2596 Carp Road Ottawa, Ontario Industrial Development Servicing and Stormwater Management Report

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Robinson Land Development

Our Project No. 18047 September 2018 Revised December 2018

Legal Notification

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1.0 INTRODUCTION

Robinson Land Development has been retained by 1384341 Ontario Ltd. to provide engineering services for a proposed 28.4 hectare industrial development located at 2596 Carp Road in the City of Ottawa (see **Figure 1 - Key Plan** following page 1). The crux of this report will focus on the stormwater management design required to develop the property and provide guidance for servicing of the proposed site.

2.0 EXISTING CONDITIONS

The 28.4 hectare property (zoned rural general industrial RG5) is mainly undeveloped. An existing private gravel access road through the site provides access from Carp Road to existing buildings and structures located adjacent to Huntley Creek as well as granular stockpiles located on the property. The site is bounded by Huntley Creek and woodlands to the north, Carp Road and commercial/industrial properties to the west and south, and undeveloped industrial land to the east. The site is constrained by a meander belt setback and 15 metre setback along the south side of Huntley Creek. The site contains existing ditches which convey stormwater runoff from the site towards Huntley Creek. Refer to **Figure 2** below for an aerial view of the site under pre-development conditions.



Figure 2 - Existing Conditions

3.0 DEVELOPMENT PROPOSAL

The subject property is intended to be developed into a concrete mixing plant. The development will include a mixing plant building, material stockpile areas and an area designated for employee parking. The existing building located on the south side of Huntley Creek is to remain and be used as an administration building for the plant. The site will be accessed by a new access road connection to Carp Road. The connection to Carp Road will be of similar location to the existing gravel access road currently used for the property. Refer to the Site Plan (DWG. OSP-1) prepared by Stantec Consulting Ltd. in **Appendix A** for more details.



4.0 GRADING DESIGN

The existing topography of the site generally slopes towards the north-east to Huntley Creek. (Refer to the Pre-Development Drainage Area Plan, DWG.18047-PRE1, in **Appendix A**). The proposed grading design of the property will be as such to tie into existing elevations along the site boundaries and to not impede any existing drainage patterns. The area of the property designated for the concrete mixing plant and associated features will be graded to sheet flow runoff towards the proposed LID stormwater management (SWM) facilities to receive quality control treatment (refer to **Section 7.2**).

The proposed washout pond (refer to location on the Site Plan in **Appendix A**) contains discharged slurry water from the concrete trucks. The washout pond is constructed such that a rainfall event would not cause the slurry water to overflow and enter the SWM facilities. A detailed description of how the washout pond functions and a detailed plan of the unit is provided in **Appendix A**.

The proposed access roadway will be of rural cross section with gravel shoulders and roadside ditches. The roadside ditches will be grassed and convey stormwater runoff from the right-of-way (ROW) areas to the designated LID SWM treatment. Refer to the Grading Plans (DWG. 18047-GR1, GR2, GR3) in **Appendix A**. Note that all elevations provided on the plans and herein are geodetic.

5.0 WATER SERVICING

An existing drilled well is located on-site to the north of the existing building (proposed administration building) adjacent to Huntley Creek. The existing well currently provides water supply to the existing building and will continue to provide water supply for the proposed administration building following development of the site.

Since no municipal watermains are located in the vicinity of the site, on-site drilled wells will be required to provide water supply for the proposed concrete mixing plant. The proposed water supply for the plant will be groundwater taken from two on-site wells (herein referred to as well #1 and well #2). The anticipated average water taking rate at the concrete plant is 210 L/min for 12 hours per day. Under maximum production, a water taking of up to 378 L/min may be required but is considered a rare occurrence. The concrete plant will also have two 10,000 litre water storage tanks located within the plant building to supplement production.

Golder Associates Ltd. (Golder) conducted field tests to determine the water yield generated from the on-site wells. Golder's testing, documented in the Hydrogeology Investigation, Terrain Analysis and Impact Assessment, concluded that both on-site wells can each provide at least 340 L/min of water supply, which is greater than the anticipated water use of 210 L/min for 12 hours per day. The water yield of the existing well was also tested and concluded that it can provide at least 18 L/min, which is greater than the anticipated water use at the administration building of 2,700 L/day (1.9 L/min).

Given that the water yields determined by Golder are higher than the anticipated water demands, it can be concluded that the proposed wells and existing well will provide adequate water supply to meet the water demands for the site. Refer to the proposed well and existing well locations shown on the Grading Plan (DWG. 18047-GR1) in **Appendix A**.

In the Hydrogeology Investigation, Terrain Analysis and Impact Assessment, Golder noted that if the Ontario Drinking Water Quality Standards (ODWQS) exceedances for total coliform are found to persist in the two proposed wells, an alternative source of drinking

water (i.e. bottled water) for the concrete mixing plant will be required. Further, Golder noted that if the ODWQS exceedances for total coliform and fecal coliform are found to persist in the existing well, an alternative source of drinking water for the administration building will also be required. The analytical results (refer to Certificate of Analysis in **Appendix B**) of the second bacteria resample found that free residual chlorine was not detected and that total coliform, fecal coliform and E coli counts were zero. Based on the analytical results, Golder concluded that the water is considered safe to drink, however, regular continued testing was recommended.

Fire suppression for the development will be provided by the local rural fire department. The proposed building will qualify for F-3 occupancy under the Ontario Building Code as the combustible content is expected to be less than 50 kg per square metre of floor area. The local Fire Chief has been contacted to provided comment on the development.

6.0 SANITARY SERVICING

An existing septic system is located on-site to the south-east of the existing building (proposed administration building) adjacent to Huntley Creek. The intention is for the existing septic system to remain in use following development of the site and function to service the proposed administration building (existing building). The existing septic system was reviewed by GEMTEC Consulting Engineers and Scientists and it is our understanding that it is suitable to service the proposed administration building.

Further, it is our understanding that the existing septic system is not sufficient to treat the additional sewage flows from the proposed plant building. Therefore, a new on-site septic system is proposed to provide treatment of all sewage flows generated from the concrete mixing plant. GEMTEC has designed a new on-site septic system (refer to the Preliminary Septic System Design, dated November 30, 2018, submitted under a separate cover) which has been sized to adequately treat all sewage flows generated from the concrete mixing plant. The general locations of the existing and proposed septic systems are shown on the Grading Plan (DWG. 18047-GR1) in **Appendix A**.

7.0 STORMWATER MANAGEMENT REQUIREMENTS

7.1 General Requirements

A primary constraint of the subject property is the adjacent Huntley Creek. According to the Carp River Subwatershed Study, this section of Huntley Creek provides cold water aquatic habitat with local groundwater recharge. The type of fish habitat present is uncommon in the Ottawa area and as such requires a high level of protection.

The local review Conservation Authority, Mississippi Valley Conservation Authority (MVCA), have been consulted and they have requested that the following design details be implemented for the subject site:

- Provide enhanced (Level 1) quality control (80% TSS removal)
- Provide thermal temperature control to 25 degrees Celsius
- No new development should occur within the floodplain or meander belt hazards

7.2 Quality Control

As directed by the MVCA, enhanced (Level 1) quality control of stormwater runoff must be achieved for the subject site. In order to meet the enhanced quality control requirement, two bioretention facilities will be utilized across the site to capture stormwater runoff and provide cleansing prior to discharge into Huntley Creek. Bioretention temporarily stores, treats (filters) and infiltrates runoff. The proposed bioretention facilities will provide enhanced quality control via filtration of stormwater through the various treatment layers within the facility, if full infiltration of the runoff volume control target (RVC_T) is achieved (refer to **Section 7.3** for details). The typical elements of a bioretention facility and their general specifications are provided in **Table 1** below.

Material	Specification	Typical Depth (m)
Mulch Layer	Shredded hardwood bark mulch	0.075
Filter Media	 to 88% sand to 12% soil fines 3 to 5% organic matter P-Index value between 10 to 30 ppm Cationic exchange capacity greater than 10 meq/ 100g pH between 5.5 to 7.5 Infiltration rate greater than 25 mm/hr 	0.50-1.25
Choke Layer	Washed 10 mm diameter clear stone	0.10
Gravel Storage Layer	Washed 50 mm diameter clear stone	0.30 MIN.
Underdrain (if required)	Perforated HDPE, minimum diameter of 100 mm	MIN. 0.10 above facility bottom

Table 1 - Bioretention Facility General Specifications

Mulch Layer

A 75 mm deep layer of mulch on the surface of the filter bed enhances plant survival, suppresses weed growth and pretreats runoff before it reaches the filter media layer. Regular fresh applications of wood mulch can also promote denitrification, reducing nitrates in impacted surface waters.

Filter Media

The primary component of the practice is the filter media which is a mixture of sand, fines and organic material. To ensure a consistent and homogeneous bed, filter media should come pre-mixed from an approved vendor. Pollutant removal benefits may be achieved in beds as shallow as 0.50 metres.

Choke Layer

A 100 mm deep layer of 10 mm diameter washed clear stone should be placed on top of the coarse gravel storage layer as a choking layer separating it from the overlying filter media bed. The use of a stone choke layer is preferred over filter fabric as filter fabric has been found to be prone to clogging.

Gravel Storage Layer

A minimum 300 mm depth of 50 mm diameter washed clear stone should be placed below the choke layer to provide quality storage volume.

Underdrain (if required)

A minimum 100 mm diameter perforated underdrain pipe may be placed in the gravel storage layer of the facility in order to provide a positive outlet for the facility in the event that infiltration is not being achieved. An underdrain is only needed where the native soil infiltration rate is less than 15 mm/hr. As per the Infiltration Rate Assessment (refer to **Appendix B**), prepared by Golder, the design infiltration rate calculated for the subject site is 22 mm/hr. Therefore, underdrains will not be required for the on-site bioretention facilities. In the event that the facilities are full, (i.e. not infiltrating stormwater into the native soils during periods of high water table), runoff will be conveyed overland via the vegetated surface swale. Surface storage and subsurface storage are available to contain all storm events up to and including the 100 year design event (as requested by the Conservation Authority) within the system (i.e. without bypassing untreated) until full infiltration can be achieved (refer to **Section 7.6**).

Monitoring Well

The monitoring well is a perforated standpipe that extends from the bottom of the facility to the top. The monitoring well allows for measurement of the subsurface water level to track the drainage performance of the facility over time. Standpipes should be securely capped on both ends and remain undamaged.

Inspection and Maintenance

Bioretention requires routine inspection and maintenance of the landscaping as well as other periodic inspection for less frequent maintenance needs. Facilities should be inspected for vegetation density, damage by foot or vehicular traffic, channelization and accumulation of debris, trash and sediment. Maintenance activities include reapplying mulch, pruning, weeding, replacing dead vegetation and repairing eroded areas as needed. Some of the most common inspection and maintenance procedures are detailed below:

General

- Inspections on the facilities should be conducted in the spring and fall of each year and after every major storm event (> 25 mm).
- Sediment depth should be measured during cleaning to estimate the accumulation rate and optimize frequency of maintenance.

Pre-Treatment Areas

- Trash, debris and sediment should be removed from the contributing drainage area biannually to quarterly.
- Trash, debris and sediment should be removed from the pre-treatment (3.0 metre pre-treatment strip) areas annually to biannually or when the sumps are half full (approximately 5 cm).

Filter Bed

- Side slopes of the facilities should be inspected for erosion.
- Inspect filter bed for standing water, barren/eroded areas, sinkholes or animal burrows.
- Remove trash from the filter bed biannually to quarterly.

- Rake filter bed regularly to redistribute mulch and prevent sediment crusts.
- Maintain 75 mm of mulch cover to prevent weed growth and soil erosion.
- Repair sunken areas when greater than 10 cm deep and barren/eroded areas when greater than 30 cm long.
- Remove sediment when greater than 5 cm deep or time to drain water ponded on the surface exceeds 48 hours.
- Removal of sediment from the filter bed surface should be done with a rake and shovel, or vacuum equipment to minimize plant disturbance. If a small excavator is to be used, keep it off the facility footprint to avoid damage to side slopes and over-compaction of the filter media.
- To avoid over-compaction of the filter media soil, any maintenance tasks involving vehicle or foot traffic on the filter bed should not be performed during wet weather.
- Grades should be restored with filter media that meets the approved design specifications.
- Replace stone, mulch and plant cover as required.
- When sediment accumulation is greater than 5 cm in depth, surface infiltration rates should be tested (one test for every 25 m² of filter bed area) to confirm greater than 25 mm/hr infiltration rate is being achieved.

Vegetation

- In the first two months water plantings frequently (as recommended by the Landscape Architect) and as needed (e.g. bimonthly) over the remainder of the first growing season.
- Remove weeds and undesirable plants biannually to quarterly.
- Replace dead plantings annually to achieve 80 percent cover by the third growing season.
- Never apply chemical fertilizers.

Additional inspection and maintenance details have been provided in **Appendix B**.

Water Table

A minimum 1.0 metre separation is recommended between the seasonally high water table and the bottom of the facility for best performance. Based on the field measurements recorded by Golder and summarized in the *Technical Memorandum – Response to City Comments on Robinson Land Development LID Design* (refer to **Appendix B**), over 1.0 metre of separation is provided between the bottom of the proposed bioretention facilities and the seasonally high water table. The seasonally high water table was interpreted to be at an elevation of 108.80 m and 108.50 m for the SWM1 and SWM2 treatment facilities respectively, which provides the recommended 1.0 metre separation from the bottom of the facilities.

7.3 Quality Storage Requirements

As per the Ministry of the Environment, Stormwater Management Planning and Design Manual (2003), enhanced level protection can be achieved using infiltration type stormwater management measures. **Table 3.2 – Water Quality Storage Requirements based on Receiving Waters** of the manual provides a required storage volume to meet enhanced level protection using infiltration measures based on the impervious level of the drainage area. However, even when using a highly impervious drainage area, the water quality storage requirements calculated using **Table 3.2** are approximately six times less (refer to **Table 2** below) than the quality storage requirements calculated using methods outlined by the Sustainable Technologies Evaluation Program (STEP). STEP is a multi-agency initiative developed to support broader implementation of sustainable technologies and practices

within a Canadian context. The water component of STEP is a partnership between Toronto and Region Conservation Authority (TRCA), Credit Valley Conservation (CVC) and Lake Simcoe Region Conservation Authority (LSRCA). Since the methods outlined by STEP, to calculate water quality storage requirements, are much more stringent than using **Table 3.2**, STEP methods will be used to size the on-site bioretention facilities.

As outlined by STEP, the total quality storage volume required can be calculated using the following equation:

 $V = RCV_T \times A_C$

Where: V = Required Storage Volume (m³) RCV_T = Runoff Volume Control Target for Site (m) A_{C} = Catchment Area (m²)

The runoff volume control target (RVC_T) for the subject site is in the range of 26 mm to 27 mm (0.026 m to 0.027 m) based on **Figure 3.67 – Recommended Regional 90% Percentile Volume Targets for Ontario** from the *Runoff Volume Control Targets for Ontario Final Report,* prepared by Aquafor Beech Ltd., for the Ministry of the Environment and Climate Change (MOECC). To be conservative, a runoff volume control target of 27 mm has been used to calculate the required storage volumes for the subject site. **Figure 3.67** has been provided in **Appendix B** for reference.

Using the above STEP equation, the required storage volumes have been calculated for each catchment area. Refer to the Stormwater Management Plan (DWG. 18047-SWM1) in **Appendix B**. The required storage volumes using STEP methods have been summarized in **Table 2** below. Required storage volumes using MOECP Table 3.2 have also been provided for comparison.

Catchment Area ID	Catchment Area (m²)	Required Storage Volume ^{*1,*2} (m ³)	Required Storage Volume per MOECP Table 3.2 ^{*3} (m ³)
SWM1	17,482	472.0	70.6
SWM2	15,243	411.5	59.0

 Table 2 - Quality Storage Volume Requirements

Notes:

1. Required Storage Volume = Runoff Volume Control Target x Catchment Area

2. Runoff Volume Control Target is 0.027m based on Figure 3.67 provided in Appendix B.

3. Required storage volume using MOECP SWM Planning & Design Manual, Table 3.2.

The required quality storage volumes for each catchment area (summarized in **Table 2** above) will be provided within their respective bioretention facility (SWM1 facility and SWM2 facility). The facilities have been sized accordingly to meet the storage volume requirements. The quality storage volume is provided within the multiple layers of the bioretention facility. The depth of filter media and gravel storage layer may vary from facility to facility based on the storage requirements and the localized constraints. The provided storage volumes for the SWM1 facility and SWM2 facility have been summarized in **Table 3** and **Table 4** below.

Layer	Surface Area ^{*2} (m ²)	Depth (m)	Void Ratio	Provided Storage Volume ^{*1} (m ³)
Mulch	1275	0.075	0.7	66.9
Filter Media	1275	0.50	0.3	191.3
Choke Layer	1275	0.10	0.4	51.0
Gravel Storage Layer	1275	0.32	0.4	163.2
Total		1.00		472.4

Table 3 - SWM1 Treatment Facility Provided Storage Volume

Notes:

1. Provided Storage Volume = Surface Area x Depth x Void Ratio

2. Facility surface areas are calculated using AutoCAD Civil 3D. The facility areas are incrementally increased until the required storage volumes are achieved.

Layer	Surface Area ^{*2} (m ²)	Depth (m)	Void Ratio	Provided Storage Volume ^{*1} (m ³)
Mulch	875	0.075	0.7	45.9
Filter Media	875	0.90	0.3	236.3
Choke Layer	875	0.10	0.4	35.0
Gravel Storage Layer	875	0.30	0.4	105.0
Total		1.38		422.2

Table 4 - SWM2 Treatment Facility Provided Storage Volume

Notes:

1. Provided Storage Volume = Surface Area x Depth x Void Ratio

2. Facility surface areas are calculated using AutoCAD Civil 3D. The facility areas are incrementally increased until the required storage volumes are achieved.

As demonstrated in **Table 3** and **Table 4** above, the bioretention facilities for catchment areas SWM1 and SWM2 have provided adequate storage volume to meet the quality storage volume requirements. The required and provided storage volumes have been summarized in **Table 5** below.

Catchment Area	Required Storage Volume (m ³)	Provided Storage Volume ^{*1,*2} (m ³)
SWM1	472.0	472.4
SWM2	411.5	422.2

Notes:

1. Provided storage volumes are contained within the multiple layers of the bioretention facility.

2. Surface storage is not included within the total provided storage volume.

As demonstrated in **Table 5** above, the bioretention facilities for catchment areas SWM1 and SWM2 have provided adequate storage volume to meet the quality control storage volume requirements using methods outlined by STEP and the Aquafor Beech Report.

