Hanley Park North Residential Subdivision

Stormwater Management Report

Part of Lots 14 & 15, Concession 1
Former Thurlow Township
City of Belleville
Hastings County

January 2020

AINLEY GRAHAM & ASSOCIATES

CONSULTING ENGINEERS AND PLANNERS
COLLINGWOOD · BARRIE · BELLEVILLE · KINGSTON · OTTAWA

File No. 18578-1

CONSULTING
ENGINEERS
PLANNERS

TABLE OF CONTENTS

1.0 INTRODUCTION

Ainley Group has been retained to undertake engineering services necessary for the completion of a stormwater management study to support Draft Plan approval for the proposed Hanley Park North residential development.

2.0 SITE DESCRIPTION

2.1 Existing Conditions

The property is legally described as part of Lots 14 and 15, Concession 1, former Township of Thurlow, now City of Belleville, Hastings County. The parcel of land is approximately 35.2 hectares (ha), 11.3 ha of which is developable. The property is bounded to the west by the existing Mercedes Meadows residential development and is bounded by vacant lands to the north, east and south. The proposed development will include extensions of the existing temporary dead-ends at Tessa Boulevard and Spruce Gardens (Mercedes Meadows development).

The Bell Creek Wetland (BCW) occurs within the subject property. The property is currently vacant and partially treed. The site is predominately flat with a slope to the southeast. Drainage is generally conveyed to the BCW. As the development lies within the Bell Creek watershed, it lies within an area that has been reviewed as part of a master drainage plan.

The Stormwater Management Report Stanley Park West Subdivisions (G.M. Sernas, June 1996) report evaluated stormwater management on a watershed basis for Bell Creek, Tributary 1. It was anticipated that the proposed development lands would be developed as a residential type land use. The recommendations in the report stated that the majority of the lands within the tributary catchment area would contribute to several centralized stormwater management facilities that would address quantity controls, however the lands along the eastern boundary of the study area were not considered as contributors in the design of the central facilities. It was proposed that the eastern lands would not require quantity controls as a means of reducing the peak flow from the drainage area by allowing the peak from the east lands to move out of the system prior to the peak from the upstream area. The quantity control / conveyance requirements for the site are further described in Section 5.0.

A site location plan is attached to this report as **Figure 1**.

2.2 Proposed Conditions

The property is proposed to be developed with the following:

- Ninety-nine (99) single family lots,
- Fifty-seven (57) townhouse lots,
- Park/Parkette blocks (5,420 m^2),
- Stormwater management facility block (5,180 m^2),
- Walkways (630 m^2), and
- Approximately 1,200m of Municipal Road Allowance with 20m width.

The current conceptual development plan is attached to this report as **Figure 2**. A portion of the development includes an extension of Spruce Gardens with six (6) single family units. The majority of the units (93 single family, 57 townhouse) in the proposed development will be in the southern portion of the property, accessed through Tessa Boulevard. The stormwater management for these distinct areas will be separate, given the distance between the two areas. The portion of the development extending from Spruce Gardens will be identified as “Area 1” whereas the portion of the development extending from Tessa Boulevard will be identified as “Area 2” (**Figure 3**).

3.0 PROPOSED STORM SEWER

Storm sewers will be provided to service the subject lands. Drainage will generally be conveyed through Area 1 toward the parkland block and drainage through Area 2 will generally be conveyed toward the southeast to the proposed SWM facility block. As shown in **Figure 3**, rear yard run-off from the majority of the lots will be directed toward the Bell Creek tributary / wetland areas and will not be directed toward the SWM facilities.

4.0 HYDROLOGY

4.1 Model Selection

Flow calculations for the post development conditions were carried out using the SWMHYMO computer program. This program is a complex hydrologic model used for the simulation and management of stormwater runoff in either small or large rural and urban areas.

4.2 Rainfall Distribution

The quality storm hyetograph was developed in accordance with a typical 4-hour distribution for the 25 mm rainfall event. Additionally, the 5 year 3-hour Chicago storm was analyzed for conveyance purposes through the SWM facility and the 100 year 3-hour Chicago distribution was evaluated for overland conveyance of runoff from the site. 3-hour Chicago storm was selected by the designer based on the time to peak for the Area 2 catchment, which is 1.3 hours. To evaluate overland conveyance through Area 1, the 100 year 1-hour Chicago distribution was used given the shorter time to peak for the smaller catchment area. The MTO IDF Look-up Tool was used to determine rainfall distribution and is included in **Appendix A**.

4.3 Model Parameters

The SWMHYMO model has been developed with consideration of the parameters interpreted from air photos, Ontario Soils Mapping, topographic information, and the designer’s knowledge of the site based on visual observations. The soils within the subject site have been identified as Soil Group ‘C’, as they are comprised of Sidney Clay. Based on the existing topography and site conditions, the soils have been assigned a Curve Number of 71 and Runoff Coefficient of 0.35. Supporting documentation is enclosed in **Appendix A**.

An estimate of the contributing site impervious cover for each area has been prepared for use in the SWMHYMO modeling and evaluation of the MOE permanent pool guidelines. It has been estimated that the portion of Area 1 requiring quality treatment will be approximately 40% impervious, with 27% directly connected. It has been estimated that the portion of Area 2 requiring quality treatment will be approximately 48% impervious, with 34% directly connected. Supporting calculations for the estimate of impervious cover are included in **Appendix A**.

4.4 Pre Development

As the proposed development is not required to provide quantity control measures as outlined in the 1996 Master Drainage Plan, no pre-development hydrologic modeling has been carried out as part of this report.

4.5 Post Development

The post development SWMHYMO model was developed to evaluate the runoff rate and volume generated by the Quality (25mm), 5-year, and 100-year Quantity events from the contributing catchment areas as outlined on **Figure 3**. The SWMHYMO output is included in **Appendix B**. A summary of the post-development flows is as follows:

- Area 1: Quality event (25mm): 0.015 m^3/s
- Area 1: Quantity event (100 year): 0.104m^3/s
- Area 2: Quality event (25mm): 0.241 m^3/s
- Area 2: 5 Year: 0.615 m^3/s
- Area 2: Quantity event (100 year): 1.341 m^3/s

5.0 STORMWATER QUANTITY CONVEYANCE

Drainage of the site will be handled by an urban cross-section including curb, gutters, and storm sewers. Storm sewers will be designed in accordance with the City of Belleville design standards to convey the 5 year flows. For Area 1, drainage will be conveyed toward the proposed parkland block and for Area 2, storm sewers will convey drainage towards the proposed SWM facility block. Site grading and grassed swales will ensure that all overland runoff in excess of the 5 year storm will be conveyed around the parkland and SWM facility and directed southeast toward the tributary of Bell Creek.

As discussed in Section 2.1, based on review of the Master Drainage Plan (1996), it is our understanding that the Stanley Park facility was designed to overcontrol discharge rates, allowing for proposed developments to the east (i.e. Mercedes Meadows, Hanley Park North) to convey stormwater directly to the Bell Creek System uncontrolled. As such, quantity control measures are not required. The property lies within close proximity to Bell Creek; conveyance of the quantity events (i.e. 0.104 m^3/s, 1.341 m^3/s; 100 year flow) from the areas to Bell Creek will need to be provided. It is proposed to provide conveyance of these flows via overland flow routes. The proposed cross-sections for Area 1 and Area 2 overland flow routes are included in **Appendix C**.

The Bell Creek wetland and / or floodplain areas identified by the Conservation Authority are proposed to remain in their natural state; no development is proposed within these areas. The uncontrolled release of rear yard runoff is not anticipated to adversely affect this environmentally protected area.

6.0 STORMWATER QUALITY CONTROL

The minor flows generated from all events up to and including the 5-year event will be conveyed through the storm sewer systems. The post-development flow for the quality (25mm) event for Area 1 is 0.015 m^3/s and for Area 2 is 0.241 m^3/s.

Given the small contributing catchment for Area 1, quality control will be possible through a level spreader berm. According to the MOE SWM Design Guidelines, this alternative is suitable for catchment areas under 2 ha, and this option would be easily implemented within the proposed parkland block to the immediate south of Area 1. Sample level spreader berm design is included in **Appendix D**. The detailed design will be included as part of the engineering for that phase of development and incorporated in the final stormwater management report for the site.

It is proposed that quality control for Area 2 will be managed through the SWM Facility located within the southeastern limits of Hanley Park North. It should be noted that the proposed development will include a 30m setback from the wetland; and will be outside of the floodline, meeting the standards and requirements from Quinte Conservation.

Using SWMHYMO, it was estimated using the ROUTE RESERVOIR command that the 25mm event would require a storage volume of 1,017 m^3 to provide a 24 hour draw down of the stormwater runoff. The resulting peak discharge rate would be 0.012 m^3/s. The SWMHYMO output files are included in **Appendix B**.

7.0 POND DESIGN

Given the large area of the contributing site (Area 2), 7.05 ha, it is proposed to provide quality controls through the use of an extended detention wet pond facility. The design guidance provided in the MOE manual, section 4.6.2 has been utilized in the design of the on-site SWM facility.

The facility will provide a permanent pool volume of approximately 1,077 m^3 (300 m^3 in the forebay, 777 m^3 in the main pond). The forebay and main pond have both been designed with a maximum permanent pool depth of 1.5 m.

Using a reverse slope outlet pipe with a 75 mm diameter orifice, a controlled discharge rate of 0.012 m^3/s has been estimated from the facility during the 25 mm quality event. Supporting calculations for the development of the stage-storage-discharge curve used in the ROUTE RESERVOIR routine in SWMHYMO is included in **Appendix E**.

An overflow spill way has been incorporated into the design of the maintenance road to convey the 5-year post development flows from the facility. Supporting calculations for the overflow are included in **Appendix E** in the Stage-Storage-Discharge curve table.

All side slopes within the permanent pool have been designed at 5:1. The active portion of the pond has side slopes of 5:1. Table 1 provides a summary of recommended design parameters (MOE) and the proposed pond design.

Table 1: Summary of Pond Design Requirements

Component	Recommended	Provided
Drainage Area	> 5 ha	7.05 ha
Treatment Volume (Table 3.2) @ 55 % imp.	1340 m^3	+2000 m^3
Quality Treatment	40 m^3/ha	25 mm event
Permanent Volume	1058 m^3	1077 m^3
Active Volume (MOE)	282 m^3	1456 m^3
Forebay Depth (permanent)	Min. 1 m	1.5 m
Main Depth (permanent)	Min. 1 m	1.1 m
Active Depth (quality)	Max 1.5	1 m
Draw Down Time	24 hour	24 hour

A design plan of the SWM facility is provided in **Figure 4** and supporting design calculations have been provided in **Appendix E**.

8.0 MAINTENANCE

Based on the annual loading rates provided in the MOE manual it has been estimated that this site will generate approximately 11.1 m^3 of sediment per year that will accumulate in the SWM facility. It has been estimated that, at this rate, the forebay berm will require cleanout on a 10-year cycle and the main pond should have a cleanout on a minimum 20-year cycle.

The permanent pool portions of the forebay and main pond were sized with consideration for the loss of storage volume based on accumulated sediment.

Supporting calculations are provided in the pond calculations within **Appendix E**.

9.0 EROSION AND SEDIMENTATION CONTROL

An erosion and sediment control strategy will be implemented as per the plan included in the detailed engineering drawing package in order to minimize the transfer of silt off-site during construction. The following measures will be incorporated into the strategy as required:

- Environmental fencing and straw bales
- Regular inspection of the erosion and sediment control devices
- Removal and disposal of the erosion and sediment control devices after the site has been stabilized
- All exposed earth to be re-vegetated within thirty days

10.0 CONCLUSIONS

- Quantity control mitigation measures are not required due to the close proximity of Bell Creek as outlined in the 1996 Master Drainage Plan. Conveyance of the quantity event

