

**Appendix E**  
**Preliminary Stormwater Management Assessment**

**Ainley & Associates Limited**

280 Pretty River Parkway, Collingwood, ON L9Y 4J5

Tel: (705) 445-3451 • Fax: (705) 445-0968

Email: collingwood@ainleygroup.com

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To: **Victoria Giangrande (Ainley)**

Copies to: Ken Pun (Ainley),  
Gary Scott (Ainley)

From: **Alireza Zareie**

Date: **August 3, 2018**

Ref: Preliminary SWM Report –Springwater Multi-Purpose Complex File: 117148

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## 1. Introduction

Ainley & Associates has been retained by the Township of Springwater (the “Town”) to prepare a Stormwater Management (SWM) Report as a part of the Town Multi-Purpose Complex development plan on a portion of the property located at 1132 Snow Valley Road in Springwater Township, Ontario. Specifically, this report has been prepared to propose different stormwater management options and to propose potential outlets associated with this development.

### 1.1. Site Description

The subject property resides within a larger land holding known as the “Hasty Tract” and is located within Lot 13, Concession 5, Springwater Township. The property consists of approximately 20.0 ha of undeveloped land and is bounded by Bayfield Street North to the east, Snow Valley Road to the south and vacant forested land known as “Museum Tract” to the north and west. Figure 1 illustrates the location of the subject property. The site is primarily wooded land and includes a trail network with the adjacent County of Simcoe land. The site is part of the Willow Creek Subwatershed as identified in the Nottawasaga Valley Conservation Authority (NVCA) Plan. According to the Springwater Township By-Law 5000 ZBA, the Hasty Tract property is currently zoned as Open Space land.

### 1.2. Objectives

The primary objective of this report is to investigate the existing drainage conditions in the area of the site in order to propose potential stormwater management alternatives that will conform to all applicable Municipal, Regional and Provincial guidelines while minimizing the impact of the development on the local drainage systems. Stormwater management option details will be provided later when the best option is selected and the site plan becomes available.

### 1.3. Background and Guidelines

This report was prepared recognizing the pertinent Municipal and Provincial guidelines on water resources and the environment including the following publications:

- NVCA Stormwater Technical Guide, Nottawasaga Valley Conservation Authority (December, 2013);
- Engineering Design Standard Specifications and Engineering Design Standard Drawings, Township of Springwater (May, 2008);
- IDF Curve Lookup, Ministry of Transportation; and
- Stormwater Management Planning and Design Manual, Ministry of the Environment (March, 2003).

The NVCA regulation mapping has been reviewed to determine if the subject property is located in a NVCA regulated area under Ontario Regulation 172/06. Specifically, the NVCA Interactive Property Map was reviewed and it has been determined that the subject property is located outside NVCA regulated areas.

Based on Simcoe County Soil Map (1959), soil in the catchment can be characterized as Sargent gravelly sandy loam with good drainage characteristics, Hydrologic Soil Group A.

#### 1.4. Proposed Land Use

The proposal for this site is to develop a multi-purpose recreational complex in two phases. The conceptual plan includes a multi-purpose recreational complex, a multi-purpose outdoor fields, a fire hall, a library, paved parking area and landscape features and hardscapes.

### 2. Existing Drainage Conditions

Existing site topography, ground cover, land use and drainage patterns on site were established through site visitation, interpretation of the available topographic maps and aerial photography. A Pre-Development Drainage Plan (Drawing DP-1) illustrating the existing drainage conditions is enclosed and should be referenced when reviewing the following sections.

The subject property is located in Willow Creek Subwatershed as identified in NVCA Watershed Plan. The drainage area is primarily wooded with gravelly sandy loam. The runoff coefficient for the existing condition estimated to be 0.08. The site drains southeast across the property as sheet flow and ultimately outlets to a ditch at northwest corner of Bayfield St N/Snow Valley Road intersection. Pre-development flows from subject property to the outlet has been quantified using Rational Method. The hydrologic analysis and associated calculations are included in Appendix B and the results are summarized in Table 1.

**Table 1: Pre-Development Hydrologic Analysis Results Summary**

Return Period	Area (ha)	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Peak Flow (m <sup>3</sup> /s)	20.0	0.057	0.076	0.088	0.118	0.146	0.161

### 3. Stormwater Management Plan

The stormwater management plan developed for the subject property is in accordance with the criteria set forth in the MOE Stormwater Management Planning and Design Manual (March 2003), the Township of Springwater Engineering Design Standard Specification and NVCA Stormwater Technical Guide. The stormwater management plan has been designed in accordance with the SWM criteria established for the site and is presented in the following sections.

#### 3.1. Design Criteria

Based on the information gathered on-site, the background information collected and our analysis of this information, a clear understanding of the SWM issues was gained. In summary, the following issues are to be addressed in the proposed SWM plan:

- The SWM plan must maintain existing stormwater runoff rates to the existing outlet points by restricting post development peak flow rates to pre-development levels for the 2-year through 100- year design storms;
- The SWM plan must achieve the required Level 1 “Enhanced” water quality treatment to Provincial standards in the form of 80% total suspended solids (TSS) removal for the site effluent in accordance with NVCA Stormwater Technical Guide; and
- The stormwater management plan must accommodate the flows from the external drainage areas west and north of the subject property and must provide safe conveyance of the Regulatory storm event peak flows through the site to the downstream drainage system.