Under pre-development conditions, drainage from the western portion of the property (which is to remain primarily undeveloped aside from the access road construction), is conveyed to an existing ditch (running parallel to the northern property boundary), before ultimately discharging into Huntley Creek. To maintain the existing drainage patterns (as much as possible) and to tie into the existing elevations along the property boundary, the outlet for the proposed access road side ditches has been designed to outlet at the approximate location of the existing ditch. As per the Geotechnical Investigation, prepared by GEMTEC, and the Infiltration Assessment, prepared by Golder, the depth from ground surface to the water table at this location is approximately 0.70 metres. Since the water table is considerably high at this location, a bioretention facility to treat stormwater runoff is not suitable. Furthermore, due to the lack of head between an inlet and positive outlet, typical treatment units are also not suitable for the location. Therefore, the runoff from catchment area SWM3 (access road and side ditches) is proposed to receive quality treatment via a "treatment train" approach and LID measures. The stormwater runoff from the access road will be "treated" by the grassed roadside ditches, followed by a rip-rap treatment strip and then by a vegetated swale before discharging into the existing ditch and ultimately Huntley Creek. Rock check dams will also be placed within the vegetated swale to slow the stormwater and promote infiltration. The "treatment train" approach will provide quality cleansing of the runoff by:

- Reducing flow velocities with low slopes within the roadside ditches and rock check dams within the vegetated swale, thereby, encouraging infiltration through the soil
- Utilizing the rip-rap strip as an energy dissipater and settling basin for larger sediments
- Promoting settling of sediments and cleansing of stormwater within the vegetation of the swale
- Re-vegetation of the swale within the meander belt setback area will be provided for additional shading of the stormwater runoff

7.4 Pre-Treatment

In addition to the quality treatment provided by the bioretention facilities themselves, the site's stormwater runoff will also experience quality cleansing via pre-treatment methods. Along the outer perimeter of the concrete mixing plant portion of the site, a 3.0 metre wide pre-treatment strip has been provided. A 2.0 metre wide rip-rap strip along the interface with the gravel surface will aid in reducing flow velocities. The rip-rap strip will also function as a "settling basin" for larger sediments. Stormwater runoff will then be conveyed from the 2.0 metre rip-rap strap to a 1.0 metre vegetation strip. The vegetation strip will be graded with a minor depression to further capture sediments contained within the runoff. The vegetation type will be specified by the Landscape Architect to achieve the desired function. The site's runoff will be pre-treated by the rip-rap strip and vegetation strip prior to entering the bioretention facilities.

Rip-rap "check dams" have been placed at intervals along the 3.0 metre pre-treatment strip to encourage flows toward the bioretention facilities and to ensure that there is no circumventing of the treatment system. Rip-rap check dams have also been placed inline with the vegetated swale/bioretention facilities to lower flow velocities and further encourage infiltration of stormwater. For portions of the catchment area SWM1, the runoff will receive additional pre-treatment from a vegetated swale. The vegetated swale, which will covey runoff to the SWM1 facility, will provide additional pre-treatment of the stormwater by:

- Reducing flow velocities with low slopes and therefore encourage infiltration through the soil
- Promoting settling of sediments within the vegetation

7.5 Infiltration Rates

STEP also outlines methods to calculate the time to drain stormwater from a bioretention facility. In the Ottawa area, the acceptable time to drain (via infiltration) is 24 to 48 hours. Using STEP methods, the time to drain is calculated using the following equation:

Time to drain = $(Vr/f') \times (Ap/P) \times \ln[(ds + (Ap/P)) / (Ap/P))$

Where:

Vr = void ratio of the media ds = depth of facility (m) f' = design infiltration rate (m/hr) Ap = area of the infiltration practice (m²) P = perimeter of the infiltration practice (m)

For the SWM1 facility the estimated time to drain has been calculated as follows:

Given:

Vr = 0.40 ds = 1.00 m f' = 0.011 mm/hr (refer to Infiltration Rate Assessment by Golder in **Appendix B**) Ap = 1275 m² P = 378 m Ap/ P = 1275 m² / 378 m = 3.4 m

Time to drain = $(0.40 / 0.011) \times (3.4) \times \ln([1.00 + 3.4] / 3.4)$

Time to drain = 31.7 hours

For the SWM2 facility the estimated time to drain has been calculated as follows:

Given:

Vr = 0.40 ds = 1.38 m f' = 0.017 mm/hr (refer to Infiltration Rate Assessment by Golder in **Appendix B**) Ap = 875 m² P = 304.5 m

Ap/ P = $875 \text{ m}^2 / 304.5 \text{ m} = 2.9 \text{ m}$

Time to drain = $(0.40 / 0.017) \times (2.9) \times \ln([1.38 + 2.9] / 2.9)$

Time to drain = 26.4 hours

As calculated above, the times to drain from the SWM1 facility and SWM2 facility are 31.7 hours and 26.4 hours respectively. It should be noted that the equation does not consider lateral infiltration through the sides of the facilities. Given that the times to drain for both facilities are within the acceptable time of 24 to 48 hours, it has been shown that the native soils at each facility location are suitable for the type of quality treatment proposed.

7.6 Water Balance/ Stormwater Flows

A water balance assessment for the existing and proposed conditions was conducted by Golder Associates Ltd. (Golder) and detailed in the *Hydrogeology Investigation, Terrain Analysis and Impact Assessment* (available under a separate cover). Based on the results of the water balance assessment, it was concluded by Golder that the site development is projected to increase the average annual infiltration by approximately 22 percent and decrease the average annual runoff volume by approximately 2 percent compared to existing conditions. A summary of the water balance results has been provided in **Table 6** below.

Development Condition	Estimated Average Annual Runoff (m ³)	Estimated Annual Infiltration (m ³)
Pre-Development	45,122	52,182
Post-Development	44,159	63,531

Table 6 – Water Balance Assessment Summary

Notes:

1. Results were determined by Golder, detailed in the Hydrogeology Investigation, Terrain Analysis and Impact Assessment (available under a separate cover).

Stormwater quantity control is not a requirement for the subject site and therefore will not be discussed within this report. However, the stormwater flows which are conveyed to the bioretention facilities and the impacts on the treatment systems will be discussed. If full infiltration of stormwater is not being achieved, the stormwater flows will be conveyed by the major overland flow route (vegetated swales) to the outlet. The flows being conveyed overland will receive cleansing by the 3.0 metre pre-treatment strip and the surface vegetation. The side slopes of the facilities have been designed to provide a freeboard of 0.20 metres before overtopping. At the downstream end of the system, the side slopes have been designed to a constant elevation to provide a "level spreader" flow if overtopping occurs. To analyze the worst-case condition (i.e. groundwater table at surface or soils are fully saturated), a release rate of zero has been assumed, however, it should be noted that this condition is highly unlikely to occur as over 1.0 metre of separation is provided between the bottom of the facilities and the seasonally high water table (refer to Technical Memorandum prepared by Golder in **Appendix B**). The stormwater flows for the 2 year, 5 year and 100 year design events and the corresponding required storage volumes (assuming zero infiltration) have been summarized in Table 7 below.

Return Period	Stormwater Flow (L/s) ^{*1}	Required Storage Volume (m ³)* ²
2 Year	399.7	383.7
5 Year	540.4	518.8
100 Year	1096.2	1052.3

Table 7 – Stormwater Flows to Treatment Facilities

Notes:

1. Flows were calculated using the Rational Method and a time of concentration estimated using the Uplands Method for the longest flow path in the contributing drainage area to the bioretention facilities. Refer to **Appendix B**.

2. Required storage volume assumes zero infiltration is occurring.

To ensure stormwater runoff does not bypass the system (i.e. pass through untreated) when full infiltration (into the surrounding soils) is not being achieved, surface storage has been provided to contain the runoff until infiltration can occur. Surface storage is provided at the downstream end of the facilities (contained by the side slopes) and at two locations upstream (contained by inline check dams). It should be noted that because temperature control is a requirement for the subject site (refer to **Section 7.7**), surface storage is only intended for rare occurrences when infiltration is limited. Any runoff contained on the surface would be "cooled" by the underlying soils when infiltration eventually does occur. In addition to surface storage, subsurface storage, within the bioretention facilities, is available. Based on the water table measurements provided by Golder (refer to Technical Memorandum in **Appendix B**), over 1.0 metre of separation is provided between the bottom of the facilities and the seasonally high water table. Therefore, it can be safely assumed that even during a period of abnormally high water table that the full storage within the facilities would be available. The total available storage volumes (surface and subsurface) have been summarized in **Table 8** below.

Table 8 – Total Available Storage Volume Summary

Available Surface Storage Volume (m ³) ^{*1}	Available Sub-Surface Storage Volume (m ³) ^{*2}	Total Available Storage Volume (m ³)
272.8	894.6	1167.7

Notes:

1. Available surface storage volumes are calculated using AutoCAD Civil 3D by Autodesk.

2. Available subsurface storage volumes are a summation of the available storage volumes contained within the multiple layers of the facilities. Refer to **Table 3** and **Table 4** above.

As indicated in **Table 8** above, 272.8 m³ of surface storage volume is available (refer to Fig. 3 - Available Surface Storage Plan in **Appendix B**). Assuming an abnormally high water table, which does not exceed the seasonally high water table by over 1.0 metre, an additional 894.6 m³ of subsurface storage volume is available, for a total available storage volume of 1167.7 m³. As shown in **Table 8** above, the system has provided adequate storage volume to contain the 2 year, 5 year and 100 year design storm event required storage volumes (assuming zero infiltration into the surrounding soils and abnormally high water table). Given that quantity control of stormwater runoff is not a requirement for the subject site, it has been demonstrated that the proposed bioretention facilities will sufficiently mitigate any impacts of storm events occurring during periods of the seasonally high water

table by providing surface and sub-surface storage volume of runoff until infiltration can be achieved.

7.7 Temperature Control

As noted in **Section 7.1** above, the MVCA has stated that thermal temperature control to 25 degrees Celsius is required for the subject site due to the proximity to Huntley Creek. The following design features have been implemented in order to meet the temperature control requirements:

- Utilization of bioretention facilities over pond facilities limits the opportunity to heat up the stormwater before it enters Huntley Creek.
- Utilization of bioretention facilities allows stormwater to infiltrate into the cooler soils limiting the opportunity to heat up before it enters Huntley Creek.
- The layers of the bioretention facilities (specifically the gravel storage layer) promotes the cooling of stormwater prior to infiltrating into the native soils (and ultimately into Huntley Creek).
- Plantings contained within the vegetated swales and bioretention facilities provide a degree of shading which limits the opportunity to heat up the stormwater.

8.0 CULVERT SIZING

The proposed access road will have two culvert crossings in order to convey stormwater runoff from the roadside ditches to the ultimate outlet of Huntley Creek. As per MTO design guidelines, the minimum road crossing culvert size is 600 mm in diameter. Although the onsite roadway is considered to be an "access road", 600 mm diameter culverts have still been specified. The contributing drainage areas were used to assess the road crossing culverts using a 10 year design storm frequency. Time of concentration values for each contributing drainage area were estimated using the Uplands Method. Using MTO culvert design charts, the maximum capacities of the culverts were determined based on the proposed culvert diameter (600 mm) and the maximum head (overtopping spill elevation of the centerline of the access road minus the invert elevation). The culvert design charts determined that the culverts were both inlet controlled with a maximum capacity of 600 L/s.

Under ideal circumstances, the culverts would not be overtopped during the 10 year design storm event. Using MTO culvert design charts, the minimum culvert diameter to avoid overtopping of the culvert (i.e. water does not exceed the obvert elevation) was determined based on the 10 year peak flow (calculated using the Rational Method) and the head (obvert elevation minus the invert elevation). The culvert design charts determined that the minimum required culvert diameter for the culvert located at STA 0+222.49 is 550 mm and <300 mm for the culvert located at STA 0+687.11. The proposed culvert design details have been summarized in **Table 9** below. Additional culvert sizing details, such as runoff coefficient calculations, time of concentration calculations and drainage area plans have been provided in **Appendix B**.

Station	10 Year Peak Flow ^{*1} (L/s)	Drainage Area (ha)	Proposed Culvert Diameter (mm)	Minimum Required Culvert Diameter ^{*3} (mm)	Maximum Culvert Capacity ^{∗4} (L/s)
0+222.49	250.6	4.24	600	550	600
0+687.11	28.8	0.14	600	<300	600

Table 9 – Culvert Design Summary

Notes:

1. Peak flows are calculated using the Rational Method. Refer to Appendix B.

2. Time of concentration values were estimated using the Uplands Method. Refer to Appendix B.

3. Minimum required culvert diameter determined using MTO culvert design charts. Refer to Appendix B.

4. Culvert capacity determined using MTO culvert design charts. Refer to Appendix B.

As shown in **Table 9** above, stormwater flows from the contributing drainage areas can be adequately conveyed by 600 mm diameter culverts for the 10 year design storm event.

9.0 EROSION AND SEDIMENT CONTROL MEASURES

Temporary erosion and sediment control measures are to be implemented and maintained during construction. At a minimum, the erosion and sediment control measures should include (but not be limited to) use of silt fences and straw bale check dams. These measures are to be inspected daily and after every rain event to determine maintenance, repair or replacement requirements. It is recommended that these measures will be implemented prior to the commencement of construction and maintained in good order until vegetation has been established (refer to details on DWG. 18047-ESC1, Erosion and Sediment Control Plan, in **Appendix A**).

A higher level of precaution will need to be implemented during the construction of the bioretention facilities to ensure that the facilities do not become compromised, thereby, reducing the long-term performance of the facilities. Erosion and sediment control measures, specific to the bioretention facilities themselves, are detailed on the Notes and Details plan (DWG. 18047-N1) in **Appendix A**.

10.0 CONCLUSIONS

It has been demonstrated that the proposed industrial development located at 2596 Carp Road can be adequately serviced to meet the requirements of the City of Ottawa and MVCA. Specifically, the on-site design will incorporate the following design features:

- Two proposed on-site drilled wells will provide the required water supply to meet the site demands.
- Sewage flows from proposed concrete mixing plant will be collected and treated by a new on-site septic system. The existing septic system will continue to treat sewage flows from the proposed administration (existing) building.
- Enhanced quality control requirements for stormwater runoff will be met by use of two bioretention facilities.
- Infiltration of stormwater from the facilities will occur in under 48 hours based on measured infiltration rates of the native soils.

- Surface and subsurface storage will contain all storm events up to an including the 100 year design event within the system (without bypassing) until infiltration/filtration can be achieved in the event of an abnormally high groundwater table (which is unlikely).
- Temperature control requirements will be met by use of infiltration measures and vegetation.
- Two new on-site 600 mm culverts will convey roadside drainage to a proper outlet.
- Development will not occur within the floodplain or meander belt hazards.
- Erosion and sediment control measures will be implemented and maintained.



Brandon MacKechnie, P.Eng. Project Engineer

Reviewed By:	A. H. JONXMAN
Angela Jonkman Senior Project M	

Appendix A

Site Plan (DWG. OSP-1) (Prepared by Stantec Consulting Ltd.)

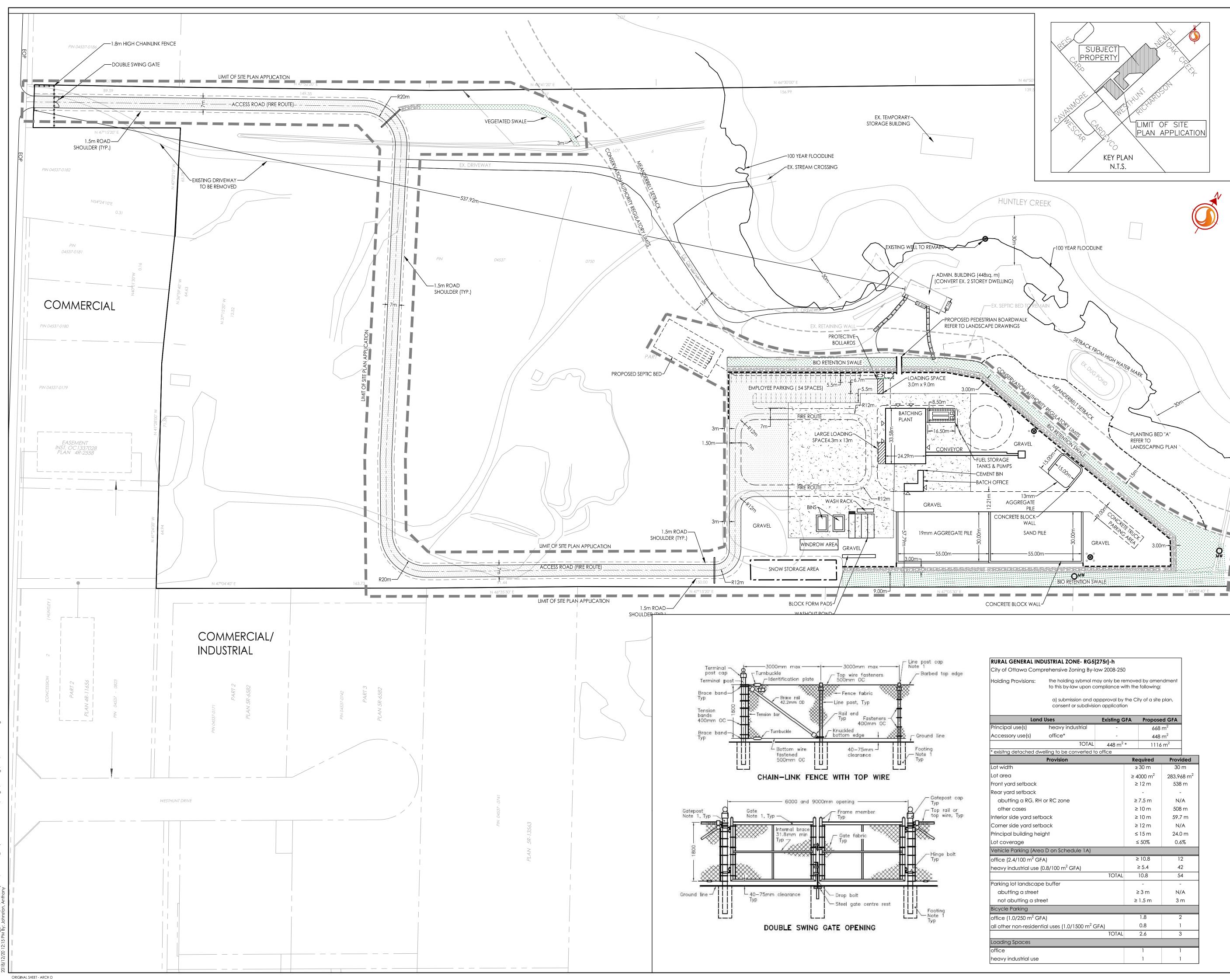
Pre-Development Drainage Area Plan (DWG. 18047-PRE1)

Washout Pond Details

Grading Plans (DWG. 18047-GR1, 18047-GR2, 18047-GR3)

Erosion and Sediment Control Plan (DWG. 18047-ESC1)

Notes and Details (DWG. 18047-N1)



consent or subdivision application							
Lane	d Uses	Existing G	FA	Propose	ed GFA		
ncipal use(s)	cipal use(s) heavy industrial			668	m ²		
ccessory use(s)	office*	-	- 448		m²		
	TOTA	110111	*	1116	5 m ²		
exisitng detached dy	welling to be converted	d to office					
	Provision			quired	Provi		
t width				30 m	30		
t area				000 m ²	283,96		
ont yard setback			≥	12 m	538	m	
ear yard setback				-	-		
abutting a RG, RH	l or RC zone			7.5 m	N/.		
other cases			≥	10 m	508		
erior side yard set			2	10 m	59.7	m	
orner side yard set		≥	12 m	N/A			
ncipal building height			≤	15 m	24.0	m	
t coverage			4	≤ 50%	0.6	%	
ehicle Parking (Are	a D on Schedule 1A)					
fice (2.4/100 m ² G	FA)		Ν	≥ 10.8	12	2	
eavy industrial use	(0.8/100 m ² GFA)			≥ 5.4	42	2	
		TOTAL		10.8	54	4	
ırking lot landscap	be buffer			-	-		
abutting a street			2	≥3 m	N/	A	
not abutting a str	eet		≥	1.5 m	3 r	n	
cycle Parking							
fice (1.0/250 m ² G	FA)			1.8	2		
other non-residential uses (1.0/1500 m ² G		² GFA)		0.8 1			
		TOTAL		2.6	3		
ading Spaces							
fice				1	1		
eavy industrial use				1	1		