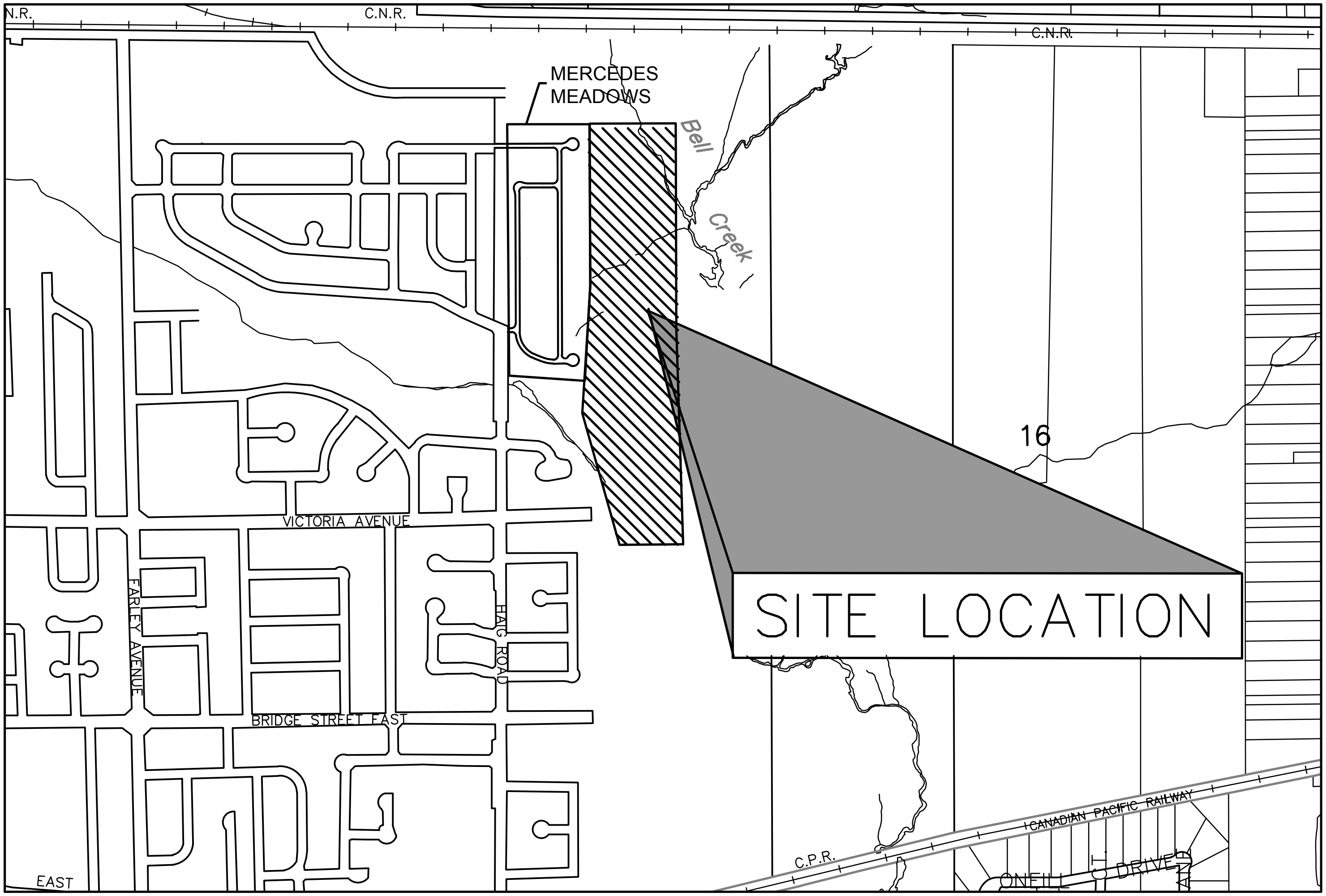
(100 year) will be provided from both areas to the tributary of Bell Creek.
- Quality control for the units extending from Spruce Gardens (Area 1) will be provided within the parkland area through a level spreader berm.
- Quality control for the units extending from Tessa Boulevard (Area 2) will be provided in a new wet pond facility.
- Silt fencing and straw bale barriers will be in place during construction.
- The forebay will require removal of accumulated sediment on a 12-year cycle and the main pond should have a cleanout on a minimum 20-year cycle.

We trust the above information meets your needs at this time and should you have any further questions or concerns, please do not hesitate to contact our office.

Sincerely,
AINLEY GRAHAM & ASSOCIATES LIMITED

Prepared by:
Victoria Chapman
Engineering Intern

Reviewed by:
Caitlin Sheahan, M.Sc., P. Eng.
Project Engineer



HANLEY PARK NORTH
CITY OF BELLEVILLE

FIGURE 1
KEY MAP

Ainley
CONSULTING
ENGINEERS
PLANNERS

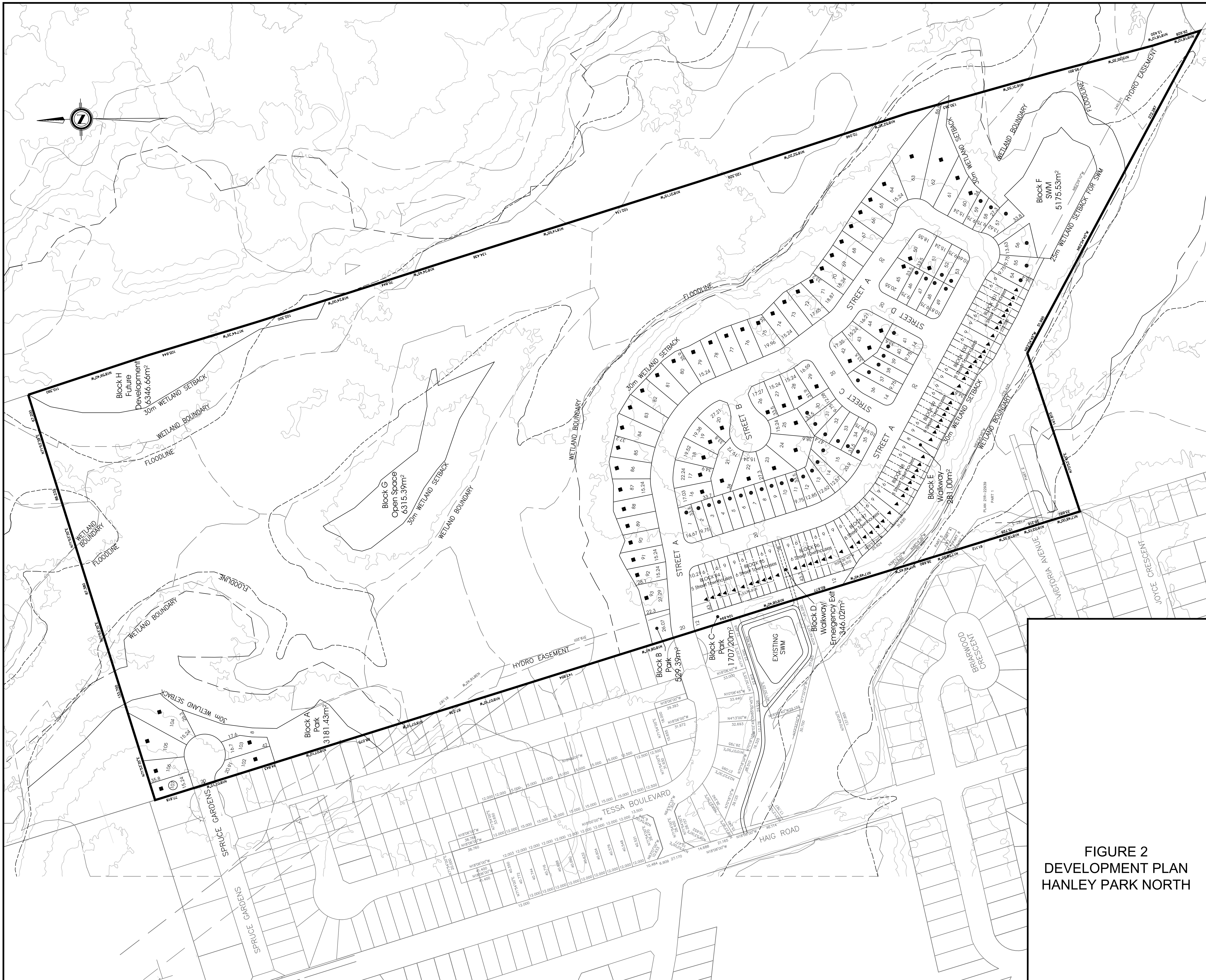
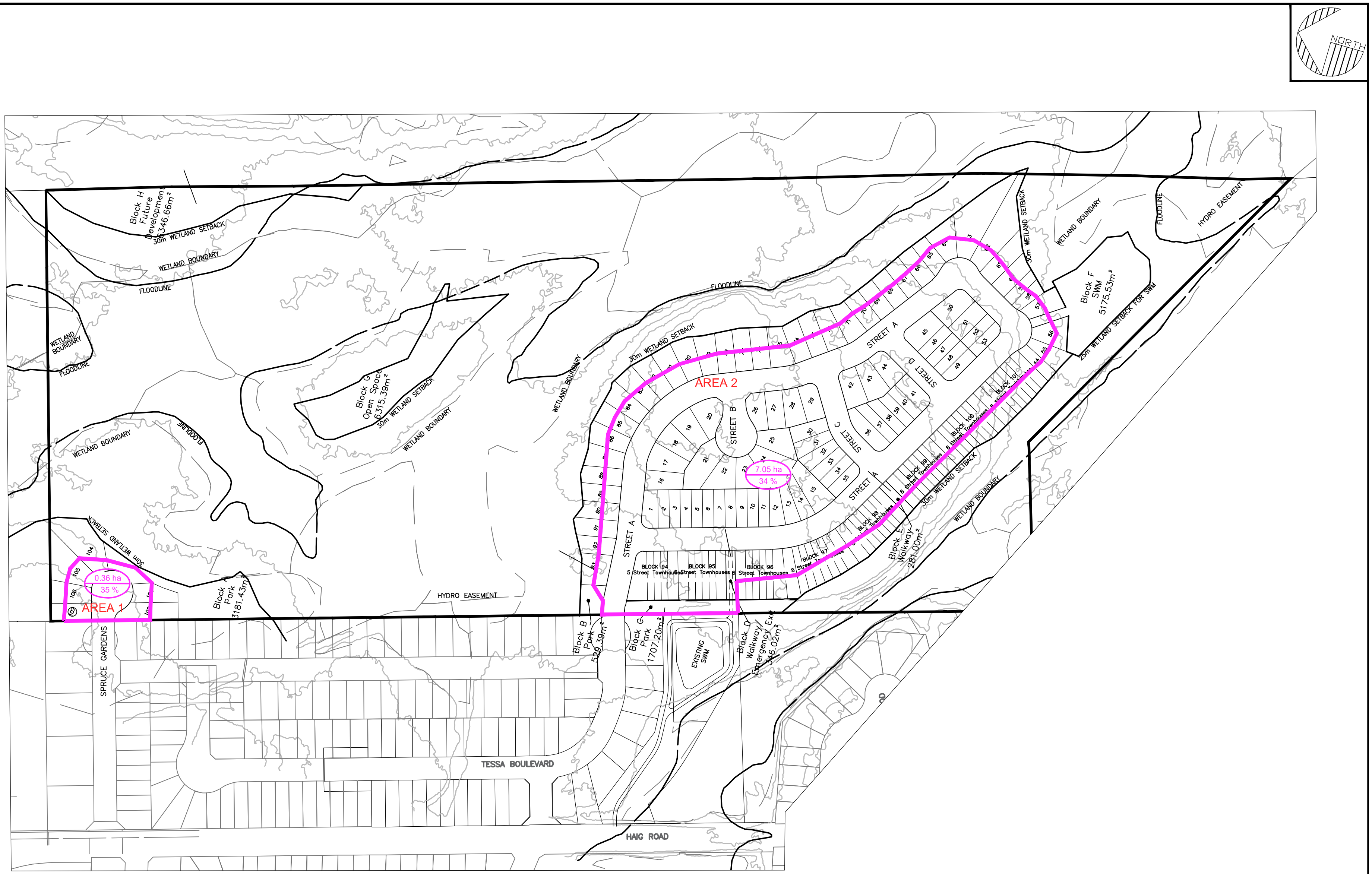


FIGURE 2
DEVELOPMENT PLAN
HANLEY PARK NORTH



7.05 ha / 34 % — DENOTES DRAINAGE AREA IN HECTARES / DENOTES PERCENT IMPERVIOUSNESS

HANLEY PARK North
CITY OF BELLEVILLE

FIGURE 3
POST DEVELOPMENT

Ainley GROUP — CONSULTING ENGINEERS PLANNERS

RESTORATION NOTES

HYDRIC/TOPSOIL SCRAPED FROM THE MAINTENANCE ROAD, OVERFLOW AND POND AREA TO BE STOCKPILED FOR USE IN FINAL GRADING OF FACILITY TO HELP NATURAL RE-VEGETATION. LOCATION TO BE AT ENGINEERS DIRECTION.

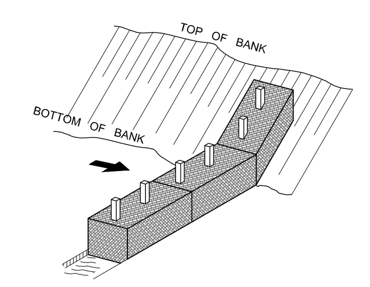
FACILITY TO BE FINISHED WITH MINIMUM OF 50mm TOPSOIL.

SEEDING TO BE AT THE DIRECTION OF THE ENGINEER USING ONTARIO MEADOW MIX (MESIC) (8KG/Ha.)

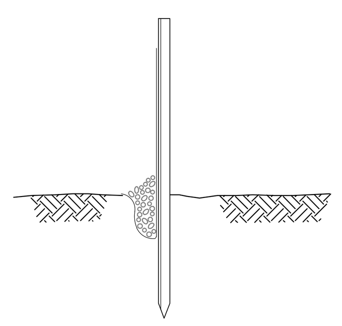
EROSION AND SEDIMENT CONTROLS DURING CONSTRUCTION.

CONTROL OF EROSION ON CONSTRUCTION SITES AND THE REMOVAL OF SEDIMENTS FROM CONSTRUCTION SITE RUN-OFF IS VERY IMPORTANT IF DOWNSTREAM AREAS ARE TO BE PROTECTED DURING ALL CONSTRUCTION. EROSION AND SEDIMENTATION SHOULD BE CONTROLLED BY THE FOLLOWING TECHNIQUES:

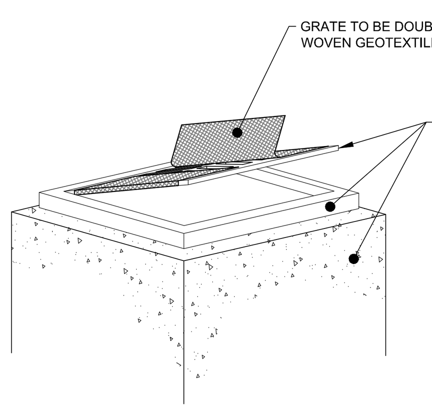
1. LIMITING THE EXTENT OF EXPOSED SOILS AT ANY GIVEN TIME.
2. REVEGETATION OF EXPOSED AREAS AS SOON AS POSSIBLE.
3. MINIMIZATION OF AREA TO BE CLEARED AND GRUBBED.
4. PROTECTION OF EXPOSED SLOPES WITH PLASTIC OR SYNTHETIC MULCHES.
5. INSTALLATION OF FILTER CLOTH BETWEEN FRAME AND COVER ON ALL PROPOSED CATCH BASINS AND CATCH BASIN MANHOLES AND ON ALL EXISTING CATCH BASINS THAT WILL BE AFFECTED BY RUN-OFF FROM THE SITE.
6. A SILT FENCE (O.P.S.D. 219.110) TO BE INSTALLED AROUND THE PERIMETER OF STOCKPILES OF ANY TOPSOIL TO BE USED OR REMOVED FROM SITE. (LOCATION TO BE DETERMINED)
7. A VISUAL INSPECTION TO BE DONE DAILY ON SEDIMENT CONTROL MEASURES AND CLEANED OF ANY ACCUMULATED SILT AS REQUIRED. THE DEPOSITS WILL BE DISPOSED OF AS PER THE REQUIREMENT OF THE CONTRACT.
8. IN SOME CASES SOME FILTER BARRIERS MAY BE REMOVED TEMPORARILY TO ACCOMMODATE THE CONSTRUCTION OPERATIONS. THE AFFECTED BARRIERS WILL BE REINSTATED AT NIGHT WHEN CONSTRUCTION IS COMPLETED. NO REMOVAL WILL OCCUR IF THERE IS A RUN OFF OR PREDICTED RAIN FALL UNLESS A NEW DEVICE HAS BEEN INSTALLED TO ENSURE THE EXISTING STORM AND SANITARY SEWER SYSTEMS WILL NOT BE CONTAMINATED.
9. NO REFUELING OR CLEANING OF EQUIPMENT NEAR ANY EXISTING WATERWAYS.



