S. LLEWELLYN & ASSOCIATES LIMITED
CONSULTING ENGINEERS

Functional Servicing Report

299-307 JOHN STREET
& 97 ST. JOSEPH'S DRIVE

CITY OF HAMILTON

SPALLACCI & SONS LTD.

DECEMBER 2019
REVISED DECEMBER 2020

SLA File # 17080

3228 South Service Road, Suite 105, East Wing Burlington, Ontario L7N 3H8
Tel. (905) 631-6978 Fax (905) 631-8927

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1.0 INTRODUCTION AND BACKGROUND

1.1 OVERVIEW

S. Llewellyn & Associates Limited has been retained by Spallacci & Sons Ltd. to provide consulting engineering services for the proposed development at 299-307 John Street & 97 St. Joseph's Drive in the City of Hamilton (see Figure 1.0 for location plan). This report will outline the functional servicing strategy for the proposed development.

The proposed development consists of constructing 3 condominium towers connected by a lower podium. The proposed building will consist of a 3 to 4-storey podium, and towers consisting of 22-storeys, 24-storeys and 25-storeys with 773 residential units and commercial space. The proposed site will also include an underground parking structure, roof top amenity areas along with an asphalt parking lot and landscaped areas.

This Functional Servicing Report will provide detailed information of the proposed servicing scheme for this development. Please refer to the preliminary site engineering plans prepared by S. Llewellyn and Associates Limited and the site plan prepared by SRN Architects Inc. for additional information.

1.2 BACKGROUND INFORMATION

The following documents were referenced in the preparation of this report:

Ref. 1: MOE Stormwater Management Practices Planning and Design Manual (Ministry of Environment, March 2003)

Ref. 2: Engineering Guidelines for Servicing Land under Development Applications (City of Hamilton, December 2012)

Ref. 3: City of Hamilton Criteria and Guidelines for Stormwater Management Infrastructure (September 2007)

Ref. 4: City of Hamilton Storm Drainage Policy (2004)

Ref. 5: Erosion & Sediment Control Guidelines for Urban Construction (December 2006)

Figure 1.0 – Location Plan

2.0 STORMWATER MANAGEMENT

The following stormwater management (SWM) criteria will be applied to the site, in accordance with the criteria stated in the City of Hamilton's memorandum dated May 05, 2017:

Quantity Control

The stormwater discharge rate from the proposed site shall be controlled to the 2-year pre-development condition discharge rate for all storm events up to and including the 100-year event.

Quality Control

The stormwater runoff from the proposed condition site must meet Level 1 (Enhanced) stormwater quality control (80% TSS removal, 90% average annual runoff treatment).

Erosion Control

Erosion and sediment control measures will be implemented in accordance with the standards of the City of Hamilton.

2.1 EXISTING CONDITIONS

In the existing condition, the site consists of a 5-storey building and an asphalt and gravel parking lot. The site is bound by Charlton Avenue East to the north, parklands to the east, John Street South to the west, and St. Joseph's Drive to the south. An existing 750mmø storm sewer is located along John Street South and a 525mmø storm sewer is located along St. Joseph's Drive.

Two catchment areas, Catchments 101 and 102 have been identified in the existing condition. Catchment 101 represents the drainage area for the portion of the site which is captured on the roof and parking areas by existing catchbasins and discharged to the existing storm sewer along John Street South. Catchment 102 represents the drainage for the portion of the site which is captured within the existing parking lot and discharged to the existing combined sewer along Charlton Avenue East. See Table 2.1 below and the Existing Condition Drainage Area Plan in Appendix A for details.

Table 2.1 – Existing Conditions Catchment Areas

Catchment ID	Description	Area (ha)	Percent Impervious	Run-off Coefficient
101	To John Street North	0.48	63	0.66
102	To Charlton Avenue East	0.38	79	0.75

An analysis was performed on Catchment 101 using the SWMHYMO hydrologic modeling program developed by J.F. Sabourin & Associates for the 2-year to 100-year City of Hamilton Mount Hope design storms. A summary of the results can be found in the Table 2.2 and detailed SWMHYMO input/output information can be found in Appendix B.

Table 2.2 – Existing Condition Site Discharge

Storm Event	Catchment 101 Discharge (m^3/s)	Catchment 102 Discharge (m^3/s)
2-Yr Event	0.063	0.062
5-Yr Event	0.092	0.088
10-Yr Event	0.113	0.107
25-Yr Event	0.141	0.130
50-Yr Event	0.163	0.148
100-Yr Event	0.186	0.166

2.2 PROPOSED CONDITIONS

It is proposed to develop the site by constructing 3 condominium towers with an underground parking structure and roof top amenity areas. The proposed site will contain associated asphalt driveway/parking lot, concrete curb/sidewalk and landscaped areas. It is proposed to service the site with a private storm sewer system designed and constructed in accordance with the standards and specifications of the City of Hamilton.

Two catchment areas, Catchment 201 and 202, have been identified in the proposed condition. Catchment 201 represents the drainage area that is captured by area drains from the roof and surface parking/landscaped areas, which will outlet via the proposed 250mmø private storm sewer and discharge to the existing 525mmø storm sewer along St. Joseph's Drive. Catchment 202 represents the drainage area that will remain uncontrolled to the right-of-way surrounding the building. See Table 2.3 below and the Proposed Condition Drainage Area Plan in Appendix A for details.

Table 2.3 – Proposed Condition Catchment Areas

Catchment ID	Description	Area (ha)	Percent Impervious	Run-off Coefficient
201	Controlled to St. Joseph's Drive	0.74	87%	0.82
202	Uncontrolled to Right-of-Way	0.12	7%	0.30

Water Quantity Control
It is proposed to apply quantity control measures to the runoff from Catchment 201 by means of a 105mmø orifice plate at the west invert of MH1 to restrict discharge from the site to the 2-year pre-development flow rate. See the Preliminary Grading & Servicing Plan for orifice location.

With the installation of on-site quantity control measures for Catchment 201, it will be required to provide stormwater storage during storm events up to and including the 100-year event. To provide the required storage, it is proposed to install a stormwater storage vault within the parking structure. Other stormwater storage options could include rooftop storage, this will be finalized at the detail design stage.

Preliminary details of the proposed storage vault can be found in the Preliminary Grading & Servicing Plan. The stage-storage-discharge characteristics can be seen in Table 2.4 below and Appendix A for details.

Table 2.4 – Proposed Condition Stage-Storage-Discharge (Catchment 201)

Elevation (m)	Storage (m^3)	Discharge (m^3/s)
119.25 (Bottom of Tank)	0	0.0075
119.75 (0.5m Depth)	53	0.0179
120.25 (1.0m Depth)	105	0.0242
120.75 (1.5m Depth)	158	0.0292
121.25 (2.0m Depth)	210	0.0334
121.75 (2.5m Depth)	263	0.0372
122.25 (3.0m Depth)	315	0.0406
122.75 (Top of Tank)	368	0.0437

An analysis was performed on the Proposed Condition site using the SWMHYMO hydrologic modeling program to determine the required volume of stormwater storage required during the 2-year to 100-year City of Hamilton Mount Hope design storms. A summary of the results can be found in Table 2.5 and detailed SWMHYMO input/output information can be found in Appendix B.

Table 2.5 – Proposed Condition Stormwater Discharge					
Storm Event	Catchment 201 Controlled Discharge (m^3/s)	Catchment 202 Uncontrolled Discharge (m^3/s)	Total Discharge (m^3/s)	Allowable Discharge* (m^3/s)	Required Storage (m^3)
2-Yr	0.024	0.002	0.026	0.063	101.4
5-Yr	0.030	0.006	0.035	0.063	163.4
10-Yr	0.033	0.009	0.040	0.063	207.2
25-Yr	0.037	0.014	0.048	0.063	265.5
50-Yr	0.040	0.017	0.054	0.063	306.7
100-Yr	0.043	0.021	0.060	0.063	353.7

*Allowable Discharge = 2-year existing conditions discharge rate from Catchment 101

This analysis determined the following:

- The proposed condition discharge rates will not exceed the existing condition 2-year discharge rate during the 2-year to 100-year design storms, with the installation of an orifice plate at the west invert of MH1.

- 353.7m^3 of stormwater storage is required during the 100-year event, which can be accommodated by the proposed storage vault, having a volume of 368m^3.

Water Quality Control
The proposed development is required to achieve an "Enhanced" (80% TSS removal) level of water quality protection. To achieve this criteria, discharge from the asphalt parking lot in Catchment 201 will be subject to treatment from a HydroStorm oil/grit separator before ultimately discharging to the existing 525mmø storm sewer along St. Joseph's Drive. The HydroStorm sizing software was used to determine the required size of oil/grit separator unit using the ETV particle size for the site. It was determined that a HydroStorm HS10 will provide 84% TSS removal and 97% average annual runoff treatment, which satisfies the requirements for an "Enhanced" level for quality control. See HydroStorm unit sizing procedures in Appendix C for details.

2.3 SEDIMENT AND EROSION CONTROL
In order to minimize erosion during the grading and site servicing period of construction, the following measures will be implemented:

- Install silt fencing along the outer boundary of the site to ensure that sediment does not migrate to the adjacent properties;

- Install sediment control (silt sacks) in the proposed catchbasins as well as the nearby existing catchbasins to ensure that no untreated runoff enters the existing conveyance system

- Stabilize all disturbed or landscaped areas with hydro seeding/sodding to minimize the opportunity for erosion.

To ensure and document the effectiveness of the erosion and sediment control structures, an appropriate inspection and maintenance program is necessary.
The program will include the following activities:

- Inspection of the erosion and sediment controls (e.g. silt fences, sediment traps, outlets, vegetation, etc.) with follow up reports to the governing municipality; and

- The developer and/or his contractor shall be responsible for any costs incurred during the remediation of problem areas.

Details of the proposed erosion & sediment control measures will be provided on the Erosion and Sediment Control Plans, which will be provided upon detailed design for Site Plan Approval.

3.0 SANITARY SEWER SERVICING

3.1 EXISTING CONDITIONS

The site is located on John Street, between Charlton Avenue East and St. Joseph's Drive with a 300mmø combined sewer located along Charlton Avenue East, a 375mmø combined sewer located along John Street South and a 450mmø combined sewer located along St. Joseph's Drive.

3.2 SANITARY DEMAND

The proposed development consists of constructing 3 condominium towers containing approximately 773 residential units and commercial space. Wastewater generation for the site was calculated based on section E.1.4 – Design Flows of the City of Hamilton's Development Engineering Guidelines.

Table 3.1 summarizes the sanitary sewer discharge rates from the proposed site. Sanitary discharge calculations will be confirmed upon completion of the Wastewater Generation Assessment, which will be prepared as part of the Site Plan Approval process.

Table 3.1 – Proposed Sanitary Sewer Discharge

Population [A]	Avg. Dry weather flows (l/s) [B]	Peaking Factor [c]	Infiltration [D] (l/s)	**Peak Flow [F] (l/s)**
1932.5 persons	8.05	4.38	0.34	**35.6**

[A] Population = 2.5 persons/unit = 2.5 persons x 773 units = 1932.5 persons
[B] Average Dry Weather Flows = 360 L/Day/cap x 1932.5 persons = 695,700 L/day
[C] Peak Factor ($2 < \text{Peak Factor} < 5$) = $(5/(\text{Population in thousands})^{0.2}) = (5/(1.9325)^{0.2}) = 4.38$
[E] Infiltration flow based on city of Hamilton Standard 0.4 l/sec/ha = 0.4 l/sec x 0.86 ha = 0.344
[F] Peak Flow = (Average Flow x Peaking Factor) + Infiltration

3.3 PROPOSED SANITARY SERVICING AND CAPACITY ANALYSIS

The proposed condominium building will be serviced by a 200mmø sanitary sewer, designed and constructed in accordance with City of Hamilton standards. Drainage from this sewer will discharge to the existing 375mmø combined sewer adjacent to the site along John Street South.

The minimum grade of the proposed 200mmø sanitary sewer will be 1.0%. At this minimum grade, the proposed sanitary sewer will have a capacity of 0.059 m^3/s (59 l/s). Therefore, the proposed 200mmø sanitary sewer at 1.0% grade is adequately sized to service the proposed development.

4.0 DOMESTIC AND FIRE WATER SUPPLY SERVICING

4.1 EXISTING CONDITIONS

The existing municipal water distribution system consists of a 150mmø watermain located along St. Joseph's Drive, a 200mmø watermain on John Street South and a 300mmø watermain along Charlton Avenue East. Existing fire hydrants are located on Charlton Avenue East, John Street South and St. Joseph's Drive, all within close proximity of the subject lands.

4.2 DOMESTIC WATER DEMAND

The following is an estimate of the water usage for the existing building. Water usage for the site was calculated based on the "Fixture Unit Method" as per Table 7.6.3.2.A. forming part of sentences 7.6.3.1(1) to (3) and 7.6.3.4.(2), (3) and (5) of the 2012 Ontario Building Code. See Table 4.1 for fixture unit (FU) calculations.

Table 4.1 – Proposed Domestic Water Demand Fixture Unit Calculations Residential Units

Component	No. of Fixtures/Unit	FU/ Fixture	No. of Units	Total FU
Lavatory (8.3L/min or less per head) (Private)*	1 2	0.7	500 273	350 382.2
Shower Head (9.5L/min or less per head) (Private)*	1 2	1.4	500 273	700 764.4
Water Closet (6 LPF or less with flush tank) (Private)*	1 2	2.2	500 273	1100 1201.2
Sink (kitchen, domestic, 8.3 L/min or less)*	1	1.4	773	1082.2
Dishwasher (domestic)*	1	1.4	773	1082.2
Clothes Washer (3.5 kg)*	1	1.4	773	1082.2
			Total FU:	**7744.4**

Commercial Units				
Component	No. of Fixtures/Unit	FU/ Fixture	No. of Units	Total FU
Lavatory (8.3L/min or less per head) (Public)*	3	2.0	7	42.0
Water Closet (6 LPF or less with flush tank) (Public)*	3	2.2	7	46.2
Sink (kitchen, commercial) (Public)*	1	4.0	3	12.0
			Total FU:	**100.2**

*Number of fixtures are assumed and will be confirmed during the site plan approval process.

7,744.4 + 100.2 = 7844.6 FU = 740 IGPM (56.1 L/s)

4.3 FIRE FLOW DEMAND

Fire flow demands for development are governed by a number of guidelines and criteria, such as the Ontario Building Code (OBC), various codes and standards published by the National Fire Protection Association (NFPA) and most recently, the Target Available Fire Flows provided by the City of Hamilton.

The proposed development consists of constructing 3 condominium towers connected by a lower podium. The proposed building will consist of a 3 to 4-storey podium, and towers consisting of 22-storeys, 24-storeys and 25-storeys, containing residential and commercial units. Existing hydrants are located along John Street South, St. Joseph's Drive and Charlton Avenue East.

The fire flow for this building was determined to be the greater of the OBC fire flow calculation (OBC section A-3.2.5.7) or the City of Hamilton Target Available Fire Flow. Since the OBC fire flow calculation has a maximum value of 150 l/sec the City of Hamilton Target Available Fire Flow for Residential Multi (greater than 3 units) will be used. Therefore, the required fire flow for this site is **150 l/sec.**

The following hydrant flow test for the public fire hydrants in closest proximity to the proposed development have been analyzed to determine if the municipal system adjacent to the subject site is adequate to provide the required fire flow, with a minimum pressure of 20 psi. Table 4.2 below summarized the hydrant flow test, provided by the City of Hamilton's Hansen System.

Table 4.2 - Hydrant Flow Test Data	
Hydrant ID	HA15H048
Location	97 ST. JOSEPH'S DR
Test Date (mm/dd/yyyy)	7/25/2018
Static Pressure	78 psi
Residual Pressure During Test Flow	70 psi
Test Flow Rate	1,060 IGPM (80.3 l/s)
Theoretical Flow @ 20 psi	**3,090 IGPM (234 l/s)**

Hydrant ID	HA15H015
Location	307 JOHN ST S
Test Date (mm/dd/yyyy)	7/25/2018
Static Pressure	44 psi
Residual Pressure During Test Flow	43 psi
Test Flow Rate	1,120 IGPM (84.9 l/s)
Theoretical Flow @ 20 psi	**6,231 IGPM (472 l/s)**
Hydrant ID	HA15H017
Location	CHARLTON AVE E
Test Date (mm/dd/yyyy)	7/24/2018
Static Pressure	98 psi
Residual Pressure During Test Flow	96 psi
Test Flow Rate	1,300 IGPM (98.5 l/s)
Theoretical Flow @ 20 psi	**9,400 IGPM (712 l/s)**

Based on the above hydrant flow test data, the theoretical maximum available flow rate is between **234 to 712 l/s at 20 psi** surrounding the site. Based on the Target Available Fire Flow, the required fire flow is **150 l/s.** Therefore, the water distribution system has adequate pressure and capacity to service the proposed development.

4.4 PROPOSED WATER SERVICING AND ANALYSIS

Proposed water servicing for the site consists of connecting a 200mmø water service off of the existing 300mmø adjacent to the site on Charlton Avenue East. The proposed 200mmø water service will provide domestic and fire water service for the proposed condominium building. Water services for the site are to be designed and constructed in accordance with City of Hamilton standards.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the information provided herein, it is concluded that the proposed development of 299-307 John Street & 97 St. Joseph's Drive can be constructed to meet the requirements of the City of Hamilton. Therefore, it is recommended that:

- The development be graded and serviced in accordance with the Preliminary Grading & Servicing Plan prepared by S.Llewellyn & Associates Limited;

- A 105mmø orifice plate be installed as per the Preliminary Grading & Servicing Plan and this report to provide adequate quantity control;

- An underground storage vault be incorporated into the underground parking structure as per the Preliminary Grading & Servicing Plan to provide stormwater storage;

- A HydroStorm HS10 oil/grit separator be installed as per the Preliminary Grading & Servicing Plan and this report to provide efficient stormwater quality control;

- Erosion and sediment controls be installed as described in this report to meet City of Hamilton requirements;

- The proposed sanitary and water servicing system be installed as per this report to adequately service the proposed development;

We trust the information enclosed herein is satisfactory. Should you have any questions please do not hesitate to contact our office.

Prepared by:
S. LLEWELLYN & ASSOCIATES LIMITED

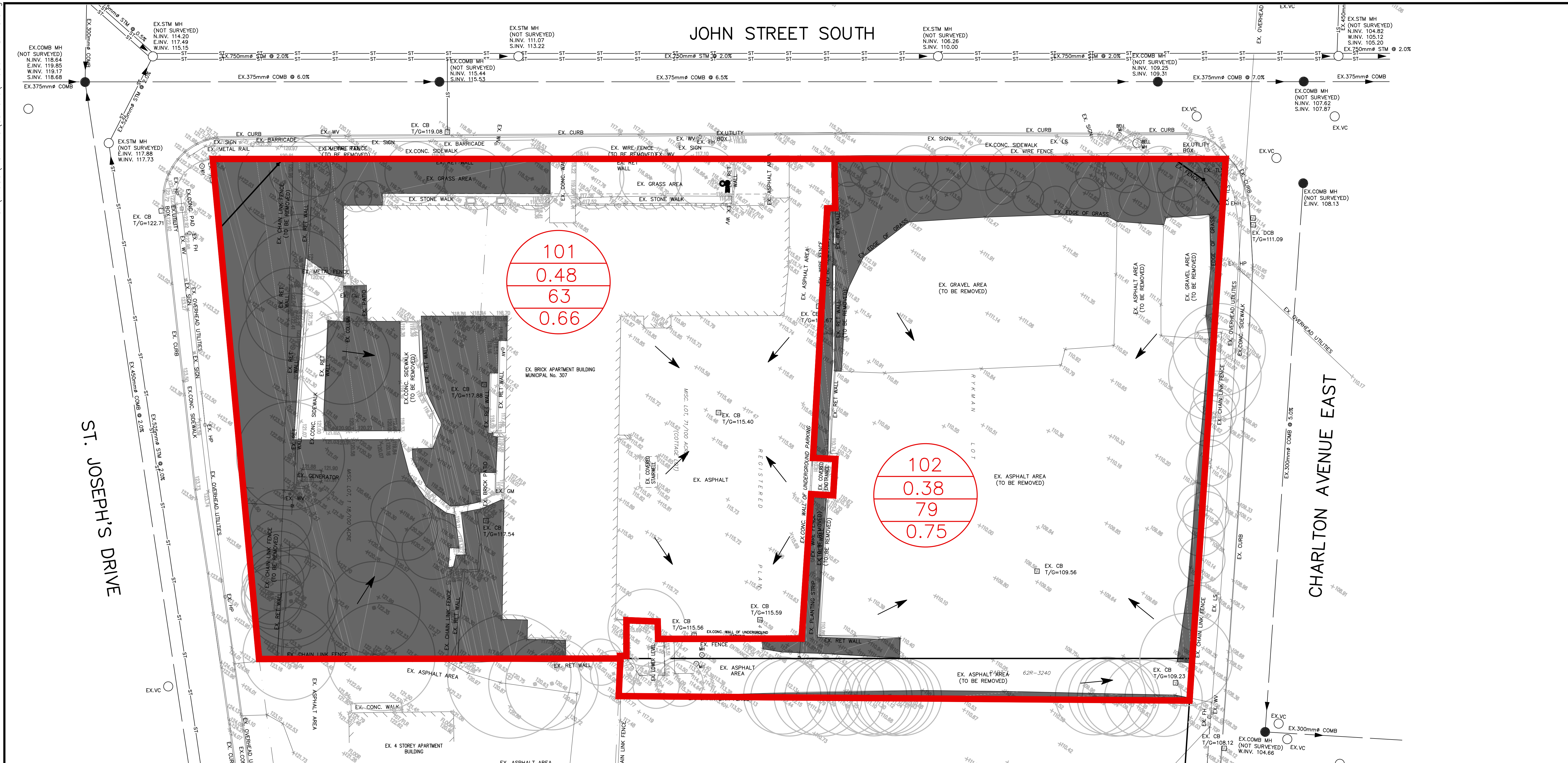
LICENSED PROFESSIONAL ENGINEER
S.V. FRANKOVICH
08/12/2020
PROVINCE OF ONTARIO

Michael

M. Colosimo, Dipl. T. S. Frankovich, P.Eng.

APPENDIX A

STORMWATER MANAGEMENT INFORMATION



LEGEND

PERVIOUS AREA

DIRECTION OF SHEET FLOW

101	DRAINAGE AREA I.D.
0.39	DRAINAGE AREA (ha)
11	PERCENT IMPERVIOUS
0.32	RUNOFF COEFFICENT

FIGURE 1.0
PRE–DEVELOPMENT STORM DRAINAGE AREA PLAN

SCALE: 1:500

PROJECT: 299–307 JOHN ST & 97 ST. JOSEPH'S DR
PROJECT No.: 17080

S. LLEWELLYN & ASSOCIATES LIMITED
CONSULTING ENGINEERS

Tel. (905) 631–6978
Fax (905) 631–8927
email: info@sla.on.ca

3228 South Service Road, Suite #105 East Wing, Burlington, Ont., L7N 3H8

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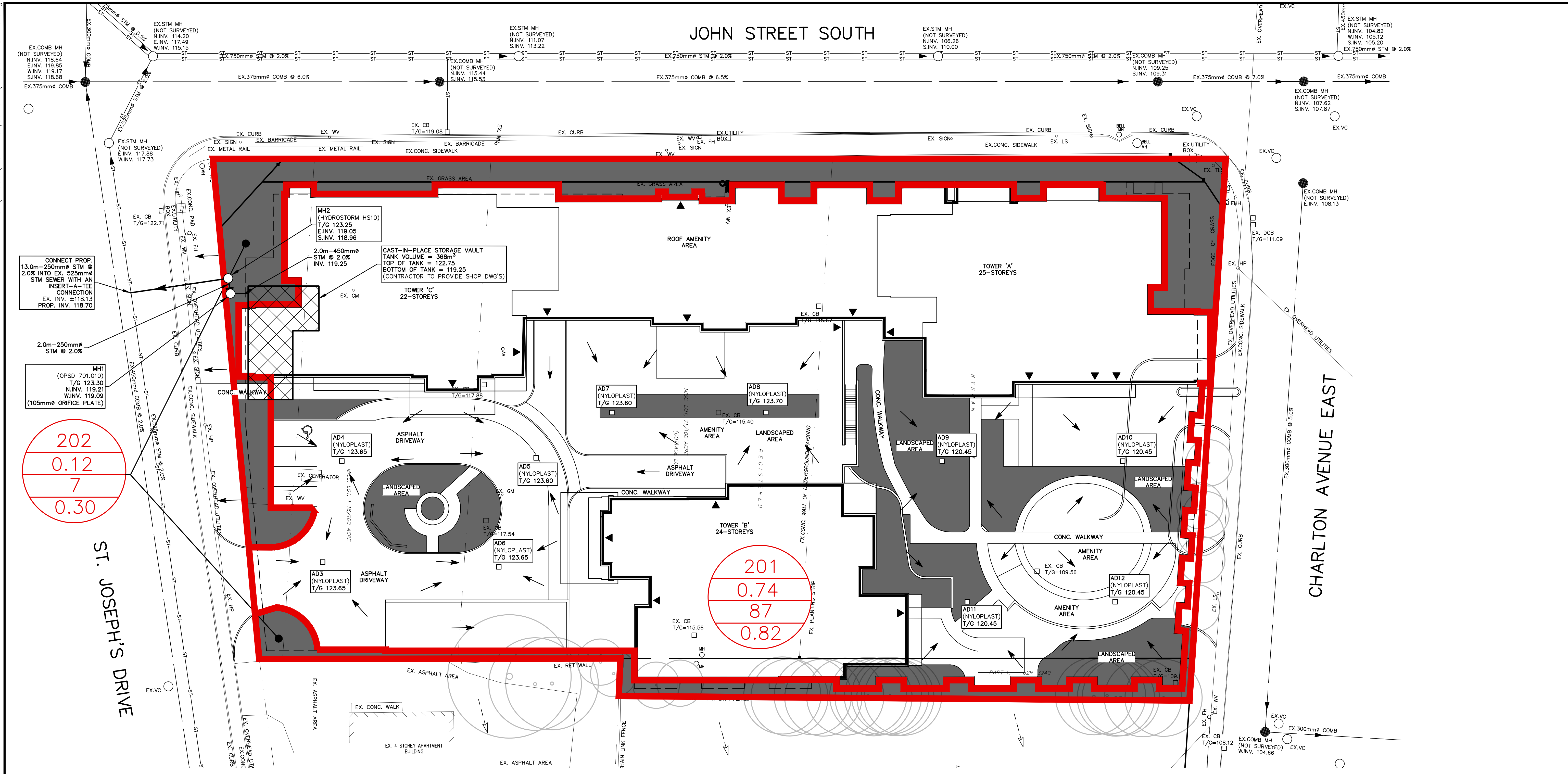

