11 YORKVILLE PARTNERS INC.

STORMWATER MANAGEMENT REPORT

BUILDING A - 11-25 YORKVILLE AVE.

AUGUST 22, 2019

STORMWATER MANAGEMENT REPORT

BUILDING A - 11-25 YORKVILLE AVE.

11 YORKVILLE PARTNERS INC.

REZONING & SITE PLAN APPLICATION

PROJECT NO.: 17M-01494-00
DATE: AUGUST 2019

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ISSUE/REVISION	FIRST ISSUE	REVISION #1	REVISION #2	REVISION #3
Remarks	RZA & SPA	RZA & SPA	RZA & SPA	RZA & SPA
Date	03/23/2018	12/14/2018	03/22/2019	08/22/2019
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Signature				
Project number	17M-01494-00	17M-01494-00	17M-01494-00	17M-01494-00

SIGNATURES

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Project Engineer, Water Resources

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PRODUCTION TEAM

CLIENT

11 Yorkville Partnership Inc.

WSP

Designer (EIT)	Nicholas Mah, EIT
Project Engineer	Iain Smith, P.Eng.

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1 INTRODUCTION

1.1 SCOPE

WSP has been retained by 11 Yorkville Partnership Inc. to prepare a Stormwater Management Report for the proposed development of 11-25 Yorkville Avenue and 16-18 Cumberland Street in the City of Toronto (herein referred to as Building A and B, respectively, or 'the site'). This report is to support the Rezoning Application and Site Plan Application for Building A and the Rezoning Application for Building B. A separate SWM report will be completed for the Site Plan Application for Building B at 16-18 Cumberland Street.

This stormwater management report examines the potential water quality, quantity and water balance impacts of the proposed development and summarizes how each will be addressed in accordance with the City of Toronto's Wet Weather Flow Management Guidelines (WWFMG).

1.2 SITE LOCATION

The site is located on the south side of Yorkville Avenue just west of Yonge Street and on the north side of Cumberland Street. The total site area is 0.28 ha. Building A is 0.24 ha and Building B is 0.04 ha. The location of the proposed development is shown in Figure 1.

1.3 STORMWATER MANAGEMENT PLAN OBJECTIVES

The objectives of the stormwater management plan are as follows:

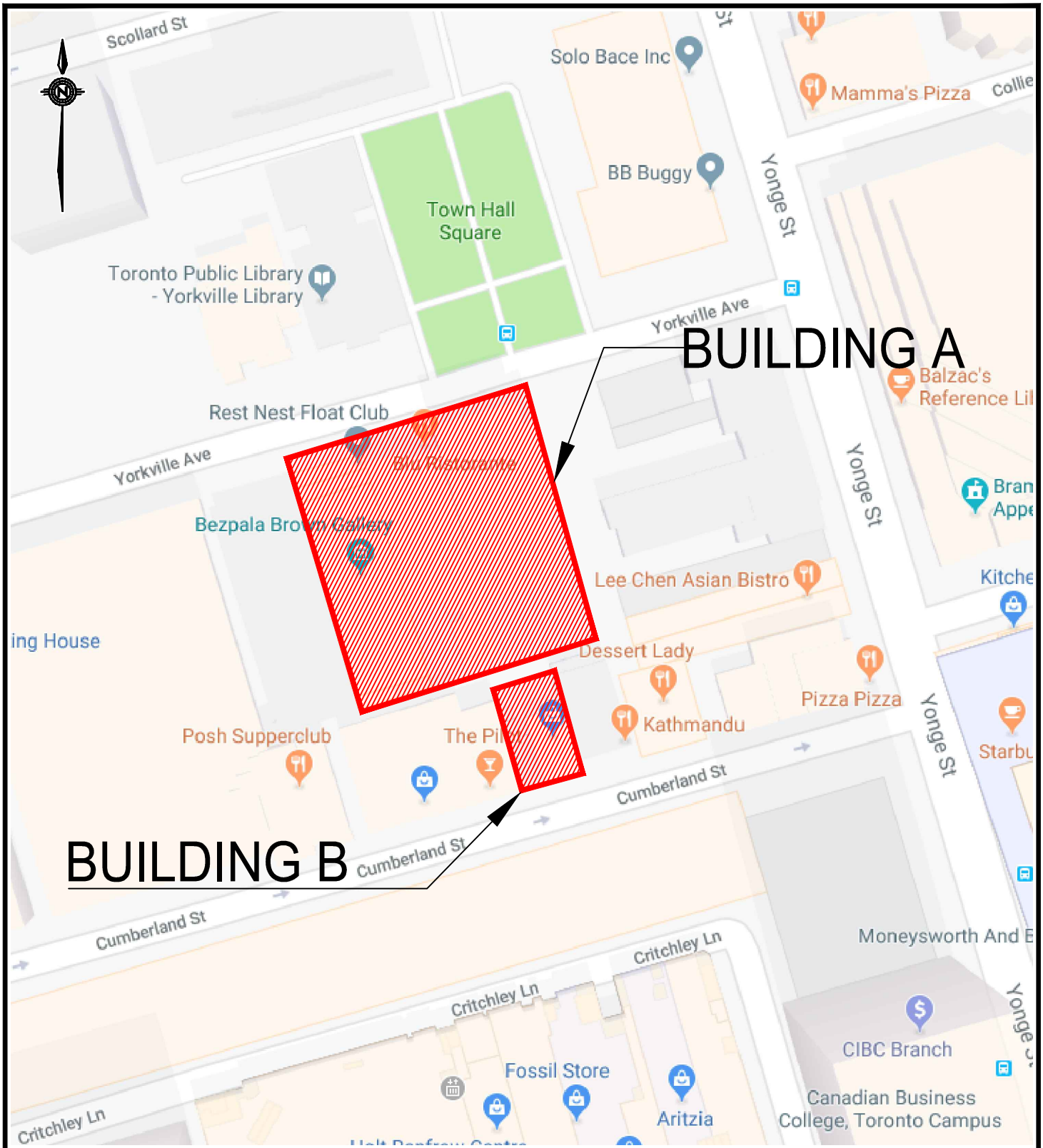
- Determine site specific stormwater management requirements to ensure that the proposals are in conformance with the City of Toronto WWFMG document;
- Evaluate various stormwater management practices that meet the requirements of the City and recommend a preferred strategy; and
- Prepare a stormwater management report documenting the strategy along with the technical information necessary for the justification and sizing of the proposed stormwater management facilities.

1.4 DESIGN CRITERIA

The City of Toronto issued the WWFMG document in November 2006 to provide direction on the management of rainfall and runoff inside the City's jurisdiction. A summary of the stormwater management criteria applicable to this project follows:

- **Water Balance** – The WWFMG requires a site to 'retain stormwater on-site, to the extent practicable, to achieve the same level of annual volume of overland runoff allowable from the development site under pre-development conditions'. According to the guidelines, if the allowable annual runoff volume from the development site under post-development conditions is less than the pre-development conditions, then the maximum allowable annual runoff is 50% of the total average annual rainfall depth. Typically, the minimum on-site runoff retention will require the site to retain all runoff from 5 mm storm event through infiltration, evapotranspiration or rainwater reuse.
- **Water Quality** – Under the WWFMG, the site is required to target a long-term removal of 80% of total suspended solids (TSS) on an annual loading basis.

- **Erosion Control** –As indicated in WWFMG, 'For small infill/redevelopment sites < 2.0 ha, erosion control in the form of stormwater detention is normally not required, provided the on-site minimum runoff retention from a small design rainfall event (typically 5 mm) is achieved under the Water Balance Criteria.' During construction, appropriate erosion and sediment controls will be implemented.
- **Water Quantity Control and Discharge to Municipal Infrastructure** – Runoff from the 2-year to 100-year design storms must not exceed the allowable release rate as stated in the WWFMG. The allowable release rate to the municipal storm sewer system from the development site is the 2-year pre-development flow rate based on a runoff coefficient of 0.50 or the capacity of the receiving sewer, whichever is less.



@2018 Google - Map data @2018 Tele Atlas

CLIENT

11 YORKVILLE PARTNERS INC.

TITLE

11–25 YORKVILLE AVE. & 16–18 CUMBERLAND ST.

SITE LOCATION

wsp

Checked SP	Drawn AutoCAD/B.K.B.
Date MARCH 2019	Proj. No. 17M–00164
Scale NTS	Figure No. 1
	Gr.No. -

2018.03.15 FIGURE 1 - Site Location.dwg 11 Yorkville Site Location J:\1441 Projects by Job Number\2017\17M-01494-00 11 Yorkville Ave\CAD\ Mar 15, 2019 - 11:18am

2 PRE-DEVELOPMENT CONDITIONS

2.1 GENERAL

Currently, 11 Yorkville is occupied by a 10-storey commercial building with an underground parking structure at its rear to the south. 17 Yorkville Avenue is occupied by a 3-storey commercial building with a small hardscaped backyard area. 19-25 Yorkville Avenue is occupied by a 4-storey commercial building. These properties total an area of 0.24 ha and drain to the Yorkville Avenue sewer.

16 Cumberland Street is occupied by a 3-storey commercial building and 18 Cumberland Street is occupied by a 2-storey commercial building. These properties total an area of 0.04 ha and are assumed to drain to the Cumberland Street sewer. An investigation into the current drainage patterns will confirm the existing drainage location of the buildings at 16 and 18 Cumberland Street.

The total site area is 0.28 ha, the majority of which consists of roof area and hard paved surfaces. It is assumed that there is currently no stormwater management system on this site. Under existing conditions, due to the high ratio of impervious surfaces, a runoff coefficient of 0.90 is estimated, however the WWFMG specify a maximum runoff coefficient of 0.50 be used when calculating runoff in existing conditions for the purposes of determining the allowable release rate.

Figure 2 illustrates the existing conditions of the subject site.

2.2 RAINFALL INFORMATION

The rainfall intensity for the site was calculated using the following equation: $I = AT^C$

Where;

I = rainfall intensity in mm/hour

T = time of concentration in hours

A and C = constant parameters (see below)

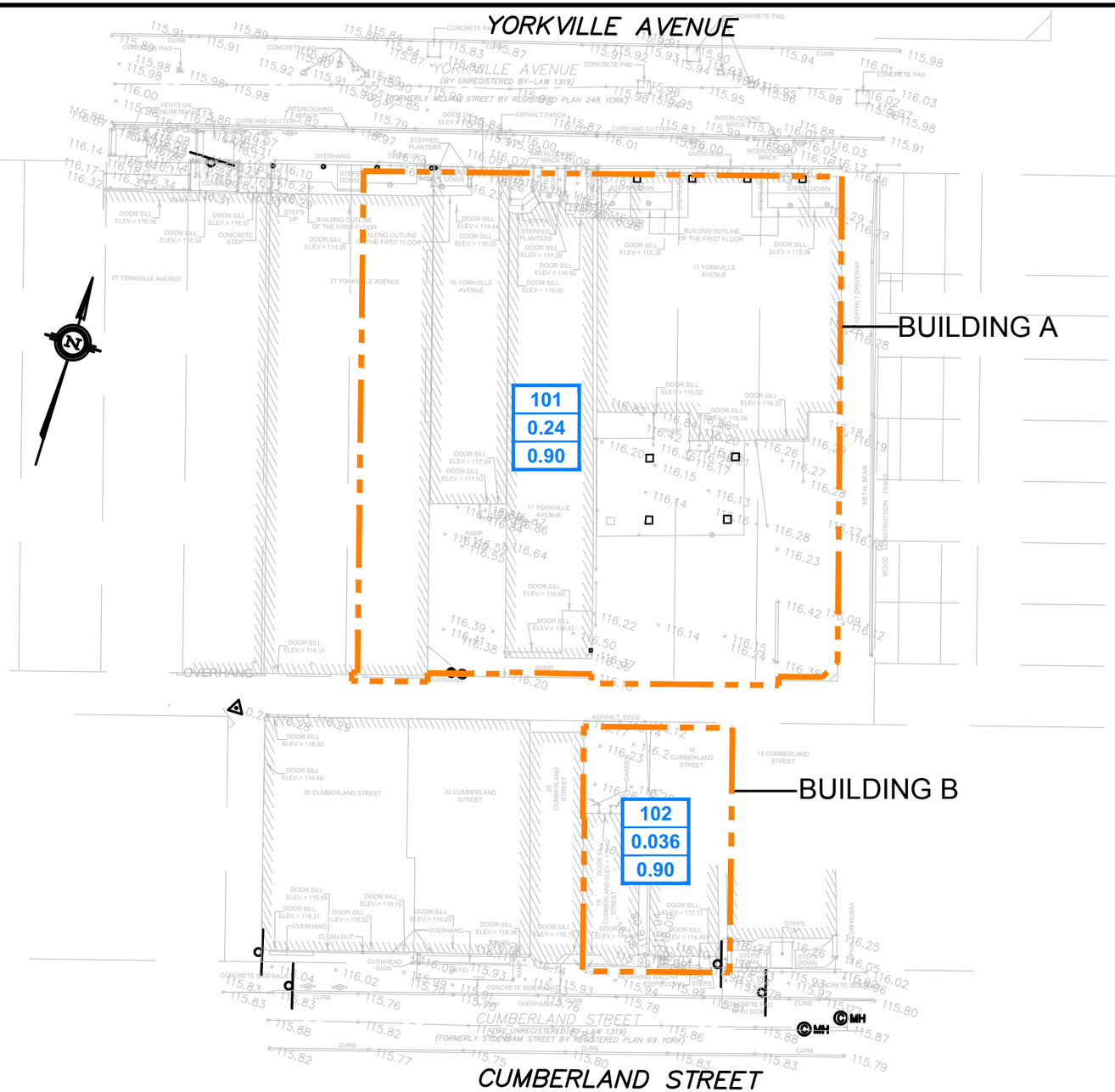
The parameters (A, C) recommended for use by the City of Toronto (per Section 3.1 of the Wet Weather Flow Management Guidelines) are summarized in Table 2.1.

Table 2.1 Rainfall Parameters

RETURN PERIOD (years)	2	5	10	25	50	100
A	21.8	32.0	38.7	45.2	53.5	59.7
C	-0.78	-0.79	-0.80	-0.80	-0.80	-0.80

Source: City of Toronto Wet Weather Flow Management Guidelines (November 2006)

An initial time of concentration, T_C, of 10 minutes (or 0.167 hours) is recommended in the WWFMG document.



LEGEND

- PROPERTY BOUNDARY
- 101 — SUBCATCHMENT ID
- 0.24 — AREA (HA)
- 0.90 — RUNOFF COEFFICIENT

CLIENT	11 YORKVILLE PARTNERS INC.
TITLE	11–25 YORKVILLE AVE. & 16–18 CUMBERLAND ST.
	EXISTING CONDITIONS

wsp

Checked SP	Drawn NM	
Date AUGUST 2019	Proj. No. 17M–01494	
Scale AS SHOWN	Figure No. 2	Gr.No. -

2019.07.29 FIGURE 2 - Existing Conditions.dwg 11 Yorkville Existing Conditions JJ\1441 Projects by Job Number\2017\17M-01494-00 11 Yorkville Ave\CAD\ Aug 14, 2019 - 4:22pm

2.3 ALLOWABLE FLOW RATES

It is assumed that runoff from the existing building roof and surrounding at-grade at 11-25 Yorkville Avenue is collected by a combined sewer system on Yorkville Street and runoff at 16-18 Cumberland Street is collect by a combined sewer system on Cumberland Street.

In accordance with the WWFMG, Section 2.2.3.8, the allowable release rate to the combined sewer on Yorkville Ave. from the existing site is 29.4 L/s from Building A. This is based on the 2-year pre-development flow rate calculated with an area of 0.24 ha and a runoff coefficient value of 0.50. The allowable release rate to the Cumberland Street sewer from Building B is 4.4 L/s. This is based on the 2-year pre-development flow rate calculated with an area of 0.04 ha and a runoff coefficient value of 0.50.

The calculated pre-development peak flow rates for the existing site for 2-year to 100-year storm events are summarized in Table 2.2. Detailed calculations are provided in Appendix A.

Table 2.2 Pre-Development Peak Flow Rate Calculations & Maximum Allowable Site Discharge Rate

RETURN PERIOD (YEARS)	RAINFALL INTENSITY, I (MM/HR)	EXISTING PEAK RUNOFF RATES, Q (L/s)[1] YORKVILLE AVENUE C=0.9	EXISTING PEAK RUNOFF RATES, Q (L/s)[2] YORKVILLE AVENUE C=0.5	WWFMG MAXIMUM ALLOWABLE RELEASE RATE, Q_A[2] (L/s) YORKVILLE AVENUE	EXISTING PEAK RUNOFF RATES, Q (L/s)[3] CUMBERLAND STREET C=0.9	EXISTING PEAK RUNOFF RATES, Q (L/s)[4] CUMBERLAND STREET C=0.5	WWFMG MAXIMUM ALLOWABLE RELEASE RATE, Q_A[4] (L/s) CUMBERLAND STREET
2	88.2	52.9	**29.4**	**29.4**	7.9	**4.4**	**4.4**
5	131.8	79.0	43.9		11.8	6.6	
10	162.3	97.3	54.1		14.5	8.1	
25	189.5	113.7	63.2		17.0	9.4	
50	224.3	134.5	74.7		20.1	11.2	
100	250.3	150.1	83.4		22.4	12.4	

[1] C=0.90, pre-development sewer drainage catchment area of 0.24 ha and time of concentration of 10 minutes

[2] C=0.50, pre-development sewer drainage catchment area of 0.24 ha and time of concentration of 10 minutes

[3] C=0.90, pre-development sewer drainage catchment area of 0.04 ha and time of concentration of 10 minutes

[4] C=0.50, pre-development sewer drainage catchment area of 0.04 ha and time of concentration of 10 minutes

3 POST-DEVELOPMENT CONDITIONS

3.1 GENERAL

The proposed development consists of one 62-storey mixed use tower (Building A) and one 2-storey retail building (Building B). Building A will have four (4) below-grade parking levels, 674 residential units and approximately 2,486 m^2 of retail space. Building B will have one below-grade concourse level and two above-ground levels.

The storm service connection for Building A will be provided to existing infrastructure on Yorkville Avenue. The storm sewer connection for Building B will be made on Cumberland Avenue. The at-grade impervious area north of Building A (163 m^2) will flow uncontrolled to Yorkville Avenue.

Please refer to Figure 3 for the proposed conditions. Tables 3.1 and 3.2 show the land-use breakdown for Building A and Building B, respectively.

Table 3.1 Proposed Land-Use Area Breakdown – Building A

LAND-USE	AREA (m^2)	RUNOFF COEFFICIENT (C)	PERCENT COVERAGE
Impervious Roof Surfaces	1496	0.90	62%
Green Roof Area	286	0.45	12%
Landscape Area	32	0.25	1%
At-Grade Impervious	421	0.90	18%
Uncontrolled Drainage	163	0.90	7%
Total Site Area	**2,397**	**0.84**	**100%**

Table 3.2 Proposed Land-Use Area Breakdown – Building B

LAND-USE	AREA (m^2)	RUNOFF COEFFICIENT (C)	PERCENT COVERAGE
Impervious Roof Surfaces	308	0.90	86%
At-Grade Impervious	50	0.90	14%
Total Site Area	**358**	**0.90**	**100%**

3.2 WATER BALANCE – BUILDING A

As noted in Section 1.4, the WWFMG states that the proponent should ensure 50% of the total average annual rainfall volume is retained on site. Due to the underground parking lot structure, infiltration is not feasible for this project. The proposed mechanism for achieving water balance will be to capture stormwater in a chamber dedicated for re-use.

The proposed reuse volume will be used for evapotranspiration through trees in Silva cells; see Silva cell locations and sections in the landscaping plans. The methodology is detailed in the following subsections with detailed calculations shown in Appendix A.

3.2.1 ANNUAL RAINFALL

Due to the seasonal-dependent nature of the water reuse strategy, an average annual water balance approach where reuse is examined based on summer (warm) and winter (cool) month operation is utilized. For the purposes of this analysis, summer months are taken as May through September and winter months are October through April.

The annual total average rainfall within the City of Toronto is 714 mm (Government of Canada, Toronto Rainfall Records from 1981 - 2010). Of the 714 mm of rainfall, 53.59% occurs from May to September for a total of 383 mm. The remaining 46.41% occurs between October and April for a total of 331 mm.

3.2.2 WATER RETENTION

It is assumed that the green roof and landscaped areas will retain the first 5 mm of precipitation during a storm event. This initial abstraction is returned back into the atmosphere by evapotranspiration. The impervious surfaces across the site are assumed to provide an initial abstraction of 1 mm during a storm event.

Discharge from the roof and controlled at-grade areas will be directed to the stormwater cistern and water balance volume through the building's mechanical systems. In the summer months, rainfall events up to a depth of 19mm shall be captured from pervious and controlled impervious areas (roof & at-grade) and stored in the water balance storage. This is equivalent to a maximum water volume of 39.0 m^3 which shall be reused through evapotranspiration via trees in Silva cells.

In the winter months, temperatures are too low for evaporation. However, winter water reuse is not required to meet the water balance requirement.