STRAWBALE SEDIMENT CONTROL
O.P.S.D. 219.100 (TYP.)
N.T.S.

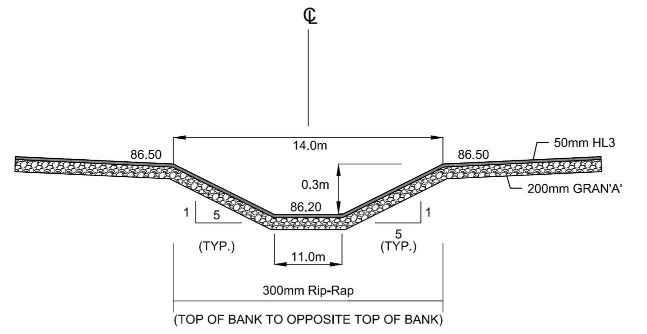


SILTATION FENCE
O.P.S.D. 219.110 (TYP.)
N.T.S

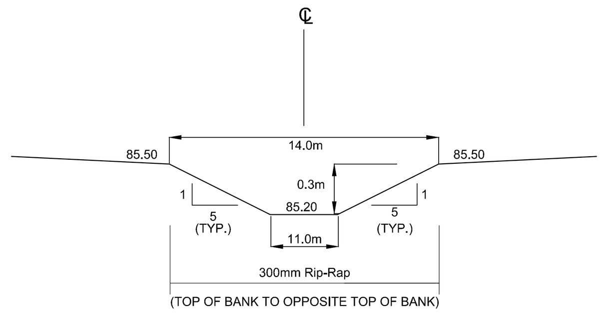


NOTES:
1. TO BE USED UNDER APPROPRIATE DRAINAGE CIRCUMSTANCES, DURING THE CONSTRUCTION PERIOD.
2. WOVEN GEOTEXTILE TO HAVE A MINIMUM EQUIVALENT OPENING SIZE OF 0.15mm AND A MAXIMUM EQUIVALENT OPENING SIZE OF 0.25mm.
3. WOVEN GEOTEXTILE TO BE REPLACES PERIODICALLY WHEN ACCUMULATED SEDIMENTS INTERFERE WITH DRAINAGE.
4. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SHOWN.

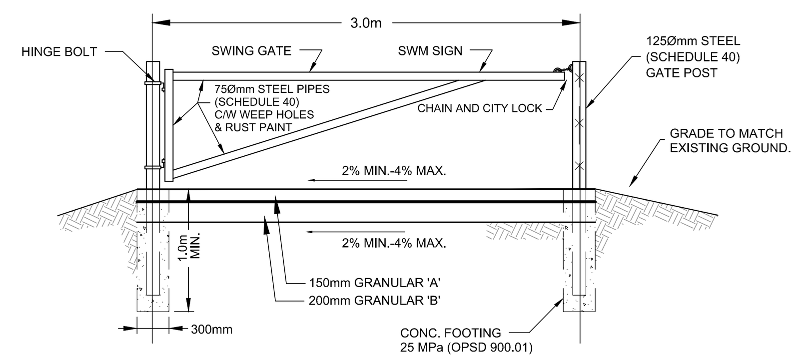
CATCH BASIN/DITCH INLET SEDIMENT BARRIER
N.T.S.



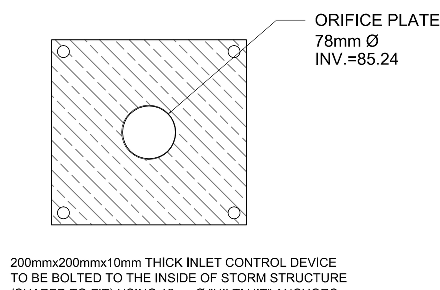
OVERFLOW SPILLWAY DETAIL
N.T.S.



SPILLWAY DETAIL
N.T.S.

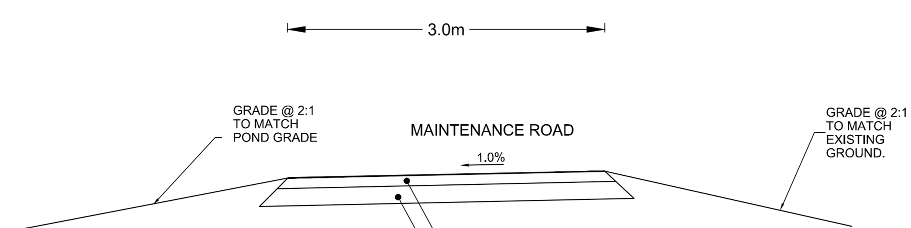


MAINTENANCE ROAD ACCESS GATE
N.T.S.

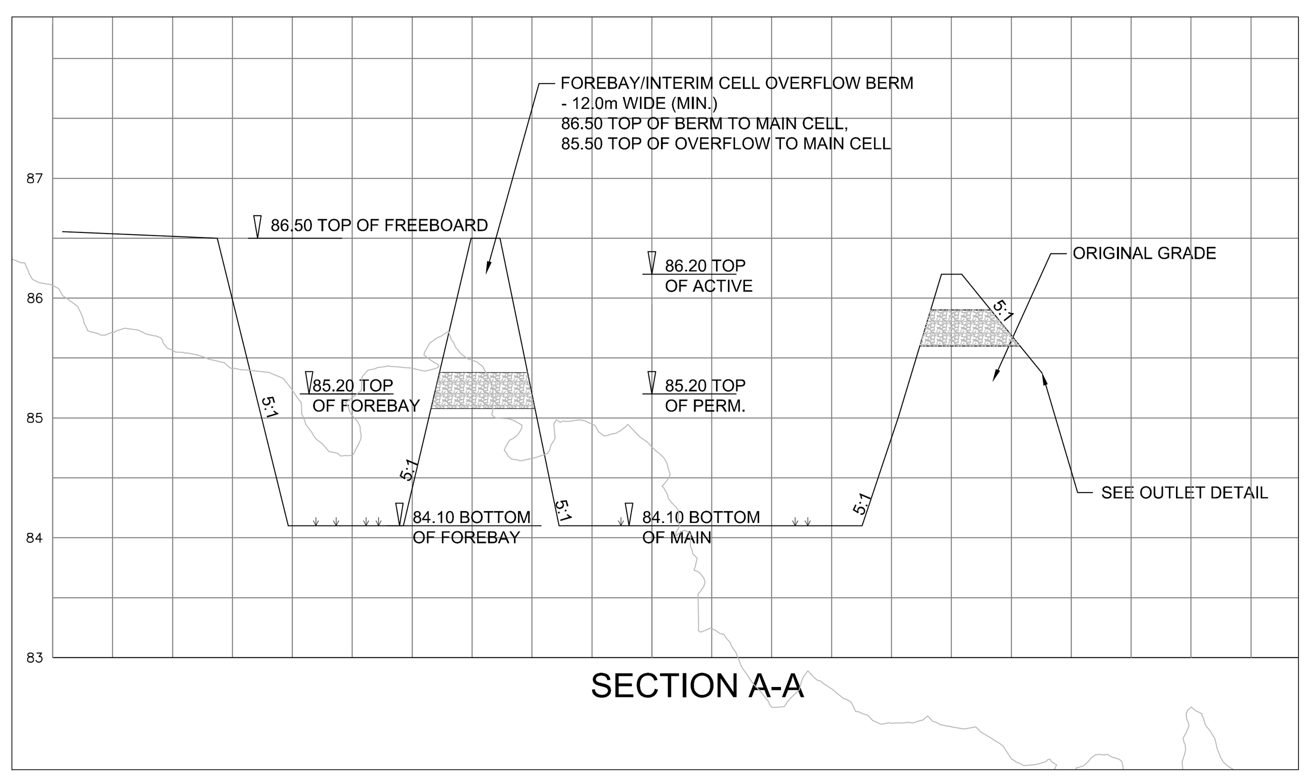


200mmx200mmx10mm THICK INLET CONTROL DEVICE TO BE BOLTED TO THE INSIDE OF STORM STRUCTURE (SHAPED TO FIT) USING 12mmØ "HILTI HIT" ANCHORS.

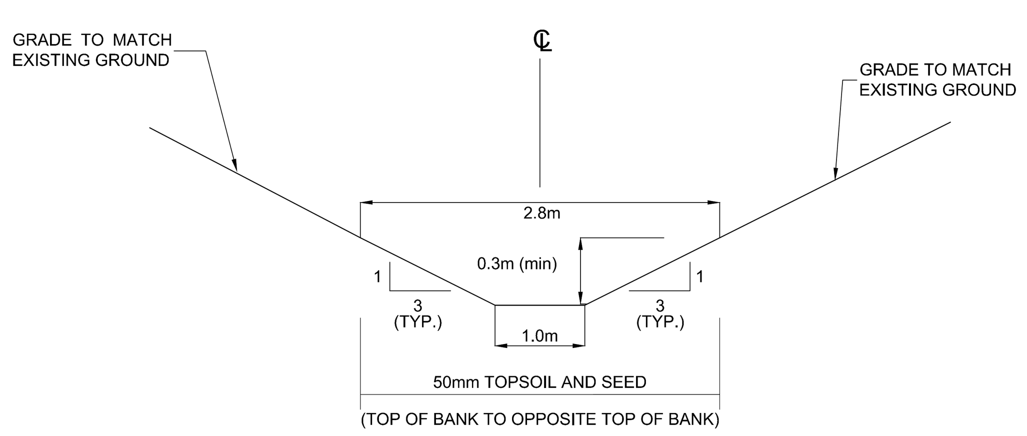
INLET CONTROL DEVICE
N.T.S.



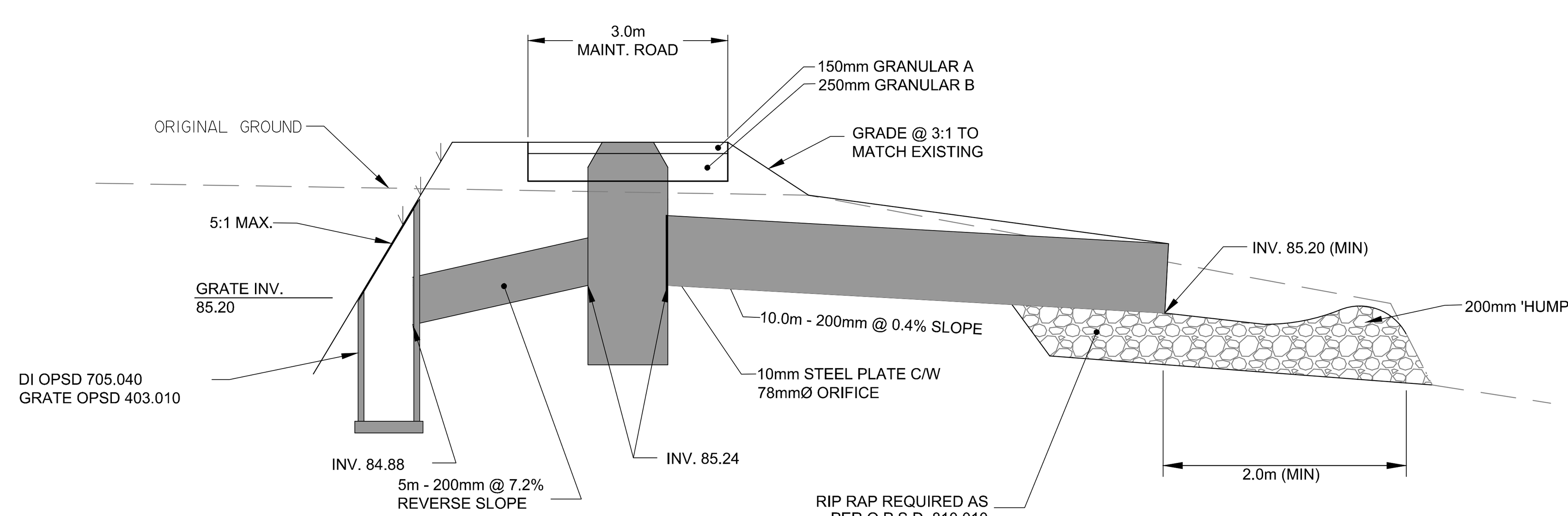
3.0m POND MAINTENANCE ROAD DETAIL
N.T.S.



