Functional Servicing Report for 1888 Gordon Street, Guelph, ON

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Sign-off Sheet

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Table of Contents

LIST OF APPENDICES

1.0 INTRODUCTION AND BACKGROUND

1.1 OVERVIEW

This Functional Servicing Report has been prepared in support of the Zoning and Official Plan amendment and the Site Plan Application for the proposed development located at 1858 & 1888 Gordon Street (Site) in the City of Guelph (City). The subject property is approximately 3.2 ha in size, and is bounded to the northwest by Brock Road Nursery, to the northeast by former open space (now in the process of being converted to residential subdivision), to the southwest by a combination of agricultural lands and rural residential properties, and to the southwest by Gordon Street. The site location is shown on Figure 1.0.

The conceptual site plan for the proposed development that forms the basis of this servicing assessment includes a mix of development styles with two 14 story apartment buildings, two 8 storey apartment buildings, a 2 storey pool and amenity building with potential for commercial space, outdoor amenity space and roadways. The bulk of site parking will be achieved through underground and at/above grade enclosed parking. For the purposes of this report, a site density of 175 units per hectare has been used with an estimated 560 apartment units.

This report outlines how the proposed development can be supplied with adequate services, including sanitary, domestic water, storm drainage and includes the preliminary design of the infiltration and water quality facilities proposed to provide the required water quality and quantity controls and the preliminary erosion and sediment control strategy to be implemented during construction.

1.2 BACKGROUND INFORMATION

A variety of sources have been referenced during the preparation of this report, and the following should be read in conjunction with this Report:

- *Hydrogeological Assessment, 1888 Gordon Street, City of Guelph, Ontario* (Stantec, September 2017)
- *Geotechnical Engineering Report, Residential Development, 1888 Gordon Street, Guelph, Ontario* (LVM, January 2014)
- *Low Impact Development Stormwater Management Planning and Design Guide* (Credit Valley Conservation Authority and Toronto and Region Conservation Authority, 2010)
- *Erosion & Sediment Control Guideline for Urban Construction*, (Greater Golden Horseshoe Area Conservation Authorities, December 2006)
- *Stormwater Management Planning and Design Manual (SWMPD Manual),* (Ontario Ministry of the Environment, March 2003)
- *Clair-Gordon Sanitary Sewer Capacity Study - Civica*

1.3 EXISTING INFRASTRUCTURE

A summary of the municipal infrastructure that currently exists near the Site is as follows:

- A 200mm sanitary sewer located on Poppy Drive.
- A 400mm watermain on Gordon Street and 150mm watermain on Poppy Drive.
- A 675mm storm sewer on Poppy Drive.

Fully constructed municipal roads include Gordon Street to the west and Poppy Drive to the north

2.0 OVERALL GRADING AND DRAINAGE

2.1 DESIGN CONSTRAINTS AND PROCEDURES

Using existing topographic information provided by Callon Dietz, the proposed Site grading will be design to generally meet the following criteria:

- Match existing grades all site boundaries.
- Match existing grades at existing tree driplines wherever possible to facilitate tree retention.
- Match into existing road grades of Gordon Street and Poppy Drive.
- Account for future urbanization of adjacent lands.
- Have consideration for future pedestrian connections north of the site towards Poppy Drive.
- Provide adequate cover over underground services.
- Ensure all building openings are protected from flooding.
- Comply with Municipal standards for minimum and maximum grades.
- Ensure grades accommodate the seasonally high ground water level to allow for 0.5m elevation separation from the underside of house foundations.
- Provide major overland flow routes for flows exceeding the storm sewer capacity.
- Maintain drainage from Gordon Street right-of-way and neighbouring properties to the south.

Considering the results of the EIS and Hydrogeological investigation, we propose the existing low depression on the site adjacent to Gordon Street will be filled for development purposes. Existing drainage to this area from the adjacent property to the south and from the west half of the Gordon Street right-of-way will be maintained and accommodated with the proposed Site grading and servicing.

2.2 PROPOSED ROAD PROFILES AND OVERALL SITE GRADING

Road profiles within the subject site were established based on the proposed street pattern to satisfy the constraints outlined in the previous Section 2.1. The road profiles have been designed to accommodate the constraints set out by the site layout and underground parking limits with grades ranging from 0.5% to 8.0% with 3:1 and 4:1 transition slopes or retaining walls utilized to accommodate the various grade changes within the proposed subdivision and at various perimeter locations. The proposed centerline road elevations and lot grades are illustrated on the Preliminary Grading plan (Drawing No. C-400) included in Appendix A. Existing grades and cross sections of Gordon Street and Poppy Drive have been considered fixed constraints in the development of the preliminary grading. Internal roads, consisting of 6.0 and 6.7m wide asphalt, will be constructed to the applicable City of Guelph and Ontario Building Code standards.

3.0 SANITARY SERVICING

The City of Guelph undertook a sanitary sewer capacity review for the Clair-Gordon service area which identified flow control requirements for various developments, including this Site, to mitigate effects of surcharging on existing downstream sewers. The *Clair-Gordon Sanitary Sewer Servicing Capacity Review prepared by Civica* (2013) has been updated with further analysis and monitoring. In an email provided August 22, 2017, the following parameters were provided.

- Total drainage area – 6.90 ha (includes subject site and adjacent nursery lands)
- Full build estimated 1085 apartment units
- Peak controlled flow – 23.8 L/s
- Pipe length – 80m
- Pipe size – 1200 x 1800 mm
- Pipe slope – 0.5% (with benching to allow self-cleansing at low flow)
- Storage – 138 m^3

This flow control system is to be located upstream of the connection to the Poppy Drive sewer in the access to Poppy Drive as shown on the Preliminary Servicing plan (Drawing No. C-100).

Based on a Site area of 3.193 ha and the City of Guelph Development Engineering Manual (November 2016), the design flow from the site will be based on 7 L/s/ha (including peaking factor) plus infiltration allowance for a total design flow of 22.8L/s.

200 mm, 250 mm and 300 mm diameter sanitary sewers are anticipated throughout the Site to provide service to each building in accordance with the requirements of the Ontario Building Code and the City of Guelph. The sanitary design utilizes one outlet on Poppy Drive East.

4.0 WATER DISTRIBUTION

The existing water distribution system near the Site includes a 400mm watermain on Gordon Street and a 150mm watermain on Poppy Drive. The primary source for the proposed development will be the Gordon Street watermain with a secondary connection to the Poppy Drive watermain to create a looped system. It is anticipated that the following connections to the existing municipal infrastructure will be made:

- Tapping sleeve and valve connection to the 400mm Gordon Street watermain (200mm connection).
- Tapping sleeve and valve connection to the 400mm Gordon Street watermain (150 mm connection).
- 150mm mechanical joint connection to the 150mm Poppy Drive watermain.

Please refer to the Preliminary Servicing plan (Drawing No. C-100) for an illustration of the watermain layout.

Based on building information currently available, a conservative fire flow requirement for the site is 150 L/s, based on typical OBC calculations as provided in Appendix B.

A 200 mm diameter watermain is proposed for the development with 150mm connections provided to each building. They are positioned as illustrated on the Preliminary Servicing plan (Drawing No. C-100).

Fire protection will be provided via onsite hydrants, adequately spaced to ensure proper coverage to all buildings, in conjunction with standpipe connections for building sprinkler systems. The City of Guelph will confirm the pipe sizing proposed provides adequate pressure to meet MOE design criteria. No backflow prevention or pressure reducing valves (PRV) have been proposed for this development.

5.0 STORMWATER DRAINAGE

Storm drainage for the Development will discharge to three onsite infiltration facilities. These facilities have been designed to accommodate the flow within the Development for the ultimate build out. Please refer to the Preliminary Servicing Plan, Drawing No. C-100, included in the Appendix A for an illustration of the storm layout. For further details of the SWM Facility design refer to applicable section within this report.

The proposed storm sewer system is designed to convey all minor storm events or those less than 5-year return-period for the majority of the development, as per the City of Guelph standards. As part of the Engineering Design rational pipe sizing was completed and submitted to the City. The conveyance system for major flow events or those greater than a 5-year return-period frequency will be confined to the road right-of-ways and generally mimics the direction of the minor system. Major flows are directed to the surface of the infiltration facilities where ponding and a lawn catch basin will be provided to ensure the major events are captured by the facility.

6.0 STORMWATER MANAGEMENT FACILITIES

6.1 DESIGN CRITERIA

6.1.1 STUDY APPROACH

The objective of this SWM Plan is to ensure that the proposed development includes the necessary controls to protect the hydrology and water quality of the receiving water systems, primarily through adherence to SWM targets. This approach involved the following study components:

- Prepare green infrastructure water balance design spreadsheets for the proposed development to complete the preliminary design of infiltration facilities that will infiltrate up to the 100-year runoff for the whole site
- Assess infiltration potential for the site
- Summarize the study by identifying conclusions and recommendations

6.1.2 DESIGN CRITERIA

SWM criteria were established based on the *Hanlon Creek Watershed Study*, and the characteristics of the receiving systems. The SWM criteria applied to the site are as follows:

- Water Quantity – Control post-development peak flows to pre-development flow rates
- Infiltration – Infiltrate all flows up to the 100-year event
- Erosion and Sediment Control – Provide appropriate erosion and sediment control during construction to protect neighboring properties and the downstream receivers from potential siltation

6.2 EXISTING CONDITIONS

6.2.1 Topography and Surface Drainage

The ground surface of the site is moderately rolling with elevations ranging between approximately 343.5 m and 351.5 m AMSL (above mean sea level). The terrain generally slopes from to the north west to a pond located across the property line, with a portion of the site draining to a small onsite wetland area located near the southeastern corner of the Site as shown on Figure 2.0.