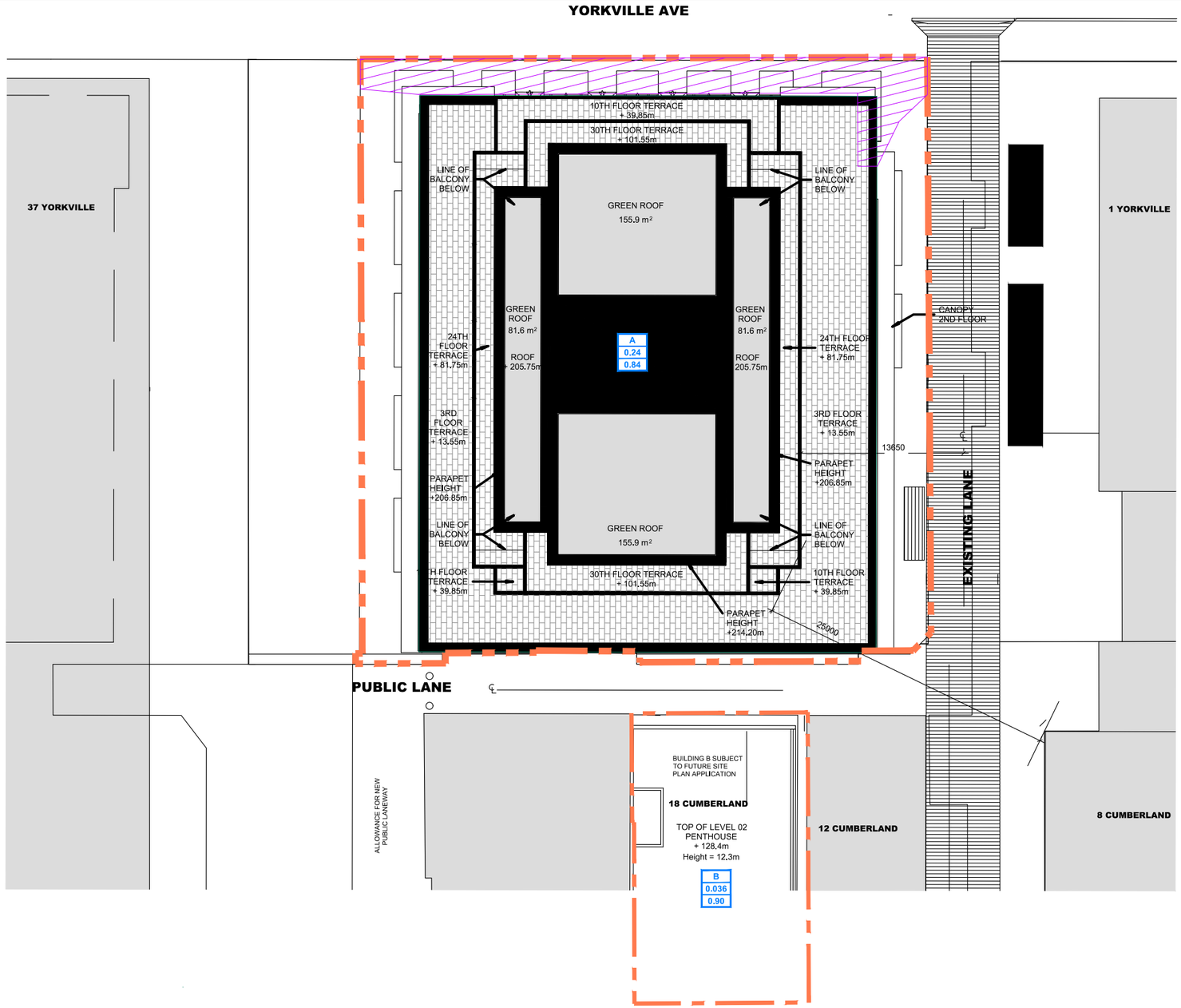
In the summer months, 8.1% of the total annual rainfall is captured by initial abstraction, 44.8% of the total annual rainfall is captured for reuse, and 8.8% of the total annual rainfall leaves the site as runoff. In the winter months, 7.0% of the total annual rainfall is captured by initial abstraction, with the 39.4% of the total annual rainfall leaving as runoff. The sum of the summer and winter runoff is 48.2%, which is less than 50% of the annual rainfall, therefore the requirement of the WWFMG water balance criteria is met.

3.2.3 WATER REUSE DEMAND

To utilize the retained 39.0 m^3 water volume outlined in Section 3.2.2 evapotranspiration via trees in Silva cells is the proposed mechanism. The water reuse method relies on mechanical systems to move the water from the storage volume to the location where it will be utilized. Please refer to the mechanical design for further details of this system. Silva cell details are provided in the landscaping plans.

There is 120 m^3 of volume available for both soil and water in the proposed Silva cells and the proposed trees require at least 100 m^3 of soil. Assuming a void ratio of the soil of 0.2, the available space within the soil for water storage can be calculated. A soil volume of 101 m^3 is proposed within the Silva cells, which will provide 20.2 m^3 of storage for water. The remaining 19 m^3 of storage available (a depth of 0.12 m on top of the soil) will be used for water storage as well. This gives a total of 39.2 m^3 of water utilized for evapotranspiration which meets the water balance criteria.

The Silva cell system will be designed at the construction drawing stage by the manufacturer. It shall have an impermeable liner which will isolate it from the parking garage and associated drains. It shall have overflow pipe(s) to discharge to grade. This overflow shall be picked up by the civil/mechanical systems and directed to the cistern for quantity control in the case of storm events in excess of the 19 mm event. It shall receive water from the water balance storage via pumping from the mechanical system. The water shall be distributed upon entry to the Silva cells by method determined by the manufacturer. Furthermore, a potable water irrigation system shall be installed for use between rainfall evets as required. It will be equipped with sensors as required to ensure potable water is only used when stormwater is not available. This system shall be designed by others.



LEGEND

- PROPERTY BOUNDARY
- SUBCATCHMENT ID (A)
- AREA (HA) (0.24)
- RUNOFF COEFFICIENT (0.82)
- UNCONTROLLED DRAINAGE

0 5 10 15 20m

CLIENT: 11 YORKVILLE PARTNERS INC.

TITLE: 11–25 YORKVILLE AVE. & 16–18 CUMBERLAND ST.

PROPOSED CONDITIONS

Checked: SP	Drawn: NM
Date: AUGUST 2019	Proj. No.: 17M–01494
Scale: AS SHOWN	Figure No.: 3
	Gr.No.:

2019.07.29 FIGURE 3 - Proposed Conditions.dwg 11 Yorkville Proposed J:\1441 Projects by Job Number\2017\17M-01494-00 11 Yorkville Ave\CAD\ Aug 14, 2019 - 4:25pm

3.3 WATER BALANCE – BUILDING B

As noted in Section 1.4, the WWFMG states that the proponent should target the retention of 5 mm of stormwater runoff from all surfaces, in order to ensure 50% of the total average annual rainfall volume is retained on site. Due to the underground parking garage occupying the entire site area, infiltration is not feasible for this project. A water reuse sump volume, stored within the stormwater cistern, is the mechanism proposed to achieve water balance requirements for Building B.

The water balance opportunities for Building B will be finalized as part of the building's detailed design. At this stage, it is assumed that sufficient opportunities exist to reuse the 1.43 m^3 of water balance for Building B. This volume will be the approximate required sump volume for Building B. Detailed calculations can be found in Appendix A. Please note that Building B will be separate from Building A for water balance.

Table 3.3 Water Balance Calculation – Building B

SURFACE TYPE	AREA (M^2)	INITIAL ABSTRACTION (M)	5 MM VOLUME (M^3)	VOLUME ABSTRACTED (M^3)	WATER BALANCE (M^3)
Impervious Roof Area	308	0.001	1.54	0.31	1.23
At-Grade Impervious	50	0.001	0.25	0.05	0.20
Total Site Area:	**358**	-	**1.79**	**0.36**	**1.43**

3.4 WATER QUALITY CONTROL

Architectural plans indicate that the majority of the site area will be covered by building rooftop surfaces or landscaping with the exception of a 421 m^2 area of controlled impervious at-grade land cover. As rooftop areas are free of typical sediment-generating activities (e.g. vehicle traffic) runoff will leave them effectively unchanged, and can be considered clean for the purposes of water quality assessment.

A Jellyfish unit has been sized to treat the runoff prior to entering the cistern. The JF4-2-1 has been sized for 80% TSS removal.

3.5 EROSION CONTROL

As mentioned in Section 1.4, this development is an overall small footprint development. According to the WWFMG, *'For small infill/redevelopment sites <2 ha, erosion control in the form of stormwater detention is normally not required, provided the on-site minimum runoff retention from a small design rainfall event (typically 5 mm) is achieved under the Water Balance Criteria.'*

The site area for this application is 0.28 ha, which is well below the 2.0 ha guideline, and the 5 mm water balance requirement has been addressed – therefore additional measures for long-term erosion control are not recommended.

3.6 WATER QUANTITY CONTROL

As noted in Section 2.3, the allowable discharge rate to the municipal sewer system on Yorkville Avenue from the site is 29.4 L/sec, which is equivalent to the peak runoff rate under pre-development conditions during a 2-year design storm event with a minimum runoff coefficient of 0.50. The allowable discharge to Cumberland Avenue is 4.4L/s.

Discharge from Building A will be directed to a SWM control tank located in the underground parking garage. The cistern is designed to have a footprint of approximately 22.20 m^2 with a height of 10.86 m. The cistern volume is 241.1 m^3. The pump will discharge to a discharge chamber, then a control manhole before discharging to the Yorkville Avenue municipal sewer. A 110 mm orifice plate will control the flow from the discharge chamber. The maximum water level above the invert of the 110 mm orifice plate is 0.5 m. A maximum discharge of 14.1 L/s from the cistern pump is assumed for outlet sizing and cistern storage calculations for Buildings A. No sump volume is provided in this tank; a separate volume for water balance will be provided. This ensures that site meets overall stormwater management criteria. It will be developer's responsibility to ensure that the proposed pump is sized to meet the assumed 14.1 L/s discharge rate. M.V. Shore have confirmed the pumping rate will not exceed 14.1 L/s. The letter is attached in Appendix C.

Discharge from Building B will be directed to a SWM control tank located at the concourse level. The cistern is designed to have a footprint of 8 m^2 with a height of 2 m. This includes the sump volume of 1.4 m^3 required for water balance. A 3-inch (76 mm) diameter SXH Hydrobrake valve has been selected to control runoff from the cistern to a maximum flow rate of 3.9 L/s and will be set at 0.18 m above the base of the cistern.

For events greater than the 100-year storm or in the event of an obstruction at the cistern outlet, excess volume from the cistern will be discharged onto the nearby grade, ultimately discharging to the north of the site on Yorkville Street.

The 'HydroCAD' software package has been used to model the behaviour of the proposed SWM system, and determine its response under various storm events. This software utilises the Modified Rational Method to calculate flow rates and related storage values. Detailed output from the model is included in Appendix B. Based on the City's WWFMG criteria – specifically the 'Discharge to Municipal Infrastructure' section – all stormwater runoff from events up to and including the 100-year storm must be contained on site and released at or below the allowable rate. Summaries of the modelled peak offsite discharge rates for the SWM cisterns in Building A and B are provided in Tables 3.4 and 3.5 show the total off site discharge to the municipal sewers on Yorkville Avenue and Cumberland Street, respectively. The proposed discharge from each building are in compliance with the WWFMG discharge rate criteria.

Table 3.4 Summary of Modelling Results – Building A

RETURN PERIOD (YEARS)	UTILIZED CISTERN STORAGE (m^3)	PEAK WATER ELEVATION IN CISTERN (m)	MAXIMUM PEAK FLOW RATE FROM DISCHARGE	UNCONTROLLED AT-GRADE FLOW RATE (L/S)	ALLOWABLE RELEASE RATE (L/s)	POST-DEVELOPMENT FLOW RATE (L/s)
2	33.3	1.50	16.9	3.6	**29.4**	20.5
5	48.7	2.20		5.4		22.3
10	58.8	2.65		6.6		23.5
25	68.7	3.10		7.7		24.6
50	88.7	3.66		9.1		26.0
100	90.7	4.09		10.2		**27.1**

Table 3.5 Summary of Modelling Results – Building B

RETURN PERIOD (YEARS)	UTILIZED CISTERN STORAGE (m^3)	PEAK WATER ELEVATION IN CISTERN (m)	ALLOWABLE RELEASE RATE (L/S)	CISTERN POST-DEVELOPMENT FLOW RATE (L/s)
2	4.2	0.53	**4.4**	2.4
5	6.4	0.80		2.6
10	7.9	0.99		3.0
25	9.2	1.16		3.3
50	11.0	1.37		3.6
100	12.3	1.54		**3.8**

All modelling results assume the sump is full at the onset of the storm event, if applicable. All storage volumes include the sump volume, if applicable. The modelling results demonstrate that the post-development peak flow rates for all events up to the 100-year storm are lower than the target release rate established in accordance with the WWFMG. The time of duration that results in the peak discharge to Yorkville Avenue from Building A has been iteratively determined to be t_d = 72 minutes (for the 100-year event) according to the modified rational method process. For Building B to Cumberland Street, t_d=16 minutes for the 100-year event.

4 CONCLUSIONS

A stormwater management plan has been prepared to support the Rezoning Application and Site Plan Application for Building A and the Rezoning Application for Building B. Building A is proposed at the municipal address 11-25 Yorkville Avenue and Building B is proposed at the municipal address 16-18 Cumberland Street in the City of Toronto. The key points are summarized below.

WATER BALANCE

Building A and B will have stormwater storage volumes that will be used for water reuse purposes.

For Building A, the proposed reuse volume will be used for evapotranspiration through trees in Silva cells. The Silva cells will be designed to have a total volume of 120 m^3. A soil volume of 101 m^3 is proposed within the Silva cells. This will provide 20.2 m^3 of storage for water assuming a 0.2 void ratio for soil. The remaining 19 m^3 of storage available (a depth of 0.12 m on top of the soil) will be used for water storage as well. This gives a total of 39.2 m^3 of water utilized for evapotranspiration which meets the water balance criteria.

The water balance opportunities for Building B will be finalized as part of the building's detailed design. At this stage, it is assumed that sufficient opportunities exist to reuse the 1.43 m^3 of water balance for Building B.

WATER QUANTITY

The storage provided by the stormwater cistern in Building A will ensure that the peak offsite discharge rates to the combined sewer on Yorkville Avenue will be below the allowable maximum rate of 29.4 L/s defined in the WWFMG for all storms up to and including the 100-year event. The release rate from cistern A is controlled to 14.1 L/s through the use of a pump from the proposed 241 m^3 cistern. A 110 mm orifice plate on the discharge chamber further ensures the flow is controlled to the allowable release rate. The storage required for the 100-year storm is 90.7 m^3. The peak discharge rate from Building A is 27.1 L/s.

For Building B, a 3 inch (76 mm) SXH HydroBrake valve is proposed on the outlet of the proposed 16 m^3 stormwater cistern. The allowable release rate to the Cumberland Street sewer is 4.4 L/s. The HydroBrake achieved a peak discharge rate of 3.9 L/s. The 100-year storm requires 12.4 m^3 of storage.

EROSION CONTROL

The site is below the 2.0 ha erosion control guideline and the on-site minimum retention of the 5 mm rainfall event is achieved under the water balance criteria, therefor no further measures are recommended.

WATER QUALITY

Under the WWFMG, the site is required to target a long-term removal of 80% of total suspended solids (TSS) on an annual loading basis. A Jellyfish unit model JF4-2-1 was sized to achieve 80% TSS removal for this site.

The proposed SWM strategy described in this report addresses all stormwater management related impacts from the project and satisfies the intent of the City of Toronto Wet Weather Flow Management Guidelines.

APPENDIX

A STORMWATER MANAGEMENT CALCULATIONS

	Stormwater Management Calculations	**Project:**	**11-25 Yorkville & 16-18 Cumberland**	**No.:**	**17M-01494**	
	Allowable Offsite Discharge Rate - Yorkville Avenue	**By:**	**TM**	**Date:**	**14/08/2019**	**Page:**
		Checked:	**SP**	**Checked:**	**14/08/2019**	**1**

Calculation of existing runoff rate is undertaken using the Rational Method: Q = 2.78 CIA

Where: Q = Peak flow rate (litres/second)
C = Runoff coefficient
I = Rainfall intensity (mm/hour)
A = Catchment area (hectares)

Project Area, A **0.24** hectares
Runoff Coef, C* 0.50

* Note - actual site runoff coefficient is approximately 0.75, however City of Toronto WWFMG states maximum runoff coefficient to be used in calculation of pre-development peak flow is 0.50 (section 2.2.3.8).

Rainfall intensity calculated in accordance with City of Toronto WWFMG (section 3.1): $I = AT^C$

Where: A and C = Parameters defined in WWFMG section 3.1.
I = Rainfall intensity (mm/hour)
T = Time of concentration (hours)

Return Period (Years)	2	5	10	25	50	100
A	21.8	32.0	38.7	45.2	53.5	59.7
C	-0.78	-0.79	-0.80	-0.80	-0.80	-0.80
T (mins) **	10	10	10	10	10	10
T (hrs)	0.167	0.167	0.167	0.167	0.167	0.167
I (mm/hr)	88.2	131.8	162.3	189.5	224.3	250.3
Q (litres/sec)	**29.4**	43.9	54.1	63.2	74.7	83.4
Q (m3/sec)	0.029	0.044	0.054	0.063	0.075	0.083

** Note recommended minimum value for time of concentration for small sites (<2.0ha) is 10 minutes.

Allowable release rate to municipal storm sewer system is therefore 29.4 litres/second.

(As per City of Toronto WWFMG section 2.2.3.7)

Calculation of existing runoff rate is undertaken using the Rational Method: Q = 2.78 CIA

Where: Q = Peak flow rate (litres/second)
C = Runoff coefficient
I = Rainfall intensity (mm/hour)
A = Catchment area (hectares)

Project Area, A **0.04** hectares
Runoff Coef, C* 0.50

* Note - actual site runoff coefficient is approximately 0.75, however City of Toronto WWFMG states maximum runoff coefficient to be used in calculation of pre-development peak flow is 0.50 (section 2.2.3.8).

Rainfall intensity calculated in accordance with City of Toronto WWFMG (section 3.1): $I = AT^C$

Where: A and C = Parameters defined in WWFMG section 3.1.
I = Rainfall intensity (mm/hour)
T = Time of concentration (hours)

Return Period (Years)	2	5	10	25	50	100
A	21.8	32.0	38.7	45.2	53.5	59.7
C	-0.78	-0.79	-0.80	-0.80	-0.80	-0.80
T (mins) **	10	10	10	10	10	10
T (hrs)	0.167	0.167	0.167	0.167	0.167	0.167
I (mm/hr)	88.2	131.8	162.3	189.5	224.3	250.3
Q (litres/sec)	**4.4**	6.6	8.1	9.4	11.2	12.4
Q (m3/sec)	0.004	0.007	0.008	0.009	0.011	0.012

** Note recommended minimum value for time of concentration for small sites (<2.0ha) is 10 minutes.

Allowable release rate to municipal storm sewer system is therefore 4.4 litres/second.

(As per City of Toronto WWFMG section 2.2.3.7)

Calculation of existing runoff rate is undertaken using the Rational Method: Q = 2.78 CIA

Where: Q = Peak flow rate (litres/second)
C = Runoff coefficient
I = Rainfall intensity (mm/hour)
A = Catchment area (hectares)

Project Area, A **0.02** hectares
Runoff Coef, C* 0.90

* Note - actual site runoff coefficient is approximately 0.75, however City of Toronto WWFMG states maximum runoff coefficient to be used in calculation of pre-development peak flow is 0.50 (section 2.2.3.8).

Rainfall intensity calculated in accordance with City of Toronto WWFMG (section 3.1): $I = AT^C$

Where: A and C = Parameters defined in WWFMG section 3.1.
I = Rainfall intensity (mm/hour)
T = Time of concentration (hours)

Return Period (Years)	2	5	10	25	50	100
A	21.8	32.0	38.7	45.2	53.5	59.7
C	-0.78	-0.79	-0.80	-0.80	-0.80	-0.80
T (mins) **	10	10	10	10	10	10
T (hrs)	0.167	0.167	0.167	0.167	0.167	0.167
I (mm/hr)	88.2	131.8	162.3	189.5	224.3	250.3
Q (litres/sec)	**3.6**	5.4	6.6	7.7	9.1	10.2
Q (m3/sec)	0.004	0.005	0.007	0.008	0.009	0.010

** Note recommended minimum value for time of concentration for small sites (<2.0ha) is 10 minutes.

Allowable release rate to municipal storm sewer system is therefore 3.6 litres/second.
(As per City of Toronto WWFMG section 2.2.3.7)

Project	11-25 Yorkville & 16-18 Cumberland		No.	17M-01494	
By	SC		Date	14/08/2019	Page
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Subject Analysis of the Total Annual Runoff Volume with Proposed SWM Strategy

Averaged Annual Rainfall Depth: (mm) 714 Source: Toronto Rainfall Records (1981 - 2010)
http://climate.weather.gc.ca/climate_normals/index_e.html

Month	May	Jun	Jul	Aug	Sep	Total
Rainfall Depth (mm)	82	70.9	63.9	81.1	84.7	383
					Annual %	53.6%

Assumptions of the analysis:

1. For imperviousness areas, the first milimeter of rainfall will get the pavement wet and sumps filled; therefore, an initial abstraction depth of 1.0 mm is assumed - this represents 10% of total average annual rainfall volume in Toronto (WWFMG 2.2.1.1 Fig.1a)
2. For green roofs, the water retention layer supporting plant growth can retain 5 mm of rainfall without discharge; therefore, green roofs can retain 48% of annual rainfall volume.
3. For soft landscaped areas, the surfaces retain 48% of annual average rainfall volume through soil retention, vegetation evapotranspiration and infiltration
4. Only water from Tower A and B roofs are used for misting, water from other impervious roof surfaces are used for toilet flushing. Irrigation is not implemented for water reuse.

