S. LLEWELLYN & ASSOCIATES LIMITED
CONSULTING ENGINEERS

Functional Servicing & Stormwater Management Report

NORTHWEST CORNER OF REBSTOCK ROAD AND RIDGE ROAD SOUTH

M5V INC.

Town of Fort Erie

May 2021
Revised: August 2021

SLA File: 21042

3228 South Service Road, Suite 105, East Wing Burlington, Ontario L7N 3H8
Tel. (905) 631-6978 www.sla.on.ca

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION AND BACKGROUND

1.1 OVERVIEW

S. Llewellyn & Associates Limited has been retained by M5V Inc. to provide Consulting Engineering services for the proposed development at the northwest corner of Rebstock Road and Ridge Road South in the Town of Fort Erie (see Figure 1.0 for location plan). This report will outline the functional servicing and stormwater management strategy for the proposed development.

The proposed development consists of constructing six stacked townhouse blocks containing a total of 154 residential units. The proposed development will include an asphalt driveway/parking lot, concrete curb/sidewalk, and landscaped areas.

This Functional Servicing & Stormwater Management 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 & Associates Limited and the Site Plan prepared by Organica Studios 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: Subdivision Control Guidelines for Development of New Subdivisions (Town of Fort Erie, 2016)

Ref. 3: Low Impact Development Stormwater Management Planning and Design Guide (Credit Valley Conservation Authority / Toronto and Region Conservation Authority, 2010)

Ref. 4: MOE Design Guidelines for Drinking-Water Systems (Ministry of Environment, 2008)

Ref. 5: Stormwater Management Guidelines (Niagara Peninsula Conservation Authority, (March 17, 2010)

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 Town of Fort Erie and the Niagara Peninsula Conservation Authority (NPCA):

Quantity Control
The stormwater discharge rate from the proposed site must be controlled to the pre-development condition discharge rates for the 2-year to 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 Town of Fort Erie and the NPCA.

2.1 PRE-DEVELOPMENT CONDITION

In the pre-development condition, the 1.5-hectare site is a vacant lot, which is entirely covered by grass. The site is bound by Rebstock Road to the south, Crystal Ridge Park to the north and west, and existing residential lands and Ridge Road South to the east.

The topography of the site predominately sheet drains north-east towards Crystal Ridge Park and drains to an existing culvert which outlets to the 1200mmø storm sewer along Ridge Road South. This 1200mmø storm sewer flows south and connects with the 675mmø storm sewer at Rebstock Road.

One catchment area, Catchment 101, has been identified in the existing condition. Catchment 101 represents the drainage area, where runoff sheet drains towards Crystal Ridge Park. For additional information regarding the pre-development catchment areas, see Table 2.1 below and the Existing Condition Storm Drainage Area Plan in Appendix A.

Table 2.1 – Pre-Development Condition Catchment Area

Catchment ID	Description	Area (ha)	Percent Impervious	Runoff Coefficient
101	To Crystal Ridge Park	1.5	0%	0.25

The existing conditions discharge from the site was calculated using the Rational Method based on the above runoff coefficient (C) and the Town of Fort Erie storm intensities at a time of concentration of 10 minutes (Tc=10min). A summary of the results can be found in Table 2.2 below.

Table 2.2 – Pre-Development Condition Site Discharge

Storm Event	Catchment 101 Discharge (m^3/s)
2-Yr Event	0.0697
5-Yr Event	0.0892
100-Yr Event	0.1430

2.2 POST-DEVELOPMENT CONDITION

It is proposed to develop the site by constructing six stacked townhouse blocks with 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 Town of Fort Erie standards.

Two catchment areas, Catchment 201 and 202, have been identified in the proposed condition. Catchment 201 represents the drainage area, where runoff will be captured on-site and controlled before discharging to the existing 675mmø storm sewer along Rebstock Road. Catchment 202 encompasses the landscaped areas and walkways located along the north property line of the site. Runoff from Catchment 202 will sheet drain uncontrolled towards Crystal Ridge Park. For additional information regarding the proposed catchment areas, see Table 2.3 below and the Proposed Condition Storm Drainage Area Plan in Appendix A.

Table 2.3 – Post-Development Condition Catchment Areas				
Catchment ID	Description	Area (ha)	Percent Impervious	Runoff Coefficient
201	To Rebstock Road (Controlled Release Rate)	1.37	74%	0.74
202	To Crystal Ridge Park (Uncontrolled)	0.13	15%	0.35

Water Quantity Control

It is proposed to apply quantity control measures to runoff from Catchment 201 by means of a 300mmø orifice plate to restrict discharge from the site to the allowable discharge rate.

With the installation of the quantity control measures for Catchment 201, it will be required to provide on-site stormwater storage for storm events up to and including the 100-year event. To provide the required storage, it is proposed to install an ACO Stormbrixx storage tank underneath the proposed parking lot. Details of the proposed storage tank can be found on the Preliminary Servicing Plan. A summary of the stage-storage-discharge calculations can be found in Table 2.4 below and in Appendix A.

Table 2.4-Post-Development Condition Stage-Storage Discharge (Catchment 201)		
Elevation (m)	Storage (m^3)	Discharge (m^3/s)
185.53 (orifice invert)	0	0.0000
185.55 (bottom of tank)	0	0.0006
185.65 (0.1m deep)	62	0.0230
185.75 (0.2m deep)	125	0.0607
185.85 (0.3m deep)	187	0.0775
185.95 (0.4m deep)	250	0.0976
186.03 (top of tank)	300	0.1111

The maximum discharge rate for Catchment 202 was calculated using the Rational Method based on the proposed condition runoff coefficients for the 2-year to 100-year storm events. Additionally, the 2-year to 100-year storage volumes for Catchment 201 was calculated using the Modified Rational Method (MRM). The proposed discharge rates and storage volumes are summarized in Table 2.5 below and in Appendix A for details.

Table 2.5- Post-Development Condition Site Discharge					
Storm Event	Controlled Discharge (CA 201) (m^3/s)	Uncontrolled Discharge (CA 202) (m^3/s)	Total Discharge (CA 201+202) (m^3/s)	Allowable Discharge (m^3/s)	Required Storage (m^3)
2-Yr Event	0.0550	0.0085	0.0635	0.0697	116.8
5-Yr Event	0.0720	0.0108	0.0828	0.0892	155.6
100-Yr Event	0.1060	0.0174	0.1234	0.1430	280.4

This analysis determined the following:

- The proposed condition discharge rates from site will not exceed the pre-development discharge rate during the 2-year to 100-year design storms, with the installation of a 300mmø orifice plate.

- Sufficient stormwater storage is provided on site. Catchment 201 provides 300m^3 of storage via the underground storage tank while only 280.4m^3 of storage is required during the 100-year storm;

Water Quality Control

The proposed development is required to achieve a Level 1 “Enhanced” (80% TSS removal, 90% average annual runoff treatment) level of water quality protection. To achieve this criterion, discharge from Catchment 201 will be subject to treatment from a HydroStorm oil/grit separator (or approved equivalent) before ultimately discharging to the proposed storm sewer system along Rebstock Road. The Hydroworks sizing software was used to determine the required size of HydroStorm unit for the site. It was determined that a HydroStorm HS6 will provide 80% TSS removal and 97% average annual runoff treatment, which satisfies the requirements for an “Enhanced” level for quality control. See the HydroStorm unit sizing procedures in Appendix B for details.

HydroStorm units require regular inspection and maintenance as per the manufacturer’s specifications to ensure the unit operates properly. See HydroStorm Maintenance Manual in Appendix B 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 low end 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;

- Install a mud mat at the construction entrance to the site to reduce mud tracking and sediment leaving the site via construction traffic;

- 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 are provided on the Preliminary Grading & Erosion Control Plan.

3.0 SANITARY SEWER SERVICING

3.1 EXISTING CONDITIONS

In the existing condition, there is a 200mmø sanitary sewer which flows east along Rebstock Road.

3.2 SANITARY DEMAND

Sanitary demand for the site was estimated in accordance with the Town of Fort Erie guidelines. Table 3.1 below summarizes the peak sanitary discharge.

Table 3.1 - Proposed Sanitary Sewer Discharge

Population [1]	Peaking Factor [2]	Site Area (ha)	Average Demand (Lcpd)	Infiltration (l/s)	**Peak Flow [3] (l/s)**
540 persons	4.5	1.5	320	0.42	**9.42**

[1]Population (P) = (60 1-bedroom units x 2 persons/unit) + (72 2-bedroom units x 4 persons/unit) + (22 3-bedroom units x 6 persons/unit) = 540 persons
[2]Peaking Factor (M) = $5/(P^{0.2})$ with P expressed in thousands, min= 2.0, max=4.5
[3]Peak Flow=MQP/86.4 + IA

3.3 PROPOSED SANITARY SERVICING

It is proposed that the subject lands will be serviced with a 200mmø sanitary sewer designed and constructed in accordance with the Town of fort Erie standards. The proposed 200mmø sanitary sewer will connect to the existing 200mmø sanitary sewer along Rebstock Road.

The minimum grade for the proposed sanitary sewers will be 0.5%. At this grade, the proposed sanitary sewers will have a capacity of 23 l/s. Therefore, the proposed 200mmø sanitary sewers at a 0.5% grade are adequately sized to service the proposed development.

4.0 DOMESTIC AND FIRE WATER SUPPLY SERVICING

4.1 EXISTING CONDITIONS

The existing municipal distribution system consists of a 150mmø watermain along Rebstock Road. There are existing fire hydrants along Rebstock Road and there is also a private fire hydrant proposed. The proposed water servicing for the subject lands consists of installing a 150mmø watermain to connect into the existing 150mmø watermain along Rebstock Road.

4.2 DOMESTIC WATER DEMAND

Water demand for the site was estimated in accordance with the Ministry of the Environment Design Guidelines for Drinking-Water Systems. Table 4.1 below summarizes the domestic water demand requirements for the Average Daily, Maximum Daily and Peaking Hourly demand scenarios.

Table 4.1 - Proposed Domestic Water Demand

Population [A]	Average Daily Demand [B] (l/s)	Max. Daily Peaking Factor [C]	Max. Hourly Peaking Factor [D]	**Max. Daily Demand [E] (l/s)**	**Max. Hourly Demand [F] (l/s)**
540 persons	2.25	2.75	4.13	**6.2**	**9.3**

[A]Population (P) = (60 1-bedroom units x 2 persons/unit) + (72 2-bedroom units x 4 persons/unit) + (22 3-bedroom units x 6 persons/unit) = 540 persons

[B] Average Daily Demand = (270 l/cap/day + 450 l/cap/day)/2 = 360 l/cap/day x population

[C] Max. Daily Peaking Factor = 2.75 (refer to Table 3-1 from MOE Manual)

[D] Max. Hourly Peaking Factor = 4.13 (refer to Table 3-1 from MOE Manual)

[E] Max. Daily Demand = Average Daily Demand x Max. Daily Peaking Factor

[F] Max. Hourly Demand = Average Daily Demand x Max. Hourly Peaking Factor

4.3 FIRE FLOW DEMAND

Fire flow demands for development are governed by a number of guidelines and criteria, such as the Water Supply for Public Fire Protection (Fire Underwriters Survey, 1999), Ontario Building Code (OBC), and various codes and standards published by the National Fire Protection Association (NFPA).

