Preliminary Stormwater Management Report

556 and 576 Conservation Drive
City of Waterloo

Revised September 2022

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September 6, 2022

GSP Group
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Attention: Ms. Kristen Barisdale MCIP RPP
Associate, Senior 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 the 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

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STV/
Enclosures (2)

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

Executive Summary

This report contains the proposed stormwater management (SWM) strategy to support a residential development in the vicinity of Conservation Drive and Beaver Creek Road in the City of Waterloo. The currently undeveloped property (the site) is located within the Beaver Creek Meadows District Plan (BCMDP) and comprises 28.6 hectares of former agricultural lands bordered by residential, agricultural, and recreational lands.

The development vision for the site includes single-family lots and multi-family condominiums with a school, park, open space, and a stormwater management facility. Approval of the proposed development is being pursued through a Draft Plan of Subdivision process with the City of Waterloo and the Region of Waterloo. The streets, park, and stormwater management facility will become property of the City of Waterloo upon registration.

The SWM plan contained in this report has been prepared in accordance with Ministry of the Environment, Conservation and Parks (MECP) guidelines, North Waterloo Scoped Subwatershed Study (NWSSS) recommendations and objectives, Grand River Conservation Authority (GRCA) regulations, City of Waterloo standards, site-specific Environmental Impact Study recommendations and best engineering practices.

Based on existing drainage conditions, the site is divided into one east and one west catchment, defined by a north-south drainage boundary. The east catchment drains 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, along the west boundary, north of Conservation Drive.

In addition to the required SWM controls within both catchments, post-development drainage conditions at the site will preserve pre-development drainage patterns in accordance with the NWSSS recommendations.

For the east catchment, minor drainage will be collected and conveyed by storm drainage infrastructure to a proposed, external SWM facility located south of Conservation Drive. If required, a temporary SWM facility at the south-east corner of the site may be implemented while approval and construction of the external facility takes place – refer to . Major drainage will continue to drain overland to the Conservation Drive ROW per pre-development conditions.

Within the west catchment, minor and major drainage will be directed to a SWM facility outletting to the wetland north of Conservation Drive.

For both catchments, 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 soak away pits and infiltration trenches. Conveyance measures include a permeable clean water collector (CWC) system designed to capture and infiltrate roof-generated runoff. The proposed end-of-pipe measure is a SWM facility comprised of a sediment forebay, a constructed wetland, and an infiltration basin.

Compliance of the proposed SWM infrastructure with the design capacity objectives is demonstrated with a combination of single-event hydrological models and hand calculations.

A continuous (PCSWMM) hydrological model will be prepared at the time of detailed design to confirm the anticipated effectiveness of the SWM system in meeting the water quantity, water quality, and water balance objectives by testing the system's response to the historical data set (50 years +) used by the NWSSS.

Since the proposed SWM plan meets all the required guidelines and standards, reviewing agencies shall approve the SWM design as presented.

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For Further Information

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Introduction

The proposed development (interchangeably referred to in this report as 'the site') is located near the intersection of Conservation Drive and Beaver Creek Road in the City of Waterloo, as shown in Figure 1. The 28.6 hectare site is bordered by existing residential lands to the east, agricultural lands to the north, external development lands and Beaver Creek to the west, and Conservation Drive to the south.

The site and the neighbouring properties north and south of Conservation Drive are located within the Beaver Creek Meadows District Plan Area, which is the subject of specific planning and environmental regulations by the City of Waterloo and the Region of Waterloo.

The site is an irregularly shaped parcel and was previously an agricultural field. The existing drainage patterns are defined by a north-south drainage boundary that divides the site into one east and one west catchment. The west catchment drains south-west towards Beaver Creek, while the east catchment drains south-east towards Conservation Drive. The drainage from both catchments eventually reaches the Laurel Creek Reservoir via Beaver Creek (west catchment) and the Beaver Creek Road right-of-way/Green Acre park overland route (east catchment).

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

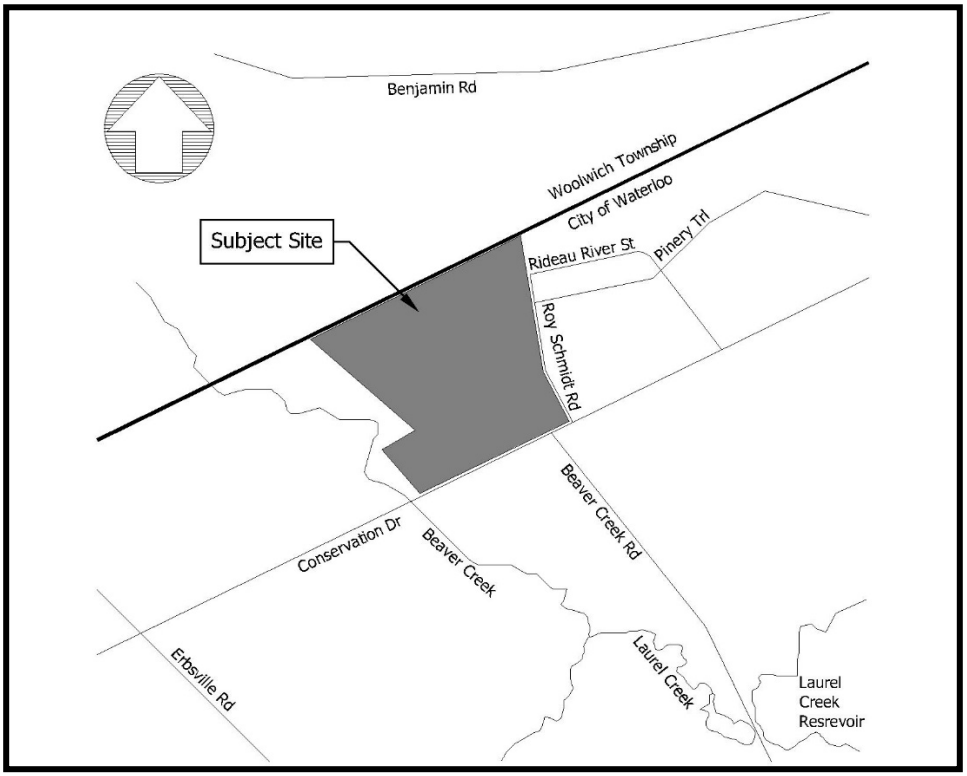


Figure 1: Subdivision Location

Approach

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

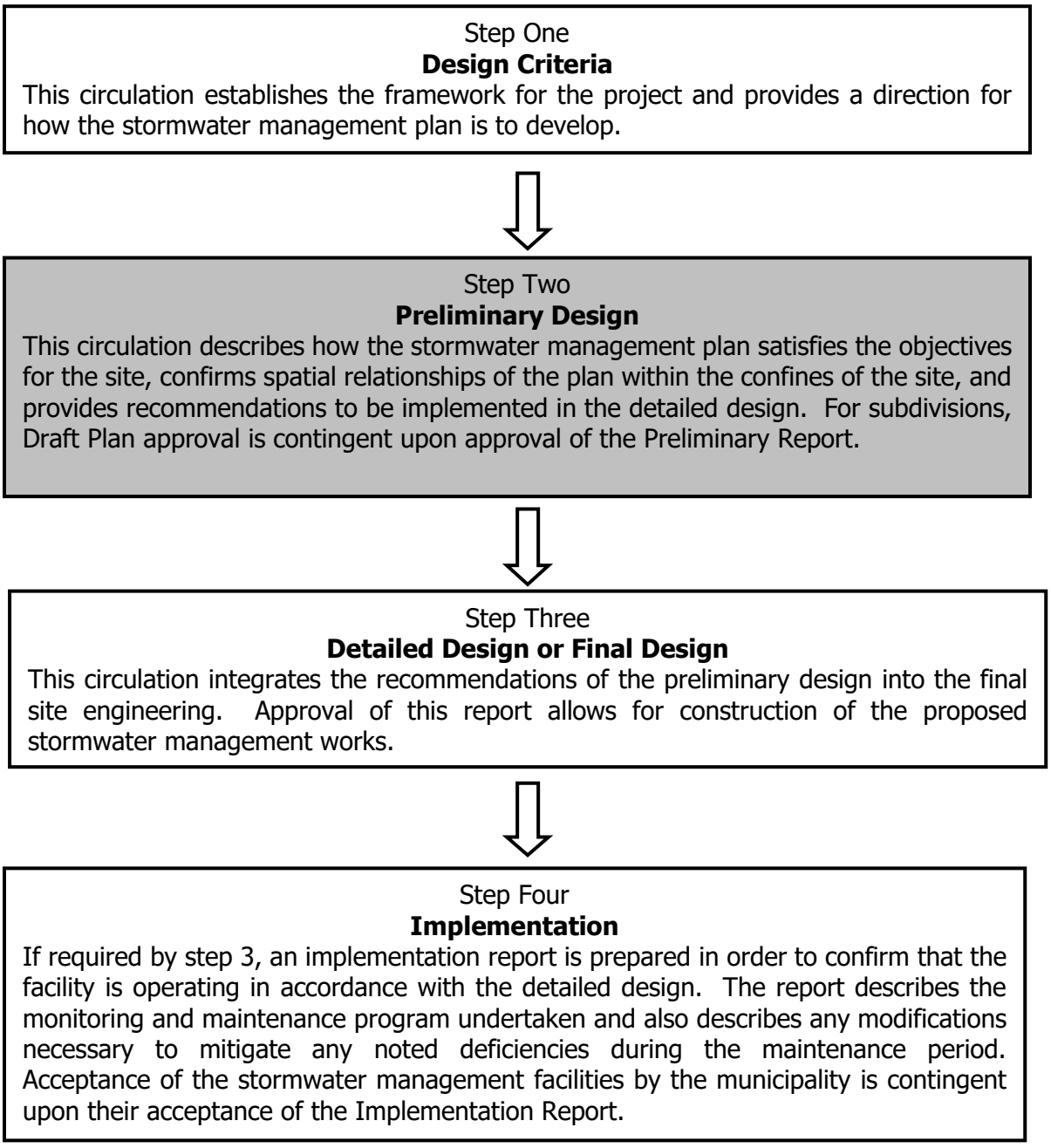


Figure 2: Approach Flowchart

A Final report will be prepared in support of engineering approvals (clearing Draft Plan Conditions).

Policy Framework

This chapter outlines the framework upon which the stormwater management plan is built upon. Examples of information described in this chapter include previous studies, municipal and provincial standards, and any field investigations undertaken to support the project. This background information is then used to build an appropriate plan for the site. The next chapter, SWM Design Strategy, 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.

Subwatershed 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 document (Part B) is assumed to provide the municipality's design preferences under normal circumstances. These guidelines are read together with the relevant municipal guidelines.

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 related detailed design provide 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 the following:

- Native soils consist primarily of topsoil overlaying a thick layer of sand. Silt was encountered at some locations.
- Groundwater is unconfined and generally 3.0 to 6.0m in depth across the site. Groundwater elevations approach existing surface elevations on the west side of the site near Beaver Creek.
- 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 including monitoring conducted since the initial study have been released.

Four monitoring wells are on the subject property: MW2, MW3, MW6, and MW7. Key findings are as follows:

- 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 ±1m variation in seasonally high to seasonally low elevations
- Elevations are highest in spring and lowest in 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.

The *Hydrogeological Assessment, 556, 560 and 576 Conservation Drive – Final Report* was prepared by Stantec in July 2020 and updated in December 2021. Excerpts from the report are included in Appendix F. With additional boreholes and monitoring wells, a better understanding of groundwater elevations throughout the site was obtained to confirm that the infiltration galleries are separated vertically from groundwater. Permeability levels

suitability was verified through infiltration testing at the proposed infiltration facility locations and a high infiltration rate was verified at the SWM facility infiltration basin location. The calculated infiltration rate for given for the SWM facility infiltration basin area is 67mm/hour. All subsurface soil layers are suitable for infiltration as they are greater than the MECP threshold of 15mm/hr.

The *Amended Soil Assessment 556, 560, 572 Conservation Drive, Waterloo, Ontario* (November 2020) evaluated the ability of the site's soils to meet the NWSSS objectives through modifications to topsoil texture composition (e.g., amended soil). This study also confirmed the anticipated performance of the infiltration measures proposed in this report towards meeting the water balance objectives for the site. It was determined that amended topsoil is not a preferred method of stormwater management and will not be utilized. This document is no longer included in Appendix F.

Stormwater Management Reports

Beaver Creek Meadows Communal Stormwater Management; Final Stormwater Management Report, MTE Consultants, September 2020
This report was prepared for the communal facility south of the site. The report states:

> *In December of 2013, Council for the City of Waterloo approved the North Waterloo Scoped Subwatershed Study (NWSSS). Active Developers within Catchment 310, including Activa, Cook/Mattamy and Northgate (referred to herein as Active Developers/Active Developments) are working together to implement the recommendations of the NWSSS.*
>
> *The City of Waterloo has confirmed a willingness to consider communal stormwater management alternatives and strategies consistent with the objectives of the NWSSS. To this end, the City of Waterloo has required a study to evaluate and select a preferred alternative to be approved by the City of Waterloo in consultation with GRCA and the Region of Waterloo.*

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 'SWM Design Strategy'. 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. Drainage from the west side goes to Beaver Creek whereas drainage from the east side flows to the south-east towards the Laurel Creek Reservoir.



Figure 3: Existing Conditions Photographs

Review Comments

Comments have been received from the following sources in response to our Third Functional Engineering Submission dated August 2020. Relevant components related to our responses have been incorporated into the revised reports.

- City of Waterloo comments dated January 19, 2021 and February 3, 2021
- Grand River Conservation Authority (GRCA) comments dated July 8, 2021

Drainage Conditions

Pre-Development Drainage

The site is divided into two major drainage areas (east and west) referred to as catchments 3101 and 3913 in the NWSSS (Figure 6.3, Secondary Study Area Catchments). Under existing (pre-development) conditions, runoff from 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. Runoff from 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 and 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's (NWSSS) "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 in 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 land
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 land
Soil Amendments	L	M	M	M	N	
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 infiltrating basin
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. This increased runoff flows faster to receiving watercourses, and developing multiple sites in a watershed can lead to downstream flooding because of it. For this reason, providing on-site or regional "holding" areas to contain the increased runoff and discharge it over a longer period of time without exceeding the targeted peak flow is important.

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 for at least a 5-year storm event and major flows will be directed to the road network as surface flows. The drainage divide is shown on Figure 11.1 of the NWSSS and is included in Appendix F.

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 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 2003 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 (e.g., recharge to groundwater) 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

Single-Event Modelling

Appropriate sizing of the proposed stormwater infrastructure for water quality as well as conveyance of minor and major events is to be confirmed by single-event hydrological models for the applicable range of synthetic design storms.

Continuous Modelling

During the detailed design phase, the anticipated effectiveness of the proposed SWM system to meet mid and long-term water quantity, water quality, and water balance objectives (e.g., recharge to groundwater) will be confirmed by testing the system's response to the 50+ years of rainfall data used in the NWSSS.

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

The historical data used by the NWSSS to establish the yearly recharge to groundwater objective, which is based on hourly precipitation records of the Guelph Arboretum station from 1958 to 2014, will be used as input to the continuous model during the detailed design phase.

Hydrogeological Design Considerations

Stantec Studies

Stantec has conducted multiple field studies that were used during the preparation of this report to better understand the hydrogeological regimes and water balance requirements within the NWSSS study area and site. These studies were consulted to establish infiltration facility design criteria and constraints such as soil types, groundwater depth and infiltration rates within the site; and to confirm the effectiveness of the proposed design towards meeting the water balance objectives. Excerpts of the hydrogeological studies completed by Stantec can be found in Appendix F.

The *North Waterloo, Phase 1 - Groundwater and Surface Water Monitoring Program* (2015) was reviewed for co-ordination of the hydrogeology of the site and to better understand the hydrogeological conditions in the vicinity of the site.

The *Hydrogeological Assessment, 556, 560 and 576 Conservation Drive* (2021) hydrogeological study concluded that the site may 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 spring and lowest in fall/early winter. Groundwater table levels responded synchronously to climatic factors between locations across the site. The calculated infiltration rate for given for the SWM facility infiltration basin area is 67mm/hour. All subsurface soil layers are suitable for infiltration as they are greater than the MECP threshold of 15mm/hr.

Groundwater Conditions

Groundwater information has been provided by the Stantec studies, the geotechnical report, and the NWSSS. Figure 5.23 of the NWSSS shows groundwater at elevations of 354 to 350 metres draining from east to west, towards Beaver Creek. By this report, groundwater occurs 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 approach 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.

The 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.

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 some 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.

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 being infiltrated.

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 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 design and construction of a temporary pond on Block 106, a multi-residential block at the southeast corner of the site, has been explored as an option should the construction of the external pond be delayed. This pond would control flows draining southeast, until the time when they can be redirected to the external communal facility. Details regarding the temporary pond as part of a "quick start" option are included in Appendix G.

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 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 the end-of-pipe facility is used as both a Priority 2 and Priority 3 component. The facility is designed with a sediment forebay, filtration strip, wetland cell and infiltrating basin. 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/infiltrating basin will discharge to Beaver Creek and includes the following:

- A central location, with easy access, for sediment removal
- Flood control up to the Regional storm event, matching flows provided in the subwatershed study
- 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 current design attempts to maintain this divide, as shown in Figure 6 of this report. The school property is split by the divide, 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

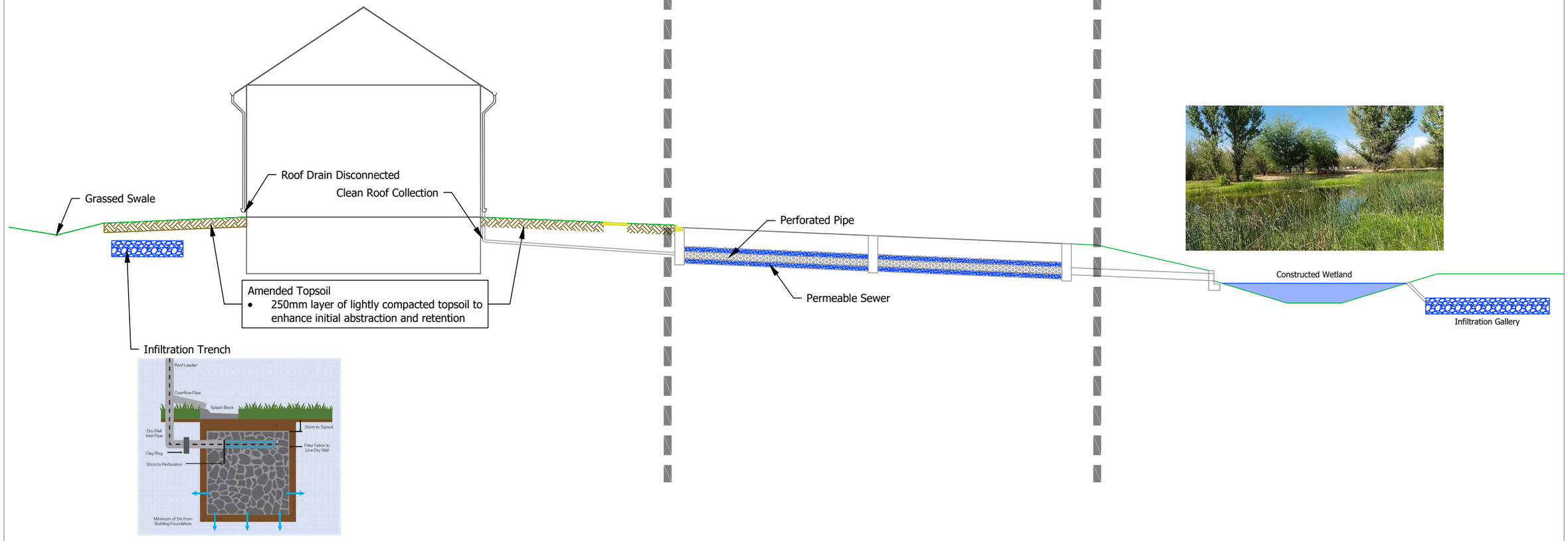
The NWSSS has determined that the Laurel Creek Reservoir will attenuate flows from the east half of the subdivision satisfactorily; additional attenuation is not required.

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. Incorporating lot-level infiltration and reduced lot grading into the detailed design can further enhance opportunities to meet objectives for sedimentation, temperature, and infiltration. The site was designed to meet the "Enhanced" level of water quality control by implementing a sediment forebay.

Best management practices (BMPs) including lot-level infiltration, reduced lot grading, 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. This 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/infiltrating basin facility. The facility treats runoff for sedimentation control within the forebay, filtration strip and wetland cell in the design quality storm. Additional Priority 2 measures are not proposed as infiltration levels are achieved with Priority 1 and Priority 3 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 as well as 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 infiltrating 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 facility:

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)
7.794	32	250	274	0	0	0

Table 3: Water Quality Storage Requirements

The contributing area is the sum of all areas draining to the facility through the storm sewers. The MOE's requirement for extended detention is for wet facilities only, therefore extended detention is not provided.

Water Balance

For the purposes of this report, the "water balance" objective refers to the annual recharge to groundwater volume required to maintain pre-development conditions. Recharge to groundwater objectives under post-development conditions can be achieved naturally through landscape and green areas, or induced through lot-level infiltration measures, soak away pits, permeable sewers and end-of-pipe infiltration facilities.

The NWSSS used 50+ years of historical rain data to estimate yearly recharge to groundwater objectives for the study area in accordance with specific hydrological, hydrogeological and environmental criteria.

This section examines the post-development infiltration measures proposed for the site, as well as the expected performance of these measures with respect to the NWSS objectives.

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 catchment	3107	11.6	281.6	32,606
West catchment	3913	11.8	265.2	31,283
Total		23.3		63,889

Table 4: Target Infiltration

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" on Figure 4). Direct connection to soak away pits or infiltration trenches can be incorporated. The majority of the proposed infiltration is to be accomplished though the use of a "third pipe" clean water collector (CWC) option, which is suggested in the NWSSS as a tool to infiltrate clean roof runoff and sump pump discharge within the rights-of-way. The CWC system will be located within the travelled portion of the road, and therefore will be composed of perforated PVC pipe to ensure it can be maintained and will continue to function well in the future.

The foundation drain for each house should discharge to a sump in the basement and be pumped over the foundation wall, then directed with a storm service to the CWC system at the street. This water should be directed 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 infiltrating basin will be installed to infiltrate large volumes due to the free-draining native materials. The 2-year and nearly all of the 5-year design storm runoff volumes will be infiltrated. This is greater than the 5mm of runoff from the contributing catchment area that was recommended by the NWSSS.

Due to the winter bypass, not all runoff that reaches the end-of-pipe facility will be able to be infiltrated. A reduction of 30%, which corresponds to the percentage of average annual precipitation occurring in the months of December through March, was applied to the calculations in Appendix C to reflect the effect of the winter bypass. The estimated annual post-development infiltration volumes are summarized in Table 5.

Description	Catchment #	Area (ha)	Infiltration Rate	Annual Infiltration (m³/yr)
Pervious areas	All	A_P=9.74	272 mm/year (average)	26,486
Rear-yard infiltration galleries	504, 505	A=1.20	90% of runoff	2,512
School roof to infiltration	502	Approx. 50,000ft²	90% of total rainfall	3,421
Conveyance (CWC)	503, 701	Roofs=4.33	90% of total rainfall	32,901
End-of-pipe	701	A_I=2.29	63% of total rainfall *	12,196

* Due to the winter bypass

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		**64,096**
Post-development	Pervious areas	26,486
	Plus galleries	32,419
	Plus conveyance CWC	65,320
	Plus end-of-pipe infiltration	**77,516**

Table 6: Pre- to Post-Development Infiltration Comparison

The detailed calculations in Appendix C show that the infiltration on the west side of the site increases by ±40% and the infiltration on the east side of the site is maintained. As described on page 5.3 of the December 2021 Hydrogeological Assessment, "…since there is no apparent permanent groundwater divide present on the Site, this infiltration can occur within either the East or West Catchment post-development stormwater drainage areas … as all water entering the subsurface and recharging AFB1 will ultimately flow to the southwest towards Beaver Creek."

In practical terms, the findings of the Hydrogeological assessment suggest that the recharge to groundwater targets for the east and west (surface) catchments can be combined to meet the overall water balance objectives for the purposes of the NWSSS.

The values presented in this section vary slightly from the December 2021 Hydrogeological Assessment due to slight changes in the catchment areas and the addition of the winter bypass.

Hydrologic Modelling

Single-event 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 6 shows the catchment areas for the proposed project, and Figure 7 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		2.297	2.297	50	30	3	74	0.263	0.720
503		9.083	9.083	70	15	3	74	1.523	3.904
504		0.303	0.303	40	15	3	74	0.030	0.085
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	6.944		6.944	60	15	3	74	0.561	2.640
702	0.917		0.917	30	90	3	74	0.065	0.215
703	1.409		1.409	10	80	3	74	0.031	0.202
704	1.116		1.116	60	15	0.5	74	0.155	0.456
801	0.850		0.850	60	15	3	74	0.123	0.323
Total	11.236	16.950	28.186						

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 combination of pond configuration and outlet control structure shown in Figure 8 satisfy multiple objectives, such as peak flow attenuation of post-development conditions to allowable rates.

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 wetland cell in the infiltrating basin is clay-lined to retain a permanent pool, and provides additional sediment capture for the infiltrating basin. From there, flow is directed to the rest of the basin. It has a peat/sand filter bedding to a depth of 0.3 m, ending 1m above the seasonally high groundwater elevation. The filter material is separated from the groundwater table by the existing sandy soil, which is anticipated to allow a similar level of infiltration as the filter material.

The available storage in the filter material, assuming a porosity of 0.35, is sufficient to retain the 2-year design storm underground. This causes no ponding or outflow to occur during the

2-year storm. It provides a high level of infiltration in general and is responsible for infiltrating the majority of the 5-year storm as well. Larger design storms do experience ponding and are outletted to a swale leading to a level spreader.

The outlet structure consists of an 90mm diameter orifice designed for the 5-year outflows, twin 525mm diameter overflow culverts, and a concrete weir that allow outflow in larger storm events. The outlet structure provides for easy maintenance, inspection and good distribution of the infiltrating water.

Elev.	Depth	Description	Discharge	Volumes					
			Total	Area	Incr. Vol.	Forebay Incr. Live Vol.	U/G Incr. Vol.	Live Stor.	Dead Stor.
(m)	(m)		(m^3/s)	(m^2)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)
Constructed Wetland/Infiltrating Pond									
353.3	-1.1	Bottom of Infiltration	0				0	0	
353.4	-1.0		0				97	97	
353.5	-0.9		0				97	194	
353.6	-0.8		0				97	291	
353.7	-0.7		0				97	388	
353.8	-0.6		0				97	485	
353.9	-0.5		0				97	582	
354.0	-0.4		0				97	679	-
354.1	-0.3		0				97	776	61
354.2	-0.2		0				97	873	126
354.3	-0.1		0				97	970	197
354.4	0.0	**Permanent Pool Outlet Orifice**	0	-	-		125	1,095	274
354.5	0.1		0.004	6,258	90		125	1,310	
354.6	0.2	Culverts	0.007	6,414	249	-	125	1,684	
354.7	0.3		0.021	6,573	427	78	-	2,189	
354.8	0.4		0.056	6,732	465	84	-	2,738	
354.9	0.5		0.109	6,893	484	89	-	3,311	
355.0	0.6	Concrete Weir	0.173	7,057	504	95	-	3,910	
355.1	0.7		0.442	7,224	525	101	-	4,536	
355.2	0.8		0.886	7,401	546	107	-	5,189	
355.3	0.9		1.450	7,588	658		-	5,847	
355.4	1.0		2.116	7,773	768		-	6,615	
355.5	1.1	Freeboard	2.877	7,954	786		-	7,401	
Forebay (Dead Storage)									
353.1	-1.5	Bottom		271	0				0
353.4	-1.2			334	91				91
353.7	-0.9			403	111				201
354.0	-0.6			476	132				333
354.3	-0.3			610	163				496
354.6	0.0	**Permanent Pool**		758	205				701

Table 9: Stage Storage Discharge for Forebay and Constructed Wetland/Infiltrating Basin

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)	Storage Volume (m^3)	Discharge (m^3/s)
Permanent pool		354.40	0.0	0	0
2-year ponding	Waterloo Guelph	- -	0.0 0.0	0 0	0 0
5-year ponding	Waterloo Guelph	354.57 354.51	0.17 0.11	255 128	0.006 0.004
100-year ponding	Waterloo Guelph	355.05 354.90	0.65 0.50	2,900 1,990	0.211 0.111
Hurricane Hazel ponding	-	355.22	0.82	4,000	1.019
Freeboard		355.50	1.10	6,056	2.877

Table 10: Pond Performance Summary

The storage volumes listed in Table 10 represent the aboveground live storage volume.

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 5 shows how these hydrographs are modeled in MIDUSS. The red shaded area represents the volume of the 2-year runoff that will be infiltrated.

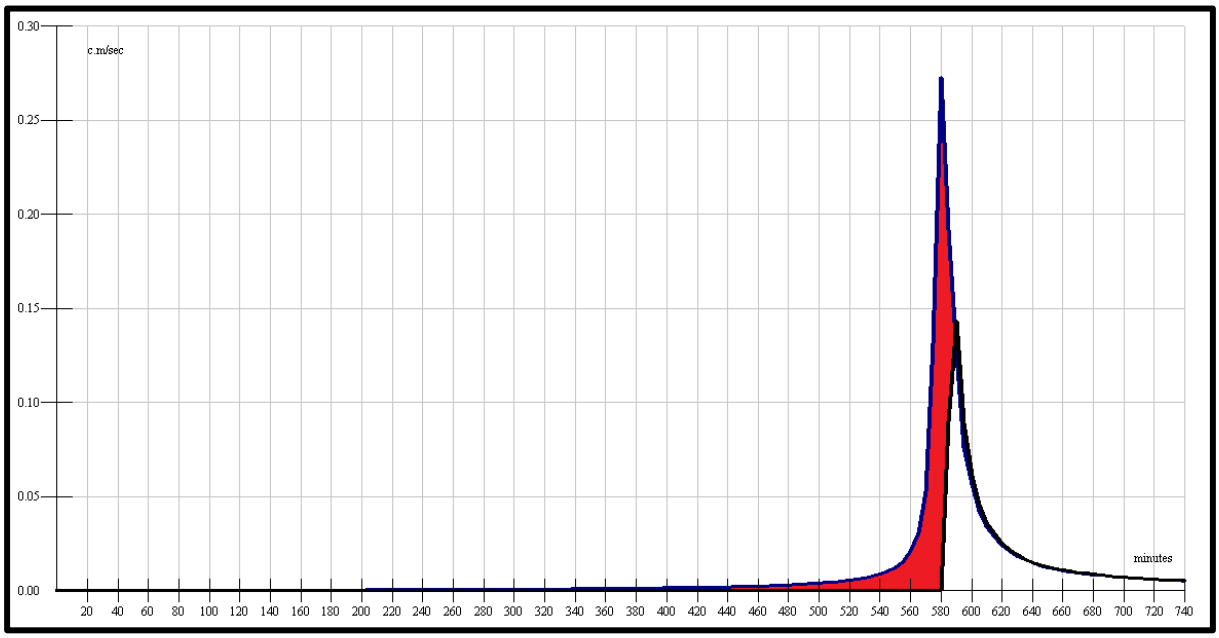


Figure 5: Infiltration Gallery Modeling

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 stormwater management pond is to a level spreader between the facility and Beaver Creek. This converts a point source discharge 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)	0.000	0.006	0.448	1.224
Attenuated post-development (Guelph Arboretum ABCs)	0.000	0.011	0.347	

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	1.787	2.435	4.641	2.048

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 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 Catchment 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 the external communal SWM facility (designed by MTE) to be located south of Conservation Drive. 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 Catchment 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 rights of way. Rear-yards for lots north of Rideau River Street, and for townhouse blocks west and south of Street F 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.

Winter Conditions

The NWSSS requires that winter runoff bypasses end-of-pipe infiltration facilities to avoid large concentrations of chlorides being infiltrated. A winter bypass system has been incorporated into the design of the outlet of the forebay, as shown on Figure 8. In the winter months, runoff will be slightly attenuated in the forebay. Using a valve, controlled flows will be piped directly to the level spreader rather than into the infiltrating basin.

In order to attenuate flows out of the forebay, 554m^3 of live storage has been provided in the forebay below the elevation of the access road, which acts as the spill over point. A piped

outlet from the manhole to the level spreader has been sized to convey 13 L/s under maximum pressure head conditions. This restricted outflow rate is necessary in order to meet the NWSSS peak flow requirements for the 2-year event. The volume of storage provided in the forebay above the permanent pool elevation is sufficient to contain the runoff generated from a 25mm rainfall over the right-of-way area. This will ensure the first runoff of water during the winter months and spring freshet, containing the highest levels of chloride, will be directed away from the infiltrating basin while still meeting quantity requirements.

The annual water balance (infiltration volume) calculations have been adjusted to reflect that runoff in the winter months does not contribute to infiltration. This has the effect of reducing the overall surplus from 30% to 20%.

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.

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/infiltration basin and forebay.

Environmental Compliance Approval

An Environmental Compliance Approval (ECA) is necessary for the storm sewers, sanitary sewers, and the stormwater management facility. If the Consolidated Linear ECAs have not been fully established at the time that ECAs are required, an application 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.

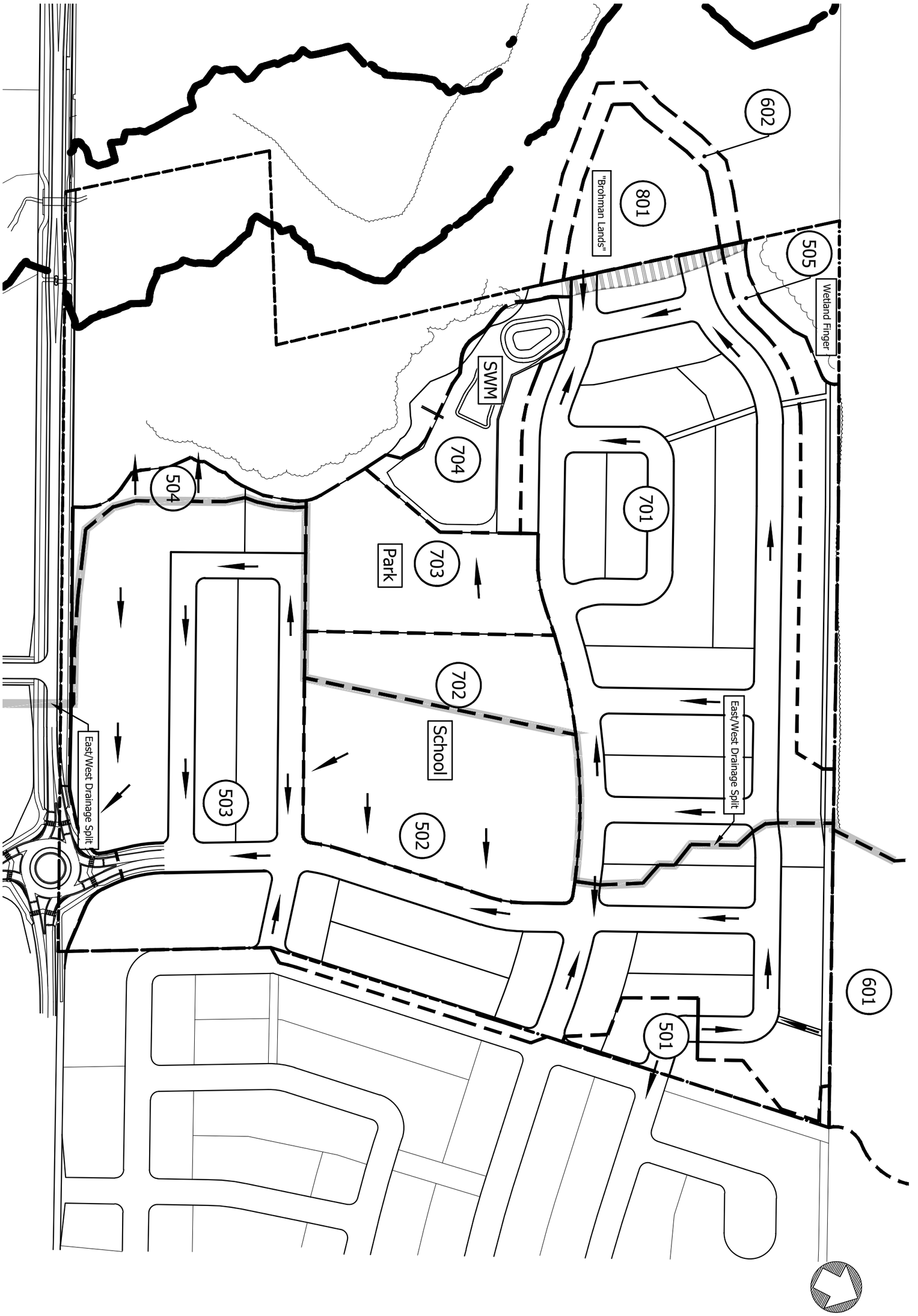
The stormwater management facility is new and is categorized as a wetland pond and infiltrating basin. The drainage area associated with the pond is 11.4ha and the predominant land use within the catchment is residential (including some parkland and institutional). A review of effluent criteria assessment 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 from 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 planted filtration strip between the forebay and the infiltrating basin
- A diverse mix of trees, and species tolerant to water level changes
- Suitable plant species to reduce the potential for slope erosion
- A 3m clearance to maintenance roads from woody plants
- Shade trees and shrubs planted along the wetland and forebay and level spreader to mitigate temperature increases in the facility through shading
- The detailed makeup of the peat/sand filter layer in the infiltrating basin



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

DRAWN BY:	STV	CHECKED BY:	CHT	SCALE:	1:2500
FILE NAME:	1279.Figures	DATE:	Aug 2022		Figure 6

MERITECH engineering
1315 Bishop Street North, Suite 202 Cambridge
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DRAWING: Post-Development Flow Chart
556 & 576 Conservation Drive

DRAWN BY: STV	CHECKED BY: CHT	SCALE: Not to Scale	
FILE NAME: 1279.Figures	DATE: Aug 2022		Figure 7

Pinery Trail

CWC Pipe

5yr Storm Sewer

3.0m-900mmø Stm @ 0.8%

Concrete headwall

300mmø reverse sloped piped outlet from forebay (c/w Hickenbottom).
Outlet pipe Inv=353.00
Hickenbottom holes above 353.85

3rd Pipe/Clean Water Collector System overflow to outlet to SWM Pond. Pipe outlet Inv=354.70

Valve closed in winter

8.8m-200mmø @ 1.0%

Concrete headwall

Forebay

Forebay Bottom=353.10

Dripline knob to be removed

Permanent Pool=354.60

Forebay, filtration strip and wetland cell to be clay lined.

Top of Pond=355.50

Filtration Strip

Wetland Cell

Wetland Bottom=354.00

Modified Peat/Sand Filter Infiltrating Basin (Dry Pond)
Ground Elevation=354.60
Bottom of Filter Elevation=354.30
Seasonally High Groundwater Elev=353.30

Permanent Pool=354.40

4.0m Maintenance Access Road

90mmø orifice plate

Valve to be opened in the winter to divert winter runoff past infiltration basin.

35.4m-200mmø @ 4.5%

Constructed Berm

2 x 16.7m-450mmø culverts @ 8.5% c/w headwall. Inv=354.60

Concrete Overflow Weir @ Elev=355.00

16.3m-300mmø Reverse Slope Pipe

Perforated Riser Pipe Outlet

Inv=353.18

Level Spreader

Existing Grades

1.4% Swale to Level Spreader

16.2m-300mmø @ 8.5%

Rip rap at Outlet

90mmø Orifice Outlet Control in 1200mmø MH

Concrete headwall

27.8m-450mmø Stm @ 1.0%

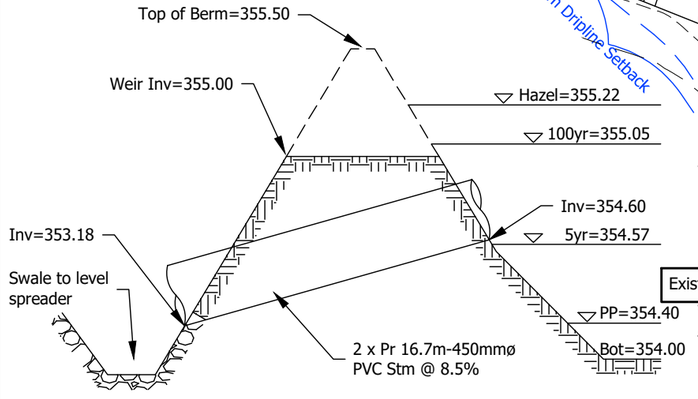
10m Dripline Setback

30m Wetland Buffer

15m Wetland Buffer

Pond Outlet Schematic

NTS



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DRAWING: Proposed Stormwater Management Facility
556 & 576 Conservation Drive

DRAWN BY:	STV	SCALE:	1:500
CHECKED BY:	CHT		Figure 8
DATE:	Aug 2022		
FILE NAME:	1279.Figures		

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	Y
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	Y
Filter surface covered with mulch and vegetation	Y

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. Due to the infiltration function of the end-of-pipe SWM facility, it should be clay-lined until build-out to prevent clogging of the infiltrating material
- 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 two years pre-development monitoring, Stage II is during construction and Stage III extends for two 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 twelve 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 three times annually
- Groundwater levels and chemistry are recorded 3 times annually in the twelve 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)

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 storage 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. The Hydrogeological Assessment prepared by Stantec provides a substantial explanation for

Post-development unattenuated flows exceed allowable flows, requiring peak flow attenuation 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 off-site communal SWM facility to the south is being designed and approved by others.

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

Average annual infiltration volumes will exceed the target of pre-development conditions.

The SWM 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 and GRCA requirements.

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.

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. A Final report should be prepared in support of engineering approvals (clearing Draft Plan Conditions).

References

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

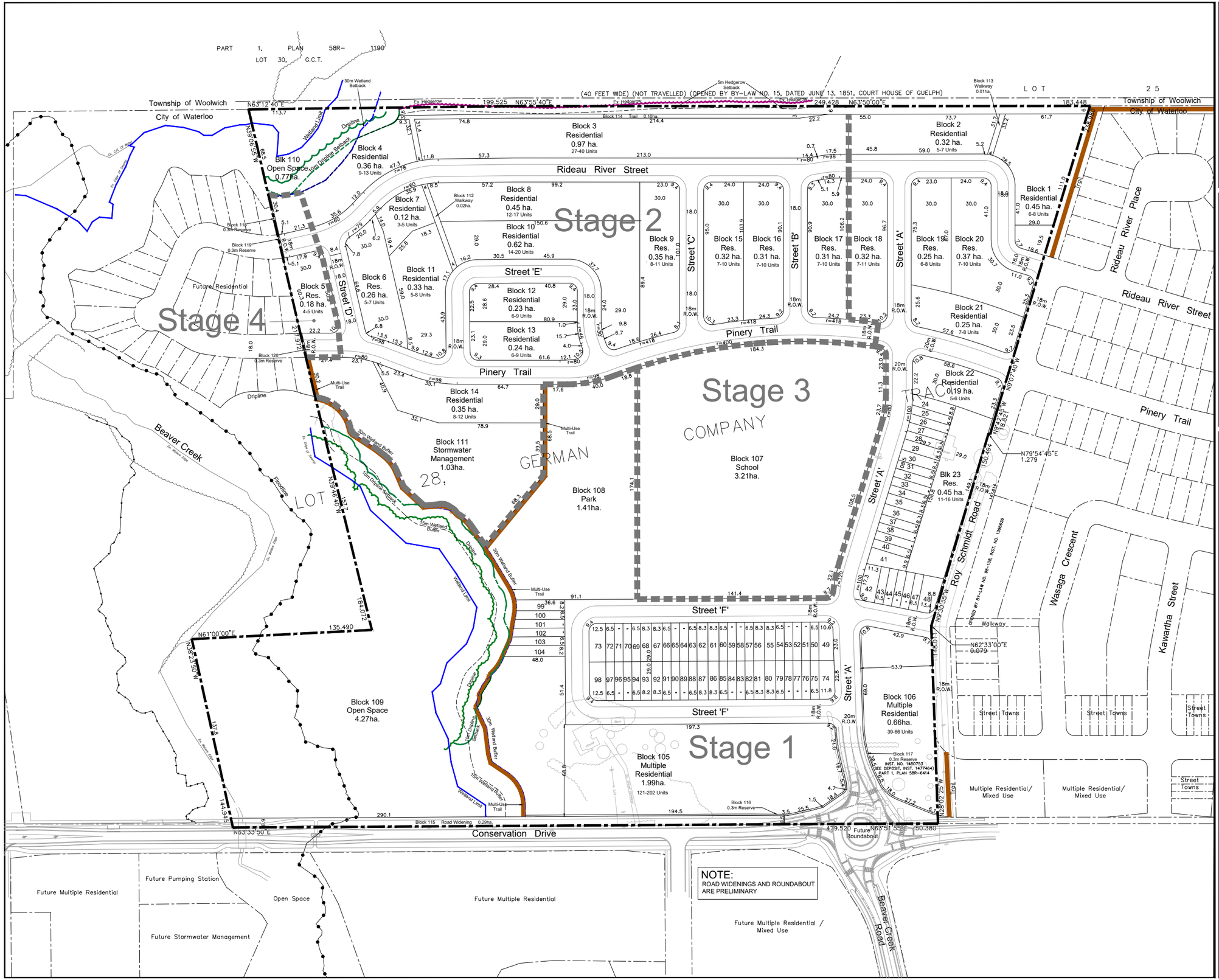
Greater Golden Horseshoe Area Conservation Authorities, Erosion & Sediment Control Guideline for Urban Construction, December 2006

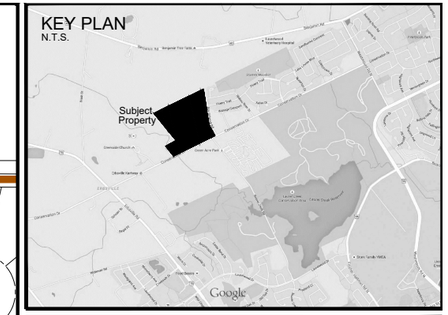
Ministry of the Environment, Stormwater Management Planning & Design Manual, Toronto ON, March 2003

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

Stantec, Hydrogeological Assessment, 556, 560 and 576 Conservation Drive, Waterloo, Ontario, December 2021

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)	1-23	182-260	7.98
Street Townhouses	24-104	81	1.73
Multiple Residential	105,106	160-268	2.65
School	107		3.21
Park	108		1.41
Open Space	109,110		5.04
Stormwater Management	111		1.03
Walkway	112,113		0.04
Trail	114		0.09
Road Widening	115		0.29
0.3m Reserve	116,120		0.00
Roads			5.16
Total		423-609	28.63

UNIT BREAKDOWN

Min. Potential Singles	182
13.1m internal lot	*152*
13.75m corner lot	*30*
Max. Potential Singles	260
9.0m internal lot	*230*
12.5m corner lot	*30*
Street Townhouses	81

NOTE: Wetland boundary provided by NRSI August 2021

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
April 30, 2020
June 25, 2020
March 10, 2020
March 15, 2020
March 19, 2020
August 19, 2021
December 15, 2021

Date: July 29, 2015 | Drawn By: S.L./ML | Dwg. File Name: dp09009zo.dwg
Scale: 1:1250 metric | Project No.: 09009.40

Appendix B: Design Drawings

Rideau River Street

Pinery Trail

Rideau River Place

Street A

Street B

Street C

Street D

Street E

Street F

SWM Pond

Park

School

Roy Schmidt Road

Wasaga Crescent

2.5m Asphalt Trail

3.0m Asphalt Walkway

Infiltration gallery

Area to be developed in the future when grading allows.

Match existing elevations along entire northern limit

Bollards/gates to be confirmed in detailed design

Proposed Conservation Drive layout

Ex. Edge of Swamp

Ex. Edge of Water

Ex. Water Edge

15m Wetland Buffer

Wetland Limit

Ditch

4.0m Maintenance Road Access

1.0m Asphalt Walkway

1 & 1/2 Storey Storm Building

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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Preliminary Grading Plan
556 & 576 Conservation Drive

DRAWN BY:	STV	CHECKED BY:	CHT
FILE NAME:	1279.Figure	DATE:	Aug 2022

SCALE: 1 : 1000

1279-SG

Split point of sanitary and 3rd pipe.

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

~Inv @ Intersection
Wat=362.70
San=361.60
CWC=362.00

~Inv @ Intersection
Stm=360.50
Wat=361.30
San=359.50
CWC=360.00

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

Rideau River Street

~Inv @ Intersection
Stm=360.95
Wat=360.75
San=360.00
CWC=360.50

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

~Inv @ Intersection
Stm=354.95
Wat=354.95
San=354.15
CWC=354.45

150mmø Wmn, Streets B, C & E

Street E

Street C

Street B

150mmø Wmn

Street A

Rideau River Place

Rideau River Street

200mmø Wmn

Street D

~Inv @ Intersection
Stm=354.30
Wat=354.45
San=353.60
CWC=354.00

~Inv @ Intersection
Stm=356.55
Wat=356.45
San=355.50
CWC=356.00

Pinery Trail

~Inv @ Intersection
Stm=360.05
Wat=359.85
San=359.00
CWC=359.50

~Inv @ Intersection
Stm=359.60
Wat=360.60
San=358.75
CWC=359.10

300mmø Wmn

Ex 200mmø Wmn

Pinery Trail

900mmø Stm into SWM Pond

~Inv @ Intersection
Stm=355.00
Wat=355.05
San=353.10
CWC=354.50

~Inv @ Intersection
Stm=355.60
Wat=355.65
San=352.70
CWC=355.00

~Inv @ Intersection
Stm=358.25
Wat=358.15
San=357.20
CWC=357.70

200mmø Wmn Pinery Trail (Street A to West End)

Split point of sanitary and 3rd pipe.

Wetland

Infiltrating Dry Pond

Diversion pipe for winter months.

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

Street A

3rd pipe (CWC) system for roof leaders.

Level spreader

15m Wetland Buffer

30m Wetland Buffer

10m Drainage Setback

200mmø San, Remainder of Subdivision

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

~Inv @ Intersection
Wat=355.65
San=351.45
CWC=356.00

~Inv @ Intersection
Stm=354.90
Wat=355.80
San=350.40
CWC=354.40

Roy Schmidt Road

Wasaga Crescent

Kawartha Street

Street F

Overflow to storm sewer from CWC system

200mmø Wmn, Street F

250mmø San, Street A (Conservation Drive to North end of Street F)

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

Street A

~Inv @ Intersection
Stm=354.45
Wat=354.85
San=350.00
CWC=354.00

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

Connection of watermain by others

Conservation Drive

Ex Gutter

Ex Gutter

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Engineering
310 Hespeler Road, Unit 1, Cambridge, ON N1R 6J9
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Preliminary Servicing Plan
556 & 576 Conservation Drive

DRAWN BY:	STV	CHECKED BY:	CHT
FILE NAME:	1279 Figures	DATE:	Aug 2022
SCALE:	1: 1000		
DRAWING:	1279-SS		

Rideau River Street

Street 'C'

Street 'B'

Street 'A'

Street 'D'

Street 'E'

Pinery Trail

Infiltration gallery

Infiltration gallery in trail block

Match existing elevations along entire northern limit

Rideau River Place

Rideau River Street

Single row silt fence, as per OPSD 219.130.