Water Balance Analysis Sheet - Summer Months (May through September)

Landuse (Storage Directed To)		Building Green Roof	Impervious Roof	Landscape	Impervious At-Grade	Uncontrolled Area (Impervious)	Site Total	Runoff (Percentage of Annual Total)
Area (m^2)		286	1,496	32	421	163	2397	
% Area Coverage		11.9%	62.4%	1.3%	17.6%	6.8%	100.0%	
5 Month Rainfall (mm) (May - September)		383	383	383	383	383	383	53.6%
Initial Abstraction (mm)		5.0	1.0	5.0	1.0	1.0	N/A	
Initial Abstraction as % Annual Average Rainfall		48%	10%	48%	10%	10%	N/A	
5 Month Summer Abstraction / Evapotranspiration/Infiltration (mm)		184	38	184	38	38	58	8.1%
Annual Water Re-use	Captured Rainfall Depth (mm)	14.0	18.0	14.0	18.0	0.0	16.2	N/A
	Storage Volume (m^3)	4.0	26.9	0.4	7.6	0.0	N/A	N/A
	Cistern Storage Required (m^3)	4.0	26.9	0.4	7.6	0.0	**39.0**	N/A
Total Rainfall Depth Captured (mm)		19.0	19.0	19.0	19.0	1.0	17.8	N/A
Equivalent % of total average annual rainfall volume in Toronto (from WWFMG 2.2.1.1 Fig.1a)		89%	89%	89%	89%	10%	84%	N/A
Depth Captured for Summer Months (mm)		341	341	341	341	38	320	44.8%
Runoff in Summer Months (mm)		**42**	**42**	**42**	**42**	**344**	**63**	**8.8%**

Total rainfall form May to September is equivalent to 53.6% of total annual rainfall.

Initial abstraction from May to September accounts for 8.1% of total annual rainfall.

The storage required In the summer months is greater than that of the winter; therfore, the summer months govern the cistern sump design.

Therefore the sump volumes required are:

Basement Cistern	8.0 m^3
MPH Cistern	30.93

Target Annual Runoff	% of Annual Runoff in Winter (Oct - Apr.)	% of Annual Runoff in Summer (May - Sept.)	Total Annual Runoff
<50%	**39.4%**	**8.8%**	**48.2%**

1781.6 Total Roof
740.53 Top Roof
284.00 **Green Roof**
456.53 **Top Imp Roof**
95.74 **30th Floor Roof**
134.43 **24th Floor Roof**
61.88 **10th Floor Roof** #REF! Basement Sump
749.05 **Remainder Roof** #REF! 72 hours flushes

#REF!

need 1144 m3 of roof storage to achieve 50% runoff (21.3% runoff in summer)

	Project	11-25 Yorkville & 16-18 Cumberland	No.	17M-01494	
	By	SC	Date	14/08/2019	Page
	Checked	SP	Date	14/08/2019	5
Subject	Analysis of the Total Annual Runoff Volume with Proposed SWM Strategy				

Averaged Annual Rainfall Depth: (mm) 714 Source: Toronto Rainfall Records (1981 - 2010)
http://climate.weather.gc.ca/climate_normals/index_e.html

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total
Rainfall Depth (mm)	64.3	75.4	38.2	29.1	29.7	33.6	61.1	331
							Annual %	46.4%

Water Balance Analysis Sheet - Winter Months (October through April)

Landuse		Building Green Roof	Impervious Roof	Landscape	Impervious At-Grade	Uncontrolled Area (Impervious)	Site Total	Runoff (Percentage of Annual Total)
Area (m^2)		286	1,496	32	421	163	2397	
% Area Coverage		11.9%	62.4%	1.3%	17.6%	6.8%	100.0%	
7 Month Rainfall (Oct - Mar) (mm)		331	331	331	331	331	331	46.4%
Initial Abstraction (mm)		5.0	1.0	5.0	1.0	1.0	N/A	
Initial Abstraction as % Annual Average Rainfall		48%	10%	48%	10%	10%	N/A	
7 Month Winter Abstraction / Evapotranspiration/Infiltration (mm)		159	33	159	33	33	50	7.0%
Annual Water Re-use	Captured Rainfall Depth (mm)	0.0	0.0	0.0	0.0	0.0	0.0	N/A
	Storage Volume (m^3)	0.0	0.0	0.0	0.0	0.0	N/A	N/A
	Active Cistern Storage Required (m^3)	0.0	0.0	0.0	0.0	0.0	**0.0**	N/A
Total Rainfall Depth Captured (mm)		5.0	1.0	5.0	1.0	1.0	1.5	N/A
Equivalent % of total average annual rainfall volume in Toronto (from WWFMG 2.2.1.1 Fig.1a)		48%	10%	48%	10%	10%	15%	N/A
Depth Captured for Winter Months (mm)		159	33	159	33	33	50	7.0%
Runoff in Winter Months (mm)		**172**	**298**	**172**	**298**	**298**	**282**	**39.4%**

Total rainfall form October to April is equivalent to 46.4% of total annual rainfall.

Initial abstraction from October to April accounts for 7.0% of total annual rainfall capture.

Target Annual Runoff	% of Annual Runoff in Winter (Oct - Apr.)	% of Annual Runoff in Summer (May - Sept.)	Total Annual Runoff
<50%	**39.4%**	**8.8%**	**48.2%**

Therefore, the Total Annual Ruonff is less than 50%, meeting the Water Balance Requirement of the WWFMG.

Discharge for a circular orifice is given by the following formula: $Q = Ca(2gh)^{0.5}$

Where: Q = Flow rate (m^3/second)

C = Discharge coefficient (unitless)

a = Submerged area (sqm)

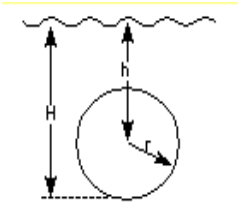
g = Gravitational constant (metres per second squared)

h = effective head (meters)

For an orifice opening in a vertical plane, the effective head is given by the following formulae:

Fully Submerged:

$$h = H - \max(r, TW)$$



Where: H = Head above invert level (metres)

r = Radius of orifice (meters)

TW = Tailwater depth above invert level (metres)

Variables:

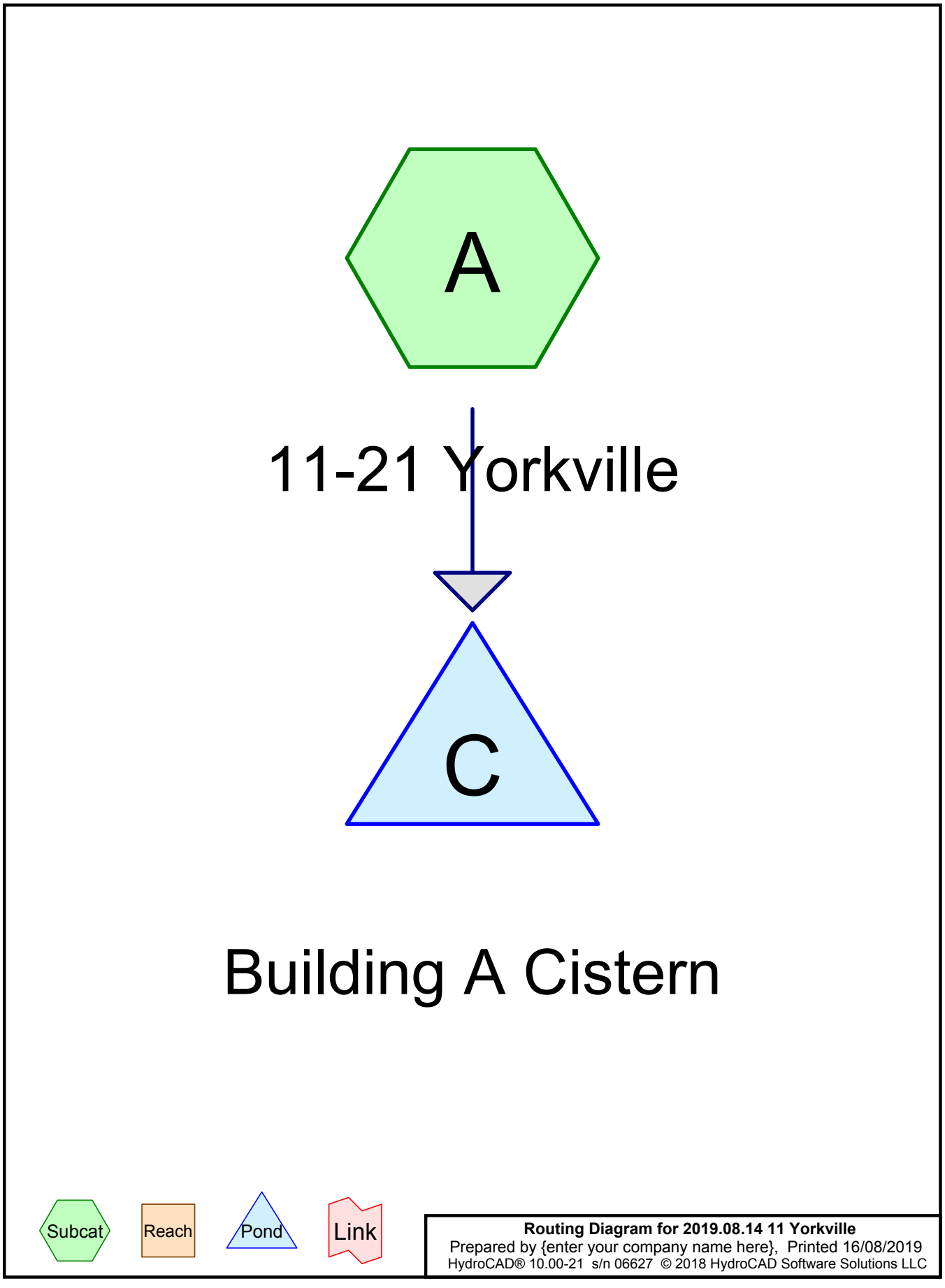
C =	**0.6**	-	(Orifice Plate)
Orifice diameter =	**110**	mm	
r =	**55**	mm	
r =	**0.055**	m	
a =	**0.00950**	sqm	
g =	**9.81**	m/sec2	
H =	**0.50**	m	
TW =	**0.00**	m	(0.00 = assume free discharge)
h =	**0.45**	m	

Calculation:

Q =	**0.01685**	m3/sec
Q =	**16.85**	l/sec

APPENDIX

B HYDROLOGIC MODEL OUTPUT (HydroCAD)



Routing Diagram for 2019.08.14 11 Yorkville
Prepared by {enter your company name here}, Printed 16/08/2019
HydroCAD® 10.00-21 s/n 06627 © 2018 HydroCAD Software Solutions LLC

Area Listing (selected nodes)

Area (sq-meters)	C	Description (subcatchment-numbers)
421.0	0.90	At-Grade Impervious (A)
286.0	0.45	Green Roof (A)
1,496.0	0.90	Impervious Roof (A)
32.0	0.25	Landscape (A)
2,235.0	**0.83**	**TOTAL AREA**

Soil Listing (selected nodes)

Area (sq-meters)	Soil Group	Subcatchment Numbers
0.0	HSG A	
0.0	HSG B	
0.0	HSG C	
0.0	HSG D	
2,235.0	Other	A
2,235.0		**TOTAL AREA**

Ground Covers (selected nodes)

HSG-A (sq-meters)	HSG-B (sq-meters)	HSG-C (sq-meters)	HSG-D (sq-meters)	Other (sq-meters)	Total (sq-meters)	Ground Cover	Sub Nur
0.0	0.0	0.0	0.0	421.0	421.0	At-Grade Impervious	
0.0	0.0	0.0	0.0	286.0	286.0	Green Roof	
0.0	0.0	0.0	0.0	1,496.0	1,496.0	Impervious Roof	
0.0	0.0	0.0	0.0	32.0	32.0	Landscape	
0.0	**0.0**	**0.0**	**0.0**	**2,235.0**	**2,235.0**	**TOTAL AREA**	

Time span=0.00-6.00 hrs, dt=0.01 hrs, 601 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: 11-21 Yorkville Runoff Area=2,235.0 m² 0.00% Impervious Runoff Depth=19 mm
Tc=10.0 min C=0.83 Runoff=0.0097 m³/s 42.1 m³

Pond C: Building A Cistern Peak Elev=1.498 m Storage=33.3 m³ Inflow=0.0097 m³/s 42.1 m³
Outflow=0.0034 m³/s 36.3 m³

Total Runoff Area = 2,235.0 m² Runoff Volume = 42.1 m³ Average Runoff Depth = 19 mm
100.00% Pervious = 2,235.0 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment A: 11-21 Yorkville

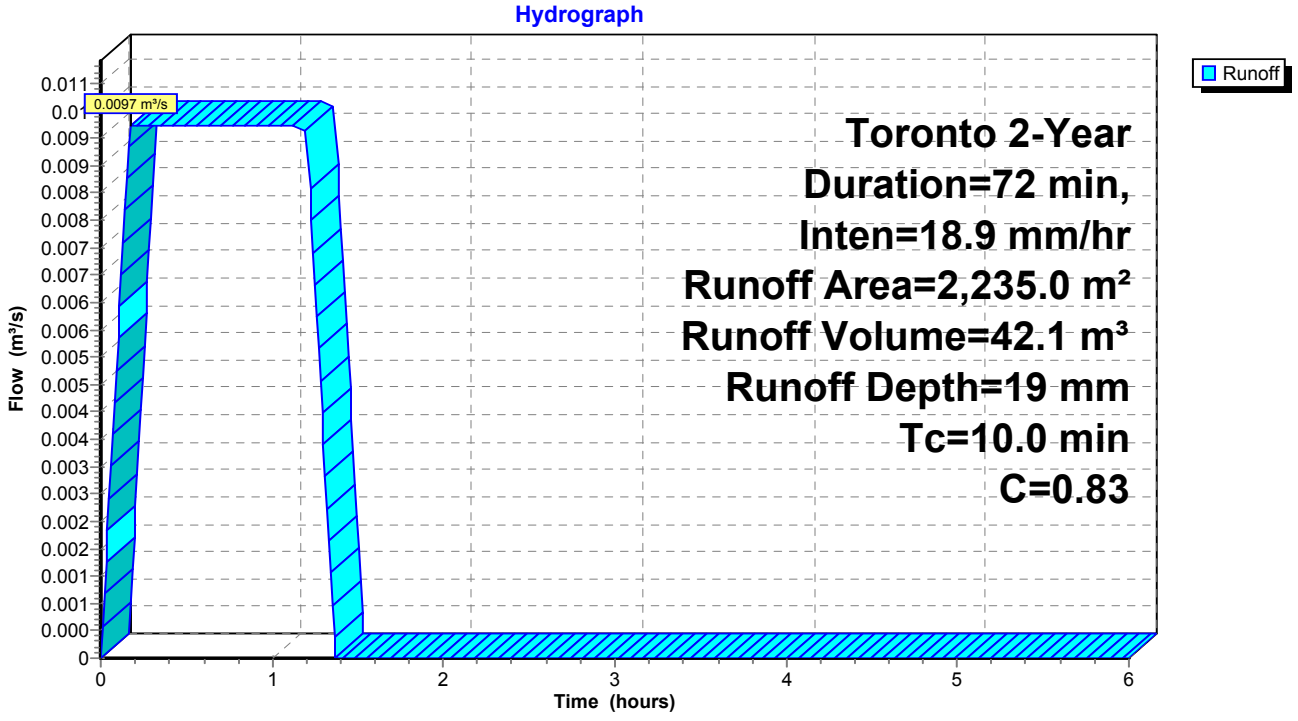
Runoff = 0.0097 m³/s @ 0.17 hrs, Volume= 42.1 m³, Depth= 19 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Toronto 2-Year Duration=72 min, Inten=18.9 mm/hr

Area (m²)	C	Description
286.0	0.45	Green Roof
1,496.0	0.90	Impervious Roof
421.0	0.90	At-Grade Impervious
32.0	0.25	Landscape
2,235.0	0.83	Weighted Average
2,235.0		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
10.0					**Direct Entry,**

Subcatchment A: 11-21 Yorkville



Summary for Pond C: Building A Cistern

Inflow Area = 2,235.0 m², 0.00% Impervious, Inflow Depth = 19 mm for 2-Year event
Inflow = 0.0097 m³/s @ 0.17 hrs, Volume= 42.1 m³
Outflow = 0.0034 m³/s @ 1.31 hrs, Volume= 36.3 m³, Atten= 65%, Lag= 68.3 min
Primary = 0.0034 m³/s @ 1.31 hrs, Volume= 36.3 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 1.498 m @ 1.31 hrs Surf.Area= 22.2 m² Storage= 33.3 m³

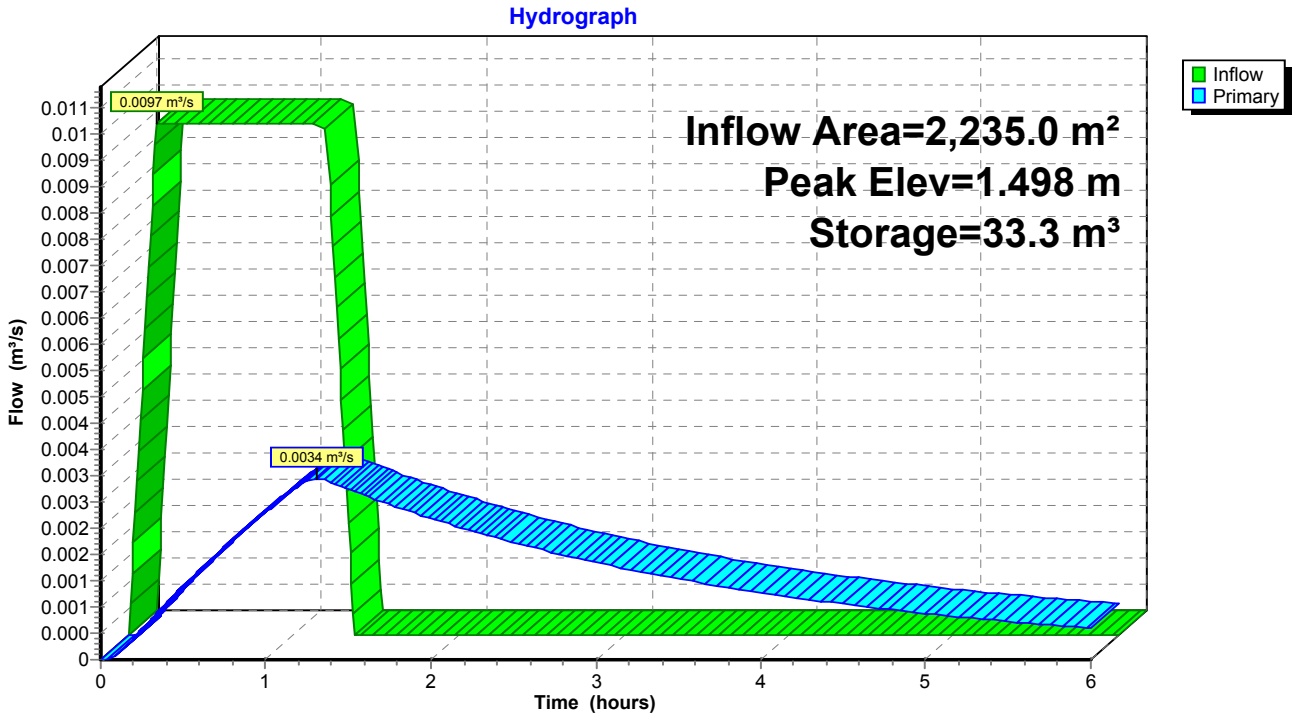
Plug-Flow detention time= 114.2 min calculated for 36.2 m³ (86% of inflow)
Center-of-Mass det. time= 109.5 min (150.5 - 41.0)

Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	241.1 m³	**22.20 mW x 1.00 mL x 10.86 mH Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.000 m	**Pump** Discharges@10.860 m Flow (l/min)= 0.0 750.0 845.0 Head (meters)= 10.860 5.430 0.000

Primary OutFlow Max=0.0034 m³/s @ 1.31 hrs HW=1.498 m (Free Discharge)
└**1=Pump** (Pump Controls 0.0034 m³/s)

Pond C: Building A Cistern



Time span=0.00-6.00 hrs, dt=0.01 hrs, 601 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: 11-21 Yorkville Runoff Area=2,235.0 m² 0.00% Impervious Runoff Depth=28 mm
Tc=10.0 min C=0.83 Runoff=0.0143 m³/s 61.7 m³

