Preliminary Stormwater Management Report

556 and 576 Conservation Drive
City of Waterloo

Revised October 2024

MERITECH

1315 Bishop Street North, Suite 202
Cambridge, ON N1R 6Z2

t 519.623.1140
f 519.623.7334
www.meritech.ca

Project No.: 1279

October 18, 2024

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: 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

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

STV/
Enclosures (2)

cc Brad Trussler, 2115881 Ontario Limited



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

Executive Summary

This report contains the proposed stormwater management (SWM) strategy to support a residential development at the northwest corner of the intersection 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 townhouse and 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 to the south, whereas the west catchment drains to a wet pond 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. Major drainage will continue to drain overland to the Conservation Drive ROW, matching pre-development conditions.

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

For both catchments, 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. Conveyance measures include a permeable clean water collection (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 wet pond, and an infiltration gallery.

Compliance of the proposed SWM infrastructure with the design quantity and quality 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 a historical data set.

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

Use and Reproduction of This Document

This document is intended only for use on this site and shall not be used in whole or in part for any other project. No part of the stormwater management plan may be reproduced, stored in a retrieval system, or transcribed in any form, or by means including electronic, mechanical, photocopying, recording and scanning without the prior written approval of the author.

For Further Information

For further information regarding this stormwater management plan please contact the author at the following address:

Meritech Engineering

Attention: Mr. Norm B. Litchfield, P.Eng., MBA
Director of Engineering
1315 Bishop Street North, Suite 202
Cambridge, ON N1R 6Z2
t (519) 623-1140
f (519) 623-7334
email: norml@meritech.ca

Table of Contents

Introduction 5
Site Description 5
Site Proposal 5
Approach 6
Policy Framework 7
Planning Documents 7
Watershed Plan 7
Subwatershed Plan 7
MECP Guidelines 7
Regional Guidelines 8
Municipal Guidelines 8
Conservation Authority Guidelines 8
Environmental Studies 8
Geotechnical Studies 9
Hydrogeological Studies 9
Stormwater Management Reports 10
Pre-Consultation/Design Criteria 10
Reconnaissance 11
Review Comments 12
Drainage Conditions 12
Pre-Development Drainage 12
Post-Development Drainage 12
SWM Design Strategy 12
Treatment Train Approach 15
Quantity 15
Quality 15
Water Balance 16
Hydrological Modelling 17
Single-Event Modelling 17
Continuous Modelling 17
Rainfall Data 17
Hydrogeological Design Considerations 18
Stantec Studies 18
Groundwater Conditions 18
Baseflow and Channel Erosion 19
Site Erosion and Sedimentation Control 19
Salt Impact Assessment 19
Environmental Constraints 21
Winter Conditions 21
Minor and Major Flow Routing 21
SWM Design Development 21
Proposed Stormwater Management Plan 25
Proposed SWM Treatment Train 26
Compliance to Design Criteria 26
Quantity 29
Allowable Discharge Flow Rates 29

Quality 32
Forebay 32
LID features 32
Extended Detention 33
Hydrologic Modelling 34
Rainfall Data 34
Catchment Numbering Convention 35
Pre-Development Hydrology 35
Post-Development Hydrology 37
Performance of the End-of-Pipe System 43
Compliance 46
Minor/Major System Routing 47
East Catchment Routing 47
West Catchment Routing 47
Winter Conditions 47
Water Balance 48
Target Infiltration & Runoff Values 48
Passive Infiltration & Runoff 49
Lot Level Infiltration Facilities 51
Clean Water Collection System 52
End-of-Pipe Facility 54
Total Post-Development Infiltration & Runoff 55
Environmental Constraint Level 58
Environmental Compliance Approval 58
Landscaping 58
Fluvial Geomorphology, Baseflow, and Channel Erosion 59
Site Erosion and Sedimentation Control 59
Construction Staging 60
Monitoring, Maintenance and Mitigation 60
Stage I Monitoring (Pre-construction) 60
Surface Water 61
Groundwater 62
Biological Monitoring (Terrestrial Field Surveys) 62
Conclusions and Recommendations 63
Stage II Monitoring (During-construction) 64
Stage III Monitoring (Post-construction) 65
Conclusions 67
Recommendations 68
References 69

List of Figures

Figure 1: Subdivision Location 5
Figure 2: Approach Flowchart 6
Figure 3: Existing Conditions Photographs 11
Figure 4: Stormwater Management Treatment Train 31
Figure 5: Extended Detention Drawdown Time 34
Figure 6: Pre-Development Catchments 36
Figure 7: Post-Development Catchments 39
Figure 8: Post-Development Flow Chart 40
Figure 9: Proposed Stormwater Management Facility 41
Figure 10: Proposed Stormwater Management Facility Cross Section 42
Figure 11: Infiltration Gallery Modeling 45

List of Tables

Table 1: Selection of Stormwater Management Practices 14
Table 2: Coefficients for Synthetic Design Storms 17
Table 3: Reasonable Use Criteria Calculation 20
Table 4: Wet Ponds - Compliance to Design Criteria 29
Table 5: Water Quality Storage Requirements (Conservative Conditions) 33
Table 6: Coefficients for Synthetic Design Storms 34
Table 7: Catchment Naming Convention 35
Table 8: Pre-Development Modelling Parameters 37
Table 9: Post-Development Modelling Parameters 38
Table 10: Peak Flow Comparison to Beaver Creek 38
Table 11: Stage Storage Discharge for Forebay and Wet Pond 44
Table 12: Pond Live Storage Performance Summary (Winter Condition) 45
Table 13: Comparison of Attenuated Peak Flows (Flows to Beaver Creek) 46
Table 14: Peak Uncontrolled Flows for the Eastern Half of the Site 46
Table 15: Target Infiltration 49
Table 16: Target Runoff 49
Table 17: Existing and Proposed Water Balance Rates on Pervious Areas 50
Table 18: Catchment 3107 Water Balance from Pervious Areas 50
Table 19: Catchment 3913 Water Balance from Pervious Areas 51
Table 20: Catchment 3913 Lot Level Controls 52
Table 21: School Roof Runoff to Infiltration 52
Table 22: CWC Infiltration of Roof Runoff 53
Table 23: CWC Infiltration of Roof Runoff 53
Table 24: Total Infiltration Excluding EOP System 54
Table 25: Total Runoff Excluding EOP System 54
Table 26: End-Of-Pipe Infiltration & Runoff 55
Table 27: Post-Development Infiltration (Catchment 3107) 56
Table 28: Post-Development Infiltration (Catchment 3913) 56
Table 29: Post-Development Runoff (Catchment 3913) 57
Table 30: Total Infiltration 57
Table 31: Factors that Increase TSS Removal Rates 59

Appendices

Appendix A: Draft Plan
Appendix B: Design Drawings
Appendix C: Design Calculations
Appendix D: Modelling
Appendix D.1: Pre-Development Conditions
Appendix D.2: Post-Development Conditions
Appendix E: Correspondence
Appendix F: Geotechnical and Hydrogeological Investigation (Excerpts)

Introduction

Site Description

The proposed development (interchangeably referred to in this report as 'the site') is located northwest of 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).

Site Proposal

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

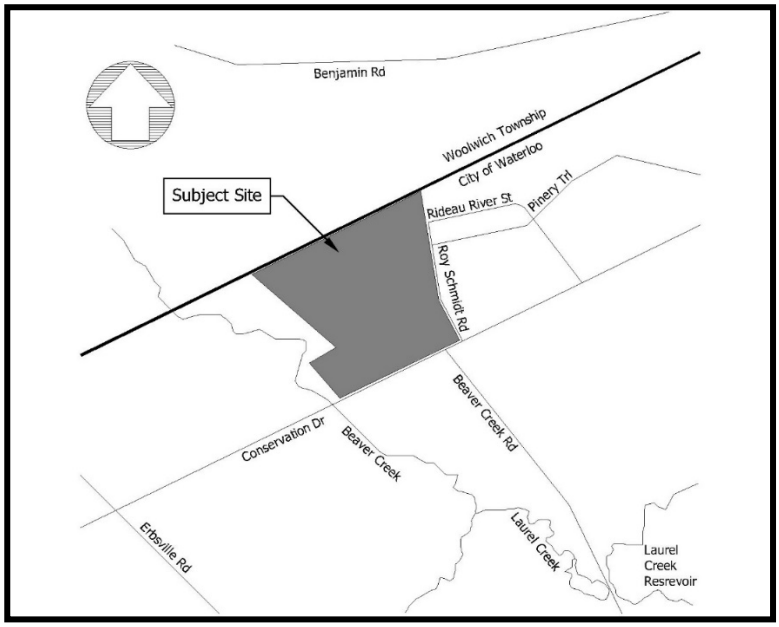


Figure 1: Subdivision Location

Approach

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

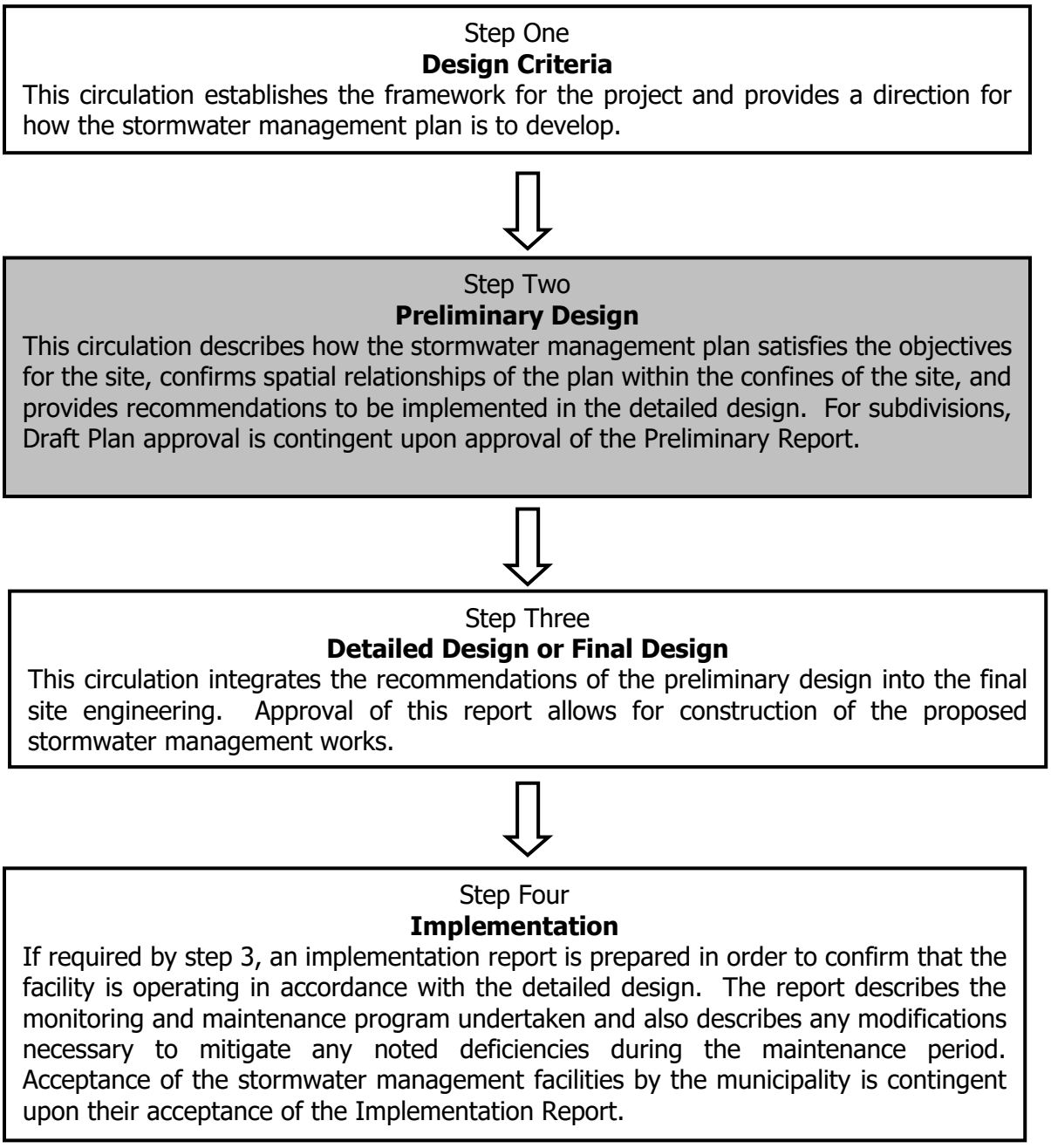


Figure 2: Approach Flowchart

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 Comprehensive Engineering and Landscape Manual, 2023
This manual provides detailed volumes addressing submissions, report writing, and the design guidelines for servicing and grading of subdivisions. It also includes a list of coefficients to be used in modelling of synthetic design storms.

Stormwater Management Master Plan (SWM-MP) Municipal Class Environmental Assessment, City of Waterloo, 2019
This manual provides design guidelines for stormwater management within the City of Waterloo.

The Stormwater Management Report is subject to AODA compliance.

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. The suitability of native soils for infiltration measures was verified through infiltration testing at the proposed infiltration facility locations; a high infiltration rate was verified at the SWM facility infiltration location. The calculated infiltration rate for given for the SWM facility infiltration 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.

Stormwater Management Reports

Beaver Creek Meadows Communal Stormwater Management; Final Stormwater Management Report, MTE Consultants, September 2020 (Revised March 2022)
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 the most recent submission dated September/October 2022, as well as from previous submission. Relevant components related to Meritech's 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
- GRCA comments dated November 18, 2022
- City of Waterloo comments dated March 3, 2023

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.

The downstream capacity of Beaver Creek was evaluated by the NWSSS and used to inform the design requirements for the proposed development. The subwatershed study explains the methodology to evaluate the impacts of development on Laurel Creek and its tributaries in Sections 6.0 and 7.0.

The downstream capacity of the storm sewers is being coordinated with Stantec. Coordination with MTE on the communal SWM pond to the south is complete and incorporates the east drainage area.

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 groundwater and 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	Wet pond preferred
Dry Pond	H	L/M	H	L	N	Wet pond preferred
Hybrid Facilities	H	H	H	L	N	Wet pond preferred
Infiltration Pond	L	H	M	M	Y	Wet pond to infiltration
Sediment Forebay	L	H	M	L	Y	Included
Wet Pond	H	H	H	L	N	c/w infiltration gallery

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 or significant changes to surface runoff volumes. 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.

Additionally, the NWSS discusses the importance of maintaining surface water contributions to the wetland along Beaver Creek:

> *Based on preliminary modeling results of the recommended stormwater management strategy, this approach will maintain existing infiltration levels in the PSA.*
>
> *In addition, existing surface water volume contributions from the PSA to wetlands within / adjacent to the PSA will be met or exceeded post-development, via a combination of groundwater recharge/discharge, SWM facility discharge during non-winter months (subject to agency confirmation (see Section 11.5C)) and/or runoff from adjacent open space and rear yard/roof areas. By matching surface water inputs, current levels of groundwater recharge occurring within the wetland features themselves will also be maintained post-development. Future site-specific studies should demonstrate that water balance to key natural features is maintained post-development.*

Section 13.1.4.4 "Maintenance of Groundwater Conditions", contains similar wording:

> *Hydrogeological and stormwater management studies, including water balance calculations, prepared in support of development applications should demonstrate maintenance of the existing surface water and groundwater regimes (i.e., flow direction and volume) to protect dependent features and ecological functions in receiving areas. Within the PSA, groundwater inputs are important to wetlands, slope woodlands and portions of Beaver Creek.*

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, 3 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 vicinity of the SWM facility is 67mm/hour. All subsurface soil layers are suitable for infiltration as they are greater than the MECP threshold of 15mm/hr.

The *North Waterloo, Phase 1 - Groundwater and Surface Water Monitoring Program* (2021-2022) discusses background of previous investigations, methodology and groundwater and surface water monitoring results.

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 borehole locations and groundwater contours provided by the geotechnical report are included in the detailed design drawings in Appendix B.

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.

Salt Impact Assessment

Background Concentration Assessment

The Regional Municipality of Waterloo's (RMOW) Salt Impact Study Guidelines specify that areas where road salt is of concern are to ensure that groundwater chloride levels will not cause adverse water quality concerns relative to the Ontario Drinking Water Quality Standards (ODWQS) and the Ministry of the Environment's Reasonable Use Concept (RUC).

The North Waterloo Scoped Subwatershed Study (NWSSS) completed a groundwater chemistry analysis for five monitoring wells. This chemistry was utilized to establish background concentrations of chloride and sodium in the groundwater at the site. Data from the monitoring wells showed that the chloride concentration ranged from 4 mg/L to 33 mg/L and sodium concentrations ranged from 1.4 mg/L to 85 mg/L. The upper limit was used for the calculations.

Table 3 outlines the RUC calculation for the development with observed readings from NWSSS.

Monitoring Well	**Concentration (mg/L)**	
	Chloride	**Sodium**
Average (Background, Cb)	33	85
ODWQS (Cr)	250	200
Constant (x) (non-health related)	0.5	0.5
RUC*	141.5	142.5

* RUC = Cb + x(Cr - Cb)

Table 3: Reasonable Use Criteria Calculation

Salt application rates are specified in the draft 2013 *Regional Implementation Guidelines for Source Water Protection Studies: Salt Impact Assessments* (Implementation Guidelines) as 22 tonnes/2-lane road/year for secondary (collector) roads and 2.2 tonnes/year for local roads. As described in section 'D' of the Implementation Guidelines, approximately 28% of salt applied to the portion of the site infiltrates to groundwater through the grassed boulevards. All of the salt applied to the west portion of the site will reach Beaver Creek by groundwater or surface water (winter bypass).

The Implementation Guidelines show a significant difference in salt application rates between secondary roads and local roads. For the purposes of the calculations, the 2020 Transportation Master Plan was reviewed to determine which streets may be considered to be secondary roads. The entire length of Pinery Trail, Esker Lake Drive from Conservation Drive to Pinery Trail, and Rushing River Street from Esker Lake Drive to the existing Activa subdivision to the east were considered as secondary roads. The result is that about one third of the roads are assumed to receive the higher salt loading.

As shown on the detailed salt loading calculations attached in Appendix C, a total of 15.4 tonnes/year of salt applied on the site reaches Beaver Creek, which produces a chloride concentration of 99 mg/L and a sodium concentration of 64 mg/L in the combination of infiltrated stormwater and runoff to Beaver Creek (predominantly winter bypass). Over 80% of the salt loading is due to Pinery Trail on the western part of the site. Combined with the initial background concentrations measured by NWSSS, the resulting concentrations of chloride and sodium at the property boundary were estimated at 132 mg/L and 149 mg/L, respectively. The value for sodium slightly exceeds the RUC value calculated in Table 3.

As the salt application rate on Pinery Trail on the west side of the site is likely conservative, no further action is recommended. Further, in detailed design the size of the catchment area can be reduced slightly at the east-west split location by inserting catchbasins "fighting grade" to reduce the road area piped to the site's SWM facility.

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.

SWM Design Development

This chapter describes the various alternatives considered when developing the SWM strategy proposed to address the stormwater management concerns associated with the proposed development in previous submissions. From the beginning, the two subwatershed catchments have been considered separately, with the runoff to Beaver Creek carefully controlled while the runoff to the south is directed to a SWM facility proposed to the south for any needed quantity and quality control. Infiltration is required for both catchments.

In the first submission, made in 2016, a wetland end-of-pipe facility was proposed, located on the west side of the subdivision, adjacent to the wetland setbacks of Beaver Creek. The SWM facility was proposed to extend within the 30m wetland buffer, as justified in the EIS. As a wetland facility, the permanent pool was 0.3m deep. The live storage depth was 2.1m, with the top of facility at an elevation of 356.90masl. The proposed access road connected to Street 'C' (now Pinery Trail) on the east side of the forebay and extended across the berm separating the forebay from the wetland permanent pool, then down into the wetland. It did not reach the proposed outlet. Retaining walls were provided near the forebay to support the required grading. This facility was proposed with a low flow outlet and an overflow weir for storms exceeding the 5-year. Both of these outlets direct the runoff to a level spreader. It was expected that the 2-year storm would fully infiltrate during the summer months. An infiltration gallery was proposed and located within the adjacent park block to provide this infiltration from the SWM facility; the connection from the SWM facility to the infiltration

gallery was noted as a reverse slope pipe but was not sized. Infiltration was expected to occur throughout the subdivision with a combination of this end-of-pipe facility and lot level galleries, leaving the precise approach to detailed design. A water balance was provided to show that these elements should be more than sufficient for the required infiltration.

GRCA comments on the design noted concerns about the proposed overflow weir and outlet positions, especially with regards to how these features would provide the required cold water flow to Beaver Creek. Questions were raised about how much runoff from Brohman lands would be directed to the subject site. The GRCA noted that the park block could not include area within the 30m wetland buffer. The GRCA agreed that opportunities for maintaining and enhancing the existing annual infiltration volumes were present, and requested that the water balance numbers use the NWSSS values instead of more generic numbers. The GRCA requested groundwater mapping in support of the design.

Comments from the Region requested more details on the infiltration measures to be taken and on the proposed water balance, with specific emphasis on the design of the clean water collection system. The Region also noted a minimum buffer from the Significant Woodland of 10m that should not have any development within it. Groundwater contours were also requested.

The initial design was revised and resubmitted in 2018, prior to Meritech receiving comments from the City and Region. The GRCA did not provide additional comments on the second submission. The SWM facility was still designed as a wetland facility with a permanent pool depth of 0.3m, with a reduction in the depth of the active storage of 1.7m. The facility was lowered overall such that the top of facility was at 355.50masl. The proposed design changed where the access road connects to Pinery Trail to the west side of the forebay. Increased retaining walls were provided near the forebay and along the west side of the access road in order for the access road to reach the top of the forebay while still providing storage to the top of active storage. These changes reduced the amount of construction to be completed in the wetland buffer, but did not remove construction from the buffer entirely. Culvert outlets were added to the SWM facility, while the proposed overflow weir was reduced in size. All outlets were still directed to the level spreader, which was changed in design. The reverse slope connection to the infiltration gallery in the park block was sized as 300mm. Meritech confirmed that as much runoff from Brohman as possible would be directed to the SWM facility, which was designed to accommodate this runoff. The clearwater collection system layout was added to the design. The proposed grading was intended to elevate areas which would direct uncontrolled runoff to Beaver Creek through the use of retaining walls.

City comments on the design noted some concerns, in particular that the SWM block should be kept outside of the buffer features and that all retaining walls should be removed or minimized, especially along the western property limit. The infiltration gallery proposed within the park block was noted to have significant construction and maintenance concerns. Discrepancies were noted in the wetland limits, and more justification was requested for including the SWM facility within the buffer limits. Retaining walls within the buffer limits were a particular point of concern. Linkages of the SWM access road and pedestrian trails on the park block were requested.

In the third submission, submitted in 2020, a wetland end-of-pipe facility was still proposed. With the removal of the retaining walls and removal of elements within the buffers, the SWM block reduced in size. In order to provide a similar volume of active storage, the base of the pond was lowered to provide an active storage depth of 2.3m. The wetland permanent pool was maintained at a depth of 0.3m. The previously proposed end-of-pipe infiltration facility was moved out of the park block. The clean water collection system was directed along the south side of the SWM block, through the wetland buffer, to act as an end-of-pipe infiltration facility that could be closed during winter months. The groundwater elevations used to inform this design were from the draft Phase 1 Groundwater and Surface Water Monitoring Program prepared by Stantec on April 2016, with numbers lower than the groundwater data that would be determined by Stantec in their 2021 hydrogeological report. Additional monitoring was ongoing at the time. The base of the SWM wetland and the connected infiltration measures were located around the elevation of 353masl based on this draft report. The access road was connected to the park trails as requested.

Additional details were provided on the proposed water balance, identifying the expected infiltration from each infiltration system to be implemented and comparing them to the proposed infiltration estimates in the NWSSS. The winter condition was accounted for by infiltrating rainfall only. Based on this estimate, the proposed infiltration exceeded the amount of infiltration expected in the NWSSS.

The issues that were raised in City comments on this design include lot level infiltration on private lands, the draft nature of the hydrogeological assessment, and the placement of infiltration facilities within the 30m buffer. The final hydrogeological assessment was required, and infiltration measures were to be moved out of the buffer area. The City requested confirmation that infiltration in the rear yards of the lots would be required to meet the infiltration targets, and that there was no way to direct this infiltration to public lands. The City noted that a continuous SWM model would be required in the detailed design stage. The GRCA comments requested further details about the water balance and updated accounting of the wetland boundaries.

In the fourth submission, completed in 2022, a hybrid wet pond/wetland facility was proposed with an infiltrating basin component in order to provide both active storage and the necessary infiltration. The groundwater elevations were updated based on the 2021 Stantec Hydrogeological Assessment Final Report, which identified the groundwater elevation at the SWM block as 353.0masl. This decreased the available depth of the proposed SWM facilities. The base of the wetland was set at 354.00masl, with a 0.4m permanent pool and a 1.1m deep active storage. Additional outlets were required to accommodate the loss of active storage.

The clean water collection system was moved out of the wetland buffer. Instead, the infiltration facility was combined with the SWM facility in the SWM block. The intention of this design choice was for the forebay, wetland and vegetated filtration sections of the SWM facility to provide the quality treatment required to support infiltration from the infiltrating basin. Separating the infiltration basin from the SWM facility fully was expected to infringe on the park block due to the layout of the SWM facility and the expected grading.

The rear yard infiltration was noted to be in areas where drainage to storm sewers was not possible and no publicly owned lands was available for the galleries. The galleries were noted as providing necessary quantity control for the 2-year design storm, not as an infiltration measure.

The issues that were raised in City comments on this design included concerns about restricting flow to the infiltration basin during winter maintenance, concerns about the overall pond design, and concerns about the amount of infrastructure in the wetland buffer. The secondary cell was noted to have the potential to short-circuit flows from the forebay to the outlet. The infiltration basin was noted to be required to hydraulically disconnect from the main facility and would require a bypass system for large flows. The open surface storage used in this design did not allow either of these elements to be provided by the infiltration basin. Quantity control was required to be provided fully separately from the infiltration system. The quality control requirements of the hybrid pond system required additional explanation to justify the values used and ensure that they were aligned with the MOE 2003 manual. Additional clarity was requested concerning how the park runoff would be directed to the SWM facility. City comments also raised concerns about the SWM access path becoming submerged.

In the fifth submission, completed in 2023, a hybrid wet pond/wetland was proposed with an infiltration facility located underneath a portion of the active storage area. The infiltration gallery was clay lined in order to ensure that only inflow entering from the connected ditch inlet catchbasins would enter the gallery. This would ensure that winter runoff was not directed to the infiltration gallery when the operations valves were closed. Infrastructure in the wetland buffer was reduced, specifically structures and sewers, and a piped storm connection was shown between the park block and the SWM facility. The infiltration gallery was hydraulically disconnected from the SWM facility but was retained within the existing SWM block. This was due to the hybrid wet pond/wetland design requiring less overall permanent pool area, while the grading continued to drive a large, shallow active storage for the SWM facility. The base area of the active storage required exceeded the top of the permanent pool and forebay such that there was sufficient area for the infiltration gallery underneath it, in theory.

The issues that were raised in conversation with the City on this design included the hybrid approach, the placement of the infiltration facility, and the details of winter operation. A hybrid wet pond/wetland approach was not preferred due to concerns about the hybrid being unable to meet the requirements of both a wet pond and a wetland facility as well as maintenance complications. This design did not provide clear information on the SWM facility's ability to meet the quantity control targets in the winter condition, when the infiltration facility would not be available as an outlet or form of storage. The placement of quantity storage for larger design storms above the proposed infiltration facility raised concerns about compaction of the infiltration facility. Maintenance and replacement of the infiltration facility would disrupt the functionality of both the dead storage and of the active storage. The removal of infrastructure from the wetland buffer was acknowledged, but the access road remaining in the wetland buffer was noted as another element to be moved.

Informed by these previous submissions and guidance from the City of Waterloo, per the meeting minutes from June 14, 2024 included with this submission as a response letter, the

current SWM design approach has separated the infiltration gallery from the main SWM quantity control facility. This facility has been changed from a wetland to a wet pond design. The design of the wet pond has been made with the intention of providing the requirements of the 2003 MOE SWM Design Manual and of meeting the design quality and quantity requirements in winter conditions. The access road was moved fully out of the wetland buffer, and was designed as directed by Operations as per the email dated August 23, 2024, included in Appendix E. The SWM block has been redesigned and increased in size in order to support the wet pond and the infiltration facility. Draft Plan redesign and grading changes were completed to ensure that the wet pond can provide the large active storage volume required. The outlet staging was designed to maximize outflow from the wet pond based on the target release rates from the NWSSS and is necessary to the function of the SWM facility.

It has been confirmed through discussion with the City of Waterloo that the lot level infiltration facilities are required in order to meet the 2-year quantity control requirements for the development, as no other outlets, storm sewers, or public lands are available to supply an outlet to these lots in the 2-year storm. As these facilities are not intended to provide groundwater recharge, they have been discounted from the water balance calculations.

In the design of the proposed infiltration gallery, the location of the gallery and the ability to access it for maintenance and future replacement without infringing on the park block or on the SWM pond.

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 on lots and a clean water collection (CWC) system within the road rights of way that will infiltrate clean roof runoff from all roofs (fronts and backs).

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 peak flow rates have been provided to ensure the proposed infrastructure is

designed with sufficient capacity. The minor flow conveyance will be through the storm sewer system and the major storm conveyance will be along the roads. Quantity control for the catchment discharging to Laurel Creek is not required in accordance with the NWSSS. Quality control for this portion of the development is to be incorporated into a pond on a downstream property and will be designed and addressed in a separate stormwater management report. This design is being undertaken by others as part of a comprehensive, shared SWM solution for multiple landowners.

The west side of the site was developed along guidelines of the Control Hierarchy Approach of the Draft LID Manual (Priorities 1, 2 and 3). Priority 1 components of this stormwater management design consist of low impact development and Best Management Practices (BMPs) focused on flow retention. These are comprised of 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, wet pond cell and infiltrating gallery. The minor (5-year) storm event is directed to the forebay, with major storms directed to the wet pond cell. The facility is proposed to outlet to an infiltration system to allow for cooling, and increased infiltration per the NWSSS. This wet pond/infiltrating gallery 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.

Compliance to Design Criteria

This section presents the design criteria required by the MOE (2003 manual) and how the Stormwater Management Facility meets those standards.

Design Element	Design Objective	Minimum Criteria	Preferred Criteria	Provided	Meets Standards?
Drainage Area	Sustaining Vegetation; Volumetric turnover	5 hectares	≥ 10 hectares	9.344	Meets minimum criteria – See modelling for details

Treatment Volume	Provision of appropriate Level of protection (see Section 3.3.1.1)	As per Table 3.2	1. Permanent Pool volume increased by expected maximum ice volume 2. Active Storage increased from 40 m³/ha to 25% of total volume		Yes - Details are provided in "Quality – Extended Detention" subheading
Active Storage Detention Time	Suspended Solids Settling	24 hrs (12 hrs if in conflict with minimum orifice size)	24 hrs	24 hrs	Yes - Details are provided in "Quality – Extended Detention" subheading
Forebay	Pre-treatment	Minimum Depth: 1 m Sized to ensure non-erosive velocities leaving forebay Maximum Area: 33% of total permanent pool	Minimum Depth: 1.5 m Maximum Volume: 20% of total Permanent Pool	1.5m Depth, 13% of total permanent pool volume, 16% of permanent pool area	Yes - Details are included in Appendix C
Length-to-Width Ratio	Maximize flow path and minimize short-circuiting potential	Overall: minimum 3:1 Forebay: minimum 2:1	From 4:1 to 5:1	Overall is 3:1 Forebay is 2:1	Yes – See Figure 9 and Appendix C for details.
Permanent Pool Depth	Minimize re-suspension, avoid anoxic conditions	Maximum Depth: 3 m Mean Depth: 1 m - 2 m	Maximum Depth: 2.5 m Mean Depth: 1 m - 2 m	2.5m from top of storage to bottom of permanent pool.	Yes - See Table 11 for details of the SSD
Active Storage Depth	Storage/Flow Control	Water Quality and Erosion Control: maximum 1.5 m Total (including quantity control): 2 m	Water Quality and Erosion Control: maximum 1.0 m Total (including quantity control): 2 m	1.0m from Top of storage to top of permanent pool (winter)	Yes - See Table 11 for details of the SSD
Side Slopes	Safety Maximize the	5:1 for 3 m above and below permanent pool	7:1 near normal water level	All side slopes 5:1.	Yes - See Figure 9.

	functionality of the pond	Maximum 3:1 elsewhere	plus, use of 0.3 m steps 4:1 elsewhere		
Inlet	Avoid clogging/freezing	Minimum 450 mm Preferred pipe slope > 1% If submerged, obvert 0.15 m below expected maximum ice depth		900mm	Yes – See Figure 9
Outlet	Avoid clogging/freezing	Minimum: 450 mm outlet pipe Reverse sloped pipe should have a minimum diameter of 150 mm Preferred pipe slope: > 1% If orifice control used, 75 mm diameter minimum	Minimum 100 mm orifice	Orifices between 110mm and 480mm	Yes – See Figure 9
Maintenance Access	Access for backhoes or dredging equipment	Provided to approval of Municipality Provision of maintenance drawdown pipe preferred		Provided per municipal standards.	Yes – See Figure 9 and City of Waterloo email in Appendix E.
Sediment Drying Area	Sediment removal	While preferable, should only be incorporated into the design when it imposes no additional land requirement	To be provided above maximum water quality water level Drainage returned to Pond	Sediment drying area has not been provided.	NA
Buffer	Safety	Minimum 7.5 m above maximum water quality/erosion control water level Minimum 3m above high water for quantity control.		Approx. 4m between freeboard and closest property line, w/ approx. 10m between	Yes – See Figure 9

				permanent pool and same property line.	

Table 4: Wet Ponds - Compliance to Design Criteria
(Compiled From 2003 MOE Manual – Table 4.6)

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 (the pre-development area of 12.3ha), which includes 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.

The downstream capacity of the development is split between the flows directed to storm sewers and to an external quality control facility leading to the Laurel Creek Reservoir, and the flows directed west to Beaver Creek. Per the NWSSS, the unit flow restrictions on catchment 3913 noted above are intended to ensure that event-related peak flows do not raise the creek flows above existing conditions, ensuring that the downstream capacity is not negatively impacted. The NWSSS discusses the methods taken to evaluate this in sections 6.0 and 7.0 of the study.

The capacity of the sewers and quality control facility to the south have been coordinated with the engineering firms responsible for their designs, Stantec and MTE. Stantec is working on behalf of the City on the Conservation Drive and Beaver Creek Road reconstruction project, and MTE is working on behalf of the developer group on the communal SWM facility.

Communication with Stantec is ongoing, as detailed coordination is necessary through the engineering approvals stage for grading and servicing. Detailed information on the minor and major flows directed to the intersection of Conservation Drive and Beaver Creek Road was provided in July 2023 (attached in Appendix E).

Coordination with MTE is complete. Figure 3.1, "Post Development Sub-Catchment Areas" shows that the eastern portion of the development, plus the external catchment to the north, was considered in the design of the communal SWM facility.

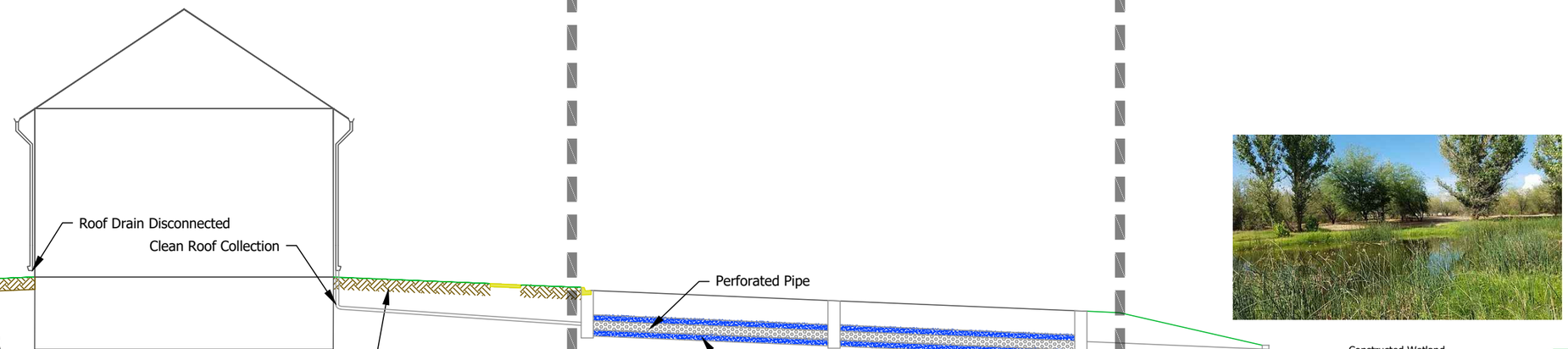
Figure 4

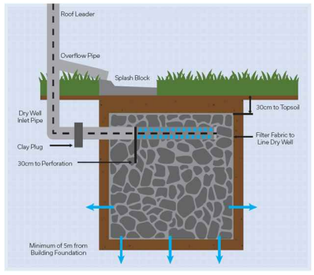
Stormwater Management Treatment Train

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 (CWC) 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 wet pond/infiltrating gallery facility. The facility treats runoff for sedimentation control within the forebay, filtration strip and wet pond 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.

Forebay

The proposed stormwater management pond includes a sediment forebay designed in accordance with the Aesthetic Design Principles for Storm Water Management Facilities in the Region of Waterloo, and Ministry of the Environment guidelines. The forebay blends into the proposed walking trails and maintenance access routes. The forebay design is included in Appendix C.

LID features

Low Impact Development Features have been included in the design. Infiltration trenches and soakaway pits have been provided at the lot level for catchments 505 and 504. A perforated pipe system has also been added to the system to infiltrate clean roof runoff along the length of the ROW. The end-of-pipe facility also includes infiltration measures. The outlet includes a level spreader to reduce the erosion risk at the outlet and to promote flows reflective of existing conditions.

Extended Detention

The end-of-pipe facility includes a wet 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 42%, 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)
9.344	116	1,086	3,290	40	374	1,446

**Summer condition* ***Winter condition*

Table 5: Water Quality Storage Requirements (Conservative Conditions)

The extended detention shown in Table 5 is defined as the active storage in the design quality (2-year) storm event in winter conditions, when the underground infiltration system is not in use. In the summer conditions, the underground infiltration system is to capture additional runoff and provide further controls to the extended detention through the slow infiltration of water from the variable permanent pool. This variable permanent pool provides the most conservative permanent pool volume in the summer condition, which has been noted in Table 5.

Based on the provided MIDUSS modelling, the extended detention in the 2-year storm in the winter condition is 1,446 m^3 and takes 86 hours to draw down. This significantly exceeds the extended detention required. As such, a control storm matching the required extended detention (374m^3) has been modelled to ensure that the extended detention is met in practice. This storm is based on the 3-hour 2-year design storm from the City of Waterloo standards, with the "A" value adjusted to provide the required target runoff volume. The result of this modelling is shown in Figure 5 below. The flow drops to 1 L/s (typically chosen as the point at which the facility is considered to be drawn down) more than 24 hours after the storm event.

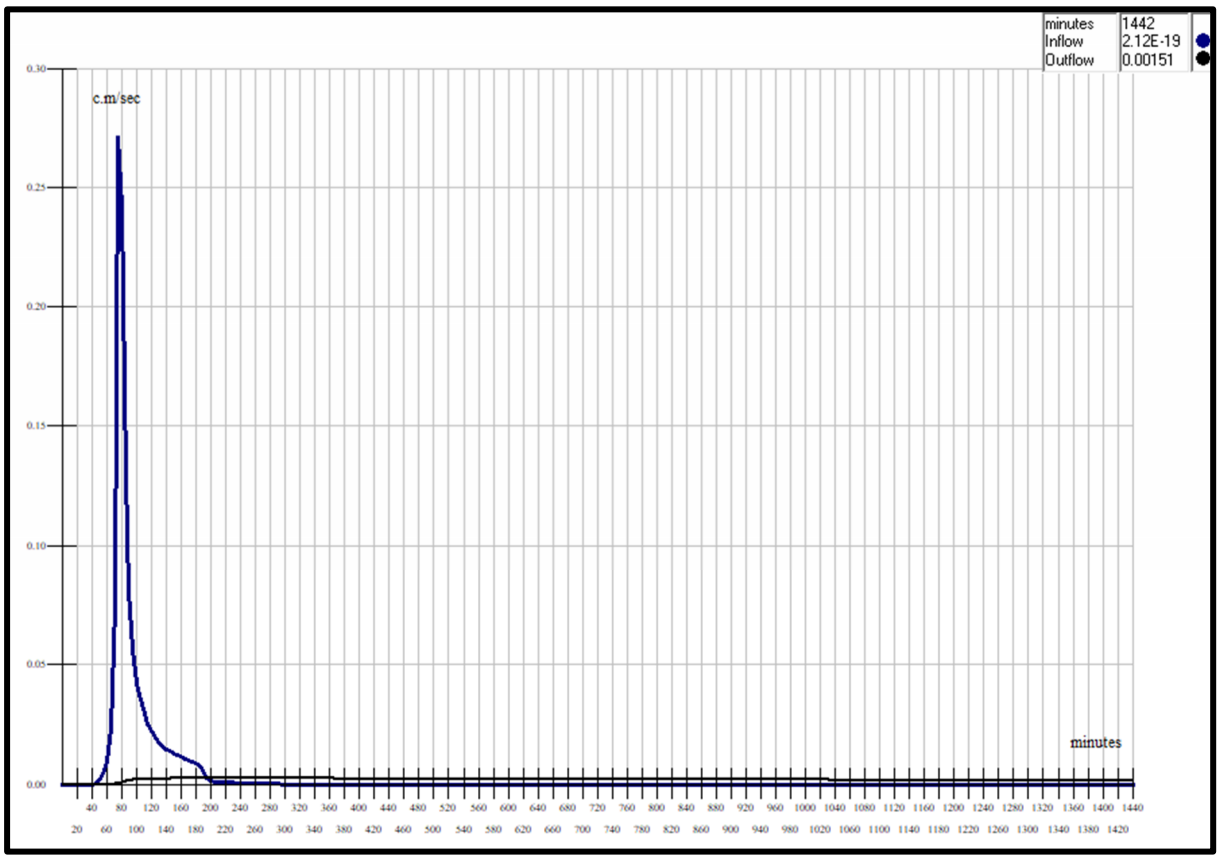


Figure 5: Extended Detention Drawdown Time

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.

Rainfall Data

Storm Event	Definition	a	b	c	r
2-year, 24 hour	Design quality	583.440	3.561	0.783	0.400
5-year, 24 hour	Minor system	956.510	5.608	0.815	0.400
100-year, 3 hour	Major system	4692.000	17.437	0.956	0.400

Table 6: Coefficients for Synthetic Design Storms

The design storms were evaluated based on both the 3-hour Chicago storms from the City of Waterloo 2023 Manual and the 24-hour SCS storms from the Guelph Arboretum data, per direction from the NWSSS. The worst-case scenario was chosen in each case to evaluate the stormwater management design.

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

Pre-Development Hydrology

The site was subdivided into pre-development catchments as shown in Figure 6. A routing flowchart is shown on the pre-development catchment plan and matches the catchments in the NWSSS.

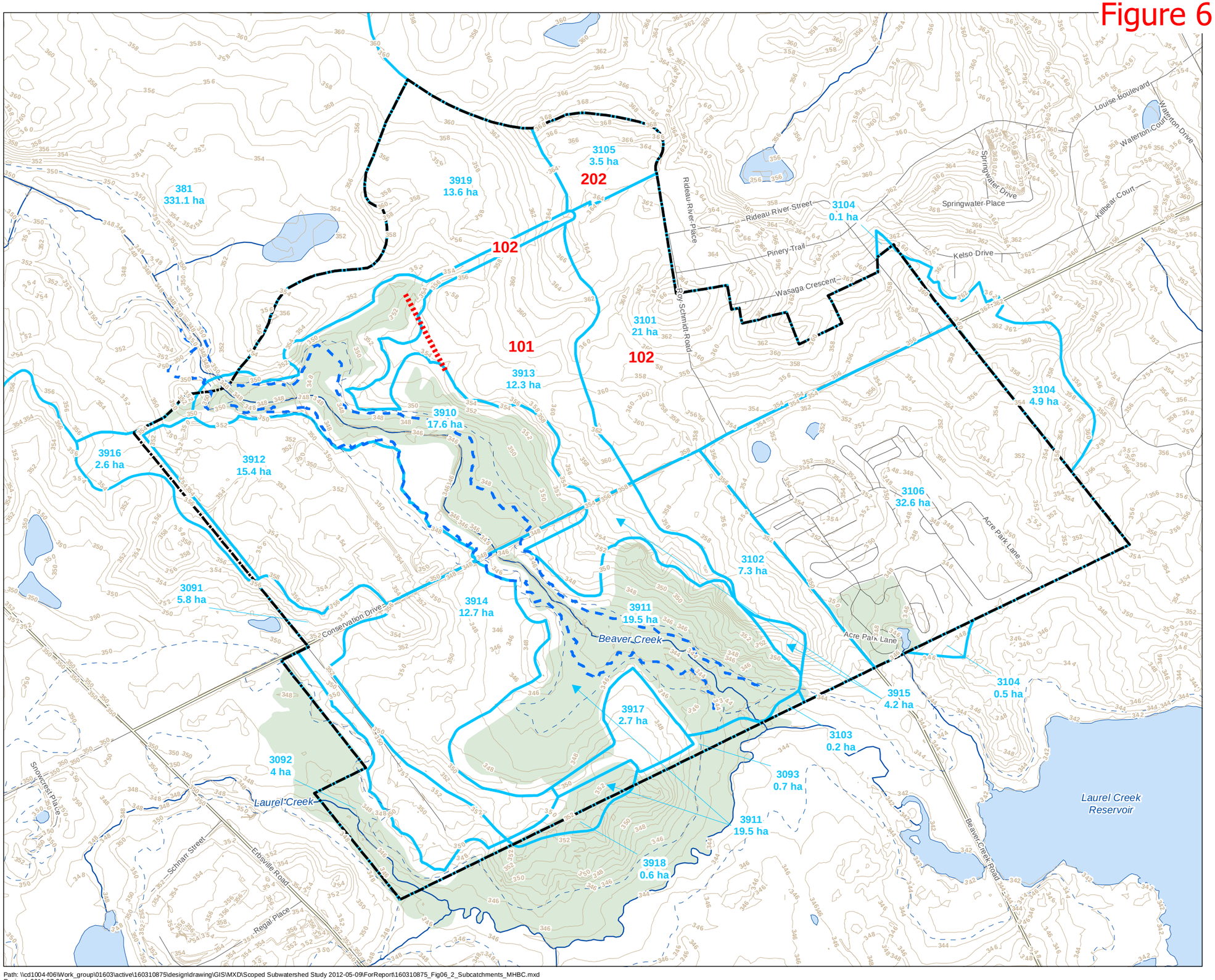
Suitable modelling parameters for each of the catchments were chosen, as presented in Table 8. The SCS curve number soil parameters, estimated from standard tables, were based on a soil type of C with good condition pasture land. Generated peak flows from each catchment are also summarized in Table 8. The MIDUSS modelling for the pre-development catchments is included in Appendix D.1.

Figure 6

NORTH WATERLOO SCOPED SUBWATERSHED STUDY

PRIMARY STUDY AREA SUBCATCHMENTS

FIGURE 6.2



Primary Study Area
Highway
Major Road
Local Road
Topographic Contour (mAMSL)
Watercourse
Waterbody
Delineated Floodplain
GRCA Floodplain
Detailed Subcatchment
Natural Heritage Features

0 50 100 200 300 400 m

1:7,500

NOTES

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

NORTH

October 2013

Stantec

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

ecoplans
A member of MMM GROUP

160310875

Path: \\cd1004-f06\Work_group\01603\active\160310875\design\drawing\GIS\MXD\Scoped Subwatershed Study 2012-05-09\ForReport\160310875_Fig06_2_Subcatchments_MHBC.mxd
Revised: 2011-07-21 By: sstroszkali

Catchment	Area (ha)			Imper-vious (%)	Slope Length (m)	Slope Gradient (%)	SCS CN (pervious)	Peak Flow (m^3/s)	
	Controlled	Uncontrolled	Total					2-year	100-year
102		13.00	13.00	0	100	5	74	0.127	1.396
101		10.36	10.36	0	100	3	74	0.159	1.752
201		1.25	1.25	0	15	3	74	0.035	0.284
202		3.50	3.50	0	90	2	74	0.045	0.483
Total		28.11	28.11						

Table 8: Pre-Development Modelling Parameters

Post-Development Hydrology

Increasing the site to 60% imperviousness with no attenuation methods would result in a sharp increase in peak flows to the Beaver Creek. Post-development catchments incorporate the routing of the minor and major storm systems to the proposed stormwater management facility. Figure 7 shows the catchment areas for the proposed project, and Figure 8 shows the routing used in the model. Figures 9 & 10 show the design of the proposed SWM facility. Suitable modelling parameters were selected for each catchment, as presented in Table 9. 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		0.356	0.356	60	15	3	74	0.052	0.135
502		2.299	2.299	50	30	3	74	0.264	0.721
503		9.130	9.130	70	15	3	74	1.531	3.924
504		0.453	0.453	20	15	3	74	0.029	0.114
505		0.898	0.898	35	15	3	74	0.079	0.242
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	5.159		5.159	60	15	3	74	0.570	1.578
702	0.920		0.920	30	90	3	74	0.065	0.216
703	1.361		1.361	20	80	3	74	0.030	0.195
704	1.054		1.054	60	15	0.5	74	0.146	0.430
705	1.908		1.908	100	5	3	-		1.271
801	0.850		0.850	60	15	3	74	0.123	0.323
Total	11.252	17.036	28.288						

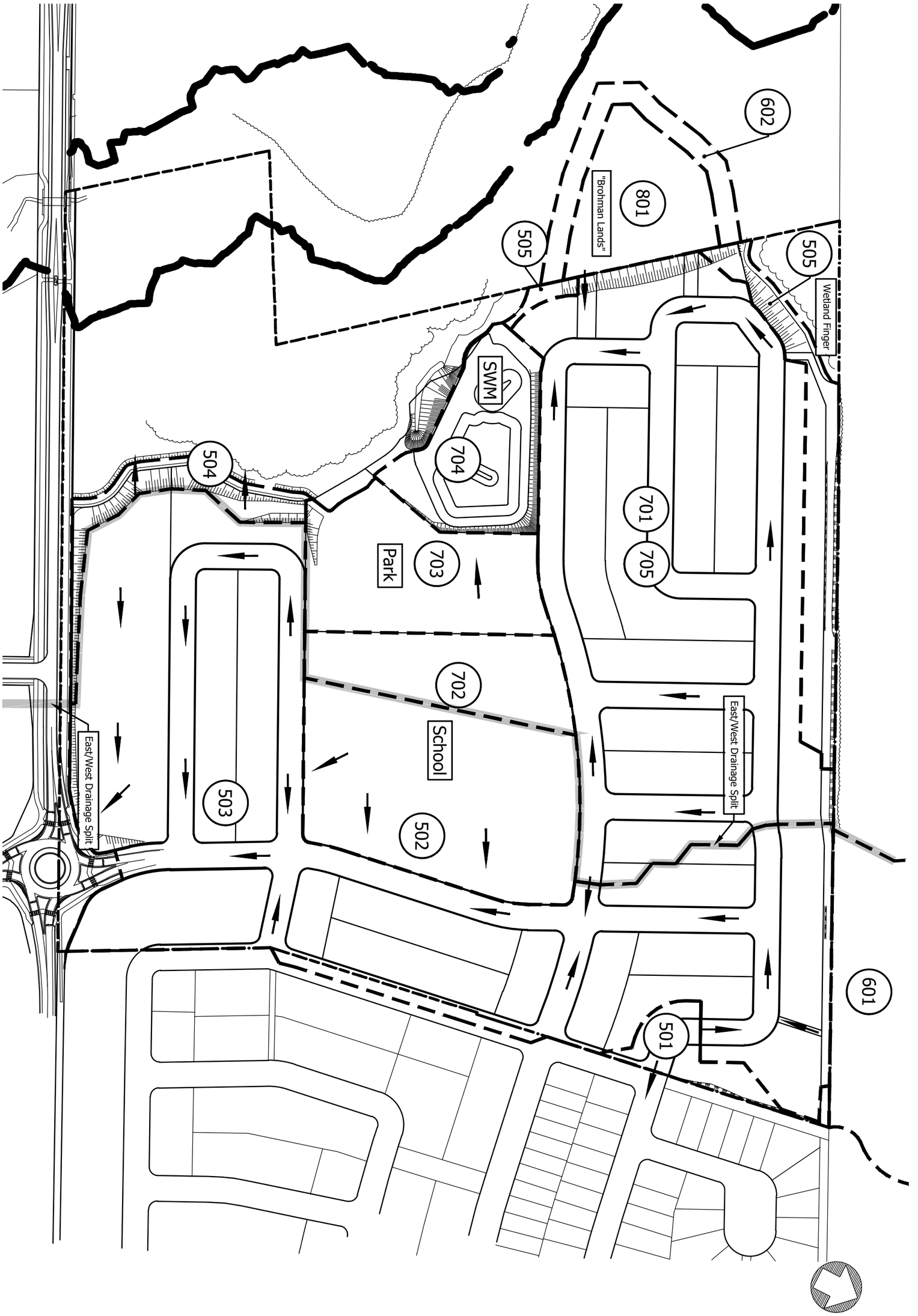
Table 9: Post-Development Modelling Parameters

The resultant uncontrolled peak flows from each catchment are summarized in Table 9. The Guelph Arboretum 24-hour storm was the most conservative for the 2-year and 5-year events while the Waterloo 3-hour rainfall was conservative for the 100-year event; these are the values represented in Table 10. Refer to the MIDUSS modelling results in Appendix D for further information.

Table 10 shows that the unattenuated post-development peak flows are greater than both the pre-development flows and the allowable flows to Beaver Creek. As a result, attenuation measures in the form of a controlled outlet pond are proposed.

Event/Condition	2-year (m^3/s)	5-year (m^3/s)	100-year (m^3/s)	Hazel (m^3/s)
Pre-development	0.142	0.339	1.524	1.640
Allowable	0.014	0.123	0.677	1.344
Unattenuated post-development	1.098	2.255	4.369	1.824

Table 10: Peak Flow Comparison to Beaver Creek



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

DRAWN BY:	STV	CHECKED BY:	CHT	SCALE:	1:2500
FILE NAME:	1279.Figures	DATE:	Oct 2024		Figure 7

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

801

701
Lots

704

Wet Pond

CWC
(Third Pipe)

705
Roofs

Major

Infiltration

702

703

Winter Bypass

Infiltration

Beaver Creek

Major

602

504

Minor

Infiltration

505

Minor

Infiltration

Major

Wetland Finger

501

To Existing Subdivision to the East

502

503

601

Minor

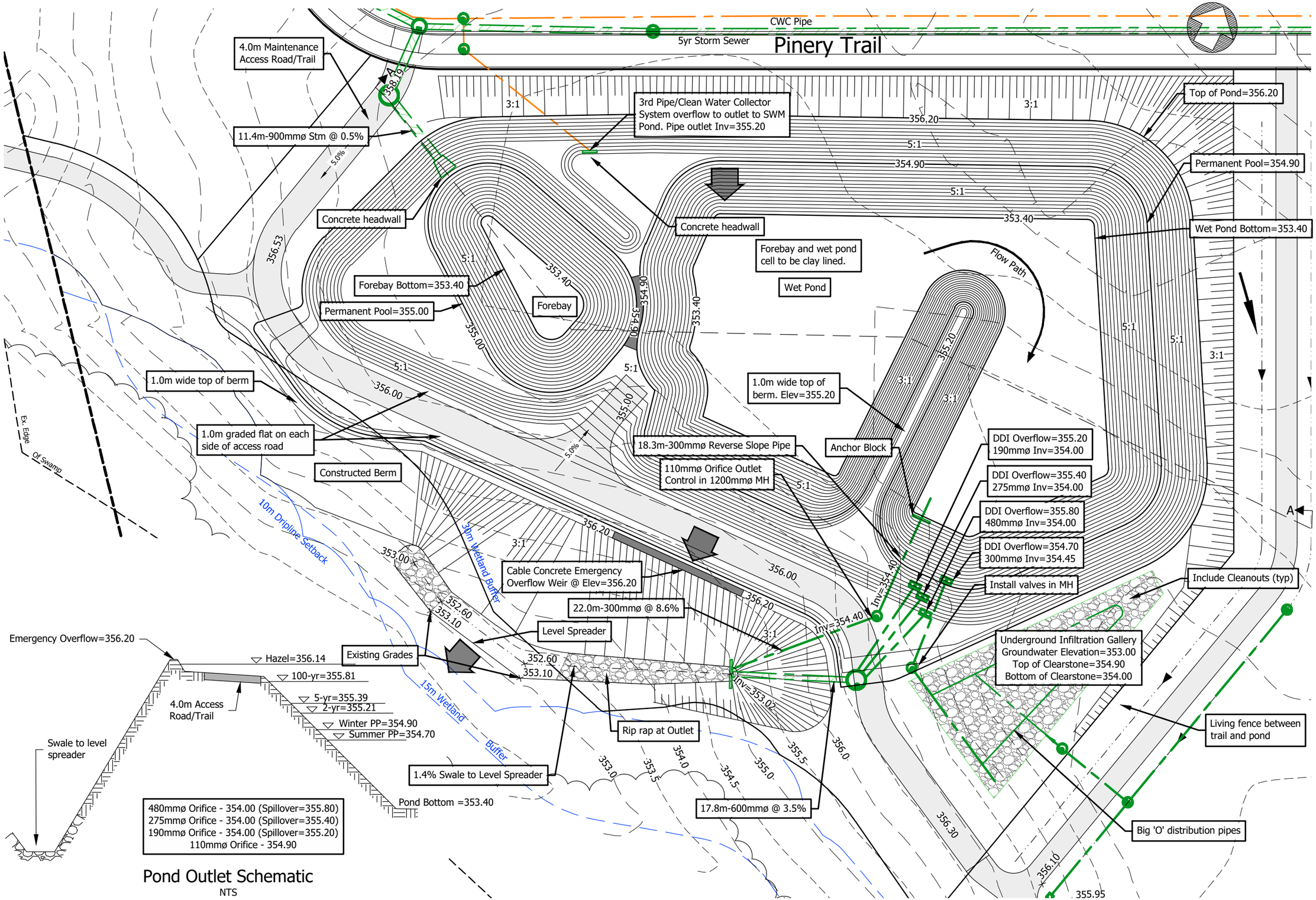
Roof Area to Infiltration

SWM Facility South of Conservation Drive

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

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

DRAWN BY: STV	CHECKED BY: CHT	SCALE: Not to Scale	
FILE NAME: 1279.Figures	DATE: Nov 2023		Figure 8



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

DRAWING: Proposed Stormwater Management Facility
556 & 576 Conservation Drive

DRAWN BY:	STV	SCALE:	1:500
CHECKED BY:	CHT		Figure 9
DATE:	Oct 2024		
FILE NAME:	1279.Figures		

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

DRAWING: Pond Cross-Section Conservation Drive

DRAWN BY:	CHECKED BY:	SCALE:	
STV	CHT	1:600	Figure 10
FILE NAME:	DATE:		
1279.PondX-Sect	Oct 2024		

File Path: C:\M\Meritech Engineering\PRJ - DOCS\1279\CAD\DP\Sheets\1279.PondX-Sect.dwg, - Plotted: October 18, 2024 by: Stefanv

Performance of the End-of-Pipe System

The combination of pond configuration and outlet control structure shown in Figure 9 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 wet pond cells are summarized in Table 10. 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 wet pond cell to prevent re-suspension of sediment.

The wet pond cell is clay-lined to retain a permanent pool and provides additional sediment capture prior to flows reaching the infiltration gallery.

The outlet structure consists of:

- a 110mm diameter orifice designed for the 2-year outflows
- a 190mm diameter orifice designed for the 5-year outflows
- a 275mm diameter orifice designed for the 100-year outflows
- a 480mm diameter orifice designed for Hurricane Hazel
- an emergency concrete weir that allows 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.	Live Stor.	Dead Stor.
(m)	(m)		(m^3/s)	(m^2)	(m^3)	(m^3)	(m^3)
Wet Pond							
353.4	-1.5	Bottom of Permanent Pool	0	1780	0		0
353.5	-1.4		0	1889	183		183
353.6	-1.3		0	2000	194		378
353.7	-1.2		0	2112	206		584
353.8	-1.1		0	2226	217		800
353.9	-1.0		0	2342	228		1029
354.0	-0.9	Bottom of Infiltration	0	2459	240		1269
354.1	-0.8		0	2578	252		1521
354.2	-0.7		0	2699	264		1785
354.3	-0.6		0	2822	276		2061
354.4	-0.5		0	2946	288		2349
354.5	-0.4		0	3073	301		2650
354.6	-0.3		0	3200	314		2964
354.7	-0.2		0	3330	327		3290
354.8	-0.1		0	3461	340		3630
354.9	0.0	**Top of Gallery & Permanent Pool Outlet Orifice (110)**	0	3594	353	0	3982
355.0	0.1		0.003	4552	414	414	
355.1	0.2		0.009	5062	481	895	
355.2	0.3	Orifice 2 (190)	0.013	5235	515	1409	
355.3	0.4		0.102	5410	532	1942	
355.4	0.5		0.107	5586	550	2492	
355.5	0.6	Orifice 3 (275)	0.306	5782	568	3060	
355.6	0.7		0.318	5946	586	3646	
355.7	0.8		0.330	6113	603	4249	
355.8	0.9	Orifice 4 (480)	0.341	6282	620	4869	
355.9	1.0	Maximum Ponding	1.002	6468	638	5507	
356.0	1.1		1.032	7260	686	6193	
356.1	1.2		1.060	7469	736	6929	
356.2	1.3	Freeboard	1.089	7677	757	7687	
Forebay (Dead Storage)							
353.4	-1.5	Bottom		103	0		0
353.7	-1.2			181	43		43
353.0	-0.9			273	68		111
354.3	-0.6			379	98		209
354.6	-0.3			500	132		340
354.9	0.0	**Permanent Pool**		634	170		510

Table 11: Stage Storage Discharge for Forebay and Wet Pond

Table 12 summarizes the overall performance of the live storage of the pond, including storage volumes of the various storm events and peak discharge rates.

Description	Rainfall Parameters	Elevation (m)	Live Storage Depth (m)	Storage Volume (m^3)	Discharge (m^3/s)
Permanent pool		354.90	0.0	0	0
2-year ponding	Guelph	355.21	0.31	1446	0.013
5-year ponding	Guelph	355.39	0.49	2445	0.107
100-year ponding	Waterloo	355.81	0.91	4900	0.373
Hurricane Hazel ponding	-	356.13	1.23	7197	1.070
Freeboard		356.20	1.30	7687	1.089

Table 12: Pond Live Storage Performance Summary (Winter Condition)

The storage volumes listed in Table 12 represent the aboveground live storage volumes of the wet pond.

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

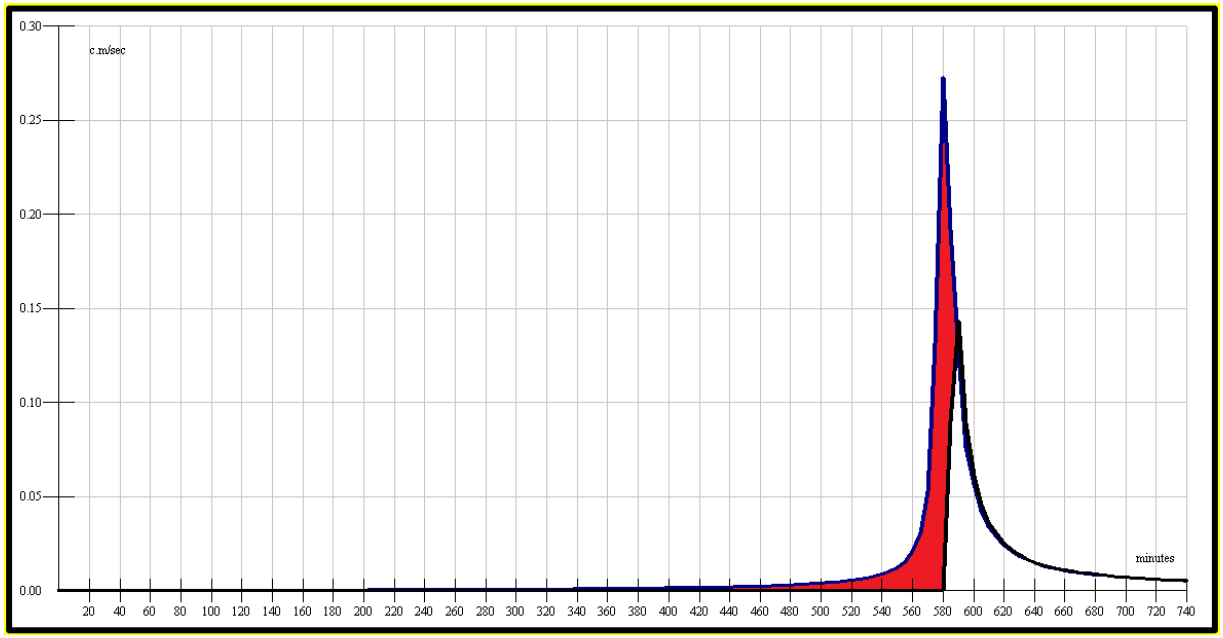


Figure 11: Infiltration Gallery Modeling

Table 13 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 wetlands 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)
Pre-development	0.142	0.339	1.524	1.640
Allowable	0.014	0.123	0.677	1.344
Attenuated post-development	0.013	0.117	0.657	1.297

Table 13: 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 14 shows these flows (using the 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	0.052	0.071	0.135	0.051
SWM south of Conservation Drive	502, 503, 601	1.795	2.446	4.661	2.055

Table 14: Peak Uncontrolled Flows for the Eastern Half of the Site

The capacity of the communal SWM pond to the south was coordinated with MTE and incorporates the east drainage area of the proposed development.

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 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 "third pipe" clean water collector system and distributed infiltration systems across 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 7.

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 wet pond 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 wet 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 Rushing River Street will be directed to infiltration galleries up to the 2-year event. Flows greater than the 2-year storm will flow uncontrolled to the wet pond. The use of rain barrels should be investigated in the detailed design stage (as long as they are not likely to negatively impact infiltration targets); 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, as shown on Figure 9. In the winter months, runoff will be attenuated in the facility. Using a valve, controlled flows will be piped directly to the level spreader rather than into the infiltration gallery.

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 infiltration surplus from what is possible.

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.

Water Balance

For the purposes of this report, the main "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, 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.

Target Infiltration & Runoff Values

In Table 11.5 of the NWSSS, the total existing water balance values for each catchment are provided based on the current catchment conditions. The subwatershed study provides example water balances for the proposed catchment conditions which account for the introduction of infiltration facilities. These values were provided based on the assumed land usage "for the purposes of discussion" based on Appendix 3E of the NWSSS. They have been used as one of two "target rates" for both the infiltration and runoff requirements for the subdivision.

Per the NWSSS and discussion with the City, the infiltration for the development will be required to maintain or improve compared to existing conditions. The "proposed" rate from the NWSSS has been considered as the optional target, with the goal of achieving close to these values. Meeting this target will improve on the existing conditions as stated in the subwatershed study. Both targets have been provided in Table 15.

The City of Waterloo has indicated that the water balance should consider the baseflow requirements of downstream receptors in the post-development scenario. Per Section 10.3 of the NWSSS, the baseflow of Beaver Creek is maintained by ensuring existing infiltration rates are sustained. At-source control methods are described as being preferable by the subwatershed study in order to maintain the spatial distribution of infiltration.

Description	NWSSS Catchment #	Area (ha)	Existing Infil Rate (mm/yr)	Existing Annual Infiltration (m^3/yr)	NWSSS Proposed Infiltration Rate (mm/yr)	NWSSS Proposed Annual Infiltration (m^3/yr)
East catchment	3107	11.79	183.4	21,614	281.6	33,187
West catchment	3913	11.75	222.5	26,153	265.2	31,172
Total		**23.54**		**47,767**		**64,359**

Table 15: Target 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 matches the NWSSS's assumptions 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 clean water collector (CWC) system in the nearby Vista Hills subdivision.

Per the NWSSS, there is a minimum runoff requirement to Beaver Creek from the West Catchment. The NWSSS explains that the surface runoff from 3913 should be maintained in order to "not starve the wetland." Per discussion with the City, it was agreed that the existing runoff value to Beaver Creek would act as the minimum allowable value, while the NWSSS proposed runoff would act as the maximum allowable value. Catchment 3107 does not have a minimum runoff requirement and should be restricted as much as possible per standard design principles.

Description	NWSSS Catchment #	Area (ha)	Existing Runoff Rate (mm/yr)	Existing Annual Runoff (m^3/yr)	NWSSS Proposed Runoff Rate (mm/yr)	NWSSS Proposed Annual Runoff (m^3/yr)
West catchment	3913	11.75	68.8	8,087	232.4	27,316

Table 16: Target Runoff

Passive Infiltration & Runoff

The proposed infiltration rates provided in Table 11.3 of the NWSSS are not reflective of the pervious rates. Instead, they incorporate and average the runoff and infiltration caused by both pervious and impervious areas, as well as incorporating the infiltration from the anticipated facilities. Per direction from the City of Waterloo, further evaluation of the rates of infiltration and runoff in both the existing and proposed pervious conditions has been completed. Table 3.1 in the MOE 2003 Manual provides typical evapotranspiration, runoff,

and infiltration rates for different types of vegetative cover. In this case, the existing conditions have been considered equivalent to "Moderately Rooted Crops" while the proposed conditions have been considered equivalent to "Urban Lawns." By comparing the runoff and infiltration values provided, it was determined that the average infiltration and runoff for soils ranging from fine sand to silt loam, the "Urban Lawn" provided 25mm of additional runoff and 15mm less infiltration than the "Moderately Rooted Crops." This provides the rates presented in Table 17 below, which will be used to evaluate the water balance volumes in the proposed conditions.

Description	NWSSS Catchment #	Existing Infiltration Rate (mm/yr)	Proposed Infiltration Rate (mm/yr)	Existing Runoff Rate (mm/yr)	Proposed Runoff Rate (mm/yr)
East catchment	3107	183.4	168.4	--	--
West catchment	3913	222.5	207.5	68.8	93.8

Table 17: Existing and Proposed Water Balance Rates on Pervious Areas

Lot-level infiltration is proposed to consist of naturally occurring infiltration on pervious surfaces, which has been termed "passive infiltration," (predominantly grass yards combined with increased topsoil depths), with several small catchments also employing infiltration galleries where grading does not 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). The catchments employing infiltration galleries will be accounted for in the next section.

Using the rates in Table 17, the amount of infiltration and runoff contributed to each catchment by pervious areas in the post-development condition can be calculated, as shown in Tables 18 & 19.

Catchment #	Area (ha)	%Pervious	Pervious Area (ha)	Annual Passive Infiltration Volume (@ 168.4mm/yr) (m3)
501	0.365	40%	0.14	240
502	2.299	50%	1.15	1,936
503	9.130	30%	2.74	4,612
		Total	**4.03**	**6,788**

Table 18: Catchment 3107 Water Balance from Pervious Areas

Catchment #	Area (ha)	%Pervious	Pervious Area (ha)	Annual Passive Infiltration Volume (@ 207.5mm/yr) (m3)	Total Annual Runoff Volume (@ 93.8mm/yr) (m3)	Annual Runoff Volume** (m3)
701	7.068	40%	2.83	5,866	2,652	981
702	0.920	70%	0.64	1,336	604	224
703	1.361	80%	1.09	2,259	1,021	378
704	1.054	40%	0.42	875	395	146
504	0.453	80%	0.36	752	Counted in the next section	
505	0.898	55%	0.49	1,025	Counted in the next section	
Total	**11.75**		**5.84**	**12,114**	**4,673**	**1,729**

**Winter months plus 10% large storms

Table 19: Catchment 3913 Water Balance from Pervious Areas

The runoff from catchments 504 and 505 will be evaluated separately, due to the impact of lot level galleries on these catchments. Due to concerns about groundwater level, the infiltration from these catchments will not be considered as part of the total infiltration provided by the development.

Lot Level Infiltration Facilities

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. Based on the RCV_T, approximately 90% of annual rainfall occurs in storms less than the 2-year design event. The remaining 10% of precipitation is contributed to the water balance from large storms. These storms are more likely to create runoff than infiltration due to the peak flows and total volumes expected.

Infiltration galleries are proposed for three catchments

- Southwest corner, 2-year runoff volume to infiltration (catchments 504)
- Northwest corner, 2-year runoff volume to infiltration (catchment 505)
- School site, all roof runoff to infiltration, 2-year runoff volume to infiltration (catchment 502)

The runoff from catchments 504 and 505 is to be directed to the infiltration galleries. It is expected that 10% of the runoff from the pervious areas and 10% of the precipitation from the roofs will be directed to Beaver Creek instead of to infiltration, as presented in Table 20.

Catchment	Contributing Area (ha)	Roof area (ha)	Annual Grass Runoff to Infiltration (m3)	Annual Roof Runoff to Infiltration (m3)	Annual Runoff to Beaver Creek (m3)
504 (rear yard/roof)	0.453	0.091	306	689	111
505 (rear yard/roof)	0.898	0.404	417	3,072	388
		Total	**723***	**3,761***	**498**

*Note: conservatively ignored in total infiltration. (Remaining 10% of P)

Table 20: Catchment 3913 Lot Level Controls

City comments have requested confirmation that the proposed rear-yard infiltration measures will be able to be designed with adequate soil cover and sufficient separation to the seasonally high groundwater table. The groundwater elevations were compared to the preliminary grading plan to confirm that adequate separation can be achieved. Based on the groundwater contour mapping provided by the Stantec Hydrogeological Assessment completed in December 2021, one area around MW6-19 on the north property line and the property line adjacent to MW2-10 appear to have groundwater elevations high enough to make infiltration galleries difficult to install even in the post-development condition. In the detailed design phase, the exact location of the distributed infiltration gallery along the north property line (under the trail) will be confirmed; there will be sections where a gallery will not be feasible. Due to this, the infiltration from these galleries has been conservatively ignored.

Similarly in catchment 502, the school roof is to be sent to its own infiltration facility. The specific location of the gallery will be determined through discussion with the school board. The current expectation is that the clean water collector (CWC) pipe system near the school will be expanded to take the runoff from the school roof, falling within the ROW and under the jurisdiction of the City to maintain. The volume of water expected to be directed from the school roof to the infiltration facilities is once again equivalent to 90% of the precipitation to the rooftop, based on the amount of annual rainfall expected to occur in storms less than the 2-year design event. The expected runoff from the school roof to the infiltration facility is calculated in Table 21.

Catchments	Contributing Area (ha)	Runoff (mm)	Annual Lot Runoff to Infiltration (m3)
502 (school roof)	0.45	760	3,421

Table 21: School Roof Runoff to Infiltration

Clean Water Collection System

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.

The runoff from the remaining roof areas to be directed to the CWC from catchments 503 and 701 has been calculated similarly. Based on the 2-year design storm 90% of the rainfall will be infiltrated from the roof area. Of the remaining 10% of runoff from the rooftops from catchment 701, it is expected that half (±5%) will be infiltrated in the end-of-pipe SWM facility, and half (±5%) will be directed to Beaver Creek as runoff. The calculations for both catchments are presented in Table 22 below.

Catchment	Contributing Area (ha)	Roof Area (ha)	Runoff (mm)	Annual Roof Runoff to CWC (m³)	Annual Roof Runoff to EOP Pond (m³)	Annual Runoff to Beaver Creek (m³)
503	9.13	2.47	760	18,743	--	--
701	7.07	1.91	760	14,510	806	806

Table 22: CWC Infiltration of Roof Runoff

The CWC system will be sized with the capacity for the 2-year design storm runoff. In the 24-year storm with a rainfall depth of 47.03mm per the MIDUSS model in Appendix D, the runoff volume from the roofs of each catchment excluding the school roof is noted in Table 23.

Catchment	Contributing Area (ha)	Roof Area (ha)	2-Year Runoff Depth (mm)	2-Year Roof Runoff to CWC (m³)	Provided Length of CWC (m)	Required Average Clear Stone Cross-Section (m²)
503	9.13	2.47	42.33	1,046	1,180	2.2
701	7.07	1.91	42.33	808	1,370	1.5
Total	**16.2**	**4.38**		**1,854**	**2,550**	

Table 23: CWC Infiltration of Roof Runoff

Given a length of 2,340 m as shown on the design drawings and the calculated runoff volume of 1,854 m³ (not counting the school roof runoff), the average cross-sectional area of clear stone required along the CWC system is shown in Table 23 above. This will be further refined in the detailed design stage.

The total infiltration and runoff not including the direct contributions from the end-of-pipe systems has been calculated as shown in Tables 24 & 25 below.

Catchment	Pre-Development Annual Infiltration (m3)	Annual Infiltration Target (m3)	Post-Development Annual Infiltration Provided (Excl. EOP) (m3)
3107	21,614	33,187	28,952
3913	26,153	31,172	27,429
Total	**47,767**	**64,359**	**56,381**

Table 24: Total Infiltration Excluding EOP System

Catchment	Pre-Development Annual Runoff (m3)	Annual Runoff Maximum (m3)	Post-Development Annual Runoff (Excl. EOP) (m3)
3913	8,087	27,316	3,033

Table 25: Total Runoff Excluding EOP System

End-of-Pipe Facility

The end-of-pipe facility will provide both infiltration and runoff for catchment 3913. The areas considered as providing runoff to the end-of-pipe facility are all impervious areas from catchments 701, 702, 703, and 704 excluding the roofs. The pervious areas and roof areas have been evaluated separately from the end-of-pipe facility, resulting in the values presented in Tables 24 and 25 above.

The end-of-pipe facility is intended to infiltrate the 10mm storm, which is slightly over 50% of the annual rainfall based on the RCV_T. All rainfall exceeding the 10mm storm is expected to contribute to the runoff volume. The runoff volume was increased by approximately 7.5% to account for large storms.

In winter months, the end-of-pipe infiltration facility will be cut off from the inflow between November 15th and April 15th. The monthly precipitation values in the Canadian climate normals data available from Environment Canada were used to determine the percentage of precipitation to be excluded from this infiltration rate. All precipitation for the impacted months was conservatively excluded to better ensure that the provided infiltration will meet the minimum requirement. This rainfall makes up 45% of the total precipitation. The remaining 55% of precipitation, excluding storms larger than the 10mm and the amount of rainfall on impervious areas directed to evapotranspiration (approximately 10%), has been evaluated to determine the total annual infiltration provided by the end-of-pipe infiltration facility.

Catchment	Contributing Impervious Area (ha)	Runoff to Infil (24.75% of Precip) (mm/yr)	Annual End-Of-Pipe Infiltration	Runoff not to Infil (Remaining Precip) (mm/yr)	Annual Runoff to Beaver Creek (m3)	Additional ±5% prec. Due to large storms (m³)
701	2.33	209	4,877	636	14,557	271
702	0.28	209	577	636	1,723	32
703	0.27	209	569	636	1,699	32
704	0.63	209	1,322	636	3,947	73
Total	3.51	--	7,345	--	21,925	408

Table 26: End-Of-Pipe Infiltration & Runoff

During summer operation, the 2-year storm will infiltrate fully. The infiltration facility has been sized to provide sufficient base area for infiltration given the infiltration rate of 67mm/hr. Storage of the runoff to be infiltrated is provided in the variable permanent pool instead. Based on the 2-year runoff volume to the SWM pond as calculated in the MIDUSS modelling, the volume to be infiltrated per storm is at most 315 m³. The storage provided in the variable permanent pool is 722 m³. Storing water intended for infiltration within the variable permanent pool allows the size of the end-of-pipe infiltration gallery to be driven by the required infiltration rate.

The required infiltration gallery base area is intended to infiltrate 315 m³ over the course of 48 hours. This ensures that sufficient runoff is captured and infiltrated even in larger storm events. The required bottom area sizing has been calculated using Equation 4.3 from the MOE 2003 MOE SWM design manual:

$$A = \frac{1000V}{Pn\Delta t}$$

A is equal to the bottom area of the trench in m². V is equal to the volume to be infiltrated, in this case 315m³. P is equal to the percolation rate of the surrounding native soil in mm/hr, which in this case is 67mm/hr. n is equal to the porosity of the storage media, which is 0.4 for clear stone. Δt is equal to the required retention time. In this case, that is 48 hours. The resulting required base area is 245 m². An infiltration gallery base area of 440m² has been provided, ensuring that in summer conditions the required infiltration to maintain the water balance from all storms will be able to infiltrate well within 48 hours.

Total Post-Development Infiltration & Runoff

The main goal of each of these infiltration and runoff features is to provide or improve on the pre-development conditions for both catchment 3107 and 3913.

Catchment 3107 gained infiltration through passive infiltration, lot level infiltration from the school roof, and infiltration from the clean water collection system. The total infiltration provided to catchment 3107 from these systems is noted in Table 27 below.

Source of Infiltration	Post-Development Annual Infiltration (m3)
Passive Infiltration	6,788
Lot Level Infiltration (502 – School Roof)	3,421
CWC System	18,743
Total	**28,952**

Table 27: Post-Development Infiltration (Catchment 3107)

In the pre-development condition, the annual infiltration for catchment 3107 is 21,416m³. The proposed post-development infiltration exceeds the existing conditions by 7,536m³, achieving the minimum required infiltration to maintain groundwater balance. This is in line with the direction of the NWSSS, which considered a post-development infiltration of 33,187m³ for catchment 3107, also exceeding the infiltration experienced in existing conditions.

Catchment 3913 has both an infiltration requirement to meet or exceed the pre-development conditions. Catchment 3913 gains infiltration through passive infiltration, lot level infiltration from catchments 504 and 505, infiltration from the clean water collection system, and infiltration from the end of pipe facility. The lot level infiltration from catchments 504 and 505 has been conservatively ignored from the post-development annual infiltration. The total infiltration provided to catchment 3913 is noted in Table 28 below.

Source of Infiltration	Post-Development Annual Infiltration (m³)
Passive Infiltration	12,114
CWC System	15,316
End-of-Pipe Infiltration	7,345
Total	**34,775**

Table 28: Post-Development Infiltration (Catchment 3913)

In the pre-development condition, the annual infiltration for catchment 3913 is 26,153m³. The proposed post-development infiltration exceeds the existing conditions by 8,622m³, achieving the minimum required infiltration to maintain groundwater balance. This is in line with the direction of the NWSSS, which considered a post-development infiltration of 31,172m³ for catchment 3913, also exceeding the infiltration experienced in existing conditions.

Catchment 3913 also has required runoff targets. The annual runoff from the development is to be greater than 8,087m³ and less than 27,316m³. The runoff from catchment 3913 comes from runoff in larger storm events that is not captured by infiltration measures, either at the lot level, by passing through the clean water collection system without infiltrating, or by

passing through the end-of-pipe SWM pond. The total runoff from catchment 3913 in the post-development condition is noted in Table 29 below.

Source of Runoff	Post-Development Annual Infiltration (m3)
Lot Level Runoff	1,729
Lot Level Runoff (502 & 504)	498
CWC System	806
End-of-Pipe Facility	22,333
Total	**25,366**

Table 29: Post-Development Runoff (Catchment 3913)

The post-development runoff from catchment 3913 is between the minimum required runoff of 8,087m³ and the maximum allowable runoff of 27,316m³. The post-development annual runoff will provide sufficient runoff to maintain the existing wetland without exceeding the maximum runoff specified by the City of Waterloo.

The total infiltration for both catchment 3107 and 3913 is presented in Table 30 below.

Catchment	Pre-Development Annual Infiltration (m3)	Annual Infiltration Target (m3)	Total Post-Development Annual Infiltration Provided (m3)
3107	21,614	33,187	28,952
3913	26,153	31,172	34,775
Total	**47,767**	**64,359**	**63,727**

Table 30: Total Infiltration

The total provided infiltration exceeds the pre-development infiltration, which acts as the required minimum infiltration for the development. The infiltration provided to each catchment also exceeds the pre-development infiltration volumes. 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 NWSSS considers an infiltration value for the development that is slightly higher than what has been provided, equivalent to approximately 1%. While this value acts as a preferred target for the infiltration, based on the NWSSS treating it as "a point of discussion," it is not

a required target to meet; instead, it is a useful guide on what the development should attempt to meet.

The post-development infiltration has conservatively discounted infiltration from the galleries in catchments 504 and 505 and has not considered infiltration that could occur at the end-of-pipe facility during the months of November and April outside of the winter bypass. Given these conservative reductions, the minor deviation from the possible post-development value provided by the NWSSS should be met, providing an infiltration surplus of 33% compared to the pre-development infiltration volume in line with the subwatershed study requirement to meet or exceed the existing infiltration for the development.

The supporting water balance calculations have also been included in Appendix C.

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.

Environmental Compliance Approval

Consolidated Linear Infrastructure Environmental Compliance Approvals (CLI-ECAs) are necessary for the stormwater management facility and the storm sewers and are exempt from Environmental Bill of Rights requirements. Public participation has already been completed through the requirements for a Planning Act approval related to a plan of subdivision.

The stormwater management facility is new and is categorized as a wet pond, with a connected infiltration facility. The drainage area associated with the pond is 9.344ha 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 0.85 ha to the northwest of the subdivision is privately held but is developing in conjunction with this development and is expected to drain to the proposed SWM facility. 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 permanent pool fringe to be planted in the stormwater management block
- A diverse mix of trees, and species tolerant to water level changes
- Suitable plant species to reduce the potential for slope erosion
- A 3m clearance to maintenance roads from woody plants

- Shade trees and shrubs planted along the wet pond and forebay and level spreader to mitigate temperature increases in the facility through shading

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 31.

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	Y
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	N

Table 31: 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. A preliminary 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.

Inspections will be in accordance with the site-specific Monitoring Plan, the City's Development monitoring protocol, and any and all GRCA requirements. The inspection requirements have been discussed in the "Monitoring, Maintenance and Mitigation" section below and will be established in more detail at detailed design.

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.
- Timing the construction and connection of the infiltration facilities to the rest of the SWM system in order to prevent sediment buildup in the proposed facilities during construction.
- Seasonal concerns, such as wet spring conditions, dry dusty summer conditions, suitability for re-vegetation and landscaping, and herpetofaunal movement times (see page 326 of the NWSSS)
- Anticipated maintenance and assumption schedules with the municipality

Monitoring, Maintenance and Mitigation

There is currently a monitoring program underway in accordance with the North Waterloo Scoped Subwatershed Study and the City of Waterloo Development Monitoring Protocol. A Terms of Reference for the entire pre-construction (i.e. Stage 1) monitoring program was approved in 2014/2015. That Terms of Reference includes biological, surface water and groundwater components and is attached. That Terms of Reference states that "Results from groundwater and surface water monitoring for Stage 1 will be presented in brief annual reports...". 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.

Stage I Monitoring (Pre-construction)

The Surface Water and Groundwater Phase 1 Monitoring Program for the Site was approved in mid-2014, which included a reduced monitoring program within the Site itself and eliminated monitoring of adjacent wells. monitoring was completed for 2016, 2018, 2020, 2021, 2022 with the results used in the Stantec's North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program, 2021-2022 Monitoring Data report for baseline and

comparable analysis. This is above and beyond the two-year initiation period as recommended in the City of Waterloo Development Monitoring Protocol in advance of grading in order to ensure that valid seasonal baseline data is available for the subject development lands in its pre-construction state. This data will facilitate a comparison with data collected through the construction phases and with other locations within the watershed. A Terms of Reference for the Stage I monitoring program was submitted to the City, Region, and GRCA and approved in 2014/2015.

The pre-construction Biological Monitoring Program for the Site as described in the approved Terms of Reference dated January 21, 2015, includes biological, surface water and groundwater components. This has been carried out by NRSI for the past 6 years (2016a, 2017, 2018, 2019, 2020, 2021, 2022, 2023) and the natural features in the area have also been well studied through the North Waterloo Scoped Subwatershed Study (NWSSS, Ecoplans et al. 2013). The monitoring program methods were developed according to the City of Waterloo Development Monitoring Protocol (1999), Sections 14 to 17 of the NWSSS (Volume 1, November 2013, Ecoplans et al. 2013) and was revised and updated based on comments received from the City of Waterloo, Grand River Conservation Authority, and the Region of Waterloo as well as results of the SAR screening, prepared separately, which was reviewed and approved by MNRF on December 15, 2014.

The results of the Stage I monitoring program are being reported to the City, Region, and GRCA on an annual basis. The North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program, 2021-2022 Monitoring Data report and the Environmental Impact Study report presents and summarizes the data that has been gathered and includes a discussion of the implications of that information.

The current Stage I monitoring program per the approved terms of reference and City of Waterloo Development Monitoring Protocol 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). This assessment should occur twice annually (preferably spring and fall). Any remedial action requirements should be identified at the time of the inspection.

Surface Water

The Laurel Creek Subwatershed Study established five parameters that must be tested - temperature, dissolved oxygen, total suspended solids, total phosphorous, and total and fecal coliform (E. coli) - and set targets for each parameter. The targets are attached in Appendix F from the North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program (2021-2022) document prepared by Stantec on May 5, 2023, the results were:

- The temperature targets were met in all samples. The highest recorded temperature was 19.9 ºC & 18.4 ºC recorded on July 7, 2021, and July 12, 2022
- The dissolved oxygen targets were met for all the samples
- The TSS targets were met in 73% and 100% of the samples in 2021 and 2022, respectively
- The total phosphorous concentration targets were met in 45% and 60% of the samples in 2021 and 2022, respectively
- Bacteria was not monitored by the City of Waterloo

The surface water quality results obtained in 2021 and 2022 are similar to the results obtained in preceding years except that the TSS targets that were met in all 2022 samples. According to Stantec's document, this is likely due to a reduction of surface runoff corresponding to the 30% reduction in that year's precipitation depth (as compared to the historical average).

Groundwater

The groundwater elevations measured in 2021 & 2022 are similar to historical data, except for the data from Fall 2022. Below-average precipitation in Fall 2022 led to lower groundwater levels. When precipitation was above average (2016-2020), the groundwater levels were shallower in all monitoring wells than what was initially presented in the NWSSS. The report advises that the subject development design review and take into account the groundwater level data across the site and take the high spring groundwater levels into consideration.

For groundwater chemistry, the results are consistent with the historic data with similar concentrations as previously reported with some natural variability. Key parameters were reviewed including sodium/chloride to evaluate potential response to changes in winter road salting activities and nitrate to evaluate potential response to changes in agricultural activities. No changes of these key parameters were noted based on the 2021 and 2022 data.

Biological Monitoring (Terrestrial Field Surveys)

The results of the pre-construction biological monitoring have been reported annually by NRSI, with monitoring still ongoing. These results are attached in Appendix F (Environmental Impact Study, NRSI, October 2023), Sections 2.0 to 5.0.

Potential impacts arising from the proposed undertaking are determined by comparing the layout and details of the proposed undertaking with the existing natural features, buffers and their ecological functions. Where the development proposal overlaps with the natural features or their buffers, impacts may arise. Buffers have been provided from the wetland and woodland boundaries to the limits of the development including the stormwater management facility. Measures to maximize infiltration of surface water have been provided throughout the site.

The following describes the types of impacts and their mitigation measures discussed within the EIS (Section 5.0 Impact Analysis and Recommendations):

- Direct impacts to the natural features on the subject lands associated with disruption or displacement caused by the actual proposed 'footprint' of the undertaking.

- Indirect impacts associated with changes in site conditions such as drainage and water quantity/quality.
- Induced impacts are those associated with post-development activities such as subsequent demand on the resources created by increased habitation/use of the area and vicinity.

Conclusions and Recommendations

Based on the pre-construction surface water and groundwater monitoring by Stantec (2018-2022) and pre-construction biological monitoring completed by NRSI (2016-2023). The following conclusions of the Phase 1 monitoring completed are provided:

- Annual precipitation in 2022 was the lowest observed in at least 50 years and was 31% lower than the 20-year annual average. Annual average precipitation in 2021 was 9% below the 20-year annual average
- Observed groundwater levels collected during the 2021 and 2022 monitoring period were generally consistent with historic levels / trends, with lower groundwater levels noted in Fall 2022 attributed to the below average precipitation
- Groundwater quality results throughout the site were generally consistent with historical data
- Surface water hydrographs were created using continuous water level loggers and manual flow measurements to develop a rating curve at each monitoring site
- Water quality monitoring at Station 17 (Beaver Creek at Conservation Drive) was completed by the City of Waterloo. At this location Laurel Creek Watershed Study (LCWS) targets were met for all temperature and dissolved oxygen measurements, the majority of TSS readings also met the target, while total phosphorous targets were met for 45% and 60% of the sampling events in 2021 and 2022, respectively
- The wetland on the subject property contains relatively good quality habitats with some areas of rich and diverse species communities. A number of regionally significant species have also been identified.
- There are areas which have experienced impacts in the past but are regenerating and naturalizing.
- No Species At Risk were observed on the property although the wetland plus 30m is a regulated habitat for Blanding's turtle which are a threatened species.
- A number of species of conservation concern and regionally significant species have been documented using the woodland/wetland.
- The wetland has been designated as a provincially significant wetland and contains significant woodlands, wildlife habitat for amphibians and species of conservation concern.
- The wetland is a part of an ecological linkage providing a travel route for wildlife along the Beaver Creek corridor to off-site habitats and Conservation Drive is a barrier to wildlife movement. This is being addressed through road improvements as part of a City of Waterloo Class EA.
- Beaver Creek is an off-site stream that flows through the wetland, draining to Laurel Creek reservoir and eventually the Grand River.

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

- The proposed grading and development within the site should be reviewed with respect to the updated peak spring groundwater levels to confirm proposed development design and grading
- Surface water levels and manual flow measurements should continue to be collected to gain further confidence in the rating curves, especially at DP5-18. Monitoring should be focused on both large storm events and low flows to define the rating curve at a wider range of water level elevations. Pre-development rating curves will provide a basis for comparison of during and post-construction monitoring results as development commences and SWM systems are installed
- Water quality monitoring at Station 17 should continue to be used to establish background water quality characteristics
- Based on the age of the loggers, it is expected that additional loggers will malfunction. It is recommended that loggers be purchased and made available for immediate replacement as required
- Monitoring well MW11-10 was noted to be damaged in 2015; however, has not yet been replaced. Based on the location, well replacement is still recommended
- Per the NWSSS (Ecoplans et al. 2013) recommendations on management, development setbacks and buffers, the layout for the development adheres to the recommended buffer between the natural feature and the developed portions of the subject lands.
- Encroachment into the outer 15m of the wetland buffer is proposed for grading, an outlet for the stormwater management facility and to accommodate a public trail. This encroachment is considered minor and is not anticipated to be a negative impact to the wetland, its functions or wildlife species.
- Buffers will be allowed to naturalize and will be supplemented with plantings.
- A sparse hedgerow at the north property boundary has been preserved as a public trail and an east-west connecting linkage and will be enhanced by plantings of trees, shrubs and groundcover.
- Rear lot fencing, a designated trail system and homeowner education are further methods of mitigating the potential for natural area impacts due to residents.
- A specific mitigation plan has been prepared for Blanding's Turtle and approved by MECP (Appendix IX).
- This stormwater management plan exceeds the targets and design objectives for water quantity and water quality control as recommended in the NWSSS.
- The Stewardship Plan shows how the Draft Plan provides a buffer between natural features and the development, and places open space land uses such as trails, stormwater management and parks adjacent to the natural area.
- Taking into account the layout of the development, the stormwater management plan, the monitoring program and the stewardship plan, and assuming the recommendations in the EIS and the reports of others are followed, no significant negative impacts to natural features are anticipated as a result of the proposed development.

Stage II Monitoring (During-construction)

The Stage II monitoring program has been developed and will be implemented according to municipal objectives and is required to protect environmental areas and maintain sedimentation control on the site through the construction period. There are site-specific

features that require monitoring as specified in the 2014/2015 approved Terms of Reference, which generally include erosion and sediment controls, stormwater management facilities, and stream rehabilitation features per the City of Waterloo Development Monitoring Protocol (April, 2020).

The works associated with construction such as vegetation removal and earth grading have the potential to result in impacts to adjacent natural features. Prior to the onset of area grading, site specific measures will be put in place to control runoff, limit the work zone and ensure that equipment is operated and maintained in an environmentally safe manner. During construction monitoring is anticipated to focus on implementing and monitoring the controls to protect surface water and groundwater as well as buffers to the adjacent woodland/wetland and will include erosion and sediment control measures as well as water quality in Beaver Creek and functioning of the stormwater management facilities.

The during-construction surface water, groundwater, and biological monitoring program are modelled after the pre-construction monitoring program and includes the same hydrological, hydrogeological, and biological monitoring conducted previously as well as compliance monitoring. The details of during construction monitoring program will be refined following the outcome of the stormwater management plan, hydrogeological assessment, and environmental impact statement, but are anticipated to follow the same general intent and methods as the pre-construction monitoring.

In addition to the monitoring initiated in Stage I, Stage II monitoring will include the erosion and sediment controls to be implemented on site during construction and the performance of the constructed stormwater management facilities. For that reason, Stage II monitoring should start with the beginning of construction activities (i.e., grading) and extend until the development reaches 90% buildout and the site is generally stable.

To facilitate the transition from Stage I to Stage II, this report should be approved, and considered an addendum to the Terms of Reference that was approved by the agencies for Stage I.

The results of the Stage II monitoring program should be reported to the City, Region, and GRCA on an annual basis. Annual reports should present and summarize the data that has been gathered and discuss any observed trends or other implications of the results. Should any monitoring reveal unusual or unexpected results, the proponent should notify the agencies immediately and forward the supporting information along with an assessment of the proposed mitigation measures.

Stage III Monitoring (Post-construction)

The original monitoring program will be continued, but the frequency will be decreased for each component as follows:

- Surface water (same parameters) with a minimum of one wet and one dry weather sample (low flow) per year,
- Temperature and chloride monitoring in Beaver Creek,
- Groundwater monitoring (same parameters) with a minimum of one wet and one dry weather sample (low flow) per year,

- Erosion: minimum of six observations per year (same timing as the surface water and water quality sampling) and one survey inspection per year,
- Aquatic habitat: two benthic invertebrate sampling events during the year (spring and fall), every two years (downstream, off-site),
- Terrestrial habitat: confirmation of vegetation community condition twice per year, every two years.
- Rehabilitation measures: Success of plantings, enhancement measures and invasive species control twice per year, every two years.
- Conservation Drive Road mortality: completed every two years.
- 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 remaining water level in the system. This should be done a minimum once annually and in the late spring to late fall months.
- Depth of storage the wet pond 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.

Stage III monitoring should be initiated when the development reaches 90% buildout, and the site is generally stable. Stage III monitoring continues for a period of two years.

The Stage II monitoring continues into Stage III; if any changes to the monitoring are required, they will be identified during Stage II. The results of the Stage III monitoring program should be reported to the City, Region, and GRCA on an annual basis per their schedules ranging from annually to every three years, unless there are unusual or unexpected results (which should be reported immediately). It is noted that the City and the Region require two years of post-construction monitoring.

Annual reports should present and summarize the data that has been gathered and discuss any observed trends or other implications of the results.

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 description of the groundwater present under the site.

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 from the site. 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, a wet pond, an infiltration gallery, and a outlet structures comprising orifice-controlled outlet pipes to attenuate various storm events, a valved connection to the infiltration gallery which provides a winter bypass, and an emergency overflow weir.

Average annual infiltration volumes will exceed the existing conditions and approach the post-development conditions used in the NWSSS. Surface runoff to Beaver Creek also at least matches pre-development conditions, to ensure that the existing wetlands is adequately supported.

The SWM Block on the Draft Plan is adequate to construct the proposed facility to meet the MOE 2003 design requirements for a wet pond, as well as the City of Waterloo SWM pond requirements. The facility has been designed to accommodate easy access for maintenance of the inlet and outlet structures as well as being 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.

The Stormwater Management Report is AODA compliant and meets the current provincial standard for compliance.

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 all roof drains/downspouts (fronts and backs of buildings) should discharge to the CWC system to promote infiltration. The use of rain barrels should be investigated in the detailed design phase: would encouraging their use lead to a significant reduction in the annual infiltration in the CWC system.

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

The design of infiltration facilities for the runoff from the school roof either in the school block or the adjacent right-of-way should be discussed with the school board as part of the detailed design to ensure that the method used will not put undue responsibility and costs on the school board.

A continuous (PCSWMM) hydrological model should 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 a local historical data set.

Sizing of the third-pipe system should be refined in the detailed design stage.

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 2023 City of Waterloo Comprehensive Engineering and Landscape Manual, Volume 7.

The 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

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

GSP draft plan

PART 1, PLAN 58R– 1190
LOT 30, G.C.T.

Township of Woolwich
City of Waterloo

(40 FEET WIDE) (NOT TRAVELLED) (OPENED BY BY–LAW NO. 15, DATED JUNE 13, 1851, COURT HOUSE OF GUELPH)

L O T 2 5

Township of Woolwich
City of Waterloo

Rideau River Street

Rushing River Street

Pinery Trail

Conservation Drive

Rideau River Place

Mono Cliffs Street

Bass Lake St

Esker Lake Dr

Roy Schmidt Road

Beaver Creek Road

Beaver Creek

Stage 1

Stage 2

Future Residential

Block 1 Residential 0.45 ha. 6-8 Units

Block 2 Residential 1.36 ha. 34-50 Units

Block 3 Residential 0.12 ha. 2-3 Units

Block 4 Residential 0.26 ha. 5-6 Units

Block 5 Residential 0.18 ha. 3-4 Units

Block 6 Residential 0.17 ha. 4-5 Units

Block 7 Residential 0.47 ha. 13-16 Units

Block 8 Residential 0.66 ha. 17-21 Units

Block 9 Residential 0.42 ha. 12-14 Units

Block 10 Residential 0.16 ha. 3-4 Units

Block 11 Residential 0.42 ha. 12-14 Units

Block 12 Res. 0.35 ha. 8-11 Units

Block 13 Res. 0.32 ha. 7-10 Units

Block 14 Res. 0.31 ha. 7-10 Units

Block 15 Res. 0.31 ha. 7-10 Units

Block 16 Res. 0.32 ha. 7-11 Units

Block 17 Res. 0.25 ha. 6-8 Units

Block 18 Res. 0.36 ha. 7-10 Units

Block 19 Residential 0.24 ha. 7-8 Units

Block 20 Residential 0.20 ha. 5-6 Units

Block 21 Res. 0.38 ha. 11-16 Units

Block 22 Street Townhouse 15 - 20 0.39ha

Block 23 Street Townhouse 5 - 9 0.16ha

Block 24 Street Townhouse 22 - 30 0.55ha

Block 25 Street Townhouse 10 - 16 0.40ha

Block 26 Street Townhouse 22 - 30 0.55ha

Block 27 Multiple Residential 1.71ha. 121-202 Units

Block 28 Multiple Residential 0.66ha. 39-66 Units

Block 29 School 3.22ha.

Block 30 Park 1.41ha.

Block 31 Open Space 4.31ha.

Block 32 Open Space 0.52ha.

Block 33 Stormwater Management 1.17ha.

Block 34 Walkway 0.01ha.

Block 35 Trail 0.43ha

Block 36 Road Widening 0.53ha

Block 37 0.3m Reserve

Block 38 0.3m Reserve INST. NO. 1450753 (SEE DEPOSIT, INST. 1477464) PART 1, PLAN 58R–6414

Block 39 Future Development 0.02 ha.

Block 40 Future Development 0.06 ha.

Future Multiple Residential

Future Pumping Station

Open Space

Future Stormwater Management

Future Multiple Residential

Future Multiple Residential / Mixed Use

Mixed Use

Walkway

Trail

Proposed Permanent Anchor Easement
Proposed Temporary Grading Easement

Proposed Temporary Grading Easement

Future Roundabout

Dripline

Wetland Limit

30m Wetland Setback

30m Wetland Buffer

15m Wetland Buffer

5m Hedgerow Setback

Ex. Hedgerow

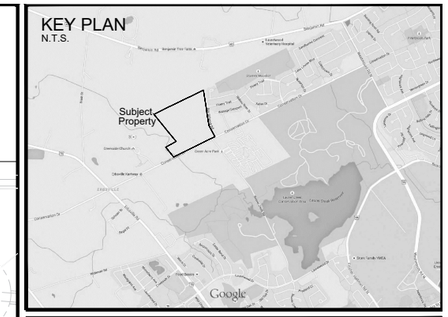
Ex. Top of Bank

Ex. Water Table

Ex. CL of Road

NOTE:
ROAD WIDENINGS AND ROUNDABOUT ARE PRELIMINARY

KEY PLAN
N.T.S.



DRAFT PLAN OF SUBDIVISION

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

LAND USE SCHEDULE

STAGE 1

DESCRIPTION	LOTS/BLKS.	UNITS	AREA (ha.)
Residential (single detached)	1-2,6-21	173-232	7.14
Street Townhouses	22-26	74-105	2.05
Multiple Residential	27,28	160-268	2.37
School	29		3.22
Park	30		1.41
Open Space	31,32		4.84
Stormwater Management	33		1.17
Walkway	34		0.01
Trail	35		0.43
Road Widening	36		0.53
0.3m Reserve	37,38		0.00
Roads			4.83
Total		404-610	28.0

STAGE 2

DESCRIPTION	LOTS/BLKS.	UNITS	AREA (ha.)
Residential (single detached)	3-5	10-13	0.56
Future Development	39,40		0.08
Total		10-13	0.65

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 I URBAN DESIGN I LANDSCAPE ARCHITECTURE
gspgroup.ca

REVISIONS

April 30, 2020	July 12, 2023
June 25, 2020	November 13, 2023
March 10, 2020	February 7,2024
March 15, 2020	July 29, 2024
March 19, 2020	August 15, 2024
August 19, 2021	August 26, 2024
May 24, 2023	

Date: July 29, 2015	Drawn By: S.L./E.F.	Dwg. File Name: dp09009zv.dwg
Scale: 1:1250 metric	Project No.: 09009.40	

Appendix B: Design Drawings

Servicing Plan

Concept plan

Split point of sanitary and 3rd pipe.

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

~Inv @ Intersection
Wat=362.70
San=361.65
CWC=362.00

~Inv @ Intersection
Stm=360.50
Wat=361.10
San=359.50
CWC=359.80

Pr Culvert

~Inv
Stm=358.50
Wat=355.79
San=356.40
CWC=358.00

Rideau River Street

~Inv @ Intersection
Stm=360.50
Wat=357.63
San=357.60
CWC=358.50

150mmø Wmn, Rideau River St, Mono Cliffs St & Bass Lake St

Rideau River Street

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

150mmø Wmn, Esker Lake Dr (Pinery Trail to Rideau River Street) & Rideau River Street

Mono Cliffs St

Bass Lake St

Esker Lake Dr

Rideau River Place

Rideau River Street

~Inv @ Intersection
Stm=357.30
Wat=355.50
San=355.20
CWC=356.80

~Inv
Stm=354.10
Wat=355.00
San=354.70
CWC=354.50

Pinery Trail

~Inv @ Intersection
Stm=360.05
Wat=358.35 (Dip)
San=359.00
CWC=359.50

~Inv @ Intersection
Stm=359.50
Wat=360.80
San=358.75
CWC=359.00

300mmø Wmn

Ex 200mmø Wmn

900mmø Stm into SWM Pond

~Inv @ Intersection
Stm=358.00
Wat=356.54 (Dip)
San=356.70
CWC=357.70

~Inv
Stm=356.00
Wat=355.80
San=354.00
CWC=355.40

200mmø Wmn Pinery Trail (Esker Lake Dr to Rideau River St)

Split point of sanitary and 3rd pipe.

Pinery Trail

Wet Pond

Ex. 100m Contour

Ex. Hedgerow

Ex. Ditch

10m Ditch/Top Setback

Infiltration Gallery

Underground Infiltration System

15m Wetland Buffer

Level spreader

300mmø Wmn, Esker Lake Dr (Conservation Drive to Pinery Trail)

Esker Lake Dr

3rd pipe (CWC) system for roof leaders.

200mmø San, Remainder of Subdivision

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

~Inv
Wat=355.65
San=352.60
CWC=355.50

~Inv @ Intersection
Stm=354.90
Wat=354.10 (dip)
San=351.40
CWC=355.50

Roy Schmidt Road

Wasaga Crescent

Rushing River St

Overflow to storm sewer from CWC system (typ)

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

200mmø Wmn, Rushing River St

250mmø San, Esker Lake Dr (Conservation Drive to North end of Rushing River St)

Infiltration gallery

30m Wetland Buffer

Ex. Waters Edge

Ex. Waters Edge

Esker Lake Dr

~Inv @ Intersection
Stm=353.50
Wat=354.80
San=350.90
CWC=353.70

Overflow to storm sewer from CWC system

Culverts to direct drainage under trail

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
Inv=349.10

Connection of watermain by others

Conservation Drive

Servicing Legend

- Ex=Existing
- Ex Sanitary/Storm Manhole/CB Manhole
- Ex Sanitary Sewer (Flow Direction)
- Ex Storm Sewer (Flow Direction)
- Ex Water Valve/Curb Stop
- Ex Fire Hydrant & Valve Set
- Pr=Proposed
- Pr Sanitary/Storm Manhole
- Pr Sanitary Sewer (Flow Direction)
- Pr Storm Sewer (Flow Direction)
- Pr Water Valve/Curb Stop/Reducer
- Pr Fire Hydrant & Valve Set

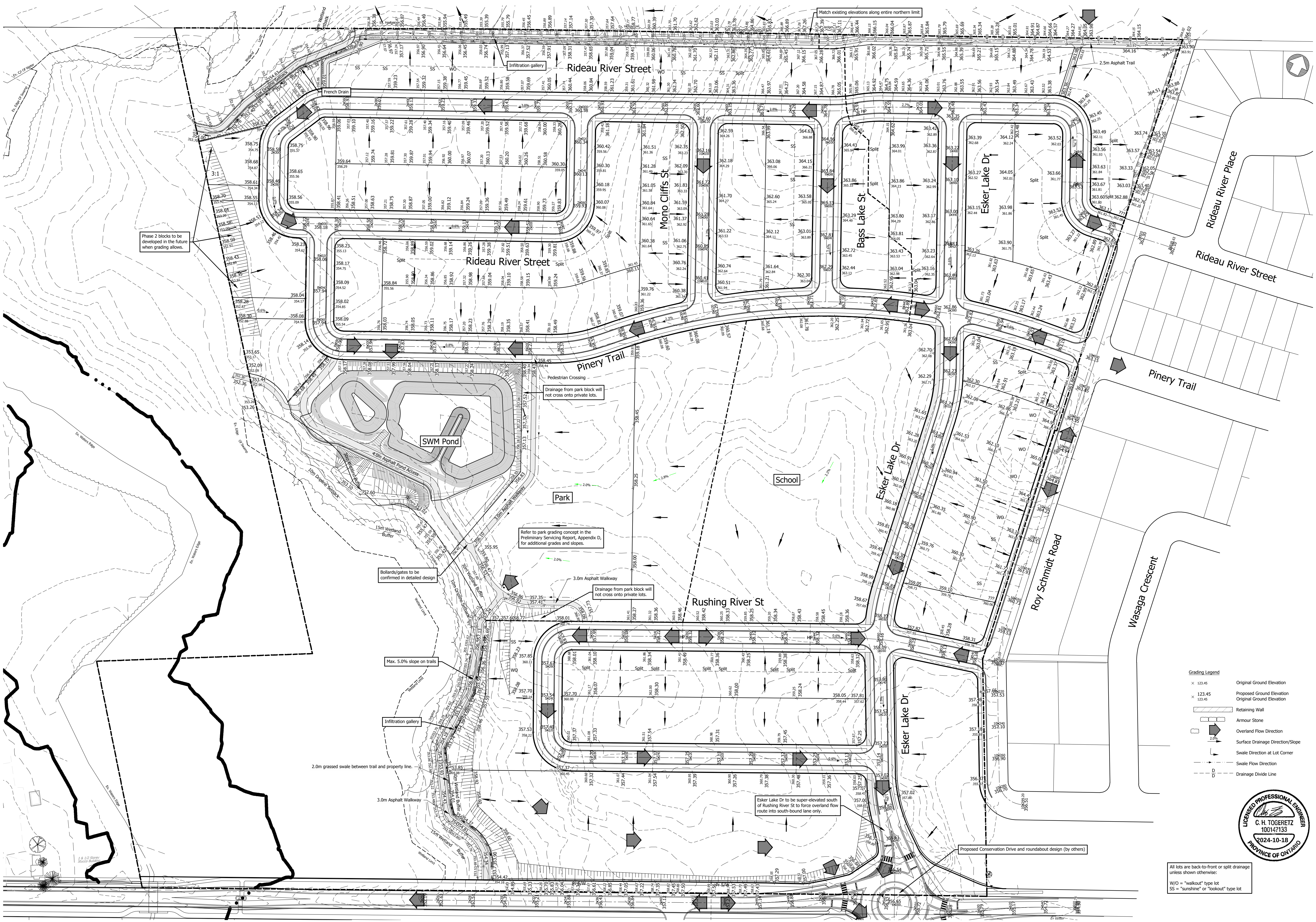
1:1000

LICENSED PROFESSIONAL ENGINEER
C. H. TOGERETZ
100147133
2024-10-18
PROVINCE OF ONTARIO

MERIDIAN ENGINEERING
315 Bishop Street North, Suite 202 Cambridge
T 519.623.1140 F 519.623.7334 www.meridian.ca

DRAWING: Preliminary Servicing Plan
556 & 576 Conservation Drive

DRAWN BY:	STV	SCALE:	1: 1000
CHECKED BY:	CHT		1279-SS
DATE:	Oct 2024		
FILE NAME:	1279 Figures		



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

DRAWING: Preliminary Grading Plan
556 & 576 Conservation Drive

DRAWN BY:	STV	CHECKED BY:	CHT
SCALE:	1: 1000		
FILE NAME:	1279.Figures	DATE:	Oct 2024
	1279-SG		

3:1 slope to match exiting elevations along western boundary in the interim condition.

Infiltration gallery in trail block

Match existing elevations along entire northern limit

Rideau River Street

Rideau River Street

Mono Cliffs Street

Bass Lake St.

Esker Lake Dr

Rideau River Place

Rideau River Street

Pinery Trail

Pinery Trail

Single row silt fence, as per OPSD 219.131.

Pinery Trail

Forebay and Wet Pond

SWM Pond to act as Temp Silt Pond during grading operations

Park

School

Esker Lake Dr

Roy Schmidt Road

Double row silt fence, as per OPSD 219.131.

Topsoil not to be stockpiled on the park block

Rushing River Street

Esker Lake Dr

Rushing River Street

Infiltration gallery

Conservation Drive

Existing or proposed ground

Proposed ground

Flow direction

0.15m Min 0.5m Max

1 : 2

1 : 2

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

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

Filter fabric

15mmø clear stone filter, 150mm thick

Hickenbottom c/w orifice

Top of berm

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

Temp Silt Pond

Double Silt Fence

Single Silt Fence

Sediment Control Pond Outlet Detail

Not to Scale

LICENSED PROFESSIONAL ENGINEER
C. H. TOGERETZ
100147133
2024-10-18
PROVINCE OF ONTARIO

MERIDIAN
Land Development Engineering
1315 Bishop Street North, Suite 202 Cambridge
T 519.623.1140 F 519.623.7334 www.meridiancie

DRAWING: Preliminary Erosion & Sediment Control Plan
556 & 576 Conservation Drive

DRAWN BY:	STV	CHECKED BY:	CHT
FILE NAME:	1279-Figures	DATE:	Oct 2024
SCALE:	1: 1000		
	1279-ESC		

Appendix C: Design Calculations

Salt impact assessment

Water balance

Forebay design calcs

Hurricane storm information

Conservation Drive

Proj #: 1279
Calc'd By: MS
Date: 2023-06-05
Checked By: CHT
Date: 2023-09-26

Estimated Salt Concentration at Property Boundary

Parameters		Units	Information Notes
Annual Volume of Infiltration	81,106	m^3/yr	Refer to Preliminary SWM report (Sept 2023) Meritech Engineering
Annual Volume of Runoff to Beaver Creek	13,496	m3/yr	Refer to Preliminary SWM report (Sept 2023) Meritech Engineering
Salt application (west)			
Length of 2-lane secondary road	0.43	km	Measured length of internal roads
Length of 2-lane local road	0.94	km	Measured length of internal roads
Percentage of Salt that Infiltrates	100%		Any salt not infiltrating on site is released to Beaver Creek via winter bypass
Area conveyed directly to off-site pond (east)			
Length of 2-lane secondary road	0.55	km	Measured length of internal roads
Length of 2-lane local road	0.84	km	Measured length of internal roads
Percentage of Salt that Infiltrates	28%		As per Regional Implementation Guidelines
Chloride % of Salt by Mass	61%		
Sodium % of Salt by Mass	39%		
Salt Application Rate (Seconday Roads)	22	tonnes/2-lane-km/yr	Application rate as per Regional Implementation Guidelines
Salt Application Rate (Local Roads)	2.2	tonnes/2-lane-km/yr	Application rate as per Regional Implementation Guidelines
Annual Mass of Salt Applied	**15.41**	tonnes/yr	Weighted average taking into account local and secondary road lengths
Yearly Mass Loading of Chloride (M_T) =	9.40	tonnes/yr	
Background Chloride Concentration =	33	mg/L	Average of MW2-10, MW3-10S, MW6-10, MW7-10 & MW11-10 from NWSSS
Chloride Concentration of Infiltration =	**99**	mg/L	Mass of chloride / infiltration volume
Chloride Concentration at Property Boundary =	**132**		Background + additional loading
Chloride RUC =	141.5	mg/L	Refer to Preliminary SWM report (Sept 2023) Meritech Engineering
Yearly Mass Loading of Sodium (M_T) =	6.01	tonnes/yr	
Background Sodium Concentration =	85	mg/L	Average of MW2-10, MW3-10S, MW6-10, MW7-10 & MW11-10 from NWSSS
Sodium Concentration of Infiltration =	**64**	mg/L	Mass of sodium / infiltration volume
Sodium Concentration at Property Boundary =	**149**		Background + additional loading
Sodium RUC =	142.5	mg/L	Refer to Preliminary SWM report (Sept 2023) Meritech Engineering

MERITECH

Project Name: Conservation Drive
Project Number: 1279
Calc'd by: ACF
Date: 18-Oct-24
Chk'd by: CHT
Date: 18-Oct-24

Sediment Forebay Sizing Calculations

(in accordance with MOE 2003)

5) 10 year Accumulated Sediment Depth

A_c = contributing area
= **9.344** ha.

L_a = annual loading
= **1.055** m^3/ha/yr

I = cleanout interval
= **10** years

V_r = required total storage volume
= **98.6** m^3

Actual total storage volume
= **509.8** m^3

6) Forebay Size in relation to Remainder of Facility

Type of facility: **Wet pond**

Forebay permanent pool **area**	**634**
Wet pond permanent pool area	**3330**
Forebay's percentage	**16%**
Minimum criteria	**Maximum 33%**
Forebay permanent pool **volume**	**510**
Wet pond permanent pool volume	**3290**
Forebay's percentage	**13%**
Preferred criteria	**Maximum 20%**

Project: Conservation Drive
File: 1279
Calc'd by: CHT
Date: 18-Oct-24
Chk'd by: ACF
Date: 18-Oct-24

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	
Ex Catchment Area (Pervious):	11.75	ha	
Ex Infiltration Rate	222.5	mm/yr	
Ex Runoff Rate	68.8	mm/yr	
Pre-Development Infiltration	26,153	m³/yr	
Pre-Development Runoff	8,087	m³/yr	
Proposed post-dev Infiltration	31,172	m^3/yr	(based on catchment areas)
	19%	Greater than pre-development	
Post-development runoff	27,316	m^3/yr	

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	
Ex Catchment Area (Pervious):	11.79	ha	
Ex Infiltration Rate	183.4	mm/yr	
Ex Runoff Rate	196.3	mm/yr	
Pre-Development Infiltration	21,614	m³/yr	
Pre-Development Runoff	23,134	m³/yr	
Proposed Post-Dev Infiltration	33,187	m^3/yr	(based on catchment areas)
	54%	Greater than pre-development	

Pervious Areas

Catchment #	Area (ha)	%Pervious	$A_{pervious}$ (ha)	Annual Passive Infiltration Volume (@ 207.5mm/yr) (m^3)	Total Annual Runoff Volume (@ 93.8mm/yr) (m^3)	Annual Runoff Volume to Beaver Creek (m^3)
701	7.068	40%	2.83	5,866	2,652	981
702	0.920	70%	0.64	1,336	604	224
703	1.361	80%	1.09	2,259	1,021	378
704	1.054	40%	0.42	875	395	146
504	0.453	80%	0.36	752	*Counted in the next section*	
505	0.898	55%	0.49	1,025	*Counted in the next section*	
Total	11.75		**5.84**	**12,114**	**4,673**	**1,729**
				Infiltration rate is conservatively assumed to be the same as pre-development conditions		*(Winter months plus 10% large storms)*

Catchment #	Area (ha)	%Pervious	$A_{pervious}$ (ha)	Annual Passive Infiltration Volume (@ 168.4mm/yr) (m^3)	
501	0.356	40%	0.14	240	
502	2.299	50%	1.15	1,936	
503	9.130	30%	2.74	4,612	
		Total	**4.03**	**6,788**	m^3/yr

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

90% of annual rainfall occurs in storms less than the 2-year design event.
90% of 93.8mm/yr of runoff from pervious areas, plus 90% of precipitation on roofs contribute to lot-level infiltration

Catchment	Contributing Area (ha)	Roof area (ha)	Annual Grass Runoff to Infiltration (m^3)	Annual Roof Runoff to Infiltration (m^3)	Annual Runoff to Beaver Creek (m^3)	
504 (rear yard/roof)	0.453	0.091	306	689	111	
505 (rear yard/roof)	0.898	0.404	417	3,072	388	
		Total	**723**	**3,761**	**498**	m^3/yr
		Note: conservatively ignored in totals below			(Remaining 10% of P)	

90% of annual rainfall occurs in storms less than the 2-year design event.
90% of precipitation on roofs contribute to lot-level infiltration

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

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

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

27% of the entire catchment area is covered by roofs.

Approximately half of the 10% of annual rainfall that occurs in larger storm events is infiltrated; the remainder is surface runoff.

Catchment	Contributing Area (ha)	Roof Area (ha)	Runoff (mm)	Annual Roof Runoff to CWC (m^3)	Annual Roof Runoff in EOP Pond (m^3)	Annual Runoff to Beaver Creek (m^3)
701	7.068	1.91	760	**14,510**	**806**	**806**
			(90%)		(±5% of P)	(Remaining ±5% of P)

Catchments	Contributing Area (ha)	Roof Area (ha)	Runoff (mm)	Annual Roof Runoff to CWC (m^3)	
503	9.130	2.47	760	**18,743**	m^3/yr

End-of-pipe (SWM Facility Infiltration)

Pond infiltrates the 10mm storm; slightly over 50% of annual rainfall occurs in storms less than this according to the MOECC's draft LID manual.

It is assumed that the winter bypass will be utilized for the months of **Nov through April** inclusive.

These five months account for 45% of annual precipitation.

The percentage of inflows to the pond in storms larger than the 10mm that will infiltrate have been conservatively ignored.

Catchment	IMP Area (excl roof) (ha)	Runoff to Infil (24.75% of Precip) (mm/yr)	Annual End-Of-Pipe Infiltration	Runoff **not** to Infil (Remaining Precip) (mm/yr)	Annual Runoff to Beaver Creek (m^3)	Additional ±5% prec. Due to large storms (m^3)
701	2.33	209	**4,877**	636	**14,557**	**271**
702	0.28	209	**577**	636	**1,723**	**32**
703	0.27	209	**569**	636	**1,699**	**32**
704	0.63	209	**1,322**	636	**3,947**	**73**

Required storage volume in pond to infiltration = 315 m³ *316*

Infiltration gallery footprint is 225 m², design infiltration rate of subsurface soils is 67 mm/hr. Infiltration rate is thus 361.8 m³/day.

