Montrin Richview GP Inc.

Stormwater Management Report

Richview Square

4620 Eglinton Avenue West and 250 Wincott Drive

FEBRUARY 28, 2020

Stormwater Management Report

Richview Square

4620 Eglinton Avenue West and 250 Wincott Drive

Montrin Richview GP Inc.

Rezoning Application

Project No.: 15M-00048-03
Date: February 2020

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Quality Management

ISSUE/REVISION	FIRST ISSUE	REVISION 1	REVISION 2	REVISION 3
Remarks	Rezoning Application	Rezoning Application	Rezoning Application	Rezoning Application
Date	2018/04/24	2019/03/18	2019/10/01	2020/02/28
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Signature				
Project number	15M-00048-03	15M-00048-03	15M-00048-03	15M-00048-03

Signatures

Prepared by

Fiona Allen

Fiona Allen
Designer, Water Resources

February 28, 2020
Date

Approved[1] by

Iain Smith, P.Eng.
Project Engineer, Water Resources

Date

[1] Approval of this document is an administrative function indicating readiness for release and does not impart legal liability on to the Approver for any technical content contained herein. Technical accuracy and fit-for-purpose of this content is obtained through the review process. The Approver shall ensure the applicable review process has occurred prior to signing the document.

Production Team

CLIENT

Montrin Richview GP Inc.

WSP

Designer	Fiona Allen
Reviewer	Iain Smith, P.Eng.

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1 Introduction

1.1 Scope

WSP has been retained by Montrin Richview GP Inc. to prepare a Stormwater Management (SWM) Report to support the zoning by-law amendment application for the proposed development at 4620 Eglinton Avenue West and 250 Wincott Drive, in the City of Toronto. This SWM report examines the potential water balance, water quality, and water quantity 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 northwest corner of Eglinton Avenue West and Wincott Drive. The location of the proposed re-development is illustrated 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 preliminary sizing of the proposed stormwater management facilities.

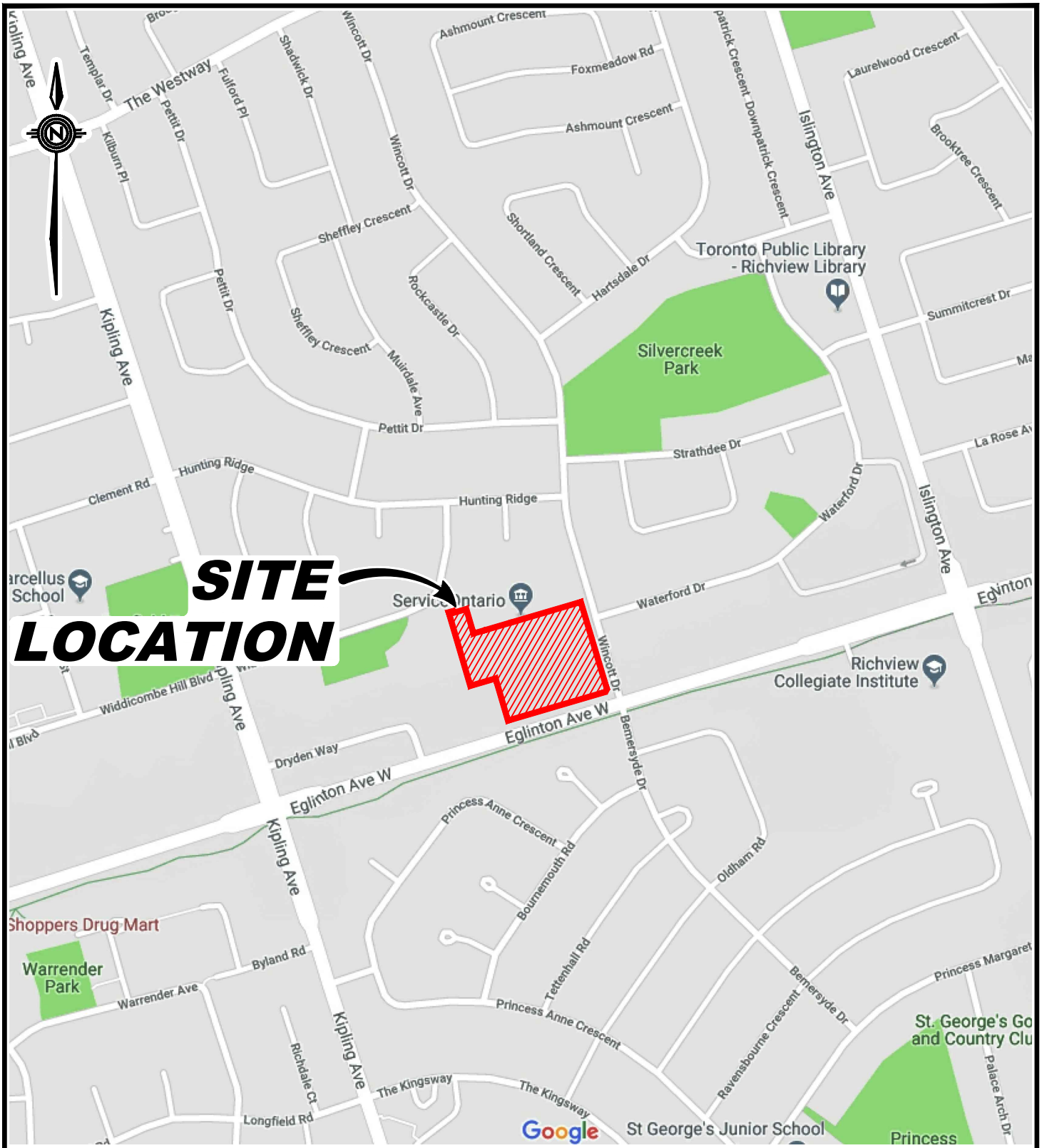
1.4 Design Criteria

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 a 5 mm storm event through infiltration, evapotranspiration or rainwater re-use.

- **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 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 developable area of the site is slightly greater than 2 ha. However, the proposed site will be delineated into two catchments that are both less than 2 ha and each will have their own stormwater management strategy. 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.



CLIENT

MONTRIN RICHVIEW GP INC.

TITLE

RICHVIEW SQUARE
4620 EGLINTON AVENUE WEST AND 250 WINCOTT DRIVE

SITE LOCATION

Checked I.S.	Drawn AutoCAD/B.K.B.
Date SEPTEMBER 2019	Proj. No. 15M-00048-03
Scale AS SHOWN	Figure No. 1 / Gr.No. 03

FIGURE 1.dwg - Richview Square - Site Location T:\Fiona\CAD\ Feb 27, 2020 - 1:15pm

2 Pre-Development Conditions

2.1 General

The 3.04 ha property is currently partially developed, hosting a 1-storey retail building, surface parking and vacant lands. For the purposes of the stormwater management strategy, only the planned development area of 2.26 ha (to be re-developed as Richview Square) will be taken into consideration, and will be referred to as the site. The existing runoff coefficient of the site is estimated at 0.60, as the site is comprised of pervious grassed areas, impervious roof and impervious paving. The existing site has a drainage split, draining to Widdicombe Hill on the northwest side delineated as catchment 101 and draining to Wincott Drive on the east side delineated as catchments 102 and 103. The site currently does not receive external drainage from adjacent areas. The existing condition of the site is shown in Figure 2.

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 1.

Table 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.

2.3 Allowable Flow Rates

The site is located within a suburban area and drains to the municipal storm sewers along Wincott Drive and Widdicombe Hill. As noted in Section 1.4, relevant policies from the WWFMG require the discharge rate from this site to be controlled to the allowable rate for discharge to municipal sewers. The pre-development Catchments 101 and 102 were delineated based on existing topographic features and storm service connections. Catchment 103 was delineated based on the study area of The Eglington Avenue Storm Conveyance and Stormwater Management report issued in October 2013 by Cole Engineering Group Limited.Table 2 provides an area breakdown by catchment. The post-development catchment area breakdowns will be discussed further in later sections.

Table 2: Area Breakdown by Catchment

	Catchment	Area (ha)	Runoff Coefficient
Pre-Development	101	0.27	0.90
	102	1.06	0.89
	103	0.93	0.29
	Total	**2.26**	**0.64**
Post-Development	201	0.40	0.70
	202	1.86	0.74
	Total	**2.26**	**0.73**

According to the WWFMG, Section 2.2.3.8, the target release rate to the municipal storm sewer system along Widdicombe Hill is based on the 2-year pre-development flow rate calculated with a maximum runoff coefficient value of 0.50 as required by the City of Toronto WWFMG. This results in a target release rate of 33.1 L/s for Catchment 201.

Catchment 202 lies within the study area of The Eglington Avenue Storm Conveyance and Stormwater Management report issued in October 2013 by Cole Engineering Group Limited. As per the analysis included in the 2013 Cole Engineering Report, the 100-year post-development peak flow rate from Catchment 202 is based on the 2-year pre-development peak flow with a maximum runoff coefficient of 0.46 and an area of 0.93 ha. This results in a target release rate of 104.9 L/s to the Eglinton Avenue West storm sewer.

The calculated peak flow rates for the site under pre-development conditions are summarized below in Tables 3 and 4. Detailed calculations are contained within Appendix A.

Table 3: Pre-Development Peak Flow Rate Calculations – Catchment 101

Return Period (Years)	Rainfall Intensity, I (mm/Hour)	Existing Peak Flow Rate, Q* (L/s)	WWFMG Allowable Release Rate, Q_a** (L/s)
2	88.2	59.6	**33.1**
5	131.8	89.0	
10	162.3	109.6	
25	189.5	128.0	
50	224.3	151.5	
100	250.3	169.1	

*Currently draining to storm sewers on Widdicombe Hill

**C=0.90, area of 0.27 ha and time of concentration of 10 minutes

***C=0.50, area of 0.27 ha and time of concentration of 10 minutes

Table 4: Pre-Development Peak Flow Rate Calculations – Catchment 102*

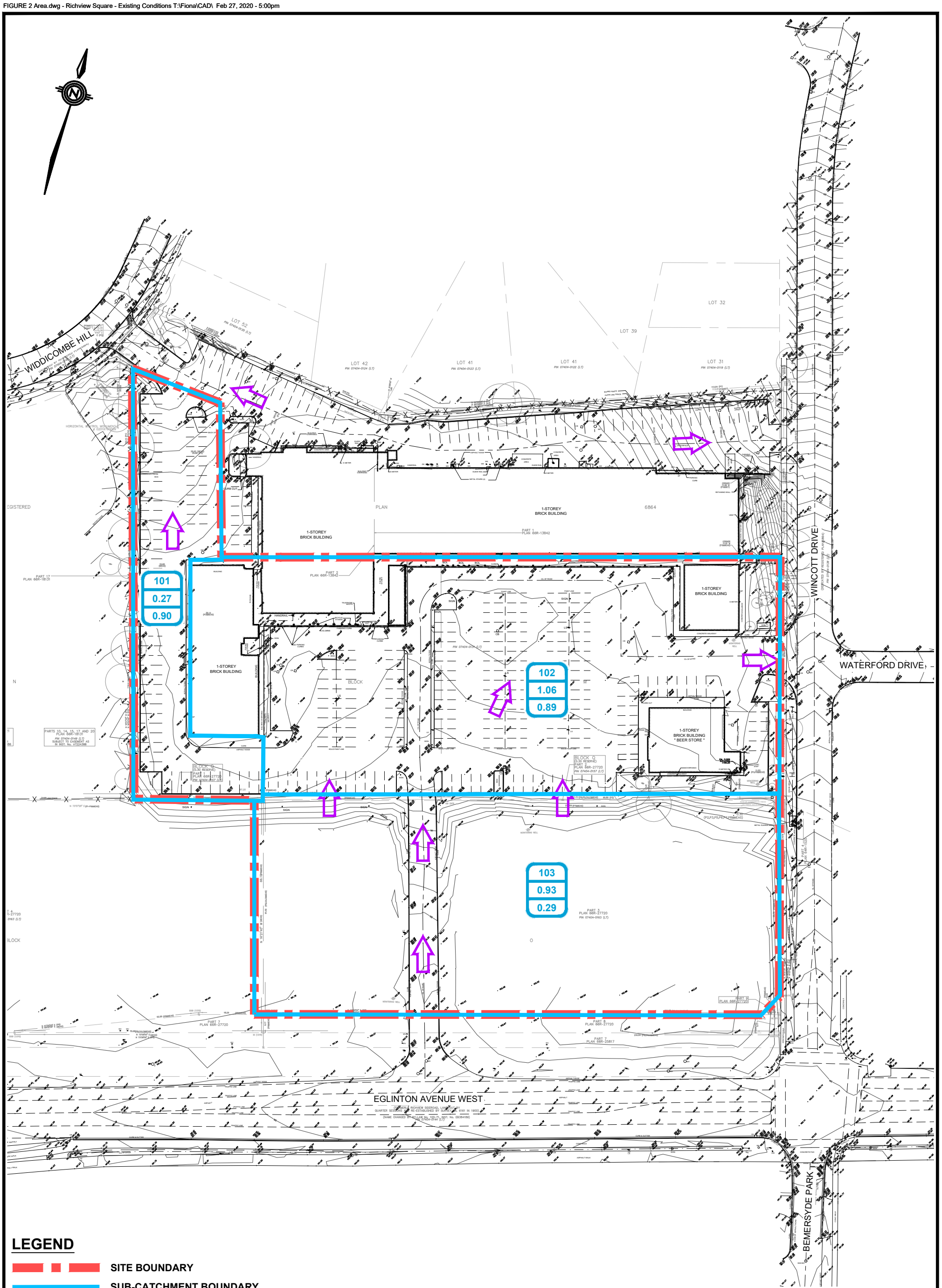
Return Period (Years)	Rainfall Intensity, I (mm/Hour)	Existing Peak Flow Rate, Q** (L/s)	WWFMG Allowable Release Rate, Q_a*** (L/s)
2	88.2	292.7	**104.9**
5	131.8	437.5	
10	162.3	538.6	
25	189.5	629.1	
50	224.3	744.6	
100	250.3	830.9	

*Currently draining to storm sewers on Wincott Drive

**C=0.60, area of 1.99 ha and time of concentration of 10 minutes

***C=0.46, area of 0.93 ha and time of concentration of 10 minutes

FIGURE 2 Area.dwg - Richview Square - Existing Conditions T:\Fiona\CAD\ Feb 27, 2020 - 5:00pm



LEGEND

- SITE BOUNDARY
- SUB-CATCHMENT BOUNDARY
- OVERLAND FLOW DIRECTION
- 101 — SUB-CATCHMENT ID.
- 0.27 — DRAINAGE AREA (ha)
- 0.90 — RUNOFF COEFFICIENT

0 10 20 30 40 50m

CLIENT

MONTRIN RICHVIEW GP INC.

TITLE

RICHVIEW SQUARE
4620 EGLINTON AVENUE WEST AND 250 WINCOTT DRIVE

EXISTING CONDITIONS

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Scale AS SHOWN	Figure No. 2 — Gr.No. 03

3 Post-Development Conditions

3.1 General

The proposed development consists of the construction of 3 new residential and commercial mixed-use buildings. The proposed Building A will be 15 storeys, Building B will be 13 storeys, and Building C will be 11 storeys. A common underground parking structure will be shared by each of the buildings, with the parking structure underlying almost the entire development footprint. Vehicular access to the site will be provided via Wincott Drive, Eglinton Avenue West and Widdicombe Hill. The loading areas and ramp to the basement parking will be entirely covered by the canopy of the building above. The site will have two separate stormwater control cisterns and as such, the proposed development will be divided into two catchments – 201 and 202. Note that due to site grading and layout, these catchments are slightly different than the existing catchments. Catchment 201, which includes Building A, will have a total area of 0.40 ha and will drain to storm sewers on Widdicombe Hill. Catchment 202 will have an area of 1.86 ha which will include Buildings B and C and will drain to storm sewers on Eglington Avenue West. In accordance with the Toronto Municipal Code, a green roof area of 967 m^2 for Building A (located on the main tower roof and the mechanical penthouse roof) and a combined area of 1931 m^2 for Buildings B and C (located on the third floor roof, tower roofs and the mechanical penthouse roofs) shall be provided.

An area breakdown for the new site layout is provided below in Tables 5 and 6. Please refer to Figure 3 for details of the post-development condition land-uses and stormwater catchments.