The existing site is an existing single family residential use with grassed area with occasional trees located throughout the site.

6.2.2 Geotechnical Information

The *Geotechnical Engineering Report* (LVM, 2014) describes the site soils as comprised of topsoil overlying layers of silt, sand, and gravel materials over clayey silt till at a depth of over 11 metres. The groundwater table documented in the Geotechnical Investigation ranges between elevations of 334.15 m and 340.4 m with some boreholes not encountering groundwater before termination.

The *Hydrogeological Assessment* (Stantec, 2017) noted that groundwater flow is westerly towards the Speed river, and:

1. Geological conditions beneath the onsite wetland and throughout the Site consist predominantly of ice-contact stratified deposits of silty sand and gravel to sandy gravelly silt that extend from the existing grade to the termination depth of onsite boreholes (i.e., from 5.0 to 14.2 m BGS).

2. Water levels near the onsite wetland in April were at approximately 345.1 m ASL.

3. Water levels within the onsite wetland are largely controlled by the positioning of the water table. The water table drops below the wetland substrate in the early spring, followed by a continued decline into the summer, resulting in the loss of a direct hydraulic connection between the wetland and the shallow groundwater system (i.e., does not receive groundwater inputs from the surrounding landscape).

4. The Site lies within the boundaries of the Paris Moraine that is understood to act as an area of groundwater recharge. Weak downward vertical hydraulic gradients (i.e., recharge condition) are present beneath the onsite wetland, which is in agreement with regional groundwater recharge mapping presented by the GRCA (2001). As such, the onsite wetland is not a groundwater discharge feature.

5. Over the monitoring period, the nearby Halls Pond PSW Complex maintained a connection to the water table, whereas the onsite wetland lost its direct hydraulic connection to the shallow groundwater system (i.e., local water table dropped and remained below the wetland substrate), suggesting that no hydrogeological interaction likely occurs between these two wetland features.

6. The onsite wetland covers approximately 4.2% of the Site area (0.135 ha of 3.2 ha). Consequently, it is reasonable to conclude that the loss of recharge function associated with the onsite wetland, if removed, will not detrimentally impact the overall groundwater recharge function provided by the Site.

Looking at the groundwater information for both studies, it was decided to assume that 345 m ASL was a reasonable estimate of the groundwater for the design of the infiltration facilities, as it represents a seasonably high groundwater table and is higher than any other monitored levels. Further groundwater monitoring will be completed during the final design for the site once the locations of the proposed infiltration facilities is finalized to confirm this assumption prior to construction of the facility. Monitoring will occur in at least two of the facilities and it is

recommended that monitoring occurs at such a time to ensure the seasonably high groundwater table at each location is adequately captured.

Additional permeameter testing was done by Stantec on November 16-17, 2017 to confirm the hydraulic conductivity of the soils for infiltration at the location of the infiltration facilities. The testing done by Stantec found that the mean infiltration rates for the soils on site were above 50 mm/hr (51-80 mm/hr). The CVC method (Appendix C of the 2010 CVC LID manual) was used to determine the design infiltration rates for the infiltration facilities. After the safety factor was applied, the design infiltration rates are as follows

- Infiltration gallery 1- 23 mm/hr
- Infiltration gallery 2- 20 mm/hr
- Infiltration gallery 3- 22 mm/hr

Figure 3.0 shows the test pit locations for the most recent testing on the site. More information on the hydrogeological investigations for the site can be found in the Hydrogeological Report (Stantec, 2018).

6.3 PROPOSED STORMWATER MANAGEMENT DESIGN

The site has several unique features and constraints, and as such, a creative stormwater approach has been taken to use a treatment train system and Low Impact Development (LID) techniques. These technologies must be looked at as a collective to fully understand the approach.

As this site is located on the Paris Moraine, the proposed scheme attempts to mimic the existing drainage patterns and infiltration while respecting the flood requirements. The site has both internal and external drainage to small wetland depressions. Groundwater was observed during geotechnical investigations, and should be confirmed at the location of the proposed infiltration galleries prior to construction. As per the attached drawing, the proposed stormwater management scheme consists of the following elements:

- Infiltration of all water will occur in three infiltration galleries located on site. The infiltration galleries will be approximately 1 m below grade with a trench depth of 2 m (2 m of active retention). Road runoff will be treated via a Stormceptor prior to infiltration to ensure the facilities do not silt up. Infiltration galleries have been located in areas where underground parking is absent. Details on the sizing and dimensions of the infiltration galleries is provided in Section 4.3 below.
- Roof water will be stored up to 0.163 m deep on the roof of all buildings to slowly drain into the infiltration galleries over three days.
- The infiltration galleries have been sized to provide for up to the 100-year storm, with an overland flow route for the regional flows to the North West to Poppy Drive East. The infiltration facilities are designed to overflow during the Regional storm to allow overland flow off the site.

As discussed previously, the proposed development consists of a mix of park area, roadways, and multiple family residential lots/blocks. The site was modelled as one catchment. The site is 3.2 ha and conditions generally consist of the following:

- **Predevelopment** – Encompasses the entire area of the site. Water drains uncontrolled across the pervious areas following the topography of the site. The site is 5% impervious, including the existing residence, driveway, and ancillary buildings.
- **Post-Development** – Encompasses the entire area of the site. Runoff from the development is directed to LID facilities. The site is 69% impervious.

6.4 INFILTRATION GALLERY

A green infrastructure water balance design spreadsheet was used to determine the runoff and infiltration for the site for the pre- and post-development conditions to size the infiltration galleries to infiltrate the 100-year event. The 25 mm 4-hour water quality storm event as also modeled to ensure the galleries meet the water quality storage volumes required in the *SWMPD Manual* (MOE, 2003). The 2-, 5-, and 25-year 3-hour Chicago events and 48-hour Hurricane Hazel event were then run to determine how the infiltration galleries perform during high flow events and provide adequate infiltration.

The water quality storage volume required for enhance water quality are shown in the table below.

Table 1: Water Quality Storage Volumes

Location	Tributary Area (ha)	Water Quality Volume Required (m^3/ha)	Water Quality Volume Required (m^3)	Water Quality Volume Provided (m^3)
Site	3.2	35	112	1,055
Water quality volume calculated as per Table 3.2 of the MOE *Stormwater Management Planning and Design Manual* for infiltration (2003) using 70% imperviousness				

6.4.1 Green Infrastructure Water Balance Design Spreadsheet

The green infrastructure water balance design spreadsheet used for this analysis tracks the volume of water in each part of the system (runoff, infiltration gallery conditions, and groundwater) during each time-step for the infiltration galleries, roof storage, and the remaining pervious area on site. The water balance spreadsheet uses the rainfall, soil characteristics, and drainage areas to calculate the volume of water for each of the following, for every time-step:

Table 2: Design Spreadsheet Parameters

Roof Storage	Infiltration Gallery	Lawns
• Rain water onto roof;	• Rain water directly to trench;	• Rain water onto lawn;

Roof Storage	Infiltration Gallery	Lawns
• Rain into Ponding; • Beginning of time-step Ponding Volume; • Ponding Depth; • Volume out of Ponding; and • Overflow	• Beginning of time-step trench water volume; • Trench exfiltration; and • Trench underdrain flow	• Unsaturated runoff; • Rain into soil; • Beginning of time-step soil water volume (initial value is set to field capacity); • Water from soil to ground water; • Water that does not exfiltrate; • Water that stays in the soil; • Saturated runoff; • Total runoff; and • Evaporation from soil

No initial abstractions or losses other than infiltration were assumed during the analysis of the scenarios. The initial condition of the amended soil water content was set to field capacity to represent a 'wet start' for the soil. It is expected that dry soils would have an increased capacity for capture above that shown in this analysis.

The volumes in each portion of the system are summed to give a total volume of water each component sees. For example, the total volume of drain flow for each time step is summed to determine the total volume of drain flow.

6.4.2 Sizing

The post-development conditions assumed the roof of the buildings were directly connected to the infiltration galleries.

The site has a moderately high groundwater table and groundwater is approximately 4 meters (345 m ASL) below ground. The soils on site are well draining with an infiltration rates ranging from 35-150 mm/hr.

The site was divided into drainage areas for the calculations:

- Infiltration gallery 1: this area includes the road and sidewalks behind buildings 1 and 2. All runoff will be treated via stormceptor prior to infiltration.
- Infiltration gallery 2: this area includes the proposed building roofs for Buildings 1, 4, and 5 as well the amenity areas and roads. The roads and sidewalks will pass through a stormceptor for treatment prior to infiltration.

