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FUNCTIONAL SERVICING REPORT

AND

STORMWATER MANAGEMENT REPORT

ARG - 90 MAPLEVIEW DRIVE WEST

CITY OF BARRIE

CITY FILE No.

UEL FILE NO: 21006.333

DATE: May 16, 2022
REVISED August 23, 2022

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PART A

FUNCTIONAL SERVICING REPORT
ARG - 90 MAPLEVIEW DRIVE WEST

CITY OF BARRIE
FILE NO: 21006.333

1.0 INTRODUCTION

The site is located at 90 Mapleview Drive West in the City of Barrie.
The total proposed development area is 4.50 Ha approx.
The site is currently zoned Light Industrial (LI). This development site is bound by a commercial building to the north, automotive dealerships to the east, Mapleview Drive West to the south, and a manufacturing facility to the west, under the same ownership as this development site.

The engineering design drawings contained herein are based on architectural plans prepared by Nestico Architect.
The site will be developed with a single industrial warehouse building.

The site currently has no access from Mapleview Drive West.
Two Driveway entrances are proposed for this development site.

A 7.5 m wide access, for vehicular traffic only, is proposed at the south limit of the development to provide one (1) direct entrance from Mapleview Drive West. This access will be aligned with the existing access for the commercial property (Canadian Tire) on the south side of Mapleview Drive West to form a four-way signalized intersection.

An additional 14.0 m wide access existing within the existing manufacturing facility to the west, under the same ownership as this development site, is proposed to provide a second entrance from Mapleview Drive, for both truck and vehicular traffic.

2.0 EXISTING SITE AND GROUNDWATER CONDITIONS

Currently, the site is vacant and undeveloped.

A Geotechnical Investigation was previously completed by Cambium Inc. for this site in 2019. Ten test pits were excavated throughout the subject property, with depths ranging from1.5 m to 2.4 m, in order to determine the composition of the site soils. Based on the results of the investigation, the on-site soils primarily consist of sand with silt trace gravel and silty sand with some gravel. The site soils are classified as hydrologic soil Group A/B, using Design Chart 1.08 of the Ministry of Transportation Ontario (MTO) Drainage Management Manual and provide moderate drainage.

Crozier Consulting Engineers was retained to conduct a Hydrogeological Investigation of the subsurface soil conditions on site . On April 9th,2020 an investigation of the five (5) existing monitoring wells on site found the groundwater levels ranged between 5.1 m to 8.2 m below ground surface ranging in elevation between 302.04 m and 300.67 m. The groundwater level readings were considered representative of the seasonally high groundwater levels found on site.

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3.0 STORMWATER QUANTITY CONTROL

Based on the existing topogrophic survey produced by Rudy Mak Surveying Ltd., the existing site drains primarily inward to the site's low point located in the middle of the eastern property limit. The subject property's existing uncontrolled overland flows discharge to an existing drainage ditch located within the neighbouring Kerbar Holdings Ltd. property to the east. The captured flows are conveyed eastward by a series of drainage ditches and storm sewers to a stormwater management pond on the east side of Bryne Drive. The captured flows ultimately discharge to a tributary of Lover's Creek. The site is treated as a single catchment, herein referred to as Catchment 101 , as the site discharges at a single point.

An excerpt of the Stormwater Management (SWM) Report prepared for the Kerbar Holdings Ltd. property (#74-80 Mapleview Drive SWM Report) is attached in the Appendix . The excerpt indicates that the Kerbar Holdings Ltd. drainage ditch has been designed to accommodate flows from upstream areas and establishes allowable release rates during the 5-year and 100-year design storms, as follows:

Return period (1 :yr)	Flow (m3)
5-Year	0.117
100-Year	0.275

Therefore, discharging to the Kerbar Holdings Ltd. drainage ditch is an acceptable outlet strategy provided that the post-development flows are controlled to the allowable release rates noted above.

In the event of a blockage in the storm sewer network, runoff will be conveyed through the internal site towards the site outlet.

4.0 STORMWATER QUALITY CONTROL

Stormwater quality criteria for the site requires "Enhanced" protection levels to achieve 80% Total Suspended Solids (TSS) Removal, in accordance with the Ministry of the Environment, Conservation and Parks SWM Planning & Design Manual (March 2003).

A Hydro International Up-Flo Filter (or approved equivalent) will be installed within the site in order to provide quality treatment of stormwater effluent prior to outletting to the Kerbar Holdings Ltd. drainage ditch. Sizing calculations for this Filter Unit are provided in Appendix .

5.0 WATER BALANCE

LSRCA guidelines indicate that new development sites which create more than 0.5 hectares of new impervious area, shall capture and retain the 25 mm runoff volume from the total impervious area of the site. However, as per the City of Barrie's Infiltration Low Impact Development Screening Process, the subject site is located within an area where directing paved areas to LIDs is not permissible. Therefore, the 25 mm runoff volume from theTotal impervious area of the site is not achievable since runoff from lhe paved areas of the site cannot be directed to infiltration LIDs.

As described later in Part B-SWM Report, the proposed LIDs have been sized to provide for on-site infiltration of 25mm of receiving rooftop runoff from the Building roof.

This total infiltration volume is equivalent to a depth of runoff over the total impervious area = 13.7 mm

6.0 STORM SERVICE CONNECTION

A 600mm storm manhole and headwall at the east limit of the property is proposed to serve as the storm outlet for this development site.

Internal storm sewers and service connection to the building will be provided from this existing storm manhole.

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7.0 WATER SERVICE CONNECTION

A review of the Mapleview Drive Improvements as-constructed drawings (Drawing No. 9124-PP2 ond 9124-PP3) identify a 400 mm diameter ductile iron watermain fronting the site within the Mapleview Drive West northerly boulevard area. A 150 mm diameter PVC Fire Service and a 100 mm diameter PVC Domestic Water Service exists near the south-eastern property limit to service any future developments on the subject property.Two existing fire hydrants front the site along the northern boulevard of Mapleview Drive West. The approximate location of the existing watermain and hydrants is identified on the Site Servicing Plan.

It is proposed that the existing 150 mm PVC fire service connection be removed and replaced with a 250 mm PVC fire service connection and the existing 100 mm domectic water service connection would remain to service this development site.

Service connections to the building will be provided through an internal 250 mm fire line and an internal 100 mm domestic line from these stub watermains.

A Backflow Preventer control is proposed to be located within the mechanical room of the proposed building for the incoming fire water line.

A Meter & Backflow Preventer control is proposed to be located within the mechanical room of the proposed building for the incoming fire domestic line.

8.0 SANITARY SERVICE CONNECTION

A review of the Mapleview Drive Improvements as-constructed drawings (Drawing No. 9124-PP2 ond 9124-PP3) identify a 600 mm diameter concrete sanitary sewer existing within the Mapleview Drive West roadway flowing from west to east. A 200 mm diameter PVC sanitary lateral exists near the south-eastern property limit to service any future developments on the subject property. The approximate location of the existing sanitary lateral connection is identified on the Site Servicing Plan.

A Service Connection Manhole is proposed at the Mapleview Drive property limit to service this development.
A Sanitary service connection to the building is proposed to be provided from this sanitary manhole.

9.0 PHOSPHORUS CONTROL

As outlined in the LSRCA Phosphorus Offsetting Policy , all new developments or redevelopments must control or offset 100% of the phosphorus leaving the site. Any phosphorus loading that cannot be controlled on-site must be offset at a ratio of 2.5:1 (ie. 2.5 kg of phosphorus per year would be removed for every 1 kg required to be offset).

The Hutchinson Environmental Sciences Ltd. Report titled "Phosphorus Coefficient for Sod Farm/Golf Course identified a Phosphorus Budget Tool in Support of Sustainable Development for the Lake Simcoe Watershed" (March 30,2012) provides phosphorus export coefficients for land uses in the Lovers Creek watershed. A best efforts approach was conducted to achieve 100% phosphorus removal. THe table below summarizes the pre- and post-development phosphorus loading conditions for the subject property.

The pre-development conditions are classified as a Low Intensity Development Sod Farm/Golf Course with a phosphorus loading rate of 0.17 kg/ha/yr. In the post-development conditions the industrial development is classified under the High Intensity Commercial / Industrial Development land use with a phosphorus loading rate of 1.82 kg/ha/yr.

TABLE - PHOSPHORUS LOADING CONDITIONS			
Pre-Development Phosphorus Loading (kg/yr)	Post-Development Phosphorus Loading without Mitigation (kg/yr)	Post-Development Phosphorus Loading wilh Mitigation (kg/yr)	Post-to-Pre Development Phosphorus Loading INCREASE (+) / REDUCTION (-) {kg/yr)
0.59	7.64	1.53	0.76

Based on the LSRCA Phosphorus Offsetting Policy ,

SUB TOTAL PHOSPHORUS POST-DEVELOPMENT SITE OFFSET FEE = $ 78,227.56

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PART B STORMWATER MANAGEMENT REPORT
ARG - 90 MAPLEVIEW DRIVE WEST

CITY OF BARRIE
FILE NO: 21006.333

1.0 INTRODUCTION

The objective of this report is to provide recommended grading and drainage proposals, which when utilized will control runoff from the site.

On-site detention of excess runoff for the site will be required in order not to exceed the allowable quantity of runoff from the site. The intent of the proposed stormwater management is to satisfy the storage requirements produced by the occurrence of a 5 year return frequency design storm and 100 year return frequency design storm. The maximum volume of runoff to be stored on site was determined using the Modified Rational Method as outlined in the American Public Works Association titled, "Practices in Detention of Urban Stormwater Runoff". The rainfall intensities were obtained from City of Barrie curves.

2.0 ALLOWABLE SITE RUNOFF

An excerpt of the Stormwater Management (SWM) Report prepared for the Kerbar Holdings Ltd. property (#74-80 Mapleview Drive SWM Report) is attached in the Appendix . The excerpt indicates that the Kerbar Holdings Ltd. drainage ditch has been designed to accommodate flows from upstream areas and establishes allowable release rates during the 5-year and 100-year design storms, as follows:

Return period (1 :yr)	Flow (m3)
5-Year	0.117
100-Year	0.275

This development block has been designed based on a maximum allowable release rate of 275 l/s and 117 l/s for the 100yr and 5yr storm events, respectively.
This development will encompass three stormwater management systems.
System "A" includes the drainage area from the proposed landcape area to the north and north east of the building, System "B" includes the drainage from the Building Roof and pavement areas and System "C" includes the drainage area from the proposed landcape area to the south east of the building.

System "A" will connect to proposed control manhole STM MH 100 and include a 80 mm orifice control plate.

System "B" will connect to proposed control manhole STM MH 200 and include a 215 mm orifice control plate. Controlled System B will subsequently drain from STM MH 200 to STM MH 100.

System "C" will connect to proposed control manhole STM MH 100 with no orifice control.

Systems "A" + "B" + "C" will combine at CBMH 100 and outlet to the existing drainage course located mid span at the east limit of ths development site

Total 100 yr Storm Allowable Release rate for System " A + B + C ", for all storm events, is:	275.0 L/s
Total 5 yr Storm Allowable Release rate for System " A + B + C ", for all storm events, is:	117.0 L/s

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3.0 POST-DEVELOPMENT SITE CONDITION

The Site has been designed on the basis of 3 drainage systems.
System A will outlet to Proposed STM MH 100
System B will outlet to Proposed STM MH 200 and ultimately to STM MH 100
System C will outlet to Proposed STM MH 100

	unit	Total	System A	System B	System C
Total Site Area	(m^2)	45022	2634	41664	724
Pavement Area	(m^2)	17882	0	17882	0
Landscaped Area	(m^2)	4334	2634	976	724
Building Area	(m^2)	21916	0	21916	0
Uncontrolled Pavement Area	(m^2)	84	0	84	0
Uncontrolled Landscape Area	(m^2)	806	0	806	0

4.0 EVALUATION OF SITE RUNOFF - SYSTEM A

4.1 Roof Top Storage

ROOF STORAGE NOT APPLICABLE

4.2 Parking Lot Storage and Release Rate

Note: 100 year runoff coefficients:

pavements - C_{100} $= C_5 \times 0.5 + 0.5 = 0.9 \times 0.5 + 0.5 = 0.95$
landscaped - C_{100} $= 0.25 \times 0.5 + 0.5 = 0.625$

4.2.1 The composite runoff coefficients for the site, excluding building, are calculated as follows:

$$C_c = \frac{0 \times 0.95 + 2634 \times 0.625}{0 + 2634}$$

$C_c =$ 0.63

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4.2.2 Release rate calculations are based on orifice flow formula:

$Q = C \times A \times (2gH)^{1/2}$
where,
Q = discharge in m^3/s
C = shape coefficient, 0.62 for orificeplate, dimensionless
A = area of orifice in m^2
g = acceleration due to gravity in m/s^2
H = head from centre of orifice to ponding level in m

Orifice Plate at Existing Storm Manhole - System A

max. ponding level	(m)	307.15
invert of orifice	(m)	305.4
head	(m)	1.7
diameter of orifice	(mm)	80
Q, orifice discharge	(l/s)	18.1

4.2.3 Using the Modified Rational Method, the maximum storage volume required on the parking lot was calculated. As shown in Appendix Table 2 and dwg SP-1, Urban Ecosystems Project No.: 21006.333
the required pond volume was calculated to be 46 m^3

Available site storage:

a) Surface Storage			=	0.0	m^3
b) Underground Storage					
0	m -	300	dia. stm =	0.0	m^3
36	m -	375	dia. stm =	4.0	m^3
0	m -	450	dia. stm =	0.0	m^3
192	m -	525	dia. stm =	41.6	m^3
0	m -	600	dia. stm =	0.0	m^3
0	m -	675	dia. stm =	0.0	m^3
3		1200 mm dia mh(@	2 m avg depth) =	6.8	m^3
0		1500 mm dia mh(@	2 m avg depth) =	0.0	m^3
0		1800 mm dia mh(@	2 m avg depth) =	0.0	m^3
0		2400 mm dia mh(@	2 m avg depth) =	0.0	m^3
			Total Underground Storage=	52.3	m^3
			Total site storage (a + b) =	52.3	m^3

Required Storage	m^3	46
Available Storage	m^3	52

Therefore, there is sufficient storage in the parking lot to self contain the drainage and control the 100 year runoff to the allowable rate within the site.

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5.0 EVALUATION OF SITE RUNOFF - SYSTEM B

5.1 Roof Top Storage

Proposed roofs to be equipped with control flow drains.

Model ID: Zurn Control Flo Z-105-5
Weir Rating 6 USGPM per inch head (0.15 L/s/cm head)
Quantity: One weir per hopper. Based on manufacturers table, one hopper drains a maximum roof area of 465m² with a maximum head of 10.16 cm

For this building 50 hoppers

Total roof outflow is calculated as:

Q_{roof} 50 x 0.15 L/s/cm hd. x 10 cm head
= 75 L/s

From Appendix - Table 1 maximum storage volumes:	required =	1068.7	m^3
	available =	1484.4	m^3

As shown, the available storage volume for the roof can easily contain the respective required maximum roof storage volumes.

Note: Peak rate of runoff, eg: Q = Rain (L/s)
= 0.95 x 0 x mm/hr x 2.778

5.2 Parking Lot Storage and Release Rate

Note: 100 year runoff coefficients:

pavements - C_{100} $= C_5 \times 0.5 + 0.5 = 0.9 \times 0.5 + 0.5 = 0.95$
landscaped - C_{100} $= 0.25 \times 0.5 + 0.5 = 0.625$

5.2.1 The composite runoff coefficients for the site, excluding building, are calculated as follows:

$$C_c = \frac{17882 \times 0.95 + 976 \times 0.625}{17882 + 976}$$

$C_c = 0.93$

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5.2.2 Release rate calculations are based on orifice flow formula:

$Q = C \times A \times (2gH)^{1/2}$

where,

Q = discharge in m^3/s

C = shape coefficient, 0.62 for orificeplate, dimensionless

A = area of orifice in m^2

g = acceleration due to gravity in m/s^2

H = head from centre of orifice to ponding level in m

Orifice Plate at Existing Storm Manhole - System B

max. ponding level	(m)	307.8
invert of orifice	(m)	305.64
head	(m)	2.0525
diameter of orifice	(mm)	215
Q, pipe discharge	(l/s)	0.0

5.2.3 Using the Modified Rational Method, the maximum storage volume required on the parking lot was calculated. As shown in Appendix Table 2 and dwg SP-1, Urban Ecosystems Project No.: 21006.333 the required pond volume was calculated to be 826.3 m^3

1) AVAILABLE TOTAL SURFACE SITE STORAGE = 952.4 m^3

2) AVAILABLE PIPE / MANHOLE STORAGE :

23	m -	300	dia. stm =	1.6	m^3
0	m -	375	dia. stm =	0.0	m^3
0	m -	450	dia. stm =	0.0	m^3
175	m -	525	dia. stm =	37.9	m^3
169	m -	600	dia. stm =	47.8	m^3
0	m -	750	dia. stm =	0.0	m^3
5	1200	mm dia mh(@	2 m avg depth) =	11.3	m^3
0	1500	mm dia mh(@	2 m avg depth) =	0.0	m^3
1	1800	mm dia mh(@	2 m avg depth) =	5.1	m^3
1	2400	mm dia mh(@	2 m avg depth) =	9.0	m^3
2) AVAILABLE TOTAL PIPE / MANHOLE STORAGE :				112.7	m^3

3) QUANTITY BASIN STORAGE :

Therefore, Proposed Infiltration Trench is as follows: Gallery Height is approx. = 0.9 metres

Number of StormTech SC-740 Chambers =	9 rows	X	31	per row =		279 chambers	
StormTech SC-740 Chamber Row Volume =	279	X	1.3	cu.m =		362.7 cu.m.	
StormTech SC-740 Chambers End Caps Volume =	6	X	0.05	cu.m =		0.3 cu.m.	
Chamber Height =	0.76 m						
Chamber Length =	2.17 m						
STONE Below Depth =	0.152 m						
STONE Above Depth =	0.152 m						
GALLERY AREA (L x W) =	70.4 m	X	12.6 m	=	883.9 sm		
GROSS VOLUME (GALLERY)) =	883.9 sm	X	1.1 m	=	972.3 cu.m.		
REQUIRED VOLUME (GALLERY)) =	883.9 sm	X	0.9 m	=	795.5 cu.m.		
STONE VOLUME (GALLERY) =	795.5 cu.m. -		363.0 cu.m. = X		40%	=	173.0 cu.m.
3) AVAILABLE QUANTITY BASIN STORAGE :							536.0 cu.m.

TOTAL QUANITY STORAGE 1) + 2) + 3)	=	1601.1 cu.m.

100 YEAR STORM EVENT

Required Storage	m^3	826
Available Storage	m^3	1601

5 YEAR STORM EVENT

Required Storage	m^3	629
Available Storage	m^3	649

Therefore, there is sufficient storage in the parking lot to self contain the drainage and control the 100 year runoff to the allowable rate within the site.

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6.0 EVALUATION OF SITE RUNOFF - SYSTEM C

6.1 Roof Top Storage

ROOF STORAGE NOT APPLICABLE

6.2 Parking Lot Storage and Release Rate

Note: 100 year runoff coefficients:

pavements - C_{100} $= C_5 \times 0.5 + 0.5 = 0.9 \times 0.5 + 0.5 = 0.95$
landscaped - C_{100} $= 0.25 \times 0.5 + 0.5 = 0.625$

6.2.1 The composite runoff coefficients for the site, excluding building, are calculated as follows:

$$C_c = \frac{0 \times 0.95 + 724 \times 0.625}{0 + 724}$$

$C_c = 0.63$

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6.2.2 Release rate calculations are based on orifice flow formula:

$Q = C \times A \times (2gH)^{1/2}$
where,
Q = discharge in m^3/s
C = shape coefficient, 0.62 for orificeplate, dimensionless
A = area of orifice in m^2
g = acceleration due to gravity in m/s^2
H = head from centre of orifice to ponding level in m

Orifice Plate at Existing Storm Manhole - System C

max. ponding level	(m)	NO ORIFICE
invert of orifice	(m)	0
head	(m)	0.0
diameter of orifice	(mm)	0
Q, Pipe discharge	(l/s)	26.7

6.2.3 Using the Modified Rational Method, the maximum storage volume required on the parking lot was calculated. As shown in Appendix Table 2 and dwg SP-1, Urban Ecosystems Project No.: 21006.333 the required pond volume was calculated to be 0 m^3

Available site storage:

a) Surface Storage			=	0.0	m^3
b) Underground Storage					
0	m -	300	dia. stm =	0.0	m^3
0	m -	375	dia. stm =	0.0	m^3
70	m -	450	dia. stm =	11.1	m^3
0	m -	525	dia. stm =	0.0	m^3
0	m -	600	dia. stm =	0.0	m^3
0	m -	675	dia. stm =	0.0	m^3
1	1200 mm dia mh(@		2 m avg depth) =	2.3	m^3
0	1500 mm dia mh(@		2 m avg depth) =	0.0	m^3
0	1800 mm dia mh(@		2 m avg depth) =	0.0	m^3
0	2400 mm dia mh(@		2 m avg depth) =	0.0	m^3
			Total Underground Storage=	13.4	m^3
			Total site storage (a + b) =	13.4	m^3

Required Storage	m^3	0
Available Storage	m^3	13

Therefore, there is sufficient storage in the parking lot to self contain the drainage and control the 100 year runoff to the allowable rate within the site.

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7.0 WATER BALANCE - RETENTION OF 25mm of WATER FROM ROOF AREA

Although LSRCA requires that the 25mm storm event be retained on site, City of Barrie acknowledges that the 25 mm runoff volume from the total impervious area of the site is not achievable since runoff from the paved areas of the site cannot be directed to infiltration LIDs and therefore will accept the proposed LIDs being sized only to provide for on-site infiltration of 25mm of receiving runoff from the Building roof.

Required Infiltration Volume =	250.0 cu.m/Ha	=	25 mm		
Roof Area =	2.192 Ha				
Required Onsite Infiltration Volume =	**2.192 Ha**	**x**	**250 cu.m/Ha**	**=**	**547.9 cu.m.**

Part A) Retention Volume within Initial Abstraction (IA)

SURFACE	AREA	Abstracti	Volume
pervious	5140 sm	25 mm	
impervious	39882 sm	1 mm	
total	45022 sm		0.0 cu.m.

Part A) Subtotal 0.0 cu.m.

Part B) Retention Volume within Proposed Infiltration Gallery

The initial basin design was based on the soil percolation rate of 50 mins/cm or 12 mm/hour and based on achieving 48 hour to 72 hour draw down time

Based on the In-Situ Guelph Permeameter Infiltration Testing Report prepared by Soil Engineers Ltd dated August 18, 2022(copy included in the Appendix of this Report), the soil surrounding the Basin is Silty Sand Till with an estimated percolation time between 16 min/cm and 27 min/cm. The least permeable infiltration test result was noted as 27 min/cm

Based on the soil percolation rate of 27 mins/cm or 22mm/hour and based on achieving 40.5 hour draw down time

$$\frac{27\ \text{min}}{1\ \text{cm}} \times \frac{1\ \text{Hr}}{60\ \text{min}} \times \frac{1\ \text{cm}}{10\ \text{mm}} = \frac{27\ \text{Hr}}{600\ \text{mm}} = \boxed{\frac{22\ \text{mm}}{\text{Hr}}}\ \text{Percolation Rate}$$

$$\frac{22\ \text{mm}}{\text{Hr}} \times 40.5\ \text{Hr} = 900\ \text{mm} = \boxed{0.90\ \text{m}}\ \text{Height}$$

Therefore, Proposed Infiltration Trench is as follows:

Number of StormTech SC-740 Chambers =	9 rows	X	32	per row =	288 chambers
StormTech SC-740 Chamber Row Volume =	288	X	1.3	cu.m =	374.4 cu.m.
StormTech SC-740 Chambers End Caps Volume =	6	X	0.05	cu.m =	0.3 cu.m.
Chamber Height =	0.76 m				
Chamber Length =	2.17 m				
STONE Below Depth =	0.152 m				
STONE Above Depth =	0.152 m				
GALLERY AREA (L x W) =	72.6 m	X	12.6 m =	911.1 sm	
GROSS VOLUME (GALLERY)) =	911.1 sm	X	1.1 m =	1002.2 cu.m.	
REQUIRED VOLUME (GALLERY)) =	911.1 sm	X	0.9 m =	820.0 cu.m.	
STONE VOLUME (GALLERY) =	820.0 cu.m. -		374.7 cu.m. = X	40% =	178.1 cu.m.
Provided Infiltration Trench Volume =					552.8 cu.m.

Part B) Subtotal 552.8 cu.m.

Required Onsite Infiltration Volume = 547.9 cu.m.

Note: Total Infiltration Volume Equivalent to a depth of runoff over total impervious area of site = 13.7 mm

Provided Onsite Infiltration Volume = PART A) + Part B) = 552.8 cu.m.

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7050 WESTON ROAD, SUITE 705
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UEL

8.0 WATER QUALITY

A Treatment Train Approach is proposed to address City and LSRCA Water quality requirement for 80% Total Suspended Soilds removal.

Roof Drainage Flows will be directed to an Infiltration Basin which includes an Isolator row to address suspended soils

Pavement Drainage Flows will be directed to an Quantity Basin which includes an Isolator row to address suspended soils

Pavement Drainage Flows from the Quantity Basin will be subsequently directed to a Hydro International Up-Flo Filter (8 modules) Unit to provide the minimum 80% TSS removal

9.0 SUMMARY

The following table summarizes the results presented in this report.

100 YR STORM EVENT

SYSTEM		A	B	C	TOTAL
orifice size	mm	80	215	NO ORIFICE	
total site release rate	L/s	18.1	175.8	26.7	220.6
allowable site release rate	L/s	0.0		275.0	275.0
maximum ponding elevation	m	307.15	307.8	0	
catchbasin elevation	m	306.85	307.5	0	
ponding depth	m	0.3	0.3	0	
required ponding storage	m^3	46	826	0	
available ponding storage	m^3	52	1601	0	

Respectfully submitted,

Urban Ecosystems Limited

LICENSED PROFESSIONAL ENGINEER
R. SACCO
40295305
PROVINCE OF ONTARIO

Rosario Sacco, P. Eng.

DATED May 16, 2022
REVISED August 23, 2022

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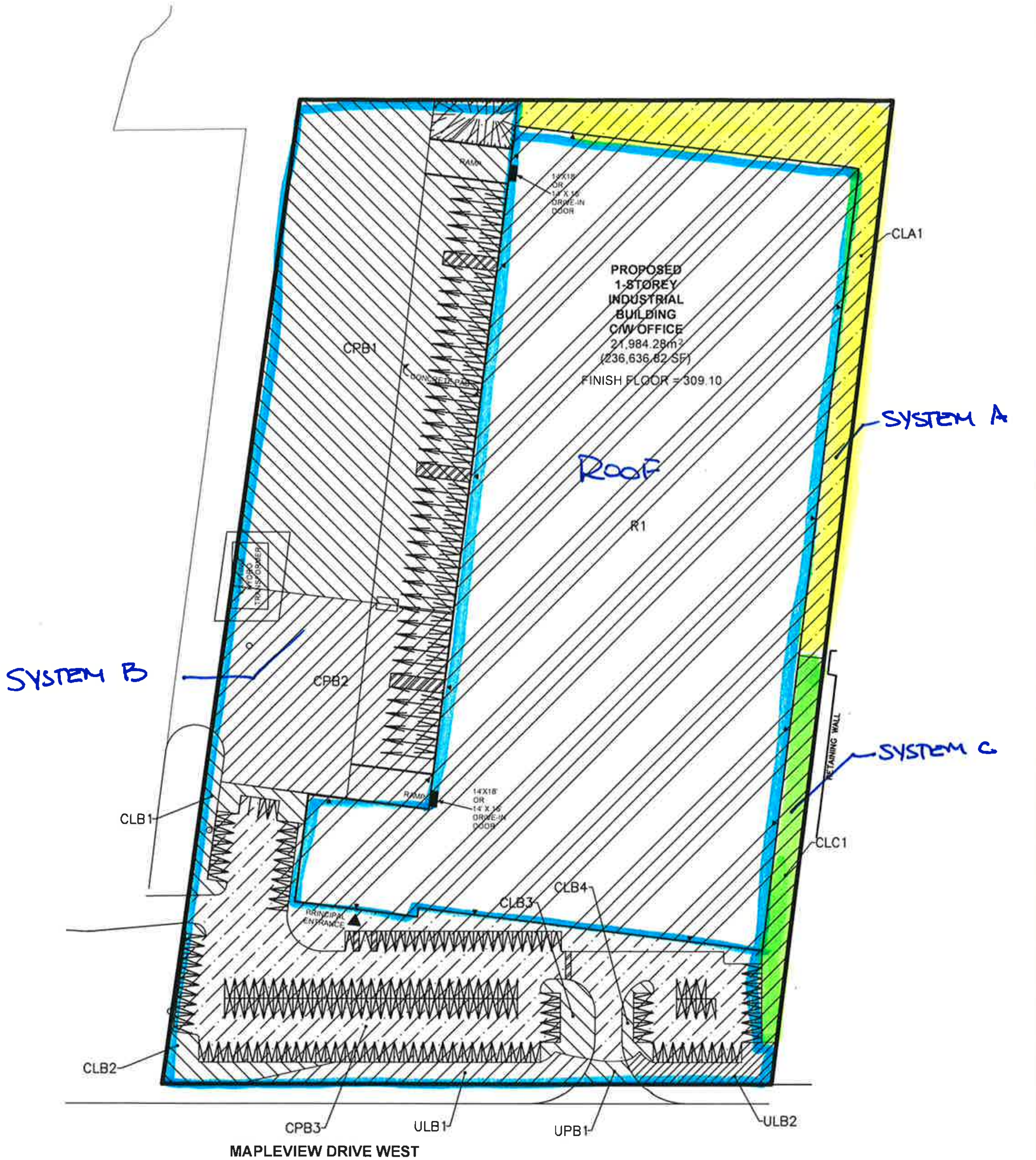
APPENDIX No 1

SWM QUANTITY CALCULATIONS



R1 = ROOF AREA	= 21,916 s.m		
CPB1	= 8,135 s.m	CLA1	= 2,634 s.m
CPB2	= 3,289 s.m	CLC1	= 724 s.m
CPB3	= 6,458 s.m	ULB1	= 513 s.m
CLB1	= 347 s.m	ULB2	= 293 s.m
CLB2	= 311 s.m	UPB1	= 84 s.m
CLB3	= 226 s.m		
CLB4	= 92 s.m		

PROJECT:	ARG - 90 MAPLEVIEW DRIVE WEST
MUNICIPALITY:	CITY OF BARRIE
FILE NO.:	21006.333
Date:	May 16, 2022 REVISED August 23, 2022
LOCATION:	

URBAN ECOSYSTEMS LIMITED
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SITE STORM WATER MANAGEMENT
SUMMARY

	TOTAL	SYSTEM A	SYSTEM B	SYSTEM C
Site area (sq.m) :	45022	2634	41664	724
Controlled Pavement area (sq.m) :	17882		17882	
Controlled Landscaped area (sq.m) :	4334	2634	976	724
Roof area (sq.m) :	21916		21916	
Uncontrolled Pavement area (sq.m.) :	84		84	
Uncontrolled Landscape area (sq.m.) :	806		806	

100 YEAR STORM EVENT

		SYSTEM A	SYSTEM B	SYSTEM C	TOTAL
CONTROLLED	**Orifice release rate (l/sec) :**	**18.1**	**142.8**	**26.7**	**187.6**
UNCONTROLLED	**Site release rate (l/sec) :**		**33.0**	**0.0**	**33.0**
TOTAL	**Site release rate (l/sec) :**	**18.1**	**175.8**	**26.7**	**220.6**
ALLOWABLE	**Site release rate (l/sec) :**				**275.0**

5 YEAR STORM EVENT

		SYSTEM A	SYSTEM B	SYSTEM C	TOTAL
CONTROLLED	**Orifice release rate (l/sec) :**	**12.8**	**89.9**	**5.5**	**108.1**
UNCONTROLLED	**Site release rate (l/sec) :**		**8.4**	**0.0**	**8.4**
TOTAL	**Site release rate (l/sec) :**	**12.8**	**98.3**	**5.5**	**116.5**
ALLOWABLE	**Site release rate (l/sec) :**				**117.0**