LEGEND

PERVIOUS AREA

DIRECTION OF SHEET FLOW

202
0.39
11
0.32

DRAINAGE AREA I.D.
DRAINAGE AREA (ha)
PERCENT IMPERVIOUS
RUNOFF COEFFICENT

FIGURE 2.0
POST-DEVELOPMENT STORM DRAINAGE AREA PLAN

SCALE: 1:500

PROJECT: 299-307 JOHN ST & 97 ST. JOSEPH'S DR
PROJECT No.: 17080

S. LLEWELLYN & ASSOCIATES LIMITED
CONSULTING ENGINEERS
Tel. (905) 631-6978
Fax (905) 631-8927
email: info@sla.on.ca
3228 South Service Road, Suite #105 East Wing, Burlington, Ont., L7N 3H8

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299-307 John Street 97 St. Joseph's Drive
Hamilton, Ontario

S. LLEWELLYN & ASSOCIATES LIMITED
CONSULTING ENGINEERS

STAGE-STORAGE-DISCHARGE CALCULATIONS

Outlet Device No. 1 (Quantity)

Type:	Orifice Plate
Diameter (mm)	105
Area (m^2)	0.00866
Invert Elev. (m)	119.09
C/L Elev. (m)	119.14
Disch. Coeff. (C_d)	0.6
Discharge (Q) =	C_d A (2 g H)$^{0.5}$
Number of Orifices:	1

		SWM Pond Volumes					Outlet No. 1	
	Elevation m	Area m^2	Incremental Volume m^3	Cumulative Volume m^3	**Total Active Storage Volume m^3**	H m	Discharge m^3/s	**Total Discharge m^3/s**
Orifice Invert	119.09				**0**	0.000	0.0000	**0.0000**
Bottom of Tank	119.25	105	0	0	**0**	0.108	0.0075	**0.0075**
0.5m Depth	119.75	105	53	53	**53**	0.608	0.0179	**0.0179**
1.0m Depth	120.25	105	53	105	**105**	1.108	0.0242	**0.0242**
1.5m Depth	120.75	105	53	158	**158**	1.608	0.0292	**0.0292**
2.0m Depth	121.25	105	53	210	**210**	2.108	0.0334	**0.0334**
2.5m Depth	121.75	105	53	263	**263**	2.608	0.0372	**0.0372**
3.0m Depth	122.25	105	53	315	**315**	3.108	0.0406	**0.0406**
Top of Tank	122.75	105	53	368	**368**	3.608	0.0437	**0.0437**

