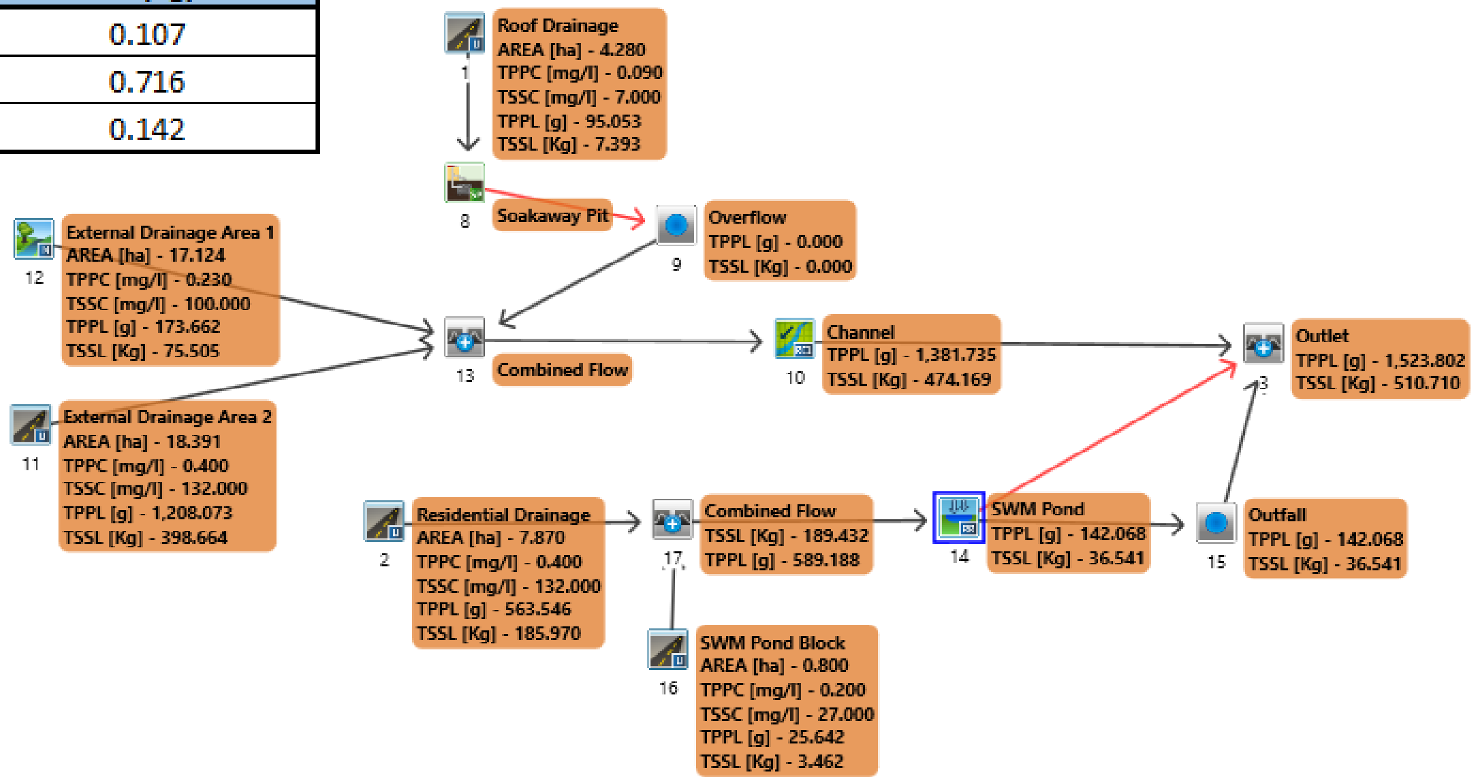
Single Event

25 mm Event Statistics		
Scenario	TSS (kg)	TP (kg)
Pre-Development	14.507	0.107
Post-Development No Controls	212.268	0.716
Post-Development with Controls	36.541	0.142

Based on the combined removal efficiency from the SWM pond and the soakaway pits, the model achieved:

