

APPENDIX C

PCSWMM Hydrological Model Development

E702 – Don Mills Channel Flood Reduction

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Executive Summary

Computational Hydraulics International has been retained by The Municipal Infrastructure Group Ltd (TMIG) for a project with the City of Markham to assemble and calibrate an integrated 1D-2D dual drainage model of the Don Mills channel. The main objectives of the modelling project were to simulate historical flooding events to assist in assessing the capacity of stormwater infrastructure. This report documents the model development, parameterization, calibration/validation and the analysis of the stormwater management system within the study area.

The Don Mills channel dual drainage model was developed in PCSWMM using data provided by TMIG and the City of Markham including: GIS files, orthophoto and digital elevation model. The completed PCSWMM model consists of more than 120 subcatchments covering the 7.3 km² study area and over 500 conduits representing almost 38 km of drainage network including storm sewer pipes, major system flow paths, ditches and the channel itself. An integrated two-dimensional (2D) model component was added to this model, as a means to better represent floodplain storage and conveyance throughout the study area. Calibration of the model was based on observed high water marks from two historical flooding events: August 18th, 2005 and July 27th, 2014.

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Introduction

Computational Hydraulics International (CHI) has been retained by The Municipal Infrastructure Group (TMIG) for a project with the City of Markham to build an integrated 1D-2D dual drainage model of the Don Mills Channel using PCSWMM. The Don Mills channel study area is highly urbanized with an approximate area of 7.3 km². Its land use varies from residential to commercial and industrial areas with limited natural cover along most of the creek. The elevation of the area varies from 193.5 m at the upstream end to 164 m near the outlet to German Mills Creek.

The City of Markham is undertaking an environmental assessment to determine the best means of reducing flooding along the Don Mills channel by developing an integrated 1D-2D dual drainage model to evaluate the overland and piped drainage networks often referred to as the major and minor drainage systems. Stormwater management within the watershed includes a minor drainage system which is a network of pipes, ditches, culverts and channels designed to convey the more frequent runoff from relatively small storm events, and a major drainage system which conveys the surface runoff that exceeds the pipe capacity during large infrequent storm events. The objectives for developing the Don Mills dual drainage model include:

- Estimate existing capacities of minor and major drainage system infrastructure under different design storms and recent major storm events
- Evaluate overland flow paths
- Estimation of hydraulic grade lines in storm sewers
- Identify problematic areas due to capacity of drainage systems
- Evaluate effects of new developments and intensification on the capacity of major and minor drainage systems

Indirect objective is to allow future applications of the model could include master planning, simulation of historical events and water quality investigations.

This report documents the model development, parameterization, calibration and validation of the Don Mills integrated 1D-2D dual drainage model.

Existing Storm Drainage System

Both minor and major systems discharges the Don Mills channel. Surface runoff from land parcels generally flows to road gutters and enters the minor drainage system through the catchbasins/curb

inlets. When the runoff flow rate exceeds the minor drainage system conveyance or inlet capacity of the catchbasin/inlet capacity, stormwater runoff is routed to the major drainage system.

Major Drainage System

The major drainage system consists of the overland flow routes within the watershed to convey additional surface runoff beyond the capacity of the minor drainage system during large storm events. Level of service very, but general practice is to design the major drainage system to convey flow from a rare (e.g. 100-year) design storm without local flooding or affecting traffic flow significantly. The main components of the Don Mills watershed major drainage system are roadway curb and gutter systems.

The City of Markham has experienced several recent major rainfall events, including August 19th, 2005 and July 27th, 2014 storm events. The major drainage system in the Don Mills channel was active during these events and have drawn attention to the need for a detailed evaluation of major and minor drainage systems to better understand how these systems behave under extreme rainfall.

Model Development

Model Overview

The Don Mills channel integrated 1D-2D dual drainage model includes subcatchments, major and minor system components, stormwater outfalls and the channel itself. An inventory of the SWMM5 entities used to model the Don Mills channel is presented in Table 1.

The following sections review the setup of the model, selection of pre-calibration parameters and assumptions made.

Table 1 - Inventory of SWMM5 entities in Don Mills Integrated 1D-2D Dual Drainage Model

SWMM5 Entity	Number	Description
Subcatchments	122	drainage areas
Channel Conduits (open watercourse)	72	Don Mills channel
Minor System Conduits	350	stormwater pipes and ditches
Major System 1D Junctions	151	1D junctions of major system flow paths
Major System 2D Junctions	24019	2D junctions of major system flow paths
Major System 1D Conduits	162	1D overland flow paths
Major system 2D Conduits	56130	2D overland flow paths
Minor System Junctions	360	manholes/catchbasins
Outfalls	1	Discharges downstream

Outlets	246	link from minor to major system at catchbasin locations
Rating Curves	65	flow restriction of catchbasin grates
Transects	149	channel geometry
Shape Curves	2	bridge geometry

Hydrology

Subcatchment Discretization

Subcatchments were discretized based on the property fabric. This was done as the majority of the watershed was developed on a site plan basis, with each site/property responsible for managing its runoff and discharging to the collection system. In total there was 122 subcatchments ranging from 0.0034 ha – 34 ha with an average area of ~6 ha.

Subcatchments bounded by Hwy 404, 407, Woodbine and the CNR were lumped into a single subcatchment as this area drains to a separate culvert under Highway 404 that outlets north of the CNR constriction on the Don Mills Channel.

Larger subcatchments with on-site controls were subdivided to match capture/treatment or other control area boundaries.

The area south of Steeles Avenue was added to the subcatchment discretization to account for the minor system drainage area.

Subcatchment Area

Subcatchment areas were calculated in PCSWMM using the subcatchment GIS coordinates.

Width / Flow length

Overland flow width in SWMM5 is defined as the subcatchment area divided by the average overland flow path length. Representative flow lengths were assigned based on the subcatchment size.

Subcatchments that had an area less than 5 ha were given a flow length of 50 m, subcatchments that had an area greater than 5 ha but less than 10 ha were given a flow length of 100 m and subcatchments greater than 10 ha were assigned a flow length of 150 m.

Slope

Overland slope was assumed to be 0.5 % for all subcatchments as it is representative of typical slopes in a developed watershed.

Roughness

Manning's roughness values of 0.015 and 0.3 were assigned to impervious and pervious areas, respectively. In areas defined as being a trail, a depression storage of 5.08 mm was used for the pervious area.

Depression Storage

Depression storage values of 1.9 mm and 2.85 mm were assigned to impervious and pervious areas respectively. In the area covered by the 2D mesh, a depression storage value of 0 mm for both the pervious and impervious areas was used.

Percent Imperviousness

The percent imperviousness of each layer was estimated using an area-weighted average based on a parcel and buildings layer provided. Impervious areas including buildings, parking lots and roads were assumed to have an impervious value of 100%. In the areas where the buildings were not defined, an impervious value of 75% was used and in areas defined as being zoned as open space a value of 0% was used. Figure 1 presents the estimated imperviousness of each subcatchment. The calculated imperviousness of the Don Mills channel study area is 80%.

Infiltration

The physically based Green-Ampt method was chosen to simulate infiltration in the model. In the soils layer provided, soil classes were assigned initial Green-Ampt parameters based on values published by Rawls *et al.* (1983) (Table 2). Rendering of the soils layer based on soil class is shown in Figure 3. Area weighted averaging was used to assign Green-Ampt parameters to all subcatchments.

Table 2 - Green-Ampt soil parameters assigned to soils

Soil Texture Class	SOIL TEXTURE	CONDUCT (mm/hr)	SUCTIONHEAD (mm)	INITDEFICIT (fraction)
MALTON CLAY	Clay	0.25	320.04	0.21
BRADY SANDY LOAM	Sandy Loam	10.92	109.98	0.368
BERRIEN SANDY LOAM	Sandy Loam	10.92	109.98	0.368
PEEL CLAY	Clay	0.25	320.04	0.21
PONTYPOOL SANDY LOAM	Sandy Loam	10.92	109.98	0.368
SIMCOE CLAY LOAM	Clay Loam	1.02	210.06	0.277

CASHEL CLAY	Clay	0.25	320.04	0.21
BOOKTON SANDY LOAM	Sandy Loam	10.92	109.98	0.368
WOBURN LOAM	Loam	3.3	88.9	0.347
BOTTOM LAND	Bottom Land	0.25	320.04	0.21
MILLIKEN LOAM	Loam	3.3	88.9	0.347

Inlet Control Device (ICD) Subcatchments

To account for the detention from the on-site inlet control devices (ICDs), the areas with an ICD were modeled as separate catchments representing the drainage area that would be routed to the ICDs.

Hydraulics

Conduits

Model hydraulics were imported from three sources: a HEC-RAS model (W10-494DMDDec21.g01), two .SHP files (StormSewers.shp and MH.shp) and a stormwater pipe layer exported from a geodatabase file (DonMills-Markham-Exported.gdb) provided December 1st, 2015. Storm sewer pipes less than 600 mm in diameter were not included in the model, see Figure 4.

Transects of the Don Mills channel and associated culverts and bridge data were imported to PCSWMM from the HEC-RAS models provided. Bridges were represented in PCSWMM with parallel conduits replicating the openings between piers based on the upstream HEC-RAS bridge cross sections. In total, 15 bridges and 55 open water course segments were imported into PCSWMM. Manning’s roughness for each channel reach in the HEC-RAS model were imported into the PCSWMM model with each transect. Culvert loss coefficients were also transferred to the PCSWMM model from the HEC-RAS model. For the other closed culverts a default entrance and exit coefficients of 0.5 and 1 as these were the most commonly used values in the HEC-RAS model. Table 3 lists the culverts imported from HEC-RAS and the associated entrance and exit loss coefficients assigned using values taken from the HEC-RAS model.

Obstructions defined in the HEC-RAS cross-sectional data were manually added to the PCSWMM model.