APPENDIX B

SWMHYMO INPUT/OUTPUT INFORMATION

```
2     Metric units
*#*****************************************************************************|
*#  Project Name: 299-307 JOHN STREET & 97 ST. JOSEPH'S DRIVE
*#                HAMILTON, ONTARIO
*#  JOB NUMBER  : 17080
*#       Date   : December 2017
*#    Revised   : July 2019
*#    Company   : S. LLEWELLYN AND ASSOCIATES LTD.
*#       File   : 17080.DAT
*#*****************************************************************************|
*
START                TZERO=[0.0],  METOUT=[2],  NSTORM=[1],  NRUN=[002]
                     MTH4002.stm
*
READ STORM           STORM_FILENAME "STORM.001"
*
*#******************************************************************************|
*#
*#         PRE-DEVELOPMENT CONDITIONS HYDROLOGIC MODELING
*#         ===============================================
*#
**#*****************************************************************************|
*# CATCHMENT 101 - EXISTING CONDITION (OUTLETS TO JOHN STREET SOUTH)
*
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                                          LGP=[15](m), MNP=[0.25], SCP=[0](min),
                     Impervious surfaces: IAimp=[1](mm), SLPI=[2.0](%),
                                          LGI=[25](m), MNI=[0.015], SCI=[0](min),
                     RAINFALL=[ ,  ,  ,  , ](mm/hr) ,  END=-1
*%-----------------|-------------------------------------------------------------|
*# CATCHMENT 102 - EXISTING CONDITION (OUTLETS TO CHARLTON AVENUE EAST)
*
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                     XIMP=[0.79], TIMP=[0.79], DWF=[0](cms), LOSS=[2],
                     SCS curve number CN=[75],
                     Pervious   surfaces: IAper=[8.47](mm), SLPP=[3.0](%),
                                          LGP=[15](m), MNP=[0.25], SCP=[0](min),
                     Impervious surfaces: IAimp=[1](mm), SLPI=[2.8](%),
                                          LGI=[25](m), MNI=[0.015], SCI=[0](min),
                     RAINFALL=[ ,  ,  ,  , ](mm/hr) ,  END=-1
*#******************************************************************************|
*#
*#         POST-DEVELOPMENT CONDITIONS HYDROLOGIC MODELING
*#         ===============================================
*#
**#*****************************************************************************|
*# CATCHMENT 201 - PROPOSED CONDITION (CONTROLLED TO JOHN STREET SOUTH)
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CALIB STANDHYD       ID=[1], NHYD=["201"], DT=[1](min), AREA=[0.74](ha),
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                                          LGP=[12](m), MNP=[0.250], SCP=[0](min),
                     Impervious surfaces: IAimp=[1.0](mm), SLPI=[1.7](%),
                                          LGI=[15](m), MNI=[0.013], SCI=[0](min),
                     RAINFALL=[ ,  ,  ,  , ](mm/hr) ,  END=-1
*%-----------------|-------------------------------------------------------------|
*# ROUTE CATCHMENT 201 - THROUGH ORIFICE
*
```

```
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                    RDT=[    ](min),
                          TABLE of ( OUTFLOW-STORAGE ) values
                                      (cms) - (ha-m)
                                       0.0    , 0.0
                                       0.0075 , 0.0000
                                       0.0179 , 0.0053
                                       0.0242 , 0.0105
                                       0.0292 , 0.0158
                                       0.0334 , 0.0210
                                       0.0372 , 0.0263
                                       0.0406 , 0.0315
                                       0.0437 , 0.0368
                                       -1  ,  -1    (max twenty pts)
                          IDovf=[3], NHYDovf=["OVF"]
*%-----------------|-----------------------------------------------------------|
*# CATCHMENT 203 - PROPOSED CONDITION (UNCONTROLLED TO ROW)
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                    DWF=[0](cms),  CN/C=[75], IA=[8.47](mm),
                    N=[3], TP=[0.1]hrs,
                    RAINFALL=[ ,  ,  ,  , ](mm/hr),  END=-1
*%-----------------|-----------------------------------------------------------|
ADD HYD             IDsum=[5], NHYD=["201+202"], IDs to add=[2, 3, 4]
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* RUN REMAINING DESIGN STORMS (HAMILTON MOUNT HOPE 5 TO 100-YR)
*
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*
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*
START               TZERO=[0.0],  METOUT=[2],  NSTORM=[1],  NRUN=[025]
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*
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                    MTH4050.stm
*
START               TZERO=[0.0],  METOUT=[2],  NSTORM=[1],  NRUN=[100]
                    MTH4100.stm
*
*%-----------------|-----------------------------------------------------------|
FINISH
```

```
==========================================================================

   SSSSS  W   W  M   M  H   H  Y   Y  M   M   OOO       999    999    =========
   S      W W W  MM MM  H   H   Y Y   MM MM  O   O     9   9  9   9
   SSSSS  W W W  M M M  HHHHH    Y    M M M  O   O  ##  9   9  9   9   Ver  4.05
       S   W W   M   M  H   H    Y    M   M  O   O      9999   9999   Sept 2011
   SSSSS   W W   M   M  H   H    Y    M   M   OOO          9      9   =========
                                                        9   9  9   9   # 3902680
        StormWater Management HYdrologic Model          999    999    =========

 ******************************************************************************
 ***************************** SWMHYMO Ver/4.05 *****************************
 *********  A single event and continuous hydrologic simulation model  *********
 *********     based on the principles of HYMO and its successors      *********
 *********                 OTTHYMO-83 and OTTHYMO-89.                  *********
 ******************************************************************************
 ********* Distributed by:  J.F. Sabourin and Associates Inc.          *********
 *********                  Ottawa,  Ontario: (613) 836-3884           *********
 *********                  Gatineau, Quebec: (819) 243-6858           *********
 *********                  E-Mail: swmhymo@jfsa.Com                    *********
 ******************************************************************************

 ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
 +++++++++ Licensed user: S. Llewellyn & Associates Ltd               +++++++++
 +++++++++                Burlington            SERIAL#:3902680       +++++++++
 ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

 ******************************************************************************
 *********            ++++++ PROGRAM ARRAY DIMENSIONS ++++++           *********
 *********            Maximum value for ID numbers  :      10          *********
 *********            Max. number of rainfall points: 105408           *********
 *********            Max. number of flow points    : 105408           *********
 ******************************************************************************


 **********************   D E T A I L E D   O U T P U T   *********************
 ******************************************************************************
 *        DATE: 2019-12-16     TIME: 17:21:51     RUN COUNTER: 001346         *
 ******************************************************************************
 * Input   filename: T:\PROJECTS\17080\FSR\SWMHYMO\17080.dat                  *
 * Output  filename: T:\PROJECTS\17080\FSR\SWMHYMO\17080.out                  *
 * Summary filename: T:\PROJECTS\17080\FSR\SWMHYMO\17080.sum                  *
 * User comments:                                                             *
 * 1:_________________________________________________________________________*
 * 2:_________________________________________________________________________*
 * 3:_________________________________________________________________________*
 ******************************************************************************

--------------------------------------------------------------------------------
001:0001------------------------------------------------------------------------
*#****************************************************************************|
*#  Project Name: 299-307 JOHN STREET & 97 ST. JOSEPH'S DRIVE
*#                HAMILTON, ONTARIO
*#  JOB NUMBER  : 17080
*#       Date   : December 2017
*#    Revised   : July 2019
*#    Company   : S. LLEWELLYN AND ASSOCIATES LTD.
*#       File   : 17080.DAT
*#****************************************************************************|
*
  ** END OF RUN :    1

*******************************************************************************




--------------------
| START            |  Project  dir.: T:\PROJECTS\17080\FSR\SWMHYMO\
--------------------  Rainfall dir.: T:\PROJECTS\17080\FSR\SWMHYMO\
    TZERO =   .00 hrs on        0
    METOUT=   2 (output = METRIC)
    NRUN  = 002
    NSTORM=   1
          #  1=MTH4002.stm
--------------------------------------------------------------------------------
002:0002------------------------------------------------------------------------
*#****************************************************************************|
*#  Project Name: 299-307 JOHN STREET & 97 ST. JOSEPH'S DRIVE
*#                HAMILTON, ONTARIO
*#  JOB NUMBER  : 17080
*#       Date   : December 2017
*#    Revised   : July 2019
*#    Company   : S. LLEWELLYN AND ASSOCIATES LTD.
*#       File   : 17080.DAT
*#****************************************************************************|
*
--------------------------------------------------------------------------------
002:0002------------------------------------------------------------------------
*
--------------------
| READ STORM       |    Filename: 2-YR MT. HOPE (A=646 B=6 C=0.781)
| Ptotal=  35.06 mm|    Comments: 2-YR MT. HOPE (A=646 B=6 C=0.781)
--------------------
              TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
               hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
               .17   2.368 |  1.17  18.525 |  2.17   5.648 |  3.17   2.846
               .33   2.712 |  1.33  74.099 |  2.33   4.806 |  3.33   2.644
               .50   3.193 |  1.50  24.316 |  2.50   4.199 |  3.50   2.472
               .67   3.921 |  1.67  12.980 |  2.67   3.739 |  3.67   2.323
               .83   5.164 |  1.83   8.954 |  2.83   3.378 |  3.83   2.193
              1.00   7.836 |  2.00   6.898 |  3.00   3.087 |  4.00   2.078

--------------------------------------------------------------------------------
002:0003------------------------------------------------------------------------
*
*#****************************************************************************|
*#
*#       PRE-DEVELOPMENT CONDITIONS HYDROLOGIC MODELING
*#       ==============================================
*#
**#***************************************************************************|
*# CATCHMENT 101 - EXISTING CONDITION (OUTLETS TO JOHN STREET SOUTH)
*
---------------------
| CALIB STANDHYD     |   Area    (ha)=     .48
| 01:101    DT= 1.00 |   Total Imp(%)=   63.00   Dir. Conn.(%)=   63.00
---------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        .30          .18
     Dep. Storage     (mm)=       1.00         8.47
     Average Slope     (%)=       2.00         3.00
     Length            (m)=      25.00        15.00
     Mannings n          =        .015         .250

     Max.eff.Inten.(mm/hr)=      74.10         9.11
                over (min)       1.00        10.00
     Storage Coeff.  (min)=       1.11 (ii)   10.16 (ii)
     Unit Hyd. Tpeak (min)=       1.00        10.00
     Unit Hyd. peak  (cms)=       1.01          .11
                                                           *TOTALS*
     PEAK FLOW       (cms)=        .06          .00          .063 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.53         1.333
     RUNOFF VOLUME    (mm)=      34.06         6.36        23.811
     TOTAL RAINFALL   (mm)=      35.06        35.06        35.063
     RUNOFF COEFFICIENT   =        .97          .18          .679

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  75.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
002:0004------------------------------------------------------------------------
*# CATCHMENT 102 - EXISTING CONDITION (OUTLETS TO CHARLTON AVENUE EAST)
*
---------------------
| CALIB STANDHYD     |   Area    (ha)=     .38
| 02:102    DT= 1.00 |   Total Imp(%)=   79.00   Dir. Conn.(%)=   79.00
---------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        .30          .08
     Dep. Storage     (mm)=       1.00         8.47
     Average Slope     (%)=       2.80         3.00
     Length            (m)=      25.00        15.00
     Mannings n          =        .015         .250

     Max.eff.Inten.(mm/hr)=      74.10         9.11
                over (min)       1.00        10.00
     Storage Coeff.  (min)=       1.00 (ii)   10.05 (ii)
     Unit Hyd. Tpeak (min)=       1.00        10.00
     Unit Hyd. peak  (cms)=       1.07          .11
                                                           *TOTALS*
     PEAK FLOW       (cms)=        .06          .00          .062 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.52         1.333
     RUNOFF VOLUME    (mm)=      34.06         6.36        28.245
     TOTAL RAINFALL   (mm)=      35.06        35.06        35.063
     RUNOFF COEFFICIENT   =        .97          .18          .806

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  75.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
002:0005------------------------------------------------------------------------
*#****************************************************************************|
*#
*#        POST-DEVELOPMENT CONDITIONS HYDROLOGIC MODELING
*#        ===============================================
*#
**#***************************************************************************|
*# CATCHMENT 201 - PROPOSED CONDITION (CONTROLLED TO JOHN STREET SOUTH)
*
---------------------
| CALIB STANDHYD     |   Area    (ha)=     .74
| 01:201    DT= 1.00 |   Total Imp(%)=   87.00   Dir. Conn.(%)=   87.00
---------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        .64          .10
     Dep. Storage     (mm)=       1.00         8.47
     Average Slope     (%)=       1.70         2.00
     Length            (m)=      15.00        12.00
     Mannings n          =        .013         .250

     Max.eff.Inten.(mm/hr)=      74.10         9.11
                over (min)       1.00        10.00
     Storage Coeff.  (min)=        .79 (ii)    9.72 (ii)
     Unit Hyd. Tpeak (min)=       1.00        10.00
     Unit Hyd. peak  (cms)=       1.22          .12
                                                           *TOTALS*
     PEAK FLOW       (cms)=        .13          .00          .133 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.52         1.333
     RUNOFF VOLUME    (mm)=      34.06         6.36        30.461
     TOTAL RAINFALL   (mm)=      35.06        35.06        35.063
     RUNOFF COEFFICIENT   =        .97          .18          .869

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  75.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
002:0006------------------------------------------------------------------------
*# ROUTE CATCHMENT 201 - THROUGH ORIFICE
*
--------------------
| ROUTE RESERVOIR   |    Requested routing time step =  1.0 min.
|  IN>01:(201   )   |
| OUT<02:(201   )   |    =========  OUTFLOW STORAGE TABLE  =========
--------------------     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
                          (cms)     (ha.m.)   |   (cms)     (ha.m.)
                           .000  .0000E+00    |     .033  .2100E-01
                           .007  .0000E+00    |     .037  .2630E-01
                           .018  .5300E-02    |     .041  .3150E-01
                           .024  .1050E-01    |     .044  .3680E-01
                           .029  .1580E-01    |     .000  .0000E+00

     ROUTING RESULTS            AREA     QPEAK     TPEAK       R.V.
     -------------------        (ha)     (cms)     (hrs)       (mm)
     INFLOW >01: (201   )        .74      .133     1.333     30.461
     OUTFLOW<02: (201   )        .74      .024     1.667     30.474
    OVERFLOW<03: (OVF   )        .00      .000      .000       .000

                   TOTAL NUMBER OF SIMULATED OVERFLOWS  =         0
                   CUMULATIVE TIME OF OVERFLOWS  (hours)=       .00
```

```
                PERCENTAGE OF TIME OVERFLOWING    (%)=      .00


                PEAK   FLOW   REDUCTION [Qout/Qin](%)=   17.865
                TIME SHIFT OF PEAK FLOW         (min)=    20.00
                MAXIMUM  STORAGE   USED       (ha.m.)=.1014E-01

--------------------------------------------------------------------------------
002:0007------------------------------------------------------------------------
*# CATCHMENT 203 - PROPOSED CONDITION (UNCONTROLLED TO ROW)
*
---------------------
| CALIB NASHYD       |   Area    (ha)=     .12   Curve Number   (CN)=75.00
| 04:202    DT= 1.00 |   Ia      (mm)=   8.470   # of Linear Res.(N)= 3.00
---------------------    U.H. Tp(hrs)=    .100

     Unit Hyd Qpeak  (cms)=     .046

     PEAK FLOW      (cms)=     .002 (i)
     TIME TO PEAK   (hrs)=    1.433
     RUNOFF VOLUME    (mm)=    6.354
     TOTAL RAINFALL   (mm)=   35.063
     RUNOFF COEFFICIENT   =     .181

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
002:0008------------------------------------------------------------------------
-----------------------
| ADD HYD (201+202   ) | ID: NHYD         AREA     QPEAK   TPEAK   R.V.    DWF
-----------------------                   (ha)     (cms)   (hrs)   (mm)   (cms)
                         ID1 02:201         .74      .024    1.67  30.47    .000
                        +ID2 03:OVF         .00      .000     .00    .00    .000
                        +ID3 04:202         .12      .002    1.43   6.35    .000
                         ========================================================
                         SUM 05:201+202     .86      .026    1.52  27.11    .000

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
002:0009------------------------------------------------------------------------
**#****************************************************************************|
* RUN REMAINING DESIGN STORMS (HAMILTON MOUNT HOPE 5 TO 100-YR)
*
  ** END OF RUN :    4

*******************************************************************************




--------------------
| START            |  Project  dir.: T:\PROJECTS\17080\FSR\SWMHYMO\
--------------------  Rainfall dir.: T:\PROJECTS\17080\FSR\SWMHYMO\
    TZERO =   .00 hrs on       0
    METOUT=   2 (output = METRIC)
    NRUN  = 005
    NSTORM=   1
           #  1=MTH4005.stm
--------------------------------------------------------------------------------
005:0002------------------------------------------------------------------------
*#*****************************************************************************|
*#  Project Name: 299-307 JOHN STREET & 97 ST. JOSEPH'S DRIVE
*#               HAMILTON, ONTARIO
*#  JOB NUMBER  : 17080
*#       Date   : December 2017
*#    Revised   : July 2019
*#    Company   : S. LLEWELLYN AND ASSOCIATES LTD.
*#       File   : 17080.DAT
*#*****************************************************************************|
*
--------------------------------------------------------------------------------
005:0002------------------------------------------------------------------------
*
--------------------
| READ STORM       |    Filename: 5-YR MT. HOPE (A=1049.5 B=8 C=0.803)
| Ptotal=  50.14 mm|    Comments: 5-YR MT. HOPE (A=1049.5 B=8 C=0.803)
--------------------
              TIME    RAIN |   TIME    RAIN |   TIME    RAIN |   TIME    RAIN
               hrs   mm/hr |    hrs   mm/hr |    hrs   mm/hr |    hrs   mm/hr
               .17   3.196 |   1.17  28.027 |   2.17   8.084 |   3.17   3.885
               .33   3.691 |   1.33 103.038 |   2.33   6.801 |   3.33   3.593
               .50   4.393 |   1.50  36.919 |   2.50   5.885 |   3.50   3.344
               .67   5.470 |   1.67  19.516 |   2.67   5.198 |   3.67   3.130
               .83   7.347 |   1.83  13.211 |   2.83   4.664 |   3.83   2.945
              1.00  11.470 |   2.00  10.009 |   3.00   4.236 |   4.00   2.782

--------------------------------------------------------------------------------
005:0003------------------------------------------------------------------------
*
*#*****************************************************************************|
*#
*#        PRE-DEVELOPMENT CONDITIONS HYDROLOGIC MODELING
*#        ==============================================
*#
**#****************************************************************************|
*# CATCHMENT 101 - EXISTING CONDITION (OUTLETS TO JOHN STREET SOUTH)
*
---------------------
| CALIB STANDHYD     |   Area    (ha)=     .48
| 01:101    DT= 1.00 |   Total Imp(%)=   63.00   Dir. Conn.(%)=   63.00
---------------------
                           IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       .30          .18
     Dep. Storage     (mm)=      1.00         8.47
     Average Slope     (%)=      2.00         3.00
     Length            (m)=     25.00        15.00
     Mannings n          =       .015         .250

     Max.eff.Inten.(mm/hr)=    103.04        25.77
                over (min)      1.00          7.00
     Storage Coeff.  (min)=       .97 (ii)    6.94 (ii)
     Unit Hyd. Tpeak (min)=      1.00         7.00
     Unit Hyd. peak  (cms)=      1.09          .16
                                                           *TOTALS*
     PEAK FLOW      (cms)=       .09          .01            .092 (iii)
     TIME TO PEAK   (hrs)=      1.33         1.42           1.333
     RUNOFF VOLUME    (mm)=     49.14        13.74          36.043
     TOTAL RAINFALL   (mm)=     50.14        50.14          50.139
```

```
     RUNOFF COEFFICIENT   =       .98          .27            .719

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  75.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
005:0004------------------------------------------------------------------------
*# CATCHMENT 102 - EXISTING CONDITION (OUTLETS TO CHARLTON AVENUE EAST)
*
---------------------
| CALIB STANDHYD     |   Area    (ha)=     .38
| 02:102    DT= 1.00 |   Total Imp(%)=   79.00   Dir. Conn.(%)=   79.00
---------------------
                           IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       .30          .08
     Dep. Storage     (mm)=      1.00         8.47
     Average Slope     (%)=      2.80         3.00
     Length            (m)=     25.00        15.00
     Mannings n          =       .015         .250

     Max.eff.Inten.(mm/hr)=    103.04        25.77
                over (min)      1.00          7.00
     Storage Coeff.  (min)=       .88 (ii)    6.85 (ii)
     Unit Hyd. Tpeak (min)=      1.00         7.00
     Unit Hyd. peak  (cms)=      1.15          .16
                                                           *TOTALS*
     PEAK FLOW      (cms)=       .09          .00            .088 (iii)
     TIME TO PEAK   (hrs)=      1.33         1.42           1.333
     RUNOFF VOLUME    (mm)=     49.14        13.74          41.706
     TOTAL RAINFALL   (mm)=     50.14        50.14          50.139
     RUNOFF COEFFICIENT   =       .98          .27            .832

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  75.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
005:0005------------------------------------------------------------------------
*#*****************************************************************************|
*#
*#        POST-DEVELOPMENT CONDITIONS HYDROLOGIC MODELING
*#        ===============================================
*#
**#****************************************************************************|
*# CATCHMENT 201 - PROPOSED CONDITION (CONTROLLED TO JOHN STREET SOUTH)
*
---------------------
| CALIB STANDHYD     |   Area    (ha)=     .74
| 01:201    DT= 1.00 |   Total Imp(%)=   87.00   Dir. Conn.(%)=   87.00
---------------------
                           IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       .64          .10
     Dep. Storage     (mm)=      1.00         8.47
     Average Slope     (%)=      1.70         2.00
     Length            (m)=     15.00        12.00
     Mannings n          =       .013         .250

     Max.eff.Inten.(mm/hr)=    103.04        25.77
                over (min)      1.00          7.00
     Storage Coeff.  (min)=       .69 (ii)    6.58 (ii)
     Unit Hyd. Tpeak (min)=      1.00         7.00
     Unit Hyd. peak  (cms)=      1.30          .17
                                                           *TOTALS*
     PEAK FLOW      (cms)=       .18          .00            .187 (iii)
     TIME TO PEAK   (hrs)=      1.33         1.42           1.333
     RUNOFF VOLUME    (mm)=     49.14        13.74          44.538
     TOTAL RAINFALL   (mm)=     50.14        50.14          50.139
     RUNOFF COEFFICIENT   =       .98          .27            .888

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  75.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
005:0006------------------------------------------------------------------------
*# ROUTE CATCHMENT 201 - THROUGH ORIFICE
*
--------------------
| ROUTE RESERVOIR   |    Requested routing time step =  1.0 min.
|  IN>01:(201   )   |
| OUT<02:(201   )   |    ========  OUTFLOW STORAGE TABLE  ========
--------------------     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
                          (cms)     (ha.m.)   |   (cms)     (ha.m.)
                            .000  .0000E+00   |     .033  .2100E-01
                            .007  .0000E+00   |     .037  .2630E-01
                            .018  .5300E-02   |     .041  .3150E-01
                            .024  .1050E-01   |     .044  .3680E-01
                            .029  .1580E-01   |     .000  .0000E+00

     ROUTING RESULTS           AREA     QPEAK     TPEAK       R.V.
     --------------------      (ha)     (cms)     (hrs)       (mm)
     INFLOW >01: (201   )       .74      .187     1.333     44.538
       OUTFLOW<02: (201   )     .74      .030     1.683     44.557
    OVERFLOW<03: (OVF   )       .00      .000      .000       .000

                   TOTAL NUMBER OF SIMULATED OVERFLOWS  =         0
                   CUMULATIVE TIME OF OVERFLOWS  (hours)=       .00
                   PERCENTAGE OF TIME OVERFLOWING    (%)=       .00


                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=   15.813
                   TIME SHIFT OF PEAK FLOW         (min)=    21.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=.1634E-01

--------------------------------------------------------------------------------
005:0007------------------------------------------------------------------------
*# CATCHMENT 203 - PROPOSED CONDITION (UNCONTROLLED TO ROW)
*
---------------------
| CALIB NASHYD       |   Area    (ha)=     .12   Curve Number   (CN)=75.00
| 04:202    DT= 1.00 |   Ia      (mm)=   8.470   # of Linear Res.(N)= 3.00
---------------------    U.H. Tp(hrs)=    .100
```

```
     Unit Hyd Qpeak  (cms)=     .046

     PEAK FLOW       (cms)=     .006 (i)
     TIME TO PEAK    (hrs)=    1.417
     RUNOFF VOLUME    (mm)=   13.742
     TOTAL RAINFALL   (mm)=   50.139
     RUNOFF COEFFICIENT   =     .274

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
005:0008------------------------------------------------------------------------
------------------------
| ADD HYD (201+202   ) | ID: NHYD         AREA     QPEAK   TPEAK   R.V.    DWF
------------------------                   (ha)     (cms)   (hrs)   (mm)   (cms)
                     ID1 02:201            .74      .030    1.68  44.56    .000
                    +ID2 03:OVF            .00      .000     .00    .00    .000
                    +ID3 04:202            .12      .006    1.42  13.74    .000
                     ===========================================================
                     SUM 05:201+202        .86      .035    1.52  40.26    .000

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
005:0009------------------------------------------------------------------------
**#*************************************************************************|
* RUN REMAINING DESIGN STORMS (HAMILTON MOUNT HOPE 5 TO 100-YR)
*
--------------------------------------------------------------------------------
005:0002------------------------------------------------------------------------
*
  ** END OF RUN :   9

*******************************************************************************




--------------------
| START           |  Project  dir.: T:\PROJECTS\17080\FSR\SWMHYMO\
--------------------  Rainfall dir.: T:\PROJECTS\17080\FSR\SWMHYMO\
    TZERO =   .00 hrs on       0
    METOUT=   2 (output = METRIC)
    NRUN  = 010
    NSTORM=   1
           #  1=MTH4010.stm
--------------------------------------------------------------------------------
010:0002------------------------------------------------------------------------
*#*************************************************************************|
*#  Project Name: 299-307 JOHN STREET & 97 ST. JOSEPH'S DRIVE
*#               HAMILTON, ONTARIO
*#  JOB NUMBER  : 17080
*#       Date   : December 2017
*#    Revised   : July 2019
*#    Company   : S. LLEWELLYN AND ASSOCIATES LTD.
*#       File   : 17080.DAT
*#*************************************************************************|
*
--------------------------------------------------------------------------------
010:0002------------------------------------------------------------------------
*
--------------------
| READ STORM       |    Filename: 10-YR MT. HOPE (A=1343.7 B=9 C=0.814)
| Ptotal=  60.22 mm|    Comments: 10-YR MT. HOPE (A=1343.7 B=9 C=0.814)
--------------------
              TIME    RAIN |   TIME    RAIN |   TIME    RAIN |   TIME    RAIN
               hrs   mm/hr |    hrs   mm/hr |    hrs   mm/hr |    hrs   mm/hr
               .17   3.725 |   1.17  34.487 |   2.17   9.714 |   3.17   4.557
               .33   4.322 |   1.33 122.292 |   2.33   8.126 |   3.33   4.203
               .50   5.173 |   1.50  45.465 |   2.50   6.998 |   3.50   3.903
               .67   6.489 |   1.67  23.981 |   2.67   6.156 |   3.67   3.646
               .83   8.802 |   1.83  16.104 |   2.83   5.503 |   3.83   3.423
              1.00  13.931 |   2.00  12.108 |   3.00   4.982 |   4.00   3.228

--------------------------------------------------------------------------------
010:0003------------------------------------------------------------------------
*
*#*************************************************************************|
*#
*#        PRE-DEVELOPMENT CONDITIONS HYDROLOGIC MODELING
*#        ==============================================
*#
**#*************************************************************************|
*# CATCHMENT 101 - EXISTING CONDITION (OUTLETS TO JOHN STREET SOUTH)
*
----------------------
| CALIB STANDHYD     |   Area    (ha)=     .48
| 01:101    DT= 1.00 |   Total Imp(%)=   63.00   Dir. Conn.(%)=   63.00
----------------------
                           IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       .30          .18
     Dep. Storage     (mm)=      1.00         8.47
     Average Slope     (%)=      2.00         3.00
     Length            (m)=     25.00        15.00
     Mannings n          =       .015         .250

     Max.eff.Inten.(mm/hr)=    122.29        39.83
                over (min)       1.00         6.00
     Storage Coeff.  (min)=       .91 (ii)     5.92 (ii)
     Unit Hyd. Tpeak (min)=      1.00         6.00
     Unit Hyd. peak  (cms)=      1.13          .19
                                                             *TOTALS*
     PEAK FLOW       (cms)=       .10          .01             .113 (iii)
     TIME TO PEAK    (hrs)=      1.33         1.40            1.333
     RUNOFF VOLUME    (mm)=     59.22        19.63           44.572
     TOTAL RAINFALL   (mm)=     60.22        60.22           60.219
     RUNOFF COEFFICIENT   =       .98          .33             .740

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  75.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
010:0004------------------------------------------------------------------------
*# CATCHMENT 102 - EXISTING CONDITION (OUTLETS TO CHARLTON AVENUE EAST)
*
----------------------
| CALIB STANDHYD     |   Area    (ha)=     .38
| 02:102    DT= 1.00 |   Total Imp(%)=   79.00   Dir. Conn.(%)=   79.00
----------------------
                           IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       .30          .08
     Dep. Storage     (mm)=      1.00         8.47
     Average Slope     (%)=      2.80         3.00
     Length            (m)=     25.00        15.00
     Mannings n          =       .015         .250

     Max.eff.Inten.(mm/hr)=    122.29        39.83
                over (min)       1.00         6.00
     Storage Coeff.  (min)=       .82 (ii)     5.83 (ii)
     Unit Hyd. Tpeak (min)=      1.00         6.00
     Unit Hyd. peak  (cms)=      1.20          .19
                                                             *TOTALS*
     PEAK FLOW       (cms)=       .10          .01             .107 (iii)
     TIME TO PEAK    (hrs)=      1.33         1.40            1.333
     RUNOFF VOLUME    (mm)=     59.22        19.63           50.906
     TOTAL RAINFALL   (mm)=     60.22        60.22           60.219
     RUNOFF COEFFICIENT   =       .98          .33             .845

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  75.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
010:0005------------------------------------------------------------------------
*#*************************************************************************|
*#
*#        POST-DEVELOPMENT CONDITIONS HYDROLOGIC MODELING
*#        ==============================================
*#
**#*************************************************************************|
*# CATCHMENT 201 - PROPOSED CONDITION (CONTROLLED TO JOHN STREET SOUTH)
*
----------------------
| CALIB STANDHYD     |   Area    (ha)=     .74
| 01:201    DT= 1.00 |   Total Imp(%)=   87.00   Dir. Conn.(%)=   87.00
----------------------
                           IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       .64          .10
     Dep. Storage     (mm)=      1.00         8.47
     Average Slope     (%)=      1.70         2.00
     Length            (m)=     15.00        12.00
     Mannings n          =       .013         .250

     Max.eff.Inten.(mm/hr)=    122.29        39.83
                over (min)       1.00         6.00
     Storage Coeff.  (min)=       .64 (ii)     5.60 (ii)
     Unit Hyd. Tpeak (min)=      1.00         6.00
     Unit Hyd. peak  (cms)=      1.34          .20
                                                             *TOTALS*
     PEAK FLOW       (cms)=       .22          .01             .225 (iii)
     TIME TO PEAK    (hrs)=      1.33         1.40            1.333
     RUNOFF VOLUME    (mm)=     59.22        19.63           54.073
     TOTAL RAINFALL   (mm)=     60.22        60.22           60.219
     RUNOFF COEFFICIENT   =       .98          .33             .898

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  75.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
010:0006------------------------------------------------------------------------
*# ROUTE CATCHMENT 201 - THROUGH ORIFICE
*
--------------------
| ROUTE RESERVOIR   |    Requested routing time step =  1.0 min.
|  IN>01:(201    )  |
| OUT<02:(201    )  |    =========  OUTLFOW STORAGE TABLE  =========
---------------------    OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
                          (cms)     (ha.m.)   |   (cms)     (ha.m.)
                           .000  .0000E+00    |     .033  .2100E-01
                           .007  .0000E+00    |     .037  .2630E-01
                           .018  .5300E-02    |     .041  .3150E-01
                           .024  .1050E-01    |     .044  .3680E-01
                           .029  .1580E-01    |     .000  .0000E+00

     ROUTING RESULTS            AREA      QPEAK      TPEAK        R.V.
     -------------------        (ha)      (cms)      (hrs)        (mm)
     INFLOW >01: (201   )        .74       .225      1.333      54.073
     OUTFLOW<02: (201   )        .74       .033      1.700      54.085
    OVERFLOW<03: (OVF   )        .00       .000       .000        .000

                   TOTAL NUMBER OF SIMULATED OVERFLOWS  =         0
                   CUMULATIVE TIME OF OVERFLOWS  (hours)=       .00
                   PERCENTAGE OF TIME OVERFLOWING    (%)=       .00


                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=   14.768
                   TIME SHIFT OF PEAK FLOW         (min)=    22.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=.2072E-01

--------------------------------------------------------------------------------
010:0007------------------------------------------------------------------------
*# CATCHMENT 203 - PROPOSED CONDITION (UNCONTROLLED TO ROW)
*
----------------------
| CALIB NASHYD       |   Area    (ha)=     .12   Curve Number   (CN)=75.00
| 04:202    DT= 1.00 |   Ia      (mm)=   8.470   # of Linear Res.(N)= 3.00
----------------------   U.H. Tp(hrs)=    .100

     Unit Hyd Qpeak  (cms)=     .046

     PEAK FLOW       (cms)=     .009 (i)
     TIME TO PEAK    (hrs)=    1.400
     RUNOFF VOLUME    (mm)=   19.629
     TOTAL RAINFALL   (mm)=   60.219
     RUNOFF COEFFICIENT   =     .326

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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010:0008------------------------------------------------------------------------
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```
| ADD HYD (201+202   ) | ID: NHYD         AREA     QPEAK   TPEAK   R.V.    DWF
-----------------------                   (ha)     (cms)   (hrs)   (mm)   (cms)
                     ID1 02:201            .74      .033    1.70  54.08    .000
                    +ID2 03:OVF            .00      .000     .00    .00    .000
                    +ID3 04:202            .12      .009    1.40  19.63    .000
                     ==========================================================
                     SUM 05:201+202        .86      .040    1.50  49.28    .000

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
010:0009-----------------------------------------------------------------------
**#****************************************************************************|
* RUN REMAINING DESIGN STORMS (HAMILTON MOUNT HOPE 5 TO 100-YR)
*
-------------------------------------------------------------------------------
010:0002-----------------------------------------------------------------------
*
-------------------------------------------------------------------------------
010:0002-----------------------------------------------------------------------
*
  ** END OF RUN :  24

*******************************************************************************




--------------------
| START            |   Project  dir.: T:\PROJECTS\17080\FSR\SWMHYMO\
--------------------   Rainfall dir.: T:\PROJECTS\17080\FSR\SWMHYMO\
    TZERO =   .00 hrs on        0
    METOUT=   2 (output = METRIC)
    NRUN  = 025
    NSTORM=   1
          #  1=MTH4025.stm
-------------------------------------------------------------------------------
025:0002-----------------------------------------------------------------------
*#****************************************************************************|
*#  Project Name: 299-307 JOHN STREET & 97 ST. JOSEPH'S DRIVE
*#               HAMILTON, ONTARIO
*#  JOB NUMBER  : 17080
*#       Date   : December 2017
*#    Revised   : July 2019
*#    Company   : S. LLEWELLYN AND ASSOCIATES LTD.
*#       File   : 17080.DAT
*#****************************************************************************|
*
-------------------------------------------------------------------------------
025:0002-----------------------------------------------------------------------
*
--------------------
| READ STORM       |     Filename: 25-YR MT. HOPE (A=1719.5 B=10 C=0.823)
| Ptotal=  73.09 mm|     Comments: 25-YR MT. HOPE (A=1719.5 B=10 C=0.823)
--------------------
              TIME    RAIN |   TIME    RAIN |   TIME    RAIN |   TIME    RAIN
               hrs   mm/hr |    hrs   mm/hr |    hrs   mm/hr |    hrs   mm/hr
               .17   4.422 |   1.17  42.745 |   2.17  11.847 |   3.17   5.440
               .33   5.152 |   1.33 146.101 |   2.33   9.863 |   3.33   5.006
               .50   6.198 |   1.50  56.322 |   2.50   8.458 |   3.50   4.639
               .67   7.827 |   1.67  29.752 |   2.67   7.413 |   3.67   4.326
               .83  10.708 |   1.83  19.870 |   2.83   6.605 |   3.83   4.055
              1.00  17.140 |   2.00  14.849 |   3.00   5.963 |   4.00   3.818

-------------------------------------------------------------------------------
025:0003-----------------------------------------------------------------------
*
*#****************************************************************************|
*#
*#        PRE-DEVELOPMENT CONDITIONS HYDROLOGIC MODELING
*#        ==============================================
*#
**#****************************************************************************|
*# CATCHMENT 101 - EXISTING CONDITION (OUTLETS TO JOHN STREET SOUTH)
*
----------------------
| CALIB STANDHYD     |    Area    (ha)=     .48
| 01:101    DT= 1.00 |    Total Imp(%)=   63.00   Dir. Conn.(%)=   63.00
----------------------
                           IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       .30          .18
     Dep. Storage     (mm)=      1.00         8.47
     Average Slope     (%)=      2.00         3.00
     Length            (m)=     25.00        15.00
     Mannings n          =       .015         .250

     Max.eff.Inten.(mm/hr)=    146.10        59.53
                over (min)       1.00         5.00
     Storage Coeff.  (min)=       .85 (ii)    5.12 (ii)
     Unit Hyd. Tpeak (min)=      1.00         5.00
     Unit Hyd. peak  (cms)=      1.18          .22
                                                          *TOTALS*
     PEAK FLOW       (cms)=       .12          .02          .141 (iii)
     TIME TO PEAK    (hrs)=      1.33         1.38         1.333
     RUNOFF VOLUME    (mm)=     72.09        27.97        55.763
     TOTAL RAINFALL   (mm)=     73.09        73.09        73.086
     RUNOFF COEFFICIENT  =        .99          .38          .763

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  75.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
025:0004-----------------------------------------------------------------------
*# CATCHMENT 102 - EXISTING CONDITION (OUTLETS TO CHARLTON AVENUE EAST)
*
----------------------
| CALIB STANDHYD     |    Area    (ha)=     .38
| 02:102    DT= 1.00 |    Total Imp(%)=   79.00   Dir. Conn.(%)=   79.00
----------------------
                           IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       .30          .08
     Dep. Storage     (mm)=      1.00         8.47
     Average Slope     (%)=      2.80         3.00
     Length            (m)=     25.00        15.00
     Mannings n          =       .015         .250
```

```
     Max.eff.Inten.(mm/hr)=    146.10        59.53
                over (min)       1.00         5.00
     Storage Coeff.  (min)=       .76 (ii)    5.03 (ii)
     Unit Hyd. Tpeak (min)=      1.00         5.00
     Unit Hyd. peak  (cms)=      1.24          .23
                                                          *TOTALS*
     PEAK FLOW       (cms)=       .12          .01          .130 (iii)
     TIME TO PEAK    (hrs)=      1.33         1.38         1.333
     RUNOFF VOLUME    (mm)=     72.09        27.97        62.822
     TOTAL RAINFALL   (mm)=     73.09        73.09        73.086
     RUNOFF COEFFICIENT  =        .99          .38          .860

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  75.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
025:0005-----------------------------------------------------------------------
*#****************************************************************************|
*#
*#        POST-DEVELOPMENT CONDITIONS HYDROLOGIC MODELING
*#        ==============================================
*#
**#****************************************************************************|
*# CATCHMENT 201 - PROPOSED CONDITION (CONTROLLED TO JOHN STREET SOUTH)
*
----------------------
| CALIB STANDHYD     |    Area    (ha)=     .74
| 01:201    DT= 1.00 |    Total Imp(%)=   87.00   Dir. Conn.(%)=   87.00
----------------------
                           IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       .64          .10
     Dep. Storage     (mm)=      1.00         8.47
     Average Slope     (%)=      1.70         2.00
     Length            (m)=     15.00        12.00
     Mannings n          =       .013         .250

     Max.eff.Inten.(mm/hr)=    146.10        59.53
                over (min)       1.00         5.00
     Storage Coeff.  (min)=       .60 (ii)    4.82 (ii)
     Unit Hyd. Tpeak (min)=      1.00         5.00
     Unit Hyd. peak  (cms)=      1.38          .23
                                                          *TOTALS*
     PEAK FLOW       (cms)=       .26          .01          .272 (iii)
     TIME TO PEAK    (hrs)=      1.33         1.38         1.333
     RUNOFF VOLUME    (mm)=     72.09        27.97        66.351
     TOTAL RAINFALL   (mm)=     73.09        73.09        73.086
     RUNOFF COEFFICIENT  =        .99          .38          .908

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  75.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
025:0006-----------------------------------------------------------------------
*# ROUTE CATCHMENT 201 - THROUGH ORIFICE
*
---------------------
| ROUTE RESERVOIR   |     Requested routing time step =  1.0 min.
|  IN>01:(201    )  |
| OUT<02:(201    )  |     =========  OUTLFOW STORAGE TABLE  =========
---------------------      OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
                             (cms)    (ha.m.)   |   (cms)    (ha.m.)
                              .000  .0000E+00   |     .033  .2100E-01
                              .007  .0000E+00   |     .037  .2630E-01
                              .018  .5300E-02   |     .041  .3150E-01
                              .024  .1050E-01   |     .044  .3680E-01
                              .029  .1580E-01   |     .000  .0000E+00

     ROUTING RESULTS             AREA     QPEAK     TPEAK        R.V.
     --------------------        (ha)     (cms)     (hrs)        (mm)
     INFLOW >01: (201   )         .74      .272     1.333      66.351
     OUTFLOW<02: (201   )         .74      .037     1.833      66.381
    OVERFLOW<03: (OVF   )         .00      .000      .000        .000

                  TOTAL NUMBER OF SIMULATED OVERFLOWS  =         0
                  CUMULATIVE TIME OF OVERFLOWS  (hours)=       .00
                  PERCENTAGE OF TIME OVERFLOWING   (%)=        .00


                  PEAK   FLOW   REDUCTION [Qout/Qin](%)=   13.750
                  TIME SHIFT OF PEAK FLOW         (min)=    30.00
                  MAXIMUM  STORAGE   USED       (ha.m.)=.2655E-01

-------------------------------------------------------------------------------
025:0007-----------------------------------------------------------------------
*# CATCHMENT 203 - PROPOSED CONDITION (UNCONTROLLED TO ROW)
*
----------------------
| CALIB NASHYD       |    Area    (ha)=     .12   Curve Number   (CN)=75.00
| 04:202    DT= 1.00 |    Ia      (mm)=   8.470   # of Linear Res.(N)= 3.00
----------------------    U.H. Tp(hrs)=    .100

     Unit Hyd Qpeak  (cms)=     .046

     PEAK FLOW       (cms)=     .014 (i)
     TIME TO PEAK    (hrs)=    1.400
     RUNOFF VOLUME    (mm)=   27.967
     TOTAL RAINFALL   (mm)=   73.086
     RUNOFF COEFFICIENT  =     .383

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
025:0008-----------------------------------------------------------------------
-----------------------
| ADD HYD (201+202   ) | ID: NHYD         AREA     QPEAK   TPEAK   R.V.    DWF
-----------------------                   (ha)     (cms)   (hrs)   (mm)   (cms)
                     ID1 02:201            .74      .037    1.83  66.38    .000
                    +ID2 03:OVF            .00      .000     .00    .00    .000
                    +ID3 04:202            .12      .014    1.40  27.97    .000
                     ==========================================================
                     SUM 05:201+202        .86      .048    1.43  61.02    .000

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
```

```
--------------------------------------------------------------------------------
025:0009------------------------------------------------------------------------
**#*****************************************************************************|
* RUN REMAINING DESIGN STORMS (HAMILTON MOUNT HOPE 5 TO 100-YR)
*
--------------------------------------------------------------------------------
025:0002------------------------------------------------------------------------
*
--------------------------------------------------------------------------------
025:0002------------------------------------------------------------------------
*
--------------------------------------------------------------------------------
025:0002------------------------------------------------------------------------
*
  ** END OF RUN :  49

********************************************************************************




--------------------
| START            |  Project  dir.: T:\PROJECTS\17080\FSR\SWMHYMO\
--------------------  Rainfall dir.: T:\PROJECTS\17080\FSR\SWMHYMO\
    TZERO =   .00 hrs on        0
    METOUT=   2 (output = METRIC)
    NRUN  = 050
    NSTORM=   1
           #  1=MTH4050.stm
--------------------------------------------------------------------------------
050:0002------------------------------------------------------------------------
*#*****************************************************************************|
*#  Project Name: 299-307 JOHN STREET & 97 ST. JOSEPH'S DRIVE
*#                HAMILTON, ONTARIO
*#  JOB NUMBER  : 17080
*#       Date   : December 2017
*#    Revised   : July 2019
*#    Company   : S. LLEWELLYN AND ASSOCIATES LTD.
*#       File   : 17080.DAT
*#*****************************************************************************|
*
--------------------------------------------------------------------------------
050:0002------------------------------------------------------------------------
*
--------------------
| READ STORM       |    Filename: 50-YR MT. HOPE (A=1954.8 B=10 C=0.826)
| Ptotal=  81.72 mm|    Comments: 50-YR MT. HOPE (A=1954.8 B=10 C=0.826)
--------------------
              TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
               hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
               .17   4.881 |  1.17  47.876 |  2.17  13.160 |  3.17   6.012
               .33   5.692 |  1.33 164.608 |  2.33  10.942 |  3.33   5.529
               .50   6.856 |  1.50  63.166 |  2.50   9.374 |  3.50   5.122
               .67   8.670 |  1.67  33.244 |  2.67   8.209 |  3.67   4.774
               .83  11.887 |  1.83  22.146 |  2.83   7.309 |  3.83   4.473
              1.00  19.086 |  2.00  16.518 |  3.00   6.594 |  4.00   4.210

--------------------------------------------------------------------------------
050:0003------------------------------------------------------------------------
*
*#*****************************************************************************|
*#
*#       PRE-DEVELOPMENT CONDITIONS HYDROLOGIC MODELING
*#       ==============================================
*#
**#****************************************************************************|
*# CATCHMENT 101 - EXISTING CONDITION (OUTLETS TO JOHN STREET SOUTH)
*
---------------------
| CALIB STANDHYD     |   Area    (ha)=     .48
| 01:101    DT= 1.00 |   Total Imp(%)=   63.00   Dir. Conn.(%)=   63.00
---------------------
                             IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        .30          .18
     Dep. Storage     (mm)=       1.00         8.47
     Average Slope     (%)=       2.00         3.00
     Length            (m)=      25.00        15.00
     Mannings n          =        .015         .250

     Max.eff.Inten.(mm/hr)=     164.61        73.90
                over (min)       1.00         5.00
     Storage Coeff.  (min)=        .81 (ii)    4.72 (ii)
     Unit Hyd. Tpeak (min)=       1.00         5.00
     Unit Hyd. peak  (cms)=       1.21          .23
                                                         *TOTALS*
     PEAK FLOW       (cms)=        .14          .03          .163 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.38         1.333
     RUNOFF VOLUME    (mm)=      80.72        33.98        63.428
     TOTAL RAINFALL   (mm)=      81.72        81.72        81.723
     RUNOFF COEFFICIENT   =        .99          .42          .776

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  75.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
050:0004------------------------------------------------------------------------
*# CATCHMENT 102 - EXISTING CONDITION (OUTLETS TO CHARLTON AVENUE EAST)
*
---------------------
| CALIB STANDHYD     |   Area    (ha)=     .38
| 02:102    DT= 1.00 |   Total Imp(%)=   79.00   Dir. Conn.(%)=   79.00
---------------------
                             IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        .30          .08
     Dep. Storage     (mm)=       1.00         8.47
     Average Slope     (%)=       2.80         3.00
     Length            (m)=      25.00        15.00
     Mannings n          =        .015         .250

     Max.eff.Inten.(mm/hr)=     164.61        73.90
                over (min)       1.00         5.00
     Storage Coeff.  (min)=        .73 (ii)    4.64 (ii)
     Unit Hyd. Tpeak (min)=       1.00         5.00
     Unit Hyd. peak  (cms)=       1.27          .24
                                                         *TOTALS*
     PEAK FLOW       (cms)=        .14          .01          .148 (iii)
```

```
     TIME TO PEAK    (hrs)=       1.33         1.38         1.333
     RUNOFF VOLUME    (mm)=      80.72        33.98        70.907
     TOTAL RAINFALL   (mm)=      81.72        81.72        81.723
     RUNOFF COEFFICIENT   =        .99          .42          .868

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  75.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
050:0005------------------------------------------------------------------------
*#*****************************************************************************|
*#
*#       POST-DEVELOPMENT CONDITIONS HYDROLOGIC MODELING
*#       ===============================================
*#
**#****************************************************************************|
*# CATCHMENT 201 - PROPOSED CONDITION (CONTROLLED TO JOHN STREET SOUTH)
*
---------------------
| CALIB STANDHYD     |   Area    (ha)=     .74
| 01:201    DT= 1.00 |   Total Imp(%)=   87.00   Dir. Conn.(%)=   87.00
---------------------
                             IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        .64          .10
     Dep. Storage     (mm)=       1.00         8.47
     Average Slope     (%)=       1.70         2.00
     Length            (m)=      15.00        12.00
     Mannings n          =        .013         .250

     Max.eff.Inten.(mm/hr)=     164.61        76.16
                over (min)       1.00         4.00
     Storage Coeff.  (min)=        .57 (ii)    4.39 (ii)
     Unit Hyd. Tpeak (min)=       1.00         4.00
     Unit Hyd. peak  (cms)=       1.40          .26
                                                         *TOTALS*
     PEAK FLOW       (cms)=        .29          .02          .309 (iii)
     TIME TO PEAK    (hrs)=       1.32         1.37         1.333
     RUNOFF VOLUME    (mm)=      80.72        33.98        74.646
     TOTAL RAINFALL   (mm)=      81.72        81.72        81.723
     RUNOFF COEFFICIENT   =        .99          .42          .913

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  75.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
050:0006------------------------------------------------------------------------
*# ROUTE CATCHMENT 201 - THROUGH ORIFICE
*
--------------------
| ROUTE RESERVOIR   |    Requested routing time step =  1.0 min.
|  IN>01:(201   )   |
| OUT<02:(201   )   |    =========  OUTFLOW STORAGE TABLE  =========
--------------------     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
                           (cms)    (ha.m.)   |   (cms)    (ha.m.)
                            .000  .0000E+00   |     .033  .2100E-01
                            .007  .0000E+00   |     .037  .2630E-01
                            .018  .5300E-02   |     .041  .3150E-01
                            .024  .1050E-01   |     .044  .3680E-01
                            .029  .1580E-01   |     .000  .0000E+00

     ROUTING RESULTS           AREA     QPEAK     TPEAK       R.V.
     --------------------      (ha)     (cms)     (hrs)       (mm)
     INFLOW >01: (201   )       .74      .309     1.333     74.646
      OUTFLOW<02: (201   )      .74      .040     1.833     74.676
    OVERFLOW<03: (OVF   )       .00      .000      .000       .000

                   TOTAL NUMBER OF SIMULATED OVERFLOWS  =         0
                   CUMULATIVE TIME OF OVERFLOWS  (hours)=       .00
                   PERCENTAGE OF TIME OVERFLOWING    (%)=       .00


                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=    12.965
                   TIME SHIFT OF PEAK FLOW         (min)=     30.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=.3067E-01

--------------------------------------------------------------------------------
050:0007------------------------------------------------------------------------
*# CATCHMENT 203 - PROPOSED CONDITION (UNCONTROLLED TO ROW)
*
---------------------
| CALIB NASHYD       |   Area    (ha)=     .12   Curve Number   (CN)=75.00
| 04:202    DT= 1.00 |   Ia      (mm)=   8.470   # of Linear Res.(N)= 3.00
---------------------    U.H. Tp(hrs)=    .100

     Unit Hyd Qpeak  (cms)=     .046

     PEAK FLOW       (cms)=     .017 (i)
     TIME TO PEAK    (hrs)=    1.400
     RUNOFF VOLUME    (mm)=   33.978
     TOTAL RAINFALL   (mm)=   81.723
     RUNOFF COEFFICIENT   =     .416

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
050:0008------------------------------------------------------------------------
-----------------------
| ADD HYD (201+202   ) | ID: NHYD        AREA     QPEAK   TPEAK   R.V.    DWF
-----------------------                  (ha)     (cms)   (hrs)   (mm)   (cms)
                        ID1 02:201         .74      .040    1.83  74.68    .000
                       +ID2 03:OVF         .00      .000     .00    .00    .000
                       +ID3 04:202         .12      .017    1.40  33.98    .000
                        ======================================================
                        SUM 05:201+202     .86      .054    1.43  69.00    .000

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
050:0009------------------------------------------------------------------------
**#****************************************************************************|
* RUN REMAINING DESIGN STORMS (HAMILTON MOUNT HOPE 5 TO 100-YR)
*
--------------------------------------------------------------------------------
050:0002------------------------------------------------------------------------
```

```
*
-------------------------------------------------------------------------------
050:0002-----------------------------------------------------------------------
*
-------------------------------------------------------------------------------
050:0002-----------------------------------------------------------------------
*
-------------------------------------------------------------------------------
050:0002-----------------------------------------------------------------------
*
  ** END OF RUN :  99

*******************************************************************************




--------------------
| START           |  Project  dir.: T:\PROJECTS\17080\FSR\SWMHYMO\
-------------------  Rainfall dir.: T:\PROJECTS\17080\FSR\SWMHYMO\
    TZERO =   .00 hrs on        0
    METOUT=   2 (output = METRIC)
    NRUN  = 100
    NSTORM=   1
           #  1=MTH4100.stm
-------------------------------------------------------------------------------
100:0002-----------------------------------------------------------------------
*#*************************************************************************|
*#  Project Name: 299-307 JOHN STREET & 97 ST. JOSEPH'S DRIVE
*#               HAMILTON, ONTARIO
*#  JOB NUMBER  : 17080
*#       Date   : December 2017
*#    Revised   : July 2019
*#    Company   : S. LLEWELLYN AND ASSOCIATES LTD.
*#       File   : 17080.DAT
*#*************************************************************************|
*
-------------------------------------------------------------------------------
100:0002-----------------------------------------------------------------------
*
--------------------
| READ STORM      |    Filename: 100-YR MT. HOPE (A=2317.4 B=11 C=0.836)
| Ptotal=  91.37 mm|    Comments: 100-YR MT. HOPE (A=2317.4 B=11 C=0.836)
--------------------
              TIME    RAIN |   TIME    RAIN |   TIME    RAIN |   TIME    RAIN
               hrs   mm/hr |    hrs   mm/hr |    hrs   mm/hr |    hrs   mm/hr
               .17   5.311 |   1.17  54.599 |   2.17  14.754 |   3.17   6.584
               .33   6.222 |   1.33 181.813 |   2.33  12.204 |   3.33   6.040
               .50   7.538 |   1.50  72.007 |   2.50  10.407 |   3.50   5.582
               .67   9.603 |   1.67  37.943 |   2.67   9.076 |   3.67   5.191
               .83  13.290 |   1.83  25.134 |   2.83   8.053 |   3.83   4.855
              1.00  21.597 |   2.00  18.629 |   3.00   7.242 |   4.00   4.561

-------------------------------------------------------------------------------
100:0003-----------------------------------------------------------------------
*
*#**************************************************************************|
*#
*#       PRE-DEVELOPMENT CONDITIONS HYDROLOGIC MODELING
*#       ==============================================
*#
**#*************************************************************************|
*# CATCHMENT 101 - EXISTING CONDITION (OUTLETS TO JOHN STREET SOUTH)
*
---------------------
| CALIB STANDHYD     |   Area    (ha)=     .48
| 01:101    DT= 1.00 |   Total Imp(%)=   63.00   Dir. Conn.(%)=   63.00
---------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        .30          .18
     Dep. Storage     (mm)=       1.00         8.47
     Average Slope     (%)=       2.00         3.00
     Length            (m)=      25.00        15.00
     Mannings n          =        .015         .250

     Max.eff.Inten.(mm/hr)=     181.81        91.27
                over (min)       1.00         4.00
     Storage Coeff.  (min)=        .77 (ii)    4.37 (ii)
     Unit Hyd. Tpeak (min)=       1.00         4.00
     Unit Hyd. peak  (cms)=       1.23          .27
                                                         *TOTALS*
     PEAK FLOW       (cms)=        .15          .03          .186 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.37         1.333
     RUNOFF VOLUME    (mm)=      90.37        41.01        72.110
     TOTAL RAINFALL   (mm)=      91.37        91.37        91.372
     RUNOFF COEFFICIENT   =        .99          .45          .789

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  75.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
100:0004-----------------------------------------------------------------------
*# CATCHMENT 102 - EXISTING CONDITION (OUTLETS TO CHARLTON AVENUE EAST)
*
---------------------
| CALIB STANDHYD     |   Area    (ha)=     .38
| 02:102    DT= 1.00 |   Total Imp(%)=   79.00   Dir. Conn.(%)=   79.00
---------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        .30          .08
     Dep. Storage     (mm)=       1.00         8.47
     Average Slope     (%)=       2.80         3.00
     Length            (m)=      25.00        15.00
     Mannings n          =        .015         .250

     Max.eff.Inten.(mm/hr)=     181.81        91.27
                over (min)       1.00         4.00
     Storage Coeff.  (min)=        .70 (ii)    4.30 (ii)
     Unit Hyd. Tpeak (min)=       1.00         4.00
     Unit Hyd. peak  (cms)=       1.29          .27
                                                         *TOTALS*
     PEAK FLOW       (cms)=        .15          .02          .166 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.37         1.333
     RUNOFF VOLUME    (mm)=      90.37        41.01        80.007
     TOTAL RAINFALL   (mm)=      91.37        91.37        91.372
     RUNOFF COEFFICIENT   =        .99          .45          .876
```

```
       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  75.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
100:0005-----------------------------------------------------------------------
*#*************************************************************************|
*#
*#       POST-DEVELOPMENT CONDITIONS HYDROLOGIC MODELING
*#       ===============================================
*#
**#************************************************************************|
*# CATCHMENT 201 - PROPOSED CONDITION (CONTROLLED TO JOHN STREET SOUTH)
*
---------------------
| CALIB STANDHYD     |   Area    (ha)=     .74
| 01:201    DT= 1.00 |   Total Imp(%)=   87.00   Dir. Conn.(%)=   87.00
---------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        .64          .10
     Dep. Storage     (mm)=       1.00         8.47
     Average Slope     (%)=       1.70         2.00
     Length            (m)=      15.00        12.00
     Mannings n          =        .013         .250

     Max.eff.Inten.(mm/hr)=     181.81        91.27
                over (min)       1.00         4.00
     Storage Coeff.  (min)=        .55 (ii)    4.10 (ii)
     Unit Hyd. Tpeak (min)=       1.00         4.00
     Unit Hyd. peak  (cms)=       1.42          .28
                                                         *TOTALS*
     PEAK FLOW       (cms)=        .33          .02          .343 (iii)
     TIME TO PEAK    (hrs)=       1.32         1.37         1.333
     RUNOFF VOLUME    (mm)=      90.37        41.01        83.956
     TOTAL RAINFALL   (mm)=      91.37        91.37        91.372
     RUNOFF COEFFICIENT   =        .99          .45          .919

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  75.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
100:0006-----------------------------------------------------------------------
*# ROUTE CATCHMENT 201 - THROUGH ORIFICE
*
--------------------
| ROUTE RESERVOIR   |    Requested routing time step =  1.0 min.
|  IN>01:(201   )   |
| OUT<02:(201   )   |    =========  OUTLFOW STORAGE TABLE  =========
--------------------     OUTFLOW    STORAGE  |  OUTFLOW    STORAGE
                           (cms)    (ha.m.)  |    (cms)    (ha.m.)
                            .000  .0000E+00  |     .033  .2100E-01
                            .007  .0000E+00  |     .037  .2630E-01
                            .018  .5300E-02  |     .041  .3150E-01
                            .024  .1050E-01  |     .044  .3680E-01
                            .029  .1580E-01  |     .000  .0000E+00

     ROUTING RESULTS           AREA     QPEAK     TPEAK       R.V.
     --------------------      (ha)     (cms)     (hrs)       (mm)
     INFLOW >01: (201   )       .74      .343     1.333     83.956
      OUTFLOW<02: (201   )      .74      .043     1.850     83.968
    OVERFLOW<03: (OVF   )       .00      .000      .000       .000

                   TOTAL NUMBER OF SIMULATED OVERFLOWS  =        0
                   CUMULATIVE TIME OF OVERFLOWS  (hours)=      .00
                   PERCENTAGE OF TIME OVERFLOWING    (%)=      .00


                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=   12.482
                   TIME SHIFT OF PEAK FLOW         (min)=    31.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=.3537E-01

-------------------------------------------------------------------------------
100:0007-----------------------------------------------------------------------
*# CATCHMENT 203 - PROPOSED CONDITION (UNCONTROLLED TO ROW)
*
---------------------
| CALIB NASHYD       |   Area     (ha)=     .12   Curve Number   (CN)=75.00
| 04:202    DT= 1.00 |   Ia       (mm)=   8.470   # of Linear Res.(N)= 3.00
---------------------    U.H. Tp(hrs)=    .100

     Unit Hyd Qpeak  (cms)=     .046

     PEAK FLOW       (cms)=     .021 (i)
     TIME TO PEAK    (hrs)=    1.400
     RUNOFF VOLUME    (mm)=   41.013
     TOTAL RAINFALL   (mm)=   91.372
     RUNOFF COEFFICIENT   =     .449

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
100:0008-----------------------------------------------------------------------
-----------------------
| ADD HYD (201+202   ) | ID: NHYD        AREA     QPEAK   TPEAK   R.V.    DWF
-----------------------                  (ha)     (cms)   (hrs)   (mm)   (cms)
                      ID1 02:201          .74      .043    1.85  83.97    .000
                     +ID2 03:OVF          .00      .000     .00    .00    .000
                     +ID3 04:202          .12      .021    1.40  41.01    .000
                      =======================================================
                      SUM 05:201+202      .86      .060    1.42  77.97    .000

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
100:0009-----------------------------------------------------------------------
**#************************************************************************|
* RUN REMAINING DESIGN STORMS (HAMILTON MOUNT HOPE 5 TO 100-YR)
*
-------------------------------------------------------------------------------
100:0002-----------------------------------------------------------------------
*
-------------------------------------------------------------------------------
100:0002-----------------------------------------------------------------------
*
```

```
-------------------------------------------------------------------------------
100:0002-----------------------------------------------------------------------
*
-------------------------------------------------------------------------------
100:0002-----------------------------------------------------------------------
*
-------------------------------------------------------------------------------
100:0002-----------------------------------------------------------------------
*
      FINISH
-------------------------------------------------------------------------------
*******************************************************************************
     WARNINGS / ERRORS / NOTES
     -------------------------
   Simulation ended on 2019-12-16     at 17:21:53
===============================================================================
```