There are existing fire hydrants located along Rebstock Road. An additional private fire hydrant is proposed to meet the required 90m separation to the building face of the proposed buildings (as per Sentence 3.2.5.7 of the 2020 Ontario Building Code).

The required fire flow for the proposed development is based on the worst-case scenario which is Block C. The proposed buildings are wood frame construction (C=1.5), with limited combustible occupancy (-15% correction) and no sprinkler system (0% correction) and exposure corrections for Block C are based on the following:

North face: 20% correction (3.1m to 10m)
South face: 20% correction (3.1m to 10m)
East face: 10% correction (20.1m to 30m)
West face: 0% correction (> 45.0m)
Total: 50%

Based on the FUS, the fire flow demand for Block C is **300 l/s**. See Fire Flow Demand Requirements in Appendix C for calculations and details.

The following hydrant flow test data for the public fire hydrants in closest proximity to the proposed development has 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 summarizes the hydrant flow data provided by the Town of Fort Erie. Refer to Appendix C for additional information.

Table 4.2 – Hydrant Flow Data	
Hydrant #1	
Location	3741 Rebstock Road
Static Pressure	74 psi
Residual Pressure During Test Flow	51 psi
Test Flow Rate	919 USGPM (58.0 l/s)
Theoretical Flow @ 20 psi	**1458 USGPM (92.0 l/s)**
Hydrant #2	
Location	Rebstock Road & Ridge Rd S (SW Corner)
Static Pressure	70 psi
Residual Pressure During Test Flow	52 psi
Test Flow Rate	978 USGPM (62.7 l/s)
Theoretical Flow @ 20 psi	**1698 USGPM (107.1 l/s)**

Based on the above hydrant flow test data, the theoretical maximum flow rate is **107.1 l/s,** but the required flow rate for Block C is **300 l/s**.

Since the required fire flow rate for Block C is greater than is provided from the existing municipal system, the following is recommended; the proposed buildings be constructed with fire walls and/or a holding tank complete with a drafting hydrant be installed on site. The details regarding proposed fire walls and/or a holding tank will be provided during the detailed design stage.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the information provided herein, it is concluded that the proposed development at the northwest corner of Rebstock Road and Ridge Road South can be constructed to meet the requirements of the Town of Fort Erie and Niagara Peninsula Conservation Authority. Therefore, it is recommended that:

- The development be graded and serviced in accordance with the Preliminary Grading & Servicing Plans prepared by S. Llewellyn & Associates Limited;
- The installation of a 300mmø orifice plate will provide effective quantity control for the site;
- An underground storage tank be installed as per this report to provide adequate stormwater storage;
- A HydroStorm HS6 oil/grit separator, or approved equivalent, be installed as per this report to provide effective stormwater quality control;
- Erosion and sediment controls be installed as described in this report to meet Town of Fort Erie and NPCA Requirements;

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

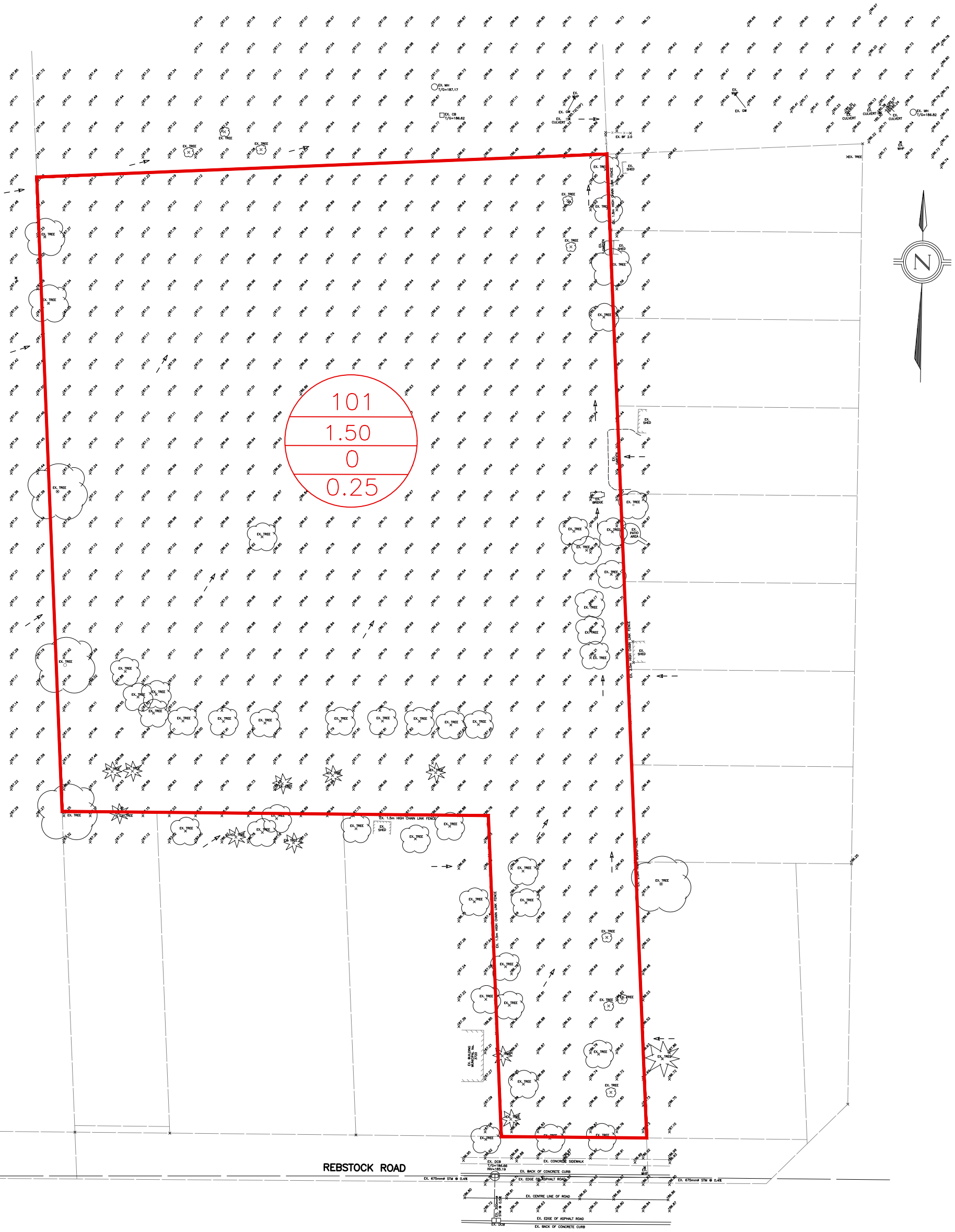
Prepared by:

S. LLEWELLYN & ASSOCIATES LIMITED

S. Nelson, P.Eng.

APPENDIX A

STORMWATER MANAGEMENT INFORMATION



LEGEND

101
1.50
0
0.25

DRAINAGE AREA I.D.

DRAINAGE AREA (ha)

PERCENT IMPERVIOUS

RUNOFF COEFFICENT

EXISTING DIRECTION OF DRAINAGE

EXISTING CONDITION
STORM DRAINAGE AREA PLAN

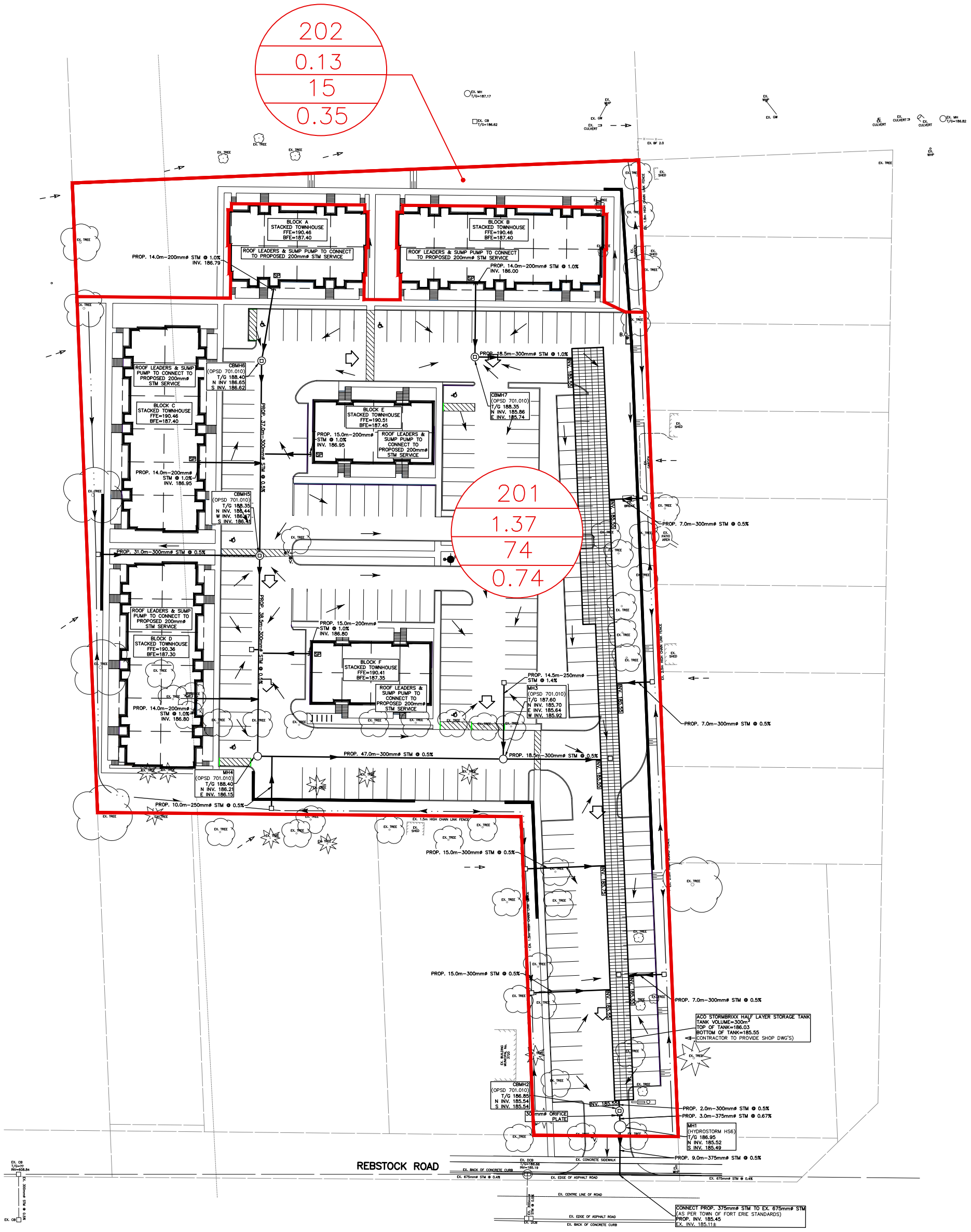
SCALE: 1:750

PROJECT: NORTHWEST CORNER OF REBSTOCK ROAD AND RIDGE ROAD SOUTH
PROJECT No.: 21042

S. LLEWELLYN & ASSOCIATES LIMITED
CONSULTING ENGINEERS

Tel. (905) 631-6978
email: info@sla.on.ca

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



LEGEND

201
1.37
74
0.74

DRAINAGE AREA I.D.