- Infiltration gallery 3: this area includes the remaining building roofs (Buildings 2 and 3) and the remaining site roads and sidewalks. The roads and sidewalks will pass through a stormceptor for treatment prior to infiltration.
- Lawns: this is the remaining pervious area on site with no ponding or amended soils.
- Off site: this includes the access road to Poppy Drive and the lawn area behind Building 3.

The inputs for the all the drainage areas, including the LID features, for the water balance can be seen in Table 3. The green infrastructure water balance design spreadsheet can be seen in Appendix C.

Table 3: Summary of Post-Development Design Water Balance Inputs

Parameter	Infiltration Gallery 1	Roof Ponding to Infiltration Gallery 2	Infiltration Gallery 2	Roof Ponding to Infiltration Gallery 2	Infiltration Gallery 3	Lawn	Drainage to Access	Unit
Impervious Area	1,651	5,865	3,455	4,842	4,863	0	1,502	Sq. m
Pervious Area	0	0	0	0	0	6,656	3,537	Sq. m
Total Area	1,747	5,865	3,455	4,842	4,863	6,656	4,479	Sq. m
Soil Depth	n/a	n/a	n/a	n/a	n/a	150	150	mm
Soil Exfiltration Rate	23	n/a	20	n/a	22	20	22	mm/hr
Soil Porosity	n/a	n/a	n/a	n/a	n/a	0.35	0.35	
Soil Field Capacity	n/a	n/a	n/a	n/a	n/a	0.15	0.15	
Soil Wilting Point	n/a	n/a	n/a	n/a	n/a	0.1	0.1	
Soil Infiltration Rate	n/a	n/a	n/a	n/a	n/a	10	10	mm/hr
Ponding Area	n/a	5,865	n/a	4,842	n/a	n/a	n/a	Sq. m
Ponding Depth	n/a	163	n/a	163	n/a	5[1]	5[1]	mm
Orifice Diameter	n/a	127	n/a	115	n/a	n/a	n/a	mm
Trench Surface Area	281	n/a	675	n/a	816	n/a	n/a	Sq. m
Trench Depth	500	n/a	2,000	n/a	1,600	n/a	n/a	mm

Trench Porosity	0.95	n/a	0.35	n/a	0.35	n/a	n/a	
[1] Ponding depth represents depression storage in the pervious areas								

6.4.3 Results

The proposed LID measures infiltrate the 25 mm 4-hour water quality event, 2-, 5-, 25-, and 100-year 3-hour Chicago events.

Table 4 summarizes the modelled conditions.

Table 4: Post Development Site Flow and Runoff Volumes

Storm Event	Post-Development Conditions	
	Peak Flow (m^3/s)[3]	Runoff Volume (m^3)
25 mm[1]	0.11	72.0
2 year[2]	0.27	154.3
5 Year[2]	0.40	280.6
25 Year [2]	0.57	490.6
100 Year[2]	0.72	688.9
Hurricane Hazel 48-Hour	0.14	1,319.9
[1] 25 mm 4-hour Chicago storm [2] 3-hour Chicago storm for Guelph [3] Flow from pervious is retained in depression storage for infiltration		

The post-development flows show some runoff occurring. The grassed areas on site have some unsaturated runoff. Unsaturated runoff occurs when the intensity of the storm is higher than the infiltration rate of the grass.

Table 5 shows the water quality and design event infiltration and flow volumes for each area. Drain flow from the infiltration gallery is directed to the bioretention for further infiltration.

Table 5: Event Infiltration Volume (IV) and Runoff Volumes (RV)

Facility		25 mm[1]	2-year[2]	5-Year[2]	25-Year[2]	100-Year[2]	Regional Event[3]
Infiltration Gallery 1	IV (m^3)	43.7	59.8	82.5	118.9	152.4	338.6
	RV (m^3)	0	0	0	0	0	159.3
Roof Ponding to Infiltration Gallery 2[4]	IV (m^3)	0	0	0	0	0	0
	RV (m^3)	146.8	200.9	277.0	399.2	511.6	1,671.5
Infiltration Gallery 2	IV (m^3)	233.2	319.2	440.1	634.4	813.1	1,585.6
	RV (m^3)	0	0	0	0	0	1,070.6
Roof Ponding to Infiltration Gallery 3[4]	IV (m^3)	0	0	0	0	0	0
	RV (m^3)	121.2	165.8	228.7	329.6	422.4	1380.0
Infiltration Gallery 3	IV (m^3)	242.9	332.4	458.3	660.6	846.6	1,880.0
	RV (m^3)	0	0	0	0	0	886.0
Lawns	IV (m^3)	136.4	150.9	164.1	180.2	191.4	1,224.7
	RV (m^3)	30.1	77.0	150.2	272.8	389.3	672.3
To Access	IV (m^3)	70.4	76.4	81.6	88.1	92.5	631.3
	RV (m^3)	41.7	77.0	129.9	216.8	298.2	645.3

[1] 25 mm 4-hour Chicago storm
[2] 3-hour Chicago storm for Guelph
[3] 48-hour Hurricane Hazel
[4] Runoff volume directed to infiltration gallery for infiltration

The recommend mitigation measures for the site infiltrate 100% of all storms up to the 100-year event for the proposed impervious areas except for a small area of road that drains towards the access (564 m^2), with only this small impervious area and the pervious lawn areas having runoff. the 564 m^2 impervious area that drains offsite makes up 7-20% of the total runoff volume and 2% of the total stormwater volume. There is unsaturated runoff from the lawn areas which account for 7-23% of the total stormwater volume. The infiltration of the lawn could be improved by ensuring that the soils are not compacted and providing more depression storage.

The gallery volumes exceed those required for enhanced water quality, providing 1,063 cubic meters of storage. The drain times for the roofs and infiltration galleries can be seen in Table 6.

Table 6: Drain Times (Hours)

Storm Event	Infiltration Gallery 1	Roof Ponding to Infiltration Gallery 2	Infiltration Gallery 2	Roof Ponding to Infiltration Gallery 3	Infiltration Gallery 3
25 mm[1]	7.2	16.4	17.2	16	
2 year[2]	9.3	18.6	23.2	16.2	
5 Year[2]	12.8	21.7	31.9	21.2	24.8
25 Year [2]	18.5	25.9	46	25.2	35.7
100 Year[2]	23.7	29.8	59	28.5	45.8
Regional Event[3]	20.8	36.8	67.2	37.2	54.8

[1] 25 mm 4-hour Chicago storm
[2] 3-hour Chicago storm for Guelph
[3] 48-hour Hurricane Hazel
[4] Drain time does not include the Storm duration time (48-hours)

6.5 WATER QUALITY AND OVERALL SITE MONTHLY INFILTRATION AND GROUNDWATER WATER BALANCE

As previously noted in Section 3.2, various criteria exist for this site as it relates to water quality. This site is relatively unique in that it offers the following opportunities:

- Soils appropriate for infiltration.
- Moderately high groundwater levels.

As such, this site is a prime candidate to incorporate Low Impact Development (LID) features to achieve the identified stormwater management criteria.

The requirement for providing an MOECC enhanced level of water quality control and meeting infiltration targets (CVC) is easily achieved in the proposed scheme as there is no direct stormwater discharge proposed to the municipal storm system for up to the 100-year event.

All impervious surfaces and pervious surfaces over the proposed underground parking are directed to infiltration. The remaining pervious areas on site flow overland following the contours and depression storage for infiltration. The storage volume provided in the infiltration galleries allows for infiltration of all runoff from the proposed development.

It should be noted that oil-grit separator units or CB Shields are provided to ensure that spill potential (floatables) and sediment will be removed from road runoff prior to infiltration.

An overall site monthly infiltration and groundwater water balance analysis for both existing and proposed development conditions was undertaken to assess the potential reduction in recharge associated with the increase in impervious coverage, and the potential mitigation benefits associated with the proposed "engineered" infiltration practices using the Thornthwaite and Mather methodology. The existing topography and land cover were used to estimate an

infiltration factor based on the approach presented in MOECC Stormwater Management Planning and Design (SWMPD) Manual (2003). Soil moisture capacities (also referred to as water holding capacity) were also obtained from the MOECC SWMPD Manual (2003) for soil types that were adopted based on the surficial geology.

Precipitation and temperature normals for the past 30 years (1981 to 2010) were obtained from the Environment Canada Website for the Guelph Arboretum station, located approximately 15 km west of the Site.

These data were used to determine the saturation vapour pressure (e_{sat}) and monthly potential evapotranspiration (PET) using the following formulae (Dingman, 1994):

$$e_{sat} = 6.11\exp(17.3T/(T+23.7.3)),$$

Where T is temperature in degrees Celsius and e_{sat} is given in millibars (mb); and

$$PET=0.409(e_{sat}),$$

Where PET is given in cm.

