STORM WATER MANAGEMENT STUDY REPORT

Prepared For

PAVARANI HOLDINGS INC
GAS BAR, STORE AND RESTAURANT
575 KING STREET EAST,
GANANOQUE, ONTARIO

GAMA ENGINEERING
PROJECT NUMBER 1830

Prepared By

Wajid Mansuri, P.Eng.
GAMA Engineering Inc.
8611 Weston Road, Suite 35B
Vaughan, Ontario
L4L 9P1

Revision 1
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1. INTRODUCTION

1.1 Study Area

The site is located at 575 King Street East, Gananoque, Ontario. The Study area is shown in Figure 1.

1.2 Background

This study has been prepared on behalf of Pavarani Holdings Inc. to address Stormwater Management (SWM) requirements for the proposed site development located at 575 King Street East in Gananoque, Ontario. The proposed works will consist of construction of a one storey combo convenience store and quick service restaurant building, fuel dispenser islands, associated canopy and underground fuel storage tanks.

This SWM Report provides details for stormwater quantity and quality control to ensure that the proposed development will not have any adverse effects on the existing drainage condition.

1.3 Objectives of Drainage and Stormwater Management Study

The objectives of the stormwater management study are to develop a strategy for the project that will:

- Identify potential stormwater runoff (quality and quantity) impacts to the receiving storm drainage networks from the proposed development area.
- Address concerns from the review agencies including the Town of Gananoque and the Ministry of Environment, Conservation and Parks (MECP) for the preparation of a Stormwater Management study for quantity and quality purposes.
- Provide an appropriate site drainage system for safe operational use.

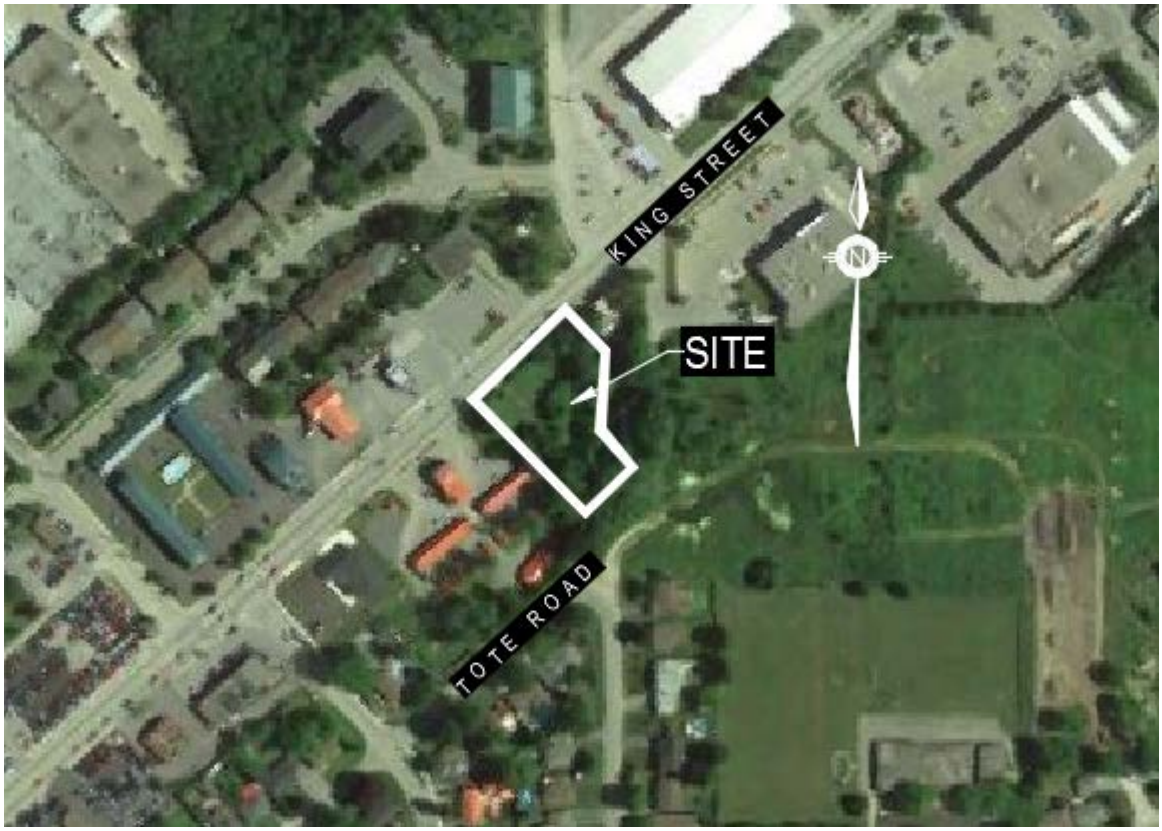


Figure 1 - Study Area

2. BACKGROUND

2.1 Background Information

Previous studies, reports and design guidelines relating to hydrology, hydraulics and stormwater management were obtained from the appropriate sources and reviewed.

Various agencies were contacted to obtain information relative to drainage and stormwater management within the project area. The agencies contacted and information obtained is as follows:

- Ministry of Environment – Stormwater Management Planning and Design Manual 2003
- Erosion & Sediment Control Guidelines for Urban Construction (TRCA, December 2006)
- Town of Gananoque Development Guidelines.

2.2 Land Use

The study area is 0.292 ha of undeveloped land designated for commercial use.

3. STORM DRAINAGE

3.1 Design Criteria

The stormwater management servicing strategy proposed for the development has been prepared utilizing the Town of Gananoque requirement, abiding by the following guidelines.