DRAINAGE AREA (ha)

PERCENT IMPERVIOUS

RUNOFF COEFFICENT

PROPOSED DIRECTION OF SHEET FLOW

EXISTING DIRECTION OF DRAINAGE

PROPOSED CONDITION
STORM DRAINAGE AREA PLAN

SCALE: 1:750

PROJECT: NORTHWEST CORNER OF REBSTOCK ROAD AND RIDGE ROAD SOUTH
PROJECT No.: 21042

S. LLEWELLYN & ASSOCIATES LIMITED
CONSULTING ENGINEERS

Tel. (905) 631-6978
email: info@sla.on.ca

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

Northwest Corner of Rebstock Road and Ridge Road South
Fort Erie, Ontario

S. LLEWELLYN & ASSOCIATES LIMITED
CONSULTING ENGINEERS

STAGE-STORAGE-DISCHARGE CALCULATIONS

Catchment 201
Outlet Device No. 1 (Quantity)

Type:	Orifice Plate
Diameter (mm)	**300**
Area (m^2)	0.07069
Invert Elev. (m)	185.53
C/L Elev. (m)	185.68
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	Tank Incremental Volume	Active Storage Volume m^3	H m	Discharge m^3/s
Orifice Invert	185.53	0	0	0	0.000	0.0000
Bottom of Tank	185.55	625	0	0	0.000	0.0006
0.10m Deep	185.65	625	62	62	0.000	0.0230
0.20m Deep	185.75	625	62	125	0.070	0.0607
0.30m Deep	185.85	625	62	187	0.170	0.0775
0.40m Deep	185.95	625	62	250	0.270	0.0976
Top of Tank	186.03	625	50	300	0.350	0.1111

Northwest Corner of Rebstock Road and Ridge Road South
Fort Erie, ON

S. LLEWELLYN & ASSOCIATES LIMITED
CONSULTING ENGINEERS

RUNOFF COEFFICIENT CALCULATIONS

Pre

		C-Value
Drainage Area #:	101	
Roof/Building Area (m²):		0.95
Asphalt/Conc. Area (m²):		0.90
Gravel Area (m²):l		0.80
Grass Area - Pervious (m²):	15000	0.25
Total Area (m²):	15000	0.25
Impervious	0	**0.00**
Pervious	15000	**1.00**
Site	15000	

Post

		C-Value
Drainage Area #:	201	
Roof/Building Area (m²):	2824	0.95
Asphalt/Conc. Area (m²):	7276	0.90
Grass Area - Pervious (m²):	3600	0.25
Total Area (m²):	13700	0.74
Impervious	10100	**0.74**
Pervious	3600	**0.26**
Site	13700	

Post

		C-Value
Drainage Area #:	202	
Roof/Building Area (m²):	0	0.95
Asphalt/Conc. Area (m²):	200	0.90
Grass Area - Pervious (m²):	1100	0.25
Total Area (m²):	1300	0.35
Impervious	200	**0.15**
Pervious	1100	**0.85**
Site	1300	

2-Year Storm - Modified Rational Method

Stormwater Storage Volume

Determination of required storage volume to control the 2-year proposed condition runoff to the allowable discharge rate. Storage volume calculated using the Modified Rational Method.

Storm Rainfall Information		
City/Town/Region:	**Fort Erie**	
Return Period:	**2**	Years
A =	**628.050**	
B =	**6.652**	
C=	**0.7960**	
Tc =	**10**	minutes
	600	seconds

Area of site being investigated (ha) = **1.37** (Lot Area)

Composite Runoff Coeff. (C) = **0.74** (Post-development "C")

Release Rate - Q (m^3/s) = **0.0550** (Controlled discharge)

Flows from Lot area calculated from area indicated above

Roof flows (Q_{ROOF}) added in as a constant flow rate into the orifice controlled system (if applicable)

Duration (T_D)		Rainfall Intensity		Post-Development Runoff			Runoff Volume	Release Volume	Storage Volume
				Site	Roof	Total "Q_{POST}"			
(min)	(sec)	(mm/hr)	(m/s)	(m^3/s)	(m^3/s)	(m^3)	(m^3)	(m^3)	(m^3)
5	300	88.949	0.0000247	0.250	0.0	0.2505	75.15	24.75	50.40
10	600	66.943	0.0000186	0.189	0.0	0.1885	113.11	33.00	80.11
15	900	54.317	0.0000151	0.153	0.0	0.1530	137.67	41.25	96.42
20	1200	46.038	0.0000128	0.130	0.0	0.1296	155.58	49.50	106.08
25	1500	40.149	0.0000112	0.113	0.0	0.1131	169.60	57.75	111.85
30	1800	35.725	0.0000099	0.101	0.0	0.1006	181.09	66.00	115.09
35	2100	32.267	0.0000090	0.091	0.0	0.0909	190.82	74.25	116.57
40	2400	29.483	0.0000082	0.083	0.0	0.0830	199.27	82.50	116.77
45	2700	27.188	0.0000076	0.077	0.0	0.0766	206.72	90.75	115.97
50	3000	25.260	0.0000070	0.071	0.0	0.0711	213.41	99.00	114.41
55	3300	23.615	0.0000066	0.067	0.0	0.0665	219.46	107.25	112.21
60	3600	22.194	0.0000062	0.063	0.0	0.0625	225.00	115.50	109.50
65	3900	20.952	0.0000058	0.059	0.0	0.0590	230.12	123.75	106.37
70	4200	19.857	0.0000055	0.056	0.0	0.0559	234.86	132.00	102.86
75	4500	18.883	0.0000052	0.053	0.0	0.0532	239.29	140.25	99.04
80	4800	18.010	0.0000050	0.051	0.0	0.0507	243.45	148.50	94.95
85	5100	17.224	0.0000048	0.049	0.0	0.0485	247.37	156.75	90.62
90	5400	16.511	0.0000046	0.046	0.0	0.0465	251.08	165.00	86.08
95	5700	15.861	0.0000044	0.045	0.0	0.0447	254.60	173.25	81.35
100	6000	15.266	0.0000042	0.043	0.0	0.0430	257.95	181.50	76.45

Max. required storage volume = 116.77 m^3

Q_{POST} = (C i A) x 10000 m^2/ha (Rational Method)

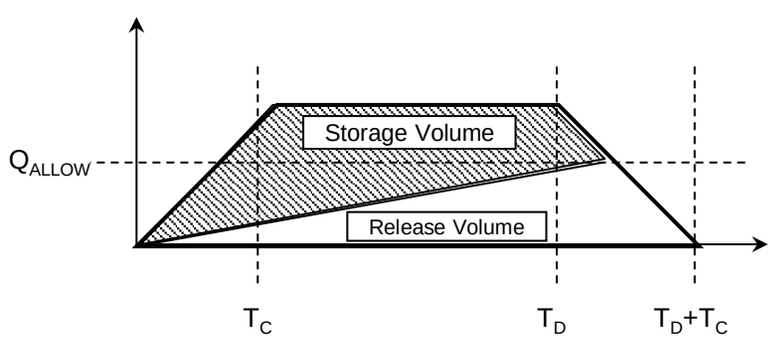
Runoff Volume = Area under trapezoidal hydrograph

= $(T_D - T_C)Q_{POST} + (T_C\ Q_{POST})$

Release Volume = Area under triangular outflow hydrograph

= ½ $(T_D + T_C)\ Q_{ALLOW}$

Storage Volume = Runoff Volume - Release Volume



5-Year Storm - Modified Rational Method

Stormwater Storage Volume

Determination of required storage volume under proposed conditions to control the 100-year proposed conditions runoff to the allowable release rate. Storage volume calculated using the Modified Rational Method.

Storm Rainfall Information		
City/Town/Region:	**Fort Erie**	
Return Period:	**5**	Years
A =	**747.930**	
B =	**6.800**	
C=	**0.7680**	
Tc =	**10**	minutes
	600	seconds

Area of site being investigated (ha) = **1.37** (Lot Area)

Composite Runoff Coeff. (C) = **0.74** (Post-development "C")

Release Rate - Q (m^3/s) = **0.0720** (Controlled discharge)

Flows from Lot area calculated from area indicated above

Roof flows (Q_{ROOF}) added in as a constant flow rate into the orifice controlled system (if applicable)

Duration (T_D)		Rainfall Intensity		Post-Development Runoff			Runoff Volume	Release Volume	Storage Volume
				Site	Roof	Total "Q_{POST}"			
(min)	(sec)	(mm/hr)	(m/s)	(m^3/s)	(m^3/s)	(m^3)	(m^3)	(m^3)	(m^3)
5	300	112.371	0.0000312	0.316	0.0	0.3165	94.94	32.40	62.54
10	600	85.669	0.0000238	0.241	0.0	0.2413	144.75	43.20	101.55
15	900	70.134	0.0000195	0.198	0.0	0.1975	177.75	54.00	123.75
20	1200	59.849	0.0000166	0.169	0.0	0.1685	202.25	64.80	137.45
25	1500	52.480	0.0000146	0.148	0.0	0.1478	221.69	75.60	146.09
30	1800	46.913	0.0000130	0.132	0.0	0.1321	237.80	86.40	151.40
35	2100	42.540	0.0000118	0.120	0.0	0.1198	251.57	97.20	154.37
40	2400	39.004	0.0000108	0.110	0.0	0.1098	263.62	108.00	155.62
45	2700	36.079	0.0000100	0.102	0.0	0.1016	274.33	118.80	155.53
50	3000	33.614	0.0000093	0.095	0.0	0.0947	283.98	129.60	154.38
55	3300	31.505	0.0000088	0.089	0.0	0.0887	292.78	140.40	152.38
60	3600	29.678	0.0000082	0.084	0.0	0.0836	300.87	151.20	149.67
65	3900	28.077	0.0000078	0.079	0.0	0.0791	308.37	162.00	146.37
70	4200	26.663	0.0000074	0.075	0.0	0.0751	315.36	172.80	142.56
75	4500	25.402	0.0000071	0.072	0.0	0.0715	321.91	183.60	138.31
80	4800	24.270	0.0000067	0.068	0.0	0.0683	328.07	194.40	133.67
85	5100	23.249	0.0000065	0.065	0.0	0.0655	333.90	205.20	128.70
90	5400	22.321	0.0000062	0.063	0.0	0.0629	339.43	216.00	123.43
95	5700	21.474	0.0000060	0.060	0.0	0.0605	344.70	226.80	117.90
100	6000	20.698	0.0000057	0.058	0.0	0.0583	349.72	237.60	112.12
105	6300	19.983	0.0000056	0.056	0.0	0.0563	354.53	248.40	106.13
110	6600	19.323	0.0000054	0.054	0.0	0.0544	359.14	259.20	99.94
115	6900	18.710	0.0000052	0.053	0.0	0.0527	363.57	270.00	93.57
120	7200	18.141	0.0000050	0.051	0.0	0.0511	367.83	280.80	87.03

Max. required storage volume = **155.62 m^3**

Q_{POST} = (C i A) x 10000 m^2/ha (Rational Method)

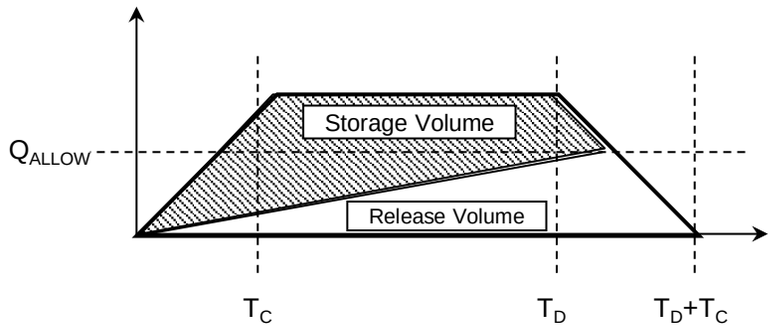
Runoff Volume = Area under trapezoidal hydrograph

= $(T_D - T_C)Q_{POST} + (T_C\, Q_{POST})$

Release Volume = Area under triangular outflow hydrograph

= ½ $(T_D + T_C)\, Q_{ALLOW}$

Storage Volume = Runoff Volume - Release Volume



100-Year Storm - Modified Rational Method

Stormwater Storage Volume

Determination of required storage volume under proposed conditions to control the 100-year proposed conditions runoff to the allowable release rate. Storage volume calculated using the Modified Rational Method.

