Preliminary Stormwater Management Report

556 and 576 Conservation Drive
City of Waterloo

Revised August 2020

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Project No.: 1279

August 14, 2020

GSP Group
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Attention: Ms. Kristen Barisdale MCIP RPP
Planner

Dear Ms. Barisdale,

Re: Preliminary Stormwater Management Report
556 and 576 Conservation Drive
City of Waterloo

Please find our revised Preliminary Stormwater Management Report for the above-noted project, in support of the current Draft Plan Application.

Our report summarizes the stormwater management requirements and presents a preliminary design configuration appropriate for Draft Plan Approval. The stormwater management plan satisfies the criteria set forth by the municipality, the conservation authority, and the Ministry of Environment, Conservation and Parks. It has been coordinated with the Environmental Impact Study, the North Waterloo Phase 1 Groundwater and Surface Water Monitoring Program, and the North Waterloo Scoped Subwatershed Study.

The proposed stormwater management plan consists of various low impact development (LID) techniques arranged in a treatment train sequence and sized for a conventional range of rainfall events. Together, these components satisfy the design objectives for quality, quantity, and a water balance, as well as being aesthetically pleasing and an asset to the project.

Yours very truly,

MERITECH ENGINEERING

LICENSED PROFESSIONAL ENGINEER
C. H. TOGERETZ
100147133
Aug 14, 2020
PROVINCE OF ONTARIO

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STV/
Enclosures (2)

cc Ian Cook, 2115881 Ontario Limited
Brad Trussler, Mattamy Development Corporation

Executive Summary

The proposed residential development (the site) is located on the north side of Conservation Drive at the northern terminus of Beaver Creek Road in Waterloo. It is bordered by residential, agricultural, and recreational lands.

The 28.64 ha site will be developed for single-family and multi-family units with a school parcel, park block, open space, and a stormwater management facility. The development is being processed through the Draft Plan of Subdivision process with the City of Waterloo and the Region of Waterloo. The lots comprising the Plan of Subdivision will become individual private properties while the multi-residential blocks will be developed as condominium sites. The streets, park block, and stormwater management block will become property of the City of Waterloo.

The stormwater management plan has been developed in accordance with the recommendations in the North Waterloo Scoped Subwatershed Study (NWSSS) and the Environmental Impact Study for the property, municipal standards, and provincial guidelines and documents.

According to the NWSSS, the site is comprised of two separate drainage catchments (east and west) under pre-development conditions. The east catchment discharges uncontrolled to the Conservation Drive and Beaver Creek Road right-of-way (ROW) to the south, whereas the west catchment drains to a wetland immediately upstream of Beaver Creek.

Under post-development conditions, the overall pre-development drainage patterns will be preserved, and stormwater management (SWM) controls will be implemented.

Minor drainage from the east catchment will be collected and conveyed by storm drainage infrastructure to a proposed SWM facility located on the east side of Beaver Creek Road, approximately 550m south of Conservation Drive. Major drainage from the east catchment will be directed to the Conservation Drive ROW per pre-development conditions.

Minor drainage from the west catchment will be conveyed to Beaver Creek by a SWM treatment train system. Major drainage from the west catchment will also be conveyed to Beaver Creek through the proposed ROW and proposed SWM pond.

SWM quantity, quality and water balance objectives will be achieved by means of a comprehensive treatment train featuring at-source, conveyance, and end-of-pipe best management practices. At-source measures include low-impact-development (LID) techniques such as lot-level infiltration trenches and amended topsoil. Conveyance measures include a LID, permeable clean water collector (CWC) system designed to capture and infiltrate roof-generated runoff. The proposed end-of-pipe measure is SWM facility comprised of a sediment forebay, a constructed wetland and an infiltration gallery.

Compliance of the proposed SWM infrastructure with the design objectives is demonstrated with a combination of single-event hydrological models and hand calculations deemed appropriate for Draft Plan Approval. A continuous model will confirm the sizing and

anticipated effectiveness of the proposed SWM measures at the detailed design stage following Draft Plan Approval.

The development configuration can accommodate all the stormwater management design criteria required to satisfy the post-development condition as described in the North Waterloo Scoped Subwatershed Study, and applicable municipal guidelines.

The SWM block is large enough to house a facility to meet the targets, a water balance can be met for infiltration, it is an easily accessible location for maintenance, enhances the buffers to the wetland, and will be aesthetically pleasing and an asset to the development.

The treatment train and construction level details for infiltration shall be reaffirmed through the detailed design process for approval by the City of Waterloo and MECP.

Approval agencies shall approve the Draft Plan and the SWM design as presented.

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For Further Information

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Introduction

The proposed subdivision is located on Conservation Drive in Waterloo, Ontario as shown in Figure 1. The 28.64 ha site is bordered by existing residential lands to the east, agricultural lands to the north, Beaver Creek to the west, agricultural lands to the south on the west side of Beaver Creek Road, and the Green Acre Park campground to the south-east. The lands south of Conservation Drive are planned for future residential development.

The site is an irregularly shaped parcel. The lands are currently farmed and there are two homes located on the site. The drainage is split; with roughly half of the site going west to Beaver Creek and the remainder draining to the south-east corner of the site where it drains towards Green Acre Park across the Conservation Drive ROW and eventually to the Laurel Creek Reservoir.

The development, shown on the Draft Plan of Subdivision in Appendix A, is primarily composed of a mix of low density residential, medium density townhomes, a block reserved for a school, and open space/parkland.

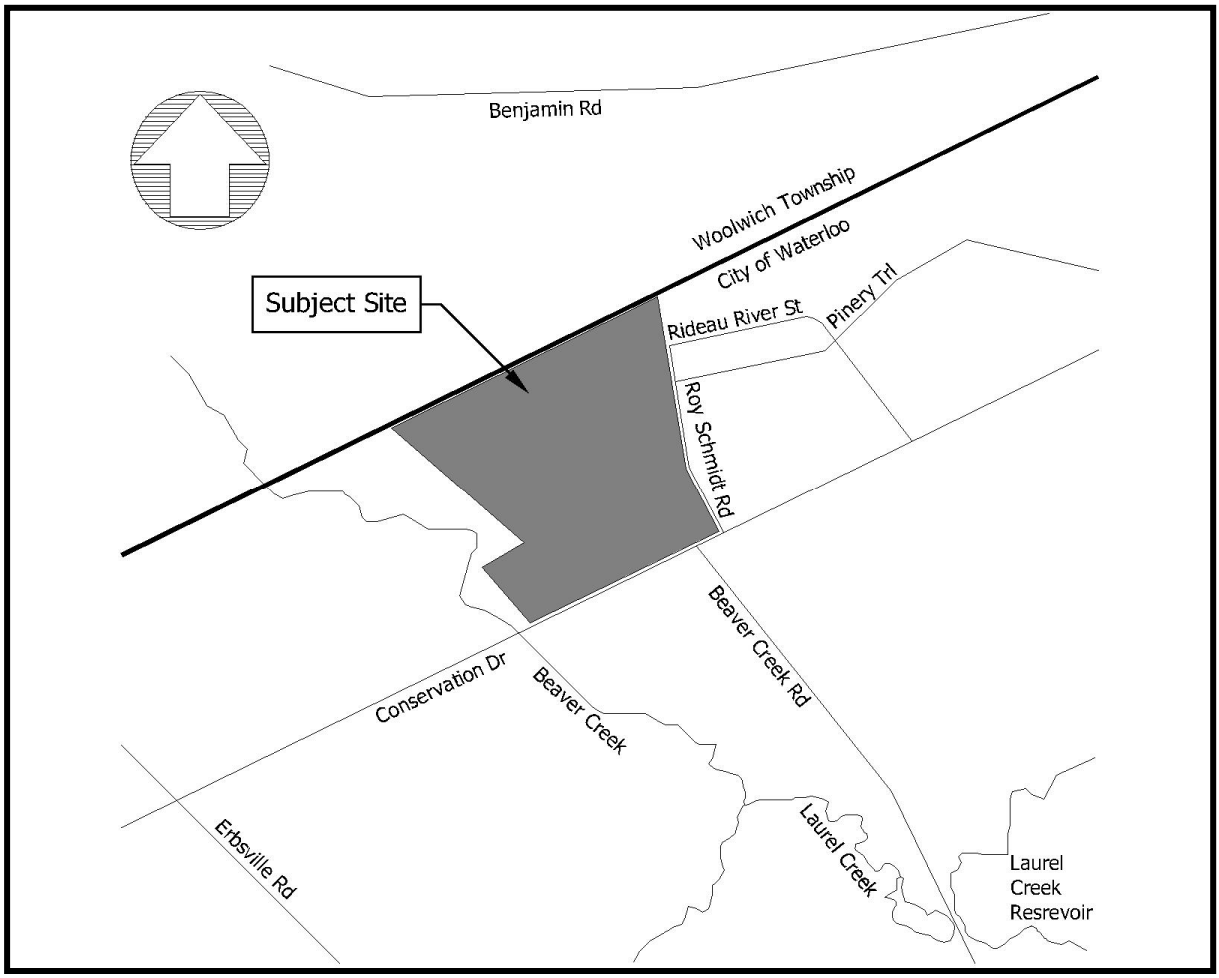


Figure 1: Subdivision Location

Approach

The following flowchart explains a typical submission and approval process. The section highlighted in grey indicates the status of this circulation:

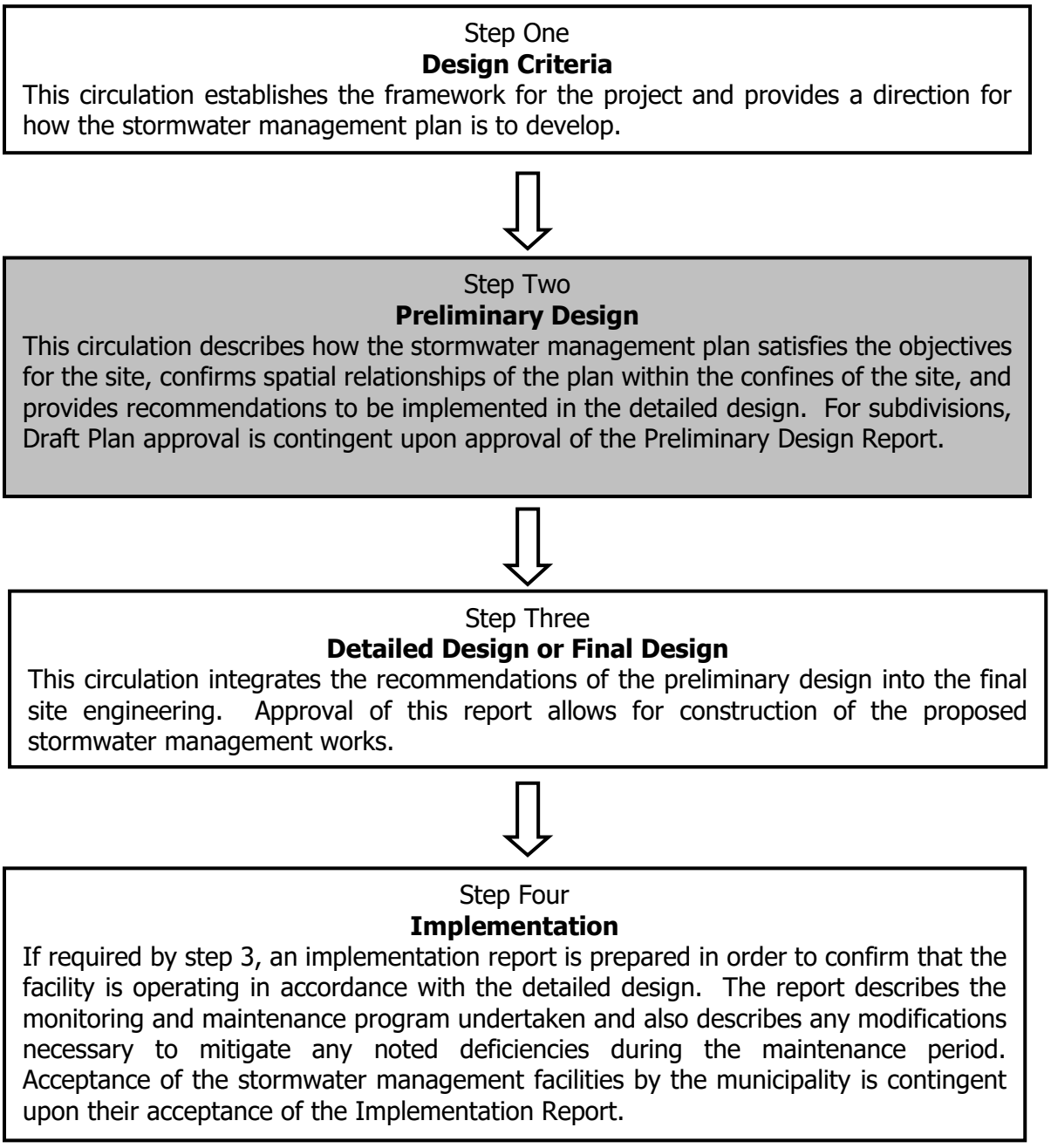


Figure 2: Approach Flowchart

Policy Framework

This chapter outlines the framework upon which the stormwater management plan, which is described in more detail in subsequent chapters, is built upon. Previous studies, municipal and provincial standards, as well as any field investigations undertaken to support the project, are examples of information described in this chapter. This background information is then used to build an appropriate plan for the site. The next chapter, Objectives and Targets, describes the site-specific requirements noted from the following sources:

Planning Documents

City of Waterloo Official Plan, October 2014
The subject lands are designated Low Density Residential with a future mixed-use node shown at the intersection of Conservation Drive and Beaver Creek Road.

City of Waterloo Zoning By-law, August 23, 2012
The subject lands are currently zoned Agricultural.

Beaver Creek Meadows District Plan, January 8, 2015
The District Plan was approved by council on January 25, 2016. It provides detail regarding the design and development of the community. The site is shown as a mix of low density residential, medium density residential, and an elementary school site and is anticipated to be part of the initial phase of development of the community district.

Watershed Plan

Laurel Creek Watershed Study, 1992
This document analyses various elements of the watershed, notably the hydrology and the response to the creek during various rainfall events and recommendations to mitigate flooding. The subject site is within catchments 301 and 310.

Sub-Watershed Plan

North Waterloo Scoped Subwatershed Study (NWSSS), 2013
This document provides technical information to assist in the development of a District Plan, the completion of Class Environmental Assessment processes, and the design of subdivisions. It provides an assumed level of imperviousness on the developed site, development setbacks and buffers, peak flow rates to Beaver Creek, high-level drainage splits, and water balance targets.

MECP Guidelines

Stormwater Management Planning and Design Manual, 2003
This manual provides guidelines on the planning and design of stormwater management facilities in Ontario.

Draft Low Impact Development (LID) Stormwater Management Guidance V. 1, 2017
This manual provides guidance on the planning of stormwater management LID technologies in Ontario. Although it is currently in a draft, it has been reviewed and referenced in order to provide a forward-looking design.

Regional Guidelines

Region of Waterloo and Area Municipalities Design Guidelines and Supplemental Specifications for Municipal Services Guidelines (DGSSMS)
The design portion of this annually-updated document (Part B) is considered as guidelines that provides the municipalities' design preferences under normal circumstances. These guidelines are read together with Municipal guidelines and standards in place.

Municipal Guidelines

City of Waterloo Development Engineering Manual, 2013
This manual provides design guidelines for servicing and grading of subdivisions. It also includes a list of coefficients to be used in modelling of synthetic design storms.

Aesthetic Principles for Storm Water Management, City of Waterloo, 1996
In accordance with accepted practice throughout the Region of Waterloo, this document describes the preferred features to be incorporated into stormwater management facilities in order to achieve aesthetic and functional objectives.

Conservation Authority Guidelines

Greater Golden Horseshoe Area Conservation Authority Erosion & Siltation Control Guideline for Urban Construction, December 2006
This document describes the methodology for determining the erosion potential of a site and the measures that should be undertaken to mitigate construction disturbance.

Environmental Studies

Beaver Creek Road and Conservation Drive Upgrades and Extension of Municipal Service Class Environmental Assessment, Stantec Consulting Ltd., December 14, 2015
The EA has recently been completed and addresses proposed upgrades to Beaver Creek Road and Conservation Drive. Water, storm, sanitary and transportation upgrades are planned adjacent to the subject lands. This report and the detailed design coming from it account for the storm drainage on the eastern half of the property into a separate facility and then to an outlet into Laurel Creek.

An Environmental Impact Study was prepared by NRSI (July 2016). NRSI inventoried and assessed terrestrial and aquatic features that could result in additional site constraints. The SWM design and facility location are proposed in conjunction with input from NRSI as to its appropriateness for the project. Further recommendations from this report guide the site servicing, grading, stormwater management design, and monitoring programs.

Geotechnical Studies

A geotechnical investigation by LVM (March 20, 2015) has revealed that:

- Native soils consist primarily of topsoil overlaying a thick layer of sand with silt being encountered at some locations
- Groundwater is unconfined and generally 3.0 to 6.0m in depth across the site. Groundwater elevations nearer to the existing surface elevation occur near Beaver Creek on the west side of the site
- Infiltration is feasible in areas where the native soils are comprised of sand and sand/silt

Excerpts from the report are included in Appendix F.

Hydrogeological Studies

The North Waterloo, Phase 1 - Groundwater and Surface Water Monitoring Program, prepared by Stantec has been reviewed for co-ordination of the hydrogeology of the site. Updates have been released to include monitoring conducted since the initial release.

Four monitoring wells are on the subject property: MW2, MW3, MW6, and MW7. A summary of key findings are that:

- The water level elevations at these four wells varies seasonally and in response to years of above and below average rainfall
- The wells respond to these climactic factors synchronously (e.g. the water level rises and drops across the site at once)
- There is up to about ±1m variation in seasonally high to seasonally low elevations
- Elevations are highest in the spring and lowest in the late fall/early winter

In section 4.2, the report states that "periods of above average precipitation and groundwater recharge in 2013 and 2014, resulted in higher shallow groundwater levels observed at all monitoring wells than suggested by the 2009/2010 data. The spring groundwater levels were compared to those originally presented in the NWSSS to evaluate the difference in levels." … "spring groundwater levels increased by 0.9 m at MW3-10S and MW7-10, 0.4 m at MW2-10 and 0.5 m at MW6-10." … "In general, the data indicated the potential for shallower groundwater conditions […] than previously expected. Within the northeastern portion of the Site, where an increase in spring groundwater levels of up to 0.9m was predicted, there is a thick unsaturated zone and minimal impact to proposed construction is expected due to this change in peak spring levels."

To date, the seasonally-high elevations at the four monitoring wells are approximately 353.0, 354.9, 352.8, and 354.4 metres. Excerpts from the report are included in Appendix F.

The *Draft Hydrogeological Assessment, 556, 560 and 576 Conservation Drive* report was prepared by Stantec in July 2020. Additional boreholes and monitoring wells were advanced to obtain a better understanding of groundwater elevations throughout the site and ensure infiltration galleries are separated vertically from groundwater. Infiltration testing was completed at the proposed infiltration facility locations to ensure permeability levels are

suitable. This report is undergoing updates; a final version is expected to be available at the detailed design stage.

Pre-Consultation/Design Criteria

Pre-Submission Comments from the Grand River Conservation Authority (GRCA) dated September 14, 2015 have been included in Appendix E. Key input from these comments is included in the following chapter 'Objectives and Targets'. Stormwater management design criteria for the site is guided by targets set in the NWSSS.

Reconnaissance

Meritech staff visited the site on November 17, 2015 in order to verify existing drainage patterns of the site and adjacent properties, to confirm existing infrastructure surrounding the site, and to make note of all aboveground features on neighbouring properties. Drainage from the site is roughly split in half with drainage from the west side going to Beaver Creek and the east side to the south-east towards the Laurel Creek Reservoir.



Figure 3: Existing Conditions Photographs

Review Comments

Comments were received from the following sources in response to the First Functional Engineering Submission and responses have been incorporated into this revised report.

- Grand River Conservation Authority, dated August 11, 2017 – In response to the submission dated July 2016 (Previously responded to as part of a Second Functional Engineering Submission in May 2018)
- City of Waterloo, dated August 31, 2018 – In response to the submission dated May 2018
- Region of Waterloo, dated June 12, 2018 – In response to the submission dated July 2016

Drainage Conditions

Pre-Development Drainage

The site is divided into two major drainage areas (east and west) called catchments 3101 and 3913 in the NWSSS (Figure 6.3, Secondary Study Area Catchments). Under existing (pre-development) conditions, the east catchment drains south to the Laurel Creek Reservoir across the Conservation Drive right of way and along the Beaver Creek Road right of way, whereas the west catchment reaches Beaver Creek via an existing wetland.

Post-development Drainage

Under post-development conditions, the existing drainage patterns are generally preserved. To mitigate the impact of the proposed development on pre-development hydrology and the downstream environment, a comprehensive stormwater management (SWM) plan based on a treatment train approach is proposed; the proposed SWM plan is discussed in detail in the following sections of this report.

SWM Design Strategy

This chapter describes the design criteria and constraints considered to develop the SWM strategy proposed to address the stormwater management concerns associated with development. In each section, a brief commentary on the application of these requirements to this project is provided, along with their associated objectives and targets. In the next chapter, Proposed Stormwater Management Plan, a more complete description is provided for how these objectives will be achieved.

The proposed stormwater management features follow the recommendations included in the subwatershed study (NWSSS)'s "Preliminary Screening of Stormwater Management Practices" shown in Table 11.1 as well as the Recommended Stormwater Management Strategy, section 11.5, of the NWSSS.

The NWSSS provides general, high-level objectives to incorporate into the SWM treatment train design for developments within the study area as follows:

- At-source LID measures and other best management practices focused on recharge to groundwater
- Conveyance LID focused on quality enhancement and recharge to groundwater
- End-of-pipe facilities focused on water quantity control and water quality enhancement
- Temperature mitigation through subterranean infiltration features where applicable

Additional considerations include:

- Rainfall data
- Environmental constraints
- Groundwater conditions
- Baseflow and erosion potential
- Sediment control requirements
- Winter conditions
- Hydrological modelling
- Minor and major drainage routing

The above criteria were taken into consideration in the design of the proposed SWM plan described in detail the following sections of this report. A qualitative assessment of the best management practices discussed in this report is presented in Table 1. The last two columns indicate whether or not the listed control is proposed in the stormwater management solution, along with a commentary of its suitability to this project.

	Water Quantity	Water Quality	Erosion	Infiltration	Incl. In Plan?	Comments
Source Controls						
Bioretention	L	H	H	H	N	Soils suitable for infiltration
Bioretention Planters	L	M	M	M	N	
Control of Foundation Drains	L	M	M	M/H	Y	To CWC system
Control of Roof Leaders	L	M	M	M/H	Y	To CWC system
Green Roofs	L	M	M	L	TBD	Possibly on future school
Infiltration Trench	L	H	M	H	Y	Perimeter lots
Flat Lot Grading	L	M	M	M/H	N	Municipal criteria
Natural Buffer Strips	L	M	M	H	TBD	Possibly within park/school blocks
Parking Lot Storage	H	L	L	L	TBD	Possibly on future school, commercial lands
Permeable Pavement	M	M	M	M	TBD	
Prefabricated Modules	L	H	H	H	TBD	
Rainwater Harvesting	L	L	M	L	TBD	
Rooftop Gardens	L	M	M	H	TBD	
Rooftop Storage	H	L	L	L	TBD	Possibly on future school, commercial lands
Soil Amendments	L	M	M	M	Y	Increased topsoil depths for initial abstraction
Soak Away Pits/Infiltration Chambers	M	M	M	M	N	Infiltration trenches and CWC preferred
Superpipe Storage	H	L	L	L	N	Not required
Vegetative Filter Strips	L	M/H	M/H	H	TBD	Possibly within park/school blocks
Conveyance Controls						
Bioswales	L	H	H	H	N	
Filters	L	H	L	L	N	
Grassed Swales	L/M	M/H	M/H	H	Y	
Pervious Catchbasins	L	M	M	H	N	
Pervious Pipe System	L	H	M/H	H	Y	Clean roof runoff only
Oil / Grit Separator	L	M	L	L	N	Forebay preferred
Underground Storage	H	H	H	L		
End of Pipe Controls						
Constructed Wetland	H	H	H	L	Y	c/w infiltration trench
Dry Pond	H	L/M	H	L	N	Wetland preferred
Hybrid Facilities	H	H	H	L	N	Wetland preferred
Infiltration Pond	L	H	M	M	Y	Wetland to infiltration
Sediment Forebay	L	H	M	L	Y	Included
Wet Pond	H	H	H	L	N	Wetland preferred

Table 1: Selection of Stormwater Management Practices
(Compiled from 2003 MOE Manual & Draft 2017 MOECC LID Manual)

Treatment Train Approach

Quantity

Development of land from rural to urban causes an increase in runoff due to the increase in impervious cover. Additionally, the increased runoff flows faster to receiving watercourses, which combined with other developed sites, may cause downstream flooding. It is, therefore, usual to provide either on-site or regional "holding" areas that act to contain the increased runoff and discharge it over a longer period of time while not exceeding the targeted peak flow.

Target unit flow rates were taken from the NWSSS for the lands flowing to Beaver Creek and are provided in Section 5.1.2 "Allowable Discharge Flow Rates" of this report. The contributing area is defined in the NWSSS as the pre-development catchments.

There are no quantity requirements for the lands flowing southeast, as the NWSSS has determined that the Laurel Creek Reservoir will attenuate flows satisfactorily. This runoff will have quality control through a facility south of Conservation Drive. Storm sewers are to be sized (at a minimum) for a 5-year storm event and major flows will be via the road network as surface flows. The drainage divide is shown on Figure 11.1 of the NWSSS and is included in Appendix B.

The MECP suggests that newly developing sites meet the Runoff Volume Control Target (RVC_T) as a minimum requirement for runoff retention. This value, established geographically through 90th percentile rainfall values across Ontario, is 29mm for the site.

Peak flow rate reduction, in addition to the RVC_T can be achieved with the use of infiltration, if the site conditions permit for such design components. When infiltration methods can be used, stormwater can be directed through the site to areas with high infiltration potential. This can be beneficial for the receiving watercourse by reducing both runoff flow rates and runoff volumes.

Quality

Water quality control is provided for several reasons, including sediment and contaminant (chemical) removal. It is now standard practice to incorporate water quality treatment into the design of any stormwater management facility. This often includes:

- Pre-treatment (for example, grassed swales)
- Treatment (for example, sediment forebay/permanent pool)
- Enhancement (for example, extended detention)

The MOECC (MECP) Draft LID Manual considers enhanced water quality (80% suspended solids removal) to be achieved if contributing drainage areas can achieve the RVC_T. The NWSSS requires enhanced water quality for all developing areas of the site. Additionally, the MOE Planning & Design Manual recommends an extended detention time of 24 hours for the design quality storm to increase settling time.

The NWSSS specifies parameters for quality control, in Beaver Creek itself:

- Temperature targets not to exceed 22°C from April 1 to October 31st and between 4°C and 14°C from November 1 to March 31st in stream,
- Dissolved Oxygen target of 5 mg/L in stream,
- Phosphorus target of 0.03mg/L in stream,
- Sediment target concentration of 25mg/L in stream,
- Bacteria target based on Provincial Water Quality Objectives of 100 CFU/100ml in stream.

Water Balance

Increased development can produce an adverse effect on the natural water cycle through decreased groundwater recharge. The increase in impervious cover prevents water from soaking into the ground. Cumulatively, these minor losses can cause significant loss to the groundwater regime. Analysis of these impacts, in the form of a water budget, is sometimes undertaken with the intent of designing appropriate mechanisms for recharge.

In accordance with the NWSSS the existing infiltration rates should be maintained or increased to ensure there is no reduction in base flow to Laurel Creek or Beaver Creek, no change in existing aquifer recharge, and no disruption in the pattern of groundwater recharge. The native soils are generally described as sand/silt deposits. Therefore, opportunity to promote infiltration and groundwater recharge exists and should be pursued by the proposed design.

Hydrological Modelling

The anticipated performance of the proposed SWM measures with respect to the design objectives is to be simulated using single-event MIDUSS models and hand calculations in accordance with the guidelines provided by the NWSSS. This level of detail is deemed appropriate to demonstrate the feasibility of the proposed design for the purposes of Draft Plan Approval. The proposed design will be validated at the detailed design stage by means of a continuous model based on the NWSSS rain data set.

Rainfall Data

The NWSSS requires that detailed design for the individual stormwater management facilities is to use an event based assessment using both the 24-hour SCS data from the Guelph Arboretum as well as the City of Waterloo 3-hour Chicago data with the most conservative result incorporated into the design. Thus, both sets of rainfall parameters have been used. The NWSSS states that the 2-year through the regional storm events are to be modeled. The regional event is the worst-case of either the 100-year event or the 48-hour Hurricane Hazel event. Table 2 has the design parameters, including storm coefficients, rainfall intensities and rainfall depths, and Appendix C has information on the Hurricane Hazel storm.

Storm Event	Definition	a	b	c	I (mm/hr)	D (mm)
City of Waterloo						
2-year, 4 hour	Design quality	1101	9.258	0.882	101.723	33.885
5-year, 3 hour	Minor system	1755	12.347	0.895	136.512	47.549
100-year, 3 hour	Major system	4692	17.437	0.956	239.793	89.960
Guelph Arboretum						
2-year, 24 hour	Design quality	583.44	3.561	0.783	104.048	47.029
5-year, 24 hour	Minor system	956.51	5.608	0.815	133.887	61.018
100-year, 24 hour	Major system	2221.21	9.093	0.866	216.370	97.564

Table 2: Coefficients for Synthetic Design Storms

Environmental Constraints

A 30m buffer from the wetland to the west is described in NRSI's report. The SWM facility is proposed to extend within this buffer and has been justified in the Environmental Impact Study as appropriate. It will provide for a further buffer from human intrusion as well as opportunity to spread the infiltration over the buffer area. Limited grading can occur between the 15m and 30m buffer limits, in accordance with recommendations in the NWSSS and the Environmental Impact Study. This allows for grading for the SWM pond to be located within the first 15m of the buffer. Maintained or increased groundwater flows to the wetland are recommended for a water balance. It also recommends quantity, quality, and Sediment and Erosion Control measures to be in accordance with the NWSSS.

Groundwater Conditions

Groundwater information has been provided in the geotechnical report and the NWSSS. The NWSSS, Figure 5.23, shows groundwater at elevations of 354 to 350 metres draining from east to west, towards Beaver Creek. The geotechnical report reports groundwater occurring in unconfined water table conditions at depths generally between 3.0 to 6.0 metres across the site, at elevations between 351 and 354 metres. Groundwater elevations are nearer to the existing ground surface on the west side of the site, directly adjacent to Beaver Creek and the surrounding wetlands.

The site is located within Wellhead Protection Area 'D' and therefore there are no restrictions on the type, scale or location of proposed infiltration measures.

Baseflow and Channel Erosion

Changes to land use can cause impacts on receiving watercourses, including erosion or a change to the baseflow. While erosion is a natural and important phenomenon, analysis of the potential erosion of the receiving watercourse is sometimes necessary.

Section 10.3 of the NWSSS states that the baseflow and low temperature of Beaver Creek are able to be maintained by ensuring existing infiltration rates are sustained. At-source control methods are described as being preferable, in order to maintain the spatial distribution of infiltration.

Erosion potential of Beaver Creek was addressed in the NWSSS. Existing conditions, as it relates to stream erosion, will be maintained or improved by achieving the peak flow targets outlined in the quantity requirements as the creek was deemed stable in its existing condition. SWM plans are to incorporate a treatment train approach including at-source infiltration, conveyance infiltration, and end of pipe facilities.

Site Erosion and Sedimentation Control

Without proper controls, construction activities can cause erosion of disturbed land by either water (alluvial) or wind (aeolian) action. Eroded soil can then be transported off the construction site to environmentally sensitive areas. However, with proper planning of construction activities, along with a concerted effort to install and maintain siltation/erosion control measures, the potential for damage is minimized. The Environmental Impact Study and the NWSSS recommend best management practices for erosion and sediment control during construction including timing of works, restricted access to buffer areas, silt ponds, steep slope stabilization, rock check dams in swales, timely revegetation and fencing along with inspection and monitoring. The plan should consider the need for wildlife movement if necessary.

Winter Conditions

The operation of the SWM system in the winter will be based on the criteria established by the NWSSS, which requires that winter runoff shall bypass end-of-pipe infiltration facilities to avoid large concentrations of chlorides reaching the downstream waters in the winter. As the surface receiver of the SWM facility is also Beaver Creek, a winter bypass is potentially unneeded.

Should the stormwater management facility outlet become clogged or frozen in winter conditions, the facility will overflow away from the development via the overflow weir toward Beaver Creek to the west. In order to protect lots backing on to the SWM block, the rear lot corners and proposed basement elevations have been set above the freeboard elevation.

Minor and Major Flow Routing

Routing of minor and major flows within the proposed development will be in accordance with sound engineering practice and the stipulations of the NWSSS, which require a catchment-specific approach. Details about the proposed minor/major routing are provided in the following sections of this report.

Proposed Stormwater Management Plan

From the background information and criteria presented in previous chapters, an appropriate stormwater management plan was developed. This chapter describes the project-specific stormwater plan in detail.

The suitability of the best management practices described in the previous section was assessed with the benefit of detailed hydrogeological studies, topographic survey and hydrological modelling tools. The resulting SWM plan is based on a comprehensive treatment train plan that includes at-source, conveyance, and end-of-pipe best management practices designed to meet the design criteria established in the previous section. The proposed SWM treatment train is illustrated in Figure 4.

The development is comprised of two catchments within the North Waterloo Scoped Subwatershed Study (NWSSS) and therefore has a drainage divide, two separate outlet locations, and two stormwater management solutions.

At-source and conveyance systems for infiltration are proposed to be implemented throughout the site. These include infiltration trenches, amended topsoil, and a clean water collection (CWC) system within the road rights of way that will infiltrate clean roof runoff.

The east side of the site and lands north of it (Catchment 3105 in the NWSSS) will outlet to proposed infrastructure south of the intersection of Conservation Drive and Beaver Creek Road, and it will be necessary to provide peak flow rates to ensure the proposed infrastructure is designed with sufficient capacity. The minor flow conveyance will be through the storm sewer system and the major storm conveyance will be along the roads. Quantity control for the catchment discharging to Laurel Creek is not required in accordance with the NWSSS. Quality control for this portion of the development is to be incorporated into a pond on a downstream property and will be designed and addressed in a separate stormwater management report. This design is being undertaken by others as part of a comprehensive, shared SWM solution for multiple landowners.

The west side of the site was developed along guidelines of the Control Hierarchy Approach of the Draft LID Manual (Priorities 1, 2 and 3). Priority 1 components of this stormwater management design consist of low impact development and Best Management Practices (BMPs) focused on flow retention. These are comprised of amended topsoil, rear-yard infiltration galleries, and roof leader and sump discharge to a clean-water-collector (CWC) system for infiltration.

Priority 2 components primarily detain and release stormwater at a controlled rate to promote evapotranspiration and infiltration, while providing filtered treatment to meet municipal standards. Priority 3 controls include end-of-pipe sedimentation and quantity control.

For this project Priority 2 strategies were not employed, and a stormwater management wetland was used as a Priority 3 component. The facility is designed with a sediment forebay and wetland cell. The minor (5-year) storm event is directed to the forebay, with major storms directed to the wetland cell. The facility is proposed to outlet to an infiltration system

to allow for cooling, and increased infiltration per the NWSSS. This constructed wetland will discharge to Beaver Creek and includes the following:

- A central location, with easy access, for sediment removal
- Extended detention water quality treatment
- Flood control up to the Regional storm event, matching flows provided in the subwatershed study
- A "baseflow" component (extended detention drawdown)
- An aesthetically pleasing facility designed to blend into surrounding lands and trails
- Easily maintainable and accessible inlets and outlets

Proposed SWM Treatment Train

The anticipated performance of the proposed SWM treatment train with respect to the design objectives established in the previous section of this report is described below.

Quantity

As presented in the NWSSS Figure 11.1, the drainage divide for the site is approximately through the centre of the property, with Catchment 3913 being 11.0ha and 3107 being 13.0ha in that study's proposed condition. The intent of this current design was to generally reflect that divide. The divide can be seen in Figure 7 of this report and basically divides the school property in half, with the eastern and southern portions discharging to the Laurel Creek Reservoir and the western portion discharging to Beaver Creek. The Runoff Volume Control Target (RVC_T) recommended by the MOECC's Draft 2017 LID Stormwater Management Design Guidance Manual is 29mm but the NWSSS requirements will be used to guide the design.

Allowable Discharge Flow Rates

The NWSSS has provided target flow rates for this site. The allowable flow was calculated for catchment 3913 (12.3ha) including the 0.85 hectares outside of the subdivision to the northwest (Brohman Lands).

- 2-year 1.1 L/s/ha x 12.3ha = 13.5L/s or 0.014m³/s
- 5-year 10 L/s/ha x 12.3ha = 123L/s or 0.123m³/s
- 100-year 55 L/s/ha x 12.3ha = 676.5L/s or 0.677m³/s
- Regional Proposed is 1.344m³/s for entire catchment

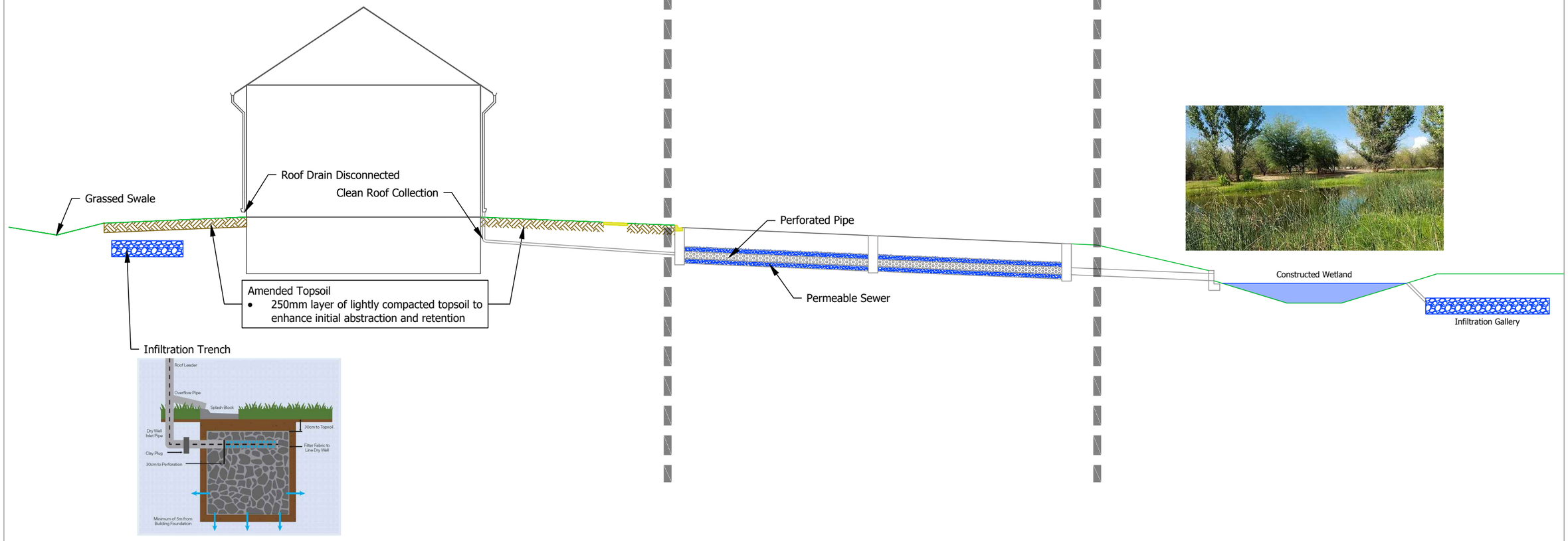
The NWSSS has determined that the Laurel Creek Reservoir will attenuate flows from the east half of the subdivision satisfactorily; additional attenuation is not required.

Stormwater Management Treatment Train

Source

Conveyance

End-Of-Pipe



Quality

Infiltration systems have been incorporated into the design to meet water balance, and quality control targets as specified by the NWSSS. The site was designed to meet the "Enhanced" level of water quality control by implementing a sediment forebay for the design quality (2-year) storm event in the stormwater management block. Implementing lot-level infiltration and reduced lot grading can be incorporated into the detailed design to further enhance opportunities for objectives for sedimentation, temperature, and infiltration. The site was designed to meet the "Enhanced" level of water quality control by implementing a sediment forebay and extended detention.

Best management practices (BMPs) including lot-level infiltration, reduced lot grading, soil amendments, and a third-pipe (clean water collection) system were implemented as Priority 1 BMPs for this development. These components are considered best strategies to deal with stormwater as they increase the ability for infiltration and evapotranspiration of rainfall where it lands, which reduces loading on municipal storm sewers and end-of-pipe stormwater management facilities. They were selected to maintain a water balance for the development on a distributed, site-wide level.

Priority 2 & 3 measures were combined within the end-of-pipe wetland pond facility. The facility treats runoff for sedimentation control and includes extended detention of the design quality storm which promotes increased infiltration and evapotranspiration through the wetland plantings, in addition to reducing erosion impacts to the Beaver Creek wetland system. Additional Priority 2 measures are not proposed as infiltration levels are achieved with Priority 1 measures, and detention and release measures can be adequately achieved within the Priority 3 stormwater management facility.

The proposed end-of-pipe facility includes a sediment forebay designed in accordance with the Aesthetic Design Principles for Storm Water Management Facilities in the Region of Waterloo, and Ministry of the Environment guidelines. The forebay blends into the proposed maintenance access route. The forebay design calculations are included in Appendix C.

Extended Detention

The end-of-pipe facility includes a wetland pond designed in accordance with Table 3.2 of the 2003 MOE (MECP) Planning & Design Manual to ensure that quality control conditions could be met. Based on an "Enhanced" level of protection and an imperviousness of 60%, the following volumes are required for the forebay and wetland:

Contributing Area (ha)	Permanent Pool Required (m^3/ha)	Permanent Pool Required (m^3)	Permanent Pool Provided (m^3)	Extended Detention Required (m^3/ha)	Extended Detention Required (m^3)	Extended Detention Provided (m^3)
11.416	70	800	1,283	40	457	1,852

Table 3: Water Quality Storage Requirements

The contributing area is the sum of all areas draining to the wetland. The "extended detention provided" shown in Table 3 is defined as the active storage in the design quality (2-year) storm event; the smaller of the two volumes from the two storm models is shown. Figure 5 shows the inflow and outflow to the pond for the design quality storm. The inflow hydrograph, as shown, is attenuated by the outlet control structure resulting in a longer drawdown time at a lower peak flow. The result is that runoff is retained in the pond over the recommended 24-hour period in order to enhance water quality. The orifice flow to Beaver Creek drops to 1 L/s 92 hours (3.8 days) after the storm event due to the limited outflow.

The outlet orifice to the level spreader is 0.2m above the outlet of the pond to the infiltration gallery, therefore the first 615m³ of storage will outlet to infiltration rather than the creek. This volume is greater than the required extended detention volume.

MIDUSS modeling was completed to show that, should a storm event take place before the infiltration system has drawn down the first 0.2m of live storage, 24 hours of extended detention will be provided. The MOE's requirement for 40m³/ha of extended detention results in 457m³ of extended detention required; the facility provides about four times more, due to the pond's size – driven by the quantity control requirements. The MECP requires confirmation that this smaller volume also draws down over a time of greater than 24 hours. MIDUSS modeling shows that the detention time for a storage volume of 457m³ is 45 hours; the peak outflow rate if only 457m³ is stored is 5 L/s.

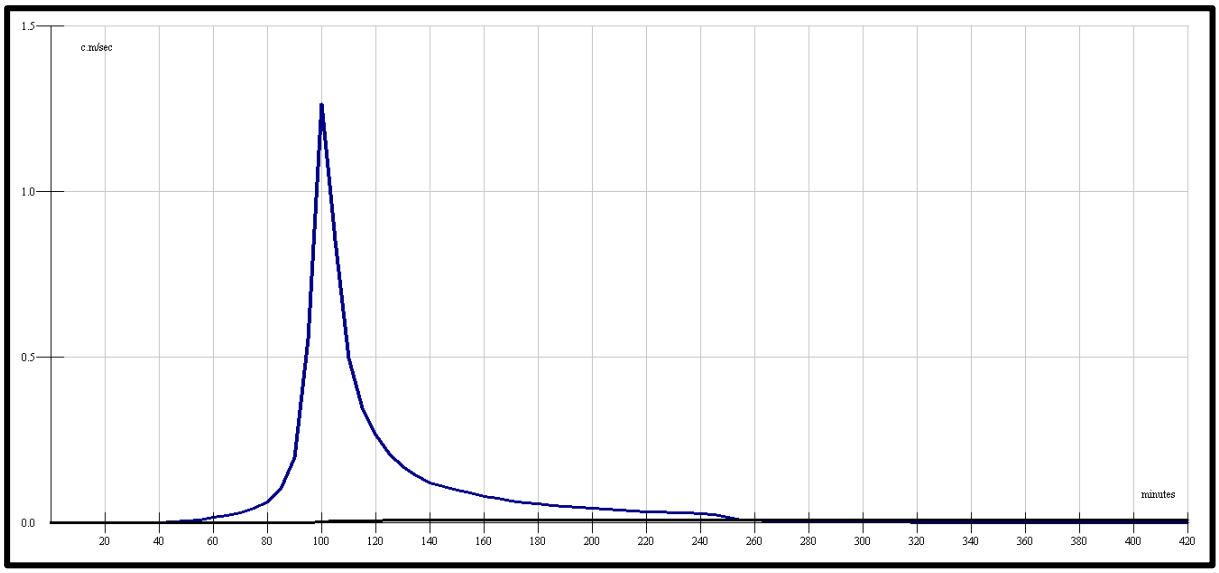


Figure 5: Drawdown of the Proposed Pond, 2-Year 3-hour Storm Event

Water Balance

A water balance is described as the water flowing in and out of a system. In this application, water flowing into the system includes precipitation or irrigation, whereas water flowing out of the system includes runoff, evapotranspiration, and infiltration. A water balance is required to minimize changes to the current equalized water balance for a site.

This section examines the proposed and post-development infiltration occurring on the site. The two key points are the average annual infiltration volume and the directionality of the groundwater flow. Taken together, these factors will influence how the post-development infiltration plan has been designed.

A water balance can be provided through a combination of lot-level soak away pits, a clean water collector "third pipe" system, and an end-of-pipe infiltrating facility.

Recharge to Groundwater Target

The NWSSS presents proposed recharge to groundwater (infiltration) targets for the subdivision, as included below in Table 4.

Description	NWSSS Catchment #	Area (ha)	Infiltration Rate (mm/yr)	Annual Infiltration (m^3/yr)
East part of site	3107	11.6	281.6	32,606
West part of site	3913	11.8	265.2	31,283
Total		23.3		63,889

Table 4: Target Infiltration

The hydrogeological study conducted by Stantec concluded that this site could potentially be supplying baseflow to Laurel Creek and its associated wetland features. It was also concluded that groundwater levels generally remained consistent with what is reported in the NWSSS. Groundwater table elevations are highest in the spring and lowest in the fall/early winter. Groundwater table levels were also determined to respond synchronically to climatic factors between locations across the site.

Post-Development Infiltration

Matching or exceeding the annual pre-development infiltration volume can be accomplished through a mix of lot-level, conveyance, and end-of-pipe infiltration measures, which was used to develop the infiltration targets. The design of these measures will be further developed within the detailed design phase. The City of Waterloo's Engineering Group has been consulted on the types of facilities to be placed in the public right-of-way, and some guidance has been provided regarding the recently-installed clean water collector (CWC) system in the nearby Vista Hills subdivision.

Lot-level infiltration is proposed to consist of naturally-occurring infiltration on pervious surfaces (predominantly grass yards combined with increased topsoil depths), with several small catchments also employing infiltration galleries where grading doesn't allow connection to municipal sewers. Within these catchments, roof leaders directed to side-yard swales and grassed areas enables infiltration of this water ("roof leader disconnection" as shown on Figure 4). Direct connection to soak away pits or infiltration trenches can be incorporated as well. The majority of the proposed infiltration is to be accomplished though the use of a "third pipe"

is suggested in the NWSSS as a tool to infiltrate clean roof runoff and sump pump discharge within the rights-of-way.

The foundation drain for each house should discharge to a sump in the basement and pumped over the foundation wall before being directed with a storm service to the CWC system at the street or to the storm sewer where no CWC system is installed. Downspouts will connect to the storm service and CWC system where it is available and discharge to grade in order to promote infiltration where no CWC system is installed.

Multiple lot-level infiltration facilities are proposed, as shown on the Conceptual Servicing Plan in Appendix B. The 2-year, 24-hour runoff depth was modelled to be 29mm, which is greater than the RVC_T for the catchments where infiltration galleries are proposed:

- Southwest corner, 2-year runoff volume of 77m³ (catchments 504)
- Northwest corner, 2-year runoff volume of 263m³ (catchment 505)
- School site, all roof runoff to infiltration (29mm runoff depth in accordance with the RVC_T for the future site plan application for that site)

Finally, within the end-of-pipe SWM facility an infiltration trench will be installed to infiltrate the first 0.2m of live storage in the pond. This volume of 615m³ is approximately 25mm of runoff from the impervious surfaces (less roofs) from the contributing Catchment 701. This is greater than the 5mm of runoff from the contributing catchment area that was recommended by the NWSSS.

The estimated annual post-development infiltration volumes are summarized in Table 5. Refer to hand calculations in Appendix C.

Description	Catchment #	Area (ha)	Infiltration Rate (mm/yr)	Annual Infiltration (m³/yr)
Pervious areas	All	A_P=9.61	272 (average)	26,116
School roof to infiltration	502	Approx. 50,000ft²	90% of total rainfall	3,421
Infiltration galleries	504, 505	A=1.23	90% of runoff	2,573
Conveyance (CWC)	503, 701	Roofs=4.45	90% of total rainfall	33,804
End-of-pipe	701	A_I=2.42	88% of total rainfall	18,015

Table 5: Post-Development Infiltration

Table 6 shows that a third-pipe system, an end-of-pipe system, and lot-level infiltration measures are able to meet and exceed the post-development infiltration target by approximately 30%.

Condition		Annual infiltration (m^3/yr)
Target		**63,889**
Post-development	Pervious areas and galleries **Plus** conveyance CWC **Plus** end-of-pipe infiltration	32,110 65,914 **83,929**

Table 6: Pre- to Post-Development Infiltration Comparison

Hydrologic Modelling

Hydrologic modelling was performed using MIDUSS software, which is a Class A Model widely accepted for urban developments, and used for many years in the Region of Waterloo. Models were created for the desired 2-year through 100-year design storms as well as the 48-hour Hurricane Hazel storm.

Catchment Numbering Convention

The following catchment number convention was used to identify the characteristics of each catchment:

Description:			Catchment #
Existing	Internal	Uncontrolled	100
Existing	External	Uncontrolled	200
Existing	Internal	Controlled	300
Existing	External	Controlled	400
Proposed	Internal	Uncontrolled	500
Proposed	External	Uncontrolled	600
Proposed	Internal	Controlled	700
Proposed	External	Controlled	800

Table 7: Catchment Naming Convention

Post-Development Hydrology

Increasing the site to 60% imperviousness with no attenuation methods would result in additional flows to the Beaver Creek. Post-development catchments incorporate the routing of the minor and major storm systems to the proposed stormwater management facility. Figure 7 shows the catchment areas for the proposed project, and Figure 8 shows the routing used in the model. Suitable modelling parameters were selected for each catchment, as presented in Table 8. The percentage impervious values were selected based on a comparison with standard coefficients used in the Rational Method, using the formula:

$$C = 0.14 + (0.65 \times \%imp) + (0.05 \times S)$$

where %imp = percent impervious (e.g. 60%), and

S = slope in percent (e.g. 2).

For example, a catchment of 60% impervious results in a rational design coefficient of 0.63, which is representative of this type of development. The SCS curve number soil parameters shown represent the pervious fraction of runoff.

Catchment	Area (ha)			Imper-vious	Slope Length	Slope Gradient	SCS CN	Uncontrolled Peak Flow (m^3/s)	
	Controlled	Uncontrolled	Total	(%)	(m)	(%)	(perv)	2-year	100-year
501		0.469	0.469	60	15	3	74	0.068	0.178
502		1.986	1.986	50	30	3	74	0.228	0.623
503		9.124	9.124	70	15	3	74	1.530	3.922
504		0.332	0.332	40	15	3	74	0.033	0.093
505		0.898	0.898	60	15	3	74	0.130	0.341
601		3.500	3.500	0	90	2	61	0.009	0.234
602		0.400	0.400	60	15	3	74	0.058	0.152
701	7.343		7.343	60	15	3	74	1.063	2.792
702	0.770		0.770	30	90	3	74	0.054	0.181
703	1.343		1.343	10	80	3	74	0.029	0.193
704	1.110		1.110	60	15	0.5	74	0.154	0.453
801	0.850		0.850	60	15	3	74	0.123	0.323
Total	11.416	16.709	28.125						

Table 8: Post-Development Modelling Parameters

The resultant uncontrolled peak flows from each catchment are summarized in Table 8. The Guelph Arboretum 24-hour storm was the most conservative for the 2-year event and Waterloo 3-hour rainfall for the 100-year was conservative; these are the values represented in Table 8. Refer to the MIDUSS modelling results in Appendix D for further information.

Performance of the End-of-Pipe System

The pond configuration and outlet control structure, Figure 9, combine to satisfy the various objectives, such as peak flow attenuation of post-development conditions to allowable rates, and extended detention of the design quality storm. For wetlands, the MOE SWM Planning & Design Manual recommends a detention time of at least 24 hours.

Pond volumes were calculated using the "average end area" method based on the areas for each contour. The resulting stage-storage characteristics of both the forebay and wetland cells are summarized in Table 9. The forebay is sized for the 5-year flow pipe capacity entering the forebay. Major flows will be directed to a low point in the road coincident with the maintenance road and will flow directly into the wetland cell to prevent re-suspension of sediment.

The outlet structure consists of an 90mm diameter orifice designed for the 2-year outflows, twin 525mm diameter overflow culverts, and a concrete weir that allow outflow in larger storm events. The first 0.2m of ponding will be directed to an infiltration gallery located under the banks of the pond. The outlet structure provides for easy maintenance, inspection and good distribution of the infiltrating water.

Elev.	Depth	Description	Discharge	Volumes			
			Total	Area	Incr. Vol.	Dead Stor.	Live Stor.
(m)	(m)		(m^3/s)	(m^2)	(m^3)	(m^3)	(m^3)
Constructed Wetland							
352.9	-0.3	Bottom		2,386			
353.0	-0.2			2,546	247	247	
353.1	-0.1			2,707	263	509	
353.2	0.0	**Permanent Pool**	0.000	2,937	282	791	0
353.3	0.1		0.000	3,077	301		301
353.4	0.2	Outlet Orifice	0.000	3,218	315		615
353.5	0.3		0.004	3,361	329		944
353.6	0.4		0.007	3,505	343		1,288
353.7	0.5		0.009	3,651	358		1,645
353.8	0.6		0.010	3,798	372		2,018
353.9	0.7		0.012	5,263	453		2,471
354.0	0.8	Culverts	0.013	5,427	535		3,006
354.1	0.9		0.027	5,594	551		3,557
354.2	1.0		0.066	5,761	568		4,124
354.3	1.1		0.124	5,930	585		4,709
354.4	1.2		0.198	6,101	602		5,310
354.5	1.3		0.282	6,258	618		5,928
354.6	1.4		0.372	6,414	634		6,562
354.7	1.5	Concrete Weir	0.462	6,573	649		7,211
354.8	1.6		0.562	6,732	665		7,877
354.9	1.7		0.677	6,893	681		8,558
355.0	1.8		0.810	7,057	698		9,255
355.1	1.9		0.965	7,224	714		9,969
355.2	2.0	Max ponding	1.144	7,401	731		10,701
355.3	2.1		1.353	7,588	749		11,450
355.4	2.2		1.595	7,773	768		12,218
355.5	2.3	Freeboard	1.872	7,954	786		13,004
Forebay							
352.3	-1.5	Bottom		156	0	0	
352.6	-1.2			210	55	55	
352.9	-0.9			270	72	127	
353.2	-0.6			335	91	218	
353.5	-0.3			454	118	336	
353.8	0.0	**Permanent Pool**		587	156	492	

Table 9: Stage Storage Discharge for Forebay and Constructed Wetland

Table 10 summarizes the overall performance of the pond, including storage volumes of the various storm events and peak discharge rates.

Description	Rainfall Parameters	Elevation (m)	Depth (m)	Volume (m^3)	Discharge (m^3/s)
Permanent pool		353.20	0.0	0	0
Live storage to infiltration		353.40	0.20	615	0
2-year ponding	Waterloo Guelph	353.90 354.00	0.70 0.80	2,473 2,998	0.012 0.013
5-year ponding	Waterloo Guelph	354.10 354.13	0.90 0.93	3,537 3,705	0.027 0.037
100-year ponding	Waterloo Guelph	354.53 354.44	1.33 1.24	6,144 5,562	0.312 0.232
Hurricane Hazel ponding	-	355.16	1.96	10,420	1.075
Maximum ponding		355.20	2.00	10,701	1.204
Freeboard		355.50	2.30	13,004	1.922

Table 10: Pond Performance Summary

The runoff from catchments 504 and 505 is directed to infiltration for flows up to the 2-year storm event with additional runoff overflowing towards the Beaver Creek wetlands. As these catchments are rear-yards and roofs, the runoff is clean, and quality control is not required. Figure 6 shows how these hydrographs are modeled in MIDUSS. The red shaded area represents the volume of the 2-year runoff that will be infiltrated.

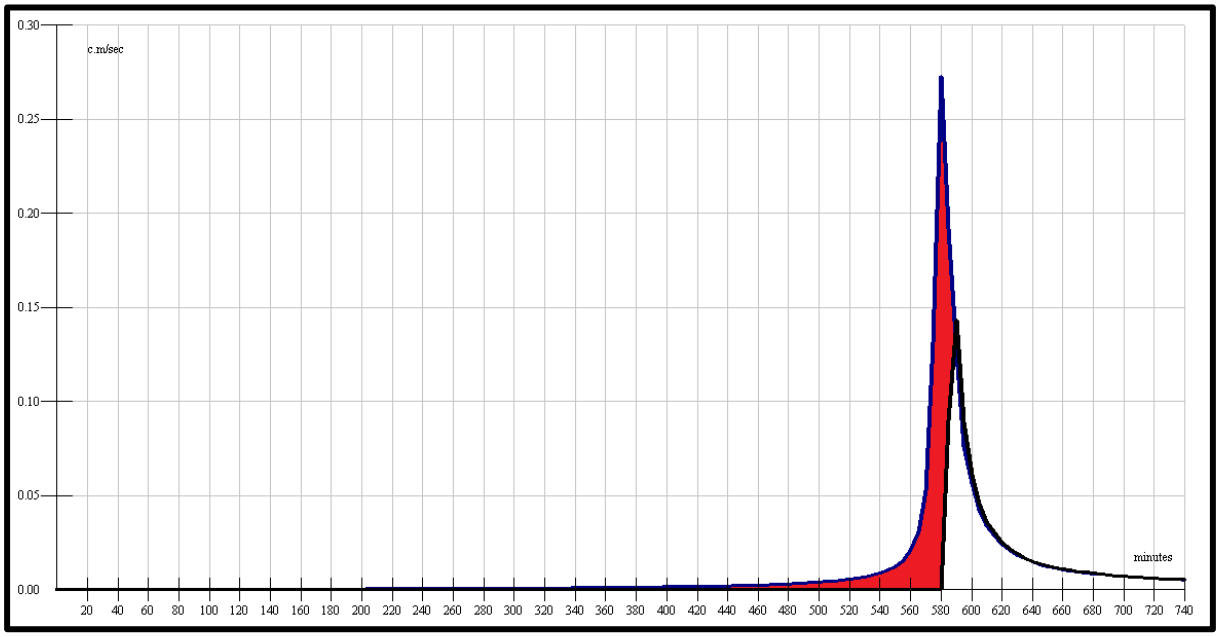


Figure 6: Infiltration Gallery Modeling

Table 11 presents the total peak flows towards Beaver Creek (SWM facility outflow plus outflows from catchments 504-506) for the range of design storms. Catchments 504 and 505 are composed of rear yards and rear roof areas directed to infiltration systems that result in a zero outflow for minor events. The uncontrolled flows from these catchments are necessary to support the wetland in this location and were proposed in response to the need within the Environmental Impact Study. Outflow from the constructed wetland is to a level spreader between the facility and Beaver Creek. This converts a point source discharge point to a sheet flow, allows for additional infiltration, provides an easy-to-inspect location to ensure the facility outflows are occurring, and adds wildlife habitat for the wetland.

Event/Condition	2-year (m^3/s)	5-year (m^3/s)	100-year (m^3/s)	Hazel (m^3/s)
Allowable	0.014	0.123	0.677	1.344
Attenuated post-development (CoW ABCs)	0.012	0.030	0.456	1.242
Attenuated post-development (Guelph Arboretum ABCs)	0.013	0.043	0.391	

Table 11: Comparison of Attenuated Peak Flows (Flows to Beaver Creek)

Runoff from the eastern and southern portions of the site is directed to the existing subdivision to the east (Rideau River Street) and to the proposed stormwater management facility south of Conservation Drive along Beaver Creek Road. Table 12 shows these flows (worst-case of the Waterloo and Guelph ABC parameters).

Outlet	Catchments	2-year (m^3/s)	5-year (m^3/s)	100-year (m^3/s)	Hazel (m^3/s)
Existing subdivision	501	0.068	0.093	0.178	0.067
SWM south of Conservation Drive	502, 503, 601	1.758	2.396	4.561	2.010

Table 12: Peak Uncontrolled Flows for the Eastern Half of the Site

Compliance

The performance of the stormwater management system meets all requirements, as outlined by the NWSSS and through the MOE's SWM Planning and Design Manual. Storm events up to the design (2-year) storm are partially controlled through infiltration measures distributed throughout the site. Storm events up to Regional level are controlled by the major system and within the wetland pond facility. The NWSSS infiltration goal of maintaining existing infiltration volumes is met through the use of a clean water collector (third-pipe) system and distributed infiltration galleries within the site.

Minor/Major System Routing

Stormwater management routing is guided by the North Waterloo Scoped Subwatershed Study. Routing of the proposed catchments are illustrated in Figure 6.

East Subdivision Routing

For storms up to and including the 5-year event, the eastern portion of the site drains to storm sewers via a collection system of catchbasins and catchbasin manholes. Flows conveyed in the minor system are discharged to a communal SWM facility (designed by others) at the southwest corner of the Green Acre Park Lands, approximately 525m south of the intersection of Conservation Drive and Beaver Creek Road. The major system consists of overland flow within the subdivision rights-of-way once the minor piped system has reached its design capacity. Flows proceed overland to the roundabout at Conservation Drive and Beaver Creek Road, and south for ultimate discharge to the Laurel Creek Reservoir.

West Subdivision Routing

The west portion of the site will be controlled in an on-site stormwater management block. Similar to the east portion, the minor system will capture runoff in storms up to the 5-year event. Water will flow along grassed lot line swales and be captured in catchbasins in the right-of-way and piped in the minor system to the stormwater management pond. Flows up to the 5-year event (minor storm) will be directed to the sediment forebay for quality control while flows greater than the 5-year event will discharge directly to the wetland cell of the pond. The major system consists of overland flow within the subdivision rights-of-way once the minor piped system has reached its design capacity. Flows proceed overland to Pinery Trail and discharge to the wetland cell of the pond. Detailed design of the right-of-way grading will ensure that maximum ponding elevations during overland flow events will be less than minimum lot corner elevation to mitigate yard flooding of private property.

For this development the foundation drain and roof leaders for each house should discharge to the storm service connection for the property for collection in a third-pipe (clean water collection) system. These flows will run through exfiltration pipes within the ROW. Rear-yards for lots north of Street B, and for townhouse blocks west and south of Street E will be directed to infiltration galleries up to the 2-year event. Flows greater than the 2-year storm will flow uncontrolled to the wetland. The use of rain barrels should be encouraged however they do not form part of the stormwater management design of the site.

Environmental Constraint Level

The above-noted design meets the established environmental constraint level of "enhanced" water quality, as identified by the NWSSS. This constraint level is met by the proposed land buffer to the wetland, a forebay and extended detention.

Environmental Compliance Approval

An Environmental Compliance Approval (ECA) is necessary for the storm sewers, sanitary sewers, and the stormwater management facility. Applications will be prepared for Transfer of Review within the Region Municipality of Waterloo for the sewers, and a separate application will be submitted directly to the MECP for the stormwater management facility. For both approvals, the applications are exempt from Environmental Bill of Rights requirements as they will complete public participation through the requirements contained for a Planning Act approval related to a plan of subdivision.

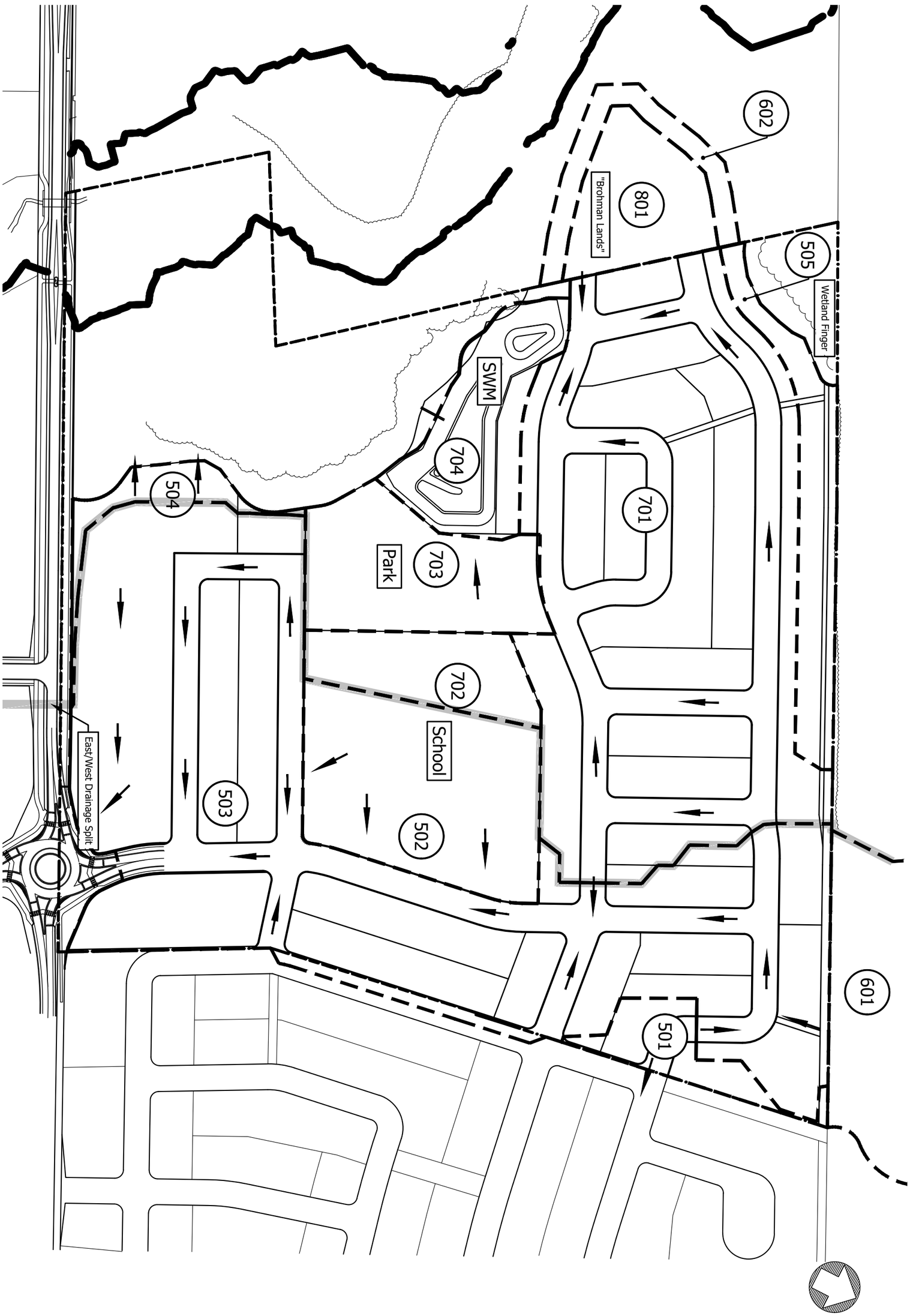
The stormwater management facility is new and is categorized as a wetland pond, which will include infiltration galleries. The drainage area associated with the pond is 11.4ha and the predominant land use within the catchment is residential (including some parkland and institutional). A review of effluent criteria assessment is not required for the facility.

The applicant for the ECAs does not own all of the lands draining to the facility. An additional 0.85ha to the northwest of the subdivision is privately held, but is developing in conjunction with this development and will drain to the proposed SWM facility. As with all subdivisions, the municipality will assume ownership of the rights-of-way and the stormwater management facilities in the future, and therefore letters of agreement for private lot owners are not required.

Landscaping

The Environmental Impact Study has recommendations for the Landscape Plan. This plan will be prepared for approvals with the detailed design of the facility following Draft Plan Approval. It is recommended to include:

- Native plantings replicating what occurs within the wetland fringe to be planted in the stormwater management block
- A diverse mix of trees, and species tolerant to water level changes
- Suitable plant species to reduce the potential for slope erosion
- Providing a 3m clearance to maintenance roads from woody plants
- Planting of shade trees and shrubs along the wetland and forebay and level spreader to mitigate temperature increases in the facility through shading



DRAWING: Post-Development Catchment Areas
556 & 576 Conservation Drive

DRAWN BY:	STV	CHECKED BY:	CHT	SCALE:	1:2500
FILE NAME:	1279.Figures	DATE:	August, 2020		Figure 7

MERITECH engineering
1315 Bishop Street North, Suite 202 Cambridge
T 519.623.1140 F 519.623.7334 www.meritech.ca

801 → 701 → 704 → Wetland

702 → 703 → 704

Wetland → Infiltration → Beaver Creek

501 → To Existing Subdivision to the East

502 → 503 ← 601

502 → 30mm (Runoff Volume Control Target) → Roof Area to Infiltration

503 → SWM Facility South of Conservation Drive

Beaver Creek → Major → 602 → Infiltration

Beaver Creek → 504 → Minor → Infiltration

Beaver Creek → 505 → Minor → Infiltration

Beaver Creek → Major → Wetland Finger

MERITECH engineering
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T 519.623.1140 F 519.623.7334 www.meritech.ca

DRAWING: Post-Development Flow Chart
556 & 576 Conservation Drive

DRAWN BY: STV	CHECKED BY: CHT	SCALE: Not to Scale	
FILE NAME: 1279.Figures	DATE: August, 2020		Figure 8

Pinery Trail

CWC Pipe

5yr Storm Sewer

Forebay

4.8m-900mmø Stm @ 0.7%

Concrete headwall

Inv=354.10

Forebay Bottom=352.30

Dripline knob to be removed

Permanent Pool=353.80

Top of Pond=355.50

Permanent Pool=353.20

Wetland Bottom=352.90

4.0m Maintenance Access Road

3rd Pipe/Clean Water Collector System to connect to infiltration gallery in the bank of the SWM Pond. Pipe Inv=353.20

Constructed Berm

30m Wetland Buffer

15m Wetland

10m Dripline Setback

Buffer

Level Spreader

Existing Grades

1.4% Swale to Level Spreader

Inv=353.18

Rip rap at Outlet

Wetland

2 x 18.0m-525mmø culverts @ 4.0% c/w headwall. Inv=353.90

Concrete Overflow Weir @ Elev=354.70

17.4m-300mmø Reverse Slope Pipe

22.4m-300mmø @ 1.7%

90mmø Orifice Outlet Control in 1200mmø MH

Micro Pool=351.90

Piped Connection to Infiltration Gallery in Bank of Pond. To be shut off during winter months. Inv=353.20

Concrete headwall

27.9m-450mmø Stm @ 1.0%

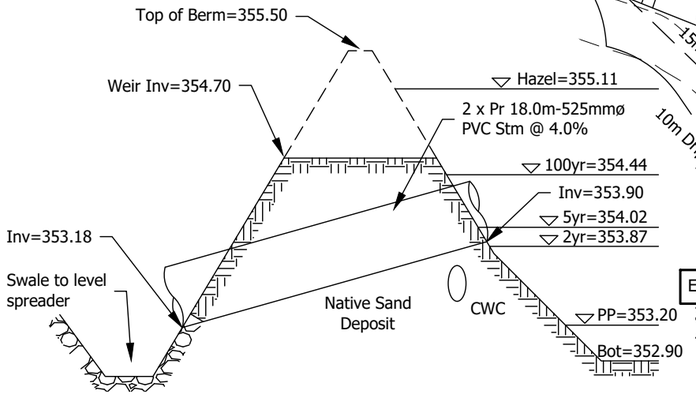
Ex. Edge

SS WO

3:1 5:1

Pond Outlet Schematic

NTS



MERITECH engineering
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T 519.623.1140 F 519.623.7334 www.meritech.ca

DRAWING: Proposed Stormwater Management Facility
556 & 576 Conservation Drive

DRAWN BY:	CHECKED BY:	SCALE:	
STV	CHT	1:500	Figure 9
FILE NAME:	DATE:		
1279.Figures	August, 2020		

Fluvial Geomorphology, Baseflow and Channel Erosion

The interactions between waterbodies and the landscape for this project are deemed to be minimal. The proposed design will attenuate peak flow rates to improve or maintain current environmental interaction. Existing infiltration rates across the site are exceeded and therefore the baseflow potential of Beaver Creek is not expected to change. Quantity detention controls, infiltration, and landscaped areas will be constructed such that environmental impacts and erosion thresholds remain consistent with the specific criteria outlined by NWSSS. The design components that were selected to enhance runoff removal rates in this project are outlined in Table 13.

Filter beds greater than 750mm in depth	N
Filter media P-Index values < 30ppm[1]	N
Properly sized (or no) underdrain system	N
Pre-treatment provided	Y
Multiple cell	N
Forebay	Y
Densely landscaped with trees, shrubs and ground cover	Y
Filter media comprised of mixture of sand, fines and organic matter	N
Filter surface covered with mulch and vegetation	N

Table 13: Factors that Increase TSS Removal Rates

Site Erosion and Sedimentation Control

Construction activities can cause erosion of native soils, and deposition of sediment on other properties or in receiving watercourses. For this development, Section 13.1.4.2 of the NWSSS recommends that an Erosion and Sediment Control plan (ESC Plan) should be prepared in support of development applications to mitigate impacts on vegetation, wildlife habitat and aquatic resources.. An ESC Plan has been created for this site, and this report serves as the ESC Plan Report. The protection of LID BMPs were also incorporated due to their susceptibility to sediment contamination.

The following measures considered for the site include:

- Construction staging
- Silt fencing
- Disturbed areas should be protected from erosion caused by rain
- Disturbed areas should be kept to a minimum and revegetated in a reasonable timeframe in order to minimize dust
- Maintenance and inspection of the installed measures
- Where the topsoil stockpile will be located, from where it will be accessed, and appropriate siltation control measures
- Temporary rock check dams in interceptor swales
- The facility shall be cleaned out and reinstated to the final design configuration before transfer of ownership

Best management practices during construction are listed on page 279 of the NWSSS and include timing of works, restricted access to future buffer areas for works and materials storage, and implementation of the erosion and sediment control plan.

Construction Staging

A staging plan will be prepared in support of engineering approvals, following Draft Plan approval. The plan should include consideration for:

- Whether the pond should initially be constructed in its final form or whether it will be part of the siltation and erosion control works during construction
- Seasonal concerns, such as wet spring conditions, dry dusty summer conditions, suitability for re-vegetation and landscaping, and herpetofaunal movement times (see page 326 of the NWSSS)
- Anticipated maintenance and assumption schedules with the municipality

Monitoring, Maintenance and Mitigation

There is currently a monitoring program underway in accordance with the North Waterloo Scoped Subwatershed Study and the City of Waterloo Development Monitoring Policy. Stage I consists of 2 years pre-development monitoring, Stage II is during construction and Stage III extends for 2 years past substantial completion of the subdivision. Stage II and Stage III monitoring programs are to be developed within the Draft Plan of Subdivision Application and recommendations are presented in this report as well as the Environmental Impact Study.

The current Stage I monitoring program includes:

- Surface water flow and depth measurements monitored along Beaver Creek and Laurel Creek three times annually
- Groundwater levels and chemistry are recorded three times annually in the 12 monitoring wells and five piezometers. Chemistry recorded is for:
    - Temperature
    - Dissolved Oxygen
    - Total Phosphorus
    - Total Suspended Solids
    - Bacteria
- Terrestrial field surveys, with wildlife observations recorded (further described in the EIS)

Proposed Stage II Monitoring

During construction, the monitoring is to mimic the Stage I work as well as compliance monitoring per the Development Monitoring Protocol. This program will include:

- Surface water flow and depth measurements monitored along Beaver Creek and Laurel Creek 3 times annually
- Groundwater levels and chemistry are recorded 3 times annually in the 12 monitoring wells and 5 piezometers. Chemistry recorded is for:
    - Temperature
    - Dissolved Oxygen

    - Total Phosphorus
    - Total Suspended Solids
    - Bacteria
- Terrestrial field surveys, with wildlife observations recorded (further described in the EIS)

Plus,

- Weekly Siltation and Erosion Control Inspections during the active construction phase,
- Quarterly E&S inspections outside active construction including inspection prior to anticipated rain events and post rain events.
- Inspection reports are to be provided to the City of Waterloo and the Grand River Conservation Authority.

Proposed Stage III Monitoring

After 90% build out of the subdivision, the monitoring program frequency is proposed to be reduced with the same parameters being monitored off-site and additional monitoring of on-site facilities as follows:

- Surface water monitoring (same parameters) with a minimum of one wet and one dry weather sample (low flow) per year.
- Ground water monitoring (same parameters) with a minimum of one wet and one dry weather sample (low flow) per year.
- Aquatic and terrestrial monitoring per the EIS
- Infiltration trenches/galleries and soak away pits on public property are to be inspected within 24 hours after a rainfall event to document the existence of water in the system and 72 hours after to show the water left the system. This should be done a minimum once annually and in the late spring to late fall months.
- Depth of the wetland and forebay cells should be recorded at the same time as the infiltration trenches, after a rainfall event plus one dry weather event to record the permanent pool level.
- Siltation and Erosion Inspections are to continue quarterly and at the time of proposed removal of any E&S Measures.

Conclusions

Infiltration forms a key part of the stormwater management design and is a mix of lot-level, conveyance, and end-of-pipe features.

Post-development unattenuated flows exceed allowable flows and, therefore, peak flow attenuation is required for the flows going west to Beaver Creek. Flows to the southeast are attenuated by the Laurel Creek Reservoir and do not require on-site attenuation prior to discharge.

The proposed stormwater management facility meets the design objectives for water quality and water quantity (flood) control. The facility includes: a forebay and constructed wetland and an outlet structure comprising an orifice-controlled outlet pipe, overflow culverts, and an overflow weir to attenuate various storm events.

Extended detention of the 2-year storm event is provided over a 24-hour period.

The block on the draft plan is adequate to construct the proposed facility to meet the Aesthetic Design Principles. The facility has been designed to accommodate easy access for maintenance of the inlet and outlet structures as well as being easily accessible for sediment removal.

The proposed stormwater management facility is aesthetically pleasing, will blend in with the surrounding environment, and is an amenity to the development.

Erosion and siltation control measures will be undertaken to ensure compliance with the NWSSS.

Recommendations

Storm service connections should be provided to each lot and connect to the internal "third pipe" clean water collector (CWC) sewer. All sump pumps and roof drains should discharge to the CWC system to promote infiltration.

The pond size and sewer routing should be refined in final design to incorporate the final servicing design.

A detailed siltation and erosion control plan should be developed as part of the final design and be approved prior to any grading. Consideration should be given to the use of the proposed facility as an interim siltation pond until such time as upstream areas are revegetated and stabilized.

A landscape plan should be completed for the final design in accordance with the Aesthetic Design Principles for Storm Water Management Facilities.

A Monitoring, Maintenance, and Mitigation plan should be further developed as part of the final design to address the need for adjustments as may be required in order to meet theoretical targets.

The possible requirement of establishing a minimum basement elevation above the seasonally high water table at the southwest corner of the development should be investigated.

Approval agencies shall review and approve this document as a suitable approach to a final design configuration and approval of the draft plan of subdivision.

References

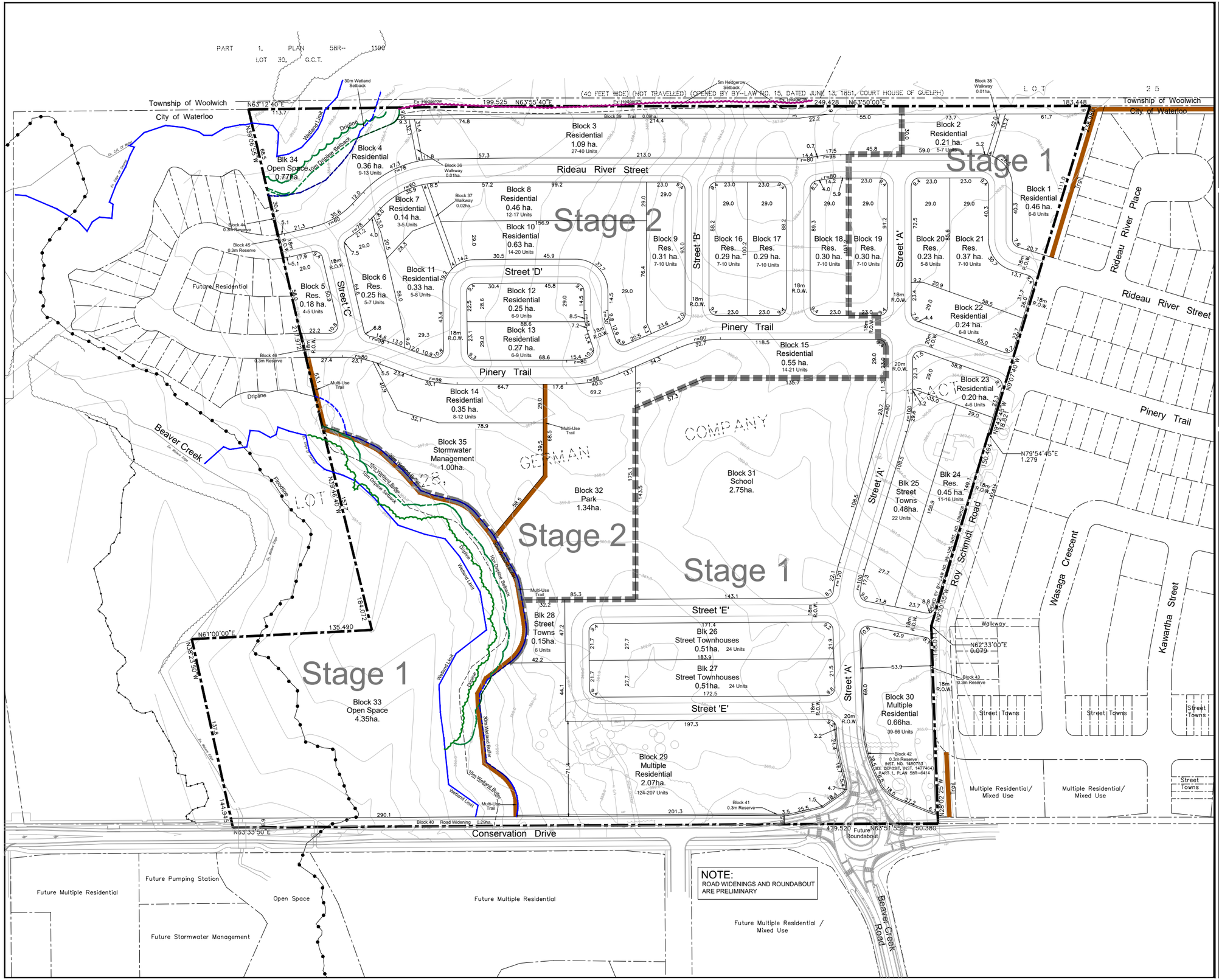
Ministry of the Environment, Stormwater Management Planning & Design Manual, Toronto ON, March 2003

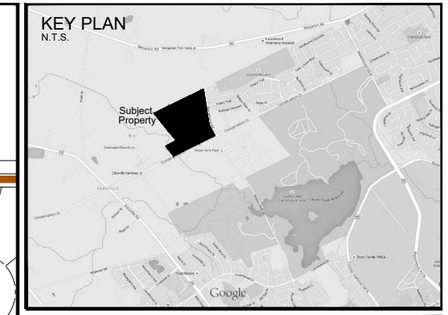
Ministry of the Environment & Climate Change, Draft Low Impact Development (LID) Stormwater Management Guidance Manual, April 2017

Greater Golden Horseshoe Area Conservation Authorities, Erosion & Sediment Control Guideline for Urban Construction, December 2006

City of Waterloo, Design Principles for Stormwater Management Facilities, Kitchener ON, April 1997

Appendix A: Draft Plan





DRAFT PLAN OF SUBDIVISION

Part of Lot 28
German Company Tract
City of Waterloo
Regional Municipality of Waterloo

LAND USE SCHEDULE

DESCRIPTION	LOTS/BLKS.	UNITS	AREA (ha.)
Residential (single detached)	1-24	192-279	8.51
Street Townhouses	25-28	76	1.50
Multiple Residential	29,30	163-273	2.73
School	31		2.75
Park	32		1.49
Open Space	33,34		5.12
Stormwater Management	35		1.00
Walkway	36-38		0.04
Trail	39		0.09
Road Widening	40		0.29
0.3m Reserve	41-46		0.00
Roads			5.12
Total		431-628	28.64

UNIT BREAKDOWN

Min. Potential Singles	192
13.1m internal lot	*162*
13.75m corner lot	*30*
Max. Potential Singles	279
9.0m internal lot	*249*
12.5m corner lot	*30*
Street Townhouses	76

ADDITIONAL INFORMATION

(UNDER SECTION 51(17) OF THE PLANNING ACT)

INFORMATION REQUIRED BY CLAUSES a,b,c,d,e,f,g,j and l ARE AS SHOWN ON THE DRAFT PLAN.
h) Municipal water supply
i) Well-drained sandy loam on lacustrine deposits
k) All sanitary and storm sewers as required

OWNER'S CERTIFICATE

I AUTHORIZE THE GSP GROUP INC. TO PREPARE AND SUBMIT THIS DRAFT PLAN OF SUBDIVISION TO THE REGIONAL MUNICIPALITY OF WATERLOO.