Pond C: Building A Cistern Peak Elev=2.195 m Storage=48.7 m³ Inflow=0.0143 m³/s 61.7 m³
Outflow=0.0051 m³/s 53.1 m³

Total Runoff Area = 2,235.0 m² Runoff Volume = 61.7 m³ Average Runoff Depth = 28 mm
100.00% Pervious = 2,235.0 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment A: 11-21 Yorkville

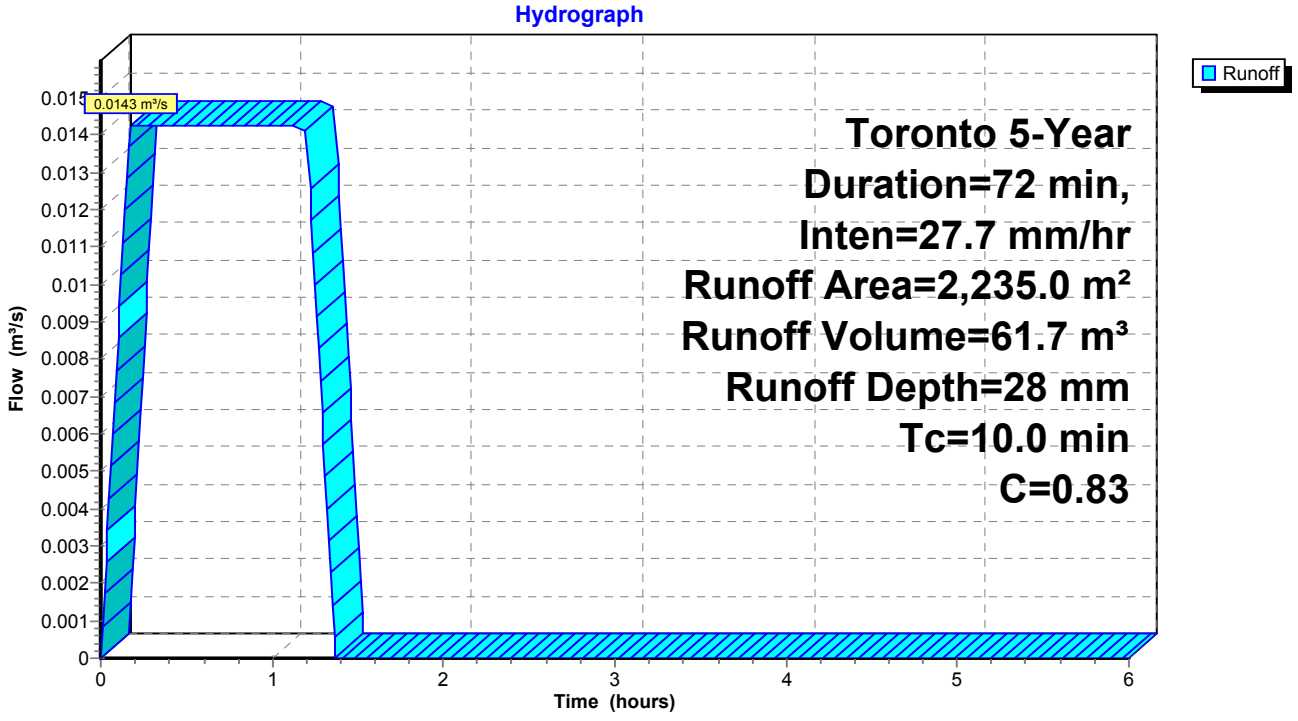
Runoff = 0.0143 m³/s @ 0.17 hrs, Volume= 61.7 m³, Depth= 28 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Toronto 5-Year Duration=72 min, Inten=27.7 mm/hr

Area (m²)	C	Description
286.0	0.45	Green Roof
1,496.0	0.90	Impervious Roof
421.0	0.90	At-Grade Impervious
32.0	0.25	Landscape
2,235.0	0.83	Weighted Average
2,235.0		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
10.0					**Direct Entry,**

Subcatchment A: 11-21 Yorkville



Summary for Pond C: Building A Cistern

Inflow Area = 2,235.0 m², 0.00% Impervious, Inflow Depth = 28 mm for 5-Year event
Inflow = 0.0143 m³/s @ 0.17 hrs, Volume= 61.7 m³
Outflow = 0.0051 m³/s @ 1.31 hrs, Volume= 53.1 m³, Atten= 65%, Lag= 68.3 min
Primary = 0.0051 m³/s @ 1.31 hrs, Volume= 53.1 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 2.195 m @ 1.31 hrs Surf.Area= 22.2 m² Storage= 48.7 m³

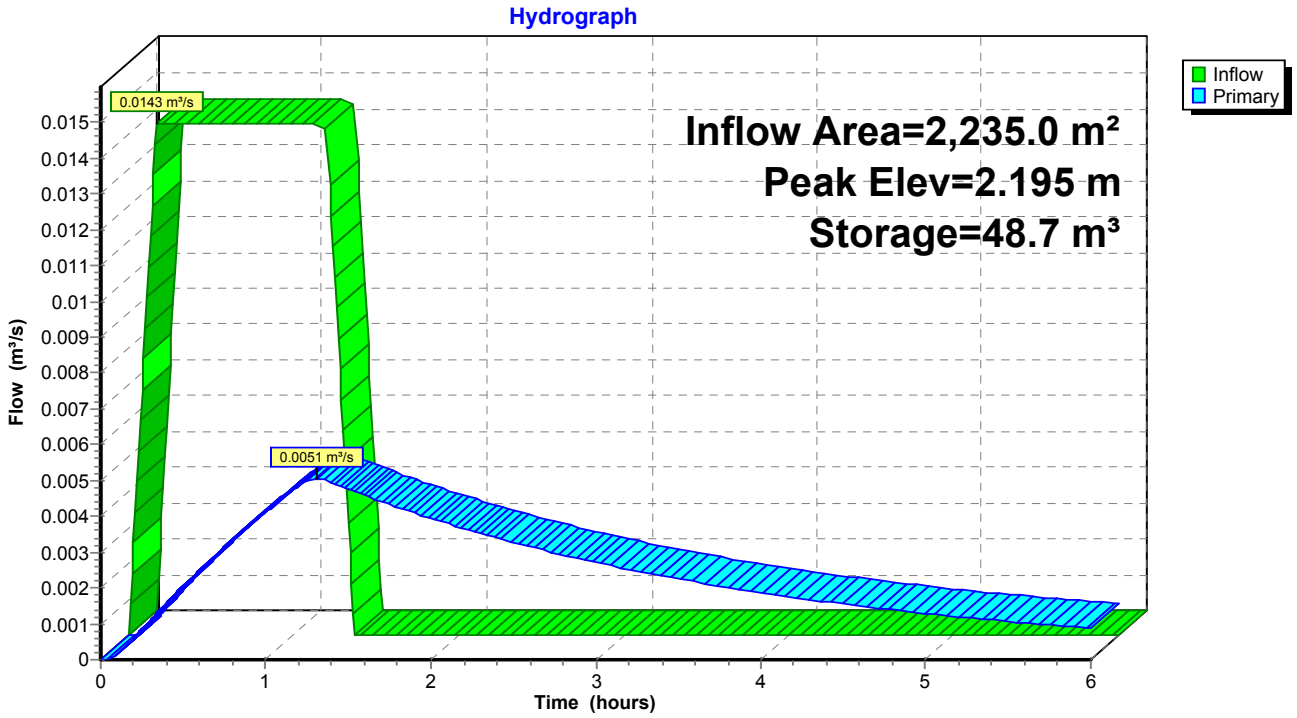
Plug-Flow detention time= 114.2 min calculated for 53.1 m³ (86% of inflow)
Center-of-Mass det. time= 109.5 min (150.5 - 41.0)

Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	241.1 m³	**22.20 mW x 1.00 mL x 10.86 mH Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.000 m	**Pump** Discharges@10.860 m Flow (l/min)= 0.0 750.0 845.0 Head (meters)= 10.860 5.430 0.000

Primary OutFlow Max=0.0051 m³/s @ 1.31 hrs HW=2.195 m (Free Discharge)
└**1=Pump** (Pump Controls 0.0051 m³/s)

Pond C: Building A Cistern



Time span=0.00-6.00 hrs, dt=0.01 hrs, 601 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: 11-21 Yorkville Runoff Area=2,235.0 m² 0.00% Impervious Runoff Depth=33 mm
Tc=10.0 min C=0.83 Runoff=0.0172 m³/s 74.5 m³

Pond C: Building A Cistern Peak Elev=2.650 m Storage=58.8 m³ Inflow=0.0172 m³/s 74.5 m³
Outflow=0.0061 m³/s 64.2 m³

Total Runoff Area = 2,235.0 m² Runoff Volume = 74.5 m³ Average Runoff Depth = 33 mm
100.00% Pervious = 2,235.0 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment A: 11-21 Yorkville

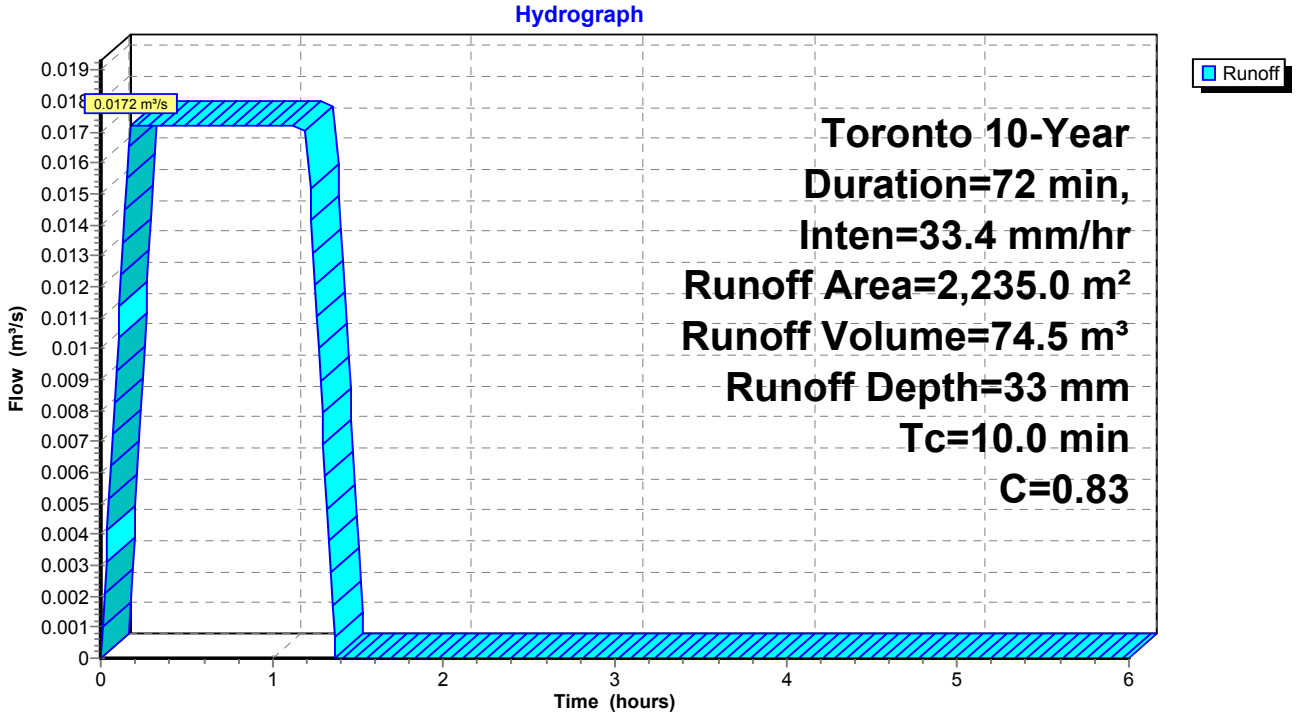
Runoff = 0.0172 m³/s @ 0.17 hrs, Volume= 74.5 m³, Depth= 33 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Toronto 10-Year Duration=72 min, Inten=33.4 mm/hr

Area (m²)	C	Description
286.0	0.45	Green Roof
1,496.0	0.90	Impervious Roof
421.0	0.90	At-Grade Impervious
32.0	0.25	Landscape
2,235.0	0.83	Weighted Average
2,235.0		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
10.0					**Direct Entry,**

Subcatchment A: 11-21 Yorkville



Summary for Pond C: Building A Cistern

Inflow Area = 2,235.0 m², 0.00% Impervious, Inflow Depth = 33 mm for 10-Year event
Inflow = 0.0172 m³/s @ 0.17 hrs, Volume= 74.5 m³
Outflow = 0.0061 m³/s @ 1.31 hrs, Volume= 64.2 m³, Atten= 65%, Lag= 68.3 min
Primary = 0.0061 m³/s @ 1.31 hrs, Volume= 64.2 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 2.650 m @ 1.31 hrs Surf.Area= 22.2 m² Storage= 58.8 m³

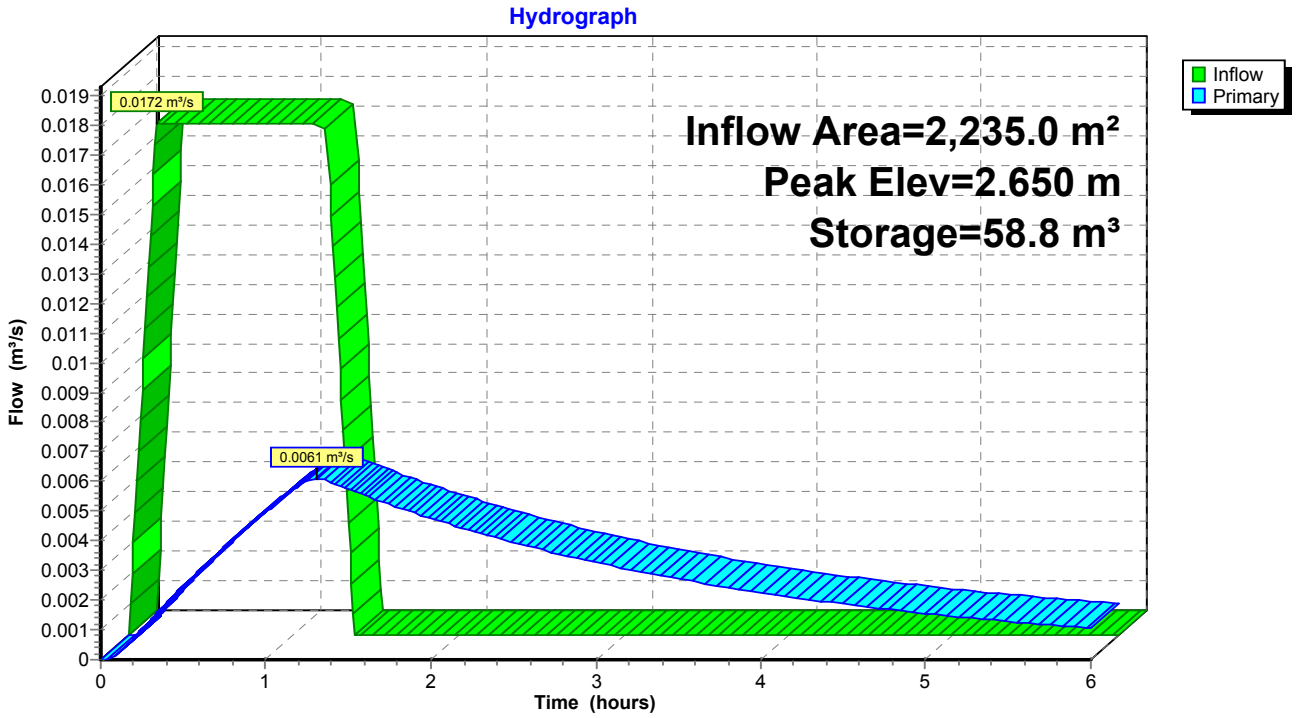
Plug-Flow detention time= 114.2 min calculated for 64.0 m³ (86% of inflow)
Center-of-Mass det. time= 109.5 min (150.5 - 41.0)

Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	241.1 m³	**22.20 mW x 1.00 mL x 10.86 mH Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.000 m	**Pump** Discharges@10.860 m Flow (l/min)= 0.0 750.0 845.0 Head (meters)= 10.860 5.430 0.000

Primary OutFlow Max=0.0061 m³/s @ 1.31 hrs HW=2.650 m (Free Discharge)
└**1=Pump** (Pump Controls 0.0061 m³/s)

Pond C: Building A Cistern



Time span=0.00-6.00 hrs, dt=0.01 hrs, 601 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

SubcatchmentA: 11-21 Yorkville Runoff Area=2,235.0 m² 0.00% Impervious Runoff Depth=39 mm
Tc=10.0 min C=0.83 Runoff=0.0201 m³/s 87.0 m³

Pond C: Building A Cistern Peak Elev=3.095 m Storage=68.7 m³ Inflow=0.0201 m³/s 87.0 m³
Outflow=0.0071 m³/s 74.9 m³

Total Runoff Area = 2,235.0 m² Runoff Volume = 87.0 m³ Average Runoff Depth = 39 mm
100.00% Pervious = 2,235.0 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment A: 11-21 Yorkville

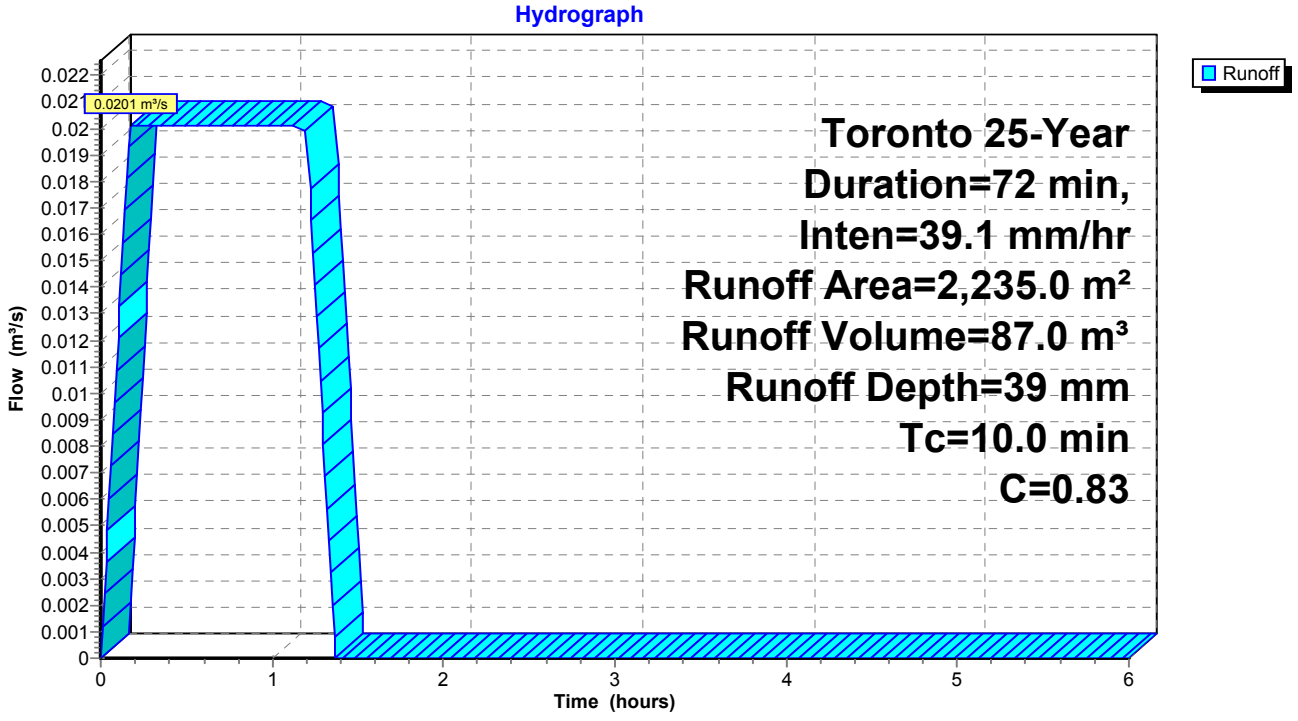
Runoff = 0.0201 m³/s @ 0.17 hrs, Volume= 87.0 m³, Depth= 39 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Toronto 25-Year Duration=72 min, Inten=39.1 mm/hr

Area (m²)	C	Description
286.0	0.45	Green Roof
1,496.0	0.90	Impervious Roof
421.0	0.90	At-Grade Impervious
32.0	0.25	Landscape
2,235.0	0.83	Weighted Average
2,235.0		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
10.0					**Direct Entry,**

Subcatchment A: 11-21 Yorkville



Summary for Pond C: Building A Cistern

Inflow Area = 2,235.0 m², 0.00% Impervious, Inflow Depth = 39 mm for 25-Year event
Inflow = 0.0201 m³/s @ 0.17 hrs, Volume= 87.0 m³
Outflow = 0.0071 m³/s @ 1.31 hrs, Volume= 74.9 m³, Atten= 65%, Lag= 68.3 min
Primary = 0.0071 m³/s @ 1.31 hrs, Volume= 74.9 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 3.095 m @ 1.31 hrs Surf.Area= 22.2 m² Storage= 68.7 m³