To determine the actual soil moisture content (S_m) at the end of each month, the following approach was used (Physical Hydrology (Dingman, 1994)):

When precipitation was greater than PET,

$$S_m=\min\{[(Precip_m-PET_m)+S_{m-1}], S_{max}\}; \text{ and}$$

When precipitation was less than PET,

$$S_m= S_{m-1} + (Precip_m - PET_m).$$

The actual evapotranspiration (ET) was in turn calculated as follows:

When precipitation was greater than PET,

$$ET_m=PET_m; \text{ and,}$$

Otherwise,

$$ET_m=Precip_m + S_{m-1}-S_m.$$

In summary, the analysis indicates that the average annual groundwater recharge rate occurring on the 0.135 ha wetland portion of the site to be 408 mm/year for a total of 551 m^3 and the remaining site 3.058 ha of the site to be 408 mm/yr for a total of 12,486 m^3. The full 3.2 ha site under predevelopment conditions is approximately 408 mm/year, for a total of 13,037 m^3, with this rate dropping to 265 mm/year post-development (total site recharge of 2,542 m^3) under an **unmitigated** post-development condition. To address the projected groundwater recharge deficit, post-development groundwater recharge augmentation has been proposed for the site;

namely, provision of at-source infiltration up to the 100-year event for all impervious and pervious over underground parking areas.

The Thornthwaite and Mather methodology is not set up to consider LID within the calculations and as such, assumptions must be made to include additional infiltration measures within the water balance calculations. The retention volumes proposed within the infiltration galleries are sufficient to detain for infiltration / evapotranspiration the runoff from the proposed rooftop and parking for the 25 mm 4 hour Chicago water quality design event. Within the current analysis, it has been conservatively estimated that 80% of the runoff volume is converted to groundwater recharge (20% is evaporated or otherwise lost to the system), even though it is expected that 100% will infiltrate, showing the proposed development conditions have a predicted recharge ***surplus*** of 4,737 m^3. Consequently, it is reasonable to assume that the pre-development groundwater recharge function of the site will be enhanced under the post-development condition if the above recharge measures are employed at the property.

Table 7: Summary Yearly Groundwater Recharge

Site Assumption	Expected Yearly Groundwater Surplus Volume
Post-development with no additional infiltration measures	-10,495
Assume 80% of water captured in infiltration galleries and bioretention are infiltrated	4,737

The detailed water balance spreadsheets can be seen in Appendix C.

7.0 EROSION AND SEDIMENT CONTROL PLAN

The erosion and sediment control (ESC) strategy has been developed to minimize the potential for offsite discharge of sediment and the resultant negative environmental impacts. This plan will focus on the protection of the Hanlon Creek watershed.

7.1 STUDY APPROACH

Erosion Potential Impact

The *Greater Golden Horseshoe Area Conservation Authorities' Erosion and Sediment Control Guideline for Urban Construction* (2006) was used to determine the erosion potential of the site. The erosion potential is based on slope gradient, slope length and soil texture and is then used to determine the appropriate erosion control methods.

Site slope gradients for the site can be summarized as gently sloped (0-5%) with an average slope in the order of 2%. The slope lengths are considered long (greater than 30 m). Site soils are comprised primarily of silty sand and gravel to sandy gravelly silt, thus, the erosion potential for the site is considered to be "high".

7.2 EROSION AND SEDIMENT CONTROL PLAN

The following approach to the ECS onsite has been prepared to minimize the potential impacts associated with onsite erosion and/or offsite transport of sediment to Hanlon Creek and other surrounding lands.

Prior to any grading or servicing works commencing onsite, ESC measures shall be implemented. The proposed erosion and sedimentation controls include the following items:

- Steep slopes (>3:1) shall have erosion blankets
- Light and/or heavy duty silt fencing will be erected on all site boundaries where there is potential for runoff to be discharged offsite, to protect adjacent and downstream lands from migration of sediment in overland flow. The location of this fencing will be adjacent to the limit of grading. Silt fencing should be erected before grading begins to protect adjacent and downstream areas from migration of sediment in overland flow

- Temporary sediment basin will be constructed to provide sediment control for the site. Standards established by the Greater Golden Horseshoe Area Conservation Authorities require 125 m³/ha for dead storage or 185 m³/ha if the L:W ratio is less than 4:1 or the draw down time for active storage is less than 48 hours. Live storage of 125 m³/ha with a minimum 48-hour draw down time and a minimum 4:1 L:W ratio is also required. The sediment control basins are to be inspected regularly and sediment removed when the depth of dead storage is reduced by one-half of the design depth.

- Erosion control berms/swales will be located in appropriate (critical) areas to divert flows to the sediment basins

- A construction entrance feature ("mud mat") will be provided at all site entrances to minimize the offsite transport of sediment via construction vehicles

- Runoff will be directed to temporary sediment basins via swales to minimize untreated runoff discharged from site

- Swales constructed onsite will have temporary rock check dams to help attenuate flows and encourage deposition of suspended sediment where appropriate

- All disturbed areas where construction is not expected for 30 days shall be re-vegetated with 50 mm of topsoil and hydro-seeded according to OPSS 572

- During construction, all catchbasins are to be sealed until roads are paved to prevent sediment deposition in the batch basin's sumps and conveyance of silt to the SWMF

- Following completion of construction, defined as 90% house construction, and site stabilization, all erosion and sediment control measures and accumulated sediment are to be removed

The erosion control measures shall be maintained in good repair during the entire construction period, and shall only be removed as contribution drainage areas are restored and stabilized. In addition, the condition of erosion control works, their overall performance, and any repairs, replacement or modifications to the installed item shall be noted in monitoring reports submitted to the Grand River Conservation Authority (GRCA) and the City of Guelph. Monitoring Reports should be submitted bi-monthly (quarterly during periods of inactivity or house construction) and should be based on inspection completed bi-weekly or after any significant rainfall events (>13mm), whichever is more frequent.

8.0 MONITORING, MAINTENANCE, AND MITIGATION PROGRAM

8.1 STORMWATER MANAGEMENT FACILITY

Monitoring and maintenance activities are an important part of a SWM Plan to ensure the designed features continue to operate as intended. As such, inspections will take place on a seasonal basis to observe any evidence of erosion or malfunctioning of the proposed site facility (3 per year). These inspections will occur following significant rainfall events, and will include inspection of the conditions of the infiltration Galleries and the OGS units to determine cleanout requirements.

The Monitoring Program described above will begin after the infiltration facilities come online and will continue for two years of post-construction monitoring. An annual report will be provided to the City to document ongoing monitoring observations, and a Final Report will be submitted at the end of the monitoring period. The Final Report will include recommendations for future inspection and maintenance requirements for the facility.

In order to monitor the performance of the infiltration facilities, observation ports will be installed to check the water levels.

The proponent will be responsible for the monitoring and inspections for the duration of the Monitoring Program as well as the long-term operation and maintenance of the facility. Long-term monitoring and maintenance should involve annual inspections of the infiltration facilities throughout their life span.

9.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the preceding report, the following conclusions can be drawn:

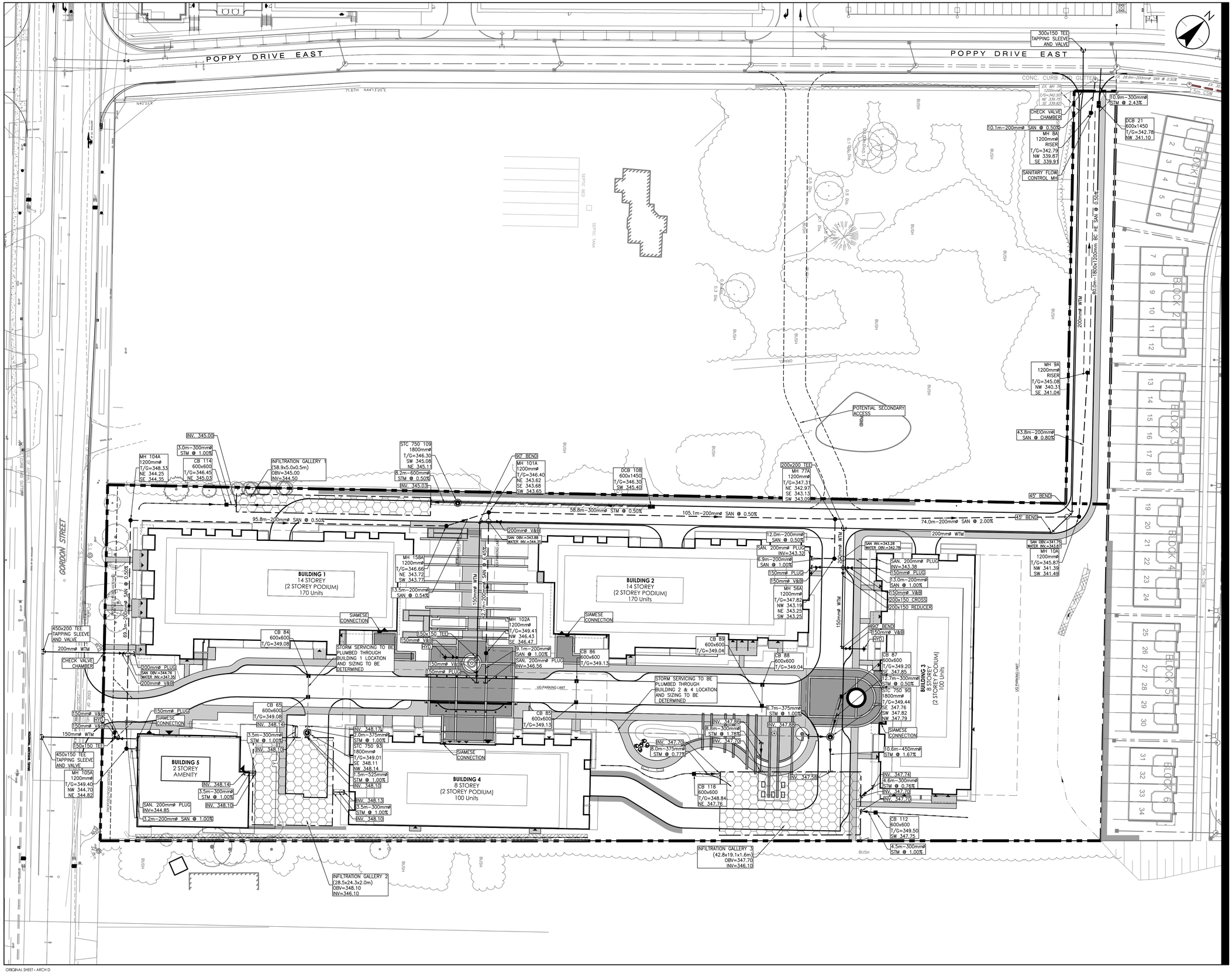
- Sanitary service is provided by the municipal system located on Poppy Drive just east of the site access. A flow control pipe and structure has been identified and is to be located within this access to restrict flow a development area that encompassed this site to 23.8 L/s.
- Water service is provided primarily from the existing 400mm watermain on Gordon Street fronting this site with a secondary connection point to the 150mm watermain on Poppy Drive to create a looped system.
- Enhanced (Level 1) water quality control will be provided for the site by a combination of OGS units, and infiltration galleries. Adequate water quality volumes will be provided to meet the MOE water quality requirements associated with infiltration facilities
- The proposed infiltration will infiltrate up to the 100-year event to maintain predevelopment conditions