- The allowable release rate from the development site during the occurrence of a 5-Year storm event must not exceed the runoff rate equivalent to the peak runoff rate achieved by the site under pre-development flow conditions during the occurrence of a 5-Year storm event.
- Runoff generated by storms up to and including the 100-year event must be contained onsite and released at the allowable release rate defined above.
- An overland flow route shall be provided within the developed site to direct runoff greater than the 100 Year storm to an approved overland flow outlet.
- A minimum of 80% long term removal of total suspended solids from stormwater flow before discharged offsite.

3.2 Pre-Development Condition

The area under stormwater management is approximately 0.292 ha of green land. The site has an asphalt paved yard and driveway. There are no storm sewers on site. The site drains overland towards the lower lands on the eastern property limit

Figure 2 illustrates the pre-development drainage condition.

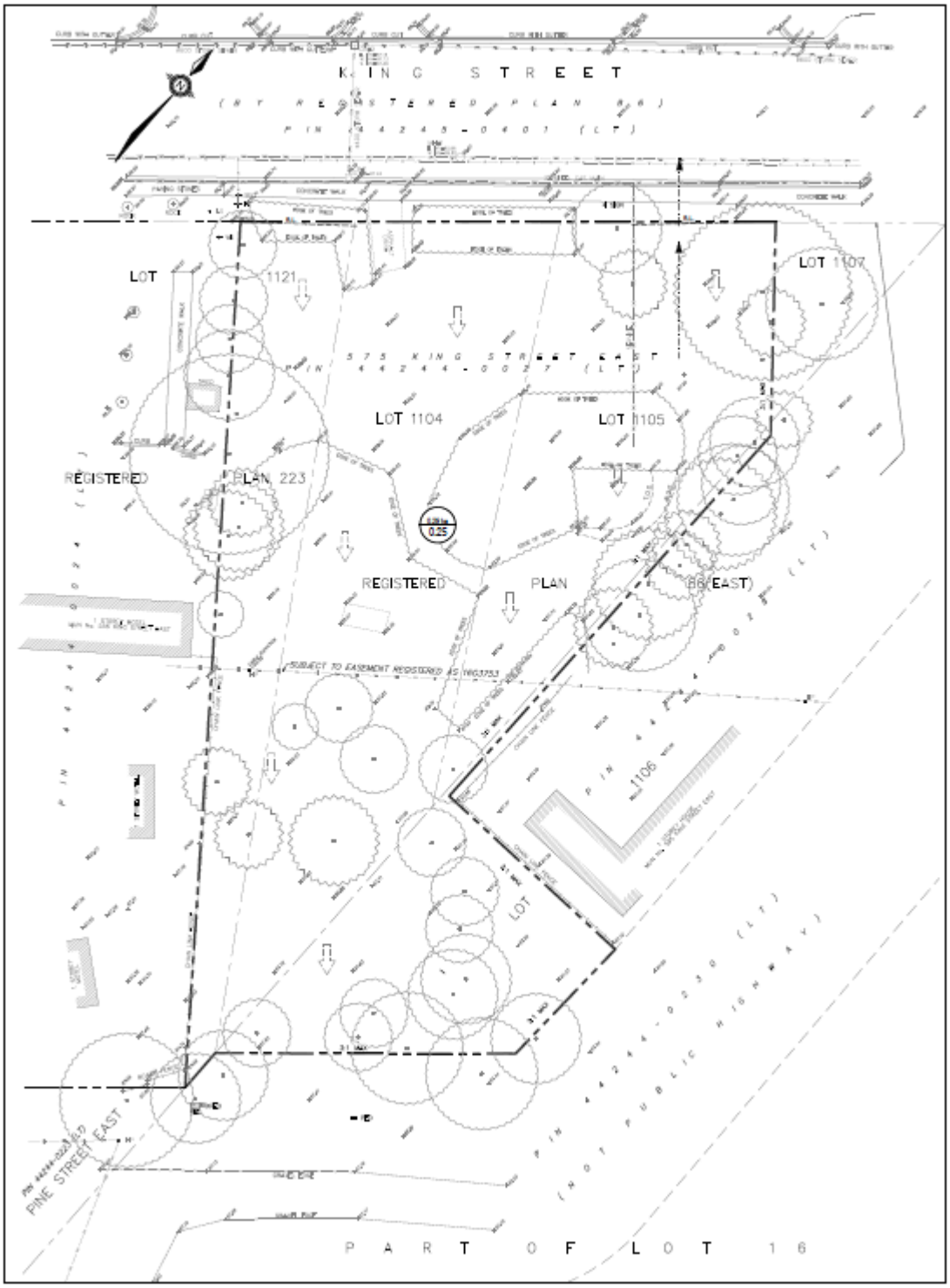


Figure 2 - Pre-Development Condition

The 5-Year return period design rainfall intensity is calculated per MTO IDF Curve for Town of Gananoque area. (Refer to Appendix 1 – Supporting Calculations).

$$I = At^B$$

Where: I -Rainfall intensity (mm/hr)

t – Time of concentration (min)

$$I_5 = 27.3\ x\ 10^{-0.699} = 72.08mm/hr$$

The corresponding 5-Year pre-development peak flow is:

$$Q = 0.00278\ \ C\ I\ A \leftarrow Equation\ \ (1)$$

Where $Q :=$ *Maximum Runoff Rate* (m^3/sec)

$C :=$ *Runoff Coefficient*

$I :=$ *Rainfall Intensity (mm/hr)*

$A :=$ *Drainage Area (ha)*

$$Q = 0.00278\ x\ 0.25\ x\ 72.08mm/hr\ x\ 0.24ha = \ 0.0193\ m^3/sec$$

3.3 Post Development Condition

The post-development hydrologic conditions for the site were established utilizing the current Town of Gananoque requirement, including the current 2-Year and 100-Year IDF data (refer to appendix), a conservative surface run-off coefficient of 0.90 was used for impervious surfaces (i.e. Roof drainage and parking area) and 0.25 was used for pervious surfaces (i.e. landscape).