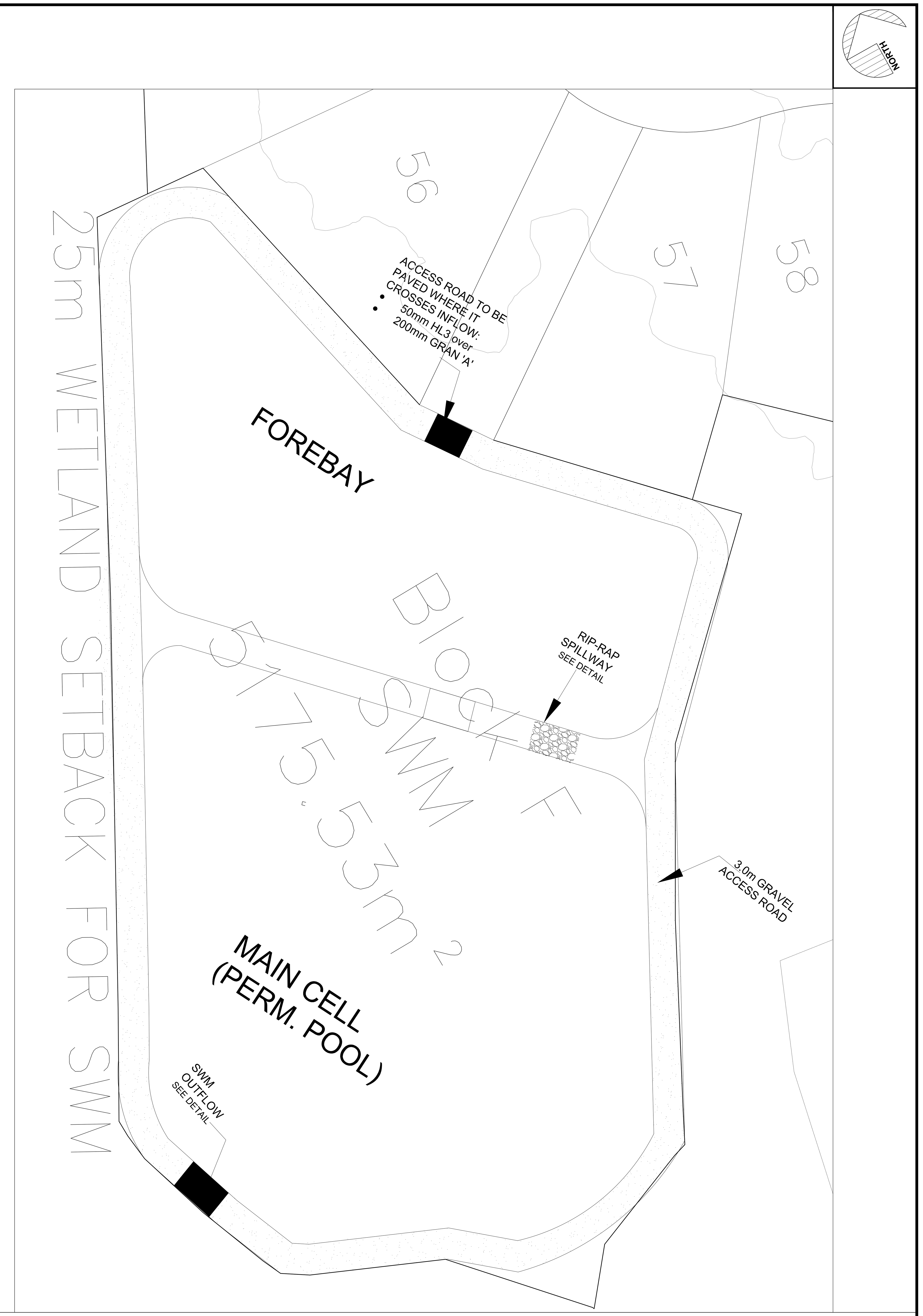
SECTION A-A



SWM INFLOW DETAIL
N.T.S.



SWM OUTFLOW DETAIL
N.T.S.



HANLEY PARK NORTH

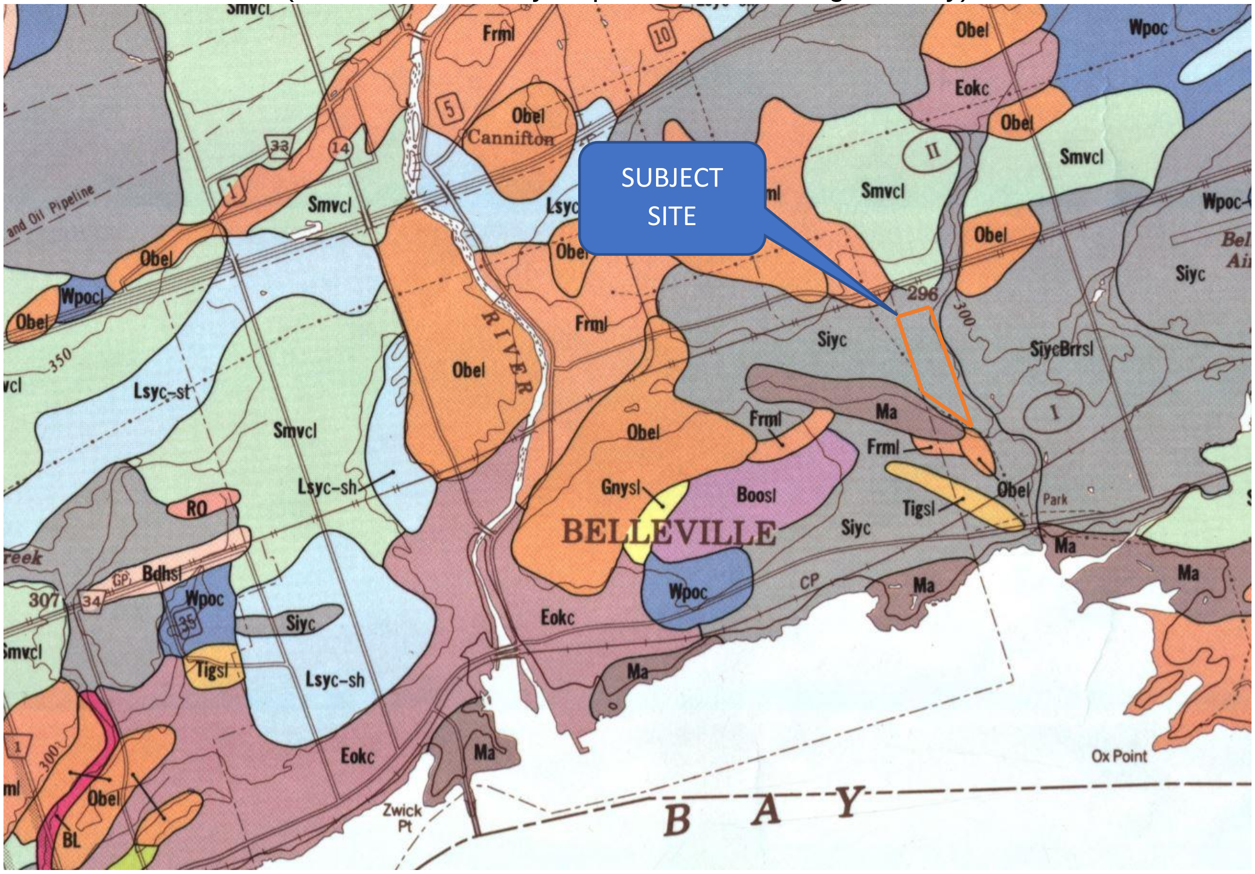
FIGURE 4
SWM POND DESIGN

Ainley GROUP
CONSULTING
ENGINEERS
PLANNERS

APPENDIX A

Model Parameters

Soil Classification
(Ontario Soil Survey Report No 27, Hastings County)



SOIL TEXTURE

c	clay
l	loam
cl	clay loam
sl	sandy loam
sil	silt loam
fsl	fine sandy loam
gs	gravelly sand
ls	loamy sand

SOIL PHASE

b	bouldery
R	rock outcrop
s	steep
sh	shallow
st	stony

Shy	**SOUTH BAY**	Gray-Brown Podzolic	Moderately well drained
Siy	**SIDNEY**	Dark Gray Gleysolic	Poor
Smv	**SOLMESVILLE**	Gray-Brown Podzolic	Imperfect

Design Chart 1.08: Hydrologic Soil Groups (Continued)

- Based on Soil Texture

Sands, Sandy Loams and Gravels	
- overlying sand, gravel or limestone bedrock, very well drained	A
- ditto, imperfectly drained	AB
- shallow, overlying Precambrian bedrock or clay subsoil	B
Medium to Coarse Loams	
- overlying sand, gravel or limestone, well drained	AB
- shallow, overlying Precambrian bedrock or clay subsoil	B
Medium Textured Loams	
- shallow, overlying limestone bedrock	B
- overlying medium textured subsoil	BC
Silt Loams, Some Loams	
- with good internal drainage	BC
- with slow internal drainage and good external drainage	C
Clays, Clay Loams, Silty Clay Loams	
- with good internal drainage	C
- with imperfect or poor external drainage	C
- with slow internal drainage and good external drainage	D

Source: U.S. Department of Agriculture (1972)

Design Chart 1.07: Runoff Coefficients (Continued)

- Rural RC

Land Use & Topography[3]	Soil Texture		
	Open Sand Loam	Loam or Silt Loam	Clay Loam or Clay
CULTIVATED			
Flat 0 - 5% Slopes	0.22	0.35	0.55
Rolling 5 - 10% Slopes	0.30	0.45	0.60
Hilly 10- 30% Slopes	0.40	0.65	0.70
PASTURE			
Flat 0 - 5% Slopes	0.10	0.28	0.40
Rolling 5 - 10% Slopes	0.15	0.35	0.45
Hilly 10- 30% Slopes	0.22	0.40	0.55
WOODLAND OR CUTOVER			
Flat 0 - 5% Slopes	0.08	0.25	0.35
Rolling 5 - 10% Slopes	0.12	0.30	0.42
Hilly 10- 30% Slopes	0.18	0.35	0.52
BARE ROCK	COVERAGE[3]		
	30%	50%	70%
Flat 0 - 5% Slopes	0.40	0.55	0.75
Rolling 5 - 10% Slopes	0.50	0.65	0.80
Hilly 10- 30% Slopes	0.55	0.70	0.85
LAKES AND WETLANDS	0.05		

2 Terrain Slopes

3 Interpolate for other values of % imperviousness

Sources: American Society of Civil Engineers - ASCE (1960)
U.S. Department of Agriculture (1972)

CN.

Design Chart 1.09: Soil Conservation Service Curve Numbers (Continued)

Land Use or Surface	Hydrologic Soil Group						
	A	AB	B	BC	C	CD	D
Fallow (special cases only)	77	82	86	89	91	93	94
Crop and other improved land	66** (62)	70** (68)	74	78	82	84	86 AMC I
Pasture & other unimproved land	58* (38)	62* (51)	65	71	76	79	81
Woodlots and forest	50* (30)	54* (44)	58	65	71	74	77
Impervious areas (paved)							98
Bare bedrock draining directly to stream by surface flow							98
Bare bedrock draining indirectly to stream as groundwater (usual case)							70
Lakes and wetlands							50

Notes

(i) All values are based on AMC II except those marked by * (AMC III) or ** (mean of AMC II and AMC III).

(ii) Values in brackets are AMC II and are to be used only for special cases.

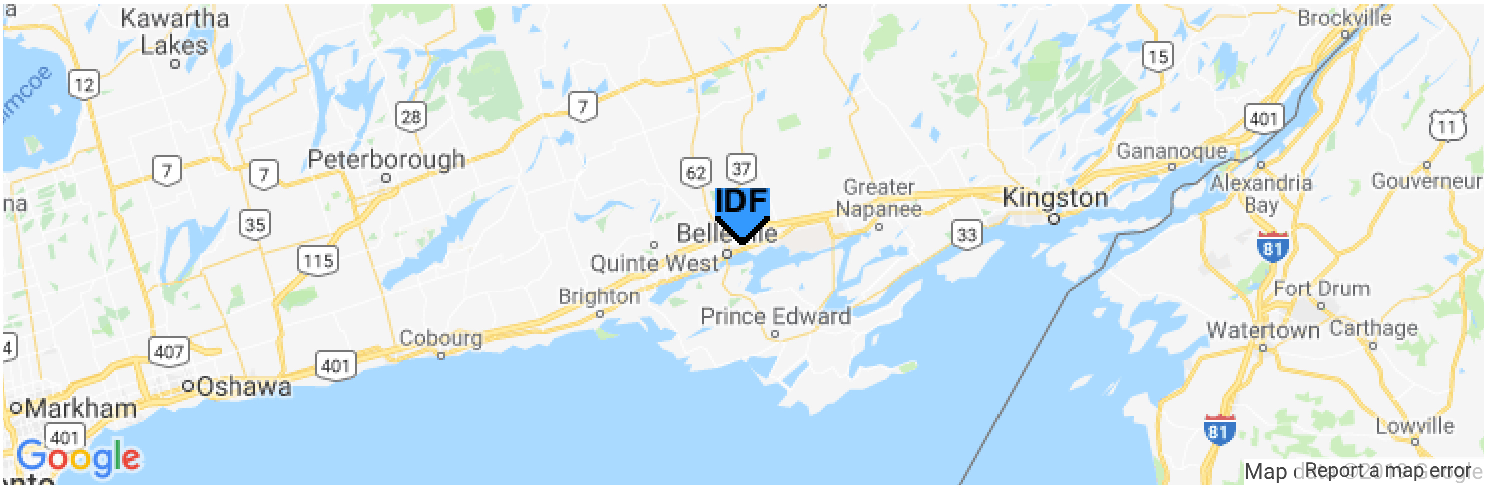
(iii) Table is not applicable to frozen soils or to periods in which snowmelt contributes to runoff.