Table 5: Proposed Conditions Area Breakdown – Catchment 201

Land-Use	Area (m^2)	% Coverage	Runoff Coefficient, C
Pervious At-Grade	593	14.7	0.25
Impervious At-Grade	2,108	52.1	0.90
Impervious Roof	379	9.36	0.90
Green Roof	967	23.9	0.45
Total Site Area	**4,047**	**100**	**0.70**

Table 6: Proposed Conditions Area Breakdown – Catchment 202

Land-Use	Area (m^2)	% Coverage	Runoff Coefficient, C
Pervious At-Grade	3,154	16.9	0.25
Impervious At-Grade	9,228	49.8	0.90
Impervious Roof	4,274	22.9	0.90
Green Roof	1,931	10.4	0.45
Total Site Area	**18,646**	**100**	**0.74**

3.1.1 Existing Building Interface with Renovation

Outside of the development boundary (northeast of Catchment 202) there are building renovations proposed. Table 7 of the Wet Weather Flow Management Guidelines provides guidance on the City's requirements and the building renovation falls under scenario 4c:

4. Non-residential and mixed uses (e.g., industrial/commercial/institutional infill) - relatively small isolated development or intensification situations with site areas less than 5 ha and storm/combined sewer infrastructure exists

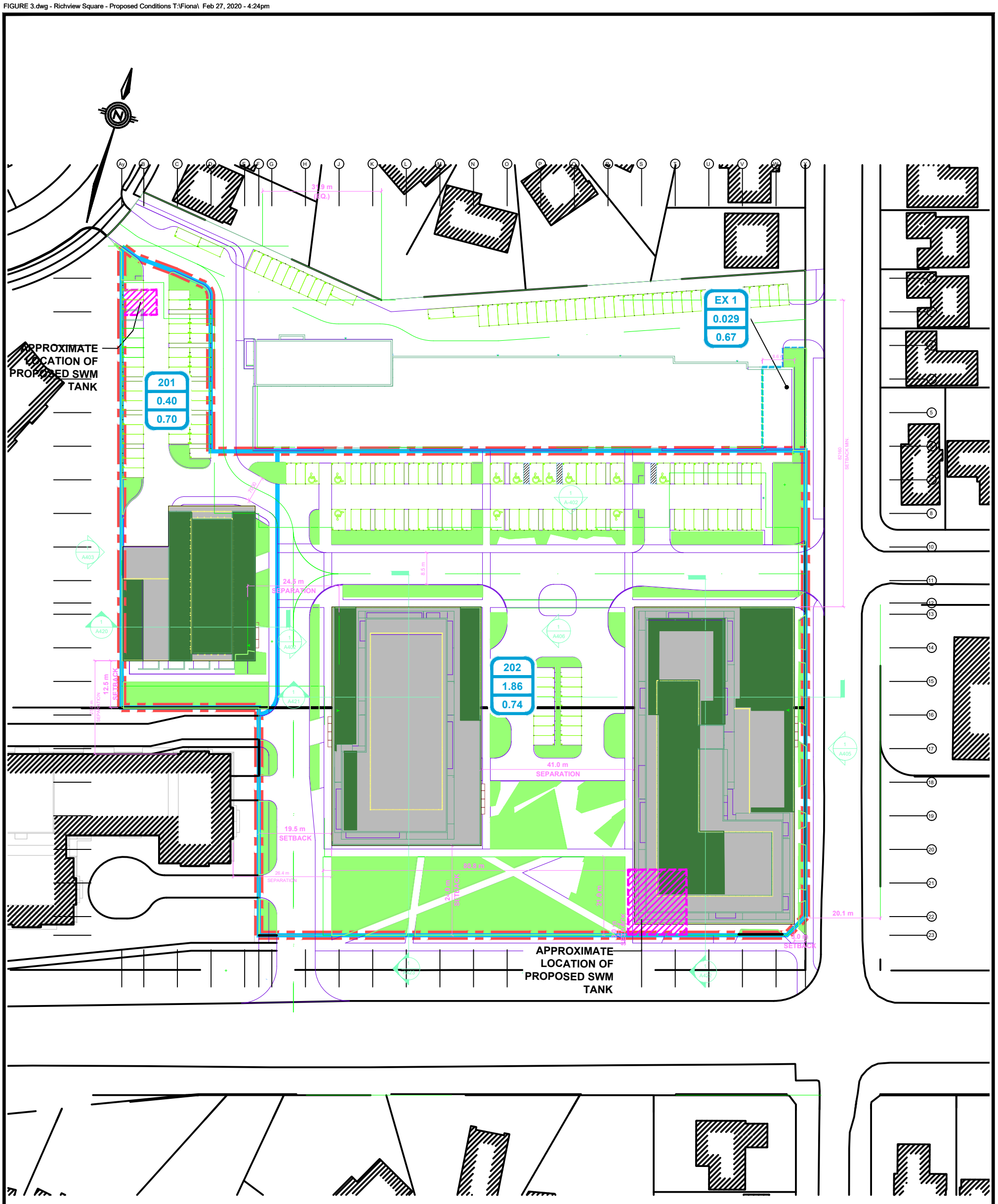
c) minor additions and/or modifications to non-residential buildings (expansion does not exceed 50% of the gross floor area of the existing building) - no site alteration

The expansion on the east end of the building does not exceed 50% of the gross floor area, therefore all the criteria do not apply except for Flood Flow Management. The Flood Flow Management criterion is:

- For development sites within the City's chronic basement flooding areas (see Basement Flooding Relief Work Program Location Map & Schedule in Appendix D), the proponent shall consult Toronto Water – Sewer Asset Planning Section for details of requirements, where applicable
- The City of Toronto has adopted the 100-year storm as the level of protection for properties, where feasible, against surface flooding from ponding on streets, particularly, in areas of the City experiencing chronic basement flooding and/or when a proper major (overland flow) stormwater drainage system does not exist (see Section 2.2.3.8 for overland flow drainage system requirements).

The site is not within the City's chronic basement flooding area (see Appendix D of WWFMG) and the overland flow routes to Wincott Drive and Widdicombe Hill are being maintained, therefore no action is required for stormwater management in this catchment.

The approximate renovation area can be seen in Figure 3, labelled EX1.



LEGEND

- SITE BOUNDARY
- SUB-CATCHMENT BOUNDARY
- EXISTING BUILDING INTERFACE WITH RENOVATION
- GREEN ROOF
- ROOF
- AT-GRADE SOFT LANDSCAPING
- 201 — SUB-CATCHMENT ID.
- 0.40 — DRAINAGE AREA (ha)
- 0.72 — RUNOFF COEFFICIENT

0 10 20 30 40 50m

CLIENT
MONTRIN RICHVIEW GP INC.

TITLE
RICHVIEW SQUARE
4620 EGLINTON AVENUE WEST AND 250 WINCOTT DRIVE

PROPOSED CONDITIONS

wsp

Checked I.S.	Drawn AutoCAD/F.A.
Date FEBRUARY 2020	Proj. No. 15M-00048-03
Scale AS SHOWN	Figure No. 3 — Gr.No. 03

3.2 Water Balance

As noted in Section 1.4, the WWFMG state 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.

For both Catchments 201 and 202, the primary mechanism to capture rainwater will be a stormwater cistern with a dedicated sump volume for re-use purposes. Discharge from all roof and at-grade areas will be directed to the underground cisterns. Allowing for an initial abstraction of 1 mm for all impervious surfaces and 5 mm for all pervious surfaces results in a water balance volume of 9.95 m^3 and 54.25 m^3 for Catchment 201 and 202, respectively.

The re-use methods for the captured stormwater are still being assessed in conjunction with the mechanical design of the building's water supply systems. Proposed re-use options include flushing of toilets in the interior amenity areas on the ground floor level, irrigation of the green roof and landscaped areas as well as any additional non-potable demand in the communal building areas. It is believed that sufficient opportunities exist within the development to re-use the full volume of retained stormwater within the required drawdown time. The mechanical design of the rainwater re-use pump systems from the cistern will ensure that the cistern is empty prior to switching to the City's water supply. A summary of the water balance provision on site is provided below in Tables 7 and 8.

Table 7: Water Balance – Catchment 201

Surface Type	Area (m^2)	5 mm Volume (m^3)	Initial Abstraction (m)	Volume Abstracted (m^3)	Water Balance (m^3)
Pervious At-Grade	593	2.97	0.005	2.97	0.00
Impervious At-Grade	2,108	10.54	0.001	2.11	8.43
Impervious Roof	379	1.89	0.001	0.38	1.52
Green Roof	967	4.84	0.005	4.84	0.00
Total Site Area	**4,047**	**20.23**	**-**	**10.29**	**9.95**

Table 8: Water Balance – Catchment 202

Surface Type	Area (m^2)	5 mm Volume (m^3)	Initial Abstraction (m)	Volume Abstracted (m^3)	Water Balance (m^3)
Pervious At-Grade	3,254	15.77	0.005	15.77	0.00
Impervious At-Grade	9,288	46.44	0.001	9.29	37.15
Impervious Roof	4,274	21.37	0.001	4.27	17.09
Green Roof	1,931	9.65	0.005	9.65	0.00
Total Site Area	**18,646**	**93.23**	**-**	**39.47**	**54.25**

3.3 Water Quality Control

The water quality criteria in the WWFMG is long-term removal of 80% TSS on an annual loading basis. A media filtration unit for each catchment is proposed to treat runoff from the at-grade areas. The roof is considered clean for the purposes of the water quality and does not require treatment.

The proposed unit for Catchment 201 is a JF4-1-1 (or approved equivalent) while the proposed unit for Catchment 202 is a JF6-6-1 (or approved equivalent). These units will provide each catchment with TSS removal for the full inflow areas and will be installed upstream of the cisterns in an offline configuration which includes bypass manholes. Flows in excess of the treatment rate will flow directly to the stormwater cisterns.

Please note that the media filtration unit calculations are for preliminary analysis only. It will be the Contractor's responsibility to ensure that the selected units meet water quality requirements per this stormwater management plan. Detailed sizing reports generated by the manufacturer are included within Appendix C.

3.4 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 each of the catchments (0.40 ha for Catchment 201 and 1.86 ha for Catchment 202) is below the 2.0 ha guideline, and the 5 mm water balance requirement has been addressed – therefore additional measures for erosion control are not recommended.

3.5 Water Quantity Control

The target release rate to the municipal sewer system from the site for Catchments 201 to Widdicombe Hill and 202 to Eglington Avenue West is 33.1 L/s and 104.9 L/s, respectively. This is equivalent to the peak runoff rate under pre-development conditions during a 2 year design storm event using a runoff coefficient of 0.50 for Catchment 201 and a runoff coefficient of 0.46 and area of 0.93 ha for Catchment 202.

A HydroCAD model of the project was constructed and utilized to determine the required storage volume in the stormwater cistern, and to calculate the discharge rates achieved by the proposed flow controls under all storm events. The Modified Rational Method (an inherent subroutine of the HydroCAD software) has been used for the modelling exercise.

An emergency overflow will be provided at the top of the cistern, with discharge to street level and the adjacent right of way. This will prevent flow backing up into the building pipework if the primary outlet is blocked, or if a storm event in excess of the 100-year return period occurs.

For Catchment 201, the cistern was designed to provide a storage volume of 140 m^3, with a base area of 70 m^2. The primary gravity outlet is set 0.20 m above the internal base, to provide a sufficient re-use volume to satisfy the water balance. A 100 mm diameter orifice plate is proposed as the primary outlet – this provides sufficient flow restriction to control release rates to within the target rate set by the WWFMG.

For Catchment 202, the cistern was designed to provide a storage volume of 711.7 m^3, with a base area of 256 m^2 and the primary gravity outlet set 0.25 m above the internal base. Based on the tank dimensions this will provide sufficient volume to satisfy the water balance. A 150 mm diameter orifice tube is proposed as the primary outlet – this provides sufficient flow restriction to control release rates to within the target rate set by the WWFMG.

A summary of the modelling results is provided below in Tables 9 and 10. HydroCAD modelling output is provided in Appendix B.

Table 9: Summary of Modelling Results – Catchment 201

RETURN PERIOD (YEARS)	MODELLED POST-DEVELOPMENT PEAK FLOW RATE (L/S)	TARGET RELEASE RATE (L/S)	UTILIZED CISTERN STORAGE (m^3)	PEAK WATER ELEVATION IN CISTERN (m)
2	13.9	33.1	48.4	0.692
5	17.7		67.7	0.967
10	19.9		81.2	1.160
25	21.8		94.1	1.344
50	24.1		110.9	1.584
100	25.7		123.6	1.766

Table 10: Summary of Modelling Results – Catchment 202

RETURN PERIOD (YEARS)	MODELLED POST-DEVELOPMENT PEAK FLOW RATE (L/S)	TARGET RELEASE RATE (L/S)	UTILIZED CISTERN STORAGE (M^3)	PEAK WATER ELEVATION IN CISTERN (m)
2	51.1	104.9	253.5	0.990
5	64.8		357.0	1.395
10	72.8		428.8	1.675
25	79.7		497.9	1.945
50	87.9		587.9	2.296
100	93.7		656.2	2.563

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 maximum required storage volume to control the 100-year post-development runoff is 123.6 m^3 and 656.2 m^3 for the cisterns in Catchment 201 and 202 respectively. Note that the total utilized storage volumes include the sump volume designated for re-use. The modelling assumes the sump volume is full at the beginning of each rainfall event.

As all flow rates are controlled by the project cistern, the rainfall intensity and storm duration resulting in the maximum utilized storage produces the largest flows. This has been iteratively

determined at t_d = 30 and t_d = 42 minutes (for the 100-year event) for Catchment 201 and 202 respectively.

3.6 Hydrogeology and Groundwater Characterization

A hydrogeological investigation was conducted in March 2019 by Brown Associates Limited in order to assess the groundwater conditions and soil characteristics of the development, and test for the presence of groundwater contamination.

Groundwater was found to enter the site; it does not meet the City of Toronto's Sewer By-Law requirements for discharge to the sanitary sewer but is proposed to be treated and discharged to the sanitary sewer. The groundwater sample, collected on February 16, 2018, exceeds the sanitary sewer standards for total suspended solids only.

As groundwater is not currently proposed to be released through the stormwater system, it will not impact the SWM design. The hydrogeological investigation report will be submitted separately from this report.

4 Conclusions

A stormwater management plan has been prepared to support the rezoning application for the proposed redevelopment of 4620 Eglinton Avenue West and 250 Wincott Drive in the City of Toronto. The key points are summarized below.

WATER BALANCE

The site is required to retain 5 mm of runoff from each rainfall event for re-use on site to meet the WWFMG requirements. Water balance strategies will be addressed through provision of green roof surfaces and sump volume (equivalent to the post-development 5 mm runoff volume) at the base of the proposed cisterns for both Catchments 201 and 202. Re-use methods for the captured stormwater are still being assessed in conjunction with the mechanical design of the buildings' water supply systems.

WATER QUANTITY

Runoff from the area within Catchment 201 will be directed to a 140 m^3 stormwater cistern and runoff from Catchment 202 will be directed to a 712 m^3 stormwater cistern. Post-development flows have been controlled to below 33.1 L/s for Catchment 201 and 104.9 L/s for Catchment 202 in compliance with the target release rate to the municipal storm sewer system.

WATER QUALITY

The target of 80% TSS removal can be achieved through the use of approved stand-alone media filtration units. Jellyfish Filter models JF4-1-1, and JF6-6-1 from Imbrium have been sized to treat at grade areas in Catchment 201 and 202 respectively.

GROUNDWATER

The groundwater on site is not proposed to be released through the stormwater system; therefore, it will not impact the SWM design.

The report has demonstrated that the proposed stormwater management strategy will address stormwater management related impacts from this project in adherence with City of Toronto's Wet Weather Flow Management Guidelines.

Respectfully submitted,

WSP

APPENDIX

A STORMWATER MANAGEMENT CALCULATIONS

	Stormwater Management Calculations	**Project:**	**Richview Square**	**No.:**	**15M-00048-03**
	Existing Offsite Discharge Rate Catchment 101	**By:**	**FA**	**Date:**	**2/27/2020**
		Checked:	**IS**	**Checked:**	**2/27/2020**

Page: 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 **0.27** hectares
Runoff Coef, C 0.90

$$I = AT^C$$

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)	59.6	89.0	109.6	128.0	151.5	169.1
Q (m3/sec)	0.060	0.089	0.110	0.128	0.152	0.169

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

	Stormwater Management Calculations	**Project:**	**Richview Square**	**No.:**	**15M-00048-03**
	Existing Offsite Discharge Rate Catchment 102+103	**By:**	**FA**	**Date:**	**2/27/2020**
		Checked:	**IS**	**Checked:**	**2/27/2020**

Page: 2

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 **1.99** hectares
Runoff Coef, C 0.62

$$I = AT^C$$

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)	302.5	452.0	556.6	650.1	769.4	858.6
Q (m3/sec)	0.302	0.452	0.557	0.650	0.769	0.859

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

	Stormwater Management Calculations	Project: Richview Square	No.: 15M-00048-03	
	Allowable Offsite Discharge Rate Catchment 101	By: FA	Date: 2/27/2020	Page:
		Checked: IS	Checked: 2/27/2020	3

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 **0.27** hectares
Runoff Coef, C* 0.50

* Note - actual site runoff coefficient is approximately 0.90, 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).

$$I = AT^C$$

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
A	21.8
C	-0.78
T (mins) **	10
T (hrs)	0.167
I (mm/hr)	88.2
Q (litres/sec)	**33.1**
Q (m3/sec)	0.033

** 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 33.1 litres/second.
(As per City of Toronto WWFMG section 2.2.3.7)

	Stormwater Management Calculations	Project: Richview Square	No.: 15M-00048-03	
	Allowable Offsite Discharge Rate Catchment 103	By: FA	Date: 2/27/2020	Page: 4
		Checked: IS	Checked: 2/27/2020	

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 **0.93** hectares
Runoff Coef, C* 0.46

* Note - actual site runoff coefficient is approximately 0.29, however the Eglinnton Avenue Storm Conveyance and Stormwater Mangement Report issued in October of 2013 by Cole Engineering Group Limited states maximum runoff coefficient to be used in calculation of pre-development peak flow is 0.46

$$I = AT^C$$

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
A	21.8
C	-0.78
T (mins) **	10
T (hrs)	0.167
I (mm/hr)	88.2
Q (litres/sec)	**104.9**
Q (m3/sec)	0.105

** 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 104.9 litres/second.
(As per City of Toronto WWFMG section 2.2.3.7)

	Stormwater Management Calculations	Project:	Richview Square	No.:	15M-00048-03	
	Abstractions and Water Balance Catchment 201	By:	FA	Date:	2/27/2020	Page: 5
		Checked:	IS	Checked:	2/27/2020	

The City of Toronto Wet Weather Flow Management Guidelines (WWFMG) require a site "to retain water 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".
- Section 2.2.1.1 (a)

In this case, the minimum on-site runoff retention will require the site to retain all runoff from 5 mm storm event through evapotranspiration infiltration, or rainwater reuse. WWFMG Section 2.2.1.1 (d).