APPENDIX C

QUALITY CONTROL INFORMATION

Hydroworks

Hydroworks Sizing Summary

299-307 John St & 97 St. Joseph's Dr.

12-17-2019

Recommended Size: HS 10

A HydroStorm HS 10 is recommended to provide 83 % annual TSS removal based on a drainage area of 0.74 (ha) with an imperviousness of 87 % and Hamilton Airport, Ontario rainfall for the ETV Canada particle size distribution.

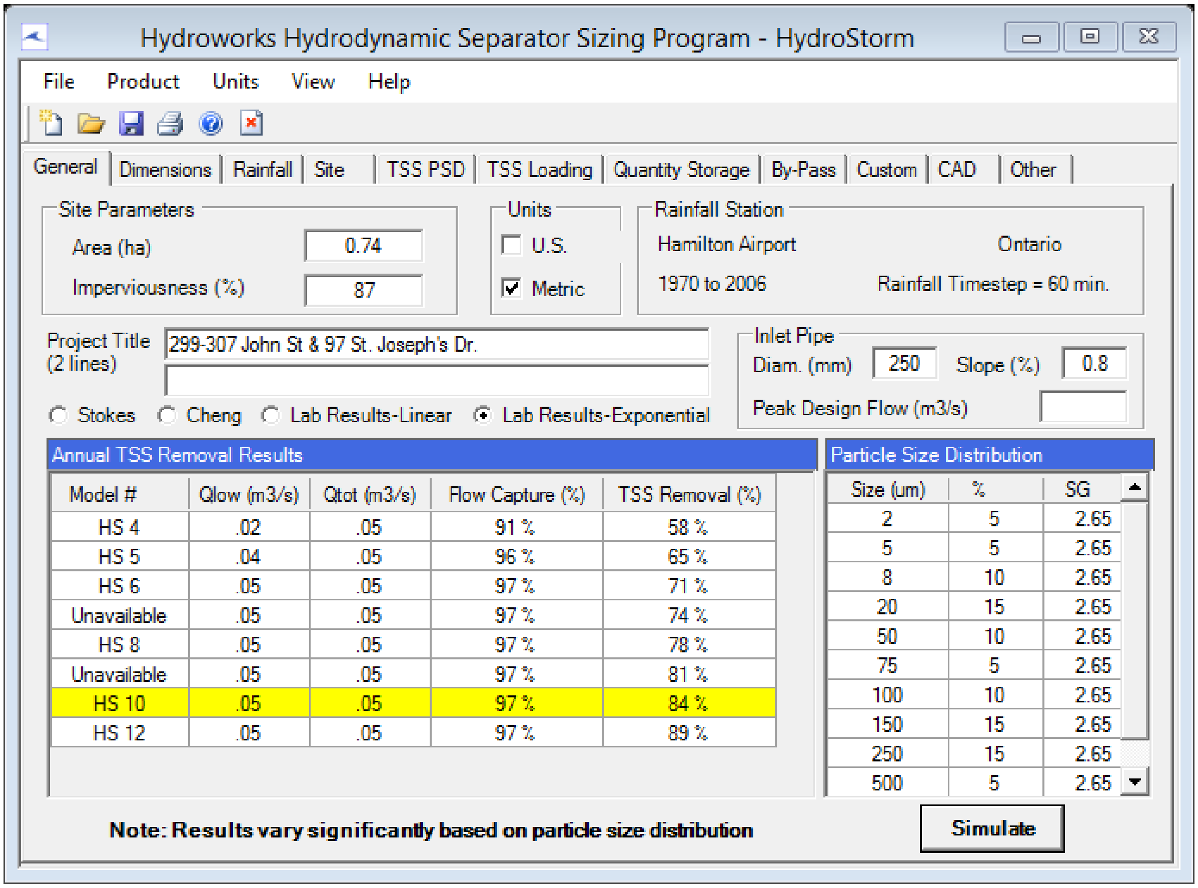
The recommended HydroStorm HS 10 treats 97 % of the annual runoff and provides 84 % annual TSS removal for the Hamilton Airport rainfall records and ETV Canada particle size distribution.

The HydroStorm has a headloss coefficient (K) of 1.04. Since a peak flow was not specified, headloss was calculated using the full pipe flow of .05 (m3/s) for the given 250 (mm) pipe diameter at .8% slope. The headloss was calculated to be 62 (mm) based on a flow depth of 250 (mm) (full pipe flow).

This summary report provides the main parameters that were used for sizing. These parameters are shown on the summary tables and graphs provided in this report.

If you have any questions regarding this sizing summary please do not hesitate to contact Hydroworks at 888-290-7900 or email us at support@hydroworks.com.

TSS Removal Sizing Summary



Hydroworks Hydrodynamic Separator Sizing Program - HydroStorm

File Product Units View Help

General | Dimensions | Rainfall | Site | TSS PSD | TSS Loading | Quantity Storage | By-Pass | Custom | CAD | Other

Site Parameters

Area (ha) 0.74

Imperviousness (%) 87

Units

☐ U.S.

☑ Metric

Rainfall Station

Hamilton Airport Ontario

1970 to 2006 Rainfall Timestep = 60 min.

Project Title (2 lines) 299-307 John St & 97 St. Joseph's Dr.

Inlet Pipe

Diam. (mm) 250 Slope (%) 0.8

Peak Design Flow (m3/s)

○ Stokes ○ Cheng ○ Lab Results-Linear ◉ Lab Results-Exponential

Annual TSS Removal Results

Model #	Qlow (m3/s)	Qtot (m3/s)	Flow Capture (%)	TSS Removal (%)
HS 4	.02	.05	91 %	58 %
HS 5	.04	.05	96 %	65 %
HS 6	.05	.05	97 %	71 %
Unavailable	.05	.05	97 %	74 %
HS 8	.05	.05	97 %	78 %
Unavailable	.05	.05	97 %	81 %
HS 10	.05	.05	97 %	84 %
HS 12	.05	.05	97 %	89 %

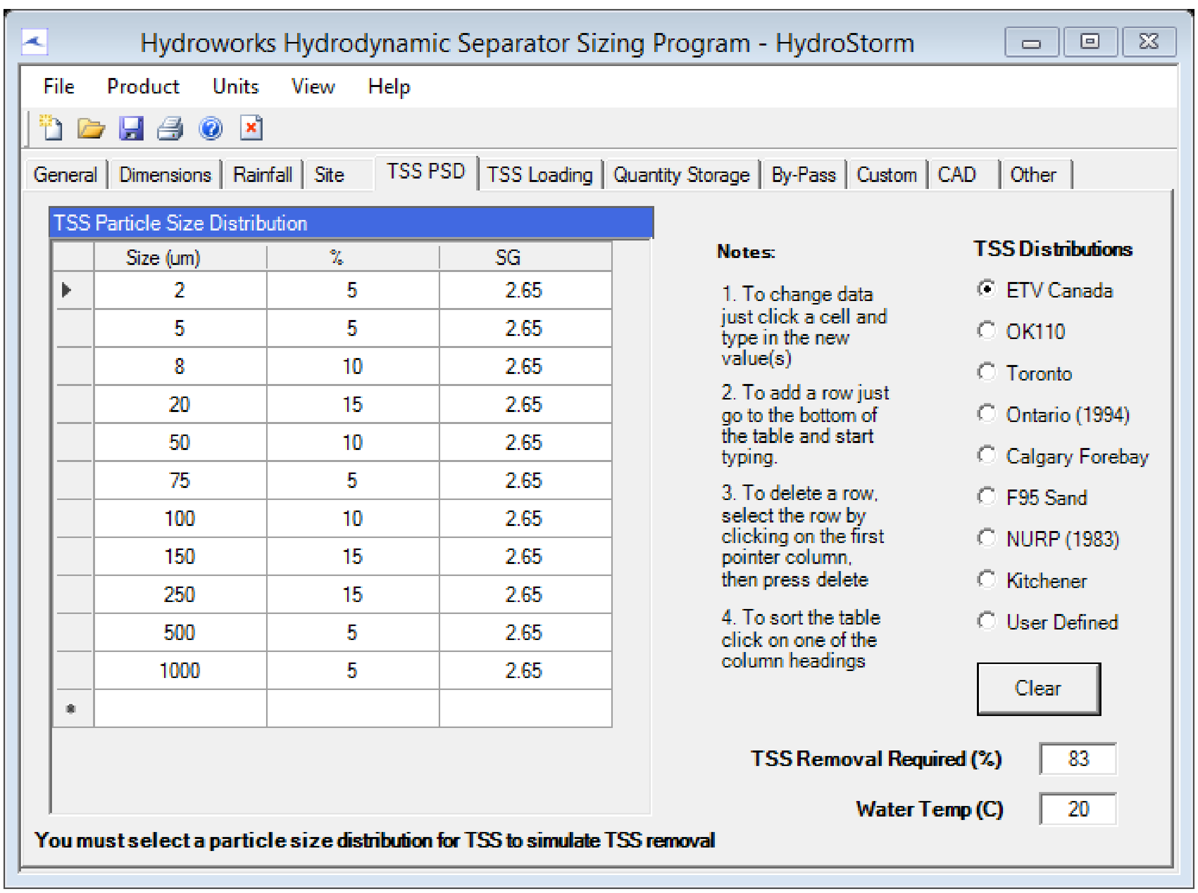
Particle Size Distribution

Size (um)	%	SG
2	5	2.65
5	5	2.65
8	10	2.65
20	15	2.65
50	10	2.65
75	5	2.65
100	10	2.65
150	15	2.65
250	15	2.65
500	5	2.65

Note: Results vary significantly based on particle size distribution

Simulate

TSS Particle Size Distribution



Hydroworks Hydrodynamic Separator Sizing Program - HydroStorm

File Product Units View Help

General | Dimensions | Rainfall | Site | TSS PSD | TSS Loading | Quantity Storage | By-Pass | Custom | CAD | Other

TSS Particle Size Distribution

Size (um)	%	SG
2	5	2.65
5	5	2.65
8	10	2.65
20	15	2.65
50	10	2.65
75	5	2.65
100	10	2.65
150	15	2.65
250	15	2.65
500	5	2.65
1000	5	2.65

Notes:

1. To change data just click a cell and type in the new value(s)
2. To add a row just go to the bottom of the table and start typing.
3. To delete a row, select the row by clicking on the first pointer column, then press delete
4. To sort the table click on one of the column headings

TSS Distributions

◉ ETV Canada

○ OK110

○ Toronto

○ Ontario (1994)

○ Calgary Forebay

○ F95 Sand

○ NURP (1983)