Stantec Consulting Ltd. 400 - 1331 Clyde Avenue Ottawa ON Tel. 613.722.4420 www.stantec.com

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Legend

- (W)PROPOSED WELL LOCATION PROPOSED BOLLARDS STORM WATER MANAGEMENT AREA CONCRETE PAD
- ASPHALT AREA
- **BUILDING ENTRANCE**

RIP-RAP

- \cap MONITORING WELL
- ENCROACHMENT BARRIER AT 3m SPACING (LARGE BOULDERS OR BLOCKS)

APPROVED	REFUSED				
THIS DAY OF	, 20				
ADAM BROWN	I, MANAGER				
DEVELOPMENT F	REVIEW RURAL				
PLANNING, INFRASTRUCTURE AND ECONOMIC					
DEVELOPMENT DEPARTM	IENT, CITY OF OTTAWA				

Notes

PROPERTY BOUNDARY BY ANNIS O'SULLIVAN VOLLEBEKK

PART OF LOT 6, CONCESSION 2, GEOGRAPHIC TOWNSHIP OF HUNTLEY PART 1 ON 4R-11656 SAVE & EXCEPT PARTS 1-10 ON 4R-17391, SAVE & EXCEPT PART 1-4 ON 4R-17194, CITY OF OTTAWA

18.12.20
18.09.19
18.08.31
18.07.17
YY.MM.DD
18.06.05

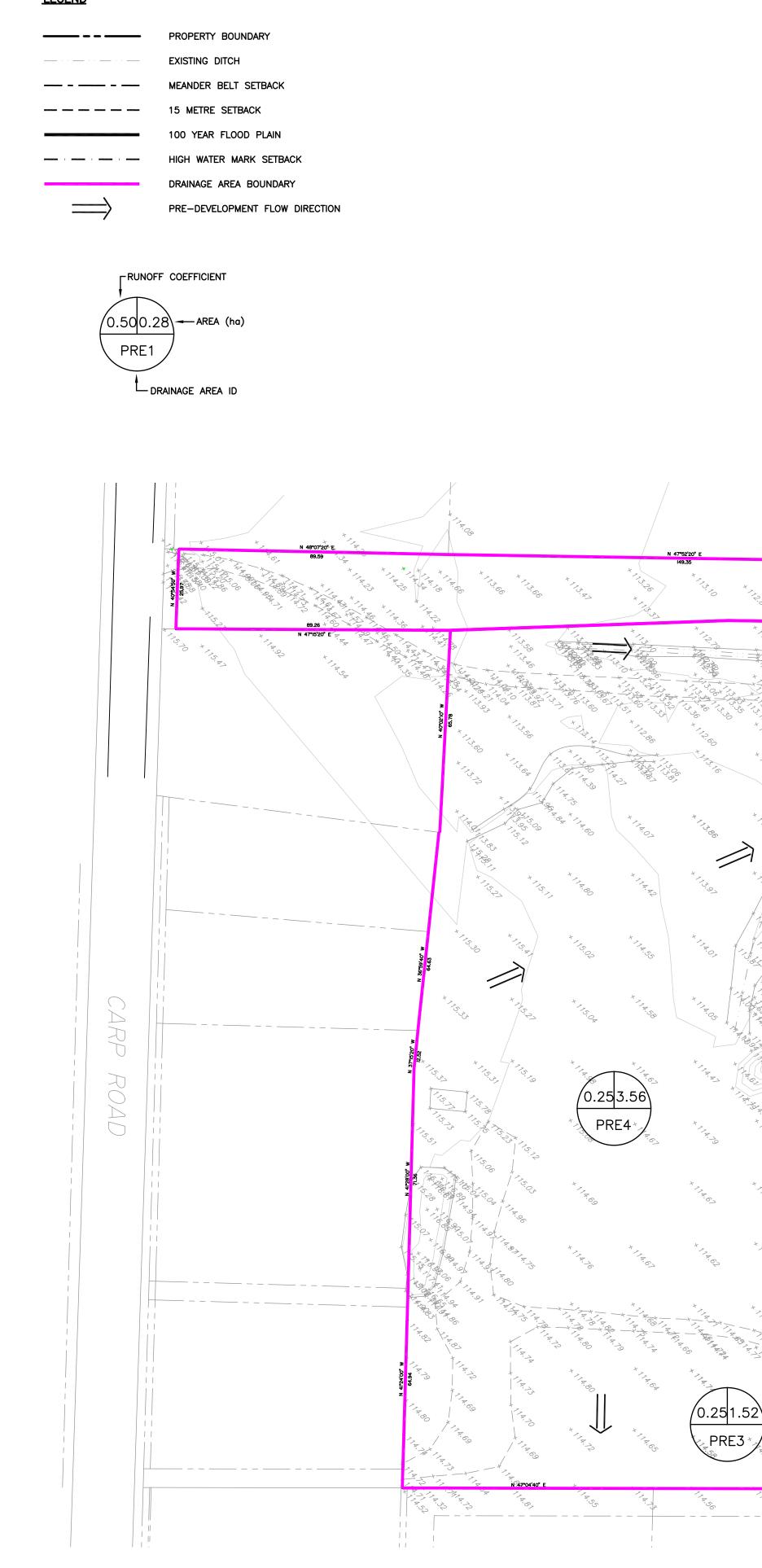
Dwn. Chkd. Dsgn. YY.MM.DD

Permit-Seal

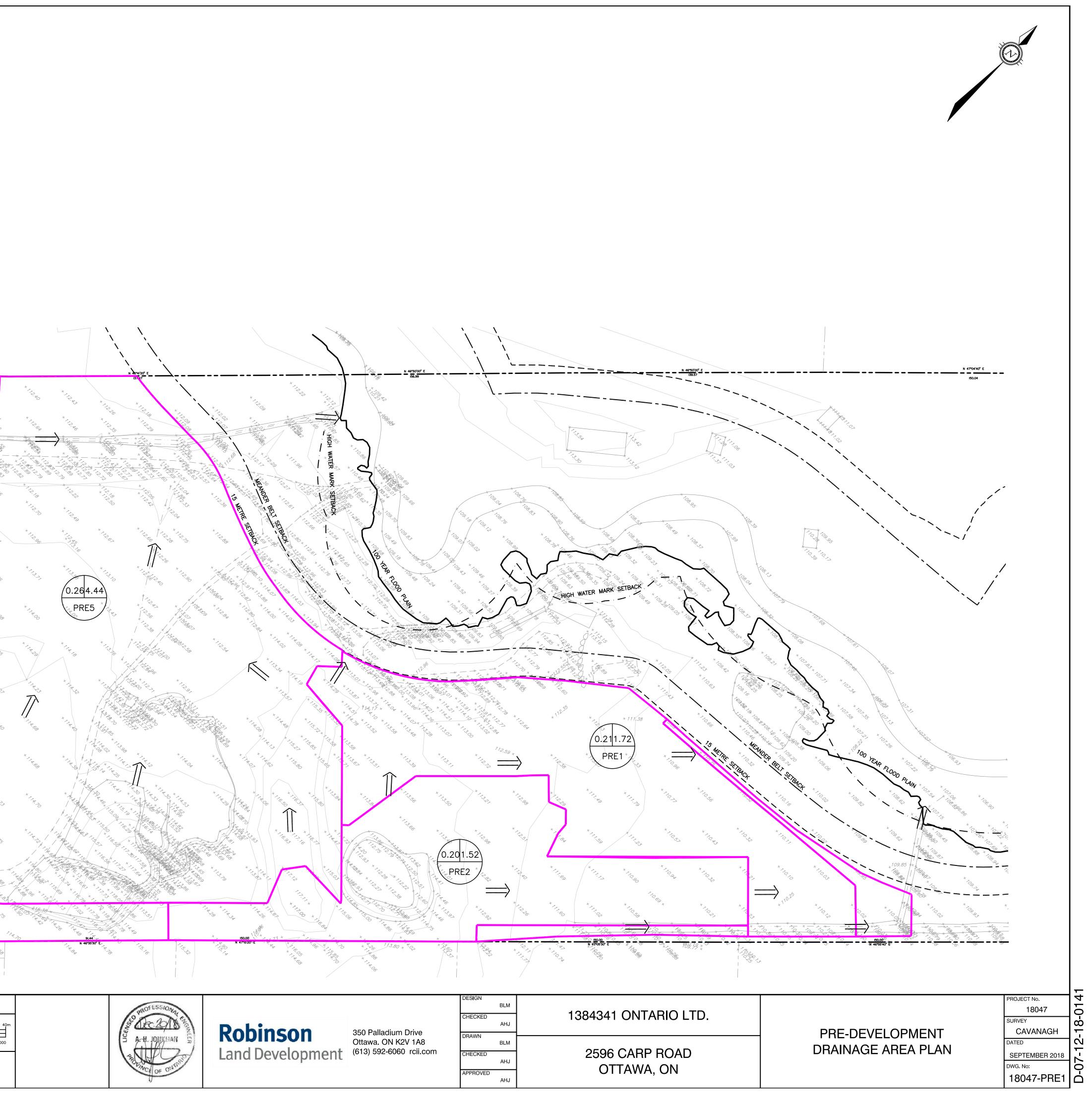
Client/Project THOMAS CAVANAGH CONSTRUCTION LIMITED 9094 CAVANAGH ROAD 2596 CARP ROAD CONCRETE BATCHING PLANT OTTAWA, ONTARIO Title SITE PLAN

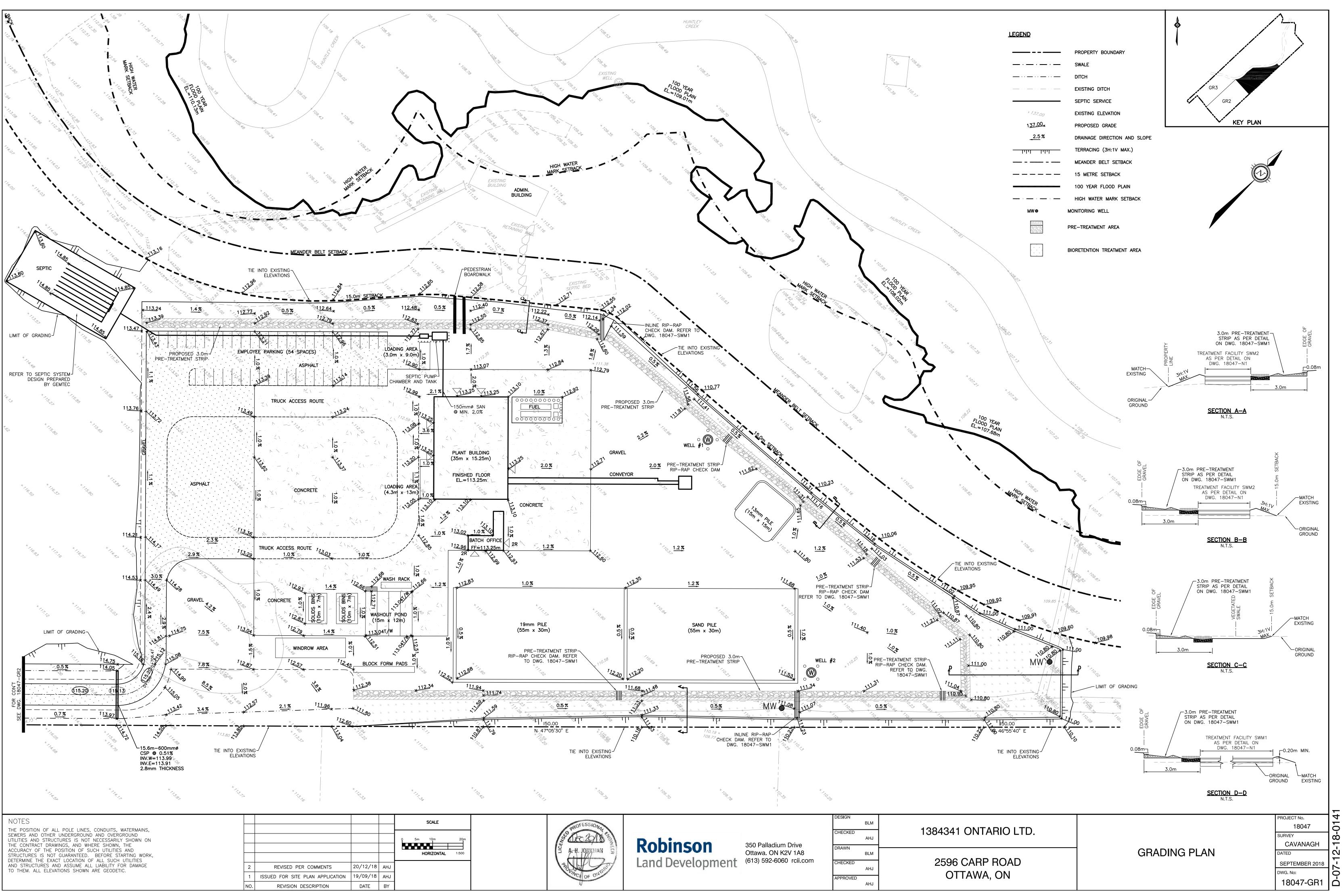
Project No. 160410099	Scale 0 10 1:1000	30 50m
Drawing No.	Sheet	Revision
OSP-1	1 of 1	4

LEGEND

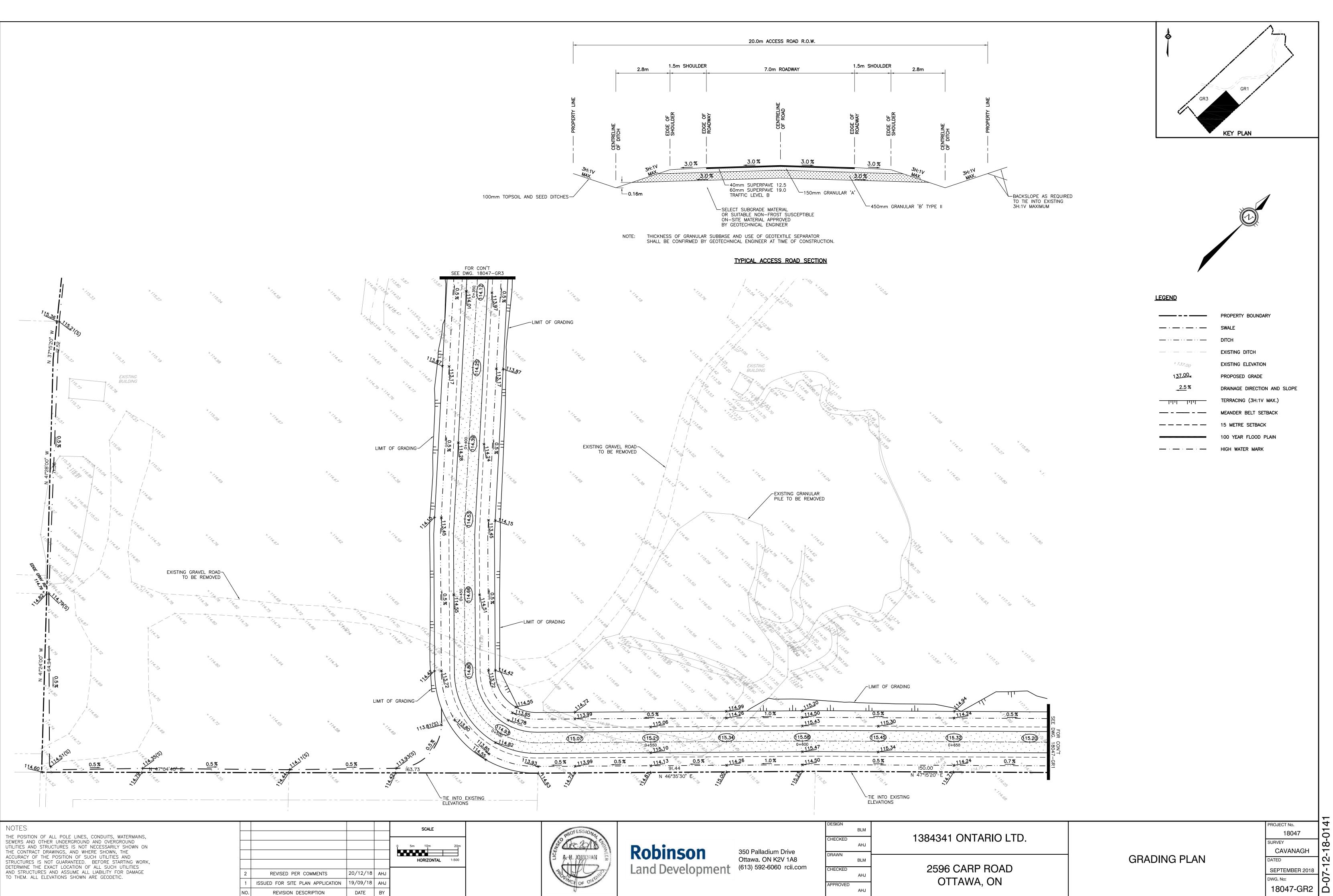


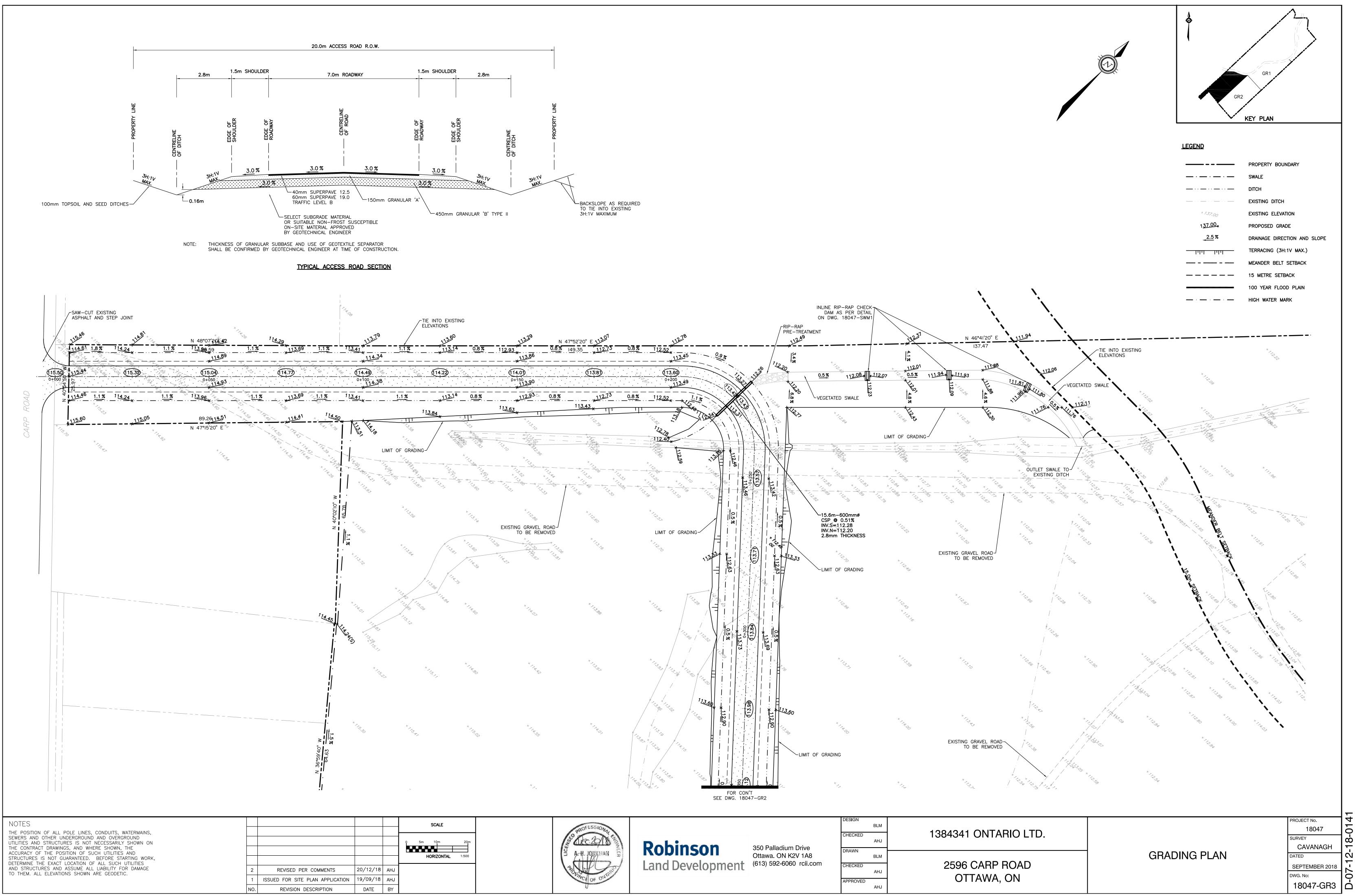
NOTES THE POSITION OF ALL POLE LINES, CONDUITS, WATERMAINS, SEWERS AND OTHER UNDERGROUND AND OVERGROUND UTILITIES AND STRUCTURES IS NOT NECESSARILY SHOWN ON THE CONTRACT DRAWINGS, AND WHERE SHOWN, THE			SCALE 0 10m 20m 40m	PROFESSIONAL ENGLISH	Robinson	350 Palladium Drive	DESIGN BLM CHECKED AHJ	138434
ACCURACY OF THE POSITION OF SUCH UTILITIES AND STRUCTURES IS NOT GUARANTEED. BEFORE STARTING WORK, DETERMINE THE EXACT LOCATION OF ALL SUCH UTILITIES AND STRUCTURES AND ASSUME ALL LIABILITY FOR DAMAGE TO THEM. ALL ELEVATIONS SHOWN ARE GEODETIC.	1 REVISED PER COMMENTS NO. REVISION DESCRIPTION	20/12/18 AHJ DATE BY	HORIZONTAL 1:1000	A.H. JONEMAN	Land Development	Ottawa. ON K2V 1A8	DRAWN BLM CHECKED AHJ APPROVED AHJ	- 259 - O