#### 3.2. Available SWM Alternatives

Conventional and innovative stormwater management measures have been considered for the subject property. The following measures have the potential to address the water balance, water quality and water quantity issues:

1. Source Control Measures;
2. Conveyance Control Measures; and
3. End-of-Pipe Control Measures

### **3.2.1. Source Control Measures**

Source control measures are small-scale stormwater management measure located at the beginning of a drainage system where stormwater is captured and treated on-site or close to where the rainfall lands. Due to the relatively small area treated by an individual measure, source controls must be well distributed to treat stormwater runoff effectively.

Source control measures are generally installed on private property and can be used within variety of land uses. In residential areas, source control measures provide treatment for the stormwater generated by roof and driveway areas. In commercial areas, these measures may target roof, side-roads, and parking areas.

Source control measures remove pollutants from stormwater through a variety of mechanisms, including mechanical filtration, biological uptake, adsorption, and settling. These measures exhibit a wide variability in their ability to remove pollutants, generally ranging between 40% and 80% in efficiency depending on the particular measure and the type of pollutant being analyzed. In addition to pollutant removal, source control measures also reduce stormwater runoff volumes through infiltration and/or reuse. Several representative source control measures applicable to the subject property are discussed below:

#### **A. Bioretention Areas:**

Bioretention systems are landscaped areas which capture, temporarily store, and treat stormwater runoff by passing it through engineered soil filter media, thereby reducing runoff volumes and pollutants. The primary component of a bioretention cell is a filter bed with a mixture of sand, soil, and organic material as filtering medium. In Hasty Tract property, bioretention areas can be used at the base of buildings, in parking lot islands, or at the edge of a parking lot where stormwater is directed to. Bioretention areas are relatively inexpensive to build, easy to maintain, and can add aesthetic value to a site, without consuming large amounts of valuable land area.

#### **B. Permeable Pavement:**

Permeable pavement systems are an alternative to traditional impervious pavements which allow stormwater to drain through into a stone reservoir where it is infiltrated into the native soil. They can be used for low traffic roads, parking lots, driveways and paths. These source controls can be used in new development areas where the systems can be used to take advantage of the large impervious parking areas and where pervious landscaped areas are limited. This design can also direct drainage to grassed areas to help remove stormwater pollutants which would otherwise be directed to storm sewers and receiving watercourses.

#### **C. Soakaway Pits/Infiltration Trenches:**

Infiltration chambers and soakaway pits are stone-filled trenches or galleries that are constructed below grade. Pre-manufactured chambers are also available. Typically, these stormwater control measures store and infiltrate runoff discharged from rooftop areas via a downspout or swale.

#### **D. Oil/Grit Separators:**

Oil/grit separators are used to trap and retain oil and/or sediment in detention chambers. These units are either located at the beginning of a storm sewer (pre-treatment or source control) or at the end of a storm sewer (end-of-pipe control).

#### **E. Green Rooftop Technology:**

These systems are constructed on buildings with flat rooftops in order to reduce runoff volume (via increased evapotranspiration), improve water quality and reduce energy usage.

### **3.2.2. Conveyance Control Measures**

Conveyance control measures are designed to treat stormwater as it travels overland or through pipes en route to the downstream outlet. Traditional urban conveyance systems are comprised of curbs, gutters and buried concrete (or other) piping systems that carry stormwater away from a development area to a water body, generally along the road network. In appropriate applications, alternative conveyance control measures can be used to improve water quality conditions at lower cost to the municipality than traditional conveyance systems. Like source controls, these systems remove a portion of the total stormwater volume from entering the storm sewer network, slow the erosive velocity of stormwater entering watercourses, and filter out pollutants from stormwater.

Conveyance control measures can often provide stormwater treatment for the collected drainage concentrated within the right-of-way. Because parking lots and roads for the proposed development account for a significant share of a site's impervious surfaces, conveyance control measures present an important opportunity to improve downstream water quality conditions (e.g. sediment, nutrient, bacteria, oil/grit, thermal impact reduction, etc.), promote groundwater recharge and minimize watercourse erosion.

Various types of conveyance control measures applicable to subject property are reviewed below:

#### **A. Grassed Swales:**

This straight-forward stormwater treatment measure consists of simple linear channels lined with grass and designed to promote shallow flow conditions. Grassed swales improve water quality through the trapping of sediment. Improvement in water quality is directly correlated to sediment trapping since contaminants typically adhere to or form part of the sediment. Dissolved contaminants, such as salt, are not treated by grassed swales.

#### **B. Bioretention/ Bioswales:**

Along access roads, bioretention areas can be placed at the edge of paved areas, either between the curb and sidewalk, or extending into the road in the approximate area of one parking spot. These 'low-tech' water quality treatment systems use plants and soil to trap and treat petroleum products, metals, nutrients, sediments and other pollutants that typically accumulate on asphalt surfaces.

#### **C. Vegetated Filter Strip:**

Filter strips are densely vegetated (planted) strips of land engineered and constructed to improve water quality by permitting sediment deposition during shallow flow conditions. Pollutant removal efficiency depends largely on the quantity of water, as channelized flow conditions do not provide treatment. The type of vegetation and the soil infiltration rate also dictate pollutant removal efficiency. Depending on the amount and type of vegetation planted and the need for replacement or amendment of soils, filter strips can be inexpensive to construct and maintain.

### **3.2.3. End-of-Pipe Measures**

End-of-pipe measures are the most commonly used stormwater management measure in most municipalities. These measures provide treatment for the collected drainage at the end of conveyance system prior to discharge of stormwater to a watercourse. End-of-pipe measures are typically implemented in urbanizing areas as a requirement of development. Typical end-of-pipe measures used to treat stormwater include stormwater ponds (dry or wet), wetlands, hybrid facilities and/or infiltration basins.