2119881 ONTARIO LIMITED — August 17, 2016 DATE

SURVEYOR'S CERTIFICATE

I CERTIFY THAT THE BOUNDARIES OF THE LAND TO BE SUBDIVIDED AND THEIR RELATIONSHIP TO THE ADJACENT LANDS ARE CORRECTLY SHOWN.

RAYMOND J SIBTHORP, O.L.S. — August 18, 2016 DATE
MacDonald Tamblyn Lord Surveying Limited

GSP group
PLANNING I URBAN DESIGN I LANDSCAPE ARCHITECTURE
gspgroup.ca

REVISIONS
May 24, 2019
June 10, 2019
August 27, 2019
August 29, 2019
September 3, 2019
February 24, 2020
April 30, 2020

Date: July 29, 2015	Drawn By: S.L. / R.T.	Dwg. File Name: dp09009ze.dwg
Scale: 1:1250 metric	Project No.: 09009.40	

Appendix B: Design Drawings

Match existing elevations along entire northern limit

Infiltration gallery

Infiltration gallery

Area to be developed in the future when grading allows.

Rideau River Street

Rideau River Street

Rideau River Place

Street 'C'

Street 'D'

Street 'B'

Street 'A'

Pinery Trail

Pinery Trail

Pinery Trail

SWM Pond

Park

School

Street 'E'

Street 'E'

Street 'A'

Roy Schmidt Road

Wasaga Crescent

Infiltration gallery

Conservation Drive

Proposed Conservation Drive layout

All lots are back-to-front or split drainage unless shown otherwise:

W/O = "walkout" type lot
SS = "sunshine" or "lookout" type lot

MERITECH
ENGINEERING LTD.
1315 Bishop Street North, Suite 202 Cambridge
T 5196231140 F 5196231704 www.meritechca

Conceptual Grading Plan
556 & 576 Conservation Drive

drawing no.:			
drawn BY:	STV	SCALE:	1 : 1000
CHECKED BY:	CHT		
FILE NAME:	1279 Figures	DATE:	July, 2020
			1279-SG

Rear yards to infiltration gallery, sized for 2-yr volume.

Rear yards to infiltration gallery, sized for 2-yr volume.

Rideau River Street

150mmø Wmn, Streets B, C & D

150mmø Wmn, Street A (Pinery Trail to Rideau River Street) & Rideau River Street

150mmø Wmn

Street C

Street D

Street B

Street A

Pinery Trail

Pinery Trail

Rideau River Place

Rideau River Street

300mmø Wmn

Ex 200mmø Wmn

900mmø Stm into SWM Pond

150mmø Wmn Pinery Trail (Street A to West End)

Pinery Trail

300mmø Wmn, Street A (Conservation Drive to Pinery Trail)

Street A

3rd pipe (CWC) system for roof leaders.

200mmø San, Remainder of Subdivision

Infiltration Gallery connected to end of 3rd pipe system and pond outlet. Pond connection to infiltration gallery to be closed during winter months.

School roof area to infiltration. Exact location to be determined.

Roy Schmidt Road

Wasaga Crescent

Kawartha Street

Street E

Overflow to storm sewer from CWC system

200mmø Wmn, Street E

250mmø San, Street A (Conservation Drive to Street E)

Rear yards to infiltration gallery, sized for 2-yr volume.

Street A

Overflow to storm sewer from CWC system

600mmø Stm to External SWM Facility
Required Inv=353.35

1050mmø Stm to External SWM Facility
Required Inv=352.90

250mmø San to External SPS
Required Inv=349.44

Conservation Drive

Ex Gutter

Ex Gutter

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Conceptual Servicing Plan
556 & 576 Conservation Drive

DRAWN BY:	STV	SCALE:	1: 1000
CHECKED BY:	CHT		
FILE NAME:	1279 Figures	DATE:	July, 2020
			1279-SS

Match existing elevations along entire northern limit

Infiltration gallery

Infiltration gallery

Area to be developed in the future when grading allows.

Rideau River Street

Rideau River Street

Rideau River Place

Street 'C'

Street 'D'

Street 'B'

Street 'A'

Pinery Trail

Pinery Trail

Pinery Trail

SWM Pond

Park

School

Street 'E'

Street 'E'

Street 'A'

Roy Schmidt Road

Wasaga Crescent

Infiltration gallery

Conservation Drive

Proposed Conservation Drive layout

All lots are back-to-front or split drainage unless shown otherwise:

W/O = "walkout" type lot
SS = "sunshine" or "lookout" type lot

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Conceptual Grading Plan
556 & 576 Conservation Drive

drawing no.:			
drawn BY:	STV	SCALE:	1 : 1000
CHECKED BY:	CHT		
FILE NAME:	1279 Figures	DATE:	July, 2020
			1279-SG

Rear yards to infiltration gallery, sized for 2-yr volume.

Rear yards to infiltration gallery, sized for 2-yr volume.

Rideau River Street

150mmø Wmn, Streets B, C & D

150mmø Wmn, Street A (Pinery Trail to Rideau River Street) & Rideau River Street

150mmø Wmn

Street C

Street D

Street B

Street A

Pinery Trail

Pinery Trail

Rideau River Place

Rideau River Street

300mmø Wmn

Ex 200mmø Wmn

900mmø Stm into SWM Pond

150mmø Wmn Pinery Trail (Street A to West End)

Pinery Trail

300mmø Wmn, Street A (Conservation Drive to Pinery Trail)

Street A

3rd pipe (CWC) system for roof leaders.

200mmø San, Remainder of Subdivision

Infiltration Gallery connected to end of 3rd pipe system and pond outlet. Pond connection to infiltration gallery to be closed during winter months.

School roof area to infiltration. Exact location to be determined.

Roy Schmidt Road

Wasaga Crescent

Kawartha Street

Street E

Overflow to storm sewer from CWC system

200mmø Wmn, Street E

250mmø San, Street A (Conservation Drive to Street E)

Rear yards to infiltration gallery, sized for 2-yr volume.

Street A

Overflow to storm sewer from CWC system

600mmø Stm to External SWM Facility
Required Inv=353.35

1050mmø Stm to External SWM Facility
Required Inv=352.90

250mmø San to External SPS
Required Inv=349.44

Conservation Drive

Ex Gutter

Ex Gutter

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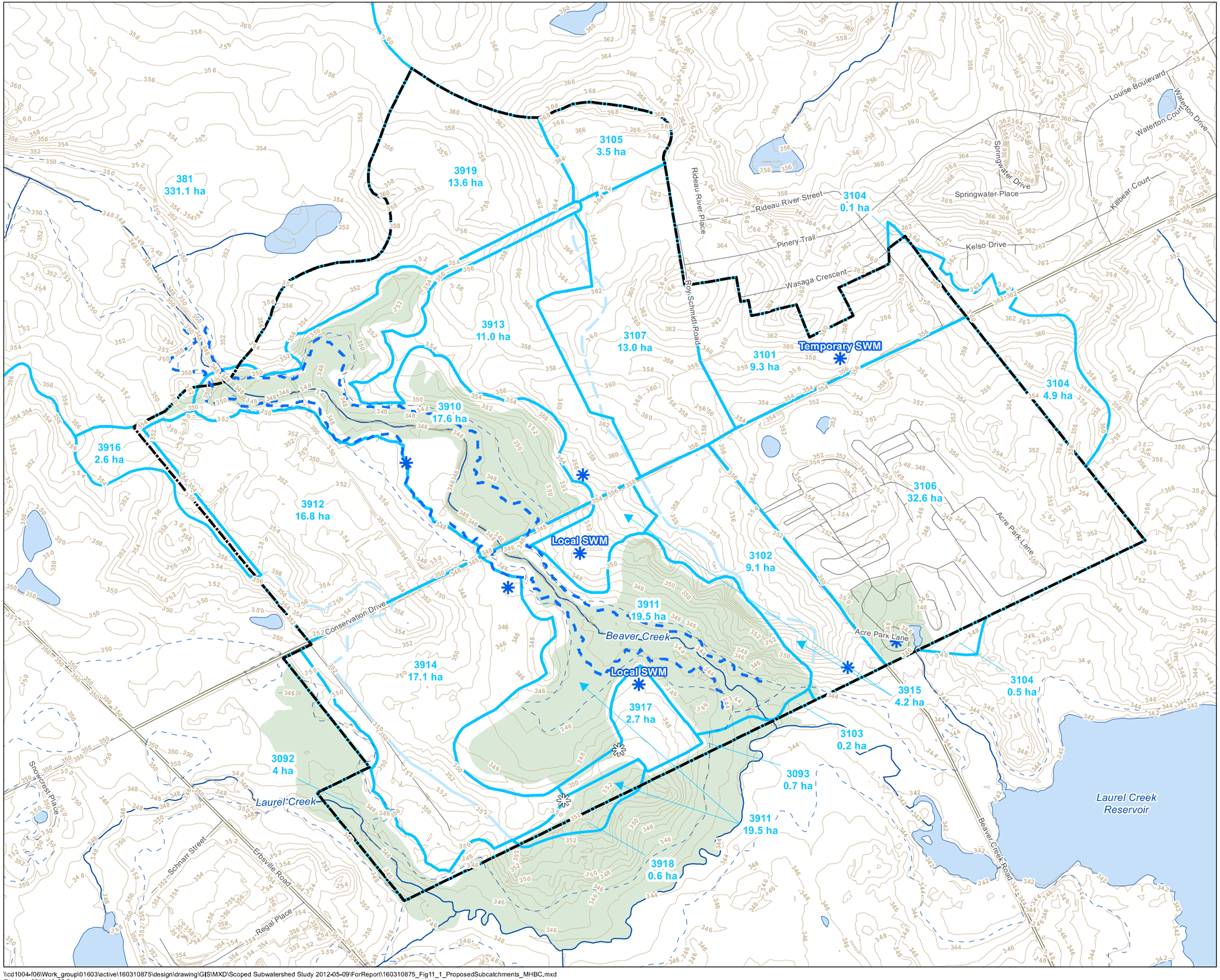
Conceptual Servicing Plan
556 & 576 Conservation Drive

DRAWN BY:	STV	SCALE:	1: 1000
CHECKED BY:	CHT		
FILE NAME:	1279 Figures	DATE:	July, 2020
			1279-SS

NORTH WATERLOO SCOPED SUBWATERSHED STUDY

PROPOSED SUBCATCHMENTS

FIGURE 11.1



- Primary Study Area
- SWM Facility
- Future Study Area
- Highway
- Major Road
- Local Road
- Topographic Contour (mAMSL)
- Watercourse
- Waterbody
- Delineated Floodplain
- GRCA Floodplain
- Proposed Detailed Subcatchment
- Existing Detailed Subcatchment
- Natural Heritage Features

0 50 100 200 300 400 m

1:7,500

NOTES

1. Coordinate System: UTM NAD 83 - Zone 17 (N).
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2011.

NORTH

October 2013

Stantec

MHBC PLANNING URBAN DESIGN & LANDSCAPE ARCHITECTURE
200-540 BINGEMANS CENTRE DR, KITCHENER, ON N2B 3X9
P: 519.576.3650 F: 519.576.0121 | WWW.MHBCPLAN.COM

ecoplans
A member of MMM GROUP

160310875

\\cd1004-f06\Work_group\01603\active\160310875\design\drawing\GIS\MXD\Scoped Subwatershed Study 2012-05-09\ForReport\160310875_Fig11_1_ProposedSubcatchments_MHBC.mxd
Revised: 2013-10-25 By: mkirkpatrick

Appendix C: Design Calculations

MERITECH

Project Name: Conservation Drive
Project Number: 1279
Calc'd by: STV
Date: 1-Apr-19
Chk'd by: CHT
Date: 20-Jul-20

Sediment Forebay Sizing Calculations

(in accordance with MOE 2003)

Forebay Dimensions

				Calculated min.	Actual	
Average bottom width	5.6	m	Average top width	17.0	17.0	m
Maximum bottom width	10.3	m	Maximum top width	21.7	21.7	m
Average bottom length	24.5	m	Average top length	35.9	35.9	m
Average depth	1.50	m	Total Volume	492	m³	
Average sideslope	3.8	:1	Usable Volume	325	m³	

1) Forebay Settling Length

Dist = forebay length (m)
r = length to width ratio at average depth
= **2.7** (should be greater than 2:1)
Q_p = peak flow rate from facility during design quality storm
= **0.013** m³/s **2 year** storm event
V_s = settling velocity (dependent on particle size)
= **0.0003** m/s for 150 μm particle
Therefore, distance = **10.8** m vs. **35.9** m provided

2) Dispersion Length

Dist = length of dispersion (m)
Q = flowrate into forebay (lesser of actual pipe capacity or 10-year peak runoff rate)
= **1.515** m³/s Pipes sized for: **5-year** storm event
d = depth of the permanent pool above the maximum sediment depth
= **0.750** m
V_f = desired velocity in the forebay
= **0.50** m/s
Therefore, distance = **32.3** m vs. **35.9** m provided
Also, min. bottom width = Dist./8 = **4.0** m vs. **5.6** m provided

3) Check Velocity Across Full Width of Forebay Above Maximum Accumulated Sediment Depth

V_a = average velocity in the forebay (m/s)
Q_i = flowrate into forebay
= **1.515** m³/s **5-year** storm event
A_x = cross sectional area of forebay perpendicular to flow
= **14.1** m² above the maximum sediment depth
Therefore, velocity = V_a = **0.11** m/s should be < tha **0.15** m/s

4) Cleanout Interval

V_u = usable accumulation storage volume of forebay at a
max. depth, d_u = **0.75** m
= **167** m³
L_a = annual loading
for **65.0** % impervious
= **2.500** m³/ha/yr
A_c = **8.140** ha of contributing land
Therefore, interval = I = **8.2** yrs between cleanouts **5.0** years min. preferred

Project Name: Conservation Drive
Project Number: 1279
Calc'd by: STV
Date: 1-Apr-19
Chk'd by: CHT
Date: 20-Jul-20

Sediment Forebay Sizing Calculations

(in accordance with MOE 2003)

5) 10 year Accumulated Sediment Depth

A_c = contributing area
= **8.140** ha.
L_a = annual loading
= **2.500** $m^3/ha/yr$
I = cleanout interval
= **10** years
V_r = required total storage volume
= **203.5** m^3
Actual total storage volume
= **491.9** m^3

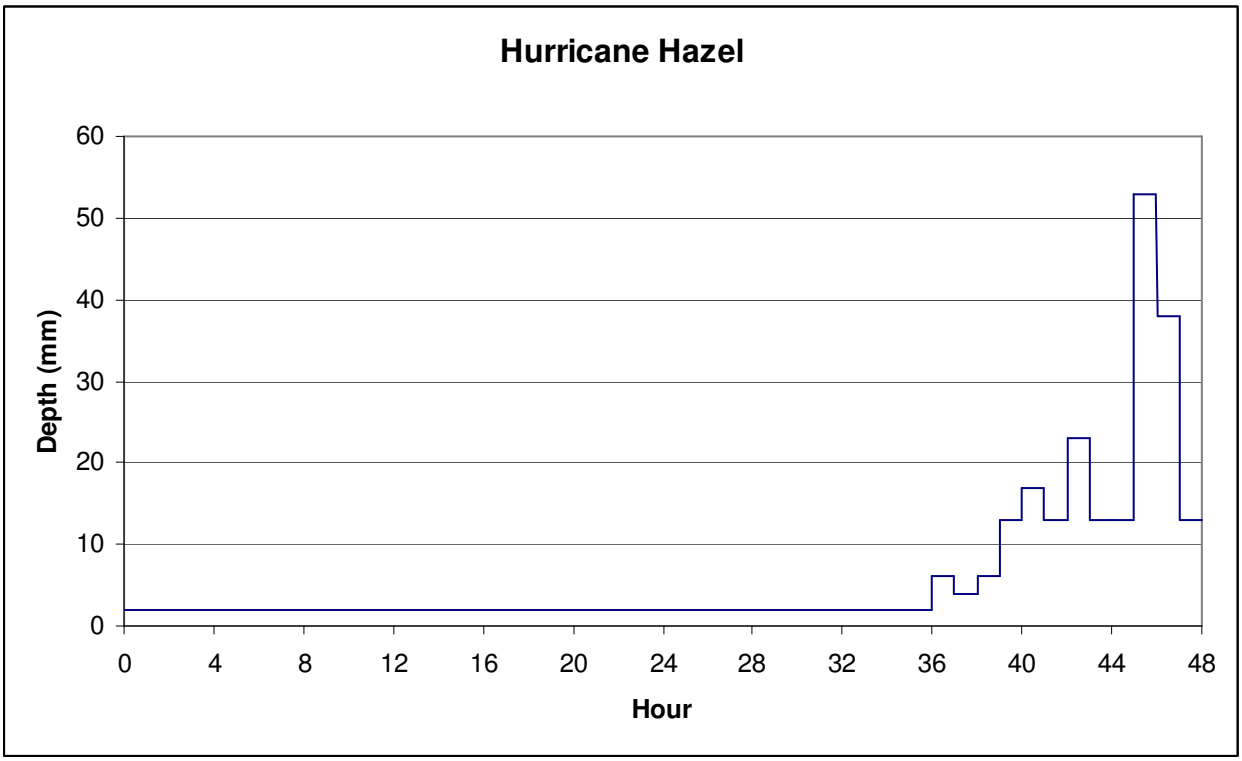
6) Forebay Size in relation to Remainder of Facility

Type of facility: **Wetland**

Forebay permanent pool **area**	**587**
Wetland permanent pool area	**2937**
Forebay's percentage	**17%**
Minimum criteria	**Maximum 20%**

Forebay permanent pool **volume**	**492**
Wetland permanent pool volume	**791**
Forebay's percentage	**38%**
Preferred criteria	**No criteria**

285mm total depth, 48 hour storm with 1 hour time steps



Time step	Fraction of total rainfall
0	0.0000
1	0.0071
2	0.0142
3	0.0213
4	0.0285
5	0.0356
6	0.0427
7	0.0498
8	0.0569
9	0.0640
10	0.0712
11	0.0783
12	0.0854
13	0.0925
14	0.0996
15	0.1067
16	0.1138
17	0.1210
18	0.1281
19	0.1352
20	0.1423
21	0.1494
22	0.1565
23	0.1636
24	0.1708
25	0.1779
26	0.1850
27	0.1921
28	0.1992
29	0.2063
30	0.2135
31	0.2206
32	0.2277
33	0.2348
34	0.2419
35	0.2490
36	0.2561
37	0.2772
38	0.2912
39	0.3123
40	0.3579
41	0.4175
42	0.4632
43	0.5439
44	0.5895
45	0.6351
46	0.8211
47	0.9544
48	1.0000

Project: Conservation Drive
File: 1279
Calc'd by: SJB
Date: 17-Jun-20
Chk'd by: CHT
Date: 7-Jul-20

Simplified Water Balance Calculations

City of Waterloo

Catchment 3913 Proposed Development Conditions (From NWSSS - 2013, Table 11.5)

P = R+I+ET, where:

P = Precipitation =	844.8	mm/yr
R = Runoff =	232.4	mm/yr
I = Infiltration =	265.2	mm/yr
ET = Evapotranspiration =	347.5	mm/yr

Target Infiltration 31,283 m^3/yr (based on catchment areas)

Catchment 3107 Proposed Development Conditions (From NWSSS - 2013, Table 11.5)

P = R+I+ET, where:

P = Precipitation =	844.8	mm/yr
R = Runoff =	196.3	mm/yr
I = Infiltration =	281.6	mm/yr
ET = Evapotranspiration	366.9	mm/yr

Target Infiltration 32,606 m^3/yr (based on catchment areas)

Passive Pervious Infiltration

Catchment #	Area (ha)	%Pervious	$A_{pervious}$ (ha)	Annual Passive Infiltration Volume (m^3)
701	7.343	40%	2.94	7,789
702	0.770	70%	0.54	1,429
703	1.343	90%	1.21	3,205
704	1.110	40%	0.44	1,177
504	0.332	60%	0.20	528
505	0.898	40%	0.36	953
		Total		**15,083** m^3/yr

Catchment #	Area (ha)	%Pervious	$A_{pervious}$ (ha)	Annual Passive Infiltration Volume (m^3)
501	0.469	40%	0.19	528
502	1.986	50%	0.99	2,796
503	9.124	30%	2.74	7,708
			Total	**11,033** m^3/yr

Lot Level Infiltration (2-year volume for Rear Yards/Roofs Galleries)

90% of annual rainfall occurs in storms less than the 2-year design event.

90% of runoff at lot-level, 90% of roof precipitation contribute to lot-level infiltration

Catchment	Contributing Area (ha)	Runoff (mm)	Annual Lot Runoff to Infiltration (m^3)
504 (rear yard/roof)	0.332	209.16	694
505 (rear yard/roof)	0.898	209.16	1,878
		Total	**2,573** m^3/yr

Catchments	Contributing Area (ha)	Runoff (mm)	Annual Lot Runoff to Infiltration (m^3)
502 (school roof)	0.45	760	**3,421** m^3/yr

Clean-Water-Collector (CWC/3rd Pipe) System

90% of annual rainfall occurs in storms less than the 2-year design event, 3rd pipe infiltration will be sized for 2-year volume.

27% of lot catchment area is roof

Catchment	Contributing Area (ha)	Roof Area (ha)	Runoff (mm)	Annual Roof Runoff to CWC (m^3)
701	7.343	1.98	760	**15,074** m^3/yr

Catchments	Contributing Area (ha)	Roof Area (ha)	Runoff (mm)	Annual Roof Runoff to CWC (m^3)
503	9.124	2.46	760.32	**18,730** m^3/yr

End-of-pipe (SWM Facility Infiltration)

Pond infiltrates first 615m^3 runoff, which equals 25.4mm across the IMP surfaces in Catchment 701 (excluding roofs).

This translates to 88% of annual rainfall directed to infiltration.

Catchment	IMP Area (excl roof) (ha)	Runoff to Infil (88% Precip) (mm)	Annual End-Of-Pipe Infiltration
701	2.42	743	**18,015** m^3/yr

Total Provided Infiltration =	50,744	m^3
Target Infiltration =	31,283	m^3
Difference =	**19,461**	**m^3**

Total Provided Infiltration =	33,184	m^3
Target Infiltration =	32,606	m^3
Difference =	**578**	**m^3**

Total Provided Infiltration=	83,928	m^3/yr
Site Wide Infiltration Target =	63,889	m^3/yr
Surplus =	**20,039**	m^3/yr

Appendix D: Modelling

```
"               MIDUSS Output ------------------------------------------------>"
"               MIDUSS version                          Version 2.25  rev. 473"
"               MIDUSS created                               February 7, 2010"
"           10  Units used:                                          ie METRIC"
"               Job folder:                  K:\PRJ - DOCS\1279\60-Design\SWM"
"               Output filename:                      1279d2yr4hrJun102020.out"
"               Licensee name:                        Stefan Van Hartingsveldt"
"               Company                                   Meritech Engineering"
"               Date & Time last used:                2020-06-10 at 4:42:34 PM"
" 81          ADD COMMENT================================================="
"          2  Lines of comment"
"             SWM Analysis of 2-yr 4 hr post-development storm event "
"             for 556 and 576 Conservation Drive, Waterloo"
" 31          TIME PARAMETERS"
"        5.000   Time Step"
"      240.000   Max. Storm length"
"     7200.000   Max. Hydrograph"
" 32          STORM Chicago storm"
"            1   Chicago storm"
"     1101.000   Coefficient A"
"        9.258   Constant B"
"        0.882   Exponent C"
"        0.400   Fraction R"
"      240.000   Duration"
"        1.000   Time step multiplier"
"             Maximum intensity          101.723    mm/hr"
"             Total depth                 33.885    mm"
"            4   2hyd   Hydrograph extension used in this file"
" 81          ADD COMMENT================================================="
"          1  Lines of comment"
"             Area to SWM facility on west side"
" 33          CATCHMENT 701"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          701   Northwest corner - lots"
"       60.000   % Impervious"
"        7.343   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        2.937   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        4.406   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.161   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.837   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    1.024     0.000     0.000     0.000 c.m/sec"
"             Catchment 701          Pervious   Impervious Total Area "
"             Surface Area           2.937      4.406      7.343      hectare"
```

```
"             Time of concentration  15.530     1.324      2.937      minutes"
"             Time to Centroid       151.167    115.087    119.185    minutes"
"             Rainfall depth         33.885     33.885     33.885     mm"
"             Rainfall volume        995.26     1492.89    2488.15    c.m"
"             Rainfall losses        28.436     5.533      14.694     mm"
"             Runoff depth           5.449      28.352     19.191     mm"
"             Runoff volume          160.05     1249.13    1409.18    c.m"
"             Runoff coefficient     0.161      0.837      0.566      "
"             Maximum flow           0.055      1.017      1.024      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     1.024     1.024     0.000     0.000"
" 33          CATCHMENT 702"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          702   Rear half of school site"
"       30.000   % Impervious"
"        0.770   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.539   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.231   Impervious Area"
"       30.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.161   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.842   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.052     1.024     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.539      0.231      0.770      hectare"
"             Time of concentration  23.539     2.006      8.649      minutes"
"             Time to Centroid       161.855    116.161    130.258    minutes"
"             Rainfall depth         33.885     33.885     33.885     mm"
"             Rainfall volume        182.64     78.27      260.91     c.m"
"             Rainfall losses        28.433     5.369      21.514     mm"
"             Runoff depth           5.452      28.515     12.371     mm"
"             Runoff volume          29.39      65.87      95.26      c.m"
"             Runoff coefficient     0.161      0.842      0.365      "
"             Maximum flow           0.008      0.051      0.052      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.052     1.077     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
"        1.343   Total Area"
```

```
"       80.000   Flow length"
"        3.000   Overland Slope"
"        1.209   Pervious Area"
"       80.000   Pervious length"
"        3.000   Pervious slope"
"        0.134   Impervious Area"
"       80.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.161   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.834   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.027     1.077     0.000     0.000 c.m/sec"
"             Catchment 703          Pervious   Impervious Total Area "
"             Surface Area           1.209      0.134      1.343      hectare"
"             Time of concentration  42.400     3.614      28.226     minutes"
"             Time to Centroid       187.069    118.866    162.145    minutes"
"             Rainfall depth         33.885     33.885     33.885     mm"
"             Rainfall volume        409.56     45.51      455.07     c.m"
"             Rainfall losses        28.431     5.616      26.149     mm"
"             Runoff depth           5.454      28.269     7.736      mm"
"             Runoff volume          65.92      37.97      103.89     c.m"
"             Runoff coefficient     0.161      0.834      0.228      "
"             Maximum flow           0.012      0.027      0.027      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.027     1.104     0.000     0.000"
" 33          CATCHMENT 704"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          704   SWM block"
"       60.000   % Impervious"
"        1.110   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.444   Pervious Area"
"       15.000   Pervious length"
"       20.000   Pervious slope"
"        0.666   Impervious Area"
"       15.000   Impervious length"
"        0.500   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.160   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.841   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.149     1.104     0.000     0.000 c.m/sec"
```

```
"             Catchment 704          Pervious   Impervious Total Area "
"             Surface Area           0.444      0.666      1.110      hectare"
"             Time of concentration  8.790      2.266      3.002      minutes"
"             Time to Centroid       142.163    116.604    119.487    minutes"
"             Rainfall depth         33.885     33.885     33.885     mm"
"             Rainfall volume        150.45     225.67     376.12     c.m"
"             Rainfall losses        28.453     5.399      14.621     mm"
"             Runoff depth           5.431      28.486     19.264     mm"
"             Runoff volume          24.11      189.71     213.83     c.m"
"             Runoff coefficient     0.160      0.841      0.569      "
"             Maximum flow           0.011      0.147      0.149      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.149     1.253     0.000     0.000"
" 33          CATCHMENT 801"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          801   Brohman Lands"
"       60.000   % Impervious"
"        0.850   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.340   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.510   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.161   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.837   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.119     1.253     0.000     0.000 c.m/sec"
"             Catchment 801          Pervious   Impervious Total Area "
"             Surface Area           0.340      0.510      0.850      hectare"
"             Time of concentration  15.530     1.324      2.937      minutes"
"             Time to Centroid       151.167    115.087    119.185    minutes"
"             Rainfall depth         33.885     33.885     33.885     mm"
"             Rainfall volume        115.21     172.81     288.02     c.m"
"             Rainfall losses        28.436     5.533      14.694     mm"
"             Runoff depth           5.449      28.352     19.191     mm"
"             Runoff volume          18.53      144.59     163.12     c.m"
"             Runoff coefficient     0.161      0.837      0.566      "
"             Maximum flow           0.006      0.118      0.119      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.119     1.372     0.000     0.000"
" 54          POND DESIGN"
"        1.372   Current peak flow    c.m/sec"
"        0.654   Target outflow    c.m/sec"
"       1985.3   Hydrograph volume    c.m"
"          24.   Number of stages"
```

```
"      353.200   Minimum water level    metre"
"      355.500   Maximum water level    metre"
"      353.400   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                353.200     0.000     0.000"
"                353.300  1.00E-07   301.000"
"                353.400  1.00E-07   615.000"
"                353.500   0.00355   944.000"
"                353.600   0.00664  1288.000"
"                353.700   0.00870  1645.000"
"                353.800   0.01035  2018.000"
"                353.900   0.01178  2471.000"
"                354.000   0.01305  3006.000"
"                354.100   0.01420  3557.000"
"                354.200   0.02851  4124.000"
"                354.300   0.06671  4709.000"
"                354.400    0.1248  5310.000"
"                354.500    0.1984  5928.000"
"                354.600    0.2826  6562.000"
"                354.700    0.3724  7211.000"
"                354.800    0.4760  7877.000"
"                354.900    0.5973  8558.000"
"                355.000    0.7368  9255.000"
"                355.100    0.8972  9969.000"
"                355.200     1.082  10701.00"
"                355.300     1.296  11450.00"
"                355.400     1.541  12218.00"
"                355.500     1.821  13004.00"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                354.700     0.900     0.200     1.000     1.000"
"           1.   ORIFICES"
"                Orifice   Orifice   Orifice Number of"
"                 invert coefficie  diameter  orifices"
"                353.400     0.630    0.0900     1.000"
"           2.   OUTFLOW PIPE"
"               Upstream Downstr'm      Pipe      Pipe   Manning     Entry"
"                 invert    invert    Length  Diameter       'n'   loss Ke"
"                354.100   353.180    18.000     0.525     0.013     0.500"
"                354.100   353.180    18.000     0.525     0.013     0.500"
"             Peak outflow                  0.012    c.m/sec"
"             Maximum level               353.900    metre"
"             Maximum storage            2472.858    c.m"
"             Centroidal lag               33.430   hours"
"                  0.119     1.372     0.012     0.000 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                  0.012    c.m/sec"
"             Hydrograph volume          1953.987    c.m"
"                     0.119     1.372     0.012     0.012"
" 81          ADD COMMENT================================================="
"          2  Lines of comment"
"             501 to the north and/or ex. subdivision to the "
"             northeast"
" 40          HYDROGRAPH Start - New Tributary"
```

```
"            2   Start - New Tributary"
"                     0.119     0.000     0.012     0.012"
" 33          CATCHMENT 501"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          501   Northeast corner of subdivision"
"       60.000   % Impervious"
"        0.469   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.188   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.281   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.161   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.837   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.065     0.000     0.012     0.012 c.m/sec"
"             Catchment 501          Pervious   Impervious Total Area "
"             Surface Area           0.188      0.281      0.469      hectare"
"             Time of concentration  15.530     1.324      2.937      minutes"
"             Time to Centroid       151.166    115.087    119.185    minutes"
"             Rainfall depth         33.885     33.885     33.885     mm"
"             Rainfall volume        63.57      95.35      158.92     c.m"
"             Rainfall losses        28.436     5.533      14.694     mm"
"             Runoff depth           5.449      28.352     19.191     mm"
"             Runoff volume          10.22      79.78      90.00      c.m"
"             Runoff coefficient     0.161      0.837      0.566      "
"             Maximum flow           0.004      0.065      0.065      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.065     0.065     0.012     0.012"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                     0.065     0.065     0.065     0.012"
" 40          HYDROGRAPH   Combine    501"
"            6   Combine "
"          501   Node #"
"                To N and NE"
"             Maximum flow                  0.065    c.m/sec"
"             Hydrograph volume            90.005    c.m"
"                     0.065     0.065     0.065     0.065"
" 81          ADD COMMENT================================================="
"          4  Lines of comment"
"             Flows from 502 and 503 are to a proposed SWM facility "
"             south of Conservation Drive. Rooftop runoff from the "
"             school (502) up to 25mm rainfall depth to infiltration"
"             but conservatively ignored in this modeling."
" 40          HYDROGRAPH Start - New Tributary"
```

```
"            2   Start - New Tributary"
"                     0.065     0.000     0.065     0.065"
" 33          CATCHMENT 601"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          601   External Area North of Site"
"        0.000   % Impervious"
"        3.500   Total Area"
"       90.000   Flow length"
"        2.000   Overland Slope"
"        3.500   Pervious Area"
"       90.000   Pervious length"
"        3.000   Pervious slope"
"        0.000   Impervious Area"
"       90.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       61.000   Pervious SCS Curve No."
"        0.051   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"       16.239   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.000   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.006     0.000     0.065     0.065 c.m/sec"
"             Catchment 601          Pervious   Impervious Total Area "
"             Surface Area           3.500      0.000      3.500      hectare"
"             Time of concentration  86.981     3.879      86.980     minutes"
"             Time to Centroid       243.882    119.242    243.880    minutes"
"             Rainfall depth         33.885     33.885     33.885     mm"
"             Rainfall volume        1185.96    0.00       1185.96    c.m"
"             Rainfall losses        32.155     5.460      32.155     mm"
"             Runoff depth           1.729      28.424     1.729      mm"
"             Runoff volume          60.52      0.00       60.52      c.m"
"             Runoff coefficient     0.051      0.000      0.051      "
"             Maximum flow           0.006      0.000      0.006      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.006     0.006     0.065     0.065"
" 33          CATCHMENT 502"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          502   Front half of school site"
"       50.000   % Impervious"
"        1.986   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.993   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.993   Impervious Area"
"       30.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
```

```
"         0.161   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.842   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     0.223     0.006     0.065     0.065 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           0.993      0.993      1.986      hectare"
"              Time of concentration  23.539     2.006      5.463      minutes"
"              Time to Centroid       161.855    116.161    123.495    minutes"
"              Rainfall depth         33.885     33.885     33.885     mm"
"              Rainfall volume        336.47     336.47     672.95     c.m"
"              Rainfall losses        28.433     5.369      16.901     mm"
"              Runoff depth           5.452      28.515     16.984     mm"
"              Runoff volume          54.14      283.16     337.30     c.m"
"              Runoff coefficient     0.161      0.842      0.501      "
"              Maximum flow           0.015      0.221      0.223      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                     0.223     0.223     0.065     0.065"
" 33           CATCHMENT 503"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           503   East part of site incl townhouses"
"        70.000   % Impervious"
"         9.124   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         2.737   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         6.387   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.161   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.837   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     1.481     0.223     0.065     0.065 c.m/sec"
"              Catchment 503          Pervious   Impervious Total Area "
"              Surface Area           2.737      6.387      9.124      hectare"
"              Time of concentration  15.530     1.324      2.405      minutes"
"              Time to Centroid       151.167    115.087    117.833    minutes"
"              Rainfall depth         33.885     33.885     33.885     mm"
"              Rainfall volume        927.49     2164.14    3091.63    c.m"
"              Rainfall losses        28.436     5.533      12.404     mm"
"              Runoff depth           5.449      28.352     21.481     mm"
"              Runoff volume          149.15     1810.78    1959.93    c.m"
"              Runoff coefficient     0.161      0.837      0.634      "
```

```
"             Maximum flow           0.051      1.474      1.481      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    1.481     1.704     0.065     0.065"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                    1.481     1.704     1.704     0.065"
" 40          HYDROGRAPH   Combine    503"
"            6   Combine "
"          503   Node #"
"                SWM facility south of Conservation Dr"
"             Maximum flow                  1.704    c.m/sec"
"             Hydrograph volume          2357.753    c.m"
"                    1.481     1.704     1.704     1.704"
" 81          ADD COMMENT================================================="
"          2  Lines of comment"
"             Minor flows (2yr and less) from catchment 504 "
"             (townhouses at SW corner) are to infiltration"
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                    1.481     0.000     1.704     1.704"
" 33          CATCHMENT 504"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          504   Townhouse area at SW corner"
"       40.000   % Impervious"
"        0.332   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.199   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.133   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.161   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.837   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.031     0.000     1.704     1.704 c.m/sec"
"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.199      0.133      0.332      hectare"
"             Time of concentration  15.530     1.324      4.503      minutes"
"             Time to Centroid       151.167    115.087    123.161    minutes"
"             Rainfall depth         33.885     33.885     33.885     mm"
"             Rainfall volume        67.50      45.00      112.50     c.m"
"             Rainfall losses        28.436     5.533      19.274     mm"
"             Runoff depth           5.449      28.352     14.610     mm"
"             Runoff volume          10.85      37.65      48.51      c.m"
"             Runoff coefficient     0.161      0.837      0.431      "
"             Maximum flow           0.004      0.031      0.031      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
```

```
"            4   Add Runoff "
"                     0.031     0.031     1.704     1.704"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                     0.031     0.031     0.031     1.704"
" 40          HYDROGRAPH   Combine    504"
"            6   Combine "
"          504   Node #"
"                Minor to infiltration"
"              Maximum flow                  0.031    c.m/sec"
"              Hydrograph volume            48.506    c.m"
"                     0.031     0.031     0.031     0.031"
" 81          ADD COMMENT================================================="
"          3  Lines of comment"
"             Flows from catchment 505 are infiltrated (2-year "
"             and less) with overflows to the wetland finger, which "
"             then is combined with pond outflows towards Beaver Ck "
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                     0.031     0.000     0.031     0.031"
" 33          CATCHMENT 505"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          505   Rear yards of lots at NW corner"
"       60.000   % Impervious"
"        0.898   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.359   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.539   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.161   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.837   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.125     0.000     0.031     0.031 c.m/sec"
"             Catchment 505          Pervious   Impervious Total Area "
"             Surface Area           0.359      0.539      0.898      hectare"
"             Time of concentration  15.530     1.324      2.937      minutes"
"             Time to Centroid       151.167    115.087    119.185    minutes"
"             Rainfall depth         33.885     33.885     33.885     mm"
"             Rainfall volume        121.71     182.57     304.28     c.m"
"             Rainfall losses        28.436     5.533      14.694     mm"
"             Runoff depth           5.449      28.352     19.191     mm"
"             Runoff volume          19.57      152.76     172.33     c.m"
"             Runoff coefficient     0.161      0.837      0.566      "
"             Maximum flow           0.007      0.124      0.125      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
```

```
"                    0.125     0.125     0.031     0.031"
" 40          HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                    0.125     0.125     0.125     0.031"
" 40          HYDROGRAPH   Combine    505"
"             6   Combine "
"           505   Node #"
"                 Minor to infiltration"
"             Maximum flow                  0.125    c.m/sec"
"             Hydrograph volume           172.333    c.m"
"                    0.125     0.125     0.125     0.125"
" 81          ADD COMMENT================================================="
"           1  Lines of comment"
"             Brohman Lands to Infiltration "
" 40          HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                    0.125     0.000     0.125     0.125"
" 33          CATCHMENT 602"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           602   Brohman to Infiltration"
"        60.000   % Impervious"
"         0.400   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.160   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.240   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.161   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.837   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                    0.056     0.000     0.125     0.125 c.m/sec"
"             Catchment 602          Pervious   Impervious Total Area "
"             Surface Area           0.160      0.240      0.400      hectare"
"             Time of concentration  15.530     1.324      2.937      minutes"
"             Time to Centroid       151.167    115.087    119.185    minutes"
"             Rainfall depth         33.885     33.885     33.885     mm"
"             Rainfall volume        54.22      81.32      135.54     c.m"
"             Rainfall losses        28.436     5.533      14.694     mm"
"             Runoff depth           5.449      28.352     19.191     mm"
"             Runoff volume          8.72       68.04      76.76      c.m"
"             Runoff coefficient     0.161      0.837      0.566      "
"             Maximum flow           0.003      0.055      0.056      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                    0.056     0.056     0.125     0.125"
" 40          HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
```

```
"                    0.056     0.056     0.056     0.125"
" 40          HYDROGRAPH   Combine    602"
"            6   Combine "
"          602   Node #"
"                Brohman Infiltration"
"              Maximum flow                 0.056    c.m/sec"
"              Hydrograph volume           76.763    c.m"
"                    0.056     0.056     0.056     0.056"
" 38          START/RE-START TOTALS 602"
"            3   Runoff Totals on EXIT"
"              Total Catchment area                    28.125    hectare"
"              Total Impervious area                   14.520    hectare"
"              Total % impervious                      51.626"
" 19          EXIT"
```

```
"                MIDUSS Output ------------------------------------------------>"
"                MIDUSS version                          Version 2.25  rev. 473"
"                MIDUSS created                               February 7, 2010"
"           10   Units used:                                          ie METRIC"
"                Job folder:                  K:\PRJ - DOCS\1279\60-Design\SWM"
"                Output filename:                    1279d2yr24hrJun102020.out"
"                Licensee name:                       Stefan Van Hartingsveldt"
"                Company                                  Meritech Engineering"
"                Date & Time last used:               2020-06-10 at 4:58:51 PM"
" 81           ADD COMMENT================================================="
"          2  Lines of comment"
"             SWM Analysis of 2-yr 24 hr post-development storm event "
"             for 556 and 576 Conservation Drive, Waterloo"
" 31           TIME PARAMETERS"
"        5.000   Time Step"
"     1440.000   Max. Storm length"
"     7200.000   Max. Hydrograph"
" 32           STORM Chicago storm"
"            1   Chicago storm"
"      583.440   Coefficient A"
"        3.561   Constant B"
"        0.783   Exponent C"
"        0.400   Fraction R"
"     1440.000   Duration"
"        1.000   Time step multiplier"
"             Maximum intensity          104.048    mm/hr"
"             Total depth                 47.029    mm"
"            4   2hyd   Hydrograph extension used in this file"
" 81           ADD COMMENT================================================="
"          1  Lines of comment"
"             Area to SWM facility on west side"
" 33           CATCHMENT 701"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          701   Northwest corner - lots"
"       60.000   % Impervious"
"        7.343   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        2.937   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        4.406   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.242   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.875   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     1.063     0.000     0.000     0.000 c.m/sec"
"             Catchment 701          Pervious   Impervious Total Area "
"             Surface Area           2.937      4.406      7.343      hectare"
```

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"             Time of concentration  12.659     1.298      3.067      minutes"
"             Time to Centroid       793.747    668.958    688.384    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        1381.35    2072.02    3453.37    c.m"
"             Rainfall losses        35.650     5.881      17.788     mm"
"             Runoff depth           11.380     41.149     29.241     mm"
"             Runoff volume          334.25     1812.94    2147.19    c.m"
"             Runoff coefficient     0.242      0.875      0.622      "
"             Maximum flow           0.083      1.041      1.063      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     1.063     1.063     0.000     0.000"
" 33          CATCHMENT 702"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          702   Rear half of school site"
"       30.000   % Impervious"
"        0.770   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.539   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.231   Impervious Area"
"       30.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.242   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.881   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.054     1.063     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.539      0.231      0.770      hectare"
"             Time of concentration  19.188     1.967      8.694      minutes"
"             Time to Centroid       809.357    670.465    724.715    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        253.49     108.64     362.13     c.m"
"             Rainfall losses        35.643     5.578      26.624     mm"
"             Runoff depth           11.386     41.451     20.406     mm"
"             Runoff volume          61.37      95.75      157.12     c.m"
"             Runoff coefficient     0.242      0.881      0.434      "
"             Maximum flow           0.011      0.052      0.054      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.054     1.118     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
"        1.343   Total Area"
```

```
"        80.000   Flow length"
"         3.000   Overland Slope"
"         1.209   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.134   Impervious Area"
"        80.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.242   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.877   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.029     1.118     0.000     0.000 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           1.209      0.134      1.343      hectare"
"              Time of concentration  34.563     3.544      25.667     minutes"
"              Time to Centroid       846.116    675.509    797.186    minutes"
"              Rainfall depth         47.029     47.029     47.029     mm"
"              Rainfall volume        568.44     63.16      631.61     c.m"
"              Rainfall losses        35.632     5.779      32.646     mm"
"              Runoff depth           11.398     41.250     14.383     mm"
"              Runoff volume          137.76     55.40      193.16     c.m"
"              Runoff coefficient     0.242      0.877      0.306      "
"              Maximum flow           0.016      0.026      0.029      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.029     1.145     0.000     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         1.110   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.444   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.666   Impervious Area"
"        15.000   Impervious length"
"         0.500   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.241   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.880   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.154     1.145     0.000     0.000 c.m/sec"
```

```
"             Catchment 704          Pervious   Impervious Total Area "
"             Surface Area           0.444      0.666      1.110      hectare"
"             Time of concentration  7.165      2.222      2.986      minutes"
"             Time to Centroid       781.076    671.334    688.286    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        208.81     313.22     522.03     c.m"
"             Rainfall losses        35.686     5.637      17.657     mm"
"             Runoff depth           11.343     41.393     29.373     mm"
"             Runoff volume          50.36      275.68     326.04     c.m"
"             Runoff coefficient     0.241      0.880      0.625      "
"             Maximum flow           0.018      0.147      0.154      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.154     1.299     0.000     0.000"
" 33          CATCHMENT 801"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          801   Brohman Lands"
"       60.000   % Impervious"
"        0.850   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.340   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.510   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.242   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.875   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.123     1.299     0.000     0.000 c.m/sec"
"             Catchment 801          Pervious   Impervious Total Area "
"             Surface Area           0.340      0.510      0.850      hectare"
"             Time of concentration  12.659     1.298      3.067      minutes"
"             Time to Centroid       793.747    668.959    688.384    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        159.90     239.85     399.75     c.m"
"             Rainfall losses        35.650     5.881      17.788     mm"
"             Runoff depth           11.380     41.149     29.241     mm"
"             Runoff volume          38.69      209.86     248.55     c.m"
"             Runoff coefficient     0.242      0.875      0.622      "
"             Maximum flow           0.010      0.121      0.123      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.123     1.422     0.000     0.000"
" 54          POND DESIGN"
"        1.422   Current peak flow    c.m/sec"
"        0.654   Target outflow    c.m/sec"
"       3072.1   Hydrograph volume    c.m"
"          24.   Number of stages"
```

```
"      353.200   Minimum water level    metre"
"      355.500   Maximum water level    metre"
"      353.400   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                353.200     0.000     0.000"
"                353.300  1.00E-07   301.000"
"                353.400  1.00E-07   615.000"
"                353.500   0.00355   944.000"
"                353.600   0.00664  1288.000"
"                353.700   0.00870  1645.000"
"                353.800   0.01035  2018.000"
"                353.900   0.01178  2471.000"
"                354.000   0.01305  3006.000"
"                354.100   0.01420  3557.000"
"                354.200   0.02851  4124.000"
"                354.300   0.06671  4709.000"
"                354.400    0.1248  5310.000"
"                354.500    0.1984  5928.000"
"                354.600    0.2826  6562.000"
"                354.700    0.3724  7211.000"
"                354.800    0.4760  7877.000"
"                354.900    0.5973  8558.000"
"                355.000    0.7368  9255.000"
"                355.100    0.8972  9969.000"
"                355.200     1.082  10701.00"
"                355.300     1.296  11450.00"
"                355.400     1.541  12218.00"
"                355.500     1.821  13004.00"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                354.700     0.900     0.200     1.000     1.000"
"           1.   ORIFICES"
"                Orifice   Orifice   Orifice Number of"
"                 invert coefficie  diameter  orifices"
"                353.400     0.630    0.0900     1.000"
"           2.   OUTFLOW PIPE"
"               Upstream Downstr'm      Pipe      Pipe   Manning     Entry"
"                 invert    invert    Length  Diameter       'n'   loss Ke"
"                354.100   353.180    18.000     0.525     0.013     0.500"
"                354.100   353.180    18.000     0.525     0.013     0.500"
"             Peak outflow                  0.013    c.m/sec"
"             Maximum level               353.998    metre"
"             Maximum storage            2997.866    c.m"
"             Centroidal lag               46.908   hours"
"                  0.123     1.422     0.013     0.000 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                  0.013    c.m/sec"
"             Hydrograph volume          2967.244    c.m"
"                     0.123     1.422     0.013     0.013"
" 81          ADD COMMENT================================================="
"          2  Lines of comment"
"             501 to the north and/or ex. subdivision to the "
"             northeast"
" 40          HYDROGRAPH Start - New Tributary"
```

```
"            2   Start - New Tributary"
"                     0.123     0.000     0.013     0.013"
" 33          CATCHMENT 501"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          501   Northeast corner of subdivision"
"       60.000   % Impervious"
"        0.469   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.188   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.281   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.242   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.875   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.068     0.000     0.013     0.013 c.m/sec"
"             Catchment 501          Pervious   Impervious Total Area "
"             Surface Area           0.188      0.281      0.469      hectare"
"             Time of concentration  12.659     1.298      3.067      minutes"
"             Time to Centroid       793.747    668.958    688.384    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        88.23      132.34     220.57     c.m"
"             Rainfall losses        35.650     5.881      17.788     mm"
"             Runoff depth           11.380     41.149     29.241     mm"
"             Runoff volume          21.35      115.79     137.14     c.m"
"             Runoff coefficient     0.242      0.875      0.622      "
"             Maximum flow           0.005      0.067      0.068      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.068     0.068     0.013     0.013"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                     0.068     0.068     0.068     0.013"
" 40          HYDROGRAPH   Combine    501"
"            6   Combine "
"          501   Node #"
"                To N and NE"
"             Maximum flow                 0.068    c.m/sec"
"             Hydrograph volume          137.141    c.m"
"                     0.068     0.068     0.068     0.068"
" 81          ADD COMMENT================================================="
"          4  Lines of comment"
"             Flows from 502 and 503 are to a proposed SWM facility "
"             south of Conservation Drive. Rooftop runoff from the "
"             school (502) up to 25mm rainfall depth to infiltration"
"             but conservatively ignored in this modeling."
" 40          HYDROGRAPH Start - New Tributary"
```

```
"            2   Start - New Tributary"
"                     0.068     0.000     0.068     0.068"
" 33          CATCHMENT 601"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          601   External Area North of Site"
"        0.000   % Impervious"
"        3.500   Total Area"
"       90.000   Flow length"
"        2.000   Overland Slope"
"        3.500   Pervious Area"
"       90.000   Pervious length"
"        3.000   Pervious slope"
"        0.000   Impervious Area"
"       90.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       61.000   Pervious SCS Curve No."
"        0.104   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"       16.239   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.000   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.009     0.000     0.068     0.068 c.m/sec"
"             Catchment 601          Pervious   Impervious Total Area "
"             Surface Area           3.500      0.000      3.500      hectare"
"             Time of concentration  65.478     3.803      65.477     minutes"
"             Time to Centroid       945.620    676.130    945.617    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        1646.03    0.00       1646.03    c.m"
"             Rainfall losses        42.122     5.722      42.122     mm"
"             Runoff depth           4.907      41.307     4.907      mm"
"             Runoff volume          171.75     0.00       171.75     c.m"
"             Runoff coefficient     0.104      0.000      0.104      "
"             Maximum flow           0.009      0.000      0.009      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.009     0.009     0.068     0.068"
" 33          CATCHMENT 502"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          502   Front half of school site"
"       50.000   % Impervious"
"        1.986   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.993   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.993   Impervious Area"
"       30.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
```

```
"         0.242   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.881   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     0.228     0.009     0.068     0.068 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           0.993      0.993      1.986      hectare"
"              Time of concentration  19.188     1.967      5.678      minutes"
"              Time to Centroid       809.357    670.466    700.396    minutes"
"              Rainfall depth         47.029     47.029     47.029     mm"
"              Rainfall volume        467.00     467.00     934.00     c.m"
"              Rainfall losses        35.643     5.578      20.611     mm"
"              Runoff depth           11.386     41.451     26.419     mm"
"              Runoff volume          113.06     411.61     524.68     c.m"
"              Runoff coefficient     0.242      0.881      0.562      "
"              Maximum flow           0.021      0.224      0.228      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                     0.228     0.228     0.068     0.068"
" 33           CATCHMENT 503"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           503   East part of site incl townhouses"
"        70.000   % Impervious"
"         9.124   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         2.737   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         6.387   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.242   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.875   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     1.530     0.228     0.068     0.068 c.m/sec"
"              Catchment 503          Pervious   Impervious Total Area "
"              Surface Area           2.737      6.387      9.124      hectare"
"              Time of concentration  12.659     1.298      2.502      minutes"
"              Time to Centroid       793.747    668.959    682.182    minutes"
"              Rainfall depth         47.029     47.029     47.029     mm"
"              Rainfall volume        1287.29    3003.68    4290.97    c.m"
"              Rainfall losses        35.650     5.881      14.811     mm"
"              Runoff depth           11.380     41.149     32.218     mm"
"              Runoff volume          311.49     2628.09    2939.58    c.m"
"              Runoff coefficient     0.242      0.875      0.685      "
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"             Maximum flow           0.078      1.509      1.530      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    1.530     1.758     0.068     0.068"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                    1.530     1.758     1.758     0.068"
" 40          HYDROGRAPH   Combine    503"
"            6   Combine "
"          503   Node #"
"                SWM facility south of Conservation Dr"
"             Maximum flow                  1.758    c.m/sec"
"             Hydrograph volume          3636.005    c.m"
"                    1.530     1.758     1.758     1.758"
" 81          ADD COMMENT================================================="
"          2  Lines of comment"
"             Minor flows (2yr and less) from catchment 504 "
"             (townhouses at SW corner) are to infiltration"
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                    1.530     0.000     1.758     1.758"
" 33          CATCHMENT 504"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          504   Townhouse area at SW corner"
"       40.000   % Impervious"
"        0.332   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.199   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.133   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.242   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.875   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.033     0.000     1.758     1.758 c.m/sec"
"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.199      0.133      0.332      hectare"
"             Time of concentration  12.659     1.298      4.629      minutes"
"             Time to Centroid       793.747    668.958    705.546    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        93.68      62.46      156.14     c.m"
"             Rainfall losses        35.650     5.881      23.742     mm"
"             Runoff depth           11.380     41.149     23.287     mm"
"             Runoff volume          22.67      54.65      77.31      c.m"
"             Runoff coefficient     0.242      0.875      0.495      "
"             Maximum flow           0.006      0.031      0.033      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
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```
"            4   Add Runoff "
"                     0.033     0.033     1.758     1.758"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                     0.033     0.033     0.033     1.758"
" 40          HYDROGRAPH   Combine    504"
"            6   Combine "
"          504   Node #"
"                Minor to infiltration"
"              Maximum flow                  0.033    c.m/sec"
"              Hydrograph volume            77.314    c.m"
"                     0.033     0.033     0.033     0.033"
" 81          ADD COMMENT================================================="
"          3  Lines of comment"
"              Flows from catchment 505 are infiltrated (2-year "
"              and less) with overflows to the wetland finger, which "
"              then is combined with pond outflows towards Beaver Ck "
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                     0.033     0.000     0.033     0.033"
" 33          CATCHMENT 505"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          505   Rear yards of lots at NW corner"
"       60.000   % Impervious"
"        0.898   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.359   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.539   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.242   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.875   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.130     0.000     0.033     0.033 c.m/sec"
"              Catchment 505          Pervious   Impervious Total Area "
"              Surface Area           0.359      0.539      0.898      hectare"
"              Time of concentration  12.659     1.298      3.067      minutes"
"              Time to Centroid       793.747    668.959    688.384    minutes"
"              Rainfall depth         47.029     47.029     47.029     mm"
"              Rainfall volume        168.93     253.39     422.32     c.m"
"              Rainfall losses        35.650     5.881      17.788     mm"
"              Runoff depth           11.380     41.149     29.241     mm"
"              Runoff volume          40.88      221.71     262.59     c.m"
"              Runoff coefficient     0.242      0.875      0.622      "
"              Maximum flow           0.010      0.127      0.130      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
```

```
"                    0.130     0.130     0.033     0.033"
" 40          HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                    0.130     0.130     0.130     0.033"
" 40          HYDROGRAPH   Combine    505"
"             6   Combine "
"           505   Node #"
"                 Minor to infiltration"
"             Maximum flow                  0.130    c.m/sec"
"             Hydrograph volume           262.587    c.m"
"                    0.130     0.130     0.130     0.130"
" 81          ADD COMMENT================================================="
"           1  Lines of comment"
"             Brohman Lands to Infiltration "
" 40          HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                    0.130     0.000     0.130     0.130"
" 33          CATCHMENT 602"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           602   Brohman to Infiltration"
"        60.000   % Impervious"
"         0.400   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.160   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.240   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.242   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.875   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                    0.058     0.000     0.130     0.130 c.m/sec"
"             Catchment 602          Pervious   Impervious Total Area "
"             Surface Area           0.160      0.240      0.400      hectare"
"             Time of concentration  12.659     1.298      3.067      minutes"
"             Time to Centroid       793.747    668.959    688.384    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        75.25      112.87     188.12     c.m"
"             Rainfall losses        35.650     5.881      17.788     mm"
"             Runoff depth           11.380     41.149     29.241     mm"
"             Runoff volume          18.21      98.76      116.97     c.m"
"             Runoff coefficient     0.242      0.875      0.622      "
"             Maximum flow           0.005      0.057      0.058      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                    0.058     0.058     0.130     0.130"
" 40          HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
```

```
"                    0.058     0.058     0.058     0.130"
" 40          HYDROGRAPH   Combine    602"
"              6   Combine "
"            602   Node #"
"                  Brohman Infiltration"
"               Maximum flow                 0.058    c.m/sec"
"               Hydrograph volume          116.965    c.m"
"                    0.058     0.058     0.058     0.058"
" 38          START/RE-START TOTALS 602"
"              3   Runoff Totals on EXIT"
"               Total Catchment area                    28.125    hectare"
"               Total Impervious area                   14.520    hectare"
"               Total % impervious                      51.626"
" 19          EXIT"
```

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"                MIDUSS Output ------------------------------------------------>"
"                MIDUSS version                          Version 2.25  rev. 473"
"                MIDUSS created                               February 7, 2010"
"           10   Units used:                                          ie METRIC"
"                Job folder:                  K:\PRJ - DOCS\1279\60-Design\SWM"
"                Output filename:                      1279d5yr3hrJun102020.out"
"                Licensee name:                        Stefan Van Hartingsveldt"
"                Company                                   Meritech Engineering"
"                Date & Time last used:                2020-06-10 at 5:05:31 PM"
" 81           ADD COMMENT================================================="
"           2  Lines of comment"
"              SWM Analysis of 5-yr 3hr post-development storm event "
"              for 556 and 576 Conservation Drive, Waterloo"
" 31           TIME PARAMETERS"
"         5.000   Time Step"
"       180.000   Max. Storm length"
"      7200.000   Max. Hydrograph"
" 32           STORM Chicago storm"
"             1   Chicago storm"
"      1755.000   Coefficient A"
"        12.347   Constant B"
"         0.895   Exponent C"
"         0.400   Fraction R"
"       180.000   Duration"
"         1.000   Time step multiplier"
"              Maximum intensity          136.512    mm/hr"
"              Total depth                 47.549    mm"
"             6   005hyd   Hydrograph extension used in this file"
" 81           ADD COMMENT================================================="
"           1  Lines of comment"
"              Area to SWM facility on west side"
" 33           CATCHMENT 701"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           701   Northwest corner - lots"
"        60.000   % Impervious"
"         7.343   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         2.937   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         4.406   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.245   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.870   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      1.412     0.000     0.000     0.000 c.m/sec"
"              Catchment 701          Pervious   Impervious Total Area "
"              Surface Area           2.937      4.406      7.343      hectare"
```

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"             Time of concentration  11.586     1.166      2.812      minutes"
"             Time to Centroid       112.272    87.475     91.391     minutes"
"             Rainfall depth         47.549     47.549     47.549     mm"
"             Rainfall volume        1396.61    2094.92    3491.53    c.m"
"             Rainfall losses        35.905     6.164      18.061     mm"
"             Runoff depth           11.644     41.385     29.488     mm"
"             Runoff volume          342.00     1823.33    2165.33    c.m"
"             Runoff coefficient     0.245      0.870      0.620      "
"             Maximum flow           0.145      1.385      1.412      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     1.412     1.412     0.000     0.000"
" 33          CATCHMENT 702"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          702   Rear half of school site"
"       30.000   % Impervious"
"        0.770   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.539   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.231   Impervious Area"
"       30.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.245   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.879   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.072     1.412     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.539      0.231      0.770      hectare"
"             Time of concentration  17.561     1.767      7.988      minutes"
"             Time to Centroid       119.503    88.287     100.582    minutes"
"             Rainfall depth         47.549     47.549     47.549     mm"
"             Rainfall volume        256.29     109.84     366.13     c.m"
"             Rainfall losses        35.905     5.740      26.856     mm"
"             Runoff depth           11.644     41.809     20.693     mm"
"             Runoff volume          62.76      96.58      159.34     c.m"
"             Runoff coefficient     0.245      0.879      0.435      "
"             Maximum flow           0.022      0.070      0.072      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.072     1.484     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
"        1.343   Total Area"
```

```
"        80.000   Flow length"
"         3.000   Overland Slope"
"         1.209   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.134   Impervious Area"
"        80.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.245   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.874   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.044     1.484     0.000     0.000 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           1.209      0.134      1.343      hectare"
"              Time of concentration  31.633     3.183      23.559     minutes"
"              Time to Centroid       136.562    90.449     123.475    minutes"
"              Rainfall depth         47.549     47.549     47.549     mm"
"              Rainfall volume        574.73     63.86      638.58     c.m"
"              Rainfall losses        35.890     5.968      32.898     mm"
"              Runoff depth           11.659     41.581     14.651     mm"
"              Runoff volume          140.92     55.84      196.76     c.m"
"              Runoff coefficient     0.245      0.874      0.308      "
"              Maximum flow           0.035      0.037      0.044      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.044     1.523     0.000     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         1.110   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.444   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.666   Impervious Area"
"        15.000   Impervious length"
"         0.500   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.243   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.879   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.206     1.523     0.000     0.000 c.m/sec"
```

```
"             Catchment 704          Pervious   Impervious Total Area "
"             Surface Area           0.444      0.666      1.110      hectare"
"             Time of concentration  6.558      1.996      2.705      minutes"
"             Time to Centroid       106.354    88.629     91.385     minutes"
"             Rainfall depth         47.549     47.549     47.549     mm"
"             Rainfall volume        211.12     316.68     527.79     c.m"
"             Rainfall losses        36.011     5.764      17.863     mm"
"             Runoff depth           11.538     41.785     29.686     mm"
"             Runoff volume          51.23      278.29     329.52     c.m"
"             Runoff coefficient     0.243      0.879      0.624      "
"             Maximum flow           0.028      0.198      0.206      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.206     1.729     0.000     0.000"
" 33          CATCHMENT 801"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          801   Brohman Lands"
"       60.000   % Impervious"
"        0.850   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.340   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.510   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.245   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.870   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.163     1.729     0.000     0.000 c.m/sec"
"             Catchment 801          Pervious   Impervious Total Area "
"             Surface Area           0.340      0.510      0.850      hectare"
"             Time of concentration  11.586     1.166      2.812      minutes"
"             Time to Centroid       112.272    87.475     91.391     minutes"
"             Rainfall depth         47.549     47.549     47.549     mm"
"             Rainfall volume        161.67     242.50     404.17     c.m"
"             Rainfall losses        35.905     6.164      18.061     mm"
"             Runoff depth           11.644     41.385     29.488     mm"
"             Runoff volume          39.59      211.06     250.65     c.m"
"             Runoff coefficient     0.245      0.870      0.620      "
"             Maximum flow           0.017      0.160      0.163      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.163     1.893     0.000     0.000"
" 54          POND DESIGN"
"        1.893   Current peak flow    c.m/sec"
"        0.654   Target outflow    c.m/sec"
"       3101.6   Hydrograph volume    c.m"
"          24.   Number of stages"
```

```
"      353.200   Minimum water level    metre"
"      355.500   Maximum water level    metre"
"      353.400   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                353.200     0.000     0.000"
"                353.300  1.00E-07   301.000"
"                353.400  1.00E-07   615.000"
"                353.500   0.00355   944.000"
"                353.600   0.00664  1288.000"
"                353.700   0.00870  1645.000"
"                353.800   0.01035  2018.000"
"                353.900   0.01178  2471.000"
"                354.000   0.01305  3006.000"
"                354.100   0.02744  3557.000"
"                354.200   0.06573  4124.000"
"                354.300    0.1239  4709.000"
"                354.400    0.1975  5310.000"
"                354.500    0.2818  5928.000"
"                354.600    0.3716  6562.000"
"                354.700    0.4620  7211.000"
"                354.800    0.5620  7877.000"
"                354.900    0.6773  8558.000"
"                355.000    0.8101  9255.000"
"                355.100    0.9645  9969.000"
"                355.200     1.144  10701.00"
"                355.300     1.353  11450.00"
"                355.400     1.595  12218.00"
"                355.500     1.872  13004.00"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                354.700     0.900     0.200     1.000     1.000"
"           1.   ORIFICES"
"                Orifice   Orifice   Orifice Number of"
"                 invert coefficie  diameter  orifices"
"                353.400     0.630    0.0900     1.000"
"           2.   OUTFLOW PIPE"
"               Upstream Downstr'm      Pipe      Pipe   Manning     Entry"
"                 invert    invert    Length  Diameter       'n'   loss Ke"
"                354.000   353.180    18.000     0.525     0.013     0.500"
"                354.000   353.180    18.000     0.525     0.013     0.500"
"             Peak outflow                 0.027    c.m/sec"
"             Maximum level              354.096    metre"
"             Maximum storage           3536.805    c.m"
"             Centroidal lag              35.488   hours"
"                  0.163     1.893     0.027     0.000 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                 0.027    c.m/sec"
"             Hydrograph volume         3037.499    c.m"
"                     0.163     1.893     0.027     0.027"
" 81          ADD COMMENT================================================="
"          2  Lines of comment"
"             501 to the north and/or ex. subdivision to the "
"             northeast"
" 40          HYDROGRAPH Start - New Tributary"
```

```
"            2   Start - New Tributary"
"                     0.163     0.000     0.027     0.027"
" 33          CATCHMENT 501"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          501   Northeast corner of subdivision"
"       60.000   % Impervious"
"        0.469   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.188   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.281   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.245   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.870   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.090     0.000     0.027     0.027 c.m/sec"
"             Catchment 501          Pervious   Impervious Total Area "
"             Surface Area           0.188      0.281      0.469      hectare"
"             Time of concentration  11.586     1.166      2.812      minutes"
"             Time to Centroid       112.272    87.475     91.391     minutes"
"             Rainfall depth         47.549     47.549     47.549     mm"
"             Rainfall volume        89.20      133.80     223.01     c.m"
"             Rainfall losses        35.905     6.164      18.061     mm"
"             Runoff depth           11.644     41.385     29.488     mm"
"             Runoff volume          21.84      116.46     138.30     c.m"
"             Runoff coefficient     0.245      0.870      0.620      "
"             Maximum flow           0.009      0.088      0.090      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.090     0.090     0.027     0.027"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                     0.090     0.090     0.090     0.027"
" 40          HYDROGRAPH   Combine    501"
"            6   Combine "
"          501   Node #"
"                To N and NE"
"             Maximum flow                 0.090    c.m/sec"
"             Hydrograph volume          138.300    c.m"
"                     0.090     0.090     0.090     0.090"
" 81          ADD COMMENT================================================="
"          4  Lines of comment"
"             Flows from 502 and 503 are to a proposed SWM facility "
"             south of Conservation Drive. Rooftop runoff from the "
"             school (502) up to 25mm rainfall depth to infiltration"
"             but conservatively ignored in this modeling."
" 40          HYDROGRAPH Start - New Tributary"
```

```
"            2   Start - New Tributary"
"                     0.090     0.000     0.090     0.090"
" 33          CATCHMENT 601"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          601   External Area North of Site"
"        0.000   % Impervious"
"        3.500   Total Area"
"       90.000   Flow length"
"        2.000   Overland Slope"
"        3.500   Pervious Area"
"       90.000   Pervious length"
"        3.000   Pervious slope"
"        0.000   Impervious Area"
"       90.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       61.000   Pervious SCS Curve No."
"        0.106   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"       16.239   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.000   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.030     0.000     0.090     0.090 c.m/sec"
"             Catchment 601          Pervious   Impervious Total Area "
"             Surface Area           3.500      0.000      3.500      hectare"
"             Time of concentration  51.688     3.417      51.687     minutes"
"             Time to Centroid       162.878    90.804     162.877    minutes"
"             Rainfall depth         47.549     47.549     47.549     mm"
"             Rainfall volume        1664.22    0.00       1664.22    c.m"
"             Rainfall losses        42.489     6.017      42.489     mm"
"             Runoff depth           5.060      41.532     5.060      mm"
"             Runoff volume          177.11     0.00       177.11     c.m"
"             Runoff coefficient     0.106      0.000      0.106      "
"             Maximum flow           0.030      0.000      0.030      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.030     0.030     0.090     0.090"
" 33          CATCHMENT 502"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          502   Front half of school site"
"       50.000   % Impervious"
"        1.986   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.993   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.993   Impervious Area"
"       30.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
```

```
"         0.245   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.879   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.304     0.030     0.090     0.090 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           0.993      0.993      1.986      hectare"
"              Time of concentration  17.561     1.767      5.208      minutes"
"              Time to Centroid       119.503    88.287     95.087     minutes"
"              Rainfall depth         47.549     47.549     47.549     mm"
"              Rainfall volume        472.16     472.16     944.32     c.m"
"              Rainfall losses        35.905     5.740      20.823     mm"
"              Runoff depth           11.644     41.809     26.726     mm"
"              Runoff volume          115.62     415.16     530.79     c.m"
"              Runoff coefficient     0.245      0.879      0.562      "
"              Maximum flow           0.041      0.299      0.304      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.304     0.305     0.090     0.090"
" 33           CATCHMENT 503"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           503   East part of site incl townhouses"
"        70.000   % Impervious"
"         9.124   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         2.737   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         6.387   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.245   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.870   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      2.033     0.305     0.090     0.090 c.m/sec"
"              Catchment 503          Pervious   Impervious Total Area "
"              Surface Area           2.737      6.387      9.124      hectare"
"              Time of concentration  11.586     1.166      2.287      minutes"
"              Time to Centroid       112.272    87.475     90.143     minutes"
"              Rainfall depth         47.549     47.549     47.549     mm"
"              Rainfall volume        1301.51    3036.86    4338.38    c.m"
"              Rainfall losses        35.905     6.164      15.087     mm"
"              Runoff depth           11.644     41.385     32.462     mm"
"              Runoff volume          318.71     2643.16    2961.88    c.m"
"              Runoff coefficient     0.245      0.870      0.683      "
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```
"             Maximum flow           0.135      2.008      2.033      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    2.033     2.338     0.090     0.090"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                    2.033     2.338     2.338     0.090"
" 40          HYDROGRAPH   Combine    503"
"            6   Combine "
"          503   Node #"
"                SWM facility south of Conservation Dr"
"             Maximum flow                  2.338    c.m/sec"
"             Hydrograph volume          3669.776    c.m"
"                    2.033     2.338     2.338     2.338"
" 81          ADD COMMENT================================================="
"          3  Lines of comment"
"             Minor flows (2yr and less) from catchment 504 "
"             (townhouses at SW corner) (77m3) are to infiltration, "
"             remainder to Beaver Creek "
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                    2.033     0.000     2.338     2.338"
" 33          CATCHMENT 504"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          504   Townhouse area at SW corner"
"       40.000   % Impervious"
"        0.332   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.199   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.133   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.245   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.870   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.044     0.000     2.338     2.338 c.m/sec"
"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.199      0.133      0.332      hectare"
"             Time of concentration  11.586     1.166      4.258      minutes"
"             Time to Centroid       112.272    87.475     94.834     minutes"
"             Rainfall depth         47.549     47.549     47.549     mm"
"             Rainfall volume        94.72      63.15      157.86     c.m"
"             Rainfall losses        35.905     6.164      24.009     mm"
"             Runoff depth           11.644     41.385     23.540     mm"
"             Runoff volume          23.19      54.96      78.15      c.m"
"             Runoff coefficient     0.245      0.870      0.495      "
"             Maximum flow           0.010      0.042      0.044      c.m/sec"
```

```
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                     0.044     0.044     2.338     2.338"
" 54          POND DESIGN"
"         0.044   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"          78.2   Hydrograph volume    c.m"
"            3.   Number of stages"
"       100.000   Minimum water level    metre"
"       102.000   Maximum water level    metre"
"       100.000   Starting water level    metre"
"             0   Keep Design Data: 1 = True; 0 = False"
"                   Level Discharge    Volume"
"                 100.000     0.000     0.000"
"                 101.000  1.01E-05    77.000"
"                 102.000     6.492  1000.000"
"            1.   WEIRS"
"                   Crest      Weir     Crest      Left     Right"
"                elevation coefficie   breadth sideslope sideslope"
"                 101.000     0.900     2.000     3.000     3.000"
"               Peak outflow                  0.001    c.m/sec"
"               Maximum level               101.000    metre"
"               Maximum storage              77.105    c.m"
"               Centroidal lag               48.717   hours"
"                     0.044     0.044     0.001     2.338 c.m/sec"
" 40            HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"               Maximum flow                  0.028    c.m/sec"
"               Hydrograph volume          3042.761    c.m"
"                     0.044     0.044     0.001     0.028"
" 81            ADD COMMENT================================================="
"           3  Lines of comment"
"              Minor flows (2yr and less) from catchment 505 "
"              (North Property Line) (263m3) are to infiltration, "
"              remainder to wetland finger to Beaver Creek "
" 40            HYDROGRAPH Start - New Tributary"
"              2   Start - New Tributary"
"                     0.044     0.000     0.001     0.028"
" 33            CATCHMENT 505"
"              1   Triangular SCS"
"              1   Equal length"
"              1   SCS method"
"            505   Rear yards of lots at NW corner"
"         60.000   % Impervious"
"          0.898   Total Area"
"         15.000   Flow length"
"          3.000   Overland Slope"
"          0.359   Pervious Area"
"         15.000   Pervious length"
"          3.000   Pervious slope"
"          0.539   Impervious Area"
"         15.000   Impervious length"
"          3.000   Impervious slope"
"          0.250   Pervious Manning 'n'"
"         74.000   Pervious SCS Curve No."
"          0.245   Pervious Runoff coefficient"
"          0.100   Pervious Ia/S coefficient"
```

```
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.870   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     0.173     0.000     0.001     0.028 c.m/sec"
"              Catchment 505          Pervious   Impervious Total Area "
"              Surface Area           0.359      0.539      0.898      hectare"
"              Time of concentration  11.586     1.166      2.812      minutes"
"              Time to Centroid       112.272    87.475     91.391     minutes"
"              Rainfall depth         47.549     47.549     47.549     mm"
"              Rainfall volume        170.80     256.19     426.99     c.m"
"              Rainfall losses        35.905     6.164      18.061     mm"
"              Runoff depth           11.644     41.385     29.488     mm"
"              Runoff volume          41.82      222.98     264.81     c.m"
"              Runoff coefficient     0.245      0.870      0.620      "
"              Maximum flow           0.018      0.169      0.173      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                     0.173     0.173     0.001     0.028"
" 54           POND DESIGN"
"         0.173   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"         264.8   Hydrograph volume    c.m"
"            3.   Number of stages"
"       100.000   Minimum water level    metre"
"       102.000   Maximum water level    metre"
"       100.000   Starting water level    metre"
"             0   Keep Design Data: 1 = True; 0 = False"
"                   Level Discharge    Volume"
"                 100.000     0.000     0.000"
"                 101.000  1.01E-05   263.000"
"                 102.000     6.492  1000.000"
"            1.   WEIRS"
"                   Crest      Weir     Crest      Left     Right"
"               elevation coefficie   breadth sideslope sideslope"
"                 101.000     0.900     2.000     3.000     3.000"
"              Peak outflow                  0.001    c.m/sec"
"              Maximum level               101.000    metre"
"              Maximum storage             263.150    c.m"
"              Centroidal lag               44.405   hours"
"                   0.173     0.173     0.001     0.028 c.m/sec"
" 40           HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"              Maximum flow                  0.029    c.m/sec"
"              Hydrograph volume          3048.729    c.m"
"                     0.173     0.173     0.001     0.029"
" 81           ADD COMMENT================================================="
"           1  Lines of comment"
"              Uncontrolled Brohman Lands "
" 40           HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                     0.173     0.000     0.001     0.029"
" 33           CATCHMENT 602"
"             1   Triangular SCS"
"             1   Equal length"
```

```
"            1   SCS method"
"          602   Brohman Uncontrolled"
"       60.000   % Impervious"
"        0.400   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.160   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.240   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.245   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.870   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.077     0.000     0.001     0.029 c.m/sec"
"             Catchment 602          Pervious   Impervious Total Area "
"             Surface Area           0.160      0.240      0.400      hectare"
"             Time of concentration  11.586     1.166      2.812      minutes"
"             Time to Centroid       112.272    87.475     91.391     minutes"
"             Rainfall depth         47.549     47.549     47.549     mm"
"             Rainfall volume        76.08      114.12     190.20     c.m"
"             Rainfall losses        35.905     6.164      18.061     mm"
"             Runoff depth           11.644     41.385     29.488     mm"
"             Runoff volume          18.63      99.32      117.95     c.m"
"             Runoff coefficient     0.245      0.870      0.620      "
"             Maximum flow           0.008      0.075      0.077      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.077     0.077     0.001     0.029"
" 54          POND DESIGN"
"        0.077   Current peak flow    c.m/sec"
"        1.000   Target outflow    c.m/sec"
"        118.0   Hydrograph volume    c.m"
"           3.   Number of stages"
"      100.000   Minimum water level    metre"
"      102.000   Maximum water level    metre"
"      100.000   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                100.000     0.000     0.000"
"                101.000  1.01E-05   117.000"
"                102.000     6.492  1000.000"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                101.000     0.900     2.000     3.000     3.000"
"             Peak outflow                  0.001    c.m/sec"
"             Maximum level                101.000    metre"
"             Maximum storage              117.093    c.m"
"             Centroidal lag                50.895   hours"
"                    0.077     0.077     0.001     0.029 c.m/sec"
```

```
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"              Maximum flow                  0.030    c.m/sec"
"              Hydrograph volume          3053.812    c.m"
"                     0.077     0.077     0.001     0.030"
" 38          START/RE-START TOTALS 602"
"            3   Runoff Totals on EXIT"
"              Total Catchment area                     28.125    hectare"
"              Total Impervious area                    14.520    hectare"
"              Total % impervious                       51.626"
" 19          EXIT"
```

```
"                MIDUSS Output ------------------------------------------------>"
"                MIDUSS version                          Version 2.25  rev. 473"
"                MIDUSS created                               February 7, 2010"
"           10   Units used:                                          ie METRIC"
"                Job folder:                  K:\PRJ - DOCS\1279\60-Design\SWM"
"                Output filename:                    1279d5yr24hrJun102020.out"
"                Licensee name:                       Stefan Van Hartingsveldt"
"                Company                                  Meritech Engineering"
"                Date & Time last used:               2020-06-10 at 5:13:39 PM"
" 81           ADD COMMENT================================================="
"          2  Lines of comment"
"             SWM Analysis of 5-yr 24hr post-development storm event "
"             for 556 and 576 Conservation Drive, Waterloo"
" 31           TIME PARAMETERS"
"        5.000   Time Step"
"     1440.000   Max. Storm length"
"     7200.000   Max. Hydrograph"
" 32           STORM Chicago storm"
"            1   Chicago storm"
"      956.510   Coefficient A"
"        5.608   Constant B"
"        0.815   Exponent C"
"        0.400   Fraction R"
"     1440.000   Duration"
"        1.000   Time step multiplier"
"             Maximum intensity          133.887    mm/hr"
"             Total depth                 61.018    mm"
"            6   005hyd   Hydrograph extension used in this file"
" 81           ADD COMMENT================================================="
"          1  Lines of comment"
"             Area to SWM facility on west side"
" 33           CATCHMENT 701"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          701   Northwest corner - lots"
"       60.000   % Impervious"
"        7.343   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        2.937   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        4.406   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.313   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.895   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     1.458     0.000     0.000     0.000 c.m/sec"
"             Catchment 701          Pervious   Impervious Total Area "
"             Surface Area           2.937      4.406      7.343      hectare"
```

```
"             Time of concentration  9.993      1.166      2.836      minutes"
"             Time to Centroid       756.254    656.264    675.183    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        1792.23    2688.34    4480.57    c.m"
"             Rainfall losses        41.904     6.416      20.611     mm"
"             Runoff depth           19.114     54.602     40.407     mm"
"             Runoff volume          561.42     2405.68    2967.09    c.m"
"             Runoff coefficient     0.313      0.895      0.662      "
"             Maximum flow           0.179      1.393      1.458      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     1.458     1.458     0.000     0.000"
" 33          CATCHMENT 702"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          702   Rear half of school site"
"       30.000   % Impervious"
"        0.770   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.539   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.231   Impervious Area"
"       30.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.314   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.903   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.077     1.458     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.539      0.231      0.770      hectare"
"             Time of concentration  15.147     1.767      7.764      minutes"
"             Time to Centroid       767.984    657.509    707.024    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        328.89     140.95     469.84     c.m"
"             Rainfall losses        41.834     5.905      31.055     mm"
"             Runoff depth           19.185     55.113     29.963     mm"
"             Runoff volume          103.41     127.31     230.72     c.m"
"             Runoff coefficient     0.314      0.903      0.491      "
"             Maximum flow           0.028      0.070      0.077      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.077     1.534     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
"        1.343   Total Area"
```

```
"       80.000   Flow length"
"        3.000   Overland Slope"
"        1.209   Pervious Area"
"       80.000   Pervious length"
"        3.000   Pervious slope"
"        0.134   Impervious Area"
"       80.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.315   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.902   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.046     1.534     0.000     0.000 c.m/sec"
"             Catchment 703          Pervious   Impervious Total Area "
"             Surface Area           1.209      0.134      1.343      hectare"
"             Time of concentration  27.284     3.184      21.461     minutes"
"             Time to Centroid       796.758    661.652    764.114    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        737.53     81.95      819.47     c.m"
"             Rainfall losses        41.821     5.973      38.236     mm"
"             Runoff depth           19.197     55.045     22.782     mm"
"             Runoff volume          232.04     73.93      305.96     c.m"
"             Runoff coefficient     0.315      0.902      0.373      "
"             Maximum flow           0.039      0.037      0.046      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.046     1.577     0.000     0.000"
" 33          CATCHMENT 704"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          704   SWM block"
"       60.000   % Impervious"
"        1.110   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.444   Pervious Area"
"       15.000   Pervious length"
"       20.000   Pervious slope"
"        0.666   Impervious Area"
"       15.000   Impervious length"
"        0.500   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.314   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.904   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.222     1.577     0.000     0.000 c.m/sec"
```

