Stormwater Management Functional Servicing Report

Part of Lot 12, Concession 10 Township of Cavan Monaghan
Ian Cameron Rural Subdivision
Engage Project No. 14016

Engage Engineering Ltd.

January 7, 2015

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1.0 Introduction

1.1 Purpose

Engage Engineering Limited (Engage) has been retained by Mr. Kevin Duguay of KMD Community Planning and Conulting Inc. (KMD) to prepare a Stormwater Management Functional Servicing Report (SWM FSR) in support of the proposed Draft Plan of Subdivision for Part of Lot 12, Concession 10 in the Township of Cavan Monaghan. The purpose of this report is to identify at a functional level the impact that a rural subdivision will have from a stormwater management (SWM) perspective and provide guidance on the most appropriate methods to provide quality and quantity control of the runoff from the site, so that the development does not impact downstream receivers.

1.2 Site Description

The subject property is located at 1844 County Road 10 (CR10) in the Township of Cavan Monaghan in the County of Peterborough. The property is legally described as Part of Lot 12, Concession 10 in the Township of Cavan Monaghan, in the County of Peterborough. The site is bordered to the east by County Road 10, to the north by rural residential properties and Sharpe Line, to the west and south by agricultural lands. The location of the site that is the subject of this report is identified on the Draft Plan of subdivision, prepared by Engage Engineering Ltd, dated December 23 2014, and is included in **Figure 1**.

2.0 Methodology

2.1 Drainage Areas and Site Characteristics

The existing 6.23 ha site currently has one (1) farmhouse, one (1) barn, and two (2) outbuildings situated on the property fronting CR10. A topographic survey was provided by J.B. Fleguel Surveyors, Ontario Land Surveyors, dated November 28, 2014. The survey was utilized to determine existing elevations, locations of existing features on the site, and to establish functional grading design for the proposed rural subdivision.

The existing topography and drainage patterns of the property were assessed based on a site visit and using the contour information generated from the topographic survey provided by Fleguel Surveyors. There are two (2) existing drainage catchment areas on the property that are identified on the Drainage Area Plan, attached as **Figure 2**. The respective catchment areas can be identified based on the following properties:

Existing catchment area **ExWS1** consists of 1.16 ha of land that surrounds the existing farmstead at the southwest corner of the proposed severance. The catchment is comprised predominately of grassed areas, but also includes wooded areas, gravel areas from existing driveways, and impervious areas from existing buildings. All surface runoff from this catchment drains to the east and into the County Road 10 right-of-way ditch.

Existing catchment area **ExWS2** consists of 5.07 ha of land that includes the majority of the proposed severance. The catchment is comprised predominately of grassed areas, but also includes agricultural areas from corn farming. All surface runoff from this catchment drains towards the northeast corner of the property, and outlets through the property at 909 Sharpe Line, into a drainage swale along the southside of 1874 CR10, and into the County Road 10 right-of-way ditch.

Under the proposed condition, the topography of the site will change from that of the existing conditions to a proposed rural subdivision. There are three (3) proposed drainage catchment areas that are identified on the Drainage Area Plan, attached as **Figure 2**. In addition, there is an external drainage area based on lands contributing from the west of the proposed severance. This drainage is proposed to be intercepted on lots 5 through 11, and conveyed through the proposed sideyard drainage swales, and into the Street 'A' drainage ditch.

Preliminary grading for the rural subdivision was established based on Street 'A' having a vertical grade of 0.7%, draining from the highpoint within the cul-de-sac (approximately 281.0m) to the lowpoint at the intersection of CR10 (approximately 279.0m). Establishing a lower Street 'A' profile is considered an important element to the functional stormwater management strategy, for the following design reasons:

- A lower overall road profile increases the number of front draining lots, wherein lot level stormwater management controls can be implemented at the front (lowpoint) of the property.
- Draining the internal road network to CR10 establishes an unencumbered overland flow route.
- Increases the post-development drainage area that can outlet to CR10 in lieu of the existing outlet at 909 Sharpe Line.
- Maintains post development peak flows outletting to the existing property at 909 Sharpe Line to below pre-development run-off rates.
- By maintaining peak flows to the existing outlet at 909 Sharpe Line, there is only one downstream stormwater management facility required.

The respective catchment areas can be identified based on the following properties:

Proposed catchment area **PrWS101** consists of 0.72 ha of land that encompasses the proposed Street 'A' road right-of-way. The catchment is comprised of grassed road-side ditch areas, gravel road shoulder, and road and driveway impervious areas. For the purposes of area calculations, Street 'A' was assumed to be a 20m right-of-way, with 7.0m wide asphalt surface and 1.0m wide gravel shoulders on either side of the

road. All surface runoff from this catchment drains in a south, then east direction within the road-side ditch towards the proposed subdivision entrance and into the County Road 10 right-of-way ditch.

Proposed catchment area **PrWS102** consists of 4.44 ha of land that encompasses the majority of the proposed severance. The catchment is comprised of grassed areas, as well as building and driveway impervious areas. For the purposes of area calculations, a building footprint of 279m^2 (3,000ft^2), and driveway dimensions of 6m x 20m. All surface runoff from this catchment drains towards the proposed Street 'A' road right-of-way.

Proposed catchment area **Pr. WS201** consists of 1.06 ha of land located at the northeast corner of the property. The catchment is comprised of grassed areas, and impervious areas from split grade building lots 1 through 5. All surface runoff from this catchment is proposed to drain towards the northeast corner of the property, and outlet through the property at 909 Sharpe Line, into the existing drainage swale along the south property line of 1874 CR10 before making its way into the County Road 10 right-of-way ditch.

The hydrologic parameters for each catchment area under existing and proposed conditions were developed based on the areas, topography, and land-use summarized in **Appendix A**. The hydrologic parameters are summarized in **Table 1** below.

Table 1 - Existing & Proposed Development Hydrologic Parameters

Hydrologic Parameters	ExWS1	ExWS2	PrWS101	PrWS102	PrWS201
Area	1.15	5.07	0.72	4.44	1.06
% Impervious	0.9	0.0	43.1	11.3	5.7
Runoff Coefficient	0.20	0.19	0.53	0.25	0.21
Tc (min)	21	55	18	46	26

2.2 Peak Runoff Calculations

The peak runoff for the existing and proposed conditions was calculated for various return periods using the Rational Method. The results are summarized in **Table 2** below. Spreadsheets documenting the calculations are included in **Appendix A**. Rainfall data for the site was taken from the Peterborough rainfall gauging station at the Peterborough Airport.