In many typical end-of-pipe measures, a permanent pool of water provides the water quality treatment. This permanent pool promotes the settling of sediments and pollutants to the bottom of the facility as stormwater travels through the facility. Provided the facility is functioning properly and is well maintained, sediments and pollutants will not be transported downstream of the facility. To optimize pollutant removal capacities, design engineers usually aim to maximize the distance that stormwater must travel through these facilities so that a larger percentage of the suspended solids will fall out of suspension.

The results of many monitoring programs indicate that most engineered wet ponds typically achieve 60-80% suspended solids (SS) removal and 40-50% total phosphorus (TP) removal. In general, a larger volume of water utilized for water quality storage will enhance performance; however, suspended solids removal performance becomes asymptotic with

increasing design storage (there is a limit to storage beyond which there are negligible increases in suspended solids settling) (MOE, 2003).

Ideally, end-of-pipe measures are designed as large centralized facilities that treat the collected drainage from as much upstream development area as is realistically possible. This will reduce construction, operations and maintenance costs.

**A. Wet Ponds:**

These facilities comprise the most common form of end-of-pipe stormwater management facilities. Wet ponds include a permanent pool of water for quality control treatment, and are also often designed with temporary extended detention storage for erosion and water quantity (flood) control.

**B. Constructed Wetlands:**

Constructed wetlands comprise one of the preferred end-of-pipe facilities for water quality enhancement. These facilities may be effective in reducing downstream erosion potential but their role in water quantity control is limited because of their limited storage volume and shallow water depth. Construction costs for wetlands systems tend to be higher other alternative end-of-pipe measures.

**C. Hybrid Wet Ponds / Wetlands:**

These systems are designed as a combination of wet ponds and constructed wetlands. Typically, the wet pond cell is constructed in series with a wetland cell. The total required permanent pool volume is shared, with approximately 50% within each element.

**D. Dry Ponds:**

Stormwater dry ponds do not have a permanent pool of water and therefore do not provide the same water quality function as wet ponds. Instead, these types of facilities are designed primarily for erosion and flood control.

**E. Infiltration Basins:**

An infiltration basin is a shallow impoundment that is designed to infiltrate stormwater into the soil. Infiltration basins can have high pollutant removal efficiency and can help recharge the groundwater, thus restoring low flows to stream systems. Infiltration basins can be designed as above ground or below ground facilities.

**F. Filters:**

These systems utilize materials such as sand, peat moss or clear stone to filter out pollutants in stormwater runoff.

**G. Oil/Grit Separators:**

These mechanical devices are used for the capture of spills and removal of coarse sediment from stormwater. Oil/grit separators are intended to remove floatables (debris, gasoline, oil, grease, light petroleum products and other floating liquids) from stormwater runoff. These systems are used for small contributing drainage areas, often less than 2 hectares. Generally, these devices are used for commercial and industrial land use but can also be used for redevelopment and infill areas where available space is constrained and traditional forms of water quality treatment cannot be implemented.

### **3.3. Proposed SWM Options**

Geological investigation shows that the regional overburden geology comprises glaciolacustrine near shore and beach deposits including sand, gravelly sand and gravel, underlain by shale, limestone, dolostone, arkose and sandstone. Site geology is favorable for infiltration options. Considering the subject property conditions, different SWM alternatives could be implemented. Grassed swales, bioretention areas, infiltration trenches, bioswales, Oil/grit separators, green roofs, wetlands and wet ponds are plausible options that could provide the required water quantity and water quality criteria.

### 3.3.1. Water Quality

In accordance with NVCA Stormwater Technical Guide, the SWM plan must achieve the required Level 1 “Enhanced” water quality treatment to Provincial standards in the form of 80% total suspended solids (TSS) removal for the site effluent. Depending on final development plan, infiltration basins, bio swales, a wetland, a wet pond or Oil/Grit separator could be utilized. Table 2 summarizes the required water quality storage for ultimate development of 20.0 ha of land with 40 % imperviousness.

**Table 2: Required Water Quality Storage(m<sup>3</sup>) for Different Quality Control Alternatives (Enhanced Protection Level)**

Water Quantity Control Alternative	Total Req. Water Quality Storage (m3)	Required Permanent Pool Storage (m3)	Required Extended Detention Storage (m3)
Infiltration Basin/Bio Swale	525	--	--
Wetland	1725	925	800
Wet Pond	3050	2250	800

Grassed swales/ bioswales could be located on both sides of property roadways, around parking areas, and around the property. However, considering the site existing grade, the wetland or wet pond are proposed to be located at the southeast corner of the property at Bayfield St N and Snow Valley Rd Intersection, otherwise huge fill will be required to direct stormwater to the proposed SWM facility. The proposed end-of-pipe SWM facility occupy approximately 1.0ha land and it is proposed to be located at the southeast corner of the subject property.

### 3.3.2. Water Quantity

The SWM plan must maintain existing stormwater runoff rates to the existing outlet points by restricting post development peak flow rates to pre-development levels for the 2-year through 100- year design storms. Modified Rational Method has been used to estimate the required storage capacity to control post-development peak flow to pre-development level. Detailed Modified Rational Method calculations are provided in Appendix C and the results are summarized in Table 3.