URBAN ECOSYSTEMS
LIMITED

PROJECT: ARG - 90 MAPLEVIEW DRIVE WEST
MUNICIPALITY: CITY OF BARRIE
JOB NO.: 21006.333
DATE: May 16, 2022
REVISED August 23, 2022

SYSTEM A 100 yr

SITE STORM WATER MANAGEMENT

SITE PLAN CHARACTERISTICS - SYSTEM A

Site area (sq.m) : 2634
Controlled Pavement area (sq.m) : 0
Controlled Landscaped area (sq.m) : 2634
Proposed Roof area (sq.m) : 0
Uncontrolled Pavement area (sq.m.) : 0
Uncontrolled Landscaped area (sq.m.) : 0

Composite runoff coefficent : 0.63

Pavement coefficient : 0.95
Landscape coefficient : 0.625
Roof area coefficient : 0.95

Orifice diameter (mm) : 80
Area of orifice (sq.m) : 0.00503
Orifice coefficient : 0.62
Max. ponding elev. : 307.15
Catchbasin elev. : 306.85
Ponding depth. : 0.30
Orifice invert : 305.4
Orifice center line elev. : 305.440
Head (m) : 1.71
Orifice release rate (l/sec) : 18.1

100 yr Rainfall intensity (mm/hr) : 1426.408*((T+5.273)^-0.759)
25 yr Rainfall intensity (mm/hr) : 1146.275*((T+4.922)^-0.757)
5 yr Rainfall intensity (mm/hr) : 853.608*((T+4.699)^-0.766)
2 yr Rainfall intensity (mm/hr) : 678.085*((T+4.699)^-0.781)

TABLE 2 - System Storage

Time (min.)	Intensity I (mm/hr)	Peak rate of runoff Q (l/sec)	Runoff volume (cu.m)	Orifice Outflow volume (cu.m)	Required storage volume (cu.m.)	
24	109.95	50.28	72.41	25.99	46.4	
26	104.57	47.82	74.60	28.16	46.4	<<------
28	99.76	45.63	76.65	30.33	46.3	
30	95.44	43.65	78.57	32.49	46.1	

Required site storage (cu. m) : 46
Available site storage (cu. m) : 52
SEE DRAWING SP-1

SYSTEM A

SITE SUMMARY

Orifice release rate (l/sec) : 18.1
Uncontrolled release rate (l/sec) :
Total site release rate (l/sec) : **18.1**

ALLOWABLE Total site release rate (l/sec) : **0.0**

PROJECT: ARG - 90 MAPLEVIEW DRIVE WEST
MUNICIPALITY: CITY OF BARRIE
JOB NO.: 21006.333
DATE: May 16, 2022
REVISED August 23, 2022

URBAN ECOSYSTEMS LIMITED

SYSTEM B 100 yr

SITE STORM WATER MANAGEMENT

SITE PLAN CHARACTERISTICS - SYSTEM B

Site area (sq.m) : 41664
Controlled Pavement area (sq.m) : 17882
Controlled Landscaped area (sq.m) : 976
Proposed Roof area (sq.m) : 21916
Uncontrolled Pave area (sq.m.) : 84
Uncontrolled Landscaped area (sq.m.) : 806

Pavement coefficient : 0.95
Landscape coefficient : 0.625
Roof area coefficient : 0.95

Rainfall intensity (mm/hr) : 1426.408*((T+5.273)^-0.759) 100 yr

ROOF DRAINAGE CHARACTERISTICS

Total roof area (sq. m) : 21916
Total number of roof hoppers : 50
Total number of weirs : 50
Max. sloped roof depth (mm) : 50.8
Max. sloped roof storage (cu.m) : 371.11
Max. parapit roof storage (cu.m) : 1113.33

Weir rating (l/sec) : 0.15
Weir area rating (sq. m.) : 465
Maximum head (cm) : 10.16
Peak roof outflow rate (l/sec) : 76.2

TABLE 1 - ROOF DRAINAGE SYSTEM

	1st ITERATION					2nd ITERATION						3rd ITERATION		
Time (min.)	Rainfall Intensity I (mm/hr)	Peak rate of runoff Q (l/sec)	Peak Runoff volume (cu.m.)	Peak roof outflow volume (cu.m)	Required storage volume (cu.m)	Volume in sloped roof areas (cu.m)	Volume contained by roof parapit (cu.m)	Total head on roof hoppers (cm)	Roof outflow rate (l/sec)	Roof outflow volume (cu.m)	Required storage volume (cu.m)	Total head on roof hoppers (cm)	Roof outflow volume (cu.m)	Required storage volume (cu.m)
5	243.43	1407.94	422.38	22.86	399.52	371.11	28.41	5.21	39.07	11.72	410.66	5.26	11.84	410.54
10	180.15	1041.99	625.19	45.72	579.47	371.11	208.36	6.03	45.23	27.14	598.05	6.12	27.52	597.67
15	145.31	840.45	756.40	68.58	687.82	371.11	316.71	6.53	48.94	44.04	712.36	6.64	44.80	711.60
20	122.92	710.96	853.15	91.44	761.71	371.11	390.60	6.86	51.47	61.76	791.39	7.00	62.98	790.17
25	107.18	619.93	929.89	114.30	815.59	371.11	444.48	7.11	53.31	79.97	849.92	7.26	81.73	848.16
30	95.44	552.02	993.63	137.16	856.47	371.11	485.36	7.29	54.71	98.48	895.15	7.47	100.86	892.77
35	86.31	499.18	1048.27	160.02	888.25	371.11	517.14	7.44	55.80	117.17	931.10	7.64	120.25	928.02
40	78.97	456.75	1096.20	182.88	913.32	371.11	542.21	7.55	56.66	135.97	960.23	7.77	139.83	956.38
45	72.93	421.84	1138.97	205.74	933.23	371.11	562.12	7.64	57.34	154.81	984.16	7.88	159.51	979.45
50	67.87	392.55	1177.65	228.60	949.05	371.11	577.94	7.72	57.88	173.63	1004.01	7.97	179.28	998.37
55	63.55	367.58	1213.00	251.46	961.54	371.11	590.43	7.77	58.31	192.41	1020.59	8.04	199.08	1013.93
60	59.82	346.00	1245.61	274.32	971.29	371.11	600.17	7.82	58.64	211.10	1034.51	8.11	218.89	1026.72
65	56.56	327.15	1275.89	297.18	978.71	371.11	607.60	7.85	58.89	229.68	1046.21	8.16	238.69	1037.20
70	53.69	310.52	1304.19	320.04	984.15	371.11	613.04	7.88	59.08	248.13	1056.06	8.21	258.47	1045.72
75	51.13	295.73	1330.78	342.90	987.88	371.11	616.77	7.89	59.21	266.43	1064.35	8.24	278.21	1052.57
80	48.84	282.47	1355.86	365.76	990.10	371.11	618.99	7.90	59.28	284.56	1071.31	8.27	297.90	1057.97
85	46.77	270.52	1379.63	388.62	991.01	371.11	619.90	7.91	59.31	302.50	1077.13	8.30	317.53	1062.10
90	44.90	259.67	1402.22	411.48	990.74	371.11	619.63	7.91	59.30	320.25	1081.98	8.32	337.11	1065.12
95	43.19	249.78	1423.76	434.34	989.42	371.11	618.31	7.90	59.26	337.78	1085.98	8.34	356.61	1067.15
100	41.62	240.73	1444.35	457.20	987.15	371.11	616.04	7.89	59.18	355.09	1089.26	8.36	376.06	1068.30
105	40.18	232.40	1464.09	480.06	984.03	371.11	612.92	7.88	59.08	372.17	1091.92	8.37	395.43	1068.66 <<------
110	38.85	224.70	1483.04	502.92	980.12	371.11	609.01	7.86	58.94	389.01	1094.03	8.38	414.74	1068.30
115	37.62	217.58	1501.28	525.78	975.50	371.11	604.39	7.84	58.78	405.60	1095.68	8.39	433.98	1067.30
120	36.47	210.95	1518.87	548.64	970.23	371.11	599.12	7.81	58.60	421.94	1096.93	8.39	453.16	1065.71
125	35.41	204.78	1535.85	571.50	964.35	371.11	593.24	7.79	58.40	438.01	1097.84	8.40	472.27	1063.57
130	34.41	199.01	1552.27	594.36	957.91	371.11	586.80	7.76	58.18	453.81	1098.45	8.40	491.33	1060.94

Qroof= R A I N
= 5.784 x I (l / sec)

Peak roof outflow rate =
no. of hoppers x weir rating x max. head
= 76.2 l/sec

Peak roof outflow volume =
= 76.2 x time x 60/1000 cu. m.

Roof outflow rate =
head x weir rating x no. of weirs
= head x 7.50 l/sec

Required max. roof stotage (cu. m.) : 1068.7
Available roof stotage (cu. m.) : 1484.4

PROJECT: ARG - 90 MAPLEVIEW DRIVE WEST
MUNICIPALITY: CITY OF BARRIE

SYSTEM B 100 yr
SITE STORM WATER MANAGEMENT

SITE PLAN CHARACTERISTICS - SYSTEM B

SITE CHARACTERISTICS

Controlled Pavement area (sq.m) :	17882
Controlled Landscaped area (sq.m) :	976
Total area - excl. Bldg (sq.m) :	18858
Composite runoff coefficent :	0.93

OUTLET CHARACTERISTICS

Orifice diameter (mm) :	215
Area of orifice (sq.m) :	0.03631
Orifice coefficient :	0.62
Max. ponding elev. :	307.80
Catchbasin elev. :	307.50
Ponding depth. :	0.30
Orifice invert :	305.64
Orifice center line elev. :	305.748
Head (m) :	2.05
Orifice release rate (l/sec) :	142.8

TABLE 2 - System Storage

Time (min.)	Intensity I (mm/hr)	Peak rate of runoff Q (l/sec)	Runoff volume (cu.m)	Orifice Outflow volume (cu.m)	Required storage volume (cu.m.)	
80	48.84	314.95	1511.78	685.63	826.1	
82	47.99	310.79	1529.09	702.77	826.3	<<------
84	47.17	306.79	1546.22	719.91	826.3	
86	46.38	302.94	1563.19	737.05	826.1	
88	45.62	299.24	1580.01	754.19	825.8	
90	44.90	295.68	1596.68	771.34	825.3	

Required site storage (cu. m) : 826
Available site storage (cu. m) : 1601
SEE DRAWING SP-1

INCLUDES ROOF RELEASE RATE = 76.2 (l/sec)

TABLE 3 - Uncontrolled Runoff

Time (min.)	Intensity I (mm/hr)	Peak rate of runoff Q (l/sec)	
10	203.31	33.0	<<------
15	158.27	25.7	
20	130.68	21.2	

Peak runoff (L/sec) : 33.0

UNCONTROLLED SITE CHARACTERISTICS

Uncontrolled Pavement area (sq.m.) :	84
Uncontrolled Landscaped area (sq.m.) :	806
Total area (sq.m) :	890
Composite runoff coefficent :	0.656

SYSTEM B
SITE SUMMARY

Pipe release rate (l/sec) :	142.8
Uncontrolled release rate (l/sec) :	33.0
Total site release rate (l/sec) :	**175.8**

URBAN ECOSYSTEMS
LIMITED

PROJECT: ARG - 90 MAPLEVIEW DRIVE WEST
MUNICIPALITY: CITY OF BARRIE
JOB NO.: 21006.333
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SYSTEM C 100 yr
SITE STORM WATER MANAGEMENT

SITE PLAN CHARACTERISTICS - SYSTEM C

Site area (sq.m) : 724
Controlled Pavement area (sq.m) : 0
Controlled Landscaped area (sq.m) : 724
Proposed Roof area (sq.m) : 0
Uncontrolled Pavement area (sq.m.) : 0
Uncontrolled Landscaped area (sq.m.) : 0

Composite runoff coefficent : 0.63

Pavement coefficient : 0.95
Landscape coefficient : 0.625
Roof area coefficient : 0.95

Rainfall intensity (mm/hr) : 1426.408*((T+5.273)^-0.759) 100 yr

Orifice diameter (mm) : NO ORIFICE
Area of orifice (sq.m) :
Orifice coefficient :
Max. ponding elev. :
Catchbasin elev. :
Ponding depth. :
Orifice invert :
Orifice center line elev. :
Head (m) :
Orifice release rate (l/sec) : 0.0

NO ORIFICE
PIPE release rate (l/sec) : 26.7

TABLE 2 - System Storage

Time (min.)	Intensity I (mm/hr)	Peak rate of runoff Q (l/sec)	Runoff volume (cu.m)	Orifice Outflow volume (cu.m)	Required storage volume (cu.m.)
7	212.68	26.74			

Required site storage (cu. m) : 0
Available site storage (cu. m) : 0
SEE DRAWING SP-1

SYSTEM C
SITE SUMMARY

Orifice release rate (l/sec) : 26.7
Uncontrolled release rate (l/sec) :
Total site release rate (l/sec) : **26.7**

PROJECT: ARG - 90 MAPLEVIEW DRIVE WEST
MUNICIPALITY: CITY OF BARRIE
JOB NO.: 21006.333
DATE: May 16, 2022
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SYSTEM A 5 yr
SITE STORM WATER MANAGEMENT

SITE PLAN CHARACTERISTICS - SYSTEM A

Site area (sq.m) : 2634
Controlled Pavement area (sq.m) : 0
Controlled Landscaped area (sq.m) : 2634
Proposed Roof area (sq.m) : 0
Uncontrolled Pavement area (sq.m.) : 0
Uncontrolled Landscaped area (sq.m.) : 0

Composite runoff coefficent : 0.25

Pavement coefficient : 0.9
Landscape coefficient : 0.25
Roof area coefficient : 0.9

Rainfall intensity (mm/hr) : 1426.408*((T+5.273)^-0.759) 100 yr
Rainfall intensity (mm/hr) : 853.608*((T+4.699)^-0.766) 5 yr

Orifice diameter (mm) : 80
Area of orifice (sq.m) : 0.00503
Orifice coefficient : 0.62
Max. ponding elev. : 306.3
Catchbasin elev. :
Ponding depth. :
Orifice invert : 305.4
Orifice center line elev. : 305.440
Head (m) : 0.86
Orifice release rate (l/sec) : 12.8

TABLE 2 - System Storage

Time (min.)	Intensity I (mm/hr)	Peak rate of runoff Q (l/sec)	Runoff volume (cu.m)	Orifice Outflow volume (cu.m)	Required storage volume (cu.m.)
10	108.92	19.93	11.96	7.68	4.3

Required site storage (cu. m) : 4
Available site storage (cu. m) : 52
SEE DRAWING SP-1

SYSTEM A
SITE SUMMARY

Orifice release rate (l/sec) : 12.8
Uncontrolled release rate (l/sec) :
Total site release rate (l/sec) : **12.8**

ALLOWABLE Total site release rate (l/sec) : **0.0**

PROJECT: ARG - 90 MAPLEVIEW DRIVE WEST
MUNICIPALITY: CITY OF BARRIE
JOB NO.: 21006.333
DATE: May 16, 2022
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URBAN ECOSYSTEMS LIMITED

SYSTEM B 5 yr

SITE STORM WATER MANAGEMENT

SITE PLAN CHARACTERISTICS - SYSTEM B

Site area (sq.m) : 41664
Controlled Pavement area (sq.m) : 17882
Controlled Landscaped area (sq.m) : 976
Proposed Roof area (sq.m) : 21916
Uncontrolled Pave area (sq.m.) : 84
Uncontrolled Landscaped area (sq.m.) : 806

Pavement coefficient : 0.9
Landscape coefficient : 0.25
Roof area coefficient : 0.9

ROOF DRAINAGE CHARACTERISTICS

Total roof area (sq. m) : 21916
Total number of roof hoppers : 50
Total number of weirs : 50
Max. sloped roof depth (mm) : 50.8
Max. sloped roof storage (cu.m) : 371.11
Max. parapit roof storage (cu.m) : 1113.33

Weir rating (l/sec) : 0.15
Weir area rating (sq. m.) : 465
Maximum head (cm) : 10.16
Peak roof outflow rate (l/sec) : 76.2

Rainfall intensity (mm/hr) : 853.608*((T+4.699)^-0.766) 5 yr

TABLE 1 - ROOF DRAINAGE SYSTEM

	1st ITERATION					2nd ITERATION						3rd ITERATION		
Time (min.)	Rainfall Intensity I (mm/hr)	Peak rate of runoff Q (l/sec)	Peak Runoff volume (cu.m.)	Peak roof outflow volume (cu.m)	Required storage volume (cu.m)	Volume in sloped roof areas (cu.m)	Volume contained by roof parapit (cu.m)	Total head on roof hoppers (cm)	Roof outflow rate (l/sec)	Roof outflow volume (cu.m)	Required storage volume (cu.m)	Total head on roof hoppers (cm)	Roof outflow volume (cu.m)	Required storage volume (cu.m)
5	149.77	820.66	246.20	22.86	223.34	223.34	-147.77	2.38	17.87	5.36	240.84	2.70	6.08	240.12
10	108.92	596.83	358.10	45.72	312.38	312.38	-58.73	4.01	30.06	18.04	340.06	4.51	20.31	337.79
15	87.04	476.93	429.23	68.58	360.65	360.65	-10.46	4.89	36.67	33.00	396.23	5.19	35.06	394.17
20	73.19	401.05	481.26	91.44	389.82	371.11	18.71	5.17	38.74	46.49	434.78	5.37	48.33	432.93
25	63.55	348.24	522.35	114.30	408.05	371.11	36.94	5.25	39.36	59.05	463.31	5.50	61.88	460.47
30	56.41	309.11	556.40	137.16	419.24	371.11	48.13	5.30	39.75	71.54	484.85	5.60	75.59	480.81
35	50.89	278.82	585.53	160.02	425.51	371.11	54.40	5.33	39.96	83.92	501.61	5.68	89.39	496.14
40	46.47	254.60	611.05	182.88	428.17	371.11	57.06	5.34	40.05	96.13	514.92	5.74	103.25	507.80
45	42.84	234.74	633.81	205.74	428.07	371.11	56.95	5.34	40.05	108.13	525.67	5.79	117.15	516.65
50	39.81	218.12	654.37	228.60	425.77	371.11	54.66	5.33	39.97	119.91	534.46	5.83	131.07	523.30
55	37.23	203.99	673.16	251.46	421.70	371.11	50.59	5.31	39.83	131.44	541.72	5.86	145.00	528.16
60	35.00	191.80	690.48	274.32	416.16	371.11	45.05	5.29	39.64	142.71	547.77	5.89	158.92	531.55
65	33.06	181.17	706.56	297.18	409.38	371.11	38.27	5.25	39.41	153.70	552.86	5.91	172.85	533.71
70	31.35	171.80	721.58	320.04	401.54	371.11	30.43	5.22	39.14	164.39	557.19	5.93	186.76	534.82
75	29.84	163.49	735.69	342.90	392.79	371.11	21.68	5.18	38.84	174.79	560.90	5.95	200.68	535.01 <<------
80	28.48	156.04	749.00	365.76	383.24	371.11	12.13	5.14	38.52	184.87	564.13	5.96	214.59	534.41
85	27.25	149.33	761.60	388.62	372.98	371.11	1.87	5.09	38.16	194.64	566.97	5.97	228.49	533.11
90	26.14	143.26	773.58	411.48	362.10	362.10	-9.01	4.92	36.87	199.08	574.50	6.01	243.33	530.26
95	25.13	137.72	785.00	434.34	350.66	350.66	-20.45	4.71	35.30	201.22	583.79	6.05	258.66	526.35
100	24.21	132.65	795.92	457.20	338.72	338.72	-32.39	4.49	33.67	202.00	593.92	6.10	274.35	521.57
105	23.36	128.00	806.38	480.06	326.32	326.32	-44.79	4.26	31.97	201.40	604.98	6.15	290.45	515.93
110	22.58	123.70	816.42	502.92	313.50	313.50	-57.61	4.03	30.21	199.42	617.01	6.20	307.00	509.42
115	21.85	119.72	826.09	525.78	300.31	300.31	-70.80	3.79	28.41	196.02	630.07	6.26	324.04	502.05
120	21.18	116.03	835.40	548.64	286.76	286.76	-84.35	3.54	26.55	191.19	644.21	6.33	341.61	493.79
125	20.55	112.59	844.40	571.50	272.90	272.90	-98.21	3.29	24.66	184.92	659.48	6.40	359.76	484.63
130	19.96	109.37	853.09	594.36	258.73	258.73	-112.33	3.03	22.72	177.19	675.90	6.47	378.54	474.56

Qroof= R A I N
= 5.479 x I (l / sec)

Peak roof outflow rate =
no. of hoppers x weir rating x max. head
= 76.2 l/sec

Peak roof outflow volume =
= 76.2 x time x 60/1000 cu. m.

Roof outflow rate =
head x weir rating x no. of weirs
= head x 7.50 l/sec

Required max. roof stotage (cu. m.) : 535.0
Available roof stotage (cu. m.) : 1484.4

PROJECT: ARG - 90 MAPLEVIEW DRIVE WEST
MUNICIPALITY: CITY OF BARRIE

SYSTEM B 5 yr
SITE STORM WATER MANAGEMENT

SITE PLAN CHARACTERISTICS - SYSTEM B

SITE CHARACTERISTICS

Controlled Pavement area (sq.m) :	17882
Controlled Landscaped area (sq.m) :	976
Total area - excl. Bldg (sq.m) :	18858
Composite runoff coefficent :	0.87

OUTLET CHARACTERISTICS

Orifice diameter (mm) :	215
Area of orifice (sq.m) :	0.03631
Orifice coefficient :	0.62
Max. ponding elev. :	306.56
Catchbasin elev. :	
Ponding depth. :	
Orifice invert :	305.64
Orifice center line elev. :	305.748
Head (m) :	0.81
Orifice release rate (l/sec) :	89.9

TABLE 2 - System Storage

Time (min.)	Intensity I (mm/hr)	Peak rate of runoff Q (l/sec)	Runoff volume (cu.m)	Orifice Outflow volume (cu.m)	Required storage volume (cu.m.)	
250	12.25	131.81	1977.18	1348.07	629.1	
252	12.18	131.48	1987.97	1358.85	629.1	<<------
254	12.11	131.15	1998.76	1369.63	629.1	
256	12.04	130.83	2009.53	1380.42	629.1	
258	11.97	130.51	2020.29	1391.20	629.1	

Required site storage (cu. m) : 629
Available site storage (cu. m) : 649
SEE DRAWING SP-1

INCLUDES ROOF RELEASE RATE = 76.2 (l/sec)

TABLE 3 - Uncontrolled Runoff

Time (min.)	Intensity I (mm/hr)	Peak rate of runoff Q (l/sec)	
10	108.92	8.4	<<------
15	87.04	6.7	
20	73.19	5.6	

Peak runoff (L/sec) : 8.4

UNCONTROLLED SITE CHARACTERISTICS

Uncontrolled Pavement area (sq.m.) :	84
Uncontrolled Landscaped area (sq.m.) :	806
Total area (sq.m) :	890
Composite runoff coefficent :	0.311

SYSTEM B
SITE SUMMARY

Orifice release rate (l/sec) :	89.9
Uncontrolled release rate (l/sec) :	8.4
Total site release rate (l/sec) :	**98.3**

PROJECT: ARG - 90 MAPLEVIEW DRIVE WEST
MUNICIPALITY: CITY OF BARRIE
JOB NO.: 21006.333
DATE: May 16, 2022
REVISED August 23, 2022

SYSTEM C 5 yr
SITE STORM WATER MANAGEMENT

SITE PLAN CHARACTERISTICS - SYSTEM C

Site area (sq.m) : 724
Controlled Pavement area (sq.m) : 0
Controlled Landscaped area (sq.m) : 724
Proposed Roof area (sq.m) : 0
Uncontrolled Pavement area (sq.m.) : 0
Uncontrolled Landscaped area (sq.m.) : 0

Composite runoff coefficent : 0.25

Pavement coefficient : 0.9
Landscape coefficient : 0.25
Roof area coefficient : 0.9

Rainfall intensity (mm/hr) : 853.608*((T+4.699)^-0.766) 5 yr

Orifice diameter (mm) : NO ORIFICE
Area of orifice (sq.m) : 0
Orifice coefficient : 0
Max. ponding elev. : 0
Catchbasin elev. : 0
Ponding depth. : 0
Orifice invert : 0
Orifice center line elev. : 0
Head (m) : 0
Orifice release rate (l/sec) : 0

NO ORIFICE
PIPE release rate (l/sec) : 5.5

TABLE 2 - System Storage

Time (min.)	Intensity I (mm/hr)	Peak rate of runoff Q (l/sec)	Runoff volume (cu.m)	Orifice Outflow volume (cu.m)	Required storage volume (cu.m.)
10	108.92	5.48			

Required site storage (cu. m) : 0
Available site storage (cu. m) : 0
SEE DRAWING SP-1

SYSTEM C
SITE SUMMARY

Orifice release rate (l/sec) : 5.5
Uncontrolled release rate (l/sec) :
Total site release rate (l/sec) : **5.5**

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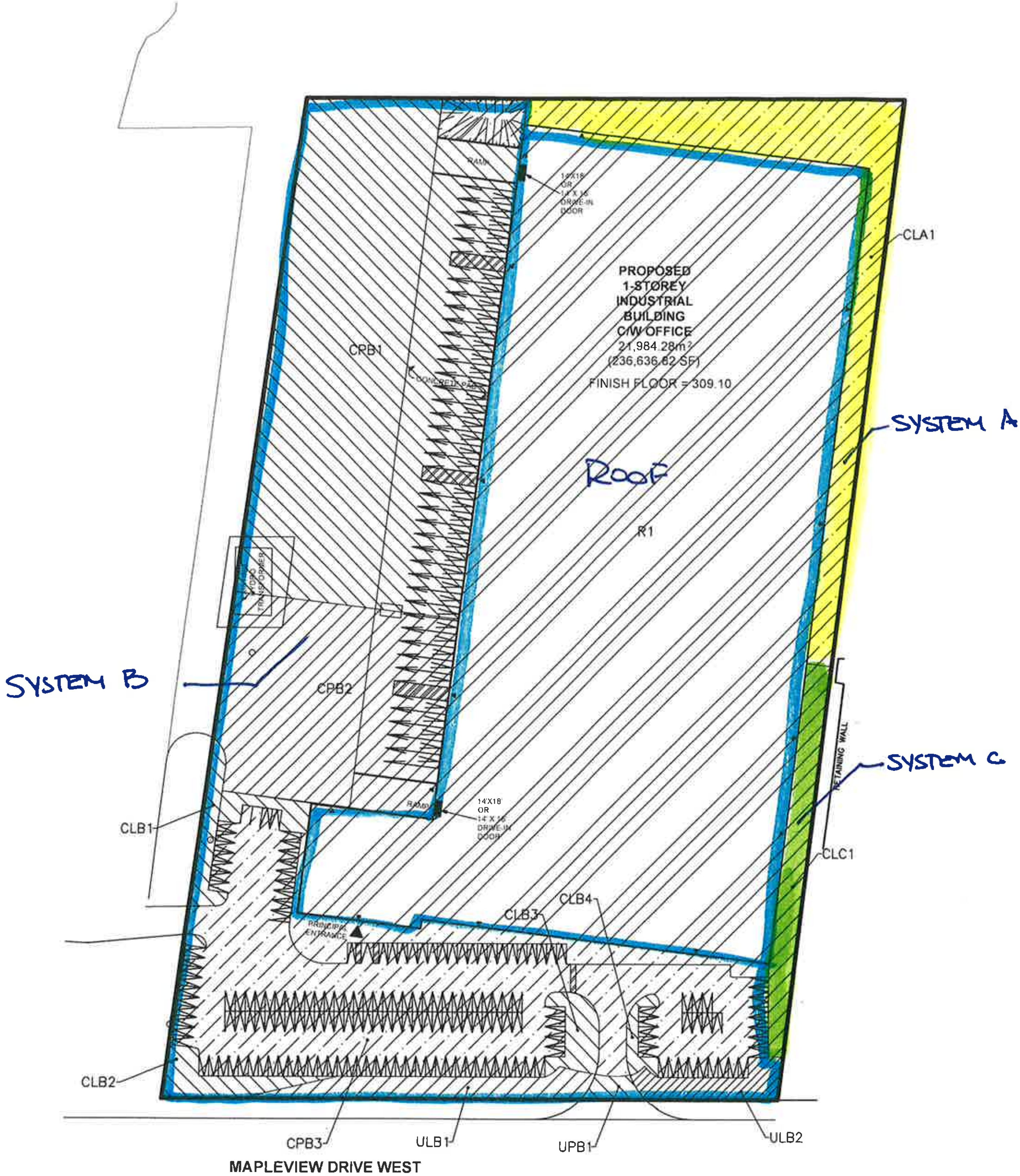
APPENDIX No 2

PHOSPHORUS LOADING CALCULATIONS



R1 = ROOF AREA	=	21,916 s.m			
CPB1	=	8,135 s.m	CLA1	=	2,634 s.m
CPB2	=	3,289 s.m	CLC1	=	724 s.m
CPB3	=	6,458 s.m	ULB1	=	513 s.m
CLB1	=	347 s.m	ULB2	=	293 s.m
CLB2	=	311 s.m	UPB1	=	84 s.m
CLB3	=	226 s.m			
CLB4	=	92 s.m			

URBAN ECOSYSTEMS
LIMITED

PROJECT:	ARG - 90 MAPLEVIEW DRIVE WEST
MUNICIPALITY:	CITY OF BARRIE
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	REVISED August 23, 2022

PHOSPHORUS LOADING

SITE PLAN CHARACTERISTICS -

Site area (sq.m) :	45022	
Controlled Pavement area (sq.m) :	17882	
Controlled Landscaped area (sq.m) :	4334	Includes System A (2634sm) + System C (724sm) = 3358
Proposed Roof area (sq.m) :	21916	
Uncontrolled Pavement area (sq.m.) :	84	
Uncontrolled Landscaped area (sq.m.) :	806	

Note: System A & C (3358 sm) discharges to the Water Quality Swale located east and downstream of Development Treatment Train

Note: Remaining balance of site discharges to the Hydro International Upflo Filter Development Treatment Train and then to Water Quality Swale located east and downstream of the site.

REFER TO DRAINAGE PLAN PROVIDED IN APPENDIX

PART A) Pre- Development Phosphorus Loading Review

Pre- Development Condition

CATCHMENT	LAND USE	AREA (ha)	Phosphorus Coefficient (kg / ha / yr)	Phosphorus Loading (kg / yr)	TOTAL Phosphorus Load (kg / yr)
Balance of Development Site	Modified Low Intensity Development	4.1664	0.13	0.54	0.54
System A + System C	Modified Low Intensity Development	0.3358	0.13	0.04	0.04
	TOTAL	4.5022			0.59

Note: Modified Phosphorus Loading Coefficient of 0.13 kg/ha/yr determined based on averaging Low Density Development Lands Uses and Sod Farm/Golf Course coefficients as lands existing are grassed surfaces with development activity. Coefficents for Development Lands Uses obtained from Phosphorus Budget tool In Support of Sustanianable Development For Lake Simcoe Watershed Report prepared by Hutchinson Environmental Services Ltd dated March 30, 2012

PART B) Post- Development Phosphorus Loading Review

Post- Development Condition

CATCHMENT	LAND USE	AREA (ha)	Phosphorus Coefficient (kg / ha / yr)	Phosphorus Loading (kg / yr)	TOTAL Phosphorus Load (kg / yr)
Balance of Development Site	Low Intensity Development	4.1664	1.82	7.58	7.58
System A + System C	Low Intensity Development	0.3358	0.17	0.06	0.06
	TOTAL	4.5022			7.64

Note: Phosphorus Loading Coefficients for Low Density Development Lands Uses obtained from Phosphorus Budget tool In Support of Sustanianable Development For Lake Simcoe Watershed Report prepared by Hutchinson Environmental Services Ltd dated March 30, 2012

PHOSPHORUS LOADING

PART C) Post- Development Phosphorus Loading with Mitigation Review

Post- Development Condition

CATCHMENT	LAND USE	AREA (ha)	Phosphorus Coefficient (kg / ha / yr)	Percentage of Area Treated with BMP
Roof	Commercial / Industrial	2.1916	1.82	100%
System A + System C	Commercial / Industrial	0.3358	0.17	0%
Remaining Site	Commercial / Industrial	1.9748	1.82	100%
	TOTAL	4.5022		

Treatment for Roof Flows

Mitigation Applied	Reduction Factor	Phosphorus Load Reduction (kg/yr)
Infiltrate 25mm Depth of Water (Roof)	1.00	3.99

Treatment for System A + C Landscape Area Flows

Mitigation Applied	Reduction Factor	Phosphorus Load Reduction (kg/yr)
System A + C	0.00	0.00

Treatment for Remaining Site Flows

1st Mitigation Applied	Reduction Factor	Phosphorus Load Reduction (kg/yr)
Hydro International Upflo Filter	0.59	2.12

Per Table 3 of Phosphorus Budget Tool in Support of Sustainable Development for the Lake Simcoe Watershed
Phosphorus Removal Efficiency of Filter System (excluding underground storage)ranges from 30%min to 59% maximum
Phosphorus Removal Efficiency of Filter System (including underground storage) of 59% included in above calculations.