Pinery Trail

Constructed Wetland/Infiltrating Basin

SWM Pond to act as Temp Silt Pond during grading operations.

School

Park

Double row silt fence, as per OPSD 219.130.

Topsoil not to be stockpiled on the park block

Street 'A'

Roy Schmidt Road

Wasaga Crescent

Kawartha Street

Street 'F'

Street 'F'

Street 'A'

Infiltration gallery

Conservation Drive

Ex. Edge of Swamp

Ex. Edge of Swamp

Ex. Wetland Edge

Water Edge

Ex. Top of Creek

Ex. Top of Bank

Ex. Hedgerow

Ex. Post & Wire Fence

Ex. Ditch

Ex. Culvert

Ex. Gutter

Ex. Gutter

Existing or proposed ground

Proposed ground

Flow direction

0.15m Min
0.5m Max

1
2

1
2

1

0.5m

Control Swale Detail

Not to Scale

Existing asphalt area

Catchbasin frame & grate

Provide erosion control filter cloth (silt sack) between catchbasin/manhole moduloc and frame. Alternatively, attach erosion control filter cloth firmly to the underside of the catchbasin lid to ensure adequate filtering of sediments.

OPSD Precast catchbasin or
OPSD Precast manhole

Catchbasin Protection in Paved Area

Not to Scale

Temp Silt Pond

Double Silt Fence

Single Silt Fence

1.0m high snow fence c/w T-bar post @ 2.0m o/c

Filter fabric

Top of berm

15mmø clear stone filter, 150mm thick

Hickenbottom c/w orifice

0.5m

Rock fill
150mmø min.

Overflow

Water level

0.3m freeboard

0.3m overboard

5.0m min.

Final lot grade

Total Basin Volume

Active Storage Volume

Pre-grade

Undisturbed ground or compacted backfill

Rip-rap, 300mm deep

Dead Storage Volume

Outlet piped to grade or storm sewer

Sediment Control Pond Outlet Detail

Not to Scale

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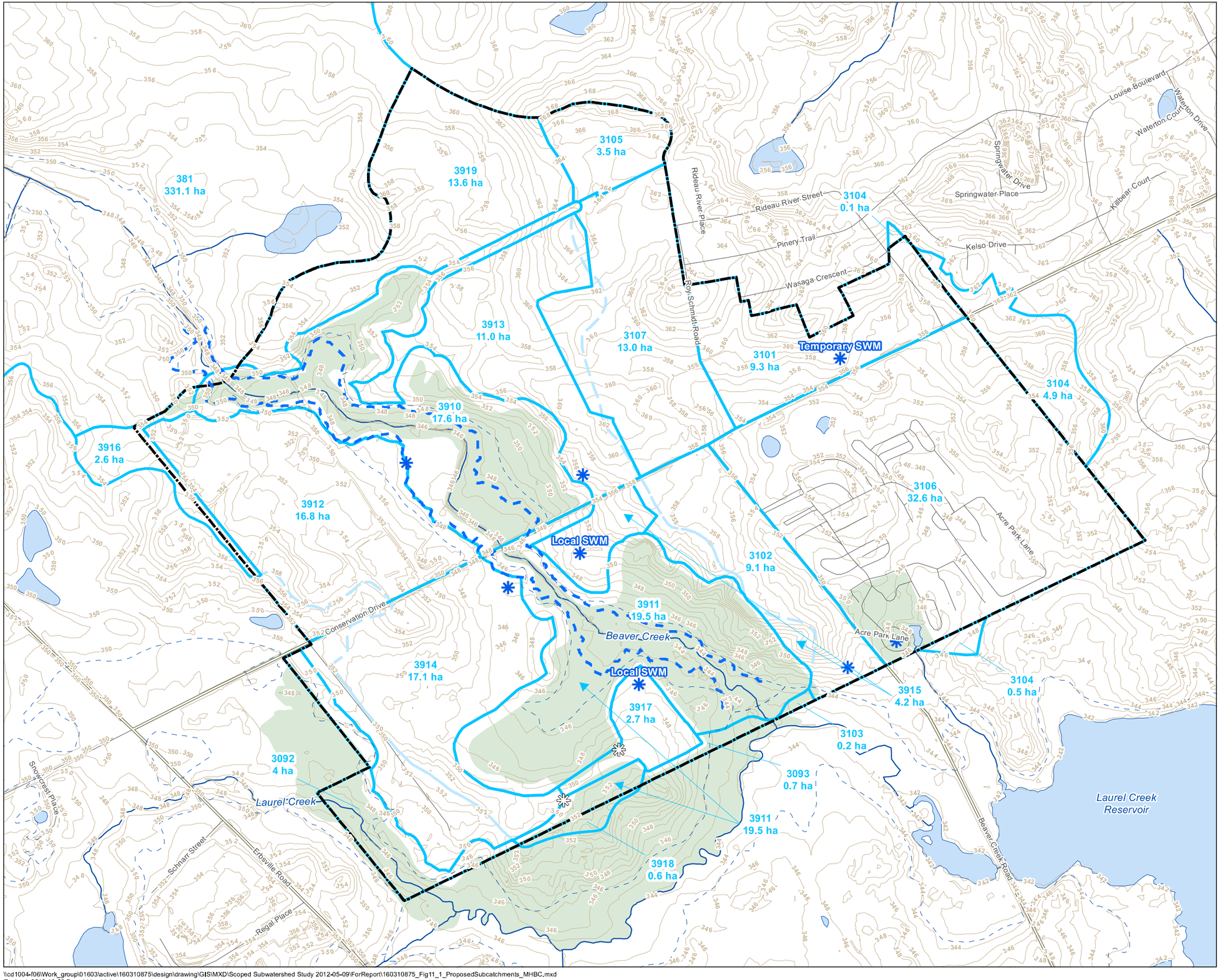
Preliminary Erosion & Sediment Control Plan
556 & 576 Conservation Drive

DRAWN BY:	STV	CHECKED BY:	CHT
FILE NAME:	1279 Figures	DATE:	Aug 2022
		SCALE:	1: 1000
			1279-ESC

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
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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: 25-Aug-22
Chk'd by: CHT
Date: 25-Aug-22

Sediment Forebay Sizing Calculations

(in accordance with MOE 2003)

Forebay Dimensions

				Calculated min.	Actual	
Average bottom width	**10.1**	m	Average top width	**21.5**	**19.8**	m
Maximum bottom width	**13.3**	m	Maximum top width	**24.7**	**24.7**	m
Average bottom length	**26.8**	m	Average top length	**38.2**	**38.2**	m
Average depth	**1.50**	m	Total Volume	**701**	m³	
Average sideslope	**3.8**	:1	Usable Volume	**424**	m³	

1) Forebay Settling Length

Dist = forebay length (m)
r = length to width ratio at average depth
= **2.2** (should be greater than 2:1)
Q_p = peak flow rate from facility during design quality storm
= **0.014** m³/s **25 mm** storm event
V_s = settling velocity (dependent on particle size)
= **0.0003** m/s for 150 μm particle
Therefore, distance = **10.1** m vs. **38.2** 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. **38.2** m provided
Also, min. bottom width = Dist./8 = **4.0** m vs. **10.1** 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
= **16.4** m² above the maximum sediment depth
Therefore, velocity = V_a = **0.09** 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
= **277** 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 = **13.6** yrs between cleanouts **5.0** years min. preferred

MERITECH

Project Name: Conservation Drive
Project Number: 1279
Calc'd by: STV
Date: 25-Aug-22
Chk'd by: CHT
Date: 25-Aug-22

Sediment Forebay Sizing Calculations

(in accordance with MOE 2003)

5) 10 year Accumulated Sediment Depth

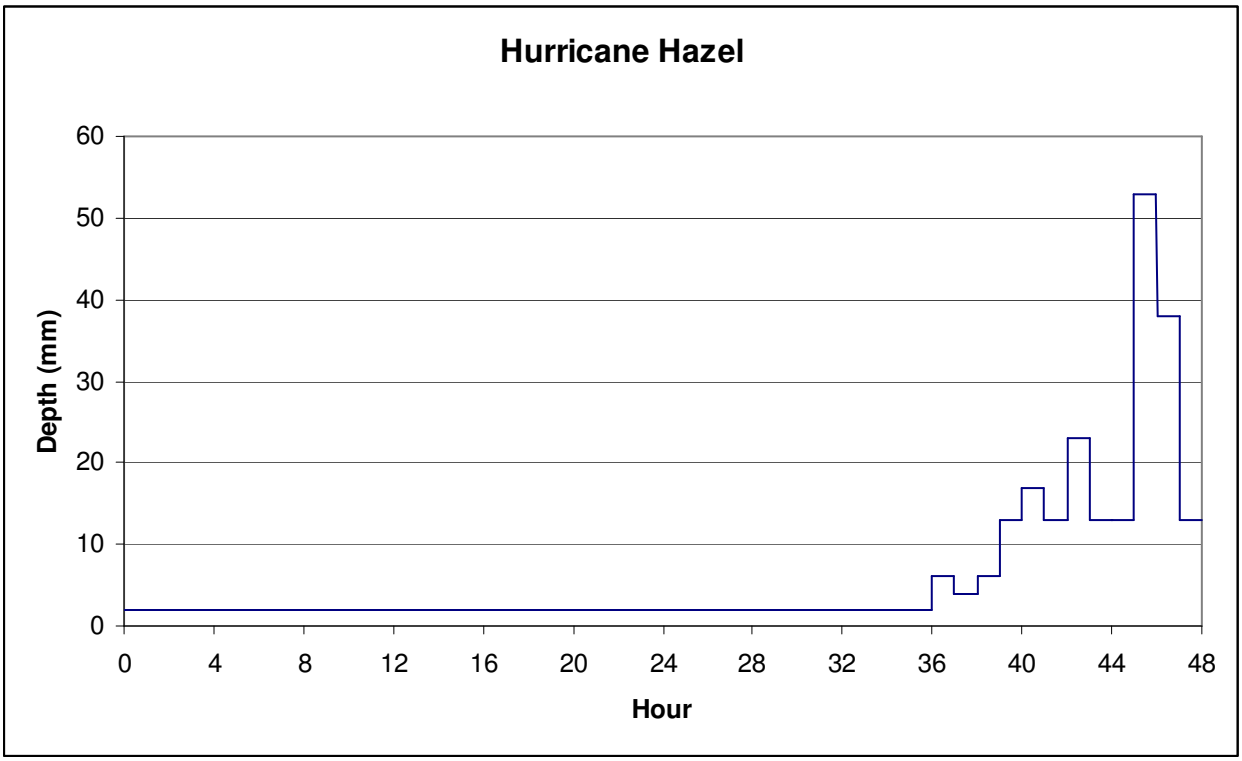
A_c = contributing area
= **8.140** ha.
L_a = annual loading
= **2.500** m^3/ha/yr
I = cleanout interval
= **10** years
V_r = required total storage volume
= **203.5** m^3
Actual total storage volume
= **700.7** m^3

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: STV
Date: 11-Jan-22
Chk'd by: CHT
Date: 25-Aug-22

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 30,729 m^3/yr (based on catchment areas)

Passive Pervious Infiltration

Catchment #	Area (ha)	%Pervious	$A_{pervious}$ (ha)	Annual Passive Infiltration Volume (@ 265.2mm/yr) (m^3)	
701	6.944	40%	2.78	7,366	
702	0.917	70%	0.64	1,702	
703	1.409	90%	1.27	3,363	
704	1.116	40%	0.45	1,184	
504	0.303	60%	0.18	482	
505	0.898	40%	0.36	953	
Total	11.59		**5.68**	**15,050**	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)	0.303	209.16	634	
505 (rear yard/roof)	0.898	209.16	1,878	
		Total	**2,512**	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	6.944	1.87	760	**14,255**	m^3/yr
			(90%)		

End-of-pipe (SWM Facility Infiltration)

Pond infiltrates the 2-yr storm runoff completely. 90% of annual rainfall occurs in storms less than the 2-year design event.

This translates to at least 90% of annual rainfall directed to infiltration. It is assumed that the winter bypass will be open for the months of Dec through March inclusive. These four months account for 30% of annual precipitation.

Catchment	IMP Area (excl roof) (ha)	Runoff to Infil (70% of 90% Precip) (mm)	Annual End-Of-Pipe Infiltration	
701	2.29	532	**12,196**	m^3/yr

West Side

Total Provided Infiltration =	44,013	m^3
Target Infiltration =	30,729	m^3
Difference =	**13,284**	**m^3**

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 33,367 m^2/yr (based on catchment areas)

Catchment #	Area (ha)	%Pervious	$A_{pervious}$ (ha)	Annual Passive Infiltration Volume (@ 281.6mm/yr) (m^3)	
501	0.469	40%	0.19	528	
502	2.297	50%	1.15	3,234	
503	9.083	30%	2.72	7,673	
		Total	**4.06**	**11,436**	m^2/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

Catchments	Contributing Area (ha)	Roof Area (ha)	Runoff (mm)	Annual Roof Runoff to CWC (m^3)	
503	9.083	2.45	760	**18,646**	m^3/yr

East Side

Total Provided Infiltration =	33,503	m^3
Target Infiltration =	33,367	m^3
Difference =	**137**	**m^3**

Total Provided Infiltration=	77,517	m^3/yr
Site Wide Infiltration Target =	64,096	m^3/yr
Surplus =	**13,421**	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:         C:\M\Meritech Engineering\PRJ - DOCS\1279\"
"                                                                  60-Design\SWM"
"                Output filename:                     1279d2yr4hrJan212022.out"
"                Licensee name:                       Stefan Van Hartingsveldt"
"                Company                                  Meritech Engineering"
"                Date & Time last used:               2022-01-21 at 3:12:21 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"
"       45.000   % Impervious"
"        5.074   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        2.791   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        2.283   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"
"                     0.534     0.000     0.000     0.000 c.m/sec"
"              Catchment 701          Pervious   Impervious Total Area "
```

```
"             Surface Area           2.791      2.283      5.074      hectare"
"             Time of concentration  15.530     1.324      4.026      minutes"
"             Time to Centroid       151.167    115.087    121.950    minutes"
"             Rainfall depth         33.885     33.885     33.885     mm"
"             Rainfall volume        945.62     773.69     1719.31    c.m"
"             Rainfall losses        28.436     5.533      18.129     mm"
"             Runoff depth           5.449      28.352     15.755     mm"
"             Runoff volume          152.07     647.36     799.43     c.m"
"             Runoff coefficient     0.161      0.837      0.465      "
"             Maximum flow           0.052      0.527      0.534      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.534     0.534     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"
"        0.917   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.642   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.275   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"
"                     0.062     0.534     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.642      0.275      0.917      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        217.51     93.22      310.72     c.m"
"             Rainfall losses        28.433     5.369      21.514     mm"
"             Runoff depth           5.452      28.515     12.371     mm"
"             Runoff volume          35.00      78.45      113.44     c.m"
"             Runoff coefficient     0.161      0.842      0.365      "
"             Maximum flow           0.009      0.061      0.062      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.062     0.596     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
```

```
"         1.409   Total Area"
"        80.000   Flow length"
"         3.000   Overland Slope"
"         1.268   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.141   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"
"                      0.029     0.596     0.000     0.000 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           1.268      0.141      1.409      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        429.69     47.74      477.43     c.m"
"              Rainfall losses        28.431     5.616      26.149     mm"
"              Runoff depth           5.454      28.269     7.736      mm"
"              Runoff volume          69.16      39.83      108.99     c.m"
"              Runoff coefficient     0.161      0.834      0.228      "
"              Maximum flow           0.013      0.028      0.029      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.029     0.625     0.000     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         1.116   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.446   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.670   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"
```

```
"                    0.150     0.625     0.000     0.000 c.m/sec"
"             Catchment 704          Pervious   Impervious Total Area "
"             Surface Area           0.446      0.670      1.116      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        151.26     226.89     378.15     c.m"
"             Rainfall losses        28.453     5.399      14.621     mm"
"             Runoff depth           5.431      28.486     19.264     mm"
"             Runoff volume          24.25      190.74     214.99     c.m"
"             Runoff coefficient     0.160      0.841      0.569      "
"             Maximum flow           0.011      0.147      0.150      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.150     0.775     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     0.775     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     0.894     0.000     0.000"
" 57          TRENCH Design d/s of 801"
"        0.894   Peak inflow"
"     1399.969   Hydrograph volume"
"      355.500   Ground elevation"
```

```
"      353.300   Downstream trench invert"
"        2.200   Trench height"
"      353.300   Water table elevation"
"       54.000   Trench top width"
"       30.000   Trench bottom width"
"      100.000   Voids ratio (%)"
"       86.000   Hydraulic conductivity"
"        0.000   Trench gradient (%)"
"      135.000   Trench length"
"        1.000   Include base width"
"          23.   Number of stages"
"                  Level Discharge    Volume"
"                353.300     0.000       0.0"
"                353.400     0.000      97.0"
"                353.500     0.000     194.0"
"                353.600     0.000     291.0"
"                353.700     0.000     388.0"
"                353.800     0.000     485.0"
"                353.900     0.000     582.0"
"                354.000     0.000     679.0"
"                354.100     0.000     776.0"
"                354.200     0.000     873.0"
"                354.300     0.000     970.0"
"                354.400     0.000    1095.0"
"                354.500     0.004    1310.0"
"                354.600     0.007    1684.0"
"                354.700     0.009    2189.0"
"                354.800     0.010    2738.0"
"                354.900     0.012    3311.0"
"                355.000     0.013    3910.0"
"                355.100     0.014    4536.0"
"                355.200     0.015    5189.0"
"                355.300     0.016    5847.0"
"                355.400     0.017    6615.0"
"                355.500     0.018    7401.0"
"            1.   ORIFICES"
"                 Orifice   Orifice   Orifice"
"                  invert coefficie  diameter"
"                354.400     0.630     0.090"
"            3.   TRENCH PIPES"
"              Downstream      Pipe      Pipe      Pipe Perf'ted?    Offset"
"                  Invert    length     diam.    grade%     0=Yes  distance"
"                354.600    18.000     0.000     7.889     1.000     0.000"
"                  0.000     0.000     0.000     0.000     0.000     0.000"
"                354.600    18.000     0.000     7.889     1.000     0.000"
"            1.   MANHOLE"
"                  Access"
"                diameter"
"                   1.200"
"              Peak outflow                  0.000    c.m/sec"
"              Outflow volume                0.001    c.m"
"              Peak exfiltration             0.230    c.m/sec"
"              Exfiltration volume        1401.094    c.m"
"              Maximum level               353.807    metre"
"              Maximum storage             491.476    c.m"
"              Centroidal lag                2.459   hours"
"              Infiltration area 2 sides   758.643   sq.metre"
"              Infiltration Base area     4050.000   sq.metre"
"                   0.119     0.894     0.000     0.230 c.m/sec"
```

```
" 40          HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"             Maximum flow                  0.000    c.m/sec"
"             Hydrograph volume             0.001    c.m"
"                     0.119     0.894     0.000     0.000"
" 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     0.000     0.000"
" 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     0.000     0.000 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     0.000     0.000"
" 40          HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                     0.065     0.065     0.065     0.000"
" 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"
"        2.297   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        1.148   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        1.148   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"
"                    0.257     0.006     0.065     0.065 c.m/sec"
"             Catchment 502          Pervious   Impervious Total Area "
"             Surface Area           1.148      1.148      2.297      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        389.16     389.16     778.33     c.m"
"             Rainfall losses        28.433     5.369      16.901     mm"
"             Runoff depth           5.452      28.515     16.984     mm"
"             Runoff volume          62.62      327.50     390.12     c.m"
"             Runoff coefficient     0.161      0.842      0.501      "
"             Maximum flow           0.017      0.256      0.257      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.257     0.257     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"
"        9.083   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        2.725   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        6.358   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"
"                       1.474     0.257     0.065     0.065 c.m/sec"
"              Catchment 503          Pervious   Impervious Total Area "
"              Surface Area           2.725      6.358      9.083      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        923.32     2154.42    3077.74    c.m"
"              Rainfall losses        28.436     5.533      12.404     mm"
"              Runoff depth           5.449      28.352     21.481     mm"
"              Runoff volume          148.48     1802.65    1951.13    c.m"
"              Runoff coefficient     0.161      0.837      0.634      "
"              Maximum flow           0.051      1.467      1.474      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       1.474     1.732     0.065     0.065"
" 40           HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                       1.474     1.732     1.732     0.065"
" 40           HYDROGRAPH   Combine    503"
"             6   Combine "
"           503   Node #"
"                 SWM facility south of Conservation Dr"
"              Maximum flow                  1.732    c.m/sec"
"              Hydrograph volume          2401.766    c.m"
"                       1.474     1.732     1.732     1.732"
" 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"
"                       1.474     0.000     1.732     1.732"
" 33           CATCHMENT 504"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           504   Townhouse area at SW corner"
"        40.000   % Impervious"
"         0.303   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.182   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.121   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"
"                       0.028     0.000     1.732     1.732 c.m/sec"
```

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"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.182      0.121      0.303      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        61.60      41.07      102.67     c.m"
"             Rainfall losses        28.436     5.533      19.274     mm"
"             Runoff depth           5.449      28.352     14.610     mm"
"             Runoff volume          9.91       34.36      44.27      c.m"
"             Runoff coefficient     0.161      0.837      0.431      "
"             Maximum flow           0.003      0.028      0.028      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"           4   Add Runoff "
"                    0.028     0.028     1.732     1.732"
" 40          HYDROGRAPH Copy to Outflow"
"           8   Copy to Outflow"
"                    0.028     0.028     0.028     1.732"
" 40          HYDROGRAPH   Combine    504"
"           6   Combine "
"         504   Node #"
"               Minor to infiltration"
"             Maximum flow                  0.028    c.m/sec"
"             Hydrograph volume            44.269    c.m"
"                    0.028     0.028     0.028     0.028"
" 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"
"                    0.028     0.000     0.028     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."
"        0.161   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     0.028     0.028 c.m/sec"
"             Catchment 505          Pervious   Impervious Total Area "
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"             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     0.028     0.028"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                     0.125     0.125     0.125     0.028"
" 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"
```

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"              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                      26.316    hectare"
"              Total Impervious area                     12.567    hectare"
"              Total % impervious                        47.754"
" 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:         C:\M\Meritech Engineering\PRJ - DOCS\1279\"
"                                                                   60-Design\SWM"
"                Output filename:                     1279d2yr24hrJan212022.out"
"                Licensee name:                        Stefan Van Hartingsveldt"
"                Company                                   Meritech Engineering"
"                Date & Time last used:                2022-01-21 at 3:15:23 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"
"       45.000   % Impervious"
"        5.074   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        2.791   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        2.283   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"
"                     0.561     0.000     0.000     0.000 c.m/sec"
"             Catchment 701          Pervious   Impervious Total Area "
```

```
"             Surface Area           2.791      2.283      5.074      hectare"
"             Time of concentration  12.659     1.298      4.168      minutes"
"             Time to Centroid       793.747    668.959    700.483    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        1312.45    1073.82    2386.27    c.m"
"             Rainfall losses        35.650     5.881      22.254     mm"
"             Runoff depth           11.380     41.149     24.776     mm"
"             Runoff volume          317.58     939.55     1257.13    c.m"
"             Runoff coefficient     0.242      0.875      0.527      "
"             Maximum flow           0.079      0.540      0.561      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.561     0.561     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"
"        0.917   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.642   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.275   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"
"                     0.065     0.561     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.642      0.275      0.917      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        301.88     129.38     431.26     c.m"
"             Rainfall losses        35.643     5.578      26.624     mm"
"             Runoff depth           11.386     41.451     20.406     mm"
"             Runoff volume          73.09      114.03     187.12     c.m"
"             Runoff coefficient     0.242      0.881      0.434      "
"             Maximum flow           0.014      0.062      0.065      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.065     0.625     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
```

```
"         1.409   Total Area"
"        80.000   Flow length"
"         3.000   Overland Slope"
"         1.268   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.141   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"
"                      0.031     0.625     0.000     0.000 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           1.268      0.141      1.409      hectare"
"              Time of concentration  34.563     3.544      25.667     minutes"
"              Time to Centroid       846.115    675.508    797.186    minutes"
"              Rainfall depth         47.029     47.029     47.029     mm"
"              Rainfall volume        596.38     66.26      662.64     c.m"
"              Rainfall losses        35.632     5.779      32.646     mm"
"              Runoff depth           11.398     41.250     14.383     mm"
"              Runoff volume          144.53     58.12      202.66     c.m"
"              Runoff coefficient     0.242      0.877      0.306      "
"              Maximum flow           0.017      0.027      0.031      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.031     0.654     0.000     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         1.116   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.446   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.670   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"
```

```
"                    0.155     0.654     0.000     0.000 c.m/sec"
"             Catchment 704          Pervious   Impervious Total Area "
"             Surface Area           0.446      0.670      1.116      hectare"
"             Time of concentration  7.165      2.222      2.986      minutes"
"             Time to Centroid       781.075    671.334    688.286    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        209.94     314.91     524.85     c.m"
"             Rainfall losses        35.686     5.637      17.657     mm"
"             Runoff depth           11.343     41.393     29.373     mm"
"             Runoff volume          50.64      277.17     327.80     c.m"
"             Runoff coefficient     0.241      0.880      0.625      "
"             Maximum flow           0.018      0.148      0.155      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.155     0.809     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     0.809     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     0.932     0.000     0.000"
" 57          TRENCH Design d/s of 801"
"        0.932   Peak inflow"
"     2223.257   Hydrograph volume"
"      355.500   Ground elevation"
```

```
"      353.300   Downstream trench invert"
"        2.200   Trench height"
"      353.300   Water table elevation"
"       54.000   Trench top width"
"       30.000   Trench bottom width"
"      100.000   Voids ratio (%)"
"       86.000   Hydraulic conductivity"
"        0.000   Trench gradient (%)"
"      135.000   Trench length"
"        1.000   Include base width"
"          23.   Number of stages"
"                  Level Discharge    Volume"
"                353.300     0.000       0.0"
"                353.400     0.000      97.0"
"                353.500     0.000     194.0"
"                353.600     0.000     291.0"
"                353.700     0.000     388.0"
"                353.800     0.000     485.0"
"                353.900     0.000     582.0"
"                354.000     0.000     679.0"
"                354.100     0.000     776.0"
"                354.200     0.000     873.0"
"                354.300     0.000     970.0"
"                354.400     0.000    1095.0"
"                354.500     0.004    1310.0"
"                354.600     0.007    1684.0"
"                354.700     0.009    2189.0"
"                354.800     0.010    2738.0"
"                354.900     0.012    3311.0"
"                355.000     0.013    3910.0"
"                355.100     0.014    4536.0"
"                355.200     0.015    5189.0"
"                355.300     0.016    5847.0"
"                355.400     0.017    6615.0"
"                355.500     0.018    7401.0"
"            1.   ORIFICES"
"                 Orifice   Orifice   Orifice"
"                  invert coefficie  diameter"
"                354.400     0.630     0.090"
"            3.   TRENCH PIPES"
"              Downstream      Pipe      Pipe      Pipe Perf'ted?    Offset"
"                  Invert    length     diam.    grade%     0=Yes  distance"
"                354.600    18.000     0.000     7.889     1.000     0.000"
"                  0.000     0.000     0.000     0.000     0.000     0.000"
"                354.600    18.000     0.000     7.889     1.000     0.000"
"            1.   MANHOLE"
"                  Access"
"                diameter"
"                   1.200"
"              Peak outflow                  0.000    c.m/sec"
"              Outflow volume                0.001    c.m"
"              Peak exfiltration             0.228    c.m/sec"
"              Exfiltration volume        2221.737    c.m"
"              Maximum level               353.789    metre"
"              Maximum storage             474.489    c.m"
"              Centroidal lag               12.141   hours"
"              Infiltration area 2 sides   732.415   sq.metre"
"              Infiltration Base area     4050.000   sq.metre"
"                   0.123     0.932     0.000     0.228 c.m/sec"
```

```
" 40          HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"             Maximum flow                  0.000    c.m/sec"
"             Hydrograph volume             0.001    c.m"
"                     0.123     0.932     0.000     0.000"
" 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     0.000     0.000"
" 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     0.000     0.000 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     0.000     0.000"
" 40          HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                     0.068     0.068     0.068     0.000"
" 40          HYDROGRAPH   Combine    501"
"             6   Combine "
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```
"          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"
```

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"       50.000   % Impervious"
"        2.297   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        1.148   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        1.148   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"
"                    0.263     0.009     0.068     0.068 c.m/sec"
"             Catchment 502          Pervious   Impervious Total Area "
"             Surface Area           1.148      1.148      2.297      hectare"
"             Time of concentration  19.188     1.967      5.678      minutes"
"             Time to Centroid       809.358    670.465    700.395    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        540.13     540.13     1080.27    c.m"
"             Rainfall losses        35.643     5.578      20.611     mm"
"             Runoff depth           11.386     41.451     26.419     mm"
"             Runoff volume          130.77     476.07     606.84     c.m"
"             Runoff coefficient     0.242      0.881      0.562      "
"             Maximum flow           0.024      0.259      0.263      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.263     0.264     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"
"        9.083   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        2.725   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        6.358   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"
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"         0.518   Impervious Initial abstraction"
"                       1.523     0.264     0.068     0.068 c.m/sec"
"              Catchment 503          Pervious   Impervious Total Area "
"              Surface Area           2.725      6.358      9.083      hectare"
"              Time of concentration  12.659     1.298      2.502      minutes"
"              Time to Centroid       793.748    668.958    682.181    minutes"
"              Rainfall depth         47.029     47.029     47.029     mm"
"              Rainfall volume        1281.51    2990.18    4271.68    c.m"
"              Rainfall losses        35.650     5.881      14.811     mm"
"              Runoff depth           11.380     41.149     32.218     mm"
"              Runoff volume          310.09     2616.29    2926.38    c.m"
"              Runoff coefficient     0.242      0.875      0.685      "
"              Maximum flow           0.077      1.503      1.523      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       1.523     1.787     0.068     0.068"
" 40           HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                       1.523     1.787     1.787     0.068"
" 40           HYDROGRAPH   Combine    503"
"             6   Combine "
"           503   Node #"
"                 SWM facility south of Conservation Dr"
"              Maximum flow                  1.787    c.m/sec"
"              Hydrograph volume          3704.961    c.m"
"                       1.523     1.787     1.787     1.787"
" 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"
"                       1.523     0.000     1.787     1.787"
" 33           CATCHMENT 504"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           504   Townhouse area at SW corner"
"        40.000   % Impervious"
"         0.303   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.182   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.121   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"
"                       0.030     0.000     1.787     1.787 c.m/sec"
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"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.182      0.121      0.303      hectare"
"             Time of concentration  12.659     1.298      4.629      minutes"
"             Time to Centroid       793.747    668.958    705.547    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        85.50      57.00      142.50     c.m"
"             Rainfall losses        35.650     5.881      23.742     mm"
"             Runoff depth           11.380     41.149     23.287     mm"
"             Runoff volume          20.69      49.87      70.56      c.m"
"             Runoff coefficient     0.242      0.875      0.495      "
"             Maximum flow           0.005      0.029      0.030      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"           4   Add Runoff "
"                    0.030     0.030     1.787     1.787"
" 40          HYDROGRAPH Copy to Outflow"
"           8   Copy to Outflow"
"                    0.030     0.030     0.030     1.787"
" 40          HYDROGRAPH   Combine    504"
"           6   Combine "
"         504   Node #"
"               Minor to infiltration"
"             Maximum flow                  0.030    c.m/sec"
"             Hydrograph volume            70.561    c.m"
"                    0.030     0.030     0.030     0.030"
" 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"
"                    0.030     0.000     0.030     0.030"
" 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     0.030     0.030 c.m/sec"
"             Catchment 505          Pervious   Impervious Total Area "
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"             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     0.030     0.030"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                     0.130     0.130     0.130     0.030"
" 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"
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"              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                     26.316    hectare"
"              Total Impervious area                    12.567    hectare"
"              Total % impervious                       47.754"
" 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:         C:\M\Meritech Engineering\PRJ - DOCS\1279\"
"                                                                  60-Design\SWM"
"                Output filename:                     1279d5yr3hrJan212022.out"
"                Licensee name:                       Stefan Van Hartingsveldt"
"                Company                                  Meritech Engineering"
"                Date & Time last used:               2022-01-21 at 3:57:56 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"
"         6.944   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         2.778   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         4.166   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"
"                      1.335     0.000     0.000     0.000 c.m/sec"
"              Catchment 701          Pervious   Impervious Total Area "
```

```
"             Surface Area           2.778      4.166      6.944      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        1320.72    1981.08    3301.81    c.m"
"             Rainfall losses        35.905     6.164      18.061     mm"
"             Runoff depth           11.644     41.385     29.488     mm"
"             Runoff volume          323.42     1724.26    2047.67    c.m"
"             Runoff coefficient     0.245      0.870      0.620      "
"             Maximum flow           0.137      1.310      1.335      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     1.335     1.335     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"
"        0.917   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.642   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.275   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"
"                     0.086     1.335     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.642      0.275      0.917      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        305.22     130.81     436.02     c.m"
"             Rainfall losses        35.905     5.740      26.856     mm"
"             Runoff depth           11.644     41.809     20.693     mm"
"             Runoff volume          74.74      115.02     189.76     c.m"
"             Runoff coefficient     0.245      0.879      0.435      "
"             Maximum flow           0.026      0.083      0.086      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.086     1.422     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
```

```
"         1.409   Total Area"
"        80.000   Flow length"
"         3.000   Overland Slope"
"         1.268   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.141   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"
"                      0.046     1.422     0.000     0.000 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           1.268      0.141      1.409      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        602.97     67.00      669.97     c.m"
"              Rainfall losses        35.890     5.968      32.898     mm"
"              Runoff depth           11.659     41.581     14.651     mm"
"              Runoff volume          147.84     58.59      206.43     c.m"
"              Runoff coefficient     0.245      0.874      0.308      "
"              Maximum flow           0.036      0.038      0.046      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.046     1.462     0.000     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         1.116   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.446   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.670   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"
```

```
"                    0.207     1.462     0.000     0.000 c.m/sec"
"             Catchment 704          Pervious   Impervious Total Area "
"             Surface Area           0.446      0.670      1.116      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        212.26     318.39     530.65     c.m"
"             Rainfall losses        36.011     5.764      17.863     mm"
"             Runoff depth           11.538     41.785     29.686     mm"
"             Runoff volume          51.51      279.79     331.30     c.m"
"             Runoff coefficient     0.243      0.879      0.624      "
"             Maximum flow           0.029      0.199      0.207      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.207     1.669     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     1.669     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     1.833     0.000     0.000"
" 57          TRENCH Design d/s of 801"
"        1.833   Peak inflow"
"     3025.809   Hydrograph volume"
"      355.500   Ground elevation"
```

```
"      353.300   Downstream trench invert"
"        2.200   Trench height"
"      353.300   Water table elevation"
"       54.000   Trench top width"
"       30.000   Trench bottom width"
"      100.000   Voids ratio (%)"
"       86.000   Hydraulic conductivity"
"        0.000   Trench gradient (%)"
"      135.000   Trench length"
"        1.000   Include base width"
"          23.   Number of stages"
"                  Level Discharge    Volume"
"                353.300     0.000       0.0"
"                353.400     0.000      97.0"
"                353.500     0.000     194.0"
"                353.600     0.000     291.0"
"                353.700     0.000     388.0"
"                353.800     0.000     485.0"
"                353.900     0.000     582.0"
"                354.000     0.000     679.0"
"                354.100     0.000     776.0"
"                354.200     0.000     873.0"
"                354.300     0.000     970.0"
"                354.400     0.000    1095.0"
"                354.500     0.004    1310.0"
"                354.600     0.007    1684.0"
"                354.700     0.009    2189.0"
"                354.800     0.010    2738.0"
"                354.900     0.012    3311.0"
"                355.000     0.013    3910.0"
"                355.100     0.014    4536.0"
"                355.200     0.015    5189.0"
"                355.300     0.016    5847.0"
"                355.400     0.017    6615.0"
"                355.500     0.018    7401.0"
"            1.   ORIFICES"
"                 Orifice   Orifice   Orifice"
"                  invert coefficie  diameter"
"                354.400     0.630     0.090"
"            2.   TRENCH PIPES"
"              Downstream      Pipe      Pipe      Pipe Perf'ted?    Offset"
"                  Invert    length     diam.    grade%     0=Yes  distance"
"                354.600    18.000     0.000     7.889     1.000     0.000"
"                  0.000     0.000     0.000     0.000     0.000     0.000"
"            1.   MANHOLE"
"                  Access"
"                diameter"
"                   1.200"
"              Peak outflow                  0.006    c.m/sec"
"              Outflow volume               20.178    c.m"
"              Peak exfiltration             0.284    c.m/sec"
"              Exfiltration volume        3005.823    c.m"
"              Maximum level               354.568    metre"
"              Maximum storage            1562.573    c.m"
"              Centroidal lag                1.991   hours"
"              Infiltration area 2 sides   1897.865   sq.metre"
"              Infiltration Base area      4050.000   sq.metre"
"                   0.163     1.833     0.006     0.284 c.m/sec"
" 40           HYDROGRAPH   Combine    704"
```

```
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                  0.006    c.m/sec"
"             Hydrograph volume            20.178    c.m"
"                    0.163     1.833     0.006     0.006"
" 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     0.006     0.006"
" 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     0.006     0.006 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     0.006     0.006"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                    0.090     0.090     0.090     0.006"
" 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"
```

```
"         2.297   Total Area"
"        30.000   Flow length"
"         3.000   Overland Slope"
"         1.148   Pervious Area"
"        30.000   Pervious length"
"         3.000   Pervious slope"
"         1.148   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"
"                      0.352     0.030     0.090     0.090 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           1.148      1.148      2.297      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        546.10     546.10     1092.20    c.m"
"              Rainfall losses        35.905     5.740      20.823     mm"
"              Runoff depth           11.644     41.809     26.726     mm"
"              Runoff volume          133.73     480.18     613.90     c.m"
"              Runoff coefficient     0.245      0.879      0.562      "
"              Maximum flow           0.047      0.346      0.352      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.352     0.352     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"
"         9.083   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         2.725   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         6.358   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"
```

```
"                    2.024     0.352     0.090     0.090 c.m/sec"
"             Catchment 503          Pervious   Impervious Total Area "
"             Surface Area           2.725      6.358      9.083      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        1295.66    3023.22    4318.88    c.m"
"             Rainfall losses        35.905     6.164      15.087     mm"
"             Runoff depth           11.644     41.385     32.462     mm"
"             Runoff volume          317.28     2631.29    2948.57    c.m"
"             Runoff coefficient     0.245      0.870      0.683      "
"             Maximum flow           0.134      1.999      2.024      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"           4   Add Runoff "
"                    2.024     2.376     0.090     0.090"
" 40          HYDROGRAPH Copy to Outflow"
"           8   Copy to Outflow"
"                    2.024     2.376     2.376     0.090"
" 40          HYDROGRAPH   Combine    503"
"           6   Combine "
"         503   Node #"
"               SWM facility south of Conservation Dr"
"             Maximum flow                  2.376    c.m/sec"
"             Hydrograph volume          3739.584    c.m"
"                    2.024     2.376     2.376     2.376"
" 81          ADD COMMENT================================================="
"           3  Lines of comment"
"              Minor flows (2yr and less) from catchment 504 "
"              (townhouses at SW corner) (71m3) are to infiltration, "
"              remainder to Beaver Creek "
" 40          HYDROGRAPH Start - New Tributary"
"           2   Start - New Tributary"
"                    2.024     0.000     2.376     2.376"
" 33          CATCHMENT 504"
"           1   Triangular SCS"
"           1   Equal length"
"           1   SCS method"
"         504   Townhouse area at SW corner"
"       40.000   % Impervious"
"        0.303   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.182   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.121   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"
"                    0.040     0.000     2.376     2.376 c.m/sec"
```

```
"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.182      0.121      0.303      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        86.44      57.63      144.07     c.m"
"             Rainfall losses        35.905     6.164      24.009     mm"
"             Runoff depth           11.644     41.385     23.540     mm"
"             Runoff volume          21.17      50.16      71.33      c.m"
"             Runoff coefficient     0.245      0.870      0.495      "
"             Maximum flow           0.009      0.038      0.040      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.040     0.040     2.376     2.376"
" 54          POND DESIGN"
"         0.040   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"          71.3   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    71.000"
"                 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                  0.000    c.m/sec"
"             Maximum level               101.000    metre"
"             Maximum storage              71.035    c.m"
"             Centroidal lag               57.368   hours"
"                  0.040     0.040     0.000     2.376 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"           6   Combine "
"         704   Node #"
"               Flows to Beaver Creek"
"             Maximum flow                  0.006    c.m/sec"
"             Hydrograph volume            24.585    c.m"
"                     0.040     0.040     0.000     0.006"
" 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"
"                     0.040     0.000     0.000     0.006"
" 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     0.000     0.006 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     0.000     0.006"
" 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     0.006 c.m/sec"
" 40           HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"              Maximum flow                  0.006    c.m/sec"
```

```
"             Hydrograph volume            30.553    c.m"
"                    0.173     0.173     0.001     0.006"
" 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     0.006"
" 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     0.006 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     0.006"
" 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     0.006 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                  0.006    c.m/sec"
"             Hydrograph volume            35.637    c.m"
"                     0.077     0.077     0.001     0.006"
" 38          START/RE-START TOTALS 602"
"            3   Runoff Totals on EXIT"
"             Total Catchment area                     28.186    hectare"
"             Total Impervious area                    14.450    hectare"
"             Total % impervious                       51.267"
" 19          EXIT"
```

```
"                MIDUSS Output ------------------------------------------------>"
"                MIDUSS version                          Version 2.25  rev. 473"
"                MIDUSS created                               February 7, 2010"
"           10   Units used:                                          ie METRIC"
"                Job folder:         C:\M\Meritech Engineering\PRJ - DOCS\1279\"
"                                                                   60-Design\SWM"
"                Output filename:                     1279d5yr24hrJan212022.out"
"                Licensee name:                        Stefan Van Hartingsveldt"
"                Company                                   Meritech Engineering"
"                Date & Time last used:                2022-01-21 at 3:23:41 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"
"         6.944   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         2.778   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         4.166   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"
"                      1.378     0.000     0.000     0.000 c.m/sec"
"              Catchment 701          Pervious   Impervious Total Area "
```

```
"             Surface Area           2.778      4.166      6.944      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        1694.84    2542.26    4237.10    c.m"
"             Rainfall losses        41.904     6.416      20.611     mm"
"             Runoff depth           19.114     54.602     40.407     mm"
"             Runoff volume          530.91     2274.96    2805.87    c.m"
"             Runoff coefficient     0.313      0.895      0.662      "
"             Maximum flow           0.169      1.317      1.378      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     1.378     1.378     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"
"        0.917   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.642   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.275   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"
"                     0.091     1.378     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.642      0.275      0.917      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        391.68     167.86     559.54     c.m"
"             Rainfall losses        41.834     5.905      31.055     mm"
"             Runoff depth           19.185     55.113     29.963     mm"
"             Runoff volume          123.15     151.62     274.76     c.m"
"             Runoff coefficient     0.314      0.903      0.491      "
"             Maximum flow           0.033      0.084      0.091      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.091     1.470     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
```

```
"         1.409   Total Area"
"        80.000   Flow length"
"         3.000   Overland Slope"
"         1.268   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.141   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"
"                      0.048     1.470     0.000     0.000 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           1.268      0.141      1.409      hectare"
"              Time of concentration  27.284     3.184      21.461     minutes"
"              Time to Centroid       796.758    661.651    764.113    minutes"
"              Rainfall depth         61.018     61.018     61.018     mm"
"              Rainfall volume        773.77     85.97      859.75     c.m"
"              Rainfall losses        41.821     5.973      38.236     mm"
"              Runoff depth           19.197     55.045     22.782     mm"
"              Runoff volume          243.44     77.56      321.00     c.m"
"              Runoff coefficient     0.315      0.902      0.373      "
"              Maximum flow           0.041      0.039      0.048      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.048     1.514     0.000     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         1.116   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.446   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.670   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"
```

```
"                    0.223     1.514     0.000     0.000 c.m/sec"
"             Catchment 704          Pervious   Impervious Total Area "
"             Surface Area           0.446      0.670      1.116      hectare"
"             Time of concentration  5.656      1.996      2.684      minutes"
"             Time to Centroid       745.656    658.155    674.590    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        272.39     408.58     680.96     c.m"
"             Rainfall losses        41.880     5.847      20.261     mm"
"             Runoff depth           19.138     55.171     40.758     mm"
"             Runoff volume          85.43      369.42     454.86     c.m"
"             Runoff coefficient     0.314      0.904      0.668      "
"             Maximum flow           0.036      0.202      0.223      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.223     1.737     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     1.737     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     1.906     0.000     0.000"
" 57          TRENCH Design d/s of 801"
"        1.906   Peak inflow"
"     4199.947   Hydrograph volume"
"      355.500   Ground elevation"
```

```
"      353.300   Downstream trench invert"
"        2.200   Trench height"
"      353.300   Water table elevation"
"       54.000   Trench top width"
"       30.000   Trench bottom width"
"      100.000   Voids ratio (%)"
"       86.000   Hydraulic conductivity"
"        0.000   Trench gradient (%)"
"      135.000   Trench length"
"        1.000   Include base width"
"          23.   Number of stages"
"                  Level Discharge    Volume"
"                353.300     0.000       0.0"
"                353.400     0.000      97.0"
"                353.500     0.000     194.0"
"                353.600     0.000     291.0"
"                353.700     0.000     388.0"
"                353.800     0.000     485.0"
"                353.900     0.000     582.0"
"                354.000     0.000     679.0"
"                354.100     0.000     776.0"
"                354.200     0.000     873.0"
"                354.300     0.000     970.0"
"                354.400     0.000    1095.0"
"                354.500     0.004    1310.0"
"                354.600     0.007    1684.0"
"                354.700     0.009    2189.0"
"                354.800     0.010    2738.0"
"                354.900     0.012    3311.0"
"                355.000     0.013    3910.0"
"                355.100     0.014    4536.0"
"                355.200     0.015    5189.0"
"                355.300     0.016    5847.0"
"                355.400     0.017    6615.0"
"                355.500     0.018    7401.0"
"            1.   ORIFICES"
"                 Orifice   Orifice   Orifice"
"                  invert coefficie  diameter"
"                354.400     0.630     0.090"
"            2.   TRENCH PIPES"
"              Downstream      Pipe      Pipe      Pipe Perf'ted?    Offset"
"                  Invert    length     diam.    grade%     0=Yes  distance"
"                354.600    18.000     0.000     7.889     1.000     0.000"
"                  0.000     0.000     0.000     0.000     0.000     0.000"
"            1.   MANHOLE"
"                  Access"
"                diameter"
"                   1.200"
"              Peak outflow                  0.004    c.m/sec"
"              Outflow volume                9.946    c.m"
"              Peak exfiltration             0.280    c.m/sec"
"              Exfiltration volume        4189.698    c.m"
"              Maximum level               354.513    metre"
"              Maximum storage            1360.495    c.m"
"              Centroidal lag               10.244   hours"
"              Infiltration area 2 sides   1816.942   sq.metre"
"              Infiltration Base area      4050.000   sq.metre"
"                   0.169     1.906     0.004     0.280 c.m/sec"
" 40           HYDROGRAPH   Combine    704"
```

```
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"              Maximum flow                  0.004    c.m/sec"
"              Hydrograph volume             9.946    c.m"
"                     0.169     1.906     0.004     0.004"
" 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     0.004     0.004"
" 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     0.004     0.004 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     0.004     0.004"
" 40           HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                     0.093     0.093     0.093     0.004"
" 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"
```

```
"         2.297   Total Area"
"        30.000   Flow length"
"         3.000   Overland Slope"
"         1.148   Pervious Area"
"        30.000   Pervious length"
"         3.000   Pervious slope"
"         1.148   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"
"                      0.363     0.033     0.093     0.093 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           1.148      1.148      2.297      hectare"
"              Time of concentration  15.147     1.767      5.222      minutes"
"              Time to Centroid       767.983    657.510    686.036    minutes"
"              Rainfall depth         61.018     61.018     61.018     mm"
"              Rainfall volume        700.79     700.79     1401.59    c.m"
"              Rainfall losses        41.834     5.905      23.869     mm"
"              Runoff depth           19.185     55.113     37.149     mm"
"              Runoff volume          220.34     632.97     853.31     c.m"
"              Runoff coefficient     0.314      0.903      0.609      "
"              Maximum flow           0.059      0.350      0.363      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.363     0.365     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"
"         9.083   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         2.725   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         6.358   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"
```

```
"                    2.070     0.365     0.093     0.093 c.m/sec"
"             Catchment 503          Pervious   Impervious Total Area "
"             Surface Area           2.725      6.358      9.083      hectare"
"             Time of concentration  9.993      1.166      2.318      minutes"
"             Time to Centroid       756.254    656.264    669.308    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        1662.69    3879.60    5542.28    c.m"
"             Rainfall losses        41.904     6.416      17.062     mm"
"             Runoff depth           19.114     54.602     43.956     mm"
"             Runoff volume          520.84     3471.68    3992.52    c.m"
"             Runoff coefficient     0.313      0.895      0.720      "
"             Maximum flow           0.166      2.010      2.070      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"           4   Add Runoff "
"                    2.070     2.435     0.093     0.093"
" 40          HYDROGRAPH Copy to Outflow"
"           8   Copy to Outflow"
"                    2.070     2.435     2.435     0.093"
" 40          HYDROGRAPH   Combine    503"
"           6   Combine "
"         503   Node #"
"               SWM facility south of Conservation Dr"
"             Maximum flow                 2.435    c.m/sec"
"             Hydrograph volume         5184.527    c.m"
"                    2.070     2.435     2.435     2.435"
" 81          ADD COMMENT================================================="
"           3  Lines of comment"
"              Minor flows (2yr and less) from catchment 504 "
"              (townhouses at SW corner) (71m3) are to infiltration, "
"              remainder to Beaver Creek "
" 40          HYDROGRAPH Start - New Tributary"
"           2   Start - New Tributary"
"                    2.070     0.000     2.435     2.435"
" 33          CATCHMENT 504"
"           1   Triangular SCS"
"           1   Equal length"
"           1   SCS method"
"         504   Townhouse area at SW corner"
"       40.000   % Impervious"
"        0.303   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.182   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.121   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"
"                    0.042     0.000     2.435     2.435 c.m/sec"
```

```
"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.182      0.121      0.303      hectare"
"             Time of concentration  9.993      1.166      4.205      minutes"
"             Time to Centroid       756.255    656.264    690.690    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        110.93     73.95      184.89     c.m"
"             Rainfall losses        41.904     6.416      27.709     mm"
"             Runoff depth           19.114     54.602     33.309     mm"
"             Runoff volume          34.75      66.18      100.93     c.m"
"             Runoff coefficient     0.313      0.895      0.546      "
"             Maximum flow           0.011      0.038      0.042      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.042     0.042     2.435     2.435"
" 54          POND DESIGN"
"        0.042   Current peak flow    c.m/sec"
"        1.000   Target outflow    c.m/sec"
"        100.9   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    71.000"
"                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              71.264    c.m"
"             Centroidal lag               21.708   hours"
"                  0.042     0.042     0.002     2.435 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                  0.004    c.m/sec"
"             Hydrograph volume            43.204    c.m"
"                    0.042     0.042     0.002     0.004"
" 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"
"                    0.042     0.000     0.002     0.004"
" 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"
```