Storm Rainfall Information		
City/Town/Region:	**Fort Erie**	
Return Period:	**100**	Years
A =	**1083.550**	
B =	**6.618**	
C=	**0.7350**	
Tc =	**10**	minutes
	600	seconds

Area of site being investigated (ha) =	**1.37**	(Lot Area)
Composite Runoff Coeff. (C) =	**0.74**	(Post development "C")
Release Rate - Q (m^3/s) =	**0.1060**	(Controlled discharge)

Flows from Lot area calculated from area indicated above

Roof flows (Q_{ROOF}) added in as a constant flow rate into the orifice controlled system (if applicable)

Duration (T_D)		Rainfall Intensity		Post-Development Runoff			Runoff Volume	Release Volume	Storage Volume
				Site	Roof	Total "Q_{POST}"			
(min)	(sec)	(mm/hr)	(m/s)	(m^3/s)	(m^3/s)	(m^3)	(m^3)	(m^3)	(m^3)
5	300	178.639	0.0000496	0.503	0.0	0.5031	150.92	47.70	103.22
10	600	137.317	0.0000381	0.387	0.0	0.3867	232.02	63.60	168.42
15	900	113.177	0.0000314	0.319	0.0	0.3187	286.85	79.50	207.35
20	1200	97.128	0.0000270	0.274	0.0	0.2735	328.23	95.40	232.83
25	1500	85.585	0.0000238	0.241	0.0	0.2410	361.52	111.30	250.22
30	1800	76.830	0.0000213	0.216	0.0	0.2164	389.45	127.20	262.25
35	2100	69.932	0.0000194	0.197	0.0	0.1969	413.57	143.10	270.47
40	2400	64.337	0.0000179	0.181	0.0	0.1812	434.83	159.00	275.83
45	2700	59.695	0.0000166	0.168	0.0	0.1681	453.89	174.90	278.99
50	3000	55.773	0.0000155	0.157	0.0	0.1571	471.19	190.80	280.39
55	3300	52.410	0.0000146	0.148	0.0	0.1476	487.05	206.70	280.35
60	3600	49.489	0.0000137	0.139	0.0	0.1394	501.72	222.60	279.12
65	3900	46.925	0.0000130	0.132	0.0	0.1321	515.37	238.50	276.87
70	4200	44.655	0.0000124	0.126	0.0	0.1258	528.16	254.40	273.76
75	4500	42.627	0.0000118	0.120	0.0	0.1200	540.19	270.30	269.89
80	4800	40.804	0.0000113	0.115	0.0	0.1149	551.57	286.20	265.37
85	5100	39.156	0.0000109	0.110	0.0	0.1103	562.36	302.10	260.26
90	5400	37.656	0.0000105	0.106	0.0	0.1060	572.63	318.00	254.63
95	5700	36.285	0.0000101	0.102	0.0	0.1022	582.44	333.90	248.54
100	6000	35.026	0.0000097	0.099	0.0	0.0986	591.83	349.80	242.03
105	6300	33.866	0.0000094	0.095	0.0	0.0954	600.83	365.70	235.13
110	6600	32.793	0.0000091	0.092	0.0	0.0923	609.49	381.60	227.89
115	6900	31.796	0.0000088	0.090	0.0	0.0895	617.84	397.50	220.34
120	7200	30.868	0.0000086	0.087	0.0	0.0869	625.89	413.40	212.49
125	7500	30.002	0.0000083	0.084	0.0	0.0845	633.67	429.30	204.37
130	7800	29.191	0.0000081	0.082	0.0	0.0822	641.20	445.20	196.00
135	8100	28.430	0.0000079	0.080	0.0	0.0801	648.50	461.10	187.40
140	8400	27.714	0.0000077	0.078	0.0	0.0780	655.59	477.00	178.59
145	8700	27.039	0.0000075	0.076	0.0	0.0761	662.47	492.90	169.57
150	9000	26.402	0.0000073	0.074	0.0	0.0744	669.16	508.80	160.36
155	9300	25.799	0.0000072	0.073	0.0	0.0727	675.68	524.70	150.98
160	9600	25.228	0.0000070	0.071	0.0	0.0710	682.03	540.60	141.43
165	9900	24.686	0.0000069	0.070	0.0	0.0695	688.22	556.50	131.72
170	10200	24.170	0.0000067	0.068	0.0	0.0681	694.27	572.40	121.87
175	10500	23.679	0.0000066	0.067	0.0	0.0667	700.17	588.30	111.87
180	10800	23.211	0.0000064	0.065	0.0	0.0654	705.95	604.20	101.75
185	11100	22.765	0.0000063	0.064	0.0	0.0641	711.59	620.10	91.49
190	11400	22.338	0.0000062	0.063	0.0	0.0629	717.12	636.00	81.12

Max. required storage volume = 280.39 m^3

Q_{POST} = (C i A) x 10000 m^2/ha (Rational Method)

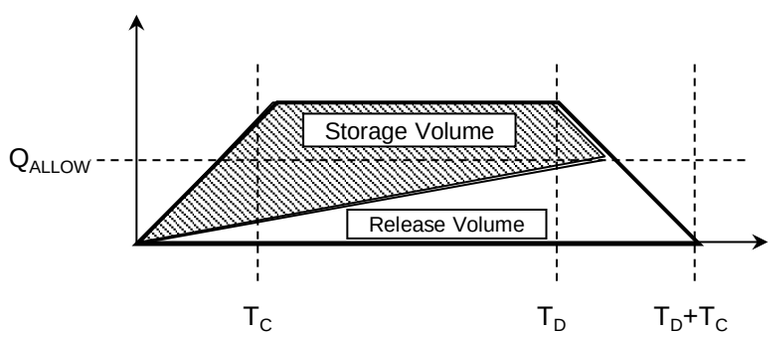
Runoff Volume = Area under trapezoidal hydrograph

= $(T_D - T_C)Q_{POST} + (T_C\, Q_{POST})$

Release Volume = Area under triangular outflow hydrograph

= ½ $(T_D + T_C)\, Q_{ALLOW}$

Storage Volume = Runoff Volume - Release Volume



STAGE-STORAGE-DISCHARGE CALCULATIONS

Catchment 201

Outlet Device No. 1 (Quantity)

Type:	Orifice Pipe
Diameter (mm)	**300**
Area (m^2)	0.07069
Invert Elev. (m)	185.53
C/L Elev. (m)	185.68
Disch. Coeff. (C_d)	0.6
Discharge (Q) =	$C_d A (2 g H)^{0.5}$
Number of Orifices:	1

Volume	Elevation	Discharge
0.00	185.55	0.0006
6.25	185.56	0.0014
12.50	185.57	0.0026
18.75	185.58	0.0041
25.00	185.59	0.0060
31.25	185.60	0.0082
37.50	185.61	0.0106
43.75	185.62	0.0134
50.00	185.63	0.0164
56.25	185.64	0.0196
62.50	185.65	0.0230
68.75	185.66	0.0266
75.00	185.67	0.0304
81.25	185.68	0.0342
87.50	185.69	0.0381
93.75	185.70	0.0420
100.00	185.71	0.0459
106.25	185.72	0.0498
112.50	185.73	0.0536
118.75	185.74	0.0572
125.00	185.75	0.0607
131.25	185.76	0.0639
137.50	185.77	0.0668
143.75	185.78	0.0694
150.00	185.79	0.0714
156.25	185.80	0.0729
162.50	185.81	0.0735
168.75	185.82	0.0730
175.00	185.83	0.0740
181.25	185.84	0.0751
187.50	185.85	0.0775
193.75	185.86	0.0797

200.00	185.87	0.0819
206.25	185.88	0.0840
212.50	185.89	0.0861
218.75	185.90	0.0881
225.00	185.91	0.0901
231.25	185.92	0.0920
237.50	185.93	0.0939
243.75	185.94	0.0958
250.00	185.95	0.0976
256.25	185.96	0.0994
262.50	185.97	0.1012
268.75	185.98	0.1029
275.00	185.99	0.1046
281.25	186.00	0.1063
287.50	186.01	0.1079
293.75	186.02	0.1095
300.00	186.03	0.1111

APPENDIX B

OIL/GRIT SEPARATOR INFORMATION

Hydroworks Sizing Summary

Northwest Corner of Rebstock Road and Ridge Road South Fort Erie, ON

05-13-2021

Recommended Size: HS 6

A HydroStorm HS 6 is recommended to provide 80 % annual TSS removal based on a drainage area of 1.37 (ha) with an imperviousness of 74 % and St. Catherines A, Ontario rainfall for the 20 um to 2000 um particle size distribution.