Treatment for Remaining Site Flows

2nd Mitigation Applied	Reduction Factor	Phosphorus Load Reduction (kg/yr)
Water Quality Swale	0.00	0.00

Note: Remaining balance of site discharges to the Hydro International Upflo Filter Development Treatment Train and then to Water Quality Swale located east and downstream of the site

SUMMARY	
MITIGATION	**Total Load Reduction (kg/yr)**
Infiltration from Roof	3.99
Infiltration from System A + C Landscape Area	0.00
Hydro International Upflo Filter	2.12
Water Quality Swale	0.00
TOTAL	6.11

TOTAL PHOSPHORUS POST-DEVELOPMENT LOAD WITHOUT BMPs = 7.64 kg/yr
TOTAL PHOSPHORUS POST-DEVELOPMENT LOAD REDUCTION WITH BMPs = 6.11 kg/yr
TOTAL PHOSPHORUS POST-DEVELOPMENT LOAD WITH BMPs = 1.53 kg/yr

% OF TOTAL PHOSPHORUS POST-DEVELOPMENT LOAD REDUCTION = 80%
% OF TOTAL PHOSPHORUS POST-DEVELOPMENT LOAD REMAINING = 20%

TOTAL PHOSPHORUS POST-DEVELOPMENT LOAD WITH BMPs = 1.53 kg/yr

TOTAL PHOSPHORUS PRE-DEVELOPMENT LOAD = 0.77 kg/yr

TOTAL PHOSPHORUS POST-DEVELOPMENT SITE INCREASE = 0.76 kg/yr

URBAN ECOSYSTEMS LIMITED

PROJECT:	ARG - 90 MAPLEVIEW DRIVE WEST
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DATE:	May 16, 2022 REVISED August 23, 2022

PHOSPHORUS LOADING

PART D) Phosphorus Offsetting Fee

TOTAL PHOSPHORUS POST-DEVELOPMENT LOAD WITH BMPs =	1.53	kg/yr
TOTAL PHOSPHORUS PRE-DEVELOPMENT LOAD =	0.77	kg/yr
TOTAL PHOSPHORUS POST-DEVELOPMENT SITE INCREASE =	0.76	
TOTAL PHOSPHORUS LOAD CHANGE (PRE-POST) =	0.76	kg/yr
TOTAL PHOSPHORUS OFFSET RATIO =	2.50 : 1	
TOTAL ADJUSTED PHOSPHORUS POST-DEVELOPMENT SITE INCREASE =	1.90	kg/yr
OFFSET VALUE =	$35,770	kg/yr
SUB TOTAL PHOSPHORUS POST-DEVELOPMENT SITE OFFSET FEE =	$68,023.97	
LSRCA ADMIN FEE (15%) =	$10,203.59	
SUB TOTAL PHOSPHORUS POST-DEVELOPMENT SITE OFFSET FEE =	**$78,227.56**	

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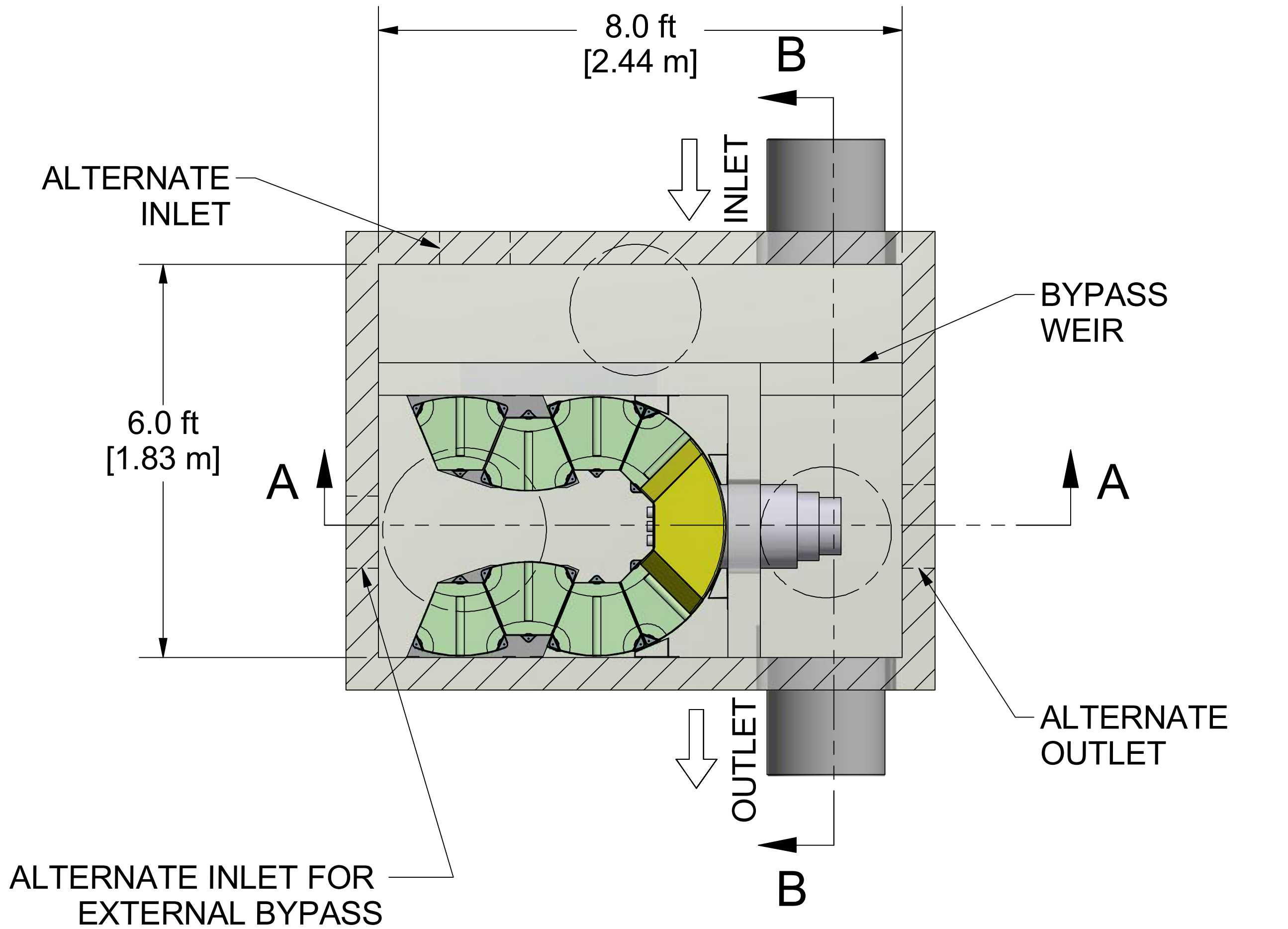
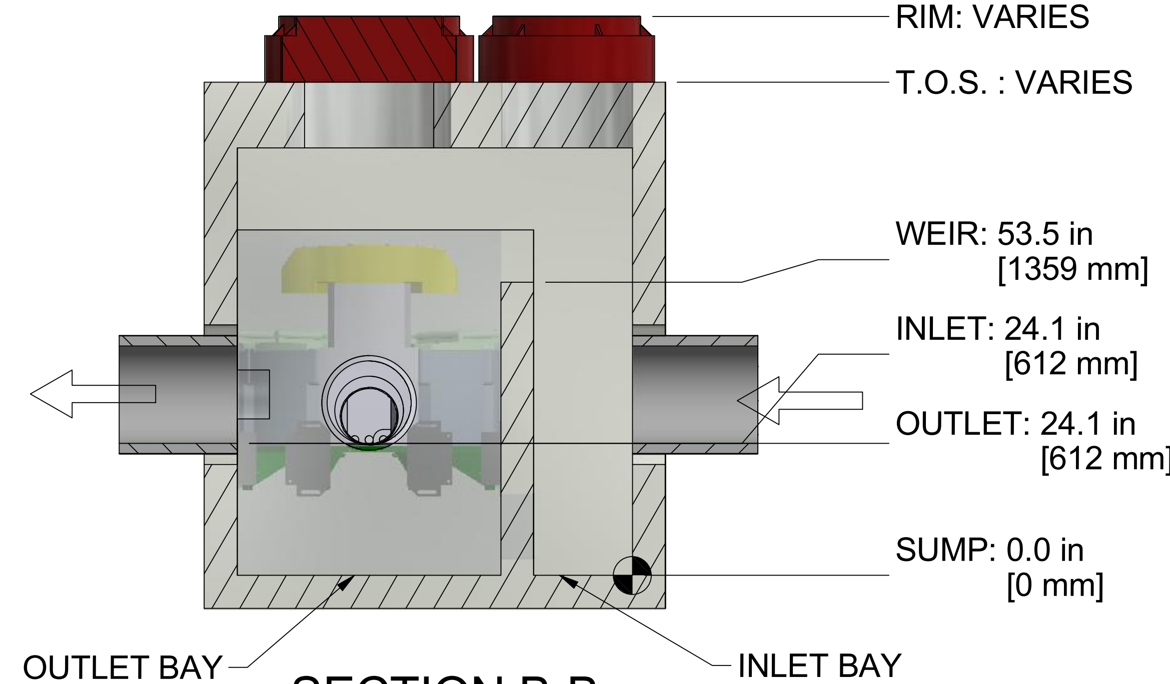
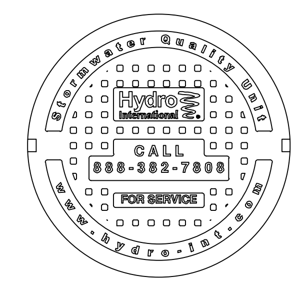
APPENDIX No 3

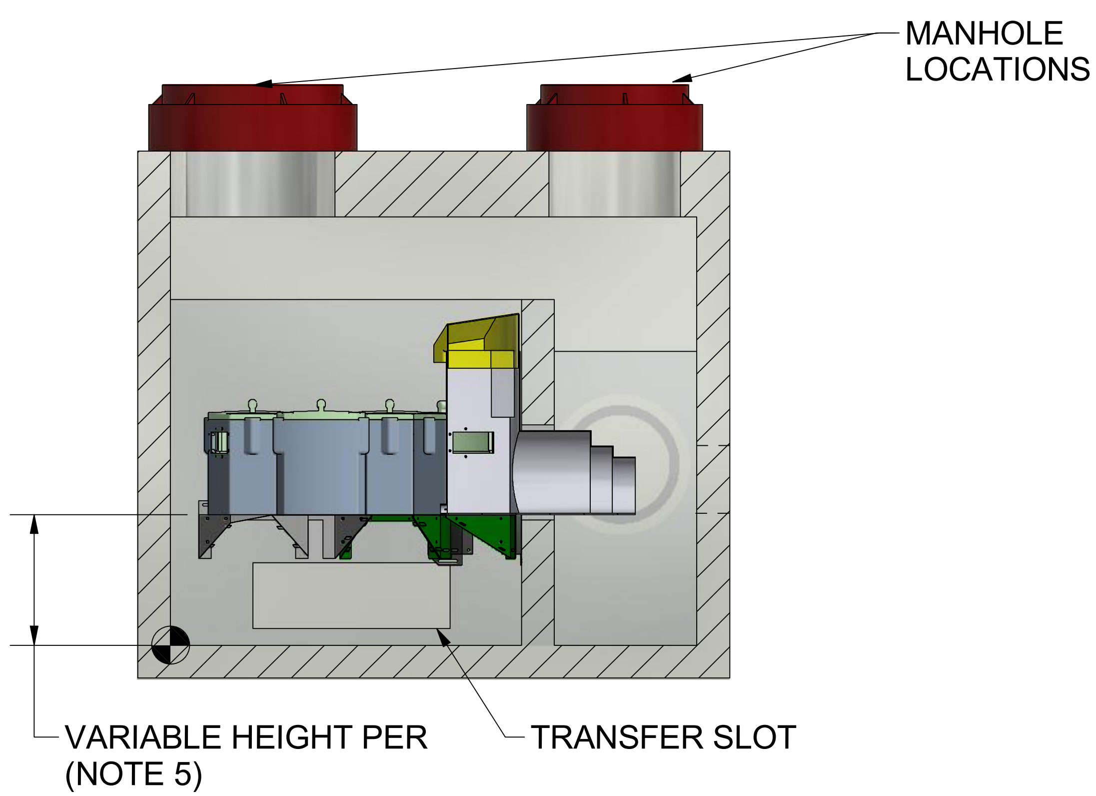
HDRO INTERNATIONAL UP-FLO QUALITY FILTER UNIT





SECTION B-B





SECTION A-A

CAPACITIES:

- Minimum performance: 80% removal. Washington DOE/NJCAT verified at the peak treatment flow.
- Peak treatment flow:
  .033 CFS (0.9 LPS) (15 GPM) per module (Ribbons)
  .022 CFS (0.6 LPS) (10 GPM) per module (Long Ribbons)
  .056 CFS (1.6 LPS) (25 GPM) per module (CPZ)
- Maximum number of ribbon modules per outlet module: 36
- Maximum number of CPZ modules per outlet module: 18 (contract Hydro if more are required)

ADDITIONAL DESIGN INFORMATION:

- Normal operating W.S.E. is 26-30" (660-762mm) above the outlet invert
- Media Types Available: Ribbons, CPZ

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES.

TOLERENCES ARE:
FRACTIONS ± 1/16
DECIMALS:
X.X ± .06
X.XX ± .03
X.XXX ± .015
ANGLES: ± .5°

PROJECTION

COMMENTS:

1. STRUCTURE WALL AND SLAB THICKNESSES ARE NOT TO SCALE
2. CONTACT HYDRO INTERNATIONAL FOR A BOTTOM OF STRUCTURE ELEVATION PRIOR TO SETTING THE STRUCTURE
3. NOT FOR CONSTRUCION CONTACT HYDRO FOR SITE SPECIFIC DRAWING
4. NOT ALL SIZES AVAILABLE IN ALL AREAS
5. SUMP DEPTH AVAILABLE IN 24" (610mm) CPZ, RIBBONS AND 36" (914mm) LONG RIBBONS DEPTH

REVISION HISTORY

REV	BY	DESCRIPTION	DATE
-	ER	FIRST RELEASE	3/8/2019

DATE: 3/8/2019	SCALE: 1:35	
DRAWN BY: ER	CHECKED BY:	APPROVED BY

Title
UP-FLO FILTER
6ft (1829mm) X 8ft (2438mm)

8 MODULES MAX

Hydro International®
94 Hutchins Drive
Portland, ME 04102
Tel: +1 (207) 756-6200
Fax: +1 (207) 756-6212
hydro-int.com

WEIGHT: N/A	MATERIAL:
NEXT ASSEMBLY: 6x8-1	
DRAWING NO.: 6x8-UFF-1	

SHEET SIZE:	SHEET:	Rev:
B	1 OF 1	-

Project Name
Project Location
Hydro Ref. #

PART 1 - GENERAL

1.01 SCOPE

A. Work described in this section includes furnishing all labor, equipment, materials, tools and incidentals required for a complete and operable installation of the stormwater filtration system as shown on the drawings and specified herein. The manufacturer shall design and supply the equipment listed in Part 4.A. and the Contractor shall install the equipment in accordance with the manufacturer's Handling, Storage, and Installation Instructions.

B. The manufacturer shall design and supply the equipment listed herein and the Contractor shall install the equipment in accordance with the manufacturer's Handling, Storage, and Installation Instructions.

1.02 GENERAL REQUIREMENTS

A. The stormwater filtration system shall be a precast, modular, upward flow, fluidized media bed filtration system, with integrated pretreatment, siphon activated bypass and drain down. The system shall be self-activating with no mechanical parts or external power requirements.

B. The stormwater filtration system shall be supplied by a manufacturer regularly engaged in such work and who has furnished stormwater filtration systems that have been in successful and continuous operation for a minimum period of five years.

C. Upon request, independently certified performance data and shall be made available to the Engineer of Record for use in determining that the treatment system meets the design criteria and performance requirements stated herein.

1.03 SUBMITTALS

A. Submittals shall be provided and shall include the following:

1. General arrangement and dimensional drawings of the filtration system.

2. Plan and elevation drawings of the filtration system as it shall be incorporated into the stormwater drainage system. The elevation drawing shall indicate the top of water level both upstream and downstream of the treatment system at the flow conditions specified herein.

3. Handling, Storage and Installation Instructions.

4. Operation and Maintenance Instructions and a Maintenance video.

1.04 QUALITY ASSURANCE

A. The stormwater filtration system shall be manufactured under the direction of an ISO 9001 Certified Company.

B. Inspection

   The stormwater filtration system shall be subject to inspection by the Engineer of Record or the owner's representative at either the place of manufacture or the project site. Any and all observed defects shall be repaired to the satisfaction of the owner or owner's representative or replacement shall be made available.

C. Warranty

   The manufacturer shall guarantee the filtration system from defects in materials and workmanship for a period of two years following installation. If during the warranty period defects in materials or workmanship are noted, then the manufacturer shall be promptly notified. The decision to repair or replace affected units shall be made at the discretion of the manufacturer.

D. Patent Indemnity

   Upon request, the manufacturer shall warrant that the treatment system does not infringe upon or violate any patent, copyright, trade secret or any other proprietary right of any third party and shall indemnify the Owner against any loss, cost, expense or liability arising out of such claim whether or not such claim is successful.

E. Certificate of Compliance

   Upon request, the manufacturer shall provide a "Letter of Certification" to certify that the stormwater filtration system adheres to the specifications required herein and complies with the project's stormwater management permit.

1.05 MANUFACTURER

A. The stormwater filtration system shall be the Up-Flo® Filter as designed by Hydro International located at 94 Hutchins Drive, Portland, Maine 04102. Telephone (207) 756-6200. Fax (207) 756-6212.

B. Alternate stormwater filtration systems must demonstrate compliance with the specifications herein and be approved by the Engineer of Record. Request for alternative filtration systems shall include:

   I. Revised site plan showing location and orientation of proposed alternative, pipe sizes, connections and excavation limits.

   II. Product installation drawings showing plan and elevation views with water elevations for the flow conditions specified herein.

   III. Verified/certified product evaluations that demonstrate proposed sizing and performance that adheres to section 2.02.

   IV. Maintenance manual including inspection and clean out costs, maintenance video and three references for verifying successful completion of the procedures and associated costs.

C. Costs for reviewing submittals for alternative filtration system shall be the Contractor's or alternative Manufacturer's responsibility.

PART 2 – STORMWATER FILTRATION SYSTEM

2.01 General

A. The stormwater filtration system shall be an Up-Flo® Filter that provides three modes of treatment; sedimentation, screening and high-rate upward flow filtration all within the same structure. Internal components shall provide a minimum 2-ft sediment storage sump, adjustable bypass hood, siphon-activated high-flow bypass hood, and drain down with integrated flow control.

B. An inlet pipe or grated surface inlet cover shall be used to convey surface runoff into a precast cylindrical or rectangular vault. Capture pollutants that settle shall be stored in a location that does not contain filtration components. Water elevations within the precast structure will be controlled with a vertical bypass chute. A water-lock baffle shall prevent the loss of captured pollutants that float on the water surface from escaping through the bypass chute.

C. The upward flow filtration system shall provide protected storage regions for captured pollutants that float and for those that settle and shall not release captured floating pollutants during surcharge conditions. The upward flow filtration system shall operate as intended and perform as specified herein as pollutants accumulate.

D. The upward flow filtration system shall fit within the limits of excavation (area and depth) as shown in the project plans and will not exceed the dimensions for the design flow rates specified herein.

E. Minimum 24-inch openings shall provide access to the sediment storage volumes from the surface for inspection and maintenance. Hand removal of media from the treatment system shall be possible; no heavy lifting equipment will be required when media exchange is required.

2.02 Performance

1. Sizing of the upward flow filtration system shall be based on independent full-scale laboratory testing and shall adhere to the Performance Specifications listed in Table 1. The laboratory testing used as the basis of product performance shall be undertaken in accordance with testing protocols approved or endorsed by the Stormwater Equipment Manufacturers Association (SWEMA) or acceptable State agency, such as a State Department of Environmental Protection (DEP) or recognized verification agency (e.g: ETV, NJCAT, NETE).
2. Independent full-scale field monitoring results shall demonstrate greater than 80% TSS removal based on a median particle size of 29 microns and removal of fine particulate matter down to 5 microns. Field performance results shall demonstrate a performance life of at least 6 years or 130 lbs of particulate material captured per Filter Module before 10% filter occlusion. Field monitoring test protocol shall adhere to, "Total Suspended Solids Removal Based on Field Testing Amendments to TARP Protocol Dated August 5, 2009".

3. Performance of the upward flow filtration system shall be based on treating the Water Quality Flow rate (WQF) without internally bypassing. The maximum filtration rate shall be greater than or equal to the WQF for an operating head of less than 30-inches. The upward flow filtration system shall remove greater than or equal to 80% of TSS based on the Target Particle Size (TPS) of 20 microns and demonstrate removal of particles down to 5 microns.
4. The upward flow filtration system shall treat all flows without internally bypassing up to the WQF and shall provide sufficient bypass capacity to convey the peak runoff flow rate without risk of flooding.

PART 3 – EQUIPMENT

A. The Up-Flo® Filter shall consist of a hollow, cylindrical or vaulted vessel with internal components.

(i) The internal components to be supplied by Hydro International shall include the Support Frames, Filter Modules, Filter Media Packs, Siphon Activated Bypass Chute with Floatables Hood, and Draindown Filter.

Materials of construction for the above components excluding the support frame shall be cross-linked polyethylene (XLPE). The component support frame and screen and all metal parts shall be Type 304 stainless steel or carbon steel powder coated in accordance with ASTM 775/ ASTM A775M with a resulting thickness of 8-12 mils. All components shall be designed to withstand all normal loadings associated with fabrication, shipping, site installation, and normal operation of the equipment.

(ii) The precast concrete structure shall be manufactured with concrete that has attained a compressive strength of 4,000 psi after 28 days. The structure shall be reinforced to withstand an HS20-44 loading. Shiplap joints shall be sealed with butyl rubber mastic sealant conforming to ASTM C990. Slab tops shall be suitably reinforced and provided with manhole openings and covers as required. The cast iron manhole frames and covers shall be sized as per the manufacturer's drawings and shall be in accordance with ASTM A48, CL.35B and AASHTO M105. The masonry fixing bolts shall be Type 304 stainless steel.

B. Each stormwater Filter Module shall be supported by a stainless steel frame which shall consist of an angled screen with 0.25-inch diameter perforations to retain all neutrally buoyant material and debris greater than 0.25-inches in diameter.

C. The upward flow filtration system shall have a flow controlled Draindown Filter to drain down the water level in the chamber between storm events. The filter media shall be positioned above the standing water level between storm events to prevent anoxic conditions in the media.

D. The stormwater filtration system shall have a self-activated siphonic bypass to convey flows in excess of the peak treatment flow rate. The bypass shall be equipped with a floatables baffle to prevent the escape of buoyant litter and debris.

E. Each stormwater filter module shall be furnished with a media pack. The media pack shall consist of the media bags placed between flow distribution media.

F. The stormwater filtration system media bags shall be one of the following:

i. Carbon-peat-zeolite (CPZ™ Mix)
ii. Carbon-peat-sand (CPS™ Mix)
iii. Hydro Filter Sand (HFS™)
iv. Perlite

PART 4 - EQUIPMENT DELIVERY

A. The Up-Flo® Filter components shall be delivered within eight weeks from the date of approved technical submittal.

B. The Up-Flo® Filter components shall be delivered to the site fully fabricated and pre-assembled within the host precast structure, with exception of the media filter bags.

C. Off-loading, storage, installation of the media filter bags, and final installation shall be by the Contractor.

D. The Contractor shall inspect and provide signed acceptance of equipment prior to unloading, or notify Hydro International of any damage to equipment to effect proper remedial action. Failure to notify Hydro International of damage to equipment prior to unloading will void all warranties pertaining to subject equipment.

PART 5 - EQUIPMENT INSTALLATION

A. The system shall be installed in strict accordance with the site plans, and the manufacturer's general arrangement drawings and Handling, Storage and Installation Instructions. The Contractor shall be responsible for installing the preassembled equipment and all necessary site connections.

B. Hydro International shall be notified immediately of any equipment which is damaged during unloading, storage, or installation. The damaged equipment shall be repaired or replaced at the discretion of Hydro International and entirely at the Contractor's expense.

C. The precast concrete structure shall be set on a granular or compacted sand subbase in accordance with local requirements for standard manhole installation.

D. The precast concrete structure shall be set level to within 0.5%.

E. Non-shrink grout shall be used to provide a water tight seal in the lifting holes and around the concrete knock-outs for the inlet and outlet pipes.

F. The Contractor shall be responsible for installing the flow distribution media and media bags for each filter module as per the manufacturer's recommendations. The maximum dry weight of each filter bag shall be no greater than 36 lbs.

Project Name
Project Location
Hydro Ref. #

PART 1 - GENERAL

1.01 SCOPE

A. Work described in this section includes furnishing all labor, equipment, materials, tools and incidentals required for a complete and operable installation of the stormwater filtration system as shown on the drawings and specified herein. The manufacturer shall design and supply the equipment listed in Part 4.A. and the Contractor shall install the equipment in accordance with the manufacturer's Handling, Storage, and Installation Instructions.

B. The manufacturer shall design and supply the equipment listed herein and the Contractor shall install the equipment in accordance with the manufacturer's Handling, Storage, and Installation Instructions.

1.02 GENERAL REQUIREMENTS

A. The stormwater filtration system shall be a precast, modular, upward flow, fluidized media bed filtration system, with integrated pretreatment, siphon activated bypass and drain down. The system shall be self-activating with no mechanical parts or external power requirements.

B. The stormwater filtration system shall be supplied by a manufacturer regularly engaged in such work and who has furnished stormwater filtration systems that have been in successful and continuous operation for a minimum period of five years.

C. Upon request, independently certified performance data and shall be made available to the Engineer of Record for use in determining that the treatment system meets the design criteria and performance requirements stated herein.

1.03 SUBMITTALS

A. Submittals shall be provided and shall include the following:

1. General arrangement and dimensional drawings of the filtration system.

2. Plan and elevation drawings of the filtration system as it shall be incorporated into the stormwater drainage system. The elevation drawing shall indicate the top of water level both upstream and downstream of the treatment system at the flow conditions specified herein.

3. Handling, Storage and Installation Instructions.

4. Operation and Maintenance Instructions and a Maintenance video.

1.04 QUALITY ASSURANCE

A. The stormwater filtration system shall be manufactured under the direction of an ISO 9001 Certified Company.

B. Inspection

The stormwater filtration system shall be subject to inspection by the Engineer of Record or the owner's representative at either the place of manufacture or the project site. Any and all observed defects shall be repaired to the satisfaction of the owner or owner's representative or replacement shall be made available.

C. Warranty

The manufacturer shall guarantee the filtration system from defects in materials and workmanship for a period of two years following installation. If during the warranty period defects in materials or workmanship are noted, then the manufacturer shall be promptly notified. The decision to repair or replace affected units shall be made at the discretion of the manufacturer.

D. Patent Indemnity

Upon request, the manufacturer shall warrant that the treatment system does not infringe upon or violate any patent, copyright, trade secret or any other proprietary right of any third party and shall indemnify the Owner against any loss, cost, expense or liability arising out of such claim whether or not such claim is successful.

E. Certificate of Compliance

Upon request, the manufacturer shall provide a "Letter of Certification" to certify that the stormwater filtration system adheres to the specifications required herein and complies with the project's stormwater management permit.

1.05 MANUFACTURER

A. The stormwater filtration system shall be the Up-Flo® Filter as designed by Hydro International located at 94 Hutchins Drive, Portland, Maine 04102. Telephone (207) 756-6200. Fax (207) 756-6212.

B. Alternate stormwater filtration systems must demonstrate compliance with the specifications herein and be approved by the Engineer of Record. Request for alternative filtration systems shall include:

I. Revised site plan showing location and orientation of proposed alternative, pipe sizes, connections and excavation limits.

II. Product installation drawings showing plan and elevation views with water elevations for the flow conditions specified herein.

III. Verified/certified product evaluations that demonstrate proposed sizing and performance that adheres to section 2.02.

IV. Maintenance manual including inspection and clean out costs, maintenance video and three references for verifying successful completion of the procedures and associated costs.

C. Costs for reviewing submittals for alternative filtration system shall be the Contractor's or alternative Manufacturer's responsibility.

PART 2 – STORMWATER FILTRATION SYSTEM

2.01 General

A. The stormwater filtration system shall be an Up-Flo® Filter that provides three modes of treatment; sedimentation, screening and high-rate upward flow filtration all within the same structure. Internal components shall provide a minimum 2-ft sediment storage sump, adjustable bypass hood, siphon-activated high-flow bypass hood, and drain down with integrated flow control.

B. An inlet pipe or grated surface inlet cover shall be used to convey surface runoff into a precast cylindrical or rectangular vault. Capture pollutants that settle shall be stored in a location that does not contain filtration components. Water elevations within the precast structure will be controlled with a vertical bypass chute. A water-lock baffle shall prevent the loss of captured pollutants that float on the water surface from escaping through the bypass chute.

C. The upward flow filtration system shall provide protected storage regions for captured pollutants that float and for those that settle and shall not release captured floating pollutants during surcharge conditions. The upward flow filtration system shall operate as intended and perform as specified herein as pollutants accumulate.

D. The upward flow filtration system shall fit within the limits of excavation (area and depth) as shown in the project plans and will not exceed the dimensions for the design flow rates specified herein.

E. Minimum 24-inch openings shall provide access to the sediment storage volumes from the surface for inspection and maintenance. Hand removal of media from the treatment system shall be possible; no heavy lifting equipment will be required when media exchange is required.

2.02 Performance

1. Sizing of the upward flow filtration system shall be based on independent full-scale laboratory testing and shall adhere to the Performance Specifications listed in Table 1. The laboratory testing used as the basis of product performance shall be undertaken in accordance with testing protocols approved or endorsed by the Stormwater Equipment Manufacturers Association (SWEMA) or acceptable State agency, such as a State Department of Environmental Protection (DEP) or recognized verification agency (e.g: ETV, NJCAT, NETE).
2. Independent full-scale field monitoring results shall demonstrate greater than 80% TSS removal based on a median particle size of 29 microns and removal of fine particulate matter down to 5 microns. Field performance results shall demonstrate a performance life of at least 6 years or 130 lbs of particulate material captured per Filter Module before 10% filter occlusion. Field monitoring test protocol shall adhere to, "Total Suspended Solids Removal Based on Field Testing Amendments to TARP Protocol Dated August 5, 2009".

3. Performance of the upward flow filtration system shall be based on treating the Water Quality Flow rate (WQF) without internally bypassing. The maximum filtration rate shall be greater than or equal to the WQF for an operating head of less than 30-inches. The upward flow filtration system shall remove greater than or equal to 80% of TSS based on the Target Particle Size (TPS) of 20 microns and demonstrate removal of particles down to 5 microns.
4. The upward flow filtration system shall treat all flows without internally bypassing up to the WQF and shall provide sufficient bypass capacity to convey the peak runoff flow rate without risk of flooding.

PART 3 – EQUIPMENT

A. The Up-Flo® Filter shall consist of a hollow, cylindrical or vaulted vessel with internal components.

(i) The internal components to be supplied by Hydro International shall include the Support Frames, Filter Modules, Filter Media Packs, Siphon Activated Bypass Chute with Floatables Hood, and Draindown Filter.