The runoff generated on the proposed site will be contained on site and captured via double catchbasin manhole located at south end of the site. The runoff flow will undergo quality treatment via an oil/grit separator before discharged off-site via a lift station.

The proposed system will discharge into the existing 600mm diameter municipal drain along King Street.

For practical reasons a portion of the landscape area along the site perimeter will flow un-controlled. There will be no increase in stormwater run-off from the un-controlled area.

Figure 3 below illustrates the Post Development drainage condition.

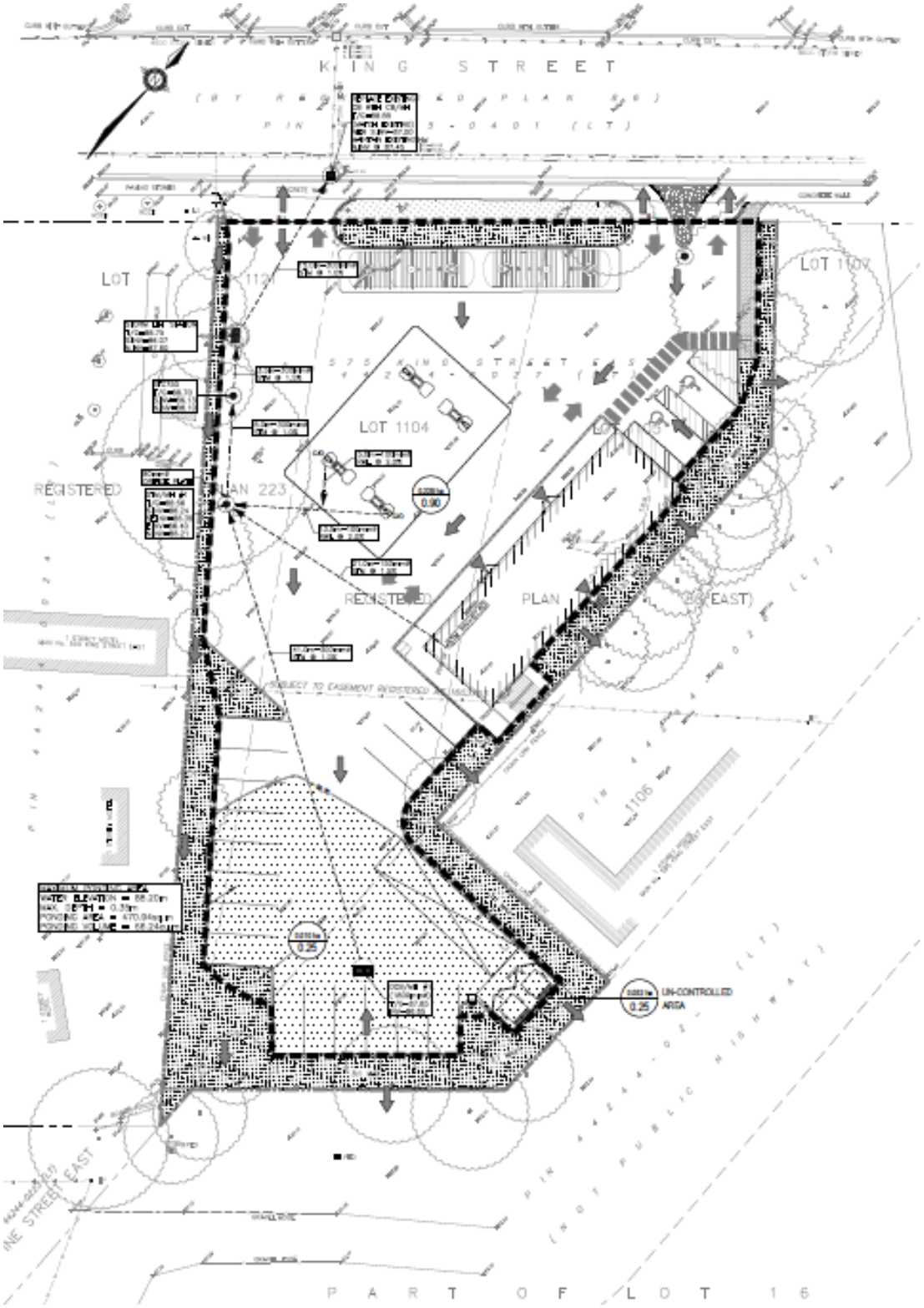


Figure 3 – Post Development Condition

The weighted surface run-off coefficients for existing and proposed site condition are shown Table 1.

Surface Composition		Impervious	Pervious	Total Controlled
Existing Condition	(m^2)	0	2380	2380
	(ha)	0.000	0.238	0.238
Runoff Coefficient		0.900	0.250	0.250

Surface Composition		Impervious	Pervious	Total Controlled
Proposed Condition	(m^2)	2285	95	2380
	(ha)	0.229	0.010	0.238
Runoff Coefficient		0.900	0.250	0.874

Table 1 Weighted Surface Run-Off Coefficient

The 100-Year return period design rainfall intensity is calculated per Town of Gananoque requirement as follows:

$$I_{100} = 45.60\ x\ 10^{-0.694} = 159.55mm/hr$$

The results of peak flow rates (m^3) generated by the "Rational Method" for existing and proposed conditions are shown on Table 3.

Storm Event	Rainfall Intensity (mm/hr)				<Equation 1> Flow Rate (m^3/sec)		
	A	B		I	Existing	Proposed	Excess Flow
2-Year	20.60	-0.699		72.08	0.0119	0.0417	0.0298
5-Year	27.30	-0.699		95.52	0.0158	0.0552	0.0394
10-Year	31.80	-0.699		111.26	0.0184	0.0643	0.0459
25-Year	37.40	-0.699		130.86	0.0216	0.0757	0.0540
50-Year	41.50	-0.699		145.20	0.0240	0.0840	0.0600
100-Year	45.60	-0.699		159.55	0.0264	0.0923	0.0659

Table 2 Controlled Area Peak Flows - 2 to 100 Year Events

3.4 Storage Requirements

With the proposed development, the drainage pattern on the controlled area is expected to change, resulting in a post-development run-off coefficient 0.874.