Table 3 - Culvert exit and entrance loss coefficients

Culvert name	Shape	Entrance Loss Coeff.	Exit Loss Coeff.	Notes
CJ31.029_2	ARCH	0	1	From HEC-RAS
CJ31.029_1	ARCH	0.7	0	From HEC-RAS
CJ31.035	ARCH	0.7	1	From HEC-RAS
CJ31.040	ARCH	0.5	1	From HEC-RAS
CJ31.044_2	ARCH	0	1	From HEC-RAS
CJ31.044_3	ARCH	0.7	0	From HEC-RAS
CJ31.056	ARCH	0.5	1	From HEC-RAS
CJ31.065	ARCH	0.5	1	From HEC-RAS
CJ31.049	HORIZ ELLIPSE	0.5	1	From HEC-RAS
CJ31.025	RECT CLOSED Used culvert code 11	0.5	1	From HEC-RAS
CJ31.061	Circular	0.5	1	From HEC-RAS
CJ31.019	Circular	0.7	1	From HEC-RAS
CJ31.007	Custom	0.7	1	Assumed
CJ31.004	Custom	0.7	1	Assumed

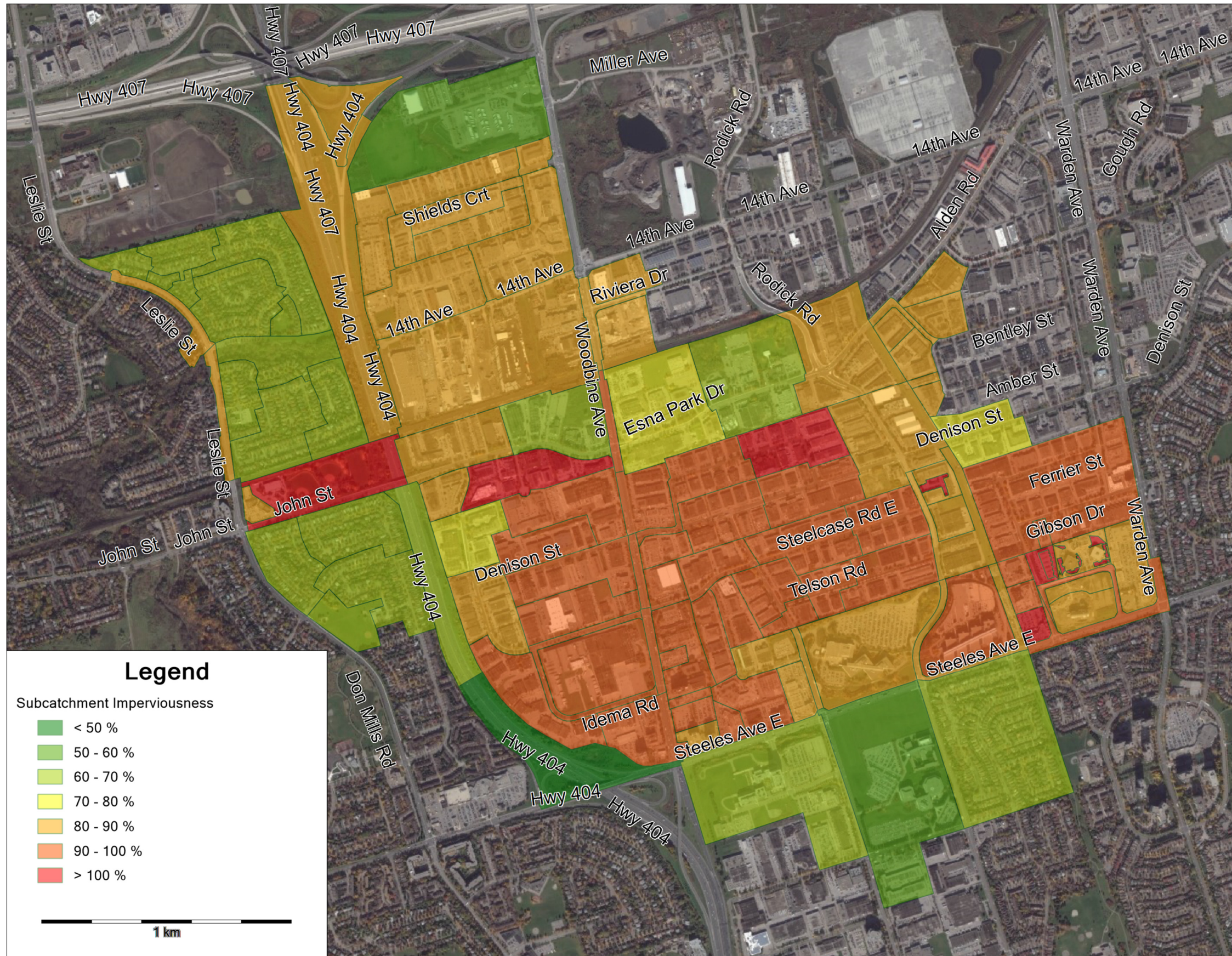


Figure 1 – Don Mills Channel drainage boundaries rendered on percent imperviousness