```
"             Catchment 704          Pervious   Impervious Total Area "
"             Surface Area           0.444      0.666      1.110      hectare"
"             Time of concentration  5.656      1.996      2.684      minutes"
"             Time to Centroid       745.656    658.155    674.589    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        270.92     406.38     677.30     c.m"
"             Rainfall losses        41.880     5.847      20.261     mm"
"             Runoff depth           19.138     55.171     40.758     mm"
"             Runoff volume          84.97      367.44     452.41     c.m"
"             Runoff coefficient     0.314      0.904      0.668      "
"             Maximum flow           0.036      0.201      0.222      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.222     1.799     0.000     0.000"
" 33          CATCHMENT 801"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          801   Brohman Lands"
"       60.000   % Impervious"
"        0.850   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.340   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.510   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.313   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.895   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.169     1.799     0.000     0.000 c.m/sec"
"             Catchment 801          Pervious   Impervious Total Area "
"             Surface Area           0.340      0.510      0.850      hectare"
"             Time of concentration  9.993      1.166      2.836      minutes"
"             Time to Centroid       756.254    656.264    675.183    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        207.46     311.19     518.65     c.m"
"             Rainfall losses        41.904     6.416      20.611     mm"
"             Runoff depth           19.114     54.602     40.407     mm"
"             Runoff volume          64.99      278.47     343.46     c.m"
"             Runoff coefficient     0.313      0.895      0.662      "
"             Maximum flow           0.021      0.161      0.169      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.169     1.967     0.000     0.000"
" 54          POND DESIGN"
"        1.967   Current peak flow    c.m/sec"
"        0.654   Target outflow    c.m/sec"
"       4299.6   Hydrograph volume    c.m"
"          24.   Number of stages"
```

```
"      353.200   Minimum water level    metre"
"      355.500   Maximum water level    metre"
"      353.400   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                353.200     0.000     0.000"
"                353.300  1.00E-07   301.000"
"                353.400  1.00E-07   615.000"
"                353.500   0.00355   944.000"
"                353.600   0.00664  1288.000"
"                353.700   0.00870  1645.000"
"                353.800   0.01035  2018.000"
"                353.900   0.01178  2471.000"
"                354.000   0.01305  3006.000"
"                354.100   0.02744  3557.000"
"                354.200   0.06573  4124.000"
"                354.300    0.1239  4709.000"
"                354.400    0.1975  5310.000"
"                354.500    0.2818  5928.000"
"                354.600    0.3716  6562.000"
"                354.700    0.4620  7211.000"
"                354.800    0.5620  7877.000"
"                354.900    0.6773  8558.000"
"                355.000    0.8101  9255.000"
"                355.100    0.9645  9969.000"
"                355.200     1.144  10701.00"
"                355.300     1.353  11450.00"
"                355.400     1.595  12218.00"
"                355.500     1.872  13004.00"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                354.700     0.900     0.200     1.000     1.000"
"           1.   ORIFICES"
"                Orifice   Orifice   Orifice Number of"
"                 invert coefficie  diameter  orifices"
"                353.400     0.630    0.0900     1.000"
"           2.   OUTFLOW PIPE"
"               Upstream Downstr'm      Pipe      Pipe   Manning     Entry"
"                 invert    invert    Length  Diameter       'n'   loss Ke"
"                354.000   353.180    18.000     0.525     0.013     0.500"
"                354.000   353.180    18.000     0.525     0.013     0.500"
"             Peak outflow                 0.037    c.m/sec"
"             Maximum level              354.126    metre"
"             Maximum storage           3704.527    c.m"
"             Centroidal lag              41.697   hours"
"                  0.169     1.967     0.037     0.000 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                 0.037    c.m/sec"
"             Hydrograph volume         4166.556    c.m"
"                     0.169     1.967     0.037     0.037"
" 81          ADD COMMENT================================================="
"          2  Lines of comment"
"             501 to the north and/or ex. subdivision to the "
"             northeast"
" 40          HYDROGRAPH Start - New Tributary"
```

```
"            2   Start - New Tributary"
"                     0.169     0.000     0.037     0.037"
" 33          CATCHMENT 501"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          501   Northeast corner of subdivision"
"       60.000   % Impervious"
"        0.469   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.188   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.281   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.313   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.895   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.093     0.000     0.037     0.037 c.m/sec"
"             Catchment 501          Pervious   Impervious Total Area "
"             Surface Area           0.188      0.281      0.469      hectare"
"             Time of concentration  9.993      1.166      2.836      minutes"
"             Time to Centroid       756.254    656.263    675.183    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        114.47     171.71     286.18     c.m"
"             Rainfall losses        41.904     6.416      20.611     mm"
"             Runoff depth           19.114     54.602     40.407     mm"
"             Runoff volume          35.86      153.65     189.51     c.m"
"             Runoff coefficient     0.313      0.895      0.662      "
"             Maximum flow           0.011      0.089      0.093      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.093     0.093     0.037     0.037"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                     0.093     0.093     0.093     0.037"
" 40          HYDROGRAPH   Combine    501"
"            6   Combine "
"          501   Node #"
"                To N and NE"
"             Maximum flow                 0.093    c.m/sec"
"             Hydrograph volume          189.509    c.m"
"                     0.093     0.093     0.093     0.093"
" 81          ADD COMMENT================================================="
"          4  Lines of comment"
"             Flows from 502 and 503 are to a proposed SWM facility "
"             south of Conservation Drive. Rooftop runoff from the "
"             school (502) up to 25mm rainfall depth to infiltration"
"             but conservatively ignored in this modeling."
" 40          HYDROGRAPH Start - New Tributary"
```

```
"            2   Start - New Tributary"
"                     0.093     0.000     0.093     0.093"
" 33          CATCHMENT 601"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          601   External Area North of Site"
"        0.000   % Impervious"
"        3.500   Total Area"
"       90.000   Flow length"
"        2.000   Overland Slope"
"        3.500   Pervious Area"
"       90.000   Pervious length"
"        3.000   Pervious slope"
"        0.000   Impervious Area"
"       90.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       61.000   Pervious SCS Curve No."
"        0.159   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"       16.239   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.000   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.033     0.000     0.093     0.093 c.m/sec"
"             Catchment 601          Pervious   Impervious Total Area "
"             Surface Area           3.500      0.000      3.500      hectare"
"             Time of concentration  42.618     3.417      42.618     minutes"
"             Time to Centroid       861.968    662.410    861.967    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        2135.64    0.00       2135.64    c.m"
"             Rainfall losses        51.341     6.070      51.341     mm"
"             Runoff depth           9.677      54.948     9.677      mm"
"             Runoff volume          338.70     0.00       338.71     c.m"
"             Runoff coefficient     0.159      0.000      0.159      "
"             Maximum flow           0.033      0.000      0.033      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.033     0.033     0.093     0.093"
" 33          CATCHMENT 502"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          502   Front half of school site"
"       50.000   % Impervious"
"        1.986   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.993   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.993   Impervious Area"
"       30.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
```

```
"         0.314   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.903   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     0.314     0.033     0.093     0.093 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           0.993      0.993      1.986      hectare"
"              Time of concentration  15.147     1.767      5.222      minutes"
"              Time to Centroid       767.983    657.510    686.035    minutes"
"              Rainfall depth         61.018     61.018     61.018     mm"
"              Rainfall volume        605.91     605.91     1211.82    c.m"
"              Rainfall losses        41.834     5.905      23.869     mm"
"              Runoff depth           19.185     55.113     37.149     mm"
"              Runoff volume          190.50     547.27     737.77     c.m"
"              Runoff coefficient     0.314      0.903      0.609      "
"              Maximum flow           0.051      0.302      0.314      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                     0.314     0.316     0.093     0.093"
" 33           CATCHMENT 503"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           503   East part of site incl townhouses"
"        70.000   % Impervious"
"         9.124   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         2.737   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         6.387   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.313   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.895   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     2.079     0.316     0.093     0.093 c.m/sec"
"              Catchment 503          Pervious   Impervious Total Area "
"              Surface Area           2.737      6.387      9.124      hectare"
"              Time of concentration  9.993      1.166      2.318      minutes"
"              Time to Centroid       756.254    656.264    669.307    minutes"
"              Rainfall depth         61.018     61.018     61.018     mm"
"              Rainfall volume        1670.19    3897.11    5567.30    c.m"
"              Rainfall losses        41.904     6.416      17.062     mm"
"              Runoff depth           19.114     54.602     43.956     mm"
"              Runoff volume          523.19     3487.35    4010.54    c.m"
"              Runoff coefficient     0.313      0.895      0.720      "
```

```
"             Maximum flow           0.166      2.019      2.079      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    2.079     2.396     0.093     0.093"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                    2.079     2.396     2.396     0.093"
" 40          HYDROGRAPH   Combine    503"
"            6   Combine "
"          503   Node #"
"                SWM facility south of Conservation Dr"
"             Maximum flow                 2.396    c.m/sec"
"             Hydrograph volume          5087.019    c.m"
"                    2.079     2.396     2.396     2.396"
" 81          ADD COMMENT================================================="
"          3  Lines of comment"
"             Minor flows (2yr and less) from catchment 504 "
"             (townhouses at SW corner) (77m3) are to infiltration, "
"             remainder to Beaver Creek "
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                    2.079     0.000     2.396     2.396"
" 33          CATCHMENT 504"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          504   Townhouse area at SW corner"
"       40.000   % Impervious"
"        0.332   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.199   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.133   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.313   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.895   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.046     0.000     2.396     2.396 c.m/sec"
"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.199      0.133      0.332      hectare"
"             Time of concentration  9.993      1.166      4.205      minutes"
"             Time to Centroid       756.254    656.264    690.691    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        121.55     81.03      202.58     c.m"
"             Rainfall losses        41.904     6.416      27.709     mm"
"             Runoff depth           19.114     54.602     33.309     mm"
"             Runoff volume          38.08      72.51      110.59     c.m"
"             Runoff coefficient     0.313      0.895      0.546      "
"             Maximum flow           0.012      0.042      0.046      c.m/sec"
```

```
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.046     0.046     2.396     2.396"
" 54          POND DESIGN"
"         0.046   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"         110.6   Hydrograph volume    c.m"
"            3.   Number of stages"
"       100.000   Minimum water level    metre"
"       102.000   Maximum water level    metre"
"       100.000   Starting water level    metre"
"             0   Keep Design Data: 1 = True; 0 = False"
"                   Level Discharge    Volume"
"                 100.000     0.000     0.000"
"                 101.000  1.01E-05    77.000"
"                 102.000     6.492  1000.000"
"            1.   WEIRS"
"                   Crest      Weir     Crest      Left     Right"
"                elevation coefficie   breadth sideslope sideslope"
"                 101.000     0.900     2.000     3.000     3.000"
"               Peak outflow                  0.002    c.m/sec"
"               Maximum level                101.000    metre"
"               Maximum storage               77.304    c.m"
"               Centroidal lag                21.071   hours"
"                      0.046     0.046     0.002     2.396 c.m/sec"
" 40            HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"               Maximum flow                   0.038    c.m/sec"
"               Hydrograph volume           4203.410    c.m"
"                      0.046     0.046     0.002     0.038"
" 81            ADD COMMENT================================================="
"           3  Lines of comment"
"              Minor flows (2yr and less) from catchment 505 "
"              (North Property Line) (263m3) are to infiltration, "
"              remainder to wetland finger to Beaver Creek "
" 40            HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                      0.046     0.000     0.002     0.038"
" 33            CATCHMENT 505"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           505   Rear yards of lots at NW corner"
"        60.000   % Impervious"
"         0.898   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.359   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.539   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.313   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
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"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.895   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     0.178     0.000     0.002     0.038 c.m/sec"
"              Catchment 505          Pervious   Impervious Total Area "
"              Surface Area           0.359      0.539      0.898      hectare"
"              Time of concentration  9.993      1.166      2.836      minutes"
"              Time to Centroid       756.254    656.264    675.183    minutes"
"              Rainfall depth         61.018     61.018     61.018     mm"
"              Rainfall volume        219.18     328.77     547.94     c.m"
"              Rainfall losses        41.904     6.416      20.611     mm"
"              Runoff depth           19.114     54.602     40.407     mm"
"              Runoff volume          68.66      294.20     362.86     c.m"
"              Runoff coefficient     0.313      0.895      0.662      "
"              Maximum flow           0.022      0.170      0.178      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                     0.178     0.178     0.002     0.038"
" 54           POND DESIGN"
"         0.178   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"         362.9   Hydrograph volume    c.m"
"            3.   Number of stages"
"       100.000   Minimum water level    metre"
"       102.000   Maximum water level    metre"
"       100.000   Starting water level    metre"
"             0   Keep Design Data: 1 = True; 0 = False"
"                   Level Discharge    Volume"
"                 100.000     0.000     0.000"
"                 101.000  1.01E-05   263.000"
"                 102.000     6.492  1000.000"
"            1.   WEIRS"
"                   Crest      Weir     Crest      Left     Right"
"               elevation coefficie   breadth sideslope sideslope"
"                 101.000     0.900     2.000     3.000     3.000"
"              Peak outflow                  0.007    c.m/sec"
"              Maximum level               101.001    metre"
"              Maximum storage             263.746    c.m"
"              Centroidal lag               17.737   hours"
"                   0.178     0.178     0.007     0.038 c.m/sec"
" 40           HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"              Maximum flow                  0.042    c.m/sec"
"              Hydrograph volume          4306.399    c.m"
"                     0.178     0.178     0.007     0.042"
" 81           ADD COMMENT================================================="
"           1  Lines of comment"
"              Uncontrolled Brohman Lands "
" 40           HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                     0.178     0.000     0.007     0.042"
" 33           CATCHMENT 602"
"             1   Triangular SCS"
"             1   Equal length"
```

```
"            1   SCS method"
"          602   Brohman Uncontrolled"
"       60.000   % Impervious"
"        0.400   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.160   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.240   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.313   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.895   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.079     0.000     0.007     0.042 c.m/sec"
"             Catchment 602          Pervious   Impervious Total Area "
"             Surface Area           0.160      0.240      0.400      hectare"
"             Time of concentration  9.993      1.166      2.836      minutes"
"             Time to Centroid       756.254    656.264    675.184    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        97.63      146.44     244.07     c.m"
"             Rainfall losses        41.904     6.416      20.611     mm"
"             Runoff depth           19.114     54.602     40.407     mm"
"             Runoff volume          30.58      131.05     161.63     c.m"
"             Runoff coefficient     0.313      0.895      0.662      "
"             Maximum flow           0.010      0.076      0.079      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.079     0.079     0.007     0.042"
" 54          POND DESIGN"
"        0.079   Current peak flow    c.m/sec"
"        1.000   Target outflow    c.m/sec"
"        161.6   Hydrograph volume    c.m"
"           3.   Number of stages"
"      100.000   Minimum water level    metre"
"      102.000   Maximum water level    metre"
"      100.000   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                100.000     0.000     0.000"
"                101.000  1.01E-05   117.000"
"                102.000     6.492  1000.000"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                101.000     0.900     2.000     3.000     3.000"
"             Peak outflow                  0.003    c.m/sec"
"             Maximum level                101.000    metre"
"             Maximum storage              117.394    c.m"
"             Centroidal lag                19.838   hours"
"                    0.079     0.079     0.003     0.042 c.m/sec"
```

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" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                  0.043    c.m/sec"
"             Hydrograph volume          4354.372    c.m"
"                    0.079     0.079     0.003     0.043"
" 38          START/RE-START TOTALS 602"
"            3   Runoff Totals on EXIT"
"             Total Catchment area                     28.125    hectare"
"             Total Impervious area                    14.520    hectare"
"             Total % impervious                       51.626"
" 19          EXIT"
```

```
"                MIDUSS Output ------------------------------------------------>"
"                MIDUSS version                          Version 2.25  rev. 473"
"                MIDUSS created                               February 7, 2010"
"           10   Units used:                                          ie METRIC"
"                Job folder:                  K:\PRJ - DOCS\1279\60-Design\SWM"
"                Output filename:                   1279d100yr3hrJun102020.out"
"                Licensee name:                       Stefan Van Hartingsveldt"
"                Company                                  Meritech Engineering"
"                Date & Time last used:             2020-06-10 at 11:41:26 PM"
" 81           ADD COMMENT================================================="
"          2  Lines of comment"
"             SWM Analysis of 100-yr 3 hr post-development storm event "
"             for 556 and 576 Conservation Drive, Waterloo"
" 31           TIME PARAMETERS"
"        5.000   Time Step"
"      180.000   Max. Storm length"
"     7200.000   Max. Hydrograph"
" 32           STORM Chicago storm"
"            1   Chicago storm"
"     4692.000   Coefficient A"
"       17.437   Constant B"
"        0.956   Exponent C"
"        0.400   Fraction R"
"      180.000   Duration"
"        1.000   Time step multiplier"
"             Maximum intensity          239.793    mm/hr"
"             Total depth                 89.960    mm"
"            6   100hyd   Hydrograph extension used in this file"
" 81           ADD COMMENT================================================="
"          1  Lines of comment"
"             Area to SWM facility on west side"
" 33           CATCHMENT 701"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          701   Northwest corner - lots"
"       60.000   % Impervious"
"        7.343   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        2.937   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        4.406   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.425   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.903   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    2.792     0.000     0.000     0.000 c.m/sec"
"             Catchment 701          Pervious   Impervious Total Area "
"             Surface Area           2.937      4.406      7.343      hectare"
```

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"             Time of concentration  6.945      0.919      2.359      minutes"
"             Time to Centroid       102.209    85.375     89.397     minutes"
"             Rainfall depth         89.960     89.960     89.960     mm"
"             Rainfall volume        2642.31    3963.46    6605.77    c.m"
"             Rainfall losses        51.719     8.749      25.937     mm"
"             Runoff depth           38.241     81.211     64.023     mm"
"             Runoff volume          1123.23    3577.99    4701.22    c.m"
"             Runoff coefficient     0.425      0.903      0.712      "
"             Maximum flow           0.667      2.549      2.792      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     2.792     2.792     0.000     0.000"
" 33          CATCHMENT 702"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          702   Rear half of school site"
"       30.000   % Impervious"
"        0.770   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.539   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.231   Impervious Area"
"       30.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.427   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.925   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.181     2.792     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.539      0.231      0.770      hectare"
"             Time of concentration  10.526     1.393      6.132      minutes"
"             Time to Centroid       106.545    85.939     96.630     minutes"
"             Rainfall depth         89.960     89.960     89.960     mm"
"             Rainfall volume        484.88     207.81     692.69     c.m"
"             Rainfall losses        51.510     6.752      38.083     mm"
"             Runoff depth           38.450     83.208     51.877     mm"
"             Runoff volume          207.24     192.21     399.46     c.m"
"             Runoff coefficient     0.427      0.925      0.577      "
"             Maximum flow           0.103      0.133      0.181      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.181     2.953     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
"        1.343   Total Area"
```

```
"       80.000   Flow length"
"        3.000   Overland Slope"
"        1.209   Pervious Area"
"       80.000   Pervious length"
"        3.000   Pervious slope"
"        0.134   Impervious Area"
"       80.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.428   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.922   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.193     2.953     0.000     0.000 c.m/sec"
"             Catchment 703          Pervious   Impervious Total Area "
"             Surface Area           1.209      0.134      1.343      hectare"
"             Time of concentration  18.961     2.510      15.783     minutes"
"             Time to Centroid       117.075    87.552     111.372    minutes"
"             Rainfall depth         89.960     89.960     89.960     mm"
"             Rainfall volume        1087.35    120.82     1208.16    c.m"
"             Rainfall losses        51.458     6.998      47.012     mm"
"             Runoff depth           38.502     82.962     42.948     mm"
"             Runoff volume          465.37     111.42     576.79     c.m"
"             Runoff coefficient     0.428      0.922      0.477      "
"             Maximum flow           0.171      0.073      0.193      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.193     3.050     0.000     0.000"
" 33          CATCHMENT 704"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          704   SWM block"
"       60.000   % Impervious"
"        1.110   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.444   Pervious Area"
"       15.000   Pervious length"
"       20.000   Pervious slope"
"        0.666   Impervious Area"
"       15.000   Impervious length"
"        0.500   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.422   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.927   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.453     3.050     0.000     0.000 c.m/sec"
```

```
"             Catchment 704          Pervious   Impervious Total Area "
"             Surface Area           0.444      0.666      1.110      hectare"
"             Time of concentration  3.931      1.573      2.122      minutes"
"             Time to Centroid       98.452     86.185     89.038     minutes"
"             Rainfall depth         89.960     89.960     89.960     mm"
"             Rainfall volume        399.42     599.13     998.56     c.m"
"             Rainfall losses        52.037     6.542      24.740     mm"
"             Runoff depth           37.923     83.418     65.220     mm"
"             Runoff volume          168.38     555.56     723.94     c.m"
"             Runoff coefficient     0.422      0.927      0.725      "
"             Maximum flow           0.111      0.380      0.453      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.453     3.503     0.000     0.000"
" 33          CATCHMENT 801"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          801   Brohman Lands"
"       60.000   % Impervious"
"        0.850   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.340   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.510   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.425   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.903   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.323     3.503     0.000     0.000 c.m/sec"
"             Catchment 801          Pervious   Impervious Total Area "
"             Surface Area           0.340      0.510      0.850      hectare"
"             Time of concentration  6.945      0.919      2.359      minutes"
"             Time to Centroid       102.209    85.375     89.397     minutes"
"             Rainfall depth         89.960     89.960     89.960     mm"
"             Rainfall volume        305.86     458.80     764.66     c.m"
"             Rainfall losses        51.719     8.749      25.937     mm"
"             Runoff depth           38.241     81.211     64.023     mm"
"             Runoff volume          130.02     414.18     544.20     c.m"
"             Runoff coefficient     0.425      0.903      0.712      "
"             Maximum flow           0.077      0.295      0.323      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.323     3.826     0.000     0.000"
" 54          POND DESIGN"
"        3.826   Current peak flow    c.m/sec"
"        0.654   Target outflow    c.m/sec"
"       6945.6   Hydrograph volume    c.m"
"          24.   Number of stages"
```

```
"      353.200   Minimum water level    metre"
"      355.500   Maximum water level    metre"
"      353.400   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                353.200     0.000     0.000"
"                353.300  1.00E-07   301.000"
"                353.400  1.00E-07   615.000"
"                353.500   0.00355   944.000"
"                353.600   0.00664  1288.000"
"                353.700   0.00870  1645.000"
"                353.800   0.01035  2018.000"
"                353.900   0.01178  2471.000"
"                354.000   0.01305  3006.000"
"                354.100   0.02744  3557.000"
"                354.200   0.06573  4124.000"
"                354.300    0.1239  4709.000"
"                354.400    0.1975  5310.000"
"                354.500    0.2818  5928.000"
"                354.600    0.3716  6562.000"
"                354.700    0.4620  7211.000"
"                354.800    0.5620  7877.000"
"                354.900    0.6773  8558.000"
"                355.000    0.8101  9255.000"
"                355.100    0.9645  9969.000"
"                355.200     1.144  10701.00"
"                355.300     1.353  11450.00"
"                355.400     1.595  12218.00"
"                355.500     1.872  13004.00"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                354.700     0.900     0.200     1.000     1.000"
"           1.   ORIFICES"
"                Orifice   Orifice   Orifice Number of"
"                 invert coefficie  diameter  orifices"
"                353.400     0.630    0.0900     1.000"
"           2.   OUTFLOW PIPE"
"               Upstream Downstr'm      Pipe      Pipe   Manning     Entry"
"                 invert    invert    Length  Diameter       'n'   loss Ke"
"                354.000   353.180    18.000     0.525     0.013     0.500"
"                354.000   353.180    18.000     0.525     0.013     0.500"
"             Peak outflow                  0.312    c.m/sec"
"             Maximum level               354.534    metre"
"             Maximum storage            6144.321    c.m"
"             Centroidal lag               20.519   hours"
"                  0.323     3.826     0.312     0.000 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                  0.312    c.m/sec"
"             Hydrograph volume          6862.077    c.m"
"                     0.323     3.826     0.312     0.312"
" 81          ADD COMMENT================================================="
"          2  Lines of comment"
"             501 to the north and/or ex. subdivision to the "
"             northeast"
" 40          HYDROGRAPH Start - New Tributary"
```

```
"            2   Start - New Tributary"
"                     0.323     0.000     0.312     0.312"
" 33          CATCHMENT 501"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          501   Northeast corner of subdivision"
"       60.000   % Impervious"
"        0.469   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.188   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.281   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.425   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.903   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.178     0.000     0.312     0.312 c.m/sec"
"             Catchment 501          Pervious   Impervious Total Area "
"             Surface Area           0.188      0.281      0.469      hectare"
"             Time of concentration  6.945      0.919      2.359      minutes"
"             Time to Centroid       102.209    85.375     89.397     minutes"
"             Rainfall depth         89.960     89.960     89.960     mm"
"             Rainfall volume        168.77     253.15     421.91     c.m"
"             Rainfall losses        51.719     8.749      25.937     mm"
"             Runoff depth           38.241     81.211     64.023     mm"
"             Runoff volume          71.74      228.53     300.27     c.m"
"             Runoff coefficient     0.425      0.903      0.712      "
"             Maximum flow           0.043      0.163      0.178      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.178     0.178     0.312     0.312"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                     0.178     0.178     0.178     0.312"
" 40          HYDROGRAPH   Combine    501"
"            6   Combine "
"          501   Node #"
"                To N and NE"
"             Maximum flow                 0.178    c.m/sec"
"             Hydrograph volume          300.268    c.m"
"                     0.178     0.178     0.178     0.178"
" 81          ADD COMMENT================================================="
"          4  Lines of comment"
"             Flows from 502 and 503 are to a proposed SWM facility "
"             south of Conservation Drive. Rooftop runoff from the "
"             school (502) up to 25mm rainfall depth to infiltration"
"             but conservatively ignored in this modeling."
" 40          HYDROGRAPH Start - New Tributary"
```

```
"            2   Start - New Tributary"
"                     0.178     0.000     0.178     0.178"
" 33          CATCHMENT 601"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          601   External Area North of Site"
"        0.000   % Impervious"
"        3.500   Total Area"
"       90.000   Flow length"
"        2.000   Overland Slope"
"        3.500   Pervious Area"
"       90.000   Pervious length"
"        3.000   Pervious slope"
"        0.000   Impervious Area"
"       90.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       61.000   Pervious SCS Curve No."
"        0.256   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"       16.239   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.000   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.234     0.000     0.178     0.178 c.m/sec"
"             Catchment 601          Pervious   Impervious Total Area "
"             Surface Area           3.500      0.000      3.500      hectare"
"             Time of concentration  26.531     2.693      26.530     minutes"
"             Time to Centroid       128.060    87.835     128.060    minutes"
"             Rainfall depth         89.960     89.960     89.960     mm"
"             Rainfall volume        3148.60    0.00       3148.60    c.m"
"             Rainfall losses        66.957     7.220      66.957     mm"
"             Runoff depth           23.003     82.740     23.003     mm"
"             Runoff volume          805.10     0.00       805.11     c.m"
"             Runoff coefficient     0.256      0.000      0.256      "
"             Maximum flow           0.234      0.000      0.234      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.234     0.234     0.178     0.178"
" 33          CATCHMENT 502"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          502   Front half of school site"
"       50.000   % Impervious"
"        1.986   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.993   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.993   Impervious Area"
"       30.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
```

```
"         0.427   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.925   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     0.623     0.234     0.178     0.178 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           0.993      0.993      1.986      hectare"
"              Time of concentration  10.526     1.393      4.280      minutes"
"              Time to Centroid       106.545    85.939     92.452     minutes"
"              Rainfall depth         89.960     89.960     89.960     mm"
"              Rainfall volume        893.30     893.30     1786.61    c.m"
"              Rainfall losses        51.510     6.752      29.131     mm"
"              Runoff depth           38.450     83.208     60.829     mm"
"              Runoff volume          381.81     826.26     1208.06    c.m"
"              Runoff coefficient     0.427      0.925      0.676      "
"              Maximum flow           0.191      0.571      0.623      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                     0.623     0.639     0.178     0.178"
" 33           CATCHMENT 503"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           503   East part of site incl townhouses"
"        70.000   % Impervious"
"         9.124   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         2.737   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         6.387   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.425   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.903   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     3.922     0.639     0.178     0.178 c.m/sec"
"              Catchment 503          Pervious   Impervious Total Area "
"              Surface Area           2.737      6.387      9.124      hectare"
"              Time of concentration  6.945      0.919      1.931      minutes"
"              Time to Centroid       102.209    85.375     88.202     minutes"
"              Rainfall depth         89.960     89.960     89.960     mm"
"              Rainfall volume        2462.39    5745.57    8207.95    c.m"
"              Rainfall losses        51.719     8.749      21.640     mm"
"              Runoff depth           38.241     81.211     68.320     mm"
"              Runoff volume          1046.74    5186.78    6233.53    c.m"
"              Runoff coefficient     0.425      0.903      0.759      "
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"             Maximum flow           0.621      3.695      3.922      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    3.922     4.561     0.178     0.178"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                    3.922     4.561     4.561     0.178"
" 40          HYDROGRAPH   Combine    503"
"            6   Combine "
"          503   Node #"
"                SWM facility south of Conservation Dr"
"             Maximum flow                 4.561    c.m/sec"
"             Hydrograph volume          8246.698    c.m"
"                    3.922     4.561     4.561     4.561"
" 81          ADD COMMENT================================================="
"          3  Lines of comment"
"             Minor flows (2yr and less) from catchment 504 "
"             (townhouses at SW corner) (77m3) are to infiltration, "
"             remainder to Beaver Creek "
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                    3.922     0.000     4.561     4.561"
" 33          CATCHMENT 504"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          504   Townhouse area at SW corner"
"       40.000   % Impervious"
"        0.332   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.199   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.133   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.425   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.903   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.093     0.000     4.561     4.561 c.m/sec"
"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.199      0.133      0.332      hectare"
"             Time of concentration  6.945      0.919      3.413      minutes"
"             Time to Centroid       102.209    85.375     92.344     minutes"
"             Rainfall depth         89.960     89.960     89.960     mm"
"             Rainfall volume        179.20     119.47     298.67     c.m"
"             Rainfall losses        51.719     8.749      34.531     mm"
"             Runoff depth           38.241     81.211     55.429     mm"
"             Runoff volume          76.18      107.85     184.03     c.m"
"             Runoff coefficient     0.425      0.903      0.616      "
"             Maximum flow           0.045      0.077      0.093      c.m/sec"
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" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                     0.093     0.093     4.561     4.561"
" 54          POND DESIGN"
"         0.093   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"         184.0   Hydrograph volume    c.m"
"            3.   Number of stages"
"       100.000   Minimum water level    metre"
"       102.000   Maximum water level    metre"
"       100.000   Starting water level    metre"
"             0   Keep Design Data: 1 = True; 0 = False"
"                   Level Discharge    Volume"
"                 100.000     0.000     0.000"
"                 101.000  1.01E-05    77.000"
"                 102.000     6.492  1000.000"
"            1.   WEIRS"
"                   Crest      Weir     Crest      Left     Right"
"                elevation coefficie   breadth sideslope sideslope"
"                 101.000     0.900     2.000     3.000     3.000"
"               Peak outflow                  0.064    c.m/sec"
"               Maximum level                101.011    metre"
"               Maximum storage               86.768    c.m"
"               Centroidal lag                 4.024   hours"
"                     0.093     0.093     0.064     4.561 c.m/sec"
" 40            HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"               Maximum flow                   0.322    c.m/sec"
"               Hydrograph volume           6973.541    c.m"
"                     0.093     0.093     0.064     0.322"
" 81            ADD COMMENT================================================="
"           3  Lines of comment"
"              Minor flows (2yr and less) from catchment 505 "
"              (North Property Line) (263m3) are to infiltration, "
"              remainder to wetland finger to Beaver Creek "
" 40            HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                     0.093     0.000     0.064     0.322"
" 33            CATCHMENT 505"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           505   Rear yards of lots at NW corner"
"        60.000   % Impervious"
"         0.898   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.359   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.539   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.425   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
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"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.903   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.341     0.000     0.064     0.322 c.m/sec"
"              Catchment 505          Pervious   Impervious Total Area "
"              Surface Area           0.359      0.539      0.898      hectare"
"              Time of concentration  6.945      0.919      2.359      minutes"
"              Time to Centroid       102.209    85.375     89.397     minutes"
"              Rainfall depth         89.960     89.960     89.960     mm"
"              Rainfall volume        323.14     484.70     807.84     c.m"
"              Rainfall losses        51.719     8.749      25.937     mm"
"              Runoff depth           38.241     81.211     64.023     mm"
"              Runoff volume          137.36     437.56     574.93     c.m"
"              Runoff coefficient     0.425      0.903      0.712      "
"              Maximum flow           0.082      0.312      0.341      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.341     0.341     0.064     0.322"
" 54           POND DESIGN"
"         0.341   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"         574.9   Hydrograph volume    c.m"
"            3.   Number of stages"
"       100.000   Minimum water level    metre"
"       102.000   Maximum water level    metre"
"       100.000   Starting water level    metre"
"             0   Keep Design Data: 1 = True; 0 = False"
"                   Level Discharge    Volume"
"                 100.000     0.000     0.000"
"                 101.000  1.01E-05   263.000"
"                 102.000     6.492  1000.000"
"            1.   WEIRS"
"                   Crest      Weir     Crest      Left     Right"
"               elevation coefficie   breadth sideslope sideslope"
"                 101.000     0.900     2.000     3.000     3.000"
"              Peak outflow                  0.217    c.m/sec"
"              Maximum level               101.033    metre"
"              Maximum storage             287.580    c.m"
"              Centroidal lag                2.619   hours"
"                      0.341     0.341     0.217     0.322 c.m/sec"
" 40           HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"              Maximum flow                  0.377    c.m/sec"
"              Hydrograph volume          7281.219    c.m"
"                      0.341     0.341     0.217     0.377"
" 81           ADD COMMENT================================================="
"           1  Lines of comment"
"              Uncontrolled Brohman Lands "
" 40           HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                      0.341     0.000     0.217     0.377"
" 33           CATCHMENT 602"
"             1   Triangular SCS"
"             1   Equal length"
```

```
"            1   SCS method"
"          602   Brohman Uncontrolled"
"       60.000   % Impervious"
"        0.400   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.160   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.240   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.425   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.903   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.152     0.000     0.217     0.377 c.m/sec"
"             Catchment 602          Pervious   Impervious Total Area "
"             Surface Area           0.160      0.240      0.400      hectare"
"             Time of concentration  6.945      0.919      2.359      minutes"
"             Time to Centroid       102.209    85.375     89.397     minutes"
"             Rainfall depth         89.960     89.960     89.960     mm"
"             Rainfall volume        143.94     215.90     359.84     c.m"
"             Rainfall losses        51.719     8.749      25.937     mm"
"             Runoff depth           38.241     81.211     64.023     mm"
"             Runoff volume          61.19      194.91     256.09     c.m"
"             Runoff coefficient     0.425      0.903      0.712      "
"             Maximum flow           0.036      0.139      0.152      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.152     0.152     0.217     0.377"
" 54          POND DESIGN"
"        0.152   Current peak flow    c.m/sec"
"        1.000   Target outflow    c.m/sec"
"        256.1   Hydrograph volume    c.m"
"           3.   Number of stages"
"      100.000   Minimum water level    metre"
"      102.000   Maximum water level    metre"
"      100.000   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                100.000     0.000     0.000"
"                101.000  1.01E-05   117.000"
"                102.000     6.492  1000.000"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                101.000     0.900     2.000     3.000     3.000"
"             Peak outflow                  0.092    c.m/sec"
"             Maximum level                101.014    metre"
"             Maximum storage              129.508    c.m"
"             Centroidal lag                 3.578   hours"
"                    0.152     0.152     0.092     0.377 c.m/sec"
```

```
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"              Maximum flow                  0.456    c.m/sec"
"              Hydrograph volume          7421.251    c.m"
"                      0.152     0.152     0.092     0.456"
" 38          START/RE-START TOTALS 602"
"            3   Runoff Totals on EXIT"
"              Total Catchment area                     28.125    hectare"
"              Total Impervious area                    14.520    hectare"
"              Total % impervious                       51.626"
" 19          EXIT"
```

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"                MIDUSS Output ------------------------------------------------>"
"                MIDUSS version                          Version 2.25  rev. 473"
"                MIDUSS created                               February 7, 2010"
"           10   Units used:                                          ie METRIC"
"                Job folder:                  K:\PRJ - DOCS\1279\60-Design\SWM"
"                Output filename:                  1279d100yr24hrJun102020.out"
"                Licensee name:                       Stefan Van Hartingsveldt"
"                Company                                  Meritech Engineering"
"                Date & Time last used:             2020-06-10 at 11:45:07 PM"
" 81           ADD COMMENT================================================="
"          2  Lines of comment"
"             SWM Analysis of 100-yr 24 hr post-development storm event "
"             for 556 and 576 Conservation Drive, Waterloo"
" 31           TIME PARAMETERS"
"        5.000   Time Step"
"     1440.000   Max. Storm length"
"     7200.000   Max. Hydrograph"
" 32           STORM Chicago storm"
"            1   Chicago storm"
"     2221.210   Coefficient A"
"        9.093   Constant B"
"        0.866   Exponent C"
"        0.400   Fraction R"
"     1440.000   Duration"
"        1.000   Time step multiplier"
"             Maximum intensity          216.370    mm/hr"
"             Total depth                 97.564    mm"
"            6   100hyd   Hydrograph extension used in this file"
" 81           ADD COMMENT================================================="
"          1  Lines of comment"
"             Area to SWM facility on west side"
" 33           CATCHMENT 701"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          701   Northwest corner - lots"
"       60.000   % Impervious"
"        7.343   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        2.937   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        4.406   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.449   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.916   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    2.636     0.000     0.000     0.000 c.m/sec"
"             Catchment 701          Pervious   Impervious Total Area "
"             Surface Area           2.937      4.406      7.343      hectare"
```

```
"             Time of concentration  6.912      0.956      2.423      minutes"
"             Time to Centroid       704.754    637.792    654.288    minutes"
"             Rainfall depth         97.564     97.564     97.564     mm"
"             Rainfall volume        2865.66    4298.50    7164.16    c.m"
"             Rainfall losses        53.747     8.194      26.415     mm"
"             Runoff depth           43.817     89.370     71.149     mm"
"             Runoff volume          1287.01    3937.48    5224.48    c.m"
"             Runoff coefficient     0.449      0.916      0.729      "
"             Maximum flow           0.646      2.319      2.636      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     2.636     2.636     0.000     0.000"
" 33          CATCHMENT 702"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          702   Rear half of school site"
"       30.000   % Impervious"
"        0.770   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.539   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.231   Impervious Area"
"       30.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.452   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.932   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.162     2.636     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.539      0.231      0.770      hectare"
"             Time of concentration  10.477     1.449      6.240      minutes"
"             Time to Centroid       712.370    638.454    677.682    minutes"
"             Rainfall depth         97.564     97.564     97.564     mm"
"             Rainfall volume        525.87     225.37     751.25     c.m"
"             Rainfall losses        53.511     6.668      39.458     mm"
"             Runoff depth           44.054     90.896     58.106     mm"
"             Runoff volume          237.45     209.97     447.42     c.m"
"             Runoff coefficient     0.452      0.932      0.596      "
"             Maximum flow           0.090      0.121      0.162      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.162     2.793     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
"        1.343   Total Area"
```

```
"        80.000   Flow length"
"         3.000   Overland Slope"
"         1.209   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.134   Impervious Area"
"        80.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.452   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.930   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.158     2.793     0.000     0.000 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           1.209      0.134      1.343      hectare"
"              Time of concentration  18.872     2.611      15.847     minutes"
"              Time to Centroid       731.523    641.646    714.807    minutes"
"              Rainfall depth         97.564     97.564     97.564     mm"
"              Rainfall volume        1179.26    131.03     1310.29    c.m"
"              Rainfall losses        53.445     6.836      48.784     mm"
"              Runoff depth           44.120     90.729     48.780     mm"
"              Runoff volume          533.27     121.85     655.12     c.m"
"              Runoff coefficient     0.452      0.930      0.500      "
"              Maximum flow           0.144      0.066      0.158      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.158     2.891     0.000     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         1.110   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.444   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.666   Impervious Area"
"        15.000   Impervious length"
"         0.500   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.447   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.933   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.430     2.891     0.000     0.000 c.m/sec"
```

```
"             Catchment 704          Pervious   Impervious Total Area "
"             Surface Area           0.444      0.666      1.110      hectare"
"             Time of concentration  3.912      1.637      2.188      minutes"
"             Time to Centroid       698.123    638.842    653.198    minutes"
"             Rainfall depth         97.564     97.564     97.564     mm"
"             Rainfall volume        433.19     649.78     1082.97    c.m"
"             Rainfall losses        53.912     6.496      25.462     mm"
"             Runoff depth           43.653     91.069     72.102     mm"
"             Runoff volume          193.82     606.52     800.33     c.m"
"             Runoff coefficient     0.447      0.933      0.739      "
"             Maximum flow           0.099      0.345      0.430      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.430     3.320     0.000     0.000"
" 33          CATCHMENT 801"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          801   Brohman Lands"
"       60.000   % Impervious"
"        0.850   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.340   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.510   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.449   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.916   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.305     3.320     0.000     0.000 c.m/sec"
"             Catchment 801          Pervious   Impervious Total Area "
"             Surface Area           0.340      0.510      0.850      hectare"
"             Time of concentration  6.912      0.956      2.423      minutes"
"             Time to Centroid       704.755    637.792    654.287    minutes"
"             Rainfall depth         97.564     97.564     97.564     mm"
"             Rainfall volume        331.72     497.58     829.30     c.m"
"             Rainfall losses        53.747     8.194      26.415     mm"
"             Runoff depth           43.817     89.370     71.149     mm"
"             Runoff volume          148.98     455.79     604.77     c.m"
"             Runoff coefficient     0.449      0.916      0.729      "
"             Maximum flow           0.075      0.268      0.305      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.305     3.625     0.000     0.000"
" 54          POND DESIGN"
"        3.625   Current peak flow    c.m/sec"
"        0.654   Target outflow    c.m/sec"
"       7732.1   Hydrograph volume    c.m"
"          24.   Number of stages"
```

```
"      353.200   Minimum water level    metre"
"      355.500   Maximum water level    metre"
"      353.400   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                353.200     0.000     0.000"
"                353.300  1.00E-07   301.000"
"                353.400  1.00E-07   615.000"
"                353.500   0.00355   944.000"
"                353.600   0.00664  1288.000"
"                353.700   0.00870  1645.000"
"                353.800   0.01035  2018.000"
"                353.900   0.01178  2471.000"
"                354.000   0.01305  3006.000"
"                354.100   0.02744  3557.000"
"                354.200   0.06573  4124.000"
"                354.300    0.1239  4709.000"
"                354.400    0.1975  5310.000"
"                354.500    0.2818  5928.000"
"                354.600    0.3716  6562.000"
"                354.700    0.4620  7211.000"
"                354.800    0.5620  7877.000"
"                354.900    0.6773  8558.000"
"                355.000    0.8101  9255.000"
"                355.100    0.9645  9969.000"
"                355.200     1.144  10701.00"
"                355.300     1.353  11450.00"
"                355.400     1.595  12218.00"
"                355.500     1.872  13004.00"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                354.700     0.900     0.200     1.000     1.000"
"           1.   ORIFICES"
"                Orifice   Orifice   Orifice Number of"
"                 invert coefficie  diameter  orifices"
"                353.400     0.630    0.0900     1.000"
"           2.   OUTFLOW PIPE"
"               Upstream Downstr'm      Pipe      Pipe   Manning     Entry"
"                 invert    invert    Length  Diameter       'n'   loss Ke"
"                354.000   353.180    18.000     0.525     0.013     0.500"
"                354.000   353.180    18.000     0.525     0.013     0.500"
"             Peak outflow                  0.232    c.m/sec"
"             Maximum level               354.441    metre"
"             Maximum storage            5562.388    c.m"
"             Centroidal lag               29.789   hours"
"                  0.305     3.625     0.232     0.000 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                  0.232    c.m/sec"
"             Hydrograph volume          7587.083    c.m"
"                     0.305     3.625     0.232     0.232"
" 81          ADD COMMENT================================================="
"          2  Lines of comment"
"             501 to the north and/or ex. subdivision to the "
"             northeast"
" 40          HYDROGRAPH Start - New Tributary"
```

```
"            2   Start - New Tributary"
"                     0.305     0.000     0.232     0.232"
" 33          CATCHMENT 501"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          501   Northeast corner of subdivision"
"       60.000   % Impervious"
"        0.469   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.188   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.281   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.449   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.916   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.168     0.000     0.232     0.232 c.m/sec"
"             Catchment 501          Pervious   Impervious Total Area "
"             Surface Area           0.188      0.281      0.469      hectare"
"             Time of concentration  6.912      0.956      2.423      minutes"
"             Time to Centroid       704.754    637.792    654.288    minutes"
"             Rainfall depth         97.564     97.564     97.564     mm"
"             Rainfall volume        183.03     274.55     457.58     c.m"
"             Rainfall losses        53.747     8.194      26.415     mm"
"             Runoff depth           43.817     89.370     71.149     mm"
"             Runoff volume          82.20      251.49     333.69     c.m"
"             Runoff coefficient     0.449      0.916      0.729      "
"             Maximum flow           0.041      0.148      0.168      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.168     0.168     0.232     0.232"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                     0.168     0.168     0.168     0.232"
" 40          HYDROGRAPH   Combine    501"
"            6   Combine "
"          501   Node #"
"                To N and NE"
"             Maximum flow                  0.168    c.m/sec"
"             Hydrograph volume           333.690    c.m"
"                     0.168     0.168     0.168     0.168"
" 81          ADD COMMENT================================================="
"          4  Lines of comment"
"             Flows from 502 and 503 are to a proposed SWM facility "
"             south of Conservation Drive. Rooftop runoff from the "
"             school (502) up to 25mm rainfall depth to infiltration"
"             but conservatively ignored in this modeling."
" 40          HYDROGRAPH Start - New Tributary"
```

```
"            2   Start - New Tributary"
"                     0.168     0.000     0.168     0.168"
" 33          CATCHMENT 601"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          601   External Area North of Site"
"        0.000   % Impervious"
"        3.500   Total Area"
"       90.000   Flow length"
"        2.000   Overland Slope"
"        3.500   Pervious Area"
"       90.000   Pervious length"
"        3.000   Pervious slope"
"        0.000   Impervious Area"
"       90.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       61.000   Pervious SCS Curve No."
"        0.278   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"       16.239   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.000   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.186     0.000     0.168     0.168 c.m/sec"
"             Catchment 601          Pervious   Impervious Total Area "
"             Surface Area           3.500      0.000      3.500      hectare"
"             Time of concentration  25.619     2.802      25.619     minutes"
"             Time to Centroid       766.357    642.203    766.357    minutes"
"             Rainfall depth         97.564     97.564     97.564     mm"
"             Rainfall volume        3414.75    0.00       3414.76    c.m"
"             Rainfall losses        70.455     6.912      70.455     mm"
"             Runoff depth           27.109     90.652     27.109     mm"
"             Runoff volume          948.82     0.00       948.82     c.m"
"             Runoff coefficient     0.278      0.000      0.278      "
"             Maximum flow           0.186      0.000      0.186      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.186     0.186     0.168     0.168"
" 33          CATCHMENT 502"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          502   Front half of school site"
"       50.000   % Impervious"
"        1.986   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.993   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.993   Impervious Area"
"       30.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
```

```
"         0.452   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.932   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     0.585     0.186     0.168     0.168 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           0.993      0.993      1.986      hectare"
"              Time of concentration  10.477     1.449      4.396      minutes"
"              Time to Centroid       712.370    638.454    662.583    minutes"
"              Rainfall depth         97.564     97.564     97.564     mm"
"              Rainfall volume        968.82     968.82     1937.63    c.m"
"              Rainfall losses        53.511     6.668      30.090     mm"
"              Runoff depth           44.054     90.896     67.475     mm"
"              Runoff volume          437.45     902.60     1340.05    c.m"
"              Runoff coefficient     0.452      0.932      0.692      "
"              Maximum flow           0.166      0.520      0.585      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                     0.585     0.608     0.168     0.168"
" 33           CATCHMENT 503"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           503   East part of site incl townhouses"
"        70.000   % Impervious"
"         9.124   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         2.737   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         6.387   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.449   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.916   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     3.657     0.608     0.168     0.168 c.m/sec"
"              Catchment 503          Pervious   Impervious Total Area "
"              Surface Area           2.737      6.387      9.124      hectare"
"              Time of concentration  6.912      0.956      1.990      minutes"
"              Time to Centroid       704.755    637.792    649.420    minutes"
"              Rainfall depth         97.564     97.564     97.564     mm"
"              Rainfall volume        2670.53    6231.25    8901.78    c.m"
"              Rainfall losses        53.747     8.194      21.860     mm"
"              Runoff depth           43.817     89.370     75.705     mm"
"              Runoff volume          1199.37    5707.91    6907.28    c.m"
"              Runoff coefficient     0.449      0.916      0.776      "
```

```
"             Maximum flow           0.602      3.361      3.657      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    3.657     4.266     0.168     0.168"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                    3.657     4.266     4.266     0.168"
" 40          HYDROGRAPH   Combine    503"
"            6   Combine "
"          503   Node #"
"                SWM facility south of Conservation Dr"
"             Maximum flow                 4.266    c.m/sec"
"             Hydrograph volume         9196.150    c.m"
"                    3.657     4.266     4.266     4.266"
" 81          ADD COMMENT================================================="
"          3  Lines of comment"
"             Minor flows (2yr and less) from catchment 504 "
"             (townhouses at SW corner) (77m3) are to infiltration, "
"             remainder to Beaver Creek "
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                    3.657     0.000     4.266     4.266"
" 33          CATCHMENT 504"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          504   Townhouse area at SW corner"
"       40.000   % Impervious"
"        0.332   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.199   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.133   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.449   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.916   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.091     0.000     4.266     4.266 c.m/sec"
"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.199      0.133      0.332      hectare"
"             Time of concentration  6.912      0.956      3.480      minutes"
"             Time to Centroid       704.754    637.792    666.169    minutes"
"             Rainfall depth         97.564     97.564     97.564     mm"
"             Rainfall volume        194.35     129.57     323.91     c.m"
"             Rainfall losses        53.747     8.194      35.526     mm"
"             Runoff depth           43.817     89.370     62.039     mm"
"             Runoff volume          87.28      118.68     205.97     c.m"
"             Runoff coefficient     0.449      0.916      0.636      "
"             Maximum flow           0.044      0.070      0.091      c.m/sec"
```

```
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.091     0.091     4.266     4.266"
" 54          POND DESIGN"
"         0.091   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"         206.0   Hydrograph volume    c.m"
"            3.   Number of stages"
"       100.000   Minimum water level    metre"
"       102.000   Maximum water level    metre"
"       100.000   Starting water level    metre"
"             0   Keep Design Data: 1 = True; 0 = False"
"                   Level Discharge    Volume"
"                 100.000     0.000     0.000"
"                 101.000  1.01E-05    77.000"
"                 102.000     6.492  1000.000"
"            1.   WEIRS"
"                   Crest      Weir     Crest      Left     Right"
"                elevation coefficie   breadth sideslope sideslope"
"                 101.000     0.900     2.000     3.000     3.000"
"               Peak outflow                  0.059    c.m/sec"
"               Maximum level                101.009    metre"
"               Maximum storage               85.356    c.m"
"               Centroidal lag                13.886   hours"
"                      0.091     0.091     0.059     4.266 c.m/sec"
" 40            HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"               Maximum flow                   0.239    c.m/sec"
"               Hydrograph volume           7716.428    c.m"
"                      0.091     0.091     0.059     0.239"
" 81            ADD COMMENT================================================="
"           3  Lines of comment"
"              Minor flows (2yr and less) from catchment 505 "
"              (North Property Line) (263m3) are to infiltration, "
"              remainder to wetland finger to Beaver Creek "
" 40            HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                      0.091     0.000     0.059     0.239"
" 33            CATCHMENT 505"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           505   Rear yards of lots at NW corner"
"        60.000   % Impervious"
"         0.898   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.359   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.539   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.449   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
```

```
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.916   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     0.322     0.000     0.059     0.239 c.m/sec"
"              Catchment 505          Pervious   Impervious Total Area "
"              Surface Area           0.359      0.539      0.898      hectare"
"              Time of concentration  6.912      0.956      2.423      minutes"
"              Time to Centroid       704.755    637.792    654.288    minutes"
"              Rainfall depth         97.564     97.564     97.564     mm"
"              Rainfall volume        350.45     525.68     876.13     c.m"
"              Rainfall losses        53.747     8.194      26.415     mm"
"              Runoff depth           43.817     89.370     71.149     mm"
"              Runoff volume          157.39     481.53     638.92     c.m"
"              Runoff coefficient     0.449      0.916      0.729      "
"              Maximum flow           0.079      0.284      0.322      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                     0.322     0.322     0.059     0.239"
" 54           POND DESIGN"
"         0.322   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"         638.9   Hydrograph volume    c.m"
"            3.   Number of stages"
"       100.000   Minimum water level    metre"
"       102.000   Maximum water level    metre"
"       100.000   Starting water level    metre"
"             0   Keep Design Data: 1 = True; 0 = False"
"                   Level Discharge    Volume"
"                 100.000     0.000     0.000"
"                 101.000  1.01E-05   263.000"
"                 102.000     6.492  1000.000"
"            1.   WEIRS"
"                   Crest      Weir     Crest      Left     Right"
"               elevation coefficie   breadth sideslope sideslope"
"                 101.000     0.900     2.000     3.000     3.000"
"              Peak outflow                  0.171    c.m/sec"
"              Maximum level               101.028    metre"
"              Maximum storage             283.654    c.m"
"              Centroidal lag               12.725   hours"
"                   0.322     0.322     0.171     0.239 c.m/sec"
" 40           HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"              Maximum flow                  0.316    c.m/sec"
"              Hydrograph volume          8094.910    c.m"
"                     0.322     0.322     0.171     0.316"
" 81           ADD COMMENT================================================="
"           1  Lines of comment"
"              Uncontrolled Brohman Lands "
" 40           HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                     0.322     0.000     0.171     0.316"
" 33           CATCHMENT 602"
"             1   Triangular SCS"
"             1   Equal length"
```

```
"            1   SCS method"
"          602   Brohman Uncontrolled"
"       60.000   % Impervious"
"        0.400   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.160   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.240   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.449   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.916   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.144     0.000     0.171     0.316 c.m/sec"
"             Catchment 602          Pervious   Impervious Total Area "
"             Surface Area           0.160      0.240      0.400      hectare"
"             Time of concentration  6.912      0.956      2.423      minutes"
"             Time to Centroid       704.754    637.792    654.288    minutes"
"             Rainfall depth         97.564     97.564     97.564     mm"
"             Rainfall volume        156.10     234.15     390.26     c.m"
"             Rainfall losses        53.747     8.194      26.415     mm"
"             Runoff depth           43.817     89.370     71.149     mm"
"             Runoff volume          70.11      214.49     284.60     c.m"
"             Runoff coefficient     0.449      0.916      0.729      "
"             Maximum flow           0.035      0.126      0.144      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.144     0.144     0.171     0.316"
" 54          POND DESIGN"
"        0.144   Current peak flow    c.m/sec"
"        1.000   Target outflow    c.m/sec"
"        284.6   Hydrograph volume    c.m"
"           3.   Number of stages"
"      100.000   Minimum water level    metre"
"      102.000   Maximum water level    metre"
"      100.000   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                100.000     0.000     0.000"
"                101.000  1.01E-05   117.000"
"                102.000     6.492  1000.000"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                101.000     0.900     2.000     3.000     3.000"
"             Peak outflow                  0.075    c.m/sec"
"             Maximum level                101.012    metre"
"             Maximum storage              127.255    c.m"
"             Centroidal lag                13.378   hours"
"                    0.144     0.144     0.075     0.316 c.m/sec"
```

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" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"              Maximum flow                  0.391    c.m/sec"
"              Hydrograph volume          8265.647    c.m"
"                     0.144     0.144     0.075     0.391"
" 38          START/RE-START TOTALS 602"
"            3   Runoff Totals on EXIT"
"              Total Catchment area                     28.125    hectare"
"              Total Impervious area                    14.520    hectare"
"              Total % impervious                       51.626"
" 19          EXIT"
```

```
"                MIDUSS Output ------------------------------------------------>"
"                MIDUSS version                          Version 2.25  rev. 473"
"                MIDUSS created                               February 7, 2010"
"           10   Units used:                                          ie METRIC"
"                Job folder:                  K:\PRJ - DOCS\1279\60-Design\SWM"
"                Output filename:                      1279dHazelJun102020.out"
"                Licensee name:                       Stefan Van Hartingsveldt"
"                Company                                 Meritech Engineering"
"                Date & Time last used:             2020-06-10 at 11:47:33 PM"
" 81           ADD COMMENT=================================================="
"          2  Lines of comment"
"             SWM Analysis of Hurricane Hazel 48 hr post-development "
"             storm event for 556 and 576 Conservation Drive, Waterloo"
" 31           TIME PARAMETERS"
"        5.000   Time Step"
"     2880.000   Max. Storm length"
"     7200.000   Max. Hydrograph"
" 32           STORM Mass Curve"
"            3   Mass Curve"
"      285.000   Rainfall depth"
"     2880.000   Duration"
"           67   C:\M\Meritech Engineering\PRJ - DOCS\1279\60-
Design\SWM\Hazel48.mrd   Hurricane Hazel (285mm, 48 hours)"
"             Maximum intensity           53.012    mm/hr"
"             Total depth                285.000    mm"
"            8   Hazelhyd   Hydrograph extension used in this file"
" 81           ADD COMMENT=================================================="
"          1  Lines of comment"
"             Area to SWM facility on west side"
" 33           CATCHMENT 701"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          701   Northwest corner - lots"
"       60.000   % Impervious"
"        7.343   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        2.937   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        4.406   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.728   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.967   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    1.048     0.000     0.000     0.000 c.m/sec"
"             Catchment 701          Pervious   Impervious Total Area "
"             Surface Area           2.937      4.406      7.343      hectare"
"             Time of concentration  9.349      1.671      4.237      minutes"
"             Time to Centroid       2498.143   2270.256   2346.417   minutes"
```

```
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        0.8371     1.2557     2.0928     ha-m"
"             Rainfall losses        77.421     9.312      36.555     mm"
"             Runoff depth           207.579    275.688    248.445    mm"
"             Runoff volume          0.6097     1.2146     1.8243     ha-m"
"             Runoff coefficient     0.728      0.967      0.872      "
"             Maximum flow           0.405      0.643      1.048      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     1.048     1.048     0.000     0.000"
" 33          CATCHMENT 702"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          702   Rear half of school site"
"       30.000   % Impervious"
"        0.770   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.539   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.231   Impervious Area"
"       30.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.730   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.963   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.109     1.048     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.539      0.231      0.770      hectare"
"             Time of concentration  14.171     2.532      9.967      minutes"
"             Time to Centroid       2505.410   2267.788   2419.590   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        1536.15    658.35     2194.50    c.m"
"             Rainfall losses        76.853     10.427     56.925     mm"
"             Runoff depth           208.147    274.573    228.075    mm"
"             Runoff volume          1121.91    634.26     1756.18    c.m"
"             Runoff coefficient     0.730      0.963      0.800      "
"             Maximum flow           0.075      0.035      0.109      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.109     1.150     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
"        1.343   Total Area"
"       80.000   Flow length"
"        3.000   Overland Slope"
```

```
"         1.209   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.134   Impervious Area"
"        80.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.731   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.975   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.191     1.150     0.000     0.000 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           1.209      0.134      1.343      hectare"
"              Time of concentration  25.525     4.562      22.819     minutes"
"              Time to Centroid       2521.584   2271.846   2489.347   minutes"
"              Rainfall depth         285.000    285.000    285.000    mm"
"              Rainfall volume        3444.80    382.76     3827.55    c.m"
"              Rainfall losses        76.640     7.070      69.683     mm"
"              Runoff depth           208.360    277.930    215.317    mm"
"              Runoff volume          2518.45    373.26     2891.71    c.m"
"              Runoff coefficient     0.731      0.975      0.755      "
"              Maximum flow           0.171      0.020      0.191      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.191     1.329     0.000     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         1.110   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.444   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.666   Impervious Area"
"        15.000   Impervious length"
"         0.500   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.728   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.965   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.156     1.329     0.000     0.000 c.m/sec"
"              Catchment 704          Pervious   Impervious Total Area "
"              Surface Area           0.444      0.666      1.110      hectare"
```

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"             Time of concentration  5.292      2.860      3.673      minutes"
"             Time to Centroid       2492.836   2265.585   2341.595   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        1265.40    1898.10    3163.50    c.m"
"             Rainfall losses        77.601     9.886      36.972     mm"
"             Runoff depth           207.399    275.114    248.028    mm"
"             Runoff volume          920.85     1832.26    2753.11    c.m"
"             Runoff coefficient     0.728      0.965      0.870      "
"             Maximum flow           0.060      0.100      0.156      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.156     1.484     0.000     0.000"
" 33          CATCHMENT 801"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          801   Brohman Lands"
"       60.000   % Impervious"
"        0.850   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.340   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.510   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.728   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.967   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.121     1.484     0.000     0.000 c.m/sec"
"             Catchment 801          Pervious   Impervious Total Area "
"             Surface Area           0.340      0.510      0.850      hectare"
"             Time of concentration  9.349      1.671      4.237      minutes"
"             Time to Centroid       2498.143   2270.256   2346.417   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        969.00     1453.50    2422.50    c.m"
"             Rainfall losses        77.421     9.312      36.555     mm"
"             Runoff depth           207.579    275.688    248.445    mm"
"             Runoff volume          705.77     1406.01    2111.78    c.m"
"             Runoff coefficient     0.728      0.967      0.872      "
"             Maximum flow           0.047      0.074      0.121      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.121     1.604     0.000     0.000"
" 54          POND DESIGN"
"        1.604   Current peak flow    c.m/sec"
"        0.654   Target outflow    c.m/sec"
"      27756.1   Hydrograph volume    c.m"
"          24.   Number of stages"
"      353.200   Minimum water level    metre"
"      355.500   Maximum water level    metre"
```

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"      353.400   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                353.200     0.000     0.000"
"                353.300  1.00E-07   301.000"
"                353.400  1.00E-07   615.000"
"                353.500   0.00355   944.000"
"                353.600   0.00664  1288.000"
"                353.700   0.00870  1645.000"
"                353.800   0.01035  2018.000"
"                353.900   0.01178  2471.000"
"                354.000   0.01305  3006.000"
"                354.100   0.02744  3557.000"
"                354.200   0.06573  4124.000"
"                354.300    0.1239  4709.000"
"                354.400    0.1975  5310.000"
"                354.500    0.2818  5928.000"
"                354.600    0.3716  6562.000"
"                354.700    0.4620  7211.000"
"                354.800    0.5620  7877.000"
"                354.900    0.6773  8558.000"
"                355.000    0.8101  9255.000"
"                355.100    0.9645  9969.000"
"                355.200     1.144  10701.00"
"                355.300     1.353  11450.00"
"                355.400     1.595  12218.00"
"                355.500     1.872  13004.00"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                354.700     0.900     0.200     1.000     1.000"
"           1.   ORIFICES"
"                Orifice   Orifice   Orifice Number of"
"                 invert coefficie  diameter  orifices"
"                353.400     0.630    0.0900     1.000"
"           2.   OUTFLOW PIPE"
"               Upstream Downstr'm      Pipe      Pipe   Manning     Entry"
"                 invert    invert    Length  Diameter       'n'   loss Ke"
"                354.000   353.180    18.000     0.525     0.013     0.500"
"                354.000   353.180    18.000     0.525     0.013     0.500"
"             Peak outflow                 1.075    c.m/sec"
"             Maximum level              355.162    metre"
"             Maximum storage          10419.966    c.m"
"             Centroidal lag              49.308   hours"
"                  0.121     1.604     1.075     0.000 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                 1.075    c.m/sec"
"             Hydrograph volume        27248.014    c.m"
"                       0.121     1.604     1.075     1.075"
" 81          ADD COMMENT================================================="
"          2  Lines of comment"
"             501 to the north and/or ex. subdivision to the "
"             northeast"
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                       0.121     0.000     1.075     1.075"
```

```
" 33          CATCHMENT 501"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           501   Northeast corner of subdivision"
"        60.000   % Impervious"
"         0.469   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.188   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.281   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.728   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.967   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.067     0.000     1.075     1.075 c.m/sec"
"              Catchment 501          Pervious   Impervious Total Area "
"              Surface Area           0.188      0.281      0.469      hectare"
"              Time of concentration  9.349      1.671      4.237      minutes"
"              Time to Centroid       2498.141   2270.257   2346.417   minutes"
"              Rainfall depth         285.000    285.000    285.000    mm"
"              Rainfall volume        534.66     801.99     1336.65    c.m"
"              Rainfall losses        77.420     9.312      36.555     mm"
"              Runoff depth           207.580    275.688    248.445    mm"
"              Runoff volume          389.42     775.79     1165.21    c.m"
"              Runoff coefficient     0.728      0.967      0.872      "
"              Maximum flow           0.026      0.041      0.067      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.067     0.067     1.075     1.075"
" 40          HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                      0.067     0.067     0.067     1.075"
" 40          HYDROGRAPH   Combine    501"
"             6   Combine "
"           501   Node #"
"                 To N and NE"
"              Maximum flow                 0.067    c.m/sec"
"              Hydrograph volume         1165.205    c.m"
"                      0.067     0.067     0.067     0.067"
" 81          ADD COMMENT================================================="
"           4  Lines of comment"
"              Flows from 502 and 503 are to a proposed SWM facility "
"              south of Conservation Drive. Rooftop runoff from the "
"              school (502) up to 25mm rainfall depth to infiltration"
"              but conservatively ignored in this modeling."
" 40          HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                      0.067     0.000     0.067     0.067"
```

```
" 33          CATCHMENT 601"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           601   External Area North of Site"
"         0.000   % Impervious"
"         3.500   Total Area"
"        90.000   Flow length"
"         2.000   Overland Slope"
"         3.500   Pervious Area"
"        90.000   Pervious length"
"         3.000   Pervious slope"
"         0.000   Impervious Area"
"        90.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        61.000   Pervious SCS Curve No."
"         0.587   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"        16.239   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.000   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.436     0.000     0.067     0.067 c.m/sec"
"              Catchment 601          Pervious   Impervious Total Area "
"              Surface Area           3.500      0.000      3.500      hectare"
"              Time of concentration  28.728     4.896      28.728     minutes"
"              Time to Centroid       2593.972   2272.633   2593.972   minutes"
"              Rainfall depth         285.000    285.000    285.000    mm"
"              Rainfall volume        9974.99    0.01       9975.00    c.m"
"              Rainfall losses        117.587    6.694      117.587    mm"
"              Runoff depth           167.413    278.306    167.413    mm"
"              Runoff volume          5859.45    0.01       5859.46    c.m"
"              Runoff coefficient     0.587      0.000      0.587      "
"              Maximum flow           0.436      0.000      0.436      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.436     0.436     0.067     0.067"
" 33          CATCHMENT 502"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           502   Front half of school site"
"        50.000   % Impervious"
"         1.986   Total Area"
"        30.000   Flow length"
"         3.000   Overland Slope"
"         0.993   Pervious Area"
"        30.000   Pervious length"
"         3.000   Pervious slope"
"         0.993   Impervious Area"
"        30.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.730   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
```

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"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.963   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     0.283     0.436     0.067     0.067 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           0.993      0.993      1.986      hectare"
"              Time of concentration  14.171     2.532      7.551      minutes"
"              Time to Centroid       2505.410   2267.787   2370.250   minutes"
"              Rainfall depth         285.000    285.000    285.000    mm"
"              Rainfall volume        2830.05    2830.05    5660.10    c.m"
"              Rainfall losses        76.853     10.427     43.640     mm"
"              Runoff depth           208.147    274.573    241.360    mm"
"              Runoff volume          2066.90    2726.51    4793.41    c.m"
"              Runoff coefficient     0.730      0.963      0.847      "
"              Maximum flow           0.138      0.149      0.283      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                     0.283     0.714     0.067     0.067"
" 33           CATCHMENT 503"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           503   East part of site incl townhouses"
"        70.000   % Impervious"
"         9.124   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         2.737   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         6.387   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.728   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.967   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     1.310     0.714     0.067     0.067 c.m/sec"
"              Catchment 503          Pervious   Impervious Total Area "
"              Surface Area           2.737      6.387      9.124      hectare"
"              Time of concentration  9.349      1.671      3.544      minutes"
"              Time to Centroid       2498.141   2270.257   2325.852   minutes"
"              Rainfall depth         285.000    285.000    285.000    mm"
"              Rainfall volume        0.7801     1.8202     2.6003     ha-m"
"              Rainfall losses        77.420     9.312      29.745     mm"
"              Runoff depth           207.580    275.688    255.255    mm"
"              Runoff volume          0.5682     1.7608     2.3290     ha-m"
"              Runoff coefficient     0.728      0.967      0.896      "
"              Maximum flow           0.378      0.932      1.310      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
```

```
"            4   Add Runoff "
"                     1.310     2.010     0.067     0.067"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                     1.310     2.010     2.010     0.067"
" 40          HYDROGRAPH   Combine    503"
"            6   Combine "
"          503   Node #"
"                SWM facility south of Conservation Dr"
"             Maximum flow                  2.010    c.m/sec"
"             Hydrograph volume         33942.363    c.m"
"                     1.310     2.010     2.010     2.010"
" 81          ADD COMMENT================================================="
"          3  Lines of comment"
"             Minor flows (2yr and less) from catchment 504 "
"             (townhouses at SW corner) (77m3) are to infiltration, "
"             remainder to Beaver Creek "
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                     1.310     0.000     2.010     2.010"
" 33          CATCHMENT 504"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          504   Townhouse area at SW corner"
"       40.000   % Impervious"
"        0.332   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.199   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.133   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.728   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.967   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.047     0.000     2.010     2.010 c.m/sec"
"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.199      0.133      0.332      hectare"
"             Time of concentration  9.349      1.671      5.743      minutes"
"             Time to Centroid       2498.142   2270.256   2391.124   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        567.72     378.48     946.20     c.m"
"             Rainfall losses        77.420     9.312      50.177     mm"
"             Runoff depth           207.580    275.688    234.823    mm"
"             Runoff volume          413.50     366.11     779.61     c.m"
"             Runoff coefficient     0.728      0.967      0.824      "
"             Maximum flow           0.027      0.019      0.047      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
```

```
"                    0.047     0.047     2.010     2.010"
" 54          POND DESIGN"
"        0.047   Current peak flow    c.m/sec"
"        1.000   Target outflow    c.m/sec"
"        779.6   Hydrograph volume    c.m"
"           3.   Number of stages"
"      100.000   Minimum water level    metre"
"      102.000   Maximum water level    metre"
"      100.000   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                100.000     0.000     0.000"
"                101.000  1.01E-05    77.000"
"                102.000     6.492  1000.000"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                101.000     0.900     2.000     3.000     3.000"
"              Peak outflow                  0.046    c.m/sec"
"              Maximum level                101.007    metre"
"              Maximum storage               83.581    c.m"
"              Centroidal lag                42.878   hours"
"                   0.047     0.047     0.046     2.010 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"              Maximum flow                   1.109    c.m/sec"
"              Hydrograph volume          27953.199    c.m"
"                       0.047     0.047     0.046     1.109"
" 81          ADD COMMENT================================================="
"          3  Lines of comment"
"             Minor flows (2yr and less) from catchment 505 "
"             (North Property Line) (263m3) are to infiltration, "
"             remainder to wetland finger to Beaver Creek "
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                    0.047     0.000     0.046     1.109"
" 33          CATCHMENT 505"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          505   Rear yards of lots at NW corner"
"        60.000   % Impervious"
"         0.898   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.359   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.539   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.728   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
```

```
"       98.000   Impervious SCS Curve No."
"        0.967   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.128     0.000     0.046     1.109 c.m/sec"
"             Catchment 505          Pervious   Impervious Total Area "
"             Surface Area           0.359      0.539      0.898      hectare"
"             Time of concentration  9.349      1.671      4.237      minutes"
"             Time to Centroid       2498.142   2270.256   2346.417   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        1023.72    1535.58    2559.30    c.m"
"             Rainfall losses        77.421     9.312      36.555     mm"
"             Runoff depth           207.579    275.688    248.445    mm"
"             Runoff volume          745.63     1485.41    2231.03    c.m"
"             Runoff coefficient     0.728      0.967      0.872      "
"             Maximum flow           0.050      0.079      0.128      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.128     0.128     0.046     1.109"
" 54          POND DESIGN"
"        0.128   Current peak flow    c.m/sec"
"        1.000   Target outflow    c.m/sec"
"       2231.0   Hydrograph volume    c.m"
"           3.   Number of stages"
"      100.000   Minimum water level    metre"
"      102.000   Maximum water level    metre"
"      100.000   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                100.000     0.000     0.000"
"                101.000  1.01E-05   263.000"
"                102.000     6.492  1000.000"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                101.000     0.900     2.000     3.000     3.000"
"              Peak outflow                 0.127    c.m/sec"
"              Maximum level              101.020    metre"
"              Maximum storage            277.478    c.m"
"              Centroidal lag              42.629   hours"
"                   0.128     0.128     0.127     1.109 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                 1.201    c.m/sec"
"             Hydrograph volume         29923.703    c.m"
"                    0.128     0.128     0.127     1.201"
" 81          ADD COMMENT================================================="
"          1  Lines of comment"
"             Uncontrolled Brohman Lands "
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                    0.128     0.000     0.127     1.201"
" 33          CATCHMENT 602"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          602   Brohman Uncontrolled"
```

```
"       60.000   % Impervious"
"        0.400   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.160   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.240   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.728   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.967   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                    0.057     0.000     0.127     1.201 c.m/sec"
"             Catchment 602          Pervious   Impervious Total Area "
"             Surface Area           0.160      0.240      0.400      hectare"
"             Time of concentration  9.349      1.671      4.237      minutes"
"             Time to Centroid       2498.143   2270.255   2346.417   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        456.00     684.00     1140.00    c.m"
"             Rainfall losses        77.421     9.312      36.555     mm"
"             Runoff depth           207.579    275.688    248.445    mm"
"             Runoff volume          332.13     661.65     993.78     c.m"
"             Runoff coefficient     0.728      0.967      0.872      "
"             Maximum flow           0.022      0.035      0.057      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.057     0.057     0.127     1.201"
" 54          POND DESIGN"
"        0.057   Current peak flow    c.m/sec"
"        1.000   Target outflow    c.m/sec"
"        993.8   Hydrograph volume    c.m"
"           3.   Number of stages"
"      100.000   Minimum water level    metre"
"      102.000   Maximum water level    metre"
"      100.000   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                100.000     0.000     0.000"
"                101.000  1.01E-05   117.000"
"                102.000     6.492  1000.000"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                101.000     0.900     2.000     3.000     3.000"
"             Peak outflow                  0.057    c.m/sec"
"             Maximum level                101.009    metre"
"             Maximum storage              124.709    c.m"
"             Centroidal lag                42.697   hours"
"                  0.057     0.057     0.057     1.201 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
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```
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                  1.242    c.m/sec"
"             Hydrograph volume         30802.945    c.m"
"                     0.057     0.057     0.057     1.242"
" 38          START/RE-START TOTALS 602"
"            3   Runoff Totals on EXIT"
"             Total Catchment area                      28.125    hectare"
"             Total Impervious area                     14.520    hectare"
"             Total % impervious                        51.626"
" 19          EXIT"
```

Appendix E: Agency Correspondence

Grand River Conservation Authority
Resource Management Division
Kaitlyn Smith, Resource Planner

400 Clyde Road, P.O. Box 729
Cambridge, Ontario N1R 5W6
Phone: (519) 621-2761 ext. 2292
Fax: (519) 621-4945
E-mail: ksmith@grandriver.ca

PLAN REVIEW REPORT:	**Region of Waterloo** **Shiling Yip**

DATE:	**YOUR FILE:**	**GRCA FILE:**
September 14, 2015	Conservation Dr. at Beaver Creek Rd.	Presub 556, 560 & 576 Conservation Drive

RE: **Presubmission Draft Plan of Subdivision & Zone Change Application**
556, 560 and 576 Conservation Drive, City of Waterloo
2115881 Ontario Limited

GRCA COMMENT*:
A portion of the subject properties are regulated by the Grand River Conservation Authority (GRCA) under Ontario Regulation 150/06. GRCA request an opportunity to review the formal applications to ensure conformance with the relevant policies of the Provincial Policy Statement, the North Waterloo Scoped Subwatershed Study, and Ontario Regulation 150/06. Please see below for our detailed review requirements.

1. **Nature of the Application:**
   It is our understanding that the applicant is proposing to develop the vacant properties with a mix of low rise residential uses, including associated school, park, open space, and stormwater management blocks.

2. **GRCA Resource Issues:**
   Information currently available at this office indicates that the subject properties contain the following natural heritage and hazard features of interest to the GRCA:

   - Sunfish Lake – Laurel Creek Provincially Significant Wetland Complex and associated 120 metre allowance
   - Beaver Creek and associated 15 metre allowance
   - One Zone floodplain and associated 5 metre allowance

   Due to the presence of these resource features, a portion of the subject properties is regulated by the GRCA under Ontario Regulation 150/06 (Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation).

3. **Review of Application under the *Planning Act*:**
   For review of the Draft Plan of Subdivision and Zone Change applications, GRCA staff will require submission of the following materials:

   - Scoped Environmental Impact Study (EIS)
   - Stormwater Management (SWM) & Servicing Report
   - Hydrogeological Assessment
   - Pre-construction Monitoring Report (2 years)
   - Preliminary Grading and Erosion and Sediment Control Plans

   We note that the North Waterloo Scoped Subwatershed Study (NWSSS) recommends a 30 metre buffer for all Provincially Significant Wetlands in the subwatershed. The preliminary plan has incorporated this buffer, which also provides sufficient development setback from the creek and floodplain. GRCA staff support the Open Space zoning; however, a portion of the buffer (Block 35) is shown as Park. This is not the intent of the 30 metre buffer; therefore, GRCA staff request that this be revised to Open Space.

We also note that Stormwater Management Blocks 38 and 39 encroach into the wetland buffer. In accordance with the NWSSS, the Scoped EIS and SWM Report will need to demonstrate that there are no feasible locations outside of the buffer and that adverse impacts to the natural features can be avoided and/or mitigated appropriately. Please be advised that buffer encroachment shall only be permitted for *a portion* of stormwater management, not entire facilities.

Trail locations should also be shown on the Draft Plan of Subdivision and addressed in the supporting documentation (with attention paid to the requirements of the NWSSS).

4. **Review of Application under Ontario Regulation 150/06:**
Development proposed with GRCA regulated areas requires prior issuance of a GRCA permit pursuant to Ontario Regulation 150/06. GRCA staff will review the Draft Plan of Subdivision and Zone Change applications for conformance with Ontario Regulation 150/06 and advise of any specific permit requirements through that process.

5. **Plan Review Fees:**
The GRCA applies Plan Review Fees for *Planning Act* applications located within GRCA areas of interest. Given that the Draft Plan of Subdivision and Zone Change applications will be submitted concurrently, only the subdivision fee will be applied.

According to the 2015 Plan Review Fee Schedule, the fee for a Draft Plan of Subdivision application is $2,050 (base fee) plus $1,070 per net hectare (to a maximum of $25,000). Upon submission of the application, the GRCA will invoice for 70% of the total fee. The remaining 30% will be due prior to GRCA providing conditions for Draft Plan Approval. Additional fees are applied for providing clearance of Draft Plan Approval conditions for registration of the plan.

Please be advised that a separate fee is applied for a GRCA permit application. A 'minor' fee of $380 is typically applied in cases where GRCA staff have already reviewed the related Draft Plan of Subdivision.

We trust this information is of assistance. If you have any questions, or require additional information, please do not hesitate to contact the undersigned.

Sincerely,

Kaitlyn Smith
Resource Planner
Grand River Conservation Authority

cc: Kristen Barisdale – GSP Group (email)
Trevor Hawkins – City of Waterloo (email)
Robyn McMullen – City of Waterloo (email)

These comments are respectfully submitted as advice and reflect resource concerns within the scope and mandate of the Grand River Conservation Authority

Appendix F: Geotechnical Investigation

LVM

Soil and Materials Engineering
Environmental Engineering
Building Science
Supply Chain Quality

2115881 Ontario Limited

Proposed Residential Development
560-576 Conservation Drive
Waterloo, Ontario

Geotechnical Engineering Report

Date: March 20, 2015
Ref. N°: 160-P-0008077-0-01-100-GE-R-0001-00

LVM, a division of EnGlobe Corp.



LVM

2115881 Ontario Limited

Proposed Residential Development
560-576 Conservation Drive
Waterloo, Ontario

Geotechnical Engineering Report |160-P-0008077-0-01-100



Prepared by:

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Property and Confidentiality

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Test results mentioned herein are only valid for the sample(s) stated in this report.

LVM's subcontractors who may have accomplished work either on site or in laboratory are duly qualified as stated in our Quality Manual's procurement procedure. Should you require any further information, please contact your Project Manager."

2115881 Ontario Limited
c/o Ian Cook Construction Limited
169 Lexington Court, Unit B-1
Waterloo, ON N2J 4R3
Attention: Ms. Nicole Simas

REVISION AND PUBLICATION REGISTER		
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1 INTRODUCTION

LVM, a division of EnGlobe Corp. (LVM) was retained by 2115881 Ontario Limited, c/o Ian Cook Construction Limited, to carry out a geotechnical investigation at the site of a proposed residential development in Waterloo, Ontario. This work was authorized by Ms. Nicole Simas of Ian Cook Construction Limited on February 12, 2015 following submission of a detailed proposal.

The project involves the proposed construction of a new 21.8 hectare residential development to be situated on a parcel of land located north of Conservation Drive in Waterloo, Ontario at the location shown on Drawing 1, in Appendix 1. It is understood the lands are designated for residential streets and houses. The lots will be serviced with municipal water and sewer. A preliminary site plan was unavailable at the time of this report. No details were available regarding placement of proposed stormwater management structures.

The purpose of the investigation was to determine the subsurface soil and groundwater conditions at the site and, based on that information, prepare this engineering report with geotechnical recommendations pertaining to the development including site grading, site servicing, pavement construction, house construction, excavations and dewatering, and stormwater infiltration.

2 PREVIOUS WORK

In 2003, LVM (formerly Naylor Engineering Associates Ltd. prior to 2009) carried out a geotechnical investigation for the land on the east side of the site. The fieldwork for this investigation comprised of drilling of twenty-one boreholes (Boreholes 1 to 21) and excavation of thirty-four test pits (Test Pits 1 through 34). The results of this investigation were provided in our Geotechnical Engineering Report No. 4500G1.R01.

In 2005, LVM carried out a geotechnical investigation on Roy Schmidt Road adjacent to the site. The fieldwork for this investigation comprised the drilling of six boreholes (Boreholes 1 through 6). The results of this investigation were provided in our Geotechnical Engineering Report No. 4500G4.R01.

The relevant geotechnical information from the above noted reports have been incorporated into this report.

3 INVESTIGATION PROCEDURE

3.1 FIELD PROGRAM

The fieldwork for this investigation was carried out between February 26 and 27, 2015 and involved the drilling of ten boreholes (Boreholes BH-01-15 to BH-10-15) to depths of 5.0 to 8.1 m. The locations of the boreholes are shown on the Site Plan, Drawing 2 in Appendix 1.

Local utility companies were contacted prior to the start of drilling activities in order to demarcate underground utilities near the boring locations.

The boreholes were advanced with a CME-75 track mounted drillrig equipped with continuous flight hollow stem augers supplied and operated by a specialist drilling contractor.

In the boreholes, representative samples of the overburden were recovered at regular intervals throughout the depths explored. Standard Penetration Tests (SPT) were carried out during sampling operations in the boreholes using conventional split spoon equipment. The SPT N-values recorded are plotted on the borehole logs in Appendix 2.

Samples of the cohesive soils were tested using a hand-held pocket penetrometer to determine approximate shear strengths. The pocket penetrometer test results are plotted on the borehole logs in Appendix 2.