West Side

	Infiltration		Runoff	
Ex Infiltration =	26,153	Total Provided =	25,366	m^3
Total Provided =	34,775	Target (pre-development) =	8,087	m^3
NWSSS proposed post-development =	31,172	Maximum =	27,316	m^3
Difference =	**3,603**	Difference =	**17,279**	**m^3**

East Side

Ex Infiltration =	21,614	m³
Total Provided Infiltration =	28,952	m^3
NWSSS proposed post-development =	33,187	m^3
Difference =	**(4,234)**	**m^3**

Total Provided Infiltration=	63,727	m^3/yr
Existing Infiltration =	47,766	m^3/yr
NWSSS proposed post-development =	64,358	
Surplus =	33%	greater than pre-development (criteria)
	-1%	greater than NWSSS proposed post-development

MERITECH

Project Name: Conservation Drive
Project Number: 1279
Calc'd by: ACF
Date: 18-Oct-24
Chk'd by: CHT
Date: 18-Oct-24

Sediment Forebay Sizing Calculations

(in accordance with MOE 2003)

Forebay Dimensions

				Calculated min.	Actual	
Average bottom width	5.0	m	Average top width	20.0	20.0	m
Maximum bottom width	8.0	m	Maximum top width	23.0	23.0	m
Average bottom length	19.0	m	Average top length	34.0	34.0	m
Average depth	1.50	m	Total Volume	510	m³	
Average sideslope	5	:1	Usable Volume	357	m³	

1) Forebay Settling Length

Dist = forebay length (m)
r = length to width ratio at average depth
= **2.1** (should be greater than 2:1)
Q_p = peak flow rate from facility during design quality storm
= **0.014** m³/s **2yr** storm event
V_s = settling velocity (dependent on particle size)
= **0.0003** m/s for 150 μm particle
Therefore, distance = **9.9** m vs. **34.0** 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)
= **1.403** 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 = **29.9** m vs. **34.0** m provided
Also, min. bottom width = Dist./8 = **3.7** m vs. **5.0** m provided

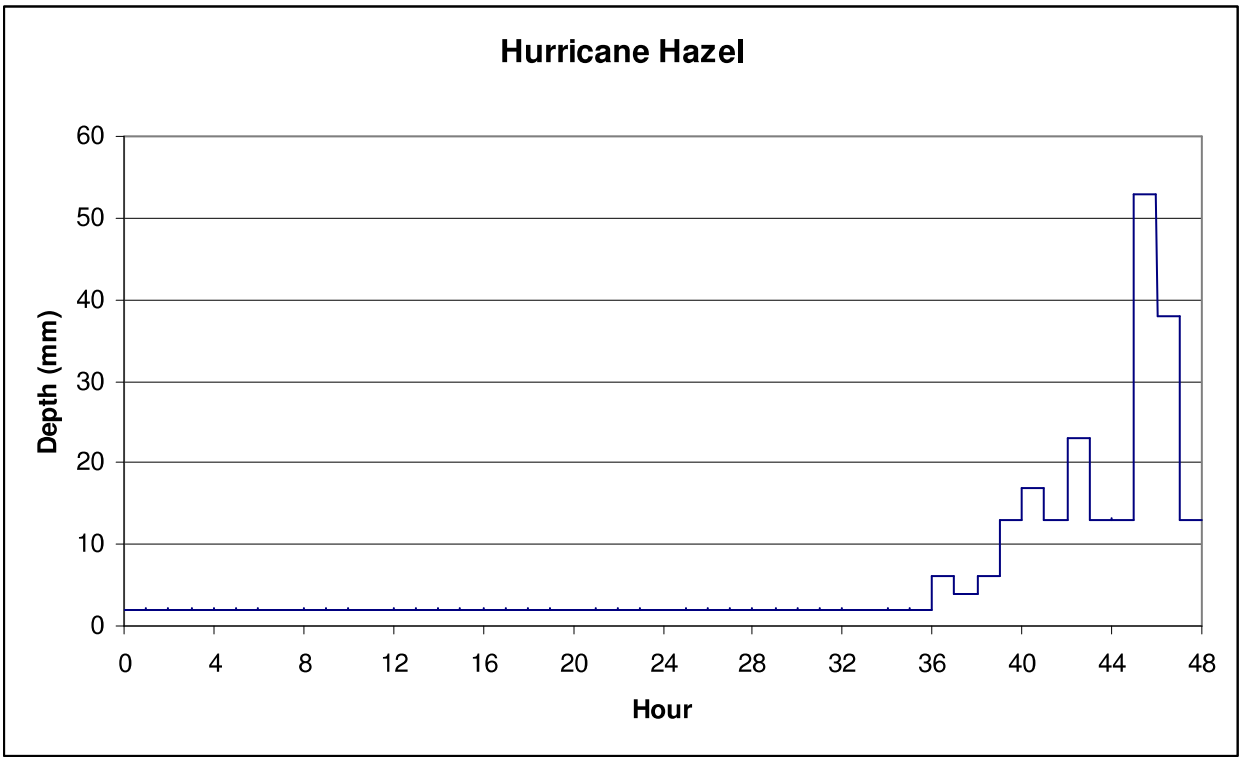
3) Check Velocity Across Full Width of Forebay Above Maximum Accumulated Sediment Depth

V_a = average velocity in the forebay (m/s)
Q_i = flowrate into forebay
= **1.403** m³/s **5-year** storm event
A_x = cross sectional area of forebay perpendicular to flow
= **14.4** m² above the maximum sediment depth
Therefore, velocity = V_a = **0.10** m/s should be < thar **0.15** m/s

4) Cleanout Interval

V_u = usable accumulation storage volume of forebay at a
max. depth, d_u = **0.75** m
= **153** m³
L_a = annual loading
for **42.0** % impervious
= **1.055** m³/ha/yr
A_c = **9.344** ha of contributing land
Therefore, interval = I = **15.5** yrs between cleanouts **5.0** years min. preferred

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

Appendix D: Modelling

Appendix D.1: Pre-Development Conditions

```
"                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\MIDUSS\Existing"
"                Output filename:                     1279x2yr24hr20240806.out"
"                Licensee name:                               Arianna Franklin"
"                Company                                 Meritech Engineering"
"                Date & Time last used:               2024-08-06 at 4:03:09 PM"
" 81           ADD COMMENT================================================="
"            2  Lines of comment"
"               SWM Analysis of 2-yr 24 hr pre-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"
"               Flow to Beaver Creek."
" 33           CATCHMENT 101"
"              1   Triangular SCS"
"              1   Equal length"
"              1   SCS method"
"            101   Internal Runoff to Beaver Creek"
"         0.000   % Impervious"
"        10.360   Total Area"
"       100.000   Flow length"
"         3.000   Overland Slope"
"        10.360   Pervious Area"
"       100.000   Pervious length"
"         3.000   Pervious slope"
"         0.000   Impervious Area"
"       100.000   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'"
"       100.000   Impervious SCS Curve No."
"         0.000   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.000   Impervious Initial abstraction"
"                      0.127     0.000     0.000     0.000 c.m/sec"
"               Catchment 101          Pervious   Impervious Total Area "
```

```
"              Surface Area           10.360     0.000      10.360     hectare"
"              Time of concentration  39.514     3.981      39.514     minutes"
"              Time to Centroid       857.962    643.580    857.961    minutes"
"              Rainfall depth         47.029     47.029     47.029     mm"
"              Rainfall volume        4872.24    0.00       4872.25    c.m"
"              Rainfall losses        35.629     0.472      35.629     mm"
"              Runoff depth           11.400     46.558     11.400     mm"
"              Runoff volume          1181.06    0.00       1181.07    c.m"
"              Runoff coefficient     0.242      0.000      0.242      "
"              Maximum flow           0.127      0.000      0.127      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.127     0.127     0.000     0.000"
" 33           CATCHMENT 201"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           201   External Runoff to Beaver Creek"
"         0.000   % Impervious"
"         1.250   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         1.250   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.000   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'"
"       100.000   Impervious SCS Curve No."
"         0.000   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.000   Impervious Initial abstraction"
"                      0.035     0.127     0.000     0.000 c.m/sec"
"              Catchment 201          Pervious   Impervious Total Area "
"              Surface Area           1.250      0.000      1.250      hectare"
"              Time of concentration  12.659     1.276      12.659     minutes"
"              Time to Centroid       793.747    635.861    793.746    minutes"
"              Rainfall depth         47.029     47.029     47.029     mm"
"              Rainfall volume        587.87     0.00       587.87     c.m"
"              Rainfall losses        35.650     0.792      35.650     mm"
"              Runoff depth           11.380     46.237     11.380     mm"
"              Runoff volume          142.25     0.00       142.25     c.m"
"              Runoff coefficient     0.242      0.000      0.242      "
"              Maximum flow           0.035      0.000      0.035      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.035     0.142     0.000     0.000"
" 40           HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                      0.035     0.142     0.142     0.000"
" 40           HYDROGRAPH   Combine    100"
"             6   Combine "
"           100   Node #"
```

```
"                To Beaver Creek"
"              Maximum flow                  0.142    c.m/sec"
"              Hydrograph volume          1323.316    c.m"
"                       0.035     0.142     0.142     0.142"
" 40           HYDROGRAPH   Confluence    100"
"             7   Confluence "
"           100   Node #"
"                To Beaver Creek"
"              Maximum flow                  0.142    c.m/sec"
"              Hydrograph volume          1323.316    c.m"
"                       0.035     0.142     0.142     0.000"
" 40           HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                       0.035     0.000     0.142     0.000"
" 81           ADD COMMENT=============================================="
"           1  Lines of comment"
"              Flow to South."
" 33           CATCHMENT 102"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           102   Internal Runoff to South"
"         0.000   % Impervious"
"        13.000   Total Area"
"       100.000   Flow length"
"         5.000   Overland Slope"
"        13.000   Pervious Area"
"       100.000   Pervious length"
"         3.000   Pervious slope"
"         0.000   Impervious Area"
"       100.000   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'"
"       100.000   Impervious SCS Curve No."
"         0.000   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.000   Impervious Initial abstraction"
"                       0.159     0.000     0.142     0.000 c.m/sec"
"              Catchment 102          Pervious   Impervious Total Area "
"              Surface Area           13.000     0.000      13.000     hectare"
"              Time of concentration  39.514     3.981      39.514     minutes"
"              Time to Centroid       857.961    643.580    857.961    minutes"
"              Rainfall depth         47.029     47.029     47.029     mm"
"              Rainfall volume        6113.82    0.01       6113.83    c.m"
"              Rainfall losses        35.629     0.472      35.629     mm"
"              Runoff depth           11.400     46.558     11.400     mm"
"              Runoff volume          1482.03    0.01       1482.04    c.m"
"              Runoff coefficient     0.242      0.000      0.242      "
"              Maximum flow           0.159      0.000      0.159      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                       0.159     0.159     0.142     0.000"
" 33           CATCHMENT 202"
"             1   Triangular SCS"
```

```
"            1   Equal length"
"            1   SCS method"
"          202   External Runoff to Beaver Creek"
"        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'"
"       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'"
"      100.000   Impervious SCS Curve No."
"        0.000   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.000   Impervious Initial abstraction"
"                    0.045     0.159     0.142     0.000 c.m/sec"
"             Catchment 202          Pervious   Impervious Total Area "
"             Surface Area           3.500      0.000      3.500      hectare"
"             Time of concentration  37.094     3.738      37.094     minutes"
"             Time to Centroid       852.149    643.039    852.148    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        1646.03    0.00       1646.03    c.m"
"             Rainfall losses        35.629     0.610      35.629     mm"
"             Runoff depth           11.400     46.420     11.400     mm"
"             Runoff volume          399.01     0.00       399.01     c.m"
"             Runoff coefficient     0.242      0.000      0.242      "
"             Maximum flow           0.045      0.000      0.045      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"           4   Add Runoff "
"                    0.045     0.204     0.142     0.000"
" 40          HYDROGRAPH Copy to Outflow"
"           8   Copy to Outflow"
"                    0.045     0.204     0.204     0.000"
" 40          HYDROGRAPH   Combine    200"
"           6   Combine "
"         200   Node #"
"               To South"
"             Maximum flow                0.204    c.m/sec"
"             Hydrograph volume        1881.046    c.m"
"                    0.045     0.204     0.204     0.204"
" 40          HYDROGRAPH   Confluence    200"
"           7   Confluence "
"         200   Node #"
"               To South"
"             Maximum flow                0.204    c.m/sec"
"             Hydrograph volume        1881.046    c.m"
"                    0.045     0.204     0.204     0.000"
" 38          START/RE-START TOTALS 200"
"           3   Runoff Totals on EXIT"
"             Total Catchment area                   28.110    hectare"
"             Total Impervious area                   0.000    hectare"
```

```
"              Total % impervious                          0.000"
" 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\MIDUSS\Existing"
"                Output filename:                     1279x5yr24hr20240806.out"
"                Licensee name:                               Arianna Franklin"
"                Company                                 Meritech Engineering"
"                Date & Time last used:               2024-08-06 at 4:04:33 PM"
" 81           ADD COMMENT================================================="
"           2  Lines of comment"
"              SWM Analysis of 5-yr 24hr pre-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"
"              Flow to Beaver Creek."
" 33           CATCHMENT 101"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           101   Internal Runoff to Beaver Creek"
"         0.000   % Impervious"
"        10.360   Total Area"
"       100.000   Flow length"
"         3.000   Overland Slope"
"        10.360   Pervious Area"
"       100.000   Pervious length"
"         3.000   Pervious slope"
"         0.000   Impervious Area"
"       100.000   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'"
"       100.000   Impervious SCS Curve No."
"         0.000   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.000   Impervious Initial abstraction"
"                      0.303     0.000     0.000     0.000 c.m/sec"
"              Catchment 101          Pervious   Impervious Total Area "
```

```
"              Surface Area           10.360     0.000      10.360     hectare"
"              Time of concentration  31.192     3.599      31.192     minutes"
"              Time to Centroid       806.083    636.868    806.082    minutes"
"              Rainfall depth         61.018     61.018     61.018     mm"
"              Rainfall volume        6321.48    0.01       6321.49    c.m"
"              Rainfall losses        41.824     0.900      41.824     mm"
"              Runoff depth           19.194     60.118     19.194     mm"
"              Runoff volume          1988.49    0.01       1988.50    c.m"
"              Runoff coefficient     0.315      0.000      0.315      "
"              Maximum flow           0.303      0.000      0.303      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.303     0.303     0.000     0.000"
" 33           CATCHMENT 201"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           201   External Runoff to Beaver Creek"
"         0.000   % Impervious"
"         1.250   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         1.250   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.000   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'"
"       100.000   Impervious SCS Curve No."
"         0.000   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.000   Impervious Initial abstraction"
"                      0.076     0.303     0.000     0.000 c.m/sec"
"              Catchment 201          Pervious   Impervious Total Area "
"              Surface Area           1.250      0.000      1.250      hectare"
"              Time of concentration  9.993      1.153      9.993      minutes"
"              Time to Centroid       756.255    629.972    756.255    minutes"
"              Rainfall depth         61.018     61.018     61.018     mm"
"              Rainfall volume        762.73     0.00       762.73     c.m"
"              Rainfall losses        41.904     1.224      41.904     mm"
"              Runoff depth           19.114     59.794     19.114     mm"
"              Runoff volume          238.93     0.00       238.93     c.m"
"              Runoff coefficient     0.313      0.000      0.313      "
"              Maximum flow           0.076      0.000      0.076      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.076     0.339     0.000     0.000"
" 40           HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                      0.076     0.339     0.339     0.000"
" 40           HYDROGRAPH   Combine    100"
"             6   Combine "
"           100   Node #"
```

```
"               To Beaver Creek"
"             Maximum flow                  0.339    c.m/sec"
"             Hydrograph volume          2227.425    c.m"
"                     0.076     0.339     0.339     0.339"
" 40          HYDROGRAPH   Confluence    100"
"            7   Confluence "
"          100   Node #"
"               To Beaver Creek"
"             Maximum flow                  0.339    c.m/sec"
"             Hydrograph volume          2227.425    c.m"
"                     0.076     0.339     0.339     0.000"
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                     0.076     0.000     0.339     0.000"
" 81          ADD COMMENT=============================================="
"          1  Lines of comment"
"             Flow to South."
" 33          CATCHMENT 102"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          102   Internal Runoff to South"
"        0.000   % Impervious"
"       13.000   Total Area"
"      100.000   Flow length"
"        5.000   Overland Slope"
"       13.000   Pervious Area"
"      100.000   Pervious length"
"        3.000   Pervious slope"
"        0.000   Impervious Area"
"      100.000   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'"
"      100.000   Impervious SCS Curve No."
"        0.000   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.000   Impervious Initial abstraction"
"                     0.380     0.000     0.339     0.000 c.m/sec"
"             Catchment 102          Pervious   Impervious Total Area "
"             Surface Area           13.000     0.000      13.000     hectare"
"             Time of concentration  31.192     3.599      31.192     minutes"
"             Time to Centroid       806.083    636.868    806.082    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        7932.36    0.01       7932.37    c.m"
"             Rainfall losses        41.824     0.900      41.824     mm"
"             Runoff depth           19.194     60.118     19.194     mm"
"             Runoff volume          2495.21    0.01       2495.22    c.m"
"             Runoff coefficient     0.315      0.000      0.315      "
"             Maximum flow           0.380      0.000      0.380      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.380     0.380     0.339     0.000"
" 33          CATCHMENT 202"
"            1   Triangular SCS"
```

```
"            1   Equal length"
"            1   SCS method"
"          202   External Runoff to Beaver Creek"
"        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'"
"       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'"
"      100.000   Impervious SCS Curve No."
"        0.000   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.000   Impervious Initial abstraction"
"                    0.107     0.380     0.339     0.000 c.m/sec"
"             Catchment 202          Pervious   Impervious Total Area "
"             Surface Area           3.500      0.000      3.500      hectare"
"             Time of concentration  29.282     3.379      29.282     minutes"
"             Time to Centroid       801.540    636.170    801.540    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        2135.64    0.00       2135.64    c.m"
"             Rainfall losses        41.824     0.803      41.824     mm"
"             Runoff depth           19.194     60.215     19.194     mm"
"             Runoff volume          671.79     0.00       671.79     c.m"
"             Runoff coefficient     0.315      0.000      0.315      "
"             Maximum flow           0.107      0.000      0.107      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"           4   Add Runoff "
"                    0.107     0.487     0.339     0.000"
" 40          HYDROGRAPH Copy to Outflow"
"           8   Copy to Outflow"
"                    0.107     0.487     0.487     0.000"
" 40          HYDROGRAPH   Combine    200"
"           6   Combine "
"         200   Node #"
"               To South"
"             Maximum flow                0.487    c.m/sec"
"             Hydrograph volume        3167.014    c.m"
"                    0.107     0.487     0.487     0.487"
" 40          HYDROGRAPH   Confluence    200"
"           7   Confluence "
"         200   Node #"
"               To South"
"             Maximum flow                0.487    c.m/sec"
"             Hydrograph volume        3167.015    c.m"
"                    0.107     0.487     0.487     0.000"
" 38          START/RE-START TOTALS 200"
"           3   Runoff Totals on EXIT"
"             Total Catchment area                   28.110    hectare"
"             Total Impervious area                   0.000    hectare"
```

```
"              Total % impervious                          0.000"
" 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\MIDUSS\Existing"
"                Output filename:                    1279x100yr3hr20240806.out"
"                Licensee name:                                Arianna Franklin"
"                Company                                  Meritech Engineering"
"                Date & Time last used:               2024-08-06 at 4:05:16 PM"
" 81           ADD COMMENT================================================="
"           2  Lines of comment"
"              SWM Analysis of 100-yr 3 hr pre-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"
"              Flow to Beaver Creek."
" 33           CATCHMENT 101"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           101   Internal Runoff to Beaver Creek"
"         0.000   % Impervious"
"        10.360   Total Area"
"       100.000   Flow length"
"         3.000   Overland Slope"
"        10.360   Pervious Area"
"       100.000   Pervious length"
"         3.000   Pervious slope"
"         0.000   Impervious Area"
"       100.000   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'"
"       100.000   Impervious SCS Curve No."
"         0.000   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.000   Impervious Initial abstraction"
"                     1.396     0.000     0.000     0.000 c.m/sec"
"              Catchment 101          Pervious   Impervious Total Area "
```

```
"              Surface Area           10.360     0.000      10.360     hectare"
"              Time of concentration  21.677     2.851      21.677     minutes"
"              Time to Centroid       120.468    85.618     120.468    minutes"
"              Rainfall depth         89.960     89.960     89.960     mm"
"              Rainfall volume        9319.85    0.01       9319.86    c.m"
"              Rainfall losses        51.437     2.044      51.436     mm"
"              Runoff depth           38.524     87.916     38.524     mm"
"              Runoff volume          3991.03    0.01       3991.04    c.m"
"              Runoff coefficient     0.428      0.000      0.428      "
"              Maximum flow           1.396      0.000      1.396      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      1.396     1.396     0.000     0.000"
" 33           CATCHMENT 201"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           201   External Runoff to Beaver Creek"
"         0.000   % Impervious"
"         1.250   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         1.250   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.000   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'"
"       100.000   Impervious SCS Curve No."
"         0.000   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.000   Impervious Initial abstraction"
"                      0.284     1.396     0.000     0.000 c.m/sec"
"              Catchment 201          Pervious   Impervious Total Area "
"              Surface Area           1.250      0.000      1.250      hectare"
"              Time of concentration  6.945      0.913      6.945      minutes"
"              Time to Centroid       102.209    82.850     102.209    minutes"
"              Rainfall depth         89.960     89.960     89.960     mm"
"              Rainfall volume        1124.50    0.00       1124.50    c.m"
"              Rainfall losses        51.719     3.531      51.719     mm"
"              Runoff depth           38.241     86.429     38.241     mm"
"              Runoff volume          478.02     0.00       478.02     c.m"
"              Runoff coefficient     0.425      0.000      0.425      "
"              Maximum flow           0.284      0.000      0.284      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.284     1.524     0.000     0.000"
" 40           HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                      0.284     1.524     1.524     0.000"
" 40           HYDROGRAPH   Combine    100"
"             6   Combine "
"           100   Node #"
```

```
"                To Beaver Creek"
"              Maximum flow                  1.524    c.m/sec"
"              Hydrograph volume          4469.062    c.m"
"                      0.284     1.524     1.524     1.524"
" 40           HYDROGRAPH   Confluence    100"
"             7   Confluence "
"           100   Node #"
"                To Beaver Creek"
"              Maximum flow                  1.524    c.m/sec"
"              Hydrograph volume          4469.062    c.m"
"                      0.284     1.524     1.524     0.000"
" 40           HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                      0.284     0.000     1.524     0.000"
" 81           ADD COMMENT============================================="
"           1  Lines of comment"
"              Flow to South."
" 33           CATCHMENT 102"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           102   Internal Runoff to South"
"         0.000   % Impervious"
"        13.000   Total Area"
"       100.000   Flow length"
"         5.000   Overland Slope"
"        13.000   Pervious Area"
"       100.000   Pervious length"
"         3.000   Pervious slope"
"         0.000   Impervious Area"
"       100.000   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'"
"       100.000   Impervious SCS Curve No."
"         0.000   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.000   Impervious Initial abstraction"
"                      1.752     0.000     1.524     0.000 c.m/sec"
"              Catchment 102          Pervious   Impervious Total Area "
"              Surface Area           13.000     0.000      13.000     hectare"
"              Time of concentration  21.677     2.851      21.677     minutes"
"              Time to Centroid       120.468    85.619     120.468    minutes"
"              Rainfall depth         89.960     89.960     89.960     mm"
"              Rainfall volume        1.1695     0.0000     1.1695     ha-m"
"              Rainfall losses        51.437     2.044      51.436     mm"
"              Runoff depth           38.524     87.916     38.524     mm"
"              Runoff volume          5008.05    0.01       5008.07    c.m"
"              Runoff coefficient     0.428      0.000      0.428      "
"              Maximum flow           1.752      0.000      1.752      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      1.752     1.752     1.524     0.000"
" 33           CATCHMENT 202"
"             1   Triangular SCS"
```

```
"            1   Equal length"
"            1   SCS method"
"          202   External Runoff to Beaver Creek"
"        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'"
"       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'"
"      100.000   Impervious SCS Curve No."
"        0.000   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.000   Impervious Initial abstraction"
"                     0.483     1.752     1.524     0.000 c.m/sec"
"             Catchment 202          Pervious   Impervious Total Area "
"             Surface Area           3.500      0.000      3.500      hectare"
"             Time of concentration  20.349     2.676      20.349     minutes"
"             Time to Centroid       118.809    85.353     118.809    minutes"
"             Rainfall depth         89.960     89.960     89.960     mm"
"             Rainfall volume        3148.60    0.00       3148.60    c.m"
"             Rainfall losses        51.433     1.837      51.433     mm"
"             Runoff depth           38.527     88.123     38.527     mm"
"             Runoff volume          1348.43    0.00       1348.44    c.m"
"             Runoff coefficient     0.428      0.000      0.428      "
"             Maximum flow           0.483      0.000      0.483      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"           4   Add Runoff "
"                     0.483     2.235     1.524     0.000"
" 40          HYDROGRAPH Copy to Outflow"
"           8   Copy to Outflow"
"                     0.483     2.235     2.235     0.000"
" 40          HYDROGRAPH   Combine    200"
"           6   Combine "
"         200   Node #"
"               To South"
"             Maximum flow                 2.235    c.m/sec"
"             Hydrograph volume         6356.504    c.m"
"                     0.483     2.235     2.235     2.235"
" 40          HYDROGRAPH   Confluence    200"
"           7   Confluence "
"         200   Node #"
"               To South"
"             Maximum flow                 2.235    c.m/sec"
"             Hydrograph volume         6356.504    c.m"
"                     0.483     2.235     2.235     0.000"
" 38          START/RE-START TOTALS 200"
"           3   Runoff Totals on EXIT"
"             Total Catchment area                    28.110    hectare"
"             Total Impervious area                    0.000    hectare"
```

```
"              Total % impervious                          0.000"
" 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\MIDUSS\Existing"
"                Output filename:                      1279xHazel20240806.out"
"                Licensee name:                              Arianna Franklin"
"                Company                                   Meritech Engineering"
"                Date & Time last used:                2024-08-06 at 4:06:46 PM"
" 81           ADD COMMENT================================================="
"           2  Lines of comment"
"              SWM Analysis of Hurricane Hazel 48 hr pre-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"
"            74   C:\M\Meritech Engineering\PRJ - DOCS\1279\60-
Design\SWM\MIDUSS\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"
"              Flow to Beaver Creek."
" 33           CATCHMENT 101"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           101   Internal Runoff to Beaver Creek"
"         0.000   % Impervious"
"        10.360   Total Area"
"       100.000   Flow length"
"         3.000   Overland Slope"
"        10.360   Pervious Area"
"       100.000   Pervious length"
"         3.000   Pervious slope"
"         0.000   Impervious Area"
"       100.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.732   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"       100.000   Impervious SCS Curve No."
"         0.000   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.000   Impervious Initial abstraction"
"                      1.474     0.000     0.000     0.000 c.m/sec"
"              Catchment 101          Pervious   Impervious Total Area "
"              Surface Area           10.360     0.000      10.360     hectare"
"              Time of concentration  29.182     5.214      29.182     minutes"
```

```
"             Time to Centroid       2526.994   2237.163   2526.993   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        2.9526     0.0000     2.9526     ha-m"
"             Rainfall losses        76.448     1.603      76.447     mm"
"             Runoff depth           208.552    283.397    208.553    mm"
"             Runoff volume          2.1606     0.0000     2.1606     ha-m"
"             Runoff coefficient     0.732      0.000      0.732      "
"             Maximum flow           1.474      0.000      1.474      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     1.474     1.474     0.000     0.000"
" 33          CATCHMENT 201"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          201   External Runoff to Beaver Creek"
"        0.000   % Impervious"
"        1.250   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        1.250   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.000   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'"
"      100.000   Impervious SCS Curve No."
"        0.000   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.000   Impervious Initial abstraction"
"                     0.172     1.474     0.000     0.000 c.m/sec"
"             Catchment 201          Pervious   Impervious Total Area "
"             Surface Area           1.250      0.000      1.250      hectare"
"             Time of concentration  9.349      1.670      9.349      minutes"
"             Time to Centroid       2498.142   2232.322   2498.141   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        3562.50    0.00       3562.50    c.m"
"             Rainfall losses        77.421     3.638      77.420     mm"
"             Runoff depth           207.579    281.362    207.580    mm"
"             Runoff volume          2594.74    0.00       2594.74    c.m"
"             Runoff coefficient     0.728      0.000      0.728      "
"             Maximum flow           0.172      0.000      0.172      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.172     1.640     0.000     0.000"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                     0.172     1.640     1.640     0.000"
" 40          HYDROGRAPH   Combine    100"
"            6   Combine "
"          100   Node #"
"                To Beaver Creek"
"             Maximum flow                 1.640    c.m/sec"
```

```
"              Hydrograph volume         24200.793    c.m"
"                      0.172     1.640     1.640     1.640"
" 40           HYDROGRAPH   Confluence    100"
"             7   Confluence "
"           100   Node #"
"                 To Beaver Creek"
"              Maximum flow                 1.640    c.m/sec"
"              Hydrograph volume         24200.795    c.m"
"                      0.172     1.640     1.640     0.000"
" 40           HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                      0.172     0.000     1.640     0.000"
" 81           ADD COMMENT================================================="
"           1  Lines of comment"
"              Flow to South."
" 33           CATCHMENT 102"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           102   Internal Runoff to South"
"         0.000   % Impervious"
"        13.000   Total Area"
"       100.000   Flow length"
"         5.000   Overland Slope"
"        13.000   Pervious Area"
"       100.000   Pervious length"
"         3.000   Pervious slope"
"         0.000   Impervious Area"
"       100.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.732   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"       100.000   Impervious SCS Curve No."
"         0.000   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.000   Impervious Initial abstraction"
"                      1.850     0.000     1.640     0.000 c.m/sec"
"              Catchment 102          Pervious   Impervious Total Area "
"              Surface Area           13.000     0.000      13.000     hectare"
"              Time of concentration  29.182     5.214      29.182     minutes"
"              Time to Centroid       2526.994   2237.162   2526.993   minutes"
"              Rainfall depth         285.000    285.000    285.000    mm"
"              Rainfall volume        3.7050     0.0000     3.7050     ha-m"
"              Rainfall losses        76.448     1.603      76.447     mm"
"              Runoff depth           208.552    283.397    208.553    mm"
"              Runoff volume          2.7112     0.0000     2.7112     ha-m"
"              Runoff coefficient     0.732      0.000      0.732      "
"              Maximum flow           1.850      0.000      1.850      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      1.850     1.850     1.640     0.000"
" 33           CATCHMENT 202"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
```

```
"          202   External Runoff to Beaver Creek"
"        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'"
"       74.000   Pervious SCS Curve No."
"        0.732   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"      100.000   Impervious SCS Curve No."
"        0.000   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.000   Impervious Initial abstraction"
"                    0.497     1.850     1.640     0.000 c.m/sec"
"             Catchment 202          Pervious   Impervious Total Area "
"             Surface Area           3.500      0.000      3.500      hectare"
"             Time of concentration  27.395     4.895      27.395     minutes"
"             Time to Centroid       2524.451   2235.117   2524.451   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        9974.99    0.01       9975.00    c.m"
"             Rainfall losses        76.459     1.038      76.459     mm"
"             Runoff depth           208.541    283.962    208.541    mm"
"             Runoff volume          7298.94    0.01       7298.95    c.m"
"             Runoff coefficient     0.732      0.000      0.732      "
"             Maximum flow           0.497      0.000      0.497      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"           4   Add Runoff "
"                    0.497     2.347     1.640     0.000"
" 40          HYDROGRAPH Copy to Outflow"
"           8   Copy to Outflow"
"                    0.497     2.347     2.347     0.000"
" 40          HYDROGRAPH   Combine    200"
"           6   Combine "
"         200   Node #"
"               To South"
"             Maximum flow                 2.347    c.m/sec"
"             Hydrograph volume        34410.777    c.m"
"                    0.497     2.347     2.347     2.347"
" 40          HYDROGRAPH   Confluence    200"
"           7   Confluence "
"         200   Node #"
"               To South"
"             Maximum flow                 2.347    c.m/sec"
"             Hydrograph volume        34410.777    c.m"
"                    0.497     2.347     2.347     0.000"
" 38          START/RE-START TOTALS 200"
"           3   Runoff Totals on EXIT"
"             Total Catchment area                    28.110    hectare"
"             Total Impervious area                    0.000    hectare"
"             Total % impervious                       0.000"
" 19          EXIT"
```

Appendix D.2: Post-Development Conditions

```
"                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\MIDUSS"
"                Output filename:                     1279d2yr24hr20241011.out"
"                Licensee name:                              Arianna Franklin"
"                Company                                   Meritech Engineering"
"                Date & Time last used:              2024-10-11 at 11:27:23 AM"
" 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 702"
"              1   Triangular SCS"
"              1   Equal length"
"              1   SCS method"
"            702   Rear half of school site"
"         30.000   % Impervious"
"          0.920   Total Area"
"         30.000   Flow length"
"          3.000   Overland Slope"
"          0.644   Pervious Area"
"         30.000   Pervious length"
"          3.000   Pervious slope"
"          0.276   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     0.000     0.000     0.000 c.m/sec"
"               Catchment 702          Pervious   Impervious Total Area "
```

```
"             Surface Area           0.644      0.276      0.920      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        302.87     129.80     432.67     c.m"
"             Rainfall losses        35.643     5.578      26.624     mm"
"             Runoff depth           11.386     41.451     20.406     mm"
"             Runoff volume          73.33      114.41     187.73     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     0.065     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
"        1.361   Total Area"
"       80.000   Flow length"
"        3.000   Overland Slope"
"        1.225   Pervious Area"
"       80.000   Pervious length"
"        3.000   Pervious slope"
"        0.136   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"
"                     0.030     0.065     0.000     0.000 c.m/sec"
"             Catchment 703          Pervious   Impervious Total Area "
"             Surface Area           1.225      0.136      1.361      hectare"
"             Time of concentration  34.563     3.544      25.667     minutes"
"             Time to Centroid       846.115    675.509    797.185    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        576.06     64.01      640.07     c.m"
"             Rainfall losses        35.632     5.779      32.646     mm"
"             Runoff depth           11.398     41.250     14.383     mm"
"             Runoff volume          139.61     56.14      195.75     c.m"
"             Runoff coefficient     0.242      0.877      0.306      "
"             Maximum flow           0.017      0.026      0.030      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.030     0.093     0.000     0.000"
" 57          TRENCH Design d/s of 703"
"         0.093   Peak inflow"
"       383.484   Hydrograph volume"
"       356.000   Ground elevation"
"       354.000   Downstream trench invert"
"         1.200   Trench height"
```

```
"       352.300   Water table elevation"
"         1.000   Trench top width"
"         1.000   Trench bottom width"
"        40.000   Voids ratio (%)"
"        86.000   Hydraulic conductivity"
"         0.000   Trench gradient (%)"
"        65.000   Trench length"
"         1.000   Include base width"
"           11.   Number of stages"
"                   Level Discharge    Volume"
"                 354.000     0.000       0.0"
"                 354.200     0.000       5.2"
"                 354.400     0.000      10.4"
"                 354.600     0.000      15.6"
"                 354.800     0.000      20.8"
"                 355.000     0.006      26.0"
"                 355.200     0.062      31.2"
"                 355.400     0.108      31.4"
"                 355.600     0.140      31.7"
"                 355.800     0.165      31.9"
"                 356.000     0.187      32.1"
"             1.   ORIFICES"
"                  Orifice   Orifice   Orifice"
"                   invert coefficie  diameter"
"                 354.900     0.630     0.300"
"             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                  0.070    c.m/sec"
"               Outflow volume              152.156    c.m"
"               Peak exfiltration             0.007    c.m/sec"
"               Exfiltration volume         232.128    c.m"
"               Maximum level               355.283    metre"
"               Maximum storage              31.294    c.m"
"               Centroidal lag               10.312   hours"
"               Infiltration area 2 sides   156.000   sq.metre"
"               Infiltration Base area       65.000   sq.metre"
"                    0.030     0.093     0.070     0.007 c.m/sec"
" 40            HYDROGRAPH Next link "
"              5   Next link "
"                       0.030     0.070     0.070     0.007"
" 33            CATCHMENT 701"
"              1   Triangular SCS"
"              1   Equal length"
"              1   SCS method"
"            701   Northwest corner - lots"
"         45.000   % Impervious"
"          5.159   Total Area"
"         15.000   Flow length"
"          3.000   Overland Slope"
"          2.837   Pervious Area"
"         15.000   Pervious length"
```

```
"         3.000   Pervious slope"
"         2.322   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"
"                      0.570     0.070     0.070     0.007 c.m/sec"
"              Catchment 701          Pervious   Impervious Total Area "
"              Surface Area           2.837      2.322      5.159      hectare"
"              Time of concentration  12.659     1.298      4.168      minutes"
"              Time to Centroid       793.748    668.959    700.483    minutes"
"              Rainfall depth         47.029     47.029     47.029     mm"
"              Rainfall volume        1334.44    1091.81    2426.25    c.m"
"              Rainfall losses        35.650     5.881      22.254     mm"
"              Runoff depth           11.380     41.149     24.776     mm"
"              Runoff volume          322.90     955.29     1278.19    c.m"
"              Runoff coefficient     0.242      0.875      0.527      "
"              Maximum flow           0.081      0.549      0.570      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.570     0.622     0.070     0.007"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         1.054   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.422   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.632   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"
"                      0.146     0.622     0.070     0.007 c.m/sec"
"              Catchment 704          Pervious   Impervious Total Area "
"              Surface Area           0.422      0.632      1.054      hectare"
"              Time of concentration  7.165      2.222      2.986      minutes"
"              Time to Centroid       781.076    671.334    688.286    minutes"
```

```
"              Rainfall depth          47.029      47.029      47.029      mm"
"              Rainfall volume         198.28      297.41      495.69      c.m"
"              Rainfall losses         35.686      5.637       17.657      mm"
"              Runoff depth            11.343      41.393      29.373      mm"
"              Runoff volume           47.82       261.77      309.59      c.m"
"              Runoff coefficient      0.241       0.880       0.625       "
"              Maximum flow            0.017       0.140       0.146       c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.146     0.768     0.070     0.007"
" 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     0.768     0.070     0.007 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     0.891     0.070     0.007"
" 54           POND DESIGN"
"         0.891   Current peak flow    c.m/sec"
"         0.654   Target outflow    c.m/sec"
"        1988.5   Hydrograph volume    c.m"
"           14.   Number of stages"
"       354.900   Minimum water level    metre"
"       356.200   Maximum water level    metre"
"       354.900   Starting water level    metre"
"             0   Keep Design Data: 1 = True; 0 = False"
```

```
"                 Level Discharge    Volume"
"               354.900     0.000     0.000"
"               355.000   0.00307   414.000"
"               355.100   0.00944   895.000"
"               355.200   0.01263  1409.000"
"               355.300   0.01516  1942.000"
"               355.400   0.01732  2492.000"
"               355.500   0.01925  3060.000"
"               355.600   0.02099  3646.000"
"               355.700   0.02261  4249.000"
"               355.800   0.02411  4869.000"
"               355.900   0.02553  5507.000"
"               356.000   0.02687  6193.000"
"               356.100   0.02815  6929.000"
"               356.200   0.02937  7687.000"
"           1.  ORIFICES"
"               Orifice   Orifice   Orifice Number of"
"                invert coefficie  diameter  orifices"
"               354.900     0.630    0.1100     1.000"
"             Peak outflow                  0.013    c.m/sec"
"             Maximum level               355.207    metre"
"             Maximum storage            1445.992    c.m"
"             Centroidal lag               38.170   hours"
"                  0.123     0.891     0.013     0.007 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"           6   Combine "
"         704   Node #"
"               Flows to Beaver Creek"
"             Maximum flow                  0.013    c.m/sec"
"             Hydrograph volume          1907.123    c.m"
"                    0.123     0.891     0.013     0.013"
" 81          ADD COMMENT================================================="
"           2  Lines of comment"
"              501 to the existing subdivision to the "
"              northeast"
" 40          HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                    0.123     0.000     0.013     0.013"
" 33          CATCHMENT 501"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           501   Northeast corner of subdivision"
"        60.000   % Impervious"
"         0.356   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.142   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.214   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"
"                      0.052     0.000     0.013     0.013 c.m/sec"
"              Catchment 501          Pervious   Impervious Total Area "
"              Surface Area           0.142      0.214      0.356      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        66.97      100.45     167.42     c.m"
"              Rainfall losses        35.650     5.881      17.788     mm"
"              Runoff depth           11.380     41.149     29.241     mm"
"              Runoff volume          16.20      87.89      104.10     c.m"
"              Runoff coefficient     0.242      0.875      0.622      "
"              Maximum flow           0.004      0.050      0.052      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                      0.052     0.052     0.013     0.013"
" 40           HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                      0.052     0.052     0.052     0.013"
" 40           HYDROGRAPH   Combine    501"
"            6   Combine "
"          501   Node #"
"                To N and NE"
"              Maximum flow                  0.052    c.m/sec"
"              Hydrograph volume           104.099    c.m"
"                      0.052     0.052     0.052     0.052"
" 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"
"                      0.052     0.000     0.052     0.052"
" 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     0.052     0.052 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     0.052     0.052"
" 33          CATCHMENT 502"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          502   Front half of school site"
"       50.000   % Impervious"
"        2.299   Total Area"
"       30.000   Flow length"
"        2.299   Overland Slope"
"        1.150   Pervious Area"
"       30.000   Pervious length"
"        3.000   Pervious slope"
"        1.150   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"
"                     0.264     0.009     0.052     0.052 c.m/sec"
"             Catchment 502          Pervious   Impervious Total Area "
"             Surface Area           1.150      1.150      2.299      hectare"
"             Time of concentration  19.188     1.967      5.678      minutes"
"             Time to Centroid       809.357    670.466    700.396    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        540.60     540.60     1081.21    c.m"
"             Rainfall losses        35.643     5.578      20.611     mm"
"             Runoff depth           11.386     41.451     26.419     mm"
"             Runoff volume          130.88     476.48     607.37     c.m"
"             Runoff coefficient     0.242      0.881      0.562      "
"             Maximum flow           0.024      0.259      0.264      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.264     0.264     0.052     0.052"
```

```
" 33          CATCHMENT 503"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           503   East part of site incl townhouses"
"        70.000   % Impervious"
"         9.130   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         2.739   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         6.391   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.242   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.875   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                     1.531     0.264     0.052     0.052 c.m/sec"
"              Catchment 503          Pervious   Impervious Total Area "
"              Surface Area           2.739      6.391      9.130      hectare"
"              Time of concentration  12.659     1.298      2.502      minutes"
"              Time to Centroid       793.747    668.958    682.182    minutes"
"              Rainfall depth         47.029     47.029     47.029     mm"
"              Rainfall volume        1288.14    3005.65    4293.79    c.m"
"              Rainfall losses        35.650     5.881      14.811     mm"
"              Runoff depth           11.380     41.149     32.218     mm"
"              Runoff volume          311.69     2629.82    2941.52    c.m"
"              Runoff coefficient     0.242      0.875      0.685      "
"              Maximum flow           0.078      1.510      1.531      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                     1.531     1.795     0.052     0.052"
" 40          HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                     1.531     1.795     1.795     0.052"
" 40          HYDROGRAPH   Combine    503"
"             6   Combine "
"           503   Node #"
"                 SWM facility south of Conservation Dr"
"              Maximum flow                 1.795    c.m/sec"
"              Hydrograph volume         3720.630    c.m"
"                     1.531     1.795     1.795     1.795"
" 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"
"                     1.531     0.000     1.795     1.795"
" 33          CATCHMENT 504"
"             1   Triangular SCS"
```

```
"            1   Equal length"
"            1   SCS method"
"          504   Townhouse area at SW corner"
"       25.000   % Impervious"
"        0.453   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.340   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.113   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"
"                    0.029     0.000     1.795     1.795 c.m/sec"
"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.340      0.113      0.453      hectare"
"             Time of concentration  12.659     1.298      6.450      minutes"
"             Time to Centroid       793.747    668.958    725.543    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        159.78     53.26      213.04     c.m"
"             Rainfall losses        35.650     5.881      28.207     mm"
"             Runoff depth           11.380     41.149     18.822     mm"
"             Runoff volume          38.66      46.60      85.26      c.m"
"             Runoff coefficient     0.242      0.875      0.400      "
"             Maximum flow           0.010      0.027      0.029      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"           4   Add Runoff "
"                    0.029     0.029     1.795     1.795"
" 40          HYDROGRAPH Copy to Outflow"
"           8   Copy to Outflow"
"                    0.029     0.029     0.029     1.795"
" 40          HYDROGRAPH   Combine    504"
"           6   Combine "
"         504   Node #"
"               Minor to infiltration"
"             Maximum flow                0.029    c.m/sec"
"             Hydrograph volume          85.264    c.m"
"                    0.029     0.029     0.029     0.029"
" 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"
"                    0.029     0.000     0.029     0.029"
" 33          CATCHMENT 505"
"           1   Triangular SCS"
"           1   Equal length"
```

```
"            1   SCS method"
"          505   Rear yards of lots at NW corner"
"       35.000   % Impervious"
"        0.898   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.584   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.314   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"
"                    0.079     0.000     0.029     0.029 c.m/sec"
"             Catchment 505          Pervious   Impervious Total Area "
"             Surface Area           0.584      0.314      0.898      hectare"
"             Time of concentration  12.659     1.298      5.153      minutes"
"             Time to Centroid       793.747    668.959    711.303    minutes"
"             Rainfall depth         47.029     47.029     47.029     mm"
"             Rainfall volume        274.51     147.81     422.32     c.m"
"             Rainfall losses        35.650     5.881      25.230     mm"
"             Runoff depth           11.380     41.149     21.799     mm"
"             Runoff volume          66.42      129.33     195.76     c.m"
"             Runoff coefficient     0.242      0.875      0.464      "
"             Maximum flow           0.017      0.074      0.079      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"           4   Add Runoff "
"                    0.079     0.079     0.029     0.029"
" 40          HYDROGRAPH Copy to Outflow"
"           8   Copy to Outflow"
"                    0.079     0.079     0.079     0.029"
" 40          HYDROGRAPH   Combine    505"
"           6   Combine "
"         505   Node #"
"               Minor to infiltration"
"             Maximum flow                 0.079    c.m/sec"
"             Hydrograph volume          195.755    c.m"
"                    0.079     0.079     0.079     0.079"
" 81          ADD COMMENT==============================================="
"         1  Lines of comment"
"             Brohman Lands to Infiltration "
" 40          HYDROGRAPH Start - New Tributary"
"           2   Start - New Tributary"
"                    0.079     0.000     0.079     0.079"
" 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     0.079     0.079 c.m/sec"
"              Catchment 602          Pervious   Impervious Total Area "
"              Surface Area           0.160      0.240      0.400      hectare"
"              Time of concentration  12.659     1.298      3.067      minutes"
"              Time to Centroid       793.747    668.959    688.384    minutes"
"              Rainfall depth         47.029     47.029     47.029     mm"
"              Rainfall volume        75.25      112.87     188.12     c.m"
"              Rainfall losses        35.650     5.881      17.788     mm"
"              Runoff depth           11.380     41.149     29.241     mm"
"              Runoff volume          18.21      98.76      116.97     c.m"
"              Runoff coefficient     0.242      0.875      0.622      "
"              Maximum flow           0.005      0.057      0.058      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                     0.058     0.058     0.079     0.079"
" 40           HYDROGRAPH Copy to Outflow"
"             8   Copy to Outflow"
"                     0.058     0.058     0.058     0.079"
" 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                      26.380    hectare"
"              Total Impervious area                     12.298    hectare"
"              Total % impervious                        46.618"
" 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\MIDUSS"
"                Output filename:                     1279d5yr24hr20241011.out"
"                Licensee name:                              Arianna Franklin"
"                Company                                   Meritech Engineering"
"                Date & Time last used:              2024-10-11 at 11:28:11 AM"
" 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"
"              Roof area to infiltration. Overflow to pond."
" 33           CATCHMENT 705"
"             2   Rectangular"
"             1   Equal length"
"             1   SCS method"
"           705   Northwest corner - roofs"
"       100.000   % Impervious"
"         1.908   Total Area"
"         5.000   Flow length"
"         5.000   Overland Slope"
"         0.000   Pervious Area"
"         5.000   Pervious length"
"         3.000   Pervious slope"
"         1.908   Impervious Area"
"         5.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.000   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"       100.000   Impervious SCS Curve No."
"         1.000   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.000   Impervious Initial abstraction"
"                      0.710     0.000     0.000     0.000 c.m/sec"
"              Catchment 705          Pervious   Impervious Total Area "
```

```
"             Surface Area           0.000      1.908      1.908      hectare"
"             Time of concentration  5.169      0.597      0.597      minutes"
"             Time to Centroid       737.337    625.886    625.886    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        0.00       1164.23    1164.23    c.m"
"             Rainfall losses        41.818     0.000      0.000      mm"
"             Runoff depth           19.201     61.018     61.018     mm"
"             Runoff volume          0.00       1164.23    1164.23    c.m"
"             Runoff coefficient     0.000      1.000      1.000      "
"             Maximum flow           0.000      0.710      0.710      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"           4   Add Runoff "
"                    0.710     0.710     0.000     0.000"
" 56          DIVERSION"
"         705   Node number"
"       0.570   Overflow threshold"
"       1.000   Required diverted fraction"
"           0   Conduit type; 1=Pipe;2=Channel"
"             Peak of diverted flow         0.140    c.m/sec"
"             Volume of diverted flow      41.880    c.m"
"             DIV00705.005hyd"
"             Major flow at 705"
"                    0.710     0.710     0.570     0.000 c.m/sec"
" 40          HYDROGRAPH   Combine    705"
"           6   Combine "
"         705   Node #"
"               CWC Overflow"
"             Maximum flow                  0.570    c.m/sec"
"             Hydrograph volume          1122.347    c.m"
"                    0.710     0.710     0.570     0.570"
" 81          ADD COMMENT================================================="
"         1  Lines of comment"
"             Park/pond area to infiltration. Overflow to pond."
" 40          HYDROGRAPH Start - New Tributary"
"           2   Start - New Tributary"
"                    0.710     0.000     0.570     0.570"
" 33          CATCHMENT 702"
"           1   Triangular SCS"
"           1   Equal length"
"           1   SCS method"
"         702   Rear half of school site"
"      30.000   % Impervious"
"       0.920   Total Area"
"      30.000   Flow length"
"       3.000   Overland Slope"
"       0.644   Pervious Area"
"      30.000   Pervious length"
"       3.000   Pervious slope"
"       0.276   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"
"                      0.092     0.000     0.570     0.570 c.m/sec"
"              Catchment 702          Pervious   Impervious Total Area "
"              Surface Area           0.644      0.276      0.920      hectare"
"              Time of concentration  15.147     1.767      7.764      minutes"
"              Time to Centroid       767.984    657.510    707.023    minutes"
"              Rainfall depth         61.018     61.018     61.018     mm"
"              Rainfall volume        392.96     168.41     561.37     c.m"
"              Rainfall losses        41.834     5.905      31.055     mm"
"              Runoff depth           19.185     55.113     29.963     mm"
"              Runoff volume          123.55     152.11     275.66     c.m"
"              Runoff coefficient     0.314      0.903      0.491      "
"              Maximum flow           0.033      0.084      0.092      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.092     0.092     0.570     0.570"
" 33           CATCHMENT 703"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           703   Park block"
"        10.000   % Impervious"
"         1.361   Total Area"
"        80.000   Flow length"
"         3.000   Overland Slope"
"         1.225   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.136   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"
"                      0.047     0.092     0.570     0.570 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           1.225      0.136      1.361      hectare"
"              Time of concentration  27.284     3.184      21.461     minutes"
"              Time to Centroid       796.757    661.652    764.114    minutes"
"              Rainfall depth         61.018     61.018     61.018     mm"
"              Rainfall volume        747.41     83.05      830.46     c.m"
"              Rainfall losses        41.821     5.973      38.236     mm"
"              Runoff depth           19.197     55.045     22.782     mm"
"              Runoff volume          235.15     74.92      310.06     c.m"
"              Runoff coefficient     0.315      0.902      0.373      "
"              Maximum flow           0.040      0.038      0.047      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.047     0.135     0.570     0.570"
" 57           TRENCH Design d/s of 703"
"         0.135   Peak inflow"
```

```
"       585.723   Hydrograph volume"
"       356.000   Ground elevation"
"       354.000   Downstream trench invert"
"         1.200   Trench height"
"       352.300   Water table elevation"
"         1.000   Trench top width"
"         1.000   Trench bottom width"
"        40.000   Voids ratio (%)"
"        86.000   Hydraulic conductivity"
"         0.000   Trench gradient (%)"
"        65.000   Trench length"
"         0.000   Include base width"
"           11.   Number of stages"
"                   Level Discharge    Volume"
"                 354.000     0.000       0.0"
"                 354.200     0.000       5.2"
"                 354.400     0.000      10.4"
"                 354.600     0.000      15.6"
"                 354.800     0.000      20.8"
"                 355.000     0.006      26.0"
"                 355.200     0.062      31.2"
"                 355.400     0.108      31.4"
"                 355.600     0.140      31.7"
"                 355.800     0.165      31.9"
"                 356.000     0.187      32.1"
"            1.   ORIFICES"
"                 Orifice   Orifice   Orifice"
"                  invert coefficie  diameter"
"                 354.900     0.630     0.300"
"            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                 0.129    c.m/sec"
"              Outflow volume             369.086    c.m"
"              Peak exfiltration            0.005    c.m/sec"
"              Exfiltration volume        219.330    c.m"
"              Maximum level              355.532    metre"
"              Maximum storage             31.575    c.m"
"              Centroidal lag              10.703   hours"
"              Infiltration area 2 sides  156.000   sq.metre"
"              Infiltration Base area        .000   sq.metre"
"                   0.047     0.135     0.129     0.005 c.m/sec"
" 40           HYDROGRAPH   Combine    705"
"             6   Combine "
"           705   Node #"
"                 CWC Overflow"
"              Maximum flow                 0.699    c.m/sec"
"              Hydrograph volume         1491.430    c.m"
"                      0.047     0.135     0.129     0.699"
" 40           HYDROGRAPH   Confluence    705"
"             7   Confluence "
"           705   Node #"
```

```
"                CWC Overflow"
"              Maximum flow                  0.699    c.m/sec"
"              Hydrograph volume          1491.430    c.m"
"                     0.047     0.699     0.129     0.000"
" 33           CATCHMENT 701"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           701   Northwest corner - lots"
"        45.000   % Impervious"
"         5.159   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         2.837   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         2.322   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"
"                     0.797     0.699     0.129     0.000 c.m/sec"
"              Catchment 701          Pervious   Impervious Total Area "
"              Surface Area           2.837      2.322      5.159      hectare"
"              Time of concentration  9.993      1.166      3.811      minutes"
"              Time to Centroid       756.254    656.264    686.225    minutes"
"              Rainfall depth         61.018     61.018     61.018     mm"
"              Rainfall volume        1731.36    1416.57    3147.93    c.m"
"              Rainfall losses        41.904     6.416      25.934     mm"
"              Runoff depth           19.114     54.602     35.084     mm"
"              Runoff volume          542.35     1267.62    1809.98    c.m"
"              Runoff coefficient     0.313      0.895      0.575      "
"              Maximum flow           0.173      0.734      0.797      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                     0.797     1.495     0.129     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         1.054   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.422   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.632   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"
"                      0.211     1.495     0.129     0.000 c.m/sec"
"              Catchment 704          Pervious   Impervious Total Area "
"              Surface Area           0.422      0.632      1.054      hectare"
"              Time of concentration  5.656      1.996      2.684      minutes"
"              Time to Centroid       745.655    658.155    674.590    minutes"
"              Rainfall depth         61.018     61.018     61.018     mm"
"              Rainfall volume        257.25     385.88     643.13     c.m"
"              Rainfall losses        41.880     5.847      20.260     mm"
"              Runoff depth           19.138     55.171     40.758     mm"
"              Runoff volume          80.69      348.90     429.59     c.m"
"              Runoff coefficient     0.314      0.904      0.668      "
"              Maximum flow           0.034      0.191      0.211      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.211     1.706     0.129     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     1.706     0.129     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     1.875     0.129     0.000"
" 54          POND DESIGN"
"        1.875   Current peak flow    c.m/sec"
"        0.654   Target outflow    c.m/sec"
"       4074.5   Hydrograph volume    c.m"
"          14.   Number of stages"
"      354.900   Minimum water level    metre"
"      356.200   Maximum water level    metre"
"      354.900   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                354.900     0.000     0.000"
"                355.000   0.00300   414.000"
"                355.100   0.00900   895.000"
"                355.200   0.01300  1409.000"
"                355.300    0.1020  1942.000"
"                355.400    0.1070  2492.000"
"                355.500    0.3060  3060.000"
"                355.600    0.3180  3646.000"
"                355.700    0.3300  4249.000"
"                355.800    0.3410  4869.000"
"                355.900     1.002  5507.000"
"                356.000     1.032  6193.000"
"                356.100     1.060  6929.000"
"                356.200     1.089  7687.000"
"             Peak outflow                  0.107    c.m/sec"
"             Maximum level               355.392    metre"
"             Maximum storage            2445.271    c.m"
"             Centroidal lag               25.705   hours"
"                  0.169     1.875     0.107     0.000 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"           6   Combine "
"         704   Node #"
"               Flows to Beaver Creek"
"             Maximum flow                  0.107    c.m/sec"
"             Hydrograph volume          3985.384    c.m"
"                     0.169     1.875     0.107     0.107"
" 81          ADD COMMENT================================================="
"           2  Lines of comment"
"             501 to the existing subdivision to the "
"             northeast"
" 40          HYDROGRAPH Start - New Tributary"
"           2   Start - New Tributary"
"                     0.169     0.000     0.107     0.107"
" 33          CATCHMENT 501"
"           1   Triangular SCS"
"           1   Equal length"
"           1   SCS method"
"         501   Northeast corner of subdivision"
"       60.000   % Impervious"
"        0.356   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.142   Pervious Area"
```

```
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.214   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"
"                     0.071     0.000     0.107     0.107 c.m/sec"
"            Catchment 501          Pervious   Impervious Total Area "
"            Surface Area           0.142      0.214      0.356      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        86.89      130.33     217.22     c.m"
"            Rainfall losses        41.904     6.416      20.611     mm"
"            Runoff depth           19.114     54.602     40.407     mm"
"            Runoff volume          27.22      116.63     143.85     c.m"
"            Runoff coefficient     0.313      0.895      0.662      "
"            Maximum flow           0.009      0.068      0.071      c.m/sec"
" 40         HYDROGRAPH Add Runoff "
"          4   Add Runoff "
"                     0.071     0.071     0.107     0.107"
" 40         HYDROGRAPH Copy to Outflow"
"          8   Copy to Outflow"
"                     0.071     0.071     0.071     0.107"
" 40         HYDROGRAPH   Combine    501"
"          6   Combine "
"        501   Node #"
"              To N and NE"
"            Maximum flow                 0.071    c.m/sec"
"            Hydrograph volume          143.849    c.m"
"                     0.071     0.071     0.071     0.071"
" 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"
"                     0.071     0.000     0.071     0.071"
" 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     0.071     0.071 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     0.071     0.071"
" 33           CATCHMENT 502"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           502   Front half of school site"
"        50.000   % Impervious"
"         2.299   Total Area"
"        30.000   Flow length"
"         3.000   Overland Slope"
"         1.150   Pervious Area"
"        30.000   Pervious length"
"         3.000   Pervious slope"
"         1.150   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"
"                      0.364     0.033     0.071     0.071 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           1.150      1.150      2.299      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        701.40     701.40     1402.81    c.m"
"             Rainfall losses        41.834     5.905      23.869     mm"
"             Runoff depth           19.185     55.113     37.149     mm"
"             Runoff volume          220.53     633.52     854.05     c.m"
"             Runoff coefficient     0.314      0.903      0.609      "
"             Maximum flow           0.059      0.350      0.364      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.364     0.366     0.071     0.071"
" 33          CATCHMENT 503"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          503   East part of site incl townhouses"
"       70.000   % Impervious"
"        9.130   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        2.739   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        6.391   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"
"                     2.081     0.366     0.071     0.071 c.m/sec"
"             Catchment 503          Pervious   Impervious Total Area "
"             Surface Area           2.739      6.391      9.130      hectare"
"             Time of concentration  9.993      1.166      2.318      minutes"
"             Time to Centroid       756.255    656.263    669.308    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
"             Rainfall volume        1671.29    3899.67    5570.96    c.m"
"             Rainfall losses        41.904     6.416      17.062     mm"
"             Runoff depth           19.114     54.602     43.956     mm"
"             Runoff volume          523.54     3489.65    4013.18    c.m"
"             Runoff coefficient     0.313      0.895      0.720      "
"             Maximum flow           0.167      2.020      2.081      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     2.081     2.446     0.071     0.071"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                     2.081     2.446     2.446     0.071"
" 40          HYDROGRAPH   Combine    503"
"            6   Combine "
"          503   Node #"
"                SWM facility south of Conservation Dr"
"             Maximum flow                 2.446    c.m/sec"
```

```
"             Hydrograph volume          5205.932    c.m"
"                    2.081     2.446     2.446     2.446"
" 81          ADD COMMENT================================================="
"           3  Lines of comment"
"              Minor flows (2yr and less) from catchment 504 "
"              (townhouses at SW corner) (85m3) are to infiltration, "
"              remainder to Beaver Creek "
" 40          HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                    2.081     0.000     2.446     2.446"
" 33          CATCHMENT 504"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           504   Townhouse area at SW corner"
"        25.000   % Impervious"
"         0.453   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.340   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.113   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"
"                    0.043     0.000     2.446     2.446 c.m/sec"
"              Catchment 504          Pervious   Impervious Total Area "
"              Surface Area           0.340      0.113      0.453      hectare"
"              Time of concentration  9.993      1.166      5.688      minutes"
"              Time to Centroid       756.254    656.263    707.483    minutes"
"              Rainfall depth         61.018     61.018     61.018     mm"
"              Rainfall volume        207.31     69.10      276.41     c.m"
"              Rainfall losses        41.904     6.416      33.032     mm"
"              Runoff depth           19.114     54.602     27.986     mm"
"              Runoff volume          64.94      61.84      126.78     c.m"
"              Runoff coefficient     0.313      0.895      0.459      "
"              Maximum flow           0.021      0.036      0.043      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                    0.043     0.043     2.446     2.446"
" 54          POND DESIGN"
"         0.043   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"         126.8   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    85.000"
"                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              85.365    c.m"
"             Centroidal lag               20.244   hours"
"                  0.043     0.043     0.003     2.446 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"           6   Combine "
"         704   Node #"
"               Flows to Beaver Creek"
"             Maximum flow                  0.109    c.m/sec"
"             Hydrograph volume          4030.504    c.m"
"                     0.043     0.043     0.003     0.109"
" 81          ADD COMMENT================================================="
"         3  Lines of comment"
"             Minor flows (2yr and less) from catchment 505 "
"             (North Property Line) (196m3) are to infiltration, "
"             remainder to wetland finger to Beaver Creek "
" 40          HYDROGRAPH Start - New Tributary"
"           2   Start - New Tributary"
"                     0.043     0.000     0.003     0.109"
" 33          CATCHMENT 505"
"           1   Triangular SCS"
"           1   Equal length"
"           1   SCS method"
"         505   Rear yards of lots at NW corner"
"      35.000   % Impervious"
"       0.898   Total Area"
"      15.000   Flow length"
"       3.000   Overland Slope"
"       0.584   Pervious Area"
"      15.000   Pervious length"
"       3.000   Pervious slope"
"       0.314   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"
"                     0.112     0.000     0.003     0.109 c.m/sec"
"             Catchment 505          Pervious   Impervious Total Area "
"             Surface Area           0.584      0.314      0.898      hectare"
"             Time of concentration  9.993      1.166      4.644      minutes"
"             Time to Centroid       756.255    656.264    695.658    minutes"
"             Rainfall depth         61.018     61.018     61.018     mm"
```

```
"             Rainfall volume        356.16     191.78     547.94     c.m"
"             Rainfall losses         41.904     6.416      29.483     mm"
"             Runoff depth            19.114     54.602     31.535     mm"
"             Runoff volume           111.57     171.62     283.18     c.m"
"             Runoff coefficient      0.313      0.895      0.517      "
"             Maximum flow            0.036      0.099      0.112      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.112     0.112     0.003     0.109"
" 54          POND DESIGN"
"         0.112   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"         283.2   Hydrograph volume    c.m"
"            3.   Number of stages"
"       100.000   Minimum water level    metre"
"       102.000   Maximum water level    metre"
"       100.000   Starting water level    metre"
"             0   Keep Design Data: 1 = True; 0 = False"
"                   Level Discharge    Volume"
"                 100.000     0.000     0.000"
"                 101.000  1.01E-05   196.000"
"                 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                  0.005    c.m/sec"
"             Maximum level               101.001    metre"
"             Maximum storage             196.680    c.m"
"             Centroidal lag               18.126   hours"
"                     0.112     0.112     0.005     0.109 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                  0.114    c.m/sec"
"             Hydrograph volume          4121.082    c.m"
"                     0.112     0.112     0.005     0.114"
" 81          ADD COMMENT================================================="
"           1  Lines of comment"
"              Uncontrolled Brohman Lands "
" 40          HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                     0.112     0.000     0.005     0.114"
" 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     0.005     0.114 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     0.005     0.114"
" 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     0.114 c.m/sec"
" 40           HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"              Maximum flow                  0.117    c.m/sec"
"              Hydrograph volume          4169.050    c.m"
"                      0.079     0.079     0.003     0.117"
" 38           START/RE-START TOTALS 602"
"              3   Runoff Totals on EXIT"
"              Total Catchment area                      28.288    hectare"
"              Total Impervious area                     14.206    hectare"
"              Total % impervious                        50.218"
```

```
" 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\MIDUSS"
"                Output filename:                    1279d100yr3hr20241011.out"
"                Licensee name:                              Arianna Franklin"
"                Company                                   Meritech Engineering"
"                Date & Time last used:             2024-10-11 at 11:29:05 AM"
" 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"
"              Roof area to infiltration. Overflow to pond."
" 33           CATCHMENT 705"
"             2   Rectangular"
"             1   Equal length"
"             1   SCS method"
"           705   Northwest corner - roofs"
"       100.000   % Impervious"
"         1.908   Total Area"
"         5.000   Flow length"
"         5.000   Overland Slope"
"         0.000   Pervious Area"
"         5.000   Pervious length"
"         3.000   Pervious slope"
"         1.908   Impervious Area"
"         5.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.000   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"       100.000   Impervious SCS Curve No."
"         1.000   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.000   Impervious Initial abstraction"
"                      1.271     0.000     0.000     0.000 c.m/sec"
"              Catchment 705          Pervious   Impervious Total Area "
```

```
"             Surface Area           0.000      1.908      1.908      hectare"
"             Time of concentration  3.592      0.472      0.472      minutes"
"             Time to Centroid       93.802     81.120     81.120     minutes"
"             Rainfall depth         89.960     89.960     89.960     mm"
"             Rainfall volume        0.00       1716.44    1716.44    c.m"
"             Rainfall losses        51.395     0.000      0.000      mm"
"             Runoff depth           38.565     89.960     89.960     mm"
"             Runoff volume          0.00       1716.44    1716.44    c.m"
"             Runoff coefficient     0.000      1.000      1.000      "
"             Maximum flow           0.000      1.271      1.271      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"           4   Add Runoff "
"                    1.271     1.271     0.000     0.000"
" 56          DIVERSION"
"         705   Node number"
"       0.570   Overflow threshold"
"       1.000   Required diverted fraction"
"           0   Conduit type; 1=Pipe;2=Channel"
"             Peak of diverted flow         0.701    c.m/sec"
"             Volume of diverted flow     287.590    c.m"
"             DIV00705.100hyd"
"             Major flow at 705"
"                    1.271     1.271     0.570     0.000 c.m/sec"
" 40          HYDROGRAPH   Combine    705"
"           6   Combine "
"         705   Node #"
"               CWC Overflow"
"             Maximum flow                  0.570    c.m/sec"
"             Hydrograph volume          1428.847    c.m"
"                    1.271     1.271     0.570     0.570"
" 81          ADD COMMENT=================================================="
"         1  Lines of comment"
"             Park/pond area to infiltration. Overflow to pond."
" 40          HYDROGRAPH Start - New Tributary"
"           2   Start - New Tributary"
"                    1.271     0.000     0.570     0.570"
" 33          CATCHMENT 702"
"           1   Triangular SCS"
"           1   Equal length"
"           1   SCS method"
"         702   Rear half of school site"
"      30.000   % Impervious"
"       0.920   Total Area"
"      30.000   Flow length"
"       3.000   Overland Slope"
"       0.644   Pervious Area"
"      30.000   Pervious length"
"       3.000   Pervious slope"
"       0.276   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"
"                      0.216     0.000     0.570     0.570 c.m/sec"
"              Catchment 702          Pervious   Impervious Total Area "
"              Surface Area           0.644      0.276      0.920      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        579.34     248.29     827.63     c.m"
"              Rainfall losses        51.510     6.752      38.083     mm"
"              Runoff depth           38.450     83.208     51.877     mm"
"              Runoff volume          247.62     229.65     477.27     c.m"
"              Runoff coefficient     0.427      0.925      0.577      "
"              Maximum flow           0.124      0.159      0.216      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.216     0.216     0.570     0.570"
" 33           CATCHMENT 703"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           703   Park block"
"        10.000   % Impervious"
"         1.361   Total Area"
"        80.000   Flow length"
"         3.000   Overland Slope"
"         1.225   Pervious Area"
"        80.000   Pervious length"
"         3.000   Pervious slope"
"         0.136   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"
"                      0.195     0.216     0.570     0.570 c.m/sec"
"              Catchment 703          Pervious   Impervious Total Area "
"              Surface Area           1.225      0.136      1.361      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        1101.92    122.44     1224.36    c.m"
"              Rainfall losses        51.458     6.998      47.012     mm"
"              Runoff depth           38.502     82.962     42.948     mm"
"              Runoff volume          471.61     112.91     584.52     c.m"
"              Runoff coefficient     0.428      0.922      0.477      "
"              Maximum flow           0.173      0.074      0.195      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.195     0.375     0.570     0.570"
" 57           TRENCH Design d/s of 703"
"         0.375   Peak inflow"
```

```
"     1061.794   Hydrograph volume"
"      356.000   Ground elevation"
"      354.000   Downstream trench invert"
"        1.200   Trench height"
"      352.300   Water table elevation"
"        1.000   Trench top width"
"        1.000   Trench bottom width"
"       40.000   Voids ratio (%)"
"       86.000   Hydraulic conductivity"
"        0.000   Trench gradient (%)"
"       65.000   Trench length"
"        0.000   Include base width"
"          11.   Number of stages"
"                  Level Discharge    Volume"
"                354.000     0.000       0.0"
"                354.200     0.000       5.2"
"                354.400     0.000      10.4"
"                354.600     0.000      15.6"
"                354.800     0.000      20.8"
"                355.000     0.007      26.0"
"                355.200     0.061      31.2"
"                355.400     0.199      31.4"
"                355.600     0.281      31.7"
"                355.800     0.344      31.9"
"                356.000     0.397      32.1"
"           1.   ORIFICES"
"                Orifice   Orifice   Orifice"
"                 invert coefficie  diameter"
"                354.900     0.630     0.450"
"           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                  0.369    c.m/sec"
"             Outflow volume              985.297    c.m"
"             Peak exfiltration             0.006    c.m/sec"
"             Exfiltration volume          78.882    c.m"
"             Maximum level               355.894    metre"
"             Maximum storage              31.986    c.m"
"             Centroidal lag                1.740   hours"
"             Infiltration area 2 sides   156.000   sq.metre"
"             Infiltration Base area         .000   sq.metre"
"                  0.195     0.375     0.369     0.006 c.m/sec"
" 40          HYDROGRAPH   Combine    705"
"           6   Combine "
"         705   Node #"
"               CWC Overflow"
"             Maximum flow                  0.919    c.m/sec"
"             Hydrograph volume          2414.143    c.m"
"                     0.195     0.375     0.369     0.919"
" 40          HYDROGRAPH   Confluence    705"
"           7   Confluence "
"         705   Node #"
```

```
"                CWC Overflow"
"              Maximum flow                  0.919    c.m/sec"
"              Hydrograph volume          2414.143    c.m"
"                      0.195     0.919     0.369     0.000"
" 33           CATCHMENT 701"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           701   Northwest corner - lots"
"        45.000   % Impervious"
"         5.159   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         2.837   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         2.322   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"
"                      1.578     0.919     0.369     0.000 c.m/sec"
"              Catchment 701          Pervious   Impervious Total Area "
"              Surface Area           2.837      2.322      5.159      hectare"
"              Time of concentration  6.945      0.919      3.120      minutes"
"              Time to Centroid       102.209    85.375     91.525     minutes"
"              Rainfall depth         89.960     89.960     89.960     mm"
"              Rainfall volume        2552.57    2088.47    4641.04    c.m"
"              Rainfall losses        51.719     8.749      32.382     mm"
"              Runoff depth           38.241     81.211     57.578     mm"
"              Runoff volume          1085.08    1885.35    2970.43    c.m"
"              Runoff coefficient     0.425      0.903      0.640      "
"              Maximum flow           0.644      1.343      1.578      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      1.578     2.431     0.369     0.000"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         1.054   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.422   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.632   Impervious Area"
"        15.000   Impervious length"
"         0.500   Impervious slope"
```

```
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.422   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"        98.000   Impervious SCS Curve No."
"         0.927   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.430     2.431     0.369     0.000 c.m/sec"
"              Catchment 704          Pervious   Impervious Total Area "
"              Surface Area           0.422      0.632      1.054      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        379.27     568.91     948.18     c.m"
"              Rainfall losses        52.037     6.542      24.740     mm"
"              Runoff depth           37.923     83.418     65.220     mm"
"              Runoff volume          159.88     527.53     687.42     c.m"
"              Runoff coefficient     0.422      0.927      0.725      "
"              Maximum flow           0.106      0.360      0.430      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.430     2.861     0.369     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     2.861     0.369     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     3.184     0.369     0.000"
" 54          POND DESIGN"
"        3.184   Current peak flow    c.m/sec"
"        0.654   Target outflow    c.m/sec"
"       6616.2   Hydrograph volume    c.m"
"          14.   Number of stages"
"      354.900   Minimum water level    metre"
"      356.200   Maximum water level    metre"
"      354.900   Starting water level    metre"
"            0   Keep Design Data: 1 = True; 0 = False"
"                  Level Discharge    Volume"
"                354.900     0.000     0.000"
"                355.000   0.00300   414.000"
"                355.100   0.00900   895.000"
"                355.200   0.01300  1409.000"
"                355.300    0.1020  1942.000"
"                355.400    0.1070  2492.000"
"                355.500    0.3060  3060.000"
"                355.600    0.3180  3646.000"
"                355.700    0.3300  4249.000"
"                355.800    0.3410  4869.000"
"                355.900     1.002  5507.000"
"                356.000     1.032  6193.000"
"                356.100     1.060  6929.000"
"                356.200     1.089  7687.000"
"             Peak outflow                  0.373    c.m/sec"
"             Maximum level               355.805    metre"
"             Maximum storage            4900.269    c.m"
"             Centroidal lag               10.654   hours"
"                  0.323     3.184     0.373     0.000 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"           6   Combine "
"         704   Node #"
"               Flows to Beaver Creek"
"             Maximum flow                  0.373    c.m/sec"
"             Hydrograph volume          6548.756    c.m"
"                    0.323     3.184     0.373     0.373"
" 81          ADD COMMENT================================================="
"           2  Lines of comment"
"             501 to the existing subdivision to the "
"             northeast"
" 40          HYDROGRAPH Start - New Tributary"
"           2   Start - New Tributary"
"                    0.323     0.000     0.373     0.373"
" 33          CATCHMENT 501"
"           1   Triangular SCS"
"           1   Equal length"
"           1   SCS method"
"         501   Northeast corner of subdivision"
"       60.000   % Impervious"
"        0.356   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.142   Pervious Area"
```

```
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.214   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"
"                     0.135     0.000     0.373     0.373 c.m/sec"
"             Catchment 501          Pervious   Impervious Total Area "
"             Surface Area           0.142      0.214      0.356      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        128.10     192.15     320.26     c.m"
"             Rainfall losses        51.719     8.749      25.937     mm"
"             Runoff depth           38.241     81.211     64.023     mm"
"             Runoff volume          54.46      173.47     227.92     c.m"
"             Runoff coefficient     0.425      0.903      0.712      "
"             Maximum flow           0.032      0.124      0.135      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"           4   Add Runoff "
"                     0.135     0.135     0.373     0.373"
" 40          HYDROGRAPH Copy to Outflow"
"           8   Copy to Outflow"
"                     0.135     0.135     0.135     0.373"
" 40          HYDROGRAPH   Combine    501"
"           6   Combine "
"         501   Node #"
"               To N and NE"
"             Maximum flow                 0.135    c.m/sec"
"             Hydrograph volume          227.922    c.m"
"                     0.135     0.135     0.135     0.135"
" 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"
"                     0.135     0.000     0.135     0.135"
" 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     0.135     0.135 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     0.135     0.135"
" 33           CATCHMENT 502"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           502   Front half of school site"
"        50.000   % Impervious"
"         2.299   Total Area"
"        30.000   Flow length"
"         3.000   Overland Slope"
"         1.150   Pervious Area"
"        30.000   Pervious length"
"         3.000   Pervious slope"
"         1.150   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"
"                      0.721     0.234     0.135     0.135 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           1.150      1.150      2.299      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        1034.09    1034.09    2068.18    c.m"
"             Rainfall losses        51.510     6.752      29.131     mm"
"             Runoff depth           38.450     83.208     60.829     mm"
"             Runoff volume          441.98     956.48     1398.46    c.m"
"             Runoff coefficient     0.427      0.925      0.676      "
"             Maximum flow           0.221      0.661      0.721      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.721     0.737     0.135     0.135"
" 33          CATCHMENT 503"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          503   East part of site incl townhouses"
"       70.000   % Impervious"
"        9.130   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        2.739   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        6.391   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"
"                     3.924     0.737     0.135     0.135 c.m/sec"
"             Catchment 503          Pervious   Impervious Total Area "
"             Surface Area           2.739      6.391      9.130      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        2464.01    5749.35    8213.35    c.m"
"             Rainfall losses        51.719     8.749      21.640     mm"
"             Runoff depth           38.241     81.211     68.320     mm"
"             Runoff volume          1047.43    5190.19    6237.63    c.m"
"             Runoff coefficient     0.425      0.903      0.759      "
"             Maximum flow           0.622      3.698      3.924      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     3.924     4.661     0.135     0.135"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                     3.924     4.661     4.661     0.135"
" 40          HYDROGRAPH   Combine    503"
"            6   Combine "
"          503   Node #"
"                SWM facility south of Conservation Dr"
"             Maximum flow                  4.661    c.m/sec"
```

```
"             Hydrograph volume          8441.192    c.m"
"                    3.924     4.661     4.661     4.661"
" 81          ADD COMMENT==================================================="
"           3  Lines of comment"
"              Minor flows (2yr and less) from catchment 504 "
"              (townhouses at SW corner) (85m3) are to infiltration, "
"              remainder to Beaver Creek "
" 40          HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                    3.924     0.000     4.661     4.661"
" 33          CATCHMENT 504"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           504   Townhouse area at SW corner"
"        25.000   % Impervious"
"         0.453   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.340   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.113   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"
"                    0.114     0.000     4.661     4.661 c.m/sec"
"             Catchment 504          Pervious   Impervious Total Area "
"             Surface Area           0.340      0.113      0.453      hectare"
"             Time of concentration  6.945      0.919      4.447      minutes"
"             Time to Centroid       102.209    85.375     95.232     minutes"
"             Rainfall depth         89.960     89.960     89.960     mm"
"             Rainfall volume        305.64     101.88     407.52     c.m"
"             Rainfall losses        51.719     8.749      40.976     mm"
"             Runoff depth           38.241     81.211     48.984     mm"
"             Runoff volume          129.93     91.97      221.90     c.m"
"             Runoff coefficient     0.425      0.903      0.545      "
"             Maximum flow           0.077      0.066      0.114      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                    0.114     0.114     4.661     4.661"
" 54          POND DESIGN"
"         0.114   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"         221.9   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    85.000"
"                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                  0.080    c.m/sec"
"              Maximum level                101.014    metre"
"              Maximum storage               97.602    c.m"
"              Centroidal lag                 3.540   hours"
"                   0.114     0.114     0.080     4.661 c.m/sec"
" 40           HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"              Maximum flow                   0.404    c.m/sec"
"              Hydrograph volume           6693.460    c.m"
"                      0.114     0.114     0.080     0.404"
" 81           ADD COMMENT================================================="
"          3  Lines of comment"
"              Minor flows (2yr and less) from catchment 505 "
"              (North Property Line) (196m3) are to infiltration, "
"              remainder to wetland finger to Beaver Creek "
" 40           HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                      0.114     0.000     0.080     0.404"
" 33           CATCHMENT 505"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          505   Rear yards of lots at NW corner"
"       35.000   % Impervious"
"        0.898   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.584   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        0.314   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"
"                      0.242     0.000     0.080     0.404 c.m/sec"
"              Catchment 505          Pervious   Impervious Total Area "
"              Surface Area           0.584      0.314      0.898      hectare"
"              Time of concentration  6.945      0.919      3.730      minutes"
"              Time to Centroid       102.209    85.375     93.229     minutes"
"              Rainfall depth         89.960     89.960     89.960     mm"
```

```
"             Rainfall volume        525.10     282.74     807.84     c.m"
"             Rainfall losses         51.719     8.749     36.679     mm"
"             Runoff depth            38.241    81.211     53.281     mm"
"             Runoff volume          223.22     255.25     478.46     c.m"
"             Runoff coefficient      0.425      0.903      0.592      "
"             Maximum flow            0.132      0.182      0.242      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.242     0.242     0.080     0.404"
" 54          POND DESIGN"
"         0.242   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"         478.5   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   196.000"
"                 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                  0.176    c.m/sec"
"               Maximum level                101.029    metre"
"               Maximum storage              219.158    c.m"
"               Centroidal lag                 2.688   hours"
"                     0.242     0.242     0.176     0.404 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"               Maximum flow                  0.566    c.m/sec"
"               Hydrograph volume          6984.144    c.m"
"                     0.242     0.242     0.176     0.566"
" 81          ADD COMMENT================================================="
"           1  Lines of comment"
"              Uncontrolled Brohman Lands "
" 40          HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                     0.242     0.000     0.176     0.566"
" 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     0.176     0.566 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     0.176     0.566"
" 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     0.566 c.m/sec"
" 40           HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"               Maximum flow                  0.657    c.m/sec"
"               Hydrograph volume          7124.158    c.m"
"                       0.152     0.152     0.092     0.657"
" 38           START/RE-START TOTALS 602"
"              3   Runoff Totals on EXIT"
"               Total Catchment area                      28.288    hectare"
"               Total Impervious area                     14.206    hectare"
"               Total % impervious                        50.218"
```

```
" 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\MIDUSS"
"                Output filename:                          1279dHazel20241011.out"
"                Licensee name:                                 Arianna Franklin"
"                Company                                  Meritech Engineering"
"                Date & Time last used:               2024-10-11 at 11:32:09 AM"
" 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"
"             74   C:\M\Meritech Engineering\PRJ - DOCS\1279\60-
Design\SWM\MIDUSS\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"
               Roof area to infiltration. Overflow to pond."
" 33           CATCHMENT 705"
"              2   Rectangular"
"              1   Equal length"
"              1   SCS method"
"            705   Northwest corner - roofs"
"       100.000   % Impervious"
"         1.908   Total Area"
"         5.000   Flow length"
"         5.000   Overland Slope"
"         0.000   Pervious Area"
"         5.000   Pervious length"
"         3.000   Pervious slope"
"         1.908   Impervious Area"
"         5.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.000   Pervious Runoff coefficient"
"         0.100   Pervious Ia/S coefficient"
"         8.924   Pervious Initial abstraction"
"         0.015   Impervious Manning 'n'"
"       100.000   Impervious SCS Curve No."
"         1.000   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.000   Impervious Initial abstraction"
"                      0.281     0.000     0.000     0.000 c.m/sec"
               Catchment 705          Pervious   Impervious Total Area "
               Surface Area           0.000      1.908      1.908      hectare"
               Time of concentration  4.836      0.864      0.864      minutes"
```

```
"             Time to Centroid       2487.814   2228.384   2228.385   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        0.01       5437.79    5437.80    c.m"
"             Rainfall losses        76.366     0.000      0.000      mm"
"             Runoff depth           208.634    285.000    285.000    mm"
"             Runoff volume          0.00       5437.80    5437.80    c.m"
"             Runoff coefficient     0.000      1.000      1.000      "
"             Maximum flow           0.000      0.281      0.281      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"           4   Add Runoff "
"                    0.281     0.281     0.000     0.000"
" 56          DIVERSION"
"         705   Node number"
"       0.570   Overflow threshold"
"       1.000   Required diverted fraction"
"           0   Conduit type; 1=Pipe;2=Channel"
"             Peak of diverted flow         0.000    c.m/sec"
"             Volume of diverted flow       0.000    c.m"
"             DIV00705.Hazelhyd"
"             Major flow at 705"
"                    0.281     0.281     0.281     0.000 c.m/sec"
" 40          HYDROGRAPH   Combine    705"
"           6   Combine "
"         705   Node #"
"               CWC Overflow"
"             Maximum flow                  0.281    c.m/sec"
"             Hydrograph volume          5437.804    c.m"
"                    0.281     0.281     0.281     0.281"
" 81          ADD COMMENT=============================================="
"         1  Lines of comment"
"             Park/pond area to infiltration. Overflow to pond."
" 40          HYDROGRAPH Start - New Tributary"
"           2   Start - New Tributary"
"                    0.281     0.000     0.281     0.281"
" 33          CATCHMENT 702"
"           1   Triangular SCS"
"           1   Equal length"
"           1   SCS method"
"         702   Rear half of school site"
"      30.000   % Impervious"
"       0.920   Total Area"
"      30.000   Flow length"
"       3.000   Overland Slope"
"       0.644   Pervious Area"
"      30.000   Pervious length"
"       3.000   Pervious slope"
"       0.276   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"
```

```
"                    0.130     0.000     0.281     0.281 c.m/sec"
"             Catchment 702          Pervious   Impervious Total Area "
"             Surface Area           0.644      0.276      0.920      hectare"
"             Time of concentration  14.171     2.532      9.967      minutes"
"             Time to Centroid       2505.410   2267.787   2419.592   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        1835.40    786.60     2622.00    c.m"
"             Rainfall losses        76.853     10.427     56.925     mm"
"             Runoff depth           208.147    274.573    228.075    mm"
"             Runoff volume          1340.47    757.82     2098.29    c.m"
"             Runoff coefficient     0.730      0.963      0.800      "
"             Maximum flow           0.089      0.041      0.130      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.130     0.130     0.281     0.281"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
"        1.361   Total Area"
"       80.000   Flow length"
"        3.000   Overland Slope"
"        1.225   Pervious Area"
"       80.000   Pervious length"
"        3.000   Pervious slope"
"        0.136   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"
"                    0.194     0.130     0.281     0.281 c.m/sec"
"             Catchment 703          Pervious   Impervious Total Area "
"             Surface Area           1.225      0.136      1.361      hectare"
"             Time of concentration  25.525     4.562      22.819     minutes"
"             Time to Centroid       2521.582   2271.847   2489.347   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        3490.97    387.88     3878.85    c.m"
"             Rainfall losses        76.640     7.070      69.683     mm"
"             Runoff depth           208.360    277.930    215.317    mm"
"             Runoff volume          2552.20    378.26     2930.47    c.m"
"             Runoff coefficient     0.731      0.975      0.755      "
"             Maximum flow           0.174      0.020      0.194      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                    0.194     0.320     0.281     0.281"
" 57          TRENCH Design d/s of 703"
"        0.320   Peak inflow"
"     5028.755   Hydrograph volume"
"      356.000   Ground elevation"
```

```
"       354.000   Downstream trench invert"
"         1.200   Trench height"
"       352.300   Water table elevation"
"         1.000   Trench top width"
"         1.000   Trench bottom width"
"        40.000   Voids ratio (%)"
"        86.000   Hydraulic conductivity"
"         0.000   Trench gradient (%)"
"        65.000   Trench length"
"         0.000   Include base width"
"           11.   Number of stages"
"                   Level Discharge    Volume"
"                 354.000     0.000       0.0"
"                 354.200     0.000       5.2"
"                 354.400     0.000      10.4"
"                 354.600     0.000      15.6"
"                 354.800     0.000      20.8"
"                 355.000     0.007      26.0"
"                 355.200     0.061      31.2"
"                 355.400     0.199      31.4"
"                 355.600     0.281      31.7"
"                 355.800     0.344      31.9"
"                 356.000     0.397      32.1"
"            1.   ORIFICES"
"                 Orifice   Orifice   Orifice"
"                  invert coefficie  diameter"
"                 354.900     0.630     0.450"
"            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                  0.314    c.m/sec"
"              Outflow volume             4396.686    c.m"
"              Peak exfiltration             0.006    c.m/sec"
"              Exfiltration volume         632.491    c.m"
"              Maximum level               355.707    metre"
"              Maximum storage              31.773    c.m"
"              Centroidal lag               42.854   hours"
"              Infiltration area 2 sides   156.000   sq.metre"
"              Infiltration Base area         .000   sq.metre"
"                   0.194     0.320     0.314     0.006 c.m/sec"
" 40           HYDROGRAPH   Combine    705"
"             6   Combine "
"           705   Node #"
"                 CWC Overflow"
"              Maximum flow                  0.595    c.m/sec"
"              Hydrograph volume          9834.487    c.m"
"                      0.194     0.320     0.314     0.595"
" 40           HYDROGRAPH   Confluence    705"
"             7   Confluence "
"           705   Node #"
"                 CWC Overflow"
"              Maximum flow                  0.595    c.m/sec"
```

```
"             Hydrograph volume          9834.486    c.m"
"                     0.194     0.595     0.314     0.000"
" 33          CATCHMENT 701"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          701   Northwest corner - lots"
"       45.000   % Impervious"
"        5.159   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        2.837   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        2.322   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"
"                     0.730     0.595     0.314     0.000 c.m/sec"
"             Catchment 701          Pervious   Impervious Total Area "
"             Surface Area           2.837      2.322      5.159      hectare"
"             Time of concentration  9.349      1.671      5.351      minutes"
"             Time to Centroid       2498.142   2270.256   2379.469   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        0.8087     0.6616     1.4703     ha-m"
"             Rainfall losses        77.420     9.312      46.772     mm"
"             Runoff depth           207.580    275.688    238.228    mm"
"             Runoff volume          0.5890     0.6400     1.2290     ha-m"
"             Runoff coefficient     0.728      0.967      0.836      "
"             Maximum flow           0.392      0.339      0.730      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.730     1.310     0.314     0.000"
" 33          CATCHMENT 704"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          704   SWM block"
"       60.000   % Impervious"
"        1.054   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        0.422   Pervious Area"
"       15.000   Pervious length"
"       20.000   Pervious slope"
"        0.632   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"
"                      0.148     1.310     0.314     0.000 c.m/sec"
"              Catchment 704          Pervious   Impervious Total Area "
"              Surface Area           0.422      0.632      1.054      hectare"
"              Time of concentration  5.292      2.860      3.673      minutes"
"              Time to Centroid       2492.837   2265.586   2341.595   minutes"
"              Rainfall depth         285.000    285.000    285.000    mm"
"              Rainfall volume        1201.56    1802.34    3003.90    c.m"
"              Rainfall losses        77.602     9.886      36.972     mm"
"              Runoff depth           207.398    275.114    248.028    mm"
"              Runoff volume          874.39     1739.82    2614.21    c.m"
"              Runoff coefficient     0.728      0.965      0.870      "
"              Maximum flow           0.057      0.095      0.148      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.148     1.458     0.314     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     1.458     0.314     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     1.577     0.314     0.000"
" 54           POND DESIGN"
"         1.577   Current peak flow    c.m/sec"
"         0.654   Target outflow    c.m/sec"
"       26850.7   Hydrograph volume    c.m"
"           14.   Number of stages"
"       354.900   Minimum water level    metre"
"       356.200   Maximum water level    metre"
"       354.900   Starting water level    metre"
"             0   Keep Design Data: 1 = True; 0 = False"
"                   Level Discharge    Volume"
"                 354.900     0.000     0.000"
"                 355.000   0.00300   414.000"
"                 355.100   0.00900   895.000"
"                 355.200   0.01300  1409.000"
"                 355.300    0.1020  1942.000"
"                 355.400    0.1070  2492.000"
"                 355.500    0.3060  3060.000"
"                 355.600    0.3180  3646.000"
"                 355.700    0.3300  4249.000"
"                 355.800    0.3410  4869.000"
"                 355.900     1.002  5507.000"
"                 356.000     1.032  6193.000"
"                 356.100     1.060  6929.000"
"                 356.200     1.089  7687.000"
"              Peak outflow                  1.070    c.m/sec"
"              Maximum level               356.135    metre"
"              Maximum storage            7196.945    c.m"
"              Centroidal lag               44.436   hours"
"                   0.121     1.577     1.070     0.000 c.m/sec"
" 40           HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"              Maximum flow                  1.070    c.m/sec"
"              Hydrograph volume         26648.547    c.m"
"                      0.121     1.577     1.070     1.070"
" 81           ADD COMMENT================================================="
"           2  Lines of comment"
"              501 to the existing subdivision to the "
"              northeast"
" 40           HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                      0.121     0.000     1.070     1.070"
" 33           CATCHMENT 501"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           501   Northeast corner of subdivision"
"        60.000   % Impervious"
"         0.356   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.142   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
```

```
"         0.214   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"
"                     0.051     0.000     1.070     1.070 c.m/sec"
"              Catchment 501          Pervious   Impervious Total Area "
"              Surface Area           0.142      0.214      0.356      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        405.84     608.76     1014.60    c.m"
"              Rainfall losses        77.420     9.312      36.555     mm"
"              Runoff depth           207.580    275.688    248.445    mm"
"              Runoff volume          295.59     588.87     884.46     c.m"
"              Runoff coefficient     0.728      0.967      0.872      "
"              Maximum flow           0.020      0.031      0.051      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.051     0.051     1.070     1.070"
" 40           HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                     0.051     0.051     0.051     1.070"
" 40           HYDROGRAPH   Combine    501"
"            6   Combine "
"          501   Node #"
"                To N and NE"
"              Maximum flow                  0.051    c.m/sec"
"              Hydrograph volume           884.463    c.m"
"                     0.051     0.051     0.051     0.051"
" 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"
"                     0.051     0.000     0.051     0.051"
" 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     0.051     0.051 c.m/sec"
"              Catchment 601          Pervious   Impervious Total Area "
"              Surface Area           3.500      0.000      3.500      hectare"
"              Time of concentration  28.728     4.896      28.728     minutes"
"              Time to Centroid       2593.972   2272.633   2593.972   minutes"
"              Rainfall depth         285.000    285.000    285.000    mm"
"              Rainfall volume        9974.99    0.01       9975.00    c.m"
"              Rainfall losses        117.587    6.694      117.587    mm"
"              Runoff depth           167.413    278.306    167.413    mm"
"              Runoff volume          5859.45    0.01       5859.46    c.m"
"              Runoff coefficient     0.587      0.000      0.587      "
"              Maximum flow           0.436      0.000      0.436      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.436     0.436     0.051     0.051"
" 33           CATCHMENT 502"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           502   Front half of school site"
"        50.000   % Impervious"
"         2.299   Total Area"
"        30.000   Flow length"
"         3.000   Overland Slope"
"         1.150   Pervious Area"
"        30.000   Pervious length"
"         3.000   Pervious slope"
"         1.150   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"
"                      0.328     0.436     0.051     0.051 c.m/sec"
"              Catchment 502          Pervious   Impervious Total Area "
"              Surface Area           1.150      1.150      2.299      hectare"
"              Time of concentration  14.171     2.532      7.551      minutes"
"              Time to Centroid       2505.411   2267.787   2370.250   minutes"
"              Rainfall depth         285.000    285.000    285.000    mm"
```

```
"             Rainfall volume        3276.07    3276.07    6552.15    c.m"
"             Rainfall losses        76.853     10.427     43.640     mm"
"             Runoff depth           208.147    274.573    241.360    mm"
"             Runoff volume          2392.65    3156.22    5548.87    c.m"
"             Runoff coefficient     0.730      0.963      0.847      "
"             Maximum flow           0.160      0.172      0.328      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.328     0.757     0.051     0.051"
" 33          CATCHMENT 503"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          503   East part of site incl townhouses"
"       70.000   % Impervious"
"        9.130   Total Area"
"       15.000   Flow length"
"        3.000   Overland Slope"
"        2.739   Pervious Area"
"       15.000   Pervious length"
"        3.000   Pervious slope"
"        6.391   Impervious Area"
"       15.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.728   Pervious Runoff coefficient"
"        0.100   Pervious Ia/S coefficient"
"        8.924   Pervious Initial abstraction"
"        0.015   Impervious Manning 'n'"
"       98.000   Impervious SCS Curve No."
"        0.967   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     1.311     0.757     0.051     0.051 c.m/sec"
"             Catchment 503          Pervious   Impervious Total Area "
"             Surface Area           2.739      6.391      9.130      hectare"
"             Time of concentration  9.349      1.671      3.544      minutes"
"             Time to Centroid       2498.142   2270.257   2325.852   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        0.7806     1.8214     2.6021     ha-m"
"             Rainfall losses        77.420     9.312      29.745     mm"
"             Runoff depth           207.580    275.688    255.255    mm"
"             Runoff volume          0.5686     1.7619     2.3305     ha-m"
"             Runoff coefficient     0.728      0.967      0.896      "
"             Maximum flow           0.378      0.933      1.311      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     1.311     2.055     0.051     0.051"
" 40          HYDROGRAPH Copy to Outflow"
"            8   Copy to Outflow"
"                     1.311     2.055     2.055     0.051"
" 40          HYDROGRAPH   Combine    503"
"            6   Combine "
"          503   Node #"
"                SWM facility south of Conservation Dr"
"             Maximum flow                  2.055    c.m/sec"
"             Hydrograph volume         34713.145    c.m"
"                     1.311     2.055     2.055     2.055"
```

```
" 81          ADD COMMENT================================================="
"           3  Lines of comment"
"              Minor flows (2yr and less) from catchment 504 "
"              (townhouses at SW corner) (85m3) are to infiltration, "
"              remainder to Beaver Creek "
" 40          HYDROGRAPH Start - New Tributary"
"             2   Start - New Tributary"
"                      1.311     0.000     2.055     2.055"
" 33          CATCHMENT 504"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           504   Townhouse area at SW corner"
"        25.000   % Impervious"
"         0.453   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.340   Pervious Area"
"        15.000   Pervious length"
"         3.000   Pervious slope"
"         0.113   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"
"                      0.063     0.000     2.055     2.055 c.m/sec"
"              Catchment 504          Pervious   Impervious Total Area "
"              Surface Area           0.340      0.113      0.453      hectare"
"              Time of concentration  9.349      1.671      6.993      minutes"
"              Time to Centroid       2498.142   2270.256   2428.214   minutes"
"              Rainfall depth         285.000    285.000    285.000    mm"
"              Rainfall volume        968.29     322.76     1291.05    c.m"
"              Rainfall losses        77.421     9.312      60.393     mm"
"              Runoff depth           207.579    275.688    224.607    mm"
"              Runoff volume          705.25     312.22     1017.47    c.m"
"              Runoff coefficient     0.728      0.967      0.788      "
"              Maximum flow           0.047      0.017      0.063      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.063     0.063     2.055     2.055"
" 54          POND DESIGN"
"         0.063   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"        1017.5   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    85.000"
"                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                  0.062    c.m/sec"
"             Maximum level               101.010    metre"
"             Maximum storage              93.801    c.m"
"             Centroidal lag               42.974   hours"
"                  0.063     0.063     0.062     2.055 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"           6   Combine "
"         704   Node #"
"               Flows to Beaver Creek"
"             Maximum flow                  1.118    c.m/sec"
"             Hydrograph volume         27583.557    c.m"
"                     0.063     0.063     0.062     1.118"
" 81          ADD COMMENT=============================================="
"           3  Lines of comment"
"             Minor flows (2yr and less) from catchment 505 "
"             (North Property Line) (196m3) are to infiltration, "
"             remainder to wetland finger to Beaver Creek "
" 40          HYDROGRAPH Start - New Tributary"
"           2   Start - New Tributary"
"                     0.063     0.000     0.062     1.118"
" 33          CATCHMENT 505"
"           1   Triangular SCS"
"           1   Equal length"
"           1   SCS method"
"         505   Rear yards of lots at NW corner"
"      35.000   % Impervious"
"       0.898   Total Area"
"      15.000   Flow length"
"       3.000   Overland Slope"
"       0.584   Pervious Area"
"      15.000   Pervious length"
"       3.000   Pervious slope"
"       0.314   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"
"                     0.126     0.000     0.062     1.118 c.m/sec"
"             Catchment 505          Pervious   Impervious Total Area "
"             Surface Area           0.584      0.314      0.898      hectare"
"             Time of concentration  9.349      1.671      6.148      minutes"
"             Time to Centroid       2498.143   2270.256   2403.124   minutes"
"             Rainfall depth         285.000    285.000    285.000    mm"
"             Rainfall volume        1663.55    895.76     2559.30    c.m"
"             Rainfall losses        77.421     9.312      53.583     mm"
```

```
"             Runoff depth           207.579    275.688    231.417    mm"
"             Runoff volume          1211.64    866.49     2078.13    c.m"
"             Runoff coefficient     0.728      0.967      0.812      "
"             Maximum flow           0.081      0.046      0.126      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.126     0.126     0.062     1.118"
" 54          POND DESIGN"
"         0.126   Current peak flow    c.m/sec"
"         1.000   Target outflow    c.m/sec"
"        2078.1   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   196.000"
"                 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                  0.125    c.m/sec"
"             Maximum level               101.019    metre"
"             Maximum storage             211.496    c.m"
"             Centroidal lag               42.836   hours"
"                  0.126     0.126     0.125     1.118 c.m/sec"
" 40          HYDROGRAPH   Combine    704"
"            6   Combine "
"          704   Node #"
"                Flows to Beaver Creek"
"             Maximum flow                  1.240    c.m/sec"
"             Hydrograph volume         29468.129    c.m"
"                     0.126     0.126     0.125     1.240"
" 81          ADD COMMENT================================================="
"          1  Lines of comment"
"             Uncontrolled Brohman Lands "
" 40          HYDROGRAPH Start - New Tributary"
"            2   Start - New Tributary"
"                     0.126     0.000     0.125     1.240"
" 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     0.125     1.240 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     0.125     1.240"
" 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     1.240 c.m/sec"
" 40           HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"              Maximum flow                 1.297    c.m/sec"
"              Hydrograph volume        30347.453    c.m"
"                     0.057     0.057     0.057     1.297"
" 38           START/RE-START TOTALS 602"
"              3   Runoff Totals on EXIT"
"              Total Catchment area                    28.288    hectare"
"              Total Impervious area                   14.206    hectare"
"              Total % impervious                      50.218"
" 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\MIDUSS"
"                Output filename:                 c1279ExtDetention20241011.out"
"                Licensee name:                               Arianna Franklin"
"                Company                                    Meritech Engineering"
"                Date & Time last used:                2024-10-11 at 2:35:30 PM"
" 81           ADD COMMENT================================================="
"            2  Lines of comment"
"               SWM Analysis of 3 hr extended detention 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"
"       500.000   Coefficient A"
"         9.258   Constant B"
"         0.882   Exponent C"
"         0.400   Fraction R"
"       180.000   Duration"
"         1.000   Time step multiplier"
"               Maximum intensity            47.983    mm/hr"
"               Total depth                  14.714    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 702"
"              1   Triangular SCS"
"              1   Equal length"
"              1   SCS method"
"            702   Rear half of school site"
"        30.000   % Impervious"
"         0.920   Total Area"
"        30.000   Flow length"
"         3.000   Overland Slope"
"         0.644   Pervious Area"
"        30.000   Pervious length"
"         3.000   Pervious slope"
"         0.276   Impervious Area"
"        30.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.024   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."
"         0.693   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.021     0.000     0.000     0.000 c.m/sec"
"               Catchment 702          Pervious   Impervious Total Area "
```

```
"             Surface Area           0.644      0.276      0.920      hectare"
"             Time of concentration  92.778     2.928      9.633      minutes"
"             Time to Centroid       207.942    93.161     101.727    minutes"
"             Rainfall depth         14.714     14.714     14.714     mm"
"             Rainfall volume        94.76      40.61      135.37     c.m"
"             Rainfall losses        14.361     4.510      11.406     mm"
"             Runoff depth           0.353      10.204     3.308      mm"
"             Runoff volume          2.27       28.16      30.43      c.m"
"             Runoff coefficient     0.024      0.693      0.225      "
"             Maximum flow           0.000      0.021      0.021      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.021     0.021     0.000     0.000"
" 33          CATCHMENT 703"
"            1   Triangular SCS"
"            1   Equal length"
"            1   SCS method"
"          703   Park block"
"       10.000   % Impervious"
"        1.361   Total Area"
"       80.000   Flow length"
"        3.000   Overland Slope"
"        1.225   Pervious Area"
"       80.000   Pervious length"
"        3.000   Pervious slope"
"        0.136   Impervious Area"
"       80.000   Impervious length"
"        3.000   Impervious slope"
"        0.250   Pervious Manning 'n'"
"       74.000   Pervious SCS Curve No."
"        0.024   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."
"        0.702   Impervious Runoff coefficient"
"        0.100   Impervious Ia/S coefficient"
"        0.518   Impervious Initial abstraction"
"                     0.011     0.021     0.000     0.000 c.m/sec"
"             Catchment 703          Pervious   Impervious Total Area "
"             Surface Area           1.225      0.136      1.361      hectare"
"             Time of concentration  167.118    5.274      43.316     minutes"
"             Time to Centroid       280.614    96.483     139.764    minutes"
"             Rainfall depth         14.714     14.714     14.714     mm"
"             Rainfall volume        180.23     20.03      200.26     c.m"
"             Rainfall losses        14.361     4.383      13.363     mm"
"             Runoff depth           0.353      10.331     1.351      mm"
"             Runoff volume          4.32       14.06      18.38      c.m"
"             Runoff coefficient     0.024      0.702      0.092      "
"             Maximum flow           0.000      0.011      0.011      c.m/sec"
" 40          HYDROGRAPH Add Runoff "
"            4   Add Runoff "
"                     0.011     0.031     0.000     0.000"
" 57          TRENCH Design d/s of 703"
"        0.031   Peak inflow"
"       48.815   Hydrograph volume"
"      356.000   Ground elevation"
"      354.000   Downstream trench invert"
"        1.200   Trench height"
```

```
"       352.300   Water table elevation"
"         1.000   Trench top width"
"         1.000   Trench bottom width"
"        40.000   Voids ratio (%)"
"        86.000   Hydraulic conductivity"
"         0.000   Trench gradient (%)"
"        65.000   Trench length"
"         1.000   Include base width"
"           11.   Number of stages"
"                   Level Discharge    Volume"
"                 354.000     0.000       0.0"
"                 354.200     0.000       5.2"
"                 354.400     0.000      10.4"
"                 354.600     0.000      15.6"
"                 354.800     0.000      20.8"
"                 355.000     0.006      26.0"
"                 355.200     0.062      31.2"
"                 355.400     0.108      31.4"
"                 355.600     0.140      31.7"
"                 355.800     0.165      31.9"
"                 356.000     0.187      32.1"
"             1.   ORIFICES"
"                  Orifice   Orifice   Orifice"
"                   invert coefficie  diameter"
"                 354.900     0.630     0.300"
"             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                  0.002    c.m/sec"
"               Outflow volume                2.346    c.m"
"               Peak exfiltration             0.005    c.m/sec"
"               Exfiltration volume          46.488    c.m"
"               Maximum level               354.872    metre"
"               Maximum storage              22.675    c.m"
"               Centroidal lag                1.628   hours"
"               Infiltration area 2 sides   113.373   sq.metre"
"               Infiltration Base area       65.000   sq.metre"
"                    0.011     0.031     0.002     0.005 c.m/sec"
" 40            HYDROGRAPH Next link "
"              5   Next link "
"                       0.011     0.002     0.002     0.005"
" 33            CATCHMENT 701"
"              1   Triangular SCS"
"              1   Equal length"
"              1   SCS method"
"            701   Northwest corner - lots"
"         45.000   % Impervious"
"          5.159   Total Area"
"         15.000   Flow length"
"          3.000   Overland Slope"
"          2.837   Pervious Area"
"         15.000   Pervious length"
```

```
"         3.000   Pervious slope"
"         2.322   Impervious Area"
"        15.000   Impervious length"
"         3.000   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.024   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."
"         0.698   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.187     0.002     0.002     0.005 c.m/sec"
"              Catchment 701          Pervious   Impervious Total Area "
"              Surface Area           2.837      2.322      5.159      hectare"
"              Time of concentration  61.210     1.932      4.321      minutes"
"              Time to Centroid       177.083    91.627     95.071     minutes"
"              Rainfall depth         14.714     14.714     14.714     mm"
"              Rainfall volume        417.50     341.59     759.09     c.m"
"              Rainfall losses        14.361     4.450      9.901      mm"
"              Runoff depth           0.353      10.264     4.813      mm"
"              Runoff volume          10.01      238.28     248.28     c.m"
"              Runoff coefficient     0.024      0.698      0.327      "
"              Maximum flow           0.001      0.187      0.187      c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.187     0.187     0.002     0.005"
" 33           CATCHMENT 704"
"             1   Triangular SCS"
"             1   Equal length"
"             1   SCS method"
"           704   SWM block"
"        60.000   % Impervious"
"         1.054   Total Area"
"        15.000   Flow length"
"         3.000   Overland Slope"
"         0.422   Pervious Area"
"        15.000   Pervious length"
"        20.000   Pervious slope"
"         0.632   Impervious Area"
"        15.000   Impervious length"
"         0.500   Impervious slope"
"         0.250   Pervious Manning 'n'"
"        74.000   Pervious SCS Curve No."
"         0.024   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."
"         0.694   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.049     0.187     0.002     0.005 c.m/sec"
"              Catchment 704          Pervious   Impervious Total Area "
"              Surface Area           0.422      0.632      1.054      hectare"
"              Time of concentration  34.646     3.307      4.012      minutes"
"              Time to Centroid       151.112    93.766     95.056     minutes"
```

```
"              Rainfall depth          14.714      14.714      14.714      mm"
"              Rainfall volume         62.03       93.05       155.09      c.m"
"              Rainfall losses         14.361      4.507       8.449       mm"
"              Runoff depth            0.352       10.207      6.265       mm"
"              Runoff volume           1.49        64.55       66.03       c.m"
"              Runoff coefficient      0.024       0.694       0.426       "
"              Maximum flow            0.000       0.049       0.049       c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.049     0.230     0.002     0.005"
" 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."
"         0.024   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."
"         0.698   Impervious Runoff coefficient"
"         0.100   Impervious Ia/S coefficient"
"         0.518   Impervious Initial abstraction"
"                      0.041     0.230     0.002     0.005 c.m/sec"
"              Catchment 801           Pervious   Impervious Total Area "
"              Surface Area            0.340       0.510       0.850       hectare"
"              Time of concentration   61.210      1.932       3.259       minutes"
"              Time to Centroid        177.083     91.627      93.541      minutes"
"              Rainfall depth          14.714      14.714      14.714      mm"
"              Rainfall volume         50.03       75.04       125.07      c.m"
"              Rainfall losses         14.361      4.450       8.415       mm"
"              Runoff depth            0.353       10.264      6.299       mm"
"              Runoff volume           1.20        52.35       53.54       c.m"
"              Runoff coefficient      0.024       0.698       0.428       "
"              Maximum flow            0.000       0.041       0.041       c.m/sec"
" 40           HYDROGRAPH Add Runoff "
"             4   Add Runoff "
"                      0.041     0.271     0.002     0.005"
" 54           POND DESIGN"
"         0.271   Current peak flow    c.m/sec"
"         0.654   Target outflow    c.m/sec"
"         370.2   Hydrograph volume    c.m"
"           14.   Number of stages"
"       354.900   Minimum water level    metre"
"       356.200   Maximum water level    metre"
"       354.900   Starting water level    metre"
"             0   Keep Design Data: 1 = True; 0 = False"
```

```
"                  Level Discharge    Volume"
"                354.900     0.000     0.000"
"                355.000   0.00307   414.000"
"                355.100   0.00944   895.000"
"                355.200   0.01263  1409.000"
"                355.300   0.01516  1942.000"
"                355.400   0.01732  2492.000"
"                355.500   0.01925  3060.000"
"                355.600   0.02099  3646.000"
"                355.700   0.02261  4249.000"
"                355.800   0.02411  4869.000"
"                355.900   0.02553  5507.000"
"                356.000   0.02687  6193.000"
"                356.100   0.02815  6929.000"
"                356.200   0.02937  7687.000"
"            1.   ORIFICES"
"                 Orifice   Orifice   Orifice Number of"
"                  invert coefficie  diameter  orifices"
"                354.900     0.630    0.1100     1.000"
"              Peak outflow                  0.003    c.m/sec"
"              Maximum level               354.985    metre"
"              Maximum storage             349.933    c.m"
"              Centroidal lag               33.827   hours"
"                   0.041     0.271     0.003     0.005 c.m/sec"
" 40           HYDROGRAPH   Combine    704"
"             6   Combine "
"           704   Node #"
"                 Flows to Beaver Creek"
"              Maximum flow                  0.003    c.m/sec"
"              Hydrograph volume           354.482    c.m"
"                     0.041     0.271     0.003     0.003"
" 38           START/RE-START TOTALS 801"
"             3   Runoff Totals on EXIT"
"              Total Catchment area                     9.344    hectare"
"              Total Impervious area                    3.876    hectare"
"              Total % impervious                      41.482"
" 19           EXIT"
```

Appendix E: Correspondence

Coordination with Stantec

City of Waterloo Pond Access Road Requirements Email

Pre-consultation comments

Stefan VanHartingsveldt

From: Darren Scott <Darren.Scott@waterloo.ca>
Sent: August 13, 2024 9:46 AM
To: Stefan VanHartingsveldt
Cc: Ian S. Robertson; Alexander Orakwue; Christopher Togeretz; Michael Stewart
Subject: RE: Conservation Drive SWM Pond Question JQ1279

Caution! This message was sent from outside your organization. Allow sender | Block sender

Hi Stefan,

Please see answers below.

Regards,

Darren Scott, P.Eng.
Manager, Development Engineering
Engineering Services, Integrated Planning & Public Works
100 Regina St. S.
PO Box 337, Station Waterloo
Waterloo ON N2J 4A8
P: 519-747-8545 **TTY:** 1-866-786-3941
E: darren.scott@waterloo.ca | www.waterloo.ca

From: Stefan VanHartingsveldt <stefanv@meritech.ca>
Sent: Wednesday, July 31, 2024 11:38 AM
To: Darren Scott <Darren.Scott@waterloo.ca>
Cc: Ian S. Robertson <ianr@meritech.ca>; Alexander Orakwue <AlexanderO@meritech.ca>; Christopher Togeretz <christophert@meritech.ca>; Michael Stewart <Michael.Stewart@waterloo.ca>
Subject: [EXTERNAL] RE: Conservation Drive SWM Pond Question JQ1279

Good morning Darren,

Following up on the previous email, I just wanted to confirm some of these items as I get everything nailed down and can't seem to find where the text you provided is from. I've attached a screenshot of the manual which I will reference in the questions.

- The new CoW engineering manual indicates that the maintenance access route is to run around the entire perimeter of the storm pond. This is new and hasn't been required up to this point and will affect the draft plan. Is this going to be required of us now as per the new manual? This will not be a requirement of this pond. The maintenance access route does not need to run around the entire perimeter of the pond.

- You indicated that the maintenance access road could be 3.0m wide. The previous design manual had a detail (W-221) specifying that pond accesses should be 4.0m wide. Can we reduce ours to 3.0m now? We will keep the access road requirement at 4m.
- The new CoW engineering manual does not specify that the pond access road is supposed to go to the bottom of the forebay, but just to the permanent pool elevation. I just wanted to verify that this is required as it changes the size/shape of the forebay. Pond access road to the permanent pool elevation is acceptable.

Thanks for your time. Hopefully we can get this wrapped up and make sure it meets all expectations.

Sincerely,

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

MERITECH 20 Years ENGINEERING

Meritech Engineering
1315 Bishop Street North, Suite 202
Cambridge ON N1R 6Z2

t 519.623.1140 x218
f 519.623.7334
www.meritech.ca

CAUTION: This message is intended only for the use of the individual or entity to which it is addressed and may contain information that is privileged, confidential and exempt from disclosure under applicable law. If the reader of this message is not the intended recipient or the employee or agent responsible for delivering the message to the intended recipient, you are hereby notified that any dissemination, distribution or copying of this communication is strictly prohibited. If you have received this communication in error, please notify the sender by return e-mail.

From: Darren Scott <Darren.Scott@waterloo.ca>
Sent: Thursday, July 11, 2024 1:44 PM
To: Stefan VanHartingsveldt <stefanv@meritech.ca>
Cc: Ian S. Robertson <ianr@meritech.ca>; Alexander Orakwue <AlexanderO@meritech.ca>; Christopher Togeretz <christophert@meritech.ca>; Michael Stewart <Michael.Stewart@waterloo.ca>
Subject: RE: Conservation Drive SWM Pond Question JQ1279

Hi Stefan,

Typically, controlled maintenance access routes shall be provided to both inlet and outlet structures and to the bottom of the forebay. A minimum 3.0m wide surface shall be provided to accommodate maintenance vehicles within a minimum 10 m turning radius (inside radius) and a flat 10m loading area. Maintenance access routes shall not exceed a maximum slope of 10:1. Maintenance access routes that are also use at trail connection should be paved, otherwise should be constructed of an Articulated Concrete Block System, typically Cable Concrete G2.

I hope that helps.

Regards,

Darren Scott, P.Eng.
Manager, Development Engineering
Engineering Services, Integrated Planning & Public Works
100 Regina St. S.
PO Box 337, Station Waterloo
Waterloo ON N2J 4A8
P: 519-747-8545 **TTY:** 1-866-786-3941
E: darren.scott@waterloo.ca | www.waterloo.ca

From: Stefan VanHartingsveldt <stefanv@meritech.ca>
Sent: Wednesday, July 10, 2024 3:12 PM
To: Darren Scott <Darren.Scott@waterloo.ca>
Cc: Ian S. Robertson <ianr@meritech.ca>; Alexander Orakwue <AlexanderO@meritech.ca>; Christopher Togeretz <christophert@meritech.ca>
Subject: [EXTERNAL] Conservation Drive SWM Pond Question JQ1279

Good afternoon Darren,
I've been working to wrap up the SWM pond design to a greater level of detail for our upcoming draft plan submission. I'd like to just be sure of a few things to ensure additional questions and requests don't come up that affect the design.

Up until this point we have been designing the pond access route to provide access to the weir between the forebay and the pond, and to the outlet structure location. Is the access road required to go down the slope into bottom of the wet pond? Is it required to go down into the bottom of the forebay?

Sincerely,

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

Meritech Engineering
1315 Bishop Street North, Suite 202
Cambridge ON N1R 6Z2

t 519.623.1140 x218
f 519.623.7334
www.meritech.ca

CAUTION: This message is intended only for the use of the individual or entity to which it is addressed and may contain information that is privileged, confidential and exempt from disclosure under applicable law. If the reader of this message is not the intended recipient or the employee or agent responsible for delivering the message to the intended recipient, you are hereby notified that any dissemination, distribution or copying of this communication is strictly prohibited. If you have received this communication in error, please notify the sender by return e-mail.

Christopher Togeretz

From: Ian S. Robertson
Sent: July 21, 2023 5:18 PM
To: Paul, Jeff
Cc: Mueller, Al; Karky, Apurba; Alexander Orakwue
Subject: RE: Beavercreek Project JQ1279
Attachments: 1279.ConservationDrRoundabout.20230721.MU.pdf; 1279.SAN (Summary).20230721.pdf; 1279.STM (Summary).20230721.pdf

Categories: Tracked To Dynamics 365

Hi Jeff, I provide the attached docs on Alexander's behalf, I trust that it makes sense and helps to inform your design.

You should find that this is very similar to the info we had previously provided (a few years back) when both our subdivision project and your road project were at an earlier stage of design.

Let us know if you have any questions.

Sincerely,

Ian S. Robertson, P.Eng.

t 519.623.1140 x212

From: Paul, Jeff <jeff.paul@stantec.com>
Sent: Friday, July 21, 2023 9:32 AM
To: Ian S. Robertson <ianr@meritech.ca>
Cc: Mueller, Al <al.mueller@stantec.com>; Karky, Apurba <Apurba.Karky@stantec.com>
Subject: RE: Beavercreek Project JQ1279

Caution! This message was sent from outside your organization. Allow sender | Block sender

Ian,

Can you send this information over to us on Monday. We are currently unable to progress our design and will not likely be able to make it to construction in 2024 if we don't have this information.

Thanks,

Jeff Paul P.Eng.
Managing Senior Principal

Mobile: 519 319-5806
jeff.paul@stantec.com

Stantec
600-171 Queens Avenue
London ON N6A 5J7

From: Ian S. Robertson <ianr@meritech.ca>
Sent: Tuesday, July 11, 2023 2:31 PM
To: Karky, Apurba <Apurba.Karky@stantec.com>
Cc: Mueller, Al <al.mueller@stantec.com>; Paul, Jeff <jeff.paul@stantec.com>
Subject: RE: Beavercreek Project JQ1279

Hi Apurba, my apologies for the delayed response, I had forwarded your earlier request to our PM. I have followed up with our design team asking for them to provide a response to your inquiry ASAP.

Sincerely,

Ian S. Robertson, P.Eng.

t 519.623.1140 x212

From: Karky, Apurba <Apurba.Karky@stantec.com>
Sent: Monday, July 10, 2023 10:10 AM
To: Ian S. Robertson <ianr@meritech.ca>
Cc: Mueller, Al <al.mueller@stantec.com>; Paul, Jeff <jeff.paul@stantec.com>
Subject: RE: Beavercreek Project

Good morning Ian,

I am following up regarding our request from June 21st and 27th to provide us with Storm and Sanitary design sheets information.

We are unable to proceed with our design without this information and the City's project schedule is likely to be impacted.

Please let me know when we can anticipate receiving this information.

Thank you,
Apurba

From: Karky, Apurba
Sent: Tuesday, June 27, 2023 5:21 PM
To: ianr@meritech.ca
Cc: Mueller, Al <al.mueller@stantec.com>
Subject: RE: Beavercreek Project

Good Afternoon Ian,

I am following up from my email dated June 21st, 2023, to see if you had a chance to look at the requested Sanitary and Storm information from your development.

Please let me know when we can expect to receive this information.

Thank you,
Apurba

From: Karky, Apurba
Sent: Wednesday, June 21, 2023 4:12 PM

To: ianr@meritech.ca
Subject: Beavercreek Project

Good Afternoon Ian,

Stantec is finalizing the design for the servicing on Conservation Drive and Beaver Creek Road (Beaver Creek Meadows). As our design will need to facilitate sanitary and storm runoff from your development site, we are requesting the sanitary and storm calculation sheets for confirmation of appropriate sizing of the receiving pipe network.

Thank you,

Apurba Karky, P.Eng
Civil Engineer

apurba.karky@stantec.com

Stantec



The content of this email is the confidential property of Stantec and should not be copied, modified, retransmitted, or used for any purpose except with Stantec's written authorization. If you are not the intended recipient, please delete all copies and notify us immediately.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Sincerely,

Kaitlyn Smith
Resource Planner
Grand River Conservation Authority

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

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

Appendix F: Geotechnical and Hydrogeological Investigation (Excerpts)

HydroG

Geotechnical

Groundwater and Surface Water Monitoring Program, 2021-2022

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

Table of Contents

ABBREVIATIONS I

1.0 INTRODUCTION 1.1

2.0 PHYSICAL SETTING 2.1
2.1 PHYSIOGRAPHY AND TOPOGRAPHY 2.1
2.2 SURFACE WATER BODIES AND WETLANDS 2.1
2.3 REGIONAL GEOLOGY AND HYDROGEOLOGY 2.2
2.4 SOURCE WATER PROTECTION 2.3
2.4.1 Ontario Clean Water Act 2.3
2.4.2 Region of Waterloo Official Plan 2.5

3.0 METHODOLOGY 3.1
3.1 HISTORICAL INVESTIGATIONS 3.1
3.2 BOREHOLE DRILLING 3.1
3.3 MONITORING WELL INSTALLATION AND DEVELOPMENT 3.2
3.4 GROUNDWATER LEVEL MONITORING 3.2
3.5 HYDRAULIC RESPONSE TESTING 3.3
3.6 INFILTRATION TESTING 3.3
3.6.1 Site 3.3
3.6.2 Proposed SWM Facility Infiltration Basin 3.4

4.0 LOCAL GEOLOGY AND HYDROGEOLOGY 4.1
4.1 GEOLOGY AND HYDROSTRATIGRAPHY 4.1
4.2 HYDROGEOLOGY 4.1
4.2.1 Groundwater Levels 4.1
4.2.2 Groundwater Flow 4.2
4.2.3 Infiltration Potential 4.3
4.2.3.1 Site 4.3
4.2.3.2 Proposed SWM Facility Infiltration Basin 4.4

5.0 RECHARGE TO GROUNDWATER STRATEGY 5.1
5.1 WATER BALANCE 5.2
5.2 SOURCE WATER PROTECTION 5.3

6.0 PROPOSED GROUNDWATER MONITORING 6.1

7.0 CONCLUSIONS 7.1

8.0 REFERENCES 8.1

LIST OF APPENDICES

APPENDIX A: AGENCY CORRESPONDENCE

APPENDIX B: FIGURES
Figure 1 – Site Plan
Figure 2 – Physiography and Topography
Figure 3 – Surficial Geology
Figure 4 – Source Water Protection – Wellhead Protection Areas
Figure 5 – Source Water Protection – Significant Groundwater Recharge Area
Figure 6 – Wellhead Protection Sensitivity Areas
Figure 7 – Hydrographs – MW1-19 to MW6-19
Figure 8 – Hydrographs – MW2-10, MW3-10(S)/-16(S), MW6-10, and MW7-10
Figure 9 – Cross-Section A-A'
Figure 10 – Cross-Section B-B'
Figure 11 – Cross-Section C-C'
Figure 12 – High Groundwater Elevations

APPENDIX C: TABLES
Table 1 – Monitoring Well Construction Details
Table 2 – Groundwater Level Data – Monitoring Wells
Table 3 – Infiltration Testing Results
Table 4 – Design Infiltration Rate Calculation

APPENDIX D: NORTH WATERLOO SCOPED SUBWATERSHED STUDY – GROUNDWATER FLOW MAPPING

APPENDIX E: SOURCE WATER PROTECTION PLAN MAPPING

APPENDIX F: WELLHEAD PROTECTION SENSITIVITY AREA CATEGORIES

APPENDIX G: BOREHOLE LOGS

APPENDIX H: HYDRAULIC CONDUCTIVITY TESTING SOLUTIONS

APPENDIX I: GRAIN SIZE ANALYSIS

APPENDIX J: PHOTOGRAPHS

APPENDIX K: SWM TREATMENT TRAIN APPROACH

APPENDIX L: AMENDED SOILS ASSESSMENT MEMO

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.

8.0 REFERENCES

American Society for Testing and Materials (ASTM) International. 2009. ASTM D2488-09a, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). West

Bajc, A.F. and Shirota, J. 2007. Three--dimensional mapping of surficial deposits in the Regional Municipality of Waterloo, Southwestern Ontario; report in Ontario Geological Survey, Groundwater Resources Study 3, 42p.

Bouwer, H., 1989. The Bouwer and Rice slug test--an update. *Ground Water* 27 (3): 304-309.

Bouwer, H., and Rice, R.C., 1976. A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells. *Water Resources Research* 12 (3): 423-428.

Chapman, L.J. and D.F. Putnam. 1984. The Physiography of Southern Ontario. Ontario Geological Survey Special Volume 2, 270 pp.

Credit Valley Conservation - Toronto and Region Conservation Authority (CVC-TRCA), 2010. Low Impact Development Stormwater Management Planning and Design Guide – Version 1.0.

Duffield, G.M., 2014. AQTESOLV™ for Windows, Version 4.5 Professional. HydroSOLVE Inc., Reston, VA.

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 1. November 2013.

Environment Canada. 2021. Canadian Climate Normals 1981-2010, Waterloo International Airport Climate Station, Climate ID 6144239. [Online] http://climate.weather.gc.ca/climate_normals/index_e.html Accessed December 2021.

Fetter, C.J., 2001. Applied Hydrogeology, Fourth Edition. Upper Saddle River, New Jersey, Prentice-Hall, Inc.

Freeze, R.A. and J.A. Cherry. 1979. Groundwater. Prentice Hall, New Jersey, 604 p.

Karrow, P.F., 1993. Quaternary Geology of the Stratford-Conestogo Area, Southern Ontario. Ontario Geologic Survey Report 283.

Lake Erie Region Source Protection Committee (LESPC), 2021a. Grand River Source Protection Area, Draft Updated Assessment Report. June 17, 2021.

Lake Erie Region Source Protection Committee (LESPC), 2021b. Grand River Source Protection Area, Draft Updated Source Protection Plan. June 17, 2021.

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

Ministry of the Environment (MOE). 1990. Wells. Regulation under the Ontario Water Resources Act. Regulation 903 of the Revised Regulations of Ontario, 1990.

Ontario Geological Survey (OGS). 2010. Surficial geology of southern Ontario; Ontario Geological Survey, Miscellaneous Release -- Data 128-REV, ISBN 978-1-4435-2483-4.

Region of Waterloo. 2015. Regional Official Plan (2031). Approved with modifications by the Ontario Municipal Board on June 18, 2015.

Stantec Consulting Ltd (Stantec). 2021. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program. Prepared for NorthGate Land Corporation, 2115881 Ontario Ltd., Activa Holdings Inc., and Erbsville Kartway. June 2021.

Terraqua Investigations Ltd, 1995. The Study of the Hydrogeology of the Waterloo Moraine. December 1995.

Todd, D.K. 1980. Groundwater Hydrology, 2nd Edition. Wiley, New York, 552 p.

APPENDIX A:
AGENCY CORRESPONDENCE

Grand River Conservation Authority

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

Phone: 519-621-2761 Toll free: 1-866-900-4722 Fax: 519-621-4844 www.grandriver.ca

August 11, 2017

Trevor Hawkins, M.PL, MCIP, RPP
Integrated Planning and Public Works
City of Waterloo
100 Regina Street South
Waterloo, ON
N2J 4A8

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

Dear Mr. Hawkins,

Grand River Conservation Authority (GRCA) staff have completed their review of the following materials, submitted in support of the above noted applications:

- NRSI, ***Environmental Impact Study***, 2115881 Ontario Limited, North Waterloo (July 2016)
- Meritech Engineering, ***Preliminary Stormwater Management Report***, 556 and 576 Conservation Drive, City of Waterloo (July 2016)
- Stantec, ***Phase 1 Groundwater and Surface Water Monitoring Program***, Northgate Corporation, 2115881 Ontario Ltd., Activa Holdings and Erbsville Kartway (May 13, 2016)
- LVM, ***Geotechnical Engineering Report***, 2115881 Ontario Limited, Proposed Residential Development, 560-576 Conservation Drive, Waterloo, Ontario (March 23, 2015)

Based on the comments provided below, GRCA staff are not in a position to recommend approval of the draft plan (30T-16042) and zone change (Z-16-14) at this time. We look forward to receiving a response and revised materials that address the following comments:

Required Comments to be Addressed:

Planning:

1. We note that a portion of the stormwater for the subject lands will be directed toward an off-site Stormwater Management (SWM) facility, the location and design of which has yet to be determined. Please note that GRCA staff are unable to provide a

comprehensive review and/or support of 30T-16402 and Z-16-14 without this information.

2. Please clarify whether any stormwater from the adjacent "Brohman lands" (620 Conservation Drive) will be directed east toward the subject site. If so, the Preliminary SWM Report will need to address whether the on-site SWM facility can adequately accommodate stormwater from the adjacent property.

3. As noted in our pre-consultation comments dated September 14, 2015, a portion of the Park Block (Block 480) is proposed within the 30 metre wetland buffer. Park is not the intended use of the buffer area; therefore, this portion should be designated as Open Space instead.

4. Section 5.4 of the Environmental Impact Study (EIS) states that "a formal trail system will be provided outside of buffers and natural areas" and GRCA staff are supportive of this approach. However, the location of any proposed trails should be illustrated directly on the Draft Plan to ensure that this recommendation is implemented.

Engineering:

5. GRCA staff agree with the target unit flow rates for discharge to Beaver Creek, as derived in the North Waterloo Scoped Subwatershed Study (NWSSS) using GAWSER modelling of event rainfall from the Guelph Arboretum and 54 years of continuous meteorological data from the Waterloo-Wellington Airport. However, in order to ensure conservative design of major system stormwater conveyance and end-of-pipe storage elements, please use the Regional Municipality of Waterloo 100-year, 3-hour IDF rainfall parameters instead of those applied by the City of Waterloo. The former has 100mm of rainfall while the latter has 90mm. For comparative purposes it is worth noting that the City of Cambridge 2011 Stormwater Management Policies and Guidelines, using AES and Shades Mill meteorological data from 1971-2008, have identified 108mm as the 100-year, 3-hour rainfall depth.

6. Please provide a section view of the proposed stormwater facility discharge controls. In particular, the nature of the 7m wide outlet control weir (as labelled in Figure 4) and its relationship to the extended detention 75mm diameter outlet control orifice is unclear.

7. Please confirm that the stormwater management facility in Block 487 will have side slopes that satisfy Ministry of the Environment (MOE) safety criteria. It would be helpful to document this in Figure 4 of the SWM Report.

Natural Heritage:

8. Section 3.3 of the EIS includes a Grand River Fisheries Management Plan which identifies the objectives for the Laurel Creek fish community as "cold water fish community in areas where geological and biophysical characteristics are present and habitat exists or has been rehabilitated." The EIS acknowledges historical brown

trout spawning in lower reaches of Laurel Creek and the confluence of Beaver Creek. The target for water quality discharging from this proposed development should be for the support of a cold water fish community.

9. Buffer and setback dimensions (EIS Section 4.9) should be identified as minimum dimensions (i.e. not fixed dimensions at this stage in the planning process).

10. EIS Section 5.4.4 should identify a thermal discharge target that will maintain water temperature supportive of the cold water fish community in Beaver Creek and Laurel Creek. Given the close proximity of the site to the confluence of Beaver Creek and Laurel Creek, the instream targets identified in the NWSSS should be used for long term monitoring.

11. Thermal discharge of surface and groundwater should be monitored and measured to assess effectiveness of mitigation measures (EIS Section 6.3).

Additional Comments to be Addressed at Detailed Design:

Further to the above, the following comments will need to be addressed at the detailed design phase in order to satisfy future GRCA permit requirements:

Engineering:

a) GRCA staff agree that the site soils, groundwater and observed ground water elevations appear to provide opportunities for maintaining and enhancing existing annual infiltration volumes. For design purposes, we suggest using site-specific water balance values provided in the NWSSS rather than the MOE Stormwater Management Planning and Design Manual generic values used in the SWM Report's appended calculations.

b) Table 6 of the SWM Report correctly uses annual infiltration values derived in the NWSSS (i.e. 188.4mm on the eastern side of a topographic divide and 222.5mm on the western side (NWSSS 2013, Fig 6.4)). However, the SWM plan uses an MOE 228mm generic for the entire development's pervious areas. As implied in the comment above, post development infiltration rates need further evaluation.

c) Unless the guidelines of the TRCA 2012 document, *Preserving and Restoring Healthy Soil: Best Management Practices for Urban Construction*, are applied, post development rates will typically be reduced due to subgrade compaction, degraded soil structure and decreased top soil depths.

d) Groundwater contour mapping is recommended using the highest observed water surface elevations from both the LVM standpipes and the Stantec monitoring wells.

Natural Heritage:

e) A detailed site grading plan will be required and a Geotechnical Engineer should assess the replacement fill material imported onto the site to ensure that it does not

interfere with surface water infiltration or groundwater movement. The importation of fill material also needs to be coordinated with the final SWM plan to ensure the intended water balance is achieved.

f) A detailed dewatering plan will be required to demonstrate how groundwater contributions to the adjacent watercourse and Provincially Significant Wetland will be maintained.

Advisory Comments for Consideration:

i. The maximum forebay velocity to prevent scour of accumulated sediment is 0.15m/s rather than the 0.5m/s identified in the design calculations. 0.5 m/s is the maximum velocity for dispersion of inflow over the forebay berm. As the proposed design achieves 0.10m/s average velocity through the forebay, this comment is advisory only.

If you have any questions or concerns regarding this letter, please do not hesitate to contact the undersigned.

Sincerely,

Kaitlyn Smith
Resource Planner - Grand River Conservation Authority
519-621-2763 ext. 2292 | ksmith@grandriver.ca

c.c. Kristen Barisdale – GSP Group (email)
2115881 Ontario Limited, 169 Lexington Court Unit B-1, Waterloo ON, N2J 4R3

Region of Waterloo

PLANNING, DEVELOPMENT
AND LEGISLATIVE SERVICES
150 Frederick Street, 8th Floor
Kitchener ON N2G 4J3 Canada
Telephone: 519-575-4400
TTY: 519-575-4608
Fax: 519-575-4449
www.regionofwaterloo.ca

Kristen Barisdale, MCIP, RPP (**via email**)
Associate, Senior Planner
GSP Group Inc.
201-72 Victoria Street South,
Kitchener ON N2G 4Y9

File: D18-20/16402
C14-60/4/16014
June 12, 2018

Ms. Barisdale:

Re: Post Circulation Comments
Revised Application for Draft Plan of Subdivision 30T-16402
Zoning By-law Amendment Application Z-16-14
2115881 Ontario Limited / GSP Group
556, 560, 576 Conservation Drive
(n/s Conservation Dr., e/s Roy Schmidt Rd.)
City of Waterloo

The subject applications were received by the Region on August 20, 2016 from GSP Group; application 30T-16402 was deemed complete by the Region's Director of Community Planning on August 23, 2016. The City of Waterloo's Director of Planning Approvals has accepted Zoning By-law Amendment Application Z-16-14 as complete.

On December 21, 2017 and January 3, 2018 respectively, the Region received revised draft plans and the required Regional re-circulation fee. The Region circulated prescribed agencies with the revised draft plan on January 4, 2018. A summary of prescribed external agency comments, as well as comments from Regional staff, is provided below.

The approximately 28.64 ha (70.8 ac) site is situated on the north side of Conservation Drive immediately west of Roy Schmidt Road, in the new Beaver Creek Meadows District area of the City. The subdivision plan dated July 29, 2015 from GSP Group provides development of primarily residential uses to be developed in a single stage and on full municipal services as follows:

Residential:
a) 242 lots for single detached dwelling units;
b) 7 blocks to contain a total of 130 street fronting townhouse dwelling units;
c) 1 block to contain a total of 44 back-to-back townhouse dwelling units; and,
d) 1 block to contain 20-25 Multiple Residential units.

School:
a) 1 block to contain a 2.99 ha (7.4 ac) school site.

Park/Open Space:
a) 2 blocks (approx. 4.86 ha (12 ac) total) for Open Space; and,
b) 1 block to contain a 1.45 ha (3.6 ac) park.

The comments below pertain to review of the submitted plan titled “Draft Plan of Subdivision”, prepared by GSP Group and dated July 29, 2015 (Project No. 09009.40) (last revised November 16, 2017), and associated submitted reports. The comments below have been numbered for discussion purposes.

DELEGATED AUTHORITY COMMENTS

1. Telecon Design (Telus) and HydroOne have each provided that they have no concerns regarding the applications.

2. Rogers Cable, Ontario Power Generation Inc., Waterloo Catholic District School Board, Conseil scolaire de district catholique Centre-Sud, and Le Conseil scolaire de district du Centre-Sud-Quest have not responded to this circulation. By separate letter including a copy of these comments, these agencies are asked to respond at their earliest opportunity if they have any comments.

3. City of Waterloo
As of the date of this letter the City of Waterloo has not provided comments on the application for draft plan of subdivision.

4. Township of Woolwich Engineering and Planning Services
In an email dated January 22, 2018, the Township’s Manager of Planning stated that Township comments dated October 18, 2016 (attached as Appendix A), which were provided in response to the original draft plan circulation, continue to apply. However the Township does note the removal of the walkway on the revised/updated draft plan. The Township is of the opinion that the deletion of the walkway and public access in this area would address Bullet No. 3 of the Township’s October 18, 2016 comments concerning the potential impacts to the adjacent farm. The Township will prefer some form of fencing along the common lot line to ensure that residents backing onto the farm fields will not encroach, use and/or dump onto the abutting lands in Woolwich. The Township is further of the opinion that it would be onerous for the property owners in Woolwich to continually monitor this area to prevent this from occurring.

5. Waterloo-North Hydro Inc.
6. In an email dated April 16, 2018 (attached as Appendix B), Waterloo-North Hydro Inc. (WNH) has advised that it will require that the owner/applicant be required to comply with its requirements and/or conditions of electrical service including the establishment of necessary easements, agreement(s), and detailed engineering design and construction. Furthermore, if necessary, the Developer will be responsible for all costs associated with relocation of any existing WNH facilities as a result of this development.

7. Union Gas
In an email dated January 4, 2018, Union Gas provided that it will require the necessary easements and/or agreements for the provision of gas services for this project to the satisfaction of Union Gas.

8. Canada Post

In an email dated January 15, 2018 Canada Post provided that there are no changes needed to its comments dated September 22, 2016 (attached as Appendix C). Canada Post provided general requirements for the location and construction of centralized Community Mail Boxes. Canada Post has requirements that can be secured through conditions of draft plan approval.

9. Bell Canada

In an email dated September 6, 2016 (attached as Appendix D), Bell Canada provided that it will require the necessary easements and/or agreements for the provision of communication/ telecommunication infrastructure for this project to the satisfaction of Bell Canada.

10. Grand River Conservation Authority

The Grand River Conservation Authority (GRCA) has reviewed the revised draft plan and supporting documentation and have identified in an email dated April 26, 2018 that their original comments dated August 11, 2017 (attached as Appendix E) will continue to apply.

11. Waterloo Region District School Board

In a letter dated September 21, 2016 (attached as Appendix F), the school board provided comments on the original proposed draft plan. Although the school board has not yet provided comments in response to the revised draft plan, it has indicated that its previous comments will continue to apply. When available, comments from the school board will be provided under separate cover.

REGIONAL COMMENTS

Water Services

12. Engineering and Planning staff have reviewed the above noted revised application(s).

13. The Servicing Strategy Report prepared for this development by Meritech, dated July 2016, is generally acceptable.

    a. The report recommends that a detailed water distribution study be prepared at detailed design stage to confirm the fire flow requirements for the subdivision, specifically the higher anticipated fire demand for the school, can be achieved by the proposed water system. Alternatively, building restrictions, materials, sprinkler requirements, etc. can be recommended based on more detailed information.
    b. The applicant should be aware that the Region is currently undertaking a study on the consolidation of Waterloo Pressures Zones 4B, 4C, and 5 which has a direct impact on the application. The objectives of the study are to ensure that once the zones are consolidated that the required level of service is provided to the existing and proposed communities. The study has evaluated the fire flow conditions under future conditions and have identified the existing and proposed fire flow availability. The detailed water distribution study shall incorporate the finding of the consolidation study.

Corridor Planning

Transit Planning

14. In 2018, transit service will be operating on Pinery Trail in this subdivision with the Route 73 Northlake (busPLUS). Transit is requesting 3 transit landing pads within this subdivision with the exact locations to be confirmed in the very near future. The final routing options for the

2018 network are in the later stages of being finalized. Once the final routing is determined Transit staff can identify more exact locations. The current cost for one transit landing pad is $2,800; the total funds for three transit landing pads required from the developer will be $8,400.

Road Traffic Noise Study

15. Corridor Planning staff has reviewed the Preliminary Environmental Noise Impact Assessment for the proposed plan of subdivision at 556 & 576 Conservation Drive, City of Waterloo, prepared by Meritech, dated July 2016. The Report has assessed traffic noise from Conservation Drive.

16. Corridor Planning staff generally concur with the conclusions and recommendations. The applicant will be required to provide a Detailed Noise Impact Assessment, including the height and exact location of the required noise walls. As the subject roads are within City of Waterloo jurisdiction, the recommendations of the study (including the installation of any noise barrier(s)) should be secured through a subdivision agreement with the City. The Region notes that the location of two noise walls identified on the "Noise Assessment Plan" within Appendix C of the Preliminary Environmental Noise Impact Assessment may change through the Detailed Noise Impact Assessment as result of the revised draft plan (last revised November 16, 2017).

Source Water Protection

17. Hydrogeology and Source Water (HSW) staff have reviewed the applicable technical reports submitted for the subject applications and can provide the following comments:

18. Planning Justification Report (GSP, 2016) and Supplementary Information (GSP, 28 July 2016): No comments.

19. Servicing Strategy Report (Meritech, 2016a)
    a. Prior to DPA:
        i. Any existing private wells at the subject property will need to be decommissioned by a licensed well driller in accordance with Ontario Regulation 903 (as amended);
        ii. Any existing septic systems at the subject property will need to be decommissioned in accordance with applicable provincial legislation; and,
        iii. Any existing tile drains at the subject property will need to be decommissioned in accordance with applicable provincial legislation.
    b. Conditions of DPA:
        i. A Salt Management Plan (SMP) will be required for the proposed school block at Site Plan Control. In the event that future revised Draft Plan of Subdivision applications include multi-residential, commercial, institutional, industrial, or community use properties are proposed, a SMP will be required for those properties at Site Plan Control.

20. Geotechnical Engineering Report (LVM, 2015): No comments.

21. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program (Stantec, 2016)
    a. General Comments:
        i. Page 4.3 indicates that at MW6—10, located within the SW portion of the property, Spring 2013/2014 groundwater levels were observed to be as

much as 0.9 m higher than previous levels presented in the NWSSS. This information should be incorporated into design considerations with respect to proposed SWM infrastructure, including lot-level, conveyance, 3rd pipe, and EOP infiltration galleries.

b. Prior to DPA:
    i. An updated groundwater contour map should be generated to reflect the high water table conditions observed across the monitoring area during the Spring 2013/2014 groundwater monitoring events. This should be submitted in an updated hydrogeological report;
    ii. The maximum groundwater elevations observed at each on-site groundwater monitoring well should be reported in m ASL in the report. This data needs to be summarized in tabular format in an updated hydrogeological report for all on-site wells, including the groundwater monitoring wells installed in 2015 by LVM; and,
    iii. Groundwater monitoring wells were installed across the site during the geotechnical investigations by LVM (2015) should be incorporated into the Phase I and Phase II monitoring program until site grading requires that they be decommissioned. Of particular interest are monitoring wells BH-4-15 and BH-05-15, which are installed in the vicinity of one EOP and one conveyance infiltration gallery. Information from these groundwater monitoring wells should be incorporated into the design considerations for these infiltration galleries. The hydrogeology report should be updated to reflect these additional groundwater monitoring locations.

22. Preliminary Stormwater Management Report (Meritech, 2016b)
    a. Prior to DPA:
        i. Table 1 indicates that “Control of Roof Leaders” is not included in the SWM Plan for the proposed development. A 3rd pipe collector system is potentially being proposed as a means to infiltrate clean roof top water from residential homes; however, this has not been confirmed in the preliminary design. It is noted that the 3rd pipe system would only collect water from the front half of the roof tops, and rear-yard roof runoff would be directed towards pervious surfaces. The conceptual design details of a 3rd pipe system were not presented in the Preliminary SWM Report. HSW will require more details as to how this system will function (i.e. will it be perforated pipe that actively infiltrates water within the road right-of-way, or will it be collected in a larger infiltration gallery and discharged in a more point-source manner?). These details need to be provided in an updated Preliminary SWM Report;
        ii. The proponent should be aware that a distributed approach to groundwater recharge will be required across the proposed development, where soil conditions permit;
        iii. Page 11 of the report cites the NWSSS and Geotechnical Report (LVM, 2015) when discussing groundwater conditions at the site. The Report does not reference the higher groundwater elevation conditions noted in Stantec (2016). The Preliminary SWM Report will need to be updated to make reference to the conditions noted in the Stantec (2016) report, and provide an opinion as to whether or not the feasibility of the SWM infrastructure is impacted by these results;
        iv. Page 14 indicates that infiltration measures that receive from the streets

should be designed to bypass in the winter months. HSW agrees with this recommendation, however, was this winter by-pass taken into consideration for the post-development water balance? This needs to be confirmed, and potentially included in a new water balance in an updated Preliminary SWM Report;

v. The assumed post-development infiltration rate on pervious surfaces was 228 mm/yr for all pervious areas within the proposed development. This is higher than either of the infiltration rates used for the pre-development conditions. The proponent should provide rationale as to a) why the property wasn't broken down into east and west portions (with different infiltration rates), as it was in the pre-development infiltration calculation, and b) why the overall infiltration rate for the site was increased to 228 mm/yr. If the rationale is not to the satisfaction of HSW, the post-development infiltration volumes will need to be re-assessed and summarized in an updated Preliminary SWM Report;

vi. The post-development infiltration area for the Clean-Water-Conveyance (CWC), or 3rd pipe system, was reported as 2.46 ha. Does this area represent the total roof area of the development, or only half of the roof area for the development? It is noted that earlier sections in the report stated that a 3rd pipe CWC system would only capture runoff from the front half of residential roof tops. This should be clarified in an updated Preliminary SWM Report;

vii. Do the infiltration galleries in Catchments 504, 505 and 506 take winter by-pass shutoffs into consideration when determining post-development infiltration volumes? This needs to be clarified in an updated Preliminary SWM Report;

viii. The Preliminary SWM Report should be updated to include an analysis demonstrating, in terms of m3/yr:

$$P_{Pre\text{-}Dev} = P_{Post\text{-}Dev}$$

$$ET_{Pre\text{-}Dev} + R_{Pre\text{-}Dev} + I_{Pre\text{-}Dev} = ET_{Post\text{-}Dev} + R_{Post\text{-}Dev} + I_{Post\text{-}Dev}$$

ix. The proposed Stage II Monitoring Program should include sodium and chloride in the groundwater quality monitoring program. Manual water levels and data logger downloads should be performed quarterly. The proposed Stage II Monitoring Program needs to identify which groundwater monitoring wells are proposed to included in the Program. Groundwater elevation and quality monitoring should be performed in the groundwater monitoring wells installed by LVM (2015) (particularly in BH-04-15 and BH-05-15). These details need to be included in an updated Preliminary SWM Report. And,

x. The Preliminary SWM Report should be updated to reflect the revision to the original draft plan of subdivision. Specifically, the water balance should be revisited to adjust for Block 243 (new proposed townhomes) and Block 251(proposed multi-res block).

b. Conditions of DPA:

i. Seasonal high groundwater elevations were observed during the spring months of 2013/2014 as presented in Stantec (2016). Proposed conveyance and EOP infiltration galleries will need to be designed to have

a separation between the bottom of the infiltration gallery and the maximum groundwater elevation observed at each respective location. The high water table across the site may influence where lot-level and 3rd pipe conveyance systems are feasible. This will need to be verified prior to approval of the Final SWM Report, to the satisfaction of the Region, City and GRCA;

ii. Any proposed lot-level infiltration galleries and / or 3rd pipe collector systems will need to be oversized by 15% to account for decreased performance over time and/or private homeowner disconnection;

iii. Any EOP infiltration galleries will need to be oversized by 15% to account for decreased performance over time;

iv. Is it feasible to install a CWC system throughout the entire 503 and 701 Catchments, given the generally lower-permeability soils identified in the eastern portion of the site? This should be addressed in the Final SWM Report;

v. It is HSW's preference to see infiltration of clean roof top runoff to achieve a net zero loss of pre-development infiltration volumes. Infiltration of impervious road runoff should only be incorporated if additional infiltration volume is required to achieve a net zero loss of pre-development infiltration volumes. This should be taken into consideration during detailed design;

vi. The proposed Stage III Monitoring Program proposes to monitor the performance of infiltration trenches/galleries and soak away pits on public property within 24 hours after a rainfall event once per year. These infiltration galleries should be equipped with continuous-read data loggers to evaluate the efficacy of the infiltration infrastructure. This will allow for multiple events of different sizes and timing to be analyzed. This detail can be included in the Final SWM Report; and,

vii. Page 28 indicates that building sump pumps should be connected to the internal storm sewer system. If a 3rd pipe CWC system is utilized at the proposed development, building sump pumps should be directed towards the CWC rather than to the storm sewer, as recommended in the NWSSS. This detail can be incorporated into the Final SWM Report.