Table 2 - Pre and Post Development Peak Flows

Design Storm (years)	Peak Flows (m^3/sec)				
	ExWS1	ExWS2	PrWS101	PrWS102	PrWS201
2	0.03	0.07	0.05	0.09	0.03
5	0.04	0.09	0.07	0.12	0.03
10	0.05	0.11	0.09	0.15	0.04
25	0.06	0.14	0.11	0.19	0.05
50	0.07	0.18	0.14	0.23	0.07
100	0.08	0.20	0.16	0.26	0.07

As anticipated, the increase in imperviousness area under post-development conditions results in an increase in the peak flows. Peak flows out letting to CR10 from PrWS101 and PrWS102 will increase. Peak flows out letting to 909 Sharpe Line from PrWS201 will actually decrease due to a significant reduction in the contributing drainage area.

2.3 Stormwater Management Options

Some form of on-site stormwater management facility is recommended for the proposed rural subdivision to provide quality and quantity control due to the increase in peak flow runoff to CR10. Quantity control is required to limit peak flows to pre-development levels thereby protecting downstream properties from flooding. Quality controls are required where the change in land use has the potential to increase sediment and contaminants in the runoff. For this site, a “Normal” level of quality control as defined in the MOE SWM Planning and Design Manual is appropriate given that the outlet from the proposed subdivision is to the County Road 10 right-of-way ditch.

Within the MOE SWM Planning and Design Manual, stormwater management measures are to be assessed in the descending order of stormwater lot level controls, stormwater conveyance controls, then end-of-pipe stormwater management facilities, per the following examples:

- **Stormwater lot level controls:** represent measures which are implemented at the individual lot level, such as soakaway pits, or flatter lot grading.
- **Stormwater conveyance controls**: represent conveyance systems used to transport stormwater runoff from the lots to the receiving waters, be that by pervious pipes or grassed swales.
- **End-of-pipe stormwater management facilities:** represent stormwater management measures used to service numerous lots or whole subdivisions, be that by either wet ponds, wetlands, or infiltration basins.

Table 3 below provides a comparison of the types of stormwater management options that are available for the proposed site. Storage volumes identified in the Table were calculated using the Modified Rational Method for pre-to post development flows, as included in **Appendix B**.

Table 3 - Stormwater Management Options

SWM Plan	Design Considerations	Comments
Wet Pond	• Requires storage volume of 554.3 m^3 for quantity control. • Requires storage volume of 361.2 m^3 for quality control based on 110 m^3/ha and 40 m^3/ha extended detention.	• Provides both quality and quantity control • Township has expressed concern over long-term maintenance requirements. • Not feasible to locate pond adjacent to CR10 outlet, due to site grading. Street 'A' is within cut from Lot 1-3 and 11-15.
Reduced Lot Grading	• Proposed grading to be generally less than 5%. Soil conditions permit minimum infiltration rate of 15mm/hr.	• Site topography allows for minimum lot grading beyond road cut limits • Existing soil conditions generally exceed minimum infiltration threshold.
Individual Detention/ Infiltration Basins	• Requires storage volume of 554.3 m^3 for quantity control. • WS102 building lots require total detention volume of 88.8 m^3 for quality control based on 20 m^3/ha.	• Proposed front draining building lots can facilitate detention basin prior to discharge into road-side ditch. • Proposed lot grading to be generally less than 5% and contributing area less than 2 ha.
Grassed Swales	• Proposed road grading to be less than 5%. • Contributing area less than 2 ha.	• Flat road grade of 0.5-0.7% and right-of-way ditch can be utilized • Rock check dams located 30-50m spacing provides for sediment removal.

Based on the above **Table 3** summary, a wet pond facility cannot be functionally located on the property, due to the site topography and road grading. In lieu of a wet pond, a treatment train approach is likely the most feasible stormwater management plan for the proposed rural subdivision.

The recommended approach for the proposed drainage catchment areas includes the following:

- **WS201** to have lot level quality controls that include reduced lot grades but no quantity controls are required.
- **WS101** to have quality controls that include enhanced grass swales, minimum grades, and rock check dams.
- **WS102** to have lot level quantity and quality controls that include reduced lot grades and grass detention basins.

Based on this recommended approach, it is important to note that constructing detention basins as lot level conveyance controls in lieu of a wet pond facility, will result in no formalized quantity control for the proposed road out letting into the CR10 ditch. In order to reduce overall flows out letting to CR10 ditch, one solution may be to over-control the lot level controls if sufficient storage volumes can be achieved on individual lots. As such, it is recommended that the proposed stormwater management strategy consider over control of lot level run-off in addition to analyzing the available capacity of the CR10 ditch at the time of detailed stormwater design.

3.0 Conclusion

Development of the proposed rural subdivision will result in an increase in peak runoff and the contaminant/sediment loading from the site. Therefore, some form of stormwater management quantity and quality controls are recommended to attenuate the peak flows and provide protection for downstream receivers. Various methods of quantity and quality controls are available however based on the nature of the proposed rural development, a stormwater management plan that employs a treatment train approach is recommended. Quantity and quality controls can functionally be provided through the implementation of lot level controls that include reduced lot grades and grass detention basins in combination with conveyance controls on Street 'A' that include grassed swales at minimum grades with rock check dams.