Standpipes were installed in Boreholes BH-01-15, BH 04-15, BH 05-15 and BH 07-15, to allow measurement of groundwater levels and the collection of groundwater samples. The standpipes installation comprises 19 mm diameter pipes with slotted screens, as well as bentonite seals near the ground surface. Details of the installations and groundwater observations and measurements are provided on the borehole logs in Appendix 2.

The standpipes were installed in accordance with Ontario Regulation 468/10 which provides requirements for wells in the Province of Ontario. The regulation encompasses test holes, and provides detailed requirements for monitoring well construction, test hole sealing, well record submission, drilling contractor licensing, well tagging, protective covers, and decommissioning.

A completed well record was submitted to the property owner and the Ministry of Environment for Ontario as per Ontario Regulation 468/10. A licensed well technician must properly decommission all standpipes before construction according to Regulation 903 of the Ontario Water Resources Act.

Upon completion of drilling, the remaining boreholes were backfilled with bentonite in accordance with the Ontario Regulation 468/10 (formerly Ontario Regulation 903) under the province's Water Resources Act.

The fieldwork was monitored throughout by a member of our geotechnical engineering staff, who documented the drilling procedures; recorded the results of the SPT and pocket penetrometer tests; documented the soil stratigraphies; monitored the groundwater conditions; documented the installation of the standpipes and, cared for the recovered soil samples.

The borehole locations and ground surface elevations were surveyed by LVM using Sokkia Model GXR 1 Global Navigation Satellite System (GNSS) rover. The borehole locations were referenced to Universal Trans Mercator North American Datum of 1983 (UTM NAD83) coordinates; the zone referenced (17T) has been excluded for presentation purposes. The ground surface elevations are geodetic, based on GNSS and local base station telemetry with a vertical root mean square error of less than 20 mm.

3.2 LABORATORY TESTING

All soil samples secured during this investigation were returned to our laboratory for visual examination, as well as moisture content tests. The moisture content test results are plotted on the borehole logs in Appendix 2. The geotechnical laboratory tests carried out on selected samples of the major subsurface soils from the investigation comprised the following:

- five particle size distribution analyses with results plotted on Figure 1 in Appendix 3; and,
- two standard Proctor moisture-density tests with results plotted on Figures 2 and 3 in Appendix 3.

The soil samples will be stored for a period of three months from the date of sampling. After this time, they will be discarded unless prior arrangements have been made for longer storage.

4 SUMMARIZED CONDITIONS

4.1 SITE DESCRIPTION

The subject property is located on the north side of Conservation Drive at the northwest corner of Waterloo, Ontario. The property is bordered on the east by an existing residential development and Roy Schmidt Road; on the south by Conservation Drive; on the west by a natural area and Beaver Creek; and on the north by agricultural land. There are two houses at 570 and 576 Conservation Drive.

The property currently comprises mostly agricultural land. The ground surface at the site slopes down from east to west (Elevation 363.1 m to Elevation 354.8 m) and from north to south (Elevation 357.6 m to Elevation 351.9 m).

4.2 SUBSOIL CONDITIONS

We refer to the appended borehole logs for detailed soil descriptions and stratigraphies; results of SPT and pocket penetrometer testing; moisture content profiles; and, groundwater observations and measurements.

In general, the subsurface stratigraphy contacted at the site comprise topsoil, overlying sand, silt and glacial till. Descriptions of the various soil deposits encountered are provided in the following subsections.

4.2.1 Topsoil

Topsoil was encountered surficially at all of the boreholes and is 150 to 1070 mm thick (average 475 mm). The topsoil comprises dark brown silt with trace sand and was frozen at the time of the fieldwork.

4.2.2 Sand

Sand was encountered beneath the topsoil in all boreholes. The sand is 2.7 and 5.0 m thick and extends below the termination depth of Boreholes BH 01-15, BH 03-15, BH 05-15, BH 07-15, BH 09-15 and BH 10-15. The sand ranges in composition from brown sand and silt with trace gravel to sand with some silt and trace gravel. The results of three grain size distribution analyses conducted on samples of sand are plotted on Figure 1 in Appendix 3 and are summarized on the following table:

Table 1: Sand Particle Size Distribution Analyses

BOREHOLE NUMBER	SAMPLE DEPTH (m)	GRAVEL (%)	SAND (%)	FINES (%)
BH-04-15	2.29 – 2.74	6	85	9
BH-05-15	1.52 – 1.98	21	65	14
BH-07-15	2.29 – 2.74	1	95	4

SPT N-values measured in the sand deposits typically range from 6 to 33 blows per 300 mm penetration of the split spoon sampler indicating a loose to dense relative density. Insitu moisture contents in the sand range from 4 to 29% indicating moist to saturated conditions.

The results of a standard Procter moisture-density test conducted on a sample of sand are provided on Figure 2 in Appendix 3 and indicates a maximum dry density of 1.771 t/m^3 at an optimum moisture content 13.4%

4.2.3 Silt

Silt was encountered beneath the sand in Boreholes BH-01-15, BH-02-15 and BH-08-15; and beneath the till at Borehole BH-04-15. The silt is 4.6 m thick in Borehole BH-01-15, and extends below the termination depths of the remaining boreholes. The silt ranges in composition from silt and sand with trace gravel and clay to clay and silt with trace sand. The results of two particle size distribution analyses conducted on samples of silt are plotted on Figure 1 in Appendix 3 and summarized in the following table:

Table 2: Silt Particle Size Distribution Analyses Results

BOREHOLE NUMBER	SAMPLE DEPTH (m)	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)
BH-01-15	3.05 – 3.51	0	9	44	47
BH-08-15	4.57 – 5.03	0	22	57	21

SPT N-values measured in the silt generally increase with depth and range from 14 to above 50 blows per 300 mm penetration of the split spoon sampler indicating a compact to very dense relative density. In-situ moisture contents of the silt range from 12 to 23% indicating very moist to wet conditions.

The results of a standard Proctor moisture-density test conducted on a sample of silt are provided on Figure 3 in Appendix 3 and indicate a maximum dry density of 1.968 t/m^3 at an optimum moisture content 11.8%.

4.2.4 Glacial Till

Glacial till was encountered at a depth of 3.0 m in Borehole BH-04-15 and at a depth of 4.6 in Borehole BH-06-15. The till is 2.1 m thick in Borehole BH-04-15 and extends below the termination depth of Borehole BH-06-15. The till ranges in composition from brown silt with some sand and trace clay and gravel to clayey silt with some sand and trace gravel.
SPT N-values measured in the till range from 14 to 30 blows per 300 mm penetration of the split spoon sampler indicating a compact to dense relative density. The till was moist or about the plastic limit at the time of fieldwork.

4.3 GROUNDWATER

Groundwater observations and measurements carried out in the open boreholes are provided on the appended borehole logs. Standpipes were installed in four boreholes drilled in various locations on the property. The groundwater level measurements are summarized in the following table:

Table 3: Groundwater Level Measurements

BOREHOLE NUMBER	GROUND SURFACE ELEVATION (m)	MEASURED MARCH 9, 2015	
		GROUNDWATER DEPTH (m)	GROUNDWATER ELEVATION (m)
BH-01-15	361.21	6.99	354.22
BH-04-15	351.86	0.95	350.91
BH-05-15	353.74	1.53	352.21
BH-07-15	354.85	2.78	352.07

Free groundwater was also encountered at a depth of 0.8 to 1.5 m in Boreholes BH-04-15 and BH-05-15; and at depths ranging from 3.0 to 6.1 m Boreholes BH-01-15, BH-02-15, BH-03-15, BH-07-15 and BH-08-15. No free groundwater was encountered in Boreholes BH-06-15, BH-09-15, and BH-10-15. The groundwater occurs in unconfined water table conditions.

Local variations and seasonal fluctuations in the groundwater levels would be expected.

5 DISCUSSIONS AND RECOMMENDATIONS

5.1 GENERAL

The project involves the proposed construction of a residential subdivision on a 21.8 hectare parcel of land located north of Conservation Drive in Waterloo, Ontario at the location shown on Drawing 1, in Appendix 1. The lands are designated for residential streets and houses. The house lots will be serviced with municipal water and sewer.

Based on the results of the geotechnical investigation, the subsurface stratigraphy comprises topsoil overlying sand, silt and glacial till. The stabilized groundwater level generally occurs between Elevation 350.9 m and 354.2 m.

Based on the results of this geotechnical investigation, there are shallow groundwater levels at the south and east portions of the property; however, the site is suitable for the proposed residential development. The following subsections of this report contain geotechnical recommendations pertaining to development of the property including site grading, site servicing, pavements, residential buildings, and stormwater infiltration.

5.2 SITE GRADING

Area grading of the property will likely be required to prepare the land for the construction of the proposed residential subdivision. A proposed grading plan was unavailable at the time this report was issued.

Prior to carrying out any cutting and engineered fill placement, the surficial topsoil and loose native deposits should be removed from cuts and critical fill areas. In calculating the approximate quantity of soil to be removed, we recommend that the thicknesses on the individual borehole logs be increased by 50 mm to account for variations and some stripping of the mineral soil below. The topsoil material could be used for landscaping fill to raise grades in the rear yards of the house lots or in park areas. The topsoil ranges in thickness from 0.2 to 1.1 m at the borehole locations (average 475 mm).

The existing houses located off Conservation Drive will likely be demolished. The floor slabs, foundations, and foundation wall backfill should be removed prior to grading of this area.

Within the low-lying areas of the site where the groundwater table is quite close to the existing ground surface (west side of site) it will likely be necessary to remove the organic deposits with a tracked hydraulic excavator.

Following removal of the topsoil, the exposed subgrade should be inspected by LVM. Any fill required at the site should be placed in maximum 300 mm thick lifts and compacted to the following minimum percentages of standard Proctor maximum dry density (SPMDD):

Table 4: Compaction Specifications

FILL USE	MINIMUM COMPACTION REQUIRED
Structural fill to support houses.	98% SPMDD
Subgrade fill beneath streets or beneath services.	95% SPMDD
Bulk fill in landscaped areas.	90% SPMDD

The silty nature of the subgrade soils, as well as shallow perched groundwater table, renders the subgrade material highly susceptible to pumping/disturbance from heavy construction equipment. It is recommended that construction traffic (particularly earth scrapers) be minimized on the finished subgrade, and the subgrade be sloped to promote rainwater drainage.

The major soils likely to be generated from cut areas at the site are silt and sand. Based on the results of insitu moisture content and standard Proctor moisture-density tests, the majority of the on-site excavated soils from above the groundwater table will be suited for reuse as road subgrade fill and structural fill if the grading work is carried out during relatively dry weather. The silt is generally very moist and will require drying or blending with dry sand prior to use as structural fill. If time is not available for drying, then this material should be used as pavement subgrade fill and in landscaped area.

Also, if structural fill operations are carried out in the fall, winter or spring, imported granular material is recommended.

Where structural fill is placed on a wet subgrade, we suggest that only a coarse sand and gravel material be used for the bottom few lifts. Also, the initial lift may be up to 750 mm thick in order to ensure trafficability and minimize compaction problems associated with instability of the subgrade caused by vibratory equipment.

The structural fill pads should extend at least 1.0 m beyond the footing edge of any building and down to the subgrade level at a slope of 45° to the horizontal. A typical detail for structural fill placement beneath house foundations is shown on Drawing 3, in Appendix 1.

Full-time testing by experienced geotechnical personnel should be carried out during fill placement and compaction to examine and approve potential sources of fill material, and to carefully monitor the placement and verify the compaction by in-situ density testing (ASTM D2167 or ASTM 2922).

5.3 SITE SERVICING

5.3.1 Excavations and Dewatering

Following site grading operations, the subdivision will be serviced to provide the individual lots with water and sewer services. It is anticipated that the invert levels for the watermain and sewers will be at conventional depths, some 2 to 4 m below finished grade through most of the site. We recommend that LVM be allowed to check the final site grading and servicing plans for the subdivision to ensure that the exploratory boreholes extend below the design invert elevations. It is noted additional boreholes may be required.

If imported fill is required onsite, we recommend structural fill used below buildings consisting of clean granular material such as OPSS Granular ‘B’. Any imported fill material should be tested and approved by a geotechnical engineer prior to use.

Temporary excavations to conventional depths for installation of underground pipes at this site must comply with the Ontario Occupational Health and Safety Act and Regulations for Construction Projects. The predominant soils encountered in the boreholes would be classified as Type 3 soils (O. Reg. 213/91, s. 226(4)). Temporary side slopes must be cut at an inclination of 1.0 horizontal to 1.0 vertical or less above the base of excavation as per O. Reg. 213/91, s. 234(2) (exclusive of groundwater effects).

Significant seepage was noted at a depth of 0.8 to 1.5 m at Boreholes BH-04-15 and BH-05-15. A positive dewatering system installed by a specialist dewatering contractor may be required if excavations extend below Elevation 354 m in the east portion of the site and below Elevation 352 m in the west portion of the site. It will be necessary to flatten the excavation side slopes where groundwater seepage is occurring to ensure stability. Every excavation that a worker may be required to enter shall be kept reasonably free of water (O. Reg. 213/91, s. 230).

A Permit to Take Water (PTTW) is required by the Ministry of Environment in the event that the daily taking of groundwater exceeds 50,000 L per day. If the contractor carefully plans and stages his work so that only short sections of trench are open at a given time, it may be possible to complete this project without the need for a PTTW.

The contractor should evaluate this latter recommendation to ensure that he is in agreement, and he should notify the prime consultant in the event that he feels that a PTTW will be needed on the basis of his excavation and pipe laying schedule.

The design of the dewatering system should be left to the contractor's discretion, and the system should meet a performance specification to maintain and control the groundwater at least 0.30 m below the invert level in order to provide a stable excavation base. Successful dewatering operations will depend on the contractor's own experience, construction techniques, sequencing, and efficiency of work force and plant. Also the dewatering must be in compliance with the Ontario Water Resources Act (OWRA) and the Water Taking and Transfer Regulation (O.Reg. 451/07).

It is recommended that several test pits be dug during the tendering stage of the project in order that prospective contractors may familiarize themselves with the soil and groundwater conditions to be contacted.

5.3.2 Pipe Bedding

The subgrade soils beneath the watermain and sewers will comprise native mineral soils or compacted fill placed during the site grading operations. No support problems are anticipated for flexible or rigid pipes founded in the native deposits or compacted on-site soils.

Pipe bedding for water and sewer services should be conventional Class 'B' pipe bedding comprising a minimum 150 mm thick layer of OPSS Granular 'A' aggregate below the pipe invert. The bedding course may be thickened if portions of the subgrade become unduly wet during excavation. Granular 'A' type aggregate should be provided around the pipe to at least 300 mm above the pipe. The bedding aggregate should be compacted to a minimum 95% standard Proctor maximum dry density (SPMDD). Water and sewer lines installed outside of heated areas should be provided with a minimum 1.2 m of soil cover or equivalent insulation for frost protection.

A well-graded clear stone such as Coarse Aggregate for HL4 Asphaltic Concrete (OPSS 1003) could be used in the sewer trenches as bedding below the spring line of the pipe to facilitate sump pump dewatering, if necessary. The clear stone should be compacted with a plate tamper.

The proposed sewers could create hydraulic connections between groundwater regimes that are not presently connected. To stop the movement of groundwater along the pipe bedding, it is recommended that concrete or clay collars be installed around the pipe. The collars should be at least 1.0 m long and in place of the standard bedding material. Clay seals shall be compacted to 95% standard Proctor maximum dry density (SPMDD) as per OPSS 410.07.18. (Also OPSD 802.095 and OPSS 1205).

Thrust blocks for the watermain should be designed using current OPSS Standards and shall conform to OPSD 1103.010 and 1103.020. The following soil parameters may be used for thrust restraint design:

- Angle of internal friction (ϕ) = 30°
- Soil cohesion (c) = 0 kPa
- Soil unit weight (γ) = 20 kN/m^3

The interface friction coefficient for granular bedding and smooth ductile iron pipe or PVC pipe would be 0.60. An appropriate factor of safety should be employed.

5.3.3 Trench Backfilling

The trenches above the specified pipe bedding should be backfilled with inorganic on-site soils placed in 300 mm thick lifts and compacted to at least 95% SPMDD.

Based on the results of insitu moisture content and standard Proctor moisture-density tests carried out on the native overburden deposits, the majority of the on-site excavated materials will be compactable to the required density. If imported fill is required we recommend OPSS Granular ‘B’ be used.

If necessary, compensation for wet trench backfill conditions can be made with additional Granular 'B' in the pavement structure.

To minimize potential problems, backfilling operations should follow closely after excavation so that only a minimal length of trench is exposed. Care should be taken to protect side slopes of excavations by diverting surface run-off away from the excavations.

If construction extends into the winter, then the backfilling operations should be planned so that exposure of the backfill material to frost is kept to a minimum and to ensure that frozen material is not used as backfill.

Frequent compaction testing by experienced geotechnical personnel should be carried out to examine and approve backfill materials, and to verify that the specified degree of compaction has been achieved.

5.4 PAVEMENTS

5.4.1 Pavement Design

Following site grading and servicing operations, the pavement subgrade will comprise native and recompacted sand and silt soils or imported granular fill.

The following pavement component thicknesses are recommended based on the City of Waterloo Development Manual 2013, the proposed pavement usage, and the frost-susceptibility and strength of the subgrade soils:

Table 5: Pavement Designs

PAVEMENT COMPONENT	COLLECTOR STREETS	LOCAL STREETS
Asphalt Hot Mix	90 mm	90 mm
OPSS 1010 Granular 'A' Base	150 mm	150 mm
OPSS 1010 Granular 'B' Type 1 Subbase	500 mm	300 mm

The pavement designs meet City of Waterloo Standard Drawings Numbers W-201 and W-203 requirements.

The pavement design is based on the assumption that construction will be carried out during the drier time of the year and that the subgrade soil is stable as determined by proof-rolling inspected by a Geotechnical Engineer. If the subgrade is wet and unstable, additional granular subbase will be required.

Samples of both the Granular 'A' and Granular 'B' aggregates should be checked for conformance to OPSS 1010 prior to utilization on site and during construction. The Granular 'B' subbase and Granular 'A' base courses must be compacted to 100% SPMDD, as verified by insitu density testing.

The asphaltic concrete should comprise a binder layer of HL8 and a surface layer of HL3. It is recommended that the compacted thicknesses be 50 mm of HL8 binder and 40 mm of HL3 surface for both collector and local streets.

The asphaltic concrete paving materials should conform to the requirements of OPSS 1150. The asphalt should be placed and compacted in accordance with OPSS 310. The Performance Graded Asphalt Cement designation for the asphaltic concrete is 58-28.

The need for continuous paving supervision by a qualified pavement technician, and quality control testing during pavement construction cannot be over emphasized.

All materials and construction services required for the work should be in accordance with the applicable sections of the Ontario Provincial Standard Specifications.

5.4.2 Subdrains

Portions of he native subgrade soils have poor natural drainage therefore we recommend that where silt is encountered at the subgrade, subdrains be installed continuously along both sides of the street and connected to the catch basins. Where sand deposits are encountered at the subgrade level it is recommended that subdrain stubs be installed at the catchbasins. This should be confirmed by a geotechnical engineer at the time of subgrade preparation.

The purpose of the subdrains is to remove excess subsurface water in order to improve pavement serviceability and increase the pavement life. A detail for a typical pavement subdrain is provided on Drawing 4, in Appendix 1.

The work of subdrain installation shall be in accordance with OPSS 405 and OPSD 216.021. The subdrain shall be 100 or 150 mm diameter perforated pipe conforming to OPSS 1801 or 1840, and wrapped with geotextile conforming to OPSS 1860.

5.4.3 Curbs and Sidewalks

The concrete for curb and gutter should be proportioned, mixed, placed, and cured in accordance with the requirements of OPSS 353 and OPSS.MUNI 1350, and shall meet the following specific requirements (OPSS 353.05.01):

- minimum 28-day compressive strength = 30 MPa
- coarse aggregate = 19.0 mm nominal max. size
- maximum slump = 60 mm
- air entrainment = 7.0 ± 1.5%

During cold weather (when the air temperature is at or is likely to fall below 5°C within 96 hours of concrete placement) the freshly placed concrete must be covered with insulating blankets to protect against freezing, as per OPSS 904. Ice and snow must be removed from

the area where concrete is to be placed and the concrete must not be placed against frozen ground. All cold weather protection material shall be on site prior to each concrete placement.

The subgrade for the concrete sidewalks should comprise undisturbed native mineral soil or well-compacted fill. A minimum 150 mm thick layer of compacted Granular 'A' type aggregate should be placed beneath the sidewalk slabs. The subgrade and granular base should be prepared in accordance with the requirements of OPSS 315.

5.5 RESIDENTIAL BUILDINGS

5.5.1 Foundations

In general, the undisturbed native mineral soils are considered suitable to support residential house foundations. Where the footing levels will be above the existing native mineral soil grade, structural fill will probably be used. House footings constructed on the compact native mineral soil or approved structural fill may be designed using the minimum footing sizes provided in the Ontario Building Code.

All founding surfaces for residential dwellings on structural fill or native soils should be inspected by LVM personnel prior to placing concrete. The purpose of the inspection is to ensure that the founding conditions are consistent with the design bearing intended by the geotechnical engineer. The on-site review of the condition of the foundation soil as foundations are constructed is an integral part of the geotechnical design function and cannot be over emphasized. These reviews are required by Section 4.2.2.2 of the Ontario Building Code.

Further geotechnical investigation will be necessary for large structures such as schools, plazas or apartment buildings to provide specific recommendations for design of these structures. The preliminary Site Classification for Seismic Site Response is 'D'.

The subgrade soils are considered to be frost susceptible and must be protected from freezing at all times including during construction. The exterior footings or footings in unheated areas should be provided with a minimum 1.20 m of earth cover upon final grading for frost protection.

5.5.2 Basements

It is recommended basement floor slabs be installed above the groundwater levels and LVM review grading plans once complete.

House basements at this site must be provided with perimeter weeping tile systems as per the Ontario Building Code (Section 9.14). The drain tile or pipe should be laid on undisturbed or well-compacted soil so that the top of the tile or pipe (minimum 100 mm diameter) is below the bottom of the basement floor slab.

The top and sides of the drain tile or pipe shall be surrounded with not less than 150 mm of crushed stone or other clean coarse granular material containing no more than 10% of material that will pass the 4 mm sieve. The pipe bedding should be wrapped with geotextile filter fabric. The weeping tile must drain to a suitable frost-free outlet or sump.

The portion of the exterior basement wall below finished ground level must be damp-proofed as per Section 9.13.2 of the Ontario Building Code (2012). The basement wall backfill should be graded to prevent drainage towards the foundation after settling as per OBC 9.12.3.

The basement walls should be designed to resist the lateral earth pressure. For calculating the lateral earth pressure, the coefficient of earth pressure (K) may be assumed as 0.5 for cohesionless sand soils and 1.0 for silt and clay. The bulk unit weight of the retained backfill may be taken as 21 kN/m^3 for well-compacted soil. An appropriate factor of safety should be employed.

The subgrade for the basement floor slabs should comprise undisturbed native soil or well-compacted fill. A minimum 100 mm thick layer of coarse clean granular material containing not more than 10% material that will pass a 4 mm sieve shall be placed beneath slabs in houses as per Section 9.16.2 of the Ontario Building Code. If the subgrade soil is wet, we recommend that LVM be notified and subfloor weeping tiles be placed and connected to the sump pit.

To prevent the migration of moisture vapour into the houses from beneath basement floor slabs, particularly where moisture sensitive floor coverings are placed, a vapour retarder shall be placed directly beneath the floor slab that meets the requirements of the designer and flooring manufacturer. Prior to installing moisture sensitive floor coverings, the moisture content of the concrete slab must be determined at operational conditions by internal relative humidity testing to ensure an acceptable slab moisture level. It should be noted that it typically takes more than ninety days at operational conditions to lower the slabs internal relative humidity to 85%. Different flooring systems have different responses to slab moisture (i.e. some systems can tolerate more moisture than others), and the flooring contractor must assess the floor moisture levels with respect to their flooring components.

5.6 AT SOURCE STORMWATER INFILTRATION

At source infiltration of water from house roof leaders into dry wells may be feasible in areas where the natural groundwater level is below the bottom of the dry well and the native soils are relatively free-draining.

Based on the results of this investigation, the general soil profile existing at the site comprises surficial topsoil overlying major native deposits of sand with interbeds of silt. The hydraulic conductivity of the sand is in the order of 10^{-5} cm/sec, indicating that water infiltration would be feasible in this soil. The silt deposit has a hydraulic conductivity of 10^{-4} cm/sec or less, and therefore is not suitable for infiltration. The inferred groundwater table within most of the proposed residential lots is at least 3 m below existing grade.

The soak-away pits should be more than 5 m from the building foundations and located so that drainage is away from the buildings as per the Ontario Building Code.

Although the sand is prevalent across the site, it is anticipated that much of the sand will be stripped from the higher areas during site grading. For this reason, it will be necessary to identify potential infiltration lots during area grading. We would be pleased to provide preliminary information on which lots would be suitable for infiltration after reviewing the Site Grading Plan.

6 STATEMENT OF LIMITATIONS

The geotechnical recommendations provided in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known at the time of report preparation, we recommend that we be retained during the final design stage to verify that the geotechnical recommendations have been correctly interpreted in the design. We also recommend that we be retained during construction to confirm that the subsurface conditions do not deviate materially from those encountered in the boreholes and to ensure that our recommendations are properly understood.

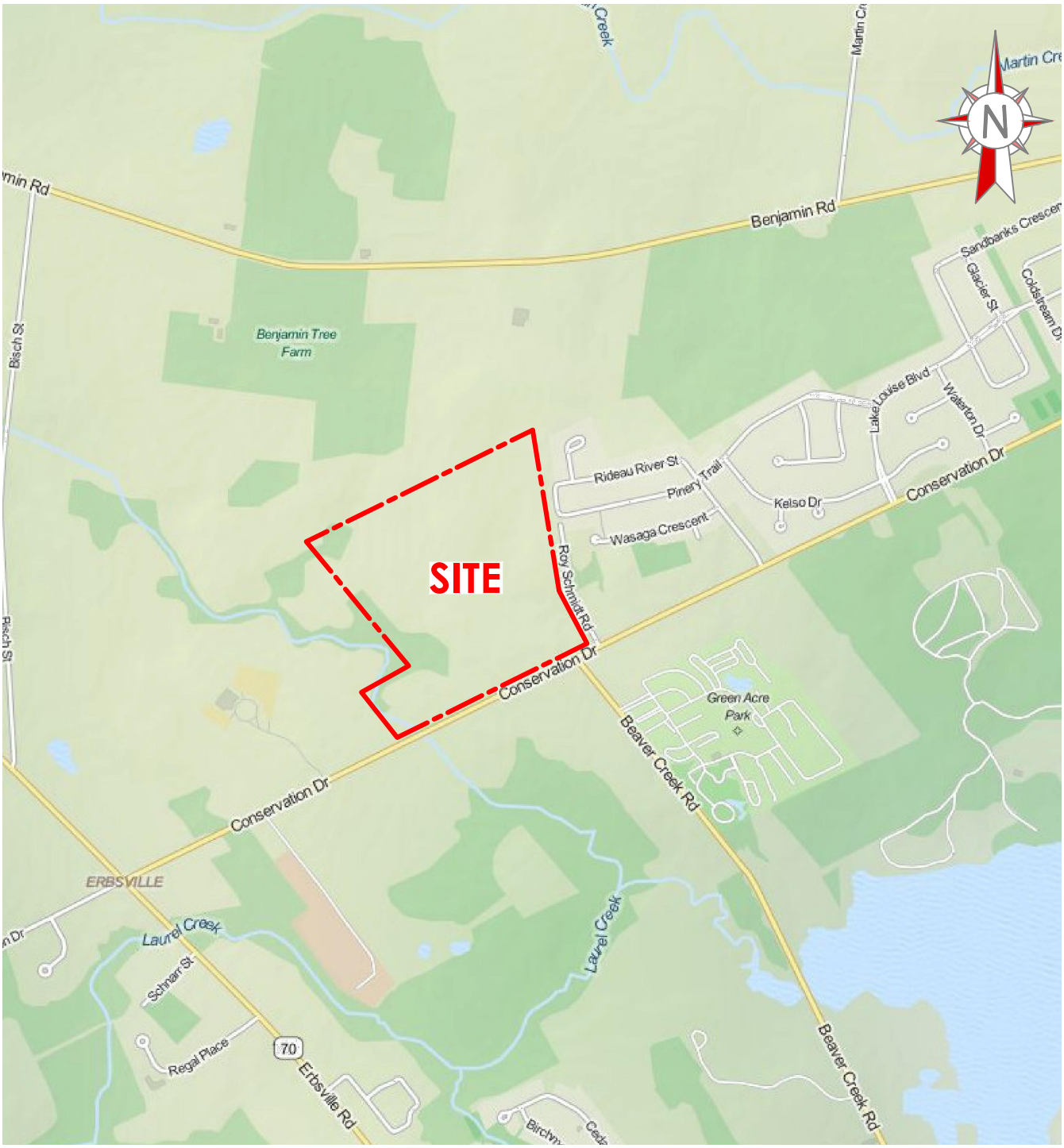
The geotechnical recommendations provided in this report are applicable only to the project described in the text and are intended for the use of the project designer. They are not intended as specifications or instructions to contractors. Any use which a contractor makes of this report, or decisions made based on it, are the responsibility of the contractor. The contractor must also accept the responsibility for means and methods of construction, seek additional information if required, and draw their own conclusions as to how the subsurface conditions may affect their work.

It is important to note that the geotechnical investigation involves a limited sampling of the site gathered at specific test hole locations and the conclusions in this report are based on this information gathered. The subsurface conditions between and beyond the boreholes will differ from those encountered at the test holes. Should subsurface conditions be encountered which differ materially from those indicated at the test holes, we request that we be notified in order to assess the additional information and determine whether or not changes should be made as a result of the conditions.

It must be recognized that the passage of time, natural occurrences and direct or indirect human intervention at or near the site have potential to alter the subsurface conditions. If during construction the soil or groundwater is found not to be of the type or in the condition used in design and as indicated on the drawings, the design shall be reassessed by the designer. If during construction, climatic (i.e. rain, frost etc.) or any other conditions (i.e. seepage, excavations etc.) have changed the properties of the soil or groundwater, the design shall be reassessed by the designer as per Section 4.2.2.3 of the Ontario Building Code.

Appendix 1 Drawings

Drawing 1: Location Plan
Drawing 2: Site Plan
Drawing 3: Typical Structural Fill Detail
Drawing 4: Typical Pavement Subdrain Detail



NOTES :
1-REFERENCES : © OpenStreetMap contributors (2013).

0 100 200 300 400 500 m
SCALE 1:15000

10 cm 0 1 2 3 4 5

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Project

Geotechnical Investigation
Proposed Residential Development

560/576 Conservation Drive, Waterloo, Ontario

Title

LOCATION PLAN

LVM
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon	Discipline	GEOTECHNICAL	Project manager	M.Wilson
Drawn	E.Ciochon	Scale	1 : 15000	Sequence no.	01 of 04
Checked	M.Wilson	Date	2015-03-03		

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0008077-0-01-100	GE	001	00



LEGEND :

- SITE BOUNDARY LINE
- BOREHOLE LOCATION
- BOREHOLE/TEST PIT LOCATION (Previous NEA Investigation Project 4500G1. Feb 2003)
- BOREHOLE (Previous NEA Investigation Project 4500G4. July 2005)
- EL. 351.86 — GROUND SURFACE ELEVATION (m)
- 252.30 — GROUND WATER ELEVATION (m)

0 20 40 60 80 100 m

SCALE 1:3000

NOTES :

1-REFERENCES : GRAND RIVER CONSERVATION AUTHORITY, 2015.

2-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.

3-Groundwater measured on March 9, 2015.

Project

Geotechnical Investigation
Proposed Residential Development

560/576 Conservation Drive, Waterloo, Ontario

Title

SITE PLAN

LVM

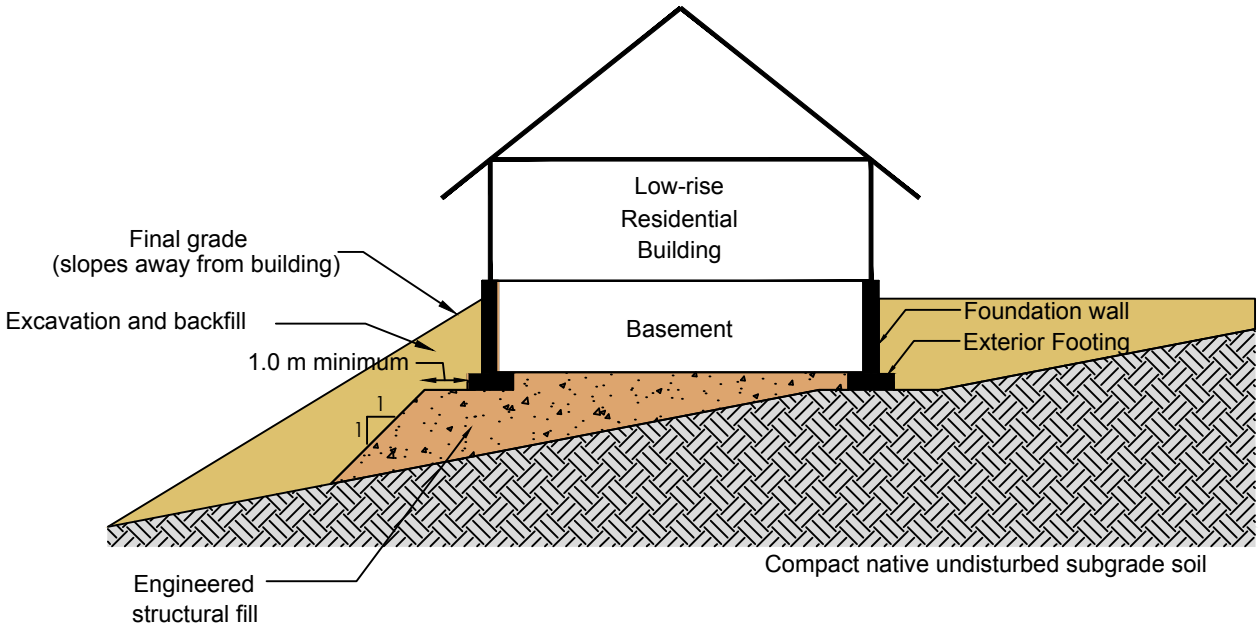
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	S.Meteer	Discipline	GEOTECHNICAL
Drawn	S.Meteer	Scale	1:3000
Checked	D.Gonser	Date	2015-02-17
Project manager	D.Gonser	Sequence no.	02 of 04

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0008077-0-01-100	GE	02	00

10 cm 0 1 2 3 4 5

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GENERAL REQUIREMENTS FOR ENGINEERED STRUCTURAL FILL

1. The area must be excavated of all pre-existing, topsoil and/or organic soil until compact native undisturbed soil is reached.

2. The excavation should allow for the structural fill to extend 1.0 m beyond the outside edge of the building footings and down to the approved subgrade soil at a slope of 1 horizontal to 1 vertical (45 °).

3. The subgrade below the engineered fill should be inspected and approved by a geotechnical engineer prior to fill construction. Fill placement and compaction operations to be carried out under full-time geotechnical supervision.

4. The structural fill should comprise sand and gravel aggregate placed in 300 mm thick lifts and compacted to at least 98 % Standard Proctor Maximum Dry Density (SPMDD). The exterior backfill should consist of approved inorganic soil also placed in 300 mm thick lifts and compacted to minimum 95 % SPMDD.

5. Exterior footings should be provided with minimum 1.2 m of soil cover for frost protection.

6. All excavations must be carried out in conformance with the current Ontario Occupational Health and Safety Act and Regulations 213/91 for construction projects.

7. This is not a design drawing or contract specification.

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Project

Geotechnical Investigation
Proposed Residential Development

560/576 Conservation Drive, Waterloo, Ontario

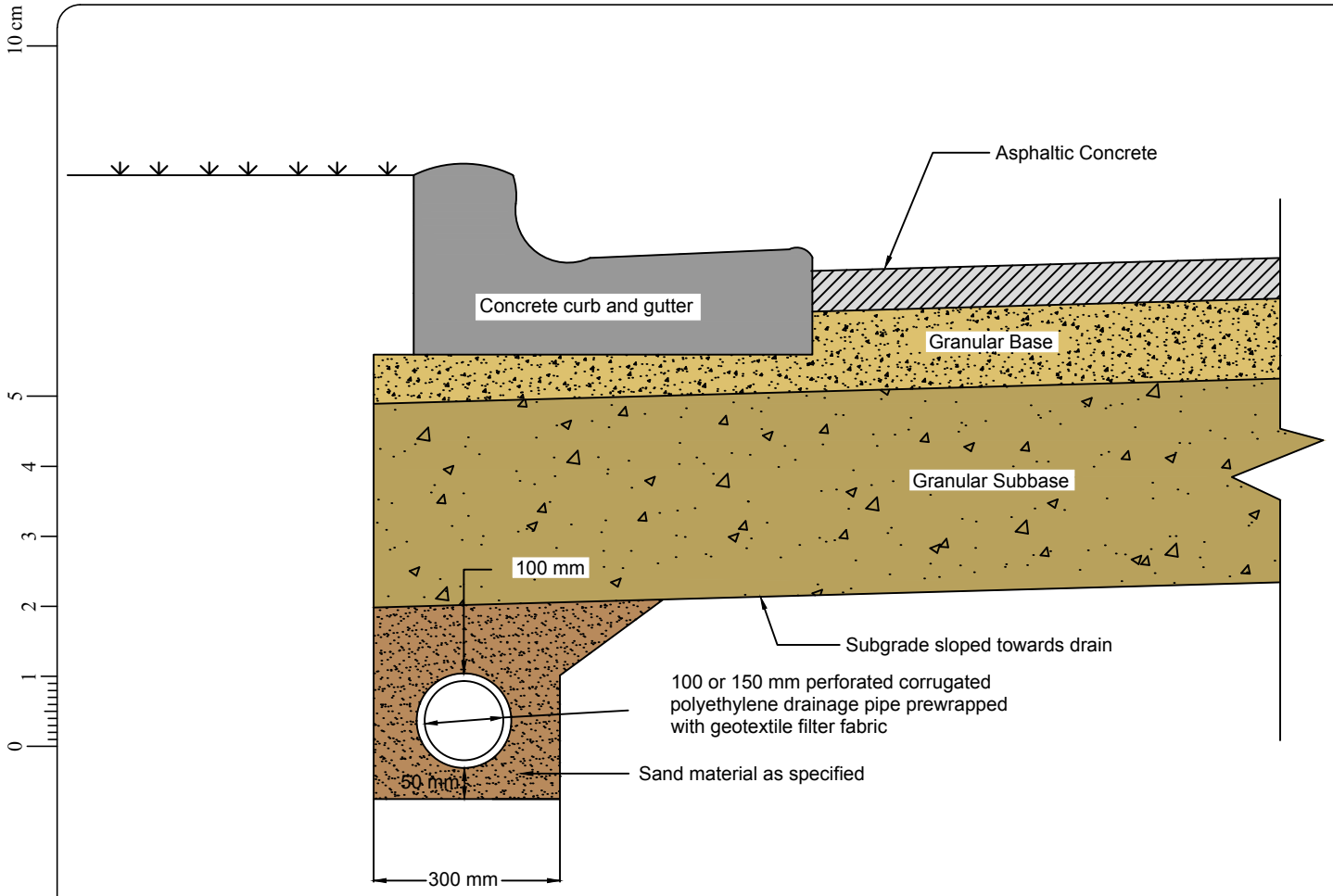
Title

TYPICAL STRUCTURAL FILL DETAIL

LVM
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Checked	M.Wilson	Date	2015-03-03		

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0008077-0-01-100	GE	003	00



GENERAL REQUIREMENTS FOR PAVEMENT SUBDRAINS

1. Perforated corrugated polyethylene drainage pipe shall meet the requirements of OPSS 1840.
2. Pipe filter fabric conforming to OPSS 1860 for geotextile Class 1 with a filtration opening size of 150 to 450 microns shall be supplied on all sections of perforated pipe.
3. The open upstream ends of pipes should be capped.
4. Subdrain pipes to be set on at least 1% grade draining to a positive frost-free outlet. If the subdrains are outletted to a ditch then the last 1.5 m of the outlet pipe should consist of a corrugated galvanized steel pipe equipped with a rodent gate.
5. Bedding and backfill material shall be concrete sand meeting the gradation requirements of OPSS 1002 (Fine Aggregate for Concrete).
6. This is not a design drawing or contract specification.

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Project

Geotechnical Investigation
Proposed Residential Development

560/576 Conservation Drive, Waterloo, Ontario

Title

TYPICAL PAVEMENT SUBDRAIN DETAIL

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Checked	M.Wilson	Date	2015-03-03		

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0008077-0-01-100	GE	004	00

Appendix 2 Borehole and Test Pit Logs

List of Abbreviations

Current Investigation: Boreholes BH-01-15 to BH-12-15

Previous Investigation: Boreholes BH1 and BH2, Test Pits TP29 and TP31 (LVM Report No.4500G1)

Previous Investigation Boreholes BH1 to BH5 (LVM Report No.4500G4)

LIST OF ABBREVIATIONS

The abbreviations commonly employed on the borehole logs, on the figures, and in the text of the report, are as follows:

Sample Types		Soil Tests and Properties	
AS	Auger Sample	SPT	Standard Penetration Test
CS	Core Sample	UC	Unconfined Compression
RC	Rock Core	FV	Field Vane Test
SS	Split Spoon	ø	Angle of internal friction
TW	Thinwall, Open	γ	Unit weight
WS	Wash Sample	w_p	Plastic limit
BS	Bulk Sample	w	Water content
GS	Grab Sample	w_L	Liquid limit
WC	Water Content Sample	I_L	Liquidity index
TP	Thinwall, Piston	I_p	Plasticity index
		PP	Pocket penetrometer

Penetration Resistances	
Dynamic Penetration Resistance	The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) diameter 60º cone a distance 300 mm (12 in.). The cone is attached to 'A' size drill rods and casing is not used.
Standard Penetration Resistance, N (ASTM D1586)	The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) required to drive a standard split spoon sampler 300 mm (12 in.)
WH	sampler advanced by static weight of hammer
PH	sampler advanced by hydraulic pressure
PM	sampler advanced by manual pressure

Soil Description			
Cohesionless Soils		**SPT N-Value**	**Relative Density (D_r)**
Compactness Condition		(blows per 0.3 m)	(%)
Very Loose		0 to 4	0 to 20
Loose		4 to 10	20 to 40
Compact		10 to 30	40 to 60
Dense		30 to 50	60 to 80
Very Dense		over 50	80 to 100
Cohesive Soils		**Undrained Shear Strength (C_u)**	
Consistency		**kPa**	**psf**
Very Soft		less than 12	less than 250
Soft		12 to 25	250 to 500
Firm		25 to 50	500 to 1000
Stiff		50 to 100	1000 to 2000
Very Stiff		100 to 200	2000 to 4000
Hard		over 200	over 4000
DTPL	Drier than plastic limit	Low Plasticity, W_L <30	
APL	About plastic limit	Medium Plasticity, 30 < W_L < 50	
WTPL	Wetter than plastic limit	High Plasticity, W_L > 50	

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Ground Elevation:	*361.21 m*	**Borehole Number:**	**BH-01-15**
Northing:	*4815267 m*	**Job N°:**	*P-0008077-0-01-100*
Easting:	*532899 m*	**Drill Date:**	*2015-02-27*
Project:	*Geotechnical Investigation, Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*560/576 Conservation Drive, Waterloo, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE								
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration	Shear Strength (PP) kPa / Shear Strength (FV) kPa	Water Content (%)	Groundwater Observations and Standpipe Details
	Ground Elevation		361.21							
	TOPSOIL: dark brown silt, trace sand, frozen		0.00 / 360.90							
	SAND: compact brown silty sand, trace gravel, frozen to moist		0.30 / 360.45							
1	very moist		0.76 / 359.69	SS-1	6-8 10	18				
	SILT: compact brown silt, some sand, trace clay and gravel, moist		1.52 / 358.92	SS-2	6-8 14	22				
2	some sand and clay, moist to very moist		2.29 / 358.16	SS-3	6-9 10	19				
3	hard grey/brown clay and silt, trace sand and gravel, DTPL		3.05	SS-4	10-13 15	28		> ▲.		bentonite seal
4										
				SS-5	11-15 18	33				
5										
6			355.11							
	SAND: very dense brown silty sand, wet		6.10	SS-6	7-24 27	51				sand pack
7										19 mm pipe 1.52 m slotted screen
	dense, saturated		7.62 / 353.59	SS-7	8-14 17	31				native cave
8	Borehole terminated at 8.08 m		353.13 / 8.08							

Dynamic Cone: 20 40 60 80 — Std Penetration: 20 40 60 80

Shear Strength (PP) kPa: 50 100 150 200 — ■ Initial, □ Remold — Shear Strength (FV) kPa: 50 100 150 200

WP WL — Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details: ▽ el. 354.22 m 2015-03-15

Vertical Scale = 1 : 50.0

Reviewed by: *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes: *Bulk sample AS-1A taken from 0.61 to 1.52 m and AS-5A from 3.05 to 4.57 m.*

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Ground Elevation:	*358.14 m*	**Borehole Number:**	**BH-02-15**
Northing:	*4815128 m*	**Job N°:**	*P-0008077-0-01-100*
Easting:	*532872 m*	**Drill Date:**	*2015-02-26*
Project:	*Geotechnical Investigation, Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*560/576 Conservation Drive, Waterloo, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE								
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration	Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa	WP WL / Water Content (%)	Groundwater Observations and Standpipe Details
	Ground Elevation		358.14				20 40 60 80	50 100 150 200	10 20 30	
	TOPSOIL: dark brown silt, trace sand, frozen		0.00							
			357.38							
1	loose, moist		0.76	SS-1	3-3 3	6				
	SAND: loose brown sand, some silt, trace topsoil, moist		357.07 1.07							
				SS-2	2-3 3	6				
2			355.85							bentonite seal
	silty sand, very moist		2.29	SS-3	3-3 3	6				
3				SS-4	1-3 7	10				
			354.33							
	wet		3.81	SS-5	3-5 6	11				
4			353.57							
	saturated		4.57	SS-6	1-3 4	7				
5										
6			352.04							native cave
	SILT: compact grey/brown silt, some clay, sand and gravel, very moist, some wet sand seams		6.10	SS-7	6-12 15	27				
7										
			350.52							
	hard, trace sand and gravel, DTPL		7.62	SS-8	10-13 17	30		>▲.		
8			350.06							
	Borehole terminated at 8.08 m		8.08							At drilling completion, wet cave at 4.27 m.

Vertical Scale = 1 : 50.0

Reviewed by: *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes: *Bulk sample taken from 2.13 to 3.05 m.*

Ground Elevation:	*356.21 m*	**Borehole Number:**	**BH-03-15**
Northing:	*4815019 m*	**Job N°:**	*P-0008077-0-01-100*
Easting:	*532995 m*	**Drill Date:**	*2015-02-26*
Project:	*Geotechnical Investigation, Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*560/576 Conservation Drive, Waterloo, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE							
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration (20 40 60 80)	Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa (50 100 150 200)	Water Content (%) WP WL (10 20 30)	Groundwater Observations and Standpipe Details
	Ground Elevation		356.21							
	TOPSOIL: dark brown sandy silt, frozen		0.00 / 356.06							
			0.15							
	SAND: compact brown sand, some silt, trace gravel, frozen			SS-1	5-6 7	13				
			354.69							
	trace silt and gravel, moist		1.52	SS-2	7-9 10	19				bentonite seal
				SS-3	6-11 13	24				
				SS-4	4-6 8	14				
			351.64							
	wet to saturated		4.57	SS-5	6-6 8	14				native cave
				SS-6	10-8 11	19				
			349.66							
	Borehole terminated at 6.55 m		6.55							At drilling completion, wet cave at 3.96 m.

Vertical Scale = 1 : 50.0

Reviewed by: *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes:

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Ground Elevation: *351.86 m* | **Borehole Number:** **BH-04-15**

Northing: *4814862 m* | **Job N°:** *P-0008077-0-01-100*

Easting: *532751 m* | **Drill Date:** *2015-02-26*

Project: *Geotechnical Investigation, Proposed Residential Development* | **Field Tech:** *D.Souter*

Location: *560/576 Conservation Drive, Waterloo, Ontario* | **Drill Method:** *Hollow Stem Auger*

Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value
	Ground Elevation		351.86			
	TOPSOIL: dark brown silt, some sand, frozen		0.00 / 351.50			
	SAND: loose brown silty sand, trace gravel, wet		0.36 / 350.34	SS-1	2-3 3	6
	compact brown sand, trace gravel and silt, saturated		1.52 / 348.81	SS-2	5-5 6	11
				SS-3	7-8 6	14
	SILT TILL: hard grey clayey silt, some sand, trace gravel, APL		3.05 / 347.29	SS-4	4-6 10	16
	very stiff, trace sand and gravel, APL to WTPL		4.57 / 346.68	SS-5	3-6 7	13
	SILT: compact grey silt, some clay and fine sand, saturated		5.18 / 343.78	SS-6	6-7 9	16
				SS-7	5-7 7	14
	Borehole terminated at 8.08 m		8.08			

Dynamic Cone: 20 40 60 80 | Std Penetration: 20 40 60 80

Shear Strength (PP) kPa: 50 100 150 200 | Initial | Remold | Shear Strength (FV) kPa: 50 100 150 200

WP WL | Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details

el. 350.91 m 2015-03-15

bentonite seal

sand pack

19 mm pipe
3.05 m slotted screen

native cave

Vertical Scale = 1 : 50.0

Reviewed by: *M.Wilson* | **Drafted by:** *E.Ciochon* | **Sheet:** *1 of 1*

Notes:

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Ground Elevation:	*353.74 m*	**Borehole Number:**	**BH-05-15**
Northing:	*4814992 m*	**Job N°:**	*P-0008077-0-01-100*
Easting:	*532711 m*	**Drill Date:**	*2015-02-26*
Project:	*Geotechnical Investigation, Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*560/576 Conservation Drive, Waterloo, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE							
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration (20 40 60 80)	Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa (50 100 150 200)	Water Content (%) WP WL (10 20 30)	Groundwater Observations and Standpipe Details
	Ground Elevation		353.74							
	TOPSOIL: dark brown silt, trace sand, frozen		0.00							
			352.90							
1	***SAND:*** compact brown sand, some silt, trace gravel, frozen to moist		0.84	SS-1	7-7 7	14				
			352.22							
	compact brown gravelly sand, some silt, trace gravel, saturated		1.52	SS-2	7-7 6	13				
2										
				SS-3	5-7 10	17				
			350.69							
3	some gravel		3.05	SS-4	3-7 12	19				
4										
			349.17							
	trace gravel		4.57	SS-5	7-10 10	20				
5										
6										
				SS-6	15-9 8	17				
			347.19							
	Borehole terminated at 6.55 m		6.55							
7										
8										

el. 352.21 m 2015-03-15

bentonite seal

19 mm pipe
1.52 m slotted screen

native cave

Vertical Scale = 1 : 50.0

Reviewed by: *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes:

Ground Elevation:	*356.92 m*	**Borehole Number:**	**BH-06-15**
Northing:	*4815119 m*	**Job N°:**	*P-0008077-0-01-100*
Easting:	*532711 m*	**Drill Date:**	*2015-02-26*
Project:	*Geotechnical Investigation, Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*560/576 Conservation Drive, Waterloo, Ontario*	**Drill Method:**	*Hollow Stem Auger*

Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value
	Ground Elevation		356.92			
	TOPSOIL: dark brown silt, trace sand and gravel, frozen		0.00 / 356.51			
	SAND: loose to compact brown sand, some silt, trace gravel, frozen		0.41 / 356.01			
1	moist		0.91 / 355.40	SS-1	3-4 5	9
	loose silty sand, very moist to wet		1.52 / 354.63	SS-2	3-3 4	7
2						
	compact, trace gravel, moist		2.29 / 352.35	SS-3	6-10 11	21
3				SS-4	5-12 16	28
4						
	SILT TILL: dense grey/brown silt, some sand, trace clay and gravel, moist		4.57 / 351.89	SS-5	10-12 18	30
5	Borehole terminated at 5.03 m		5.03			
6						
7						
8						

Dynamic Cone: 20 40 60 80
Std Penetration: 20 40 60 80
Shear Strength (PP) kPa: 50 100 150 200
Initial
Remold
Shear Strength (FV) kPa: 50 100 150 200
WP WL
Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details

bentonite seal

At drilling completion, borehole open and dry.

Vertical Scale = 1 : 50.0

Reviewed by: *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes: *Bulk sample taken from 2.44 to 3.66 m.*

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Ground Elevation:	*354.85 m*	**Borehole Number:**	**BH-07-15**
Northing:	*4815131 m*	**Job N°:**	*P-0008077-0-01-100*
Easting:	*532578 m*	**Drill Date:**	*2015-02-27*
Project:	*Geotechnical Investigation, Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*560/576 Conservation Drive, Waterloo, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE		SAMPLE							
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration (20 40 60 80)	Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa (50 100 150 200)	Water Content (%) WP WL (10 20 30)	Groundwater Observations and Standpipe Details
	Ground Elevation		354.85							
	TOPSOIL: dark brown silt, trace sand, frozen		0.00 / 354.44							
	SAND: loose brown sand, some silt, frozen to moist		0.41 / 354.09							
1	moist		0.76 / 353.33	SS-1	2-3 3	6				
	trace silt and gravel		1.52	SS-2	1-1 3	4				
2				SS-3	2-3 3	6				
3			351.80							
	some silt and gravel, saturated		3.05	SS-4	8-10 12	22				
4										
	dense		350.28 / 4.57	SS-5	8-14 19	33				
5	Borehole terminated at 5.03 m		349.82 / 5.03							
6										
7										
8										

el. 352.07 m 2015-03-15

bentonite seal

sand pack

19 mm pipe
1.52 m slotted screen

Vertical Scale = 1 : 50.0

Reviewed by: *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes:

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Ground Elevation:	*357.56 m*	**Borehole Number:**	**BH-08-15**
Northing:	*4815292 m*	**Job N°:**	*P-0008077-0-01-100*
Easting:	*532630 m*	**Drill Date:**	*2015-02-27*
Project:	*Geotechnical Investigation, Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*560/576 Conservation Drive, Waterloo, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE							
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration	Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa	WP WL / Water Content (%)	Groundwater Observations and Standpipe Details
	Ground Elevation		357.56				20 40 60 80	50 100 150 200	10 20 30	
	TOPSOIL: dark brown silt, some sand, frozen		0.00 357.41 0.15							
	SAND: brown sand, some silt and topsoil, frozen		356.80 0.76							
1	compact, some silt, trace gravel, moist			SS-1	4-6 5	11				
			356.04							
	compact brown silty sand, trace gravel, wet		1.52	SS-2	5-5 8	13				
2										
				SS-3	4-6 7	13				bentonite seal
3										
				SS-4	7-18 20	38				
4										
			352.99							
	SILT: dense grey/brown sandy clayey silt, trace gravel, very moist		4.57	SS-5	8-19 16	35				
5										
6			351.46							native cave
	compact		6.10	SS-6	9-10 16	26				
			351.01							At drilling completion, wet cave at 5.79 m.
	Borehole terminated at 6.55 m		6.55							
7										
8										

Reviewed by: *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes:

Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011

Ground Elevation:	*361.96 m*	**Borehole Number:**	**BH-09-15**
Northing:	*4815237 m*	**Job N°:**	*P-0008077-0-01-100*
Easting:	*532778 m*	**Drill Date:**	*2015-02-26*
Project:	*Geotechnical Investigation, Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*560/576 Conservation Drive, Waterloo, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE							
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration	Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa	WP WL / Water Content (%)	Groundwater Observations and Standpipe Details
	Ground Elevation		361.96							
	TOPSOIL: dark brown silt, trace sand, frozen		0.00							
			361.05							
1	***SAND:*** loose brown fine sand, some silt, moist		0.91	SS-1	2-3 3	6				
			360.44							
	compact		1.52	SS-2	4-6 9	15				
2										
				SS-3	5-10 10	20				bentonite seal
3			358.91							
	dense		3.05	SS-4	10-16 17	33				
4										
			357.24							
	sand, trace silt		4.72	SS-5	15-18 25	43				
5			356.93							
	Borehole terminated at 5.03 m		5.03							At drilling completion, borehole open and dry.
6										
7										
8										

Dynamic Cone / Std Penetration: 20 40 60 80

Shear Strength (PP) kPa / Shear Strength (FV) kPa: 50 100 150 200 — Initial, Remold

WP WL / Water Content (%): 10 20 30

Reviewed by: *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes: *Bulk sample taken from 1.52 to 3.05 m.*

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Ground Elevation:	*363.11 m*	**Borehole Number:**	**BH-10-15**
Northing:	*4815398 m*	**Job N°:**	*P-0008077-0-01-100*
Easting:	*532842 m*	**Drill Date:**	*2015-02-27*
Project:	*Geotechnical Investigation, Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*560/576 Conservation Drive, Waterloo, Ontario*	**Drill Method:**	*Hollow Stem Auger*

Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value
	Ground Elevation		363.11			
	TOPSOIL: dark brown silt, trace sand, frozen		0.00 362.96 0.15			
	SAND: compact brown silty fine sand, frozen		362.50 0.61			
1	moist			SS-1	3-5 6	11
	some silt		361.59 1.52	SS-2	3-5 7	12
2				SS-3	3-7 7	14
3	some silty sand seams		360.06 3.05	SS-4	7-12 14	26
4						
5				SS-5	7-7 10	17
6				SS-6	7-9 13	22
	Borehole terminated at 6.55 m		356.56 6.55			
7						
8						

Dynamic Cone: 20 40 60 80
Std Penetration: 20 40 60 80
Shear Strength (PP) kPa: 50 100 150 200
Initial
Remold
Shear Strength (FV) kPa: 50 100 150 200
WP WL
Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details

benonite seal

native cave

At drillig completion, borehole open and dry.

Vertical Scale = 1 : 50.0

Reviewed by: *M.Wilson* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes: *Bulksample AS-4A taken from 3.05 to 4.57 m.*

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

BOREHOLE: 1
Sheet 1 of 1

PROJECT Proposed Residential Subdivision
DATE 6 December 2002
JOB NO. 4500G01
LOCATION Activa Conservation Lands, Waterloo, Ontario
FIELD ENG/TECH RM

DEPTH (m)	DESCRIPTION	LEGEND	ELEV.	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES N-VALUE
	GROUND ELEVATION: 364.23					
0	0.20 TOPSOIL: dark brown silt, moist		364			
	SILT: compact brown silt, some sand, trace clay, wet			1	SS	16
1	1.50 compact to dense		363			
				2	SS	43
2			362	3	SS	20
3			361	4	SS	29
4	3.95 SILT TILL: very stiff grey clayey silt, trace sand, APL		360			
				5	SS	17
5	5.05 Borehole terminated at 5.05 m.					

SHEAR STRENGTH. kPa(ksf)
FV. NAT. ■ REM. □
UC ✕ PP ▲
50(1)100(2)150(3)200(4)
PENETRATION RESISTANCE
DYNAMIC CONE ✕
STANDARD PENETRATION ●
20 40 60 80

150 mm

WATER CONTENT (%)
Wp W Wl
10 20 30

GROUNDWATER OBSERVATIONS & PIEZOMETER DETAILS

bentonite seal

13 mm pipe

native backfill

1.2 m slotted filter

At drilling completion, dry cave at 4.6 m.

December 12, 2002
Water level at 4.28 m
(Elev. 359.95)

NOTES:

DRILLING METHOD: Solid Stem Augers

ENGINEER: JD

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

BOREHOLE: 2
Sheet 1 of 1

PROJECT Proposed Residential Subdivision
DATE 6 December 2002
JOB NO. 4500G01
LOCATION Activa Conservation Lands, Waterloo, Ontario
FIELD ENG/TECH RM

DEPTH (m)	DESCRIPTION	ELEV.	NUMBER	TYPE	N-VALUE
	GROUND ELEVATION: 362.60				
0	TOPSOIL: dark brown silt, moist				
0.30	SILT: compact to dense brown silt, trace sand and clay, wet	362	1	SS	12
1		361	2	SS	32
2					
2.45					
2.60	SILT TILL: dense brown silt, some clay, wet	360	3	SS	44
3	hard grey clayey silt, trace sand, APL	359	4	SS	22
3.95	brown; some silt layers, wet	358	5	SS	45
4					
5.05	Borehole terminated at 5.05 m.				
5					

SHEAR STRENGTH, kPa(ksf)
FV. NAT. ■ REM. □
UC ✜ PP ▲
50(1)100(2)150(3)200(4)
PENETRATION RESISTANCE
DYNAMIC CONE ×
STANDARD PENETRATION ●
20 40 60 80

WATER CONTENT (%)
Wp W Wl
10 20 30

GROUNDWATER OBSERVATIONS & PIEZOMETER DETAILS

bentonite seal

13 mm pipe

native backfill

1.2 m slotted filter

At drilling completion, dry cave at 4.6 m.

December 12, 2002
Water level at 4.74 m
(Elev. 357.86)

NOTES: Bulk sample taken at 2.4 to 3.4 m.

DRILLING METHOD: Solid Stem Augers

ENGINEER: JD

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

TEST PIT: 29

LOCATION Proposed Residential Subdivision DATE 10 December 2002 JOB NO. 4500G01

PROJECT Activa Conservation Lands, Waterloo, Ontario FIELD ENG/TECH RM

SOIL PROFILE					WATER CONTENT (%) Wp W Wl	GROUNDWATER OBSERVATIONS AND HEADSPACE READINGS (ppm)
DEPTH m	DESCRIPTION	LEGEND	ELEV.	SAMPLE	10 20 30	
	GROUND ELEVATION: 363.73					
0	TOPSOIL: dark brown silt, moist					
0.55	SILT: rusty brown silt, trace sand, wet		363			
0.80	brown				⊙	
1.10	Test pit terminated at 1.10 m.					Upon completion of excavation, test pit sidewalls stable. No free groundwater encountered during excavation.

NOTES:

ENGINEER:

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

TEST PIT: 31

LOCATION Proposed Residential Subdivision DATE 10 December 2002 JOB NO. 4500G01

PROJECT Activa Conservation Lands, Waterloo, Ontario FIELD ENG/TECH RM

SOIL PROFILE					WATER CONTENT (%) Wp W Wl	GROUNDWATER OBSERVATIONS AND HEADSPACE READINGS (ppm)
DEPTH m	DESCRIPTION	LEGEND	ELEV.	SAMPLE	10 20 30	
	GROUND ELEVATION: 362.62					
0	TOPSOIL: dark brown silt, moist					
0.35	SAND: rusty brown fine to medium sand, some silt, moist		362			
0.85	brown, trace silt					
1.00	Test pit terminated at 1.00 m.					Test pit sidewalls caving below 0.4 m. No free groundwater encountered during excavation.

NOTES:

ENGINEER: JD

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

Borehole Number: 1

Ground Elevation: ***N/A***

Project: ***Emergency Access Road***

Job No.: ***4500G4***

Location: ***Roy Schmidt Road, Waterloo, Ontario***

Drill Date: ***July 18, 2005***

Depth (m)	Description	Symbol	Elevation (m)	Sample Number	Sample Type	N-Value
	Ground Elevation		0.00			
0.00	***PAVEMENT STRUCTURE:*** Asphaltic Concrete: 50 mm; Granular 'A': 150 mm					
	SAND: compact fine brown sand, trace silt, damp			1	SS	14
1.00			-1.00	2	SS	10
	compact light brown fine sand, some silt, wet			3	SS	17
2.00	Borehole terminated at 1.98 m.		-2.00			

Dynamic Cone: X 20 40 60 80 X
Standard Penetration: ● 20 40 60 80 ●
Shear Strength (PP) kPa: ▲ 50 100 150 200 ▲
Shear Strength (FV) kPa: ■ 50 100 150 200 ■
WP WL
Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details

dry-pack asphalt seal

native backfill

native cave

At drilling completion, dry cave at 1.52 m.

Reviewed by: ***D.M.***

Field Tech.: ***D.M.***

Drill Method: ***Solid Stem Auger***

Sheet: ***1 of 1***

Notes:

Drafted by: ***A.G._01a***

Naylor Engineering Associates Ltd.
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Borehole Number: 2

Ground Elevation: ***N/A***

Project: ***Emergency Access Road***

Job No.: ***4500G4***

Location: ***Roy Schmidt Road, Waterloo, Ontario***

Drill Date: ***July 18, 2005***

Depth (m)	Description	Elevation (m)	Number	Type	N-Value
	Ground Elevation	0.00			
0.00	***PAVEMENT STRUCTURE:*** Asphaltic Concrete: 40 mm; Granular 'A': 125 mm				
	FILL: loose dark brown silt, some clay and gravel, trace sand, very moist		1	SS	7
1.00	***SAND:*** very loose brown sand, some silt, moist	-1.00	2	SS	4
	SAND AND GRAVEL: compact brown medium to coarse sand and gravel, trace silt, moist		3	SS	13
2.00	Borehole terminated at 1.98 m.	-2.00			

Dynamic Cone: 20 40 60 80
Standard Penetration: 20 40 60 80
Shear Strength (PP) kPa: 50 100 150 200
Shear Strength (FV) kPa: 50 100 150 200
WP WL
Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details:
- dry-pack asphalt seal
- native backfill
- native cave
- At drilling completion, dry cave at 1.52 m.

Reviewed by: ***D.M.***

Field Tech.: ***D.M.***

Drill Method: ***Solid Stem Auger***

Sheet: ***1 of 1***

Notes:

Drafted by: ***A.G._01a***

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

Borehole Number: 3

Ground Elevation: ***N/A***

Project: ***Emergency Access Road***

Job No.: ***4500G4***

Location: ***Roy Schmidt Road, Waterloo, Ontario***

Drill Date: ***July 18, 2005***

Depth (m)	Description	Elevation (m)	Number	Type	N-Value
	Ground Elevation	0.00			
0.00	***PAVEMENT STRUCTURE:*** Asphaltic Concrete: 40 mm; Granular 'A': 205 mm				
	FILL: firm dark brown clayey silt, some gravel, trace sand, damp		1	SS	8
	SILT: light brown silt, some sand, trace gravel, moist				
	silt, trace sand, trace gravel, very moist		2	SS	10
1.00		-1.00			
	SAND: dense light brown silty fine sand, very moist to wet		3	SS	39
2.00	Borehole terminated at 1.98 m.	-2.00			

Dynamic Cone: 20 40 60 80
Standard Penetration: 20 40 60 80
Shear Strength (PP) kPa: 50 100 150 200
Shear Strength (FV) kPa: 50 100 150 200
WP WL
Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details:
- dry-pack asphalt seal
- native backfill
- native cave
- At drilling completion, dry cave at 1.52 m.

Reviewed by: ***D.M.***

Field Tech.: ***D.M.***

Drill Method: ***Solid Stem Auger***

Sheet: ***1 of 1***

Notes:

Drafted by: ***A.G._01a***

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Borehole Number: 4

Ground Elevation: ***N/A***

Project: ***Emergency Access Road***

Job No.: ***4500G4***

Location: ***Roy Schmidt Road, Waterloo, Ontario***

Drill Date: ***July 18, 2005***

Depth (m)	Description	Elevation (m)	Sample Number	Sample Type	N-Value
	Ground Elevation	0.00			
0.00	***PAVEMENT STRUCTURE:*** Asphaltic Concrete: 50 mm; Granular 'A': 100 mm				
	FILL: firm dark brown clayey silt, some gravel, trace sand, damp				
	SAND: compact rusty brown sand, some silt, moist		1	SS	11
	compact light brown fine sand, some silt, moist		2	SS	18
1.00		-1.00			
	wet		3	SS	22
2.00	Borehole terminated at 1.98 m.	-2.00			

Dynamic Cone: X 20 40 60 80 X
Standard Penetration: ● 20 40 60 80 ●
Shear Strength (PP) kPa: ▲ 50 100 150 200 ▲
Shear Strength (FV) kPa: ■ 50 100 150 200 ■
Water Content (%): WP WL; 10 20 30

Groundwater Observations and Standpipe Details:
- dry-pack asphalt seal
- native backfill
- native cave
- At drilling completion, dry cave at 1.52 m.

Reviewed by: ***D.M.***

Field Tech.: ***D.M.***

Drill Method: ***Solid Stem Auger***

Sheet: ***1 of 1***

Notes:

Drafted by: ***A.G._01a***

Naylor Engineering Associates Ltd.
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Borehole Number: 5

Ground Elevation: ***N/A***

Project: ***Emergency Access Road***

Job No.: ***4500G4***

Location: ***Roy Schmidt Road, Waterloo, Ontario***

Drill Date: ***July 18, 2005***

Depth (m)	Description	Elevation (m)	Sample Number	Sample Type	N-Value
0.00	Ground Elevation	0.00			
	FILL: Topsoil Fill: 50 mm; Granular 'A': 150 mm				
	SAND: compact brown sand, trace silt, moist		1	SS	10
1.00	***SILT:*** very loose mottled brown/rusty silt, some sand, very moist	-1.00	2	SS	4
	compact light brown silt, trace sand, very moist		3	SS	12
2.00	Borehole terminated at 1.98 m.	-2.00			

Dynamic Cone: X 20 40 60 80 X
Standard Penetration: ● 20 40 60 80 ●
Shear Strength (PP) kPa: ▲ 50 100 150 200 ▲
Shear Strength (FV) kPa: ■ 50 100 150 200 ■
Water Content (%): WP — WL; 10 20 30

Groundwater Observations and Standpipe Details:
- native backfill
- native cave
- At drilling completion, dry cave at 1.52 m.

Reviewed by: ***D.M.***

Field Tech.: ***D.M.***

Drill Method: ***Solid Stem Auger***

Sheet: ***1 of 1***

Notes:

Drafted by: ***A.G._01a***

Appendix 3 Figures

Figures 1 and 2: Particle Size Distribution Analyses
Figures 3 and 4: Standard Proctor Moisture-Density Test Results

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PARTICLE SIZE ANALYSIS

Project: **Geotechnical Investigation, Proposed Residential Development**

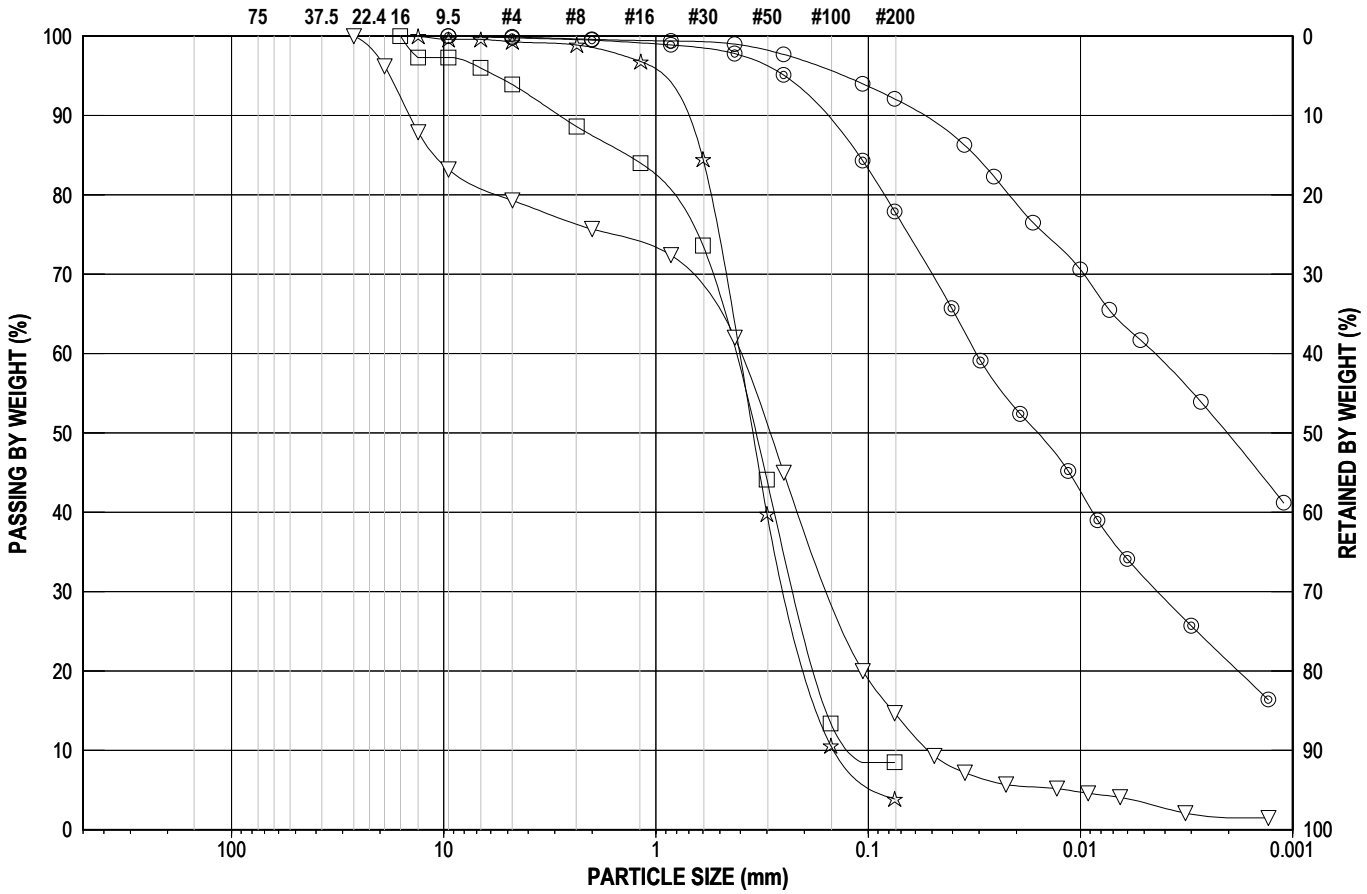
Figure No : **1**

Location: **560/576 Conservation Drive, Waterloo, Ontario**

File No : **P-0008077-0-01-100**

UNIFIED SOIL CLASSIFICATION

COBBLES	*GRAVEL*		*SAND*			*SILT OR CLAY*
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN MILLIMETRES			*U.S. STANDARD SIEVE No.*			*HYDROMETER*



Symbol	Borehole n°	Sample n°	Depth (m)	Description
○	BH-01-15	SS-4	3.05 - 3.51	SILT and CLAY, trace Sand
□	BH-04-15	SS-3	2.29 - 2.74	SAND, trace Gravel and Silt
▽	BH-05-15	SS-2	1.52 - 1.98	Gravelly SAND, some Silt, trace Clay
☆	BH-07-15	SS-3	2.29 - 2.74	SAND, trace Gravel and Silt
◎	BH-08-15	SS-5	4.57 - 5.03	Sandy, Clayey SILT

FIGURE NO. 2

LABORATORY PROCTOR MOISTURE–DENSITY TEST

PROJECT Proposed Residential Development

LOCATION 560 / 576 Conservation Drive, □aterloo, Ontario JOB NO. P-0008077-0-01-100

BOREHOLE NO. BH-09-15 Bulk Sample DATE TESTED March, 2015

SAMPLE DEPTH 1.52 m - 3.05 m TESTED BY M.D

SOIL TYPE SA□D MOISTURE CONTENT 9.5 %

REMARKS

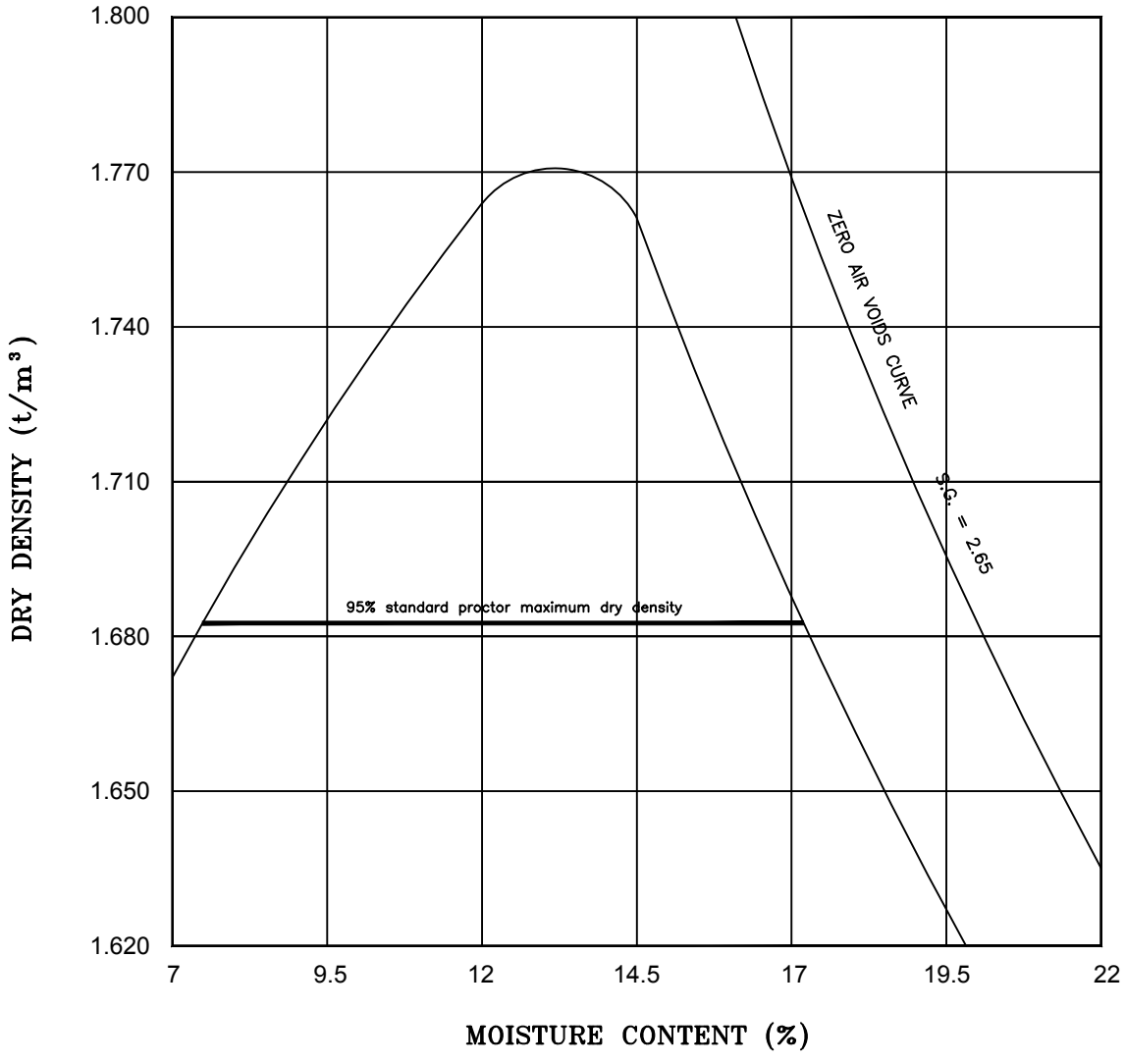
METHOD LS – 706

PROCEDURE: 1☒ 2☐ 3☐

Procedure 1 (Mold ø – 101.6 mm)
Procedure 2 (Mold ø – 101.6 mm)
Procedure 3 (Mold ø – 152.4 mm)

MAXIMUM DRY DENSITY 1.771 t/m³

OPTIMUM MOISTURE 13.4 %



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FIGURE NO. 3

LABORATORY PROCTOR MOISTURE–DENSITY TEST

PROJECT Proposed Residential Development

LOCATION 560 / 576 Conservation Drive, □aterloo, Ontario JOB NO. P-0008077-0-01-100

BOREHOLE NO. BH-01-15 Auger Sample □6 DATE TESTED March 4, 2015

SAMPLE DEPTH 3.05 - 4.57 m TESTED BY M.Dalgliesh

SOIL TYPE S□LT MOISTURE CONTENT 18.9 %

REMARKS

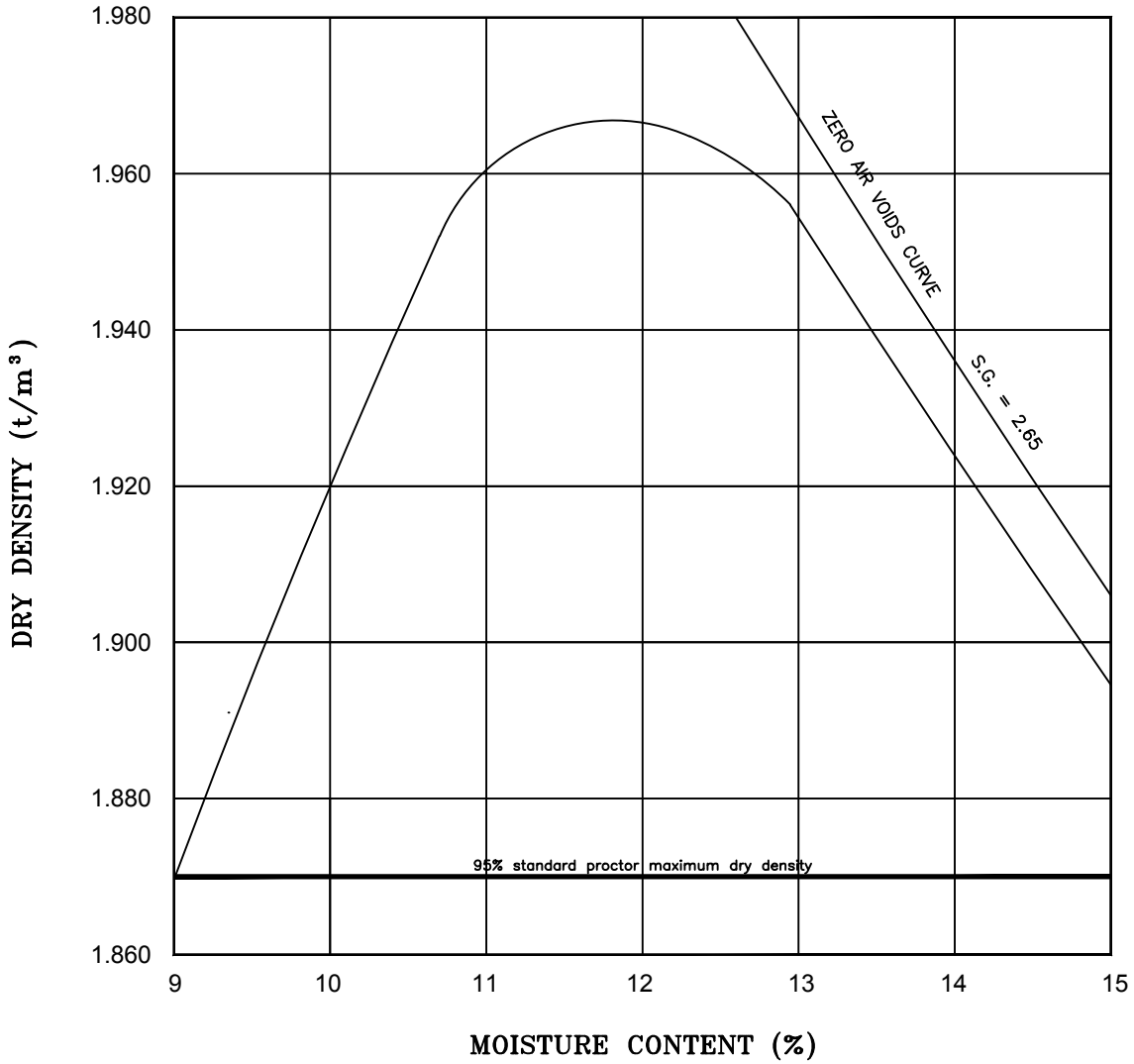
METHOD LS – 706

PROCEDURE: 1☒ 2☐ 3☐

Procedure 1 (Mold ø – 101.6 mm)
Procedure 2 (Mold ø – 101.6 mm)
Procedure 3 (Mold ø – 152.4 mm)

MAXIMUM DRY DENSITY 1.968 t/m³

OPTIMUM MOISTURE 11.8 %



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North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program

DRAFT

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Activa Holdings, and
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Sign-off Sheet

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Abbreviations

BGS	below ground surface
BTOC	below top of casing
City	City of Waterloo
the Client	Northgate Corporation, 2115881 Ontario Ltd., Activa Holdings, and Erbsville Kartway
HDPE	high density polyethylene
KWCS	Kitchener-Waterloo Climate Station
LCWS	Laurel Creek Watershed Study
NWSSS	North Waterloo Scoped Subwatershed Study
MNR	Ministry of Natural Resources
RCS	Roseville Climate Station
Region	Regional Municipality of Waterloo
the Site	proposed development, generally bounded by Erbsville Road, Beaver Creek Road, Laurel Creek Conservation lands and City limits
Stantec	Stantec Consulting Ltd.
SWMF	storm water management facility
TSS	total suspended solids
UWWS	University of Waterloo Weather Station

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1.0 INTRODUCTION

Northgate Corporation, 2115881 Ontario Ltd., Activa Holdings, and Erbsville Kartway (the client) are proposing future development within properties located in the northwestern portion of the City of Waterloo (City), within the Regional Municipality of Waterloo (Region). The City of Waterloo formally refers to this area as the Beaver Creek Meadows District. The proposed development is generally bounded by Erbsville Road to the west, Beaver Creek Road to the east, the Laurel Creek Conservation lands to the south and the City limits to the north (the Site). This Site is located within the study boundary of the North Waterloo Scoped Subwatershed Study (NWSSS).