Based on the findings of the report, the following recommendations are provided:

- The proposed SWM measures provided in this report be constructed as designed
- The ESC measures documented herein be implemented during construction
- The Stormwater Monitoring and Maintenance Program be carried out during and following construction
- The proposed development can be adequately serviced through the connection to the existing services
- Overall site grading will provide for "major" overland flow conveyance to the downstream municipal road allowance, provide adequate cover over municipal services and generally match existing roads and boundary grades
- The servicing and grading have been designed to meet MOE and municipal standards

APPENDIX A

Preliminary Servicing and Grading Plan



Stantec

300 Hagey Blvd. Suite 100
Waterloo, ON, N2L 0A4
Tel. 519.579.4410
www.stantec.com

Notes

1. BENCHMARK 00819698108 ELEVATION 345.284
LOCATION: 108–69: ONE AND ONE–HALF STOREY STONE HOUSE (OWNED BY MR. F. BLAIR) ON EAST SIDE OF WELLINGTON CTY RD 46, 6.2 KM NORTH OF JCT OFWELLINGTON CTY RD 46 AND HWY 401 (INTERCHANGE 37) AT MORRISTON, 0.8 KM NORTH OF PUSLINCH TWP RD 15 AND 60.4 M EAST OF CENTER LINE OF WELLINGTON CTY RD 46. TABLET IS SET HORIZONTALLY IN SOUTH FACE OF STONE FOUNDATION, 30 CM EAST OF S.W. CORNER AND 9 CM ABOVE GROUND LEVEL.
2. EXISTING SURVEY COMPLETED BY CALLON DIETZ (DECEMBER, 2013)
3. THE CONTRACTOR IS TO VERIFY ALL EXISTING ELEVATIONS AND EXISTING CONDITIONS AND TO REPORT ANY DISCREPANCIES TO THE CONSULTING ENGINEER
4. SITE PLAN PREPARED BY STANTEC, DATED SEPT, 2017.

Legend

PROPOSED		EXISTING
●	STORM MAINTENANCE HOLE	⊙
◉	STORM CATCHBASIN MAINTENANCE HOLE	◉
■	CATCHBASIN	▣
●	SANITARY MAINTENANCE HOLE	○
⋈	VALVE & BOX	⋈
⊘	CURB STOP	⊘
⊷	HYDRANT SET	⊹⋈
⊷	SIAMESE CONNECTION	⊷
⟵●⟶	STORM SEWER	⟵●⟶
⟵●⟶	SANITARY SEWER	⟵●⟶
⟵●⟶	WATERMAIN	⟵●⟶
⟵●⟶	SWALE	⟵●⟶
▨	PIPE INSULATION (SEE C–500 FOR DETAILS)	

Revision	By	Appd.	YY.MM.DD
File Name: 161401285C-UG.dwg	Dwn.	Chkd.	Dsgn. 16.11.22 YY.MM.DD

Permit-Seal

Client/Project
TRICAR DEVELOPMENT INC.

1888 GORDON STREET

Guelph, Ontario

Title
PRELIMINARY SERVICING

Project No.	Scale	Revision
161401285	1:500 (0 5 15 25m)	
Drawing No.	Sheet	
C-100	of	0

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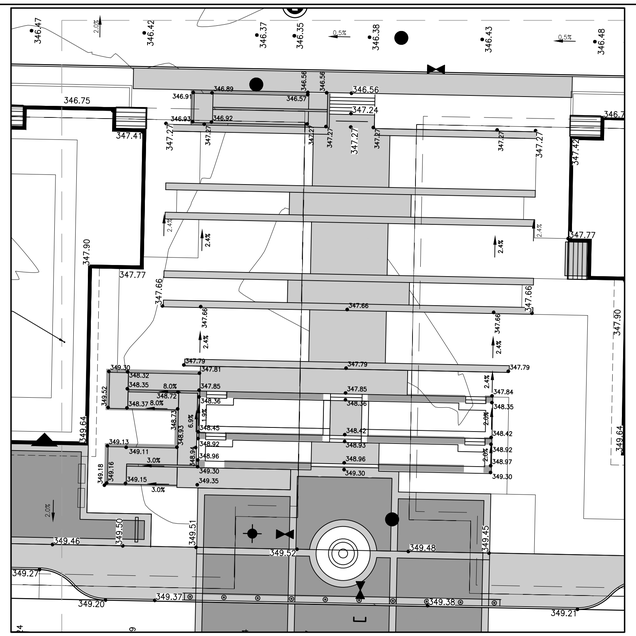
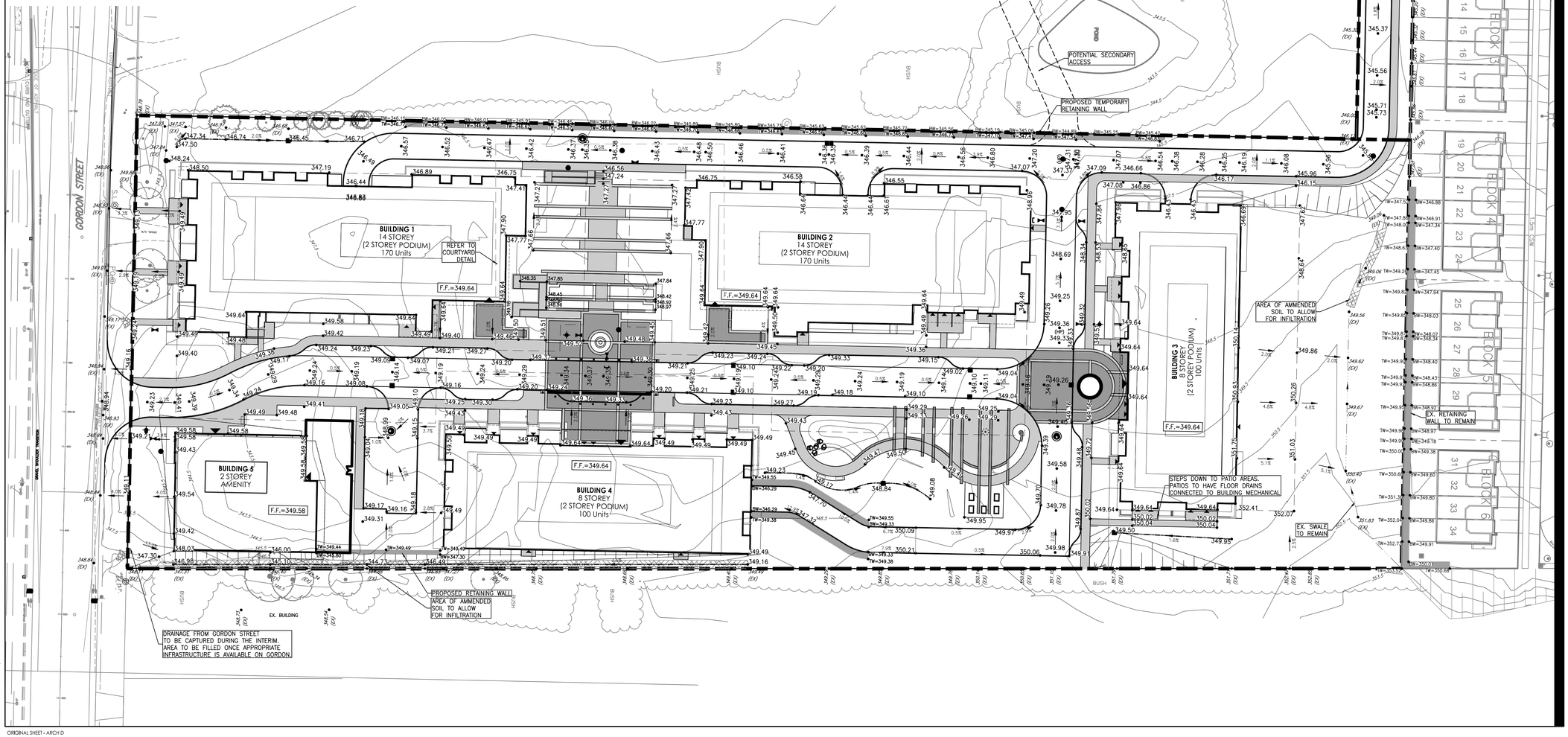
2016/01/08 2:44 PM By: Hernandez, Javier

ORIGINAL SHEET - ARCH D



COURTYARD DETAIL
SCALE: 1:250



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4. SITE PLAN PREPARED BY STANTEC, DATED SEPT, 2017.