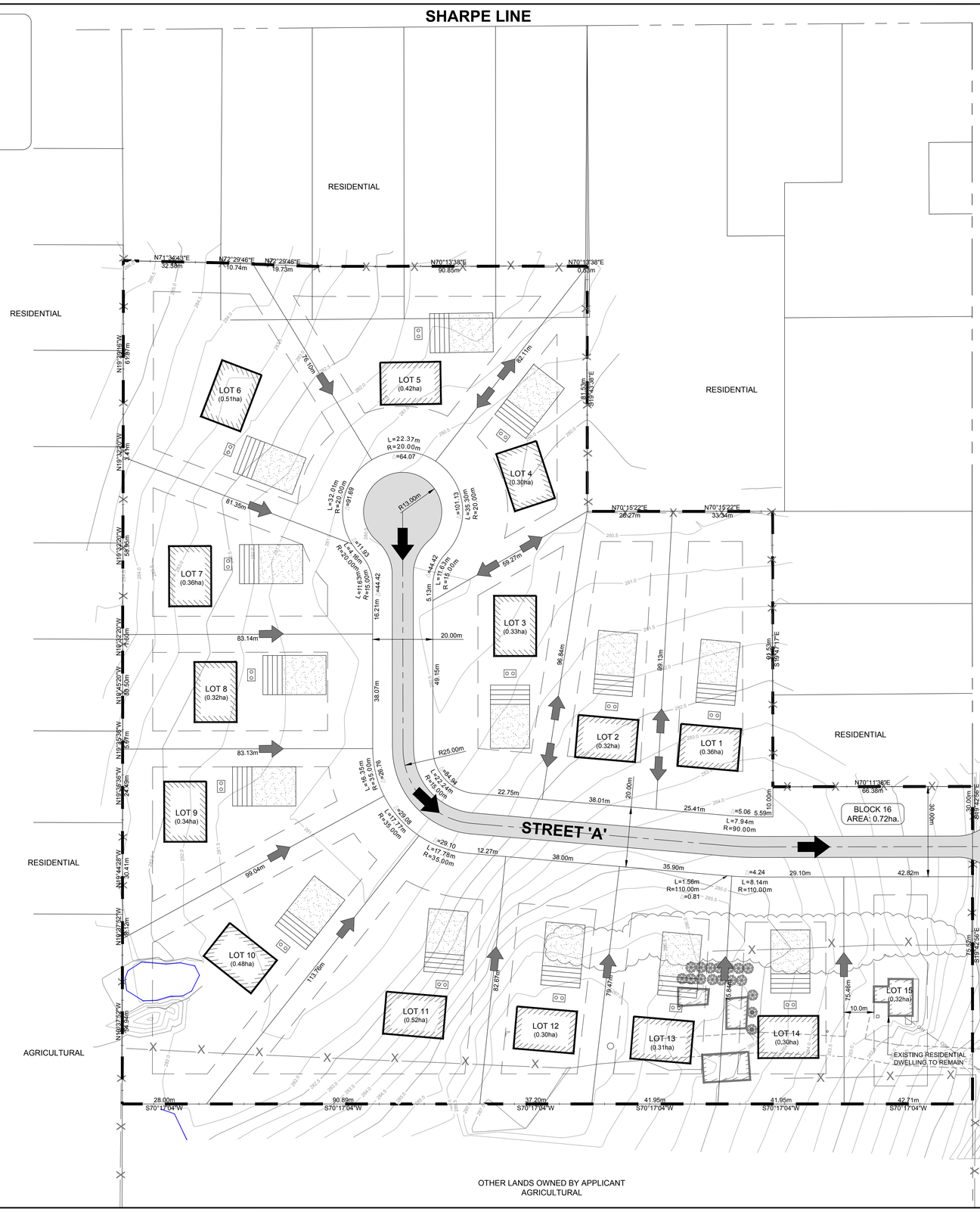
This report provides guidance at a functional level and is not based on detailed design. When the plan of subdivision proceeds to the detailed engineering design phase, a detailed Stormwater Management Report should be prepared to address the specific requirements of the proposed development.

Submitted by:

Aaron Hill, P.Eng.
Engage Engineering

ADDITIONAL INFORMATION AS REQUIRED BY SEC 51 (17) OF THE PLANNING ACT (1990)

(a) AS SHOWN ON DRAFT PLAN
(b) AS SHOWN
(c) AS SHOWN
(d) REFER TO THE SCHEDULE OF LAND USE
(e) RESIDENTIAL & AGRICULTURAL
(f) AS SHOWN ON DRAFT PLAN
(g) AS SHOWN ON DRAFT PLAN
(h) PRIVATE WELLS, PRIVATE SEPTICS
(i) SOIL TYPES: SAND, GRAVEL, SILT
(j) AS SHOWN ON DRAFT PLAN
(k) MUNICIPAL SERVICES AVAILABLE: ELECTRICAL, TELEPHONE, GARBAGE COLLECTION, GAS
(l) NONE



DRAFT PLAN OF SUBDIVISION

IAN CAMERON RURAL SUBDIVISION
CAVAN MONAGHAN TOWNSHIP

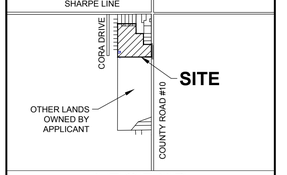
PLAN OF:
PROPOSED SUBDIVISION ON
PART OF LOT 12
CONCESSION 10
GEOGRAPHIC TOWNSHIP OF CAVAN
TOWNSHIP OF CAVAN MONAGHAN
COUNTY OF PETERBOROUGH

LAND USE SCHEDULE

LOT/BLOCK	AREA (ha)	FRONTAGE	INTENDED USE
1	0.36 ha	38.13	SINGLE DETACHED DWELLING
2	0.32 ha	38.01	SINGLE DETACHED DWELLING
3	0.33 ha	38.87	SINGLE DETACHED DWELLING
4	0.30 ha	47.70	SINGLE DETACHED DWELLING
5	0.42 ha	38.52	SINGLE DETACHED DWELLING
6	0.51 ha	38.00	SINGLE DETACHED DWELLING
7	0.36 ha	38.15	SINGLE DETACHED DWELLING
8	0.32 ha	38.07	SINGLE DETACHED DWELLING
9	0.34 ha	23.71	SINGLE DETACHED DWELLING
10	0.48 ha	23.66	SINGLE DETACHED DWELLING
11	0.52 ha	38.08	SINGLE DETACHED DWELLING
12	0.30 ha	38.00	SINGLE DETACHED DWELLING
13	0.31 ha	38.30	SINGLE DETACHED DWELLING
14	0.30 ha	38.18	SINGLE DETACHED DWELLING
15	0.32 ha	75.52	SINGLE DETACHED DWELLING
16	0.72 ha	-	ROAD
TOTAL SITE AREA			6.22ha

BENCHMARK -
ELEVATION -
ADD BENCHMARK DESCRIPTION HERE

KEY PLAN



LEGEND

- PROPOSED BUILDING FOOTPRINT
- PROPOSED SEPTIC TANK
- PROPOSED RAISED BED SEPTIC & MANTLE
- LOT DRAINAGE FLOW ROUTE
- ROAD DRAINAGE FLOW ROUTE

OWNER'S CERTIFICATE

I AUTHORIZE KEVIN M. DUGUAY COMMUNITY PLANNING & CONSULTING INC. TO SUBMIT THIS DRAFT PLAN OF SUBDIVISION TO THE TOWNSHIP OF CAVAN MONAGHAN.

DATE: _____ _____
IAN CAMERON

SURVEYOR'S CERTIFICATE

I CERTIFY THAT:

1. THIS SURVEY AND PLAN ARE CORRECT AND ARE IN ACCORDANCE WITH THE SURVEYS ACT , THE SURVEYORS ACT AND THE LAND TITLES ACT AND THE REGULATIONS MADE UNDER THEM.
2. THE SURVEY WAS COMPLETED ON NOVEMBER 12, 2014.