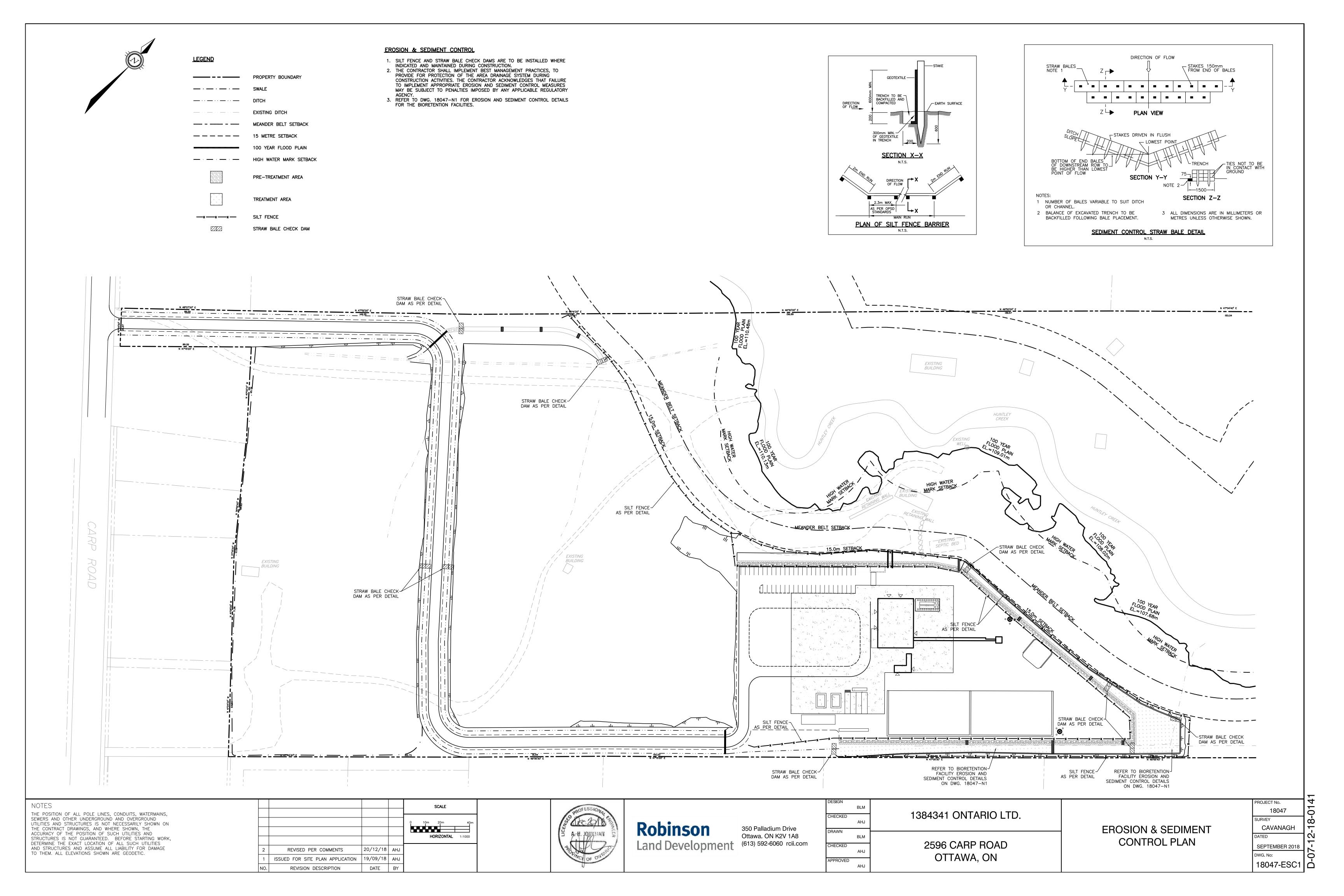




20m	PROFESSIONAL FRANCIS	Robinson	350 Palladium Drive	DESIGN BLM CHECKED AHJ	13843
:500	A.H. JONKMAN	Land Development	Ottawa. ON K2V 1A8 (613) 592-6060 rcii.com	DRAWN BLM CHECKED AHJ APPROVED AHJ	- 259







BIORETENTION GENERAL NOTES

- 1. BIORETENTION FILTER MEDIA SHOULD BE OBTAINED PREMIXED FROM APPROVED VENDOR. VENDOR TO PROVIDE TESTING RESULTS PRIOR TO INSTALLATION. DELIVERED MEDIA SHALL BE TESTED AND APPROVED BY ENGINEER PRIOR TO INSTALLATION. MEDIA INSTALLED WITHOUT FIELD ENGINEER CLEARANCE SHALL BE REMOVED AT THE CONTRACTOR'S EXPENSE IF DEEMED NECESSARY BY THE FIELD ENGINEER. THE CONTRACTOR WILL BE SOLELY RESPONSIBLE FOR ALL REQUIRED MEDIA TESTING EXPENSES. THE CONTRACTOR IS RESPONSIBLE FOR ANY DELAYS SUFFERED AS A RESULT OF TESTING. NO COMPENSATION WILL BE
- PROVIDED FOR DELAYS DUE TO MEDIA ANALYSIS. 2. SEDIMENT CONTROL MEASURES SHALL BE INSTALLED PRIOR TO THE COMMENCEMENT OF CONSTRUCTION TO PREVENT RUNOFF FROM CONTAMINATING EXCAVATED SURFACE OF THE NATIVE SOILS.
- FINAL GRADE OF BIORETENTION FACILITIES TO BE EXCAVATED IMMEDIATELY PRIOR TO BACKFILLING WITH SPECIFIED FILTER MEDIA TO AVOID PREMATURE FACILITY CLOGGING. OPEN EXCAVATIONS BEYOND 1 DAY SHALL INSTALL TEMPORARY
- SACRIFICIAL FILTER FABRIC. 4. APPROVED FILTER MEDIA MIXES SHALL BE INSTALLED IMMEDIATELY PRIOR TO
- INSTALLATION OF THE PLANTINGS AND STABILIZATION MEASURES. 5. REFER TO THE SERVICING & STORMWATER MANAGEMENT REPORT, PREPARED BY ROBINSON LAND DEVELOPMENT.

CONSTRUCTION SEQUENCING

- I. EROSION AND SEDIMENTATION PROTECTION MEASURES ARE REQUIRED PRIOR TO THE COMMENCEMENT OF ANY ALL EXCAVATION ACTIVITIES. 2. FINAL GRADE OF THE FACILITIES ARE TO BE EXCAVATED IMMEDIATELY PRIOR TO
- BACKFILLING WITH SPECIFIED FILTER MEDIA TO AVOID PREMATURE FACILITY CLOGGING. 3. EXCAVATION, BACKFILLING AND MEDIA INSTALLATION IS ONLY TO OCCUR AFTER
- THE CONTRIBUTING DRAINAGE AREA HAS BEEN STABILIZED. 4. APPLY FILTER MEDIA IN 300mm LIFTS UNTIL DESIRED ELEVATION IS ACHIEVED. THOROUGHLY WET EACH LIFT BEFORE ADDING NEXT LEVEL. ALLOW WATER TO
- FULLY PERCOLATE THROUGH THE SOIL BEFORE ADDING EACH COURSE. 5. THE FILTER MEDIA SHALL BE FINE GRADED AFTER PLACEMENT. FINISHED
- GRADING SHALL CONFORM TO THE ELEVATIONS SHOWN ON THE DESIGN DRAWINGS AND SHALL BE FREE OF DEBRIS AND OTHER MATERIALS THAT WOULD
- BE DETRIMENTAL TO THE PERFORMANCE OF THE GROWING MEDIA. 6. THE FINISHED SURFACE SHALL BE SMOOTH AND UNIFORM, AND BE FIRM
- AGAINST DEEP FOOTPRINTING, WITH A FINE LOOSE SURFACE TEXTURE. 7. PROTECTION OF THE FINISHED GRADE AND CORRECTION OF ANY IRREGULARITIES CAUSED BY WORK OPERATIONS OVER THE FINISHED GRADE SHALL BE ENFORCED.
- 8. SETTLING OF ANY FINISHED GRADE SHALL NOT BE MORE THAN 10cm FROM SPECIFIED ELEVATIONS, AND IF SETTLING IS GREATER. THE CONTRACTOR SHALL BRING THE GRADE TO THE SPECIFIED ELEVATIONS USING APPROVED MATERIALS.
- 9. PLANTING NOT TO OCCUR PRIOR TO 5 DAYS AFTER MEDIA PLACEMENT TO ALLOW FOR MEDIA SETTLEMENT. ADD ADDITIONAL MEDIA IF REQUIRED. 10. PLANTING IS TO OCCUR IN ACCORDANCE WITH THE LANDSCAPE PLANS. AS
- NECESSARY, PROVIDE A MINIMUM OF 1 IRRIGATION PER WEEK THROUGHOUT THE MAINTENANCE PERIOD AS REQUIRED. 11. AFTER PLANTING, 75mm OF SHREDDED HARDWOOD MULCH (AGED A MINIMUM OF 12 MONTHS) IS TO BE PLACED ON TOP OF THE FILTER MEDIA AND AROUND
- PLANT MATERIAL. MULCH SHALL BE FREE OF ALL DELETERIOUS SUBSTANCES AND SHALL CONTAIN ONLY 100% SHREDDED HARDWOOD MUCH. MULCH SAMPLES SHALL BE SUBMITTED TO FIELD ENGINEER FOR APPROVAL PRIOR TO INSTALLATION. MULCH INSTALLATION WITHOUT FIELD ENGINEER APPROVAL SHALL BE REMOVED AT THE CONTRACTOR'S EXPENSE.
- 12. BIORETENTION FACILITIES SHOULD BE INSPECTED BY THE CONTRACTOR AFTER EACH STORM > 25mm OR A MINIMUM OF TWICE POST INSTALLATION DURING THE FIRST SIX MONTHS AFTER PLACING THE FACILITY ON-LINE. ANY DEVIATIONS FROM DESIGN DRAWINGS ARE TO BE CORRECTED IMMEDIATELY.
- 13. BIORETENTION FACILITIES ARE TO BE INSPECTED A MINIMUM OF ONCE ANNUALLY (TYPICALLY IN SPRING) AND AFTER EACH EVENT GREATER THAN 60mm.

BIORETENTION EROSION AND SEDIMENT CONTROL

- 1. DURING CONSTRUCTION, PROVISION SHALL BE MADE FOR PROPER WATER MANAGEMENT AND DRAINAGE OF THE SITE. AT NO TIME SHALL SEDIMENT LADEN WATER BE ALLOWED TO ENTER THE EXCAVATED/BACKFILLED OR COMPLETED BIORETENTION AREAS. PRIOR TO STABILIZATION OF THE PLANTING MATERIAL. NO SITE DRAINAGE IS TO ENTER THE PROPOSED FACILITIES. SHOULD SEDIMENT ENTER THE FACILITY PRIOR TO RECEIVING APPROVAL FROM THE FIELD ENGINEER, THE INFILTRATION RATE OF THE CONTAMINATED AREA SHOULD BE TESTED USING GUELPH PERMEAMETER TEST OR DOUBLE-RING INFILTRATION TEST, TO CONFIRM NO LOSS IN INFILTRATION POTENTIAL. SHOULD A LOSS OF INFILTRATION CAPACITY BE CONFIRMED, THE CONTRACTOR WILL BE RESPONSIBLE FOR THE REPAIR/REMEDIATION OF THE CONTAMINATED AREA TO THE SATISFACTION OF THE ENGINEER, USING APPROVED MEASURES, MATERIALS AND PRACTICES.
- 2. TEMPORARY SEDIMENT CONTROLS ARE TO BE INSTALLED PRIOR TO THE START OF CONSTRUCTION. 3. SILT FENCE SHALL BE INSTALLED AROUND THE PERIMETER OF THE FACILITIES PRIOR TO CONSTRUCTION TO PREVENT SEDIMENT ENTRY INTO THE FACILITIES. 4. CONTRACTOR IS RESPONSIBLE FOR ANY REMEDIATION/REPAIR OF INFILTRATION
- FACILITIES DAMAGED AS A RESULT OF INADEQUATE OR IMPROPER SEDIMENT CONTROL. 5. THE CONTRACTOR SHALL DELINEATE THE REQUIRED WORKING AREA ON-SITE
- PRIOR TO THE START OF WORK AND SHALL CONFINE OPERATIONS WITHIN THE DEFINED AREA. 6. TEMPORARY TOPSOIL AND/OR FILL MATERIAL STOCKPILE AREAS TO BE ENCLOSED WITH SEDIMENT CONTROLS.
- 7. WORKING AREAS, ACCESS REQUIREMENTS, AND TEMPORARY MATERIAL STORAGE AREAS TO BE MAINTAINED IN GOOD CONDITION BY THE CONTRACTOR AT ALL TIMES. AREAS AFFECTED BY THE CONTRACTOR'S ACTIVITIES TO BE REINSTATED TO THE EXISTING CONDITIONS OR BETTER.
- 8. ALL ACCUMULATED SEDIMENTS TO BE REMOVED PRIOR TO THE REMOVAL OF CONTROLS AND DISPOSED OF IN AN APPROVED ON-SITE LOCATION BY THE
- CONTRACTOR 9. ON-SITE EQUIPMENT REFUELING AND MAINTENANCE TO BE ONLY COMPLETED IN DESIGNATED AREAS. 10. SEDIMENT CONTROLS TO BE INSPECTED DAILY AND AFTER EACH RAINFALL EVENT. SEDIMENT CONTROLS TO BE MAINTAINED AND REPAIRED BY THE
- CONTRACTOR UNTIL COMPLETION OF CONSTRUCTION AND SITE RESTORATION. 11. REMOVE TEMPORARY SEDIMENT CONTROLS FOLLOWING COMPLETION OF CONSTRUCTION AND SITE RESTORATION, AND REINSTATE AFFECTED AREAS TO EXISTING CONDITIONS OR BETTER.

INSPECTION AND MAINTENANCE

- 1. TRASH, DEBRIS AND SEDIMENT SHOULD BE REMOVED FROM THE CONTRIBUTING DRAINAGE AREA BIANNUALLY TO QUARTERLY. 2. TRASH DEBRIS, AND SEDIMENT SHOULD BE REMOVED FROM THE
- PRE-TREATMENT AREAS ANNUALLY TO BIANNUALLY OR WHEN SUMPS ARE HALF FULL
- 3. SIDE SLOPES OF THE FACILITIES SHOULD BE INSPECTED FOR EROSION. REMOVED TRASH FROM THE FILTER BED BIANNUALLY TO QUARTERLY.
- 5. RAKE FILTER BED REGULARLY TO REDISTRIBUTE MULCH AND PREVENT SEDIMENT CRUSTS. 6. MAINTAIN 75mm OF MULCH COVER TO PREVENT WEED GROWTH AND SOIL
- EROSION. 7. REPAIR SUNKEN AREAS WHEN GREATER THAT 10 cm DEEP AND
- BARREN/ERODED AREAS WHEN GREATER THAN 30 cm LONG.
- 8. REMOVE SEDIMENT FROM FILTER BED WHEN GREATER THAN 5 cm DEEP OR TIME TO DRAIN WATER PONDED ON THE SURFACE EXCEEDS 48 HOURS. 9. REMOVAL OF SEDIMENT FROM THE FILTER BED SURFACE SHOULD BE DONE WITH A RAKE AND SHOVEL, OR VACUUM EQUIPMENT TO MINIMIZE PLANT DISTURBANCE. IF A SMALL EXCAVATOR IS TO BE USED, KEEP IT OFF THE FACILITY FOOTPRINT TO AVOID DAMAGE TO SIDE SLOPES AND OVER-COMPACTION
- OF THE FILTER MEDIA. 10. TO AVOID OVER-COMPACTION OF THE FILTER MEDIA SOIL, ANY MAINTENANCE TASKS INVOLVING VEHICLE OR FOOT TRAFFIC ON THE FILTER BED SHOULD NOT
- BE PERFORMED DURING WET WEATHER. 11. GRADES SHOULD BE RESTORED WITH FILTER MEDIA THAT MEETS THE APPROVED DESIGN SPECIFICATIONS. 12. REPLACE STONE, MULCH AND PLANT COVER AS REQUIRED.
- 13. WHEN SEDIMENT ACCUMULATION IS GREATER THAN 5 cm IN DEPTH, SURFACE INFILTRATION RATES SHOULD BE TESTED (ONE TEST FOR EVERY 25 SQUARE METRES OF FILTER BED AREA) TO CONFIRM GREATER THAN 25 mm/hr IS BEING ACHIEVED.
- 14. WATER PLANTINGS FREQUENTLY, AS RECOMMENDED BY THE LANDSCAPE ARCHITEC1
- 15. REMOVE WEEDS AND UNDESIRABLE PLANTS BIANNUALLY TO QUARTERLY. 16. REPLACE DEAD PLANTINGS ANNUALLY TO ACHIEVE 80 PERCENT COVER BY THE THIRD GROWING SEASON.
- 17. NEVER APPLY CHEMICAL FERTILIZERS.