The current area measurements and land use types for the site are as follows:

Land Use	Area (m^2)	Runoff C	Impervious	CN	% Coverage
Pervious At-Grade	593	0.25	0%	74	14.7
Impervious At-Grade	2,108	0.90	100%	98	52.1
Impervious Roof	379	0.90	100%	98	9.4
Green Roof	967	0.45	0%	81	23.9
Total Site Area:	**4,047**	**0.70**	**61%**	**90**	**100.0**

Surface Type	Area (m^2)	5 mm Volume (m^3)	IA (m)	Volume Abstracted (m^3)	Water Balance (m^3)
Pervious	593	2.97	0.005	2.97	0.00
Impervious At-Grade	2,108	10.54	0.001	2.11	8.43
Roof	379	1.89	0.001	0.38	1.52
Green Roof	967	4.84	0.005	4.84	0.00
Total Site Area:	**4,047**	**20.23**	**-**	**10.29**	**9.95**

For the purposes of the water balance calculation it is assumed that green roofs can accept 10 mm of rainfall without producing any runoff.

This is supported by EPA analysis of green roof manufacturer data sheets (dry unit weights versus saturated unit weights).

It is assumed that the remaining hard surfaces on the site can abstract 1 mm of rainfall, and that all soft landscaped areas can absorb 5 mm

Therefore, volume of runoff during a 5 mm storm event: **9.95** m^3

	Stormwater Management Calculations	Project:	Richview Square	No.:	15M-00048-03	
	Abstractions and Water Balance Catchment 202	By:	FA	Date:	2/27/2020	Page: 6
		Checked:	IS	Checked:	2/27/2020	

The City of Toronto Wet Weather Flow Management Guidelines (WWFMG) require a site "to retain water 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".
- Section 2.2.1.1 (a)
In this case, the minimum on-site runoff retention will require the site to retain all runoff from 5 mm storm event through evapotranspiration infiltration, or rainwater reuse. WWFMG Section 2.2.1.1 (d).

The current area measurements and land use types for the site are as follows:

Land Use	Area (m^2)	Runoff C	Impervious	CN	% Coverage
Pervious At-Grade	3,154	0.25	0%	74	16.9
Impervious At-Grade	9,288	0.90	100%	98	49.8
Impervious Roof	4,274	0.90	100%	98	22.9
Green Roof	1,931	0.45	0%	81	10.4
Total Site Area:	**18,646**	**0.74**	**73%**	**92**	**100**

Surface Type	Area (m^2)	5 mm Volume (m^3)	IA (m)	Volume Abstracted (m^3)	Water Balance (m^3)
Pervious	3,154	15.77	0.005	15.77	0.00
Impervious At-Grade	9,288	46.44	0.001	9.29	37.15
Impervious Roof	4,274	21.37	0.001	4.27	17.09
Green Roof	1,931	9.65	0.005	9.65	0.00
Total Site Area:	**18,646**	**93.23**	**-**	**38.98**	**54.25**

For the purposes of the water balance calculation it is assumed that green roofs can accept 10 mm of rainfall without producing any runoff.

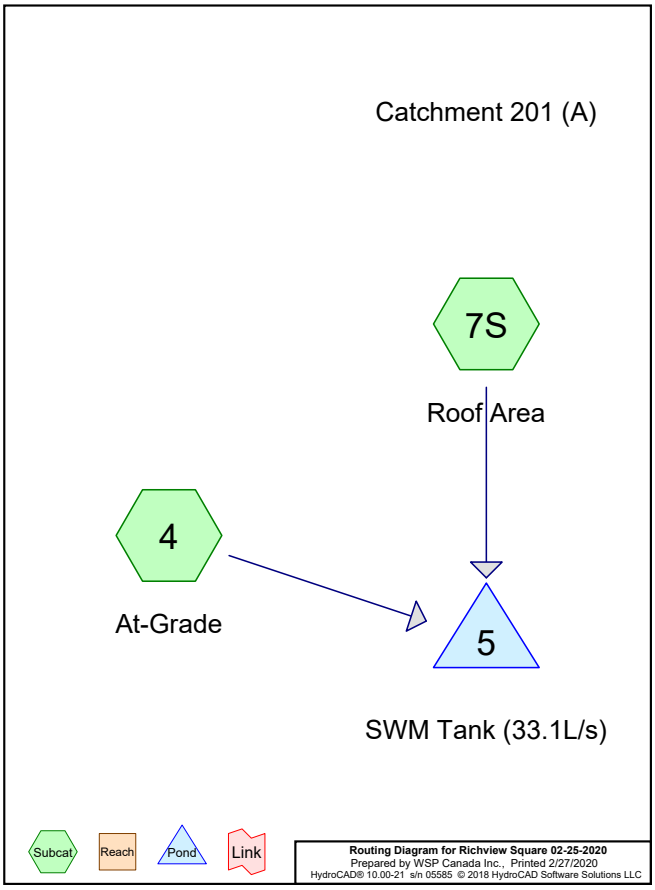
This is supported by EPA analysis of green roof manufacturer data sheets (dry unit weights versus saturated unit weights).

It is assumed that the remaining hard surfaces on the site can abstract 1 mm of rainfall, and that all soft landscaped areas can absorb 5 mm

Therefore, volume of runoff during a 5 mm storm event: **54.25** m^3

APPENDIX

B HYDROLOGIC MODEL OUTPUT (HYDROCAD)



Area Listing (selected nodes)

Area (sq-meters)	C	Description (subcatchment-numbers)
967.0	0.45	Green Roof (7S)
379.0	0.90	Impervious Roof (7S)
2,108.0	0.90	Paved Area (4)
593.0	0.25	Pervious Area (4)
4,047.0	**0.70**	**TOTAL AREA**

Notes Listing (selected nodes)

Line#	Node Number	Notes
1	4	Remaining landscaped areas to be defined (pavestone, grass, ect)

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

Subcatchment4: At-Grade Runoff Area=2,701.0 m² 0.00% Impervious Runoff Depth=13 mm
Tc=10.0 min C=0.76 Runoff=0.0282 m³/s 35.5 m³

Subcatchment7S: Roof Area Runoff Area=1,346.0 m² 0.00% Impervious Runoff Depth=10 mm
Tc=10.0 min C=0.58 Runoff=0.0107 m³/s 13.5 m³

Pond 5: SWM Tank (33.1L/s) Peak Elev=0.692 m Storage=48.4 m³ Inflow=0.0389 m³/s 49.0 m³
Outflow=0.0139 m³/s 48.9 m³

Total Runoff Area = 4,047.0 m² Runoff Volume = 49.0 m³ Average Runoff Depth = 12 mm
100.00% Pervious = 4,047.0 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 4: At-Grade

Remaining landscaped areas to be defined (pavestone, grass, ect)

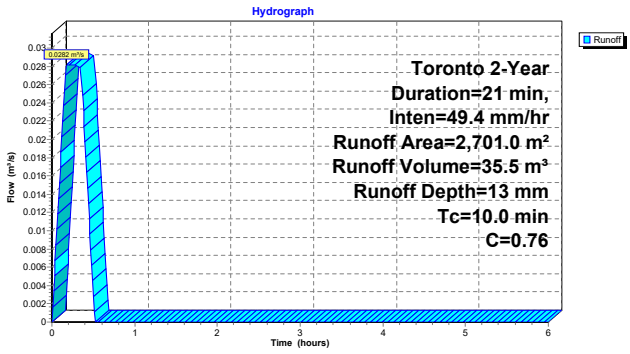
Runoff = 0.0282 m³/s @ 0.17 hrs, Volume= 35.5 m³, Depth= 13 mm

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=21 min, Inten=49.4 mm/hr

Area (m²)	C	Description
593.0	0.25	Pervious Area
2,108.0	0.90	Paved Area
2,701.0	0.76	Weighted Average
2,701.0		100.00% Pervious Area

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

Subcatchment 4: At-Grade



Summary for Subcatchment 7S: Roof Area

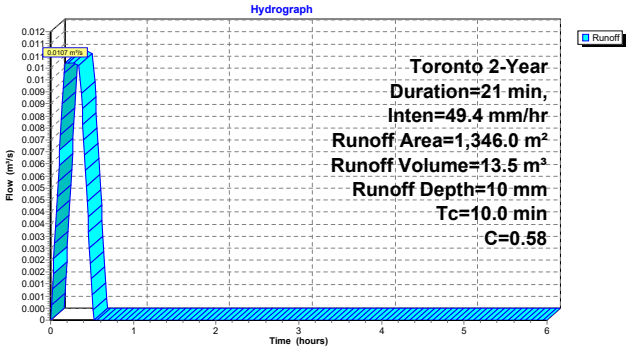
Runoff = 0.0107 m³/s @ 0.17 hrs, Volume= 13.5 m³, Depth= 10 mm

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=21 min, Inten=49.4 mm/hr

Area (m²)	C	Description
967.0	0.45	Green Roof
379.0	0.90	Impervious Roof
1,346.0	0.58	Weighted Average
1,346.0		100.00% Pervious Area

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

Subcatchment 7S: Roof Area



Summary for Pond 5: SWM Tank (33.1L/s)

Inflow Area = 4,047.0 m², 0.00% Impervious, Inflow Depth = 12 mm for 2-Year event
Inflow = 0.0389 m³/s @ 0.17 hrs, Volume= 49.0 m³
Outflow = 0.0139 m³/s @ 0.46 hrs, Volume= 48.9 m³, Atten= 64%, Lag= 17.2 min
Primary = 0.0139 m³/s @ 0.46 hrs, Volume= 48.9 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 0.200 m Surf.Area= 70.0 m² Storage= 14.0 m³
Peak Elev= 0.692 m @ 0.46 hrs Surf.Area= 70.0 m² Storage= 48.4 m³ (34.4 m³ above start)

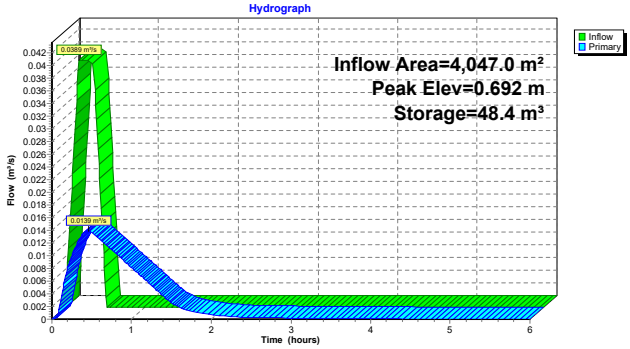
Plug-Flow detention time= 50.8 min calculated for 34.9 m³ (71% of inflow)
Center-of-Mass det. time= 35.0 min (50.5 - 15.5)

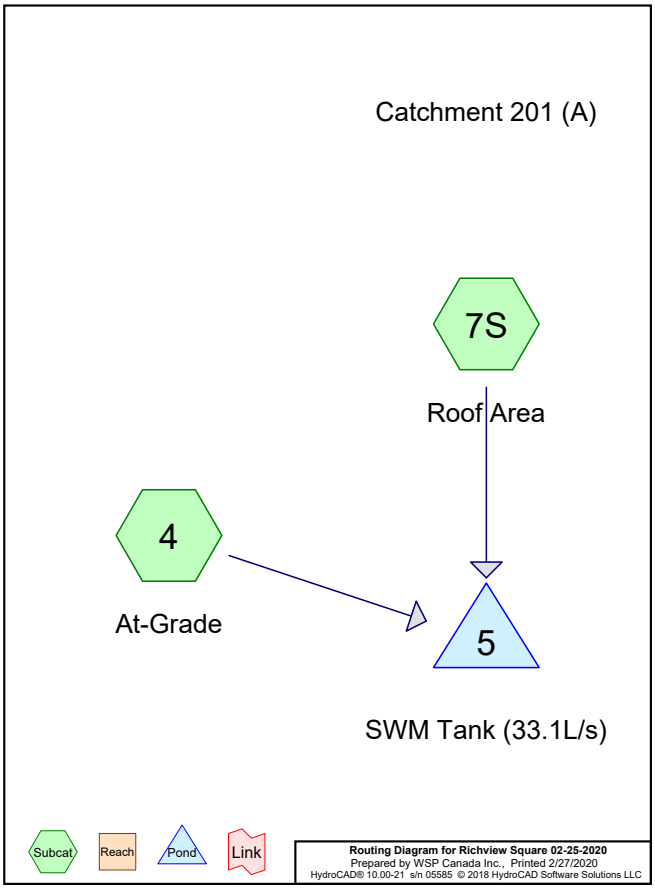
Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	140.0 m³	**1.00 mW x 70.00 mL x 2.00 mH Cistern + Orifice**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.200 m	**100 mm Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.0139 m³/s @ 0.46 hrs HW=0.692 m (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 0.0139 m³/s @ 1.77 m/s)

Pond 5: SWM Tank (33.1L/s)





Area Listing (selected nodes)

Area (sq-meters)	C	Description (subcatchment-numbers)
967.0	0.45	Green Roof (7S)
379.0	0.90	Impervious Roof (7S)
2,108.0	0.90	Paved Area (4)
593.0	0.25	Pervious Area (4)
4,047.0	**0.70**	**TOTAL AREA**

Notes Listing (selected nodes)

Line#	Node Number	Notes
1	4	Remaining landscaped areas to be defined (pavestone, grass, ect)

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

Subcatchment4: At-Grade Runoff Area=2,701.0 m² 0.00% Impervious Runoff Depth=20 mm
Tc=10.0 min C=0.76 Runoff=0.0376 m³/s 54.2 m³

Subcatchment7S: Roof Area Runoff Area=1,346.0 m² 0.00% Impervious Runoff Depth=15 mm
Tc=10.0 min C=0.58 Runoff=0.0143 m³/s 20.6 m³

Pond 5: SWM Tank (33.1L/s) Peak Elev=0.967 m Storage=67.7 m³ Inflow=0.0519 m³/s 74.8 m³
Outflow=0.0177 m³/s 74.7 m³

Total Runoff Area = 4,047.0 m² Runoff Volume = 74.8 m³ Average Runoff Depth = 18 mm
100.00% Pervious = 4,047.0 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 4: At-Grade

Remaining landscaped areas to be defined (pavestone, grass, ect)

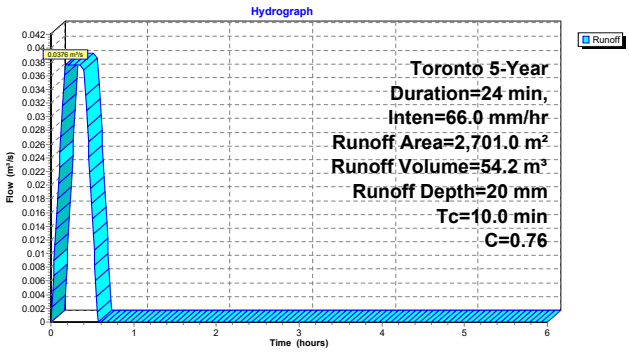
Runoff = 0.0376 m³/s @ 0.17 hrs, Volume= 54.2 m³, Depth= 20 mm

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=24 min, Inten=66.0 mm/hr

Area (m²)	C	Description
593.0	0.25	Pervious Area
2,108.0	0.90	Paved Area
2,701.0	0.76	Weighted Average
2,701.0		100.00% Pervious Area

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

Subcatchment 4: At-Grade



Summary for Subcatchment 7S: Roof Area

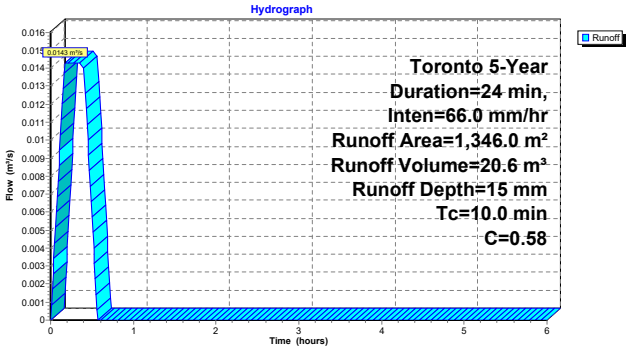
Runoff = 0.0143 m³/s @ 0.17 hrs, Volume= 20.6 m³, Depth= 15 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Toronto 5-Year Duration=24 min, Inten=66.0 mm/hr

Area (m²)	C	Description
967.0	0.45	Green Roof
379.0	0.90	Impervious Roof
1,346.0	0.58	Weighted Average
1,346.0		100.00% Pervious Area

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

Subcatchment 7S: Roof Area



Summary for Pond 5: SWM Tank (33.1L/s)

Inflow Area = 4,047.0 m², 0.00% Impervious, Inflow Depth = 18 mm for 5-Year event
Inflow = 0.0519 m³/s @ 0.17 hrs, Volume= 74.8 m³
Outflow = 0.0177 m³/s @ 0.51 hrs, Volume= 74.7 m³, Atten= 66%, Lag= 20.4 min
Primary = 0.0177 m³/s @ 0.51 hrs, Volume= 74.7 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 0.200 m Surf.Area= 70.0 m² Storage= 14.0 m³
Peak Elev= 0.967 m @ 0.51 hrs Surf.Area= 70.0 m² Storage= 67.7 m³ (53.7 m³ above start)

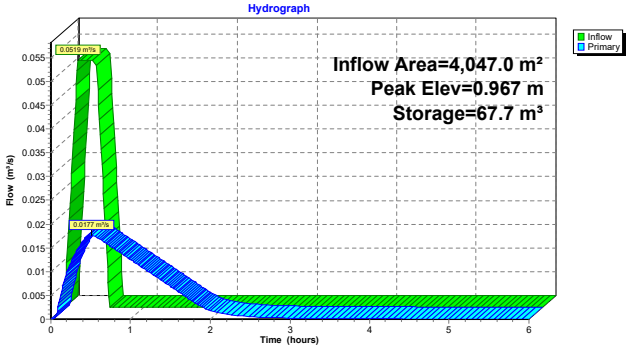
Plug-Flow detention time= 51.3 min calculated for 60.7 m³ (81% of inflow)
Center-of-Mass det. time= 39.7 min (56.7 - 17.0)