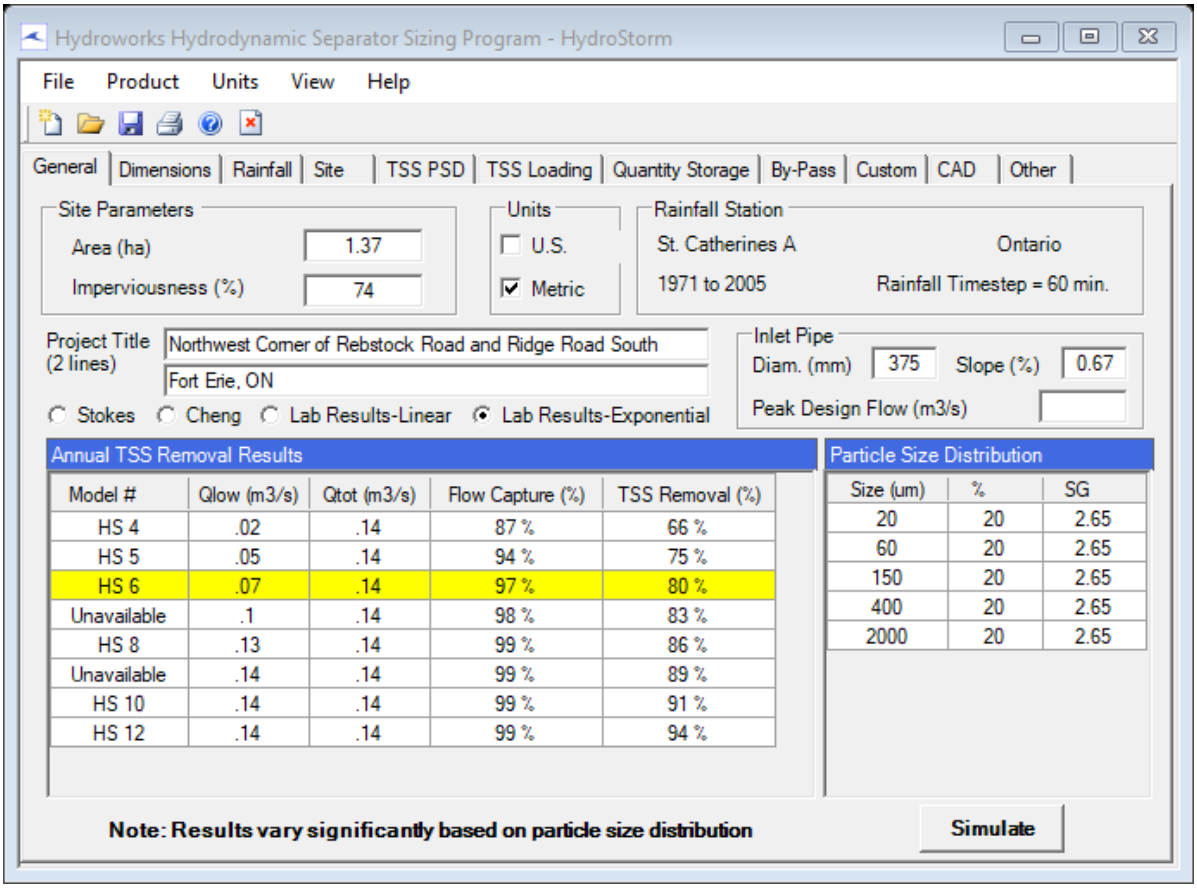
The recommended HydroStorm HS 6 treats 97 % of the annual runoff and provides 80 % annual TSS removal for the St. Catherines A rainfall records and 20 um to 2000 um particle size distribution.

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 .14 (m3/s) for the given 375 (mm) pipe diameter at .7% slope. The headloss was calculated to be 90 (mm) based on a flow depth of 375 (mm) (full pipe flow).

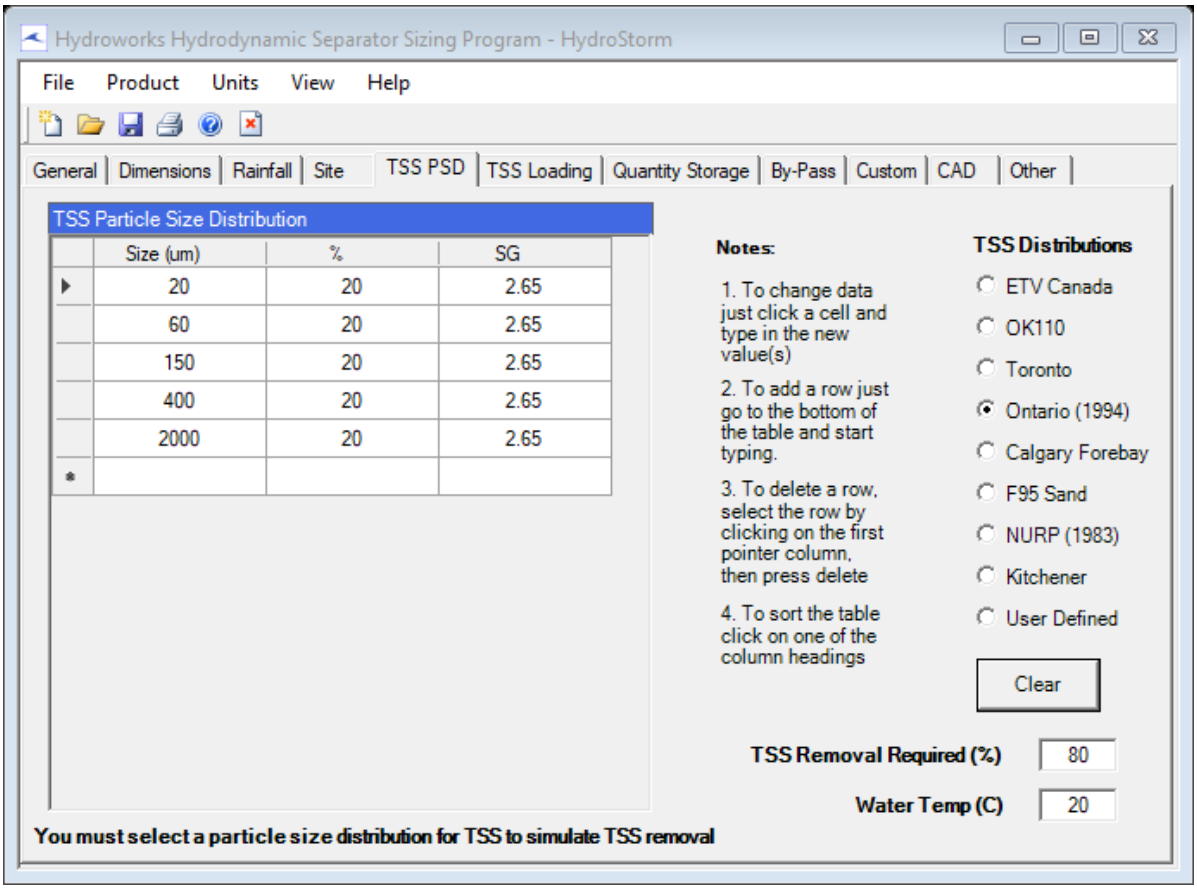
This summary report provides the main parameters that were used for sizing. These parameters are shown on the summary tables and graphs provided in this report.

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.