Legend

PROPOSED		EXISTING
⊙	STORM MAINTENANCE HOLE	⊙
⊙	STORM CATCHBASIN MAINTENANCE HOLE	⊙
■	CATCHBASIN	
●	SANITARY MAINTENANCE HOLE	
⋈	VALVE & BOX	⋈
⊘	CURB STOP	⊘
⊕	HYDRANT SET	⊕
	SIAMESE CONNECTION	
	FENCE	
	SLOPE (3:1 UNLESS NOTED OTHERWISE)	
• 352.90	ELEVATION	• 349.11 (EX)
	CONTOUR	349.0

Revision	By	Appd.	YY.MM.DD

File Name: 161401285C-GP.dwg | Dwn. | Chkd. | Dsgn. | 16.11.09 YY.MM.DD

Permit-Seal

Client/Project
TRICAR DEVELOPMENT INC.

1888 GORDON STREET

Guelph, Ontario

Title
GRADING PLAN

Project No.	Scale	Sheet	Revision
161401285	1:500 (0, 5, 15, 25m)		
Drawing No.			
C-400		of	0

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2018/01/08 11:36 AM By: Hernandez, Javier

ORIGINAL SHEET - ARCH D

APPENDIX B

Design Sheets

SUBDIVISION

1888 Gordon Street

SANITARY SEWER

DESIGN SHEET

DATE: September 7, 2017
DESIGNED BY:
CHECKED BY: CJH

FILE NUMBERS: 161401285

DESIGN PARAMETERS — City of Guelph

AVERAGE DAILY FLOW PER PERSON =	350	l/p/day	RESIDENTIAL:	0.0030 L/s/ha
			COMMERCIAL:	1.7000 L/s/Ha
MINIMUM VELOCITY =	0.600	m/s	INDUSTRIAL:	1.7000 L/s/Ha
n =	0.013		INSTITUTIONAL:	2.5000 L/s/Ha
MAX PEAK FAC.=	4.500		INFILTRATION:	0.1500 L/s/Ha
MIN PEAK FAC.=	1.500		RESIDENTIAL HARMON PEAKING FACTOR	

LOCATION			RESIDENTIAL AREA AND POPULATION						COMM		INDUST		INSTIT		C+I+I	INFILTRATION			TOTAL	PIPE					
STREET	FROM M.H.	TO M.H.	AREA (ha)	POP. DENSITY (p/ha)	POP.	CUMULATIVE AREA (ha)	CUMULATIVE POP.	PEAK FACT.	PEAK FLOW (L/s)	AREA (ha)	ACCU. AREA (ha)	AREA (ha)	ACCU. AREA (ha)	AREA (ha)	ACCU. AREA (ha)	PEAK FLOW (L/s)	TOTAL AREA (ha)	ACCU. AREA (ha)	INFILT. FLOW (L/s)	**FLOW** (L/s)	DIST (m)	DIA (mm)	SLOPE (%)	CAP. (FULL) (L/s)	VEL. (FULL) (m/s)	VEL. (ACT.) (m/s)
1888 Gordon St			3.19			3.19	0		22.330		0.00		0.00		0.00	0.000	3.19	3.19	0.479	0 22.809						

*based on 7L/s/ha

APPENDIX C

Stormwater Design Calculations

1888 Gordon Street, Guelph
Stormwater Management Parameters

MOE Water Quality Parameters

	Total SWMF	Site	
Tributary Area (ha)	3.20		
Tributary Area requiring quality control (ha)	3.20	3.20	
MOE Quality Control Requirement	Level 1		
Basin Design	Infiltration		
[1]Quality Control Volume Requirement (m^3/ha)	35	35	
Quality Control Volume Requirement (m^3)	112	112	
[2]Permanent Pool (m^3)	-16	-16	
[3]Extended Detention - Quality Control (m^3)	128	128	

[1] Based on MOE guidelines and overall percent impervious

[2] Permanent Pool sized for quality control - All but 40 m^3/ha of required quality control volume

[3] Extended Detention sized for quality control - 40 m^3/ha

Catchment Number	Area (ha)	% Imperv (XIMP)
Site	3.20	70%
Total Quality Control	**3.20**	**100%**
Quantity Control	**3.20**	**100%**

Roof Ponding (buildings 1+5)			Infiltration Gallery 2			Lawn Areas			Roof Ponding (Buildings 2+3+4)			Infiltration Gallery 3			Infiltration Gallery 1			External Areas		
Impervious area	5865	sq.m	Roof area		sq.m	Paved Area	0	sq.m	Impervious area	4842	sq.m	Roof area		sq.m	Roof area		sq.m	Parking area	938	sq.m
			RG Area		sq.m	Pervious Areas	6680	sq.m				RG Area	0	sq.m	RG Area	0	sq.m	Pervious Areas	2977	sq.m
			Directly to Tench	3455	sq.m							Directly to Tench	4863	sq.m	Directly to Tench	1747	sq.m	Road	564	sq.m
Total area:	5865	sq.m	Total area:	3455	sq.m	Total area:	6680	sq.m	Total area:	4842	sq.m	Total area:	4863	sq.m	Total area:	1747	sq.m	Total area:	3915	sq.m
			Trench surf. area:	690	sq.m	Trench surf. area:	0	sq.m				Trench surf. area:	842	sq.m	Trench surf. area:	281	sq.m	Trench surf. area:	0	sq.m
			Trench depth:	2	m	Trench depth:	0	m				Trench depth:	1.6	m	Trench depth:	0.5	m	Trench depth:	0	m
			Trench porosity:	0.35		Trench porosity:	0.35					Trench porosity:	0.35		Trench porosity:	0.95		Trench porosity:	0.35	
			Trench full:	483	cu.m	Trench full:	0	cu.m				Trench full:	471.52	cu.m	Trench full:	133.475	cu.m	Trench full:	0	cu.m
			Trench initial vol:	0	cu.m	Trench initial vol:	0	cu.m				Trench initial vol:	0	cu.m	Trench initial vol:	0	cu.m	Trench initial vol:	0	cu.m
			Subsoil exfil. rate:	20	mm/hr	Subsoil exfil. rate:	20	mm/hr				Subsoil exfil. rate:	22	mm/hr	Subsoil exfil. rate:	23	mm/hr	Subsoil exfil. rate:	22	mm/hr
			Soil depth:		mm	Soil depth:	150	mm				Soil depth:		mm	Soil depth:		mm	Soil depth:	150	mm
			Soil porosity:			Soil porosity:	0.35					Soil porosity:			Soil porosity:			Soil porosity:	0.35	
			Soil field cap:			Soil field cap:	0.15					Soil field cap:			Soil field cap:			Soil field cap:	0.15	
			Soil wilt point:			Soil wilt point:	0.1					Soil wilt point:			Soil wilt point:			Soil wilt point:	0.1	
			Soil infil. rate		mm/hr	Soil infil. rate	10	mm/hr				Soil infil. rate		mm/hr	Soil infil. rate		mm/hr	Soil infil. rate	10	mm/hr
			Soil wilt point vol:		cu.m	Soil wilt point vol:	100.2	cu.m				Soil wilt point vol:		cu.m	Soil wilt point vol:		cu.m	Soil wilt point vol:	44.7	cu.m
depth of rain	0.087		Soil porosity vol:		cu.m	Soil porosity vol:	350.7	cu.m	depth of rain	0.087		Soil porosity vol:		cu.m	Soil porosity vol:		cu.m	Soil porosity vol:	156.3	cu.m
Rain Volume	511.6		Soil field cap vol:		cu.m	Soil field cap vol:	150.3	cu.m	Rain Volume	422.4		Soil field cap vol:		cu.m	Soil field cap vol:		cu.m	Soil field cap vol:	67.0	cu.m
P volume	956.0		Soil initial vol:		cu.m	Soil initial vol:	150.3	cu.m	P volume	789.2		Soil initial vol:		cu.m	Soil initial vol:		cu.m	Soil initial vol:	67.0	cu.m
Ponding	0.163	m	Ponding		m	Ponding	0.0050	m	Ponding	0.163	m	Ponding		m	Ponding		m	Ponding	0.0050	m
Orifice	125.00	mm	I/P	5.0		I/P	0.0		Orifice	115.00	mm	I/P	5.8		I/P	6.2		I/P	0.3	
			Safety Factor	0.2								Safety Factor	0.2		Safety Factor	0.2				
			Area with SF	828								Area with SF	1010		Area with SF	337				

Summary	Roof (1+5+4)	IG 2	Lawn	Roof (2+3)	IG 3	IG 1	Ex	Total
Total evaporation		0.0	0.0		0.0	0.0	0.0	0.0
Total exfiltration		813.1	192.1		846.6	152.4	92.5	2096.7
Total drainflow	511.6	0.0	0.0	422.4	0.0	0.0	0.0	0.0
Total runoff	0.0	0.0	390.7	0.0	0.0	0.0	298.2	688.9
Total Reused								
Sum	511.6	813.1	582.7	422.4	846.6	152.4	390.7	2785.6
Total rainfall	511.6	813.1	582.7	422.4	846.6	152.4	390.7	2785.6
% Treated	100%	100%	33%	100%	100%	100%	24%	75%
% untreated	0%	0%	67%	0%	0%	0%	76%	25%
% Captured	0%	100%	33%	0%	100%	100%	24%	75%
EIA	100%	0%	67%	100%	0%	0%	76%	25%

Peak Flow= 0.72 cms
runoff Volume= 688.9 c.m.