Ontario IDF CURVE LOOKUP

Active coordinate

44° 10' 45" N, 77° 20' 14" W (44.179167,-77.337500)

Retrieved: Tue, 23 Jul 2019 12:42:32 GMT



Location summary

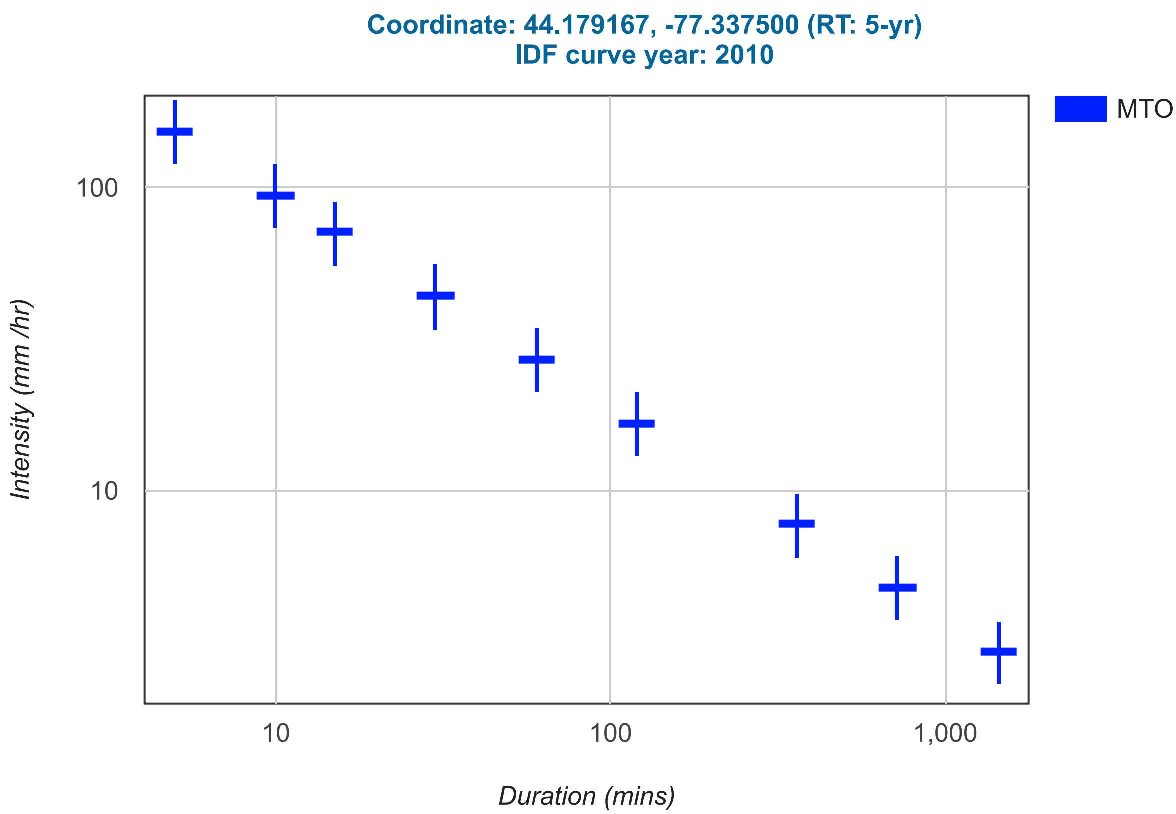
These are the locations in the selection.

IDF Curve: 44° 10' 45" N, 77° 20' 14" W (44.179167,-77.337500)

Results

An IDF curve was found.

Return period: 5-yr Modify selection



Coefficient summary

IDF Curve: 44° 10' 45" N, 77° 20' 14" W (44.179167,-77.337500)

Retrieved: Tue, 23 Jul 2019 12:42:32 GMT

Data year: 2010
IDF curve year: 2010

A: 27.7 (+6.8, -6.8)

B: -0.699

Statistics

Rainfall intensity (mm hr^{-1})

Duration	5-min		10-min		15-min		30-min		1-hr		2-hr		6-hr		12-hr		24-hr	
Intensity (mm hr^{-1})	157.3	+38.7	96.9	+23.9	73.0	+18.0	45.0	+11.1	27.7	+6.8	17.1	+4.2	7.9	+2.0	4.9	+1.2	3.0	+0.7
		-38.7		-23.8		-18.0		-11.1		-6.8		-4.2		-1.9		-1.2		-0.7

Rainfall depth (mm)

Duration	5-min		10-min		15-min		30-min		1-hr		2-hr		6-hr		12-hr		24-hr	
Depth (mm)	13.1	+3.2	16.2	+3.9	18.2	+4.6	22.5	+5.6	27.7	+6.8	34.1	+8.5	47.5	+11.9	58.5	+14.7	72.1	+16.7
		-3.2		-4.0		-4.4		-5.6		-6.8		-8.3		-11.5		-14.1		-16.9

Terms of Use

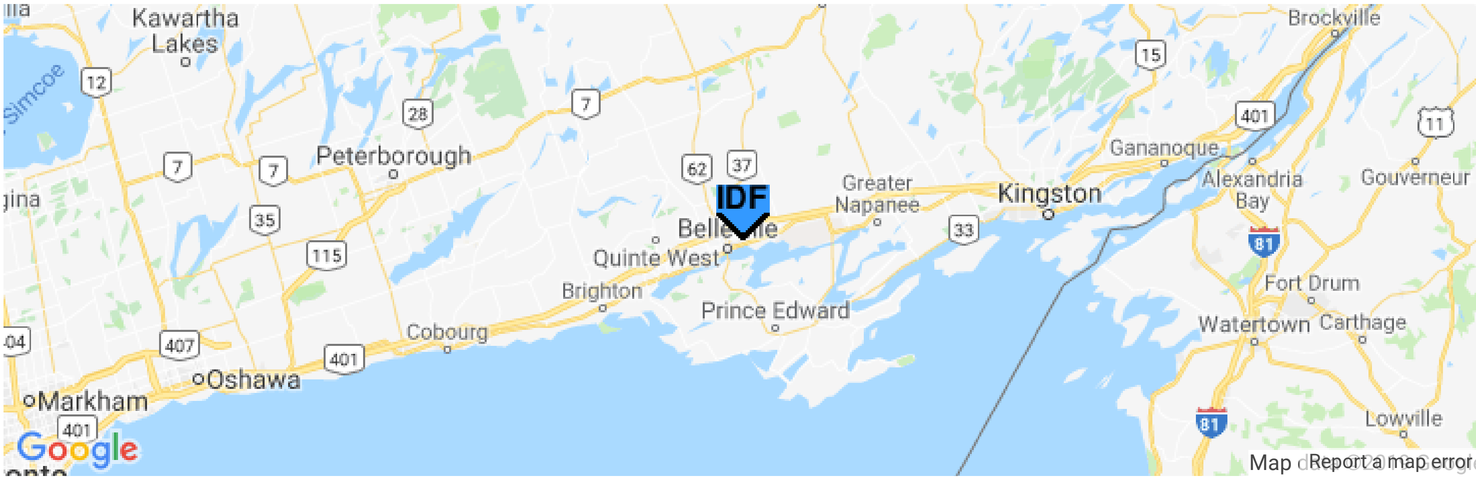
You agree to the Terms of Use of this site by reviewing, using, or interpreting these data.

Ontario IDF CURVE LOOKUP

Active coordinate

44° 10' 45" N, 77° 20' 14" W (44.179167,-77.337500)

Retrieved: Tue, 23 Jul 2019 12:40:11 GMT



Location summary

These are the locations in the selection.

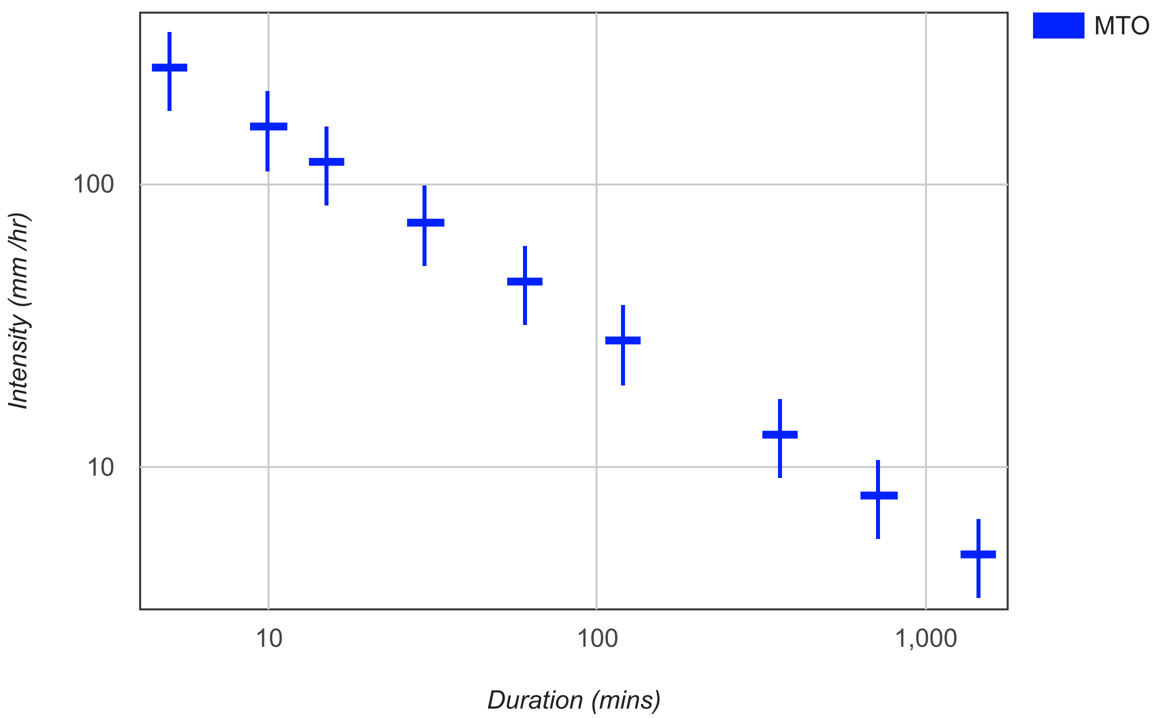
IDF Curve: 44° 10' 45" N, 77° 20' 14" W (44.179167,-77.337500)

Results

An IDF curve was found.

Return period: 100-yr Modify selection

Coordinate: 44.179167, -77.337500 (RT: 100-yr)
IDF curve year: 2010



Coefficient summary

IDF Curve: 44° 10' 45" N, 77° 20' 14" W (44.179167,-77.337500)

Retrieved: Tue, 23 Jul 2019 12:40:11 GMT

Data year: 2010
IDF curve year: 2010

A: 46.2 (+14.8, -14.8)

B: -0.699

Statistics

Rainfall intensity (mm hr^{-1})

Duration	5-min		10-min		15-min		30-min		1-hr		2-hr		6-hr		12-hr		24-hr	
Intensity (mm hr^{-1})	262.4	+84.1	161.6	+51.9	121.8	+39.0	75.0	+24.1	46.2	+14.8	28.5	+9.1	13.2	+4.2	8.1	+2.6	5.0	+1.6
		-84.1		-51.8		-39.1		-24.1		-14.8		-9.2		-4.2		-2.6		-1.6

Rainfall depth (mm)

Duration	5-min		10-min		15-min		30-min		1-hr		2-hr		6-hr		12-hr		24-hr	
Depth (mm)	21.9	+7.0	26.9	+8.7	30.4	+9.8	37.5	+12.0	46.2	+14.8	56.9	+18.3	79.2	+25.2	97.6	+30.8	120.3	+38.1
		-7.0		-8.6		-9.7		-12.1		-14.8		-18.3		-25.2		-31.6		-38.7

Terms of Use

Hanley Park North - Area 1

Estimate of Impervious Cover - Post-Development					CN	C	
Total Area			**0.36**	ha	71	0.35	Directly Connected or not
	#units	**Area (m2)**					
Driveway	6	24	*144.00*	m2	98	0.95	y
Singles	6	135	*810.00*	m2	98	0.95	y (50%)
Towns	0	120	*0.00*	m2	98	0.95	y (50%)
			954.00	m2			
Sidewalk	45	1.5	*67.50*	m2	98	0.95	y (50%)
Road	45	9	*405.00*	m2	98	0.95	y
Total			472.50	m2			
		Total Impervious =	*1426.50*	m2			
			39.63	%			
		Directly Connected Impervious	987.75	m2			
			27.44	%			

Average CN

	A	CN	A*CN	
Total Area	0.36			
Impervious Area	0.14265	98	13.98	
Pervious Area	0.21735	71	15.43	
		SUM	**29.41**	**82**

Average RC

	A	C	A*C	
Total Area	0.36			
Impervious Area	0.14265	0.95	0.14	
Pervious Area	0.21735	0.35	0.08	
		SUM	**0.21**	**0.59**

Hanley Park North- Area 2

Estimate of Impervious Cover - Post-Development					CN	C	
Total Area			**7.05**	ha	71	0.35	Directly Connected or not
	#units	**Area (m2)**					
Driveway	150	24	*3600.00*	m2	98	0.95	y
Singles	93	135	*12555.00*	m2	98	0.95	y (50%)
Towns	57	120	*6840.00*	m2	98	0.95	y (50%)
			22995.00	m2			
Sidewalk	-	730	*730.00*	m2	98	0.95	y (50%)
Road		10300	*10300.00*	m2	98	0.95	y
Total			11030.00	m2			
		Total Impervious =	*34025.00*	m2			
			48.26	%			
		Directly Connected Impervious	23962.50	m2			
			33.99	%			

Average CN

	A	**CN**	**A*CN**	
Total Area	7.05			
Impervious Area	3.4025	98	333.45	
Pervious Area	3.6475	71	258.97	
		SUM	**592.42**	**84**