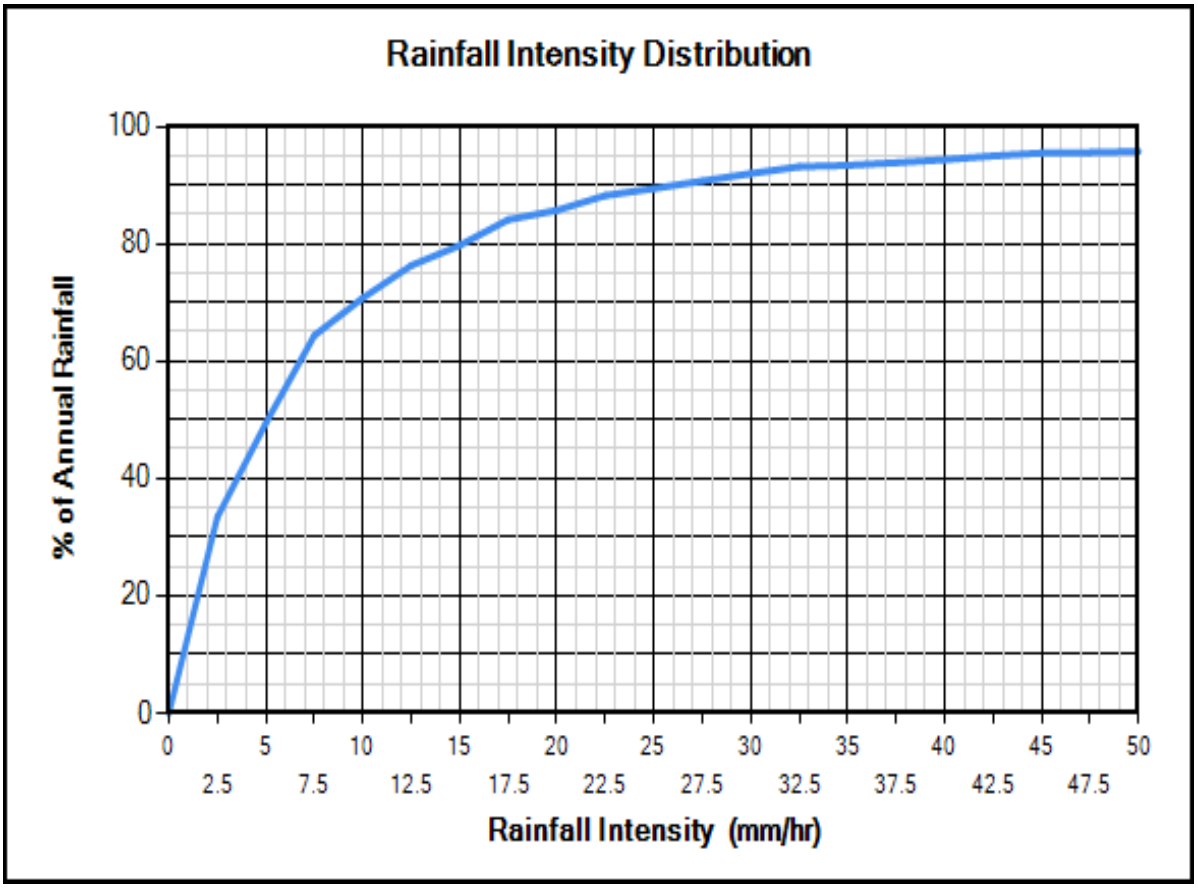
TSS Removal Sizing Summary



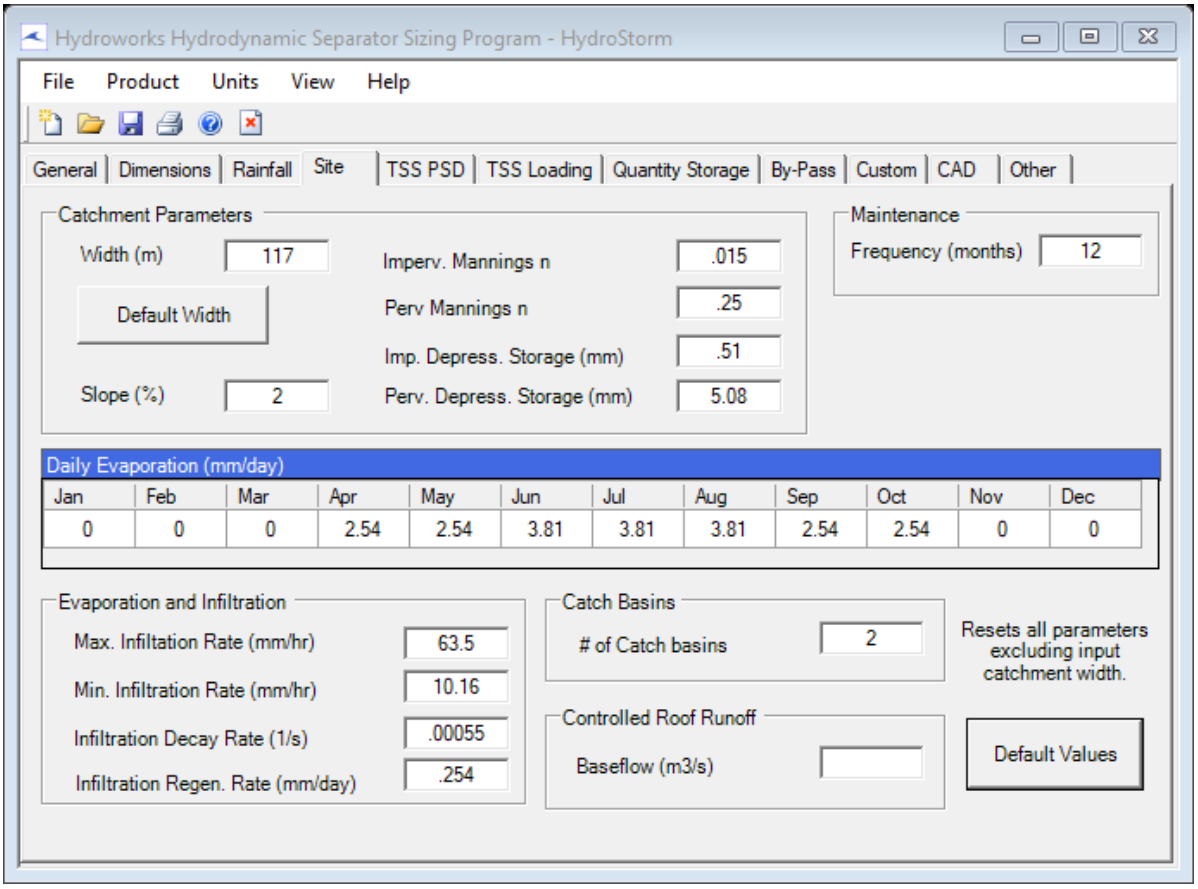
TSS Particle Size Distribution



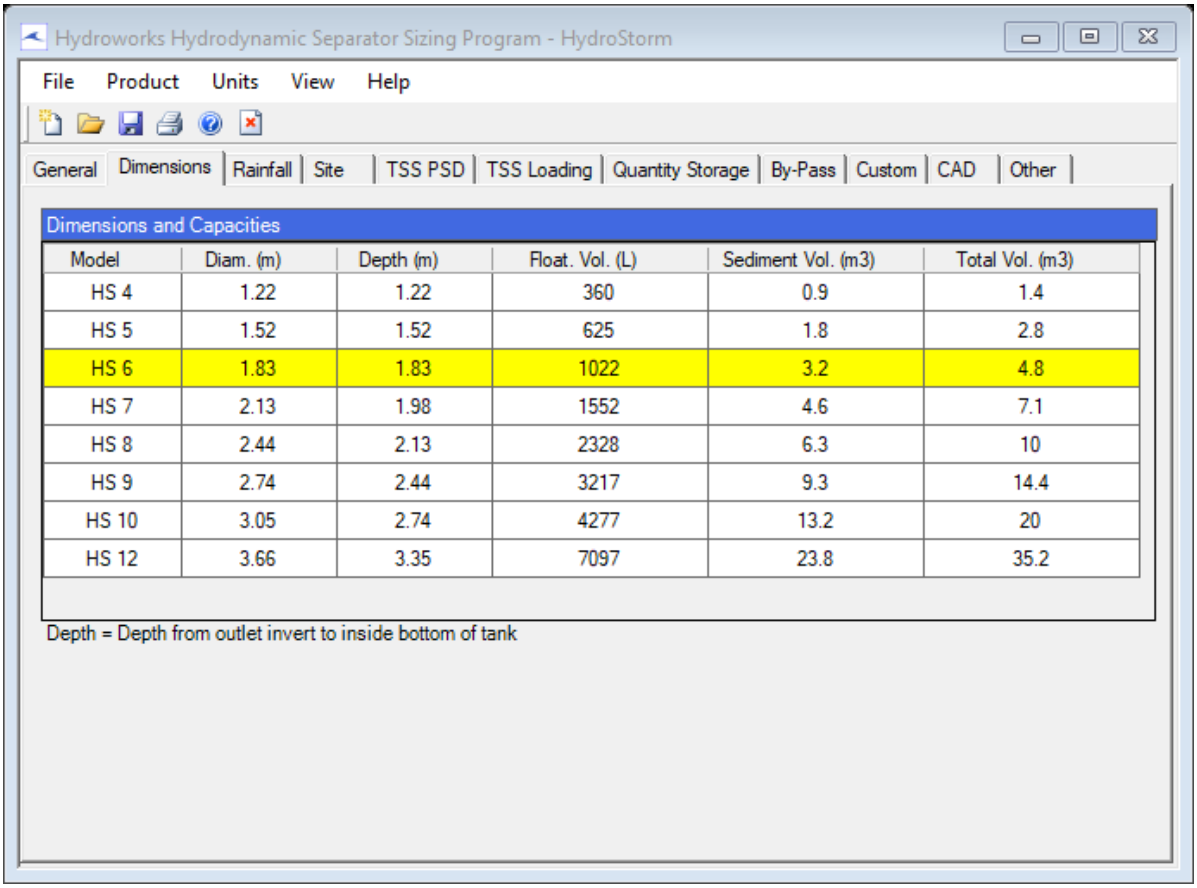
Rainfall Station - St. Catherines A, Ontario(1971 to 2005)



Site Physical Characteristics



Dimensions And Capacities

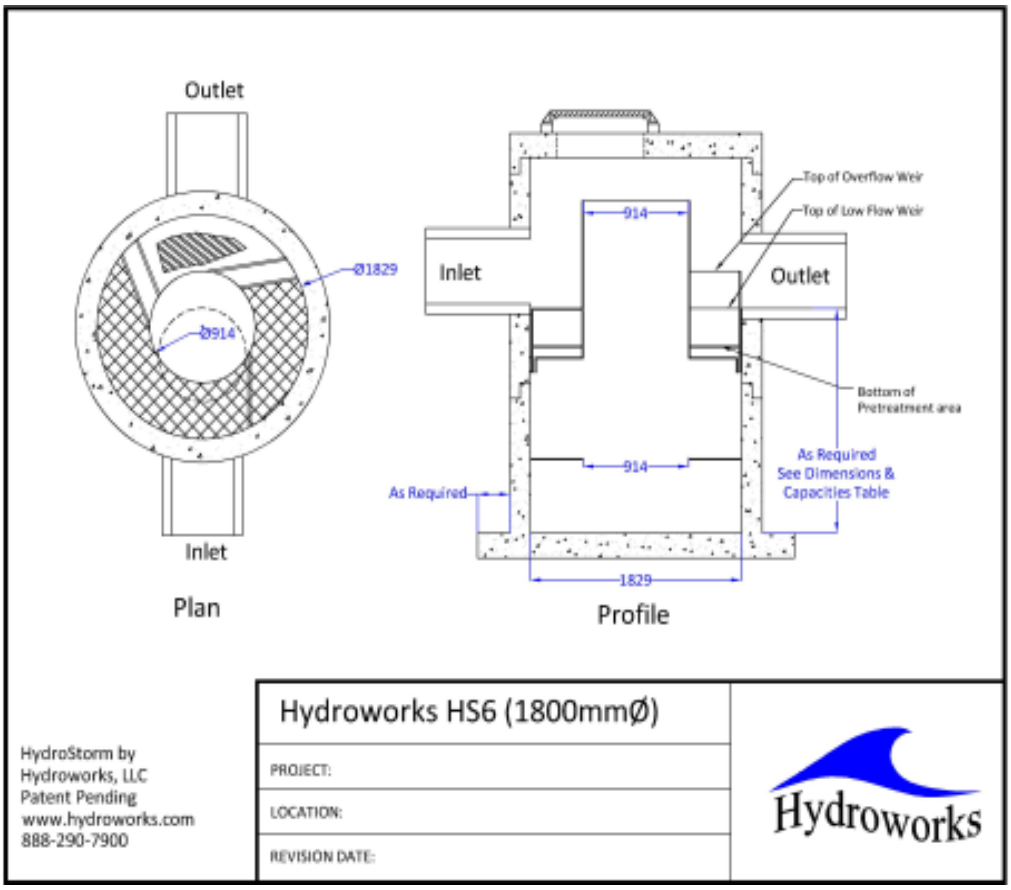


Dimensions and Capacities

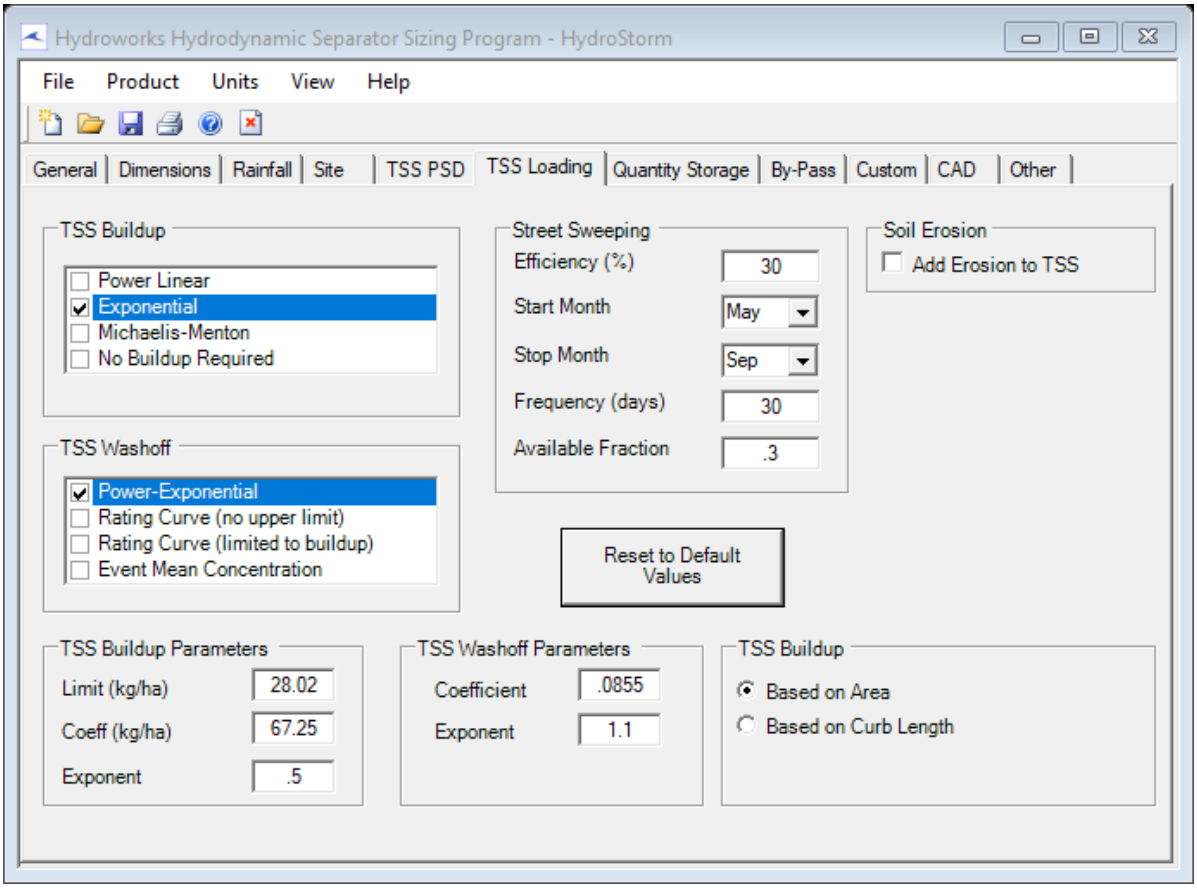
Model	Diam. (m)	Depth (m)	Float. Vol. (L)	Sediment Vol. (m3)	Total Vol. (m3)
HS 4	1.22	1.22	360	0.9	1.4
HS 5	1.52	1.52	625	1.8	2.8
HS 6	1.83	1.83	1022	3.2	4.8
HS 7	2.13	1.98	1552	4.6	7.1
HS 8	2.44	2.13	2328	6.3	10
HS 9	2.74	2.44	3217	9.3	14.4
HS 10	3.05	2.74	4277	13.2	20
HS 12	3.66	3.35	7097	23.8	35.2