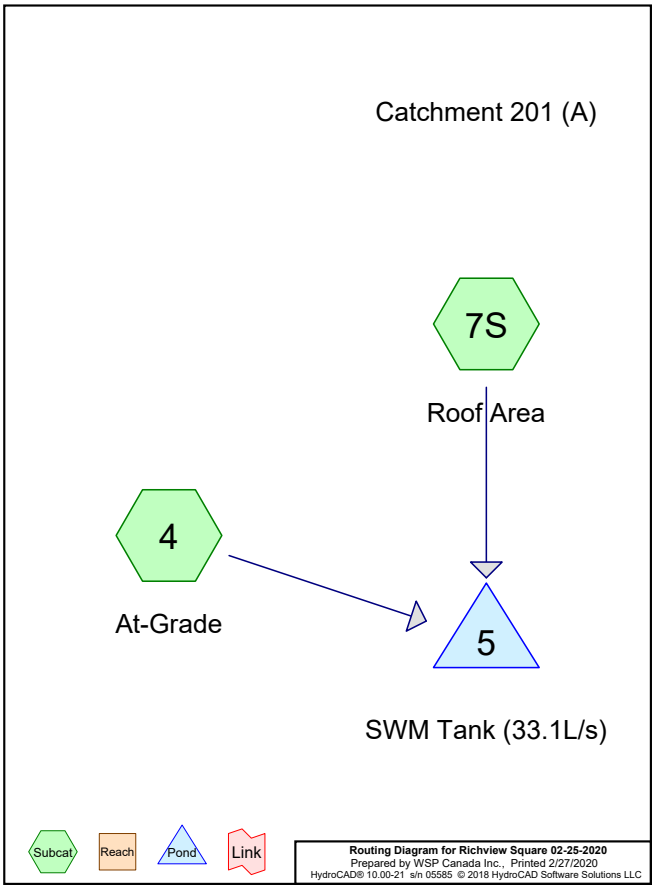
Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	140.0 m³	**1.00 mW x 70.00 mL x 2.00 mH Cistern + Orifice**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.200 m	**100 mm Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.0177 m³/s @ 0.51 hrs HW=0.967 m (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 0.0177 m³/s @ 2.25 m/s)

Pond 5: SWM Tank (33.1L/s)





Area Listing (selected nodes)

Area (sq-meters)	C	Description (subcatchment-numbers)
967.0	0.45	Green Roof (7S)
379.0	0.90	Impervious Roof (7S)
2,108.0	0.90	Paved Area (4)
593.0	0.25	Pervious Area (4)
4,047.0	**0.70**	**TOTAL AREA**

Notes Listing (selected nodes)

Line#	Node Number	Notes
1	4	Remaining landscaped areas to be defined (pavestone, grass, ect)

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

Subcatchment4: At-Grade Runoff Area=2,701.0 m² 0.00% Impervious Runoff Depth=24 mm
Tc=10.0 min C=0.76 Runoff=0.0459 m³/s 66.1 m³

Subcatchment7S: Roof Area Runoff Area=1,346.0 m² 0.00% Impervious Runoff Depth=19 mm
Tc=10.0 min C=0.58 Runoff=0.0175 m³/s 25.2 m³

Pond 5: SWM Tank (33.1L/s) Peak Elev=1.160 m Storage=81.2 m³ Inflow=0.0634 m³/s 91.3 m³
Outflow=0.0199 m³/s 91.2 m³

Total Runoff Area = 4,047.0 m² Runoff Volume = 91.3 m³ Average Runoff Depth = 23 mm
100.00% Pervious = 4,047.0 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 4: At-Grade

Remaining landscaped areas to be defined (pavestone, grass, ect)

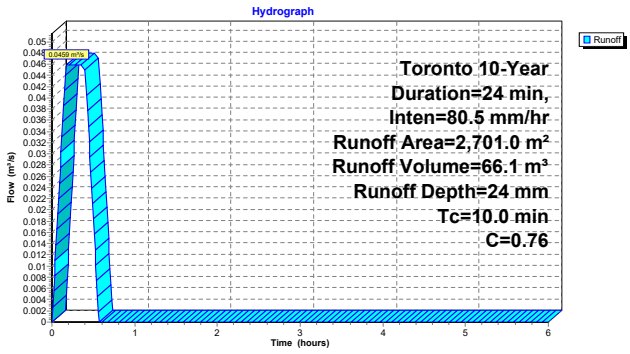
Runoff = 0.0459 m³/s @ 0.17 hrs, Volume= 66.1 m³, Depth= 24 mm

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=24 min, Inten=80.5 mm/hr

Area (m²)	C	Description
593.0	0.25	Pervious Area
2,108.0	0.90	Paved Area
2,701.0	0.76	Weighted Average
2,701.0		100.00% Pervious Area

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

Subcatchment 4: At-Grade



Summary for Subcatchment 7S: Roof Area

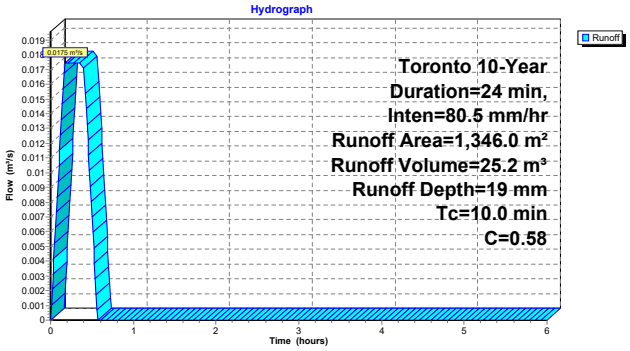
Runoff = 0.0175 m³/s @ 0.17 hrs, Volume= 25.2 m³, Depth= 19 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Toronto 10-Year Duration=24 min, Inten=80.5 mm/hr

Area (m²)	C	Description
967.0	0.45	Green Roof
379.0	0.90	Impervious Roof
1,346.0	0.58	Weighted Average
1,346.0		100.00% Pervious Area

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

Subcatchment 7S: Roof Area



Summary for Pond 5: SWM Tank (33.1L/s)

Inflow Area = 4,047.0 m², 0.00% Impervious, Inflow Depth = 23 mm for 10-Year event
Inflow = 0.0634 m³/s @ 0.17 hrs, Volume= 91.3 m³
Outflow = 0.0199 m³/s @ 0.51 hrs, Volume= 91.2 m³, Atten= 69%, Lag= 20.7 min
Primary = 0.0199 m³/s @ 0.51 hrs, Volume= 91.2 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 0.200 m Surf.Area= 70.0 m² Storage= 14.0 m³
Peak Elev= 1.160 m @ 0.51 hrs Surf.Area= 70.0 m² Storage= 81.2 m³ (67.2 m³ above start)

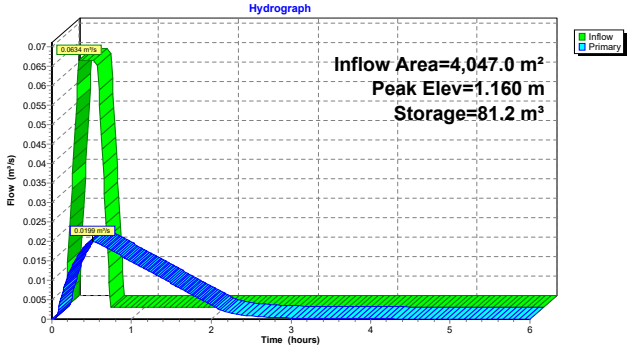
Plug-Flow detention time= 52.5 min calculated for 77.0 m³ (84% of inflow)
Center-of-Mass det. time= 42.9 min (59.9 - 17.0)

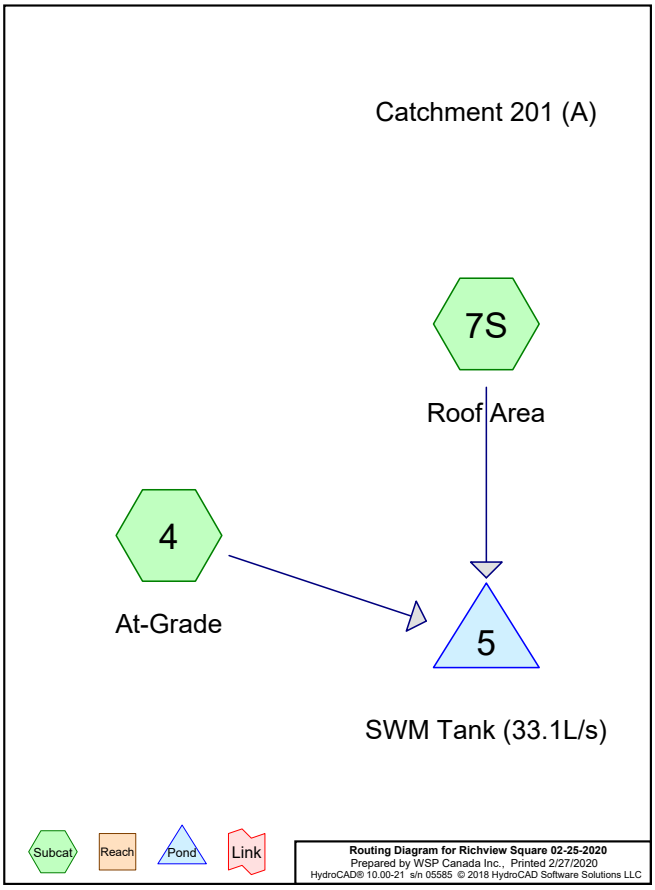
Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	140.0 m³	**1.00 mW x 70.00 mL x 2.00 mH Cistern + Orifice**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.200 m	**100 mm Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.0199 m³/s @ 0.51 hrs HW=1.160 m (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 0.0199 m³/s @ 2.54 m/s)

Pond 5: SWM Tank (33.1L/s)





Area Listing (selected nodes)

Area (sq-meters)	C	Description (subcatchment-numbers)
967.0	0.45	Green Roof (7S)
379.0	0.90	Impervious Roof (7S)
2,108.0	0.90	Paved Area (4)
593.0	0.25	Pervious Area (4)
4,047.0	**0.70**	**TOTAL AREA**

Notes Listing (selected nodes)

Line#	Node Number	Notes
1	4	Remaining landscaped areas to be defined (pavestone, grass, ect)

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

Subcatchment4: At-Grade Runoff Area=2,701.0 m² 0.00% Impervious Runoff Depth=29 mm
Tc=10.0 min C=0.76 Runoff=0.0503 m³/s 78.5 m³

Subcatchment7S: Roof Area Runoff Area=1,346.0 m² 0.00% Impervious Runoff Depth=22 mm
Tc=10.0 min C=0.58 Runoff=0.0191 m³/s 29.8 m³

Pond 5: SWM Tank (33.1L/s) Peak Elev=1.344 m Storage=94.1 m³ Inflow=0.0695 m³/s 108.3 m³
Outflow=0.0218 m³/s 108.1 m³

Total Runoff Area = 4,047.0 m² Runoff Volume = 108.3 m³ Average Runoff Depth = 27 mm
100.00% Pervious = 4,047.0 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 4: At-Grade

Remaining landscaped areas to be defined (pavestone, grass, ect)

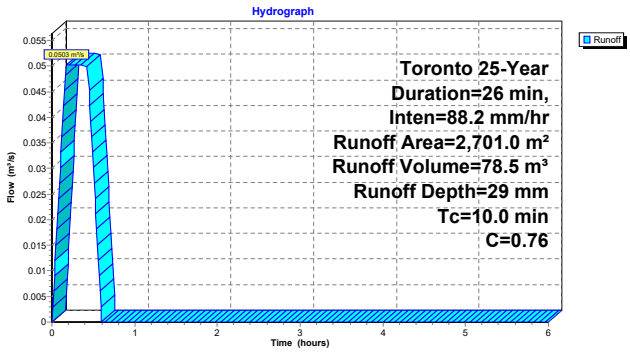
Runoff = 0.0503 m³/s @ 0.17 hrs, Volume= 78.5 m³, Depth= 29 mm

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=26 min, Inten=88.2 mm/hr

Area (m²)	C	Description
593.0	0.25	Pervious Area
2,108.0	0.90	Paved Area
2,701.0	0.76	Weighted Average
2,701.0		100.00% Pervious Area

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

Subcatchment 4: At-Grade



Summary for Subcatchment 7S: Roof Area

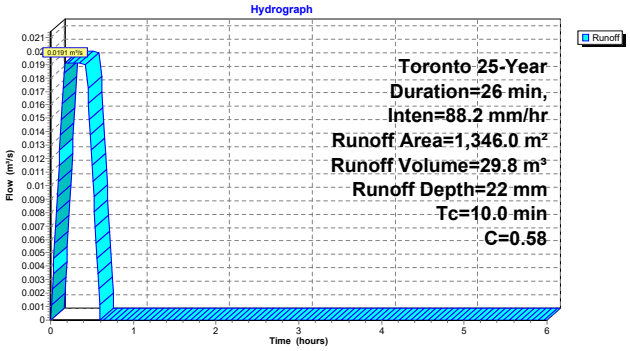
Runoff = 0.0191 m³/s @ 0.17 hrs, Volume= 29.8 m³, Depth= 22 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Toronto 25-Year Duration=26 min, Inten=88.2 mm/hr

Area (m²)	C	Description
967.0	0.45	Green Roof
379.0	0.90	Impervious Roof
1,346.0	0.58	Weighted Average
1,346.0		100.00% Pervious Area

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

Subcatchment 7S: Roof Area



Summary for Pond 5: SWM Tank (33.1L/s)

Inflow Area = 4,047.0 m², 0.00% Impervious, Inflow Depth = 27 mm for 25-Year event
Inflow = 0.0695 m³/s @ 0.17 hrs, Volume= 108.3 m³
Outflow = 0.0218 m³/s @ 0.55 hrs, Volume= 108.1 m³, Atten= 69%, Lag= 22.7 min
Primary = 0.0218 m³/s @ 0.55 hrs, Volume= 108.1 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 0.200 m Surf.Area= 70.0 m² Storage= 14.0 m³
Peak Elev= 1.344 m @ 0.55 hrs Surf.Area= 70.0 m² Storage= 94.1 m³ (80.1 m³ above start)

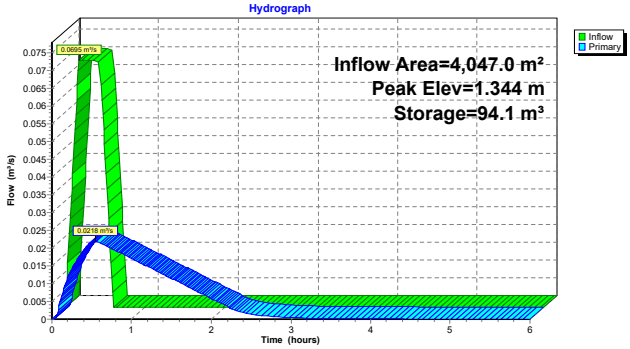
Plug-Flow detention time= 54.9 min calculated for 94.1 m³ (87% of inflow)
Center-of-Mass det. time= 45.8 min (63.8 - 18.0)

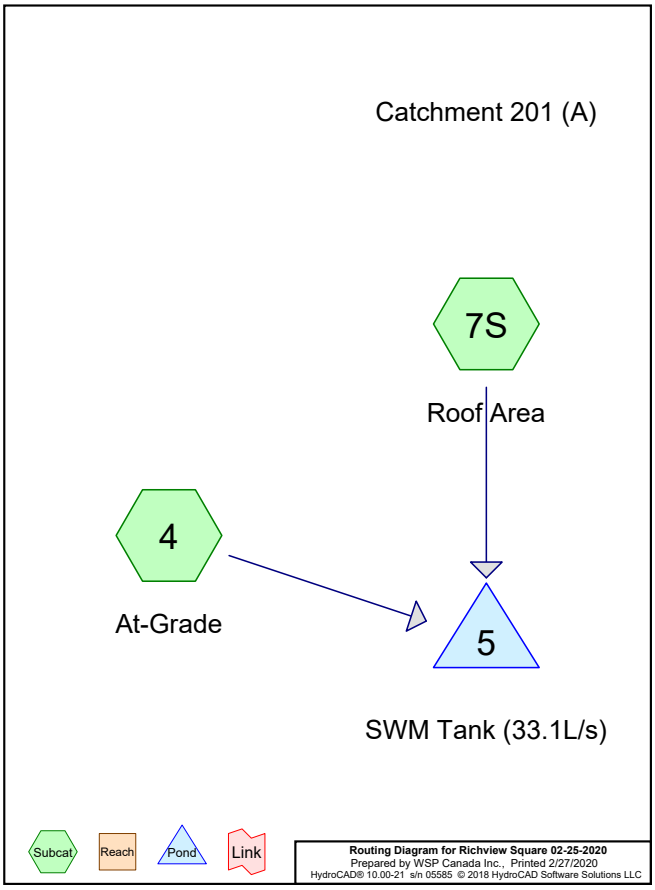
Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	140.0 m³	**1.00 mW x 70.00 mL x 2.00 mH Cistern + Orifice**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.200 m	**100 mm Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.0218 m³/s @ 0.55 hrs HW=1.344 m (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 0.0218 m³/s @ 2.78 m/s)

Pond 5: SWM Tank (33.1L/s)





Area Listing (selected nodes)

Area (sq-meters)	C	Description (subcatchment-numbers)
967.0	0.45	Green Roof (7S)
379.0	0.90	Impervious Roof (7S)
2,108.0	0.90	Paved Area (4)
593.0	0.25	Pervious Area (4)
4,047.0	**0.70**	**TOTAL AREA**

Notes Listing (selected nodes)

Line#	Node Number	Notes
1	4	Remaining landscaped areas to be defined (pavestone, grass, ect)

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

Subcatchment4: At-Grade Runoff Area=2,701.0 m² 0.00% Impervious Runoff Depth=35 mm
Tc=10.0 min C=0.76 Runoff=0.0578 m³/s 93.6 m³

Subcatchment7S: Roof Area Runoff Area=1,346.0 m² 0.00% Impervious Runoff Depth=26 mm
Tc=10.0 min C=0.58 Runoff=0.0220 m³/s 35.6 m³