DATE: _____. _____
CHRISTOPHER E. MUSCLOW
Ontario Land Surveyor

IAN CAMERON RURAL SUBDIVISION

TOWNSHIP OF CAVAN MONAGHAN

DRAFT PLAN OF SUBDIVISION

No.	DATE	BY	REVISION
A	23-12-14	J.A.	FOR DRAFT PLAN SUBMISSION

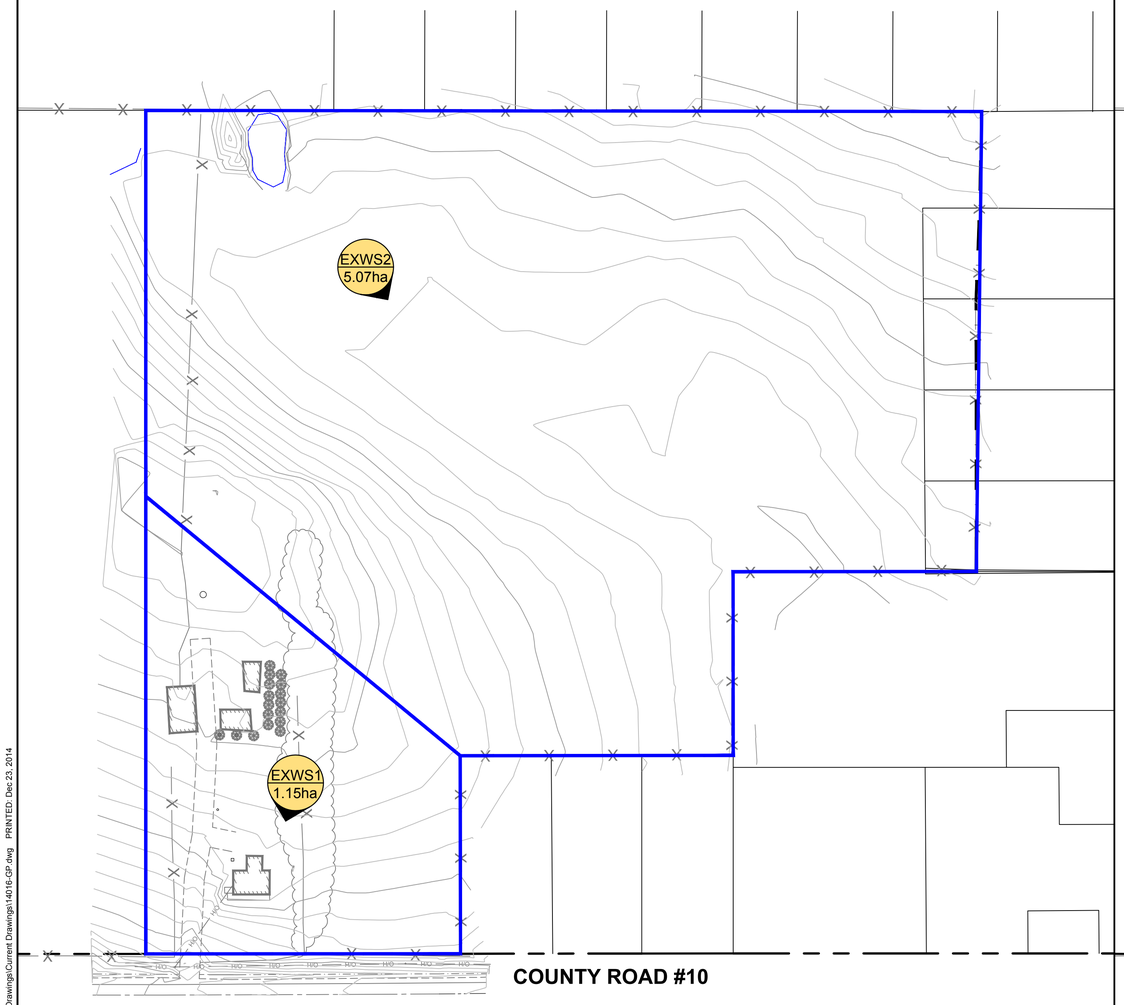
ENGAGE ENGINEERING

DRAWN: J.ARMSTRONG
DESIGNED: J.ARMSTRONG
APPROVED: A.HILL
DATE: DECEMBER 23, 2014
SCALE: HORZ. 1:750 VERT. -
0 15 30 Meters

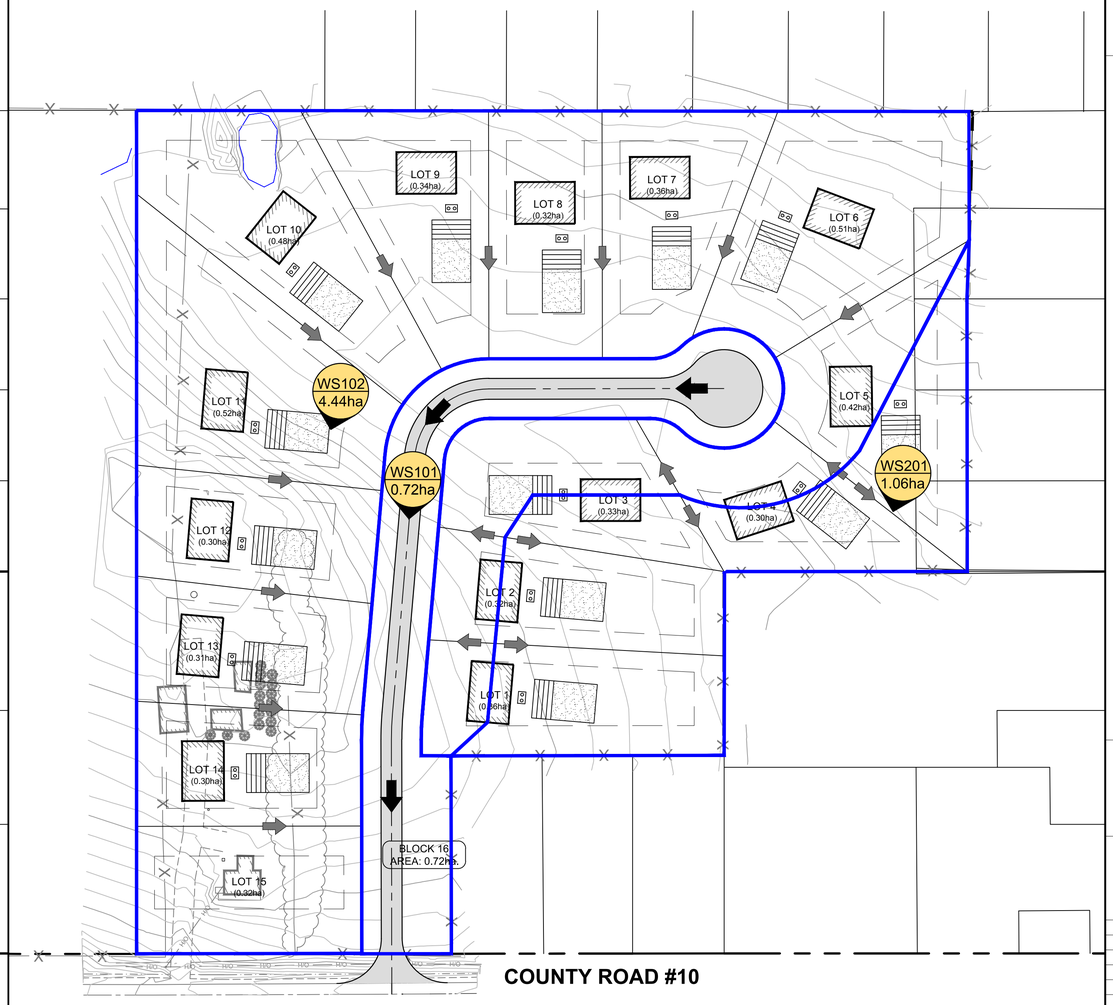
PROJECT NO.: 14016
DRAWING FILE NO.: 14016-DP
SHT. NO.: 01