○ Kitchener

○ User Defined

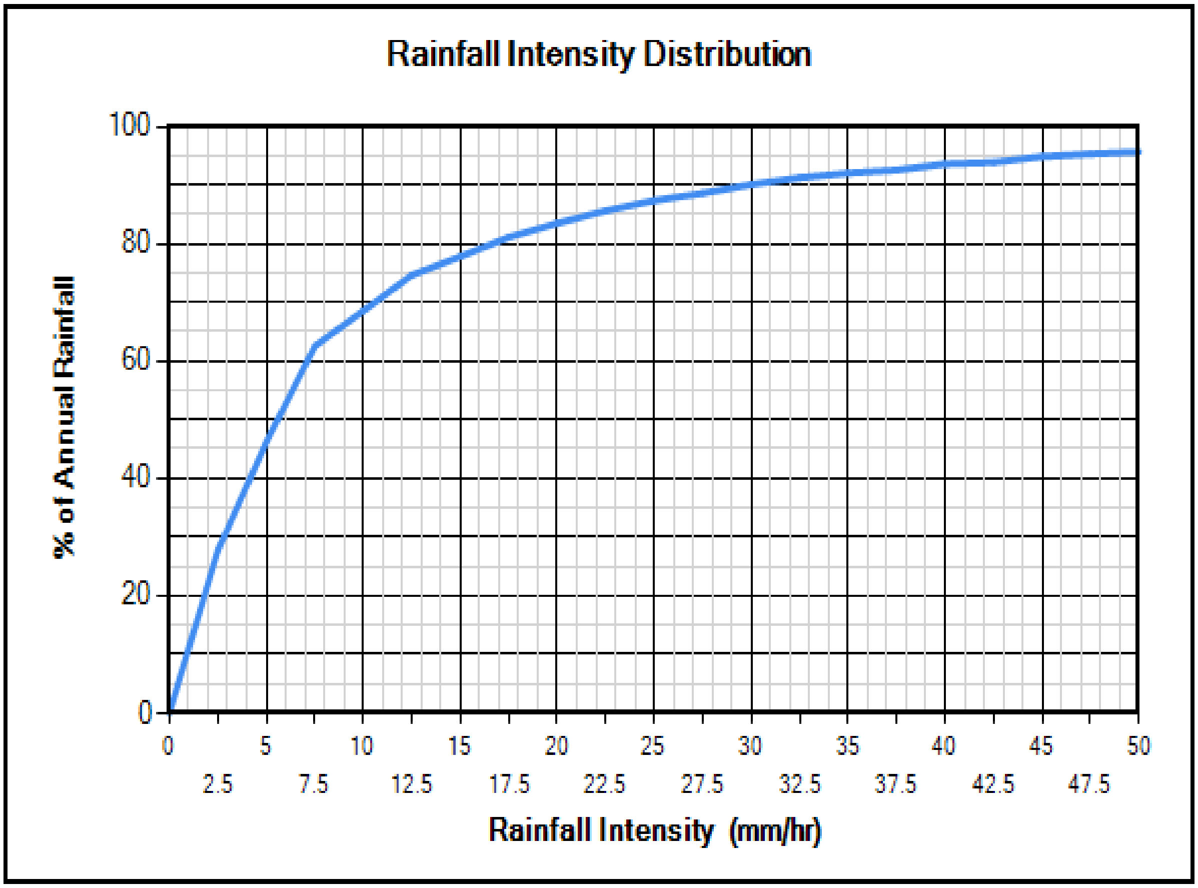
Clear

TSS Removal Required (%) 83

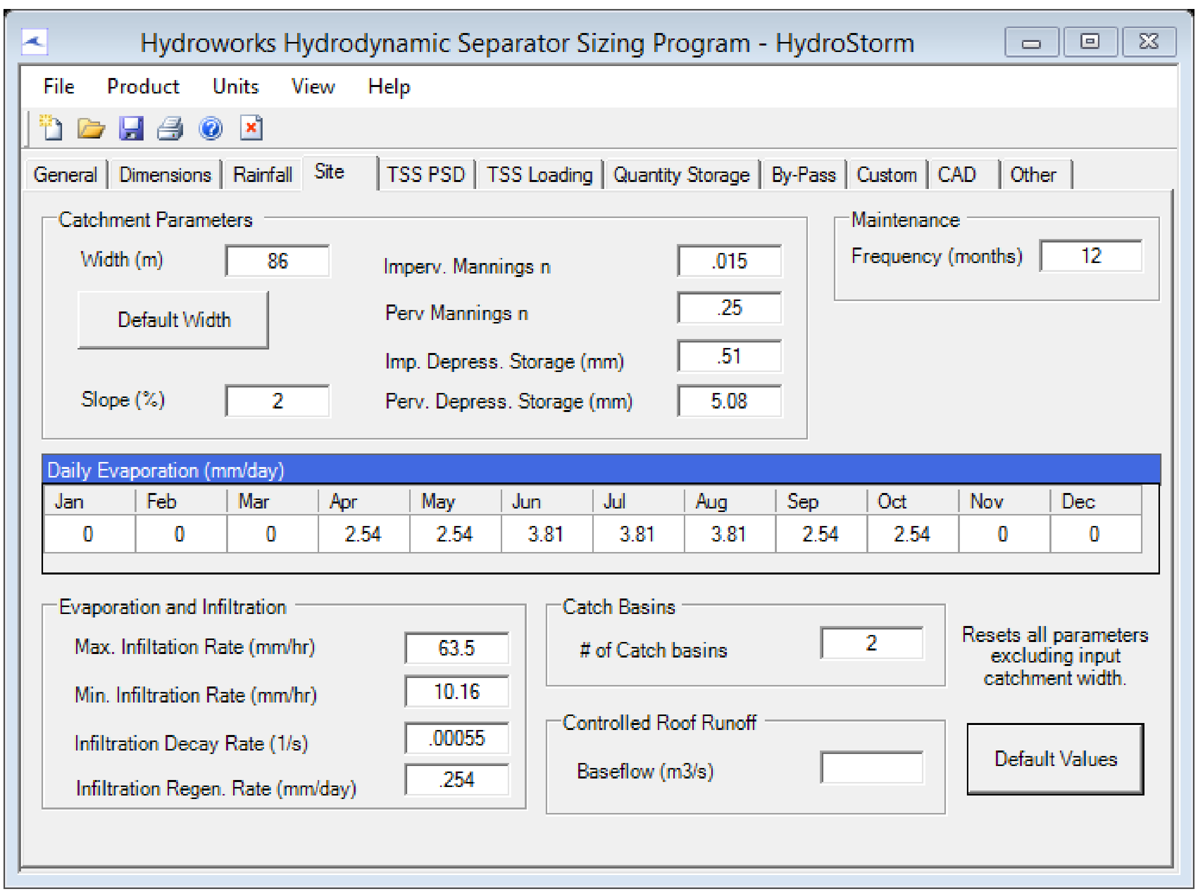
Water Temp (C) 20

You must select a particle size distribution for TSS to simulate TSS removal

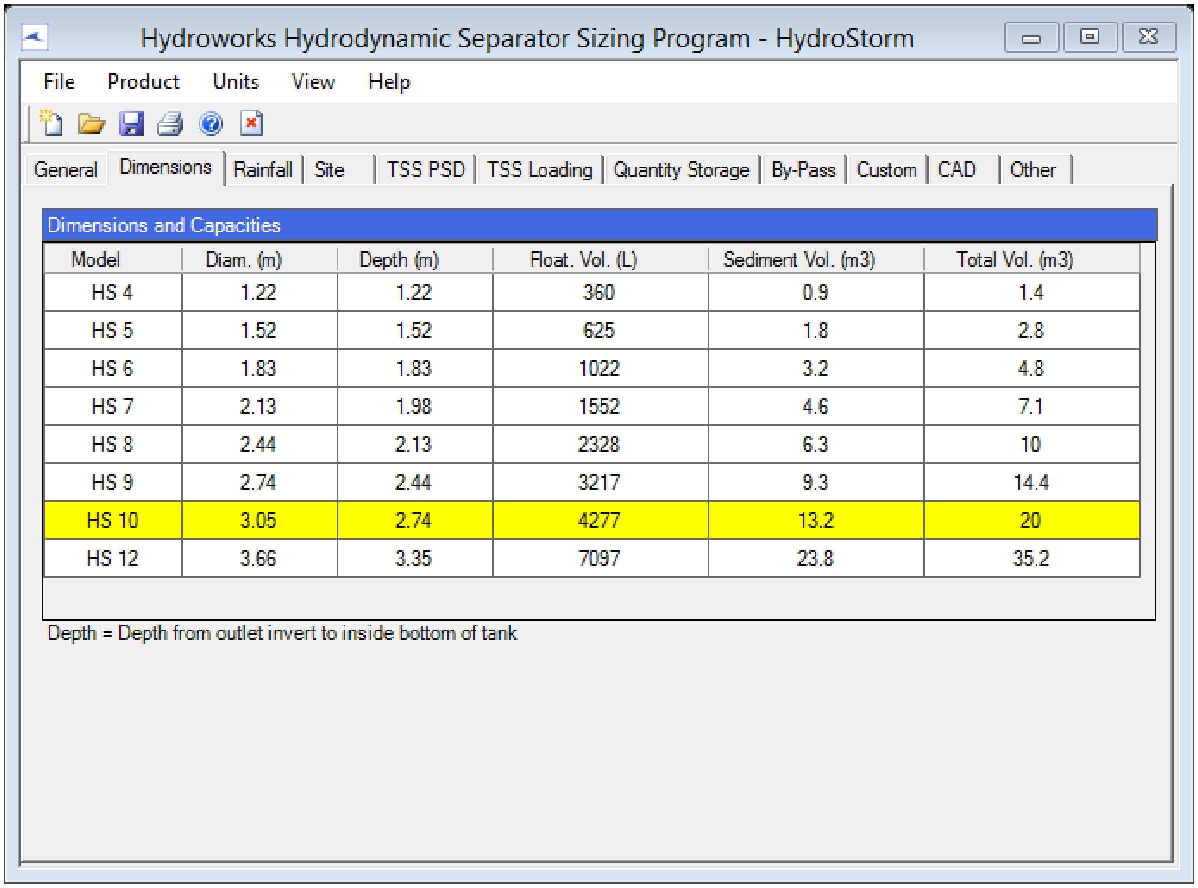
Rainfall Station - Hamilton Airport, Ontario(1970 to 2006)



Site Physical Characteristics



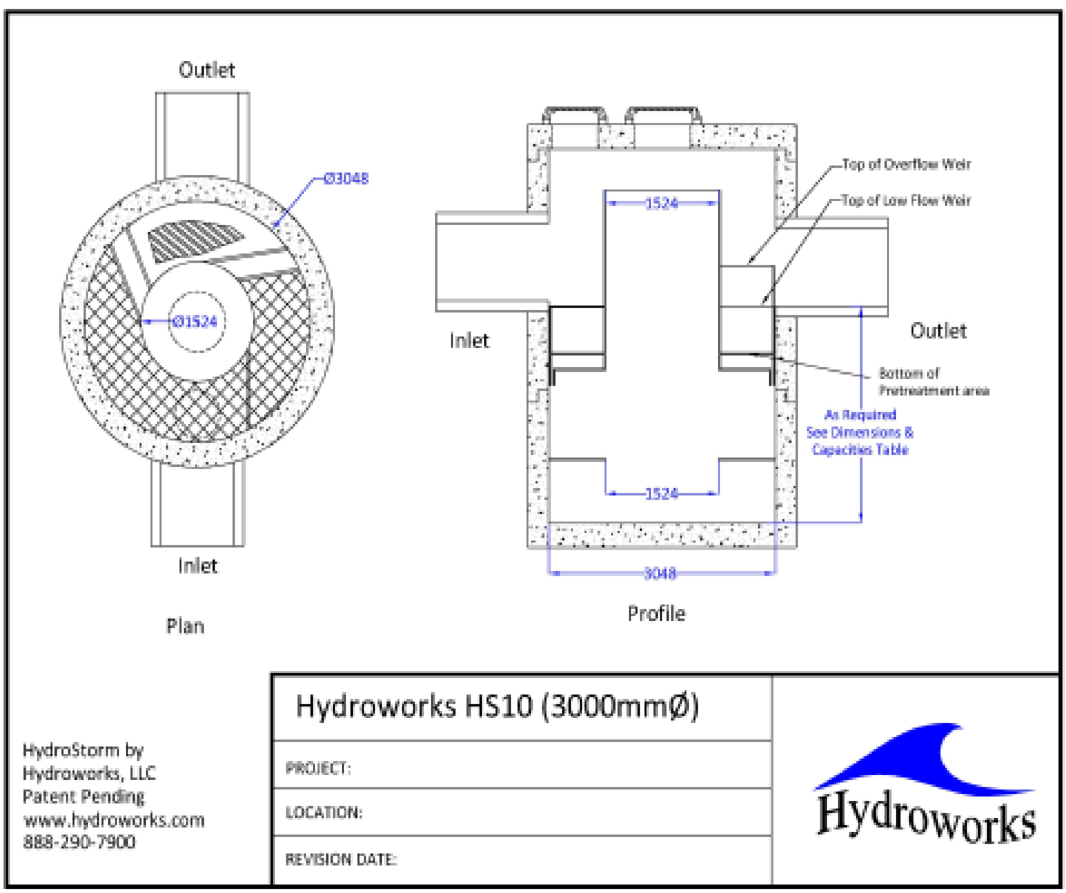
Dimensions And Capacities



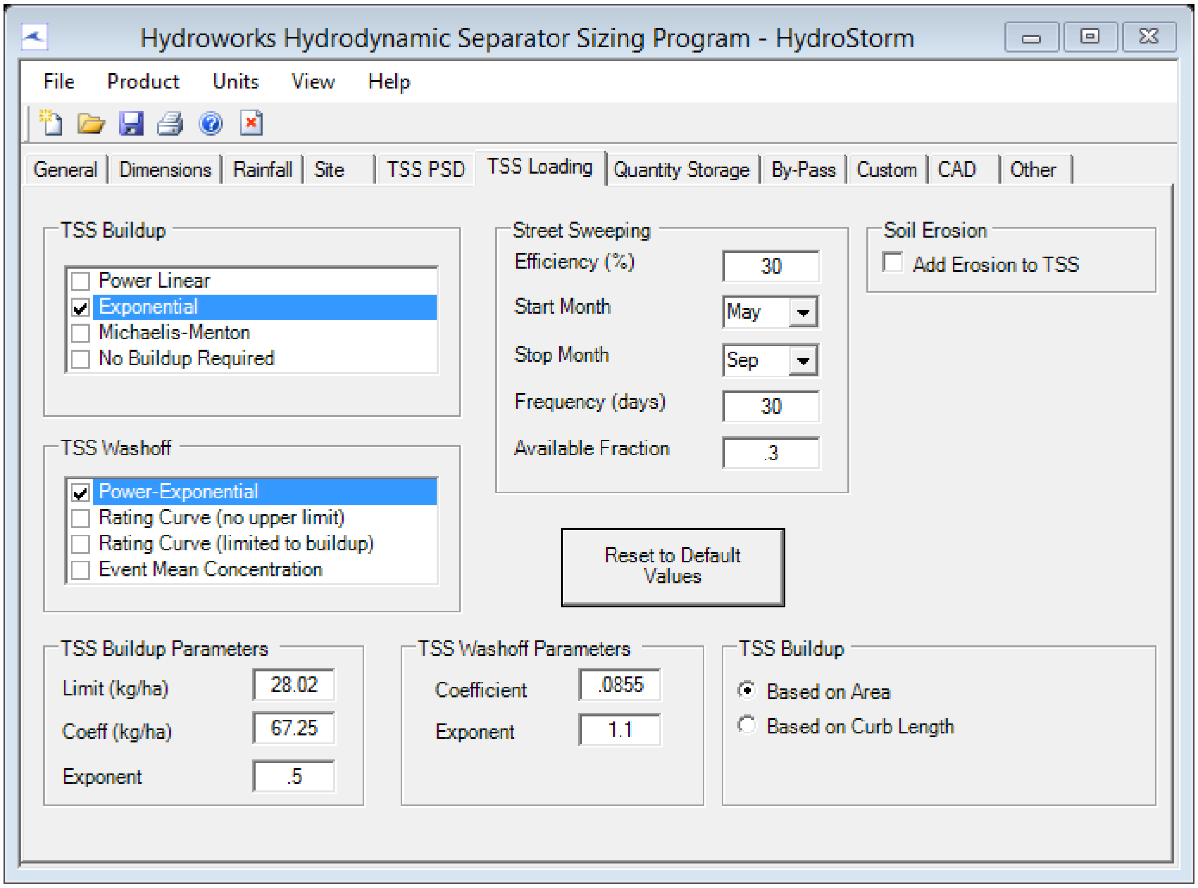
Model	Diam. (m)	Depth (m)	Float. Vol. (L)	Sediment Vol. (m3)	Total Vol. (m3)
HS 4	1.22	1.22	360	0.9	1.4
HS 5	1.52	1.52	625	1.8	2.8
HS 6	1.83	1.83	1022	3.2	4.8
HS 7	2.13	1.98	1552	4.6	7.1
HS 8	2.44	2.13	2328	6.3	10
HS 9	2.74	2.44	3217	9.3	14.4
HS 10	3.05	2.74	4277	13.2	20
HS 12	3.66	3.35	7097	23.8	35.2

Depth = Depth from outlet invert to inside bottom of tank

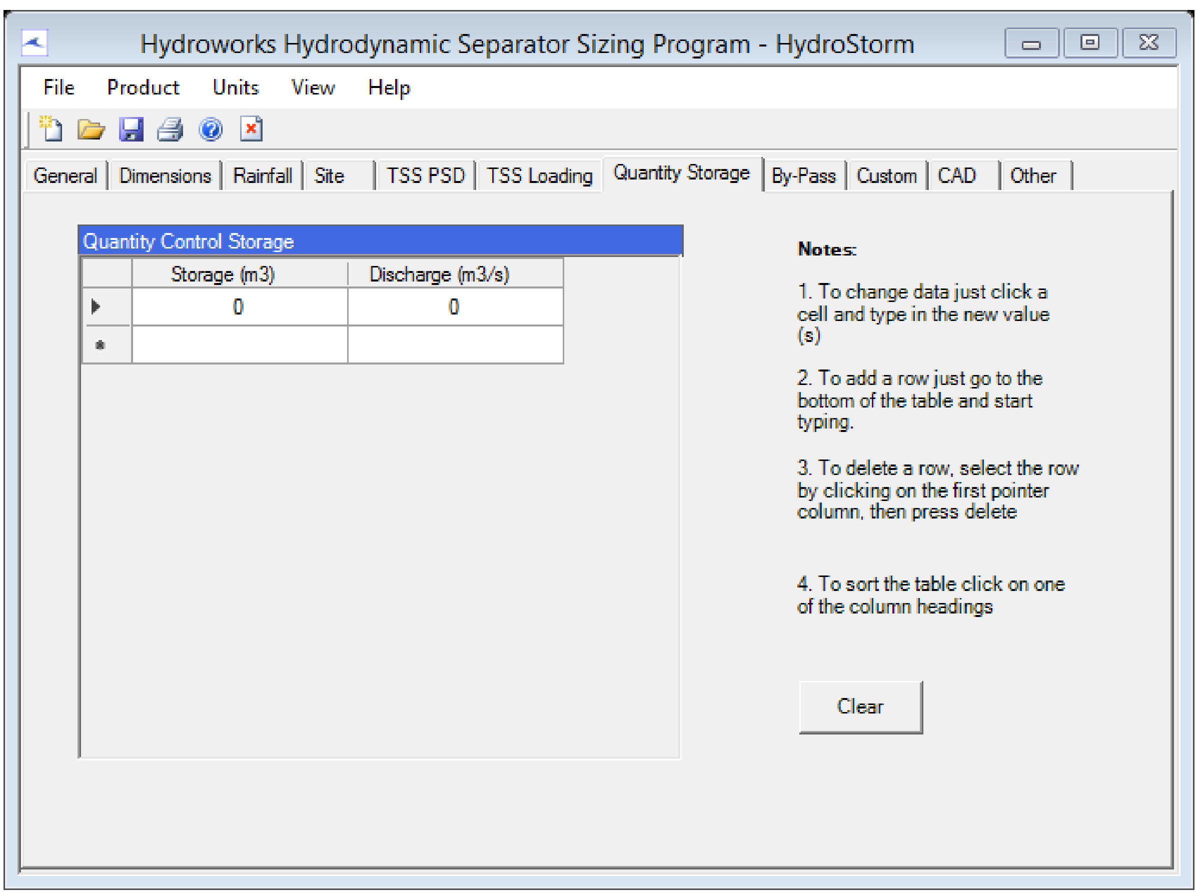
Generic HS 10 CAD Drawing



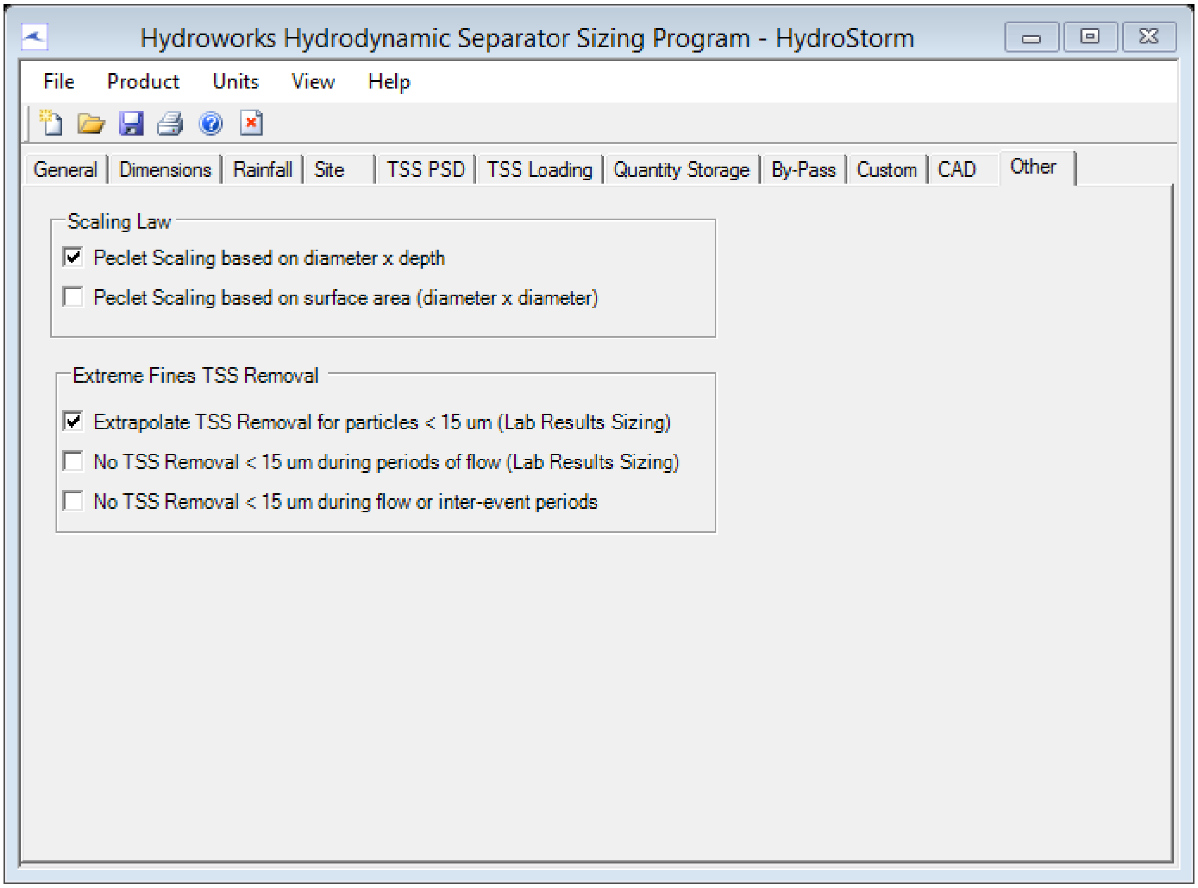
TSS Buildup And Washoff



Upstream Quantity Storage



Other Parameters



Hydroworks Sizing Program - Version 4.9

◆ Verification Statement ◆ Verification Statement ◆ Verification Statement ◆

VERIFICATION STATEMENT

GLOBE Performance Solutions

Verifies the performance of

Hydroworks® HydroStorm (HS) Hydrodynamic Separator

Developed by Hydroworks, LLC
Clark, NJ, USA

In accordance with

ISO 14034:2016

Environmental management — Environmental technology verification (ETV)

John D. Wiebe, PhD
Executive Chairman
GLOBE Performance Solutions

May 15, 2018
Vancouver, BC, Canada

GLOBE PERFORMANCE SOLUTIONS

Verification Body
GLOBE Performance Solutions
404 – 999 Canada Place | Vancouver, B.C | Canada |V6C 3E2

Technology description and application

The Hydroworks® HydroStorm (HS) Hydrodynamic Separator is a concrete cylindrical device with an annular pre-treatment channel, an inner chamber, and lower collection sump. A schematic of the HS 4 test unit is shown in Figure 1. The pre-treatment channel extends below the outlet pipe invert and contains three intermediate low-flow weirs (flush with the outlet invert), and two downstream higher bypass weirs that extend above the outlet invert. The higher weirs bypass high flows to prevent oil and solids from being scoured out of the separator.

As water enters the unit through one or more inlets, coarser solids immediately start to settle below a horizontal grate extending from the inlet to two sets of lower weirs near the outlet pipe. The grating is positioned over the pre-treatment channel to help displace the inflow turbulence and protect the captured sediment from scour. Openings are located on the horizontal plate upstream of each weir to allow the flow to be conveyed into the inner chamber and lower sump. The weirs are positioned to create a counter clockwise rotation of water in the inner chamber to minimize turbulence and maximize settling. After water spirals down the inner chamber to the main settling chamber towards the floor of the separator where it deposits suspended sediments, it flows upwards between the wall of the unit and the outer edge of the disk extended from the inner chamber and through an arced opening at the bottom of the pre-treatment disk, downstream of the bypass weirs, where it is conveyed into the outlet pipe. An annular secondary horizontal plate with 32% of open-perforations is located within the lower sump to protect the collected sediment from scour. Oil and light liquids enter the inner chamber through the holes, reaching the bottom of the pre-treatment area and rises to the top of the water level where they are trapped.