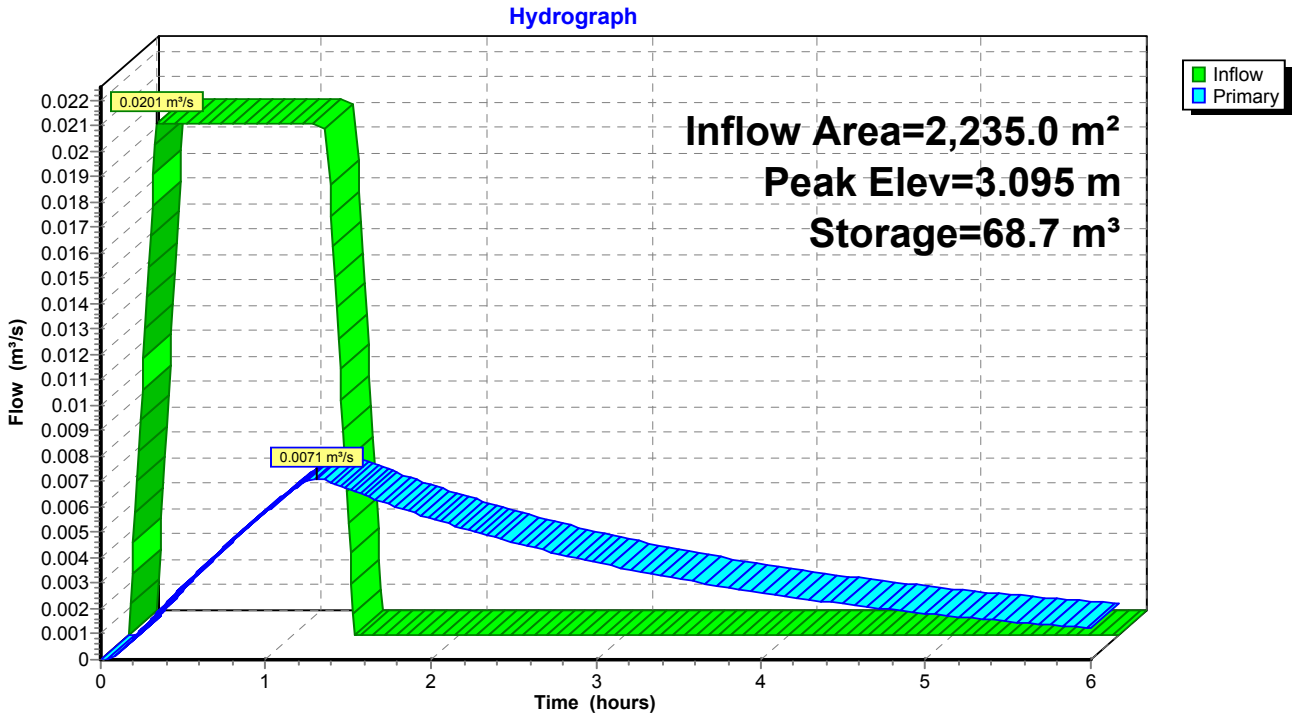
Plug-Flow detention time= 114.2 min calculated for 74.8 m³ (86% of inflow)
Center-of-Mass det. time= 109.5 min (150.5 - 41.0)

Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	241.1 m³	**22.20 mW x 1.00 mL x 10.86 mH Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.000 m	**Pump** Discharges@10.860 m Flow (l/min)= 0.0 750.0 845.0 Head (meters)= 10.860 5.430 0.000

Primary OutFlow Max=0.0071 m³/s @ 1.31 hrs HW=3.095 m (Free Discharge)
└**1=Pump** (Pump Controls 0.0071 m³/s)

Pond C: Building A Cistern



Time span=0.00-6.00 hrs, dt=0.01 hrs, 601 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: 11-21 Yorkville Runoff Area=2,235.0 m² 0.00% Impervious Runoff Depth=46 mm
Tc=10.0 min C=0.83 Runoff=0.0238 m³/s 102.9 m³

Pond C: Building A Cistern Peak Elev=3.663 m Storage=81.3 m³ Inflow=0.0238 m³/s 102.9 m³
Outflow=0.0084 m³/s 88.7 m³

Total Runoff Area = 2,235.0 m² Runoff Volume = 102.9 m³ Average Runoff Depth = 46 mm
100.00% Pervious = 2,235.0 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment A: 11-21 Yorkville

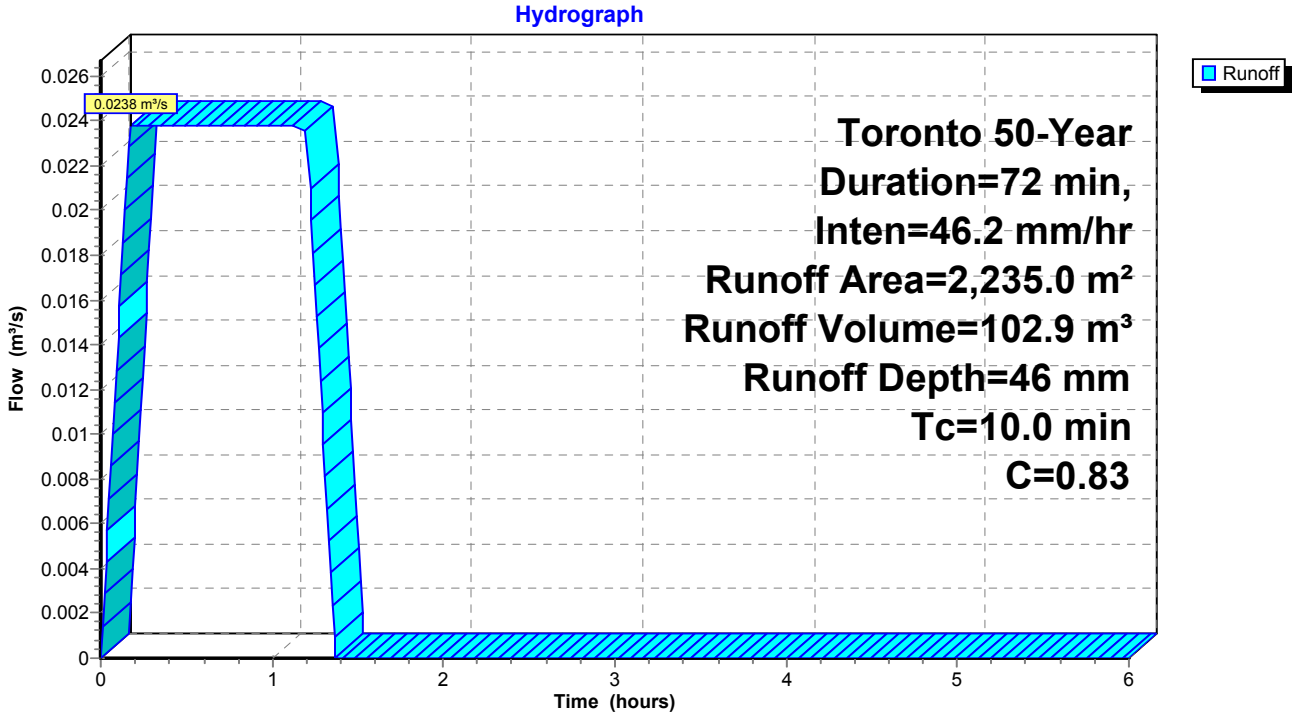
Runoff = 0.0238 m³/s @ 0.17 hrs, Volume= 102.9 m³, Depth= 46 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Toronto 50-Year Duration=72 min, Inten=46.2 mm/hr

Area (m²)	C	Description
286.0	0.45	Green Roof
1,496.0	0.90	Impervious Roof
421.0	0.90	At-Grade Impervious
32.0	0.25	Landscape
2,235.0	0.83	Weighted Average
2,235.0		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
10.0					**Direct Entry,**

Subcatchment A: 11-21 Yorkville



Summary for Pond C: Building A Cistern

Inflow Area = 2,235.0 m², 0.00% Impervious, Inflow Depth = 46 mm for 50-Year event
Inflow = 0.0238 m³/s @ 0.17 hrs, Volume= 102.9 m³
Outflow = 0.0084 m³/s @ 1.31 hrs, Volume= 88.7 m³, Atten= 65%, Lag= 68.3 min
Primary = 0.0084 m³/s @ 1.31 hrs, Volume= 88.7 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 3.663 m @ 1.31 hrs Surf.Area= 22.2 m² Storage= 81.3 m³

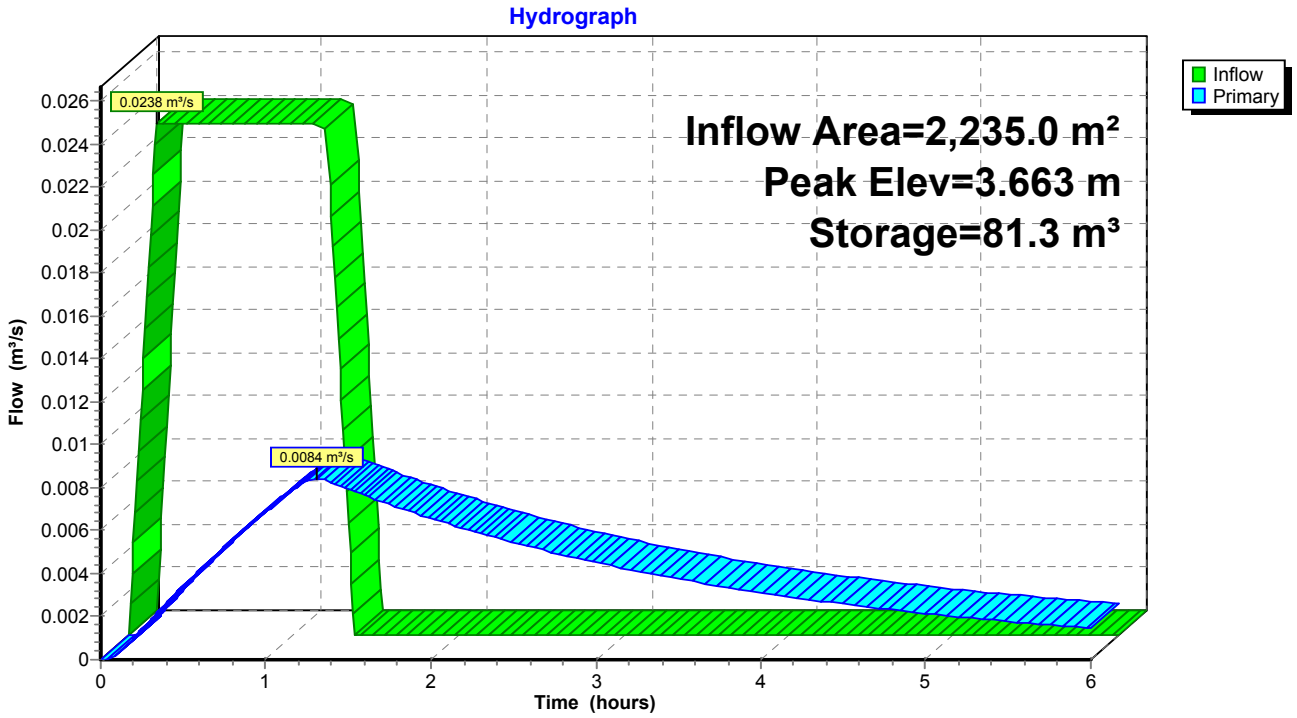
Plug-Flow detention time= 114.5 min calculated for 88.7 m³ (86% of inflow)
Center-of-Mass det. time= 109.5 min (150.5 - 41.0)

Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	241.1 m³	**22.20 mW x 1.00 mL x 10.86 mH Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.000 m	**Pump** Discharges@10.860 m Flow (l/min)= 0.0 750.0 845.0 Head (meters)= 10.860 5.430 0.000

Primary OutFlow Max=0.0084 m³/s @ 1.31 hrs HW=3.663 m (Free Discharge)
└**1=Pump** (Pump Controls 0.0084 m³/s)

Pond C: Building A Cistern



Time span=0.00-6.00 hrs, dt=0.01 hrs, 601 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment A: 11-21 Yorkville Runoff Area=2,235.0 m² 0.00% Impervious Runoff Depth=51 mm
Tc=10.0 min C=0.83 Runoff=0.0266 m³/s 114.9 m³

Pond C: Building A Cistern Peak Elev=4.088 m Storage=90.7 m³ Inflow=0.0266 m³/s 114.9 m³
Outflow=0.0094 m³/s 99.0 m³

Total Runoff Area = 2,235.0 m² Runoff Volume = 114.9 m³ Average Runoff Depth = 51 mm
100.00% Pervious = 2,235.0 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment A: 11-21 Yorkville

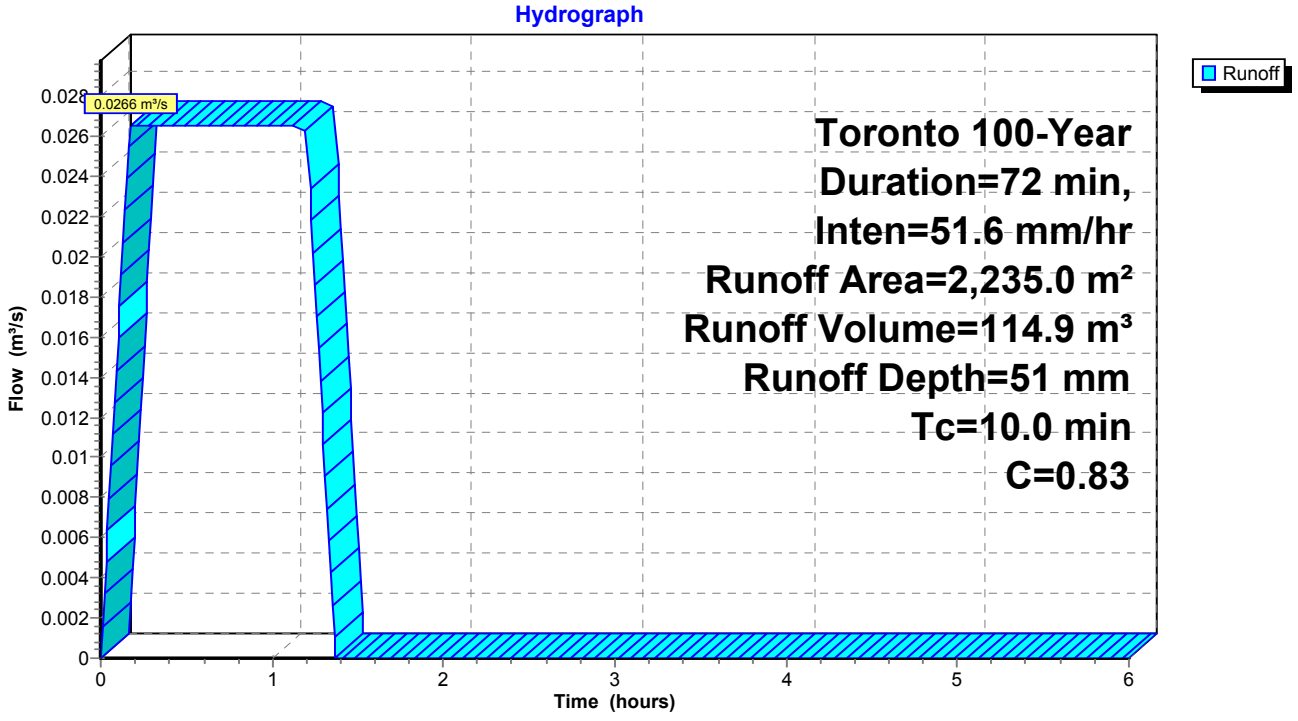
Runoff = 0.0266 m³/s @ 0.17 hrs, Volume= 114.9 m³, Depth= 51 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Toronto 100-Year Duration=72 min, Inten=51.6 mm/hr

Area (m²)	C	Description
286.0	0.45	Green Roof
1,496.0	0.90	Impervious Roof
421.0	0.90	At-Grade Impervious
32.0	0.25	Landscape
2,235.0	0.83	Weighted Average
2,235.0		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
10.0					**Direct Entry,**

Subcatchment A: 11-21 Yorkville



Summary for Pond C: Building A Cistern

Inflow Area = 2,235.0 m², 0.00% Impervious, Inflow Depth = 51 mm for 100-Year event
Inflow = 0.0266 m³/s @ 0.17 hrs, Volume= 114.9 m³
Outflow = 0.0094 m³/s @ 1.31 hrs, Volume= 99.0 m³, Atten= 65%, Lag= 68.3 min
Primary = 0.0094 m³/s @ 1.31 hrs, Volume= 99.0 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 4.088 m @ 1.31 hrs Surf.Area= 22.2 m² Storage= 90.7 m³

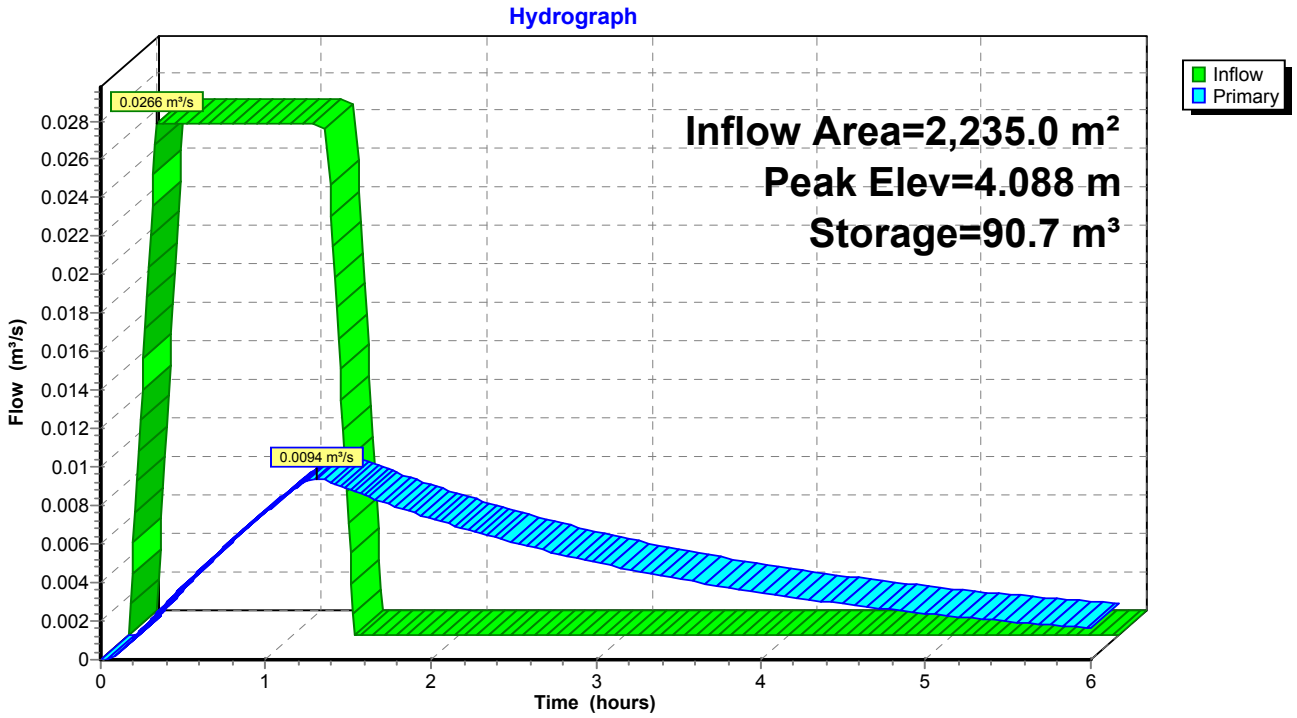
Plug-Flow detention time= 114.2 min calculated for 98.8 m³ (86% of inflow)
Center-of-Mass det. time= 109.5 min (150.5 - 41.0)

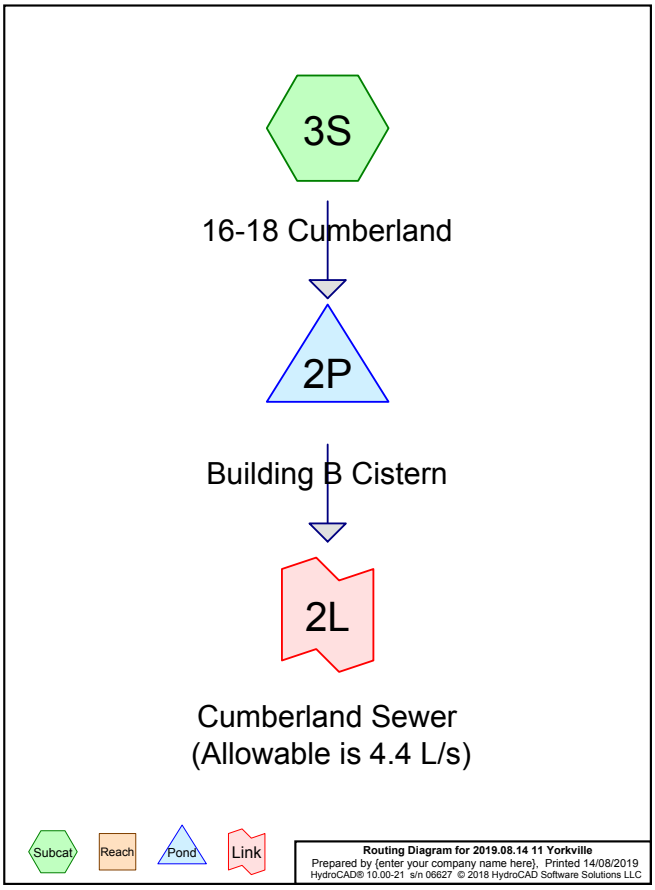
Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	241.1 m³	**22.20 mW x 1.00 mL x 10.86 mH Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.000 m	**Pump** Discharges@10.860 m Flow (l/min)= 0.0 750.0 845.0 Head (meters)= 10.860 5.430 0.000