Pond 5: SWM Tank (33.1L/s) Peak Elev=1.584 m Storage=110.9 m³ Inflow=0.0798 m³/s 129.2 m³
Outflow=0.0241 m³/s 129.0 m³

Total Runoff Area = 4,047.0 m² Runoff Volume = 129.2 m³ Average Runoff Depth = 32 mm
100.00% Pervious = 4,047.0 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 4: At-Grade

Remaining landscaped areas to be defined (pavestone, grass, ect)

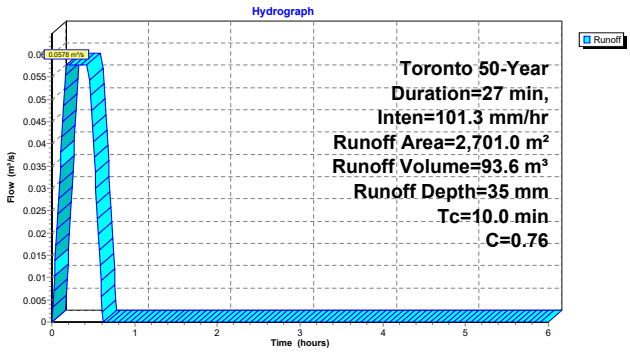
Runoff = 0.0578 m³/s @ 0.17 hrs, Volume= 93.6 m³, Depth= 35 mm

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=27 min, Inten=101.3 mm/hr

Area (m²)	C	Description
593.0	0.25	Pervious Area
2,108.0	0.90	Paved Area
2,701.0	0.76	Weighted Average
2,701.0		100.00% Pervious Area

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

Subcatchment 4: At-Grade



Summary for Subcatchment 7S: Roof Area

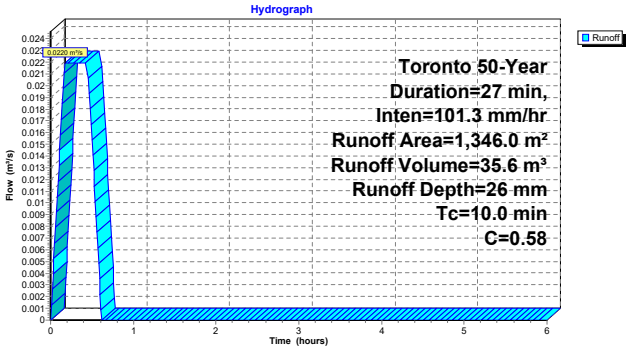
Runoff = 0.0220 m³/s @ 0.17 hrs, Volume= 35.6 m³, Depth= 26 mm

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=27 min, Inten=101.3 mm/hr

Area (m²)	C	Description
967.0	0.45	Green Roof
379.0	0.90	Impervious Roof
1,346.0	0.58	Weighted Average
1,346.0		100.00% Pervious Area

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

Subcatchment 7S: Roof Area



Summary for Pond 5: SWM Tank (33.1L/s)

Inflow Area = 4,047.0 m², 0.00% Impervious, Inflow Depth = 32 mm for 50-Year event
Inflow = 0.0798 m³/s @ 0.17 hrs, Volume= 129.2 m³
Outflow = 0.0241 m³/s @ 0.57 hrs, Volume= 129.0 m³, Atten= 70%, Lag= 23.8 min
Primary = 0.0241 m³/s @ 0.57 hrs, Volume= 129.0 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 0.200 m Surf.Area= 70.0 m² Storage= 14.0 m³
Peak Elev= 1.584 m @ 0.57 hrs Surf.Area= 70.0 m² Storage= 110.9 m³ (96.9 m³ above start)

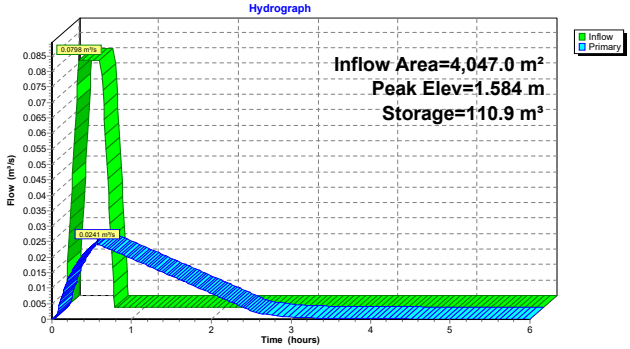
Plug-Flow detention time= 57.1 min calculated for 114.8 m³ (89% of inflow)
Center-of-Mass det. time= 49.4 min (67.9 - 18.5)

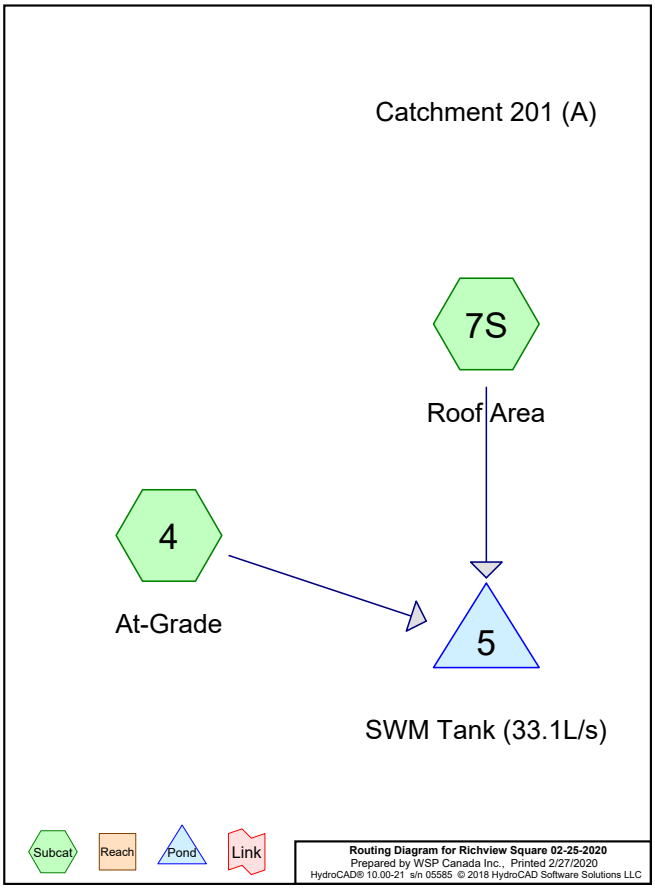
Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	140.0 m³	**1.00 mW x 70.00 mL x 2.00 mH Cistern + Orifice**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.200 m	**100 mm Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.0241 m³/s @ 0.57 hrs HW=1.584 m (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 0.0241 m³/s @ 3.07 m/s)

Pond 5: SWM Tank (33.1L/s)





Area Listing (selected nodes)

Area (sq-meters)	C	Description (subcatchment-numbers)
967.0	0.45	Green Roof (7S)
379.0	0.90	Impervious Roof (7S)
2,108.0	0.90	Paved Area (4)
593.0	0.25	Pervious Area (4)
4,047.0	**0.70**	**TOTAL AREA**

Notes Listing (selected nodes)

Line#	Node Number	Notes
1	4	Remaining landscaped areas to be defined (pavestone, grass, ect)

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

Subcatchment4: At-Grade Runoff Area=2,701.0 m² 0.00% Impervious Runoff Depth=39 mm
Tc=10.0 min C=0.76 Runoff=0.0593 m³/s 106.7 m³

Subcatchment7S: Roof Area Runoff Area=1,346.0 m² 0.00% Impervious Runoff Depth=30 mm
Tc=10.0 min C=0.58 Runoff=0.0225 m³/s 40.6 m³

Pond 5: SWM Tank (33.1L/s) Peak Elev=1.766 m Storage=123.6 m³ Inflow=0.0818 m³/s 147.3 m³
Outflow=0.0257 m³/s 147.0 m³

Total Runoff Area = 4,047.0 m² Runoff Volume = 147.3 m³ Average Runoff Depth = 36 mm
100.00% Pervious = 4,047.0 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 4: At-Grade

Remaining landscaped areas to be defined (pavestone, grass, ect)

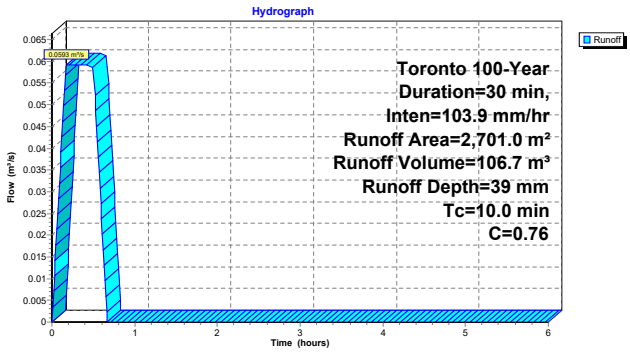
Runoff = 0.0593 m³/s @ 0.17 hrs, Volume= 106.7 m³, Depth= 39 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs
Toronto 100-Year Duration=30 min, Inten=103.9 mm/hr

Area (m²)	C	Description
593.0	0.25	Pervious Area
2,108.0	0.90	Paved Area
2,701.0	0.76	Weighted Average
2,701.0		100.00% Pervious Area

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

Subcatchment 4: At-Grade



Summary for Subcatchment 7S: Roof Area

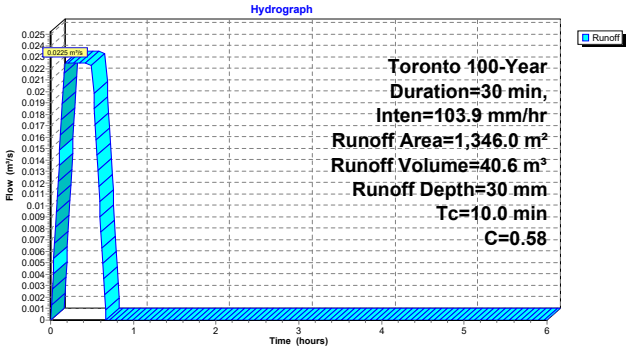
Runoff = 0.0225 m³/s @ 0.17 hrs, Volume= 40.6 m³, Depth= 30 mm

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=30 min, Inten=103.9 mm/hr

Area (m²)	C	Description
967.0	0.45	Green Roof
379.0	0.90	Impervious Roof
1,346.0	0.58	Weighted Average
1,346.0		100.00% Pervious Area

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

Subcatchment 7S: Roof Area



Summary for Pond 5: SWM Tank (33.1L/s)

Inflow Area = 4,047.0 m², 0.00% Impervious, Inflow Depth = 36 mm for 100-Year event
Inflow = 0.0818 m³/s @ 0.17 hrs, Volume= 147.3 m³
Outflow = 0.0257 m³/s @ 0.61 hrs, Volume= 147.0 m³, Atten= 69%, Lag= 26.7 min
Primary = 0.0257 m³/s @ 0.61 hrs, Volume= 147.0 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 0.200 m Surf.Area= 70.0 m² Storage= 14.0 m³
Peak Elev= 1.766 m @ 0.61 hrs Surf.Area= 70.0 m² Storage= 123.6 m³ (109.6 m³ above start)

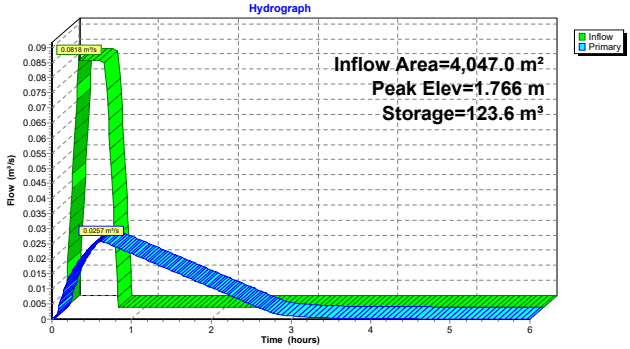
Plug-Flow detention time= 59.6 min calculated for 133.0 m³ (90% of inflow)
Center-of-Mass det. time= 52.0 min (72.0 - 20.0)

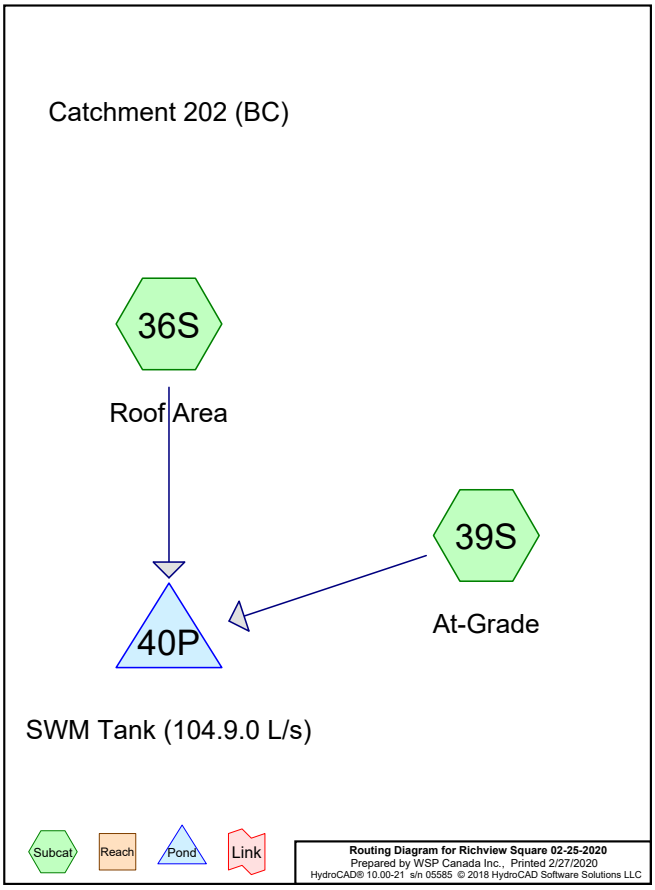
Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	140.0 m³	**1.00 mW x 70.00 mL x 2.00 mH Cistern + Orifice**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.200 m	**100 mm Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.0257 m³/s @ 0.61 hrs HW=1.766 m (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 0.0257 m³/s @ 3.27 m/s)

Pond 5: SWM Tank (33.1L/s)





Area Listing (selected nodes)

Area (sq-meters)	C	Description (subcatchment-numbers)
1,930.5	0.45	Green Roof (36S)
9,288.0	0.90	Impervious (39S)
4,274.6	0.90	Impervious Roof (36S)
3,153.7	0.25	Soft Landscaping (39S)
18,646.8	**0.74**	**TOTAL AREA**

Notes Listing (selected nodes)

Line#	Node Number	Notes
1	36S	Collection from various impervious roof areas

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

Subcatchment36S: Roof Area Runoff Area=6,205.1 m² 0.00% Impervious Runoff Depth=14 mm
Tc=10.0 min C=0.76 Runoff=0.0490 m³/s 88.3 m³

Subcatchment39S: At-Grade Runoff Area=12,441.7 m² 0.00% Impervious Runoff Depth=14 mm
Tc=10.0 min C=0.74 Runoff=0.0957 m³/s 172.3 m³

Pond 40P: SWM Tank (104.9.0 L/s) Peak Elev=0.990 m Storage=253.5 m³ Inflow=0.1448 m³/s 260.6 m³
Outflow=0.0511 m³/s 258.3 m³

Total Runoff Area = 18,646.8 m² Runoff Volume = 260.6 m³ Average Runoff Depth = 14 mm
100.00% Pervious = 18,646.8 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 36S: Roof Area

Collection from various impervious roof areas

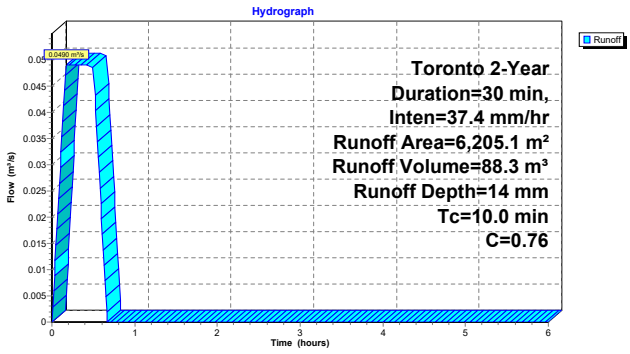
Runoff = 0.0490 m³/s @ 0.17 hrs, Volume= 88.3 m³, Depth= 14 mm

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=30 min, Inten=37.4 mm/hr

Area (m²)	C	Description
4,274.6	0.90	Impervious Roof
1,930.5	0.45	Green Roof
6,205.1	0.76	Weighted Average
6,205.1		100.00% Pervious Area

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

Subcatchment 36S: Roof Area



Summary for Subcatchment 39S: At-Grade

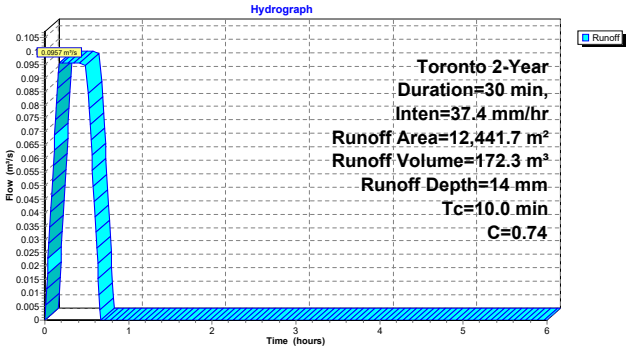
Runoff = 0.0957 m³/s @ 0.17 hrs, Volume= 172.3 m³, Depth= 14 mm

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=30 min, Inten=37.4 mm/hr

Area (m²)	C	Description
9,288.0	0.90	Impervious
3,153.7	0.25	Soft Landscaping
12,441.7	0.74	Weighted Average
12,441.7		100.00% Pervious Area