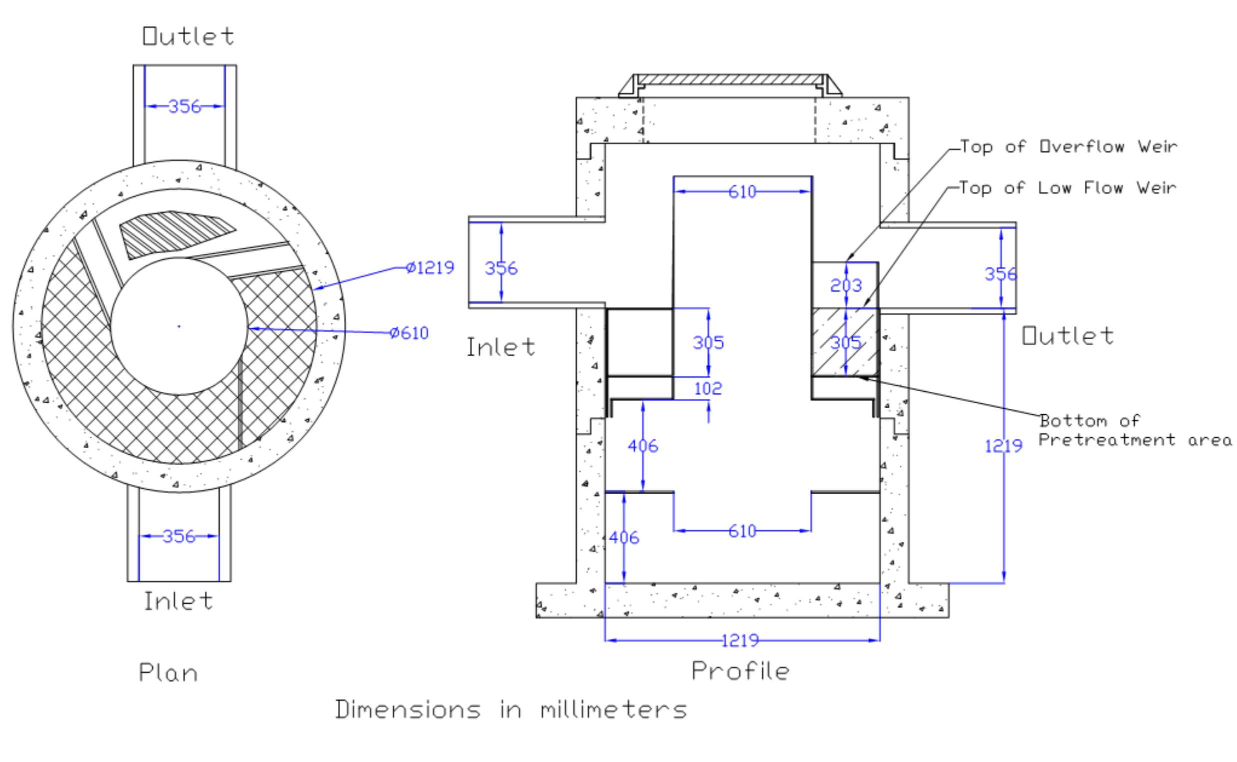


Figure 1: Schematic of the Hydroworks® HS4 Hydrodynamic Separator treatment unit tested as part of this verification.

Performance conditions

The data and results published in this Technology Fact Sheet were obtained from the testing program conducted on the Hydroworks® HS4 Hydrodynamic Separator, in accordance with the *Procedure for Laboratory Testing of Oil-Grit Separators (Version 3.0, June 2014)*. The Procedure was prepared by the Toronto and Region Conservation Authority (TRCA) for the Canadian Environmental Technology Verification Program. A copy of the Procedure may be accessed on the Canadian ETV website at www.etvcanada.ca.

Performance claim(s)

Capture test[1]:

During the capture test, the Hydroworks® HS Hydrodynamic Separator, with a false floor set to 50% of the manufacturer's recommended maximum sediment storage depth and a constant influent test sediment concentration of 200 mg/L, removes 69, 64, 60, 56, 46, 41, and 36 percent of influent sediment by mass at surface loading rates of 40, 80, 200, 400, 600, 1000, and 1400 L/min/m^2, respectively.

Scour test[1]:

During the scour test, the Hydroworks® HS Hydrodynamic Separator, with 10.2 cm (4 inches) of test sediment pre-loaded onto a false floor reaching 50% of the manufacturer's recommended maximum sediment sump storage depth and sediment loaded onto the pre-treatment channel emulating depositional pattern of the 40 L/min/m^2 capture test, generate corrected effluent concentrations of 22.4, 28.5, 20.0, 19.1, and 24.4 mg/L at 5-minute duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m^2, respectively.

Light liquid re-entrainment test[1]:

During the light liquid re-entrainment test, the Hydroworks® HS Hydrodynamic Separator with surrogate low-density polyethylene beads preloaded within the inner chamber, representing a floating light liquid volume equal to a depth of 50.8 mm over the sedimentation area, retains 100, 99.9, 95.4, 95.7, and 97.5 percent of loaded beads by mass during the 5-minute duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m^2, respectively.

Performance results

The test sediment consisted of ground silica (1 – 1000 micron) with a specific gravity of 2.65, uniformly mixed to meet the particle size distribution specified in the testing procedure. The *Procedure for Laboratory Testing of Oil Grit Separators* requires that the three sample average of the test sediment particle size distribution (PSD) meet the specified PSD percent less than values within a boundary threshold of 6%. The comparison of the average test sediment PSD to the CETV specified PSD in Figure 2indicates that the test sediment used for the capture and scour tests met this condition.

[1] The claim can be applied to other units smaller or larger than the tested unit as long as the untested units meet the scaling rule specified in the Procedure for Laboratory of Testing of Oil Grit Separators (Version 3.0, June 2014)

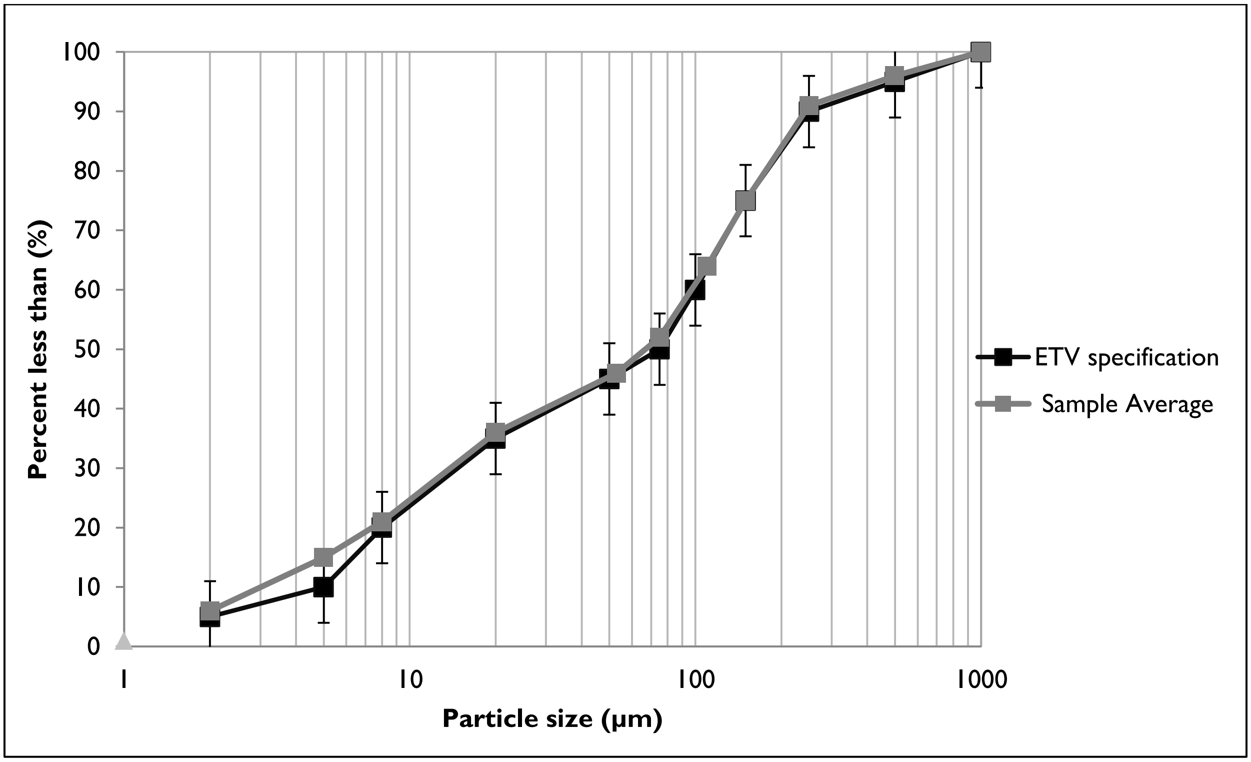


Figure 2. The three sample average particle size distribution (PSD) of the test sediment used for the capture and scour test compared to the specified PSD.

The capacity of the device to retain sediment was determined at seven surface loading rates using the modified mass balance method. This method involved measuring the mass and particle size distribution of the injected and retained sediment for each test run. Performance was evaluated with a false floor at 0.15 m from the bottom, simulating the technology filled to 50% of the manufacturer's recommended maximum sediment storage depth. The test was carried out with clean water that maintained a sediment concentration below 20 mg/L. Based on these conditions, removal efficiencies for individual particle size classes and for the test sediment as a whole were determined for each of the tested surface loading rates (Table 1).

In some instances, the removal efficiencies were above 100% for certain particle size fractions. These discrepancies are not unique to any one test laboratory and may be attributed to errors relating to the blending of sediment, collection of representative samples for laboratory submission, and laboratory analysis of PSD. Due to these errors, caution should be exercised in applying the removal efficiencies by particle size fraction for the purposes of sizing the tested device (see Bulletin # CETV 2016-11-0001). The results for "all particle sizes by mass balance" (see Table 1 and 2) are based on measurements of the total injected and retained sediment mass, and are therefore not subject to blending, sampling or PSD analysis errors.

Table 1. Removal efficiencies (%) of the HS4 unit at specified surface loading rates.

Particle size fraction (µm)	**Surface loading rate (L/min/m²)**						
	40	80	200	400	600	1000	1400
>500	73	100*	98	67	100*	100*	26
250 - 500	100	100*	92	64	100*	98	48
150 - 250	100*	75	89	72	89	60	69
105 - 150	94	100*	100*	100*	78	99	91
75 - 105	96	76	79	95	68	54	46
53 - 75	87	100*	100*	100*	56	69	65
20 - 53	71	54	46	44	19	14	10
8 - 20	38	23	15	8	2	2	2
5 – 8	13	6	1	1	0	0	0
<5	8	0	0	0	0	0	0
All particle sizes by mass balance	**68.6**	**64.0**	**60.0**	**56.1**	**46.1**	**41.2**	**35.7**

* Removal efficiencies were calculated to be above 100%. Calculated values ranged between 103 and 194% (average 128%). See text and Bulletin # CETV 2016-11-0001 for more information.

Figure 3 compares the particle size distribution (PSD) of the three sample average of the test sediment to the PSD of the sediment retained by the HS4 unit at each of the tested surface loading rates. As expected, the capture efficiency for fine particles in the unit was generally found to decrease as surface loading rates increased.

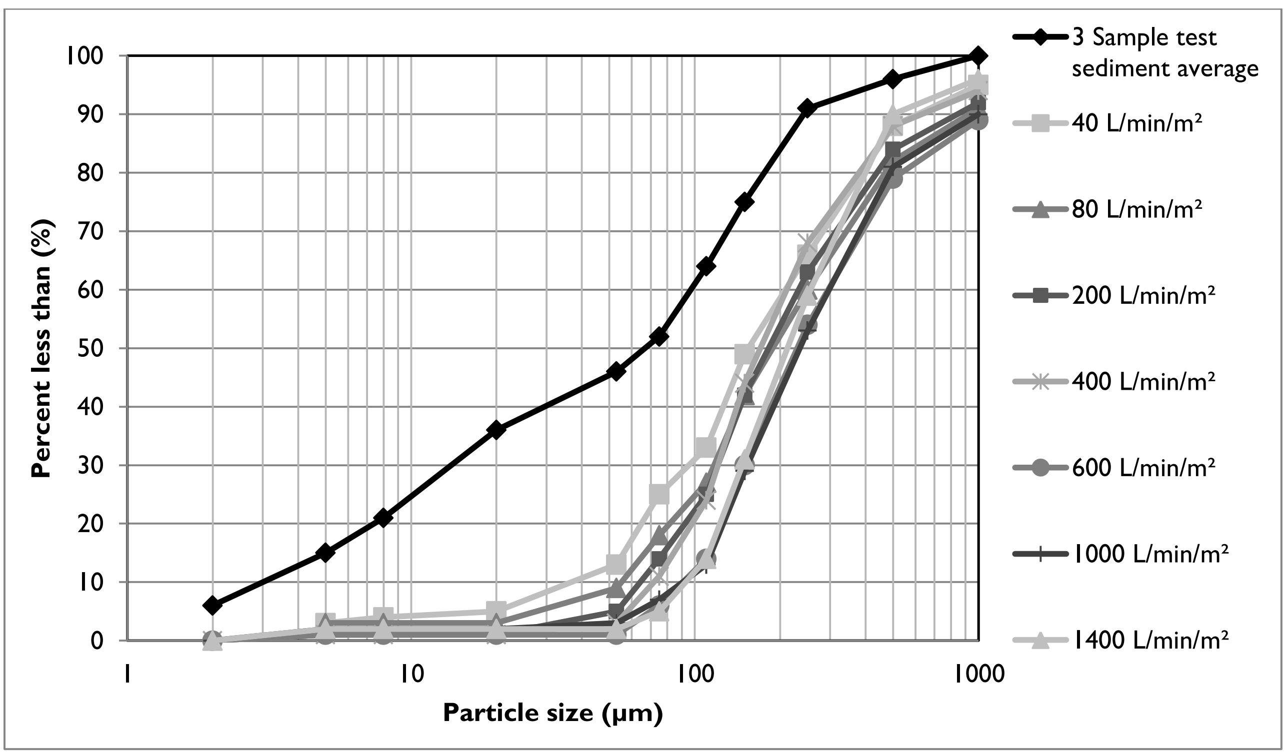


Figure 3. Particle size distribution of sediment retained in the HS4 unit in relation to the injected test sediment average.

For the sediment scour and re-suspension test, two tests were conducted. The first test was conducted with the secondary plate used in the capture tests. The second used a perforated secondary plate. Since sediment during the capture tests was found to settle in the pre-treatment channel, and in roughly the same quantities on the secondary plate and collection sump, all three of these surfaces were preloaded with sediment during the first test. The pre-treatment channel only captures coarse sediment. Therefore, this area was pre-loaded with sediment having a PSD similar to the PSD of the sediment that settled in this area during the 40 L/min/m^2 SLR sediment capture test. The pre-loaded sediment in the pre-treatment channel was shaped and leveled to correspond with sedimentation patterns and depths observed by the laboratory technician during the 40 L/min/m^2 SLR capture test. It should be noted that the actual sediment preloaded in this area was finer than the PSD of sediment captured in the same area during the 40 L/min/m^2 SLR capture test, particularly for particle sizes less than the median size. Both the sump and secondary plate were pre-loaded with the 1-1000 µm sediment mix to a depth of 10.2 cm. The preloaded sediment in the lower sump was placed on a false floor to mimic a device filled to 50% of the manufacturer's maximum recommended sediment storage depth.

After pre-loading the sediment, clean water was run through the device at five SLRs over a 25 minute period. At each SLR, five effluent samples were collected over a four minute interval (one per minute) with the first sample collected at the beginning of each flow rate, and the last collected just prior to the one minute transition to the next flow rate or end of the test. Effluent samples were analyzed for Suspended Sediment Concentration (SSC) and PSD by methods prescribed in the *Procedure*. The effluent samples were subsequently adjusted based on the background concentration of the influent water and the smallest 5% of particles captured during the 40 L/min/m^2 sediment capture test (7 um), as per the method described in Bulletin # CETV 2016-09-0001.

Measurements of sediment depths in the sump after the first test showed that most of the sediment from the secondary plate was carried into the lower sump. During this process, the fine sediment was likely re-suspended and carried out of the unit with the flow. The average adjusted effluent suspended sediment concentrations for each SLR ranged from 11.3 mg/L at the 200 L/min/m2 SLR to 196.7 mg/L at the 1400 L/min/m2 SLR. Effluent SSCs declined after the 1400 L/min/m2 SLR because the unit begins to bypass flow at this rate. It should be noted that this was a very conservative test as sediment was preloaded in three areas, rather than in the lower sump alone, and the preloaded sediment on the pre-treatment channel and secondary plate had a finer PSD than the sediment found to settle in these areas during the lowest SLR capture test.

The second sediment scour test was conducted on an identical unit but with a 32% open-area perforated secondary plate of the same size and orientation as the solid plate used in the first test. The perforated plate was intended to allow most of the sediment to settle in the lower sump, while still protecting against sediment scour, and not affecting the capacity of the unit to capture sediment. A second capture test was run at the 600 L/min/m^2 SLR to confirm that the perforated plate would have the same flow characteristics and removal efficiencies as the solid plate. Results of this comparison presented in Table 2 show that removal efficiencies were not affected and that the collection sump was receiving the majority of sediment transported into the lower chamber. Based on the observed sediment deposition zones, the second repeat test with the perforated plate had sediment preloaded in the pre-treatment channel and the lower collection sump only (*i.e.* the major deposition zones). The collection sump was preloaded with 10.2 cm of the 1- 1000 µm test sediment mix, as in the first test, and the pre-treatment channel was preloaded in much the same way as the first test, but with a sediment PSD that more closely mimicked the PSD of sediment observed to settle in this area during the 40 L/min/m^2 sediment capture test.

Table 2: Injected mass captured at the 600 L/min/m² SLR for two different configurations of the secondary plate

Secondary Plate type	Target Surface Loading Rate (L/min/m²)	Tested Flow Rate (L/min)	Removal Efficiency (%)	Pre-treatment Channel (%)	Secondary Plate (%)	Outlet Dispersion Plate (%)	Collection Sump (%)
Solid Plate	600	736.2	46.1	24.7	8.5	3.1	9.9
Perforated Plate	600	740.9	45.9	25.8	2.7	3.0	14.5

Results of the second test are presented in Table 3. Background concentrations were maintained below 10.5 mg/L. The average adjusted effluent suspended sediment concentrations ranged from 19.1 to 28.5 mg/L. Since the commercially available unit will have a perforated secondary plate, these concentrations are the appropriate values to consider for approvals. The verifier acknowledges that the sediment capture removal efficiencies were not all tested with the perforated plate (see variance notes below), but that the repeat test results at the 600 L/min/m² SLR and a statement from the independent test laboratory were sufficient to provide reasonable confidence that the added perforations in the secondary plate would have negligible influence on sediment removal efficiencies.

Table 3. Scour test adjusted effluent sediment concentrations

Run	Surface loading rate (L/min/m²)	Run time (min)	Background sample concentration (mg/L)[a]	Average adjusted effluent suspended sediment concentration (mg/L)[b]
1	200	5	3.6	22.4
2	800	5	8.9	28.5
3	1400	5	7.6	20.0
4	2000	5	10.4	19.1
5	2600	5	6.0	24.4

[a] Background concentrations shown here are approximate values based on graphical interpolation

[b] The adjusted effluent suspended sediment concentration represents the actual measured effluent concentration minus the background concentration. For more information see Bulletin # CETV 2016-09-0001. Adjusted concentrations were only calculated for the average of the five samples collected per surface loading rate.

The results of the light liquid re-entrainment test used to evaluate the unit's capacity to prevent re-entrainment of light liquids are reported in Table 4. The test involved preloading 58.3 L (corresponding to a 5 cm depth over the collection sump area of 1.17m²) of surrogate low-density polyethylene beads (Dow Chemical Dowlex™ 2517) within the inner chamber and running clean water through the device continuously at five surface loading rates (200, 800, 1400, 2000, and 2600 L/min/m²). Each flow rate was maintained for 5 minutes with approximately 1 minute transition time between flow rates (30 minutes total). The effluent flow was screened to capture all re-entrained pellets throughout the test. Results showed maximum re-entrainment of 4.6% at 1400 L/min/m², which is the highest SLR without bypass. Re-entrainment decreased at subsequent SLRs as bypass volumes increased.

Table 4. Light liquid re-entrainment test results for the HS4

Surface Loading Rate (L/min/m²)	Time Stamp (min)	Amount of Beads Re-entrained			
		Mass (g)	Volume (L)	% of Pre-loaded Mass Re-entrained	% of Pre-loaded Mass Retained
200	1:00 – 6:00	0	0	0.00	100
800	7:00 – 12:00	49	0.1	0.1	99.9
1400	13:00 – 18:00	1523	2.7	4.6	95.4
2000	19:00 – 24:00	1445	2.5	4.3	95.7
2600	25:00 – 30:00	847	1.5	2.5	97.5
Interim Collection Net		39	0.1	0.1	99.9
Total Re-entrained		3902	6.8	11.7	--
Total Retained		29,497	51.5	--	88.3
Total Loaded		33,399	58.3	--	--

Variances from testing Procedure

The following deviations from the *Procedure for Laboratory Testing of Oil-Grit Separators* (Version 3.0, June 2014) have been noted:

1. The Procedure stipulates that the tested device "must be a full scale, commercially available device with the same configuration and components that would be typical for an actual installation." As noted above, the sediment capture tests were conducted with a solid secondary plate. The solid secondary plate was later modified to a 32% open area perforated plate to reduce sediment settling on the plate, while continuing to provide scour prevention. As described above, the scour test was repeated with the perforated secondary plate, but the sediment capture test was only repeated at the 600 L/min/m² SLR (i.e. one of seven tested SLRs). Removal efficiency results for the repeat test showed very close correspondence with the earlier test using the solid plate and much of the sediment that previously settled on the secondary plate was deposited in the lower collection sump (see Table 2). The independent laboratory provided the following statement regarding the potential for the added perforations to affect sediment removal efficiencies: "Taking into account the close proximity of the plate to the collection sump, as well as our knowledge of sediment transport, it is expected that the deposited sediment would have settled in the lower sump, with no impact on removal efficiency, if the plate was removed." While the verifier acknowledges that stronger evidence would have been provided by additional repeat testing at a lower and higher SLR, the close correlation between the original and repeat test, combined with the statement from the lab were sufficient to provide reasonable confidence that adding the perforations would not likely have changed the capture test results significantly.

2. The repeat test at the 600 L/min/m² SLR had background concentrations exceeding the 20 mg/L threshold during the last half of the test. The exceedances occurred in 4 of the 8 samples collected, reaching a maximum of 28.4 mg/L. The experimental apparatus is a closed loop system. Therefore, the sediment in the background samples consists of fine particles not captured by the device, and would therefore not likely bias the mass balance results.

3. It was necessary to change flow meters during the sediment scour and light liquid re-entrainment test, as the required flows exceeded the minimum and/or maximum range of any single meter. When the flow capacity of the selected meter was reached, the flow was shut down over a period of approximately 10 seconds and all flow data saved. The next data acquisition file was executed and flow increased at a rate that corresponded to reaching each previous target flow after a period of 1-minute. This procedure was approved by CETV prior to testing, in recognition that most particles susceptible to scour at low flows would not be in the sump at higher flows. Similarly, re-entrainment of the oil beads was not expected to be significantly affected by the flow meter change.

4. As part of the capture test, evaluation of the 40 and 80 L/min/m^2 surface loading rate was split into 3 and 2 parts, respectively, due to the long duration needed to feed the required minimum of 11.3 kg of test sediment into the unit. At the end of the first and second parts of the test, the flow rates were gradually shutdown to prevent capture of particles that would have been washed out under normal circumstances. The amended procedure was reviewed and approved by the verifier prior to testing.

Verification

The verification was completed by the Verification Expert, Toronto and Region Conservation Authority, contracted by GLOBE Performance Solutions, using the International Standard ***ISO 14034:2016 Environmental management -- Environmental technology verification (ETV)***. Data and information provided by Hydroworks, LLC to support the performance claim included the following: Performance test report prepared by Alden Research Laboratory, Inc., and dated February 2018. This report is based on testing completed in accordance with the *Procedure for Laboratory Testing of Oil-Grit Separators* (Version 3.0, June 2014).

What is ISO14034:2016 Environmental management – Environmental technology verification (ETV)?

ISO 14034:2016 specifies principles, procedures and requirements for environmental technology verification (ETV), and was developed and published by the *International Organization for Standardization (ISO)*. The objective of ETV is to provide credible, reliable and independent verification of the performance of environmental technologies. An environmental technology is a technology that either results in an environmental added value or measures parameters that indicate an environmental impact. Such technologies have an increasingly important role in addressing environmental challenges and achieving sustainable development.

For more information on the Hydroworks® HS Hydrodynamic Separator please contact:

Hydroworks, LLC
136 Central Ave., 2nd FL
Clark, NJ
07066 USA
Tel: 888-290-7900
Email: info@hydroworks.com
www.hydroworks.com

For more information on ISO 14034:2016 / ETV please contact:

GLOBE Performance Solutions
404 – 999 Canada Place
Vancouver, BC
V6C 3E2 Canada
Tel: 604-695-5018 / Toll Free: 1-855-695-5018
etv@globeperformance.com
www.globeperformance.com

Hydroworks® HydroStorm

Operations & Maintenance Manual

Version 1.0

Please call Hydroworks at 888-290-7900 or email us at support@hydroworks.com if you have any questions regarding the Inspection Checklist. Please fax a copy of the completed checklist to Hydroworks at 888-783-7271 for our records.

Introduction

The HydroStorm is a state of the art hydrodynamic separator. Hydrodynamic separators remove solids, debris and lighter than water (oil, trash, floating debris) pollutants from stormwater. Hydrodynamic separators and other water quality measures are mandated by regulatory agencies (Town/City, State, Federal Government) to protect storm water quality from pollution generated by urban development (traffic, people) as part of new development permitting requirements.

As storm water treatment structures fill up with pollutants they become less and less effective in removing new pollution. Therefore, it is important that storm water treatment structures be maintained on a regular basis to ensure that they are operating at optimum performance. The HydroStorm is no different in this regard and this manual has been assembled to provide the owner/operator with the necessary information to inspect and coordinate maintenance of their HydroStorm.