Average RC

	A	**C**	**A*C**	
Total Area	7.05			
Impervious Area	3.4025	0.95	3.23	
Pervious Area	3.6475	0.35	1.28	
		SUM	**4.51**	**0.64**

APPENDIX B

SWMHYMO Output

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

SSSSS   W   W   M   M   H   H   Y   Y   M   M    OOO        222    000    11   77777 =========
S       W W W   MM MM   H   H    Y Y    MM MM   O   O         2   0   0   11   7   7
SSSSS   W W W   M M M   HHHHH     Y     M M M   O   O         2   0   0   11       7 Ver4.05.0
    S    W W    M   M   H   H     Y     M   M   O   O       222   0   0   11      7  APR 2017
SSSSS    W W    M   M   H   H     Y     M   M    OOO        2     0   0   11     7   =========
                                                            2     0   0   11    7    # 2196493
      StormWater Management HYdrologic Model                222    000    11    7    =========

*****************************************************************************************
**************************************  SWMHYMO Ver4.05.0  *******************************
******************  A single event and continuous hydrologic simulation model  ************
******************     based on the principles of HYMO and its successors      ************
******************                 OTTHYMO-83 and OTTHYMO-89.                  ************
*****************************************************************************************
****************** Distributed by:  J.F. Sabourin and Associates Inc.          ************
******************                  Ottawa,  Ontario: (613) 836-3884           ************
******************                  Gatineau, Quebec: (819) 243-6858           ************
******************                  E-Mail: swmhymo@jfsa.com                   ************
*****************************************************************************************

+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++ Licensed user: Ainley Group                               ++++++++++++
++++++++++++++++++                Belleville           SERIAL#:2196493        ++++++++++++
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

*****************************************************************************************
******************            ++++++ PROGRAM ARRAY DIMENSIONS ++++++           ************
******************            Maximum value for ID numbers  :     11           ************
******************            Max. number of rainfall points: 105408           ************
******************            Max. number of flow points    : 105408           ************
*****************************************************************************************

*****************************************************************************************
**************************************  SWMHYMO Ver4.05.0  *******************************
******************  A single event and continuous hydrologic simulation model  ************
******************     based on the principles of HYMO and its successors      ************
******************                 OTTHYMO-83 and OTTHYMO-89.                  ************
*****************************************************************************************
****************** Distributed by:  J.F. Sabourin and Associates Inc.          ************
******************                  Ottawa,  Ontario: (613) 836-3884           ************
******************                  Gatineau, Quebec: (819) 243-6858           ************
******************                  E-Mail: swmhymo@jfsa.com                   ************
*****************************************************************************************

+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++ Licensed user: Ainley Group                               ++++++++++++
++++++++++++++++++                Belleville           SERIAL#:2196493        ++++++++++++
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

*****************************************************************************************
******************            ++++++ PROGRAM ARRAY DIMENSIONS ++++++           ************
******************            Maximum value for ID numbers  :     11           ************
******************            Max. number of rainfall points: 105408           ************
******************            Max. number of flow points    : 105408           ************
*****************************************************************************************


*****************************   D E T A I L E D   O U T P U T   *************************
*****************************************************************************************
*                 RUN DATE: 2020-01-22     TIME: 15:05:23     RUN COUNTER: 000003       *
*****************************************************************************************
* Input   file: V:\18578-1 - Hanley Park Phase 2\SWM\SWMHYMO\hp3.dat                   *
* Output  file: V:\18578-1 - Hanley Park Phase 2\SWM\SWMHYMO\hp3.out                   *
* Summary file: V:\18578-1 - Hanley Park Phase 2\SWM\SWMHYMO\hp3.sum                   *
* User comments:                                                                        *
* 1:____________________________________________________________________________________*
* 2:____________________________________________________________________________________*
* 3:____________________________________________________________________________________*
*****************************************************************************************

-----------------------------------------------------------------------------------------
R0001:C00001-----------------------------------------------------------------------------
*
* FILE:  18578-1
*
* Hanley Park North
*
--------------------
| START             | Project  dir.:V:\18578-1 - Hanley Park Phase 2\SWM\SWMHYMO\
--------------------- Rainfall dir.:V:\18578-1 - Hanley Park Phase 2\SWM\SWMHYMO\
    TZERO =   .00 hrs on        0
    METOUT=   2 (output = METRIC)
    NRUN  = 0001
    NSTORM=   0
-----------------------------------------------------------------------------------------
R0001:C00002-----------------------------------------------------------------------------
*
*******************************************************************************
*******************************************************************************
*
*********************
* 25 mm QUALITY EVENT
*********************
*
--------------------
| READ STORM        |  Filename: V:\18578-1 - Hanley Park Phase 2\SWM\SWMHYMO\25mm.STM
| Ptotal=  25.00 mm|  Comments: Twenty-Five mm Four Hour Chicago Storm
--------------------
      TIME    RAIN|   TIME    RAIN|   TIME    RAIN|   TIME    RAIN|   TIME    RAIN|   TIME    RAIN
     hh:mm   mm/hr|  hh:mm   mm/hr|  hh:mm   mm/hr|  hh:mm   mm/hr|  hh:mm   mm/hr|  hh:mm   mm/hr
      0:10   2.071|   0:50   3.382|   1:30  50.214|   2:10   5.194|   2:50   3.252|   3:30   2.476
      0:20   2.266|   1:00   4.175|   1:40  13.366|   2:20   4.466|   3:00   3.010|   3:40   2.346
      0:30   2.524|   1:10   5.696|   1:50   8.286|   2:30   3.949|   3:10   2.799|   3:50   2.233
      0:40   2.880|   1:20  10.777|   2:00   6.295|   2:40   3.560|   3:20   2.622|   4:00   2.136

-----------------------------------------------------------------------------------------
R0001:C00003-----------------------------------------------------------------------------
*
* AREA 1
*
--------------------------
| CALIB STANDHYD          |   Area    (ha)=     .36
| 01:       100 DT= 2.00 |   Total Imp(%)=   40.00   Dir. Conn.(%)=   27.00
--------------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        .14          .22
     Dep. Storage     (mm)=        .60         2.50
     Average Slope     (%)=        .60         2.00
     Length            (m)=      40.00        35.00
     Mannings n          =        .013         .250

     Max.eff.Inten.(mm/hr)=      50.21        14.61
                over (min)        2.00        16.00
     Storage Coeff.  (min)=       2.26 (ii)   16.32 (ii)
     Unit Hyd. Tpeak (min)=       2.00        16.00
     Unit Hyd. peak  (cms)=        .50          .07
                                                           *TOTALS*
     PEAK FLOW       (cms)=        .01          .01           .015 (iii)
     TIME TO PEAK    (hrs)=       1.50         1.73          1.500
     RUNOFF VOLUME    (mm)=      24.39         8.80         13.011
     TOTAL RAINFALL   (mm)=      25.00        25.00         24.996
     RUNOFF COEFFICIENT   =        .98          .35           .521

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  85.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-----------------------------------------------------------------------------------------
R0001:C00004-----------------------------------------------------------------------------
*
*AREA 2
*
--------------------------
| CALIB STANDHYD          |   Area    (ha)=    7.05
| 01:       100 DT= 5.00 |   Total Imp(%)=   48.00   Dir. Conn.(%)=   34.00
--------------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       3.38         3.67
     Dep. Storage     (mm)=        .60         2.50
     Average Slope     (%)=        .60         2.00
     Length            (m)=     500.00        35.00
     Mannings n          =        .013         .250

     Max.eff.Inten.(mm/hr)=      50.21        12.49
                over (min)       10.00        25.00
     Storage Coeff.  (min)=      10.30 (ii)   25.27 (ii)
     Unit Hyd. Tpeak (min)=      10.00        25.00
     Unit Hyd. peak  (cms)=        .11          .04
                                                           *TOTALS*
     PEAK FLOW       (cms)=        .21          .07           .241 (iii)
     TIME TO PEAK    (hrs)=       1.58         1.83          1.583
     RUNOFF VOLUME    (mm)=      24.40         9.09         14.293
     TOTAL RAINFALL   (mm)=      25.00        25.00         24.996
     RUNOFF COEFFICIENT   =        .98          .36           .572

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  85.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-----------------------------------------------------------------------------------------
R0001:C00005-----------------------------------------------------------------------------
*
--------------------
| COMPUTE VOLUME    |
| ID:01  (000100)  |              DISCHARGE      TIME
--------------------                (cms)        (hrs)
           START CONTROLLING AT     .000         .250
           INFLOW HYD. PEAKS AT     .241        1.583
           STOP  CONTROLLING AT     .000         .000

           REQUIRED STORAGE VOLUME (ha.m.)=    .1008
           TOTAL HYDROGRAPH VOLUME (ha.m.)=    .1008
           % OF HYDROGRAPH TO STORE       =  99.9996

            NOTE:  Storage was computed to reduce the Inflow

*** WARNING: Calculated volume may not be the maximum.

-----------------------------------------------------------------------------------------
R0001:C00006-----------------------------------------------------------------------------
*
* 24 hour draw down of 25 mm runoff
*
* 1017 cm / 24 hr / 60 min per hr / 60 s per min = 0.0118 cms
*
--------------------
| SAVE HYD          |   AREA      (ha)=    7.050
| ID=01:        100 |   QPEAK     (cms)=     .241 (i)
| DT= 5.00 PCYC=-1 |   TPEAK     (hrs)=    1.583
--------------------   VOLUME     (mm)=   14.293
  Filename: IN
  Comments: IN

     (i)  PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
-----------------------------------------------------------------------------------------
R0001:C00007-----------------------------------------------------------------------------
*
-----------------------
|  ROUTE RESERVOIR -> |    Requested routing time step =  5.0 min.
|  IN>01:        100   |
| OUT<02:        200   | ========================  OUTLFOW STORAGE TABLE  ========================
----------------------- OUTFLOW   STORAGE| OUTFLOW   STORAGE| OUTFLOW   STORAGE| OUTFLOW   STORAGE
                          (cms)   (ha.m.)|   (cms)   (ha.m.)|   (cms)   (ha.m.)|   (cms)   (ha.m.)
                           .000 .0000E+00|    .007 .3900E-01|    .010 .7180E-01|    .171 .1205E+00
                           .003 .9300E-02|    .008 .4960E-01|    .010 .8340E-01|    .461 .1336E+00
                           .005 .1890E-01|    .009 .6020E-01|    .011 .9540E-01|    .836 .1471E+00
                           .006 .2880E-01|    .010 .7180E-01|    .012 .1077E+00|    .000 .0000E+00

     ROUTING RESULTS             AREA     QPEAK     TPEAK       R.V.
     ----------------------      (ha)     (cms)     (hrs)       (mm)
     INFLOW > 01:       100     7.050      .241     1.583     14.293
    OUTFLOW < 02:       200     7.050      .010     4.500     14.293

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)=    4.330
                  TIME SHIFT OF PEAK FLOW         (min)=   175.00
                  MAXIMUM  STORAGE   USED       (ha.m.)=.8879E-01

-----------------------------------------------------------------------------------------
R0001:C00008-----------------------------------------------------------------------------
*
--------------------
| SAVE HYD          |   AREA      (ha)=    7.050
| ID=02:        200 |   QPEAK     (cms)=     .010 (i)
| DT= 5.00 PCYC=-1 |   TPEAK     (hrs)=    4.500
--------------------   VOLUME     (mm)=   14.293
  Filename: OUT
  Comments: OUT

     (i)  PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
-----------------------------------------------------------------------------------------
R0001:C00009-----------------------------------------------------------------------------
*
*******************************************************************************
*******************************************************************************
*
*AREA 2
*
******************
* 5 YEAR
******************
*
--------------------
| CHICAGO STORM     |    IDF curve parameters: A= 569.052
| Ptotal= 39.32 mm |                          B=   1.500
--------------------                          C=    .725
                        used in:   INTENSITY =  A / (t + B)^C

                        Duration of storm  =  3.00 hrs
                        Storm time step    =  2.00 min
                        Time to peak ratio =   .33

                    The CORRELATION coefficient is = .9996798

                     TIME        ENTERED            COMPUTED
                    (min)        (mm/hr)             (mm/hr)
                      5.          157.30              146.48
                     10.           96.90               96.86
                     15.           73.00               74.55
                     30.           45.00               46.65
                     60.           27.70               28.72
                    120.           17.10               17.53
                    360.            7.90                7.95
                    720.            4.90                4.82
                   1440.            3.00                2.92

      TIME    RAIN|   TIME    RAIN|   TIME    RAIN|   TIME    RAIN|   TIME    RAIN|   TIME    RAIN
     hh:mm   mm/hr|  hh:mm   mm/hr|  hh:mm   mm/hr|  hh:mm   mm/hr|  hh:mm   mm/hr|  hh:mm   mm/hr
      0:02   3.765|   0:32   6.521|   1:02  91.299|   1:32   9.942|   2:02   6.025|   2:32   4.490
      0:04   3.865|   0:34   6.902|   1:04  52.682|   1:34   9.491|   2:04   5.884|   2:34   4.419
      0:06   3.971|   0:36   7.341|   1:06  37.779|   1:36   9.086|   2:06   5.750|   2:36   4.350
      0:08   4.084|   0:38   7.853|   1:08  29.840|   1:38   8.719|   2:08   5.623|   2:38   4.285
      0:10   4.206|   0:40   8.457|   1:10  24.882|   1:40   8.385|   2:10   5.502|   2:40   4.221
      0:12   4.337|   0:42   9.186|   1:12  21.475|   1:42   8.080|   2:12   5.388|   2:42   4.159
      0:14   4.477|   0:44  10.082|   1:14  18.979|   1:44   7.800|   2:14   5.279|   2:44   4.100
      0:16   4.629|   0:46  11.216|   1:16  17.066|   1:46   7.542|   2:16   5.175|   2:46   4.043
      0:18   4.794|   0:48  12.707|   1:18  15.549|   1:48   7.304|   2:18   5.076|   2:48   3.987
      0:20   4.973|   0:50  14.765|   1:20  14.313|   1:50   7.082|   2:20   4.981|   2:50   3.933
      0:22   5.170|   0:52  17.823|   1:22  13.285|   1:52   6.876|   2:22   4.891|   2:52   3.881
      0:24   5.385|   0:54  22.926|   1:24  12.414|   1:54   6.683|   2:24   4.804|   2:54   3.831
      0:26   5.624|   0:56  33.462|   1:26  11.667|   1:56   6.503|   2:26   4.720|   2:56   3.782
      0:28   5.889|   0:58  71.562|   1:28  11.018|   1:58   6.334|   2:28   4.641|   2:58   3.735
      0:30   6.186|   1:00 229.458|   1:30  10.448|   2:00   6.175|   2:30   4.564|   3:00   3.689