In support of development, the City requires that monitoring programs be completed by the developer and must include Stage I, II and III monitoring per the Laurel Creek Watershed Development Monitoring Program. Stage I consists of 2 years of pre-development monitoring, Stage II represents during construction conditions, and Stage III extends for 24 months following substantial completion of the development (i.e., 90% stabilization of the catchment area).

The NWSSS presented initial groundwater and surface water monitoring results from 2009 and 2010 (Ecoplans, MHBC, Stantec, 2013). Stantec Consulting Ltd. (Stantec) was retained to complete the 2011 to 2015 surface water and groundwater monitoring and to prepare the 2014 and 2015 monitoring report in support of proposed development of the Site. Natural Resource Solutions Inc. was retained to complete the terrestrial monitoring components, which are provided under separate cover. The following report presents the surface water and groundwater monitoring data collected from 2011 to 2015 along with the historical data for reference.

This report is arranged in six sections, including this introduction. Section 2 presents a background of the previous investigations. Section 3 presents the methodology while the 2009 to 2015 monitoring results are presented in Section 4. Section 5 provides conclusions and recommendations based on the 2011 to 2015 monitoring program results while Section 6 provides a list of references.

All figures and tables referenced in the report are presented in Appendices A and B, respectively. Appendices C to E present the approved Phase I Monitoring Program, surface water flow data and analysis and laboratory certificates of analysis, respectively.

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2.0 BACKGROUND

The NWSSS focused on lands located in the northwestern portion of the City including the current Site. The overall goal of the NWSSS was to assess existing characteristics within the study area and develop a management strategy for the study area that protected, maintained and enhanced the ecological function and significant natural features.

2.1 NWSSS HYDROGEOLOGIC INVESTIGATION

The following section presents a summary of the findings from the NWSSS (2013) hydrogeologic investigation with respect to the current Site. Full details of the investigation and reports are included in the subwatershed report (Ecoplans, MHBC, Stantec, 2013).

The Site is located within the Waterloo Moraine, a complex deposit of ice contact and glacial outwash sands and gravels separated by silt and clay tills. The conceptual hydrogeologic model for the moraine consists of four (4) overburden aquifers (Aquifers 1 to 4), separated by four aquitards (Aquitards 1 to 4). The upper portion of the bedrock aquifer in the area was classified as being part of the fourth aquifer unit. The overburden in the vicinity of the Site is approximately 70 m thick and overlies dolostone and shale bedrock of the Salina Formation.

The surficial geology within the Site consists predominately of sandy glaciofluvial deposits associated with Aquifer 1 overlain by discontinuous deposits of clay to silt-textured till associated with Aquitard 1. Modern alluvial deposits were found in low lying areas associated with Beaver Creek and Laurel Creek.

Aquitards 2/3 are generally continuous within the Waterloo Moraine; however, within the Site, Aquitards 2/3 were eroded by a glacial meltwater channel that extends in a general northwest to southeast direction. Aquitard 2 was absent within select areas of the Site and within the meltwater channel, Aquitard 3 was eroded to only 6 m. The erosion of Aquitard 2/3 created hydraulic connections with the underlying aquifer.

Groundwater flow within the shallow deposits of Aquifer 1 is predominantly towards Beaver Creek and Laurel Creek from areas of topographic highs. The local groundwater flow contours are consistent with regional groundwater flow direction. Groundwater level data from monitoring wells within the Site and available topography suggest that groundwater discharge to Laurel Creek may be occurring.

Based on surface water flow rate data and groundwater / surface water hydraulic gradients, groundwater discharge conditions are interpreted along Laurel Creek during both low and high groundwater levels. Minimal groundwater discharge/recharge is interpreted along the majority of Beaver Creek with the exception of seasonal groundwater discharge conditions interpreted at the southern extent of the creek. Groundwater recharge conditions may be occurring within Beaver Creek to the northwest of the Site during low groundwater conditions.

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Water quality results within deposits of Aquifer 1 within the northeastern portion of the Site were characterized by aerobic groundwater with nitrate present suggesting influence from local agricultural fields. Within the western portion of the property, shallow water quality results indicated slightly anaerobic water with both manganese and nitrate present and typically low dissolved oxygen levels. Water quality results within the deep monitoring wells at the western extent of the Site including MW8-10D and MW12-10D indicated elevated sulphate concentrations of up to 370 mg/L, suggesting a hydraulic connection with the deeper hydrostratigraphic units, likely a result of the eroded deposits of Aquitards 2/3 within the glacial meltwater channel.

2.2 NWSSS SURFACE WATER INVESTIGATION

The following section presents a summary of the findings from the NWSSS (2013) surface water investigation with respect to the current Site. Full details of the investigation and reports are included in the subwatershed report (Ecoplans, MHBC, Stantec, 2013).

Laurel Creek and its associated tributaries represent the main surface water feature near the Site. Laurel Creek flows immediately south of the Site discharging into the Laurel Creek Reservoir. Beaver Creek, a tributary of Laurel Creek, flows from the northwest of the Site, meanders through the Site before discharging to Laurel Creek just upstream of the Laurel Creek Reservoir.

Laurel Creek is a headwater tributary of the Grand River that flows in a southeasterly direction through the Site and discharges to the Grand River south of the Site. The reach immediately downstream of the Site (and upstream of the reservoir) has been classified as an existing coldwater system as well as an important source for groundwater discharge, possibly supplying baseflow to the creek and its associated wetland features (GRCA 1993). In addition, the portion of Laurel Creek within the Site is considered by the Ministry of Natural Resources (MNR) to be 'a trout stream containing a naturally reproducing population of Brown Trout and possibly Brook Trout.

Beaver Creek is a headwater tributary of Laurel Creek and flows in a southerly direction through the Site, discharging into Laurel Creek at the southern end of the Site. According to the Laurel Creek Watershed Study (LCWS) (GRCA 1993), this tributary was classified as a potential coldwater stream, although portions of the watercourse have been degraded by intensive agricultural activities through the years.

2.3 NORTH WATERLOO MONITORING PROGRAM

The NWSSS included groundwater and surface water monitoring data for the Site from 2009 and 2010. The groundwater and surface water monitoring has been on-going since 2011. The Phase 1 Monitoring Program for the Site was approved in mid-2014, which included a reduced monitoring program within the Site itself and eliminated monitoring of adjacent wells. The monitoring wells and current status are detailed in Table 1. A copy of the approved monitoring program is included in Appendix C.

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3.0 METHODOLOGY

The following section details the methodology for monitoring from 2011 to 2015, including groundwater and surface water level monitoring, surface water flow monitoring, groundwater quality sampling and analysis, and climate data.

3.1.1 Water Level Monitoring

In 2011, the groundwater and surface water level monitoring was continued at the Site for all locations included in the original monitoring program for the NWSSS. The monitoring locations are presented on Figure 1 with well construction details and monitoring status presented in Table 1. Since 2011, the following modifications were completed to the program:

- Groundwater level monitoring was completed at WN1-91-1/2/3/4 until September 2013. The loggers were removed to allow well upgrades by the Region. Stantec indicated that no additional monitoring was required at this location
- Groundwater level monitoring was completed at WN2-91-1/4 until April 2014. Stantec indicated that no additional monitoring was required at this location and the Region was planning to abandon this well
- Groundwater level monitoring was completed at WN3-91-1/2 until September 2013. Stantec indicated that no additional monitoring was required at this location and the Region abandoned this well
- Groundwater level monitoring was attempted at MW9-10S/D; however, due to on-going issues with artesian conditions, the wells were abandoned in December 2013
- With the approval of the 2014 monitoring program, groundwater level monitoring requirement was removed for the majority of locations outside of the Site. The following locations were removed from the monitoring program between Spring and Fall 2014:
    - Monitoring wells MW1-05, MW8-05, WN-TW2-06, MW1-10, MW4-10 and MW5-10
    - Drivepoint Piezometers DP2-09, DP4-09, DP6-09 and DP8-09
- Groundwater and surface water level monitoring was completed at DP7-09 until September 2014. The surface water characteristics at the drivepoint had changed over the monitoring period and accurate stream flow data could no longer be recorded. Drivepoint Piezometer DP10-14 was installed in September 2014 downstream of DP7-09, as a replacement. This location was considered the closest suitable monitoring location based on stream conditions

Groundwater and surface water level monitoring was completed using a combination of manual and automated techniques. Monitoring wells and drivepoint piezometers were instrumented with Solinst® LT Leveloggers® and were set to record at 15-minute intervals (in September 2015, the interval was increased to 60-min). The Leveloggers® are not vented to the atmosphere and therefore record total pressure. As a result, data obtained from the

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Leveloggers® was corrected for atmospheric pressure to obtain the actual height of water above the sensor. The atmospheric corrections were made using data collected from a Solinst Barologger®, which was initially located at MW1-05 and later moved to MW7-10.

Manual measurements were collected at all wells using a battery operated probe and calibrated tape. Water depths were recorded in meters below the top of the well casing (BTOC).

The surface water level data and groundwater level data from the drivepoint monitoring locations were reviewed. Surface water data were omitted when temperatures as recorded by the logger decreased below 0°C. Groundwater data were reviewed and omitted if clearly impacted by freezing conditions. It is expected that some of the groundwater and surface water level data from the drivepoints are still impacted by freezing conditions, and care should be given when interpreting winter data.

Groundwater and surface water level hydrographs are presented in Figures 2 to 6 for all monitoring locations.

3.1.2 Surface Water Flow Monitoring

The locations of the drivepoint piezometers established along Laurel Creek (DP6-09, DP7-09, DP9-09, and DP10-14) and Beaver Creek (DP1-09 to DP5-09 and DP8-09) are shown on Figure 1.

Stream flow at each drivepoint location was calculated using the velocity-area method (Dingman, 1994). Measurements were obtained by placing a measuring tape across the width of the stream and dividing the distance into equal sections. At each point, the depth of water was measured and the flow rate recorded using a Marsh-McBirney Inc. Model 201 portable water flow meter. Total discharge through the section was then calculated using the U.S. Geological Survey approved mid-section method as discussed in Hipolito and Loureiro (1988) and Dingman (1994).

Stream flows were measured at DP1-09 to DP9-09 on eight (8) select dates between May 2012 and August 2014. Stream flows were measured at DP1-09, DP3-09, DP5-09 and DP9-09 on at least three (3) occasions between August and December 2014, and three (3) occasions in 2015. Monitoring was also completed at DP7-09 in 2014 before this location was replaced be DP10-14 for the 2015 monitoring. Table 2 presents a summary of manual stream flow measurements at each location with detailed stream flow data and calculations included in Appendix D.

3.1.3 Surface Water Quality

Water quality sampling for City of Waterloo Monitoring Station 17 - Beaver Creek at Conservation Drive (DP3-09) was completed by the City of Waterloo. Beaver Creek converges with Laurel Creek just upstream of the Laurel Creek Reservoir. Since the watercourse is part of the Laurel Creek Watershed, it is governed by in-stream water quality targets established in the LCWS (GRCA, 1993). The in-stream quality targets are summarized below:

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- **Temperature** – Target in-stream surface water temperatures to protect the coldwater fish species upstream of the Laurel Creek reservoir are:
    - Laurel Creek (cold water) - 22°C from April 1 to October 31 and between 4°C and 14°C from November 1 to March 31
    - Beaver Creek (warm water) - 29 °C from May 31 to October 31 and 26°C from June 1 to August
- **Dissolved Oxygen** – Target in-stream dissolved oxygen concentrations upstream of Laurel Creek Reservoir are:
    - Laurel Creek (cold water) – 6 mg/L
    - Beaver Creek (warm water) – 5 mg/L
- **Total Phosphorous** – Target instream phosphorous concentrations upstream of the Laurel Creek Reservoir are:
    - Laurel Creek (cold water) – 0.03 mg/L
    - Beaver Creek (warm water) – 0.08 mg/L
- **Total Suspended Solids (TSS)** – Maintain a concentration of less than 25 mg/L TSS for the effluent from storm water management facility (SWMF)
- **Bacteria** – Specific targets have not been established for new development, other than "maximizing bacteria removal." The LCWS target for *E.Coli* is based on Provincial Water Quality Guidelines for bathing beaches. The instream target for *E.Coli* is 100 CFU/100 mL for areas tributary to the Laurel Creek Reservoir

3.1.4 Groundwater Sampling and Water Quality Testing

Stantec completed groundwater water quality sampling within the shallow and deep monitoring wells at MW2-10, MW3-10, MW4-10, MW6-10, MW7-10, MW8-10S/D, and MW10-10 through MW13-10 in August 2014 and September 2015. The sampling was completed to document water quality prior to construction activity.

Groundwater samples were primarily collected using dedicated inertial-lift Waterra™ sampling pumps. The use of dedicated equipment reduced the possibility of cross contamination of samples between sampling locations. The Waterra™ sampling pumps were constructed of 16 mm diameter high density polyethylene (HDPE) tubing connected to a Waterra™ Delrin foot valve. For deep monitoring wells including MW3-10D, MW8-10D, and MW12-10D, a 38 mm Waterra™ submersible pump attached to 16 mm diameter HDPE tubing was employed to facilitate sample collection. Efforts were made to remove at least three (3) casing volumes from each well prior to sampling to remove stagnant water from the well casing. In cases where the well was purged dry, the well was allowed to fully recover prior to sampling. Prior to sample collection, the sampling system was lowered to within or just above the top of the well screen.

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Field measurements of conductivity, temperature and pH were made using a Hanna Instruments model HI 991300 multiparameter water quality meter. This meter was calibrated prior to use according to the manufacturers' specifications with the appropriate calibration standards. Field parameters were monitored and allowed to stabilize prior to sampling.

Following purging, groundwater samples were collected directly from the HDPE tubing into the appropriate pre-labeled sample containers. Groundwater samples for metals analysis were field-filtered using disposable, in-line, 0.45 µm filters attached to the HDPE tubing and as such the results for metal parameters represent dissolved concentrations.

All groundwater samples collected were packed into sample coolers, which were refrigerated using ice packs, and delivered to Maxxam Analytics Inc. for laboratory analyses. All groundwater samples were analyzed for general inorganic, metals and nutrient analysis. Chain of custody forms were completed and included with the samples. The results of the groundwater quality testing are presented in Table 3 with a copy of the Laboratory Certificates of Analysis being provided in Appendix E.

3.1.5 Climatic Data

The University of Waterloo Weather Station (UWWS) is located approximately 4 km southeast of the Site. Except in 2015 when issues arose with UWWS data, daily precipitation and temperature data were collected from the UWWS. The 2015 data were obtained from the Environment Canada for the Kitchener-Waterloo Climate Station (KWCS) (located at the Region of Waterloo International Airport) and Roseville Climate Station (RCS). The KWCS and RCS are located approximately 24 km to the southeast and 20 km to the south of the Site, respectively. Historical precipitation data were obtained from RCS. Recent and historical precipitation data are presented on Figure 7.

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4.0 MONITORING RESULTS

The 2011 to 2015 monitoring data was summarized with hydrographs presented in Figures 2 to 6, well construction details in Table 1, surface water flow data in Table 2 and groundwater analytical data in Table 3. In general, groundwater and surface water observations from 2011 to 2015 were consistent with the overall results and interpretations as presented in the NWSSS with respect to groundwater flow, levels and chemistry and surface water conditions. The following sections detail additional observations, clarifications or changes to the understanding of Site conditions since the NWSSS.

4.1 LOW PRECIPITATION - SUMMER 2012

Historical precipitation data for the RCS and from the UWWS was reviewed with a graph of the historical data presented on Figure 7. Over the 17 year monitoring period at UWWS (1998-2014), the average annual precipitation was 909 mm, and over the 30 year monitoring period at the RCS (1996-2015), the annual average precipitation was 899 mm.

The 2011 to 2015 data generally indicated above or near annual average precipitation over the monitoring period, with the exception of 2012, where below average precipitation was generally noted from February to August 2012. The annual precipitation in 2012 was recorded as 754 mm from the RCS, which is 16% below the 30-year average and 789 mm from the UWWS, which is 13% below the 17-year average.

Groundwater hydrographs from the monitoring wells and drivepoint piezometers within and adjacent to the Site are presented in Figures 2 to 6. The below average precipitation in summer 2012 resulted in groundwater level decrease at all shallow monitoring wells, with many monitoring wells reaching their lowest observed levels from 2009 to 2015. Precipitation and recharge in Fall 2012, resulted in groundwater level recovery at all locations.

The NWSSS indicated variable vertical hydraulic gradients along both Beaver Creek and Laurel Creek and did not consistently indicate areas of groundwater recharge or discharge. During the summer of 2012, gradients along Beaver Creek remained upward at DP1-09, DP2-09 and DP5-09 but became downward at DP8-09, DP3-09 and DP4-09, while along Laurel Creek gradients remained upward at DP7-09 and neutral at DP9-09 but became downward at DP6-09. Vertical gradients returned to previous conditions in Fall 2012, following precipitation events.

Stream flows along Beaver Creek and Laurel Creek measured during August 2012 ranged from 6 L/s to 10 L/s and 16 L/s to 21 L/s, respectively. Stream flow data were generally at their lowest historical levels. Surface water flow rates indicated some variation along the flow path but did not indicate a consistent increase or decrease in flow rate, suggesting the streams are not gaining or losing within the Site during this period.

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This period of below average precipitation in summer 2012 indicated the potential for lower groundwater levels than previously presented in the NWSSS and also indicated that groundwater discharge conditions may not be occurring within Laurel Creek during periods of low groundwater conditions.

4.2 GROUNDWATER LEVELS – SPRING 2013/2014

As previously stated, the 2011 to 2015 data generally indicated above or near average annual precipitation over the monitoring period, with the exception of 2012 as discussed above. The annual precipitation in 2013 was recorded at 1231 mm from the UWWS, which is 35% above average. Above average monthly precipitation was measured in nine months in 2013, with peak precipitation occurring in July and October 2013. The annual precipitation in 2014 was recorded at 946 mm from the UWWS, which is 4% above average, with above average monthly precipitation primarily occurring in July and September 2014.

Within the shallow monitoring wells installed within Aquitard 1, the hydrographs indicated rapid response to individual precipitation events as the ground became saturated and water slowly infiltrated as noted at MW8-10S (Figure 4). Monitoring wells installed within deposits of Aquifer 1, with a larger unsaturated zone, such as MW7-10 (Figure 5) indicated a steady response to overall precipitation and recharge, but did not respond to individual events. These trends and responses to precipitation are consistent with the NWSSS.

However, the periods of above average precipitation and groundwater recharge in 2013 and 2014, resulted in higher shallow groundwater levels observed at all monitoring wells than suggested by the 2009/2010 data. The spring groundwater levels were compared to those originally presented in the NWSSS to evaluate the difference in levels. Levels were compared after a period of minimal precipitation in order to represent steady state levels. Within the Site, peak spring water levels increased at the following locations:

- At MW8-10S, located at the western extent of the Site, spring levels increased by 0.9 m compared to data from May 2012. This monitoring well is located adjacent to a swale area south of Conservation Drive, and is likely influenced by surface water / recharge occurring within the swale.
- At MW12-10S and MW13-10, located at the southern extent of the Site, spring groundwater levels increased by 0.6 m to 0.2 m, respectively.
- At MW10-10, within the western portion of the Site, spring groundwater levels did not significantly change as they were already at or near ground surface.
- Within the northeastern portion of the Site, spring groundwater levels increased by 0.9 m at MW3-10S and MW7-10, 0.4 m at MW2-10 and 0.5 m at MW6-10.

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In general, these data indicate the potential for shallower groundwater conditions across the Site than previously expected. Within the northeastern portion of the Site, where an increase in spring groundwater levels of up to 0.9 m was predicted, there is a thick unsaturated zone and minimal impact to proposed construction is expected due to this change in peak spring levels.

Within the southern portion of the property, spring groundwater levels are generally expected to increase 0.2 m to 0.6 m from previous levels presented in the NWSSS. The NWSSS indicated that spring groundwater levels within the developable portion of the southern portion of the Site were generally expected at greater than 3 m below ground surface (BGS). The higher spring groundwater levels could impact some areas depending on proposed construction. The proposed development should take these revised levels into consideration.

4.3 GROUNDWATER CHEMISTRY 2014 AND 2015

Stantec completed groundwater water quality sampling at MW2-10, MW3-10S/D, MW4-10, MW6-10, MW7-10, MW8-10S/D, MW10-10, MW12-10S/D and MW13-10 in August 2014 and September 2015. MW11-10 was sampled in August 2014 but could not be sampled in September 2015 as the well had been damaged. Stantec is currently organizing well replacement. Water quality results are presented in Table 3 with copies of the laboratory certificates of analysis included in Appendix E. In general, the results are consistent with the data presented in the NWSSS, with the exception of:

- A decrease in chloride concentration at MW8-10S from 800 mg/L and 970 mg/L in 2010 to 500 mg/L in 2014 and 550 mg/L in 2015. This monitoring well is located near a swale adjacent to Conservation Drive and is influenced by winter road salting activities. It is interpreted that chloride concentration may fluctuate at this location, but remain elevated
- At MW3-10S, MW6-10 and MW11-10, water chemistry has changed since initial monitoring

At MW3-10S, the following changes were noted:

  - chloride decreasing from 28 and 23 mg/L in 2010 to 15 mg/L in 2014 and 17 mg/L in 2015
  - nitrate decreasing from 37 and 28 mg/L in 2010 to 22 mg/L in 2014 and 24 mg/L in 2015

At MW6-10, the following changes were noted:

  - nitrate decreasing from 23 mg/L in 2010 to 20 mg/L in 2014 and 16 mg/L in 2015

At MW11-10, the following changes were noted (monitoring could not be completed in 2015 as mentioned previously):

  - sulphate decreasing from 32 and 55 mg/L in 2010 to 18 mg/L in 2014
  - sodium decreasing from 46 and 85 mg/L in 2010 to 13 mg/L in 2014

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- nitrate increasing from 11 and 13 mg/L in 2010 to 16 mg/L in 2014

These changes in shallow groundwater chemistry may be a function of changes in agricultural activity within the Site.

4.4 SURFACE WATER FLOW AND WATER LEVEL ANALYSIS

Historical flow and manual water level measurements were used to develop a rating curve for each of the flow monitoring sites. The rating curve was then applied to the continuous water level measurements derived from the deployed leveloggers to produce a hydrograph. Rating curves and associated hydrographs are presented in Appendix D.

A rating curve and hydrograph has not been produced for DP10-14 as it was installed in 2014 and does not have enough data to develop a rating curve at this time. This monitoring location was installed to replace DP7-10 as flow at this location is too disperse for accurate measurement.

In general, flow measurements during low flow and base flow events have produced consistent values, resulting in a well-defined rating curve for flow conditions at or near baseflow. Only a few flow measurements have been completed during periods of high flow, resulting in a rating curve producing significant increases in flow for marginal increases in water surface elevation. Future surface water flow measurements should be attempted during larger monitoring events in order to supplement the missing data within the presented rating curves.

4.5 SURFACE WATER QUALITY RESULTS

Surface water quality results for Beaver Creek at Conservation Drive – Station 17 were provided by the City of Waterloo, and are included in Appendix D. Water quality results were compared to targets established in the LCWS. The results of the analysis are listed below:

- TSS targets were met in 54% of the samples
- Dissolved oxygen targets were met in 90% of the samples
- Total phosphorous concentration targets were met in 790% of the samples
- Temperature targets were met in all samples
- Bacteria was not monitored by the City of Waterloo

Flow measurements completed by the City of Waterloo at Station 17 were cross referenced with estimated flows established using the rating curves developed as part of this study. Estimated flows were similar to those measured, however did not match up exactly. Further development of the rating curves should allow for estimated flow rates and flow rates measured by others to converge as more data is incorporated.

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5.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the Phase 1 monitoring completed following the NWSSS, the following conclusions are provided:

- The NWSSS indicated that groundwater discharge conditions were expected within Laurel Creek, south of the Site, during both low and high groundwater conditions. Data during summer 2012 indicated that during prolonged periods of below average precipitation, groundwater levels will decrease and groundwater discharge to Laurel Creek may not be occurring

- Spring groundwater levels from 2013 and 2014 indicated an increase in peak groundwater levels throughout the Site of up to 0.9 m depending on the location. It is interpreted that this increase will have minimal impact on the northeastern portion of the Site due to the thick unsaturated zone. Groundwater levels within the developable portion of the southern portion of the Site were generally expected to be greater than 3 m BGS and the higher spring groundwater levels could impact some areas depending on proposed construction

- Groundwater quality results throughout the Site were generally consistent with historical data. Minor water quality changes at MW3-10S, MW6-10 and MW11-10 observed in 2014/2015 may be a function of changes in agricultural activity in the area

- Surface water hydrographs were created through the use of continuous water level loggers and manual flow measurements to develop a rating curve at each monitoring site

- Water quality monitoring at Station 17 (Beaver Creek at Conservation Drive) was completed by the City of Waterloo. In general LCWS targets were met for dissolved oxygen and temperature, however targets were not met for TSS and total phosphorous on a regular basis

Based on the results of the Phase 1 monitoring, the following recommendations are provided:

- The proposed grading and development within the Site should be reviewed with respect to the updated peak spring groundwater levels to confirm development design and grading

- Surface water levels and manual flow measurements should continue to be collected to gain further confidence in the rating curves. Monitoring should be focused on larger storm events to further refine the rating curve at higher water level elevations. Pre-development rating curves will provide a basis for comparison of during and post-construction monitoring results as development commences and SWM systems are installed

- Water quality monitoring at Station 17 should continue to be used to establish background water quality characteristics

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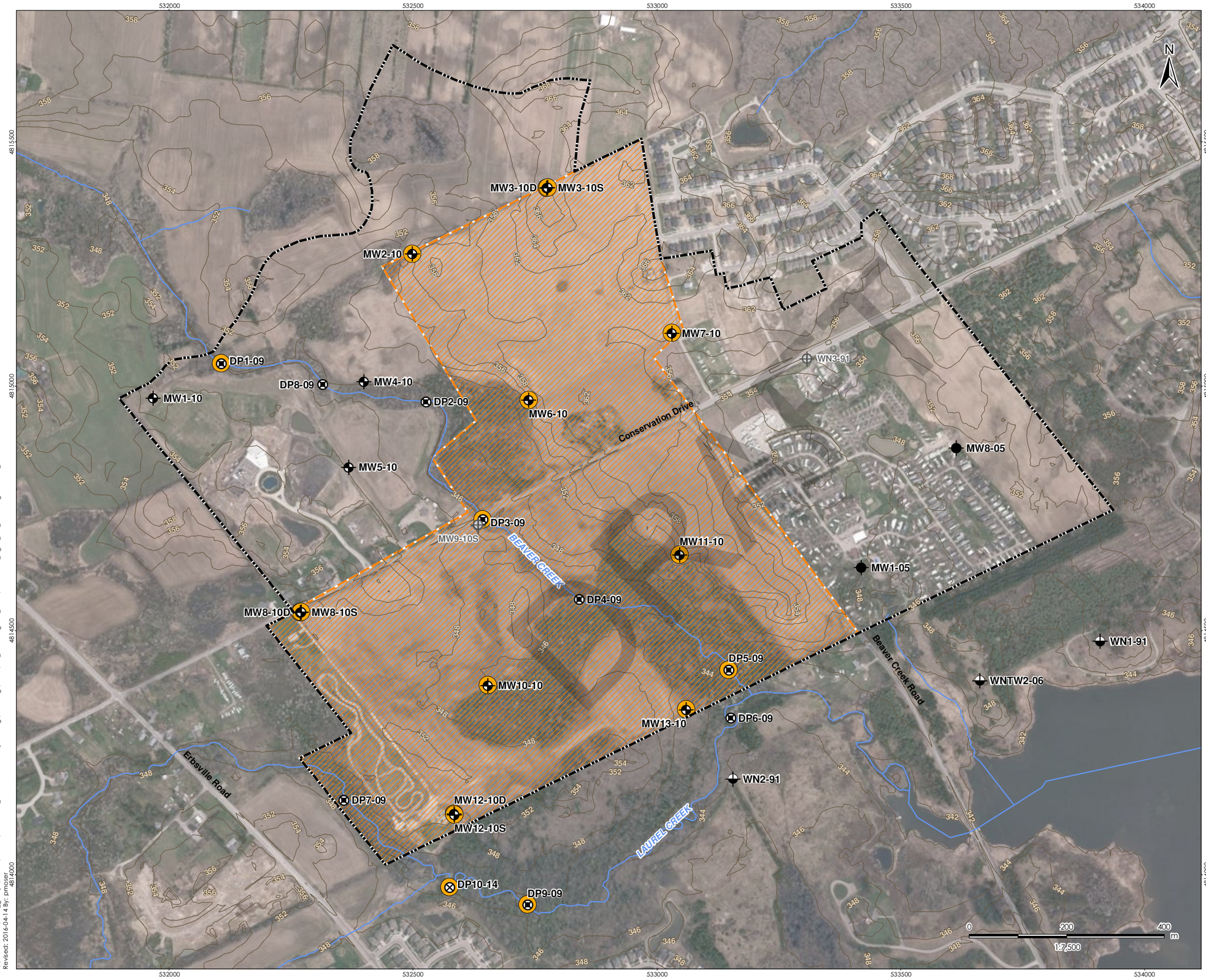
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APPENDIX A
FIGURES



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Legend

- North Waterloo Scoped Subwatershed Study area
- Monitoring Well (Stantec, 2010)
- Monitoring Well (Stantec, 2005)
- Monitoring Well (Other)
- Drive-Point Piezometer (Stantec, 2010)
- Drive Point Piezometer (Stantec, 2014)
- Abandoned Monitoring Well (Other)
- Phase 1 Monitoring Location
- Watercourse
- Topographic Contour - 2m Inerval
- Proposed Development Area



Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.
3. Orthoimagery © First Base Solutions, 2014.
4. Topogrpahic Contours © Region of Waterloo, 2008

April 2016
160310875

Client/Project

North Waterloo Scoped Watershed Study
Phase I - Groundwater and
Surface Water Monitoring Program

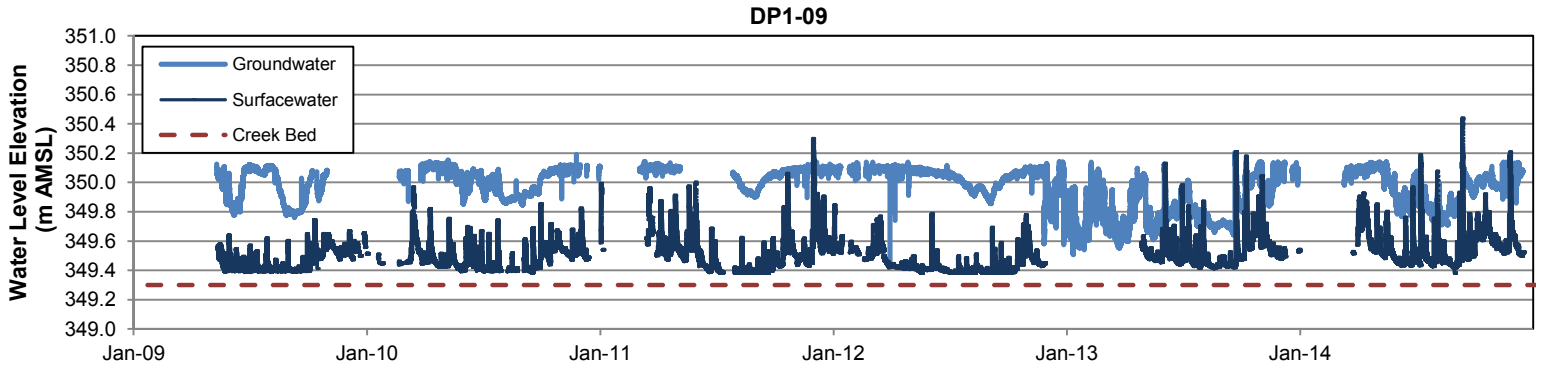
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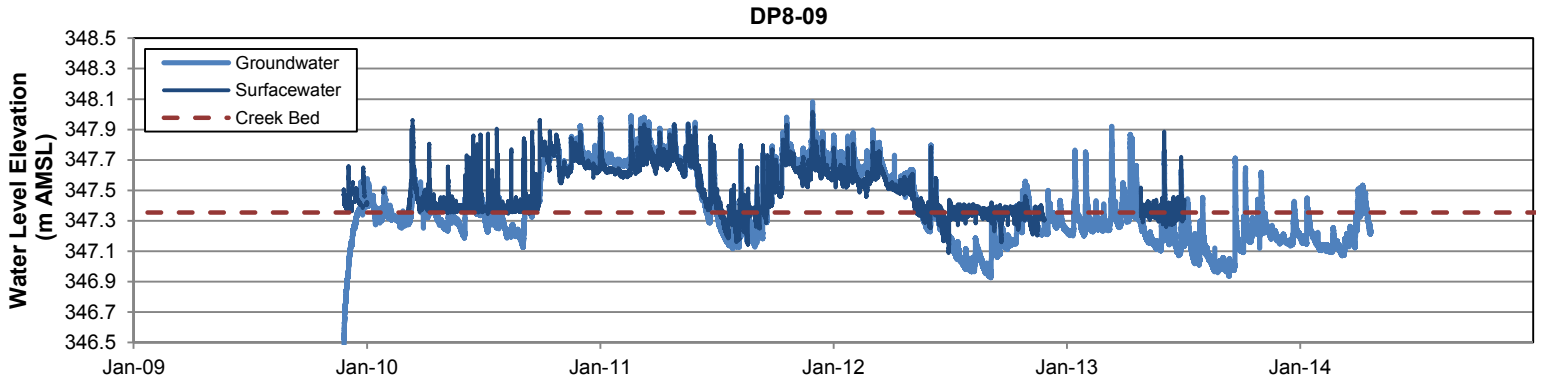
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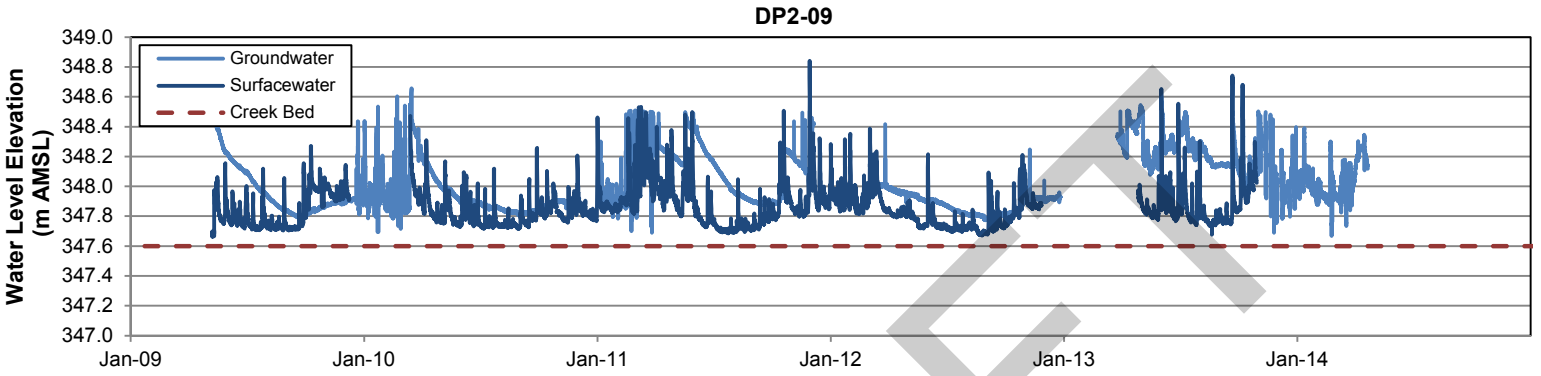
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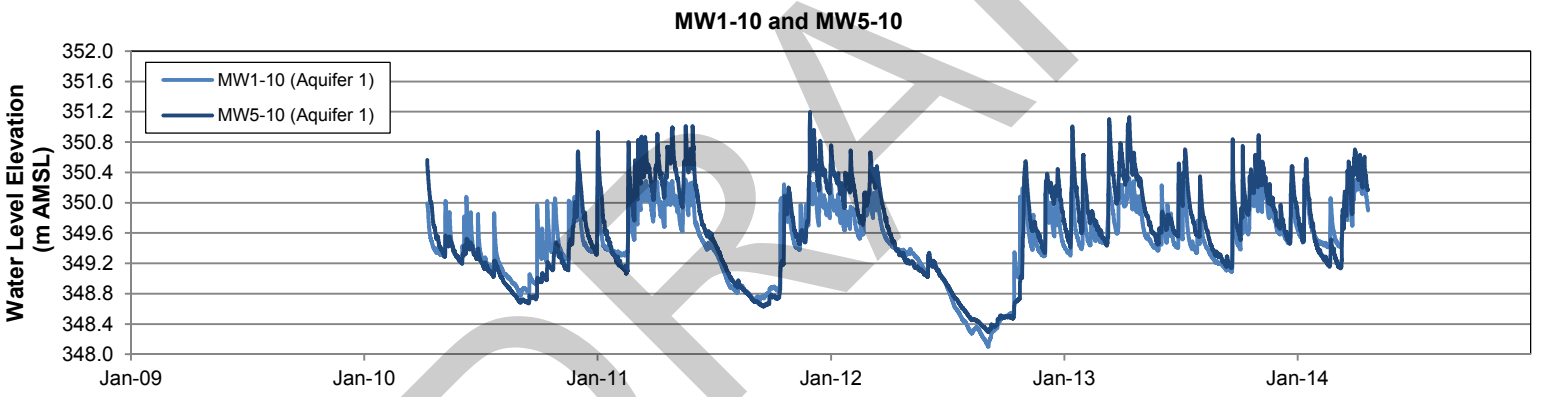
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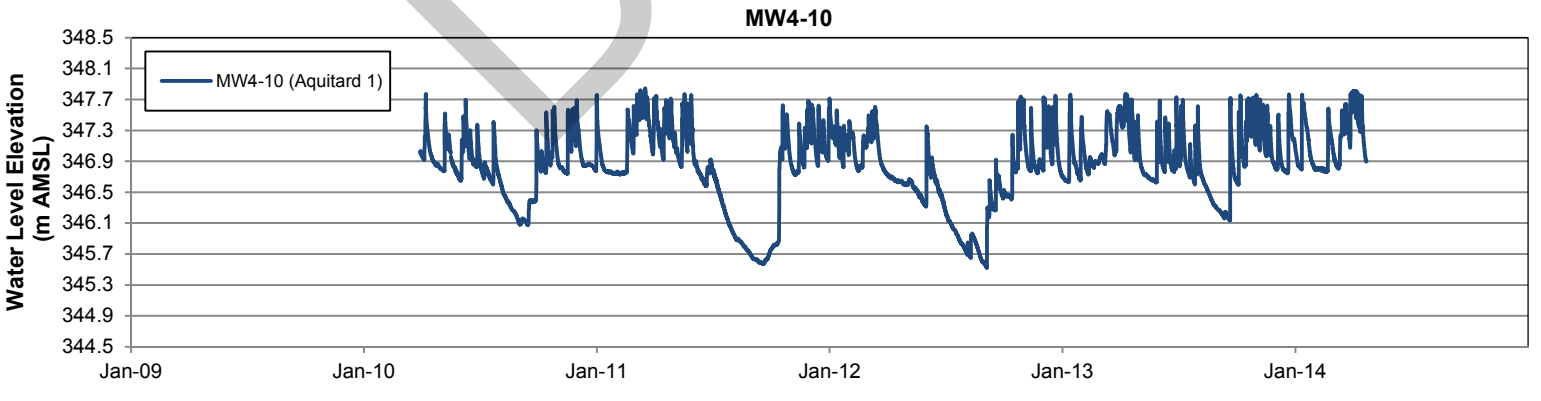
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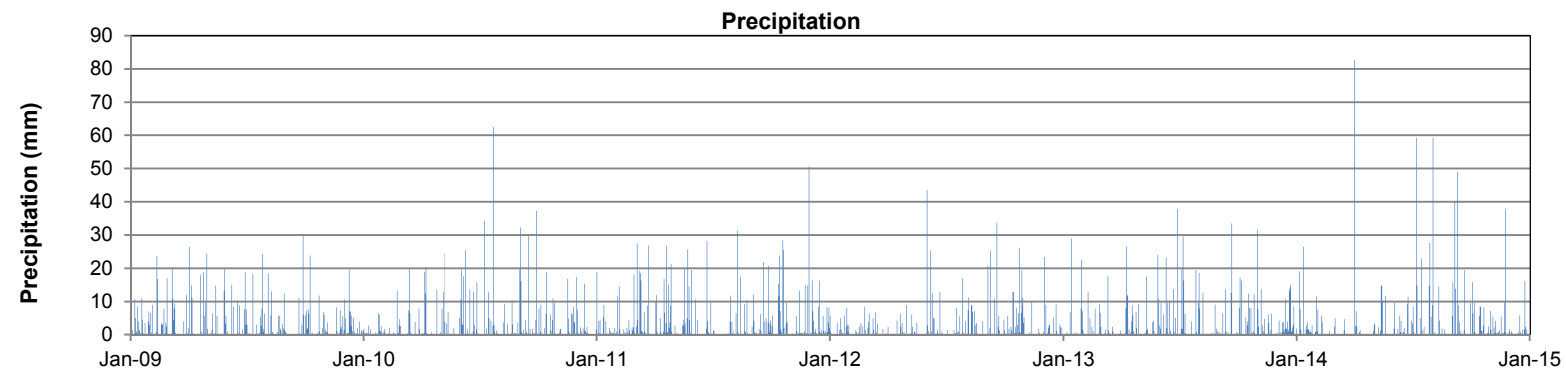












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Figure to be updated to be consistent with Figures 4 to 6. Only DP1-09 was monitored in 2015.

Client/Project

NORTH WATERLOO, PHASE 1 GROUNDWATER AND SURFACE WATER MONITORING PROGRAM

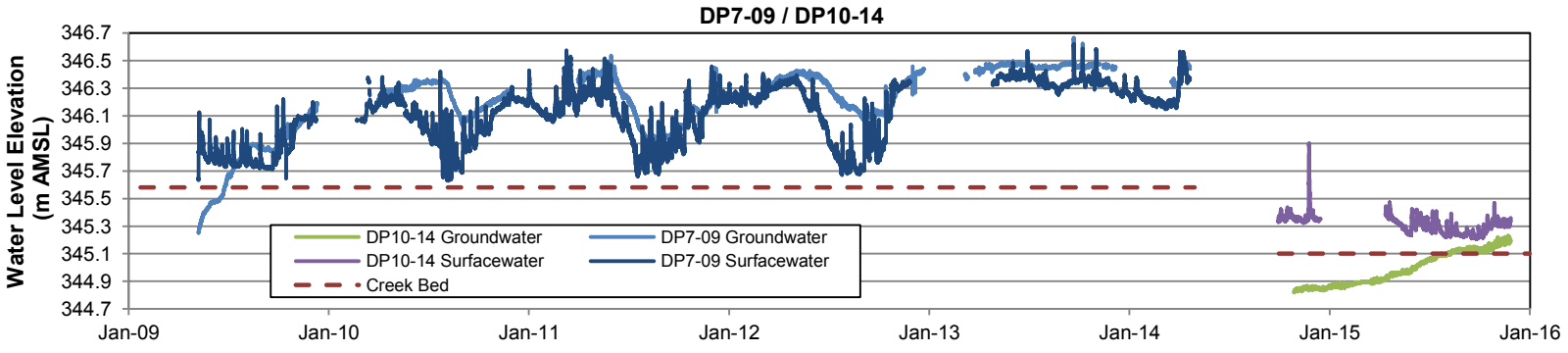
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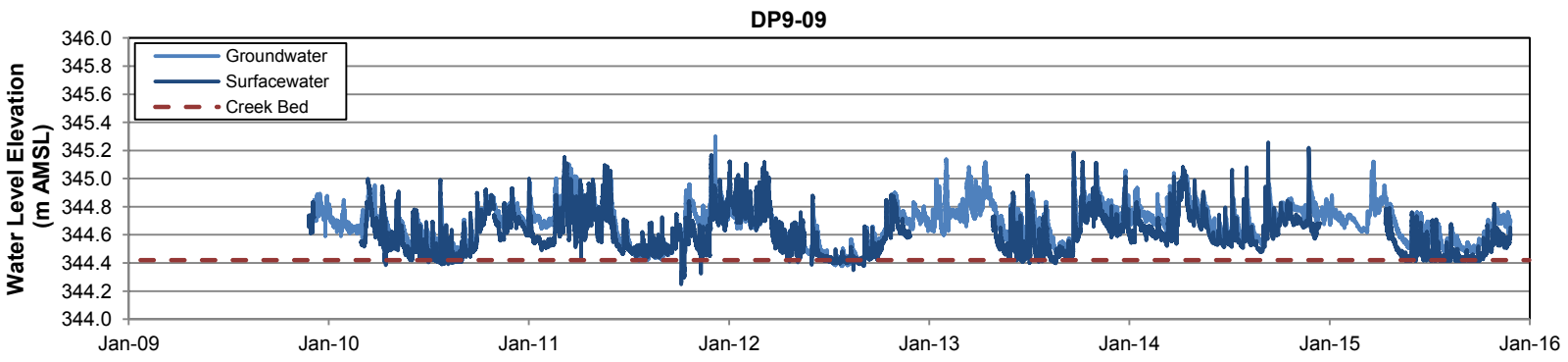
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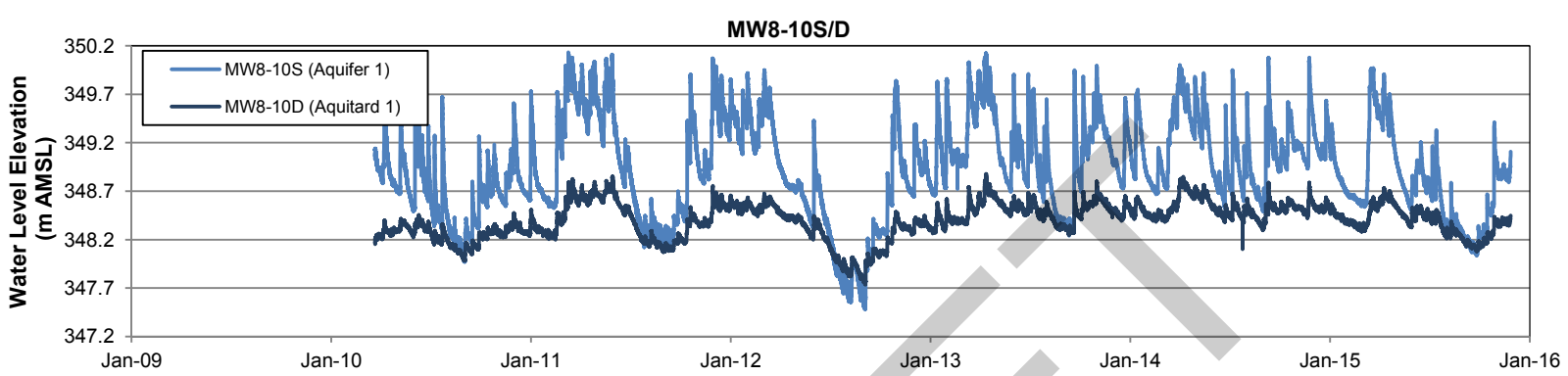
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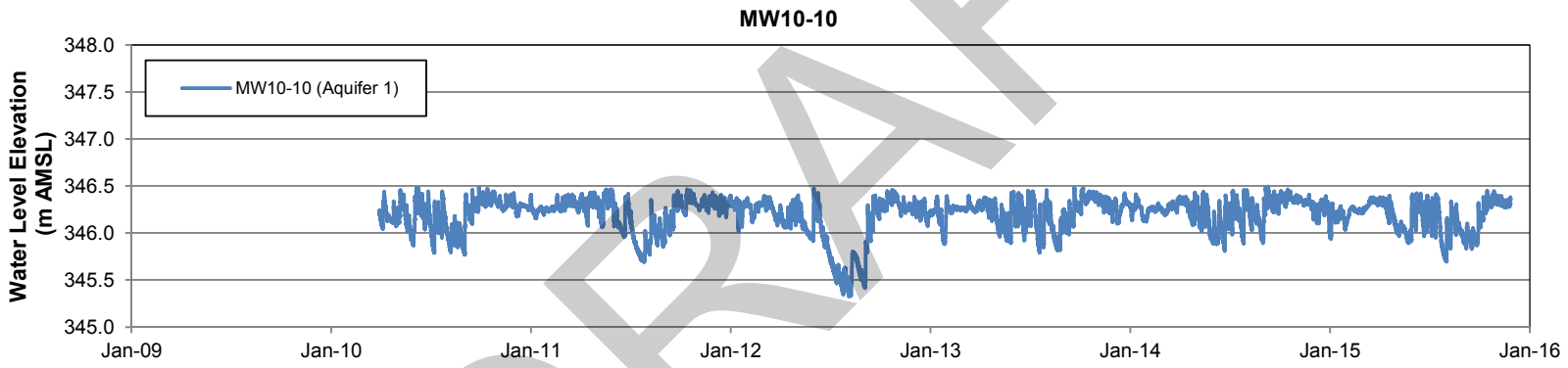
Water Level Hydrographs
Northwestern Monitoring Locations

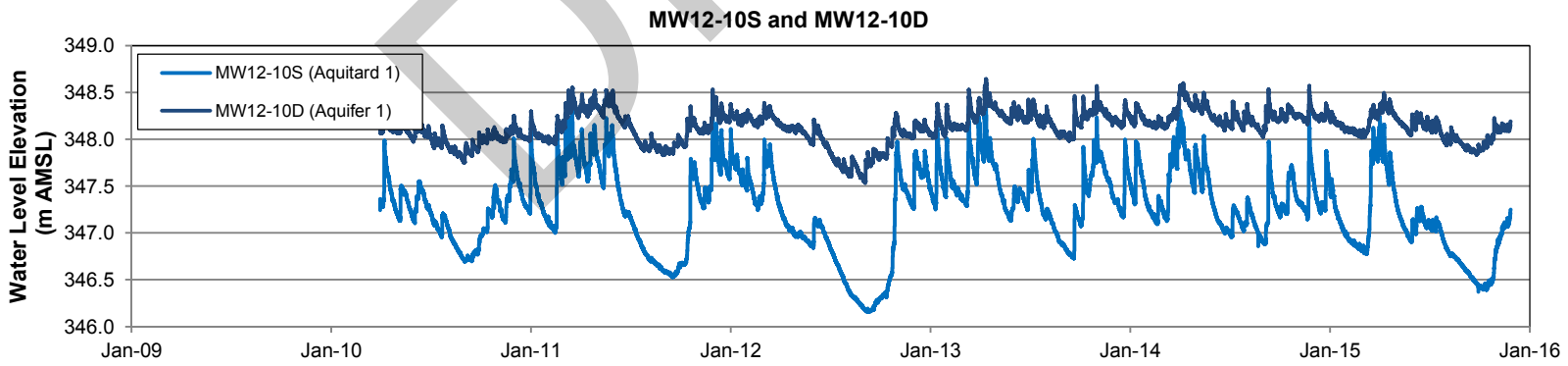
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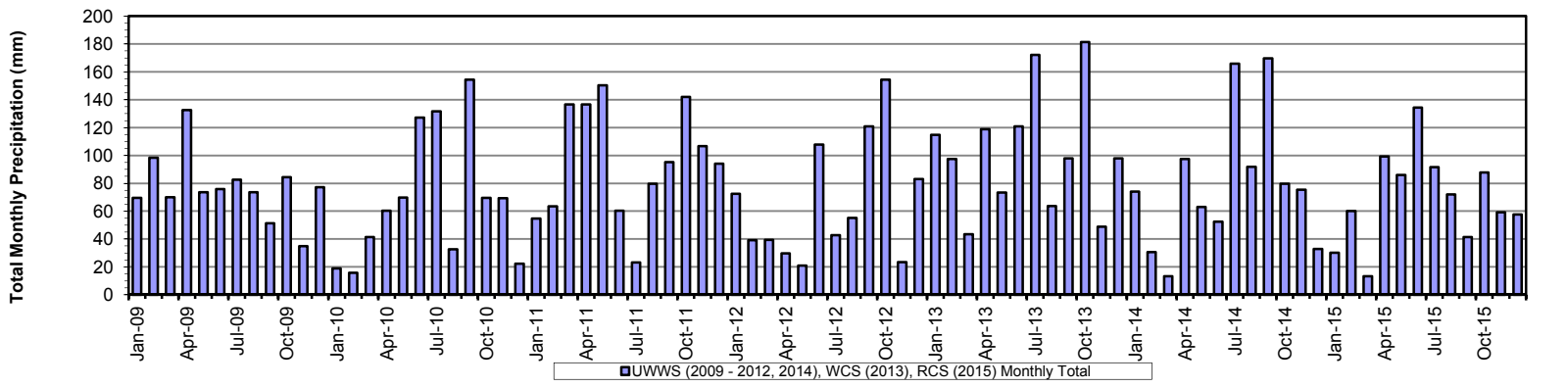












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Top of casing and streambed elevations at DP10-14 are estimated based on topographic mapping and DP7-09 and DP9-09.

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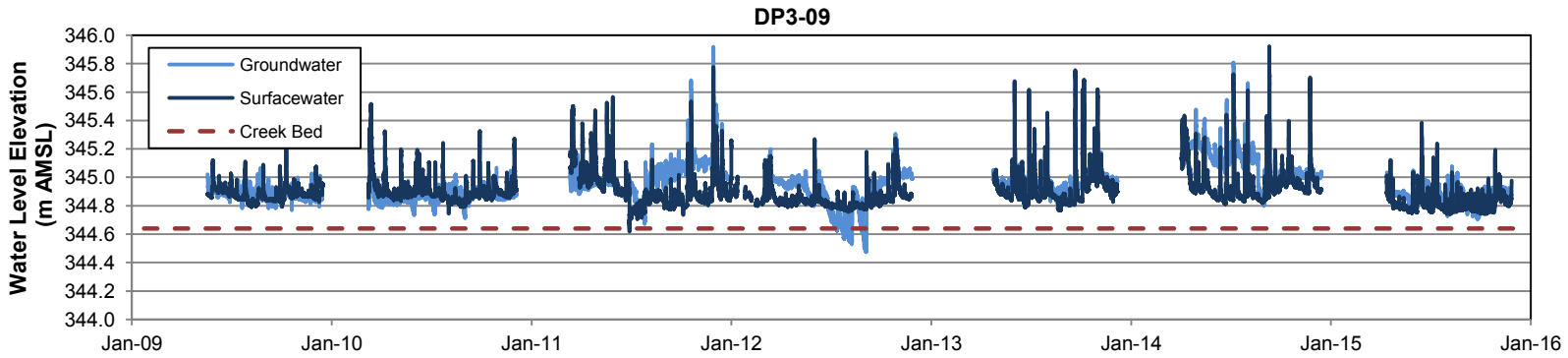
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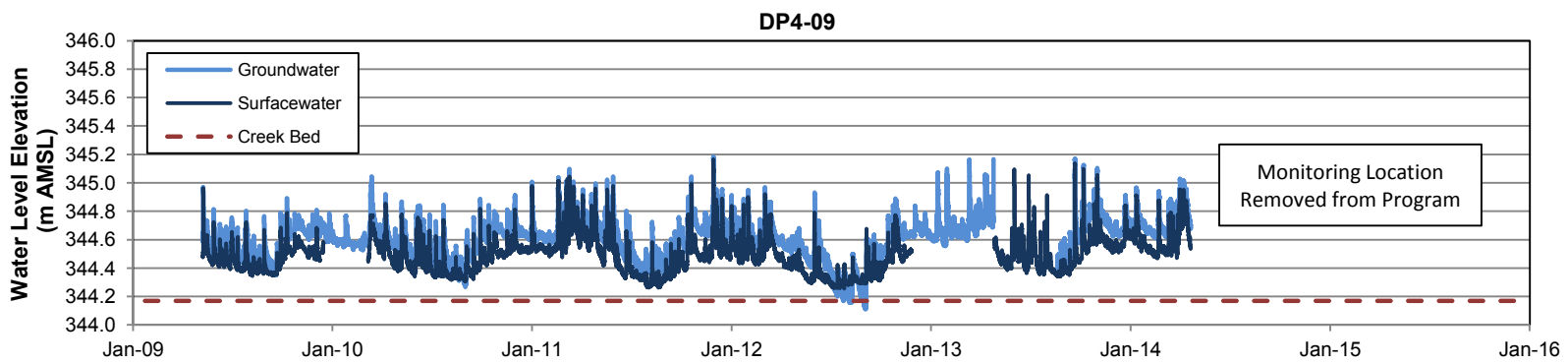
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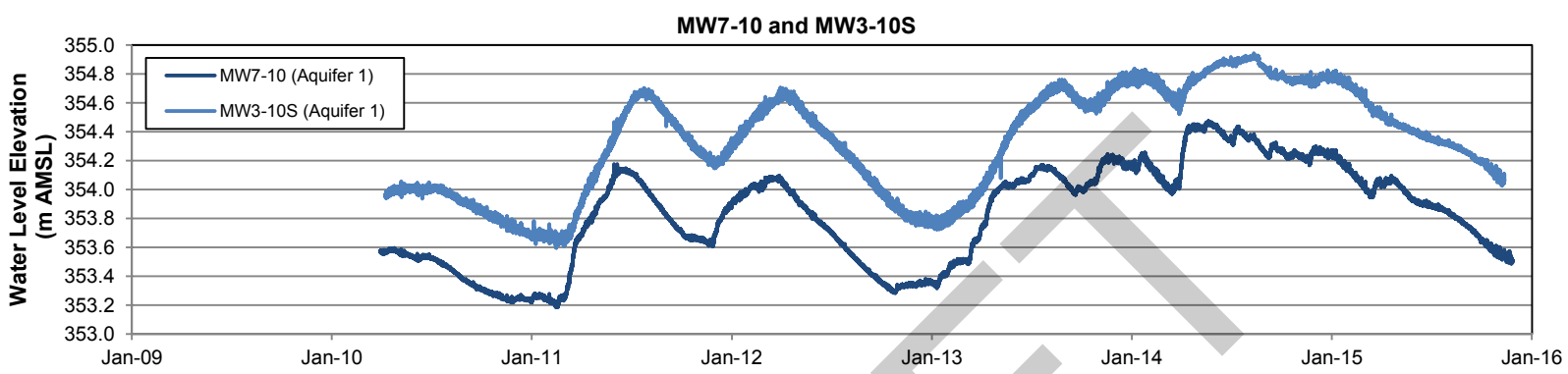
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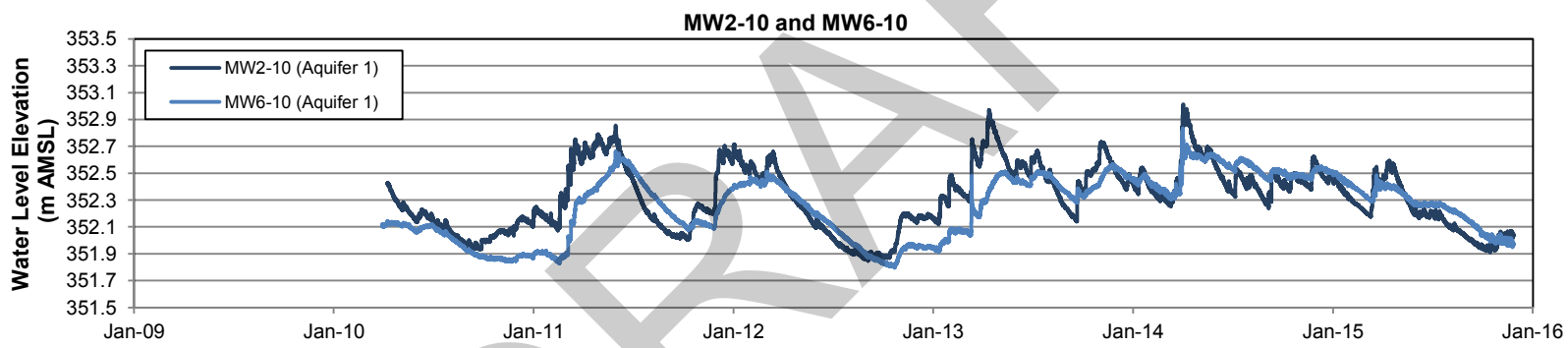
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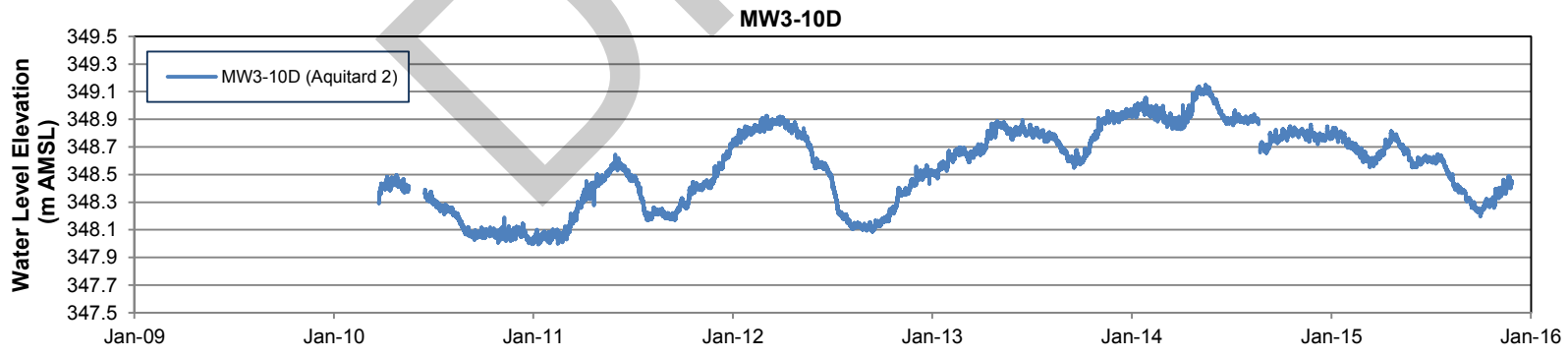
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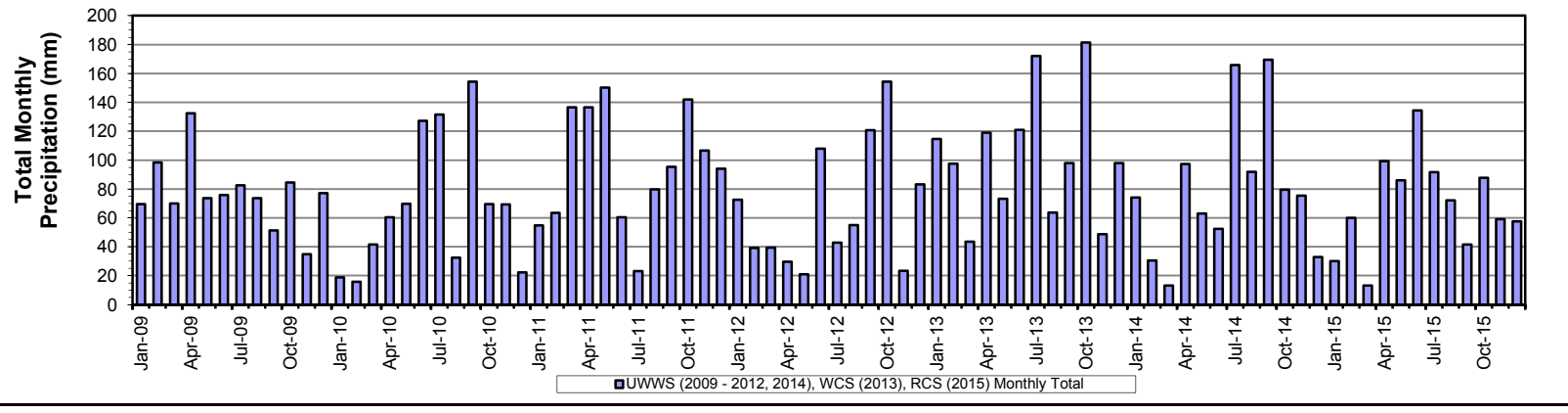












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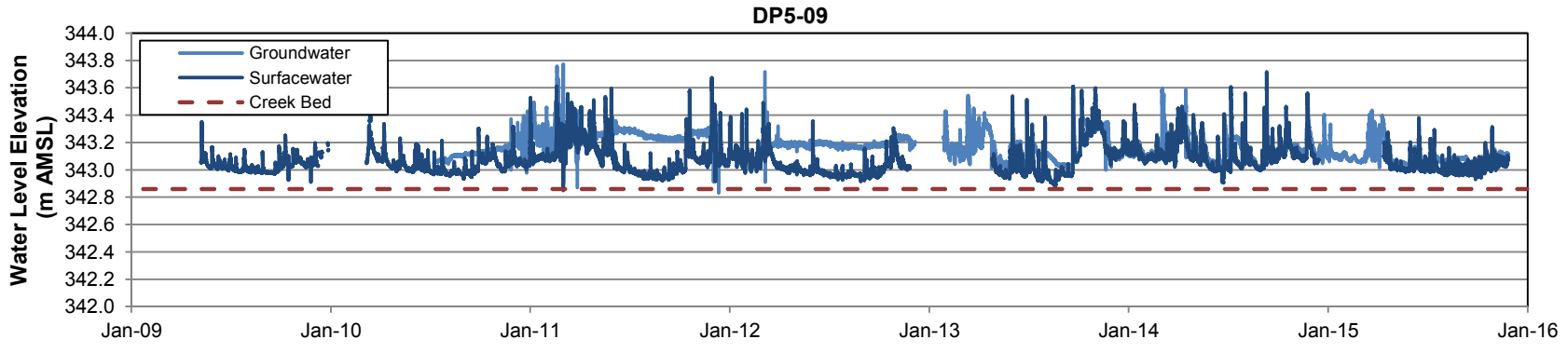
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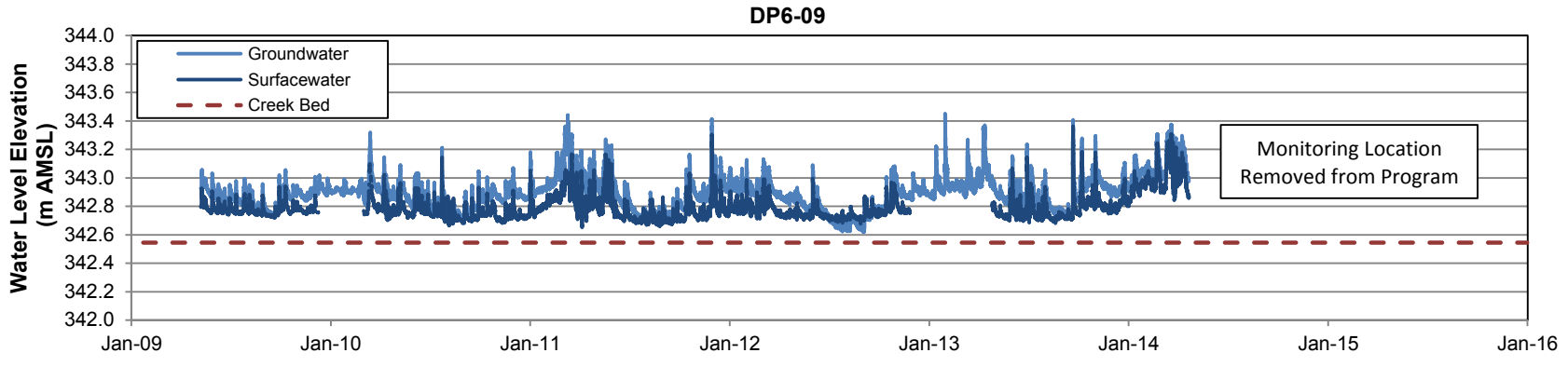
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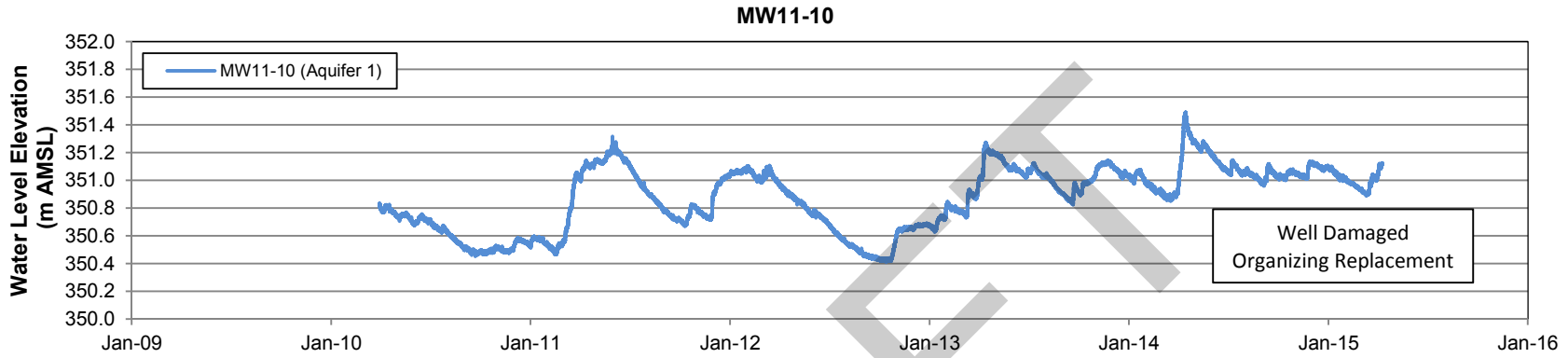
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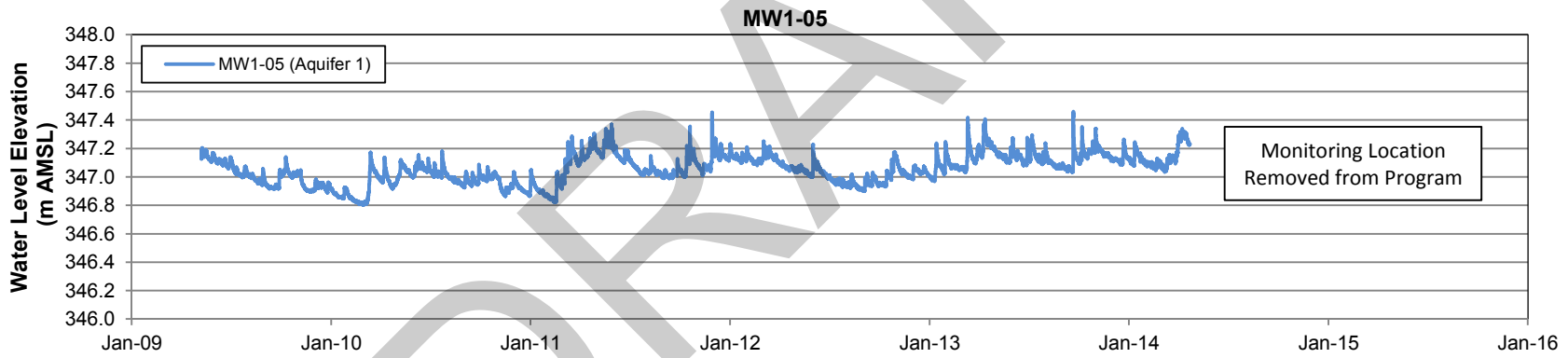
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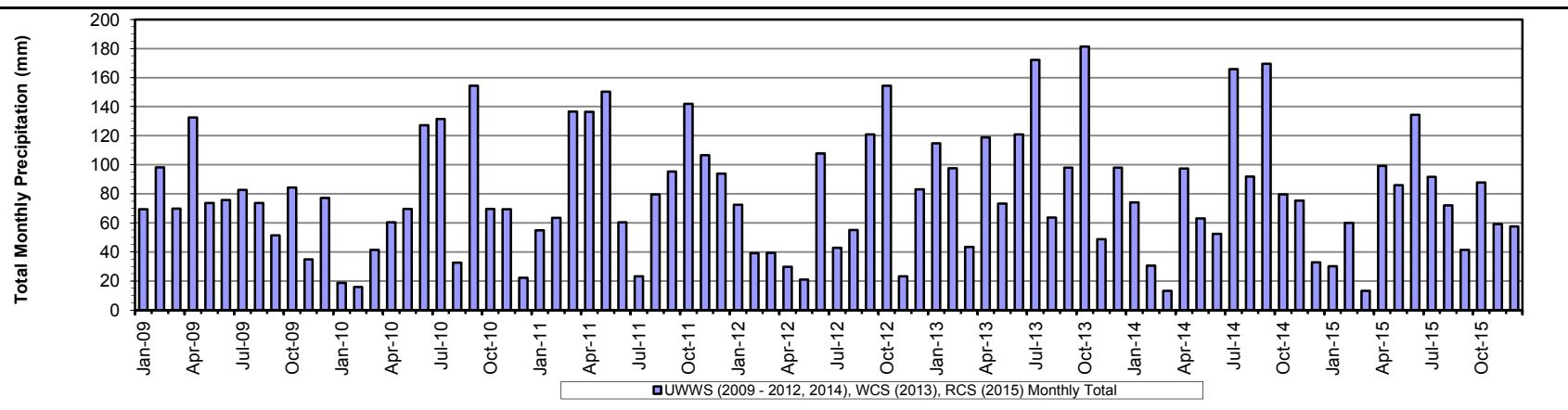
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Central/Northeastern Monitoring Locations











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NORTH WATERLOO, PHASE 1 GROUNDWATER AND SURFACE WATER MONITORING PROGRAM

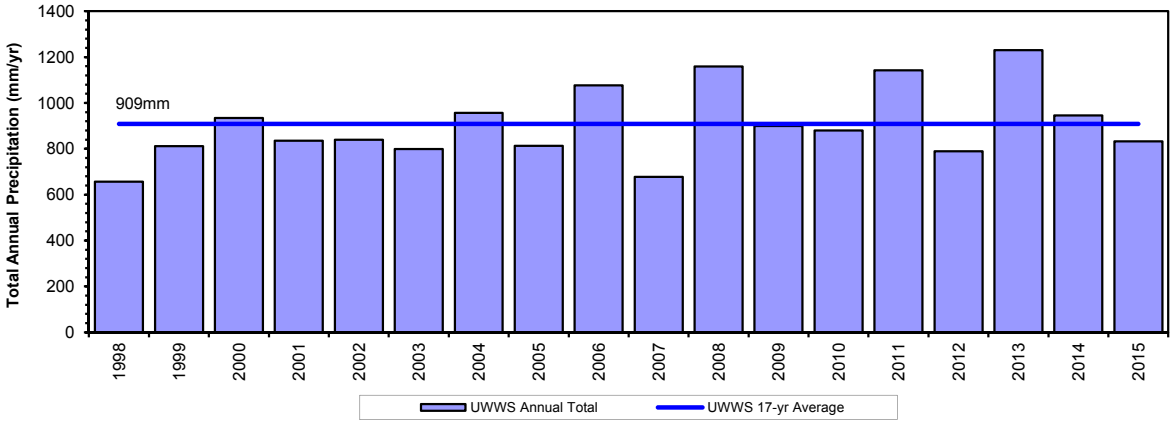
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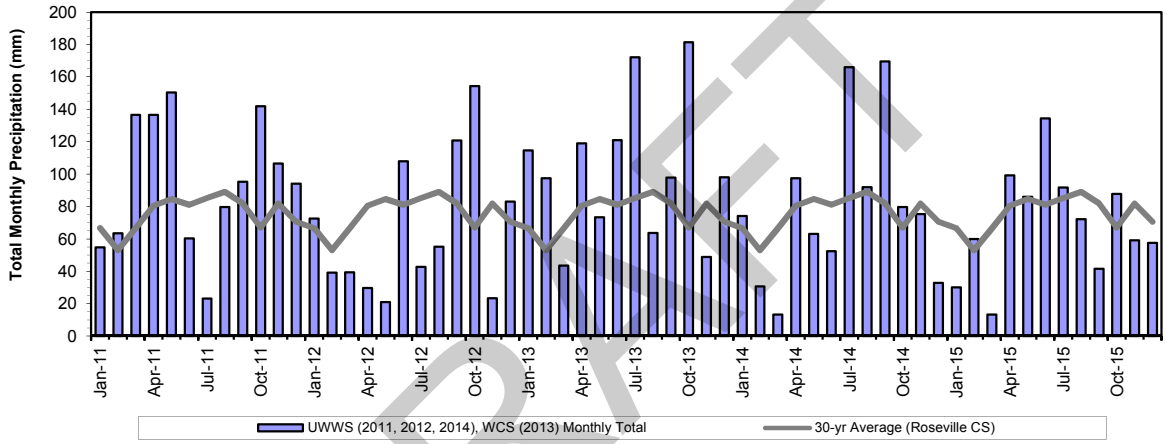
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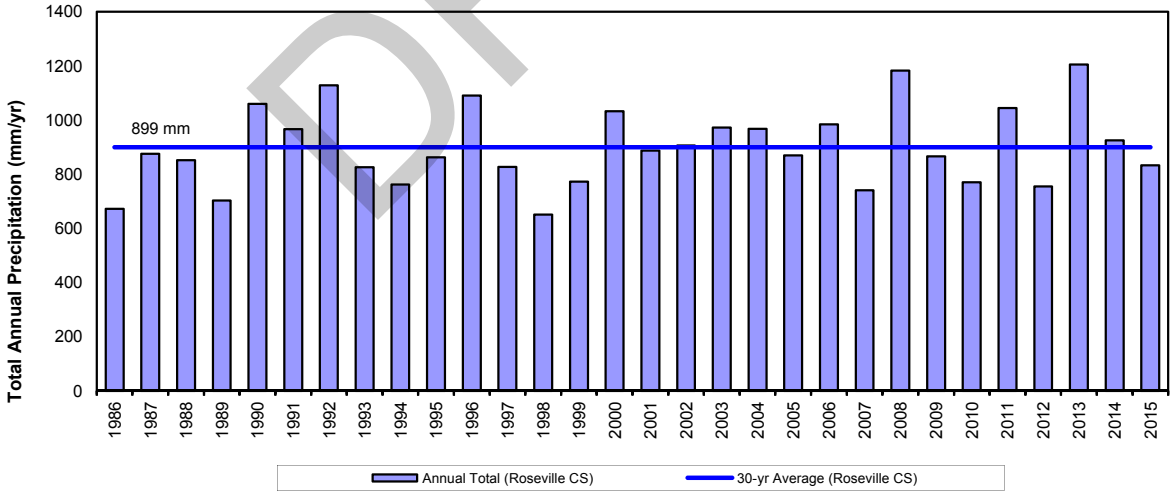
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Notes:

Precipitation data obtained from University of Waterloo Climate Station (UWWS), except for 2015 data which was obtained from Roseville Climate Station (RCS). The UWWS and RCS are located approximately 4 km to the southeast and 20 km to the south of the Site, respectively.





Notes:

Precipitation data obtained from Roseville Climate Station (RCS). For 2014, missing values from RCS in September (7 days), November (7 days) and December (3 days) supplemented with data from Waterloo-Wellington Climate Station.

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Stantec	NORTH WATERLOO, PHASE 1 GROUNDWATER AND SURFACE WATER MONITORING	
	TRENDS IN TOTAL PRECIPITATION	
DATE: 12-Apr-15	SCALE: not to scale	PROJECT No. 1603-10875 / FIGURE No. FIGURE 7

APPENDIX C
PHASE I MONITORING PROGRAM

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NORTH WATERLOO
PROPOSED PHASE 1 MONITORING PROGRAM
2014

1.0 STUDY AREA AND CONTEXT

The subject properties comprise a large portion of the Primary Study Area from the North Waterloo Scoped Subwatershed Study. The lands are located in the northwest portion of the City Urban Area and are generally bounded by City limits to the north, Beaver Creek Road / Roy Schmidt Road to the east and Laurel Creek Nature Centre to the south.

The subject properties and adjacent lands are representative of a typical southern Ontario landscape mosaic, consisting of urban, rural residential, institutional (church), natural, agricultural, educational (Laurel Creek Nature Centre), and recreational (Erbsville Kartway) uses.

The broader landscape is predominantly agricultural, with large blocks of natural heritage features. The agricultural areas were generally cleared for agriculture in the early 1800s and have been generally unchanged (notwithstanding year-to-year variations in plough limits and some tree cutting). Rural residential properties have been present on the landscape for many decades; urban residential development is relatively recent and progressing from the south and east toward the north / northwest limits of the City.

The Laurel Creek Forest (ESPA 80) encompasses the forest features south of Conservation Drive and extends beyond the subject properties along Laurel Creek and adjacent features. The Sunfish Lake - Laurel Creek PSW encompasses wetlands north and south of Conservation Drive on the subject properties as part of a large complex of wetlands across the landscape. These designations overlap on the subject properties with additional designations including significant woodlands and natural hazards (i.e., floodplain).

Lands to the north and west of the subject properties, outside the City, are comprised of extensive farmlands designated as Prime Agricultural Areas in the Regional Official Polices Plan (ROPP). Features located on the subject properties extend beyond the City into Woolwich and Wellesley Townships along the Beaver Creek Corridor, providing an ecological link from Laurel Creek (and associated features) to the south and the Laurel Creek Headwaters Environmentally Sensitive Landscape (ESL) in the townships. South and east of the subject properties is the Laurel Creek Conservation Area (CA) and Laurel Creek ESPA 18.

The Study Team is very familiar with the area through extensive surveys and preparation of the North Waterloo Scoped Subwatershed Study for these lands.

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2.0 MONITORING STUDY APPROACH

The City of Waterloo requires that monitoring programs be completed for new development applications. These monitoring programs are the responsibility of the developer, and include Stage I, II and III monitoring per the Laurel Creek Watershed Development Monitoring Program. Stage I consists of 2 years of pre-development monitoring, Stage II represents during construction conditions, and Stage III extends for 24 months following substantial completion of the development (i.e., 90% stabilization of the catchment area). Recommended Stage I monitoring components are discussed below. The Stage II and III monitoring programs are to be verified at the draft plan of subdivision application and final engineering design stages (respectively). Monitoring programs will be undertaken by the developer.

2.1 SURFACE WATER MONITORING

Surface water monitoring components prior to development/construction are generally addressed through the City's System Monitoring Program. Monitoring includes water quality (chemistry) and flows (hydrology) where Beaver Creek crosses Conservation Drive (Station #17), and this data will be summarized and discussed in the context of the North Waterloo area monitoring program. Surface water monitoring will be undertaken by Stantec with the monitoring locations shown on Figure 1. Additional monitoring will include:

2.1.1 Surface Water Flow Monitoring

Location. Surface water flow measurements will be completed along Beaver Creek at three (3) drivepoint piezometers (DP1-09, DP3-09 and DP5-09) and along Laurel Creek at two (2) drivepoint piezometers (DP7-09 and DP9-09). The monitoring locations along Laurel Creek will be reviewed in 2014. Sections of Laurel Creek do not exhibit channel flow and there is ponding in the area. The monitoring locations may be modified/replaced based on site conditions to obtain representative flow data. The drivepoint locations are shown on Figure 1.

Timing. Flow measurement will be completed three (3) times annually at the same time as manual water level monitoring is conducted.

Methodology. Surface water flow measurements will be completed using the velocity-area method. Measurements will be obtained at regular intervals across the creek and will include the depth of the tributary and the flow rate recorded using a Marsh-McBirney Inc. Model 201 portable water flow meter.

2.1.2 Water Level Monitoring

Location. Surface water level monitoring will be completed along Beaver Creek at three (3) drivepoint piezometers (DP1-09, DP3-09 and DP5-09) and along Laurel Creek at two (2)

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drivepoint piezometers (DP7-09 and DP9-09, or as modified). The drivepoint locations are shown on Figure 1.

Timing. Manual measurements will be collected three (3) times per year and the continuous loggers will be downloaded during each monitoring event.

Methodology. Water level measurements would be collected using a combination of manual and automated techniques.

2.2 GROUNDWATER MONITORING

Groundwater monitoring within the subject properties should include water level measurements and water chemistry analysis under Stage I, II and III conditions.

Due to the expected staged development of the property, it is anticipated that several years may pass between Draft Plan Approval and construction of all stages of the development. The following groundwater monitoring program is recommended for the Stage I monitoring. It is expected that the future monitoring may be reduced in scope based on timing and location of development. Groundwater monitoring will be undertaken by Stantec.