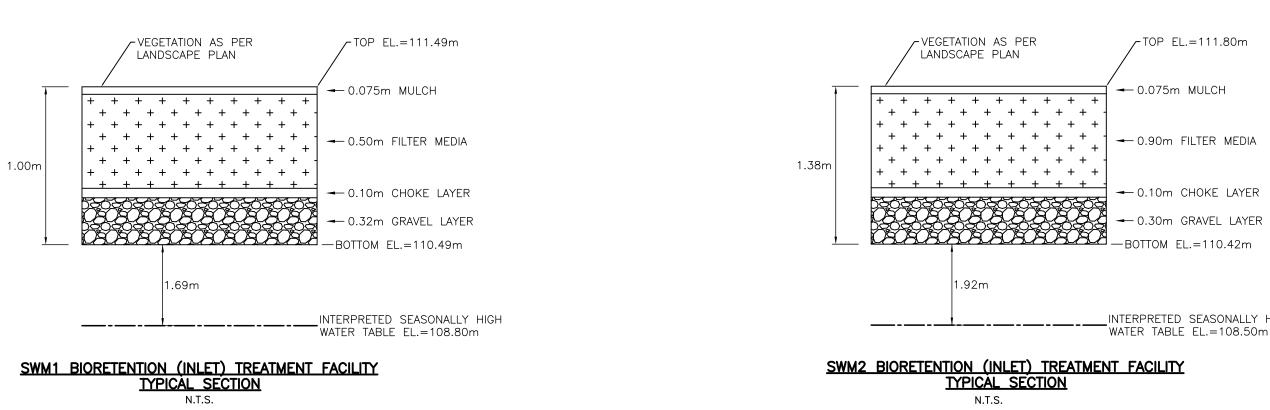
NOTES

THE POSITION OF ALL POLE LINES, CONDUITS, WATERMAINS, SEWERS AND OTHER UNDERGROUND AND OVERGROUND UTILITIES AND STRUCTURES IS NOT NECESSARILY SHOWN ON THE CONTRACT DRAWINGS, AND WHERE SHOWN, THE ACCURACY OF THE POSITION OF SUCH UTILITIES AND STRUCTURES IS NOT GUARANTEED. BEFORE STARTING WORK, DETERMINE THE EXACT LOCATION OF ALL SUCH UTILITIES AND STRUCTURES AND ASSUME ALL LIABILITY FOR DAMAGE TO THEM. ALL ELEVATIONS SHOWN ARE GEODETIC.

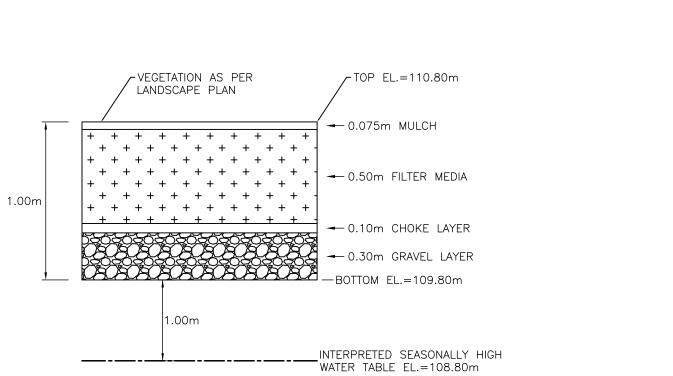
BIORETENTION TREATMENT FACILITY SPECIFICATIONS					
MATERIAL	SPECIFICATION				
MULCH LAYER	SHREDDED HARDWOOD BARK MULCH				
FILTER MEDIA	SOIL MIXTURE TO CONTAIN: - 85 TO 88% SAND - 8 TO 12% SOIL FINES - 3 TO 5% ORGANIC MATTER - P-INDEX VALUE BETWEEN 10 TO 30 PPM - CATIONIC EXCHANGE CAPACITY GREATER THAN 10 meq/100 g - pH BETWEEN 5.5 TO 7.5 - INFILTRATION RATE GREATER THAN 25mm/hr				
CHOKE LAYER WASHED 3 TO 10mm DIAMETER CLEAR STONE					
GRAVEL STORAGE LAYER	WASHED 50mm DIAMETER CLEAR STONE				

NOTES 1. FILTER MEDIA OBTAINED FROM VENDOR TO BE TESTED TO CONFIRM DESIGN

SPECIFICATIONS PRIOR TO INSTALLATION. 2. REFER TO SURFACE VEGETATION SPECIFIED ON THE LANDSCAPE PLAN BY STANTEC.

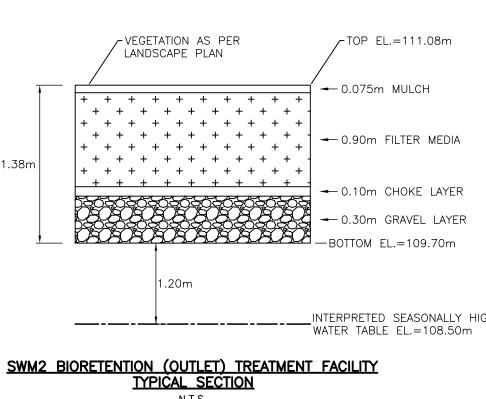


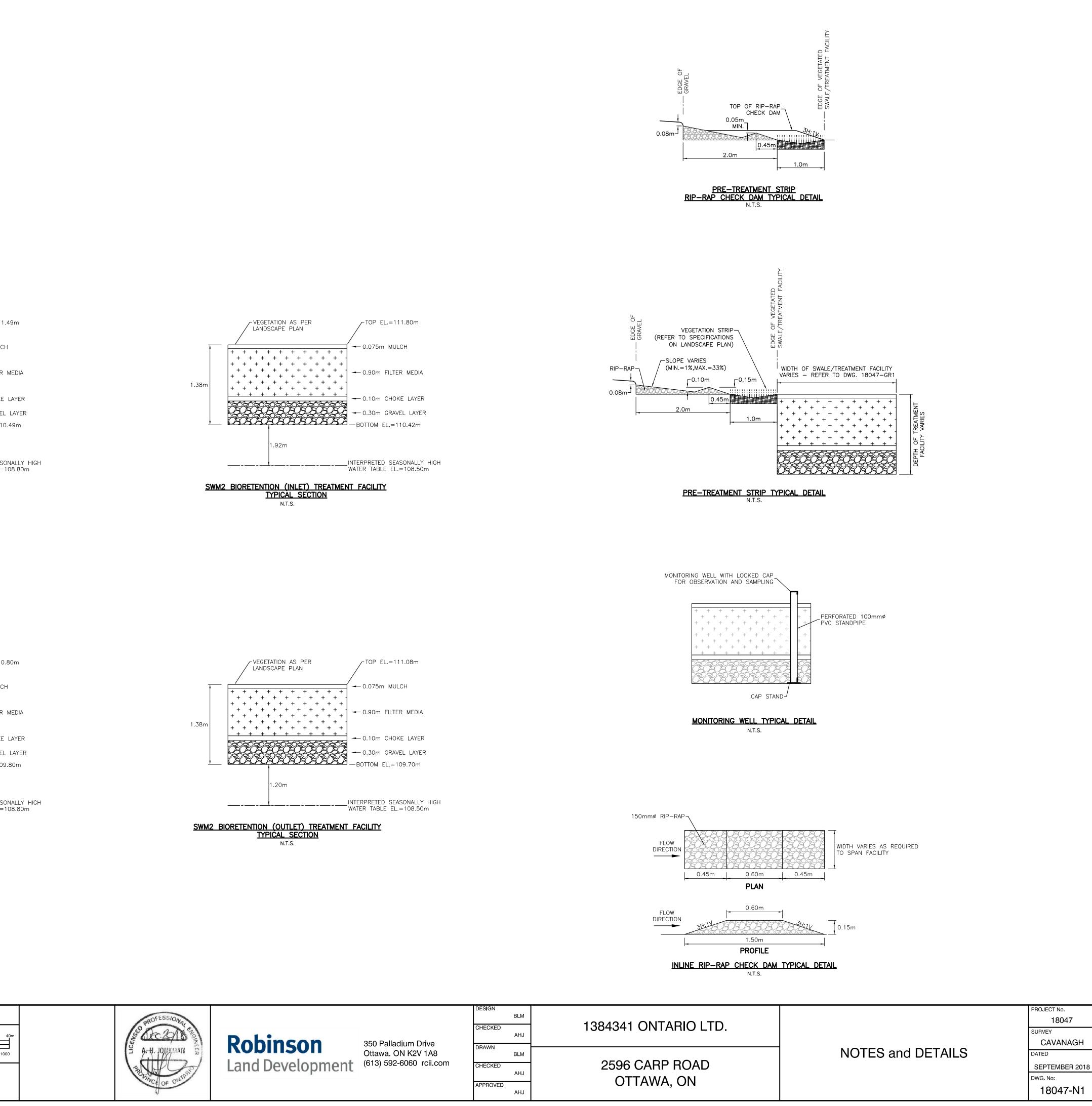




SWM1 BIORETENTION (OUTLET) TREATMENT FACILITY TYPICAL SECTION N.T.S.

				SCALE
				0 10m 20m 40m
				HORIZONTAL 1:1000
1	REVISED PER COMMENTS	20/12/18	AHJ	
NO.	REVISION DESCRIPTION	DATE	BY	





 \mathbf{O} \square

Brandon Mackechnie

Subject: Attachments: 2596 Carp Road Washout Pit Design.docx

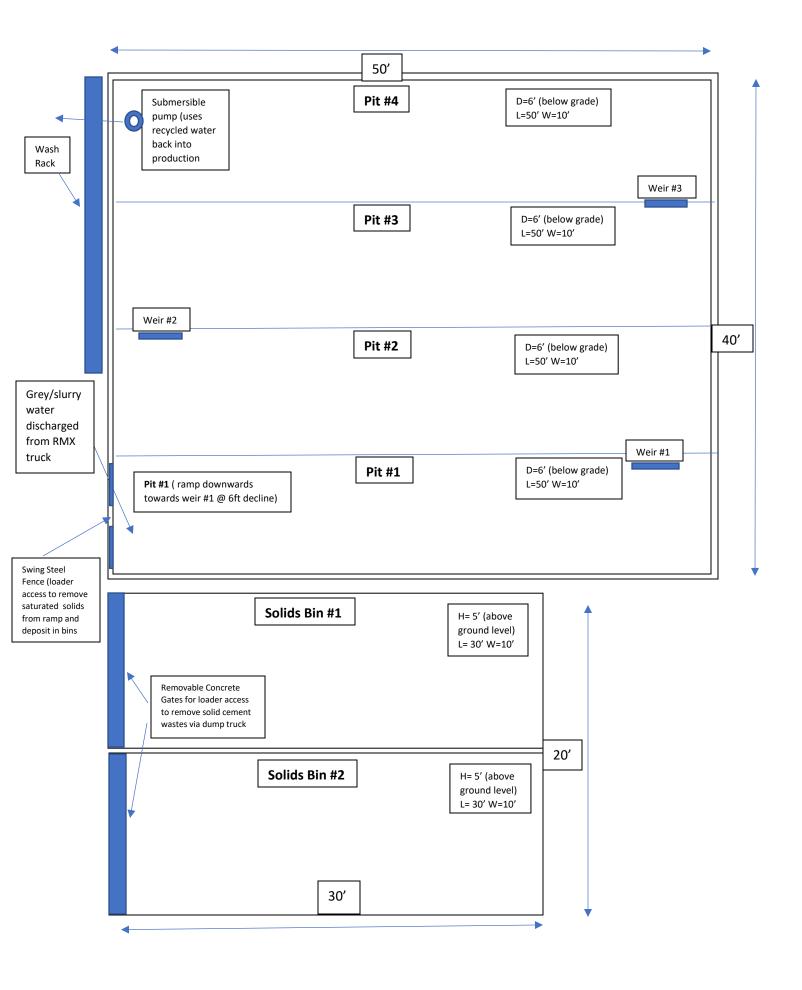
Hi Brandon,

Concrete pad will be sloped towards the washout pits. At conclusion of shift for each truck, driver will add 300-400L of water to drum, mix and discharge slurry water into "Pit #1" on diagram. This is a ramp sloped down to a 6' drop. Weirs are cut into the concrete walls in the upper portion at opposite ends of each of the 4 pits. As the dirty, slurry water travels, the heavier fines rest at the bottom of the pits and cleaner water continues to filter as it progresses through each pit as more volume is added. The dirtiest pit being "Pit #1" sludge is removed by a front end loader and deposited into one of the two "Solids Bin" to dry out. Once majority of moisture dries out from the sludge by the sun in the enclosed concrete bin, material is loaded into dump trucks and brought to a Cavanagh quarry to be dumped. Since pits 2-4 cannot be accessed by a loader, these pits will cleaned out by a hydrovac truck as needed. (typically every couple months since majority of slurry solids stay in Pit #1.) Pit #4 in the washout system contains a submersible pump. Drivers will adjust (slump) their loads with the recycled water out of pit #4 after loading from the plant. This pit will eventually be plumbed directly to the water scale in the plant so the batcher can use 10% maximum directly in concrete batches to better manage the volume of recycled water in the pit. The entire system will need to be enclosed with a heater and access door for winter use. The washout pits will also capture truck rinse down after loading.

Kevin Brennan, PMP Operations Manager

Cavanagh Concrete Ltd. C: 613-327-3483 www.cavanaghconcrete.ca





Appendix B

Certificate of Analysis

Runoff Coefficient Calculations

Inspection and Maintenance

Figure 3.67 – Recommended Regional 90% Percentile Volume Control Targets for Ontario

Stormwater Management Plan (DWG. 18047-SWM1)

Infiltration Rate Assessment (Prepared by Golder Associates Ltd.)

Technical Memorandum (Prepared by Golder Associates Ltd.)

Treatment Facility Flow Calculations

Figure 3 - Available Surface Storage Plan

Culvert Sizing Details

Certificate of Analysis Environment Testing

Client: Golder Associates Ltd. (Ottawa) Report Number: 1816624 1931 Robertson Road Date Submitted: 2018-09-13 Ottawa, ON Date Reported: 2018-09-17 K2H 5B7 Project: 1543767 Attention: Ms. Loren Bekeris COC #: 199023 PO#: Page 1 of 2 Invoice to: Golder Associates Ltd. (Ottawa)

Dear Loren Bekeris:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

APPROVAL:

Krista Quantrill, Microbiology Supervisor

All analysis is completed in Ottawa, Ontario (unless otherwise indicated).

Eurofins Ottawa is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on our CALA scope of accreditation. It can be found at http://www.cala.ca/scopes/2602.pdf.

Eurofins (Ottawa) is certified and accredited for specific parameters by OMAFRA, Ontario Ministry of Agriculture, Food and Rural Affairs (for farm soils). Licensed by Ontario MOE for specific tests in drinking water.

Please note: Field data, where presented on the report, has been provided by the client and is presented for informational purposes only. Guideline values listed on this report are provided for ease of use (informational purposes) only. Eurofins recommends consulting the official provincial or federal guideline as required.

Certificate of Analysis

Environment Testing

Client:	Golder Associates Ltd. (Ottawa)	Report Number: Date Submitted:	1816624
	1931 Robertson Road		2018-09-13
	Ottawa, ON	Date Reported:	2018-09-17
	K2H 5B7	Project:	1543767
Attention:	Ms. Loren Bekeris	COC #:	199023
PO#:			
Invoice to:	Golder Associates Ltd. (Ottawa)		

Group	Analyte	MRL	Units	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D. Guideline	1387247 GW 2018-09-13 2596 Carp Road
Group	Analyte	MIRL	Units	Guideline	
General Chemistry	Chlorine (free)	0.04	mg/L		<0.04
	Chlorine (total)	0.04	mg/L		0.09
Microbiology	Heterotrophic Plate Count	0	ct/1mL		18
Others	Escherichia Coli	0	ct/100mL	MAC 0	0
	Faecal Coliforms	0	ct/100mL		0
	Total Coliforms	0	ct/100mL	MAC 0	0

Guideline = ODWSOG

eurofins

* = Guideline Exceedence

Results relate only to the parameters tested on the samples submitted. **Analytical Method: AMBCOLM1** additional QA/QC information available on request.

Post-Development Runoff Coefficient Calculations

Drainage Area ID	Impervious Area (ha)	Pervious Area (ha)	Gravel Area (ha)	Total Area (ha)	С	C (100 YR)
SWM1	0.68	0.25	0.81	1.75	0.75	0.89
SWM2	0.55	0.29	0.69	1.52	0.72	0.86
SWM3	0.42	0.71	0.18	1.31	0.50	0.59
SWM4	0.00	3.56	0.00	3.56	0.20	0.25
SWM5	0.00	4.44	0.00	4.44	0.20	0.25

Pre-Development Runoff Coefficient Calculations

Drainage Area ID	Impervious Area (ha)	Pervious Area (ha)	Gravel Area (ha)	Total Area (ha)	С	C (100 YR)
PRE1	0.00	1.73	0.01	1.75	0.20	0.26
PRE2	0.00	1.52	0.00	1.52	0.20	0.25
PRE3	0.00	1.20	0.11	1.31	0.25	0.31
PRE4	0.01	3.25	0.30	3.56	0.25	0.31
PRE5	0.00	3.97	0.47	4.44	0.26	0.33

Notes:

1. $C_{impervious} = 0.90$, $C_{pervious} = 0.20$, $C_{gravel} = 0.80$

2. C_{100yr}, impervious =1.0, C_{100yr}, pervious=0.25, C_{100yr}, gravel=1.0

FACT SHEET

Sustainable Technologies

EVALUATION PROGRAM

Bioretention

Inspection and Maintenance of Stormwater Best Management Practices

Bioretention is a general term that refers to vegetated stormwater best management practices (BMPs) that temporarily store rainwater or snowmelt from roofs or pavements (i.e., stormwater runoff) in depressed planting beds or other structures (e.g., concrete planters). Bioretention treats stormwater by slowing it down, filtering it through soil and plant roots, soaking it into the ground and evaporating it back to the atmosphere. Runoff water is delivered to the practice through inlets such as curb-cuts, spillways or other concrete structures, sheet flow from pavement edges, or pipes connected to catchbasins or roof downspouts. The planting bed and side slopes are typically covered with a mixture of plants, mulch and stone. Water in excess of its storage capacity overflows to another BMP or the municipal storm sewer. Filtered water is either infiltrated into the underlying soil to replenish groundwater, or collected by a sub-drain (i.e., underground perforated pipe) and discharged to the storm sewer system or another BMP. Depending on the permeability of the underlying soil or other constraints, it may be designed with no sub-drain for full infiltration, with a sub-drain for partial infiltration, or with an impermeable liner and sub-drain for a no infiltration practice. The sub-drain pipe may feature a flow restrictor (e.g., orifice cap or valve) for gradually releasing detained water and optimizing the amount drained by infiltration. Key components of bioretention practices for inspection and maintenance are described in Table 1 and Figure 2.

Key components of bioretention to pay close attention to are the inlets, filter bed surface and overflow outlets. Trash, debris and sediment builds up at these locations and can prevent water from flowing into or out of the practice.

RELATED TERMS

Bioretention cell: A flat-bottomed, depressed planting bed containing filter media soil, a gravel water storage layer and optional sub-drain pipe(s); Also known as a **rain garden**.