Materials of construction for the above components excluding the support frame shall be cross-linked polyethylene (XLPE). The component support frame and screen and all metal parts shall be Type 304 stainless steel or carbon steel powder coated in accordance with ASTM 775/ ASTM A775M with a resulting thickness of 8-12 mils. All components shall be designed to withstand all normal loadings associated with fabrication, shipping, site installation, and normal operation of the equipment.

(ii) The precast concrete structure shall be manufactured with concrete that has attained a compressive strength of 4,000 psi after 28 days. The structure shall be reinforced to withstand an HS20-44 loading. Shiplap joints shall be sealed with butyl rubber mastic sealant conforming to ASTM C990. Slab tops shall be suitably reinforced and provided with manhole openings and covers as required. The cast iron manhole frames and covers shall be sized as per the manufacturer's drawings and shall be in accordance with ASTM A48, CL.35B and AASHTO M105. The masonry fixing bolts shall be Type 304 stainless steel.

B. Each stormwater Filter Module shall be supported by a stainless steel frame which shall consist of an angled screen with 0.25-inch diameter perforations to retain all neutrally buoyant material and debris greater than 0.25-inches in diameter.

C. The upward flow filtration system shall have a flow controlled Draindown Filter to drain down the water level in the chamber between storm events. The filter media shall be positioned above the standing water level between storm events to prevent anoxic conditions in the media.

D. The stormwater filtration system shall have a self-activated siphonic bypass to convey flows in excess of the peak treatment flow rate. The bypass shall be equipped with a floatables baffle to prevent the escape of buoyant litter and debris.

E. Each stormwater filter module shall be furnished with a media pack. The media pack shall consist of the media bags placed between flow distribution media.

F. The stormwater filtration system media bags shall be one of the following:

i. Carbon-peat-zeolite (CPZ™ Mix)
ii. Carbon-peat-sand (CPS™ Mix)
iii. Hydro Filter Sand (HFS™)
iv. Perlite

PART 4 - EQUIPMENT DELIVERY

A. The Up-Flo® Filter components shall be delivered within eight weeks from the date of approved technical submittal.

B. The Up-Flo® Filter components shall be delivered to the site fully fabricated and pre-assembled within the host precast structure, with exception of the media filter bags.

C. Off-loading, storage, installation of the media filter bags, and final installation shall be by the Contractor.

D. The Contractor shall inspect and provide signed acceptance of equipment prior to unloading, or notify Hydro International of any damage to equipment to effect proper remedial action. Failure to notify Hydro International of damage to equipment prior to unloading will void all warranties pertaining to subject equipment.

PART 5 - EQUIPMENT INSTALLATION

A. The system shall be installed in strict accordance with the site plans, and the manufacturer's general arrangement drawings and Handling, Storage and Installation Instructions. The Contractor shall be responsible for installing the preassembled equipment and all necessary site connections.

B. Hydro International shall be notified immediately of any equipment which is damaged during unloading, storage, or installation. The damaged equipment shall be repaired or replaced at the discretion of Hydro International and entirely at the Contractor's expense.

C. The precast concrete structure shall be set on a granular or compacted sand subbase in accordance with local requirements for standard manhole installation.

D. The precast concrete structure shall be set level to within 0.5%.

E. Non-shrink grout shall be used to provide a water tight seal in the lifting holes and around the concrete knock-outs for the inlet and outlet pipes.

F. The Contractor shall be responsible for installing the flow distribution media and media bags for each filter module as per the manufacturer's recommendations. The maximum dry weight of each filter bag shall be no greater than 36 lbs.

Project Name
Project Location
Hydro Ref. #

PART 1 - GENERAL

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B. Hydro International shall be notified immediately of any equipment which is damaged during unloading, storage, or installation. The damaged equipment shall be repaired or replaced at the discretion of Hydro International and entirely at the Contractor's expense.

C. The precast concrete structure shall be set on a granular or compacted sand subbase in accordance with local requirements for standard manhole installation.

D. The precast concrete structure shall be set level to within 0.5%.

E. Non-shrink grout shall be used to provide a water tight seal in the lifting holes and around the concrete knock-outs for the inlet and outlet pipes.

F. The Contractor shall be responsible for installing the flow distribution media and media bags for each filter module as per the manufacturer's recommendations. The maximum dry weight of each filter bag shall be no greater than 36 lbs.

URBAN ECOSYSTEMS LIMITED
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WOODBRIDGE, ONTARIO L4L 8G7
uel@urbanecosystems.com
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f. (905)856-0698

APPENDIX No 4

ADS STORAGE & INFILTRATION BASINS

PROJECT INFORMATION	
ENGINEERED PRODUCT MANAGER:	CODY NEATH 519-465-9958 CODY.NEATH@ADS-PIPE.COM
ADS SALES REP:	RYAN MARTIN 705-207-3059 RYAN.MARTIN@ADS-PIPE.COM
PROJECT NO:	S260345
ADS SITE COORDINATOR:	MATTHEW BEGHIN 519-710-3687 MATTHEW.BEGHIN@ADS-PIPE.COM

ADS™
Advanced Drainage Systems, Inc.

SiteASSIST™
FOR STORMTECH INSTRUCTIONS, DOWNLOAD THE INSTALLATION APP

90 MAPLEVIEW DR. WEST

BARRIE, ON.

SC-740 STORMTECH CHAMBER SPECIFICATIONS

1. CHAMBERS SHALL BE STORMTECH SC-740.
2. CHAMBERS SHALL BE ARCH-SHAPED AND SHALL BE MANUFACTURED FROM VIRGIN, IMPACT-MODIFIED POLYPROPYLENE COPOLYMERS.
3. CHAMBERS SHALL BE CERTIFIED TO CSA B184, "POLYMERIC SUB-SURFACE STORMWATER MANAGEMENT STRUCTURES", AND MEET THE REQUIREMENTS OF ASTM F2418, "STANDARD SPECIFICATION FOR POLYPROPYLENE (PP) CORRUGATED WALL STORMWATER COLLECTION CHAMBERS".
4. CHAMBER ROWS SHALL PROVIDE CONTINUOUS, UNOBSTRUCTED INTERNAL SPACE WITH NO INTERNAL SUPPORTS THAT WOULD IMPEDE FLOW OR LIMIT ACCESS FOR INSPECTION.
5. THE STRUCTURAL DESIGN OF THE CHAMBERS, THE STRUCTURAL BACKFILL, AND THE INSTALLATION REQUIREMENTS SHALL ENSURE THAT THE LOAD FACTORS SPECIFIED IN THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS, SECTION 12.12, ARE MET FOR: 1) LONG-DURATION DEAD LOADS AND 2) SHORT-DURATION LIVE LOADS, BASED ON THE CSA S6 CL-625 TRUCK AND THE AASHTO DESIGN TRUCK WITH CONSIDERATION FOR IMPACT AND MULTIPLE VEHICLE PRESENCES.
6. CHAMBERS SHALL BE DESIGNED, TESTED AND ALLOWABLE LOAD CONFIGURATIONS DETERMINED IN ACCORDANCE WITH ASTM F2787, "STANDARD PRACTICE FOR STRUCTURAL DESIGN OF THERMOPLASTIC CORRUGATED WALL STORMWATER COLLECTION CHAMBERS". LOAD CONFIGURATIONS SHALL INCLUDE: 1) INSTANTANEOUS (<1 MIN) AASHTO DESIGN TRUCK LIVE LOAD ON MINIMUM COVER 2) MAXIMUM PERMANENT (75-YR) COVER LOAD AND 3) ALLOWABLE COVER WITH PARKED (1-WEEK) AASHTO DESIGN TRUCK.
7. REQUIREMENTS FOR HANDLING AND INSTALLATION:
   - TO MAINTAIN THE WIDTH OF CHAMBERS DURING SHIPPING AND HANDLING, CHAMBERS SHALL HAVE INTEGRAL, INTERLOCKING STACKING LUGS.
   - TO ENSURE A SECURE JOINT DURING INSTALLATION AND BACKFILL, THE HEIGHT OF THE CHAMBER JOINT SHALL NOT BE LESS THAN 50 mm (2").
   - TO ENSURE THE INTEGRITY OF THE ARCH SHAPE DURING INSTALLATION, a) THE ARCH STIFFNESS CONSTANT SHALL BE GREATER THAN OR EQUAL TO 550 LBS/IN/IN. THE ASC IS DEFINED IN SECTION 6.2.8 OF ASTM F2418. AND b) TO RESIST CHAMBER DEFORMATION DURING INSTALLATION AT ELEVATED TEMPERATURES (ABOVE 23° C / 73° F), CHAMBERS SHALL BE PRODUCED FROM REFLECTIVE GOLD OR YELLOW COLORS.
8. ONLY CHAMBERS THAT ARE APPROVED BY THE SITE DESIGN ENGINEER WILL BE ALLOWED. UPON REQUEST BY THE SITE DESIGN ENGINEER OR OWNER, THE CHAMBER MANUFACTURER SHALL SUBMIT A STRUCTURAL EVALUATION FOR APPROVAL BEFORE DELIVERING CHAMBERS TO THE PROJECT SITE AS FOLLOWS:
   - THE STRUCTURAL EVALUATION SHALL BE SEALED BY A REGISTERED PROFESSIONAL ENGINEER.
   - THE STRUCTURAL EVALUATION SHALL DEMONSTRATE THAT THE SAFETY FACTORS ARE GREATER THAN OR EQUAL TO 1.95 FOR DEAD LOAD AND 1.75 FOR LIVE LOAD, THE MINIMUM REQUIRED BY ASTM F2787 AND BY SECTIONS 3 AND 12.12 OF THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS FOR THERMOPLASTIC PIPE.
   - THE TEST DERIVED CREEP MODULUS AS SPECIFIED IN ASTM F2418 SHALL BE USED FOR PERMANENT DEAD LOAD DESIGN EXCEPT THAT IT SHALL BE THE 75-YEAR MODULUS USED FOR DESIGN.
9. CHAMBERS AND END CAPS SHALL BE PRODUCED AT AN ISO 9001 CERTIFIED MANUFACTURING FACILITY.

IMPORTANT - NOTES FOR THE BIDDING AND INSTALLATION OF THE SC-740 SYSTEM

1. STORMTECH SC-740 CHAMBERS SHALL NOT BE INSTALLED UNTIL THE MANUFACTURER'S REPRESENTATIVE HAS COMPLETED A PRE-CONSTRUCTION MEETING WITH THE INSTALLERS.
2. STORMTECH SC-740 CHAMBERS SHALL BE INSTALLED IN ACCORDANCE WITH THE "STORMTECH SC-310/SC-740/DC-780 CONSTRUCTION GUIDE".
3. CHAMBERS ARE NOT TO BE BACKFILLED WITH A DOZER OR AN EXCAVATOR SITUATED OVER THE CHAMBERS. STORMTECH RECOMMENDS 3 BACKFILL METHODS:
   - STONESHOOTER LOCATED OFF THE CHAMBER BED.
   - BACKFILL AS ROWS ARE BUILT USING AN EXCAVATOR ON THE FOUNDATION STONE OR SUBGRADE.
   - BACKFILL FROM OUTSIDE THE EXCAVATION USING A LONG BOOM HOE OR EXCAVATOR.
4. THE FOUNDATION STONE SHALL BE LEVELED AND COMPACTED PRIOR TO PLACING CHAMBERS.
5. JOINTS BETWEEN CHAMBERS SHALL BE PROPERLY SEATED PRIOR TO PLACING STONE.
6. MAINTAIN MINIMUM - 150 mm (6") SPACING BETWEEN THE CHAMBER ROWS.
7. EMBEDMENT STONE SURROUNDING CHAMBERS MUST BE A CLEAN, CRUSHED, ANGULAR STONE 20-50 mm (3/4-2").
8. THE CONTRACTOR MUST REPORT ANY DISCREPANCIES WITH CHAMBER FOUNDATION MATERIALS BEARING CAPACITIES TO THE SITE DESIGN ENGINEER.
9. ADS RECOMMENDS THE USE OF "FLEXSTORM CATCH IT" INSERTS DURING CONSTRUCTION FOR ALL INLETS TO PROTECT THE SUBSURFACE STORMWATER MANAGEMENT SYSTEM FROM CONSTRUCTION SITE RUNOFF.

NOTES FOR CONSTRUCTION EQUIPMENT

1. STORMTECH SC-740 CHAMBERS SHALL BE INSTALLED IN ACCORDANCE WITH THE "STORMTECH SC-310/SC-740/DC-780 CONSTRUCTION GUIDE".
2. THE USE OF CONSTRUCTION EQUIPMENT OVER SC-740 CHAMBERS IS LIMITED:
   - NO EQUIPMENT IS ALLOWED ON BARE CHAMBERS.
   - NO RUBBER TIRED LOADERS, DUMP TRUCKS, OR EXCAVATORS ARE ALLOWED UNTIL PROPER FILL DEPTHS ARE REACHED IN ACCORDANCE WITH THE "STORMTECH SC-310/SC-740/DC-780 CONSTRUCTION GUIDE".
   - WEIGHT LIMITS FOR CONSTRUCTION EQUIPMENT CAN BE FOUND IN THE "STORMTECH SC-310/SC-740/DC-780 CONSTRUCTION GUIDE".
3. FULL 900 mm (36") OF STABILIZED COVER MATERIALS OVER THE CHAMBERS IS REQUIRED FOR DUMP TRUCK TRAVEL OR DUMPING.

USE OF A DOZER TO PUSH EMBEDMENT STONE BETWEEN THE ROWS OF CHAMBERS MAY CAUSE DAMAGE TO THE CHAMBERS AND IS NOT AN ACCEPTABLE BACKFILL METHOD. ANY CHAMBERS DAMAGED BY THE "DUMP AND PUSH" METHOD ARE NOT COVERED UNDER THE STORMTECH STANDARD WARRANTY.

CONTACT STORMTECH AT 1-888-892-2694 WITH ANY QUESTIONS ON INSTALLATION REQUIREMENTS OR WEIGHT LIMITS FOR CONSTRUCTION EQUIPMENT.

PROPOSED LAYOUT - EAST SYSTEM

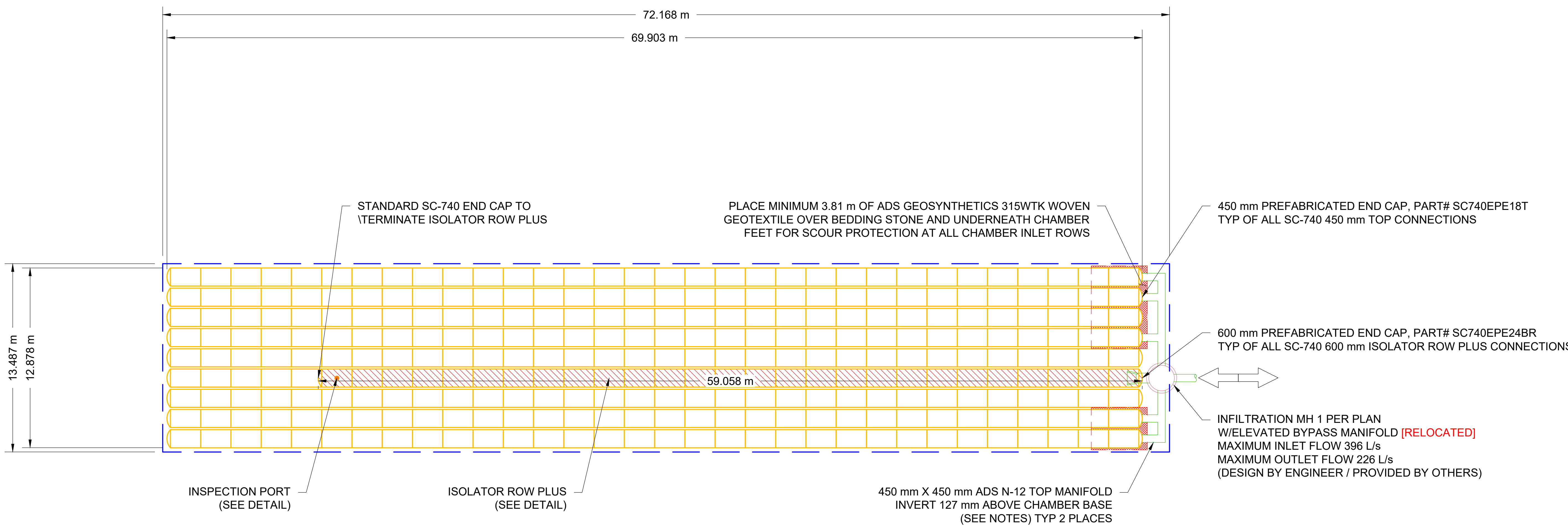
288	STORMTECH SC-740 CHAMBERS
19	STORMTECH SC-740 END CAPS
152	STONE ABOVE (mm)
152	STONE BELOW (mm)
40	% STONE VOID
639.8	**INSTALLED SYSTEM VOLUME (m³) (PERIMETER STONE INCLUDED)**
973.3	SYSTEM AREA (m²)
171.3	SYSTEM PERIMETER (m)

PROPOSED ELEVATIONS - EAST SYSTEM

308.097	MAXIMUM ALLOWABLE GRADE (TOP OF PAVEMENT/UNPAVED):
306.269	MINIMUM ALLOWABLE GRADE (UNPAVED WITH TRAFFIC):
306.116	MINIMUM ALLOWABLE GRADE (UNPAVED NO TRAFFIC):
306.116	MINIMUM ALLOWABLE GRADE (BASE OF FLEXIBLE PAVEMENT):
306.116	MINIMUM ALLOWABLE GRADE (TOP OF RIGID PAVEMENT):
305.811	TOP OF STONE:
305.659	TOP OF SC-740 CHAMBER:
305.025	450 mm TOP MANIFOLD INVERT:
304.900	600 mm ISOLATOR ROW PLUS INVERT:
304.897	BOTTOM OF SC-740 CHAMBER:
304.745	BOTTOM OF STONE:

NOTES

- MANIFOLD SIZE TO BE DETERMINED BY SITE DESIGN ENGINEER. SEE TECHNICAL NOTE 6.32 FOR MANIFOLD SIZING GUIDANCE.
- DUE TO THE ADAPTATION OF THIS CHAMBER SYSTEM TO SPECIFIC SITE AND DESIGN CONSTRAINTS, IT MAY BE NECESSARY TO CUT AND COUPLE ADDITIONAL PIPE TO STANDARD MANIFOLD COMPONENTS IN THE FIELD.
- THE SITE DESIGN ENGINEER MUST REVIEW ELEVATIONS AND IF NECESSARY ADJUST GRADING TO ENSURE THE CHAMBER COVER REQUIREMENTS ARE MET.
- THIS CHAMBER SYSTEM WAS DESIGNED WITHOUT SITE-SPECIFIC INFORMATION ON SOIL CONDITIONS OR BEARING CAPACITY. THE SITE DESIGN ENGINEER IS RESPONSIBLE FOR DETERMINING THE SUITABILITY OF THE SOIL AND PROVIDING THE BEARING CAPACITY OF THE INSITU SOILS. THE BASE STONE DEPTH MAY BE INCREASED OR DECREASED ONCE THIS INFORMATION IS PROVIDED.
- **NOT FOR CONSTRUCTION**: THIS LAYOUT IS FOR DIMENSIONAL PURPOSES ONLY TO PROVE CONCEPT & THE REQUIRED STORAGE VOLUME CAN BE ACHIEVED ON SITE.



90 MAPLEVIEW DR. WEST
BARRIE, ON.

DATE:	09/28/21	DRAWN:	RCT
PROJECT #:	S260345	CHECKED:	RCT

DATE	DRWN	CHKD	DESCRIPTION

StormTech® Chamber System
888-892-2694 | WWW.STORMTECH.COM

ADS
4640 TRUEMAN BLVD
HILLIARD, OH 43026

SCALE = 1 : 300

SHEET 2 OF 6

PROPOSED LAYOUT - WEST SYSTEM

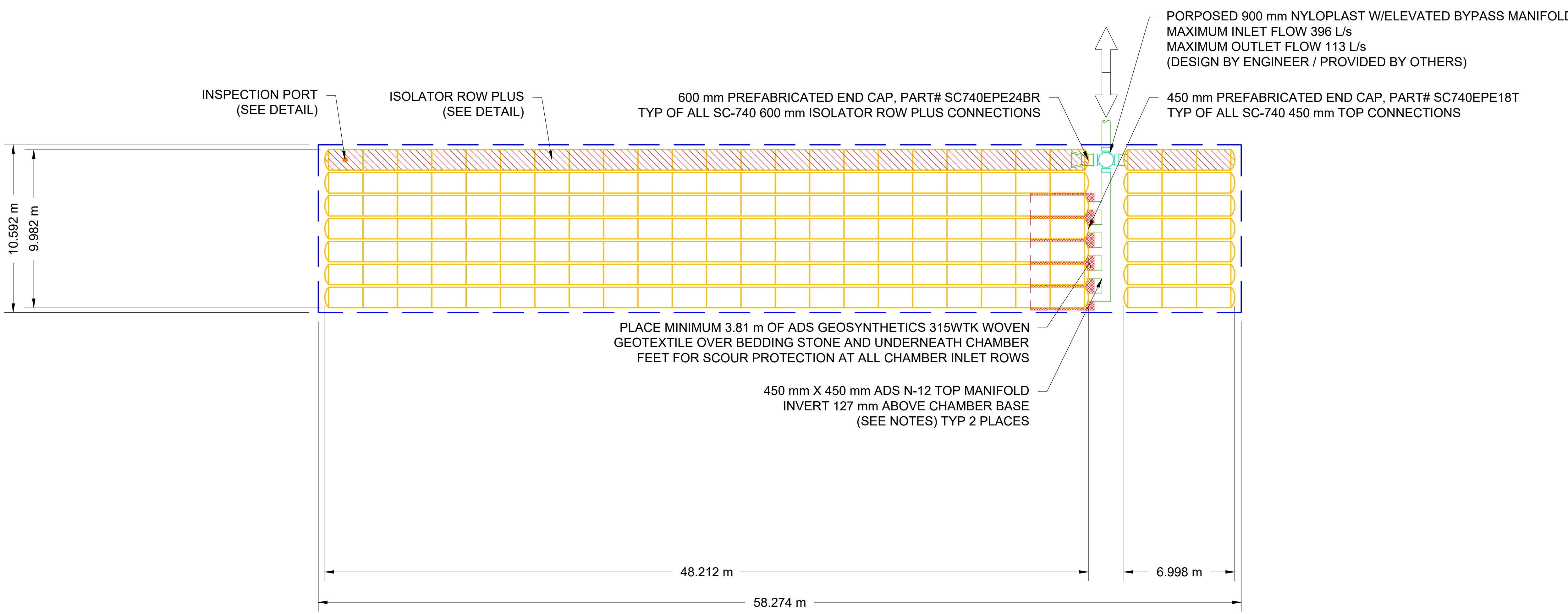
175	STORMTECH SC-740 CHAMBERS
28	STORMTECH SC-740 END CAPS
152	STONE ABOVE (mm)
152	STONE BELOW (mm)
40	% STONE VOID
400.0	**INSTALLED SYSTEM VOLUME (m³) (PERIMETER STONE INCLUDED)**
617.2	SYSTEM AREA (m²)
137.7	SYSTEM PERIMETER (m)

PROPOSED ELEVATIONS - WEST SYSTEM

308.797	MAXIMUM ALLOWABLE GRADE (TOP OF PAVEMENT/UNPAVED):
306.969	MINIMUM ALLOWABLE GRADE (UNPAVED WITH TRAFFIC):
306.816	MINIMUM ALLOWABLE GRADE (UNPAVED NO TRAFFIC):
306.816	MINIMUM ALLOWABLE GRADE (BASE OF FLEXIBLE PAVEMENT):
306.816	MINIMUM ALLOWABLE GRADE (TOP OF RIGID PAVEMENT):
306.511	TOP OF STONE:
306.359	TOP OF SC-740 CHAMBER:
305.725	450 mm TOP MANIFOLD INVERT:
305.600	600 mm ISOLATOR ROW PLUS INVERT:
305.597	BOTTOM OF SC-740 CHAMBER:
305.445	BOTTOM OF STONE:

NOTES

- MANIFOLD SIZE TO BE DETERMINED BY SITE DESIGN ENGINEER. SEE TECHNICAL NOTE 6.32 FOR MANIFOLD SIZING GUIDANCE.
- DUE TO THE ADAPTATION OF THIS CHAMBER SYSTEM TO SPECIFIC SITE AND DESIGN CONSTRAINTS, IT MAY BE NECESSARY TO CUT AND COUPLE ADDITIONAL PIPE TO STANDARD MANIFOLD COMPONENTS IN THE FIELD.
- THE SITE DESIGN ENGINEER MUST REVIEW ELEVATIONS AND IF NECESSARY ADJUST GRADING TO ENSURE THE CHAMBER COVER REQUIREMENTS ARE MET.
- THIS CHAMBER SYSTEM WAS DESIGNED WITHOUT SITE-SPECIFIC INFORMATION ON SOIL CONDITIONS OR BEARING CAPACITY. THE SITE DESIGN ENGINEER IS RESPONSIBLE FOR DETERMINING THE SUITABILITY OF THE SOIL AND PROVIDING THE BEARING CAPACITY OF THE INSITU SOILS. THE BASE STONE DEPTH MAY BE INCREASED OR DECREASED ONCE THIS INFORMATION IS PROVIDED.



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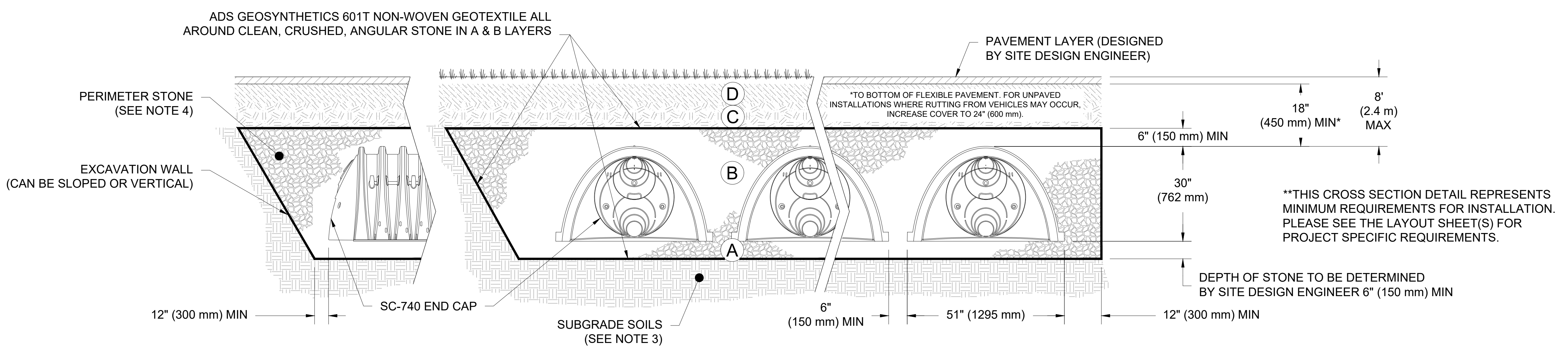
0 1' 2'

ACCEPTABLE FILL MATERIALS: STORMTECH SC-740 CHAMBER SYSTEMS

MATERIAL LOCATION		DESCRIPTION	AASHTO MATERIAL CLASSIFICATIONS	COMPACTION / DENSITY REQUIREMENT
D	**FINAL FILL:** FILL MATERIAL FOR LAYER 'D' STARTS FROM THE TOP OF THE 'C' LAYER TO THE BOTTOM OF FLEXIBLE PAVEMENT OR UNPAVED FINISHED GRADE ABOVE. NOTE THAT PAVEMENT SUBBASE MAY BE PART OF THE 'D' LAYER.	ANY SOIL/ROCK MATERIALS, NATIVE SOILS, OR PER ENGINEER'S PLANS. CHECK PLANS FOR PAVEMENT SUBGRADE REQUIREMENTS.	N/A	PREPARE PER SITE DESIGN ENGINEER'S PLANS. PAVED INSTALLATIONS MAY HAVE STRINGENT MATERIAL AND PREPARATION REQUIREMENTS.
C	**INITIAL FILL:** FILL MATERIAL FOR LAYER 'C' STARTS FROM THE TOP OF THE EMBEDMENT STONE ('B' LAYER) TO 18" (450 mm) ABOVE THE TOP OF THE CHAMBER. NOTE THAT PAVEMENT SUBBASE MAY BE A PART OF THE 'C' LAYER.	GRANULAR WELL-GRADED SOIL/AGGREGATE MIXTURES, <35% FINES OR PROCESSED AGGREGATE. MOST PAVEMENT SUBBASE MATERIALS CAN BE USED IN LIEU OF THIS LAYER.	AASHTO M145[1] A-1, A-2-4, A-3 OR AASHTO M43[1] 3, 357, 4, 467, 5, 56, 57, 6, 67, 68, 7, 78, 8, 89, 9, 10	BEGIN COMPACTIONS AFTER 12" (300 mm) OF MATERIAL OVER THE CHAMBERS IS REACHED. COMPACT ADDITIONAL LAYERS IN 6" (150 mm) MAX LIFTS TO A MIN. 95% PROCTOR DENSITY FOR WELL GRADED MATERIAL AND 95% RELATIVE DENSITY FOR PROCESSED AGGREGATE MATERIALS. ROLLER GROSS VEHICLE WEIGHT NOT TO EXCEED 12,000 lbs (53 kN). DYNAMIC FORCE NOT TO EXCEED 20,000 lbs (89 kN).
B	**EMBEDMENT STONE:** FILL SURROUNDING THE CHAMBERS FROM THE FOUNDATION STONE ('A' LAYER) TO THE 'C' LAYER ABOVE.	CLEAN, CRUSHED, ANGULAR STONE	AASHTO M43[1] 3, 357, 4, 467, 5, 56, 57	NO COMPACTION REQUIRED.
A	**FOUNDATION STONE:** FILL BELOW CHAMBERS FROM THE SUBGRADE UP TO THE FOOT (BOTTOM) OF THE CHAMBER.	CLEAN, CRUSHED, ANGULAR STONE	AASHTO M43[1] 3, 357, 4, 467, 5, 56, 57	PLATE COMPACT OR ROLL TO ACHIEVE A FLAT SURFACE.[2,3]

PLEASE NOTE:
1. THE LISTED AASHTO DESIGNATIONS ARE FOR GRADATIONS ONLY. THE STONE MUST ALSO BE CLEAN, CRUSHED, ANGULAR. FOR EXAMPLE, A SPECIFICATION FOR #4 STONE WOULD STATE: "CLEAN, CRUSHED, ANGULAR NO. 4 (AASHTO M43) STONE".
2. STORMTECH COMPACTION REQUIREMENTS ARE MET FOR 'A' LOCATION MATERIALS WHEN PLACED AND COMPACTED IN 6" (150 mm) (MAX) LIFTS USING TWO FULL COVERAGES WITH A VIBRATORY COMPACTOR.
3. WHERE INFILTRATION SURFACES MAY BE COMPROMISED BY COMPACTION, FOR STANDARD DESIGN LOAD CONDITIONS, A FLAT SURFACE MAY BE ACHIEVED BY RAKING OR DRAGGING WITHOUT COMPACTION EQUIPMENT. FOR SPECIAL LOAD DESIGNS, CONTACT STORMTECH FOR COMPACTION REQUIREMENTS.
4. ONCE LAYER 'C' IS PLACED, ANY SOIL/MATERIAL CAN BE PLACED IN LAYER 'D' UP TO THE FINISHED GRADE. MOST PAVEMENT SUBBASE SOILS CAN BE USED TO REPLACE THE MATERIAL REQUIREMENTS OF LAYER 'C' OR 'D' AT THE SITE DESIGN ENGINEER'S DISCRETION.