2.2.1 Water Level Monitoring

Location. Groundwater level monitoring will be completed at the 2010 monitoring wells located within the subject lands and within drivepoint piezometers located along Beaver Creek and Laurel Creek including:

- Twelve (12) monitoring wells (MW2-10, MW3-10S, MW3-10D, MW6-10, MW7-10, MW8-10S, MW8-10D, MW10-10, MW11-10, MW12-10S, MW12-10D, MW13-10) including shallow and deep monitoring locations; and
- Three (3) drivepoint piezometers along Beaver Creek (DP1-09, DP3-09 and DP5-09).
- Two (2) drivepoint piezometers along Laurel Creek (DP7-09 and DP9-09, or as modified).

Timing. Manual measurements will be collected three (3) times per year and the loggers will be downloaded during each monitoring event.

Methodology. Water level measurements would be collected using a combination of manual and automated techniques.

2.2.2 Water Chemistry Monitoring

Location. Groundwater quality sampling will be completed at the 2010 monitoring wells located within the subject lands including:

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- Twelve (12) monitoring wells (MW2-10, MW3-10S, MW3-10D, MW6-10, MW7-10, MW8-10S, MW8-10D, MW10-10, MW11-10, MW12-10S, MW12-10D, MW13-10) including shallow and deep monitoring locations.

Timing. Water quality samples will be collected once per year in the spring. The 2014 sampling will be completed in August 2014.

Methodology. Groundwater samples will be collected using foot valve / tubing or submersible pump depending on the location. Each well will be purged of three (3) casing volumes prior to sampling. Groundwater samples for metals analysis will be field filtered. Water quality samples would be analyzed for metals, nutrients and general chemistry.

3.0 REPORTING

Results from groundwater and surface water monitoring for Stage I monitoring will be presented in brief annual reports that include an assessment of results, integration of other monitoring data (as relevant) and recommendations for management or changes to future monitoring protocols, as required. Data sheets and representative photographs will be appended.

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Hydrogeological Assessment, 556, 560 and 576 Conservation Drive, Waterloo, Ontario

DRAFT REPORT

August 2020

Prepared for:

2115881 Ontario Limited
c/o Meritech Engineering
1315 Bishop Street North, Suite 202
Cambridge, ON N1R 6Z2

Prepared by:

Stantec Consulting Ltd.
100-300 Hagey Boulevard
Waterloo, ON N2L 0A4

File No. 160900921

Sign-off Sheet

This document entitled Hydrogeological Assessment, 556, 560 and 576 Conservation Drive, Waterloo, Ontario was prepared by Stantec Consulting Ltd. (“Stantec”) for the account of 2115881 Ontario Limited (the “Client”). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec’s professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

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Prepared by _____
(signature)

Grant Whitehead, MES, P.Geo. (Limited)
Senior Hydrogeologist

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Reviewed by _____
(signature)

Roger Freymond, P.Eng.
Senior Hydrogeologist

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Abbreviations

AMSL	above mean sea level
ASTM	American Society for Testing and Materials
BGS	below ground surface
Client	2115881 Ontario Limited
City	City of Waterloo
GRCA	Grand River Conservation Area
LID	Low Impact Development
Meritech	Meritech Engineering
NWSSS	North Waterloo Scoped Subwatershed Study
Region	Regional Municipality of Waterloo
Site	556, 560 and 576 Conservation Drive, Waterloo, Ontario
Stantec	Stantec Consulting Ltd.

1.0 INTRODUCTION

Meritech Engineering (Meritech), on behalf of 2115881 Ontario Limited (Client), retained Stantec Consulting Limited (Stantec) to complete a hydrogeological assessment for the lands located at 556, 560 and 576 Conservation Drive, in the City of Waterloo, Ontario (Site) (Figure 1) in support of Zone Change Application Z-16-14 and Draft Plan of Subdivision Application 30T-16402 (Figure 1). The Site is bounded to the east by the Conservation Meadows Subdivision, to the south by agricultural lands and the Green Acre Park campground, to the west by Beaver Creek and the Sunfish Lake-Laurel Creek Wetland Complex, and to the north by active agricultural fields.

The Site will be developed for single-family and multi-family units, with a school block, park block, open space, and a stormwater management (SWM) facility. Stantec identified the objectives of the hydrogeological assessment based on comments provided in the following documents (Appendix A)

- Grand River Conservation Authority (GRCA) - Integrated Planning and Public Works, 2017. Re: Zone Change Application Z-16-14, Draft Plan of Subdivision Application 30T-16402, 556, 560 and 576 Conservation Drive, City of Waterloo, 2115881 Ontario Limited / GSP Group. Dated August 11, 2017.
- Region of Waterloo (Region) - Planning, Development and Legislative Services, 2018. Post Circulation Comments, Revised Application for Draft Plan of Subdivision 30T-16402, Zone Change Application Z-16-14, 2115881 Ontario Limited / GSP Group, 556, 560 and 576 Conservation Drive (n/s Conservation Dr., e/s Roy Schmidt Rd.), City of Waterloo. Letter dated June 12, 2018.
- City of Waterloo (City) – Integrated Planning and Public Works, 2018. Second Submission Comments, Zone Change Application Z-16-1, Draft Plan of Subdivision Application 30T-16402, 556, 560 and 576 Conservation Drive.

and comments provided in the e-mail issued by Meritech titled “Cook-Mattamy hydrogeology JQ1279” dated November 8, 2018.

Based on a review of the above documentation, the identified objectives of the hydrogeological investigation are to:

1. Confirm high groundwater levels in those areas of the Site where at source infiltration measures (i.e., infiltration galleries) are proposed, including the gallery associated with the stormwater management (SWM) pond.
2. Prepare a groundwater elevation contour / flow interpretation map representing high groundwater conditions across the Site (as requested by the GRCA and Region of Waterloo).

The Site resides within the North Waterloo Scoped Subwatershed Study (NWSSS) area (Ecoplans Ltd. *et al.*, 2013). Stantec utilized information provided in this study together with field investigation results presented in this report to meet the previously mentioned hydrogeological assessment objectives.

Introduction
July 2020

This report is arranged into eight sections, including this introduction (Section 1). Section 2 presents the physical setting of the Site at a regional scale. Section 3 outlines the methods utilized to evaluate the Site hydrogeological conditions. Section 4 presents the results of the Site investigation, with Section 5 discussing the comprehensive treatment train strategy to be utilized at the Site to exceed NWSSS groundwater recharge targets. Section 6 provides a recommended program for continued groundwater monitoring at the Site, which is required for Draft Plan approvals by the City of Waterloo. Report conclusions and references are listed in Sections 7 and 8, respectively.

Appendix A provides correspondence received by review agencies, including the Region of Waterloo, City of Waterloo, and the Grand River Conservation Authority. All figures and tables referenced in this report are presented in Appendices B and C, respectively. Appendices D to G include Regional Groundwater Flow Mapping, Borehole Logs, Hydraulic Conductivity Analytical Solutions, and Grain-Size Testing Results.

2.0 PHYSICAL SETTING

2.1 PHYSIOGRAPHY AND TOPOGRAPHY

Most of the Site is situated within the Waterloo Hills physiographic region, with the northern portion of the Site extending into the Oxford Till Plain (Figure 2). As defined by Chapman and Putnam (1984), the Oxford Till Plain is a drumlinized till plain characterized by undulating to gently rolling topography and soils of a calcareous nature. The Waterloo Hills (also commonly referred to as the Waterloo Moraine) occupies a large portion of the Regional Municipality of Waterloo, with the surface of this physiographic feature consisting of sandy hills, ridges of sandy till, kames or kame moraines and intervening hollows of outwash sand and gravel, which all can be capped by glacial till.

As shown in Figure 2, the Site is characterized by hummocky terrain, with two topographic high points occurring in the northern portion of the property where elevations of 367 m AMSL are observed. From these topographic high points, a portion of the Site slopes to the east to northeast to an approximate elevation of 362 m AMSL along the property boundary with the Conservation Meadows Subdivision. The remainder of the Site generally slopes from the previously mentioned topographic high points to the southwest towards Beaver Creek, where elevations ranging from 353 to 348 m AMSL along the Site western boundaries are encountered.

2.2 SURFACE WATER BODIES AND WETLANDS

As shown in Figure 2, Beaver Creek is located at an approximate distance of 200 m from the north end of the western Site boundary, with the creek moving closer to the property limits moving southward until the creek eventually crosses into the Site. Beaver Creek flows south into the Laurel Creek Reservoir, which is located approximately 250 m to the southeast of the Site, before flowing east to the Grand River (approximately 8.25 km away from the Site). The Sunfish Lake and Laurel Creek Wetland Complex is a provincially significant wetland (PSW) associated with the two creeks and reservoir, with a section of this wetland occupying the southwestern portion of the Site.

Beaver Creek is a potential coldwater system, but its function as a groundwater discharge area has been degraded over the years by intensive agricultural activity in the subwatershed. Minimal groundwater-surface water interactions were interpreted along the majority of Beaver Creek in the NWSSS, except for seasonal groundwater discharge along the southern extents of this watercourse, located approximately 350 m south of Conservation Drive (Figure 5.22 as per Ecoplans Ltd. *et al.*, 2013, Appendix D).

2.3 REGIONAL GEOLOGY AND HYDROGEOLOGY

The Site is largely located within the Waterloo Moraine, a kame moraine formed in an interlobate position between ice lobes extending from the Lake Ontario-Erie, Huron, and Georgian bay areas (Karrow, 1993). Numerous advances and retreats of the ice lobes during the Wisconsinan glaciation resulted in a complex



deposit of ice-contact and glacial outwash sands and gravels separated by silt- and clay-rich tills. The conceptual hydrogeologic model for the Waterloo Moraine comprises four main aquifers and aquitards after Terraqua Investigations Ltd (1995), which was broken down further into 19 hydrostratigraphic units after Bajc and Shirota (2007). The model generally does not include more recent deposits shown on surficial geology mapping such as modern alluvium (Unit 19, Figure 3), which are found in the creek/river valleys.

The four regionally based hydrostratigraphic units generally encountered in the area containing the Site, and at depths associated with the current investigation, are described below. The units are described from ground surface downward, with Bajc and Shirota (2007) unit names shown in parentheses.

Aquitard 1 (ATB1): Surficial and spatially discontinuous glacial till unit, which along the eastern flank of the Moraine consists of the Upper Maryhill Till (clayey silt to silty clay) (Unit 5d, Figure 3). Aquitard 1 is characterized by low permeability and forms a relatively impermeable barrier that effectively limits the downward movement of surface water to the deeper aquifer systems. Perched groundwater conditions are commonly encountered within this unit.

Aquifer 1 (AFB1/ATB2/AFB2): This hydrostratigraphic unit represents the main water supply aquifer in the core areas of the Waterloo Moraine. Depending on the depositional environment, the composition of Aquifer 1 varies from a layered silt and fine sand to coarse sand and gravel (Unit 6, Figure 3). Throughout the core areas of the moraine, Aquifer 1 corresponds to a thick, laterally extensive sand and/or gravel aquifer overlying Aquitard 2 and is often exposed at surface in the core areas of the moraine. In some areas, Aquifer 1 is interpreted to be bisected by the Middle Maryhill Till (ATB2), effectively separating Aquifer 1 into two units, AFB1 and AFB2. Along the flanks of the Moraine, Aquifer 1 generally thins as the ground surface elevation decreases and approaches Aquitard 2.

Aquitard 2 (ATB3): Aquitard 2 corresponds to the Lower Maryhill Till (silty to clayey till) and represents one of the primary regional hydrostratigraphic units. The Maryhill Till is broken down into Upper (ATB1), Middle (ATB2) and Lower (ATB3) units by Bajc and Shirota (2007). Along the flanks of the moraine, the Maryhill Till is often found to be discontinuous or has been re-worked and re-deposited as glaciofluvial sediments. ATB3 is present throughout most of the North Waterloo Subwatershed, except for localized areas where it has been eroded by glacial meltwater channels.

Aquitard 3 (ATC1): Aquitard 3 corresponds to the Catfish Creek Till, an olive-grey, very dense sandy to stony silt till that is often referred to as “hardpan” in. This unit together with Aquitard 2 form a key stratigraphic aquitard unit throughout the Waterloo Moraine, with the Catfish Creek Till beneath the Site reported to range from 10 to 40 m in thickness. Within the till, a thin aquifer (generally less than 3 m thick) of limited lateral extent can be found, consisting of stratified silt and sand or coarse gravel. This aquifer is referred to by Bajc and Shirota (2007) as AFC1, separating Aquitard 3 into an upper (ATC1) and lower (ATC2) aquitard.

As shown in Figure 5.22 from the NWSSS (Appendix D; Ecoplans Ltd. *et al.*, 2013), the interpreted direction of groundwater flow through Aquifer 1 (AFB1) is from northeast to southwest across the Site towards Beaver Creek.



3.0 METHODOLOGY

The hydrogeological site investigation included the:

- review of historical groundwater monitoring data from previous studies
- drilling of boreholes and installation of monitoring wells
- monitoring of groundwater levels
- performing hydraulic response (hydraulic conductivity) testing
- performing infiltration testing of onsite soils.

The methodology for these tasks is described in Section 3.1 to 3.6 below.

3.1 HISTORICAL INVESTIGATIONS

As part of the NWSSS (Ecoplans *et al.*, 2013), Stantec observed the installation of 17 monitoring wells throughout the NWSSS investigation area. Six of these monitoring wells (i.e., MW2-10, MW3-10S, MW3-10D, MW3-16S, MW6-10, MW7-10) occur within the boundaries of the Site (Figure 1). The continuous monitoring of groundwater levels in these wells for the NWSSS have been ongoing since March 2010, with the most recent results presented in Stantec (2020). These groundwater level monitoring results are considered to fall under the City's Phase 1 monitoring program, given that no construction to date has started on any of the properties located within the NWSSS area. A copy of the borehole / well construction logs for the previously mentioned wells is provided in Appendix E.

3.2 BOREHOLE DRILLING

From April 11 to 12, 2019 boreholes were advanced at six locations across the Site (Figure 1) using a CME track-mounted drilling rig equipped with hollow-stem augers operated by a licensed drilling subcontractor (Aardvark Drilling Inc.). The depth of the boreholes extended to 5.2 m to 9.1 m below ground surface (BGS), with each borehole being equipped with a single monitoring well (i.e., MW1-19 to MW6-19). Soil sampling occurred using a 0.6 m long stainless-steel split spoon sampler at 0.75 m (2.5 feet) intervals for the first 3.6 m (12 feet) of drilling depth, followed by sample collection occurring at approximately every 1.5 m (5 feet) to the termination depth of the borehole. Stantec personnel directed the drilling and soil sampling operations and logged the borehole stratigraphy. The borehole logs contain descriptions (where relevant and possible) of soil type, texture, colour, structure, consistency, plasticity, moisture content, and other visual and olfactory observations as per the procedures outlined in ASTM (2009) specification D2488-09a. Overall, the boreholes were strategically positioned throughout the Site to confirm shallow soil conditions and seasonal groundwater depths to assist in the design of Low Impact Development (LID) stormwater management structures. Copies of the borehole logs are provided in Appendix E.

3.3 MONITORING WELL INSTALLATION AND DEVELOPMENT

Stantec observed the installation of monitoring wells in the six boreholes advanced at the Site (i.e., MW1-19 to MW6-19), with the wells being installed to allow for the measurement of groundwater levels and the completion of other hydrogeological testing. Installation details for each of the monitoring wells are summarized in Table 1. Each monitoring well is constructed of 50 mm inside diameter, Schedule 40 polyvinyl chloride (PVC) pipe, having a No. 10 slot screen (0.01-inch slot) measuring 3.0 m in length. Backfilling of the screened interval consisted of silica sand to a height of approximately 0.3 m above the top of screen, followed by granular bentonite to ground surface prevent a hydraulic connection from occurring between the screened formation and overlying soils. The completion of each monitoring well involved encasing the pipe stick-up within a lockable steel casing. Stantec Geomatics surveyed the ground surface and top-of-pipe elevations at each monitoring well location to a geodetic benchmark using the Can-Net GPS Survey system, having a spatial accuracy of +/- 0.03 m and +/- 0.02 m in the vertical and horizontal plane, respectively.

Following installation, Stantec personnel developed the six monitoring wells. The purpose of developing the monitoring wells is to remove drilling fluids, solids or other particulates that may have been introduced during drilling. Stantec personnel purged each monitoring well using dedicated 16 mm inside diameter high density polyethylene (HDPE) tubing connected to a D-25 Waterra™ foot valve. Where possible, Stantec personnel purged from eight to ten standing column volumes from the well to clear out any fine-grained sediments and, subsequently, establish a proper hydraulic connection with the native aquifer material.

3.4 GROUNDWATER LEVEL MONITORING

Groundwater levels were recorded in each of the new monitoring wells (i.e., MW1-19 to MW6-19) from May 2019 to May 2020 using a combination of automated and manual measurement methods. Solinst® Edge Leveloggers® (Leveloggers) were installed in all monitoring wells to allow automatic measurement of water levels. The Leveloggers were suspended into the water column at each monitoring well and set to record water levels at 60-minute intervals. Leveloggers are not vented to the atmosphere and therefore record total pressure (where total pressure is the sum of the atmospheric pressure and the height of water column). To obtain an accurate measurement of the groundwater level at each well, the water level data obtained from the Leveloggers were corrected for atmospheric pressure using data obtained from a Solinst® Edge Barologger® (Barologger), which was suspended in the air column at monitoring well MW1-19.

Groundwater levels were manually measured several times from the onsite monitoring wells (eight events) and the multi-level drive-point piezometer (six events) between May 2019 and May 2020. The groundwater level measurements were recorded in metres to the nearest 0.01 m using a battery-operated water level indicator. Manual groundwater level measurements were used to verify data recorded by the Leveloggers. Manual water levels collected from the monitoring wells are presented in Table 2. Hydrographs presenting both the automatic and manually measured groundwater level data from MW1-19 to MW6-19 are provided in Figure 7.

As mentioned previously, continuous and manual monitoring of groundwater levels in the onsite NWSSS wells (i.e., MW2-10, MW3-10S, MW3-10D, MW3-16S, MW6-10, MW7-10) has been ongoing since March 2010 using similar methods as described above. Details of the NWSSS groundwater monitoring program are described in greater detail in Ecoplans *et al.* (2013).

3.5 HYDRAULIC RESPONSE TESTING

To estimate the horizontal hydraulic conductivity of the deposits beneath the Site, Stantec performed in-situ hydraulic response testing on MW1-19 to MW6-19 on May 10, 2019. The testing completed on MW2-10, MW3-10S, MW3-10D, MW6-10, MW7-10 occurred as part of the NWSSS (Ecoplans Ltd. *et al.*, 2013). The testing performed for this investigation consisted of creating an instantaneous change in the monitoring well water level by removing a known volume of water from the well (i.e., rising head / bail test), followed by recording the time taken for the resulting water level to return to static conditions using a combination manual and continuous (i.e., datalogger) measurements. The testing results were analyzed using the Bouwer and Rice (1976) / Bouwer (1989) solution provided in the software package AQTESOLV™ Pro Version 4.5 (Duffield, 2014) to calculate the horizontal hydraulic conductivity of the aquifer sediments within the immediate vicinity of the screened interval of each monitoring well. Table 1 provides a summary of the calculated horizontal hydraulic conductivities, with the analytical solutions for the data being presented in Appendix F.

3.6 INFILTRATION TESTING

Assessment of the infiltration potential for the onsite soils involved the using of a Guelph Permeameter or double ring infiltrometer.

A Guelph Permeameter is a constant head permeameter designed to measure in-situ vertical hydraulic conductivities of a given substrate. Stantec personnel used a hand auger to drill an approximately 0.6 to 0.7 m deep, 50 mm diameter cylindrical hole into the native soil at four locations for testing (i.e., GP101 to GP104, Figure 1). The Guelph Permeameter was then filled with water, inserted into the hole while making a concerted effort to avoid knocking debris into the excavation, and stabilized against the substrate. Stantec personnel then proceeded to record the eventual steady-state rate of water recharge into the soil at different hydraulic heads. Similar testing was completed previously at the Site as part of the NWSSS program (Ecoplans Ltd. *et al.*, 2013), with two locations being tested in the northern area of the property (i.e., GP5 and GP6, Figure 1). The infiltration rate for each soil tested was converted from the measured vertical hydraulic conductivity using the established relationship between vertical hydraulic conductivity and infiltration rate presented in the Credit Valley Conservation and Toronto and Region Conservation (2010) Low Impact Stormwater Management Planning and Design Guideline. Table 3 presents the results of this soil infiltration testing.

Infiltration testing using the double ring infiltrometer involves driving two concentric rings into the ground, filling the rings with water, and documenting the drop in water level in the inner ring over a defined period. The observed drop in water level over time (mm/hr) yields the infiltration rate. Prior to testing, the rings are filled with water, allowing the soil to saturate for a period of 30 minutes. The outer ring acts as a buffer



for the inner ring, ensuring the soils adjacent to the testing zone are saturated and thus eliminating any horizontal component of infiltration. Once the soils have been saturated, testing is performed, and the infiltration rate is recorded. Stantec personnel used the double ring infiltrometer to test the infiltration potential of the topsoil layer at the same locations where the Guelph Permeameter testing occurred (i.e., GP101 to GP104). Stantec personnel also collected samples of the topsoil at these locations, which were submitted to a laboratory for grain-size analysis. Results of the infiltration and grain-size analysis testing for the topsoil layer at the Site is provided in Table 3 and Appendix G, respectively.

Stantec also used the in-situ hydraulic response testing results obtained at MW1-19 to MW6-19, as well at the NWSSS monitoring wells MW2-10, MW5-10, MW6-10 and MW7-10, to estimate infiltration rates of the deeper overburden soils (i.e., ranging from 1.5 m to 9.1 m BGS). Since hydraulic conductivity in the horizontal direction is generally an order (potentially two orders for clay-based deposits) of magnitude higher than hydraulic conductivity in the vertical direction (Todd 1980; Freeze and Cherry 1979), the vertical hydraulic conductivities for overburden deposits surrounding the well screens were assumed to be one order of magnitude lower than in-situ measured horizontal hydraulic conductivities. The CVC-TRCA (2010) method for converting vertical hydraulic conductivity to an infiltration rate was then applied to these data, with the results being presented in Table 3.

4.0 LOCAL GEOLOGY AND HYDROGEOLOGY

4.1 GEOLOGY AND HYDROSTRATIGRAPHY

Figure 3 presents the surficial geological conditions within the Site and surrounding area as mapped by the OGS (2010) and the locations of Cross Sections A-A' (Figure 4), B-B' (Figure 5), and C-C' (Figure 6). These cross-sections were constructed using historical borehole information and the results of onsite drilling investigations recently completed by Stantec. A summary of these drilling results is shown on the borehole logs provided in Appendix D.

As shown in Figure 3, surficial deposits of glaciolacustrine-derived silty to clayey till occupy the central portion of the Site, with these deposits extending eastward to the property boundary adjoining to the Conservation Meadows Subdivision. This deposit is interpreted to represent the Upper Maryhill Till of Aquitard 1 (ATB1), with results of the onsite drilling indicating that this unit extends from existing grades to depths ranging from 1.0 to 3.0 m below ground surface (BGS). The drilling results also suggest that the Maryhill Till continues northward across the Site, with clayey silt deposits being found in the shallow subsurface at MW6-19 and MW2-10 (Figure 4).

Ice-contact stratified deposits of fine to medium-grained sand, silty sand, sandy silt and silt cover the remainder of the Site, with these deposits extending up to 23 m beneath the property to an approximate elevation of 344 m AMSL (Figure 5). These sandy to silty soils represent deposits associated with Aquifer 1 (AFB1) / the Upper Moraine stratified sediments. Below these deposits lies the Lower Maryhill Till (silty to clayey till) of Aquitard 2 (ATB3), which in turn overlies the Catfish Creek Till (Aquitard 3, ATC1). Beneath the Site, the Catfish Creek Till is encountered at an elevation of approximately 327 m AMSL (Figure 5).

4.2 HYDROGEOLOGY

4.2.1 Groundwater Levels

Table 2 provides a summary of the manual groundwater level measurements obtained from MW1-19 to MW6-19 between May 2019 and May 2020. Hydrographs presenting the continuous and manual water levels recorded within these previously mentioned monitoring wells are provided in Figure 7, with Figure 8 providing groundwater level data collected from the NWSSS monitoring wells (i.e., MW2-10, MW3-10S, MW3-10D, MW3-16S, MW6-10, MW7-10).

Groundwater contour mapping showing the historical high groundwater elevations recorded at each of the previously mentioned monitoring wells (i.e., highest water level observed in all measurements taken from a given well) is presented on Figure 9. In general, groundwater elevations are highest in the northern end of the Site, with these elevations progressively declining southward across the property towards Beaver Creek and the Sunfish Lake and Laurel Creek Wetland Complex. Overall, the high groundwater table

ranges from 357.24 m AMSL to 351.95 m AMSL across the Site, equating to depths of less than 0.1 m BGS (MW6-19) to 7.2 m BGS (MW4-19) based on existing grades.

As shown in the hydrographs (Figures 7 and 8), the groundwater table demonstrated a similar pattern in fluctuations across the Site, with high groundwater conditions predominantly occurring in the spring (i.e., early March to early June) as a result of lower evapotranspiration losses and a melting snowpack, which in turn provides a greater volume of water available to infiltrate and recharge the groundwater system. Moving through the summer months and into the late fall, the groundwater table declines as a response to more water being drawn from the subsurface over this period to meet evapotranspiration demands.

Groundwater level fluctuations observed at MW2-19 and MW6-19 are shown to respond more readily to climatic conditions (e.g., water table rise from precipitation events, declines from evapotranspiration losses) when compared to fluctuations occurring at the other monitoring well locations. The reason for these differences is due to these monitoring wells being largely screened in the clayey silt to silty clay deposits of the Upper Maryhill Till (Aquitard 1). The smaller pore spaces associated with these finer-grained deposits require a lower volume of water to infiltrate and/or be removed from the subsurface to illicit a rise / fall in the groundwater table compared to the monitoring well locations where the screen intervals are constructed into the coarser-grained sandy deposits of Aquifer 1. The low hydraulic conductivity associated with the Upper Maryhill Till (Aquitard 1) and portions of Aquifer 1 where finer-grained silt deposits predominate (i.e., 10^{-7} to 10^{-9} m/s; Table 1; Appendix E) also limits the ability of infiltrating water reaching the groundwater table to horizontally move through these deposits, causing a mounding effect to occur at these locations during the wetter periods of the year.

4.2.2 Groundwater Flow

Figure 9 presents groundwater elevation contours and the interpreted direction of horizontal flow through the groundwater system beneath the Site using historical high level measurements collected from the on-site monitoring wells. In general, groundwater contours mimic the prevailing topography of the Site, with horizontal flow predominantly moving in a southwestern direction across the property towards Beaver Creek. This interpreted direction of groundwater flow agrees with flow mapping presented in the NWSSS (Appendix D; Ecoplans Ltd. *et al.*, 2013). However, due to localized groundwater mounding effects that can occur in areas of the Site where low permeability deposits of silt and clay characterize the subsurface, a portion of this horizontal flow may also periodically move to the north to northeast during the wetter parts of the year (i.e., late fall to spring).

Horizontal hydraulic conductivity estimates calculated from onsite hydraulic response testing completed at the monitoring wells completed within the shallow overburden deposits (i.e., 1.3 to 13.7 m BGS) ranged from 2.8×10^{-4} m/s to 1.8×10^{-9} m/s (Table 1; Appendix E), for an estimated bulk (i.e., geometric mean) horizontal hydraulic conductivity of 8.0×10^{-6} m/s (Table 1). Based on the groundwater elevation contours presented in Figure 9, groundwater is interpreted to flow across the Site at an average horizontal hydraulic gradient of 0.01 m/m. Applying Darcy's law:



$$v = \frac{K \nabla}{\theta}$$

where: v = velocity (m/yr)
K = hydraulic conductivity (8.0×10^{-6} m/s)
∇ = hydraulic gradient (0.01 m/m)
θ = effective porosity (0.35 for mixed/silty sand to silt, after Fetter 2001)

The estimated average velocity of horizontal groundwater flow through the subsurface of the Site is calculated to be approximately 8.7 m per year.

4.2.3 Infiltration Potential

Estimated infiltration rates for the overburden deposits are provided in Table 3. Infiltration rates were calculated based on an established relationship between vertical hydraulic conductivity and infiltration rate presented in CVC-TRCA (2010), with vertical hydraulic conductivities being estimated based on a combination of results obtained from Guelph Permeameter and infiltrometer testing of surficial soils, and in-situ hydraulic response testing completed at selected monitoring wells (Section 3.6).

Infiltration rates calculated for the topsoil layer (tested using the infiltrometer) throughout the Site ranged from 16 mm/hour to 173 mm/hour, depending on the percentages of sand/gravel and silt/clay found in these soils. As expected, topsoil samples tested that contained a greater percentage of sand/gravel were characterized by higher infiltration rates, whereas samples containing a larger percentage of silt/clay had lower infiltration rates.

Tested vertical hydraulic conductivities for native fine to medium-grained sand deposits directly underlying the topsoil (tested using the Guelph Permeameter) ranged from 2.1×10^{-4} m/s to 7.5×10^{-6} m/s, equating to infiltration rates ranging from 79 mm/hour to 194 mm/hour (Table 3). For those native deposits of silty to clayey sand to silt, vertical hydraulic conductivities ranged from 2.3×10^{-7} m/s to 7.3×10^{-8} m/s, equating to infiltration rates ranging from 23 mm/hour to 31 mm/hour (Table 3). Stantec notes that these previously mentioned deposits were tested at depths ranging from 0.3 m to 0.7 m BGS at the Site.

Vertical hydraulic conductivities for overburden deposits screened at depths between 1.5 m to 9.1 m beneath the Site and tested via in-situ hydraulic response testing completed at the onsite monitoring wells is assumed to be one order of magnitude lower than in-situ measured horizontal hydraulic conductivities at these locations (Todd, 1980; Freeze and Cherry, 1979) resulting in values ranging from 2.8×10^{-5} to 1.3×10^{-6} m/s and equating to infiltration rates ranging from 50 mm/hour to 113 mm/hour. For the fine sand having some silt and clay, silt, and clayey silt deposits, vertical hydraulic conductivities ranged from 8.0×10^{-8} m/s to 1.8×10^{-10} m/s, equating to infiltration rates ranging from 5 mm/hour to 23 mm/hour (Table 3).

Overall, the fine to medium-grained sand deposits present at depths ranging from 0.3 m to 9.1 m BGS across the Site are found to have infiltration rates ranging from 79 mm/hour to 194 mm/hour, equating to a geometric mean infiltration rate of 89 mm/hour. For the deposits of fine sand having some silt and clay, silt, and clayey silt, infiltration rates range from 5 mm/hour to 31 mm/hour, equating to a geometric mean infiltration rate of 16 mm/hour (Table 3).



5.0 RECHARGE TO GROUNDWATER STRATEGY

A water balance analysis was completed as part of the NWSSS for the 31.8 ha subcatchment of the North Waterloo Subwatershed that includes the Site (Ecoplans Ltd. *et al.*, 2013). The analysis was based on the results of a hydrological model developed for the North Waterloo Subwatershed with the GAWSER modelling software. The analysis made use of regional inputs such as soils, land use, and topography, and local inputs such as meteorological data from the Laurel Dam weather station, and stream flow data from Beaver and Laurel creeks. A key recommendation coming from the NWSSS is that existing pre-development infiltration rates for land parcels throughout the subcatchment be maintained or increased under the post-development condition to mitigate any potential effects to groundwater recharge function and subsequent inputs / discharge to both Laurel and Beaver Creeks. For this Site, Meritech will be employing a comprehensive treatment train strategy designed to exceed NWSSS groundwater recharge targets.

Low impact development (LID) is a stormwater management (SWM) strategy that seeks to mitigate the impacts of increased stormwater runoff by managing this runoff as close to source as possible, with the implementation of such strategies also providing the residual benefit of offsetting potential infiltration losses associated with the increase in impervious surfaces associated with a given development. The NWSSS recommends that the following LID techniques be considered in stormwater management strategies (for the Site) to meet the previously mentioned objective:

- At source infiltration measures (e.g., soak away pits / infiltration galleries) located in high density areas of the development where suitable soils are present.
- Conveyance controls with roof leader connections for single, semi-detached, and townhouses.
- End-of-pipe facilities with wetland basins and/or infiltration trenches.

As documented and discussed in the Meritech (2020) *Preliminary Stormwater Management Report*, the following post-development LID SWM measures are proposed for the Site to offset potential infiltration losses associated with the increase in impervious surfaces associated with the given development:

- At source infiltration measures that will consist of constructing rear-yard infiltration galleries.
- Construction of a clean water collection (CWC) “third pipe” system, consisting of a conveyance system of perforated / exfiltration pipes constructed within the roadway rights of way, which will receive, and infiltrate clean water captured from the residential foundation drains and rooftops of the development.
- SWM pond / constructed wetland, which will receive stormwater runoff from the development via the CWC system and outlet to an infiltration gallery constructed within the bank of the facility (i.e., end-of-pipe infiltrating facility).

- Use of amended soils (i.e., a minimally compacted 250 mm layer of topsoil versus the standard 100 mm used in conventional developments) to promote infiltration of precipitation falling on remaining pervious areas of the development, as well as residential roof leaders not connected to the CWC systems or rear-yard infiltration galleries.

The proposed locations of the previously mentioned LID SWM facilities (i.e., infiltration galleries) are shown on Figure 9. Further details on the LID SWM facility sizing, depths, functionality, and other associated design parameters are discussed in Meritech (2020).

As per Meritech (2020), the design of the onsite LID SWM facilities will be further developed during the detailed design stage of the project. Overall, as shown on Figure 9, the proposed infiltration galleries will be constructed largely in the permeable fine to medium-grained sand deposits that characterize the subsurface of the Site where infiltration rates range from 79 mm/hour to 194 mm/hour (Section 4.2.3). In addition, existing grades throughout the Site will be adjusted to account for the high groundwater table condition and permit the base elevation of the proposed infiltration galleries to remain above the groundwater table and, subsequently, allow for these LID structures to function as designed.

5.1 WATER BALANCE

The water balance analysis for the Site is currently in progress and will be included as part of the detailed design submission. Specifically, this section will demonstrate how the planned comprehensive treatment train strategy, which includes at source, conveyance, and end-of-pipe best management practices for stormwater management, will exceed the NWSSS water balance objectives for this Site.

6.0 PROPOSED GROUNDWATER MONITORING

The NWSSS (Ecoplans et al., 2013) proposes that *"in addition to typical 'during-construction' monitoring'… pre', 'during' and 'post'- construction…groundwater monitoring should be prepared as part of supporting studies for future development applications. Terms of Reference for monitoring programs should be submitted for approval by agencies having jurisdiction (e.g., GRCA, Regional Municipality of Waterloo] and City [of Waterloo]) at least two years in advance of a development application being filed on a property."*

The intent of the various stages of proposed monitoring are as follows:

Stage 1. Pre-Construction – Groundwater monitoring within and surrounding the development site to quantitatively identify, and establish a baseline for, hydrogeological site conditions. A minimum of two years of monitoring is required. Stantec notes that the monitoring of groundwater levels at MW1-19 to MW6-19 has been occurring at the Site since May 2019, with those monitoring wells located within the Site that were installed as part of the NWSSS having been monitored since 2010 (i.e., MW2-10, MW3-16S, MW3-10D, MW6-10, MW7-10).

Stage 2. During-Construction – Continuation of Stage 1 monitoring, including MW1-19 to MW6-19, unless these monitoring wells require decommissioning due to their location falling within the proposed footprint of the development. Monitoring should be completed for the duration of construction.

Stage 3. Post-Construction – Monitoring, as required, to assess the efficacy of mitigation measures implemented during construction. At minimum two years of monitoring is required.

Stage 2 and Stage 3 monitoring plans would at a minimum continue the continuous and manual monitoring of groundwater levels in all onsite wells: MW1-19 to MW6-19. Stantec also recommends that continuous water level data collected at MW2-10, MW3-16S, MW3-10D, MW6-10, MW7-10 as part of the North Waterloo Phase 1 monitoring program also be reviewed during these stages. The details of each monitoring phase will be confirmed by the City at each transition stage of the development.

7.0 CONCLUSIONS

The following conclusions are provided based on the completed hydrogeological assessment

1. Surficial deposits of glaciolacustrine-derived silty to clayey till, interpreted to represent the Upper Maryhill Till (Aquitard 1; ATB1), occupy the central portion of the Site, with these deposits extending eastward to the property boundary adjoining to the Conservation Meadows Subdivision. The Upper Maryhill Till extends to a depth ranging from 1.0 to 3.0 m BGS, which is underlain by fine to medium-grained sand, silty sand, sandy silt, and silt deposits of Aquifer 1 (AFB1). The deposits of Aquifer 1 occur at ground surface over the remainder of the Site, extending to depths up to 23 m beneath the property to an approximate elevation of 344 m AMSL. Below these deposits lies the Lower Maryhill Till (silty to clayey till) of Aquitard 2 (ATB3), which in turn overlies the Catfish Creek Till (Aquitard 3, ATC1). Beneath the Site, the Catfish Creek Till is encountered at an elevation of approximately 327 m AMSL.

2. The high groundwater table ranges from 357.24 m AMSL to 351.95 m AMSL across the Site, equating to depths of less than 0.1 m BGS to 7.2 m BGS based on existing grades. In general, groundwater elevations are highest in the northern end of the Site, with these elevations progressively declining as one moves southward across the property towards Beaver Creek and the Sunfish Lake and Laurel Creek Wetland Complex.

3. In general, groundwater contours mimic the prevailing topography of the Site, with horizontal flow predominantly moving in a southwestern direction across the property towards Beaver Creek. This interpreted direction of groundwater flow agrees with flow mapping presented in the NWSSS. However, due to localized groundwater mounding effects that can occur in areas of the Site where low permeability deposits of silt and clay characterize the subsurface, a portion of this horizontal flow may also periodically move to the north to northeast during the wetter parts of the year (i.e., late fall to spring).

4. The estimated average velocity of horizontal groundwater flow through the shallow subsurface of the Site is calculated to be approximately 8.7 m per year.

5. Overall, the fine to medium-grained sand deposits encountered at depths ranging from 0.3 m to 9.1 m BGS across the Site are found to have infiltration rates ranging from 79 mm/hour to 194 mm/hour, equating to a geometric mean infiltration rate of 89 mm/hour. For the deposits of fine sand having some silt and clay, silt, and clayey silt, infiltration rates range from 5 mm/hour to 31 mm/hour, equating to a geometric mean infiltration rate of 16 mm/hour (Table 3).

6. Infiltration rates calculated for the topsoil layer throughout the Site ranged from 16 mm/hour to 173 mm/hour, depending on the percentages of sand/gravel and silt/clay found in these soils. In general, topsoil samples tested that contained a greater percentage of sand/gravel were characterized by higher infiltration rates, whereas samples containing a larger percentage of silt/clay had lower infiltration rates.

7. Meritech (2020) will be employing a comprehensive treatment train strategy at the Site designed to exceed NWSSS groundwater recharge targets. These measures are to include at source infiltration measures (i.e., rear-yard infiltration galleries), a clean water collection (CWC) “third pipe” system constructed in roadway rights of way, end-of pipe infiltration galleries, and amended soils in remaining

pervious areas of the development. Overall, these post-development groundwater recharge measures will be constructed largely in the permeable fine to medium-grained sand deposits that characterize the subsurface of the Site. In addition, existing grades throughout the Site will be adjusted to account for the high groundwater table condition and permit the base elevation of the proposed treatment train strategies to remain above the groundwater table and, subsequently, allow for these structures to function as designed. Further details on the treatment train facility sizing, depths, functionality, and other associated design parameters are discussed in the Meritech Preliminary Stormwater Management Report.

8. The Site occurs in the North Waterloo Scoped Subwatershed Study Area and, as such, a groundwater monitoring program is proposed to document pre-, during- and post-construction hydrogeological conditions.

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APPENDIX A:
AGENCY CORRESPONDENCE

Grand River Conservation Authority

Administration Centre: 400 Clyde Road, P.O. Box 729 Cambridge, ON N1R 5W6

Phone: 519-621-2761 Toll free: 1-866-900-4722 Fax: 519-621-4844 www.grandriver.ca

August 11, 2017

Trevor Hawkins, M.PL, MCIP, RPP
Integrated Planning and Public Works
City of Waterloo
100 Regina Street South
Waterloo, ON
N2J 4A8

Re: Zone Change Application: Z-16-14
Draft Plan of Subdivision Application: 30T-16402
556, 560, and 576 Conservation Drive, City of Waterloo
2115881 Ontario Limited / GSP Group

Dear Mr. Hawkins,

Grand River Conservation Authority (GRCA) staff have completed their review of the following materials, submitted in support of the above noted applications:

- NRSI, ***Environmental Impact Study***, 2115881 Ontario Limited, North Waterloo (July 2016)
- Meritech Engineering, ***Preliminary Stormwater Management Report***, 556 and 576 Conservation Drive, City of Waterloo (July 2016)
- Stantec, ***Phase 1 Groundwater and Surface Water Monitoring Program***, Northgate Corporation, 2115881 Ontario Ltd., Activa Holdings and Erbsville Kartway (May 13, 2016)
- LVM, ***Geotechnical Engineering Report***, 2115881 Ontario Limited, Proposed Residential Development, 560-576 Conservation Drive, Waterloo, Ontario (March 23, 2015)

Based on the comments provided below, GRCA staff are not in a position to recommend approval of the draft plan (30T-16042) and zone change (Z-16-14) at this time. We look forward to receiving a response and revised materials that address the following comments:

Required Comments to be Addressed:

Planning:

1. We note that a portion of the stormwater for the subject lands will be directed toward an off-site Stormwater Management (SWM) facility, the location and design of which has yet to be determined. Please note that GRCA staff are unable to provide a

comprehensive review and/or support of 30T-16402 and Z-16-14 without this information.

2. Please clarify whether any stormwater from the adjacent "Brohman lands" (620 Conservation Drive) will be directed east toward the subject site. If so, the Preliminary SWM Report will need to address whether the on-site SWM facility can adequately accommodate stormwater from the adjacent property.

3. As noted in our pre-consultation comments dated September 14, 2015, a portion of the Park Block (Block 480) is proposed within the 30 metre wetland buffer. Park is not the intended use of the buffer area; therefore, this portion should be designated as Open Space instead.

4. Section 5.4 of the Environmental Impact Study (EIS) states that "a formal trail system will be provided outside of buffers and natural areas" and GRCA staff are supportive of this approach. However, the location of any proposed trails should be illustrated directly on the Draft Plan to ensure that this recommendation is implemented.

Engineering:

5. GRCA staff agree with the target unit flow rates for discharge to Beaver Creek, as derived in the North Waterloo Scoped Subwatershed Study (NWSSS) using GAWSER modelling of event rainfall from the Guelph Arboretum and 54 years of continuous meteorological data from the Waterloo-Wellington Airport. However, in order to ensure conservative design of major system stormwater conveyance and end-of-pipe storage elements, please use the Regional Municipality of Waterloo 100-year, 3-hour IDF rainfall parameters instead of those applied by the City of Waterloo. The former has 100mm of rainfall while the latter has 90mm. For comparative purposes it is worth noting that the City of Cambridge 2011 Stormwater Management Policies and Guidelines, using AES and Shades Mill meteorological data from 1971-2008, have identified 108mm as the 100-year, 3-hour rainfall depth.

6. Please provide a section view of the proposed stormwater facility discharge controls. In particular, the nature of the 7m wide outlet control weir (as labelled in Figure 4) and its relationship to the extended detention 75mm diameter outlet control orifice is unclear.

7. Please confirm that the stormwater management facility in Block 487 will have side slopes that satisfy Ministry of the Environment (MOE) safety criteria. It would be helpful to document this in Figure 4 of the SWM Report.

Natural Heritage:

8. Section 3.3 of the EIS includes a Grand River Fisheries Management Plan which identifies the objectives for the Laurel Creek fish community as "cold water fish community in areas where geological and biophysical characteristics are present and habitat exists or has been rehabilitated." The EIS acknowledges historical brown

trout spawning in lower reaches of Laurel Creek and the confluence of Beaver Creek. The target for water quality discharging from this proposed development should be for the support of a cold water fish community.

9. Buffer and setback dimensions (EIS Section 4.9) should be identified as minimum dimensions (i.e. not fixed dimensions at this stage in the planning process).

10. EIS Section 5.4.4 should identify a thermal discharge target that will maintain water temperature supportive of the cold water fish community in Beaver Creek and Laurel Creek. Given the close proximity of the site to the confluence of Beaver Creek and Laurel Creek, the instream targets identified in the NWSSS should be used for long term monitoring.

11. Thermal discharge of surface and groundwater should be monitored and measured to assess effectiveness of mitigation measures (EIS Section 6.3).

Additional Comments to be Addressed at Detailed Design:

Further to the above, the following comments will need to be addressed at the detailed design phase in order to satisfy future GRCA permit requirements:

Engineering:

a) GRCA staff agree that the site soils, groundwater and observed ground water elevations appear to provide opportunities for maintaining and enhancing existing annual infiltration volumes. For design purposes, we suggest using site-specific water balance values provided in the NWSSS rather than the MOE Stormwater Management Planning and Design Manual generic values used in the SWM Report's appended calculations.

b) Table 6 of the SWM Report correctly uses annual infiltration values derived in the NWSSS (i.e. 188.4mm on the eastern side of a topographic divide and 222.5mm on the western side (NWSSS 2013, Fig 6.4)). However, the SWM plan uses an MOE 228mm generic for the entire development's pervious areas. As implied in the comment above, post development infiltration rates need further evaluation.

c) Unless the guidelines of the TRCA 2012 document, *Preserving and Restoring Healthy Soil: Best Management Practices for Urban Construction*, are applied, post development rates will typically be reduced due to subgrade compaction, degraded soil structure and decreased top soil depths.

d) Groundwater contour mapping is recommended using the highest observed water surface elevations from both the LVM standpipes and the Stantec monitoring wells.

Natural Heritage:

e) A detailed site grading plan will be required and a Geotechnical Engineer should assess the replacement fill material imported onto the site to ensure that it does not

interfere with surface water infiltration or groundwater movement. The importation of fill material also needs to be coordinated with the final SWM plan to ensure the intended water balance is achieved.

f) A detailed dewatering plan will be required to demonstrate how groundwater contributions to the adjacent watercourse and Provincially Significant Wetland will be maintained.

Advisory Comments for Consideration:

i. The maximum forebay velocity to prevent scour of accumulated sediment is 0.15m/s rather than the 0.5m/s identified in the design calculations. 0.5 m/s is the maximum velocity for dispersion of inflow over the forebay berm. As the proposed design achieves 0.10m/s average velocity through the forebay, this comment is advisory only.

If you have any questions or concerns regarding this letter, please do not hesitate to contact the undersigned.

Sincerely,

Kaitlyn Smith
Resource Planner - Grand River Conservation Authority
519-621-2763 ext. 2292 | ksmith@grandriver.ca

c.c. Kristen Barisdale – GSP Group (email)
2115881 Ontario Limited, 169 Lexington Court Unit B-1, Waterloo ON, N2J 4R3

Region of Waterloo

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Kristen Barisdale, MCIP, RPP (**via email**)
Associate, Senior Planner
GSP Group Inc.
201-72 Victoria Street South,
Kitchener ON N2G 4Y9

File: D18-20/16402
C14-60/4/16014
June 12, 2018

Ms. Barisdale:

Re: Post Circulation Comments
Revised Application for Draft Plan of Subdivision 30T-16402
Zoning By-law Amendment Application Z-16-14
2115881 Ontario Limited / GSP Group
556, 560, 576 Conservation Drive
(n/s Conservation Dr., e/s Roy Schmidt Rd.)
City of Waterloo

The subject applications were received by the Region on August 20, 2016 from GSP Group; application 30T-16402 was deemed complete by the Region's Director of Community Planning on August 23, 2016. The City of Waterloo's Director of Planning Approvals has accepted Zoning By-law Amendment Application Z-16-14 as complete.

On December 21, 2017 and January 3, 2018 respectively, the Region received revised draft plans and the required Regional re-circulation fee. The Region circulated prescribed agencies with the revised draft plan on January 4, 2018. A summary of prescribed external agency comments, as well as comments from Regional staff, is provided below.

The approximately 28.64 ha (70.8 ac) site is situated on the north side of Conservation Drive immediately west of Roy Schmidt Road, in the new Beaver Creek Meadows District area of the City. The subdivision plan dated July 29, 2015 from GSP Group provides development of primarily residential uses to be developed in a single stage and on full municipal services as follows:

Residential:
a) 242 lots for single detached dwelling units;
b) 7 blocks to contain a total of 130 street fronting townhouse dwelling units;
c) 1 block to contain a total of 44 back-to-back townhouse dwelling units; and,
d) 1 block to contain 20-25 Multiple Residential units.

School:
a) 1 block to contain a 2.99 ha (7.4 ac) school site.

Park/Open Space:
a) 2 blocks (approx. 4.86 ha (12 ac) total) for Open Space; and,
b) 1 block to contain a 1.45 ha (3.6 ac) park.

The comments below pertain to review of the submitted plan titled “Draft Plan of Subdivision”, prepared by GSP Group and dated July 29, 2015 (Project No. 09009.40) (last revised November 16, 2017), and associated submitted reports. The comments below have been numbered for discussion purposes.

DELEGATED AUTHORITY COMMENTS

1. Telecon Design (Telus) and HydroOne have each provided that they have no concerns regarding the applications.

2. Rogers Cable, Ontario Power Generation Inc., Waterloo Catholic District School Board, Conseil scolaire de district catholique Centre-Sud, and Le Conseil scolaire de district du Centre-Sud-Quest have not responded to this circulation. By separate letter including a copy of these comments, these agencies are asked to respond at their earliest opportunity if they have any comments.

3. City of Waterloo
As of the date of this letter the City of Waterloo has not provided comments on the application for draft plan of subdivision.

4. Township of Woolwich Engineering and Planning Services
In an email dated January 22, 2018, the Township’s Manager of Planning stated that Township comments dated October 18, 2016 (attached as Appendix A), which were provided in response to the original draft plan circulation, continue to apply. However the Township does note the removal of the walkway on the revised/updated draft plan. The Township is of the opinion that the deletion of the walkway and public access in this area would address Bullet No. 3 of the Township’s October 18, 2016 comments concerning the potential impacts to the adjacent farm. The Township will prefer some form of fencing along the common lot line to ensure that residents backing onto the farm fields will not encroach, use and/or dump onto the abutting lands in Woolwich. The Township is further of the opinion that it would be onerous for the property owners in Woolwich to continually monitor this area to prevent this from occurring.

5. Waterloo-North Hydro Inc.
6. In an email dated April 16, 2018 (attached as Appendix B), Waterloo-North Hydro Inc. (WNH) has advised that it will require that the owner/applicant be required to comply with its requirements and/or conditions of electrical service including the establishment of necessary easements, agreement(s), and detailed engineering design and construction. Furthermore, if necessary, the Developer will be responsible for all costs associated with relocation of any existing WNH facilities as a result of this development.

7. Union Gas
In an email dated January 4, 2018, Union Gas provided that it will require the necessary easements and/or agreements for the provision of gas services for this project to the satisfaction of Union Gas.

8. Canada Post
In an email dated January 15, 2018 Canada Post provided that there are no changes needed to its comments dated September 22, 2016 (attached as Appendix C). Canada Post provided general requirements for the location and construction of centralized Community Mail Boxes. Canada Post has requirements that can be secured through conditions of draft plan approval.

9. Bell Canada
In an email dated September 6, 2016 (attached as Appendix D), Bell Canada provided that it will require the necessary easements and/or agreements for the provision of communication/ telecommunication infrastructure for this project to the satisfaction of Bell Canada.

10. Grand River Conservation Authority
The Grand River Conservation Authority (GRCA) has reviewed the revised draft plan and supporting documentation and have identified in an email dated April 26, 2018 that their original comments dated August 11, 2017 (attached as Appendix E) will continue to apply.

11. Waterloo Region District School Board
In a letter dated September 21, 2016 (attached as Appendix F), the school board provided comments on the original proposed draft plan. Although the school board has not yet provided comments in response to the revised draft plan, it has indicated that its previous comments will continue to apply. When available, comments from the school board will be provided under separate cover.

REGIONAL COMMENTS

Water Services
12. Engineering and Planning staff have reviewed the above noted revised application(s).

13. The Servicing Strategy Report prepared for this development by Meritech, dated July 2016, is generally acceptable.
    a. The report recommends that a detailed water distribution study be prepared at detailed design stage to confirm the fire flow requirements for the subdivision, specifically the higher anticipated fire demand for the school, can be achieved by the proposed water system. Alternatively, building restrictions, materials, sprinkler requirements, etc. can be recommended based on more detailed information.
    b. The applicant should be aware that the Region is currently undertaking a study on the consolidation of Waterloo Pressures Zones 4B, 4C, and 5 which has a direct impact on the application. The objectives of the study are to ensure that once the zones are consolidated that the required level of service is provided to the existing and proposed communities. The study has evaluated the fire flow conditions under future conditions and have identified the existing and proposed fire flow availability. The detailed water distribution study shall incorporate the finding of the consolidation study.

Corridor Planning
Transit Planning
14. In 2018, transit service will be operating on Pinery Trail in this subdivision with the Route 73 Northlake (busPLUS). Transit is requesting 3 transit landing pads within this subdivision with the exact locations to be confirmed in the very near future. The final routing options for the

2018 network are in the later stages of being finalized. Once the final routing is determined Transit staff can identify more exact locations. The current cost for one transit landing pad is $2,800; the total funds for three transit landing pads required from the developer will be $8,400.

Road Traffic Noise Study

15. Corridor Planning staff has reviewed the Preliminary Environmental Noise Impact Assessment for the proposed plan of subdivision at 556 & 576 Conservation Drive, City of Waterloo, prepared by Meritech, dated July 2016. The Report has assessed traffic noise from Conservation Drive.

16. Corridor Planning staff generally concur with the conclusions and recommendations. The applicant will be required to provide a Detailed Noise Impact Assessment, including the height and exact location of the required noise walls. As the subject roads are within City of Waterloo jurisdiction, the recommendations of the study (including the installation of any noise barrier(s)) should be secured through a subdivision agreement with the City. The Region notes that the location of two noise walls identified on the "Noise Assessment Plan" within Appendix C of the Preliminary Environmental Noise Impact Assessment may change through the Detailed Noise Impact Assessment as result of the revised draft plan (last revised November 16, 2017).

Source Water Protection

17. Hydrogeology and Source Water (HSW) staff have reviewed the applicable technical reports submitted for the subject applications and can provide the following comments:

18. Planning Justification Report (GSP, 2016) and Supplementary Information (GSP, 28 July 2016): No comments.

19. Servicing Strategy Report (Meritech, 2016a)
    a. Prior to DPA:
        i. Any existing private wells at the subject property will need to be decommissioned by a licensed well driller in accordance with Ontario Regulation 903 (as amended);
        ii. Any existing septic systems at the subject property will need to be decommissioned in accordance with applicable provincial legislation; and,
        iii. Any existing tile drains at the subject property will need to be decommissioned in accordance with applicable provincial legislation.
    b. Conditions of DPA:
        i. A Salt Management Plan (SMP) will be required for the proposed school block at Site Plan Control. In the event that future revised Draft Plan of Subdivision applications include multi-residential, commercial, institutional, industrial, or community use properties are proposed, a SMP will be required for those properties at Site Plan Control.

20. Geotechnical Engineering Report (LVM, 2015): No comments.

21. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program (Stantec, 2016)
    a. General Comments:
        i. Page 4.3 indicates that at MW6—10, located within the SW portion of the property, Spring 2013/2014 groundwater levels were observed to be as

much as 0.9 m higher than previous levels presented in the NWSSS. This information should be incorporated into design considerations with respect to proposed SWM infrastructure, including lot-level, conveyance, 3rd pipe, and EOP infiltration galleries.

b. Prior to DPA:
    i. An updated groundwater contour map should be generated to reflect the high water table conditions observed across the monitoring area during the Spring 2013/2014 groundwater monitoring events. This should be submitted in an updated hydrogeological report;
    ii. The maximum groundwater elevations observed at each on-site groundwater monitoring well should be reported in m ASL in the report. This data needs to be summarized in tabular format in an updated hydrogeological report for all on-site wells, including the groundwater monitoring wells installed in 2015 by LVM; and,
    iii. Groundwater monitoring wells were installed across the site during the geotechnical investigations by LVM (2015) should be incorporated into the Phase I and Phase II monitoring program until site grading requires that they be decommissioned. Of particular interest are monitoring wells BH-4-15 and BH-05-15, which are installed in the vicinity of one EOP and one conveyance infiltration gallery. Information from these groundwater monitoring wells should be incorporated into the design considerations for these infiltration galleries. The hydrogeology report should be updated to reflect these additional groundwater monitoring locations.

22. Preliminary Stormwater Management Report (Meritech, 2016b)
    a. Prior to DPA:
        i. Table 1 indicates that “Control of Roof Leaders” is not included in the SWM Plan for the proposed development. A 3rd pipe collector system is potentially being proposed as a means to infiltrate clean roof top water from residential homes; however, this has not been confirmed in the preliminary design. It is noted that the 3rd pipe system would only collect water from the front half of the roof tops, and rear-yard roof runoff would be directed towards pervious surfaces. The conceptual design details of a 3rd pipe system were not presented in the Preliminary SWM Report. HSW will require more details as to how this system will function (i.e. will it be perforated pipe that actively infiltrates water within the road right-of-way, or will it be collected in a larger infiltration gallery and discharged in a more point-source manner?). These details need to be provided in an updated Preliminary SWM Report;
        ii. The proponent should be aware that a distributed approach to groundwater recharge will be required across the proposed development, where soil conditions permit;
        iii. Page 11 of the report cites the NWSSS and Geotechnical Report (LVM, 2015) when discussing groundwater conditions at the site. The Report does not reference the higher groundwater elevation conditions noted in Stantec (2016). The Preliminary SWM Report will need to be updated to make reference to the conditions noted in the Stantec (2016) report, and provide an opinion as to whether or not the feasibility of the SWM infrastructure is impacted by these results;
        iv. Page 14 indicates that infiltration measures that receive from the streets

should be designed to bypass in the winter months. HSW agrees with this recommendation, however, was this winter by-pass taken into consideration for the post-development water balance? This needs to be confirmed, and potentially included in a new water balance in an updated Preliminary SWM Report;

v. The assumed post-development infiltration rate on pervious surfaces was 228 mm/yr for all pervious areas within the proposed development. This is higher than either of the infiltration rates used for the pre-development conditions. The proponent should provide rationale as to a) why the property wasn't broken down into east and west portions (with different infiltration rates), as it was in the pre-development infiltration calculation, and b) why the overall infiltration rate for the site was increased to 228 mm/yr. If the rationale is not to the satisfaction of HSW, the post-development infiltration volumes will need to be re-assessed and summarized in an updated Preliminary SWM Report;

vi. The post-development infiltration area for the Clean-Water-Conveyance (CWC), or 3rd pipe system, was reported as 2.46 ha. Does this area represent the total roof area of the development, or only half of the roof area for the development? It is noted that earlier sections in the report stated that a 3rd pipe CWC system would only capture runoff from the front half of residential roof tops. This should be clarified in an updated Preliminary SWM Report;

vii. Do the infiltration galleries in Catchments 504, 505 and 506 take winter by-pass shutoffs into consideration when determining post-development infiltration volumes? This needs to be clarified in an updated Preliminary SWM Report;

viii. The Preliminary SWM Report should be updated to include an analysis demonstrating, in terms of m3/yr:

$$P_{Pre\text{-}Dev} = P_{Post\text{-}Dev}$$

$$ET_{Pre\text{-}Dev} + R_{Pre\text{-}Dev} + I_{Pre\text{-}Dev} = ET_{Post\text{-}Dev} + R_{Post\text{-}Dev} + I_{Post\text{-}Dev}$$

ix. The proposed Stage II Monitoring Program should include sodium and chloride in the groundwater quality monitoring program. Manual water levels and data logger downloads should be performed quarterly. The proposed Stage II Monitoring Program needs to identify which groundwater monitoring wells are proposed to included in the Program. Groundwater elevation and quality monitoring should be performed in the groundwater monitoring wells installed by LVM (2015) (particularly in BH-04-15 and BH-05-15). These details need to be included in an updated Preliminary SWM Report. And,

x. The Preliminary SWM Report should be updated to reflect the revision to the original draft plan of subdivision. Specifically, the water balance should be revisited to adjust for Block 243 (new proposed townhomes) and Block 251(proposed multi-res block).

b. Conditions of DPA:

i. Seasonal high groundwater elevations were observed during the spring months of 2013/2014 as presented in Stantec (2016). Proposed conveyance and EOP infiltration galleries will need to be designed to have

a separation between the bottom of the infiltration gallery and the maximum groundwater elevation observed at each respective location. The high water table across the site may influence where lot-level and 3rd pipe conveyance systems are feasible. This will need to be verified prior to approval of the Final SWM Report, to the satisfaction of the Region, City and GRCA;

ii. Any proposed lot-level infiltration galleries and / or 3rd pipe collector systems will need to be oversized by 15% to account for decreased performance over time and/or private homeowner disconnection;

iii. Any EOP infiltration galleries will need to be oversized by 15% to account for decreased performance over time;

iv. Is it feasible to install a CWC system throughout the entire 503 and 701 Catchments, given the generally lower-permeability soils identified in the eastern portion of the site? This should be addressed in the Final SWM Report;

v. It is HSW's preference to see infiltration of clean roof top runoff to achieve a net zero loss of pre-development infiltration volumes. Infiltration of impervious road runoff should only be incorporated if additional infiltration volume is required to achieve a net zero loss of pre-development infiltration volumes. This should be taken into consideration during detailed design;

vi. The proposed Stage III Monitoring Program proposes to monitor the performance of infiltration trenches/galleries and soak away pits on public property within 24 hours after a rainfall event once per year. These infiltration galleries should be equipped with continuous-read data loggers to evaluate the efficacy of the infiltration infrastructure. This will allow for multiple events of different sizes and timing to be analyzed. This detail can be included in the Final SWM Report; and,

vii. Page 28 indicates that building sump pumps should be connected to the internal storm sewer system. If a 3rd pipe CWC system is utilized at the proposed development, building sump pumps should be directed towards the CWC rather than to the storm sewer, as recommended in the NWSSS. This detail can be incorporated into the Final SWM Report.

23. General Comments

a. The proposed development lies within a Wellhead Protection Area (WHPA) D-2 for the Waterloo North Well Field, and requires a Section 59 Notice to be provided in accordance with the Clean Water Act.

b. Prior to DPA:

i. Generally, the SWM plan proposed in the Preliminary SWM Report is vague with respect to what types of engineered infiltration measures will be utilized at the proposed development. HSW recognizes that detailed stormwater infrastructure designs will be completed and presented in a Final SWM Report; however, there should be more direction in an updated Preliminary SWM Report. In order to match or exceed the pre-development infiltration volumes, it is HSW's preference to see distributed infiltration of clean roof top runoff in areas where soils are conducive to infiltration. This may be via lot-level infiltration galleries and/or 3rd pipe systems, or a combination of both. The post-development infiltration volumes can be topped up with runoff from impervious road surfaces;

ii. If a significant volume of infiltration is proposed from runoff originating from paved surfaces (via conveyance and/or EOP infiltration galleries), HSW will require a Chloride Impact Assessment to be completed prior to DPA, which can be included as a new section within an updated Preliminary SWM Plan; and,
iii. Alternatively, if winter by-pass valves are proposed on conveyance and EOP infiltration galleries, HSW would re-consider the need for a Chloride Impact Assessment.

Environmental Planning

24. Environmental planning staff has reviewed the reports and revised plans related to the proposed residential subdivision by Cook Homes at Conservation Drive and Beaver Creek Road in Waterloo. Environmental Planning staff have the following comments for your consideration:

25. Draft Plan of Subdivision

a. What is meant by the area identified as “Not included in dripline setback” (Block 256)? This area is identified as Significant Woodland and afforded a 10-metre buffer on Map 6 of the EIS but not identified as a Significant Natural Feature on Map 7 of the EIS. Please clarify.

26. Environmental Impact Study

a. Editorial note – Parts of the report do not have page numbers.

b. The Region’s Greenlands Network Implementation Guideline was endorsed by Regional Council in June 2016 (p.2). Please ensure that the EIS references the 2016 version of this document.

c. 4.6 Ecological Linkages (p.43) – While staff agrees that the Beaver Creek corridor is the primary existing ecological linkage, does the NWSSS not identify a linkage to be enhanced along the northern property limit (see NWSSS Figure 14.4)? Please clarify. Staff raised this issue at the October 2016 agency site walk and recommended considering enhancements to this linkage through removal of invasive species and planting a mix and range of trees/meadow species similar to the existing trail to the east of the subject lands.

d. 5.4.1 Encroachment into Buffers (p.53) – First bullet states “the buffer provided always meets or exceeds the minimum Region of Waterloo recommended buffer of 10m from dripline for Core Environmental Features.” Please note that a 10-metre buffer is a requirement under ROP Policy 7.C.11 and not a “recommendation.” In addition, the Conceptual Grading Plan and Figure 4 of the SWM Report (Meritech, July 2016) appears to show grading in the SWM block up to/within the dripline of the Core Environmental Feature (Significant Woodland). However, the encroachment is difficult to determine since the woodland dripline and buffer are not shown on the grading plan. Please clarify with respect to how site alteration in this area would comply with ROP Policy 7.C.6.

e. 5.6.1 Wetland/Woodland Edge Buffer (p.62) – The last sentence of this section makes reference to a “farm dump area”. Where is this area located and could it be identified on one of the maps (i.e. EIS Map 7)?

f. 6.3 Post Construction Monitoring (p. 66) – How long will post construction monitoring continue following 90% buildout of the subdivision? Please note that the Region typically requires 2 years of post-construction monitoring.

27. Stormwater Management Report

a. Figure 4 – The limit of grading for the SWM facility appears to be coincident/within with the boundary of the Significant Woodland. The minimum buffer for Regional Core Environmental Features is 10 metres according to the ROP. Please clarify.

b. Quantity (p. 15) – For Catchment 504, if a bioswale is to be used (instead or oil/grit separator), where would it be located? The last sentence of this section is somewhat vague in this regard. Please clarify.

Archaeology

28. Staff have received the Archaeological Assessment Report Entitled, "Original Report” Archaeological Assessment (Stages 1 & 2) by Archaeological Research Associates Ltd. dated June 17, 2016, and acknowledge that a Stage 3 site-specific assessment is recommended for two locations of archaeological materials: Euro-Canadian Findspots 3 and 4. Such assessment, as well as an acknowledgement letter from the Ministry of Tourism, Culture and Sport (with two (2) copies of assessment provided to Region) that such report has been entered into the Ontario Public Registrar of Archaeological Reports, will need to be completed prior to Draft Plan Approval.

General

29. If any part of the development may potentially create a Non-Municipal Year-Round Residential System (NMYRRS) under the Safe Drinking Water Act (SDWA), 2002, such must be confirmed prior to draft plan approval and in consultation with the City of Waterloo; additional requirements may be applicable under the SDWA if a NMYRRS is confirmed.

30. Pursuant to the Region’s standard conditions for Draft Plans of Subdivision and Condominium, a development is required to contain a permanent secondary access if more than 26 units are developed with only one point of access. The north-west portion of this plan would exceed this maximum requirement, and, depending on when/how lands to the east are ultimately developed, all lands north of Street ‘E’ could also exceed this maximum. Additional information showing how this issue can be resolved will be required prior to issuing a decision.

31. Regional staff has no objection in principle at this juncture with the proposed draft plan of subdivision, and associated zone change application. As stated in the aforementioned comments, Regional staff will require additional information prior to granting draft approval, and will consider additional comments (including the City’s) as they are received.

Region Planning Fees

32. Regional staff acknowledges receipt of the application fees for the plan of subdivision, and zone change and EIS review. The developer should be advised of the following fees and charges (subject to annual change by By-law):

Subdivision Plans:

Draft Approval - $4,025.00 Registration Release - $2,000.00

If you have any questions, please don't hesitate to contact the undersigned.

Yours truly,



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Principal Planner
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(519) 575-4757 ex. 3120

cc. N. Hardacre, MCIP, RPP, City of Waterloo Planning (via email)
J. Scarfone, Manager of Planning, Township of Woolwich (via email)
R. Wei, Waterloo North Hydro (via email)
J. Bere, Canada Post Corp. (via email)
M. Palynchuk, Access Networking Provisioning (Bell) (via email)
Grand River Conservation Authority (via email)
Waterloo Region District School Board (via email)
Region of Waterloo – Water Services; Corridor Planning; Source Water Protection; Environmental Planning; and, Cultural Heritage (all via email)

THE CITY OF Waterloo | **Integrated Planning & Public Works**

Planning Approvals

August 31, 2018

Mrs. Brenna MacKinnon
Planning, Development and Legislative Services
Regional Municipality of Waterloo
150 Frederick Street
Kitchener, ON N2G 4J3

Mrs. Kristen Barisdale, MCIP, RPP
Associate, Senior Planner
GSP Group Inc.
72 Victoria Street South, Suite 201
Kitchener, ON N2G 4Y9

Mrs. MacKinnon & Mrs. Barisdale:

Re: Second Submission Comments
Zone Change Application Z-16-14
Draft Plan of Subdivision 30T-16402
556, 560 and 576 Conservation Drive

Please accept this correspondence in relation to Zone Change Application Z-16-14 and Draft Plan of Subdivision Application 30T-16402 and as a formal response to two submissions made by GSP Group on November 30, 2017 and June 15, 2018. Details of the materials provided in each submission are outlined as follows:

Submission of November 22, 2017:

- Revised Draft Plan of Subdivision, prepared by GSP Group, dated July 29, 2015 and revised November 16, 2017, annotated with changes.

Submission of June 15, 2018:

- Draft Plan of Subdivision, prepared by GSP Group, dated July 29, 2015 and revised February 23, 2018
- Preliminary Environmental Noise Impact Assessment, prepared by Meritech, dated May 2018
- Conceptual Erosion & Sediment Control Plan, dated February 2018
- Servicing Strategy Report, prepared by Meritech, dated May 2018
- Preliminary Stormwater Management Report (revised), prepared by Meritech, dated May 2018

City of Waterloo staff has completed a preliminary review of the information listed above and provides the listed comments below, in response. Prior to the City being in a position to recommend Draft Approval of the subdivision to the Region, or approval of the Zone Change application to Waterloo City Council, the following must be addressed and responded to in writing, with supporting studies and/or plans where necessary.

PART A – PLANNING COMMENTS

Density

1. Based on the current Draft Plan, the density of the proposed development is between 44 and 50 residents and jobs per hectare (rj/ha). The planned density of the Beaver Creek Meadows District Plan (BCMDP) area is 58 rj/ha as per OPA 15, which applies to the entire BCMDP area. Any shortfalls in the density of this subdivision area will impact, and need to be made-up in, other areas of the BCMDP. Please confirm the total density (in rj/ha) to be generated by this development

2. The density of the Mixed-Use Node appears under capacity compared to the land uses and density contemplated in the Official Plan and BCMDP. Density targets included within Table 3 of the District Plan for Mixed-Use Medium Density Residential is between 60 to 100 units per hectare. The proposed Draft Plan is showing approximately 53 units per hectare for the Mixed-Use Medium Density Residential lands. Please demonstrate how the density of the Node is consistent with the planned density outlined in the BCMDP and the Official Plan. Consider increasing density, in particular Block 251 (Multiple Residential).

Park Block and Open Space Block

3. Block 253 (Park) must be a minimum dedication of 5% of the Draft Plan lands. All natural features and associated buffers must not be included within this calculation. Land within buffers will not be considered as contributing to the parkland dedication requirements (Official Plan policy 8.2.4(12)).

4. A portion of Block 253 (Park) remains within the buffer area of the adjacent natural environmental feature. Revise the limits of Block 254 (Open Space) and Block 253 (Park). All natural features and associated buffers should be within Block 254 (Open Space). All lands within Block 253 (Park) should be unencumbered.

5. A portion of Block 256 (SWM) remains within the buffer area of the adjacent natural environmental feature. Revise the limits of Block 254 (Open Space) and Block 256 (SWM). All natural features and associated buffers should be within Block 254 (Open Space). All SWM features (including infiltration galleries) and trails/maintenance access should be located within the limits of Block 256 (SWM). Please also refer to the Environmental comments below.

6. Block 253 (Park) is in the same location as the park lands identified in the BCMDP, however, the south side of the park frontage is limited and partially blocked by Block 244 (Street Townhouses). While the park frontage has been slightly increased from previous versions of the proposed Draft Plan, the frontage to the park still remains limited due to the location of Block 244 (Street Townhouse). Policy 3.8.3 of the BCMDP requires that the park maximizes its accessibility to residents and visual presence within the community. Policy 3.8.4 of the BCMDP identifies that parkland should have sufficient frontage to the satisfaction of the City of Waterloo, to enhance visibility. Furthermore, street townhouses were not contemplated in the BCMDP in this location (Block 244).

7. Block 253 (Park) is in the same location as the park lands identified in the BCMDP, however, the north side of the park frontage is limited and partially blocked by Lot 154 and Lot 155. Policy 3.8.3 of the BCMDP requires that the park maximizes its accessibility to residents and visual presence within the community. Policy 3.8.4 of the BCMDP identifies that parkland should have sufficient frontage to the satisfaction of the City of Waterloo, to enhance visibility. Please remove Lot 154 and Lot 155.

School Block

8. As per the BCMDP, the subject lands are planned to include an elementary school in a central location and north of the Mixed-Use Node. Block 252 (School) is 2.99 ha in size, consistent with policy 3.7.5(b) of the BCMDP. Final site design and layout of the school site should be coordinated with the School Board, in accordance with policies 3.7.5 of the BCMDP.

Single Detached Lots (Lots 1-242)

9. Additional information is required in support of the requested site specific reductions. Please provide a Lot Plan(s) showing a typical single detached dwelling on a typical lot (both internal and corner lots) with the requested yard setbacks. Please also provide additional rationale and/or justification for each proposed reduction to the zoning regulations, including encroachments.

10. Staff have concerns with the request to reduce front yard setbacks. Front yard setbacks should comply with zoning standards. A front yard setback of 4.0 metres plus an allowance for a porch encroachment of 1.5 metres will negatively impact the streetscape. This results in a minimum front yard setback of 2.5 metres deep. Rideau River Street and Pinery Trail have larger front yard setbacks. A front yard depth of 4.0 metres is insufficient for a car to park in the driveway. In addition, a 2.0 metre wide easement is required along the frontage of each lot.

11. Lot depths shown are a minimum of 28 metres (with the exception of Lot 108 and Lot 109 which has a depth of 27.8 m). This is below the typical lot depth of 30 m. Consider increasing lot depths to achieve required front yard and rear yard setbacks, and to provide appropriate amenity area in the front and rear yards.

12. Staff have concerns with the request to reduce side yard setbacks. Reduced side yard setbacks will increase the need for easements to access the rear yard, provide insufficient space to maintain the house and side yard, and provide insufficient space for infrastructure (i.e., meters, air conditioning units). The need for easements to access private single detached backyard does not seem reasonable. This indicates the house is too large for the lot. Side yard setbacks should comply with zoning standards.

13. Lot 138 and Lot 242 appear to be very small corner lots. Ensure lot dimensions are such that minimum flankage yard setbacks can be accommodated along the entire length of the flankage façade (i.e., both front and back corners of the dwelling). Consider increasing the size of these lots or provide Lot Plans for each lot to show how required setbacks will be met.

14. The requested maximum porch encroachment into the side yard of 1.5 metres is greater than either of the minimum side yard setbacks requested (0.6 metres and 1.2 metres). This is not reasonable.

15. Confirm proposed coverage. Combination of reduced front yard, rear yard and side yards means the dwelling is too large for the lot. Smaller lots, shorter front yards and reduced side yards are all out of character with the existing homes on Pinery Trail and Rideau River Street and would not provide sufficient amenity space for future home owners/residents.

16. Confirm proposed garage and driveway dimensions. Minimum standards for garage sizes and driveway sizes will be recommended through zoning to ensure appropriate and sufficient parking is provided.

<u>Townhouse Blocks (Blocks 243-250)</u>

17. Additional information is required in support of the requested site specific reductions to the various forms of dwelling units. Please provide Lot Plan(s) showing typical street townhouse dwelling and requested yard setbacks. Please also provide additional rationale and/or justification for each proposed reduction to the zoning regulations, including encroachments.

18. Provide additional information related to the Back-to-Back Townhouse dwellings proposed on Block 250 in the form of a concept plan showing building form and setbacks. Additional rationale and/or justification is also required for the requested setbacks, including encroachments.

19. Provide a conceptual lot layout for all townhouse blocks. Are the townhouse dwellings intended to be condominium units? Lotted on the final plan to be registered?

20. Please remove Block 244 (Street Townhouses). Townhouse dwellings are not contemplated in this location in the District Plan (refer to #6).

21. Please increase the depth of Block 248 and 249 (Street Townhouses). A depth of 25.1 to 26.2 metres does not appear to be sufficient for the intended units while still providing appropriate outdoor amenity area.

22. Block 250 (Back-to-Back Townhouses) is only 28 metres deep, while Block 246 (Street Townhouses) is 27 metres deep. Confirmation is required that a depth of 28.0 metres is sufficient for back-to-back townhouse units without negatively impacting the streetscape and still providing adequate outdoor amenity area. Please demonstrate how this design would be achieved with such a narrow block depth (see also #18).

23. It is not clear how uses along Conservation Drive will address the street while avoiding backing onto interior blocks. Policies 3.2.10 and 3.2.19(b) of the BCMDP discourage back-lotting onto municipal streets such as Conservation Drive and Beaver Creek Road. Block 248 and 249 (Street Townhouses) are proposed to front Conservation Drive and Street A, and back onto Street F. Having Block 248 and 249 'back' onto the front yards of the townhouse units in Block 250 (Back-to-Back Townhouse) is not an appropriate configuration. Please consider revising the configuration of the townhouse blocks. Staff have reviewed possible configurations for this area and are available to meet to discuss these options, should you wish.

24. Please confirm if commercial is proposed within any of the Townhouse Blocks. This is strongly encouraged within the Mixed-Use Medium Density Residential lands and within the Mixed-Use Node. Blocks 245, 246 and 250 could contain a mixture of street townhouses and live/work style townhouses to achieve density targets and design priorities of the BCMDP.

25. Confirm proposed coverage. Combination of reduced front yard, rear yard and side yards means the dwelling is too large for the lot. Smaller lots, shorter front yards and reduced side yards are all out of character with the existing homes on Pinery Trail and Rideau River Street and would not provide sufficient amenity space for future home owners/residents.

26. Staff have concerns with the request to reduce front yard setbacks. Front yard setbacks should comply with zoning standards. A front yard depth of 4.0 metres plus an allowance for a porch encroachment of 1.5 metres will negatively impact the streetscape. This results in a minimum front yard setback of 2.5 metres deep. Rideau River Street and Pinery Trail have larger front yard setbacks. In addition, a front yard depth of 4.0 metres is insufficient for a car to park in the driveway. A 2.0 metre wide easement is required along the frontage of each lot.

27. A maximum height of 10.5 metres is being requested for townhouse dwellings. A height of greater than 10 metres will require an Official Plan Amendment for Blocks outside the Mixed-Use Node (i.e., Block 243 (Street Townhouse)).

28. Block 243 has been modified from single detached units to townhouse units. This is consistent with the direction of the BCMDP.

29. Confirm proposed garage and driveway dimensions. Minimum standards for garage sizes and driveway sizes will be recommended through zoning to ensure appropriate and sufficient parking is provided.

30. Have stacked townhouse dwellings been considered?

Multiple Residential Block (Block 251)

31. Please confirm built form proposed for Block 251 (Multiple Residential). Show conceptual plan(s) for the proposed / possible development of this block.

32. Please show dimensions (i.e., frontage) on the Draft Plan for Block 251 (Multiple Residential).

33. Density targets included in the BCMDP for the Mixed-Use Medium Density Residential lands within the Mixed-Use Node is between 60 to 100 units per hectare. The proposed density of Block 251 (Multiple Residential) is 30 to 37 units per hectare. Consider increasing the density of Block 251 (Multiple Residential).

34. Additional land will be required along the eastern boundary of Block 251 (Multiple Residential) which will form part of the ultimate road allowance and future road construction of Roy Schmidt Road (refer to 'Roy Schmidt Road' comments below).

35. Commercial is strongly encouraged to be included as part of the development of Block 251 (Multiple Residential). This aligns with the policies of the BCMDP.

36. The Draft Plan has been revised from previous versions to include Multiple Residential on Block 251 instead of townhouse units. This change is consistent with the BCMDP.

37. It is recommended that the land uses of Block 251 (Multiple Residential) be coordinated and compatible with the lands to the east which also form part of the Mixed-Use Node.

Mixed-Use Node

38. Special Provision Area 37 (SPA 37) of the Official Plan applies to a portion of the subject lands identified as the Beaver Creek Node, which allow for higher densities and building heights, as well as a wide range of uses to create a mixed-use centre with a concentration of neighbourhood-oriented retail, service commercial uses, institutional employment and residential uses. The extent of the node has been determined through the BCMDP. Blocks 245 to 251 are within the identified node area. Development within these blocks is permitted to be as high as 20 metres and permitted to have a density of up to 300 bedrooms per hectare.

39. SPA 37 of the Official Plan encourages a mix of uses. Staff recommends that a wide range of uses be considered for Blocks 245 to 251 including commercial, and to develop these blocks as a mixed-use area, consistent with SPA 37.

40. Policy 3.4.14 of the BCMDP outlines a range of commercial uses both permitted and encouraged within the Mixed-Use Node. Staff recommends commercial uses and live/work style units within the Mixed-Use Node (refer to policy 3.4.13 of the BCMDP). The inclusion of limited commercial uses and live/work units, well integrated with residential uses within the Node, is an important component of the overall vision and structure of the BCMDP.

41. The heights of the buildings within the Mixed-Use Node should be a minimum of 9.0 metres and should not exceed six storeys. The BCMDP contemplates a range of uses within the Node, with a high degree of pedestrian orientation. Policy 3.6.2 of the BCMDP encourages a range of residential uses to provide accommodation for a broad income and social mix. The proposed development should be consistent with policies 3.6.3 and 3.6.4, which require high quality urban design and visually interesting spaces that consider pedestrian movement and streetscapes.

42. At a minimum, buildings along Conservation Drive should be designed to accommodate future main floor commercial uses (minimum ground floor height will be recommended).

<u>Roy Schmidt Road</u>

43. Roy Schmidt Road shall have a road allowance width of 18.0 metres, to be measured at 9.0 metres on either side of the historic centre line of the road.

44. The developer shall coordinate the design of Roy Schmidt Road and cost-share on the reconstruction with the owner/developer of the lands on the east side of the road (Draft Plan 30T-17403), including a new multi-use trail extending from Conservation Drive to the City of Waterloo boundary north of Pinery Trail.

45. The width of Roy Schmidt Road south of Street E does not appear to be 18 metres, specifically along the eastern property line of Block 251 (Multiple Residential). The configuration of Block 251 (Multiple Residential) should be modified to allow sufficient road width.

46. The Draft Plan shows Roy Schmidt Road to be closed between Rideau River Street and Pinery Trail. Roy Schmidt Road is only proposed to be closed at the intersection of Conservation Drive. The remainder of Roy Schmidt Road is to remain open. The width of Roy Schmidt Road north of Pinery Trail shall be 18.0 metres. Lot 211 and Lot 212 will need to be revised to allow sufficient road width.

47. Registration of Lots 226 to 242 will be conditional upon the construction of Roy Schmidt Road.

48. Roy Schmidt Road is to be closed at Conservation Drive. A trail connection is required from Roy Schmidt Road to Conservation Drive in the location of the shared boundary between this development and the adjacent lands (Draft Plan 30T-17403), in the form of a 4.0 metre walkway block for a multi-use trail. If additional land is required to provide proper grading and drainage of the trail, this additional land will be included in the walkway block and conveyed to the City. City land outside that needed for the walkway block may be declared surplus. Such lands may be sold by the City in accordance with the City's Disposition of Property process.

49. Show accurate lot lines of adjacent / surrounding lands on the Draft Plan, including lands owned by the City in the area of Roy Schmidt Road.

Street Alignment

50. Staff support the accesses provided to the future development lands to the west (Brohman lands), through the extension of Pinery Trail and Street B. The precise location of these streets should be coordinated with the adjacent land owner throughout the Draft Plan process. The final location of Pinery Trail and Street B are to be located in such a way as to permit, and not hinder, the appropriate development of the adjacent lands (Brohman lands).