Depth = Depth from outlet invert to inside bottom of tank

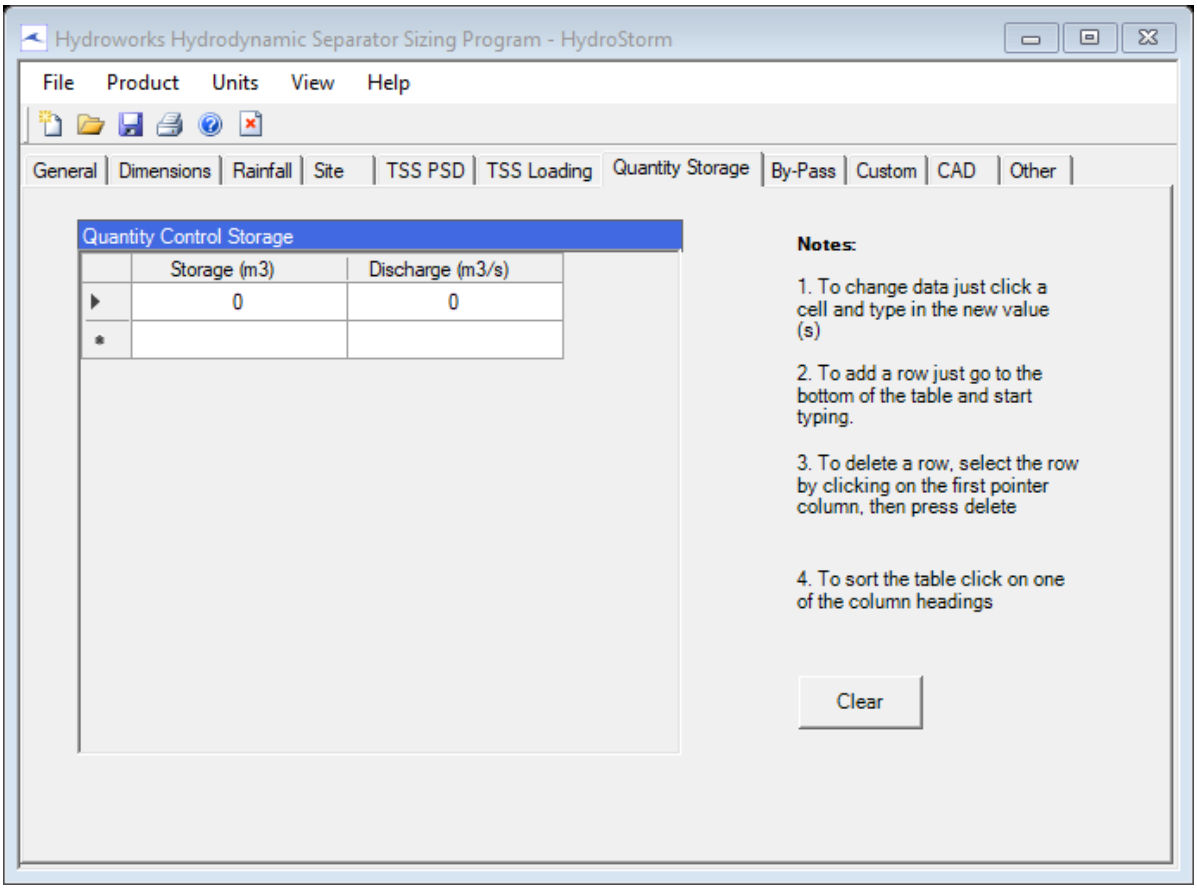
Generic HS 6 CAD Drawing



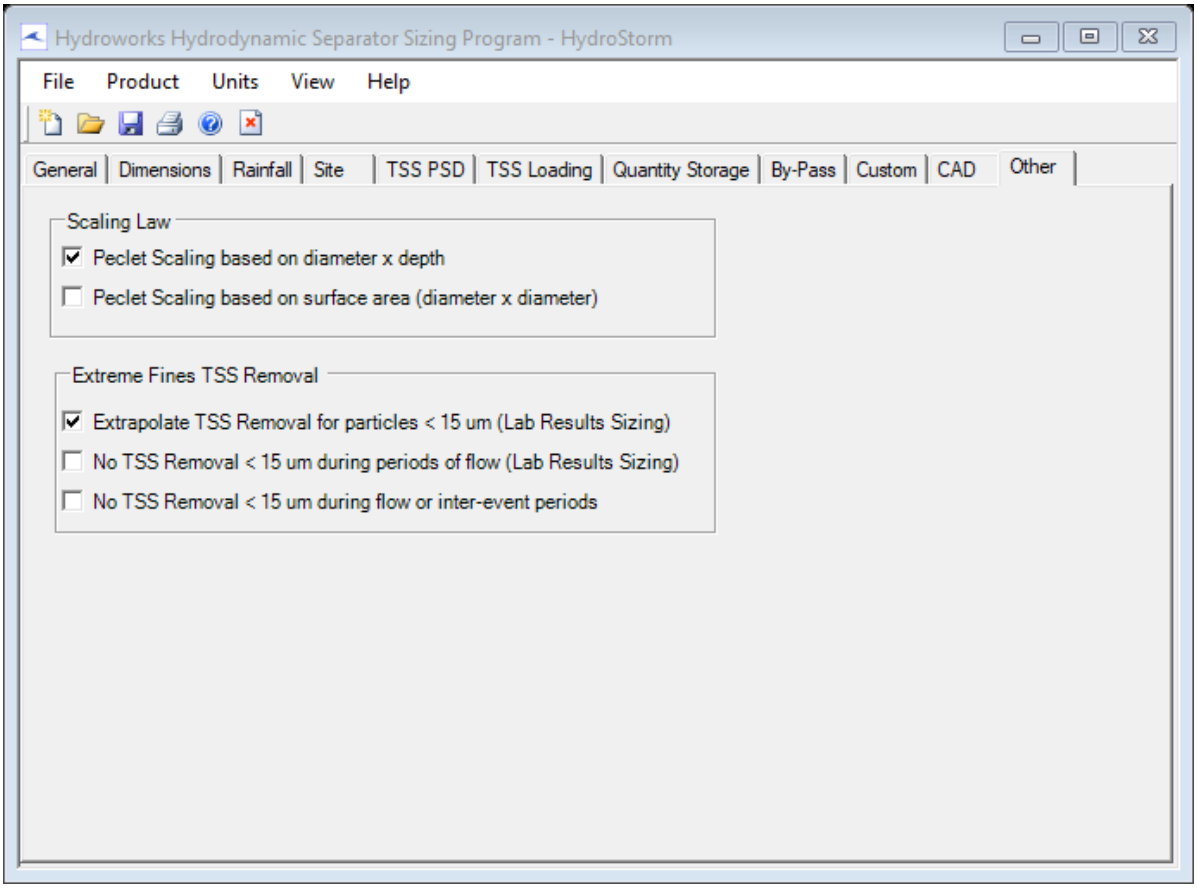
TSS Buildup And Washoff



Upstream Quantity Storage



Other Parameters



Hydroworks Sizing Program - Version 4.9

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.