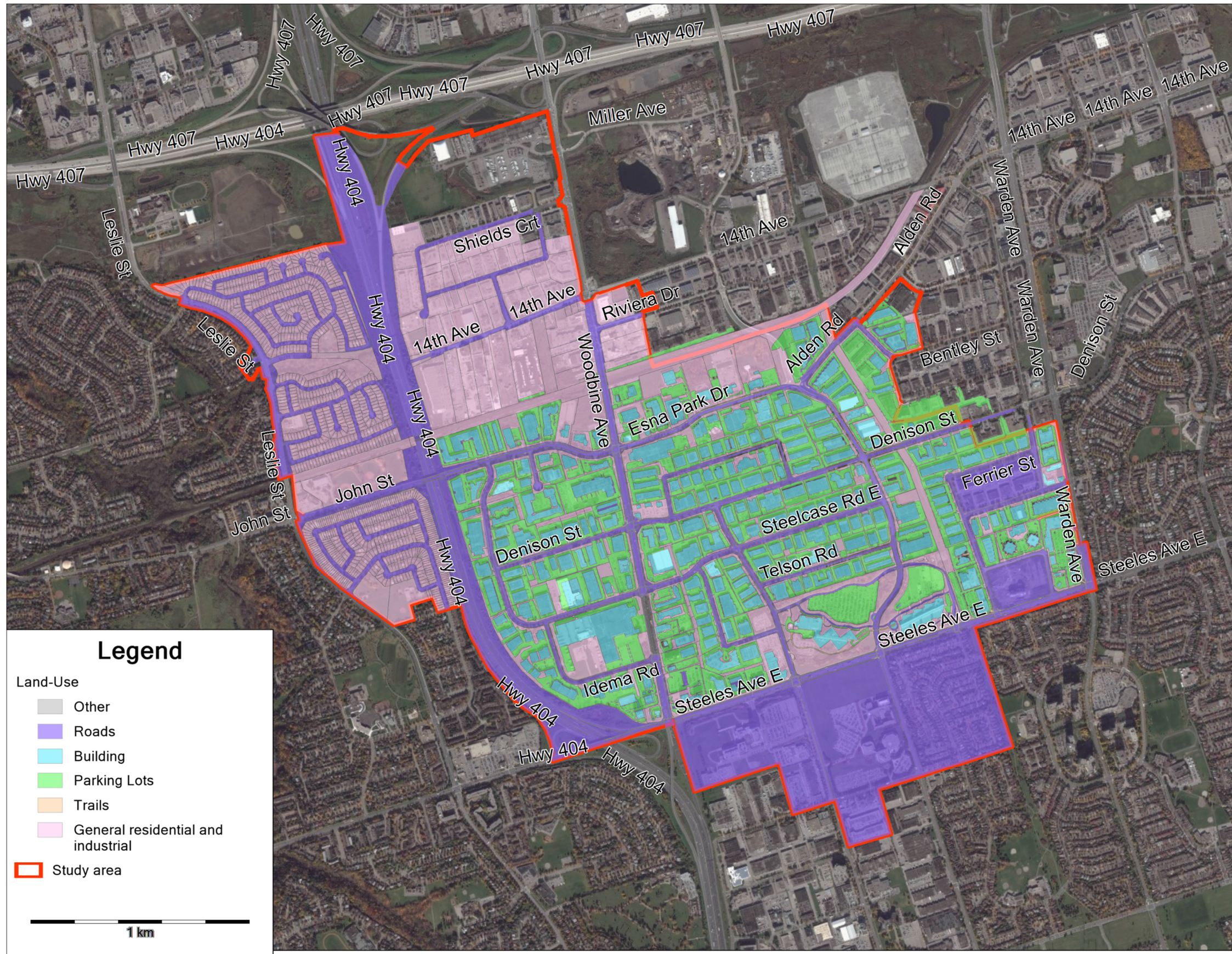


Figure 2 – Don Mills channel study area land use

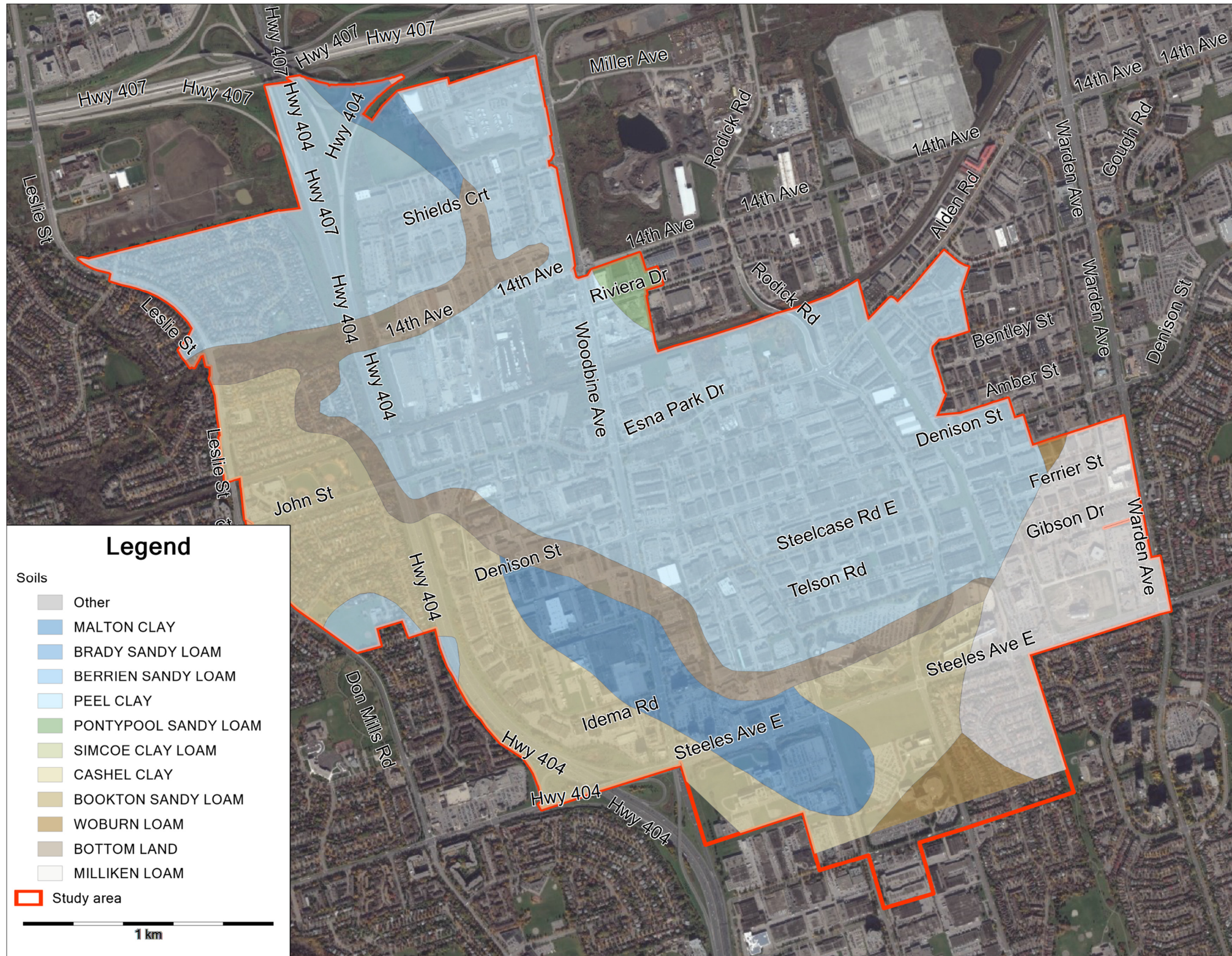


Figure 3 - Distribution of soil types in the Don Mills study area

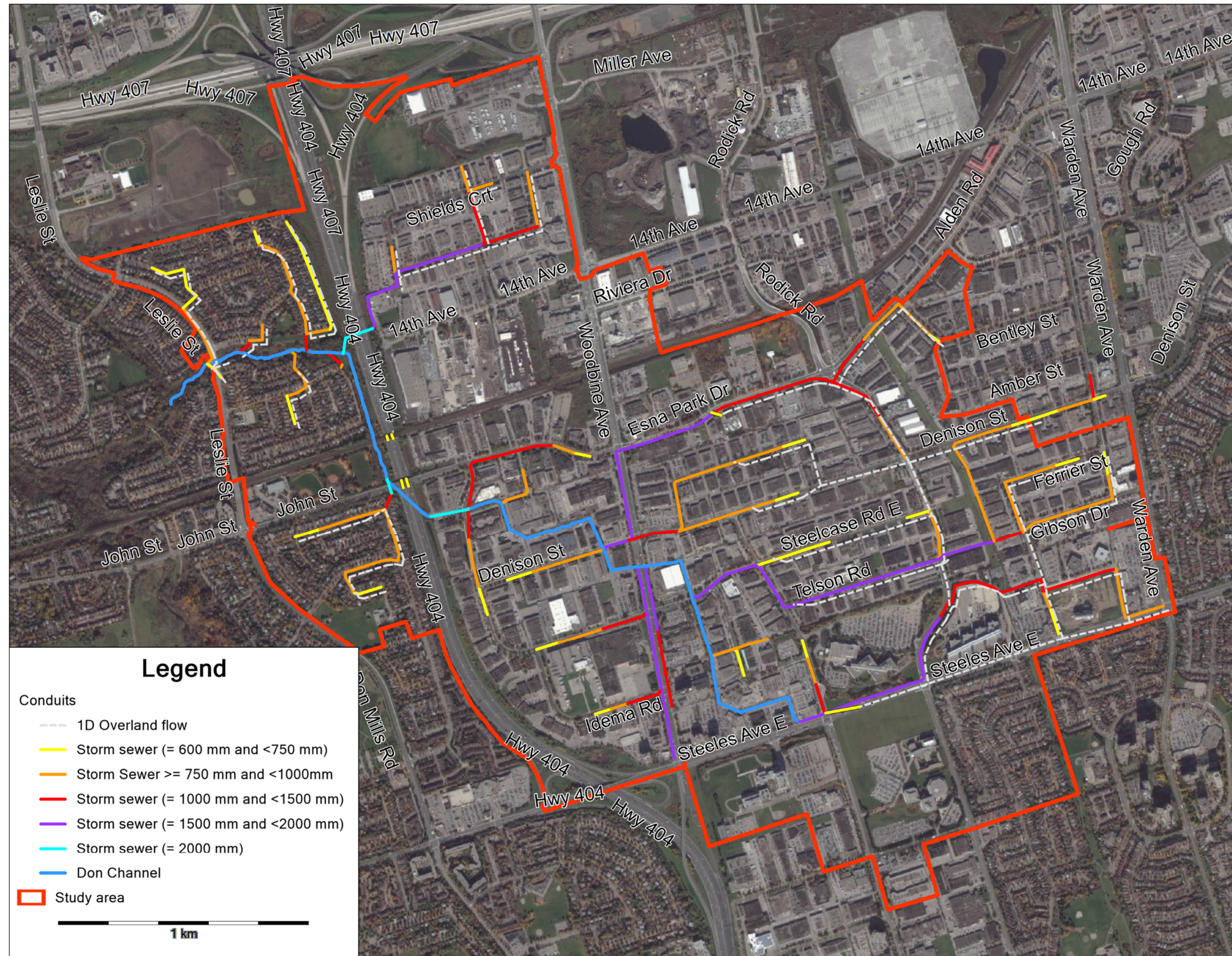


Figure 4 - Major-minor system base map

Stormwater conduits and junctions were imported from two .shp files representing the manholes and stormwater pipes from the City of Markham, and a stormwater pipe layer extracted from a geodatabase supplied by York Region. In both of the stormwater pipe network layers provided, attribute data was imported by matching the SWMM5 attributes to the representative layer parameters as shown in Table 4 - Table 6.

Table 4 - Imported conduit attributes from DonMills-Markham-Exported.gdb

Source file: DonMills-Markham-Exported.gdb Attribute Name	SWMM 5 Conduit attributes
CLASSID	Name
UPSTRMNODE	Inlet Node
DNSTRMNODE	Outlet Node
MATERIAL	Description
XSEC_SHP	Cross-section *converted to m
WIDTH	Geom(1)
HEIGHT	Geom(2)
UPSTRMINVR	Invert Elevation
DNSTRMINVR	Outlet Elevation
UPSTRMOBVR	Upstream node Rim Elevation (Junctions)
DNSTRMOBVR	Downstream node Rim Elevation (Junctions)

Table 5 - Imported conduit attributes from StormSewers.shp

Source file: StormSewers.shp Attribute name	SWMM 5 Conduit attributes
LINKID	Name
DWNELEV	Outlet Elevation
PIPEDIAM	Geom(1) *converted to m
UNITID	Inlet Node
UNITID2	Outlet Node

Table 6 - Imported junction attributes from MH.shp

MH.shp Attribute name	SWMM 5 Junction attributes
MHDPTH	Depth
ELEVATION	Rim elevation

Coordinates, diameters, materials, slopes and lengths for minor system pipes were obtained from GIS data. Each of the pipe conduits were assigned a Manning’s roughness coefficient of 0.013.

Major system conduits representing street flow were generated using PCSWMM’s dual drainage creator tool. Along major streets which had no minor system conduits running parallel, major system conduits were added manually using Google Earth to determine the number of lanes and width of the road. It was assumed that all major system conduits had an average transverse slope of 2% from crown to curb. A Manning’s roughness of 0.015 was assigned to all major system conduits to represent asphalt pavements.

Junctions

Minor system junction locations were imported from the GIS layer containing manhole data provided. Manholes invert elevations were estimated considering the lowest connected pipe invert elevation at each junction. When pipe inverts were not available, junction inverts were interpolated between the upstream and downstream conduits with available inverts. Rim elevations were estimated from the DEM. For the creek junctions, invert elevations and depths were imported directly from the HEC-RAS models.

To prevent loss of water from the model, the major drainage system junctions were assigned an initial ponded area. This ponded area allows water to accumulate at the junctions until there is capacity available in connected conduits. Junctions within the 2D portion of the model were not assigned a ponded area to avoid duplication of storage around these junctions which is accounted for in the 2D mesh. The minor system junctions and major system junctions within the flood inundated areas were assigned a surcharge depth to accommodate increased water depth during flooding.

When the water level at a junction reaches its assigned depth (or height of the street transect in the case of major drainage system – 0.23m), any additional water draining to that junction is stored in the ponded area. Water can pond at any junction if it is located at a sag point and or the capacity of

outflowing conduits and minor system inlets (i.e. catchbasins) is less than the inflow. Water can accumulate until it is high enough to flow through to the next adjacent higher junction in the drainage system or enter the minor system as flow capacity become available. The maximum ponded depth can also be used to determine flooding locations and water depths at these locations.

Major/Minor System Connections

At each manhole location a SWMM5 outlet link was used to control flow from the major system to the minor system. Flow through each outlet was defined by the rating curve considering a 600mm x 600mm herringbone grate (DD-713B - City of Toronto) multiplied by the number of catchbasins within the subcatchment. The rating curve for a single 600mm x 600mm herringbone grate is provided in Table 7. Note that head is based on depth above the rum elevation defined for the model junction.

Table 7 - Rating curve for a single herringbone grated catchbasin (DD-713B - City of Toronto)

Head (m)	Outflow (m ³ /s)
0	0
0.060	0.0073
0.065	0.0115
0.070	0.0143
0.080	0.0226
0.090	0.0354
0.100	0.0461
0.104	0.0500
0.110	0.0549
0.120	0.0644
0.130	0.0726
0.140	0.0802
0.150	0.0872
0.200	0.1165
0.250	0.1393
0.300	0.1579

A typical roadway cross section was used to model the major system or roadway conveyance. Roadway transects were defined with a standard 1-, 2-, or 3- lane right-of-way cross section, as appropriate.

Integrated 1D-2D model

Surface flooding conditions result when streamflows overtop the banks or when the hydraulic gradeline in piped collection systems rises above the catchbasin inlet elevation. Overland flood flows such as these are potentially problematic using a strictly 1D model representation: there may be multiple flow pathways around and through obstructions, and overland flow paths can be ill-defined and variable between flood events.

With PCSWMM, the fully dynamic 1D approach of SWMM is extended to simulate the routing of overland free surface flows through an interconnected two-dimensional link-node mesh. As a result, PCSWMM can provide accurate modeling of flood depths, flows and velocities for both urban and rural applications, including river-based flooding, major/minor (dual drainage) modeling, or simply overland routing of rainfall runoff. In addition to representing overbank flooding from watercourses or overland surface flooding from piped systems, the 2D modeling approach can be used for distributed hydrologic modeling (i.e., gridded rainfall data can be applied to individual cells within the 2D mesh).

In essence, PCSWMM 2D approximates two-dimensional flood routing using the dynamic wave solution within the SWMM computational engine (i.e., the full 1D Saint-Venant equations, solved in multiple directions). In SWMM, the typical formulation of the 1D depth-averaged momentum and continuity equations for homogeneous fluids is solved along each component of a computational cell, over a network of model nodes and free-surface links that represents the physical hydrography, bathymetry or topography. PCSWMM 2D does not solve the full 2D shallow water flow equations, nor does it consider the Coriolis force (which is a factor for very large study areas), wind shear forces or turbulent eddy viscosity.

An integrated 1D-2D model was added to the 1D component of the model to account for the overland flooding. An initial boundary was defined using a study area polygon provided. This boundary was adjusted iteratively to ensure the flooding was captured in the model. Areas outside of the flooding zone retained their 1D model representation.

Roadways were modeled using a directional mesh with a resolution of 4 meters and assigned a Manning's roughness of 0.015. In some cases, the resolution was reduced to 3 m to capture the detail and contours of the roadway. Separate bounding polygons were used to represent the flooding in the

channel. The remaining areas were modeled using a hexagonal mesh with a resolution of 10 m and a roughness of 0.05. The DEM provided had a resolution of 1m but was derived using a 10 m DEM.

Four 1D conduits were added to the 2D mesh to represent the roadway conveyance under Hwy 404 and the CPR line. To do this, two rectangular roadway cross-sections were assigned to these conduits to reflect the hydraulic flow connection through the underpass.

An obstruction layer was used to model the 2D flow conveyance around the buildings. These buildings were taken from a buildings layer provided. In addition, an additional obstruction was added to the buildings layer representing the jersey barriers on Hwy 404.