Hydroworks® HydroStorm Operation

The Hydroworks HydroStorm (HS) separator is a unique hydrodynamic by-pass separator. It incorporates a protected submerged pretreatment zone to collect larger solids, a treatment tank to remove finer solids, and a dual set of weirs to create a high flow bypass. High flows are conveyed directly to the outlet and do not enter the treatment area, however, the submerged pretreatment area still allows removal of coarse solids during high flows.

Under normal or low flows, water enters an inlet area with a horizontal grate. The area underneath the grate is submerged with openings to the main treatment area of the separator. Coarse solids fall through the grate and are either trapped in the pretreatment area or conveyed into the main treatment area depending on the flow rate. Fines are transported into the main treatment area. Openings and weirs in the pretreatment area allow entry of water and solids into the main treatment area and cause water to rotate in the main treatment area creating a vortex motion. Water in the main treatment area is forced to rise along the walls of the separator to discharge from the treatment area to the downstream pipe.

The vortex motion forces solids and floatables to the middle of the inner chamber. Floatables are trapped since the inlet to the treatment area is submerged. The design maximizes the retention of settled solids since solids are forced to the center of the inner chamber by the vortex motion of water while water must flow up the walls of the separator to discharge into the downstream pipe.

A set of high flow weirs near the outlet pipe create a high flow bypass over both the pretreatment area and main treatment chamber. The rate of flow into the treatment area is regulated by the number and size of openings into the treatment chamber and the height of by-pass weirs. High flows flow over the weirs directly to the outlet pipe preventing the scour and resuspension of any fines collected in the treatment chamber.

A central access tube is located in the structure to provide access for cleaning. The arrangement of the inlet area and bypass weirs near the outlet pipe facilitate the use of multiple inlet pipes.

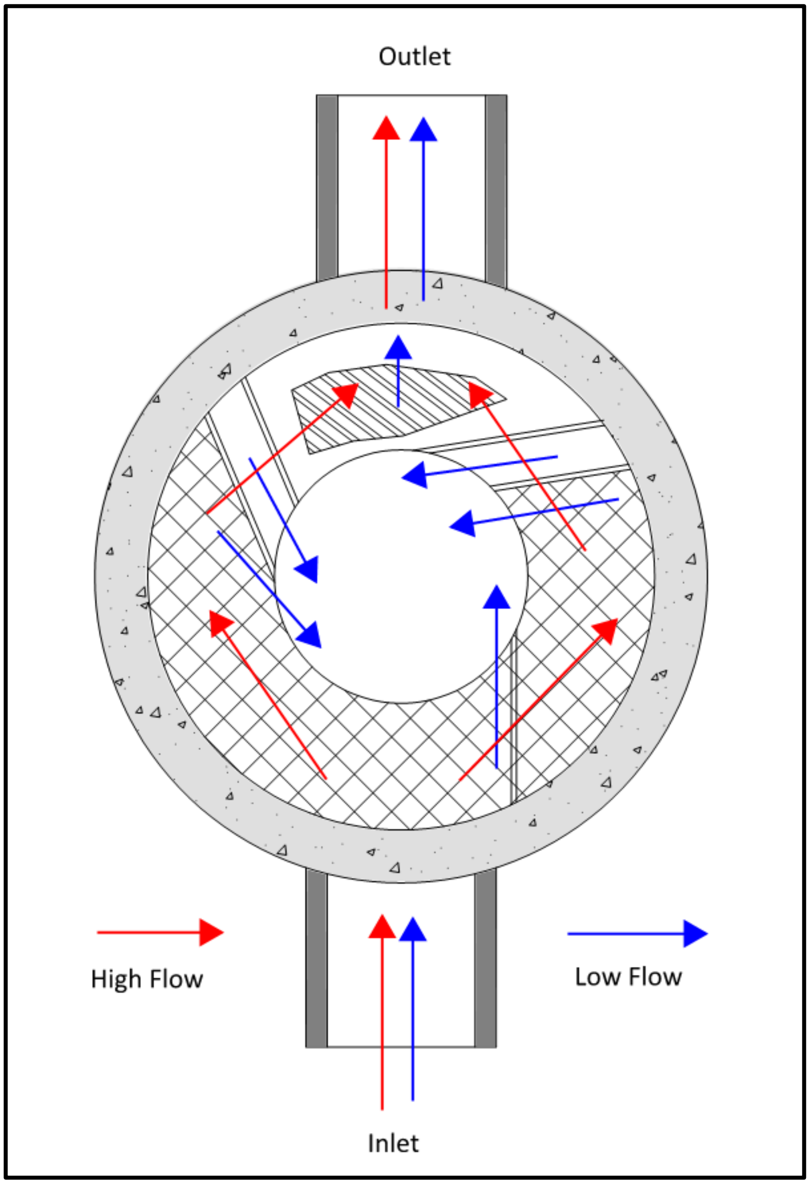


Figure 1. Hydroworks HydroStorm Operation – Plan View

Figure 2 is a profile view of the HydroStorm separator showing the flow patterns for low and high flows.

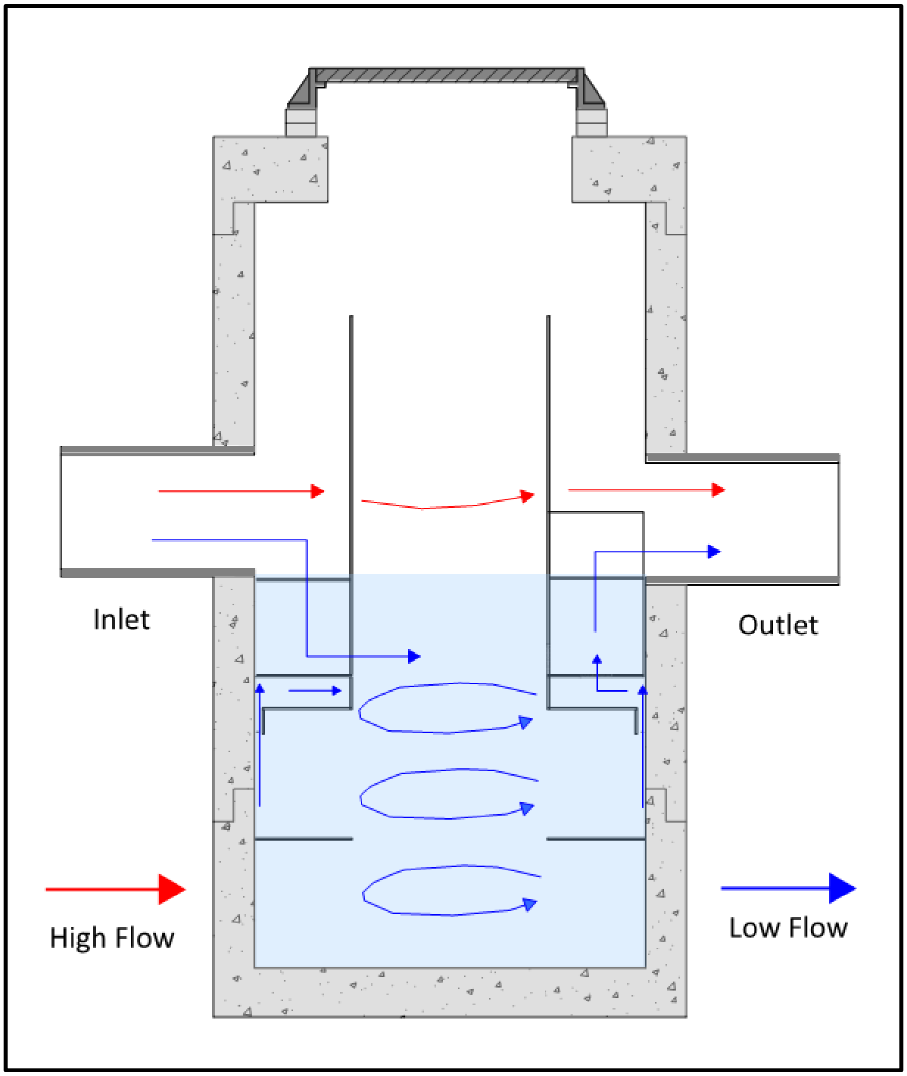


Figure 2. Hydroworks HydroStorm Operation – Profile View

The HS 4i is an inlet version of the HS 4 separator. There is a catch-basin grate on top of the HS 4i. A funnel sits sits underneath the grate on the frame and directs the water to the inlet side of the separator to ensure all lows flows are properly treated. The whole funnel is removed for inspection and cleaning.

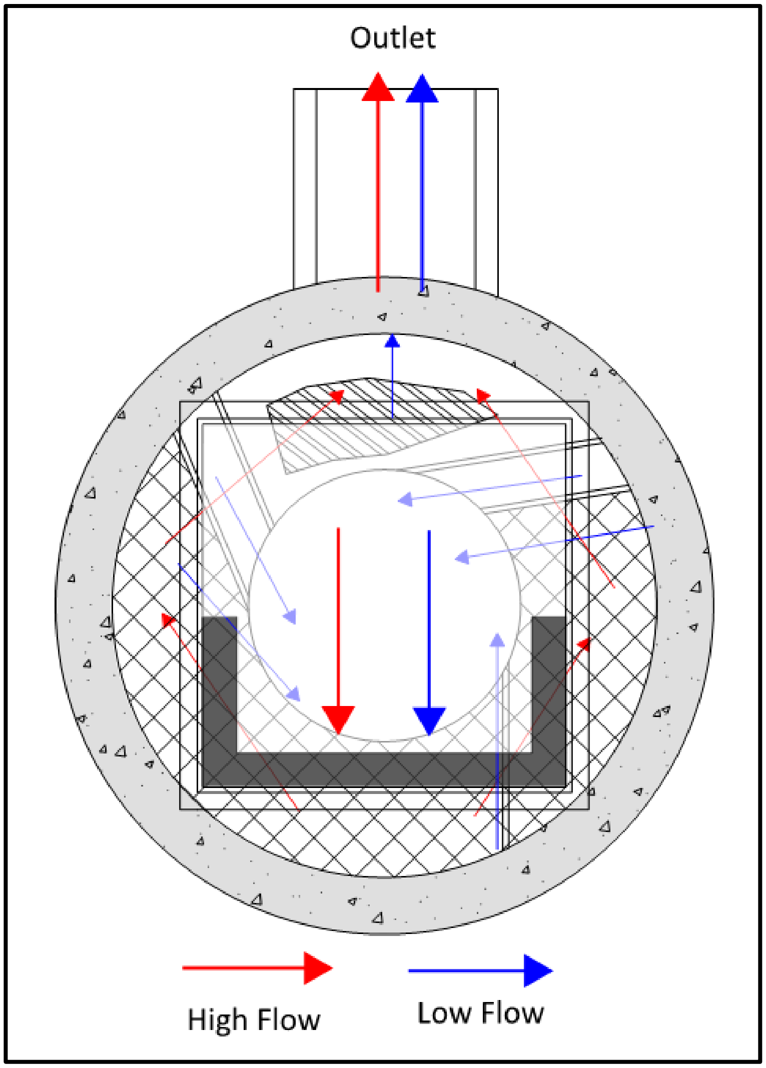


Figure 3. Hydroworks HS 4i Funnel

Inspection

Procedure

Floatables

A visual inspection can be conducted for floatables by removing the covers and looking down into the center access tube of the separator. Separators with an inlet grate (HS 4i or custom separator) will have a plastic funnel located under the grate that must be removed from the frame prior to inspection or maintenance. If you are missing a funnel please contact Hydroworks at the numbers provided at the end of this document.

TSS/Sediment

Inspection for TSS build-up can be conducted using a Sludge Judge®, Core Pro®, AccuSludge® or equivalent sampling device that allows the measurement of the depth of TSS/sediment in the unit. These devices typically have a ball valve at the bottom of the tube that allows water and TSS to flow into the tube when lowering the tube into the unit. Once the unit touches the bottom of the device, it is quickly pulled upward such that the water and TSS in the tube forces the ball valve closed allowing the user to see a full core of water/TSS in the unit. The unit should be inspected for TSS through each of the access covers. Several readings (2 or 3) should be made at each access cover to ensure that an accurate TSS depth measurement is recorded.

Frequency

Construction Period

The HydroStorm separator should be inspected every four weeks and after every large storm (over 0.5” (12.5 mm) of rain) during the construction period.

Post-Construction Period

The Hydroworks HydroStorm separator should be inspected during the first year of operation for normal stabilized sites (grassed or paved areas). If the unit is subject to oil spills or runoff from unstabilized (storage piles, exposed soils) areas the HydroStorm separator should be inspected more frequently (4 times per year). The initial annual inspection will indicate the required future frequency of inspection and maintenance if the unit was maintained after the construction period.

Reporting

Reports should be prepared as part of each inspection and include the following information:

1. Date of inspection
2. GPS coordinates of Hydroworks unit
3. Time since last rainfall
4. Date of last inspection
5. Installation deficiencies (missing parts, incorrect installation of parts)
6. Structural deficiencies (concrete cracks, broken parts)
7. Operational deficiencies (leaks, blockages)
8. Presence of oil sheen or depth of oil layer
9. Estimate of depth/volume of floatables (trash, leaves) captured
10. Sediment depth measured
11. Recommendations for any repairs and/or maintenance for the unit
12. Estimation of time before maintenance is required if not required at time of inspection

A sample inspection checklist is provided at the end of this manual.

Maintenance

Procedure

The Hydroworks HydroStorm unit is typically maintained using a vacuum truck. There are numerous companies that can maintain the HydroStorm separator. Maintenance with a vacuum truck involves removing all of the water and sediment together. The water is then separated from the sediment on the truck or at the disposal facility.

A central access opening (24" or greater) is provided to the gain access to the lower treatment tank of the unit. This is the primary location to maintain by vacuum truck. The pretreatment area can also be vacuumed and/or flushed into the lower treatment tank of the separator for cleaning via the central access once the water level is lowered below the pretreatment floor.

In instances where a vacuum truck is not available other maintenance methods (i.e. clamshell bucket) can be used, but they will be less effective. If a clamshell bucket is used the water must be decanted prior to cleaning since the sediment is under water and typically fine in nature. Disposal of the water will depend on local requirements. Disposal options for the decanted water may include:

1. Discharge into a nearby sanitary sewer manhole
2. Discharge into a nearby LID practice (grassed swale, bioretention)
3. Discharge through a filter bag into a downstream storm drain connection

The local municipality should be consulted for the allowable disposal options for both water and sediments prior to any maintenance operation. Once the water is decanted the sediment can be removed with the clamshell bucket.

Disposal of the contents of the separator depend on local requirements. Maintenance of a Hydroworks HydroStorm unit will typically take 1 to 2 hours based on a vacuum truck and longer for other cleaning methods (i.e. clamshell bucket).

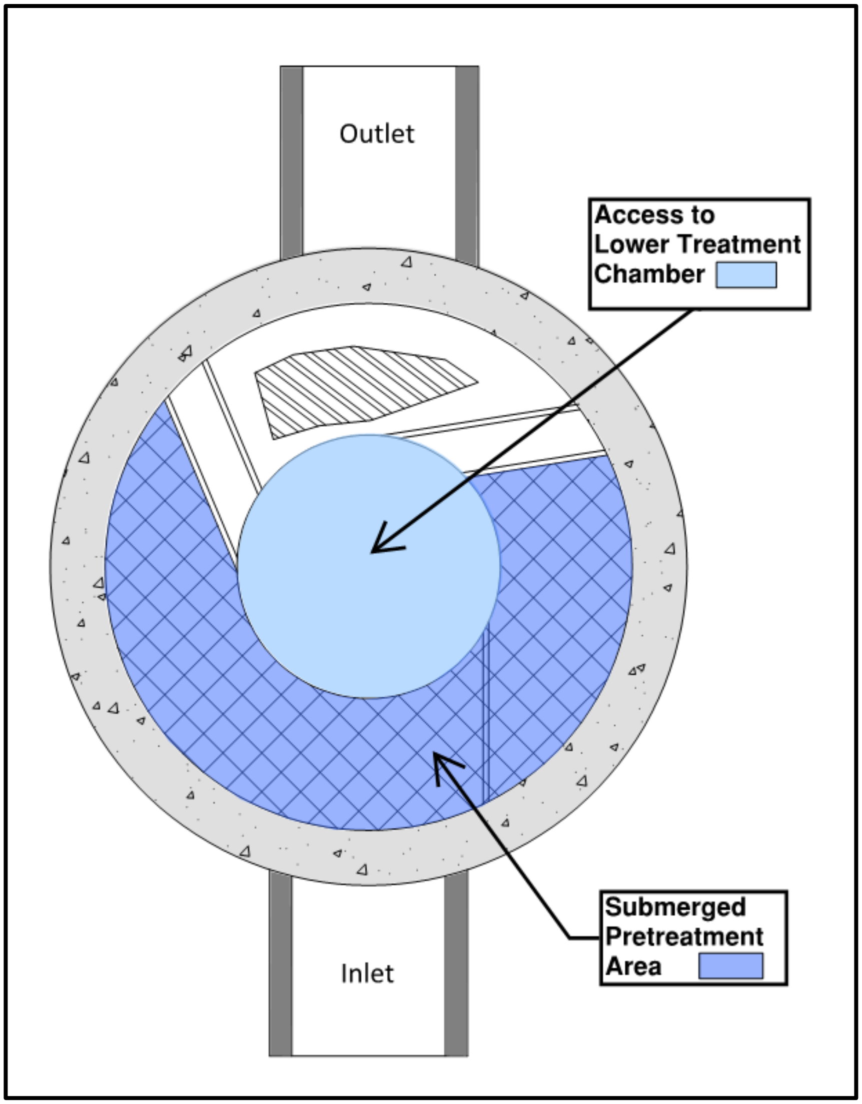


Figure 3. Maintenance Access

Frequency

Construction Period

A HydroStorm separator can fill with construction sediment quickly during the construction period. The HydroStorm must be maintained during the construction period when the depth of TSS/sediment reaches 24” (600 mm). It must also be maintained during the construction period if there is an appreciable depth of oil in the unit (more than a sheen) or if floatables other than oil cover over 50% of the area of the separator

The HydroStorm separator should be maintained at the end of the construction period, prior to operation for the post-construction period.

Post-Construction Period

The HydroStorm was independently tested by Alden Research Laboratory in 2017. A HydroStorm HS 4 was tested for scour with a 50% sediment depth of 0.5 ft. Therefore, maintenance for sediment accumulation is required if the depth of sediment is 1 ft or greater in separators with standard water (sump) depths (Table 1).

There will be designs with increased sediment storage based on specifications or site-specific criteria. A measurement of the total water depth in the separator through the central access tube should be taken and compared to water depth given in Table 1. The standard water depth from Table 1 should be subtracted from the measured water depth and the resulting extra depth should be added to the 1 ft to determine the site-specific sediment maintenance depth for that separator.

For example, if the measured water depth in the HS-7 is 7 feet, then the sediment maintenance depth for that HS-7 is 2 ft (= 1 + 7 – 6) and the separator does not need to be cleaned for sediment accumulation until the measure sediment depth is 2 ft.

The HydroStorm separator must also be maintained if there is an appreciable depth of oil in the unit (more than a sheen) or if floatables other than oil cover over 50% of the water surface of the separator.

Table 1 Standard Dimensions for Hydroworks HydroStorm Models

Model	Diameter (ft)	Total Water Depth (ft)	Sediment Maintenance Depth for Table 1 Total Water Depth(ft)
HS-3	3	3	1
HS-4	4	4	1
HS-5	5	4	1
HS-6	6	4	1
HS-7	7	6	1
HS-8	8	7	1
HS-9	9	7.5	1
HS-10	10	8	1
HS-11	11	9	1
HS-12	12	9.5	1

HYDROSTORM INSPECTION SHEET

Date ______________________________

Date of Last Inspection ______________________________

Site ______________________________

City ______________________________

State ______________________________

Owner ______________________________

GPS Coordinates ______________________________

Date of last rainfall ______________________________

Site Characteristics	**Yes**	**No**
Soil erosion evident	☐	☐
Exposed material storage on site	☐	☐
Large exposure to leaf litter (lots of trees)	☐	☐
High traffic (vehicle) area	☐	☐

HydroStorm	**Yes**	**No**
Obstructions in the inlet or outlet	☐ *	☐
Missing internal components	☐ **	☐
Improperly installed inlet or outlet pipes	☐ ***	☐
Internal component damage (cracked, broken, loose pieces)	☐ **	☐
Floating debris in the separator (oil, leaves, trash)	☐	☐
Large debris visible in the separator	☐ *	☐
Concrete cracks/deficiencies	☐ ***	☐
Exposed rebar	☐ **	☐
Water seepage (water level not at outlet pipe invert)	☐ ***	☐
Water level depth below outlet pipe invert ________ "		

Routine Measurements				
Floating debris depth	**< 0.5" (13mm)**	☐	**>0.5" 13mm)**	☐ *
Floating debris coverage	**< 50% of surface area**	☐	**> 50% surface area**	☐ *
Sludge depth	**< 12" (300mm)**	☐	**> 12" (300mm)**	☐ *****

* Maintenance required

** Repairs required

*** Further investigation is required

Hydroworks

Other Comments:

Hydroworks

Hydroworks® HydroStorm

One Year Limited Warranty

Hydroworks, LLC warrants, to the purchaser and subsequent owner(s) during the warranty period subject to the terms and conditions hereof, the Hydroworks HydroStorm to be free from defects in material and workmanship under normal use and service, when properly installed, used, inspected and maintained in accordance with Hydroworks written instructions, for the period of the warranty. The standard warranty period is 1 year.

The warranty period begins once the separator has been manufactured and is available for delivery. Any components determined to be defective, either by failure or by inspection, in material and workmanship will be repaired, replaced or remanufactured at Hydroworks' option provided, however, that by doing so Hydroworks, LLC will not be obligated to replace an entire insert or concrete section, or the complete unit. This warranty does not cover shipping charges, damages, labor, any costs incurred to obtain access to the unit, any costs to repair/replace any surface treatment/cover after repair/replacement, or other charges that may occur due to product failure, repair or replacement.

This warranty does not apply to any material that has been disassembled or modified without prior approval of Hydroworks, LLC, that has been subjected to misuse, misapplication, neglect, alteration, accident or act of God, or that has not been installed, inspected, operated or maintained in accordance with Hydroworks, LLC instructions and is in lieu of all other warranties expressed or implied. Hydroworks, LLC does not authorize any representative or other person to expand or otherwise modify this limited warranty.

The owner shall provide Hydroworks, LLC with written notice of any alleged defect in material or workmanship including a detailed description of the alleged defect upon discovery of the defect. Hydroworks, LLC should be contacted at 136 Central Ave., Clark, NJ 07066 or any other address as supplied by Hydroworks, LLC. (888-290-7900).

This limited warranty is exclusive. There are no other warranties, express or implied, or merchantability or fitness for a particular purpose and none shall be created whether under the uniform commercial code, custom or usage in the industry or the course of dealings between the parties. Hydroworks, LLC will replace any goods that are defective under this warranty as the sole and exclusive remedy for breach of this warranty.

Subject to the foregoing, all conditions, warranties, terms, undertakings or liabilities (including liability as to negligence), expressed or implied, and howsoever arising, as to the condition, suitability, fitness, safety, or title to the Hydroworks HydroStorm are hereby negated and excluded and Hydroworks, LLC gives and makes no such representation, warranty or undertaking except as expressly set forth herein. Under no circumstances shall Hydroworks, LLC be liable to the Purchaser or to any third party for product liability claims; claims arising from the design, shipment, or installation of the HydroStorm, or the cost of other goods or services related to the purchase and installation of the HydroStorm. For this Limited Warranty to apply, the HydroStorm must be installed in accordance with all site conditions required by state and local codes; all other applicable laws; and Hydroworks' written installation instructions.

Hydroworks, LLC expressly disclaims liability for special, consequential or incidental damages (even if it has been advised of the possibility of the same) or breach of expressed or implied warranty. Hydroworks, LLC shall not be liable for penalties or liquidated damages, including loss of production and profits; labor and materials; overhead costs; or other loss or expense incurred by the purchaser or any third party. Specifically excluded from limited warranty coverage are damages to the HydroStorm arising from ordinary wear and tear; alteration, accident, misuse, abuse or neglect; improper maintenance, failure of the product due to improper installation of the concrete sections or improper sizing; or any other event not caused by Hydroworks, LLC. This limited warranty represents Hydroworks' sole liability to the purchaser for claims related to the HydroStorm, whether the claim is based upon contract, tort, or other legal basis.

VERIFICATION STATEMENT

GLOBE Performance Solutions

Verifies the performance of

Hydroworks® HydroStorm (HS) Hydrodynamic Separator

Developed by Hydroworks, LLC
Clark, NJ, USA

In accordance with

ISO 14034:2016

Environmental management — Environmental technology verification (ETV)

John D. Wiebe, PhD
Executive Chairman
GLOBE Performance Solutions

May 15, 2018
Vancouver, BC, Canada

GLOBE PERFORMANCE SOLUTIONS

Verification Body
GLOBE Performance Solutions
404 – 999 Canada Place | Vancouver, B.C | Canada |V6C 3E2

Technology description and application

The Hydroworks® HydroStorm (HS) Hydrodynamic Separator is a concrete cylindrical device with an annular pre-treatment channel, an inner chamber, and lower collection sump. A schematic of the HS 4 test unit is shown in Figure 1. The pre-treatment channel extends below the outlet pipe invert and contains three intermediate low-flow weirs (flush with the outlet invert), and two downstream higher bypass weirs that extend above the outlet invert. The higher weirs bypass high flows to prevent oil and solids from being scoured out of the separator.