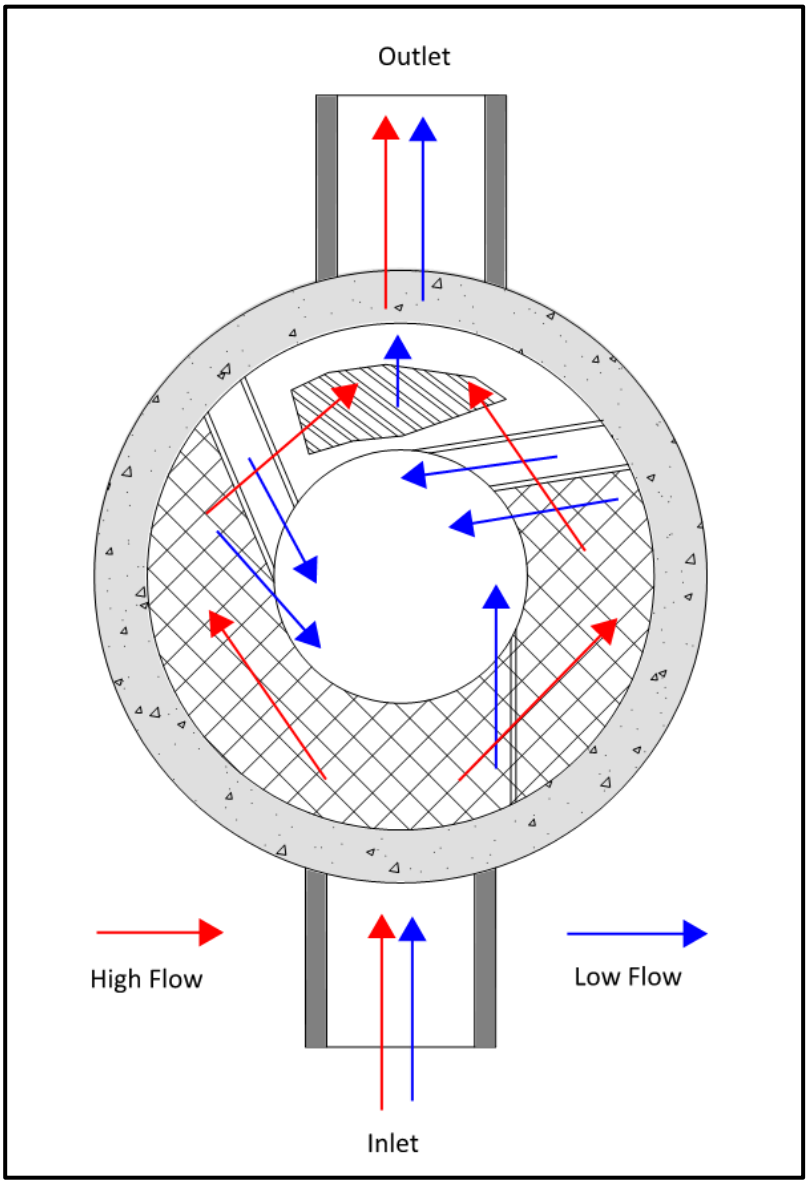


Figure 1. Hydroworks HydroStorm Operation – Plan View

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

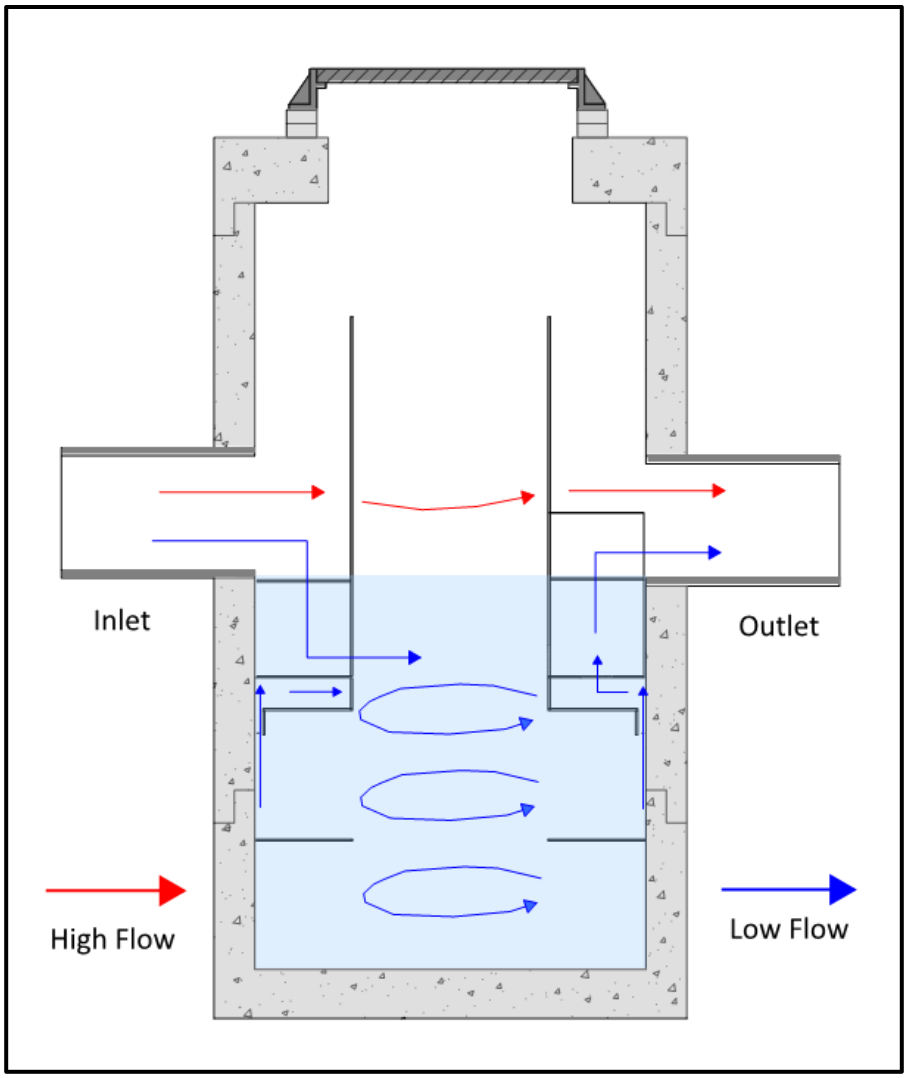


Figure 2. Hydroworks HydroStorm Operation – Profile View

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.

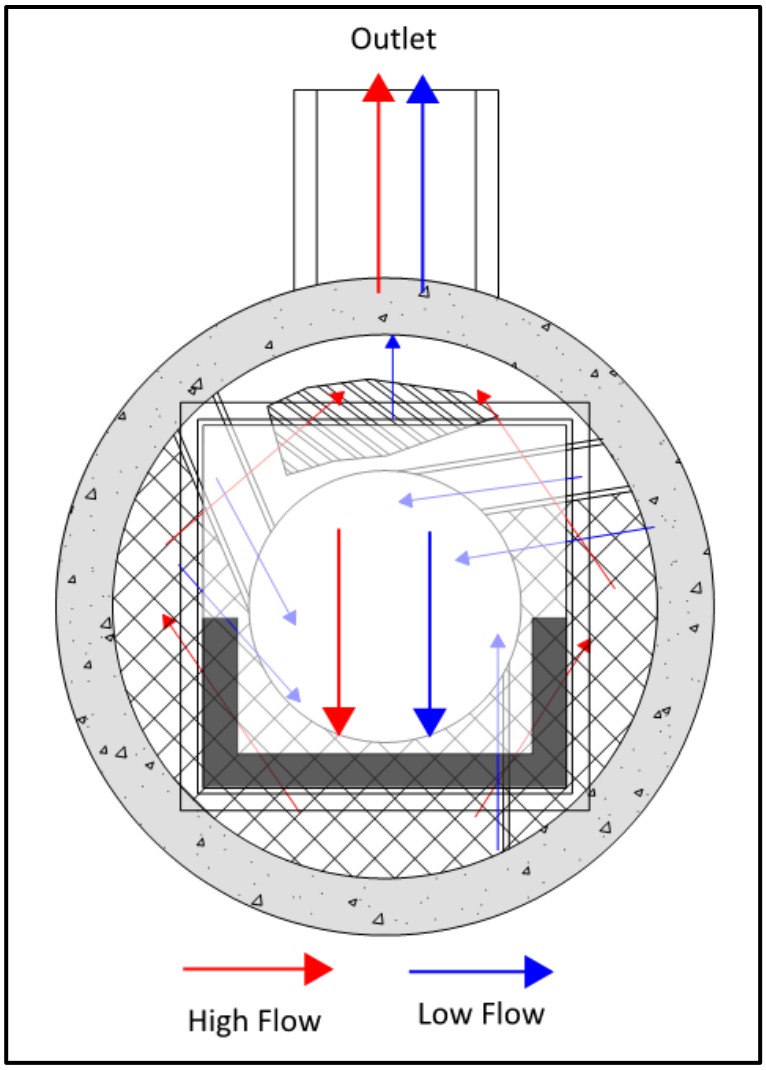


Figure 3. Hydroworks HS 4i Funnel

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.

Hydroworks

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).

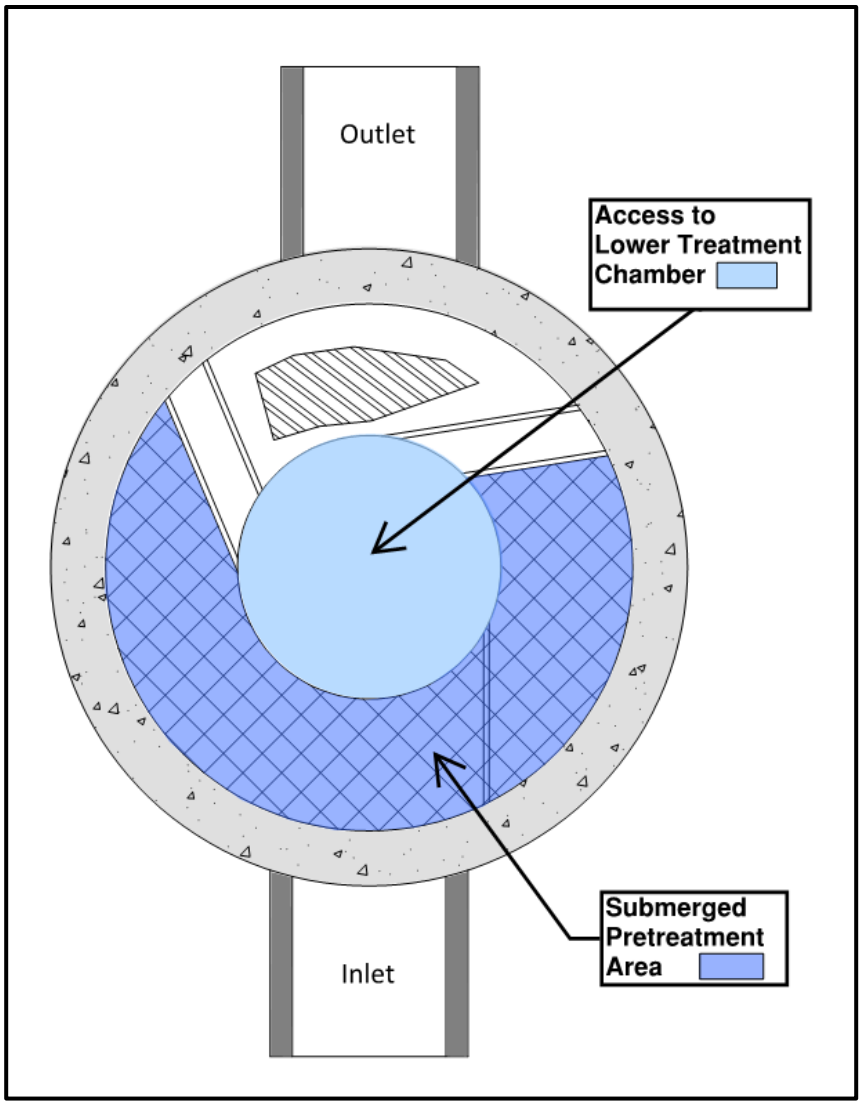


Figure 3. Maintenance Access

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.

APPENDIX C

WATER ANALYSIS INFORMATION

FIRE FLOW DEMAND REQUIREMENTS - FIRE UNDERWRITERS SURVEY (FUS GUIDELINES)

Project Number: **21042**
Project Name: **Northwest Corner of Rebstock Road and Ridge Road South**
Date: **13-May-21**

Fire flow demands for the FUS method is based on information and guidance provided in "Water Supply for Public Protection" (Fire Underwriters Survey, 1999).

An estimate of the fire flow required is given by the following formula:

$$F = 220\,C\sqrt{A} \qquad \textbf{(1)}$$

where:

F = the required fire flow in litres per minute
C = coefficient related to the type of construction
= 1.5 for wood frame construction (structure essentially all combustible).
= 1.0 for ordinary construction (brick or other masonry walls, combustible floor and interior)
= 0.8 for non-combustible construction (unprotected metal structural components, masonry or metal walls)
= 0.6 for fire-resistive construction (fully protected frame, floors, roof)
A = Total floor area in square metres

	Building Area				(1)		(2)			(3)		(4)		Final Adjusted Fire Flow	
Building / Location	Footprint Area (m^2)	# of Storeys	**Total GFA (m^2)**	Type of Construction	***Fire Flow "F"*** (l/min)	***Fire Flow "F"*** (l/s)	***Occupancy*** %	***Occupancy*** Adjustment (l/min)	***Occupancy*** **Adjusted Fire Flow (l/min)**	***Sprinkler*** %	***Sprinkler*** Adjustment (l/min)	***Exposure*** %	***Exposure*** Adjustment (l/min)	**(l/min)**	**(l/s)**
Stacked Townhouse Block C	**1900.0**	**1**	**1900**	**1.5**	14000	233.3	**-15**	-2100.0	**11900.0**	**0**	0.0	50	5950.0	**18000**	**300**

(2) Occupancy

Non-Combustible	-25%
Limited Combustible	-15%
Combustible	No charge
Free Burning	15%
Rapid Burning	25%

(3) Sprinkler

Minimum credit for systems designed to NFPA 13 is 30%.

If the domestic and fire services are supplied by the same municipal water system, then take an additional 10%.

If the sprinkler system is fully supervised (ie. annunciator panel that alerts the Fire Dept., such as a school), then an additional 10% can be taken. Maximum credit = 50%.

(4) Exposure

0 to 3m	25%	
3.1 to 10m	20%	Calculate for all
10.1 to 20m	15%	sides. Maximum
20.1 to 30m	10%	charge shall not
30.1 to 45m	5%	exceed 75%

Side	Exposure (m)	Charge (%)
North =	**3.1 to 10m**	**20**
South =	**3.1 to 10m**	**20**
East =	**20.1 to 30m**	**10**
West =	**>45m**	**0**
Total Expoure =		***50***