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"         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"
"         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     0.004 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     0.004"
" 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     0.004 c.m/sec"
" 40           HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"              Maximum flow                  0.008    c.m/sec"
```

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"             Hydrograph volume           146.195    c.m"
"                    0.178     0.178     0.007     0.008"
" 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     0.008"
" 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     0.008 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     0.008"
" 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     0.008 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                 0.011    c.m/sec"
"             Hydrograph volume          194.167    c.m"
"                     0.079     0.079     0.003     0.011"
" 38          START/RE-START TOTALS 602"
"            3   Runoff Totals on EXIT"
"             Total Catchment area                    28.186    hectare"
"             Total Impervious area                   14.450    hectare"
"             Total % impervious                      51.267"
" 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:         C:\M\Meritech Engineering\PRJ - DOCS\1279\"
"                                                                  60-Design\SWM"
"                Output filename:                    1279d100yr3hrJan212022.out"
"                Licensee name:                        Stefan Van Hartingsveldt"
"                Company                                   Meritech Engineering"
"                Date & Time last used:                2022-01-21 at 3:31:20 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"
"        6.944   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        2.778   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        4.166   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"
"                    2.640     0.000     0.000     0.000 c.m/sec"
"             Catchment 701          Pervious   Impervious Total Area "
```

```
"             Surface Area           2.778      4.166      6.944      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        2498.73    3748.10    6246.83    c.m"
"             Rainfall losses        51.719     8.749      25.937     mm"
"             Runoff depth           38.241     81.211     64.023     mm"
"             Runoff volume          1062.19    3383.57    4445.77    c.m"
"             Runoff coefficient     0.425      0.903      0.712      "
"             Maximum flow           0.630      2.410      2.640      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     2.640     2.640     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"
"        0.917   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.642   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.275   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"
"                     0.215     2.640     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.642      0.275      0.917      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        577.45     247.48     824.93     c.m"
"             Rainfall losses        51.510     6.752      38.083     mm"
"             Runoff depth           38.450     83.208     51.877     mm"
"             Runoff volume          246.81     228.91     475.72     c.m"
"             Runoff coefficient     0.427      0.925      0.577      "
"             Maximum flow           0.123      0.158      0.215      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.215     2.832     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
```

```
"         1.409   Total Area"
"        80.000   Flow length"
"         3.000   Overland Slope"
"         1.268   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.141   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"
"                      0.202     2.832     0.000     0.000 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           1.268      0.141      1.409      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        1140.78    126.75     1267.54    c.m"
"              Rainfall losses        51.458     6.998      47.012     mm"
"              Runoff depth           38.502     82.962     42.948     mm"
"              Runoff volume          488.24     116.89     605.14     c.m"
"              Runoff coefficient     0.428      0.922      0.477      "
"              Maximum flow           0.179      0.076      0.202      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.202     2.934     0.000     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         1.116   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.446   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.670   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"
```

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"                    0.456     2.934     0.000     0.000 c.m/sec"
"             Catchment 704          Pervious   Impervious Total Area "
"             Surface Area           0.446      0.670      1.116      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        401.58     602.37     1003.95    c.m"
"             Rainfall losses        52.037     6.542      24.740     mm"
"             Runoff depth           37.923     83.418     65.220     mm"
"             Runoff volume          169.29     558.57     727.85     c.m"
"             Runoff coefficient     0.422      0.927      0.725      "
"             Maximum flow           0.112      0.382      0.456      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.456     3.389     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     3.389     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     3.713     0.000     0.000"
" 57          TRENCH Design d/s of 801"
"        3.713   Peak inflow"
"     6798.667   Hydrograph volume"
"      355.500   Ground elevation"
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```
"       353.300   Downstream trench invert"
"         2.200   Trench height"
"       353.300   Water table elevation"
"        54.000   Trench top width"
"        30.000   Trench bottom width"
"       100.000   Voids ratio (%)"
"        86.000   Hydraulic conductivity"
"         0.000   Trench gradient (%)"
"       135.000   Trench length"
"         1.000   Include base width"
"           23.   Number of stages"
"                   Level Discharge    Volume"
"                 353.300     0.000       0.0"
"                 353.400     0.000      97.0"
"                 353.500     0.000     194.0"
"                 353.600     0.000     291.0"
"                 353.700     0.000     388.0"
"                 353.800     0.000     485.0"
"                 353.900     0.000     582.0"
"                 354.000     0.000     679.0"
"                 354.100     0.000     776.0"
"                 354.200     0.000     873.0"
"                 354.300     0.000     970.0"
"                 354.400     0.000    1095.0"
"                 354.500     0.004    1310.0"
"                 354.600     0.007    1684.0"
"                 354.700     0.021    2189.0"
"                 354.800     0.056    2738.0"
"                 354.900     0.109    3311.0"
"                 355.000     0.173    3910.0"
"                 355.100     0.244    4536.0"
"                 355.200     0.316    5189.0"
"                 355.300     0.385    5847.0"
"                 355.400     0.448    6615.0"
"                 355.500     0.505    7401.0"
"             1.   ORIFICES"
"                  Orifice   Orifice   Orifice"
"                   invert coefficie  diameter"
"                 354.400     0.630     0.090"
"             3.   TRENCH PIPES"
"               Downstream      Pipe      Pipe      Pipe Perf'ted?    Offset"
"                   Invert    length     diam.    grade%     0=Yes  distance"
"                 354.600    18.000     0.000     7.889     1.000    26.775"
"                   0.000     0.000     0.000     0.000     0.000     0.000"
"                 354.600    18.000     0.000     7.889     1.000    26.775"
"             1.   MANHOLE"
"                   Access"
"                 diameter"
"                     1.200"
"             2.   OUTFLOW PIPE"
"             0.   Inflow at upstream end of trench: 1=True; 0=False"
"                 Upstream Downstr'm      Pipe      Pipe   Manning     Entry"
"                   invert    invert    Length  Diameter       'n'   loss Ke"
"                 354.600   353.180    18.000     0.450     0.013     0.500"
"                 354.600   353.180    18.000     0.450     0.013     0.500"
"               Peak outflow                  0.211    c.m/sec"
"               Outflow volume             1230.902    c.m"
"               Peak exfiltration             0.319    c.m/sec"
"               Exfiltration volume        5569.705    c.m"
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"             Maximum level               355.054    metre"
"             Maximum storage            4245.298    c.m"
"             Centroidal lag                2.413   hours"
"             Infiltration area 2 sides   2625.573   sq.metre"
"             Infiltration Base area      4050.000   sq.metre"
"                  0.323     3.713     0.211     0.319 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"           6   Combine "
"         704   Node #"
"               Flows to Beaver Creek"
"             Maximum flow                  0.211    c.m/sec"
"             Hydrograph volume          1230.902    c.m"
"                    0.323     3.713     0.211     0.211"
" 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     0.211     0.211"
" 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     0.211     0.211 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 "
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"                    0.178     0.178     0.211     0.211"
" 40          HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                    0.178     0.178     0.178     0.211"
" 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 "
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"                    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"
"         2.297   Total Area"
"        30.000   Flow length"
"         3.000   Overland Slope"
"         1.148   Pervious Area"
"        30.000   Pervious length"
"         3.000   Pervious slope"
"         1.148   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"
"                    0.720     0.234     0.178     0.178 c.m/sec"
"             Catchment 502          Pervious   Impervious Total Area "
"             Surface Area           1.148      1.148      2.297      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        1033.19    1033.19    2066.38    c.m"
"             Rainfall losses        51.510     6.752      29.131     mm"
"             Runoff depth           38.450     83.208     60.829     mm"
"             Runoff volume          441.60     955.65     1397.24    c.m"
"             Runoff coefficient     0.427      0.925      0.676      "
"             Maximum flow           0.220      0.661      0.720      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                    0.720     0.737     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"
"         9.083   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         2.725   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         6.358   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"
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"         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"
"                       3.904     0.737     0.178     0.178 c.m/sec"
"              Catchment 503          Pervious   Impervious Total Area "
"              Surface Area           2.725      6.358      9.083      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        2451.32    5719.75    8171.07    c.m"
"              Rainfall losses        51.719     8.749      21.640     mm"
"              Runoff depth           38.241     81.211     68.320     mm"
"              Runoff volume          1042.04    5163.47    6205.52    c.m"
"              Runoff coefficient     0.425      0.903      0.759      "
"              Maximum flow           0.618      3.678      3.904      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       3.904     4.641     0.178     0.178"
" 40           HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                       3.904     4.641     4.641     0.178"
" 40           HYDROGRAPH   Combine    503"
"             6   Combine "
"           503   Node #"
"                 SWM facility south of Conservation Dr"
"              Maximum flow                  4.641    c.m/sec"
"              Hydrograph volume          8407.866    c.m"
"                       3.904     4.641     4.641     4.641"
" 81           ADD COMMENT==================================================="
"           3  Lines of comment"
"              Minor flows (2yr and less) from catchment 504 "
"              (townhouses at SW corner) (71m3) are to infiltration, "
"              remainder to Beaver Creek "
" 40           HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                       3.904     0.000     4.641     4.641"
" 33           CATCHMENT 504"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           504   Townhouse area at SW corner"
"        40.000   % Impervious"
"         0.303   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.182   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.121   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"
"                    0.085     0.000     4.641     4.641 c.m/sec"
"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.182      0.121      0.303      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        163.55     109.03     272.58     c.m"
"             Rainfall losses        51.719     8.749      34.531     mm"
"             Runoff depth           38.241     81.211     55.429     mm"
"             Runoff volume          69.52      98.43      167.95     c.m"
"             Runoff coefficient     0.425      0.903      0.616      "
"             Maximum flow           0.041      0.070      0.085      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.085     0.085     4.641     4.641"
" 54          POND DESIGN"
"        0.085   Current peak flow    c.m/sec"
"        1.000   Target outflow    c.m/sec"
"        168.0   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    71.000"
"                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               101.010    metre"
"             Maximum storage              79.916    c.m"
"             Centroidal lag                4.228   hours"
"                  0.085     0.085     0.057     4.641 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"           6   Combine "
"         704   Node #"
"               Flows to Beaver Creek"
"             Maximum flow                  0.227    c.m/sec"
"             Hydrograph volume          1332.626    c.m"
"                    0.085     0.085     0.057     0.227"
" 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"
"                    0.085     0.000     0.057     0.227"
" 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"
"        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     0.057     0.227 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     0.057     0.227"
" 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     0.227 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                  0.356    c.m/sec"
"             Hydrograph volume          1640.299    c.m"
"                      0.341     0.341     0.217     0.356"
" 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     0.356"
" 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     0.356 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     0.356"
" 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     0.356 c.m/sec"
" 40           HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"              Maximum flow                  0.448    c.m/sec"
"              Hydrograph volume          1780.317    c.m"
"                      0.152     0.152     0.092     0.448"
" 38           START/RE-START TOTALS 602"
"            3   Runoff Totals on EXIT"
"              Total Catchment area                    28.186    hectare"
"              Total Impervious area                   14.450    hectare"
"              Total % impervious                      51.267"
" 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:         C:\M\Meritech Engineering\PRJ - DOCS\1279\"
"                                                                   60-Design\SWM"
"                Output filename:                  1279d100yr24hrJan212022.out"
"                Licensee name:                       Stefan Van Hartingsveldt"
"                Company                                  Meritech Engineering"
"                Date & Time last used:               2022-01-21 at 3:40:28 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"
"        6.944   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        2.778   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        4.166   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"
"                     2.493     0.000     0.000     0.000 c.m/sec"
"             Catchment 701          Pervious   Impervious Total Area "
```

```
"             Surface Area           2.778      4.166      6.944      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        2709.95    4064.93    6774.88    c.m"
"             Rainfall losses        53.747     8.194      26.415     mm"
"             Runoff depth           43.817     89.370     71.149     mm"
"             Runoff volume          1217.07    3723.53    4940.60    c.m"
"             Runoff coefficient     0.449      0.916      0.729      "
"             Maximum flow           0.611      2.193      2.493      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     2.493     2.493     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"
"        0.917   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.642   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.275   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"
"                     0.193     2.493     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.642      0.275      0.917      hectare"
"             Time of concentration  10.477     1.449      6.240      minutes"
"             Time to Centroid       712.369    638.454    677.681    minutes"
"             Rainfall depth         97.564     97.564     97.564     mm"
"             Rainfall volume        626.27     268.40     894.67     c.m"
"             Rainfall losses        53.511     6.668      39.458     mm"
"             Runoff depth           44.054     90.896     58.106     mm"
"             Runoff volume          282.78     250.05     532.84     c.m"
"             Runoff coefficient     0.452      0.932      0.596      "
"             Maximum flow           0.107      0.144      0.193      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.193     2.679     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
```

```
"         1.409   Total Area"
"        80.000   Flow length"
"         3.000   Overland Slope"
"         1.268   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.141   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"
"                      0.166     2.679     0.000     0.000 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           1.268      0.141      1.409      hectare"
"              Time of concentration  18.872     2.611      15.847     minutes"
"              Time to Centroid       731.523    641.646    714.806    minutes"
"              Rainfall depth         97.564     97.564     97.564     mm"
"              Rainfall volume        1237.21    137.47     1374.68    c.m"
"              Rainfall losses        53.445     6.836      48.784     mm"
"              Runoff depth           44.120     90.729     48.780     mm"
"              Runoff volume          559.48     127.84     687.32     c.m"
"              Runoff coefficient     0.452      0.930      0.500      "
"              Maximum flow           0.151      0.070      0.166      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.166     2.782     0.000     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         1.116   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.446   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.670   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"
```

```
"                    0.432     2.782     0.000     0.000 c.m/sec"
"             Catchment 704          Pervious   Impervious Total Area "
"             Surface Area           0.446      0.670      1.116      hectare"
"             Time of concentration  3.912      1.637      2.188      minutes"
"             Time to Centroid       698.123    638.841    653.198    minutes"
"             Rainfall depth         97.564     97.564     97.564     mm"
"             Rainfall volume        435.53     653.29     1088.82    c.m"
"             Rainfall losses        53.912     6.496      25.462     mm"
"             Runoff depth           43.653     91.069     72.102     mm"
"             Runoff volume          194.87     609.80     804.66     c.m"
"             Runoff coefficient     0.447      0.933      0.739      "
"             Maximum flow           0.099      0.347      0.432      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.432     3.214     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     3.214     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     3.519     0.000     0.000"
" 57          TRENCH Design d/s of 801"
"        3.519   Peak inflow"
"     7570.181   Hydrograph volume"
"      355.500   Ground elevation"
```

```
"      353.300   Downstream trench invert"
"        2.200   Trench height"
"      353.300   Water table elevation"
"       54.000   Trench top width"
"       30.000   Trench bottom width"
"      100.000   Voids ratio (%)"
"       86.000   Hydraulic conductivity"
"        0.000   Trench gradient (%)"
"      135.000   Trench length"
"        1.000   Include base width"
"          23.   Number of stages"
"                  Level Discharge    Volume"
"                353.300     0.000       0.0"
"                353.400     0.000      97.0"
"                353.500     0.000     194.0"
"                353.600     0.000     291.0"
"                353.700     0.000     388.0"
"                353.800     0.000     485.0"
"                353.900     0.000     582.0"
"                354.000     0.000     679.0"
"                354.100     0.000     776.0"
"                354.200     0.000     873.0"
"                354.300     0.000     970.0"
"                354.400     0.000    1095.0"
"                354.500     0.004    1310.0"
"                354.600     0.007    1684.0"
"                354.700     0.021    2189.0"
"                354.800     0.056    2738.0"
"                354.900     0.109    3311.0"
"                355.000     0.173    3910.0"
"                355.100     0.244    4536.0"
"                355.200     0.316    5189.0"
"                355.300     0.385    5847.0"
"                355.400     0.448    6615.0"
"                355.500     0.505    7401.0"
"            1.   ORIFICES"
"                 Orifice   Orifice   Orifice"
"                  invert coefficie  diameter"
"                354.400     0.630     0.090"
"            3.   TRENCH PIPES"
"              Downstream      Pipe      Pipe      Pipe Perf'ted?    Offset"
"                  Invert    length     diam.    grade%     0=Yes  distance"
"                354.600    18.000     0.000     7.889     1.000    26.775"
"                  0.000     0.000     0.000     0.000     0.000     0.000"
"                354.600    18.000     0.000     7.889     1.000    26.775"
"            1.   MANHOLE"
"                  Access"
"                diameter"
"                   1.200"
"            2.   OUTFLOW PIPE"
"            0.   Inflow at upstream end of trench: 1=True; 0=False"
"                Upstream Downstr'm      Pipe      Pipe   Manning     Entry"
"                  invert    invert    Length  Diameter       'n'   loss Ke"
"                354.600   353.180    18.000     0.450     0.013     0.500"
"                354.600   353.180    18.000     0.450     0.013     0.500"
"              Peak outflow                  0.111    c.m/sec"
"              Outflow volume              610.839    c.m"
"              Peak exfiltration             0.308    c.m/sec"
"              Exfiltration volume        6958.556    c.m"
```

```
"             Maximum level               354.904    metre"
"             Maximum storage            3335.031    c.m"
"             Centroidal lag               10.782   hours"
"             Infiltration area 2 sides   2401.631   sq.metre"
"             Infiltration Base area      4050.000   sq.metre"
"                  0.305     3.519     0.111     0.308 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"           6   Combine "
"         704   Node #"
"               Flows to Beaver Creek"
"             Maximum flow                  0.111    c.m/sec"
"             Hydrograph volume           610.839    c.m"
"                    0.305     3.519     0.111     0.111"
" 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     0.111     0.111"
" 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     0.111     0.111 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     0.111     0.111"
" 40          HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                    0.168     0.168     0.168     0.111"
" 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"
"         2.297   Total Area"
"        30.000   Flow length"
"         3.000   Overland Slope"
"         1.148   Pervious Area"
"        30.000   Pervious length"
"         3.000   Pervious slope"
"         1.148   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"
"                    0.677     0.186     0.168     0.168 c.m/sec"
"             Catchment 502          Pervious   Impervious Total Area "
"             Surface Area           1.148      1.148      2.297      hectare"
"             Time of concentration  10.477     1.449      4.396      minutes"
"             Time to Centroid       712.369    638.453    662.584    minutes"
"             Rainfall depth         97.564     97.564     97.564     mm"
"             Rainfall volume        1120.53    1120.53    2241.06    c.m"
"             Rainfall losses        53.511     6.668      30.090     mm"
"             Runoff depth           44.054     90.896     67.475     mm"
"             Runoff volume          505.96     1043.94    1549.90    c.m"
"             Runoff coefficient     0.452      0.932      0.692      "
"             Maximum flow           0.192      0.601      0.677      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                    0.677     0.700     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"
"         9.083   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         2.725   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         6.358   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"
"                       3.641     0.700     0.168     0.168 c.m/sec"
"              Catchment 503          Pervious   Impervious Total Area "
"              Surface Area           2.725      6.358      9.083      hectare"
"              Time of concentration  6.912      0.956      1.990      minutes"
"              Time to Centroid       704.755    637.792    649.419    minutes"
"              Rainfall depth         97.564     97.564     97.564     mm"
"              Rainfall volume        2658.53    6203.25    8861.78    c.m"
"              Rainfall losses        53.747     8.194      21.860     mm"
"              Runoff depth           43.817     89.370     75.705     mm"
"              Runoff volume          1193.98    5682.26    6876.25    c.m"
"              Runoff coefficient     0.449      0.916      0.776      "
"              Maximum flow           0.599      3.346      3.641      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       3.641     4.341     0.168     0.168"
" 40           HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                       3.641     4.341     4.341     0.168"
" 40           HYDROGRAPH   Combine    503"
"             6   Combine "
"           503   Node #"
"                 SWM facility south of Conservation Dr"
"              Maximum flow                  4.341    c.m/sec"
"              Hydrograph volume          9374.956    c.m"
"                       3.641     4.341     4.341     4.341"
" 81           ADD COMMENT================================================="
"           3  Lines of comment"
"              Minor flows (2yr and less) from catchment 504 "
"              (townhouses at SW corner) (71m3) are to infiltration, "
"              remainder to Beaver Creek "
" 40           HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                       3.641     0.000     4.341     4.341"
" 33           CATCHMENT 504"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           504   Townhouse area at SW corner"
"        40.000   % Impervious"
"         0.303   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.182   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.121   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"
"                    0.083     0.000     4.341     4.341 c.m/sec"
"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.182      0.121      0.303      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        177.37     118.25     295.62     c.m"
"             Rainfall losses        53.747     8.194      35.526     mm"
"             Runoff depth           43.817     89.370     62.039     mm"
"             Runoff volume          79.66      108.32     187.98     c.m"
"             Runoff coefficient     0.449      0.916      0.636      "
"             Maximum flow           0.040      0.064      0.083      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.083     0.083     4.341     4.341"
" 54          POND DESIGN"
"        0.083   Current peak flow    c.m/sec"
"        1.000   Target outflow    c.m/sec"
"        188.0   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    71.000"
"                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                  0.053    c.m/sec"
"             Maximum level               101.008    metre"
"             Maximum storage              78.558    c.m"
"             Centroidal lag               14.051   hours"
"                  0.083     0.083     0.053     4.341 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"           6   Combine "
"         704   Node #"
"               Flows to Beaver Creek"
"             Maximum flow                  0.123    c.m/sec"
"             Hydrograph volume           728.509    c.m"
"                    0.083     0.083     0.053     0.123"
" 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"
"                    0.083     0.000     0.053     0.123"
" 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     0.053     0.123 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     0.053     0.123"
" 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"
```

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"             Centroidal lag               12.725   hours"
"                  0.322     0.322     0.171     0.123 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"             Maximum flow                  0.272    c.m/sec"
"             Hydrograph volume          1106.987    c.m"
"                       0.322     0.322     0.171     0.272"
" 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     0.272"
" 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     0.272 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     0.272"
" 54          POND DESIGN"
"         0.144   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"         284.6   Hydrograph volume    c.m"
```