C:\Users\Jason\SharePoint\Paul Hurley\Engage Shared\14016 Village of Ida CR10\Design\Drawings\Current Drawings\14016-DP.dwg PRINTED: Dec 23, 2014

PRE-DEVELOPMENT DRAINAGE AREAS

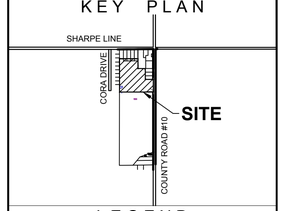


POST-DEVELOPMENT DRAINAGE AREAS



BENCHMARK -
ELEVATION -
ADD BENCHMARK DESCRIPTION HERE

KEY PLAN



LEGEND

PR WS — WATERSHED IDENTIFICATION
1.80ha — DRAINAGE AREA IN ha
DRAINAGE AREA BOUNDARY

IAN CAMERON
RURAL SUBDIVISION

TOWNSHIP OF CAVAN MONAGHAN

DRAINAGE AREA PLAN

No.	DATE	BY	REVISION
A	23-12-14	JA	ISSUED FOR SUBMISSION

ENGAGE ENGINEERING

DRAWN:	J.ARMSTRONG
DESIGNED:	J.ARMSTRONG
APPROVED:	A.HILL
DATE:	DECEMBER 23, 2014
SCALE:	HORZ. 1:1000 VERT. -
PROJECT NO.:	14016
DRAWING FILE NO.:	14016-STM
SHT. NO.:	01

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Appendix A: Peak Flow Calculations

Pre-Development Condition ExWS1
Rational Method Calculations

Project No: 14016 Project Name: Ian Cameron Rural Subdivision Designer: AMH

Site Characteristics

Land Use and Areas

Grass:	0.87	ha		Soil Type:	Sandy Till
Agriculture:		ha		Hydrologic Soil Group:	B
Woods:	0.20	ha			
Wetland:		ha		Length of Watershed:	155 m
Gravel:	0.07	ha		Slope:	5.5 %
Bare Earth:		ha		Terrain:	Rolling
Impervious:	0.01	ha	0.9%		
TOTAL:	1.15	ha			

Hydrologic Parameters

Runoff Coefficient							
Wetland	Woods	Grass	Agriculture	Gravel	Bare Earth	Impervious	Composite C
0.05	0.11	0.17	0.30	0.65	0.63	0.90	0.20

Time of Concentration, Tc	20.92	min.

Rainfall Data

Gauging Station: Peterborough

100 Year, 12 hour Depth: 90

	IDF Parameters - Peterborough					
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
A	662.00	1098.00	1560.00	2010.00	2200.00	2507.00
B	7.50	10.10	13.00	14.00	14.60	14.80
C	0.79	0.83	0.86	0.88	0.87	0.88

Peak Flow Calculations

Return Interval	Area (ha)	Composite C	Time of Conc., Tc (min.)	Intensity, I (mm/hr)	Flow, Q (m3/s)
2 Year	1.15	0.20	20.92	47.0	0.03
5 Year	1.15	0.20	20.92	63.5	0.04
10 Year	1.15	0.20	20.92	75.3	0.05
25 Year	1.15	0.21	20.92	88.2	0.06
50 Year	1.15	0.23	20.92	98.5	0.07
100 Year	1.15	0.24	20.92	107.8	0.08

Notes:

1. Soils group taken from MTO Drainage Manual, Chart H2-6A.
2. Runoff coefficients taken from MTO Drainage Manual, Chart 1.07
3. Time of concentration calculated using Airport Equation for C<0.4 and Bransby-Williams for C>0.4
4. Runoff Coefficient has been adjusted as follows for storms exceeding 10-year return period:
   25-year: 10%, 50-year: 20%; 100-year: 25%.

Pre-Development Condition ExWS2
Rational Method Calculations

Project No: 14016 Project Name: Ian Cameron Rural Subdivision Designer: AMH

Site Characteristics

Land Use and Areas

Grass:	4.23 ha		Soil Type:	Sandy Till	
Agriculture:	0.84 ha		Hydrologic Soil Group:	B	
Woods:	0.00 ha				
Wetland:	0 ha		Length of Watershed:	275	m
Gravel:	0 ha		Slope:	0.70	%
Bare Earth:	0 ha		Terrain:	Rolling	
Impervious:	0.00 ha	0.0%			
TOTAL:	5.07 ha				

Hydrologic Parameters

Runoff Coefficient							
Wetland	Woods	Grass	Agriculture	Gravel	Bare Earth	Impervious	Composite C
0.05	0.11	0.17	0.30	0.65	0.63	0.90	0.19

Time of Concentration, Tc	55.25	min.

Rainfall Data

Gauging Station: Peterborough

100 Year, 12 hour Depth: 90

	IDF Parameters - Peterborough					
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
A	662.00	1098.00	1560.00	2010.00	2200.00	2507.00
B	7.50	10.10	13.00	14.00	14.60	14.80
C	0.79	0.83	0.86	0.88	0.87	0.88

Peak Flow Calculations

Return Interval	Area (ha)	Composite C	Time of Conc., Tc (min.)	Intensity, I (mm/hr)	Flow, Q (m3/s)
2 Year	5.07	0.19	55.25	25.2	0.07
5 Year	5.07	0.19	55.25	34.2	0.09
10 Year	5.07	0.19	55.25	41.3	0.11
25 Year	5.07	0.21	55.25	48.3	0.14
50 Year	5.07	0.23	55.25	54.7	0.18
100 Year	5.07	0.24	55.25	59.6	0.20

Notes:

1. Soils group taken from MTO Drainage Manual, Chart H2-6A.
2. Runoff coefficients taken from MTO Drainage Manual, Chart 1.07
3. Time of concentration calculated using Airport Equation for C<0.4 and Bransby-Williams for C>0.4
4. Runoff Coefficient has been adjusted as follows for storms exceeding 10-year return period:

   25-year: 10%, 50-year: 20%; 100-year: 25%.