51. Show and dimension daylight triangles where streets intersect, particularly in the location of Street H, at Conservation Drive. How will reduced flankage affect visibility on corner lots? Daylight triangles shall be provided as per TAC guidelines.

52. The configuration of Street corners should be curved. Ninety degree angles are not desirable and create driveway issues (Street E).

53. Consider revising Street E and Street F as one Street name (as a future crescent). The current configuration of Street E and Street F creates confusion – where does one end and the next begin? Street G and Street H could remain with separate names.

54. Temporary cul-de-sacs will be required at the terminus of Street B, Pinery Trail and Street E.

55. Include 0.3 metre reserves between Conservation Drive and proposed residential Blocks to restrict driveway access.

56. Street H alignment / functioning is to conform with correspondence dated July 7, 2017 *(Conservation Drive and Beaver Creek Road Upgrades and Extension of Municipal Services – Update to Transportation Forecasts and Left Turn Lane Requirements, Stantec, 2017)*, which was provided to the Beaver Creek Meadows Developer's Group on July 14, 2017.

57. A Traffic Management Plan is required to be submitted with all subdivision applications, as per Policy 3.9.1(f) of the BCMDP. Traffic calming measures are to be recommended, reviewed and implemented as the subdivision is built, rather than retrofitted after the fact. Such measures will be included as conditions of Draft Approval, to be implemented as the subdivision is built out. For additional information refer to Part D.

Pedestrian Connectivity

58. There is a lack of pedestrian connections between streets. Please show walkways in strategic locations throughout the Draft Plan to increase pedestrian connectivity and to reduce walking distances.

59. In previous versions of the Draft Plan an east-west walkway was proposed between Street B and Rideau River Street. This connection has since been removed. It is recommended this connection be retained as limited east-west connections exist in this area. Maintaining this connection is consistent with policies 3.9.5 and 3.9.6 of the BCMDP.

60. A pedestrian connection should be included between Street B and Street D to improve north south pedestrian connections, consistent with policies 3.9.5 and 3.9.6 of the BCMDP.

61. The Draft Plan shows very limited active transportation connections. This is inconsistent with policy 3.9.4 of the BCMDP, which requires the active transportation network to be designed to ensure convenient and safe travel throughout the community. Proposed lots along the north limit of the Draft Plan have no direct access to key areas such as the school, park, Mixed-Use Node, or transit services. Policy 3.9.5 of the BCMDP requires an active transportation network that provides multiple options for pedestrians and cyclists to travel within the community.

62. Map 5 of the BCMDP shows a proposed trail connection running north-south including a route along the buffer area on the west side of the plan. Staff recommends that a pedestrian connection along the buffer be implemented, subject to environmental sensitivities. The EIS submitted as part of this proposal should confirm the feasibility of implementing a trail in this buffer area prior to final development approval. All trails should be developed in accordance with policies 3.9.7- 3.9.15 of the BCMDP.

63. A continuation of the Avon Trail was previously shown along the north boundary of the Draft Plan, as per policy 4.4.8 of the BCMDP and has since been removed. This is an important community trail connection.

64. Consider including a walkway connection from the roundabout at Beaver Creek Road and Conservation Drive to Street E / Street F through Block 249 (Street Townhouse).

65. Overall, the proposed Draft Plan does not meet the intent of Policy 3.9.2 to 3.9.6 for an active transportation system. Please refer to Map 5 of the BCMDP.

Phasing

66. If phasing of the development is proposed, please submit a Phasing Plan. Also, confirm how the phasing of the development will relate to the availability and timing of the broader stormwater management plan.

Retaining Walls

67. All proposed retaining walls throughout the plan (i.e., at west property limit, within SWM Blocks, etc.) shall be removed or minimized to the extent possible.

Noise

68. The Preliminary Environmental Noise Impact Assessment, prepared by Meritech, dated May 2018 recommends a 1.8 metre high noise wall along Conservation Drive and Street A, along with noise warning clauses for lots within 20 metres and 40 metres of Conservation Drive. Staff do not support the use of noise walls to mitigate noise levels generated by traffic along Conservation Drive. Acceptable measures include building orientation / site layout, berms, and setbacks (physical separation).

Design Considerations

69. Development of the subject lands should be consistent with urban design policies of the BCMDP (Section 4). Generally, the Draft Plan should reflect a complete community with high quality design, a high degree of connectivity, well designed and attractive streetscapes, and a sense of identity. Good urban design principles should also be incorporated into the built form, including each dwelling unit type. In particular, townhouses should be consistent with policies 3.4.17-19 of the BCMDP.

70. The development as a whole should be consistent with the City's Urban Design Manual.

71. An Urban Design Brief was not submitted. Subdivision Urban Design Guidelines will be required as a condition of draft approval.

PART B – ENVIRONMENTAL PLANNING COMMENTS

72. When compared to the previous submission, the wetland limits shown on the Draft Plan of Subdivision (last revised February 23, 2018) have changed. The rationale for the new limits needs to be confirmed, as does GRCA's acceptance of the new limits. Also, the wetland limits shown on the Draft Plan differ from those shown on the Conceptual Erosion and Sediment Control Plan (dated February 2018). The wetland limits on the Conceptual Erosion and Sediment Control Plan match those from the previous version of the Draft Plan. Further, the dripline shown in the northwest corner of the site on the Draft Plan is different than that shown on the Conceptual Erosion and Sediment Control Plan.

73. Figure 6 of the Preliminary Stormwater Management Report (Revised May 2018) includes a note that reads "Dripline knob to be removed". Through the EIS, the "knob" is mapped as Significant Woodland (Core Natural Feature) and Significant Wildlife Habitat (Supporting Natural Feature). Official Plan policies 8.2.4(2) and 8.2.5(2) require the form and ecological function of such features to be maintained, enhanced or, where feasible, restored. Policies 8.2.4(3) and 8.2.5(3) also restrict development and site alteration within such features to a limited range of uses/activities. As per the Official Plan and the North Waterloo Scoped Subwatershed Study (NWSSS), the feature should remain intact and be afforded a 10 metre buffer. In terms of that buffer, as set out in Official Plan policy 8.2.4(9), buffers are to remain in or be restored to a primarily natural state and portions of stormwater management facilities may be permitted in them where the feature is enhanced, no other alternative location is feasible, low impact development measures are implemented to the extent feasible outside the buffer, root zones are not impacted, and the facility replicates or complements an existing function of the buffer lands.

74. It is unclear whether the constructed wetland will include a cooling trench. Figure 6 of the Preliminary Stormwater Management Report (Revised May 2018) shows a level spreader but a cooling trench is referenced on page 29.

75. While the Preliminary Stormwater Management Report (Revised May 2018) sets out recommendations for the during-development and post-construction monitoring programs, the Terms of Reference for each phase will need to be finalized at the time of transition. This comment also applies to the monitoring recommendations put forward in the EIS. Further, while the 2016 and 2017 Pre-development Biological Monitoring Reports were submitted in early 2017 and 2018 respectively, the 2016 Groundwater and Surface Water Monitoring Report and subsequent reports are still outstanding. These reports should be submitted together and as soon as possible following the end of the monitoring year.

76. Based on the direction provided in the District Plan, a trail, that would have to be supported through the EIS if it is in the buffer, should be incorporated into the plan that extends from Block 256 (Stormwater Management) down to Conservation Drive. Further, approximate trail locations should be shown.

77. Section 5.4.7 of the EIS states that the wet cells of the pond have been placed outside of the Category 2 habitat of the Blanding's turtle which will avoid the need for registering any maintenance works for an exemption under the ESA. However, in MNRF's comments, it was noted that the stormwater management pond could become Blanding's Turtle habitat in the future and would therefore require any maintenance of the pond to proceed in consultation with MNRF to ensure the species is not negatively impacted. This needs to be clarified and City Engineering staff need to be made aware of the requirements.

78. The Preliminary Stormwater Management Report (Revised May 2018) and the Conceptual Erosion and Sediment Control Plan (dated February 2018) show part of an infiltration gallery within the wetland buffer (to varying degrees, as different wetland limits are used on each plan). Official Plan policy 8.2.4(9) states that buffers are to remain in or be restored to a primarily natural state and portions of stormwater management facilities may be permitted in them where the feature is enhanced, no other alternative location is feasible, low impact development measures are implemented to the extent feasible outside the buffer, root zones are not impacted, and the facility replicates or complements an existing function of the buffer lands. It has not been demonstrated that these criteria are met. If it can be shown that the criteria are met, details on the design of the infiltration galleries are needed, as they may be incompatible with a naturalized buffer. Potential areas of incompatibility include whether access to the galleries needs to be maintained, whether the vegetation over top of the galleries need to be maintained/manicured, whether tree roots will interfere with gallery function as the buffer matures from a meadow community to a treed one, and whether the galleries will need to be maintained in the short or long term, since accessing them would disrupt the buffer and remove any habitat that has been created, the provision of which is identified as a key ecological enhancement in the NWSSS.

79. Sections 3.2 and 5.4.3 of the EIS note that Stantec is preparing a hydrogeological study as part of the application. A Terms of Reference for a hydrogeological assessment was submitted to the City on November 9, 2016. Has that assessment been completed and submitted?

80. Given the required removal of the suitable bat habitat features (residential buildings and isolated landscape trees), is there opportunity to create bat habitat in the buffer areas?

81. Figure 14.4 of the NWSSS shows the northern edge of the property as an area to enhance in terms of its linkage function. While the EIS notes the lack of linkage connection/corridor function the hedgerow currently provides (page 41 and 50), the feasibility of enhancement has not been evaluated or addressed.

82. The Draft Plan of Subdivision (last revised February 23, 2018) shows encroachment into buffers in three locations – a) in the residential lots that back onto the northern hedgerow, b) in the stormwater management block, and c) in the park block.

    a) With respect to the residential lots that back onto the hedgerow, while a 5 metre buffer is shown on the Draft Plan, both the hedgerow and buffer are, to varying degrees, within the lots. Could the lots be graded without interfering with the hedgerow? What is to prevent removal of the hedgerow by future homeowners if it is within the lot lines? Further, the Preliminary Stormwater Management Report (Revised May 2018) shows both a maximum 2 metre high retaining wall and infiltration gallery along that boundary. It is presumed such infrastructure would require the removal of the hedgerow. The previous comment dealing with the linkage function of the hedgerow needs to be addressed to inform how the hedgerow will be managed. In addition to the

impact the retaining wall and infiltration gallery would have on the hedgerow, their location would also pose significant challenges in terms of infrastructure maintenance. Access to the retaining wall would be severely restricted and the infiltration gallery would be on a number of private properties, with limited access and no opportunity to ensure functionality or prevent removal.

b) With respect to the stormwater management block, the criteria listed in Official Plan policy 8.2.4(9) needs to be fully addressed in order to contemplate the location of the constructed wetland and infiltration gallery as currently proposed. Specific concerns regarding the infiltration gallery in the buffer are previously noted. In addition to these concerns, the proposed maximum 1.7 metre high retaining wall would pose a significant challenge in terms of maintenance and buffer functionality, as the buffer would need to be cleared to enable access.

c) With respect to the park block, Official Plan policy 8.2.4(9) states that permitted uses within buffers are to be limited to low impact uses consistent with those permitted within designated features. Active park land is not one of those uses. Further, the policy states that buffers are to remain in or be restored to a primarily natural state. The buffer lands are therefore to be removed from the Park Block. This is consistent with Official Plan policy 8.2.4(12) which states buffers will not be considered as contributing to parkland dedication requirements. The situation is further complicated because a trail is to be potentially built within the buffer (as per an earlier comment). The combination of an infiltration galley and a trail could result in very little naturally-vegetated buffer.

83. The EIS recognizes that the timing of construction activities must have regard for the breeding bird season. Consistent with the Westside Subdivisions, a timing window of April 1 to September 10 should be used. All land clearing, earthen works, servicing works, infrastructure work and tree removal between April 1 and September 10 should be prohibited unless a nesting survey is undertaken that demonstrates the activities will not have the potential to disturb or destroy migratory birds or their active nests.

84. The EIS notes that there will be an increase of 11-46% in post-development infiltration (page 56), with the Preliminary Stormwater Management Report (Revised May 2018) providing further details (page 25). While the NWSSS recommends existing infiltration rates be maintained or increased, a potential increase of 46% seems significant. Section 4.2 of the EIS notes that the wetlands' primary hydrologic function appears to be the storage of surface water and the storage and expression of groundwater. Would increasing the rates this substantially result in impacts to the wetlands? Is groundwater mounding a risk?

85. As per the direction provided by the NWSSS and the EIS, a condition of draft plan approval will require the distribution of an environmental stewardship brochure. The City has a universal one available for purchase entitled "Naturally Your Waterloo". Experience has shown that requiring builders to distribute the brochure to new

homeowners is challenging because of the time span over which the development occurs. Given this, the applicant should either be required to purchase all of the brochures needed for the subdivision upfront from the City and distribute them as appropriate or provide the funds necessary to print all the required brochures but rely on the City to distribute them as the subdivision builds out (e.g. it could be given out alongside the Building Permit). Further discussion is needed to determine the preferred approach.

86. The environmental lands and their buffers (i.e. the Open Space blocks) are to be dedicated to the City free of charge and without any encumbrances.

87. Under section 5.6.1 of the EIS, a historic farm dump is noted. This area will need to be cleaned up as a condition of approval.

88. Invasive Phragmites is discussed under section 5.6.3 of the EIS. An invasive species management plan will need to be provided as a condition of approval.

89. City-standard chain link fencing needs to be installed along the private-public interface.

PART C – LANDSCAPE COMMENTS

90. Block 253 (Park) cannot include buffer lands within the lands calculated toward the 5% parkland dedication. Likewise, areas of the park encumbered with infrastructure such as stormwater management facilities and infiltration galleries cannot be included in the 5% parkland calculations.

91. Why is the Avon Trail link deleted? This is an important community trail connection.

92. The hedgerow at the north and its 5.0 metre buffer are now incorporated into the rear lots of homes. This is not a viable way to protect, conserve and enhance this hedgerow. Regionally significant bird species are noted in this hedgerow therefore measures to preserve and enhance this feature should be undertaken. There is very limited protection for hedgerows when located within private property.

93. The servicing plan indicates that infiltration infrastructure is proposed in the lots at the north end of the site, between Rideau River Street and Street B. They seem to indicate water will flow off site, which is not permitted.

94. The servicing submission from Meritech (dated May 2018) shows the proposed locations for infiltration galleries. Most of these are inaccessible for future maintenance. Please revise or confirm how maintenance will be addressed.

95. The proposed development to the east (Draft Plan 30T-17403) does not show a vehicular connection at the end of Street E as indicated on this Draft Plan. Coordination between plans and consulting firms is required.

96. The stormwater management pond maintenance access road is typically designed to form part of the overall pedestrian trail system. Linkages to the park and to the north-south trail system on the west edge of the property should be incorporated into the access road.

97. It is recommended that a 2.0 metre wide (minimum) flat area be designed behind the residential lots that back onto the stormwater management pond rather than the 3:1slope beginning at property line.

98. The location of the infiltration gallery proposed within Block 252 (School) must be accepted by the School Board, to not encumber the development potential of this block.

99. The EIS does not speak to the north-south trail connection through the buffer lands or other trails. The trail system should be shown conceptually. This trail connection should be provided within the buffer from Conservation Drive to the stormwater management pond. The City standard 3.0 metre wide asphalt trail with supporting buffer plantings is required.

100. The trail/linkage system should be designed holistically so that walkway blocks connect to major points of attraction such as the park and the school. Although the BCMDP shows this conceptually, the Draft Plan does not create these linkages. Linkages are not linking street to street in a linear fashion. Future residents should be able to use a walkway block from Street B to connect to Street D, and then to the park, etc.

101. Block 253 (Park) must be unencumbered and for recreational purposes only. Portions of the park that do not provide useable parkland should be eliminated from the overall park calculation and/or moved out of the park block. These include the infiltration gallery and the sanitary service. These facilities are typically not permitted in parkland.

102. Block 253 (Park) should be 80% flat tableland with grades no steeper than 2%. Areas of steep slopes will not be accepted.

103. City standard 1.5 metre high black vinyl chain-link fencing shall be provided at all public private interfaces where private lands abut wetlands, buffer lands, environmental lands, woodlots and open spaces meant to be naturalized to minimize encroachment. In all other areas, the City standard property demarcation posts and living fence shall be provided.

104. The City is interested in discussing the School Board proposals for layout of the new school and associated green space. Given the size and layout of Block 253 (Park), it is perhaps not conducive to sharing sporting facilities and therefore the School Board may need to provide these 100% on their lands.

105. Sufficient deterrents need to be designed into the shared property line between Block 253 (Park) and Block 256 (SWM) to maintain safety given the slopes of the pond and the proximity of the park.

106. Please confirm the design intentions of Blocks 254 and 255 (Open Space) and who is to maintain it. If it is Open Space, the developer must enter into an agreement to maintain these lands until the subdivision is build out.

107. The design and incorporation of a layby for bus drop-off for Block 252 (School) should be considered.

108. Walkway blocks shown on previous iterations of the plan have been removed. Interconnectivity throughout the neighbourhood must be provided. Walkway blocks are 4.0 metres wide, unless additional services are required which may warrant a width of 6.0 metres to 9.0 metres.

109. A 6.0 metre high retaining wall is proposed along the west property limit. This is significant. Why does the west property limit not meet existing grades? How does the retaining wall work at future road extension (i.e., Pinery Trail and Street B)?

110. A Vegetation Management Plan will be required as part of the first engineering submission.

111. A Hedgerow Enhancement Planting Plan is required.

112. An Invasive Species Control Plan is required.

113. An infiltration gallery cannot be located within buffers. Buffers can contain trails and naturalized plant material and some minor re-grading only.

114. Block 252 (Park) will require stormwater, hydro and water stubs for playground and for a future rink area.

115. Infrastructure shall not be in parks unless required by the park.

116. Any garbage in the buffer, wetland, woodlands shall be removed by the developer to the satisfaction of the City of Waterloo. This includes any farm dump, old fences, building materials, etc..

117. Educational signage is required to be designed, approved and installed in the buffer area to educate property owners regarding encroachment and dumping, ownership, etc. Signage plan to be submitted for approval.

118. The plan for the restoration and enhancement measures to protect wildlife and cut down invasive species along Conservation Drive is required.

119. The plan for the animal crossing/ecological linkage enhancement crossing is required.

120. Park, SWM, OS, buffer, naturalization, living fence and property demarcation, fencing, signage plans are required to estimate the Letter of Credit requirements in Schedule B of the Subdivision Agreement. Developer to submit street tree planting plan OR to confirm with Parks and Environment to have the City undertake the street tree planting.

121. Topsoil is not permitted to be stockpiled within Block 253 (Park).

PART D – TRANSPORTATION AND ACTIVE TRANSPORTATION COMMENTS

Road Widenings and Lands to be Conveyed to the City

122. The existing road allowance of Roy Schmidt Road appears to be 12 metres wide. A road widening on the west side of Roy Schmidt Road shall be conveyed to the City for the entire length of Roy Schmidt Road to establish the new property line at 9.0 metres from the historic centreline of Roy Schmidt Road. A similar widening has been requested from the developer of the proposed subdivision on the east side of the road (Draft Plan 30T-17403).

123. Roy Schmidt Road is to be closed at Conservation Drive but the City will retain a 4.0 metre wide walkway block for a MUT in this location (between Roy Schmidt Road and Conservation Drive). If additional land is required to provide proper grading and drainage of the trail, this additional land will be included in the walkway block and conveyed to the City. City land outside that needed for the walkway block may be declared surplus. Such lands may be sold by the City in accordance with the City's Disposition of Property process;

124. The developer shall confirm that the north limit of Conservation Drive is 13 metres from the historic centreline of the road, to facilitate the ultimate road allowance of 26 metres as per the City's Official Plan.

125. 4.0 metre* wide walkway blocks are required:
    a. Inside the west limit of the plan from Pinery Trail to Block 255 (Open Space).
    b. Adjacent to the rear of Lot 46 to Lot 71 on Street B.
    c. Adjacent to the rear of Lot 7 to Lot 23 on Rideau River Street to connect to the existing trail at the east limit of the Draft Plan and the trail on the west limit of the Draft Plan.
    d. Between Lot 45 and Lot 46 on Street B, between Lot 23 and Lot 24 on Rideau River Street, and between Lot 6 and Lot 7 (or Lot 7 and Lot 8) on Rideau River Street to connect the public sidewalks to the trail inside the north limit of the Draft Plan.

126. The trail within the plan is to be designated The Avon Trail:
    a. Along the east limit of Block 254 (Open Space) from Conservation Drive to Pinery Trail.

b. Inside the west limit of the Draft Plan from Pinery Trail to Block 255 (Open Space).
c. Along the south limit of Block 255 (Open Space) to the north limit of the Draft Plan.
d. Inside the north limit of the Draft Plan from Block 255 (Open Space) to the existing trail along the east limit of the Draft Plan.

*__Note:__ *where detailed engineering determines that grading and drainage of trails, walkways or park facilities require additional land or easements, such transfers must be conveyed to the City at the time of engineering approvals.*

Transportation Study and Implementation

127. The Developer shall submit a Transportation Study prepared by a qualified Transportation Engineer, for the review and approval of the City's Director of Engineering, to address the needs of all road users: pedestrians, cyclists, transit users, and drivers.

128. The Transportation Study will use as background information the transportation studies for Conservation Drive and Beaver Creek Road, and provide projected peak hour and AADT volumes for each transportation mode on the following streets (which are considered to be feeder roads):
    a. Street H
    b. Pinery Trail
    c. Street A, from Conservation Drive to Pinery Trail
    d. Street E, from Roy Schmidt Road to Street A

129. Above feeder roads should have a Multi-Use Trail (MUT) on one side, and the study should provide options for enhanced crossings at all intersections on these roads.

130. The Transportation Study shall determine the sight daylighting requirements at all roads intersecting with Conservation Drive. Lands to accommodate daylighting requirements shall be conveyed to the City.

131. The Transportation Study shall include options and recommendations for enhanced pedestrian and cycling safety, and shall design and construct any traffic calming facilities and road safety features recommended by the Transportation Study.

Multi-Use Trails (MUTs) and Sidewalks

132. All design and construction to be undertaken by the developer shall be to the satisfaction of the City's Director of Engineering Services.

133. The detailed design of City sidewalks, trails and parks shall address all grading and drainage issues to meet AODA requirements. Should additional land or easements be

required to accommodate City infrastructure needs, the developer shall convey such transfers to the City at the time of engineering approval.

134. A MUT is required within the Roy Schmidt Road right of way. The City preferred location for this 3.0 metre wide MUT is on the west side of the road (due to a fewer number of driveways). This MUT will extend from Conservation Drive, up to and along Roy Schmidt Road, to the existing trail at the north limit of the Draft Plan. A 1.8 metre sidewalk is required along the entire length of Roy Schmidt Road, within the right of way on the east side of the road. The developer shall coordinate the design of Roy Schmidt Road with the developer of the lands to the east.

135. While the City is constructing a MUT on the east side of Beaver Creek Road south of Conservation Drive, and on the south side of Conservation Drive, the preferred location of the MUT is on the west side of Street A adjacent to Block 252 (School). This will require enhanced crossings on the east and north legs of the roundabout at Street A and Conservation Drive.

136. The developer shall design and construct the following 3.0 metre* wide Multi-Use Trails (MUT):
    a. Along the east limit of Block 254 (Open Space) from Conservation Drive to Pinery Trail.
    b. Inside the west limit of the Draft Plan from Pinery Trail to the south limit of Block 255 (Open Space).
    c. Between Block 255 (Open Space) and the rear of Lot 63 to Lot 71 on Street B.
    d. Inside the north limit of the Draft Plan from the MUT on Block 255 (Open Space) to connect to the existing trail at the north-east limit of the Draft Plan.
    e. Along the east limit of Block 256 (SWM) connecting the MUT on Block 254 (Open Space) to the MUT at the north limit of Block 256 (SWM).
    f. Along the north limit of Block 256 (SWM) connecting Pinery Trail to the MUT on the east side of Block 253 (Park).
    g. Along the south and east limit of Block 253 (Park) connecting the MUT on Block 254 (Open Space) to Pinery Trail.
    h. On the west side of Street A from Conservation Drive to Pinery Trail.
    i. On the north side of Street E from Roy Schmidt Road to the property line between Block 252 (School) and Block 244 (Street Townhouse).
    j. Along the south limit of Block 252 (School) from the MUT in (i.) above, to the MUT on Block 253 (Park).

Note: *where Block 244 (Street Townhouse) is removed, the MUT on the north side of Street E should connect from Street A to Block 253 (Park).*

137. The developer shall design and construct 1.8 metre concrete sidewalks on the following streets:
    a. On both sides of all streets with the exception of Street D and streets with a 3.0 metre MUT on one side.

b. On streets with a 3.0 metre MUT on one side, a 1.8 metre sidewalk is required on the opposite side of the street.
c. On Street D, a 1.8 metre sidewalk is required on one side only, in front of Lots 108 to Lot 128.

Bike Lanes

138. The developer shall design and prepare a pavement marking plan showing 1.5 metre painted bike lanes with a 0.3 metre painted buffer on Pinery Trail, and on Street A from Conservation Drive to Pinery Trail.

139. In accordance with the Transportation Study, the developer shall prepare a detailed design of the Pinery Trail and Roy Schmidt Road intersection to safely connect the MUT on Roy Schmidt to the buffered bike lanes on Pinery Trail.

Transportation Operations

140. Streets with bike lanes may not be able to accommodate on-street parking, due to the width of the road. Bike lanes on Street A will restrict on-street parking for the school and Block 243 (Street Townhouse). Bike lanes on Pinery Trail will restrict on-street parking at the park.

141. Please provide additional information with respect to the type of traffic control and traffic calming measures planned for the proposed Draft Plan.

142. How will school traffic be accommodated? The area around the school will have limited on-street parking to assist with student drop-off and pick-up.

143. The radius elbow corner on Rideau River Street presents a challenge for winter operations. Please consider modifying this design.

144. Driveway access to Block 251 is recommended from Street A and/or Street E, not from Roy Schmidt Road. The City intends to minimize the number of driveways on Roy Schmidt Road, because the preferred location for the MUT is on the west side of Roy Schmidt Road from Conservation Drive to the existing trail at the north limit of the subdivision; the driveways that conflict with the MUT are limited to Lots 226-242.

145. The developer shall design and construct a pedestrian refuge island and crossing within Conservation Drive at Street H, and at the MUT on Block 254 (Open Space). These are required to facilitate connections to facilities being constructed by the City, including bike lanes on both sides of Conservation Drive, and the MUT on the south side of Conservation Drive.

146. The Street H connection with Conservation Drive is located just west of the proposed roundabout at Beaver Creek Road. Stantec completed a turn lane analysis for all subdivision entrances onto Conservation Drive and Beaver Creek Road. There were

four recommendations made from the analysis. In its current location, Street H, will be limited to right-in/right-out (RIRO) movement only based on the recommendations outlined in the *Update to Transportation Forecast and Left Turn Lane Requirements Technical Memo* (Stantec, July 7, 2017). Should the developer maintain the location of Street H an analysis of the RIRO configuration and resulting reassignment of traffic for the proposed operations of the roundabout will need to be completed. Should RIRO not be desirable for Street H, please review the July 7, 2017 Turn Lane Analysis Memo for more intersection spacing options. Options may be investigated to remove Street H and extend Street E from Street F to Conservation Drive.

147. Please ensure appropriate coordination between the lighting plan for the proposed Draft Plan and the lighting plan for Conservation Drive.

PART D – ENGINEERING COMMENTS

148. The Beaver Creek Road Sewage Pumping Station must be in place prior to final registration of the Draft Plan and the issuance of any building permits.

149. The Communal SWM facility must be constructed prior to servicing of the subdivision for water quality control.

150. The SWM report indicates an additional SWM Report will be submitted for the "off-site" stormwater management. City staff would not be in a position to accept this dual management proposal without further details of the off-site facility as well as securities/assurances that it will be built and available to this development.

151. Several discussions have been held about the off-site SWM pond concept. A letter has been sent offering options.

152. If it is determined that the external facility is not feasible or it does not materialize, all SWM controls would be required within the development, requiring significant revisions to the design and layout of the plan.

153. The servicing strategy report indicates that matching elevations along the neighbouring properties is a design consideration. The conceptual grading plan includes some significant deviations from existing elevations on adjacent lands, namely a 6.0 metre high retaining wall in the northwest corner of the site and a 2.0 metre high retaining wall along the north property line. This will not be accepted by staff. This grading strategy will effectively preclude development of the adjacent property, and will incur significant costs for retaining walls and importing fill. A realistic proposal needs to be provided. Development of the Draft Plan lands must be completed in a way that will not to negatively impact or encumber the adjacent lands.

Please note that City staff reserves the right to provide additional comments, or modify the above noted comments subject to further review and/or additional information as may be provided.

I trust the foregoing is satisfactory, however should you have any questions please do not hesitate to contact the undersigned.

Sincerely,



Natalie Hardacre BES, MCIP, RPP
Development Planner
Planning Approvals
Integrated Planning & Public Works
City of Waterloo
P: 519.514.0225
F: 519.747.8523
TTY: 1.866.786.3941
E: natalie.hardacre@waterloo.ca

APPENDIX B:
FIGURES



Stantec

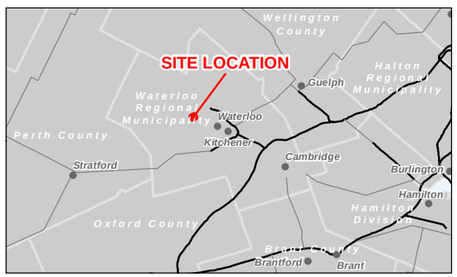
Legend

- Site Boundary
- Monitoring Well (Stantec, 2020)
- Monitoring Well (Ecoplans et al., 2013)
- Drive Point Piezometer (Ecoplans et al., 2013)
- Guelph Permeameter/Infiltrometer (Stantec, 2020)
- Guelph Permeameter (Ecoplans et al., 2013)
- Test Pit (Ecoplans et al., 2013)
- Abandoned Monitoring Well
- Proposed Draft Plan
- Watercourse
- Wetland - Evaluated (Provincial)

0 100 200 metres

1:3,500 (At original document size of 11x17)

Notes
1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2020.
3. Orthoimagery © First Base Solutions, 2020. Imagery Date, 2019.



Project Location
Waterloo, ON

160900921 REVA
Prepared by CMC on 2020-07-20
Technical Review by GW on 2020-06-30

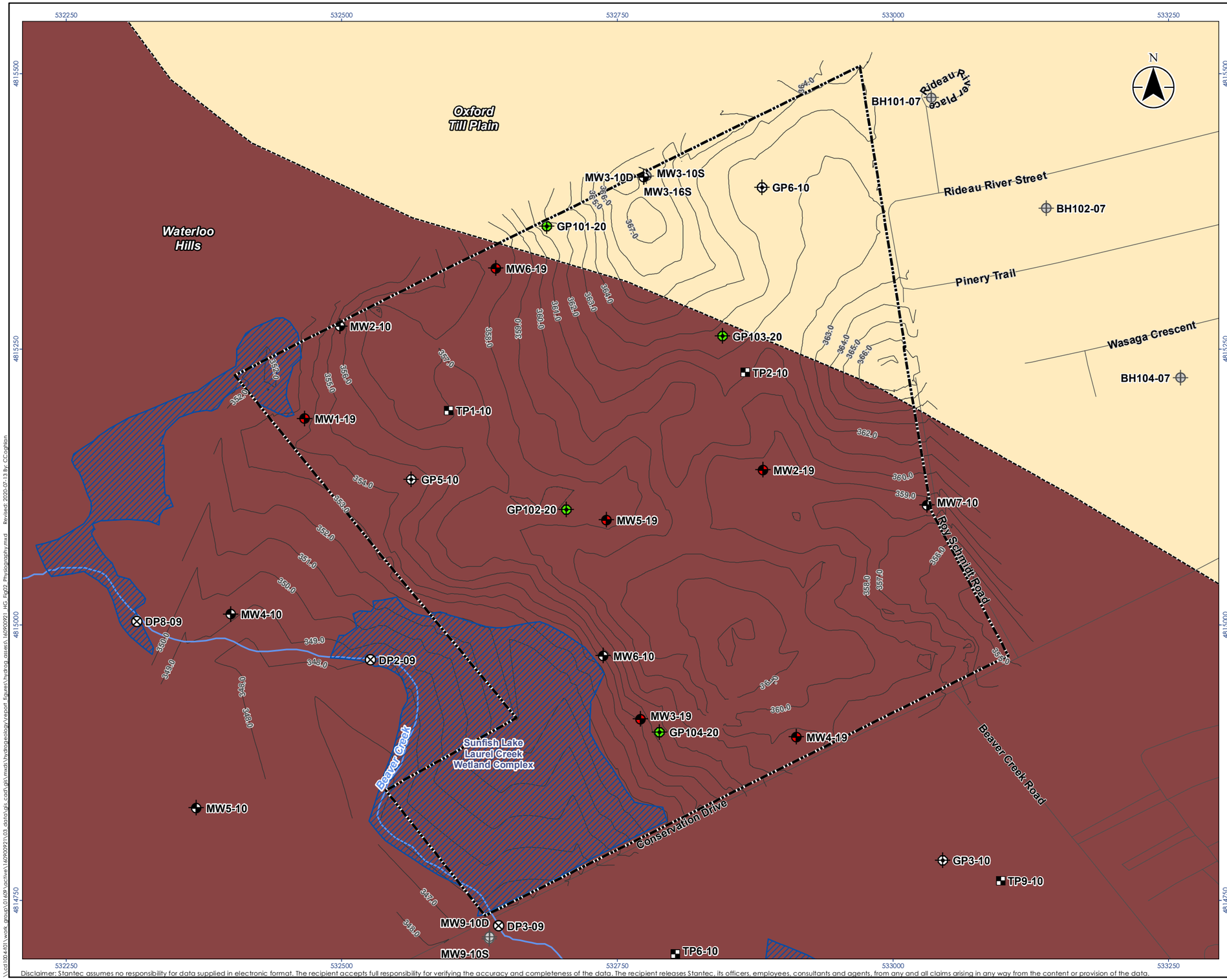
Client/Project
2115881 ONTARIO LIMITED
556 & 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
1

Title
Site Plan

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Revised: 2020-07-20 By: CCughlan
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Stantec

Legend

- Site Boundary
- Monitoring Well (Stantec, 2020)
- Monitoring Well (Ecoplans et al., 2013)
- Drive Point Piezometer (Ecoplans et al., 2013)
- Guelph Permeameter/Infiltrometer (Stantec, 2020)
- Guelph Permeameter (Ecoplans et al., 2013)
- Test Pit (Ecoplans et al., 2013)
- Abandoned Monitoring Well
- Topographic Contour (mAMSL)
- Watercourse
- Wetland - Evaluated (Provincial)
- Physiographic Region Boundary

Physiography

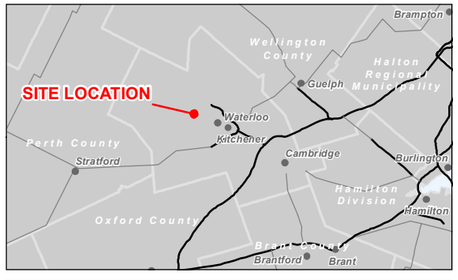
- 6: Till Plains (Drumlinized)
- 4: Kame Moraines

0 100 200 metres

1:3,500 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2017.
3. Orthoimagery © First Base Solutions, 2019. Imagery Date, 2018.
4. Chapman, L.J. and Putnam, D.F. 2007. Physiography of southern Ontario; Ontario Geological Survey, Miscellaneous Release—Data 228.



Project Location
Waterloo, ON

160900921 REVA
Prepared by CMC on 2020-07-13
Technical Review by ABC on yyyy-mm-dd

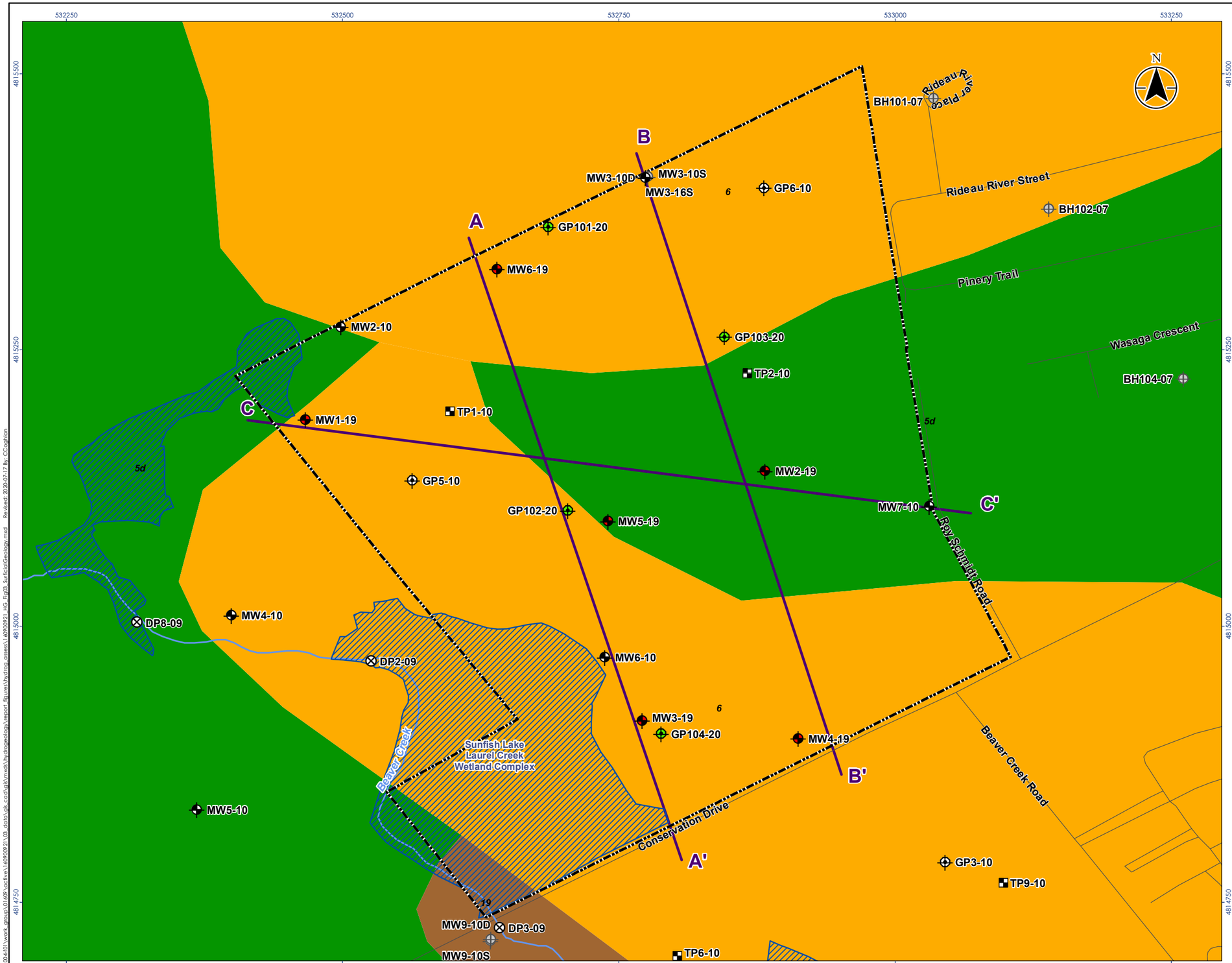
Client/Project
2115881 ONTARIO LIMITED
556 & 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
2

Title
Physiography and Topography

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Stantec

Legend

- Site Boundary
- Monitoring Well (Stantec, 2020)
- Monitoring Well (Ecoplans et al., 2013)
- Drive Point Piezometer (Ecoplans et al., 2013)
- Guelph Permeameter/Infiltrometer (Stantec, 2020)
- Guelph Permeameter (Ecoplans et al., 2013)
- Test Pit (Ecoplans et al., 2013)
- Abandoned Monitoring Well
- Cross-Section Location
- Watercourse
- Wetland - Evaluated (Provincial)

Surficial Geology

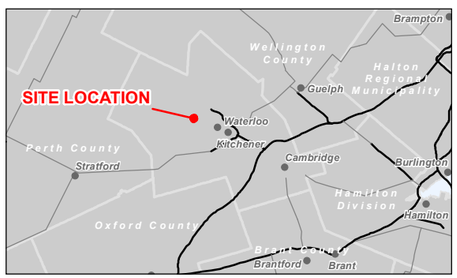
- 19: Modern alluvial deposits
- 6: Ice-contact stratified deposits
- 5d: Glaciolacustrine-derived silty to clayey till

0 100 200 metres

1:3,500 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2017.
3. Ontario Geological Survey 2010. Surficial geology of Southern Ontario: Ontario Geological Survey, Miscellaneous Release--Data 128-REV ISBN 978-1-4435-2483-4



Project Location
Waterloo, ON

160900921 REVA
Prepared by CMC on 2020-07-17
Technical Review by ABC on yyyy-mm-dd

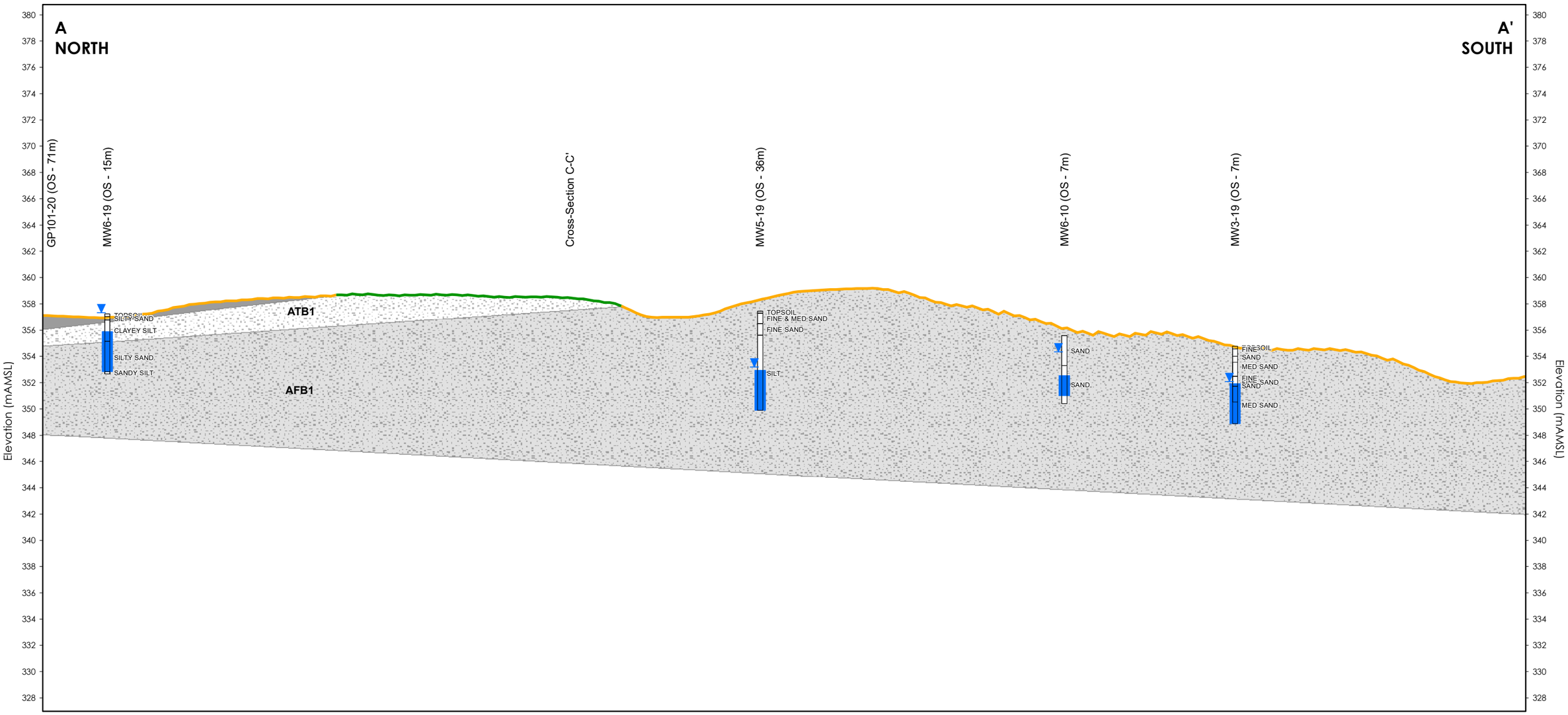
Client/Project
2115881 ONTARIO LIMITED
556 & 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

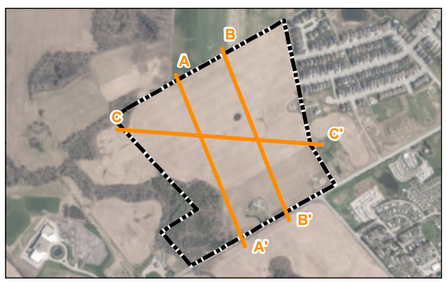
Figure No.
3

Title
Surficial Geology

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MW1-15 (OS m)
Sand

Well ID (Offset)

Stratigraphy

Water Level (High Groundwater Conditions)

Well Screen

Surficial Geology

- 5d: Glaciolacustrine-derived silty to clayey till
- 6: Ice-contact stratified deposits
- Fill / Topsoil
- ATB1 Upper Maryhill Till (silty to clayey till) - Aquitard 1
- AFB1 Upper Moraine stratified sediments (fine to coarse sand, silt) - Aquifer 1

5x Vertical Exaggeration

0 25 50 metres

1:1,500 (At original document size of 11x17)

Notes

1. Orthoimagery © First Base Solutions, 2020. Imagery Date, 2019.

Stantec

Project Location
Waterloo, ON

160900921 REVA
Prepared by CCoghlan on 2020-07-13
Technical Review by xxx on xxxx-xx-xx

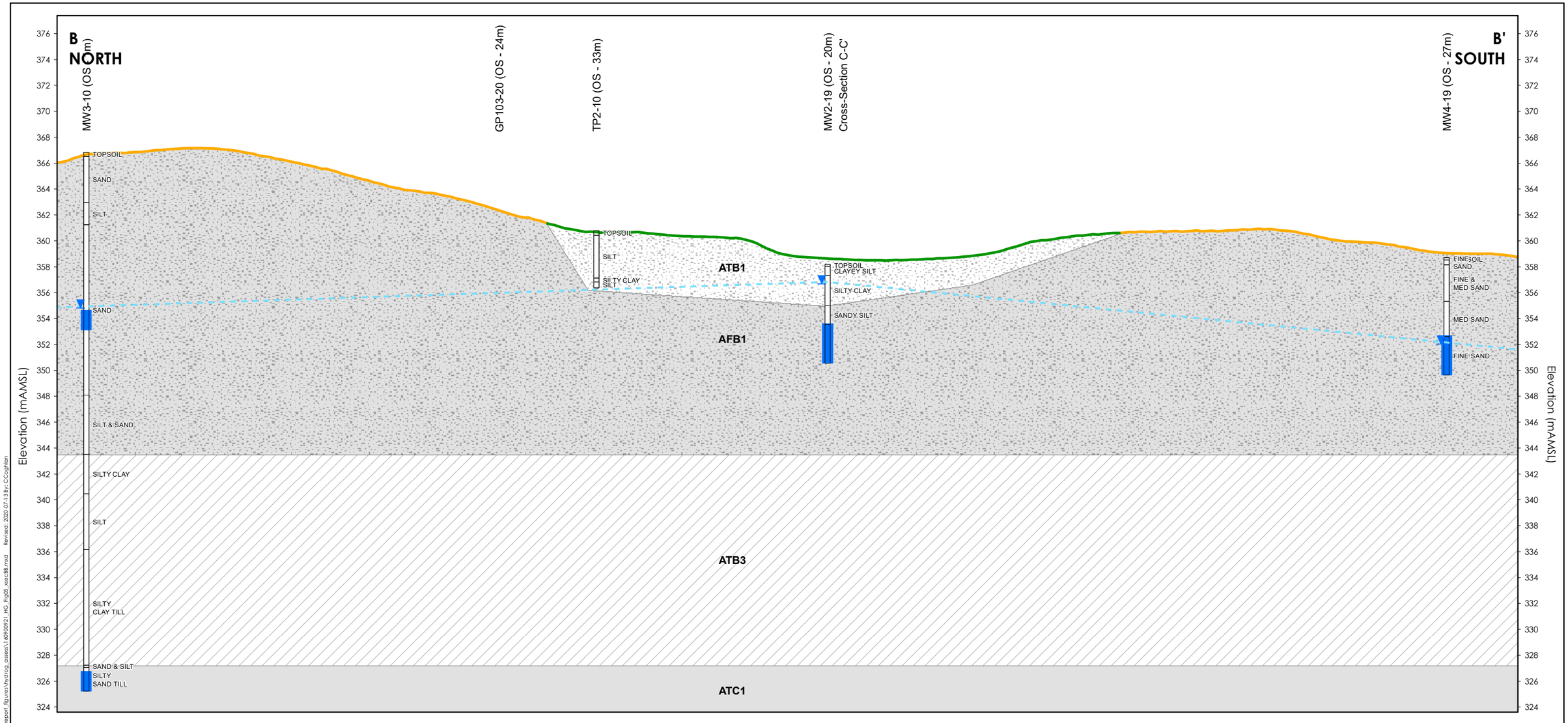
Client/Project
2115881 ONTARIO LIMITED
556 & 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

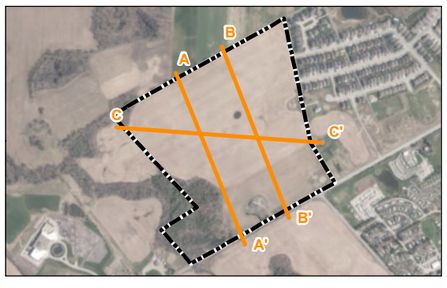
Figure No.
4

Title
Cross-Section A-A'

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MW1-15 (OS m)

Sand

Well ID (Offset)

Stratigraphy

Water Level (High Groundwater Conditions)

Well Screen

High Groundwater Table

Surficial Geology

5d: Glaciolacustrine-derived silty to clayey till

6: Ice-contact stratified deposits

ATB1 Upper Maryhill Till (silty to clayey till) - Aquitard 1

AFB1 Upper Moraine stratified sediments (fine to coarse sand, silt) - Aquifer 1

ATB3 Lower Maryhill Till (silty to clayey till) - Aquitard 2

ATC1 Catfish Creek Till (sandy to stoney silt till) - Aquitard 3

5x Vertical Exaggeration

0 25 50 metres

1:1,500 (At original document size of 11x17)

Notes

1. Orthoimagery © First Base Solutions, 2020. Imagery Date, 2019.

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Project Location
Waterloo, ON

160900921 REVA
Prepared by CCoghlan on 2020-07-13
Technical Review by xxx on xxxx-xx-xx

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Figure No.
5

Title
Cross-Section B-B'

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\\cd1004101\work_group\01609\active\160900921\03_data\gis_cad\gis\mxd\hydrogeology\report_figures\hydrog_assess\160900921_HG_Fig05_xsectBB.mxd Revised: 2020-07-13 By: CCoghlan

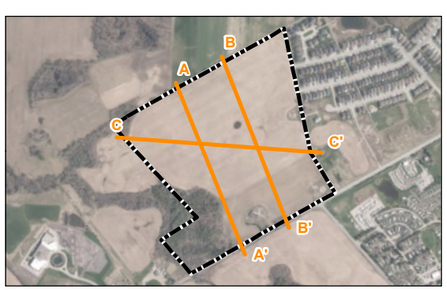
C
WEST

C'
EAST

Elevation (mAMSL)

MW1-19 (OS - 7m)
TP1-10 (OS - 31m)
Cross-Section A-A'
GP102-20 (OS - 44m)
MW5-19 (OS - 49m)
Cross-Section B-B'
MW2-19 (OS - 14m)
MW7-10 (OS - 2m)

TOPSOIL
FINE SAND
MED SAND
TOPSOIL
SAND
SILT
SAND
SILTY CLAY
TOPSOIL
FINE & MED SAND
FINE SAND
SILT
ATB1
AFB1
TOPSOIL
CLAYEY SILT
SILTY CLAY
SANDY SILT
TOPSOIL
CLAYEY SILT
SAND
SILT
SAND



MW1-15 (OS m)
Sand

Well ID (Offset)

Stratigraphy

Water Level
(High Groundwater Conditions)

Well Screen

High Groundwater Table

Surficial Geology

5d: Glaciolacustrine-derived silty to clayey till

6: Ice-contact stratified deposits

ATB1 Upper Maryhill Till (silty to clayey till) - Aquitard 1

AFB1 Upper Moraine stratified sediments (fine to coarse sand, silt) - Aquifer 1

5x Vertical Exaggeration

0 30 60 metres

1:1,750 (At original document size of 11x17)

Notes

1. Orthoimagery © First Base Solutions, 2020. Imagery Date, 2019.

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Project Location
Waterloo, ON

160900921 REVA
Prepared by CCoghlan on 2020-07-13
Technical Review by xxx on xxxx-xx-xx

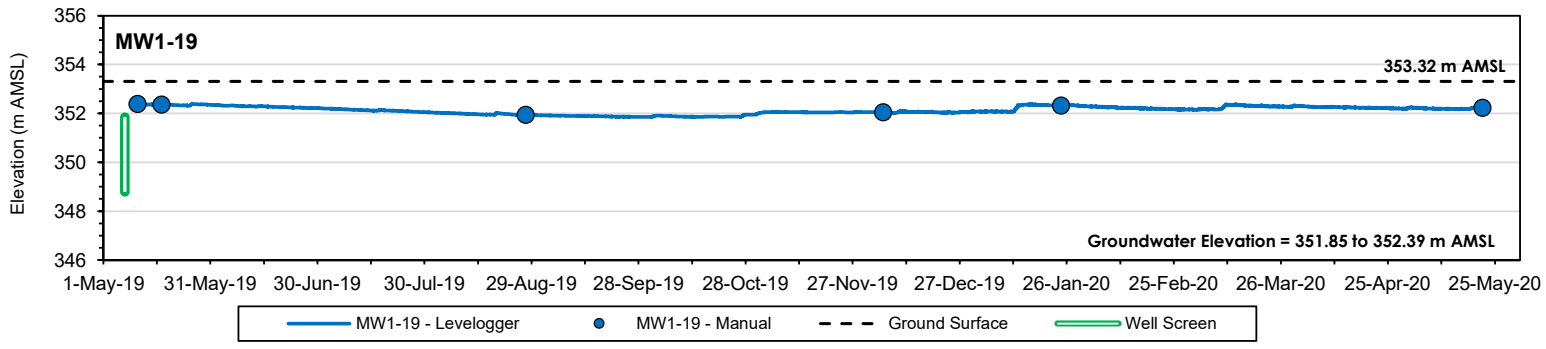
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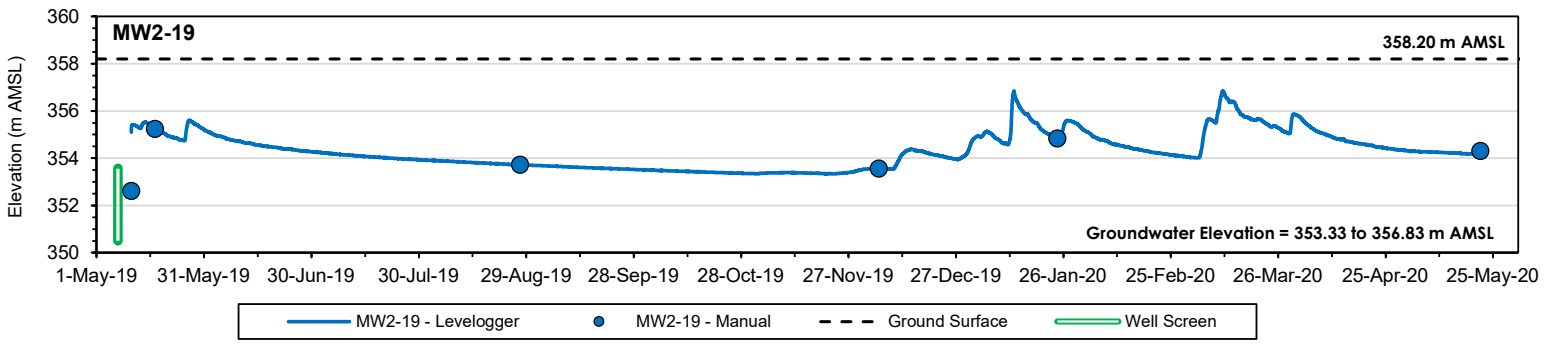
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6

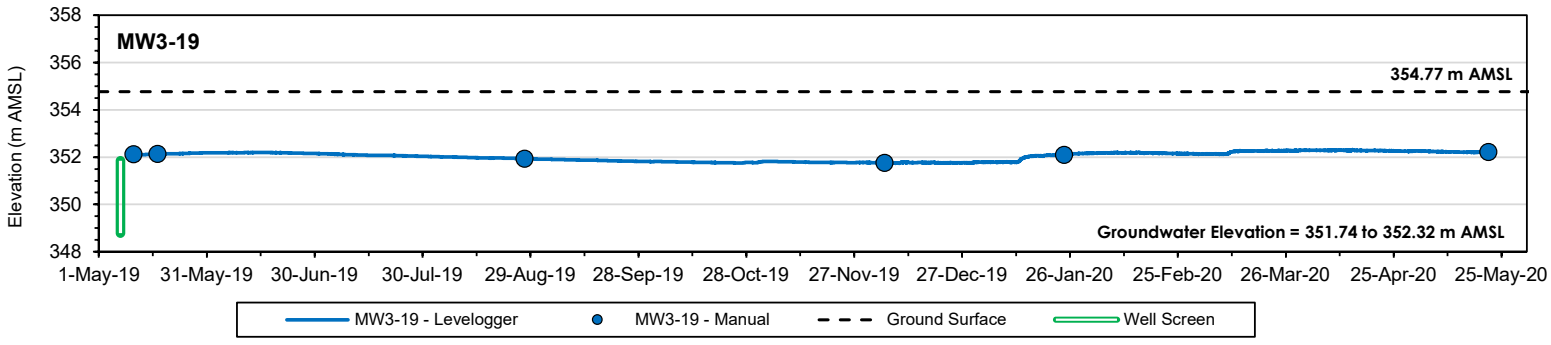
Title
Cross-Section C-C'

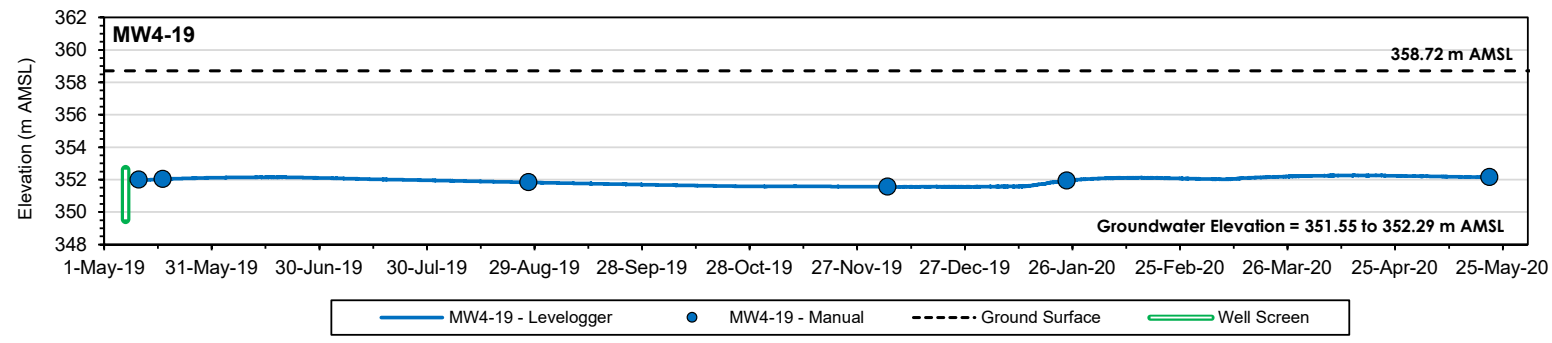
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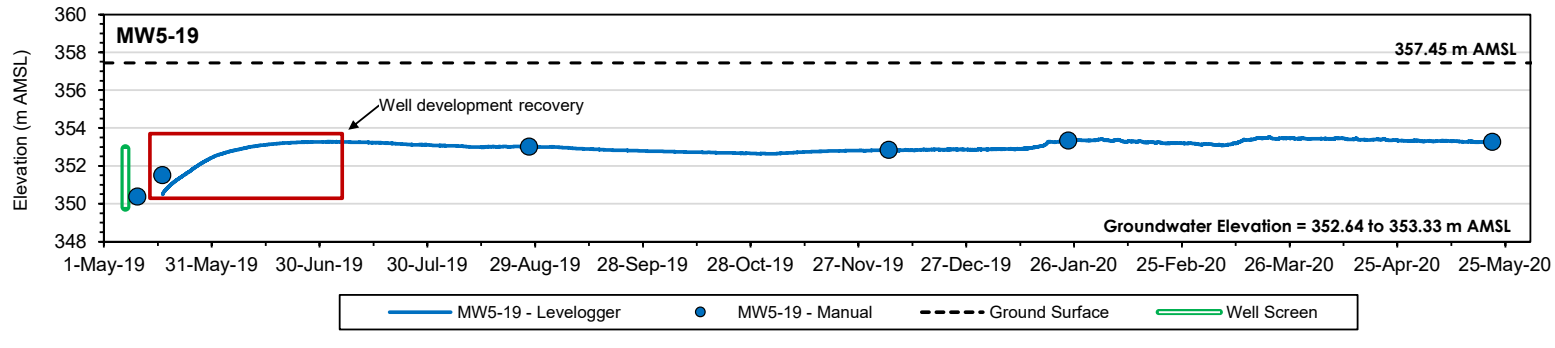
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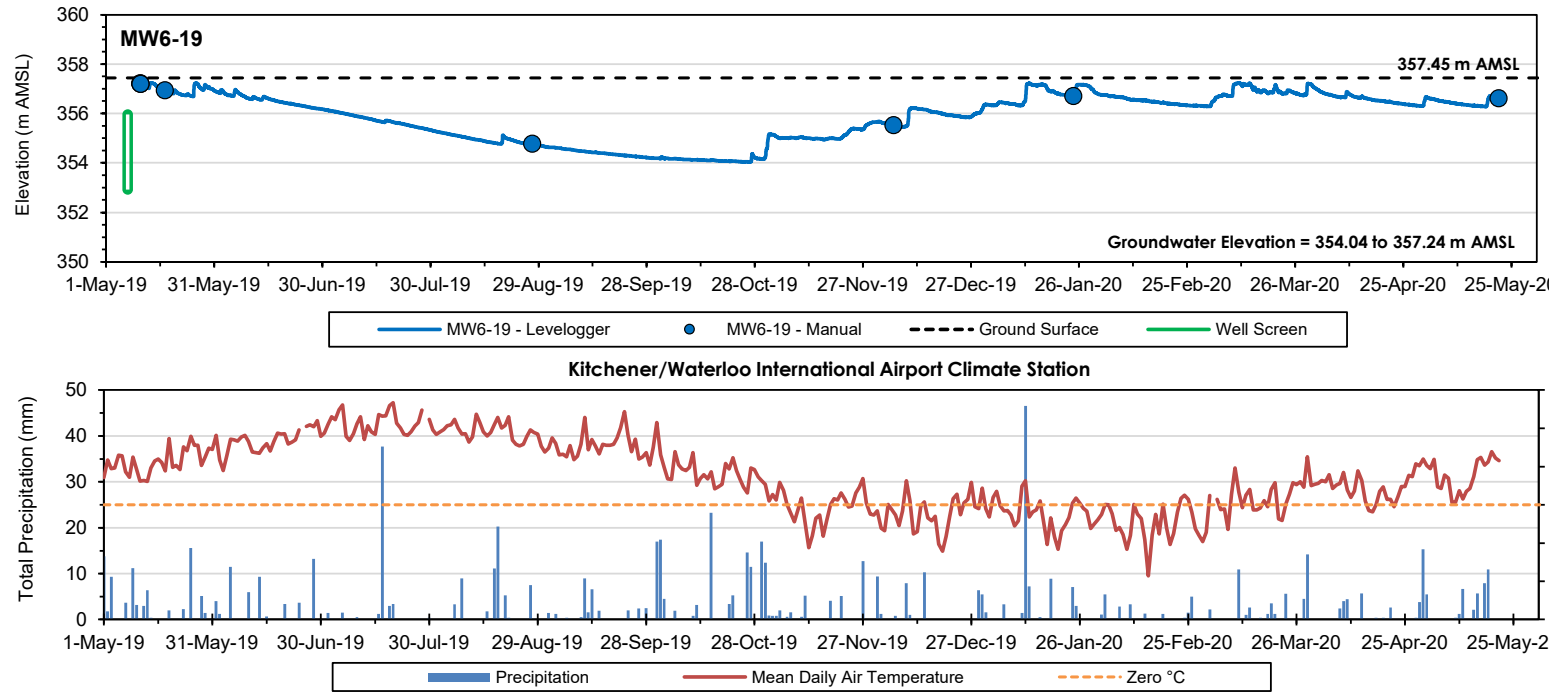












Notes

(1) Precipitation and temperature data were obtained from Environment Canada for the Region of Waterloo International Airport (ID 6144239), accessed May 22, 2020.

(2) Data range for MW5-19 does not include water levels recorded during recovery from hydraulic conductivity test.

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Meritech Engineering

556, 560, and 576 Conservation Drive

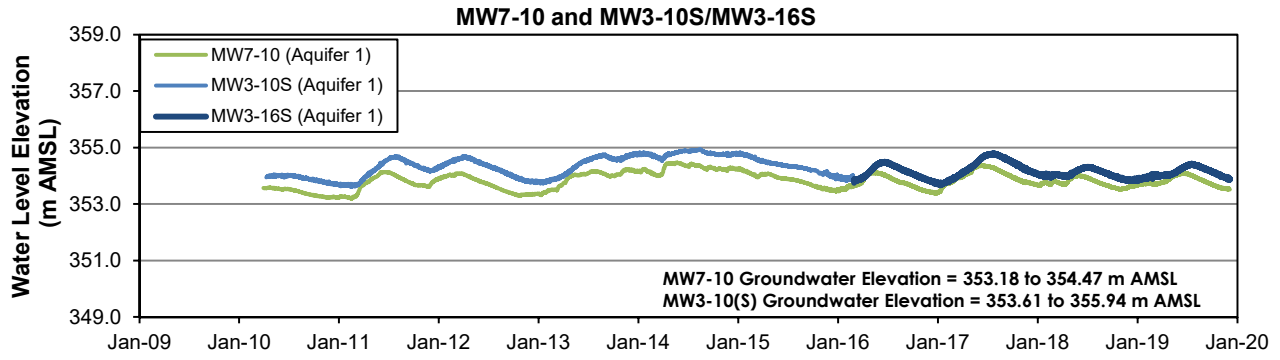
Hydrogeological Assessment

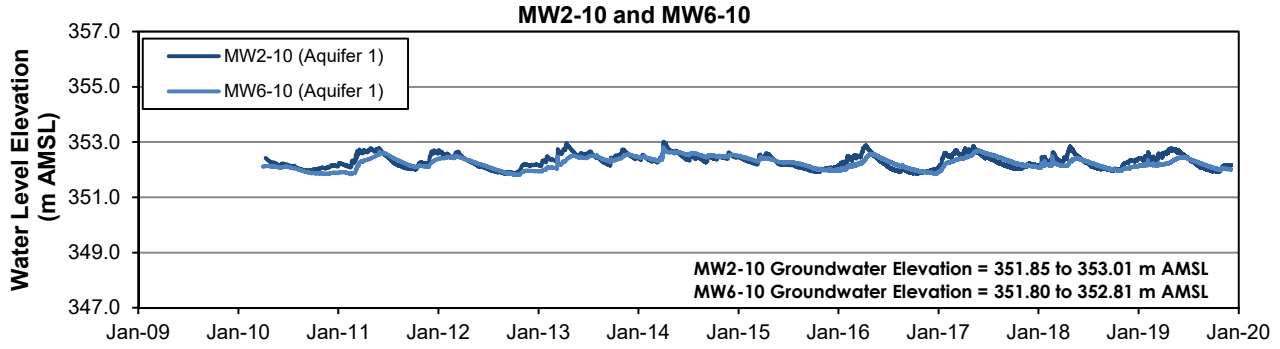
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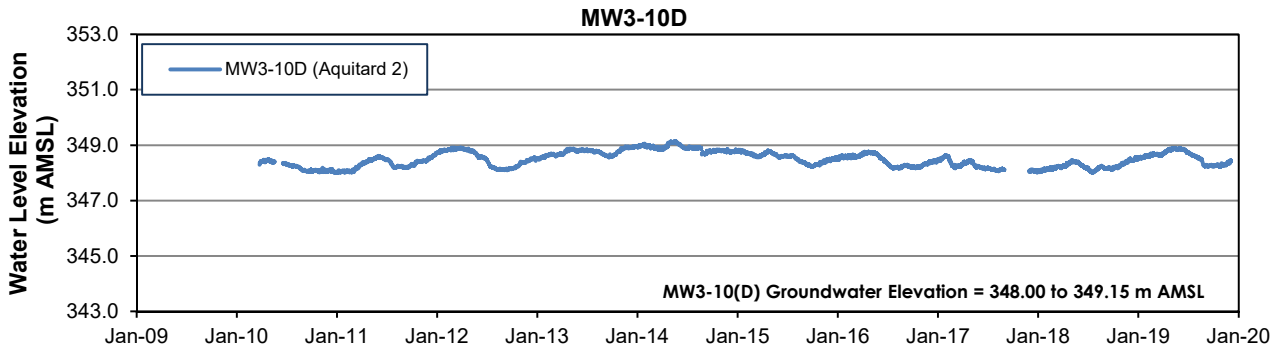
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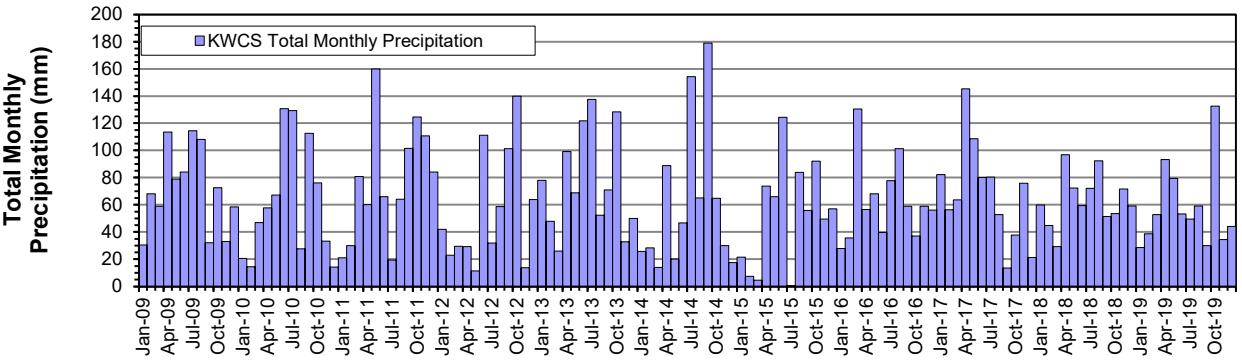
Title **HYDROGRAPHS**

MW1-19 to MW6-19









Source

Stantec Consulting Limited. 2020. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program.

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HYDROGEOLOGICAL ASSESSMENT

Figure No.

8

Title

HYDROGRAPHS
MW2-10, MW3-10(S/D), MW6-10 AND MW7-10

Stantec



Stantec

Legend

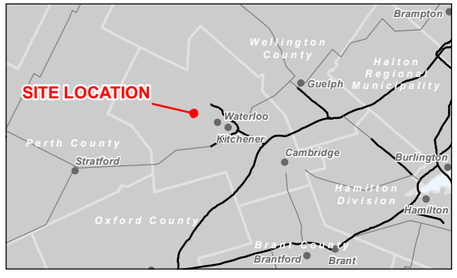
- Site Boundary
- Monitoring Well (Stantec, 2020)
- Monitoring Well (Ecoplans et al., 2013)
- Guelph Permeameter/Infiltrometer (Stantec, 2020)
- Guelph Permeameter (Ecoplans et al., 2013)
- Topographic Contour (m AMSL)
- 357.54 Groundwater Elevation (m AMSL)
- (358.50) Infiltration Gallery Invert Elevation (mAMSL)
- Infiltration Gallery
- Groundwater Contour (m AMSL)
- Interpreted Groundwater Contour (m AMSL)
- Interpreted Direction of Groundwater Flow
- Watercourse
- Wetland - Evaluated (Provincial)

0 100 200 metres

1:3,500 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2017.
3. Ontario Geological Survey 2010. Surficial geology of Southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 128-REV ISBN 978-1-4435-2483-4
4. Invert elevation for infiltration gallery located along northern property boundary varies, but will remain above the high groundwater elevation.



Project Location
Waterloo, ON

160900921 REVA
Prepared by CMC on 2020-07-29
Technical Review by ABC on yyyy-mm-dd

Client/Project
2115881 ONTARIO LIMITED
556 & 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
9

Title
High Groundwater Elevations

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APPENDIX C:
TABLES

TABLE 1
MONITORING WELL CONSTRUCTION DETAILS

Well ID	UTM Coordinates		Elevations		Well Stick-up (m)	Well Depth (m BTOC)	Well Depth (m BGS)	Well Base Elevation (m AMSL)	Screened Interval				Screened Material Description [a] (% of screened interval)	Probable Hydrostratigraphic Unit	Hydraulic Conductivity [b] (m/s)
	Northing	Easting	Top of Casing (m AMSL)	Ground Surface (m AMSL)					Top Elevation (m BGS)	Top Elevation (m AMSL)	Bottom Elevation (m BGS)	Bottom Elevation (m AMSL)			
MONITORING WELLS															
MW1-19	4815187	532466	354.10	353.32	0.78	5.20	4.42	348.90	1.37	351.95	4.42	348.90	Medium SAND (100%)	Aquifer 1	2.8E-04
MW2-19	4815140	532882	358.92	358.20	0.72	8.38	7.66	350.54	4.61	353.59	7.66	350.54	Fine SAND, some silt/clay (100%)	Aquifer 1	8.0E-07
MW3-19	4814915	532771	355.59	354.77	0.82	6.70	5.88	348.89	2.83	351.94	5.88	348.89	Medium SAND (100%)	Aquifer 1	1.8E-04
MW4-19	4814898	532912	359.49	358.72	0.77	9.85	9.08	349.64	6.03	352.69	9.08	349.64	Fine SAND, trace silt/clay (100%)	Aquifer 1	1.9E-04
MW5-19	4815095	532740	358.23	357.45	0.78	8.33	7.55	349.90	4.50	352.95	7.55	349.90	SILT, some clay (100%)	Aquifer 1	1.8E-09
MW6-19	4815323	532640	358.02	357.24	0.78	5.18	4.40	352.84	1.35	355.89	4.40	352.84	Clayey SILT (20%) / Silty SAND (80%)	Aquitard 1 / Aquifer 1	1.6E-07
MW2-10	4815271	532498	356.52	355.56	0.96	5.53	4.57	350.99	3.05	352.51	4.57	350.99	Fine to Medium SAND (100%)	Aquifer 1	6.6E-05
MW3-10S	4815407	532776	367.62	366.81	0.81	14.53	13.72	353.09	12.20	354.61	13.72	353.09	Fine to Medium SAND (100%)	Aquifer 1	3.4E-06
MW3-10D	4815406	532774	367.60	366.84	0.76	42.37	41.61	325.23	40.09	326.75	41.61	325.23	Sandy SILT TILL (100%)	Aquitard 2	8.4E-08
MW3-16S	4815406	532774	367.70	366.84	0.86	14.58	13.72	353.12	12.20	354.64	13.72	353.12	Fine SAND (100%)	Aquifer 1	-
MW4-10	4815010	532399	348.64	347.87	0.77	3.82	3.05	344.82	1.53	346.34	3.05	344.82	Silty SAND (60%) / Clayey SILT (40%)	Aquifer 1 / Aquitard 1	2.2E-06
MW5-10	4814834	532368	351.91	351.08	0.83	5.10	4.27	346.81	2.75	348.33	4.27	346.81	Silty SAND (100%)	Aquifer 1	1.3E-05
MW6-10	4814972	532737	356.48	355.58	0.90	5.47	4.57	351.01	3.05	352.53	4.57	351.01	Medium SAND (100%)	Aquifer 1	5.1E-05
MW7-10	4815108	533031	359.67	358.74	0.93	8.25	7.32	351.42	5.80	352.94	7.32	351.42	Fine to Medium SAND (100%)	Aquifer 1	8.7E-05
														GEOMEAN (Aquitard 1 / Aquifer 1) =	**8.0E-06**

Notes:

(a) Refer to **Appendix E** for borehole and well construction logs
(b) Refer to **Appendix F** hydraulic conductivity analytical solutions

m AMSL = meters above mean sea level
m BGS = meters below ground surface
m BTOC = meters below top of well casing
- = data not available

TABLE 2
GROUNDWATER LEVEL DATA - MONITORING WELLS

Well ID	Date	Time	Well Depth			Screen Length	Top of Casing Elevation	Ground Surface Elevation	Pipe Stick-up	Groundwater Level		
			(m BTOC)	(m BGS)	(m AMSL)	(m)	(m AMSL)	(m AMSL)	(m)	(m BGS) [1]	(m BTOC)	(m AMSL)
MW1-19	10-May-19	1:23 PM	5.20	4.42	348.90	3.05	354.10	353.32	0.78	0.93	1.71	352.39
	17-May-19	9:13 AM								0.97	1.75	352.35
	27-Aug-19	9:05 AM								1.38	2.16	351.94
	5-Dec-19	-								1.27	2.05	352.05
	24-Jan-20	10:55 AM								1.00	1.78	352.32
	20-May-20	12:21 PM								1.09	1.87	352.23
MW2-19	10-May-19	9:33 AM	8.38	7.66	350.54	3.05	358.92	358.20	0.72	2.77	3.49	355.43
	17-May-19	8:53 AM								2.96	3.68	355.24
	27-Aug-19	9:25 AM								4.48	5.20	353.72
	5-Dec-19	1:04 PM								4.63	5.35	353.57
	24-Jan-20	10:20 AM								3.36	4.08	354.84
	20-May-20	1:26 PM								3.90	4.62	354.30
MW3-19	10-May-19	4:20 PM	6.70	5.88	348.89	3.05	355.59	354.77	0.82	2.65	3.47	352.12
	17-May-19	8:31 AM								2.64	3.46	352.13
	27-Aug-19	9:45 AM								2.84	3.66	351.93
	5-Dec-19	12:22 PM								3.01	3.83	351.76
	24-Jan-20	9:46 AM								2.67	3.49	352.10
	20-May-20	8:39 AM								2.55	3.37	352.22
MW4-19	10-May-19	3:14 PM	9.85	9.08	349.64	3.05	359.49	358.72	0.77	6.73	7.50	351.99
	17-May-19	8:40 AM								6.69	7.46	352.03
	27-Aug-19	9:50 AM								6.89	7.66	351.83
	5-Dec-19	12:10 PM								7.16	7.93	351.56
	24-Jan-20	9:39 AM								6.79	7.56	351.93
	20-May-20	8:23 AM								6.57	7.34	352.15
MW5-19	10-May-19	10:30 AM	8.33	7.55	349.90	3.05	358.23	357.45	0.78	4.53	5.31	352.92
	17-May-19	8:59 AM								5.97	6.75	351.48
	27-Aug-19	9:35 AM								4.45	5.23	353.00
	5-Dec-19	12:36 PM								4.62	5.40	352.83
	24-Jan-20	9:39 AM								4.12	4.90	353.33
	20-May-20	10:16 AM								4.18	4.96	353.27
MW6-19	10-May-19	12:19 PM	5.18	4.40	352.84	3.05	358.02	357.24	0.78	0.02	0.80	357.22
	17-May-19	9:23 AM								0.31	1.09	356.93
	27-Aug-19	8:54 AM								2.47	3.25	354.77
	5-Dec-19	12:36 PM								1.72	2.50	355.52
	24-Jan-20	10:49 AM								0.54	1.32	356.70
	20-May-20	12:34 PM								0.62	1.40	356.62

Notes:

(1) A negative value indicates that the water level measured within the pipe is located above ground surface

m BGS = meters below ground surface
m BTOC = meters below top of casing
DRY = no groundwater or surface water was observed in the piezometer or watercourse, respectively
- = measurement not available

TABLE 3
INFILTRATION TESTING RESULTS

Testing Location ID	Source	Horizontal Hydraulic Conductivity (m/s)	Vertical Hydraulic Conductivity[2] (cm/s)	Vertical Hydraulic Conductivity[2] (m/s)	Infiltration Rate[1] (mm/hr)	Pit Depth (m BGS)	Screened Interval (m BGS)	Soil Substrate Tested (% of screened interval)	Topsoil Thickness (m)	Grain Size Proportions (%)
Guelph Permeameter Testing										
GP5	Ecoplans (2013)[a]	-	7.5E-04	7.5E-06	79	0.36	-	Medium SAND	-	-
GP6	Ecoplans (2013)[a]	-	8.0E-04	8.0E-06	81	0.28	-	Medium SAND	-	-
GP101	Stantec (2020)	-	-	-	66	0.03	-	TOPSOIL	0.35	Gravel (0.1), Sand (30.0), Silt (42.9), Clay (27.0)
GP101	Stantec (2020)	-	2.3E-05	2.3E-07	31	0.57	-	SILT, trace fine sand and clay	-	Gravel (0.0), Sand (25.8), Silt (41.7), Clay (32.5)
GP102	Stantec (2020)	-	-	-	173	0.03	-	TOPSOIL	0.35	Gravel (3.5), Sand (81.1), Silt (8.9), Clay (6.5)
GP102	Stantec (2020)	-	1.0E-03	1.0E-05	86	0.70	-	Silty SAND, trace clay and fine gravel	-	-
GP103	Stantec (2020)	-	-	-	16	0.01	-	TOPSOIL	0.45	Gravel (0.2), Sand (37.7), Silt (45.1), Clay (17.0)
GP103	Stantec (2020)	-	7.3E-06	7.3E-08	23	0.70	-	Silty SAND, trace clay and fine gravel	-	-
GP104	Stantec (2020)	-	-	-	107	0.02	-	TOPSOIL	0.25	Gravel (15.2), Sand (71.2), Silt (9.1), Clay (4.5)
GP104	Stantec (2020)	-	2.1E-02	2.1E-04	194	0.55	-	Fine SAND	-	-
In-situ Hydraulic Response Testing										
MW1-19	Stantec (2019)	2.8E-04	2.8E-03	2.8E-05	113	-	1.5 - 4.5	Medium SAND, trace silt/clay	-	-
MW2-19	Stantec (2019)	8.0E-07	8.0E-06	8.0E-08	23	-	4.6 - 7.6	Fine SAND, some silt/clay	-	-
MW3-19	Stantec (2019)	1.8E-04	1.8E-03	1.8E-05	100	-	2.9 - 5.9	Medium SAND, trace gravel	-	-
MW4-19	Stantec (2019)	1.9E-04	1.9E-03	1.9E-05	100	-	6.1 - 9.1	Fine SAND, trace silt/clay	-	-
MW5-19	Stantec (2019)	1.8E-09	1.8E-08	1.8E-10	5	-	4.6 - 7.6	SILT, some clay	-	-
MW6-19	Stantec (2019)	1.6E-07	1.6E-06	1.6E-08	15	-	1.5 - 4.5	Clayey SILT (20%) / Silty SAND (80%)	-	-
MW2-10	Ecoplans (2013)[b]	6.6E-05	6.6E-04	6.6E-06	77	-	3.1 - 4.6	Fine to Medium SAND	-	-
MW5-10	Ecoplans (2013)[b]	1.3E-05	1.3E-04	1.3E-06	50	-	2.8 - 4.3	Silty SAND, fine to medium-grained	-	-
MW6-10	Ecoplans (2013)[b]	5.1E-05	5.1E-04	5.1E-06	71	-	3.1 - 4.6	Medium SAND, trace gravel	-	-
MW7-10	Ecoplans (2013)[b]	8.7E-05	8.7E-04	8.7E-06	82	-	5.8 - 7.3	Fine to Medium SAND	-	-
GEOMEAN (Fine to Medium SAND) =				**1.2E-05**	**89**					
GEOMEAN (Silty to Clayey SAND, SILT to Clayey SILT) =				**2.1E-08**	**16**					

Notes:

(1) Infiltration rate calculated based on established relationship between vertical hydraulic conductivity and infiltration rate presented in *Credit Valley Conservation and* Toronto and Region Conservation (2010) Low Impact Stormwater Management Planning *and Design Guideline - Version 1.0*.