Outfall

The model outfall represents conditions in of the Don Mills channel downstream of the study area. A normal outfall was assigned with a fixed tailwater elevation of 164 m, taken from the HEC-RAS model provided.

Inlet Control Devices

The ICDs were modeled as storage units connected to orifices. The invert and rim elevations of the storage units were set to the defined pipe invert elevation and the 100 year water level. Surface storage volumes, ICD diameters and other details were taken from available reports and design drawings provided. Appendix A summarizes this information.

Calibration – High water marks

Calibration was completed using available high water mark information for two recent flooding events. This was done as there was no flow monitoring data available for calibration.

A shape file with the high water elevations was supplied for the July 27th, 2014 event. A comparison of the high water marks to the closest junction in the node can be found below.

Location	Observed high water mark (m)	Computed high water mark (m) with ICDs	Difference (m)
85 Torbay Rd	176.61	176.27	0.06
55 Torbay Rd	175.34	176.27	0.93
7270 Woodbine Ave	176.08	176.16	0.08
7310 Woodbine Ave	176.06	175.17	0.89

130 Denison St	174.61	174.55	0.06
50 Steelcase Rd E	176.13	176.1 1	0.03

The observed data indicates that there is a 1.27 m maximum WSE difference between 85 Torbay Road and 55 Torbay Road which is unlikely as the locations are approximately 70 m apart. This may account for the 0.93 m difference between the observed and computed values at 55 Torby Rd (see Figure 5).

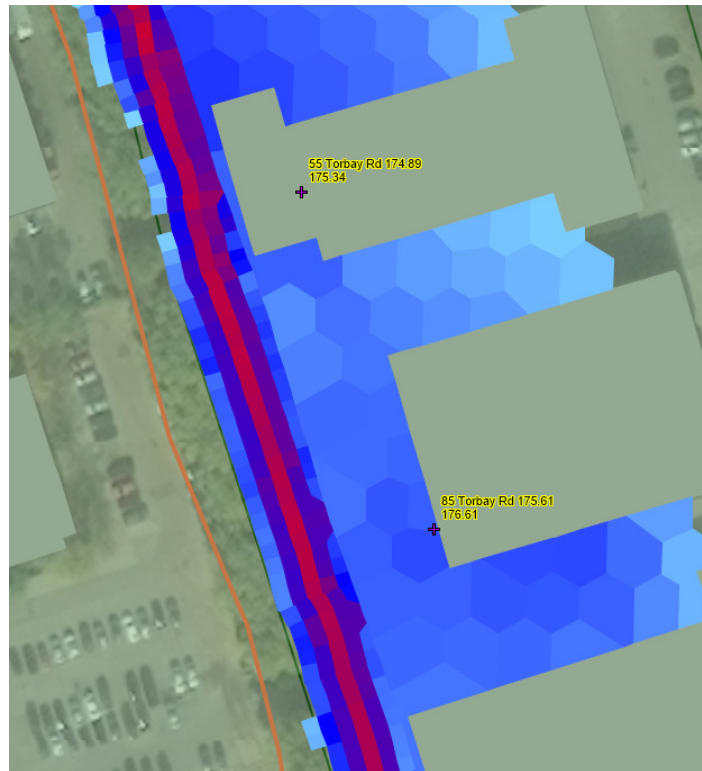


Figure 5 - 55 and 85 Torby Road observed max. WSE values

A shape file with the high water elevations was supplied for the August 18th, 2005 event. A comparison of the high water marks to the closest junction in the node can be found below.

Location	Observed high water mark (m)	Computed high water mark (m) with ICDs	Difference (m)
3120 Steeles	178.13	177.29	0.84
7063 Woodbine NE	177.34	176.8	0.54
7063 Woodbine	177.2	176.68	0.52
7063 Woodbine N	177.09	176.69	0.4

7270 Woodbine S	176.89	176.78	0.11
7270 Woodbine	176.48	176.39	0.09
7270 Woodbine NW	176.19	176.19	0
7301 Woodbine	176.418	176.4	0.018
7270 Woodbine NE	176.042	176.27	0.228
50 Steelcase	175.94	176.39	0.45

Discussion and Conclusion

The Don Mills channel dual drainage model was developed in PCSWMM using data provided by TMIG and the City of Markham. An integrated two-dimensional (2D) model component was added to this model, as a means to better represent floodplain storage and conveyance throughout the study area. Calibration of the model was based on observed high water marks from two historical flooding events: August 18th, 2005 and July 27th, 2014.

The computed peak water surface elevation results for the two events are very close at the majority of locations. Some locations had larger discrepancies, potentially due to errors in estimating high water levels, debris clogging inlets (unmolded response) and rainfall variability.

Based on our calibration results, the model calibration is deemed acceptable for the purposes of this study. It is recommended that a full model calibration using observed sewer flows is completed in the future to further improve the model.

Appendix A - Inlet Control Devices

270-330 Esna Park Drive (OR10)

270-330 Esna Park Drive	
Approximate Area Serviced (ha)	0.5
Approx Orifice Size (mm)	100
Orifice Type	Plate
100 yr WL	187.44
Pipe Inv	185.8
Approx 100 yr Outflow (cms)	0.03
Approx 2 Year Pre (Area Serviced with C = 0.3, 90.8mm/hr - Markham IDF)	0.038
Approx 2 Year Pre (Area Serviced with C = 0.7, 90.8mm/hr - Markham IDF)	0.088
100 yr Outflow Lower Than 2 Year Pre (C=0.3)?	Yes
100 yr Outflow Lower Than 2 Year Pre (C=0.7)?	Yes
Detailed drawings	No
Included in model	Yes

Modeling notes:

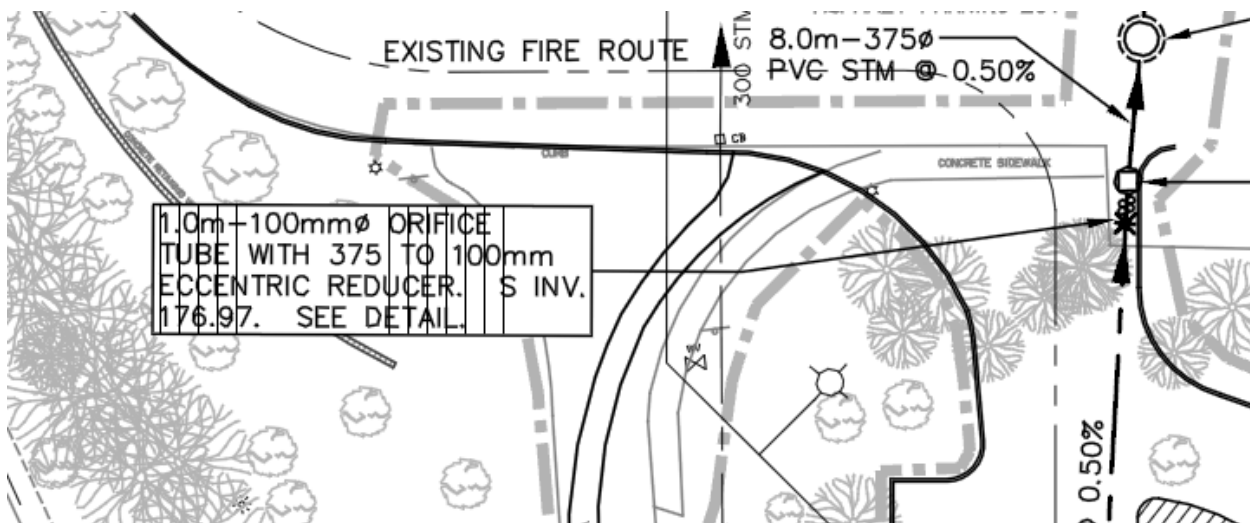
- SWM implemented for parking lot re-construction in 2006 (buildings not changed)
- Separated the parking lot from the building area and modeled parking lot draining into a single orifice link.

3500 Steeles Ave. East (ORICD26)

Original Construction 1988, SW parking re-done in 2008 - Drawings for 1988 Work Not found, but Underground/Parking Lot Storage Used

3500 Steeles Ave. East	
Approximate Area Serviced (ha)	16.5
Approx Orifice Size (mm)	100
Orifice Type	
Flow Control	Orifice

100 yr WL	
Pipe Inv	176.97
Approx 100 yr Outflow (cms)	
Approx 2 Year Pre (Area Serviced with C = 0.3, 90.8mm/hr - Markham IDF)	1.249
Approx 2 Year Pre (Area Serviced with C = 0.7, 90.8mm/hr - Markham IDF)	2.913
100 yr Outflow Lower Than 2 Year Pre (C=0.3)?	Not provided
100 yr Outflow Lower Than 2 Year Pre (C=0.7)?	Not provided
Detailed drawings	Yes
Included in model	Yes



Modeling notes:

- 3500 Steeles was modeled using a storage unit and a side circular weir with a height of 0.1 m.

3600 Steeles Ave. East (OR1)

File Lost - Underground/Parking Lot Storage used - Assume 100 yr Post to 2 year Pre (C = 0.3)

Flow controls and ponding areas are not indicated in drawings

3600 Steeles Ave. East	
Approximate Area Serviced (ha)	10.3
Approx Orifice Size (mm)	Assumed 100

Orifice Type	
Flow Control	Orifice
100 yr WL	
Pipe Inv	Assumed 181.0
Approx 100 yr Outflow (cms)	
Approx 2 Year Pre (Area Serviced with C = 0.3, 90.8mm/hr - Markham IDF)	0.779
Approx 2 Year Pre (Area Serviced with C = 0.7, 90.8mm/hr - Markham IDF)	1.819
100 yr Outflow Lower Than 2 Year Pre (C=0.3)?	
100 yr Outflow Lower Than 2 Year Pre (C=0.7)?	
Detailed drawings	No
Included in model	Yes

Modeling notes:

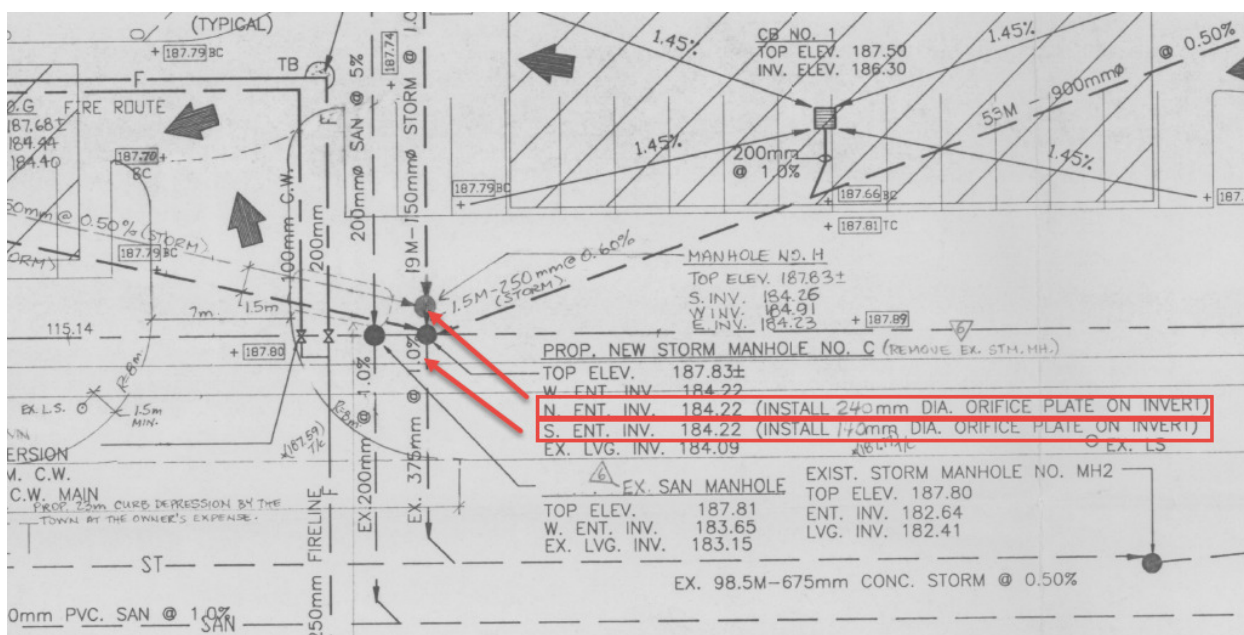
- 3600 Steeles was modeled using a storage unit and a side circular weir with an assumed height of 0.1 m and an assumed elevation of 181 m.