**Table 3: Required Storage Volume (m<sup>3</sup>) for Water Quantity Control Purposes**

Return Period	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Post-Development Peak Flow (m <sup>3</sup> /s)	0.36	0.477	0.554	0.75	0.95	1.114
Pre-Development Peak Flow (m <sup>3</sup> /s)	0.057	0.076	0.088	0.118	0.146	0.161
Req. Storage Volume (m <sup>3</sup> )	2183	2876	3348	4267	5129	6018

Required storage could be provided in swales, on parking lot areas or in an end-of-pipe SWM facility. SWM facility outlet details will be provided when preferred option is selected and development plan becomes available.

### 3.3.3. Potential Outlet

The site drains southeast across the property as sheet flow to a ditch at northwest corner of Bayfield Street/Snow Valley Road intersection and eventually outlets to a tributary of Willow Creek approximately 950 m south the intersection. All roads/entrance roads on the Bayfield St N ditch—except the entrance to 1152 Bayfield St N—have a 500mm/600mm CSP culvert. The existing culverts as well as the ditch are partially filled with sediment and need to be cleaned up. The ditch and culverts seem to have enough capacity; however, this will be checked when the survey or existing As-Builts become available. Considering the topography and existing drainage condition, the Bayfield St

N ditch with minor adjustments is the best option that could collect the post-development runoff from all of the subject property and convey it to a tributary of Willow Creek.

The outlet to the north along the Bayfield St N could only drain parts of the property and is not the preferred option.

#### **4. Siltation and Erosion Control**

Siltation and erosion control will be implemented for all construction activities within the development site, including vegetation clearing, topsoil stripping, road construction and stockpiling of materials. The basic principles considered to minimize erosion and sedimentation and resultant negative environmental impacts include:

- Minimize disturbance activities where possible;
- Expose the smallest possible land area to erosion for the shortest possible time;
- Institute erosion control measures as-required immediately;
- Implement sediment control measures before the outset of construction activities; and,
- Carry out regular inspections of erosion/sediment control measures and repair or maintain as necessary.

The detailed siltation and erosion control measures proposed to be implemented during and after construction are identified and include the following:

- Heavy duty silt fences will be erected around the perimeter of the site before any grading operations commence to control sediment movement sites;
- A construction vehicle entrance will be constructed and maintained consisting of a stone mud mat to reduce off-site tracking of materials;
- Ditch inlet catchbasins will be fitted with sediment traps during construction activities, and cleaned out as required; and
- Straw bale flow check dams and rock flow check dams will be installed in the on-site and off-site overland flow routes/ditches to prevent the movement of sediment downstream to Black Ash Creek.

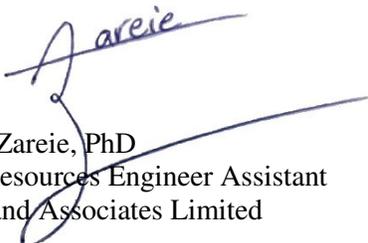
#### **5. Conclusions**

The preliminary stormwater management report summarizes actions that need to be taken to meet the established criteria with respect to stormwater management set forth in governing documents in order to proceed without negatively impacting the local drainage systems.

The report evaluates different SWM quality control options and proposes plausible options to provide “Enhanced” water quality control in the form of 80 % TSS removal. It also evaluates the existing drainage condition of the subject property and proposed required storage to meet the NVCA quantity control criteria in the form of post to pre-development peak flow matching. A potential outlet as well as related actions to enhance the conveyance properties of the existing ditch on Bayfield St N provided.

In conclusion, a wide range of SWM options including enhanced swales, green roofs, infiltration trenches, a wet pond, a wetland, underground storage chambers could be designed to mitigate anticipated stormwater impacts associated with the development of the subject property and provide the water quality and water quantity control as required by NVCA.

Prepared by:



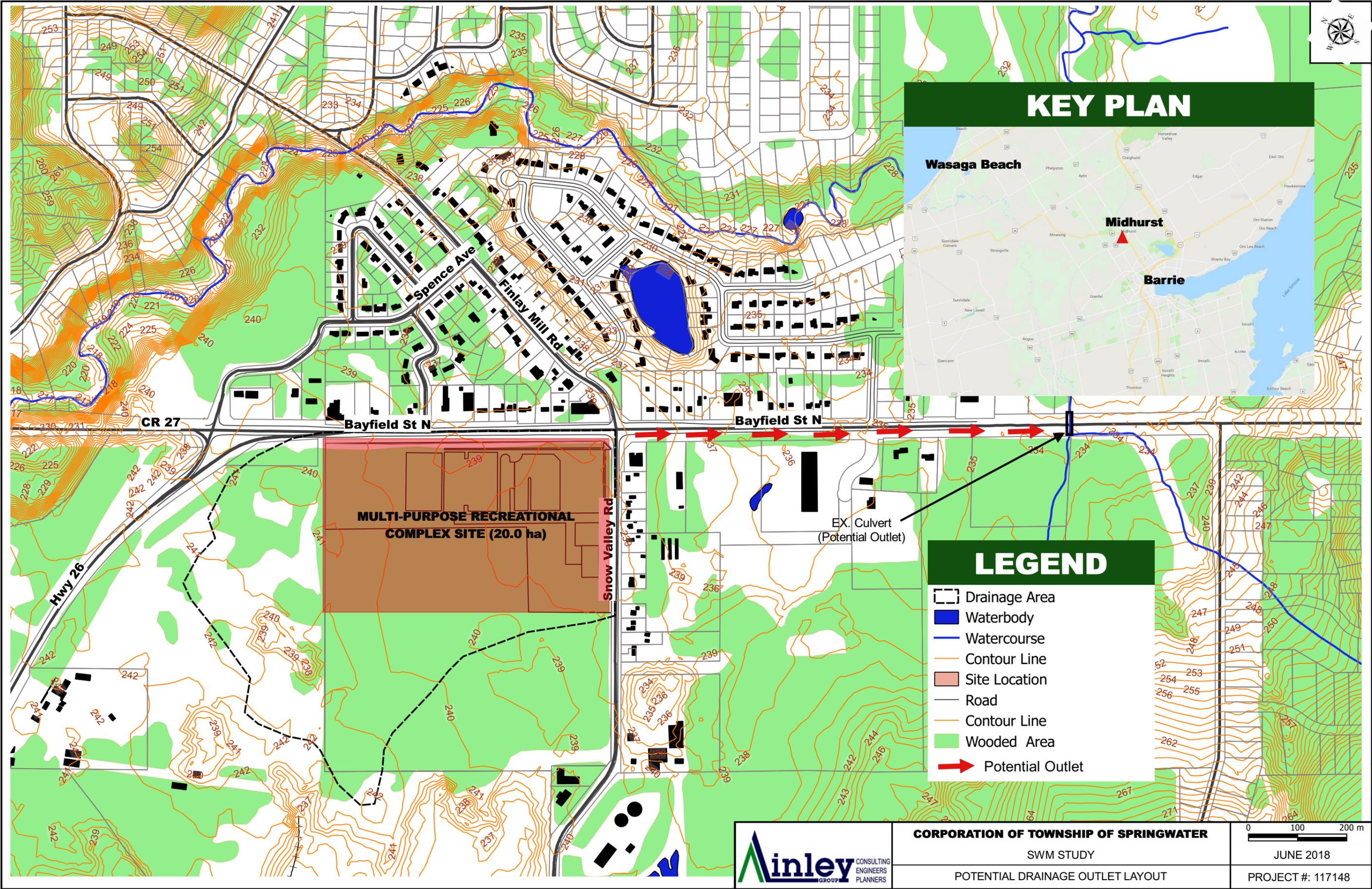
Alireza Zareie, PhD  
Water Resources Engineer Assistant  
Ainley and Associates Limited

**Appendices:**

Appendix A:	Figures
Appendix B:	Rainfall-Runoff Parameters Calculation Sheets
Appendix C:	Detailed Modified Rational Method Calculations

# APPENDIX A

(Figures)



# KEY PLAN



# LEGEND

- Drainage Area
- Waterbody
- Watercourse
- Contour Line
- Site Location
- Road
- Contour Line
- Wooded Area
- Potential Outlet



**CORPORATION OF TOWNSHIP OF SPRINGWATER**  
 SWM STUDY  
 POTENTIAL DRAINAGE OUTLET LAYOUT

0 100 200 m  
 JUNE 2018  
 PROJECT #: 117148

# APPENDIX B

(Rainfall-Runoff Parameters Calculation Sheets)

## Rainfall-Runoff Parameters Calculation Sheet

**Project Name:**

**Project No.:**

**Consulting Engineer:** Ainley & Associates

**Designed By:** AZ

**Checked By:** KP

**Date:** June 14, 2018

**Area Name** Pre-D

**Total Drainage Area (ha)** 20

### Composite Curve Number Calculation

Soil Type	Soil Series Symbol	Drainage	Hydrologic Group	Land Use		Forest/Woodland			Building			Rooftop			Pasture/Grass			Cultivated			Avg. CN	
				Area (ha)	Area (%)	Area (ha)	Area (%)	CN	Area (ha)	Area (%)	CN	Area (ha)	Area (%)	CN	Area (ha)	Area (%)	CN	Area (ha)	Area (%)	CN		
Sargent Gravelly Sandy Loam	Stsl	Good	A	20	100	20	100	50	0	0	98	0	0	98	0	0	58	0	0	66	50	
<b>Total Area</b>				<b>20</b>																	<b>Composite CN.= 50</b>	

### Initial Abstraction Calculation

Land Cover type	Area (ha)	Area (%)	IA
Impervious	0	0	2
Pasture/Lawns	0	0	5
Cultivated	0	0	7
Forest/woodland	20	100	10
Gravel	0	0	3
<b>Total Area</b>	<b>20</b>	<b>Avg. IA=</b>	<b>10</b>

### Composite Runoff Coefficient

Soil Type	Sandy Loam		Loam	
Land Use	Area (ha)	RC	Area (ha)	RC
Woodland	20	0.08	0	0.25
Pasture/Lawn	0	0.1	0	0.28
Cultivated	0	0.22	0	0.35
Pavement	0	0.9	0	0.9
<b>Composite Runoff Coefficient</b>				<b>0.08</b>

### Time of Concentration

	Airport	Bransby Williams
<b>tc (min)</b>	<b>128.06</b>	36.01
<b>c</b>	0.08	
<b>L (m)</b>	670	
<b>S (%)</b>	0.3	
<b>A (ha)</b>	20	