To satisfy the municipal requirements, the runoff generated by storms up to and including the 100-year event must be contained onsite and released at the allowable release rate (5-Year Storm Event).

$$Q_{Allowable} = 0.0158 m^3/sec$$

To mitigate the impacts of the proposed development, onsite storage and flow control is provided using an orifice plate restrictor located at STM/MH #1 of the developed site to limit the release rate to the 5-Year pre-development condition.

Sizing of the orifice is given by the formula:

$$Q = CA\sqrt{2gh} \leftarrow Equation\ (2)$$

Where Q = Flow Rate through orifice (m^3/sec) = Q allowable

C = Contraction Coefficient = 0.63 (for orifice plate)

A = Area of orifice opening (m^2)

g = Gravity acceleration (m/sec^2) = 9.81 m/sec^2

The maximum water level of on-site ponding during a major storm event is 88.20 m. By trial and error calculations an 80mm diameter orifice plate is required to control the flow rate to 5 Year Storm Event predevelopment levels (0.0193 m^3/s).

$$Q = 0.63\,\pi\,(0.070^2/4)\sqrt{2(9.81)\left(88.20 - \left(86.21 + \frac{0.070}{2}\right)\right)}$$

$$= 0.0150\ m^3/\text{sec}\ (Actual\ rate) < 0.0158\ m^3/\text{sec}\ (Allowable\ rate)$$

Based on the chosen 70 mm diameter orifice plate the actual required retention volume is calculated using the “Modified Rational Method” and is shown in Table 4.

Stm Event	Td	Id	Qpost	Qorifice	Excess Flow	Volume(m^3)
	2	491.44	0.2842	0.0150	0.2692	32.30
	5	259.01	0.1498	0.0150	0.1348	40.44
	7	204.72	0.1184	0.0150	0.1034	43.43
	10	159.55	0.0923	0.0150	0.0773	46.36
	15	120.17	0.0695	0.0150	0.0545	49.05
100 Year	20	98.28	0.0568	0.0150	0.0418	50.20
	22	91.95	0.0532	0.0150	0.0382	50.39
	40	60.54	0.0350	0.0150	0.0200	48.03
	50	51.80	0.0300	0.0150	0.0150	44.87
	60	45.60	0.0264	0.0150	0.0114	40.94
				Max Volume Required	cum	**50.39**

Table 3 Required Storage Volume 100 Year Event

Referring to Table 4 above, 50.39 m^3 is the required on-site storage volume for the worst-case scenario during a 100 Year Storm Event.

Table 5 below illustrates how the required storage is provided.

Structure	Diameter (mm)	Area (m^2)	Maximum. Water level	Invert	Volume (m^3)
DCB/MH#1	1800	2.54	87.85	86.65	3.05
STM/MH#1	1200	1.13	88.20	86.21	2.25
Sum					**5.30**

U/G Conduit	Diameter (mm)	Area (m^2)	Length (m)	Volume (m^3)
1	300	0.07	41.0	2.90
Sum				**2.90**

Storage Volume For 100-Year Event (m^3)	
Catch Basins & Manholes	5.30
Underground Conduits	2.90
Surface Ponding	66.24
Total Provided	**74.44**

Table 4 Actual Storage Provided

The proposed drainage system can store up to 74.44 m^3 of stormwater runoff which exceeds the required volume of 50.39 m^3.

When the storm event exceeds the 100 Year return storm event parameters and the entire available on-site storage is used the system will discharge overland via laminary flow at the south corner of the property.

3.5 Quality Control

For quality control purposes, installation of a Stormceptor STC750 is proposed for the "ENHANCED LEVEL". The proposed location of the Stormceptor is at the north-west side of the property. Sizing of the Stormceptor is based on guidelines provided by the manufacturer (refer to Detailed Stormceptor Sizing Report Appendix 2).
The Stormceptor unit will be inspected and maintenance procedures will be performed per manufacturer's recommendations as stated below.
Post construction inspection is required prior to putting the Stormceptor in service.

- Routine inspections to be performed during the first year of operation to accurately assess the sediment accumulation.
- Inspection frequency in subsequent years is based on the maintenance plan developed on the first year.
- Inspections should also be performed immediately after oil, fuel or any other chemical spill.
- The unit to be cleaned out once the sediment depth reaches the recommended maintenance sediment depth 230mm, which is approximately 15% of the unit's total storage capacity.

The "*Stormceptor System Technical Manual*" is attached for your reference.

4. EROSION AND SEDIMENT CONTROL DURING CONSTRUCTION

The erosion potential of the study area was assessed using methods described in the "*MTO Drainage Management Manual*" of temporary erosion and sediment control measures suitable for construction sites close to highways.

During Site construction, various temporary measures will be implemented to prevent the discharge of sediment laden Stormwater from the Site. These measures include silt fencing, catch basin buffers and mud-mats as shown on drawing GP-1 - Grading Plan.

In addition to the above, the following "good housekeeping" measures are recommended:

- All exposed soil shall be stabilized as soon as possible with a seed and mulch application as directed by the Engineer.
- No construction activity or machinery shall intrude beyond the silt/snow fence or limit of construction area. All construction vehicles shall leave the site at designated locations as shown on the plans.
- Stockpiles of soil shall be set back from any watercourse and stabilized against erosion as soon as possible. A set back of at least 15m from any top-of-bank, watercourse or pond is required.
- Cleaning and repairs of mud-mats and any other temporary sediment control measures shall be completed as deemed necessary through regular inspection.
- Sediment/silt shall be removed from the sediment control devices after storm events and deposited in areas as approved by the engineer.
- All re-graded areas within the development which are not occupied by buildings, roadways, sidewalks, or driveways shall be top-soiled and sodded/seeded immediately after completion of final grading operations as directed by the engineer.