23. General Comments

a. The proposed development lies within a Wellhead Protection Area (WHPA) D-2 for the Waterloo North Well Field, and requires a Section 59 Notice to be provided in accordance with the Clean Water Act.

b. Prior to DPA:

i. Generally, the SWM plan proposed in the Preliminary SWM Report is vague with respect to what types of engineered infiltration measures will be utilized at the proposed development. HSW recognizes that detailed stormwater infrastructure designs will be completed and presented in a Final SWM Report; however, there should be more direction in an updated Preliminary SWM Report. In order to match or exceed the pre-development infiltration volumes, it is HSW's preference to see distributed infiltration of clean roof top runoff in areas where soils are conducive to infiltration. This may be via lot-level infiltration galleries and/or 3rd pipe systems, or a combination of both. The post-development infiltration volumes can be topped up with runoff from impervious road surfaces;

ii. If a significant volume of infiltration is proposed from runoff originating from paved surfaces (via conveyance and/or EOP infiltration galleries), HSW will require a Chloride Impact Assessment to be completed prior to DPA, which can be included as a new section within an updated Preliminary SWM Plan; and,
iii. Alternatively, if winter by-pass valves are proposed on conveyance and EOP infiltration galleries, HSW would re-consider the need for a Chloride Impact Assessment.

Environmental Planning

24. Environmental planning staff has reviewed the reports and revised plans related to the proposed residential subdivision by Cook Homes at Conservation Drive and Beaver Creek Road in Waterloo. Environmental Planning staff have the following comments for your consideration:

25. Draft Plan of Subdivision

a. What is meant by the area identified as "Not included in dripline setback" (Block 256)? This area is identified as Significant Woodland and afforded a 10-metre buffer on Map 6 of the EIS but not identified as a Significant Natural Feature on Map 7 of the EIS. Please clarify.

26. Environmental Impact Study

a. Editorial note – Parts of the report do not have page numbers.

b. The Region's Greenlands Network Implementation Guideline was endorsed by Regional Council in June 2016 (p.2). Please ensure that the EIS references the 2016 version of this document.

c. 4.6 Ecological Linkages (p.43) – While staff agrees that the Beaver Creek corridor is the primary existing ecological linkage, does the NWSSS not identify a linkage to be enhanced along the northern property limit (see NWSSS Figure 14.4)? Please clarify. Staff raised this issue at the October 2016 agency site walk and recommended considering enhancements to this linkage through removal of invasive species and planting a mix and range of trees/meadow species similar to the existing trail to the east of the subject lands.

d. 5.4.1 Encroachment into Buffers (p.53) – First bullet states "the buffer provided always meets or exceeds the minimum Region of Waterloo recommended buffer of 10m from dripline for Core Environmental Features." Please note that a 10-metre buffer is a requirement under ROP Policy 7.C.11 and not a "recommendation." In addition, the Conceptual Grading Plan and Figure 4 of the SWM Report (Meritech, July 2016) appears to show grading in the SWM block up to/within the dripline of the Core Environmental Feature (Significant Woodland). However, the encroachment is difficult to determine since the woodland dripline and buffer are not shown on the grading plan. Please clarify with respect to how site alteration in this area would comply with ROP Policy 7.C.6.

e. 5.6.1 Wetland/Woodland Edge Buffer (p.62) – The last sentence of this section makes reference to a “farm dump area”. Where is this area located and could it be identified on one of the maps (i.e. EIS Map 7)?

f. 6.3 Post Construction Monitoring (p. 66) – How long will post construction monitoring continue following 90% buildout of the subdivision? Please note that the Region typically requires 2 years of post-construction monitoring.

27. Stormwater Management Report

a. Figure 4 – The limit of grading for the SWM facility appears to be coincident/within with the boundary of the Significant Woodland. The minimum buffer for Regional Core Environmental Features is 10 metres according to the ROP. Please clarify.

b. Quantity (p. 15) – For Catchment 504, if a bioswale is to be used (instead or oil/grit separator), where would it be located? The last sentence of this section is somewhat vague in this regard. Please clarify.

Archaeology

28. Staff have received the Archaeological Assessment Report Entitled, "Original Report” Archaeological Assessment (Stages 1 & 2) by Archaeological Research Associates Ltd. dated June 17, 2016, and acknowledge that a Stage 3 site-specific assessment is recommended for two locations of archaeological materials: Euro-Canadian Findspots 3 and 4. Such assessment, as well as an acknowledgement letter from the Ministry of Tourism, Culture and Sport (with two (2) copies of assessment provided to Region) that such report has been entered into the Ontario Public Registrar of Archaeological Reports, will need to be completed prior to Draft Plan Approval.

General

29. If any part of the development may potentially create a Non-Municipal Year-Round Residential System (NMYRRS) under the Safe Drinking Water Act (SDWA), 2002, such must be confirmed prior to draft plan approval and in consultation with the City of Waterloo; additional requirements may be applicable under the SDWA if a NMYRRS is confirmed.

30. Pursuant to the Region’s standard conditions for Draft Plans of Subdivision and Condominium, a development is required to contain a permanent secondary access if more than 26 units are developed with only one point of access. The north-west portion of this plan would exceed this maximum requirement, and, depending on when/how lands to the east are ultimately developed, all lands north of Street ‘E’ could also exceed this maximum. Additional information showing how this issue can be resolved will be required prior to issuing a decision.

31. Regional staff has no objection in principle at this juncture with the proposed draft plan of subdivision, and associated zone change application. As stated in the aforementioned comments, Regional staff will require additional information prior to granting draft approval, and will consider additional comments (including the City’s) as they are received.

Region Planning Fees
32. Regional staff acknowledges receipt of the application fees for the plan of subdivision, and zone change and EIS review. The developer should be advised of the following fees and charges (subject to annual change by By-law):

Subdivision Plans:
Draft Approval - $4,025.00 Registration Release - $2,000.00

If you have any questions, please don't hesitate to contact the undersigned.

Yours truly,



Adam Betteridge, MCIP, RPP
Principal Planner
abetteridge@regionofwaterloo.ca
(519) 575-4757 ex. 3120

cc. N. Hardacre, MCIP, RPP, City of Waterloo Planning (via email)
J. Scarfone, Manager of Planning, Township of Woolwich (via email)
R. Wei, Waterloo North Hydro (via email)
J. Bere, Canada Post Corp. (via email)
M. Palynchuk, Access Networking Provisioning (Bell) (via email)
Grand River Conservation Authority (via email)
Waterloo Region District School Board (via email)
Region of Waterloo – Water Services; Corridor Planning; Source Water Protection; Environmental Planning; and, Cultural Heritage (all via email)

THE CITY OF Waterloo | **Integrated Planning & Public Works**

Planning Approvals

August 31, 2018

Mrs. Brenna MacKinnon
Planning, Development and Legislative Services
Regional Municipality of Waterloo
150 Frederick Street
Kitchener, ON N2G 4J3

Mrs. Kristen Barisdale, MCIP, RPP
Associate, Senior Planner
GSP Group Inc.
72 Victoria Street South, Suite 201
Kitchener, ON N2G 4Y9

Mrs. MacKinnon & Mrs. Barisdale:

Re: Second Submission Comments
Zone Change Application Z-16-14
Draft Plan of Subdivision 30T-16402
556, 560 and 576 Conservation Drive

Please accept this correspondence in relation to Zone Change Application Z-16-14 and Draft Plan of Subdivision Application 30T-16402 and as a formal response to two submissions made by GSP Group on November 30, 2017 and June 15, 2018. Details of the materials provided in each submission are outlined as follows:

Submission of November 22, 2017:

- Revised Draft Plan of Subdivision, prepared by GSP Group, dated July 29, 2015 and revised November 16, 2017, annotated with changes.

Submission of June 15, 2018:

- Draft Plan of Subdivision, prepared by GSP Group, dated July 29, 2015 and revised February 23, 2018
- Preliminary Environmental Noise Impact Assessment, prepared by Meritech, dated May 2018
- Conceptual Erosion & Sediment Control Plan, dated February 2018
- Servicing Strategy Report, prepared by Meritech, dated May 2018
- Preliminary Stormwater Management Report (revised), prepared by Meritech, dated May 2018

City of Waterloo staff has completed a preliminary review of the information listed above and provides the listed comments below, in response. Prior to the City being in a position to recommend Draft Approval of the subdivision to the Region, or approval of the Zone Change application to Waterloo City Council, the following must be addressed and responded to in writing, with supporting studies and/or plans where necessary.

PART A – PLANNING COMMENTS

Density

1. Based on the current Draft Plan, the density of the proposed development is between 44 and 50 residents and jobs per hectare (rj/ha). The planned density of the Beaver Creek Meadows District Plan (BCMDP) area is 58 rj/ha as per OPA 15, which applies to the entire BCMDP area. Any shortfalls in the density of this subdivision area will impact, and need to be made-up in, other areas of the BCMDP. Please confirm the total density (in rj/ha) to be generated by this development

2. The density of the Mixed-Use Node appears under capacity compared to the land uses and density contemplated in the Official Plan and BCMDP. Density targets included within Table 3 of the District Plan for Mixed-Use Medium Density Residential is between 60 to 100 units per hectare. The proposed Draft Plan is showing approximately 53 units per hectare for the Mixed-Use Medium Density Residential lands. Please demonstrate how the density of the Node is consistent with the planned density outlined in the BCMDP and the Official Plan. Consider increasing density, in particular Block 251 (Multiple Residential).

Park Block and Open Space Block

3. Block 253 (Park) must be a minimum dedication of 5% of the Draft Plan lands. All natural features and associated buffers must not be included within this calculation. Land within buffers will not be considered as contributing to the parkland dedication requirements (Official Plan policy 8.2.4(12)).

4. A portion of Block 253 (Park) remains within the buffer area of the adjacent natural environmental feature. Revise the limits of Block 254 (Open Space) and Block 253 (Park). All natural features and associated buffers should be within Block 254 (Open Space). All lands within Block 253 (Park) should be unencumbered.

5. A portion of Block 256 (SWM) remains within the buffer area of the adjacent natural environmental feature. Revise the limits of Block 254 (Open Space) and Block 256 (SWM). All natural features and associated buffers should be within Block 254 (Open Space). All SWM features (including infiltration galleries) and trails/maintenance access should be located within the limits of Block 256 (SWM). Please also refer to the Environmental comments below.

6. Block 253 (Park) is in the same location as the park lands identified in the BCMDP, however, the south side of the park frontage is limited and partially blocked by Block 244 (Street Townhouses). While the park frontage has been slightly increased from previous versions of the proposed Draft Plan, the frontage to the park still remains limited due to the location of Block 244 (Street Townhouse). Policy 3.8.3 of the BCMDP requires that the park maximizes its accessibility to residents and visual presence within the community. Policy 3.8.4 of the BCMDP identifies that parkland should have sufficient frontage to the satisfaction of the City of Waterloo, to enhance visibility. Furthermore, street townhouses were not contemplated in the BCMDP in this location (Block 244).

7. Block 253 (Park) is in the same location as the park lands identified in the BCMDP, however, the north side of the park frontage is limited and partially blocked by Lot 154 and Lot 155. Policy 3.8.3 of the BCMDP requires that the park maximizes its accessibility to residents and visual presence within the community. Policy 3.8.4 of the BCMDP identifies that parkland should have sufficient frontage to the satisfaction of the City of Waterloo, to enhance visibility. Please remove Lot 154 and Lot 155.

School Block

8. As per the BCMDP, the subject lands are planned to include an elementary school in a central location and north of the Mixed-Use Node. Block 252 (School) is 2.99 ha in size, consistent with policy 3.7.5(b) of the BCMDP. Final site design and layout of the school site should be coordinated with the School Board, in accordance with policies 3.7.5 of the BCMDP.

Single Detached Lots (Lots 1-242)

9. Additional information is required in support of the requested site specific reductions. Please provide a Lot Plan(s) showing a typical single detached dwelling on a typical lot (both internal and corner lots) with the requested yard setbacks. Please also provide additional rationale and/or justification for each proposed reduction to the zoning regulations, including encroachments.

10. Staff have concerns with the request to reduce front yard setbacks. Front yard setbacks should comply with zoning standards. A front yard setback of 4.0 metres plus an allowance for a porch encroachment of 1.5 metres will negatively impact the streetscape. This results in a minimum front yard setback of 2.5 metres deep. Rideau River Street and Pinery Trail have larger front yard setbacks. A front yard depth of 4.0 metres is insufficient for a car to park in the driveway. In addition, a 2.0 metre wide easement is required along the frontage of each lot.

11. Lot depths shown are a minimum of 28 metres (with the exception of Lot 108 and Lot 109 which has a depth of 27.8 m). This is below the typical lot depth of 30 m. Consider increasing lot depths to achieve required front yard and rear yard setbacks, and to provide appropriate amenity area in the front and rear yards.

12. Staff have concerns with the request to reduce side yard setbacks. Reduced side yard setbacks will increase the need for easements to access the rear yard, provide insufficient space to maintain the house and side yard, and provide insufficient space for infrastructure (i.e., meters, air conditioning units). The need for easements to access private single detached backyard does not seem reasonable. This indicates the house is too large for the lot. Side yard setbacks should comply with zoning standards.

13. Lot 138 and Lot 242 appear to be very small corner lots. Ensure lot dimensions are such that minimum flankage yard setbacks can be accommodated along the entire length of the flankage façade (i.e., both front and back corners of the dwelling). Consider increasing the size of these lots or provide Lot Plans for each lot to show how required setbacks will be met.

14. The requested maximum porch encroachment into the side yard of 1.5 metres is greater than either of the minimum side yard setbacks requested (0.6 metres and 1.2 metres). This is not reasonable.

15. Confirm proposed coverage. Combination of reduced front yard, rear yard and side yards means the dwelling is too large for the lot. Smaller lots, shorter front yards and reduced side yards are all out of character with the existing homes on Pinery Trail and Rideau River Street and would not provide sufficient amenity space for future home owners/residents.

16. Confirm proposed garage and driveway dimensions. Minimum standards for garage sizes and driveway sizes will be recommended through zoning to ensure appropriate and sufficient parking is provided.

<u>Townhouse Blocks (Blocks 243-250)</u>

17. Additional information is required in support of the requested site specific reductions to the various forms of dwelling units. Please provide Lot Plan(s) showing typical street townhouse dwelling and requested yard setbacks. Please also provide additional rationale and/or justification for each proposed reduction to the zoning regulations, including encroachments.

18. Provide additional information related to the Back-to-Back Townhouse dwellings proposed on Block 250 in the form of a concept plan showing building form and setbacks. Additional rationale and/or justification is also required for the requested setbacks, including encroachments.

19. Provide a conceptual lot layout for all townhouse blocks. Are the townhouse dwellings intended to be condominium units? Lotted on the final plan to be registered?

20. Please remove Block 244 (Street Townhouses). Townhouse dwellings are not contemplated in this location in the District Plan (refer to #6).

21. Please increase the depth of Block 248 and 249 (Street Townhouses). A depth of 25.1 to 26.2 metres does not appear to be sufficient for the intended units while still providing appropriate outdoor amenity area.

22. Block 250 (Back-to-Back Townhouses) is only 28 metres deep, while Block 246 (Street Townhouses) is 27 metres deep. Confirmation is required that a depth of 28.0 metres is sufficient for back-to-back townhouse units without negatively impacting the streetscape and still providing adequate outdoor amenity area. Please demonstrate how this design would be achieved with such a narrow block depth (see also #18).

23. It is not clear how uses along Conservation Drive will address the street while avoiding backing onto interior blocks. Policies 3.2.10 and 3.2.19(b) of the BCMDP discourage back-lotting onto municipal streets such as Conservation Drive and Beaver Creek Road. Block 248 and 249 (Street Townhouses) are proposed to front Conservation Drive and Street A, and back onto Street F. Having Block 248 and 249 'back' onto the front yards of the townhouse units in Block 250 (Back-to-Back Townhouse) is not an appropriate configuration. Please consider revising the configuration of the townhouse blocks. Staff have reviewed possible configurations for this area and are available to meet to discuss these options, should you wish.

24. Please confirm if commercial is proposed within any of the Townhouse Blocks. This is strongly encouraged within the Mixed-Use Medium Density Residential lands and within the Mixed-Use Node. Blocks 245, 246 and 250 could contain a mixture of street townhouses and live/work style townhouses to achieve density targets and design priorities of the BCMDP.

25. Confirm proposed coverage. Combination of reduced front yard, rear yard and side yards means the dwelling is too large for the lot. Smaller lots, shorter front yards and reduced side yards are all out of character with the existing homes on Pinery Trail and Rideau River Street and would not provide sufficient amenity space for future home owners/residents.

26. Staff have concerns with the request to reduce front yard setbacks. Front yard setbacks should comply with zoning standards. A front yard depth of 4.0 metres plus an allowance for a porch encroachment of 1.5 metres will negatively impact the streetscape. This results in a minimum front yard setback of 2.5 metres deep. Rideau River Street and Pinery Trail have larger front yard setbacks. In addition, a front yard depth of 4.0 metres is insufficient for a car to park in the driveway. A 2.0 metre wide easement is required along the frontage of each lot.

27. A maximum height of 10.5 metres is being requested for townhouse dwellings. A height of greater than 10 metres will require an Official Plan Amendment for Blocks outside the Mixed-Use Node (i.e., Block 243 (Street Townhouse)).

28. Block 243 has been modified from single detached units to townhouse units. This is consistent with the direction of the BCMDP.

29. Confirm proposed garage and driveway dimensions. Minimum standards for garage sizes and driveway sizes will be recommended through zoning to ensure appropriate and sufficient parking is provided.

30. Have stacked townhouse dwellings been considered?

Multiple Residential Block (Block 251)

31. Please confirm built form proposed for Block 251 (Multiple Residential). Show conceptual plan(s) for the proposed / possible development of this block.

32. Please show dimensions (i.e., frontage) on the Draft Plan for Block 251 (Multiple Residential).

33. Density targets included in the BCMDP for the Mixed-Use Medium Density Residential lands within the Mixed-Use Node is between 60 to 100 units per hectare. The proposed density of Block 251 (Multiple Residential) is 30 to 37 units per hectare. Consider increasing the density of Block 251 (Multiple Residential).

34. Additional land will be required along the eastern boundary of Block 251 (Multiple Residential) which will form part of the ultimate road allowance and future road construction of Roy Schmidt Road (refer to 'Roy Schmidt Road' comments below).

35. Commercial is strongly encouraged to be included as part of the development of Block 251 (Multiple Residential). This aligns with the policies of the BCMDP.

36. The Draft Plan has been revised from previous versions to include Multiple Residential on Block 251 instead of townhouse units. This change is consistent with the BCMDP.

37. It is recommended that the land uses of Block 251 (Multiple Residential) be coordinated and compatible with the lands to the east which also form part of the Mixed-Use Node.

Mixed-Use Node

38. Special Provision Area 37 (SPA 37) of the Official Plan applies to a portion of the subject lands identified as the Beaver Creek Node, which allow for higher densities and building heights, as well as a wide range of uses to create a mixed-use centre with a concentration of neighbourhood-oriented retail, service commercial uses, institutional employment and residential uses. The extent of the node has been determined through the BCMDP. Blocks 245 to 251 are within the identified node area. Development within these blocks is permitted to be as high as 20 metres and permitted to have a density of up to 300 bedrooms per hectare.

39. SPA 37 of the Official Plan encourages a mix of uses. Staff recommends that a wide range of uses be considered for Blocks 245 to 251 including commercial, and to develop these blocks as a mixed-use area, consistent with SPA 37.

40. Policy 3.4.14 of the BCMDP outlines a range of commercial uses both permitted and encouraged within the Mixed-Use Node. Staff recommends commercial uses and live/work style units within the Mixed-Use Node (refer to policy 3.4.13 of the BCMDP). The inclusion of limited commercial uses and live/work units, well integrated with residential uses within the Node, is an important component of the overall vision and structure of the BCMDP.

41. The heights of the buildings within the Mixed-Use Node should be a minimum of 9.0 metres and should not exceed six storeys. The BCMDP contemplates a range of uses within the Node, with a high degree of pedestrian orientation. Policy 3.6.2 of the BCMDP encourages a range of residential uses to provide accommodation for a broad income and social mix. The proposed development should be consistent with policies 3.6.3 and 3.6.4, which require high quality urban design and visually interesting spaces that consider pedestrian movement and streetscapes.

42. At a minimum, buildings along Conservation Drive should be designed to accommodate future main floor commercial uses (minimum ground floor height will be recommended).

Roy Schmidt Road

43. Roy Schmidt Road shall have a road allowance width of 18.0 metres, to be measured at 9.0 metres on either side of the historic centre line of the road.

44. The developer shall coordinate the design of Roy Schmidt Road and cost-share on the reconstruction with the owner/developer of the lands on the east side of the road (Draft Plan 30T-17403), including a new multi-use trail extending from Conservation Drive to the City of Waterloo boundary north of Pinery Trail.

45. The width of Roy Schmidt Road south of Street E does not appear to be 18 metres, specifically along the eastern property line of Block 251 (Multiple Residential). The configuration of Block 251 (Multiple Residential) should be modified to allow sufficient road width.

46. The Draft Plan shows Roy Schmidt Road to be closed between Rideau River Street and Pinery Trail. Roy Schmidt Road is only proposed to be closed at the intersection of Conservation Drive. The remainder of Roy Schmidt Road is to remain open. The width of Roy Schmidt Road north of Pinery Trail shall be 18.0 metres. Lot 211 and Lot 212 will need to be revised to allow sufficient road width.

47. Registration of Lots 226 to 242 will be conditional upon the construction of Roy Schmidt Road.

48. Roy Schmidt Road is to be closed at Conservation Drive. A trail connection is required from Roy Schmidt Road to Conservation Drive in the location of the shared boundary between this development and the adjacent lands (Draft Plan 30T-17403), in the form of a 4.0 metre walkway block for a multi-use trail. If additional land is required to provide proper grading and drainage of the trail, this additional land will be included in the walkway block and conveyed to the City. City land outside that needed for the walkway block may be declared surplus. Such lands may be sold by the City in accordance with the City's Disposition of Property process.

49. Show accurate lot lines of adjacent / surrounding lands on the Draft Plan, including lands owned by the City in the area of Roy Schmidt Road.

Street Alignment

50. Staff support the accesses provided to the future development lands to the west (Brohman lands), through the extension of Pinery Trail and Street B. The precise location of these streets should be coordinated with the adjacent land owner throughout the Draft Plan process. The final location of Pinery Trail and Street B are to be located in such a way as to permit, and not hinder, the appropriate development of the adjacent lands (Brohman lands).

51. Show and dimension daylight triangles where streets intersect, particularly in the location of Street H, at Conservation Drive. How will reduced flankage affect visibility on corner lots? Daylight triangles shall be provided as per TAC guidelines.

52. The configuration of Street corners should be curved. Ninety degree angles are not desirable and create driveway issues (Street E).

53. Consider revising Street E and Street F as one Street name (as a future crescent). The current configuration of Street E and Street F creates confusion – where does one end and the next begin? Street G and Street H could remain with separate names.

54. Temporary cul-de-sacs will be required at the terminus of Street B, Pinery Trail and Street E.

55. Include 0.3 metre reserves between Conservation Drive and proposed residential Blocks to restrict driveway access.

56. Street H alignment / functioning is to conform with correspondence dated July 7, 2017 *(Conservation Drive and Beaver Creek Road Upgrades and Extension of Municipal Services – Update to Transportation Forecasts and Left Turn Lane Requirements, Stantec, 2017)*, which was provided to the Beaver Creek Meadows Developer's Group on July 14, 2017.

57. A Traffic Management Plan is required to be submitted with all subdivision applications, as per Policy 3.9.1(f) of the BCMDP. Traffic calming measures are to be recommended, reviewed and implemented as the subdivision is built, rather than retrofitted after the fact. Such measures will be included as conditions of Draft Approval, to be implemented as the subdivision is built out. For additional information refer to Part D.

Pedestrian Connectivity

58. There is a lack of pedestrian connections between streets. Please show walkways in strategic locations throughout the Draft Plan to increase pedestrian connectivity and to reduce walking distances.

59. In previous versions of the Draft Plan an east-west walkway was proposed between Street B and Rideau River Street. This connection has since been removed. It is recommended this connection be retained as limited east-west connections exist in this area. Maintaining this connection is consistent with policies 3.9.5 and 3.9.6 of the BCMDP.

60. A pedestrian connection should be included between Street B and Street D to improve north south pedestrian connections, consistent with policies 3.9.5 and 3.9.6 of the BCMDP.

61. The Draft Plan shows very limited active transportation connections. This is inconsistent with policy 3.9.4 of the BCMDP, which requires the active transportation network to be designed to ensure convenient and safe travel throughout the community. Proposed lots along the north limit of the Draft Plan have no direct access to key areas such as the school, park, Mixed-Use Node, or transit services. Policy 3.9.5 of the BCMDP requires an active transportation network that provides multiple options for pedestrians and cyclists to travel within the community.

62. Map 5 of the BCMDP shows a proposed trail connection running north-south including a route along the buffer area on the west side of the plan. Staff recommends that a pedestrian connection along the buffer be implemented, subject to environmental sensitivities. The EIS submitted as part of this proposal should confirm the feasibility of implementing a trail in this buffer area prior to final development approval. All trails should be developed in accordance with policies 3.9.7- 3.9.15 of the BCMDP.

63. A continuation of the Avon Trail was previously shown along the north boundary of the Draft Plan, as per policy 4.4.8 of the BCMDP and has since been removed. This is an important community trail connection.

64. Consider including a walkway connection from the roundabout at Beaver Creek Road and Conservation Drive to Street E / Street F through Block 249 (Street Townhouse).

65. Overall, the proposed Draft Plan does not meet the intent of Policy 3.9.2 to 3.9.6 for an active transportation system. Please refer to Map 5 of the BCMDP.

Phasing

66. If phasing of the development is proposed, please submit a Phasing Plan. Also, confirm how the phasing of the development will relate to the availability and timing of the broader stormwater management plan.

Retaining Walls

67. All proposed retaining walls throughout the plan (i.e., at west property limit, within SWM Blocks, etc.) shall be removed or minimized to the extent possible.

Noise

68. The Preliminary Environmental Noise Impact Assessment, prepared by Meritech, dated May 2018 recommends a 1.8 metre high noise wall along Conservation Drive and Street A, along with noise warning clauses for lots within 20 metres and 40 metres of Conservation Drive. Staff do not support the use of noise walls to mitigate noise levels generated by traffic along Conservation Drive. Acceptable measures include building orientation / site layout, berms, and setbacks (physical separation).

Design Considerations

69. Development of the subject lands should be consistent with urban design policies of the BCMDP (Section 4). Generally, the Draft Plan should reflect a complete community with high quality design, a high degree of connectivity, well designed and attractive streetscapes, and a sense of identity. Good urban design principles should also be incorporated into the built form, including each dwelling unit type. In particular, townhouses should be consistent with policies 3.4.17-19 of the BCMDP.

70. The development as a whole should be consistent with the City's Urban Design Manual.

71. An Urban Design Brief was not submitted. Subdivision Urban Design Guidelines will be required as a condition of draft approval.

PART B – ENVIRONMENTAL PLANNING COMMENTS

72. When compared to the previous submission, the wetland limits shown on the Draft Plan of Subdivision (last revised February 23, 2018) have changed. The rationale for the new limits needs to be confirmed, as does GRCA's acceptance of the new limits. Also, the wetland limits shown on the Draft Plan differ from those shown on the Conceptual Erosion and Sediment Control Plan (dated February 2018). The wetland limits on the Conceptual Erosion and Sediment Control Plan match those from the previous version of the Draft Plan. Further, the dripline shown in the northwest corner of the site on the Draft Plan is different than that shown on the Conceptual Erosion and Sediment Control Plan.

73. Figure 6 of the Preliminary Stormwater Management Report (Revised May 2018) includes a note that reads "Dripline knob to be removed". Through the EIS, the "knob" is mapped as Significant Woodland (Core Natural Feature) and Significant Wildlife Habitat (Supporting Natural Feature). Official Plan policies 8.2.4(2) and 8.2.5(2) require the form and ecological function of such features to be maintained, enhanced or, where feasible, restored. Policies 8.2.4(3) and 8.2.5(3) also restrict development and site alteration within such features to a limited range of uses/activities. As per the Official Plan and the North Waterloo Scoped Subwatershed Study (NWSSS), the feature should remain intact and be afforded a 10 metre buffer. In terms of that buffer, as set out in Official Plan policy 8.2.4(9), buffers are to remain in or be restored to a primarily natural state and portions of stormwater management facilities may be permitted in them where the feature is enhanced, no other alternative location is feasible, low impact development measures are implemented to the extent feasible outside the buffer, root zones are not impacted, and the facility replicates or complements an existing function of the buffer lands.

74. It is unclear whether the constructed wetland will include a cooling trench. Figure 6 of the Preliminary Stormwater Management Report (Revised May 2018) shows a level spreader but a cooling trench is referenced on page 29.

75. While the Preliminary Stormwater Management Report (Revised May 2018) sets out recommendations for the during-development and post-construction monitoring programs, the Terms of Reference for each phase will need to be finalized at the time of transition. This comment also applies to the monitoring recommendations put forward in the EIS. Further, while the 2016 and 2017 Pre-development Biological Monitoring Reports were submitted in early 2017 and 2018 respectively, the 2016 Groundwater and Surface Water Monitoring Report and subsequent reports are still outstanding. These reports should be submitted together and as soon as possible following the end of the monitoring year.

76. Based on the direction provided in the District Plan, a trail, that would have to be supported through the EIS if it is in the buffer, should be incorporated into the plan that extends from Block 256 (Stormwater Management) down to Conservation Drive. Further, approximate trail locations should be shown.

77. Section 5.4.7 of the EIS states that the wet cells of the pond have been placed outside of the Category 2 habitat of the Blanding's turtle which will avoid the need for registering any maintenance works for an exemption under the ESA. However, in MNRF's comments, it was noted that the stormwater management pond could become Blanding's Turtle habitat in the future and would therefore require any maintenance of the pond to proceed in consultation with MNRF to ensure the species is not negatively impacted. This needs to be clarified and City Engineering staff need to be made aware of the requirements.

78. The Preliminary Stormwater Management Report (Revised May 2018) and the Conceptual Erosion and Sediment Control Plan (dated February 2018) show part of an infiltration gallery within the wetland buffer (to varying degrees, as different wetland limits are used on each plan). Official Plan policy 8.2.4(9) states that buffers are to remain in or be restored to a primarily natural state and portions of stormwater management facilities may be permitted in them where the feature is enhanced, no other alternative location is feasible, low impact development measures are implemented to the extent feasible outside the buffer, root zones are not impacted, and the facility replicates or complements an existing function of the buffer lands. It has not been demonstrated that these criteria are met. If it can be shown that the criteria are met, details on the design of the infiltration galleries are needed, as they may be incompatible with a naturalized buffer. Potential areas of incompatibility include whether access to the galleries needs to be maintained, whether the vegetation over top of the galleries need to be maintained/manicured, whether tree roots will interfere with gallery function as the buffer matures from a meadow community to a treed one, and whether the galleries will need to be maintained in the short or long term, since accessing them would disrupt the buffer and remove any habitat that has been created, the provision of which is identified as a key ecological enhancement in the NWSSS.

79. Sections 3.2 and 5.4.3 of the EIS note that Stantec is preparing a hydrogeological study as part of the application. A Terms of Reference for a hydrogeological assessment was submitted to the City on November 9, 2016. Has that assessment been completed and submitted?

80. Given the required removal of the suitable bat habitat features (residential buildings and isolated landscape trees), is there opportunity to create bat habitat in the buffer areas?

81. Figure 14.4 of the NWSSS shows the northern edge of the property as an area to enhance in terms of its linkage function. While the EIS notes the lack of linkage connection/corridor function the hedgerow currently provides (page 41 and 50), the feasibility of enhancement has not been evaluated or addressed.

82. The Draft Plan of Subdivision (last revised February 23, 2018) shows encroachment into buffers in three locations – a) in the residential lots that back onto the northern hedgerow, b) in the stormwater management block, and c) in the park block.

    a) With respect to the residential lots that back onto the hedgerow, while a 5 metre buffer is shown on the Draft Plan, both the hedgerow and buffer are, to varying degrees, within the lots. Could the lots be graded without interfering with the hedgerow? What is to prevent removal of the hedgerow by future homeowners if it is within the lot lines? Further, the Preliminary Stormwater Management Report (Revised May 2018) shows both a maximum 2 metre high retaining wall and infiltration gallery along that boundary. It is presumed such infrastructure would require the removal of the hedgerow. The previous comment dealing with the linkage function of the hedgerow needs to be addressed to inform how the hedgerow will be managed. In addition to the

impact the retaining wall and infiltration gallery would have on the hedgerow, their location would also pose significant challenges in terms of infrastructure maintenance. Access to the retaining wall would be severely restricted and the infiltration gallery would be on a number of private properties, with limited access and no opportunity to ensure functionality or prevent removal.

b) With respect to the stormwater management block, the criteria listed in Official Plan policy 8.2.4(9) needs to be fully addressed in order to contemplate the location of the constructed wetland and infiltration gallery as currently proposed. Specific concerns regarding the infiltration gallery in the buffer are previously noted. In addition to these concerns, the proposed maximum 1.7 metre high retaining wall would pose a significant challenge in terms of maintenance and buffer functionality, as the buffer would need to be cleared to enable access.

c) With respect to the park block, Official Plan policy 8.2.4(9) states that permitted uses within buffers are to be limited to low impact uses consistent with those permitted within designated features. Active park land is not one of those uses. Further, the policy states that buffers are to remain in or be restored to a primarily natural state. The buffer lands are therefore to be removed from the Park Block. This is consistent with Official Plan policy 8.2.4(12) which states buffers will not be considered as contributing to parkland dedication requirements. The situation is further complicated because a trail is to be potentially built within the buffer (as per an earlier comment). The combination of an infiltration galley and a trail could result in very little naturally-vegetated buffer.

83. The EIS recognizes that the timing of construction activities must have regard for the breeding bird season. Consistent with the Westside Subdivisions, a timing window of April 1 to September 10 should be used. All land clearing, earthen works, servicing works, infrastructure work and tree removal between April 1 and September 10 should be prohibited unless a nesting survey is undertaken that demonstrates the activities will not have the potential to disturb or destroy migratory birds or their active nests.

84. The EIS notes that there will be an increase of 11-46% in post-development infiltration (page 56), with the Preliminary Stormwater Management Report (Revised May 2018) providing further details (page 25). While the NWSSS recommends existing infiltration rates be maintained or increased, a potential increase of 46% seems significant. Section 4.2 of the EIS notes that the wetlands' primary hydrologic function appears to be the storage of surface water and the storage and expression of groundwater. Would increasing the rates this substantially result in impacts to the wetlands? Is groundwater mounding a risk?

85. As per the direction provided by the NWSSS and the EIS, a condition of draft plan approval will require the distribution of an environmental stewardship brochure. The City has a universal one available for purchase entitled "Naturally Your Waterloo". Experience has shown that requiring builders to distribute the brochure to new

homeowners is challenging because of the time span over which the development occurs. Given this, the applicant should either be required to purchase all of the brochures needed for the subdivision upfront from the City and distribute them as appropriate or provide the funds necessary to print all the required brochures but rely on the City to distribute them as the subdivision builds out (e.g. it could be given out alongside the Building Permit). Further discussion is needed to determine the preferred approach.

86. The environmental lands and their buffers (i.e. the Open Space blocks) are to be dedicated to the City free of charge and without any encumbrances.

87. Under section 5.6.1 of the EIS, a historic farm dump is noted. This area will need to be cleaned up as a condition of approval.

88. Invasive Phragmites is discussed under section 5.6.3 of the EIS. An invasive species management plan will need to be provided as a condition of approval.

89. City-standard chain link fencing needs to be installed along the private-public interface.

PART C – LANDSCAPE COMMENTS

90. Block 253 (Park) cannot include buffer lands within the lands calculated toward the 5% parkland dedication. Likewise, areas of the park encumbered with infrastructure such as stormwater management facilities and infiltration galleries cannot be included in the 5% parkland calculations.

91. Why is the Avon Trail link deleted? This is an important community trail connection.

92. The hedgerow at the north and its 5.0 metre buffer are now incorporated into the rear lots of homes. This is not a viable way to protect, conserve and enhance this hedgerow. Regionally significant bird species are noted in this hedgerow therefore measures to preserve and enhance this feature should be undertaken. There is very limited protection for hedgerows when located within private property.

93. The servicing plan indicates that infiltration infrastructure is proposed in the lots at the north end of the site, between Rideau River Street and Street B. They seem to indicate water will flow off site, which is not permitted.

94. The servicing submission from Meritech (dated May 2018) shows the proposed locations for infiltration galleries. Most of these are inaccessible for future maintenance. Please revise or confirm how maintenance will be addressed.

95. The proposed development to the east (Draft Plan 30T-17403) does not show a vehicular connection at the end of Street E as indicated on this Draft Plan. Coordination between plans and consulting firms is required.

96. The stormwater management pond maintenance access road is typically designed to form part of the overall pedestrian trail system. Linkages to the park and to the north-south trail system on the west edge of the property should be incorporated into the access road.

97. It is recommended that a 2.0 metre wide (minimum) flat area be designed behind the residential lots that back onto the stormwater management pond rather than the 3:1 slope beginning at property line.

98. The location of the infiltration gallery proposed within Block 252 (School) must be accepted by the School Board, to not encumber the development potential of this block.

99. The EIS does not speak to the north-south trail connection through the buffer lands or other trails. The trail system should be shown conceptually. This trail connection should be provided within the buffer from Conservation Drive to the stormwater management pond. The City standard 3.0 metre wide asphalt trail with supporting buffer plantings is required.

100. The trail/linkage system should be designed holistically so that walkway blocks connect to major points of attraction such as the park and the school. Although the BCMDP shows this conceptually, the Draft Plan does not create these linkages. Linkages are not linking street to street in a linear fashion. Future residents should be able to use a walkway block from Street B to connect to Street D, and then to the park, etc.

101. Block 253 (Park) must be unencumbered and for recreational purposes only. Portions of the park that do not provide useable parkland should be eliminated from the overall park calculation and/or moved out of the park block. These include the infiltration gallery and the sanitary service. These facilities are typically not permitted in parkland.

102. Block 253 (Park) should be 80% flat tableland with grades no steeper than 2%. Areas of steep slopes will not be accepted.

103. City standard 1.5 metre high black vinyl chain-link fencing shall be provided at all public private interfaces where private lands abut wetlands, buffer lands, environmental lands, woodlots and open spaces meant to be naturalized to minimize encroachment. In all other areas, the City standard property demarcation posts and living fence shall be provided.

104. The City is interested in discussing the School Board proposals for layout of the new school and associated green space. Given the size and layout of Block 253 (Park), it is perhaps not conducive to sharing sporting facilities and therefore the School Board may need to provide these 100% on their lands.

105. Sufficient deterrents need to be designed into the shared property line between Block 253 (Park) and Block 256 (SWM) to maintain safety given the slopes of the pond and the proximity of the park.

106. Please confirm the design intentions of Blocks 254 and 255 (Open Space) and who is to maintain it. If it is Open Space, the developer must enter into an agreement to maintain these lands until the subdivision is build out.

107. The design and incorporation of a layby for bus drop-off for Block 252 (School) should be considered.

108. Walkway blocks shown on previous iterations of the plan have been removed. Interconnectivity throughout the neighbourhood must be provided. Walkway blocks are 4.0 metres wide, unless additional services are required which may warrant a width of 6.0 metres to 9.0 metres.

109. A 6.0 metre high retaining wall is proposed along the west property limit. This is significant. Why does the west property limit not meet existing grades? How does the retaining wall work at future road extension (i.e., Pinery Trail and Street B)?

110. A Vegetation Management Plan will be required as part of the first engineering submission.

111. A Hedgerow Enhancement Planting Plan is required.

112. An Invasive Species Control Plan is required.

113. An infiltration gallery cannot be located within buffers. Buffers can contain trails and naturalized plant material and some minor re-grading only.

114. Block 252 (Park) will require stormwater, hydro and water stubs for playground and for a future rink area.

115. Infrastructure shall not be in parks unless required by the park.

116. Any garbage in the buffer, wetland, woodlands shall be removed by the developer to the satisfaction of the City of Waterloo. This includes any farm dump, old fences, building materials, etc..

117. Educational signage is required to be designed, approved and installed in the buffer area to educate property owners regarding encroachment and dumping, ownership, etc. Signage plan to be submitted for approval.

118. The plan for the restoration and enhancement measures to protect wildlife and cut down invasive species along Conservation Drive is required.

119. The plan for the animal crossing/ecological linkage enhancement crossing is required.

120. Park, SWM, OS, buffer, naturalization, living fence and property demarcation, fencing, signage plans are required to estimate the Letter of Credit requirements in Schedule B of the Subdivision Agreement. Developer to submit street tree planting plan OR to confirm with Parks and Environment to have the City undertake the street tree planting.

121. Topsoil is not permitted to be stockpiled within Block 253 (Park).

PART D – TRANSPORTATION AND ACTIVE TRANSPORTATION COMMENTS

Road Widenings and Lands to be Conveyed to the City

122. The existing road allowance of Roy Schmidt Road appears to be 12 metres wide. A road widening on the west side of Roy Schmidt Road shall be conveyed to the City for the entire length of Roy Schmidt Road to establish the new property line at 9.0 metres from the historic centreline of Roy Schmidt Road. A similar widening has been requested from the developer of the proposed subdivision on the east side of the road (Draft Plan 30T-17403).

123. Roy Schmidt Road is to be closed at Conservation Drive but the City will retain a 4.0 metre wide walkway block for a MUT in this location (between Roy Schmidt Road and Conservation Drive). If additional land is required to provide proper grading and drainage of the trail, this additional land will be included in the walkway block and conveyed to the City. City land outside that needed for the walkway block may be declared surplus. Such lands may be sold by the City in accordance with the City's Disposition of Property process;

124. The developer shall confirm that the north limit of Conservation Drive is 13 metres from the historic centreline of the road, to facilitate the ultimate road allowance of 26 metres as per the City's Official Plan.

125. 4.0 metre* wide walkway blocks are required:
    a. Inside the west limit of the plan from Pinery Trail to Block 255 (Open Space).
    b. Adjacent to the rear of Lot 46 to Lot 71 on Street B.
    c. Adjacent to the rear of Lot 7 to Lot 23 on Rideau River Street to connect to the existing trail at the east limit of the Draft Plan and the trail on the west limit of the Draft Plan.
    d. Between Lot 45 and Lot 46 on Street B, between Lot 23 and Lot 24 on Rideau River Street, and between Lot 6 and Lot 7 (or Lot 7 and Lot 8) on Rideau River Street to connect the public sidewalks to the trail inside the north limit of the Draft Plan.

126. The trail within the plan is to be designated The Avon Trail:
    a. Along the east limit of Block 254 (Open Space) from Conservation Drive to Pinery Trail.

b. Inside the west limit of the Draft Plan from Pinery Trail to Block 255 (Open Space).
c. Along the south limit of Block 255 (Open Space) to the north limit of the Draft Plan.
d. Inside the north limit of the Draft Plan from Block 255 (Open Space) to the existing trail along the east limit of the Draft Plan.

*__Note:__ *where detailed engineering determines that grading and drainage of trails, walkways or park facilities require additional land or easements, such transfers must be conveyed to the City at the time of engineering approvals.*

Transportation Study and Implementation

127. The Developer shall submit a Transportation Study prepared by a qualified Transportation Engineer, for the review and approval of the City's Director of Engineering, to address the needs of all road users: pedestrians, cyclists, transit users, and drivers.

128. The Transportation Study will use as background information the transportation studies for Conservation Drive and Beaver Creek Road, and provide projected peak hour and AADT volumes for each transportation mode on the following streets (which are considered to be feeder roads):
    a. Street H
    b. Pinery Trail
    c. Street A, from Conservation Drive to Pinery Trail
    d. Street E, from Roy Schmidt Road to Street A

129. Above feeder roads should have a Multi-Use Trail (MUT) on one side, and the study should provide options for enhanced crossings at all intersections on these roads.

130. The Transportation Study shall determine the sight daylighting requirements at all roads intersecting with Conservation Drive. Lands to accommodate daylighting requirements shall be conveyed to the City.

131. The Transportation Study shall include options and recommendations for enhanced pedestrian and cycling safety, and shall design and construct any traffic calming facilities and road safety features recommended by the Transportation Study.

Multi-Use Trails (MUTs) and Sidewalks

132. All design and construction to be undertaken by the developer shall be to the satisfaction of the City's Director of Engineering Services.

133. The detailed design of City sidewalks, trails and parks shall address all grading and drainage issues to meet AODA requirements. Should additional land or easements be

required to accommodate City infrastructure needs, the developer shall convey such transfers to the City at the time of engineering approval.

134. A MUT is required within the Roy Schmidt Road right of way. The City preferred location for this 3.0 metre wide MUT is on the west side of the road (due to a fewer number of driveways). This MUT will extend from Conservation Drive, up to and along Roy Schmidt Road, to the existing trail at the north limit of the Draft Plan. A 1.8 metre sidewalk is required along the entire length of Roy Schmidt Road, within the right of way on the east side of the road. The developer shall coordinate the design of Roy Schmidt Road with the developer of the lands to the east.

135. While the City is constructing a MUT on the east side of Beaver Creek Road south of Conservation Drive, and on the south side of Conservation Drive, the preferred location of the MUT is on the west side of Street A adjacent to Block 252 (School). This will require enhanced crossings on the east and north legs of the roundabout at Street A and Conservation Drive.

136. The developer shall design and construct the following 3.0 metre* wide Multi-Use Trails (MUT):
    a. Along the east limit of Block 254 (Open Space) from Conservation Drive to Pinery Trail.
    b. Inside the west limit of the Draft Plan from Pinery Trail to the south limit of Block 255 (Open Space).
    c. Between Block 255 (Open Space) and the rear of Lot 63 to Lot 71 on Street B.
    d. Inside the north limit of the Draft Plan from the MUT on Block 255 (Open Space) to connect to the existing trail at the north-east limit of the Draft Plan.
    e. Along the east limit of Block 256 (SWM) connecting the MUT on Block 254 (Open Space) to the MUT at the north limit of Block 256 (SWM).
    f. Along the north limit of Block 256 (SWM) connecting Pinery Trail to the MUT on the east side of Block 253 (Park).
    g. Along the south and east limit of Block 253 (Park) connecting the MUT on Block 254 (Open Space) to Pinery Trail.
    h. On the west side of Street A from Conservation Drive to Pinery Trail.
    i. On the north side of Street E from Roy Schmidt Road to the property line between Block 252 (School) and Block 244 (Street Townhouse).
    j. Along the south limit of Block 252 (School) from the MUT in (i.) above, to the MUT on Block 253 (Park).

Note: *where Block 244 (Street Townhouse) is removed, the MUT on the north side of Street E should connect from Street A to Block 253 (Park).*

137. The developer shall design and construct 1.8 metre concrete sidewalks on the following streets:
    a. On both sides of all streets with the exception of Street D and streets with a 3.0 metre MUT on one side.

b. On streets with a 3.0 metre MUT on one side, a 1.8 metre sidewalk is required on the opposite side of the street.
c. On Street D, a 1.8 metre sidewalk is required on one side only, in front of Lots 108 to Lot 128.

Bike Lanes

138. The developer shall design and prepare a pavement marking plan showing 1.5 metre painted bike lanes with a 0.3 metre painted buffer on Pinery Trail, and on Street A from Conservation Drive to Pinery Trail.

139. In accordance with the Transportation Study, the developer shall prepare a detailed design of the Pinery Trail and Roy Schmidt Road intersection to safely connect the MUT on Roy Schmidt to the buffered bike lanes on Pinery Trail.

Transportation Operations

140. Streets with bike lanes may not be able to accommodate on-street parking, due to the width of the road. Bike lanes on Street A will restrict on-street parking for the school and Block 243 (Street Townhouse). Bike lanes on Pinery Trail will restrict on-street parking at the park.

141. Please provide additional information with respect to the type of traffic control and traffic calming measures planned for the proposed Draft Plan.

142. How will school traffic be accommodated? The area around the school will have limited on-street parking to assist with student drop-off and pick-up.

143. The radius elbow corner on Rideau River Street presents a challenge for winter operations. Please consider modifying this design.

144. Driveway access to Block 251 is recommended from Street A and/or Street E, not from Roy Schmidt Road. The City intends to minimize the number of driveways on Roy Schmidt Road, because the preferred location for the MUT is on the west side of Roy Schmidt Road from Conservation Drive to the existing trail at the north limit of the subdivision; the driveways that conflict with the MUT are limited to Lots 226-242.

145. The developer shall design and construct a pedestrian refuge island and crossing within Conservation Drive at Street H, and at the MUT on Block 254 (Open Space). These are required to facilitate connections to facilities being constructed by the City, including bike lanes on both sides of Conservation Drive, and the MUT on the south side of Conservation Drive.

146. The Street H connection with Conservation Drive is located just west of the proposed roundabout at Beaver Creek Road. Stantec completed a turn lane analysis for all subdivision entrances onto Conservation Drive and Beaver Creek Road. There were

four recommendations made from the analysis. In its current location, Street H, will be limited to right-in/right-out (RIRO) movement only based on the recommendations outlined in the *Update to Transportation Forecast and Left Turn Lane Requirements Technical Memo* (Stantec, July 7, 2017). Should the developer maintain the location of Street H an analysis of the RIRO configuration and resulting reassignment of traffic for the proposed operations of the roundabout will need to be completed. Should RIRO not be desirable for Street H, please review the July 7, 2017 Turn Lane Analysis Memo for more intersection spacing options. Options may be investigated to remove Street H and extend Street E from Street F to Conservation Drive.

147. Please ensure appropriate coordination between the lighting plan for the proposed Draft Plan and the lighting plan for Conservation Drive.

PART D – ENGINEERING COMMENTS

148. The Beaver Creek Road Sewage Pumping Station must be in place prior to final registration of the Draft Plan and the issuance of any building permits.

149. The Communal SWM facility must be constructed prior to servicing of the subdivision for water quality control.

150. The SWM report indicates an additional SWM Report will be submitted for the "off-site" stormwater management. City staff would not be in a position to accept this dual management proposal without further details of the off-site facility as well as securities/assurances that it will be built and available to this development.

151. Several discussions have been held about the off-site SWM pond concept. A letter has been sent offering options.

152. If it is determined that the external facility is not feasible or it does not materialize, all SWM controls would be required within the development, requiring significant revisions to the design and layout of the plan.

153. The servicing strategy report indicates that matching elevations along the neighbouring properties is a design consideration. The conceptual grading plan includes some significant deviations from existing elevations on adjacent lands, namely a 6.0 metre high retaining wall in the northwest corner of the site and a 2.0 metre high retaining wall along the north property line. This will not be accepted by staff. This grading strategy will effectively preclude development of the adjacent property, and will incur significant costs for retaining walls and importing fill. A realistic proposal needs to be provided. Development of the Draft Plan lands must be completed in a way that will not to negatively impact or encumber the adjacent lands.

Please note that City staff reserves the right to provide additional comments, or modify the above noted comments subject to further review and/or additional information as may be provided.

I trust the foregoing is satisfactory, however should you have any questions please do not hesitate to contact the undersigned.

Sincerely,



Natalie Hardacre BES, MCIP, RPP
Development Planner
Planning Approvals
Integrated Planning & Public Works
City of Waterloo
P: 519.514.0225
F: 519.747.8523
TTY: 1.866.786.3941
E: natalie.hardacre@waterloo.ca

APPENDIX B:
Figures



Stantec

Legend

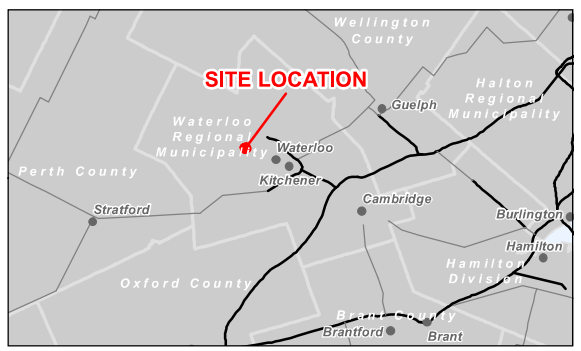
- Site Boundary
- Monitoring Well (Stantec, 2020 -2021)
- Monitoring Well (Ecoplans et al., 2013)
- Drive Point Piezometer (Ecoplans et al., 2013)
- Guelph Permeameter/Infiltrometer (Stantec, 2020)
- Guelph Permeameter (Ecoplans et al., 2013)
- Test Pit (Stantec, 2010)
- Test Pit (Stantec, 2021)
- Abandoned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

0 100 200 metres

1:3,500 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2020.
3. Orthoimagery © First Base Solutions, 2021. Imagery Date, 2020.



Project Location
Waterloo, ON

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

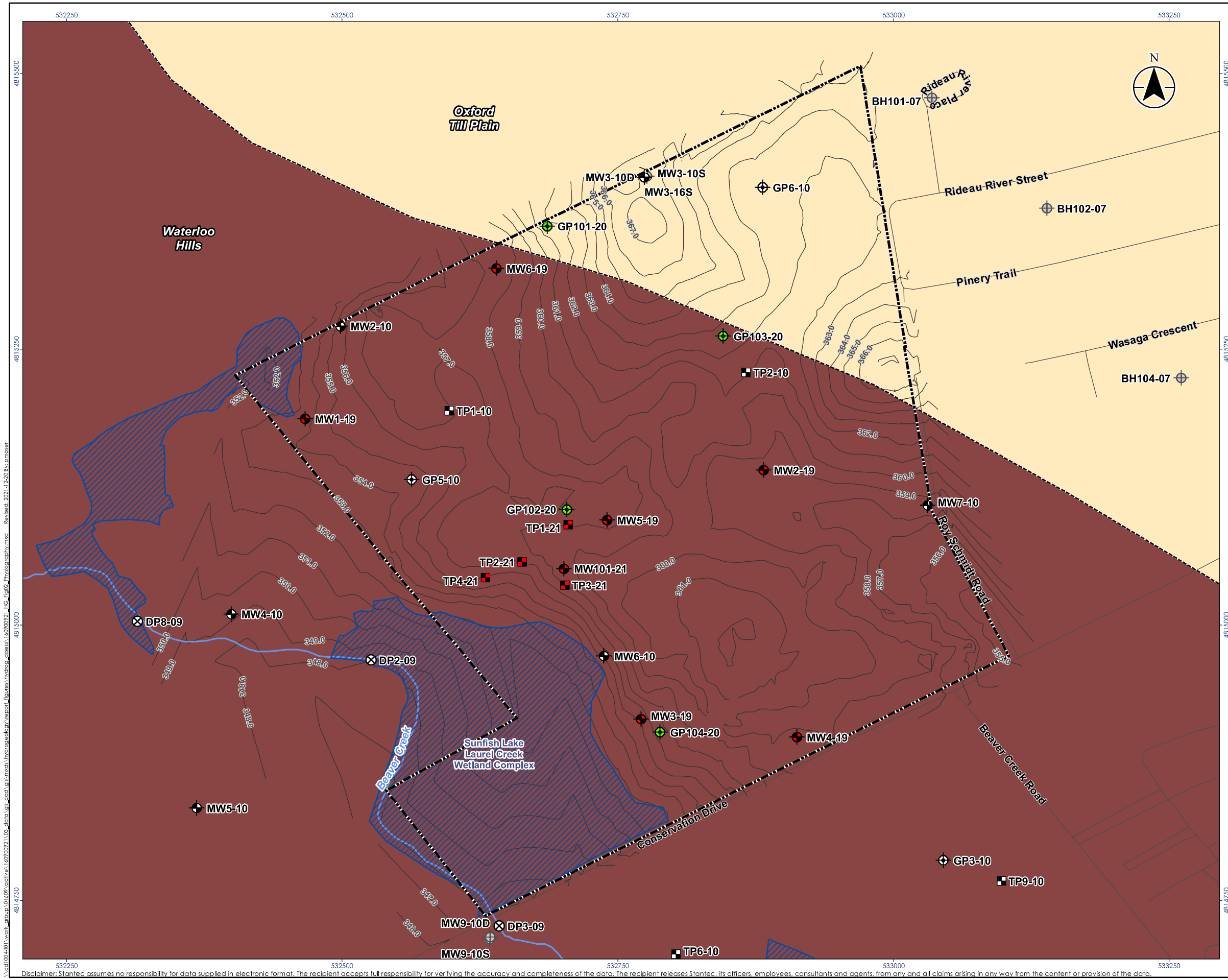
Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
1

Title
Site Plan

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

\\cal101a01.wsatl.stanap.ad\cal101a01\active\160921\09_data\gis_cad\gis\mxds\Hydrogeology\report_figures\Hydrogeology_assess\160921_HG_Fig01_SitePlan.mxd Revised: 2021-12-20 By: prmoser



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

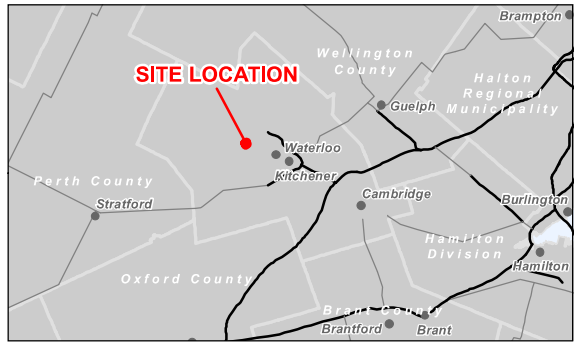
- 6: Till Plains (Drumlinized)
- 4: Kame Moraines

0 100 200 metres

1:3,500 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2017.
3. Orthoimagery © First Base Solutions, 2019. Imagery Date, 2018.
4. Chapman, L.J. and Putnam, D.F. 2007. Physiography of southern Ontario; Ontario Geological Survey, Miscellaneous Release—Data 228.



Project Location
Waterloo, ON

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

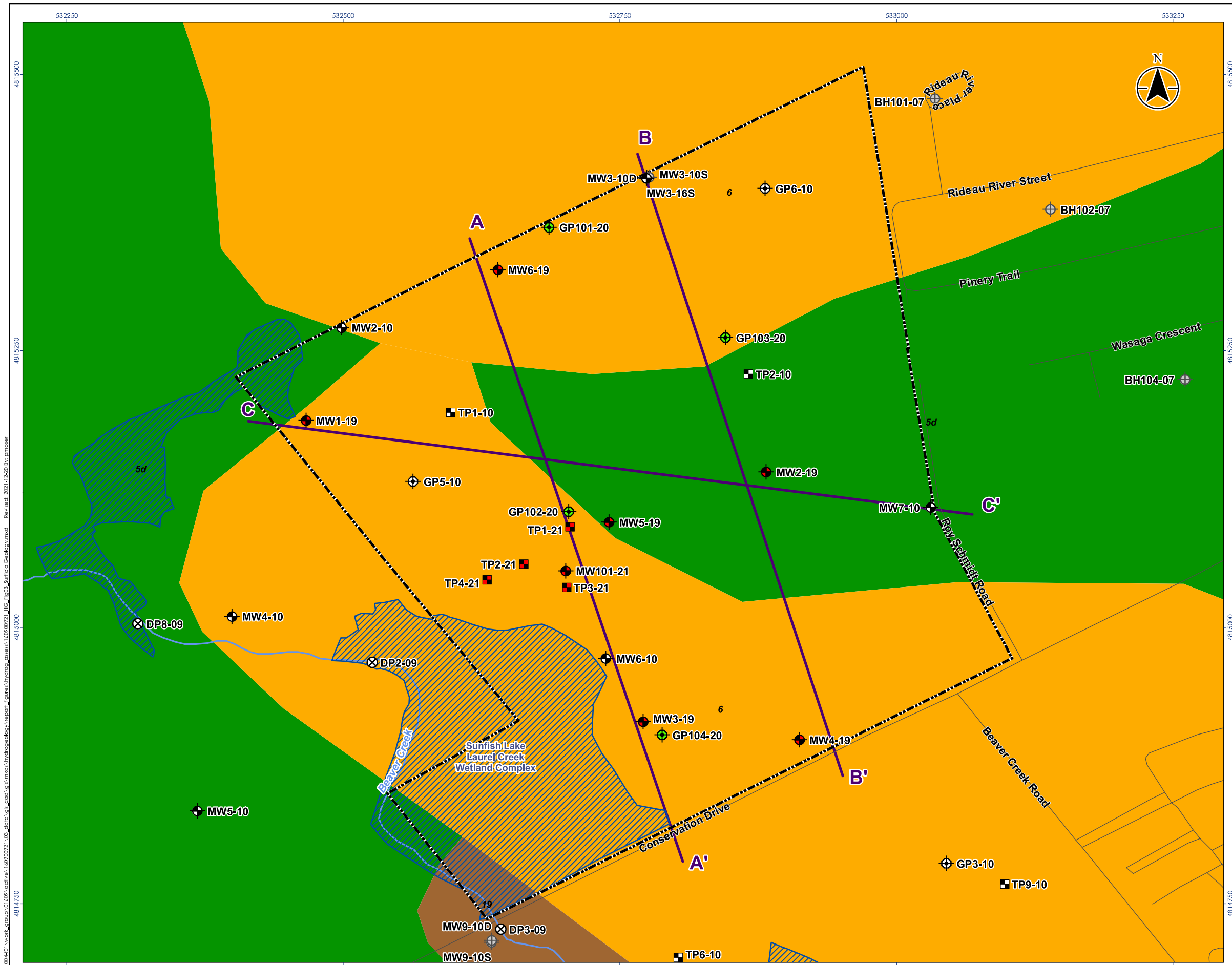
Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
2

Title
Physiography and Topography

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

\\cd1004401\work_group\01499\active\160900921\03_data\gis_cad\gis\mxds\hydrogeology report\figures\physio_topo\160900921_H15_Fig02_Physiography.mxd Revised: 2021-12-20 By: pmoser



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

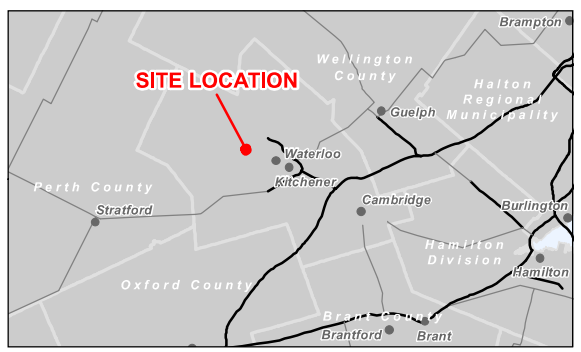
- 19: Modern alluvial deposits
- 6: Ice-contact stratified deposits (AFB1)
- 5d: Glaciolacustrine-derived silty to clayey till (ATB1)

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

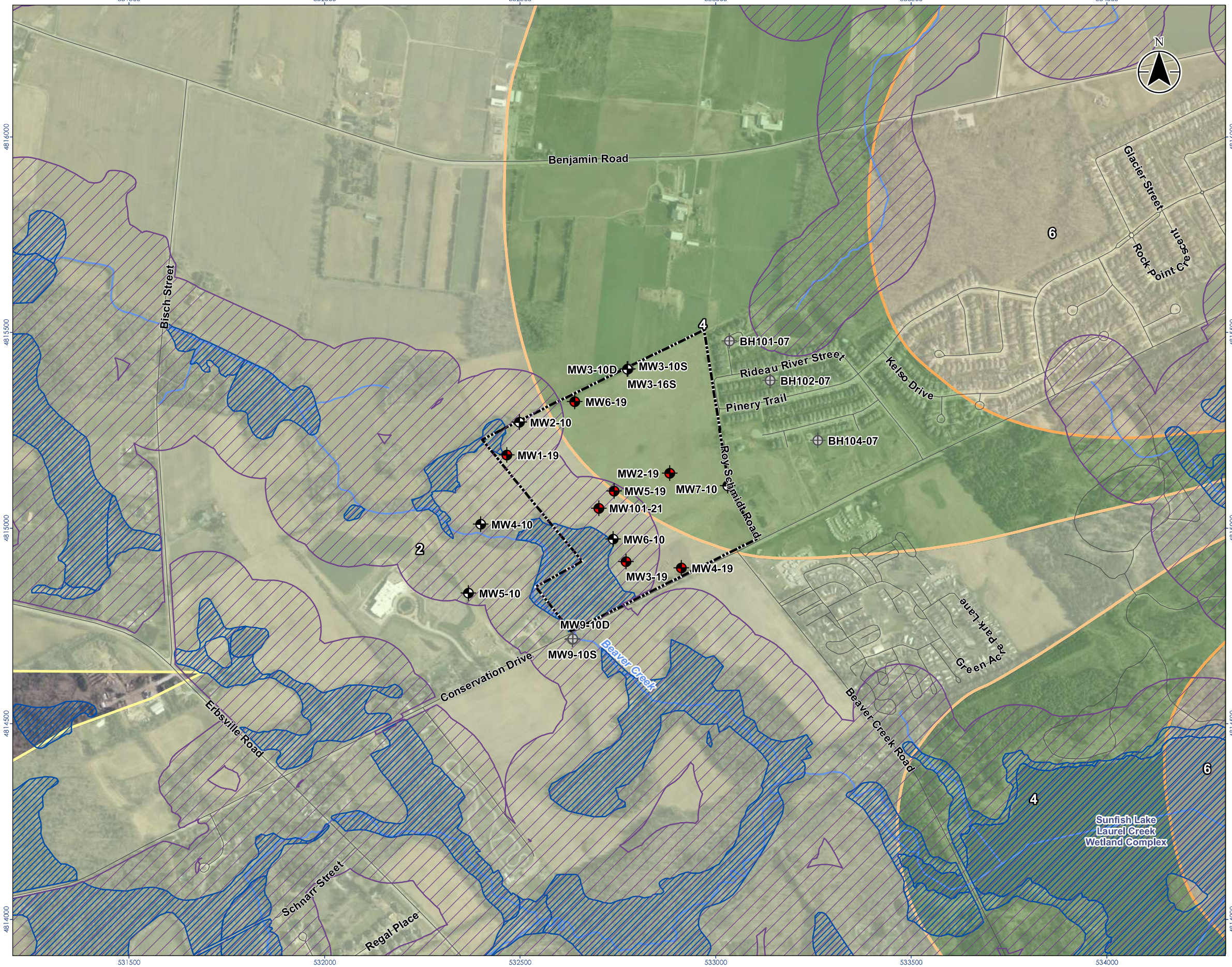
Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
3

Title
Surficial Geology

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

C:\1160900401 work groups\01499 active\160900921\03_data\gis_cad\gis\mxds\hydrogeology report figures\hydrogeology assess\160900921_HG_Fig03_SurficialGeology.mxd Revised: 2021-12-20 By: prmoore



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

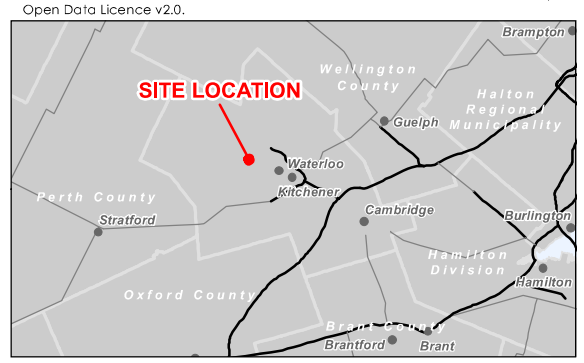
- 10
- 8
- 6
- 4
- 2

0 250 500 metres

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

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
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 2021-12-12

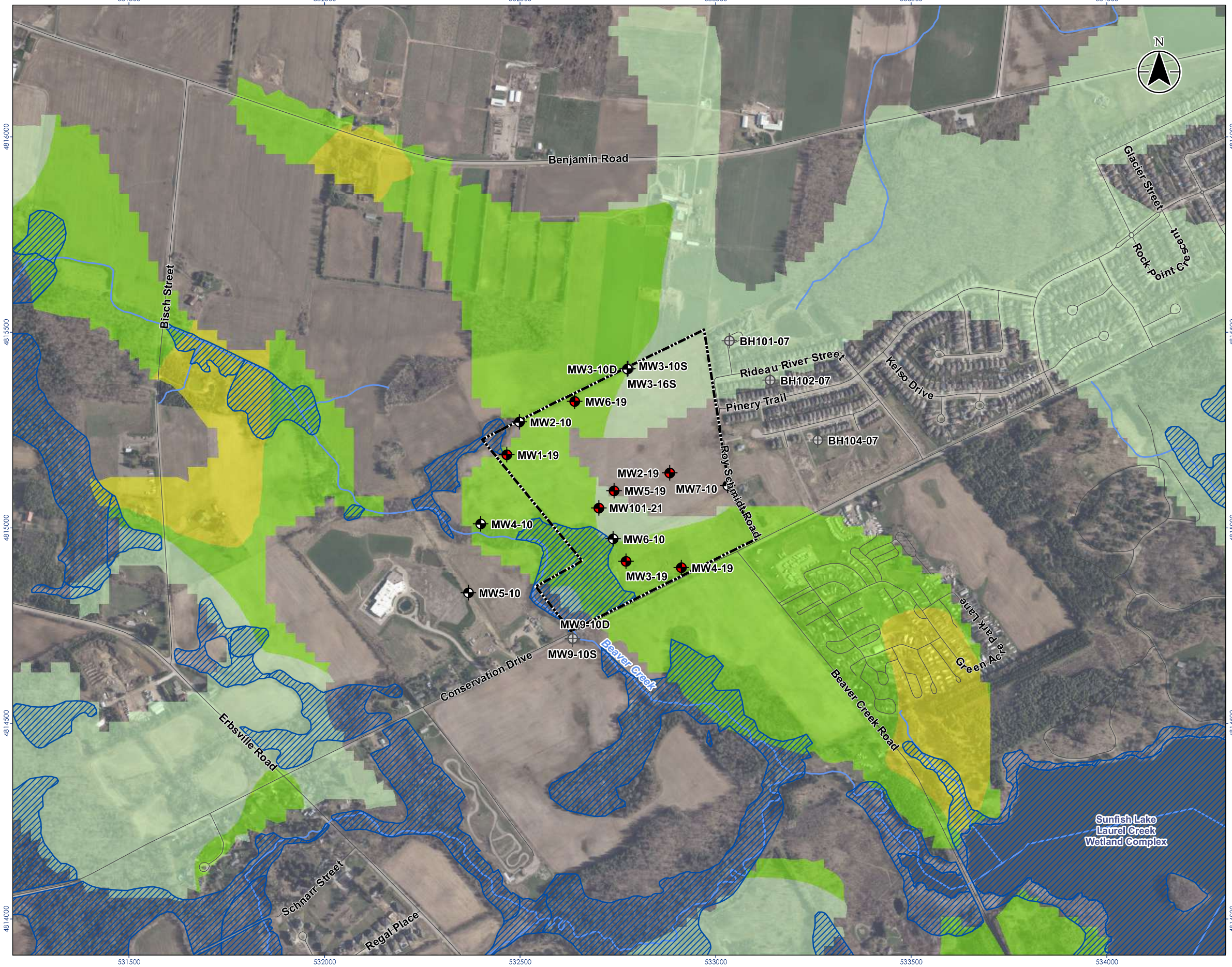
Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
4

Title
Source Water Protection – Wellhead Protection Areas

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

\\cd1004-01\work_group\01\active\160900921\03_data\gis_cad\gis\mxds\Hydrogeology report_figures\Hydrogeology report_figures\160900921_HG_Figure4_Source_Water_Protection_Wellhead_Protection_Areas.mxd Revised: 2021-12-20 By: pmosser



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

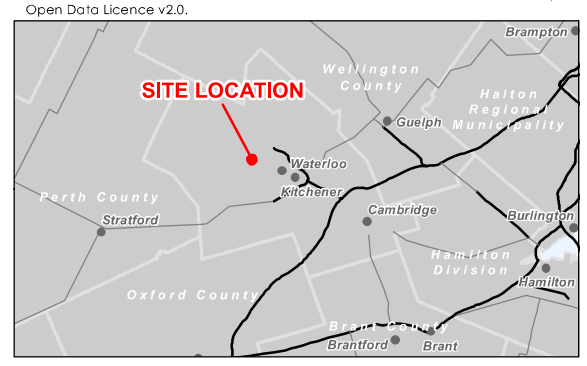
- 2
- 4
- 6

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

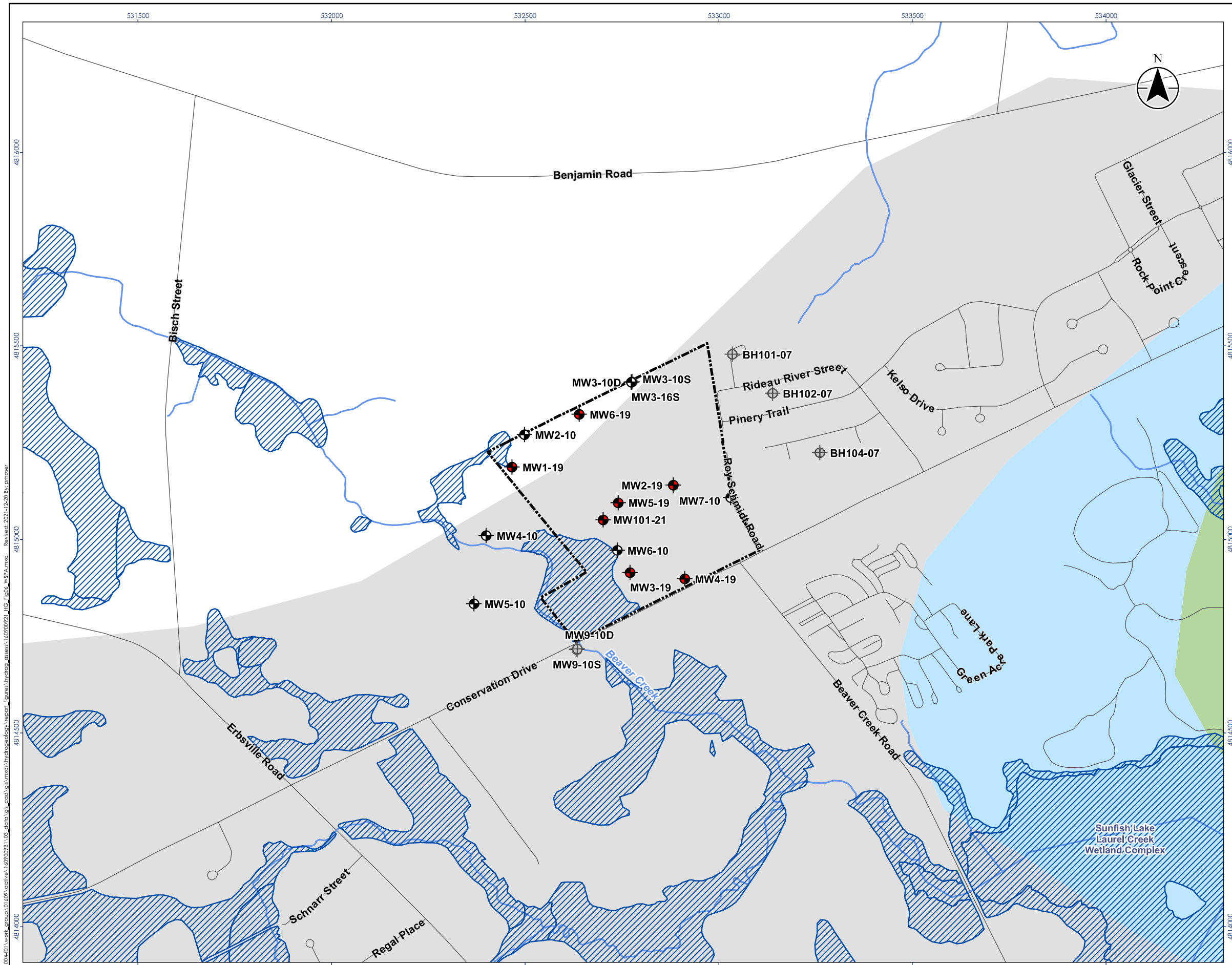
Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
5

Title
Source Water Protection – Significant Groundwater Recharge Area

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

\\cd1004-001\work_group\01\159\active\160900921\03_data\gis_cad\gis\mxds\hydrogeology\report_figures\hydrogeology_report_figures_Recharge.mxd Revised: 2021-12-20 By: pmosse



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

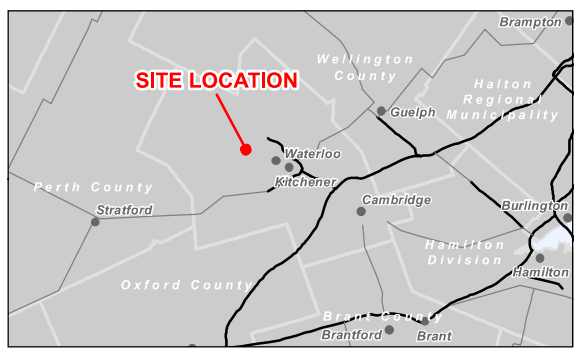
- WPSA-4
- WPSA-6
- WPSA-7
- WPSA-8

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

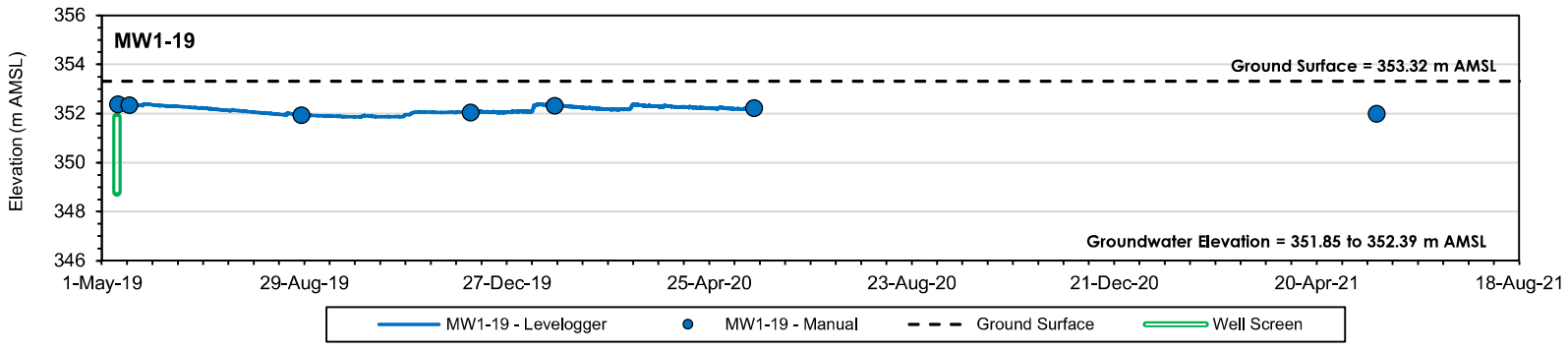
Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

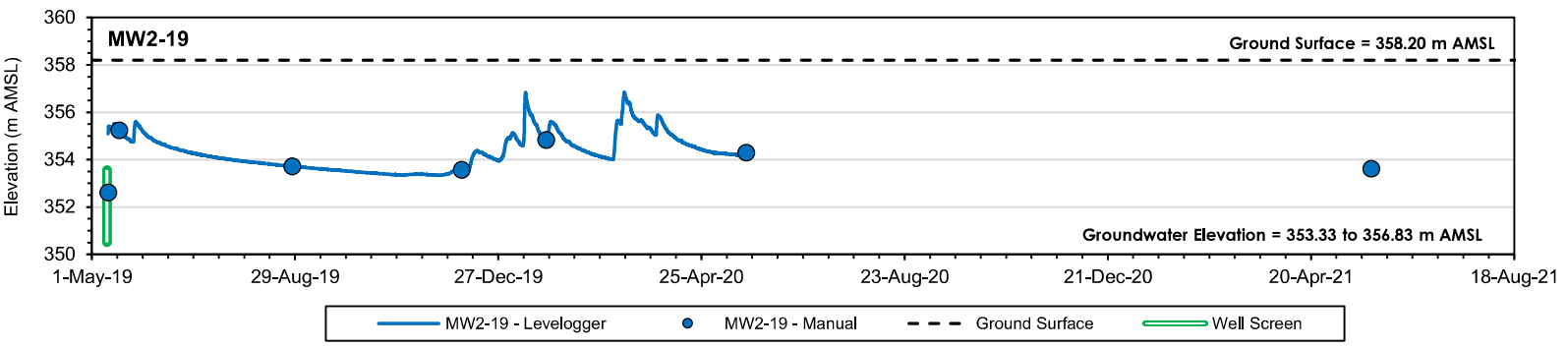
Figure No.
6

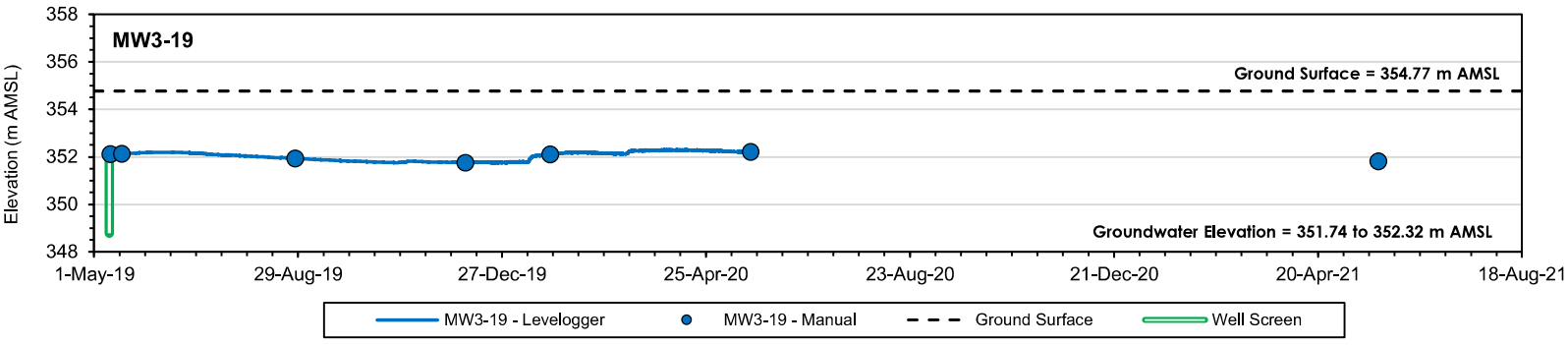
Title
Wellhead Protection Sensitivity Areas

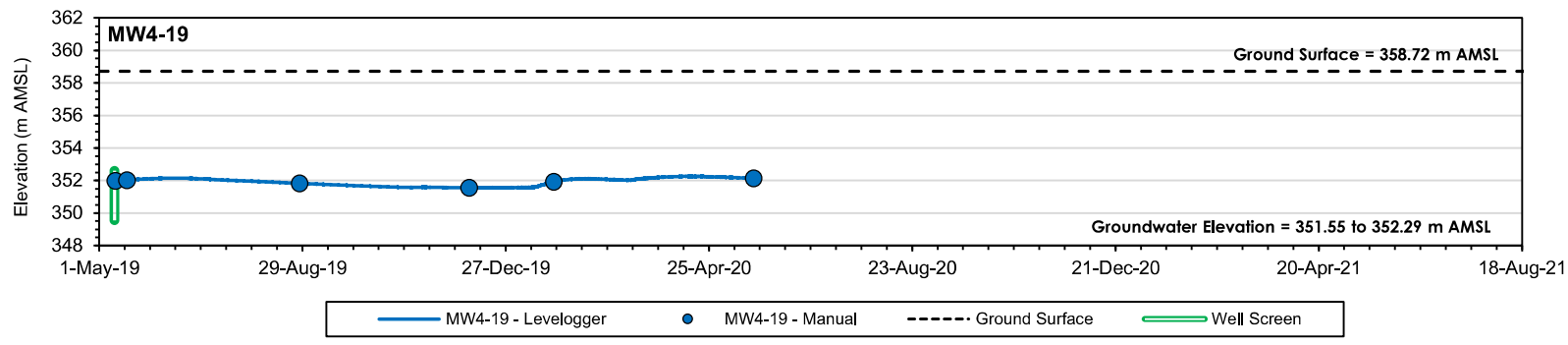
Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

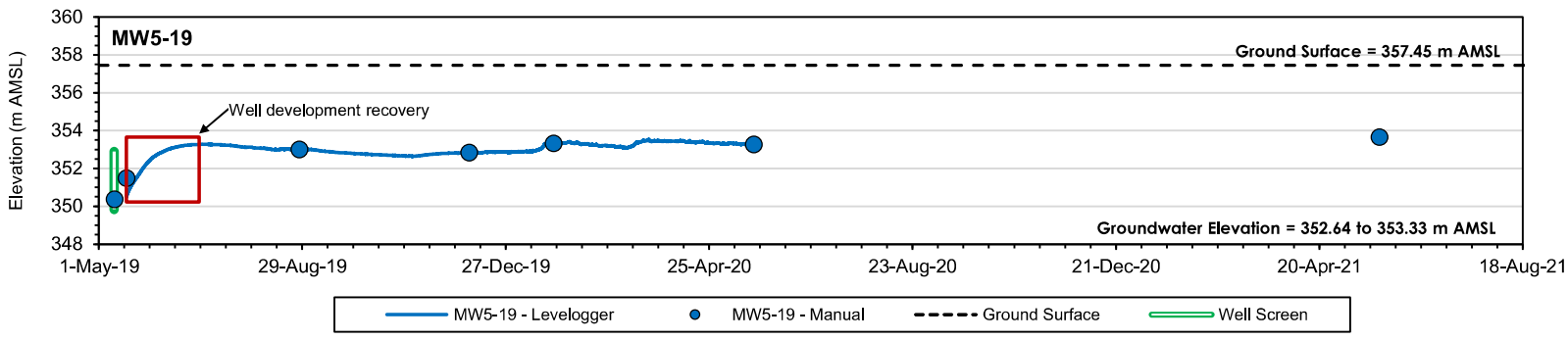
C:\1070401 work group\01699 active\160900921\03_data\gis_cad\gis\mxds\hydrogeology report figures\hydrop_assess\160900921_HG_Fig06_WSPA.mxd Revised: 2021-12-20 By: pmoser

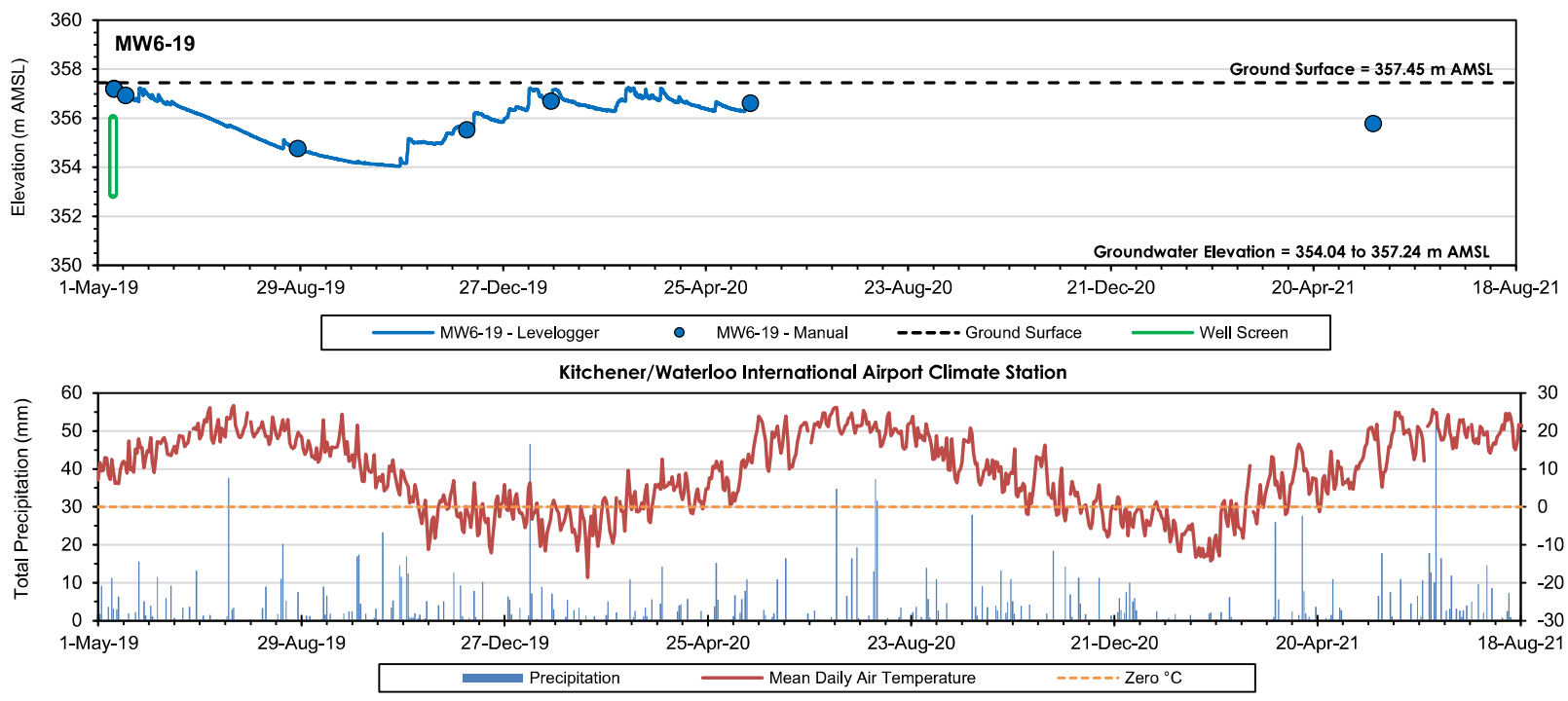












Notes

(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

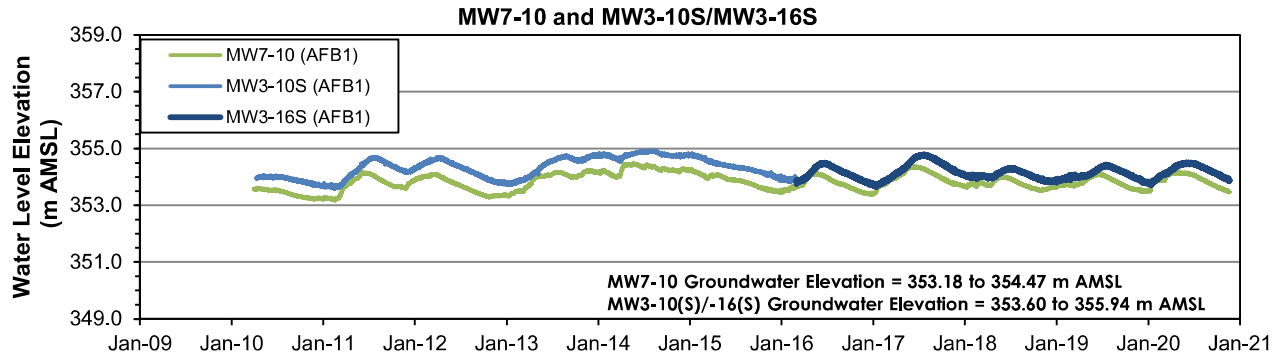
Hydrogeological Assessment

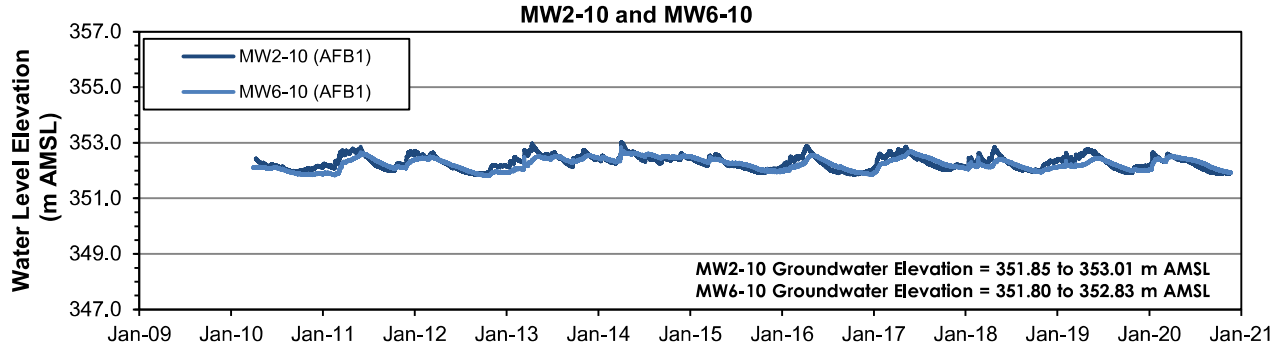
Figure No.

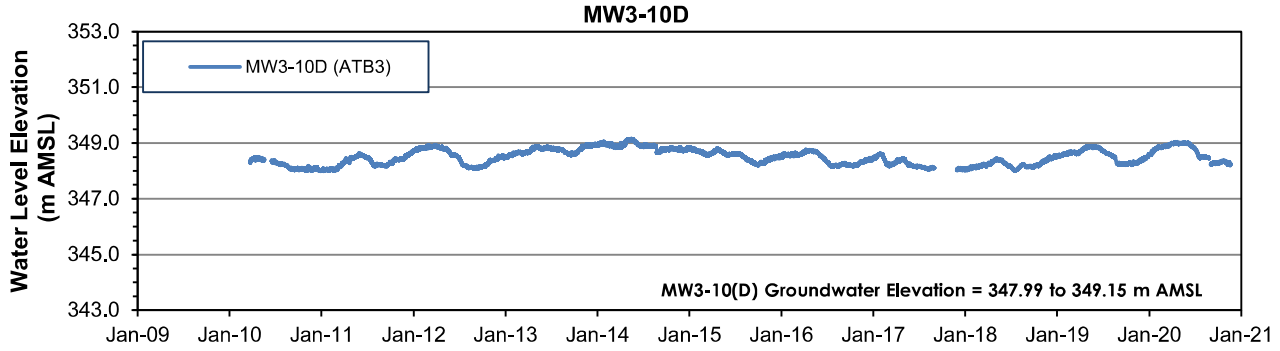
7

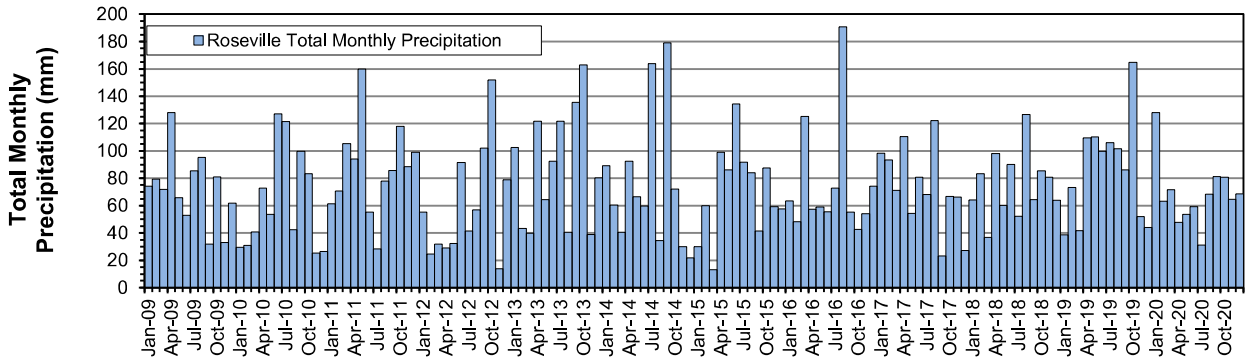
Title **HYDROGRAPHS**

MW1-19 to MW6-19









Source

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

Client/Project

2115881 ONTARIO LIMITED
556, 560 & 576 CONSERVATION DRIVE, WATERLOO
HYDROGEOLOGICAL ASSESSMENT

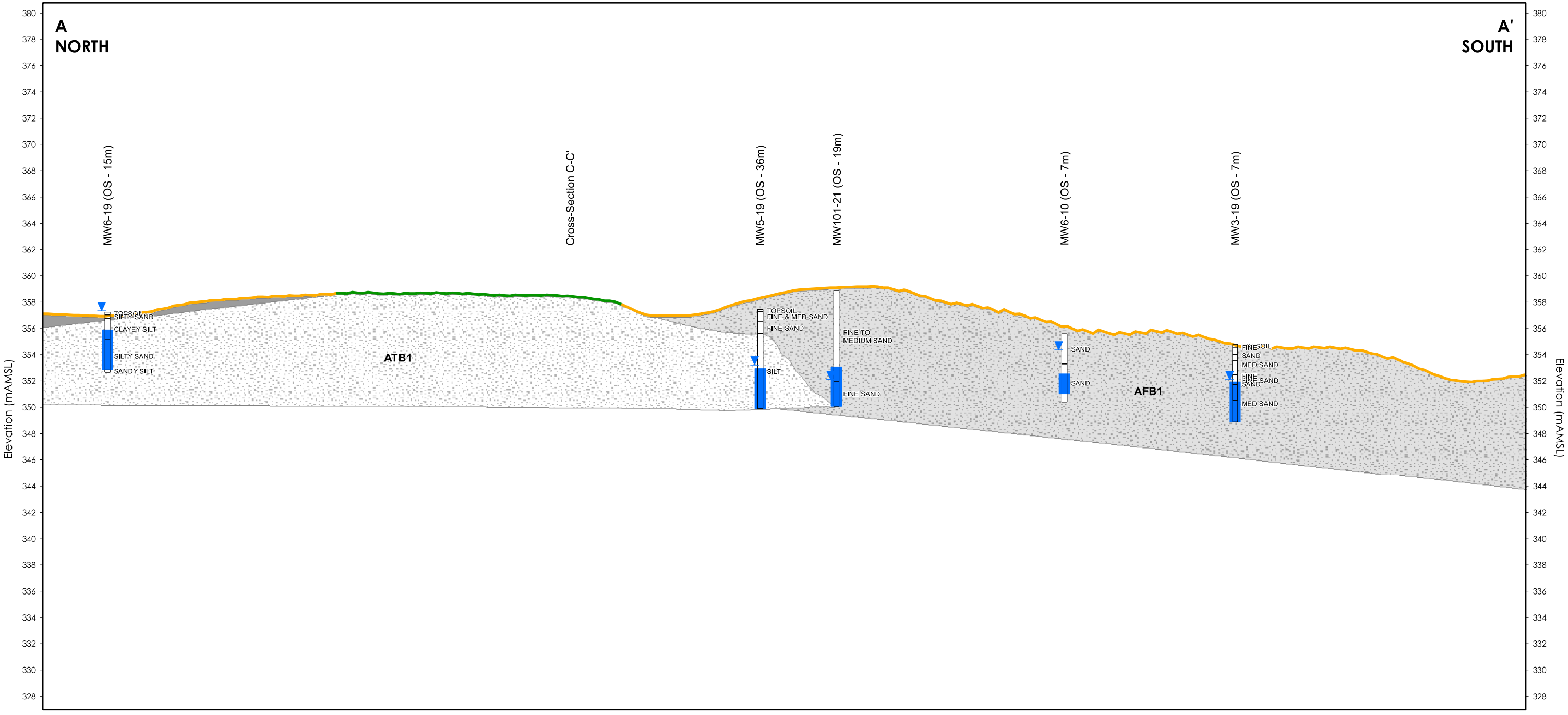
Figure No.

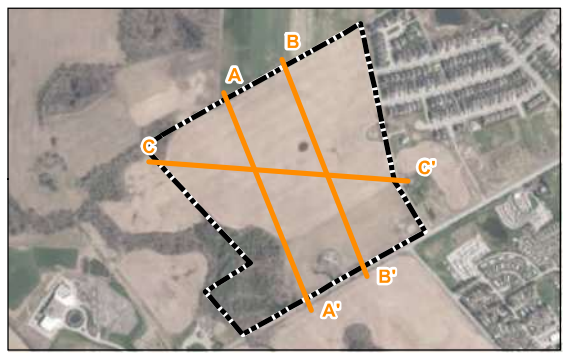
8

Stantec

Title

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





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.

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

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'

C:\cad\160401\work_group\01\609\active\160900921\100_data\gis_cad\gis\mxds\hydrogeology\report_figures\hydrog_assess\160900921_HG_fig09_xsecAA.mxd Revised: 2021-12-20 By: pmoser

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)

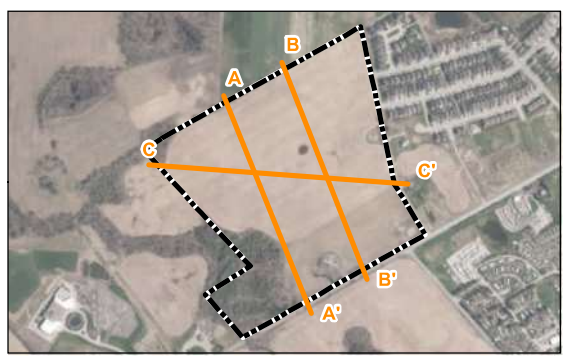
TOPSOIL
SAND
SILT
SAND
SILT & SAND
SILTY CLAY
SILT
SILTY
CLAY TILL
SAND & SILT
SILTY
SAND TILL

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.

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.
10

Title
Cross-Section B-B'

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

\\cd1004-01\work_group\01.609\active\160900921\03_data\gis_cad\gis\mxds\hydrogeology report_figures\Hydro_cases\160900921_HG_Fig10_xsecBB.mxd Revised: 2021-12-20 By: pmoser

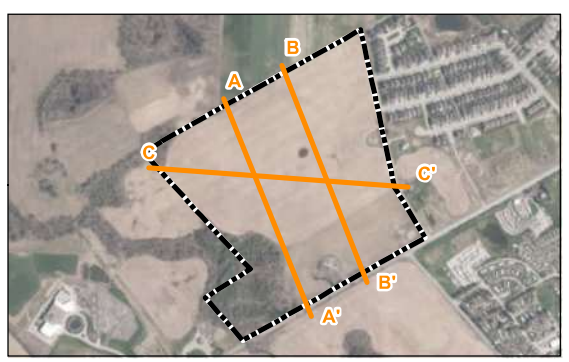
C
WEST

C'
EAST

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

Elevation (mAMSL)
388 386 384 382 380 378 376 374 372 370 368 366 364 362 360 358 356 354 352 350 348 346 344 342 340 338 336 334 332 330 328



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.

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.
11

Title
Cross-Section C-C'

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

\\cal1004-f01\work_group\01609\active\160900921\03_data gis_cad\gis\mxds\hydrogeology\report_figures\hydrog_zones\160900921_HG_Fig11_xsecCC.mxd Revised: 2021-12-20 By: pmoser



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

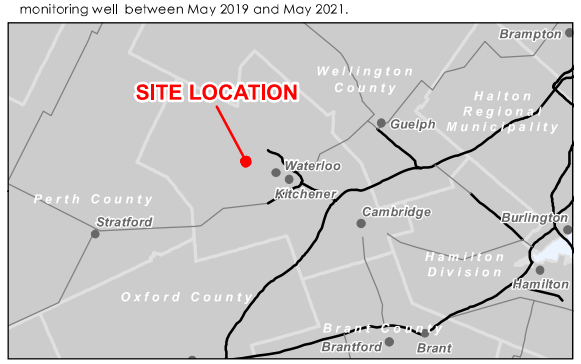
- 19: Modern alluvial deposits
- 6: Ice-contact stratified deposits (AFB1)
- 5d: Glaciolacustrine-derived silty to clayey till (ATB1)

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

160900921 REVA
Prepared by PRM on 2021-12-21
Technical Review by GW on 2021-12-21

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

Figure No.
12

Title
High Groundwater Elevations

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

C:\1070401 work group\01609 active\160900921\03_data\gis_cad\gis\mxds\hydrogeology report figures\hydrogeology_assess\160900921_HG_Fig12_HighGWElev.mxd Revised: 2021-12-21 By: prmoser

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

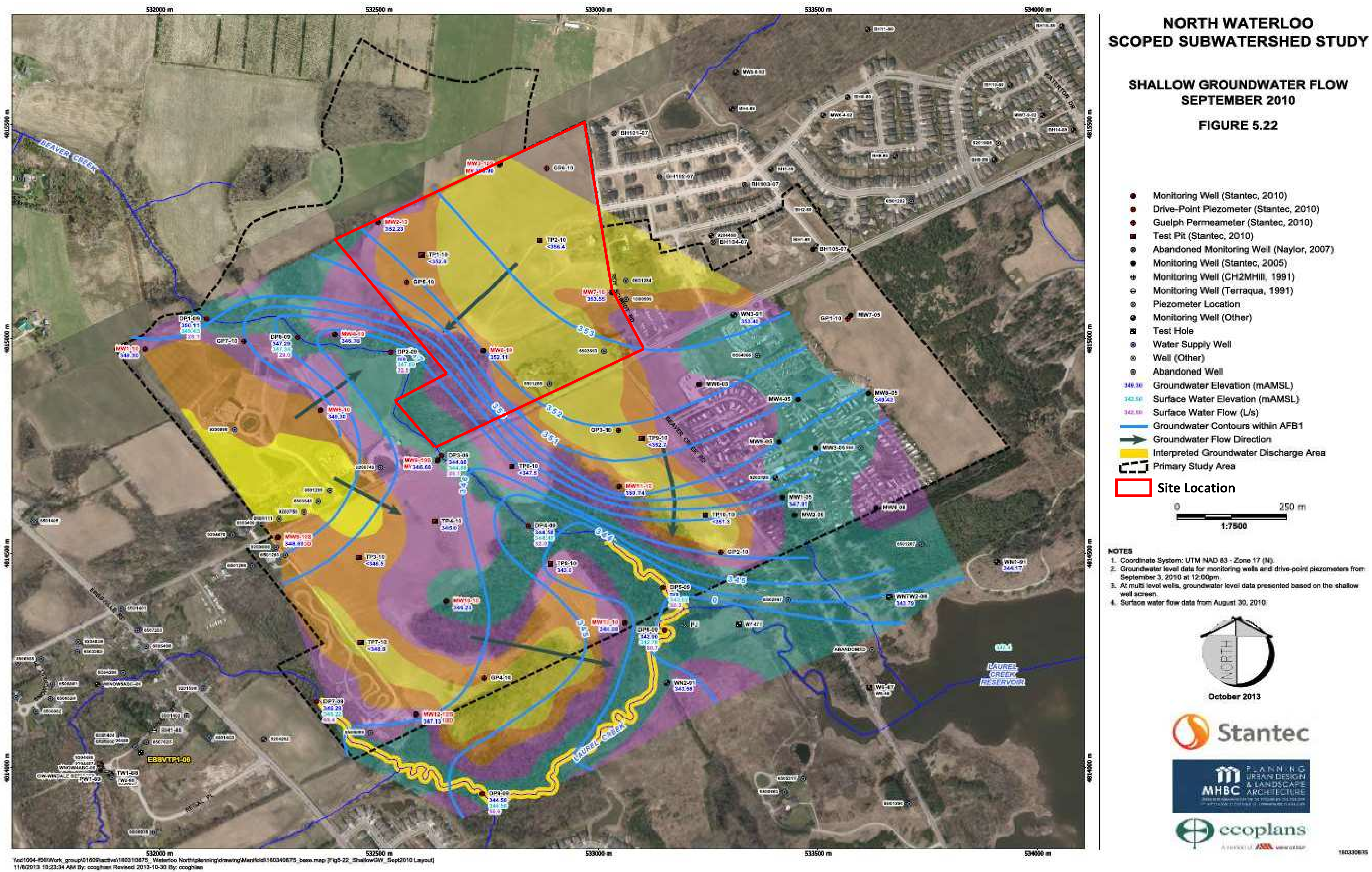
Ratio of Mean Measured Infiltration Rates[1]	Safety Correction Factor[2]
≤ 1	2.5
1.1 to 4.0	3.5
4.1 to 8.0	4.5
8.1 to 16.0	6.5
16.1 or greater	8.5

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.

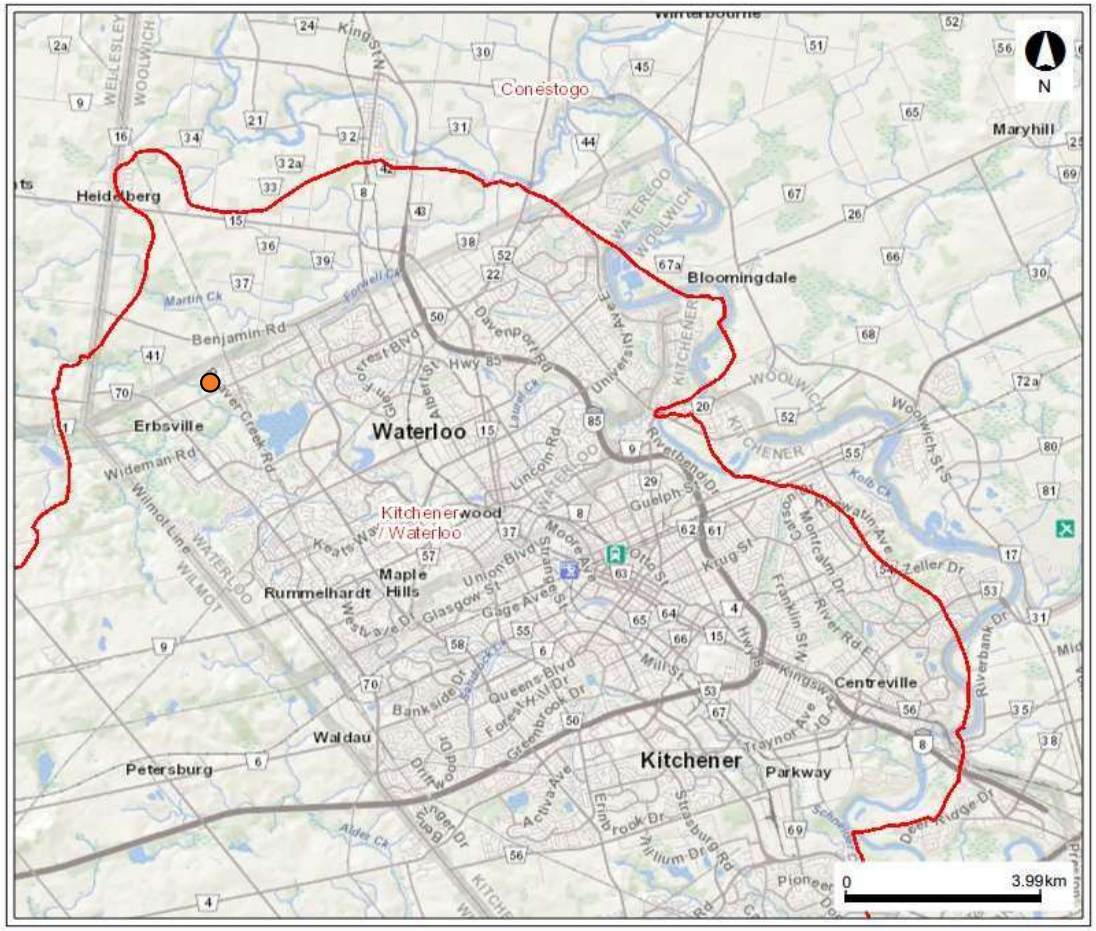
APPENDIX D:
North Waterloo Scoped Subwatershed Study – Groundwater Flow Mapping



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



Ontario © Queen's Printer for Ontario, 2021

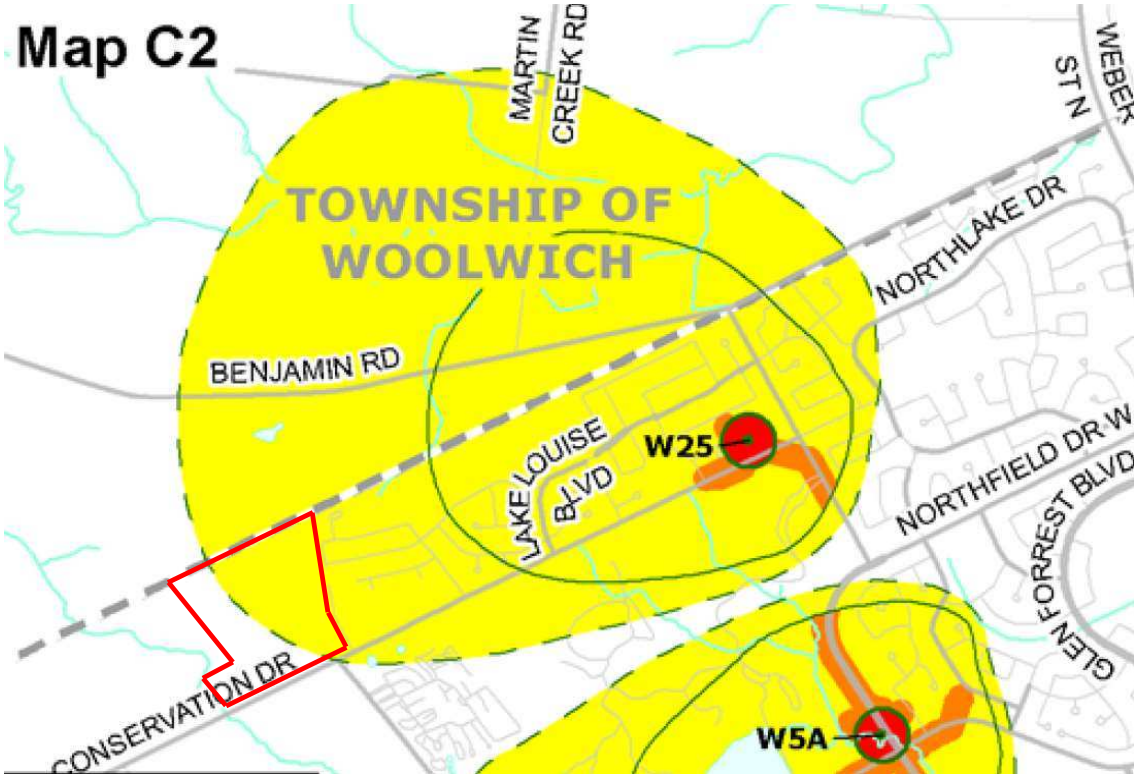
Map Created: 12/12/2021
Map Center: 43.47208 N, -80.51012 W

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

Stantec

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

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								Concrete
			SILTY SAND some organics, light brown	0.23 349.31			1	SS	0-0-2-2 (2)	10" 42%		
			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 becoming light greyish brown at 2.3 m BGS	1.52			3	SS	0-1-2-2 (3)	15" 63%		
			becoming wet at 2.8 m BGS	347.02			4	SS	0-0-0-0 (0)	23" 96%		Top of sand (2.4 m BGS)
10			SILTY SAND fine grained, light brown, wet	3.05			5	SS	0-0-0-0 (0)	21" 88%		Top of screen (3.1 m BGS) No.2 Silica Sand
	4				AFB1 / AFB2	Upper / Middle Moraine Stratified Sediments and Equivalents						No.10 Slot PVC screen 50 mm diameter
15			SAND medium grained, light brown/grey, wet	345.29 4.78 344.89			6	SS	2-2-3-5 (5)	21" 88%		Bottom of screen (4.6 m BGS)
			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

Stantec

Sheet 1 of 1

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

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 = 0.96 m
0	0		Ground Surface	355.56								
			TOPSOIL organics and fine sand, very dark brown, very moist	0.00 355.25								Concrete
			SAND fine grained, trace gravel, dark brown, loose, moist	0.30			1	SS	0-1-1-4 (2)	16.5" 69%		
			becoming brown, very moist, very loose at 0.9 m BGS				2	SS	0-1-0-1 (1)	10.5" 44%		52 mm Schedule 40 PVC casing
5			fine to medium grained sand beginning at 1.5 m BGS				3	SS	0-0-0-0 (0)	13" 54%		Holeplug
	2		becoming grey-brown at 2.3 m BGS		AFB1 / AFB2	Upper / Middle Moraine Stratified Sediments and Equivalents	4	SS	0-0-1-7 (1)	n/a		Top of sand (2.4 m BGS)
10			becoming wet at 3.1 m BGS				5	SS	4-5-8-8 (13)	n/a		Top of screen (3.1 m BGS) No.2 Silica Sand
	4											No.10 Slot PVC screen 50 mm diameter
15							6	SS	3-9-9-12 (18)	n/a		Bottom of screen (4.6 m BGS)
				350.38								
			End of Borehole	5.18								
20	6											
25	8											

Screen Interval: 3.05 - 4.57 m BGS
Sand Pack Interval: 2.44 - 4.57 m BGS
Well Seal Interval: 0.30 - 2.44 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
n/a - not available

mAMSL - metres above mean sea level
mBGS - metres below ground surface

Drawn By/Checked By: OR/LV

Stantec

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 fine sand, dark brown, loose, wet	0.00 366.53			1	SS	1-10-11-3 (21)	15" 63%
			SAND fine grained, brown, loose, wet	0.30			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 some fine grained sand, brown, firm to stiff, wet	3.86			6	PQ	n/a	58" 100%
15										
				361.25						
			SAND fine grained, brown, loose	5.59			7	PQ	n/a	58" 97%
20	6		fine to medium grained, some coarse grained, brown, loose, wet				8	PQ	n/a	50" 83%
25	8						9	PQ	n/a	57" 97%
30										
	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							
			some silt beginning at 17.7 m BGS				15	PQ	n/a	51" 85%
60	18			348.09						
			SILT AND SAND fine grained sand, brown, loose, wet	18.75			16	PQ	n/a	48.5" 81%
65	20									
			layer of fine sand with silt, stiff, brownish grey at 20.3 to 21.8 m BGS				17	PQ	n/a	52" 87%
70										
	22		some clay, grey beginning at 21.8 m BGS				18	PQ	n/a	41" 68%
75				343.52						
			SILTY CLAY grey, stiff, wet	23.32			19	PQ	n/a	46" 77%
	24									
80							20	PQ	n/a	56" 93%
85	26			340.47						
			SILT some fine sand, trace to some clay, greyish brown, soft, wet	26.37	ATB2	Middle Maryhill Till and Equivalents	21	PQ	n/a	57" 95%
90	28									

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 40 PVC casing
Holeplug
52 mm Schedule 80 PVC casing
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)
Bentonite Grout

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

Stantec

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									
100				336.15			23	PQ	n/a	59" 97%
			SILTY CLAY TILL trace coarse sand and fine gravel, greyish brown, very stiff, wet	30.68						
105	32						24	PQ	n/a	58.5" 98%
110							25	PQ	n/a	52" 88%
	34		trace coarse grained gravel beginning at 34.0 m BGS							
115					ATB3	Lower Maryhill Till and Equivalents	26	PQ	n/a	61" 100%
	36		some coarse sand, fine to coarse gravel, dark brown beginning at 35.5 m BGS				27	PQ	n/a	61" 102%
120			cobble, 0.13 m diameter, at 36.7 m BGS							
125	38						28	PQ	n/a	55" 92%
				327.21						
130			SAND AND SILT some gravel, firm to stiff, wet	39.62 327.04			29	PQ	n/a	60" 100%
	40		SILTY SAND TILL some sand and gravel, grey, very hard, moist	39.80	ATC1	Upper/ Main Catfish Creek Till				
135							30	PQ	n/a	60" 100%
				325.23						
	42		End of Borehole	41.61						
140										
145	44									
150										
155	46									
	48									
160										
165	50									
170										
	52									
175										
	54									
180										
185	56									

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

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
10			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
							5	SS	2-5-6-9 (11)	0" 0%		Bottom of screen (3.0 m BGS)
			End of Borehole	3.66								
15	4											
20	6											
25	8											

Screen Interval: 1.52 - 3.05 m BGS
Sand Pack Interval: 0.91 - 3.05 m BGS
Well Seal Interval: 0.15 - 0.91 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
n/a - not available

Drawn By/Checked By: OR/LV

Stantec

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
0	0		Ground Surface	351.08								
			TOPSOIL dark brown, moist	0.00 350.93								Concrete
			CLAYEY SILT trace organics, light reddish brown, firm to stiff	0.15			1	SS	0-2-4-8 (6)	18" 75%		Holeplug
							2	SS	2-3-4-6 (7)	11" 46%		
5			some gravel light brown beginning at 1.5 m BGS seams of medium grained sand beginning at 1.7 m BGS		ATB1	Upper Maryhill Port Stanley Till and Equivalents						52 mm Schedule 40 PVC casing
	2						3	SS	2-4-12-7 (16)	24" 100%		Top of sand (2.1 m BGS)
			layer of coarse gravel at 2.1 m BGS trace sand and gravel at 2.3 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								
	4				AFB1 / AFB2	Upper / Middle Moraine Stratified Sediments and Equivalents	5	SS	10-14-12-8 (26)	14" 58%		No.2 Silica Sand
15				346.51								No.10 Slot PVC screen 50 mm diameter
			End of Borehole	4.57								Bottom of screen (4.3 m BGS)
												Natural cave
20	6											
25	8											

Screen Interval: 2.74 - 4.27 m BGS
Sand Pack Interval: 2.13 - 4.27 m BGS
Well Seal Interval: 0.30 - 2.13 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
n/a - not available

Drawn By/Checked By: OR/LV

Stantec

STANTEC BOREHOLE AND WELL 160330875 - DPS.GPJ EQUIS DATA TEMPLATE.GDT 2/1/11 MJFRASER

Monitoring Well: MW6-10

Project:	North Waterloo Subwatershed Study	**Drilling method:**	Track Mount, CME55, Hollow Stem Auger
Client:		**Date started/completed:**	18-Mar-2010
Location:	North Waterloo, ON	**Ground surface elevation:**	355.58 m AMSL
Number:	160340875	**Top of casing elevation:**	356.48 m AMSL
Field investigator:	A.Vandenhoff	**Easting:**	532737
Contractor:	Pro Core Drilling	**Northing:**	4814972

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS				WELL DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	N Value	Recovery	Diagram	Description
												Stick-up = 0.90 m
0	0		Ground Surface	355.58								
			SAND fine to medium grained,dark brown, loose, moist	0.00			1	SS	3-4-5-5 (9)	13" 54%		Concrete
			becoming reddish brown at 0.8 m BGS				2	SS	2-3-3-3 (6)	14" 58%		52 mm Schedule 40 PVC casing
5			trace gravel beginning at 1.5 m BGS				3	SS	1-1-1-2 (2)	14" 58%		Holeplug
	2			353.29								
			SAND medium grained, trace gravel, light brown, loose, moist	2.29	AFB1 / AFB2	Upper / Middle Moraine Stratified Sediments and Equivalents	4	SS	3-5-5-5 (10)	16" 67%		Top of sand (2.4 m BGS)
10							5	SS	3-3-2-4 (5)	13" 54%		Top of screen (3.1 m BGS) No.2 Silica Sand
	4		some gravel, wet at 3.6 m BGS									No.10 Slot PVC screen 50 mm diameter
15			some coarse grained sand, trace gravel at 4.6 m BGS				6	SS	4-15-20-25 (35)	20" 83%		Bottom of screen (4.6 m BGS)
				350.40								
20	6		End of Borehole	5.18								
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

Stantec

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

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 = 0.93 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	6		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					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)
											Natural Cave
			End of Borehole	350.51 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

Sheet 1 of 1

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

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	0.38						Bentonite Pellets 0 to 1.2 m
	1		reddish orange mottled discolourations at 0.81 m BGS becoming wet at 0.84 m BGS	352.23	2	SS	14" 58%	2-2-3-4 (5)		Water Level 0.93 m BGS 10-May-19
4			MEDIUM SAND loose, greyish brown (10YR 5/2), trace silt/clay, some fine grained sand, trace coarse grained sand, wet	1.09						
			compact at 1.52 m BGS		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							210 mm diameter borehole
8			trace fine gravel, subrounded, beginning at 2.59 m BGS		4	SS	24" 100%	1-6-8-10 (14)		
10	3									No. 2 Silica Sand 1.2 to 4.6 m
					5	SS	21" 88%	4-7-8-8 (15)		No. 10 Slot Schedule 40 PVC Screen 52 mm I.D. 1.5 to 4.6 m
12	4									
14										
16	5				6	SS	24" 100%	3-5-6-9 (11)		
			grading coarser, increase in coarse grained sand at 5.03 m BGS	348.14						
			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 soft, dark brown (10YR 3/3), clayey silt, trace fine grained sand, moist	0.00 358.05					
			CLAYEY SILT soft, dark brown (10YR 3/3), some sand, moist yellowish brown mottling at 0.48 m BGS	0.15	1	SS	24" 100%	2-1-2-2 (3)	
				357.36					
			coarse grained sand and fine gravel present from 0.84 to 0.86 m BGS	0.86					
			SILTY CLAY very soft, yellowish brown (10YR 5/4), trace fine grained sand, poorly graded, moist		2	SS	16" 67%	1-1-1-2 (2)	
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

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						
										Above Ground Casing 0.82 m stick-up
0	0		Ground Surface	354.77						
			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	1	SS	21" 88%	2-2-4-2 (6)		
				354.01						
	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)		
5										Bentonite Pellets 0 to 2.7 m
	2		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)		
				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
				351.72						
10	3		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									
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. 2 Silica Sand 2.7 to 6.0 m 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		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)		
20				348.06						
			End of Borehole	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

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)		
			FINE TO MEDIUM SAND	0.15						
			loose, light brownish grey (10YR 6/2), trace coarse grained sand, trace fine gravel, moist							
				356.51						
			FINE SAND	0.94	2	SS	16" 67%	4-7-5-4 (12)		
			compact, pale brown (10YR 6/3), some silt/clay, moist, laminations of silt/clay with purplish brown discolourations							
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	1.85						Bentonite Pellets 0 to 4.3 m
			dense to very dense, pale brown (10YR 6/3), trace clay and fine grained sand, blocky, moist							
			some fine grained sand at 2.29 m BGS		4	SS	24" 100%	8-14-20-17 (34)		
10										210 mm diameter borehole
			trace coarse grained sand and trace fine gravel beginning at 3.25 m BGS		5	SS	24" 100%	12-18-22-26 (40)		
	4									
15										Water Level 4.53 m BGS 10-May-19
			some clay, greyish brown (10YR 5/2), well graded at 4.57 m BGS		6	SS	24" 100%	8-21-20-27 (41)		
	6									No. 2 Silica Sand 4.3 to 7.6 m
20					7	SS	24" 100%	17-25-32-30 (57)		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
4	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)	
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 SILTY SAND compact, brown (10 YR 5/4), fine grained sand, trace clay, wet	2.08					210 mm diameter borehole
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								
14				352.67					
			SANDY SILT dense, pale brown (10YR 6/3), fine grained sand, trace clay, blocky, moist	4.57					
16	5				6	SS	23" 96%	6-19-19-19 (38)	
			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

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							
			Ground Surface	358.88							Above Ground Casing 0.99 m stick-up
0	0		TOPSOIL (SAND)	0.00							
			Fine grained, trace organics, yellowish brown (10YR 5/4), dry	358.73	1	SS	18" 75%	2-4-9-7 (13)			Cement Seal 0 to 0.3 m
			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								
			Trace fine and coarse gravel starting at 0.76 m		2	SS	17" 71%	3-7-10-8 (17)			
			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
					12	SS	24" 146%	1-5-15/4.4" (15/4.4")			
				350.08							
			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				
14	4				1	GS	
16	5				2	GS	
18							
	6		Water table at 5.7 m BGS End of Test Pit	352.24 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			
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

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							Backfilled with Natural Cave 0 to 4 m
	2						
8							
10	3						
12							
	4		Sample collected from below test pit base	351.83 4.00	2	GS	
14			End of Test Pit				

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

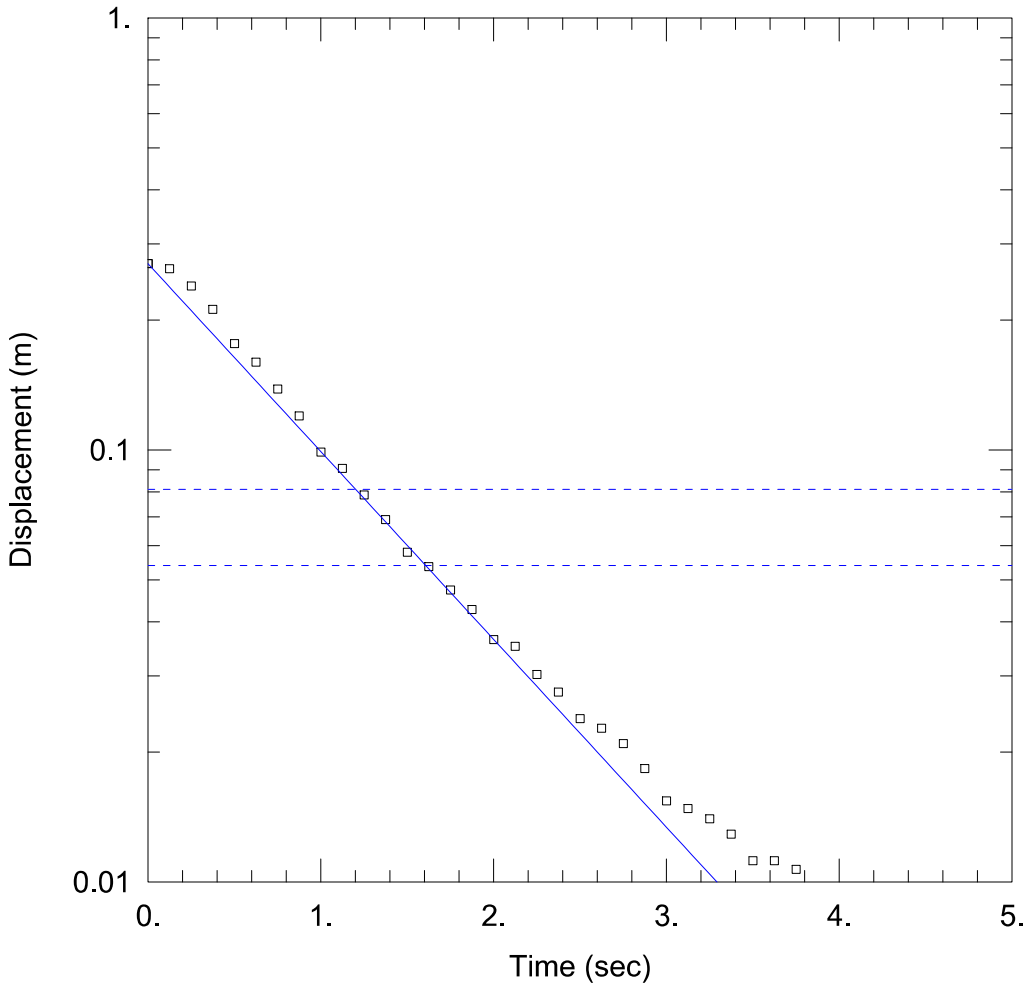
Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
GS - grab sample
n/a - not available

Stantec

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

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

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

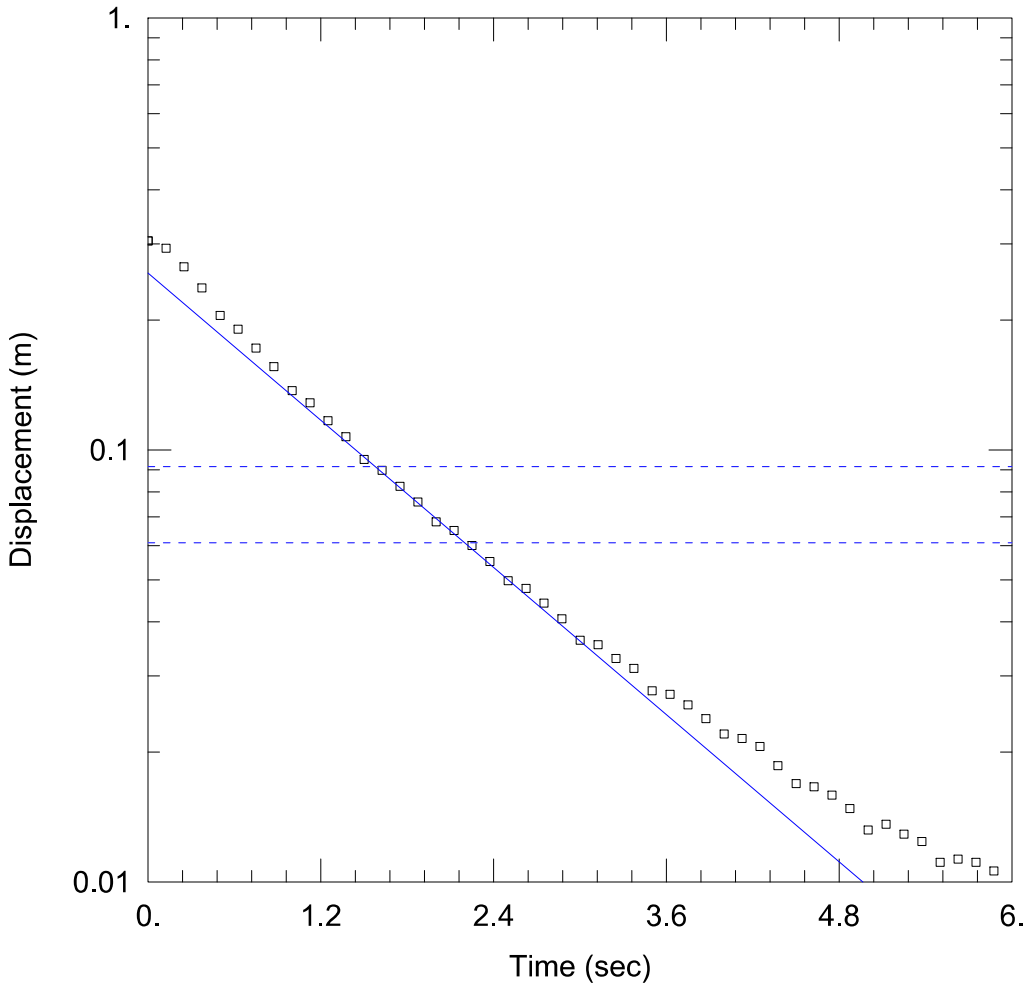
Saturated Thickness: 4.15 m Anisotropy Ratio (Kz/Kr): 0.5

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

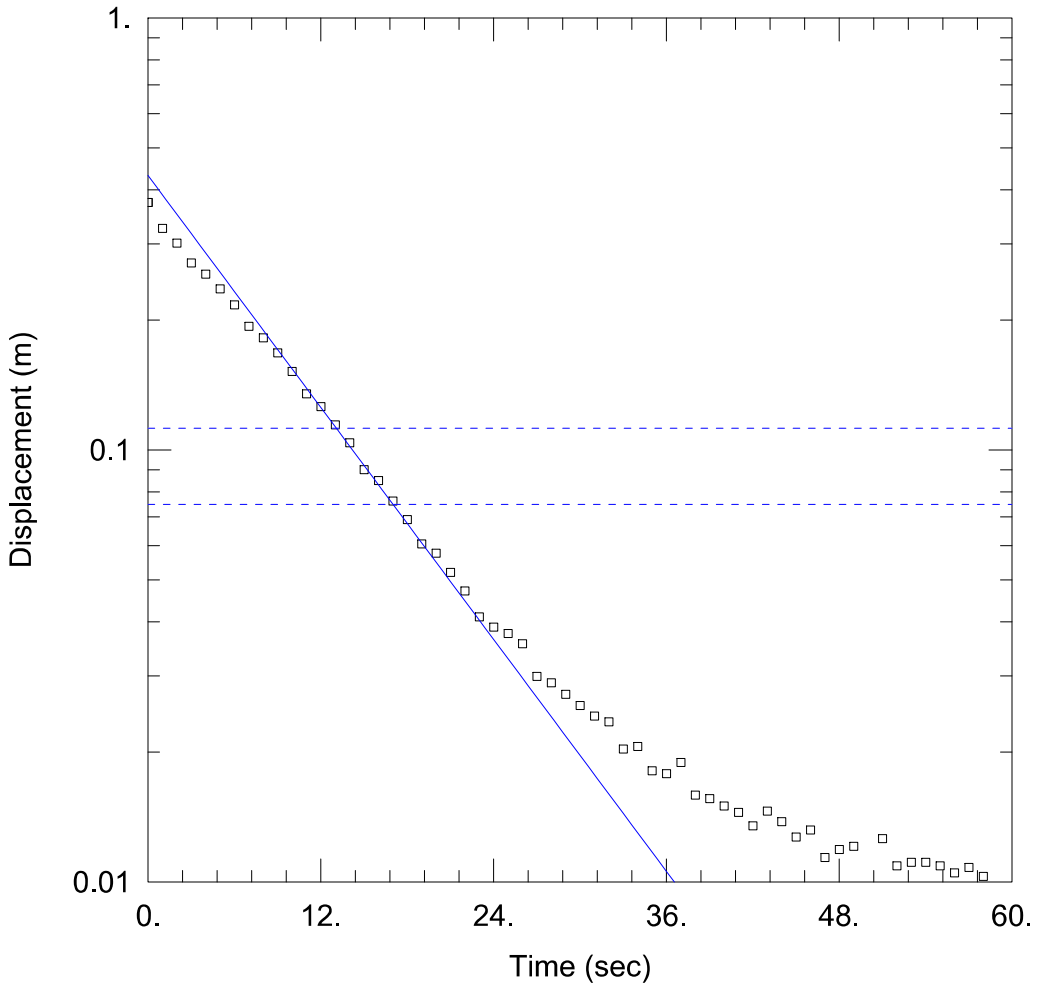
Saturated Thickness: 3.955 m Anisotropy Ratio (Kz/Kr): 0.5