## Rainfall-Runoff Parameters Calculation Sheet

**Project Name:**

**Project No.:**

**Consulting Engineer:** Ainley & Associates

**Designed By:** AZ

**Checked By:** KP

**Date:** June 14, 2018

**Area Name** Post-D

**Total Drainage Area (ha)** 20

### Composite Curve Number Calculation

Soil Type	Soil Series Symbol	Drainage	Hydrologic Group	Land Use		Forest/Woodland			Building			Cultivated			Pasture/Grass			Cultivated			Avg. CN	
				Area (ha)	Area (%)	Area (ha)	Area (%)	CN	Area (ha)	Area (%)	CN	Area (ha)	Area (%)	CN	Area (ha)	Area (%)	CN	Area (ha)	Area (%)	CN		
Sargent Gravelly Sandy Loam	Stsl	Good	A	20	100	0	0	50	7.3	36.5	98	0	0	98	12.7	63.5	58	0	0	66	72.6	
<b>Total Area</b>				<b>20</b>																<b>Composite CN.= 72.6</b>		

### Initial Abstraction Calculation

Land Cover type	Area (ha)	Area (%)	IA
Impervious	7.3	36.5	2
Pasture/Lawns	12.7	63.5	5
Cultivated	0	0	7
Forest/woodland	0	0	10
Gravel	0	0	3
<b>Total Area</b>	<b>20</b>	<b>Avg. IA=</b>	<b>3.9</b>

### Composite Runoff Coefficient

Soil Type	Sandy Loam		Loam	
Land Use	Area (ha)	RC	Area (ha)	RC
Woodland	0	0.08	0	0.25
Pasture/Lawn	12.7	0.1	0	0.28
Cultivated	0	0.22	0	0.35
Paved/ Impervious	7.3	0.9	0	0.9
<b>Composite Runoff Coefficient</b>				<b>0.39</b>

### Time of Concentration

	Airport	Bransby Williams
<b>tc (min)</b>	<b>89.14</b>	<b>36.01</b>
<b>c</b>	0.39	
<b>L (m)</b>	670	
<b>S (%)</b>	0.3	
<b>A (ha)</b>	20	

# APPENDIX C

(Detailed Modified Rational Method Calculations)



**Project** Hasty Tract -Proposed Recreational Complex  
**Project No.** 117148  
**Prepared by:** AZ  
**Checked by:** KP  
**Last Revised:** June 14, 2018

**Modified Rational Method Storage Sizing- 2 yr Event**

**Design Equations**

$$I = A \times t_c^B$$

$$Q_{Uncont.} = 2.78 \times A \times C \times I$$

$$S_d = Q_{Uncont.} \times T_d - Q_{pre} \times (T_d + T_c) / 2$$

Pre-Development Scenario Data			
Inputs		Outputs	
IDF Location	MTO Curve	Intensity (mm/hr)	12.89
Return Period	Look-up		
Time of Concentration (min)	2 yr		
Chicago Design	128.1		
Storm Parameters	A	21.9	
	B	-0.699	
Runoff Coefficient (unadjusted)	0.08	Flow (m <sup>3</sup> /s)	0.057
Runoff Coefficient (adjusted)	0.08		
Area (ha)	20		

Post-Development Scenario Data			
Inputs		Outputs	
IDF Location	MTO Curve	Intensity (mm/hr)	16.61
Return Period	Look-up		
Time of Concentration (min)	2 yr		
Chicago Design	89.1		
Storm Parameters	A	21.9	
	B	-0.699	
Runoff Coefficient (unadjusted)	0.39	Flow (m <sup>3</sup> /s)	0.36
Runoff Coefficient (adjusted)	0.39		
Area (ha)	20		

Target Flow (m3/s) 0.057

Required Storage Volume (m3) 2183.35

Storage Volume Determination (Detailed)			
<i>T<sub>d</sub></i> <i>min</i>	<i>I</i> <i>mm/hr</i>	<i>Q<sub>Uncont.</sub></i> <i>m3/s</i>	<i>S<sub>d</sub></i> <i>m3</i>
40	29.08	0.631	1226.95
80	17.91	0.388	1506.55
120	13.49	0.293	1685.35
160	11.03	0.239	1801.75
200	9.44	0.205	1898.95
240	8.31	0.18	1962.55
280	7.46	0.162	2023.75
320	6.8	0.147	2056.15
360	6.26	0.136	2102.95
400	5.81	0.126	2120.95
440	5.44	0.118	2143.75
480	5.12	0.111	2156.95
520	4.84	0.105	2167.75
560	4.6	0.1	2183.35
600	4.38	0.095	2174.95
640	4.19	0.091	2180.95
680	4.01	0.087	2167.75
720	3.86	0.084	2178.55

\*\*\*\*



**Project** Hasty Tract -Proposed Recreational Complex  
**Project No.** 117148  
**Prepared by:** AZ  
**Checked by:** KP  
**Last Revised:** June 14, 2018

**Modified Rational Method Storage Sizing- 5 yr Event**

**Design Equations**

$$I = A \times t_c^B$$

$$Q_{Uncont.} = 2.78 \times A \times C \times I$$

$$S_d = Q_{Uncont.} \times T_d - Q_{pre}(T_d + T_c)/2$$

Pre-Development Scenario Data			
Inputs		Outputs	
IDF Location	MTO Curve	Intensity (mm/hr)	17.07
Return Period	Look-up		
Time of Concentration (min)	5 yr		
Chicago Design	128.1	Flow (m <sup>3</sup> /s)	0.076
Storm Parameters	29		
Runoff Coefficient (unadjusted)	-0.699		
Runoff Coefficient (adjusted)	0.08		
Area (ha)	20		