As water enters the unit through one or more inlets, coarser solids immediately start to settle below a horizontal grate extending from the inlet to two sets of lower weirs near the outlet pipe. The grating is positioned over the pre-treatment channel to help displace the inflow turbulence and protect the captured sediment from scour. Openings are located on the horizontal plate upstream of each weir to allow the flow to be conveyed into the inner chamber and lower sump. The weirs are positioned to create a counter clockwise rotation of water in the inner chamber to minimize turbulence and maximize settling. After water spirals down the inner chamber to the main settling chamber towards the floor of the separator where it deposits suspended sediments, it flows upwards between the wall of the unit and the outer edge of the disk extended from the inner chamber and through an arced opening at the bottom of the pre-treatment disk, downstream of the bypass weirs, where it is conveyed into the outlet pipe. An annular secondary horizontal plate with 32% of open-perforations is located within the lower sump to protect the collected sediment from scour. Oil and light liquids enter the inner chamber through the holes, reaching the bottom of the pre-treatment area and rises to the top of the water level where they are trapped.

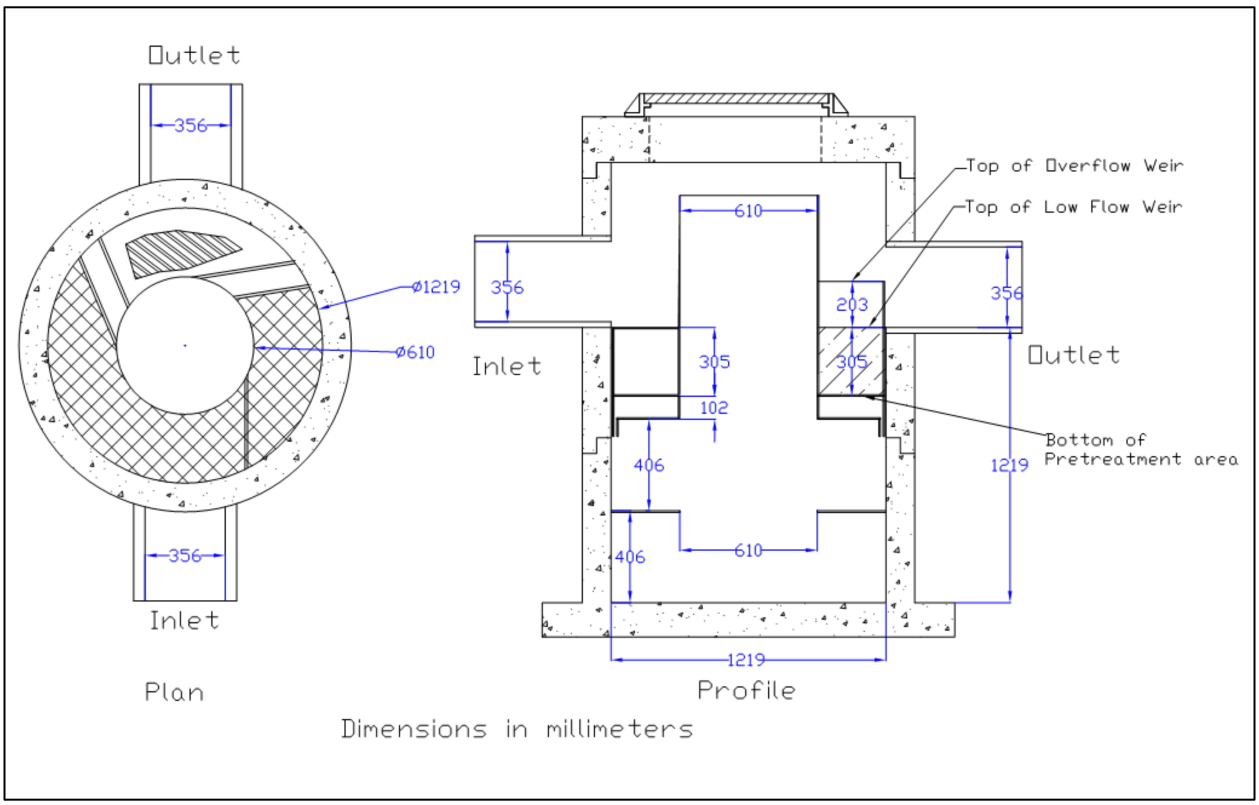


Figure 1: Schematic of the Hydroworks® HS4 Hydrodynamic Separator treatment unit tested as part of this verification.

Performance conditions

The data and results published in this Technology Fact Sheet were obtained from the testing program conducted on the Hydroworks® HS4 Hydrodynamic Separator, in accordance with the *Procedure for Laboratory Testing of Oil-Grit Separators (Version 3.0, June 2014)*. The Procedure was prepared by the Toronto and Region Conservation Authority (TRCA) for the Canadian Environmental Technology Verification Program. A copy of the Procedure may be accessed on the Canadian ETV website at www.etvcanada.ca.

Performance claim(s)

Capture test[1]:

During the capture test, the Hydroworks® HS Hydrodynamic Separator, with a false floor set to 50% of the manufacturer's recommended maximum sediment storage depth and a constant influent test sediment concentration of 200 mg/L, removes 69, 64, 60, 56, 46, 41, and 36 percent of influent sediment by mass at surface loading rates of 40, 80, 200, 400, 600, 1000, and 1400 L/min/m^2, respectively.

Scour test[1]:

During the scour test, the Hydroworks® HS Hydrodynamic Separator, with 10.2 cm (4 inches) of test sediment pre-loaded onto a false floor reaching 50% of the manufacturer's recommended maximum sediment sump storage depth and sediment loaded onto the pre-treatment channel emulating depositional pattern of the 40 L/min/m^2 capture test, generate corrected effluent concentrations of 22.4, 28.5, 20.0, 19.1, and 24.4 mg/L at 5-minute duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m^2, respectively.

Light liquid re-entrainment test[1]:

During the light liquid re-entrainment test, the Hydroworks® HS Hydrodynamic Separator with surrogate low-density polyethylene beads preloaded within the inner chamber, representing a floating light liquid volume equal to a depth of 50.8 mm over the sedimentation area, retains 100, 99.9, 95.4, 95.7, and 97.5 percent of loaded beads by mass during the 5-minute duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m^2, respectively.

Performance results

The test sediment consisted of ground silica (1 – 1000 micron) with a specific gravity of 2.65, uniformly mixed to meet the particle size distribution specified in the testing procedure. The *Procedure for Laboratory Testing of Oil Grit Separators* requires that the three sample average of the test sediment particle size distribution (PSD) meet the specified PSD percent less than values within a boundary threshold of 6%. The comparison of the average test sediment PSD to the CETV specified PSD in Figure 2indicates that the test sediment used for the capture and scour tests met this condition.

[1] The claim can be applied to other units smaller or larger than the tested unit as long as the untested units meet the scaling rule specified in the Procedure for Laboratory of Testing of Oil Grit Separators (Version 3.0, June 2014)

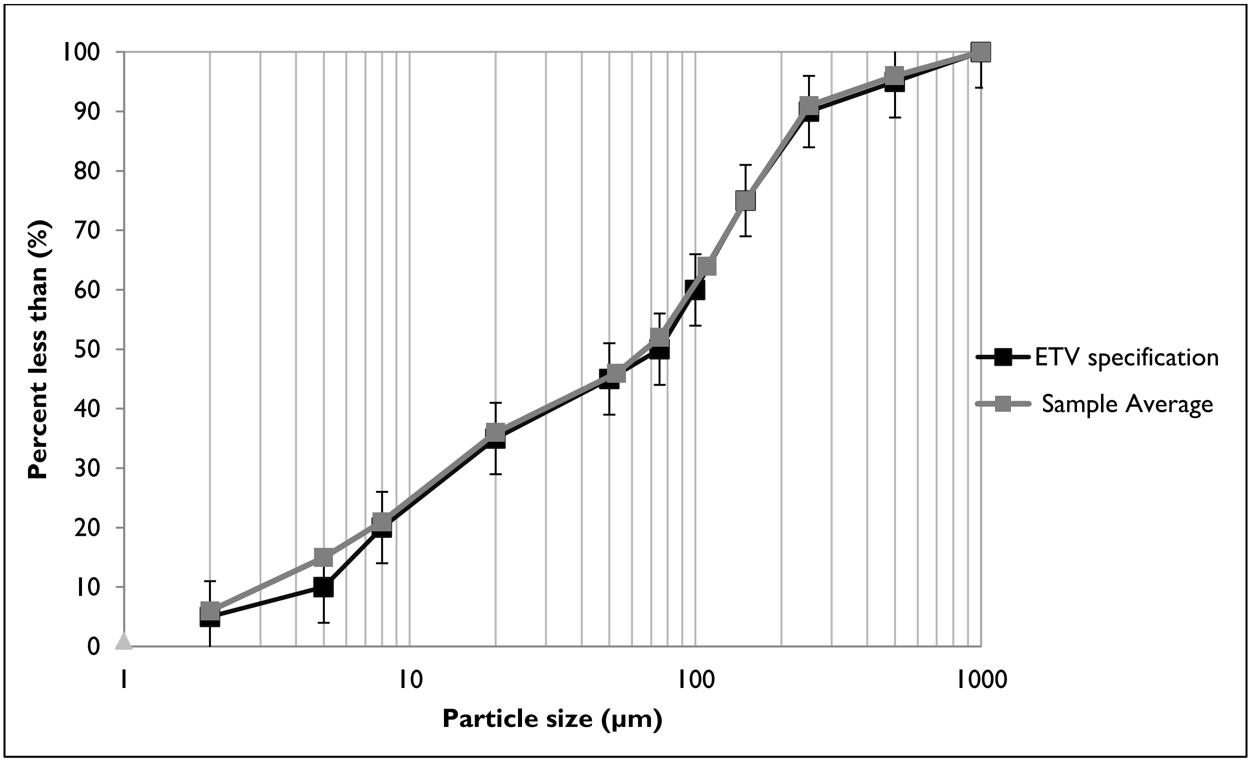


Figure 2. The three sample average particle size distribution (PSD) of the test sediment used for the capture and scour test compared to the specified PSD.

The capacity of the device to retain sediment was determined at seven surface loading rates using the modified mass balance method. This method involved measuring the mass and particle size distribution of the injected and retained sediment for each test run. Performance was evaluated with a false floor at 0.15 m from the bottom, simulating the technology filled to 50% of the manufacturer's recommended maximum sediment storage depth. The test was carried out with clean water that maintained a sediment concentration below 20 mg/L. Based on these conditions, removal efficiencies for individual particle size classes and for the test sediment as a whole were determined for each of the tested surface loading rates (Table 1).

In some instances, the removal efficiencies were above 100% for certain particle size fractions. These discrepancies are not unique to any one test laboratory and may be attributed to errors relating to the blending of sediment, collection of representative samples for laboratory submission, and laboratory analysis of PSD. Due to these errors, caution should be exercised in applying the removal efficiencies by particle size fraction for the purposes of sizing the tested device (see Bulletin # CETV 2016-11-0001). The results for "all particle sizes by mass balance" (see Table 1 and 2) are based on measurements of the total injected and retained sediment mass, and are therefore not subject to blending, sampling or PSD analysis errors.

Table 1. Removal efficiencies (%) of the HS4 unit at specified surface loading rates.

Particle size fraction (µm)	Surface loading rate (L/min/m²)						
	40	80	200	400	600	1000	1400
>500	73	100*	98	67	100*	100*	26
250 - 500	100	100*	92	64	100*	98	48
150 - 250	100*	75	89	72	89	60	69
105 - 150	94	100*	100*	100*	78	99	91
75 - 105	96	76	79	95	68	54	46
53 - 75	87	100*	100*	100*	56	69	65
20 - 53	71	54	46	44	19	14	10
8 - 20	38	23	15	8	2	2	2
5 – 8	13	6	1	1	0	0	0
<5	8	0	0	0	0	0	0
All particle sizes by mass balance	**68.6**	**64.0**	**60.0**	**56.1**	**46.1**	**41.2**	**35.7**

* Removal efficiencies were calculated to be above 100%. Calculated values ranged between 103 and 194% (average 128%). See text and Bulletin # CETV 2016-11-0001 for more information.

Figure 3 compares the particle size distribution (PSD) of the three sample average of the test sediment to the PSD of the sediment retained by the HS4 unit at each of the tested surface loading rates. As expected, the capture efficiency for fine particles in the unit was generally found to decrease as surface loading rates increased.

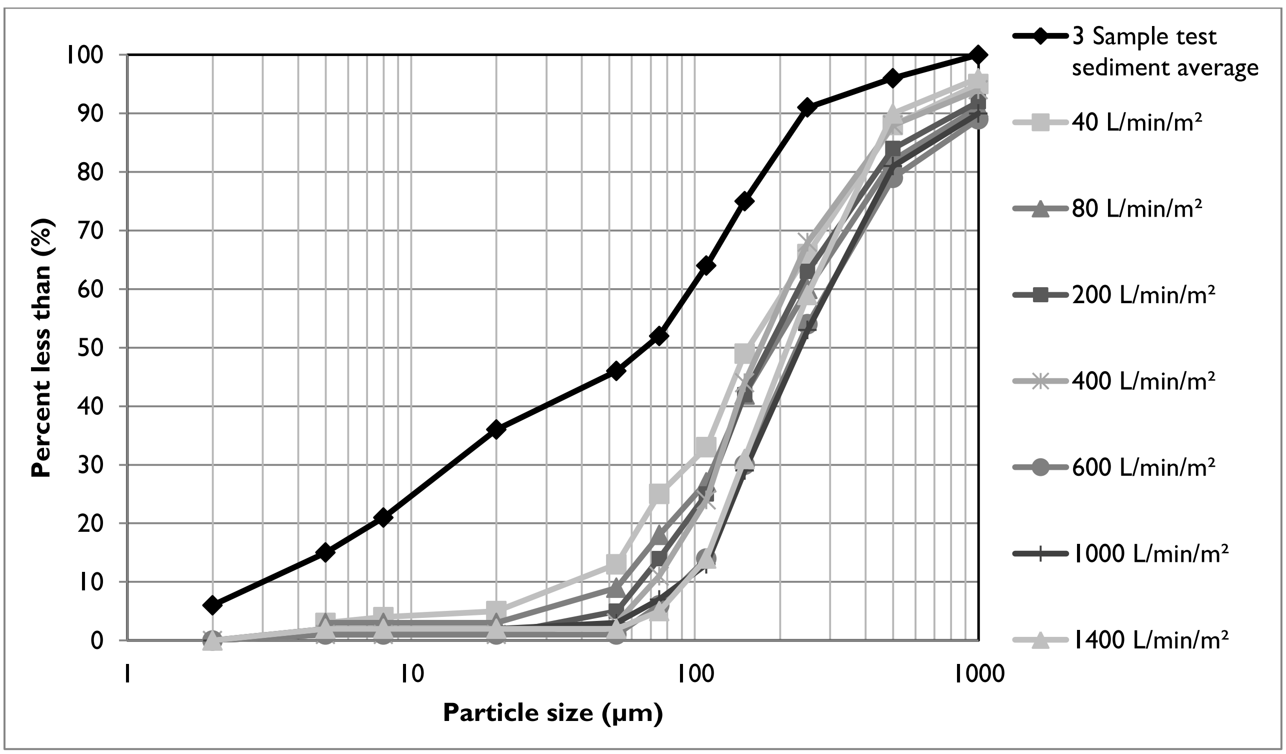


Figure 3. Particle size distribution of sediment retained in the HS4 unit in relation to the injected test sediment average.

For the sediment scour and re-suspension test, two tests were conducted. The first test was conducted with the secondary plate used in the capture tests. The second used a perforated secondary plate. Since sediment during the capture tests was found to settle in the pre-treatment channel, and in roughly the same quantities on the secondary plate and collection sump, all three of these surfaces were preloaded with sediment during the first test. The pre-treatment channel only captures coarse sediment. Therefore, this area was pre-loaded with sediment having a PSD similar to the PSD of the sediment that settled in this area during the 40 L/min/m^2 SLR sediment capture test. The pre-loaded sediment in the pre-treatment channel was shaped and leveled to correspond with sedimentation patterns and depths observed by the laboratory technician during the 40 L/min/m^2 SLR capture test. It should be noted that the actual sediment preloaded in this area was finer than the PSD of sediment captured in the same area during the 40 L/min/m^2 SLR capture test, particularly for particle sizes less than the median size. Both the sump and secondary plate were pre-loaded with the 1-1000 µm sediment mix to a depth of 10.2 cm. The preloaded sediment in the lower sump was placed on a false floor to mimic a device filled to 50% of the manufacturer's maximum recommended sediment storage depth.

After pre-loading the sediment, clean water was run through the device at five SLRs over a 25 minute period. At each SLR, five effluent samples were collected over a four minute interval (one per minute) with the first sample collected at the beginning of each flow rate, and the last collected just prior to the one minute transition to the next flow rate or end of the test. Effluent samples were analyzed for Suspended Sediment Concentration (SSC) and PSD by methods prescribed in the *Procedure*. The effluent samples were subsequently adjusted based on the background concentration of the influent water and the smallest 5% of particles captured during the 40 L/min/m^2 sediment capture test (7 um), as per the method described in Bulletin # CETV 2016-09-0001.

Measurements of sediment depths in the sump after the first test showed that most of the sediment from the secondary plate was carried into the lower sump. During this process, the fine sediment was likely re-suspended and carried out of the unit with the flow. The average adjusted effluent suspended sediment concentrations for each SLR ranged from 11.3 mg/L at the 200 L/min/m2 SLR to 196.7 mg/L at the 1400 L/min/m2 SLR. Effluent SSCs declined after the 1400 L/min/m2 SLR because the unit begins to bypass flow at this rate. It should be noted that this was a very conservative test as sediment was preloaded in three areas, rather than in the lower sump alone, and the preloaded sediment on the pre-treatment channel and secondary plate had a finer PSD than the sediment found to settle in these areas during the lowest SLR capture test.

The second sediment scour test was conducted on an identical unit but with a 32% open-area perforated secondary plate of the same size and orientation as the solid plate used in the first test. The perforated plate was intended to allow most of the sediment to settle in the lower sump, while still protecting against sediment scour, and not affecting the capacity of the unit to capture sediment. A second capture test was run at the 600 L/min/m^2 SLR to confirm that the perforated plate would have the same flow characteristics and removal efficiencies as the solid plate. Results of this comparison presented in Table 2 show that removal efficiencies were not affected and that the collection sump was receiving the majority of sediment transported into the lower chamber. Based on the observed sediment deposition zones, the second repeat test with the perforated plate had sediment preloaded in the pre-treatment channel and the lower collection sump only (*i.e.* the major deposition zones). The collection sump was preloaded with 10.2 cm of the 1- 1000 µm test sediment mix, as in the first test, and the pre-treatment channel was preloaded in much the same way as the first test, but with a sediment PSD that more closely mimicked the PSD of sediment observed to settle in this area during the 40 L/min/m^2 sediment capture test.

Table 2: Injected mass captured at the 600 L/min/m² SLR for two different configurations of the secondary plate

Secondary Plate type	Target Surface Loading Rate (L/min/m²)	Tested Flow Rate (L/min)	Removal Efficiency (%)	Pre-treatment Channel (%)	Secondary Plate (%)	Outlet Dispersion Plate (%)	Collection Sump (%)
Solid Plate	600	736.2	46.1	24.7	8.5	3.1	9.9
Perforated Plate	600	740.9	45.9	25.8	2.7	3.0	14.5

Results of the second test are presented in Table 3. Background concentrations were maintained below 10.5 mg/L. The average adjusted effluent suspended sediment concentrations ranged from 19.1 to 28.5 mg/L. Since the commercially available unit will have a perforated secondary plate, these concentrations are the appropriate values to consider for approvals. The verifier acknowledges that the sediment capture removal efficiencies were not all tested with the perforated plate (see variance notes below), but that the repeat test results at the 600 L/min/m² SLR and a statement from the independent test laboratory were sufficient to provide reasonable confidence that the added perforations in the secondary plate would have negligible influence on sediment removal efficiencies.

Table 3. Scour test adjusted effluent sediment concentrations

Run	Surface loading rate (L/min/m²)	Run time (min)	Background sample concentration (mg/L)[a]	Average adjusted effluent suspended sediment concentration (mg/L)[b]
1	200	5	3.6	22.4
2	800	5	8.9	28.5
3	1400	5	7.6	20.0
4	2000	5	10.4	19.1
5	2600	5	6.0	24.4

[a] Background concentrations shown here are approximate values based on graphical interpolation

[b] The adjusted effluent suspended sediment concentration represents the actual measured effluent concentration minus the background concentration. For more information see Bulletin # CETV 2016-09-0001. Adjusted concentrations were only calculated for the average of the five samples collected per surface loading rate.

The results of the light liquid re-entrainment test used to evaluate the unit's capacity to prevent re-entrainment of light liquids are reported in Table 4. The test involved preloading 58.3 L (corresponding to a 5 cm depth over the collection sump area of 1.17m²) of surrogate low-density polyethylene beads (Dow Chemical Dowlex™ 2517) within the inner chamber and running clean water through the device continuously at five surface loading rates (200, 800, 1400, 2000, and 2600 L/min/m²). Each flow rate was maintained for 5 minutes with approximately 1 minute transition time between flow rates (30 minutes total). The effluent flow was screened to capture all re-entrained pellets throughout the test. Results showed maximum re-entrainment of 4.6% at 1400 L/min/m², which is the highest SLR without bypass. Re-entrainment decreased at subsequent SLRs as bypass volumes increased.

Table 4. Light liquid re-entrainment test results for the HS4

Surface Loading Rate (L/min/m²)	Time Stamp (min)	Amount of Beads Re-entrained			
		Mass (g)	Volume (L)	% of Pre-loaded Mass Re-entrained	% of Pre-loaded Mass Retained
200	1:00 – 6:00	0	0	0.00	100
800	7:00 – 12:00	49	0.1	0.1	99.9
1400	13:00 – 18:00	1523	2.7	4.6	95.4
2000	19:00 – 24:00	1445	2.5	4.3	95.7
2600	25:00 – 30:00	847	1.5	2.5	97.5
Interim Collection Net		39	0.1	0.1	99.9
Total Re-entrained		3902	6.8	11.7	--
Total Retained		29,497	51.5	--	88.3
Total Loaded		33,399	58.3	--	--

Variances from testing Procedure

The following deviations from the *Procedure for Laboratory Testing of Oil-Grit Separators* (Version 3.0, June 2014) have been noted:

1. The Procedure stipulates that the tested device "must be a full scale, commercially available device with the same configuration and components that would be typical for an actual installation." As noted above, the sediment capture tests were conducted with a solid secondary plate. The solid secondary plate was later modified to a 32% open area perforated plate to reduce sediment settling on the plate, while continuing to provide scour prevention. As described above, the scour test was repeated with the perforated secondary plate, but the sediment capture test was only repeated at the 600 L/min/m² SLR (i.e. one of seven tested SLRs). Removal efficiency results for the repeat test showed very close correspondence with the earlier test using the solid plate and much of the sediment that previously settled on the secondary plate was deposited in the lower collection sump (see Table 2). The independent laboratory provided the following statement regarding the potential for the added perforations to affect sediment removal efficiencies: "Taking into account the close proximity of the plate to the collection sump, as well as our knowledge of sediment transport, it is expected that the deposited sediment would have settled in the lower sump, with no impact on removal efficiency, if the plate was removed." While the verifier acknowledges that stronger evidence would have been provided by additional repeat testing at a lower and higher SLR, the close correlation between the original and repeat test, combined with the statement from the lab were sufficient to provide reasonable confidence that adding the perforations would not likely have changed the capture test results significantly.

2. The repeat test at the 600 L/min/m² SLR had background concentrations exceeding the 20 mg/L threshold during the last half of the test. The exceedances occurred in 4 of the 8 samples collected, reaching a maximum of 28.4 mg/L. The experimental apparatus is a closed loop system. Therefore, the sediment in the background samples consists of fine particles not captured by the device, and would therefore not likely bias the mass balance results.

3. It was necessary to change flow meters during the sediment scour and light liquid re-entrainment test, as the required flows exceeded the minimum and/or maximum range of any single meter. When the flow capacity of the selected meter was reached, the flow was shut down over a period of approximately 10 seconds and all flow data saved. The next data acquisition file was executed and flow increased at a rate that corresponded to reaching each previous target flow after a period of 1-minute. This procedure was approved by CETV prior to testing, in recognition that most particles susceptible to scour at low flows would not be in the sump at higher flows. Similarly, re-entrainment of the oil beads was not expected to be significantly affected by the flow meter change.

4. As part of the capture test, evaluation of the 40 and 80 L/min/m^2 surface loading rate was split into 3 and 2 parts, respectively, due to the long duration needed to feed the required minimum of 11.3 kg of test sediment into the unit. At the end of the first and second parts of the test, the flow rates were gradually shutdown to prevent capture of particles that would have been washed out under normal circumstances. The amended procedure was reviewed and approved by the verifier prior to testing.

Verification

The verification was completed by the Verification Expert, Toronto and Region Conservation Authority, contracted by GLOBE Performance Solutions, using the International Standard ***ISO 14034:2016 Environmental management -- Environmental technology verification (ETV)***. Data and information provided by Hydroworks, LLC to support the performance claim included the following: Performance test report prepared by Alden Research Laboratory, Inc., and dated February 2018. This report is based on testing completed in accordance with the *Procedure for Laboratory Testing of Oil-Grit Separators* (Version 3.0, June 2014).

What is ISO14034:2016 Environmental management – Environmental technology verification (ETV)?

ISO 14034:2016 specifies principles, procedures and requirements for environmental technology verification (ETV), and was developed and published by the *International Organization for Standardization (ISO)*. The objective of ETV is to provide credible, reliable and independent verification of the performance of environmental technologies. An environmental technology is a technology that either results in an environmental added value or measures parameters that indicate an environmental impact. Such technologies have an increasingly important role in addressing environmental challenges and achieving sustainable development.

For more information on the Hydroworks® HS Hydrodynamic Separator please contact:

Hydroworks, LLC
136 Central Ave., 2nd FL
Clark, NJ
07066 USA
Tel: 888-290-7900
Email: info@hydroworks.com
www.hydroworks.com

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GLOBE Performance Solutions
404 – 999 Canada Place
Vancouver, BC
V6C 3E2 Canada
Tel: 604-695-5018 / Toll Free: 1-855-695-5018
etv@globeperformance.com
www.globeperformance.com

Limitation of verification

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