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"           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     0.272 c.m/sec"
" 40           HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"              Maximum flow                  0.347    c.m/sec"
"              Hydrograph volume          1277.725    c.m"
"                      0.144     0.144     0.075     0.347"
" 38           START/RE-START TOTALS 602"
"            3   Runoff Totals on EXIT"
"              Total Catchment area                    28.186    hectare"
"              Total Impervious area                   14.450    hectare"
"              Total % impervious                      51.267"
" 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:         C:\M\Meritech Engineering\PRJ - DOCS\1279\"
"                                                                   60-Design\SWM"
"                Output filename:                      1279dHazelJan212022.out"
"                Licensee name:                       Stefan Van Hartingsveldt"
"                Company                                  Meritech Engineering"
"                Date & Time last used:               2022-01-21 at 3:43:50 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"
"        6.944   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        2.778   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        4.166   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"
"                    0.991     0.000     0.000     0.000 c.m/sec"
"             Catchment 701          Pervious   Impervious Total Area "
"             Surface Area           2.778      4.166      6.944      hectare"
"             Time of concentration  9.349      1.671      4.237      minutes"
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"             Time to Centroid       2498.142   2270.256   2346.417   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        0.7916     1.1874     1.9790     ha-m"
"             Rainfall losses        77.420     9.312      36.555     mm"
"             Runoff depth           207.580    275.688    248.445    mm"
"             Runoff volume          0.5766     1.1486     1.7252     ha-m"
"             Runoff coefficient     0.728      0.967      0.872      "
"             Maximum flow           0.383      0.608      0.991      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.991     0.991     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"
"        0.917   Total Area"
"       30.000   Flow length"
"        3.000   Overland Slope"
"        0.642   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        0.275   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"
"                     0.129     0.991     0.000     0.000 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.642      0.275      0.917      hectare"
"             Time of concentration  14.171     2.532      9.967      minutes"
"             Time to Centroid       2505.411   2267.787   2419.590   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        1829.42    784.03     2613.45    c.m"
"             Rainfall losses        76.853     10.427     56.925     mm"
"             Runoff depth           208.147    274.573    228.075    mm"
"             Runoff volume          1336.10    755.35     2091.45    c.m"
"             Runoff coefficient     0.730      0.963      0.800      "
"             Maximum flow           0.089      0.041      0.129      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.129     1.112     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
"        1.409   Total Area"
"       80.000   Flow length"
```

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"         3.000   Overland Slope"
"         1.268   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.141   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"
"                      0.200     1.112     0.000     0.000 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           1.268      0.141      1.409      hectare"
"              Time of concentration  25.525     4.562      22.819     minutes"
"              Time to Centroid       2521.582   2271.846   2489.347   minutes"
"              Rainfall depth         285.000    285.000    285.000    mm"
"              Rainfall volume        3614.08    401.57     4015.65    c.m"
"              Rainfall losses        76.640     7.070      69.683     mm"
"              Runoff depth           208.360    277.930    215.317    mm"
"              Runoff volume          2642.22    391.60     3033.82    c.m"
"              Runoff coefficient     0.731      0.975      0.755      "
"              Maximum flow           0.180      0.021      0.200      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.200     1.302     0.000     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         1.116   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.446   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.670   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"
"                      0.157     1.302     0.000     0.000 c.m/sec"
"              Catchment 704          Pervious   Impervious Total Area "
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"             Surface Area           0.446      0.670      1.116      hectare"
"             Time of concentration  5.292      2.860      3.673      minutes"
"             Time to Centroid       2492.838   2265.585   2341.595   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        1272.24    1908.36    3180.60    c.m"
"             Rainfall losses        77.602     9.886      36.972     mm"
"             Runoff depth           207.398    275.114    248.028    mm"
"             Runoff volume          925.83     1842.16    2767.99    c.m"
"             Runoff coefficient     0.728      0.965      0.870      "
"             Maximum flow           0.061      0.101      0.157      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.157     1.459     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     1.459     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     1.578     0.000     0.000"
" 57          TRENCH Design d/s of 801"
"         1.578   Peak inflow"
"     27257.025   Hydrograph volume"
"       355.500   Ground elevation"
"       353.300   Downstream trench invert"
"         2.200   Trench height"
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"      353.300   Water table elevation"
"       54.000   Trench top width"
"       30.000   Trench bottom width"
"      100.000   Voids ratio (%)"
"       86.000   Hydraulic conductivity"
"        0.000   Trench gradient (%)"
"      135.000   Trench length"
"        1.000   Include base width"
"          23.   Number of stages"
"                  Level Discharge    Volume"
"                353.300     0.000       0.0"
"                353.400     0.000      97.0"
"                353.500     0.000     194.0"
"                353.600     0.000     291.0"
"                353.700     0.000     388.0"
"                353.800     0.000     485.0"
"                353.900     0.000     582.0"
"                354.000     0.000     679.0"
"                354.100     0.000     776.0"
"                354.200     0.000     873.0"
"                354.300     0.000     970.0"
"                354.400     0.000    1095.0"
"                354.500     0.004    1310.0"
"                354.600     0.007    1684.0"
"                354.700     0.021    2189.0"
"                354.800     0.056    2738.0"
"                354.900     0.109    3311.0"
"                355.000     0.173    3910.0"
"                355.100     0.442    4536.0"
"                355.200     0.886    5189.0"
"                355.300     1.450    5847.0"
"                355.400     2.116    6615.0"
"                355.500     2.877    7401.0"
"            1.   WEIRS"
"                   Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                355.000     0.900     4.000     1.000     1.000"
"            1.   ORIFICES"
"                 Orifice   Orifice   Orifice"
"                  invert coefficie  diameter"
"                354.400     0.630     0.090"
"            3.   TRENCH PIPES"
"              Downstream      Pipe      Pipe      Pipe Perf'ted?    Offset"
"                  Invert    length     diam.    grade%     0=Yes  distance"
"                354.600    18.000     0.000     7.889     1.000    26.775"
"                  0.000     0.000     0.000     0.000     0.000     0.000"
"                354.600    18.000     0.000     7.889     1.000    26.775"
"            1.   MANHOLE"
"                  Access"
"                diameter"
"                   1.200"
"            2.   OUTFLOW PIPE"
"            0.   Inflow at upstream end of trench: 1=True; 0=False"
"                Upstream Downstr'm      Pipe      Pipe   Manning     Entry"
"                  invert    invert    Length  Diameter       'n'   loss Ke"
"                354.600   353.180    18.000     0.450     0.013     0.500"
"                354.600   353.180    18.000     0.450     0.013     0.500"
"              Peak outflow                 1.019    c.m/sec"
"              Outflow volume            7526.685    c.m"
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"             Peak exfiltration             0.331    c.m/sec"
"             Exfiltration volume       19732.285    c.m"
"             Maximum level               355.224    metre"
"             Maximum storage            5344.584    c.m"
"             Centroidal lag               46.481   hours"
"             Infiltration area 2 sides   2880.267   sq.metre"
"             Infiltration Base area      4050.000   sq.metre"
"                  0.121     1.578     1.019     0.331 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"           6   Combine "
"         704   Node #"
"               Flows to Beaver Creek"
"             Maximum flow                  1.019    c.m/sec"
"             Hydrograph volume          7526.685    c.m"
"                     0.121     1.578     1.019     1.019"
" 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     1.019     1.019"
" 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     1.019     1.019 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"
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" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       0.067     0.067     1.019     1.019"
" 40          HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                       0.067     0.067     0.067     1.019"
" 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"
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" 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"
"         2.297   Total Area"
"        30.000   Flow length"
"         3.000   Overland Slope"
"         1.148   Pervious Area"
"        30.000   Pervious length"
"         3.000   Pervious slope"
"         1.148   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"
"                       0.327     0.436     0.067     0.067 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           1.148      1.148      2.297      hectare"
"              Time of concentration  14.171     2.532      7.551      minutes"
"              Time to Centroid       2505.411   2267.788   2370.250   minutes"
"              Rainfall depth         285.000    285.000    285.000    mm"
"              Rainfall volume        3273.22    3273.22    6546.45    c.m"
"              Rainfall losses        76.853     10.427     43.640     mm"
"              Runoff depth           208.147    274.573    241.360    mm"
"              Runoff volume          2390.57    3153.47    5544.04    c.m"
"              Runoff coefficient     0.730      0.963      0.847      "
"              Maximum flow           0.159      0.172      0.327      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       0.327     0.757     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"
"         9.083   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         2.725   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         6.358   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
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"       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"
"                     1.304     0.757     0.067     0.067 c.m/sec"
"             Catchment 503          Pervious   Impervious Total Area "
"             Surface Area           2.725      6.358      9.083      hectare"
"             Time of concentration  9.349      1.671      3.544      minutes"
"             Time to Centroid       2498.143   2270.257   2325.852   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        0.7766     1.8121     2.5887     ha-m"
"             Rainfall losses        77.421     9.312      29.745     mm"
"             Runoff depth           207.579    275.688    255.255    mm"
"             Runoff volume          0.5656     1.7529     2.3185     ha-m"
"             Runoff coefficient     0.728      0.967      0.896      "
"             Maximum flow           0.376      0.928      1.304      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"           4   Add Runoff "
"                     1.304     2.048     0.067     0.067"
" 40          HYDROGRAPH Copy to Outflow"
"           8   Copy to Outflow"
"                     1.304     2.048     2.048     0.067"
" 40          HYDROGRAPH   Combine    503"
"           6   Combine "
"         503   Node #"
"               SWM facility south of Conservation Dr"
"             Maximum flow                  2.048    c.m/sec"
"             Hydrograph volume         34588.336    c.m"
"                     1.304     2.048     2.048     2.048"
" 81          ADD COMMENT================================================="
"           3  Lines of comment"
"              Minor flows (2yr and less) from catchment 504 "
"              (townhouses at SW corner) (71m3) are to infiltration, "
"              remainder to Beaver Creek "
" 40          HYDROGRAPH Start - New Tributary"
"           2   Start - New Tributary"
"                     1.304     0.000     2.048     2.048"
" 33          CATCHMENT 504"
"           1   Triangular SCS"
"           1   Equal length"
"           1   SCS method"
"         504   Townhouse area at SW corner"
"       40.000   % Impervious"
"        0.303   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.182   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.121   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
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"         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"
"                     0.043     0.000     2.048     2.048 c.m/sec"
"              Catchment 504          Pervious   Impervious Total Area "
"              Surface Area           0.182      0.121      0.303      hectare"
"              Time of concentration  9.349      1.671      5.743      minutes"
"              Time to Centroid       2498.142   2270.256   2391.125   minutes"
"              Rainfall depth         285.000    285.000    285.000    mm"
"              Rainfall volume        518.13     345.42     863.55     c.m"
"              Rainfall losses        77.420     9.312      50.177     mm"
"              Runoff depth           207.580    275.688    234.823    mm"
"              Runoff volume          377.38     334.13     711.51     c.m"
"              Runoff coefficient     0.728      0.967      0.824      "
"              Maximum flow           0.025      0.018      0.043      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                     0.043     0.043     2.048     2.048"
" 54           POND DESIGN"
"         0.043   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"         711.5   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    71.000"
"                 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                  0.042    c.m/sec"
"              Maximum level               101.007    metre"
"              Maximum storage              77.044    c.m"
"              Centroidal lag               42.913   hours"
"                   0.043     0.043     0.042     2.048 c.m/sec"
" 40           HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"              Maximum flow                  1.058    c.m/sec"
"              Hydrograph volume          8169.681    c.m"
"                     0.043     0.043     0.042     1.058"
" 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"
```

```
"                    0.043     0.000     0.042     1.058"
" 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     0.042     1.058 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     0.042     1.058"
" 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     1.058 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"           6   Combine "
"         704   Node #"
"               Flows to Beaver Creek"
"             Maximum flow                  1.172    c.m/sec"
"             Hydrograph volume         10140.051    c.m"
"                    0.128     0.128     0.127     1.172"
" 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     1.172"
" 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     1.172 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     1.172"
" 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     1.172 c.m/sec"
" 40           HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"              Maximum flow                  1.224    c.m/sec"
"              Hydrograph volume         11019.689    c.m"
"                      0.057     0.057     0.057     1.224"
" 38           START/RE-START TOTALS 602"
"              3   Runoff Totals on EXIT"
"              Total Catchment area                    28.186    hectare"
"              Total Impervious area                   14.450    hectare"
"              Total % impervious                      51.267"
" 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

Administration Centre: 400 Clyde Road, P.O. Box 729 Cambridge, ON N1R 5W6

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July 8, 2021

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Re: Draft Plan of Subdivision 30T-16402
Zone Change Application Z-16-14
556, 560 and 576 Conservation Drive, City of Waterloo
2115881 Ontario Limited

The Grand River Conservation Authority (GRCA) has reviewed the following in support of the Draft Plan of Subdivision application:

- Planning Justification Report (GSP, July 2016)
- Hydrogeological Report (Stantec, August 2020)
- Geotechnical Report (LVM, March 2015)
- Environmental Impact Study (NRSI, September 2020)
- Servicing Strategy Report (Meritech, August 2020)
- Preliminary Stormwater Management Report (Meritech, August 2020)
- Draft Plan (GSP, revised June 25, 2020)
- Grading Plan (Meritech, July 2020)

At this time, GRCA staff are not in a position to recommend approval of the above-noted applications at this time. Please refer to our comments below:

Stormwater Management

1. The Beaver Creek Meadows Communal Stormwater Management (SWM) Facility is proposed to service post-development subcatchment 3107 for this subdivision. The GRCA has been providing comments to MTE regarding this facility, and all contributing developments must demonstrate meeting and

exceeding their respective infiltration targets. The high-level calculations provided are insufficient to confirm that the proposed post-development infiltration volumes are achievable.

a. For draft plan approval, please provide a monthly water balance that clearly demonstrates that this subdivision's infiltration target is met with an appropriate factor of safety.
b. Please provide the monthly water balance for each catchment (east and west) in the pre-development, post-development and post-development with mitigation conditions.
c. Please include the post-development infiltration volumes for the east and west catchments separately, to confirm that the infiltration rates specified for the communal SWM facility and the North Waterloo Scoped Subwatershed Study (NWSSS) are being met, respectively.

2. In a letter to the Beaver Creek Meadows Developers Group dated December 11, 2020, the City of Waterloo advised that it "does not support private subsurface engineered [low impact development] approaches for lands not held in municipal ownership within the Beaver Creek District Plan area that would count towards overall sub-catchment and catchment SWM infiltration goals," with some exceptions noted. The GRCA supports the City's position and will analyze proposed infiltration in the same manner.

   It is proposed that a portion of the post-development infiltration deficit is mitigated through lot level controls. While we are supportive of additional infiltration measures, we will be unable to support a water balance relying on lot-level infiltration on private property, and we request that proposed infiltration mitigation calculations do not include amended topsoil and disconnected downspouts. Supporting information and details regarding infiltration facilities that will count towards meeting the infiltration targets should be provided, including seasonally high groundwater levels.

Natural Heritage

3. Wetland boundaries on this site were last verified by the GRCA in 2015. Given the amount of buffer encroachment proposed within the vicinity of the on-site SWM facility, we request that this section of the wetland be delineated and, if necessary, resurveyed.

4. With respect to areas of minor buffer encroachment, detailed grading and landscaping plans are required at detailed design to demonstrate how buffer functions within these areas will be maintained or enhanced. All plans must clearly illustrate a 15-metre minimum grading setback from all wetland areas.

5. The environmental impact study (EIS) suggests that measures will be implemented in order to meet or exceed the post-development infiltration target recommended by the NWSSS. However, further detail was lacking in the EIS. It

appears the modelling information presented in the SWM report was not interpreted. The additional infiltration and water balance details (as requested in comment 1) should be reviewed as part of the EIS.

6. We note that the hydrogeology assessment is undergoing updates. We request that a final assessment report be submitted to the GRCA at the detailed design stage.

Advisory Comments

7. A treed section of the 30-metre wetland buffer will be directly impacted by grading for the on-site SWM facility, and while the limit of grading respects the 15-metre setback from the surveyed wetland limit, it may impact the contiguous woodland. The woodland was last surveyed in 2016. Given the presence of several regionally significant species within the woodland, we recommend that this section of the woodland be reviewed by the Region and resurveyed if necessary.

8. We recommend that no vegetation be removed during the active bat season and the breeding bird season.

9. According to Meritech, “as the surface receiver of the SWM facility is also Beaver Creek, a winter bypass is potentially unneeded.” Given the past evidence of trout spawning along Laurel Creek (per NWSSS) and the potential for salmonids to inhabit the lower reaches of Beaver Creek, a winter bypass is recommended. We understand that a bypass will be proposed in upcoming revisions to the SWM facility. Please provide additional details regarding its proposed location / outlet and operation.

10. Continued surface water quality monitoring along Beaver Creek and at the stormwater outfall is recommended in order to assess overall conditions, to verify whether or not mitigation measures are adequate, and determine if surface discharge from the SWM facility is a source of adverse water quality impacts to the creek.

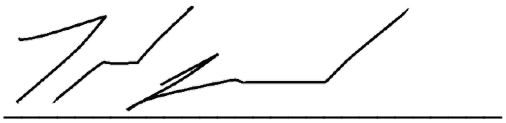
Fees

11. We wish to acknowledge receipt of a cheque in the amount of $17,500.00. Subdivision fees for applications filed prior to 2018 were capped at $25,000.00, so this covers the required 70% of the required total review fees. Prior to issuance of conditions of draft plan approval, we will require the remaining fees of $7,500.00. Additional fees will be required for clearance, and a separate fee will be required for any GRCA permits.

Please provide a comment-response matrix with all subsequent submissions outlining how all GRCA comments have been addressed.

We trust this information is of assistance. If you have any questions, or require additional information, please contact me at 519-621-2763 ext. 2292 or theywood@grandriver.ca.

Sincerely,



Trevor Heywood
Resource Planner
Grand River Conservation Authority

c.c. Kristen Barisdale, GSP Group
Jane Gurney, Region of Waterloo
Robyn McMullen, City of Waterloo

Appendix F: Geotechnical and Hydrogeological Investigation (Excerpts)

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:

Montana Wilson, M.Eng., P.Eng., PMP
Geotechnical Group Leader



Prepared by:

Vanessa Marshall, M.Eng., P.Eng.
Team Leader, Engineering Group

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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		
Revision N°	Date	Modification And/Or Publication Details
00	2015-03-20	Report Issued

DISTRIBUTION	
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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.

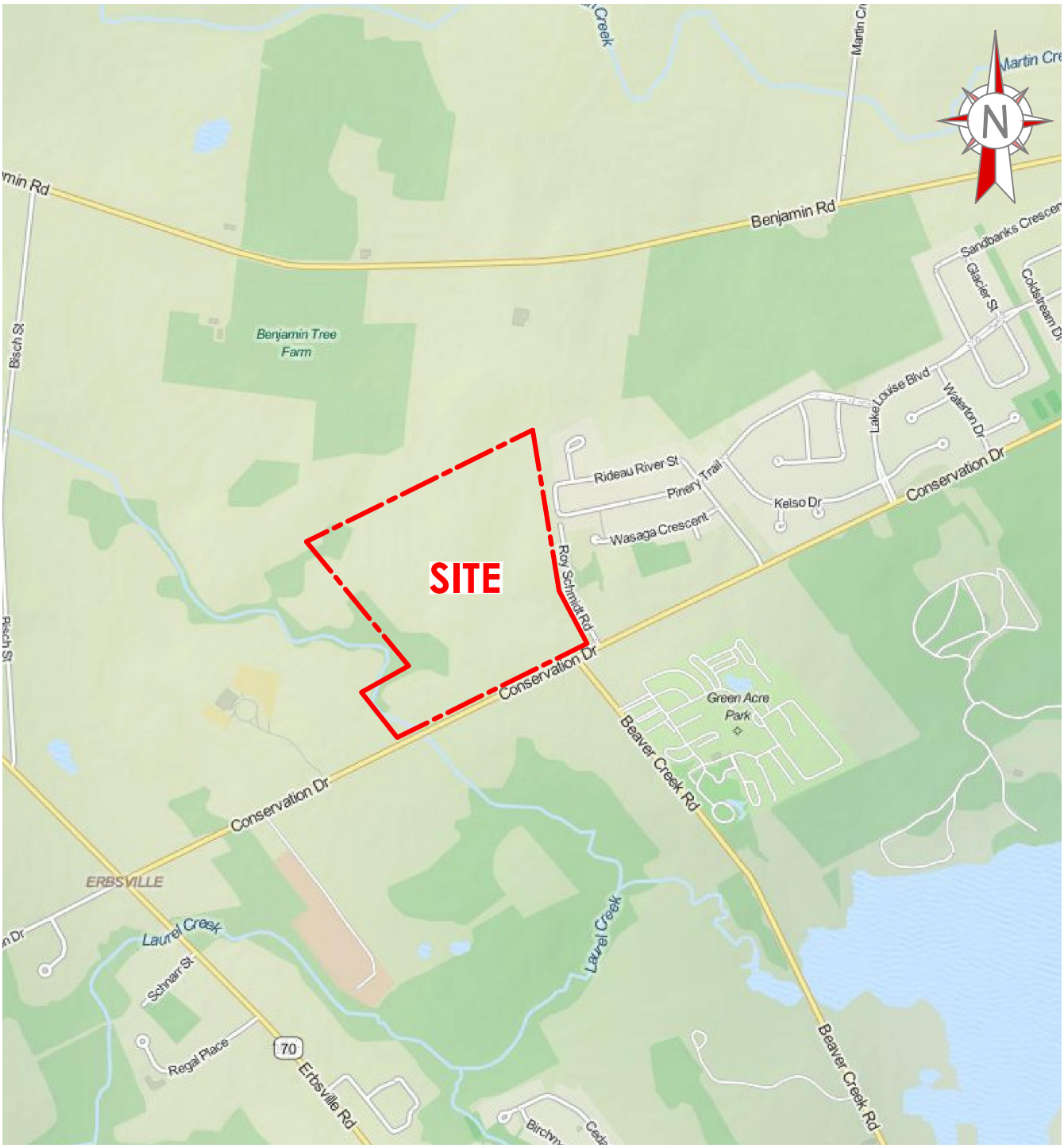
The geotechnical recommendations provided in this report are applicable only to the project described in the text and are intended for the use of the project designer. They are not intended as specifications or instructions to contractors. Any use which a contractor makes of this report, or decisions 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
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Prepared	E.Ciochon	Discipline	GEOTECHNICAL	Project manager	M.Wilson
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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	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

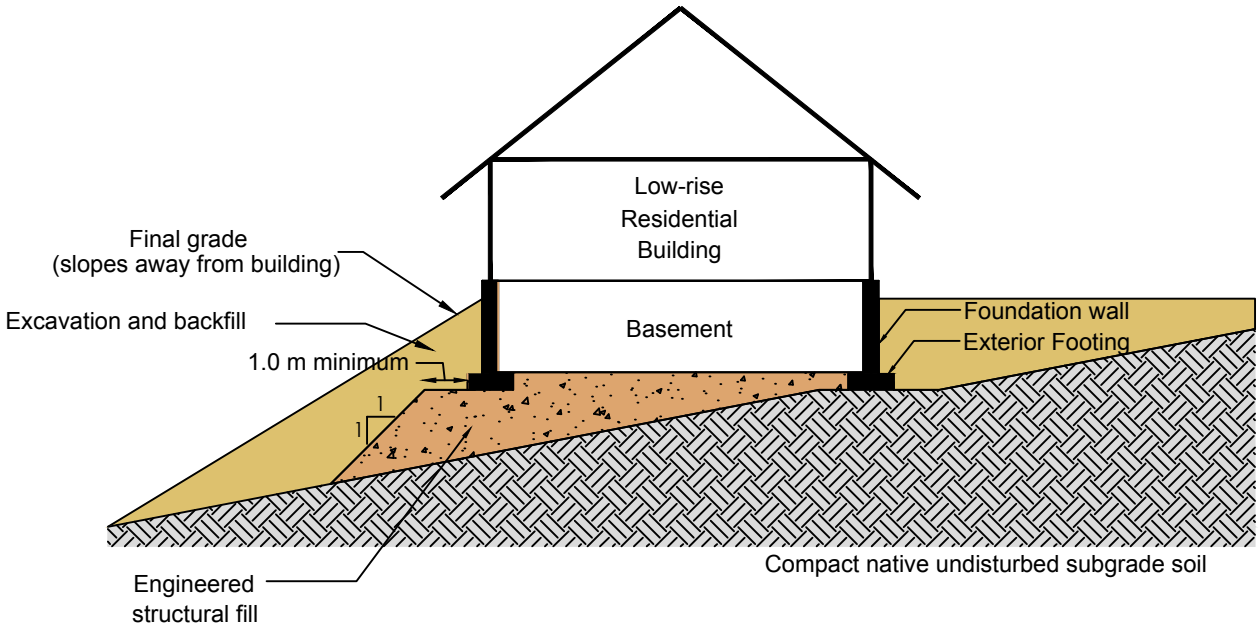
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Project manager	D.Gonser	Sequence no.	02 of 04

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

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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

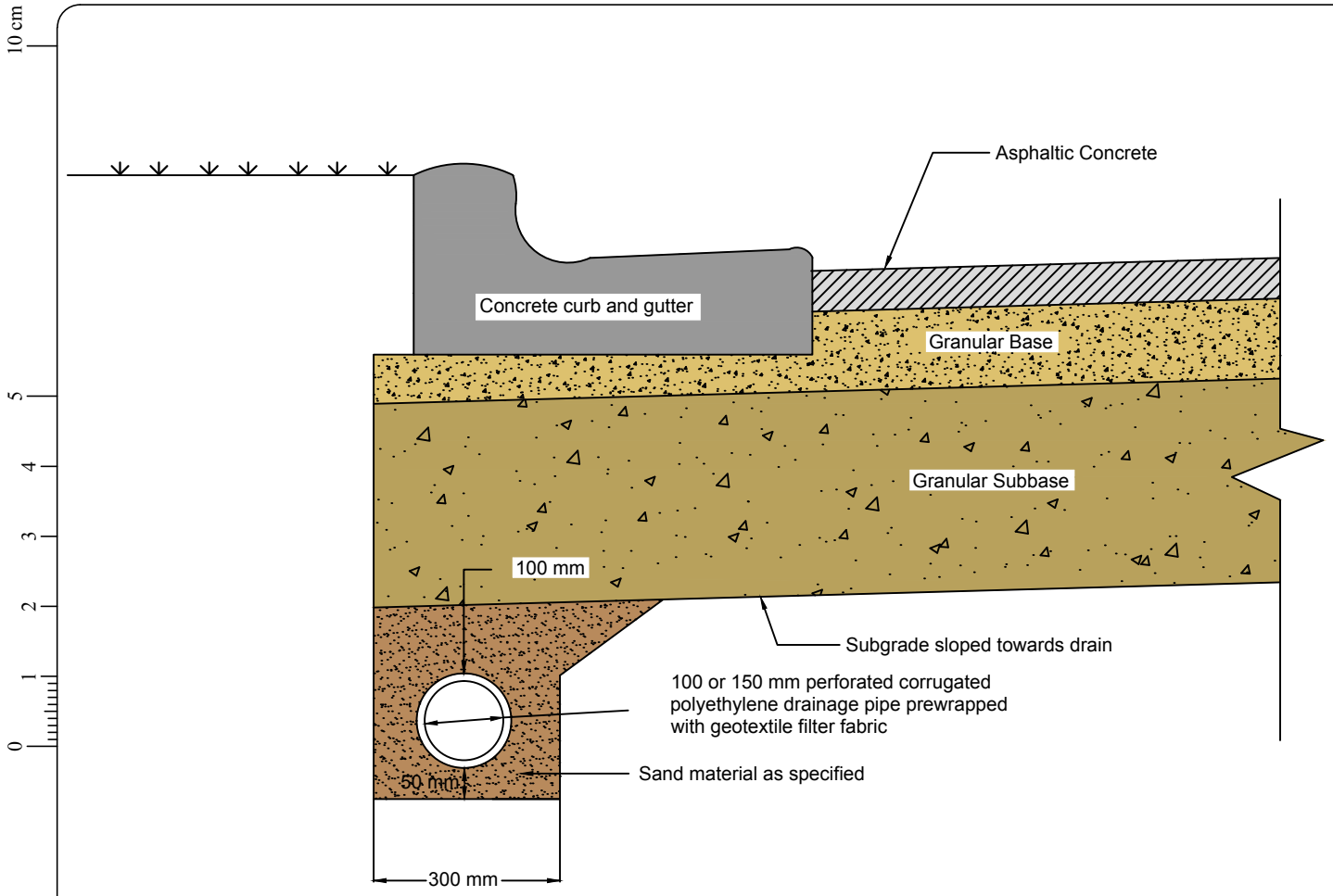
Title

TYPICAL STRUCTURAL FILL DETAIL

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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

LVM
353, Bridge Street East
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Prepared	E.Ciochon	Discipline	GEOTECHNICAL	Project manager	M.Wilson
Drawn	E.Ciochon	Scale	NTS	Sequence no.	04 of 04
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

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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

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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

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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

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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

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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

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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

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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.
CONSULTING ENGINEERS

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***

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

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.
CONSULTING ENGINEERS

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

Z:\Style_LVM_Ontario\Lab Lab_Particle_Size_LVM_Ontario.STY - Printed: 2015-03-16T09:40:16

PARTICLE SIZE ANALYSIS

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

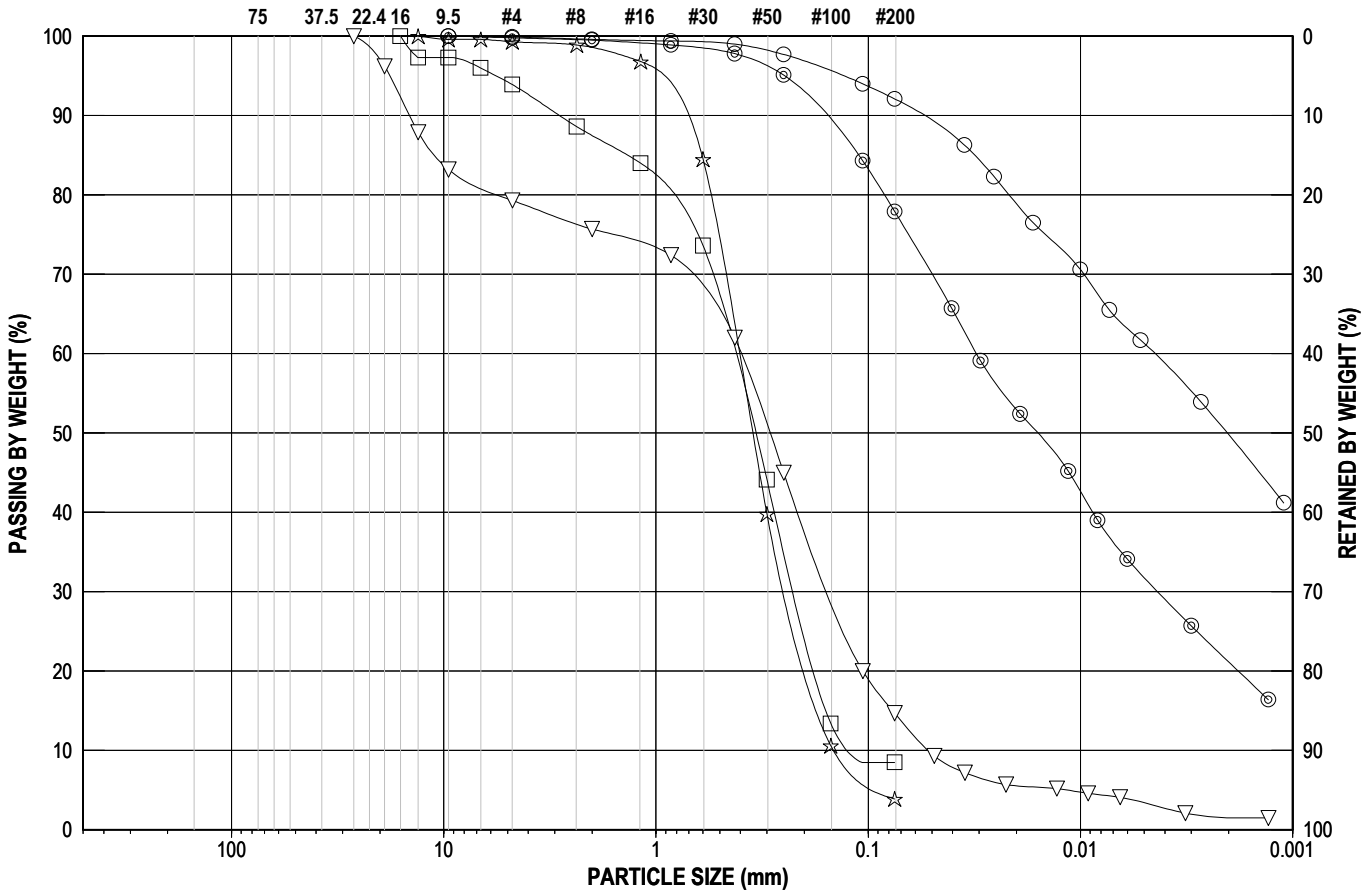
Figure No : **1**

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

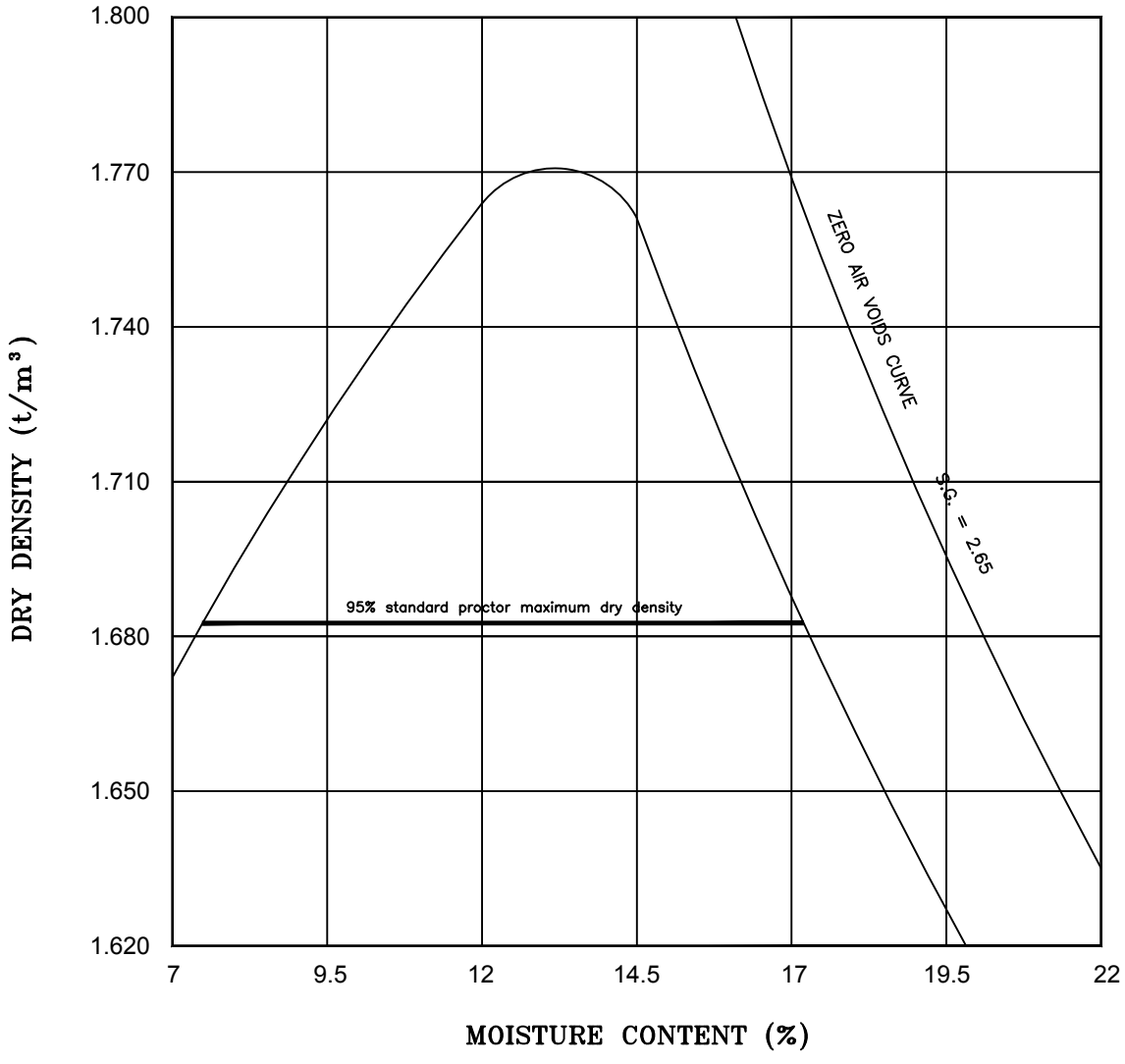
METHOD LS – 706

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 %



G:\160\P0008077\z5_CAD\WP100\P-0008077-0-01-100_Fig002.dwg

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

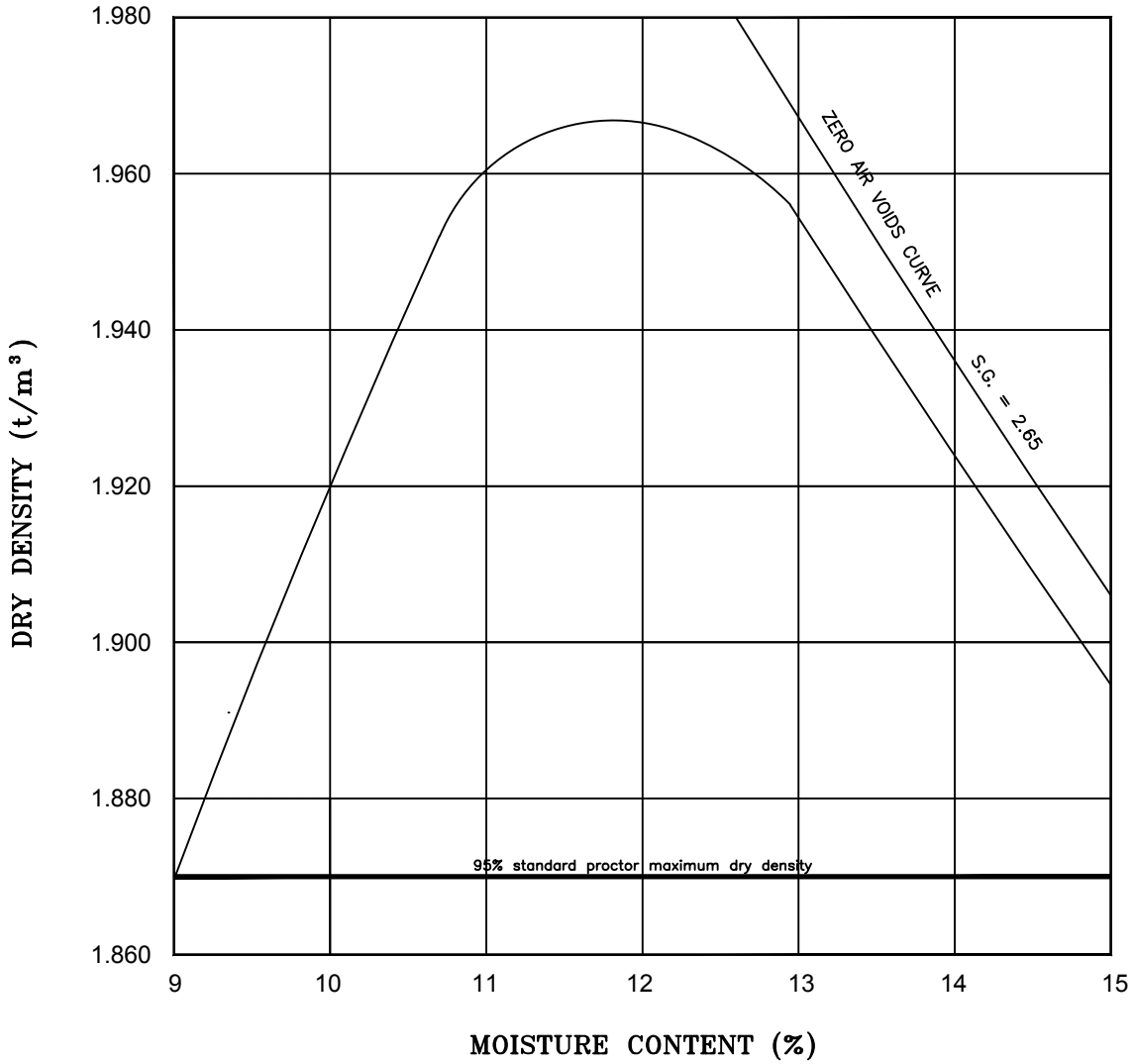
METHOD LS – 706

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

FINAL REPORT

December 2021

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.

Prepared by  Digitally signed by Grant Whitehead Date: 2021.12.22 10:17:42 -05'00'

(signature)

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

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
m	meters
m/s	meters per second
mm	millimeters
mm/hour	millimeters per hour
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.
SWM	stormwater management

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).

Introduction
December 2021

In 2021, as per the authorization of Meritech, Stantec performed additional field studies designed to confirm the groundwater elevation and infiltration rates for those soils located beneath the proposed footprint of the on-Site SWM facility.

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.

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 L include Regional Groundwater Flow Mapping, Source Water Protection Plan Mapping, Wellhead Protection Sensitivity Area Categories, Borehole Logs, Hydraulic Conductivity Analytical Solutions, Grain Size Analysis, Photographs, SWM Treatment Train Approach, and Amended Soils Assessment Memo, respectively.

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 towards the south 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 - 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 that occurs 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 the MECP water well records. 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.

2.4 SOURCE WATER PROTECTION

2.4.1 Ontario Clean Water Act

As established under the Ontario *Clean Water Act*, 2006, S.O., 2006, c. 22, source protection areas and associated land use restrictions exist for all municipal drinking water sources located throughout the Lake Erie Source Protection Area (LESPA).

The Ontario Ministry of the Environment (now the MECP) introduced the *Clean Water Act* as a means of ensuring the protection of drinking water sources within the Province. The *Clean Water Act* requires that a detailed Assessment Report be prepared for each municipal drinking water system, with this Assessment Report incorporating numerous components as outlined in the document “Technical Rules: Assessment Report, *Clean Water Act* (2006), November 16, 2009”. This legislation provides a basic framework for communities to follow in developing an approach to protecting their municipal water supplies, with the key components of this approach being as follows:

- Identification and assessment of risks to the quality and quantity of municipal drinking water sources and determine which risks are significant and require immediate action, which risks need monitoring to ensure they do not become significant, or which pose low to negligible risk. This information is presented in a detailed Assessment Report, with the content of this report consisting of (i) the defining of Well Head Protection Areas (WHPA) for groundwater drinking water sources and Intake Protection Zones (IPZ) for surface water drinking water sources, (ii) completion of a vulnerability assessment for each WHPA and IPZ, and (iii) identification of drinking water issues and threats.
- Preparation of a Source Protection Plan (SPP) that addresses identified drinking water threats, particularly significant threats.
- Carry out the SPP through existing land use planning and regulatory requirements.
- Perform ongoing monitoring and reporting to measure the effectiveness of the actions taken to protect drinking water sources and ensure that they are protected in the future.

Within the LESPA and specifically the Grand River Source Protection Area, the MECP has designated the following types of vulnerable areas that apply to drinking water sources:

Wellhead Protection Area (WHPA): an area delineated on the ground surface that represents the capture zone for the underlying aquifer in which a given municipal well draws its water. The zone represents the total amount of time it would take for groundwater to flow through the aquifer system and reach the intake of a given municipal well. The zones are defined as follows:

- WHPA-A: 100 m radius around the municipal well.
- WHPA-B: Horizontal time-of-travel to the municipal well is two years or less.
- WHPA-C: Horizontal time-of-travel to the municipal well is equal to or less than five years and greater than two years.
- WHPA-D: Horizontal time-of-travel to the municipal well is equal to or less than 25 years and greater than five years.

Based on a review of the online MECP Source Water Protection Information Atlas (2021) and as shown in Figure 4, the central to eastern portions of the Site is intercepted by WHPA-C for Waterloo North Production Well W25 (Well W25), with the remainder of the Site falling within WHPA-D of this same municipal well. The vulnerability score for the Well W25 WHPA-C that intercept the Site is 4, with the WHPA-D having a vulnerability score of 2.

Significant Groundwater Recharge Areas (SGRA): Groundwater recharge represents the proportion of precipitation and/or surface water run-off that infiltrates to the subsurface and reaches the groundwater table. Recharge areas are classified as “significant” when they supply more water to an aquifer used as a drinking water source than the surrounding area. The volume of water that infiltrates to the subsurface is largely influenced by site topography, the physical properties of the soil, and land cover characteristics. The LESPC (2021a) defines a significant groundwater recharge area (SGRA) to be an area where the annual recharge rate is greater than the average plus 15% or more across the source protection region. As per the Assessment Report (LESPC, 2021a), lands within the Grand River Source Protection Area (i.e., the Grand River Watershed) are deemed to be SGRA when the annual recharge rate is greater than 176 mm/year. Areas of the Site designated as SGRA are presented on Figure 5, with the vulnerability scoring for these areas being assigned 2 or 4.

Highly Vulnerable Aquifer (HVA): Defined as subsurface, geologic formations that are sources of drinking water, which could be easily affected by the release of pollutants on the ground surface. The HVA is identified using variables that include depth to the aquifer, physical properties of the overlying soil and/or rock, and the aquifer composition. In general, an HVA will consist of granular aquifer materials (i.e., sands and gravels) that are exposed near the ground surface and where a relatively shallow water table is present. Based on a review of the online MECP Source Water Protection Information Atlas (2021), the proposed Site development area does not occur within an area designated as HVA.

Intake Protection Zones (IPZ): A zone established around a drinking/surface water intake within which a spill or leak may get to the intake too quickly for the operators of the municipal water treatment plant to shut the intake down until the pollutant passes by. Based on a review of the online MECP Source Water Protection Information Atlas (2021) and as shown in Figure 4, the area of the Site extending westward from the WHPA-C boundary to Beaver Creek is intercepted by an IPZ-3. The IPZ-3 encompasses Beaver Creek and its adjacent lands (i.e., GRCA Regulation Limit or 120 m horizontal distance from the creek, whichever is greater), representing an area that may capture runoff from extreme storm events (e.g., 100-year rainfall event) and, subsequently, transport a spill or leak potentially occurring within this area downstream to the intake(s) associated with the municipal surface water drinking-water system.

Water Quantity Vulnerable Areas: Water quantity vulnerable areas are determined through a tiered process of water budget analyses as set out in the Technical Rules under O. Reg. 287/07. WHPA-Q is defined as an area where an activity can occur and pose a threat to drinking water quantities. Any activity that takes water without returning it to the same source or an activity which reduces recharge may be a threat in WHPA-Q. Based on a review of the online MECP Source Water Protection Information Atlas (2021), the Site occurs within an area designated as WHPA-Q (Figure E-1, Appendix E).