Post Development Drainage Area PrWS101
Rational Method Calculations

Project No: 14016 Project Name: Ian Cameron Rural Subdivision Designer: AMH

Site Characteristics

Land Use and Areas

Grass:	0.34 ha		Soil Type:	Sandy Till	
Agriculture:	0 ha		Hydrologic Soil Group:	B	
Woods:	0.00 ha				
Wetland:	0 ha		Length of Watershed:	300	
Gravel:	0.07 ha		Slope:	0.7	%
Bare Earth:	0 ha		Terrain:	Rolling	
Impervious:	0.31 ha	43.1%			
TOTAL:	0.72 ha				

Hydrologic Parameters

Runoff Coefficient							
Wetland	Woods	Grass	Agriculture	Gravel	Bare Earth	Impervious	Composite C
0.05	0.11	0.17	0.30	0.65	0.63	0.90	0.53

Time of Concentration, Tc	17.77	min.

Rainfall Data

Gauging Station: Peterborough

100 Year, 12 hour Depth: 90

	IDF Parameters - Peterborough					
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
A	662.00	1098.00	1560.00	2010.00	2200.00	2507.00
B	7.50	10.10	13.00	14.00	14.60	14.80
C	0.79	0.83	0.86	0.88	0.87	0.88

Peak Flow Calculations

Return Interval	Area (ha)	Composite C	Time of Conc., Tc (min.)	Intensity, I (mm/hr)	Flow, Q (m3/s)
2 Year	0.72	0.53	17.77	51.6	0.05
5 Year	0.72	0.53	17.77	69.4	0.07
10 Year	0.72	0.53	17.77	81.9	0.09
25 Year	0.72	0.58	17.77	95.8	0.11
50 Year	0.72	0.64	17.77	106.8	0.14
100 Year	0.72	0.66	17.77	116.9	0.16

Notes:

1. Soils group taken from MTO Drainage Manual, Chart H2-6A.
2. Runoff coefficients taken from MTO Drainage Manual, Chart 1.07
3. Time of concentration calculated using Airport Equation for C<0.4 and Bransby-Williams for C>0.4
4. Runoff Coefficient has been adjusted upwards as follows for storms exceeding 10-year return period:
   25-year: 10%, 50-year: 20%; 100-year: 25%.

Post Development Drainage Area PrWS102
Rational Method Calculations

Project No: 14016 Project Name: Ian Cameron Rural Subdivision Designer: AMH

Site Characteristics

Land Use and Areas

Grass:	3.94 ha		Soil Type:	Sandy Till	
Agriculture:	0 ha		Hydrologic Soil Group:	B	
Woods:	0.00 ha				
Wetland:	0 ha		Length of Watershed:	400	
Gravel:	0 ha		Slope:	1.8	%
Bare Earth:	0 ha		Terrain:	Rolling	
Impervious:	0.50 ha	11.3%			
TOTAL:	4.44 ha				

Hydrologic Parameters

Runoff Coefficient							
Wetland	Woods	Grass	Agriculture	Gravel	Bare Earth	Impervious	Composite C
0.05	0.11	0.17	0.30	0.65	0.63	0.90	0.25

Time of Concentration, Tc	45.53	min.

Rainfall Data

Gauging Station: Peterborough

100 Year, 12 hour Depth: 90

	IDF Parameters - Peterborough					
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
A	662.00	1098.00	1560.00	2010.00	2200.00	2507.00
B	7.50	10.10	13.00	14.00	14.60	14.80
C	0.79	0.83	0.86	0.88	0.87	0.88

Peak Flow Calculations

Return Interval	Area (ha)	Composite C	Time of Conc., Tc (min.)	Intensity, I (mm/hr)	Flow, Q (m3/s)
2 Year	4.44	0.25	45.53	28.7	0.09
5 Year	4.44	0.25	45.53	39.1	0.12
10 Year	4.44	0.25	45.53	47.1	0.15
25 Year	4.44	0.28	45.53	55.1	0.19
50 Year	4.44	0.30	45.53	62.3	0.23
100 Year	4.44	0.32	45.53	68.0	0.26

Notes:

1. Soils group taken from MTO Drainage Manual, Chart H2-6A.
2. Runoff coefficients taken from MTO Drainage Manual, Chart 1.07
3. Time of concentration calculated using Airport Equation for C<0.4 and Bransby-Williams for C>0.4
4. Runoff Coefficient has been adjusted upwards as follows for storms exceeding 10-year return period:
   25-year: 10%, 50-year: 20%; 100-year: 25%.

Post-Development Drainage Area PrWS201
Rational Method Calculations

Project No: 14016 Project Name: Ian Cameron Rural Subdivision Designer: AMH

Site Characteristics

Land Use and Areas

Grass:	1.00 ha		Soil Type:	Sandy Till	
Agriculture:	ha		Hydrologic Soil Group:	B	
Woods:	0 ha				
Wetland:	0 ha		Length of Watershed:	160	m
Gravel:	0 ha		Slope:	2.80	%
Bare Earth:	0 ha		Terrain:	Rolling	
Impervious:	0.06 ha	5.7%			
TOTAL:	1.06 ha				

Hydrologic Parameters

Runoff Coefficient							
Wetland	Woods	Grass	Agriculture	Gravel	Bare Earth	Impervious	Composite C
0.05	0.11	0.17	0.30	0.65	0.63	0.90	0.21

Time of Concentration, Tc	26.09	min.

Rainfall Data

Gauging Station: Peterborough

100 Year, 12 hour Depth: 90

	IDF Parameters - Peterborough					
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
A	662.00	1098.00	1560.00	2010.00	2200.00	2507.00
B	7.50	10.10	13.00	14.00	14.60	14.80
C	0.79	0.83	0.86	0.88	0.87	0.88

Peak Flow Calculations

Return Interval	Area (ha)	Composite C	Time of Conc., Tc (min.)	Intensity, I (mm/hr)	Flow, Q (m3/s)
2 Year	1.06	0.21	26.09	41.2	0.03
5 Year	1.06	0.21	26.09	55.8	0.03
10 Year	1.06	0.21	26.09	66.7	0.04
25 Year	1.06	0.23	26.09	78.1	0.05
50 Year	1.06	0.25	26.09	87.5	0.07
100 Year	1.06	0.26	26.09	95.7	0.07

Notes:

1. Soils group taken from MTO Drainage Manual, Chart H2-6A.
2. Runoff coefficients taken from MTO Drainage Manual, Chart 1.07
3. Time of concentration calculated using Airport Equation for C<0.4 and Bransby-Williams for C>0.4
4. Runoff Coefficient has been adjusted as follows for storms exceeding 10-year return period:

   25-year: 10%, 50-year: 20%; 100-year: 25%.