3636 Steeles Ave. East (ORICD9)

Multiple Orifices at site outlet (140mm Final Plate)

3600 Steeles Ave. East	
Approximate Area Serviced (ha)	1.4
Approx Orifice Size (mm)	140 240
Orifice Type	
Flow Control	Orifice plate
100 yr WL	187.8
Pipe Inv	184.22 184.22
Approx 100 yr Outflow (cms)	0.08

Approx 2 Year Pre (Area Serviced with C = 0.3, 90.8mm/hr - Markham IDF)	0.106
Approx 2 Year Pre (Area Serviced with C = 0.7, 90.8mm/hr - Markham IDF)	0.247
100 yr Outflow Lower Than 2 Year Pre (C=0.3)?	Yes
100 yr Outflow Lower Than 2 Year Pre (C=0.7)?	Yes
Detailed drawings	
Included in model	Yes



Modeling notes:

- 3636 Steeles Ave. was modeled using a storage unit and a single orifice.

7010 - 7080 Warden Ave (ORT26, ORT30, ORT28, ORT27, OR27)

3 parallel orifice structures, and multiple OGS (3) on site, report likely available

7010 - 7080 Warden Ave	
Approximate Area Serviced (ha)	5.27
Approx Orifice Size (mm)	150
	150

	100 200 150
Orifice Type	All are tube
Flow Control	Orifice
100 yr WL	193.8
Pipe Inv	189.5 189.29 190.95 188.78 188.26
Approx 100 yr Outflow (cms)	0.054
Approx 2 Year Pre (Area Serviced with C = 0.3, 90.8mm/hr - Markham IDF)	0.076
Approx 2 Year Pre (Area Serviced with C = 0.7, 90.8mm/hr - Markham IDF)	0.177
100 yr Outflow Lower Than 2 Year Pre (C=0.3)?	Yes
100 yr Outflow Lower Than 2 Year Pre (C=0.7)?	Yes
Detailed drawings	No
Included in model	Yes

Modeling notes:

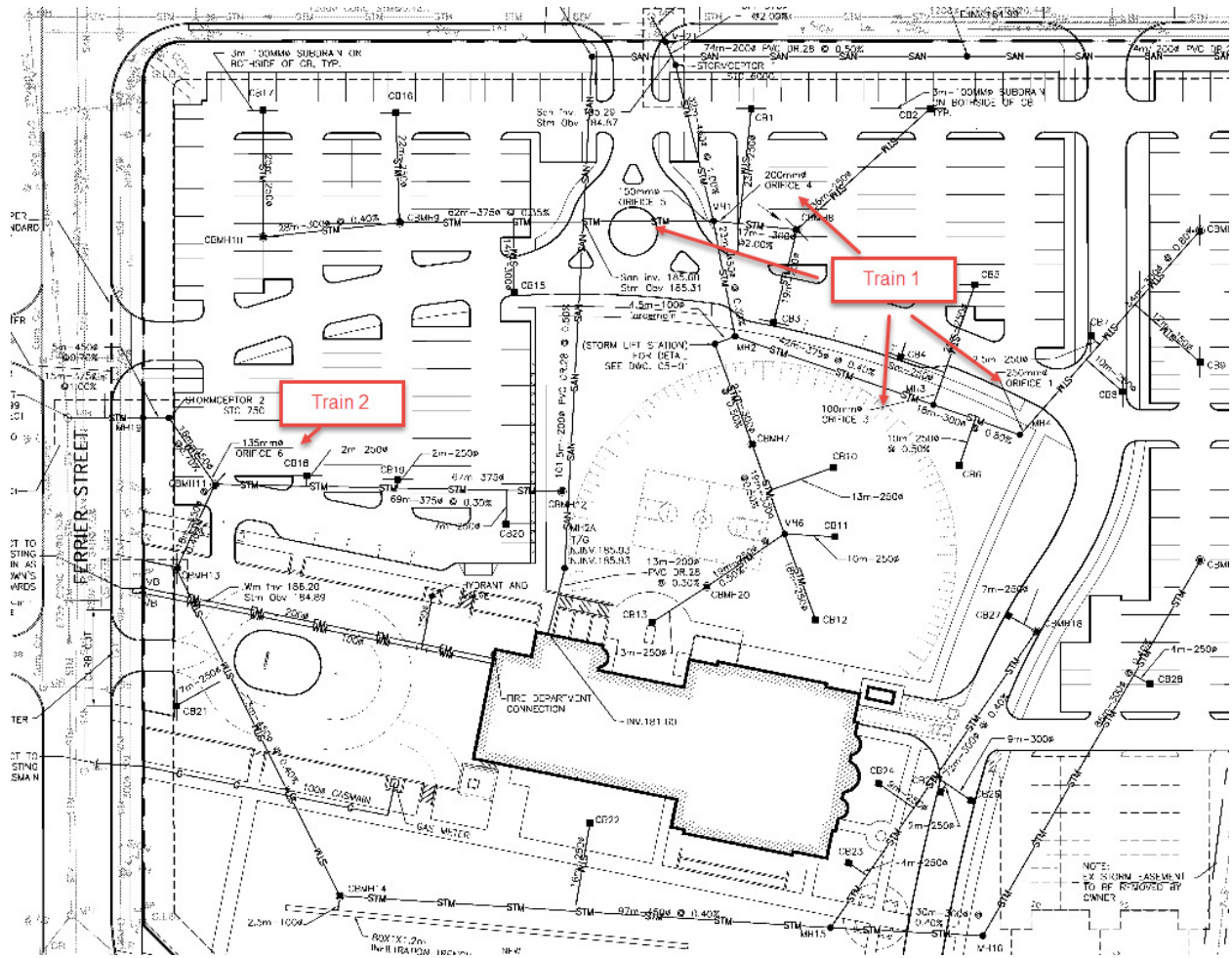
- Lumped 7010 – 7080 into a single subcatchment with 5 parallel orifices. Not able to see orifices on drawing. Assumed all orifices were parallel.

455 Ferrier St (ORT14, OR120, OR121, OR122, OR123)

Infiltration trenches also installed, 135mm tube specified - likely 150mm installed

455 Ferrier St	
Approximate Area Serviced (ha)	4.9
Approx Orifice Size (mm)	Orifice 1 (MH4) - 250 Orifice 3 (MH3) - 250

	Orifice 4 (MH1) - 200 Orifice 5 (MH1) - 150 Orifice 6 (CBMH11) – 135 (used 150 in model)
Orifice Type	All are Orifice Tube
Flow Control	Orifice
100 yr WL	187.5
Pipe Inv	Orifice 1 - 187.2 Orifice 3 - 187.2 Orifice 4 - 186.16 Orifice 5 - 185.07 Orifice 6 - 184.36
Approx 100 yr Outflow (cms)	0.09
Approx 2 Year Pre (Area Serviced with C = 0.3, 90.8mm/hr - Markham IDF)	0.371
Approx 2 Year Pre (Area Serviced with C = 0.7, 90.8mm/hr - Markham IDF)	0.865
100 yr Outflow Lower Than 2 Year Pre (C=0.3)?	Yes
100 yr Outflow Lower Than 2 Year Pre (C=0.7)?	Yes
Detailed drawings	
Included in model	



Modeling notes:

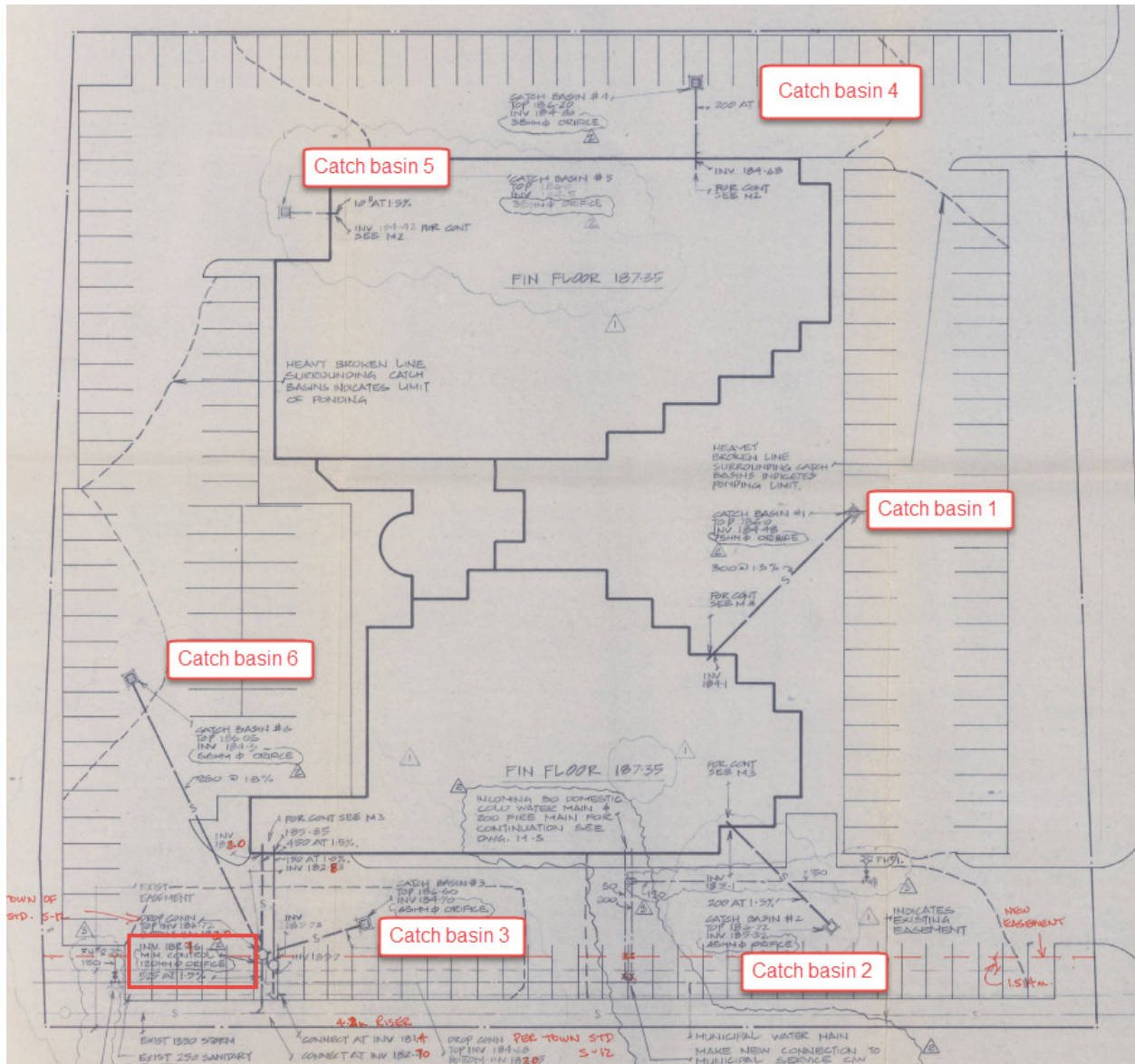
- 455 Ferrier Street had two stormwater ICD trains draining to different locations in the minor system. To model the two trains, subcatchment S_90 was split. The first train, draining the area in the north side of the subcatchment, included orifices 1, 3, 5 and 5 and were modelled as parallel orifices, while the other train drained the southern side of the site included orifice 6 and was modeled using a 150 mm diameter.