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

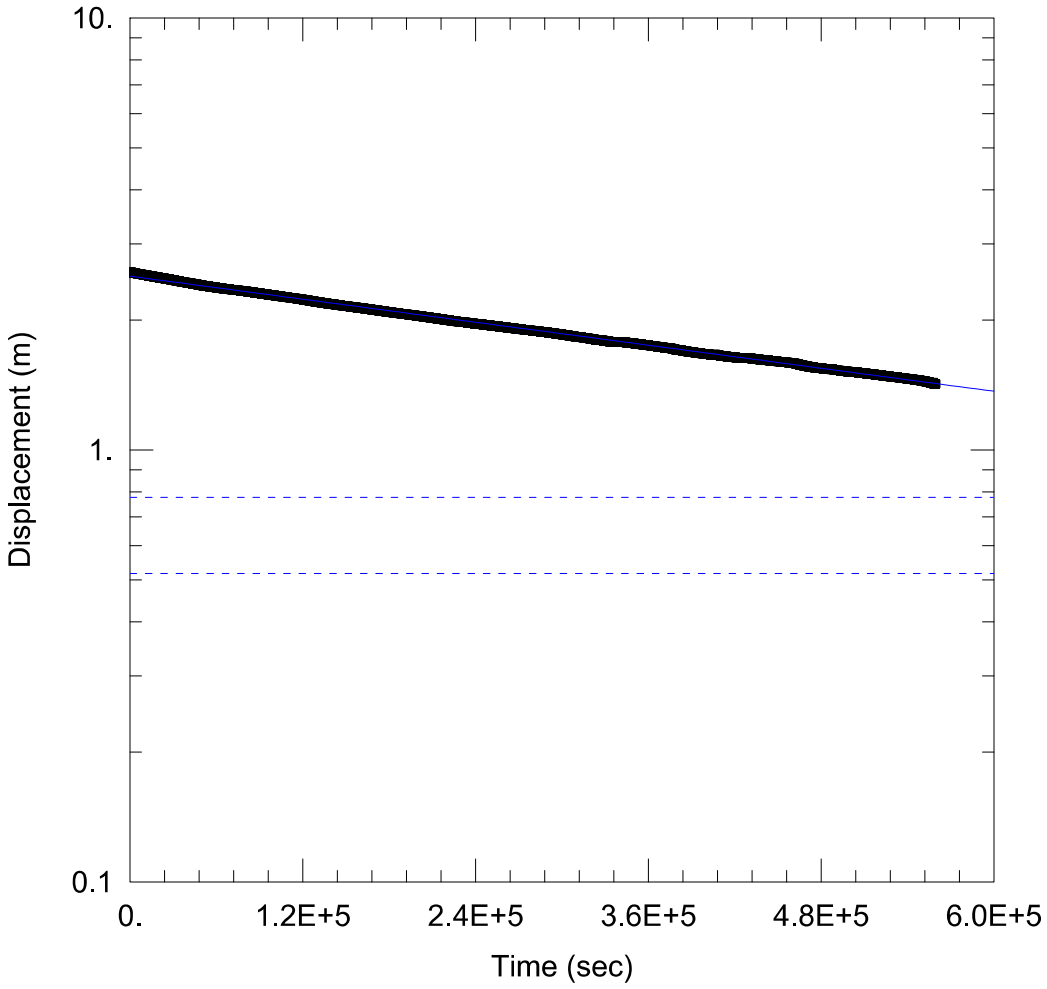
WELL DATA (MW4-19)

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

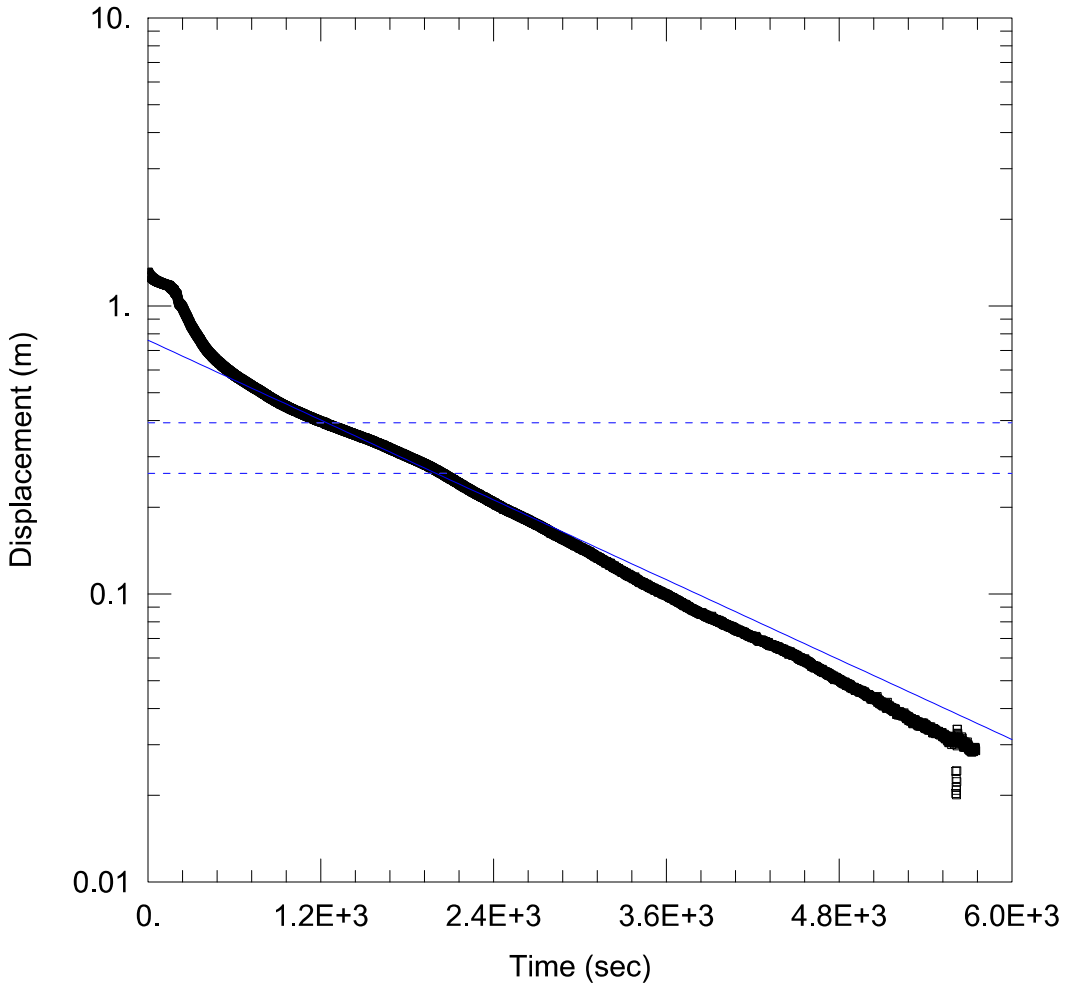
WELL DATA (MW5-19)

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

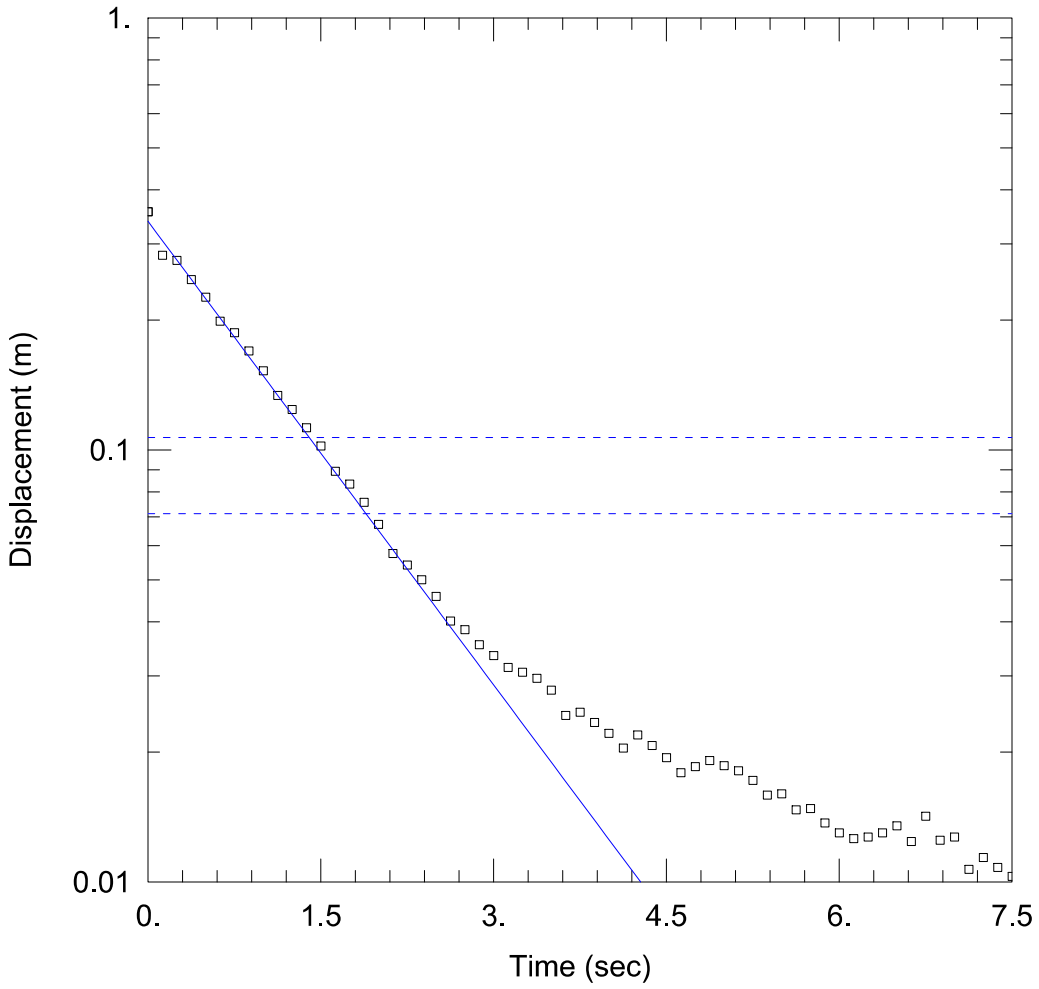
Saturated Thickness: 2.57 m Anisotropy Ratio (Kz/Kr): 0.2

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

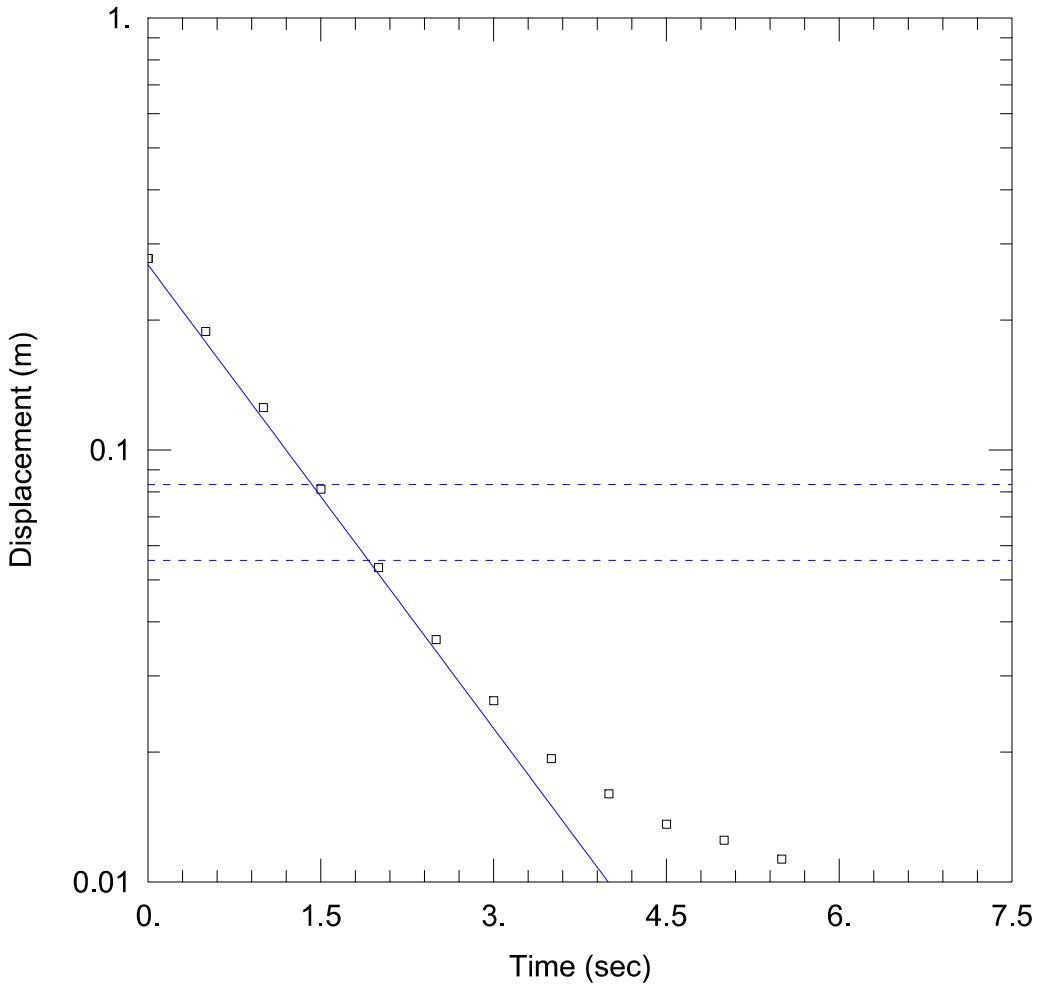
WELL DATA (MW101-21)

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
Tel: (519) 741-1313 Fax: (519) 741-5422
E-Mail: kitchener@englobecorp.com Website: www.englobecorp.com

GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-696 PROJECT LOCATION: Waterloo, Ontario FIGURE No.: 1

BOREHOLE / TEST PIT NUMBER:	GP 101-20
SAMPLING DEPTH:	0 - 35 cm
SAMPLE NUMBER:	01
SAMPLED BY:	Client
SAMPLE DESCRIPTION:	Topsoil
SAMPLE NATURAL MOISTURE:	-
SAMPLE RECEIVED DATE:	6/23/2020
GRAIN SIZE PROPORTIONS, %	
% GRAVEL (> 4.75 mm):	0.1
% SAND (75 µm to 4.75 mm):	30.0
% Silt (2 µm to 75 µm):	42.9
% Clay (<2 µm):	27.0
SUSCEPTIBILITY TO FROST HEAVING:	-

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	60.2
37.5	100.0	0.026	54.9
26.5	100.0	0.017	51.4
19.0	100.0	0.010	46.2
13.2	100.0	0.007	42.7
9.5	100.0	0.005	37.5
4.75	99.9	0.003	30.5
2.00	99.6	0.001	24.4
0.850	99.6	ATTERBERG LIMITS, %	
0.425	98.0		
0.250	94.1	Plastic Limit	
0.106	77.0	Liquid Limit	
0.075	69.9	Plastic Index	

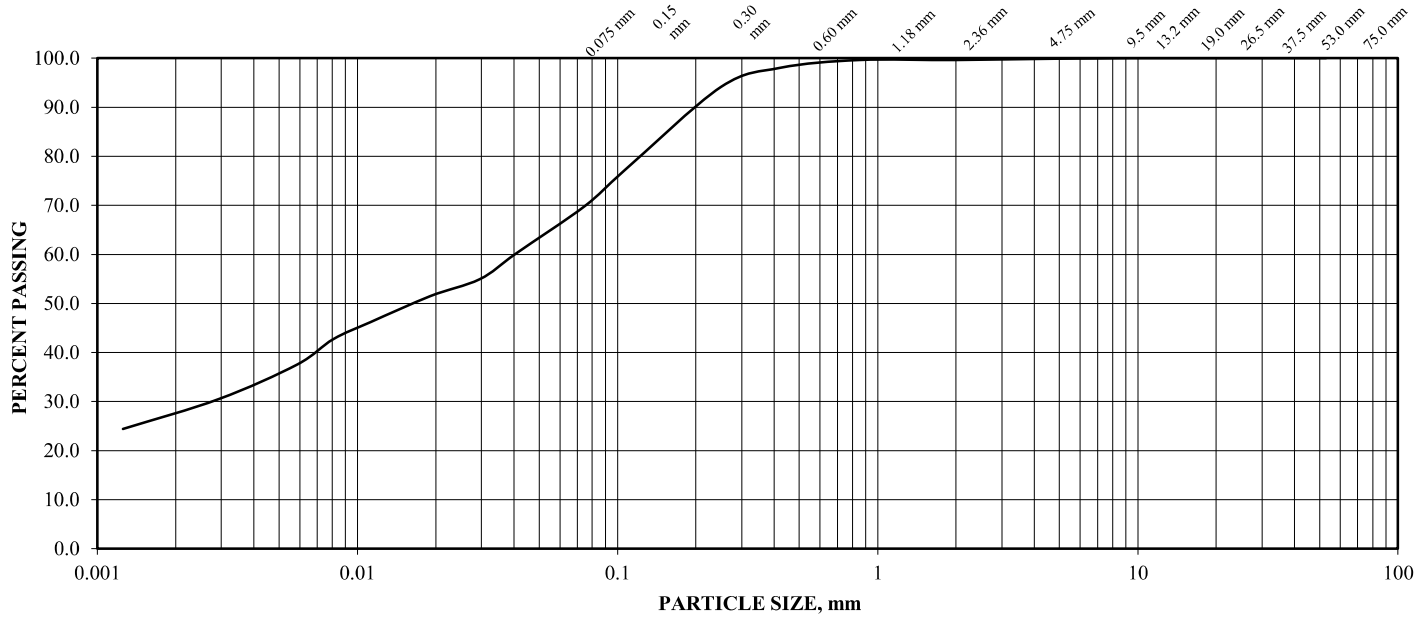
PARTICLE SIZE DISTRIBUTION, MTO LS-702

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

CLAY	SILT	VERY FINE	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

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



SIGNED: _____ DATE: 07/07/2020

O. Rexha

Englobe
353 Bridge Street East, Kitchener, ON N2K 2Y5
Tel: (519) 741-1313 Fax: (519) 741-5422
E-Mail: kitchener@englobecorp.com Website: www.englobecorp.com

GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-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	

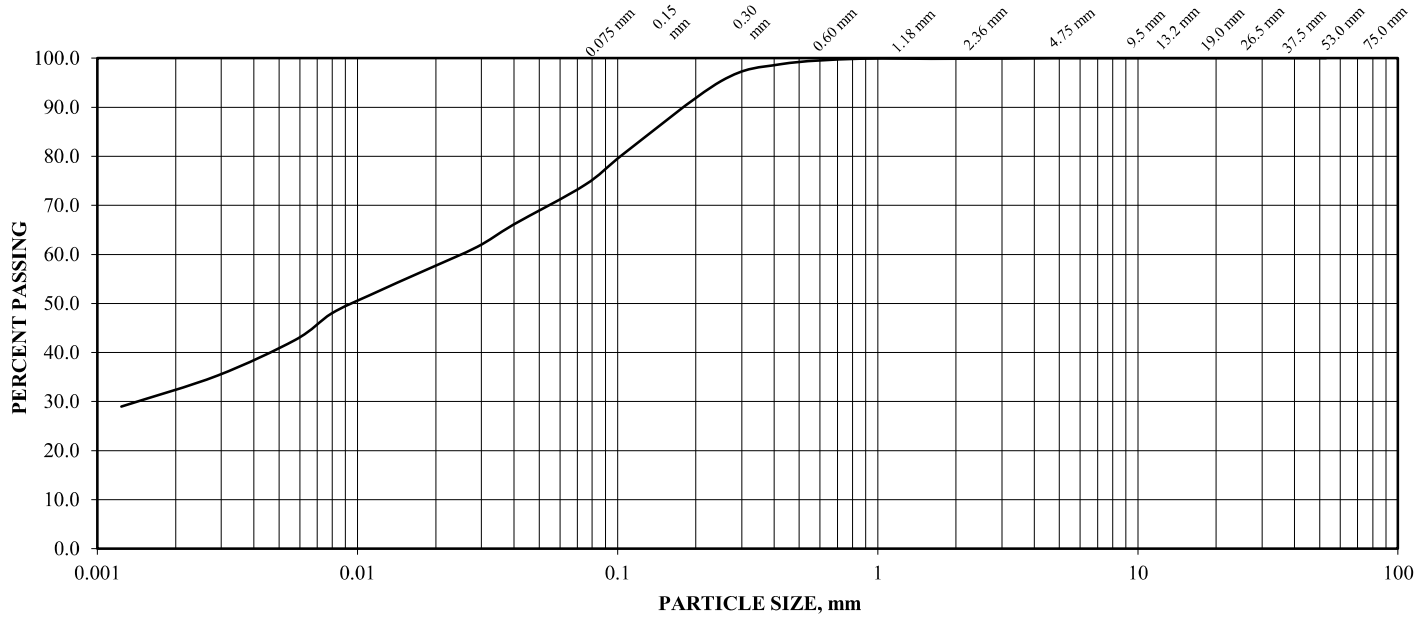
PARTICLE SIZE DISTRIBUTION, MTO LS-702

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

Englobe
353 Bridge Street East, Kitchener, ON N2K 2Y5
Tel: (519) 741-1313 Fax: (519) 741-5422
E-Mail: kitchener@englobecorp.com Website: www.englobecorp.com

GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-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	

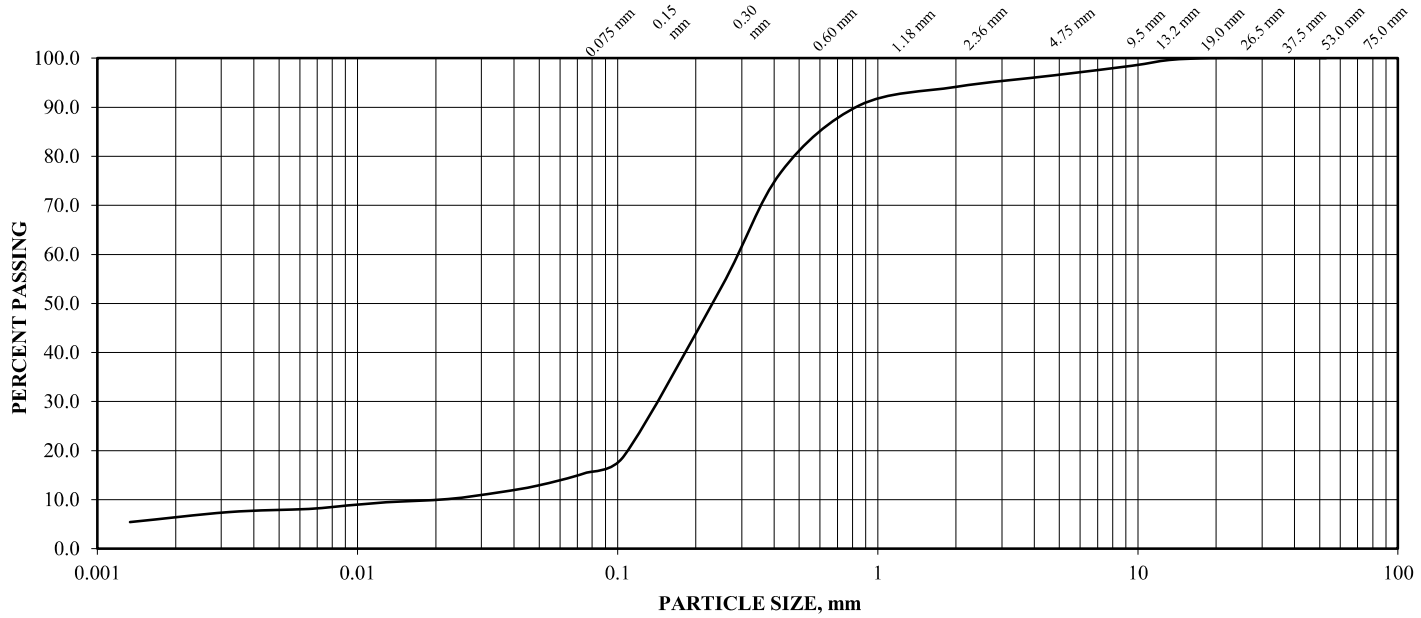
PARTICLE SIZE DISTRIBUTION, MTO LS-702

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

Englobe
353 Bridge Street East, Kitchener, ON N2K 2Y5
Tel: (519) 741-1313 Fax: (519) 741-5422
E-Mail: kitchener@englobecorp.com Website: www.englobecorp.com

GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-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	

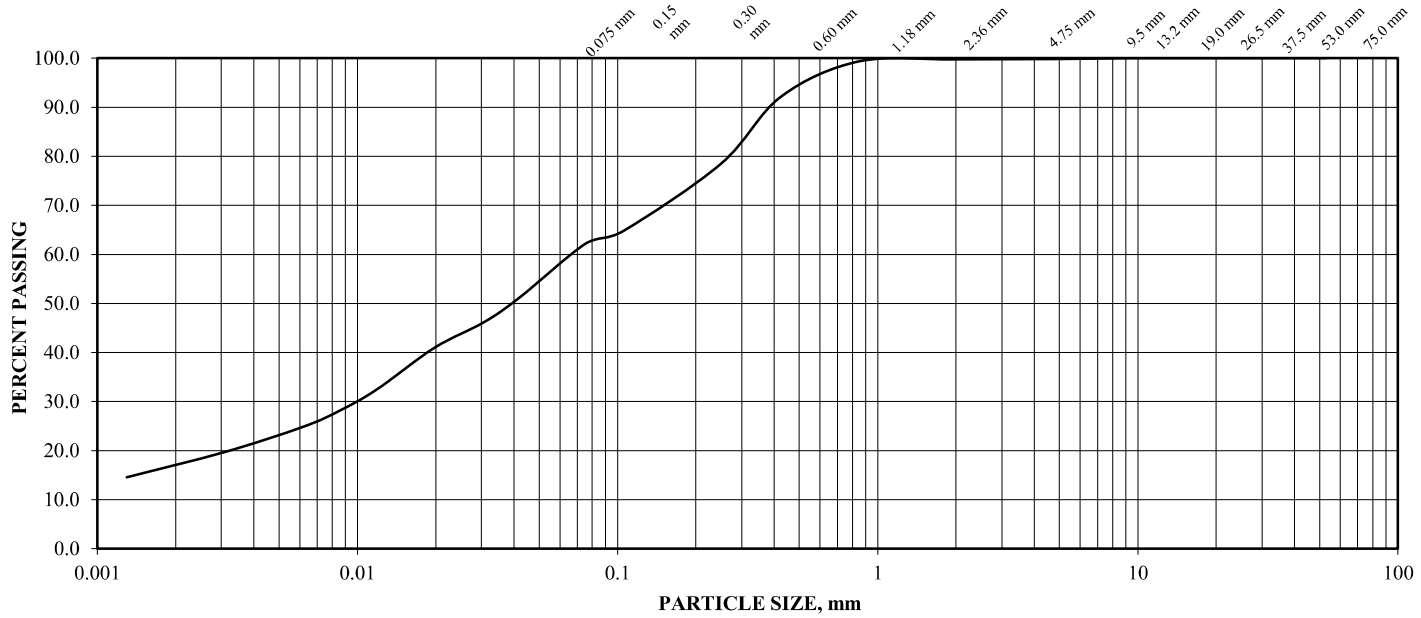
PARTICLE SIZE DISTRIBUTION, MTO LS-702

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

Englobe
353 Bridge Street East, Kitchener, ON N2K 2Y5
Tel: (519) 741-1313 Fax: (519) 741-5422
E-Mail: kitchener@englobecorp.com Website: www.englobecorp.com

GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-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	

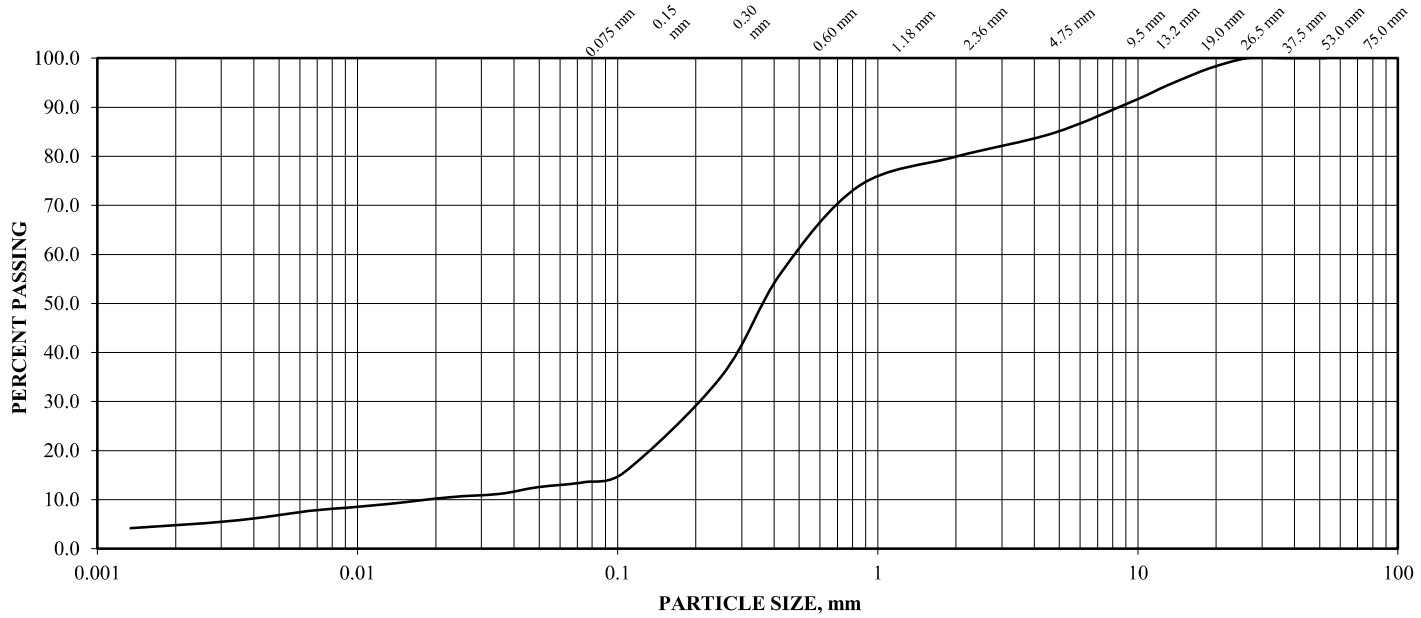
PARTICLE SIZE DISTRIBUTION, MTO LS-702

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

Englobe SWO - Kitchener
London
Brantford

englobecorp.com

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

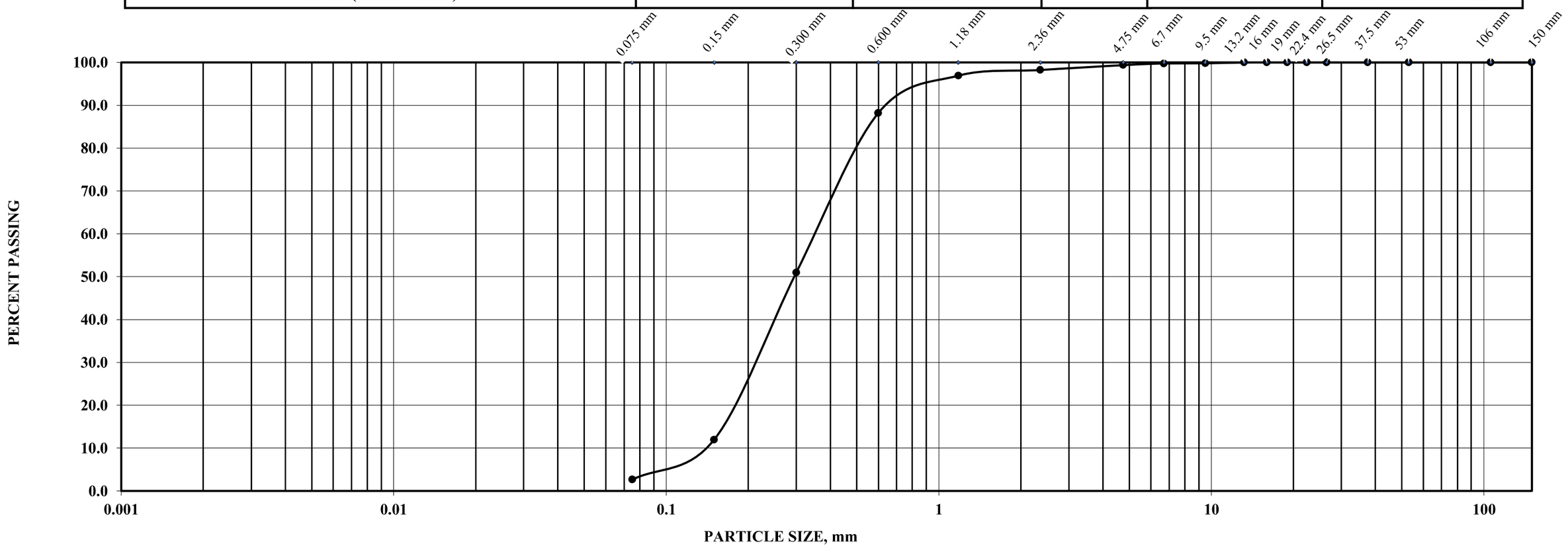
PARTICLE SIZE DISTRIBUTION, MTO LS-602

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

Englobe SWO - Kitchener
London
Brantford

englobecorp.com

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

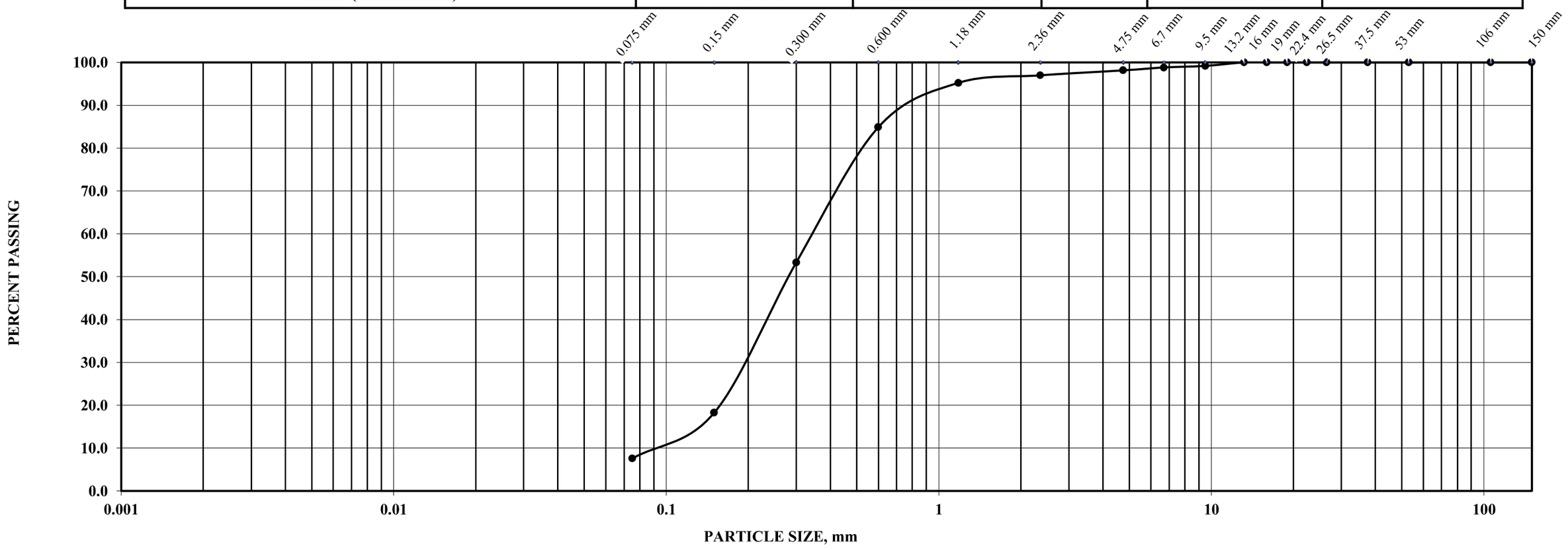
PARTICLE SIZE DISTRIBUTION, MTO LS-602

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

Englobe SWO - Kitchener
London
Brantford

englobecorp.com

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

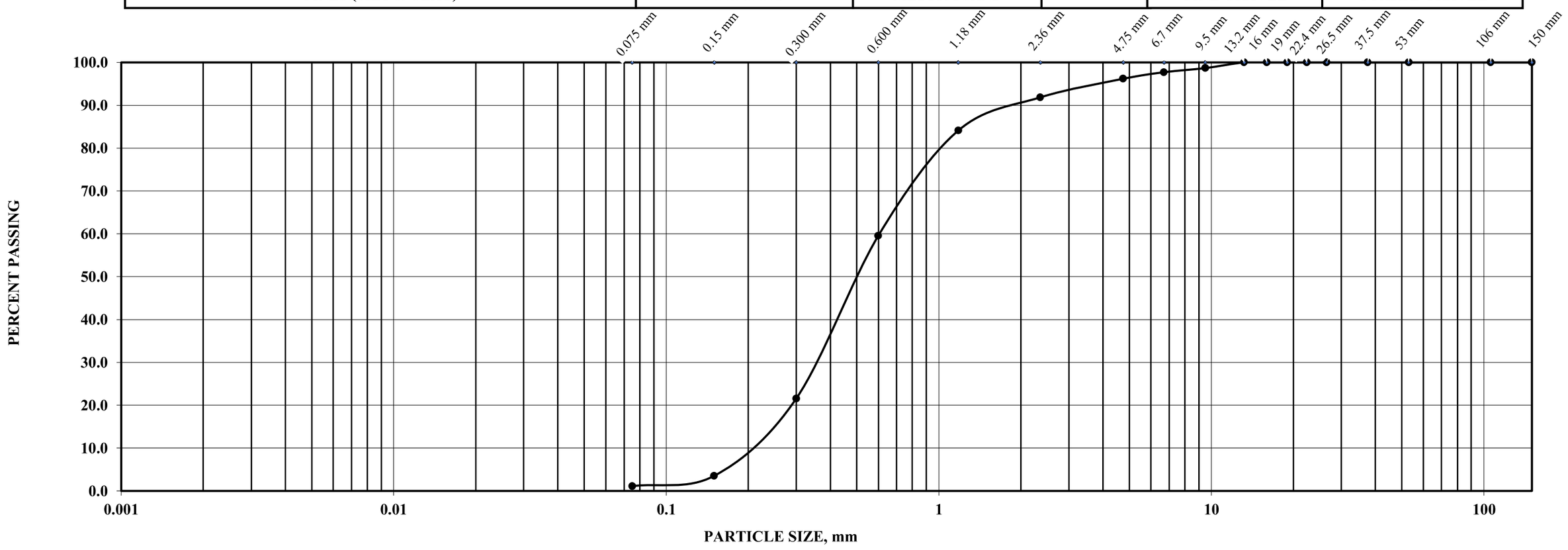
PARTICLE SIZE DISTRIBUTION, MTO LS-602

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

Englobe SWO - Kitchener
London
Brantford

englobecorp.com

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

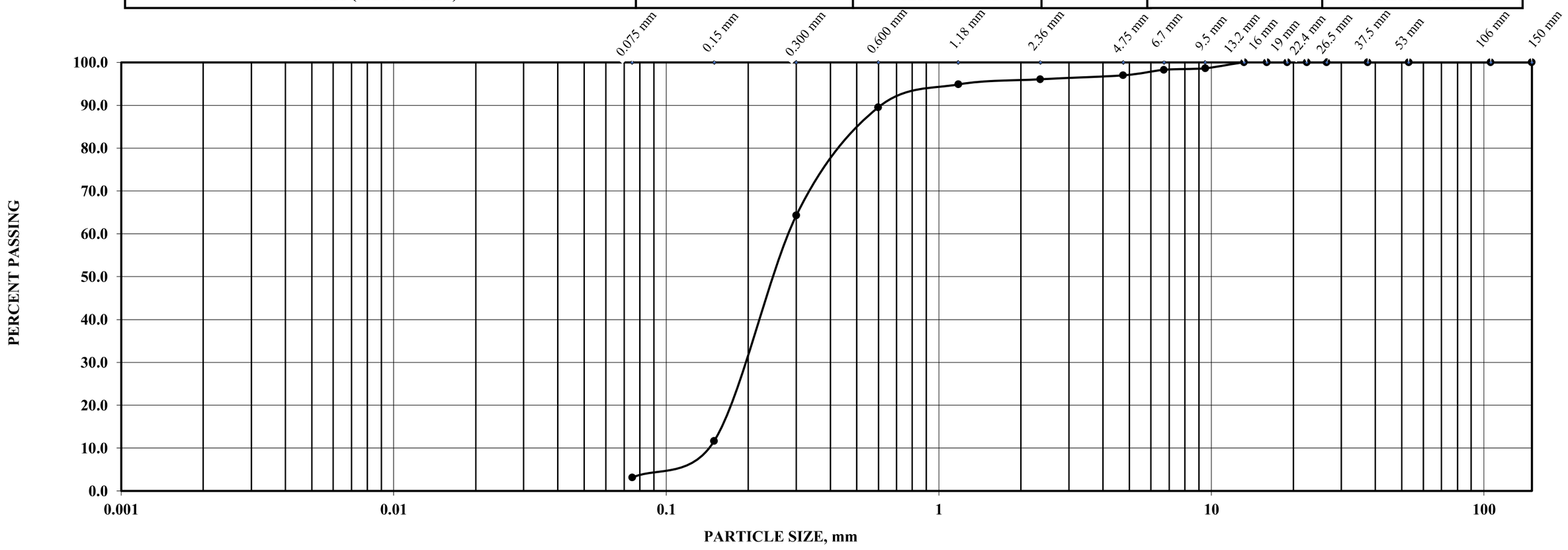
PARTICLE SIZE DISTRIBUTION, MTO LS-602

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

Englobe SWO - Kitchener
London
Brantford

englobecorp.com

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

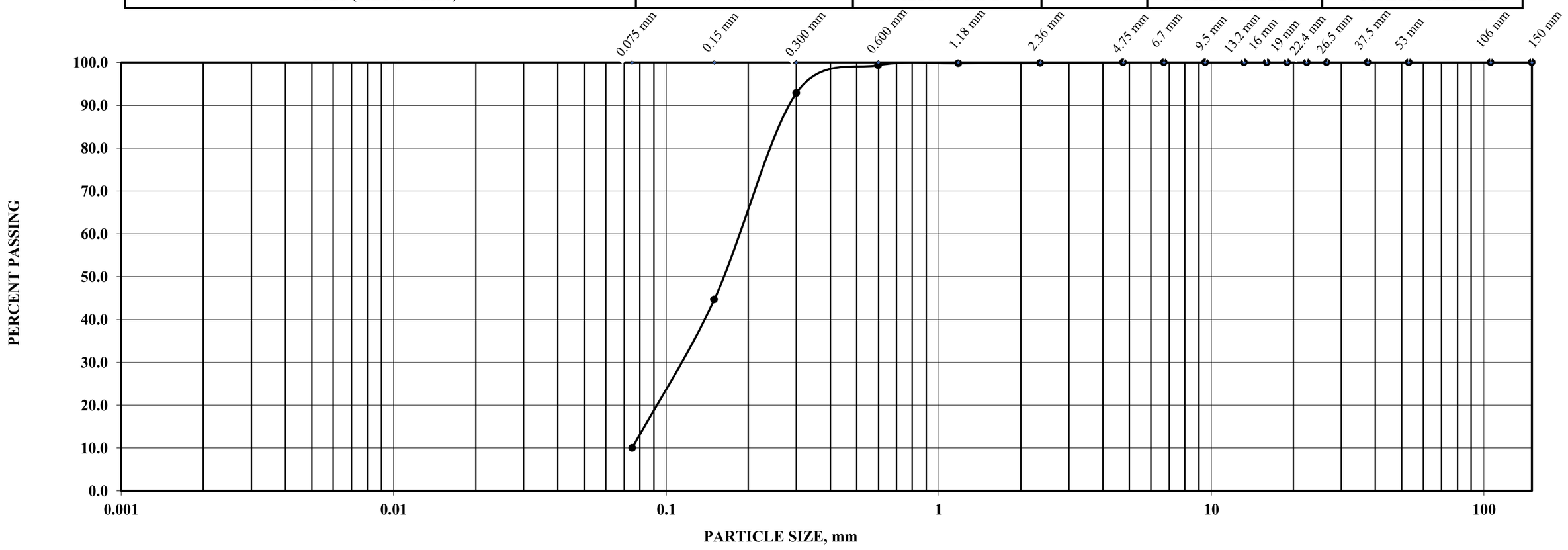
PARTICLE SIZE DISTRIBUTION, MTO LS-602

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

Englobe SWO - Kitchener
London
Brantford

englobecorp.com

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

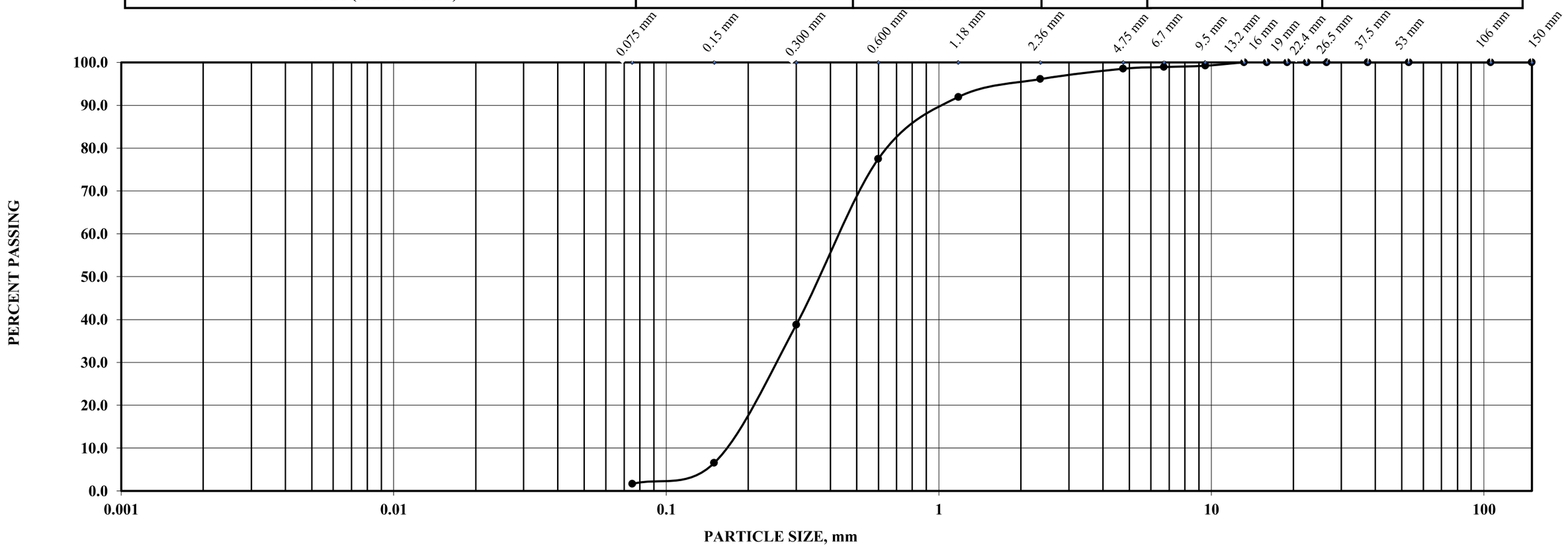
PARTICLE SIZE DISTRIBUTION, MTO LS-602

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

Englobe SWO - Kitchener
London
Brantford

englobecorp.com

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

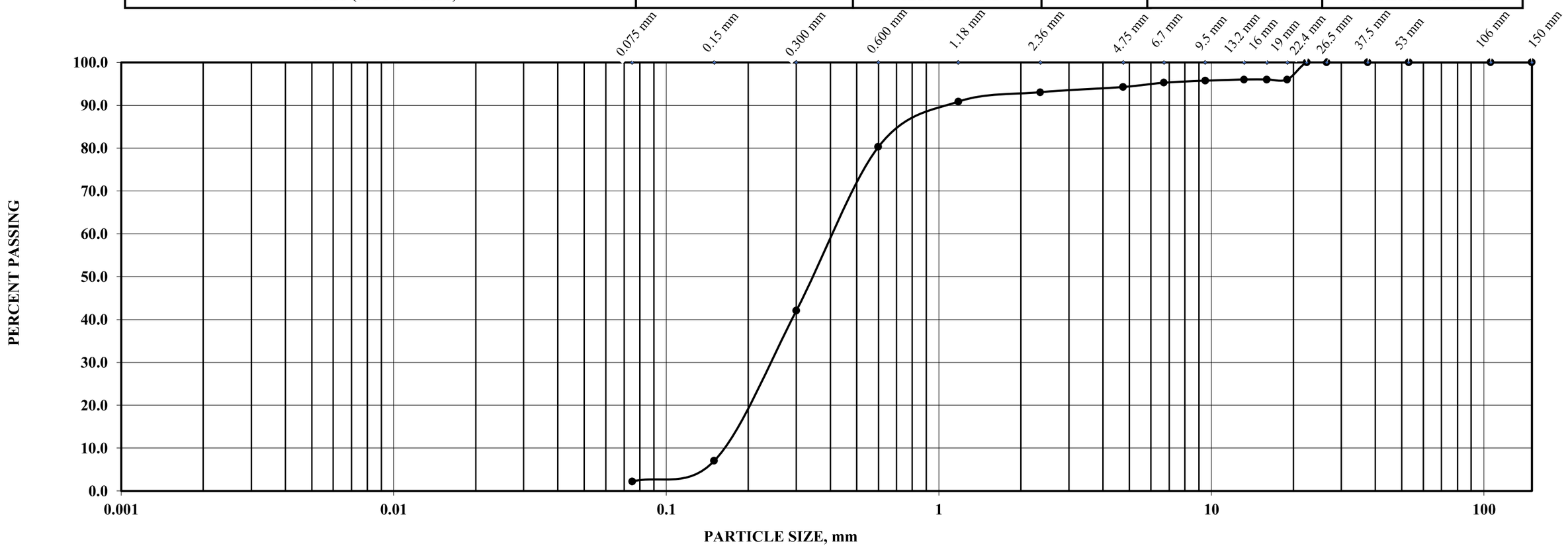
PARTICLE SIZE DISTRIBUTION, MTO LS-602

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

Englobe SWO - Kitchener
London
Brantford

englobecorp.com

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

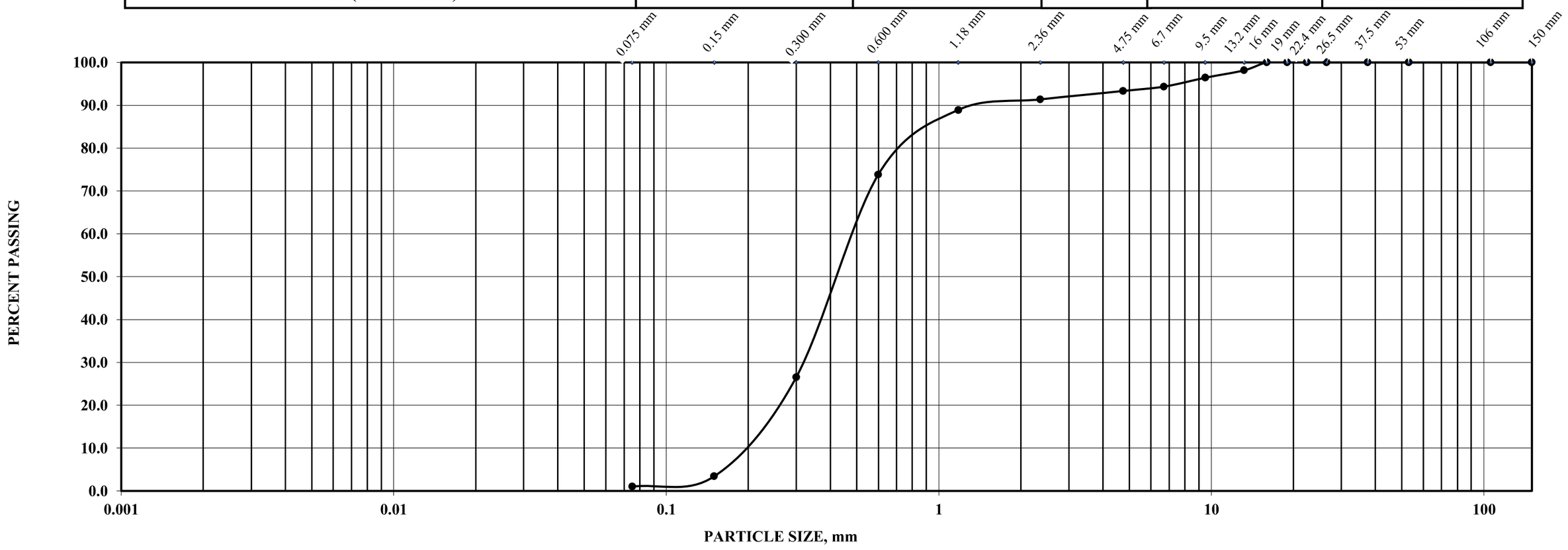
PARTICLE SIZE DISTRIBUTION, MTO LS-602

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.

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

Stantec

Client/Project
2115881 Ontario Limited
Hydrogeological Assessment
556, 560 and 576 Conservation Drive,
Waterloo

December 2021
160900921

Appendix
J

Title
PHOTOGRAPHIC RECORD



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.

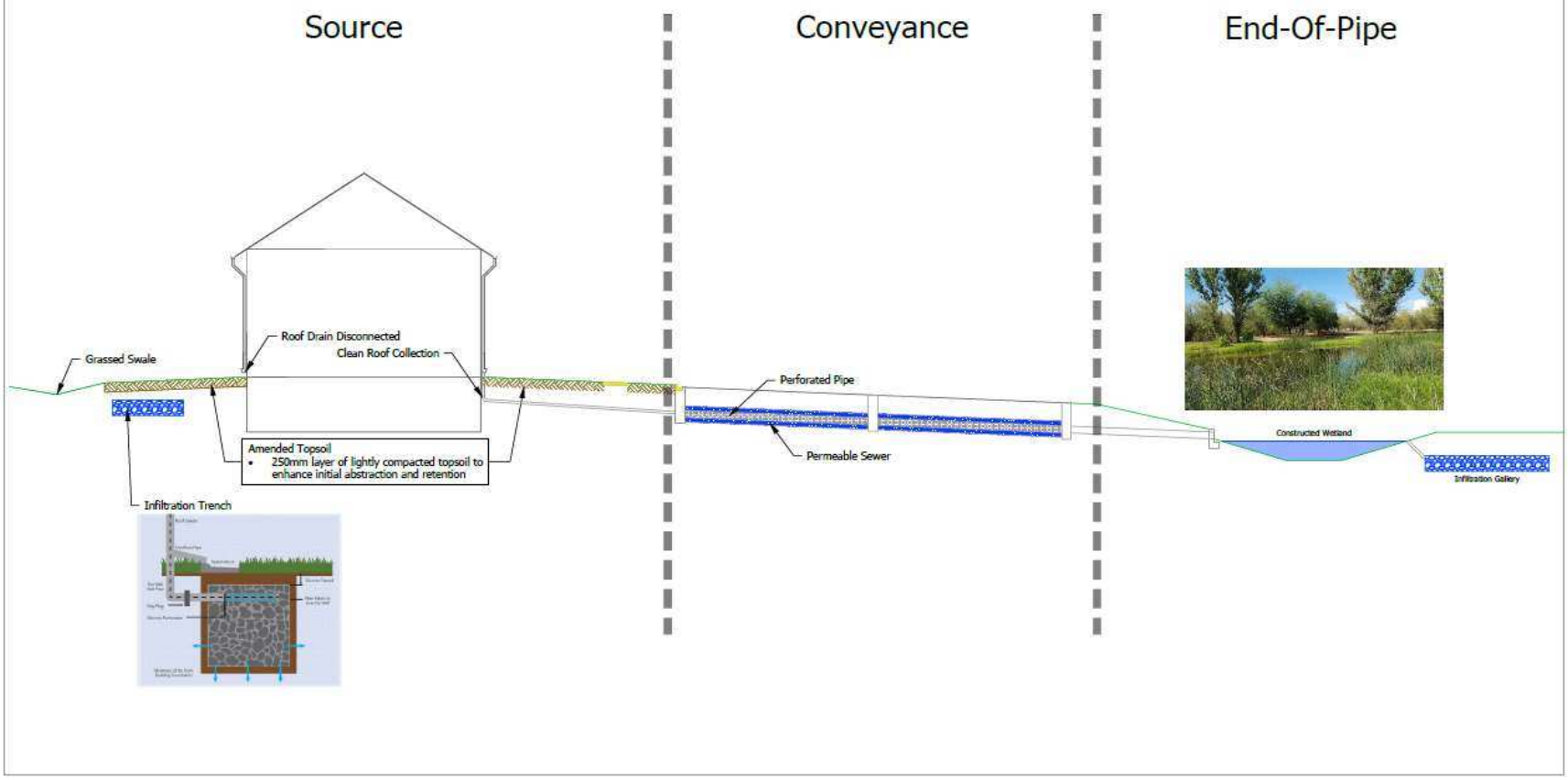


Photo 12: Test Pit 4 (TP4) – May 28, 2021. Note that grain-size analysis testing indicates that soils up to a depth of 4.4 meters below existing grade comprise 92% sand.

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

Month		Precip (mm)	Kitchener ETO
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	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

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
0.09	0.00	0.09	6.765	0.00	0.09	0.0930	0.00	0.00	0.00
0.00	0.00	0.00	6.858	0.00	0.00	0.0000	0.00	0.00	0.00
0.09	0.00	0.09	6.858	0.00	0.09	0.0930	0.00	0.00	0.00
0.19	0.00	0.19	6.951	0.00	0.19	0.1860	0.00	0.00	0.00
0.19	0.00	0.19	7.137	0.00	0.19	0.1860	0.00	0.00	0.00
0.09	0.00	0.09	7.323	0.00	0.09	0.0930	0.00	0.00	0.00
0.00	0.00	0.00	7.416	0.00	0.00	0.0000	0.00	0.00	0.00
0.09	0.00	0.09	7.416	0.00	0.09	0.0930	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.09	0.00	0.09	7.509	0.00	0.09	0.0930	0.00	0.00	0.00
0.00	0.00	0.00	7.602	0.00	0.00	0.0000	0.00	0.00	0.00
0.09	0.00	0.09	7.602	0.00	0.09	0.0930	0.00	0.00	0.00
0.09	0.00	0.09	7.695	0.00	0.09	0.0930	0.00	0.00	0.00
0.09	0.00	0.09	7.788	0.00	0.09	0.0930	0.00	0.00	0.00
0.09	0.00	0.09	7.881	0.00	0.09	0.0930	0.00	0.00	0.00
0.19	0.00	0.19	7.974	0.00	0.19	0.1860	0.00	0.00	0.00
0.09	0.00	0.09	8.16	0.00	0.09	0.0930	0.00	0.00	0.00
0.09	0.00	0.09	8.253	0.00	0.09	0.0930	0.00	0.00	0.00
0.09	0.00	0.09	8.346	0.00	0.09	0.0930	0.00	0.00	0.00
0.09	0.00	0.09	8.439	0.00	0.09	0.0930	0.00	0.00	0.00
0.09	0.00	0.09	8.532	0.00	0.09	0.0930	0.00	0.00	0.00
0.09	0.00	0.09	8.625	0.00	0.09	0.0930	0.00	0.00	0.00
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

	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

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		0		0	0	0	0	0	0
2	07/02/2017 11:15		0.1	0	0.118	0	0.118	7.64	0	0.118	0.1180	0	0	0
2	07/02/2017 11:20		0	0	0	0	0	7.758	0	0	0.0000	0	0	0
2	07/02/2017 11:25		0.1	0	0.118	0	0.118	7.758	0	0.118	0.1180	0	0	0
2	07/02/2017 11:30		0.2	0	0.236	0	0.236	7.876	0	0.236	0.2360	0	0	0
2	07/02/2017 11:35		0.2	0	0.236	0	0.236	8.112	0	0.236	0.2360	0	0	0
2	07/02/2017 11:40		0.1	0	0.118	0	0.118	8.348	0	0.118	0.1180	0	0	0
2	07/02/2017 11:45		0	0	0	0	0	8.466	0	0	0.0000	0	0	0
2	07/02/2017 11:50		0.1	0	0.118	0	0.118	8.466	0	0.118	0.1180	0	0	0
2	07/02/2017 11:55		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:00		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:05		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:10		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:15		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:20		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:25		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:30		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:35		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:40		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:45		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:50		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:55		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 13:00		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 13:05		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 13:10		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 13:15		0.1	0	0.118	0	0.118	8.584	0	0.118	0.1180	0	0	0
2	07/02/2017 13:20		0	0	0	0	0	8.702	0	0	0.0000	0	0	0
2	07/02/2017 13:25		0.1	0	0.118	0	0.118	8.702	0	0.118	0.1180	0	0	0
2	07/02/2017 13:30		0.1	0	0.118	0	0.118	8.82	0	0.118	0.1180	0	0	0
2	07/02/2017 13:35		0.1	0	0.118	0	0.118	8.938	0	0.118	0.1180	0	0	0
2	07/02/2017 13:40		0.1	0	0.118	0	0.118	9.056	0	0.118	0.1180	0	0	0
2	07/02/2017 13:45		0.2	0	0.236	0	0.236	9.174	0	0.236	0.2360	0	0	0
2	07/02/2017 13:50		0.1	0	0.118	0	0.118	9.41	0	0.118	0.1180	0	0	0
2	07/02/2017 13:55		0.1	0	0.118	0	0.118	9.528	0	0.118	0.1180	0	0	0
2	07/02/2017 14:00		0.1	0	0.118	0	0.118	9.646	0	0.118	0.1180	0	0	0
2	07/02/2017 14:05		0.1	0	0.118	0	0.118	9.764	0	0.118	0.1180	0	0	0
2	07/02/2017 14:10		0.1	0	0.118	0	0.118	9.882	0	0.118	0.1180	0	0	0
2	07/02/2017 14:15		0.1	0	0.118	0	0.118	10	0	0.118	0.1180	0	0	0
2	07/02/2017 14:20		0.1	0	0.118	0	0.118	10.118	0	0.118	0.1180	0	0	0

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

TABLE OF CONTENTS

1 INTRODUCTION 1

2 PREVIOUS WORK 1

3 INVESTIGATION PROCEDURE 2

3.1 Field Program 2
3.2 Laboratory Testing 3

4 SUMMARIZED CONDITIONS 3

4.1 Site Description 3
4.2 Subsoil Conditions 4
4.2.1 Topsoil 4
4.2.2 Sand 4
4.2.3 Silt 5
4.2.4 Glacial Till 5
4.3 Groundwater 6

5 DISCUSSIONS AND RECOMMENDATIONS 6

5.1 General 6
5.2 Site Grading 7
5.3 Site Servicing 8
5.3.1 Excavations and Dewatering 8
5.3.2 Pipe Bedding 9
5.3.3 Trench Backfilling 10
5.4 Pavements 11
5.4.1 Pavement Design 11
5.4.2 Subdrains 12
5.4.3 Curbs and Sidewalks 12
5.5 Residential Buildings 13
5.5.1 Foundations 13
5.5.2 Basements 13
5.6 At Source Stormwater Infiltration 14

6 STATEMENT OF LIMITATIONS 16

TABLE OF CONTENTS

Tables

Table 1: Sand Particle Size Distribution Analyses....4
Table 2: Silt Particle Size Distribution Analyses Results....5
Table 3: Groundwater Level Measurements....6
Table 4: Compaction Specifications....7
Table 5: Pavement Designs....11

Appendices

Appendix 1 Drawings
Appendix 2 Borehole Logs
Appendix 3 Figures

Property and Confidentiality

"This engineering document is the property of LVM, a division of EnGlobe Corp. and, as such, is protected under Copyright Law. It can only be used for the purposes mentioned herein. Any reproduction or adaptation, whether partial or total, is strictly prohibited without having obtained LVM's and its client's prior written authorization to do so.

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	
1 Electronic Copy / 4 Hard copies	Ms. Nicole Simas, 2115881 Ontario Limited c/o Ian Cook Construction Limited
1 Electronic Copy	File

alc

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.

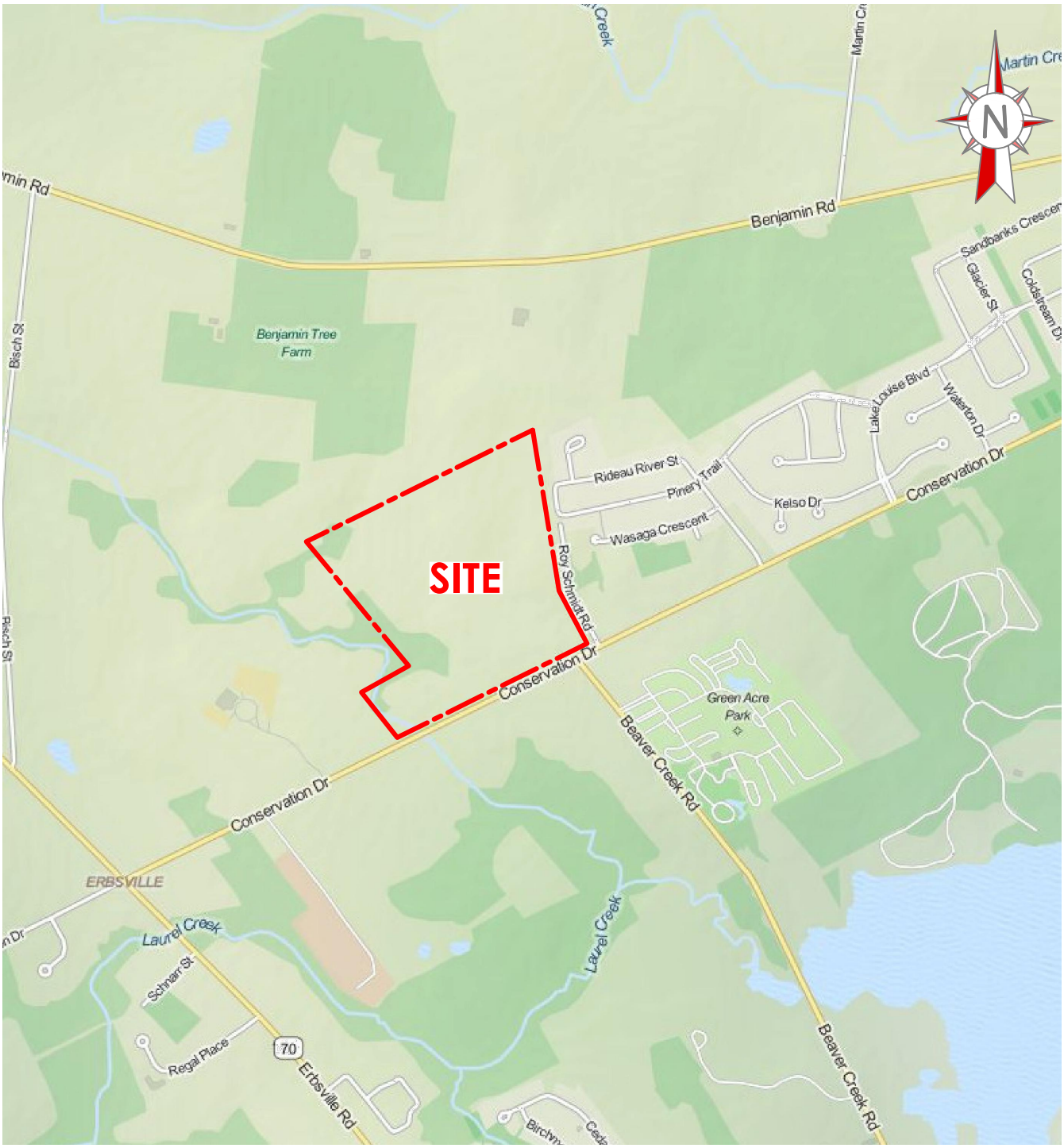
The geotechnical recommendations provided in this report are applicable only to the project described in the text and are intended for the use of the project designer. They are not intended as specifications or instructions to contractors. Any use which a contractor makes of this report, or decisions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

G:\160\P0008077\Z5_CAD\WP100\P-0008077-0-01-100_DWG001.DWG

Project

Geotechnical Investigation
Proposed Residential Development

560/576 Conservation Drive, Waterloo, Ontario

Title

LOCATION PLAN

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

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

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



LEGEND :

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

0 20 40 60 80 100 m

SCALE 1:3000

NOTES :

1-REFERENCES : GRAND RIVER CONSERVATION AUTHORITY, 2015.

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

3-Groundwater measured on March 9, 2015.

Project

Geotechnical Investigation
Proposed Residential Development

560/576 Conservation Drive, Waterloo, Ontario

Title

SITE PLAN

LVM

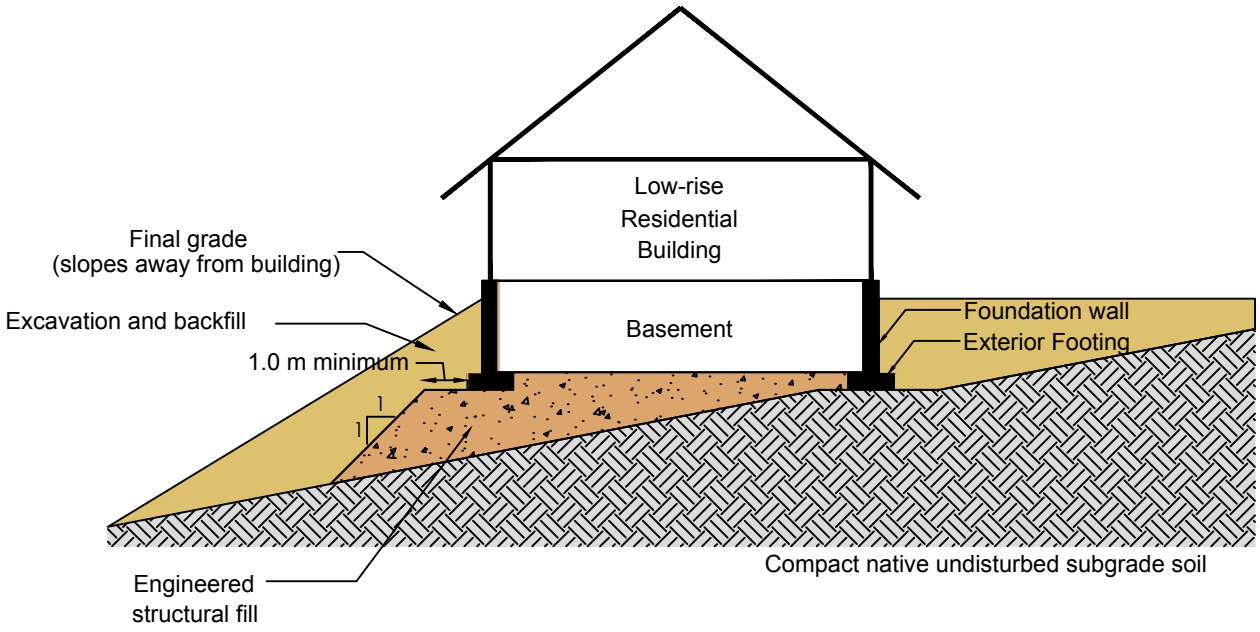
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

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

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

10 cm 0 1 2 3 4 5

G:\160\P0008077\25_CAD\WP100160-P-0008077-0-01-100_DWG002_SMDM.DWG



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.

G:\160\P0008077\Z5_CAD\WP100\P-0008077-0-01-100_DWG003.DWG

Project

Geotechnical Investigation
Proposed Residential Development

560/576 Conservation Drive, Waterloo, Ontario

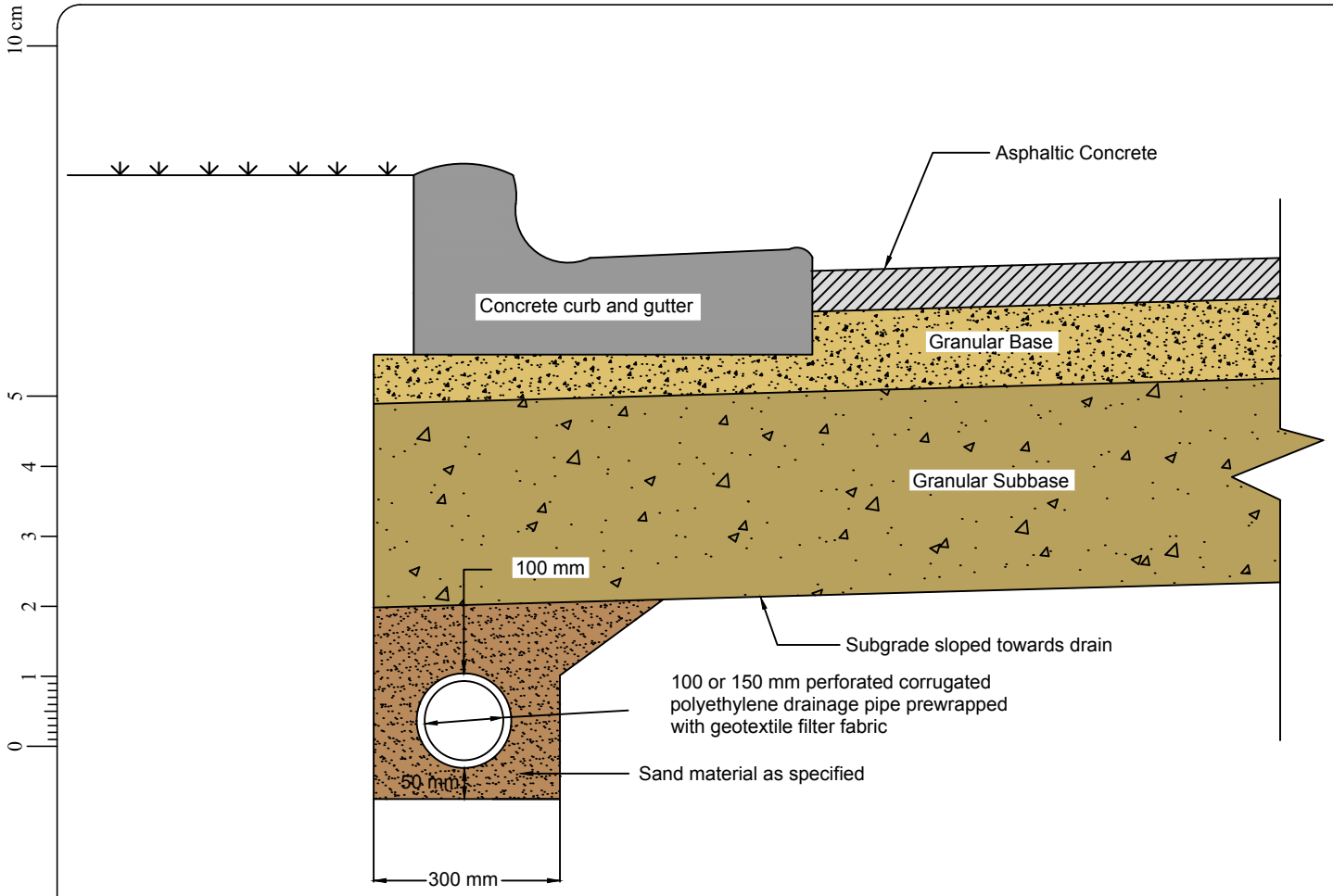
Title

TYPICAL STRUCTURAL FILL DETAIL

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

Prepared	E.Ciochon	Discipline	GEOTECHNICAL	Project manager	M.Wilson
Drawn	E.Ciochon	Scale	NTS	Sequence no.	03 of 04
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.

G:\160\P0008077\Z5_CAD\WP100\P-0008077-0-01-100_DWG004.DWG

Project

Geotechnical Investigation
Proposed Residential Development

560/576 Conservation Drive, Waterloo, Ontario

Title

TYPICAL PAVEMENT SUBDRAIN DETAIL

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

Prepared	E.Ciochon	Discipline	GEOTECHNICAL	Project manager	M.Wilson
Drawn	E.Ciochon	Scale	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	

Z:\Style_LVM_Ontario\LogBorehole_Log_LVM_Ontario.sty- Printed : 2015-03-12 14h

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.*

Z:\Style_LVM_Ontario\LogBorehole_Log_LVM_Ontario.sty- Printed : 2015-03-12 14h

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

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

Vertical Scale = 1 : 50.0

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

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

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

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

Vertical Scale = 1 : 50.0

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

Notes:

Z:\Style_LVM_Ontario\LogBorehole_Log_LVM_Ontario.sty- Printed : 2015-03-12 14h

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

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

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

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

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

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

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

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

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

Groundwater Observations and Standpipe Details

el. 350.91 m 2015-03-15

bentonite seal

sand pack

19 mm pipe
3.05 m slotted screen

native cave

Vertical Scale = 1 : 50.0

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

Notes:

EQ-09-Ge-72 R.1 18.02.2011

Z:\Style_LVM_Ontario\LogBorehole_Log_LVM_Ontario.sty- Printed : 2015-03-12 14h

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

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

el. 352.21 m 2015-03-15

bentonite seal

19 mm pipe
1.52 m slotted screen

native cave

Vertical Scale = 1 : 50.0

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

Notes:

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

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

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

Groundwater Observations and Standpipe Details

bentonite seal

At drilling completion, borehole open and dry.

Vertical Scale = 1 : 50.0

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

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

Z:\Style_LVM_Ontario\LogBorehole_Log_LVM_Ontario.sty- Printed : 2015-03-12 14h

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

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

el. 352.07 m 2015-03-15

bentonite seal

sand pack

19 mm pipe
1.52 m slotted screen

Vertical Scale = 1 : 50.0

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

Notes:

Z:\Style_LVM_Ontario\LogBorehole_Log_LVM_Ontario.sty- Printed : 2015-03-16 09h

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

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

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

Notes:

Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011

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

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

Dynamic Cone / Std Penetration: 20 40 60 80

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

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

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

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

Z:\Style_LVM_Ontario\LogBorehole_Log_LVM_Ontario.sty- Printed : 2015-03-12 14h

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**

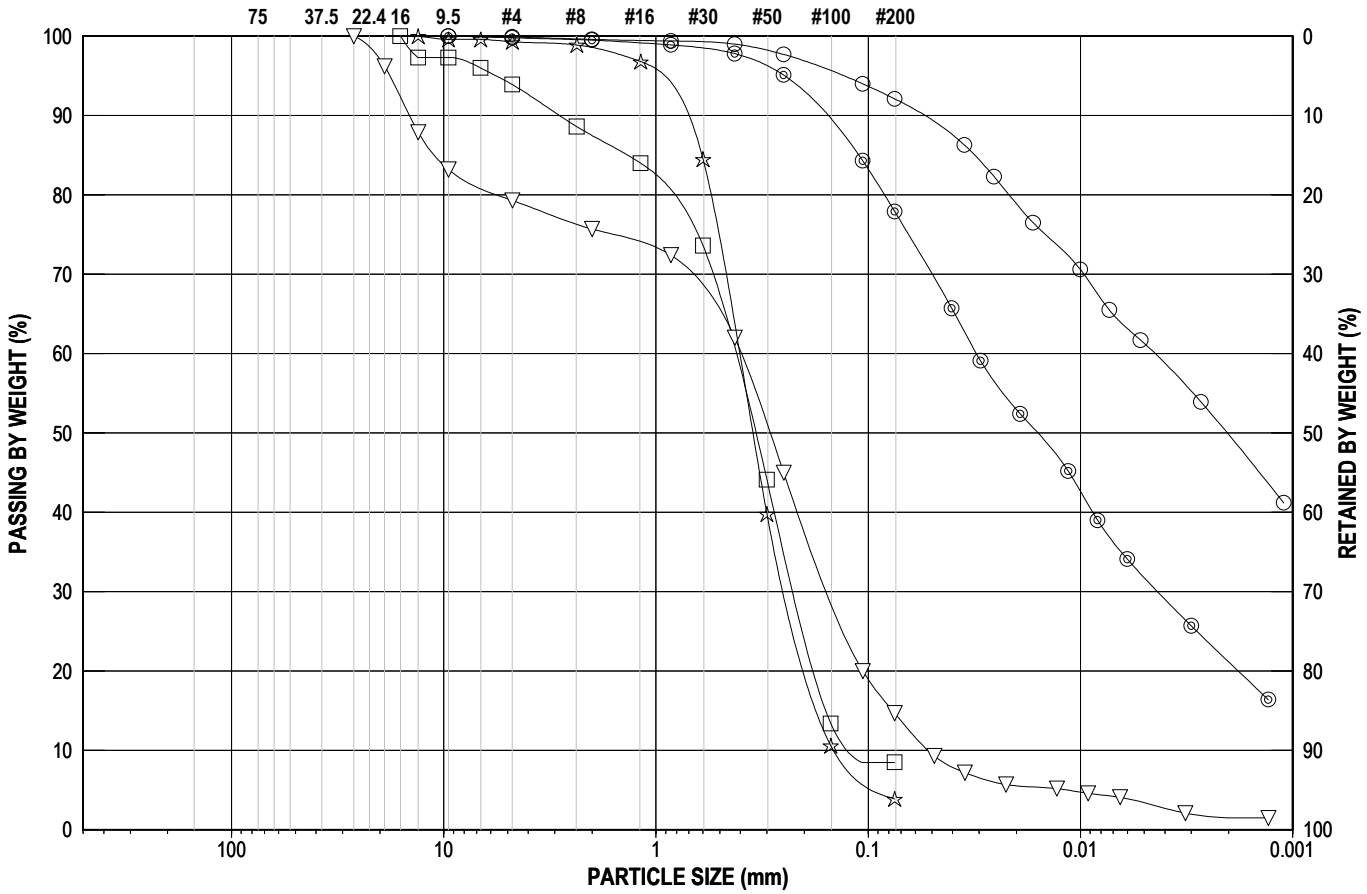
Figure No : **1**

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

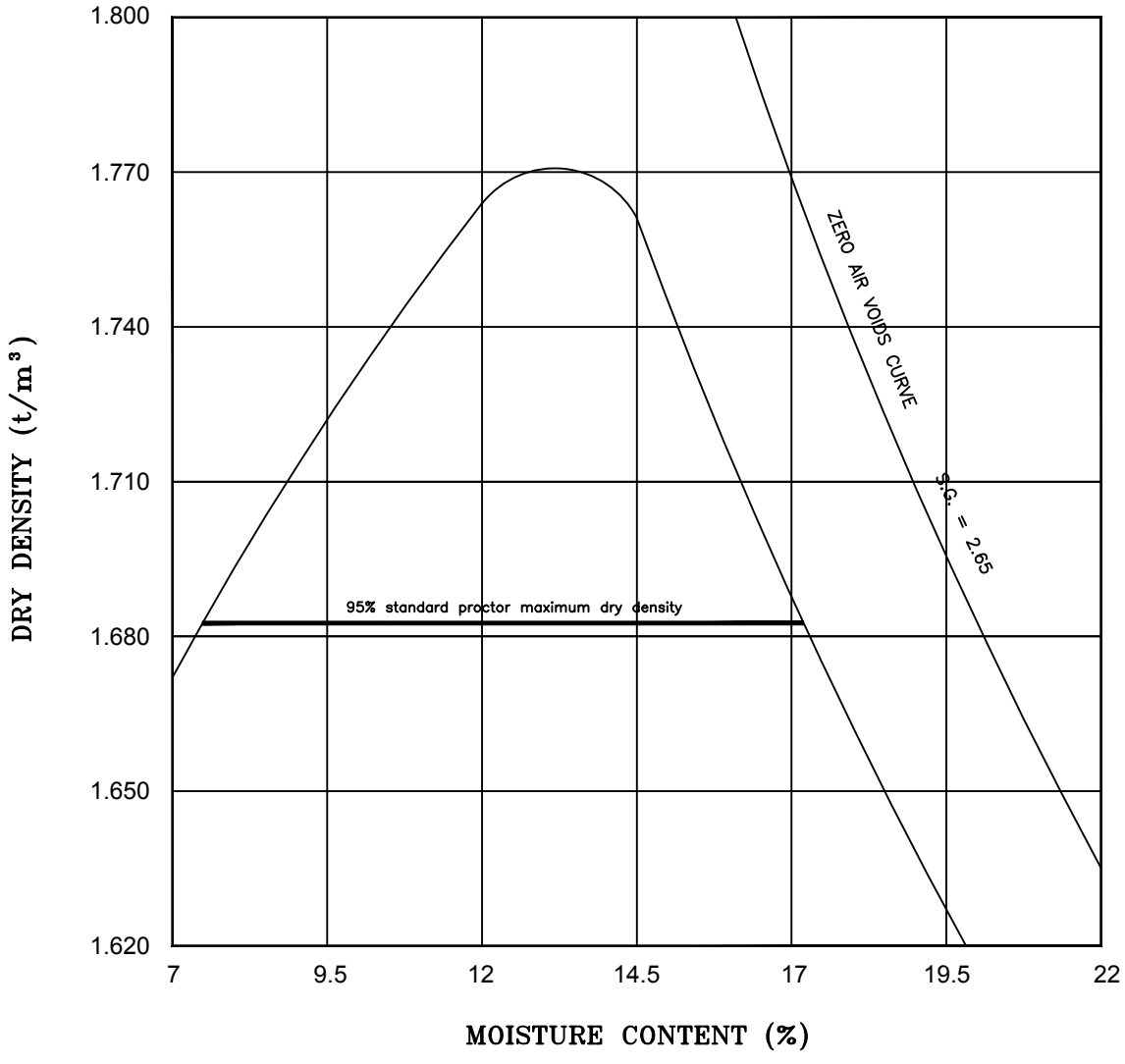
METHOD LS – 706

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

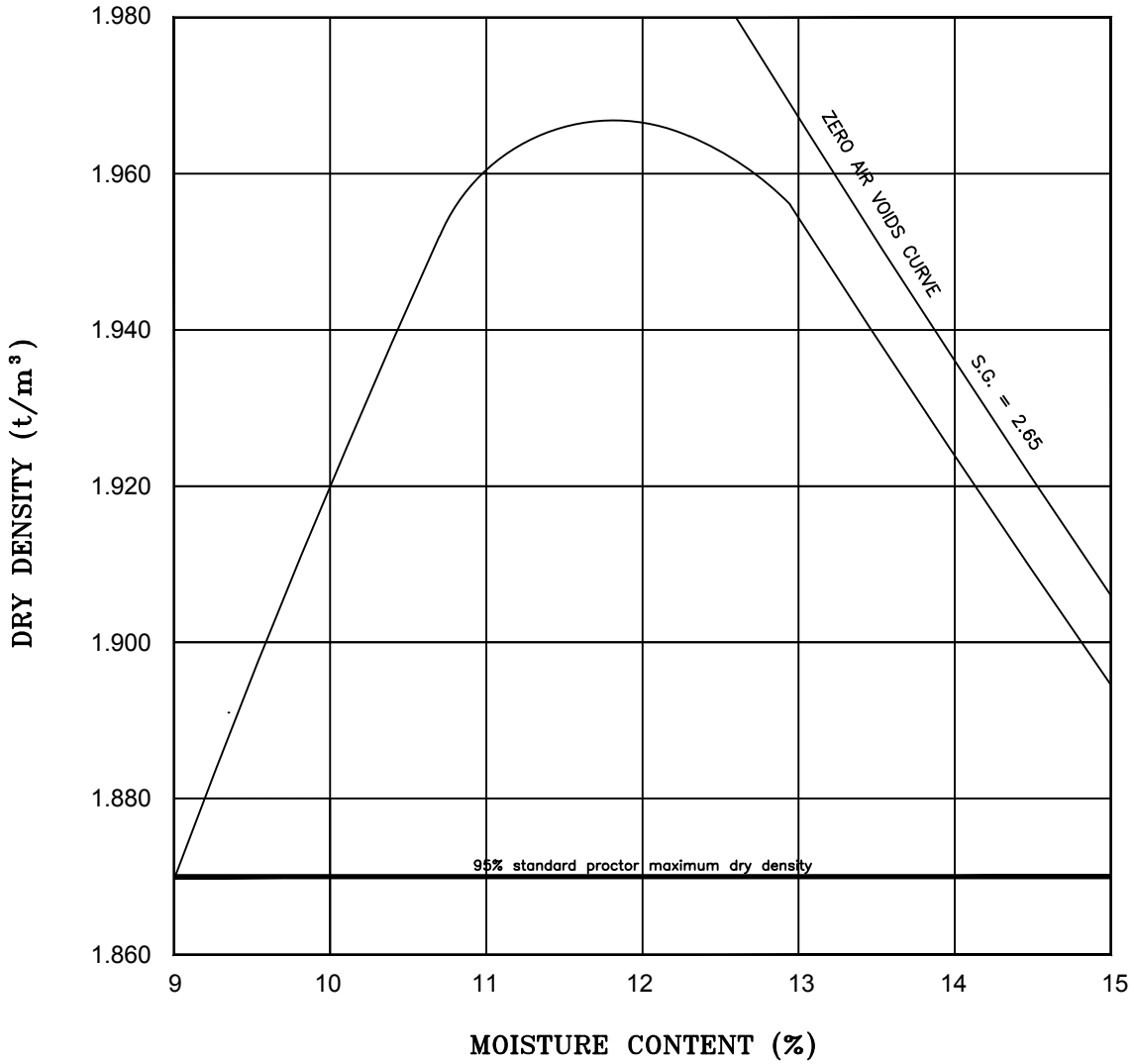
METHOD LS – 706

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 %



G:\160\P0008077\z5_CAD\WP100\P-0008077-0-01-100_Fig003.dwg



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

Table of Contents

ABBREVIATIONS I

1.0 INTRODUCTION 1.1

2.0 PHYSICAL SETTING 2.1
2.1 PHYSIOGRAPHY AND TOPOGRAPHY 2.1
2.2 SURFACE WATER BODIES AND WETLANDS 2.1
2.3 REGIONAL GEOLOGY AND HYDROGEOLOGY 2.2
2.4 SOURCE WATER PROTECTION 2.3
2.4.1 Ontario Clean Water Act 2.3
2.4.2 Region of Waterloo Official Plan 2.5

3.0 METHODOLOGY 3.1
3.1 HISTORICAL INVESTIGATIONS 3.1
3.2 BOREHOLE DRILLING 3.1
3.3 MONITORING WELL INSTALLATION AND DEVELOPMENT 3.2
3.4 GROUNDWATER LEVEL MONITORING 3.2
3.5 HYDRAULIC RESPONSE TESTING 3.3
3.6 INFILTRATION TESTING 3.3
3.6.1 Site 3.3
3.6.2 Proposed SWM Facility Infiltration Basin 3.4

4.0 LOCAL GEOLOGY AND HYDROGEOLOGY 4.1
4.1 GEOLOGY AND HYDROSTRATIGRAPHY 4.1
4.2 HYDROGEOLOGY 4.1
4.2.1 Groundwater Levels 4.1
4.2.2 Groundwater Flow 4.2
4.2.3 Infiltration Potential 4.3
4.2.3.1 Site 4.3
4.2.3.2 Proposed SWM Facility Infiltration Basin 4.4

5.0 RECHARGE TO GROUNDWATER STRATEGY 5.1
5.1 WATER BALANCE 5.2
5.2 SOURCE WATER PROTECTION 5.3

6.0 PROPOSED GROUNDWATER MONITORING 6.1

7.0 CONCLUSIONS 7.1

8.0 REFERENCES 8.1

LIST OF APPENDICES

APPENDIX A: AGENCY CORRESPONDENCE

APPENDIX B: FIGURES
Figure 1 – Site Plan
Figure 2 – Physiography and Topography
Figure 3 – Surficial Geology
Figure 4 – Source Water Protection – Wellhead Protection Areas
Figure 5 – Source Water Protection – Significant Groundwater Recharge Area
Figure 6 – Wellhead Protection Sensitivity Areas
Figure 7 – Hydrographs – MW1-19 to MW6-19
Figure 8 – Hydrographs – MW2-10, MW3-10(S)/-16(S), MW6-10, and MW7-10
Figure 9 – Cross-Section A-A'
Figure 10 – Cross-Section B-B'
Figure 11 – Cross-Section C-C'
Figure 12 – High Groundwater Elevations

APPENDIX C: TABLES
Table 1 – Monitoring Well Construction Details
Table 2 – Groundwater Level Data – Monitoring Wells
Table 3 – Infiltration Testing Results
Table 4 – Design Infiltration Rate Calculation

APPENDIX D: NORTH WATERLOO SCOPED SUBWATERSHED STUDY – GROUNDWATER FLOW MAPPING

APPENDIX E: SOURCE WATER PROTECTION PLAN MAPPING

APPENDIX F: WELLHEAD PROTECTION SENSITIVITY AREA CATEGORIES

APPENDIX G: BOREHOLE LOGS

APPENDIX H: HYDRAULIC CONDUCTIVITY TESTING SOLUTIONS

APPENDIX I: GRAIN SIZE ANALYSIS

APPENDIX J: PHOTOGRAPHS

APPENDIX K: SWM TREATMENT TRAIN APPROACH

APPENDIX L: AMENDED SOILS ASSESSMENT MEMO

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.

8.0 REFERENCES

American Society for Testing and Materials (ASTM) International. 2009. ASTM D2488-09a, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). West

Bajc, A.F. and Shirota, J. 2007. Three--dimensional mapping of surficial deposits in the Regional Municipality of Waterloo, Southwestern Ontario; report in Ontario Geological Survey, Groundwater Resources Study 3, 42p.

Bouwer, H., 1989. The Bouwer and Rice slug test--an update. *Ground Water* 27 (3): 304-309.

Bouwer, H., and Rice, R.C., 1976. A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells. *Water Resources Research* 12 (3): 423-428.

Chapman, L.J. and D.F. Putnam. 1984. The Physiography of Southern Ontario. Ontario Geological Survey Special Volume 2, 270 pp.

Credit Valley Conservation - Toronto and Region Conservation Authority (CVC-TRCA), 2010. Low Impact Development Stormwater Management Planning and Design Guide – Version 1.0.

Duffield, G.M., 2014. AQTESOLV™ for Windows, Version 4.5 Professional. HydroSOLVE Inc., Reston, VA.

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 1. November 2013.

Environment Canada. 2021. Canadian Climate Normals 1981-2010, Waterloo International Airport Climate Station, Climate ID 6144239. [Online] http://climate.weather.gc.ca/climate_normals/index_e.html Accessed December 2021.

Fetter, C.J., 2001. Applied Hydrogeology, Fourth Edition. Upper Saddle River, New Jersey, Prentice-Hall, Inc.

Freeze, R.A. and J.A. Cherry. 1979. Groundwater. Prentice Hall, New Jersey, 604 p.

Karrow, P.F., 1993. Quaternary Geology of the Stratford-Conestogo Area, Southern Ontario. Ontario Geologic Survey Report 283.

Lake Erie Region Source Protection Committee (LESPC), 2021a. Grand River Source Protection Area, Draft Updated Assessment Report. June 17, 2021.

Lake Erie Region Source Protection Committee (LESPC), 2021b. Grand River Source Protection Area, Draft Updated Source Protection Plan. June 17, 2021.

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

Ministry of the Environment (MOE). 1990. Wells. Regulation under the Ontario Water Resources Act. Regulation 903 of the Revised Regulations of Ontario, 1990.

Ontario Geological Survey (OGS). 2010. Surficial geology of southern Ontario; Ontario Geological Survey, Miscellaneous Release -- Data 128-REV, ISBN 978-1-4435-2483-4.

Region of Waterloo. 2015. Regional Official Plan (2031). Approved with modifications by the Ontario Municipal Board on June 18, 2015.

Stantec Consulting Ltd (Stantec). 2021. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program. Prepared for NorthGate Land Corporation, 2115881 Ontario Ltd., Activa Holdings Inc., and Erbsville Kartway. June 2021.

Terraqua Investigations Ltd, 1995. The Study of the Hydrogeology of the Waterloo Moraine. December 1995.

Todd, D.K. 1980. Groundwater Hydrology, 2nd Edition. Wiley, New York, 552 p.

APPENDIX A:
AGENCY CORRESPONDENCE

Grand River Conservation Authority

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

Phone: 519-621-2761 Toll free: 1-866-900-4722 Fax: 519-621-4844 www.grandriver.ca

August 11, 2017

Trevor Hawkins, M.PL, MCIP, RPP
Integrated Planning and Public Works
City of Waterloo
100 Regina Street South
Waterloo, ON
N2J 4A8

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

Dear Mr. Hawkins,

Grand River Conservation Authority (GRCA) staff have completed their review of the following materials, submitted in support of the above noted applications:

- NRSI, ***Environmental Impact Study***, 2115881 Ontario Limited, North Waterloo (July 2016)
- Meritech Engineering, ***Preliminary Stormwater Management Report***, 556 and 576 Conservation Drive, City of Waterloo (July 2016)
- Stantec, ***Phase 1 Groundwater and Surface Water Monitoring Program***, Northgate Corporation, 2115881 Ontario Ltd., Activa Holdings and Erbsville Kartway (May 13, 2016)
- LVM, ***Geotechnical Engineering Report***, 2115881 Ontario Limited, Proposed Residential Development, 560-576 Conservation Drive, Waterloo, Ontario (March 23, 2015)

Based on the comments provided below, GRCA staff are not in a position to recommend approval of the draft plan (30T-16042) and zone change (Z-16-14) at this time. We look forward to receiving a response and revised materials that address the following comments:

Required Comments to be Addressed:

Planning:

1. We note that a portion of the stormwater for the subject lands will be directed toward an off-site Stormwater Management (SWM) facility, the location and design of which has yet to be determined. Please note that GRCA staff are unable to provide a

comprehensive review and/or support of 30T-16402 and Z-16-14 without this information.

2. Please clarify whether any stormwater from the adjacent "Brohman lands" (620 Conservation Drive) will be directed east toward the subject site. If so, the Preliminary SWM Report will need to address whether the on-site SWM facility can adequately accommodate stormwater from the adjacent property.

3. As noted in our pre-consultation comments dated September 14, 2015, a portion of the Park Block (Block 480) is proposed within the 30 metre wetland buffer. Park is not the intended use of the buffer area; therefore, this portion should be designated as Open Space instead.

4. Section 5.4 of the Environmental Impact Study (EIS) states that "a formal trail system will be provided outside of buffers and natural areas" and GRCA staff are supportive of this approach. However, the location of any proposed trails should be illustrated directly on the Draft Plan to ensure that this recommendation is implemented.

Engineering:

5. GRCA staff agree with the target unit flow rates for discharge to Beaver Creek, as derived in the North Waterloo Scoped Subwatershed Study (NWSSS) using GAWSER modelling of event rainfall from the Guelph Arboretum and 54 years of continuous meteorological data from the Waterloo-Wellington Airport. However, in order to ensure conservative design of major system stormwater conveyance and end-of-pipe storage elements, please use the Regional Municipality of Waterloo 100-year, 3-hour IDF rainfall parameters instead of those applied by the City of Waterloo. The former has 100mm of rainfall while the latter has 90mm. For comparative purposes it is worth noting that the City of Cambridge 2011 Stormwater Management Policies and Guidelines, using AES and Shades Mill meteorological data from 1971-2008, have identified 108mm as the 100-year, 3-hour rainfall depth.

6. Please provide a section view of the proposed stormwater facility discharge controls. In particular, the nature of the 7m wide outlet control weir (as labelled in Figure 4) and its relationship to the extended detention 75mm diameter outlet control orifice is unclear.

7. Please confirm that the stormwater management facility in Block 487 will have side slopes that satisfy Ministry of the Environment (MOE) safety criteria. It would be helpful to document this in Figure 4 of the SWM Report.

Natural Heritage:

8. Section 3.3 of the EIS includes a Grand River Fisheries Management Plan which identifies the objectives for the Laurel Creek fish community as "cold water fish community in areas where geological and biophysical characteristics are present and habitat exists or has been rehabilitated." The EIS acknowledges historical brown

trout spawning in lower reaches of Laurel Creek and the confluence of Beaver Creek. The target for water quality discharging from this proposed development should be for the support of a cold water fish community.

9. Buffer and setback dimensions (EIS Section 4.9) should be identified as minimum dimensions (i.e. not fixed dimensions at this stage in the planning process).

10. EIS Section 5.4.4 should identify a thermal discharge target that will maintain water temperature supportive of the cold water fish community in Beaver Creek and Laurel Creek. Given the close proximity of the site to the confluence of Beaver Creek and Laurel Creek, the instream targets identified in the NWSSS should be used for long term monitoring.

11. Thermal discharge of surface and groundwater should be monitored and measured to assess effectiveness of mitigation measures (EIS Section 6.3).

Additional Comments to be Addressed at Detailed Design:

Further to the above, the following comments will need to be addressed at the detailed design phase in order to satisfy future GRCA permit requirements:

Engineering:

a) GRCA staff agree that the site soils, groundwater and observed ground water elevations appear to provide opportunities for maintaining and enhancing existing annual infiltration volumes. For design purposes, we suggest using site-specific water balance values provided in the NWSSS rather than the MOE Stormwater Management Planning and Design Manual generic values used in the SWM Report's appended calculations.

b) Table 6 of the SWM Report correctly uses annual infiltration values derived in the NWSSS (i.e. 188.4mm on the eastern side of a topographic divide and 222.5mm on the western side (NWSSS 2013, Fig 6.4)). However, the SWM plan uses an MOE 228mm generic for the entire development's pervious areas. As implied in the comment above, post development infiltration rates need further evaluation.

c) Unless the guidelines of the TRCA 2012 document, *Preserving and Restoring Healthy Soil: Best Management Practices for Urban Construction*, are applied, post development rates will typically be reduced due to subgrade compaction, degraded soil structure and decreased top soil depths.

d) Groundwater contour mapping is recommended using the highest observed water surface elevations from both the LVM standpipes and the Stantec monitoring wells.

Natural Heritage:

e) A detailed site grading plan will be required and a Geotechnical Engineer should assess the replacement fill material imported onto the site to ensure that it does not

interfere with surface water infiltration or groundwater movement. The importation of fill material also needs to be coordinated with the final SWM plan to ensure the intended water balance is achieved.

f) A detailed dewatering plan will be required to demonstrate how groundwater contributions to the adjacent watercourse and Provincially Significant Wetland will be maintained.

Advisory Comments for Consideration:

i. The maximum forebay velocity to prevent scour of accumulated sediment is 0.15m/s rather than the 0.5m/s identified in the design calculations. 0.5 m/s is the maximum velocity for dispersion of inflow over the forebay berm. As the proposed design achieves 0.10m/s average velocity through the forebay, this comment is advisory only.

If you have any questions or concerns regarding this letter, please do not hesitate to contact the undersigned.

Sincerely,

Kaitlyn Smith
Resource Planner - Grand River Conservation Authority
519-621-2763 ext. 2292 | ksmith@grandriver.ca

c.c. Kristen Barisdale – GSP Group (email)
2115881 Ontario Limited, 169 Lexington Court Unit B-1, Waterloo ON, N2J 4R3

Region of Waterloo

PLANNING, DEVELOPMENT
AND LEGISLATIVE SERVICES
150 Frederick Street, 8th Floor
Kitchener ON N2G 4J3 Canada
Telephone: 519-575-4400
TTY: 519-575-4608
Fax: 519-575-4449
www.regionofwaterloo.ca

Kristen Barisdale, MCIP, RPP (**via email**)
Associate, Senior Planner
GSP Group Inc.
201-72 Victoria Street South,
Kitchener ON N2G 4Y9

File: D18-20/16402
C14-60/4/16014
June 12, 2018

Ms. Barisdale:

Re: Post Circulation Comments
Revised Application for Draft Plan of Subdivision 30T-16402
Zoning By-law Amendment Application Z-16-14
2115881 Ontario Limited / GSP Group
556, 560, 576 Conservation Drive
(n/s Conservation Dr., e/s Roy Schmidt Rd.)
City of Waterloo

The subject applications were received by the Region on August 20, 2016 from GSP Group; application 30T-16402 was deemed complete by the Region's Director of Community Planning on August 23, 2016. The City of Waterloo's Director of Planning Approvals has accepted Zoning By-law Amendment Application Z-16-14 as complete.

On December 21, 2017 and January 3, 2018 respectively, the Region received revised draft plans and the required Regional re-circulation fee. The Region circulated prescribed agencies with the revised draft plan on January 4, 2018. A summary of prescribed external agency comments, as well as comments from Regional staff, is provided below.

The approximately 28.64 ha (70.8 ac) site is situated on the north side of Conservation Drive immediately west of Roy Schmidt Road, in the new Beaver Creek Meadows District area of the City. The subdivision plan dated July 29, 2015 from GSP Group provides development of primarily residential uses to be developed in a single stage and on full municipal services as follows:

Residential:
a) 242 lots for single detached dwelling units;
b) 7 blocks to contain a total of 130 street fronting townhouse dwelling units;
c) 1 block to contain a total of 44 back-to-back townhouse dwelling units; and,
d) 1 block to contain 20-25 Multiple Residential units.

School:
a) 1 block to contain a 2.99 ha (7.4 ac) school site.

Park/Open Space:
a) 2 blocks (approx. 4.86 ha (12 ac) total) for Open Space; and,
b) 1 block to contain a 1.45 ha (3.6 ac) park.

The comments below pertain to review of the submitted plan titled “Draft Plan of Subdivision”, prepared by GSP Group and dated July 29, 2015 (Project No. 09009.40) (last revised November 16, 2017), and associated submitted reports. The comments below have been numbered for discussion purposes.

DELEGATED AUTHORITY COMMENTS

1. Telecon Design (Telus) and HydroOne have each provided that they have no concerns regarding the applications.

2. Rogers Cable, Ontario Power Generation Inc., Waterloo Catholic District School Board, Conseil scolaire de district catholique Centre-Sud, and Le Conseil scolaire de district du Centre-Sud-Quest have not responded to this circulation. By separate letter including a copy of these comments, these agencies are asked to respond at their earliest opportunity if they have any comments.

3. City of Waterloo
As of the date of this letter the City of Waterloo has not provided comments on the application for draft plan of subdivision.

4. Township of Woolwich Engineering and Planning Services
In an email dated January 22, 2018, the Township’s Manager of Planning stated that Township comments dated October 18, 2016 (attached as Appendix A), which were provided in response to the original draft plan circulation, continue to apply. However the Township does note the removal of the walkway on the revised/updated draft plan. The Township is of the opinion that the deletion of the walkway and public access in this area would address Bullet No. 3 of the Township’s October 18, 2016 comments concerning the potential impacts to the adjacent farm. The Township will prefer some form of fencing along the common lot line to ensure that residents backing onto the farm fields will not encroach, use and/or dump onto the abutting lands in Woolwich. The Township is further of the opinion that it would be onerous for the property owners in Woolwich to continually monitor this area to prevent this from occurring.

5. Waterloo-North Hydro Inc.
6. In an email dated April 16, 2018 (attached as Appendix B), Waterloo-North Hydro Inc. (WNH) has advised that it will require that the owner/applicant be required to comply with its requirements and/or conditions of electrical service including the establishment of necessary easements, agreement(s), and detailed engineering design and construction. Furthermore, if necessary, the Developer will be responsible for all costs associated with relocation of any existing WNH facilities as a result of this development.

7. Union Gas
In an email dated January 4, 2018, Union Gas provided that it will require the necessary easements and/or agreements for the provision of gas services for this project to the satisfaction of Union Gas.

8. Canada Post

In an email dated January 15, 2018 Canada Post provided that there are no changes needed to its comments dated September 22, 2016 (attached as Appendix C). Canada Post provided general requirements for the location and construction of centralized Community Mail Boxes. Canada Post has requirements that can be secured through conditions of draft plan approval.

9. Bell Canada

In an email dated September 6, 2016 (attached as Appendix D), Bell Canada provided that it will require the necessary easements and/or agreements for the provision of communication/ telecommunication infrastructure for this project to the satisfaction of Bell Canada.

10. Grand River Conservation Authority

The Grand River Conservation Authority (GRCA) has reviewed the revised draft plan and supporting documentation and have identified in an email dated April 26, 2018 that their original comments dated August 11, 2017 (attached as Appendix E) will continue to apply.

11. Waterloo Region District School Board

In a letter dated September 21, 2016 (attached as Appendix F), the school board provided comments on the original proposed draft plan. Although the school board has not yet provided comments in response to the revised draft plan, it has indicated that its previous comments will continue to apply. When available, comments from the school board will be provided under separate cover.

REGIONAL COMMENTS

Water Services

12. Engineering and Planning staff have reviewed the above noted revised application(s).

13. The Servicing Strategy Report prepared for this development by Meritech, dated July 2016, is generally acceptable.

    a. The report recommends that a detailed water distribution study be prepared at detailed design stage to confirm the fire flow requirements for the subdivision, specifically the higher anticipated fire demand for the school, can be achieved by the proposed water system. Alternatively, building restrictions, materials, sprinkler requirements, etc. can be recommended based on more detailed information.
    b. The applicant should be aware that the Region is currently undertaking a study on the consolidation of Waterloo Pressures Zones 4B, 4C, and 5 which has a direct impact on the application. The objectives of the study are to ensure that once the zones are consolidated that the required level of service is provided to the existing and proposed communities. The study has evaluated the fire flow conditions under future conditions and have identified the existing and proposed fire flow availability. The detailed water distribution study shall incorporate the finding of the consolidation study.

Corridor Planning

Transit Planning

14. In 2018, transit service will be operating on Pinery Trail in this subdivision with the Route 73 Northlake (busPLUS). Transit is requesting 3 transit landing pads within this subdivision with the exact locations to be confirmed in the very near future. The final routing options for the

2018 network are in the later stages of being finalized. Once the final routing is determined Transit staff can identify more exact locations. The current cost for one transit landing pad is $2,800; the total funds for three transit landing pads required from the developer will be $8,400.

Road Traffic Noise Study

15. Corridor Planning staff has reviewed the Preliminary Environmental Noise Impact Assessment for the proposed plan of subdivision at 556 & 576 Conservation Drive, City of Waterloo, prepared by Meritech, dated July 2016. The Report has assessed traffic noise from Conservation Drive.

16. Corridor Planning staff generally concur with the conclusions and recommendations. The applicant will be required to provide a Detailed Noise Impact Assessment, including the height and exact location of the required noise walls. As the subject roads are within City of Waterloo jurisdiction, the recommendations of the study (including the installation of any noise barrier(s)) should be secured through a subdivision agreement with the City. The Region notes that the location of two noise walls identified on the "Noise Assessment Plan" within Appendix C of the Preliminary Environmental Noise Impact Assessment may change through the Detailed Noise Impact Assessment as result of the revised draft plan (last revised November 16, 2017).

Source Water Protection

17. Hydrogeology and Source Water (HSW) staff have reviewed the applicable technical reports submitted for the subject applications and can provide the following comments:

18. Planning Justification Report (GSP, 2016) and Supplementary Information (GSP, 28 July 2016): No comments.

19. Servicing Strategy Report (Meritech, 2016a)
    a. Prior to DPA:
        i. Any existing private wells at the subject property will need to be decommissioned by a licensed well driller in accordance with Ontario Regulation 903 (as amended);
        ii. Any existing septic systems at the subject property will need to be decommissioned in accordance with applicable provincial legislation; and,
        iii. Any existing tile drains at the subject property will need to be decommissioned in accordance with applicable provincial legislation.
    b. Conditions of DPA:
        i. A Salt Management Plan (SMP) will be required for the proposed school block at Site Plan Control. In the event that future revised Draft Plan of Subdivision applications include multi-residential, commercial, institutional, industrial, or community use properties are proposed, a SMP will be required for those properties at Site Plan Control.

20. Geotechnical Engineering Report (LVM, 2015): No comments.

21. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program (Stantec, 2016)
    a. General Comments:
        i. Page 4.3 indicates that at MW6—10, located within the SW portion of the property, Spring 2013/2014 groundwater levels were observed to be as

much as 0.9 m higher than previous levels presented in the NWSSS. This information should be incorporated into design considerations with respect to proposed SWM infrastructure, including lot-level, conveyance, 3rd pipe, and EOP infiltration galleries.

b. Prior to DPA:
    i. An updated groundwater contour map should be generated to reflect the high water table conditions observed across the monitoring area during the Spring 2013/2014 groundwater monitoring events. This should be submitted in an updated hydrogeological report;
    ii. The maximum groundwater elevations observed at each on-site groundwater monitoring well should be reported in m ASL in the report. This data needs to be summarized in tabular format in an updated hydrogeological report for all on-site wells, including the groundwater monitoring wells installed in 2015 by LVM; and,
    iii. Groundwater monitoring wells were installed across the site during the geotechnical investigations by LVM (2015) should be incorporated into the Phase I and Phase II monitoring program until site grading requires that they be decommissioned. Of particular interest are monitoring wells BH-4-15 and BH-05-15, which are installed in the vicinity of one EOP and one conveyance infiltration gallery. Information from these groundwater monitoring wells should be incorporated into the design considerations for these infiltration galleries. The hydrogeology report should be updated to reflect these additional groundwater monitoring locations.

22. Preliminary Stormwater Management Report (Meritech, 2016b)
    a. Prior to DPA:
        i. Table 1 indicates that “Control of Roof Leaders” is not included in the SWM Plan for the proposed development. A 3rd pipe collector system is potentially being proposed as a means to infiltrate clean roof top water from residential homes; however, this has not been confirmed in the preliminary design. It is noted that the 3rd pipe system would only collect water from the front half of the roof tops, and rear-yard roof runoff would be directed towards pervious surfaces. The conceptual design details of a 3rd pipe system were not presented in the Preliminary SWM Report. HSW will require more details as to how this system will function (i.e. will it be perforated pipe that actively infiltrates water within the road right-of-way, or will it be collected in a larger infiltration gallery and discharged in a more point-source manner?). These details need to be provided in an updated Preliminary SWM Report;
        ii. The proponent should be aware that a distributed approach to groundwater recharge will be required across the proposed development, where soil conditions permit;
        iii. Page 11 of the report cites the NWSSS and Geotechnical Report (LVM, 2015) when discussing groundwater conditions at the site. The Report does not reference the higher groundwater elevation conditions noted in Stantec (2016). The Preliminary SWM Report will need to be updated to make reference to the conditions noted in the Stantec (2016) report, and provide an opinion as to whether or not the feasibility of the SWM infrastructure is impacted by these results;
        iv. Page 14 indicates that infiltration measures that receive from the streets

should be designed to bypass in the winter months. HSW agrees with this recommendation, however, was this winter by-pass taken into consideration for the post-development water balance? This needs to be confirmed, and potentially included in a new water balance in an updated Preliminary SWM Report;

v. The assumed post-development infiltration rate on pervious surfaces was 228 mm/yr for all pervious areas within the proposed development. This is higher than either of the infiltration rates used for the pre-development conditions. The proponent should provide rationale as to a) why the property wasn't broken down into east and west portions (with different infiltration rates), as it was in the pre-development infiltration calculation, and b) why the overall infiltration rate for the site was increased to 228 mm/yr. If the rationale is not to the satisfaction of HSW, the post-development infiltration volumes will need to be re-assessed and summarized in an updated Preliminary SWM Report;

vi. The post-development infiltration area for the Clean-Water-Conveyance (CWC), or 3rd pipe system, was reported as 2.46 ha. Does this area represent the total roof area of the development, or only half of the roof area for the development? It is noted that earlier sections in the report stated that a 3rd pipe CWC system would only capture runoff from the front half of residential roof tops. This should be clarified in an updated Preliminary SWM Report;

vii. Do the infiltration galleries in Catchments 504, 505 and 506 take winter by-pass shutoffs into consideration when determining post-development infiltration volumes? This needs to be clarified in an updated Preliminary SWM Report;

viii. The Preliminary SWM Report should be updated to include an analysis demonstrating, in terms of m3/yr:

$$P_{Pre\text{-}Dev} = P_{Post\text{-}Dev}$$

$$ET_{Pre\text{-}Dev} + R_{Pre\text{-}Dev} + I_{Pre\text{-}Dev} = ET_{Post\text{-}Dev} + R_{Post\text{-}Dev} + I_{Post\text{-}Dev}$$

ix. The proposed Stage II Monitoring Program should include sodium and chloride in the groundwater quality monitoring program. Manual water levels and data logger downloads should be performed quarterly. The proposed Stage II Monitoring Program needs to identify which groundwater monitoring wells are proposed to included in the Program. Groundwater elevation and quality monitoring should be performed in the groundwater monitoring wells installed by LVM (2015) (particularly in BH-04-15 and BH-05-15). These details need to be included in an updated Preliminary SWM Report. And,

x. The Preliminary SWM Report should be updated to reflect the revision to the original draft plan of subdivision. Specifically, the water balance should be revisited to adjust for Block 243 (new proposed townhomes) and Block 251(proposed multi-res block).

b. Conditions of DPA:

i. Seasonal high groundwater elevations were observed during the spring months of 2013/2014 as presented in Stantec (2016). Proposed conveyance and EOP infiltration galleries will need to be designed to have

a separation between the bottom of the infiltration gallery and the maximum groundwater elevation observed at each respective location. The high water table across the site may influence where lot-level and 3rd pipe conveyance systems are feasible. This will need to be verified prior to approval of the Final SWM Report, to the satisfaction of the Region, City and GRCA;

ii. Any proposed lot-level infiltration galleries and / or 3rd pipe collector systems will need to be oversized by 15% to account for decreased performance over time and/or private homeowner disconnection;

iii. Any EOP infiltration galleries will need to be oversized by 15% to account for decreased performance over time;

iv. Is it feasible to install a CWC system throughout the entire 503 and 701 Catchments, given the generally lower-permeability soils identified in the eastern portion of the site? This should be addressed in the Final SWM Report;

v. It is HSW's preference to see infiltration of clean roof top runoff to achieve a net zero loss of pre-development infiltration volumes. Infiltration of impervious road runoff should only be incorporated if additional infiltration volume is required to achieve a net zero loss of pre-development infiltration volumes. This should be taken into consideration during detailed design;

vi. The proposed Stage III Monitoring Program proposes to monitor the performance of infiltration trenches/galleries and soak away pits on public property within 24 hours after a rainfall event once per year. These infiltration galleries should be equipped with continuous-read data loggers to evaluate the efficacy of the infiltration infrastructure. This will allow for multiple events of different sizes and timing to be analyzed. This detail can be included in the Final SWM Report; and,

vii. Page 28 indicates that building sump pumps should be connected to the internal storm sewer system. If a 3rd pipe CWC system is utilized at the proposed development, building sump pumps should be directed towards the CWC rather than to the storm sewer, as recommended in the NWSSS. This detail can be incorporated into the Final SWM Report.

23. General Comments

a. The proposed development lies within a Wellhead Protection Area (WHPA) D-2 for the Waterloo North Well Field, and requires a Section 59 Notice to be provided in accordance with the Clean Water Act.

b. Prior to DPA:

i. Generally, the SWM plan proposed in the Preliminary SWM Report is vague with respect to what types of engineered infiltration measures will be utilized at the proposed development. HSW recognizes that detailed stormwater infrastructure designs will be completed and presented in a Final SWM Report; however, there should be more direction in an updated Preliminary SWM Report. In order to match or exceed the pre-development infiltration volumes, it is HSW's preference to see distributed infiltration of clean roof top runoff in areas where soils are conducive to infiltration. This may be via lot-level infiltration galleries and/or 3rd pipe systems, or a combination of both. The post-development infiltration volumes can be topped up with runoff from impervious road surfaces;

ii. If a significant volume of infiltration is proposed from runoff originating from paved surfaces (via conveyance and/or EOP infiltration galleries), HSW will require a Chloride Impact Assessment to be completed prior to DPA, which can be included as a new section within an updated Preliminary SWM Plan; and,
iii. Alternatively, if winter by-pass valves are proposed on conveyance and EOP infiltration galleries, HSW would re-consider the need for a Chloride Impact Assessment.

Environmental Planning

24. Environmental planning staff has reviewed the reports and revised plans related to the proposed residential subdivision by Cook Homes at Conservation Drive and Beaver Creek Road in Waterloo. Environmental Planning staff have the following comments for your consideration:

25. Draft Plan of Subdivision

a. What is meant by the area identified as "Not included in dripline setback" (Block 256)? This area is identified as Significant Woodland and afforded a 10-metre buffer on Map 6 of the EIS but not identified as a Significant Natural Feature on Map 7 of the EIS. Please clarify.

26. Environmental Impact Study

a. Editorial note – Parts of the report do not have page numbers.

b. The Region's Greenlands Network Implementation Guideline was endorsed by Regional Council in June 2016 (p.2). Please ensure that the EIS references the 2016 version of this document.

c. 4.6 Ecological Linkages (p.43) – While staff agrees that the Beaver Creek corridor is the primary existing ecological linkage, does the NWSSS not identify a linkage to be enhanced along the northern property limit (see NWSSS Figure 14.4)? Please clarify. Staff raised this issue at the October 2016 agency site walk and recommended considering enhancements to this linkage through removal of invasive species and planting a mix and range of trees/meadow species similar to the existing trail to the east of the subject lands.

d. 5.4.1 Encroachment into Buffers (p.53) – First bullet states "the buffer provided always meets or exceeds the minimum Region of Waterloo recommended buffer of 10m from dripline for Core Environmental Features." Please note that a 10-metre buffer is a requirement under ROP Policy 7.C.11 and not a "recommendation." In addition, the Conceptual Grading Plan and Figure 4 of the SWM Report (Meritech, July 2016) appears to show grading in the SWM block up to/within the dripline of the Core Environmental Feature (Significant Woodland). However, the encroachment is difficult to determine since the woodland dripline and buffer are not shown on the grading plan. Please clarify with respect to how site alteration in this area would comply with ROP Policy 7.C.6.

e. 5.6.1 Wetland/Woodland Edge Buffer (p.62) – The last sentence of this section makes reference to a “farm dump area”. Where is this area located and could it be identified on one of the maps (i.e. EIS Map 7)?

f. 6.3 Post Construction Monitoring (p. 66) – How long will post construction monitoring continue following 90% buildout of the subdivision? Please note that the Region typically requires 2 years of post-construction monitoring.

27. Stormwater Management Report

a. Figure 4 – The limit of grading for the SWM facility appears to be coincident/within with the boundary of the Significant Woodland. The minimum buffer for Regional Core Environmental Features is 10 metres according to the ROP. Please clarify.

b. Quantity (p. 15) – For Catchment 504, if a bioswale is to be used (instead or oil/grit separator), where would it be located? The last sentence of this section is somewhat vague in this regard. Please clarify.

Archaeology

28. Staff have received the Archaeological Assessment Report Entitled, "Original Report” Archaeological Assessment (Stages 1 & 2) by Archaeological Research Associates Ltd. dated June 17, 2016, and acknowledge that a Stage 3 site-specific assessment is recommended for two locations of archaeological materials: Euro-Canadian Findspots 3 and 4. Such assessment, as well as an acknowledgement letter from the Ministry of Tourism, Culture and Sport (with two (2) copies of assessment provided to Region) that such report has been entered into the Ontario Public Registrar of Archaeological Reports, will need to be completed prior to Draft Plan Approval.

General

29. If any part of the development may potentially create a Non-Municipal Year-Round Residential System (NMYRRS) under the Safe Drinking Water Act (SDWA), 2002, such must be confirmed prior to draft plan approval and in consultation with the City of Waterloo; additional requirements may be applicable under the SDWA if a NMYRRS is confirmed.

30. Pursuant to the Region’s standard conditions for Draft Plans of Subdivision and Condominium, a development is required to contain a permanent secondary access if more than 26 units are developed with only one point of access. The north-west portion of this plan would exceed this maximum requirement, and, depending on when/how lands to the east are ultimately developed, all lands north of Street ‘E’ could also exceed this maximum. Additional information showing how this issue can be resolved will be required prior to issuing a decision.

31. Regional staff has no objection in principle at this juncture with the proposed draft plan of subdivision, and associated zone change application. As stated in the aforementioned comments, Regional staff will require additional information prior to granting draft approval, and will consider additional comments (including the City’s) as they are received.

Region Planning Fees
32. Regional staff acknowledges receipt of the application fees for the plan of subdivision, and zone change and EIS review. The developer should be advised of the following fees and charges (subject to annual change by By-law):

Subdivision Plans:
Draft Approval - $4,025.00 Registration Release - $2,000.00

If you have any questions, please don't hesitate to contact the undersigned.

Yours truly,



Adam Betteridge, MCIP, RPP
Principal Planner
abetteridge@regionofwaterloo.ca
(519) 575-4757 ex. 3120

cc. N. Hardacre, MCIP, RPP, City of Waterloo Planning (via email)
J. Scarfone, Manager of Planning, Township of Woolwich (via email)
R. Wei, Waterloo North Hydro (via email)
J. Bere, Canada Post Corp. (via email)
M. Palynchuk, Access Networking Provisioning (Bell) (via email)
Grand River Conservation Authority (via email)
Waterloo Region District School Board (via email)
Region of Waterloo – Water Services; Corridor Planning; Source Water Protection; Environmental Planning; and, Cultural Heritage (all via email)

THE CITY OF Waterloo | **Integrated Planning & Public Works**

Planning Approvals

August 31, 2018

Mrs. Brenna MacKinnon
Planning, Development and Legislative Services
Regional Municipality of Waterloo
150 Frederick Street
Kitchener, ON N2G 4J3

Mrs. Kristen Barisdale, MCIP, RPP
Associate, Senior Planner
GSP Group Inc.
72 Victoria Street South, Suite 201
Kitchener, ON N2G 4Y9

Mrs. MacKinnon & Mrs. Barisdale:

Re: Second Submission Comments
Zone Change Application Z-16-14
Draft Plan of Subdivision 30T-16402
556, 560 and 576 Conservation Drive

Please accept this correspondence in relation to Zone Change Application Z-16-14 and Draft Plan of Subdivision Application 30T-16402 and as a formal response to two submissions made by GSP Group on November 30, 2017 and June 15, 2018. Details of the materials provided in each submission are outlined as follows:

Submission of November 22, 2017:

- Revised Draft Plan of Subdivision, prepared by GSP Group, dated July 29, 2015 and revised November 16, 2017, annotated with changes.

Submission of June 15, 2018:

- Draft Plan of Subdivision, prepared by GSP Group, dated July 29, 2015 and revised February 23, 2018
- Preliminary Environmental Noise Impact Assessment, prepared by Meritech, dated May 2018
- Conceptual Erosion & Sediment Control Plan, dated February 2018
- Servicing Strategy Report, prepared by Meritech, dated May 2018
- Preliminary Stormwater Management Report (revised), prepared by Meritech, dated May 2018

City of Waterloo staff has completed a preliminary review of the information listed above and provides the listed comments below, in response. Prior to the City being in a position to recommend Draft Approval of the subdivision to the Region, or approval of the Zone Change application to Waterloo City Council, the following must be addressed and responded to in writing, with supporting studies and/or plans where necessary.

PART A – PLANNING COMMENTS

Density

1. Based on the current Draft Plan, the density of the proposed development is between 44 and 50 residents and jobs per hectare (rj/ha). The planned density of the Beaver Creek Meadows District Plan (BCMDP) area is 58 rj/ha as per OPA 15, which applies to the entire BCMDP area. Any shortfalls in the density of this subdivision area will impact, and need to be made-up in, other areas of the BCMDP. Please confirm the total density (in rj/ha) to be generated by this development

2. The density of the Mixed-Use Node appears under capacity compared to the land uses and density contemplated in the Official Plan and BCMDP. Density targets included within Table 3 of the District Plan for Mixed-Use Medium Density Residential is between 60 to 100 units per hectare. The proposed Draft Plan is showing approximately 53 units per hectare for the Mixed-Use Medium Density Residential lands. Please demonstrate how the density of the Node is consistent with the planned density outlined in the BCMDP and the Official Plan. Consider increasing density, in particular Block 251 (Multiple Residential).

Park Block and Open Space Block

3. Block 253 (Park) must be a minimum dedication of 5% of the Draft Plan lands. All natural features and associated buffers must not be included within this calculation. Land within buffers will not be considered as contributing to the parkland dedication requirements (Official Plan policy 8.2.4(12)).

4. A portion of Block 253 (Park) remains within the buffer area of the adjacent natural environmental feature. Revise the limits of Block 254 (Open Space) and Block 253 (Park). All natural features and associated buffers should be within Block 254 (Open Space). All lands within Block 253 (Park) should be unencumbered.

5. A portion of Block 256 (SWM) remains within the buffer area of the adjacent natural environmental feature. Revise the limits of Block 254 (Open Space) and Block 256 (SWM). All natural features and associated buffers should be within Block 254 (Open Space). All SWM features (including infiltration galleries) and trails/maintenance access should be located within the limits of Block 256 (SWM). Please also refer to the Environmental comments below.

6. Block 253 (Park) is in the same location as the park lands identified in the BCMDP, however, the south side of the park frontage is limited and partially blocked by Block 244 (Street Townhouses). While the park frontage has been slightly increased from previous versions of the proposed Draft Plan, the frontage to the park still remains limited due to the location of Block 244 (Street Townhouse). Policy 3.8.3 of the BCMDP requires that the park maximizes its accessibility to residents and visual presence within the community. Policy 3.8.4 of the BCMDP identifies that parkland should have sufficient frontage to the satisfaction of the City of Waterloo, to enhance visibility. Furthermore, street townhouses were not contemplated in the BCMDP in this location (Block 244).

7. Block 253 (Park) is in the same location as the park lands identified in the BCMDP, however, the north side of the park frontage is limited and partially blocked by Lot 154 and Lot 155. Policy 3.8.3 of the BCMDP requires that the park maximizes its accessibility to residents and visual presence within the community. Policy 3.8.4 of the BCMDP identifies that parkland should have sufficient frontage to the satisfaction of the City of Waterloo, to enhance visibility. Please remove Lot 154 and Lot 155.

School Block

8. As per the BCMDP, the subject lands are planned to include an elementary school in a central location and north of the Mixed-Use Node. Block 252 (School) is 2.99 ha in size, consistent with policy 3.7.5(b) of the BCMDP. Final site design and layout of the school site should be coordinated with the School Board, in accordance with policies 3.7.5 of the BCMDP.

Single Detached Lots (Lots 1-242)

9. Additional information is required in support of the requested site specific reductions. Please provide a Lot Plan(s) showing a typical single detached dwelling on a typical lot (both internal and corner lots) with the requested yard setbacks. Please also provide additional rationale and/or justification for each proposed reduction to the zoning regulations, including encroachments.

10. Staff have concerns with the request to reduce front yard setbacks. Front yard setbacks should comply with zoning standards. A front yard setback of 4.0 metres plus an allowance for a porch encroachment of 1.5 metres will negatively impact the streetscape. This results in a minimum front yard setback of 2.5 metres deep. Rideau River Street and Pinery Trail have larger front yard setbacks. A front yard depth of 4.0 metres is insufficient for a car to park in the driveway. In addition, a 2.0 metre wide easement is required along the frontage of each lot.

11. Lot depths shown are a minimum of 28 metres (with the exception of Lot 108 and Lot 109 which has a depth of 27.8 m). This is below the typical lot depth of 30 m. Consider increasing lot depths to achieve required front yard and rear yard setbacks, and to provide appropriate amenity area in the front and rear yards.

12. Staff have concerns with the request to reduce side yard setbacks. Reduced side yard setbacks will increase the need for easements to access the rear yard, provide insufficient space to maintain the house and side yard, and provide insufficient space for infrastructure (i.e., meters, air conditioning units). The need for easements to access private single detached backyard does not seem reasonable. This indicates the house is too large for the lot. Side yard setbacks should comply with zoning standards.

13. Lot 138 and Lot 242 appear to be very small corner lots. Ensure lot dimensions are such that minimum flankage yard setbacks can be accommodated along the entire length of the flankage façade (i.e., both front and back corners of the dwelling). Consider increasing the size of these lots or provide Lot Plans for each lot to show how required setbacks will be met.

14. The requested maximum porch encroachment into the side yard of 1.5 metres is greater than either of the minimum side yard setbacks requested (0.6 metres and 1.2 metres). This is not reasonable.

15. Confirm proposed coverage. Combination of reduced front yard, rear yard and side yards means the dwelling is too large for the lot. Smaller lots, shorter front yards and reduced side yards are all out of character with the existing homes on Pinery Trail and Rideau River Street and would not provide sufficient amenity space for future home owners/residents.

16. Confirm proposed garage and driveway dimensions. Minimum standards for garage sizes and driveway sizes will be recommended through zoning to ensure appropriate and sufficient parking is provided.

<u>Townhouse Blocks (Blocks 243-250)</u>

17. Additional information is required in support of the requested site specific reductions to the various forms of dwelling units. Please provide Lot Plan(s) showing typical street townhouse dwelling and requested yard setbacks. Please also provide additional rationale and/or justification for each proposed reduction to the zoning regulations, including encroachments.

18. Provide additional information related to the Back-to-Back Townhouse dwellings proposed on Block 250 in the form of a concept plan showing building form and setbacks. Additional rationale and/or justification is also required for the requested setbacks, including encroachments.

19. Provide a conceptual lot layout for all townhouse blocks. Are the townhouse dwellings intended to be condominium units? Lotted on the final plan to be registered?

20. Please remove Block 244 (Street Townhouses). Townhouse dwellings are not contemplated in this location in the District Plan (refer to #6).

21. Please increase the depth of Block 248 and 249 (Street Townhouses). A depth of 25.1 to 26.2 metres does not appear to be sufficient for the intended units while still providing appropriate outdoor amenity area.

22. Block 250 (Back-to-Back Townhouses) is only 28 metres deep, while Block 246 (Street Townhouses) is 27 metres deep. Confirmation is required that a depth of 28.0 metres is sufficient for back-to-back townhouse units without negatively impacting the streetscape and still providing adequate outdoor amenity area. Please demonstrate how this design would be achieved with such a narrow block depth (see also #18).

23. It is not clear how uses along Conservation Drive will address the street while avoiding backing onto interior blocks. Policies 3.2.10 and 3.2.19(b) of the BCMDP discourage back-lotting onto municipal streets such as Conservation Drive and Beaver Creek Road. Block 248 and 249 (Street Townhouses) are proposed to front Conservation Drive and Street A, and back onto Street F. Having Block 248 and 249 'back' onto the front yards of the townhouse units in Block 250 (Back-to-Back Townhouse) is not an appropriate configuration. Please consider revising the configuration of the townhouse blocks. Staff have reviewed possible configurations for this area and are available to meet to discuss these options, should you wish.

24. Please confirm if commercial is proposed within any of the Townhouse Blocks. This is strongly encouraged within the Mixed-Use Medium Density Residential lands and within the Mixed-Use Node. Blocks 245, 246 and 250 could contain a mixture of street townhouses and live/work style townhouses to achieve density targets and design priorities of the BCMDP.

25. Confirm proposed coverage. Combination of reduced front yard, rear yard and side yards means the dwelling is too large for the lot. Smaller lots, shorter front yards and reduced side yards are all out of character with the existing homes on Pinery Trail and Rideau River Street and would not provide sufficient amenity space for future home owners/residents.

26. Staff have concerns with the request to reduce front yard setbacks. Front yard setbacks should comply with zoning standards. A front yard depth of 4.0 metres plus an allowance for a porch encroachment of 1.5 metres will negatively impact the streetscape. This results in a minimum front yard setback of 2.5 metres deep. Rideau River Street and Pinery Trail have larger front yard setbacks. In addition, a front yard depth of 4.0 metres is insufficient for a car to park in the driveway. A 2.0 metre wide easement is required along the frontage of each lot.

27. A maximum height of 10.5 metres is being requested for townhouse dwellings. A height of greater than 10 metres will require an Official Plan Amendment for Blocks outside the Mixed-Use Node (i.e., Block 243 (Street Townhouse)).

28. Block 243 has been modified from single detached units to townhouse units. This is consistent with the direction of the BCMDP.

29. Confirm proposed garage and driveway dimensions. Minimum standards for garage sizes and driveway sizes will be recommended through zoning to ensure appropriate and sufficient parking is provided.

30. Have stacked townhouse dwellings been considered?

Multiple Residential Block (Block 251)

31. Please confirm built form proposed for Block 251 (Multiple Residential). Show conceptual plan(s) for the proposed / possible development of this block.

32. Please show dimensions (i.e., frontage) on the Draft Plan for Block 251 (Multiple Residential).

33. Density targets included in the BCMDP for the Mixed-Use Medium Density Residential lands within the Mixed-Use Node is between 60 to 100 units per hectare. The proposed density of Block 251 (Multiple Residential) is 30 to 37 units per hectare. Consider increasing the density of Block 251 (Multiple Residential).

34. Additional land will be required along the eastern boundary of Block 251 (Multiple Residential) which will form part of the ultimate road allowance and future road construction of Roy Schmidt Road (refer to 'Roy Schmidt Road' comments below).

35. Commercial is strongly encouraged to be included as part of the development of Block 251 (Multiple Residential). This aligns with the policies of the BCMDP.

36. The Draft Plan has been revised from previous versions to include Multiple Residential on Block 251 instead of townhouse units. This change is consistent with the BCMDP.

37. It is recommended that the land uses of Block 251 (Multiple Residential) be coordinated and compatible with the lands to the east which also form part of the Mixed-Use Node.

Mixed-Use Node

38. Special Provision Area 37 (SPA 37) of the Official Plan applies to a portion of the subject lands identified as the Beaver Creek Node, which allow for higher densities and building heights, as well as a wide range of uses to create a mixed-use centre with a concentration of neighbourhood-oriented retail, service commercial uses, institutional employment and residential uses. The extent of the node has been determined through the BCMDP. Blocks 245 to 251 are within the identified node area. Development within these blocks is permitted to be as high as 20 metres and permitted to have a density of up to 300 bedrooms per hectare.

39. SPA 37 of the Official Plan encourages a mix of uses. Staff recommends that a wide range of uses be considered for Blocks 245 to 251 including commercial, and to develop these blocks as a mixed-use area, consistent with SPA 37.

40. Policy 3.4.14 of the BCMDP outlines a range of commercial uses both permitted and encouraged within the Mixed-Use Node. Staff recommends commercial uses and live/work style units within the Mixed-Use Node (refer to policy 3.4.13 of the BCMDP). The inclusion of limited commercial uses and live/work units, well integrated with residential uses within the Node, is an important component of the overall vision and structure of the BCMDP.

41. The heights of the buildings within the Mixed-Use Node should be a minimum of 9.0 metres and should not exceed six storeys. The BCMDP contemplates a range of uses within the Node, with a high degree of pedestrian orientation. Policy 3.6.2 of the BCMDP encourages a range of residential uses to provide accommodation for a broad income and social mix. The proposed development should be consistent with policies 3.6.3 and 3.6.4, which require high quality urban design and visually interesting spaces that consider pedestrian movement and streetscapes.

42. At a minimum, buildings along Conservation Drive should be designed to accommodate future main floor commercial uses (minimum ground floor height will be recommended).

Roy Schmidt Road

43. Roy Schmidt Road shall have a road allowance width of 18.0 metres, to be measured at 9.0 metres on either side of the historic centre line of the road.

44. The developer shall coordinate the design of Roy Schmidt Road and cost-share on the reconstruction with the owner/developer of the lands on the east side of the road (Draft Plan 30T-17403), including a new multi-use trail extending from Conservation Drive to the City of Waterloo boundary north of Pinery Trail.

45. The width of Roy Schmidt Road south of Street E does not appear to be 18 metres, specifically along the eastern property line of Block 251 (Multiple Residential). The configuration of Block 251 (Multiple Residential) should be modified to allow sufficient road width.