(2) Vertical hydraulic conductivities assumed to be one order of magnitude lower than in-situ measured horizontal hydraulic conductivities.

References:

(a) Ecoplans Ltd (a member of MMM Group), MacNaughton Hermsen Britton Clarkson Planning Limited (MHBC), and Stantec Consulting Ltd (Stantec). 2013. North Waterloo Scoped Subwatershed Study, Volume 3B (Table B1). November 2013.

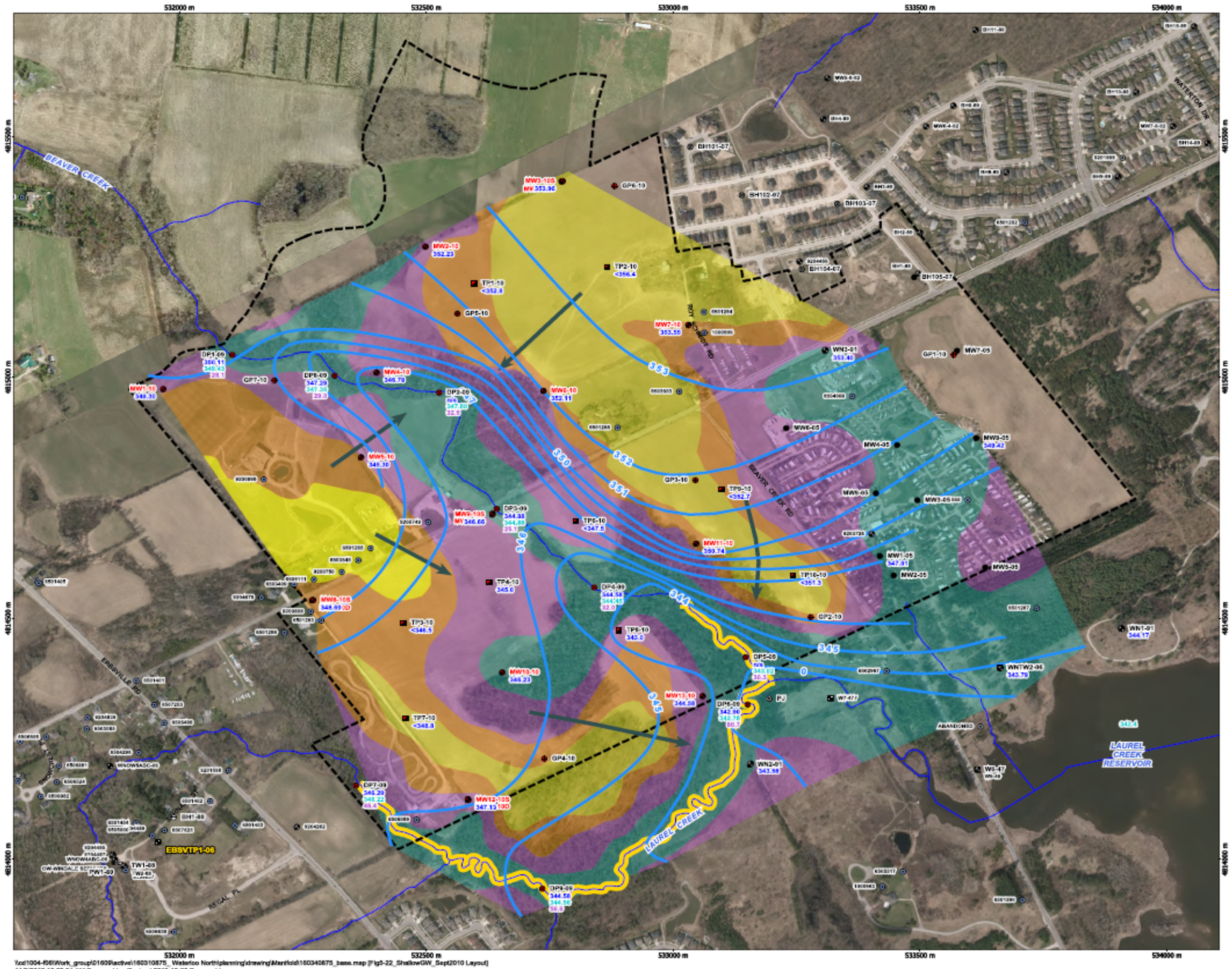
(b) Ecoplans Ltd (a member of MMM Group), MacNaughton Hermsen Britton Clarkson Planning Limited (MHBC), and Stantec Consulting Ltd (Stantec). 2013. North Waterloo Scoped Subwatershed Study, Volume 3A (Table A1). November 2013.

APPENDIX D:
NORTH WATERLOO SCOPED SUBWATERSHED STUDY – GROUNDWATER FLOW MAPPING

NORTH WATERLOO SCOPED SUBWATERSHED STUDY

SHALLOW GROUNDWATER FLOW SEPTEMBER 2010

FIGURE 5.22



- Monitoring Well (Stantec, 2010)
- Drive-Point Piezometer (Stantec, 2010)
- Guelph Permeameter (Stantec, 2010)
- Test Pit (Stantec, 2010)
- Abandoned Monitoring Well (Naylor, 2007)
- Monitoring Well (Stantec, 2005)
- Monitoring Well (CH2MHill, 1991)
- Monitoring Well (Terraqua, 1991)
- Piezometer Location
- Monitoring Well (Other)
- Test Hole
- Water Supply Well
- Well (Other)
- Abandoned Well
- 349.30 Groundwater Elevation (mAMSL)
- 342.50 Surface Water Elevation (mAMSL)
- 342.50 Surface Water Flow (L/s)
- Groundwater Contours within AFB1
- Groundwater Flow Direction
- Interpreted Groundwater Discharge Area
- Primary Study Area

NOTES

1. Coordinate System: UTM NAD 83 - Zone 17 (N).
2. Groundwater level data for monitoring wells and drive-point piezometers from September 3, 2010 at 12:00pm.
3. At multi level wells, groundwater level data presented based on the shallow well screen.
4. Surface water flow data from August 30, 2010.

NORTH

October 2013

Stantec

MHBC PLANNING URBAN DESIGN & LANDSCAPE ARCHITECTURE

ecoplans A member of

160330675

\\cd1004-f06\Work_group\01609\Active\160330875_ Waterloo North\planning\drawing\Mainfold\160340875_base.map [Fig5-22_ShallowGW_Sept2010 Layout]
11/8/2013 10:23:34 AM By: ccoghlan Revised 2013-10-30 By: ccoghlan

APPENDIX E:
BOREHOLE LOGS

Monitoring Well: MW1-10

Project:	North Waterloo Subwatershed Study	**Drilling method:**	Track Mount, CME55, Hollow Stem Auger
Client:		**Date started/completed:**	19-Mar-2010
Location:	North Waterloo, ON	**Ground surface elevation:**	350.07 m AMSL
Number:	160340875	**Top of casing elevation:**	350.96 m AMSL
Field investigator:	A.Vandenhoff	**Easting:**	531967
Contractor:	Pro Core Drilling	**Northing:**	4814976

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS				WELL DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	N Value	Recovery	Diagram	Description
												Stick-up = 0.89 m
0	0		Ground Surface	350.07								
			TOPSOIL some sand and organics, dark brown	0.00 349.84			1	SS	0-0-2-2 (2)	10" 42%		Concrete
			SILTY SAND some organics, light brown	0.23 349.31								
			CLAYEY SILT trace sand sand content increasing with depth	0.76			2	SS	0-1-2-4 (3)	24" 100%		52 mm Schedule 40 PVC casing
5			clay content decreasing with depth	348.54	ATB1	Upper Maryhill Till and Equivalents						Holeplug
	2		SANDY SILT fine grained sand, some clay, grey	1.52			3	SS	0-1-2-2 (3)	15" 63%		
			becoming light greyish brown at 2.3 m BGS				4	SS	0-0-0-0 (0)	23" 96%		Top of sand (2.4 m BGS)
10			becoming wet at 2.8 m BGS	347.02								
			SILTY SAND fine grained, light brown, wet	3.05	AFB1 / AFB2	Upper / Middle Moraine Stratified Sediments and Equivalents	5	SS	0-0-0-0 (0)	21" 88%		Top of screen (3.1 m BGS) No.2 Silica Sand
	4											No.10 Slot PVC screen 50 mm diameter
15				345.29								Bottom of screen (4.6 m BGS)
			SAND medium grained, light brown/grey, wet	4.78 344.89			6	SS	2-2-3-5 (5)	21" 88%		
			End of Borehole	5.18								
20	6											
25	8											

Screen Interval: 3.05 - 4.57 m BGS
Sand Pack Interval: 2.44 - 4.57 m BGS
Well Seal Interval: 0.30 - 2.44 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
n/a - not available

Drawn By/Checked By: OR/LV

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STANTEC BOREHOLE AND WELL 160330875 - DPS.GPJ EQUIS DATA TEMPLATE.GDT 2/1/11 MJFRASER

Monitoring Well: MW2-10

Project:	North Waterloo Subwatershed Study	**Drilling method:**	Track Mount, CME55, Hollow Stem Auger
Client:		**Date started/completed:**	17-Mar-2010
Location:	North Waterloo, ON	**Ground surface elevation:**	355.56 m AMSL
Number:	160340875	**Top of casing elevation:**	356.52 m AMSL
Field investigator:	A.MacKay	**Easting:**	532498
Contractor:	Pro Core Drilling	**Northing:**	4815271

Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	N Value	Recovery	Diagram	Description
												Stick-up = 0.96 m
0	0		Ground Surface	355.56								
			TOPSOIL organics and fine sand, very dark brown, very moist	0.00 355.25								Concrete
			SAND fine grained, trace gravel, dark brown, loose, moist	0.30			1	SS	0-1-1-4 (2)	16.5" 69%		
			becoming brown, very moist, very loose at 0.9 m BGS				2	SS	0-1-0-1 (1)	10.5" 44%		52 mm Schedule 40 PVC casing
5			fine to medium grained sand beginning at 1.5 m BGS				3	SS	0-0-0-0 (0)	13" 54%		Holeplug
	2		becoming grey-brown at 2.3 m BGS		AFB1 / AFB2	Upper / Middle Moraine Stratified Sediments and Equivalents	4	SS	0-0-1-7 (1)	n/a		Top of sand (2.4 m BGS)
10			becoming wet at 3.1 m BGS				5	SS	4-5-8-8 (13)	n/a		Top of screen (3.1 m BGS) No.2 Silica Sand
	4											No.10 Slot PVC screen 50 mm diameter
15							6	SS	3-9-9-12 (18)	n/a		Bottom of screen (4.6 m BGS)
				350.38								
			End of Borehole	5.18								
20	6											
25	8											

Screen Interval: 3.05 - 4.57 m BGS
Sand Pack Interval: 2.44 - 4.57 m BGS
Well Seal Interval: 0.30 - 2.44 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
n/a - not available

mAMSL - metres above mean sea level
mBGS - metres below ground surface

Drawn By/Checked By: OR/LV

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Sheet 1 of 1

STANTEC BOREHOLE AND WELL 160330875 - DPS.GPJ EQUIS DATA TEMPLATE.GDT 2/1/11 MJFRASER

Monitoring Well: MW3-10

Project: North Waterloo Subwatershed Study
Client:
Location: North Waterloo, ON; 03
Number: 160340875

Field investigator: A.MacKay
Contractor: Pro Core Drilling
Drilling method: Track Mount, CME55, Hollow Stem Auger
Date started/completed: 12-Mar-2010 / 17-Mar-2010

Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	N Value	Recovery
			Ground Surface	366.84						
0	0		TOPSOIL	0.00						
			fine sand, dark brown, loose, wet	366.53						
			SAND	0.30						
			fine grained, brown, loose, wet				1	SS	1-10-11-3 (21)	15" 63%
							2	SS	1-2-3-3 (5)	13" 54%
5	2		light brown from 1.5 to 2.9 m BGS				3	SS	2-5-5-5 (10)	12" 50%
							4	SS	1-1 (1)	13" 54%
10			fine to medium grained sand beginning at 2.9 m BGS				5	PQ	n/a	31" 124%
			some coarse grained sand beginning at 3.6 m BGS	362.98						
	4		SILT	3.86						
15			some fine grained sand, brown, firm to stiff, wet				6	PQ	n/a	58" 100%
				361.25						
			SAND	5.59						
20	6		fine grained, brown, loose				7	PQ	n/a	58" 97%
			fine to medium grained, some coarse grained, brown, loose, wet				8	PQ	n/a	50" 83%
25	8									
30							9	PQ	n/a	57" 97%
	10		layer of fine sand, trace silt, stiff, wet at 10 m to 10.3 m BGS				10	PQ	n/a	56" 93%
35										
					AFB1	Upper Moraine Stratified Sediments and Equivalents	11	PQ	n/a	55" 90%
40	12									
							12	PQ	n/a	49" 82%
45										
	14		fine to medium grained, trace silt, brown, loose, wet				13	PQ	n/a	45" 75%
50										
							14	PQ	n/a	41" 68%
55	16									
			layer of fine sand and silt, stiff at 17.4 to 17.7 m BGS				15	PQ	n/a	51" 85%
60			some silt beginning at 17.7 m BGS							
	18			348.09						
			SILT AND SAND	18.75			16	PQ	n/a	48.5" 81%
65			fine grained sand, brown, loose, wet							
	20									
70			layer of fine sand with silt, stiff, brownish grey at 20.3 to 21.8 m BGS				17	PQ	n/a	52" 87%
	22		some clay, grey beginning at 21.8 m BGS				18	PQ	n/a	41" 68%
75				343.52						
			SILTY CLAY	23.32						
80	24		grey, stiff, wet				19	PQ	n/a	46" 77%
							20	PQ	n/a	56" 93%
85	26			340.47						
			SILT	26.37	ATB2	Middle Maryhill Till and Equivalents	21	PQ	n/a	57" 95%
90	28		some fine sand, trace to some clay, greyish brown, soft, wet							

WELL DETAILS

GS Elev: 366.84 m AMSL	GS Elev: 366.81 m AMSL
TOC Elev: 367.60 m AMSL	TOC Elev: 367.62 m AMSL
Easting: 532774	Easting: 532776
Northing: 4815406	Northing: 4815407
Stick-up: 0.76 m	Stick-up: 0.81 m

Cement
Holeplug
52 mm Schedule 80 PVC casing
Bentonite Grout

Cement
52 mm Schedule 40 PVC casing
Holeplug
Top of sand (11.6 m BGS)
Top of screen (12.2 m BGS)
No.2 Silica Sand
No.10 Slot PVC screen 50 mm diameter
Bottom of screen (13.7 m BGS)

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
PQ - wireline continuous core sample
n/a - not available

mAMSL - metres above mean sea level
mBGS - metres below ground surface

PQ - continuous core sampling
SS - split spoon sampling

Drawn By/Checked By: OR/LV

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STANTEC BOREHOLE AND WELL - CLUST 11X17 160330875 - DPS.GPJ EQUIS DATA TEMPLATE.GDT 2/1/11 MJFRASER

Monitoring Well: MW3-10

Project: North Waterloo Subwatershed Study
Client:
Location: North Waterloo, ON; 03
Number: 160340875

Field investigator: A.MacKay
Contractor: Pro Core Drilling
Drilling method: Track Mount, CME55, Hollow Stem Auger
Date started/completed: 12-Mar-2010 / 17-Mar-2010

Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	N Value	Recovery
95			SILT some fine sand, trace to some clay, greyish brown, soft, wet				22	PQ	n/a	44" 75%
	30						23	PQ	n/a	59" 97%
100				336.15						
			SILTY CLAY TILL trace coarse sand and fine gravel, greyish brown, very stiff, wet	30.68			24	PQ	n/a	58.5" 98%
105	32									
							25	PQ	n/a	52" 88%
110										
	34		trace coarse grained gravel beginning at 34.0 m BGS							
					ATB3	Lower Maryhill Till and Equivalents	26	PQ	n/a	61" 100%
115										
			some coarse sand, fine to coarse gravel, dark brown beginning at 35.5 m BGS				27	PQ	n/a	61" 102%
	36									
120										
			cobble, 0.13 m diameter, at 36.7 m BGS				28	PQ	n/a	55" 92%
	38									
125										
							29	PQ	n/a	60" 100%
				327.21						
130			SAND AND SILT some gravel, firm to stiff, wet	39.62 327.04						
	40		SILTY SAND TILL some sand and gravel, grey, very hard, moist	39.80	ATC1	Upper/ Main Catfish Creek Till	30	PQ	n/a	60" 100%
135										
				325.23						
			End of Borehole	41.61						
	42									
140										
	44									
145										
150	46									
155										
	48									
160										
	50									
165										
170	52									
175										
	54									
180										
	56									
185										

WELL DETAILS

GS Elev: 366.84 m AMSL
TOC Elev: 367.60 m AMSL
Easting: 532774
Northing: 4815406
Stick-up: 0.76 m

GS Elev: 366.81 m AMSL
TOC Elev: 367.62 m AMSL
Easting: 532776
Northing: 4815407
Stick-up: 0.81 m

Bentonite Grout
Holelplug
Top of sand (37.6 m BGS)
Top of screen (38.6 m BGS)
No.2 Silica Sand
No.10 Slot PVC screen 50 mm diameter
Bottom of screen (41.6 m BGS)

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
PQ - wireline continuous core sample
n/a - not available

mAMSL - metres above mean sea level
mBGS - metres below ground surface

PQ - continuous core sampling
SS - split spoon sampling

Drawn By/Checked By: OR/LV

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STANTEC BOREHOLE AND WELL - CLUST 11X17 160330875 - DPS.GPJ EQUIS DATA TEMPLATE.GDT 2/1/11 MJFRASER

Monitoring Well: MW4-10

Project:	North Waterloo Subwatershed Study	**Drilling method:**	Track Mount, CME55, Hollow Stem Auger
Client:		**Date started/completed:**	18-Mar-2010
Location:	North Waterloo, ON	**Ground surface elevation:**	347.87 m AMSL
Number:	160340875	**Top of casing elevation:**	348.64 m AMSL
Field investigator:	A.Vandenhoff	**Easting:**	532399
Contractor:	Pro Core Drilling	**Northing:**	4815010

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS				WELL DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	N Value	Recovery	Diagram	Description
												Stick-up = 0.77 m
0	0		Ground Surface	347.87								
			TOPSOIL dark brown, moist	0.00 347.26			1	SS	0-0-3-3 (3)	8" 33%		Concrete Holeplug
			SANDY SILT fine grained sand, light brown, moist	0.61 346.60			2	SS	1-2-3-3 (5)	22" 92%		Top of sand (0.9 m BGS)
5	2		SILTY SAND fine grained, light brown, loose, wet silt content increasing with depth	1.27 345.43	ATB1	Upper Maryhill Port Stanley Till and Equivalents	3	SS	6-4-4-3 (8)	18" 75%		52 mm Schedule 40 PVC casing Top of screen (1.5 m BGS) No.2 Silica Sand
			CLAYEY SILT trace sand	2.44 344.21			4	SS	0-2-3-4 (5)	24" 100%		No.10 Slot PVC screen 50 mm diameter
10	4						5	SS	2-5-6-9 (11)	0" 0%		Bottom of screen (3.0 m BGS)
			End of Borehole	3.66								
15												
20	6											
25	8											

Screen Interval: 1.52 - 3.05 m BGS
Sand Pack Interval: 0.91 - 3.05 m BGS
Well Seal Interval: 0.15 - 0.91 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
n/a - not available

Drawn By/Checked By: OR/LV

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Sheet 1 of 1

STANTEC BOREHOLE AND WELL 160330875 - DPS.GPJ EQUIS DATA TEMPLATE.GDT 2/1/11 MJFRASER

Monitoring Well: MW5-10

Project:	North Waterloo Subwatershed Study	**Drilling method:**	Track Mount, CME55, Hollow Stem Auger
Client:		**Date started/completed:**	19-Mar-2010
Location:	North Waterloo, ON	**Ground surface elevation:**	351.08 m AMSL
Number:	160340875	**Top of casing elevation:**	351.91 m AMSL
Field investigator:	A.Vandenhoff	**Easting:**	532368
Contractor:	Pro Core Drilling	**Northing:**	4814834

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS				WELL DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	N Value	Recovery	Diagram	Description
												Stick-up = 0.8. m
			Ground Surface	351.08								
0	0		TOPSOIL dark brown, moist	0.00 350.93			1	SS	0-2-4-8 (6)	18" 75%		Concrete
			CLAYEY SILT trace organics, light reddish brown, firm to stiff	0.15								Holeplug
					ATB1	Upper Maryhill Port Stanley Till and Equivalents	2	SS	2-3-4-6 (7)	11" 46%		52 mm Schedule 40 PVC casing
5			some gravel light brown beginning at 1.5 m BGS seams of medium grained sand beginning at 1.7 m BGS				3	SS	2-4-12-7 (16)	24" 100%		
	2		layer of coarse gravel at 2.1 m BGS trace sand and gravel at 2.3 m BGS									Top of sand (2.1 m BGS)
				348.33			4	SS	9-11-10-11 (21)	9" 38%		Top of screen (2.7 m BGS)
10			SILTY SAND fine to medium grained sand, light brown, wet	2.74			5	SS	10-14-12-8 (26)	14" 58%		No.2 Silica Sand
	4				AFB1 / AFB2	Upper / Middle Moraine Stratified Sediments and Equivalents						No.10 Slot PVC screen 50 mm diameter
15				346.51								Bottom of screen (4.3 m BGS)
			End of Borehole	4.57								Natural cave
20	6											
25	8											

Screen Interval: 2.74 - 4.27 m BGS
Sand Pack Interval: 2.13 - 4.27 m BGS
Well Seal Interval: 0.30 - 2.13 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
n/a - not available

Drawn By/Checked By: OR/LV

Stantec

STANTEC BOREHOLE AND WELL 160330875 - DPS.GPJ EQUIS DATA TEMPLATE.GDT 2/1/11 MJFRASER

Monitoring Well: MW6-10

Project:	North Waterloo Subwatershed Study	**Drilling method:**	Track Mount, CME55, Hollow Stem Auger
Client:		**Date started/completed:**	18-Mar-2010
Location:	North Waterloo, ON	**Ground surface elevation:**	355.58 m AMSL
Number:	160340875	**Top of casing elevation:**	356.48 m AMSL
Field investigator:	A.Vandenhoff	**Easting:**	532737
Contractor:	Pro Core Drilling	**Northing:**	4814972

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS				WELL DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	N Value	Recovery	Diagram	Description
												Stick-up = 0.90 m
0	0		Ground Surface	355.58								
			SAND fine to medium grained,dark brown, loose, moist	0.00			1	SS	3-4-5-5 (9)	13" 54%		Concrete
			becoming reddish brown at 0.8 m BGS				2	SS	2-3-3-3 (6)	14" 58%		52 mm Schedule 40 PVC casing
5			trace gravel beginning at 1.5 m BGS				3	SS	1-1-1-2 (2)	14" 58%		Holeplug
	2			353.29								
			SAND medium grained, trace gravel, light brown, loose, moist	2.29	AFB1 / AFB2	Upper / Middle Moraine Stratified Sediments and Equivalents	4	SS	3-5-5-5 (10)	16" 67%		Top of sand (2.4 m BGS)
10							5	SS	3-3-2-4 (5)	13" 54%		Top of screen (3.1 m BGS) No.2 Silica Sand
	4		some gravel, wet at 3.6 m BGS									No.10 Slot PVC screen 50 mm diameter
15			some coarse grained sand, trace gravel at 4.6 m BGS				6	SS	4-15-20-25 (35)	20" 83%		Bottom of screen (4.6 m BGS)
				350.40								
			End of Borehole	5.18								
20	6											
25	8											

Screen Interval: 3.05 - 4.57 m BGS
Sand Pack Interval: 2.44 - 4.57 m BGS
Well Seal Interval: 0.15 - 2.44 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
n/a - not available

Drawn By/Checked By: OR/LV

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STANTEC BOREHOLE AND WELL 160330875 - DPS.GPJ EQUIS DATA TEMPLATE.GDT 2/1/11 MJFRASER

Monitoring Well: MW7-10

Project:	North Waterloo Subwatershed Study	**Drilling method:**	Track Mount, CME55, Hollow Stem Auger
Client:		**Date started/completed:**	18-Mar-2010
Location:	North Waterloo, ON	**Ground surface elevation:**	358.74 m AMSL
Number:	160340875	**Top of casing elevation:**	359.67 m AMSL
Field investigator:	A.Vandenhoff	**Easting:**	533031
Contractor:	Pro Core Drilling	**Northing:**	4815108

Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	N Value	Recovery	Diagram	Description
												Stick-up = 0.93 m
0	0		Ground Surface	358.74								
			TOPSOIL dark brown	0.00 358.48								Concrete
			CLAYEY SILT trace gravel, light brown, firm to stiff, moist	0.25			1	SS	1-1-2-3 (3)	19" 79%		
							2	SS	2-3-5-5 (8)	13" 54%		52 mm Schedule 40 PVC casing
				357.52								
5	2		SAND fine to medium grained, trace silt, trace gravel, light reddish brown, loose, moist	1.22			3	SS	6-1-4-5 (5)	11" 46%		
				356.30	ATB1	Upper Maryhill Port Stanley Till and Equivalents						Holeplug
			SILT trace fine to coarse sand, trace gravel, stiff, light brown, moist	2.44			4	SS	1-5-7-12 (12)	15" 63%		
10	4		becoming clayey at 3.1 m BGS				5	SS	2-5-6-10 (11)	24" 100%		
				354.17								
15			SAND fine to medium grained, light brown, compact, moist	4.57			6	SS	4-14-20-24 (34)	18" 75%		Top of sand (5.2 m BGS)
			becoming wet at 5.2 to 6.1 m BGS									Top of screen (5.8 m BGS)
20	6				AFB1 / AFB2	Upper / Middle Moraine Stratified Sediments and Equivalents	7	SS	8-20-22->50 (>42)	24" 100%		No.2 Silica Sand
												No.10 Slot PVC screen 50 mm diameter
25	8						8	SS	9-20-32-39 (52)	24" 100%		Bottom of screen (7.3 m BGS)
				350.51								Natural Cave
			End of Borehole	8.23								

Screen Interval: 5.79 - 7.32 m BGS
Sand Pack Interval: 5.18 - 7.32 m BGS
Well Seal Interval: 0.30 - 5.18 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
n/a - not available

Drawn By/Checked By: OR/LV

Stantec

STANTEC BOREHOLE AND WELL 160330875 - DPS.GPJ EQUIS DATA TEMPLATE.GDT 2/1/11 MJFRASER

Monitoring Well: MW1-19

Project:	556 & 576 Conservation Drive, Waterloo	**Method:**	Track Mounted CME 850 Hollow Stem Auger
Client:	2115881 Ontario Limited	**Date started/completed:**	12-Apr-2019
Location:	Waterloo, Ontario	**Ground surface elevation:**	353.32 m AMSL
Number:	160900921	**Top of casing elevation:**	354.10 m AMSL
Field investigator:	D. Smith	**Easting:**	532466
Contractor:	Aardvark Drilling Inc.	**Northing:**	4815187

SUBSURFACE PROFILE				SAMPLE DETAILS				INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Stratigraphic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Recovery	N Value	Diagram / Description
				354.10					
-2									Above Ground Casing 0.78 m stick-up
0	0		Ground Surface	353.32					
			TOPSOIL soft, dark brown (10 YR 3/3), fine grained sand, some silt/clay, trace medium grained sand, trace fine gravel, moist	0.00 352.94	1	SS	24" 100%	1-3-2-3 (5)	
2			FINE SAND soft, dark yellowish brown (10YR 4/6), some silt/clay, trace medium grained sand, trace fine gravel, moist colour change to light yellowish brown (10YR 6/4) at 0.56 m BGS reddish orange mottled discolourations at 0.81 m BGS becoming wet at 0.84 m BGS	0.38 352.23	2	SS	14" 58%	2-2-3-4 (5)	Bentonite Pellets 0 to 1.2 m Water Level 0.93 m BGS 10-May-19
4	1		MEDIUM SAND loose, greyish brown (10YR 5/2), trace silt/clay, some fine grained sand, trace coarse grained sand, wet compact at 1.52 m BGS	1.09	3	SS	21" 88%	3-6-6-6 (12)	
6	2		fine grained sand and silt/clay seam from 1.98 to 2.03 m BGS		4	SS	24" 100%	1-6-8-10 (14)	210 mm diameter borehole
8			trace fine gravel, subrounded, beginning at 2.59 m BGS						
10	3				5	SS	21" 88%	4-7-8-8 (15)	No. 2 Silica Sand 1.2 to 4.6 m No. 10 Slot Schedule 40 PVC Screen 52 mm I.D. 1.5 to 4.6 m
12	4								
14									
16	5		grading coarser, increase in coarse grained sand at 5.03 m BGS	348.14	6	SS	24" 100%	3-5-6-9 (11)	
			End of Borehole	5.18					

Screen Interval: 1.52 - 4.57 m BGS
Sand Pack Interval: 1.52 - 4.57 m BGS
Well Seal Interval: 0.00 - 1.22 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
SS - split-spoon sample
n/a - not available

Stantec

Drawn By/Checked By: D.S. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 21/7/20 AHEALEY

Monitoring Well: MW2-19

Project:	556 & 576 Conservation Drive, Waterloo	**Method:**	Track Mounted CME 850 Hollow Stem Auger
Client:	2115881 Ontario Limited	**Date started/completed:**	11-Apr-2019
Location:	Waterloo, Ontario	**Ground surface elevation:**	358.20 m AMSL
Number:	160900921	**Top of casing elevation:**	358.92 m AMSL
Field investigator:	D. Smith	**Easting:**	532882
Contractor:	Aardvark Drilling Inc.	**Northing:**	4815140

SUBSURFACE PROFILE				SAMPLE DETAILS				INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Stratigraphic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Recovery	N Value	Diagram / Description
				358.92					
			Ground Surface	358.20					Above Ground Casing 0.69 m stick-up
0	0		TOPSOIL	0.00					
			soft, dark brown (10YR 3/3), clayey silt, trace fine grained sand, moist	358.05	1	SS	24" 100%	2-1-2-2 (3)	
			CLAYEY SILT soft, dark brown (10YR 3/3), some sand, moist yellowish brown mottling at 0.48 m BGS	0.15					
				357.36					
			coarse grained sand and fine gravel present from 0.84 to 0.86 m BGS	0.86	2	SS	16" 67%	1-1-1-2 (2)	
			SILTY CLAY very soft, yellowish brown (10YR 5/4), trace fine grained sand, poorly graded, moist						
5									
			stiff, increase in silt, change to clayey silt at 1.68 m BGS		3	SS	24" 100%	1-4-5-8 (9)	
	2								Bentonite Pellets 0 to 4.3 m
			very stiff, trace fine gravel and coarse grained sand beginning at 2.29 m BGS						
			silty sand seam, wet, from 2.59 to 2.64 m BGS increase in clay, change to silty clay at 2.64 m BGS		4	SS	24" 100%	4-9-16-16 (25)	Water Level 2.77 m BGS 10-May-19
10				355.00					210 mm diameter borehole
			SANDY SILT compact, yellowish brown (10YR 5/4), some clay, fine grained sand, trace fine gravel, moist	3.20	5	SS	24" 100%	7-12-16-20 (28)	
	4								
15				353.55					
			FINE SAND compact, brown (10YR 5/3), some silt/clay, trace medium grained sand, moist becomes wet at 4.83 m BGS clay seam from 5.03 to 5.06 m BGS becomes moist at 5.05 m BGS	4.65	6	SS	21" 88%	4-12-14-14 (26)	
	6								No. 2 Silica Sand 4.3 to 7.6 m
20			wet from 6.10 to 6.25 m BGS increase in silt to silty sand, becomes stiff at 6.25 m BGS		7	SS	24" 100%	5-5-8-9 (13)	No. 10 Slot Schedule 40 PVC Screen 52 mm I.D. 4.6 to 7.6 m
			becomes wet at 6.66 m BGS						
25									
			decrease in silt to fine sand with some silt, trace fine gravel present, change to firm at 7.62 m BGS		8	SS	21" 88%	3-5-3-7 (8)	
	8		silty clay seam from 8.00 to 8.08 m BGS	349.97					
			End of Borehole	8.23					

Screen Interval: 4.57 - 7.62 m BGS
Sand Pack Interval: 4.57 - 7.62 m BGS
Well Seal Interval: 0.00 - 4.27 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
SS - split-spoon sample
n/a - not available

Stantec

Drawn By/Checked By: D.S. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 21/7/20 AHEALEY

Monitoring Well: MW3-19

Project:	556 & 576 Conservation Drive, Waterloo	**Method:**	Track Mounted CME 850 Hollow Stem Auger
Client:	2115881 Ontario Limited	**Date started/completed:**	11-Apr-2019
Location:	Waterloo, Ontario	**Ground surface elevation:**	354.77 m AMSL
Number:	160900921	**Top of casing elevation:**	355.59 m AMSL
Field investigator:	D. Smith	**Easting:**	532771
Contractor:	Aardvark Drilling Inc.	**Northing:**	4814915

SUBSURFACE PROFILE				SAMPLE DETAILS				INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Stratigraphic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Recovery	N Value	Diagram / Description
				355.59					
			Ground Surface	354.77					Above Ground Casing 0.82 m stick-up
0	0		TOPSOIL loose, dark brown (10YR 3/3), fine grained sand topsoil, trace organics, trace silt/clay, moist	0.00 354.57					
			FINE SAND loose, dark yellowish brown (10YR 4/6), trace silt/clay, trace medium grained sand, moist	0.20 354.01	1	SS	21" 88%	2-2-4-2 (6)	
	1		MEDIUM SAND compact, brown (10YR 5/3), some fine and coarse grained sand, trace fine and coarse gravel, subrounded, moist	0.76	2	SS	12" 50%	3-8-8-5 (16)	Bentonite Pellets 0 to 2.7 m
5			loose, poorly graded medium grained sand with some fine grained sand, change to pale brown (10YR 6/3) at 1.52 m BGS		3	SS	18" 75%	2-4-4-5 (8)	
	2			352.48					210 mm diameter borehole
			FINE SAND loose, light brownish grey (10 YR 6/2), trace silt/clay, trace medium grained sand, moist	2.29	4	SS	16" 67%	1-3-7-7 (10)	Water Level 2.65 m BGS 10-May-19
10	3			351.72					
			MEDIUM SAND compact, light brownish grey (10YR 6/2), some fine grained sand, trace coarse grained sand and fine gravel, subrounded, wet grading finer beginning at 3.45 m BGS	3.05	5	SS	22" 92%	4-6-9-8 (15)	
	4								No. 2 Silica Sand 2.7 to 6.0 m
15			soft fine grained sand seam with trace silt/clay from 4.57 to 4.93 m BGS		6	SS	24" 100%	4-8-11-11 (19)	No. 10 Slot Schedule 40 PVC Screen 52 mm I.D. 3.0 to 6.0 m
	5		becomes loose at 4.93 m BGS						
	6								
20			becomes compact at 6.10 m BGS trace fine gravel and coarse grained sand beginning at 6.27 m BGS		7	SS	24" 100%	3-9-11-19 (20)	
			End of Borehole	348.06 6.71					

Screen Interval: 3.05 - 6.10 m BGS
Sand Pack Interval: 3.05 - 6.10 m BGS
Well Seal Interval: 0.00 - 2.74 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
SS - split-spoon sample
n/a - not available

Stantec

Drawn By/Checked By: D.S. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 21/7/20 AHEALEY

Monitoring Well: MW4-19

Project:	556 & 576 Conservation Drive, Waterloo	**Method:**	Track Mounted CME 850 Hollow Stem Auger
Client:	2115881 Ontario Limited	**Date started/completed:**	12-Apr-2019
Location:	Waterloo, Ontario	**Ground surface elevation:**	358.72 m AMSL
Number:	160900921	**Top of casing elevation:**	359.49 m AMSL
Field investigator:	D. Smith	**Easting:**	532912
Contractor:	Aardvark Drilling Inc.	**Northing:**	4814898

SUBSURFACE PROFILE				SAMPLE DETAILS				INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Stratigraphic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Recovery / N Value	Diagram	Description
				359.49					
			Ground Surface	358.72					Above Ground Casing 0.77 m stick-up
0	0		TOPSOIL	0.00					
			loose, very dark brown (10YR 2/2), fine grained sand, some silt/clay, trace organics, moist	358.52	1	SS	24" 100% 1-1-2-2 (3)		
			FINE SAND	0.20					
			loose, very dark brown (10YR 2/2), some silt/clay, moist	358.16					
			colour change to dark yellowish brown (10YR 4/4) at 0.36 m BGS	0.56					
			FINE TO MEDIUM SAND						
			compact, pale brown (10YR 6/3), trace silt/clay, moist		2	SS	14" 58% 2-3-8-8 (11)		
			trace fine gravel and coarse grained sand, subrounded, beginning at 0.94 m BGS						
5			fine grained sand seam with some silt/clay from 1.60 to 1.80 m BGS		3	SS	18" 75% 4-5-11-16 (16)		
	2								
			black laminations begin, becomes poorly graded fine and medium grained sand beginning at 2.29 m BGS		4	SS	20" 83% 6-16-13-15 (29)		
10									Bentonite Pellets 0 to 5.8 m
				355.32	5	SS	19" 79% 5-11-16-18 (27)		
			MEDIUM SAND	3.40					
	4		compact, light grey (10YR 7/2), some fine grained sand, trace coarse grained sand, moist						
15			dense beginning at 4.6 m BGS		6	SS	20" 83% 12-18-18-20 (36)		210 mm diameter borehole
	6			352.62					
20			dense, light brownish grey (10YR 6/2), trace silt/clay, poorly graded, black laminations, moist	6.10	7	SS	19" 79% 10-16-22-26 (38)		Water Level 6.73 m BGS 10-May-19
25			increase in medium grained sand at 7.6 m BGS		8	SS	24" 100% 4-16-15 (31)		No. 2 Silica Sand 5.8 to 9.1 m No. 10 Slot Schedule 40 PVC Screen 52 mm I.D. 6.1 to 9.1 m
	8								
30				349.57					
			End of Borehole	9.14					

Screen Interval: 6.10 - 9.14 m BGS
Sand Pack Interval: 6.10 - 9.14 m BGS
Well Seal Interval: 0.00 - 5.79 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
SS - split-spoon sample
n/a - not available

Stantec

Drawn By/Checked By: D.S. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 21/7/20 AHEALEY

Monitoring Well: MW5-19

Project:	556 & 576 Conservation Drive, Waterloo	**Method:**	Track Mounted CME 850 Hollow Stem Auger
Client:	2115881 Ontario Limited	**Date started/completed:**	11-Apr-2019
Location:	Waterloo, Ontario	**Ground surface elevation:**	357.45 m AMSL
Number:	160900921	**Top of casing elevation:**	358.23 m AMSL
Field investigator:	D. Smith	**Easting:**	532740
Contractor:	Aardvark Drilling Inc.	**Northing:**	4815095

SUBSURFACE PROFILE				SAMPLE DETAILS				INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Stratigraphic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Recovery / N Value	Diagram	Description
				358.23					
									Above Ground Casing 0.78 m stick-up
0	0		Ground Surface	357.45					
			TOPSOIL	0.00					
			loose, silty sand topsoil, fine grained sand, trace clay, trace organics, moist, poor recovery - depth estimated	357.30	1	SS	3" 13% 1-3-1-2 (4)		
				0.15					
			FINE TO MEDIUM SAND loose, light brownish grey (10YR 6/2), trace coarse grained sand, trace fine gravel, moist	356.51					
			FINE SAND compact, pale brown (10YR 6/3), some silt/clay, moist, laminations of silt/clay with purplish brown discolourations	0.94	2	SS	16" 67% 4-7-5-4 (12)		
5			becomes wet, trace medium grained sand beginning at 1.73 m BGS	355.59	3	SS	18" 75% 3-2-4-6 (6)		
	2		SILT dense to very dense, pale brown (10YR 6/3), trace clay and fine grained sand, blocky, moist	1.85					Bentonite Pellets 0 to 4.3 m
			some fine grained sand at 2.29 m BGS		4	SS	24" 100% 8-14-20-17 (34)		
10			trace coarse grained sand and trace fine gravel beginning at 3.25 m BGS		5	SS	24" 100% 12-18-22-26 (40)		210 mm diameter borehole
	4								
15			some clay, greyish brown (10YR 5/2), well graded at 4.57 m BGS		6	SS	24" 100% 8-21-20-27 (41)		Water Level 4.53 m BGS 10-May-19
20	6				7	SS	24" 100% 17-25-32-30 (57)		No. 2 Silica Sand 4.3 to 7.6 m No. 10 Slot Schedule 40 PVC Screen 52 mm I.D. 4.6 to 7.6 m
25			trace sand, increase in clay to silty clay at 7.62 m BGS		8	SS	24" 100% 15-20-28-30 (48)		
	8			349.22					
			End of Borehole	8.23					

Screen Interval: 4.57 - 7.62 m BGS
Sand Pack Interval: 4.57 - 7.62 m BGS
Well Seal Interval: 0.00 - 4.27 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
SS - split-spoon sample
n/a - not available

Stantec

Drawn By/Checked By: D.S. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 21/7/20 AHEALEY

Monitoring Well: MW6-19

Project:	556 & 576 Conservation Drive, Waterloo	**Method:**	Track Mounted CME 850 Hollow Stem Auger
Client:	2115881 Ontario Limited	**Date started/completed:**	12-Apr-2019
Location:	Waterloo, Ontario	**Ground surface elevation:**	357.24 m AMSL
Number:	160900921	**Top of casing elevation:**	358.02 m AMSL
Field investigator:	D. Smith	**Easting:**	532640
Contractor:	Aardvark Drilling Inc.	**Northing:**	4815323

SUBSURFACE PROFILE				SAMPLE DETAILS				INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Stratigraphic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Recovery	N Value	Diagram / Description
				358.02					
-2									Above Ground Casing 0.78 m stick-up
0	0		Ground Surface	357.24					
			TOPSOIL loose, dark yellowish brown (10YR 4/4), silty sand topsoil, fine grained sand, trace clay, moist	0.00 357.04					Water Level 0.02 m BGS 10-May-19
			SILTY SAND loose, yellowish brown (10YR 5/4), trace clay, fine grained sand, moist	0.20 356.78	1	SS	22" 92%	1-2-2-1 (4)	
2			CLAYEY SILT firm to stiff, dark yellowish brown (10YR 4/4), some fine grained sand, moist	0.46					Bentonite Pellets 0 to 1.2 m
	1		colour change to brown (10YR 5/3), decrease in fine grained sand to trace, trace medium and coarse grained sand beginning at 0.84 m BGS trace fine and coarse gravel, subrounded, beginning at 1.02 m BGS		2	SS	17" 71%	2-3-5-6 (8)	
4									
6	2		fine grained sand seam, wet, from 1.96 to 1.98 m BGS	355.16	3	SS	24" 100%	2-4-5-7 (9)	
			black gravel beginning at 2.01 m BGS	2.08					210 mm diameter borehole
			SILTY SAND compact, brown (10 YR 5/4), fine grained sand, trace clay, wet						
8					4	SS	20" 83%	3-7-10-7 (17)	No. 2 Silica Sand 1.2 to 4.4 m
10	3		hard clay seam with purplish brown discolourations from 3.20 to 3.28 m BGS		5	SS	21" 88%	3-3-5-3 (8)	No. 10 Slot Schedule 40 PVC Screen 52 mm I.D. 1.4 to 4.4 m
12	4			352.67					
14			SANDY SILT dense, pale brown (10YR 6/3), fine grained sand, trace clay, blocky, moist	4.57	6	SS	23" 96%	6-19-19-19 (38)	
16	5		hard clay seam with purplish brown discolourations from 5.13 to 5.18 m BGS	352.06					
			End of Borehole	5.18					

Screen Interval: 1.40 - 4.40 m BGS
Sand Pack Interval: 1.40 - 4.40 m BGS
Well Seal Interval: 0.00 - 1.22 m BGS

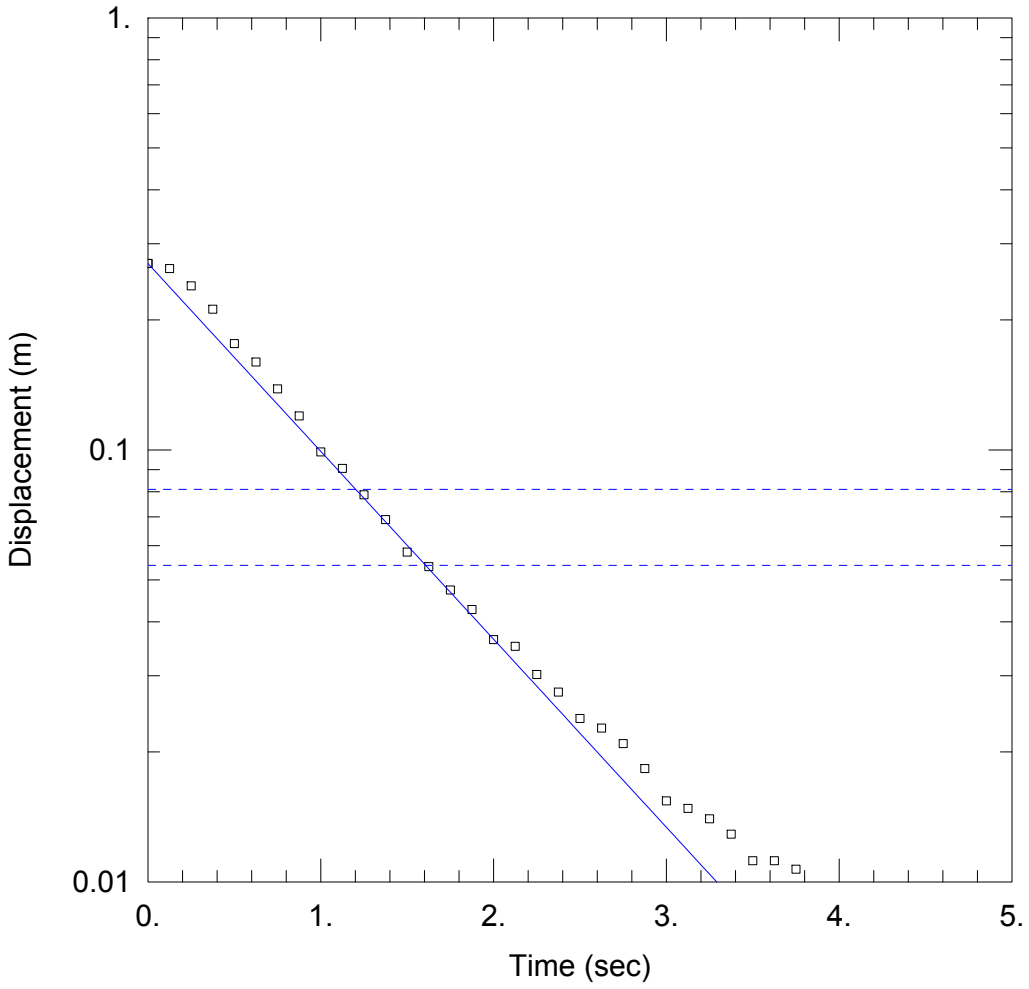
Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
SS - split-spoon sample
n/a - not available

Stantec

Drawn By/Checked By: D.S. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 21/7/20 AHEALEY

APPENDIX F:
HYDRAULIC CONDUCTIVITY TESTING SOLUTIONS



MW1-19

Data Set: \...\MW1-19_DS_JK.aqt
Date: 06/05/19 Time: 11:54:27

PROJECT INFORMATION

Company: Stantec
Project: 160900921
Location: Waterloo
Test Well: MW1-19
Test Date: May 10, 2019

AQUIFER DATA

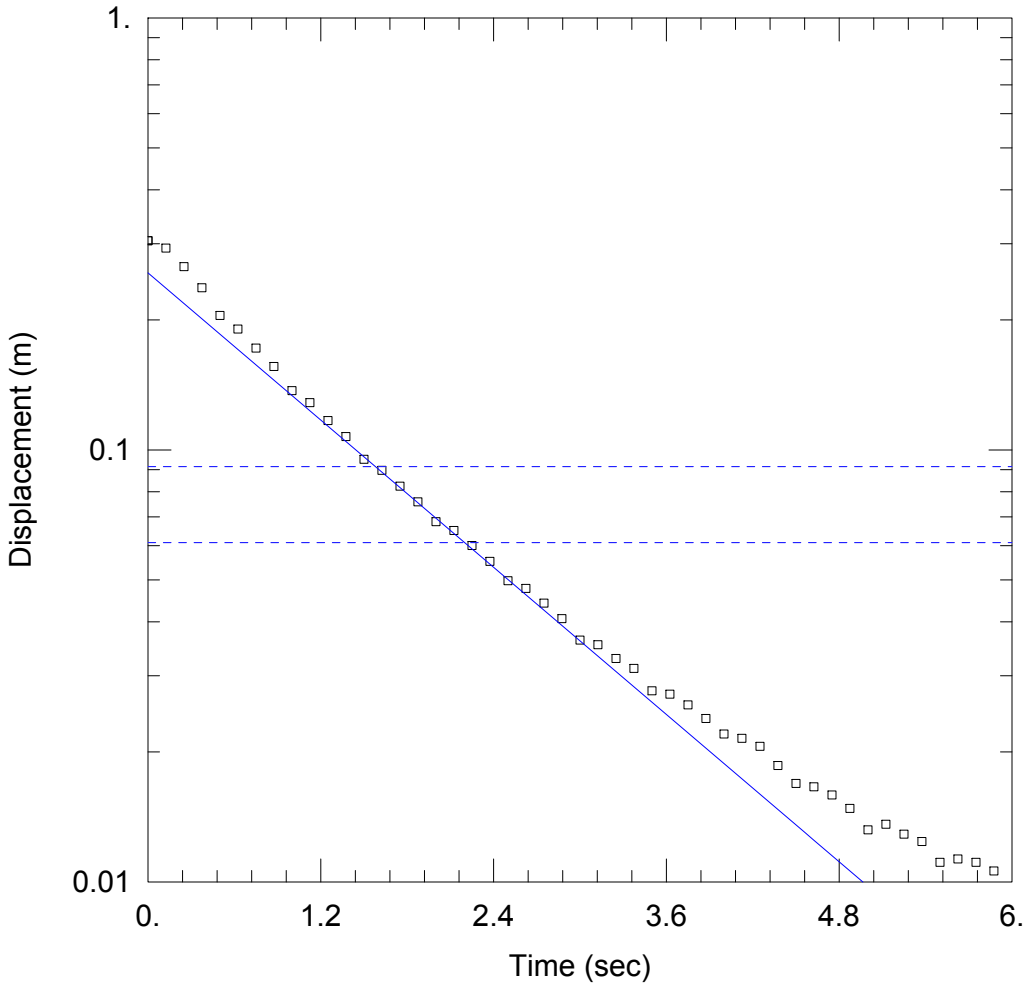
Saturated Thickness: 4.15 m Anisotropy Ratio (Kz/Kr): 0.5

WELL DATA (MW1-19)

Initial Displacement: 0.2702 m
Total Well Penetration Depth: 3.48 m
Casing Radius: 0.0254 m
Static Water Column Height: 3.485 m
Screen Length: 3.05 m
Well Radius: 0.105 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.00028 m/sec
y0 = 0.27 m



MW3-19

Data Set: \...\MW3-19_DS_JK.aqt
Date: 06/05/19 Time: 13:26:11

PROJECT INFORMATION

Company: Stantec
Project: 160900921
Location: Waterloo
Test Well: MW3-19
Test Date: May 10, 2019

AQUIFER DATA

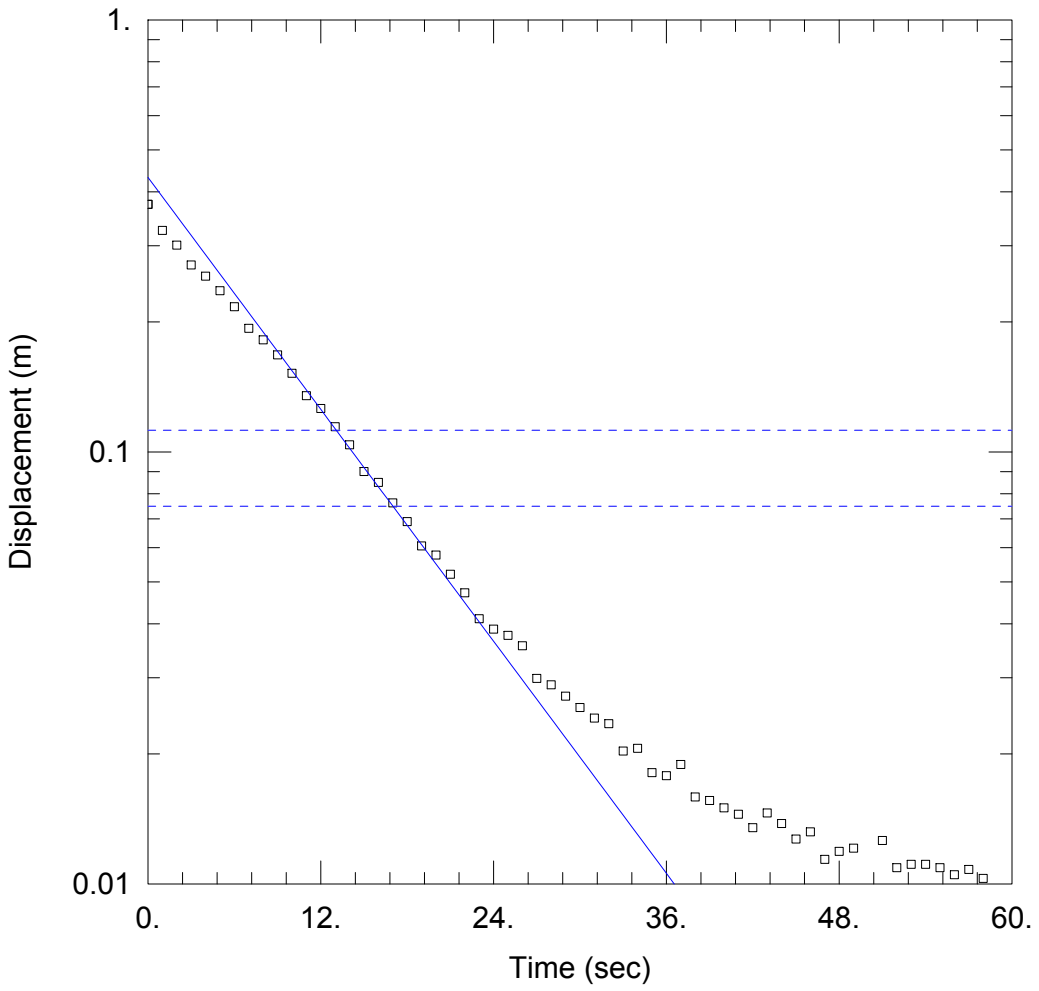
Saturated Thickness: 3.955 m Anisotropy Ratio (Kz/Kr): 0.5

WELL DATA (MW3-19)

Initial Displacement: 0.3049 m
Total Well Penetration Depth: 3.245 m
Casing Radius: 0.0254 m
Static Water Column Height: 3.245 m
Screen Length: 3.05 m
Well Radius: 0.105 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.00018 m/sec
y0 = 0.2569 m



MW4-19

Data Set: \...\MW4-19_DS_JK.aqt
Date: 06/05/19 Time: 13:31:58

PROJECT INFORMATION

Company: Stantec
Project: 160900921
Location: Waterloo
Test Well: MW4-19
Test Date: May 10, 2019

AQUIFER DATA

Saturated Thickness: 2.37 m Anisotropy Ratio (Kz/Kr): 0.4

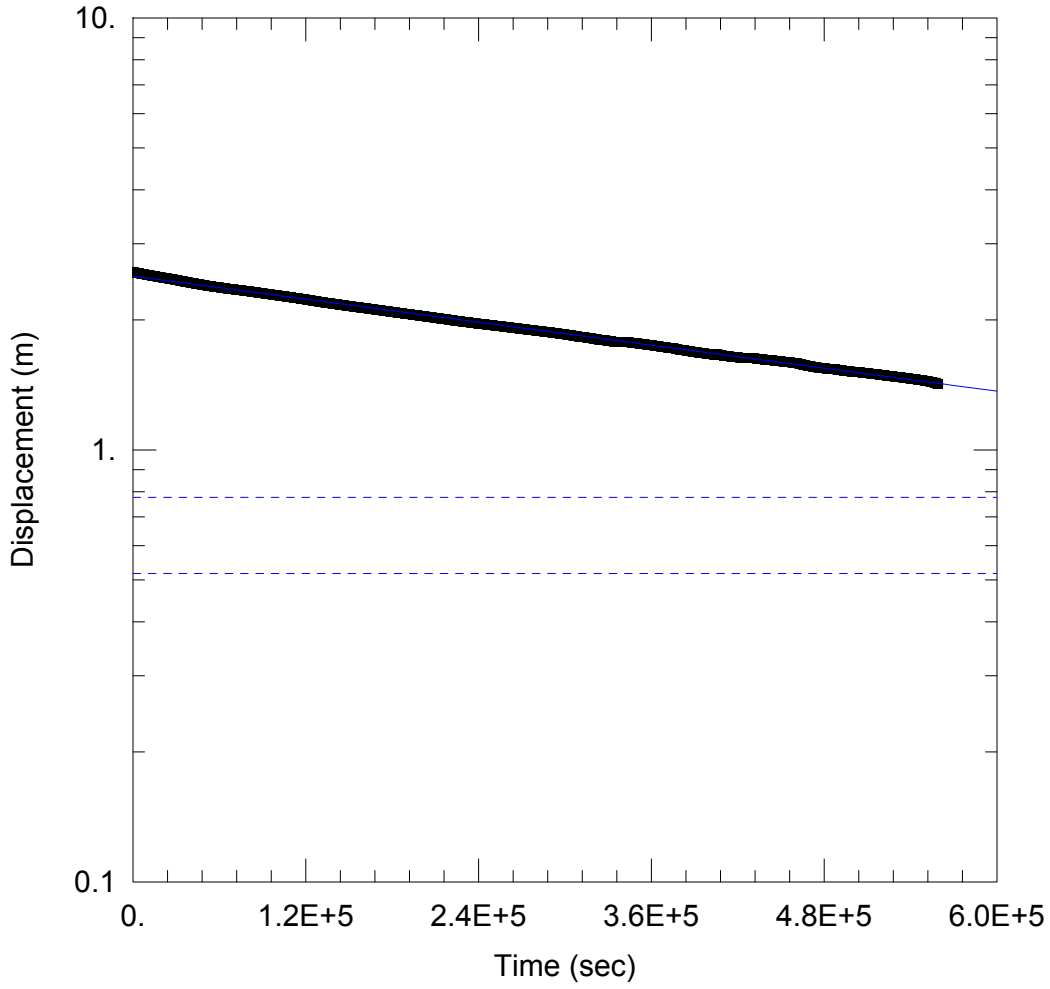
WELL DATA (MW4-19)

Initial Displacement: 0.3742 m
Total Well Penetration Depth: 2.37 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.37 m
Screen Length: 2.37 m
Well Radius: 0.105 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.00019 m/sec y0 = 0.4319 m



MW5-19

Data Set: \...\MW5-19_incomplete ktest_DS_JK.aqt
Date: 06/05/19 Time: 13:55:19

PROJECT INFORMATION

Company: Stantec
Project: 160900921
Location: Waterloo
Test Well: MW5-19
Test Date: May 10, 2019

AQUIFER DATA

Saturated Thickness: 3.635 m Anisotropy Ratio (Kz/Kr): 0.25

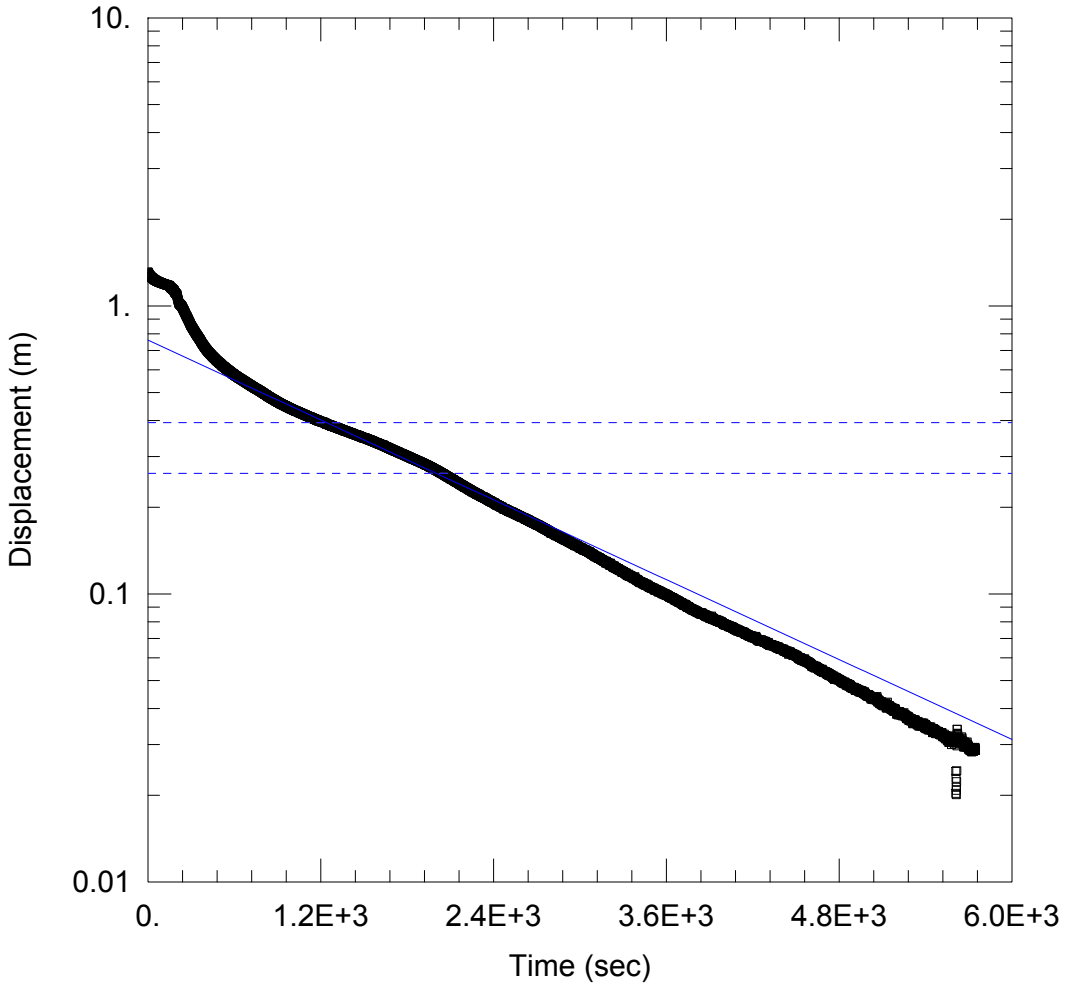
WELL DATA (MW5-19)

Initial Displacement: 2.588 m
Total Well Penetration Depth: 3.05 m
Casing Radius: 0.0254 m
Static Water Column Height: 3.05 m
Screen Length: 3.05 m
Well Radius: 0.105 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 1.8E-9 m/sec y0 = 2.525 m



MW6-19

Data Set: \...\MW6-19_DS_JK.aqt
Date: 06/05/19 Time: 14:07:31

PROJECT INFORMATION

Company: Stantec
Project: 160900921
Location: Waterloo
Test Well: MW6-19
Test Date: May 10, 2019

AQUIFER DATA

Saturated Thickness: 2.57 m Anisotropy Ratio (Kz/Kr): 0.2

WELL DATA (MW6-19)

Initial Displacement: 1.311 m
Total Well Penetration Depth: 2.57 m
Casing Radius: 0.0254 m
Static Water Column Height: 4.5 m
Screen Length: 2.57 m
Well Radius: 0.105 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 1.6E-7 m/sec
y0 = 0.7609 m

APPENDIX G:
GRAIN SIZE ANALYSIS

Englobe
353 Bridge Street East, Kitchener, ON N2K 2Y5
Tel: (519) 741-1313 Fax: (519) 741-5422
E-Mail: kitchener@englobecorp.com Website: www.englobecorp.com

GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-696 PROJECT LOCATION: Waterloo, Ontario FIGURE No.: 1

BOREHOLE / TEST PIT NUMBER:	GP 101-20
SAMPLING DEPTH:	0 - 35 cm
SAMPLE NUMBER:	01
SAMPLED BY:	Client
SAMPLE DESCRIPTION:	Topsoil
SAMPLE NATURAL MOISTURE:	-
SAMPLE RECEIVED DATE:	6/23/2020

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	0.1
% SAND (75 µm to 4.75 mm):	30.0
% Silt (2 µm to 75 µm):	42.9
% Clay (<2 µm):	27.0
SUSCEPTIBILITY TO FROST HEAVING:	-

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	60.2
37.5	100.0	0.026	54.9
26.5	100.0	0.017	51.4
19.0	100.0	0.010	46.2
13.2	100.0	0.007	42.7
9.5	100.0	0.005	37.5
4.75	99.9	0.003	30.5
2.00	99.6	0.001	24.4
0.850	99.6	ATTERBERG LIMITS, %	
0.425	98.0		
0.250	94.1	Plastic Limit	
0.106	77.0	Liquid Limit	
0.075	69.9	Plastic Index	

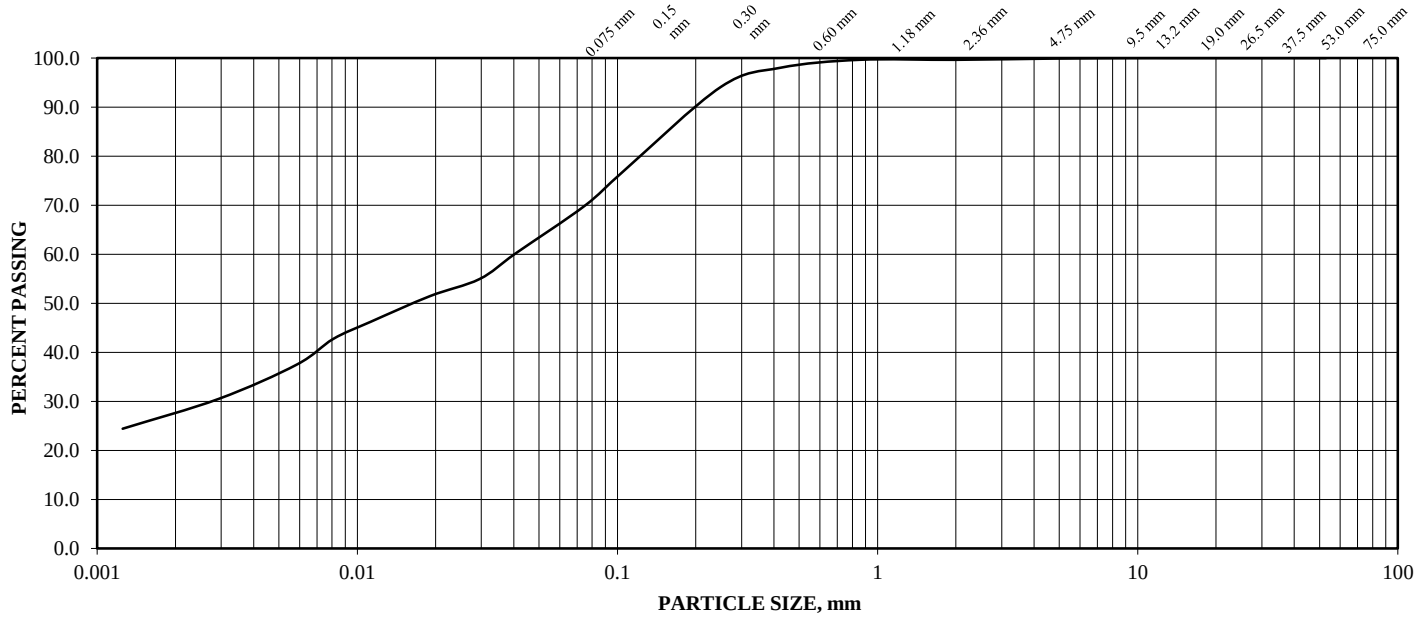
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



SIGNED: _____ DATE: 07/07/2020

O. Rexha

Englobe
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E-Mail: kitchener@englobecorp.com Website: www.englobecorp.com

GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-697 PROJECT LOCATION: Waterloo, Ontario FIGURE No.: 2

BOREHOLE / TEST PIT NUMBER:	GP 101-20
SAMPLING DEPTH:	35 - 55 cm
SAMPLE NUMBER:	02
SAMPLED BY:	Client
SAMPLE DESCRIPTION:	SILT, fine sand, clay
SAMPLE NATURAL MOISTURE:	-
SAMPLE RECEIVED DATE:	6/23/2020

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	0.0
% SAND (75 µm to 4.75 mm):	25.8
% Silt (2 µm to 75 µm):	41.7
% Clay (<2 µm):	32.5
SUSCEPTIBILITY TO FROST HEAVING:	-

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	66.1
37.5	100.0	0.026	61.5
26.5	100.0	0.017	57.0
19.0	100.0	0.010	51.6
13.2	100.0	0.007	48.0
9.5	100.0	0.005	42.5
4.75	100.0	0.003	35.3
2.00	99.9	0.001	29.0
0.850	99.9	ATTERBERG LIMITS, %	
0.425	98.8		
0.250	95.3	Plastic Limit	
0.106	80.6	Liquid Limit	
0.075	74.2	Plastic Index	

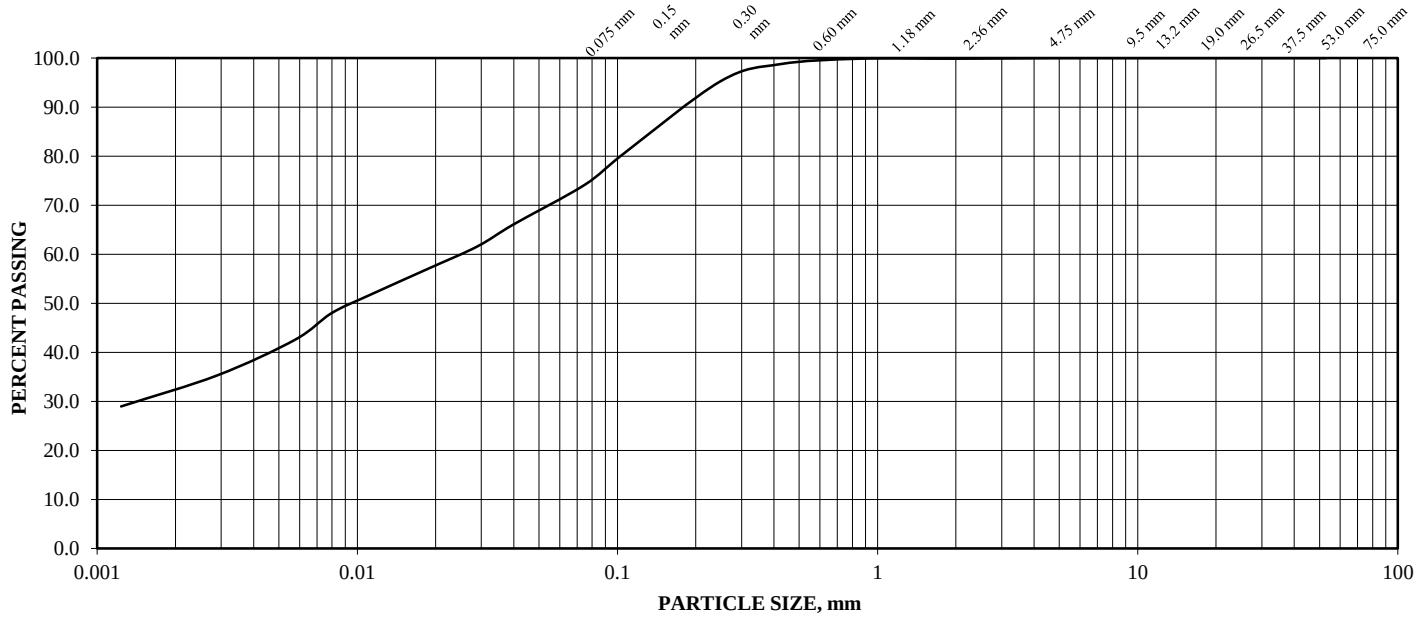
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



SIGNED: _____ DATE: 07/07/2020

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GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-698 PROJECT LOCATION: Waterloo, Ontario FIGURE No.: 3

BOREHOLE / TEST PIT NUMBER:	GP 102-20
SAMPLING DEPTH:	0 - 35 cm
SAMPLE NUMBER:	01
SAMPLED BY:	Client
SAMPLE DESCRIPTION:	Topsoil
SAMPLE NATURAL MOISTURE:	-
SAMPLE RECEIVED DATE:	6/23/2020

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	3.5
% SAND (75 µm to 4.75 mm):	81.1
% Silt (2 µm to 75 µm):	8.9
% Clay (<2 µm):	6.5
SUSCEPTIBILITY TO FROST HEAVING:	-

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	12.8
37.5	100.0	0.026	11.5
26.5	100.0	0.017	10.1
19.0	100.0	0.010	9.4
13.2	99.6	0.007	8.8
9.5	98.5	0.005	8.1
4.75	96.5	0.003	7.4
2.00	94.2	0.001	5.4
0.850	90.4	ATTERBERG LIMITS, %	
0.425	76.7		
0.250	53.2	Plastic Limit	
0.106	18.9	Liquid Limit	
0.075	15.4	Plastic Index	

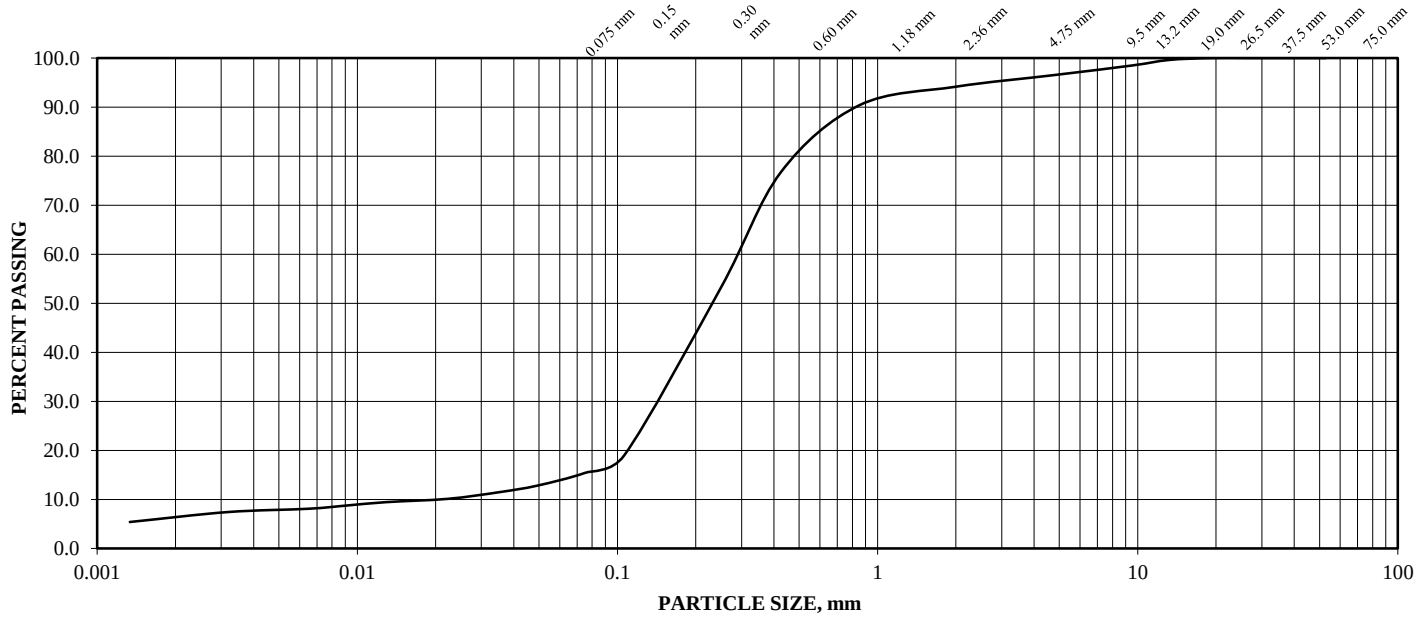
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



SIGNED: _____ DATE: 07/07/2020

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GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-699 PROJECT LOCATION: Waterloo, Ontario FIGURE No.: 4

BOREHOLE / TEST PIT NUMBER:	GP 103-20
SAMPLING DEPTH:	0 - 15 cm
SAMPLE NUMBER:	01
SAMPLED BY:	Client
SAMPLE DESCRIPTION:	Topsoil
SAMPLE NATURAL MOISTURE:	-
SAMPLE RECEIVED DATE:	6/23/2020
GRAIN SIZE PROPORTIONS, %	
% GRAVEL (> 4.75 mm):	0.2
% SAND (75 µm to 4.75 mm):	37.7
% Silt (2 µm to 75 µm):	45.1
% Clay (<2 µm):	17.0
SUSCEPTIBILITY TO FROST HEAVING:	-

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	51.3
37.5	100.0	0.026	46.1
26.5	100.0	0.017	41.0
19.0	100.0	0.010	32.5
13.2	100.0	0.007	28.2
9.5	100.0	0.005	24.8
4.75	99.8	0.003	19.6
2.00	99.7	0.001	14.5
0.850	99.4	ATTERBERG LIMITS, %	
0.425	92.1		
0.250	78.5	Plastic Limit	
0.106	64.8	Liquid Limit	
0.075	62.1	Plastic Index	

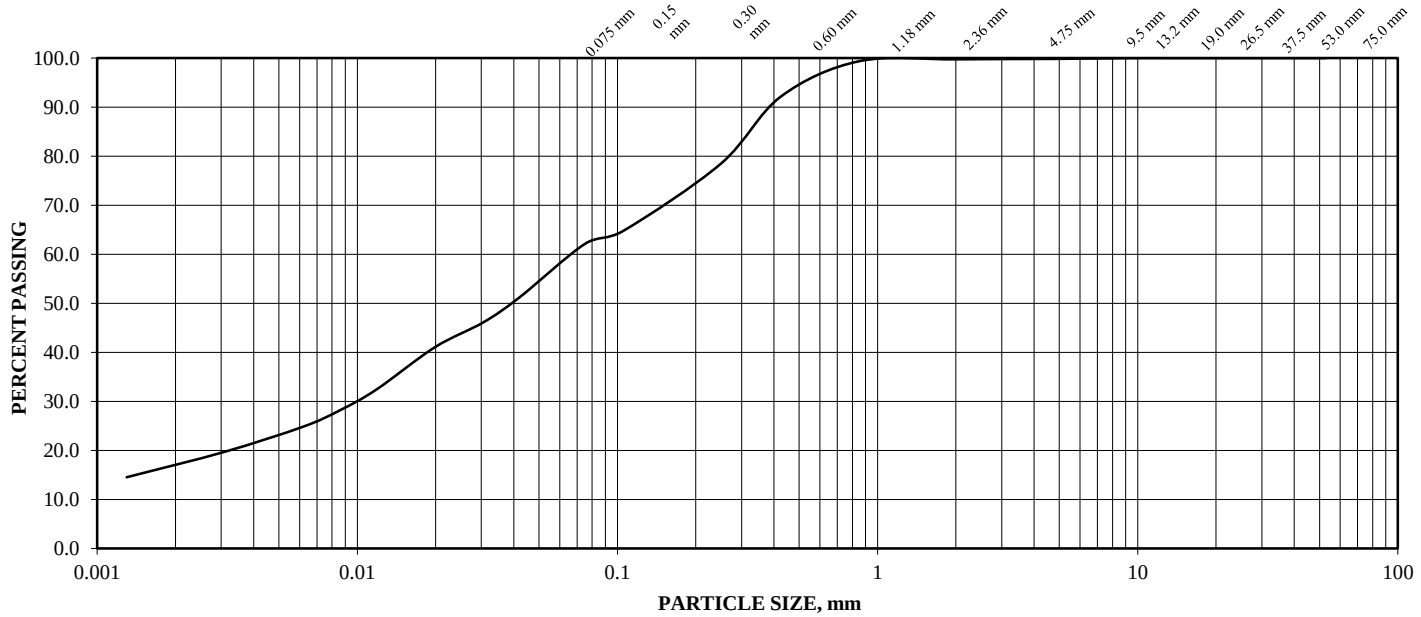
PARTICLE SIZE DISTRIBUTION, MTO LS-702

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



SIGNED: _____ DATE: 07/07/2020

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E-Mail: kitchener@englobecorp.com Website: www.englobecorp.com

GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-700 PROJECT LOCATION: Waterloo, Ontario FIGURE No.: 5

BOREHOLE / TEST PIT NUMBER:	GP 104-20
SAMPLING DEPTH:	0 - 25 cm
SAMPLE NUMBER:	01
SAMPLED BY:	Client
SAMPLE DESCRIPTION:	Topsoil
SAMPLE NATURAL MOISTURE:	-
SAMPLE RECEIVED DATE:	6/23/2020

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	15.2
% SAND (75 µm to 4.75 mm):	71.2
% Silt (2 µm to 75 µm):	9.1
% Clay (<2 µm):	4.5
SUSCEPTIBILITY TO FROST HEAVING:	-

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	12.5
37.5	100.0	0.026	11.1
26.5	100.0	0.017	10.5
19.0	98.0	0.010	9.1
13.2	94.6	0.007	8.4
9.5	91.1	0.005	7.7
4.75	84.8	0.003	5.6
2.00	79.9	0.001	4.2
0.850	74.0	ATTERBERG LIMITS, %	
0.425	56.2		
0.250	35.0	Plastic Limit	
0.106	15.5	Liquid Limit	
0.075	13.6	Plastic Index	

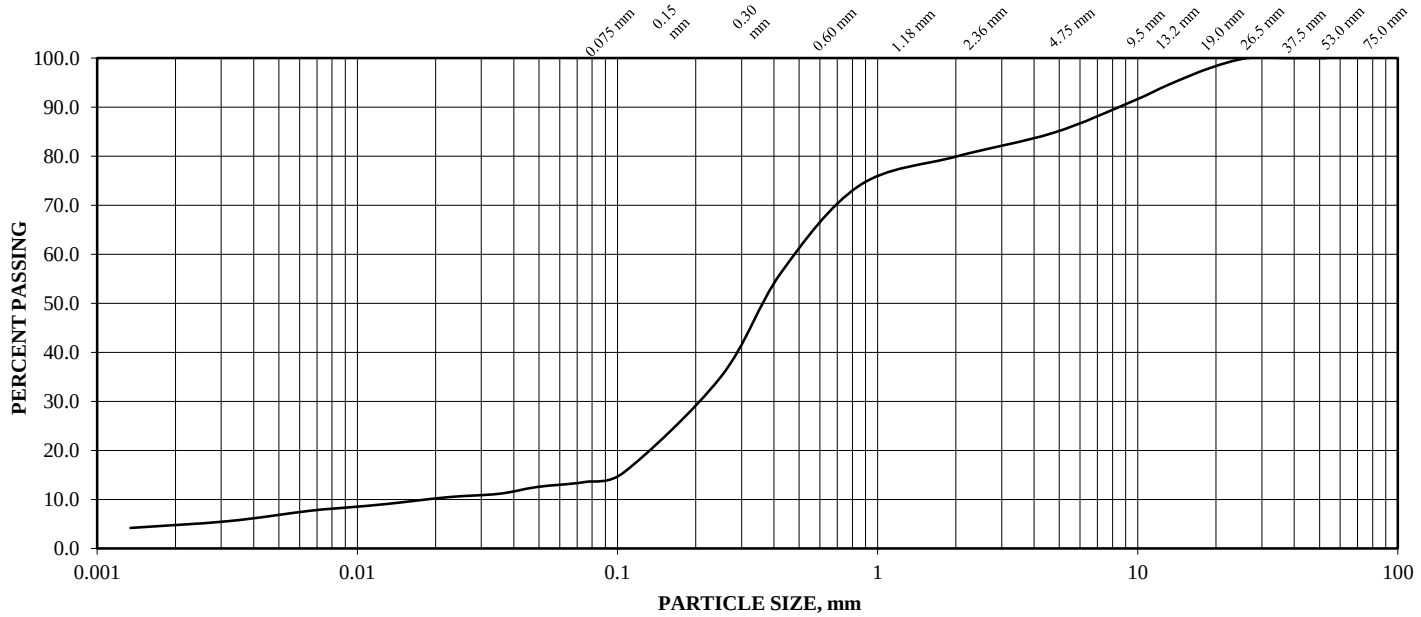
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U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



SIGNED: _____ DATE: 07/07/2020

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