340 Ferrier St (ORCB7)

120mm orifice at site outfall - Report likely available through records

340 Ferrier St	
Approximate Area Served (ha)	1.2
Approx Orifice Size (mm)	75
	45

	45 38 38 66 120
Orifice Type	Plate
Flow Control	
100 yr WL	186.35
Pipe Inv	184.48 185.32 184.4 184.8 184.5 184.3 182.76
Approx 100 yr Outflow (cms)	0.06
Approx 2 Year Pre (Area Serviced with C = 0.3, 90.8mm/hr - Markham IDF)	0.091
Approx 2 Year Pre (Area Serviced with C = 0.7, 90.8mm/hr - Markham IDF)	0.212
100 yr Outflow Lower Than 2 Year Pre (C=0.3)?	Yes
100 yr Outflow Lower Than 2 Year Pre (C=0.7)?	Yes
Detailed drawings	
Included in model	



Modeling notes:

- Catchbasin 1, 2, 3, 4, 5 and 6 all have an orifice downstream which appears to be draining to the stormwater minor system and routed off site via 120 mm orifice. For this site only the furthest 120 mm downstream orifice was modeled.

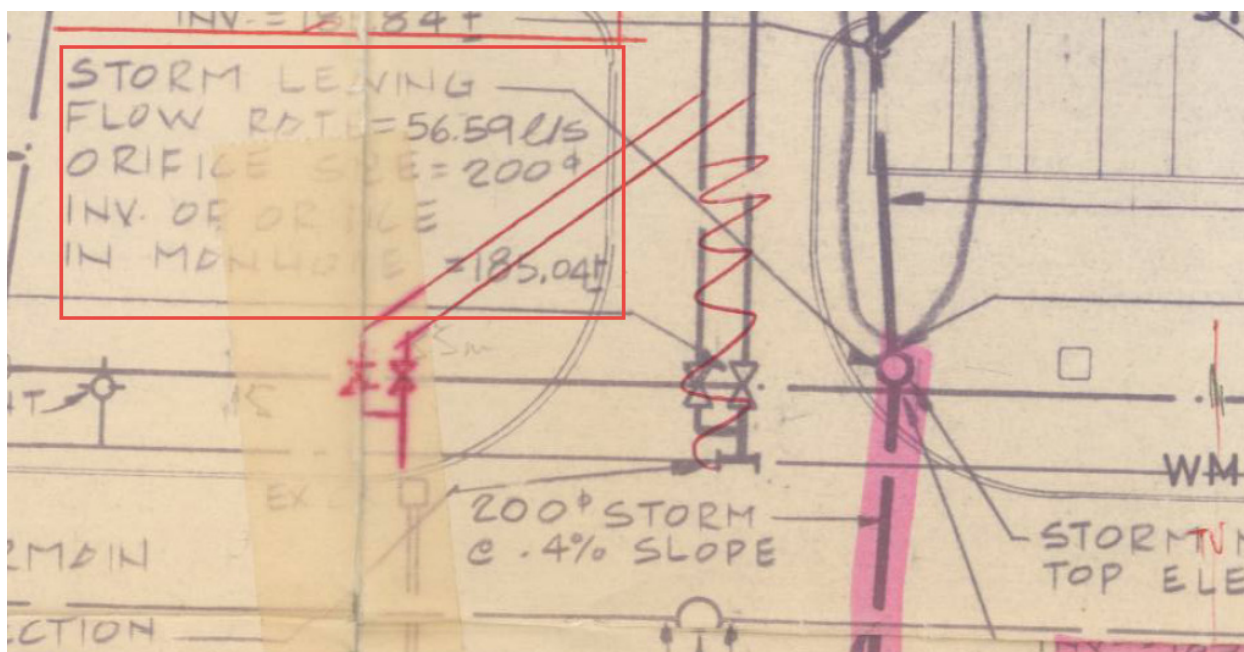
50-100 Acadia Ave (OR127, OR126, OR128, OR124, OR125, OR119, OR16, OR24)

CB Inlet controls and 110mm orifice (per 100 Acadia drawing)

50 Acadia Ave	
Approximate Area Served (ha)	1.5
	1.6

Approx Orifice Size (mm)	1200 150 150 200 150 150 150 Assumed 150 250 200 250
Orifice Type	Plate IPEX ICDs
Flow Control	
100 yr WL	185.57
Pipe Inv	187.92 187.57 190.18 188.08 188.06 (d) 186.11 187.75 187 187.3 185.04 187.13
Approx 100 yr Outflow (cms)	0.05 0.09
Approx 2 Year Pre (Area Serviced with C = 0.3, 90.8mm/hr - Markham IDF)	0.114 0.121

Approx 2 Year Pre (Area Serviced with C = 0.7, 90.8mm/hr - Markham IDF)	0.265 0.282
100 yr Outflow Lower Than 2 Year Pre (C=0.3)?	Yes
100 yr Outflow Lower Than 2 Year Pre (C=0.7)?	Yes
Detailed drawings	Yes
Included in model	Yes



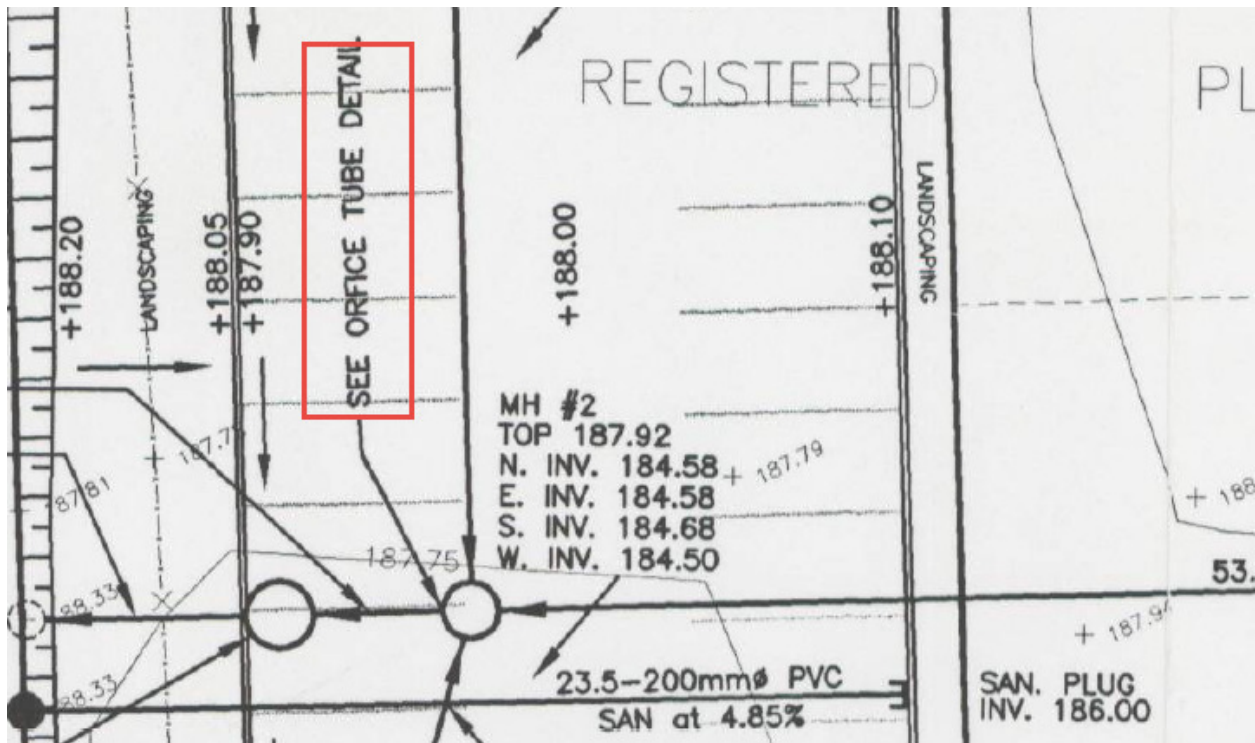
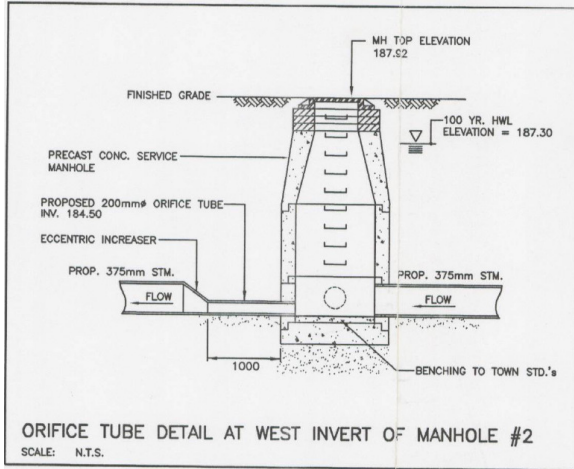
Modeling notes:

- This site was divided using the indicated ponding areas shown in the site drawing. For all the areas the ICDs were modeled using a storage units where the curve was defined defined using the indicated water detention ponding area provided in the drawing.