Appendix B: Storage Volume Calculations

Modified Rational Method for PrWS101 & PrWS102

Project Name:	Ian Cameron	Designed By: AH
Project No:	14016	Checked By: PH
Date:	December 19, 2014	

Drainage Area	5.16	ha
Runoff Coefficient	0.29	
Extranious Flows	0.00	m^3/s
Bottom of Tc Range	50.0	min
Time Increment	1.0	min
Discharge Rate	0.030	m^3/s
Storage Required	246.60	m^3

Rainfall Data

Rainfall Gauging Station :		Peterborough
100 Yr, 12 Hour Rainfall depth =	90.4	mm
Return Interval Storm	2 Year	

IDF Parameters	
a:	662
b:	7.5
c:	0.79

T (min)	I (mm/hr)	Inflow (m^3/s)		Volume (m^3)		
		Catchment Runoff	Extranious Flows	Incoming	Released	Net Storage
50.0	27.0	0.112	0.00	335.4	90.0	245.4
51.0	26.6	0.110	0.00	337.5	91.8	245.7
52.0	26.2	0.109	0.00	339.5	93.6	245.9
53.0	25.9	0.107	0.00	341.5	95.4	246.1
54.0	25.6	0.106	0.00	343.5	97.2	246.3
55.0	25.2	0.105	0.00	345.4	99.0	246.4
56.0	24.9	0.103	0.00	347.3	100.8	246.5
57.0	24.6	0.102	0.00	349.2	102.6	246.6
58.0	24.3	0.101	0.00	351.0	104.4	246.6
59.0	24.0	0.100	0.00	352.8	106.2	246.6
60.0	23.8	0.098	0.00	354.6	108.0	246.6
61.0	23.5	0.097	0.00	356.3	109.8	246.5
62.0	23.2	0.096	0.00	358.0	111.6	246.4
63.0	23.0	0.095	0.00	359.7	113.4	246.3
64.0	22.7	0.094	0.00	361.4	115.2	246.2
65.0	22.4	0.093	0.00	363.0	117.0	246.0
66.0	22.2	0.092	0.00	364.7	118.8	245.9
67.0	22.0	0.091	0.00	366.3	120.6	245.7
68.0	21.7	0.090	0.00	367.8	122.4	245.4
69.0	21.5	0.089	0.00	369.4	124.2	245.2

Modified Rational Method for PrWS101 & PrWS102

Project Name:	Ian Cameron	Designed By: AH
Project No:	14016	Checked By: PH
Date:	December 19, 2014	Sheet 1 of 1

Drainage Area	5.16	ha
Runoff Coefficient	0.29	
Extranious Flows	0.00	m^3/s
Bottom of Tc Range	50.0	min
Time Increment	1.0	min
Discharge Rate	0.040	m^3/s
Storage Required	342.24	m^3

Rainfall Data

Rainfall Gauging Station :		Lindsay
100 Yr, 12 Hour Rainfall depth =	114.28	mm
Return Interval Storm	5 Year	

IDF Parameters	
a:	820.23
b:	6.01
c:	0.77

T (min)	I (mm/hr)	Inflow (m^3/s)		Volume (m^3)		
		Catchment Runoff	Extranious Flows	Incoming	Released	Net Storage
50.0	37.0	0.153	0.00	459.8	120.0	339.8
51.0	36.5	0.151	0.00	462.7	122.4	340.3
52.0	36.0	0.149	0.00	465.5	124.8	340.7
53.0	35.5	0.147	0.00	468.2	127.2	341.0
54.0	35.1	0.145	0.00	470.9	129.6	341.3
55.0	34.6	0.144	0.00	473.6	132.0	341.6
56.0	34.2	0.142	0.00	476.2	134.4	341.8
57.0	33.8	0.140	0.00	478.8	136.8	342.0
58.0	33.4	0.138	0.00	481.3	139.2	342.1
59.0	33.0	0.137	0.00	483.8	141.6	342.2
60.0	32.6	0.135	0.00	486.2	144.0	342.2
61.0	32.2	0.134	0.00	488.6	146.4	342.2
62.0	31.8	0.132	0.00	491.0	148.8	342.2
63.0	31.5	0.131	0.00	493.4	151.2	342.2
64.0	31.1	0.129	0.00	495.7	153.6	342.1
65.0	30.8	0.128	0.00	497.9	156.0	341.9
66.0	30.5	0.126	0.00	500.2	158.4	341.8
67.0	30.1	0.125	0.00	502.4	160.8	341.6
68.0	29.8	0.124	0.00	504.6	163.2	341.4
69.0	29.5	0.122	0.00	506.7	165.6	341.1

Modified Rational Method for PrWS101 & PrWS102

Project Name:	Ian Cameron	Designed By: AH
Project No:	14016	Checked By: PH
Date:	December 19, 2014	Sheet 1 of 1

Drainage Area	5.16	ha
Runoff Coefficient	0.29	
Extranious Flows	0.00	m^3/s
Bottom of Tc Range	50.0	min
Time Increment	1.0	min
Discharge Rate	0.050	m^3/s
Storage Required	401.88	m^3

Rainfall Data

Rainfall Gauging Station :	Peterborough	
100 Yr, 12 Hour Rainfall depth =	90.4	mm
Return Interval Storm	10 Year	

IDF Parameters	
a:	1560
b:	13
c:	0.86

T (min)	I (mm/hr)	Inflow (m^3/s)		Volume (m^3)		
		Catchment Runoff	Extranious Flows	Incoming	Released	Net Storage
50.0	44.2	0.183	0.00	550.2	150.0	400.2
51.0	43.6	0.181	0.00	553.6	153.0	400.6
52.0	43.1	0.179	0.00	557.0	156.0	401.0
53.0	42.5	0.176	0.00	560.3	159.0	401.3
54.0	41.9	0.174	0.00	563.6	162.0	401.6
55.0	41.4	0.172	0.00	566.7	165.0	401.7
56.0	40.9	0.170	0.00	569.8	168.0	401.8
57.0	40.4	0.168	0.00	572.9	171.0	401.9
58.0	39.9	0.165	0.00	575.9	174.0	401.9
59.0	39.4	0.163	0.00	578.8	177.0	401.8
60.0	39.0	0.162	0.00	581.7	180.0	401.7
61.0	38.5	0.160	0.00	584.5	183.0	401.5
62.0	38.1	0.158	0.00	587.2	186.0	401.2
63.0	37.6	0.156	0.00	589.9	189.0	400.9
64.0	37.2	0.154	0.00	592.6	192.0	400.6
65.0	36.8	0.153	0.00	595.2	195.0	400.2
66.0	36.4	0.151	0.00	597.8	198.0	399.8
67.0	36.0	0.149	0.00	600.3	201.0	399.3
68.0	35.6	0.148	0.00	602.8	204.0	398.8
69.0	35.3	0.146	0.00	605.3	207.0	398.3