Issue Contributing Area: A delineated area identifying where activities and conditions as a result of past activities have or are likely to contribute to the elevated concentration of a substance in a muncipal well (i.e., allowing activities to be deemed significant drinking water threats in a larger portion of a WHPA than would normaly be allowed). Based on a review of the online MECP Source Water Protection Information Atlas (2021), the Site does not occur within an Issue Contributing Area.

2.4.2 Region of Waterloo Official Plan

In the Region of Waterloo, sensitivity rankings were developed for the municipal well fields, with these rankings being based on modeled time-of-travel capture zones and the vulnerability of the groundwater to contamination at each individual well head. A Sensitive Area 1 designation represented an area surrounding the well head that has the highest potential for groundwater contamination, whereas a Sensitivity Area 8 designation represents the lowest. As per the Region of Waterloo Official Plan (ROP) (2015), Wellhead Protection Sensitivity Areas (WPSA) are categorized under eight categories (WPSA 1 to WPSA 8). This range of classifications allows for varying degrees of management relative to the vulnerability of the underlying groundwater to contamination, the importance of the subject well to the capacity of the municipal drinking-water supply system, and the length of time groundwater within the WPSA will take to reach the municipal well.

As shown in Figure 6, the Site is located within the WPSA of Waterloo North Production Well W25 (Well W25). The specific WPSA is as follows:

WPSA-8: Where covering the Site, this WPSA indicates that groundwater takes greater than 10 years to flow to the intake of a given municipal production well. As per the ROP (2015) Schedule B, only Category ‘A’ (Very High Risk) land uses are not permitted in this zone, whereas Category ‘B’ (High Risk) and ‘C’ (Moderate Risk) land uses are permitted. Category ‘D’ land uses represent *preferential*

pathways or other land uses that involve soil excavation and/or the creation of subsurface facilities that contribute risk to municipal drinking-water systems by increasing *vulnerability*. Within a WPSA-8, Category 'D' land uses are permitted, except for underground parking garages, geothermal wells, and/or mineral aggregate operations, which must meet the requirements of Policy 8.A.4 before being permitted. A copy of Schedule B from the ROP (2015) that lists the various land uses associated with each Category is provided in Appendix F.

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
- excavation of test pits and performing infiltration testing of onsite soils.

The methodology for these tasks is described in Sections 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, MW3-10(S), MW3-10(D), MW3-16(S), 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 (2021). 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 G.

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). On May 25, 2021, Aardvark Drilling Inc. drilled one additional borehole within the footprint of the proposed end-of pipe SWM facility / infiltrating basin to a depth of 8.8 m BGS, which is also equipped with a single monitoring well (i.e., MW101-21). 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. However, for MW101-21, soil sampling occurred at every 0.75 m for the entire 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 G.

3.3 MONITORING WELL INSTALLATION AND DEVELOPMENT

Stantec observed the installation of monitoring wells in the seven boreholes advanced throughout the Site (i.e., MW1-19 to MW6-19 and MW101-21), 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 seven 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 2021 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 multiple times from the onsite monitoring wells between May 2019 and May 2021. 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). Hydrographs presenting groundwater level data measured from these previously mentioned monitoring wells are provided in Figure 8.

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, and MW101-21 on June 1, 2021. 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 H.

3.6 INFILTRATION TESTING

3.6.1 Site

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 in May 2020 (i.e., GP101-20 to GP104-20, 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., GP101-20 to GP104-20). 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 I, 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.

3.6.2 Proposed SWM Facility Infiltration Basin

On May 27, 2021, TDC Excavating Ltd. (TDC) excavated four test pits (i.e., TP1-21 to TP4-21) within the footprint of the proposed end-of pipe SWM facility. As described in the Meritech (2021) *Preliminary Stormwater Management Report*, the SWM facility design consists of a sediment forebay, filtration strip, wetland cell, and infiltrating basin. Under the supervision of Stantec personnel, the test pit excavations occurred within the footprint of the infiltrating basin and extended to the projected base elevation of the basin for the performing of soil infiltration testing. Once completing the soil infiltration testing at the proposed base elevation of the basin, the test pits were then excavated further to depths of at least 1.5 m below the base elevation, with the soils at these depths also being subjected to infiltration testing as per the protocols outlined in the Credit Valley Conservation (CVC) and Toronto and Region Conservation (TRCA) (2010) *Low Impact Stormwater Management Planning and Design Guideline*. Stantec personnel classified the soils targeted for infiltration testing using the ASTM guideline for visual-manual description and identification of soils (ASTM D2488-00) and once the test pit was no longer required, TDC backfilled the excavations to the existing grade.

Assessment of the infiltration potential for the on-Site soils involved the use of a Guelph Permeameter (a constant head permeameter designed to measure in-situ vertical hydraulic conductivities of a given substrate). At the various excavated depths of the test pits, Stantec personnel used a hand auger to drill an approximately 0.5 m deep, 50 mm diameter cylindrical hole into the native soil to be tested. 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 then stabilized against the substrate. Stantec personnel then proceeded to record the eventual steady-state rate of water recharge into the soil. 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 by the CVC/TRCA (2010). Table 3 presents the results of this soil infiltration testing, with photo documentation of the test pit excavation and soil permeability testing work completed being presented in Appendix J.

Using the infiltration testing results, Stantec proceeded to calculate the Design Infiltration Rate for each infiltration facility as per the approach outlined by the CVC/TRCA (2010). The calculated infiltration rate used in the design of the SWM facility infiltrating basin is 67 mm/hour (Table 4).

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 9), B-B' (Figure 10), and C-C' (Figure 11). 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 G.

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 Upper Maryhill Till continues northward across the Site, with clayey silt deposits being found in the shallow subsurface at MW6-19 and MW2-10 (Figure 9).

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 10). 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 10).

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 and MW101-21 between May 2019 and May 2021. 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 12. 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 - Laurel Creek Wetland Complex. Overall, the high groundwater table

ranges from 357.24 m AMSL to 351.48 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) due to 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 H) 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 12 presents groundwater elevation contours and the interpreted direction of horizontal flow through the groundwater system beneath the Site using historical high water 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 1.6×10^{-3} m/s to 1.8×10^{-9} m/s (Table 1; Appendix H), for an estimated bulk (i.e., geometric mean) horizontal hydraulic conductivity of 1.2×10^{-5} m/s (Table 1). Based on the groundwater elevation contours presented in Figure 12, 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 13.1 m per year.

4.2.3 Infiltration Potential

4.2.3.1 Site

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).

4.2.3.2 Proposed SWM Facility Infiltration Basin

Results of the infiltration testing completed on the subsurface soils located within the footprint of the proposed SWM facility infiltrating basin are summarized 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 from Guelph Permeameter tests completed at the proposed base elevation of the basin and approximately 1.5 m below this base elevation (Section 3.6).

Tested vertical hydraulic conductivities for predominantly native fine to coarse-grained sand deposits that lie beneath the footprint of the infiltration basin ranged from 8.1×10^{-4} m/s to 3.4×10^{-5} m/s, for a geometric mean vertical hydraulic conductivity of 1.3×10^{-4} m/s. These vertical hydraulic conductivities equate to infiltration rates ranging from 119 mm/hour to 278 mm/hour (Table 3). A tested vertical hydraulic conductivity of 6.1×10^{-6} m/s occurred at a depth of 2.9 m BGS (352.93 m AMSL) in TP4-21, equating to a calculated infiltration rate of 75 mm/hour; however, this relatively lower rate is not representative of the high infiltration rates that mostly characterize the sand deposit that lies beneath the proposed infiltration basin between the depths of 2.9 to 5.5 m BGS (353.98 to 351.43 m AMSL).

As per CVC-TRCA (2010), the calculated design infiltration rate used by Meritech (2021) for the sizing of the proposed infiltration basin is 67 mm/year (Table 4).

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 located throughout the subcatchment are to 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 (2021) will be employing a comprehensive treatment train approach 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 (2021) *Preliminary Stormwater Management Report*, the following post-development LID SWM measures were considered to offset potential infiltration losses associated with the increase in impervious surfaces associated with the proposed development.
A conceptual figure showing the proposed stormwater management treatment train approach that is proposed for the Site is provided in Appendix K. Specifically, this approach will include:

- Lot-level infiltration measures consisting of roof leaders from on-Site buildings being directed to side-yard swales and grassed areas (i.e., roof leader disconnection) or to rear-yard soak away pits / infiltration trenches.
- Use of amended soils in the form of a thicker topsoil layer in remaining post-development pervious areas. This technique would involve using a 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. However, as documented in Stantec's (2020*) Amended*

Soils Assessment (Appendix L), the proposed re-distribution of existing topsoil on-Site (i.e., topsoil moved from areas converted to impervious surfaces and used to increase the thickness of topsoil in remaining pervious areas) would have no impact on the volume of water captured and, subsequently, infiltrated by this measure. As such, Meritech concluded that the use of a thicker topsoil layer was not a necessity to meet the water balance objectives established by the NWSSS for the Site, although this LID technique may still be utilized in the treatment train approach for the purpose of enhancing the initial retention of rooftop water directed to side-yard swales and grassed areas.

- 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 that will receive and infiltrate clean water captured from the rooftops of the development.

- Establishment of a SWM facility equipped with an infiltrating basin, which will receive stormwater runoff from the development via the storm sewer system and be capable of infiltrating 2-year and 5-year design storm runoff volumes. The proposed location of the SWM facility infiltrating basin is shown on Figure 1. Further details on the SWM facility sizing, depths, functionality, and other associated design parameters are discussed in Meritech (2021).

As per Meritech (2021), the design of the onsite LID post-development infiltration measures will be further developed during the detailed design stage of the project. Overall, the proposed post-development infiltration structures will be constructed largely in the permeable fine to coarse-grained sand deposits that characterize the subsurface of the Site, with these sand deposits having a geometric mean infiltration rate of 135 mm/hour (Table 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

As per the NWSSS (Ecoplans Ltd. *et al.*, 2013), existing infiltration rates (i.e., recharge to groundwater) are to be maintained or increased to ensure that 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.

As documented in the NWSSS, the Site is divided into two major drainage areas: East and West Catchments. Under existing pre-development conditions, runoff from the East Catchment drains south to the Laurel Creek Reservoir across the Conservation Drive right-of-way and along Beaver Creek Road right-of-way. Runoff from the West Catchment drains westward across the Site, passing through the Sunfish Lake - Laurel Creek Wetland Complex before discharging to Beaver Creek. Although a surface water drainage divide characterizes the Site, a similar divide is not present for groundwater. As shown on Figure 5.22 from the NWSSS (Appendix D; Ecoplans Ltd. *et al.*, 2013), groundwater moves to the southwest across the Site towards Beaver Creek, with this flow direction being confirmed via the field work completed as part of the current hydrogeological assessment (Section 4.2.2; Figure 12). As such, any post-development LID infiltration measures employed across the Site, whether occurring within the

East or West Catchments, will contribute to the recharge of AFB1 and ultimately flow to the southwest towards Beaver Creek, which is identified as a potential groundwater discharge feature (Ecoplans Ltd. *et al.*, 2013).

As presented in the NWSSS, the pre-development infiltration targets required to be maintained under the post-development condition for the Site are as follows:

- East Catchment (NWSSS Catchment # 3107): 32,606 m^3/year (281.6 mm/year).
- West Catchment (NWSSS Catchment # 3913): 31,283 m^3/year (265.2 mm/year).

In total, approximately 63,889 m^3 of infiltration must occur on-Site post-development to meet the pre-development target.

As per the water balance calculations / post-development infiltration strategy proposed for the Site by Meritech (2021), the estimated infiltration volumes that will occur on-Site via the proposed treatment train approach are as follows (noting that refinements to these estimates will be further made during the detailed design stage of the project):

- Remaining Pervious Areas = 26,115 m^3/year.
- Rear-Yard Infiltration Galleries = 2,573 m^3/year.
- School Rooftop to Infiltration Gallery = 3,421 m^3/year.
- CWC Conveyance = 33,804 m^3/year.
- End-of-Pipe SWM Facility Infiltrating Basin = 18,424 m^3/year.

In total, approximately 84,337 m^3 of stormwater is expected to be returned to the Site subsurface under the post-development condition, resulting in an infiltration surplus of 20,448 m^3 and exceeding the pre-development infiltration target by approximately 30%. As mentioned previously, since there is no apparent permanent groundwater divide present on the Site, this infiltration can occur within either the East or West Catchment post-development stormwater drainage areas (refer to Figure 6 in Meritech (2021)) as all water entering the subsurface and recharging AFB1 will ultimately flow to the southwest towards Beaver Creek. Overall, the implementation of these infiltration measures is projected to at least maintain, if not enhance, pre-development infiltration volumes throughout the Site under the post-development condition.

5.2 SOURCE WATER PROTECTION

A drinking-water threat is an activity or condition that adversely affects or has the potential to adversely affect the quality or quantity of any water that is or may be used as a source of drinking water. The following activities are prescribed by the province of Ontario under O. Reg. 287/07 to be drinking water threats (i.e., Significant Drinking Water Threat Policy Categories):



1. The establishment, operation, or maintenance of a waste disposal site within the meaning of Part V of the *Environmental Protection Act*.

    a. Untreated sewage
    b. Waste disposal
    c. Mine tailings

2. The establishment, operation, or maintenance of a system that collects, stores, transmits, treats, or disposes of sewage.

    a. Stormwater management
    b. Wastewater treatment plants/sewer systems
    c. On-site sewage systems
    d. Industrial effluent

3. The application of agricultural source material to land.

4. The storage of agricultural source material.

5. The management of agricultural source material.

6. The application of non-agricultural source material to land.

7. The handling and storage of non-agricultural source material.

8. The application of commercial fertilizer to land.

9. The handling and storage of commercial fertilizer.

10. The application of pesticide to land.

11. The handling and storage of pesticide.

12. The application of road salt.

13. The handling and storage of road salt.

14. The storage of snow.

15. The handling and storage of fuel.

16. The handling and storage of a dense non-aqueous phase liquid (DNAPL).

17. The handling and storage of an organic solvent.

18. The management of runoff that contains chemicals used in the de-icing of aircraft.

19. An activity that takes water from an aquifer or a surface water body without returning the water taken to the same aquifer or surface water body.

20. An activity that reduces the recharge of an aquifer.

21. The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard.

22. The establishment and operation of a liquid hydrocarbon pipeline as per O. Reg. 385/08, s. 3.

As discussed in Section 2.4, the central to eastern portions of the Site is intercepted by WHPA-C for Waterloo North Production Well W25 (Well W25), with the remainder of the Site falling within WHPA-D of this same municipal well. Assigned vulnerability scores for the WHPA range from two (2) to four (4) (Figure 4), indicating that the threat of an activity or condition occurring at ground surface within this area and subsequently adversely affecting the quality and/or quantity of the aquifer system in which these municipal production wells draw their groundwater supply is low. The Site also falls within WHPA-Q1 and WHPA-Q2 (Figure E-1, Appendix E).

As per the SPP (LERSPC, 2021b) Map C2 (Figure E-2, Appendix E), the portion of the Site intercepted by Well W25 WHPA-C is only subject to the protection policies specified under Significant Drinking Water Threat Policy Category 16 (DNAPLs). Since the planned use for the Site will not involve the onsite handling and storage of DNAPLs, the SPP policies under Category 16 do not apply.

The area of the Site extending westward from the WHPA-C boundary to Beaver Creek is intercepted by an IPZ-3 (Figure 4). Since the IPZ-3 has a vulnerability score of 3.6 (as per the MECP Source Water Protection Information Atlas (2021)), these areas of the Site are subsequently not subject to the land use restrictions specified under the previously mentioned Significant Drinking Water Threat Policy Categories.

Policies in the SPP that address significant threat activities that pose a risk to the quantity of source water available for municipal well use (i.e., Significant Drinking Water Threat Policies 19 and 20) apply to WHPA-Q. Since the Site lies within a WHPA-Q, the Region of Waterloo will likely require that any groundwater taking (e.g., via dewatering or loss of infiltration) be shown to not impact the sustainability of the municipal water supply. As discussed in Section 5.1, water balance calculations indicate that pre-development infiltration volumes can be maintained throughout the Site with the use of post-development infiltration augmentation measures and, ultimately, maintain the groundwater recharge function that the Site currently provides to underlying aquifer systems (i.e., AFB1). Potential effects and mitigation strategies associated with dewatering at the Site (if required) can be addressed at the detail design stage of the development through the completion of a groundwater dewatering assessment.

Although SGRA is identified as occurring within the Site, the SPP (LERSPC, 2021b) currently contains no policies that are applicable to this source protection category. However, as mentioned above, pre-development groundwater recharge volumes at the Site will be achieved under the post-development condition via the proposed stormwater management treatment train approach.

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 (Figure 7). In addition, groundwater levels in those monitoring wells constructed throughout the Site as part of the NWSSS (i.e., MW2-10, MW3-16(S), MW3-10(D), MW6-10, MW7-10) have been continuously monitored using data loggers since 2010 as part of the North Waterloo Phase 1 Monitoring Program (Stantec, 2021) (Figure 8).

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 post-construction monitoring is required, with this phase beginning after 90% build-out of the development has been achieved.

Stage 2 and Stage 3 monitoring plans would at a minimum continue the continuous and manual monitoring of groundwater levels in all onsite wells installed as part of this hydrogeological assessment (i.e., MW1-19 to MW6-19 and MW101-21). Stantec also recommends that continuous water level data collected at MW2-10, MW3-16(S), MW3-10(D), 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 351.48 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 - 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 13.1 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 94 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. Within the footprint of the proposed SWM facility infiltrating basin (a component of the post-development stormwater management treatment train approach), calculated infiltration rates for the fine to coarse-grained sand deposits that underlie this basin (between the elevations of 353.98 to 351.43 m AMSL) predominantly range from 119 mm/hour to 278 mm/hour.

8. Meritech (2021) will be employing a comprehensive stormwater management treatment train approach at the Site designed to exceed NWSSS groundwater recharge targets. These measures are to include lot-level infiltration measures (i.e., rear-yard infiltration galleries), a clean water collection (CWC) “third pipe” system constructed in roadway rights of way, an end-of pipe SWM facility infiltrating basin, 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 (2021) Preliminary Stormwater Management Report.

9. Water balance calculations performed by Meritech (2021) indicate that implementing the stormwater management treatment train approach will result in an infiltration surplus of approximately 20,448 m^3 occurring at the Site, exceeding the pre-development infiltration target by approximately 30%. Given that there is no apparent permanent groundwater divide present on the Site, this infiltration can occur within either the East or West Catchment post-development stormwater drainage areas (refer to Figure 6 in Meritech (2021)) as all water entering the subsurface and recharging AFB1 will ultimately flow to the southwest towards Beaver Creek.

10. The Site is intercepted by WHPA-C and WHPA-D of Waterloo North Production Well W25. The Source Water Protection (SPP) policies for DNAPLs (Category 16) apply for WHPA-C; however, since the planned use for the Site will not involve the onsite handling and storage of DNAPLs, these policies do not apply.

11. The area of the Site extending westward from the WHPA-C boundary to Beaver Creek is intercepted by an IPZ-3. Since the IPZ-3 has a vulnerability score of 3.6, these areas of the Site are subsequently not subject to the land use restrictions specified under the previously mentioned Significant Drinking Water Threat Policy Categories.

12. Since the Site lies within a WHPA-Q, the Region of Waterloo will likely require that any groundwater taking (e.g., via dewatering or loss of infiltration) be shown to not impact the sustainability of the municipal water supply. As discussed in Section 5.1, water balance calculations indicate that pre-development infiltration volumes can be maintained throughout the Site with the use of post-development infiltration augmentation measures and, ultimately, maintain the groundwater recharge function that the Site currently provides to underlying aquifer systems (i.e., AFB1). Potential effects and mitigation strategies associated with dewatering at the Site (if required) can be addressed at the detail design stage of the development through the completion of a groundwater dewatering assessment.

13. Although SGRA is identified as occurring within the Site, the SPP currently contains no policies that are applicable to this source protection category. However, the function of the SGRA will not be impacted by the proposed development, given that pre-development groundwater recharge volumes at the Site will be achieved under the post-development condition via the proposed stormwater management treatment train approach.

14. Most of the Site lies within WPSA-8 of Waterloo North Production Well W25. As per the ROP (2015) Schedule B, Category 'A' (Very High Risk) land uses are not permitted in this zone, whereas Category 'B' (High Risk) and 'C' (Moderate Risk) land uses are permitted. Category 'D' (Low Risk) land uses involving underground infrastructure, such as the post-development infiltration measures proposed for the Site (i.e., infiltration trenches, clean water collection (CWC) conveyance system, and SWM facilities) are also permitted in this WPSA.

15. The Site occurs in the NWSSS 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

APPENDIX B:
Figures



Stantec

Legend

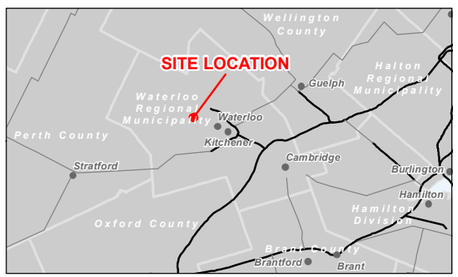
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- Monitoring Well (Stantec, 2020 -2021)
- Monitoring Well (Ecoplans et al., 2013)
- Drive Point Piezometer (Ecoplans et al., 2013)
- Guelph Permeameter/Infiltrometer (Stantec, 2020)
- Guelph Permeameter (Ecoplans et al., 2013)
- Test Pit (Stantec, 2010)
- Test Pit (Stantec, 2021)
- Abandoned Monitoring Well
- Proposed Draft Plan
- Proposed SWM Facility Infiltration Basin
- Watercourse
- Wetland - Evaluated (Provincial)

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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, 2021. Imagery Date, 2020.



Project Location
Waterloo, ON

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Prepared by PRM on 2021-12-20
Technical Review by GW on 2021-12-20

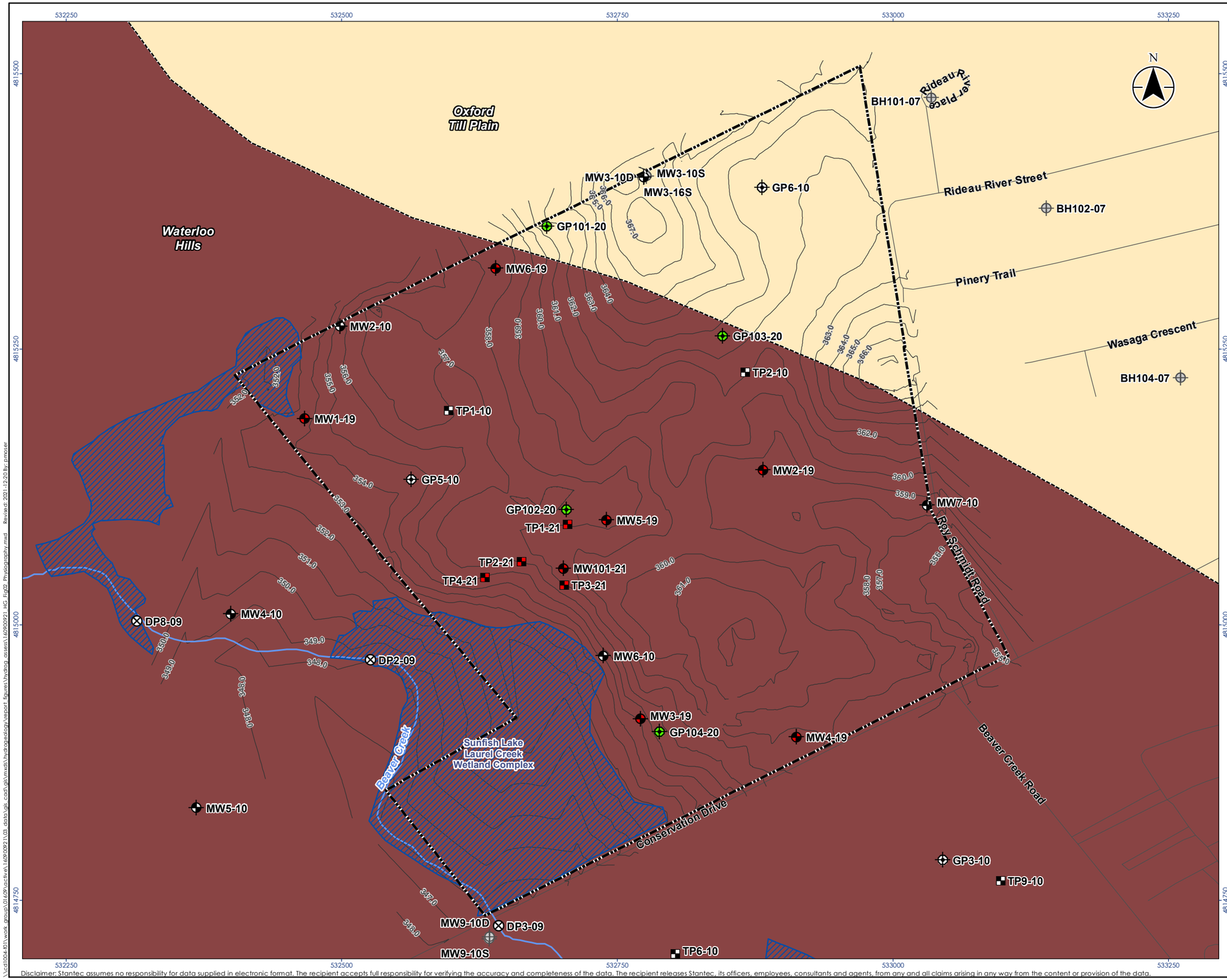
Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
1

Title
Site Plan

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Stantec

Legend

- Site Boundary
- Monitoring Well (Stantec, 2020 -2021)
- 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 (Stantec, 2010)
- Test Pit (Stantec, 2021)
- Abandoned Monitoring Well
- Topographic Contour (mAMSL)
- Watercourse
- Wetland - Evaluated (Provincial)
- Physiographic Region Boundary

Physiography

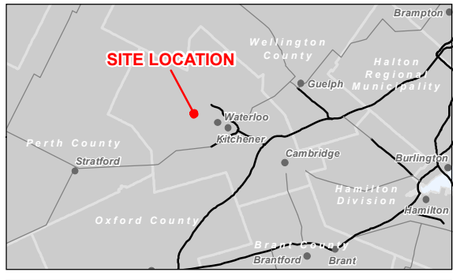
- 6: Till Plains (Drumlinized)
- 4: Kame Moraines

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Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
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4. Chapman, L.J. and Putnam, D.F. 2007. Physiography of southern Ontario; Ontario Geological Survey, Miscellaneous Release—Data 228.



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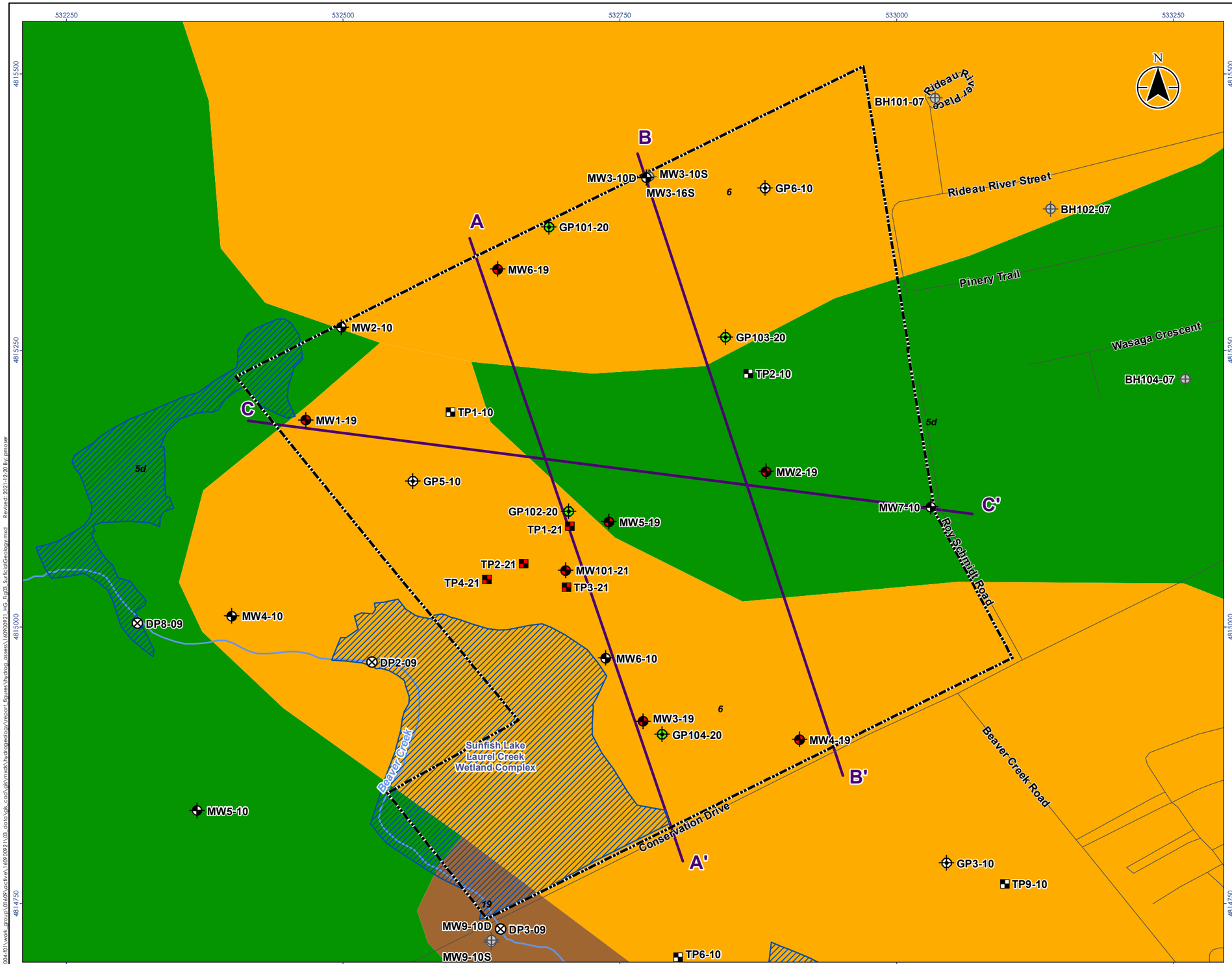
Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
2

Title
Physiography and Topography

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Stantec

Legend

- Site Boundary
- Monitoring Well (Stantec, 2020 -2021)
- 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 (Stantec, 2010)
- Test Pit (Stantec, 2021)
- Abandoned Monitoring Well
- Cross-Section Location
- Watercourse
- Wetland - Evaluated (Provincial)

Surficial Geology

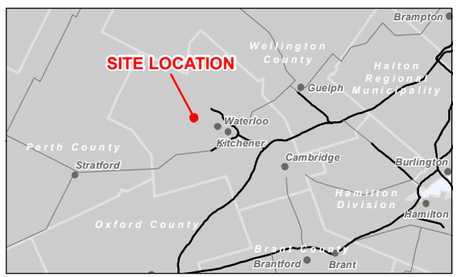
- 19: Modern alluvial deposits
- 6: Ice-contact stratified deposits (AFB1)
- 5d: Glaciolacustrine-derived silty to clayey till (ATB1)

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 PRM on 2021-12-20
Technical Review by GW on 2021-12-20

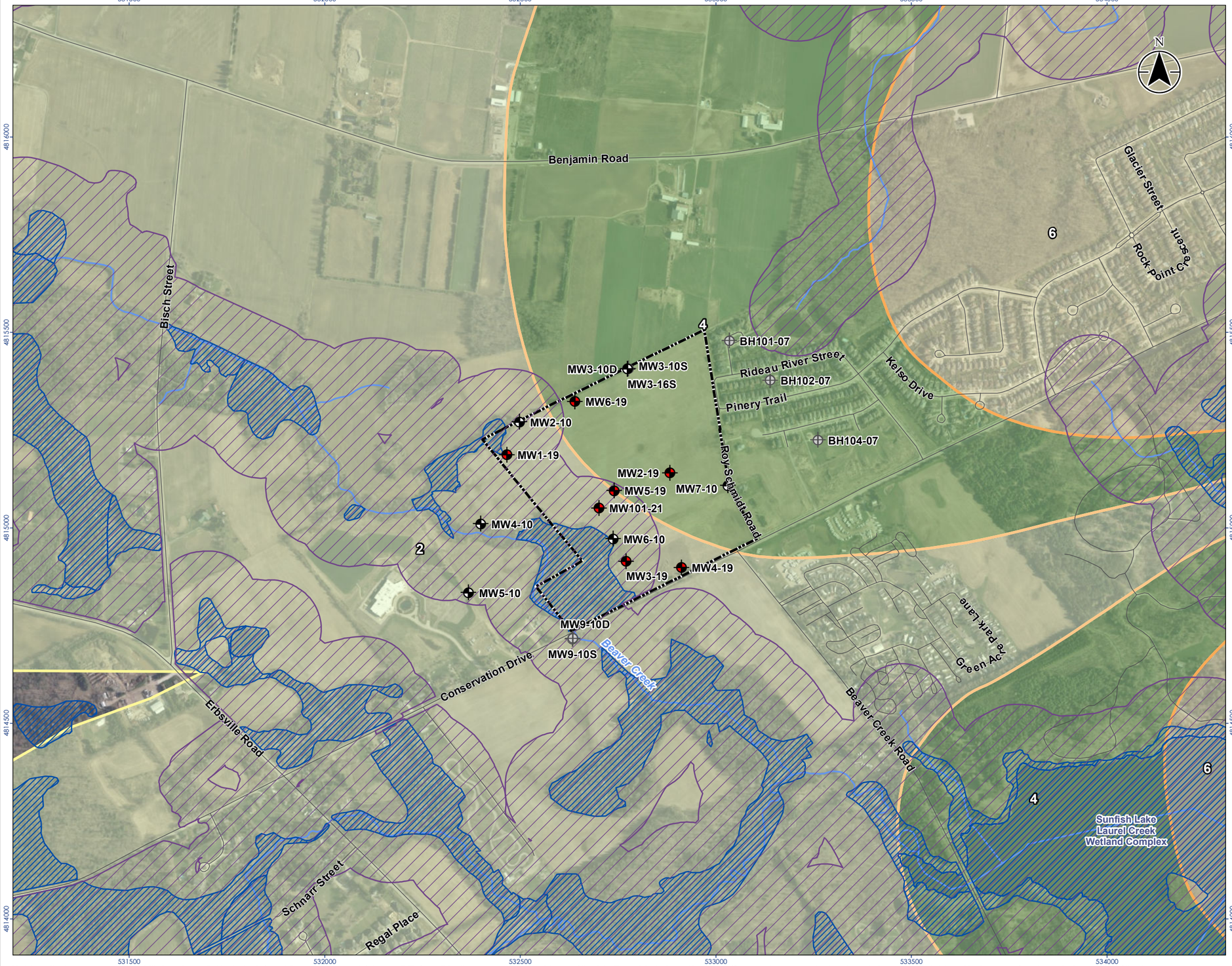
Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
3

Title
Surficial Geology

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Stantec

Legend

- Site Boundary
- Monitoring Well (Stantec, 2020 -2021)
- Monitoring Well (Ecoplans et al., 2013)
- Abandoned Monitoring Well
- Watercourse
- Wetland - Evaluated (Provincial)

Intake Protection Zone

- IPZ-3

Wellhead Protection Areas

- WHPA-A
- WHPA-B
- WHPA-C
- WHPA-D

Wellhead Protection Areas Vulnerability

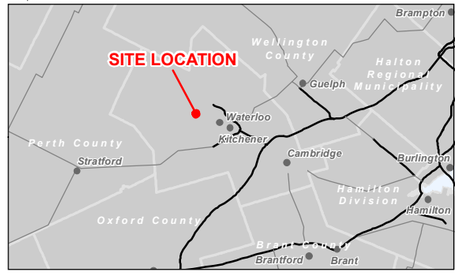
- 10
- 8
- 6
- 4
- 2

0 250 500 metres

1:10,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
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3. Orthoimagery © First Base Solutions, 2021. Imagery Date, 2020.
4. Contains Information made available under Grand River Conservation Authority's Open Data Licence v2.0.



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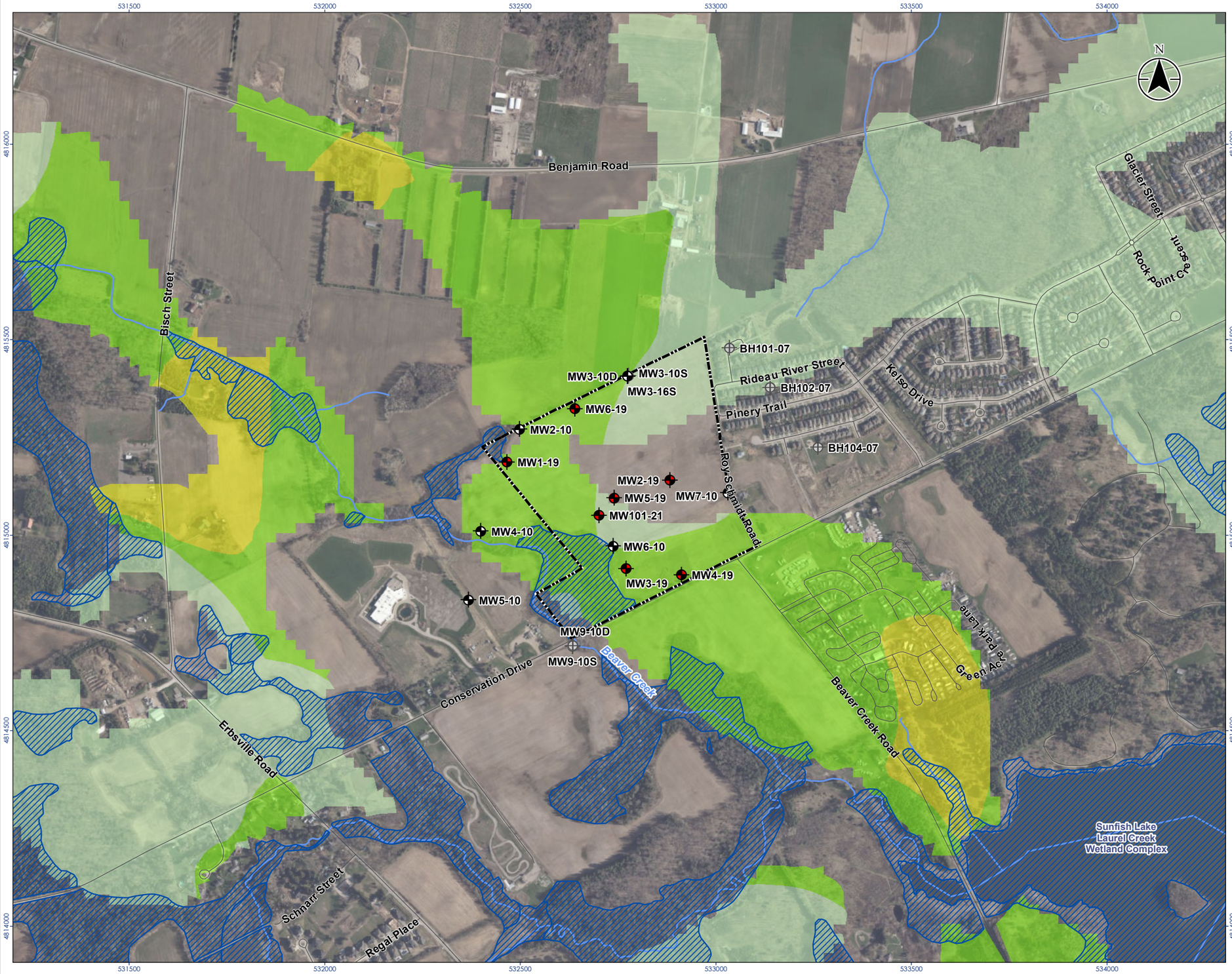
Client/Project
2115881 ONTARIO LIMITED
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HYDROGEOLOGICAL ASSESSMENT

Figure No.
4

Title
Source Water Protection – Wellhead Protection Areas

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Stantec

Legend

- Site Boundary
- Monitoring Well (Stantec, 2020 -2021)
- Monitoring Well (Ecoplans et al., 2013)
- Abandoned Monitoring Well
- Watercourse
- Wetland - Evaluated (Provincial)

Significant Groundwater Recharge Area Vulnerability

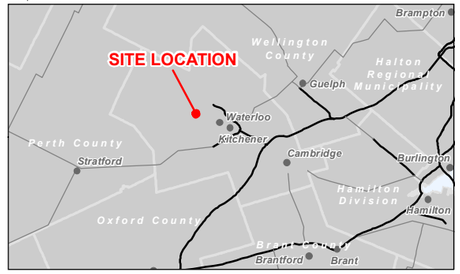
- 2
- 4
- 6

0 250 500 metres

1:10,000 (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, 2021. Imagery Date, 2020.
4. Contains Information made available under Grand River Conservation Authority's Open Data Licence v2.0.



Project Location
Waterloo, ON

160900921 REVA
Prepared by PRM on 2021-12-20
Technical Review by GW on 2021-12-20

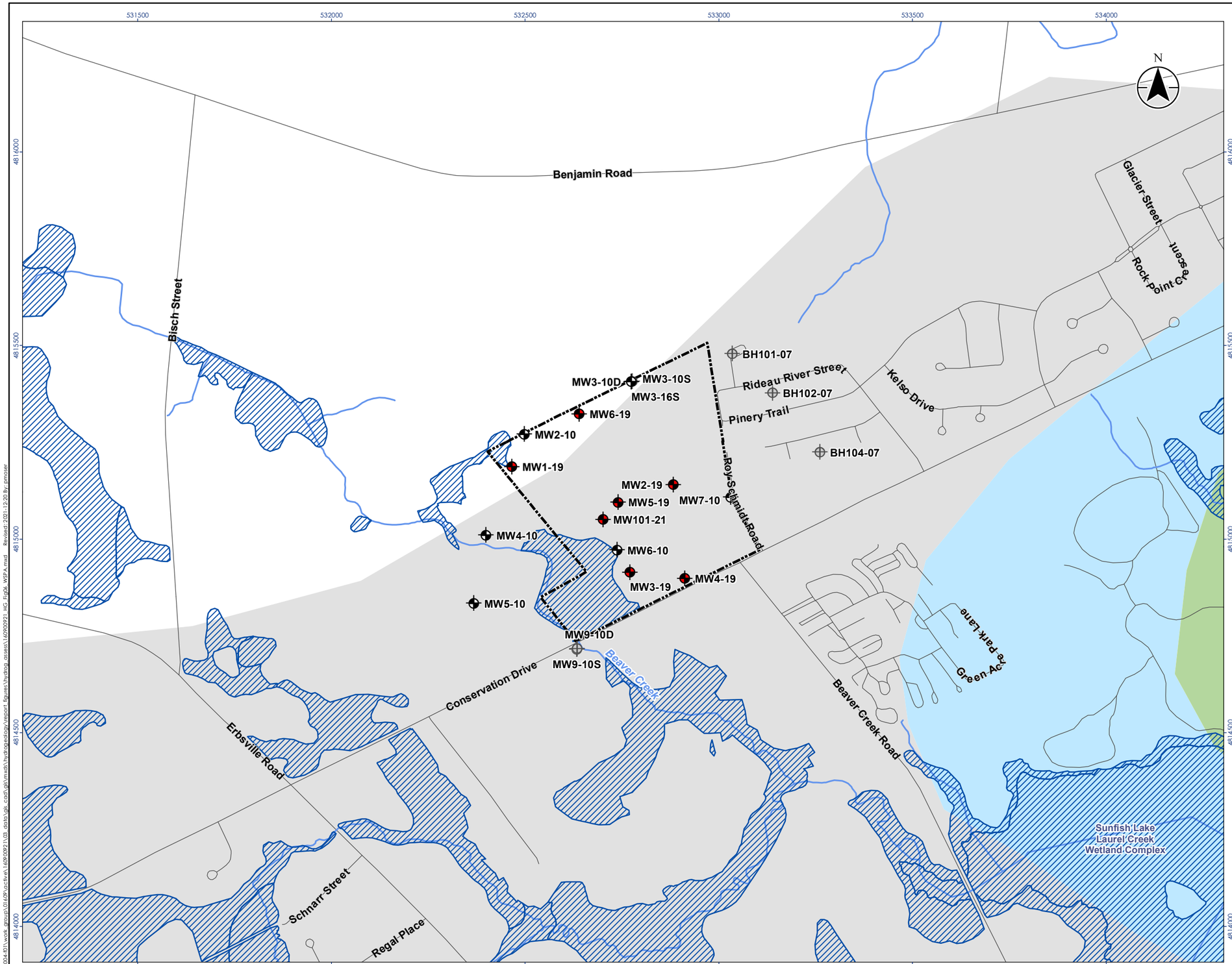
Client/Project
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HYDROGEOLOGICAL ASSESSMENT

Figure No.
5

Title
Source Water Protection – Significant Groundwater Recharge Area

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\\cd1004-f01\work_group\01\609\active\160900921\03_data\gis_cad\gis\mxds\Hydrogeology\report figures\Hydrogeology Report Figures\Hydrogeology Report Figure 5 Source Water Protection_Signif_GW_Recharge.mxd Revised: 2021-12-20 By: pmorse



Stantec

Legend

- Site Boundary
- Monitoring Well (Stantec, 2020 -2021)
- Monitoring Well (Ecoplans et al., 2013)
- Abandoned Monitoring Well
- Watercourse
- Wetland - Evaluated (Provincial)

Wellhead Protection Areas

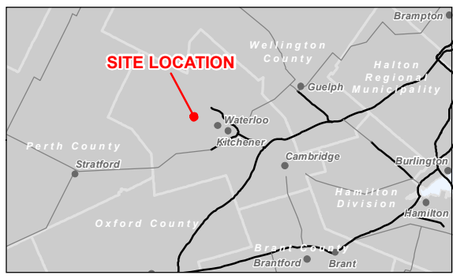
- WPSA-4
- WPSA-6
- WPSA-7
- WPSA-8

0 250 500 metres

1:10,000 (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. Wellhead Protection Areas © Region of Waterloo Official Plan, 2015.



Project Location
Waterloo, ON

160900921 REVA
Prepared by PRM on 2021-12-20
Technical Review by GW on 2021-12-20

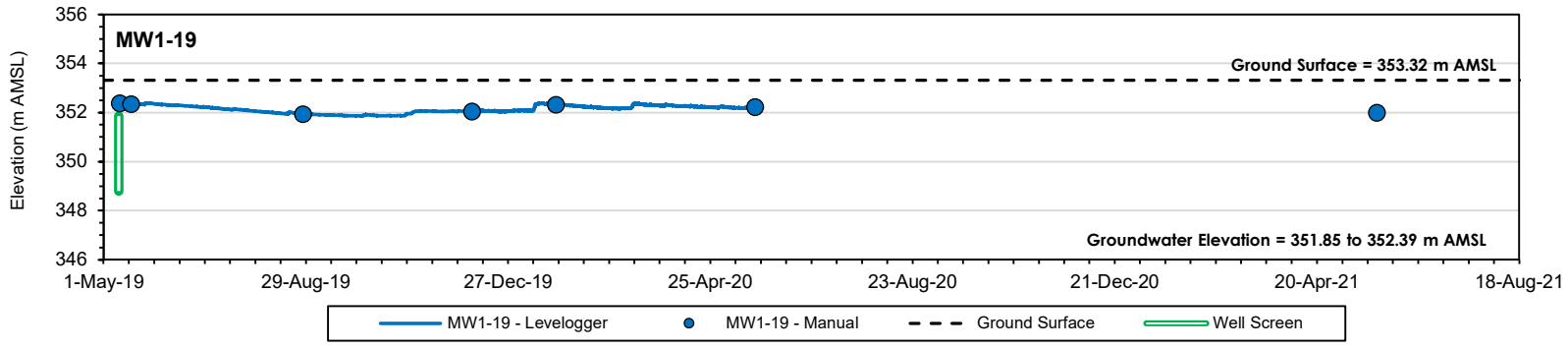
Client/Project
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HYDROGEOLOGICAL ASSESSMENT

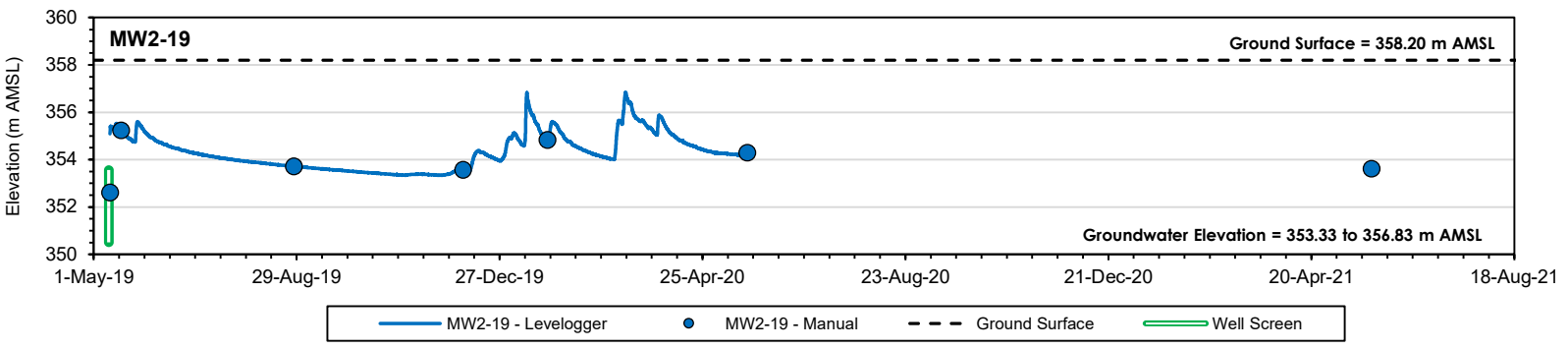
Figure No.
6

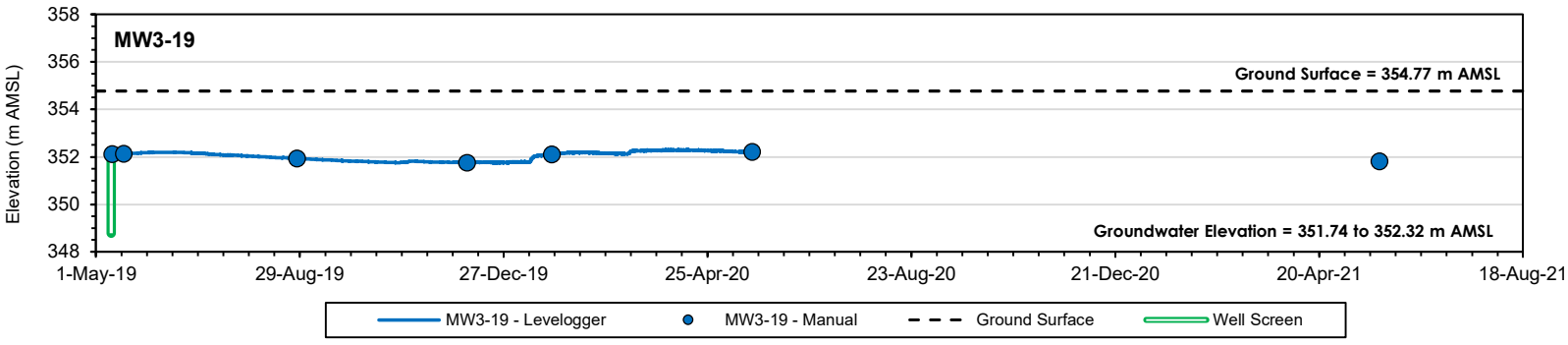
Title
Wellhead Protection Sensitivity Areas

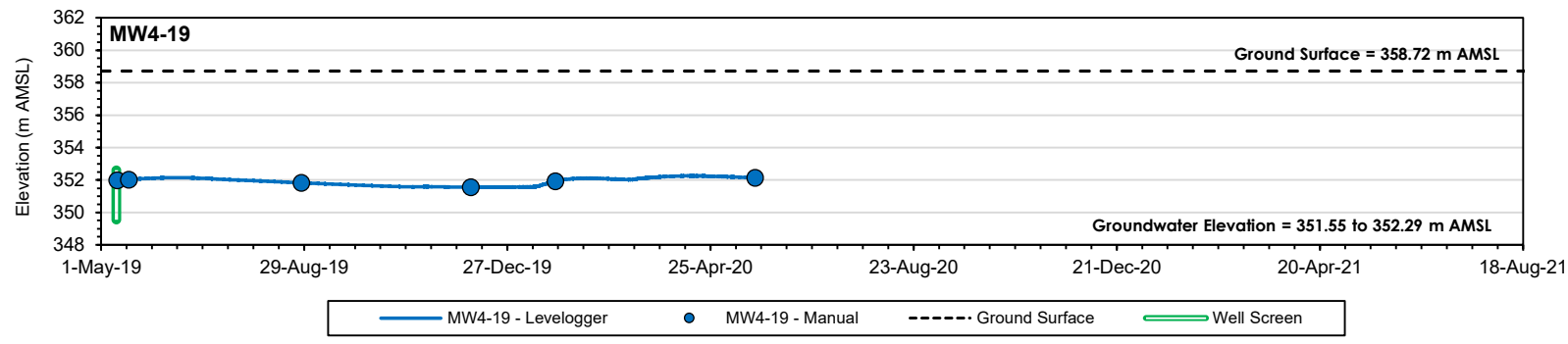
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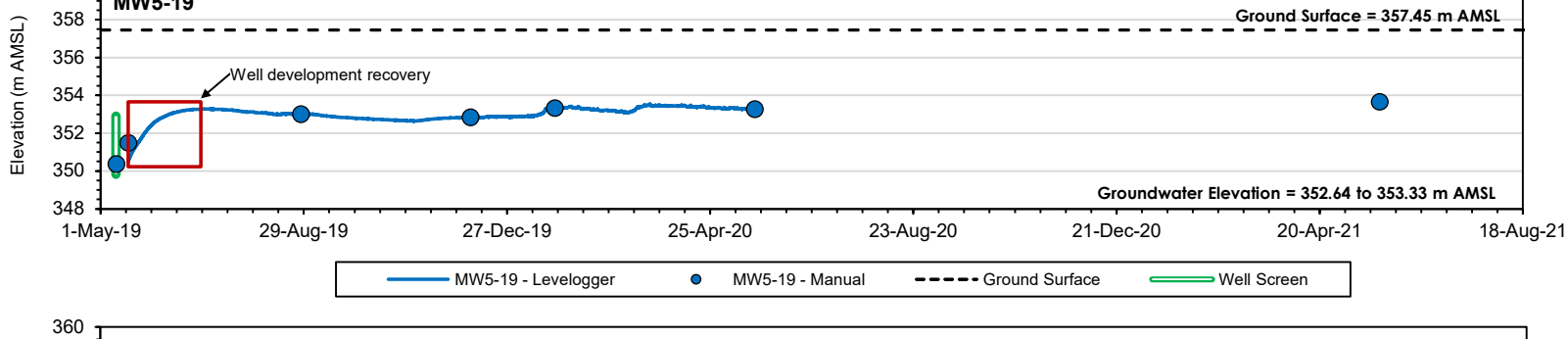
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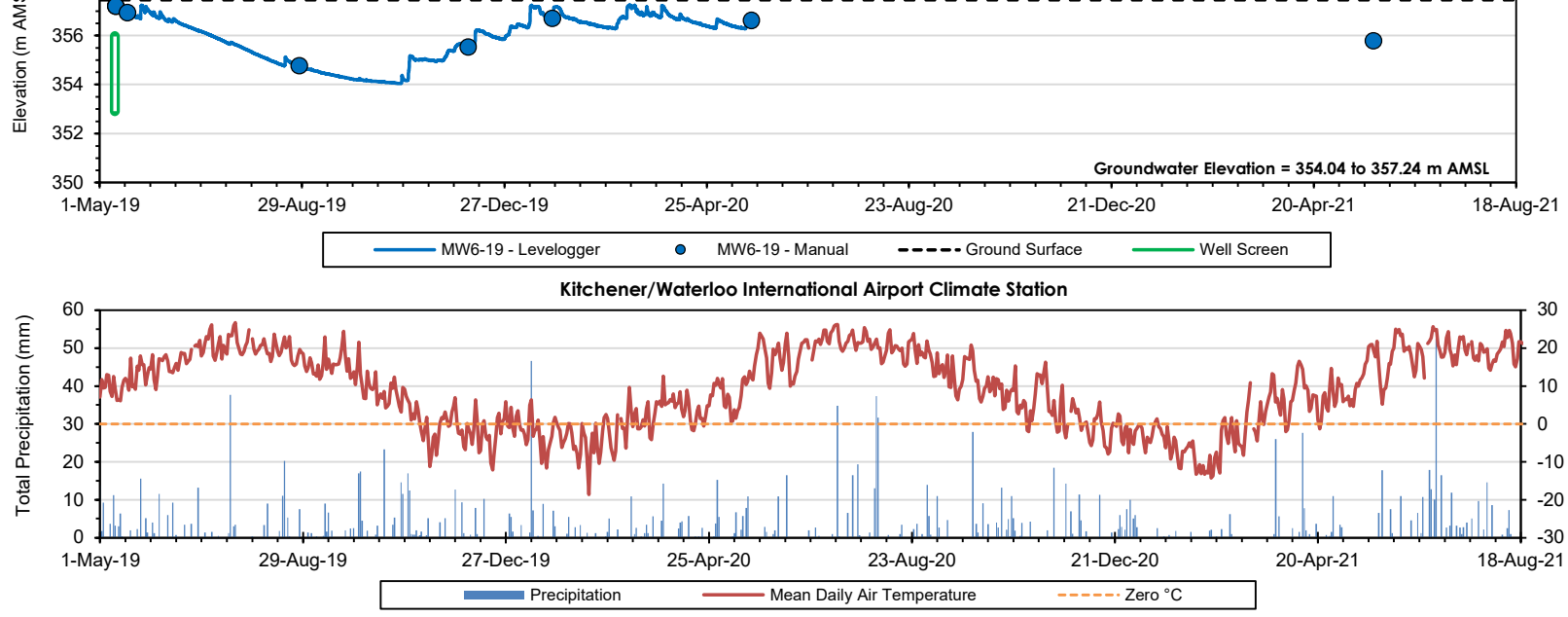












Notes

(1) Precipitation and temperature data were obtained from Environment Canada for the Region of Waterloo International Airport (ID 6144239), accessed December 2021.

(2) Data range for MW5-19 does not include water levels recorded during recovery from hydraulic conductivity test.

Stantec

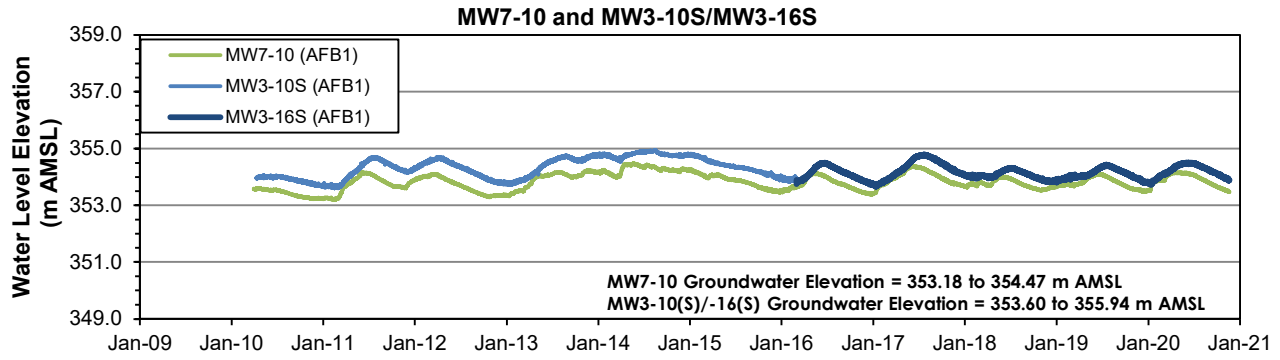
Client/Project

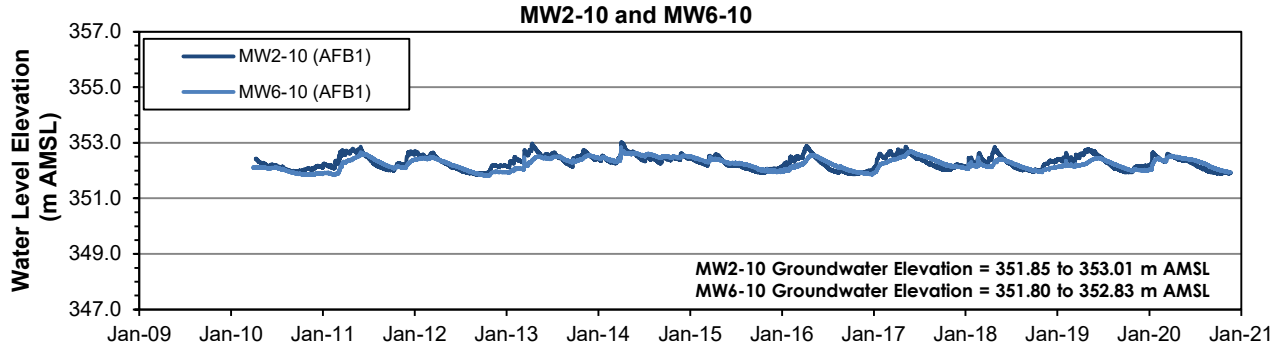
2115881 Ontario Limited
556, 560, and 576 Conservation Drive
Hydrogeological Assessment

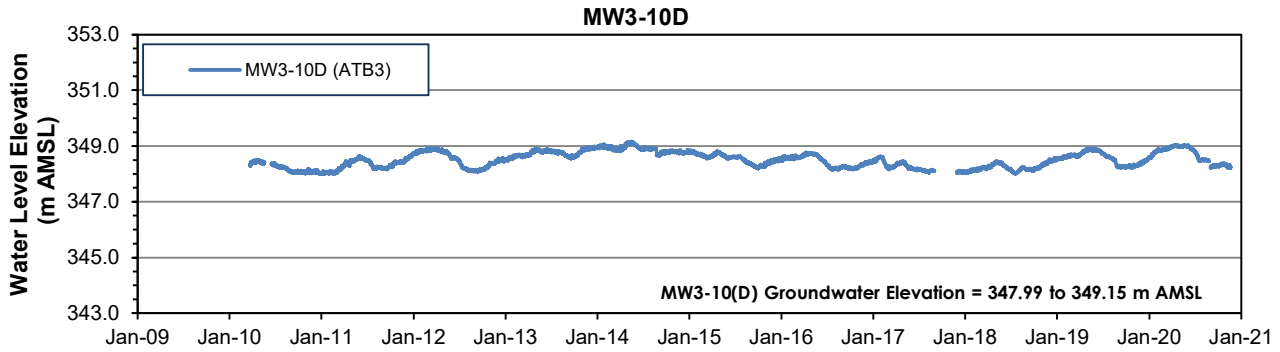
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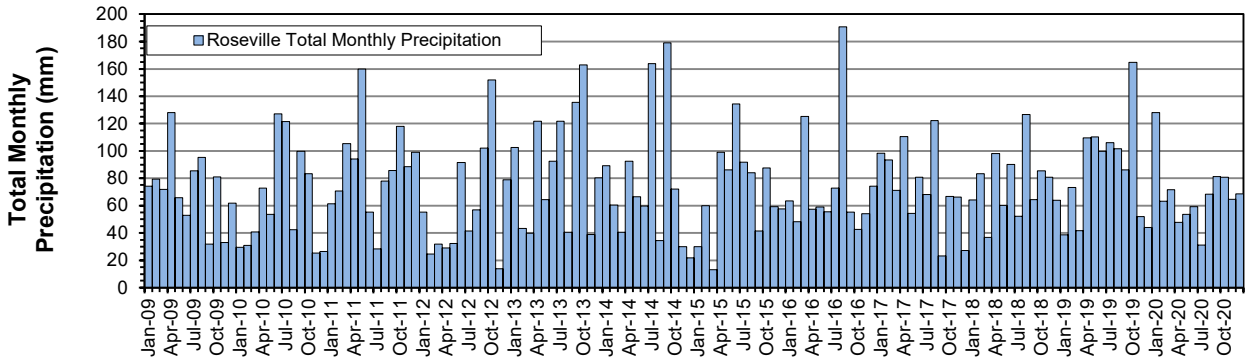
7

Title **HYDROGRAPHS**
MW1-19 to MW6-19









Source

Stantec Consulting Limited. 2021. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program.

Client/Project

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556, 560 & 576 CONSERVATION DRIVE, WATERLOO
HYDROGEOLOGICAL ASSESSMENT

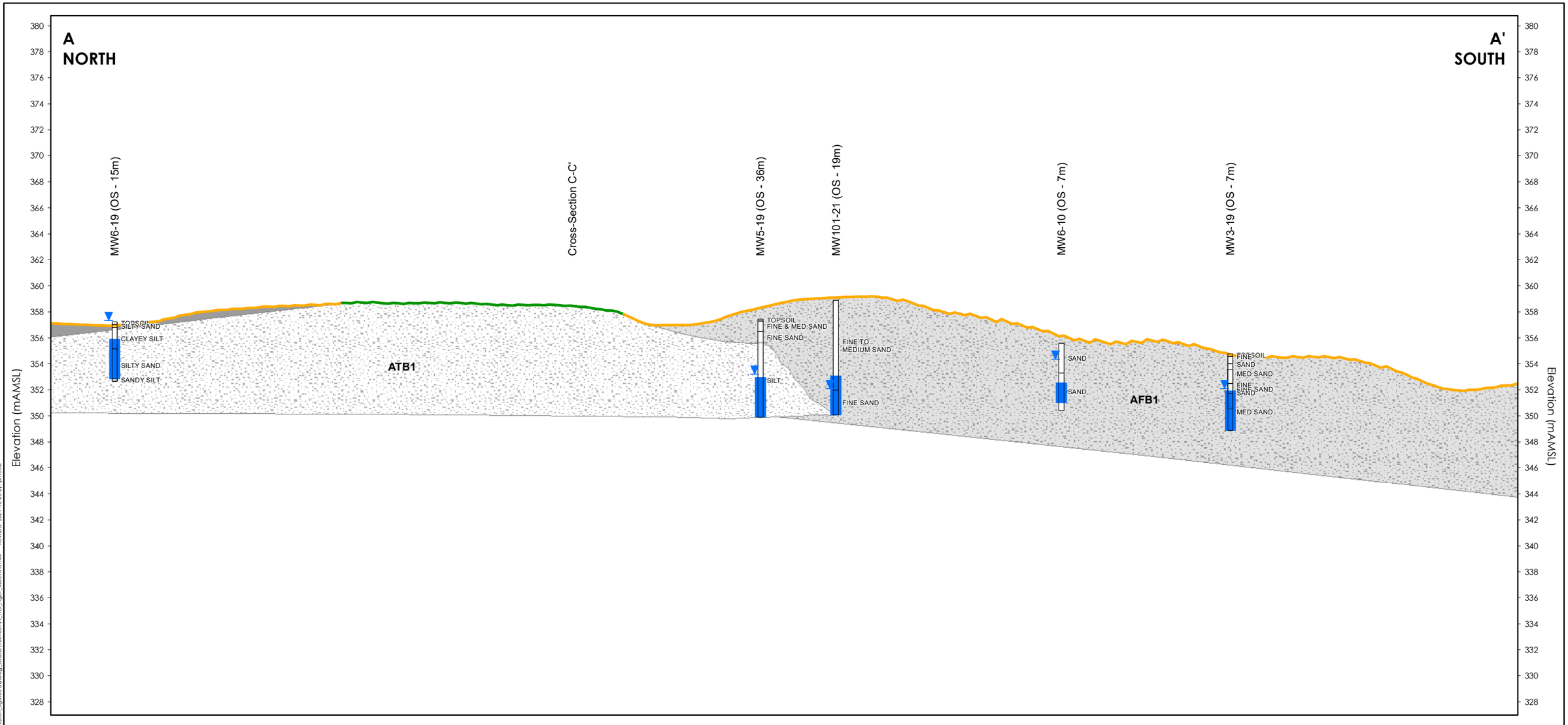
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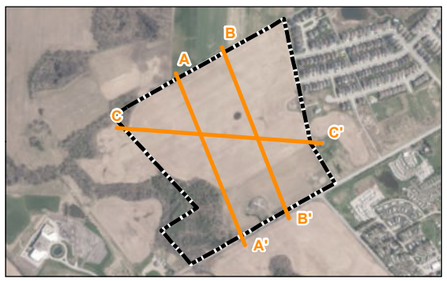
8

Title

HYDROGRAPHS
MW2-10, MW3-10(S)/-16(S), MW3-10(D), MW6-10, AND MW7-10

Stantec





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.
2. Groundwater elevations shown represent highest values recorded at each monitoring well between May 2019 and May 2021.

Stantec

Project Location
Waterloo, ON

160900921 REVA
Prepared by pmoser on 2021-12-20
Technical Review by GW on 2021-12-20

Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
9

Title
Cross-Section A-A'

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B
NORTH

B'
SOUTH

MW3-10 (OS-1m)
GP103-20 (OS-24m)
TP2-10 (OS-33m)
MW2-19 (OS-20m)
Cross-Section C-C'
MW4-19 (OS-27m)

Elevation (mAMSL)

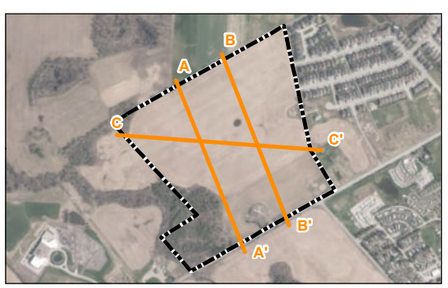
TOPSOIL
SAND
SILT
SAND
SILT & SAND
SILTY CLAY
SILT
SILTY CLAY TILL
SAND & SILT
SILTY SAND TILL

TOPSOIL
SILT
SILTY CLAY
SILT

TOPSOIL
CLAYEY SILT
SILTY CLAY
SANDY SILT

FINESOIL
SAND
FINE & MED SAND
MED SAND
FINE SAND

ATB1
AFB1
ATB3
ATC1



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.
2. Groundwater elevations shown represent highest values recorded at each monitoring well between May 2019 and May 2021.

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Project Location
Waterloo, ON

160900921 REVA
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Technical Review by GW on 2021-12-20

Client/Project
2115881 ONTARIO LIMITED
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HYDROGEOLOGICAL ASSESSMENT

Figure No.
10

Title
Cross-Section B-B'

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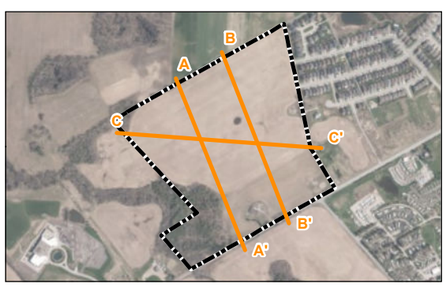
C
WEST

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
AFB1
TOPSOIL
FINE & MED SAND
FINE SAND
SILT
ATB1
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.
2. Groundwater elevations shown represent highest values recorded at each monitoring well between May 2019 and May 2021.

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Figure No.
11

Title
Cross-Section C-C'

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Stantec

Legend

- Site Boundary
- 357.54 Groundwater Elevation (m AMSL)
- Monitoring Well (Stantec, 2020 - 2021)
- Monitoring Well (Ecoplans et al., 2013)
- Guelph Permeameter/Infiltrometer (Stantec, 2020)
- Guelph Permeameter (Ecoplans et al., 2013)
- Topographic Contour (m AMSL)
- Proposed SWM Facility Infiltration Basin
- Groundwater Contour (m AMSL)
- Interpreted Groundwater Contour (m AMSL)
- Interpreted Direction of Groundwater Flow
- Watercourse
- Wetland - Evaluated (Provincial)

Surficial Geology

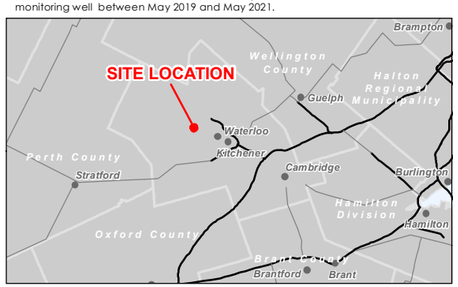
- 19: Modern alluvial deposits
- 6: Ice-contact stratified deposits (AFB1)
- 5d: Glaciolacustrine-derived silty to clayey till (ATB1)

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. Groundwater elevations shown represent highest values recorded at each monitoring well between May 2019 and May 2021.



Project Location
Waterloo, ON