46. The Draft Plan shows Roy Schmidt Road to be closed between Rideau River Street and Pinery Trail. Roy Schmidt Road is only proposed to be closed at the intersection of Conservation Drive. The remainder of Roy Schmidt Road is to remain open. The width of Roy Schmidt Road north of Pinery Trail shall be 18.0 metres. Lot 211 and Lot 212 will need to be revised to allow sufficient road width.

47. Registration of Lots 226 to 242 will be conditional upon the construction of Roy Schmidt Road.

48. Roy Schmidt Road is to be closed at Conservation Drive. A trail connection is required from Roy Schmidt Road to Conservation Drive in the location of the shared boundary between this development and the adjacent lands (Draft Plan 30T-17403), in the form of a 4.0 metre walkway block for a multi-use trail. If additional land is required to provide proper grading and drainage of the trail, this additional land will be included in the walkway block and conveyed to the City. City land outside that needed for the walkway block may be declared surplus. Such lands may be sold by the City in accordance with the City's Disposition of Property process.

49. Show accurate lot lines of adjacent / surrounding lands on the Draft Plan, including lands owned by the City in the area of Roy Schmidt Road.

Street Alignment

50. Staff support the accesses provided to the future development lands to the west (Brohman lands), through the extension of Pinery Trail and Street B. The precise location of these streets should be coordinated with the adjacent land owner throughout the Draft Plan process. The final location of Pinery Trail and Street B are to be located in such a way as to permit, and not hinder, the appropriate development of the adjacent lands (Brohman lands).

51. Show and dimension daylight triangles where streets intersect, particularly in the location of Street H, at Conservation Drive. How will reduced flankage affect visibility on corner lots? Daylight triangles shall be provided as per TAC guidelines.

52. The configuration of Street corners should be curved. Ninety degree angles are not desirable and create driveway issues (Street E).

53. Consider revising Street E and Street F as one Street name (as a future crescent). The current configuration of Street E and Street F creates confusion – where does one end and the next begin? Street G and Street H could remain with separate names.

54. Temporary cul-de-sacs will be required at the terminus of Street B, Pinery Trail and Street E.

55. Include 0.3 metre reserves between Conservation Drive and proposed residential Blocks to restrict driveway access.

56. Street H alignment / functioning is to conform with correspondence dated July 7, 2017 *(Conservation Drive and Beaver Creek Road Upgrades and Extension of Municipal Services – Update to Transportation Forecasts and Left Turn Lane Requirements, Stantec, 2017)*, which was provided to the Beaver Creek Meadows Developer's Group on July 14, 2017.

57. A Traffic Management Plan is required to be submitted with all subdivision applications, as per Policy 3.9.1(f) of the BCMDP. Traffic calming measures are to be recommended, reviewed and implemented as the subdivision is built, rather than retrofitted after the fact. Such measures will be included as conditions of Draft Approval, to be implemented as the subdivision is built out. For additional information refer to Part D.

Pedestrian Connectivity

58. There is a lack of pedestrian connections between streets. Please show walkways in strategic locations throughout the Draft Plan to increase pedestrian connectivity and to reduce walking distances.

59. In previous versions of the Draft Plan an east-west walkway was proposed between Street B and Rideau River Street. This connection has since been removed. It is recommended this connection be retained as limited east-west connections exist in this area. Maintaining this connection is consistent with policies 3.9.5 and 3.9.6 of the BCMDP.

60. A pedestrian connection should be included between Street B and Street D to improve north south pedestrian connections, consistent with policies 3.9.5 and 3.9.6 of the BCMDP.

61. The Draft Plan shows very limited active transportation connections. This is inconsistent with policy 3.9.4 of the BCMDP, which requires the active transportation network to be designed to ensure convenient and safe travel throughout the community. Proposed lots along the north limit of the Draft Plan have no direct access to key areas such as the school, park, Mixed-Use Node, or transit services. Policy 3.9.5 of the BCMDP requires an active transportation network that provides multiple options for pedestrians and cyclists to travel within the community.

62. Map 5 of the BCMDP shows a proposed trail connection running north-south including a route along the buffer area on the west side of the plan. Staff recommends that a pedestrian connection along the buffer be implemented, subject to environmental sensitivities. The EIS submitted as part of this proposal should confirm the feasibility of implementing a trail in this buffer area prior to final development approval. All trails should be developed in accordance with policies 3.9.7- 3.9.15 of the BCMDP.

63. A continuation of the Avon Trail was previously shown along the north boundary of the Draft Plan, as per policy 4.4.8 of the BCMDP and has since been removed. This is an important community trail connection.

64. Consider including a walkway connection from the roundabout at Beaver Creek Road and Conservation Drive to Street E / Street F through Block 249 (Street Townhouse).

65. Overall, the proposed Draft Plan does not meet the intent of Policy 3.9.2 to 3.9.6 for an active transportation system. Please refer to Map 5 of the BCMDP.

Phasing

66. If phasing of the development is proposed, please submit a Phasing Plan. Also, confirm how the phasing of the development will relate to the availability and timing of the broader stormwater management plan.

Retaining Walls

67. All proposed retaining walls throughout the plan (i.e., at west property limit, within SWM Blocks, etc.) shall be removed or minimized to the extent possible.

Noise

68. The Preliminary Environmental Noise Impact Assessment, prepared by Meritech, dated May 2018 recommends a 1.8 metre high noise wall along Conservation Drive and Street A, along with noise warning clauses for lots within 20 metres and 40 metres of Conservation Drive. Staff do not support the use of noise walls to mitigate noise levels generated by traffic along Conservation Drive. Acceptable measures include building orientation / site layout, berms, and setbacks (physical separation).

Design Considerations

69. Development of the subject lands should be consistent with urban design policies of the BCMDP (Section 4). Generally, the Draft Plan should reflect a complete community with high quality design, a high degree of connectivity, well designed and attractive streetscapes, and a sense of identity. Good urban design principles should also be incorporated into the built form, including each dwelling unit type. In particular, townhouses should be consistent with policies 3.4.17-19 of the BCMDP.

70. The development as a whole should be consistent with the City's Urban Design Manual.

71. An Urban Design Brief was not submitted. Subdivision Urban Design Guidelines will be required as a condition of draft approval.

PART B – ENVIRONMENTAL PLANNING COMMENTS

72. When compared to the previous submission, the wetland limits shown on the Draft Plan of Subdivision (last revised February 23, 2018) have changed. The rationale for the new limits needs to be confirmed, as does GRCA's acceptance of the new limits. Also, the wetland limits shown on the Draft Plan differ from those shown on the Conceptual Erosion and Sediment Control Plan (dated February 2018). The wetland limits on the Conceptual Erosion and Sediment Control Plan match those from the previous version of the Draft Plan. Further, the dripline shown in the northwest corner of the site on the Draft Plan is different than that shown on the Conceptual Erosion and Sediment Control Plan.

73. Figure 6 of the Preliminary Stormwater Management Report (Revised May 2018) includes a note that reads "Dripline knob to be removed". Through the EIS, the "knob" is mapped as Significant Woodland (Core Natural Feature) and Significant Wildlife Habitat (Supporting Natural Feature). Official Plan policies 8.2.4(2) and 8.2.5(2) require the form and ecological function of such features to be maintained, enhanced or, where feasible, restored. Policies 8.2.4(3) and 8.2.5(3) also restrict development and site alteration within such features to a limited range of uses/activities. As per the Official Plan and the North Waterloo Scoped Subwatershed Study (NWSSS), the feature should remain intact and be afforded a 10 metre buffer. In terms of that buffer, as set out in Official Plan policy 8.2.4(9), buffers are to remain in or be restored to a primarily natural state and portions of stormwater management facilities may be permitted in them where the feature is enhanced, no other alternative location is feasible, low impact development measures are implemented to the extent feasible outside the buffer, root zones are not impacted, and the facility replicates or complements an existing function of the buffer lands.

74. It is unclear whether the constructed wetland will include a cooling trench. Figure 6 of the Preliminary Stormwater Management Report (Revised May 2018) shows a level spreader but a cooling trench is referenced on page 29.

75. While the Preliminary Stormwater Management Report (Revised May 2018) sets out recommendations for the during-development and post-construction monitoring programs, the Terms of Reference for each phase will need to be finalized at the time of transition. This comment also applies to the monitoring recommendations put forward in the EIS. Further, while the 2016 and 2017 Pre-development Biological Monitoring Reports were submitted in early 2017 and 2018 respectively, the 2016 Groundwater and Surface Water Monitoring Report and subsequent reports are still outstanding. These reports should be submitted together and as soon as possible following the end of the monitoring year.

76. Based on the direction provided in the District Plan, a trail, that would have to be supported through the EIS if it is in the buffer, should be incorporated into the plan that extends from Block 256 (Stormwater Management) down to Conservation Drive. Further, approximate trail locations should be shown.

77. Section 5.4.7 of the EIS states that the wet cells of the pond have been placed outside of the Category 2 habitat of the Blanding's turtle which will avoid the need for registering any maintenance works for an exemption under the ESA. However, in MNRF's comments, it was noted that the stormwater management pond could become Blanding's Turtle habitat in the future and would therefore require any maintenance of the pond to proceed in consultation with MNRF to ensure the species is not negatively impacted. This needs to be clarified and City Engineering staff need to be made aware of the requirements.

78. The Preliminary Stormwater Management Report (Revised May 2018) and the Conceptual Erosion and Sediment Control Plan (dated February 2018) show part of an infiltration gallery within the wetland buffer (to varying degrees, as different wetland limits are used on each plan). Official Plan policy 8.2.4(9) states that buffers are to remain in or be restored to a primarily natural state and portions of stormwater management facilities may be permitted in them where the feature is enhanced, no other alternative location is feasible, low impact development measures are implemented to the extent feasible outside the buffer, root zones are not impacted, and the facility replicates or complements an existing function of the buffer lands. It has not been demonstrated that these criteria are met. If it can be shown that the criteria are met, details on the design of the infiltration galleries are needed, as they may be incompatible with a naturalized buffer. Potential areas of incompatibility include whether access to the galleries needs to be maintained, whether the vegetation over top of the galleries need to be maintained/manicured, whether tree roots will interfere with gallery function as the buffer matures from a meadow community to a treed one, and whether the galleries will need to be maintained in the short or long term, since accessing them would disrupt the buffer and remove any habitat that has been created, the provision of which is identified as a key ecological enhancement in the NWSSS.

79. Sections 3.2 and 5.4.3 of the EIS note that Stantec is preparing a hydrogeological study as part of the application. A Terms of Reference for a hydrogeological assessment was submitted to the City on November 9, 2016. Has that assessment been completed and submitted?

80. Given the required removal of the suitable bat habitat features (residential buildings and isolated landscape trees), is there opportunity to create bat habitat in the buffer areas?

81. Figure 14.4 of the NWSSS shows the northern edge of the property as an area to enhance in terms of its linkage function. While the EIS notes the lack of linkage connection/corridor function the hedgerow currently provides (page 41 and 50), the feasibility of enhancement has not been evaluated or addressed.

82. The Draft Plan of Subdivision (last revised February 23, 2018) shows encroachment into buffers in three locations – a) in the residential lots that back onto the northern hedgerow, b) in the stormwater management block, and c) in the park block.

    a) With respect to the residential lots that back onto the hedgerow, while a 5 metre buffer is shown on the Draft Plan, both the hedgerow and buffer are, to varying degrees, within the lots. Could the lots be graded without interfering with the hedgerow? What is to prevent removal of the hedgerow by future homeowners if it is within the lot lines? Further, the Preliminary Stormwater Management Report (Revised May 2018) shows both a maximum 2 metre high retaining wall and infiltration gallery along that boundary. It is presumed such infrastructure would require the removal of the hedgerow. The previous comment dealing with the linkage function of the hedgerow needs to be addressed to inform how the hedgerow will be managed. In addition to the

impact the retaining wall and infiltration gallery would have on the hedgerow, their location would also pose significant challenges in terms of infrastructure maintenance. Access to the retaining wall would be severely restricted and the infiltration gallery would be on a number of private properties, with limited access and no opportunity to ensure functionality or prevent removal.

b) With respect to the stormwater management block, the criteria listed in Official Plan policy 8.2.4(9) needs to be fully addressed in order to contemplate the location of the constructed wetland and infiltration gallery as currently proposed. Specific concerns regarding the infiltration gallery in the buffer are previously noted. In addition to these concerns, the proposed maximum 1.7 metre high retaining wall would pose a significant challenge in terms of maintenance and buffer functionality, as the buffer would need to be cleared to enable access.

c) With respect to the park block, Official Plan policy 8.2.4(9) states that permitted uses within buffers are to be limited to low impact uses consistent with those permitted within designated features. Active park land is not one of those uses. Further, the policy states that buffers are to remain in or be restored to a primarily natural state. The buffer lands are therefore to be removed from the Park Block. This is consistent with Official Plan policy 8.2.4(12) which states buffers will not be considered as contributing to parkland dedication requirements. The situation is further complicated because a trail is to be potentially built within the buffer (as per an earlier comment). The combination of an infiltration galley and a trail could result in very little naturally-vegetated buffer.

83. The EIS recognizes that the timing of construction activities must have regard for the breeding bird season. Consistent with the Westside Subdivisions, a timing window of April 1 to September 10 should be used. All land clearing, earthen works, servicing works, infrastructure work and tree removal between April 1 and September 10 should be prohibited unless a nesting survey is undertaken that demonstrates the activities will not have the potential to disturb or destroy migratory birds or their active nests.

84. The EIS notes that there will be an increase of 11-46% in post-development infiltration (page 56), with the Preliminary Stormwater Management Report (Revised May 2018) providing further details (page 25). While the NWSSS recommends existing infiltration rates be maintained or increased, a potential increase of 46% seems significant. Section 4.2 of the EIS notes that the wetlands' primary hydrologic function appears to be the storage of surface water and the storage and expression of groundwater. Would increasing the rates this substantially result in impacts to the wetlands? Is groundwater mounding a risk?

85. As per the direction provided by the NWSSS and the EIS, a condition of draft plan approval will require the distribution of an environmental stewardship brochure. The City has a universal one available for purchase entitled "Naturally Your Waterloo". Experience has shown that requiring builders to distribute the brochure to new

homeowners is challenging because of the time span over which the development occurs. Given this, the applicant should either be required to purchase all of the brochures needed for the subdivision upfront from the City and distribute them as appropriate or provide the funds necessary to print all the required brochures but rely on the City to distribute them as the subdivision builds out (e.g. it could be given out alongside the Building Permit). Further discussion is needed to determine the preferred approach.

86. The environmental lands and their buffers (i.e. the Open Space blocks) are to be dedicated to the City free of charge and without any encumbrances.

87. Under section 5.6.1 of the EIS, a historic farm dump is noted. This area will need to be cleaned up as a condition of approval.

88. Invasive Phragmites is discussed under section 5.6.3 of the EIS. An invasive species management plan will need to be provided as a condition of approval.

89. City-standard chain link fencing needs to be installed along the private-public interface.

PART C – LANDSCAPE COMMENTS

90. Block 253 (Park) cannot include buffer lands within the lands calculated toward the 5% parkland dedication. Likewise, areas of the park encumbered with infrastructure such as stormwater management facilities and infiltration galleries cannot be included in the 5% parkland calculations.

91. Why is the Avon Trail link deleted? This is an important community trail connection.

92. The hedgerow at the north and its 5.0 metre buffer are now incorporated into the rear lots of homes. This is not a viable way to protect, conserve and enhance this hedgerow. Regionally significant bird species are noted in this hedgerow therefore measures to preserve and enhance this feature should be undertaken. There is very limited protection for hedgerows when located within private property.

93. The servicing plan indicates that infiltration infrastructure is proposed in the lots at the north end of the site, between Rideau River Street and Street B. They seem to indicate water will flow off site, which is not permitted.

94. The servicing submission from Meritech (dated May 2018) shows the proposed locations for infiltration galleries. Most of these are inaccessible for future maintenance. Please revise or confirm how maintenance will be addressed.

95. The proposed development to the east (Draft Plan 30T-17403) does not show a vehicular connection at the end of Street E as indicated on this Draft Plan. Coordination between plans and consulting firms is required.

96. The stormwater management pond maintenance access road is typically designed to form part of the overall pedestrian trail system. Linkages to the park and to the north-south trail system on the west edge of the property should be incorporated into the access road.

97. It is recommended that a 2.0 metre wide (minimum) flat area be designed behind the residential lots that back onto the stormwater management pond rather than the 3:1 slope beginning at property line.

98. The location of the infiltration gallery proposed within Block 252 (School) must be accepted by the School Board, to not encumber the development potential of this block.

99. The EIS does not speak to the north-south trail connection through the buffer lands or other trails. The trail system should be shown conceptually. This trail connection should be provided within the buffer from Conservation Drive to the stormwater management pond. The City standard 3.0 metre wide asphalt trail with supporting buffer plantings is required.

100. The trail/linkage system should be designed holistically so that walkway blocks connect to major points of attraction such as the park and the school. Although the BCMDP shows this conceptually, the Draft Plan does not create these linkages. Linkages are not linking street to street in a linear fashion. Future residents should be able to use a walkway block from Street B to connect to Street D, and then to the park, etc.

101. Block 253 (Park) must be unencumbered and for recreational purposes only. Portions of the park that do not provide useable parkland should be eliminated from the overall park calculation and/or moved out of the park block. These include the infiltration gallery and the sanitary service. These facilities are typically not permitted in parkland.

102. Block 253 (Park) should be 80% flat tableland with grades no steeper than 2%. Areas of steep slopes will not be accepted.

103. City standard 1.5 metre high black vinyl chain-link fencing shall be provided at all public private interfaces where private lands abut wetlands, buffer lands, environmental lands, woodlots and open spaces meant to be naturalized to minimize encroachment. In all other areas, the City standard property demarcation posts and living fence shall be provided.

104. The City is interested in discussing the School Board proposals for layout of the new school and associated green space. Given the size and layout of Block 253 (Park), it is perhaps not conducive to sharing sporting facilities and therefore the School Board may need to provide these 100% on their lands.

105. Sufficient deterrents need to be designed into the shared property line between Block 253 (Park) and Block 256 (SWM) to maintain safety given the slopes of the pond and the proximity of the park.

106. Please confirm the design intentions of Blocks 254 and 255 (Open Space) and who is to maintain it. If it is Open Space, the developer must enter into an agreement to maintain these lands until the subdivision is build out.

107. The design and incorporation of a layby for bus drop-off for Block 252 (School) should be considered.

108. Walkway blocks shown on previous iterations of the plan have been removed. Interconnectivity throughout the neighbourhood must be provided. Walkway blocks are 4.0 metres wide, unless additional services are required which may warrant a width of 6.0 metres to 9.0 metres.

109. A 6.0 metre high retaining wall is proposed along the west property limit. This is significant. Why does the west property limit not meet existing grades? How does the retaining wall work at future road extension (i.e., Pinery Trail and Street B)?

110. A Vegetation Management Plan will be required as part of the first engineering submission.

111. A Hedgerow Enhancement Planting Plan is required.

112. An Invasive Species Control Plan is required.

113. An infiltration gallery cannot be located within buffers. Buffers can contain trails and naturalized plant material and some minor re-grading only.

114. Block 252 (Park) will require stormwater, hydro and water stubs for playground and for a future rink area.

115. Infrastructure shall not be in parks unless required by the park.

116. Any garbage in the buffer, wetland, woodlands shall be removed by the developer to the satisfaction of the City of Waterloo. This includes any farm dump, old fences, building materials, etc..

117. Educational signage is required to be designed, approved and installed in the buffer area to educate property owners regarding encroachment and dumping, ownership, etc. Signage plan to be submitted for approval.

118. The plan for the restoration and enhancement measures to protect wildlife and cut down invasive species along Conservation Drive is required.

119. The plan for the animal crossing/ecological linkage enhancement crossing is required.

120. Park, SWM, OS, buffer, naturalization, living fence and property demarcation, fencing, signage plans are required to estimate the Letter of Credit requirements in Schedule B of the Subdivision Agreement. Developer to submit street tree planting plan OR to confirm with Parks and Environment to have the City undertake the street tree planting.

121. Topsoil is not permitted to be stockpiled within Block 253 (Park).

PART D – TRANSPORTATION AND ACTIVE TRANSPORTATION COMMENTS

Road Widenings and Lands to be Conveyed to the City

122. The existing road allowance of Roy Schmidt Road appears to be 12 metres wide. A road widening on the west side of Roy Schmidt Road shall be conveyed to the City for the entire length of Roy Schmidt Road to establish the new property line at 9.0 metres from the historic centreline of Roy Schmidt Road. A similar widening has been requested from the developer of the proposed subdivision on the east side of the road (Draft Plan 30T-17403).

123. Roy Schmidt Road is to be closed at Conservation Drive but the City will retain a 4.0 metre wide walkway block for a MUT in this location (between Roy Schmidt Road and Conservation Drive). If additional land is required to provide proper grading and drainage of the trail, this additional land will be included in the walkway block and conveyed to the City. City land outside that needed for the walkway block may be declared surplus. Such lands may be sold by the City in accordance with the City's Disposition of Property process;

124. The developer shall confirm that the north limit of Conservation Drive is 13 metres from the historic centreline of the road, to facilitate the ultimate road allowance of 26 metres as per the City's Official Plan.

125. 4.0 metre* wide walkway blocks are required:
    a. Inside the west limit of the plan from Pinery Trail to Block 255 (Open Space).
    b. Adjacent to the rear of Lot 46 to Lot 71 on Street B.
    c. Adjacent to the rear of Lot 7 to Lot 23 on Rideau River Street to connect to the existing trail at the east limit of the Draft Plan and the trail on the west limit of the Draft Plan.
    d. Between Lot 45 and Lot 46 on Street B, between Lot 23 and Lot 24 on Rideau River Street, and between Lot 6 and Lot 7 (or Lot 7 and Lot 8) on Rideau River Street to connect the public sidewalks to the trail inside the north limit of the Draft Plan.

126. The trail within the plan is to be designated The Avon Trail:
    a. Along the east limit of Block 254 (Open Space) from Conservation Drive to Pinery Trail.

b. Inside the west limit of the Draft Plan from Pinery Trail to Block 255 (Open Space).
c. Along the south limit of Block 255 (Open Space) to the north limit of the Draft Plan.
d. Inside the north limit of the Draft Plan from Block 255 (Open Space) to the existing trail along the east limit of the Draft Plan.

*__Note:__ *where detailed engineering determines that grading and drainage of trails, walkways or park facilities require additional land or easements, such transfers must be conveyed to the City at the time of engineering approvals.*

Transportation Study and Implementation

127. The Developer shall submit a Transportation Study prepared by a qualified Transportation Engineer, for the review and approval of the City's Director of Engineering, to address the needs of all road users: pedestrians, cyclists, transit users, and drivers.

128. The Transportation Study will use as background information the transportation studies for Conservation Drive and Beaver Creek Road, and provide projected peak hour and AADT volumes for each transportation mode on the following streets (which are considered to be feeder roads):
    a. Street H
    b. Pinery Trail
    c. Street A, from Conservation Drive to Pinery Trail
    d. Street E, from Roy Schmidt Road to Street A

129. Above feeder roads should have a Multi-Use Trail (MUT) on one side, and the study should provide options for enhanced crossings at all intersections on these roads.

130. The Transportation Study shall determine the sight daylighting requirements at all roads intersecting with Conservation Drive. Lands to accommodate daylighting requirements shall be conveyed to the City.

131. The Transportation Study shall include options and recommendations for enhanced pedestrian and cycling safety, and shall design and construct any traffic calming facilities and road safety features recommended by the Transportation Study.

Multi-Use Trails (MUTs) and Sidewalks

132. All design and construction to be undertaken by the developer shall be to the satisfaction of the City's Director of Engineering Services.

133. The detailed design of City sidewalks, trails and parks shall address all grading and drainage issues to meet AODA requirements. Should additional land or easements be

required to accommodate City infrastructure needs, the developer shall convey such transfers to the City at the time of engineering approval.

134. A MUT is required within the Roy Schmidt Road right of way. The City preferred location for this 3.0 metre wide MUT is on the west side of the road (due to a fewer number of driveways). This MUT will extend from Conservation Drive, up to and along Roy Schmidt Road, to the existing trail at the north limit of the Draft Plan. A 1.8 metre sidewalk is required along the entire length of Roy Schmidt Road, within the right of way on the east side of the road. The developer shall coordinate the design of Roy Schmidt Road with the developer of the lands to the east.

135. While the City is constructing a MUT on the east side of Beaver Creek Road south of Conservation Drive, and on the south side of Conservation Drive, the preferred location of the MUT is on the west side of Street A adjacent to Block 252 (School). This will require enhanced crossings on the east and north legs of the roundabout at Street A and Conservation Drive.

136. The developer shall design and construct the following 3.0 metre* wide Multi-Use Trails (MUT):
    a. Along the east limit of Block 254 (Open Space) from Conservation Drive to Pinery Trail.
    b. Inside the west limit of the Draft Plan from Pinery Trail to the south limit of Block 255 (Open Space).
    c. Between Block 255 (Open Space) and the rear of Lot 63 to Lot 71 on Street B.
    d. Inside the north limit of the Draft Plan from the MUT on Block 255 (Open Space) to connect to the existing trail at the north-east limit of the Draft Plan.
    e. Along the east limit of Block 256 (SWM) connecting the MUT on Block 254 (Open Space) to the MUT at the north limit of Block 256 (SWM).
    f. Along the north limit of Block 256 (SWM) connecting Pinery Trail to the MUT on the east side of Block 253 (Park).
    g. Along the south and east limit of Block 253 (Park) connecting the MUT on Block 254 (Open Space) to Pinery Trail.
    h. On the west side of Street A from Conservation Drive to Pinery Trail.
    i. On the north side of Street E from Roy Schmidt Road to the property line between Block 252 (School) and Block 244 (Street Townhouse).
    j. Along the south limit of Block 252 (School) from the MUT in (i.) above, to the MUT on Block 253 (Park).

Note: *where Block 244 (Street Townhouse) is removed, the MUT on the north side of Street E should connect from Street A to Block 253 (Park).*

137. The developer shall design and construct 1.8 metre concrete sidewalks on the following streets:
    a. On both sides of all streets with the exception of Street D and streets with a 3.0 metre MUT on one side.

b. On streets with a 3.0 metre MUT on one side, a 1.8 metre sidewalk is required on the opposite side of the street.
c. On Street D, a 1.8 metre sidewalk is required on one side only, in front of Lots 108 to Lot 128.

Bike Lanes

138. The developer shall design and prepare a pavement marking plan showing 1.5 metre painted bike lanes with a 0.3 metre painted buffer on Pinery Trail, and on Street A from Conservation Drive to Pinery Trail.

139. In accordance with the Transportation Study, the developer shall prepare a detailed design of the Pinery Trail and Roy Schmidt Road intersection to safely connect the MUT on Roy Schmidt to the buffered bike lanes on Pinery Trail.

Transportation Operations

140. Streets with bike lanes may not be able to accommodate on-street parking, due to the width of the road. Bike lanes on Street A will restrict on-street parking for the school and Block 243 (Street Townhouse). Bike lanes on Pinery Trail will restrict on-street parking at the park.

141. Please provide additional information with respect to the type of traffic control and traffic calming measures planned for the proposed Draft Plan.

142. How will school traffic be accommodated? The area around the school will have limited on-street parking to assist with student drop-off and pick-up.

143. The radius elbow corner on Rideau River Street presents a challenge for winter operations. Please consider modifying this design.

144. Driveway access to Block 251 is recommended from Street A and/or Street E, not from Roy Schmidt Road. The City intends to minimize the number of driveways on Roy Schmidt Road, because the preferred location for the MUT is on the west side of Roy Schmidt Road from Conservation Drive to the existing trail at the north limit of the subdivision; the driveways that conflict with the MUT are limited to Lots 226-242.

145. The developer shall design and construct a pedestrian refuge island and crossing within Conservation Drive at Street H, and at the MUT on Block 254 (Open Space). These are required to facilitate connections to facilities being constructed by the City, including bike lanes on both sides of Conservation Drive, and the MUT on the south side of Conservation Drive.

146. The Street H connection with Conservation Drive is located just west of the proposed roundabout at Beaver Creek Road. Stantec completed a turn lane analysis for all subdivision entrances onto Conservation Drive and Beaver Creek Road. There were

four recommendations made from the analysis. In its current location, Street H, will be limited to right-in/right-out (RIRO) movement only based on the recommendations outlined in the *Update to Transportation Forecast and Left Turn Lane Requirements Technical Memo* (Stantec, July 7, 2017). Should the developer maintain the location of Street H an analysis of the RIRO configuration and resulting reassignment of traffic for the proposed operations of the roundabout will need to be completed. Should RIRO not be desirable for Street H, please review the July 7, 2017 Turn Lane Analysis Memo for more intersection spacing options. Options may be investigated to remove Street H and extend Street E from Street F to Conservation Drive.

147. Please ensure appropriate coordination between the lighting plan for the proposed Draft Plan and the lighting plan for Conservation Drive.

PART D – ENGINEERING COMMENTS

148. The Beaver Creek Road Sewage Pumping Station must be in place prior to final registration of the Draft Plan and the issuance of any building permits.

149. The Communal SWM facility must be constructed prior to servicing of the subdivision for water quality control.

150. The SWM report indicates an additional SWM Report will be submitted for the "off-site" stormwater management. City staff would not be in a position to accept this dual management proposal without further details of the off-site facility as well as securities/assurances that it will be built and available to this development.

151. Several discussions have been held about the off-site SWM pond concept. A letter has been sent offering options.

152. If it is determined that the external facility is not feasible or it does not materialize, all SWM controls would be required within the development, requiring significant revisions to the design and layout of the plan.

153. The servicing strategy report indicates that matching elevations along the neighbouring properties is a design consideration. The conceptual grading plan includes some significant deviations from existing elevations on adjacent lands, namely a 6.0 metre high retaining wall in the northwest corner of the site and a 2.0 metre high retaining wall along the north property line. This will not be accepted by staff. This grading strategy will effectively preclude development of the adjacent property, and will incur significant costs for retaining walls and importing fill. A realistic proposal needs to be provided. Development of the Draft Plan lands must be completed in a way that will not to negatively impact or encumber the adjacent lands.

Please note that City staff reserves the right to provide additional comments, or modify the above noted comments subject to further review and/or additional information as may be provided.

I trust the foregoing is satisfactory, however should you have any questions please do not hesitate to contact the undersigned.

Sincerely,



Natalie Hardacre BES, MCIP, RPP
Development Planner
Planning Approvals
Integrated Planning & Public Works
City of Waterloo
P: 519.514.0225
F: 519.747.8523
TTY: 1.866.786.3941
E: natalie.hardacre@waterloo.ca

APPENDIX B:
Figures



Stantec

Legend

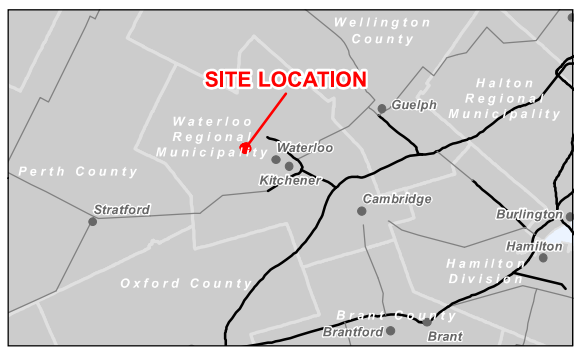
- Site Boundary
- Monitoring Well (Stantec, 2020 -2021)
- Monitoring Well (Ecoplans et al., 2013)
- Drive Point Piezometer (Ecoplans et al., 2013)
- Guelph Permeameter/Infiltrometer (Stantec, 2020)
- Guelph Permeameter (Ecoplans et al., 2013)
- Test Pit (Stantec, 2010)
- Test Pit (Stantec, 2021)
- Abandoned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

0 100 200 metres

1:3,500 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2020.
3. Orthoimagery © First Base Solutions, 2021. Imagery Date, 2020.



Project Location
Waterloo, ON

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

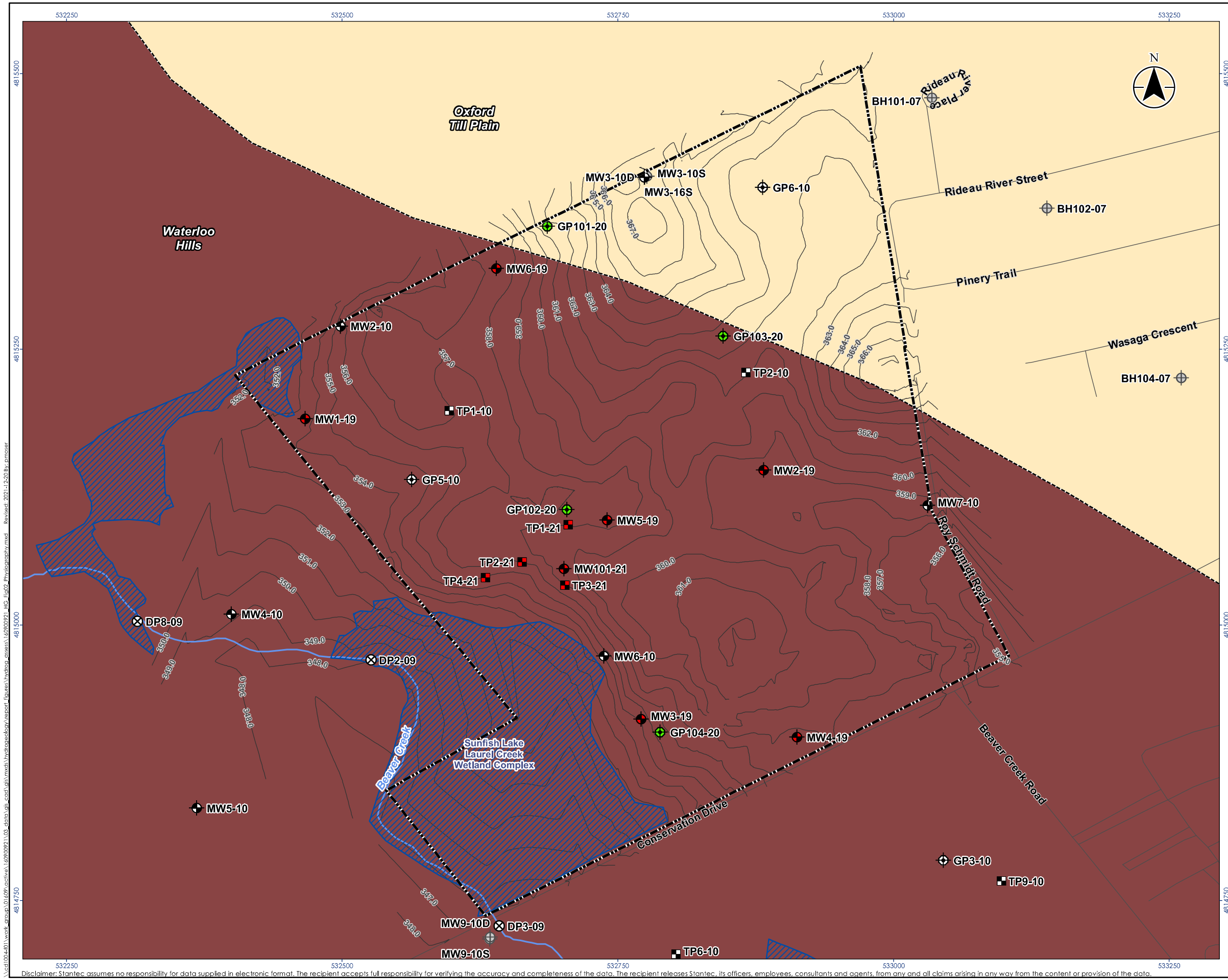
Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
1

Title
Site Plan

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

\\cal101a01.wsatl.stanap.ad\cal101a01\active\160921\09_data\gis_cad\gis\mxds\Hydrogeology\report_figures\Hydrogeology_assess\160921_HG_Fig01_SitePlan.mxd Revised: 2021-12-20 By: prmoser



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

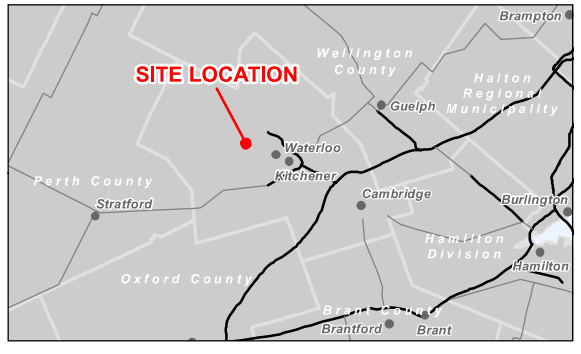
- 6: Till Plains (Drumlinized)
- 4: Kame Moraines

0 100 200 metres

1:3,500 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2017.
3. Orthoimagery © First Base Solutions, 2019. Imagery Date, 2018.
4. Chapman, L.J. and Putnam, D.F. 2007. Physiography of southern Ontario; Ontario Geological Survey, Miscellaneous Release—Data 228.



Project Location
Waterloo, ON

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

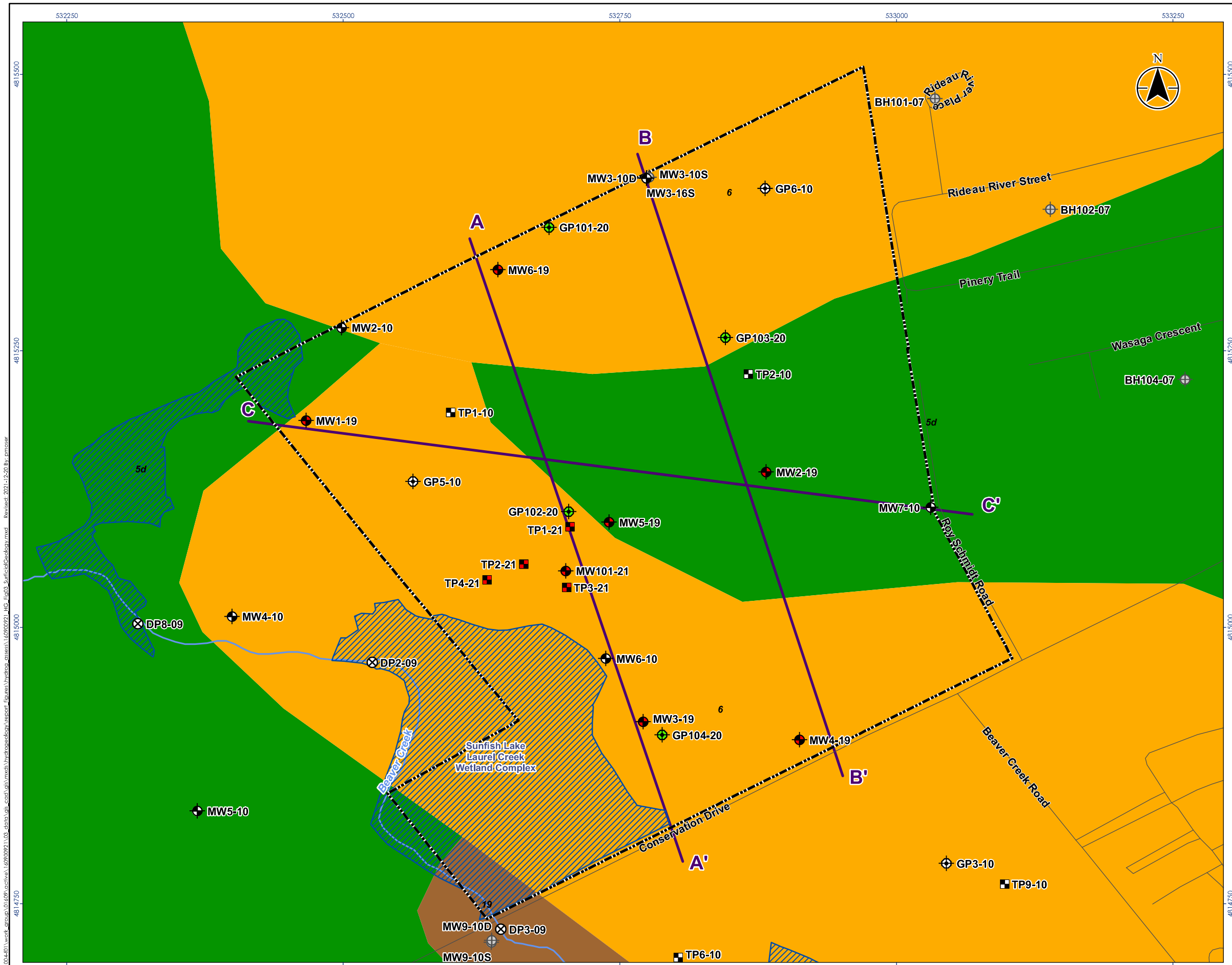
Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
2

Title
Physiography and Topography

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

\\cd1004401\work_group\01499\active\160900921\03_data\gis_cad\gis\mxds\hydrogeology report\figures\physio_topo\160900921_H15_Fig02_Physiography.mxd Revised: 2021-12-20 By: pmoser



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

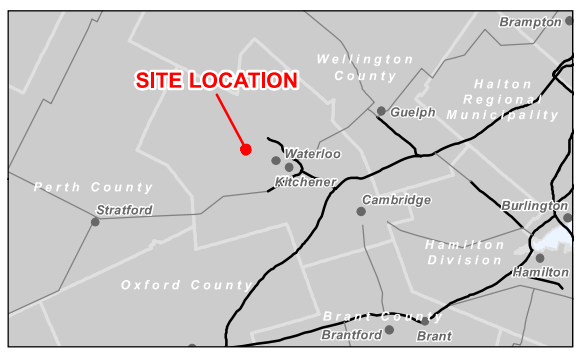
- 19: Modern alluvial deposits
- 6: Ice-contact stratified deposits (AFB1)
- 5d: Glaciolacustrine-derived silty to clayey till (ATB1)

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

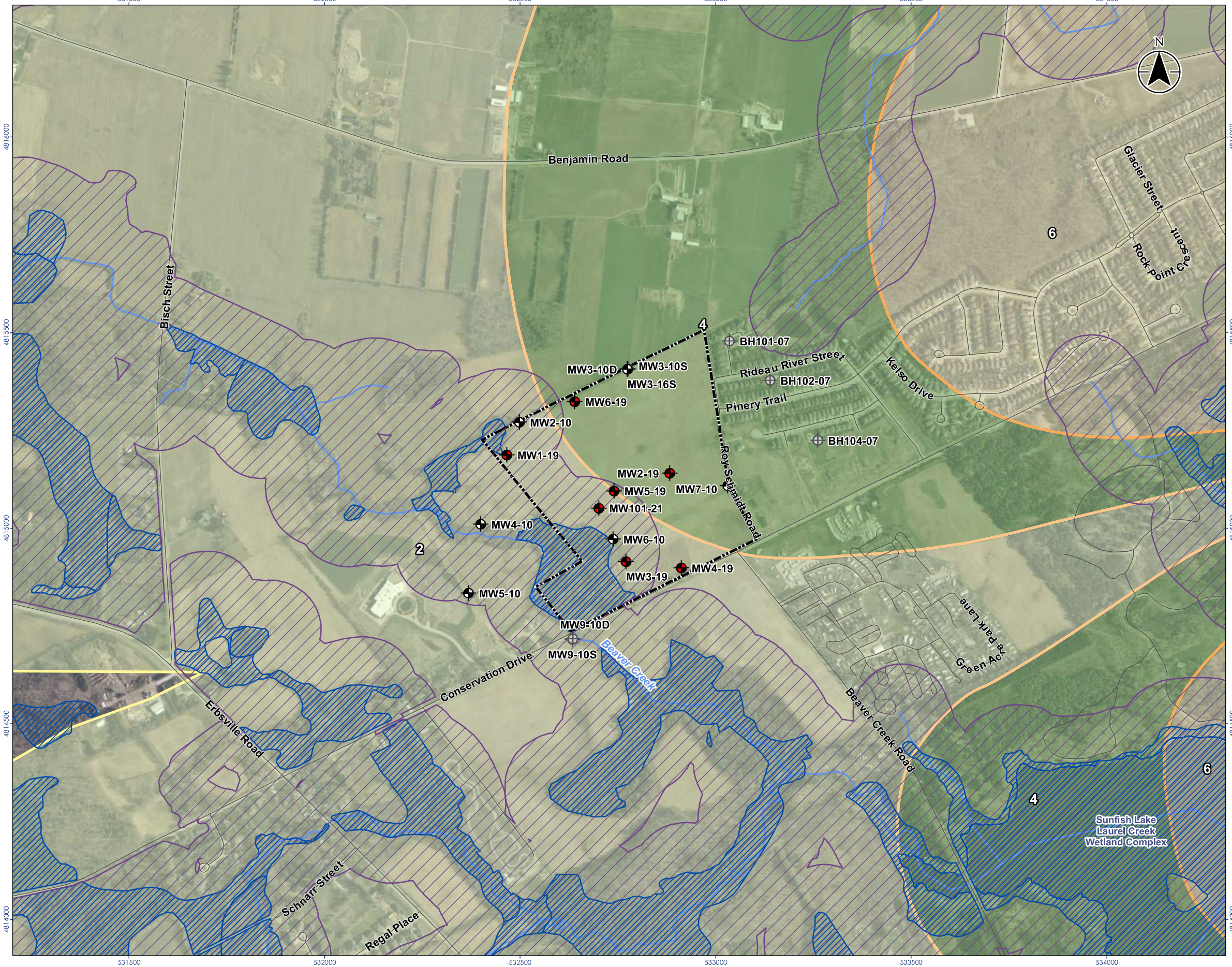
Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
3

Title
Surficial Geology

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

C:\1160900401 work groups\01499 active\160900921\03_data\gis_cad\gis\mxds\hydrogeology report figures\hydrogeology assess\160900921_HG_Fig03_SurficialGeology.mxd Revised: 2021-12-20 By: prmoore



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

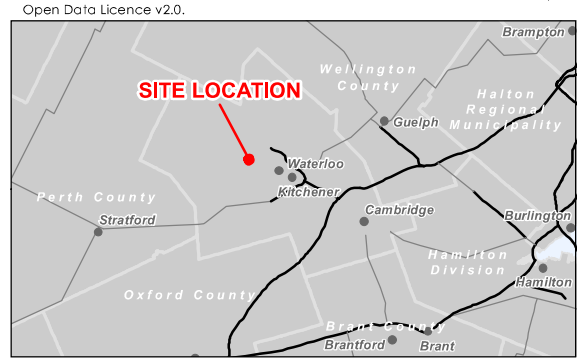
- 10
- 8
- 6
- 4
- 2

0 250 500 metres

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

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
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 2021-12-12

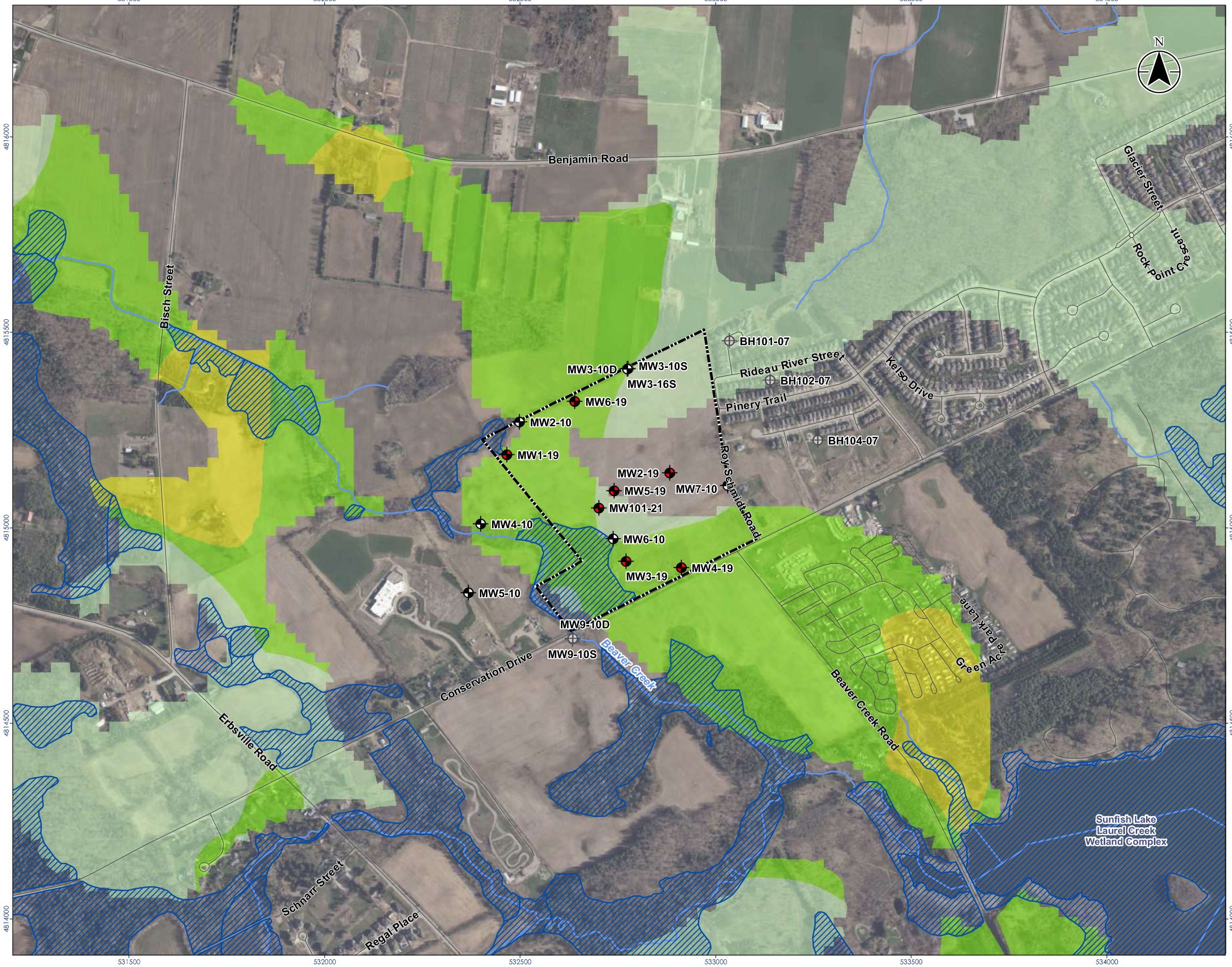
Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
4

Title
Source Water Protection – Wellhead Protection Areas

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

\\cd1004-01\work_group\01\active\160900921\03_data\gis_cad\gis\mxds\Hydrogeology report_figures\Hydrogeology report_figures\160900921_HG_Figure4_Source_Water_Protection_Wellhead_Protection_Areas.mxd Revised: 2021-12-20 By: pmosser



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

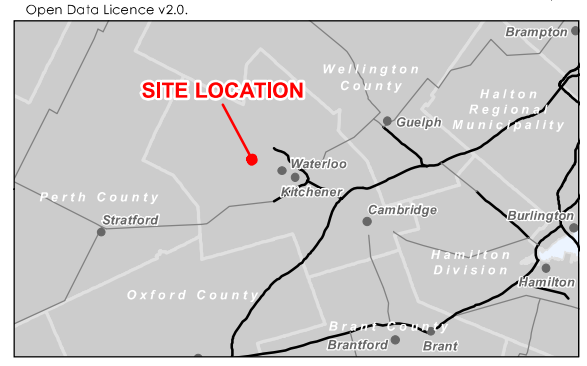
- 2
- 4
- 6

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

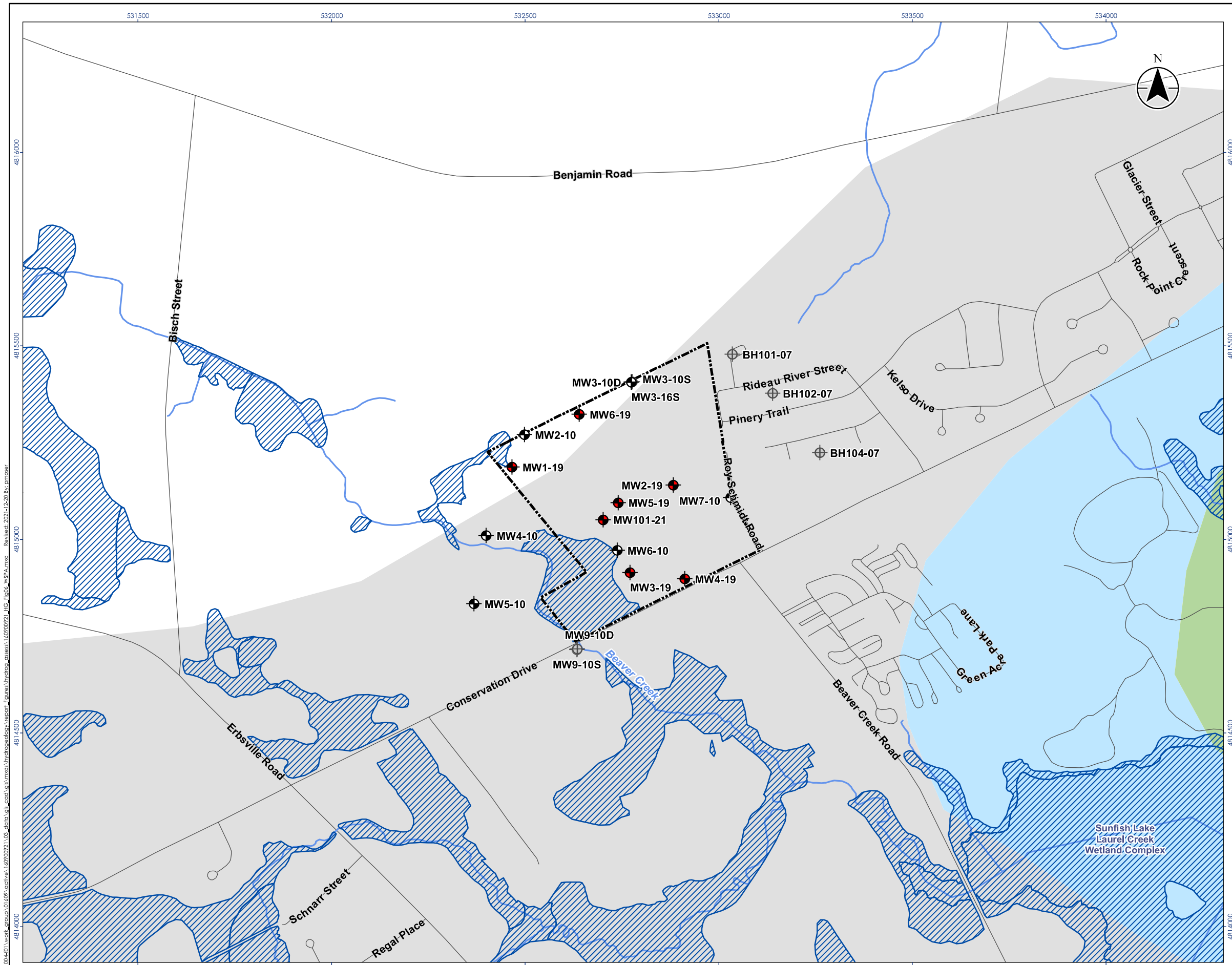
Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

Figure No.
5

Title
Source Water Protection – Significant Groundwater Recharge Area

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

\\cd1004-001\work_group\01\159\active\160900921\03_data\gis_cad\gis\mxds\hydrogeology\report_figures\hydrogeology_report_figures_Recharge.mxd Revised: 2021-12-20 By: pmosse



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

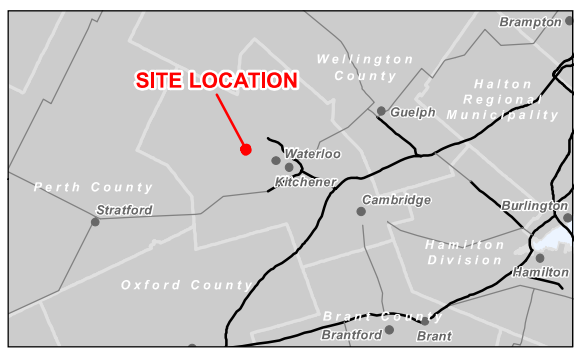
- WPSA-4
- WPSA-6
- WPSA-7
- WPSA-8

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

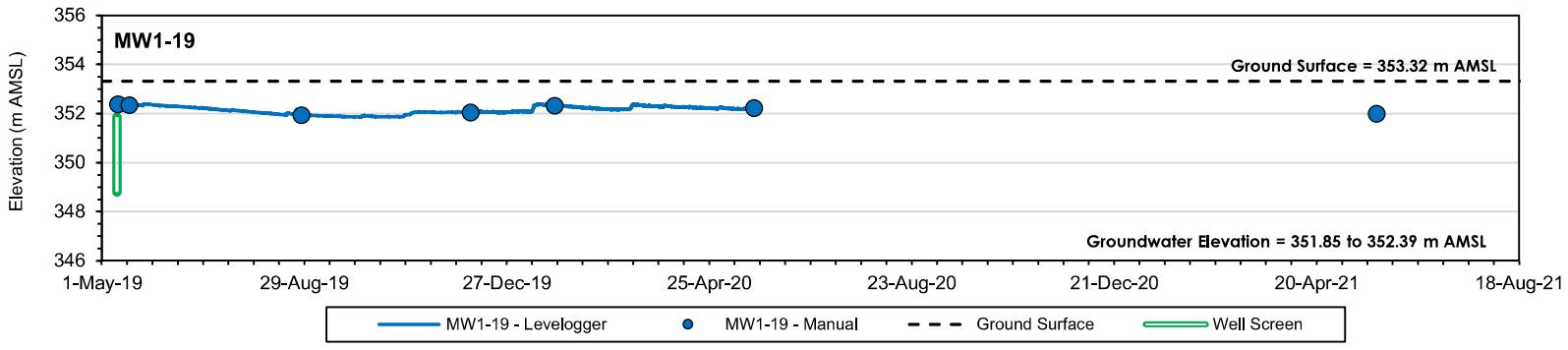
Client/Project
2115881 ONTARIO LIMITED
556, 560 AND 576 CONSERVATION DR., WATERLOO, ON
HYDROGEOLOGICAL ASSESSMENT

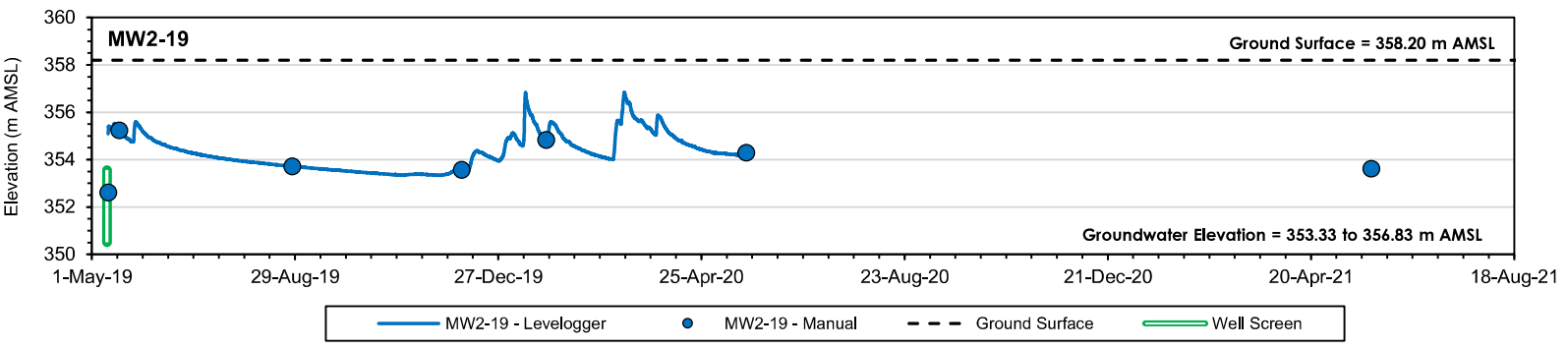
Figure No.
6

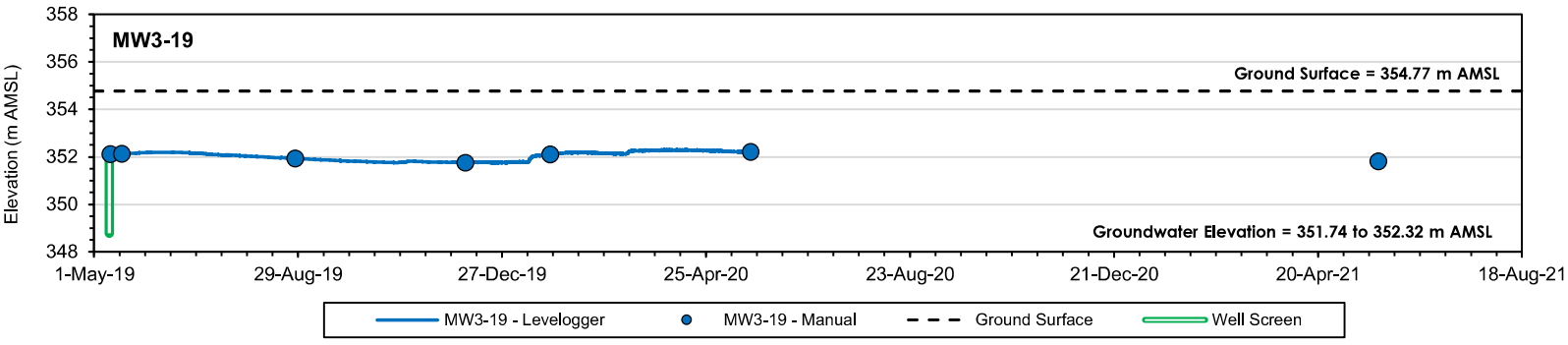
Title
Wellhead Protection Sensitivity Areas

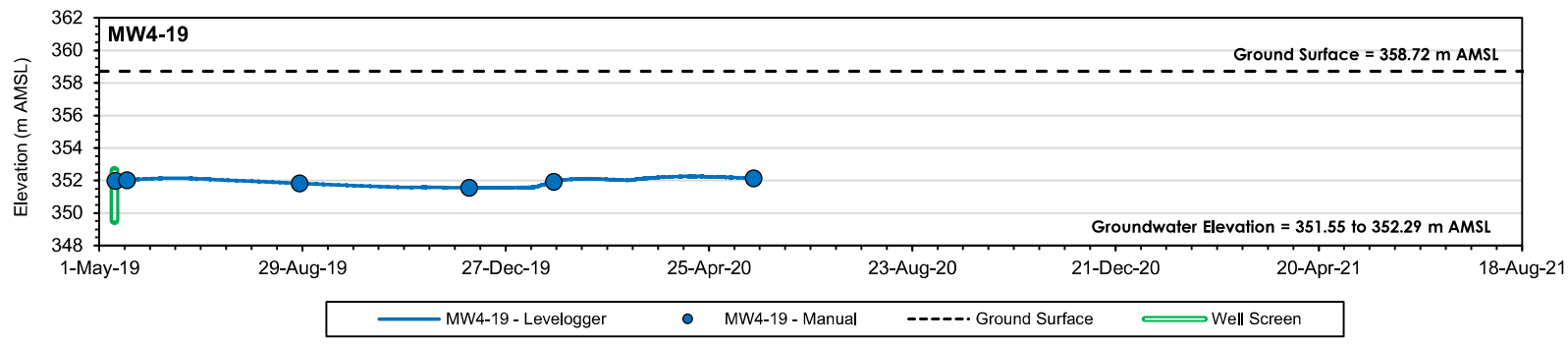
Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

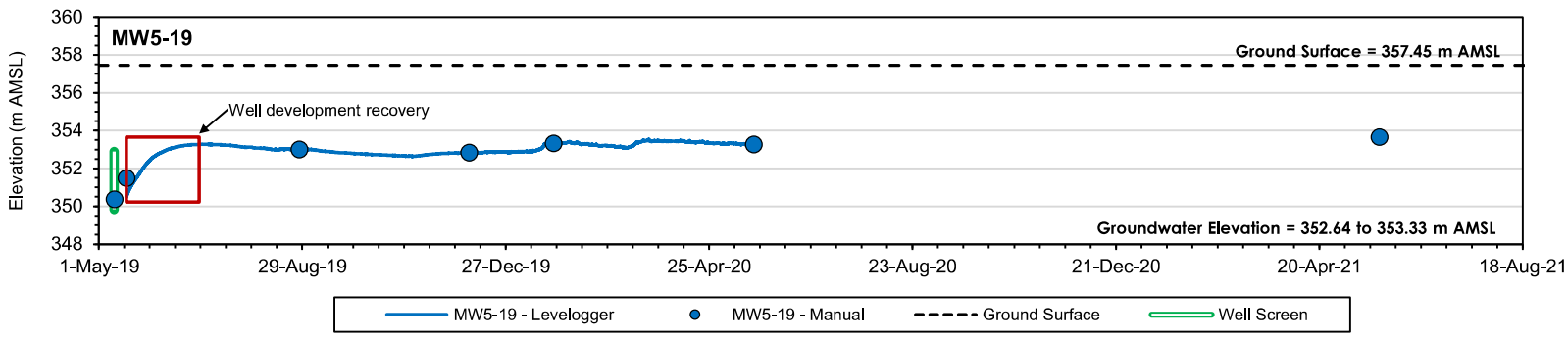
C:\1070401 work group\01699 active\160900921\03_data\gis_cad\gis\mxds\hydrogeology report figures\hydrop_assess\160900921_HG_Fig06_WSPA.mxd Revised: 2021-12-20 By: pmoser

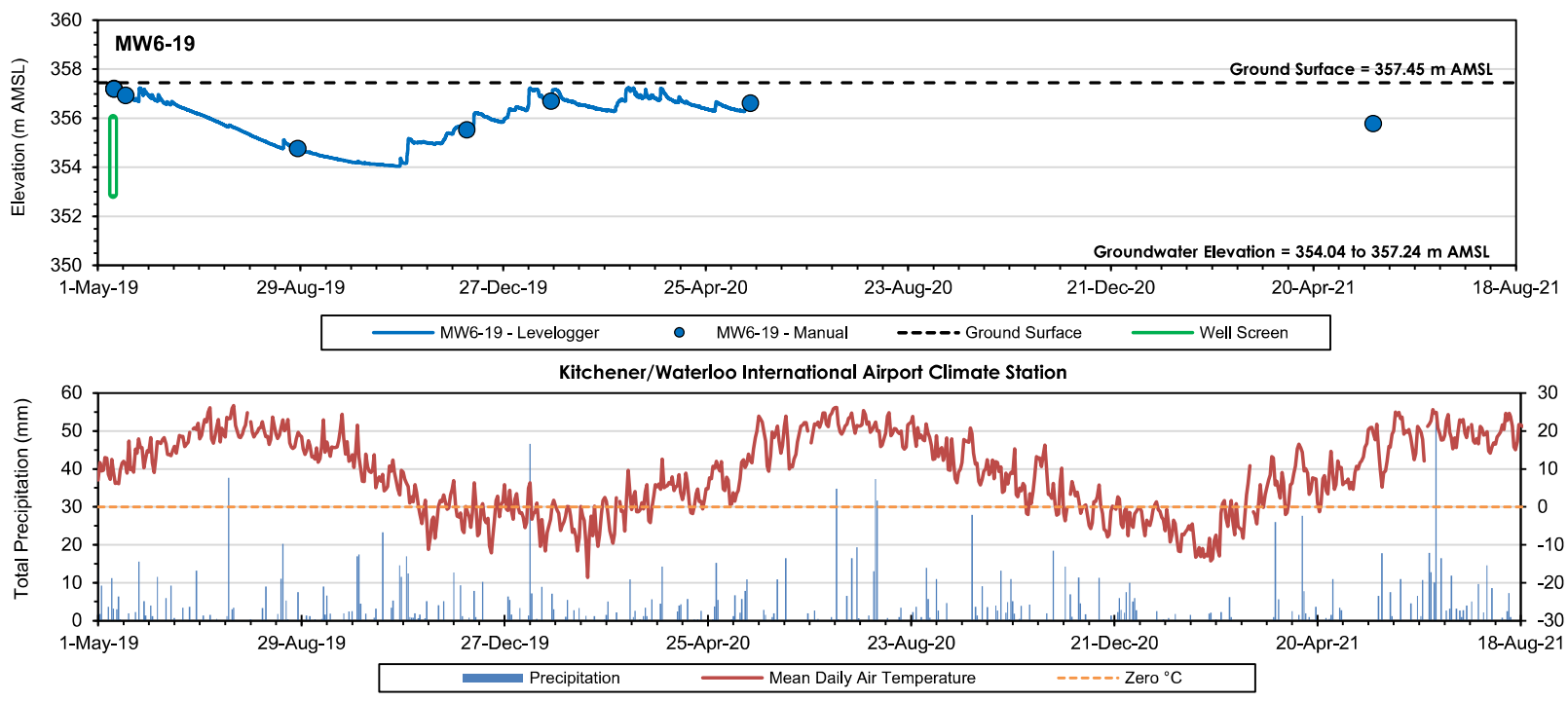












Notes

(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

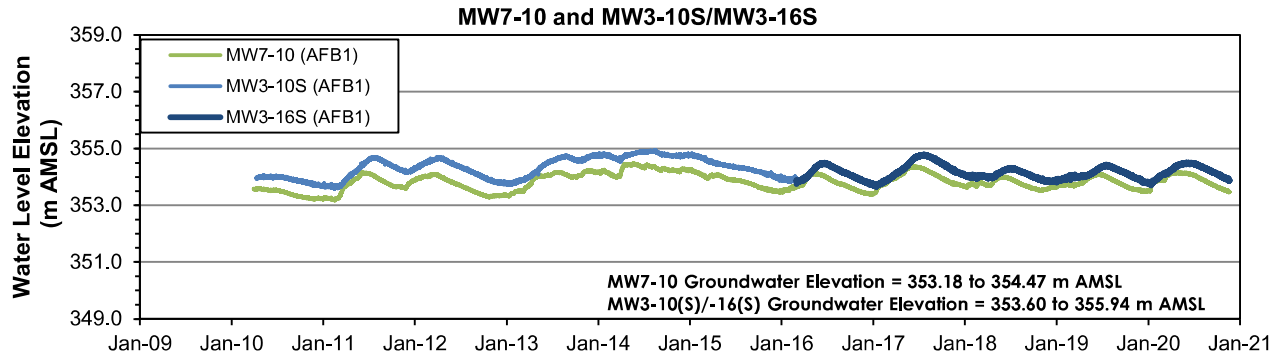
Hydrogeological Assessment

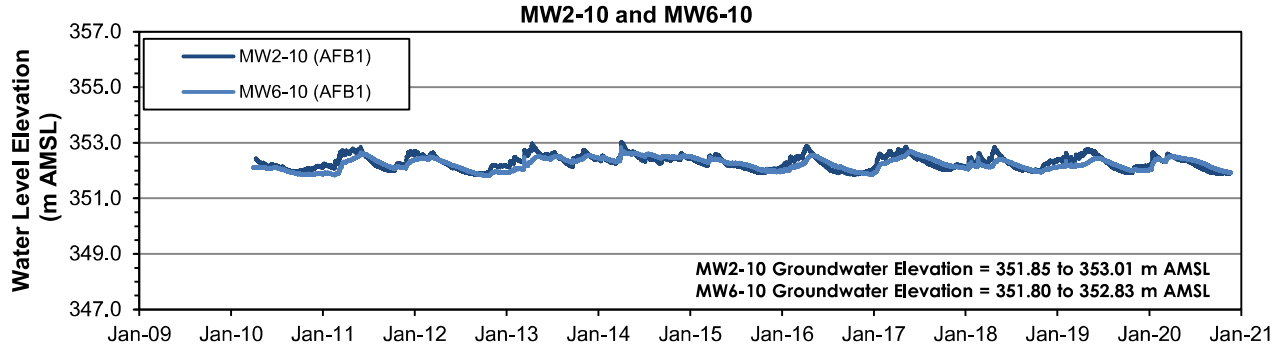
Figure No.

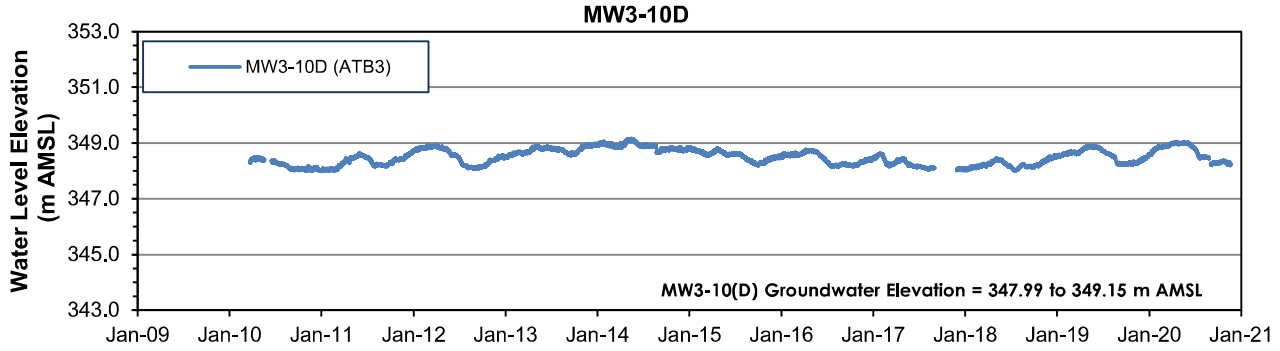
7

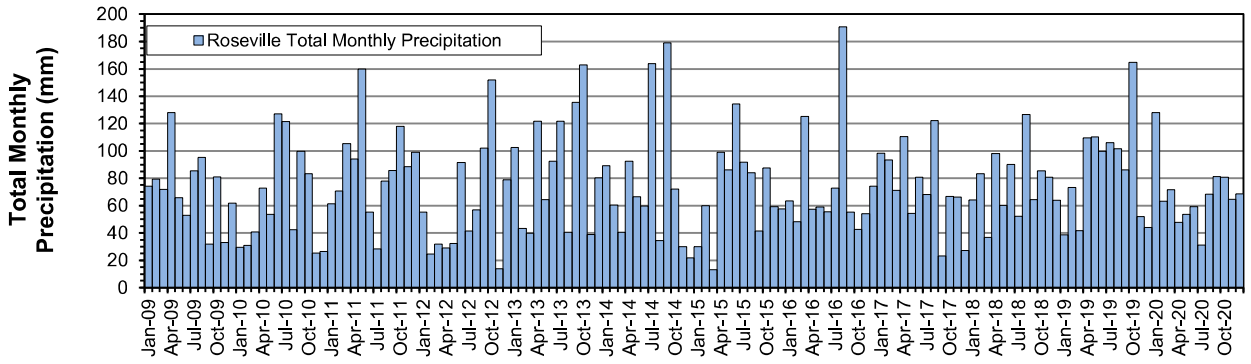
Title **HYDROGRAPHS**

MW1-19 to MW6-19









Source

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

Client/Project

2115881 ONTARIO LIMITED
556, 560 & 576 CONSERVATION DRIVE, WATERLOO
HYDROGEOLOGICAL ASSESSMENT

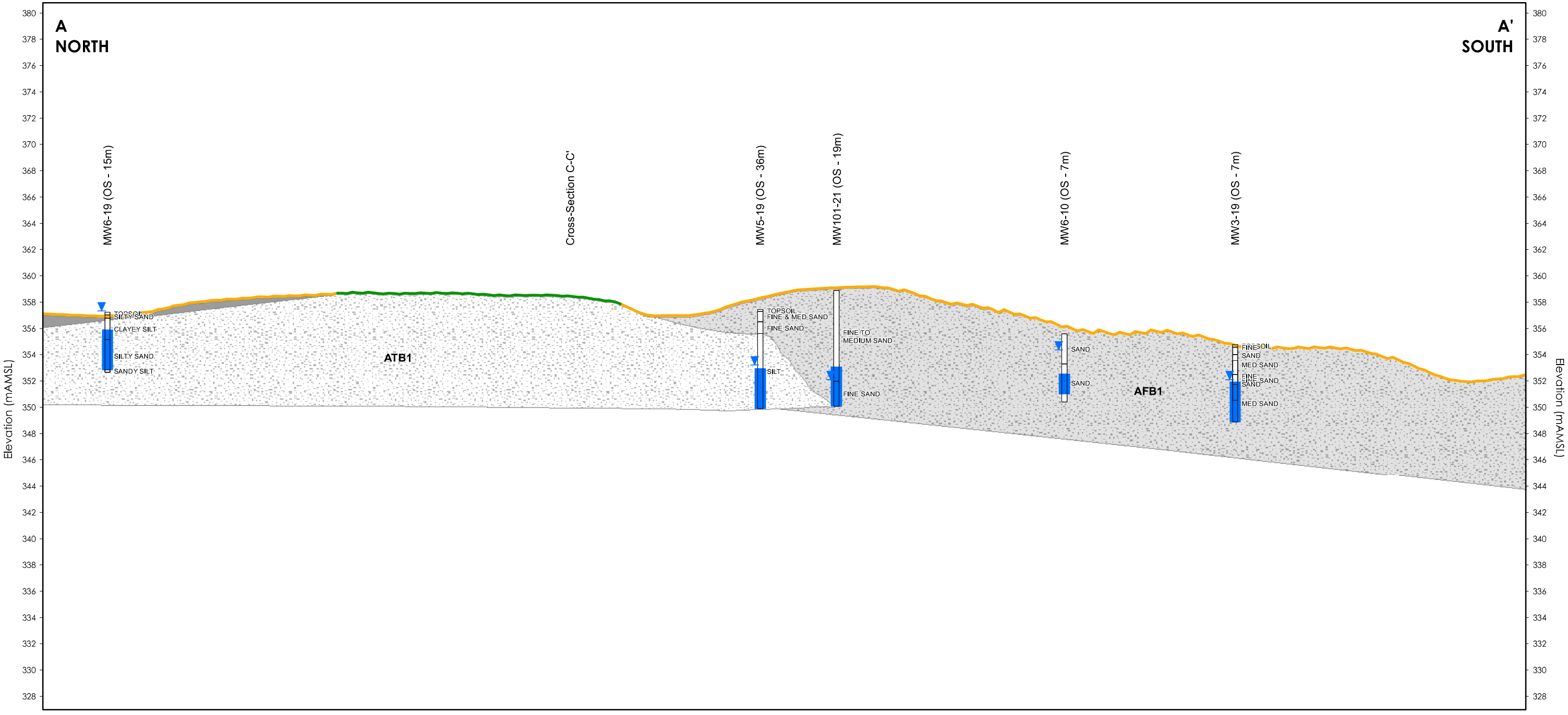
Figure No.

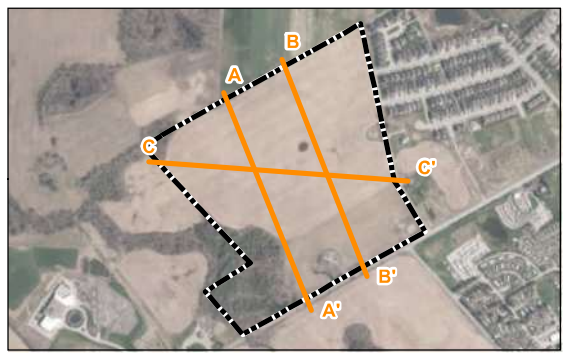
8

Stantec

Title

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





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.

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

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'

C:\cad\160401\work_group\01\609\active\160900921\100_data\gis_cad\gis\mxds\hydrogeology\report_figures\hydrog_assess\160900921_HG_fig09_xsecAA.mxd Revised: 2021-12-20 By: pmoser

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)

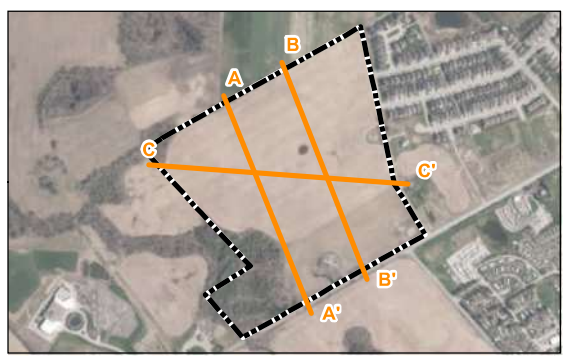
TOPSOIL
SAND
SILT
SAND
SILT & SAND
SILTY CLAY
SILT
SILTY
CLAY TILL
SAND & SILT
SILTY
SAND TILL

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.

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.
10

Title
Cross-Section B-B'

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

\\cd1004-01\work_group\01.609\active\160900921\03_data\gis_cad\gis\mxds\hydrogeology report_figures\Hydro_cases\160900921_HG_Fig10_xsecBB.mxd Revised: 2021-12-20 By: pmoser

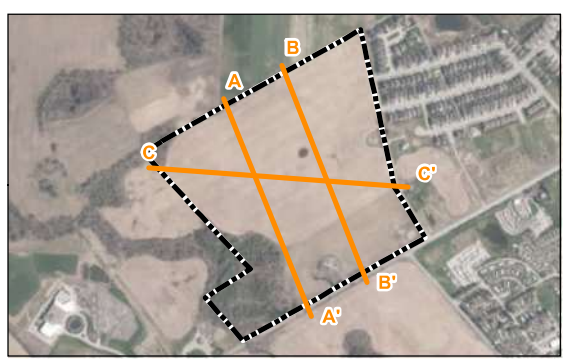
C
WEST

C'
EAST

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

Elevation (mAMSL)
388 386 384 382 380 378 376 374 372 370 368 366 364 362 360 358 356 354 352 350 348 346 344 342 340 338 336 334 332 330 328



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.

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.
11

Title
Cross-Section C-C'

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

\\cal1004-f01\work_group\01609\active\160900921\03_data gis_cad\gis\mxds\hydrogeology\report_figures\hydrog_zones\160900921_HG_Fig11_xsecCC.mxd Revised: 2021-12-20 By: pmoser



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

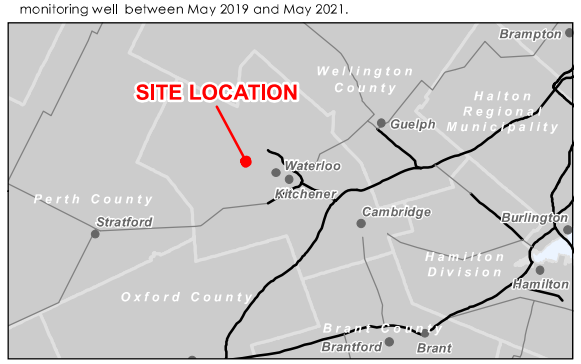
- 19: Modern alluvial deposits
- 6: Ice-contact stratified deposits (AFB1)
- 5d: Glaciolacustrine-derived silty to clayey till (ATB1)

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

160900921 REVA
Prepared by PRM on 2021-12-21
Technical Review by GW on 2021-12-21

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

Figure No.
12

Title
High Groundwater Elevations

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

C:\1070401 work group\01609 active\160900921\03_data\gis_cad\gis\mxds\hydrogeology report figures\hydrogeology_assess\160900921_HG_Fig12_HighGWElev.mxd Revised: 2021-12-21 By: prmoser

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

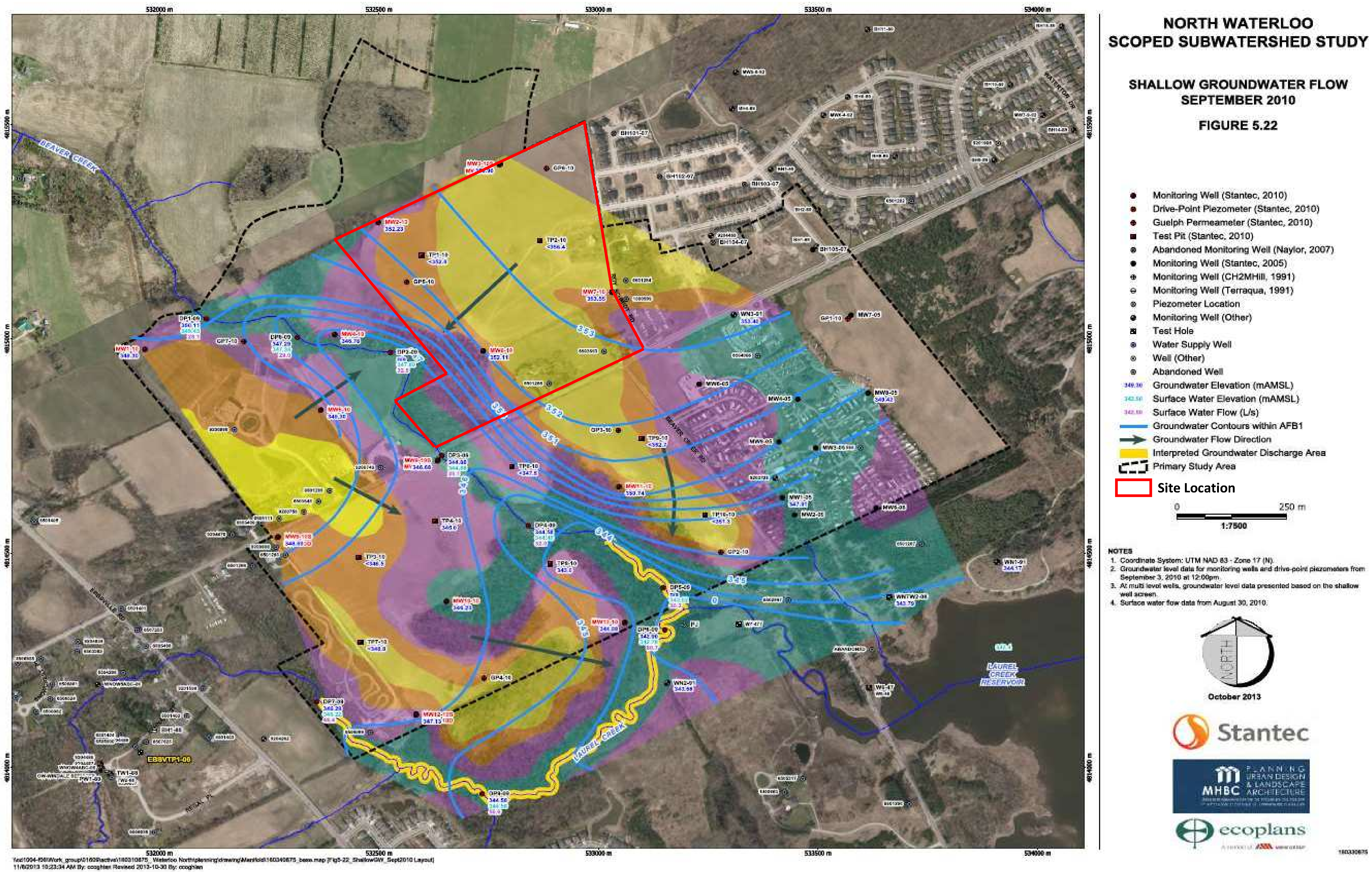
Ratio of Mean Measured Infiltration Rates[1]	Safety Correction Factor[2]
≤ 1	2.5
1.1 to 4.0	3.5
4.1 to 8.0	4.5
8.1 to 16.0	6.5
16.1 or greater	8.5

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.

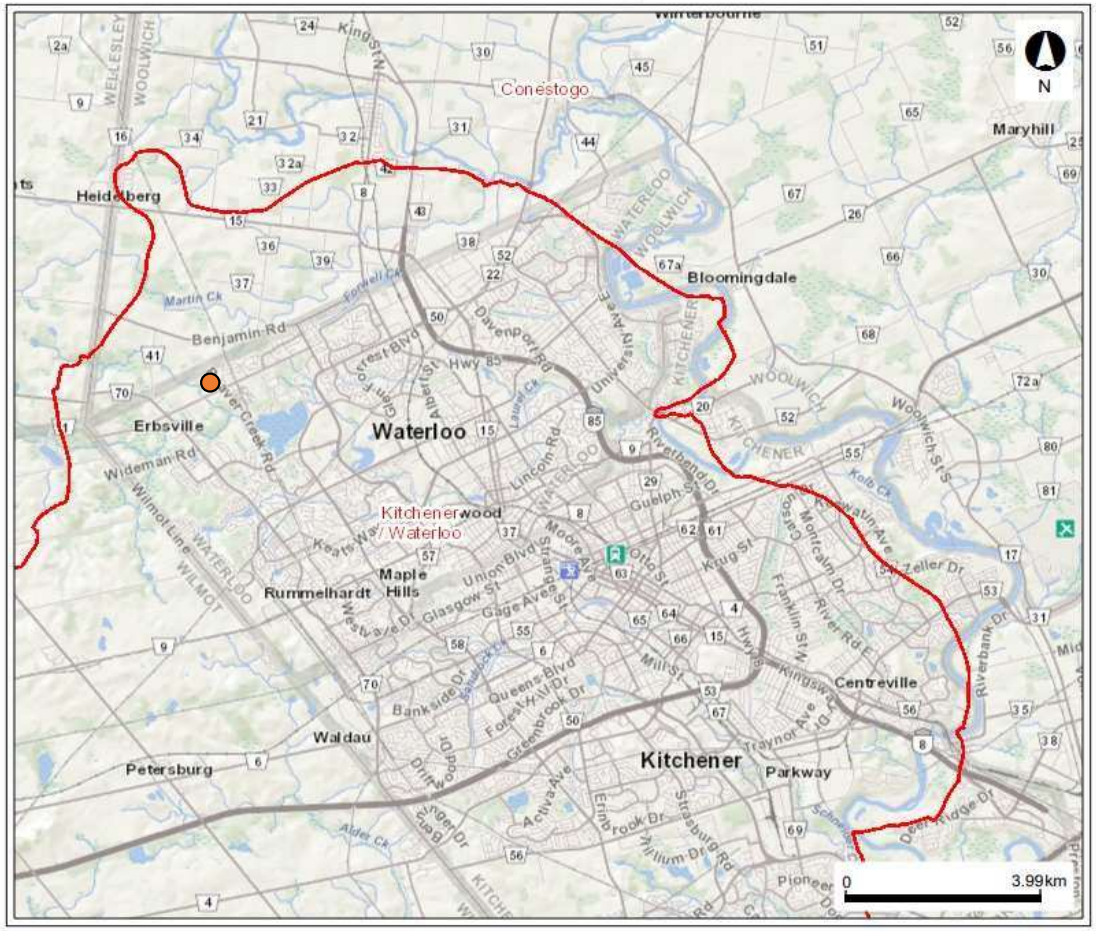
APPENDIX D:
North Waterloo Scoped Subwatershed Study – Groundwater Flow Mapping



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



Ontario © Queen's Printer for Ontario, 2021

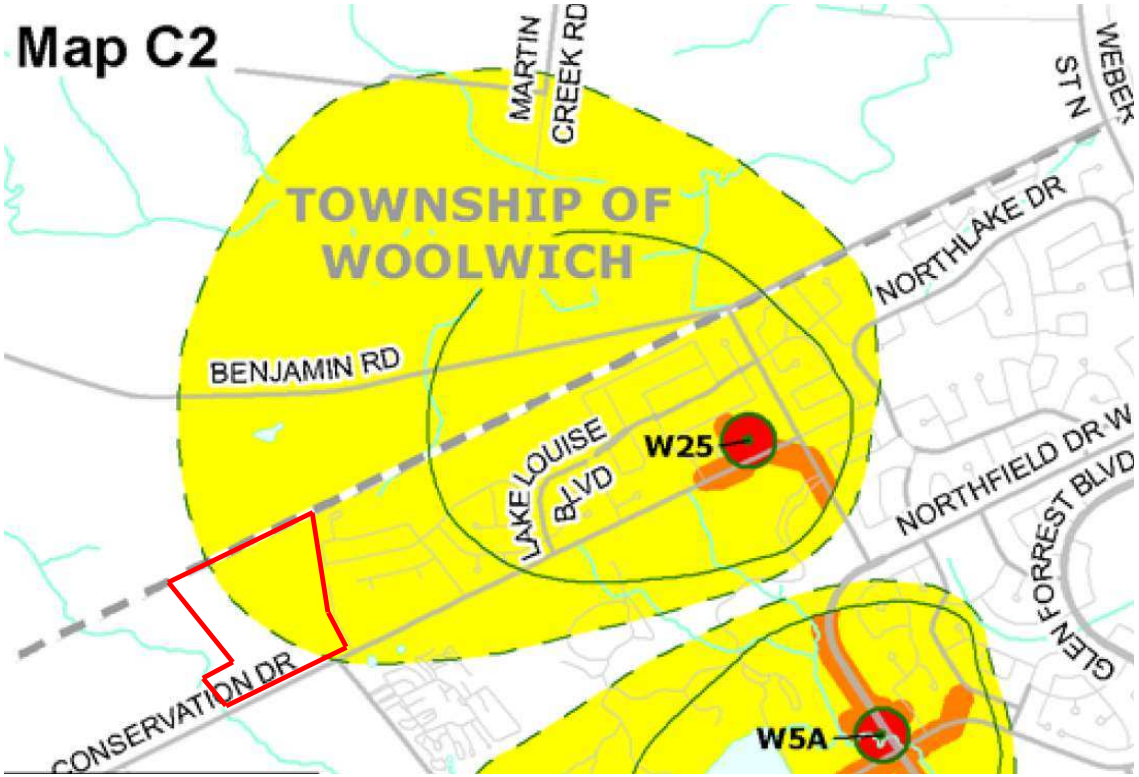
Map Created: 12/12/2021
Map Center: 43.47208 N, -80.51012 W

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

Stantec

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

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								Concrete
			SILTY SAND some organics, light brown	0.23 349.31			1	SS	0-0-2-2 (2)	10" 42%		
			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 becoming light greyish brown at 2.3 m BGS	1.52			3	SS	0-1-2-2 (3)	15" 63%		
			becoming wet at 2.8 m BGS	347.02			4	SS	0-0-0-0 (0)	23" 96%		Top of sand (2.4 m BGS)
10			SILTY SAND fine grained, light brown, wet	3.05			5	SS	0-0-0-0 (0)	21" 88%		Top of screen (3.1 m BGS) No.2 Silica Sand
	4				AFB1 / AFB2	Upper / Middle Moraine Stratified Sediments and Equivalents						No.10 Slot PVC screen 50 mm diameter
15			SAND medium grained, light brown/grey, wet	345.29 4.78 344.89			6	SS	2-2-3-5 (5)	21" 88%		Bottom of screen (4.6 m BGS)
			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

Stantec

Sheet 1 of 1

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

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 = 0.96 m
0	0		Ground Surface	355.56								
			TOPSOIL organics and fine sand, very dark brown, very moist	0.00 355.25								Concrete
			SAND fine grained, trace gravel, dark brown, loose, moist	0.30			1	SS	0-1-1-4 (2)	16.5" 69%		
			becoming brown, very moist, very loose at 0.9 m BGS				2	SS	0-1-0-1 (1)	10.5" 44%		52 mm Schedule 40 PVC casing
5			fine to medium grained sand beginning at 1.5 m BGS				3	SS	0-0-0-0 (0)	13" 54%		Holeplug
	2		becoming grey-brown at 2.3 m BGS		AFB1 / AFB2	Upper / Middle Moraine Stratified Sediments and Equivalents	4	SS	0-0-1-7 (1)	n/a		Top of sand (2.4 m BGS)
10			becoming wet at 3.1 m BGS				5	SS	4-5-8-8 (13)	n/a		Top of screen (3.1 m BGS) No.2 Silica Sand
	4											No.10 Slot PVC screen 50 mm diameter
15							6	SS	3-9-9-12 (18)	n/a		Bottom of screen (4.6 m BGS)
				350.38								
			End of Borehole	5.18								
20	6											
25	8											

Screen Interval: 3.05 - 4.57 m BGS
Sand Pack Interval: 2.44 - 4.57 m BGS
Well Seal Interval: 0.30 - 2.44 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
n/a - not available

mAMSL - metres above mean sea level
mBGS - metres below ground surface

Drawn By/Checked By: OR/LV

Stantec

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 fine sand, dark brown, loose, wet	0.00 366.53			1	SS	1-10-11-3 (21)	15" 63%
			SAND fine grained, brown, loose, wet	0.30			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 some fine grained sand, brown, firm to stiff, wet	3.86			6	PQ	n/a	58" 100%
15										
				361.25						
			SAND fine grained, brown, loose	5.59			7	PQ	n/a	58" 97%
20	6		fine to medium grained, some coarse grained, brown, loose, wet				8	PQ	n/a	50" 83%
25	8						9	PQ	n/a	57" 97%
30										
	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							
			some silt beginning at 17.7 m BGS				15	PQ	n/a	51" 85%
60	18			348.09						
			SILT AND SAND fine grained sand, brown, loose, wet	18.75			16	PQ	n/a	48.5" 81%
65	20									
			layer of fine sand with silt, stiff, brownish grey at 20.3 to 21.8 m BGS				17	PQ	n/a	52" 87%
70										
	22		some clay, grey beginning at 21.8 m BGS				18	PQ	n/a	41" 68%
75				343.52						
			SILTY CLAY grey, stiff, wet	23.32			19	PQ	n/a	46" 77%
	24									
80							20	PQ	n/a	56" 93%
85	26			340.47						
			SILT some fine sand, trace to some clay, greyish brown, soft, wet	26.37	ATB2	Middle Maryhill Till and Equivalents	21	PQ	n/a	57" 95%
90	28									

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 40 PVC casing
Holeplug
52 mm Schedule 80 PVC casing
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)
Bentonite Grout

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

Stantec

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									
100				336.15			23	PQ	n/a	59" 97%
			SILTY CLAY TILL trace coarse sand and fine gravel, greyish brown, very stiff, wet	30.68						
105	32						24	PQ	n/a	58.5" 98%
110							25	PQ	n/a	52" 88%
	34		trace coarse grained gravel beginning at 34.0 m BGS							
115					ATB3	Lower Maryhill Till and Equivalents	26	PQ	n/a	61" 100%
	36		some coarse sand, fine to coarse gravel, dark brown beginning at 35.5 m BGS				27	PQ	n/a	61" 102%
120			cobble, 0.13 m diameter, at 36.7 m BGS							
125	38						28	PQ	n/a	55" 92%
				327.21						
130			SAND AND SILT some gravel, firm to stiff, wet	39.62 327.04			29	PQ	n/a	60" 100%
	40		SILTY SAND TILL some sand and gravel, grey, very hard, moist	39.80	ATC1	Upper/ Main Catfish Creek Till				
135							30	PQ	n/a	60" 100%
				325.23						
	42		End of Borehole	41.61						
140										
145	44									
150										
155	46									
	48									
160										
165	50									
170										
	52									
175										
	54									
180										
185	56									

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

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
10			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
							5	SS	2-5-6-9 (11)	0" 0%		Bottom of screen (3.0 m BGS)
			End of Borehole	3.66								
15	4											
20	6											
25	8											

Screen Interval: 1.52 - 3.05 m BGS
Sand Pack Interval: 0.91 - 3.05 m BGS
Well Seal Interval: 0.15 - 0.91 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
n/a - not available

Drawn By/Checked By: OR/LV

Stantec

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
0	0		Ground Surface	351.08								
			TOPSOIL dark brown, moist	0.00 350.93								Concrete
			CLAYEY SILT trace organics, light reddish brown, firm to stiff	0.15			1	SS	0-2-4-8 (6)	18" 75%		Holeplug
							2	SS	2-3-4-6 (7)	11" 46%		
5			some gravel light brown beginning at 1.5 m BGS seams of medium grained sand beginning at 1.7 m BGS		ATB1	Upper Maryhill Port Stanley Till and Equivalents						52 mm Schedule 40 PVC casing
	2						3	SS	2-4-12-7 (16)	24" 100%		Top of sand (2.1 m BGS)
			layer of coarse gravel at 2.1 m BGS trace sand and gravel at 2.3 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								
	4				AFB1 / AFB2	Upper / Middle Moraine Stratified Sediments and Equivalents	5	SS	10-14-12-8 (26)	14" 58%		No.2 Silica Sand
15				346.51								No.10 Slot PVC screen 50 mm diameter
			End of Borehole	4.57								Bottom of screen (4.3 m BGS)
												Natural cave
20	6											
25	8											

Screen Interval: 2.74 - 4.27 m BGS
Sand Pack Interval: 2.13 - 4.27 m BGS
Well Seal Interval: 0.30 - 2.13 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
n/a - not available

Drawn By/Checked By: OR/LV

Stantec

STANTEC BOREHOLE AND WELL 160330875 - DPS.GPJ EQUIS DATA TEMPLATE.GDT 2/1/11 MJFRASER

Monitoring Well: MW6-10

Project:	North Waterloo Subwatershed Study	**Drilling method:**	Track Mount, CME55, Hollow Stem Auger
Client:		**Date started/completed:**	18-Mar-2010
Location:	North Waterloo, ON	**Ground surface elevation:**	355.58 m AMSL
Number:	160340875	**Top of casing elevation:**	356.48 m AMSL
Field investigator:	A.Vandenhoff	**Easting:**	532737
Contractor:	Pro Core Drilling	**Northing:**	4814972

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS				WELL DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	N Value	Recovery	Diagram	Description
												Stick-up = 0.90 m
0	0		Ground Surface	355.58								
			SAND fine to medium grained,dark brown, loose, moist	0.00			1	SS	3-4-5-5 (9)	13" 54%		Concrete
			becoming reddish brown at 0.8 m BGS				2	SS	2-3-3-3 (6)	14" 58%		52 mm Schedule 40 PVC casing
5			trace gravel beginning at 1.5 m BGS				3	SS	1-1-1-2 (2)	14" 58%		Holeplug
	2			353.29								
			SAND medium grained, trace gravel, light brown, loose, moist	2.29	AFB1 / AFB2	Upper / Middle Moraine Stratified Sediments and Equivalents	4	SS	3-5-5-5 (10)	16" 67%		Top of sand (2.4 m BGS)
10							5	SS	3-3-2-4 (5)	13" 54%		Top of screen (3.1 m BGS) No.2 Silica Sand
	4		some gravel, wet at 3.6 m BGS									No.10 Slot PVC screen 50 mm diameter
15			some coarse grained sand, trace gravel at 4.6 m BGS				6	SS	4-15-20-25 (35)	20" 83%		Bottom of screen (4.6 m BGS)
				350.40								
20	6		End of Borehole	5.18								
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

Stantec

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

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 = 0.93 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	6		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					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)
											Natural Cave
			End of Borehole	350.51 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

Sheet 1 of 1

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

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	0.38						Bentonite Pellets 0 to 1.2 m
	1		reddish orange mottled discolourations at 0.81 m BGS becoming wet at 0.84 m BGS	352.23	2	SS	14" 58%	2-2-3-4 (5)		Water Level 0.93 m BGS 10-May-19
4			MEDIUM SAND loose, greyish brown (10YR 5/2), trace silt/clay, some fine grained sand, trace coarse grained sand, wet	1.09						
			compact at 1.52 m BGS		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							210 mm diameter borehole
8			trace fine gravel, subrounded, beginning at 2.59 m BGS		4	SS	24" 100%	1-6-8-10 (14)		
10	3									No. 2 Silica Sand 1.2 to 4.6 m
					5	SS	21" 88%	4-7-8-8 (15)		No. 10 Slot Schedule 40 PVC Screen 52 mm I.D. 1.5 to 4.6 m
12	4									
14										
16	5				6	SS	24" 100%	3-5-6-9 (11)		
			grading coarser, increase in coarse grained sand at 5.03 m BGS	348.14						
			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 soft, dark brown (10YR 3/3), clayey silt, trace fine grained sand, moist	0.00 358.05					
			CLAYEY SILT soft, dark brown (10YR 3/3), some sand, moist yellowish brown mottling at 0.48 m BGS	0.15	1	SS	24" 100%	2-1-2-2 (3)	
				357.36					
			coarse grained sand and fine gravel present from 0.84 to 0.86 m BGS	0.86					
			SILTY CLAY very soft, yellowish brown (10YR 5/4), trace fine grained sand, poorly graded, moist		2	SS	16" 67%	1-1-1-2 (2)	
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

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						
										Above Ground Casing 0.82 m stick-up
0	0		Ground Surface	354.77						
			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	1	SS	21" 88%	2-2-4-2 (6)		
				354.01						
	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)		
5										Bentonite Pellets 0 to 2.7 m
	2		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)		
				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
				351.72						
10	3		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									
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. 2 Silica Sand 2.7 to 6.0 m 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		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)		
20				348.06						
			End of Borehole	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

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)		
			FINE TO MEDIUM SAND	0.15						
			loose, light brownish grey (10YR 6/2), trace coarse grained sand, trace fine gravel, moist							
				356.51						
			FINE SAND	0.94	2	SS	16" 67%	4-7-5-4 (12)		
			compact, pale brown (10YR 6/3), some silt/clay, moist, laminations of silt/clay with purplish brown discolourations							
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	1.85						Bentonite Pellets 0 to 4.3 m
			dense to very dense, pale brown (10YR 6/3), trace clay and fine grained sand, blocky, moist							
			some fine grained sand at 2.29 m BGS		4	SS	24" 100%	8-14-20-17 (34)		
10										210 mm diameter borehole
			trace coarse grained sand and trace fine gravel beginning at 3.25 m BGS		5	SS	24" 100%	12-18-22-26 (40)		
	4									
15										Water Level 4.53 m BGS 10-May-19
			some clay, greyish brown (10YR 5/2), well graded at 4.57 m BGS		6	SS	24" 100%	8-21-20-27 (41)		
	6									No. 2 Silica Sand 4.3 to 7.6 m
20					7	SS	24" 100%	17-25-32-30 (57)		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
4	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)	
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 SILTY SAND compact, brown (10 YR 5/4), fine grained sand, trace clay, wet	2.08					210 mm diameter borehole
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								
14				352.67					
			SANDY SILT dense, pale brown (10YR 6/3), fine grained sand, trace clay, blocky, moist	4.57					
16	5				6	SS	23" 96%	6-19-19-19 (38)	
			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

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							
			Ground Surface	358.88							Above Ground Casing 0.99 m stick-up
0	0		TOPSOIL (SAND)	0.00							
			Fine grained, trace organics, yellowish brown (10YR 5/4), dry	358.73	1	SS	18" 75%	2-4-9-7 (13)			Cement Seal 0 to 0.3 m
			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								
			Trace fine and coarse gravel starting at 0.76 m		2	SS	17" 71%	3-7-10-8 (17)			
			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
					12	SS	24" 146%	1-5-15/4.4" (15/4.4")			
				350.08							
			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				
14	4				1	GS	
16	5				2	GS	
18							
	6		Water table at 5.7 m BGS End of Test Pit	352.24 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			
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

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							Backfilled with Natural Cave 0 to 4 m
	2						
8							
10	3						
12							
	4		Sample collected from below test pit base	351.83 4.00	2	GS	
14			End of Test Pit				

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

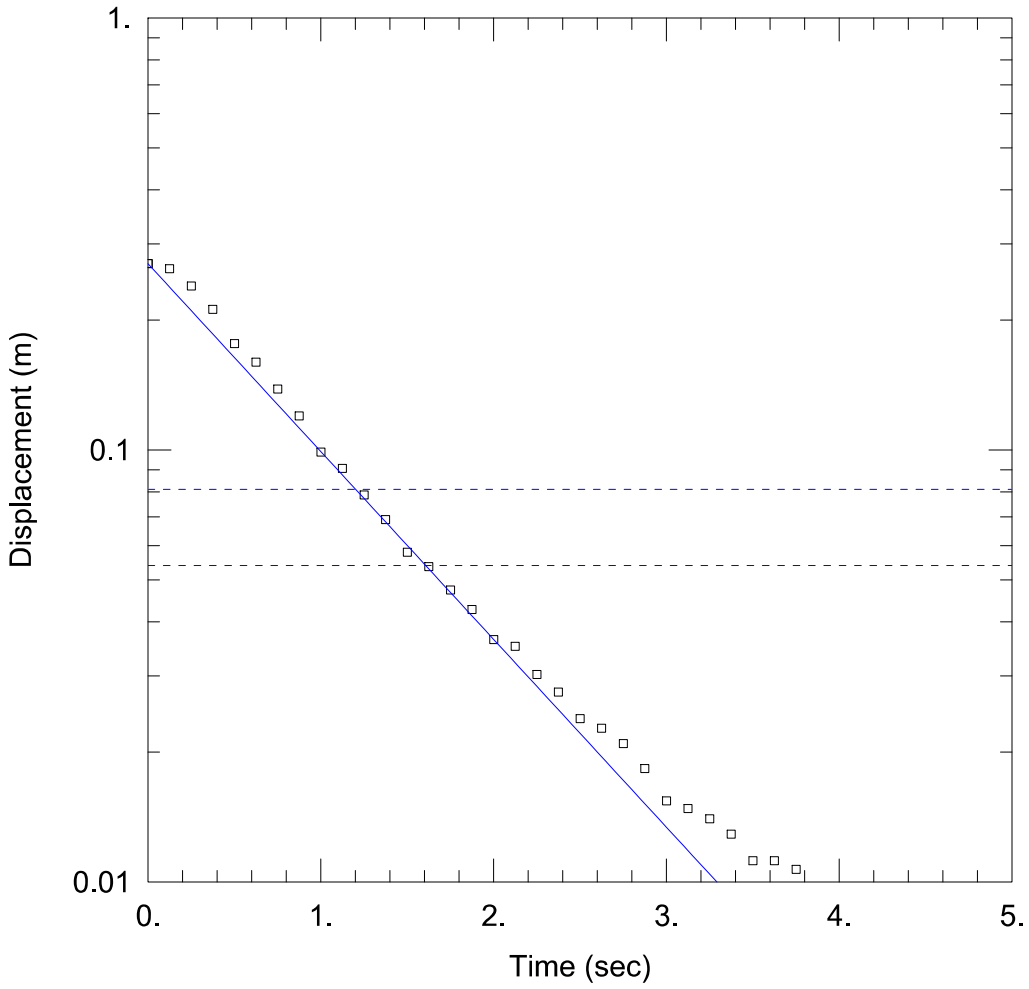
Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
GS - grab sample
n/a - not available

Stantec

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

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

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

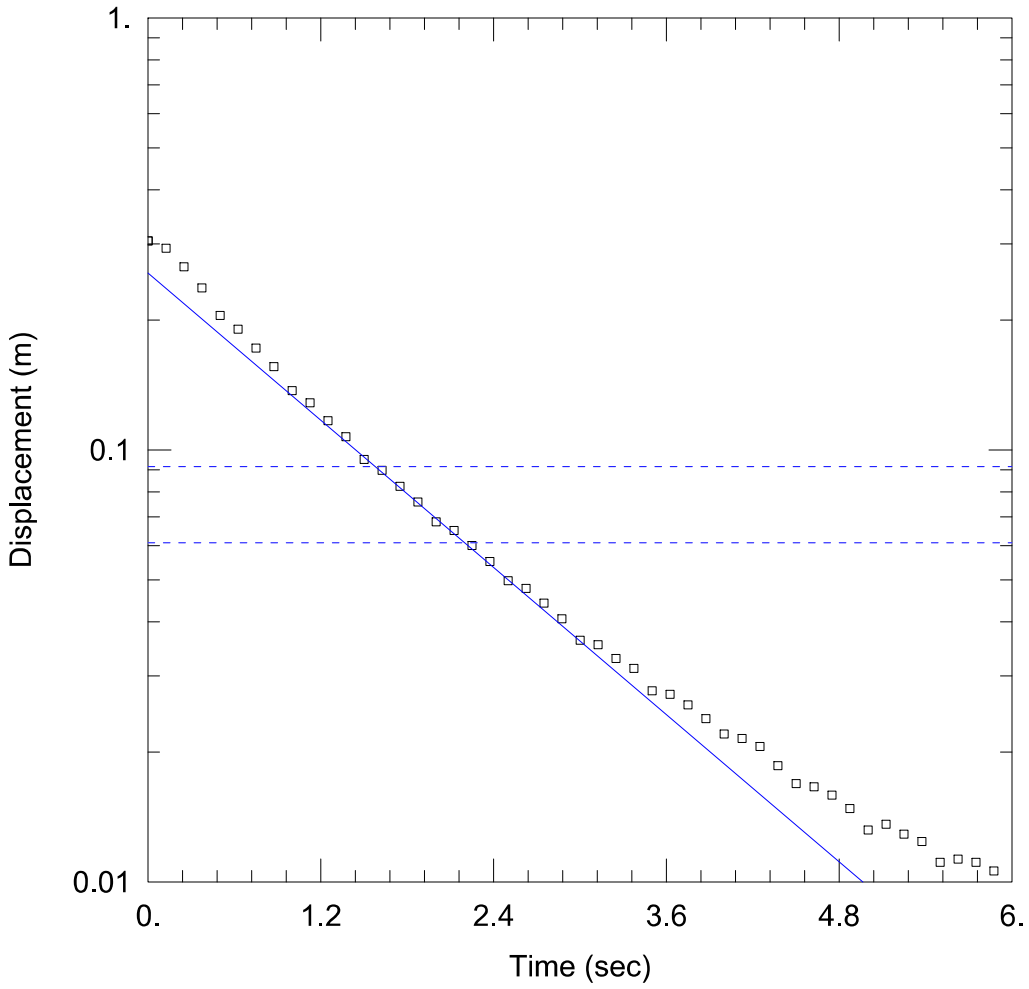
Saturated Thickness: 4.15 m Anisotropy Ratio (Kz/Kr): 0.5

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

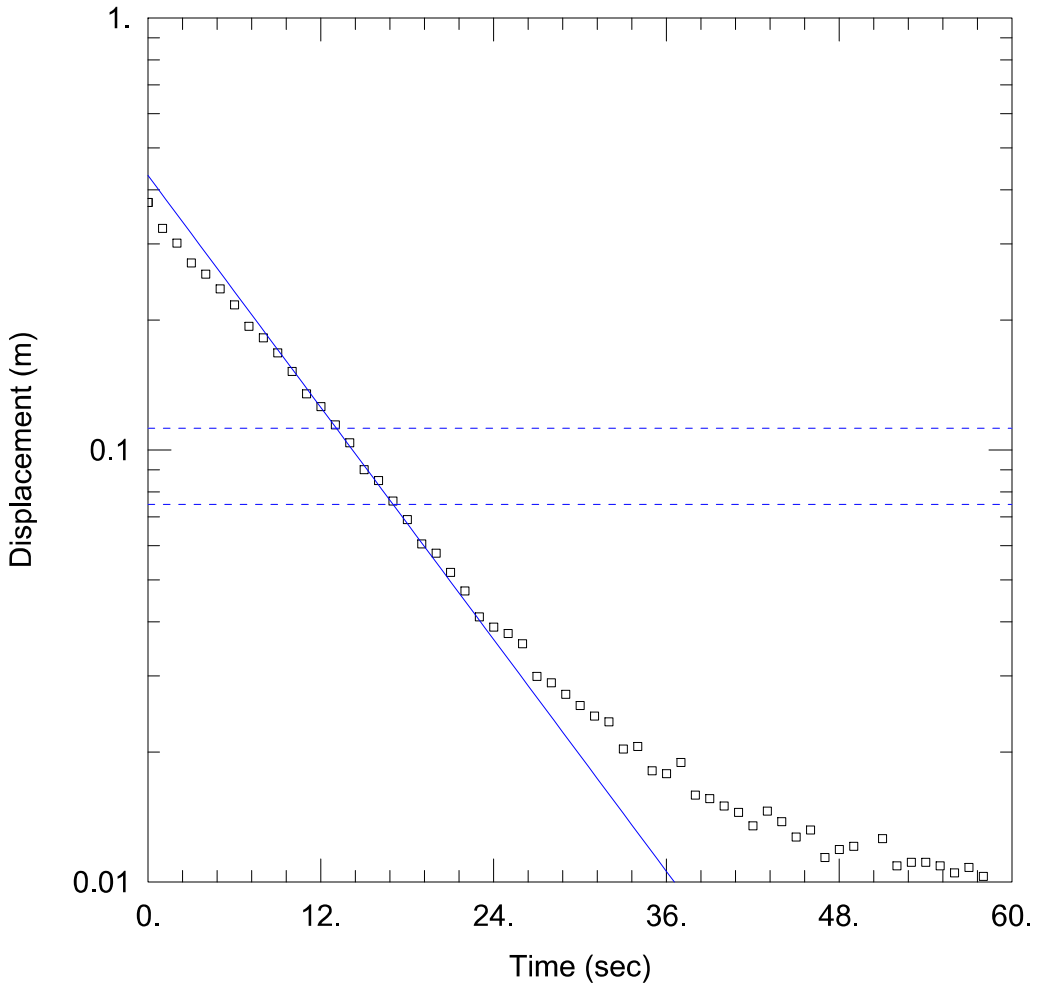
Saturated Thickness: 3.955 m Anisotropy Ratio (Kz/Kr): 0.5

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

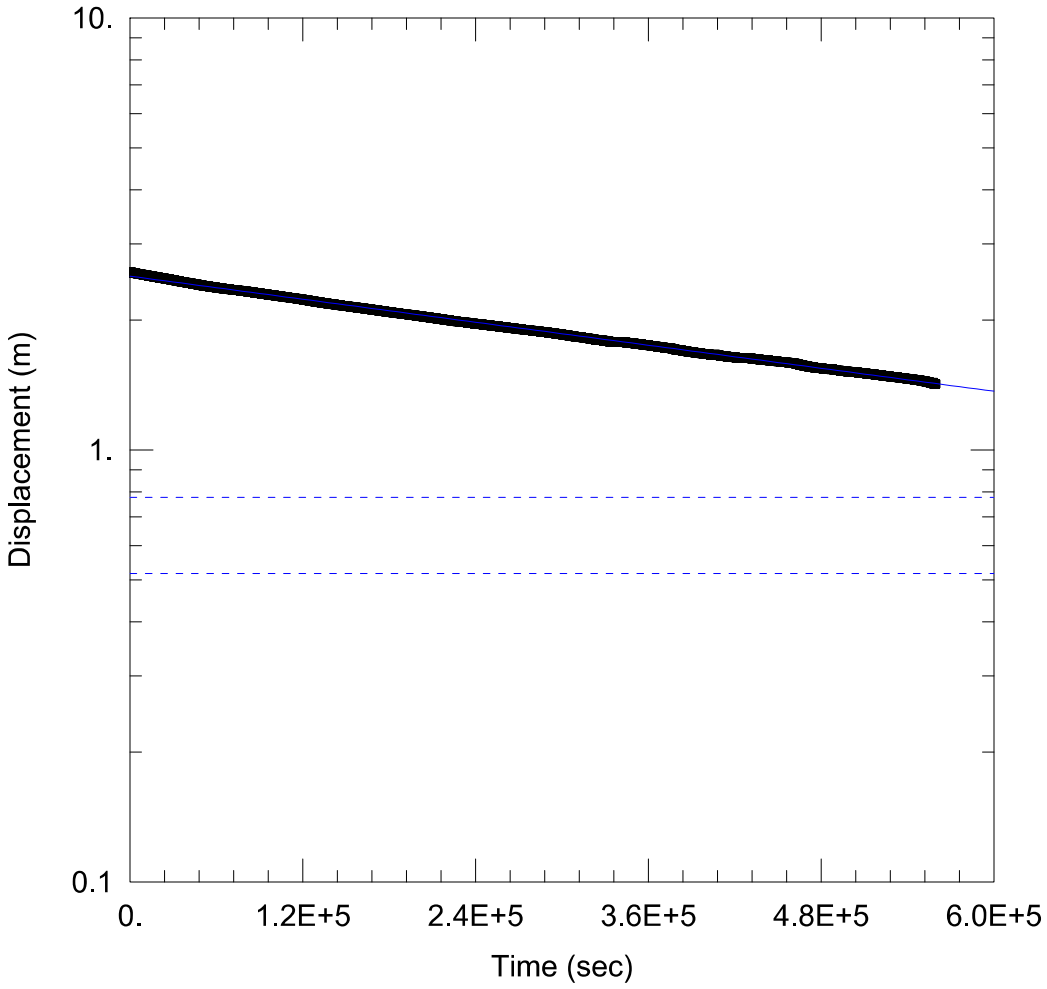
WELL DATA (MW4-19)

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

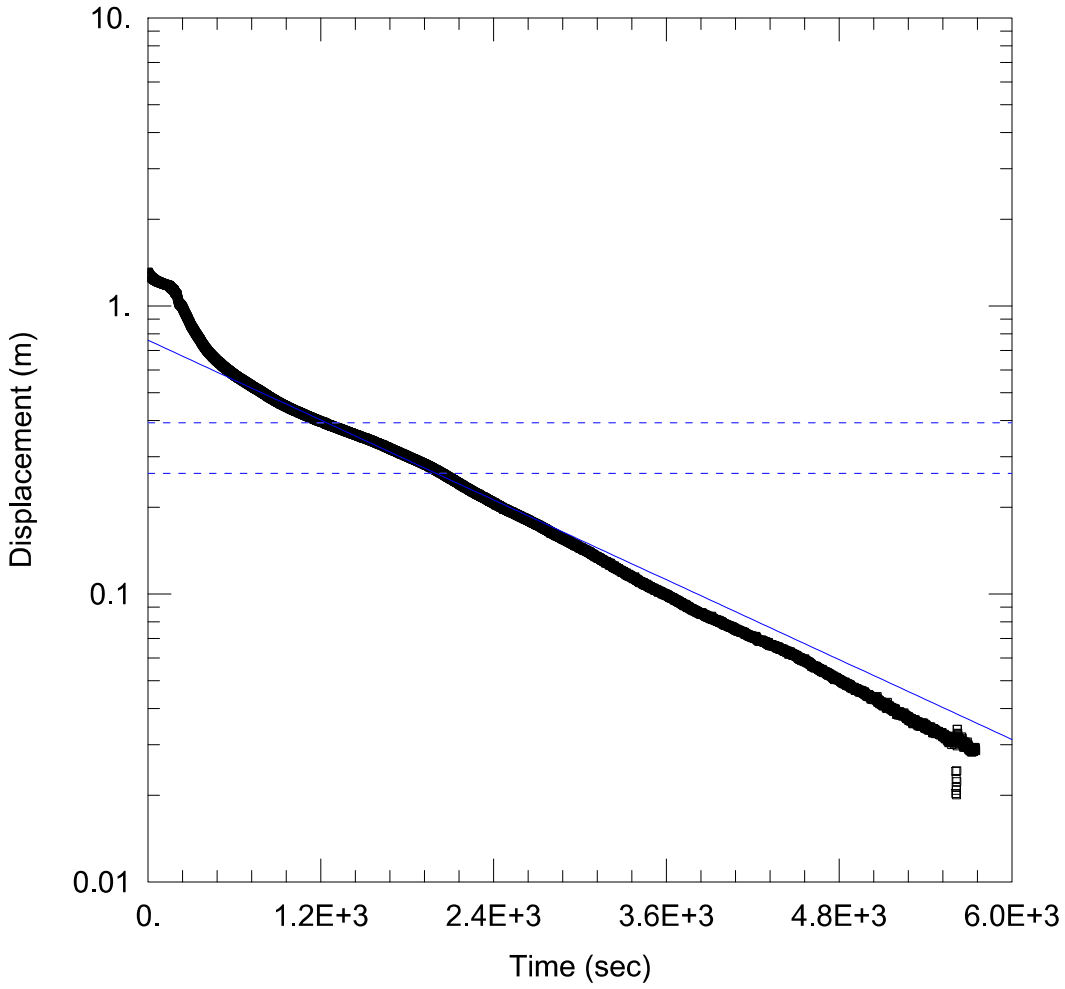
WELL DATA (MW5-19)

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

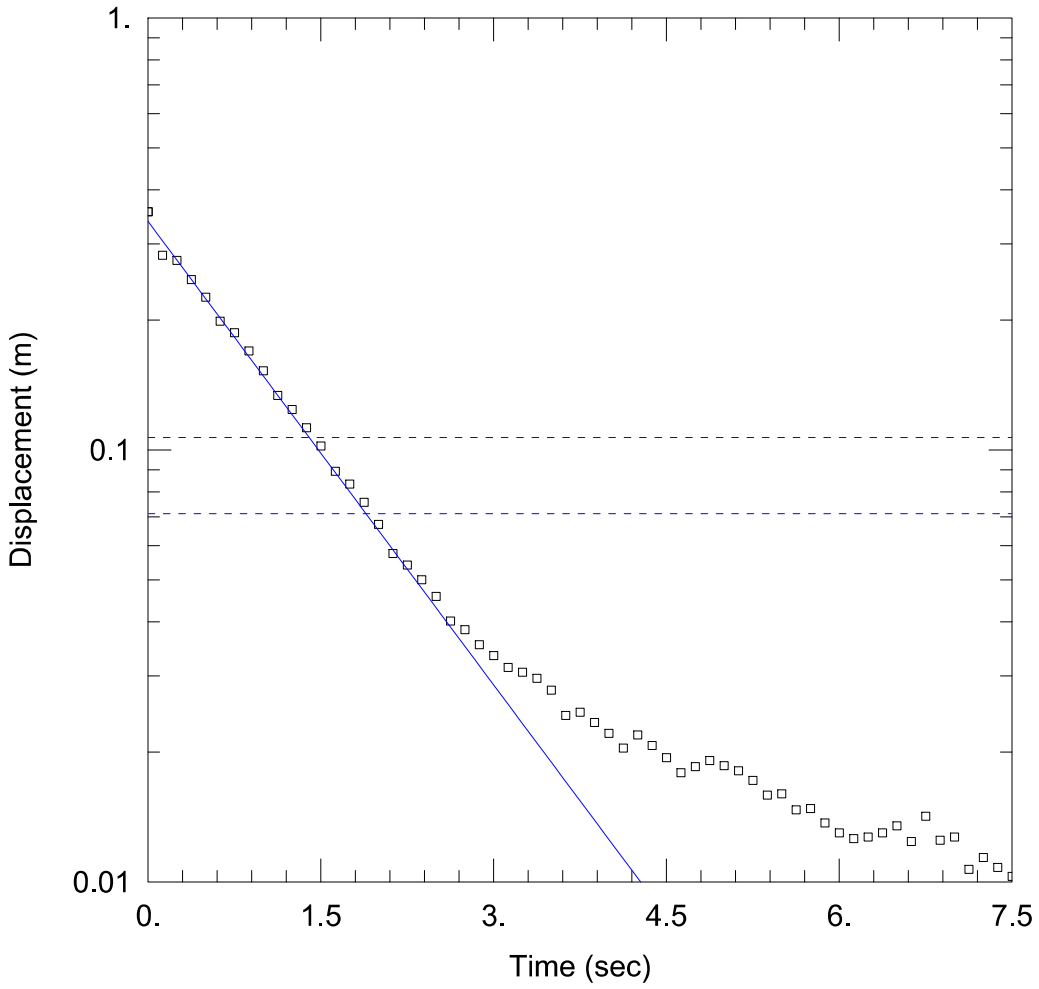
Saturated Thickness: 2.57 m Anisotropy Ratio (Kz/Kr): 0.2

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

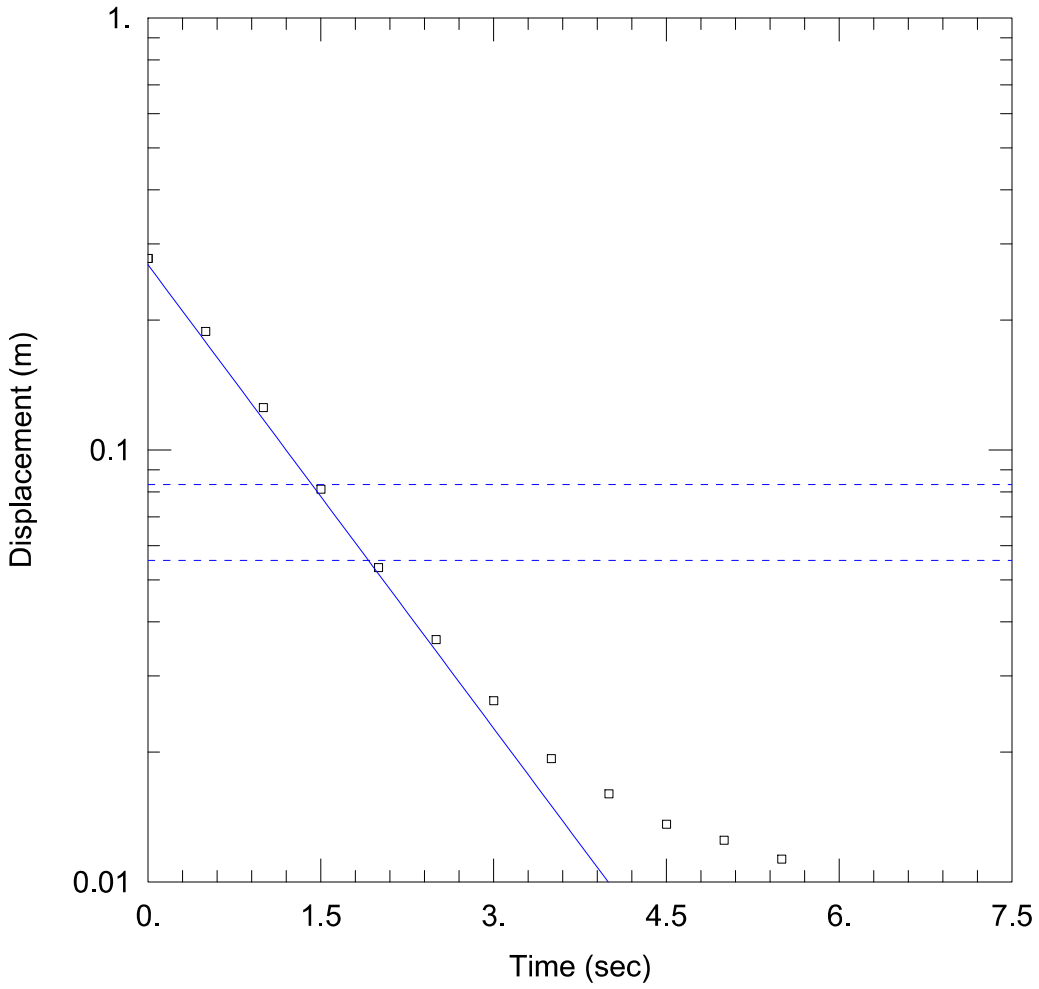
WELL DATA (MW101-21)

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
Tel: (519) 741-1313 Fax: (519) 741-5422
E-Mail: kitchener@englobecorp.com Website: www.englobecorp.com

GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-696 PROJECT LOCATION: Waterloo, Ontario FIGURE No.: 1

BOREHOLE / TEST PIT NUMBER:	GP 101-20
SAMPLING DEPTH:	0 - 35 cm
SAMPLE NUMBER:	01
SAMPLED BY:	Client
SAMPLE DESCRIPTION:	Topsoil
SAMPLE NATURAL MOISTURE:	-
SAMPLE RECEIVED DATE:	6/23/2020
GRAIN SIZE PROPORTIONS, %	
% GRAVEL (> 4.75 mm):	0.1
% SAND (75 µm to 4.75 mm):	30.0
% Silt (2 µm to 75 µm):	42.9
% Clay (<2 µm):	27.0
SUSCEPTIBILITY TO FROST HEAVING:	-

GRAIN SIZE ANALYSIS		HYDROMETER ANALYSIS	
SIEVE SIZE mm	% PASSING	DIAMETER mm	% PASSING
53.0	100.0	0.037	60.2
37.5	100.0	0.026	54.9
26.5	100.0	0.017	51.4
19.0	100.0	0.010	46.2
13.2	100.0	0.007	42.7
9.5	100.0	0.005	37.5
4.75	99.9	0.003	30.5
2.00	99.6	0.001	24.4
0.850	99.6	ATTERBERG LIMITS, %	
0.425	98.0		
0.250	94.1	Plastic Limit	
0.106	77.0	Liquid Limit	
0.075	69.9	Plastic Index	

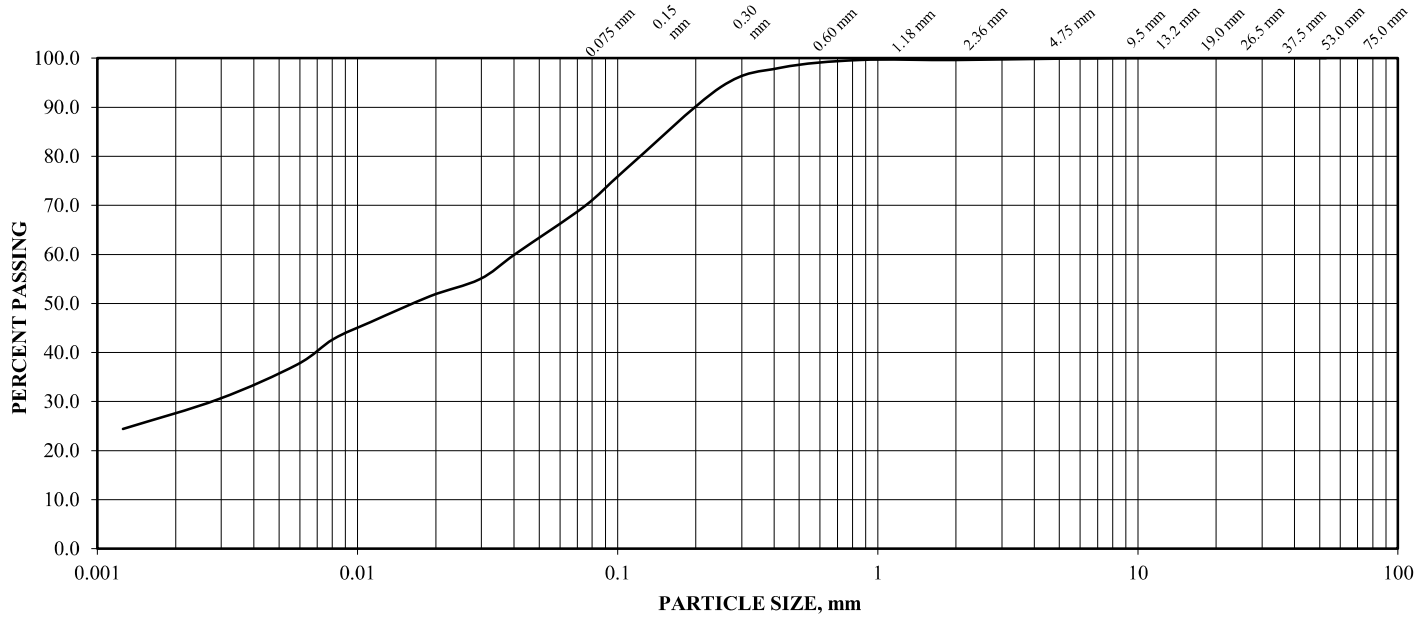
PARTICLE SIZE DISTRIBUTION, MTO LS-702

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

CLAY	SILT	VERY FINE	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL

UNIFIED SOILS CLASSIFICATION ASTM D 2487

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



SIGNED: _____ DATE: 07/07/2020

O. Rexha

Englobe
353 Bridge Street East, Kitchener, ON N2K 2Y5
Tel: (519) 741-1313 Fax: (519) 741-5422
E-Mail: kitchener@englobecorp.com Website: www.englobecorp.com

GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-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	

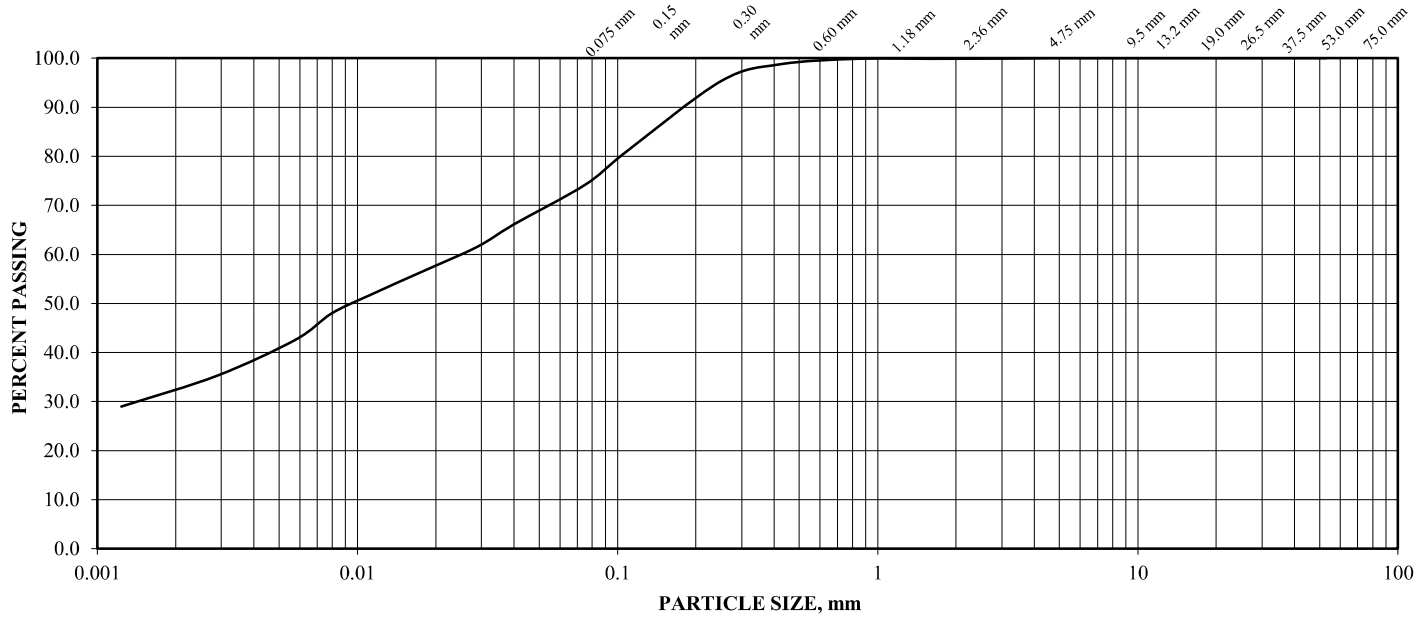
PARTICLE SIZE DISTRIBUTION, MTO LS-702

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

Englobe
353 Bridge Street East, Kitchener, ON N2K 2Y5
Tel: (519) 741-1313 Fax: (519) 741-5422
E-Mail: kitchener@englobecorp.com Website: www.englobecorp.com

GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-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	