Stormwater planter: A bioretention cell contained within an engineered (e.g., concrete) structure.
Biofilter: Bioretention cell or swale with an impermeable liner or containment structure and sub-drain.
Bioretention swale: A gently sloping, linear oriented bioretention practice designed to be capable of conveying water across an elevation gradient. Also known as a bioswale or dry swale.

BENEFITS

• Reduce the quantity of runoff and pollutants being discharged to municipal storm sewers and receiving waters (i.e., rivers, lakes and wetlands);

• Replenish groundwater resources and keep the flow of water to our rivers and lakes cool for temperature-sensitive fish like trout and salmon;

• Can be adapted to fit into many contexts (e.g., roadways, parking lots, plazas, parks and yards);

Can provide a convenient area for snow storage and snowmelt treatment; and

• Can provide aesthetic value as attractive landscaped features. Figure 1. Bioretention in residential area



TIPS TO HELP PRESERVE BMP FUNCTION

• Maintain grading of the filter bed (or grass filter strip if present) at curb-cut inlets so at least 5 cm of the back of the curb is visible through regular sediment removal and regrading;

• To avoid over-compaction of the filter media soil, any maintenance tasks involving vehicle or foot traffic on the filter bed should not be performed during wet weather;

• For bioretention with sod (i.e., turf grass) as vegetation cover, maintain with a push mower or the lightest mulching ride mower available and core aerate and dethatch annually in the spring to help maintain permeability;

• Pruning of mature trees should be performed under the guidance of a Certified Arborist;

• Woody vegetation should not be planted or allowed to become established where snow will be piled/stored during winter; and

• Removal of sediment from the filter bed surface should be done with rake and shovel, or vacuum equipment to minimize plant disturbance. If a small excavator is to be used, keep it off the BMP footprint to avoid damage to side slopes/ embankments and over-compaction of the filter media.

KEY COMPONENTS AND INSPECTION AND MAINTENANCE TASKS

Figure 2. Generalized plan and cross-section view of a bioretention cell showing key components

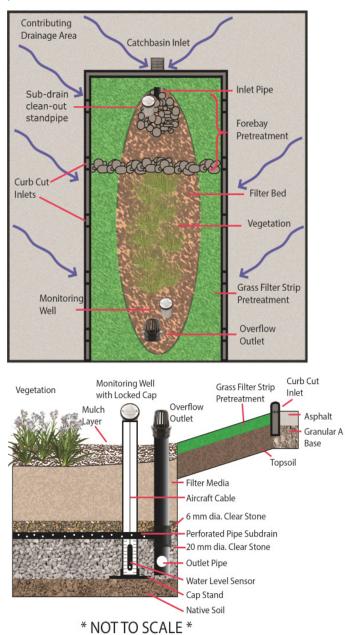


Figure 3. Biofilter swale retrofit within the road right-of-way



Component	Description	Inspection and Maintenance Tasks
Contributing drainage area (CDA)	Area(s) from which runoff directed to the BMP originates; includes both impervious and pervious areas.	 Remove trash, debris and sediment from pavements (biannually to quarterly) and eavestroughs (annually); Replant or seed bare soil areas as needed.
Pretreatment	Devices or features that retain trash, debris and sediment; help to extend the operating life cycle; examples are eavestrough screens, catchbasin inserts and sumps, oil and grit separators, geotextile-lined inlets, gravel trenches, grass filter strips, forebays.	 Remove trash, debris and sediment annually to biannually or when the device sump is half full; Measure sediment depth or volume during each cleaning, or annually to estimate accumulation rate and optimize frequency of maintenance.
Inlets	Structures that deliver water to the BMP (e.g., curb-cuts, spillways, pavement edges, catchbasins, pipes).	 Keep free of obstructions; Remove trash, debris and sediment biannually to quarterly; Measure sediment depth or volume during each cleaning or annually to estimate accumulation rate and optimize frequency of maintenance; Remove woody vegetation from filter bed at inlets annually.
Perimeter	Side slopes or structures that define the BMP footprint; may be covered by a mixture of vegetation, mulch and stone with slopes up to 2:1 (H:V), or concrete or masonry structures with vertical walls.	 Confirm the surface ponding footprint area dimensions are within ±10% of the design and that maximum surface ponding depth meets design specifications; Check for side slope erosion or damage that compromises water storage capacity.
Filter bed	Flat or gently sloping area composed of a 0.5 to 1 m deep layer of filter media soil covered by a mixture of vegetation, mulch and stone where surface ponding and filtration of runoff occurs.	 Check for standing water, barren/eroded areas, sinkholes or animal burrows; Remove trash biannually to quarterly; Rake regularly to redistribute mulch and prevent sediment crusts; Maintain 5 to 10 cm of mulch or stone cover to prevent weed growth and soil erosion; Repair sunken areas when ≥ 10 cm deep and barren/eroded areas when ≥ 30 cm long; Remove sediment when > 5 cm deep or time to drain water ponded on the surface exceeds 48 hours.
Vegetation	A mixture of deep rooting perennial plants, tolerant to both wet and dry conditions and salt (if receiving pavement runoff); can include grasses, flowers, shrubs and trees; roots uptake water and return it to the atmosphere; provide habitat for organisms that break down trapped pollutants and help maintain soil structure and permeability.	 Routine maintenance is the same as a conventional perennial garden bed; In the first 2 months water plantings frequently (biweekly in the absence or rain) and as needed (e.g., bimonthly) over the remainder of the first growing season; Remove weeds and undesirable plants biannually to quarterly; Replace dead plantings annually to achieve 80% cover by the third growing season; Do not apply chemical fertilizers.
Overflow Outlet	Structures that convey overflows to another BMP or municipal storm sewer.	 Keep free of obstructions; Remove trash, debris and sediment biannually to quarterly.
Sub-drain	Optional component; perforated pipe(s) surrounded by gravel and may be wrapped in geotextile filter fabric; installed below the filter media soil layer to collect and convey treated water to an adjacent drainage system; may also include a flow restrictor.	 Include standpipes or access points to provide means of flushing the perforated pipe; Keep pipe and flow restrictor free of obstructions by flushing annually; Inspect flow restrictor frequently (e.g., biannually to quarterly).
Monitoring well	Perforated standpipe that extends from the bottom of the BMP to above the invert of the overflow outlet. Allows measurement of subsurface water level to track drainage performance over time.	 Standpipes should be securely capped on both ends and remain undamaged.





REHABILITATION

Table 2. Key components, typical problems and rehabilitation tasks.

Component	Problem	Rehabilitation Tasks
Inlets	Inlet is producing concentrated flow and causing filter bed erosion	Add flow spreading device or re-grade existing device back to level. Rake to regrade damaged portion of the filter bed and replant or restore mulch/ stone cover. If problem persists, replace some mulch cover with stone.
Filter bed	Local or average sediment accumulation ≥ 5 cm in depth	At inlets remove stone and use vacuum equipment or rake and shovel to remove sediment. For large areas or BMPs, use of a small excavator may be preferable. Restore grades with filter media that meets design specifications. Test surface infiltration rate (one test for every 25 m ² of filter bed area) to confirm it is > 25 mm/h. Replace stone, mulch and plant cover (re-use/transplant where possible). If problem persists, add pretreatment device(s) or investigate the source(s).
	Surface ponding remains for > 48 hours or surface infiltration rate is <25 mm/h.	Remove sediment as described above. Core aerate (for sodded bioretention); or remove stone, sediment, mulch, and plant cover and till the exposed filter media to a depth of 20 cm; or remove and replace the uppermost 15 cm of material with filter media that meets specifications. Test surface infiltration rate (one test for every 25 m ² of filter bed area) to confirm it is > 25 mm/h. Replace stone, mulch and plants (re-use/ transplant where possible).
	Damage to filter bed or slide slope is present (e.g., erosion rills, animal burrows, sink holes, ruts)	Regrade damaged portion by raking and replant or restore mulch/stone cover. Animal burrows, sink holes and compacted areas should be tilled to 20 cm depth prior to re-grading. If problems persist, consider adding flow spreading device to prevent erosion or barriers to discourage foot or vehicular traffic.
Vegetation	Vegetation is not thriving AND filter media is low in organic matter (<3%) or extractable phosphorus (<10 mg/kg)	Remove stone, mulch and plant cover and uppermost 5 cm of filter media, spread 5 cm of yard waste compost, incorporate into filter media to 20 cm depth by tilling. Replace stone, mulch and plants (re-use/transplant where possible).
Sub-drain	Sub-drain perforated pipe is obstructed by sediment or roots	Schedule hydro-vac truck or drain-snaking service to clear the obstruction.

TYPES OF INSPECTIONS

Routine Operation: Regular inspections (twice annually, at a minimum) done as part of routine maintenance tasks over the operating phase of the BMP life cycle to determine if maintenance task frequencies are adequate and determine when rehabilitation or further investigations into BMP function are warranted.

Maintenance and Performance Verification: Periodic inspections done every 5 years (Maintenance Verifications) and every 15 years (Performance Verifications) post-construction over the operating phase of the BMP life cycle to ensure compliance with maintenance agreement (e.g., Environmental Compliance Approval permit) conditions, evaluate functional performance and determine when rehabilitation or replacement is warranted.

INSPECTION TIME COMMITMENTS AND COSTS

Estimates are based on a typical partial infiltration bioretention design (i.e., includes a sub-drain); estimates for other designs (i.e., full infiltration and no-infiltration) are described in the Low Impact Development (LID) Stormwater Management Practice Inspection and Maintenance Guide available at https://sustainabletechnologies.ca.

Table 5. Time communents and costs for inspection								
Bioretention	Routine Operation	Maintenance Verification	Performance Verification					
Tasks to complete	18	15	15					
Visits (per year)	2	1 every 5 years	1 every 15 years 0.010 \$2.31					
Time (hours per m² BMP area)	0.012	0.010						
Cost	\$1.33	\$0.66						
Performance	/erification (Options (\$ per n	n² BMP area)					
Surface infiltra	Surface infiltration rate testing: \$5.48, 5 tests							
Simulated stor	m event testi	ng: \$15.70						
Natural storm e	event testing:	\$15.00, 2 month	ns monitoring					

Table 3. Time commitments and costs for inspection

Figure 5. Sediment removal in Spring



Table 4. Task cost estimates for maintenance and rehabilitation of a partial infiltration bioretention

Bioretention	Costs per m ² of BMP area			
Tasks	Min.	High		
Watering - first year only	\$3.67	\$3.67		
Watering - second year only	\$1.24	\$1.51		
Annual watering - Starts in year 3	\$0.37	\$0.73		
Drought watering	\$0.19	\$0.19		
Remove litter and debris	\$0.33	\$0.63		
Prune shrubs or trees	\$0.45	\$0.45		
Weeding	\$0.31	\$0.61		
Sediment removal - starts year 2	\$1.36	\$2.71		
Add mulch to maintain 5 to 10 cm - starts year 2	\$3.77	\$3.77		
Replace dead plantings - starts year 2	\$3.35	\$6.69		
Flush sub-drain - starts year 2	\$0.59	\$0.59		
Rehabilitation (every 25 years)	\$59.46	\$59.46		

Figure 5. Leaves clogging inlet to bioretention



For a detailed description of construction, inspection, maintenance and rehabilitation cost assumptions see section 7.1.7 of the LID Stormwater Management Practice Inspection and Maintenance Guide. To generate BMP-specific cost estimates use the LID Life Cycle Costing Tool available at https://sustainabletechnologies.ca.

Table 2. Construction and life cycle cost estimates

Bioretention	Costs per m ² of BMP area + CDA				
bioretention	Minimum	High			
Construction	\$17.02				
LIFE CYCLE COSTS					
25 year evaluation period					
Average annual maintenance	\$0.75	\$1.08			
Maintenance and rehabilitation	\$21.33	\$28.36			
50 year evaluation period					
Average annual maintenance	\$0.70	\$0.98			
Maintenance and rehabilitation	\$39.09	\$53.25			

Figure 6. Continuous water level monitoring in a bioretention

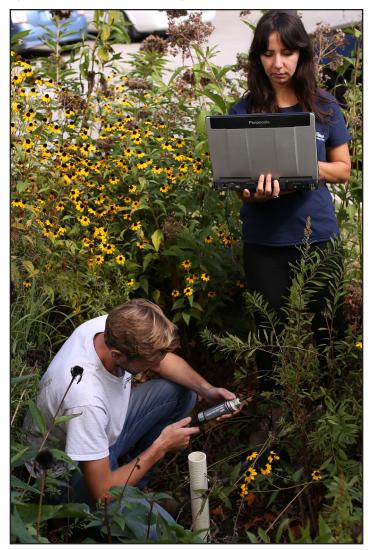


Figure 7. Overflow pipe in bioretention



This communication has been prepared by the Sustainable Technologies Evaluation Program (STEP) with funding support from the Toronto and Region Remedial Action Plan (RAP), Region of Peel, York Region and City of Toronto. The contents of this fact sheet do not necessarily represent the policies of the supporting agencies and the funding does not indicate an endorsement of the contents.

For more detailed information on inspection, testing and maintenance of bioretention and a field data form (checklist) to use for collecting and recording inspection results, please refer to Appendix D of the Low Impact Development Stormwater Management Practice Inspection and Maintenance Guide, available at https://sustainabletechologies.ca.

For more information about STEP and other resources and studies related to stormwater management, visit our website or email us at **STEP@trca.on.ca**.





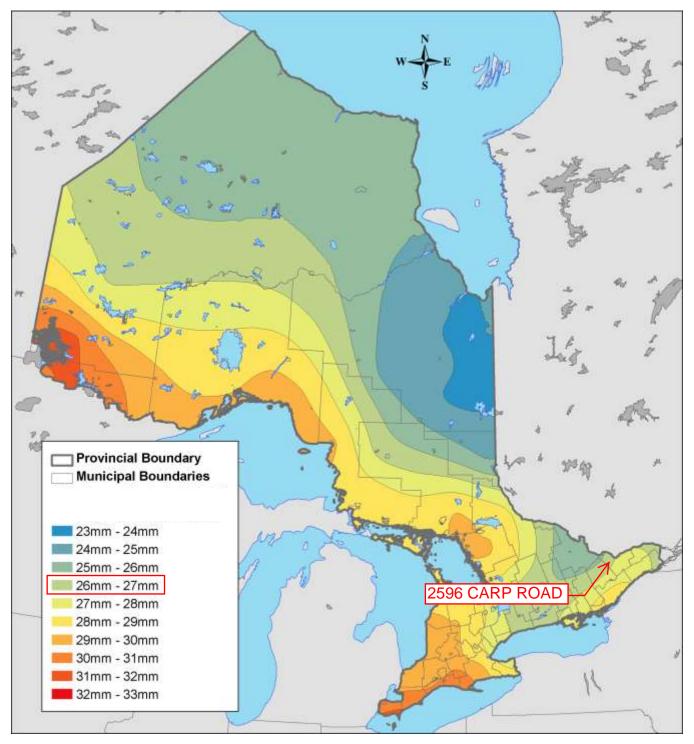
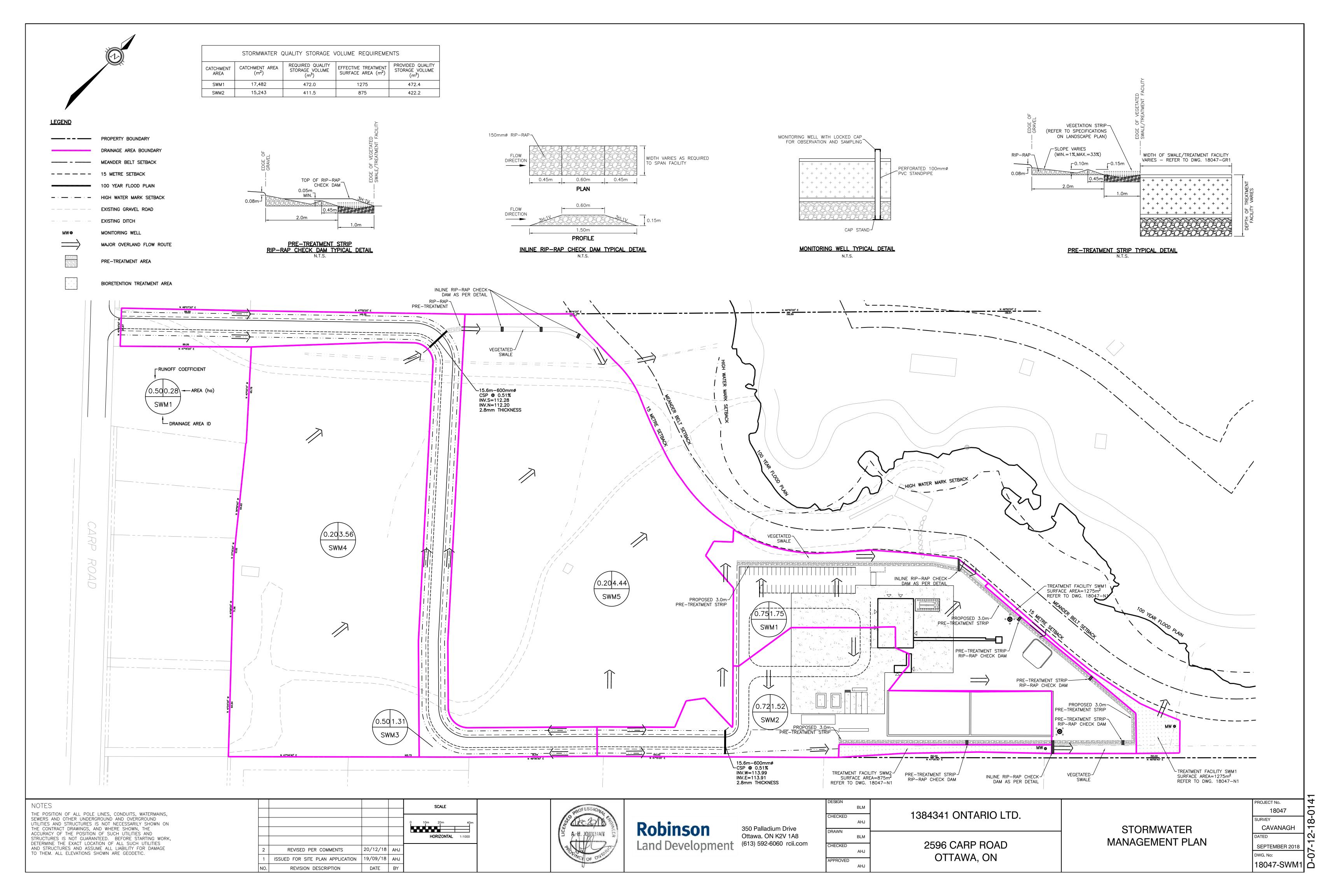


Figure 3.67 – Recommended Regional 90% Percentile Volume Targets for Ontario (represented by the 95th percentile daily rainfall contours April - October, where daily volume exceeds 2 mm).





TECHNICAL MEMORANDUM

Project No. 1543767-2001

EMAIL bbyerley@golder.com

DATE September 5, 2018

TO Ben Houle, P.Eng. Cavanagh Developments

FROM Brian Byerley, P.Eng.

INFILTRATION RATE ASSESSMENT 2596 CARP ROAD, OTTAWA, ONTARIO

Golder Associates Ltd. (Golder), under contract with Cavanagh Developments (Cavanagh), undertook an assessment of the infiltration characteristics of the soils at eleven locations within the footprint of a proposed stormwater management system. The tests were completed at 2596 Carp Road in Ottawa, Ontario, in order to support the stormwater management system design by Robinson Land Development Inc. (Robinson). Figure 1, attached, shows the site and testing locations.