83 % TSS Removal

80 % TP Removal



Step 13: Water Quality

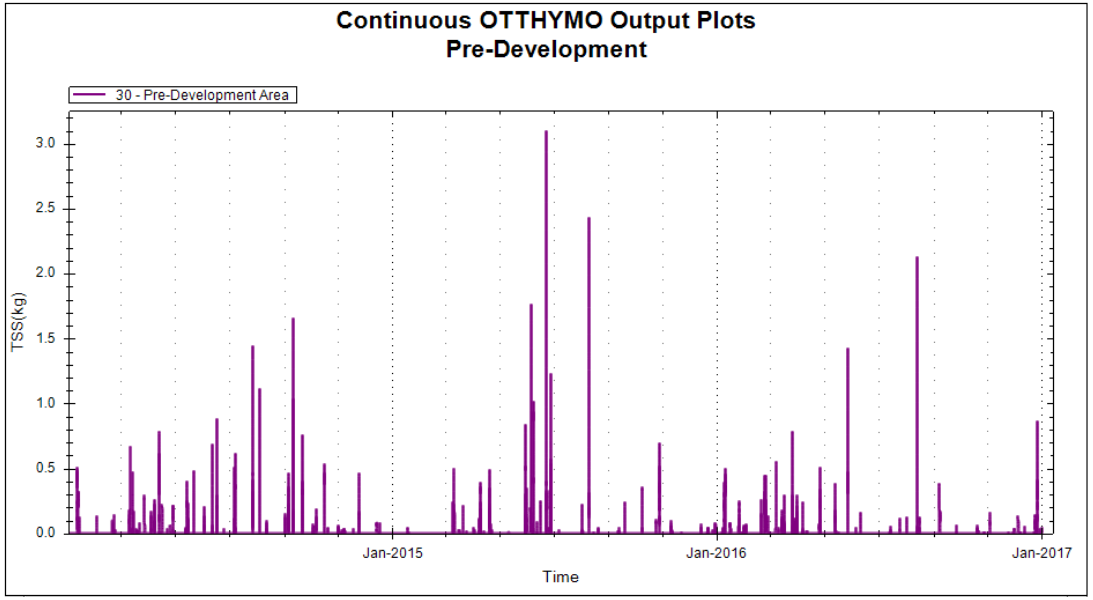
Continuous Simulation

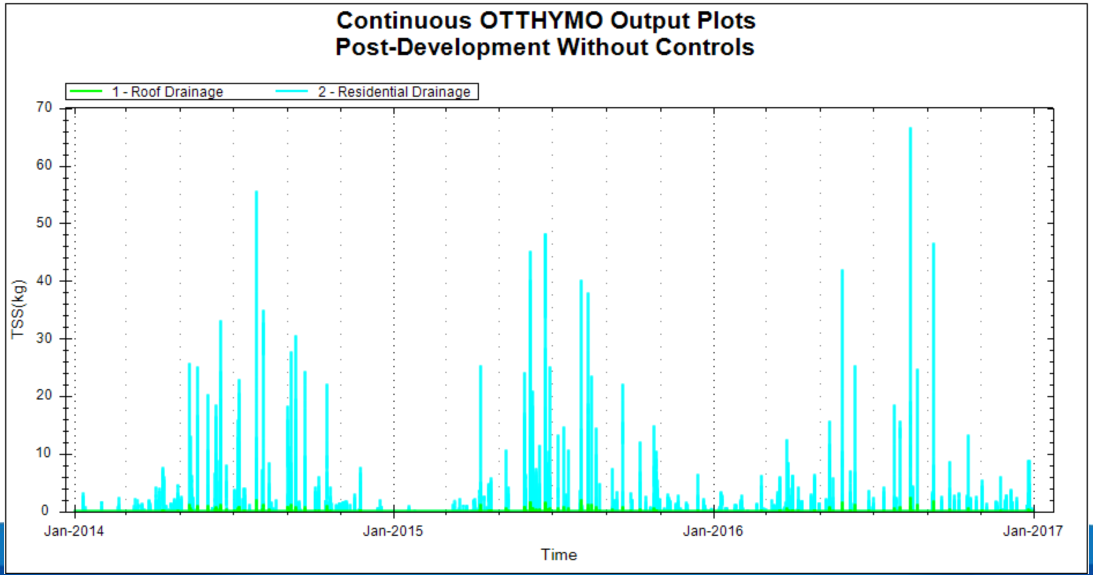
Continous Simulation Statistics (2014-2016)		
Scenario	**TSS (kg)**	**TP (kg)**
Pre-Development	1326.02	9.82
Post-Development No Controls	16306.05	55.18
Post-Development with Controls	2904.91	11.28

Based on the combined removal efficiency from the SWM pond and the soakaway pits, the model achieved:

82 % TSS Removal

80 % TP Removal





Conclusions

- Stormwater Management Criteria can be met with a combination of LIDs and traditional SWM controls (e.g. Ponds).

- Analysis tools are available to help manage runoff (evaluate and design facilities).

- Management involves a treatment train of measures. These can be assessed with varying configurations to match site constraints.

Questions