NOTES:

1. CHAMBERS SHALL MEET THE REQUIREMENTS OF ASTM F2418, "STANDARD SPECIFICATION FOR POLYPROPYLENE (PP) CORRUGATED WALL STORMWATER COLLECTION CHAMBERS".
2. SC-740 CHAMBERS SHALL BE DESIGNED IN ACCORDANCE WITH ASTM F2787 "STANDARD PRACTICE FOR STRUCTURAL DESIGN OF THERMOPLASTIC CORRUGATED WALL STORMWATER COLLECTION CHAMBERS".
3. THE SITE DESIGN ENGINEER IS RESPONSIBLE FOR ASSESSING THE BEARING RESISTANCE (ALLOWABLE BEARING CAPACITY) OF THE SUBGRADE SOILS AND THE DEPTH OF FOUNDATION STONE WITH CONSIDERATION FOR THE RANGE OF EXPECTED SOIL MOISTURE CONDITIONS.
4. PERIMETER STONE MUST BE EXTENDED HORIZONTALLY TO THE EXCAVATION WALL FOR BOTH VERTICAL AND SLOPED EXCAVATION WALLS.
5. REQUIREMENTS FOR HANDLING AND INSTALLATION:
   - TO MAINTAIN THE WIDTH OF CHAMBERS DURING SHIPPING AND HANDLING, CHAMBERS SHALL HAVE INTEGRAL, INTERLOCKING STACKING LUGS.
   - TO ENSURE A SECURE JOINT DURING INSTALLATION AND BACKFILL, THE HEIGHT OF THE CHAMBER JOINT SHALL NOT BE LESS THAN 2".
   - TO ENSURE THE INTEGRITY OF THE ARCH SHAPE DURING INSTALLATION, a) THE ARCH STIFFNESS CONSTANT AS DEFINED IN SECTION 6.2.8 OF ASTM F2418 SHALL BE GREATER THAN OR EQUAL TO 550 LBS/IN/IN. AND b) TO RESIST CHAMBER DEFORMATION DURING INSTALLATION AT ELEVATED TEMPERATURES (ABOVE 73° F / 23° C), CHAMBERS SHALL BE PRODUCED FROM REFLECTIVE GOLD OR YELLOW COLORS.

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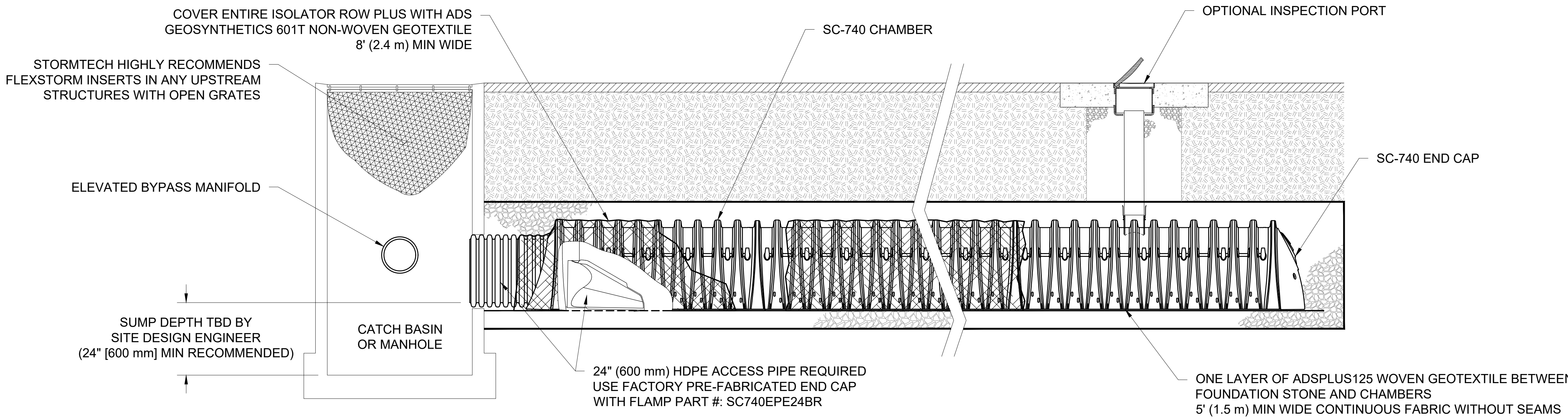


SC-740 ISOLATOR ROW PLUS DETAIL

NTS

INSPECTION & MAINTENANCE

STEP 1) INSPECT ISOLATOR ROW PLUS FOR SEDIMENT
- A. INSPECTION PORTS (IF PRESENT)
  - A.1. REMOVE/OPEN LID ON NYLOPLAST INLINE DRAIN
  - A.2. REMOVE AND CLEAN FLEXSTORM FILTER IF INSTALLED
  - A.3. USING A FLASHLIGHT AND STADIA ROD, MEASURE DEPTH OF SEDIMENT AND RECORD ON MAINTENANCE LOG
  - A.4. LOWER A CAMERA INTO ISOLATOR ROW PLUS FOR VISUAL INSPECTION OF SEDIMENT LEVELS (OPTIONAL)
  - A.5. IF SEDIMENT IS AT, OR ABOVE, 3" (80 mm) PROCEED TO STEP 2. IF NOT, PROCEED TO STEP 3.
- B. ALL ISOLATOR PLUS ROWS
  - B.1. REMOVE COVER FROM STRUCTURE AT UPSTREAM END OF ISOLATOR ROW PLUS
  - B.2. USING A FLASHLIGHT, INSPECT DOWN THE ISOLATOR ROW PLUS THROUGH OUTLET PIPE
    - i) MIRRORS ON POLES OR CAMERAS MAY BE USED TO AVOID A CONFINED SPACE ENTRY
    - ii) FOLLOW OSHA REGULATIONS FOR CONFINED SPACE ENTRY IF ENTERING MANHOLE
  - B.3. IF SEDIMENT IS AT, OR ABOVE, 3" (80 mm) PROCEED TO STEP 2. IF NOT, PROCEED TO STEP 3.

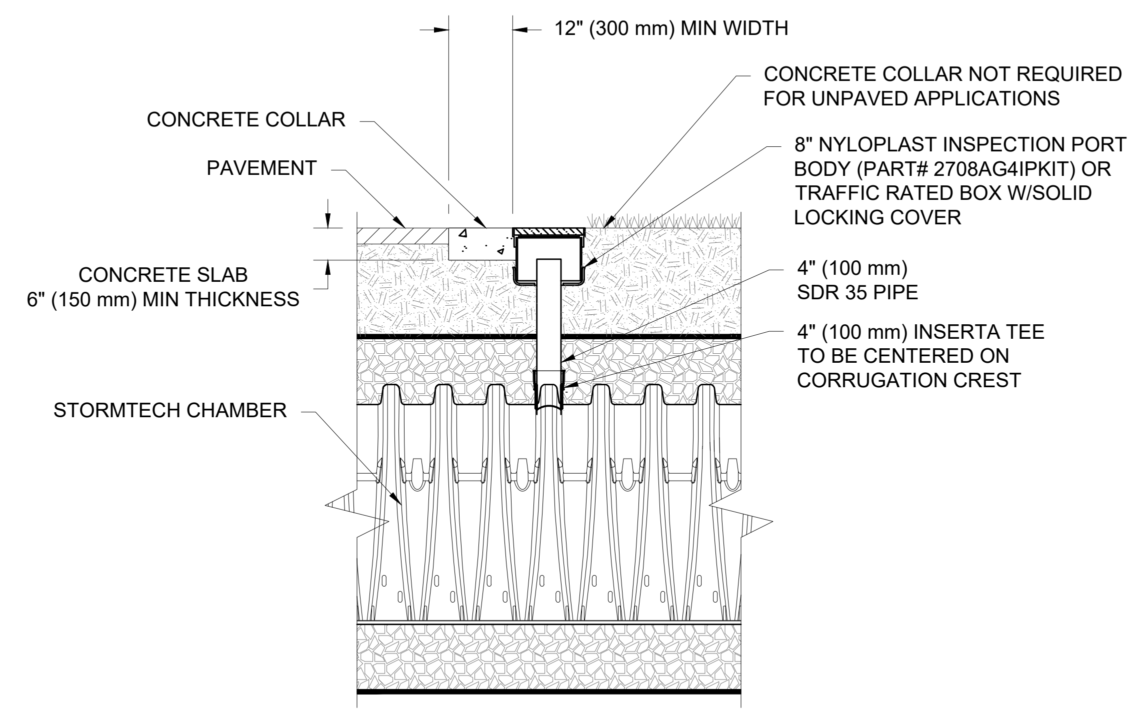
STEP 2) CLEAN OUT ISOLATOR ROW PLUS USING THE JETVAC PROCESS
- A. A FIXED CULVERT CLEANING NOZZLE WITH REAR FACING SPREAD OF 45" (1.1 m) OR MORE IS PREFERRED
- B. APPLY MULTIPLE PASSES OF JETVAC UNTIL BACKFLUSH WATER IS CLEAN
- C. VACUUM STRUCTURE SUMP AS REQUIRED

STEP 3) REPLACE ALL COVERS, GRATES, FILTERS, AND LIDS; RECORD OBSERVATIONS AND ACTIONS.

STEP 4) INSPECT AND CLEAN BASINS AND MANHOLES UPSTREAM OF THE STORMTECH SYSTEM.

NOTES

1. INSPECT EVERY 6 MONTHS DURING THE FIRST YEAR OF OPERATION. ADJUST THE INSPECTION INTERVAL BASED ON PREVIOUS OBSERVATIONS OF SEDIMENT ACCUMULATION AND HIGH WATER ELEVATIONS.
2. CONDUCT JETTING AND VACTORING ANNUALLY OR WHEN INSPECTION SHOWS THAT MAINTENANCE IS NECESSARY.



NOTE:
INSPECTION PORTS MAY BE CONNECTED THROUGH ANY CHAMBER CORRUGATION CREST.

4" PVC INSPECTION PORT DETAIL
(SC SERIES CHAMBER)

NTS

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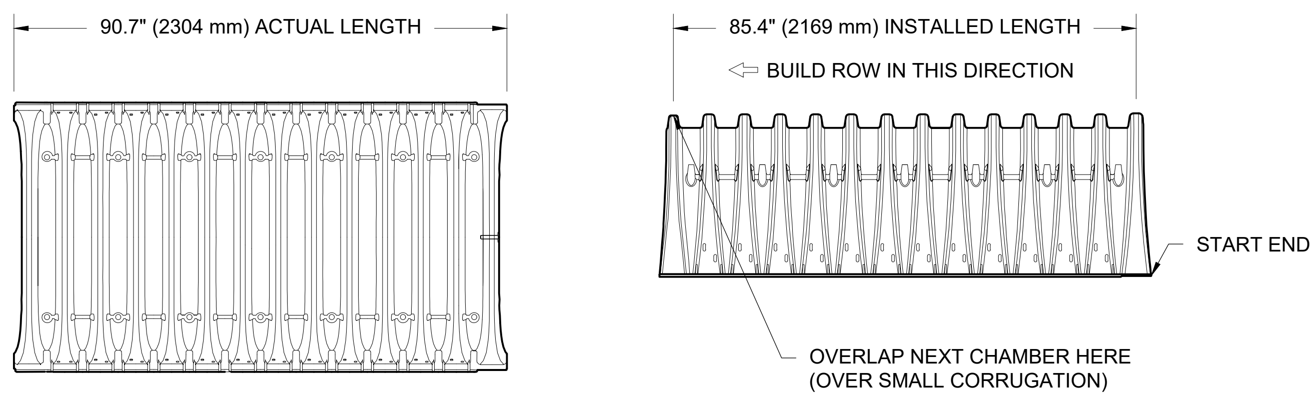
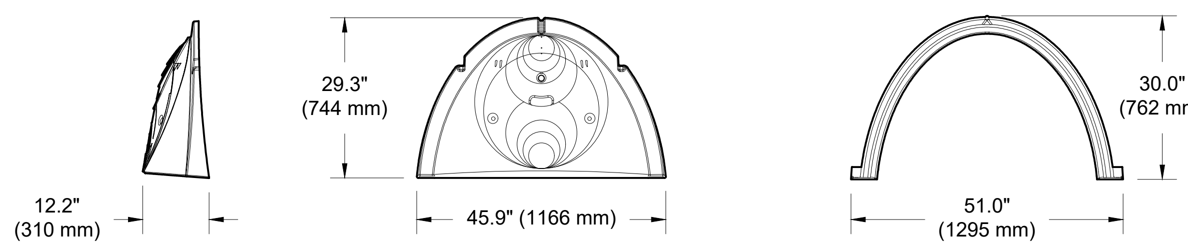
SC-740 TECHNICAL SPECIFICATION

NTS

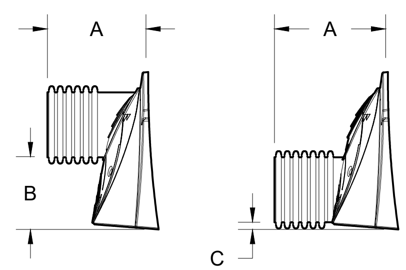




NOMINAL CHAMBER SPECIFICATIONS

SIZE (W X H X INSTALLED LENGTH)	51.0" X 30.0" X 85.4"	(1295 mm X 762 mm X 2169 mm)
CHAMBER STORAGE	45.9 CUBIC FEET	(1.30 m³)
MINIMUM INSTALLED STORAGE*	74.9 CUBIC FEET	(2.12 m³)
WEIGHT	75.0 lbs.	(33.6 kg)

*ASSUMES 6" (152 mm) STONE ABOVE, BELOW, AND BETWEEN CHAMBERS



PRE-FAB STUB AT BOTTOM OF END CAP WITH FLAMP END WITH "BR"
PRE-FAB STUBS AT BOTTOM OF END CAP FOR PART NUMBERS ENDING WITH "B"
PRE-FAB STUBS AT TOP OF END CAP FOR PART NUMBERS ENDING WITH "T"
PRE-CORED END CAPS END WITH "PC"

PART #	STUB	A	B	C
SC740EPE06T / SC740EPE06TPC	6" (150 mm)	10.9" (277 mm)	18.5" (470 mm)	---
SC740EPE06B / SC740EPE06BPC			---	0.5" (13 mm)
SC740EPE08T /SC740EPE08TPC	8" (200 mm)	12.2" (310 mm)	16.5" (419 mm)	---
SC740EPE08B / SC740EPE08BPC			---	0.6" (15 mm)
SC740EPE10T / SC740EPE10TPC	10" (250 mm)	13.4" (340 mm)	14.5" (368 mm)	---
SC740EPE10B / SC740EPE10BPC			---	0.7" (18 mm)
SC740EPE12T / SC740EPE12TPC	12" (300 mm)	14.7" (373 mm)	12.5" (318 mm)	---
SC740EPE12B / SC740EPE12BPC			---	1.2" (30 mm)
SC740EPE15T / SC740EPE15TPC	15" (375 mm)	18.4" (467 mm)	9.0" (229 mm)	---
SC740EPE15B / SC740EPE15BPC			---	1.3" (33 mm)
SC740EPE18T / SC740EPE18TPC	18" (450 mm)	19.7" (500 mm)	5.0" (127 mm)	---
SC740EPE18B / SC740EPE18BPC			---	1.6" (41 mm)
SC740EPE24B*	24" (600 mm)	18.5" (470 mm)	---	0.1" (3 mm)
SC740EPE24BR*	24" (600 mm)	18.5" (470 mm)	---	0.1" (3 mm)

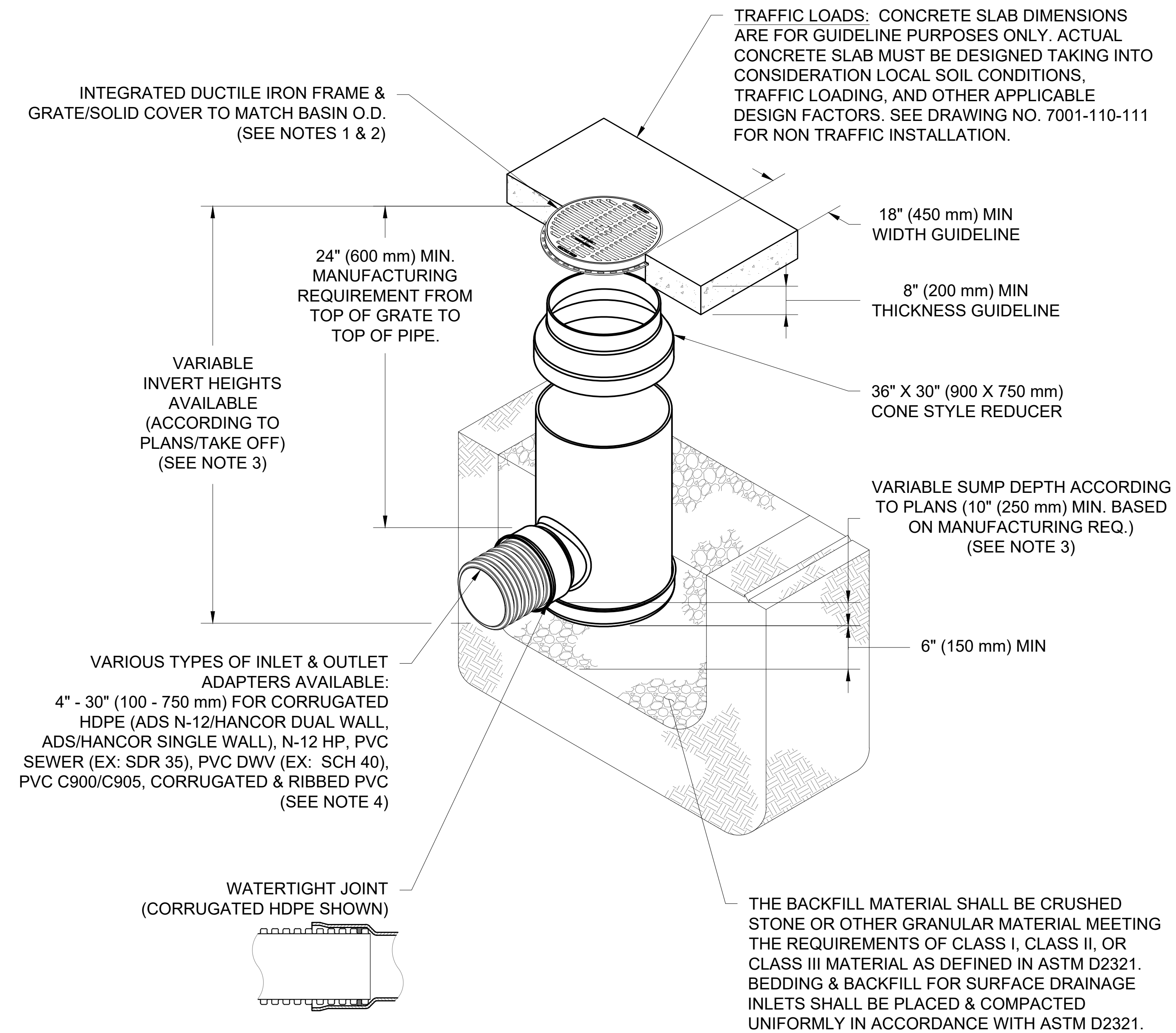
ALL STUBS, EXCEPT FOR THE SC740EPE24B/SC740EPE24BR ARE PLACED AT BOTTOM OF END CAP SUCH THAT THE OUTSIDE DIAMETER OF THE STUB IS FLUSH WITH THE BOTTOM OF THE END CAP. FOR ADDITIONAL INFORMATION CONTACT STORMTECH AT 1-888-892-2694.

* FOR THE SC740EPE24B/SC740EPE24BR THE 24" (600 mm) STUB LIES BELOW THE BOTTOM OF THE END CAP APPROXIMATELY 1.75" (44 mm). BACKFILL MATERIAL SHOULD BE REMOVED FROM BELOW THE N-12 STUB SO THAT THE FITTING SITS LEVEL.

NOTE: ALL DIMENSIONS ARE NOMINAL

36" (900 mm) NYLOPLAST DRAIN BASIN

NTS



NOTES

1. GRATES/SOLID COVER SHALL BE DUCTILE IRON PER ASTM A536 GRADE 70-50-05.
2. FRAMES SHALL BE DUCTILE IRON PER ASTM A536 GRADE 70-50-05.
3. DRAIN BASIN TO BE CUSTOM MANUFACTURED ACCORDING TO PLAN DETAILS. RISERS ARE NEEDED FOR BASINS OVER 84" (2.13 m) DUE TO SHIPPING RESTRICTIONS. SEE DRAWING NO. 7001-110-065.
4. DRAINAGE CONNECTION STUB JOINT TIGHTNESS SHALL CONFORM TO ASTM D3212 FOR CORRUGATED HDPE (ADS N-12/HANCOR DUAL WALL), N-12 HP, & PVC SEWER.
5. ADAPTERS CAN BE MOUNTED ON ANY ANGLE 0° TO 360°. TO DETERMINE MINIMUM ANGLE BETWEEN ADAPTERS SEE DRAWING NO. 7001-110-012.

GRATE OPTION	LOAD RATING	PART #	DWG #
PEDESTRIAN	MEETS H-20	3099CGP	7001-110-220
STANDARD	MEETS H-20	3099CGS	7001-110-221
SOLID COVER	MEETS H-20	3099CGC	7001-110-222
DOME	N/A	3099CGD	7001-110-223

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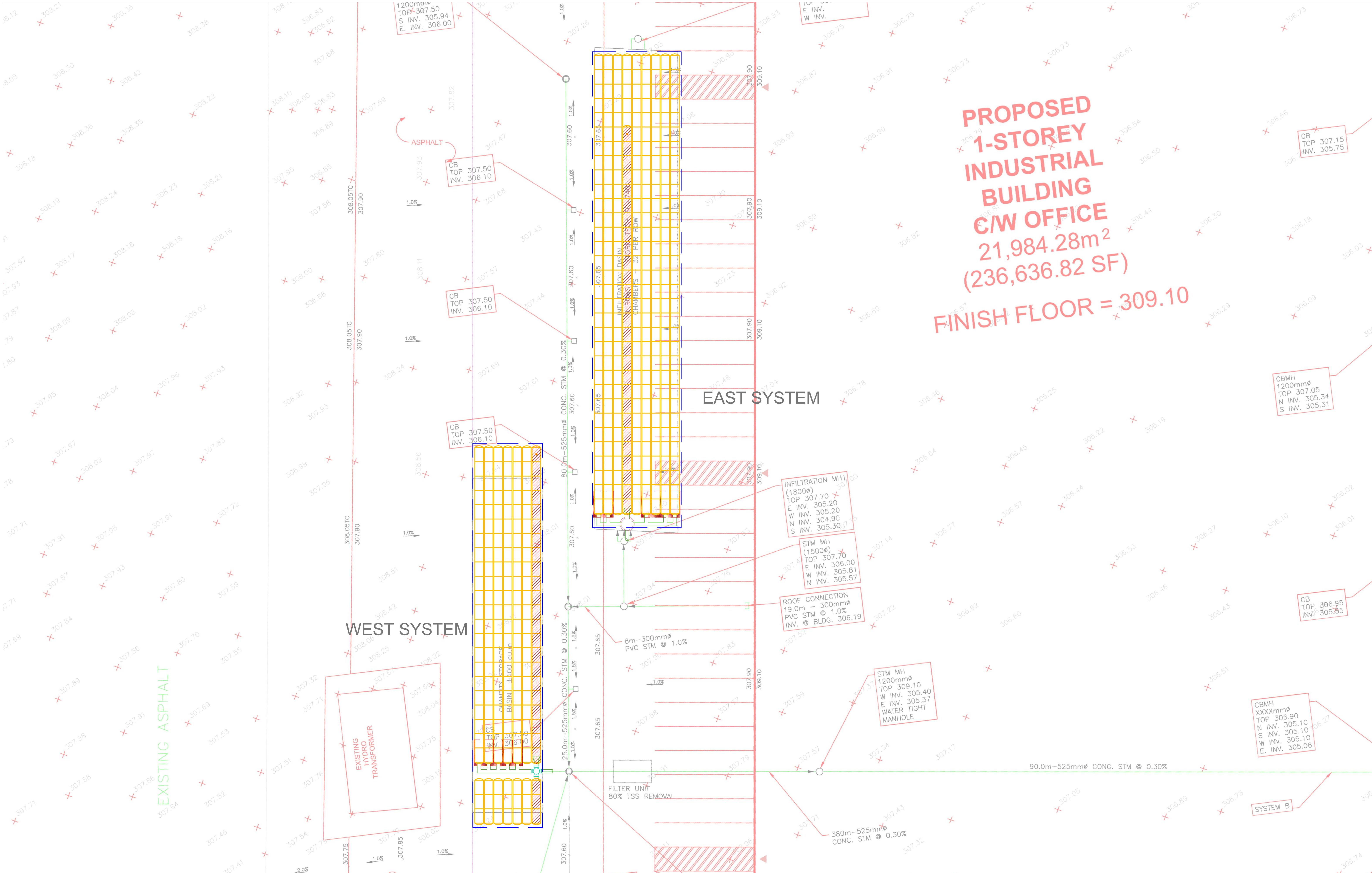
PROPOSED
1-STOREY
INDUSTRIAL
BUILDING
C/W OFFICE
21,984.28m²
(236,636.82 SF)
FINISH FLOOR = 309.10
EAST SYSTEM
WEST SYSTEM
EXISTING ASPHALT
EXISTING HYDRO TRANSFORMER
ASPHALT
INFILTRATION BASIN
QUANTITY STORAGE BASIN
CB TOP 307.50 INV. 306.10
CB TOP 307.15 INV. 305.75
CB TOP 306.95 INV. 305.55
CBMH 1200mmø TOP 307.05 N INV. 305.34 S INV. 305.31
INFILTRATION MH1 (1800ø) TOP 307.70 E INV. 305.20 W INV. 305.20 N INV. 304.90 S INV. 305.30
STM MH (1500ø) TOP 307.70 E INV. 306.00 W INV. 305.81 N INV. 305.57
ROOF CONNECTION 19.0m – 300mmø PVC STM @ 1.0% INV. @ BLDG. 306.19
8m–300mmø PVC STM @ 1.0%
STM MH 1200mmø TOP 309.10 W INV. 305.40 E INV. 305.37 WATER TIGHT MANHOLE
CBMH XXXXmmø TOP 306.90 N INV. 305.10 S INV. 305.10 W INV. 305.10 E. INV. 305.06
90.0m–525mmø CONC. STM @ 0.30%
80.0m–525mmø CONC. STM @ 0.30%
25.0m–525mmø CONC. STM @ 0.30%
380m–525mmø CONC. STM @ 0.30%
FILTER UNIT 80% TSS REMOVAL
SYSTEM B
1200mmø TOP 307.50 S INV. 305.94 E. INV. 306.00

URBAN ECOSYSTEMS LIMITED
7050 WESTON ROAD, SUITE 705
WOODBRIDGE, ONTARIO L4L 8G7
uel@urbanecosystems.com
t (905)856-0629
f (905)856-0698

APPENDIX No 5

GEOTECHNICAL REPORT

Soil Engineers Ltd.
CONSULTING ENGINEERS
GEOTECHNICAL • ENVIRONMENTAL • HYDROGEOLOGICAL • BUILDING SCIENCE
90 WEST BEAVER CREEK ROAD, SUITE 100, RICHMOND HILL, ONTARIO L4B 1E7 · TEL: (416) 754-8515 · FAX: (905) 881-8335

BARRIE	MISSISSAUGA	OSHAWA	NEWMARKET	GRAVENHURST	HAMILTON
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FAX: (705) 721-7864	FAX: (905) 542-2769	FAX: (905) 725-1315	FAX: (905) 881-8335	FAX: (705) 684-8522	FAX: (905) 542-2769

A REPORT TO
A.R.G. GROUP INC.

A GEOTECHNICAL INVESTIGATION FOR PROPOSED INDUSTRIAL DEVELOPMENT

90 MAPLEVIEW DRIVE WEST

CITY OF BARRIE

REFERENCE NO. 2109-S054

DECEMBER 2021

DISTRIBUTION

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1 Copy - Soil Engineers Ltd. (Richmond Hill)

TABLE OF CONTENTS

TABLES

DIAGRAM

ENCLOSURES

1.0 INTRODUCTION

In accordance with the authorization from Mr. Neil Palmer of A.R.G. Group Inc., dated September 2, 2021, a geotechnical investigation was conducted at 90 Mapleview Drive West, in the City of Barrie.

The purpose of the investigation was to reveal the subsurface conditions and determine the engineering properties of the disclosed soils for the design and construction of an industrial building. The geotechnical findings and resulting recommendations are presented in this Report.

2.0 SITE AND PROJECT DESCRIPTION

The City of Barrie is located within the periphery of Lake Simcoe basin where the glacial till has been partly eroded, in places, by glacial Lake Algonquin and filled with glaciolacustrine sand, silt, clay and reworked till.

The subject site is rectangular in shape, having an approximate area of 42 hectares, fronting Mapleview Drive West, approximately 300 m east of Veterans Drive, in the City of Barrie. It is a vacant field, covered with grass, weeds, and with trees in places. The ground is relatively flat and it drops slightly towards to the northeast.

Based on a site plan prepared by Nestico Architect Inc. dated July 16, 2021, a single-storey industrial building, occupying an area of 21,984.28 m^2, is proposed at the site, with loading bays, local driveway and on-grade parking.

3.0 FIELD WORK

The field work, consisting of thirteen (13) sampled boreholes extending to a depth of 3.5 to 6.6 m, was performed between November 4 and 8, 2021, at the locations shown on the Borehole Location Plan, Drawing No. 1.

The boreholes were advanced at intervals to the sampling depths by a track-mounted, continuous-flight power-auger machine equipped for soil sampling. Standard Penetration Tests, using the procedures described on the enclosed “List of Abbreviations and Terms”, were performed at the sampling depths. The results are recorded as the Standard Penetration Resistance (or ‘N’ values) of the subsoil. The relative density of the non-cohesive strata and the consistency of the cohesive strata are inferred from the ‘N’ values. Split-spoon samples were recovered for soil classification and laboratory testing.

The ground elevation at each borehole location was obtained using a hand-held Global Navigation Satellite System (GNSS) equipment.

4.0 SUBSURFACE CONDITIONS

The site is a vacant lot with grass and weed cover. The investigation has disclosed that beneath the topsoil and a layer of earth fill, the site is underlain by silty sand till and sand deposits.

Detailed descriptions of the subsurface conditions are presented on the Borehole Logs, comprising Figures 1 to 13, inclusive. The revealed stratigraphy is plotted on the Subsurface Profile, Drawing Nos. 2 and 3. The engineering properties of the disclosed soils are discussed herein.

4.1 **Topsoil** (All Boreholes)

Topsoil, approximately 20 cm to 36 cm in thickness, was encountered at the ground surface. Thicker topsoil layers may be encountered in other areas beyond the borehole locations, particularly in low lying or treed areas.

4.2 **Earth Fill** (All Boreholes)

A layer of earth fill, consisting of sand, silt and clay, with topsoil and organic inclusions, was contacted beneath the topsoil. It extends to a depth of 0.7 m to 1.4 m from the prevailing ground surface.

The obtained 'N' values range from 3 to 10 blows per 30 cm of penetration, indicating the fill is non-uniform in compaction and without quality control. Hence, it is unsuitable for supporting any structure sensitive to ground movement.

One must be aware that the samples retrieved from the boreholes may not be truly representative of the geotechnical quality of the earth fill, and do not indicate whether topsoil beneath the earth fill was completely stripped before placement. This should be further assessed by test pits.

4.3 **Silty Sand Till** (All Boreholes)

Below the topsoil and earth fill layers, a native silty sand till was contacted in the boreholes. It consists of a random mixture of soils; the particle sizes ranging from clay to gravel, with the sand and silt fraction exerting the dominant influence on the soil properties. Sample examinations disclosed that the till is slightly cemented and displays some cohesion when remoulded. Intermittent hard resistance to augering was encountered, indicating the presence of cobbles and boulders in the till deposit. Grain size analyses were performed on two representative samples; the results are plotted on Figure 14.

The obtained 'N' values range from 18 to over 100, with a median of 47 blows per 30 cm of penetration, indicating the till deposit is compact to very dense in relative density, generally in a dense condition.

The natural water content values of the glacial till samples range from 1% to 13%, with a median of 8%, indicating damp to moist conditions.

The engineering properties of the silty sand till are listed below:

- Moderately high frost susceptibility and low water erodibility.
- Semi-pervious to relatively low permeability, with an estimated coefficient of permeability of 10^{-4} to 10^{-5} cm/sec and a percolation time of 12 to 20 min/cm.
- The till will be stable in relatively steep slope excavation; however, the sand till deposit may slough under prolonged exposure.
- Moderate corrosivity to buried metal, with an estimated electrical resistivity of 4500 ohm·cm.