Primary OutFlow Max=0.0094 m³/s @ 1.31 hrs HW=4.087 m (Free Discharge)
└**1=Pump** (Pump Controls 0.0094 m³/s)

Pond C: Building A Cistern





Area Listing (selected nodes)

Area (sq-meters)	C	Description (subcatchment-numbers)
50.4	0.90	At-grade Impervious (3S)
307.3	0.90	Impervious Roof (3S)
357.7	**0.90**	**TOTAL AREA**

Soil Listing (selected nodes)

Area (sq-meters)	Soil Group	Subcatchment Numbers
0.0	HSG A	
0.0	HSG B	
0.0	HSG C	
0.0	HSG D	
357.7	Other	3S
357.7		**TOTAL AREA**

Ground Covers (selected nodes)

HSG-A (sq-meters)	HSG-B (sq-meters)	HSG-C (sq-meters)	HSG-D (sq-meters)	Other (sq-meters)	Total (sq-meters)	Ground Cover	Sub Num
0.0	0.0	0.0	0.0	50.4	50.4	At-grade Impervious	
0.0	0.0	0.0	0.0	307.3	307.3	Impervious Roof	
0.0	**0.0**	**0.0**	**0.0**	**357.7**	**357.7**	**TOTAL AREA**	

Time span=0.00-6.00 hrs, dt=0.01 hrs, 601 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment3S: 16-18 Cumberland Runoff Area=357.7 m² 0.00% Impervious Runoff Depth=15 mm
Tc=10.0 min C=0.90 Runoff=0.0055 m³/s 5.2 m³

Pond 2P: Building B Cistern Peak Elev=0.528 m Storage=4.2 m³ Inflow=0.0055 m³/s 5.2 m³
Outflow=0.0024 m³/s 5.2 m³

Link 2L: Cumberland Sewer (Allowable is 4.4 L/s) Inflow=0.0024 m³/s 5.2 m³
Primary=0.0024 m³/s 5.2 m³

Total Runoff Area = 357.7 m² Runoff Volume = 5.2 m³ Average Runoff Depth = 15 mm
100.00% Pervious = 357.7 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 3S: 16-18 Cumberland

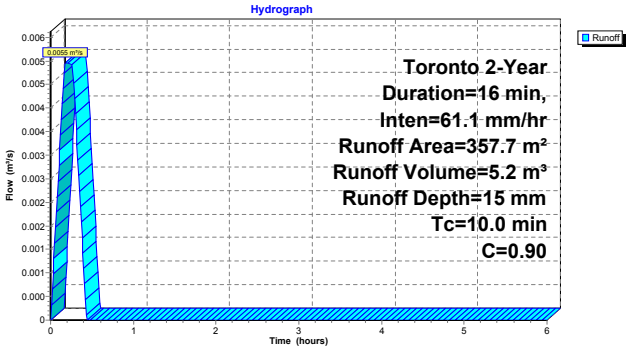
Runoff = 0.0055 m³/s @ 0.17 hrs, Volume= 5.2 m³, Depth= 15 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Toronto 2-Year Duration=16 min, Inten=61.1 mm/hr

Area (m²)	C	Description
307.3	0.90	Impervious Roof
50.4	0.90	At-grade Impervious
357.7	0.90	Weighted Average
357.7		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
10.0					**Direct Entry,**

Subcatchment 3S: 16-18 Cumberland



Summary for Pond 2P: Building B Cistern

Inflow Area = 357.7 m², 0.00% Impervious, Inflow Depth = 15 mm for 2-Year event
Inflow = 0.0055 m³/s @ 0.17 hrs, Volume= 5.2 m³
Outflow = 0.0024 m³/s @ 0.18 hrs, Volume= 5.2 m³, Atten= 56%, Lag= 0.6 min
Primary = 0.0024 m³/s @ 0.18 hrs, Volume= 5.2 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Starting Elev= 0.180 m Surf.Area= 8.0 m² Storage= 1.4 m³
Peak Elev= 0.528 m @ 0.37 hrs Surf.Area= 8.0 m² Storage= 4.2 m³ (2.8 m³ above start)

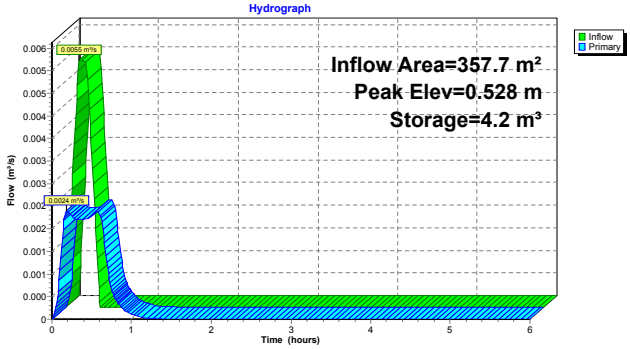
Plug-Flow detention time= 21.1 min calculated for 3.8 m³ (73% of inflow)
Center-of-Mass det. time= 12.8 min (25.8 - 13.0)

Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	16.0 m³	**8.00 mW x 1.00 mL x 2.00 mH Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.180 m	**Reg-U-Flo SXH 3.0-in Metric - Extended**

Primary OutFlow Max=0.0024 m³/s @ 0.18 hrs HW=0.334 m (Free Discharge)
↑**1=Reg-U-Flo SXH 3.0-in Metric - Extended** (Custom Controls 0.0024 m³/s)

Pond 2P: Building B Cistern

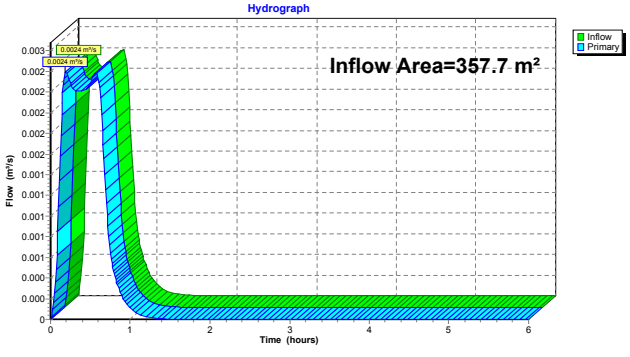


Summary for Link 2L: Cumberland Sewer (Allowable is 4.4 L/s)

Inflow Area = 357.7 m², 0.00% Impervious, Inflow Depth = 15 mm for 2-Year event
Inflow = 0.0024 m³/s @ 0.18 hrs, Volume= 5.2 m³
Primary = 0.0024 m³/s @ 0.18 hrs, Volume= 5.2 m³, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs

Link 2L: Cumberland Sewer (Allowable is 4.4 L/s)



Time span=0.00-6.00 hrs, dt=0.01 hrs, 601 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment3S: 16-18 Cumberland Runoff Area=357.7 m² 0.00% Impervious Runoff Depth=22 mm
Tc=10.0 min C=0.90 Runoff=0.0081 m³/s 7.8 m³

Pond 2P: Building B Cistern Peak Elev=0.802 m Storage=6.4 m³ Inflow=0.0081 m³/s 7.8 m³
Outflow=0.0026 m³/s 7.8 m³

Link 2L: Cumberland Sewer (Allowable is 4.4 L/s) Inflow=0.0026 m³/s 7.8 m³
Primary=0.0026 m³/s 7.8 m³

Total Runoff Area = 357.7 m² Runoff Volume = 7.8 m³ Average Runoff Depth = 22 mm
100.00% Pervious = 357.7 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 3S: 16-18 Cumberland

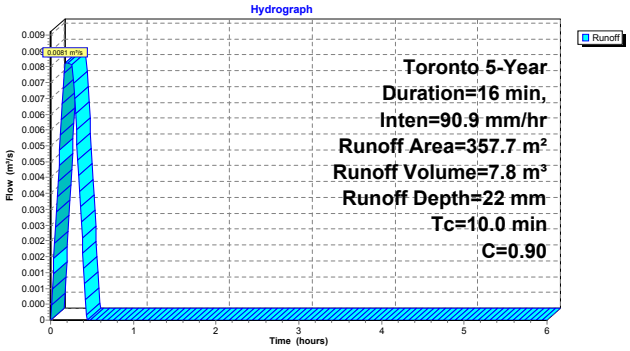
Runoff = 0.0081 m³/s @ 0.17 hrs, Volume= 7.8 m³, Depth= 22 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Toronto 5-Year Duration=16 min, Inten=90.9 mm/hr

Area (m²)	C	Description
307.3	0.90	Impervious Roof
50.4	0.90	At-grade Impervious
357.7	0.90	Weighted Average
357.7		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
10.0					**Direct Entry,**

Subcatchment 3S: 16-18 Cumberland



Summary for Pond 2P: Building B Cistern

Inflow Area = 357.7 m², 0.00% Impervious, Inflow Depth = 22 mm for 5-Year event
Inflow = 0.0081 m³/s @ 0.17 hrs, Volume= 7.8 m³
Outflow = 0.0026 m³/s @ 0.38 hrs, Volume= 7.8 m³, Atten= 68%, Lag= 12.6 min
Primary = 0.0026 m³/s @ 0.38 hrs, Volume= 7.8 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Starting Elev= 0.180 m Surf.Area= 8.0 m² Storage= 1.4 m³
Peak Elev= 0.802 m @ 0.38 hrs Surf.Area= 8.0 m² Storage= 6.4 m³ (5.0 m³ above start)

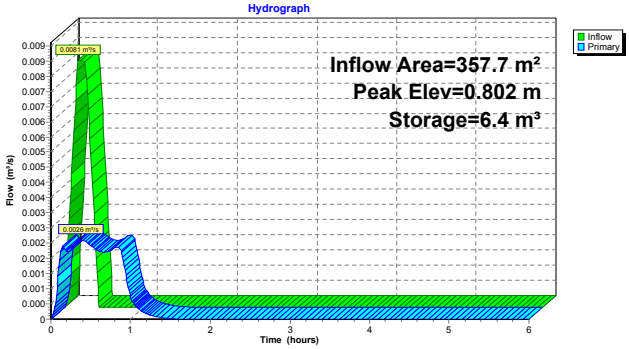
Plug-Flow detention time= 26.7 min calculated for 6.4 m³ (82% of inflow)
Center-of-Mass det. time= 19.6 min (32.6 - 13.0)

Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	16.0 m³	**8.00 mW x 1.00 mL x 2.00 mH Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.180 m	**Reg-U-Flo SXH 3.0-in Metric - Extended**

Primary OutFlow Max=0.0026 m³/s @ 0.38 hrs HW=0.802 m (Free Discharge)
↑**1=Reg-U-Flo SXH 3.0-in Metric - Extended** (Custom Controls 0.0026 m³/s)

Pond 2P: Building B Cistern

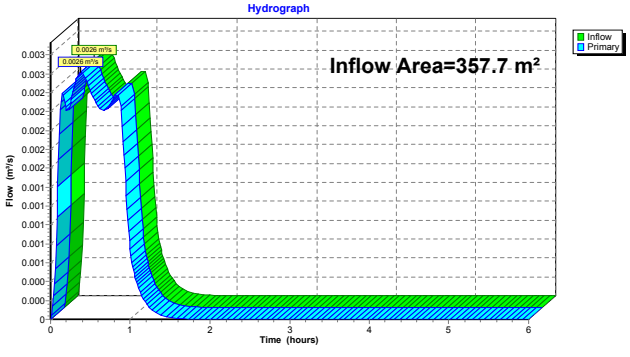


Summary for Link 2L: Cumberland Sewer (Allowable is 4.4 L/s)

Inflow Area = 357.7 m², 0.00% Impervious, Inflow Depth = 22 mm for 5-Year event
Inflow = 0.0026 m³/s @ 0.38 hrs, Volume= 7.8 m³
Primary = 0.0026 m³/s @ 0.38 hrs, Volume= 7.8 m³, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs

Link 2L: Cumberland Sewer (Allowable is 4.4 L/s)



Time span=0.00-6.00 hrs, dt=0.01 hrs, 601 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment3S: 16-18 Cumberland Runoff Area=357.7 m² 0.00% Impervious Runoff Depth=27 mm
Tc=10.0 min C=0.90 Runoff=0.0100 m³/s 9.6 m³

Pond 2P: Building B Cistern Peak Elev=0.986 m Storage=7.9 m³ Inflow=0.0100 m³/s 9.6 m³
Outflow=0.0030 m³/s 9.6 m³

Link 2L: Cumberland Sewer (Allowable is 4.4 L/s) Inflow=0.0030 m³/s 9.6 m³
Primary=0.0030 m³/s 9.6 m³

Total Runoff Area = 357.7 m² Runoff Volume = 9.6 m³ Average Runoff Depth = 27 mm
100.00% Pervious = 357.7 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 3S: 16-18 Cumberland

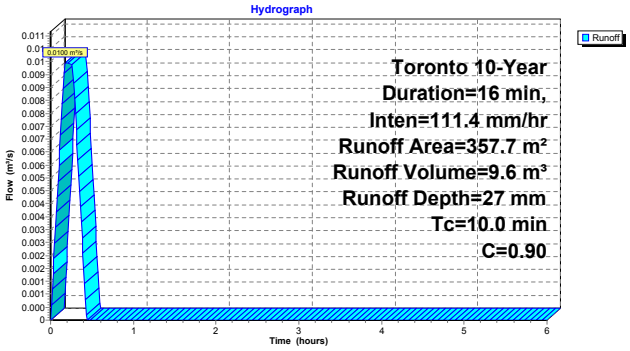
Runoff = 0.0100 m³/s @ 0.17 hrs, Volume= 9.6 m³, Depth= 27 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Toronto 10-Year Duration=16 min, Inten=111.4 mm/hr

Area (m²)	C	Description
307.3	0.90	Impervious Roof
50.4	0.90	At-grade Impervious
357.7	0.90	Weighted Average
357.7		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
10.0					**Direct Entry,**

Subcatchment 3S: 16-18 Cumberland



Summary for Pond 2P: Building B Cistern

Inflow Area = 357.7 m², 0.00% Impervious, Inflow Depth = 27 mm for 10-Year event
Inflow = 0.0100 m³/s @ 0.17 hrs, Volume= 9.6 m³
Outflow = 0.0030 m³/s @ 0.38 hrs, Volume= 9.6 m³, Atten= 70%, Lag= 12.8 min
Primary = 0.0030 m³/s @ 0.38 hrs, Volume= 9.6 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Starting Elev= 0.180 m Surf.Area= 8.0 m² Storage= 1.4 m³
Peak Elev= 0.986 m @ 0.38 hrs Surf.Area= 8.0 m² Storage= 7.9 m³ (6.5 m³ above start)

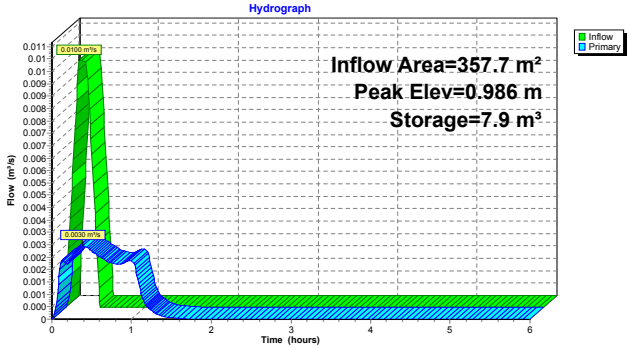
Plug-Flow detention time= 29.7 min calculated for 8.1 m³ (85% of inflow)
Center-of-Mass det. time= 23.2 min (36.2 - 13.0)

Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	16.0 m³	**8.00 mW x 1.00 mL x 2.00 mH Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.180 m	**Reg-U-Flo SXH 3.0-in Metric - Extended**

Primary OutFlow Max=0.0030 m³/s @ 0.38 hrs HW=0.986 m (Free Discharge)
↑**1=Reg-U-Flo SXH 3.0-in Metric - Extended** (Custom Controls 0.0030 m³/s)

Pond 2P: Building B Cistern

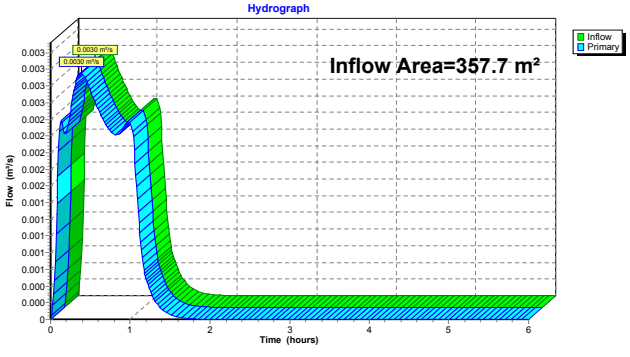


Summary for Link 2L: Cumberland Sewer (Allowable is 4.4 L/s)

Inflow Area = 357.7 m², 0.00% Impervious, Inflow Depth = 27 mm for 10-Year event
Inflow = 0.0030 m³/s @ 0.38 hrs, Volume= 9.6 m³
Primary = 0.0030 m³/s @ 0.38 hrs, Volume= 9.6 m³, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs

Link 2L: Cumberland Sewer (Allowable is 4.4 L/s)



Time span=0.00-6.00 hrs, dt=0.01 hrs, 601 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment3S: 16-18 Cumberland Runoff Area=357.7 m² 0.00% Impervious Runoff Depth=31 mm
Tc=10.0 min C=0.90 Runoff=0.0116 m³/s 11.2 m³

Pond 2P: Building B Cistern Peak Elev=1.156 m Storage=9.2 m³ Inflow=0.0116 m³/s 11.2 m³
Outflow=0.0033 m³/s 11.2 m³

Link 2L: Cumberland Sewer (Allowable is 4.4 L/s) Inflow=0.0033 m³/s 11.2 m³
Primary=0.0033 m³/s 11.2 m³

Total Runoff Area = 357.7 m² Runoff Volume = 11.2 m³ Average Runoff Depth = 31 mm
100.00% Pervious = 357.7 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 3S: 16-18 Cumberland

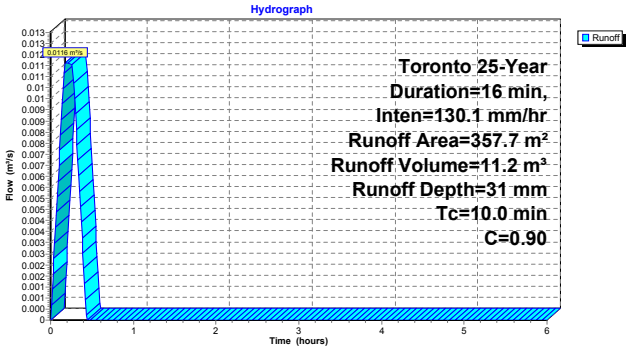
Runoff = 0.0116 m³/s @ 0.17 hrs, Volume= 11.2 m³, Depth= 31 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Toronto 25-Year Duration=16 min, Inten=130.1 mm/hr

Area (m²)	C	Description
307.3	0.90	Impervious Roof
50.4	0.90	At-grade Impervious
357.7	0.90	Weighted Average
357.7		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
10.0					**Direct Entry,**

Subcatchment 3S: 16-18 Cumberland



Summary for Pond 2P: Building B Cistern

Inflow Area = 357.7 m², 0.00% Impervious, Inflow Depth = 31 mm for 25-Year event
Inflow = 0.0116 m³/s @ 0.17 hrs, Volume= 11.2 m³
Outflow = 0.0033 m³/s @ 0.39 hrs, Volume= 11.2 m³, Atten= 72%, Lag= 13.0 min
Primary = 0.0033 m³/s @ 0.39 hrs, Volume= 11.2 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Starting Elev= 0.180 m Surf.Area= 8.0 m² Storage= 1.4 m³
Peak Elev= 1.156 m @ 0.39 hrs Surf.Area= 8.0 m² Storage= 9.2 m³ (7.8 m³ above start)

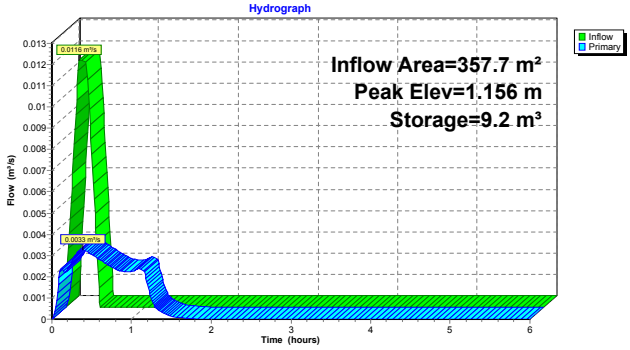
Plug-Flow detention time= 32.0 min calculated for 9.7 m³ (87% of inflow)
Center-of-Mass det. time= 26.1 min (39.1 - 13.0)

Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	16.0 m³	**8.00 mW x 1.00 mL x 2.00 mH Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.180 m	**Reg-U-Flo SXH 3.0-in Metric - Extended**

Primary OutFlow Max=0.0033 m³/s @ 0.39 hrs HW=1.155 m (Free Discharge)
↑**1=Reg-U-Flo SXH 3.0-in Metric - Extended**(Custom Controls 0.0033 m³/s)

Pond 2P: Building B Cistern

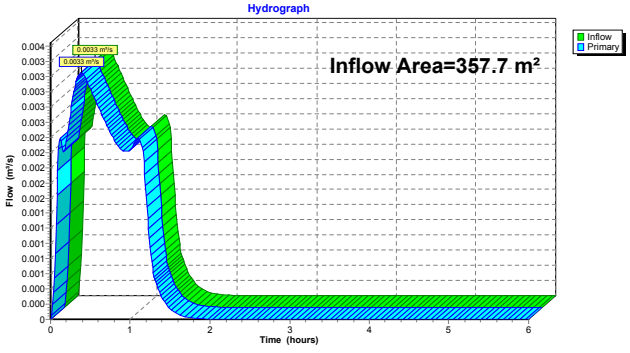


Summary for Link 2L: Cumberland Sewer (Allowable is 4.4 L/s)

Inflow Area = 357.7 m², 0.00% Impervious, Inflow Depth = 31 mm for 25-Year event
Inflow = 0.0033 m³/s @ 0.39 hrs, Volume= 11.2 m³
Primary = 0.0033 m³/s @ 0.39 hrs, Volume= 11.2 m³, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs

Link 2L: Cumberland Sewer (Allowable is 4.4 L/s)



Time span=0.00-6.00 hrs, dt=0.01 hrs, 601 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment3S: 16-18 Cumberland Runoff Area=357.7 m² 0.00% Impervious Runoff Depth=37 mm
Tc=10.0 min C=0.90 Runoff=0.0138 m³/s 13.2 m³

Pond 2P: Building B Cistern Peak Elev=1.374 m Storage=11.0 m³ Inflow=0.0138 m³/s 13.2 m³
Outflow=0.0036 m³/s 13.2 m³

Link 2L: Cumberland Sewer (Allowable is 4.4 L/s) Inflow=0.0036 m³/s 13.2 m³
Primary=0.0036 m³/s 13.2 m³

Total Runoff Area = 357.7 m² Runoff Volume = 13.2 m³ Average Runoff Depth = 37 mm
100.00% Pervious = 357.7 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 3S: 16-18 Cumberland

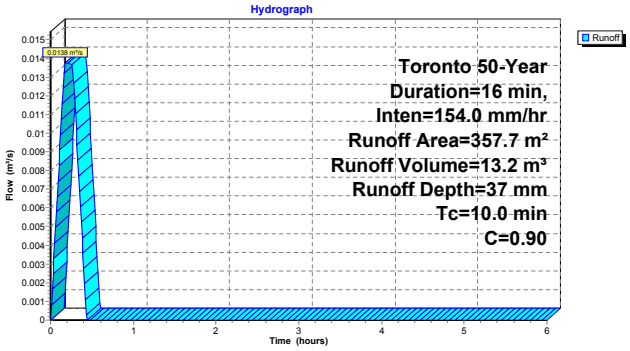
Runoff = 0.0138 m³/s @ 0.17 hrs, Volume= 13.2 m³, Depth= 37 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Toronto 50-Year Duration=16 min, Inten=154.0 mm/hr

Area (m²)	C	Description
307.3	0.90	Impervious Roof
50.4	0.90	At-grade Impervious
357.7	0.90	Weighted Average
357.7		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
10.0					**Direct Entry,**

Subcatchment 3S: 16-18 Cumberland



Summary for Pond 2P: Building B Cistern

Inflow Area = 357.7 m², 0.00% Impervious, Inflow Depth = 37 mm for 50-Year event
Inflow = 0.0138 m³/s @ 0.17 hrs, Volume= 13.2 m³
Outflow = 0.0036 m³/s @ 0.39 hrs, Volume= 13.2 m³, Atten= 74%, Lag= 13.2 min
Primary = 0.0036 m³/s @ 0.39 hrs, Volume= 13.2 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Starting Elev= 0.180 m Surf.Area= 8.0 m² Storage= 1.4 m³
Peak Elev= 1.374 m @ 0.39 hrs Surf.Area= 8.0 m² Storage= 11.0 m³ (9.5 m³ above start)

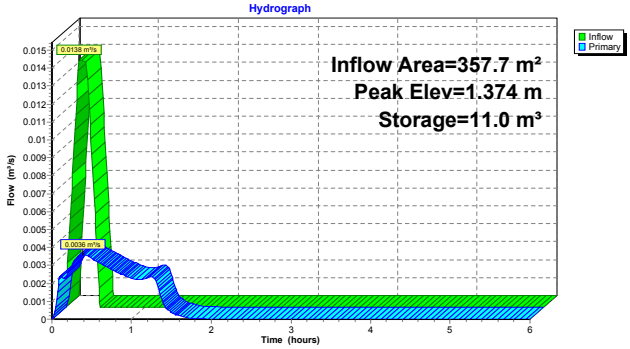
Plug-Flow detention time= 34.4 min calculated for 11.8 m³ (89% of inflow)
Center-of-Mass det. time= 29.2 min (42.3 - 13.0)

Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	16.0 m³	**8.00 mW x 1.00 mL x 2.00 mH Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.180 m	**Reg-U-Flo SXH 3.0-in Metric - Extended**

Primary OutFlow Max=0.0036 m³/s @ 0.39 hrs HW=1.374 m (Free Discharge)
↑**1=Reg-U-Flo SXH 3.0-in Metric - Extended** (Custom Controls 0.0036 m³/s)

Pond 2P: Building B Cistern

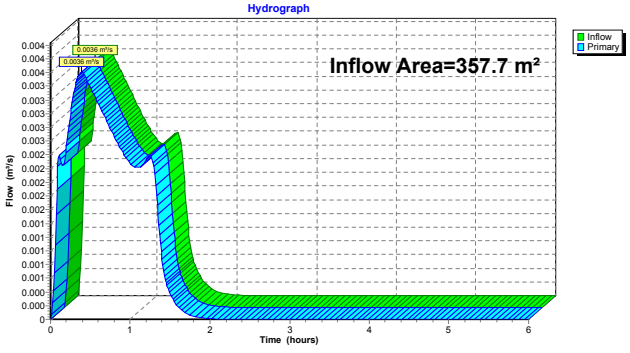


Summary for Link 2L: Cumberland Sewer (Allowable is 4.4 L/s)

Inflow Area = 357.7 m², 0.00% Impervious, Inflow Depth = 37 mm for 50-Year event
Inflow = 0.0036 m³/s @ 0.39 hrs, Volume= 13.2 m³
Primary = 0.0036 m³/s @ 0.39 hrs, Volume= 13.2 m³, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs

Link 2L: Cumberland Sewer (Allowable is 4.4 L/s)



Time span=0.00-6.00 hrs, dt=0.01 hrs, 601 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment3S: 16-18 Cumberland Runoff Area=357.7 m² 0.00% Impervious Runoff Depth=41 mm
Tc=10.0 min C=0.90 Runoff=0.0154 m³/s 14.8 m³

Pond 2P: Building B Cistern Peak Elev=1.538 m Storage=12.3 m³ Inflow=0.0154 m³/s 14.8 m³
Outflow=0.0038 m³/s 14.8 m³

Link 2L: Cumberland Sewer (Allowable is 4.4 L/s) Inflow=0.0038 m³/s 14.8 m³
Primary=0.0038 m³/s 14.8 m³

Total Runoff Area = 357.7 m² Runoff Volume = 14.8 m³ Average Runoff Depth = 41 mm
100.00% Pervious = 357.7 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 3S: 16-18 Cumberland

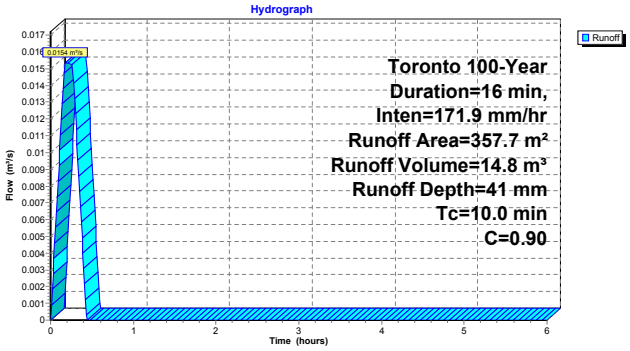
Runoff = 0.0154 m³/s @ 0.17 hrs, Volume= 14.8 m³, Depth= 41 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Toronto 100-Year Duration=16 min, Inten=171.9 mm/hr

Area (m²)	C	Description
307.3	0.90	Impervious Roof
50.4	0.90	At-grade Impervious
357.7	0.90	Weighted Average
357.7		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
10.0					**Direct Entry,**

Subcatchment 3S: 16-18 Cumberland



Summary for Pond 2P: Building B Cistern

Inflow Area = 357.7 m², 0.00% Impervious, Inflow Depth = 41 mm for 100-Year event
Inflow = 0.0154 m³/s @ 0.17 hrs, Volume= 14.8 m³
Outflow = 0.0038 m³/s @ 0.39 hrs, Volume= 14.8 m³, Atten= 75%, Lag= 13.3 min
Primary = 0.0038 m³/s @ 0.39 hrs, Volume= 14.8 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Starting Elev= 0.180 m Surf.Area= 8.0 m² Storage= 1.4 m³
Peak Elev= 1.538 m @ 0.39 hrs Surf.Area= 8.0 m² Storage= 12.3 m³ (10.9 m³ above start)

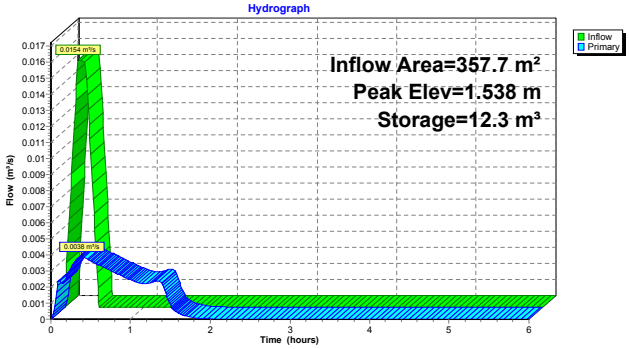
Plug-Flow detention time= 36.5 min calculated for 13.3 m³ (90% of inflow)
Center-of-Mass det. time= 31.4 min (44.4 - 13.0)

Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	16.0 m³	**8.00 mW x 1.00 mL x 2.00 mH Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.180 m	**Reg-U-Flo SXH 3.0-in Metric - Extended**

Primary OutFlow Max=0.0038 m³/s @ 0.39 hrs HW=1.538 m (Free Discharge)
↑**1=Reg-U-Flo SXH 3.0-in Metric - Extended**(Custom Controls 0.0038 m³/s)

Pond 2P: Building B Cistern

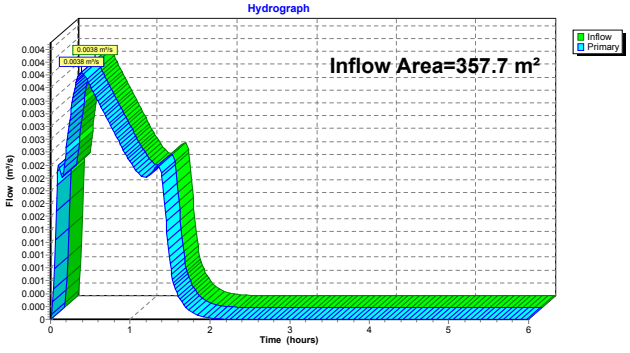


Summary for Link 2L: Cumberland Sewer (Allowable is 4.4 L/s)

Inflow Area = 357.7 m², 0.00% Impervious, Inflow Depth = 41 mm for 100-Year event
Inflow = 0.0038 m³/s @ 0.39 hrs, Volume= 14.8 m³
Primary = 0.0038 m³/s @ 0.39 hrs, Volume= 14.8 m³, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs

Link 2L: Cumberland Sewer (Allowable is 4.4 L/s)



APPENDIX

C SUPPORTING STORMWATER MANAGEMENT DOCUMENTS

M.V. SHORE
ASSOCIATES (1993) LIMITED

Consulting Professional Engineers

July 26, 2019 Project no: 19-002

Attention: **Executive Director, Engineering & Construction Services**
16/F, 55 John Street, Toronto, ON M5V 3C6
c/o: **Avi Bachar, P.Eng. PMP**
Manager, Development Engineering
Engineering and Construction Services

cc: **General Manager, Toronto Water**
c/o: **Manager, Environmental Monitoring & Protection Unit**
30 Dee Ave, Toronto ON M9N 1S8

Address: **11 Yorkville Avenue, Toronto**

Dear Sir or Madame;

This letter is to confirm that the designed pumped discharge rate from the storm water cistern to the discharge chamber will be a maximum flow rate no greater than 14.1L/S (225gpm).

For additional information, please contact the undersigned.

LICENSED PROFESSIONAL ENGINEER
C.W.B. CHAN
7446503
PROVINCE OF ONTARIO

.....
Bill Chan, P.Eng.

Seal

1200 Eglinton Avenue East • Suite 402 • Don Mills • Ontario • Canada • M3C 1H9
Phone: (416) 443-1995 • Fax: (416) 443-1415
email: mvs@mvshore.com

APPENDIX

D WATER QUALITY DOCUMENTS

STANDARD OFFLINE
Jellyfish Filter Sizing Report

Project Information

Date	Tuesday, August 13, 2019
Project Name	11 Yorkville Ave.
Project Number	17M-01494
Location	Toronto

Jellyfish Filter Design Overview

This report provides information for the sizing and specification of the Jellyfish Filter. When designed properly in accordance to the guidelines detailed in the Jellyfish Filter Technical Manual, the Jellyfish Filter will exceed the performance and longevity of conventional horizontal bed and granular media filters.

Please see ***www.ImbriumSystems.com*** *for more information.*

Jellyfish Filter System Recommendation

The Jellyfish Filter model JF4-2-1 is recommended to meet the water quality objective by treating a flow of 12.6 L/s, which meets or exceeds 90% of the average annual rainfall runoff volume based on 18 years of TORONTO CENTRAL rainfall data for this site. This model has a sediment capacity of 142 kg, which meets or exceeds the estimated average annual sediment load.

Jellyfish Model	Number of High-Flo Cartridges	Number of Draindown Cartridges	Manhole Diameter (m)	Treatment Flow Rate (L/s)	Sediment Capacity (kg)
JF4-2-1	2	1	1.2	12.6	142

The Jellyfish Filter System

The patented Jellyfish Filter is an engineered stormwater quality treatment technology featuring unique membrane filtration in a compact stand-alone treatment system that removes a high level and wide variety of stormwater pollutants. Exceptional pollutant removal is achieved at high treatment flow rates with minimal head loss and low maintenance costs. Each lightweight Jellyfish Filter cartridge contains an extraordinarily large amount of membrane surface area, resulting in superior flow capacity and pollutant removal capacity.

Maintenance

Regular scheduled inspections and maintenance is necessary to assure proper functioning of the Jellyfish Filter. The maintenance interval is designed to be a minimum of 12 months, but this will vary depending on site loading conditions and upstream pretreatment measures. Quarterly inspections and inspections after all storms beyond the 5-year event are recommended until enough historical performance data has been logged to comfortably initiate an alternative inspection interval.

Please see ***www.ImbriumSystems.com*** *for more information.*

Thank you for the opportunity to present this information to you and your client.

Performance

Jellyfish efficiently captures a high level of Stormwater pollutants, including:

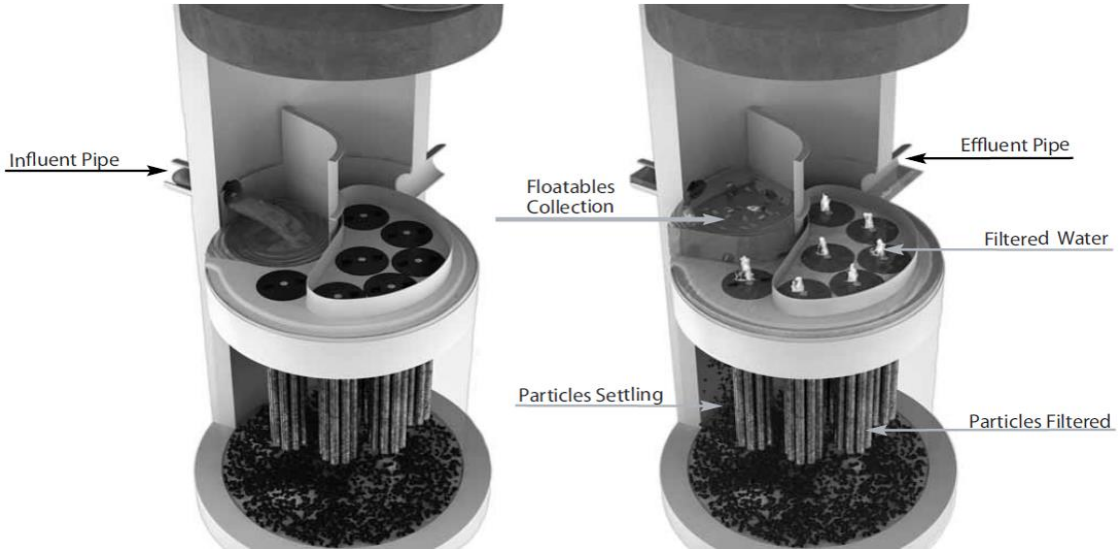
- ☑ 89% of the total suspended solids (TSS) load, including particles less than 5 microns
- ☑ 59% TP removal & 51% TN removal
- ☑ 90% Total Copper, 81% Total Lead, 70% Total Zinc
- ☑ Particulate-bound pollutants such as nutrients, toxic metals, hydrocarbons and bacteria
- ☑ Free oil, Floatable trash and debris

Field Proven Peformance

The Jellyfish filter has been field-tested on an urban site with 25 TARP qualifying rain events and field monitored according to the TARP field test protocol, demonstrating:

- A median TSS removal efficiency of 89%, and a median SSC removal of 99%;
- The ability to capture fine particles as indicated by an effluent d50 median of 3 microns for all monitotred storm events, and a median effluent turbidity of 5 NTUs;
- A median Total Phosphorus removal of 59%, and a median Total Nitrogen removal of 51%.

Jellyfish Filter Treatment Functions



Pre-treatment and Membrane Filtration

Jellyfish® Filter

Project Information

Date:	Tuesday, August 13, 2019
Project Name:	11 Yorkville Ave.
Project Number:	17M-01494
Location:	Toronto

Designer Information

Company:	WSP Canada Group Ltd.
Contact:	Victoria Blake
Phone #:	

Notes

Rainfall

Name:	TORONTO CENTRAL
State:	ON
ID:	100
Record:	1982 to 1999
Co-ords:	45°30'N, 90°30'W

Drainage Area

Total Area:	0.28 ha
Runoff Coefficient:	0.84

Upstream Detention

Peak Release Rate:	n/a
Pretreatment Credit:	n/a

Design System Requirements

Flow Loading	90% of the Average Annual Runoff based on 18 years of TORONTO CENTRAL rainfall data:	**7.8 L/s**
Sediment Loading	Treating 90% of the average annual runoff volume, 1529 m³, with a suspended sediment concentration of 60 mg/L.	**92 kg**

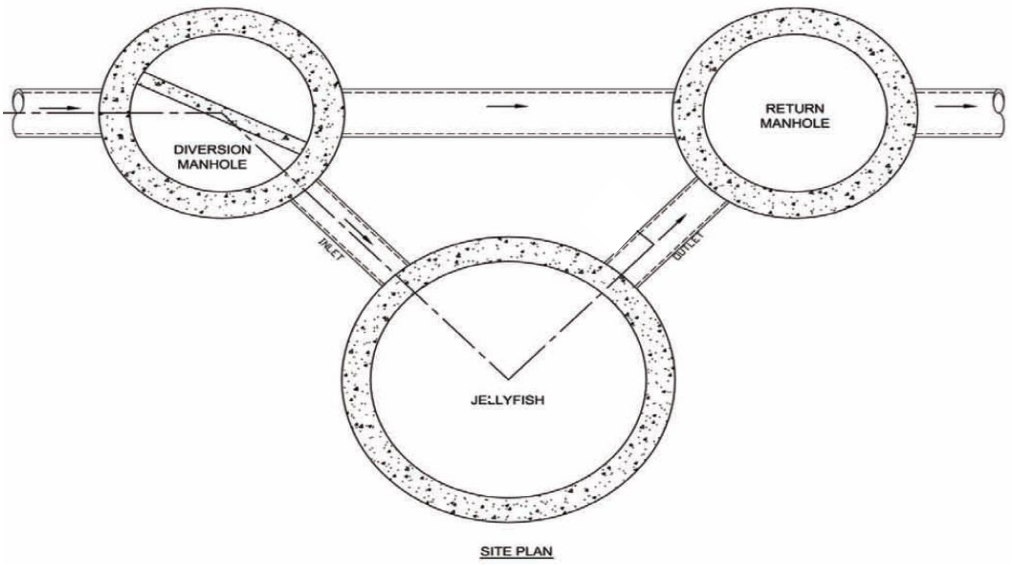
Recommendation

The Jellyfish Filter model JF4-2-1 is recommended to meet the water quality objective by treating a flow of 12.6 L/s, which meets or exceeds 90% of the average annual rainfall runoff volume based on 18 years of TORONTO CENTRAL rainfall data for this site. This model has a sediment capacity of 142 kg, which meets or exceeds the estimated average annual sediment load.