351 Ferrier Street (OR23)

351 Ferrier Street	
Approximate Area Serviced (ha)	1.1 2.52
Approx Orifice Size (mm)	200 - Loading Dock(s) and Parking Lot 300 - Roof Top Detention

Orifice Type	
Flow Control	Orifice Tube Orifice Tube
100 yr WL	187.2 183
Pipe Inv	184.25 180.33 (too low and could not confirm in drawing, assumed 183.229 m, the elevation of the connected junction)
Storage	235.3 209
Max ponding Elevation (m)	0.5 0.15
Approx 100 yr Outflow (cms)	0.201 0.430
Approx 2 Year Pre (Area Serviced with C = 0.3, 90.8mm/hr - Markham IDF)	0.083 0.191
Approx 2 Year Pre (Area Serviced with C = 0.7, 90.8mm/hr - Markham IDF)	0.194 0.445
100 yr Outflow Lower Than 2 Year Pre (C=0.3)?	No No
100 yr Outflow Lower Than 2 Year Pre (C=0.7)?	No Yes
Detailed drawings	Yes
Included in model	Yes

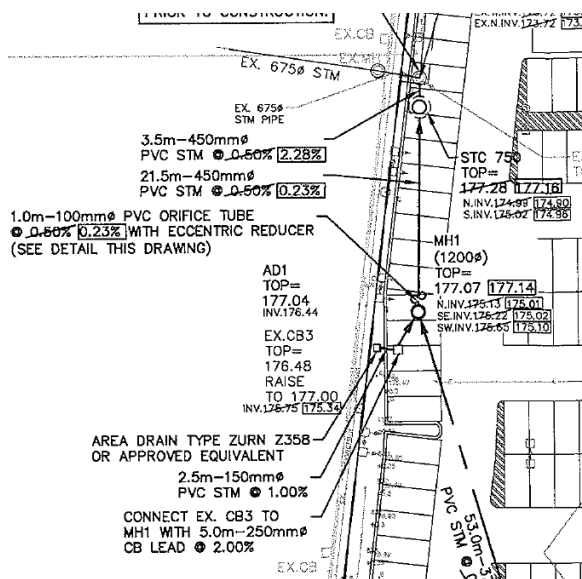


Modeling notes:

- Site SWM plan has surcharge through building mechanical system
- Rodick Road Widening, quantity provided, but not to overcontrol standard - Several drawings available
- Separated the roof area from the original subcatchment parcel. The inlet elevation of the roof drainage pipe was thought to be too low (180.33 m) and was adjusted.

3120 Steeles Ave E (OR3)

3120 Steeles Ave. E	
Approximate Area Serviced (ha)	1.5
Approx Orifice Size (mm)	100
Orifice Type	Tube
Flow Control	
100 yr WL	177.2
Pipe Inv	175.13
Approx 100 yr Outflow (cms)	0.042
Approx 2 Year Pre (Area Serviced with C = 0.3, 90.8mm/hr - Markham IDF)	0.114
Approx 2 Year Pre (Area Serviced with C = 0.7, 90.8mm/hr - Markham IDF)	0.265
100 yr Outflow Lower Than 2 Year Pre (C=0.3)?	Yes
100 yr Outflow Lower Than 2 Year Pre (C=0.7)?	Yes
Detailed drawings	Yes
Included in model	Yes



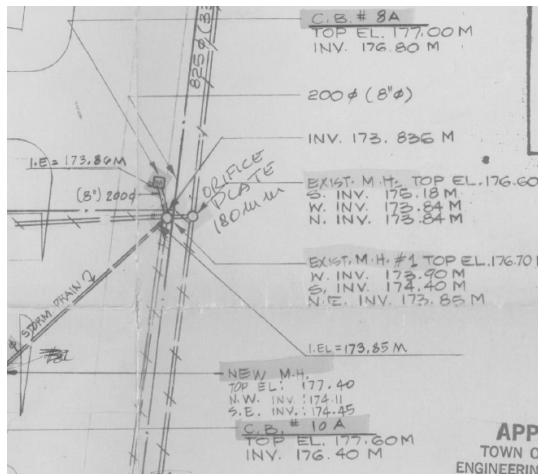
Modeling notes:

- SWM Control - 10 year post -> 2 year Pre
- This site routes all the stormwater to a 100 mm orifice. In this case a single orifice was modeled and a tabular relationship was used with an assumed manhole surface area of 1m². Because the ICD was within the 2D boundary area, it was connected to the 2D overland mesh using a direct connection.

3000-3100 Steeles Ave E (OR4)

SWM Control for 3100 Steeles (123mm Orifice), includes 7063 Woodbine

3120 Steeles Ave. E	
Approximate Area Serviced (ha)	1.68
Approx Orifice Size (mm)	180
Orifice Type	Plate
Flow Control	
100 yr WL	176.9
Pipe Inv	174.25 174.25
Approx 100 yr Outflow (cms)	0.05
Approx 2 Year Pre (Area Serviced with C = 0.3, 90.8mm/hr - Markham IDF)	0.127
Approx 2 Year Pre (Area Serviced with C = 0.7, 90.8mm/hr - Markham IDF)	0.297
100 yr Outflow Lower Than 2 Year Pre (C=0.3)?	Yes
100 yr Outflow Lower Than 2 Year Pre (C=0.7)?	Yes
Detailed drawings	Yes
Included in model	Yes



Modeling notes:

- Modeled as a storage unit with a single orifice that used a tabular relationship and an assumed manhole surface area of 1m². Because the ICD was within the 2D boundary area, it was connected to the 2D overland mesh using a direct connection.

7063 Woodbine Ave (OR5)

See red-lined drawing - 180mm orifice structure

7063 Woodbine Ave	
Approximate Area Serviced (ha)	1.56
Approx Orifice Size (mm)	180
Orifice Type	Plate
Flow Control	
100 yr WL	177.9
Pipe Inv	173.84
Approx 100 yr Outflow (cms)	0.14
Approx 2 Year Pre (Area Serviced with C = 0.3, 90.8mm/hr - Markham IDF)	0.118
Approx 2 Year Pre (Area Serviced with C = 0.7, 90.8mm/hr - Markham IDF)	0.275
100 yr Outflow Lower Than 2 Year Pre (C=0.3)?	Yes
100 yr Outflow Lower Than 2 Year Pre (C=0.7)?	Yes
Detailed drawings	Yes

Included in model	Yes
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Modeling notes:

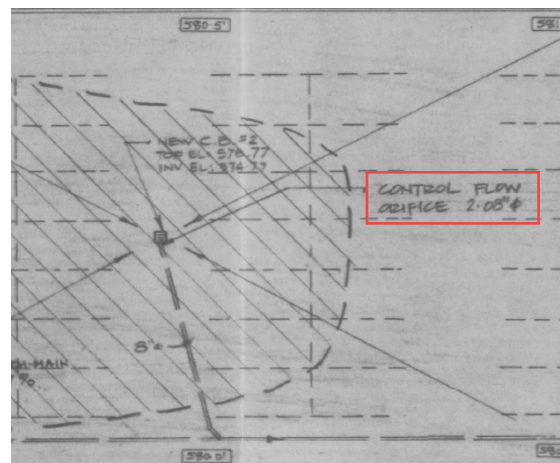
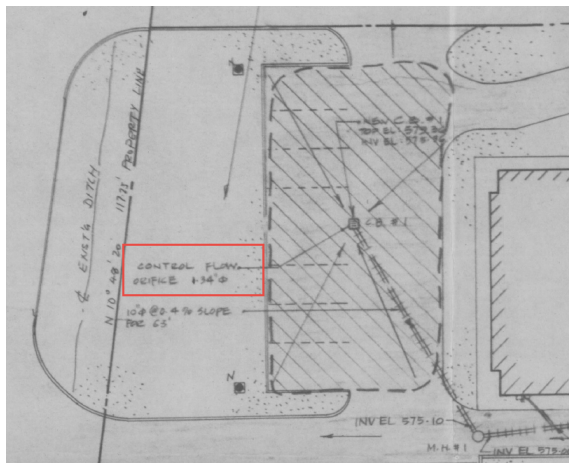
- In this case a single orifice was modeled and a tabular relationship was used with an assumed manhole surface area of 1m². Because the ICD was within the 2D boundary area, it was connected to the 2D overland mesh using a direct connection.

7085 Woodbine Ave (OR6, OR7)

See red-lined drawing - 180mm orifice structure

7085 Woodbine Ave	
Approximate Area Serviced (ha)	0.22
	0.1
	Total area = 1.22 ha
Approx Orifice Size (mm)	60
	35
Orifice Type	Plate
	Plate
	Tube
	Control Flow Roof Drain

Flow Control	
100 yr WL	176.40 176.88
Pipe Inv	175.09 175.36
Approx 100 yr Outflow (cms)	0.009 0.003
Approx 2 Year Pre (Area Serviced with C = 0.3, 90.8mm/hr - Markham IDF)	0.024
Approx 2 Year Pre (Area Serviced with C = 0.7, 90.8mm/hr - Markham IDF)	0.039
100 yr Outflow Lower Than 2 Year Pre (C=0.3)?	Yes
100 yr Outflow Lower Than 2 Year Pre (C=0.7)?	Yes
Detailed drawings	Yes
Included in model	Yes



Modeling notes:

- In this case there were two orifices that drained into the same outlet so they were modeled as parallel orifices and a tabular relationship was used with an assumed manhole surface area of 1m². Because the ICD was within the 2D boundary area, it was connected to the 2D overland mesh using a direct connection.

1 Steelcase Rd W (OR8, OR28)

Partial SWM for some areas retrofitted in 2001, small area pumped, multiple discharge points
Flow split is difficult to follow

1 Steelcase Rd W	
Approximate Area Serviced (ha)	3.14
Approx Orifice Size (mm)	250 150
Orifice Type	Tube Tube
Flow Control	
100 yr WL	179.7 177.15
Pipe Inv	177.83 175.91
Approx 100 yr Outflow (cms)	0.25 0.07
Approx 2 Year Pre (Area Serviced with C = 0.3, 90.8mm/hr - Markham IDF)	0.238
Approx 2 Year Pre (Area Serviced with C = 0.7, 90.8mm/hr - Markham IDF)	0.554 0.000
100 yr Outflow Lower Than 2 Year Pre (C=0.3)?	No No
100 yr Outflow Lower Than 2 Year Pre (C=0.7)?	No No
Detailed drawings	Flow split is difficult to follow
Included in model	Yes

Modeling notes:

- The two orifices were modeled using two parallel orifices and a tabular relationship was used with an assumed manhole surface area of 1m². Because the ICD was within the 2D boundary area, it was connected to the 2D overland mesh using a direct connection.