Method

Measurement of the field-saturated hydraulic conductivity (K_{fs}) of near surface soils was carried out using a Guelph Permeameter apparatus (Model 2800K1) at 11 on-site locations by Golder personnel between August 13 and August 23, 2018. Testing locations were evenly distributed within the footprint of the proposed stormwater management system. The test locations, identified as GP-01 through GP-11 (see attached Figure 1), were surveyed by Cavanagh. The testing methodology was based on the stormwater infiltration best management practices described in the Stormwater Management Criteria: Appendix B: Water Balance and Recharge document prepared by the Credit Valley Conservation Authority (CVCA, 2012).

At each testing location, the Guelph Permeameter was installed in a 6 centimeter (cm) diameter hand-augered hole at a depth ranging from 0.27 to 1.25 metres below ground surface. All tests were completed in unsaturated soils (above the water table). The soils encountered during the hand augering were documented at each location. The Guelph Permeameter was operated according to the single head method. The outflow of water at the testing depth was monitored until it was determined that it had reached steady-state. The field-saturated hydraulic conductivity of the soil was estimated using the following equation (Elrick et al., 1989):

$$K_{fs} = \frac{C_1 Q_1}{2H_1^2 + \pi a^2 C_1 + 2\pi \frac{H_1}{a^*}}$$

Where: C1 = shape factor

 $Q_1 = flow rate (cm^3/s)$

H₁ = water column height (cm)

 a^* = alpha factor (0.12 cm⁻¹)

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In accordance with CVCA, 2012, the percolation rate ("T-time" in min/cm) corresponding to each K_{fs} was estimated based on information presented in Tables 2 and 3 of the Supplementary Standard SB-6 Percolation Time and Soil Descriptions, of the Ontario Building Code (OMMAH, 2012) summarized below:

Field-Saturated Hydraulic Conductivity K _{fs} (cm/s)	Estimated Percolation Time, T (min/cm)	Infiltration Rate, 1/T (mm/hr)		
10 ⁻¹	2	300		
10-2	4	150		
10 ⁻³	8	75		
10-4	12	50		
10 ⁻⁵	20	30		
10-6	50	12		

Design infiltration rates were then determined in accordance with Table B3 of the Stormwater Management Criteria: Appendix B: Water Balance and Recharge document prepared by the Credit Valley Conservation Authority (CVCA, 2012).

Results

Description of the soils encountered during the hand augering for the Guelph Permeameter testing are presented in the auger holes records included in Attachment 1. The soils identified at the testing locations consist of silty sand, sandy silt, glacial till, sand fill and silty clay.

Groundwater conditions observed in each auger hole are included in Attachment 1. Groundwater levels were also measured in nearby monitoring wells as follows (Borehole Records are included as Attachment 2):

Monitoring Well Location	Measurement Date	Depth to Water Table (m)	Water Table Elevation (masl)	
BH15-4	Aug 16, 2018	2.50	107.81	
BH15-4	April 26, 2017	1.52	108.79	
BH18-13	Aug 24, 2018	>4.19	<107.40	
*BH18-6	Aug 18, 2018	1.25	109.61	
*BH18-7	Aug 17, 2018	1.52	111.18	
*BH 18-1	Aug 17, 2018	0.69	112.21	

* Installed by Gemtec

The depth to the water table at/near the Guelph Permeameter testing locations ranged from 0.43 metres at GP1 to greater than 4.19 metres at BH18-13.

The results of the infiltration tests are summarized in the attached Table 1. Based on the testing results, the mean field-saturated hydraulic conductivity of the native soils ranges from 1×10^{-4} cm/s (silty sand) to 8×10^{-6} cm/s (silty clay). One test was completed in sand fill. Testing results indicate that the saturated hydraulic conductivity of the sand fill is 3×10^{-3} cm/s.

The percolation times (T-time) and the infiltration rates associated with each test result were determined, and are also summarized in Table 1. Percolation times range from 6 min/cm to 22 min/cm. Infiltration rates (the inverse of the T-times) were calculated to range from 27 mm/hr to 100 mm/hr.

Ben Houle, P.Eng.	Project No. 1543767-2001
Cavanagh Developments	September 5, 2018

Because the results of the Guelph Permeameter testing indicate that, at each testing location, K_{fs} does not decrease with depth, the recommended "safety correction factor" to calculate the design infiltration rate is 2.5 (CVCA, 2012). Therefore, the design infiltration rates were calculated to range from 11 mm/hr to 40 mm/hr. The design infiltration rate calculated using the geomean of the infiltration rates at all Guelph Permeameter testing locations is 22 mm/hr.

Closure

We trust the information included meets your current needs. Should you require clarification, please do not hesitate to contact us.

Yours truly,

Golder Associates Ltd.

Loren Bekeris, M.Sc., P.Eng. Environmental Engineer

Brian Byerley, M.Sc., P-Eng. Senior Hydrogeologist/Principal



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Attachments: Table 1: Guelph Permeameter Infiltration Rate Testing Results August 2018 Figure 1: Field Investigation Locations Attachment 1: Record of Guelph Permeameter Testing Auger Holes Attachment 2: Borehole Records

References

BTB/LEB/sg

Elrick, D.E., W.D. Reynolds, and K.A. Tan. 1989. Hydraulic conductivity measurements in the unsaturated zone using improved well analyses. Ground Water Monitoring Review. 9:184-193.

Credit Valley Conservation Authority (CVCA). 2012. Stormwater Management Criteria: Appendix B: Water Balance and Recharge document.

Ontario Ministry of Municipal Affairs and Housing (OMMAH). 2012. Supplementary Guidelines to the Ontario Building Code 2012. SG-6 Percolation Time and Soil Descriptions. Toronto, Ontario.

st Depth (m)	Test Elevation (masl)	Material	Depth to Water Table (m) ¹	K _{sat} (cm/s)	T-Time (min/cm)	1/T (Infiltration Rate mm/hr)	Design Infiltration Rate (mm/hr)
0.27	112.3	sand (fill)	0.43	3E-03	6	100	40
1.15	111.2	silty sand	dry to 1.15	1E-04	12	50	20
0.90	112.1	glacial till	dry to 0.90	6E-04	9	67	27
1.01	111.6	silty sand	dry to 1.01	8E-05	13	46	18
1.08	110.9	sandy silt	1.35	4E-05	14	43	17
1.25	109.0	weathered crust	2.50 ²	6E-05	13	46	18
1.18	108.9	silty clay	dry to 1.18	8E-06	22	27	11
1.10	108.9	silty sand	dry to 1.10	2E-04	10	60	24
1.12	109.4	silty sand to sand	dry to 1.12	1E-03	8	75	30
1.02	109.6	sandy silt	dry to 4.19 ³	3E-05	14	43	17
1.15	111.1	silty sand	dry to 4.19 ³	1E-04	12	50	20

Table 1: Guelph Permeameter Infiltration Rate Testing Results August 2018

in open auger hole except for GP-6, GP-10 and GP-11

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ATTACHMENT 1

Record of Guelph Permeameter Testing Auger Holes



RECORD OF GUELPH PERMEAMETER TESTING AUGER HOLES

Test Location Number	Depth (m)	DESCRIPTION
GP-01	0.00 - 0.15 0.15 - 0.50 0.50	TOPSOIL SAND, light brown; non-cohesive; moist (Fill) End of Test Location (test run at 0.27 m; water table at 0.43 m)
GP-02	0.00 - 0.45 0.45 - 0.70 0.70 - 1.15 1.15	SAND, light brown; non-cohesive; moist (Fill) SANDY SILT to SILTY SAND; grey-brown; non-cohesive; moist SILTY SAND to SAND; grey-brown; non-cohesive; moist End of Test Location
GP-03	0.00 - 0.32 0.32 - 0.41 0.41 - 0.77 0.77 - 0.90 0.90	TOPSOIL SILTY SAND; brown; non-cohesive; moist SILTY SAND; some gravel; brown; non-cohesive; moist SILTY SAND; cobbles; some gravel; brown; non-cohesive; moist (GLACIAL TILL) End of Test Location (auger refusal on cobble)
GP-04	0.00 - 0.25 0.25 - 0.60 0.60 - 1.01 1.01	TOPSOIL SILTY SAND; some gravel; brown; non-cohesive; moist SILTY SAND; some gravel; grey-brown; non-cohesive; moist End of Test Location
GP-05	0.00 - 0.10 0.10 - 0.95 0.95 - 1.35 1.35	TOPSOIL SAND, light brown; non-cohesive; moist (Fill) SANDY SILT; grey-brown; non-cohesive; moist End of Test Location (test run at 1.08 m; water table at 1.35 m)
GP-06	0.00 - 0.25 0.25 - 0.65 0.65 - 1.25 1.25	TOPSOIL SILTY SAND; brown; non-cohesive; moist SILTY CLAY; sand seams; grey-brown; cohesive; moist (Weathered Crust) End of Test Location
GP-07	0.00 - 0.30 0.30 - 0.70 0.70 - 0.95 0.95 - 1.18 1.18	TOPSOIL SILTY SAND to SAND; light brown; non-cohesive; moist SILTY CLAY; sand seams; grey-brown; cohesive; moist (Weathered Crust) SILTY CLAY; sand seams; grey-brown; cohesive; moist End of Test Location



RECORD OF GUELPH PERMEAMETER TESTING AUGER HOLES

Test Location Number	Depth (m)	DESCRIPTION
GP-08	0.00 - 0.20 0.20 - 0.80 0.8 - 1.10 1.10	TOPSOIL SILTY CLAY; sand seams; grey-brown; cohesive; moist (Weathered Crust) SILTY SAND; grey-brown; non-cohesive; moist End of Test Location
GP-09	0.00 - 0.30 0.30 - 0.60 0.60 - 0.85 0.85 - 1.12 1.12	SANDY SILT; grey-brown; non-cohesive; moist
GP-10	0.00 - 0.40 0.40 - 0.80 0.80 - 1.02 1.02	TOPSOIL SILTY SAND; light brown; non-cohesive; moist SANDY SILT; grey-brown; non-cohesive; moist End of Test Location
GP-11	0.0 – 0.10 0.10 – 1.15 1.15	TOPSOIL SILTY SAND; brown; non-cohesive; moist End of Test Location



ATTACHMENT 2

Borehole Records

24



PROJECT: 1543767

RECORD OF BOREHOLE: 15-4

SHEET 1 OF 1 DATUM: CGVD28

LOCATION: See Site Plan

SAMPLER HAMMER, 64kg; DROP, 760mm

BORING DATE: December 7, 2015

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

<u> </u>	P	SOIL PROFILE			SA	MPL	_	DYNAMIC PENETRATION RESISTANCE, BLOWS/0,3m	k, cm/s	PIEZOMETER
DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV DEPTH (m)	NUMBER	ТҮРЕ	BLOWS/0.30m	20 40 60 80 SHEAR STRENGTH nat V + 0 - 0 Cu, kPa rem V ⊕ U - 0 20 40 60 80	10 ⁶ 10 ⁵ 10 ⁻¹ 10 ³ WATER CONTENT PERCENT Wp I VI 20 40 60 80	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		110,31						
Ĩ		TOPSOIL - (SM) SILTY SAND; dark brown; non-cohesive, moist	THE PARTY	0,00						
		(SM) SILTY SAND to sandy SILT;	100	109,90	2					
		brown; non-cohesive, moist		109,55						
		(CI/CH) SILTY CLAY to CLAY, trace sand, grey brown (WEATHERED	122	0,76						
1		CRUST): cohesive, w>PL, very stiff (SM) SILTY SAND, fine, trace gravel: brown, contains organics, non-cohesive.		SMB11	1	SS	10			Cuttings
		moist, compact			2	ss	17			7
2	Storn)	(SM) gravelly SILTY SAND; grey brown, contains cobbles and boulders	282 213	108.25 2,06						Cuttings 🗸
	200 mm Diam. (Hollow Stern)	(GLACIAL TILL); non-cohesive, moist, dense to very dense			3	ss	30			
з	200 mm	(SM) gravelly SILTY SAND; grey, contains cobbles and boulders		107.25 3,05	4	SS	53			Bentonite Seal
		(GLACIAL TILL)	100		4	22	23			Silica Sand
4					5	ss	82			
										51 mm Diam. PVC #10 Slot Screen
5				105.05	6	SS	41			
		End of Borehole Auger Refusal	0.000	5.26						W.L. in Screen at Elev, 108,79 m on April 26, 2017
6										
7										
в										
9										
10										
	THIS	CALE						GOLDER		LOGGED: HEC

PROJECT: 1543767

MIS-BHS 001 1543767.GPJ GAL-MIS.GDT 09/05/18 JEM

RECORD OF BOREHOLE: 18-13

SHEET 1 OF 1 DATUM: CGVD28

LOCATION: See Site Plan

SAMPLER HAMMER, 64kg; DROP, 760mm

BORING DATE: August 24, 2018

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

		SOIL PROFILE		_	SA	MPL	ES	DYNAMIC PENETRA	TION	HYDRAULIC CONDUCTIVITY,	-	
DEPTH SCALE METRES	BORING METHOD		5			-		RESISTANCE, BLOV 20 40	WS/0.3m 60 80	$k_{\rm cm/s}$ 10 ^{-z} 10 ^{-z} 10 ^{-z}	ADDITIONAL LAB TESTING	PIEZOMETER
PTH S METR	N C	ହ ଅଧି ଅଧି DESCRIPTION		ELEV	NUMBER	ТҮРЕ	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa		WATER CONTENT PERCENT	DITIC	STANDPIPE
Ш Ш	BORI	NOG C	STRA'	DEPTH (m)	Π _N	Ĥ	BLOW				A A	
		GROUND SURFACE		111.59				20 40	60 80	20 40 60 80		
2 3 6 7 7		GROUND SURFACE Sandy GRAVEL; brown grey, contains cobbles (GLACIAL TILL); non-cohesive		(m) 111.59 0.00			BLC					Rentonite Seal
10												-
									I			
		SCALE				X		GOL	DER			DGGED: EL
1:5	0										CHE	ECKED: BTB

CLIENT: Cavanagh Developments PROJECT: 2596 Carp Road JOB#: 61318,20 LOCATION: See Borehole Location Plan, Figure 2

SHEET:	1 OF 1
DATUM:	CGVD2013
BORING DATE:	Aug 8 2018

alle	THOD	2	SOIL PROFILE	_F	1		SAN	IPLES	-	● PE RE	NETR SIST	ATION	N), BLC)ws/0.	3m -+	SHEAR : - NATUR	STREN RAL ⊕	IGTH (C REMOI	u), kPA JLDED	ING	DIEZO	METER
DEPTH SCALE METRES	BORING METHOD		DESCRIPTION	STRATA PLOT	ELEV,	NUMBER	ТҮРЕ	RECOVERY.	BLOWS/0.3m	A DY RE		C PENI	ETRATI N), BLC	ION WS/0.	3m '	WAT	ER CO V	NTENT, ∦	% ⊣wլ	ADDITIONAL LAB. TESTING	STAN)r DPIPE
μ	BOR			STRAI	DEPTH (m)	N N	۴	REC	BLOW						50	•			90	AD		
- 0			Ground Surface TOPSOIL	42.3	112.90					1111 118			: ::::::::::::::::::::::::::::::::::::			0 1000						
36 0			Brown SAND, trace silt	1	0.05	1	GS				C					: : ::::: : :::::				м	Bentonite se	əl
1	Power Auger	Hollow Stem Auger (210mm OD)	Grey SILTY SAND, trace clay		112.49 0.41	2	GS													-	Filter san 51 mr diametre, 1.5 m long we	Ž
2			End of borehole		110.77 2.13	<	5	Ş	P												m long wa scree	m 2 all and a state of the stat
3																						
														2.00								
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RECORD	OF B	OREHOLI	E 18-6
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 CLIENT:
 Cavanagh Developments

 PROJECT:
 2596 Carp Road

 JOB#:
 61318,20

 LOCATION:
 See Borehole Location Plan, Figure 2

SHEET:	1 OF 1
DATUM:	CGVD2013
BORING DATE:	Aug 8 2018

CALE ES		ETHOD	SOIL PROFILE	L		-	SAN	IPLES	F	● PE RE	NETR.	ATION NCE (N), BL	ows/	0.3m	+ NATI	JRAL €	REMO	Cu), kPA IULDED	NAL	PIEZOMETER
DEPTH SCALE METRES		BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV, DEPTH (m)	NUMBER	ТҮРЕ	RECOVERY. mm	BLOWS/0.3m		NAMIC		ETRAT N), BL 30	non ows/ 40	0.3m 50	WA W _P ├─ 60	TER CC	NTENT	- % ₩_ 90	ADDITIONAL LAB. TESTING	OR STANDPIPE INSTALLATIO
- 0			Ground Surface		110.86					11111	1111			123		13 11	11 233	1 13			
ŝ			TOPSOIL Dark brown SILTY SAND	11	0.05	1	GS			:::ž	:111						12) I.U.				Bentonile seal
					110,56 0.30					1013 2111	111				28 22 23 13				1 2431 2 2231		8
			Brown SAND, trace silt and gravel	- सिंह	110.35	2	GS				14011 2011	ici de El se									Filter sand
	Power Auger	ger (210	Grey brown SILTY SAND							000T											
	Power	Hollow Stem Auger (210mm OD)									1101								1 		
1		follow S				3	GS			(ICEE)			0		61 81 61 83	fa na			- 44	м	
																32 <u>92</u>			1.11		51 mm
										111	2222	litins 1979				n ni	11 123 15 53	1 (1475) 1 (124)			51 mm diametre, 1.52 m long well screen
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	β	SOIL PROFILE				SAN	IPLES		• PE RE	NETRA SISTAN	TION	N), BLO	WS/0.:	3m -	SHEAR H NATL	STREN	GTH (C REMO	u), kPA JLDED	وب	
METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	▲ DY RE	NAMIC SISTAN	PENE ICE (I	ETRATION), BLO	DN WS/0,3	3m	wa ⁻ w _P	TER CO		, % — W _L	ADDITIONAL LAB. TESTING	PIEZOMETI OR STANDPIF INSTALLATI
_	8	Ground Surface	STF	(m) 112.68	2		8	BLC	8	0 20	0	30 4	10	50	60	70	80	90		
0		TOPSOIL Loose, brown SILTY SAND, trace gravel	1.48	0.05	1 1B	SS SS	430	7		o									м	Benionile seal
1	Jer (210mm OD)	very dense, grey brown silty sand, trace to some gravel with possible cobbles and boulders (GLACIAL TILL)		<u>111.61</u> 1.07	2	SS	480	10												Filter sand
2	Power Auger Hollow Stern Auger (210mm				3	SS	610	54						•						Ā
					<	5	2	Y				1115 1115 1115 1115								51 mm diametre, 1.52 m long well screen
			a 0 0 0 0	100.78	4	SS	410	>50 f	or 150 i	nm			6 1 5:5:				111			
3		End of borehole Auger refusal on inferred bedrock		2.90									2023 2023 2023 2023 2023 2023 2023 2023							
4											5945 1 421 1 121							1121 1111 1111 1111		
																		1111 1111 1111 1111 1111 1111 1111 1111 1111		
																		1000 1000 1000 1000 1000		GROUNDWATE OBSERVATION DATE DEPTH 18/08/17 1.52

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TECHNICAL MEMORANDUM

DATE December 18, 2018

Project No. 1543767-2001

EMAIL bbyerley@golder.com

TO Ben Houle, P.Eng. Cavanagh Developments

FROM Brian Byerley, P.Eng.