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Prepared by PRM on 2021-12-21
Technical Review by GW on 2021-12-21

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HYDROGEOLOGICAL ASSESSMENT

Figure No.
12

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															
MW101-21	4815051	532701	359.87	358.88	0.99	9.79	8.80	350.08	5.75	353.13	8.80	350.08	SAND, trace silt	Aquifer 1	1.6E-03
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) =	**1.2E-05**

Notes:

(a) Refer to **Appendix G** for borehole and well construction logs
(b) Refer to **Appendix H** 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
	25-May-21	12:40 PM								1.33	2.11	351.99
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
	25-May-21	12:52 PM								4.58	5.30	353.62
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
	25-May-21	1:30 PM								2.96	3.78	351.81
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
	25-May-21	-								-	-	-
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
	25-May-21	11:48 AM								4.58	5.36	352.87
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
	25-May-21	12:45 PM								1.45	2.23	355.79
MW101-21	26-May-21	8:15 AM	9.79	8.80	350.08	3.05	359.87	358.88	0.99	6.63	7.62	352.25

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	Ground Surface Elevation [3] (m AMSL)	Horizontal Hydraulic Conductivity (m/s)	Vertical Hydraulic Conductivity[2] (cm/s)	Vertical Hydraulic Conductivity[2] (m/s)	Infiltration Rate[1] (mm/hr)	Testing Depth (m BGS)	Testing Depth (m AMSL)	Screened Interval (m BGS)	Soil Substrate Tested (% of screened interval)	Topsoil Thickness (m)	Grain Size Proportions (%)
Guelph Permeameter Testing (Site)												
GP5-10	Ecoplans (2013)[a]	-	-	7.5E-04	7.5E-06	79	0.36	-	-	Medium SAND	-	-
GP6-10	Ecoplans (2013)[a]	-	-	8.0E-04	8.0E-06	81	0.28	-	-	Medium SAND	-	-
GP101-20	Stantec (2020)	-	-	-	-	66	0.03	-	-	TOPSOIL	0.35	Gravel (0.1), Sand (30.0), Silt (42.9), Clay (27.0)
GP101-20	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)
GP102-20	Stantec (2020)	-	-	-	-	173	0.03	-	-	TOPSOIL	0.35	Gravel (3.5), Sand (81.1), Silt (8.9), Clay (6.5)
GP102-20	Stantec (2020)	-	-	1.0E-03	1.0E-05	86	0.70	-	-	Silty SAND, trace clay and fine gravel	-	-
GP103-20	Stantec (2020)	-	-	-	-	16	0.01	-	-	TOPSOIL	0.45	Gravel (0.2), Sand (37.7), Silt (45.1), Clay (17.0)
GP103-20	Stantec (2020)	-	-	7.3E-06	7.3E-08	23	0.70	-	-	Silty SAND, trace clay and fine gravel	-	-
GP104-20	Stantec (2020)	-	-	-	-	107	0.02	-	-	TOPSOIL	0.25	Gravel (15.2), Sand (71.2), Silt (9.1), Clay (4.5)
GP104-20	Stantec (2020)	-	-	2.1E-02	2.1E-04	194	0.55	-	-	Fine SAND	-	-
In-situ Hydraulic Response Testing (Site)												
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%)	-	-
MW101-21	Stantec (2021)		1.6E-03	1.6E-02	1.6E-04	180	-		5.7 - 8.8	SAND, trace silt	-	-
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	-	-
			AVERAGE (TOPSOIL) =		**-**	**91**						
			GEOMEAN (Fine to Medium SAND) =		**1.4E-05**	**94**						
			GEOMEAN (Silty to Clayey SAND, SILT to Clayey SILT) =		**2.1E-08**	**16**						
Guelph Permeameter Testing (Proposed SWM Facility Infiltration Basin)												
TP1-21 (GP1)	Stantec (2021)	357.94	-	6.1E-03	6.1E-05	139	4.40	353.54	-	SAND, trace silt	-	Gravel (0.6), Sand (96.7), Silt (2.7)
TP1-21 (GP2)	Stantec (2021)	357.94	-	3.4E-02	3.4E-04	220	4.50	353.44	-	SAND	-	-
TP1-21 (GP3)	Stantec (2021)	357.94	-	2.5E-02	2.5E-04	203	5.50	352.44	-	SAND, trace silt	-	Gravel (1.9), Sand (90.5), Silt (7.6)
TP2-21 (GP1)	Stantec (2021)	356.77	-	2.6E-02	2.6E-04	205	2.90	353.87	-	SAND, trace gravel and silt	-	Gravel (3.8), Sand (95.1), Silt (1.1)
TP2-21 (GP2)	Stantec (2021)	356.77	-	1.0E-02	1.0E-04	160	2.90	353.87	-	SAND	-	-
TP2-21 (GP3)	Stantec (2021)	356.77	-	2.4E-02	2.4E-04	200	4.30	352.47	-	SAND, trace gravel and silt	-	Gravel (3.0), Sand (93.9), Silt (3.1)
TP3-21 (GP1)	Stantec (2021)	357.98	-	5.0E-03	5.0E-05	132	4.00	353.98	-	SAND, some silt	-	Sand (90.0), Silt (10.0)
TP3-21 (GP2)	Stantec (2021)	357.98	-	1.3E-02	1.3E-04	170	4.00	353.98	-	SAND	-	-
TP3-21 (GP3)	Stantec (2021)	357.98	-	3.4E-03	3.4E-05	119	5.50	352.48	-	SAND	-	-
TP3-21 (GP4)	Stantec (2021)	357.98	-	4.1E-02	4.1E-04	232	5.50	352.48	-	SAND, trace gravel and silt	-	Gravel (1.5), Sand (96.9), Silt (1.6)
TP4-21 (GP1)	Stantec (2021)	355.83	-	6.1E-04	6.1E-06	75	2.90	352.93	-	SAND, trace gravel and silt	-	Gravel (5.7), Sand (92.1), Silt (2.2)
TP4-21 (GP2)	Stantec (2021)	355.83	-	8.1E-02	8.1E-04	278	4.40	351.43	-	SAND, trace gravel and silt	-	Gravel (6.7), Sand (92.3), Silt (1.0)
TP4-21 (GP3)	Stantec (2021)	355.83	-	3.4E-02	3.4E-04	221	4.40	351.43	-	SAND	-	-
			GEOMEAN (Fine to Coarse SAND) =		**1.3E-04**	**170**						
All Testing Locations												
			GEOMEAN (Fine to Coarse SAND) =		**5.4E-05**	**135**						

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.

(3) Stantec Geomatics surveyed the ground surface elevations at each test pit 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.

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.

TABLE 4 - DESIGN INFILTRATION RATE CALCULATION

Proposed Infiltration Facility															
	Calculated Vertical Hydraulic Conductivities (m/s)													Geomean	Infiltration Rate (mm/hr)
Test Location	TP1-GP1	TP1-GP2	TP1-GP3	TP2-GP1	TP2-GP2	TP2-GP3	TP3-GP1	TP3-GP2	TP3-GP3	TP3-GP4	TP4-GP1	TP4-GP2	TP4-GP3		
Base of Facility	6.1E-05	3.4E-04		2.6E-04	1.0E-04		5.0E-05	1.3E-04						1.2E-04	168
~1.5 m below Base			2.5E-04			2.4E-04			3.4E-05	4.1E-04		8.1E-04	3.4E-04	2.5E-04	203
Ratio (Base / 1.5 m)															*0.8*
Safety Factor															2.5
Design Infiltration Rate															***67***

=168/203

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) Table C2 provided on Page C8 (Appendix C) of the *CVC/TRCA (2020) Low Impact Stormwater Management Planning and Design Guideline - Version 1.0.*

Table C2: Safety correction factors for calculating design infiltration rates

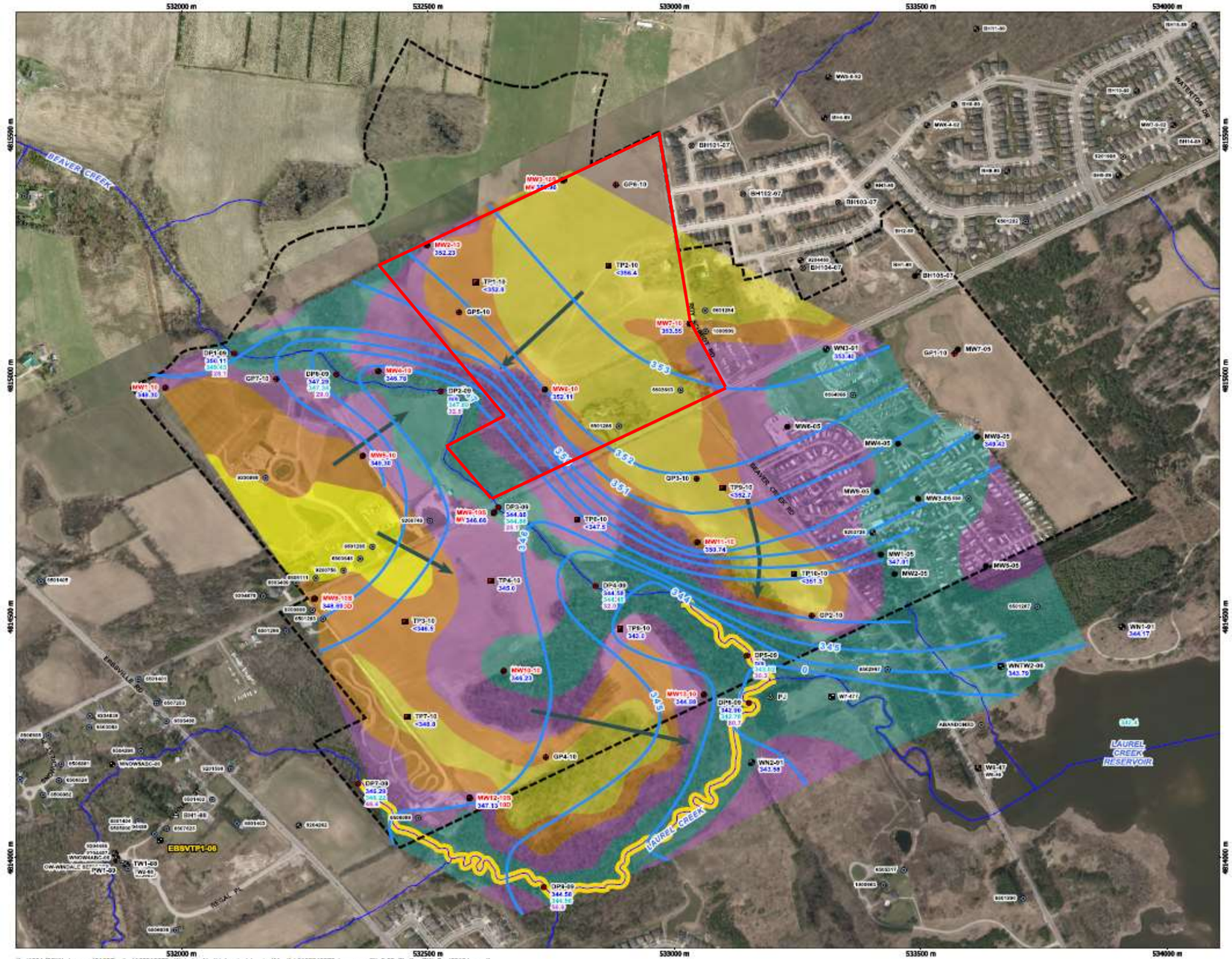
Ratio of Mean Measured Infiltration Rates[1]	Safety Correction Factor[2]
≤ 1	2.5
1.1 to 4.0	3.5
4.1 to 8.0	4.5
8.1 to 16.0	6.5
16.1 or greater	8.5

Source: Wisconsin Department of Natural Resources. 2004. Conservation Practice Standards. Site Evaluation for Stormwater Infiltration (1002). Madison, WI.

Notes:

1. Ratio is determined by dividing the geometric mean measured infiltration rate at the proposed bottom elevation of the BMP by the geometric mean measured infiltration rate of the least permeable soil horizon within 1.5 metres below the proposed bottom elevation of the BMP.
2. The design infiltration rate is calculated by dividing the geometric mean measured infiltration rate at the proposed bottom elevation of the BMP by the safety correction factor.

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
- Site Location

0 250 m

1:7500

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

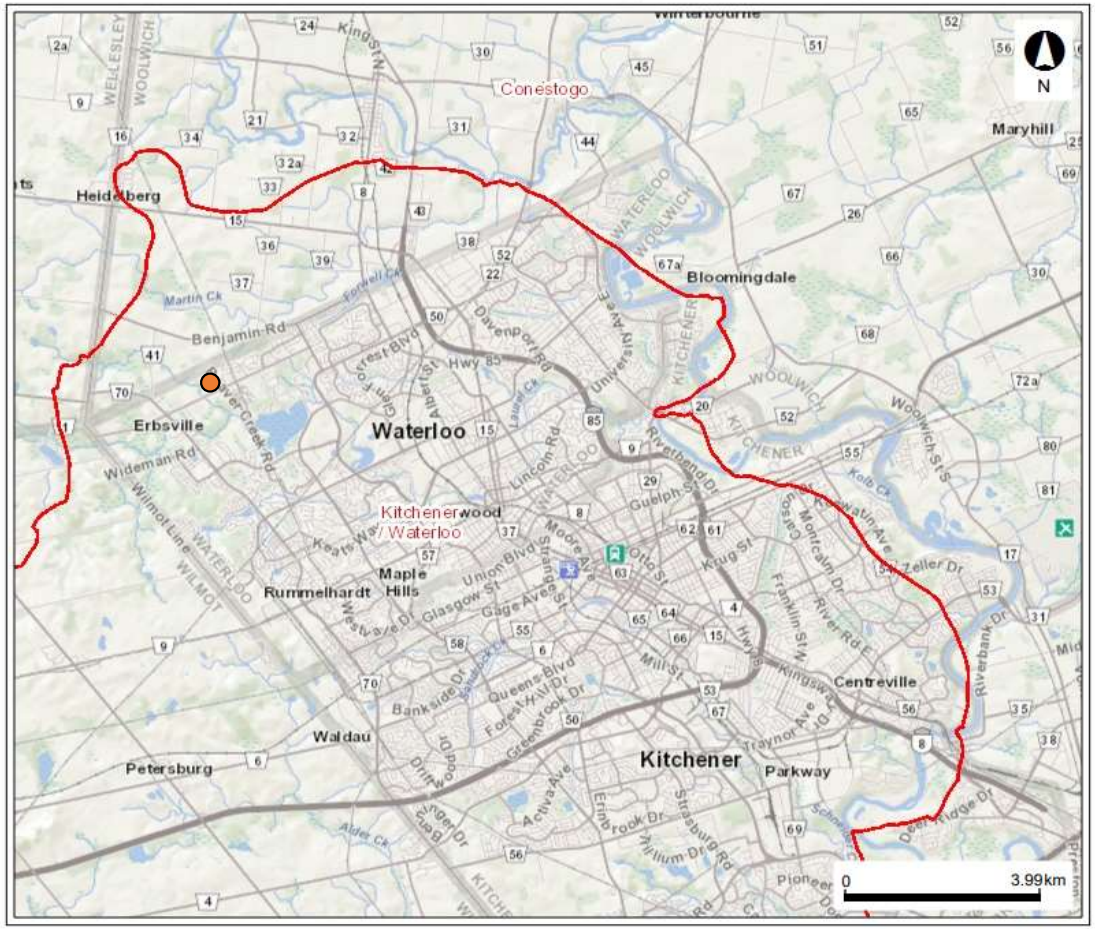
ecoplans

160330675

Source: Ecoplans Ltd., MacNaughton Hermsen Britton Clarkson Planning Limited (MHBC), and Stantec Consulting Ltd (Stantec). 2013. North Waterloo Scoped Subwatershed Study, Volume 1. November 2013.

APPENDIX E:
Source Water Protection Plan Mapping

WHPA-Q1 and WHPA-Q2



Legend

- Source Protection Areas
- Wellhead Protection Area Q1
- Wellhead Protection Area Q2
- **Site Location**

This map should not be relied on as a precise indicator of routes or locations, nor as a guide to navigation. The Ontario Ministry of Environment, Conservation and Parks (MECP) shall not be liable in any way for the use or any information on this map. of, or reliance upon, this map.

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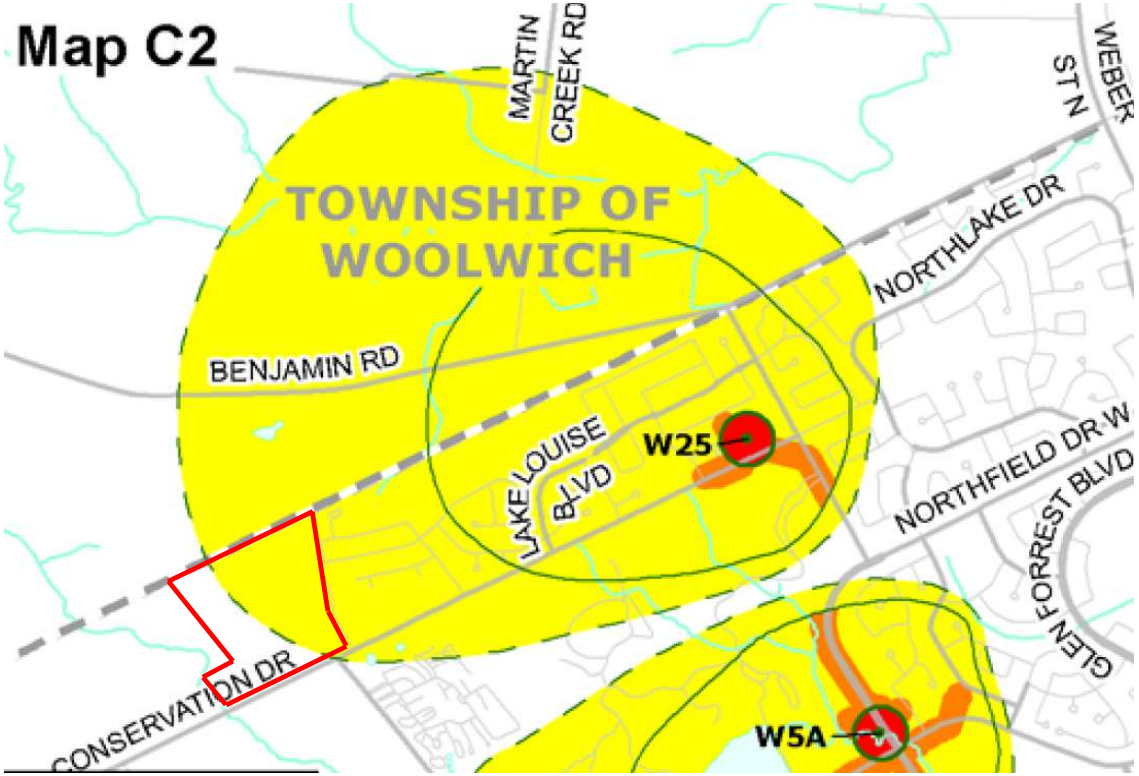
Map Created: 12/12/2021
Map Center: 43.47208 N, -80.51012 W

Note: WHPA-Q1 and WHPA-Q2 represented by same boundary as shown.

Stantec

Project:	556, 560 and 576 Conservation Drive, Waterloo Hydrogeological Assessment
Figure:	**E-1**
Title:	**WHPA-Q1 and WHPA-Q2**

10.8 Schedule D: Region of Waterloo Groundwater Systems: Map C



DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Significant Drinking Water Threat Policy Applicability

	Significant Drinking Water Threat Policy Categories	Vulnerability Scores on Map		
		10	8	2,4,6
1.	Waste Disposal			
2.	Sewage Systems			
3, 4.	Agricultural Source Material			
6, 7.	Non-Agricultural Source Material*			
8, 9.	Commercial Fertilizer*			
10, 11.	Pesticide			
12, 13.	Road Salt*			
14.	Storage of Snow			
15.	Fuel			
16.	DNAPLs			
17.	Organic Solvents			
18.	Aircraft De-icing			
21.	Livestock Area			
22.	Oil Pipelines			

Note: This table provides a summary of the activities listed in the Clean Water Act (2006) that apply as Prescribed Drinking Water Threats (PDWT) within Non-GUDI Wellhead Protection Zones on this map. For details refer to the Drinking Water Threats Tables from the Ministry of the Environment and Climate Change, and the text of this Source Protection Plan.
*Application of Commercial Fertilizer, Non-Agricultural Source Material, and Road Salt may not be a significant drinking water threat in some areas due to the % managed land, livestock density, and/or % impervious surface calculations for these areas. See the text of this plan for further details.

Well
Main Road
Minor River
Lake / Main River
Lower Tier Boundary

Wellhead Protection Zones:
WHPA-A
WHPA-B
WHPA-C
Site Location

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Project:	556, 560 and 576 Conservation Drive, Waterloo Hydrogeological Assessment
Figure:	**E-2**
Title:	**Source Protection Plan - Significant Drinking Water Threat Policy Applicability**

APPENDIX F:
Wellhead Protection Sensitivity Area Categories

Schedule B: Source Water Protection Land Use Categories

Category 'A'

- Waste treatment and disposal facilities, including lagoons, landfills, communal/municipal sewage treatment facilities and including large sewage vaults at sewage pumping stations, but not including facilities regulated under the Nutrient Management Act.
- Salvage yards, including automobile wrecking yards or premises
- Bulk storage of hazardous chemicals and hazardous substances (as listed in O.Reg. 347 under the Environmental Protection Act), including bulk storage of oil, gasoline or petroleum products, and including transportation terminals for these substances/chemicals (including truck/trailer/container parking, washing or cleaning depots)

Category 'B'

- Bulk storage of road salt and snow disposal sites
- Primary metal manufacturing, including iron and steel mills and ferro-alloy manufacturing; steel product manufacturing from purchased steel; alumina and aluminum production and processing; non-ferrous metal production and processing; and foundries
- Manufacturing of fabricated metal products, including manufacturing of unfinished metal products and metal finishing operations
- Manufacturing and assembly of transportation equipment, including motor vehicles and parts, aerospace products and parts, rail cars, ships and boats
- Manufacturing of machinery, including agricultural, commercial, industrial, and other machinery
- Chemical manufacturing including chemicals; resins; fertilizers, pesticides and other agricultural chemicals; pharmaceutical and medicines; paint, coating and adhesives; inks and other chemicals but excluding soap and cleaning compound manufacturing. Including manufacturing, packaging, repackaging, and bottling. Excludes uses involving bulk storage of hazardous materials which are included under Category 'A'
- Manufacturing of petroleum and coal products, including manufacturing of asphalt materials. Excludes uses involving bulk storage of hazardous materials which are included under Category 'A'
- Manufacturing of electronic components such as semiconductors, printed circuit boards, and cathode ray tubes
- Manufacturing of electrical equipment, appliances and components
- Commercial or industrial dry cleaning of textiles and textile products, excluding depots not performing on-site dry cleaning
- Manufacturing of leather and allied products including footwear
- Wood and wood product preservation and treatment
- Gasoline stations and other retail establishments with gasoline sales
- Wholesale/distributing of cleaning products, pesticides, herbicides, fungicides and chemicals

Category 'C'

- Manufacturing of rubber products
- Manufacturing of soap, cleaning compounds and toilet preparations
- Textile and fabric finishing and fabric coating
- Manufacturing of plastic products
- Manufacturing of wood products including wood furniture, and excluding wood preservation
- Manufacturing of glass and glass products
- Manufacturing of paper and paper products including newsprint and boxes
- Printing and related support activities, excluding business support services such as photocopy services
- Repair and Maintenance of automobiles and automotive machinery, electronic equipment, industrial and commercial machinery, and personal and household goods repair
- Golf courses
- Airports, train and public transit terminals, except terminals with no fuel storage or transfer of shipped goods or materials
- Medical, health and other laboratories (other than clinics generally associated with commercial plazas)
- Miscellaneous manufacturing not included elsewhere, including jewellery, silverware, medical equipment and signs
- Recycling, recovery, or remanufacturing of materials including the collection, processing, manufacturing, or reuse of post-consumer or post-industrial materials, not including recycling or disposal of hazardous materials, and not including salvage yards or facilities with outdoor operations which are Category 'A' uses

Category 'D'

- Underground parking garages
- *Geothermal wells*
- *Mineral aggregate operations* including *wayside pits and quarries*

Schedule C: Other information and materials that may be required to process an application

Digital Plans

- Subdivision/Condominium Plan(s)

Cultural

- *Archaeological Assessment*
- *Cultural Heritage Impact Assessment*

Environmental

- Aggregate/Mineral Resource Analysis
- Local Air Quality Study

- Salt Impact Assessment
- Salt Management Plans
- Cut & Fill Analysis
- *Environmental Impact Statement*
- Comprehensive *Environmental Impact Statement*
- Natural Habitat Inventory
- Environmental Management Plan
- Tree Conservation and Planting Plans
- *Provincial and Federal Requirements* for *Fish Habitat*
- Slope Stability Study and Report
- Floodline Delineation Study/Hydraulics Study
- Hydrologic and Hydrogeologic Studies
- Source Water Protection Studies
- Best Management Practices for development within the Regional Recharge Area
- Best Management Practices (for golf courses)
- Environmental Site Assessment and/or Record of Site Condition
- *Cumulative Impact* Assessment
- Site Plan, Spill Protection Measures and other Best Management Practices for *Mineral Aggregate Operations*
- Final Rehabilitation Plan (for *mineral aggregate operations*)

Construction, Servicing and Infrastructure

- Preliminary Grading Plan
- Preliminary Stormwater Management Report/Plan and/or update to an existing Stormwater Management Plan
- Soils/Geotechnical Study
- Construction Methods and Spills Protection Measures
- Servicing Options Report
- Development Phasing Plan
- Water and Wastewater Servicing Plans and associated studies
- Hydrogeologic Studies for Privately Serviced Developments
- Impact on Existing Infrastructure Study

Land Use Compatibility

- Air Quality Assessment
- Dust Impact Analysis
- Land Use Compatibility Study
- Landfill Impact Study
- Agricultural Impact Assessment
- *Minimum Distance Separation*
- Noise Study
- Odour Impact Assessment
- Vibration Study
- Written Provincial approval (pursuant to the Environmental Protection Act for development within former waste management facilities)

- *Provincial and Federal Requirements* for *Alternative and/or Renewable Energy Systems* and *Fish Habitat*
- Approval from the Grand River Conservation Authority

Planning

- Affordable Housing Report/Rental Conversion Assessment
- Detailed Property Assessment of Affordable Rental Housing
- Farm Viability Study
- Planning Report
- Land Use Study for Retail/Commercial Land Uses in Support of the Planned Community Structure or Retail/Commercial Impact Analysis
- Retail Commercial Market Impact Study
- Urban Design Report/Brief

Transportation

- Transportation Impact Study
- Transportation System Impact Study
- Parking Analysis
- *Pedestrian* Route and Sidewalk Analysis
- Roundabout Feasibility Analysis
- Traffic Calming Options Report
- Transit Assessment
- Transportation Demand Management Options Report
- Provincial Requirements and Permits under the Public Transportation Act and Highway Improvements Act
- Environmental Assessment and Other Appropriate Studies for development adjacent to Proposed Regional and Provincial Corridors

APPENDIX G:
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

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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

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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

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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

Monitoring Well: MW101-21

Project:	556, 560 & 576 Conservation Drive, Waterloo	**Drilling method:**	Track Mounted CME 850 Hollow Stem Auger
Client:	2115881 Ontario Limited	**Date started/completed:**	25-May-2021
Location:	Waterloo, Ontario	**Ground surface elevation:**	358.88 m AMSL
Number:	160900921	**Top of casing elevation:**	359.87 m AMSL
Field investigator:	D. Smith	**Easting:**	532701
Contractor:	Aardvark Drilling Inc.	**Northing:**	4815051

SUBSURFACE PROFILE				SAMPLE DETAILS					INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Recovery	N Value	Lab Analyses	Diagram / Description
				359.62						Above Ground Casing 0.99 m stick-up
			Ground Surface	358.88						
0	0		TOPSOIL (SAND)	0.00						Cement Seal 0 to 0.3 m
			Fine grained, trace organics, yellowish brown (10YR 5/4), dry	358.73	1	SS	18" 75%	2-4-9-7 (13)		
			SAND	0.15						
			Fine to medium grained, some coarse grained sand to coarse gravel, subangular, trace silt/clay, grayish brown (10YR 5/2), loose to compact, moist		2	SS	17" 71%	3-7-10-8 (17)		
			Trace fine and coarse gravel starting at 0.76 m							
			10 cm seam of fine grained sand, trace silt/clay at 1.01 m							
5					3	SS	19" 79%	2-4-5-9 (9)		
	2									210 mm diameter borehole
			Fine to medium grained sand, trace coarse grained sand to fine gravel starting at 2.29 m		4	SS	20" 83%	3-8-8-9 (16)		
10										Bentonite Chips 0.3 to 5.5 m BGS
					5	SS	20" 83%	3-7-12-16 (19)		
			2 cm seam of crushed rock at 3.38 m							
			Increase in moisture, small black laminations starting at 3.43 m	355.07						
	4		SAND	3.81						
			Fine grained, trace medium grained sand and silt, light grayish brown (10YR 6/2), moist, compact, poorly graded	354.92	6	SS	19" 79%	5-11-12-14 (23)		
			SAND	3.96						
15			Fine to medium grained, trace coarse grained sand, gravel, and silt/clay, grayish brown (10YR 5/2), moist, compact		7	SS	21" 88%	5-8-13-16 (21)		
					8	SS	19" 79%	6-11-14-15 (25)		
20	6									No. 2 Silica Sand 5.5 to 8.8 m
					9	SS	21" 88%	6-12-14-16 (26)		Water Level 6.6 m BGS 26-May-21
			Some coarse grained sand starting at 6.55 m	352.02						
			SAND	6.86						
			Fine grained, trace medium grained sand to fine gravel, trace silt/clay, grayish brown (10YR 5/2), wet, compact, poorly graded		10	SS	23" 96%	10-13-16-17 (29)		
25										
	8				11	SS	24" 100%	1-9-8-12 (17)		
			Some medium grained sand starting at 8.05 m							No. 10 Slot Schedule 40 PVC Screen 52 mm I.D. 5.7 to 8.8 m
				350.08	12	SS	24" 146%	1-5-15/4.4" (15/4.4")		
			End of Borehole	8.80						
30										

Screen Interval: 6.10 - 8.80 m BGS
Sand Pack Interval: 5.79 - 8.80 m BGS
Well Seal Interval: 0.30 - 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

GSA - Grain Size Analysis

Stantec

Drawn By/Checked By: A.H. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 12/10/21 ARUCHKALL

Test Pit: TP1-21

Project:	556, 560 & 576 Conservation Drive, Waterloo	**Drilling method:**	Backhoe
Client:	2115881 Ontario Limited	**Date started/completed:**	27-May-2021
Location:	Waterloo, Ontario	**Ground surface elevation:**	357.94 m AMSL
Number:	160900921	**Top of casing elevation:**	n/a
Field investigator:	M. Steinepreis	**Easting:**	532705
Contractor:	TDC Excavating Ltd.	**Northing:**	4815091

SUBSURFACE PROFILE				SAMPLE DETAILS		INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Diagram / Description
			Ground Surface	357.94			
			TOPSOIL Sand	0.00 357.69			
			SAND Fine to coarse grained, trace silt, white/gray, moist, compact	0.25			
2	1						
4							
6	2						
8							
10	3						Backfilled with Natural Cave 0 to 5.7 m
12			30 cm thick isolated, discontinuous pockets of silty sand starting at 3.5 m BGS				
12	4				1	GS	
14							
16	5				2	GS	
18							
			Water table at 5.7 m BGS	352.24			
	6		End of Test Pit	5.70			

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
GS - grab sample
n/a - not available

Stantec

Drawn By/Checked By: A.H. /

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 12/10/21 ARUCHKALL

Test Pit: TP2-21

Project:	556, 560 & 576 Conservation Drive, Waterloo	**Drilling method:**	Backhoe
Client:	2115881 Ontario Limited	**Date started/completed:**	27-May-2021
Location:	Waterloo, Ontario	**Ground surface elevation:**	356.77 m AMSL
Number:	160900921	**Top of casing elevation:**	n/a
Field investigator:	M. Steinepreis	**Easting:**	532663
Contractor:	TDC Excavating Ltd.	**Northing:**	4815057

SUBSURFACE PROFILE				SAMPLE DETAILS		INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Diagram / Description
			Ground Surface	356.77			
			TOPSOIL Sand	0.00 356.54			
			SAND Fine to coarse grained, trace gravel, trace silt, white/gray, moist	0.23			
2	1						
4							
6	2						Backfilled with Natural Cave 0 to 4 m
8					1	GS	
10	3						
12				352.77			
	4		Sample collected from below test pit base	4.00	2	GS	
14			End of Test Pit				

Screen Interval: n/a
Sand Pack Interval: n/a
Well Seal Interval: n/a

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
GS - grab sample
n/a - not available

Stantec

Drawn By/Checked By: A.H. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 12/10/21 ARUCHKALL

Test Pit: TP3-21

Project:	556, 560 & 576 Conservation Drive, Waterloo	**Drilling method:**	Backhoe
Client:	2115881 Ontario Limited	**Date started/completed:**	27-May-2021
Location:	Waterloo, Ontario	**Ground surface elevation:**	357.98 m AMSL
Number:	160900921	**Top of casing elevation:**	n/a
Field investigator:	M. Steinepreis	**Easting:**	532702
Contractor:	TDC Excavating Ltd.	**Northing:**	4815036

SUBSURFACE PROFILE				SAMPLE DETAILS		INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Diagram / Description
			Ground Surface	357.98			
			TOPSOIL Sand, brown	0.00 357.78			
			SAND Medium to coarse grained, some silt, trace gravel, gray/white, moist, compact	0.20			
2			10 cm seam of gravelly sand, fine to coarse gravel, medium to coarse grained sand, subrounded, gray/white, moist from 0.7 to 0.8 m				
	1						
4							
6							
	2						
8							Backfilled with Natural Cave 0 to 5.2 m
10							
	3						
12					1	GS	
	4						
14							
16				352.77			
	5		Sample collected from below test pit base	5.21	2	GS	
18			End of Test Pit				
	6						

Screen Interval: n/a
Sand Pack Interval: n/a
Well Seal Interval: n/a

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
GS - grab sample
n/a - not available

Stantec

Drawn By/Checked By: A.H. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 12/10/21 ARUCHKALL

Test Pit: TP4-21

Project:	556, 560 & 576 Conservation Drive, Waterloo	**Drilling method:**	Backhoe
Client:	2115881 Ontario Limited	**Date started/completed:**	27-May-2021
Location:	Waterloo, Ontario	**Ground surface elevation:**	355.83 m AMSL
Number:	160900921	**Top of casing elevation:**	n/a
Field investigator:	M. Steinepreis	**Easting:**	532630
Contractor:	TDC Excavating Ltd.	**Northing:**	4815043

SUBSURFACE PROFILE				SAMPLE DETAILS		INSTALLATION DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Sample Number	Sample Type	Diagram / Description
			Ground Surface	355.83			
			SAND Fine to coarse grained, white/gray, moist	0.00			
2							
	1				1	GS	
4							
6							
	2						Backfilled with Natural Cave 0 to 4 m
8							
10	3						
12							
	4			351.83			
			Sample collected from below test pit base	4.00			
14					2	GS	
			End of Test Pit				

Screen Interval: n/a
Sand Pack Interval: n/a
Well Seal Interval: n/a

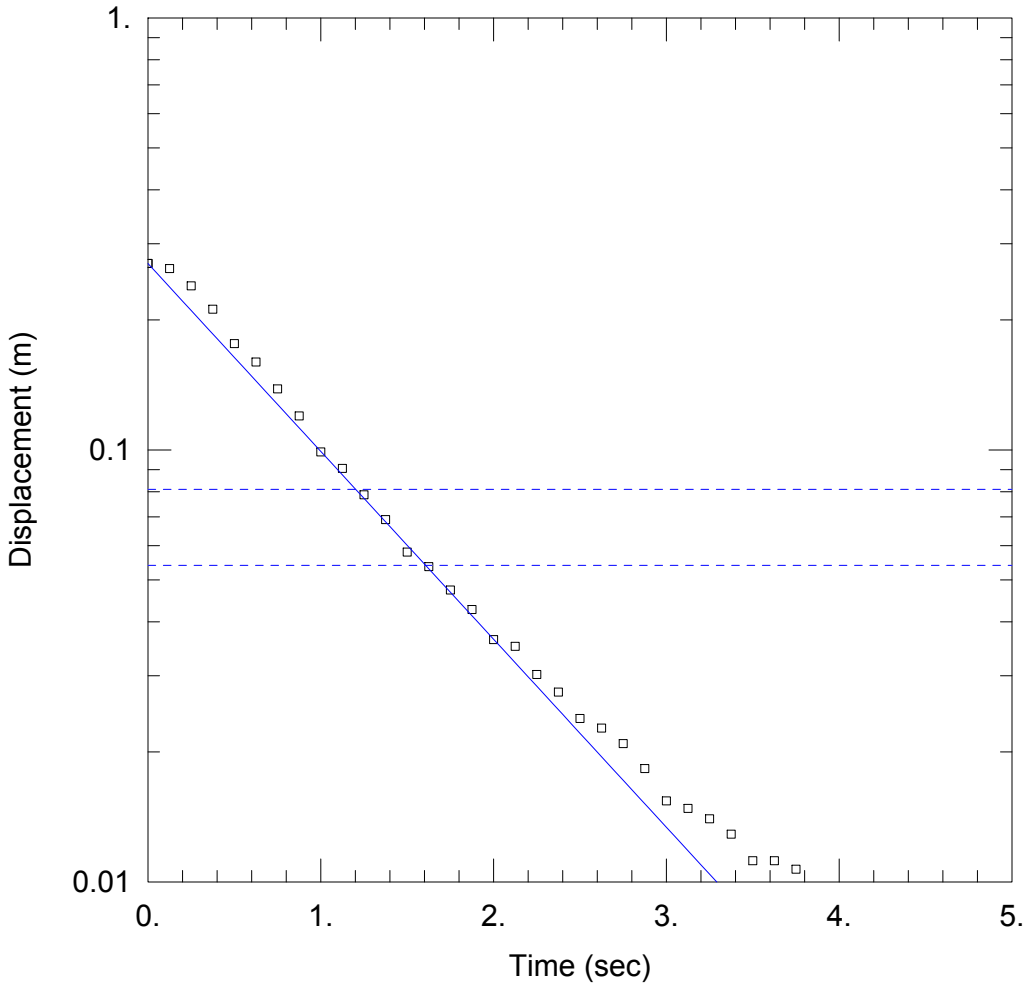
Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
GS - grab sample
n/a - not available

Stantec

Drawn By/Checked By: A.H. / G.W.

STANTEC BOREHOLE AND WELL V2 160900921.GPJ STANTEC - DATA TEMPLATE.GDT 12/10/21 ARUCHKALL

APPENDIX H:
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

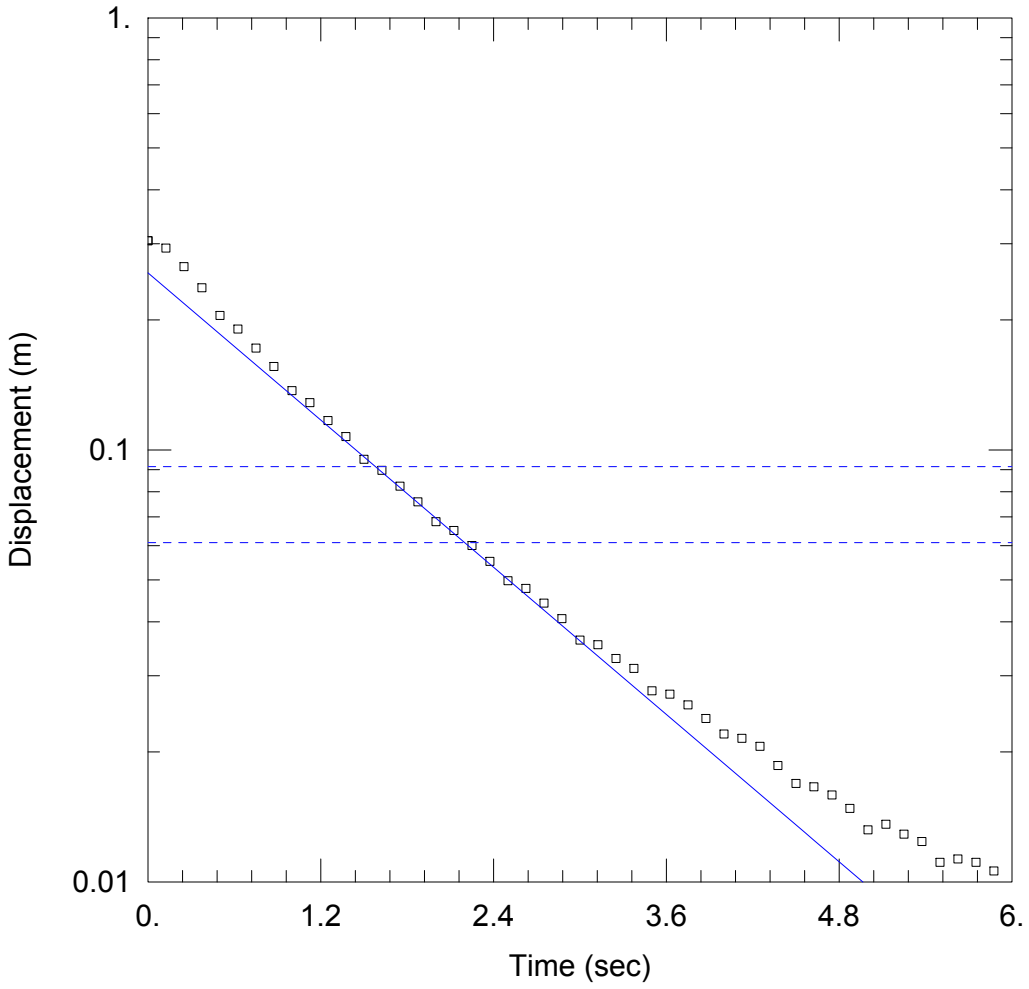
Saturated Thickness: 4.15 m Anisotropy Ratio (Kz/Kr): 0.5

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

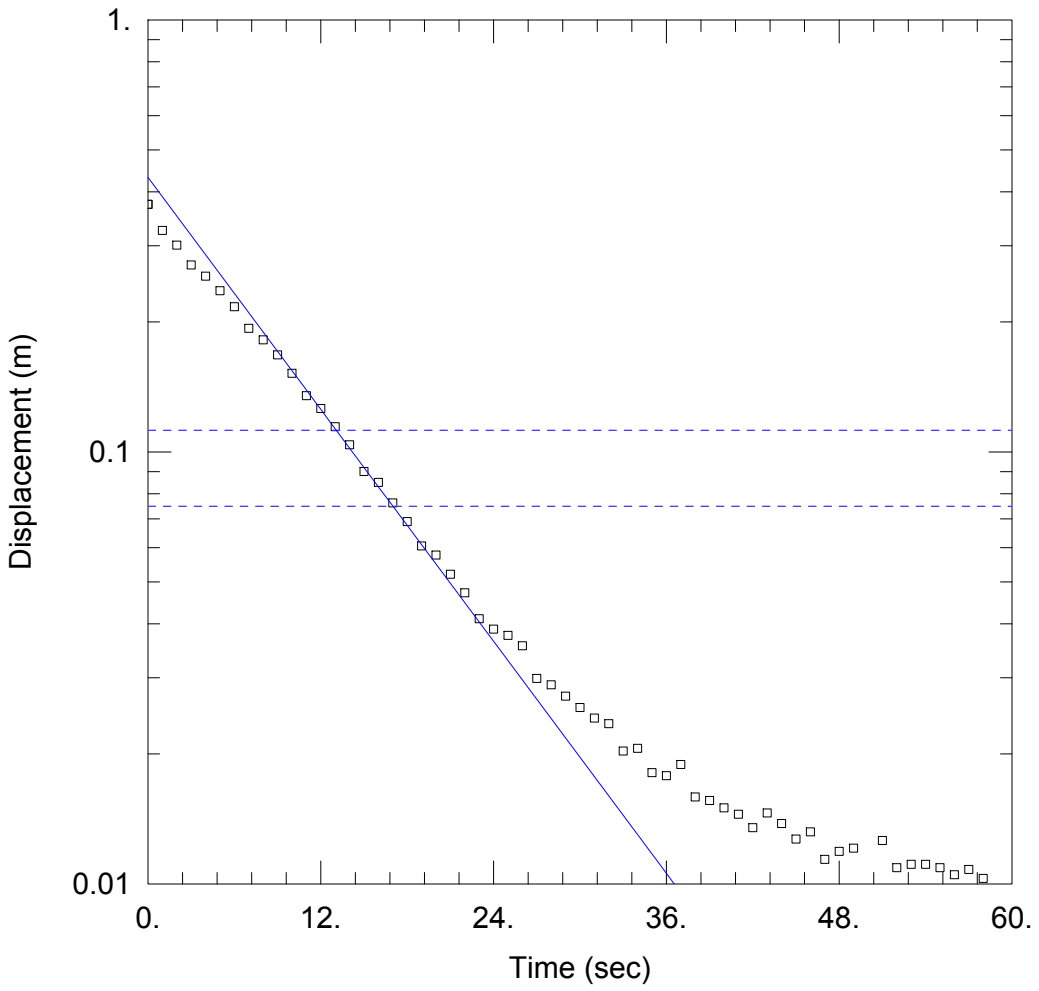
Saturated Thickness: 3.955 m Anisotropy Ratio (Kz/Kr): 0.5

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

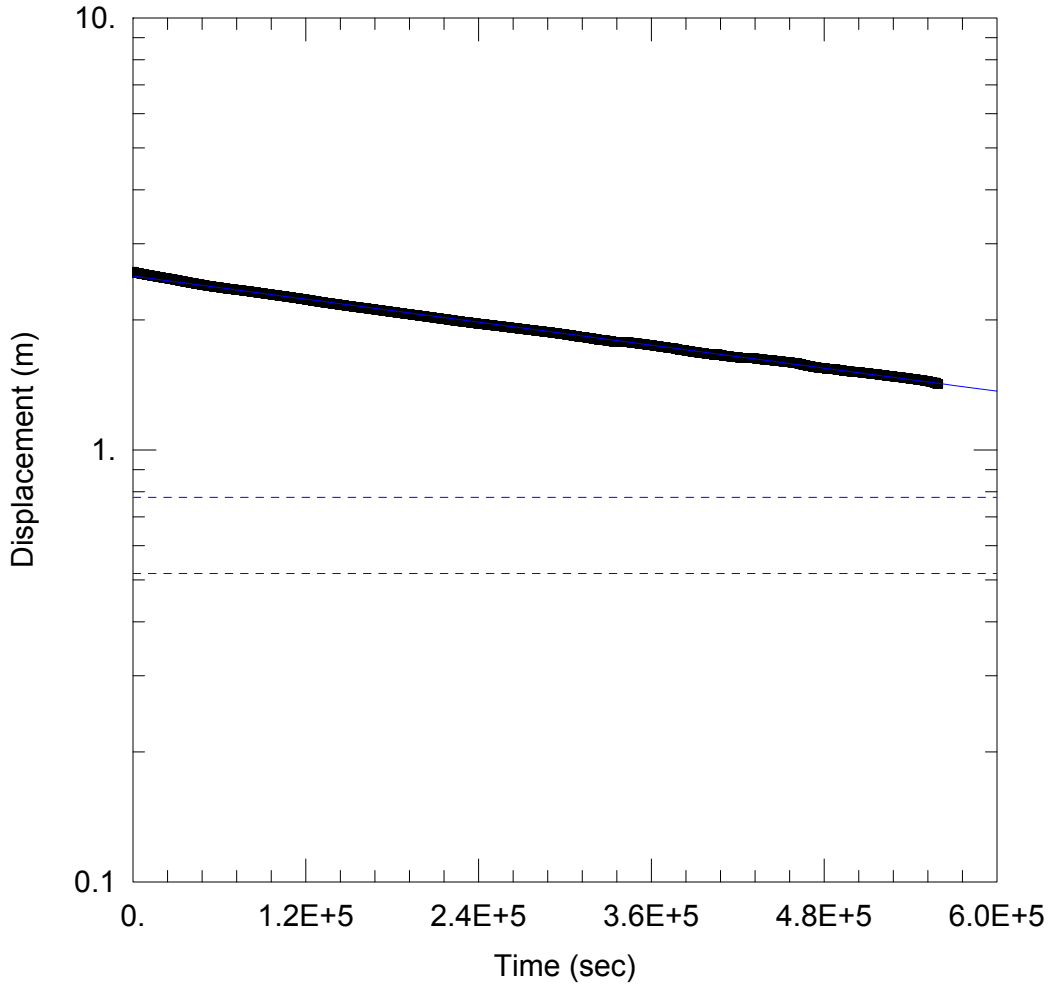
WELL DATA (MW4-19)

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

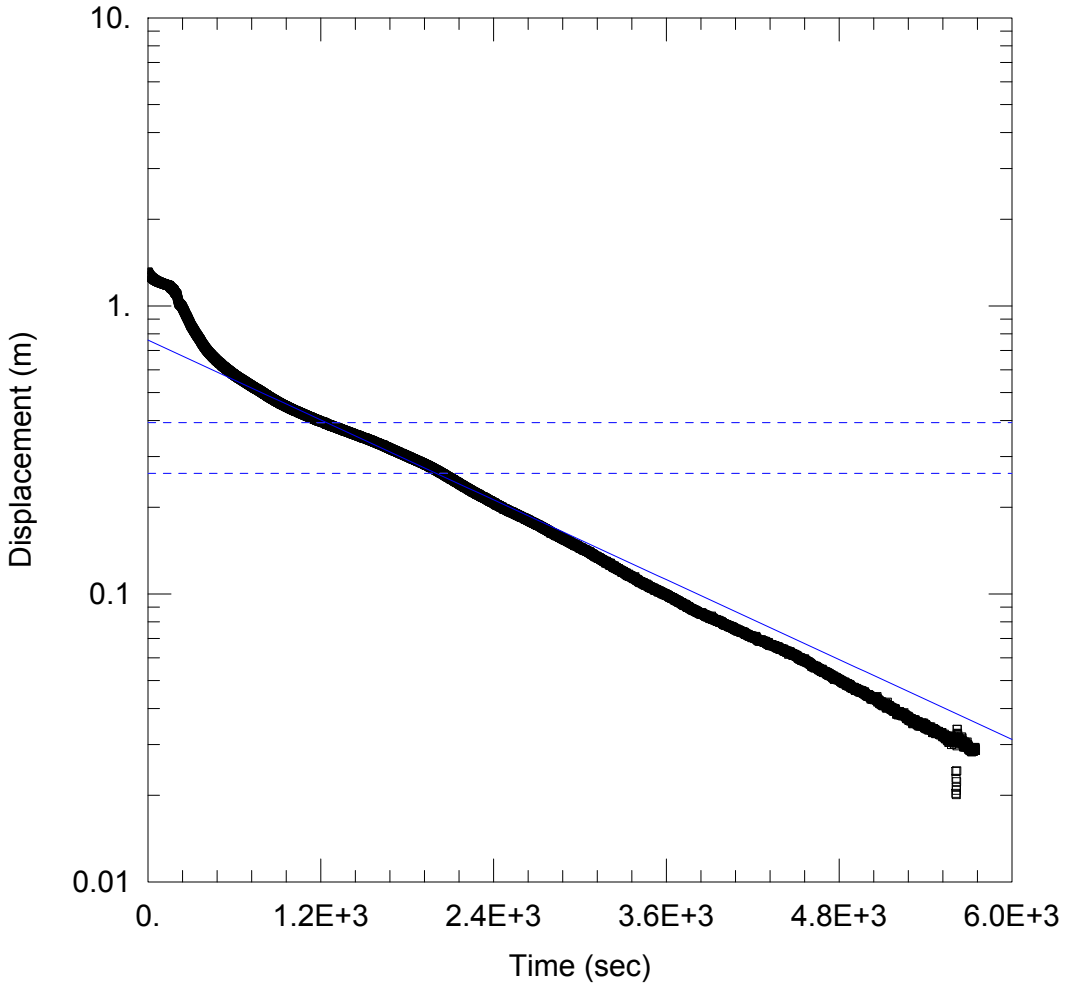
WELL DATA (MW5-19)

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

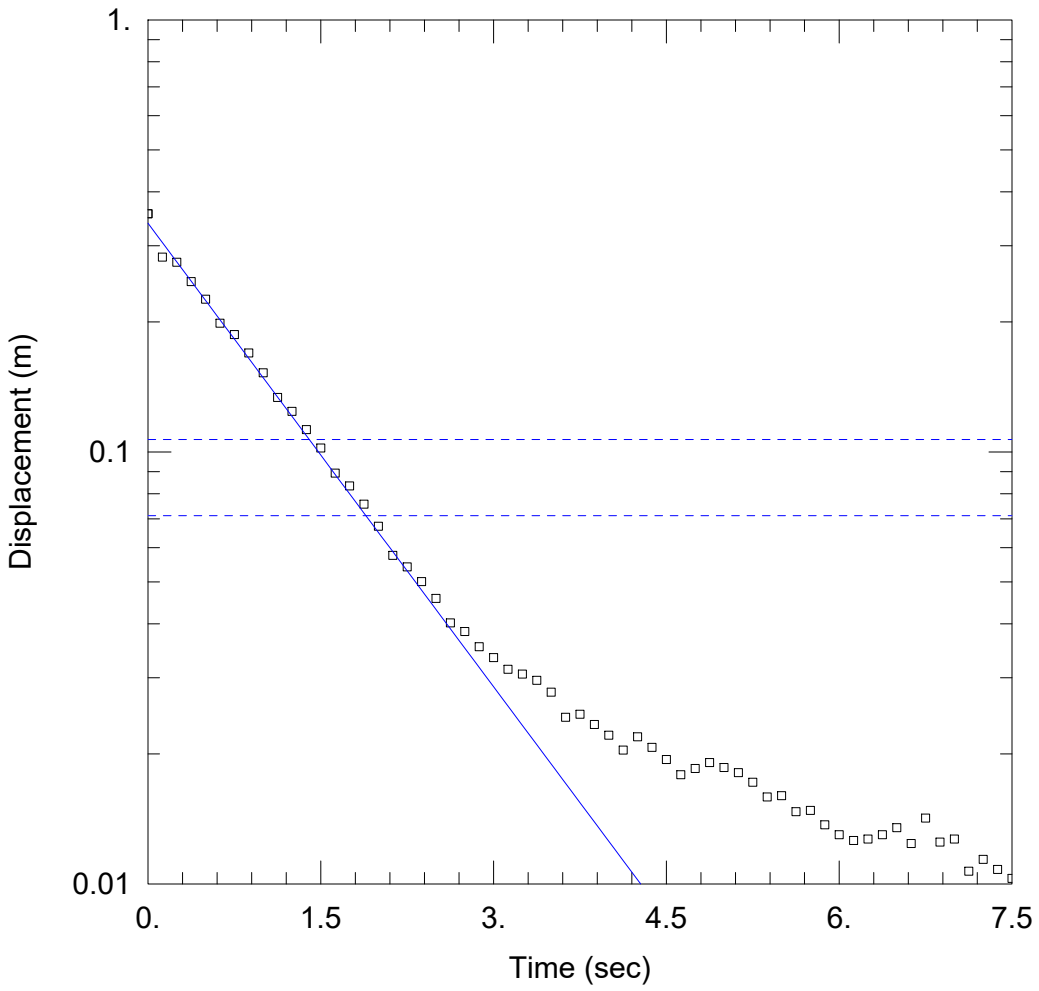
WELL DATA (MW6-19)

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



MW101-21 TEST 2

Data Set: \...\MW101-21_eighth second test_DS_JK.aqt
Date: 06/01/21 Time: 17:50:42

PROJECT INFORMATION

Company: Stantec
Project: 160900921
Location: Waterloo, Ontario
Test Well: MW101-21
Test Date: May 26, 2021

AQUIFER DATA

Saturated Thickness: 2.18 m Anisotropy Ratio (Kz/Kr): 0.5

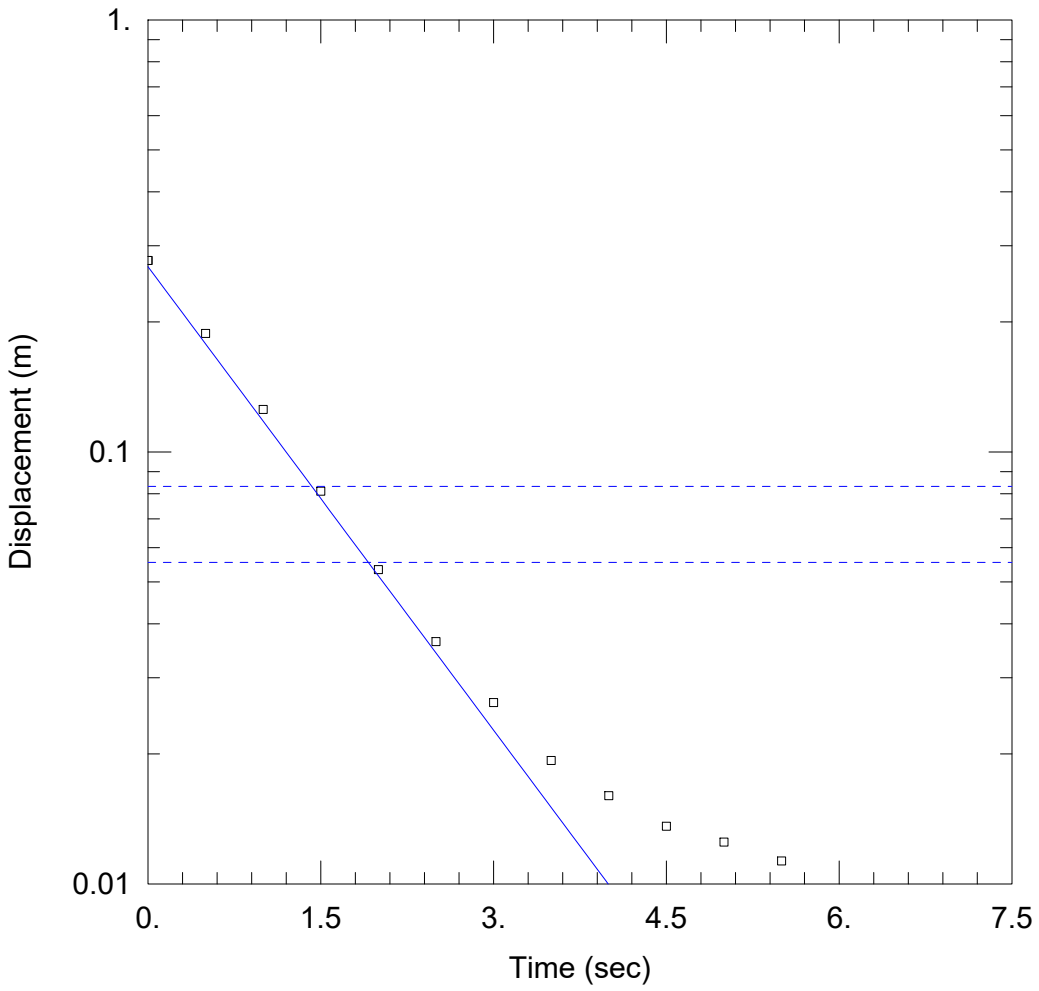
WELL DATA (MW101-21)

Initial Displacement: 0.356 m
Total Well Penetration Depth: 2.18 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.18 m
Screen Length: 2.18 m
Well Radius: 0.105 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.0016 m/sec y0 = 0.3383 m



MW101-21

Data Set: \...\MW101-21_half second test_DS_JK.aqt
Date: 06/01/21 Time: 17:52:15

PROJECT INFORMATION

Company: Stantec
Project: 160900921
Location: Waterloo, Ontario
Test Well: MW101-21
Test Date: May 26, 2021

AQUIFER DATA

Saturated Thickness: 2.18 m Anisotropy Ratio (Kz/Kr): 0.5

WELL DATA (MW101-21)

Initial Displacement: 0.2774 m
Total Well Penetration Depth: 2.18 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.18 m
Screen Length: 2.18 m
Well Radius: 0.105 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.0016 m/sec y0 = 0.2684 m

APPENDIX I:
Grain Size Analysis

Englobe
353 Bridge Street East, Kitchener, ON N2K 2Y5
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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-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	

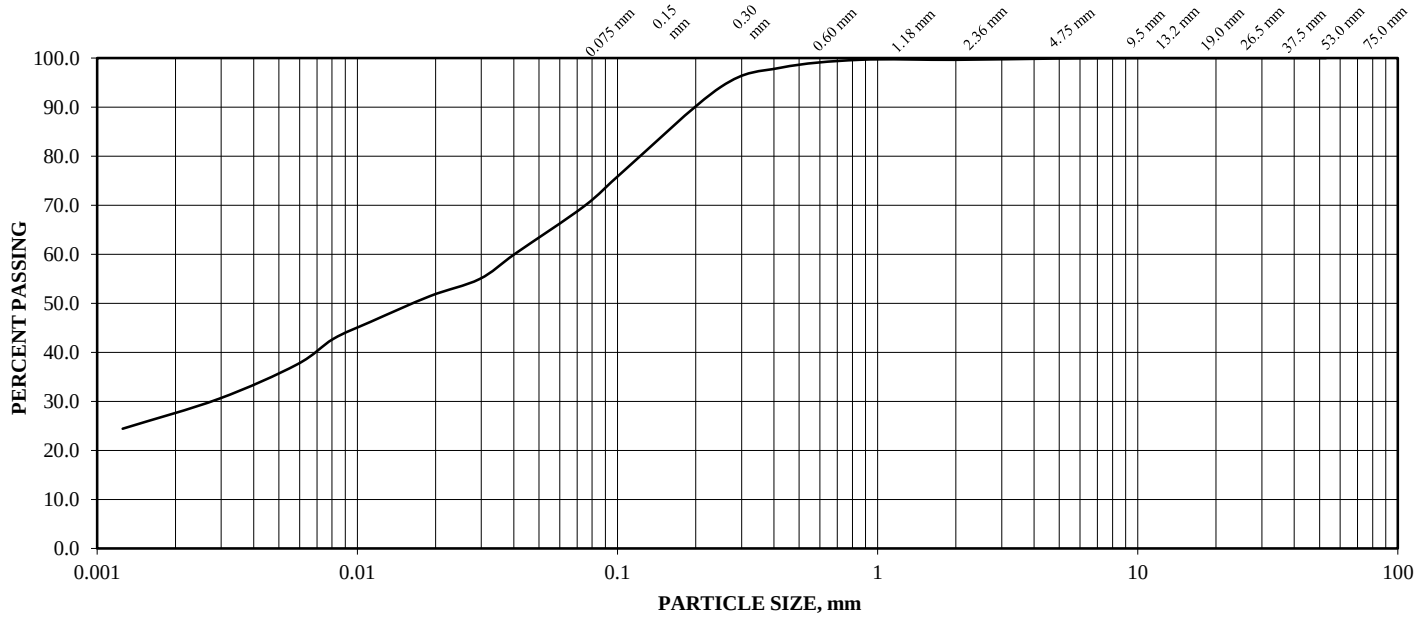
PARTICLE SIZE DISTRIBUTION, MTO LS-702

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

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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	

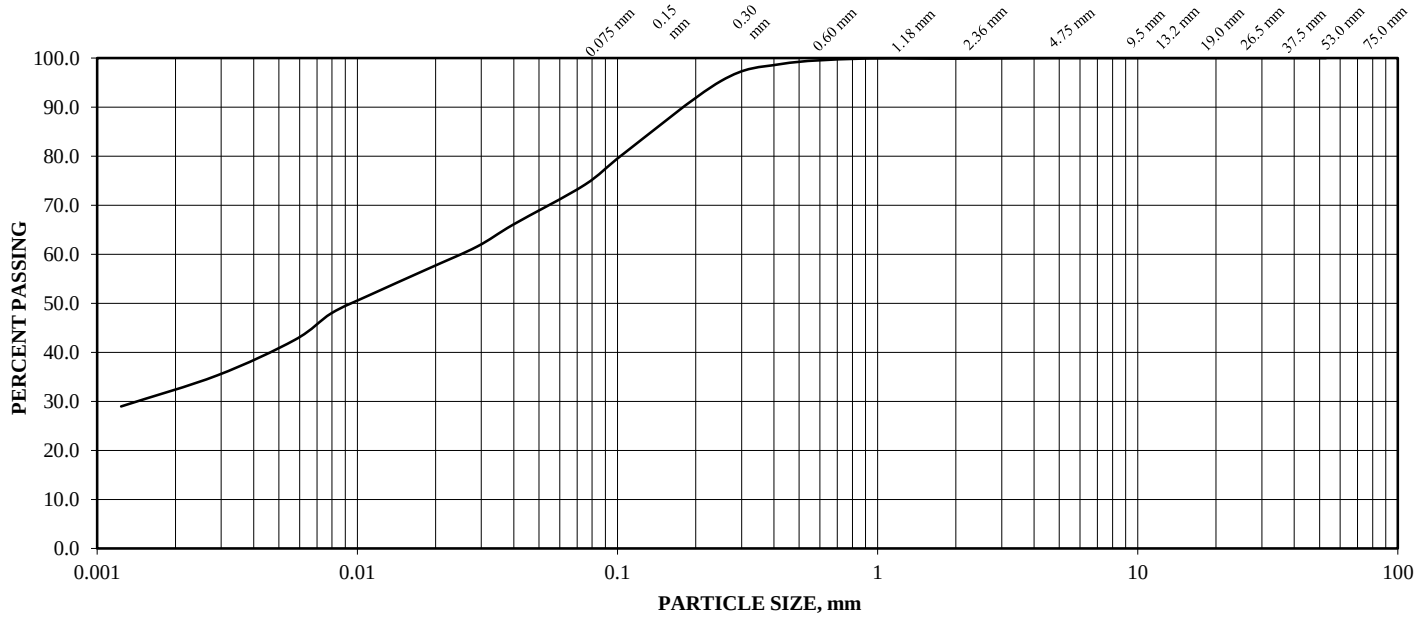
PARTICLE SIZE DISTRIBUTION, MTO LS-702

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

O. Rexha

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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	

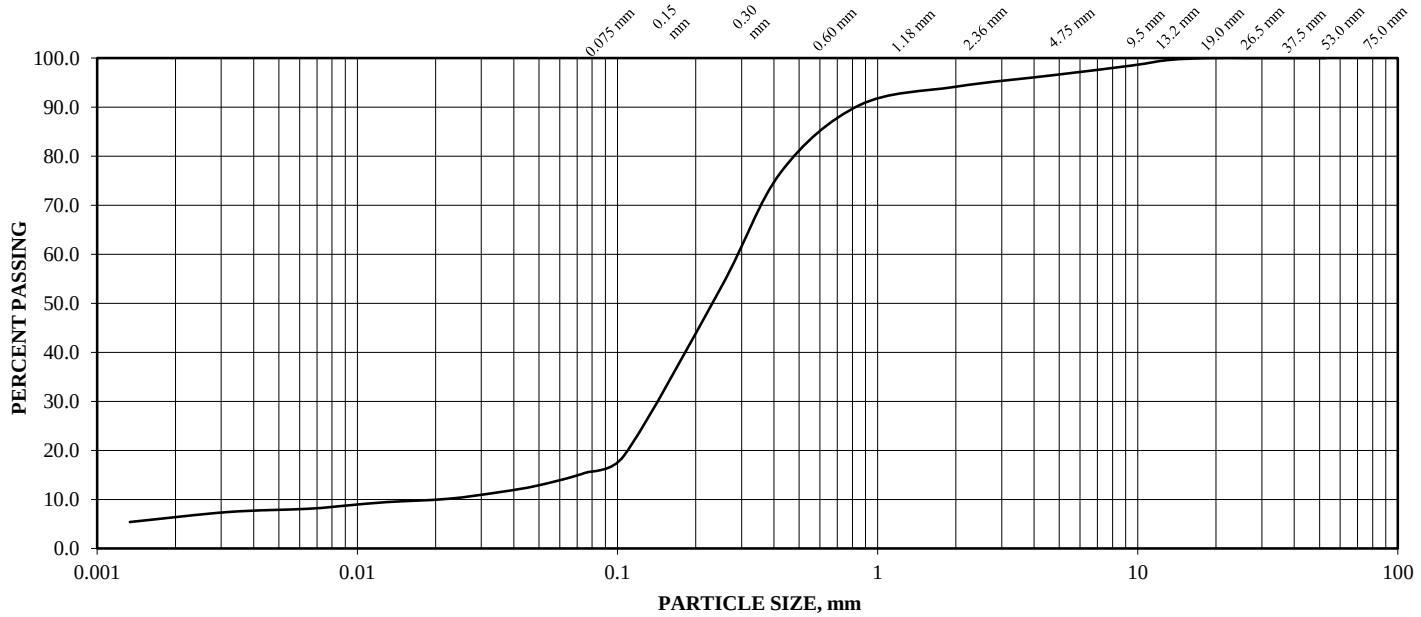
PARTICLE SIZE DISTRIBUTION, MTO LS-702

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

O. Rexha

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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	

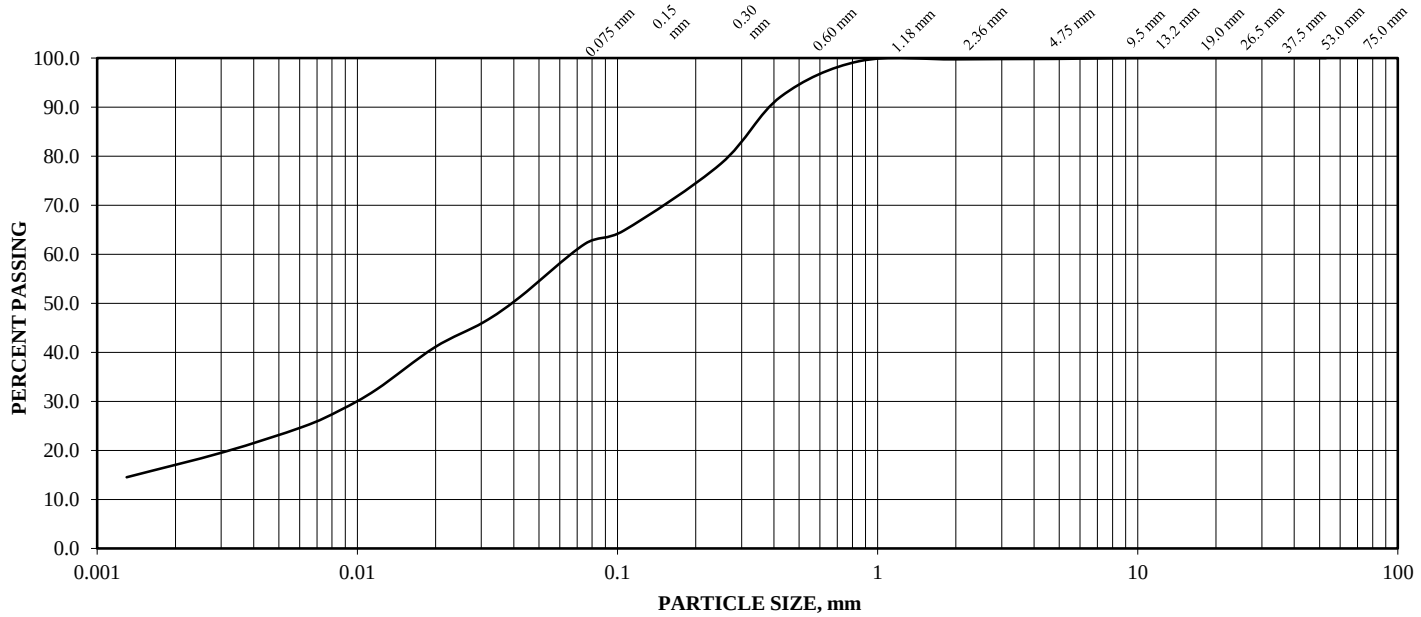
PARTICLE SIZE DISTRIBUTION, MTO LS-702

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

O. Rexha

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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-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	

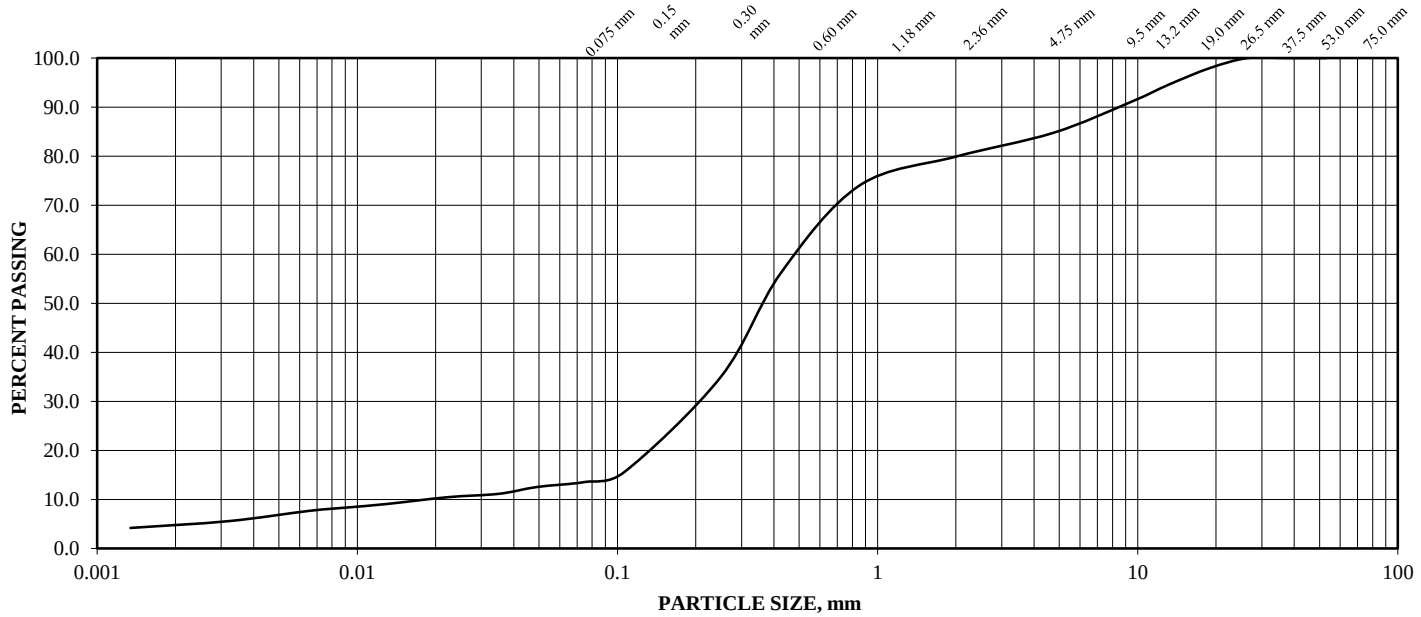
PARTICLE SIZE DISTRIBUTION, MTO LS-702

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

TP1-GP1

GRAIN SIZE ANALYSIS REPORT
LS-602

PROJECT NUMBER:	04.P0019533.500	**PROJECT NAME:**	556 & 576 Conservation Drive - Waterloo	**CLIENT:**	Stantec
LAB NUMBER:	S-797	**SAMPLE ID:**	TP1-21 Sample 01	**SAMPLE DEPTH:**	4.0 - 4.4m
SAMPLED BY:	Client	**DATE RECEIVED:**	June 10, 2021	**DATE COMPLETED:**	June 14, 2021

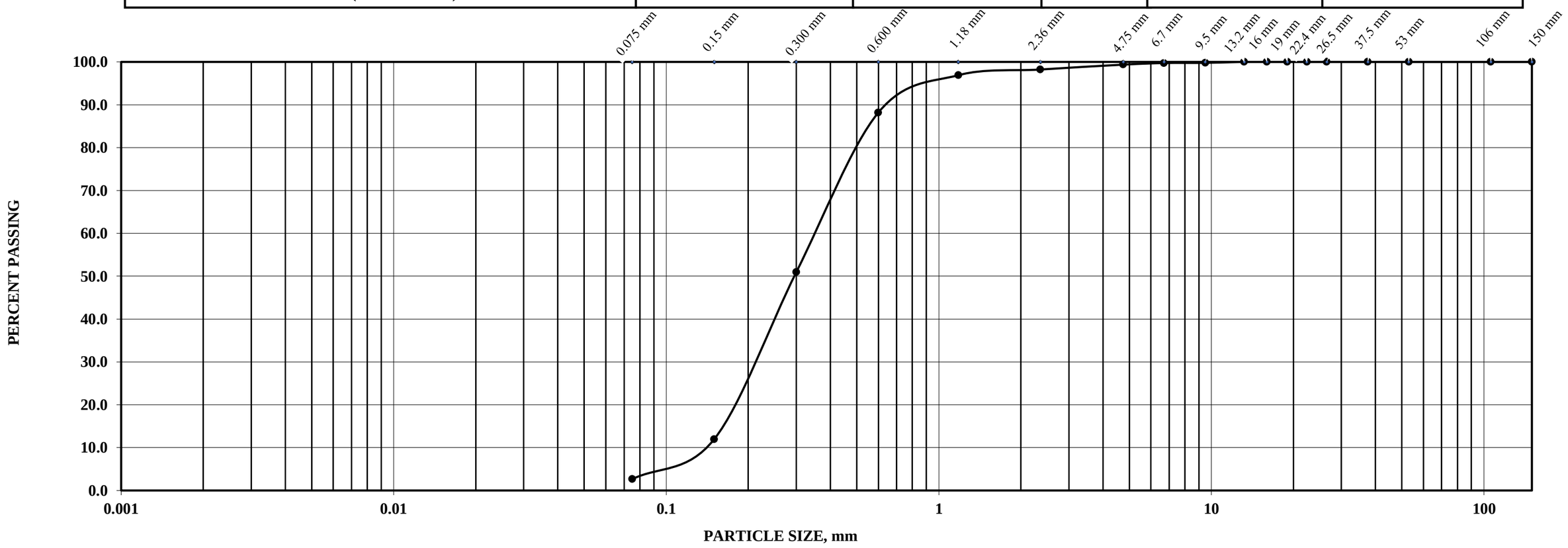
PARTICLE SIZE DISTRIBUTION, MTO LS-602

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM	COARSE	FINE	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



COEFFICIENTS

D60	0.373	**D30**	0.219	**D10**	0.134	**Cc**	0.963	**Cu**	2.78

GRAIN SIZE ANALYSIS

SIEVE SIZE mm	% PASSING
150	100.0
106	100.0
53	100.0
37.5	100.0
26.5	100.0
22.4	100.0
19	100.0
16	100.0
13.2	100.0
9.5	99.8
6.7	99.7
4.75	99.4
2.36	98.2
1.18	96.9
0.6	88.2
0.3	50.9
0.15	12.0
0.075	2.7

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	0.6
% SAND (75 µm to 4.75 mm):	96.7
% SILT (2 µm to 75 µm):	2.7
% CLAY (<2 µm):	-

SOIL DESCRIPTION:	SP	SAND, trace Silt

REMARKS

Figure: 2

TESTED BY: Kevin Frank — Laboratory Technician

REVIEWED BY David McBay, C.Tech. — Laboratory Supervisor

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TP1-GP3

GRAIN SIZE ANALYSIS REPORT
LS-602

PROJECT NUMBER:	04.P0019533.500	**PROJECT NAME:**	556 & 576 Conservation Drive - Waterloo	**CLIENT:**	Stantec
LAB NUMBER:	S-798	**SAMPLE ID:**	TP1-21 Sample 02	**SAMPLE DEPTH:**	5.0 - 5.5m
SAMPLED BY:	Client	**DATE RECEIVED:**	June 10, 2021	**DATE COMPLETED:**	June 14, 2021

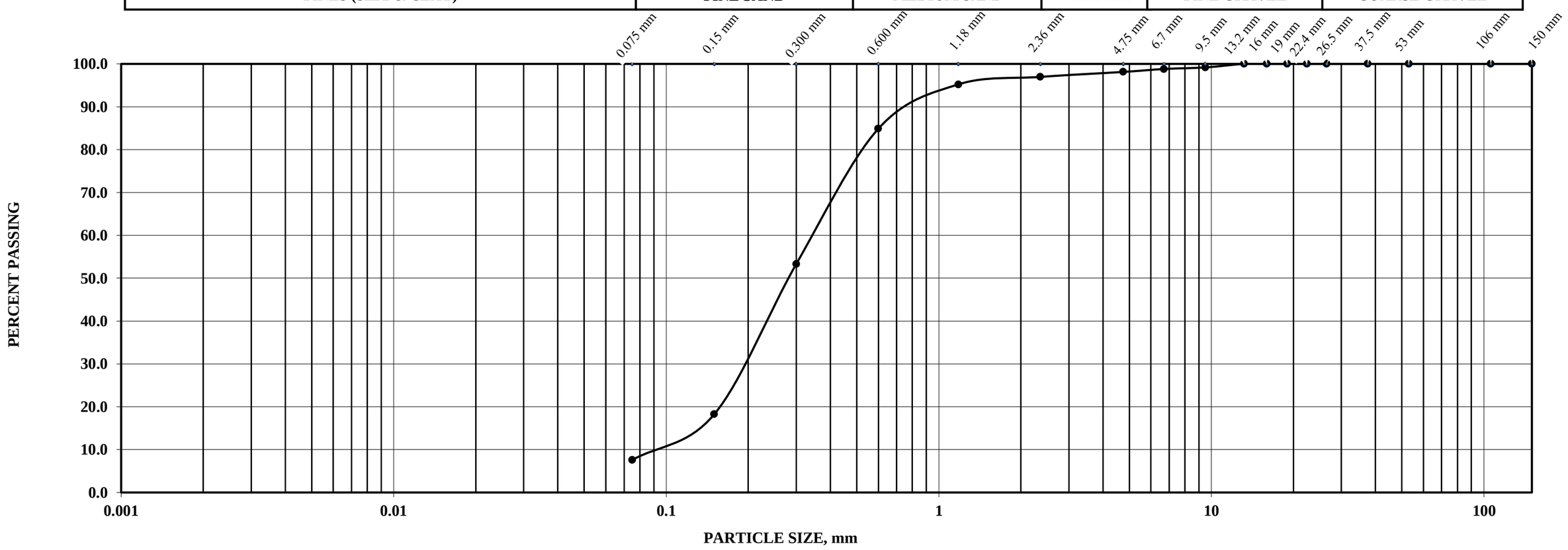
PARTICLE SIZE DISTRIBUTION, MTO LS-602

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM	COARSE	FINE	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



COEFFICIENTS

D60	0.363	**D30**	0.200	**D10**	0.092	**Cc**	1.200	**Cu**	3.95

GRAIN SIZE ANALYSIS

SIEVE SIZE mm	% PASSING
150	100.0
106	100.0
53	100.0
37.5	100.0
26.5	100.0
22.4	100.0
19	100.0
16	100.0
13.2	100.0
9.5	99.2
6.7	98.8
4.75	98.1
2.36	97.0
1.18	95.2
0.6	84.9
0.3	53.3
0.15	18.3
0.075	7.6

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	1.9
% SAND (75 µm to 4.75 mm):	90.5
% SILT (2 µm to 75 µm):	7.6
% CLAY (<2 µm):	-

SOIL DESCRIPTION:	SP	SAND, trace Silt

REMARKS

Figure: 3

TESTED BY: Kevin Frank — Laboratory Technician

REVIEWED BY David McBay, C.Tech. — Laboratory Supervisor

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TP2-GP1

GRAIN SIZE ANALYSIS REPORT
LS-602

PROJECT NUMBER:	04.P0019533.500	**PROJECT NAME:**	556 & 576 Conservation Drive - Waterloo	**CLIENT:**	Stantec
LAB NUMBER:	S-799	**SAMPLE ID:**	TP2-21 Sample 01	**SAMPLE DEPTH:**	2.6 - 2.9m
SAMPLED BY:	Client	**DATE RECEIVED:**	June 10, 2021	**DATE COMPLETED:**	June 14, 2021

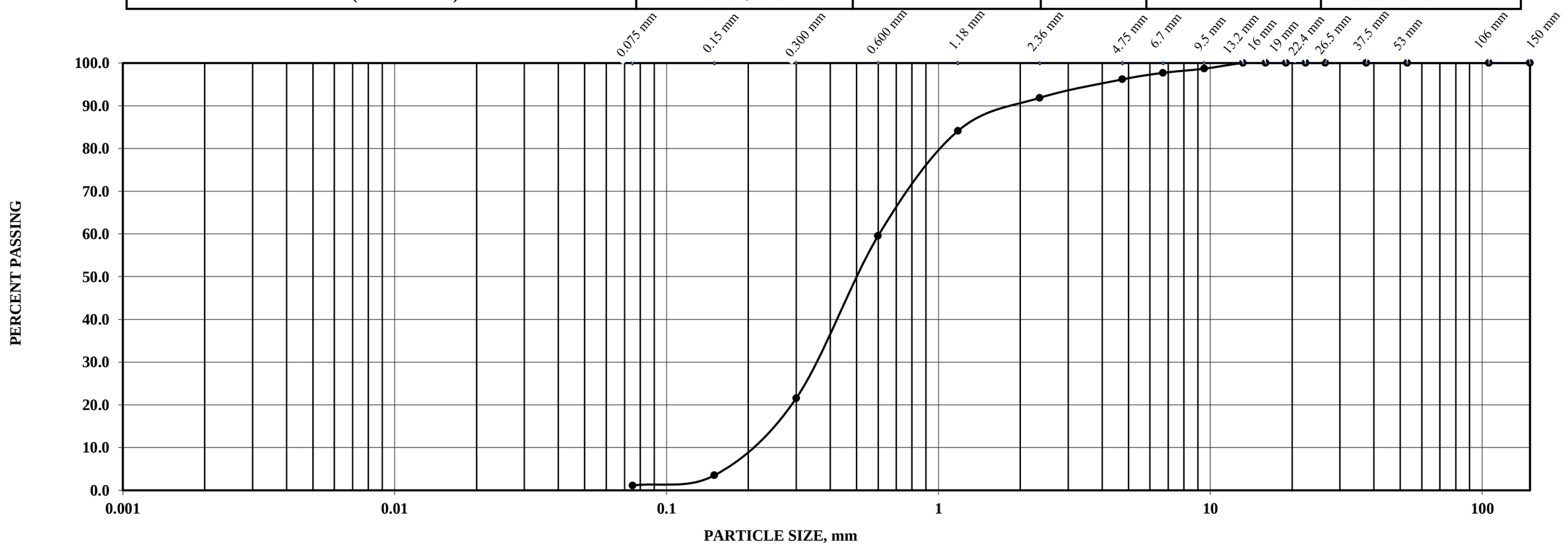
PARTICLE SIZE DISTRIBUTION, MTO LS-602

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM	COARSE	FINE	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



COEFFICIENTS

D60	0.610	**D30**	0.367	**D10**	0.204	**Cc**	1.080	**Cu**	2.99

GRAIN SIZE ANALYSIS	
SIEVE SIZE mm	**% PASSING**
150	100.0
106	100.0
53	100.0
37.5	100.0
26.5	100.0
22.4	100.0
19	100.0
16	100.0
13.2	100.0
9.5	98.7
6.7	97.7
4.75	96.2
2.36	91.9
1.18	84.1
0.6	59.6
0.3	21.6
0.15	3.5
0.075	1.1

GRAIN SIZE PROPORTIONS, %		
% GRAVEL (> 4.75 mm):	3.8	
% SAND (75 µm to 4.75 mm):	95.1	
% SILT (2 µm to 75 µm):	1.1	
% CLAY (<2 µm):	-	
SOIL DESCRIPTION:	SP	SAND, traces of Gravel and Silt

REMARKS

Figure: 4

TESTED BY: Kevin Frank
Laboratory Technician

REVIEWED BY David McBay, C.Tech.
Laboratory Supervisor

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TP2-GP3

GRAIN SIZE ANALYSIS REPORT
LS-602

PROJECT NUMBER:	04.P0019533.500	**PROJECT NAME:**	556 & 576 Conservation Drive - Waterloo	**CLIENT:**	Stantec
LAB NUMBER:	S-800	**SAMPLE ID:**	TP2-21 Sample 02	**SAMPLE DEPTH:**	4.0 - 4.4m
SAMPLED BY:	Client	**DATE RECEIVED:**	June 10, 2021	**DATE COMPLETED:**	June 14, 2021

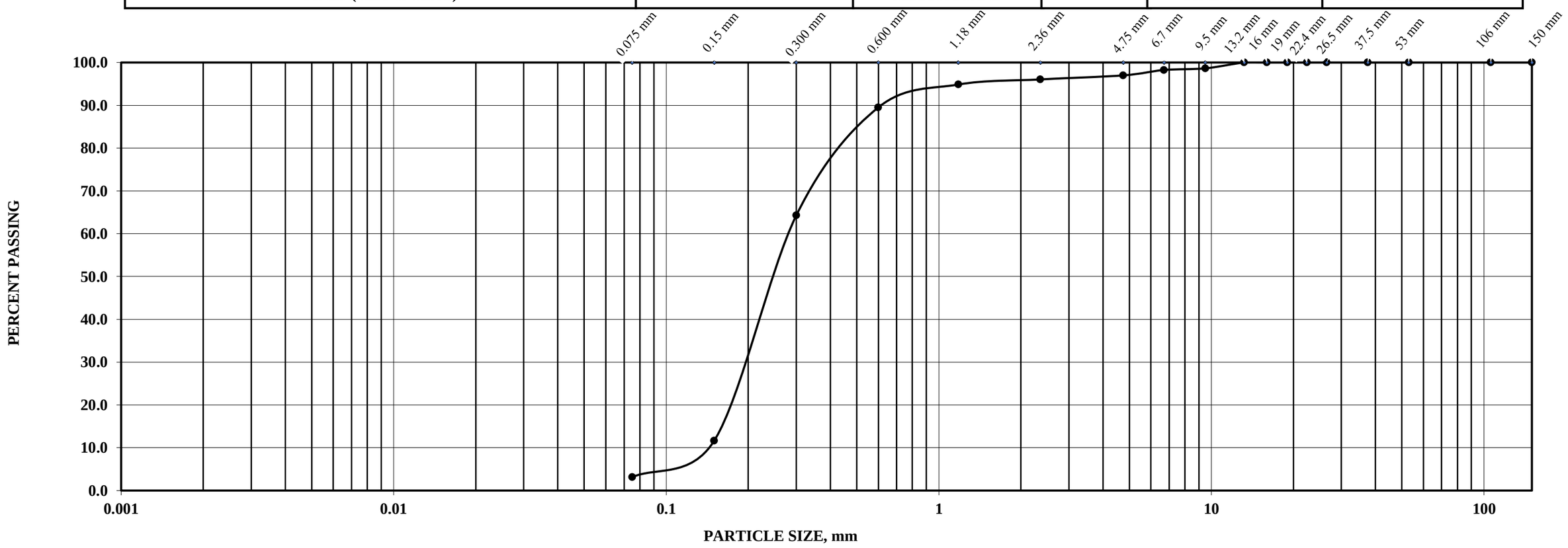
PARTICLE SIZE DISTRIBUTION, MTO LS-602

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM	COARSE	FINE	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



COEFFICIENTS

D60	0.288	**D30**	0.202	**D10**	0.135	**Cc**	1.051	**Cu**	2.13

GRAIN SIZE ANALYSIS

SIEVE SIZE mm	% PASSING
150	100.0
106	100.0
53	100.0
37.5	100.0
26.5	100.0
22.4	100.0
19	100.0
16	100.0
13.2	100.0
9.5	98.6
6.7	98.2
4.75	97.0
2.36	96.0
1.18	94.9
0.6	89.5
0.3	64.3
0.15	11.7
0.075	3.1

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	3.0
% SAND (75 µm to 4.75 mm):	93.9
% SILT (2 µm to 75 µm):	3.1
% CLAY (<2 µm):	-

SOIL DESCRIPTION:	SP	SAND, traces of Gravel and Silt

REMARKS

Figure: 5

TESTED BY: Kevin Frank — Laboratory Technician

REVIEWED BY David McBay, C.Tech. — Laboratory Supervisor

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TP3-GP1

GRAIN SIZE ANALYSIS REPORT
LS-602

PROJECT NUMBER:	04.P0019533.500	**PROJECT NAME:**	556 & 576 Conservation Drive - Waterloo	**CLIENT:**	Stantec
LAB NUMBER:	S-801	**SAMPLE ID:**	TP3-21 Sample 01	**SAMPLE DEPTH:**	3.7 - 4.0m
SAMPLED BY:	Client	**DATE RECEIVED:**	June 10, 2021	**DATE COMPLETED:**	June 14, 2021

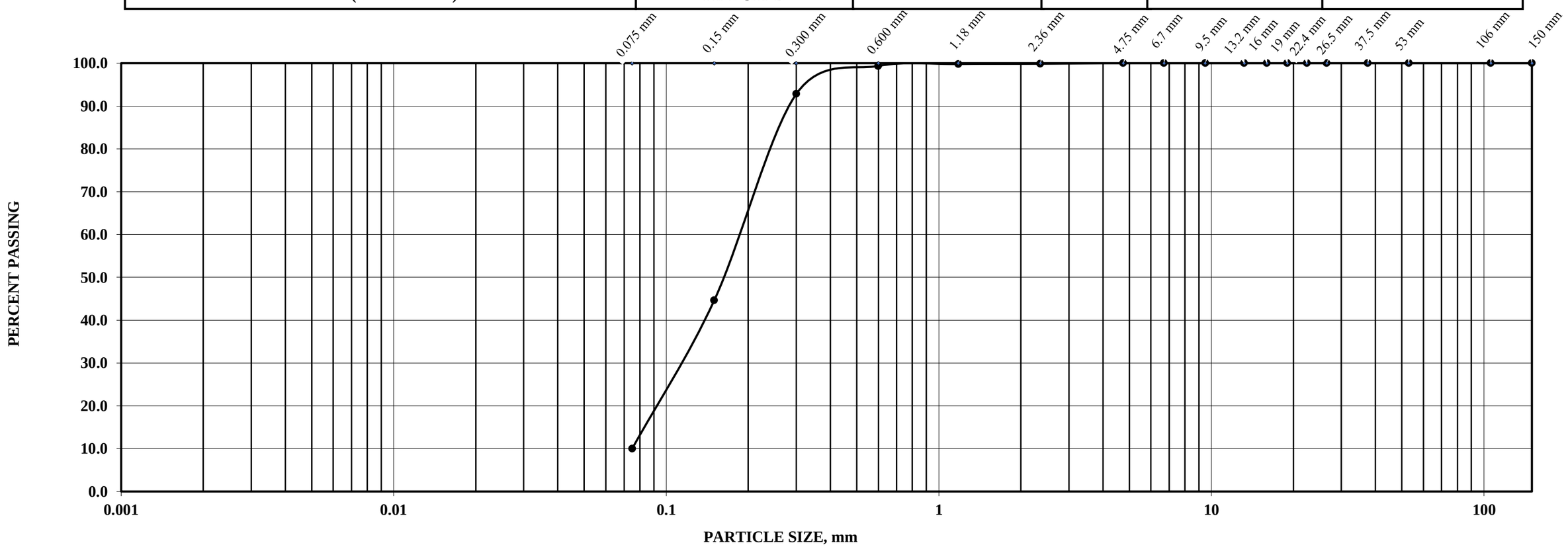
PARTICLE SIZE DISTRIBUTION, MTO LS-602

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM	COARSE	FINE	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



COEFFICIENTS

D60	0.198	**D30**	0.118	**D10**	0.075	**Cc**	0.944	**Cu**	2.64

GRAIN SIZE ANALYSIS	
SIEVE SIZE mm	**% PASSING**
150	100.0
106	100.0
53	100.0
37.5	100.0
26.5	100.0
22.4	100.0
19	100.0
16	100.0
13.2	100.0
9.5	100.0
6.7	100.0
4.75	100.0
2.36	99.9
1.18	99.8
0.6	99.4
0.3	92.8
0.15	44.6
0.075	10.0

GRAIN SIZE PROPORTIONS, %		
% GRAVEL (> 4.75 mm):		
% SAND (75 µm to 4.75 mm):	90.0	
% SILT (2 µm to 75 µm):	10.0	
% CLAY (<2 µm):	-	
SOIL DESCRIPTION:	SP - SM	SAND, some Silt

REMARKS

Figure: 6

TESTED BY: Kevin Frank
Laboratory Technician

REVIEWED BY David McBay, C.Tech.
Laboratory Supervisor

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TP3-GP4

GRAIN SIZE ANALYSIS REPORT
LS-602

PROJECT NUMBER:	04.P0019533.500	**PROJECT NAME:**	556 & 576 Conservation Drive - Waterloo	**CLIENT:**	Stantec
LAB NUMBER:	S-802	**SAMPLE ID:**	TP3-21 Sample 02	**SAMPLE DEPTH:**	5.2 - 5.4m
SAMPLED BY:	Client	**DATE RECEIVED:**	June 10, 2021	**DATE COMPLETED:**	June 14, 2021

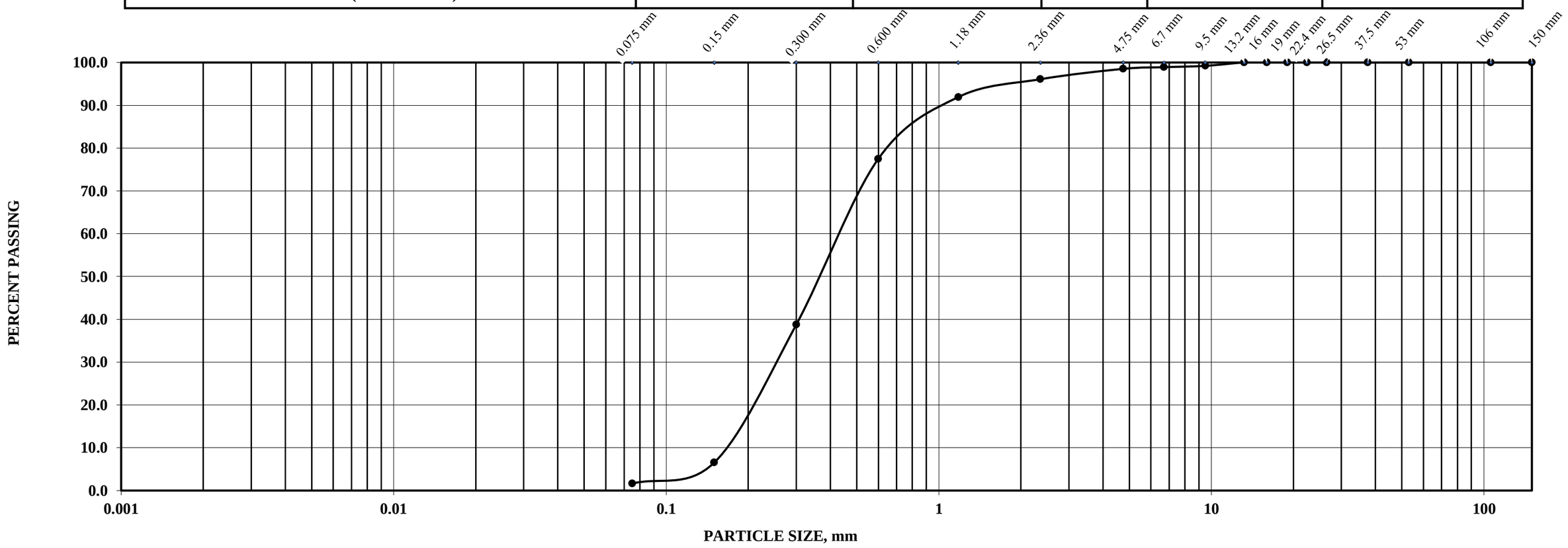
PARTICLE SIZE DISTRIBUTION, MTO LS-602

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM	COARSE	FINE	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



COEFFICIENTS

D60	0.464	**D30**	0.232	**D10**	0.166	**Cc**	0.698	**Cu**	2.80

GRAIN SIZE ANALYSIS

SIEVE SIZE mm	% PASSING
150	100.0
106	100.0
53	100.0
37.5	100.0
26.5	100.0
22.4	100.0
19	100.0
16	100.0
13.2	100.0
9.5	99.2
6.7	98.9
4.75	98.5
2.36	96.1
1.18	91.9
0.6	77.5
0.3	38.8
0.15	6.5
0.075	1.6

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	1.5
% SAND (75 µm to 4.75 mm):	96.9
% SILT (2 µm to 75 µm):	1.6
% CLAY (<2 µm):	-

SOIL DESCRIPTION:	SP	SAND, traces of Gravel and Silt

REMARKS

Figure: 7

TESTED BY: Kevin Frank — Laboratory Technician

REVIEWED BY David McBay, C.Tech. — Laboratory Supervisor

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TP4-GP1

GRAIN SIZE ANALYSIS REPORT
LS-602

PROJECT NUMBER:	04.P0019533.500	**PROJECT NAME:**	556 & 576 Conservation Drive - Waterloo	**CLIENT:**	Stantec
LAB NUMBER:	S-803	**SAMPLE ID:**	TP4-21 Sample 01	**SAMPLE DEPTH:**	2.6 - 2.9m
SAMPLED BY:	Client	**DATE RECEIVED:**	June 10, 2021	**DATE COMPLETED:**	June 14, 2021

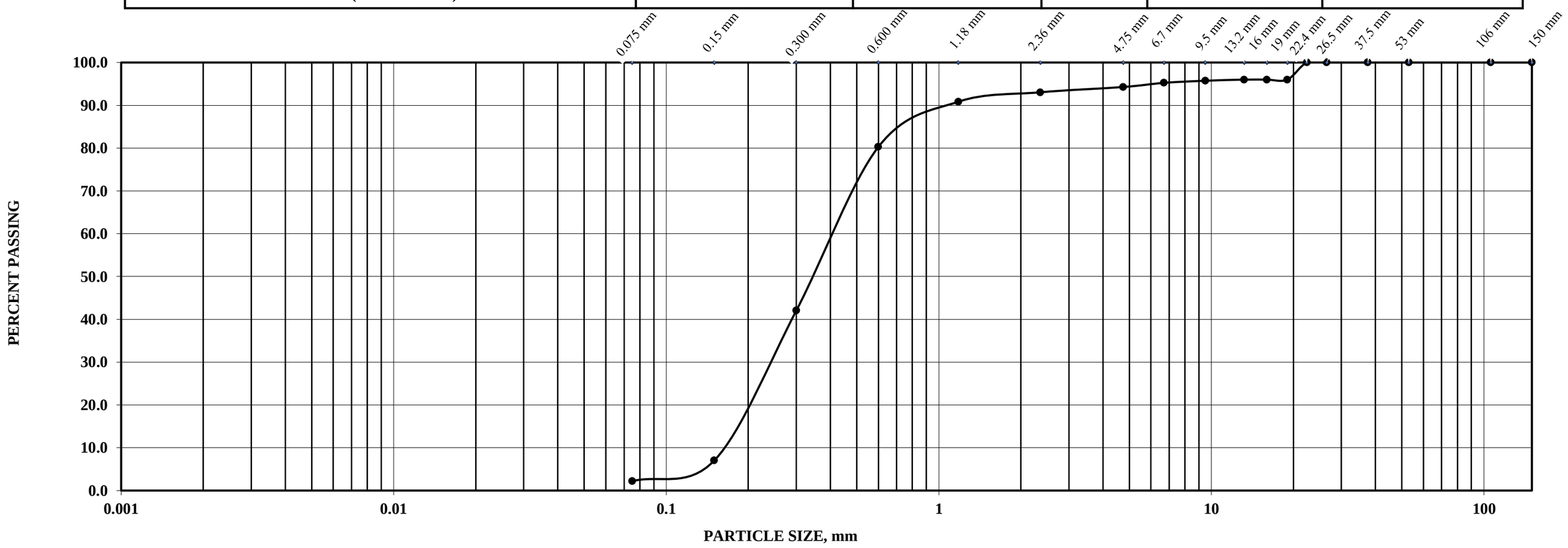
PARTICLE SIZE DISTRIBUTION, MTO LS-602

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM	COARSE	FINE	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



COEFFICIENTS

D60	0.441	**D30**	0.248	**D10**	0.163	**Cc**	0.860	**Cu**	2.71

GRAIN SIZE ANALYSIS

SIEVE SIZE mm	% PASSING
150	100.0
106	100.0
53	100.0
37.5	100.0
26.5	100.0
22.4	100.0
19	96.0
16	96.0
13.2	96.0
9.5	95.7
6.7	95.2
4.75	94.3
2.36	93.0
1.18	90.8
0.6	80.3
0.3	42.0
0.15	7.0
0.075	2.2

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	5.7
% SAND (75 µm to 4.75 mm):	92.1
% SILT (2 µm to 75 µm):	2.2
% CLAY (<2 µm):	-

SOIL DESCRIPTION:	SP	SAND, traces of Gravel and Silt

REMARKS

Figure: 8

TESTED BY: Kevin Frank — Laboratory Technician

REVIEWED BY David McBay, C.Tech. — Laboratory Supervisor

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TP4-GP2

GRAIN SIZE ANALYSIS REPORT
LS-602

PROJECT NUMBER:	04.P0019533.500	**PROJECT NAME:**	556 & 576 Conservation Drive - Waterloo	**CLIENT:**	Stantec