-----------------------------------------------------------------------------------------
R0001:C00010-----------------------------------------------------------------------------
*
--------------------------
| CALIB STANDHYD          |   Area    (ha)=    7.05
| 03:       100 DT= 5.00 |   Total Imp(%)=   48.00   Dir. Conn.(%)=   34.00
--------------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       3.38         3.67
     Dep. Storage     (mm)=        .60         2.50
     Average Slope     (%)=        .60         2.00
     Length            (m)=     500.00        35.00
     Mannings n          =        .013         .250

     Max.eff.Inten.(mm/hr)=     111.25        44.12
                over (min)        8.00        16.00
     Storage Coeff.  (min)=       7.49 (ii)   16.53 (ii)
     Unit Hyd. Tpeak (min)=       8.00        16.00
     Unit Hyd. peak  (cms)=        .15          .07
                                                           *TOTALS*
     PEAK FLOW       (cms)=        .49          .26           .615 (iii)
     TIME TO PEAK    (hrs)=       1.07         1.27          1.133
     RUNOFF VOLUME    (mm)=      36.22        17.31         23.742
     TOTAL RAINFALL   (mm)=      39.32        39.32         39.317
     RUNOFF COEFFICIENT   =        .92          .44           .604

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  85.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-----------------------------------------------------------------------------------------
R0001:C00011-----------------------------------------------------------------------------
*
-----------------------
|  ROUTE RESERVOIR -> |    Requested routing time step =  5.0 min.
|  IN>03:        100   |
| OUT<04:        200   | ========================  OUTLFOW STORAGE TABLE  ========================
----------------------- OUTFLOW   STORAGE| OUTFLOW   STORAGE| OUTFLOW   STORAGE| OUTFLOW   STORAGE
                          (cms)   (ha.m.)|   (cms)   (ha.m.)|   (cms)   (ha.m.)|   (cms)   (ha.m.)
                           .000 .0000E+00|    .007 .3900E-01|    .010 .7180E-01|    .171 .1205E+00
                           .003 .9300E-02|    .008 .4960E-01|    .010 .8340E-01|    .461 .1336E+00
                           .005 .1890E-01|    .009 .6020E-01|    .011 .9540E-01|    .836 .1471E+00
                           .006 .2880E-01|    .010 .7180E-01|    .012 .1077E+00|    .000 .0000E+00

     ROUTING RESULTS             AREA     QPEAK     TPEAK       R.V.
     ----------------------      (ha)     (cms)     (hrs)       (mm)
     INFLOW > 03:       100     7.050      .615     1.133     23.742
    OUTFLOW < 04:       200     7.050      .154     1.933     23.742

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)=   25.037
                  TIME SHIFT OF PEAK FLOW         (min)=    48.00
                  MAXIMUM  STORAGE   USED       (ha.m.)=.1191E+00

-----------------------------------------------------------------------------------------
R0001:C00012-----------------------------------------------------------------------------
*
******************
* 100 YEAR
******************
*
--------------------
| CHICAGO STORM     |    IDF curve parameters: A= 950.966
| Ptotal= 65.36 mm |                          B=   1.500
--------------------                          C=    .726
                        used in:   INTENSITY =  A / (t + B)^C

                        Duration of storm  =  3.00 hrs
                        Storm time step    =  2.00 min
                        Time to peak ratio =   .33

                    The CORRELATION coefficient is = .9996881

                     TIME        ENTERED            COMPUTED
                    (min)        (mm/hr)             (mm/hr)
                      5.          262.40              244.34
                     10.          161.60              161.47
```

```
                   15.         121.80               124.24
                   30.          75.00                77.69
                   60.          46.20                47.80
                  120.          28.50                29.16
                  360.          13.20                13.21
                  720.           8.10                 8.00
                 1440.           5.00                 4.84

        TIME    RAIN|   TIME    RAIN|   TIME    RAIN|   TIME    RAIN|   TIME    RAIN|   TIME    RAIN
       hh:mm   mm/hr|  hh:mm   mm/hr|  hh:mm   mm/hr|  hh:mm   mm/hr|  hh:mm   mm/hr|  hh:mm   mm/hr
        0:02   6.237|   0:32  10.811|   1:02 152.131|   1:32  16.496|   2:02   9.989|   2:32   7.440
        0:04   6.403|   0:34  11.445|   1:04  87.686|   1:34  15.747|   2:04   9.754|   2:34   7.322
        0:06   6.579|   0:36  12.174|   1:06  62.839|   1:36  15.073|   2:06   9.531|   2:36   7.209
        0:08   6.767|   0:38  13.024|   1:08  49.611|   1:38  14.463|   2:08   9.321|   2:38   7.099
        0:10   6.969|   0:40  14.029|   1:10  41.353|   1:40  13.909|   2:10   9.121|   2:40   6.994
        0:12   7.186|   0:42  15.239|   1:12  35.680|   1:42  13.402|   2:12   8.931|   2:42   6.892
        0:14   7.419|   0:44  16.728|   1:14  31.526|   1:44  12.937|   2:14   8.750|   2:44   6.793
        0:16   7.671|   0:46  18.614|   1:16  28.343|   1:46  12.509|   2:16   8.578|   2:46   6.698
        0:18   7.945|   0:48  21.092|   1:18  25.818|   1:48  12.112|   2:18   8.413|   2:48   6.606
        0:20   8.243|   0:50  24.514|   1:20  23.763|   1:50  11.744|   2:20   8.256|   2:50   6.517
        0:22   8.568|   0:52  29.603|   1:22  22.053|   1:52  11.402|   2:22   8.105|   2:52   6.430
        0:24   8.926|   0:54  38.095|   1:24  20.606|   1:54  11.082|   2:24   7.961|   2:54   6.347
        0:26   9.322|   0:56  55.645|   1:26  19.363|   1:56  10.783|   2:26   7.823|   2:56   6.266
        0:28   9.762|   0:58 119.193|   1:28  18.284|   1:58  10.502|   2:28   7.690|   2:58   6.187
        0:30  10.255|   1:00 382.976|   1:30  17.336|   2:00  10.238|   2:30   7.563|   3:00   6.111

--------------------------------------------------------------------------------------------------
R0001:C00013---------------------------------------------------------------------------------------
*
--------------------------
| CALIB STANDHYD         |   Area    (ha)=    7.05
| 05:       100 DT= 5.00 |   Total Imp(%)=   48.00   Dir. Conn.(%)=   34.00
--------------------------
                               IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=        3.38          3.67
     Dep. Storage     (mm)=         .60          2.50
     Average Slope     (%)=         .60          2.00
     Length            (m)=      500.00         35.00
     Mannings n           =        .013          .250

     Max.eff.Inten.(mm/hr)=      251.08        116.44
                over (min)         4.00         12.00
     Storage Coeff.  (min)=        5.41 (ii)    11.54 (ii)
     Unit Hyd. Tpeak (min)=        4.00         12.00
     Unit Hyd. peak  (cms)=         .22           .10
                                                          *TOTALS*
     PEAK FLOW       (cms)=         .99           .71          1.341 (iii)
     TIME TO PEAK    (hrs)=        1.00          1.20          1.067
     RUNOFF VOLUME    (mm)=       60.63         37.13         45.122
     TOTAL RAINFALL   (mm)=       65.36         65.36         65.364
     RUNOFF COEFFICIENT   =         .93           .57           .690

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  85.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------------------------
R0001:C00014---------------------------------------------------------------------------------------
*
-----------------------
|  ROUTE RESERVOIR -> |    Requested routing time step =  2.0 min.
|  IN>05:       100   |
| OUT<06:       200   | =========================  OUTLFOW STORAGE TABLE  =========================
----------------------- OUTFLOW   STORAGE| OUTFLOW   STORAGE| OUTFLOW   STORAGE| OUTFLOW   STORAGE
                          (cms)   (ha.m.)|   (cms)   (ha.m.)|   (cms)   (ha.m.)|   (cms)   (ha.m.)
                           .000 .0000E+00|    .007 .3900E-01|    .010 .7180E-01|    .171 .1205E+00
                           .003 .9300E-02|    .008 .4960E-01|    .010 .8340E-01|    .461 .1336E+00
                           .005 .1890E-01|    .009 .6020E-01|    .011 .9540E-01|    .836 .1471E+00
                           .006 .2880E-01|    .010 .7180E-01|    .012 .1077E+00|    .000 .0000E+00

     ROUTING RESULTS             AREA     QPEAK     TPEAK       R.V.
     ----------------------      (ha)     (cms)     (hrs)       (mm)
     INFLOW > 05:       100     7.050     1.341     1.067     45.122
    OUTFLOW < 06:       200     7.050      .769     1.333     45.122

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)=   57.395
                  TIME SHIFT OF PEAK FLOW         (min)=    16.00
                  MAXIMUM  STORAGE   USED       (ha.m.)=.1448E+00

--------------------------------------------------------------------------------------------------
R0001:C00015---------------------------------------------------------------------------------------
*
*AREA 1
*
*******************
* 100 YEAR
*******************
*
--------------------
| CHICAGO STORM    |    IDF curve parameters: A= 950.966
| Ptotal= 47.79 mm |                          B=   1.500
--------------------                          C=    .726
                        used in:   INTENSITY =  A / (t + B)^C

                        Duration of storm  =  1.00 hrs
                        Storm time step    =  2.00 min
                        Time to peak ratio =   .33

                    The CORRELATION coefficient is = .9996881

                     TIME        ENTERED            COMPUTED
                    (min)        (mm/hr)             (mm/hr)
                      5.         262.40              244.34
                     10.         161.60              161.47
                     15.         121.80              124.24
                     30.          75.00               77.69
                     60.          46.20               47.80
                    120.          28.50               29.16
                    360.          13.20               13.21
                    720.           8.10                8.00
                   1440.           5.00                4.84

        TIME    RAIN|   TIME    RAIN|   TIME    RAIN|   TIME    RAIN|   TIME    RAIN|   TIME    RAIN
       hh:mm   mm/hr|  hh:mm   mm/hr|  hh:mm   mm/hr|  hh:mm   mm/hr|  hh:mm   mm/hr|  hh:mm   mm/hr
        0:02  15.239|   0:12  29.603|   0:22 152.131|   0:32  35.680|   0:42  22.053|   0:52  16.496
        0:04  16.728|   0:14  38.095|   0:24  87.686|   0:34  31.526|   0:44  20.606|   0:54  15.747
        0:06  18.614|   0:16  55.645|   0:26  62.839|   0:36  28.343|   0:46  19.363|   0:56  15.073
        0:08  21.092|   0:18 119.193|   0:28  49.611|   0:38  25.818|   0:48  18.284|   0:58  14.463
        0:10  24.514|   0:20 382.976|   0:30  41.353|   0:40  23.763|   0:50  17.336|   1:00  13.909

--------------------------------------------------------------------------------------------------
R0001:C00016---------------------------------------------------------------------------------------
*
--------------------------
| CALIB STANDHYD         |   Area    (ha)=     .36
| 07:       100 DT= 1.00 |   Total Imp(%)=   40.00   Dir. Conn.(%)=   27.00
--------------------------
                               IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=         .14           .22
     Dep. Storage     (mm)=         .60          2.50
     Average Slope     (%)=         .60          2.00
     Length            (m)=       40.00         35.00
     Mannings n           =        .013          .250

     Max.eff.Inten.(mm/hr)=      382.98        128.74
                over (min)         1.00          7.00
     Storage Coeff.  (min)=        1.00 (ii)     6.89 (ii)
     Unit Hyd. Tpeak (min)=        1.00          7.00
     Unit Hyd. peak  (cms)=        1.07           .16
                                                          *TOTALS*
     PEAK FLOW       (cms)=         .09           .05           .104 (iii)
     TIME TO PEAK    (hrs)=         .33           .45           .333
     RUNOFF VOLUME    (mm)=       47.19         25.33         31.234
     TOTAL RAINFALL   (mm)=       47.79         47.79         47.793
     RUNOFF COEFFICIENT   =         .99           .53           .654