Month #	Month	Days	Monthly Evap (mm)
1	Jan	31	
2	Feb	28	
3	Mar	31	
4	Apr	30	
5	May	31	
6	Jun	30	
7	Jul	31	
8	Aug	31	
9	Sep	30	
10	Oct	31	
11	Nov	30	
12	Dec	31	

Roof Ponding (buildings 1+5)

22,274 Impervious area	5865	sq.m
70%		
31931 Total area:	5865	sq.m
depth of rain	0.087	
Rain Volume	511.6	
P volume	956.0	
Ponding	0.163	m
Orifice	125.00	mm

Infiltration Gallery 2

Roof area		sq.m
RG Area		sq.m
Directly to Trench	3455	sq.m
Total area:	3455	sq.m
Trench surf. area:	690	sq.m
Trench depth:	2	m
Trench porosity:	0.35	
Trench full:	483	cu.m
Trench initial vol:	0	cu.m
Subsoil exfil. rate:	20	mm/hr
Soil depth:		mm
Soil porosity:		
Soil field cap:		
Soil wilt point:		
Soil infil. rate		mm/hr
Soil wilt point vol:		cu.m
Soil porosity vol:		cu.m
Soil field cap vol:		cu.m
Soil initial vol:		cu.m
Ponding		m
I/P	5.0	
Safety Factor	0.2	
Area with SF	828	

Lawn Areas

Paved Area	0	sq.m
Pervious Areas	6680	sq.m
Total area:	6680	sq.m
Trench surf. area:	0	sq.m
Trench depth:	0	m
Trench porosity:	0.35	
Trench full:	0	cu.m
Trench initial vol:	0	cu.m
Subsoil exfil. rate:	20	mm/hr
Soil depth:	150	mm
Soil porosity:	0.35	
Soil field cap:	0.15	
Soil wilt point:	0.1	
Soil infil. rate	10	mm/hr
Soil wilt point vol:	100.2	cu.m
Soil porosity vol:	350.7	cu.m
Soil field cap vol:	150.3	cu.m
Soil initial vol:	150.3	cu.m
Ponding	0.0050	m
I/P	0.0	

Roof Ponding (Buildings 2+3+4)

Impervious area	4842	sq.m
Total area:	4842	sq.m
depth of rain	0.087	
Rain Volume	422.4	
P volume	789.2	
Ponding	0.163	m
Orifice	115.00	mm

Infiltration Gallery 3

Roof area		sq.m
RG Area		sq.m
Directly to Trench	4863	sq.m
Total area:	4863	sq.m
Trench surf. area:	842	sq.m
Trench depth:	1.6	m
Trench porosity:	0.35	
Trench full:	471.52	cu.m
Trench initial vol:	0	cu.m
Subsoil exfil. rate:	22	mm/hr
Soil depth:		mm
Soil infil. rate		mm/hr
Ponding		m
I/P	5.8	
Safety Factor	0.2	
Area with SF	1010	

Infiltration Gallery 1

Roof area		sq.m
RG Area	0	sq.m
Directly to Trench	1747	sq.m
Total area:	1747	sq.m
Trench surf. area:	281	sq.m
Trench depth:	0.5	m
Trench porosity:	0.95	
Trench full:	133.475	cu.m
Trench initial vol:	0	cu.m
Subsoil exfil. rate:	23	mm/hr
Soil depth:		mm
Soil infil. rate		mm/hr
Ponding		m
I/P	6.2	
Safety Factor	0.2	
Area with SF	337	

External Areas

Parking area	938	sq.m
Pervious Areas	2977	sq.m
Road		564 sq.m
Total area:	3915	sq.m
Trench surf. area:	0	sq.m
Trench depth:	0	m
Trench porosity:	0.35	
Trench full:	0	cu.m
Trench initial vol:	0	cu.m
Subsoil exfil. rate:	22	mm/hr
Soil depth:	150	mm
Soil porosity:	0.35	
Soil field cap:	0.15	
Soil wilt point:	0.1	
Soil infil. rate	10	mm/hr
Soil wilt point vol:	44.7	cu.m
Soil porosity vol:	156.3	cu.m
Soil field cap vol:	67.0	cu.m
Soil initial vol:	67.0	cu.m
Ponding	0.0050	m
I/P	0.3	

Summary	Roof (1+5+4)	IG 2	Lawn	Roof (2+3)	IG 3	IG 1	Ex	Total
Total evaporation		0.0	0.0		0.0	0.0	0.0	0.0
Total exfiltration		813.1	192.1		846.6	152.4	92.5	2096.7
Total drainflow	511.6	0.0	0.0	422.4	0.0	0.0	0.0	0.0
Total runoff	0.0	0.0	390.7	0.0	0.0	0.0	298.2	688.9
Total Reused								
Sum	511.6	813.1	582.7	422.4	846.6	152.4	390.7	2785.6
Total rainfall	511.6	813.1	582.7	422.4	846.6	152.4	390.7	2785.6
% Treated	100%	100%	33%	100%	100%	100%	24%	75%
% untreated	0%	0%	67%	0%	0%	0%	76%	25%
% Captured	0%	100%	33%	0%	100%	100%	24%	75%
EIA	100%	0%	67%	100%	0%	0%	76%	25%

*drainflow for roof and RG redirected to Trench for exfiltration

49 7%

2%

639.7

23%

Peak Flow= 0.72 cms

runoff Volume= 688.9 c.m.

MONTHLY WATER BALANCE

Update cells with red text. See cell comments for additional notes.

Monthly Water Balance Analysis - Groundwater Recharge

1888 Gordon Road

Pre Development

Wetland Area

Land Description Factors	Site
Topography	
Soils	
Cover	
Sum (Infiltration Factor)	1
Soil Moisture Capacity (mm)	150
Percentage of Total Site Area	100%
Total Site Area (ha)	0.135

Land Cover Descriptions

Site Silt, Sand, Gravel, Pasture/Shrub, rolling

Infiltration factor set to 1.0 as depression does not experience runoff

Check **100%** **OK**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Comment
Climate Data (Data from Waterloo Wellington Airport - Climate Normals from 1981-2010)														
Average Daily Temperature (°C)	-6.5	-5.5	-1.0	6.2	12.5	17.6	20.0	18.9	14.5	8.2	2.5	-3.3		Daily average temperature in each month
Precipitation (mm)	65.2	54.9	61.0	74.5	82.3	82.4	98.6	83.9	87.8	67.4	87.4	71.2	**916.6**	
Evapotranspiration Analysis														
Saturation Vapour Pressure (mb)	3.75	4.05	5.68	9.49	14.52	20.17	23.45	21.89	16.55	10.89	7.32	4.79		
PET (Malstrom, 1969) (mm/month)	0.00	0.00	0.00	38.82	59.39	82.51	95.89	89.54	67.67	44.54	29.93	0.00	**508.3**	
Precipitation - PET (mm)	65.20	54.90	61.00	35.68	22.91	-0.11	2.71	-5.64	20.13	22.86	57.47	71.20		
Weighted Soil Storage Capacity (mm)	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00		
Actual Soil Moisture (mm)	150.00	150.00	150.00	150.00	150.00	149.89	150.00	144.36	150.00	150.00	150.00	150.00		Assume April soil moisture is at max capacity (saturated)
Change in Soil Moisture (mm)	0.00	0.00	0.00	0.00	0.00	-0.11	0.11	-5.64	5.64	0.00	0.00	0.00		
Actual Evapotranspiration (mm)	**0.00**	**0.00**	**0.00**	**38.82**	**59.39**	**82.51**	**95.89**	**89.54**	**67.67**	**44.54**	**29.93**	**0.00**	**508.3**	
Recharge/Runoff Analysis														
Surplus	65.2	54.9	61.0	35.7	22.9	0.0	2.6	0.0	14.5	22.9	57.5	71.2	**408.3**	
Deficit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	
Weighted Infiltration Factor	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		Based on MOE SWM Manual (2003)
Runoff (mm)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0**	Assume no runoff in sub-zero months
Recharge (mm)	**0.00**	**0.00**	**0.00**	**287.98**	**22.91**	**0.00**	**2.59**	**0.00**	**14.48**	**22.86**	**57.47**	**0.00**	**408.3**	
												Balance Check (should equal zero)	0	Balance Check (should equal zero)