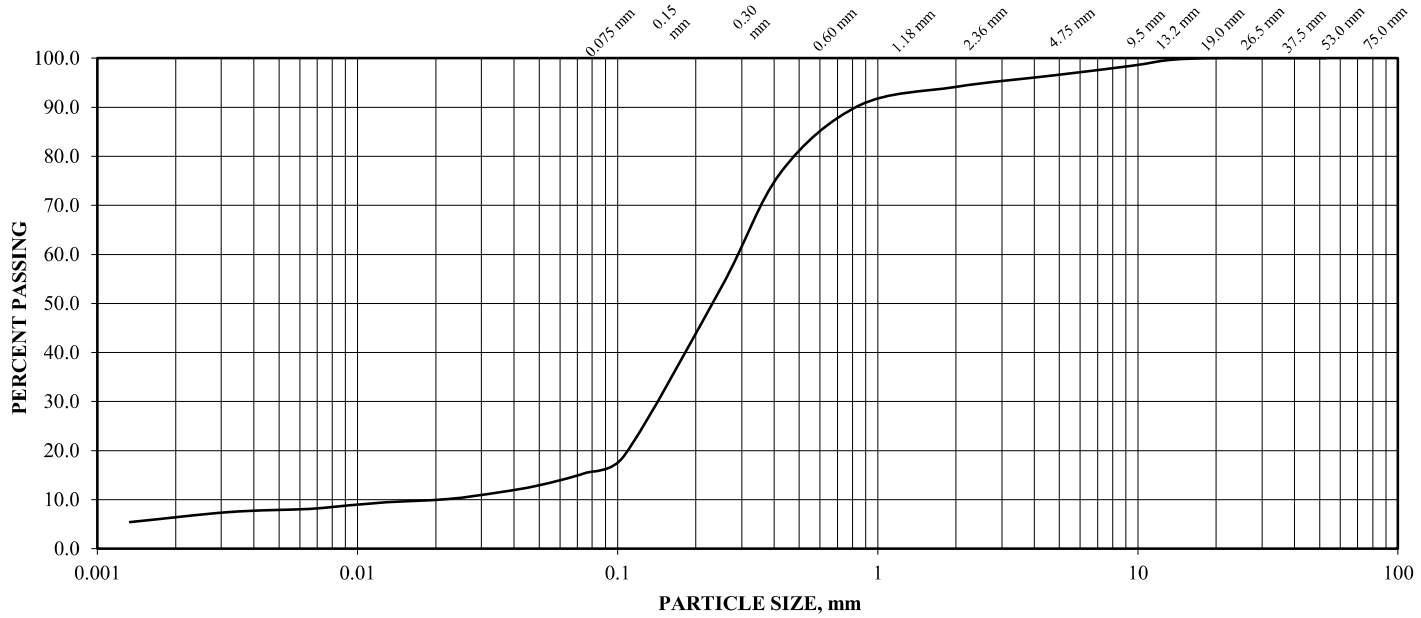
PARTICLE SIZE DISTRIBUTION, MTO LS-702

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

Englobe
353 Bridge Street East, Kitchener, ON N2K 2Y5
Tel: (519) 741-1313 Fax: (519) 741-5422
E-Mail: kitchener@englobecorp.com Website: www.englobecorp.com

GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-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	

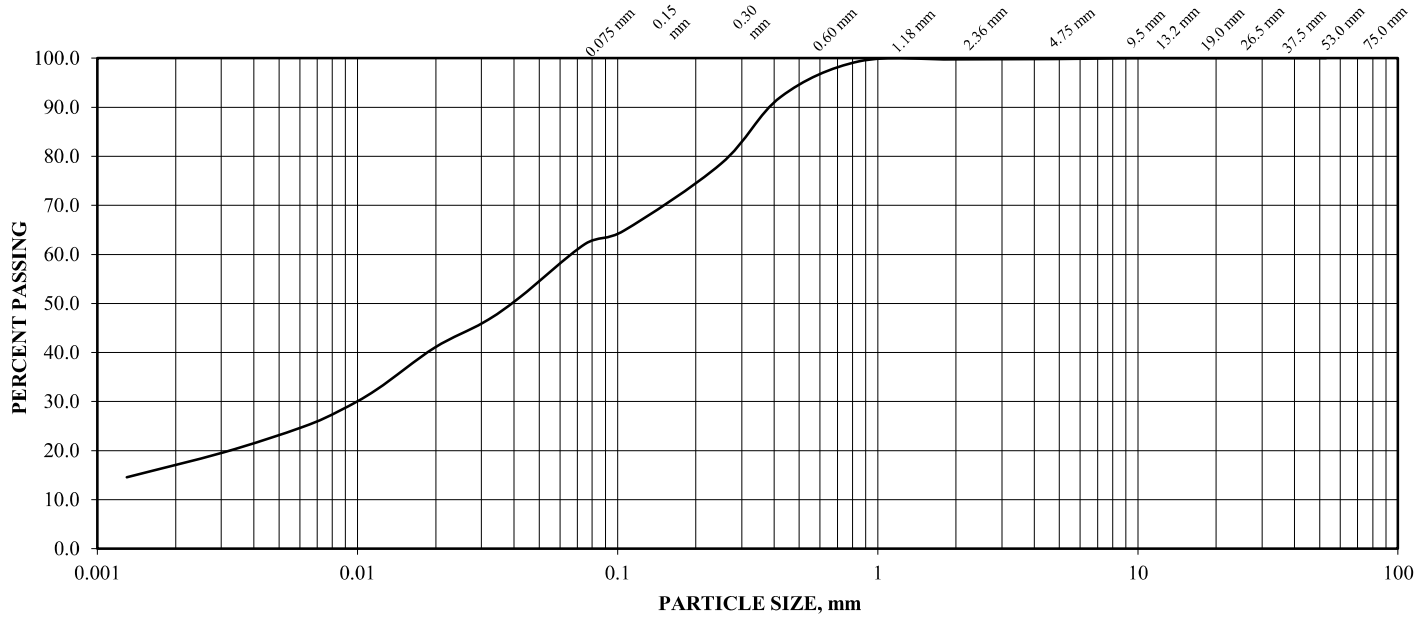
PARTICLE SIZE DISTRIBUTION, MTO LS-702

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

Englobe
353 Bridge Street East, Kitchener, ON N2K 2Y5
Tel: (519) 741-1313 Fax: (519) 741-5422
E-Mail: kitchener@englobecorp.com Website: www.englobecorp.com

GRAIN SIZE ANALYSIS AND HYDROMETER TEST REPORT
MTO LS-602, 702, AND 703/704

PROJECT NO.: 160-P-0019533-0-01-500 PROJECT NAME: 556 & 576 Conservation Drive / 160900921

LAB SAMPLE ID: S-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	

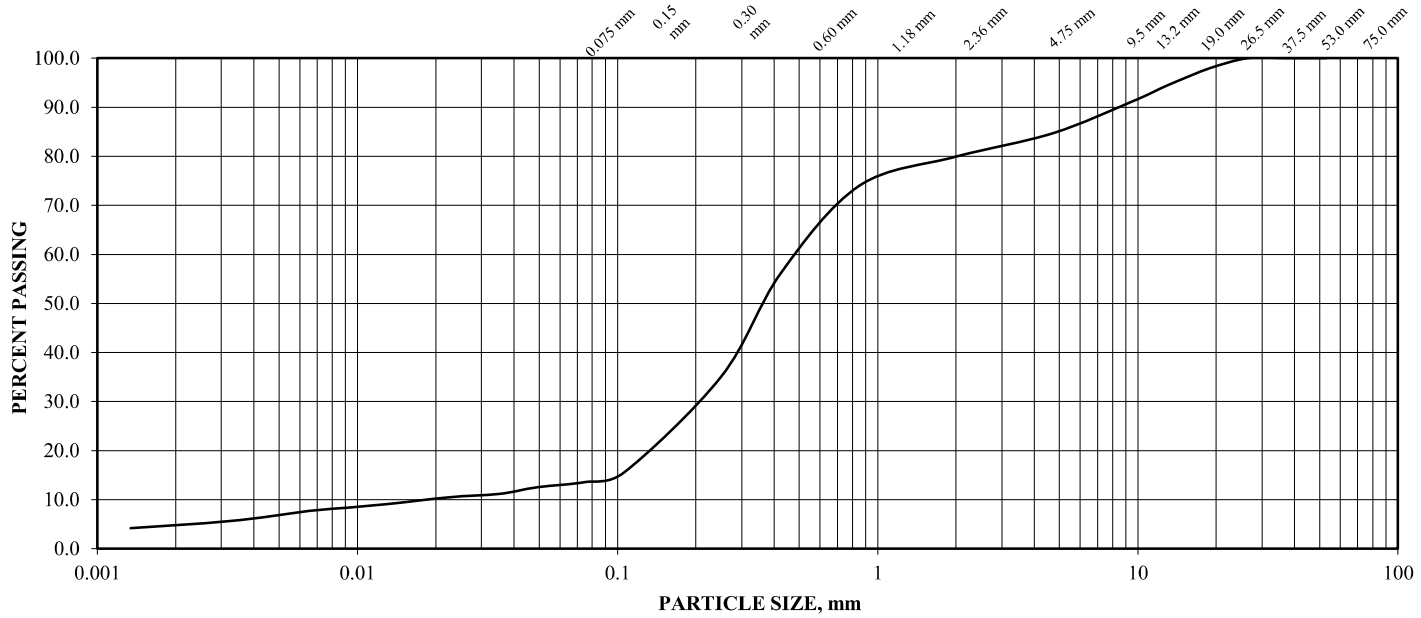
PARTICLE SIZE DISTRIBUTION, MTO LS-702

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

Englobe SWO - Kitchener
London
Brantford

englobecorp.com

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

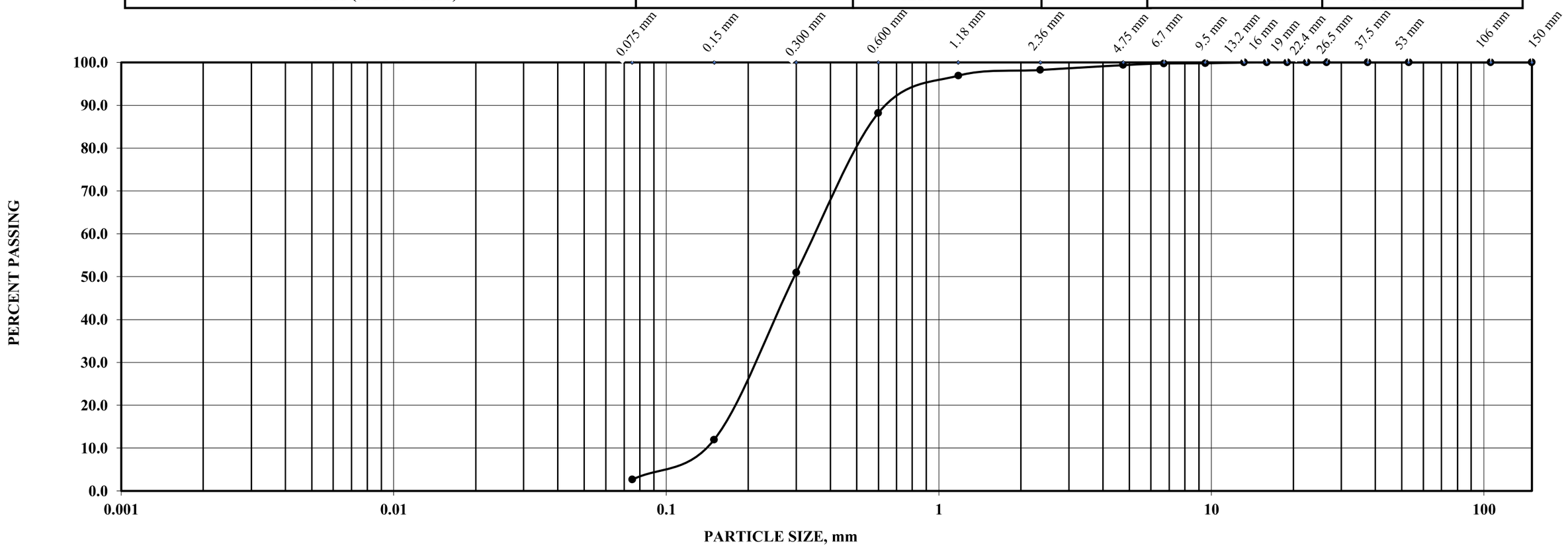
PARTICLE SIZE DISTRIBUTION, MTO LS-602

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

Englobe SWO - Kitchener
London
Brantford

englobecorp.com

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

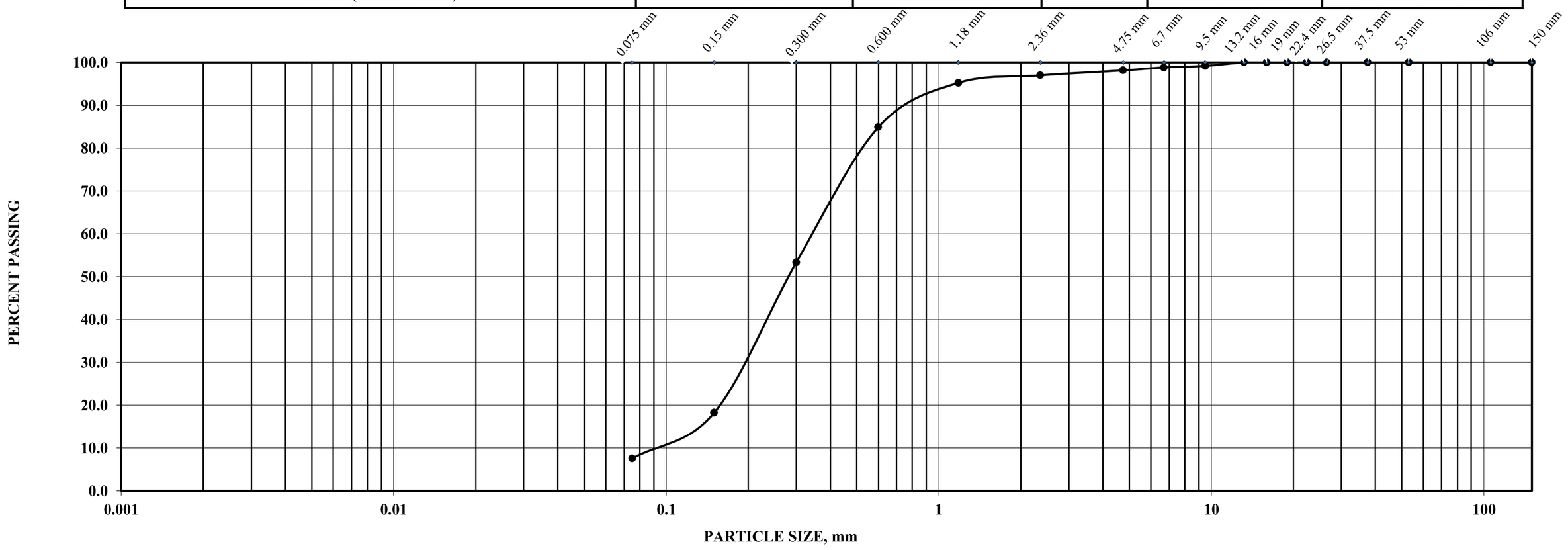
PARTICLE SIZE DISTRIBUTION, MTO LS-602

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

Englobe SWO - Kitchener
London
Brantford

englobecorp.com

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

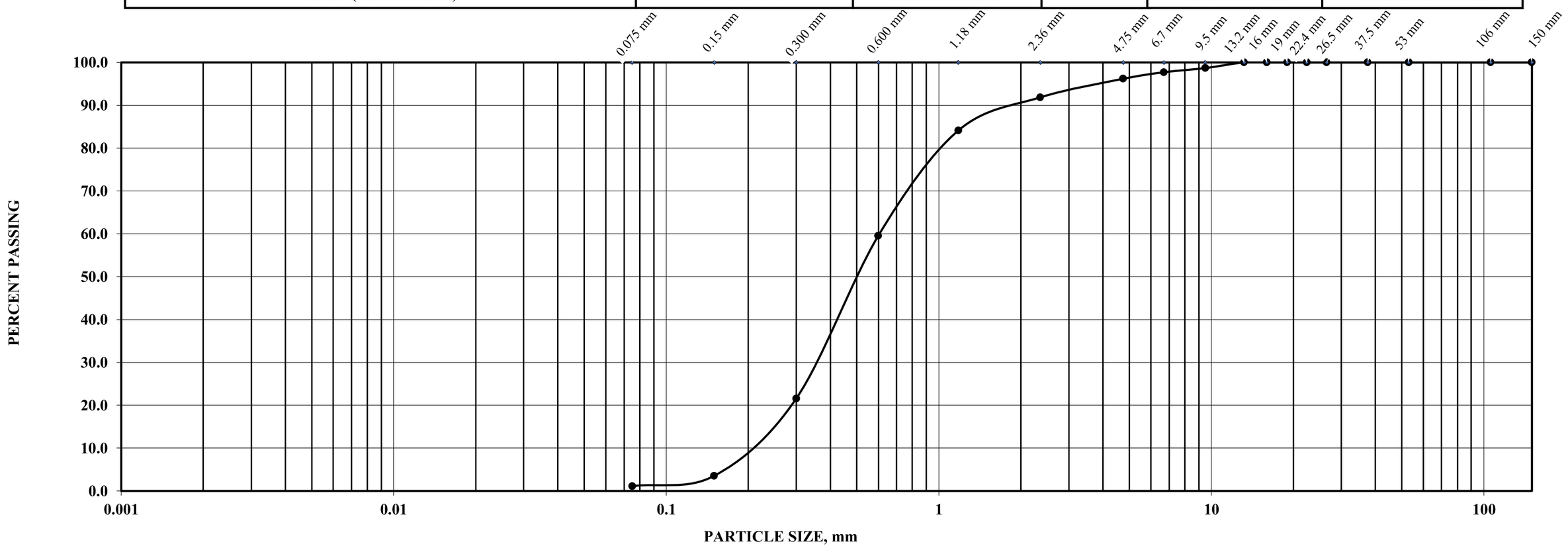
PARTICLE SIZE DISTRIBUTION, MTO LS-602

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

Englobe SWO - Kitchener
London
Brantford

englobecorp.com

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

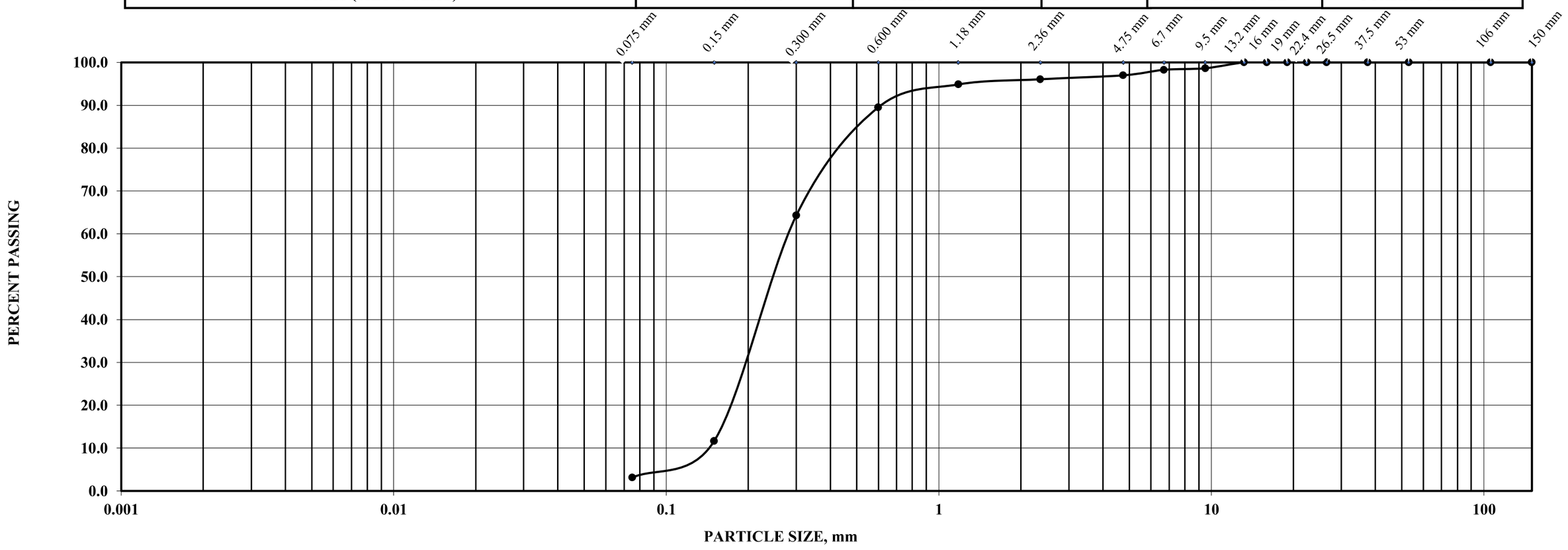
PARTICLE SIZE DISTRIBUTION, MTO LS-602

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

Englobe SWO - Kitchener
London
Brantford

englobecorp.com

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

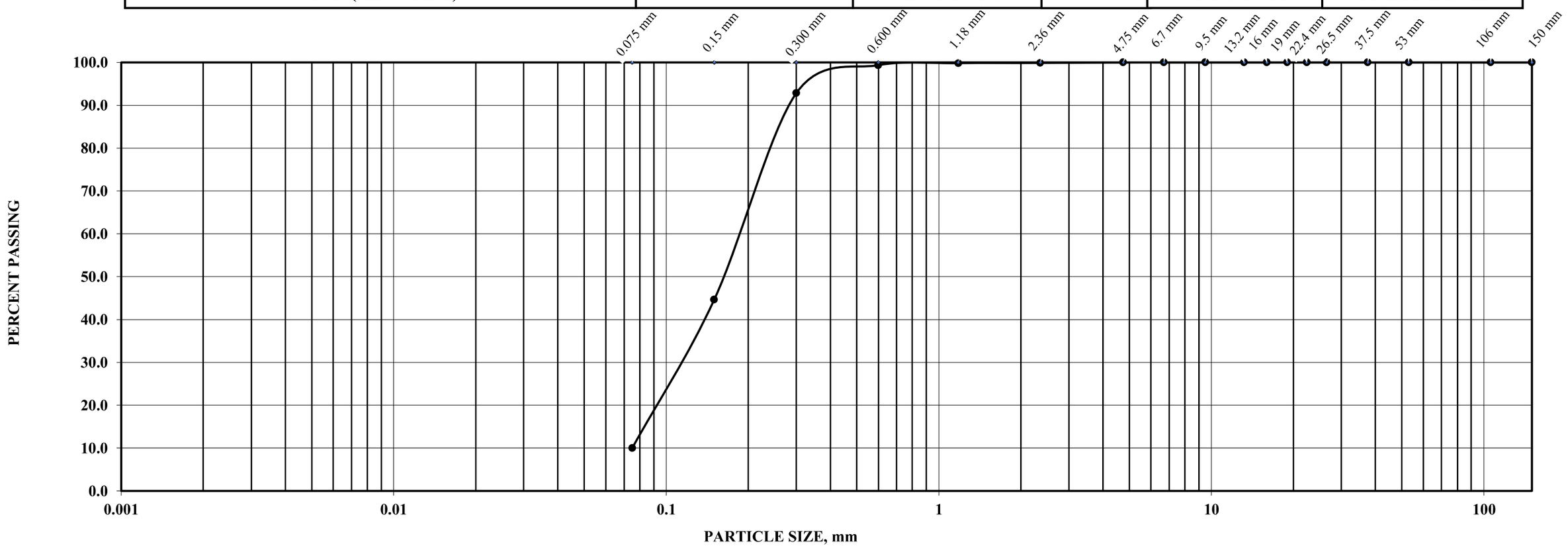
PARTICLE SIZE DISTRIBUTION, MTO LS-602

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

Englobe SWO - Kitchener
London
Brantford

englobecorp.com

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

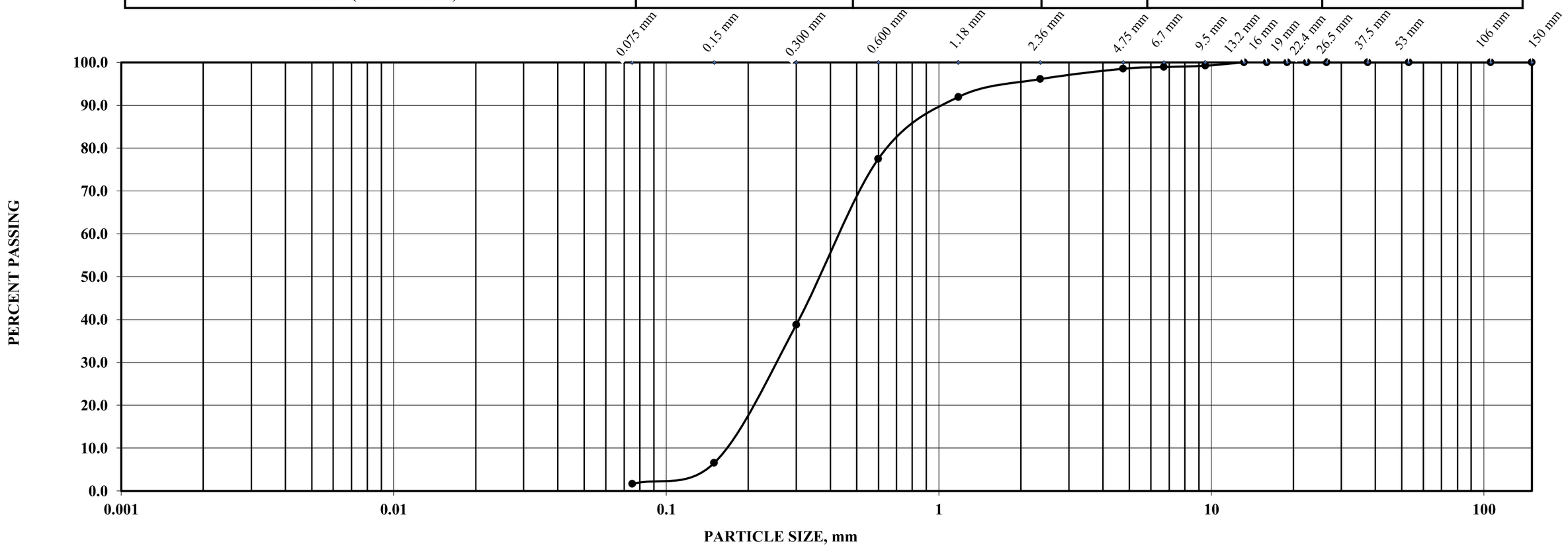
PARTICLE SIZE DISTRIBUTION, MTO LS-602

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

Englobe SWO - Kitchener
London
Brantford

englobecorp.com

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

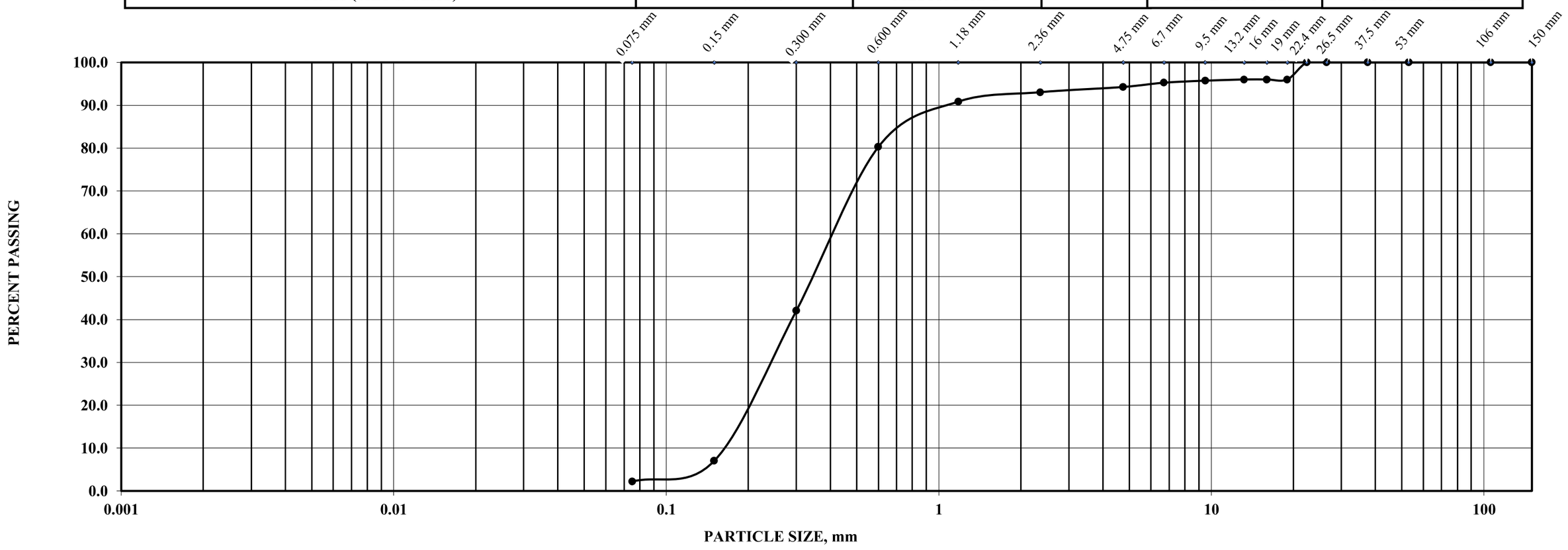
PARTICLE SIZE DISTRIBUTION, MTO LS-602

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

Englobe SWO - Kitchener
London
Brantford

englobecorp.com

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

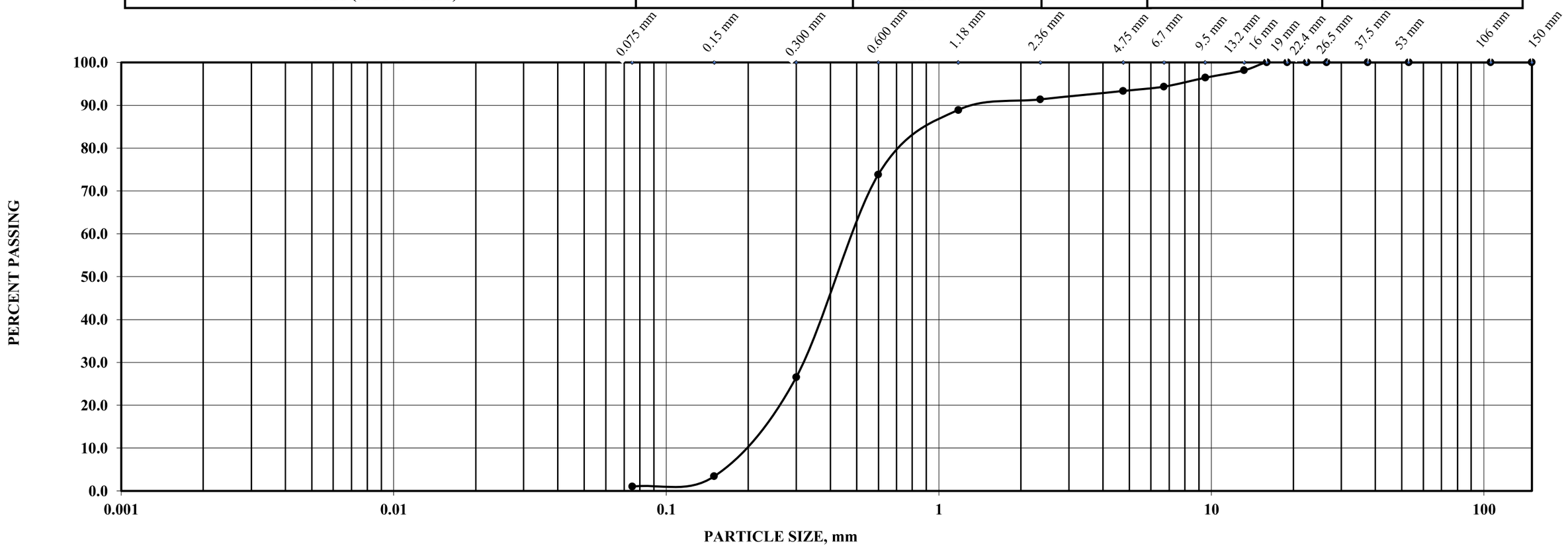
PARTICLE SIZE DISTRIBUTION, MTO LS-602

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.

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

Stantec

Client/Project
2115881 Ontario Limited
Hydrogeological Assessment
556, 560 and 576 Conservation Drive,
Waterloo

December 2021
160900921

Appendix
J

Title
PHOTOGRAPHIC RECORD



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.

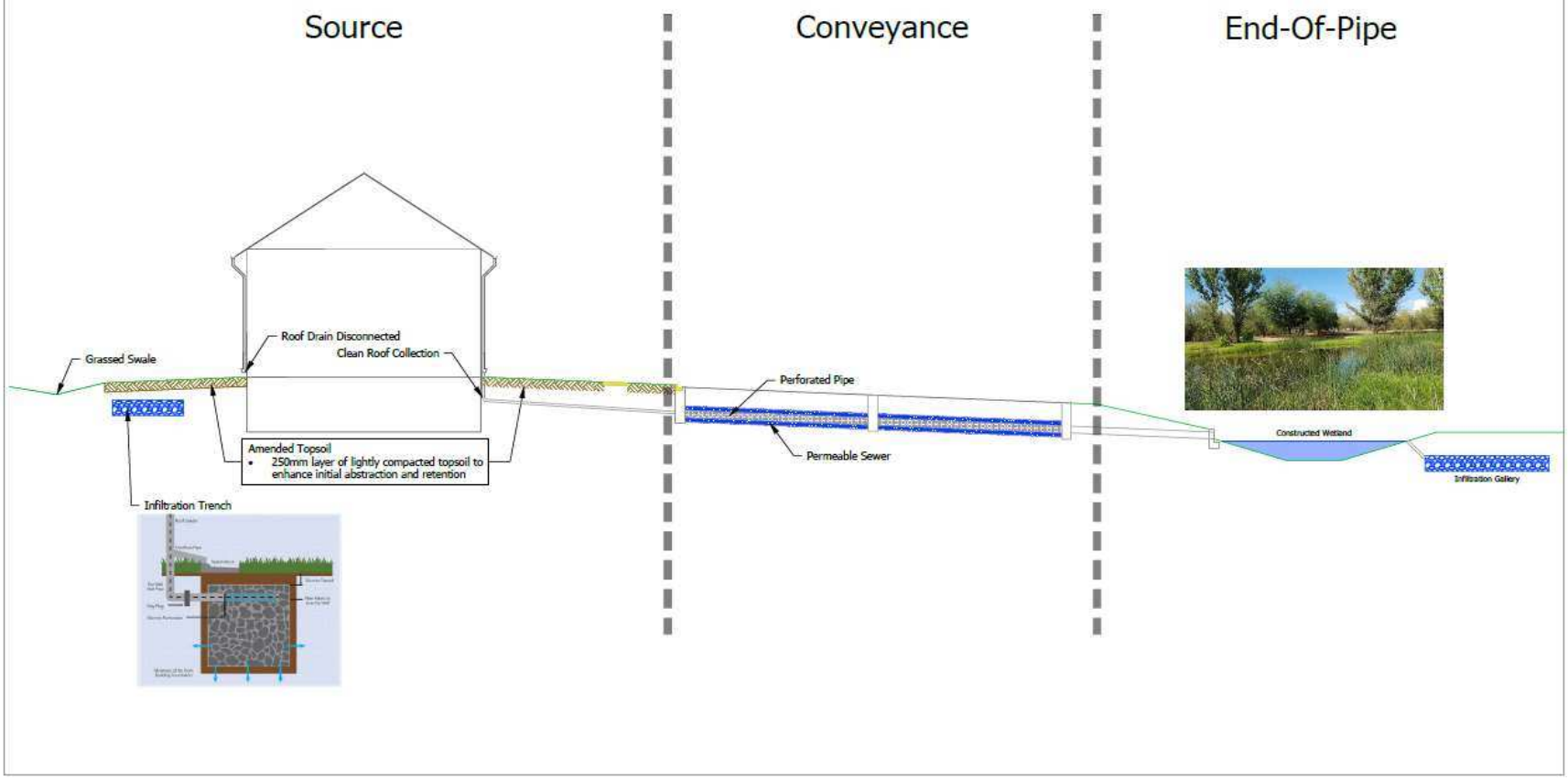


Photo 12: Test Pit 4 (TP4) – May 28, 2021. Note that grain-size analysis testing indicates that soils up to a depth of 4.4 meters below existing grade comprise 92% sand.

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

Month		Precip (mm)	Kitchener ETO
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	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

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
0.09	0.00	0.09	6.765	0.00	0.09	0.0930	0.00	0.00	0.00
0.00	0.00	0.00	6.858	0.00	0.00	0.0000	0.00	0.00	0.00
0.09	0.00	0.09	6.858	0.00	0.09	0.0930	0.00	0.00	0.00
0.19	0.00	0.19	6.951	0.00	0.19	0.1860	0.00	0.00	0.00
0.19	0.00	0.19	7.137	0.00	0.19	0.1860	0.00	0.00	0.00
0.09	0.00	0.09	7.323	0.00	0.09	0.0930	0.00	0.00	0.00
0.00	0.00	0.00	7.416	0.00	0.00	0.0000	0.00	0.00	0.00
0.09	0.00	0.09	7.416	0.00	0.09	0.0930	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.00	0.00	0.00	7.509	0.00	0.00	0.0000	0.00	0.00	0.00
0.09	0.00	0.09	7.509	0.00	0.09	0.0930	0.00	0.00	0.00
0.00	0.00	0.00	7.602	0.00	0.00	0.0000	0.00	0.00	0.00
0.09	0.00	0.09	7.602	0.00	0.09	0.0930	0.00	0.00	0.00
0.09	0.00	0.09	7.695	0.00	0.09	0.0930	0.00	0.00	0.00
0.09	0.00	0.09	7.788	0.00	0.09	0.0930	0.00	0.00	0.00
0.09	0.00	0.09	7.881	0.00	0.09	0.0930	0.00	0.00	0.00
0.19	0.00	0.19	7.974	0.00	0.19	0.1860	0.00	0.00	0.00
0.09	0.00	0.09	8.16	0.00	0.09	0.0930	0.00	0.00	0.00
0.09	0.00	0.09	8.253	0.00	0.09	0.0930	0.00	0.00	0.00
0.09	0.00	0.09	8.346	0.00	0.09	0.0930	0.00	0.00	0.00
0.09	0.00	0.09	8.439	0.00	0.09	0.0930	0.00	0.00	0.00
0.09	0.00	0.09	8.532	0.00	0.09	0.0930	0.00	0.00	0.00
0.09	0.00	0.09	8.625	0.00	0.09	0.0930	0.00	0.00	0.00
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

	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

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		0		0	0	0	0	0	0
2	07/02/2017 11:15		0.1	0	0.118	0	0.118	7.64	0	0.118	0.1180	0	0	0
2	07/02/2017 11:20		0	0	0	0	0	7.758	0	0	0.0000	0	0	0
2	07/02/2017 11:25		0.1	0	0.118	0	0.118	7.758	0	0.118	0.1180	0	0	0
2	07/02/2017 11:30		0.2	0	0.236	0	0.236	7.876	0	0.236	0.2360	0	0	0
2	07/02/2017 11:35		0.2	0	0.236	0	0.236	8.112	0	0.236	0.2360	0	0	0
2	07/02/2017 11:40		0.1	0	0.118	0	0.118	8.348	0	0.118	0.1180	0	0	0
2	07/02/2017 11:45		0	0	0	0	0	8.466	0	0	0.0000	0	0	0
2	07/02/2017 11:50		0.1	0	0.118	0	0.118	8.466	0	0.118	0.1180	0	0	0
2	07/02/2017 11:55		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:00		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:05		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:10		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:15		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:20		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:25		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:30		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:35		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:40		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:45		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:50		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 12:55		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 13:00		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 13:05		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 13:10		0	0	0	0	0	8.584	0	0	0.0000	0	0	0
2	07/02/2017 13:15		0.1	0	0.118	0	0.118	8.584	0	0.118	0.1180	0	0	0
2	07/02/2017 13:20		0	0	0	0	0	8.702	0	0	0.0000	0	0	0
2	07/02/2017 13:25		0.1	0	0.118	0	0.118	8.702	0	0.118	0.1180	0	0	0
2	07/02/2017 13:30		0.1	0	0.118	0	0.118	8.82	0	0.118	0.1180	0	0	0
2	07/02/2017 13:35		0.1	0	0.118	0	0.118	8.938	0	0.118	0.1180	0	0	0
2	07/02/2017 13:40		0.1	0	0.118	0	0.118	9.056	0	0.118	0.1180	0	0	0
2	07/02/2017 13:45		0.2	0	0.236	0	0.236	9.174	0	0.236	0.2360	0	0	0
2	07/02/2017 13:50		0.1	0	0.118	0	0.118	9.41	0	0.118	0.1180	0	0	0
2	07/02/2017 13:55		0.1	0	0.118	0	0.118	9.528	0	0.118	0.1180	0	0	0
2	07/02/2017 14:00		0.1	0	0.118	0	0.118	9.646	0	0.118	0.1180	0	0	0
2	07/02/2017 14:05		0.1	0	0.118	0	0.118	9.764	0	0.118	0.1180	0	0	0
2	07/02/2017 14:10		0.1	0	0.118	0	0.118	9.882	0	0.118	0.1180	0	0	0
2	07/02/2017 14:15		0.1	0	0.118	0	0.118	10	0	0.118	0.1180	0	0	0
2	07/02/2017 14:20		0.1	0	0.118	0	0.118	10.118	0	0.118	0.1180	0	0	0

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

TABLE OF CONTENTS

1 INTRODUCTION 1

2 PREVIOUS WORK 1

3 INVESTIGATION PROCEDURE 2

3.1 Field Program 2
3.2 Laboratory Testing 3

4 SUMMARIZED CONDITIONS 3

4.1 Site Description 3
4.2 Subsoil Conditions 4
4.2.1 Topsoil 4
4.2.2 Sand 4
4.2.3 Silt 5
4.2.4 Glacial Till 5
4.3 Groundwater 6

5 DISCUSSIONS AND RECOMMENDATIONS 6

5.1 General 6
5.2 Site Grading 7
5.3 Site Servicing 8
5.3.1 Excavations and Dewatering 8
5.3.2 Pipe Bedding 9
5.3.3 Trench Backfilling 10
5.4 Pavements 11
5.4.1 Pavement Design 11
5.4.2 Subdrains 12
5.4.3 Curbs and Sidewalks 12
5.5 Residential Buildings 13
5.5.1 Foundations 13
5.5.2 Basements 13
5.6 At Source Stormwater Infiltration 14

6 STATEMENT OF LIMITATIONS 16

TABLE OF CONTENTS

Tables

Table 1: Sand Particle Size Distribution Analyses....4
Table 2: Silt Particle Size Distribution Analyses Results....5
Table 3: Groundwater Level Measurements....6
Table 4: Compaction Specifications....7
Table 5: Pavement Designs....11

Appendices

Appendix 1 Drawings
Appendix 2 Borehole Logs
Appendix 3 Figures

Property and Confidentiality

"This engineering document is the property of LVM, a division of EnGlobe Corp. and, as such, is protected under Copyright Law. It can only be used for the purposes mentioned herein. Any reproduction or adaptation, whether partial or total, is strictly prohibited without having obtained LVM's and its client's prior written authorization to do so.

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	
1 Electronic Copy / 4 Hard copies	Ms. Nicole Simas, 2115881 Ontario Limited c/o Ian Cook Construction Limited
1 Electronic Copy	File

alc

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.

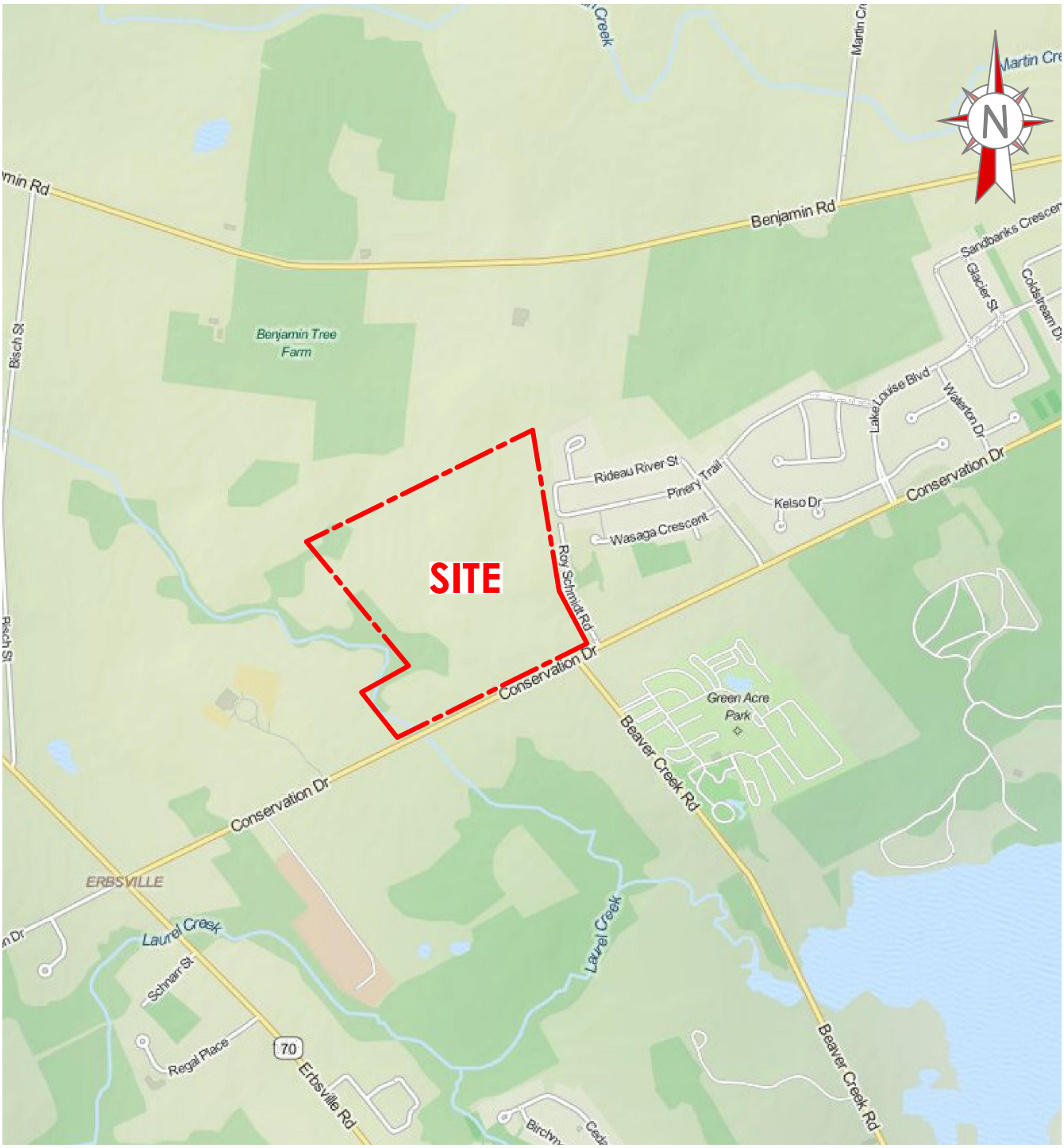
The geotechnical recommendations provided in this report are applicable only to the project described in the text and are intended for the use of the project designer. They are not intended as specifications or instructions to contractors. Any use which a contractor makes of this report, or decisions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

G:\160\P0008077\Z5_CAD\WP100\P-0008077-0-01-100_DWG001.DWG

Project

Geotechnical Investigation
Proposed Residential Development

560/576 Conservation Drive, Waterloo, Ontario

Title

LOCATION PLAN

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

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

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



LEGEND :

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

0 20 40 60 80 100 m

SCALE 1:3000

NOTES :

1-REFERENCES : GRAND RIVER CONSERVATION AUTHORITY, 2015.

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

3-Groundwater measured on March 9, 2015.

Project

Geotechnical Investigation
Proposed Residential Development

560/576 Conservation Drive, Waterloo, Ontario

Title

SITE PLAN

LVM

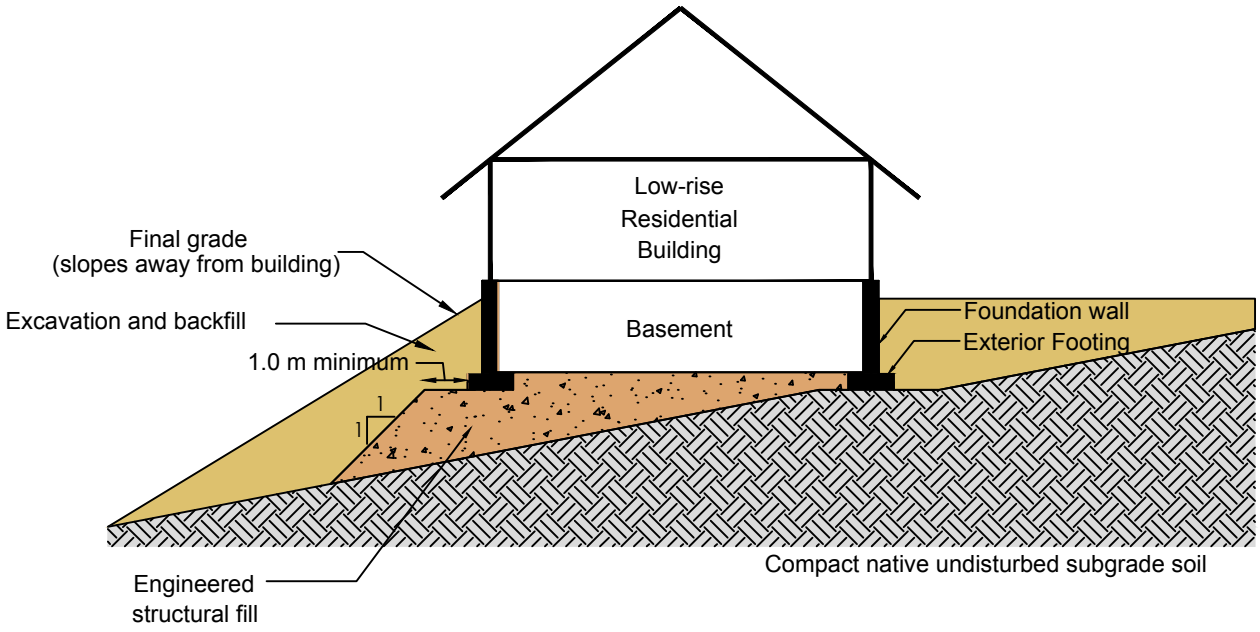
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

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

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

10 cm 0 1 2 3 4 5

G:\160\P0008077\25_CAD\WP100160-P-0008077-0-01-100_DWG002_SMDM.DWG



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.

G:\160\P0008077\Z5_CAD\WP100\P-0008077-0-01-100_DWG003.DWG

Project

Geotechnical Investigation
Proposed Residential Development

560/576 Conservation Drive, Waterloo, Ontario

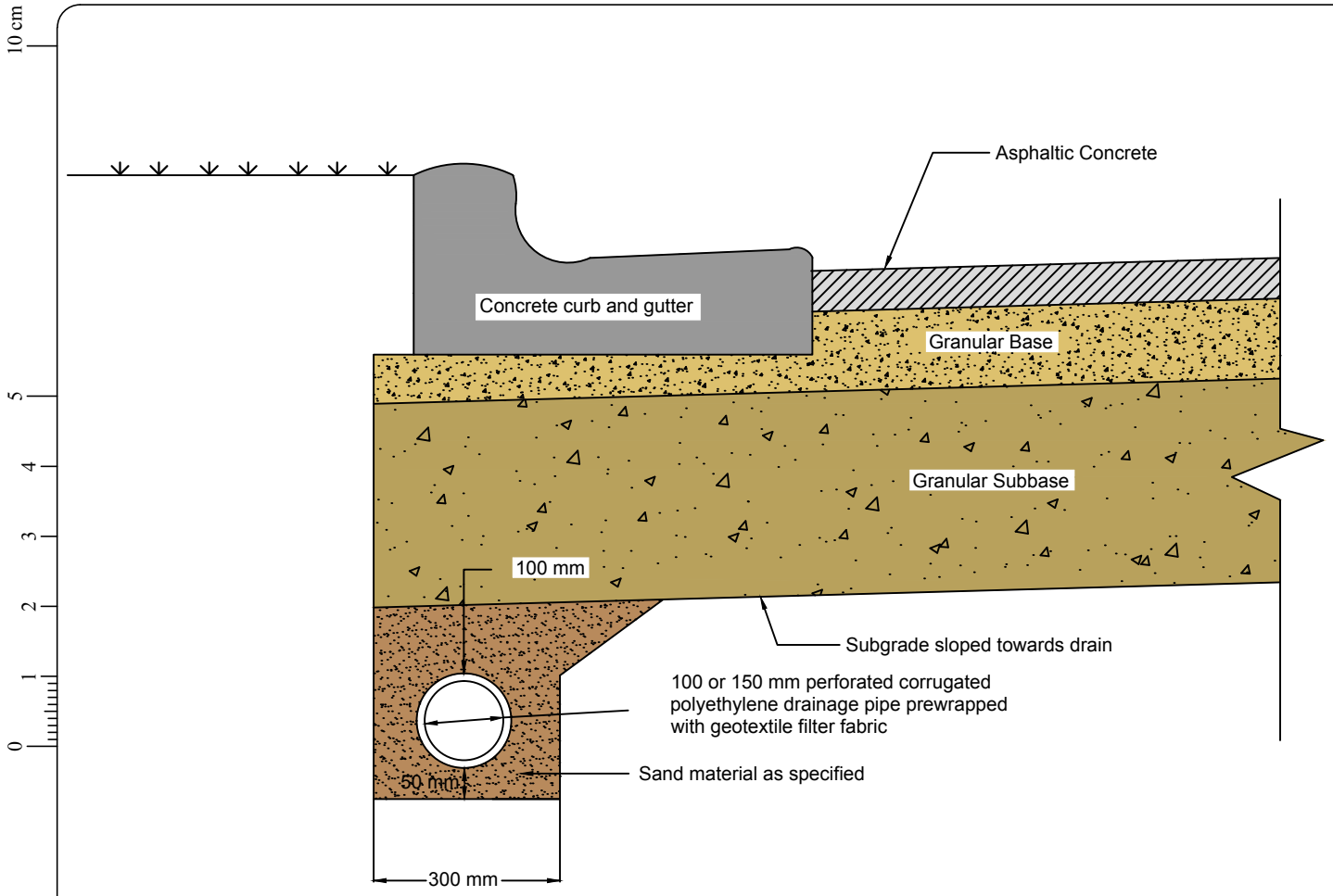
Title

TYPICAL STRUCTURAL FILL DETAIL

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

Prepared	E.Ciochon	Discipline	GEOTECHNICAL	Project manager	M.Wilson
Drawn	E.Ciochon	Scale	NTS	Sequence no.	03 of 04
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.

G:\160\P0008077\Z5_CAD\WP100\P-0008077-0-01-100_DWG004.DWG

Project

Geotechnical Investigation
Proposed Residential Development

560/576 Conservation Drive, Waterloo, Ontario

Title

TYPICAL PAVEMENT SUBDRAIN DETAIL

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

Prepared	E.Ciochon	Discipline	GEOTECHNICAL	Project manager	M.Wilson
Drawn	E.Ciochon	Scale	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	

Z:\Style_LVM_Ontario\LogBorehole_Log_LVM_Ontario.sty- Printed : 2015-03-12 14h

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.*

Z:\Style_LVM_Ontario\LogBorehole_Log_LVM_Ontario.sty- Printed : 2015-03-12 14h

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

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

Vertical Scale = 1 : 50.0

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

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

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

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

Vertical Scale = 1 : 50.0

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

Notes:

Z:\Style_LVM_Ontario\LogBorehole_Log_LVM_Ontario.sty- Printed : 2015-03-12 14h

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

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

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

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

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

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

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

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

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

Groundwater Observations and Standpipe Details

el. 350.91 m 2015-03-15

bentonite seal

sand pack

19 mm pipe
3.05 m slotted screen

native cave

Vertical Scale = 1 : 50.0

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

Notes:

EQ-09-Ge-72 R.1 18.02.2011

Z:\Style_LVM_Ontario\LogBorehole_Log_LVM_Ontario.sty- Printed : 2015-03-12 14h

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

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

el. 352.21 m 2015-03-15

bentonite seal

19 mm pipe
1.52 m slotted screen

native cave

Vertical Scale = 1 : 50.0

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

Notes:

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

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

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

Groundwater Observations and Standpipe Details

bentonite seal

At drilling completion, borehole open and dry.

Vertical Scale = 1 : 50.0

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

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

Z:\Style_LVM_Ontario\LogBorehole_Log_LVM_Ontario.sty- Printed : 2015-03-12 14h

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

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

el. 352.07 m 2015-03-15

bentonite seal

sand pack

19 mm pipe
1.52 m slotted screen

Vertical Scale = 1 : 50.0

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

Notes:

Z:\Style_LVM_Ontario\LogBorehole_Log_LVM_Ontario.sty- Printed : 2015-03-16 09h

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

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

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

Notes:

Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011

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

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

Dynamic Cone / Std Penetration: 20 40 60 80

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

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

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

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

Z:\Style_LVM_Ontario\LogBorehole_Log_LVM_Ontario.sty- Printed : 2015-03-12 14h

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**

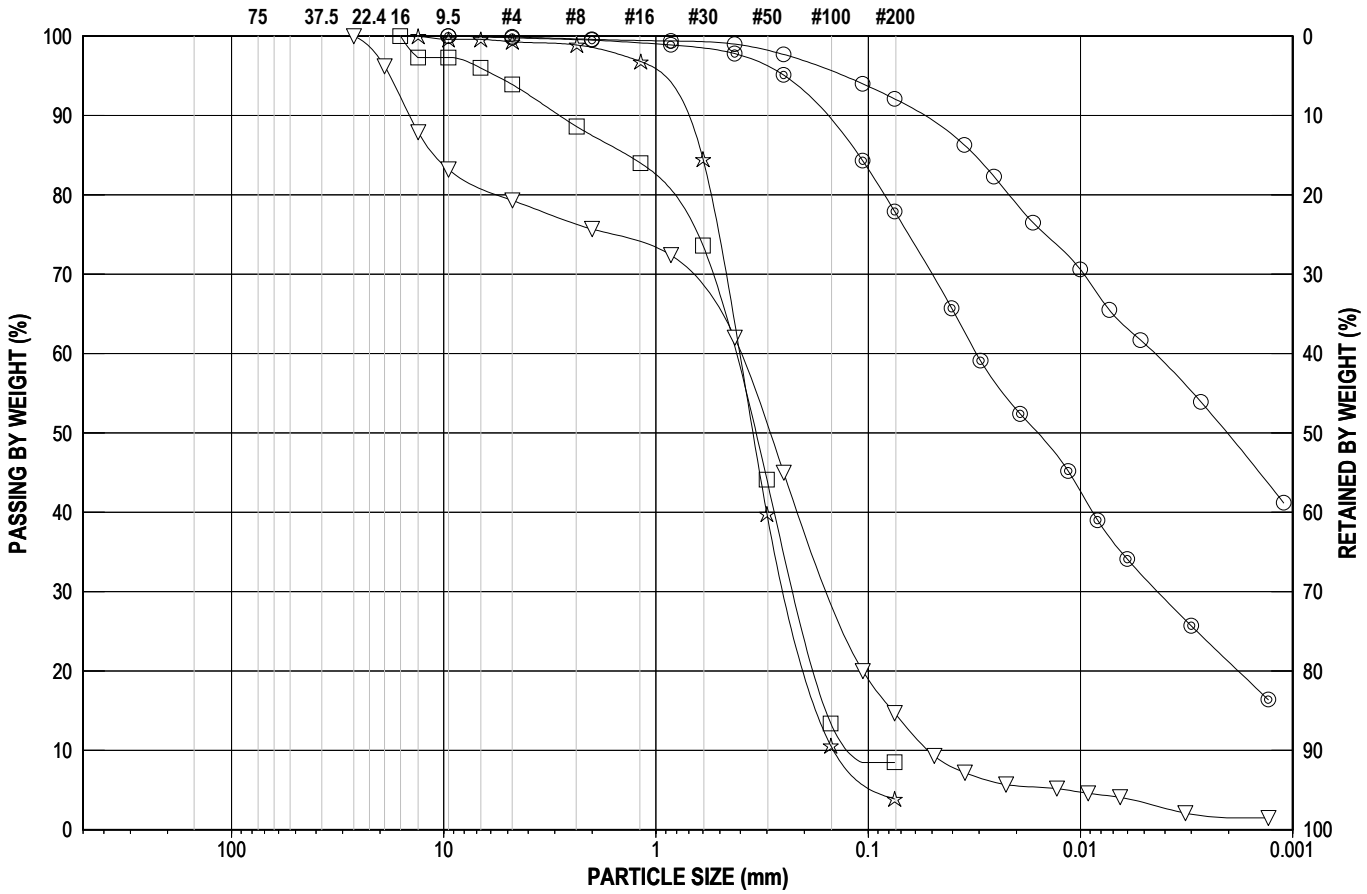
Figure No : **1**

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

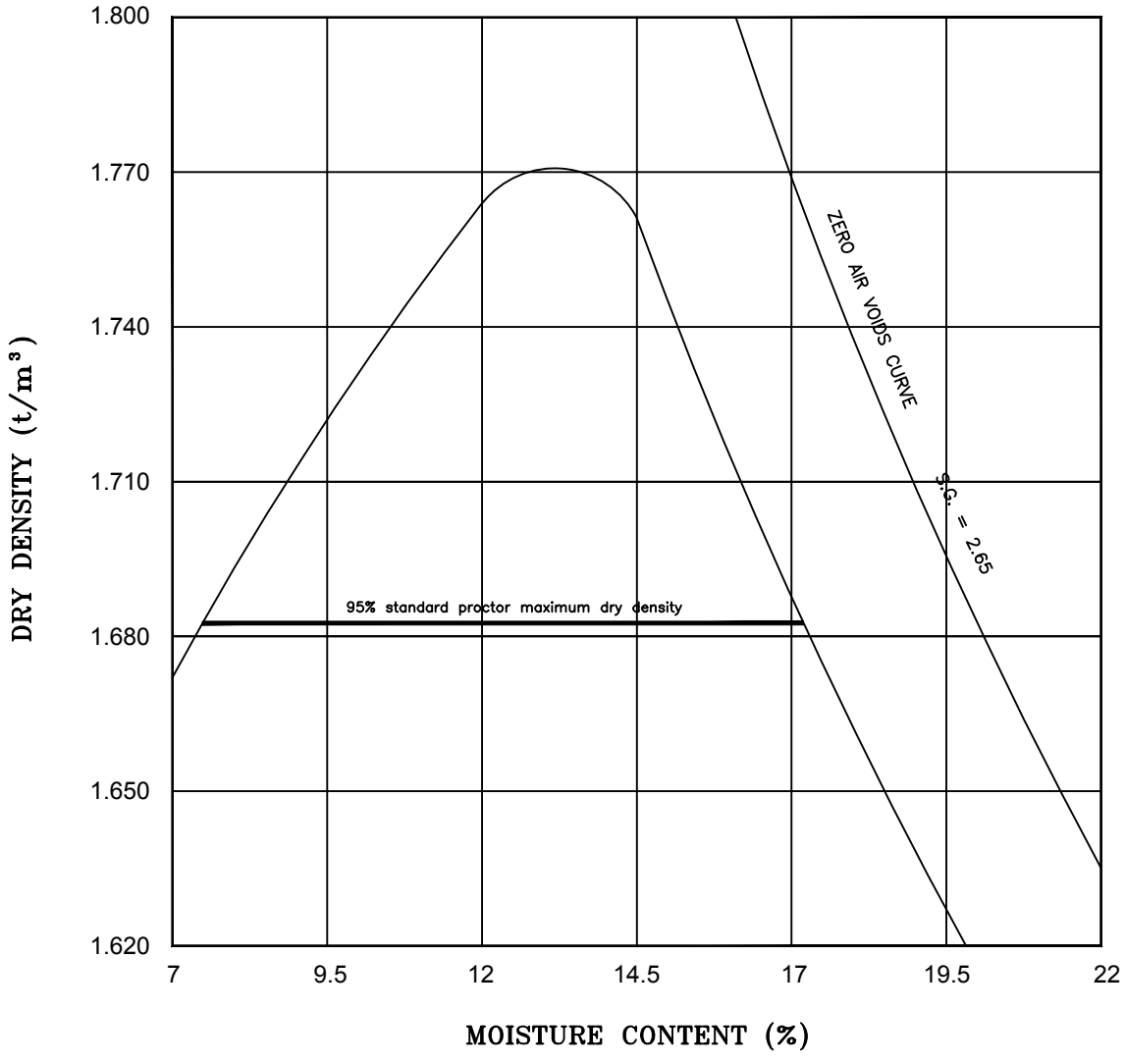
METHOD LS – 706

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

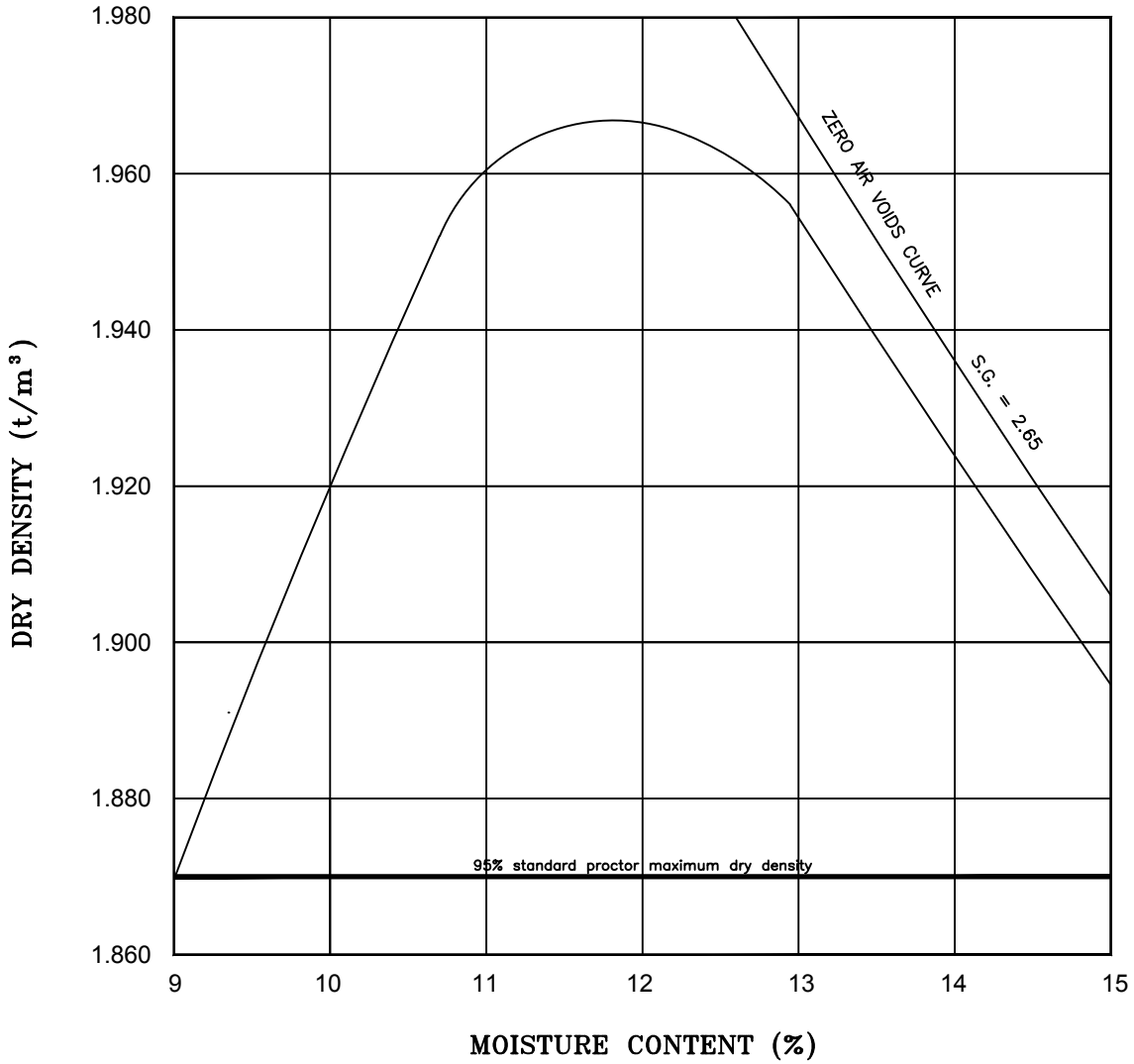
METHOD LS – 706

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 %



G:\160\P0008077\z5_CAD\WP100\P-0008077-0-01-100_Fig003.dwg



North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program, 2023 Monitoring Data

June 14, 2024

Prepared for:

NorthGate Land Corporation,
2115881 Ontario Ltd.,
Activa Holdings, and
Erbsville Kartway

Prepared by:

Stantec Consulting Ltd.
100-300 Hagey Boulevard
Waterloo, ON N2L 0A4
Tel.: (519) 579-4410

160310875

This document entitled North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program, 2023 Monitoring Data was prepared by Stantec Consulting Ltd. (“Stantec”) for the account of NorthGate Land Corporation, 2115881 Ontario Ltd., Activa Holdings, and Erbsville Kartway (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 _____
(signature)

Julian Murray, M.Sc., GIT
Environmental Scientist

Prepared by _____
(signature)

Amy Kyle, B.Eng
Water Resources Specialist

Reviewed by _____
(signature)

Lesley Veale, M.Sc., P.Geo.
Senior Hydrogeologist

Reviewed by _____
(signature)

Nathan Yokich, P.Eng., CAN-CISEC
Water Resources Engineer

Table of Contents

ABBREVIATIONS ..... **II**

1.0 INTRODUCTION **1.1**

2.0 BACKGROUND **2.1**
2.1 NWSSS HYDROGEOLOGIC INVESTIGATION 2.1
2.2 NWSSS SURFACE WATER INVESTIGATION 2.2
2.3 NORTH WATERLOO MONITORING PROGRAM 2.2

3.0 METHODOLOGY **3.1**
3.1 WATER LEVEL MONITORING 3.1
3.2 SURFACE WATER FLOW MONITORING 3.2
3.3 SURFACE WATER QUALITY 3.2
3.4 GROUNDWATER SAMPLING AND WATER QUALITY TESTING 3.3
3.5 CLIMATIC DATA 3.4

4.0 MONITORING RESULTS **4.1**
4.1 PRECIPITATION 4.1
4.2 GROUNDWATER LEVELS – 2023 ..... 4.1
4.3 GROUNDWATER CHEMISTRY – 2023 ..... 4.1
4.4 SURFACE WATER FLOW AND WATER LEVEL ANALYSIS 4.2
4.5 SURFACE WATER QUALITY RESULTS 4.3

5.0 CONCLUSIONS AND RECOMMENDATIONS **5.1**

6.0 REFERENCES **6.1**

LIST OF APPENDICES

Appendix A: Figures
Appendix B: Tables
Appendix C: Phase Monitoring Program
Appendix D: Surface Water Flow Data
Appendix E: Laboratory Certificate of Analysis

Abbreviations

City	City of Waterloo
the Client	Northgate Corporation, 2115881 Ontario Ltd., Activa Holdings, and Erbsville Kartway
HDPE	high density polyethylene
KWCS	Kitchener-Waterloo Climate Station
LCWS	Laurel Creek Watershed Study
NWSSS	North Waterloo Scoped Subwatershed Study
RCS	Roseville Climate Station
the Site	proposed development, generally bounded by Erbsville Road, Beaver Creek Road, Laurel Creek Conservation lands and City limits
Stantec	Stantec Consulting Ltd.
TSS	total suspended solids
UWWS	University of Waterloo Weather Station

1.0 INTRODUCTION

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

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

The NWSSS presented initial groundwater and surface water monitoring results from 2009 and 2010 (Ecoplans, MHBC, Stantec, 2013). Subsequent reports detailed the 2011 to 2022 monitoring (Stantec, 2023). The following report presents the surface water and groundwater monitoring data collected in 2023, along with historical data for reference.

This report is arranged in six sections, including this introduction. Section 2 presents a background of the previous investigations. Section 3 presents the methodology while the 2023 monitoring results are presented in Section 4. Section 5 provides conclusions and recommendations while Section 6 provides a list of references. All figures and tables referenced in the report are presented in Appendices A and B, respectively. Appendices C to E present the approved Phase I Monitoring Program, surface water flow data and analysis, and laboratory certificates of analysis, respectively.

2.0 BACKGROUND

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

2.1 NWSSS HYDROGEOLOGIC INVESTIGATION

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

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

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

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

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

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

Water quality results within deposits of Aquifer 1 within the northeastern portion of the Site were characterized by aerobic groundwater with nitrate present suggesting influence from local agricultural fields. Within the western portion of the property, shallow water quality results indicated slightly anaerobic water with both manganese and nitrate present and typically low dissolved oxygen levels. Water quality results within the deep monitoring wells at the western extent of the Site including MW8-10D and MW12-10D indicated elevated sulphate concentrations of up to 410 mg/L, suggesting a hydraulic connection with the deeper hydrostratigraphic units, likely a result of the eroded deposits of Aquitards 2/3 within the glacial meltwater channel.

2.2 NWSSS SURFACE WATER INVESTIGATION

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

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

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

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

2.3 NORTH WATERLOO MONITORING PROGRAM

The NWSSS included groundwater and surface water monitoring data for the Site from 2009 and 2010. The groundwater and surface water monitoring has been on-going since 2011. The Phase 1 Monitoring Program for the Site was approved in mid-2014, which included a reduced monitoring program within the Site itself and eliminated monitoring of adjacent wells. Additional modifications were recommended by Stantec (2016). The monitoring wells and current status are detailed in Table 1. A copy of the approved monitoring program is included in Appendix C.



3.0 METHODOLOGY

The following section details the methodology for monitoring in 2023, including groundwater and surface water level monitoring, surface water flow monitoring, groundwater quality sampling and analysis, and climate data.

3.1 WATER LEVEL MONITORING

The groundwater and surface water level monitoring locations are presented on Figure 1 with well construction details and monitoring status presented in Table 1. Since the start of the monitoring program, the following changes to the monitoring locations has occurred:

- In 2015, the monitoring wells MW3-10S and MW11-10 were observed to be damaged. MW3-10S was abandoned and replaced with MW3-16S in February 2016. Stantec recommended replacement of MW11-10 but to date has not been completed.
- In early 2018, DP5-09 was damaged by stream flow debris and was replaced by DP5-18 in June 2018.
- In March 2023, DP3-09 was found to be damaged and was subsequently replaced by DP3-23 in November 2023.

Monitoring was completed in spring, summer and fall in 2023 in eleven (11) shallow and deep monitoring wells (MW2-10, MW3-16S, MW3-10D, MW6-10, MW7-10, MW8-10S, MW8-10D, MW10-10, MW12-10S, MW12-10D and MW13-10) and five (5) drivepoint piezometers (DP1-09, DP3-09 and DP5-18 along Beaver Creek and DP10-14 and DP9-09 along Laurel Creek).

Groundwater and surface water level monitoring was completed using a combination of manual and automated techniques. Monitoring wells and drivepoint piezometers were instrumented with Solinst® LT Leveloggers® and were set to record at 60-minute intervals (or 15-minute intervals for surface water loggers). The Leveloggers® are not vented to the atmosphere and therefore record total pressure. As a result, data obtained from the Leveloggers® was corrected for atmospheric pressure to obtain the actual height of water above the sensor. The atmospheric corrections were made using data collected from a Solinst Barologger® installed in monitoring well MW7-10.

In 2023, the following loggers experienced issues:

- At DP1-09, the groundwater logger was found to be missing in March 2023. In July 2023, Stantec modified installation so the groundwater logger is harder to retrieve. In December 2023, the groundwater logger couldn't be accessed due to ice buildup. As a result, only four months of groundwater level data are available at the time of report preparation. The remaining 2023 data will be included in the 2024 report.

- At DP3-09, the drivepoint casing was noted as damaged with the groundwater logger missing in March 2023. A replacement drivepoint piezometer and logger were installed in November 2023. As a result, no groundwater level data was available for DP3-09 in 2023.

- Groundwater loggers located at MW7-10, MW8-10D and MW12-10D malfunctioned in 2023 and were replaced.

Based on the number of loggers included in the monitoring program and the duration of monitoring, it is expected that data loggers will occasionally malfunction or reach the end of their lifetime and require replacement. Based on the extensive historical dataset, the omitted data from 2023 did not impact the overall conclusions from this report. Future monitoring will further document conditions.

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

During the 2023 monitoring, surface water loggers were removed in winter months to prevent erroneous data readings and/or logger damage due to frozen surface water conditions, while groundwater loggers were typically left in place over winter months, which is consistent with previous years. Groundwater level data were reviewed and omitted if clearly impacted by freezing conditions.

Groundwater and surface water level hydrographs are presented in Figures 2 to 4 for current monitoring locations.

3.2 SURFACE WATER FLOW MONITORING

Surface water flow monitoring was completed at the locations of the drivepoint piezometers established along Beaver Creek (DP1-09, DP3-09 and DP5-18) and along Laurel Creek (DP10-14 and DP9-09) and are shown on Figure 1. Stream flows were measured on two occasions in 2023, with additional flow monitoring at DP1-09 in July 2023. Table 2 presents a summary of manual stream flow measurements at each current monitoring location with detailed stream flow data and calculations included in Appendix D.

Stream flow at each drivepoint location was calculated using the velocity-area method (Dingman, 1994). Measurements were obtained by placing a measuring tape across the width of the stream and dividing the distance into equal sections. The depth of the water was measured at each point, and the flow rate recorded using a HACH Company Model FH950 portable water flow meter. Total discharge through the section was then calculated using the U.S. Geological Survey approved mid-section method as discussed in Hipolito and Loureiro (1988) and Dingman (1994).

3.3 SURFACE WATER QUALITY

Water quality sampling for City of Waterloo Monitoring Station 17 - Beaver Creek at Conservation Drive (DP3-09) was completed by the City. Beaver Creek converges with Laurel Creek just upstream of the Laurel Creek Reservoir. Since the watercourse is part of the Laurel Creek Watershed, it is governed by

in-stream water quality targets established in the LCWS (GRCA, 1993). The in-stream quality targets are summarized below:

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

3.4 GROUNDWATER SAMPLING AND WATER QUALITY TESTING

Stantec completed groundwater water quality sampling within the shallow and deep monitoring wells at MW2-10, MW3-10D, MW6-10, MW7-10, MW8-10S, MW8-10D, MW10-10, MW12-10S, MW12-10D and MW13-10 in November/December 2023.

Groundwater samples were primarily collected using dedicated inertial-lift Waterra™ sampling pumps. The use of dedicated equipment reduced the possibility of cross contamination of samples between sampling locations. The Waterra™ sampling pumps were constructed of 16 mm diameter high density polyethylene (HDPE) tubing connected to a Waterra™ Delrin foot valve. For deep monitoring wells including MW3-10D, MW8-10D, and MW12-10D, a hydrolift attached to 16 mm diameter HDPE tubing was employed to facilitate sample collection. Efforts were made to remove at least three (3) casing

volumes from each well prior to sampling to remove stagnant water from the well casing. In cases where the well was purged dry, the well was allowed to fully recover prior to sampling. Prior to sample collection, the sampling system was lowered to within or just above the top of the well screen.

Field measurements of conductivity, temperature and pH were made using a YSI model Pro Plus MPI. This meter was calibrated prior to use according to the manufacturers' specifications with the appropriate calibration standards. Field parameters were monitored and allowed to stabilize prior to sampling. Following purging, groundwater samples were collected directly from the HDPE tubing into the appropriate pre-labeled sample containers. Groundwater samples for metals analysis were field-filtered using disposable, in-line, 0.45 µm filters attached to the HDPE tubing and as such the results for metal parameters represent dissolved concentrations.

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

3.5 CLIMATIC DATA

The Roseville Climate Station (RCS) is located approximately 20 km to the south of the Site. Daily precipitation and temperature data from 1973 to present were collected from the RCS (Environment Canada, 2023). Monthly gaps in data from the RCS were supplemented with data from the next closest station, Environment Canada Kitchener-Waterloo Climate Station (KWCS) (located at the Region of Waterloo International Airport). The KWCS is located approximately 20 km to the east of the Site. Recent and historical precipitation data are presented on Figure 5.

Historically, climate data was obtained from the University of Waterloo Weather Station (UWWS), which is located approximately 4 km southeast of the Site (Stantec, 2016, 2018), as the primary location and supplemented with data from the RCS. Issues arose with UWWS data starting in 2015, and as a result, RCS was selected as the primary data source for climate data for the Site, due to its proximity and data quality.

4.0 MONITORING RESULTS

The 2009 to 2023 monitoring data was summarized with hydrographs presented in Figures 2 to 4, well construction details in Table 1, surface water flow data in Table 2 and groundwater analytical data in Table 3. In general, groundwater and surface water observations in 2023 were consistent with the overall results and interpretations as presented by Ecoplans, MHBC, Stantec (2013) and Stantec (2016, 2018, 2020, 2021, 2023). The following sections detail additional observations, clarifications, or changes to the understanding of Site conditions based on results from the monitoring periods in 2023.

4.1 PRECIPITATION

Historical precipitation data from the RCS, along with supplementary data from the KWCS was reviewed with a graph of the historical data presented on Figure 5. Over a 20-year monitoring period at the RCS (2004-2023), the average annual precipitation was 928 mm. In 2023, the total annual precipitation recorded at the RCS was 996 mm, which is 7% higher than the 20-year average. In 2023, the highest total monthly precipitation from the RCS was recorded in July (190 mm) and the driest period recorded was in September (24 mm). In comparison, the 2022 data indicated a total of 641 mm of precipitation, which was more than 30% below the historical average.

4.2 GROUNDWATER LEVELS – 2023

Groundwater levels showed similar trends as discussed by Ecoplans, MHBC, Stantec (2013) and Stantec (2016, 2018, 2020, 2021, 2023), with seasonal groundwater level fluctuations and response to precipitation events. Similar to previous years, response to individual precipitation events was noted within monitoring wells installed within Aquitard 1 such as MW8-10S and MW12-10S (Figure 4), while monitoring wells installed within deposits of Aquifer 1, with a larger unsaturated zone, such as MW7-10 (Figure 3) indicated a steady response to overall precipitation and recharge, but did not respond to individual events. Groundwater level and surface water level results at the drivepoint locations from 2023 are generally consistent with historical data.

As discussed by Stantec in previous reports, periods of above average precipitation and groundwater recharge resulted in higher shallow groundwater levels at all monitoring wells than initially presented in the NWSSS. The proposed development design should review the groundwater level data across the Site and take the high spring groundwater levels into consideration.

4.3 GROUNDWATER CHEMISTRY – 2023

Stantec conducted a water quality sampling program in November/December 2023 which included wells MW2-10, MW3-10D, MW3-16S MW6-10, MW7-10, MW8-10S/D, MW10-10, MW12-10S/D and MW13-10. MW11-10 could not be sampled, as the well had been damaged since 2015. Water quality results are presented in Table 3 with copies of the laboratory certificates of analysis included in Appendix E.

In general, the results are consistent with the historic data with similar concentrations as previously reported with some natural variability. Key parameters were reviewed including sodium/chloride to evaluate potential response to changes in winter road salting activities and nitrate to evaluate potential response to changes in agricultural activities. No changes of these key parameters were noted based on the 2023 data.

4.4 SURFACE WATER FLOW AND WATER LEVEL ANALYSIS

Surface water flow rates in 2023 indicated some variation along the flow path; however, there was generally a consistent increase or decrease in flow rate between monitoring stations at each timestep along Beaver Creek and Laurel Creek. This is consistent with historical monitoring and suggests that significant groundwater discharge and/or recharge along the flow path was not occurring. Flow rates at all stations have returned to levels consistent with historical monitoring after low flow rates in 2022, when precipitation levels were lower than average. Data from November 30 and December 1, 2023, suggests an increase in surface water flow from DP3-09 to DP5-18; however, this increase is likely a function of monitoring at DP5-18 following a precipitation event.

Historical flow and manual water level measurements were used to develop rating curves for each of the flow monitoring sites. The rating curves were then applied to the continuous water level measurements derived from the deployed Leveloggers® to produce hydrographs. The rating curve for the new gauging station at DP5-18 did not have sufficient data to accurately represent the flow from 2018-2023, therefore the hydrograph for DP5-18 was not included. It is anticipated that as monitoring continues, enough flow measurements will be collected at DP5-18 to obtain a rating curve.

Furthermore, surface water data from DP3-09 between March 29 and April 10, 2023, was removed from analysis due to data inconsistencies likely resulting from damage to the drivepoint, as noted in Section 3.1. The drivepoint piezometer at the DP3-09 gauging station was replaced following data collection in November 2023 with the goal of obtaining accurate readings for the 2024 monitoring program. Surface water data from DP9-09 between November 30 and December 31, 2023 was removed from analysis due to data inconsistencies likely resulting from temperature impacts and/or freezing conditions.

Rating curves and associated hydrographs for the monitoring locations are presented in Appendix D. In general, flow measurements during low flow and base flow events have produced consistent values. The addition of high flow measurements obtained within the study period resulted in well-defined rating curves for a range of flow conditions extending beyond baseflow. Additional flow measurements during discrete storm events will provide more data that is expected to further refine the rating curves at all five locations and will be especially useful in characterizing the curve at DP5-18.



4.5 SURFACE WATER QUALITY RESULTS

Surface water quality results for Laurel Creek at Conservation Drive – Station 17 were provided by the City of Waterloo and are included in Appendix D. Water quality results were compared to targets established for Beaver Creek in the LCWS. The 2023 results of the analysis are summarized below:

- TSS targets were met in 100% of the samples in 2023 (100% in 2022, 73% in 2021, 88% in 2020, 92% in 2019, 75% in 2018 and 80% in 2016 – 2017).
- Dissolved oxygen targets were met in 100% of the samples in 2023 (100% in 2022, 100% in 2021, 88% in 2020, 100% in 2018-2019 and 90% in 2016 – 2017).
- Total phosphorous concentration targets were met in 100% of samples in 2023 (60% in 2022, 45% in 2021 75% in 2019-2020, 46% in 2018 and 55% in 2016 – 2017).
- Temperature targets were met in all samples. The highest recorded temperature was 20.4 ºC. recorded July 27th, 2023, which is comparable to the highest temperature recorded in previous years.
- Bacteria was not monitored by the City.

LCWS water quality targets were achieved for all samples at Station 17 in 2023. Surface water quality results obtained in 2023 are a slight improvement over results from previous years. Results from 2024 surface water quality testing will help to determine whether results from 2023 are a part of a larger trend of improved water quality, or if the 2023 results are an anomaly.



5.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the Phase 1 monitoring completed during the 2023 monitoring period, the following conclusions are provided:

- Annual average precipitation in 2023 was 7% above the 20-year annual average.
- Observed groundwater levels collected during the 2023 monitoring period were generally consistent with historic levels / trends.
- Groundwater quality results throughout the Site were generally consistent with historical data.
- Surface water hydrographs were created using continuous water Leveloggers® and manual flow measurements to develop a rating curve at each monitoring site.
- Water quality monitoring at Station 17 (Beaver Creek at Conservation Drive) was completed by the City. At this location LCWS targets were met for temperature, dissolved oxygen, TSS, and total phosphorous for all measurements.

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

- The proposed grading and development within the Site should be reviewed with respect to the updated peak spring groundwater levels to confirm proposed development design and grading.
- Surface water levels and manual flow measurements should continue to be collected to gain further confidence in the rating curves, especially at DP5-18. Monitoring should be focused on both large storm events and low flows to define the rating curve at a wider range of water level elevations. Pre-development rating curves will provide a basis for comparison of during and post-construction monitoring results as development commences and SWM systems are installed.
- Water quality monitoring at Station 17 should continue to be used to establish background water quality characteristics.
- Based on the age of the loggers, it is expected that additional loggers will malfunction. It is recommended that loggers be purchased and made available for immediate replacement as required.
- Monitoring Well MW11-10 was noted to be damaged in 2015; however, has not yet been replaced. Based on the location, well replacement is still recommended.

6.0 REFERENCES

Dingman, S.L., 1994. Physical Hydrology. Prentice-Hall. New Jersey.

Ecoplans, MHBC and Stantec, 2013. North Waterloo Scoped Subwatershed Study, Volume 1, November 2013.

Environment Canada, 2024. Canadian National Climate Archives. [Online] Station: Roseville, Ontario. Climate Identifier 6147188. http://climate.weather.gc.ca Accessed January, 2024.

Grand River Conservation Authority (GRCA), 1993. Laurel Creek Watershed Study, Technical Appendix 4 (Hydrogeology), Report Prepared by Terraqua Investigations Ltd.

Hipolito, J.N. and J.M. Loureiro. 1988. Analysis of some velocity-area methods for calculating open-channel flow. Hydrogeological Sciences Journal 33:311-320.

Stantec, 2016. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program. Prepared for Northgate Corporation, 2115881 Ontario Ltd., Activa Holdings, and Erbsville Kartway. May 13, 2016.

Stantec, 2018. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program. Prepared for Northgate Corporation, 2115881 Ontario Ltd., Activa Holdings, and Erbsville Kartway. May 18, 2018.

Stantec, 2020. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program – Draft Report. Prepared for Northgate Corporation, 2115881 Ontario Ltd., Activa Holdings, and Erbsville Kartway. April 8, 2020.

Stantec, 2021. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program. Prepared for Northgate Land Corporation, 2115881 Ontario Ltd., Activa Holdings, and Erbsville Kartway. June 10, 2021.

Stantec, 2023. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program, 2021-2022 Monitoring Data. Prepared for Northgate Land Corporation, 2115881 Ontario Ltd., Activa Holdings, and Erbsville Kartway. January 20, 2023.

APPENDIX A:
Figures



Stantec

Legend

- North Waterloo Scoped Subwatershed Study Area
- Monitoring Well (Stantec, 2016)
- Monitoring Well (Stantec, 2010)
- Monitoring Well (Stantec, 2005)
- Monitoring Well (Other)
- Drive-Point Piezometer (Stantec, 2010)
- Drive Point Piezometer (Stantec, 2014)
- Drive-Point Piezometer (Stantec, 2018)
- Abandoned Monitoring Well (Other)
- Abandoned Drive-Point Piezometer
- Phase 1 Monitoring Location
- Watercourse
- Topographic Contour - 2m Inerval
- Proposed Development Area

0 250 500 metres

1:8,000 (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, 2014.
3. Orthoimagery © First Base Solutions, 2020. Imagery Date, 2018



Project Location
Region of Waterloo

161450875 REVA
Prepared by PRM on 2020-02-05
Technical Review by SB on 2021-01-20

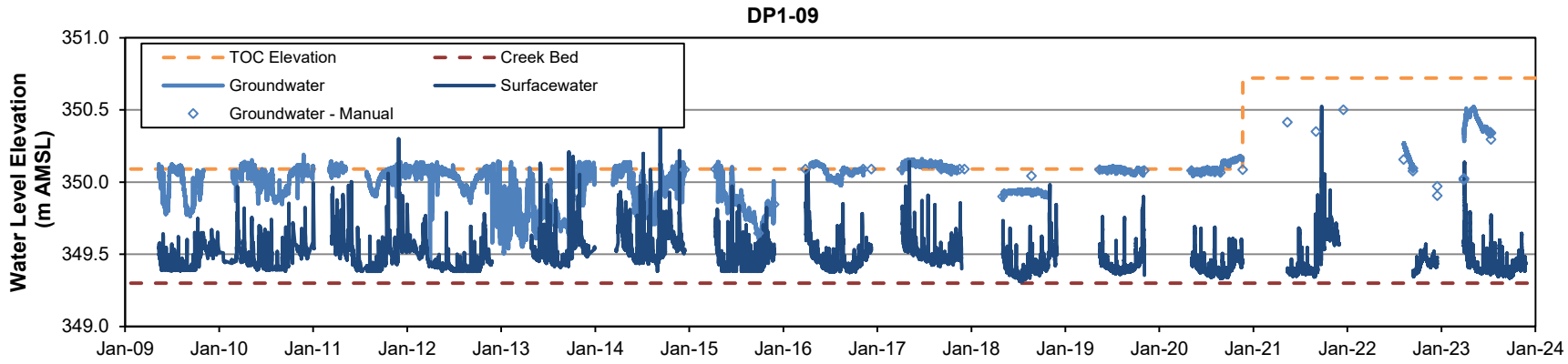
Client/Project
NORTH WATERLOO SCOPED WATERSHED STUDY
PHASE I - GROUNDWATER AND
SURFACE WATER MONITORING PROGRAM

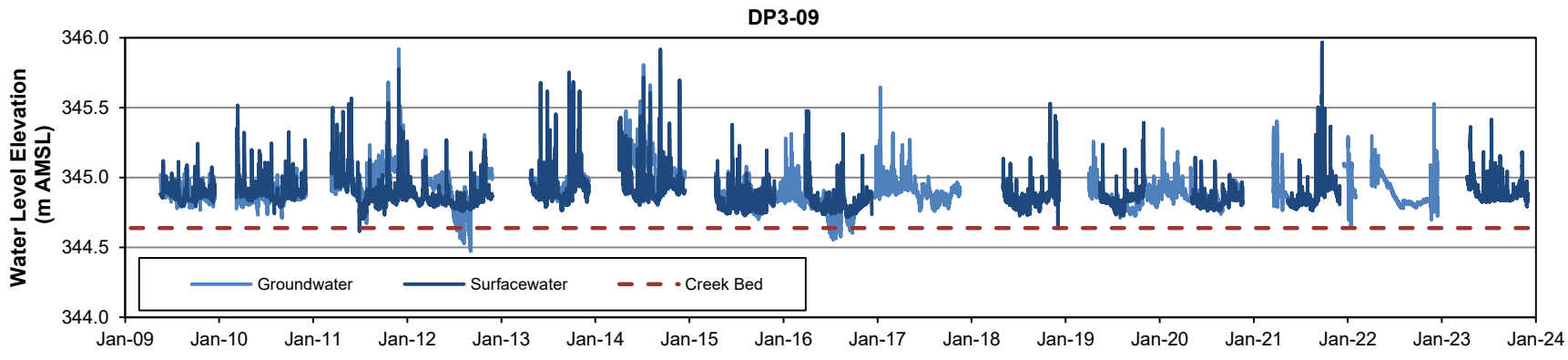
Figure No.
1

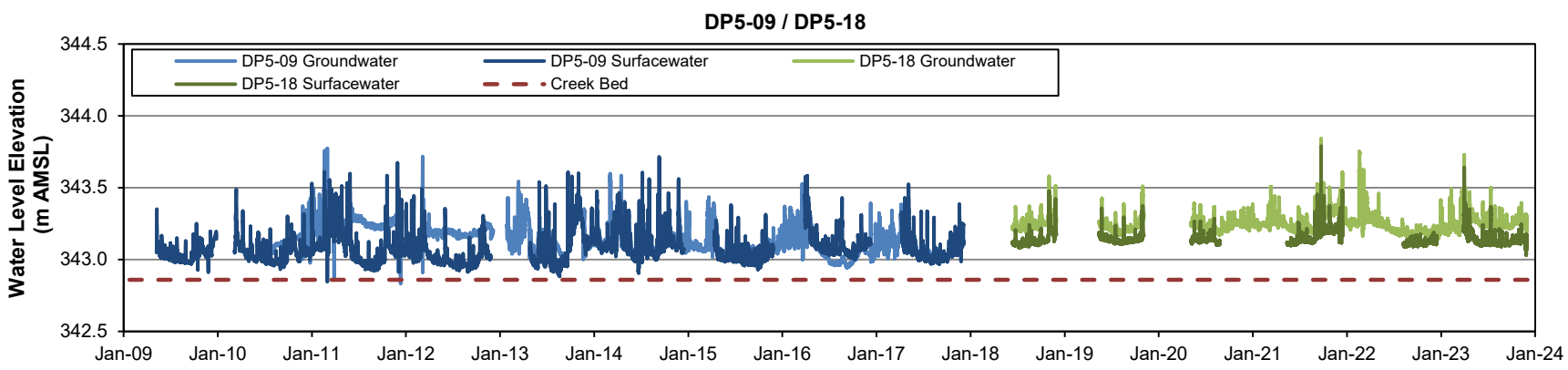
Title
Site Location

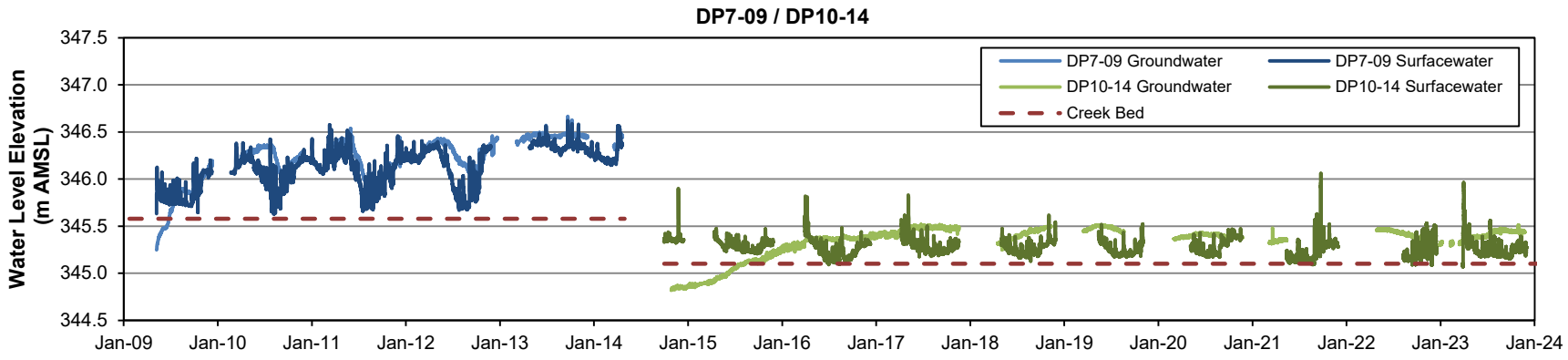
Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

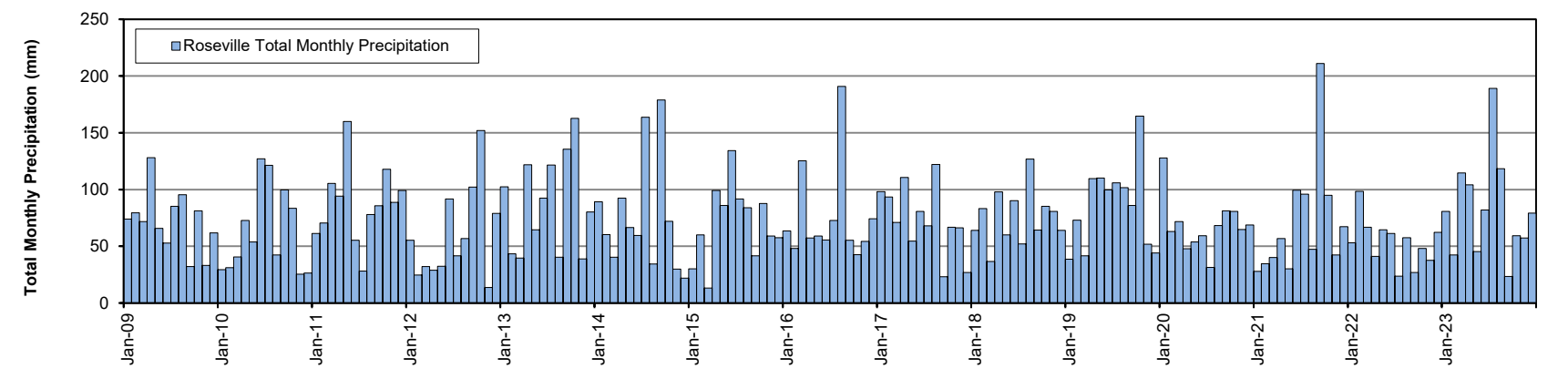
C:\GIS\04\01\01629_active\161450875_Waterloo North\Mapping\Report\2020\Apr\A Figures Revised: 2021-01-20 By: rboer











-Top of casing and streambed elevations at DP10-14 are estimated based on topographic mapping and DP7-09 and DP9-09.
-Top of casing and streambed elevations at DP5-18 are estimated based on DP5-09 survey data
-Top of casing at DP1-09 was extended in 2021. Groundwater level elevations from 2009 to 2020 may be an underestimate.

Client/Project

NORTH WATERLOO, PHASE 1 GROUNDWATER AND SURFACE WATER MONITORING PROGRAM

Figure No.

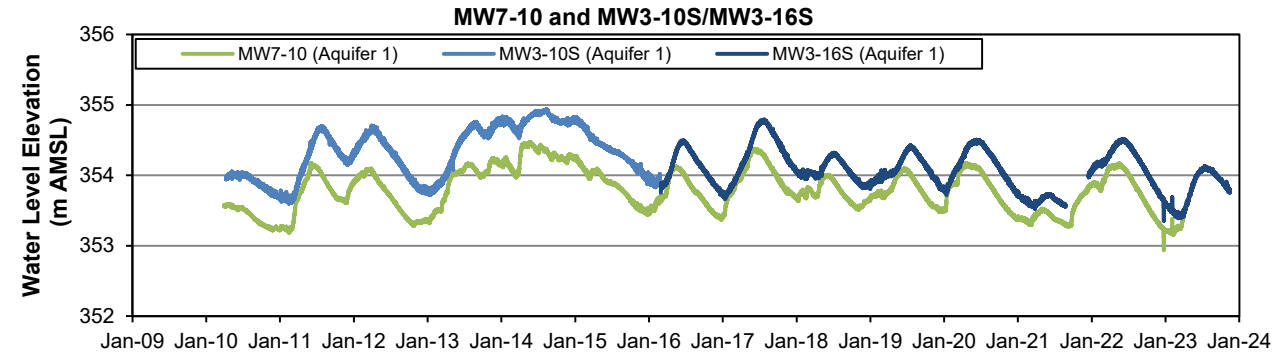
2

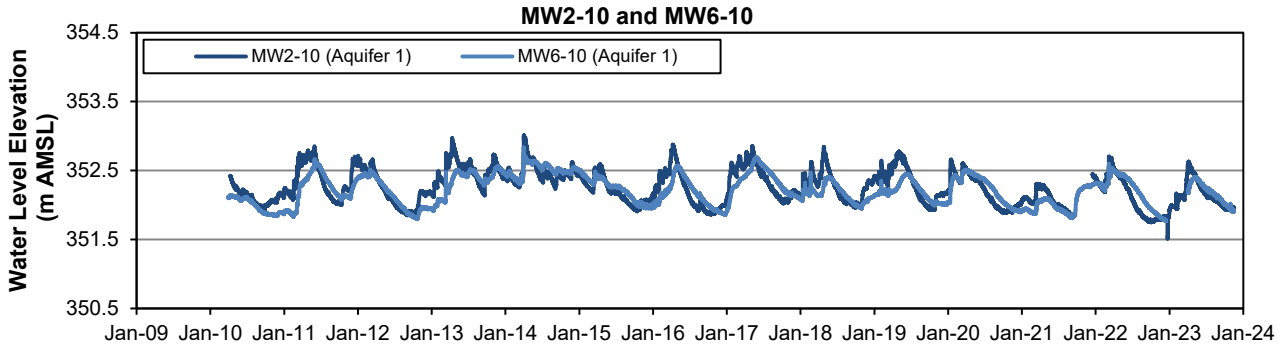
Title

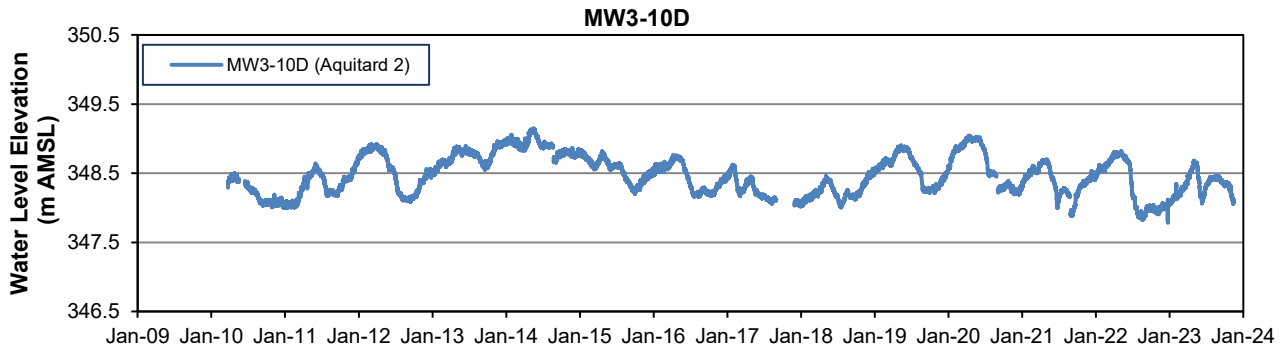
Water Level Hydrographs
Drivepoint Piezometer Monitoring Locations

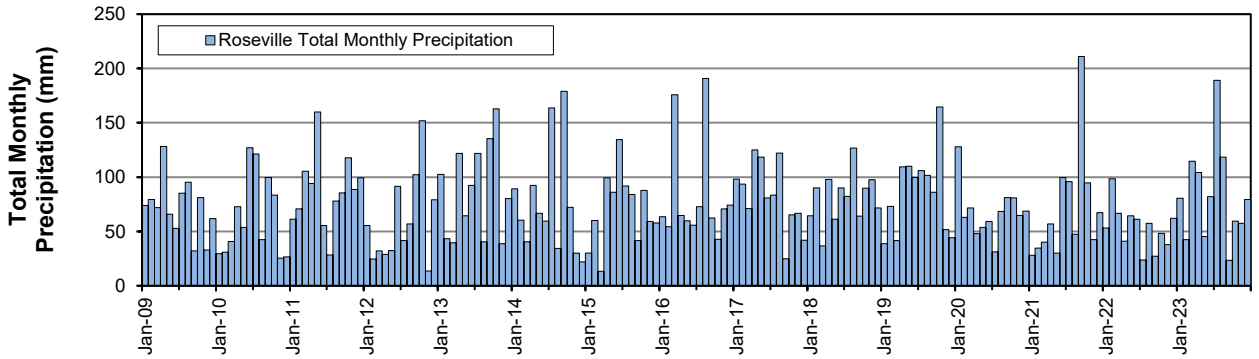
Stantec

\\Cd1004-f01\01609\active\160310875_ Waterloo North\project_management\planning\field_data\levelogger\Corrected_data\2023_report\Figure_2_hydrographs_2023_Drivepoints.xlsx









Client/Project

NORTH WATERLOO, PHASE 1 GROUNDWATER AND SURFACE WATER MONITORING PROGRAM

Figure No.

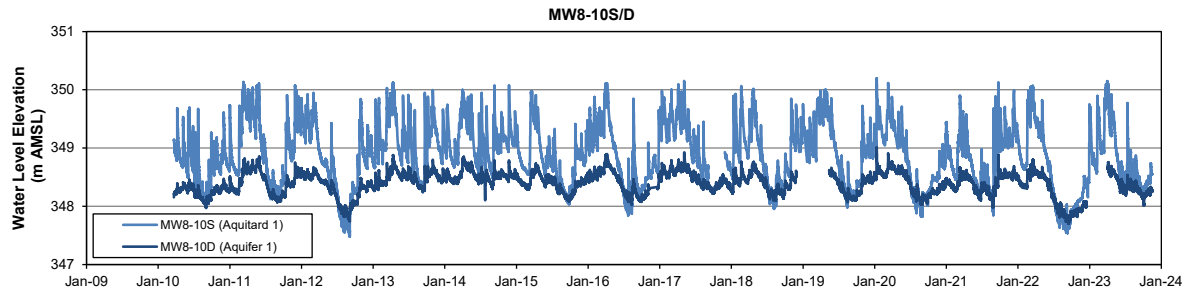
3

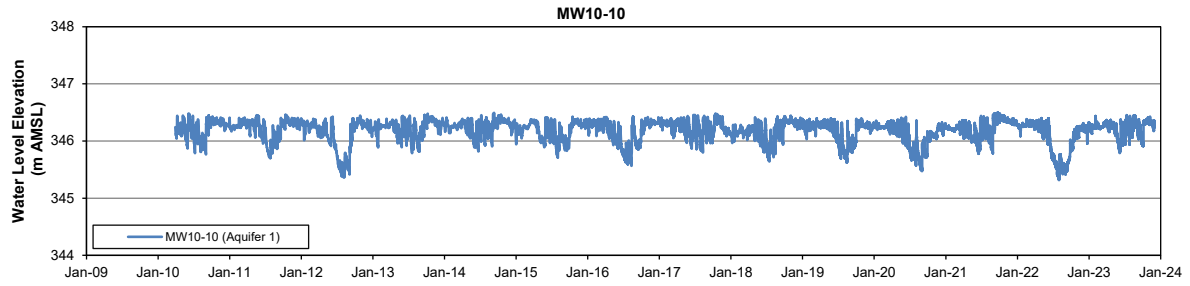
Title

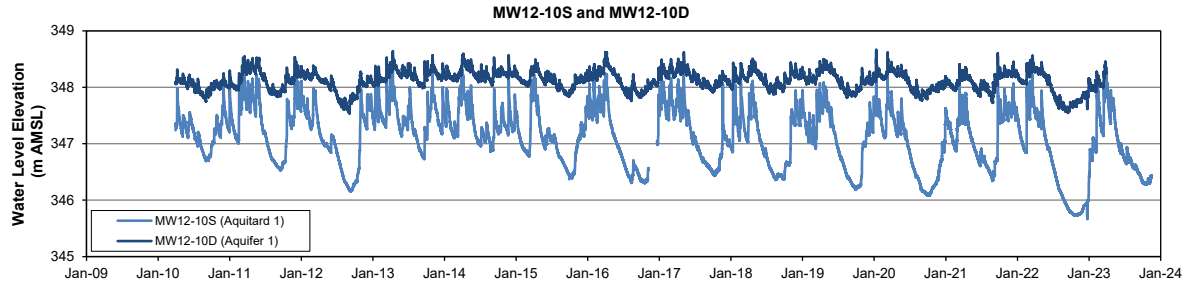
Water Level Hydrographs
Northern Monitoring Locations

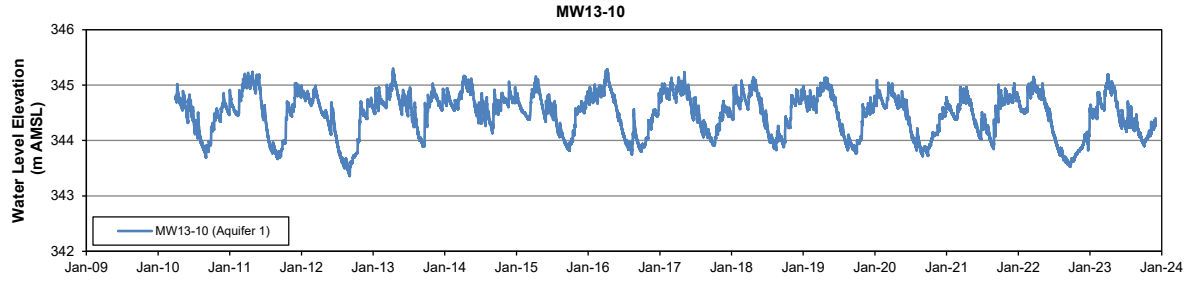
Stantec

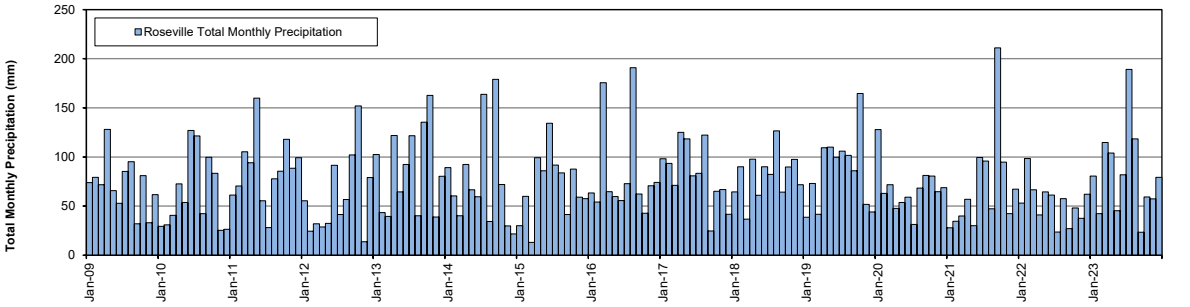
\\Cd1004-f01\01609\active\160310875_ Waterloo North\planning\field_data\levelogger\Corrected_data\2023_report\Figure_3_hydrographs_2023_Northern_sites.xlsx











Client/Project

NORTH WATERLOO, PHASE 1 GROUNDWATER AND SURFACE WATER MONITORING PROGRAM

Figure No.

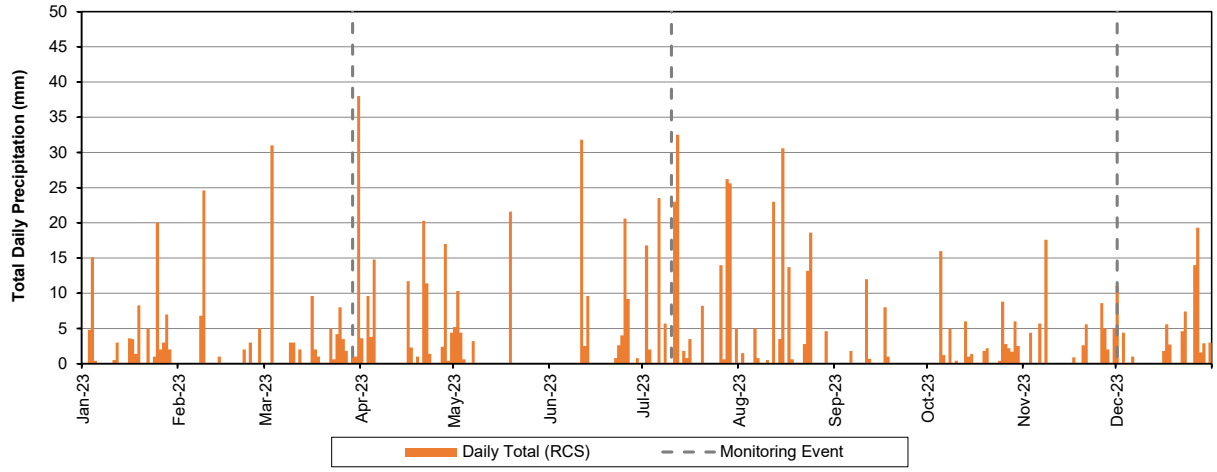
4

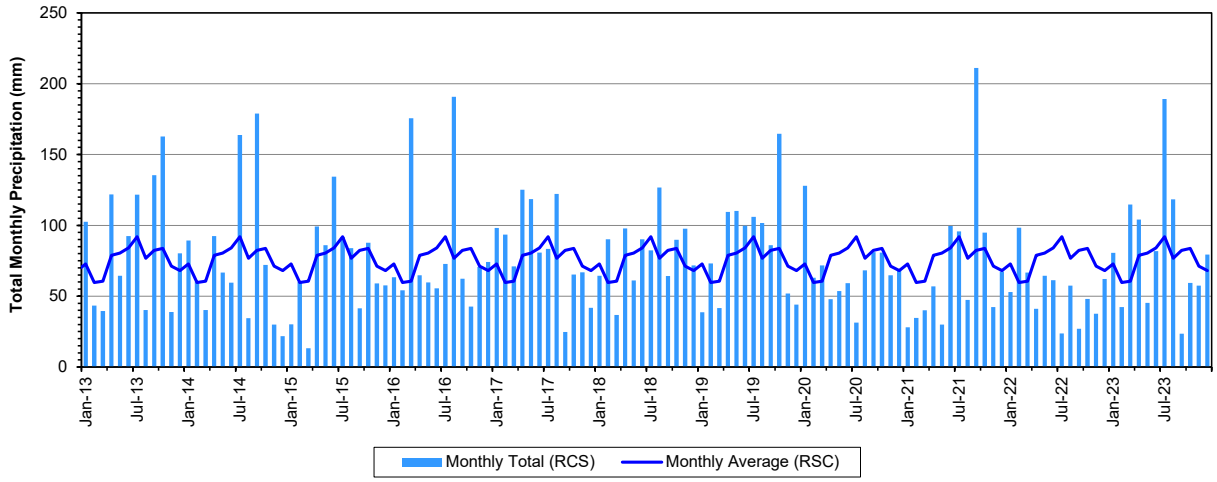
Title

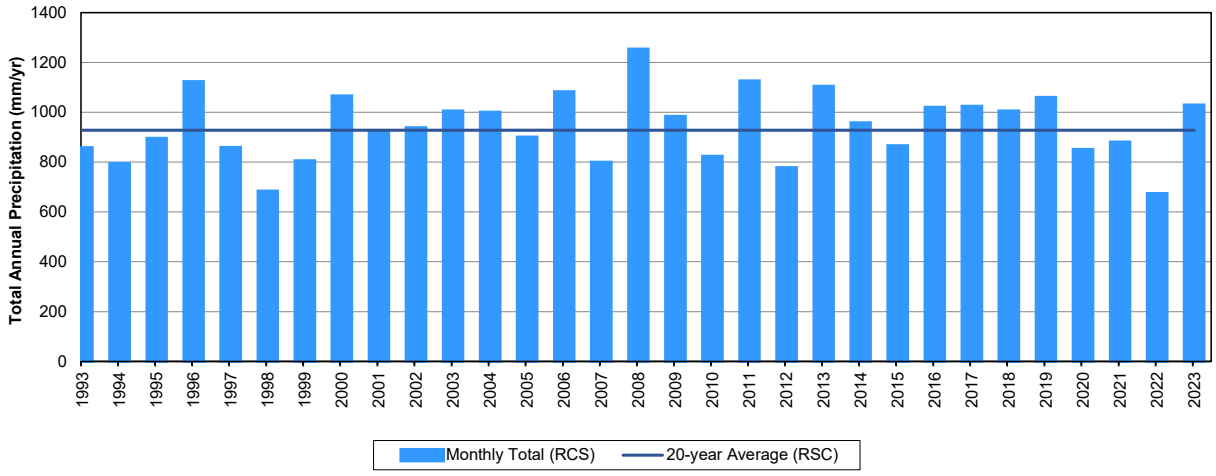
Water Level Hydrographs
Southern Monitoring Locations

Stantec

\\Cd1004-f01\01609\active\160310875_ Waterloo North\planning\field_data\levelogger\Corrected_data\2023_report\Figure_4_hydrographs_2023_Southern_sites.xlsx







Notes:

(1) Precipitation data obtained from the Roseville Climate Station (RCS). Missing monthly values were supplemented from the Kitchener-Waterloo Climate Station (KWCS, formerly the Waterloo International Airport Climate Station). The RCS is located approximately 20 km south of the Site, while the KWCS is located approximately 20 km to the west of the Site.

Client/Project

NORTH WATERLOO, PHASE 1 GROUNDWATER AND SURFACE WATER MONITORING PROGRAM

Figure No.

5

Title

Trends in Total Precipitation

Stantec

\\Cd1004-f01\01609\active\160310875_ Waterloo North\planning\field_data\levelogger\Corrected_data\2023_report\Figure_5_hydrographs_2023_Precip_trends_rev.xlsx

APPENDIX B:
Tables

TABLE 1
WELL INSTALLATION DETAILS

Monitoring Well ID	Date Installed	Location			Elevations			Measured Total Depth	Well Casing			Screened Interval				Screened Material		Monitoring Status
		Northing NAD 83	Easting NAD 83	Coordinate Source	Top of Casing	Ground Surface	Source		Depth	Diameter	Stick-up	Top of Screen		Bottom of Screen				
					(mAMSL)	(mAMSL)		(mBGS)	(mBGS)	(mm)	(mAGS)	(mBGS)	(mAMSL)	(mBGS)	(mAMSL)	Unit	Description	
Monitoring Wells																		
MW1-05	Jan-05	4,814,629	533,419	Total Station (Stantec, 2010)	349.22	348.37	Total Station (Stantec, 2010)	3.73	-	50	0.87	2.10	346.3	3.60	344.8	Aquifer 1	Gravelly Sand	Removed from program in 2014
MW8-05	Feb-05	4,814,874	533,614	Total Station (Stantec, 2010)	350.85	349.94	Total Station (Stantec, 2010)	3.77	-	50	0.84	2.30	347.6	3.80	346.1	Aquitard 1	Silt with trace Sand	Removed from program in 2014
WN1-91-1	Aug-91	4,814,480	533,907	Total Station (Stantec, 2010)	347.18	346.44	Total Station (Stantec, 2010)	>60	68.00	51	0.74	68.00	278.4	70.40	276.0	Aquifer 3	Clay Till / Shale	Removed from program in 2014
WN1-91-2	Aug-91	4,814,478	533,908	Total Station (Stantec, 2010)	347.57	346.64	Total Station (Stantec, 2010)	44.86	41.00	32	0.93	41.00	305.6	47.00	299.6	Aquifer 3	Fine Sand, some gravel	Removed from program in 2014
WN1-91-3	Aug-91	4,814,478	533,908	Total Station (Stantec, 2010)	347.57	346.64	Total Station (Stantec, 2010)	7.57	25.50	32	0.93	25.50	321.1	28.50	318.1	Aquitard 3	Silt Till	Removed from program in 2014
WN1-91-4	Aug-91	4,814,478	533,908	Total Station (Stantec, 2010)	347.57	346.64	Total Station (Stantec, 2010)	8.14	7.50	32	0.93	7.50	339.1	8.30	338.3	Aquitard 1	Fine Sand, silty	Removed from program in 2014
WN2-91-1	Aug-91	4,814,196	533,156	Total Station (Stantec, 2010)	345.35	344.65	Total Station (Stantec, 2010)	>60	68.00	51	0.70	68.00	276.7	71.93	272.7	Bedrock	Shale	Removed from program in 2014
WN2-91-4	Aug-91	4,814,199	533,157	Total Station (Stantec, 2010)	345.18	344.65	Total Station (Stantec, 2010)	10.05	9.00	51	0.53	9.00	335.7	10.50	334.2	Aquifer 1	Sand and Silt, some clay	Removed from program in 2014
WN3-91-1	Sep-91	4,815,057	533,308	Total Station (Stantec, 2010)	354.78	354.86	Total Station (Stantec, 2010)	>60	60.50	51	-0.08	60.50	294.4	64.92	289.9	Aquitard 4 Bedrock	Sand Till / Shale	Well Abandoned
WN3-91-2	Sep-91	4,815,056	533,308	Total Station (Stantec, 2010)	354.71	354.79	Total Station (Stantec, 2010)		9.00	51	-0.08	9.00	345.8	11.50	343.3	Aquifer 1	Silt Till / Fine Sand	Well Abandoned
WNTW2-06	Oct-06	4,814,398	533,662	Total Station (Stantec, 2010)	349.26	348.59	Total Station (Stantec, 2010)	>60	64.92	159	0.67	64.92	283.7	73.15	275.4	Bedrock	Bedrock	Removed from program in 2014
MW1-10	Mar-10	4,814,976	531,967	Total Station (Stantec, 2010)	350.96	350.07	Total Station (Stantec, 2010)	4.5	3.05	51	0.89	3.05	347.0	4.57	345.5	Aquifer 1	Silty Sand	Removed from program in 2014
MW2-10	Mar-10	4,815,271	532,498	Total Station (Stantec, 2010)	356.52	355.56	Total Station (Stantec, 2010)	4.4	3.08	51	0.96	3.08	352.5	4.60	351.0	Aquifer 1	Sand	North Waterloo Monitoring Location
MW3-10S	Mar-10	4,815,407	532,776	Total Station (Stantec, 2010)	367.62	366.81	Total Station (Stantec, 2010)	13.6	12.18	51	0.81	12.18	354.6	13.70	353.1	Aquifer 1	Sand	Well damaged and replaced by MW3-16S
MW3-16S	Mar-16	4,815,406	532,774	Estimated based on MW3-10D	367.70	366.84	Estimated based on MW3-10D	13.7	12.19	51	0.86	12.19	354.7	13.72	353.1	Aquifer 1	Sand	North Waterloo Monitoring Location (replaced MW3-10S)
MW3-10D	Mar-10	4,815,406	532,774	Total Station (Stantec, 2010)	367.60	366.84	Total Station (Stantec, 2010)	41.7	40.08	51	0.76	40.08	326.8	41.60	325.2	Aquitard 2	Clay Till / Sand Till	North Waterloo Monitoring Location
MW4-10	Mar-10	4,815,010	532,399	Total Station (Stantec, 2010)	348.64	347.87	Total Station (Stantec, 2010)	2.8	1.52	51	0.77	1.52	346.3	3.05	344.8	Aquitard 1	Silty Sand to Clayey Silt	Removed from program in 2014
MW5-10	Mar-10	4,814,834	532,368	Total Station (Stantec, 2010)	351.91	351.08	Total Station (Stantec, 2010)	4.1	2.74	51	0.83	2.74	348.3	4.27	346.8	Aquifer 1	Silty Sand	Removed from program in 2014
MW6-10	Mar-10	4,814,972	532,737	Total Station (Stantec, 2010)	356.48	355.58	Total Station (Stantec, 2010)	4.3	3.05	51	0.90	3.05	352.5	4.57	351.0	Aquifer 1	Medium Sand	North Waterloo Monitoring Location
MW7-10	Mar-10	4,815,108	533,031	Total Station (Stantec, 2010)	359.67	358.74	Total Station (Stantec, 2010)	7.1	5.79	51	0.93	5.79	352.9	7.32	351.4	Aquifer 1	Fine to Medium Sand	North Waterloo Monitoring Location
MW8-10S	Mar-10	4,814,538	532,271	Total Station (Stantec, 2010)	351.28	350.38	Total Station (Stantec, 2010)	3.84	3.05	51	0.90	3.05	347.3	4.57	345.8	Aquitard 1	Silt	North Waterloo Monitoring Location
MW8-10D	Mar-10	4,814,537	532,269	Total Station (Stantec, 2010)	351.26	350.44	Total Station (Stantec, 2010)	38.62	38.16	51	0.82	38.16	312.3	39.68	310.8	Aquifer 1	Sand / Sand and cobble	North Waterloo Monitoring Location

Notes:

(mAMSL) metres above mean sea level
(mBGS) metres below ground surface
(mAGS) metres above ground surface

TABLE 1
WELL INSTALLATION DETAILS

Monitoring Well ID	Date Installed	Location			Elevations			Measured Total Depth	Well Casing			Screened Interval				Screened Material		Monitoring Status
		Northing NAD 83	Easting NAD 83	Coordinate Source	Top of Casing	Ground Surface	Source		Depth	Diameter	Stick-up	Top of Screen		Bottom of Screen				
					(mAMSL)	(mAMSL)		(mBGS)	(mBGS)	(mm)	(mAGS)	(mBGS)	(mAMSL)	(mBGS)	(mAMSL)	Unit	Description	
Monitoring Wells																		
MW9-10S	Mar-10	4,814,715	532,634	Total Station (Stantec, 2010)	346.69	345.83	Total Station (Stantec, 2010)	4.58	3.05	51	0.86	3.05	342.8	4.57	341.3	Aquitard 1	Clay	Well Abandoned
MW9-10D	Mar-10	4,814,717	532,634	Total Station (Stantec, 2010)	346.50	345.71	Total Station (Stantec, 2010)	27.69	25.99	51	0.79	25.99	319.7	27.51	318.2	Aquitard 3	Silt Till	Well Abandoned
MW10-10	Mar-10	4,814,388	532,654	Total Station (Stantec, 2010)	347.05	346.25	Total Station (Stantec, 2010)	2.8	1.52	51	0.80	1.52	344.7	3.05	343.2	Aquifer 1	Fine Sand	North Waterloo Monitoring Location
MW11-10	Mar-10	4,814,655	533,047	Total Station (Stantec, 2010)	355.96	355.07	Total Station (Stantec, 2010)	5.8	4.27	51	0.89	4.27	350.8	5.79	349.3	Aquifer 1	Fine to Coarse Sand	North Waterloo Monitoring Location Well Damaged, Replacement Recommended
MW12-10S	Mar-10	4,814,123	532,585	Total Station (Stantec, 2010)	349.35	348.51	Total Station (Stantec, 2010)	6.6	5.06	51	0.84	5.06	343.5	6.58	341.9	Aquitard 1	Silty Clay	North Waterloo Monitoring Location
MW12-10D	Mar-10	4,814,125	532,584	Total Station (Stantec, 2010)	349.52	348.63	Total Station (Stantec, 2010)	25.5	23.98	51	0.89	23.98	324.7	25.50	323.1	Aquifer 1	Sand and Gravel	North Waterloo Monitoring Location
MW13-10	Mar-10	4,814,339	533,060	Total Station (Stantec, 2010)	346.15	345.34	Total Station (Stantec, 2010)	4.4	3.05	51	0.81	3.05	342.3	4.57	340.8	Aquifer 1	Silty Sand	North Waterloo Monitoring Location
Drivepoint Piezometers																		
DP1-09	Apr-09	4,815,046	532,107	Total Station (Stantec, 2010)	350.09	349.30	Total Station (Stantec, 2010)	-	1.04	25	0.79	1.04	348.3	1.46	347.8	-	-	North Waterloo Monitoring Location
DP2-09	Apr-09	4,814,968	532,526	Total Station (Stantec, 2010)	348.46	347.60	Total Station (Stantec, 2010)	-	0.97	25	0.86	0.97	346.6	1.39	346.2	-	-	Removed from program in 2014
DP3-09	Apr-09	4,814,727	532,643	Total Station (Stantec, 2010)	346.65	345.07	Total Station (Stantec, 2010)	-	0.72	25	1.58	0.72	344.4	1.14	343.9	-	-	Drivepoint damaged, replaced by DP3-23
DP3-23	Nov-24	4,814,727	532,643	Estimated based on DP3-09	346.62	345.70	Estimated based on DP3-09	-	1.22	25	0.92	1.22	344.5	1.63	344.1	-	-	North Waterloo Monitoring Location
DP4-09	Apr-09	4,814,564	532,840	Total Station (Stantec, 2010)	345.13	344.17	Total Station (Stantec, 2010)	-	1.17	25	0.96	1.17	343.0	1.59	342.6	-	-	Removed from program in 2014
DP5-09	Apr-09	4,814,419	533,147	Total Station (Stantec, 2010)	343.84	342.86	Total Station (Stantec, 2010)	-	1.15	25	0.98	1.15	341.7	1.57	341.3	-	-	Drivepoint damaged, replaced by DP5-18
DP5-18	Jun-18	4,814,441	533,145	Handheld GPS (Stantec, 2018)	343.71	342.86	Estimated based in DP5-09	-	1.28	25	0.85	1.28	341.6	1.70	341.2	-	-	North Waterloo Monitoring Location (replaced DP5-09)
DP6-09	Apr-09	4,814,321	533,151	Total Station (Stantec, 2010)	343.44	342.55	Total Station (Stantec, 2010)	-	1.24	25	0.90	1.24	341.3	1.66	340.9	-	-	Removed from program in 2014
DP7-09	Apr-09	4,814,153	532,358	Total Station (Stantec, 2010)	346.46	345.58	Total Station (Stantec, 2010)	-	0.95	25	0.88	0.95	344.6	1.37	344.2	-	-	Non-ideal flow conditions, replaced by DP10-14
DP8-09	Nov-09	4,815,003	532,314	Total Station (Stantec, 2010)	348.27	347.36	Total Station (Stantec, 2010)	-	1.22	25	0.92	1.22	346.1	1.64	345.7	-	-	Removed from program in 2014
DP9-09	Nov-09	4,813,939	532,735	Total Station (Stantec, 2010)	345.45	344.48	Total Station (Stantec, 2010)	-	1.16	25	0.97	1.16	343.3	1.58	342.9	-	-	North Waterloo Monitoring Location
DP10-14	Sep-14	4,813,975	532,575	Aerial Mapping	346.39	345.10	Estimated based on DP9-09 and DP7-09	-	0.87	25	1.26	0.87	344.2	1.29	343.8	-	-	North Waterloo Monitoring Location (replaced DP7-09)

Notes:

(mAMSL) metres above mean sea level
(mBGS) metres below ground surface
(mAGS) metres above ground surface

Table 2
Stream Flow Measurements

Date	Monitoring Locations within Beaver Creek									Monitoring Locations within Laurel Creek								
	DP1-09			DP3-09			DP5-09			DP7-09			DP10-14			DP9-09		
	Flow (L/s)	Max. Depth (m)	Width (m)	Flow (L/s)	Max. Depth (m)	Width (m)	Flow (L/s)	Max. Depth (m)	Width (m)	Flow (L/s)	Max. Depth (m)	Width (m)	Flow (L/s)	Max. Depth (m)	Width (m)	Flow (L/s)	Max. Depth (m)	Width (m)
23-Apr-09	70.9	0.20	3.30	92.4	0.29	2.95	90.4	0.25	3.40	-	-	-	-	-	-	-	-	-
15-Oct-09	47.2	0.27	3.10	39.5	0.19	2.80	36.4	0.15	2.40	106.1	0.38	4.10	-	-	-	-	-	-
25-Nov-09	84.8	0.29	3.40	59.8 60.6	0.23 0.23	2.90 2.90	74.8	0.16	3.20	108.7	0.61	4.50	-	-	-	82.5	0.29	5.80
31-Mar-10	58.6	0.21	2.75	40.7	0.19	3.00	51.9	0.14	3.00	172.3	0.73	5.80	-	-	-	143.5	0.18	5.50
20-May-10	28.1	0.16	2.00	25.1	0.15	2.60	30.3	0.10	2.45	46.4	0.72	5.70	-	-	-	56.6	0.10	5.00
23-Jul-10	366	0.56	4.75	421	0.56	3.00	401	0.30	3.85	-	-	-	-	-	-	2799	0.54	5.50
30-Aug-10	7.9	0.11	1.20	8.6	0.12	1.90	4.7	0.06	2.20	11.0	0.28	3.00	-	-	-	31.0	0.21	4.25
29-Oct-10	56.0	0.32	3.80	46.2	0.16	2.90	44.3	0.21	3.80	108.2	0.71	5.90	-	-	-	115.8	0.38	5.80
17-May-12	16.8	0.10	2.15	15.6	0.13	1.95	11.0	0.09	2.70	20.9	0.80	5.50	-	-	-	41.3	0.11	4.75
28-Aug-12	9.4	0.08	1.40	7.9	0.09	2.20	5.7	0.07	2.65	19.5	0.25	3.40	-	-	-	16.4	0.07	3.15
26-Nov-12	34.3	0.18	2.40	40.3	0.16	3.00	35.0	0.14	2.90	87.3	0.85	5.80	-	-	-	78.8	0.22	5.75
25-Apr-13	124.9	0.31	3.45	167.3	0.30	3.50	155.4	0.27	3.50	na	Ponded	Ponded	-	-	-	344.9	0.34	5.85
20-Aug-13	15.8	0.21	2.10	16.4	0.14	2.20	13.2	0.08	2.50	na	Ponded	Ponded	-	-	-	48.4	0.11	5.30
29-Oct-13	95.5	0.33	3.90	111.3	0.31	3.30	107.0	0.38	4.40	na	Ponded	Ponded	-	-	-	215.9	0.34	5.90
16-Jan-14	110.0	0.24	3.60	117.4	0.29	2.75	151.2	0.28	4.70	na	Frozen	Frozen	-	-	-	334.9	0.38	5.80
21-Apr-14	96.2	0.21	3.25	107.6	0.21	3.00	120.3	0.20	3.65	na	Ponded	Ponded	-	-	-	276.4	0.29	5.80
21-Aug-14	29.5	0.15	2.50	30.6	0.14	3.00	41.3	0.10	3.00	Replaced by SF10			93.6	0.3	4.25	82.7	0.12	5.50
29-Sep-14	-	-	-	-	-	-	-	-	-	-	-	-	121.1	0.34	4.4	-	-	-
28-Oct-14	57.1	0.30	3.50	58.3	0.26	2.80	68.1	0.20	3.70	-	-	-	116.7	0.36	4.5	119.7	0.26	5.85
15-Dec-14	54.5	0.22	2.60	70.2	0.23	2.75	67.6	0.18	3.60	-	-	-	132.7	0.36	4.8	145.6	0.24	5.80
13-Apr-15	104.5	0.38	3.75	131.3	0.28	3.40	134.7	0.19	3.45	-	-	-	307.6	0.39	4.95	319.9	0.30	5.95
28-Sep-15	4.3	0.11	1.80	4.7	0.09	1.80	4.4	0.08	2.40	-	-	-	30.7	0.21	3.6	28.1	0.08	4.40
27-Nov-15	89.0	0.31	3.00	113.5	0.27	2.80	121.4	0.24	3.90	-	-	-	228.3	0.37	5.3	236.0	0.32	5.90
28-Mar-16	385.1	0.62	5.00	483.2	0.62	4.10	541.0	0.50	4.40	-	-	-	694.1	0.5	6.9	691.0	0.50	5.85
25-Aug-16	22.4	0.15	2.25	25.5	0.15	2.35	27.5	0.10	2.90	-	-	-	78.1	0.28	4	75.6	0.12	5.70
7-Nov-16	33.5	0.18	3.20	33.9	0.15	2.35	36.0	0.16	3.45	-	-	-	82.8	0.32	4.6	75.1	0.20	5.75
7-Apr-17	384.6	0.50	4.60	422.3	0.55	3.95	438.0	0.45	4.45	-	-	-	851.1	0.58	7.5	-	-	-
10-Apr-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	278.2	0.28	6.00
6-Sep-17	30.9	0.14	3.30	41.2	0.16	2.45	43.5	0.10	3.00	-	-	-	115.9	0.3	4.4	116.3	0.14	5.80
17-Nov-17	84.9	0.23	3.20	95.8	0.22	2.70	92.0	0.21	3.70	-	-	-	142.6	0.35	5.2	164.3	0.25	5.90
3-May-18	117.3	0.26	3.80	114.2	0.30	2.85	143.0	0.23	4.50	-	-	-	168.8	0.4	5.1	155.7	0.30	4.90
23-Aug-18	46.0	0.15	3.20	43.1	0.18	2.40	51.6	0.18	4.10	-	-	-	136.1	0.27	3.6	131.1	0.21	5.00
29-Nov-18	68.6	0.23	4.00	93.4	0.26	2.50	95.4	0.21	4.20	-	-	-	182.0	0.46	4.8	202.0	0.42	5.50
14-May-19	160.7	0.30	3.60	183.3	0.30	2.90	147.9	0.21	4.00	-	-	-	504.6	0.42	5	490.2	0.49	5.80
20-Aug-19	25.0	0.13	2.40	19.9	0.14	2.00	17.9	0.12	3.60	-	-	-	124.0	0.3	4.2	92.8	0.13	5.50
4-Nov-19	80.1	0.31	3.60	87.6	0.24	2.40	92.6	0.20	4.00	-	-	-	162.3	0.35	4.5	178.2	0.35	5.70
5-May-20	69.9	0.20	3.00	80.5	0.20	2.60	68.6	0.20	4.75	-	-	-	147.5	0.3	4	122.4	0.22	5.75
26-Aug-20	9.9	0.10	2.20	8.0	0.10	2.20	9.4	0.12	3.90	-	-	-	31.8	0.22	3.2	37.8	0.13	4.50
20-Nov-20	30.4	0.18	3.20	34.2	0.16	2.50	23.2	0.14	4.00	-	-	-	73.8	0.36	3.8	65.8	0.24	5.60
13-May-21	20.5	0.11	2.80	24.1	0.14	2.50	23.8	0.14	4.00	-	-	-	64.7	0.23	3.6	78.6	0.20	5.60
1-Sep-21	8.4	0.12	2.50	18.4	0.14	2.60	18.4	0.14	4.10	-	-	-	75.9	0.2	3.6	85.1	0.16	5.20
30-Nov-21	60.8	0.30	3.20	62.2	0.26	3.20	82.7	0.20	4.60	-	-	-	124.1	0.3	4	124.9	0.39	5.80
8-Aug-22	13.7	0.10	2.80	11.8	0.15	2.30	5.6	0.15	4.40	-	-	-	25.2	0.28	3.75	32.1	0.14	5.40
13-Sep-22	12.7	0.10	2.90	12.7	0.12	2.10	7.1	0.16	4.20	-	-	-	36.6	0.28	3.7	23.9	0.13	5.50
16-Dec-22	54.6	0.20	3.30	66.1	0.24	3.00	65.5	0.13	4.30	-	-	-	122.1	0.3	4.3	105.4	0.32	4.90
29-Mar-23	151.0	0.32	3.80	223.1	0.41	3.30	177.8	0.27	4.80	-	-	-	404.0	0.53	5	449.3	0.57	5.40
10-Jul-23	17.3	0.12	3.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30-Nov-23	25.1	0.14	3.60	35.9	0.20	3.00	-	-	-	-	-	-	90.6	0.29	4.2	86.3	0.22	6.10
1-Dec-23	-	-	-	-	-	-	100.8	0.20	4.80	-	-	-	-	-	-	-	-	-

Table 3
Summary of Groundwater Analytical Results
Waterloo North Hydrogeological Assessment

Sample Location			MW1-10		MW2-10												MW3-10D				
Sample Date			18-May-10	26-Oct-10	17-May-10	25-Oct-10	21-Aug-14	28-Sep-15	25-Aug-16	31-Aug-17	21-Aug-18	20-Aug-19	26-Aug-20	24-Aug-21	29-Aug-22	16-Nov-23	20-May-10	27-Oct-10	21-Aug-14	28-Sep-15	25-Aug-16
Sample ID			WG-160340875-20100518-AV09	WG-160340875-20101026-JK8	WG-160340875-20100517-AV05	WG-160340875-20101025-JK2	WG-160310875-20140821-AV02	WG-160310875-20150928-AV04	WG-160310875-20160825-AV07	WG-160310875-20170831-AV02	WG-150310875-20180821-DS04	WG-161450875-20190820-DS02	WG-161450875-20200826-DS-03	WG-161450875-20210824-AV01	WG-161450875-20220829-JM02	MW2-10	WG-160340875-20100520-AV17	WG-160340875-20101027-JK 12	WG-160310875-20140821-AV03	WG-160310875-20150928-AV03	WG-160310875-20160825-AV08
Sampling Company			STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC
Laboratory			MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	BV	BV	BV	BV	BV	MAXX	MAXX	MAXX	MAXX	MAXX
Laboratory Work Order			B062483	B0F2316	B062483	B0F1430	B4F3646	B5J8856	B6I3010	B7J0582	B8L6839	B9N2253	C0M1964	C1O3272	C2P0302	C3AC977	B064180	B0F3108	B4F3646	B5J8856	B6I3010
Laboratory Sample ID			FX4449	HQ0824	FX4445	HP6282	XG4185	BBU089	CYS143	FBA581	HNX849	KOP306	NMK092	QMC301	TPN285	XQK216	FY2702	HQ4300	XG4186	BBU088	CYS144
Sample Type	Units	ODWS																			
Field Parameters																					
Dissolved Oxygen, Field	mg/L	n/v	3.9	1.0	5.9	-	-	-	-	5.20	9.3	4.8	-	-	-	-	-	2.3	-	2.38	5.90
General Chemistry																					
Alkalinity, Bicarbonate (as CaCO3)	mg/L	n/v	349	355	138	154	170	180	170	160	160	160	170	140	160	170	155	158	180	200	180
Alkalinity, Carbonate (as CaCO3)	mg/L	n/v	5	3	2	1	1.3	1.1	1.6	1.5	1.5	1.7	1.0	1.3	1.7	1.6	3	2	2.6	1.1	2.5
Alkalinity, Total (as CaCO3)	mg/L	30-500[D]	353	358	140	155	170	180	170	170	160	170	170	140	170	170	158	160	180	200	190
Ammonia (as N)	mg/L	n/v	0.06	0.16	<0.05	0.06	0.051	<0.050	<0.050	0.087	<0.050	<0.050	<0.050	<0.050	0.16	<0.050	0.11	0.23	0.29	0.18	0.14
Anion Sum	me/L	n/v	8.45	8.47	3.91	4.79	4.84	4.75	4.76	4.07	4.36	5.02	4.20	5.83	4.31	4.41	3.58	4.31	4.45	5.03	4.60
Cation Sum	me/L	n/v	8.84	8.29	3.93	4.95	5.03	4.86	4.64	4.08	4.07	5.12	4.04	5.48	4.45	4.38	3.31	4.42	4.57	4.46	4.40
Chloride	mg/L	250[B]	12	13	4	6	14	3.5	1.8	1.0	19	15	16	44	9.3	13	6	12	7	8.4	7.2
Dissolved Organic Carbon (DOC)	mg/L	5[B]	2.0	2.3	1.4	1.7	1.1	1.4	1.1	1.3	1.3	1.3	1.2	1.1	1.5	1.3	**5.1[B]**	**5.7[B]**	**6.5[B]**	4.8	3.4
Electrical Conductivity, Lab	µmhos/cm	n/v	755	760	388	473	480	460	470	380	420	500	410	590	400	440	342	432	410	440	450
Hardness (as CaCO3)	mg/L	80-100[D]	**430[D]**	**400[D]**	**190[D]**	**240[D]**	**240[D]**	**240[D]**	**230[D]**	**200[D]**	**200[D]**	**250[D]**	**200[D]**	**270[D]**	**220[D]**	**210[D]**	**43[D]**	**66[D]**	**64[D]**	**78[D]**	83
Ion Balance	%	n/v	2.29	1.12	0.270	1.58	1.95	1.10	1.23	0.0900	3.43	1.00	1.88	3.08	1.55	0.390	3.91	1.26	1.35	5.98	2.30
Langelier Index (at 20 C)	none	n/v	1.25	0.973	0.653	0.559	0.599	0.490	0.656	0.577	0.574	0.720	0.409	0.607	0.685	0.658	0.140	0.128	0.275	-0.0170	0.355
Langelier Index (at 4 C)	none	n/v	0.996	0.725	0.404	0.310	0.350	0.241	0.408	0.327	0.324	0.470	0.159	0.358	0.435	0.408	-0.110	-0.121	0.0260	-0.267	0.106
Nitrate (as N)	mg/L	10.0_d[A]	<0.1	<0.1	**12[A]**	**19[A]**	**12.0[A]**	**12.1[A]**	**17.3[A]**	6.57	6.18	**15.0[A]**	3.01	**21.5[A]**	6.18	5.75	<0.1	<0.1	<0.10	<0.10	0.52
Nitrate + Nitrite (as N)	mg/L	10.0_d[A]	<0.1	<0.1	**12[A]**	**19[A]**	**12.0[A]**	**12.1[A]**	**17.3[A]**	6.57	6.18	**15.0[A]**	3.01	**21.5[A]**	6.18	5.75	<0.1	<0.1	<0.10	<0.10	0.52
Nitrite (as N)	mg/L	1.0_d[A]	0.03	<0.01	<0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.01	<0.01	<0.010	0.021	<0.010
Orthophosphate (as P)	mg/L	n/v	<0.01	<0.01	<0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.08	0.06	0.068	0.021	0.019
pH, lab	S.U.	6.5-8.5[D]	8.1	7.88	8.1	7.92	7.90	7.79	8.00	7.97	7.99	8.03	7.80	7.99	8.05	8.00	8.3	8.09	8.20	7.78	8.15
Saturation pH (at 20 C)	none	n/v	6.89	6.90	7.49	7.36	7.30	7.30	7.35	7.39	7.42	7.31	7.39	7.39	7.37	7.34	8.15	7.96	7.93	7.80	7.80
Saturation pH (at 4 C)	none	n/v	7.14	7.15	7.74	7.61	7.55	7.54	7.60	7.64	7.67	7.56	7.64	7.63	7.62	7.59	8.40	8.21	8.17	8.05	8.05
Sulfate	mg/L	500_h[B]	50	47	6	6	5	4.6	3.6	12	5.7	10	3.7	14	14	7.0	12	37	33	37	30
Total Dissolved Solids (Calculated)	mg/L	500[B]	441	433	226	289	280	270	280	220	230	290	220	340	240	240	194	250	260	270	250
Metals																					
Aluminum	mg/L	0.1[D]	<0.005	<0.005	0.006	0.012	0.0080	<0.0050	<0.0050	0.0054	<0.0050	<0.0050	0.0059	<0.0049	0.0053	<0.0049	0.011	0.011	0.020	0.012	<0.0050
Antimony	mg/L	0.006[A]	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005	0.0010	<0.00050	<0.00050
Arsenic	mg/L	0.01[A]	<0.001	<0.001	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.003	0.002	0.0020	0.0018	0.0015
Barium	mg/L	1[A]	0.087	0.083	0.012	0.016	0.011	0.011	0.010	0.0068	0.0080	0.0099	0.0079	0.013	0.010	0.012	0.012	0.015	0.025	0.034	0.024
Beryllium	mg/L	n/v	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050
Boron	mg/L	5[A]	<0.01	<0.01	<0.01	0.01	0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.14	0.16	0.16	0.14	0.13
Cadmium	mg/L	0.005[A]	<0.0001	0.0001	<0.0001	0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010
Calcium	mg/L	n/v	100	99	57	73	75	71	69	60	59	77	59	80	65	66	11	17	17	20	22
Chromium	mg/L	0.05[A]	<0.005	<0.005	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050
Cobalt	mg/L	n/v	0.0025	0.0019	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.0008	<0.0005	0.0010	<0.00050	<0.00050
Copper	mg/L	1[B]	0.002	0.001	0.003	0.002	0.0020	0.0013	0.0069	0.0030	0.0016	0.0015	0.0014	0.0014	0.0013	0.0013	<0.001	<0.001	0.0010	<0.0010	<0.0010
Iron	mg/L	0.3[B]	<0.1	<0.1	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10	<0.10
Lead	mg/L	0.01[A]	<0.0005	<0.0005	0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050
Magnesium	mg/L	n/v	41	37	12	14	14	15	13	12	13	14	12	16	13	12	3.8	5.5	5.2	6.6	7.0
Manganese	mg/L	0.05[B]	**0.33[B]**	**0.34[B]**	0.005	0.003	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.010	<0.0020	**0.080[B]**	**0.097[B]**	**0.055[B]**	0.049	0.040
Molybdenum	mg/L	n/v	0.003	0.003	<0.001	<0.001	0.0010	0.00068	0.00053	<0.00050	<0.00050	<0.00050	<0.00050	0.00054	0.00059	0.00056	0.042	0.039	0.038	0.031	0.029
Nickel	mg/L	n/v	0.002	<0.001	0.001	<0.001	0.0070	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.001	0.002	0.0030	<0.0010	<0.0010
Phosphorus	mg/L	n/v	<0.1	<0.1	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.2	0.1	<0.10	<0.10	<0.10
Potassium	mg/L	n/v	3.0	2.6	2.6	3.3	3.6	3.6	3.3	2.2	2.3	2.0	2.6	3.7	3.3	2.9	1.1	1.1	0.96	0.90	0.88
Selenium	mg/L	0.05[A]	<0.002	<0.002	<0.002	<0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.002	<0.002	<0.0020	<0.0020	<0.0020
Silicon	mg/L	n/v	6.5	7.0	2.0	2.5	2.5	2.6	2.3	2.3	2.2	2.5	2.3	2.1	2.4	2.3	4.6	4.9	5.1	4.7	4.4
Silver	mg/L	n/v	<0.0001	<0.0001	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010
Sodium	mg/L	200_g[B] 20_g[C]	5.9	5.1	1.4	1.6	1.6	1.1	0.99	0.90	0.90	1.0	0.87	0.97	1.1	1.2	**55[C]**	**70[C]**	**75[C]**	**66[C]**	**62[C]**
Strontium	mg/L	n/v	0.26	0.22	0.069	0.092	0.092	0.095	0.088	0.075	0.074	0.093	0.071	0.11	0.085	0.093	0.19	0.26	0.29	0.38	0.37
Thallium	mg/L	n/v	<0.00005	<0.00005	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050
Titanium	mg/L	n/v	<0.005	<0.005	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050
Uranium	mg/L	0.02[A]	0.0059	0.0049	0.0002	0.0002	<0.00010	0.00015	0.00013	0.00012	0.00011	0.00014	0.00012	0.00012	0.00014	0.00013	0.0009	0.0013	0.0020	0.0022	0.0014
Vanadium	mg/L	n/v	<0.001	<0.001	<0.001	<0.001	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.001	0.001	0.0020	0.0013	0.00065
Zinc	mg/L	5[B]	0.14	0.009	0.016	0.017	0.0080	<0.0050	0.0070	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.017	0.013	0.0070	<0.0050	<0.0050

See notes on last page.