Modified Rational Method for PrWS101 & PrWS102

Project Name:	Ian Cameron	Designed By: AH
Project No:	14016	Checked By: PH
Date:	December 19, 2014	Sheet 1 of 1

Drainage Area	5.16	ha
Runoff Coefficient	0.29	
Extranious Flows	0.00	m^3/s
Bottom of Tc Range	50.0	min
Time Increment	1.0	min
Discharge Rate	0.060	m^3/s
Storage Required	464.55	m^3

Rainfall Data

Rainfall Gauging Station :	Peterborough	
100 Yr, 12 Hour Rainfall depth =	90.4	mm
Return Interval Storm	25 Year	

IDF Parameters	
a:	2010
b:	14
c:	0.88

T (min)	I (mm/hr)	Inflow (m^3/s)		Volume (m^3)		
		Catchment Runoff	Extranious Flows	Incoming	Released	Net Storage
50.0	51.7	0.215	0.00	643.5	180.0	463.5
51.0	51.0	0.212	0.00	647.5	183.6	463.9
52.0	50.3	0.209	0.00	651.4	187.2	464.2
53.0	49.7	0.206	0.00	655.2	190.8	464.4
54.0	49.0	0.203	0.00	658.9	194.4	464.5
55.0	48.4	0.201	0.00	662.6	198.0	464.6
56.0	47.8	0.198	0.00	666.1	201.6	464.5
57.0	47.2	0.196	0.00	669.6	205.2	464.4
58.0	46.6	0.193	0.00	673.0	208.8	464.2
59.0	46.1	0.191	0.00	676.4	212.4	464.0
60.0	45.5	0.189	0.00	679.6	216.0	463.6
61.0	45.0	0.187	0.00	682.8	219.6	463.2
62.0	44.5	0.184	0.00	686.0	223.2	462.8
63.0	44.0	0.182	0.00	689.1	226.8	462.3
64.0	43.5	0.180	0.00	692.1	230.4	461.7
65.0	43.0	0.178	0.00	695.1	234.0	461.1
66.0	42.5	0.176	0.00	698.0	237.6	460.4
67.0	42.0	0.174	0.00	700.9	241.2	459.7
68.0	41.6	0.172	0.00	703.7	244.8	458.9
69.0	41.2	0.171	0.00	706.5	248.4	458.1

Modified Rational Method for PrWS101 & PrWS102

Project Name:	Ian Cameron	Designed By: AH
Project No:	14016	Checked By: PH
Date:	December 19, 2014	Sheet 1 of 1

Drainage Area	5.16	ha
Runoff Coefficient	0.29	
Extranious Flows	0.00	m^3/s
Bottom of Tc Range	50.0	min
Time Increment	1.0	min
Discharge Rate	0.070	m^3/s
Storage Required	519.89	m^3

Rainfall Data

Rainfall Gauging Station :		Peterborough
100 Yr, 12 Hour Rainfall depth =		90.4 mm
Return Interval Storm	50 Year	**IDF Parameters**
		a: 2200
		b: 14.6
		c: 0.87

T (min)	I (mm/hr)	Inflow (m^3/s)		Volume (m^3)		
		Catchment Runoff	Extranious Flows	Incoming	Released	Net Storage
50.0	58.5	0.243	0.00	728.3	210.0	518.3
51.0	57.8	0.240	0.00	733.1	214.2	518.9
52.0	57.0	0.236	0.00	737.7	218.4	519.3
53.0	56.3	0.233	0.00	742.2	222.6	519.6
54.0	55.6	0.230	0.00	746.6	226.8	519.8
55.0	54.9	0.228	0.00	750.9	231.0	519.9
56.0	54.2	0.225	0.00	755.1	235.2	519.9
57.0	53.5	0.222	0.00	759.2	239.4	519.8
58.0	52.9	0.219	0.00	763.3	243.6	519.7
59.0	52.3	0.217	0.00	767.3	247.8	519.5
60.0	51.7	0.214	0.00	771.2	252.0	519.2
61.0	51.1	0.212	0.00	775.0	256.2	518.8
62.0	50.5	0.209	0.00	778.7	260.4	518.3
63.0	49.9	0.207	0.00	782.4	264.6	517.8
64.0	49.4	0.205	0.00	786.0	268.8	517.2
65.0	48.8	0.202	0.00	789.6	273.0	516.6
66.0	48.3	0.200	0.00	793.1	277.2	515.9
67.0	47.8	0.198	0.00	796.5	281.4	515.1
68.0	47.3	0.196	0.00	799.8	285.6	514.2
69.0	46.8	0.194	0.00	803.2	289.8	513.4

Modified Rational Method for PrWS101 & PrWS102

Project Name:	Ian Cameron	Designed By: AH
Project No:	14016	Checked By: PH
Date:	December 19, 2014	Sheet 1 of 1

Drainage Area	5.16	ha
Runoff Coefficient	0.29	
Extranious Flows	0.00	m^3/s
Bottom of Tc Range	50.0	min
Time Increment	1.0	min
Discharge Rate	0.080	m^3/s
Storage Required	554.32	m^3

Rainfall Data

Rainfall Gauging Station :	Peterborough	
100 Yr, 12 Hour Rainfall depth =	90.4	mm
Return Interval Storm	100 Year	

IDF Parameters	
a:	2507
b:	14.8
c:	0.88

T (min)	I (mm/hr)	Inflow (m^3/s)		Volume (m^3)		
		Catchment Runoff	Extranious Flows	Incoming	Released	Net Storage
50.0	63.8	0.265	0.00	793.9	240.0	553.9
51.0	63.0	0.261	0.00	799.0	244.8	554.2
52.0	62.1	0.258	0.00	803.9	249.6	554.3
53.0	61.3	0.254	0.00	808.7	254.4	554.3
54.0	60.5	0.251	0.00	813.4	259.2	554.2
55.0	59.8	0.248	0.00	818.0	264.0	554.0
56.0	59.0	0.245	0.00	822.5	268.8	553.7
57.0	58.3	0.242	0.00	827.0	273.6	553.4
58.0	57.6	0.239	0.00	831.3	278.4	552.9
59.0	56.9	0.236	0.00	835.5	283.2	552.3
60.0	56.2	0.233	0.00	839.7	288.0	551.7
61.0	55.6	0.231	0.00	843.8	292.8	551.0
62.0	55.0	0.228	0.00	847.8	297.6	550.2
63.0	54.3	0.225	0.00	851.7	302.4	549.3
64.0	53.7	0.223	0.00	855.5	307.2	548.3
65.0	53.1	0.220	0.00	859.3	312.0	547.3
66.0	52.6	0.218	0.00	863.0	316.8	546.2
67.0	52.0	0.216	0.00	866.7	321.6	545.1
68.0	51.4	0.213	0.00	870.3	326.4	543.9
69.0	50.9	0.211	0.00	873.8	331.2	542.6