LAB NUMBER:	S-804	**SAMPLE ID:**	TP4-21 Sample 02	**SAMPLE DEPTH:**	4.0 - 4.4m
SAMPLED BY:	Client	**DATE RECEIVED:**	June 10, 2021	**DATE COMPLETED:**	June 14, 2021

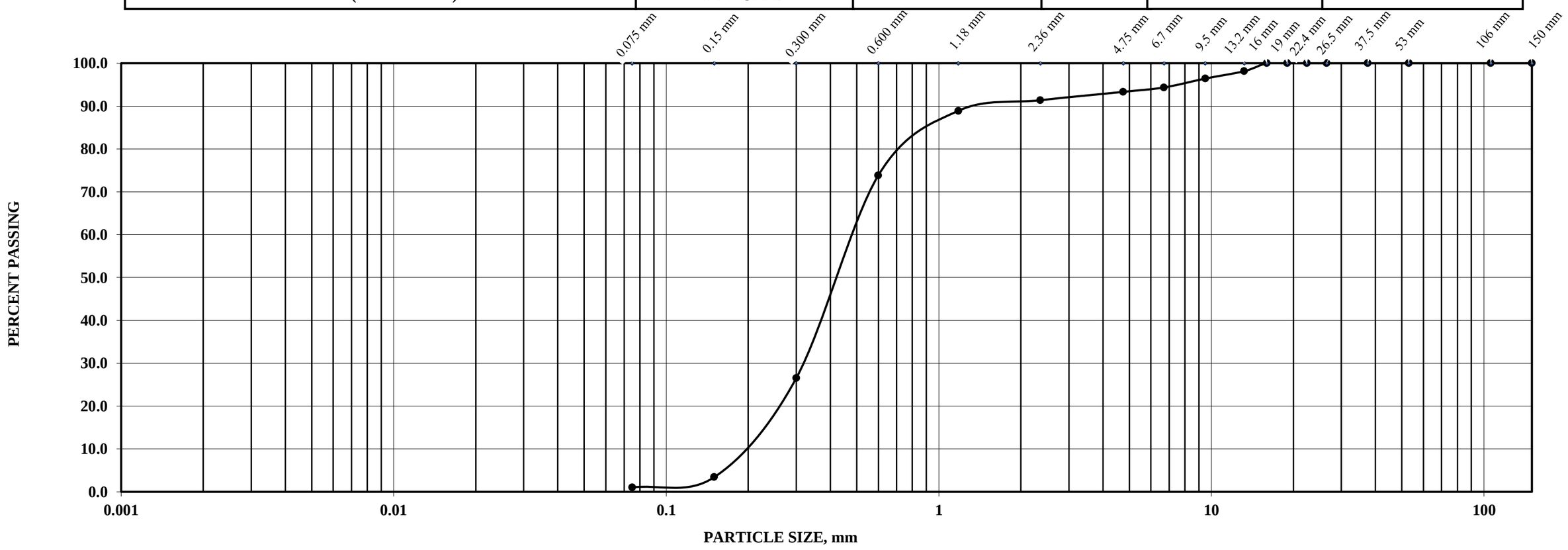
PARTICLE SIZE DISTRIBUTION, MTO LS-602

U.S. BUREAU OF SOILS CLASSIFICATION (AS USED IN MINISTRY OF TRANSPORTATION OF ONTARIO PAVEMENT DESIGNS)

CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM	COARSE	FINE	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

FINES (SILT & CLAY)	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	COARSE GRAVEL



COEFFICIENTS

D60	0.512	**D30**	0.322	**D10**	0.193	**Cc**	1.050	**Cu**	2.66

GRAIN SIZE ANALYSIS

SIEVE SIZE mm	% PASSING
150	100.0
106	100.0
53	100.0
37.5	100.0
26.5	100.0
22.4	100.0
19	100.0
16	100.0
13.2	98.1
9.5	96.4
6.7	94.3
4.75	93.3
2.36	91.4
1.18	88.9
0.6	73.8
0.3	26.5
0.15	3.4
0.075	1.0

GRAIN SIZE PROPORTIONS, %

% GRAVEL (> 4.75 mm):	6.7
% SAND (75 µm to 4.75 mm):	92.3
% SILT (2 µm to 75 µm):	1.0
% CLAY (<2 µm):	-

SOIL DESCRIPTION:	SP	SAND, traces of Gravel and Silt

REMARKS

Figure: 9

TESTED BY: Kevin Frank — Laboratory Technician

REVIEWED BY David McBay, C.Tech. — Laboratory Supervisor

APPENDIX J:
Photographs



Photo 1: MW101-21 – May 28, 2021.



Photo 2: Completion of soil permeability testing using a Guelph Permeameter in Test Pit 1 (TP1) – May 28, 2021. The location of this test pit is within the northeast corner of the proposed SWM infiltration basin.



Photo 3: Test Pit 1 (TP1) – May 28, 2021. Note that grain-size analysis testing indicates that soils up to a depth of 5.5 meters below existing grade comprise 90% to 97% sand.



Photo 4: Completion of soil permeability testing using a Guelph Permeameter in Test Pit 1 (TP1) – May 28, 2021.



Photo 5: Excavation of Test Pit 2 (TP2) – May 28, 2021. Note that grain-size analysis testing indicates that soils up to a depth of 4.3 meters below existing grade comprise 94% to 95% sand.



Photo 6: Completion of soil permeability testing using a Guelph Permeameter in Test Pit 2 (TP2) – May 28, 2021.

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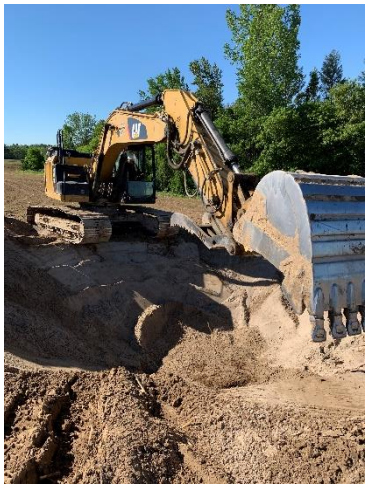


Photo 7: Excavation of Test Pit 3 (TP3) – May 28, 2021. Note that grain-size analysis testing indicates that soils up to a depth of 5.5 meters below existing grade comprise 90% to 97% sand.



Photo 8: Hand augering of hole in Test Pit 3 (TP3) for insertion of Guelph Permeameter – May 28, 2021



Photo 9: Completion of soil permeability testing using a Guelph Permeameter in Test Pit 3 (TP3) – May 28, 2021



Photo 10: Test Pit 3 (TP3) infilled – May 28, 2021.



Photo 11: Various test pit excavations – May 28, 2021.

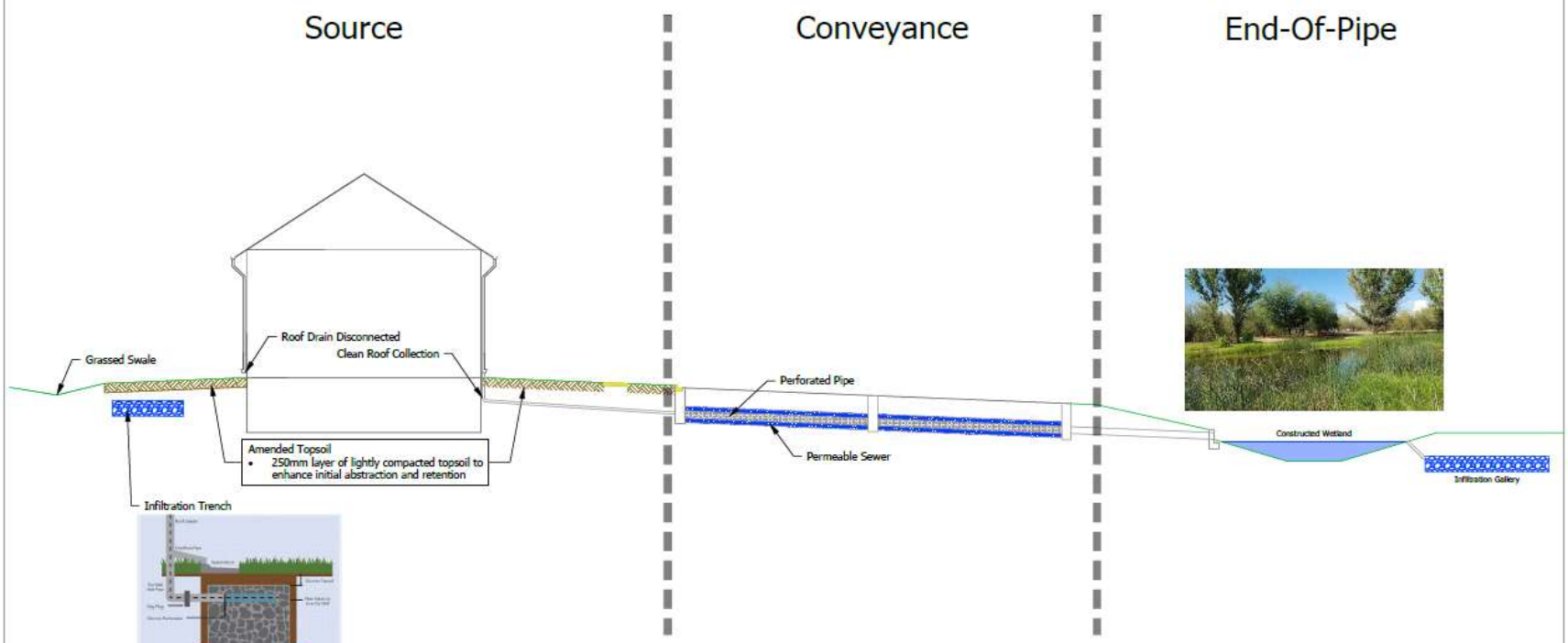


Photo 12: Test Pit 4 (TP4) – May 28, 2021. Note that grain-size analysis testing indicates that soils up to a depth of 4.4 meters below existing grade comprise 92% sand.

Filepath:\\cd1004-f01\01609\active\160900921\05_report_deliv\draft_doc\ver.2\appendices\appendix_j_photos\photographs_160900921.docx

APPENDIX K:
SWM Treatment Train Approach

Stormwater Management Treatment Train



Source: Meritech Engineering. 2021. Preliminary Stormwater Management Report. Revised October 2021.

Stantec

Project:	556, 560 and 576 Conservation Drive, Waterloo Hydrogeological Assessment
Figure:	**K-1**
Title:	**Stormwater Management Treatment Train**

APPENDIX L:
Amended Soils Assessment Memo

Stantec

Memo

To:	Abraham J. Barrios, P.Eng Meritech Engineering	From:	Jennifer Young, P.Eng Stantec Consulting
File:	556, 5060, and 576 Conservation Drive, Waterloo, Ontario	Date:	November 19, 2020

Reference: Amended Soils Assessment, 556, 560, 576 Conservation Drive, Waterloo, Ontario

Meritech Engineering (Meritech) on behalf of 2115881 Ontario Limited (Client), retained Stantec Consulting Limited (Stantec) to complete an assessment of the effectiveness of an increased depth of amended soils as an LID feature to meet infiltration water balance targets.

AMENDED SOILS ANAYSIS

The Treatment Train Tool (TTT, STEP V 1.2.1) was proposed to complete the analysis on the site soils. However, after setting up the model, Stantec came to the conclusion that the TTT was not able to perform the needed assessment and produce meaningful results. Consequently, the decision was made to move to a spreadsheet based analysis to determine the effect of soil depth on infiltration potential.

A water balance design spreadsheet was created to analyze the proposed lot level amended soils on typical townhome and single family residential lots.

SITE GEOLOGICAL AND HYDROGELOLGICAL CONDITIONS

The *Hydrogeological Assessment, 556, 560, and 576 Conservation Drive, Waterloo Ontario* (Stantec, November 2020) describes the site geology as located within the Waterloo Moraine with outwash sands and gravels separated by silt- and clay-tills. The groundwater table ranges from 0.1 m BGS to 7.2 m BGS.

Infiltration testing was conducted on the onsite topsoil using a double-ring infiltrometer to determine the infiltration rates of the existing topsoil for use as an LID feature. The measured infiltration rates for the soils onsite are summarized in Table 1.

Table 1: Infiltration Rate

Location	Infiltration Rate (mm/hr)
GP101	66
GP102	173
GP104	16

To be conservative, the lower range of infiltration for the topsoil was selected for design: 16 mm/hr. The possibility exists that the topsoil will have a greater capacity in some areas.

WATER BALANCE DESIGN SPREADSHEET

The water balance design spreadsheet used for the sizing and infiltration analyses tracks the volume of water in each part of the system (runoff, soil conditions, and groundwater) during each time-step for each of the

Reference: **Amended Soils Assessment, 556, 560, 576 Conservation Drive, Waterloo, Ontario**

proposed LID/GI features on the site. This assessment considered two components: lawn areas for single family residential areas and lawn areas for townhome areas. The selected time-step for the design is five (5) minutes to be consistent with the available rainfall record. The water balance spreadsheet uses the rainfall, local soil characteristics as determined by the hydrogeological investigation, and drainage areas to each feature to calculate the volume of water for each of the following, for every time-step. Design parameters are summarized in Table 2.

Table 2: Design Spreadsheet Parameters

Amended Soils
• Rainwater directed onto pervious surfaces (includes roofs and lawn areas only);
• Beginning of time-step unsaturated runoff;
• Rain into soil;
• Beginning of time-step soil water volume;
• Water from soil to groundwater;
• Water that stays in soil;
• Beginning of time-step saturated runoff;
• Total runoff (saturated and unsaturated); and
• Evaporation

The set-up of the model included the following parameters:

- No initial abstractions or losses other than infiltration and evaporation were assumed during the analysis of the scenarios.
- The sum of the volume from each portion of the system represents a total volume of water in retention. For example, the total volume of unsaturated runoff (i.e., any volume of water that is unable to infiltrate into the soil) for each time step is summed to determine the total volume of unsaturated runoff.
- To accurately assess the operations of the soils, a continuous rainfall record was used. Although Waterloo Airport has long-term precipitation records, the Toronto and Region Conservation Authority (TRCA) collects long-term rainfall data across a wide area that is easily accessible, and in a readily usable format for this assessment. The Rathwood station was selected for its proximity to Waterloo, length of record (approximately three years), and similarity in annual rainfall amounts (903 mm/year).
- The soil depth was varied between 150 and 300 mm.
- The initial condition of the soil water content was set to the field capacity value at the last time step to balance the volumes within the calculation. Typical evaporation values were included to show the wetting and drying front experienced by the soils over the three year rainfall record.

Reference: **Amended Soils Assessment, 556, 560, 576 Conservation Drive, Waterloo, Ontario**

- The soil porosity, field capacity, and wilting point are representative of non-engineered sandy-loam or loam soils and represent a natural soil capacity.
- The spreadsheet model assumed that rooftop surfaces were disconnected and flowed onto the lawn area. The inputs for the drainage areas to each infiltration component for the water balance is presented in Table 33. The green infrastructure water balance design spreadsheet is in Appendix D.

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

Parameter	Townhomes	Single Family	Unit
Impervious Area	710	510	Sq. m
Pervious Area	470	420	Sq. m
Total Area	1,180	930	Sq. m
Soil Depth	150	150	mm
Soil Exfiltration Rate	1	1	mm/hr
Soil Porosity	0.35[1]	0.35[1]	
Soil Field Capacity	0.15[1]	0.15[1]	
Soil Wilting Point	0.1[1]	0.1[1]	
Soil Infiltration Rate	16	16	mm/hr
[1]Typical values for sandy-loam, loam soils adapted from the BC Agricultural, Food, and Fisheries Ministry			

Results

Based on the spreadsheet analysis, directing the roof runoff to the lawns does not capture 90% of the typical yearly rainfall. The 90% capture target corresponds to the water balance requirements for the site; basically, if 90% of the annual rainfall can infiltrate and evapotranspirate, the site is achieving the predevelopment water balance. In this case, the limiting factor to the infiltration system (soils) is the topsoil infiltration rate of 16 mm/hr. This rate limits the infiltration of precipitation with higher intensities into the soil, resulting in unsaturated runoff. Due to the limitations of the infiltration rates, the depth of soil has no impact on the volume of water captured by the LID feature. To achieve the 90% capture target, the soil would have to be amended with sand to increase the infiltration rate to one that could accept higher intensity rainfall. This soil would look more like a bioretention soil mix having over 60% sand, which is very difficult to grow turf on without extensive watering.

Since the existing onsite soils do have moderately high infiltration rates, further analysis was done to compare the assumed infiltration rates (mm/yr) from the *Preliminary Stormwater Management Report 556 and 557 Conservation Drive, City of Waterloo* (Meritech, 2020) to those seen in the design water balance spreadsheet. As part of the treatment train approach for the site, the assumed annual infiltration rate for pervious areas in Table 5 of the Meritech report is 272 mm/year on average. This rate of 272 mm/year, along with the other proposed infiltration measures, meets the water balance requirements for the site.

Reference: **Amended Soils Assessment, 556, 560, 576 Conservation Drive, Waterloo, Ontario**

To determine the annual infiltration rate in the spreadsheet, the total volume contributing to groundwater was divided by the total rainfall volume for the area to get a percent value. This value was then multiplied by the average yearly rainfall in mm/yr to determine a yearly groundwater contribution depth in mm/yr. This approach was also repeated for the evaporation for each area. Table 4 shows the infiltration and evaporation rates for the lawn areas onsite in the design water balance spreadsheet.

Table 4: Pre- and Post-Development Retention and Runoff Results (Total Site)

Area	Average Yearly Rainfall	Percent Average Rainfall Capture	Infiltration		Evaporation	
	mm/yr		%	mm/yr	%	mm/yr
Townhomes	903	78%	41%	374.0	37%	332.6
Single Family	903	81%	42%	378.0	39%	354.0

Comparing the yearly infiltration rates shows that the Meritech infiltration rate of 272 mm/year represents an appropriate assumption in the water balance assessment and validates the approach in the SWM report Based on this analysis, the topsoil onsite has an annual infiltration rate that supports the treatment train approach to meet the water balance for the site in post-development conditions.

The above conclusions are based on the assumption that the topsoil will be reapplied to the site in such a way that the native infiltration rates are maintained post development. This means that the soils will not be over compacted (maintain existing bulk density of soils) or otherwise impacted during construction. We recommend performing infiltration testing after installation to confirm infiltration rates.

Stantec Consulting Ltd.

Jennifer Young P.Eng
Senior Water Resources Engineer

Phone: 519 575 4123
Fax: 519 579 6733
Jennifer.Young@stantec.com

Attachment: Green Infrastructure Design Spreadsheet – Single Family
Green Infrastructure Design Spreadsheet – Townhome

Fill in RED text

Month #	Month	Days	Monthly Evap (mm)
1	Jan	31	0
2	Feb	28	0
3	Mar	31	0
4	Apr	30	38.82
5	May	31	59.39
6	Jun	30	82.51
7	Jul	31	95.89
8	Aug	31	89.54
9	Sep	30	67.67
10	Oct	31	44.54
11	Nov	30	29.93
12	Dec	31	0

03/02/2017 14:55	1322.024306	days
17/09/2020 15:30	3270.700	mm
	3.621984399	
	903.0132767	mm/yr average

Lawns		
Impervious Area To Lawn	510	sq.m
Lawn Area	420	sq.m
Total area:	930	sq.m
Subsoil exfil. rate:	1	mm/hr
Soil depth:	150	mm
Soil porosity:	0.35	
Soil field cap:	0.15	
Soil wilt point:	0.1	
Soil infil. rate	16	mm/hr
Soil wilt point vol:	6.3	cu.m
Soil porosity vol:	22.1	cu.m
Soil field cap vol:	9.5	cu.m
Soil initial vol:	6.3	cu.m
I/P	1	

Summary	Lawns	Total	
Total evaporation	1135.8	1135.8	
Total exfiltration	1212.4	1212.4	
Total drainflow	0.0	0.0	
Total runoff	548.3	548.3	
Total Reused			
Sum	2896.5	2896.5	
Total rainfall	2896.5	2896.5	
% Treated	81%	81%	
% untreated	19%	19%	
% Captured	81%	81%	
EIA	19%	19%	
Infiltration	42%	377.98	mm/yr
Evapouration	39%	354.09	mm/yr

Lawns

All in cubic metres

Month		Precip (mm)	Kitchener ETO	Rain Water onto pervious	Unsaturated Runoff	Rain into Soil	beginning Soil Water Volume	Water from Soil to GW	Water that does not exfiltrate	Water that Stays in Soil	beginning water that runsoff	Total Runoff	Evaporation
						0.00		0.00	0.00	0	0.00	0.00	0.00
2	07/02/2017 11:15	0.1	0	0.09	0.00	0.09	6.765	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 11:20	0	0	0.00	0.00	0.00	6.858	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 11:25	0.1	0	0.09	0.00	0.09	6.858	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 11:30	0.2	0	0.19	0.00	0.19	6.951	0.00	0.19	0.1860	0.00	0.00	0.00
2	07/02/2017 11:35	0.2	0	0.19	0.00	0.19	7.137	0.00	0.19	0.1860	0.00	0.00	0.00
2	07/02/2017 11:40	0.1	0	0.09	0.00	0.09	7.323	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 11:45	0	0	0.00	0.00	0.00	7.416	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 11:50	0.1	0	0.09	0.00	0.09	7.416	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 11:55	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:00	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:05	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:10	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:15	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:20	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:25	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:30	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:35	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:40	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:45	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:50	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 12:55	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 13:00	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 13:05	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 13:10	0	0	0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 13:15	0.1	0	0.09	0.00	0.09	7.509	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 13:20	0	0	0.00	0.00	0.00	7.602	0.00	0.00	0.0000	0.00	0.00	0.00
2	07/02/2017 13:25	0.1	0	0.09	0.00	0.09	7.602	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 13:30	0.1	0	0.09	0.00	0.09	7.695	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 13:35	0.1	0	0.09	0.00	0.09	7.788	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 13:40	0.1	0	0.09	0.00	0.09	7.881	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 13:45	0.2	0	0.19	0.00	0.19	7.974	0.00	0.19	0.1860	0.00	0.00	0.00
2	07/02/2017 13:50	0.1	0	0.09	0.00	0.09	8.16	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 13:55	0.1	0	0.09	0.00	0.09	8.253	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 14:00	0.1	0	0.09	0.00	0.09	8.346	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 14:05	0.1	0	0.09	0.00	0.09	8.439	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 14:10	0.1	0	0.09	0.00	0.09	8.532	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 14:15	0.1	0	0.09	0.00	0.09	8.625	0.00	0.09	0.0930	0.00	0.00	0.00
2	07/02/2017 14:20	0.1	0	0.09	0.00	0.09	8.718	0.00	0.09	0.0930	0.00	0.00	0.00

Fill in RED text

Month #	Month	Days	Monthly Evap (mm)
1	Jan	31	0
2	Feb	28	0
3	Mar	31	0
4	Apr	30	38.82
5	May	31	59.39
6	Jun	30	82.51
7	Jul	31	95.89
8	Aug	31	89.54
9	Sep	30	67.67
10	Oct	31	44.54
11	Nov	30	29.93
12	Dec	31	0

03/02/2017 14:55	1322.024306	days
17/09/2020 15:30	3270.700	mm
	3.621984399	
	903.0132767	mm/yr average

			Precip (mm)	Kitchener ETO
Month				
2	07/02/2017 11:15	0.1	0	
2	07/02/2017 11:20	0	0	
2	07/02/2017 11:25	0.1	0	
2	07/02/2017 11:30	0.2	0	
2	07/02/2017 11:35	0.2	0	
2	07/02/2017 11:40	0.1	0	
2	07/02/2017 11:45	0	0	
2	07/02/2017 11:50	0.1	0	
2	07/02/2017 11:55	0	0	
2	07/02/2017 12:00	0	0	
2	07/02/2017 12:05	0	0	
2	07/02/2017 12:10	0	0	
2	07/02/2017 12:15	0	0	
2	07/02/2017 12:20	0	0	
2	07/02/2017 12:25	0	0	
2	07/02/2017 12:30	0	0	
2	07/02/2017 12:35	0	0	
2	07/02/2017 12:40	0	0	
2	07/02/2017 12:45	0	0	
2	07/02/2017 12:50	0	0	
2	07/02/2017 12:55	0	0	
2	07/02/2017 13:00	0	0	
2	07/02/2017 13:05	0	0	
2	07/02/2017 13:10	0	0	
2	07/02/2017 13:15	0.1	0	
2	07/02/2017 13:20	0	0	
2	07/02/2017 13:25	0.1	0	
2	07/02/2017 13:30	0.1	0	
2	07/02/2017 13:35	0.1	0	
2	07/02/2017 13:40	0.1	0	
2	07/02/2017 13:45	0.2	0	
2	07/02/2017 13:50	0.1	0	
2	07/02/2017 13:55	0.1	0	
2	07/02/2017 14:00	0.1	0	
2	07/02/2017 14:05	0.1	0	
2	07/02/2017 14:10	0.1	0	
2	07/02/2017 14:15	0.1	0	
2	07/02/2017 14:20	0.1	0	

Lawns		
Impervious Area To Lawn	710	sq.m
Lawn Area	470	sq.m
Total area:	1180	sq.m
Subsoil exfil. rate:	1	mm/hr
Soil depth:	150	mm
Soil porosity:	0.35	
Soil field cap:	0.15	
Soil wilt point:	0.1	
Soil infil. rate	16	mm/hr
Soil wilt point vol:	7.1	cu.m
Soil porosity vol:	24.7	cu.m
Soil field cap vol:	10.6	cu.m
Soil initial vol:	7.1	cu.m
I/P	2	

Summary	Lawns	Total	
Total evaporation	1353.8	1353.8	
Total exfiltration	1522.2	1522.2	
Total drainflow	0.0	0.0	
Total runoff	799.1	799.1	
Total Reused			
Sum	3675.1	3675.1	
Total rainfall	3675.1	3675.1	
% Treated	78%	78%	
% untreated	22%	22%	
% Captured	78%	78%	
EIA	22%	22%	
Infiltration	41%	374.03	mm/yr
Evapouration	37%	332.63	mm/yr

Lawns

All in cubic metres

Rain Water onto pervious	Unsaturated Runoff	Rain into Soil	beginning Soil Water Volume	Water from Soil to GW	Water that does not exfiltrate	Water that Stays in Soil	beginning water that runsoff	Total Runoff	Evaporation
		0		0	0	0	0	0	0
0.118	0	0.118	7.64	0	0.118	0.1180	0	0	0
0	0	0	7.758	0	0	0.0000	0	0	0
0.118	0	0.118	7.758	0	0.118	0.1180	0	0	0
0.236	0	0.236	7.876	0	0.236	0.2360	0	0	0
0.236	0	0.236	8.112	0	0.236	0.2360	0	0	0
0.118	0	0.118	8.348	0	0.118	0.1180	0	0	0
0	0	0	8.466	0	0	0.0000	0	0	0
0.118	0	0.118	8.466	0	0.118	0.1180	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0	0	0	8.584	0	0	0.0000	0	0	0
0.118	0	0.118	8.584	0	0.118	0.1180	0	0	0
0	0	0	8.702	0	0	0.0000	0	0	0
0.118	0	0.118	8.702	0	0.118	0.1180	0	0	0
0.118	0	0.118	8.82	0	0.118	0.1180	0	0	0
0.118	0	0.118	8.938	0	0.118	0.1180	0	0	0
0.118	0	0.118	9.056	0	0.118	0.1180	0	0	0
0.236	0	0.236	9.174	0	0.236	0.2360	0	0	0
0.118	0	0.118	9.41	0	0.118	0.1180	0	0	0
0.118	0	0.118	9.528	0	0.118	0.1180	0	0	0
0.118	0	0.118	9.646	0	0.118	0.1180	0	0	0
0.118	0	0.118	9.764	0	0.118	0.1180	0	0	0
0.118	0	0.118	9.882	0	0.118	0.1180	0	0	0
0.118	0	0.118	10	0	0.118	0.1180	0	0	0
0.118	0	0.118	10.118	0	0.118	0.1180	0	0	0

Appendix G: "Quick-Start" Servicing and Stormwater Management Option Letter

September 6, 2022

GSP Group
72 Victoria Street South, Suite 201
Kitchener, ON N2G 2A9

Attention: Ms. Kristen Barisdale, MCIP RPP
Associate, Senior Planner

Dear Ms. Barisdale,

Re: "Quick-Start" Servicing and Stormwater Management Option
556 and 576 Conservation Drive
City of Waterloo

This "quick-start" servicing option is being presented in order to provide an opportunity to begin construction of a small portion of the project without relying on external factors. Construction of the majority of the subdivision is currently reliant on the reconstruction of Beaver Creek Road and Conservation Drive, with the addition of road upgrades, watermain, sanitary and storm sewers as well as the off-site SWM facility and a pumping station to the south on Beaver Creek Road.

However, with the extension of Rideau River Street and Pinery Trail into the site, a "crescent" street will be formed along Street A. This provides sufficient municipal services and emergency access to the area. A sketch showing the proposed limits of the "quick-start" phase is attached.

Sanitary

An existing sanitary trunk sewer is located in Rideau River Street, in the existing subdivision to the east, with an invert elevation of 357.46m (refer to drawing 5-2198 attached). The sewer would be extended into the site and be able to provide an outlet for Blocks 1, 2, 18-22, and part of Blocks 3 and 17. A total of approximately 45-65 single detached lots would be able to be serviced.

Water

An existing 200mm diameter watermain loops from Rideau River Street through Roy Schmidt Road to Pinery Trail in the existing subdivision to the east. The water modeling letter we received from the Region has a junction located at the intersection of Street A and Pinery Trail, within the subject site. As we would be further looping the watermain through Street A to Rideau River Street, the flows available will be similar to what is shown in the Region's model.

Design flows of up to 120 L/s are available with a residual pressure of 17.0m. This is more than sufficient to provide adequate protection of the single detached homes according to FUS requirements.

Storm & Stormwater Management

The design, construction, and operation of a temporary SWM facility to service the site's east drainage area is a viable option should the construction of the external communal SWM facility be delayed.

Storm runoff for the "quick-start" area would be collected by the local storm sewer and conveyed south towards the south-east corner of the site. A temporary stormwater management facility would be constructed in this location to control and attenuate the flows. As described below, an appropriately sized SWM facility can be constructed on Block 106 to serve the entire portion of the site that drains to the south. Soils in this location have a very high infiltration rate.

Under ultimate conditions, the external SWM facility will receive *partially-controlled* flows from Catchments 502 and 503, as well as the uncontrolled flows from external Catchment 601 per Figure 7 of the SWM report. In an interim condition scenario, the temporary SWM facility would receive the *uncontrolled* flows from fully developed Catchments 502 and 503 and the uncontrolled flows from external Catchment 601. This conservative approach ensures that the temporary SWM facility is adequately sized for any combination of imperviousness conditions between pre-development and ultimate post-development stages.

The temporary SWM facility would be located within Block 106 of the current plan as shown in the figure attached and comprises a sediment forebay and a dry main cell with an infiltration basin at the bottom. The temporary SWM facility would meet all the SWM design objectives applicable to the external facility until the time when the external communal SWM facility becomes operational. The temporary SWM facility can be designed to receive and control minor flows, to convey major flows, and to minimize adjustments to the (by then existing) stormwater infrastructure upon decommissioning.

Quality Control

The main stormwater quality control feature of the temporary SWM facility is a sediment forebay sized to treat a 2-year storm event in accordance with MECP criteria. The applicable design calculations are attached.

Additional considerations in the sediment forebay design include the Aesthetic Design Principles for Storm Water Management Facilities in the Region of Waterloo and sound engineering practices.

Quantity Control

The temporary SWM facility includes a dry cell that will provide sufficient storage to contain minor flows. Since the soils in this area are suitable for infiltration, the dry cell will operate as an infiltration basin (e.g. no outlet pipe) to minimize future disturbances to the stormwater

infrastructure within the road right of way. An emergency weir will provide an outlet to the ultimate conditions overland route as established in the SWM report.

Performance of the Temporary SWM Facility

The pond configuration and overflow weir combine to satisfy the post to pre peak flow control objectives.

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 dry pond are summarized in Table 1. 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 dry pond to prevent re-suspension of sediment within the forebay.

The outlet structure consists of a concrete weir that allow outflow in larger storm events. The first 2.3m of ponding depth will be contained within the pond and infiltrated. In accordance with available hydrogeological and geotechnical data, the seasonally high groundwater table is at an elevation of approximately 354.2; the bottom of the pond has been set 1.0 metres higher.

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)
	Dry Cell						
355.2	0.0	Bottom	0	1,062	-		0
355.4	0.2		0	1,189	225		225
355.6	0.4		0	1,319	251		476
355.8	0.6		0	1,450	277		753
356.0	0.8		0	1,584	303		1,056
356.2	1.0		0	1,721	330		1,387
356.4	1.2		0	2,935	466		1,852
356.6	1.4		0	3,234	617		2,469
356.8	1.6		0	3,534	677		3,146
357.0	1.8		0	3,837	737		3,883
357.2	2.0		0	4,141	798		4,681
357.4	2.2		0	4,339	848		5,529
357.5	2.3	Concrete Weir	0	4,440	439		5,968
357.6	2.4		0.25	4,542	449		6,417
357.8	2.6	Freeboard	1.32	4,735	929		7,346
	Forebay						
354.7	-1.5	Bottom		201	0	0	
355.0	-1.2			288	73	73	
355.3	-0.9			384	101	174	
355.6	-0.6			490	131	305	
355.9	-0.3			604	164	469	
356.2	0.0	**Permanent Pool**		727	200	669	

Table 1: Stage Storage Discharge for Forebay and Infiltrating Dry Pond

Table 2 summarizes the overall performance of the Temporary SWM Facility, including storage volumes of the various storm events and peak discharge rates.

Description	Rainfall Parameters	Elevation (m)	Depth (m)	Maximum Storage Volume (m^3)	Discharge (m^3/s)
Pond Bottom		355.20	0.0	0	0
5-year ponding	Waterloo	356.94	1.74	3,670	0.000
Concrete weir		357.50	2.30	5,968	0.000
100-year ponding	Waterloo	357.65	2.45	6,651	0.514
Freeboard		357.80	2.60	7,346	1.317

Table 2: Pond Performance Summary

Table 3 presents the total peak flows towards Beaver Creek Road for the range of design storms. The pre-development peak flows are taken from the existing peak flow rates shown in Table 11.3 of the NWSSS. Flow rates from catchment 3101 were pro-rated so that only the flows from the subject site were used to determine the pre-development rates. This was combined with the catchment 3105 flows to calculate the pre-development rate.

Event/Condition	5-year (m^3/s)	100-year (m^3/s)
Pre-Development	0.166	0.561
Attenuated post-development (CoW ABCs)	0	0.514

Table 3: Comparison of Attenuated Peak Flows (Flows to Beaver Creek Road)

Closing

We trust the information contained in this letter demonstrates that a portion of the subdivision can be serviced prior to the construction of any works on Beaver Creek Road to the south.

Yours very truly,

MERITECH ENGINEERING

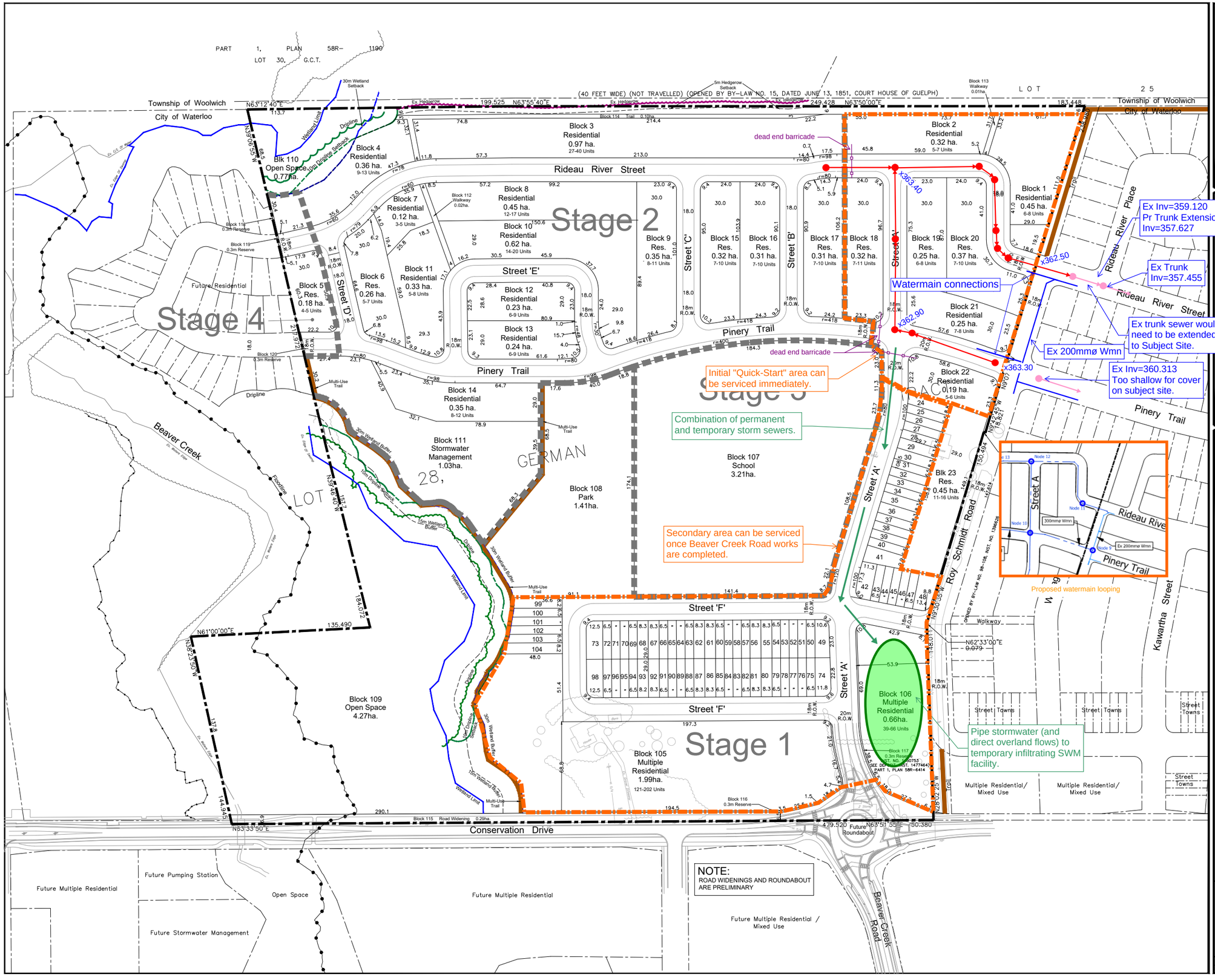


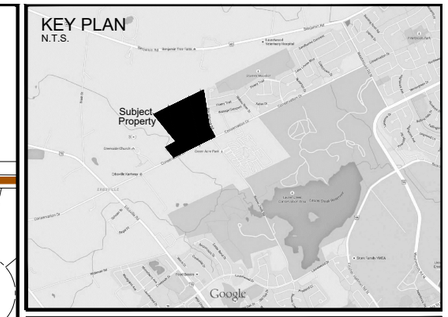
Stefan Van Hartingsveldt, C.E.T.
Project Lead

Chris H. Togeretz, P.Eng.
Manager, Design Services

STV/
Enclosures (Servicing "Quick-Start" Option Markup; Drawing 52198; Temporary Pond Concept; Forebay Sizing Calculations; MIDUSS modeling output files)

cc





DRAFT PLAN OF SUBDIVISION

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

Servicing "Quick-Start" Option Markup
Meritech Engineering
Aug 24, 2022

LAND USE SCHEDULE

DESCRIPTION	LOTS/BLKS.	UNITS	AREA (ha.)
Residential (single detached)	1-23	182-260	7.98
Street Townhouses	24-104	81	1.73
Multiple Residential	105,106	160-268	2.65
School	107		3.21
Park	108		1.41
Open Space	109,110		5.04
Stormwater Management	111		1.03
Walkway	112,113		0.04
Trail	114		0.09
Road Widening	115		0.29
0.3m Reserve	116,120		0.00
Roads			5.16
Total		423-609	28.63

UNIT BREAKDOWN

Min. Potential Singles	182
13.1m internal lot	*152*
13.75m corner lot	*30*
Max. Potential Singles	260
9.0m internal lot	*230*
12.5m corner lot	*30*
Street Townhouses	81

NOTE: Wetland boundary provided by NRSI August 2021

ADDITIONAL INFORMATION

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

INFORMATION REQUIRED BY CLAUSES a,b,c,d,e,f,g,j and I 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.

2115681 ONTARIO LIMITED — August 17, 2016 DATE

SURVEYOR'S CERTIFICATE

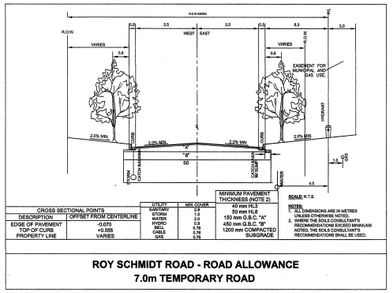
I CERTIFY THAT THE BOUNDARIES OF THE LAND TO BE SUBDIVIDED AND THEIR RELATIONSHIP TO THE ADJACENT LANDS ARE CORRECTLY SHOWN.

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

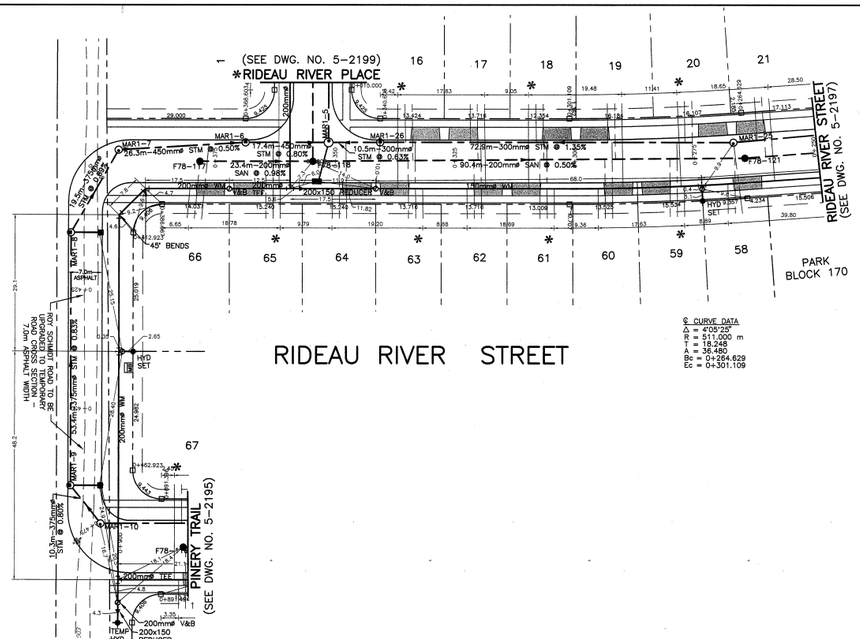
GSP group
PLANNING | URBAN DESIGN | LANDSCAPE ARCHITECTURE
gspgroup.ca

REVISIONS
April 30, 2020
June 25, 2020
March 10, 2020
March 15, 2020
March 19, 2020
August 19, 2021
December 15, 2021

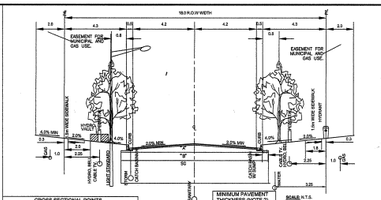
Date: July 29, 2015 | Drawn By: S.L./ML | Dwg. File Name: dp09009zo.dwg
Scale: 1:1250 metric | Project No.: 09009.40



ROY SCHMIDT ROAD - ROAD ALLOWANCE
7.0m TEMPORARY ROAD



STANDARD ROAD ALLOWANCE
18.0m R.O.W. -9m ROAD
W-202



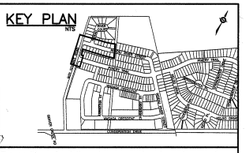
RIDEAU RIVER STREET
0+000 TO 0+392
NTS

LOT #	SAN. INV.	STM. INV.
16	359.60	361.10
17	359.75	361.25
18	359.76	361.26
19	360.03	361.53
20	359.93	361.42
21	360.04	361.54
58	360.19	361.68
59	360.12	361.62
60	359.95	361.45
61	359.89	361.39
62	359.81	361.31
63	359.41	360.91
64	359.38	360.88
65	359.40	360.90
66	359.45	360.95

LEGEND:

MH 17	STORM MANHOLE
CBMH 18	STORM CATCHBASIN MANHOLE
	STORM CATCHBASIN
	DOUBLE CATCHBASIN
MH 6A	SANITARY MANHOLE
HYD SET	FIRE HYDRANT c/w VALVE & BOX
V&B	WATERMAIN VALVE & BOX
200x150mmø TEE	WATERMAIN TEE
	STANDARD IRON BAR (SIB)
	SANITARY SERVICE LATERAL (100mmø)
	STORM SERVICE LATERAL (150mmø)
	WATERMAIN SERVICE LATERAL (25mmø)
*	DENOTES NON-STANDARD SERVICE LATERAL LOCATIONS

KEY PLAN
NTS



The position of existing above ground and underground utilities and facilities are not necessarily shown on the drawings, and where shown, the accuracy of the position of such utilities and facilities is not guaranteed. Before starting work, the contractor shall confirm the exact location of all existing utilities and facilities, and shall assume all liability for damage to them. Drawings shall not be used for construction unless sealed. All work to be performed in accordance with the Occupational Health & Safety Act 1990.

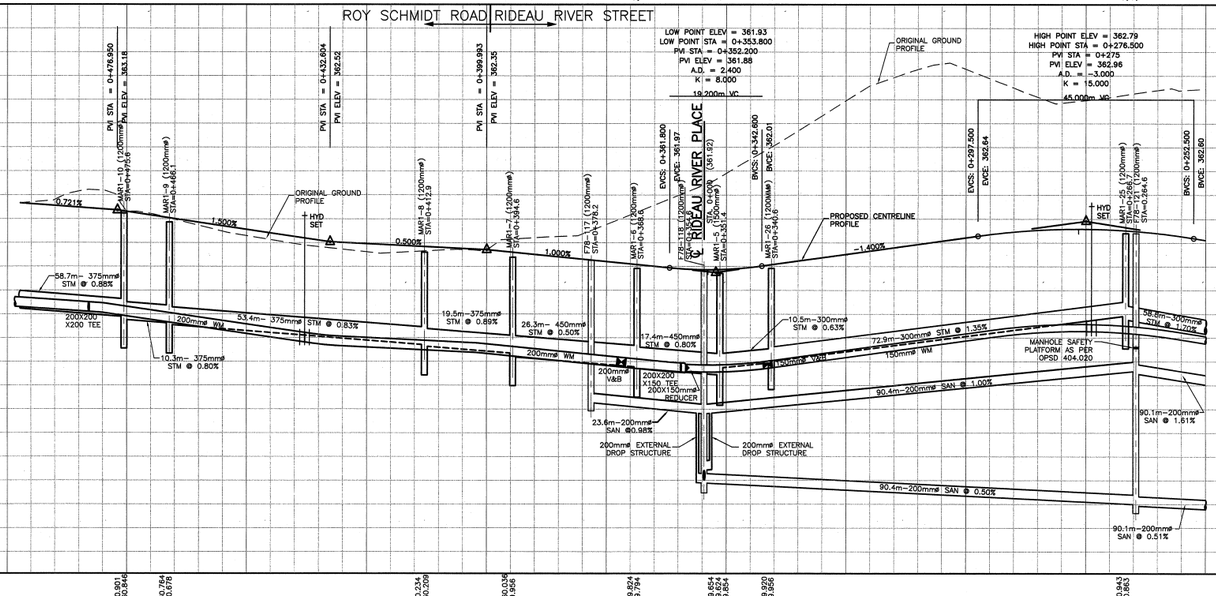
NOTES

1. BENCHMARKS:
   - CONCRETE MONUMENT No. 030-97-0009 LOCATED ON THE FRONT LOT CORNER OF LOT 78 AND BLOCK 178 ON WATERTON DRIVE. ELEVATION = 356.326m
   - CONCRETE MONUMENT No. 030-97-0010 LOCATED ON THE NORTHWEST CORNER OF THE INTERSECTION OF PINERY TRAIL AND LAKE LOUISE BLVD. ELEVATION = 359.268m
2. SANITARY SEWER
   - 200mmø PVC PIPE SDR 35
3. SANITARY SEWER MANHOLES
   - OPSD 701.010 (MH 3A-5A, 9A)
4. STORM SEWERS
   - 300 to 600 PVC ULTRARIB
   - >600mmø 65-D CONC. UNLESS OTHERWISE NOTED
5. STORM MANHOLES
   - OPSD 701.010 (MH/CBMH 4-10)
   - OPSD 701.011 (MH 11) C/W 600mm SUMP
6. CATCHBASINS
   - OPSD 705.010
   - CB FRAME AS PER CITY OF WATERLOO STD. DWG W-520 (FISH TYPE)
7. CATCHBASIN LEADS
   - 300mmø PVC SDR35 OR ULTRARIB, MIN. SLOPE 1.0%
8. WATERMAIN
   - CLASS 150 AWWA C-900 PVC PIPE
   - MINIMUM COVER 2.0m
   - MINIMUM VERTICAL CLEARANCE BETWEEN WATERMAIN AND OTHER SERVICES = 0.5m
9. PAVEMENT CONSTRUCTION
   40mm HL3
   50mm HL8
   150mm G.B.C. 'A'
   450mm G.B.C. 'B'
10. CURB RADII AT INTERSECTIONS ARE 9.0m, UNLESS OTHWERWISE NOTED.
11. ALL HYDRANTS
    - 2-65mm and 1-100mm (STORZ) NOZZLES
    - 150mm MECHANICAL JOINT INLET
12. ALL SERVICE LATERALS GREATER THAN 4.0m DEEP SHALL INCORPORATE A RISER (OPSD 1006.02) MODIFIED, SUCH THAT THE SERVICE LATERAL AT PROPERTY LINE IS NOT DEEPER THAN 3.5m
13. CONCRETE CURB & GUTTER
    - OPSD 600.040
14. ROAD CROSS-SECTION
    - STD. DWG. No. W-202 (18m ROW)
15. SEWER BEDDING SHALL CONFORM TO OPSD 802.010 'CLASS B' FOR PVC PIPE, AND 802.030 TO 802.032 'CLASS B' FOR CONC. PIPE, USING GRANULAR "A" AS BEDDING MATERIAL.

C/L ROADWAY CHAINAGE: 0+500 | 0+475 | 0+450 | 0+425 | 0+400 | 0+375 | 0+350 | 0+325 | 0+300 | 0+275 | 0+250

ELEVATION FIN. C/L: 363.14 | 362.96 | 362.79 | 362.48 | 362.35 | 362.25 | 362.14 | 361.96 | 361.93 | 361.86 | 361.96 | 362.25 | 362.70 | 362.74 | 362.70 | 362.76 | 362.74 | 362.99 | 362.86 | 362.58

ELEVATION FIN. CASTING: 363.14 | 362.96 | 362.36 | 362.25 | 362.14 | 361.96 | 361.93 | 361.86 | 361.96 | 362.70 | 362.74



STM. SEWER INVERT: E360.901 W360.946 | SE360.784 N360.678 | S360.034 NE360.209 | SW360.036 E359.956 | W359.824 E359.794 | W359.654 E359.504 | W359.654 E359.854 | W358.920 E359.820 | W360.843 E360.883

SAN. SEWER INVERT: E359.120 | W358.890 (DROP) W357.465 E357.455 | W357.654 E358.900 (LOCAL) | W358.843 (LOCAL) W357.000 E356.984 E359.758 (LOCAL)

Stantec

CERTIFIED ENGINEERING TECHNOLOGIST — JEROME J.C. GRUBB — № 050228

REGISTERED PROFESSIONAL ENGINEER — M. JONES — PROVINCE OF ONTARIO

J.L.G.	06.08.18	AS RECORDED - STAGE 1
J.L.G.	06.01.09	STREET NAMES
J.L.G.	05.12.16	CITY COMMENTS
INT.	YY.MM.DD	REVISION

CITY OF WATERLOO

SEAL

TITLE:
ACTIVA-CONSERVATION DRIVE SUBDIVISION
RIDEAU RIVER STREET
0+250 TO 0+392
ROY SCHMIDT ROAD
0+392 TO 0+500

DATE: AUGUST 2005	DESIGNED BY: KD/JLG
SCALE : 1:500	DRAWN BY: KD
	CHECKED BY: JLG
FILE NO. 30T-03401	DRAWING NO.
FIELD BK. PAGE DATE	5-2198

X:\p\1603\active\1603871\construction\drawing\w_revised\1603871-c-202-25_rideau south.dwg
2007-05-16 07:29:56 by Carpenter

Temporary Pond Concept
Meritech Engineering
STV
1:500

Temporary Pond Inlet

Temporary Storm Sewer

Overland Flow Route

Forebay

Street 'A'

5m Wide Outlet Weir
Inv=357.50

Infiltrating Dry Pond

Seasonally High
Groundwater=354.20

Grading split

MERITECH

Project Name: Conservation Drive
Project Number: 1279
Calc'd by: STV
Date: 4-Oct-21
Chk'd by: CHT
Date: 27-Jan-22

Sediment Forebay Sizing Calculations

(in accordance with MOE 2003)

Forebay Dimensions

				Calculated min.	Actual	
Average bottom width	7.9	m	Average top width	19.9	19.9	m
Maximum bottom width	8.5	m	Maximum top width	20.5	20.5	m
Average bottom length	25.5	m	Average top length	37.5	37.5	m
Average depth	1.50	m	Total Volume	669	m³	
Average sideslope	4	:1	Usable Volume	432	m³	

1) Forebay Settling Length

Dist = forebay length (m)
r = length to width ratio at average depth
= **2.3** (should be greater than 2:1)
Q_p = peak flow rate from facility during design quality storm
= **0.000** m³/s **2 year** storm event
V_s = settling velocity (dependent on particle size)
= **0.0003** m/s for 150 μm particle
Therefore, distance = **0.0** m vs. **37.5** 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)
= **1.740** 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 = **37.1** m vs. **37.5** m provided
Also, min. bottom width = Dist./8 = **4.6** m vs. **7.9** 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
= **1.740** m³/s **5-year** storm event
A_x = cross sectional area of forebay perpendicular to flow
= **13.1** m² above the maximum sediment depth
Therefore, velocity = V_a = **0.13** m/s should be < thai **0.15** m/s

4) Cleanout Interval

V_u = usable accumulation storage volume of forebay at a
max. depth, d_u = **0.75** m
= **237** m³
L_a = annual loading
for **51.0** % impervious
= **1.640** m³/ha/yr
A_c = **14.610** ha of contributing land
Therefore, interval = I = **9.9** yrs between cleanouts **5.0** years min. preferred

5) 10 year Accumulated Sediment Depth

A_c = contributing area
= **14.610** ha.
L_a = annual loading
= **1.640** m³/ha/yr
I = cleanout interval
= **10** years
V_r = required total storage volume
= **239.6** m³
Actual total storage volume
= **669.3** m³