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

Subcatchment 39S: At-Grade



Summary for Pond 40P: SWM Tank (104.9.0 L/s)

Inflow Area = 18,646.8 m², 0.00% Impervious, Inflow Depth = 14 mm for 2-Year event
Inflow = 0.1448 m³/s @ 0.17 hrs, Volume= 260.6 m³
Outflow = 0.0511 m³/s @ 0.61 hrs, Volume= 258.3 m³, Atten= 65%, Lag= 26.3 min
Primary = 0.0511 m³/s @ 0.61 hrs, Volume= 258.3 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 0.250 m Surf.Area= 256.0 m² Storage= 64.0 m³
Peak Elev= 0.990 m @ 0.61 hrs Surf.Area= 256.0 m² Storage= 253.5 m³ (189.5 m³ above start)

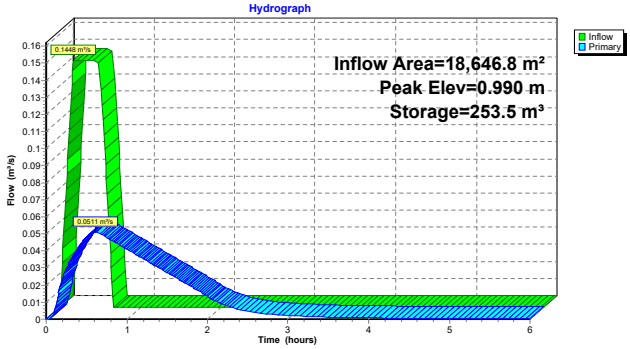
Plug-Flow detention time= 68.7 min calculated for 194.3 m³ (75% of inflow)
Center-of-Mass det. time= 49.6 min (69.6 - 20.0)

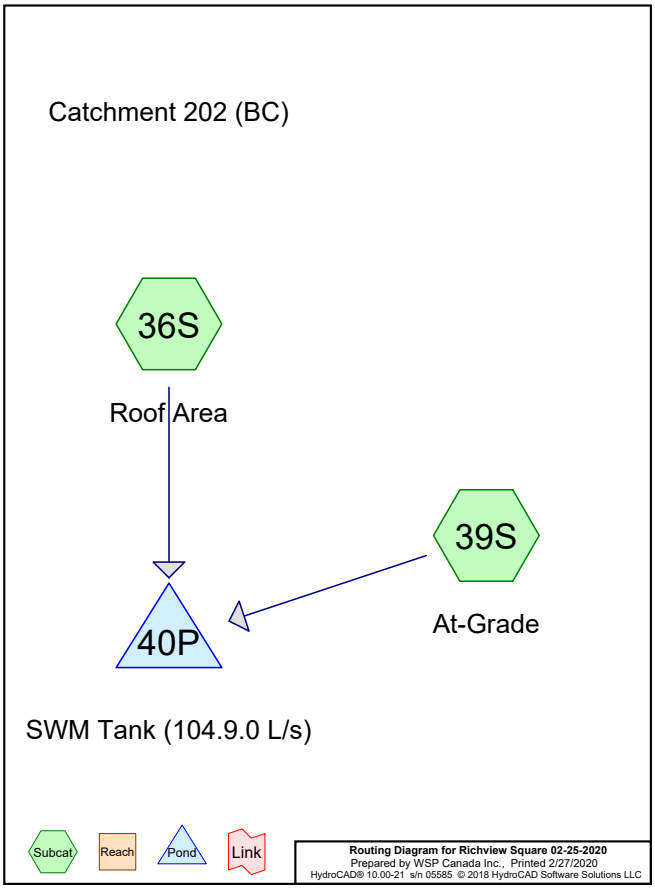
Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	711.7 m³	**1.00 mW x 256.00 mL x 2.78 mH Cistern + Orifice**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.250 m	**150 mm Vert. Orifice/Grate** C= 0.800

Primary OutFlow Max=0.0511 m³/s @ 0.61 hrs HW=0.990 m (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 0.0511 m³/s @ 2.89 m/s)

Pond 40P: SWM Tank (104.9.0 L/s)





Area Listing (selected nodes)

Area (sq-meters)	C	Description (subcatchment-numbers)
1,930.5	0.45	Green Roof (36S)
9,288.0	0.90	Impervious (39S)
4,274.6	0.90	Impervious Roof (36S)
3,153.7	0.25	Soft Landscaping (39S)
18,646.8	**0.74**	**TOTAL AREA**

Notes Listing (selected nodes)

Line#	Node Number	Notes
1	36S	Collection from various impervious roof areas

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

Subcatchment36S: Roof Area Runoff Area=6,205.1 m² 0.00% Impervious Runoff Depth=21 mm
Tc=10.0 min C=0.76 Runoff=0.0672 m³/s 133.1 m³

Subcatchment39S: At-Grade Runoff Area=12,441.7 m² 0.00% Impervious Runoff Depth=21 mm
Tc=10.0 min C=0.74 Runoff=0.1312 m³/s 259.9 m³

Pond 40P: SWM Tank (104.9.0 L/s) Peak Elev=1.395 m Storage=357.0 m³ Inflow=0.1985 m³/s 393.0 m³
Outflow=0.0648 m³/s 389.9 m³

Total Runoff Area = 18,646.8 m² Runoff Volume = 393.0 m³ Average Runoff Depth = 21 mm
100.00% Pervious = 18,646.8 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 36S: Roof Area

Collection from various impervious roof areas

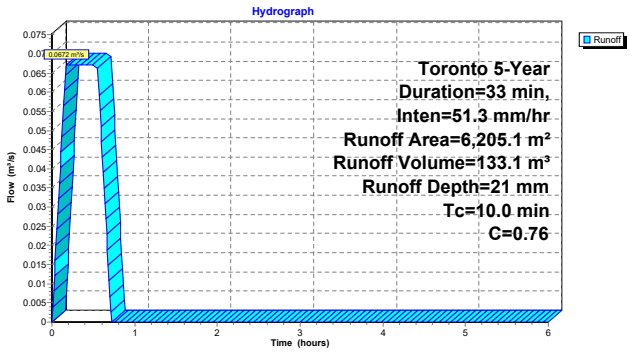
Runoff = 0.0672 m³/s @ 0.17 hrs, Volume= 133.1 m³, Depth= 21 mm

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=33 min, Inten=51.3 mm/hr

Area (m²)	C	Description
4,274.6	0.90	Impervious Roof
1,930.5	0.45	Green Roof
6,205.1	0.76	Weighted Average
6,205.1		100.00% Pervious Area

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

Subcatchment 36S: Roof Area



Summary for Subcatchment 39S: At-Grade

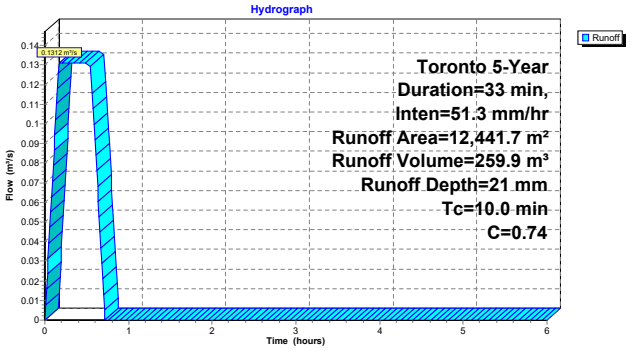
Runoff = 0.1312 m³/s @ 0.17 hrs, Volume= 259.9 m³, Depth= 21 mm

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=33 min, Inten=51.3 mm/hr

Area (m²)	C	Description
9,288.0	0.90	Impervious
3,153.7	0.25	Soft Landscaping
12,441.7	0.74	Weighted Average
12,441.7		100.00% Pervious Area

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

Subcatchment 39S: At-Grade



Summary for Pond 40P: SWM Tank (104.9.0 L/s)

Inflow Area = 18,646.8 m², 0.00% Impervious, Inflow Depth = 21 mm for 5-Year event
Inflow = 0.1985 m³/s @ 0.17 hrs, Volume= 393.0 m³
Outflow = 0.0648 m³/s @ 0.66 hrs, Volume= 389.9 m³, Atten= 67%, Lag= 29.5 min
Primary = 0.0648 m³/s @ 0.66 hrs, Volume= 389.9 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 0.250 m Surf.Area= 256.0 m² Storage= 64.0 m³
Peak Elev= 1.395 m @ 0.66 hrs Surf.Area= 256.0 m² Storage= 357.0 m³ (293.0 m³ above start)

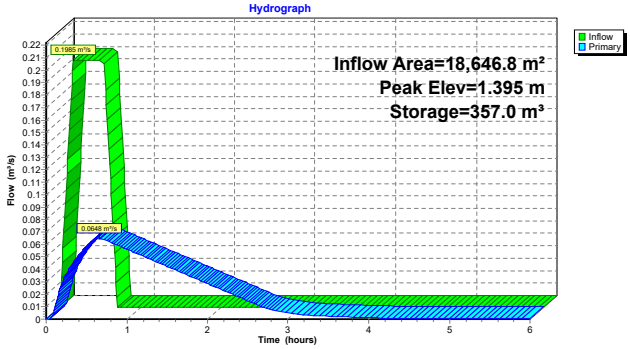
Plug-Flow detention time= 70.6 min calculated for 325.4 m³ (83% of inflow)
Center-of-Mass det. time= 56.8 min (78.3 - 21.5)

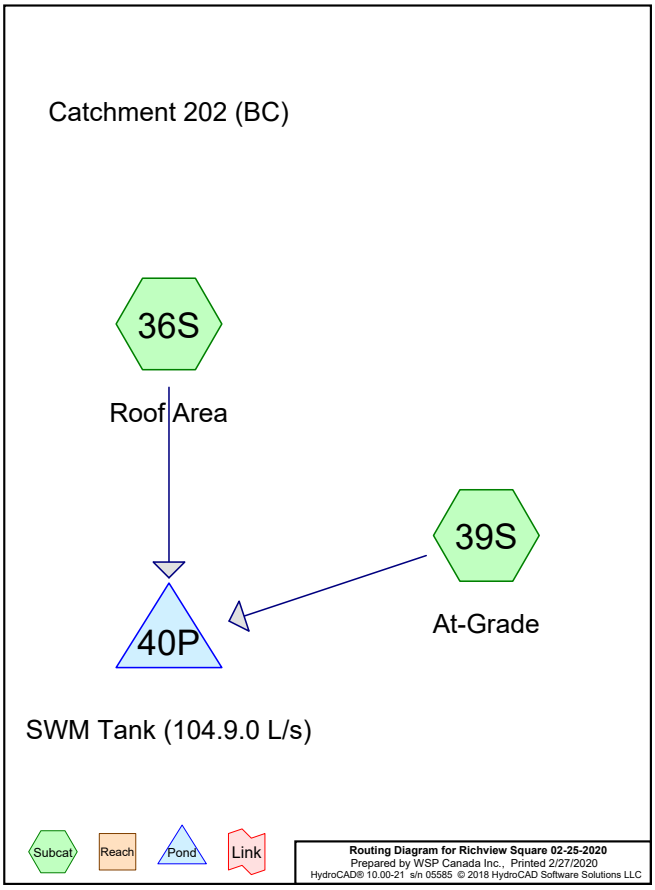
Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	711.7 m³	**1.00 mW x 256.00 mL x 2.78 mH Cistern + Orifice**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.250 m	**150 mm Vert. Orifice/Grate** C= 0.800

Primary OutFlow Max=0.0648 m³/s @ 0.66 hrs HW=1.394 m (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 0.0648 m³/s @ 3.66 m/s)

Pond 40P: SWM Tank (104.9.0 L/s)





Area Listing (selected nodes)

Area (sq-meters)	C	Description (subcatchment-numbers)
1,930.5	0.45	Green Roof (36S)
9,288.0	0.90	Impervious (39S)
4,274.6	0.90	Impervious Roof (36S)
3,153.7	0.25	Soft Landscaping (39S)
18,646.8	**0.74**	**TOTAL AREA**

Notes Listing (selected nodes)

Line#	Node Number	Notes
1	36S	Collection from various impervious roof areas

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

Subcatchment36S: Roof Area Runoff Area=6,205.1 m² 0.00% Impervious Runoff Depth=26 mm
Tc=10.0 min C=0.76 Runoff=0.0818 m³/s 161.9 m³

Subcatchment39S: At-Grade Runoff Area=12,441.7 m² 0.00% Impervious Runoff Depth=25 mm
Tc=10.0 min C=0.74 Runoff=0.1597 m³/s 316.2 m³

Pond 40P: SWM Tank (104.9.0 L/s) Peak Elev=1.675 m Storage=428.7 m³ Inflow=0.2415 m³/s 478.1 m³
Outflow=0.0728 m³/s 474.6 m³

Total Runoff Area = 18,646.8 m² Runoff Volume = 478.1 m³ Average Runoff Depth = 26 mm
100.00% Pervious = 18,646.8 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 36S: Roof Area

Collection from various impervious roof areas

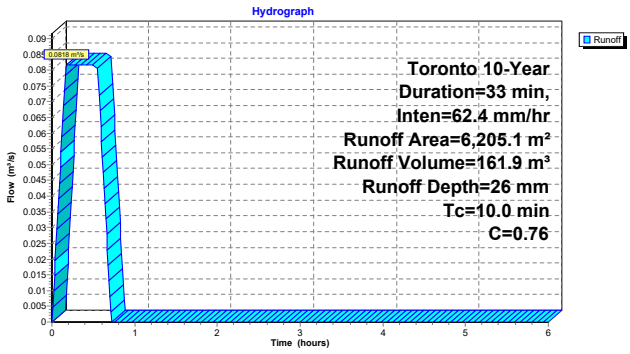
Runoff = 0.0818 m³/s @ 0.17 hrs, Volume= 161.9 m³, Depth= 26 mm

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=33 min, Inten=62.4 mm/hr

Area (m²)	C	Description
4,274.6	0.90	Impervious Roof
1,930.5	0.45	Green Roof
6,205.1	0.76	Weighted Average
6,205.1		100.00% Pervious Area

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

Subcatchment 36S: Roof Area



Summary for Subcatchment 39S: At-Grade

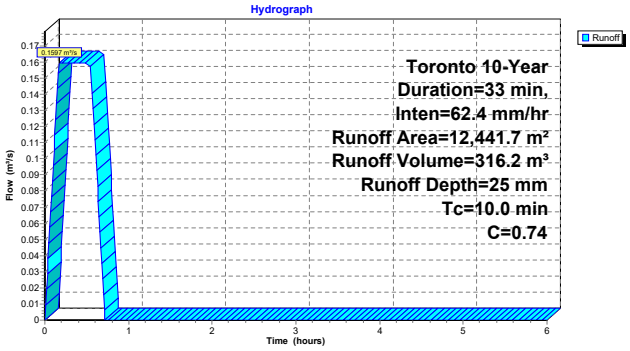
Runoff = 0.1597 m³/s @ 0.17 hrs, Volume= 316.2 m³, Depth= 25 mm

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=33 min, Inten=62.4 mm/hr

Area (m²)	C	Description
9,288.0	0.90	Impervious
3,153.7	0.25	Soft Landscaping
12,441.7	0.74	Weighted Average
12,441.7		100.00% Pervious Area

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

Subcatchment 39S: At-Grade



Summary for Pond 40P: SWM Tank (104.9.0 L/s)

Inflow Area = 18,646.8 m², 0.00% Impervious, Inflow Depth = 26 mm for 10-Year event
Inflow = 0.2415 m³/s @ 0.17 hrs, Volume= 478.1 m³
Outflow = 0.0728 m³/s @ 0.67 hrs, Volume= 474.6 m³, Atten= 70%, Lag= 29.8 min
Primary = 0.0728 m³/s @ 0.67 hrs, Volume= 474.6 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 0.250 m Surf.Area= 256.0 m² Storage= 64.0 m³
Peak Elev= 1.675 m @ 0.67 hrs Surf.Area= 256.0 m² Storage= 428.7 m³ (364.7 m³ above start)

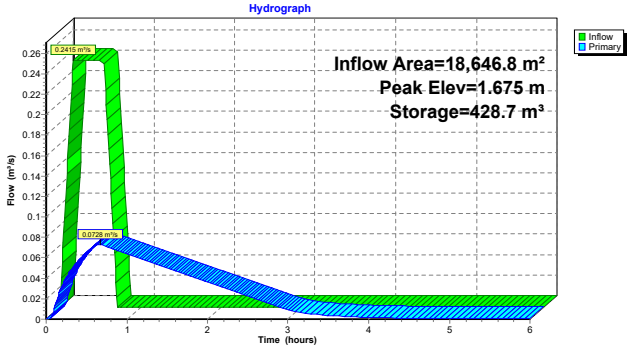
Plug-Flow detention time= 73.4 min calculated for 409.9 m³ (86% of inflow)
Center-of-Mass det. time= 61.5 min (83.0 - 21.5)

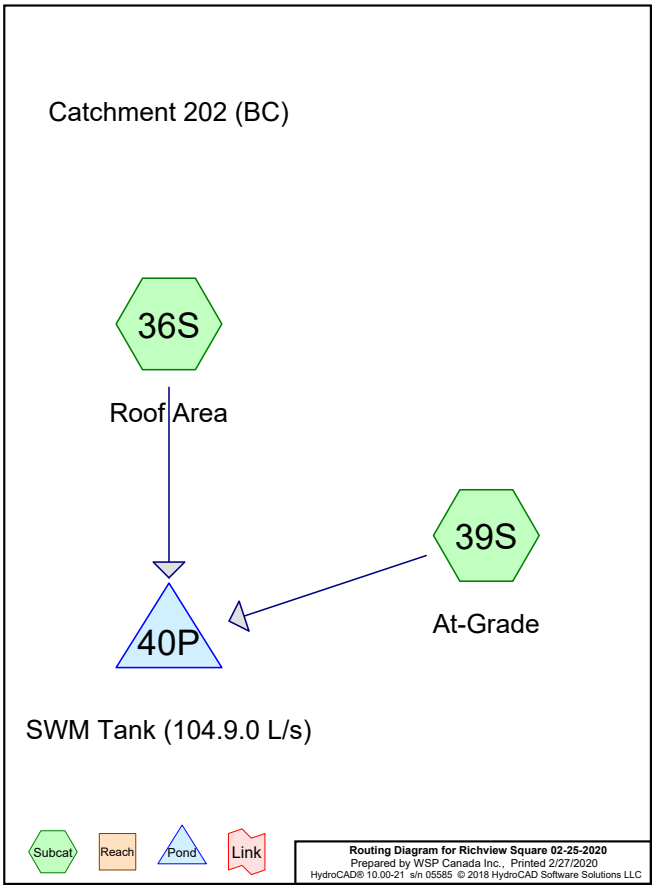
Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	711.7 m³	**1.00 mW x 256.00 mL x 2.78 mH Cistern + Orifice**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.250 m	**150 mm Vert. Orifice/Grate** C= 0.800