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  85.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------------------------
R0001:C00017---------------------------------------------------------------------------------------
*
*****************************************************************************
*****************************************************************************
*
--------------------
| FINISH           |
--------------------
--------------------------------------------------------------------------------------------------
**************************************************************************************************
     WARNINGS / ERRORS / NOTES
     -------------------------
R0001:C00005  COMPUTE VOLUME
*** WARNING: Calculated volume may not be the maximum.
   Simulation ended on 2020-01-22     at 15:05:23
==================================================================================================
```

APPENDIX C

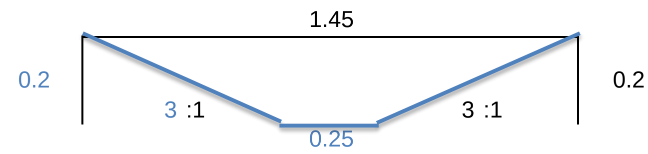
Overland Spillway Cross-Sections

Hydraulic Capacity Check

OVERLAND DRAINAGE SWALE -AREA 1

Swale Capacity/Velocity Calculation V = 1/n * (A/P)^0.667 * (S)^0.5	
Channel Bottom Width	0.25 m
Channel Side Slopes (X : 1)	3 to 1
Flow Depth	0.2
Manning's n	0.035 Grass
Slope (%)	1 %
Calculated Area	0.17 m²
Calculated Wetted Perimeter	1.51 m
Calculated Width Required	1.45
Velocity Calculated	0.66 m/s
Q Peak	0.113 m³/s
Required Q Peak	0.104 m³/s
Flow Depth during Required Event	0.190 m
Velocity during Required Event	0.645 m/s

Inputs

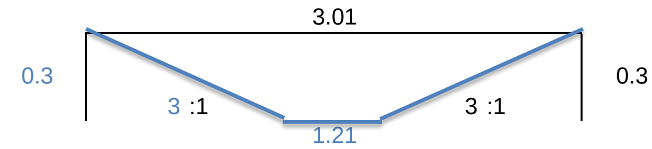


Hydraulic Capacity Check

OVERLAND DRAINAGE SWALE-AREA 2

Swale Capacity/Velocity Calculation V = 1/n * (A/P)^0.667 * (S)^0.5		
Channel Bottom Width	1.21	m
Channel Side Slopes (X : 1)	3	to 1
Flow Depth	0.3	
Manning's n	0.035	Grass
Slope (%)	1	%
Calculated Area	0.63	m²
Calculated Wetted Perimeter	3.11	m
Calculated Width Required	3.01	
Velocity Calculated	0.99	m/s
Q Peak	0.626	m³/s
Required Q Peak	0.615	m³/s
Flow Depth during Required Event	0.290	m
Velocity during Required Event	0.971	m/s

Inputs



APPENDIX D

Sample Level Spreader Design

One of the benefits of pervious catchbasins which are located off-line is that they can be plugged until construction has finished and the development has been stabilized. This helps to prolong the life of the exfiltration storage.

Pre-treatment of road drainage before it reaches the pervious catchbasins will enhance the longevity of the system and reduce the potential for groundwater contamination. Frequent catchbasin cleaning is required to ensure the longevity of this SWMP. Eventually, the exfiltration storage will become clogged and need to be replaced.

4.5.12 Vegetated Filter Strips

Vegetated filter strips are engineered stormwater conveyance systems which treat small drainage areas. Generally, a vegetated filter strip consists of a level spreader and planted vegetation. The level spreader ensures uniform flow over the vegetation which filters out pollutants, and promotes infiltration of the stormwater.

There are two types of vegetated filter strips: grass filter strips, and forested filter strips. There is a need for further research comparing the efficiency of these two systems for water quality enhancement, since the research to date has focussed on their individual assessment.

Vegetated filter strips are best utilized adjacent to a buffer strip, watercourse or drainage swale since the discharge will be in the form of sheet flow, making it difficult to convey the stormwater downstream in a normal conveyance system (swale or pipe).

Design Guidance

Drainage Area

Vegetated filter strips are feasible for small drainage areas (< 2 ha).

Slope and Width

Vegetated filter strips should be located in flat areas (< 10%) to promote sheet flow and maximize the filtration potential. The ideal slope in a vegetated filter strip is < 5% (1% - 5%).

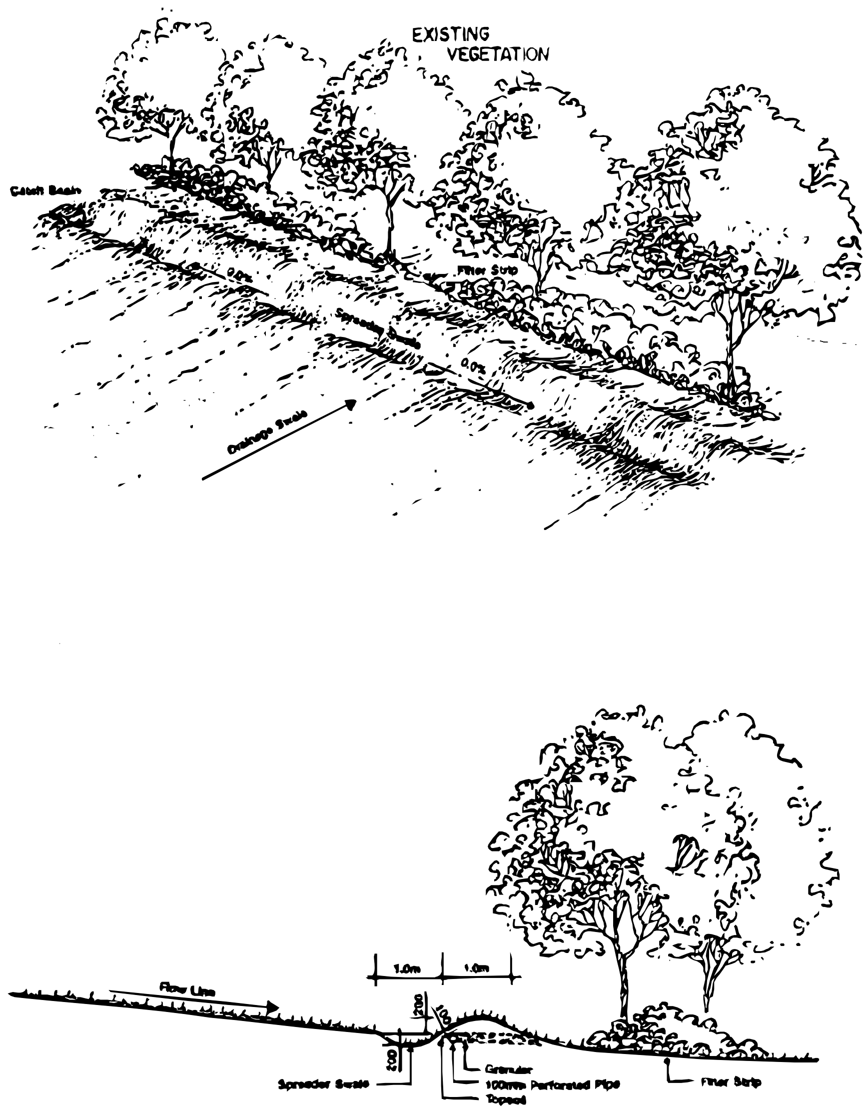
The vegetated filter strip should be 10 m - 20 m wide in the direction of flow to provide sufficient stormwater quality enhancement (Osborne et al., 1993; Metropolitan Washington Council of Governments, 1992; Minnesota Pollution Control Agency, 1989). The slope of the vegetated filter strip should dictate the actual width. Shorter vegetated filter strip widths (10 m - 15 m) are appropriate for flat slopes, whereas longer vegetated filter strips (15 m - 20 m) are required in areas with a higher slope (5% - 10%).

Level Spreader

The level spreader consists of a raised weir constructed perpendicular to the direction of flow. Water is conveyed over the spreader as sheet flow to maximize the contact area with the vegetation. Although the spreader can be engineered using concrete, more natural spreader designs/materials are recommended to maintain a natural appearance.

Figure 4.16 illustrates a typical level spreader design. A small berm is used as the level spreader. It creates a damming effect, preventing stormwater from entering the vegetation until the water level exceeds the height of the spreader. A perforated pipe (100 mm diameter) is installed in the spreader berm to ensure that any water which is trapped behind the berm after a storm can be drained. The perforated pipe should be wrapped in a filter sock to ensure that native material does not infiltrate the pipe.

Figure 4.16: Typical Filter Strip



The length of the level spreader should be chosen based on site specifics (topography, outlet location, drainage area configuration). It should be recognized, however, that a shorter level spreader necessitates the trade-off of greater upstream storage to maintain the desired flow depth over the vegetation. It is recommended that the level spreader length, and hence vegetated filter strip length, be as large as possible.

Flow Depth

The level spreader and vegetated filter strip should be designed such that the peak flow from a 4 hour Chicago 10 mm storm results in a flow depth of 50 - 100 mm through the vegetation. The flow depth over the level spreader can be calculated using a standard broad crested weir equation (Equation 4.4).

$$Q = \alpha L H^{1.5}$$ **Equation 4.4: Weir Flow**

where Q = discharge
α = coefficient
L = length of crest of weir
H = head

Storage

Storage will be required behind the level spreader depending on the level of control desired, and the length of the level spreader itself. The amount of storage required should be based on the excess runoff from a 4 hour Chicago distribution of a 10 mm storm, accounting for the flow over the weir. The 10 mm storm was chosen recognizing that 70% of all daily precipitation depths are less than or equal to this amount.

Vegetation

Species such as red fescue, tall fescue and redtop can be introduced in addition to the natural surrounding vegetation to filter out stormwater pollutants. Species native to the area should be used, where commercially available, in the planting strategy.

Technical Effectiveness

Vegetated filter strips have limited effectiveness for water quality control due to the difficulty of maintaining sheet flow (i.e., preventing channelization) through the vegetation. They are best implemented as one in a series of SWMPs in a stormwater management plan.

4.5.13 Stream and Valley Corridor Buffer Strips

Buffer strips are simply natural areas between development and the receiving waters. There are two broad resource management objectives associated with buffer strips:

- The protection of the stream and valley corridor system to ensure their continued ecological form and functions; and

Level Spreader Calculation

Equation 4.4: Weir Flow (MOE Design Manual)
$Q = a * L * H^{1.5}$

Q (m^3/s)	0.02	
a	1.67	(broad-crested weir coefficient)
H (mm)	50	
L (m)	1.07	

L = Recommended Length of Weir / Level Spreader Berm = 1.07 m

APPENDIX E

Pond Calculations

Stage-Storage-Discharge Relationship

orifice	*Q=cA(2gh)^0.5*			**overflow**	*Q=CLH^1.5*
orifice diameter	0.075	c	0.6	c	1.67
orifice radius	0.0375	g	9.81	L	3
orifice area	0.00442	2g	19.62	Leff	L-0.2H

					Orifice		**Orifice**		
Description	**Stage**	**Storage (m3)**	**ha m**	**Head (m)**	**Discharge (m3/s)**	**Head (m)**	**Discharge (m3/s)**	**Qt**	
bottom of pond	0.00	0	0.0000	0	0.000			0.000	
	0.10	93	0.0093	0.06	0.003			0.003	
	0.20	189	0.0189	0.16	0.005			0.005	
	0.30	288	0.0288	0.26	0.006			0.006	
	0.40	390	0.0390	0.36	0.007			0.007	
	0.50	496	0.0496	0.46	0.008			0.008	
	0.60	602	0.0602	0.56	0.009			0.009	
	0.70	718	0.0718	0.66	0.010			0.010	
	0.80	834	0.0834	0.76	0.010			0.010	
	0.90	954	0.0954	0.86	0.011			0.011	
Top of Active	1.00	1077	0.1077	0.96	0.012			0.012	
	1.10	1205	0.1205	1.06	0.012	0.10	0.158	0.171	Overflow
	1.20	1336	0.1336	1.16	0.013	0.20	0.448	0.461	
Top of Free Board	1.30	1471	0.1471	1.26	0.013	0.30	0.823	0.836	Wier

24 hour Draw Down

Event	25 mm	
volume	1017	m^3
24 hr avg	0.0118	m^3/s

Forebay Sizing Calculations

Settling Calculation

D=SQRT(rQp/Vs)

r	2	
Qp	0.0118	m^3/s
Vs	0.0003	m^3/s
D	**8.86**	**m**

Dispersion Calculation

D=8Q/dVf

Q	0.625	m^3/s
d	1.1	m
Vf	0.5	m/s
D	**9.09**	**m**

Width Calculation

W=D/8

D	8.86	m
W	**1.11**	**m**

Note:

Qp = discharge of quality event for 24 hr draw down

Q = Q 5 from SWMHYMO model

Minimum Permanent Pool and Active Pool Volume Calculations per MOE SWM Design Guidelines

Area	7.05	hectares
%imp	0.55	55%

Table 3.2 - Wet Pond Guideline

40 m^3/ha x 7.05 ha = 282.0 m^3

Perm Pool = 150 x 6.47	1057.5	m^3
Active Pool = 40 x 6.47	282	m^3
Total	1339.5	m^3

Sediment Accumulation

Initial Volume Available in Main Pond	777	cubic metres
Initial Volume Available in Forebay	300	cubic metres
Target Volume for Cleanout	75 % remaining	
Contributing Area	7.05	ha
Annual Loading @ 35%	0.6	cubic metres\ha
Annual Loading @ 55%	1.9	cubic metres\ha
Annual Loading @ 50%	1.575	cubic metres\ha
annual accumulation (site)	11.10375	cubic metres
80 % annual accum.	8.883	cubic metres

Main Pond 20 % of sediment

Year	Volume Available	Accumulated Sediment	% Volume Remaining
0	777	0	100
1	775.2	1.8	100
2	773.4	3.6	100
3	771.7	5.3	99
4	769.9	7.1	99
5	768.1	8.9	99
6	766.3	10.7	99
7	764.6	12.4	98
8	762.8	14.2	98
9	761.0	16.0	98
10	759.2	17.8	98
11	757.5	19.5	97
12	755.7	21.3	97
13	753.9	23.1	97
14	752.1	24.9	97
15	750.4	26.6	97
16	748.6	28.4	96
17	746.8	30.2	96
18	745.0	32.0	96
19	743.2	33.8	96
20	741.5	35.5	95

Forebay 80 % of sediment

Year	Volume Available	Accumulated Sediment	% Volume Remaining
0	300	0	100
1	292.9	7.1	98
2	285.8	14.2	95
3	278.7	21.3	93
4	271.6	28.4	91
5	264.5	35.5	88
6	257.4	42.6	86
7	250.3	49.7	83
8	243.1	56.9	81
9	236.0	64.0	79
10	228.9	71.1	**76**
11	221.8	78.2	74