```
"               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:               1279d5yr3hrJan122021(Temp).out"
"               Licensee name:                       Stefan Van Hartingsveldt"
"               Company                                  Meritech Engineering"
"               Date & Time last used:              2021-01-12 at 2:42:26 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================================================="
"          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"
"                    0.000     0.000     0.000     0.000"
" 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."
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"         0.000   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                       0.030     0.000     0.000     0.000 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"
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"             4   Add Runoff "
"                       0.030     0.030     0.000     0.000"
" 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     0.000     0.000 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     0.000     0.000"
" 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     0.000     0.000 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      "
"             Maximum flow           0.135      2.008      2.033      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    2.033     2.338     0.000     0.000"
" 54          POND DESIGN"
"        2.338   Current peak flow    c.m/sec"
"        0.654   Target outflow    c.m/sec"
"       3669.8   Hydrograph volume    c.m"
"          15.   Number of stages"
"      355.200   Minimum water level    metre"
"      357.800   Maximum water level    metre"
"      355.200   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                355.200     0.000     0.000"
"                355.400  1.01E-05   225.000"
"                355.600  1.01E-05   476.000"
"                355.800  1.01E-05   753.000"
"                356.000  1.01E-05  1056.000"
"                356.200  1.01E-05  1387.000"
"                356.400  1.01E-05  1852.000"
"                356.600  1.01E-05  2469.000"
"                356.800  1.01E-05  3146.000"
"                357.000  1.01E-05  3883.000"
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```
"                357.200  1.01E-05  4681.000"
"                357.400  1.01E-05  5529.000"
"                357.500  1.01E-05  5968.000"
"                357.600    0.2463  6417.000"
"                357.800     1.317  7346.000"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                357.500     0.900     5.000     1.000     1.000"
"              Peak outflow                  0.000    c.m/sec"
"              Maximum level               355.432    metre"
"              Maximum storage             264.882    c.m"
"              Centroidal lag               60.463   hours"
"                   2.033     2.338     0.000     0.000 c.m/sec"
" 40           HYDROGRAPH   Combine    503"
"             6   Combine "
"           503   Node #"
"                 SWM facility south of Conservation Dr"
"              Maximum flow                  0.000    c.m/sec"
"              Hydrograph volume             4.333    c.m"
"                      2.033     2.338     0.000     0.000"
" 38           START/RE-START TOTALS 503"
"             3   Runoff Totals on EXIT"
"              Total Catchment area                     14.610    hectare"
"              Total Impervious area                     7.380    hectare"
"              Total % impervious                       50.512"
" 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:             1279d100yr3hrJan122021(Temp).out"
"                Licensee name:                       Stefan Van Hartingsveldt"
"                Company                                  Meritech Engineering"
"                Date & Time last used:              2021-01-12 at 2:44:36 PM"
" 81           ADD COMMENT=================================================="
"           2  Lines of comment"
"              SWM Analysis of 100-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"
"      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================================================="
"           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"
"                       0.000     0.000     0.000     0.000"
" 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     0.000     0.000 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     0.000     0.000"
" 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     0.000     0.000 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     0.000     0.000"
" 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     0.000     0.000 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      "
"             Maximum flow           0.621      3.695      3.922      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    3.922     4.561     0.000     0.000"
" 54          POND DESIGN"
"        4.561   Current peak flow    c.m/sec"
"        0.654   Target outflow    c.m/sec"
"       8246.7   Hydrograph volume    c.m"
"          15.   Number of stages"
"      355.200   Minimum water level    metre"
"      357.800   Maximum water level    metre"
"      355.200   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                355.200     0.000     0.000"
"                355.400  1.01E-05   225.000"
"                355.600  1.01E-05   476.000"
"                355.800  1.01E-05   753.000"
"                356.000  1.01E-05  1056.000"
"                356.200  1.01E-05  1387.000"
"                356.400  1.01E-05  1852.000"
"                356.600  1.01E-05  2469.000"
"                356.800  1.01E-05  3146.000"
"                357.000  1.01E-05  3883.000"
```

```
"                357.200  1.01E-05  4681.000"
"                357.400  1.01E-05  5529.000"
"                357.500  1.01E-05  5968.000"
"                357.600    0.2463  6417.000"
"                357.800     1.317  7346.000"
"           1.   WEIRS"
"                  Crest      Weir     Crest      Left     Right"
"              elevation coefficie   breadth sideslope sideslope"
"                357.500     0.900     5.000     1.000     1.000"
"              Peak outflow                  0.514    c.m/sec"
"              Maximum level               357.650    metre"
"              Maximum storage            6651.392    c.m"
"              Centroidal lag                2.753   hours"
"                   3.922     4.561     0.514     0.000 c.m/sec"
" 40           HYDROGRAPH   Combine    503"
"             6   Combine "
"           503   Node #"
"                 SWM facility south of Conservation Dr"
"              Maximum flow                  0.514    c.m/sec"
"              Hydrograph volume          2283.001    c.m"
"                      3.922     4.561     0.514     0.514"
" 38           START/RE-START TOTALS 503"
"              3   Runoff Totals on EXIT"
"              Total Catchment area                     14.610    hectare"
"              Total Impervious area                     7.380    hectare"
"              Total % impervious                       50.512"
" 19           EXIT"
```