Primary OutFlow Max=0.0727 m³/s @ 0.67 hrs HW=1.675 m (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 0.0727 m³/s @ 4.12 m/s)

Pond 40P: SWM Tank (104.9.0 L/s)





Area Listing (selected nodes)

Area (sq-meters)	C	Description (subcatchment-numbers)
1,930.5	0.45	Green Roof (36S)
9,288.0	0.90	Impervious (39S)
4,274.6	0.90	Impervious Roof (36S)
3,153.7	0.25	Soft Landscaping (39S)
18,646.8	**0.74**	**TOTAL AREA**

Notes Listing (selected nodes)

Line#	Node Number	Notes
1	36S	Collection from various impervious roof areas

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

Subcatchment36S: Roof Area Runoff Area=6,205.1 m² 0.00% Impervious Runoff Depth=31 mm
Tc=10.0 min C=0.76 Runoff=0.0891 m³/s 192.5 m³

Subcatchment39S: At-Grade Runoff Area=12,441.7 m² 0.00% Impervious Runoff Depth=30 mm
Tc=10.0 min C=0.74 Runoff=0.1740 m³/s 375.7 m³

Pond 40P: SWM Tank (104.9.0 L/s) Peak Elev=1.945 m Storage=497.8 m³ Inflow=0.2631 m³/s 568.2 m³
Outflow=0.0797 m³/s 564.2 m³

Total Runoff Area = 18,646.8 m² Runoff Volume = 568.2 m³ Average Runoff Depth = 30 mm
100.00% Pervious = 18,646.8 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 36S: Roof Area

Collection from various impervious roof areas

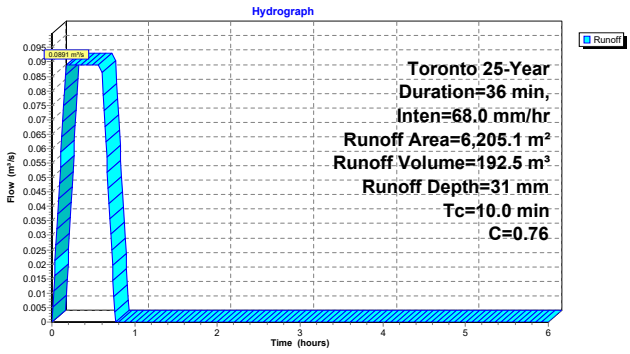
Runoff = 0.0891 m³/s @ 0.17 hrs, Volume= 192.5 m³, Depth= 31 mm

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=36 min, Inten=68.0 mm/hr

Area (m²)	C	Description
4,274.6	0.90	Impervious Roof
1,930.5	0.45	Green Roof
6,205.1	0.76	Weighted Average
6,205.1		100.00% Pervious Area

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

Subcatchment 36S: Roof Area



Summary for Subcatchment 39S: At-Grade

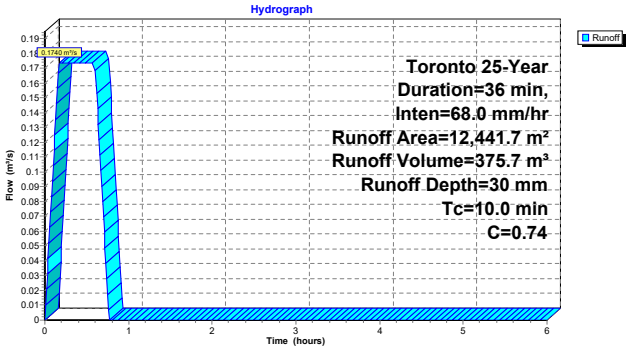
Runoff = 0.1740 m³/s @ 0.17 hrs, Volume= 375.7 m³, Depth= 30 mm

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=36 min, Inten=68.0 mm/hr

Area (m²)	C	Description
9,288.0	0.90	Impervious
3,153.7	0.25	Soft Landscaping
12,441.7	0.74	Weighted Average
12,441.7		100.00% Pervious Area

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

Subcatchment 39S: At-Grade



Summary for Pond 40P: SWM Tank (104.9.0 L/s)

Inflow Area = 18,646.8 m², 0.00% Impervious, Inflow Depth = 30 mm for 25-Year event
Inflow = 0.2631 m³/s @ 0.17 hrs, Volume= 568.2 m³
Outflow = 0.0797 m³/s @ 0.72 hrs, Volume= 564.2 m³, Atten= 70%, Lag= 32.8 min
Primary = 0.0797 m³/s @ 0.72 hrs, Volume= 564.2 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 0.250 m Surf.Area= 256.0 m² Storage= 64.0 m³
Peak Elev= 1.945 m @ 0.72 hrs Surf.Area= 256.0 m² Storage= 497.8 m³ (433.8 m³ above start)

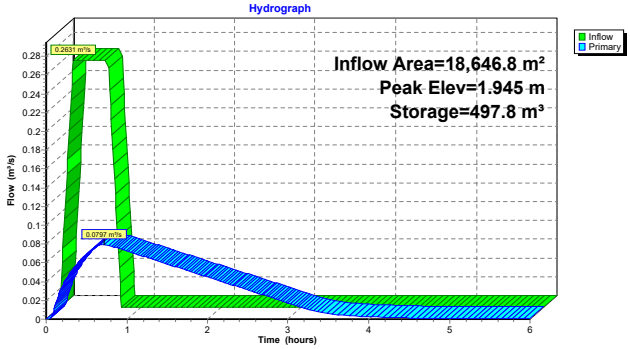
Plug-Flow detention time= 76.6 min calculated for 499.3 m³ (88% of inflow)
Center-of-Mass det. time= 65.9 min (88.9 - 23.0)

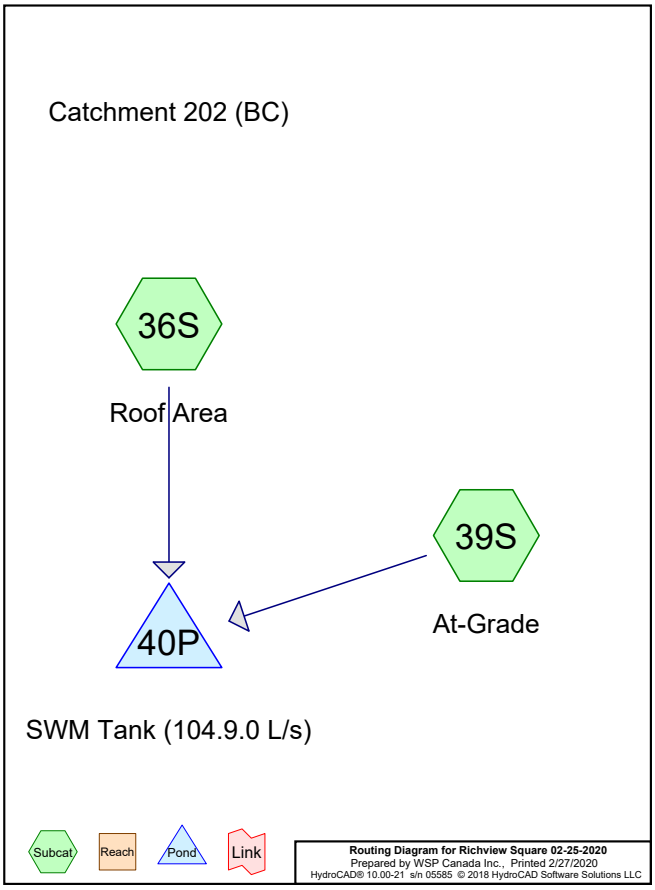
Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	711.7 m³	**1.00 mW x 256.00 mL x 2.78 mH Cistern + Orifice**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.250 m	**150 mm Vert. Orifice/Grate** C= 0.800

Primary OutFlow Max=0.0797 m³/s @ 0.72 hrs HW=1.944 m (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 0.0797 m³/s @ 4.51 m/s)

Pond 40P: SWM Tank (104.9.0 L/s)





Area Listing (selected nodes)

Area (sq-meters)	C	Description (subcatchment-numbers)
1,930.5	0.45	Green Roof (36S)
9,288.0	0.90	Impervious (39S)
4,274.6	0.90	Impervious Roof (36S)
3,153.7	0.25	Soft Landscaping (39S)
18,646.8	**0.74**	**TOTAL AREA**

Notes Listing (selected nodes)

Line#	Node Number	Notes
1	36S	Collection from various impervious roof areas

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

Subcatchment36S: Roof Area Runoff Area=6,205.1 m² 0.00% Impervious Runoff Depth=37 mm
Tc=10.0 min C=0.76 Runoff=0.0989 m³/s 231.5 m³

Subcatchment39S: At-Grade Runoff Area=12,441.7 m² 0.00% Impervious Runoff Depth=36 mm
Tc=10.0 min C=0.74 Runoff=0.1931 m³/s 451.9 m³

Pond 40P: SWM Tank (104.9.0 L/s) Peak Elev=2.296 m Storage=587.8 m³ Inflow=0.2920 m³/s 683.4 m³
Outflow=0.0879 m³/s 678.6 m³

Total Runoff Area = 18,646.8 m² Runoff Volume = 683.4 m³ Average Runoff Depth = 37 mm
100.00% Pervious = 18,646.8 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 36S: Roof Area

Collection from various impervious roof areas

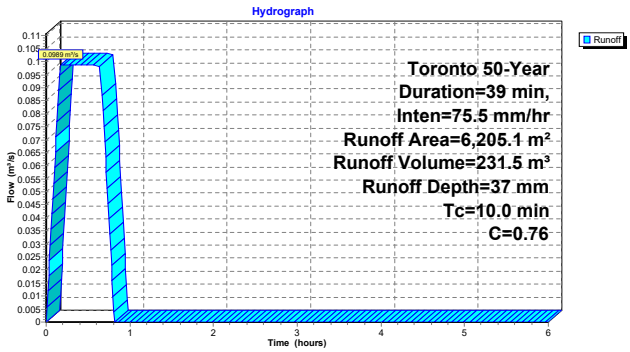
Runoff = 0.0989 m³/s @ 0.17 hrs, Volume= 231.5 m³, Depth= 37 mm

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=39 min, Inten=75.5 mm/hr

Area (m²)	C	Description
4,274.6	0.90	Impervious Roof
1,930.5	0.45	Green Roof
6,205.1	0.76	Weighted Average
6,205.1		100.00% Pervious Area

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

Subcatchment 36S: Roof Area



Summary for Subcatchment 39S: At-Grade

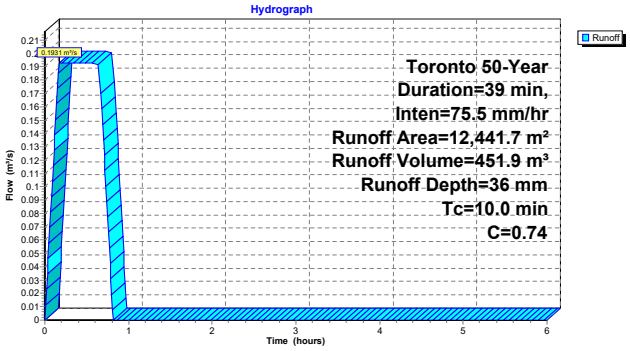
Runoff = 0.1931 m³/s @ 0.17 hrs, Volume= 451.9 m³, Depth= 36 mm

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=39 min, Inten=75.5 mm/hr

Area (m²)	C	Description
9,288.0	0.90	Impervious
3,153.7	0.25	Soft Landscaping
12,441.7	0.74	Weighted Average
12,441.7		100.00% Pervious Area

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

Subcatchment 39S: At-Grade



Summary for Pond 40P: SWM Tank (104.9.0 L/s)

Inflow Area = 18,646.8 m², 0.00% Impervious, Inflow Depth = 37 mm for 50-Year event
Inflow = 0.2920 m³/s @ 0.17 hrs, Volume= 683.4 m³
Outflow = 0.0879 m³/s @ 0.77 hrs, Volume= 678.6 m³, Atten= 70%, Lag= 35.8 min
Primary = 0.0879 m³/s @ 0.77 hrs, Volume= 678.6 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 0.250 m Surf.Area= 256.0 m² Storage= 64.0 m³
Peak Elev= 2.296 m @ 0.77 hrs Surf.Area= 256.0 m² Storage= 587.8 m³ (523.8 m³ above start)

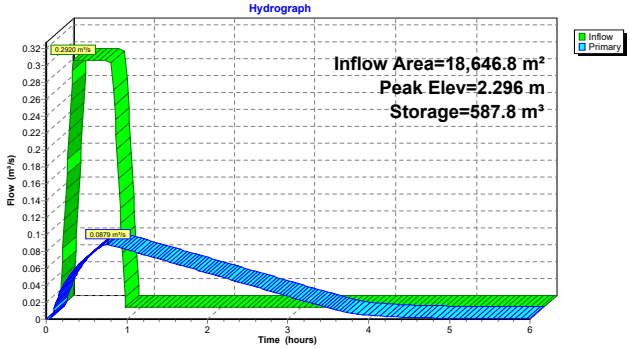
Plug-Flow detention time= 80.9 min calculated for 613.6 m³ (90% of inflow)
Center-of-Mass det. time= 71.2 min (95.7 - 24.5)

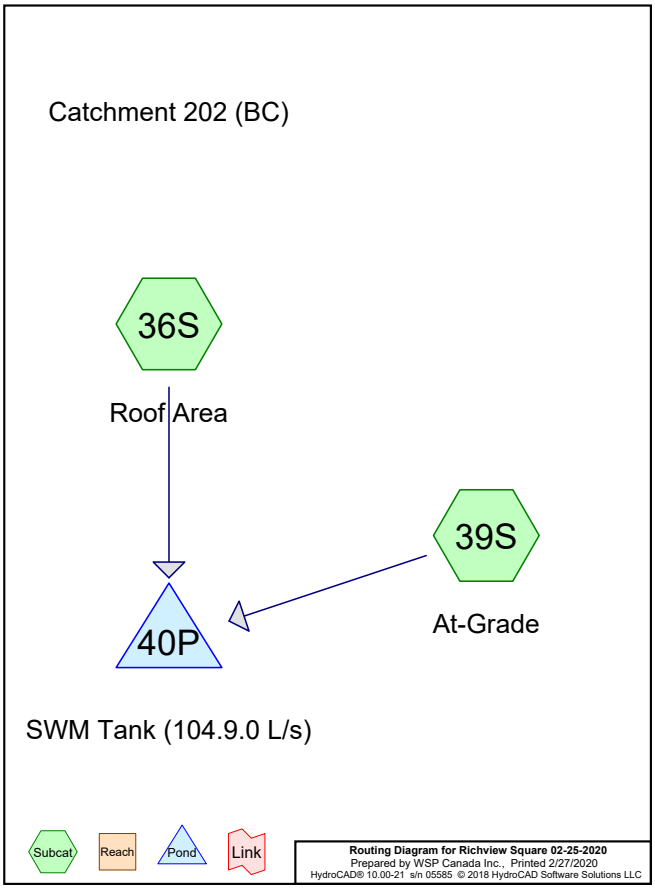
Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	711.7 m³	**1.00 mW x 256.00 mL x 2.78 mH Cistern + Orifice**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.250 m	**150 mm Vert. Orifice/Grate** C= 0.800

Primary OutFlow Max=0.0879 m³/s @ 0.77 hrs HW=2.296 m (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 0.0879 m³/s @ 4.97 m/s)

Pond 40P: SWM Tank (104.9.0 L/s)





Area Listing (selected nodes)

Area (sq-meters)	C	Description (subcatchment-numbers)
1,930.5	0.45	Green Roof (36S)
9,288.0	0.90	Impervious (39S)
4,274.6	0.90	Impervious Roof (36S)
3,153.7	0.25	Soft Landscaping (39S)
18,646.8	**0.74**	**TOTAL AREA**

Notes Listing (selected nodes)

Line#	Node Number	Notes
1	36S	Collection from various impervious roof areas

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

Subcatchment36S: Roof Area Runoff Area=6,205.1 m² 0.00% Impervious Runoff Depth=42 mm
Tc=10.0 min C=0.76 Runoff=0.1040 m³/s 262.2 m³

Subcatchment39S: At-Grade Runoff Area=12,441.7 m² 0.00% Impervious Runoff Depth=41 mm
Tc=10.0 min C=0.74 Runoff=0.2031 m³/s 511.8 m³

Pond 40P: SWM Tank (104.9.0 L/s) Peak Elev=2.563 m Storage=656.2 m³ Inflow=0.3071 m³/s 774.0 m³
Outflow=0.0937 m³/s 768.6 m³

Total Runoff Area = 18,646.8 m² Runoff Volume = 774.0 m³ Average Runoff Depth = 42 mm
100.00% Pervious = 18,646.8 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 36S: Roof Area