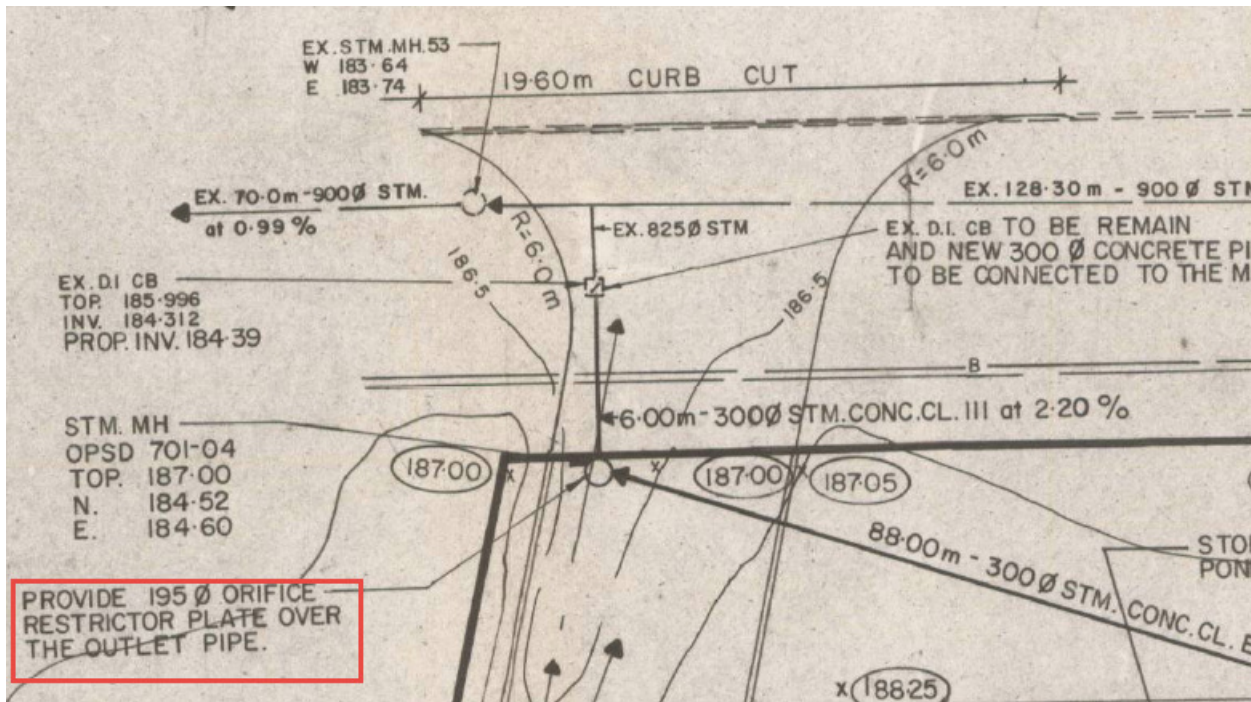
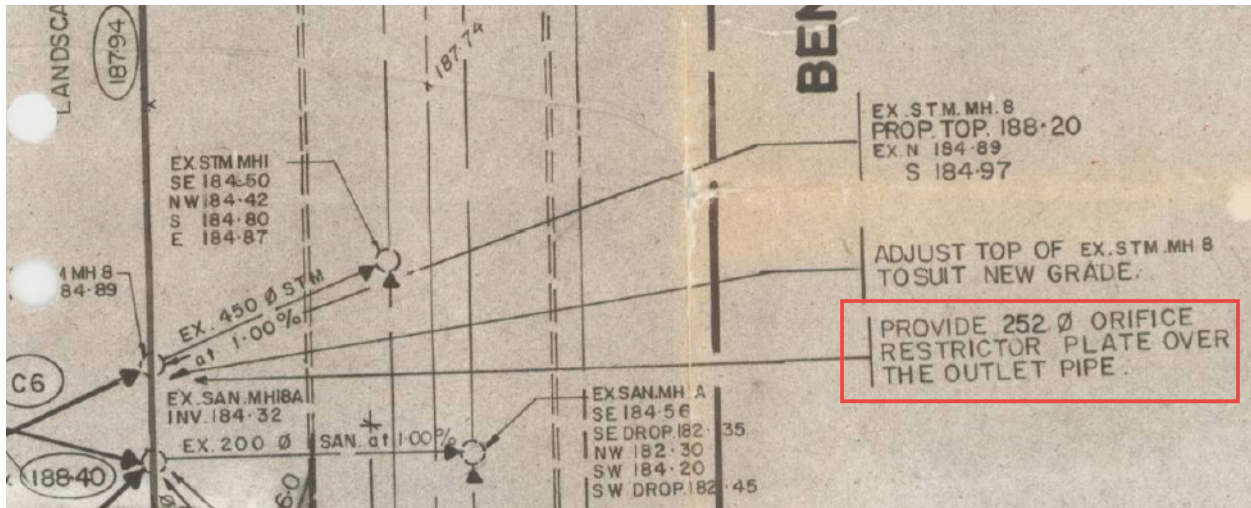
200-400 Bentley St. (OR12, OR13)

227mm Orifice for 200-380, 3 parallel tubes/plates for 400 Bentley

200-400 Bentley St	
Approximate Area Serviced (ha)	1.5 1.5
Minimum Elevation (m)	189.82 189.82
Storage	129.2 24
Minimum Ponding Elevation (m)	189.82
Approx Orifice Size (mm)	227 (200 - 400) Bentley Street 100
Orifice Type	Plate Tube
Flow Control	
100 yr WL	189.85 189.5
Pipe Inv	186.16 186
Approx 100 yr Outflow (cms)	0.21 0.05
Approx 2 Year Pre (Area Serviced with C = 0.3, 90.8mm/hr - Markham IDF)	0.114 0.114
Approx 2 Year Pre (Area Serviced with C = 0.7, 90.8mm/hr - Markham IDF)	0.265 0.265
100 yr Outflow Lower Than 2 Year Pre (C=0.3)?	No

	187.65 187.65
Maximum Elevation	188.05 188.05 187.88 187.88
Storage	63 13.4 65.3 53.8
Maximum Ponding elevation	188.05 188.05 187.88 187.88
Orifice Type	Plate Plate
Flow Control	
100 yr WL	188.05 187.88
Pipe Inv	184.52 184.89
Approx 100 yr Outflow (cms)	0.15 0.24
Approx 2 Year Pre (Area Serviced with C = 0.3, 90.8mm/hr - Markham IDF)	0.038 0.076
Approx 2 Year Pre (Area Serviced with C = 0.7, 90.8mm/hr - Markham IDF)	0.088 0.177
100 yr Outflow Lower Than 2 Year Pre (C=0.3)?	No No
100 yr Outflow Lower Than 2 Year Pre (C=0.7)?	No No

Detailed drawings	Yes
Included in model	Yes



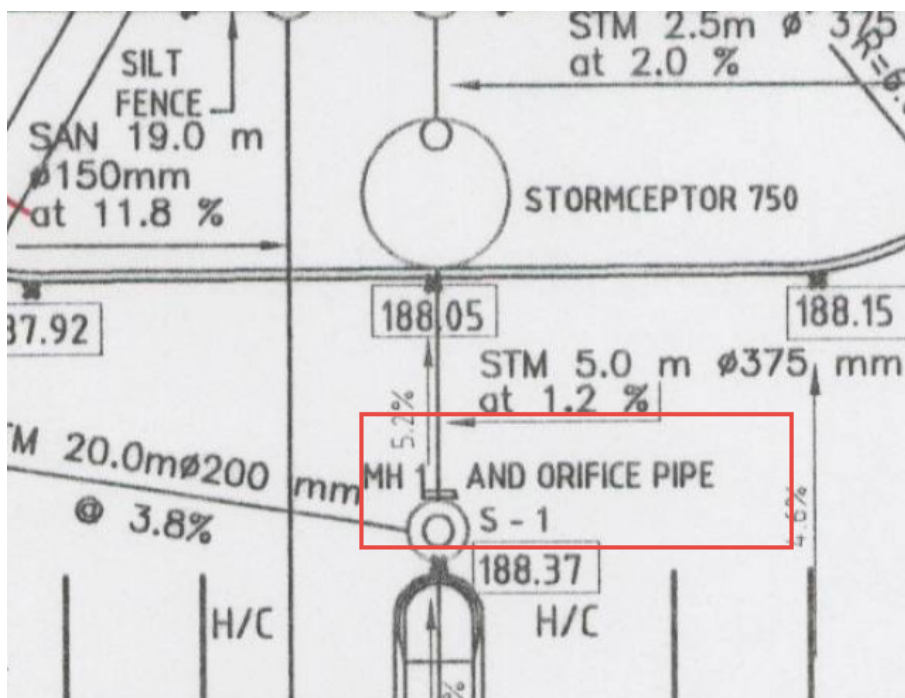
Modeling notes:

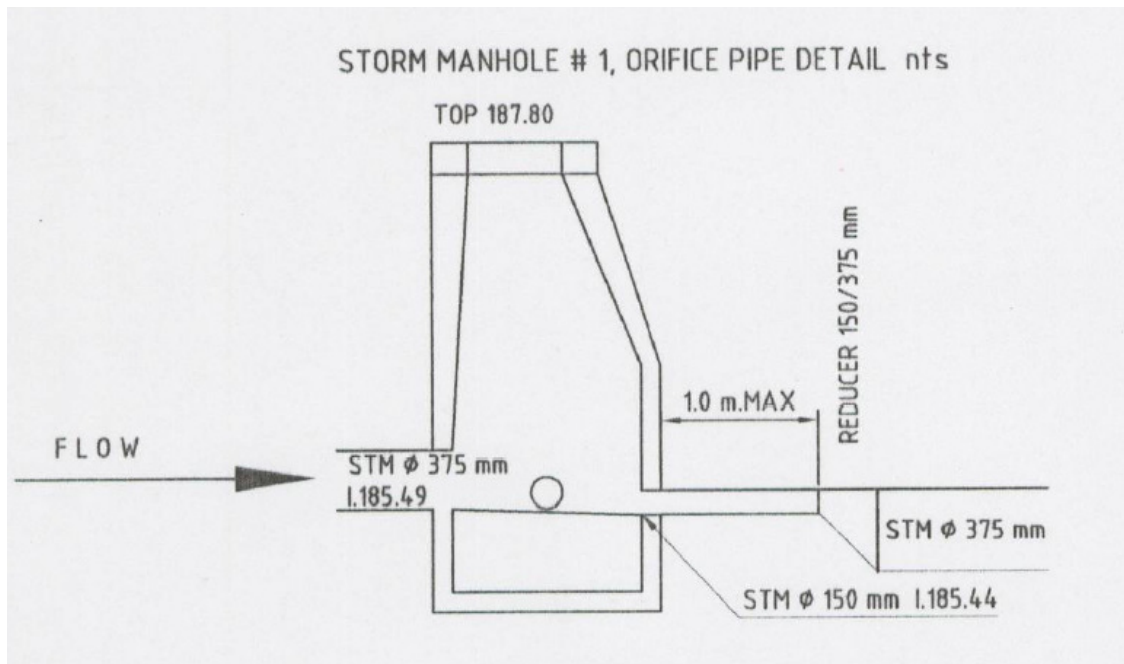
- Modeled as two parallel orifices connected to a storage unit.

165 Gibson Dr (OR11)

Designed to surcharge through building mechanical system

165 Gibson Dr	
Approximate Area Serviced (ha)	0.5
Approx Orifice Size (mm)	150
Orifice Type	Tube
Flow Control	
100 yr WL	187.9
Pipe Inv	185.44
Invert elevation	187.80
Approx 100 yr Outflow (cms)	0.10
Approx 2 Year Pre (Area Serviced with C = 0.3, 90.8mm/hr - Markham IDF)	0.038
Approx 2 Year Pre (Area Serviced with C = 0.7, 90.8mm/hr - Markham IDF)	0.088
100 yr Outflow Lower Than 2 Year Pre (C=0.3)?	No
100 yr Outflow Lower Than 2 Year Pre (C=0.7)?	No
Detailed drawings	Yes
Included in model	Yes





Modeling notes:

- Modeled as a storage unit with a single functional orifice.