5. SUMMARY AND CONCLUSIONS

In summary, all required conditions of the Town of Gananoque have been satisfied as follows:

- There is no increase in Stormwater flow from the Site.
- The SWM facilities provide ENHANCED LEVEL treatment.
- The Sediment and Erosion Control Plan demonstrates how erosion and sedimentation will be minimized during construction

This SWM Report satisfies all requirements for stormwater quantity, quality, and sedimentation and erosion control.

Wajid Mansuri, BSc. Arch. & P.Eng.

GAMA Engineering Inc.

8611 Weston Road, Suite 35B

Vaughan, Ontario, L4L 9P1
C: (647) 224-9295,
O: (905) 264-9295,
Email: W.Mansuri@sympatico.ca

Appendix 1

SUPPORTING CALCULATION

Ontario IDF CURVE LOOKUP

Active coordinate

44° 20' 15" N, 76° 9' 15" W (44.337500,-76.154167)

Retrieved: Wed, 17 Apr 2019 15:27:05 GMT

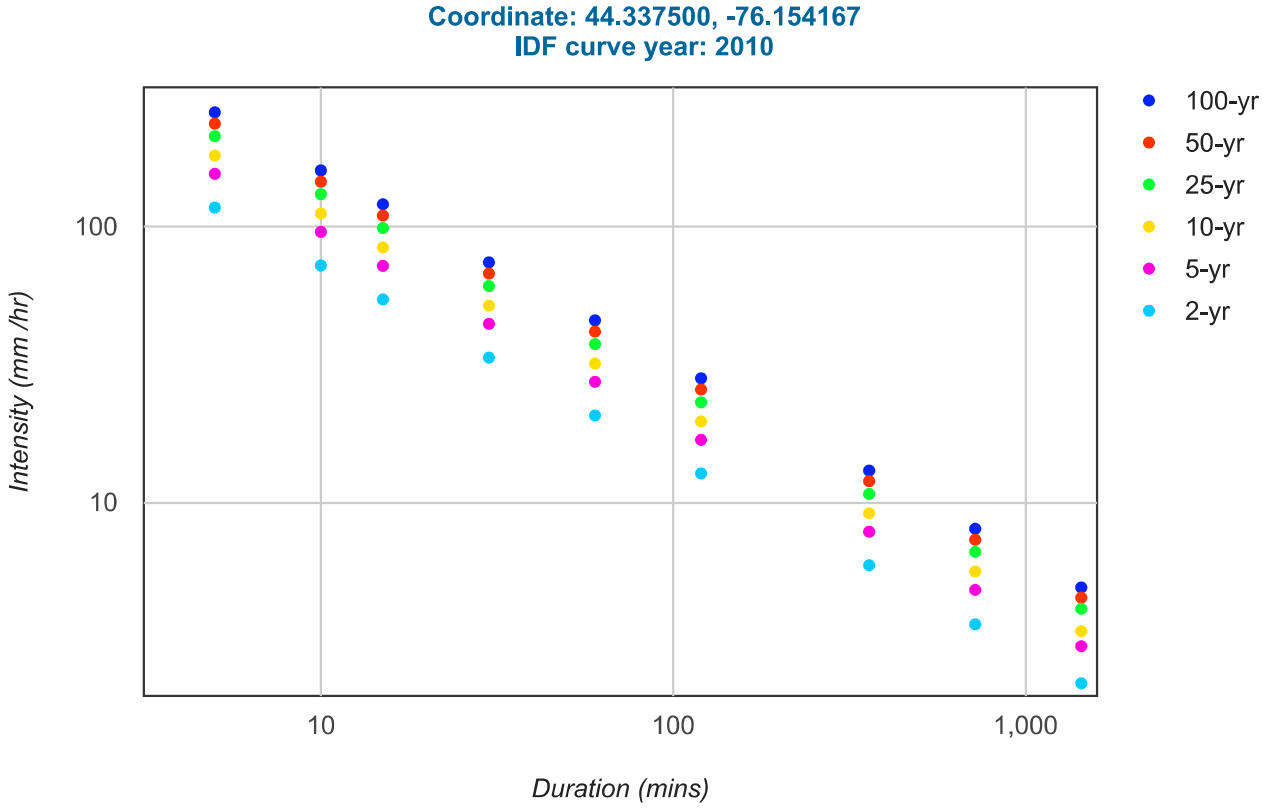
Location summary

These are the locations in the selection.

IDF Curve: 44° 20' 15" N, 76° 9' 15" W (44.337500,-76.154167)

Results

An IDF curve was found.



Coefficient summary

IDF Curve: 44° 20' 15" N, 76° 9' 15" W (44.337500,-76.154167)

Retrieved: Wed, 17 Apr 2019 15:27:05 GMT

Data year: 2010
IDF curve year: 2010

Return period	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
A	20.6	27.3	31.8	37.4	41.5	45.6
B	-0.699	-0.699	-0.699	-0.699	-0.699	-0.699

Statistics

Rainfall intensity (mm hr^{-1})

Duration	5-min	10-min	15-min	30-min	1-hr	2-hr	6-hr	12-hr	24-hr
2-yr	117.0	72.1	54.3	33.4	20.6	12.7	5.9	3.6	2.2
5-yr	155.1	95.5	71.9	44.3	27.3	16.8	7.8	4.8	3.0
10-yr	180.6	111.3	83.8	51.6	31.8	19.6	9.1	5.6	3.4
25-yr	212.4	130.9	98.6	60.7	37.4	23.0	10.7	6.6	4.1
50-yr	235.7	145.2	109.4	67.4	41.5	25.6	11.9	7.3	4.5
100-yr	259.0	159.5	120.2	74.0	45.6	28.1	13.0	8.0	4.9