Table 3
Summary of Groundwater Analytical Results
Waterloo North Hydrogeological Assessment

Sample Location			MW3-10D (Contd.)							MW3-10S				MW3-16S						MW4-10	
Sample Date			31-Aug-17	22-Aug-18	21-Aug-19	27-Aug-20	24-Aug-21	30-Aug-22	17-Nov-23	19-May-10	25-Oct-10	21-Aug-14	29-Sep-15	31-Aug-17	21-Aug-18	20-Aug-19	26-Aug-20	29-Aug-22	16-Nov-23	17-May-10	25-Oct-10
Sample ID			WG-160310875-20170831-AV03	WG-160310875-20180822-DS05	WG-161450875-20190821-DS07	WG-161450875-20200827-DS-07	WG-161450875-20210824-AV05	WG-161450875-20220830-JM05	MW3-10D	WG-160340875-20100519-AV13	WG-160310875-20101025-JK1	WG-160310875-20140821-AV01	WG-160310875-20150929-AV06	WG-160310875-20170831-AV01	WG-160310875-20180821-DS03	WG-161450875-20190820-DS01	WG-161450875-20200826-DS-02	WG-161450875-20220829-JM01	MW3-16S	WG-160340875-20100517-AV04	WG-160340875-20101025-JK3
Sampling Company			STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC
Laboratory			MAXX	MAXX	BV	BV	BV	BV	BV	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	BV	BV	BV	BV	MAXX	MAXX
Laboratory Work Order			B7J0582	B8L6839	B9N2253	C0M1964	C1O3272	C2P0302	C3AC977	B064180	B0F1430	B4F3646	B5J8856	B7J0582	B8L6839	B9N2253	C0M1964	C2P0302	C3AC977	B062483	B0F1430
Laboratory Sample ID			FBA582	HNX850	KOP311	NMK096	QMC305	TPN288	XQK218	FY2698	HP6281	XG4184	BBU091	FBA580	HNX848	KOP305	NMK091	TPN284	XQK215	FX4444	HP6283
Sample Type	Units	ODWS																			
Field Parameters																					
Dissolved Oxygen, Field	mg/L	n/v	7.60	1.5	1.1	-	2.0	-	-	6.6	-	-	19.08	11.29	6.9	8.8	-	-	-	2.9	-
General Chemistry																					
Alkalinity, Bicarbonate (as CaCO3)	mg/L	n/v	170	170	170	160	170	150	360	223	229	240	250	260	270	260	270	270	240	309	338
Alkalinity, Carbonate (as CaCO3)	mg/L	n/v	2.6	2.6	4.2	2.2	3.3	3.3	8.1	3	2	1.7	1.7	2.1	2.8	3.1	2.0	2.7	3.1	4	2
Alkalinity, Total (as CaCO3)	mg/L	30-500[D]	170	170	170	170	170	150	360	226	231	240	250	270	270	260	270	270	250	313	340
Ammonia (as N)	mg/L	n/v	0.19	0.31	0.26	0.22	0.17	0.39	0.55	0.09	0.07	0.082	<0.050	<0.050	<0.050	<0.050	0.051	0.11	<0.050	0.09	0.15
Anion Sum	me/L	n/v	3.81	3.69	3.77	3.52	3.72	3.33	7.93	8.65	7.96	7.62	7.99	8.11	8.62	8.43	8.88	8.21	7.96	6.76	7.33
Cation Sum	me/L	n/v	3.30	3.20	3.32	3.30	3.12	3.35	3.64	8.18	7.69	7.86	7.84	7.75	7.93	8.28	8.22	8.34	7.97	7.18	7.52
Chloride	mg/L	250[B]	4.7	4.4	8.1	3.9	4.4	4.8	<20 DB	28	23	15	17	17	20	22	24	29	31	6	6
Dissolved Organic Carbon (DOC)	mg/L	5[B]	3.2	**5.2[B]**	3.5	3.1	3.1	3.3	**5.9[B]**	1.7	1.7	1.6	1.9	1.5	1.6	1.3	1.3	1.2	1.4	1.4	1.7
Electrical Conductivity, Lab	µmhos/cm	n/v	340	330	300	300	300	300	340	847	774	720	760	760	800	790	820	760	780	625	667
Hardness (as CaCO3)	mg/L	80-100[D]	**44[D]**	**41[D]**	**40[D]**	**42[D]**	**40[D]**	**39[D]**	**44[D]**	**390[D]**	**360[D]**	**360[D]**	**360[D]**	**360[D]**	**380[D]**	**390[D]**	**380[D]**	**390[D]**	**370[D]**	**350[D]**	**370[D]**
Ion Balance	%	n/v	7.17	7.11	6.47	3.26	8.67	0.240	37.1	2.78	1.70	1.54	0.950	2.26	4.18	0.890	3.83	0.730	0.0700	2.99	1.29
Langelier Index (at 20 C)	none	n/v	0.122	0.0910	0.289	0.0380	0.183	0.177	0.578	0.989	0.733	0.780	0.787	0.853	0.991	1.03	0.838	0.987	1.05	1.13	0.896
Langelier Index (at 4 C)	none	n/v	-0.128	-0.159	0.0390	-0.212	-0.0670	-0.0730	0.329	0.741	0.485	0.532	0.539	0.605	0.743	0.781	0.590	0.739	0.806	0.883	0.647
Nitrate (as N)	mg/L	10.0_g[A]	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	**37[A]**	**28[A]**	**22.5[A]**	**24.3[A]**	**24.9[A]**	**28.2[A]**	**28.0[A]**	**30.2[A]**	**22.2[A]**	**24.1[A]**	2.1	2.9
Nitrate + Nitrite (as N)	mg/L	10.0_g[A]	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	**37[A]**	**28[A]**	**22.5[A]**	**24.3[A]**	**24.9[A]**	**28.2[A]**	**28.0[A]**	**30.2[A]**	**22.2[A]**	**24.1[A]**	2.1	2.9
Nitrite (as N)	mg/L	1.0_g[A]	<0.010	<0.010	<0.010	<0.010	<0.010	0.029	0.014	0.03	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.02	<0.01
Orthophosphate (as P)	mg/L	n/v	0.10	0.081	0.13	0.12	0.14	0.094	0.34	<0.01	0.03	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.01	0.01
pH, lab	S.U.	6.5-8.5[D]	8.22	8.21	8.42	8.16	8.31	8.36	8.38	8.1	7.86	7.89	7.87	7.94	8.05	8.10	7.90	8.04	8.13	8.1	7.80
Saturation pH (at 20 C)	none	n/v	8.09	8.12	8.13	8.12	8.13	8.18	7.80	7.13	7.13	7.11	7.08	7.08	7.05	7.07	7.06	7.05	7.08	6.95	6.90
Saturation pH (at 4 C)	none	n/v	8.34	8.37	8.38	8.37	8.38	8.43	8.05	7.38	7.37	7.36	7.33	7.33	7.30	7.32	7.31	7.30	7.33	7.20	7.15
Sulfate	mg/L	500_h[B]	10	7.9	2.9	4.6	4.6	5.3	30	35	34	35	37	26	30	26	30	21	21	9	8
Total Dissolved Solids (Calculated)	mg/L	500[B]	200	190	200	190	190	190	340	**519[B]**	469	450	470	460	490	490	**510[B]**	470	460	349	375
Metals																					
Aluminum	mg/L	0.1[D]	0.0086	0.0088	0.056	0.076	0.058	0.018	0.052	<0.005	0.024	0.0050	<0.0050	0.0067	<0.0050	0.0059	0.0053	0.0086	<0.0049	<0.005	<0.005
Antimony	mg/L	0.006[A]	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.0006	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005
Arsenic	mg/L	0.01[A]	0.0033	0.0034	0.0043	0.0042	0.0040	0.0042	0.0046	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.001	<0.001
Barium	mg/L	1[A]	0.017	0.017	0.018	0.014	0.015	0.017	0.030	0.067	0.050	0.074	0.074	0.067	0.054	0.056	0.050	0.048	0.043	0.047	0.058
Beryllium	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.0005	<0.0005
Boron	mg/L	5[A]	0.15	0.14	0.16	0.15	0.15	0.15	0.13	0.02	0.02	0.024	0.020	0.021	0.012	0.019	0.017	0.020	0.021	<0.01	0.01
Cadmium	mg/L	0.005[A]	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001
Calcium	mg/L	n/v	11	11	10	11	10	10	12	96	94	92	96	90	96	95	94	97	97	96	100
Chromium	mg/L	0.05[A]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005
Cobalt	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005
Copper	mg/L	1[B]	<0.0010	<0.0010	<0.0010	<0.00090	0.0015	<0.00090	<0.00090	0.003	0.002	0.0020	0.0021	<0.0010	<0.0010	<0.0010	0.0015	0.0013	<0.00090	0.002	0.002
Iron	mg/L	0.3[B]	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1
Lead	mg/L	0.01[A]	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005
Magnesium	mg/L	n/v	3.7	3.4	3.4	3.4	3.4	3.3	3.6	35	31	31	29	33	33	37	36	36	32	26	27
Manganese	mg/L	0.05[B]	0.021	0.021	0.017	0.019	0.022	0.014	0.015	0.047	0.008	<0.0020	<0.0020	0.0032	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.028	0.036
Molybdenum	mg/L	n/v	0.038	0.038	0.040	0.038	0.037	0.037	0.030	0.001	<0.001	0.0010	<0.00050	0.00071	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.001	<0.001
Nickel	mg/L	n/v	<0.0010	<0.0010	0.0017	<0.0010	<0.0010	<0.0010	<0.0010	0.002	<0.001	0.0010	<0.0010	<0.0010	0.0015	<0.0010	<0.0010	<0.0010	<0.0010	0.002	0.001
Phosphorus	mg/L	n/v	0.19	0.19	0.18	0.18	0.18	0.10	<0.10	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1
Potassium	mg/L	n/v	0.64	0.60	0.59	0.56	0.63	0.67	0.90	2.9	1.8	1.8	1.7	5.0	3.4	5.1	4.2	5.0	2.6	1.4	1.9
Selenium	mg/L	0.05[A]	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.002	<0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.002	<0.002
Silicon	mg/L	n/v	4.6	4.4	5.0	5.0	4.2	4.6	4.5	6.8	6.6	7.3	6.8	6.0	6.3	7.0	6.9	6.9	6.8	4.4	5.0
Silver	mg/L	n/v	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001
Sodium	mg/L	200_g[B] 20_g[C]	**55[C]**	**54[C]**	**57[C]**	**56[C]**	**53[C]**	**58[C]**	**62[C]**	8.9	9.0	14	14	9.4	7.9	9.0	10	8.9	10	3.7	3.8
Strontium	mg/L	n/v	0.22	0.22	0.21	0.21	0.22	0.22	0.25	0.22	0.16	0.14	0.15	0.20	0.16	0.19	0.17	0.18	0.17	0.17	0.20
Thallium	mg/L	n/v	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00005	<0.00005
Titanium	mg/L	n/v	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005
Uranium	mg/L	0.02[A]	0.00032	0.00042	0.00039	0.00031	0.00033	0.0016	0.0035	0.0032	0.0009	0.0010	0.00081	0.00098	0.00049	0.00052	0.00049	0.00047	0.00048	0.0012	0.0013
Vanadium	mg/L	n/v	<0.00050	<0.00050	0.0015	0.0015	0.0017	0.0036	0.0032	<0.001	<0.001	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.001	<0.001
Zinc	mg/L	5[B]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.086	0.017	0.0050	0.020	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.009	0.006

See notes on last page.

Table 3
Summary of Groundwater Analytical Results
Waterloo North Hydrogeological Assessment

Sample Location			MW5-10		MW6-10												MW7-10				
Sample Date			17-May-10	26-Oct-10	17-May-10	27-Oct-10	22-Aug-14	28-Sep-15	26-Aug-16	5-Sep-17	21-Aug-18	20-Aug-19	26-Aug-20	24-Aug-21	30-Aug-22	16-Nov-23	17-May-10	26-Oct-10	22-Aug-14	28-Sep-15	26-Aug-16
Sample ID			WG-160340875-20100517-AV08	WG-160340875-20101026-JK9	WG-160340875-20100517-AV01	WG-160340875-20101027-JK 15	WG-160310875-20140822-AV11	WG-160310875-20150928-AV05	WG-160310875-20160826-AV09	WG-160310875-20170905-AV10	WG-160310875-20180821-DS01	WG-161450875-20190820-DS03	WG-161450875-20200826-DS-04	WG-161450875-20210824-AV02	WG-161450875-20220830-JM06	MW6-10	WG-160340875-20100517-AV02	WG-160340875-20101026-JK11	WG-160310875-20140822-AV12	WG-160310875-20150928-AV02	WG-160310875-20160826-AV10
Sampling Company			STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC
Laboratory			MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	BV	BV	BV	BV	BV	MAXX	MAXX	MAXX	MAXX	MAXX
Laboratory Work Order			B062483	B0F2316	B062483	B0F3108	B4F3646	B5J8856	B6I3010	B7J2479	B8L6839	B9N2253	C0M1964	C1O3272	C2P0302	C3AC977	B062483	B0F2316	B4F3646	B5J8856	B6I3010
Laboratory Sample ID			FX4448	HQ0825	FX4441	HQ4303	XG4194	BBU090	CYS145	FBK361	HNX846	KOP307	NMK093	QMC302	TPN289	XQK217	FX4442	HQ0827	XG4195	BBU087	CYS146
Sample Type	Units	ODWS																			
Field Parameters																					
Dissolved Oxygen, Field	mg/L	n/v	4.9	2.5	7.7	1.0	-	32.43	10.33	11.57	7.7	8.2	-	7.5	-	-	6.9	1.2	-	-	11.48
General Chemistry																					
Alkalinity, Bicarbonate (as CaCO3)	mg/L	n/v	252	317	130	153	160	180	180	180	180	180	190	170	180	180	267	313	250	280	280
Alkalinity, Carbonate (as CaCO3)	mg/L	n/v	2	2	1	2	1.3	<1.0	1.8	1.6	2.7	2.0	1.5	1.6	1.8	1.6	2	3	2.1	1.9	2.5
Alkalinity, Total (as CaCO3)	mg/L	30-500[D]	254	319	132	155	170	180	180	180	190	180	200	170	180	180	269	316	260	280	280
Ammonia (as N)	mg/L	n/v	0.07	0.19	<0.05	0.05	<0.050	0.11	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.06	0.09	<0.050	<0.050	<0.050
Anion Sum	me/L	n/v	5.51	6.85	4.53	5.28	5.27	5.23	5.02	4.89	4.67	5.08	4.94	5.75	5.37	4.93	6.23	7.18	5.55	6.24	6.35
Cation Sum	me/L	n/v	6.28	7.10	4.63	5.40	5.23	4.91	5.06	4.81	4.31	5.14	4.68	5.46	5.48	4.92	7.31	7.23	5.79	6.24	6.34
Chloride	mg/L	250[B]	7	7	4	14	12	11	6.8	4.9	7.4	11	12	28	23	14	10	10	6	8.7	12
Dissolved Organic Carbon (DOC)	mg/L	5[B]	0.8	1.3	1.2	1.6	0.79	1.1	1.0	1.1	1.3	1.1	0.92	0.93	0.93	1.0	0.9	1.2	0.48	0.69	0.56
Electrical Conductivity, Lab	µmhos/cm	n/v	508	621	469	531	530	510	500	480	430	500	470	570	510	490	571	654	510	570	590
Hardness (as CaCO3)	mg/L	80-100[D]	**310[D]**	**340[D]**	**230[D]**	**260[D]**	**250[D]**	**240[D]**	**240[D]**	**230[D]**	**210[D]**	**250[D]**	**230[D]**	**270[D]**	**260[D]**	**240[D]**	**350[D]**	**350[D]**	**280[D]**	**300[D]**	**310[D]**
Ion Balance	%	n/v	6.60	1.75	1.07	1.06	0.400	3.24	0.450	0.800	4.02	0.580	2.69	2.64	1.06	0.160	8.00	0.350	2.05	0.0100	0.0700
Langelier Index (at 20 C)	none	n/v	0.923	0.902	0.564	0.767	0.626	0.429	0.743	0.692	0.871	0.826	0.661	0.730	0.788	0.708	0.936	1.02	0.846	0.808	0.954
Langelier Index (at 4 C)	none	n/v	0.674	0.654	0.315	0.518	0.376	0.180	0.494	0.442	0.621	0.577	0.412	0.481	0.539	0.459	0.687	0.769	0.597	0.559	0.705
Nitrate (as N)	mg/L	10.0_d[A]	1.1	1.1	**23[A]**	**23[A]**	**20.3[A]**	**15.9[A]**	**15.1[A]**	**12.8[A]**	8.29	**12.9[A]**	7.40	**18.8[A]**	**11.9[A]**	9.30	2.6	3.0	1.87	2.56	3.54
Nitrate + Nitrite (as N)	mg/L	10.0_d[A]	1.1	1.1	**23[A]**	**23[A]**	**20.3[A]**	**15.9[A]**	**15.1[A]**	**12.8[A]**	8.29	**12.9[A]**	7.40	**18.8[A]**	**11.9[A]**	9.30	2.6	3.0	1.87	2.56	3.54
Nitrite (as N)	mg/L	1.0_d[A]	<0.01	<0.01	<0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.01	<0.01	<0.010	<0.010	<0.010
Orthophosphate (as P)	mg/L	n/v	<0.01	<0.01	<0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.01	<0.01	<0.010	<0.010	<0.010
pH, lab	S.U.	6.5-8.5[D]	8.0	7.82	8.0	8.10	7.93	7.71	8.02	7.97	8.19	8.08	7.92	8.01	8.03	7.98	7.9	7.96	7.95	7.85	7.99
Saturation pH (at 20 C)	none	n/v	7.07	6.91	7.45	7.33	7.30	7.28	7.27	7.28	7.32	7.25	7.26	7.28	7.24	7.27	7.01	6.94	7.11	7.04	7.04
Saturation pH (at 4 C)	none	n/v	7.32	7.16	7.70	7.58	7.55	7.53	7.52	7.53	7.57	7.50	7.51	7.53	7.49	7.52	7.25	7.19	7.36	7.29	7.29
Sulfate	mg/L	500_h[B]	7	10	6	7	8	7.0	6.1	7.6	8.3	9.8	7.8	12	11	9.5	18	18	7	9.9	9.0
Total Dissolved Solids (Calculated)	mg/L	500[B]	296	355	283	323	310	300	290	280	250	290	260	330	310	270	344	373	290	320	330
Metals																					
Aluminum	mg/L	0.1[D]	<0.005	<0.005	0.007	0.006	0.013	<0.0050	<0.0050	0.0063	<0.0050	<0.0050	<0.0049	<0.0049	<0.0049	<0.0049	<0.005	<0.005	<0.0050	<0.0050	<0.0050
Antimony	mg/L	0.006[A]	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050
Arsenic	mg/L	0.01[A]	<0.001	<0.001	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.001	<0.001	<0.0010	<0.0010	<0.0010
Barium	mg/L	1[A]	0.024	0.032	0.017	0.015	0.020	0.016	0.019	0.017	0.014	0.019	0.018	0.019	0.038	0.017	0.025	0.021	0.015	0.015	0.014
Beryllium	mg/L	n/v	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050
Boron	mg/L	5[A]	0.01	0.01	<0.01	<0.01	0.010	<0.010	<0.010	<0.010	<0.010	0.012	0.010	0.013	0.011	0.011	<0.01	<0.01	<0.010	<0.010	<0.010
Cadmium	mg/L	0.005[A]	<0.0001	<0.0001	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	0.0001	<0.00010	<0.00010	<0.00010
Calcium	mg/L	n/v	89	100	69	80	80	74	77	73	66	80	71	83	84	76	99	100	80	86	88
Chromium	mg/L	0.05[A]	<0.005	<0.005	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050
Cobalt	mg/L	n/v	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050
Copper	mg/L	1[B]	0.002	0.002	0.002	0.002	0.0020	0.0012	0.0034	0.0038	0.0018	0.0024	0.0027	0.0026	0.0047	0.0012	0.002	0.001	0.0010	<0.0010	0.0010
Iron	mg/L	0.3[B]	<0.1	<0.1	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10	<0.10
Lead	mg/L	0.01[A]	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.0012	<0.0005	<0.00050	<0.00050	<0.00050
Magnesium	mg/L	n/v	20	21	13	15	13	13	13	12	11	12	12	14	13	12	26	24	20	21	21
Manganese	mg/L	0.05[B]	0.028	**0.059[B]**	<0.002	<0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.0023	<0.0020	<0.0020	<0.0020	<0.0020	0.012	<0.002	<0.0020	<0.0020	<0.0020
Molybdenum	mg/L	n/v	0.002	<0.001	<0.001	<0.001	0.0010	<0.00050	0.00054	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00054	<0.00050	<0.001	<0.001	<0.00050	<0.00050	<0.00050
Nickel	mg/L	n/v	<0.001	0.001	<0.001	<0.001	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.001	<0.001	0.0010	<0.0010	<0.0010
Phosphorus	mg/L	n/v	<0.1	<0.1	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10	<0.10
Potassium	mg/L	n/v	1.5	1.8	2.2	1.9	4.6	2.5	4.9	4.5	2.8	5.3	4.6	2.9	5.2	3.4	0.8	0.8	0.68	0.72	0.71
Selenium	mg/L	0.05[A]	<0.002	<0.002	<0.002	<0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.002	<0.002	<0.0020	<0.0020	<0.0020
Silicon	mg/L	n/v	5.1	5.8	2.6	3.3	2.7	3.1	2.9	2.8	2.7	2.8	2.7	2.9	3.0	2.9	5.8	5.8	5.3	5.3	5.3
Silver	mg/L	n/v	<0.0001	<0.0001	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010
Sodium	mg/L	200_g[B] 20_g[C]	3.4	3.6	1.6	2.7	1.7	1.3	1.5	1.3	1.1	1.3	1.2	1.4	1.6	1.4	5.1	5.3	3.5	3.6	3.8
Strontium	mg/L	n/v	0.15	0.16	0.081	0.10	0.099	0.10	0.11	0.10	0.088	0.11	0.098	0.12	0.11	0.11	0.11	0.12	0.086	0.10	0.10
Thallium	mg/L	n/v	<0.00005	<0.00005	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050
Titanium	mg/L	n/v	<0.005	<0.005	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050
Uranium	mg/L	0.02[A]	0.0009	0.0007	0.0002	<0.0001	<0.00010	0.00019	0.00018	0.00017	0.00018	0.00018	0.00019	0.00016	0.00018	0.00017	0.0002	0.0002	<0.00010	0.00019	0.00019
Vanadium	mg/L	n/v	<0.001	0.004	<0.001	0.001	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.001	<0.001	<0.00050	<0.00050	<0.00050
Zinc	mg/L	5[B]	0.043	0.044	0.006	0.006	0.0070	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.014	0.006	0.0080	<0.0050	<0.0050

See notes on last page.

Table 3
Summary of Groundwater Analytical Results
Waterloo North Hydrogeological Assessment

Sample Location			MW7-10 (Contd.)							MW8-10D											
Sample Date			5-Sep-17	21-Aug-18	20-Aug-19	26-Aug-20	25-Aug-21	29-Aug-22	17-Nov-23	18-May-10	26-Oct-10	22-Aug-14	29-Sep-15	24-Aug-16	5-Sep-17	22-Aug-18	20-Aug-19	26-Aug-20	25-Aug-21	6-Sep-22	17-Nov-23
Sample ID			WG-160310875-20170905-AV11	WG-160310875-20180821-DS02	WG-161450875-20190820-DS04	WG-161450875-20200826-DS-01	WG-161450875-20210825-AV10	WG-161450875-20220829-JM03	MW7-10	WG-160340875-20100518-AV11	WG-160340875-20101026-JK5	WG-160310875-20140822-AV08	WG-160310875-20150929-AV010	WG-160310875-20160824-AV03	WG-160310875-20170905-AV08	WG-160310875-20180822-DS07	WG-161450875-20190820-DS05	WG-161450875-20200826-DS-06	WG-161450875-20210825-AV09	WG-161459875-20220906-JM11	MW8-10D
Sampling Company			STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC
Laboratory			MAXX	BVL6839	BV	BV	BV	BV	BV	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	BV	BV	BV	BV	BV
Laboratory Work Order			B7J2479	HNX847	B9N2253	C0M1964	C1O3272	C2P0302	C3AC977	B064180	B0F2316	B4F3646	B5J8856	B6I3010	B7J2479	B8L6839	B9N2253	C0M1964	C1O3272	C2P6965	C3AC977
Laboratory Sample ID			FBK362	HNX847	KOP308	NMK090	QMC310	TPN286	XQK223	FY2696	HQ0821	XG4191	BBU095	CYS139	FBK359	HNX852	KOP309	NMK095	QMC309	TQZ171	XQK219
Sample Type	Units	ODWS																			
Field Parameters																					
Dissolved Oxygen, Field	mg/L	n/v	9.67	6.6	7.2	-	7.64	-	-	0.7	0.8	-	1.65	3.83	2.82	0.2	0.5	-	0.34	-	-
General Chemistry																					
Alkalinity, Bicarbonate (as CaCO3)	mg/L	n/v	300	320	320	360	360	340	380	238	233	240	240	240	240	240	230	230	230	230	230
Alkalinity, Carbonate (as CaCO3)	mg/L	n/v	2.4	2.6	2.4	2.4	3.2	2.6	2.3	3	2	2.1	1.8	2.9	2.2	2.5	2.7	1.7	2.2	2.8	1.9
Alkalinity, Total (as CaCO3)	mg/L	30-500[D]	310	320	320	360	360	340	380	241	235	240	240	240	240	240	240	240	240	230	230
Ammonia (as N)	mg/L	n/v	<0.050	<0.050	0.060	0.10	<0.050	<0.050	<0.050	0.11	0.18	0.12	0.087	0.12	0.10	0.11	0.14	0.14	0.072	0.087	0.12
Anion Sum	me/L	n/v	7.06	7.68	7.67	8.61	8.69	8.34	9.14	7.50	7.25	6.94	7.00	7.02	6.98	6.89	6.88	6.73	7.16	6.69	7.04
Cation Sum	me/L	n/v	7.15	7.48	8.03	8.61	8.28	8.70	9.23	7.17	7.43	7.17	6.92	7.01	7.20	6.34	6.93	6.70	7.28	6.97	7.26
Chloride	mg/L	250[B]	16	18	12	15	17	16	15	11	7	26	26	23	20	12	20	14	23	23	18
Dissolved Organic Carbon (DOC)	mg/L	5[B]	0.69	0.79	0.64	0.71	0.64	0.91	0.70	**7.1[B]**	**7.5[B]**	0.74	0.86	0.62	0.70	0.67	0.54	0.55	0.57	0.51	0.64
Electrical Conductivity, Lab	µmhos/cm	n/v	660	690	710	770	760	740	850	688	673	660	660	670	650	620	640	590	660	610	680
Hardness (as CaCO3)	mg/L	80-100[D]	**350[D]**	**360[D]**	**390[D]**	**410[D]**	**390[D]**	**420[D]**	**440[D]**	**290[D]**	**320[D]**	**290[D]**	**290[D]**	**300[D]**	**310[D]**	**280[D]**	**300[D]**	**300[D]**	**310[D]**	**300[D]**	**320[D]**
Ion Balance	%	n/v	0.660	1.31	2.25	0.0300	2.39	2.15	0.500	2.23	1.26	1.59	0.550	0.0400	1.55	4.17	0.360	0.250	0.840	2.00	1.53
Langelier Index (at 20 C)	none	n/v	0.963	1.01	1.01	1.02	1.12	1.07	1.04	0.977	0.804	0.818	0.756	0.965	0.858	0.880	0.937	0.746	0.876	0.959	0.816
Langelier Index (at 4 C)	none	n/v	0.715	0.760	0.766	0.770	0.869	0.821	0.789	0.729	0.556	0.569	0.508	0.716	0.610	0.631	0.688	0.498	0.627	0.709	0.568
Nitrate (as N)	mg/L	10.0_g[A]	5.04	6.06	9.14	9.04	7.25	8.54	8.72	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Nitrate + Nitrite (as N)	mg/L	10.0_g[A]	5.04	6.06	9.14	9.08	7.25	8.54	8.72	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Nitrite (as N)	mg/L	1.0_g[A]	<0.010	<0.010	<0.010	0.043	<0.010	<0.010	<0.010	<0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Orthophosphate (as P)	mg/L	n/v	<0.050 DB	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
pH, lab	S.U.	6.5-8.5[D]	7.93	7.93	7.90	7.85	7.97	7.91	7.81	8.1	7.93	7.98	7.91	8.11	7.99	8.05	8.09	7.90	8.01	8.11	7.94
Saturation pH (at 20 C)	none	n/v	6.96	6.92	6.89	6.83	6.85	6.84	6.77	7.17	7.13	7.16	7.16	7.15	7.13	7.17	7.15	7.15	7.13	7.15	7.12
Saturation pH (at 4 C)	none	n/v	7.21	7.17	7.14	7.08	7.10	7.09	7.02	7.41	7.38	7.41	7.40	7.39	7.38	7.42	7.40	7.40	7.38	7.40	7.37
Sulfate	mg/L	500_h[B]	6.9	15	13	18	19	20	21	110	110	69	72	77	77	80	77	78	86	68	89
Total Dissolved Solids (Calculated)	mg/L	500[B]	370	400	420	460	450	450	490	423	419	390	390	390	400	370	390	380	410	380	400
Metals																					
Aluminum	mg/L	0.1[D]	<0.0050	<0.0050	<0.0050	<0.0049	<0.0049	0.022	<0.0049	<0.005	0.007	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0049	<0.0049	<0.0049	<0.0049
Antimony	mg/L	0.006[A]	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic	mg/L	0.01[A]	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.004	0.004	0.0040	0.0046	0.0043	0.0044	0.0044	0.0045	0.0043	0.0044	0.0044	0.0044
Barium	mg/L	1[A]	0.016	0.017	0.018	0.020	0.021	0.023	0.025	0.049	0.045	0.039	0.041	0.044	0.044	0.042	0.044	0.044	0.046	0.048	0.049
Beryllium	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040
Boron	mg/L	5[A]	<0.010	<0.010	<0.010	<0.010	0.011	<0.010	0.010	0.04	0.03	0.036	0.030	0.029	0.036	0.030	0.035	0.033	0.043	0.035	0.037
Cadmium	mg/L	0.005[A]	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090
Calcium	mg/L	n/v	98	100	110	120	110	120	130	80	90	81	81	83	86	77	83	83	88	84	90
Chromium	mg/L	0.05[A]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Cobalt	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Copper	mg/L	1[B]	<0.0010	0.0012	<0.0010	<0.00090	0.0015	<0.00090	<0.00090	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.00090	<0.00090	<0.00090	<0.00090
Iron	mg/L	0.3[B]	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	**0.5[B]**	**0.6[B]**	**0.73[B]**	**0.69[B]**	**0.76[B]**	**0.84[B]**	**0.80[B]**	**0.79[B]**	**0.77[B]**	**0.95[B]**	**0.93[B]**	**0.93[B]**
Lead	mg/L	0.01[A]	<0.00050	<0.00050	<0.00050	<0.00050	0.0012	<0.00050	<0.00050	<0.0005	<0.0005	0.0020	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Magnesium	mg/L	n/v	25	25	26	29	29	29	30	22	23	23	22	22	23	22	22	22	22	22	23
Manganese	mg/L	0.05[B]	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.0047	<0.0020	**0.075[B]**	**0.12[B]**	**0.11[B]**	**0.097[B]**	**0.099[B]**	**0.090[B]**	**0.076[B]**	**0.077[B]**	**0.072[B]**	**0.086[B]**	**0.069[B]**	**0.066[B]**
Molybdenum	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.004	0.004	0.0010	0.0014	0.0013	0.0012	0.0011	0.0012	0.0011	0.0013	0.0013	0.0012
Nickel	mg/L	n/v	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus	mg/L	n/v	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.12	<0.10
Potassium	mg/L	n/v	0.78	0.79	0.77	0.89	0.92	0.97	1.0	1.3	1.3	1.0	0.94	0.92	0.96	0.86	0.87	0.87	0.90	0.89	0.93
Selenium	mg/L	0.05[A]	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.002	<0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicon	mg/L	n/v	5.9	5.5	6.1	6.3	5.7	6.3	6.8	9.1	9.4	9.4	9.1	8.8	9.6	8.4	9.2	9.2	8.8	9.3	9.4
Silver	mg/L	n/v	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090
Sodium	mg/L	200_g[B] 20_g[C]	4.9	5.2	5.6	6.7	8.7	6.2	8.1	**30[C]**	**24[C]**	**28[C]**	**23[C]**	**23[C]**	**22[C]**	15	20	16	**23[C]**	**21[C]**	19
Strontium	mg/L	n/v	0.12	0.13	0.13	0.14	0.15	0.15	0.17	1.6	1.7	1.5	1.3	1.3	1.5	1.5	1.5	1.3	1.5	1.4	1.4
Thallium	mg/L	n/v	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Titanium	mg/L	n/v	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Uranium	mg/L	0.02[A]	0.00021	0.00023	0.00024	0.00025	0.00026	0.00024	0.00023	0.0006	0.0005	<0.00010	0.00030	0.00029	0.00026	0.00019	0.00023	0.00022	0.00025	0.00021	0.00019
Vanadium	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.001	<0.001	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc	mg/L	5[B]	<0.0050	<0.0050	0.0075	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050

See notes on last page.

Table 3
Summary of Groundwater Analytical Results
Waterloo North Hydrogeological Assessment

Sample Location			MW8-10S												MW9-10D		MW9-10S		MW10-10		
Sample Date			18-May-10	26-Oct-10	22-Aug-14	29-Sep-15	24-Aug-16	5-Sep-17	21-Aug-18	20-Aug-19	26-Aug-20	25-Aug-21	30-Aug-22	17-Nov-23	20-May-10	27-Oct-10	18-May-10	26-Oct-10	17-May-10	27-Oct-10	21-Aug-14
Sample ID			WG-160340875-20100518-AV12	WG-160340875-20101026-JK4	WG-160310875-20140822-AV09	WG-160310875-20150929-AV011	WG-160310875-20160824-AV04	WG-160310875-20170905-AV09	WG-150310875-20180821-SB01	WG-161450875-20190820-DS06	WG-161450875-20200826-DS-05	WG-161450875-20210825-AV11	WG-161450875-20220830-JM07	MW8-10S	WG-160340875-20100520-AV18	WG-160340875-20101027-JK 14	WG-160340875-20100518-AV10	WG-160340875-20101026-JK10	WG-160340875-20100517-AV06	WG-160340875-20101027-JK 16	WG-160310875-20140821-AV05
Sampling Company			STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC
Laboratory			MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	BV	BV	BV	BV	BV	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX
Laboratory Work Order			B064180	B0F2316	B4F3646	B5J8856	B6I3010	B7J2479	B8L6839	B9N2253	C0M1964	C1O3272	C2P0302	C3AC977	B064180	B0F3108	B064180	B0F2316	B062483	B0F3108	B4F3646
Laboratory Sample ID			FY2697	HQ0820	XG4192	BBU096	CYS140	FBK360	HNX842	KOP310	NMK094	QMC311	TPN290	XQK220	FY2703	HQ4302	FY2695	HQ0826	FX4446	HQ4304	XG4188
Sample Type	Units	ODWS																			
Field Parameters																					
Dissolved Oxygen, Field	mg/L	n/v	0	-	-	3.64	6.91	3.08	0.9	0.6	-	-	-	-	2.2	0.8	0	0.5	0	-	-
General Chemistry																					
Alkalinity, Bicarbonate (as CaCO3)	mg/L	n/v	278	307	350	310	300	310	250	300	320	310	300	290	228	217	238	235	239	248	250
Alkalinity, Carbonate (as CaCO3)	mg/L	n/v	3	2	3.0	2.1	2.0	2.5	1.5	2.2	2.1	2.2	2.2	1.5	4	4	3	2	4	3	2.4
Alkalinity, Total (as CaCO3)	mg/L	30-500[D]	281	309	350	320	310	310	260	300	330	310	310	290	232	221	241	237	243	251	260
Ammonia (as N)	mg/L	n/v	0.09	<0.05	0.065	<0.050	<0.050	<0.050	0.079	0.088	0.051	<0.050	<0.050	0.077	<0.05	0.19	0.17	0.27	0.23	0.34	0.32
Anion Sum	me/L	n/v	29.3	34.3	21.7	22.2	26.9	28.9	33.2	32.1	30.1	28.5	29.9	27.9	6.08	5.74	7.66	6.01	5.26	5.51	5.49
Cation Sum	me/L	n/v	30.6	36.1	23.6	22.7	27.0	29.2	33.7	32.4	31.3	27.5	31.5	35.4	5.89	6.43	7.04	6.14	5.40	5.53	5.48
Chloride	mg/L	250[B]	**800[B]**	**970[B]**	**500[B]**	**550[B]**	**720[B]**	**790[B]**	**980[B]**	**910[B]**	**810[B]**	**770[B]**	**820[B]**	**760[B]**	11	8	13	14	2	2	2
Dissolved Organic Carbon (DOC)	mg/L	5[B]	2.1	2.1	2.4	1.5	1.3	1.8	2.2	1.3	1.7	1.4	1.4	2.0	1.6	3.9	1.2	1.4	1.0	1.5	2.2
Electrical Conductivity, Lab	µmhos/cm	n/v	3,330	3,680	2,400	2,400	2,900	3,100	3,600	3,300	3,300	2,900	3,200	3,200	569	542	714	558	474	489	480
Hardness (as CaCO3)	mg/L	80-100[D]	**530[D]**	**600[D]**	**280[D]**	**290[D]**	**410[D]**	**480[D]**	**600[D]**	**590[D]**	**530[D]**	**480[D]**	**520[D]**	**840[D]**	**230[D]**	**240[D]**	**230[D]**	**220[D]**	**250[D]**	**260[D]**	**250[D]**
Ion Balance	%	n/v	2.16	2.57	4.12	1.06	0.0700	0.440	0.620	0.500	2.05	1.67	2.58	11.9	1.57	5.67	4.22	1.02	1.33	0.210	0.0900
Langelier Index (at 20 C)	none	n/v	1.05	0.849	0.871	0.723	0.824	0.979	0.846	0.996	0.932	0.911	0.944	0.986	0.896	0.906	0.734	0.679	0.979	0.902	0.726
Langelier Index (at 4 C)	none	n/v	0.808	0.606	0.626	0.478	0.579	0.734	0.602	0.752	0.688	0.667	0.700	0.742	0.647	0.657	0.486	0.430	0.730	0.653	0.477
Nitrate (as N)	mg/L	10.0_d[A]	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.13
Nitrate + Nitrite (as N)	mg/L	10.0_d[A]	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.14
Nitrite (as N)	mg/L	1.0_d[A]	0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.01	0.02	0.02	0.01	<0.01	0.12	0.013
Orthophosphate (as P)	mg/L	n/v	<0.01	<0.01	<0.010	<0.010	<0.010	<0.050 DB	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.010
pH, lab	S.U.	6.5-8.5[D]	8.0	7.74	7.96	7.85	7.84	7.93	7.81	7.88	7.83	7.87	7.88	7.75	8.2	8.24	8.1	8.01	8.3	8.16	8.00
Saturation pH (at 20 C)	none	n/v	6.97	6.89	7.09	7.13	7.01	6.95	6.97	6.89	6.90	6.96	6.94	6.76	7.32	7.34	7.35	7.34	7.29	7.26	7.28
Saturation pH (at 4 C)	none	n/v	7.22	7.13	7.33	7.38	7.26	7.20	7.21	7.13	7.15	7.21	7.18	7.00	7.57	7.59	7.59	7.59	7.54	7.51	7.52
Sulfate	mg/L	500_h[B]	50	40	24	21	24	16	19	22	28	24	24	23	55	53	120	42	17	20	15
Total Dissolved Solids (Calculated)	mg/L	500[B]	**1,680[B]**	**1,980[B]**	**1,300[B]**	**1,300[B]**	**1,500[B]**	**1,600[B]**	**1,900[B]**	**1,800[B]**	**1,700[B]**	**1,600[B]**	**1,700[B]**	**1,700[B]**	327	326	425	330	279	293	290
Metals																					
Aluminum	mg/L	0.1[D]	0.006	0.017	0.0080	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0049	<0.0049	<0.0049	**0.42[D]**	<0.005	<0.005	0.006	0.081	<0.005	<0.005	0.0050
Antimony	mg/L	0.006[A]	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	0.0007	0.0008	<0.0005	<0.0005	<0.0005	<0.00050
Arsenic	mg/L	0.01[A]	<0.001	<0.005	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.002	0.001	0.003	0.005	**0.011[A]**	**0.012[A]**	**0.015[A]**
Barium	mg/L	1[A]	0.20	0.15	0.11	0.098	0.13	0.16	0.17	0.18	0.17	0.13	0.18	0.15	0.082	0.078	0.12	0.071	0.068	0.068	0.10
Beryllium	mg/L	n/v	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050
Boron	mg/L	5[A]	0.02	0.02	0.011	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.03	0.04	0.03	0.03	0.02	0.03	0.030
Cadmium	mg/L	0.005[A]	<0.0001	0.0002	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.00010
Calcium	mg/L	n/v	160	180	88	89	130	150	180	180	160	150	160	250	55	56	53	52	55	57	54
Chromium	mg/L	0.05[A]	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.0050
Cobalt	mg/L	n/v	0.0012	<0.0005	0.0010	<0.00050	<0.00050	<0.00050	<0.00050	0.00054	<0.00050	<0.00050	<0.00050	0.00070	<0.0005	<0.0005	0.0008	0.0007	0.0010	0.0007	<0.00050
Copper	mg/L	1[B]	0.003	0.002	0.0030	<0.0010	<0.0020 MI	<0.0010	<0.0010	<0.0010	0.0043	0.0028	0.0032	0.0035	<0.001	<0.001	0.001	<0.001	0.001	0.001	0.0010
Iron	mg/L	0.3[B]	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	**1.4[B]**	0.1	<0.1	<0.1	0.2	<0.1	<0.1	0.17
Lead	mg/L	0.01[A]	<0.0005	0.0011	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.0016	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050
Magnesium	mg/L	n/v	32	35	16	16	23	27	35	32	30	28	30	51	22	24	24	22	27	28	28
Manganese	mg/L	0.05[B]	**0.28[B]**	**0.21[B]**	**0.056[B]**	**0.066[B]**	0.037	**0.087[B]**	0.042	**0.064[B]**	**0.058[B]**	0.012	0.020	**0.21[B]**	**0.070[B]**	**0.13[B]**	**0.13[B]**	**0.20[B]**	**0.070[B]**	**0.067[B]**	0.025
Molybdenum	mg/L	n/v	0.004	0.004	0.0010	0.00051	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.006	0.009	0.007	0.004	0.001	0.001	0.0010
Nickel	mg/L	n/v	0.004	0.001	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0011	0.0010	<0.0010	<0.0010	0.0016	0.001	0.010	0.002	<0.001	0.001	0.001	0.0010
Phosphorus	mg/L	n/v	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.31	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10
Potassium	mg/L	n/v	5.8	5.9	3.0	3.1	3.1	3.4	3.7	3.3	3.3	3.0	3.2	3.2	1.3	1.8	2.1	1.7	1.4	1.3	1.5
Selenium	mg/L	0.05[A]	<0.002	<0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0020
Silicon	mg/L	n/v	4.3	4.8	4.4	4.2	4.0	4.5	4.1	4.4	4.5	4.0	4.3	4.9	6.7	6.2	7.0	8.3	11	12	12
Silver	mg/L	n/v	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.00010
Sodium	mg/L	200_g[B] 20_g[C]	**460[BC]**	**550[BC]**	**410[BC]**	**390[BC]**	**430[BC]**	**450[BC]**	**490[BC]**	**470[BC]**	**470[BC]**	**410[BC]**	**480[BC]**	**430[BC]**	**30[C]**	**37[C]**	**54[C]**	**37[C]**	8.1	8.1	9.2
Strontium	mg/L	n/v	0.50	0.46	0.19	0.19	0.28	0.31	0.40	0.39	0.32	0.32	0.35	0.44	0.35	0.63	0.31	0.30	0.29	0.32	0.32
Thallium	mg/L	n/v	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050	<0.000050	0.000054	0.000056	<0.000050	<0.000050	0.000061	0.000062	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.000050
Titanium	mg/L	n/v	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.027	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.0050
Uranium	mg/L	0.02[A]	0.0079	0.0048	0.0010	0.00075	0.00082	0.00094	0.00065	0.00083	0.00074	0.00068	0.00075	0.00094	0.0013	0.0017	0.0029	0.0022	0.0013	0.0005	<0.00010
Vanadium	mg/L	n/v	<0.001	<0.005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.0020	<0.001	0.001	<0.001	<0.001	<0.001	0.001	<0.00050
Zinc	mg/L	5[B]	0.010	0.009	0.012	0.0066	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	0.008	<0.005	0.006	<0.005	0.0090

See notes on last page.

Table 3
Summary of Groundwater Analytical Results
Waterloo North Hydrogeological Assessment

Sample Location			MW10-10 (Contd.)									MW11-10			MW12-10D						
Sample Date			29-Sep-15	24-Aug-16	1-Sep-17	22-Aug-18	20-Aug-19	26-Aug-20	24-Aug-21	30-Aug-22	1-Dec-23	19-May-10	27-Oct-10	22-Aug-14	19-May-10	26-Oct-10	22-Aug-14	29-Sep-15	24-Aug-16	31-Aug-17	22-Aug-18
Sample ID			WG-160310875-20150929-AV07	WG-160310875-20160824-AV05	WG-160310875-20170901-AV07	WG-160310875-20180822-SB03	WG-161450875-20190820-SB02	WG-161450875-20200826-SB-02	WG-161450875-20210824-AV04	WG-161450875-20220830-JM10	MW10-10	WG-160340875-20100519-AV16	WG-160340875-20101027-JK 17	WG-160310875-20140822-AV10	WG-160340875-20100519-AV14	WG-160340875-20101026-JK6	WG-160310875-20140822-AV06	WG-160310875-20150929-AV08	WG-160310875-20160824-AV01	WG-160310875-20170831-AV04	WG-160310875-20180822-DS06
Sampling Company			STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC
Laboratory			MAXX	MAXX	MAXX	MAXX	BV	BV	BV	BV	BV	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX
Laboratory Work Order			B5J8856	B6I3010	B7J0582	B8L6839	B9N2253	C0M1964	C1O3272	C2P0302	C3AT024	B064180	B0F3108	B4F3646	B064180	B0F2316	B4F3646	B5J8856	B6I3010	B7J0582	B8L6839
Laboratory Sample ID			BBU092	CYS141	FBA586	HNX844	KOP302	NMK088	QMC304	TPN293	XTW489	FY2701	HQ4305	XG4193	FY2699	HQ0822	XG4189	BBU093	CYS137	FBA583	HNX851
Sample Type	Units	ODWS																			
Field Parameters																					
Dissolved Oxygen, Field	mg/L	n/v	1.67	0.94	1.76	0.5		-	0.7	-	-	-	-	-	0.7	-	-	1.40	2.60	0.17	0.4
General Chemistry																					
Alkalinity, Bicarbonate (as CaCO3)	mg/L	n/v	250	260	250	260	260	270	260	250	250	241	231	230	271	244	250	250	240	250	250
Alkalinity, Carbonate (as CaCO3)	mg/L	n/v	2.2	3.2	4.1	2.9	3.2	2.1	3.4	3.0	2.0	4	3	2.1	2	1	1.6	1.3	1.8	1.8	2.1
Alkalinity, Total (as CaCO3)	mg/L	30-500[D]	250	260	260	260	260	270	260	250	250	245	234	230	273	245	250	250	250	250	250
Ammonia (as N)	mg/L	n/v	0.27	<0.050	0.20	0.38	0.15	0.19	0.20	0.32	0.18	<0.05	0.08	0.075	0.08	0.29	0.15	0.16	0.15	0.14	0.13
Anion Sum	me/L	n/v	5.45	5.54	5.45	5.54	5.80	5.89	5.69	5.62	5.25	7.47	7.22	6.87	13.0	13.2	12.4	13.9	14.1	13.7	14.0
Cation Sum	me/L	n/v	5.25	5.53	5.47	5.22	5.92	5.81	5.27	11.0	5.60	7.56	7.52	6.77	12.5	13.9	13.5	14.2	14.1	14.0	14.1
Chloride	mg/L	250[B]	1.9	2.3	1.9	1.8	4.9	4.2	2.9	2.4	<1.0	24	33	27	21	20	20	20	20	22	24
Dissolved Organic Carbon (DOC)	mg/L	5[B]	1.0	0.84	0.88	0.87	0.91	0.85	0.87	0.77	0.88	2.0	3.2	1.9	**14.4[B]**	2.8	0.63	0.86	0.79	0.88	0.85
Electrical Conductivity, Lab	µmhos/cm	n/v	480	520	480	480	530	500	490	480	490	739	705	670	1,140	1,210	1,200	1,200	1,300	1,200	1,200
Hardness (as CaCO3)	mg/L	80-100[D]	**240[D]**	**260[D]**	**250[D]**	**240[D]**	**270[D]**	**270[D]**	**240[D]**	**520[D]**	**260[D]**	**190[D]**	**270[D]**	**300[D]**	**560[D]**	**650[D]**	**630[D]**	**660[D]**	**660[D]**	**660[D]**	**660[D]**
Ion Balance	%	n/v	1.89	0.130	0.190	2.93	1.04	0.650	3.87	32.6	3.23	0.610	2.02	0.670	1.80	2.81	4.08	0.820	0.140	1.24	0.460
Langelier Index (at 20 C)	none	n/v	0.684	0.873	0.948	0.794	0.895	0.710	0.847	1.18	0.660	0.832	0.907	0.852	0.991	0.901	0.975	0.897	1.05	1.06	1.12
Langelier Index (at 4 C)	none	n/v	0.435	0.624	0.699	0.545	0.646	0.461	0.598	0.927	0.411	0.584	0.658	0.604	0.745	0.654	0.728	0.650	0.802	0.809	0.872
Nitrate (as N)	mg/L	10.0_d[A]	0.11	<0.10	<0.10	0.15	0.11	0.12	<0.10	0.27	<0.10	**11[A]**	**13[A]**	**16.1[A]**	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10
Nitrate + Nitrite (as N)	mg/L	10.0_d[A]	0.16	0.12	<0.10	0.16	0.14	0.14	<0.10	0.31	<0.10	**11[A]**	**13[A]**	**16.1[A]**	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10
Nitrite (as N)	mg/L	1.0_d[A]	0.056	0.042	<0.010	0.017	0.025	0.029	<0.010	0.036	0.015	0.02	0.08	<0.010	0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010
Orthophosphate (as P)	mg/L	n/v	0.010	0.010	0.013	0.011	<0.010	<0.010	0.017	0.012	<0.010	<0.01	<0.01	0.046	<0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010
pH, lab	S.U.	6.5-8.5[D]	7.97	8.12	8.24	8.08	8.12	7.93	8.13	8.10	7.94	8.2	8.14	7.99	7.9	7.75	7.82	7.74	7.89	7.89	7.95
Saturation pH (at 20 C)	none	n/v	7.29	7.25	7.29	7.29	7.23	7.22	7.29	6.93	7.28	7.37	7.23	7.14	6.87	6.84	6.84	6.84	6.85	6.83	6.83
Saturation pH (at 4 C)	none	n/v	7.54	7.50	7.54	7.54	7.48	7.47	7.54	7.18	7.52	7.62	7.48	7.39	7.12	7.09	7.09	7.09	7.09	7.08	7.08
Sulfate	mg/L	500[B]	14	13	14	14	20	19	15	25	12	55	32	18	330	370	330	410	420	380	400
Total Dissolved Solids (Calculated)	mg/L	500[B]	280	290	290	290	310	310	290	400	280	437	422	390	**767[B]**	**810[B]**	**760[B]**	**850[B]**	**860[B]**	**830[B]**	**850[B]**
Metals																					
Aluminum	mg/L	0.1[D]	<0.0050	<0.0050	0.0064	<0.0050	0.0078	<0.0049	<0.0049	**1.7[D]**	0.015	0.007	0.007	0.010	0.005	<0.005	0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Antimony	mg/L	0.006[A]	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic	mg/L	0.01[A]	**0.015[A]**	**0.016[A]**	**0.015[A]**	**0.015[A]**	**0.015[A]**	**0.014[A]**	**0.014[A]**	**0.019[A]**	**0.013[A]**	<0.001	<0.001	<0.0010	0.003	0.003	0.0030	0.0032	0.0028	0.0031	0.0032
Barium	mg/L	1[A]	0.099	0.11	0.11	0.10	0.13	0.11	0.11	0.14	0.10	0.039	0.047	0.047	0.042	0.039	0.024	0.027	0.025	0.023	0.022
Beryllium	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040	<0.0005	<0.0005	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron	mg/L	5[A]	0.025	0.020	0.029	0.019	0.026	0.023	0.027	0.027	0.021	0.01	0.01	0.012	0.06	0.06	0.053	0.051	0.050	0.052	0.051
Cadmium	mg/L	0.005[A]	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.00010	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Calcium	mg/L	n/v	53	57	52	52	60	59	51	130	55	50	71	88	160	190	190	200	200	190	200
Chromium	mg/L	0.05[A]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Cobalt	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00050	0.00076	<0.00050	<0.00050	0.0035	<0.00050	<0.0005	<0.0005	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Copper	mg/L	1[B]	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.00090	<0.00090	0.010	<0.00090	0.003	0.008	0.0030	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Iron	mg/L	0.3[B]	0.20	0.11	0.20	0.24	**0.78[B]**	0.30	0.30	**4.3[B]**	0.29	<0.1	<0.1	<0.10	**1.2[B]**	**1.3[B]**	**1.3[B]**	**1.3[B]**	**1.3[B]**	**1.3[B]**	**1.3[B]**
Lead	mg/L	0.01[A]	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.0070	<0.00050	<0.0005	<0.0005	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Magnesium	mg/L	n/v	27	28	30	27	30	30	28	45	30	16	22	21	38	40	41	42	41	42	41
Manganese	mg/L	0.05[B]	0.022	0.024	0.019	0.021	0.021	0.017	0.016	**0.28[B]**	0.022	0.014	0.017	0.014	**0.13[B]**	**0.089[B]**	0.036	0.037	0.035	0.032	0.033
Molybdenum	mg/L	n/v	0.0010	0.0010	0.00097	0.00093	0.00091	0.00087	0.0011	0.00084	0.0011	0.003	0.002	0.0010	0.003	<0.001	0.0010	0.00073	0.00068	0.00064	0.00069
Nickel	mg/L	n/v	<0.0010	<0.0010	<0.0010	<0.0010	0.0011	<0.0010	<0.0010	0.0048	0.0039	0.002	0.001	0.0010	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus	mg/L	n/v	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.46	<0.10	<0.1	<0.1	<0.10	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10
Potassium	mg/L	n/v	1.4	1.4	1.4	1.3	1.4	1.4	1.3	1.8	1.3	3.6	4.8	4.9	1.7	1.5	1.4	1.5	1.4	1.4	1.4
Selenium	mg/L	0.05[A]	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.002	<0.002	<0.0020	<0.002	<0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicon	mg/L	n/v	12	12	12	12	12	12	11	15	12	5.1	5.9	5.3	8.0	7.7	7.8	7.6	7.1	7.6	7.0
Silver	mg/L	n/v	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.00010	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Sodium	mg/L	200_g[B] 20_g[C]	7.8	7.7	8.2	7.8	8.1	8.2	7.6	8.0	8.3	**85[C]**	**46[C]**	13	**28[C]**	18	19	18	19	19	20
Strontium	mg/L	n/v	0.35	0.36	0.37	0.35	0.38	0.36	0.39	0.48	0.38	0.13	0.18	0.13	2.8	3.2	3.0	3.1	2.9	2.9	3.0
Thallium	mg/L	n/v	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000068	<0.000050	<0.00005	<0.00005	<0.000050	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Titanium	mg/L	n/v	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.065	<0.0050	<0.005	<0.005	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Uranium	mg/L	0.02[A]	0.00012	0.00017	0.00014	0.00014	0.00015	0.00012	0.00014	0.0012	0.00010	0.0048	0.0035	0.0020	0.0007	0.0005	<0.00010	0.00030	0.00030	0.00027	0.00028
Vanadium	mg/L	n/v	<0.00050	0.00066	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.0059	<0.00050	<0.001	0.001	<0.00050	<0.001	<0.001	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc	mg/L	5[B]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.022	<0.0050	0.006	0.008	0.0070	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050

See notes on last page.

Table 3
Summary of Groundwater Analytical Results
Waterloo North Hydrogeological Assessment

Sample Location			MW12-10D (Contd.)							MW12-10S											
Sample Date			20-Aug-19	27-Aug-20	25-Aug-21	6-Sep-22	17-Nov-23	17-Nov-23		19-May-10	26-Oct-10	22-Aug-14	29-Sep-15	24-Aug-16	31-Aug-17	22-Aug-18	20-Aug-19	26-Aug-20	25-Aug-21	30-Aug-22	17-Nov-23
Sample ID			WG-161450875-20190820-SB03	WG-161450875-20200827-DS-08	WG-161450875-20210825-AV06	WG-161459875-20220906-JM12	MW12-10D	DUPLICATE		WG-160340875-20100519-AV15	WG-160340875-20101026-JK7	WG-160310875-20140822-AV07	WG-160310875-20150929-AV09	WG-160310875-20160824-AV02	WG-160310875-20170831-AV05	WG-160310875-20180822-SB04	WG-161450875-20190820-SB04	WG-161450875-20200826-SB-03	WG-161450875-20210825-AV08	WG-161450875-20220830-JM08	MW12-10S
Sampling Company			STANTEC BV	STANTEC BV	STANTEC BV	STANTEC BV	STANTEC BV	STANTEC BV		STANTEC MAXX	STANTEC MAXX	STANTEC MAXX	STANTEC MAXX	STANTEC MAXX	STANTEC MAXX	STANTEC MAXX	STANTEC BV	STANTEC BV	STANTEC BV	STANTEC BV	STANTEC BV
Laboratory			B9N2253	C0M1964	C1O3272	C2P6965	C3AC977	C3AC977		B064180	B0F2316	B4F3646	B5J8856	B6I3010	B7J0582	B8L6839	B9N2253	C0M1964	C1O3272	C2P0302	C3AC977
Laboratory Work Order			KOP303	NMK097	QMC306	TQZ172	XQK221	XQK224		FY2700	HQ0823	XG4190	BBU094	CYS138	FBA584	HNX845	KOP304	NMK089	QMC308	TPN291	XQK222
Laboratory Sample ID																					
Sample Type	Units	ODWS						Field Duplicate	RPD (%)												
Field Parameters																					
Dissolved Oxygen, Field	mg/L	n/v	0.7	-	0.42	-	-	-	-	6.6	1.2	-	1.57	3.48	4.83	1.2	1.3	-	-	-	-
General Chemistry																					
Alkalinity, Bicarbonate (as CaCO3)	mg/L	n/v	240	240	240	240	240	240	0%	434	459	430	410	420	420	420	410	410	410	390	410
Alkalinity, Carbonate (as CaCO3)	mg/L	n/v	1.6	1.5	2.4	2.0	1.5	1.7	nc	5	2	2.5	2.2	3.5	3.4	3.7	3.3	2.7	3.4	3.2	2.3
Alkalinity, Total (as CaCO3)	mg/L	30-500[D]	250	250	250	240	240	240	0%	439	461	430	420	420	420	420	410	410	410	400	410
Ammonia (as N)	mg/L	n/v	0.22	0.17	0.11	0.14	0.17	0.19	nc	0.11	0.11	0.095	<0.050	<0.050	<0.050	0.077	0.16	0.090	<0.050	0.12	0.054
Anion Sum	me/L	n/v	13.3	14.1	14.2	14.2	14.3	14.3	nc	9.87	10.3	9.61	9.24	9.29	9.27	9.32	9.07	9.02	9.01	8.71	8.83
Cation Sum	me/L	n/v	14.8	14.9	14.8	15.3	14.9	14.9	nc	9.98	10.3	9.92	9.64	9.26	9.30	8.76	9.40	8.81	8.44	9.05	8.72
Chloride	mg/L	250[B]	24	25	28	27	25	25	0%	18	18	14	15	14	13	11	11	9.3	9.2	10	7.9
Dissolved Organic Carbon (DOC)	mg/L	5[B]	0.78	0.79	0.80	0.74	0.76	0.75	nc	1.5	1.7	0.96	0.85	0.70	0.80	0.78	0.84	0.72	0.57	0.57	0.74
Electrical Conductivity, Lab	µmhos/cm	n/v	1,200	1,300	1,200	1,200	1,300	1,300	0%	878	908	850	830	820	810	790	800	790	760	740	790
Hardness (as CaCO3)	mg/L	80-100[D]	**690[D]**	**700[D]**	**680[D]**	**710[D]**	**690[D]**	**690[D]**	0%	**480[D]**	**490[D]**	**480[D]**	**460[D]**	**440[D]**	**450[D]**	**420[D]**	**450[D]**	**420[D]**	**410[D]**	**440[D]**	**420[D]**
Ion Balance	%	n/v	5.12	2.94	1.93	3.64	2.30	1.95	nc	0.560	0.100	1.59	2.12	0.120	0.160	3.05	1.76	1.19	3.25	1.91	0.620
Langelier Index (at 20 C)	none	n/v	1.02	0.980	1.19	1.12	0.997	1.04	nc	1.30	0.931	1.02	0.974	1.15	1.14	1.16	1.14	1.02	1.11	1.11	0.965
Langelier Index (at 4 C)	none	n/v	0.775	0.734	0.939	0.877	0.751	0.789	nc	1.05	0.683	0.769	0.726	0.904	0.889	0.912	0.894	0.769	0.866	0.862	0.717
Nitrate (as N)	mg/L	10.0_d[A]	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	nc	0.5	0.4	1.19	0.95	0.75	1.56	1.46	1.33	1.89	2.04	1.91	1.60
Nitrate + Nitrite (as N)	mg/L	10.0_d[A]	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	nc	0.5	0.4	1.19	0.97	0.76	1.56	1.51	1.52	1.89	2.04	1.91	1.60
Nitrite (as N)	mg/L	1.0_d[A]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	nc	0.02	0.01	<0.010	0.013	0.014	<0.010	0.055	0.192	<0.010	<0.010	<0.010	<0.010
Orthophosphate (as P)	mg/L	n/v	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	nc	<0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
pH, lab	S.U.	6.5-8.5[D]	7.85	7.80	8.02	7.95	7.83	7.87	nc	8.1	7.66	7.79	7.75	7.95	7.94	7.98	7.94	7.84	7.95	7.94	7.78
Saturation pH (at 20 C)	none	n/v	6.82	6.82	6.83	6.83	6.83	6.83	nc	6.76	6.73	6.77	6.77	6.80	6.80	6.82	6.80	6.82	6.84	6.83	6.82
Saturation pH (at 4 C)	none	n/v	7.07	7.07	7.08	7.07	7.08	7.08	nc	7.01	6.98	7.02	7.02	7.05	7.05	7.06	7.04	7.07	7.09	7.07	7.06
Sulfate	mg/L	500_h[B]	370	410	410	420	420	420	0%	27	26	22	20	21	19	19	18	18	18	18	15
Total Dissolved Solids (Calculated)	mg/L	500[B]	**830[B]**	**870[B]**	**870[B]**	**890[B]**	**880[B]**	**880[B]**	0%	500	**520[B]**	490	480	470	470	460	460	450	440	450	440
Metals																					
Aluminum	mg/L	0.1[D]	<0.0050	<0.0049	<0.0049	0.015	<0.0049	<0.0049	nc	0.014	<0.005	<0.0050	<0.0050	<0.0050	0.0058	<0.0050	<0.0050	<0.0049	<0.0049	0.013	<0.0049
Antimony	mg/L	0.006[A]	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	nc	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic	mg/L	0.01[A]	0.0031	0.0033	0.0035	0.0032	0.0034	0.0031	nc	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Barium	mg/L	1[A]	0.023	0.025	0.025	0.024	0.024	0.023	4%	0.087	0.078	0.10	0.092	0.097	0.10	0.093	0.098	0.098	0.082	0.10	0.090
Beryllium	mg/L	n/v	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	nc	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040
Boron	mg/L	5[A]	0.060	0.054	0.057	0.059	0.056	0.056	0%	0.02	0.02	0.018	0.011	0.015	0.016	<0.010	0.016	0.014	0.012	0.015	0.017
Cadmium	mg/L	0.005[A]	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	nc	<0.0001	0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090
Calcium	mg/L	n/v	210	210	200	210	210	210	0%	120	120	110	120	110	110	100	110	100	100	110	110
Chromium	mg/L	0.05[A]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	nc	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Cobalt	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	nc	0.0006	0.0009	0.0010	<0.00050	0.0013	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Copper	mg/L	1[B]	<0.0010	<0.00090	<0.00090	<0.00090	<0.00090	<0.00090	nc	0.002	0.001	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.00090	0.0028	<0.00090	0.0018
Iron	mg/L	0.3[B]	**1.2[B]**	**1.3[B]**	**1.3[B]**	**1.3[B]**	**1.2[B]**	**1.2[B]**	0%	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Lead	mg/L	0.01[A]	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	nc	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Magnesium	mg/L	n/v	42	43	43	44	41	42	2%	46	46	46	42	42	42	40	42	39	38	40	37
Manganese	mg/L	0.05[B]	0.033	0.033	0.034	0.035	0.034	0.033	3%	**0.18[B]**	**0.22[B]**	**0.11[B]**	**0.061[B]**	**0.11[B]**	**0.077[B]**	0.026	0.027	0.033	0.020	0.023	0.018
Molybdenum	mg/L	n/v	0.00068	0.00066	0.00073	0.00081	0.00076	0.00071	nc	0.002	0.002	0.0010	<0.00050	0.00088	0.00061	<0.00050	<0.00050	<0.00050	<0.00050	0.00054	<0.00050
Nickel	mg/L	n/v	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	nc	0.002	<0.001	0.0010	<0.0010	0.0014	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus	mg/L	n/v	<0.10	<0.10	<0.10	0.13	<0.10	<0.10	nc	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Potassium	mg/L	n/v	1.5	1.4	1.5	1.5	1.5	1.6	6%	3.4	3.1	2.9	2.5	2.9	2.6	2.2	2.4	2.2	1.6	2.3	1.9
Selenium	mg/L	0.05[A]	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	nc	<0.002	<0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicon	mg/L	n/v	8.2	8.1	7.4	7.9	7.7	7.6	1%	8.0	8.5	8.0	8.2	7.4	7.8	7.2	7.9	7.5	7.0	7.9	7.7
Silver	mg/L	n/v	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	nc	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090
Sodium	mg/L	200_g[B] 20_g[C]	**22[C]**	**22[C]**	**23[C]**	**23[C]**	**24[C]**	**24[C]**	0%	8.0	9.1	8.0	6.7	7.3	6.9	6.1	7.0	6.6	5.5	6.3	5.8
Strontium	mg/L	n/v	3.2	3.2	3.3	3.3	3.2	3.2	0%	0.46	0.45	0.44	0.35	0.39	0.40	0.34	0.37	0.33	0.30	0.37	0.33
Thallium	mg/L	n/v	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	nc	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Titanium	mg/L	n/v	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	nc	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Uranium	mg/L	0.02[A]	0.00028	0.00028	0.00026	0.00029	0.00025	0.00023	nc	0.0064	0.0044	0.0020	0.0014	0.0016	0.0016	0.0014	0.0014	0.0013	0.0011	0.0013	0.0011
Vanadium	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	nc	<0.001	<0.001	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00050
Zinc	mg/L	5[B]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	nc	0.013	<0.005	0.0060	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0079

See notes on last page.

Table 3
Summary of Groundwater Analytical Results
Waterloo North Hydrogeological Assessment

Sample Location			MW13-10											
Sample Date			17-May-10	27-Oct-10	21-Aug-14	28-Sep-15	25-Aug-16	1-Sep-17	22-Aug-18	20-Aug-19	26-Aug-20	24-Aug-21	30-Aug-22	1-Dec-23
Sample ID			WG-160340875-20100517-AV07	WG-160340875-20101027-JK 13	WG-160310875-20140821-AV04	WG-160310875-20150928-AV01	WG-160310875-20160825-AV06	WG-160310875-20170901-AV06	WG-160310875-20180822-SB02	WG-161450875-20190820-SB01	WG-161450875-20200826-SB-01	WG-161450875-20210824-AV03	WG-161450875-20220830-JM09	MW13-10
Sampling Company			STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC
Laboratory			MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	BV	BV	BV	BV	BV
Laboratory Work Order			B062483	B0F3108	B4F3646	B5J8856	B6I3010	B7J0582	B8L6839	B9N2253	C0M1964	C1O3272	C2P0302	C3AT024
Laboratory Sample ID			FX4447	HQ4301	XG4187	BBU085	CYS142	FBA585	HNX843	KOP301	NMK087	QMC303	TPN292	XTW488
Sample Type	Units	ODWS												
Field Parameters														
Dissolved Oxygen, Field	mg/L	n/v	0.6	0.7	-	-	-	1.92	1.1	2.8	-	0.6	-	-
General Chemistry														
Alkalinity, Bicarbonate (as CaCO3)	mg/L	n/v	276	314	340	320	320	340	300	330	340	310	330	330
Alkalinity, Carbonate (as CaCO3)	mg/L	n/v	2	3	2.3	2.0	3.0	2.3	2.5	2.9	2.4	2.4	2.5	1.9
Alkalinity, Total (as CaCO3)	mg/L	30-500[D]	279	318	340	320	330	340	310	330	340	320	330	340
Ammonia (as N)	mg/L	n/v	0.07	0.14	<0.050	<0.050	<0.050	<0.050	0.058	0.068	0.075	<0.050	0.14	<0.050
Anion Sum	me/L	n/v	6.80	7.64	8.31	7.73	7.56	8.05	7.49	7.91	8.26	7.79	8.08	7.98
Cation Sum	me/L	n/v	8.04	8.59	8.30	7.60	7.93	7.85	7.81	8.35	7.93	8.01	8.43	8.61
Chloride	mg/L	250[B]	11	12	12	14	9.9	12	14	15	17	16	18	13
Dissolved Organic Carbon (DOC)	mg/L	5[B]	0.7	1.4	1.1	0.66	0.53	0.65	0.54	0.53	0.51	0.43	0.42	0.51
Electrical Conductivity, Lab	µmhos/cm	n/v	629	705	710	700	710	710	660	710	700	690	700	740
Hardness (as CaCO3)	mg/L	80-100[D]	**390[D]**	**420[D]**	**400[D]**	**370[D]**	**380[D]**	**380[D]**	**380[D]**	**410[D]**	**390[D]**	**390[D]**	**410[D]**	**420[D]**
Ion Balance	%	n/v	8.40	5.85	0.0800	0.870	2.38	1.24	2.06	2.75	2.05	1.44	2.08	3.80
Langelier Index (at 20 C)	none	n/v	0.979	1.13	0.978	0.896	1.08	0.947	0.988	1.09	0.972	0.985	1.03	0.910
Langelier Index (at 4 C)	none	n/v	0.731	0.883	0.730	0.648	0.826	0.699	0.739	0.843	0.724	0.736	0.780	0.662
Nitrate (as N)	mg/L	10.0_d[A]	1.8	0.9	3.37	3.36	3.21	2.80	2.52	4.00	4.28	2.45	4.05	2.29
Nitrate + Nitrite (as N)	mg/L	10.0_d[A]	1.8	0.9	3.37	3.36	3.21	2.80	2.52	4.00	4.28	2.45	4.05	2.29
Nitrite (as N)	mg/L	1.0_d[A]	0.02	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Orthophosphate (as P)	mg/L	n/v	<0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.030 MI
pH, lab	S.U.	6.5-8.5[D]	8.0	8.03	7.86	7.83	7.99	7.86	7.94	7.98	7.87	7.91	7.91	7.78
Saturation pH (at 20 C)	none	n/v	6.98	6.90	6.88	6.93	6.91	6.91	6.95	6.89	6.90	6.93	6.89	6.87
Saturation pH (at 4 C)	none	n/v	7.22	7.15	7.13	7.18	7.16	7.16	7.20	7.14	7.15	7.17	7.13	7.12
Sulfate	mg/L	500_h[B]	37	42	40	33	25	34	38	28	30	39	31	35
Total Dissolved Solids (Calculated)	mg/L	500[B]	379	416	440	400	400	410	400	420	430	410	430	430
Metals														
Aluminum	mg/L	0.1[D]	<0.005	0.010	<0.0050	<0.0050	0.023	<0.0050	<0.0050	<0.0050	<0.0049	<0.0049	0.0069	<0.0049
Antimony	mg/L	0.006[A]	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic	mg/L	0.01[A]	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Barium	mg/L	1[A]	0.070	0.086	0.088	0.075	0.077	0.075	0.070	0.070	0.073	0.070	0.092	0.078
Beryllium	mg/L	n/v	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040
Boron	mg/L	5[A]	<0.01	0.01	0.011	<0.010	<0.010	0.010	<0.010	0.010	<0.010	0.011	<0.010	<0.010
Cadmium	mg/L	0.005[A]	<0.0001	0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090
Calcium	mg/L	n/v	100	110	110	100	100	100	100	110	100	110	110	110
Chromium	mg/L	0.05[A]	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Cobalt	mg/L	n/v	<0.0005	<0.0005	<0.00050	<0.00050	0.0014	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Copper	mg/L	1[B]	0.002	0.002	0.0020	0.0010	<0.0010	<0.0010	<0.0010	0.0011	0.0025	0.0014	0.0038	0.0023
Iron	mg/L	0.3[B]	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Lead	mg/L	0.01[A]	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Magnesium	mg/L	n/v	32	33	32	28	29	31	31	32	31	31	33	33
Manganese	mg/L	0.05[B]	**0.055[B]**	**0.052[B]**	0.0070	0.0058	0.0093	0.0068	0.0082	0.0033	<0.0020	0.025	<0.0020	<0.0020
Molybdenum	mg/L	n/v	<0.001	<0.001	0.0020	0.00054	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Nickel	mg/L	n/v	0.002	0.001	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0014	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus	mg/L	n/v	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Potassium	mg/L	n/v	1.0	1.4	1.0	1.0	1.3	1.1	0.94	0.86	0.86	0.87	0.84	0.91
Selenium	mg/L	0.05[A]	<0.002	<0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicon	mg/L	n/v	6.2	7.0	6.8	6.4	6.2	6.4	6.1	7.1	6.6	6.2	6.6	6.9
Silver	mg/L	n/v	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090
Sodium	mg/L	200_g[B] 20_g[C]	3.6	5.3	4.6	3.2	6.1	4.0	4.1	3.7	3.7	3.7	3.3	3.8
Strontium	mg/L	n/v	0.15	0.18	0.15	0.15	0.15	0.15	0.15	0.15	0.14	0.16	0.16	0.17
Thallium	mg/L	n/v	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Titanium	mg/L	n/v	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Uranium	mg/L	0.02[A]	0.0010	0.0012	0.0010	0.00079	0.00087	0.00076	0.00079	0.00074	0.00066	0.00081	0.00071	0.00077
Vanadium	mg/L	n/v	<0.001	<0.001	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc	mg/L	5[B]	0.013	0.010	0.016	0.040	0.0081	0.0071	0.0088	0.015	0.011	0.010	0.011	0.016

See notes on last page.

Table 3
Summary of Groundwater Analytical Results
Waterloo North Hydrogeological Assessment

Notes:

ODWS	Ontario Drinking Water Quality Standards (January 1, 2018)
A	Schedule 2 - Chemical Standards (expressed as a maximum acceptable concentration)
B	ODWS Table 4 - Chemical/Physical Objectives and Guidelines, Aesthetic Objectives
C	ODWS Table 4 - Medical Officer of Health Reporting Limit
D	ODWS Table 4 - Chemical/Physical Objectives and Guidelines, Operational Guidelines
6.5[A]	Concentration exceeds the indicated standard.
15.2	Measured concentration did not exceed the indicated standard.
<0.50	Laboratory reporting limit was greater than the applicable standard.
<0.03	Analyte was not detected at a concentration greater than the laboratory reporting limit.
n/v	No standard/guideline value.
-	Parameter not analyzed / not available.
d	Where both nitrate and nitrite are present, the total of the two should not exceed 10 mg/L (as nitrogen).
g	The aesthetic objective for sodium in drinking water is 200 mg/L. The local Medical Officer of Health should be notified when the sodium concentration exceeds 20 mg/L so that this information may be communicated to local physicians for their use with patients on sodium restricted diets.
h	When sulfate levels exceed 500 mg/L, water may have a laxative effect on some people.
DB	Due to the sample matrix, sample required dilution. Detection limit was adjusted accordingly.
MI	Detection limits raised due to matrix interference.
RPD	Relative Percent Difference.
61%	RPD exceeds data quality objective of 30%.
nc	RPD is not calculated if one or more values is non detect or if one or more values is less than five times the reportable detection limit.

APPENDIX C:
Phase Monitoring Program

NORTH WATERLOO
PROPOSED PHASE 1 MONITORING PROGRAM
2014

1.0 STUDY AREA AND CONTEXT

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

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

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

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

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

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

2.0 MONITORING STUDY APPROACH

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

2.1 SURFACE WATER MONITORING

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

2.1.1 Surface Water Flow Monitoring

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

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

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

2.1.2 Water Level Monitoring

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

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

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

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

2.2 GROUNDWATER MONITORING

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

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

2.2.1 Water Level Monitoring

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

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

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

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

2.2.2 Water Chemistry Monitoring

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

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

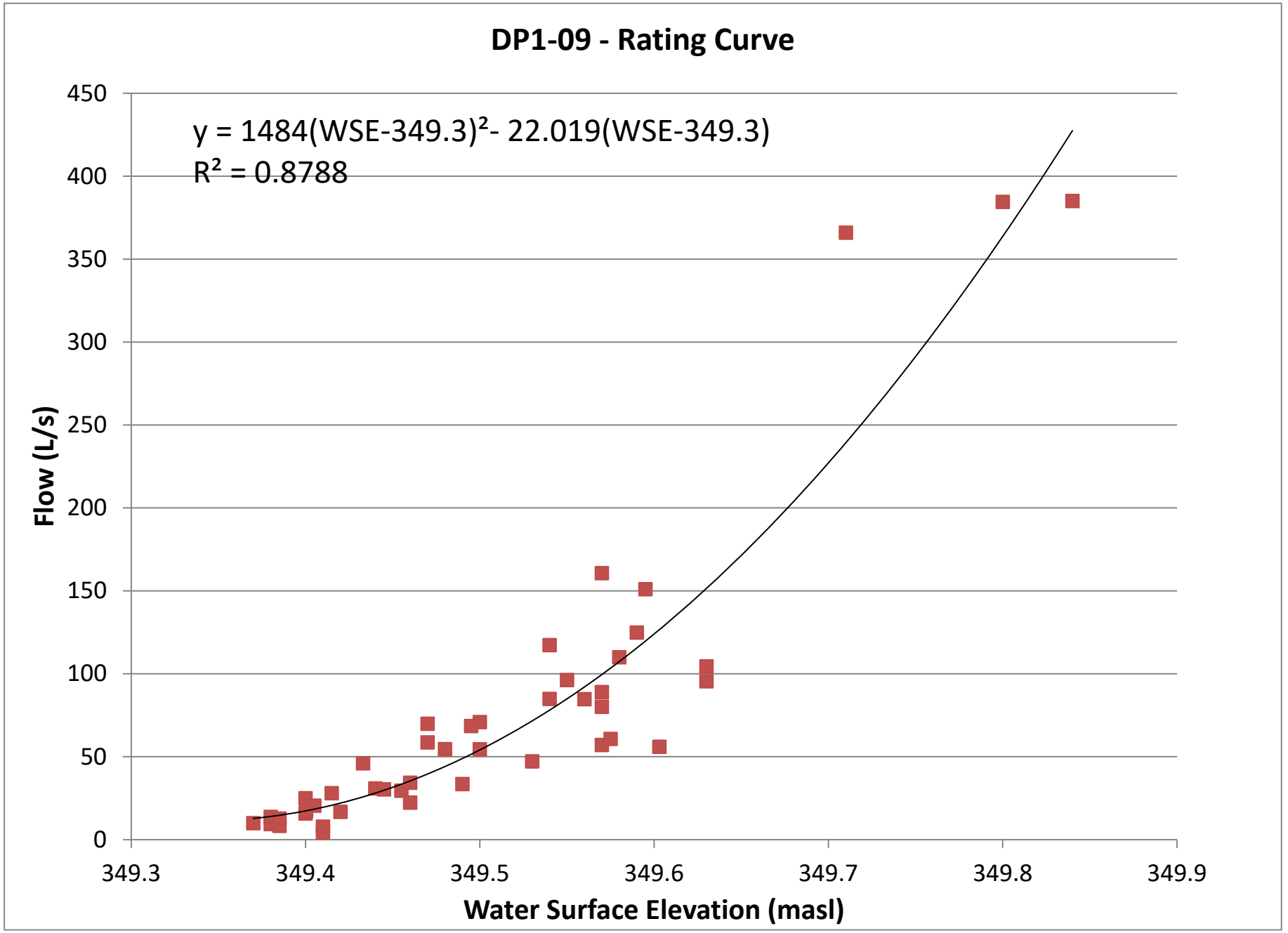
Timing. Water quality samples will be collected once per year in the spring. The 2014 sampling will be completed in August 2014.

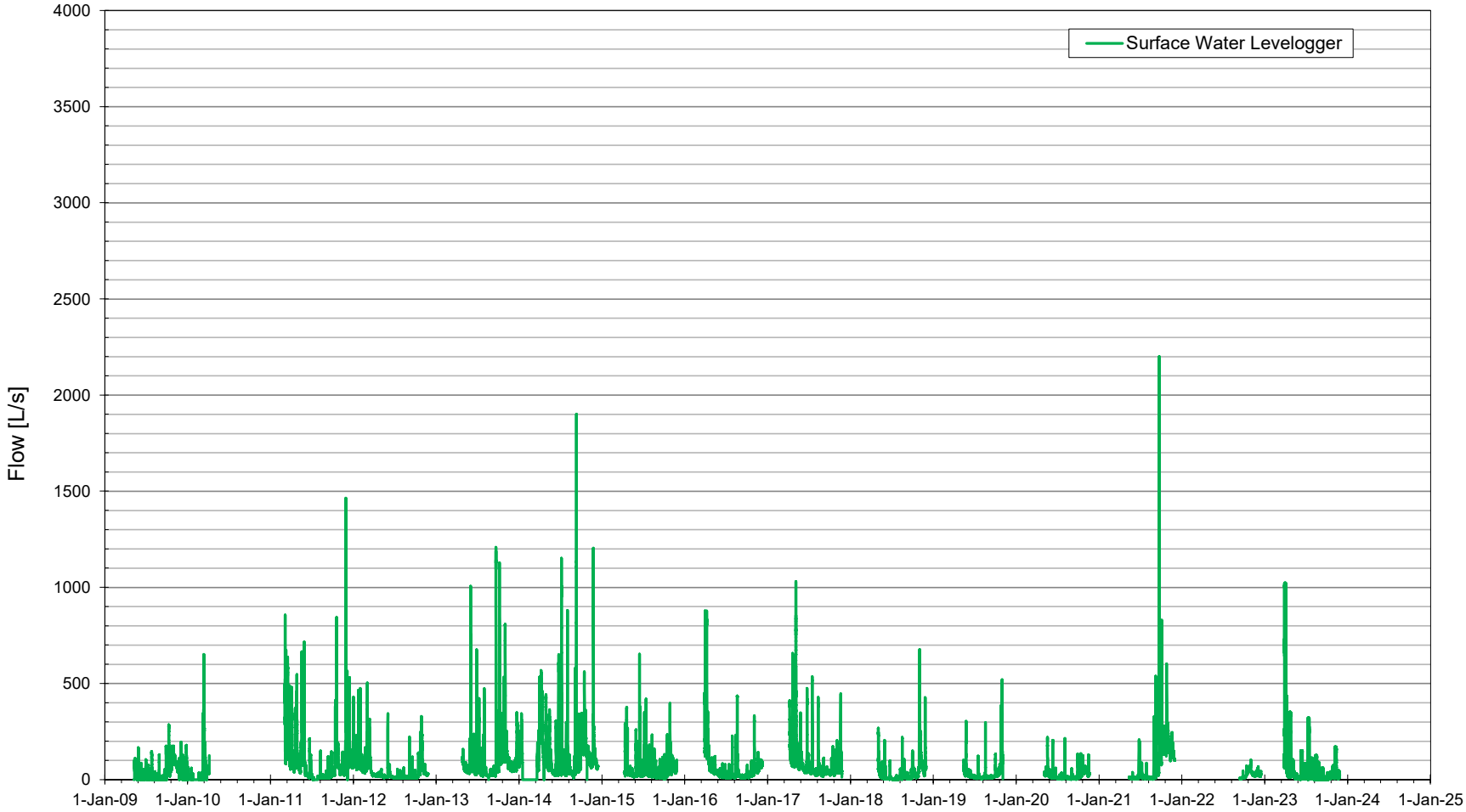
Methodology. Groundwater samples will be collected using foot valve / tubing or submersible pump depending on the location. Each well will be purged of three (3) casing volumes prior to sampling. Groundwater samples for metals analysis will be field filtered. Water quality samples would be analyzed for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

3.0 REPORTING

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

APPENDIX D:
Surface Water Flow Data


DP1-09 - Rating Curve
y = 1484(WSE-349.3)²- 22.019(WSE-349.3)
R² = 0.8788
Flow (L/s)
450
400
350
300
250
200
150
100
50
0
349.3
349.4
349.5
349.6
349.7
349.8
349.9
Water Surface Elevation (masl)

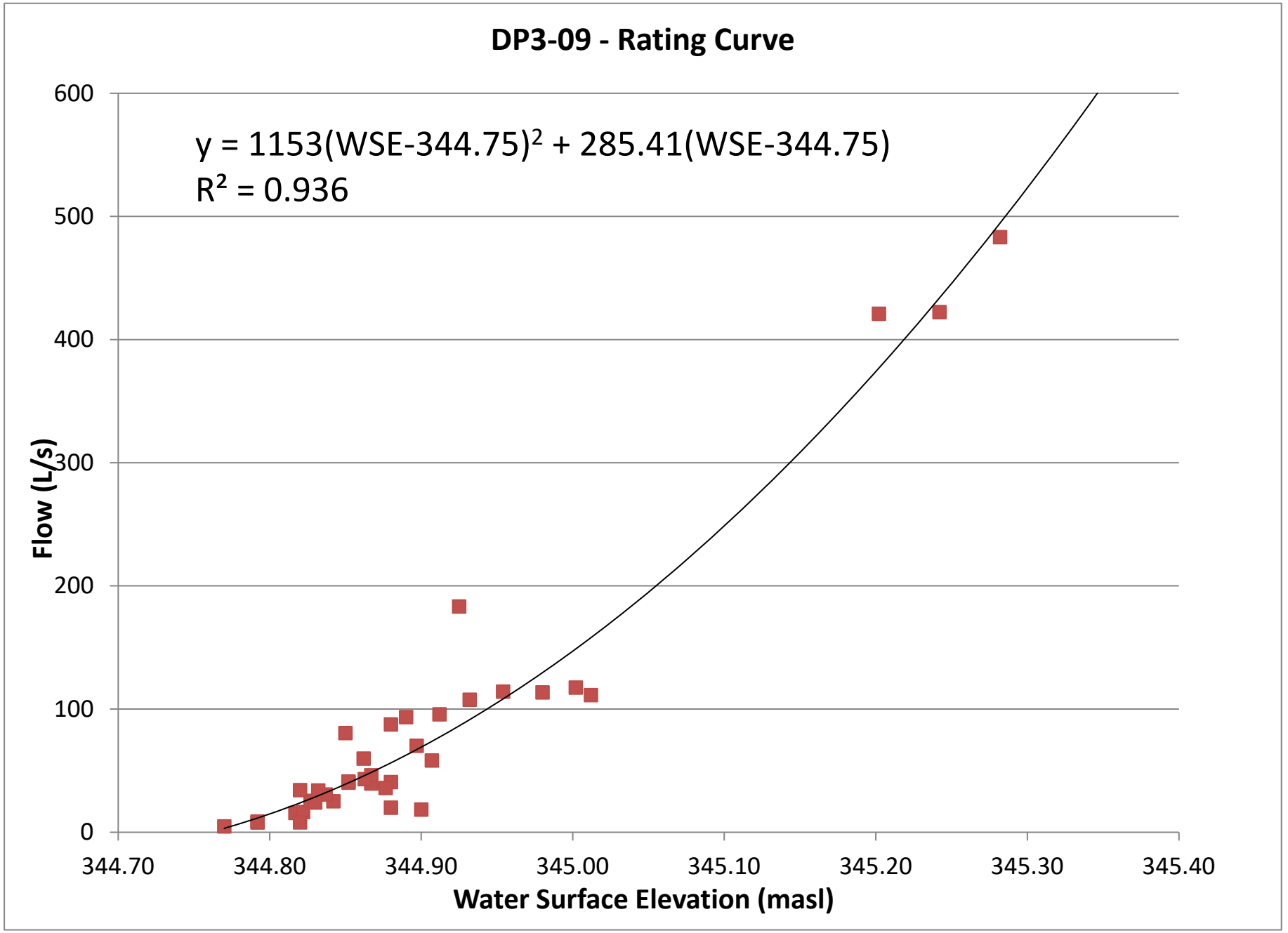


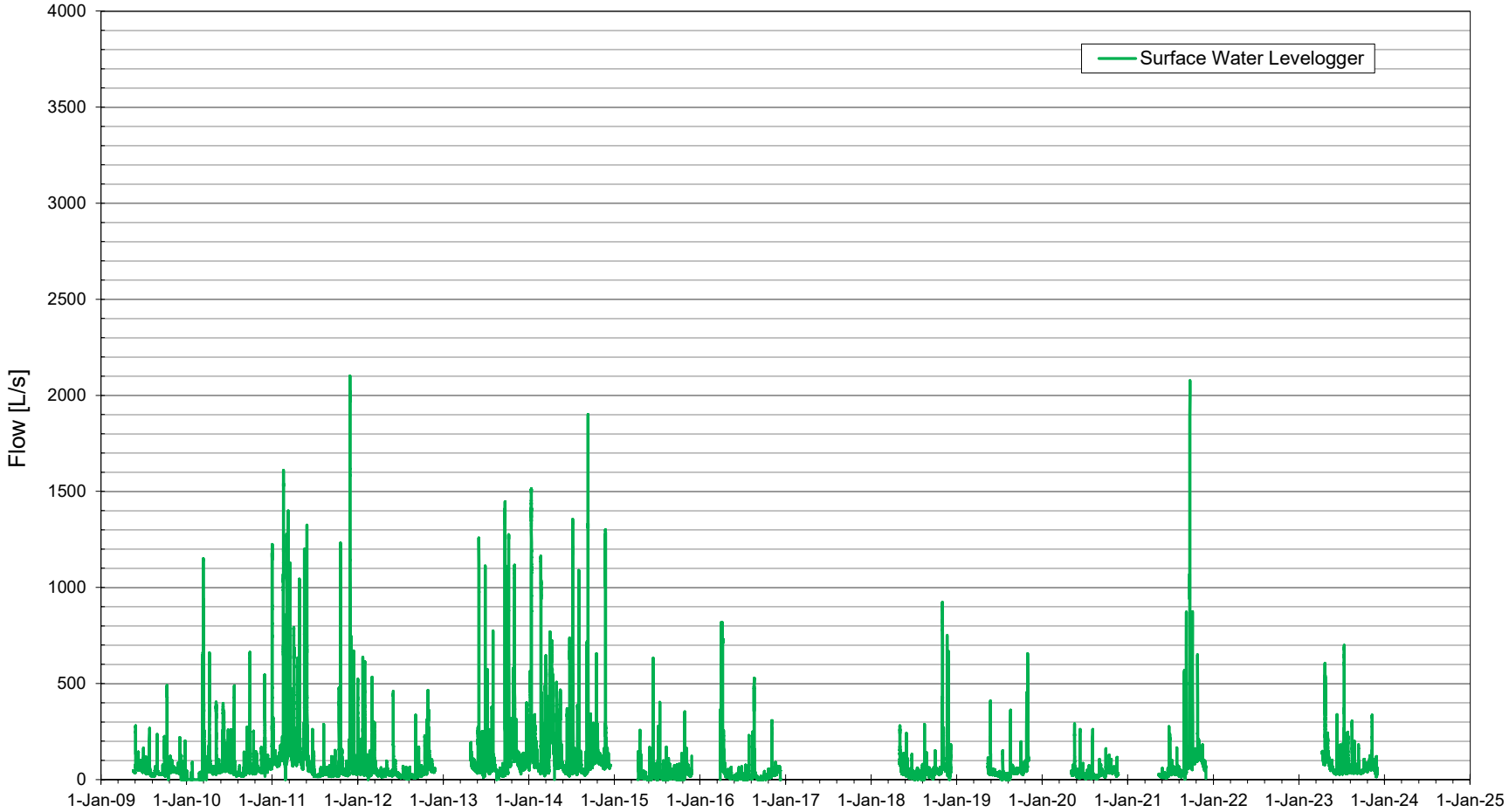
Note: Surface water logger removed for winters 2013-2023

Project: North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program

Stantec

Title: DP1-09 (Hydrograph)


DP3-09 - Rating Curve
y = 1153(WSE-344.75)² + 285.41(WSE-344.75)
R² = 0.936
600
500
400
300
200
100
0
Flow (L/s)
344.70
344.80
344.90
345.00
345.10
345.20
345.30
345.40
Water Surface Elevation (masl)



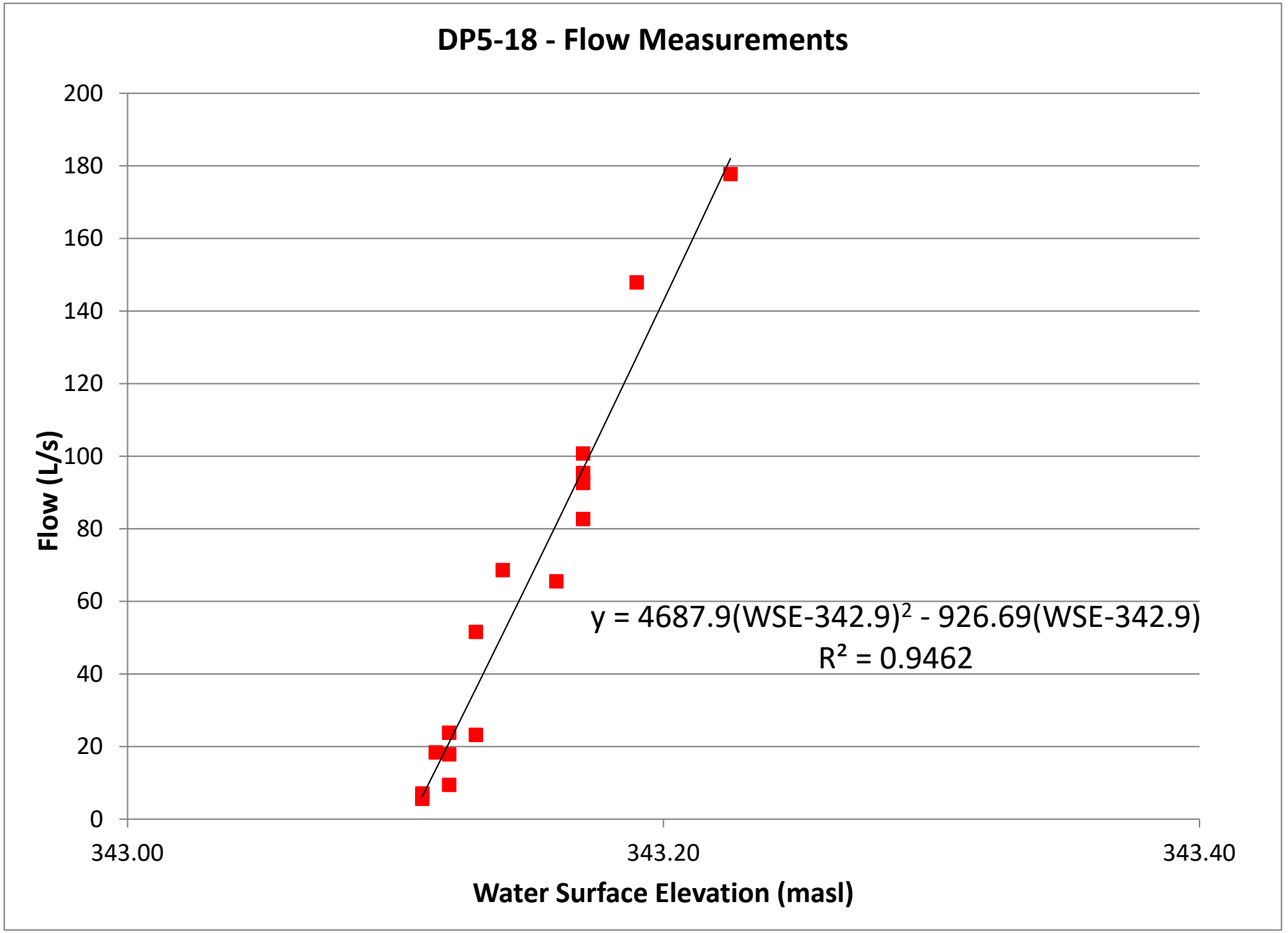
Note: Surface water logger removed for winters 2013 and 2015-2023, logger malfunction in 2022

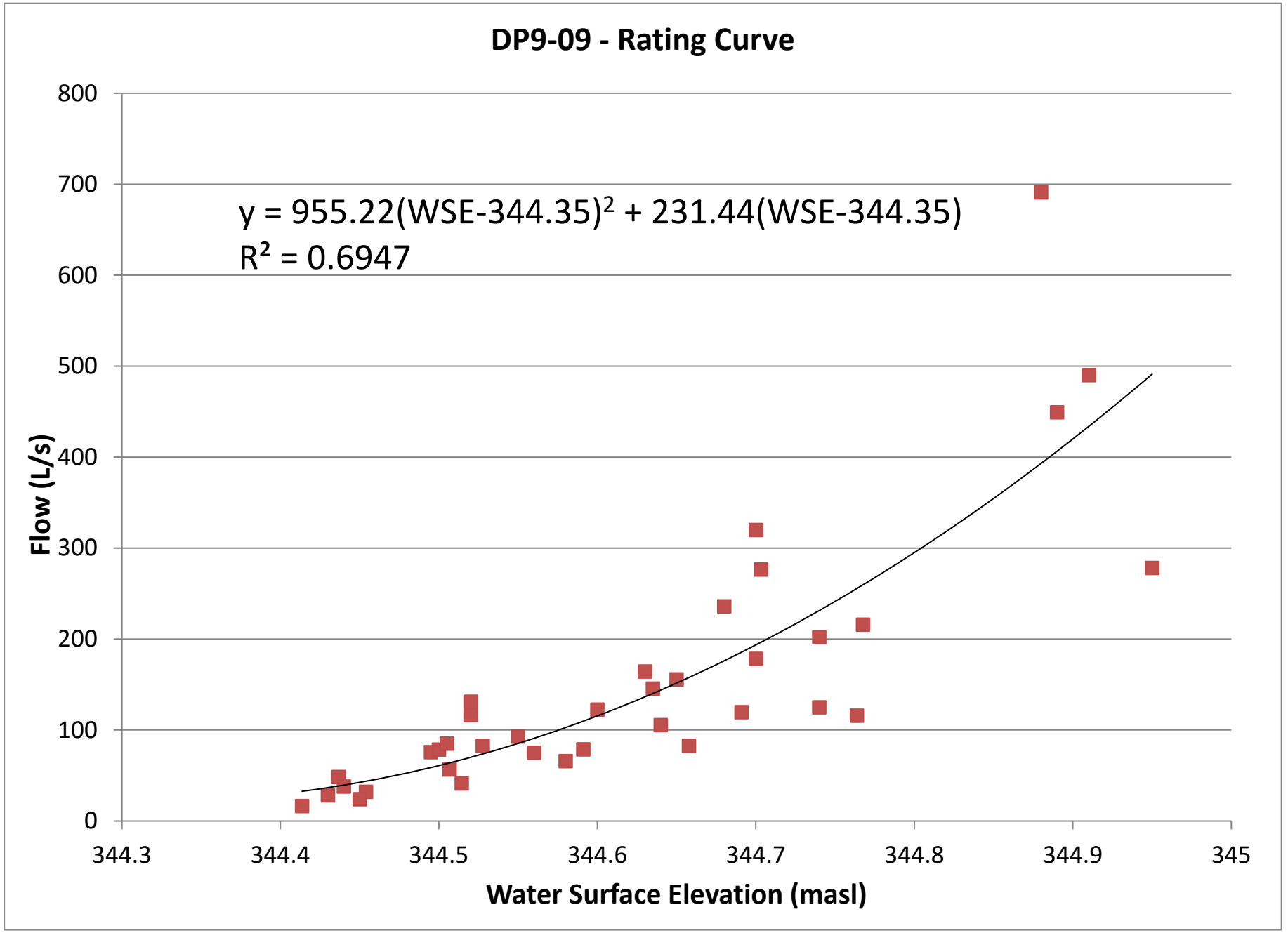
Project

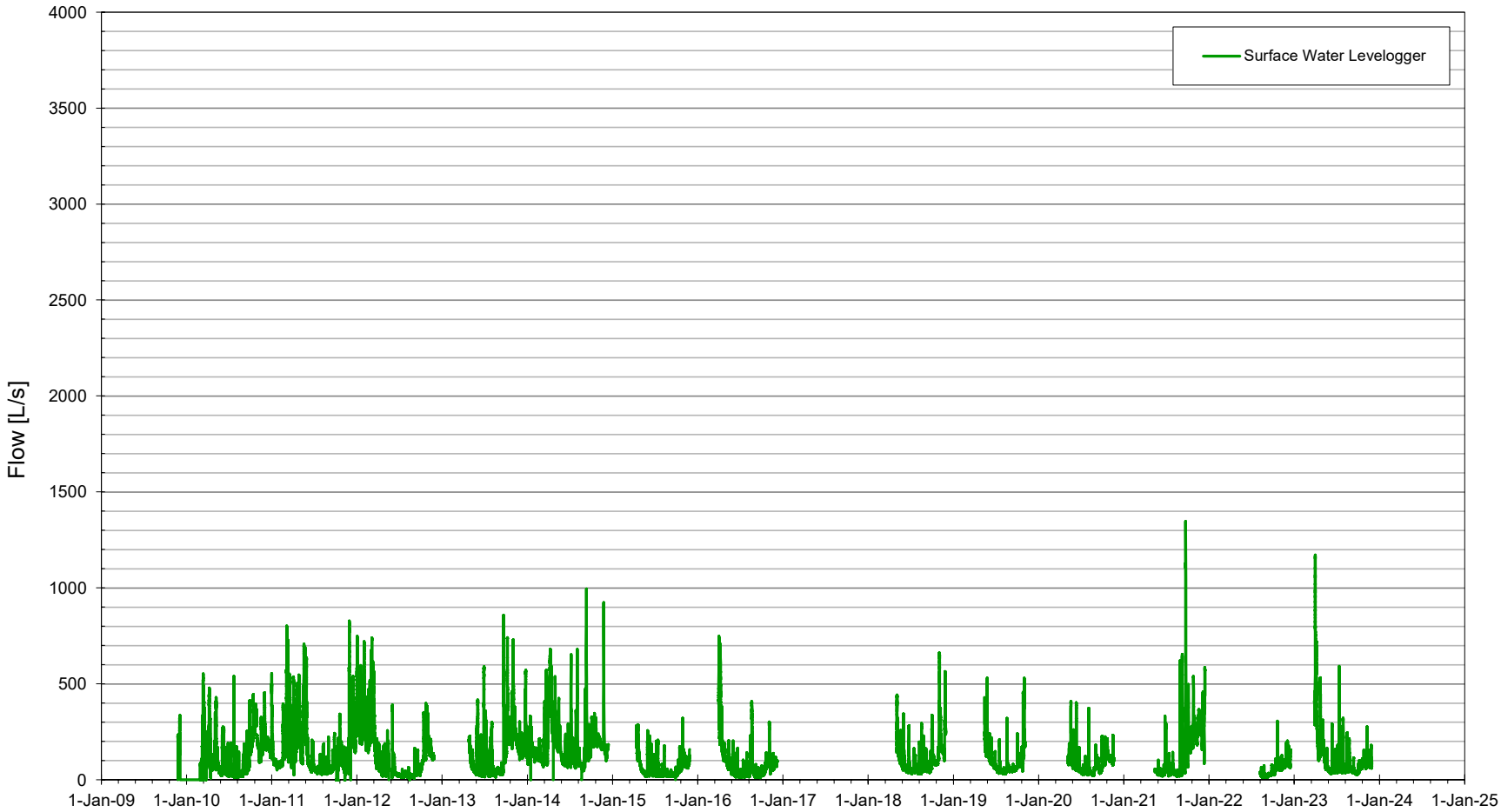
North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program

Stantec

Title DP3-09 (Hydrograph)


DP5-18 - Flow Measurements
200
180
160
140
120
100
80
60
40
20
0
Flow (L/s)
343.00
343.20
343.40
Water Surface Elevation (masl)
y = 4687.9(WSE-342.9)² - 926.69(WSE-342.9)
R² = 0.9462


DP9-09 - Rating Curve
y = 955.22(WSE-344.35)² + 231.44(WSE-344.35)
R² = 0.6947
800
700
600
500
400
300
200
100
0
Flow (L/s)
344.3
344.4
344.5
344.6
344.7
344.8
344.9
345
Water Surface Elevation (masl)

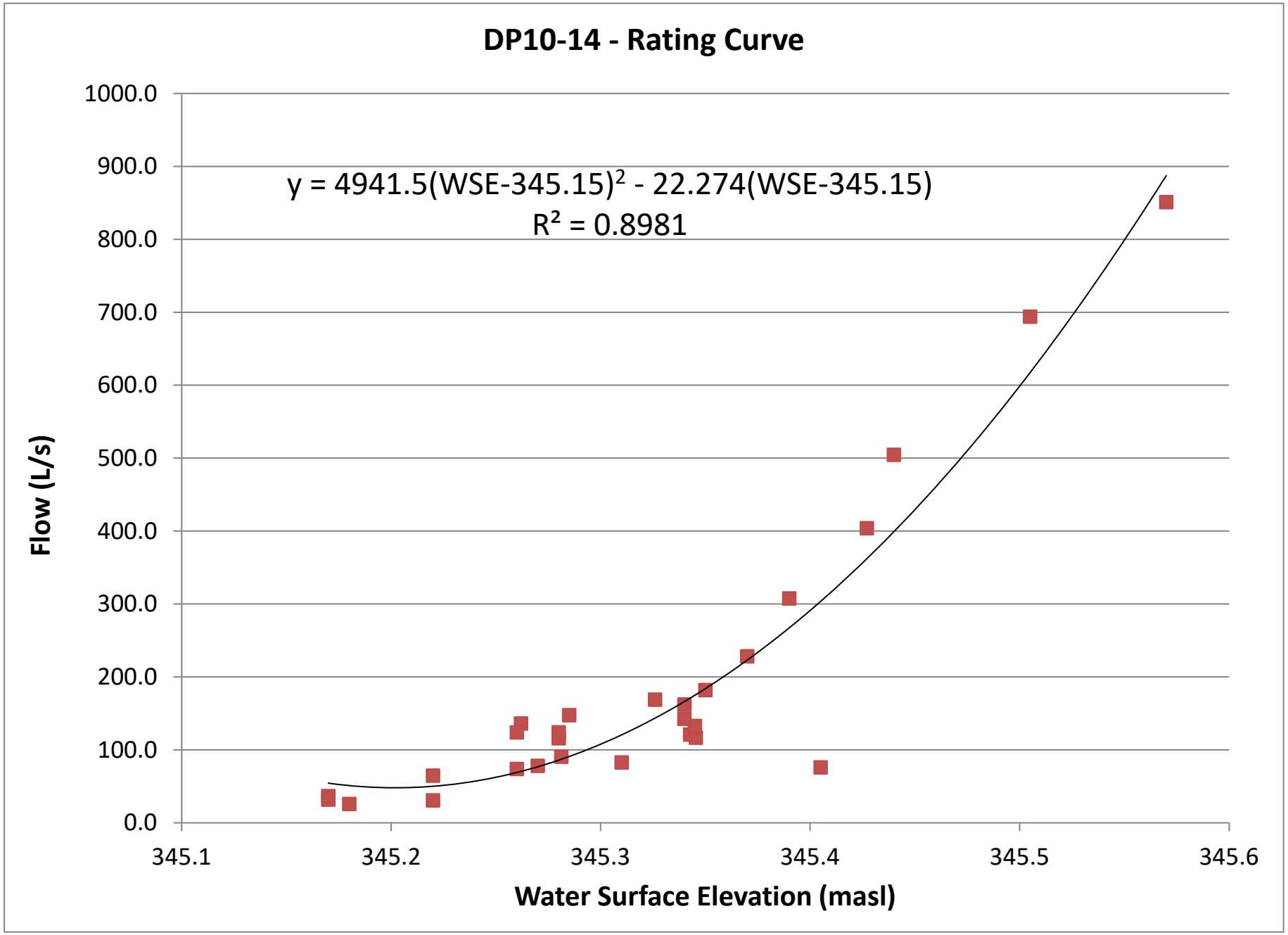


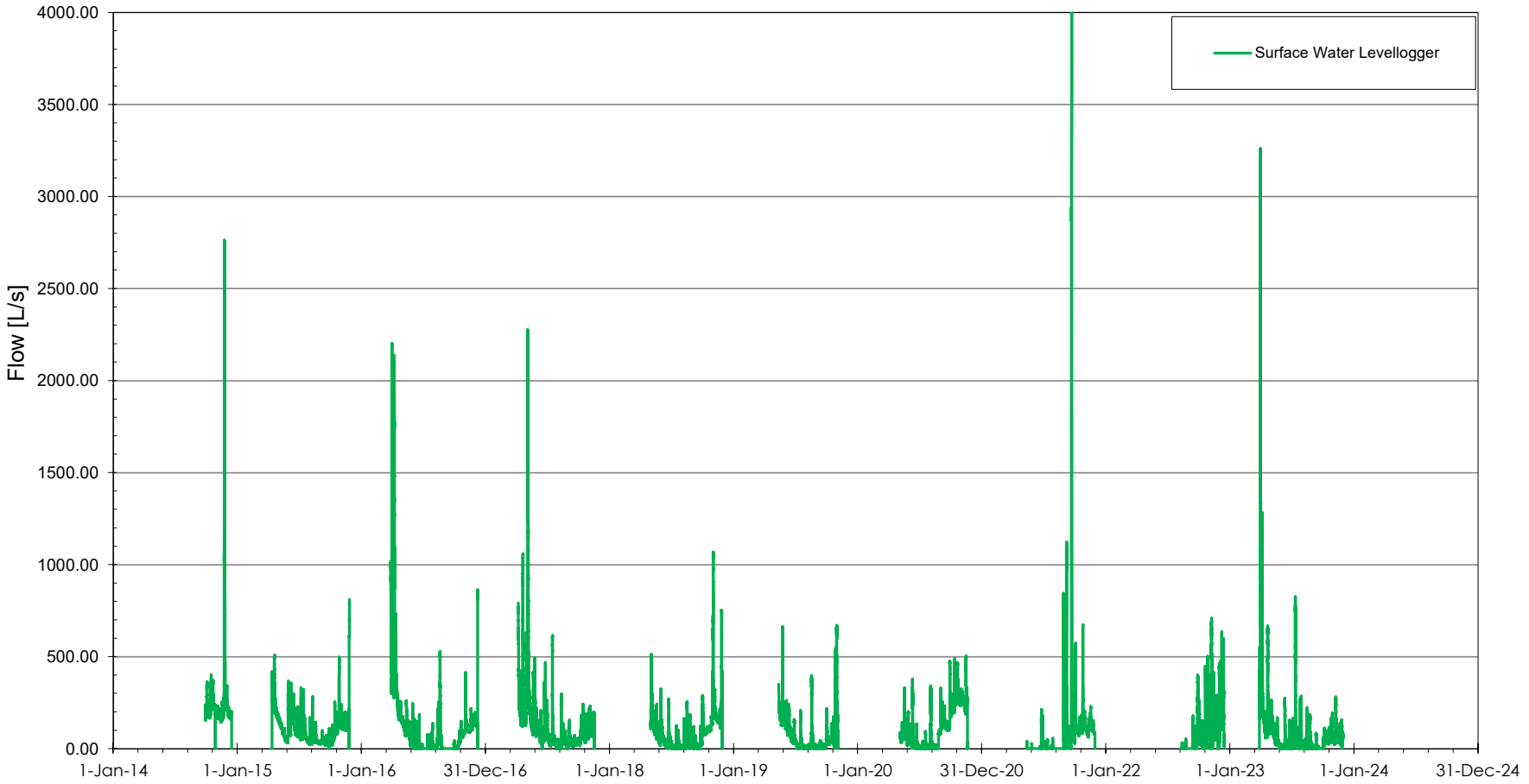
Note: Surface water logger removed for winter 2013, 2015, 2016, 2017, 2020-2023

Project: North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program

Stantec

Title: DP9-09 (Hydrograph)


DP10-14 - Rating Curve
y = 4941.5(WSE-345.15)² - 22.274(WSE-345.15)
R² = 0.8981
Flow (L/s)
1000.0
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
345.1
345.2
345.3
345.4
345.5
345.6
Water Surface Elevation (masl)



Note: Loggers removed in winters 2015-2023

Project

North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program

Stantec

Title DP10-14 (Hydrograph)

LAUREL CREEK WATERSHED
CITY SAMPLE STATION #: 17
SITE DESCRIPTION: BEAVER CREEK @ CONSERVATION DRIVE

Date	Site	Time	Classification	1 Day Antecedant + Current Morning Precipitation (mm)	Daily Total Precipitation (mm)	3 Day Antecedant Precipitation (mm)	7 Day Antecedent Precipitation (mm)	Q (m^3/sec)	Spec Cond (uS/cm)	DO (mg/L)	Temp (C)	pH	TSS (mg/L)	TP (ug/L)
March 25, 2023	**17**	11:13	Agricultural	12.4	12.4	3.8	3.8	0.2200	552	12.36	1.1	7.84	7.2	35.2
March 28, 2023	**17**	12:20	Agricultural	4.5	0.0	16.9	20.7	0.2127	512	13.70	3.0	7.94	<3	29.1
April 2, 2023	**17**	13:55	Agricultural	13.4	0.0	36.9	43.4	0.2700	299	15.22	3.7	8.00	12.2	66.2
May 2, 2023	**17**	18:25	Agricultural	12.5	8.1	13.0	16.2	0.1645	554	9.92	7.1	7.86	<3	46.1
May 18, 2023	**17**	18:40	Agricultural	0.0	0.0	0.0	0.0	0.0432	593	10.49	13.3	8.37	3.3	18.3
May 30, 2023	**17**	14:22	Agricultural	0.0	0.0	0.0	0.0	0.0233	611	9.30	17.5	7.99	5.3	35.1
June 13, 2023	**17**	14:30	Agricultural	22	1.7	34.7	35.9	0.0572	653	8.35	13.8	7.91	<3	36.6
June 27, 2023	**17**	12:30	Agricultural	20.6	9.2	18.4	21.3	0.0734	645	7.77	16.8	7.87	<3	52.6
July 11, 2023	**17**	10:34	Agricultural	14.8	7.3	5.7	29.2	0.0265	653	7.79	17.5	7.96	4.9	66.5
July 25, 2023	**17**	11:40	Agricultural	0.0	0.0	0.0	13.6	0.0102	635	7.85	17.4	7.95	<3	56.6
July 27, 2023	**17**	15:40	Agricultural	26.0	3.8	22.2	35.8	0.0980	613	7.38	20.4	7.73	4.2	64.1
August 8, 2023	**17**	11:15	Agricultural	2.2	0.2	5.0	8.0	0.0275	622	7.55	16.4	8.01	6.5	60.0
August 16, 2023	**17**	15:46	Agricultural	29.6	0	29.6	45.4	0.0883	630	7.61	18.2	7.87	5.3	68.3
August 22, 2023	**17**	11:05	Agricultural	0.0	0.0	0.0	50.6	0.0290	630	8.29	15.1	7.93	<3	59.0
September 5, 2023	**17**	09:35	Agricultural	0.0	0.0	0.0	6.0	0.0165	610	7.51	17.6	7.87	<3	62.8
September 19, 2023	**17**	16:45	Agricultural	0.8	0.0	7.5	18.4	0.0123	606	8.85	13.3	8.12	<3	50.9

APPENDIX E:
Laboratory Certificate of Analysis

Your Project #: 160310875
Your C.O.C. #: N/A

Attention: Lesley Veale

Stantec Consulting Ltd
300 Hagey Blvd
Suite 100
Waterloo, ON
CANADA N2L 0A4

Report Date: 2023/11/30
Report #: R7934680
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C3AC977
Received: 2023/11/18, 12:15

Sample Matrix: Water
Samples Received: 10

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity	9	N/A	2023/11/23	CAM SOP-00448	SM 24 2320 B m
Alkalinity	1	N/A	2023/11/28	CAM SOP-00448	SM 24 2320 B m
Carbonate, Bicarbonate and Hydroxide	10	N/A	2023/11/24	CAM SOP-00102	APHA 4500-CO2 D
Chloride by Automated Colourimetry	9	N/A	2023/11/22	CAM SOP-00463	SM 23 4500-Cl E m
Chloride by Automated Colourimetry	1	N/A	2023/11/27	CAM SOP-00463	SM 23 4500-Cl E m
Conductivity	9	N/A	2023/11/23	CAM SOP-00414	SM 23 2510 m
Conductivity	1	N/A	2023/11/29	CAM SOP-00414	SM 23 2510 m
Dissolved Organic Carbon (DOC) (1)	10	N/A	2023/11/21	CAM SOP-00446	SM 24 5310 B m
Hardness (calculated as CaCO3)	10	N/A	2023/11/23	CAM SOP 00102/00408/00447	SM 2340 B
Dissolved Metals by ICPMS	9	N/A	2023/11/22	CAM SOP-00447	EPA 6020B m
Dissolved Metals by ICPMS	1	N/A	2023/11/29	CAM SOP-00447	EPA 6020B m
Ion Balance (% Difference)	10	N/A	2023/11/24		
Anion and Cation Sum	10	N/A	2023/11/24		
Total Ammonia-N	10	N/A	2023/11/22	CAM SOP-00441	USGS I-2522-90 m
Nitrate & Nitrite as Nitrogen in Water (2)	10	N/A	2023/11/22	CAM SOP-00440	SM 23 4500-NO3I/NO2B
pH	9	2023/11/21	2023/11/23	CAM SOP-00413	SM 24th - 4500H+ B
pH	1	2023/11/28	2023/11/29	CAM SOP-00413	SM 24th - 4500H+ B
Orthophosphate	10	N/A	2023/11/22	CAM SOP-00461	SM 23 4500-P E m
Sat. pH and Langelier Index (@ 20C)	10	N/A	2023/11/24		Auto Calc
Sat. pH and Langelier Index (@ 4C)	10	N/A	2023/11/24		Auto Calc
Sulphate by Automated Turbidimetry	9	N/A	2023/11/22	CAM SOP-00464	SM 23 4500-SO42- E m
Sulphate by Automated Turbidimetry	1	N/A	2023/11/27	CAM SOP-00464	SM 23 4500-SO42- E m
Total Dissolved Solids (TDS calc)	10	N/A	2023/11/24		Auto Calc

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCCFP, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in

Your Project #: 160310875
Your C.O.C. #: N/A

Attention: Lesley Veale

Stantec Consulting Ltd
300 Hagey Blvd
Suite 100
Waterloo, ON
CANADA N2L 0A4

Report Date: 2023/11/30
Report #: R7934680
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C3AC977

Received: 2023/11/18, 12:15

writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) Dissolved Organic Carbon (DOC) present in the sample should be considered as non-purgeable DOC.
(2) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to:
Julie Clement, Technical Account Manager
Email: Julie.CLEMENT@bureauveritas.com
Phone# (613)868-6079

==========

This report has been generated and distributed using a secure automated process.
Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Rodney Major, General Manager responsible for Ontario Environmental laboratory operations.