4.4 **Sand** (Boreholes 2, 3, 5, 6, 7, 8 and 10) and **Silty Sand** (Boreholes 1, 4, 5, 6 and 7)

The sand deposit was generally contacted below the till stratum with an exception in Borehole 2. It is fine grained with silt seams and gravel. Silty sand deposit is only contacted at the lower stratigraphy. Grain size analyses were performed on two sand samples; the results are plotted on Figure 15.

The obtained 'N' values range from 20 to over 100, with a median of 56 blows per 30 cm of penetration, indicating the relative density of the sand and silty sand deposit is compact to very dense, generally in a very dense condition. The relatively low 'N' value in Borehole 2 is excluded since the soil sample is likely be disturbed or weathered near the ground surface.

The natural water content values range from 1% and 24%, with a median of 7%, indicating moist to wet conditions. Saturated sand was evident in the lower stratum.

The engineering properties of the sand and silty sand deposits are given below:

- High water erodibility.
- Pervious, with an estimated coefficient of permeability of 10^{-2} to 10^{-3} cm/sec and a percolation time between 4 min/cm and 8 min/cm.
- The shear strength is primarily derived from internal friction and is density dependent.
- In excavation, the sand will slough and run with water seepage. It will boil with a piezometric head of 0.3 m.
- Fair to good pavement-supportive material, with an estimated CBR value above 10%.
- Moderately low corrosivity to buried metal, with an estimated electrical resistivity of 5500 ohm·cm.

5.0 GROUNDWATER CONDITION

The boreholes were checked for the presence of groundwater upon completion of drilling. Free groundwater was contacted in six of thirteen boreholes at depths from 4.9 to 5.8 m below grade, or El. 301.1 to 301.8 m. The findings are summarized in Table 1.

Table 1 - Groundwater Level upon Completion of Drilling

Borehole	Ground Elevation (m)	Recorded Groundwater Level	
		Depth (m)	Elevation (m)
1	306.9	5.8	301.1
2	306.7	5.5	301.2
3	306.1	4.9	301.2
4	307.6	5.8	301.8
5	306.6	5.5	301.1
8	307.0	5.8	301.2

The recorded groundwater level generally represents a continuous groundwater condition within the subject site and is subject to seasonal fluctuation.

6.0 DISCUSSION AND RECOMMENDATIONS

The site is a vacant lot with grass and weed cover. The investigation has disclosed that beneath the topsoil and a layer of earth fill, the site is underlain by silty sand till and sand deposits.

Free groundwater was contacted in six of thirteen boreholes at depths from 4.9 to 5.8 m below grade, or El. 301.1 to 301.8 m. The recorded groundwater level generally represents a continuous groundwater condition within the subject site and is subject to seasonal fluctuation.

Based on a site plan prepared by Nestico Architect Inc. dated July 16, 2021, a single-storey industrial building, occupying an area of 21,984.28 m^2, is proposed at the site, with loading bays, local driveway and on-grade parking. The geotechnical findings warranting special consideration for the proposed project are presented below:

1. After removal of topsoil and vegetation, the site can be re-graded for development. The topsoil can only be reused for landscape purpose. Any surplus must be removed off site.
2. Due to the presence of topsoil and organics within the earth fill, it cannot be used to support any structure sensitive to ground movement at its current state. It should be subexcavated, sorted free of topsoil and organics prior to be reused for structural backfill.
3. Where additional earth filling is required for site grading, it is economical to place an engineered fill for building, pavement and service construction.
4. The proposed building can be constructed on conventional footings founded on sound native soil or engineered fill.
5. A Class 'B' bedding, consisting of compacted 19-mm Crusher-Run Limestone (CRL), or equivalent, is recommended for the construction of underground services.

The recommendations appropriate for the project described in Section 2.0 are presented herein. One must be aware that the subsurface conditions may vary between boreholes. Should subsurface variances become apparent during construction, a geotechnical engineer must be consulted to determine whether the following recommendations require revision.

6.1 Site Preparation

Topsoil and vegetation should be removed for site development. The topsoil can only be reused for landscape purpose. Any surplus must be removed off site.

Due to the presence of topsoil and organics within the earth fill, it cannot be used to support any structure sensitive to ground movement at its current state. It should be subexcavated, sorted free of topsoil and organics prior to be reused for structural backfill. This should be further assessed to determine its suitability from test pits.

Where additional earth filling is required for site grading, it is economical to place an engineered fill for building, pavement and service construction. The requirements for engineered fill are presented below:

1. The excavation and fill operation must be fully supervised and monitored by a geotechnical technician, under the direction of a geotechnical engineer.
2. The vegetation and topsoil must be removed for site development. Any existing earth fill or weathered soil must be subexcavated, sorted free of topsoil and organics, aerated and properly compacted in layers.
3. Inorganic soils must be used for backfilling, and they must be uniformly compacted in lifts of 20 cm thick to 98% Standard Proctor dry density (SPDD) up to the proposed finished grade. If the building foundations are to be built soon after the fill placement, the densification process for the engineered fill must be increased to 100% SPDD.
4. If imported fill is to be used, it should be inorganic soils, free of deleterious or any material with environmental issue (contamination). Any potential imported earth fill from off site must be reviewed for geotechnical and environmental quality by the appropriate personnel as authorized by the developer or agency, before being hauled to the site.
5. Where the fill is to be placed on a bank steeper than 1 vertical:3 horizontal, the face of the bank must be benched or flattened so that it is suitable for safe operation of the compactor and the required compaction can be obtained.
6. Where the ground is wet, an appropriate drainage scheme must be implemented prior to the fill placement.
7. The engineered fill must not be placed during the period from late November to early April when freezing ambient temperatures occur either persistently or intermittently. This is to ensure that the fill is free of frozen soils, ice and snow.
8. If the engineered fill is to be left over the winter months, adequate earth cover or equivalent must be provided for protection against frost action.
9. The engineered fill must extend over the entire graded area; the engineered fill envelope and finished elevations must be clearly and accurately defined in the field, and must be precisely documented by qualified surveyors.
10. The footing subgrade must be inspected by the geotechnical consulting firm that supervised the engineered fill placement. This is to ensure that the foundations are placed within the engineered fill envelope, and the integrity of the fill has not been compromised by interim construction, environmental degradation and/or disturbance by the footing excavation.
11. Any excavation carried out in certified engineered fill must be reported to the geotechnical consultant who supervised the fill placement in order to document the locations of excavation and/or to supervise reinstatement of the excavated areas to engineered fill status. If construction on the engineered fill does not commence within a period of 2 years from the date of certification, the condition of the engineered fill must be assessed for re-certification.
12. Despite stringent control in the placement of the engineered fill, variations in soil type and density may occur in the engineered fill. Building foundations founded on engineered fill

must be reinforced by at least two 20-mm steel reinforcing bars in the footings and upper section of the foundation walls, or be designed by a structural engineer to distribute the stress induced by the potential abrupt differential settlement.

6.2 **Foundation**

The proposed building can be supported on conventional footings founded on sound native soil or engineered fill. The recommended soil bearing pressures for the design of conventional footings are presented below:

- Maximum Soil Bearing Pressure at Serviceability Limit State (SLS) = 150 kPa
- Factored Ultimate Bearing Pressure at Ultimate Limit State (ULS) = 250 kPa

Alternatively, drilled concrete piers (caissons) can be constructed for the interior columns. The caissons should be at least 0.8 m in diameter, extending into the dense to very dense stratum below the depth of 2.5 m from the prevailing ground surface. The recommended end bearing pressures for the design of caissons are presented below:

- Maximum End Bearing Pressure at SLS = 500 kPa
- Factored Ultimate Bearing Pressure at ULS = 800 kPa

The minimum spacing between caissons must be at least three times the diameter of the largest adjacent caisson base.

The total and differential settlements of structures designing for the bearing pressures at SLS are estimated within 25 mm and 20 mm, respectively.

The foundation subgrade should be inspected by the geotechnical engineer to ensure that the revealed conditions are compatible with the design requirements.

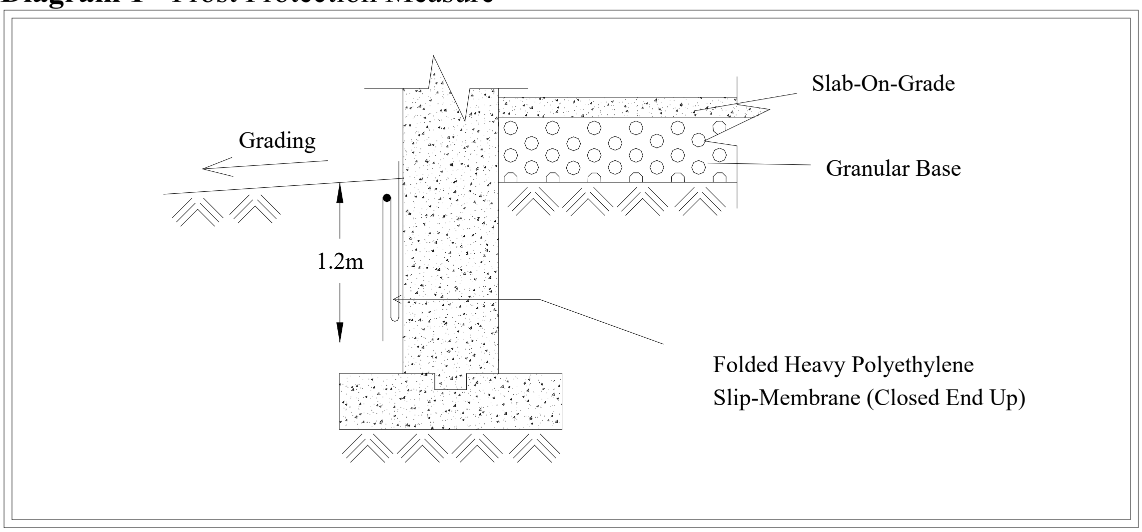
Foundation subsoil exposed to weathering or in unheated areas should have at least 1.5 m of earth cover for protection against frost action.

If groundwater seepage is encountered in excavation, the foundation must be poured immediately after subgrade inspection or the subgrade should be protected by a concrete mud-slab immediately after exposure. This will prevent construction disturbance and costly rectification of the bearing subsoil.

The building foundations should meet the requirements specified in the latest Ontario Building Code and the structures should be designed to resist an earthquake force using Site Classification 'D' (stiff soil).

The on-site material has moderately high soil adfreezing potential. Where on-site material is to be used for foundation wall backfill, the foundation wall must be constructed of concrete and shielded with multi polyethylene slip membrane extending below the frost depth to alleviate the risk of frost damage. Alternatively, the foundation wall backfill should consist of non-frost susceptible granular material. The recommended measure is presented on Diagram 1.

Diagram 1 - Frost Protection Measure



6.3 Slab-On-Grade Construction

The building floor can be constructed on sound native soil or properly compacted inorganic earth fill.

The final subgrade should be inspected and assessed by proof-rolling. Any soft spots as identified should be subexcavated and replaced with selected material, free of organics, compacted to 98% SPDD in lifts no more than 200 mm thick.

The slab-on-grade should be poured on the granular base of at least 20 cm in thickness, consisting of 19-mm Crusher-Run Limestone (CRL), or equivalent, compacted to 100% SPDD. A Modulus of Subgrade Reaction (k_s) of 20 MPa/m can be used for slab design.

6.4 **Loading Docks**

The foundation walls at the loading dock should be designed at a retaining structure using the soil parameters presented in Section 6.9 of this report.

In the loading dock area, the subgrade soils below the building floor will be subjected to freezing temperature. The earth fill behind the loading dock should consist of non-frost susceptible granular material. Alternatively, 50-mm thick rigid foam insulation is recommended behind the wall exposed to the freezing temperature.

A concrete apron may be specified at the truck loading area and ramp. It should be supported on compacted granular base of 30 cm thick, consisting of 19-mm CRL, and compacted to 100% SPDD.

Subgrade preparation for concrete apron and ramp will be similar for slab-on-grade construction. It should be inspected and assessed by proof-rolling prior to the placement of granular bedding.

6.5 **Underground Services**

Service pipes should be constructed on sound native soil or properly compacted inorganic earth fill. Where incompetent soil is encountered, it should be subexcavated and replaced with the bedding material, compacted to at least 98% SPDD.

A Class 'B' bedding, consisting of compacted 19-mm CRL, or equivalent, should be used for the pipe bedding.

The pipe joints into manholes or catch basins must be connected by leak-proof joints to prevent subgrade upfiltration through the joints.

In order to prevent pipe floatation when the sewer trench is deluged with water, a soil cover of at least two times the diameter of the pipe should be in place at all times after completion of the pipe installation.

Openings to subdrains and catch basins should be shielded with a fabric filter to prevent blockage by silting.

6.6 Backfilling in Trenches and Excavated Areas

The obtainable degree of compaction in the excavated material at the site is primarily dependent on the soil moisture and, to a lesser extent, on the type of compactor used and the effort applied. As a general guide, the typical water content values of the revealed soils for Standard Proctor compaction are presented in Table 2.

Table 2 - Estimated Water Content for Compaction of On-site Material

Soil Type	Determined Natural Water Content (%)	Water Content (%) for Standard Proctor Compaction	
		100% (optimum)	Range for 95% or +
Existing Earth Fill	9 to 23	12	8 to 15
Sand	1 and 24, (median 7)	10	6 to 13
Silty Sand Till	1 to 13 (median 8)	12	8 to 15

On-site material is generally suitable for use as structural backfill. Where wet soil is contacted, if any, it should be spread thinly on ground surface and aerated during warm and dry weather.

Existing earth fill must be sorted free of organics and topsoil prior to be reused for structural backfill.

The backfill in service trenches should be compacted to at least 95% SPDD. Below concrete floor subgrade and in the zone within 1.0 m below the pavement, the material should be compacted to 98% SPDD with the water content 2% to 3% drier than the optimum.

Narrow service trenches should be cut at 1 vertical:2 or + horizontal so that the backfill can be effectively compacted. Otherwise, soil arching will prevent the achievement of proper compaction. The lift of each backfill layer should either be limited to a thickness of 20 cm, or the thickness should be determined by test strips.

In normal construction practice, the problem areas of settlement largely occur adjacent to manholes, catch basins, services crossings, foundation walls and columns. In areas which are inaccessible to a heavy compactor, imported sand backfill should be used so that the backfill can be compacted with a light compactor.

6.7 Sidewalk and Interlocking Stone Pavement

On-grade sidewalk and structures must be designed to tolerate ground movement due to frost heaving. In areas which are sensitive to frost-induced ground movement, such as the sidewalk and barrier-free ramp in front of building entrances, they can be constructed on a free-draining, non-frost-susceptible granular material such as Granular 'B', extending to a depth of 1.5 m, and provided with weeper subdrains at the base draining towards manholes or catch basins.

Alternatively, the sidewalk and barrier-free ramp subgrade can be insulated with 50-mm Styrofoam, with free-draining granular material for the ramp construction above grade only.

The exterior grade should slope away from the building to prevent ponding of water in the areas adjacent to the building.

6.8 Pavement Design

The recommended pavement design for on-grade parking and driveway is given in Table 3.

Table 3 - Pavement Design

Course	Thickness (mm)	OPS Specifications
Asphalt Surface	35	HL3
Asphalt Binder Light-Duty Parking Heavy-Duty/Fire Route	 40 65	HL8
Granular Base	150	Granular 'A' or 19-mm CRL
Granular Sub-base Light-Duty Parking Heavy-Duty/Fire Route	 200 300	Granular 'B' or equivalent

After fine grading, the pavement subgrade must be inspected and proof-rolled. Any soft spot identified should be rectified by subexcavation and backfilled with competent earth fill.
The earth fill within the zone of 1.0 m below the pavement must be compacted to 98% SPDD, with the moisture content controlled at 2% to 3% drier than the optimum. In the lower zone, a 95% SPDD is considered adequate. The granular bases should be compacted to 100% SPDD.

The subgrade will suffer a strength regression if water is allowed to saturate the mantle. The following measures should, therefore, be incorporated in the construction procedures and road design:

- The subgrade should be properly crowned and smooth-rolled to allow interim precipitation to be properly drained.
- The areas adjacent to the pavement should be properly graded to prevent ponding of large amounts of water. Otherwise, the water will seep into the subgrade mantle and induce a regression of the subgrade strength, with costly consequences for the pavement construction.
- Fabric filter-encased subdrains will be required in the subgrade at the low spots around catch basins. The subdrains should be connected into the catch basins or manholes where water can be drained.

6.9 Soil Parameters

The recommended soil parameters for the project design are given in Table 4.

Table 4 - Soil Parameters

Unit Weight and Bulk Factor	**Unit Weight γ (kN/m³)**		**Estimated Bulk Factor**	
	Bulk	**Submerged**	**Loose**	**Compacted**
Silty Sand Till	22.5	12.5	1.20	1.00
Earth Fill, Sand and Silty Sand	21.5	11.5	1.20	1.00
Lateral Earth Pressure Coefficients		**Active K_a**	**At Rest K_0**	**Passive K_p**
Compacted Earth Fill		0.40	0.55	2.50
Native Sand and Silty Sand and Silty Sand Till		0.31	0.47	3.25
Coefficients of Friction				
Between concrete and fine grained soil				0.35
Between concrete and granular soil				0.50
Maximum Allowable Soil Pressure (SLS) For Thrust Block Design				
Engineered fill and sound native soils				75 kPa

6.10 Excavation

Excavation should be carried out in accordance with Ontario Regulation 213/91. The types of soils are classified in Table 5.

Table 5 - Classification of Soils for Excavation

Material	Type
Silty Sand Till	2
Earth Fill, Sand	3
Saturated soil, if any	4

The water-bearing sand stratum in the lower stratigraphy represents the groundwater regime in the area, which is subject to seasonal fluctuation.

For excavation above groundwater level, the groundwater yield, if any, is expected to be slow in rate and limited in quantity. It can be drained into a sump pit and removed by conventional pumping.

Where excavation extends below the water level, the water yield is expected to be moderate and may become persistent. Dewatering from closely spaced sumps or deep wells may be required.

7.0 LIMITATIONS OF REPORT

This report was prepared for the account of A.R.G. Group Inc. and for review by the designated consultants, contractors, financial institutions, and government agencies. The material in the report reflects the judgment of Daric Yang, B.A.Sc. and Kin Fung Li, P.Eng., in light of the information available to it at the time of preparation.

Use of the report is subject to the conditions and limitations of the contractual agreement. Any use which a Third Party makes of this report, and/or any reliance on decisions to be made based on it are the responsibility of such Third Parties. Soil Engineers Ltd. accepts no responsibility for damages, if any, suffered by any Third Party as a result of decisions made or actions based on this report.

SOIL ENGINEERS LTD.

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LIST OF ABBREVIATIONS AND DESCRIPTION OF TERMS

The abbreviations and terms commonly employed on the borehole logs and figures, and in the text of the report, are as follows:

SAMPLE TYPES

AS	Auger sample
CS	Chunk sample
DO	Drive open (split spoon)
DS	Denison type sample
FS	Foil sample
RC	Rock core (with size and percentage recovery)
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

PENETRATION RESISTANCE

Dynamic Cone Penetration Resistance:

A continuous profile showing the number of blows for each foot of penetration of a 2-inch diameter, 90° point cone driven by a 140-pound hammer falling 30 inches.

Plotted as '—•—'

Standard Penetration Resistance or 'N' Value:

The number of blows of a 140-pound hammer falling 30 inches required to advance a 2-inch O.D. drive open sampler one foot into undisturbed soil.

Plotted as '○'

WH	Sampler advanced by static weight
PH	Sampler advanced by hydraulic pressure
PM	Sampler advanced by manual pressure
NP	No penetration

SOIL DESCRIPTION

Cohesionless Soils:

'N' (blows/ft)	Relative Density
0 to 4	very loose
4 to 10	loose
10 to 30	compact
30 to 50	dense
over 50	very dense

Cohesive Soils:

Undrained Shear Strength (ksf)	'N' (blows/ft)	Consistency
less than 0.25	0 to 2	very soft
0.25 to 0.50	2 to 4	soft
0.50 to 1.0	4 to 8	firm
1.0 to 2.0	8 to 16	stiff
2.0 to 4.0	16 to 32	very stiff
over 4.0	over 32	hard

Method of Determination of Undrained Shear Strength of Cohesive Soils:

x 0.0 Field vane test in borehole; the number denotes the sensitivity to remoulding

△ Laboratory vane test

☐ Compression test in laboratory

For a saturated cohesive soil, the undrained shear strength is taken as one half of the undrained compressive strength

METRIC CONVERSION FACTORS

1 ft = 0.3048 metres
1lb = 0.454 kg
1 inch = 25.4 mm
1ksf = 47.88 kPa

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JOB NO.: 2109-S054

LOG OF BOREHOLE: 1

FIGURE NO.: 1

PROJECT DESCRIPTION: Proposed Industrial Development

METHOD OF BORING: Flight Auger (Solid Stem)

PROJECT LOCATION: 90 Mapleview Drive West, Town of Newmarktet

DRILLING DATE: November 4, 2021

El. (m) / Depth (m)	SOIL DESCRIPTION	Sample Number	Type	N-Value	Penetration Resistance (blows/30 cm)	Moisture Content (%)	WATER LEVEL
306.9	Ground Surface						
	20 cm TOPSOIL						
	EARTH FILL Dark brown mixture of sand, silt and clay occ. topsoil and organic inclusions	1	DO	5		14	
		2	DO	7		9	
305.5 / 1.4	Brown, very dense **SILTY SAND TILL** traces of clay and gravel occ. cobbles and boulders	3	DO	54		8	
		4	DO	64		8	
		5	DO	76		8	
302.9 / 4.0	Brown, very dense **SILTY SAND** fine grained	6	DO	66		20	W.L. @ El. 301.1 m on completion
		7	DO	64		20	
300.3 / 6.6	**END OF BOREHOLE**						

Depth Scale (m): 0, 1, 2, 3, 4, 5, 6, 7, 8

● Dynamic Cone (blows/30 cm): 10, 30, 50, 70, 90

X Shear Strength (kN/m²): 50, 100, 150, 200

○ Penetration Resistance (blows/30 cm): 10, 30, 50, 70, 90

Atterberg Limits: PL, LL

● Moisture Content (%): 10, 20, 30, 40

JOB NO.: 2109-S054

LOG OF BOREHOLE: 2

FIGURE NO.: 2

PROJECT DESCRIPTION: Proposed Industrial Development

METHOD OF BORING: Flight Auger (Solid Stem)

PROJECT LOCATION: 90 Mapleview Drive West, Town of Newmarktet

DRILLING DATE: November 5, 2021

El. (m) / Depth (m)	SOIL DESCRIPTION	Sample Number	Type	N-Value	Depth (m)	Penetration Resistance (blows/30 cm)	Moisture Content (%)	WATER LEVEL
306.7	Ground Surface				0			
	30 cm TOPSOIL							
0.3	**EARTH FILL** Dark brown mixture of sand, silt and clay occ. topsoil and organic inclusions	1	DO	3		○	23	
		2	DO	3	1	○	16	
305.3 / 1.4	Brown, compact to very dense **SAND** fine grained a trace of silt	3	DO	20		○	5	
		4	DO	46	2	○	2	
		5	DO	60	3	○	4	
		6	DO	56	4	○	12	W.L. @ El. 301.2 m on completion
		7	DO	62	6	○	19	
300.1 / 6.6	**END OF BOREHOLE**							

Legend: ● Dynamic Cone (blows/30 cm) 10 30 50 70 90; × Shear Strength (kN/m²) 50 100 150 200; ○ Penetration Resistance (blows/30 cm) 10 30 50 70 90; Atterberg Limits PL — LL; ● Moisture Content (%) 10 20 30 40

Depth Scale (m): 0 1 2 3 4 5 6 7 8

JOB NO.: 2109-S054

LOG OF BOREHOLE: 3

FIGURE NO.: 3

PROJECT DESCRIPTION: Proposed Industrial Development

METHOD OF BORING: Flight Auger (Solid Stem)

PROJECT LOCATION: 90 Mapleview Drive West, Town of Newmarktet

DRILLING DATE: November 5, 2021

El. (m) / Depth (m)	SOIL DESCRIPTION	Sample Number	Sample Type	N-Value	Depth Scale (m)	Penetration Resistance (blows/30 cm)	Moisture Content (%)	WATER LEVEL
306.1	Ground Surface							
	36 cm TOPSOIL				0			
0.3	**EARTH FILL** Dark brown mixture of sand, silt and clay occ. topsoil and organic inclusions	1	DO	5			16	
305.4 / 0.7	Brown, compac **SILTY SAND TILL** traces of clay and gravel occ. cobbles and boulders	2	DO	24	1		8	
304.7 / 1.4	Brown, dense to very dense **SAND** fine grained a trace of silt	3	DO	36			6	
					2			
		4	DO	49			5	
					3			
		5	DO	72			13	
					4			
		6	DO	50/15			18	W.L. @ El. 301.2 m on completion
					5			
					6			
		7	DO	50			21	
299.5 / 6.6	**END OF BOREHOLE**							
					7			
					8			

Legend: ● Dynamic Cone (blows/30 cm) 10 30 50 70 90; ✕ Shear Strength (kN/m²) 50 100 150 200; ○ Penetration Resistance (blows/30 cm) 10 30 50 70 90; Atterberg Limits PL LL; ● Moisture Content (%) 10 20 30 40

JOB NO.: 2109-S054

LOG OF BOREHOLE: 4

FIGURE NO.: 4

PROJECT DESCRIPTION: Proposed Industrial Development

METHOD OF BORING: Flight Auger (Solid Stem)

PROJECT LOCATION: 90 Mapleview Drive West, Town of Newmarktet

DRILLING DATE: November 4, 2021

El. (m) / Depth (m)	SOIL DESCRIPTION
307.6	Ground Surface
	30 cm TOPSOIL
0.3	**EARTH FILL** Dark brown mixture of sand, silt and clay occ. topsoil and organic inclusions
306.9 / 0.7	Brown, compact to very dense **SILTY SAND TILL** traces of clay and gravel occ. cobbles and boulders
302.1 / 5.5	Brown, dense **SILTY SAND** fine grained
301.0 / 6.6	**END OF BOREHOLE**

Sample Number	Type	N-Value	Moisture Content (%)
1	DO	4	18
2	DO	39	8
3	DO	60	9
4	DO	52	6
5	DO	59	8
6	DO	20	10
7	DO	45	24

Depth Scale (m): 0 – 8

Dynamic Cone (blows/30 cm): 10 30 50 70 90

Shear Strength (kN/m²): 50 100 150 200

Penetration Resistance (blows/30 cm): 10 30 50 70 90

Atterberg Limits: PL LL

Moisture Content (%): 10 20 30 40

WATER LEVEL: W.L. @ El. 301.8 m on completion

Soil Engineers Ltd.

JOB NO.: 2109-S054

LOG OF BOREHOLE: 5

FIGURE NO.: 5

PROJECT DESCRIPTION: Proposed Industrial Development

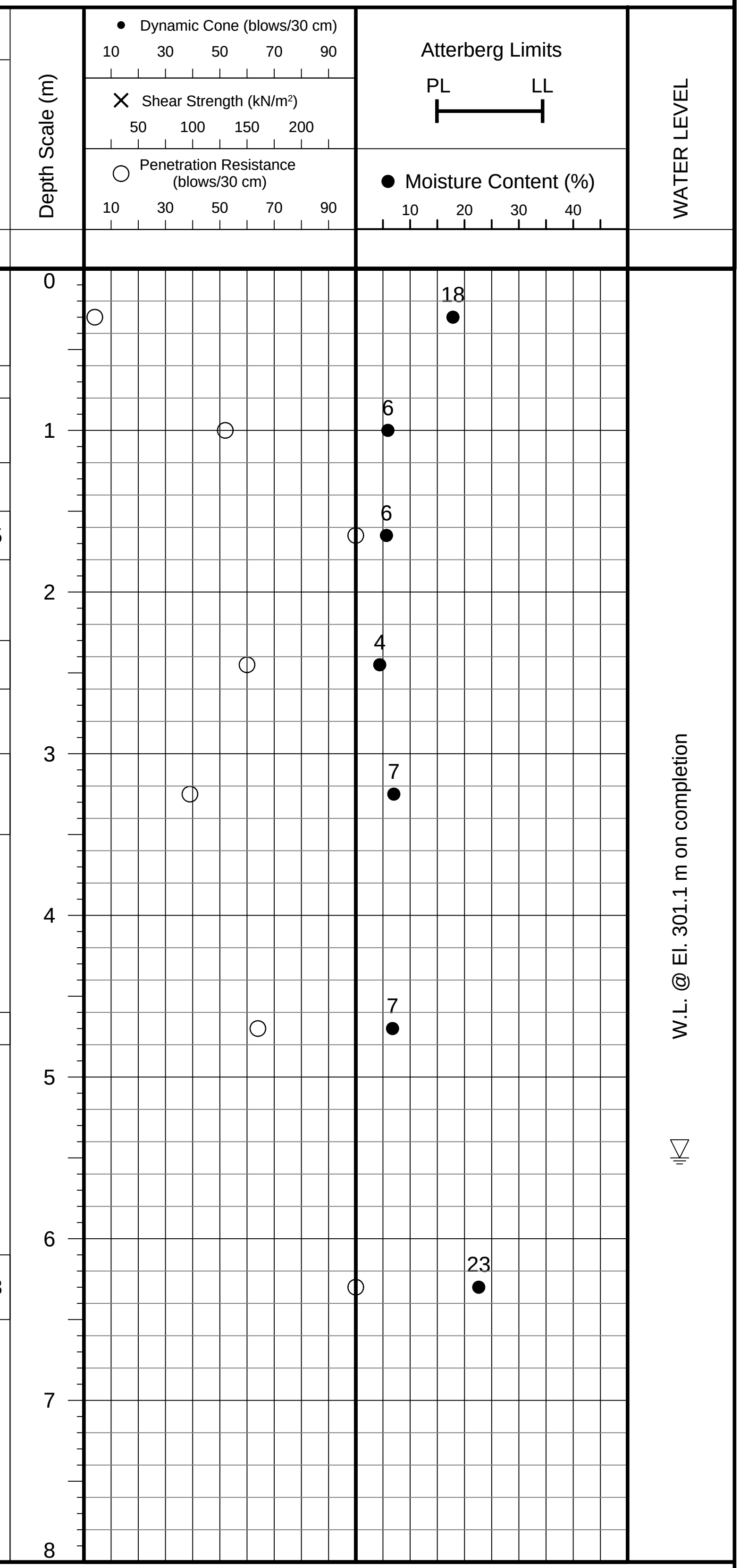
METHOD OF BORING: Flight Auger (Solid Stem)

PROJECT LOCATION: 90 Mapleview Drive West, Town of Newmarktet

DRILLING DATE: November 8, 2021

El. (m) / Depth (m)	SOIL DESCRIPTION
306.6	Ground Surface
	30 cm TOPSOIL
0.3	**EARTH FILL** Dark brown mixture of sand, silt and clay occ. topsoil and organic inclusions
305.9 / 0.7	Brown, dense to very dense **SAND** fine grained occ. silt seams (silt seams)
301.6 / 5.0	Brown, very dense **SILTY SAND** fine grained
300.1 / 6.5	**END OF BOREHOLE**

SAMPLES Number	Type	N-Value
1	DO	4
2	DO	52
3	DO	50/15
4	DO	60
5	DO	39
6	DO	64
7	DO	86/28



JOB NO.: 2109-S054

LOG OF BOREHOLE: 6

FIGURE NO.: 6

PROJECT DESCRIPTION: Proposed Industrial Development

METHOD OF BORING: Flight Auger (Solid Stem)