Post-Development Scenario Data			
Inputs		Outputs	
IDF Location	MTO Curve	Intensity (mm/hr)	22
Return Period	Look-up		
Time of Concentration (min)	5 yr		
Chicago Design	89.1	Flow (m <sup>3</sup> /s)	0.477
Storm Parameters	29		
Runoff Coefficient (unadjusted)	-0.699		
Runoff Coefficient (adjusted)	0.39		
Area (ha)	20		

Target Flow (m3/s) 0.076

Required Storage Volume (m3) 2875.93

Storage Volume Determination (Detailed)			
<i>T<sub>d</sub></i>	<i>I</i>	<i>Q<sub>Uncont.</sub></i>	<i>S<sub>d</sub></i>
<i>min</i>	<i>mm/hr</i>	<i>m3/s</i>	<i>m3</i>
40	38.5	0.835	1620.73
80	23.72	0.514	1992.73
120	17.86	0.387	2220.73
160	14.61	0.317	2386.33
200	12.5	0.271	2503.93
240	11	0.239	2602.33
280	9.88	0.214	2664.73
320	9	0.195	2722.33
360	8.29	0.18	2775.13
400	7.7	0.167	2803.93
440	7.2	0.156	2823.13
480	6.78	0.147	2847.13
520	6.41	0.139	2859.13
560	6.09	0.132	2866.33
600	5.8	0.126	2875.93
640	5.54	0.12	2856.73
680	5.31	0.115	2849.53
720	5.11	0.111	2861.53

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Project Hasty Tract -Proposed Recreational C  
 Project No. 117148  
 Prepared by: AZ  
 Checked by: KP  
 Last Revised: June 14, 2018

**Modified Rational Method Storage Sizing- 10 yr Event**

**Design Equations**

$$I = A \times t_c^B$$

$$Q_{Uncont.} = 2.78 \times A \times C \times I$$

$$S_d = Q_{Uncont.} \times T_d - Q_{pre}(T_d + T_c)/2$$

Pre-Development Scenario Data			
Inputs		Outputs	
IDF Location	MTO Curve	Intensity (mm/hr)	19.83
Return Period	Look-up		
Time of Concentration (min)	10 yr		
Chicago Design	128.1		
Storm Parameters	A	33.7	
	B	-0.699	
Runoff Coefficient (unadjusted)	0.08	Flow (m <sup>3</sup> /s)	0.088
Runoff Coefficient (adjusted)	0.08		
Area (ha)	20		

Post-Development Scenario Data			
Inputs		Outputs	
IDF Location	MTO Curve	Intensity (mm/hr)	25.56
Return Period	Look-up		
Time of Concentration (min)	10 yr		
Chicago Design	89.1		
Storm Parameters	A	33.7	
	B	-0.699	
Runoff Coefficient (unadjusted)	0.39	Flow (m <sup>3</sup> /s)	0.554
Runoff Coefficient (adjusted)	0.39		
Area (ha)	20		

Target Flow (m3/s) 0.088

Required Storage Volume (m3) 3348.22

Storage Volume Determination (Detailed)			
T <sub>d</sub>	I	Q <sub>Uncont.</sub>	S <sub>d</sub>
min	mm/hr	m3/s	m3
40	44.74	0.97	1884.22
80	27.56	0.598	2321.02
120	20.76	0.45	2585.02
160	16.98	0.368	2772.22
200	14.53	0.315	2913.82
240	12.79	0.277	3017.02
280	11.48	0.249	3105.82
320	10.46	0.227	3175.42
360	9.63	0.209	3225.82
400	8.95	0.194	3261.82
440	8.37	0.181	3278.62
480	7.88	0.171	3319.42
520	7.45	0.162	3343.42
560	7.07	0.153	3324.22
600	6.74	0.146	3333.82
640	6.44	0.14	3348.22
680	6.17	0.134	3333.82
720	5.93	0.129	3333.82

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**Project** Hasty Tract -Proposed Recreational C  
**Project No.** 117148  
**Prepared by:** AZ  
**Checked by:** KP  
**Last Revised:** June 14, 2018

**Modified Rational Method Storage Sizing- 25 yr Event**

**Design Equations**

$$I = A \times t_c^B$$

$$Q_{Uncont.} = 2.78 \times A \times C \times I$$

$$S_d = Q_{Uncont.} \times T_d - Q_{pre}(T_d + T_c)/2$$

Pre-Development Scenario Data			
Inputs		Outputs	
IDF Location	MTO Curve	Intensity (mm/hr)	23.53
Return Period	Look-up		
Time of Concentration (min)	25 yr		
Chicago Design	126.8		
Storm Parameters	A	39.7	
	B	-0.699	
Runoff Coefficient (unadjusted)		0.08	Flow (m <sup>3</sup> /s)
Runoff Coefficient (adjusted)		0.09	
Area (ha)		20	

Post-Development Scenario Data			
Inputs		Outputs	
IDF Location	MTO Curve	Intensity (mm/hr)	31.35
Return Period	Look-up		
Time of Concentration (min)	25 yr		
Chicago Design	84.1		
Storm Parameters	A	39.7	
	B	-0.699	
Runoff Coefficient (unadjusted)		0.39	Flow (m <sup>3</sup> /s)
Runoff Coefficient (adjusted)		0.43	
Area (ha)		20	