Jellyfish Model	Number of High-Flo Cartridges	Number of Draindown Cartridges	Manhole Diameter (m)	Wet Vol Below Deck (L)	Sump Storage (m³)	Oil Capacity (L)	Treatment Flow Rate (L/s)	Sediment Capacity (kg)
JF4-1-1	1	1	1.2	2313	0.34	379	7.6	85
JF4-2-1	**2**	**1**	**1.2**	**2313**	**0.34**	**379**	**12.6**	**142**
JF6-3-1	3	1	1.8	5205	0.79	848	17.7	199
JF6-4-1	4	1	1.8	5205	0.79	848	22.7	256
JF6-5-1	5	1	1.8	5205	0.79	848	27.8	313
JF6-6-1	6	1	1.8	5205	0.79	848	28.6	370
JF8-6-2	6	2	2.4	9252	1.42	1469	35.3	398
JF8-7-2	7	2	2.4	9252	1.42	1469	40.4	455
JF8-8-2	8	2	2.4	9252	1.42	1469	45.4	512
JF8-9-2	9	2	2.4	9252	1.42	1469	50.5	569
JF8-10-2	10	2	2.4	9252	1.42	1469	50.5	626
JF10-11-3	11	3	3.0	14456	2.21	2302	63.1	711
JF10-12-3	12	3	3.0	14456	2.21	2302	68.2	768
JF10-12-4	12	4	3.0	14456	2.21	2302	70.7	796
JF10-13-4	13	4	3.0	14456	2.21	2302	75.7	853
JF10-14-4	14	4	3.0	14456	2.21	2302	78.9	910
JF10-15-4	15	4	3.0	14456	2.21	2302	78.9	967
JF10-16-4	16	4	3.0	14456	2.21	2302	78.9	1024
JF10-17-4	17	4	3.0	14456	2.21	2302	78.9	1081
JF10-18-4	18	4	3.0	14456	2.21	2302	78.9	1138
JF10-19-4	19	4	3.0	14456	2.21	2302	78.9	1195
JF12-20-5	20	5	3.6	20820	3.2	2771	113.6	1280
JF12-21-5	21	5	3.6	20820	3.2	2771	113.7	1337
JF12-22-5	22	5	3.6	20820	3.2	2771	113.7	1394
JF12-23-5	23	5	3.6	20820	3.2	2771	113.7	1451
JF12-24-5	24	5	3.6	20820	3.2	2771	113.7	1508
JF12-25-5	25	5	3.6	20820	3.2	2771	113.7	1565
JF12-26-5	26	5	3.6	20820	3.2	2771	113.7	1622
JF12-27-5	27	5	3.6	20820	3.2	2771	113.7	1679

Jellyfish Filter Design Notes

- Typically the Jellyfish Filter is designed in an offline configuration, as all stormwater filter systems will perform for a longer duration between required maintenance services when designed and applied in off-line configurations. Depending on the design parameters, an optional internal bypass may be incorporated into the Jellyfish Filter, however note the inspection and maintenance frequency should be expected to increase above that of an off-line system. Speak to your local representative for more information.



Jellyfish Filter Typical Layout

- Typically, 18 inches (457 mm) of driving head is designed into the system, calculated as the difference in elevation between the top of the diversion structure weir and the invert of the Jellyfish Filter outlet pipe. Alternative driving head values can be designed as 12 to 24 inches (305 to 610mm) depending on specific site requirements, requiring additional sizing and design assistance.
- Typically, the Jellyfish Filter is designed with the inlet pipe configured 6 inches (150 mm) above the outlet invert elevation. However, depending on site parameters this can vary to an optional configuration of the inlet pipe entering the unit below the outlet invert elevation.
- The Jellyfish Filter can accommodate multiple inlet pipes within certain restrictions.
- While the optional inlet below deck configuration offers 0 to 360 degree flexibility between the inlet and outlet pipe, typical systems conform to the following:

Model Diameter (m)	Minimum Angle Inlet / Outlet Pipes	Minimum Inlet Pipe Diameter (mm)	Minimum Outlet Pipe Diameter (mm)
1.2	**62º**	**150**	**200**
1.8	59º	200	250
2.4	52º	250	300
3.0	48º	300	450
3.6	40º	300	450

- The Jellyfish Filter can be built at all depths of cover generally associated with conventional stormwater conveyance systems. For sites that require minimal depth of cover for the stormwater infrastructure, the Jellyfish Filter can be applied in a shallow application using a hatch cover. The general minimum depth of cover is 36 inches (915 mm) from top of the underslab to outlet invert.
- If driving head caclulations account for water elevation during submerged conditions the Jellyfish Filter will function effectively under submerged condtions.
- Jellyfish Filter systems may incorporate grated inlets depending on system configuration.
- For sites with water quality treatment flow rates or mass loadings that exceed the design flow rate of the largest standard Jellyfish Filter manhole models, systems can be designed that hydraulically connect multiple Jellyfish Filters in series or alternatively Jellyfish Vault units can be designed.

STANDARD SPECIFICATION
STORMWATER QUALITY – MEMBRANE FILTRATION TREATMENT DEVICE

PART 1 – GENERAL

1.1 WORK INCLUDED

Specifies requirements for construction and performance of an underground stormwater quality membrane filtration treatment device that removes pollutants from stormwater runoff through the unit operations of sedimentation, floatation, and membrane filtration.

1.2 REFERENCE STANDARDS

ASTM C 891: Specification for Installation of Underground Precast Concrete Utility Structures
ASTM C 478: Specification for Precast Reinforced Concrete Manhole Sections
ASTM C 443: Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM D 4101: Specification for Copolymer steps construction

CAN/CSA-A257.4-M92
Joints for Circular Concrete Sewer and Culvert Pipe, Manhole Sections and Fittings Using Rubber Gaskets

CAN/CSA-A257.4-M92
Precast Reinforced Circular Concrete Manhole Sections, Catch Basins and Fittings

Canadian Highway Bridge Design Code

1.3 SHOP DRAWINGS

Shop drawings for the structure and performance are to be submitted with each order to the contractor. Contractor shall forward shop drawing submittal to the consulting engineer for approval. Shop drawings are to detail the structure's precast concrete and call out or note the fiberglass (FRP) internals/components.

1.4 PRODUCT SUBSTITUTIONS

No product substitutions shall be accepted unless submitted 10 days prior to project bid date, or as directed by the engineer of record. Submissions for substitutions require review and approval by the Engineer of Record, for hydraulic performance, impact to project designs, equivalent treatment performance, and any required project plan and report (hydrology/hydraulic, water quality, stormwater pollution) modifications that would be required by the approving jurisdictions/agencies. Contractor to coordinate with the Engineer of Record any applicable modifications to the project estimates of cost, bonding amount determinations, plan check fees for changes to approved documents, and/or any other regulatory requirements resulting from the product substitution.

1.5 HANDLING AND STORAGE

Prevent damage to materials during storage and handling.

PART 2 – PRODUCTS

2.1 GENERAL

2.1.1 The device shall be a cylindrical or rectangular, all concrete structure (including risers), constructed from precast concrete riser and slab components or monolithic precast structure(s), installed to conform to ASTM C 891 and to any required state highway, municipal or local specifications; whichever is more stringent. The device shall be watertight.

2.1.2 Cartridge Deck The cylindrical concrete device shall include a fiberglass deck. The rectangular concrete device shall include a coated aluminum deck. In either instance, the insert shall be bolted and sealed watertight inside the precast concrete chamber. The deck shall serve as: (a) a horizontal divider between the lower treatment zone and the upper treated effluent zone; (b) a deck for attachment of filter cartridges such that the membrane filter elements of each cartridge extend into the lower treatment zone; (c) a platform for maintenance workers to service the filter cartridges (maximum manned weight = 450 pounds (204 kg)); (d) a conduit for conveyance of treated water to the effluent pipe.

2.1.3 Membrane Filter Cartridges Filter cartridges shall be comprised of reusable cylindrical membrane filter elements connected to a perforated head plate. The number of membrane filter elements per cartridge shall be a minimum of eleven 2.75-inch (70-mm) diameter elements. The length of each filter element shall be a minimum 15 inches (381 mm). Each cartridge shall be fitted into the cartridge deck by insertion into a cartridge receptacle that is permanently mounted into the cartridge deck. Each cartridge shall be secured by a cartridge lid that is threaded onto the receptacle, or similar mechanism to secure the cartridge into the deck. The maximum treatment flow rate of a filter cartridge shall be controlled by an orifice in the cartridge lid, or on the individual cartridge itself, and based on a design flux rate (surface loading rate) determined by the maximum treatment flow rate per unit of filtration membrane surface area. The maximum design flux rate shall be 0.21 gpm/ft² (0.142 lps/m²).

Each membrane filter cartridge shall allow for manual installation and removal. Each filter cartridge shall have filtration membrane surface area and dry installation weight as follows (if length of filter cartridge is between those listed below, the surface area and weight shall be proportionate to the next length shorter and next length longer as shown below):

Filter Cartridge Length (in / mm)	Minimum Filtration Membrane Surface Area (ft2 / m2)	Maximum Filter Cartridge Dry Weight (lbs / kg)
15	106 / 9.8	10.5 / 4.8
27	190 / 17.7	15.0 / 6.8
40	282 / 26.2	20.5 / 9.3
54	381 / 35.4	25.5 / 11.6

2.1.4 Backwashing Cartridges The filter device shall have a weir extending above the cartridge deck, or other mechanism, that encloses the high flow rate filter cartridges when placed in their respective cartridge receptacles within the cartridge deck. The weir, or other mechanism, shall collect a pool of filtered water during inflow events that backwashes the high flow rate cartridges when the inflow

event subsides. All filter cartridges and membranes shall be reusable and allow for the use of filtration membrane rinsing procedures to restore flow capacity and sediment capacity; extending cartridge service life.

2.1.5 Maintenance Access to Captured Pollutants The filter device shall contain an opening(s) that provides maintenance access for removal of accumulated floatable pollutants and sediment, removal of and replacement of filter cartridges, cleaning of the sump, and rinsing of the deck. Access shall have a minimum clear vertical clear space over all of the filter cartridges. Filter cartridges shall be able to be lifted straight vertically out of the receptacles and deck for the entire length of the cartridge.

2.1.6 Bend Structure The device shall be able to be used as a bend structure with minimum angles between inlet and outlet pipes of 90-degrees or less in the stormwater conveyance system.

2.1.7 Double-Wall Containment of Hydrocarbons The cylindrical precast concrete device shall provide double-wall containment for hydrocarbon spill capture by a combined means of an inner wall of fiberglass, to a minimum depth of 12 inches (305 mm) below the cartridge deck, and the precast vessel wall.

2.1.8 Baffle The filter device shall provide a baffle that extends from the underside of the cartridge deck to a minimum length equal to the length of the membrane filter elements. The baffle shall serve to protect the membrane filter elements from contamination by floatables and coarse sediment. The baffle shall be flexible and continuous in cylindrical configurations, and shall be a straight concrete or aluminum wall in rectangular configurations.

2.1.9 Sump The device shall include a minimum 24 inches (610 mm) of sump below the bottom of the cartridges for sediment accumulation, unless otherwise specified by the design engineer. Depths less than 24 inches may have an impact on the total performance and/or longevity between cartridge maintenance/replacement of the device.

2.2 PRECAST CONCRETE SECTIONS

All precast concrete components shall be manufactured to a minimum live load of HS-20 truck loading or greater based on local regulatory specifications, unless otherwise modified or specified by the design engineer, and shall be watertight.

2.3 JOINTS All precast concrete manhole configuration joints shall use nitrile rubber gaskets and shall meet the requirements of ASTM C443, Specification C1619, Class D or engineer approved equal to ensure oil resistance. Mastic sealants or butyl tape are not an acceptable alternative.

2.4 GASKETS Only profile neoprene or nitrile rubber gaskets in accordance to CSA A257.3-M92 will be accepted. Mastic sealants, butyl tape or Conseal CS-101 are not acceptable gasket materials.

2.5 FRAME AND COVER Frame and covers must be manufactured from cast-iron or other composite material tested to withstand H-20 or greater design loads, and as approved by the

local regulatory body. Frames and covers must be embossed with the name of the device manufacturer or the device brand name.

2.6 DOORS AND HATCHES If provided shall meet designated loading requirements or at a minimum for incidental vehicular traffic.

2.7 CONCRETE All concrete components shall be manufactured according to local specifications and shall meet the requirements of ASTM C 478.

2.8 FIBERGLASS The fiberglass portion of the filter device shall be constructed in accordance with the following standard: ASTM D-4097: Contact Molded Glass Fiber Reinforced Chemical Resistant Tanks.

2.9 STEPS Steps shall be constructed according to ASTM D4101 of copolymer polypropylene, and be driven into preformed or pre-drilled holes after the concrete has cured, installed to conform to applicable sections of state, provincial and municipal building codes, highway, municipal or local specifications for the construction of such devices.

2.10 INSPECTION All precast concrete sections shall be inspected to ensure that dimensions, appearance and quality of the product meet local municipal specifications and ASTM C 478.

PART 3 – PERFORMANCE

3.1 GENERAL

3.1.1 Verification – The stormwater quality filter must be verified in accordance with ISO 14034:2016 Environmental management – Environmental technology verification (ETV).

3.1.2 Function - The stormwater quality filter treatment device shall function to remove pollutants by the following unit treatment processes; sedimentation, floatation, and membrane filtration.

3.1.3 Pollutants - The stormwater quality filter treatment device shall remove oil, debris, trash, coarse and fine particulates, particulate-bound pollutants, metals and nutrients from stormwater during runoff events.

3.1.4 Bypass - The stormwater quality filter treatment device shall typically utilize an external bypass to divert excessive flows. Internal bypass systems shall be equipped with a floatables baffle, and must avoid passage through the sump and/or cartridge filtration zone.

3.1.5 Treatment Flux Rate (Surface Loading Rate) – The stormwater quality filter treatment device shall treat 100% of the required water quality treatment flow based on a maximum design treatment flux rate (surface loading rate) across the membrane filter cartridges of 0.21 gpm/ft² (0.142 lps/m²).

3.2 FIELD TEST PERFORMANCE

At a minimum, the stormwater quality filter device shall have been field tested and verified with a minimum 25 TARP qualifying storm events and field monitoring shall have been conducted according to the TARP 2009 NJDEP TARP field test protocol, and have received NJCAT verification.

3.2.1 Suspended Solids Removal - The stormwater quality filter treatment device shall have demonstrated a minimum median TSS removal efficiency of 85% and a minimum median SSC removal efficiency of 95%.

3.2.2 Runoff Volume – The stormwater quality filter treatment device shall be engineered, designed, and sized to treat a minimum of 90 percent of the annual runoff volume determined from use of a minimum 15-year rainfall data set.

3.2.3 Fine Particle Removal - The stormwater quality filter treatment device shall have demonstrated the ability to capture fine particles as indicated by a minimum median removal efficiency of 75% for the particle fraction less than 25 microns, an effluent d_{50} of 15 microns or lower for all monitored storm events.

3.2.4 Turbidity Reduction - The stormwater quality filter treatment device shall have demonstrated the ability to reduce the turbidity from influent from a range of 5 to 171 NTU to an effluent turbidity of 15 NTU or lower.

3.2.5 Nutrient (Total Phosphorus & Total Nitrogen) Removal - The stormwater quality filter treatment device shall have demonstrated a minimum median Total Phosphorus removal of 55%, and a minimum median Total Nitrogen removal of 50%.

3.2.6 Metals (Total Zinc & Total Copper) Removal - The stormwater quality filter treatment device shall have demonstrated a minimum median Total Zinc removal of 55%, and a minimum median Total Copper removal of 85%.

3.3 INSPECTION and MAINTENANCE

The stormwater quality filter device shall have the following features:

3.3.1 Durability of membranes are subject to good handling practices during inspection and maintenance (removal, rinsing, and reinsertion) events, and site specific conditions that may have heavier or lighter loading onto the cartridges, and pollutant variability that may impact the membrane structural integrity. Membrane maintenance and replacement shall be in accordance with manufacturer's recommendations.

3.3.2 Inspection which includes trash and floatables collection, sediment depth determination, and visible determination of backwash pool depth shall be easily conducted from grade (outside the structure).

3.3.3 Manual rinsing of the reusable filter cartridges shall promote restoration of the flow capacity and sediment capacity of the filter cartridges, extending cartridge service life.

3.3.4 The filter device shall have a minimum 12 inches (305 mm) of sediment storage depth, and a minimum of 12 inches between the top of the sediment storage and bottom of the filter cartridge tentacles, unless otherwise specified by the design engineer. Variances may have an impact on the total performance and/or longevity between cartridge maintenance/replacement of the device.

3.3.5 Sediment removal from the filter treatment device shall be able to be conducted using a standard maintenance truck and vacuum apparatus, and a minimum one point of entry to the sump that is unobstructed by filter cartridges.

3.3.6 Maintenance access shall have a minimum clear height that provides suitable vertical clear space over all of the filter cartridges. Filter cartridges shall be able to be lifted straight vertically out of the receptacles and deck for the entire length of the cartridge.

3.3.7 Filter cartridges shall be able to be maintained without the requirement of additional lifting equipment.

PART 4 – EXECUTION

4.1 INSTALLATION

4.1.1 PRECAST DEVICE CONSTRUCTION SEQUENCE

The installation of a watertight precast concrete device should conform to ASTM C 891 and to any state highway, municipal or local specifications for the construction of manholes, whichever is more stringent. Selected sections of a general specification that are applicable are summarized below.

4.1.1.1 The watertight precast concrete device is installed in sections in the following sequence:

- aggregate base
- base slab
- treatment chamber and cartridge deck riser section(s)
- bypass section
- connect inlet and outlet pipes
- concrete riser section(s) and/or transition slab (if required)
- maintenance riser section(s) (if required)
- frame and access cover

4.1.2 The precast base should be placed level at the specified grade. The entire base should be in contact with the underlying compacted granular material. Subsequent sections, complete with joint seals, should be installed in accordance with the precast concrete manufacturer's recommendations.

4.1.3 Adjustment of the stormwater quality treatment device can be performed by lifting the upper sections free of the excavated area, re-leveling the base, and re-installing the sections. Damaged sections and gaskets should be repaired or replaced as necessary to restore original condition and watertight seals. Once the stormwater quality treatment device has been constructed, any/all lift holes must be plugged watertight with mortar or non-shrink grout.

4.1.4 Inlet and Outlet Pipes Inlet and outlet pipes should be securely set into the device using approved pipe seals (flexible boot connections, where applicable) so that the structure is watertight, and such that any pipe intrusion into the device does not impact the device functionality.

4.1.5 Frame and Cover Installation Adjustment units (e.g. grade rings) should be installed to set the frame and cover at the required elevation. The adjustment units should be laid in a full bed of mortar with successive units being joined using sealant recommended by the manufacturer. Frames for the cover should be set in a full bed of mortar at the elevation specified.

4.2 MAINTENANCE ACCESS WALL
In some instances the Maintenance Access Wall, if provided, shall require an extension attachment and sealing to the precast wall and cartridge deck at the job site, rather than at the precast facility. In this instance, installation of these components shall be performed according to instructions provided by the manufacturer.

4.3 FILTER CARTRIDGE INSTALLATION Filter cartridges shall be installed in the cartridge deck only after the construction site is fully stabilized and in accordance with the manufacturer's guidelines and recommendations. Contractor to contact the manufacturer to schedule cartridge delivery and review procedures/requirements to be completed to the device prior to installation of the cartridges and activation of the system.

PART 5 – QUALITY ASSURANCE

5.1 FILTER CARTRIDGE INSTALLATION Manufacturer shall coordinate delivery of filter cartridges and other internal components with contractor. Filter cartridges shall be delivered and installed complete after site is stabilized and unit is ready to accept cartridges. Unit is ready to accept cartridges after is has been cleaned out and any standing water, debris, and other materials have been removed. Contractor shall take appropriate action to protect the filter cartridge receptacles and filter cartridges from damage during construction, and in accordance with the manufacturer's recommendations and guidance. For systems with cartridges installed prior to full site stabilization and prior to system activation, the contractor can plug inlet and outlet pipes to prevent stormwater and other influent from entering the device. Plugs must be removed during the activation process.

5.2 INSPECTION AND MAINTENANCE

5.2.1 The manufacturer shall provide an Owner's Manual upon request.

5.2.2 After construction and installation, and during operation, the device shall be inspected and cleaned as necessary based on the manufacturer's recommended inspection and maintenance guidelines and the local regulatory agency/body.

5.3 REPLACEMENT FILTER CARTRIDGES When replacement membrane filter elements and/or other parts are required, only membrane filter elements and parts approved by the manufacturer for use with the stormwater quality filter device shall be installed.

END OF SECTION