PROJECT LOCATION: 90 Mapleview Drive West, Town of Newmarktet

DRILLING DATE: November 5, 2021

El. (m) / Depth (m)	SOIL DESCRIPTION	Sample Number	Type	N-Value	Depth Scale (m)	Penetration Resistance (blows/30 cm)	Moisture Content (%)	WATER LEVEL
307.9	Ground Surface				0			
	25 cm TOPSOIL							
0.3	**EARTH FILL** Dark brown mixture of sand, silt and clay occ. topsoil and organic inclusions	1	DO	5		○	15	
307.2 / 0.7	Brown, compac to very dense **SILTY SAND TILL** traces of clay and gravel occ. cobbles and boulders	2	DO	25	1	○	8	
		3	DO	38	2	○	7	
		4	DO	64		○	7	
		5	DO	86	3	○	8	
303.9 / 4.0	Brown, dense **SILTY SAND** fine grained; — — — gravel layers	6	DO	49	4–5	○	13	Dry upon Completion
302.1 / 5.8	Brown, very dense **SAND** some gravel	7	DO	56	6	○	2	
301.3 / 6.6	**END OF BOREHOLE**				7–8			

Chart scales: Dynamic Cone (blows/30 cm) 10 30 50 70 90; Shear Strength (kN/m²) 50 100 150 200; Penetration Resistance (blows/30 cm) 10 30 50 70 90; Atterberg Limits PL LL; Moisture Content (%) 10 20 30 40

JOB NO.: 2109-S054

LOG OF BOREHOLE: 7

FIGURE NO.: 7

PROJECT DESCRIPTION: Proposed Industrial Development

METHOD OF BORING: Flight Auger (Solid Stem)

PROJECT LOCATION: 90 Mapleview Drive West, Town of Newmarktet

DRILLING DATE: November 5, 2021

El. (m) / Depth (m)	SOIL DESCRIPTION	Sample Number	Type	N-Value	Moisture Content (%)	Water Level
307.6	Ground Surface					
0.3	**30 cm TOPSOIL**					
306.9 / 0.7	**EARTH FILL** Dark brown mixture of sand, silt and clay occ. topsoil and organic inclusions	1	DO	5	20	
305.4 / 2.2	Brown, compact to dense **SILTY SAND TILL** traces of clay and gravel occ. cobbles and boulders	2	DO	24	9	
		3	DO	40	7	
302.1 / 5.5	Brown, dense to very dense **SAND** fine to medium grained occ. silt seams	4	DO	60	3	
		5	DO	42	3	
		6	DO	46	1	Dry upon Completion
301.2 / 6.4	Brown, very dense **SILTY SAND** fine grained	7	DO	50/15	16	
	END OF BOREHOLE					

Dynamic Cone (blows/30 cm): 10 30 50 70 90
Shear Strength (kN/m²): 50 100 150 200
Penetration Resistance (blows/30 cm): 10 30 50 70 90
Atterberg Limits: PL LL
Moisture Content (%): 10 20 30 40
Depth Scale (m): 0 1 2 3 4 5 6 7 8

JOB NO.: 2109-S054

LOG OF BOREHOLE: 8

FIGURE NO.: 8

PROJECT DESCRIPTION: Proposed Industrial Development

METHOD OF BORING: Flight Auger (Solid Stem)

PROJECT LOCATION: 90 Mapleview Drive West, Town of Newmarktet

DRILLING DATE: November 5, 2021

El. (m) / Depth (m)	SOIL DESCRIPTION	Sample Number	Type	N-Value	Depth Scale (m)	Penetration Resistance (blows/30 cm)	Moisture Content (%)	WATER LEVEL
307.0	Ground Surface				0			
	36 cm TOPSOIL							
0.3	**EARTH FILL** Dark brown mixture of sand, silt and clay occ. topsoil and organic inclusions	1	DO	7			20	
306.3 / 0.7	Brown, dense to very dense **SILTY SAND TILL** traces of clay and gravel occ. cobbles and boulders	2	DO	46	1		7	
		3	DO	80/25			6	
		4	DO	47	2		7	
		5	DO	53	3		7	
303.1 / 3.9	Brown, very dense **SAND** fine grained a trace of silt	6	DO	53	4		1	
	gravel layers	7	DO	90/25	6		19	W.L. @ El. 301.2 m on completion
300.5 / 6.5	**END OF BOREHOLE**				7, 8			

Legend: ● Dynamic Cone (blows/30 cm) 10 30 50 70 90; × Shear Strength (kN/m²) 50 100 150 200; ○ Penetration Resistance (blows/30 cm) 10 30 50 70 90; Atterberg Limits PL LL; ● Moisture Content (%) 10 20 30 40

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JOB NO.: 2109-S054

LOG OF BOREHOLE: 9

FIGURE NO.: 9

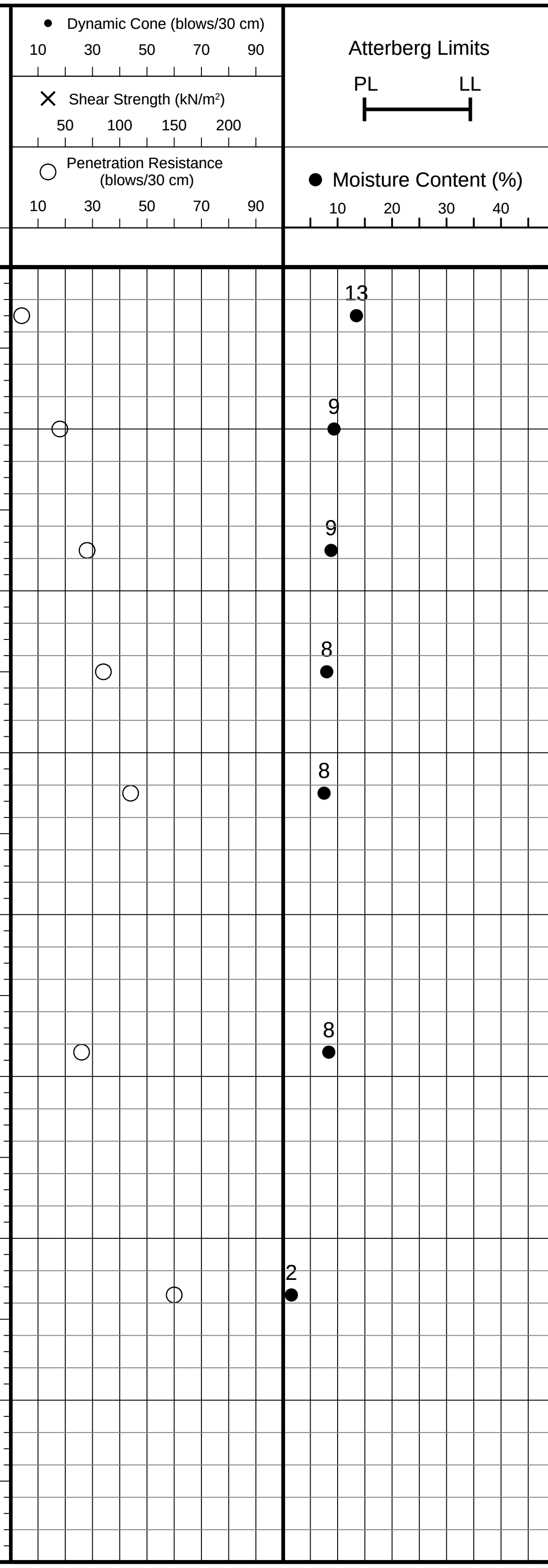
PROJECT DESCRIPTION: Proposed Industrial Development

METHOD OF BORING: Flight Auger (Solid Stem)

PROJECT LOCATION: 90 Mapleview Drive West, Town of Newmarktet

DRILLING DATE: November 5, 2021

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Moisture Content (%)	WATER LEVEL
308.2	Ground Surface				0		
	30 cm TOPSOIL						
0.3	**EARTH FILL** Dark brown mixture of sand, silt and clay occ. topsoil and organic inclusions	1	DO	4		13	
307.2 1.0	Brown, compact to very dense **SILTY SAND TILL** traces of clay and gravel occ. cobbles and boulders	2	DO	18	1	9	
		3	DO	28	2	9	
		4	DO	34		8	
		5	DO	44	3	8	
					4		Dry upon Completion
		6	DO	26	5	8	
		7	DO	60	6	2	
301.6 6.6	**END OF BOREHOLE**				7		
					8		



JOB NO.: 2109-S054

LOG OF BOREHOLE: 10

FIGURE NO.: 10

PROJECT DESCRIPTION: Proposed Industrial Development

METHOD OF BORING: Flight Auger (Solid Stem)

PROJECT LOCATION: 90 Mapleview Drive West, Town of Newmarktet

DRILLING DATE: November 8, 2021

El. (m) / Depth (m)	SOIL DESCRIPTION
308.3	Ground Surface
	36 cm TOPSOIL
	EARTH FILL Dark brown mixture of sand, silt and clay occ. topsoil and organic inclusions
307.6 / 0.7	Brown, loose to dense **SAND** fine to medium grained a trace to some silt occ. cobbles — — — gravel layers
306.1 / 2.2	Brown, dense to very dense **SILTY SAND TILL** traces of clay and gravel occ. cobbles and boulders — — — gravel layers
301.7 / 6.6	**END OF BOREHOLE**

SAMPLES Number	Type	N-Value	Moisture Content (%)
1	DO	4	21
2	DO	6	4
3	DO	38	4
4	DO	34	10
5	DO	72	8
6	DO	74	11
7	DO	82	1

Depth Scale (m): 0–8

● Dynamic Cone (blows/30 cm) 10 30 50 70 90

× Shear Strength (kN/m²) 50 100 150 200

○ Penetration Resistance (blows/30 cm) 10 30 50 70 90

Atterberg Limits PL LL

● Moisture Content (%) 10 20 30 40

WATER LEVEL: Dry upon Completion

JOB NO.: 2109-S054

LOG OF BOREHOLE: 11

FIGURE NO.: 11

PROJECT DESCRIPTION: Proposed Industrial Development

METHOD OF BORING: Flight Auger (Solid Stem)

PROJECT LOCATION: 90 Mapleview Drive West, Town of Newmarktet

DRILLING DATE: November 8, 2021

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Penetration Resistance (blows/30 cm)	Moisture Content (%)	WATER LEVEL
308.2	Ground Surface							
	36 cm TOPSOIL	1	DO	7	0		11	
307.5 / 0.7	**EARTH FILL** Dark brown mixture of sand, silt and clay occ. topsoil and organic inclusions							
	Brown, dense to very dense **SILTY SAND TILL** traces of clay and gravel occ. cobbles and boulders	2	DO	33	1		7	
		3	DO	78			6	
		4	DO	42	2		8	
		5	DO	46	3		7	
304.7 / 3.5	**END OF BOREHOLE**				4			Dry upon Completion

Dynamic Cone (blows/30 cm): 10 30 50 70 90

Shear Strength (kN/m²): 50 100 150 200

Penetration Resistance (blows/30 cm): 10 30 50 70 90

Atterberg Limits: PL LL

Moisture Content (%): 10 20 30 40

Depth Scale (m): 0 1 2 3 4 5 6 7 8

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JOB NO.: 2109-S054

LOG OF BOREHOLE: 12

FIGURE NO.: 12

PROJECT DESCRIPTION: Proposed Industrial Development

METHOD OF BORING: Flight Auger (Solid Stem)

PROJECT LOCATION: 90 Mapleview Drive West, Town of Newmarktet

DRILLING DATE: November 8, 2021

El. (m) / Depth (m)	SOIL DESCRIPTION	Sample Number	Type	N-Value	Depth Scale (m)	Penetration Resistance (blows/30 cm)	Moisture Content (%)	WATER LEVEL
308.5	Ground Surface				0			
	36 cm TOPSOIL	1	DO	10			18	
0.4	**EARTH FILL** Dark brown mixture of sand, silt and clay occ. topsoil and organic inclusions							
307.8 / 0.7	Brown, dense to very dense **SILTY SAND TILL** traces of clay and gravel occ. cobbles and boulders	2	DO	44	1		7	
		3	DO	66			7	
		4	DO	72	2		7	
		5	DO	46	3		7	
305.0 / 3.5	**END OF BOREHOLE**							Dry upon Completion

Chart legend: ● Dynamic Cone (blows/30 cm) 10 30 50 70 90; × Shear Strength (kN/m²) 50 100 150 200; ○ Penetration Resistance (blows/30 cm) 10 30 50 70 90; Atterberg Limits PL LL; ● Moisture Content (%) 10 20 30 40

Depth Scale (m): 0 1 2 3 4 5 6 7 8

JOB NO.: 2109-S054

LOG OF BOREHOLE: 13

FIGURE NO.: 13

PROJECT DESCRIPTION: Proposed Industrial Development

METHOD OF BORING: Flight Auger (Solid Stem)

PROJECT LOCATION: 90 Mapleview Drive West, Town of Newmarktet

DRILLING DATE: November 4, 2021

El. (m) / Depth (m)	SOIL DESCRIPTION	Sample Number	Type	N-Value	Depth Scale (m)	Penetration Resistance (blows/30 cm)	Moisture Content (%)	WATER LEVEL
307.6	Ground Surface							
	25 cm TOPSOIL	1	DO	5	0	5	17	
0.4	**EARTH FILL** Dark brown mixture of sand, silt and clay occ. topsoil and organic inclusions							
306.9 / 0.7	Brown, dense to very dense **SILTY SAND TILL** traces of clay and gravel occ. cobbles and boulders	2	DO	38	1	38	8	
		3	DO	86	2	86	6	
		4	DO	76		76	7	
		5	DO	52	3	52	7	
304.1 / 3.5	**END OF BOREHOLE**							Dry upon Completion

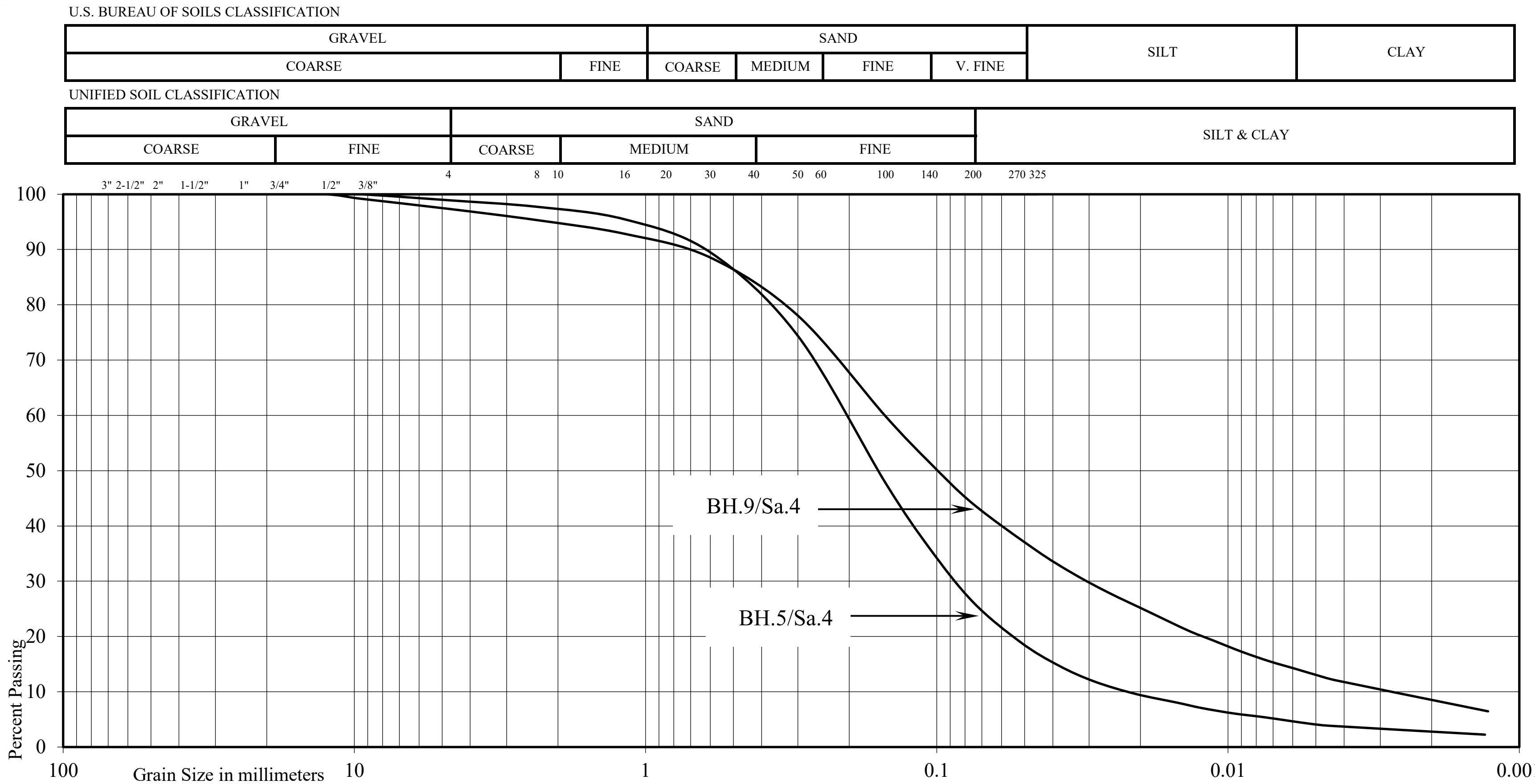
Legend: ● Dynamic Cone (blows/30 cm) 10 30 50 70 90; × Shear Strength (kN/m²) 50 100 150 200; ○ Penetration Resistance (blows/30 cm) 10 30 50 70 90; Atterberg Limits PL LL; ● Moisture Content (%) 10 20 30 40

Depth Scale (m): 0 1 2 3 4 5 6 7 8

GRAIN SIZE DISTRIBUTION

Soil Engineers Ltd.

Reference No: 2109-S054



Project:	Proposed Industrial Development		
Location:	90 Mapleview Drive West, Town of Newmarket		
Borehole No:	5	9	
Sample No:	4	4	
Depth (m):	2.3	2.4	
Elevation (m):	304.3	305.8	

BH./Sa.	5/4	9/4
Liquid Limit (%) =	-	-
Plastic Limit (%) =	-	-
Plasticity Index (%) =	-	-
Moisture Content (%) =	4	8
Estimated Permeability (cm./sec.) =	10^{-4}	10^{-5}

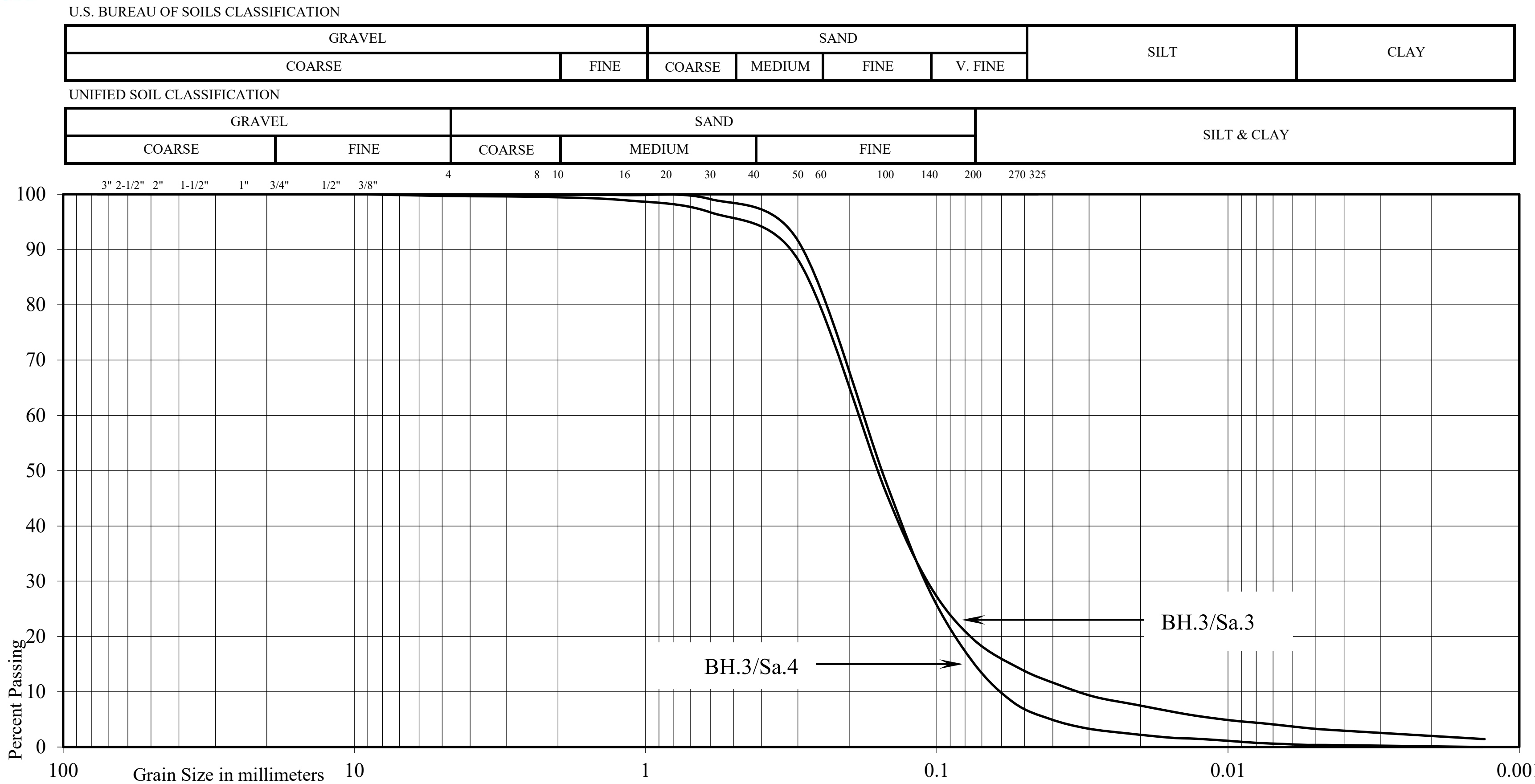
Classification of Sample [& Group Symbol]: SILTY SAND TILL, traces of clay and gravel

Figure: 14

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 2109-S054

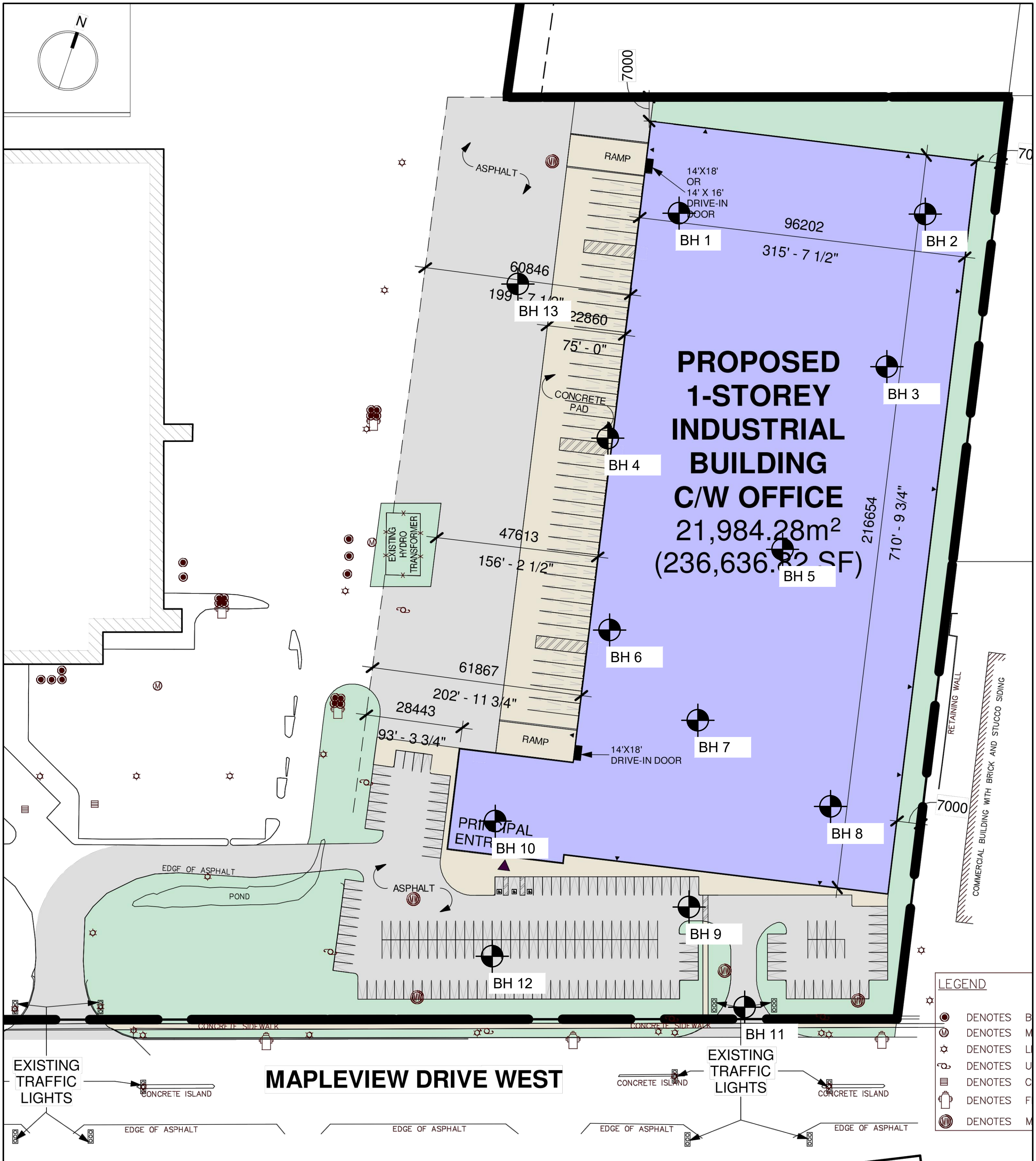


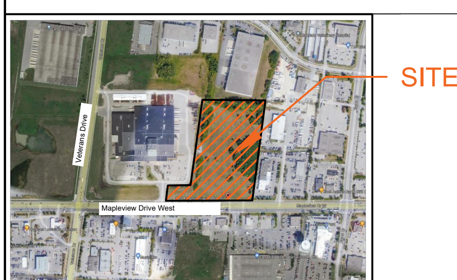
Project:	Proposed Industrial Development	
Location:	90 Mapleview Drive West, Town of Newmarket	
Borehole No:	3	3
Sample No:	3	4
Depth (m):	1.5	2.3
Elevation (m):	304.6	303.8

BH./Sa.	3/3	3/4
Liquid Limit (%) =	-	-
Plastic Limit (%) =	-	-
Plasticity Index (%) =	-	-
Moisture Content (%) =	6	5
Estimated Permeability (cm./sec.) =	10^{-3}	10^{-2}

Classification of Sample [& Group Symbol]: FINE SAND, a trace of silt

Figure: 15





Soil Engineers Ltd.
CONSULTING ENGINEERS
GEOTECHNICAL | ENVIRONMENTAL | HYDROGEOLOGICAL | BUILDING SCIENCE
90 WEST BEAVER CREEK ROAD, SUITE #100, RICHMOND HILL, ONTARIO L4B 1E7 · TEL: (416) 754-8515 · FAX: (905) 881-8335

Borehole Location Plan

SITE: 90 Mapleview Drive West, City of Barrie			
DESIGNED BY: DY	**CHECKED BY:** KL	**DWG NO.:** 1	
SCALE: 1:1500	**REF. NO.:** 2109-S054	**DATE:** December 2021	**REV**

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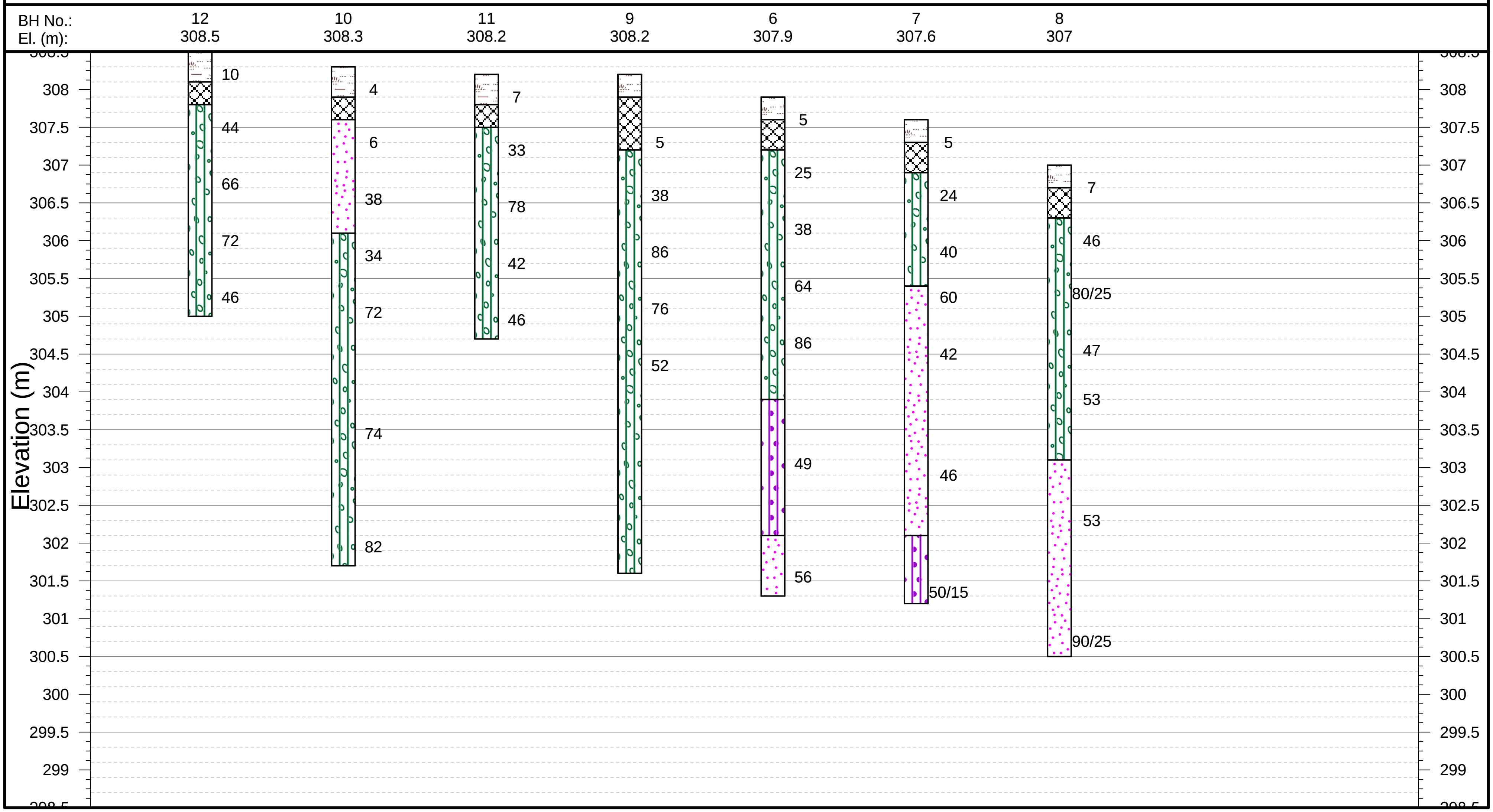
SUBSURFACE PROFILE
DRAWING NO. 2
SCALE: AS SHOWN

JOB NO.: 2109-S054
REPORT DATE: December 2021
PROJECT DESCRIPTION: Proposed Industrial Development
PROJECT LOCATION: 90 Mapleview Drive West, Town of Newmarktet

LEGEND

FILL · SILTY SAND · SILTY SAND TILL · TOPSOIL · SAND

WATER LEVEL (END OF DRILLING)