Target Flow (m3/s) 0.118

Required Storage Volume (m3) 4267.13

Storage Volume Determination (Detailed)			
$T_d$ min	$I$ mm/hr	$Q_{Uncont.}$ m3/s	$S_d$ m3
40	52.71	1.26	2433.53
80	32.47	0.776	2992.73
120	24.46	0.585	3338.33
160	20	0.478	3573.53
200	17.11	0.409	3751.13
240	15.06	0.36	3885.53
280	13.53	0.323	3986.33
320	12.32	0.295	4082.33
360	11.35	0.271	4130.33
400	10.54	0.252	4183.13
440	9.86	0.236	4223.93
480	9.28	0.222	4245.53
520	8.77	0.21	4262.33
560	8.33	0.199	4255.13
600	7.94	0.19	4267.13
640	7.59	0.181	4235.93
680	7.27	0.174	4243.13
720	6.99	0.167	4216.73

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**Project** Hasty Tract -Proposed Recreational C  
**Project No.** 117148  
**Prepared by:** AZ  
**Checked by:** KP  
**Last Revised:** June 14, 2018

**Modified Rational Method Storage Sizing- 50 yr Event**

**Design Equations**

$$I = A \times t_c^B$$

$$Q_{Uncont.} = 2.78 \times A \times C \times I$$

$$S_d = Q_{Uncont.} \times T_d - Q_{pre}(T_d + T_c)/2$$

Pre-Development Scenario Data			
Inputs		Outputs	
IDF Location	MTO Curve	Intensity (mm/hr)	26.33
Return Period	Look-up		
Time of Concentration (min)	50 yr		
Chicago Design	125.5		
Storm Parameters	A	44.1	
	B	-0.699	
Runoff Coefficient (unadjusted)		0.08	Flow (m <sup>3</sup> /s)
Runoff Coefficient (adjusted)		0.1	0.146
Area (ha)		20	

Post-Development Scenario Data			
Inputs		Outputs	
IDF Location	MTO Curve	Intensity (mm/hr)	36.35
Return Period	Look-up		
Time of Concentration (min)	50 yr		
Chicago Design	79.1		
Storm Parameters	A	44.1	
	B	-0.699	
Runoff Coefficient (unadjusted)		0.39	Flow (m <sup>3</sup> /s)
Runoff Coefficient (adjusted)		0.47	0.95
Area (ha)		20	

Target Flow (m3/s)	0.146
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Required Storage Volume (m3)	5128.71
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Storage Volume Determination (Detailed)			
<i>T<sub>d</sub></i> <i>min</i>	<i>I</i> <i>mm/hr</i>	<i>Q<sub>Uncont.</sub></i> <i>m3/s</i>	<i>S<sub>d</sub></i> <i>m3</i>
40	58.55	1.53	2947.11
80	36.07	0.943	3626.31
120	27.17	0.71	4036.71
160	22.22	0.581	4327.11
200	19.01	0.497	4538.31
240	16.73	0.437	4691.91
280	15.02	0.393	4826.31
320	13.69	0.358	4922.31
360	12.6	0.329	4979.91
400	11.71	0.306	5042.31
440	10.95	0.286	5073.51
480	10.31	0.269	5095.11
520	9.75	0.255	5128.71
560	9.26	0.242	5128.71
600	8.82	0.23	5102.31
640	8.43	0.22	5095.11
680	8.08	0.211	5080.71
720	7.76	0.203	5066.31

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**Project** Hasty Tract -Proposed Recreational C  
**Project No.** 117148  
**Prepared by:** AZ  
**Checked by:** KP  
**Last Revised:** June 14, 2018

**Modified Rational Method Storage Sizing- 100 yr Event**

**Design Equations**

$$I = A \times t_c^B$$

$$Q_{Uncont.} = 2.78 \times A \times C \times I$$

$$S_d = Q_{Uncont.} \times T_d - Q_{pre}(T_d + T_c)/2$$

Pre-Development Scenario Data			
Inputs		Outputs	
IDF Location	MTO Curve	Intensity (mm/hr)	28.95
Return Period	Look-up		
Time of Concentration (min)	100 yr		
Chicago Design	125.5		
Storm Parameters	A	48.5	
	B	-0.699	
Runoff Coefficient (unadjusted)		0.08	Flow (m <sup>3</sup> /s)
Runoff Coefficient (adjusted)		0.1	
Area (ha)		20	

Post-Development Scenario Data			
Inputs		Outputs	
IDF Location	MTO Curve	Intensity (mm/hr)	40.89
Return Period	Look-up		
Time of Concentration (min)	100 yr		
Chicago Design	76.6		
Storm Parameters	A	48.5	
	B	-0.699	
Runoff Coefficient (unadjusted)		0.39	Flow (m <sup>3</sup> /s)
Runoff Coefficient (adjusted)		0.49	
Area (ha)		20	

Target Flow (m3/s)	0.161
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Required Storage Volume (m3)	6017.84
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Storage Volume Determination (Detailed)			
$T_d$ min	$I$ mm/hr	$Q_{Uncont.}$ m3/s	$S_d$ m3
40	64.39	1.754	3410.24
80	39.67	1.081	4196.24
120	29.88	0.814	4675.04
160	24.43	0.666	5014.64
200	20.9	0.569	5255.84
240	18.4	0.501	5449.04
280	16.52	0.45	5601.44
320	15.05	0.41	5720.24
360	13.86	0.378	5819.84
400	12.88	0.351	5885.84
440	12.05	0.328	5927.84
480	11.34	0.309	5974.64
520	10.72	0.292	5992.64
560	10.18	0.277	5996.24
600	9.7	0.264	5999.84
640	9.27	0.253	6017.84
680	8.89	0.242	5983.04
720	8.54	0.233	5981.84

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