RESPONSE TO CITY COMMENTS ON ROBINSON LAND DEVELOPMENT LID DESIGN 2596 CARP ROAD, OTTAWA, ONTARIO

Golder Associates Ltd. (Golder), under contract with Cavanagh Developments (Cavanagh), undertook an assessment of the infiltration characteristics of the soils at eleven locations within the footprint of a proposed stormwater management system. The tests were completed at 2596 Carp Road in Ottawa, Ontario, in order to support the stormwater management (SWM) facility design, based on current Low Impact Development (LID) guidance, by Robinson Land Development Inc. (Robinson).

Following submission of the design to the City of Ottawa (City), the City provided comments related to the hydrogeological aspects of the design. Following are the City comments (*in italics*) and Golder's responses.

Both the MOE SWMP and the LID manual state that the bottom of the Bioretention basin or infiltration trench should be separated from the seasonally high water table by a minimum of one (1) metre. I understand that water tables fluctuate over time, and I further understand that the CA have offered to be flexible on this distance. However as the water table level was established on a warm day in August - during an admitted dry spell - it is suggested that the value obtained currently be taken as the seasonally LOW level. Please provide a value of an annual average high groundwater elevation.

Groundwater elevations have been measured at a number of groundwater monitoring wells on four occasions (see attached table). The measurements in August 2018 may be considered representative of the seasonal low level while the measurements in April 2017 and December 2018 may be considered representative of the seasonal high level. The April 2017 measurements are the highest values and indicate that the expected pre-development maximum seasonal fluctuation of the water table at this site is approximately 1.1 metres (i.e. the maximum observed difference between seasonal low and seasonal high water table elevation). The post-development water table elevation would be expected to decline if LID is not implemented.

The water table elevations indicated on the Robinson Stormwater Management Plan drawing number 18047-SWM1 were obtained from the Golder memorandum dated September 5, 2018. However, these elevations are not water table elevations, but are in fact the elevations of the infiltration testing, which in all cases were above the water table. Comparison of the bottom elevations of the SWM facilities to the water table elevations at the nearest groundwater monitoring wells indicates that, in all cases, the SWM facilities are located above the seasonal high water table elevations and/or are located more than 1.1 meters above the seasonal low water table elevations. Following are the interpreted seasonal high water table elevations at the SWM facilities.

T: +1 613 592 9600 +1 613 592 9601

SWM Facility	Groundwater Monitor	Water Table Elevation (masl)
SWM1	BH15-4	108.8
SWM2	BH18-13	108.5

Note: masl = metres above sea level

Groundwater mounding occurs when the water table is shallow, and water soaks into the soil faster than it can percolate away. Will this be an issue here?

Groundwater mounding is not anticipated to be an issue because the SWM facilities were designed in accordance with current LID guidance using the site-specific design infiltration rates determined by Golder, as reported in Golder's memorandum dated September 5, 2018.

The bio-retention trench is very close to the existing septic system leaching bed. Will it interfere with the functioning of the septic bed?

The infiltration testing completed by Golder in the area close to the septic system leaching bed (testing location GP-05), encountered the water table at a depth of 1.35 metres below ground surface in August 2018. The SWM facility at this location is designed to be a vegetated swale that will direct surface flow to the east, towards the SWM 1 bioretention treatment facility. The swale is not designed to retain or infiltrate surface water, but is designed to convey surface water to the treatment facility. The elevation of the swale in the area of the existing septic system leaching bed is approximately the same as the existing ground surface elevation, and as such will be approximately 1.3 meters above the water table elevation measured at GP-05. Therefore, we do not anticipate that the proposed swale will interfere with the functioning of the septic bed.

Closure

We trust the information included meets your current needs. Should you require clarification, please do not hesitate to contact us.

Yours truly,

Golder Associates Ltd.

Jun t

Loren Bekeris, M.Sc., P.Eng. Environmental Engineer

Brian Byerley, M.Sc., P.Eng. Senior Hydrogeologist/Principal



BTB/LEB/sg n:\active\2015\3 proj\1543767 cavanagh industrial subdivision carp\04_reporting\hydrogeology\stormwater infiltration\1543767-tm- lid comments_18dec2018.docx

Attachments: Table 1: Groundwater Level Measurements



Table 1 Groundwater Level Measurements

	Ground Surface Flevation	Top of Casing	Cantonia I Live of	Depth of Screened				Groundwater Levels	ter Levels			
Mell ID			Screened Interval		22-D	22-Dec-15	26-A	26-Apr-17	22-A	22-Aug-18	14-D	14-Dec-18
	(masl)	(masl)		(sbqm)	Depth (mbgs)	Elevation (masi)	Depth (mbgs)	Elevation (masl)	Depth (mbgs)	Elevation (masi)	Depth (mbgs)	Elevation (masl)
15-1	114.57	115.45	Silty Sand over Silty Sand and Gravel	5.8-7.4	1.44	113.13	0.22	114.35				
15-2	114.99	115.79	Glacial Till	4.6-6.1	>6.38	<108.61	5.26	109.73		1.		
15-4	110.31	111.24	111.24 Glacial Till	3.7 - 5.3	2.67	107.64	1.52	108.79	2.50	107.81	2.20	108.11
15-5	109.50	110.33	110.33 Silty Clay over Glacial Till	4.6-6.1	1.72	107.78	0.88	108.62	1.86	107.64		
15-6	109.54	110.34	Layers of Silty Sand and Silty Clay	4.1 - 5.6	3.36	106.18	3.13	106.41		3		
Gemtec 18-7	112.68	113.63	Glacial Till	1.4 - 2.9				a	1.85	110.84	1.11	111.57
Gemtec 18-11	110.87	111.82	Glacial Till	1.4 - 2.9		3		a	1.62	109.25		
18-13	111.59	112.32	Glacial Till	2.7 - 4.2					>4.19	<107.40	3.35	108.24
Gemtec 18-6	110.86	111.79	Silty Sand	0.6 - 2.1					1.25	109.61	0.88	109.98

Notes: mbgs = metres below ground surface masl = metres above sea level

Treatment Facility Stormwater Flow Calculations

Given: Area (ha) = 3.27 (SWM1 + SWM2) C = 0.74 C (100 YR) = 0.88

Return Period	Time (min)	Intensity (mm/hr)	Flow (L/s) ^{*1}	Allowable Release Rate (L/s)	Net Runoff to be Stored (L/s)	Storage Required (m ³)
	5	242.7	1934.2	0.0	1934.2	580.2
	10	178.6	1423.0	0.0	1423.0	853.8
100 Year	16	137.5	1096.2	0.0	1096.2	1052.3
loo real	20	120.0	955.9	0.0	955.9	1147.1
	25	103.8	827.6	0.0	827.6	1241.4
	30	91.9	732.1	0.0	732.1	1317.8
	5	141.2	948.3	0.0	948.3	284.5
	10	104.2	699.8	0.0	699.8	419.9
5 Year	16	80.5	540.4	0.0	540.4	518.8
5 Teal	20	70.3	471.9	0.0	471.9	566.2
	25	60.9	409.0	0.0	409.0	613.5
	30	53.9	362.2	0.0	362.2	652.0
	5	103.6	695.7	0.0	695.7	208.7
	10	76.8	515.9	0.0	515.9	309.5
2 Year	16	59.5	399.7	0.0	399.7	383.7
2 1 801	20	52.0	349.5	0.0	349.5	419.4
	25	45.2	303.4	0.0	303.4	455.1
	30	40.0	269.0	0.0	269.0	484.1

Notes:

1. Q = 2.78 CiA

Time of Concentration Calculations

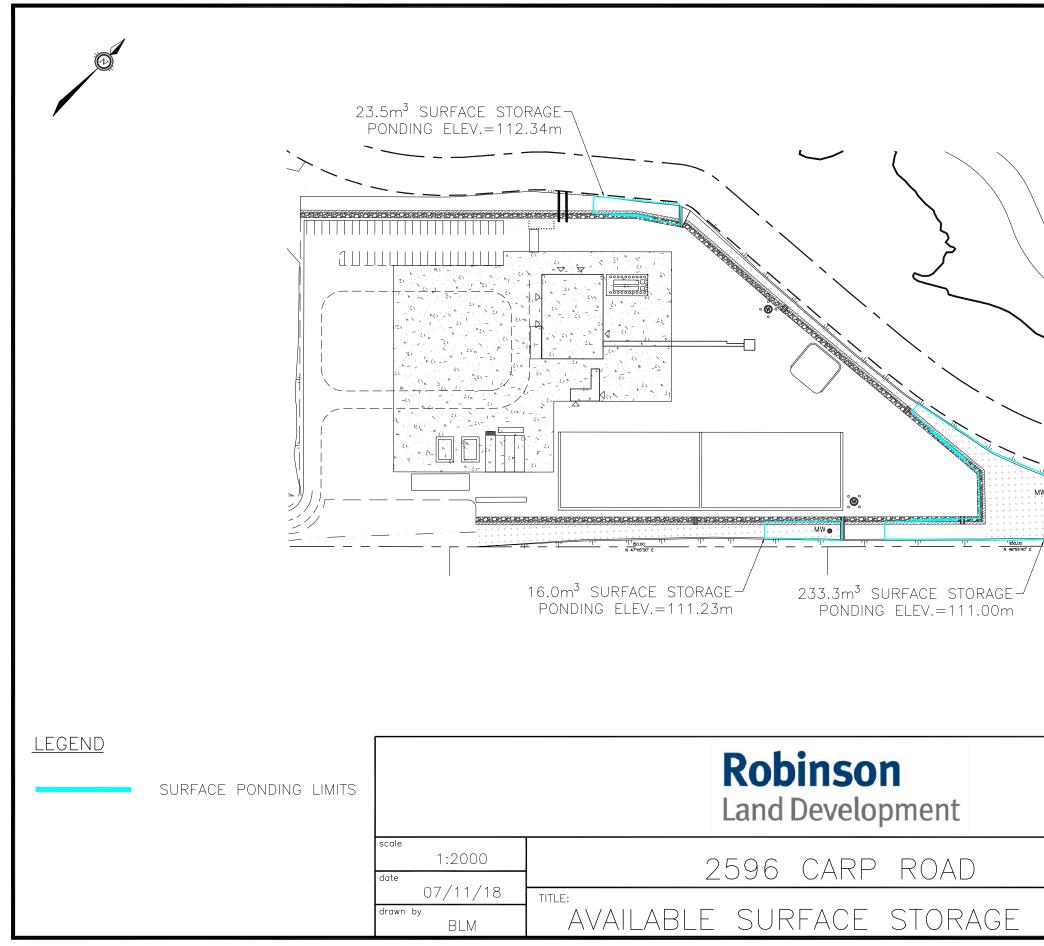
Drainage Area	Average Slope (m/m)	Length (m)	V/S ^{0.5} (m/s) ^{*1}	Velocity (m/s)	Tc (min.) ^{*2,*3}
SWM1/SWM2	0.009	417.0	4.6	0.43	16.0

Notes:

1. V/S^{0.5} value from Table 3.9 of Uplands Method for "grassed waterway" land cover. Refer to Appendix B.

2. Time of Concentration = Length / Velocity

3. Final values are calculated using non-rounded numbers. Discrepencies may occur with manual computations.



	project no. 18047
PLAN	FIG 3

Runoff Coefficient Calculations

Drainage Area	Impervious Area (ha)	Pervious Area (ha)	Gravel Area (ha)	Total Area (ha)	C *2
A1	0.208	3.942	0.089	4.240	0.25
A2	0.031	0.095	0.016	0.142	0.42

Notes:

1. $C_{impervious} = 0.90$, $C_{pervious} = 0.20$, $C_{gravel} = 0.80$

2. Final values are calculated using non-rounded numbers. Discrepencies may occur with manual computations.

Time of Concentration Calculations

Drainage Area	Average Slope (m/m)	Length (m)	V/S ^{0.5} (m/s) ^{*1}	Velocity (m/s)	Tc (min.) ^{*2,*3}
A1	0.0056	383.95	4.6	0.34	18.59
A2	0.0052	87.20	4.6	0.33	4.38

Notes:

1. V/S^{0.5} value from Table 3.9 of Uplands Method for "grassed waterway" land cover. Refer to **Appendix B**.

2. Time of Concentration = Length / Velocity

3. Final values are calculated using non-rounded numbers. Discrepencies may occur with manual computations.

Culvert Design (10 Year Design Storm)

Station	Contributing Drainage Area	Area (ha)	Time of Concentration (min) ^{*2}	10 YR Intensity (mm/hr) ^{*3}	Runoff Coefficient	10 Year Peak Flow (L/s) ^{*4}	Proposed Culvert Diameter (mm)	Culvert Capacity (L/s) ^{*1}
0+222.49	A1	4.24	18.59	86.04	0.25	250.6	600	600
0+687.11	A2	0.14	4.38	173.78	0.42	28.8	600	600

Notes:

1. Culvert capacity determined using MTO culvert design charts. Refer to Appendix B.

2. Time of Concentration estimated using the Uplands Method. Refer to Appendix B.

3. Rainfall intensity calculated using City of Ottawa IDF Curves.

4. Peak Flow calculated using the Rational Method.

Table 3.9 V/S^{0.5} relationship for various land covers

Land Cover	V/S ^{0.5} (m/s)
Forest with heavy ground litter, hay meadow (overland flow)	0.6
Trash fallow or minimum tillage cultivation, contour, strip cropped woodland (overland flow)	1.5
Short grass pasture (overland flow)	2.3
Cultivated, straight row (overland flow)	2.7
Nearly bare and untilled (overland flow) or alluvial fans in Western mountain regions	3.0
Grassed waterway	4.6
Paved areas (sheet flow); small upland gullies	6.1

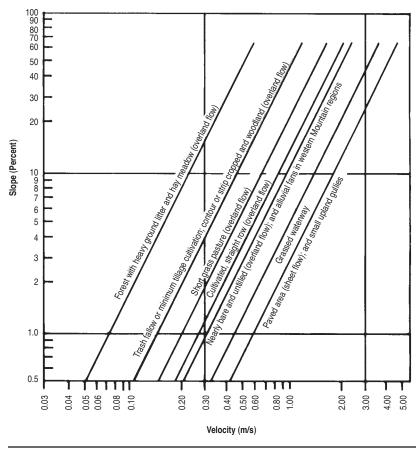
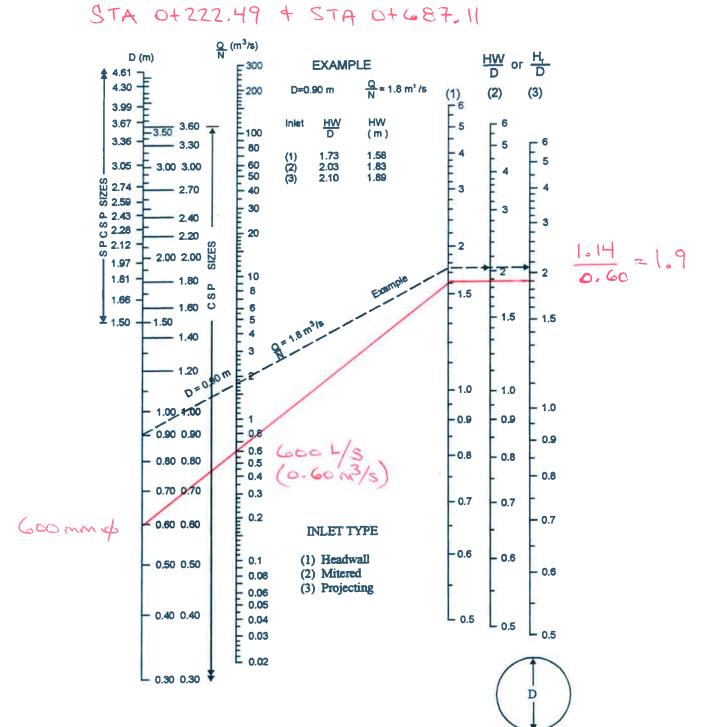


Figure 3.12 Velocities for Upland method for estimating travel time for overland flow.

MTO Drainage Management Manual

Drainage Management Manual Maximum Capacity
Design Chart 2.32: Inlet Control: Circular CSP and SPCSP Culverts

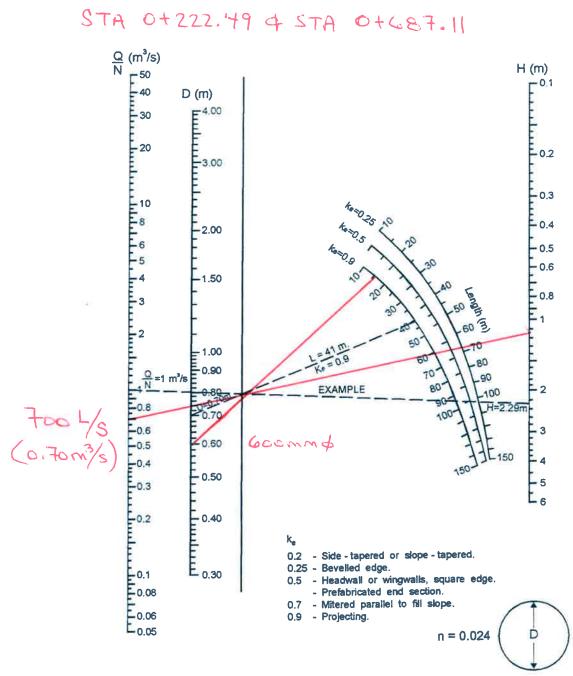


Source: Herr (1977)

Maximum Capacity

Design Charts





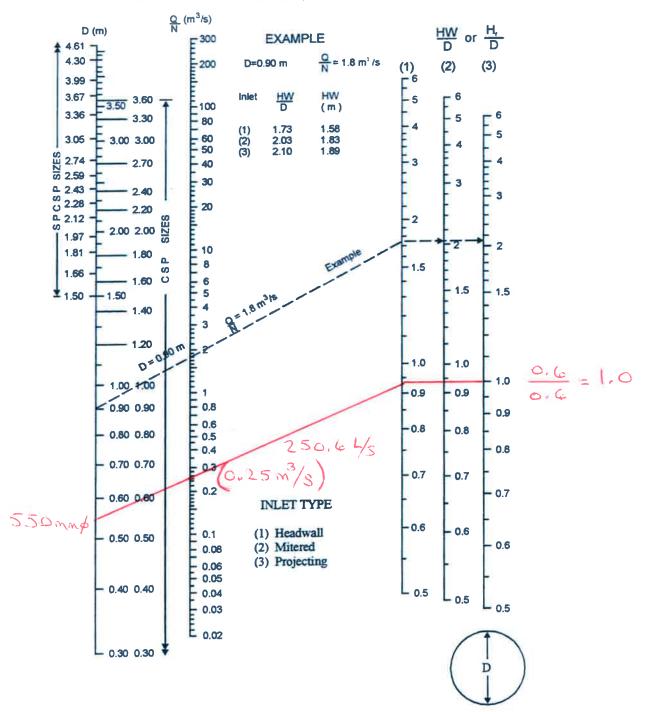
Source: Herr (1977)

MTO Drainage Management Manual Min, Diameter For Overt

Design Chart 2.32: Inlet Control: Circular CSP and SPCSP Culverts

ing CSP

STA 0+222.49



Source: Herr (1977)

MTO Drainage Management Manual Min, Diameter for Overtopping CSP

Design Chart 2.32: Inlet Control: Circular CSP and SPCSP Culverts