Rainfall depth (mm)

Duration	5-min	10-min	15-min	30-min	1-hr	2-hr	6-hr	12-hr	24-hr
2-yr	9.8	12.0	13.6	16.7	20.6	25.4	35.3	43.5	53.6
5-yr	12.9	15.9	18.0	22.2	27.3	33.6	46.8	57.7	71.1
10-yr	15.1	18.5	21.0	25.8	31.8	39.2	54.5	67.2	82.8
25-yr	17.7	21.8	24.6	30.4	37.4	46.1	64.1	79.0	97.3
50-yr	19.6	24.2	27.3	33.7	41.5	51.1	71.2	87.7	108.0
100-yr	21.6	26.6	30.0	37.0	45.6	56.2	78.2	96.3	118.7

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Appendix 2

STORMCEPTOR SIZING REPORT

Detailed Stormceptor Sizing Report – Gananoque

Project Information & Location			
Project Name	1830 Gananoque	**Project Number**	1830
City	Gananoque	**State/ Province**	Ontario
Country	Canada	**Date**	4/17/2019
Designer Information		**EOR Information (optional)**	
Name	Mishel Gjata	**Name**	
Company	MG	**Company**	
Phone #	647-740-8036	**Phone #**	
Email	mishelg@hotmail.com	**Email**	

Stormwater Treatment Recommendation

The recommended Stormceptor Model(s) which achieve or exceed the user defined water quality objective for each site within the project are listed in the below Sizing Summary table.

Site Name	Gananoque
Recommended Stormceptor Model	STC 750
Target TSS Removal (%)	80.0
TSS Removal (%) Provided	85
PSD	Fine Distribution
Rainfall Station	KINGSTON PUMPING STATION

The recommended Stormceptor model achieves the water quality objectives based on the selected inputs, historical rainfall records and selected particle size distribution.

Stormceptor Sizing Summary		
Stormceptor Model	**% TSS Removal Provided**	**% Runoff Volume Captured Provided**
STC 300	77	97
STC 750	85	99
STC 1000	86	99
STC 1500	87	99
STC 2000	89	100
STC 3000	90	100
STC 4000	92	100
STC 5000	93	100
STC 6000	94	100
STC 9000	96	100
STC 10000	96	100
STC 14000	97	100
StormceptorMAX	Custom	Custom

Stormceptor
The Stormceptor oil and sediment separator is sized to treat stormwater runoff by removing pollutants through gravity separation and flotation. Stormceptor's patented design generates positive TSS removal for each rainfall event, including large storms. Significant levels of pollutants such as heavy metals, free oils and nutrients are prevented from entering natural water resources and the re-suspension of previously captured sediment (scour) does not occur.
Stormceptor provides a high level of TSS removal for small frequent storm events that represent the majority of annual rainfall volume and pollutant load. Positive treatment continues for large infrequent events, however, such events have little impact on the average annual TSS removal as they represent a small percentage of the total runoff volume and pollutant load.

Design Methodology
Stormceptor is sized using PCSWMM for Stormceptor, a continuous simulation model based on US EPA SWMM. The program calculates hydrology using local historical rainfall data and specified site parameters. With US EPA SWMM's precision, every Stormceptor unit is designed to achieve a defined water quality objective. The TSS removal data presented follows US EPA guidelines to reduce the average annual TSS load. The Stormceptor's unit process for TSS removal is settling. The settling model calculates TSS removal by analyzing:
• Site parameters
• Continuous historical rainfall data, including duration, distribution, peaks & inter-event dry periods
• Particle size distribution, and associated settling velocities (Stokes Law, corrected for drag)
• TSS load
• Detention time of the system

Hydrology Analysis

PCSWMM for Stormceptor calculates annual hydrology with the US EPA SWMM and local continuous historical rainfall data. Performance calculations of Stormceptor are based on the average annual removal of TSS for the selected site parameters. The Stormceptor is engineered to capture sediment particles by treating the required average annual runoff volume, ensuring positive removal efficiency is maintained during each rainfall event, and preventing negative removal efficiency (scour).
Smaller recurring storms account for the majority of rainfall events and average annual runoff volume, as observed in the historical rainfall data analyses presented in this section.

Rainfall Station

State/Province	Ontario	**Total Number of Rainfall Events**	4483
Rainfall Station Name	KINGSTON PUMPING STATION	**Total Rainfall (mm)**	22574.7
Station ID #	4175	**Average Annual Rainfall (mm)**	513.1
Coordinates	44°14'N, 76°29'W	**Total Evaporation (mm)**	1694.4
Elevation (ft)	251	**Total Infiltration (mm)**	3877.0
Years of Rainfall Data	44	**Total Rainfall that is Runoff (mm)**	17003.3

Notes

• Stormceptor performance estimates are based on simulations using PCSWMM for Stormceptor, which uses the EPA Rainfall and Runoff modules.
• Design estimates listed are only representative of specific project requirements based on total suspended solids (TSS) removal defined by the selected PSD, and based on stable site conditions only, after construction is completed.
• For submerged applications or sites specific to spill control, please contact your local Stormceptor representative for further design assistance.