Collection from various impervious roof areas

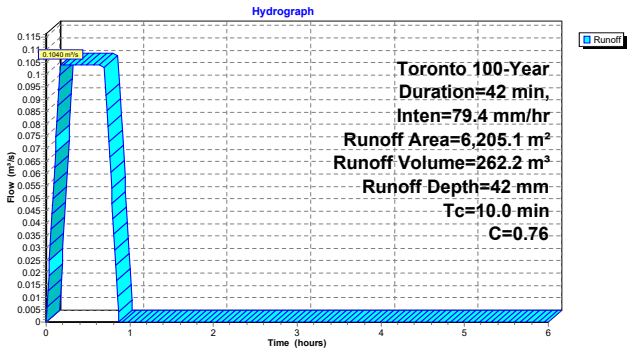
Runoff = 0.1040 m³/s @ 0.17 hrs, Volume= 262.2 m³, Depth= 42 mm

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=42 min, Inten=79.4 mm/hr

Area (m²)	C	Description
4,274.6	0.90	Impervious Roof
1,930.5	0.45	Green Roof
6,205.1	0.76	Weighted Average
6,205.1		100.00% Pervious Area

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

Subcatchment 36S: Roof Area



Summary for Subcatchment 39S: At-Grade

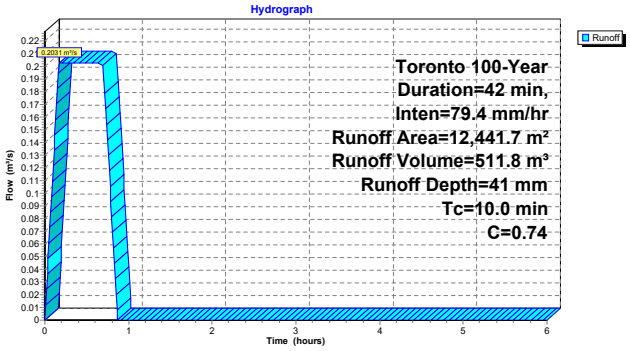
Runoff = 0.2031 m³/s @ 0.17 hrs, Volume= 511.8 m³, Depth= 41 mm

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=42 min, Inten=79.4 mm/hr

Area (m²)	C	Description
9,288.0	0.90	Impervious
3,153.7	0.25	Soft Landscaping
12,441.7	0.74	Weighted Average
12,441.7		100.00% Pervious Area

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

Subcatchment 39S: At-Grade



Summary for Pond 40P: SWM Tank (104.9.0 L/s)

Inflow Area = 18,646.8 m², 0.00% Impervious, Inflow Depth = 42 mm for 100-Year event
Inflow = 0.3071 m³/s @ 0.17 hrs, Volume= 774.0 m³
Outflow = 0.0937 m³/s @ 0.82 hrs, Volume= 768.6 m³, Atten= 69%, Lag= 38.7 min
Primary = 0.0937 m³/s @ 0.82 hrs, Volume= 768.6 m³

Routing by Stor-Ind method, Time Span= 0.00-6.00 hrs, dt= 0.01 hrs / 3
Starting Elev= 0.250 m Surf.Area= 256.0 m² Storage= 64.0 m³
Peak Elev= 2.563 m @ 0.82 hrs Surf.Area= 256.0 m² Storage= 656.2 m³ (592.2 m³ above start)

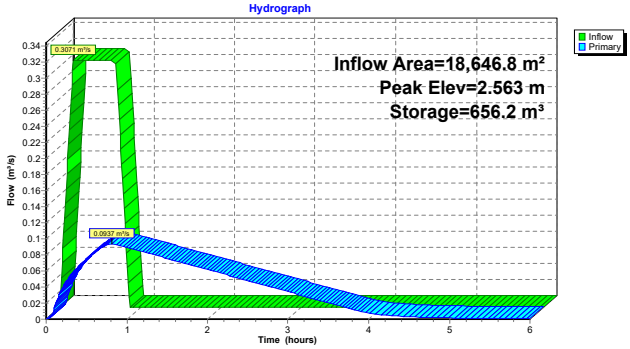
Plug-Flow detention time= 84.1 min calculated for 703.4 m³ (91% of inflow)
Center-of-Mass det. time= 75.0 min (101.0 - 26.0)

Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	711.7 m³	**1.00 mW x 256.00 mL x 2.78 mH Cistern + Orifice**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.250 m	**150 mm Vert. Orifice/Grate** C= 0.800

Primary OutFlow Max=0.0937 m³/s @ 0.82 hrs HW=2.563 m (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 0.0937 m³/s @ 5.30 m/s)

Pond 40P: SWM Tank (104.9.0 L/s)



APPENDIX

C WATER QUALITY UNIT DETAILS

STANDARD OFFLINE
Jellyfish Filter Sizing Report

Project Information

Date	Thursday, February 27, 2020
Project Name	Richview Square - Catchment 201
Project Number	15M-00048-03
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 JF4-1-1 is recommended to meet the water quality objective by treating a flow of 7.6 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 85 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)
JF4-1-1	1	1	1.2	7.6	85

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:

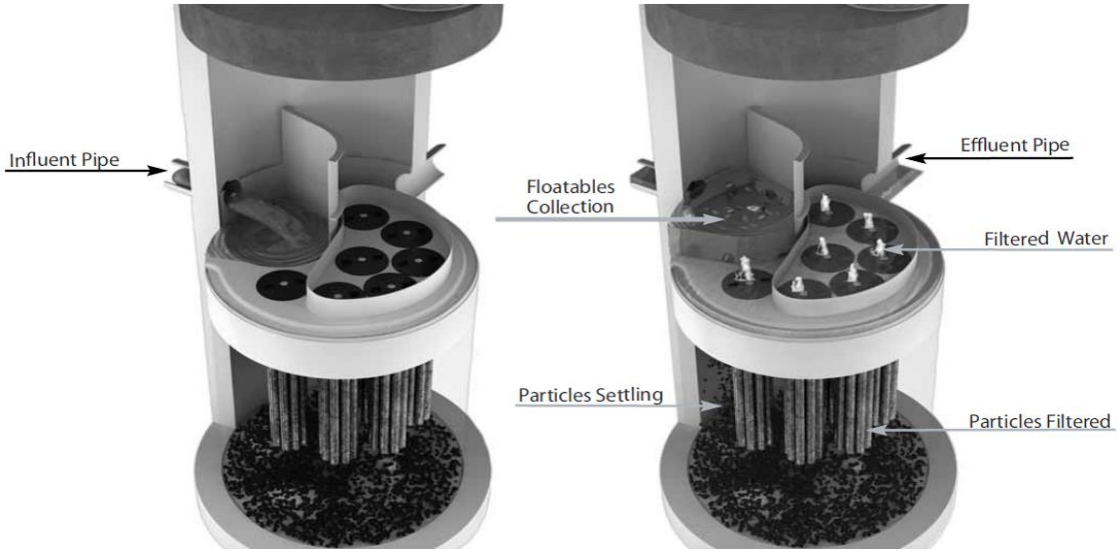
- ☑ 89% of the total suspended solids (TSS) load, including particles less than 5 microns
- ☑ 59% TP removal & 51% TN removal
- ☑ 90% Total Copper, 81% Total Lead, 70% Total Zinc
- ☑ Particulate-bound pollutants such as nutrients, toxic metals, hydrocarbons and bacteria
- ☑ Free oil, Floatable trash 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:	Thursday, February 27, 2020
Project Name:	Richview Square - Catchment 201
Project Number:	15M-00048-03
Location:	Toronto

Designer Information

Company:	WSP Canada Group Ltd.
Contact:	Samer Elhallak
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:	0.27 ha
Runoff Coefficient:	0.76

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 L/s**
Sediment Loading	Treating 90% of the average annual runoff volume, 1299 m³, with a suspended sediment concentration of 60 mg/L.	**78 kg**

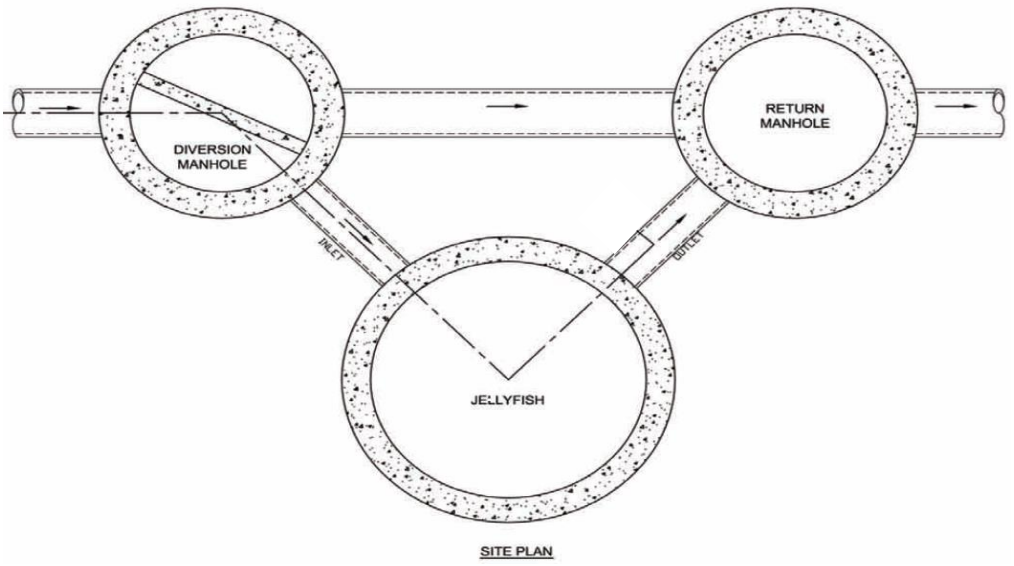
Recommendation

The Jellyfish Filter model JF4-1-1 is recommended to meet the water quality objective by treating a flow of 7.6 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 85 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

STANDARD OFFLINE
Jellyfish Filter Sizing Report

Project Information

Date	Thursday, February 27, 2020
Project Name	Richview Square - Catchment 202
Project Number	15M-00048-03
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 JF6-6-1 is recommended to meet the water quality objective by treating a flow of 28.6 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 370 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)
JF6-6-1	6	1	1.8	28.6	370

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:

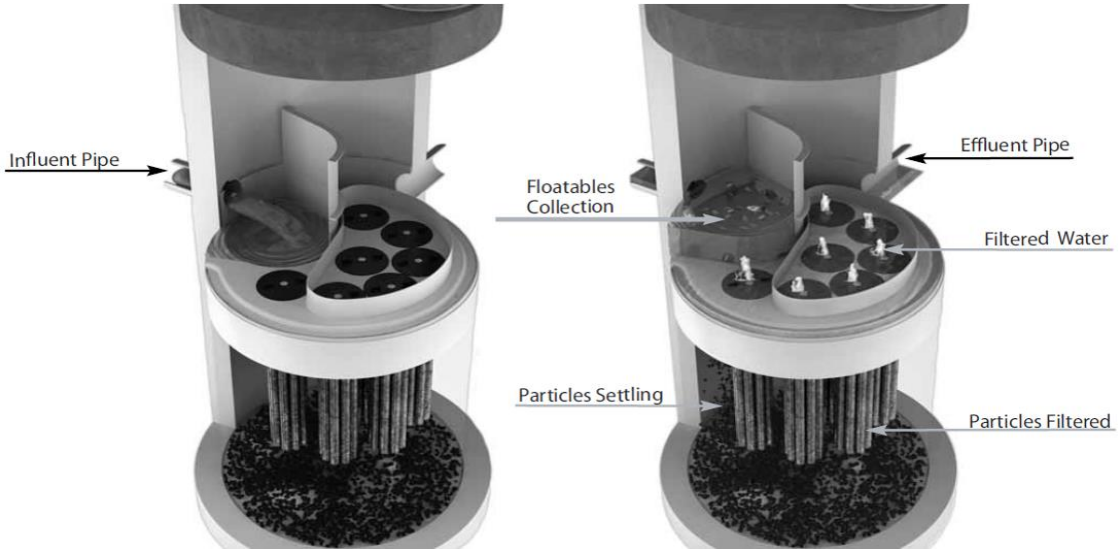
- ☑ 89% of the total suspended solids (TSS) load, including particles less than 5 microns
- ☑ 59% TP removal & 51% TN removal
- ☑ 90% Total Copper, 81% Total Lead, 70% Total Zinc
- ☑ Particulate-bound pollutants such as nutrients, toxic metals, hydrocarbons and bacteria
- ☑ Free oil, Floatable trash 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:	Thursday, February 27, 2020
Project Name:	Richview Square - Catchment 202
Project Number:	15M-00048-03
Location:	Toronto

Designer Information

Company:	WSP Canada Group Ltd.
Contact:	Samer Elhallak
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:	1.24 ha
Runoff Coefficient:	0.73

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:	**24.8 L/s**
Sediment Loading	Treating 90% of the average annual runoff volume, 5626 m³, with a suspended sediment concentration of 60 mg/L.	**338 kg***

** Indicates that sediment loading is the limiting parameter in the sizing of this Jellyfish system*

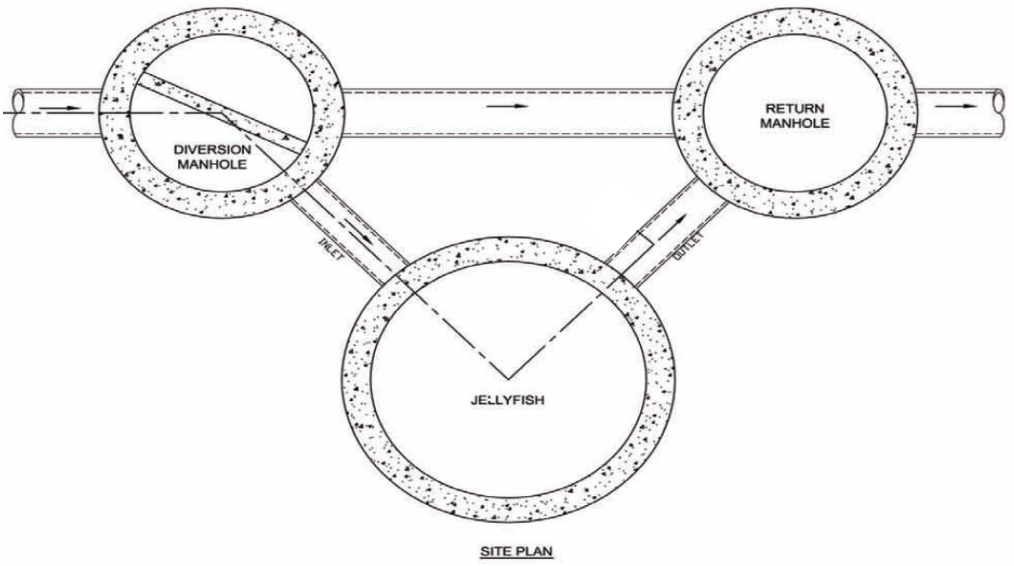
Recommendation

The Jellyfish Filter model JF6-6-1 is recommended to meet the water quality objective by treating a flow of 28.6 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 370 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

STANDARD PERFORMANCE SPECIFICATION
STORMWATER QUALITY – MEMBRANE FILTRATION TREATMENT DEVICE

PART 1 – GENERAL

1.1 WORK INCLUDED

This section specifies requirements for selecting, sizing, and designing 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 & PROCEDURES

ISO 14034:2016 Environmental Management – Environmental Technology Verification (ETV)

1.3 SUBMITTALS

1.3.1 All submittals, including sizing reports & shop drawings, shall be submitted upon request with each order to the contractor then forwarded to the Engineer of Record for review and acceptance. Shop drawings shall detail all OGS components, elevations, and sequence of construction.

1.3.2 Alternative devices shall have features identical to or greater than the specified device, including: filtration surface area, treatment chamber diameter, treatment chamber wet volume, sediment storage volume, and oil storage volume.

1.3.3 Unless directed otherwise by the Engineer of Record, filtration treatment device product substitutions or alternatives submitted within ten days prior to project bid shall not be accepted. All alternatives or substitutions submitted shall be signed and sealed by a local registered Professional Engineer, based on the exact same criteria detailed in Section 3, in entirety, subject to review and approval by the Engineer of Record.

PART 2 – PRODUCTS

2.1 GENERAL

2.1.1 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 internal components. 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 their installed placement for the entire length of the cartridge.

2.1.2 Pollutant Storage: The Filter device shall include a sump for sediment storage, and a protected volume for the capture and storage of petroleum hydrocarbons and buoyant gross pollutants.

PART 3 – PERFORMANCE

3.1 GENERAL

3.1.1 Verification – The stormwater quality filter treatment device shall have been field tested in accordance with either TARP Tier II Protocol (TARP, 2003) and New Jersey Tier II Stormwater Test Requirements – Amendments to TARP Tier II Protocol (NJDEP, 2009) or Washington State Technology Assessment Protocol – Ecology (TAPE), 2011 or later version. The field test shall have been verified in accordance with ISO 14034:2016 Environmental Management – Environmental Technology Verification (ETV). See Section 3.2 of this specification for field test performance requirements.

3.2 FIELD TEST PERFORMANCE

The field test (as specified in section 3.1.1)shall have monitored a minimum of twenty (20) TARP or TAPE qualifying storm events, and report at **minimum** the following results:

3.2.1 Suspended Solids Removal - The stormwater quality filter treatment device shall have ISO 14034 ETV verified load based median TSS removal efficiency of at least 85% and load based median SSC removal efficiency of at least 98%.

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, and 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 turbidity such that effluent turbidity is 15 NTU or lower.

3.2.5 Nutrients & Metals – The stormwater quality filter treatment device shall have ISO 14034 ETV Verified minimum load based removal efficiencies for the following:

3.2.5.1 Total Phosphorus (TP) Removal - Median TP removal efficiency of at least 49%.

3.2.5.2 Total Nitrogen (TN) Removal - Median TN removal efficiency of at least 39%.

3.2.5.3 Total Zinc (Zn) Removal - Median Zn removal efficiency of at least 69%.

3.2.5.4 Total Copper (Cu) Removal - Median Cu removal efficiency of at least 91%.

END OF SECTION