Volume-Based Balance (m^3)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Precipitation	88	74	82	101	111	111	133	113	119	91	118	96	1,237
Evapotranspiration	0	0	0	52	80	111	129	121	91	60	40	0	686
Runoff	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater Recharge	0	0	0	389	31	0	4	0	20	31	78	0	551
Total Groundwater Recharge	**0**	**0**	**0**	**389**	**31**	**0**	**4**	**0**	**20**	**31**	**78**	**0**	**551**

Remainder of Site

Land Description Factors	Site
Topography	
Soils	
Cover	
Sum (Infiltration Factor)	1
Soil Moisture Capacity (mm)	150
Percentage of Total Site Area	100%
Total Site Area (ha)	3.058

GRCA modelling shows 0 RNF for this Site

Land Cover Descriptions

Site Silt, Sand, Gravel, Pasture/Shrub, rolling

Check **100%** **OK**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Comment
Climate Data (Data from Waterloo Wellington Airport - Climate Normals from 1981-2010)														
Average Daily Temperature (°C)	-6.5	-5.5	-1.0	6.2	12.5	17.6	20.0	18.9	14.5	8.2	2.5	-3.3		Daily average temperature in each month
Precipitation (mm)	65.2	54.9	61.0	74.5	82.3	82.4	98.6	83.9	87.8	67.4	87.4	71.2	**916.6**	
Evapotranspiration Analysis														
Saturation Vapour Pressure (mb)	3.75	4.05	5.68	9.49	14.52	20.17	23.45	21.89	16.55	10.89	7.32	4.79		
PET (Malstrom, 1969) (mm/month)	0.00	0.00	0.00	38.82	59.39	82.51	95.89	89.54	67.67	44.54	29.93	0.00	**508.3**	
Precipitation - PET (mm)	65.20	54.90	61.00	35.68	22.91	-0.11	2.71	-5.64	20.13	22.86	57.47	71.20		
Weighted Soil Storage Capacity (mm)	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00		
Actual Soil Moisture (mm)	150.00	150.00	150.00	150.00	150.00	149.89	150.00	144.36	150.00	150.00	150.00	150.00		Assume April soil moisture is at max capacity (saturated)
Change in Soil Moisture (mm)	0.00	0.00	0.00	0.00	0.00	-0.11	0.11	-5.64	5.64	0.00	0.00	0.00		
Actual Evapotranspiration (mm)	**0.00**	**0.00**	**0.00**	**38.82**	**59.39**	**82.51**	**95.89**	**89.54**	**67.67**	**44.54**	**29.93**	**0.00**	**508.3**	
Recharge/Runoff Analysis														
Surplus	65.2	54.9	61.0	35.7	22.9	0.0	2.6	0.0	14.5	22.9	57.5	71.2	**408.3**	
Deficit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	
Weighted Infiltration Factor	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		Based on MOE SWM Manual (2003)
Runoff (mm)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0**	Assume no runoff in sub-zero months
Recharge (mm)	**0.00**	**0.00**	**0.00**	**287.98**	**22.91**	**0.00**	**2.59**	**0.00**	**14.48**	**22.86**	**57.47**	**0.00**	**408.3**	
												Balance Check (should equal zero)	0	Balance Check (should equal zero)

Volume-Based Balance (m^3)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Precipitation	1,994	1,679	1,865	2,278	2,517	2,520	3,015	2,566	2,685	2,061	2,673	2,177	28,031
Evapotranspiration	0	0	0	1,187	1,816	2,523	2,932	2,738	2,070	1,362	915	0	15,544
Runoff	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater Recharge	0	0	0	8,807	701	0	79	0	443	699	1,758	0	12,486
Total Groundwater Recharge	**0**	**0**	**0**	**8,807**	**701**	**0**	**79**	**0**	**443**	**699**	**1,758**	**0**	**12,486**

Total Predevelopment Results

Volume-Based Balance (m^3)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Precipitation	2,082	1,753	1,948	2,379	2,628	2,631	3,148	2,679	2,804	2,152	2,791	2,273	29,268
Evapotranspiration	0	0	0	1,240	1,896	2,635	3,062	2,859	2,161	1,422	956	0	16,231
Runoff	0	0	0	0	0	0	0	0	0	0	0	0	0
Groundwater Recharge	0	0	0	9,195	731	0	83	0	463	730	1,835	0	13,037
Total Groundwater Recharge	**0**	**0**	**0**	**9,195**	**731**	**0**	**83**	**0**	**463**	**730**	**1,835**	**0**	**13,037**

408

Post Development

Land Description Factors	Site	Impervious
Topography	0.2	-
Soils	0.4	-
Cover	0.05	-
Sum (Infiltration Factor)	0.65	-
Soil Moisture Capacity (mm)	75	-
Percentage of Total Site Area	30%	70%
Total Site Area (ha)	3.2	

Check **100%** **OK**

Land Cover Descriptions

Site Silt, Sand, Gravel, lawn, rolling

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Comment
Climate Data (Data from Waterloo Wellington Airport - Climate Normals from 1981-2010)														
Average Daily Temperature (°C)	-6.5	-5.5	-1.0	6.2	12.5	17.6	20.0	18.9	14.5	8.2	2.5	-3.3		Daily average temperature in each month
Precipitation (mm)	65.2	54.9	61.0	74.5	82.3	82.4	98.6	83.9	87.8	67.4	87.4	71.2	**916.6**	
Evapotranspiration Analysis														
Saturation Vapour Pressure (mb)	3.75	4.05	5.68	9.49	14.52	20.17	23.45	21.89	16.55	10.89	7.32	4.79		
PET (Malstrom, 1969) (mm/month)	0.00	0.00	0.00	38.82	59.39	82.51	95.89	89.54	67.67	44.54	29.93	0.00	**508.3**	
Precipitation - PET (mm)	65.2	54.90	61.00	35.68	22.91	-0.11	2.71	-5.64	20.13	22.86	57.47	71.20		
Weighted Soil Storage Capacity (mm)	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50		
Actual Soil Moisture (mm)	22.50	22.50	22.50	22.50	22.50	22.39	22.50	16.86	22.50	22.50	22.50	22.50		Assume April soil moisture is at max capacity (saturated)
Change in Soil Moisture (mm)	0.00	0.00	0.00	0.00	0.00	-0.11	0.11	-5.64	5.64	0.00	0.00	0.00		
Actual Evapotranspiration (mm)	**0.00**	**0.00**	**0.00**	**38.82**	**59.39**	**82.51**	**95.89**	**89.54**	**67.67**	**44.54**	**29.93**	**0.00**	**508.3**	
Recharge/Runoff Analysis														
Surplus	65.2	54.9	61.0	35.7	22.9	0.0	2.6	0.0	14.5	22.9	57.5	71.2	**408.3**	
Deficit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	
Weighted Infiltration Factor	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650		Based on MOE SWM Manual (2003)
Runoff (mm)	**0.00**	**0.00**	**0.00**	**100.79**	**8.02**	**0.00**	**0.91**	**0.00**	**5.07**	**8.00**	**20.11**	**0.00**	**142.9**	Assume no runoff in sub-zero months
Recharge (mm)	**0.00**	**0.00**	**0.00**	**187.19**	**14.89**	**0.00**	**1.69**	**0.00**	**9.42**	**14.86**	**37.36**	**0.00**	**265.4**	
												Balance Check (should equal zero)	0	Balance Check (should equal zero)

Volume-Based Balance (m^3)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Precipitation	2,082	1,753	1,948	2,379	2,628	2,631	3,148	2,679	2,804	2,152	2,791	2,273	29,268
Evapotranspiration	0	0	0	372	569	790	919	858	648	427	287	0	4,869
Runoff	0	0	0	966	77	0	9	0	49	77	193	0	1,369
Impervious Runoff	0	0	0	7,305	1,840	1,842	2,204	1,875	1,962	1,507	1,954	0	20,488
Total Runoff	0	0	0	8,270	1,916	1,842	2,213	1,875	2,011	1,583	2,146	0	21,856
Groundwater Recharge from Pervious Areas	**0**	**0**	**0**	**1,793**	**143**	**0**	**16**	**0**	**90**	**142**	**358**	**0**	**2,542**	10,495
												Balance Check (should equal zero)	0	

Infiltration Augmentation - All Impervious Areas- 20,772 square meters to infiltration, assume 80% infiltrates														
Rooftop Runoff to Infiltration Trenches	0	0	0	5,431	1,368	1,369	1,638	1,394	1,459	1,120	1,452	0	15,232	
Final Groundwater Recharge	**0**	**0**	**0**	**7,224**	**1,510**	**1,369**	**1,655**	**1,394**	**1,549**	**1,262**	**1,810**	**0**	**17,774**	
Final Recharge Surplus	0	0	0	-1,972	779	1,369	1,572	1,394	1,087	532	-25	0	4,737	

Monthly Water Balance - Groundwater Recharge (Site)
1614-01285- 1888 Gordon Road Guelph