Drainage Area	
Total Area (ha)	0.29
Imperviousness %	82.8

Up Stream Storage	
Storage (ha-m)	Discharge (cms)
0.000	0.000

Water Quality Objective	
TSS Removal (%)	80.0
Runoff Volume Capture (%)	90.00
Oil Spill Capture Volume (L)	
Peak Conveyed Flow Rate (L/s)	
Water Quality Flow Rate (L/s)	

Up Stream Flow Diversion	
Max. Flow to Stormceptor (cms)	

Design Details	
Stormceptor Inlet Invert Elev (m)	
Stormceptor Outlet Invert Elev (m)	
Stormceptor Rim Elev (m)	
Normal Water Level Elevation (m)	
Pipe Diameter (mm)	
Pipe Material	
Multiple Inlets (Y/N)	No
Grate Inlet (Y/N)	No

Particle Size Distribution (PSD)

Removing the smallest fraction of particulates from runoff ensures the majority of pollutants, such as metals, hydrocarbons and nutrients are captured. The table below identifies the Particle Size Distribution (PSD) that was selected to define TSS removal for the Stormceptor design.

Fine Distribution		
Particle Diameter (microns)	Distribution %	Specific Gravity
20.0	20.0	1.30
60.0	20.0	1.80
150.0	20.0	2.20
400.0	20.0	2.65
2000.0	20.0	2.65

Site Name	Gananoque

Site Details

Drainage Area

Total Area (ha)	0.29
Imperviousness %	82.8

Surface Characteristics

Width (m)	108.00
Slope %	2
Impervious Depression Storage (mm)	0.508
Pervious Depression Storage (mm)	5.08
Impervious Manning's n	0.015
Pervious Manning's n	0.25

Maintenance Frequency

Maintenance Frequency (months) >	12

Infiltration Parameters

Horton's equation is used to estimate infiltration

Max. Infiltration Rate (mm/hr)	61.98
Min. Infiltration Rate (mm/hr)	10.16
Decay Rate (1/sec)	0.00055
Regeneration Rate (1/sec)	0.01

Evaporation

Daily Evaporation Rate (mm/day)	2.54

Dry Weather Flow

Dry Weather Flow (lps)	0

Winter Months

Winter Infiltration	0

TSS Loading Parameters

TSS Loading Function	

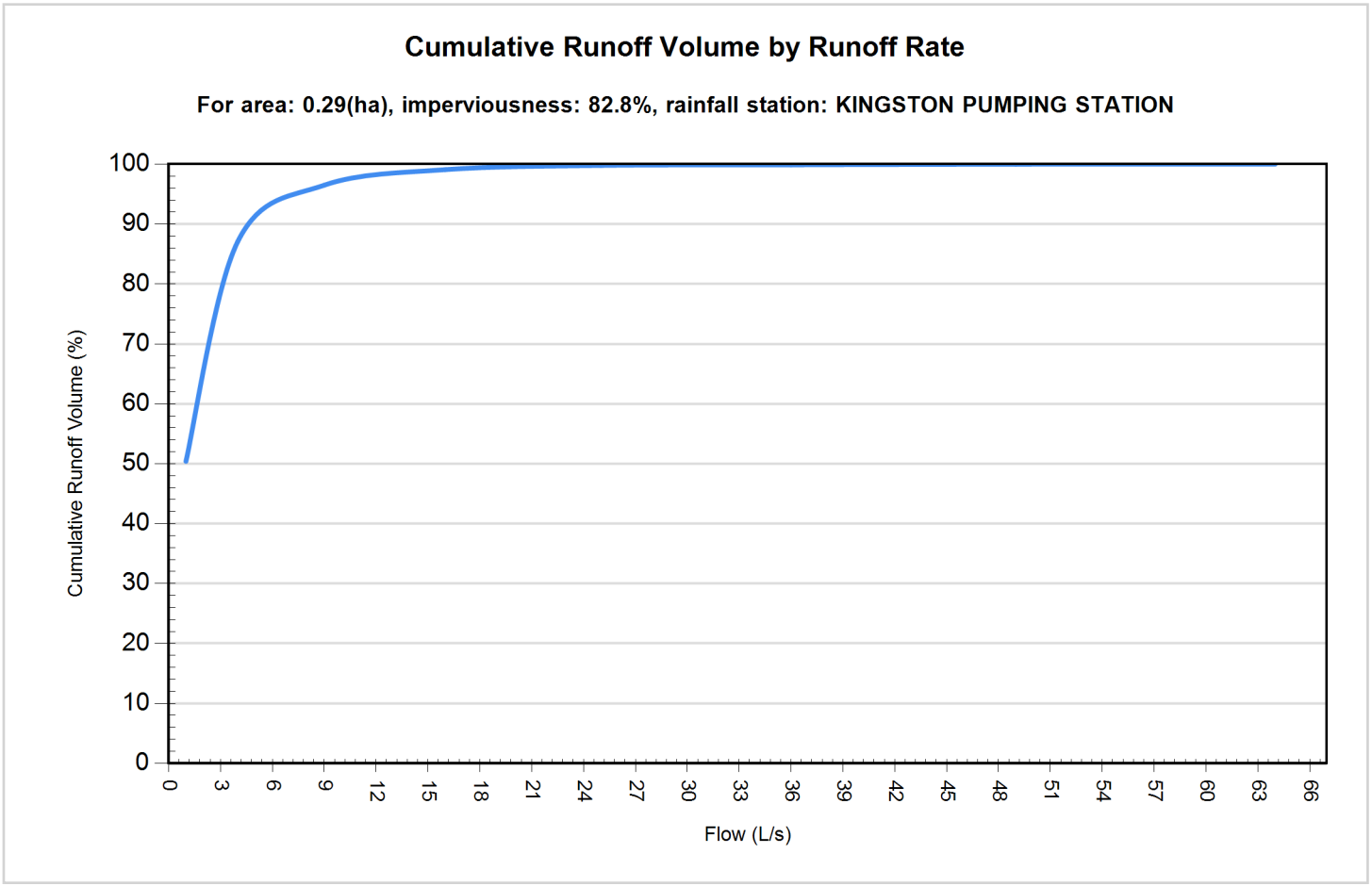
Buildup/Wash-off Parameters

Target Event Mean Conc. (EMC) mg/L	
Exponential Buildup Power	
Exponential Washoff Exponent	