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SUBSURFACE PROFILE
DRAWING NO. 3
SCALE: AS SHOWN

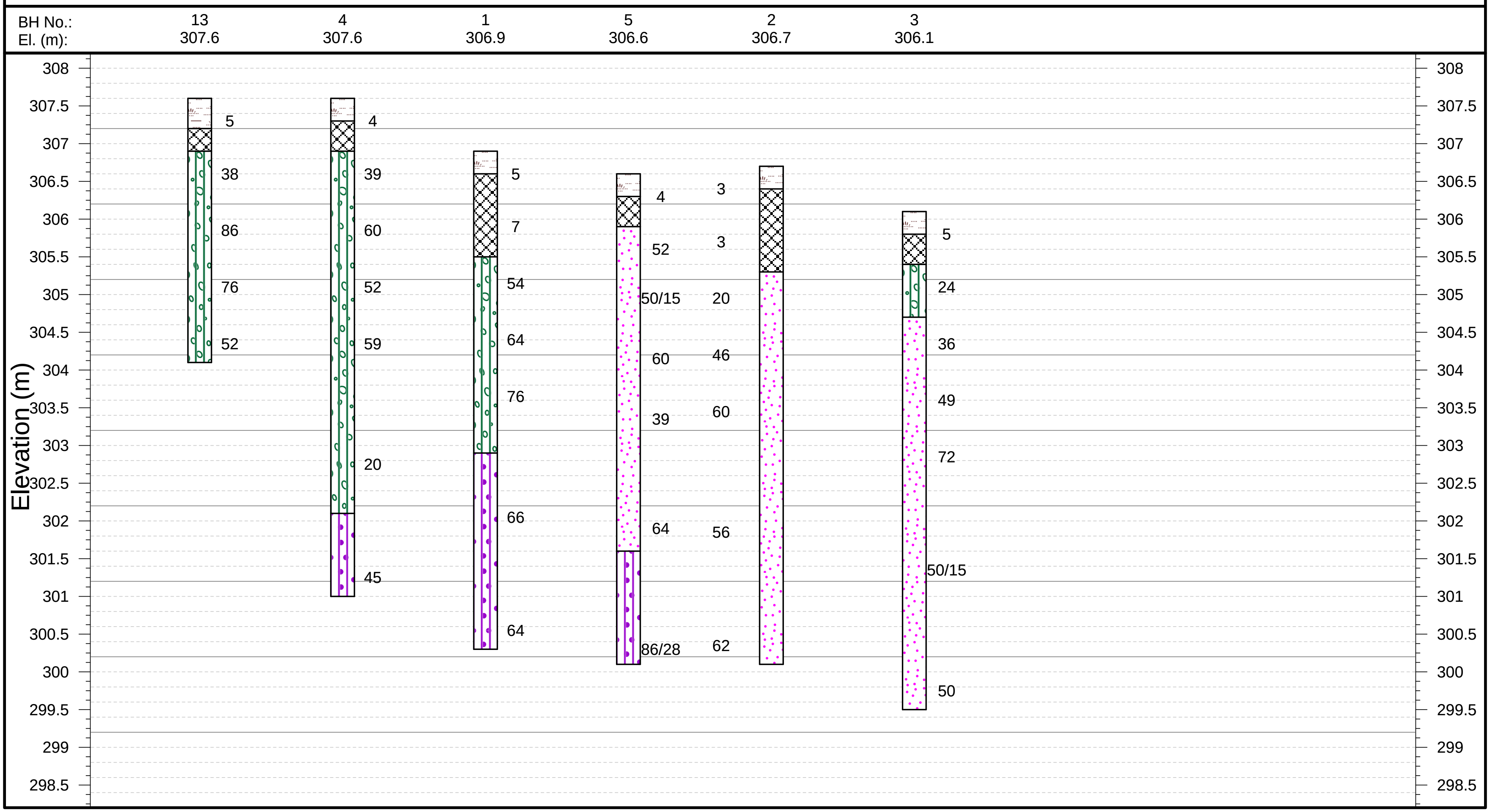
JOB NO.: 2109-S054
REPORT DATE: December 2021
PROJECT DESCRIPTION: Proposed Industrial Development

PROJECT LOCATION: 90 Mapleview Drive West, Town of Newmarktet

LEGEND

FILL | SILTY SAND | SILTY SAND TILL | TOPSOIL | SAND

WATER LEVEL (END OF DRILLING)



URBAN ECOSYSTEMS LIMITED
7050 WESTON ROAD, SUITE 705
WOODBRIDGE, ONTARIO L4L 8G7
uel@urbanecosystems.com
t (905)856-0629
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APPENDIX No 6

IN-SITU PERCOLATION TESTING REPORT

Soil Engineers Ltd.
CONSULTING ENGINEERS
GEOTECHNICAL • ENVIRONMENTAL • HYDROGEOLOGICAL • BUILDING SCIENCE
90 WEST BEAVER CREEK ROAD, SUITE 100, RICHMOND HILL, ONTARIO L4B 1E7 · TEL: (416) 754-8515 · FAX: (905) 881-8335

BARRIE	MISSISSAUGA	OSHAWA	NEWMARKET	GRAVENHURST	HAMILTON
TEL: (705) 721-7863	TEL: (905) 542-7605	TEL: (905) 440-2040	TEL: (905) 853-0647	TEL: (705) 684-4242	TEL: (905) 777-7956
FAX: (705) 721-7864	FAX: (905) 542-2769	FAX: (905) 725-1315	FAX: (905) 881-8335	FAX: (705) 684-8522	FAX: (905) 542-2769

August 18, 2022

A.R.G. Group of Companies
111 Creditstone Road
Concord, Ontario
L4K 1N3

Attention: Mr. Niel Palmer

**Re: In-Situ Guelph Permeameter Infiltration Testing
Proposed Industrial Development
90 Mapleview Drive West
City of Barrie**

Dear Sir:

As requested, we have completed in-situ infiltration testing and laboratory analysis for collected shallow soil samples in support of proposed Low Impact Development (LID) stormwater management planning and design for the above-captioned development site. Our assessment and findings are presented in this letter report.

Background

The subject site is located at 90 Mapleview Drive West, in the City of Barrie. A proposed industrial development is intended for construction at the site, where it is proposed that Low Impact Development (LID) infiltration infrastructure will be implemented to promote infiltration and to address future stormwater management planning and design for the proposed development.

This study was undertaken to verify the permeability, and percolation times and infiltration estimates for shallow native subsoil beneath the subject site, to confirm that it is feasible for the design of infiltration infrastructure to manage collected stormwater runoff, for its redirection to the subsurface, to recharge groundwater, to meet the stormwater management planning design objectives for the proposed developed site.

Work Program

On August 16, 2022 our representative performed a site visit to carry out in-situ percolation/infiltration testing. An excavator contractor was provided by the client to excavate to the target depths at the test pit locations, to the indicated depths.

The UTM coordinates and ground surface elevations at the test pit locations, are provided in Table 1.

Table 1: Test Pit Excavation

Test Pit No.	UTM Coordinates	Existing Ground Elevation (masl)	Estimated Bottom Elevation (masl)	Test Pit Depth (mbgs)
1	E 604015.3	±307.2	±304.9	±2.3
	N 4909904.1		±303.4	±3.8
2	E 604005.1	±306.8	±305.2	±1.6
	N 4909945.8		±303.7	±3.1

Mbgs: meters below ground surface *masl: meters above sea level*

The ground surface elevations and the UTM coordinates at the test pit locations were surveyed using the Trimble unit, model TSC3 which has an accuracy of ± 0.05 m.

For this study three (3) in-situ infiltration tests were initiated within the excavated test pits; two tests at the bottom elevations for the proposed LID infrastructure, and one (1) test at a depth of 1.5 meters below the bottom elevation of the proposed LID infrastructure, in support of proposed LID infrastructure for stormwater management planning and design. The in-situ infiltration percolation testing was performed using the Guelph Permeameter (GP) instrument (Model 2800K1). The in-situ tests were conducted at the approximate depths ranging from of ±1.6 m to ±3.8 m below the existing surface grade levels. The approximate test pit locations, where the in-situ tests were attempted are shown on Drawing No. 1, enclosed.

It is critical to note that hydraulic conductivity and infiltration rates are two different concepts, and that conversion from one parameter to another cannot be done though unit conversion. In accordance with the Toronto and Region Conservation Authority (TRCA) and Credit Valley Conservation Authority (CVC) the estimated infiltration rates are based on “Low Impact Development Stormwater Management Planning and Design Guide” Table C1, provided below.

Table C1

Hydraulic Conductivity, K_{fs} (cm/Sec)	Percolation Time, T (min/cm)	Infiltration Rate, 1/T (mm/hr)
0.1	2	300
0.01	4	150
0.001	8	75
0.0001	12	50
0.00001	20	30
0.000001	50	12

Source: Ontario Ministry of Municipal Affairs and Housing (OMMAH). 1997. Supplementary Guidelines to the Ontario Building Code 197. SG-6 Percolation Time and Soil Description. Toronto, Ontario.
Kfs – field saturated hydraulic conductivity

Methodology

The Guelph Permeameter is a constant head infiltrometer instrument which operates using the Marriott Bottle principal, whereby a constant, ponded head of water is allowed to infiltrate into the unsaturated surface soil via a small test hole augered to penetrate the shallow subsoil horizon. The constant water head for the instrument is maintained within the test hole by an air tube and its height setting within the instrument. A steady-state flow of water into the soil should result after a relatively short period of time, corresponding to the instrument's ponded water head settings. A higher ponded head setting should result in a higher steady-state flow of water into the soil than the previous lower ponded water head setting. The hydraulic conductivity (K) estimate for the soil is obtained using the mathematical equations established for the instrument, whereby two (2) steady-state flow measurements, corresponding to the two (2) ponded water head settings for the instrument, can be used as minimum information to estimate K for the soil. The K estimates can also be determined using the one ponded water head approach which corresponds to one steady-state water flow measurement into the soil.

Test Results

The in-situ, infiltration tests were conducted at depths ranging from 1.6 to 3.8 ± m below existing grade levels. Based on our visual observations in the field, the existing shallow soils beneath the site are comprise of:

- Earthfill, Silty Sand Till, having a trace of clay and gravel, with occasional cobbles and boulders, and Sand, having a trace of gravel, with occasional cobbles and boulders.

The results from the attempted in-situ testing and the interpreted percolation and infiltrate rate estimates that were assessed from the tests at the testing depths are summarized in the Table 2:

Table 2: Estimated Hydraulic Conductivity, Percolation time and Infiltration Rate

Test No.	Test and Depth (m)	Groundwater Seepage Depth (masl)	Soil Type	Ponded Water Head Setting (cm)	Steady State Flow (cm³/sec)	In-Situ Testing of Hydraulic Conductivity (cm/sec)	Estimated T Time (min/cm)	Estimated Infiltration Rate (mm/hr)
1	***A** ±2.3	No Seepage	Brown, dense Silty Sand Till, trace of clay and gravel, with occ. Cobbles and boulders	(H1) 12	N/A	8.23 x 10^{-6} (GP)	25	24
				(H2) 24	0.02935			
				H2	Single Head Approach			
	***B** ±2.3	No Seepage	Brown, dense Silty Sand Till, trace of clay and gravel, with occ. cobbles and boulders	(H1) 12	N/A	6.59 x 10^{-6} (GP)	27	22
				(H2) 24	0.02348			
				H2	Single Head Approach			
	***C** ±3.8	No Seepage	Brown, dense Sand with gravel, occ. cobbles and boulders	(H1) 5	0.059	4.75 x 10^{-5} (GP)	16	38
				(H2) 10	0.088			
				Same as above	Double Head Approach			
2	***A** ±1.6	No Seepage	Brown, very dense Silty Sand Till trace of clay and gravel, with occ. Cobbles and boulders	N/A	N/A	N/A	*20	*30
	***B** ±3.1	No Seepage	Brown, dense Sand with gravel, occ. cobbles and boulders	(H1) 10	N/A	1.72 x 10^{-5} (GP)	21	29
				(H2) 23	0.0587			
				H2	Single Head Approach			

GP – Guelph Permeameter *GS – Soil grain Size Distribution* **inferred soil textured based on visual examination*

Based on use of the Guelph Permeameter ponded water head settings (single and double head ponded approaches), from the resulting steady-state flow measurements into the subsoil the estimated hydraulic conductivities for Test No.'s 1A, 1B, 1C and 2B ranges from 1.72 x 10^{-5} cm/sec to 8.23 x 10^{-6} cm/sec. The estimated percolation (T) times for the soil contacted at the depths for the infiltration testing ranging from 16 to 27 min/cm having the corresponding infiltration rates ranges from 22 to 38 mm/hr.

Attempts were made to complete the in-situ infiltration tests at Test Pit 2 A, however due to the occurrence of compact, very dense, low permeable shallow subsoil at the testing locations, and at the indicated depths, the in-situ test could not be successfully performed using the GP instrument at all the test pit locations.

The estimated percolation (T) times for the subsoil contacted at the depth for test pit 2A for the infiltration testing is about 20 min/cm having the corresponding infiltration rate of 30 mm/hr. The infiltration rates will vary depending on the soil density and the amounts of sand and/or silt present in the native soil, and the presence of any vertical soil structure fracturing, and/or macro pores.

General Comments

The geometric mean for the hydraulic conductivity estimates from the above in-situ infiltration testing performed at test pit 1A, 1B, 1C and 2A locations is 2.58×10^{-5} cm/sec, and the resulting geometric mean infiltration rates from these tests is 27.62 mm/hr. The least permeable infiltration test result listed above is 22 mm/hr. The ratio of the geometric mean for the above infiltration rates divided by the lowest infiltration rate gives a factor of 1.26.

Any infiltration system infrastructure designed for the site should include an overflow valve to divert any excess runoff to a second infiltration gallery, or to a grass swale, or to the municipal storm sewer at the surface, should a high intensity runoff event not be adequately accommodated by any proposed holding tank, and/or an infiltration trench/exfiltration tank, or infiltration gallery completed for the developed site.

We trust that this correspondence addresses your current needs and ask that you contact the undersigned should you have any questions or require additional information.

Yours truly,
SOIL ENGINEERS LTD.

Bhawandeep S. Brar

Bhawandeep S. Brar, B.Sc.

Gavin O'Brien, M.Sc., P.Geo.

PROFESSIONAL GEOSCIENTISTS ONTARIO
GAVIN R. O'BRIEN
PRACTISING MEMBER
1267
Aug 25, 2022

BB/GO:

ENCLOSURES

In-Situ Infiltration Testing Location .... Drawing No. 1
Guelph Permeameter Calculations Test 1A, 1B, 1C & 2B
Photographs In-Situ testing Location Attachment

N

Approximate Test Pit Location (Infiltration Test)

Soil Engineers Ltd.

Title:

In-Situ Infiltration Testing

Project:
Proposed Industrial Development
90 Mapleview Drive West
City of Barrie

Date:

August 18, 2022

Reference No.

2208-W125

Scale:

N.T.S

Drawing No.

1

SOILMOISTURE Guelph Permeameter

Input

Result

Single Head Method (1)

Reservoir Cross-sectional area in cm²

(enter "35.22" for Combined and "2.16" for Inner reservoir): **35.22**

Enter water Head Height ("H" in cm): **12**

Enter the Borehole Radius ("a" in cm): **3**

Enter the soil texture-structure category (enter one of the below numbers): **2**

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): **0.0000**

Res Type	35.22
H	12
a	3
H/a	4
a*	0.04
C0.01	1.348
C0.04	1.436
C0.12	1.449
C0.36	1.449
C	1.436
R	0.000
Q	0
pi	3.142

α*= 0.04 cm^{-1}

C = 1.43553

Q = 0

K_{fs} = 0.00E+00 cm/sec
0.00E+00 cm/min
0.00E+00 m/sec
0.00E+00 inch/min
0.00E+00 inch/sec

Φ_m = 0.00E+00 cm^2/min

Single Head Method (2)

Reservoir Cross-sectional area in cm²

(enter "35.22" for Combined and "2.16" for Inner reservoir): **35.22**

Enter water Head Height ("H" in cm): **24**

Enter the Borehole Radius ("a" in cm): **3**

Enter the soil texture-structure category (enter one of the below numbers): **2**

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): **0.0500**

Res Type	35.22
H	24
a	3
H/a	8
a*	0.04
C0.01	1.91215
C0.04	2.0893
C0.12	2.19621
C0.36	2.19621
C	2.0893
R	0.050
Q	0.02935
pi	3.1415

α*= 0.04 cm^{-1}

C = 2.0893

Q = 0.02935

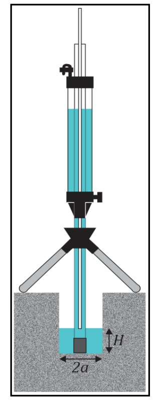
K_{fs} = 8.23E-06 cm/sec
4.94E-04 cm/min
8.23E-08 m/ses
1.94E-04 inch/min
3.24E-06 inch/sec

Φ_m = 2.06E-04 cm^2/min

Average

K_{fs} = 4.12E-06 cm/sec
2.47E-04 cm/min
4.12E-08 m/s
9.72E-05 inch/min
1.62E-06 inch/sec

Φ_m = 1.03E-04 cm^2/min



Double Head Method

Reservoir Cross-sectional area in cm²

(enter "35.22" for Combined and "2.16" for Inner reservoir): **35.22**

Enter the first water Head Height ("H1" in cm): **12**

Enter the second water Head Height ("H2" in cm): **24**

Enter the Borehole Radius ("a" in cm): **3**

Enter the soil texture-structure category (enter one of the below numbers): **2**

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

α*= 0.04 cm^{-1}

α= -0.0791

Steady State Rate of Water Level Change ("R1" in cm/min): **0.0000**

Steady State Rate of Water Level Change ("R2" in cm/min): **0.0500**

Res Type:	35.22
H1/a:	4
H2/a:	8
C1-0.01:	1.34796
C2-0.01:	1.91215
C1-0.04:	1.43553
C2-0.04:	2.0893
C1-0.12:	1.44896
C2-0.12:	2.19621
C1-0.36:	1.44896
C2-0.36:	2.19621

Q_1 = 0

Q_2 = 0.02935

C_1 = 1.43553

C_2 = 2.0893

G_1 = 0.00159

G_2 = 0.00116

G_3 = 0.03918

G_4 = 0.01466

K_{fs} = 3.40E-05 cm/sec
2.04E-03 cm/min
3.40E-07 m/sec
8.04E-04 inch/min
1.34E-05 inch/sec

Φ_m = -4.30E-04 cm^2/min

Θ_{fs} = 0.65 cm^3/cm^3

Θ_i = 0.4 cm^3/cm^3

Sorptivity #NUM! $(cm\ min^{-½})$

Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1=\left(\frac{H_2/a}{2.081+0.121\left(H_2/a\right)}\right)^{0.672}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1=\left(\frac{H_1/a}{1.992+0.091\left(H_1/a\right)}\right)^{0.683}$ $C_2=\left(\frac{H_2/a}{1.992+0.091\left(H_2/a\right)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1=\left(\frac{H_1/a}{2.074+0.093\left(H_1/a\right)}\right)^{0.754}$ $C_2=\left(\frac{H_2/a}{2.074+0.093\left(H_2/a\right)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1=\left(\frac{H_1/a}{2.074+0.093\left(H_1/a\right)}\right)^{0.754}$ $C_2=\left(\frac{H_2/a}{2.074+0.093\left(H_2/a\right)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm²/s), a^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1=\bar{R}_1\times 35.22$	$K_{fs}=\frac{C_1\times Q_1}{2\pi H_1^2+\pi a^2C_1+2\pi\left(\frac{H_1}{a^*}\right)}$ $\Phi_m=\frac{C_1\times Q_1}{(2\pi H_1^2+\pi a^2C_1)a^*+2\pi H_1}$
One Head, Inner Reservoir	$Q_1=\bar{R}_1\times 2.16$	
Two Head, Combined Reservoir	$Q_1=\bar{R}_1\times 35.22$ $Q_2=\bar{R}_2\times 35.22$	$G_1=\frac{H_2C_1}{\pi(2H_1H_2(H_2-H_1)+a^2(H_1C_2-H_2C_1))}$ $G_2=\frac{H_1C_2}{\pi(2H_1H_2(H_2-H_1)+a^2(H_1C_2-H_2C_1))}$ $K_{fs}=G_2Q_2-G_1Q_1$ $G_3=\frac{(2H_2^2+a^2C_2)C_1}{2\pi(2H_1H_2(H_2-H_1)+a^2(H_1C_2-H_2C_1))}$ $G_4=\frac{(2H_1^2+a^2C_1)C_2}{2\pi(2H_1H_2(H_2-H_1)+a^2(H_1C_2-H_2C_1))}$ $\Phi_m=G_3Q_1-G_4Q_2$
Two Head, Inner Reservoir	$Q_1=\bar{R}_1\times 2.16$ $Q_2=\bar{R}_2\times 2.16$	

Guelph Permeameter

Input	(green)
Result	(yellow)

Single Head Method (1)

Reservoir Cross-sectional area in cm
(enter "35.22" for Combined and "2.16" for Inner reservoir): **35.22**
Enter water Head Height ("H" in cm): **12**
Enter the Borehole Radius ("a" in cm): **3**

Enter the soil texture-structure category (enter one of the below numbers): **2**

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): **0.0000**

Res Type	35.22
H	12
a	3
H/a	4
a*	0.04
C0.01	1.348
C0.04	1.436
C0.12	1.449
C0.36	1.449
C	1.436
R	0.000
Q	0
pi	3.142

α^* = 0.04 cm^{-1}

C = 1.43553
Q = 0

K_{fs} =
0.00E+00 cm/sec
0.00E+00 cm/min
0.00E+00 m/sec
0.00E+00 inch/min
0.00E+00 inch/sec

Φ_m = 0.00E+00 cm^2/min

Single Head Method (2)

Reservoir Cross-sectional area in cm
(enter "35.22" for Combined and "2.16" for Inner reservoir): **35.22**
Enter water Head Height ("H" in cm): **24**
Enter the Borehole Radius ("a" in cm): **3**

Enter the soil texture-structure category (enter one of the below numbers): **2**

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): **0.0400**

Res Type	35.22
H	24
a	3
H/a	8
a*	0.04
C0.01	1.91215
C0.04	2.0893
C0.12	2.19621
C0.36	2.19621
C	2.0893
R	0.040
Q	0.02348
pi	3.1415

α^* = 0.04 cm^{-1}

C = 2.0893
Q = 0.02348

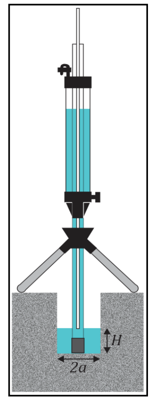
K_{fs} =
6.59E-06 cm/sec
3.95E-04 cm/min
6.59E-08 m/ses
1.56E-04 inch/min
2.59E-06 inch/sec

Φ_m = 1.65E-04 cm^2/min

Average

K_{fs} =
3.29E-06 cm/sec
1.98E-04 cm/min
3.29E-08 m/s
7.78E-05 inch/min
1.30E-06 inch/sec

Φ_m = 8.23E-05 cm^2/min



Double Head Method

Reservoir Cross-sectional area in cm
(enter "35.22" for Combined and "2.16" for Inner reservoir): **35.22**

Enter the first water Head Height ("H1" in cm): **12**
Enter the second water Head Height ("H2" in cm): **24**

Enter the Borehole Radius ("a" in cm): **3**

Enter the soil texture-structure category (enter one of the below numbers): **2**

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

α^* = 0.04 cm^{-1}

α = -0.0791

Steady State Rate of Water Level Change ("R1" in cm/min): **0.0000**
Steady State Rate of Water Level Change ("R2" in cm/min): **0.0400**

Res Type:	35.22
H1/a:	4
H2/a:	8
C1-0.01:	1.34796
C2-0.01:	1.91215
C1-0.04:	1.43553
C2-0.04:	2.0893
C1-0.12:	1.44896
C2-0.12:	2.19621
C1-0.36:	1.44896
C2-0.36:	2.19621

Q_1 = 0
Q_2 = 0.02348
C_1 = 1.43553
C_2 = 2.0893
G_1 = 0.00159
G_2 = 0.00116
G_3 = 0.03918
G_4 = 0.01466

K_{fs} =
2.72E-05 cm/sec
1.63E-03 cm/min
2.72E-07 m/sec
6.43E-04 inch/min
1.07E-05 inch/sec

Φ_m = -3.44E-04 cm^2/min

Θ_{fs} = 0.65 cm^3/cm^3

Θ_i = 0.4 cm^3/cm^3

Sorptivity #NUM! $(cm\ min^{-1/2})$

Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_2/a}{2.081 + 0.121(H_2/a)}\right)^{0.672}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm²/s), a^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $K_{fs} = G_2Q_2 - G_1Q_1$ $G_3 = \frac{(2H_2^2 + a^2C_2)C_1}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_4 = \frac{(2H_1^2 + a^2C_1)C_2}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $\Phi_m = G_3Q_1 - G_4Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

SOILMOISTURE® Guelph Permeameter

Input

Result

Single Head Method (1)

Reservoir Cross-sectional area in cm²

(enter "35.22" for Combined and "2.16" for Inner reservoir): **35.22**

Enter water Head Height ("H" in cm): **5**

Enter the Borehole Radius ("a" in cm): **3**

Enter the soil texture-structure category (enter one of the below numbers): **2**

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): **0.1000**

Res Type	35.22
H	5
a	3
H/a	1.667
a*	0.04
C0.01	0.809
C0.04	0.842
C0.12	0.803
C0.36	0.803
C	0.842
R	0.100
Q	0.059
pi	3.142

α^* = **0.04** cm^{-1}

C = 0.84206

Q = 0.0587

K_{fs} = **5.12E-05** cm/sec; **3.07E-03** cm/min; **5.12E-07** m/sec; **1.21E-03** inch/min; **2.01E-05** inch/sec

Φ_m = **1.28E-03** cm^2/min

Single Head Method (2)

Reservoir Cross-sectional area in cm²

(enter "35.22" for Combined and "2.16" for Inner reservoir): **35.22**

Enter water Head Height ("H" in cm): **10**

Enter the Borehole Radius ("a" in cm): **3**

Enter the soil texture-structure category (enter one of the below numbers): **2**

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): **0.1500**

Res Type	35.22
H	10
a	3
H/a	3.33333
a*	0.04
C0.01	1.21841
C0.04	1.29023
C0.12	1.28754
C0.36	1.28754
C	1.29023
R	0.150
Q	0.08805
pi	3.1415

α^* = **0.04** cm^{-1}

C = 1.29023

Q = 0.08805

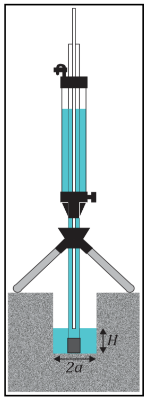
K_{fs} = **5.08E-05** cm/sec; **3.05E-03** cm/min; **5.08E-07** m/ses; **1.20E-03** inch/min; **2.00E-05** inch/sec

Φ_m = **1.27E-03** cm^2/min

Average

K_{fs} = **5.10E-05** cm/sec; **3.06E-03** cm/min; **5.10E-07** m/s; **1.20E-03** inch/min; **2.01E-05** inch/sec

Φ_m = **1.27E-03** cm^2/min



Double Head Method

Reservoir Cross-sectional area in cm²

(enter "35.22" for Combined and "2.16" for Inner reservoir): **35.22**

Enter the first water Head Height ("H1" in cm): **5**

Enter the second water Head Height ("H2" in cm): **10**

Enter the Borehole Radius ("a" in cm): **3**

Enter the soil texture-structure category (enter one of the below numbers): **2**

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

α^* = **0.04** cm^{-1}

α = **0.0367**

Steady State Rate of Water Level Change ("R1" in cm/min): **0.1000**

Steady State Rate of Water Level Change ("R2" in cm/min): **0.1500**

Res Type:	35.22
H1/a:	1.66667
H2/a:	3.33333
C1-0.01:	0.80949
C2-0.01:	1.21841
C1-0.04:	0.84206
C2-0.04:	1.29023
C1-0.12:	0.80315
C2-0.12:	1.28754
C1-0.36:	0.80315
C2-0.36:	1.28754

Q_1 = 0.0587

Q_2 = 0.08805

C_1 = 0.84206

C_2 = 1.29023

G_1 = 0.00542

G_2 = 0.00415

G_3 = 0.05881

G_4 = 0.02452

K_{fs} = **4.75E-05** cm/sec; **2.85E-03** cm/min; **4.75E-07** m/sec; **1.12E-03** inch/min; **1.87E-05** inch/sec

Φ_m = **1.29E-03** cm^2/min

Θ_{fs} = **0.65** cm^3/cm^3

Θ_i = **0.4** cm^3/cm^3

Sorptivity **0.0254** ($cm\ min^{-1/2}$)

Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_2/a}{2.081 + 0.121(H_2/a)}\right)^{0.672}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm²/s), a^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	$\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $K_{fs} = G_2Q_2 - G_1Q_1$ $G_3 = \frac{(2H_2^2 + a^2C_2)C_1}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	$G_4 = \frac{(2H_1^2 + a^2C_1)C_2}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $\Phi_m = G_3Q_1 - G_4Q_2$

Guelph Permeameter

Input

Result

Single Head Method (1)

Reservoir Cross-sectional area in cm²

(enter "35.22" for Combined and "2.16" for Inner reservoir): 35.22
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 2

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.0000

Res Type 35.22
H 10
a 3
H/a 3.333
a* 0.04
C0.01 1.218
C0.04 1.29
C0.12 1.288
C0.36 1.288
C 1.29
R 0.000
Q 0
pi 3.142

α^* = 0.04 cm^{-1}

C = 1.29023
Q = 0

K_{fs} = 0.00E+00 cm/sec
0.00E+00 cm/min
0.00E+00 m/sec
0.00E+00 inch/min
0.00E+00 inch/sec

Φ_m = 0.00E+00 cm^2/min

Single Head Method (2)

Reservoir Cross-sectional area in cm²

(enter "35.22" for Combined and "2.16" for Inner reservoir): 35.22
Enter water Head Height ("H" in cm): 23
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 2

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.1000

Res Type 35.22
H 23
a 3
H/a 7.66667
a* 0.04
C0.01 1.87494
C0.04 2.04504
C0.12 2.14467
C0.36 2.14467
C 2.04504
R 0.100
Q 0.0587
pi 3.1415

α^* = 0.04 cm^{-1}

C = 2.04504
Q = 0.0587

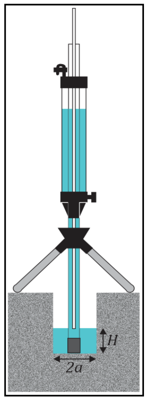
K_{fs} = 1.72E-05 cm/sec
1.03E-03 cm/min
1.72E-07 m/ses
4.05E-04 inch/min
6.76E-06 inch/sec

Φ_m = 4.29E-04 cm^2/min

Average

K_{fs} = 8.58E-06 cm/sec
5.15E-04 cm/min
8.58E-08 m/s
2.03E-04 inch/min
3.38E-06 inch/sec

Φ_m = 2.15E-04 cm^2/min



Double Head Method

Reservoir Cross-sectional area in cm²

(enter "35.22" for Combined and "2.16" for Inner reservoir): 35.22

Enter the first water Head Height ("H1" in cm): 10
Enter the second water Head Height ("H2" in cm): 23

Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 2

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

α^* = 0.04 cm^{-1}

α = -0.0936

Steady State Rate of Water Level Change ("R1" in cm/min): 0.0000
Steady State Rate of Water Level Change ("R2" in cm/min): 0.1000

Q_1 = 0

Q_2 = 0.0587

Res Type: 35.22
H1/a: 3.33333
H2/a: 7.66667
C1-0.01: 1.21841
C2-0.01: 1.87494
C1-0.04: 1.29023
C2-0.04: 2.04504
C1-0.12: 1.28754
C2-0.12: 2.14467
C1-0.36: 1.28754
C2-0.36: 2.14467

C_1 = 1.29023

C_2 = 2.04504

G_1 = 0.00159

G_2 = 0.00109

G_3 = 0.03748

G_4 = 0.01168

K_{fs} = 6.42E-05 cm/sec
3.85E-03 cm/min
6.42E-07 m/sec
1.52E-03 inch/min
2.53E-05 inch/sec

Φ_m = -6.86E-04 cm^2/min

Θ_{fs} = 0.65 cm^3/cm^3

Θ_i = 0.4 cm^3/cm^3

Sorptivity #NUM! ($cm\ min^{-1/2}$)

Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_2/a}{2.081 + 0.121\left(H_2/a\right)}\right)^{0.672}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091\left(H_1/a\right)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091\left(H_2/a\right)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093\left(H_1/a\right)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093\left(H_2/a\right)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093\left(H_1/a\right)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093\left(H_2/a\right)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm²/s), a^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $K_{fs} = G_2 Q_2 - G_1 Q_1$ $G_3 = \frac{(2H_2^2 + a^2 C_2)C_1}{2\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $G_4 = \frac{(2H_1^2 + a^2 C_1)C_2}{2\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $\Phi_m = G_3 Q_1 - G_4 Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

Reference No. 2208-W125

Test 1A

Test 1C

Reference No. 2208-W125

Test 2A

Test 2B