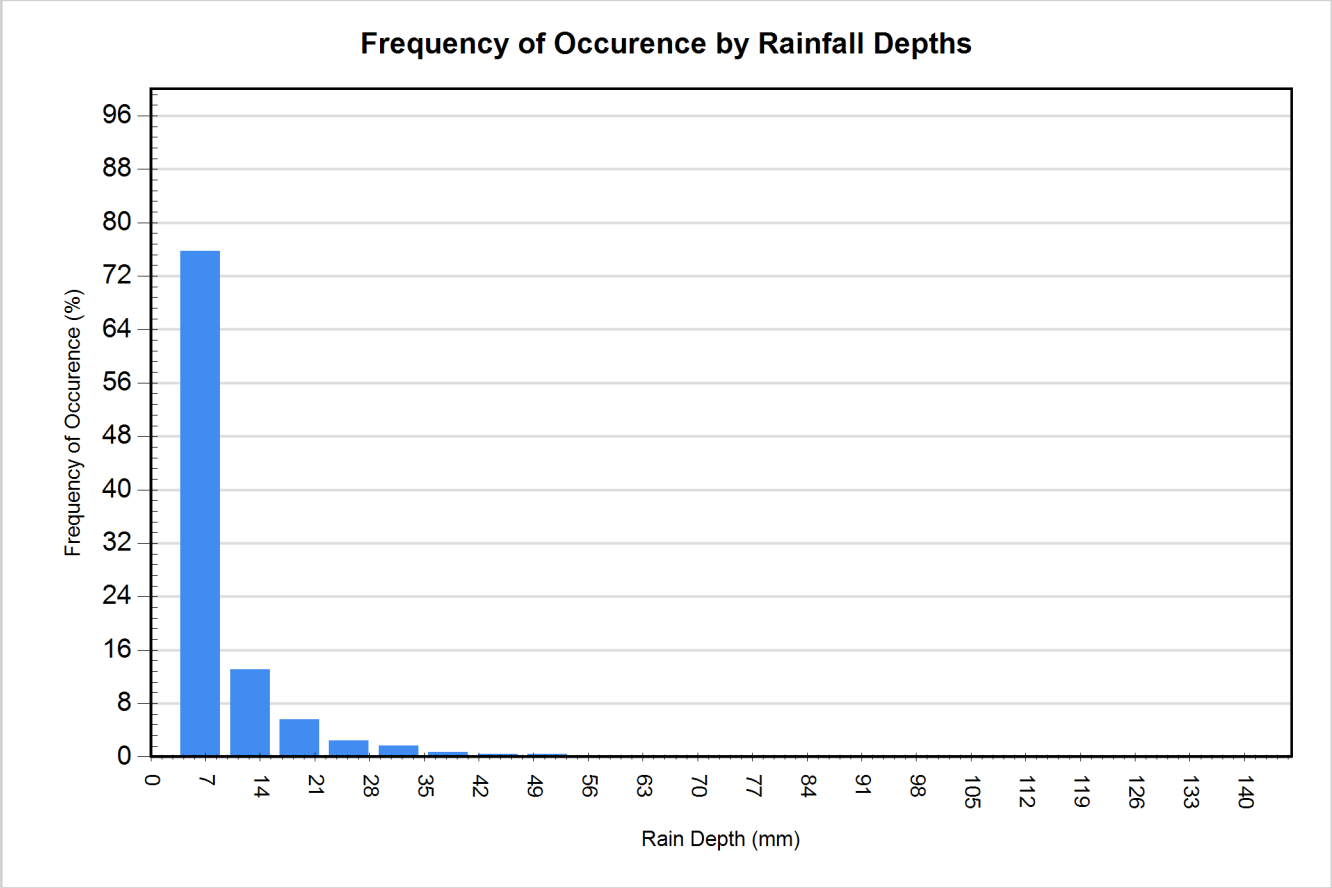
TSS Availability Parameters

Availability Constant A	
Availability Factor B	
Availability Exponent C	
Min. Particle Size Affected by Availability (micron)	

Cumulative Runoff Volume by Runoff Rate			
Runoff Rate (L/s)	**Runoff Volume (m^3)**	**Volume Over (m^3)**	**Cumulative Runoff Volume (%)**
1	25033	24618	50.4
4	43259	6392	87.1
9	47923	1728	96.5
16	49213	439	99.1
25	49531	120	99.8
36	49620	31	99.9
49	49644	8	100.0
64	49651	0	100.0



Rainfall Event Analysis				
Rainfall Depth (mm)	**No. of Events**	**Percentage of Total Events (%)**	**Total Volume (mm)**	**Percentage of Annual Volume (%)**
6.35	3392	75.7	5714	25.3
12.70	586	13.1	5353	23.7
19.05	250	5.6	3871	17.1
25.40	107	2.4	2388	10.6
31.75	74	1.7	2082	9.2
38.10	30	0.7	1053	4.7
44.45	19	0.4	768	3.4
50.80	16	0.4	737	3.3
57.15	4	0.1	215	1.0
63.50	1	0.0	58	0.3
69.85	2	0.0	132	0.6
76.20	0	0.0	0	0.0
82.55	1	0.0	78	0.3
88.90	0	0.0	0	0.0
95.25	0	0.0	0	0.0
101.60	0	0.0	0	0.0
107.95	0	0.0	0	0.0
114.30	0	0.0	0	0.0
120.65	0	0.0	0	0.0
127.00	1	0.0	124	0.5
133.35	0	0.0	0	0.0
139.70	0	0.0	0	0.0



For Stormceptor Specifications and Drawings Please Visit:
http://www.imbriumsystems.com/technical-specifications