Bureau Veritas Job #: C3AC977
Report Date: 2023/11/30

Stantec Consulting Ltd
Client Project #: 160310875
Sampler Initials: JM

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK215			XQK215			XQK216		
Sampling Date		2023/11/16 15:00			2023/11/16 15:00			2023/11/16 15:25		
COC Number		N/A			N/A			N/A		
	UNITS	MW3-16S	RDL	QC Batch	MW3-16S Lab-Dup	RDL	QC Batch	MW2-10	RDL	QC Batch
Calculated Parameters										
Anion Sum	me/L	7.96	N/A	9059962				4.41	N/A	9059962
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	240	1.0	9059958				170	1.0	9059958
Calculated TDS	mg/L	460	1.0	9059965				240	1.0	9059965
Carb. Alkalinity (calc. as CaCO3)	mg/L	3.1	1.0	9059958				1.6	1.0	9059958
Cation Sum	me/L	7.97	N/A	9059962				4.38	N/A	9059962
Hardness (CaCO3)	mg/L	370	1.0	9059711				210	1.0	9059711
Ion Balance (% Difference)	%	0.0700	N/A	9059961				0.390	N/A	9059961
Langelier Index (@ 20C)	N/A	1.05		9059963				0.658		9059963
Langelier Index (@ 4C)	N/A	0.806		9059964				0.408		9059964
Saturation pH (@ 20C)	N/A	7.08		9059963				7.34		9059963
Saturation pH (@ 4C)	N/A	7.33		9059964				7.59		9059964
Inorganics										
Total Ammonia-N	mg/L	<0.050	0.050	9063571				<0.050	0.050	9063571
Conductivity	umho/cm	780	1.0	9062429	790	1.0	9062429	440	1.0	9062429
Dissolved Organic Carbon	mg/L	1.4	0.40	9062077				1.3	0.40	9062077
Orthophosphate (P)	mg/L	<0.010	0.010	9063531				<0.010	0.010	9063531
pH	pH	8.13		9062437	8.08		9062437	8.00		9062437
Dissolved Sulphate (SO4)	mg/L	21	1.0	9063527				7.0	1.0	9063527
Alkalinity (Total as CaCO3)	mg/L	250	1.0	9062424	250	1.0	9062424	170	1.0	9062424
Dissolved Chloride (Cl-)	mg/L	31	1.0	9063521				13	1.0	9063521
Nitrite (N)	mg/L	<0.010	0.010	9062426				<0.010	0.010	9062426
Nitrate (N)	mg/L	24.1	0.50	9062426				5.75	0.10	9062426
Nitrate + Nitrite (N)	mg/L	24.1	0.50	9062426				5.75	0.10	9062426
Metals										
Dissolved Aluminum (Al)	mg/L	<0.0049	0.0049	9061821				<0.0049	0.0049	9061821
Dissolved Antimony (Sb)	mg/L	<0.00050	0.00050	9061821				<0.00050	0.00050	9061821
Dissolved Arsenic (As)	mg/L	<0.0010	0.0010	9061821				<0.0010	0.0010	9061821
Dissolved Barium (Ba)	mg/L	0.043	0.0020	9061821				0.012	0.0020	9061821
Dissolved Beryllium (Be)	mg/L	<0.00040	0.00040	9061821				<0.00040	0.00040	9061821
Dissolved Boron (B)	mg/L	0.021	0.010	9061821				<0.010	0.010	9061821

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK215			XQK215			XQK216		
Sampling Date		2023/11/16 15:00			2023/11/16 15:00			2023/11/16 15:25		
COC Number		N/A			N/A			N/A		
	UNITS	MW3-16S	RDL	QC Batch	MW3-16S Lab-Dup	RDL	QC Batch	MW2-10	RDL	QC Batch
Dissolved Cadmium (Cd)	mg/L	<0.000090	0.000090	9061821				<0.000090	0.000090	9061821
Dissolved Calcium (Ca)	mg/L	97	0.20	9061821				66	0.20	9061821
Dissolved Chromium (Cr)	mg/L	<0.0050	0.0050	9061821				<0.0050	0.0050	9061821
Dissolved Cobalt (Co)	mg/L	<0.00050	0.00050	9061821				<0.00050	0.00050	9061821
Dissolved Copper (Cu)	mg/L	<0.00090	0.00090	9061821				0.0013	0.00090	9061821
Dissolved Iron (Fe)	mg/L	<0.10	0.10	9061821				<0.10	0.10	9061821
Dissolved Lead (Pb)	mg/L	<0.00050	0.00050	9061821				<0.00050	0.00050	9061821
Dissolved Magnesium (Mg)	mg/L	32	0.050	9061821				12	0.050	9061821
Dissolved Manganese (Mn)	mg/L	<0.0020	0.0020	9061821				<0.0020	0.0020	9061821
Dissolved Molybdenum (Mo)	mg/L	<0.00050	0.00050	9061821				0.00056	0.00050	9061821
Dissolved Nickel (Ni)	mg/L	<0.0010	0.0010	9061821				<0.0010	0.0010	9061821
Dissolved Phosphorus (P)	mg/L	<0.10	0.10	9061821				<0.10	0.10	9061821
Dissolved Potassium (K)	mg/L	2.6	0.20	9061821				2.9	0.20	9061821
Dissolved Selenium (Se)	mg/L	<0.0020	0.0020	9061821				<0.0020	0.0020	9061821
Dissolved Silicon (Si)	mg/L	6.8	0.050	9061821				2.3	0.050	9061821
Dissolved Silver (Ag)	mg/L	<0.000090	0.000090	9061821				<0.000090	0.000090	9061821
Dissolved Sodium (Na)	mg/L	10	0.10	9061821				1.2	0.10	9061821
Dissolved Strontium (Sr)	mg/L	0.17	0.0010	9061821				0.093	0.0010	9061821
Dissolved Thallium (Tl)	mg/L	<0.000050	0.000050	9061821				<0.000050	0.000050	9061821
Dissolved Titanium (Ti)	mg/L	<0.0050	0.0050	9061821				<0.0050	0.0050	9061821
Dissolved Uranium (U)	mg/L	0.00048	0.00010	9061821				0.00013	0.00010	9061821
Dissolved Vanadium (V)	mg/L	<0.00050	0.00050	9061821				<0.00050	0.00050	9061821
Dissolved Zinc (Zn)	mg/L	<0.0050	0.0050	9061821				<0.0050	0.0050	9061821

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK216			XQK217			XQK217		
Sampling Date		2023/11/16 15:25			2023/11/16 17:05			2023/11/16 17:05		
COC Number		N/A			N/A			N/A		
	UNITS	MW2-10 Lab-Dup	RDL	QC Batch	MW6-10	RDL	QC Batch	MW6-10 Lab-Dup	RDL	QC Batch
Calculated Parameters										
Anion Sum	me/L				4.93	N/A	9059962			
Bicarb. Alkalinity (calc. as CaCO3)	mg/L				180	1.0	9059958			
Calculated TDS	mg/L				270	1.0	9059965			
Carb. Alkalinity (calc. as CaCO3)	mg/L				1.6	1.0	9059958			
Cation Sum	me/L				4.92	N/A	9059962			
Hardness (CaCO3)	mg/L				240	1.0	9059711			
Ion Balance (% Difference)	%				0.160	N/A	9059961			
Langelier Index (@ 20C)	N/A				0.708		9059963			
Langelier Index (@ 4C)	N/A				0.459		9059964			
Saturation pH (@ 20C)	N/A				7.27		9059963			
Saturation pH (@ 4C)	N/A				7.52		9059964			
Inorganics										
Total Ammonia-N	mg/L				<0.050	0.050	9063571			
Conductivity	umho/cm				490	1.0	9062429			
Dissolved Organic Carbon	mg/L				1.0	0.40	9062077	0.91	0.40	9062077
Orthophosphate (P)	mg/L	<0.010	0.010	9063531	<0.010	0.010	9063531			
pH	pH				7.98		9062437			
Dissolved Sulphate (SO4)	mg/L	6.8	1.0	9063527	9.5	1.0	9063527			
Alkalinity (Total as CaCO3)	mg/L				180	1.0	9062424			
Dissolved Chloride (Cl-)	mg/L	13	1.0	9063521	14	1.0	9063521			
Nitrite (N)	mg/L				<0.010	0.010	9062426			
Nitrate (N)	mg/L				9.30	0.10	9062426			
Nitrate + Nitrite (N)	mg/L				9.30	0.10	9062426			
Metals										
Dissolved Aluminum (Al)	mg/L				<0.0049	0.0049	9061821			
Dissolved Antimony (Sb)	mg/L				<0.00050	0.00050	9061821			
Dissolved Arsenic (As)	mg/L				<0.0010	0.0010	9061821			
Dissolved Barium (Ba)	mg/L				0.017	0.0020	9061821			
Dissolved Beryllium (Be)	mg/L				<0.00040	0.00040	9061821			
Dissolved Boron (B)	mg/L				0.011	0.010	9061821			

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK216			XQK217			XQK217		
Sampling Date		2023/11/16 15:25			2023/11/16 17:05			2023/11/16 17:05		
COC Number		N/A			N/A			N/A		
	UNITS	MW2-10 Lab-Dup	RDL	QC Batch	MW6-10	RDL	QC Batch	MW6-10 Lab-Dup	RDL	QC Batch
Dissolved Cadmium (Cd)	mg/L				<0.000090	0.000090	9061821			
Dissolved Calcium (Ca)	mg/L				76	0.20	9061821			
Dissolved Chromium (Cr)	mg/L				<0.0050	0.0050	9061821			
Dissolved Cobalt (Co)	mg/L				<0.00050	0.00050	9061821			
Dissolved Copper (Cu)	mg/L				0.0012	0.00090	9061821			
Dissolved Iron (Fe)	mg/L				<0.10	0.10	9061821			
Dissolved Lead (Pb)	mg/L				<0.00050	0.00050	9061821			
Dissolved Magnesium (Mg)	mg/L				12	0.050	9061821			
Dissolved Manganese (Mn)	mg/L				<0.0020	0.0020	9061821			
Dissolved Molybdenum (Mo)	mg/L				<0.00050	0.00050	9061821			
Dissolved Nickel (Ni)	mg/L				<0.0010	0.0010	9061821			
Dissolved Phosphorus (P)	mg/L				<0.10	0.10	9061821			
Dissolved Potassium (K)	mg/L				3.4	0.20	9061821			
Dissolved Selenium (Se)	mg/L				<0.0020	0.0020	9061821			
Dissolved Silicon (Si)	mg/L				2.9	0.050	9061821			
Dissolved Silver (Ag)	mg/L				<0.000090	0.000090	9061821			
Dissolved Sodium (Na)	mg/L				1.4	0.10	9061821			
Dissolved Strontium (Sr)	mg/L				0.11	0.0010	9061821			
Dissolved Thallium (Tl)	mg/L				<0.000050	0.000050	9061821			
Dissolved Titanium (Ti)	mg/L				<0.0050	0.0050	9061821			
Dissolved Uranium (U)	mg/L				0.00017	0.00010	9061821			
Dissolved Vanadium (V)	mg/L				<0.00050	0.00050	9061821			
Dissolved Zinc (Zn)	mg/L				<0.0050	0.0050	9061821			

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK218			XQK219		XQK220		
Sampling Date		2023/11/17 10:15			2023/11/17 12:20		2023/11/17 13:35		
COC Number		N/A			N/A		N/A		
	UNITS	MW3-10D	RDL	QC Batch	MW8-10D	RDL	MW8-10S	RDL	QC Batch
Calculated Parameters									
Anion Sum	me/L	7.93	N/A	9059962	7.04	N/A	27.9	N/A	9059962
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	360	1.0	9059958	230	1.0	290	1.0	9059958
Calculated TDS	mg/L	340	1.0	9059965	400	1.0	1700	1.0	9059965
Carb. Alkalinity (calc. as CaCO3)	mg/L	8.1	1.0	9059958	1.9	1.0	1.5	1.0	9059958
Cation Sum	me/L	3.64	N/A	9059962	7.26	N/A	35.4	N/A	9059962
Hardness (CaCO3)	mg/L	44	1.0	9059711	320	1.0	840	1.0	9059711
Ion Balance (% Difference)	%	37.1	N/A	9059961	1.53	N/A	11.9	N/A	9059961
Langelier Index (@ 20C)	N/A	0.578		9059963	0.816		0.986		9059963
Langelier Index (@ 4C)	N/A	0.329		9059964	0.568		0.742		9059964
Saturation pH (@ 20C)	N/A	7.80		9059963	7.12		6.76		9059963
Saturation pH (@ 4C)	N/A	8.05		9059964	7.37		7.00		9059964
Inorganics									
Total Ammonia-N	mg/L	0.55	0.050	9063571	0.12	0.050	0.077	0.050	9063571
Conductivity	umho/cm	340	1.0	9077212	680	1.0	3200	1.0	9062429
Dissolved Organic Carbon	mg/L	5.9	0.40	9062077	0.64	0.40	2.0	0.40	9062077
Orthophosphate (P)	mg/L	0.34	0.20	9063531	<0.010	0.010	<0.010	0.010	9063531
pH	pH	8.38		9077215	7.94		7.75		9062437
Dissolved Sulphate (SO4)	mg/L	30	20	9072078	89	1.0	23	1.0	9063527
Alkalinity (Total as CaCO3)	mg/L	360	1.0	9071842	230	1.0	290	1.0	9062424
Dissolved Chloride (Cl-)	mg/L	<20 (1)	20	9072076	18	1.0	760	9.0	9063521
Nitrite (N)	mg/L	0.014	0.010	9062426	<0.010	0.010	<0.010	0.010	9062426
Nitrate (N)	mg/L	<0.10	0.10	9062426	<0.10	0.10	<0.10	0.10	9062426
Nitrate + Nitrite (N)	mg/L	<0.10	0.10	9062426	<0.10	0.10	<0.10	0.10	9062426
Metals									
Dissolved Aluminum (Al)	mg/L	0.052	0.0049	9078870	<0.0049	0.0049	0.42	0.0049	9061821
Dissolved Antimony (Sb)	mg/L	<0.00050	0.00050	9078870	<0.00050	0.00050	<0.00050	0.00050	9061821
Dissolved Arsenic (As)	mg/L	0.0046	0.0010	9078870	0.0044	0.0010	<0.0010	0.0010	9061821
Dissolved Barium (Ba)	mg/L	0.030	0.0020	9078870	0.049	0.0020	0.15	0.0020	9061821
Dissolved Beryllium (Be)	mg/L	<0.00040	0.00040	9078870	<0.00040	0.00040	<0.00040	0.00040	9061821
Dissolved Boron (B)	mg/L	0.13	0.010	9078870	0.037	0.010	<0.010	0.010	9061821

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable
(1) Due to the sample matrix, sample required dilution. Detection limit was adjusted accordingly.

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK218			XQK219		XQK220		
Sampling Date		2023/11/17 10:15			2023/11/17 12:20		2023/11/17 13:35		
COC Number		N/A			N/A		N/A		
	UNITS	MW3-10D	RDL	QC Batch	MW8-10D	RDL	MW8-10S	RDL	QC Batch
Dissolved Cadmium (Cd)	mg/L	<0.000090	0.000090	9078870	<0.000090	0.000090	<0.000090	0.000090	9061821
Dissolved Calcium (Ca)	mg/L	12	0.20	9078870	90	0.20	250	0.20	9061821
Dissolved Chromium (Cr)	mg/L	<0.0050	0.0050	9078870	<0.0050	0.0050	<0.0050	0.0050	9061821
Dissolved Cobalt (Co)	mg/L	<0.00050	0.00050	9078870	<0.00050	0.00050	0.00070	0.00050	9061821
Dissolved Copper (Cu)	mg/L	<0.00090	0.00090	9078870	<0.00090	0.00090	0.0035	0.00090	9061821
Dissolved Iron (Fe)	mg/L	<0.10	0.10	9078870	0.93	0.10	1.4	0.10	9061821
Dissolved Lead (Pb)	mg/L	<0.00050	0.00050	9078870	<0.00050	0.00050	0.0016	0.00050	9061821
Dissolved Magnesium (Mg)	mg/L	3.6	0.050	9078870	23	0.050	51	0.050	9061821
Dissolved Manganese (Mn)	mg/L	0.015	0.0020	9078870	0.066	0.0020	0.21	0.0020	9061821
Dissolved Molybdenum (Mo)	mg/L	0.030	0.00050	9078870	0.0012	0.00050	<0.00050	0.00050	9061821
Dissolved Nickel (Ni)	mg/L	<0.0010	0.0010	9078870	<0.0010	0.0010	0.0016	0.0010	9061821
Dissolved Phosphorus (P)	mg/L	<0.10	0.10	9078870	<0.10	0.10	0.31	0.10	9061821
Dissolved Potassium (K)	mg/L	0.90	0.20	9078870	0.93	0.20	3.2	0.20	9061821
Dissolved Selenium (Se)	mg/L	<0.0020	0.0020	9078870	<0.0020	0.0020	<0.0020	0.0020	9061821
Dissolved Silicon (Si)	mg/L	4.5	0.050	9078870	9.4	0.050	4.9	0.050	9061821
Dissolved Silver (Ag)	mg/L	<0.000090	0.000090	9078870	<0.000090	0.000090	<0.000090	0.000090	9061821
Dissolved Sodium (Na)	mg/L	62	0.10	9078870	19	0.10	430	0.10	9061821
Dissolved Strontium (Sr)	mg/L	0.25	0.0010	9078870	1.4	0.0010	0.44	0.0010	9061821
Dissolved Thallium (Tl)	mg/L	<0.000050	0.000050	9078870	<0.000050	0.000050	0.000062	0.000050	9061821
Dissolved Titanium (Ti)	mg/L	<0.0050	0.0050	9078870	<0.0050	0.0050	0.027	0.0050	9061821
Dissolved Uranium (U)	mg/L	0.0035	0.00010	9078870	0.00019	0.00010	0.00094	0.00010	9061821
Dissolved Vanadium (V)	mg/L	0.0032	0.00050	9078870	<0.00050	0.00050	0.0020	0.00050	9061821
Dissolved Zinc (Zn)	mg/L	<0.0050	0.0050	9078870	<0.0050	0.0050	<0.0050	0.0050	9061821

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK221			XQK221		
Sampling Date		2023/11/17 15:15			2023/11/17 15:15		
COC Number		N/A			N/A		
	UNITS	MW12-10D	RDL	QC Batch	MW12-10D Lab-Dup	RDL	QC Batch
Calculated Parameters							
Anion Sum	me/L	14.3	N/A	9059962			
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	240	1.0	9059958			
Calculated TDS	mg/L	880	1.0	9059965			
Carb. Alkalinity (calc. as CaCO3)	mg/L	1.5	1.0	9059958			
Cation Sum	me/L	14.9	N/A	9059962			
Hardness (CaCO3)	mg/L	690	1.0	9059711			
Ion Balance (% Difference)	%	2.30	N/A	9059961			
Langelier Index (@ 20C)	N/A	0.997		9059963			
Langelier Index (@ 4C)	N/A	0.751		9059964			
Saturation pH (@ 20C)	N/A	6.83		9059963			
Saturation pH (@ 4C)	N/A	7.08		9059964			
Inorganics							
Total Ammonia-N	mg/L	0.17	0.050	9063571	0.17	0.050	9063571
Conductivity	umho/cm	1300	1.0	9062429			
Dissolved Organic Carbon	mg/L	0.76	0.40	9062077			
Orthophosphate (P)	mg/L	<0.010	0.010	9063531			
pH	pH	7.83		9062437			
Dissolved Sulphate (SO4)	mg/L	420	2.0	9063527			
Alkalinity (Total as CaCO3)	mg/L	240	1.0	9062424			
Dissolved Chloride (Cl-)	mg/L	25	1.0	9063521			
Nitrite (N)	mg/L	<0.010	0.010	9062426			
Nitrate (N)	mg/L	<0.10	0.10	9062426			
Nitrate + Nitrite (N)	mg/L	<0.10	0.10	9062426			
Metals							
Dissolved Aluminum (Al)	mg/L	<0.0049	0.0049	9061821			
Dissolved Antimony (Sb)	mg/L	<0.00050	0.00050	9061821			
Dissolved Arsenic (As)	mg/L	0.0034	0.0010	9061821			
Dissolved Barium (Ba)	mg/L	0.024	0.0020	9061821			
Dissolved Beryllium (Be)	mg/L	<0.00040	0.00040	9061821			
Dissolved Boron (B)	mg/L	0.056	0.010	9061821			

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK221			XQK221		
Sampling Date		2023/11/17 15:15			2023/11/17 15:15		
COC Number		N/A			N/A		
	UNITS	MW12-10D	RDL	QC Batch	MW12-10D Lab-Dup	RDL	QC Batch
Dissolved Cadmium (Cd)	mg/L	<0.000090	0.000090	9061821			
Dissolved Calcium (Ca)	mg/L	210	0.20	9061821			
Dissolved Chromium (Cr)	mg/L	<0.0050	0.0050	9061821			
Dissolved Cobalt (Co)	mg/L	<0.00050	0.00050	9061821			
Dissolved Copper (Cu)	mg/L	<0.00090	0.00090	9061821			
Dissolved Iron (Fe)	mg/L	1.2	0.10	9061821			
Dissolved Lead (Pb)	mg/L	<0.00050	0.00050	9061821			
Dissolved Magnesium (Mg)	mg/L	41	0.050	9061821			
Dissolved Manganese (Mn)	mg/L	0.034	0.0020	9061821			
Dissolved Molybdenum (Mo)	mg/L	0.00076	0.00050	9061821			
Dissolved Nickel (Ni)	mg/L	<0.0010	0.0010	9061821			
Dissolved Phosphorus (P)	mg/L	<0.10	0.10	9061821			
Dissolved Potassium (K)	mg/L	1.5	0.20	9061821			
Dissolved Selenium (Se)	mg/L	<0.0020	0.0020	9061821			
Dissolved Silicon (Si)	mg/L	7.7	0.050	9061821			
Dissolved Silver (Ag)	mg/L	<0.000090	0.000090	9061821			
Dissolved Sodium (Na)	mg/L	24	0.10	9061821			
Dissolved Strontium (Sr)	mg/L	3.2	0.0010	9061821			
Dissolved Thallium (Tl)	mg/L	<0.000050	0.000050	9061821			
Dissolved Titanium (Ti)	mg/L	<0.0050	0.0050	9061821			
Dissolved Uranium (U)	mg/L	0.00025	0.00010	9061821			
Dissolved Vanadium (V)	mg/L	<0.00050	0.00050	9061821			
Dissolved Zinc (Zn)	mg/L	<0.0050	0.0050	9061821			

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK222	XQK223			XQK223		
Sampling Date		2023/11/17 16:35	2023/11/17 17:30			2023/11/17 17:30		
COC Number		N/A	N/A			N/A		
	UNITS	MW12-10S	MW7-10	RDL	QC Batch	MW7-10 Lab-Dup	RDL	QC Batch
Calculated Parameters								
Anion Sum	me/L	8.83	9.14	N/A	9059962			
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	410	380	1.0	9059958			
Calculated TDS	mg/L	440	490	1.0	9059965			
Carb. Alkalinity (calc. as CaCO3)	mg/L	2.3	2.3	1.0	9059958			
Cation Sum	me/L	8.72	9.23	N/A	9059962			
Hardness (CaCO3)	mg/L	420	440	1.0	9059711			
Ion Balance (% Difference)	%	0.620	0.500	N/A	9059961			
Langelier Index (@ 20C)	N/A	0.965	1.04		9059963			
Langelier Index (@ 4C)	N/A	0.717	0.789		9059964			
Saturation pH (@ 20C)	N/A	6.82	6.77		9059963			
Saturation pH (@ 4C)	N/A	7.06	7.02		9059964			
Inorganics								
Total Ammonia-N	mg/L	0.054	<0.050	0.050	9063571			
Conductivity	umho/cm	790	850	1.0	9062429			
Dissolved Organic Carbon	mg/L	0.74	0.70	0.40	9062077			
Orthophosphate (P)	mg/L	<0.010	<0.010	0.010	9063531			
pH	pH	7.78	7.81		9062437			
Dissolved Sulphate (SO4)	mg/L	15	21	1.0	9063527			
Alkalinity (Total as CaCO3)	mg/L	410	380	1.0	9062424			
Dissolved Chloride (Cl-)	mg/L	7.9	15	1.0	9063521			
Nitrite (N)	mg/L	<0.010	<0.010	0.010	9062426	<0.010	0.010	9062426
Nitrate (N)	mg/L	1.60	8.72	0.10	9062426	8.84	0.10	9062426
Nitrate + Nitrite (N)	mg/L	1.60	8.72	0.10	9062426	8.84	0.10	9062426
Metals								
Dissolved Aluminum (Al)	mg/L	<0.0049	<0.0049	0.0049	9061821			
Dissolved Antimony (Sb)	mg/L	<0.00050	<0.00050	0.00050	9061821			
Dissolved Arsenic (As)	mg/L	<0.0010	<0.0010	0.0010	9061821			
Dissolved Barium (Ba)	mg/L	0.090	0.025	0.0020	9061821			
Dissolved Beryllium (Be)	mg/L	<0.00040	<0.00040	0.00040	9061821			
Dissolved Boron (B)	mg/L	0.017	0.010	0.010	9061821			

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK222	XQK223			XQK223		
Sampling Date		2023/11/17 16:35	2023/11/17 17:30			2023/11/17 17:30		
COC Number		N/A	N/A			N/A		
	UNITS	MW12-10S	MW7-10	RDL	QC Batch	MW7-10 Lab-Dup	RDL	QC Batch
Dissolved Cadmium (Cd)	mg/L	<0.000090	<0.000090	0.000090	9061821			
Dissolved Calcium (Ca)	mg/L	110	130	0.20	9061821			
Dissolved Chromium (Cr)	mg/L	<0.0050	<0.0050	0.0050	9061821			
Dissolved Cobalt (Co)	mg/L	<0.00050	<0.00050	0.00050	9061821			
Dissolved Copper (Cu)	mg/L	0.0018	<0.00090	0.00090	9061821			
Dissolved Iron (Fe)	mg/L	<0.10	<0.10	0.10	9061821			
Dissolved Lead (Pb)	mg/L	<0.00050	<0.00050	0.00050	9061821			
Dissolved Magnesium (Mg)	mg/L	37	30	0.050	9061821			
Dissolved Manganese (Mn)	mg/L	0.018	<0.0020	0.0020	9061821			
Dissolved Molybdenum (Mo)	mg/L	<0.00050	<0.00050	0.00050	9061821			
Dissolved Nickel (Ni)	mg/L	<0.0010	<0.0010	0.0010	9061821			
Dissolved Phosphorus (P)	mg/L	<0.10	<0.10	0.10	9061821			
Dissolved Potassium (K)	mg/L	1.9	1.0	0.20	9061821			
Dissolved Selenium (Se)	mg/L	<0.0020	<0.0020	0.0020	9061821			
Dissolved Silicon (Si)	mg/L	7.7	6.8	0.050	9061821			
Dissolved Silver (Ag)	mg/L	<0.000090	<0.000090	0.000090	9061821			
Dissolved Sodium (Na)	mg/L	5.8	8.1	0.10	9061821			
Dissolved Strontium (Sr)	mg/L	0.33	0.17	0.0010	9061821			
Dissolved Thallium (Tl)	mg/L	<0.000050	<0.000050	0.000050	9061821			
Dissolved Titanium (Ti)	mg/L	<0.0050	<0.0050	0.0050	9061821			
Dissolved Uranium (U)	mg/L	0.0011	0.00023	0.00010	9061821			
Dissolved Vanadium (V)	mg/L	0.00050	<0.00050	0.00050	9061821			
Dissolved Zinc (Zn)	mg/L	0.0079	<0.0050	0.0050	9061821			

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK224		
Sampling Date		2023/11/17		
COC Number		N/A		
	UNITS	**DUPLICATE**	**RDL**	**QC Batch**
Calculated Parameters				
Anion Sum	me/L	14.3	N/A	9059962
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	240	1.0	9059958
Calculated TDS	mg/L	880	1.0	9059965
Carb. Alkalinity (calc. as CaCO3)	mg/L	1.7	1.0	9059958
Cation Sum	me/L	14.9	N/A	9059962
Hardness (CaCO3)	mg/L	690	1.0	9059711
Ion Balance (% Difference)	%	1.95	N/A	9059961
Langelier Index (@ 20C)	N/A	1.04		9059963
Langelier Index (@ 4C)	N/A	0.789		9059964
Saturation pH (@ 20C)	N/A	6.83		9059963
Saturation pH (@ 4C)	N/A	7.08		9059964
Inorganics				
Total Ammonia-N	mg/L	0.19	0.050	9063571
Conductivity	umho/cm	1300	1.0	9062429
Dissolved Organic Carbon	mg/L	0.75	0.40	9062077
Orthophosphate (P)	mg/L	<0.010	0.010	9063531
pH	pH	7.87		9062437
Dissolved Sulphate (SO4)	mg/L	420	2.0	9063527
Alkalinity (Total as CaCO3)	mg/L	240	1.0	9062424
Dissolved Chloride (Cl-)	mg/L	25	1.0	9063521
Nitrite (N)	mg/L	<0.010	0.010	9062426
Nitrate (N)	mg/L	<0.10	0.10	9062426
Nitrate + Nitrite (N)	mg/L	<0.10	0.10	9062426
Metals				
Dissolved Aluminum (Al)	mg/L	<0.0049	0.0049	9061821
Dissolved Antimony (Sb)	mg/L	<0.00050	0.00050	9061821
Dissolved Arsenic (As)	mg/L	0.0031	0.0010	9061821
Dissolved Barium (Ba)	mg/L	0.023	0.0020	9061821
Dissolved Beryllium (Be)	mg/L	<0.00040	0.00040	9061821
Dissolved Boron (B)	mg/L	0.056	0.010	9061821
Dissolved Cadmium (Cd)	mg/L	<0.000090	0.000090	9061821

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK224		
Sampling Date		2023/11/17		
COC Number		N/A		
	UNITS	**DUPLICATE**	**RDL**	**QC Batch**
Dissolved Calcium (Ca)	mg/L	210	0.20	9061821
Dissolved Chromium (Cr)	mg/L	<0.0050	0.0050	9061821
Dissolved Cobalt (Co)	mg/L	<0.00050	0.00050	9061821
Dissolved Copper (Cu)	mg/L	<0.00090	0.00090	9061821
Dissolved Iron (Fe)	mg/L	1.2	0.10	9061821
Dissolved Lead (Pb)	mg/L	<0.00050	0.00050	9061821
Dissolved Magnesium (Mg)	mg/L	42	0.050	9061821
Dissolved Manganese (Mn)	mg/L	0.033	0.0020	9061821
Dissolved Molybdenum (Mo)	mg/L	0.00071	0.00050	9061821
Dissolved Nickel (Ni)	mg/L	<0.0010	0.0010	9061821
Dissolved Phosphorus (P)	mg/L	<0.10	0.10	9061821
Dissolved Potassium (K)	mg/L	1.6	0.20	9061821
Dissolved Selenium (Se)	mg/L	<0.0020	0.0020	9061821
Dissolved Silicon (Si)	mg/L	7.6	0.050	9061821
Dissolved Silver (Ag)	mg/L	<0.000090	0.000090	9061821
Dissolved Sodium (Na)	mg/L	24	0.10	9061821
Dissolved Strontium (Sr)	mg/L	3.2	0.0010	9061821
Dissolved Thallium (Tl)	mg/L	<0.000050	0.000050	9061821
Dissolved Titanium (Ti)	mg/L	<0.0050	0.0050	9061821
Dissolved Uranium (U)	mg/L	0.00023	0.00010	9061821
Dissolved Vanadium (V)	mg/L	<0.00050	0.00050	9061821
Dissolved Zinc (Zn)	mg/L	<0.0050	0.0050	9061821

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

TEST SUMMARY

Bureau Veritas ID: XQK215
Sample ID: MW3-16S
Matrix: Water

Collected: 2023/11/16
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9061821	N/A	2023/11/22	Azita Fazaeli
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas ID: XQK215 Dup
Sample ID: MW3-16S
Matrix: Water

Collected: 2023/11/16
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai

Bureau Veritas ID: XQK216
Sample ID: MW2-10
Matrix: Water

Collected: 2023/11/16
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9061821	N/A	2023/11/22	Azita Fazaeli
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

TEST SUMMARY

Bureau Veritas ID: XQK216 **Collected:** 2023/11/16
Sample ID: MW2-10 **Shipped:**
Matrix: Water **Received:** 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas ID: XQK216 Dup **Collected:** 2023/11/16
Sample ID: MW2-10 **Shipped:**
Matrix: Water **Received:** 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu

Bureau Veritas ID: XQK217 **Collected:** 2023/11/16
Sample ID: MW6-10 **Shipped:**
Matrix: Water **Received:** 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9061821	N/A	2023/11/22	Azita Fazaeli
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas ID: XQK217 Dup **Collected:** 2023/11/16
Sample ID: MW6-10 **Shipped:**
Matrix: Water **Received:** 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

TEST SUMMARY

Bureau Veritas ID: XQK218
Sample ID: MW3-10D
Matrix: Water

Collected: 2023/11/17
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9071842	N/A	2023/11/28	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9072076	N/A	2023/11/27	Massarat Jan
Conductivity	AT	9077212	N/A	2023/11/29	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9078870	N/A	2023/11/29	Arefa Dabhad
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9077215	2023/11/28	2023/11/29	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9072078	N/A	2023/11/27	Massarat Jan
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas ID: XQK219
Sample ID: MW8-10D
Matrix: Water

Collected: 2023/11/17
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9061821	N/A	2023/11/22	Azita Fazaeli
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

TEST SUMMARY

Bureau Veritas ID: XQK220
Sample ID: MW8-10S
Matrix: Water

Collected: 2023/11/17
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9061821	N/A	2023/11/22	Azita Fazaeli
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas ID: XQK221
Sample ID: MW12-10D
Matrix: Water

Collected: 2023/11/17
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9061821	N/A	2023/11/22	Azita Fazaeli
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

TEST SUMMARY

Bureau Veritas ID: XQK221 Dup
Sample ID: MW12-10D
Matrix: Water

Collected: 2023/11/17
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru

Bureau Veritas ID: XQK222
Sample ID: MW12-10S
Matrix: Water

Collected: 2023/11/17
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9061821	N/A	2023/11/22	Azita Fazaeli
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas ID: XQK223
Sample ID: MW7-10
Matrix: Water

Collected: 2023/11/17
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9061821	N/A	2023/11/22	Azita Fazaeli
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

TEST SUMMARY

Bureau Veritas ID: XQK223 **Collected:** 2023/11/17
Sample ID: MW7-10 **Shipped:**
Matrix: Water **Received:** 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas ID: XQK223 Dup **Collected:** 2023/11/17
Sample ID: MW7-10 **Shipped:**
Matrix: Water **Received:** 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal

Bureau Veritas ID: XQK224 **Collected:** 2023/11/17
Sample ID: DUPLICATE **Shipped:**
Matrix: Water **Received:** 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9061821	N/A	2023/11/22	Azita Fazaeli
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	5.3°C

Sample XQK218 [MW3-10D] : Total Phosphorus < ortho-Phosphate: Both values fall within the method uncertainty for duplicates and are likely equivalent.

Results relate only to the items tested.

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

QUALITY ASSURANCE REPORT

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
9061821	Dissolved Aluminum (Al)	2023/11/22	99	80 - 120	99	80 - 120	<0.0049	mg/L		
9061821	Dissolved Antimony (Sb)	2023/11/22	107	80 - 120	103	80 - 120	<0.00050	mg/L	NC	20
9061821	Dissolved Arsenic (As)	2023/11/22	99	80 - 120	98	80 - 120	<0.0010	mg/L	NC	20
9061821	Dissolved Barium (Ba)	2023/11/22	99	80 - 120	99	80 - 120	<0.0020	mg/L	0.063	20
9061821	Dissolved Beryllium (Be)	2023/11/22	99	80 - 120	99	80 - 120	<0.00040	mg/L	NC	20
9061821	Dissolved Boron (B)	2023/11/22	99	80 - 120	98	80 - 120	<0.010	mg/L	1.2	20
9061821	Dissolved Cadmium (Cd)	2023/11/22	100	80 - 120	99	80 - 120	<0.000090	mg/L	NC	20
9061821	Dissolved Calcium (Ca)	2023/11/22	NC	80 - 120	101	80 - 120	<0.20	mg/L		
9061821	Dissolved Chromium (Cr)	2023/11/22	97	80 - 120	96	80 - 120	<0.0050	mg/L	NC	20
9061821	Dissolved Cobalt (Co)	2023/11/22	95	80 - 120	95	80 - 120	<0.00050	mg/L	0.95	20
9061821	Dissolved Copper (Cu)	2023/11/22	98	80 - 120	96	80 - 120	<0.00090	mg/L	0.14	20
9061821	Dissolved Iron (Fe)	2023/11/22	99	80 - 120	99	80 - 120	<0.10	mg/L		
9061821	Dissolved Lead (Pb)	2023/11/22	98	80 - 120	99	80 - 120	<0.00050	mg/L	NC	20
9061821	Dissolved Magnesium (Mg)	2023/11/22	NC	80 - 120	97	80 - 120	<0.050	mg/L		
9061821	Dissolved Manganese (Mn)	2023/11/22	97	80 - 120	96	80 - 120	<0.0020	mg/L		
9061821	Dissolved Molybdenum (Mo)	2023/11/22	105	80 - 120	102	80 - 120	<0.00050	mg/L	8.2	20
9061821	Dissolved Nickel (Ni)	2023/11/22	95	80 - 120	95	80 - 120	<0.0010	mg/L	0.48	20
9061821	Dissolved Phosphorus (P)	2023/11/22	106	80 - 120	101	80 - 120	<0.10	mg/L		
9061821	Dissolved Potassium (K)	2023/11/22	100	80 - 120	100	80 - 120	<0.20	mg/L		
9061821	Dissolved Selenium (Se)	2023/11/22	100	80 - 120	99	80 - 120	<0.0020	mg/L	NC	20
9061821	Dissolved Silicon (Si)	2023/11/22	100	80 - 120	102	80 - 120	<0.050	mg/L		
9061821	Dissolved Silver (Ag)	2023/11/22	99	80 - 120	98	80 - 120	<0.000090	mg/L	NC	20
9061821	Dissolved Sodium (Na)	2023/11/22	96	80 - 120	98	80 - 120	<0.10	mg/L	0.77	20
9061821	Dissolved Strontium (Sr)	2023/11/22	99	80 - 120	99	80 - 120	<0.0010	mg/L		
9061821	Dissolved Thallium (Tl)	2023/11/22	99	80 - 120	100	80 - 120	<0.000050	mg/L	NC	20
9061821	Dissolved Titanium (Ti)	2023/11/22	100	80 - 120	98	80 - 120	<0.0050	mg/L		
9061821	Dissolved Uranium (U)	2023/11/22	91	80 - 120	91	80 - 120	<0.00010	mg/L	0.44	20
9061821	Dissolved Vanadium (V)	2023/11/22	99	80 - 120	98	80 - 120	<0.00050	mg/L	10	20
9061821	Dissolved Zinc (Zn)	2023/11/22	95	80 - 120	97	80 - 120	<0.0050	mg/L	4.3	20
9062077	Dissolved Organic Carbon	2023/11/21	88	80 - 120	93	80 - 120	<0.40	mg/L	11	20
9062424	Alkalinity (Total as CaCO3)	2023/11/23			99	85 - 115	<1.0	mg/L	2.9	20

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
9062426	Nitrate (N)	2023/11/22	94	80 - 120	101	80 - 120	<0.10	mg/L	1.4	20
9062426	Nitrite (N)	2023/11/22	102	80 - 120	104	80 - 120	<0.010	mg/L	NC	20
9062429	Conductivity	2023/11/23			102	85 - 115	<1.0	umho/cm	2.3	10
9062437	pH	2023/11/23			102	98 - 103			0.71	N/A
9063521	Dissolved Chloride (Cl-)	2023/11/22	90	80 - 120	97	80 - 120	<1.0	mg/L	0.51	20
9063527	Dissolved Sulphate (SO4)	2023/11/22	91	75 - 125	97	80 - 120	<1.0	mg/L	3.1	20
9063531	Orthophosphate (P)	2023/11/22	94	75 - 125	94	80 - 120	<0.010	mg/L	NC	20
9063571	Total Ammonia-N	2023/11/22	102	75 - 125	98	80 - 120	<0.050	mg/L	1.1	20
9071842	Alkalinity (Total as CaCO3)	2023/11/28			102	85 - 115	<1.0	mg/L	1.5	20
9072076	Dissolved Chloride (Cl-)	2023/11/27	86	80 - 120	94	80 - 120	<1.0	mg/L	0.59	20
9072078	Dissolved Sulphate (SO4)	2023/11/27	NC	75 - 125	96	80 - 120	<1.0	mg/L	0.11	20
9077212	Conductivity	2023/11/29			102	85 - 115	<1.0	umho/cm	0.96	10
9077215	pH	2023/11/29			102	98 - 103			1.9	N/A
9078870	Dissolved Aluminum (Al)	2023/11/29	102	80 - 120	103	80 - 120	<0.0049	mg/L		
9078870	Dissolved Antimony (Sb)	2023/11/29	106	80 - 120	105	80 - 120	<0.00050	mg/L		
9078870	Dissolved Arsenic (As)	2023/11/29	102	80 - 120	100	80 - 120	<0.0010	mg/L		
9078870	Dissolved Barium (Ba)	2023/11/29	103	80 - 120	99	80 - 120	<0.0020	mg/L		
9078870	Dissolved Beryllium (Be)	2023/11/29	96	80 - 120	102	80 - 120	<0.00040	mg/L		
9078870	Dissolved Boron (B)	2023/11/29	92	80 - 120	99	80 - 120	<0.010	mg/L		
9078870	Dissolved Cadmium (Cd)	2023/11/29	103	80 - 120	102	80 - 120	<0.000090	mg/L		
9078870	Dissolved Calcium (Ca)	2023/11/29	NC	80 - 120	104	80 - 120	<0.20	mg/L		
9078870	Dissolved Chromium (Cr)	2023/11/29	97	80 - 120	97	80 - 120	<0.0050	mg/L		
9078870	Dissolved Cobalt (Co)	2023/11/29	99	80 - 120	102	80 - 120	<0.00050	mg/L		
9078870	Dissolved Copper (Cu)	2023/11/29	105	80 - 120	105	80 - 120	<0.00090	mg/L		
9078870	Dissolved Iron (Fe)	2023/11/29	NC	80 - 120	101	80 - 120	<0.10	mg/L	1.1	20
9078870	Dissolved Lead (Pb)	2023/11/29	100	80 - 120	103	80 - 120	<0.00050	mg/L		
9078870	Dissolved Magnesium (Mg)	2023/11/29	99	80 - 120	101	80 - 120	<0.050	mg/L		
9078870	Dissolved Manganese (Mn)	2023/11/29	NC	80 - 120	99	80 - 120	<0.0020	mg/L	1.4	20
9078870	Dissolved Molybdenum (Mo)	2023/11/29	106	80 - 120	103	80 - 120	<0.00050	mg/L		
9078870	Dissolved Nickel (Ni)	2023/11/29	102	80 - 120	99	80 - 120	<0.0010	mg/L		
9078870	Dissolved Phosphorus (P)	2023/11/29	103	80 - 120	104	80 - 120	<0.10	mg/L		

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
9078870	Dissolved Potassium (K)	2023/11/29	106	80 - 120	103	80 - 120	<0.20	mg/L		
9078870	Dissolved Selenium (Se)	2023/11/29	102	80 - 120	102	80 - 120	<0.0020	mg/L		
9078870	Dissolved Silicon (Si)	2023/11/29	NC	80 - 120	102	80 - 120	<0.050	mg/L		
9078870	Dissolved Silver (Ag)	2023/11/29	56 (1)	80 - 120	101	80 - 120	<0.000090	mg/L		
9078870	Dissolved Sodium (Na)	2023/11/29	108	80 - 120	103	80 - 120	<0.10	mg/L		
9078870	Dissolved Strontium (Sr)	2023/11/29	102	80 - 120	101	80 - 120	<0.0010	mg/L		
9078870	Dissolved Thallium (Tl)	2023/11/29	103	80 - 120	106	80 - 120	<0.000050	mg/L		
9078870	Dissolved Titanium (Ti)	2023/11/29	105	80 - 120	101	80 - 120	<0.0050	mg/L		
9078870	Dissolved Uranium (U)	2023/11/29	99	80 - 120	102	80 - 120	<0.00010	mg/L		
9078870	Dissolved Vanadium (V)	2023/11/29	100	80 - 120	99	80 - 120	<0.00050	mg/L		
9078870	Dissolved Zinc (Zn)	2023/11/29	101	80 - 120	100	80 - 120	<0.0050	mg/L		

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

(1) Matrix Spike exceeds acceptance limits, probable matrix interference

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:

Anastassia Hamanov, Scientific Specialist

Cristina Carriere, Senior Scientific Specialist

Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Rodney Major, General Manager responsible for Ontario Environmental laboratory operations.

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

www.BVNA.com

6740 Campobello Road, Mississauga, Ontario L5N 2L8
Phone: 905-817-5700 Fax: 905-817-5779 Toll Free: 800-563-6266

CHAIN OF CUSTODY RECORD

ENV COC - 00014v3

NONT-2023-11-492

Invoice Information	Invoice to (requires report) ☐	Report Information (if differs from invoice)		Project Information	
Company:	Stantec Consulting Ltd.	Company:		Quotation #:	
Contact Name:	Accounts Payable	Contact Name:		P.O. #/ AFE#:	
Street Address:	300 Hagey Blvd suite 100	Street Address:		Project #:	160310875
City:	Waterloo Prov: ON Postal Code: N2L0A4	City:	Prov: Postal Code:	Site #:	
Phone:	1 519 579 4410	Phone:		Site Location:	
Email:	accounts.payable@stantec.com	Email:		Site Location Province:	
Copies:	kesley.vowell@stantec.com	Copies:		Sampled By:	Julian Murray

Regulatory Criteria

REG 153: ☐ Table 1 ☐ Table 2 ☐ Table 3 ☐ Table ____ ☐ Res/Park ☐ Ind/Comm ☐ Agri/other ☐ Med/Fine ☐ Course ☐ For RSC

OTHER: ☐ CCME ☐ Reg 558* ☐ *min 3 day TAT ☐ MISA ☐ PWQO ☐ Reg 406, Table: ____ ☐ Sanitary Sewer Bylaw ☐ Storm Sewer Bylaw Municipality ☒ Other: OWRS

Include Criteria on Certificate of Analysis (check if yes): ☐

SAMPLES MUST BE KEPT COOL (<10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BUREAU VERITAS

	Sample Identification	Date Sampled YY	MM	DD	Time (24hr) HH	MM	Matrix	1 FIELD FILTERED	2 FIELD PRESERVED	3 LAB FILTRATION REQUIRED	4 BTEX/ F1	5 F2 - F4	6 VOCs	7 Reg 153 metals and inorganics	8 Reg 153 ICPMS metals	9 Reg 153 metals (Hg, Cr VI, ICPMS metals, HWS - B)	10 RCAp - comprehensive	11	12	13	14	15	16	17	18	19	20	21 # OF CONTAINERS SUBMITTED	22 HOLD - DO NOT ANALYZE
								Metals	Metals, Ammonia																				
1	MW3-16S	23	11	16	15	00	GW	X	X								X											4	
2	MW2-10	23	11	16	15	29	GW	X	X								X											4	
3	MW6-10	23	11	16	17	05	GW	X	X								X											4	
4	MW3-10D	23	11	17	10	19	GW	X	X								X											4	
5	MW8-10D	23	11	17	12	20	GW	X	X								X											4	
6	MW8-10S	23	11	17	13	35	GW	X	X								X											4	
7	MW12-10D	23	11	17	15	15	GW	X	X								X											4	
8	MW12-10S	23	11	17	16	35	GW	X	X								X											4	
9	MW7-10	23	11	17	17	30	GW	X	X								X											4	
10																													
11																													
12																													

Regular Turnaround Time (TAT): ☒ 5 to 7 Day ☐ 10 Day

Rush Turnaround Time (TAT) Surcharges apply: ☐ Same Day ☐ 1 Day ☐ 2 Day ☐ 3 Day ☐ 4 Day

Date Required: YY MM DD

Comments

*UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BUREAU VERITAS STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS AND CONDITIONS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVNA.COM/TERMS-AND-CONDITIONS OR BY CALLING THE LABORATORY LISTED ABOVE TO OBTAIN A COPY

LAB USE ONLY	Yes	No	°C	1	2	3
Seal present	✓					
Seal intact	✓					
Cooling media present	✓					
				5	6	5

LAB USE ONLY	Yes	No	°C	1	2	3
Seal present						
Seal intact						
Cooling media present						

LAB USE ONLY	Yes	No	°C	1	2	3
Seal present						
Seal intact						
Cooling media present						

Temperature reading by:

Relinquished by: (Signature/ Print)	Date YY	MM	DD	Time HH	MM	Received by: (Signature/ Print)	Date YY	MM	DD	Time HH	MM	Special instructions
1 Julian Murray	2023	11	17	18	15	1 AVISHEK SHRESTHA	2023	11	18	12	15	
2						2						

Your Project #: 161450875
Your C.O.C. #: 959584-02-01

Attention: Lesley Veale

Stantec Consulting Ltd
300 Hagey Blvd
Suite 100
Waterloo, ON
CANADA N2L 0A4

Report Date: 2023/12/08
Report #: R7946167
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C3AT024
Received: 2023/12/02, 11:40

Sample Matrix: Water
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity	2	N/A	2023/12/05	CAM SOP-00448	SM 24 2320 B m
Carbonate, Bicarbonate and Hydroxide	2	N/A	2023/12/05	CAM SOP-00102	APHA 4500-CO2 D
Chloride by Automated Colourimetry	2	N/A	2023/12/05	CAM SOP-00463	SM 24 4500-Cl E m
Conductivity	2	N/A	2023/12/05	CAM SOP-00414	SM 24 2510 m
Dissolved Organic Carbon (DOC) (1)	2	N/A	2023/12/05	CAM SOP-00446	SM 24 5310 B m
Hardness (calculated as CaCO3)	2	N/A	2023/12/06	CAM SOP 00102/00408/00447	SM 2340 B
Dissolved Metals by ICPMS	2	N/A	2023/12/05	CAM SOP-00447	EPA 6020B m
Ion Balance (% Difference)	2	N/A	2023/12/06		
Anion and Cation Sum	2	N/A	2023/12/06		
Total Ammonia-N	2	N/A	2023/12/07	CAM SOP-00441	USGS I-2522-90 m
Nitrate & Nitrite as Nitrogen in Water (2)	2	N/A	2023/12/05	CAM SOP-00440	SM 24 4500-NO3I/NO2B
pH	2	2023/12/04	2023/12/05	CAM SOP-00413	SM 24th - 4500H+ B
Orthophosphate	2	N/A	2023/12/04	CAM SOP-00461	SM 24 4500-P E
Sat. pH and Langelier Index (@ 20C)	2	N/A	2023/12/06		Auto Calc
Sat. pH and Langelier Index (@ 4C)	2	N/A	2023/12/06		Auto Calc
Sulphate by Automated Turbidimetry	2	N/A	2023/12/05	CAM SOP-00464	SM 24 4500-SO42- E m
Total Dissolved Solids (TDS calc)	2	N/A	2023/12/06		Auto Calc

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCCFP, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report.

Your Project #: 161450875
Your C.O.C. #: 959584-02-01

Attention: Lesley Veale

Stantec Consulting Ltd
300 Hagey Blvd
Suite 100
Waterloo, ON
CANADA N2L 0A4

Report Date: 2023/12/08
Report #: R7946167
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C3AT024

Received: 2023/12/02, 11:40

Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) Dissolved Organic Carbon (DOC) present in the sample should be considered as non-purgeable DOC.
(2) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to:
Julie Clement, Technical Account Manager
Email: Julie.CLEMENT@bureauveritas.com
Phone# (613)868-6079

==========

This report has been generated and distributed using a secure automated process.
Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Rodney Major, General Manager responsible for Ontario Environmental laboratory operations.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XTW488			XTW488		
Sampling Date		2023/12/01 15:40			2023/12/01 15:40		
COC Number		959584-02-01			959584-02-01		
	UNITS	MW13-10	RDL	QC Batch	MW13-10 Lab-Dup	RDL	QC Batch
Calculated Parameters							
Anion Sum	me/L	7.98	N/A	9087967			
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	330	1.0	9087962			
Calculated TDS	mg/L	430	1.0	9087968			
Carb. Alkalinity (calc. as CaCO3)	mg/L	1.9	1.0	9087962			
Cation Sum	me/L	8.61	N/A	9087967			
Hardness (CaCO3)	mg/L	420	1.0	9087958			
Ion Balance (% Difference)	%	3.80	N/A	9087965			
Langelier Index (@ 20C)	N/A	0.910		9087963			
Langelier Index (@ 4C)	N/A	0.662		9087966			
Saturation pH (@ 20C)	N/A	6.87		9087963			
Saturation pH (@ 4C)	N/A	7.12		9087966			
Inorganics							
Total Ammonia-N	mg/L	<0.050	0.050	9094508			
Conductivity	umho/cm	740	1.0	9089367			
Dissolved Organic Carbon	mg/L	0.51	0.40	9088929			
Orthophosphate (P)	mg/L	<0.030 (1)	0.030	9088781			
pH	pH	7.78		9089366			
Dissolved Sulphate (SO4)	mg/L	35	1.0	9088805			
Alkalinity (Total as CaCO3)	mg/L	340	1.0	9089363			
Dissolved Chloride (Cl-)	mg/L	13	1.0	9088799			
Nitrite (N)	mg/L	<0.010	0.010	9088873			
Nitrate (N)	mg/L	2.29	0.10	9088873			
Nitrate + Nitrite (N)	mg/L	2.29	0.10	9088873			
Metals							
Dissolved Aluminum (Al)	mg/L	<0.0049	0.0049	9091730	<0.0049	0.0049	9091730
Dissolved Antimony (Sb)	mg/L	<0.00050	0.00050	9091730	<0.00050	0.00050	9091730
Dissolved Arsenic (As)	mg/L	<0.0010	0.0010	9091730	<0.0010	0.0010	9091730
Dissolved Barium (Ba)	mg/L	0.078	0.0020	9091730	0.077	0.0020	9091730
Dissolved Beryllium (Be)	mg/L	<0.00040	0.00040	9091730	<0.00040	0.00040	9091730

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable
(1) Detection Limit was raised due to matrix interferences.

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XTW488			XTW488		
Sampling Date		2023/12/01 15:40			2023/12/01 15:40		
COC Number		959584-02-01			959584-02-01		
	UNITS	MW13-10	RDL	QC Batch	MW13-10 Lab-Dup	RDL	QC Batch
Dissolved Boron (B)	mg/L	<0.010	0.010	9091730	<0.010	0.010	9091730
Dissolved Cadmium (Cd)	mg/L	<0.000090	0.000090	9091730	<0.000090	0.000090	9091730
Dissolved Calcium (Ca)	mg/L	110	0.20	9091730	120	0.20	9091730
Dissolved Chromium (Cr)	mg/L	<0.0050	0.0050	9091730	<0.0050	0.0050	9091730
Dissolved Cobalt (Co)	mg/L	<0.00050	0.00050	9091730	<0.00050	0.00050	9091730
Dissolved Copper (Cu)	mg/L	0.0023	0.00090	9091730	0.0018	0.00090	9091730
Dissolved Iron (Fe)	mg/L	<0.10	0.10	9091730	<0.10	0.10	9091730
Dissolved Lead (Pb)	mg/L	<0.00050	0.00050	9091730	<0.00050	0.00050	9091730
Dissolved Magnesium (Mg)	mg/L	33	0.050	9091730	34	0.050	9091730
Dissolved Manganese (Mn)	mg/L	<0.0020	0.0020	9091730	<0.0020	0.0020	9091730
Dissolved Molybdenum (Mo)	mg/L	<0.00050	0.00050	9091730	<0.00050	0.00050	9091730
Dissolved Nickel (Ni)	mg/L	<0.0010	0.0010	9091730	<0.0010	0.0010	9091730
Dissolved Phosphorus (P)	mg/L	<0.10	0.10	9091730	<0.10	0.10	9091730
Dissolved Potassium (K)	mg/L	0.91	0.20	9091730	0.90	0.20	9091730
Dissolved Selenium (Se)	mg/L	<0.0020	0.0020	9091730	<0.0020	0.0020	9091730
Dissolved Silicon (Si)	mg/L	6.9	0.050	9091730	7.1	0.050	9091730
Dissolved Silver (Ag)	mg/L	<0.000090	0.000090	9091730	<0.000090	0.000090	9091730
Dissolved Sodium (Na)	mg/L	3.8	0.10	9091730	3.8	0.10	9091730
Dissolved Strontium (Sr)	mg/L	0.17	0.0010	9091730	0.17	0.0010	9091730
Dissolved Thallium (Tl)	mg/L	<0.000050	0.000050	9091730	<0.000050	0.000050	9091730
Dissolved Titanium (Ti)	mg/L	<0.0050	0.0050	9091730	<0.0050	0.0050	9091730
Dissolved Uranium (U)	mg/L	0.00077	0.00010	9091730	0.00079	0.00010	9091730
Dissolved Vanadium (V)	mg/L	<0.00050	0.00050	9091730	<0.00050	0.00050	9091730
Dissolved Zinc (Zn)	mg/L	0.016	0.0050	9091730	0.017	0.0050	9091730

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XTW489		
Sampling Date		2023/12/01 15:20		
COC Number		959584-02-01		
	UNITS	MW10-10	RDL	QC Batch
Calculated Parameters				
Anion Sum	me/L	5.25	N/A	9087967
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	250	1.0	9087962
Calculated TDS	mg/L	280	1.0	9087968
Carb. Alkalinity (calc. as CaCO3)	mg/L	2.0	1.0	9087962
Cation Sum	me/L	5.60	N/A	9087967
Hardness (CaCO3)	mg/L	260	1.0	9087958
Ion Balance (% Difference)	%	3.23	N/A	9087965
Langelier Index (@ 20C)	N/A	0.660		9087963
Langelier Index (@ 4C)	N/A	0.411		9087966
Saturation pH (@ 20C)	N/A	7.28		9087963
Saturation pH (@ 4C)	N/A	7.52		9087966
Inorganics				
Total Ammonia-N	mg/L	0.18	0.050	9094908
Conductivity	umho/cm	490	1.0	9089367
Dissolved Organic Carbon	mg/L	0.88	0.40	9088929
Orthophosphate (P)	mg/L	<0.010	0.010	9088781
pH	pH	7.94		9089366
Dissolved Sulphate (SO4)	mg/L	12	1.0	9088805
Alkalinity (Total as CaCO3)	mg/L	250	1.0	9089363
Dissolved Chloride (Cl-)	mg/L	<1.0	1.0	9088799
Nitrite (N)	mg/L	0.015	0.010	9088873
Nitrate (N)	mg/L	<0.10	0.10	9088873
Nitrate + Nitrite (N)	mg/L	<0.10	0.10	9088873
Metals				
Dissolved Aluminum (Al)	mg/L	0.015	0.0049	9091730
Dissolved Antimony (Sb)	mg/L	<0.00050	0.00050	9091730
Dissolved Arsenic (As)	mg/L	0.013	0.0010	9091730
Dissolved Barium (Ba)	mg/L	0.10	0.0020	9091730
Dissolved Beryllium (Be)	mg/L	<0.00040	0.00040	9091730
Dissolved Boron (B)	mg/L	0.021	0.010	9091730
Dissolved Cadmium (Cd)	mg/L	<0.000090	0.000090	9091730

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XTW489		
Sampling Date		2023/12/01 15:20		
COC Number		959584-02-01		
	UNITS	**MW10-10**	**RDL**	**QC Batch**
Dissolved Calcium (Ca)	mg/L	55	0.20	9091730
Dissolved Chromium (Cr)	mg/L	<0.0050	0.0050	9091730
Dissolved Cobalt (Co)	mg/L	<0.00050	0.00050	9091730
Dissolved Copper (Cu)	mg/L	<0.00090	0.00090	9091730
Dissolved Iron (Fe)	mg/L	0.29	0.10	9091730
Dissolved Lead (Pb)	mg/L	<0.00050	0.00050	9091730
Dissolved Magnesium (Mg)	mg/L	30	0.050	9091730
Dissolved Manganese (Mn)	mg/L	0.022	0.0020	9091730
Dissolved Molybdenum (Mo)	mg/L	0.0011	0.00050	9091730
Dissolved Nickel (Ni)	mg/L	0.0039	0.0010	9091730
Dissolved Phosphorus (P)	mg/L	<0.10	0.10	9091730
Dissolved Potassium (K)	mg/L	1.3	0.20	9091730
Dissolved Selenium (Se)	mg/L	<0.0020	0.0020	9091730
Dissolved Silicon (Si)	mg/L	12	0.050	9091730
Dissolved Silver (Ag)	mg/L	<0.000090	0.000090	9091730
Dissolved Sodium (Na)	mg/L	8.3	0.10	9091730
Dissolved Strontium (Sr)	mg/L	0.38	0.0010	9091730
Dissolved Thallium (Tl)	mg/L	<0.000050	0.000050	9091730
Dissolved Titanium (Ti)	mg/L	<0.0050	0.0050	9091730
Dissolved Uranium (U)	mg/L	0.00010	0.00010	9091730
Dissolved Vanadium (V)	mg/L	<0.00050	0.00050	9091730
Dissolved Zinc (Zn)	mg/L	<0.0050	0.0050	9091730

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

TEST SUMMARY

Bureau Veritas ID: XTW488 **Collected:** 2023/12/01
Sample ID: MW13-10 **Shipped:**
Matrix: Water **Received:** 2023/12/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9089363	N/A	2023/12/05	Nachiketa Gohil
Carbonate, Bicarbonate and Hydroxide	CALC	9087962	N/A	2023/12/05	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9088799	N/A	2023/12/05	Alina Dobreanu
Conductivity	AT	9089367	N/A	2023/12/05	Nachiketa Gohil
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9088929	N/A	2023/12/05	Gyulshen Idriz
Hardness (calculated as CaCO3)		9087958	N/A	2023/12/06	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9091730	N/A	2023/12/05	Prempal Bhatti
Ion Balance (% Difference)	CALC	9087965	N/A	2023/12/06	Automated Statchk
Anion and Cation Sum	CALC	9087967	N/A	2023/12/06	Automated Statchk
Total Ammonia-N	LACH/NH4	9094508	N/A	2023/12/07	Shivani Shivani
Nitrate & Nitrite as Nitrogen in Water	LACH	9088873	N/A	2023/12/05	Chandra Nandlal
pH	AT	9089366	2023/12/04	2023/12/05	Nachiketa Gohil
Orthophosphate	KONE	9088781	N/A	2023/12/04	Massarat Jan
Sat. pH and Langelier Index (@ 20C)	CALC	9087963	N/A	2023/12/06	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9087966	N/A	2023/12/06	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9088805	N/A	2023/12/05	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9087968	N/A	2023/12/06	Automated Statchk

Bureau Veritas ID: XTW488 Dup **Collected:** 2023/12/01
Sample ID: MW13-10 **Shipped:**
Matrix: Water **Received:** 2023/12/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Dissolved Metals by ICPMS	ICP/MS	9091730	N/A	2023/12/05	Prempal Bhatti

Bureau Veritas ID: XTW489 **Collected:** 2023/12/01
Sample ID: MW10-10 **Shipped:**
Matrix: Water **Received:** 2023/12/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9089363	N/A	2023/12/05	Nachiketa Gohil
Carbonate, Bicarbonate and Hydroxide	CALC	9087962	N/A	2023/12/05	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9088799	N/A	2023/12/05	Alina Dobreanu
Conductivity	AT	9089367	N/A	2023/12/05	Nachiketa Gohil
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9088929	N/A	2023/12/05	Gyulshen Idriz
Hardness (calculated as CaCO3)		9087958	N/A	2023/12/06	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9091730	N/A	2023/12/05	Prempal Bhatti
Ion Balance (% Difference)	CALC	9087965	N/A	2023/12/06	Automated Statchk
Anion and Cation Sum	CALC	9087967	N/A	2023/12/06	Automated Statchk
Total Ammonia-N	LACH/NH4	9094908	N/A	2023/12/07	Shivani Shivani
Nitrate & Nitrite as Nitrogen in Water	LACH	9088873	N/A	2023/12/05	Chandra Nandlal
pH	AT	9089366	2023/12/04	2023/12/05	Nachiketa Gohil
Orthophosphate	KONE	9088781	N/A	2023/12/04	Massarat Jan
Sat. pH and Langelier Index (@ 20C)	CALC	9087963	N/A	2023/12/06	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9087966	N/A	2023/12/06	Automated Statchk

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

Bureau Veritas Job #: C3AT024
Report Date: 2023/12/08

Stantec Consulting Ltd
Client Project #: 161450875
Sampler Initials: JM

TEST SUMMARY

Bureau Veritas ID: XTW489
Sample ID: MW10-10
Matrix: Water

Collected: 2023/12/01
Shipped:
Received: 2023/12/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Sulphate by Automated Turbidimetry	SKAL	9088805	N/A	2023/12/05	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9087968	N/A	2023/12/06	Automated Statchk

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	0.0°C

Results relate only to the items tested.

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

QUALITY ASSURANCE REPORT

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
9088781	Orthophosphate (P)	2023/12/04	89	75 - 125	89	80 - 120	<0.010	mg/L	NC	20
9088799	Dissolved Chloride (Cl-)	2023/12/05	92	80 - 120	94	80 - 120	<1.0	mg/L	0.61	20
9088805	Dissolved Sulphate (SO4)	2023/12/05	NC	75 - 125	94	80 - 120	<1.0	mg/L	1.1	20
9088873	Nitrate (N)	2023/12/05	91	80 - 120	94	80 - 120	<0.10	mg/L	NC	20
9088873	Nitrite (N)	2023/12/05	100	80 - 120	103	80 - 120	<0.010	mg/L	NC	20
9088929	Dissolved Organic Carbon	2023/12/05	87	80 - 120	97	80 - 120	<0.40	mg/L	2.0	20
9089363	Alkalinity (Total as CaCO3)	2023/12/05			97	85 - 115	<1.0	mg/L	0.36	20
9089366	pH	2023/12/05			101	98 - 103			1.2	N/A
9089367	Conductivity	2023/12/05			101	85 - 115	<1.0	umho/cm	0.38	10
9091730	Dissolved Aluminum (Al)	2023/12/05	106	80 - 120	115	80 - 120	<0.0049	mg/L	NC	20
9091730	Dissolved Antimony (Sb)	2023/12/05	111	80 - 120	103	80 - 120	<0.00050	mg/L	NC	20
9091730	Dissolved Arsenic (As)	2023/12/05	106	80 - 120	102	80 - 120	<0.0010	mg/L	NC	20
9091730	Dissolved Barium (Ba)	2023/12/05	107	80 - 120	103	80 - 120	<0.0020	mg/L	1.3	20
9091730	Dissolved Beryllium (Be)	2023/12/05	103	80 - 120	100	80 - 120	<0.00040	mg/L	NC	20
9091730	Dissolved Boron (B)	2023/12/05	101	80 - 120	98	80 - 120	<0.010	mg/L	NC	20
9091730	Dissolved Cadmium (Cd)	2023/12/05	107	80 - 120	100	80 - 120	<0.000090	mg/L	NC	20
9091730	Dissolved Calcium (Ca)	2023/12/05	NC	80 - 120	107	80 - 120	<0.20	mg/L	2.4	20
9091730	Dissolved Chromium (Cr)	2023/12/05	107	80 - 120	103	80 - 120	<0.0050	mg/L	NC	20
9091730	Dissolved Cobalt (Co)	2023/12/05	105	80 - 120	102	80 - 120	<0.00050	mg/L	NC	20
9091730	Dissolved Copper (Cu)	2023/12/05	109	80 - 120	103	80 - 120	<0.00090	mg/L	NC	20
9091730	Dissolved Iron (Fe)	2023/12/05	109	80 - 120	104	80 - 120	<0.10	mg/L	NC	20
9091730	Dissolved Lead (Pb)	2023/12/05	105	80 - 120	101	80 - 120	<0.00050	mg/L	NC	20
9091730	Dissolved Magnesium (Mg)	2023/12/05	NC	80 - 120	105	80 - 120	<0.050	mg/L	0.38	20
9091730	Dissolved Manganese (Mn)	2023/12/05	106	80 - 120	102	80 - 120	<0.0020	mg/L	NC	20
9091730	Dissolved Molybdenum (Mo)	2023/12/05	114	80 - 120	105	80 - 120	<0.00050	mg/L	NC	20
9091730	Dissolved Nickel (Ni)	2023/12/05	101	80 - 120	99	80 - 120	<0.0010	mg/L	NC	20
9091730	Dissolved Phosphorus (P)	2023/12/05	117	80 - 120	109	80 - 120	<0.10	mg/L	NC	20
9091730	Dissolved Potassium (K)	2023/12/05	112	80 - 120	107	80 - 120	<0.20	mg/L	1.5	20
9091730	Dissolved Selenium (Se)	2023/12/05	104	80 - 120	99	80 - 120	<0.0020	mg/L	NC	20
9091730	Dissolved Silicon (Si)	2023/12/05	110	80 - 120	106	80 - 120	<0.050	mg/L	2.0	20
9091730	Dissolved Silver (Ag)	2023/12/05	106	80 - 120	100	80 - 120	<0.000090	mg/L	NC	20

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
9091730	Dissolved Sodium (Na)	2023/12/05	109	80 - 120	106	80 - 120	<0.10	mg/L	1.6	20
9091730	Dissolved Strontium (Sr)	2023/12/05	107	80 - 120	102	80 - 120	<0.0010	mg/L	0.49	20
9091730	Dissolved Thallium (Tl)	2023/12/05	106	80 - 120	103	80 - 120	<0.000050	mg/L	NC	20
9091730	Dissolved Titanium (Ti)	2023/12/05	109	80 - 120	102	80 - 120	<0.0050	mg/L	NC	20
9091730	Dissolved Uranium (U)	2023/12/05	107	80 - 120	103	80 - 120	<0.00010	mg/L	2.8	20
9091730	Dissolved Vanadium (V)	2023/12/05	108	80 - 120	103	80 - 120	<0.00050	mg/L	NC	20
9091730	Dissolved Zinc (Zn)	2023/12/05	104	80 - 120	101	80 - 120	<0.0050	mg/L	1.5	20
9094508	Total Ammonia-N	2023/12/07	82	75 - 125	100	80 - 120	<0.050	mg/L	0.53	20
9094908	Total Ammonia-N	2023/12/07	98	75 - 125	99	80 - 120	<0.050	mg/L	2.4	20

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

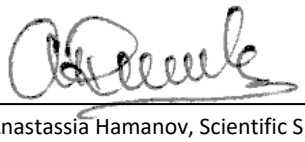
NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:



Anastassia Hamanov, Scientific Specialist

Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Rodney Major, General Manager responsible for Ontario Environmental laboratory operations.

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

Bureau Veritas
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel:(905) 817-5700 Toll-free:800-563-6266 Fax:(905) 817-5777 www.bvna.com

02-Dec-23 11:40
Julie Clement
C3AT024
JDK ENV-1647

C#959584-02-01

INVOICE TO:

Company Name: #9197 Stantec Consulting Ltd
Attention: Accounts Payable
Address: 300 Hagey Blvd Suite 100
Waterloo ON N2L 0A4
Tel: (519) 579-4410 Fax: (519) 579-6733
Email: SAPinvoices@Stantec.com

REPORT TO:

Company Name:
Attention: Lesley Veale
Address:
Tel: (519) 585-7377 Fax:
Email: lesley.veale@stantec.com

PROJECT INFORMA

Quotation #: C31067
P.O. #: 161450875
Project:
Project Name:
Site #:
Sampled By: Julian Murray

ory Use Only:

Bottle Order #: 959584
Project Manager: Julie Clement

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BUREAU VERITAS DRINKING WATER CHAIN OF CUSTODY

Regulation 153 (2011)
☐ Table 1 ☐ Res/Park ☐ Medium/Fine
☐ Table 2 ☐ Ind/Comm ☐ Coarse
☐ Table 3 ☐ Agri/Other ☐ For RSC
☐ Table ___

Other Regulations
☐ CCME ☐ Sanitary Sewer Bylaw
☐ Reg 558 ☐ Storm Sewer Bylaw
☐ MISA Municipality ___
☐ PWQO ☐ Reg 406 Table ___
☒ Other ODWS

Special Instructions

Include Criteria on Certificate of Analysis (Y/N)? ___

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required:
Please provide advance notice for rush projects

Regular (Standard) TAT: ☒
(will be applied if Rush TAT is not specified)
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: ___ Time Required: ___ ☐
Rush Confirmation Number: ___ *(call lab for #)*

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered (please circle): (Metals / Hg / Cr VI)	RCAp - Comprehensive	# of Bottles	Comments
1		MW13-10	Dec.1/23	15:40	GW	Y	X	4	
2		MW10-10	↓	15:20	GW	Y	X	4	
3									
4									
5									
6									
7									
8									
9									
10									

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
Julian Murray / JULIAN MURRAY	23/12/01	19:00		23/12/02	11:40	

Laboratory Use Only
Time Sensitive
Temperature (°C) on Recei: 0 | 0 | 0
Custody Seal Present ✓ Intact

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BUREAU VERITAS'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVNA.COM/ENVIRONMENTAL-LABORATORIES/RESOURCES/COC-TERMS-AND-CONDITIONS.
* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.
** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT WWW.BVNA.COM/ENVIRONMENTAL-LA[redacted]-COCS.

SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BUREAU VERITAS

White: Bureau Veritas Yellow: Client

North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program, 2023 Monitoring Data

June 14, 2024

Prepared for:

NorthGate Land Corporation,
2115881 Ontario Ltd.,
Activa Holdings, and
Erbsville Kartway

Prepared by:

Stantec Consulting Ltd.
100-300 Hagey Boulevard
Waterloo, ON N2L 0A4
Tel.: (519) 579-4410

160310875

This document entitled North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program, 2023 Monitoring Data was prepared by Stantec Consulting Ltd. (“Stantec”) for the account of NorthGate Land Corporation, 2115881 Ontario Ltd., Activa Holdings, and Erbsville Kartway (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 Murray, Julian Date: 2024.06.19 23:32:43 -04'00'

(signature)

Julian Murray, M.Sc., GIT
Environmental Scientist

Prepared by _____ Digitally signed by Kyle, Amy Date: 2024.06.14 11:40:23 -04'00'

(signature)

Amy Kyle, B.Eng
Water Resources Specialist

Reviewed by _____ Digitally signed by Veale, Lesley Date: 2024.06.14 12:28:48 -04'00'

(signature)

Lesley Veale, M.Sc., P.Geo.
Senior Hydrogeologist

Reviewed by _____ Digitally signed by Yokich, Nathan Date: 2024.06.14 10:58:28 -04'00' Adobe Acrobat version: 2024.002.20759

(signature)

Nathan Yokich, P.Eng., CAN-CISEC
Water Resources Engineer

Table of Contents

ABBREVIATIONS ..... **II**

1.0 INTRODUCTION **1.1**

2.0 BACKGROUND **2.1**
2.1 NWSSS HYDROGEOLOGIC INVESTIGATION 2.1
2.2 NWSSS SURFACE WATER INVESTIGATION 2.2
2.3 NORTH WATERLOO MONITORING PROGRAM 2.2

3.0 METHODOLOGY **3.1**
3.1 WATER LEVEL MONITORING 3.1
3.2 SURFACE WATER FLOW MONITORING 3.2
3.3 SURFACE WATER QUALITY 3.2
3.4 GROUNDWATER SAMPLING AND WATER QUALITY TESTING 3.3
3.5 CLIMATIC DATA 3.4

4.0 MONITORING RESULTS **4.1**
4.1 PRECIPITATION 4.1
4.2 GROUNDWATER LEVELS – 2023 ..... 4.1
4.3 GROUNDWATER CHEMISTRY – 2023 ..... 4.1
4.4 SURFACE WATER FLOW AND WATER LEVEL ANALYSIS 4.2
4.5 SURFACE WATER QUALITY RESULTS 4.3

5.0 CONCLUSIONS AND RECOMMENDATIONS **5.1**

6.0 REFERENCES **6.1**

LIST OF APPENDICES

Appendix A: Figures
Appendix B: Tables
Appendix C: Phase Monitoring Program
Appendix D: Surface Water Flow Data
Appendix E: Laboratory Certificate of Analysis

Abbreviations

City	City of Waterloo
the Client	Northgate Corporation, 2115881 Ontario Ltd., Activa Holdings, and Erbsville Kartway
HDPE	high density polyethylene
KWCS	Kitchener-Waterloo Climate Station
LCWS	Laurel Creek Watershed Study
NWSSS	North Waterloo Scoped Subwatershed Study
RCS	Roseville Climate Station
the Site	proposed development, generally bounded by Erbsville Road, Beaver Creek Road, Laurel Creek Conservation lands and City limits
Stantec	Stantec Consulting Ltd.
TSS	total suspended solids
UWWS	University of Waterloo Weather Station

1.0 INTRODUCTION

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

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

The NWSSS presented initial groundwater and surface water monitoring results from 2009 and 2010 (Ecoplans, MHBC, Stantec, 2013). Subsequent reports detailed the 2011 to 2022 monitoring (Stantec, 2023). The following report presents the surface water and groundwater monitoring data collected in 2023, along with historical data for reference.

This report is arranged in six sections, including this introduction. Section 2 presents a background of the previous investigations. Section 3 presents the methodology while the 2023 monitoring results are presented in Section 4. Section 5 provides conclusions and recommendations while Section 6 provides a list of references. All figures and tables referenced in the report are presented in Appendices A and B, respectively. Appendices C to E present the approved Phase I Monitoring Program, surface water flow data and analysis, and laboratory certificates of analysis, respectively.

2.0 BACKGROUND

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

2.1 NWSSS HYDROGEOLOGIC INVESTIGATION

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

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

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

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

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

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

Water quality results within deposits of Aquifer 1 within the northeastern portion of the Site were characterized by aerobic groundwater with nitrate present suggesting influence from local agricultural fields. Within the western portion of the property, shallow water quality results indicated slightly anaerobic water with both manganese and nitrate present and typically low dissolved oxygen levels. Water quality results within the deep monitoring wells at the western extent of the Site including MW8-10D and MW12-10D indicated elevated sulphate concentrations of up to 410 mg/L, suggesting a hydraulic connection with the deeper hydrostratigraphic units, likely a result of the eroded deposits of Aquitards 2/3 within the glacial meltwater channel.

2.2 NWSSS SURFACE WATER INVESTIGATION

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

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

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

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

2.3 NORTH WATERLOO MONITORING PROGRAM

The NWSSS included groundwater and surface water monitoring data for the Site from 2009 and 2010. The groundwater and surface water monitoring has been on-going since 2011. The Phase 1 Monitoring Program for the Site was approved in mid-2014, which included a reduced monitoring program within the Site itself and eliminated monitoring of adjacent wells. Additional modifications were recommended by Stantec (2016). The monitoring wells and current status are detailed in Table 1. A copy of the approved monitoring program is included in Appendix C.

3.0 METHODOLOGY

The following section details the methodology for monitoring in 2023, including groundwater and surface water level monitoring, surface water flow monitoring, groundwater quality sampling and analysis, and climate data.

3.1 WATER LEVEL MONITORING

The groundwater and surface water level monitoring locations are presented on Figure 1 with well construction details and monitoring status presented in Table 1. Since the start of the monitoring program, the following changes to the monitoring locations has occurred:

- In 2015, the monitoring wells MW3-10S and MW11-10 were observed to be damaged. MW3-10S was abandoned and replaced with MW3-16S in February 2016. Stantec recommended replacement of MW11-10 but to date has not been completed.
- In early 2018, DP5-09 was damaged by stream flow debris and was replaced by DP5-18 in June 2018.
- In March 2023, DP3-09 was found to be damaged and was subsequently replaced by DP3-23 in November 2023.

Monitoring was completed in spring, summer and fall in 2023 in eleven (11) shallow and deep monitoring wells (MW2-10, MW3-16S, MW3-10D, MW6-10, MW7-10, MW8-10S, MW8-10D, MW10-10, MW12-10S, MW12-10D and MW13-10) and five (5) drivepoint piezometers (DP1-09, DP3-09 and DP5-18 along Beaver Creek and DP10-14 and DP9-09 along Laurel Creek).

Groundwater and surface water level monitoring was completed using a combination of manual and automated techniques. Monitoring wells and drivepoint piezometers were instrumented with Solinst® LT Leveloggers® and were set to record at 60-minute intervals (or 15-minute intervals for surface water loggers). The Leveloggers® are not vented to the atmosphere and therefore record total pressure. As a result, data obtained from the Leveloggers® was corrected for atmospheric pressure to obtain the actual height of water above the sensor. The atmospheric corrections were made using data collected from a Solinst Barologger® installed in monitoring well MW7-10.

In 2023, the following loggers experienced issues:

- At DP1-09, the groundwater logger was found to be missing in March 2023. In July 2023, Stantec modified installation so the groundwater logger is harder to retrieve. In December 2023, the groundwater logger couldn't be accessed due to ice buildup. As a result, only four months of groundwater level data are available at the time of report preparation. The remaining 2023 data will be included in the 2024 report.

- At DP3-09, the drivepoint casing was noted as damaged with the groundwater logger missing in March 2023. A replacement drivepoint piezometer and logger were installed in November 2023. As a result, no groundwater level data was available for DP3-09 in 2023.

- Groundwater loggers located at MW7-10, MW8-10D and MW12-10D malfunctioned in 2023 and were replaced.

Based on the number of loggers included in the monitoring program and the duration of monitoring, it is expected that data loggers will occasionally malfunction or reach the end of their lifetime and require replacement. Based on the extensive historical dataset, the omitted data from 2023 did not impact the overall conclusions from this report. Future monitoring will further document conditions.

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

During the 2023 monitoring, surface water loggers were removed in winter months to prevent erroneous data readings and/or logger damage due to frozen surface water conditions, while groundwater loggers were typically left in place over winter months, which is consistent with previous years. Groundwater level data were reviewed and omitted if clearly impacted by freezing conditions.

Groundwater and surface water level hydrographs are presented in Figures 2 to 4 for current monitoring locations.

3.2 SURFACE WATER FLOW MONITORING

Surface water flow monitoring was completed at the locations of the drivepoint piezometers established along Beaver Creek (DP1-09, DP3-09 and DP5-18) and along Laurel Creek (DP10-14 and DP9-09) and are shown on Figure 1. Stream flows were measured on two occasions in 2023, with additional flow monitoring at DP1-09 in July 2023. Table 2 presents a summary of manual stream flow measurements at each current monitoring location with detailed stream flow data and calculations included in Appendix D.

Stream flow at each drivepoint location was calculated using the velocity-area method (Dingman, 1994). Measurements were obtained by placing a measuring tape across the width of the stream and dividing the distance into equal sections. The depth of the water was measured at each point, and the flow rate recorded using a HACH Company Model FH950 portable water flow meter. Total discharge through the section was then calculated using the U.S. Geological Survey approved mid-section method as discussed in Hipolito and Loureiro (1988) and Dingman (1994).

3.3 SURFACE WATER QUALITY

Water quality sampling for City of Waterloo Monitoring Station 17 - Beaver Creek at Conservation Drive (DP3-09) was completed by the City. Beaver Creek converges with Laurel Creek just upstream of the Laurel Creek Reservoir. Since the watercourse is part of the Laurel Creek Watershed, it is governed by

in-stream water quality targets established in the LCWS (GRCA, 1993). The in-stream quality targets are summarized below:

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

3.4 GROUNDWATER SAMPLING AND WATER QUALITY TESTING

Stantec completed groundwater water quality sampling within the shallow and deep monitoring wells at MW2-10, MW3-10D, MW6-10, MW7-10, MW8-10S, MW8-10D, MW10-10, MW12-10S, MW12-10D and MW13-10 in November/December 2023.

Groundwater samples were primarily collected using dedicated inertial-lift Waterra™ sampling pumps. The use of dedicated equipment reduced the possibility of cross contamination of samples between sampling locations. The Waterra™ sampling pumps were constructed of 16 mm diameter high density polyethylene (HDPE) tubing connected to a Waterra™ Delrin foot valve. For deep monitoring wells including MW3-10D, MW8-10D, and MW12-10D, a hydrolift attached to 16 mm diameter HDPE tubing was employed to facilitate sample collection. Efforts were made to remove at least three (3) casing

volumes from each well prior to sampling to remove stagnant water from the well casing. In cases where the well was purged dry, the well was allowed to fully recover prior to sampling. Prior to sample collection, the sampling system was lowered to within or just above the top of the well screen.

Field measurements of conductivity, temperature and pH were made using a YSI model Pro Plus MPI. This meter was calibrated prior to use according to the manufacturers' specifications with the appropriate calibration standards. Field parameters were monitored and allowed to stabilize prior to sampling. Following purging, groundwater samples were collected directly from the HDPE tubing into the appropriate pre-labeled sample containers. Groundwater samples for metals analysis were field-filtered using disposable, in-line, 0.45 µm filters attached to the HDPE tubing and as such the results for metal parameters represent dissolved concentrations.

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

3.5 CLIMATIC DATA

The Roseville Climate Station (RCS) is located approximately 20 km to the south of the Site. Daily precipitation and temperature data from 1973 to present were collected from the RCS (Environment Canada, 2023). Monthly gaps in data from the RCS were supplemented with data from the next closest station, Environment Canada Kitchener-Waterloo Climate Station (KWCS) (located at the Region of Waterloo International Airport). The KWCS is located approximately 20 km to the east of the Site. Recent and historical precipitation data are presented on Figure 5.

Historically, climate data was obtained from the University of Waterloo Weather Station (UWWS), which is located approximately 4 km southeast of the Site (Stantec, 2016, 2018), as the primary location and supplemented with data from the RCS. Issues arose with UWWS data starting in 2015, and as a result, RCS was selected as the primary data source for climate data for the Site, due to its proximity and data quality.

4.0 MONITORING RESULTS

The 2009 to 2023 monitoring data was summarized with hydrographs presented in Figures 2 to 4, well construction details in Table 1, surface water flow data in Table 2 and groundwater analytical data in Table 3. In general, groundwater and surface water observations in 2023 were consistent with the overall results and interpretations as presented by Ecoplans, MHBC, Stantec (2013) and Stantec (2016, 2018, 2020, 2021, 2023). The following sections detail additional observations, clarifications, or changes to the understanding of Site conditions based on results from the monitoring periods in 2023.

4.1 PRECIPITATION

Historical precipitation data from the RCS, along with supplementary data from the KWCS was reviewed with a graph of the historical data presented on Figure 5. Over a 20-year monitoring period at the RCS (2004-2023), the average annual precipitation was 928 mm. In 2023, the total annual precipitation recorded at the RCS was 996 mm, which is 7% higher than the 20-year average. In 2023, the highest total monthly precipitation from the RCS was recorded in July (190 mm) and the driest period recorded was in September (24 mm). In comparison, the 2022 data indicated a total of 641 mm of precipitation, which was more than 30% below the historical average.

4.2 GROUNDWATER LEVELS – 2023

Groundwater levels showed similar trends as discussed by Ecoplans, MHBC, Stantec (2013) and Stantec (2016, 2018, 2020, 2021, 2023), with seasonal groundwater level fluctuations and response to precipitation events. Similar to previous years, response to individual precipitation events was noted within monitoring wells installed within Aquitard 1 such as MW8-10S and MW12-10S (Figure 4), while monitoring wells installed within deposits of Aquifer 1, with a larger unsaturated zone, such as MW7-10 (Figure 3) indicated a steady response to overall precipitation and recharge, but did not respond to individual events. Groundwater level and surface water level results at the drivepoint locations from 2023 are generally consistent with historical data.

As discussed by Stantec in previous reports, periods of above average precipitation and groundwater recharge resulted in higher shallow groundwater levels at all monitoring wells than initially presented in the NWSSS. The proposed development design should review the groundwater level data across the Site and take the high spring groundwater levels into consideration.

4.3 GROUNDWATER CHEMISTRY – 2023

Stantec conducted a water quality sampling program in November/December 2023 which included wells MW2-10, MW3-10D, MW3-16S MW6-10, MW7-10, MW8-10S/D, MW10-10, MW12-10S/D and MW13-10. MW11-10 could not be sampled, as the well had been damaged since 2015. Water quality results are presented in Table 3 with copies of the laboratory certificates of analysis included in Appendix E.

In general, the results are consistent with the historic data with similar concentrations as previously reported with some natural variability. Key parameters were reviewed including sodium/chloride to evaluate potential response to changes in winter road salting activities and nitrate to evaluate potential response to changes in agricultural activities. No changes of these key parameters were noted based on the 2023 data.

4.4 SURFACE WATER FLOW AND WATER LEVEL ANALYSIS

Surface water flow rates in 2023 indicated some variation along the flow path; however, there was generally a consistent increase or decrease in flow rate between monitoring stations at each timestep along Beaver Creek and Laurel Creek. This is consistent with historical monitoring and suggests that significant groundwater discharge and/or recharge along the flow path was not occurring. Flow rates at all stations have returned to levels consistent with historical monitoring after low flow rates in 2022, when precipitation levels were lower than average. Data from November 30 and December 1, 2023, suggests an increase in surface water flow from DP3-09 to DP5-18; however, this increase is likely a function of monitoring at DP5-18 following a precipitation event.

Historical flow and manual water level measurements were used to develop rating curves for each of the flow monitoring sites. The rating curves were then applied to the continuous water level measurements derived from the deployed Leveloggers® to produce hydrographs. The rating curve for the new gauging station at DP5-18 did not have sufficient data to accurately represent the flow from 2018-2023, therefore the hydrograph for DP5-18 was not included. It is anticipated that as monitoring continues, enough flow measurements will be collected at DP5-18 to obtain a rating curve.

Furthermore, surface water data from DP3-09 between March 29 and April 10, 2023, was removed from analysis due to data inconsistencies likely resulting from damage to the drivepoint, as noted in Section 3.1. The drivepoint piezometer at the DP3-09 gauging station was replaced following data collection in November 2023 with the goal of obtaining accurate readings for the 2024 monitoring program. Surface water data from DP9-09 between November 30 and December 31, 2023 was removed from analysis due to data inconsistencies likely resulting from temperature impacts and/or freezing conditions.

Rating curves and associated hydrographs for the monitoring locations are presented in Appendix D. In general, flow measurements during low flow and base flow events have produced consistent values. The addition of high flow measurements obtained within the study period resulted in well-defined rating curves for a range of flow conditions extending beyond baseflow. Additional flow measurements during discrete storm events will provide more data that is expected to further refine the rating curves at all five locations and will be especially useful in characterizing the curve at DP5-18.



4.5 SURFACE WATER QUALITY RESULTS

Surface water quality results for Laurel Creek at Conservation Drive – Station 17 were provided by the City of Waterloo and are included in Appendix D. Water quality results were compared to targets established for Beaver Creek in the LCWS. The 2023 results of the analysis are summarized below:

- TSS targets were met in 100% of the samples in 2023 (100% in 2022, 73% in 2021, 88% in 2020, 92% in 2019, 75% in 2018 and 80% in 2016 – 2017).
- Dissolved oxygen targets were met in 100% of the samples in 2023 (100% in 2022, 100% in 2021, 88% in 2020, 100% in 2018-2019 and 90% in 2016 – 2017).
- Total phosphorous concentration targets were met in 100% of samples in 2023 (60% in 2022, 45% in 2021 75% in 2019-2020, 46% in 2018 and 55% in 2016 – 2017).
- Temperature targets were met in all samples. The highest recorded temperature was 20.4 ºC. recorded July 27th, 2023, which is comparable to the highest temperature recorded in previous years.
- Bacteria was not monitored by the City.

LCWS water quality targets were achieved for all samples at Station 17 in 2023. Surface water quality results obtained in 2023 are a slight improvement over results from previous years. Results from 2024 surface water quality testing will help to determine whether results from 2023 are a part of a larger trend of improved water quality, or if the 2023 results are an anomaly.



5.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the Phase 1 monitoring completed during the 2023 monitoring period, the following conclusions are provided:

- Annual average precipitation in 2023 was 7% above the 20-year annual average.
- Observed groundwater levels collected during the 2023 monitoring period were generally consistent with historic levels / trends.
- Groundwater quality results throughout the Site were generally consistent with historical data.
- Surface water hydrographs were created using continuous water Leveloggers® and manual flow measurements to develop a rating curve at each monitoring site.
- Water quality monitoring at Station 17 (Beaver Creek at Conservation Drive) was completed by the City. At this location LCWS targets were met for temperature, dissolved oxygen, TSS, and total phosphorous for all measurements.

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

- The proposed grading and development within the Site should be reviewed with respect to the updated peak spring groundwater levels to confirm proposed development design and grading.
- Surface water levels and manual flow measurements should continue to be collected to gain further confidence in the rating curves, especially at DP5-18. Monitoring should be focused on both large storm events and low flows to define the rating curve at a wider range of water level elevations. Pre-development rating curves will provide a basis for comparison of during and post-construction monitoring results as development commences and SWM systems are installed.
- Water quality monitoring at Station 17 should continue to be used to establish background water quality characteristics.
- Based on the age of the loggers, it is expected that additional loggers will malfunction. It is recommended that loggers be purchased and made available for immediate replacement as required.
- Monitoring Well MW11-10 was noted to be damaged in 2015; however, has not yet been replaced. Based on the location, well replacement is still recommended.

6.0 REFERENCES

Dingman, S.L., 1994. Physical Hydrology. Prentice-Hall. New Jersey.

Ecoplans, MHBC and Stantec, 2013. North Waterloo Scoped Subwatershed Study, Volume 1, November 2013.

Environment Canada, 2024. Canadian National Climate Archives. [Online] Station: Roseville, Ontario. Climate Identifier 6147188. http://climate.weather.gc.ca Accessed January, 2024.

Grand River Conservation Authority (GRCA), 1993. Laurel Creek Watershed Study, Technical Appendix 4 (Hydrogeology), Report Prepared by Terraqua Investigations Ltd.

Hipolito, J.N. and J.M. Loureiro. 1988. Analysis of some velocity-area methods for calculating open-channel flow. Hydrogeological Sciences Journal 33:311-320.

Stantec, 2016. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program. Prepared for Northgate Corporation, 2115881 Ontario Ltd., Activa Holdings, and Erbsville Kartway. May 13, 2016.

Stantec, 2018. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program. Prepared for Northgate Corporation, 2115881 Ontario Ltd., Activa Holdings, and Erbsville Kartway. May 18, 2018.

Stantec, 2020. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program – Draft Report. Prepared for Northgate Corporation, 2115881 Ontario Ltd., Activa Holdings, and Erbsville Kartway. April 8, 2020.

Stantec, 2021. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program. Prepared for Northgate Land Corporation, 2115881 Ontario Ltd., Activa Holdings, and Erbsville Kartway. June 10, 2021.

Stantec, 2023. North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program, 2021-2022 Monitoring Data. Prepared for Northgate Land Corporation, 2115881 Ontario Ltd., Activa Holdings, and Erbsville Kartway. January 20, 2023.

APPENDIX A:
Figures



Stantec

Legend

- North Waterloo Scoped Subwatershed Study Area
- Monitoring Well (Stantec, 2016)
- Monitoring Well (Stantec, 2010)
- Monitoring Well (Stantec, 2005)
- Monitoring Well (Other)
- Drive-Point Piezometer (Stantec, 2010)
- Drive Point Piezometer (Stantec, 2014)
- Drive-Point Piezometer (Stantec, 2018)
- Abandoned Monitoring Well (Other)
- Abandoned Drive-Point Piezometer
- Phase 1 Monitoring Location
- Watercourse
- Topographic Contour - 2m Inerval
- Proposed Development Area

0 250 500 metres

1:8,000 (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, 2014.
3. Orthoimagery © First Base Solutions, 2020. Imagery Date, 2018



Project Location
Region of Waterloo

161450875 REVA
Prepared by PRM on 2020-02-05
Technical Review by SB on 2021-01-20

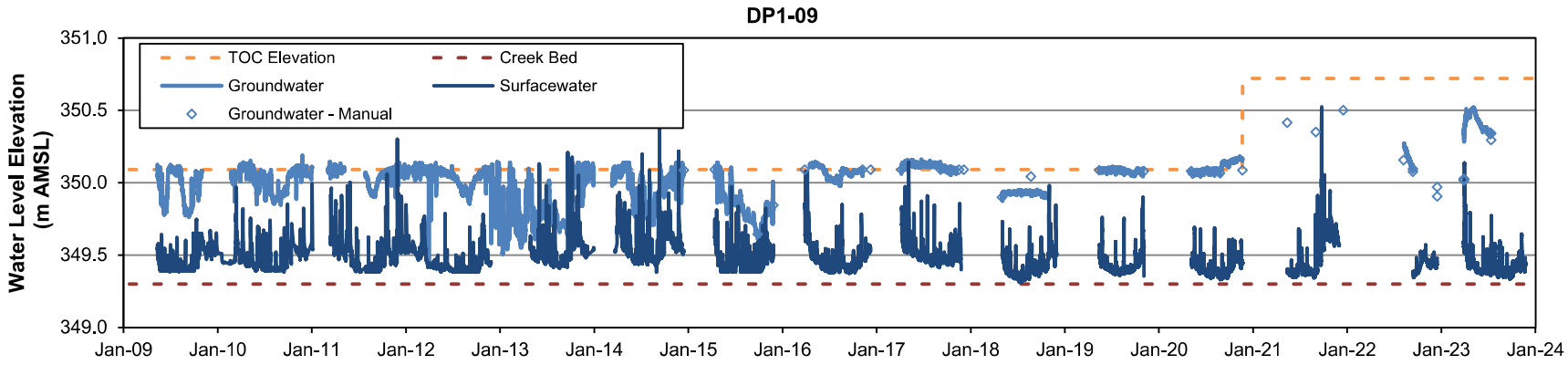
Client/Project
NORTH WATERLOO SCOPED WATERSHED STUDY
PHASE I - GROUNDWATER AND
SURFACE WATER MONITORING PROGRAM

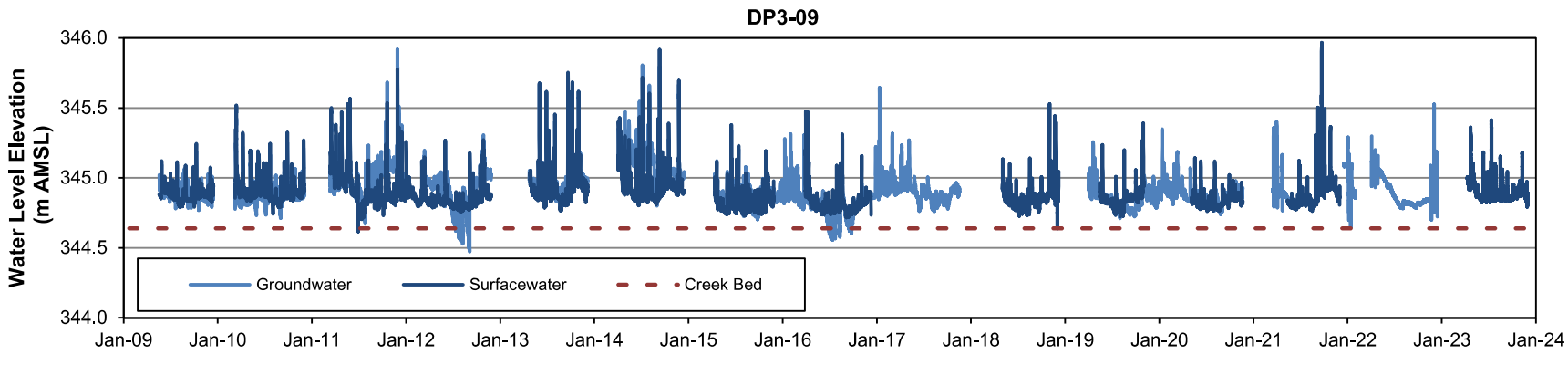
Figure No.
1

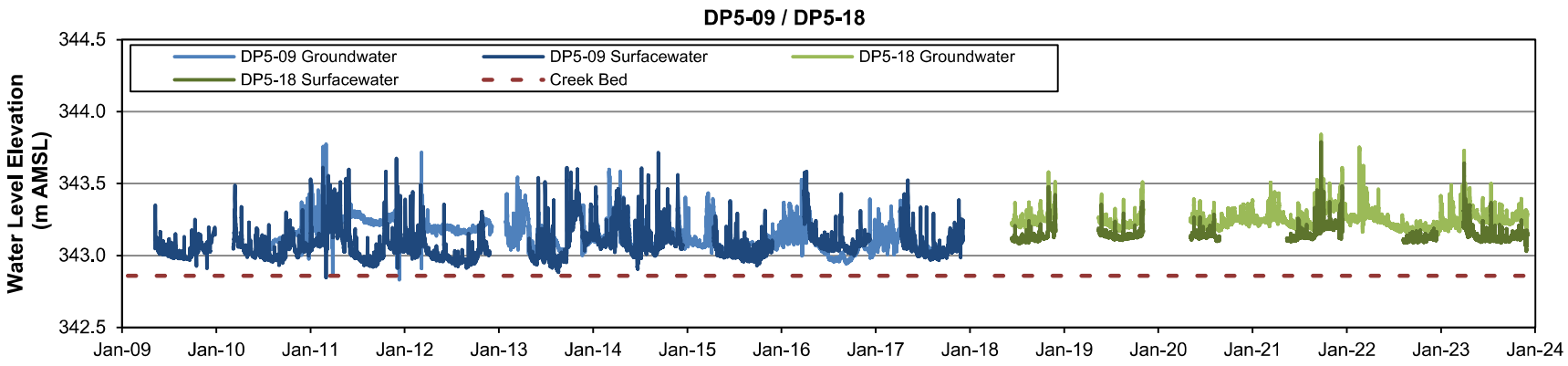
Title
Site Location

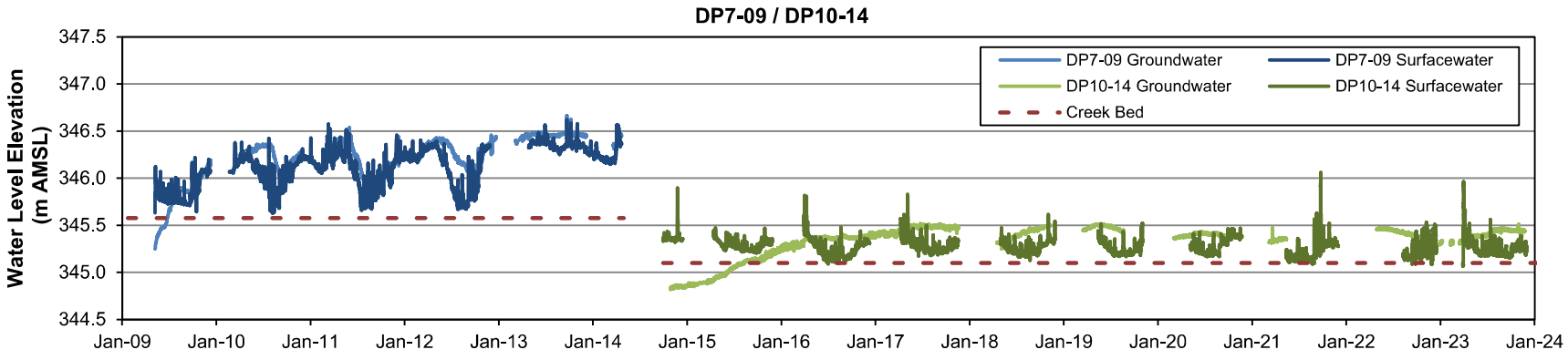
Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

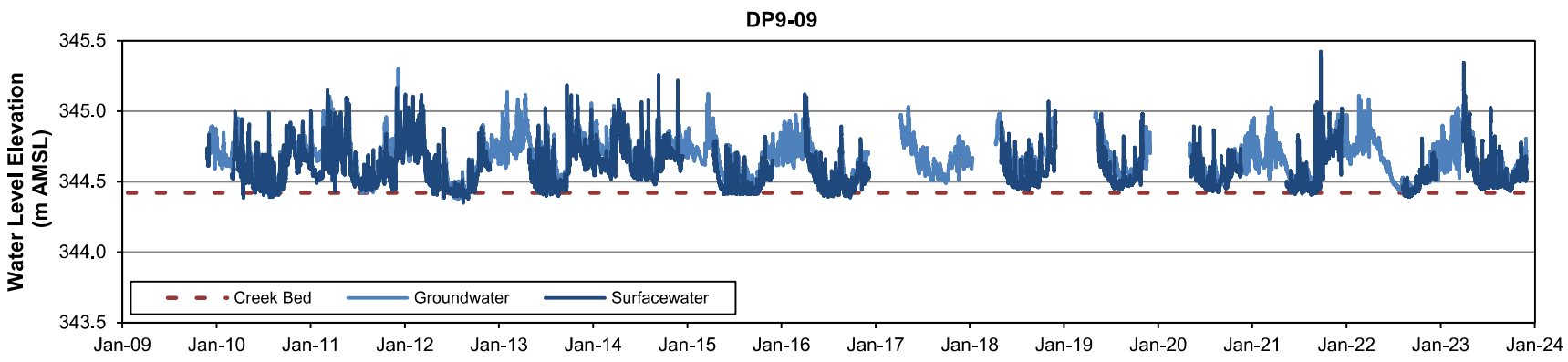
C:\Git\0045\01\01\60\Sydney\161310825_Waterloo North\Planning\report\2020\Apps A Figures_Revised 2021-01-20 By: sbaer

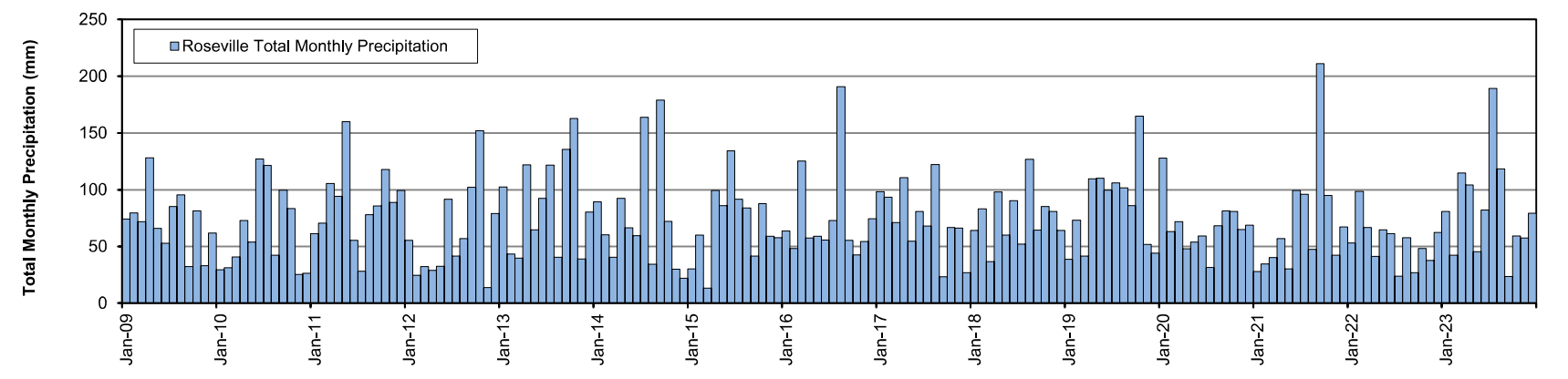












-Top of casing and streambed elevations at DP10-14 are estimated based on topographic mapping and DP7-09 and DP9-09.
-Top of casing and streambed elevations at DP5-18 are estimated based on DP5-09 survey data
-Top of casing at DP1-09 was extended in 2021. Groundwater level elevations from 2009 to 2020 may be an underestimate.

Client/Project

NORTH WATERLOO, PHASE 1 GROUNDWATER AND SURFACE WATER MONITORING PROGRAM

Figure No.

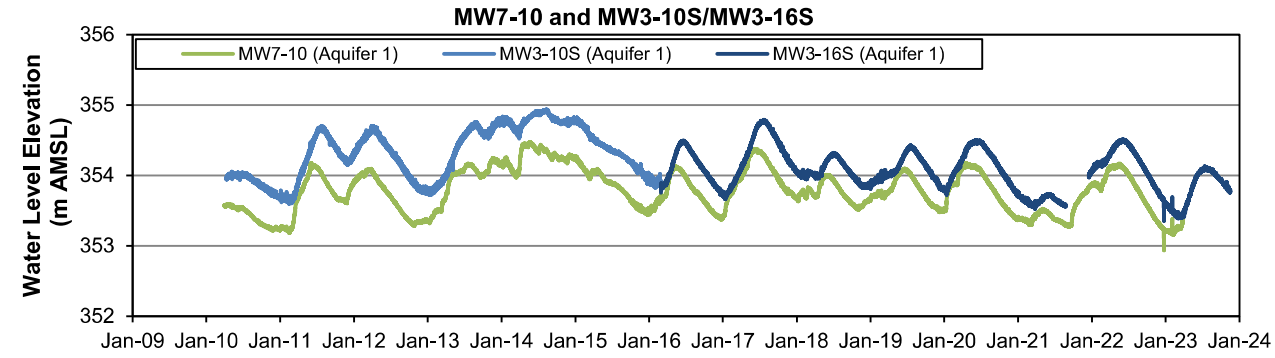
2

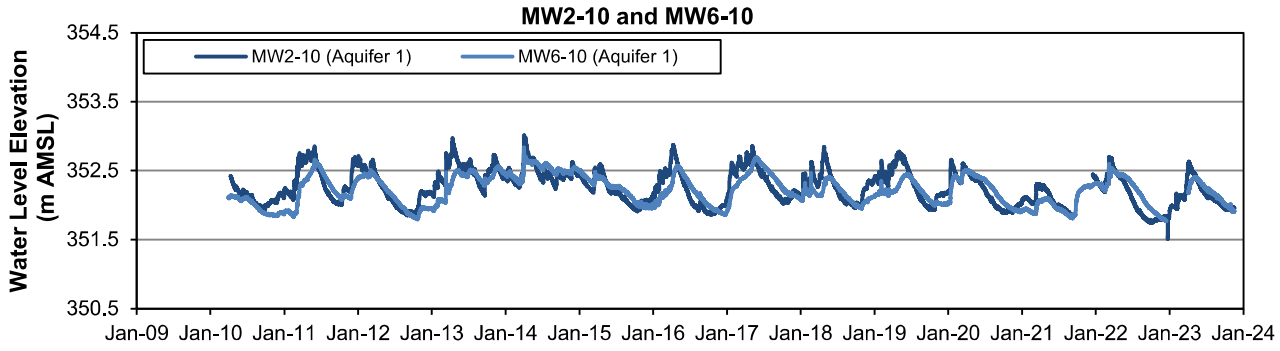
Title

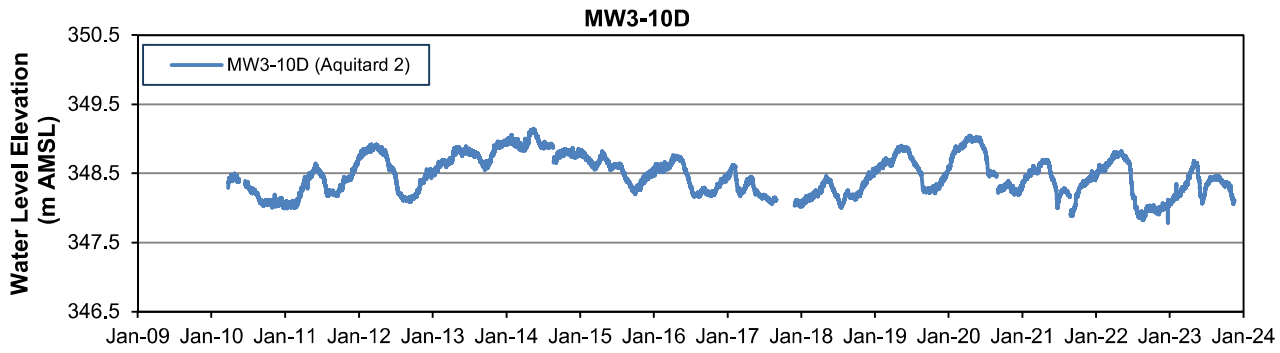
Water Level Hydrographs
Drivepoint Piezometer Monitoring Locations

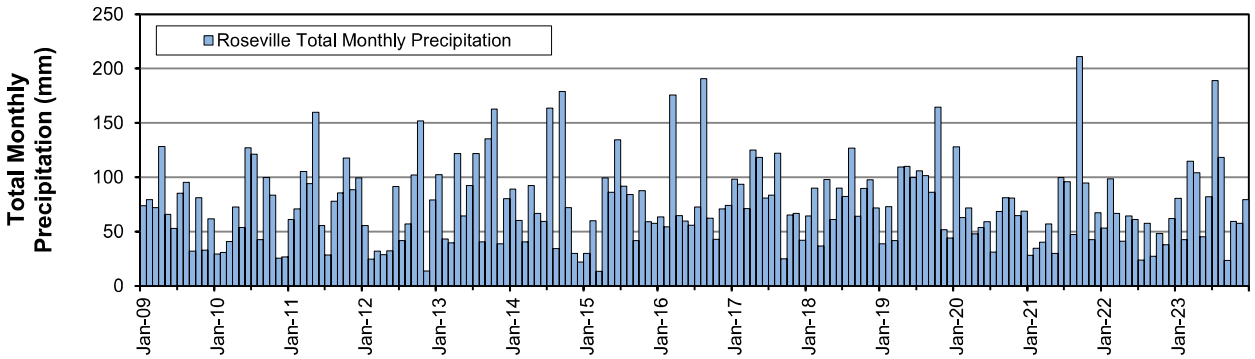
Stantec

\\Cd1004-f01\01609\active\160310875_ Waterloo North\project_management\planning\field_data\levelogger\Corrected_data\2023_report\Figure_2_hydrographs_2023_Drivepoints.xlsx









Client/Project

NORTH WATERLOO, PHASE 1 GROUNDWATER AND SURFACE WATER MONITORING PROGRAM

Figure No.

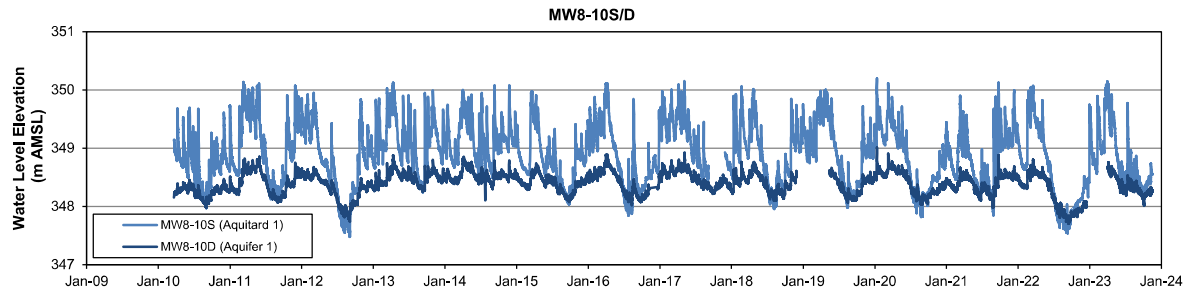
3

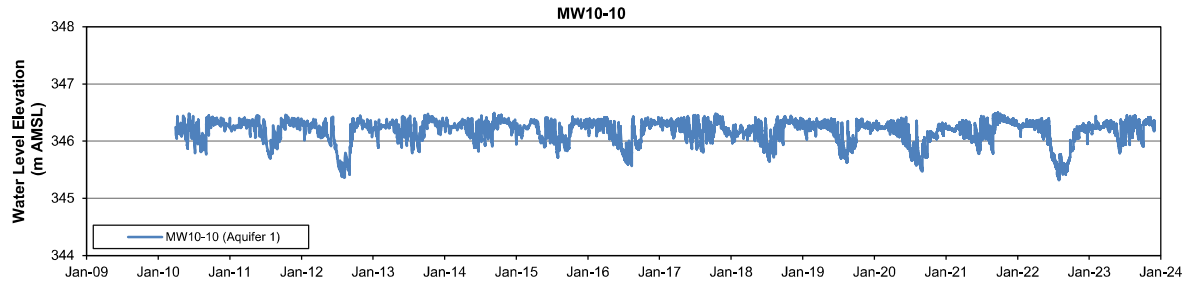
Title

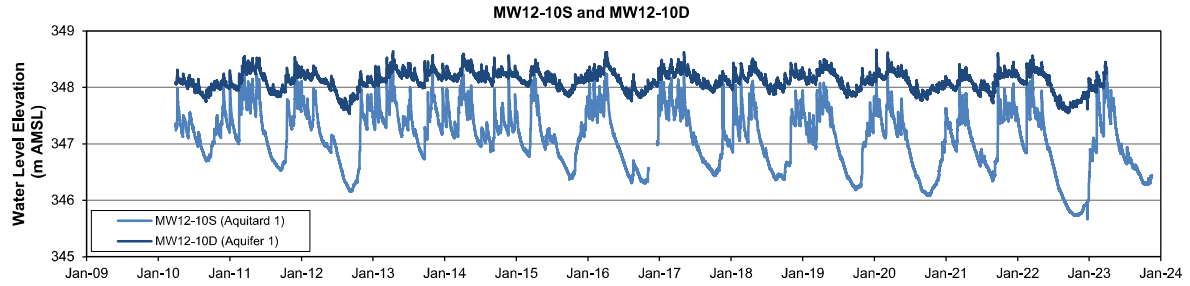
Water Level Hydrographs
Northern Monitoring Locations

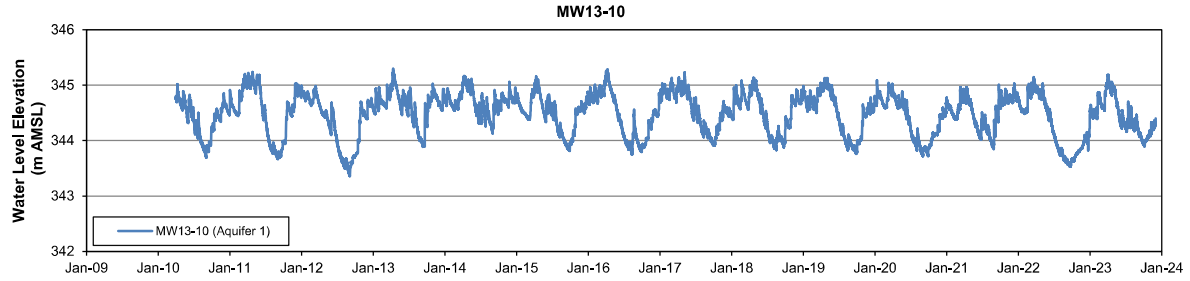
Stantec

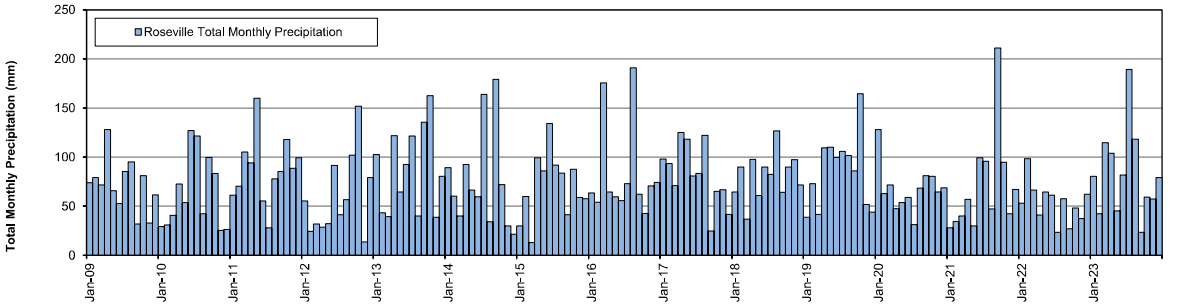
\\Cd1004-f01\01609\active\160310875_ Waterloo North\planning\field_data\levelogger\Corrected_data\2023_report\Figure_3_hydrographs_2023_Northern_sites.xlsx











Client/Project

NORTH WATERLOO, PHASE 1 GROUNDWATER AND SURFACE WATER MONITORING PROGRAM

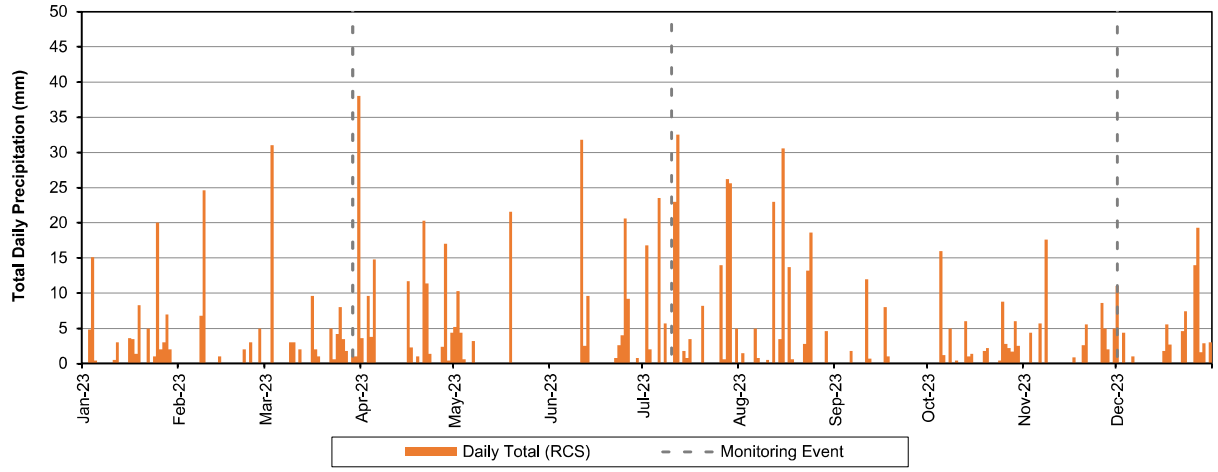
Figure No.

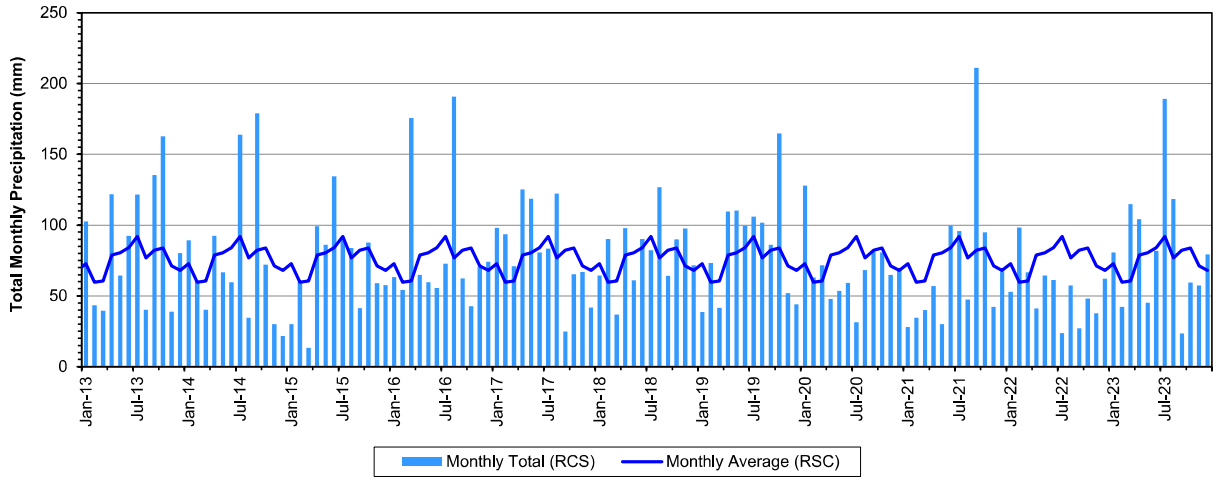
4

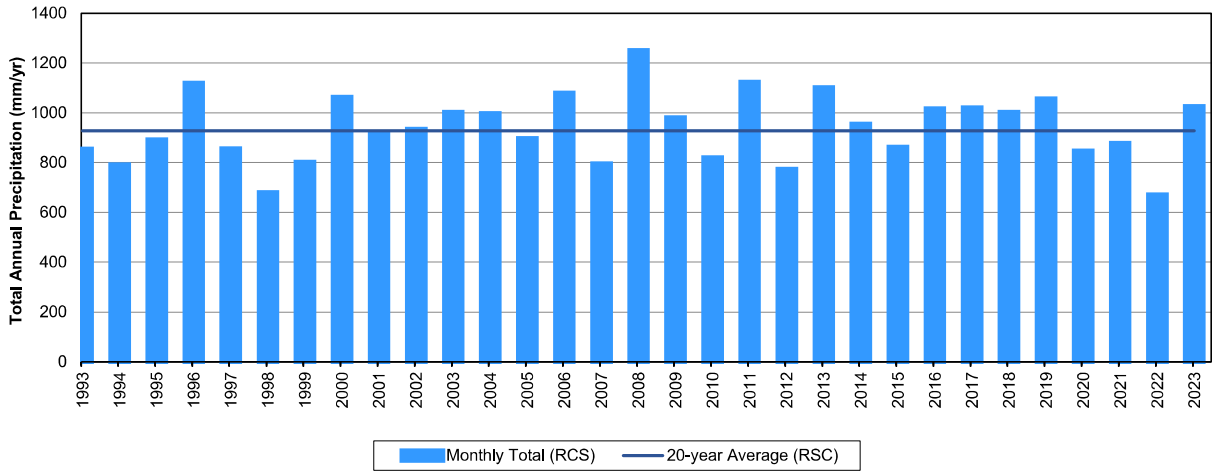
Title

Water Level Hydrographs
Southern Monitoring Locations

Stantec







Notes:

(1) Precipitation data obtained from the Roseville Climate Station (RCS). Missing monthly values were supplemented from the Kitchener-Waterloo Climate Station (KWCS, formerly the Waterloo International Airport Climate Station). The RCS is located approximately 20 km south of the Site, while the KWCS is located approximately 20 km to the west of the Site.

Client/Project

NORTH WATERLOO, PHASE 1 GROUNDWATER AND SURFACE WATER MONITORING PROGRAM

Figure No.

5

Title

Trends in Total Precipitation

Stantec

\\Cd1004-f01\01609\active\160310875_ Waterloo North\planning\field_data\levelogger\Corrected_data\2023_report\Figure_5_hydrographs_2023_Precip_trends_rev.xlsx

APPENDIX B:
Tables

TABLE 1
WELL INSTALLATION DETAILS

Monitoring Well ID	Date Installed	Location			Elevations			Measured Total Depth	Well Casing			Screened Interval				Screened Material		Monitoring Status
		Northing NAD 83	Easting NAD 83	Coordinate Source	Top of Casing	Ground Surface	Source		Depth	Diameter	Stick-up	Top of Screen		Bottom of Screen				
					(mAMSL)	(mAMSL)		(mBGS)	(mBGS)	(mm)	(mAGS)	(mBGS)	(mAMSL)	(mBGS)	(mAMSL)	Unit	Description	
Monitoring Wells																		
MW1-05	Jan-05	4,814,629	533,419	Total Station (Stantec, 2010)	349.22	348.37	Total Station (Stantec, 2010)	3.73	-	50	0.87	2.10	346.3	3.60	344.8	Aquifer 1	Gravelly Sand	Removed from program in 2014
MW8-05	Feb-05	4,814,874	533,614	Total Station (Stantec, 2010)	350.85	349.94	Total Station (Stantec, 2010)	3.77	-	50	0.84	2.30	347.6	3.80	346.1	Aquitard 1	Silt with trace Sand	Removed from program in 2014
WN1-91-1	Aug-91	4,814,480	533,907	Total Station (Stantec, 2010)	347.18	346.44	Total Station (Stantec, 2010)	>60	68.00	51	0.74	68.00	278.4	70.40	276.0	Aquifer 3	Clay Till / Shale	Removed from program in 2014
WN1-91-2	Aug-91	4,814,478	533,908	Total Station (Stantec, 2010)	347.57	346.64	Total Station (Stantec, 2010)	44.86	41.00	32	0.93	41.00	305.6	47.00	299.6	Aquifer 3	Fine Sand, some gravel	Removed from program in 2014
WN1-91-3	Aug-91	4,814,478	533,908	Total Station (Stantec, 2010)	347.57	346.64	Total Station (Stantec, 2010)	7.57	25.50	32	0.93	25.50	321.1	28.50	318.1	Aquitard 3	Silt Till	Removed from program in 2014
WN1-91-4	Aug-91	4,814,478	533,908	Total Station (Stantec, 2010)	347.57	346.64	Total Station (Stantec, 2010)	8.14	7.50	32	0.93	7.50	339.1	8.30	338.3	Aquitard 1	Fine Sand, silty	Removed from program in 2014
WN2-91-1	Aug-91	4,814,196	533,156	Total Station (Stantec, 2010)	345.35	344.65	Total Station (Stantec, 2010)	>60	68.00	51	0.70	68.00	276.7	71.93	272.7	Bedrock	Shale	Removed from program in 2014
WN2-91-4	Aug-91	4,814,199	533,157	Total Station (Stantec, 2010)	345.18	344.65	Total Station (Stantec, 2010)	10.05	9.00	51	0.53	9.00	335.7	10.50	334.2	Aquifer 1	Sand and Silt, some clay	Removed from program in 2014
WN3-91-1	Sep-91	4,815,057	533,308	Total Station (Stantec, 2010)	354.78	354.86	Total Station (Stantec, 2010)	>60	60.50	51	-0.08	60.50	294.4	64.92	289.9	Aquitard 4 Bedrock	Sand Till / Shale	Well Abandoned
WN3-91-2	Sep-91	4,815,056	533,308	Total Station (Stantec, 2010)	354.71	354.79	Total Station (Stantec, 2010)		9.00	51	-0.08	9.00	345.8	11.50	343.3	Aquifer 1	Silt Till / Fine Sand	Well Abandoned
WNTW2-06	Oct-06	4,814,398	533,662	Total Station (Stantec, 2010)	349.26	348.59	Total Station (Stantec, 2010)	>60	64.92	159	0.67	64.92	283.7	73.15	275.4	Bedrock	Bedrock	Removed from program in 2014
MW1-10	Mar-10	4,814,976	531,967	Total Station (Stantec, 2010)	350.96	350.07	Total Station (Stantec, 2010)	4.5	3.05	51	0.89	3.05	347.0	4.57	345.5	Aquifer 1	Silty Sand	Removed from program in 2014
MW2-10	Mar-10	4,815,271	532,498	Total Station (Stantec, 2010)	356.52	355.56	Total Station (Stantec, 2010)	4.4	3.08	51	0.96	3.08	352.5	4.60	351.0	Aquifer 1	Sand	North Waterloo Monitoring Location
MW3-10S	Mar-10	4,815,407	532,776	Total Station (Stantec, 2010)	367.62	366.81	Total Station (Stantec, 2010)	13.6	12.18	51	0.81	12.18	354.6	13.70	353.1	Aquifer 1	Sand	Well damaged and replaced by MW3-16S
MW3-16S	Mar-16	4,815,406	532,774	Estimated based on MW3-10D	367.70	366.84	Estimated based on MW3-10D	13.7	12.19	51	0.86	12.19	354.7	13.72	353.1	Aquifer 1	Sand	North Waterloo Monitoring Location (replaced MW3-10S)
MW3-10D	Mar-10	4,815,406	532,774	Total Station (Stantec, 2010)	367.60	366.84	Total Station (Stantec, 2010)	41.7	40.08	51	0.76	40.08	326.8	41.60	325.2	Aquitard 2	Clay Till / Sand Till	North Waterloo Monitoring Location
MW4-10	Mar-10	4,815,010	532,399	Total Station (Stantec, 2010)	348.64	347.87	Total Station (Stantec, 2010)	2.8	1.52	51	0.77	1.52	346.3	3.05	344.8	Aquitard 1	Silty Sand to Clayey Silt	Removed from program in 2014
MW5-10	Mar-10	4,814,834	532,368	Total Station (Stantec, 2010)	351.91	351.08	Total Station (Stantec, 2010)	4.1	2.74	51	0.83	2.74	348.3	4.27	346.8	Aquifer 1	Silty Sand	Removed from program in 2014
MW6-10	Mar-10	4,814,972	532,737	Total Station (Stantec, 2010)	356.48	355.58	Total Station (Stantec, 2010)	4.3	3.05	51	0.90	3.05	352.5	4.57	351.0	Aquifer 1	Medium Sand	North Waterloo Monitoring Location
MW7-10	Mar-10	4,815,108	533,031	Total Station (Stantec, 2010)	359.67	358.74	Total Station (Stantec, 2010)	7.1	5.79	51	0.93	5.79	352.9	7.32	351.4	Aquifer 1	Fine to Medium Sand	North Waterloo Monitoring Location
MW8-10S	Mar-10	4,814,538	532,271	Total Station (Stantec, 2010)	351.28	350.38	Total Station (Stantec, 2010)	3.84	3.05	51	0.90	3.05	347.3	4.57	345.8	Aquitard 1	Silt	North Waterloo Monitoring Location
MW8-10D	Mar-10	4,814,537	532,269	Total Station (Stantec, 2010)	351.26	350.44	Total Station (Stantec, 2010)	38.62	38.16	51	0.82	38.16	312.3	39.68	310.8	Aquifer 1	Sand / Sand and cobble	North Waterloo Monitoring Location

Notes:
(mAMSL) metres above mean sea level
(mBGS) metres below ground surface
(mAGS) metres above ground surface

TABLE 1
WELL INSTALLATION DETAILS

Monitoring Well ID	Date Installed	Location			Elevations			Measured Total Depth	Well Casing			Screened Interval				Screened Material		Monitoring Status
		Northing NAD 83	Easting NAD 83	Coordinate Source	Top of Casing	Ground Surface	Source		Depth	Diameter	Stick-up	Top of Screen		Bottom of Screen				
					(mAMSL)	(mAMSL)		(mBGS)	(mBGS)	(mm)	(mAGS)	(mBGS)	(mAMSL)	(mBGS)	(mAMSL)	Unit	Description	
Monitoring Wells																		
MW9-10S	Mar-10	4,814,715	532,634	Total Station (Stantec, 2010)	346.69	345.83	Total Station (Stantec, 2010)	4.58	3.05	51	0.86	3.05	342.8	4.57	341.3	Aquitard 1	Clay	Well Abandoned
MW9-10D	Mar-10	4,814,717	532,634	Total Station (Stantec, 2010)	346.50	345.71	Total Station (Stantec, 2010)	27.69	25.99	51	0.79	25.99	319.7	27.51	318.2	Aquitard 3	Silt Till	Well Abandoned
MW10-10	Mar-10	4,814,388	532,654	Total Station (Stantec, 2010)	347.05	346.25	Total Station (Stantec, 2010)	2.8	1.52	51	0.80	1.52	344.7	3.05	343.2	Aquifer 1	Fine Sand	North Waterloo Monitoring Location
MW11-10	Mar-10	4,814,655	533,047	Total Station (Stantec, 2010)	355.96	355.07	Total Station (Stantec, 2010)	5.8	4.27	51	0.89	4.27	350.8	5.79	349.3	Aquifer 1	Fine to Coarse Sand	North Waterloo Monitoring Location Well Damaged, Replacement Recommended
MW12-10S	Mar-10	4,814,123	532,585	Total Station (Stantec, 2010)	349.35	348.51	Total Station (Stantec, 2010)	6.6	5.06	51	0.84	5.06	343.5	6.58	341.9	Aquitard 1	Silty Clay	North Waterloo Monitoring Location
MW12-10D	Mar-10	4,814,125	532,584	Total Station (Stantec, 2010)	349.52	348.63	Total Station (Stantec, 2010)	25.5	23.98	51	0.89	23.98	324.7	25.50	323.1	Aquifer 1	Sand and Gravel	North Waterloo Monitoring Location
MW13-10	Mar-10	4,814,339	533,060	Total Station (Stantec, 2010)	346.15	345.34	Total Station (Stantec, 2010)	4.4	3.05	51	0.81	3.05	342.3	4.57	340.8	Aquifer 1	Silty Sand	North Waterloo Monitoring Location
Drivepoint Piezometers																		
DP1-09	Apr-09	4,815,046	532,107	Total Station (Stantec, 2010)	350.09	349.30	Total Station (Stantec, 2010)	-	1.04	25	0.79	1.04	348.3	1.46	347.8	-	-	North Waterloo Monitoring Location
DP2-09	Apr-09	4,814,968	532,526	Total Station (Stantec, 2010)	348.46	347.60	Total Station (Stantec, 2010)	-	0.97	25	0.86	0.97	346.6	1.39	346.2	-	-	Removed from program in 2014
DP3-09	Apr-09	4,814,727	532,643	Total Station (Stantec, 2010)	346.65	345.07	Total Station (Stantec, 2010)	-	0.72	25	1.58	0.72	344.4	1.14	343.9	-	-	Drivepoint damaged, replaced by DP3-23
DP3-23	Nov-24	4,814,727	532,643	Estimated based on DP3-09	346.62	345.70	Estimated based on DP3-09	-	1.22	25	0.92	1.22	344.5	1.63	344.1	-	-	North Waterloo Monitoring Location
DP4-09	Apr-09	4,814,564	532,840	Total Station (Stantec, 2010)	345.13	344.17	Total Station (Stantec, 2010)	-	1.17	25	0.96	1.17	343.0	1.59	342.6	-	-	Removed from program in 2014
DP5-09	Apr-09	4,814,419	533,147	Total Station (Stantec, 2010)	343.84	342.86	Total Station (Stantec, 2010)	-	1.15	25	0.98	1.15	341.7	1.57	341.3	-	-	Drivepoint damaged, replaced by DP5-18
DP5-18	Jun-18	4,814,441	533,145	Handheld GPS (Stantec, 2018)	343.71	342.86	Estimated based in DP5-09	-	1.28	25	0.85	1.28	341.6	1.70	341.2	-	-	North Waterloo Monitoring Location (replaced DP5-09)
DP6-09	Apr-09	4,814,321	533,151	Total Station (Stantec, 2010)	343.44	342.55	Total Station (Stantec, 2010)	-	1.24	25	0.90	1.24	341.3	1.66	340.9	-	-	Removed from program in 2014
DP7-09	Apr-09	4,814,153	532,358	Total Station (Stantec, 2010)	346.46	345.58	Total Station (Stantec, 2010)	-	0.95	25	0.88	0.95	344.6	1.37	344.2	-	-	Non-ideal flow conditions, replaced by DP10-14
DP8-09	Nov-09	4,815,003	532,314	Total Station (Stantec, 2010)	348.27	347.36	Total Station (Stantec, 2010)	-	1.22	25	0.92	1.22	346.1	1.64	345.7	-	-	Removed from program in 2014
DP9-09	Nov-09	4,813,939	532,735	Total Station (Stantec, 2010)	345.45	344.48	Total Station (Stantec, 2010)	-	1.16	25	0.97	1.16	343.3	1.58	342.9	-	-	North Waterloo Monitoring Location
DP10-14	Sep-14	4,813,975	532,575	Aerial Mapping	346.39	345.10	Estimated based on DP9-09 and DP7-09	-	0.87	25	1.26	0.87	344.2	1.29	343.8	-	-	North Waterloo Monitoring Location (replaced DP7-09)

Notes:

(mAMSL) metres above mean sea level
(mBGS) metres below ground surface
(mAGS) metres above ground surface

Table 2
Stream Flow Measurements

Date	Monitoring Locations within Beaver Creek									Monitoring Locations within Laurel Creek								
	DP1-09			DP3-09			DP5-09			DP7-09			DP10-14			DP9-09		
	Flow (L/s)	Max. Depth (m)	Width (m)	Flow (L/s)	Max. Depth (m)	Width (m)	Flow (L/s)	Max. Depth (m)	Width (m)	Flow (L/s)	Max. Depth (m)	Width (m)	Flow (L/s)	Max. Depth (m)	Width (m)	Flow (L/s)	Max. Depth (m)	Width (m)
23-Apr-09	70.9	0.20	3.30	92.4	0.29	2.95	90.4	0.25	3.40	-	-	-	-	-	-	-	-	-
15-Oct-09	47.2	0.27	3.10	39.5	0.19	2.80	36.4	0.15	2.40	106.1	0.38	4.10	-	-	-	-	-	-
25-Nov-09	84.8	0.29	3.40	59.8 60.6	0.23 0.23	2.90 2.90	74.8	0.16	3.20	108.7	0.61	4.50	-	-	-	82.5	0.29	5.80
31-Mar-10	58.6	0.21	2.75	40.7	0.19	3.00	51.9	0.14	3.00	172.3	0.73	5.80	-	-	-	143.5	0.18	5.50
20-May-10	28.1	0.16	2.00	25.1	0.15	2.60	30.3	0.10	2.45	46.4	0.72	5.70	-	-	-	56.6	0.10	5.00
23-Jul-10	366	0.56	4.75	421	0.56	3.00	401	0.30	3.85	-	-	-	-	-	-	2799	0.54	5.50
30-Aug-10	7.9	0.11	1.20	8.6	0.12	1.90	4.7	0.06	2.20	11.0	0.28	3.00	-	-	-	31.0	0.21	4.25
29-Oct-10	56.0	0.32	3.80	46.2	0.16	2.90	44.3	0.21	3.80	108.2	0.71	5.90	-	-	-	115.8	0.38	5.80
17-May-12	16.8	0.10	2.15	15.6	0.13	1.95	11.0	0.09	2.70	20.9	0.80	5.50	-	-	-	41.3	0.11	4.75
28-Aug-12	9.4	0.08	1.40	7.9	0.09	2.20	5.7	0.07	2.65	19.5	0.25	3.40	-	-	-	16.4	0.07	3.15
26-Nov-12	34.3	0.18	2.40	40.3	0.16	3.00	35.0	0.14	2.90	87.3	0.85	5.80	-	-	-	78.8	0.22	5.75
25-Apr-13	124.9	0.31	3.45	167.3	0.30	3.50	155.4	0.27	3.50	na	Ponded	Ponded	-	-	-	344.9	0.34	5.85
20-Aug-13	15.8	0.21	2.10	16.4	0.14	2.20	13.2	0.08	2.50	na	Ponded	Ponded	-	-	-	48.4	0.11	5.30
29-Oct-13	95.5	0.33	3.90	111.3	0.31	3.30	107.0	0.38	4.40	na	Ponded	Ponded	-	-	-	215.9	0.34	5.90
16-Jan-14	110.0	0.24	3.60	117.4	0.29	2.75	151.2	0.28	4.70	na	Frozen	Frozen	-	-	-	334.9	0.38	5.80
21-Apr-14	96.2	0.21	3.25	107.6	0.21	3.00	120.3	0.20	3.65	na	Ponded	Ponded	-	-	-	276.4	0.29	5.80
21-Aug-14	29.5	0.15	2.50	30.6	0.14	3.00	41.3	0.10	3.00	Replaced by SF10			93.6	0.3	4.25	82.7	0.12	5.50
29-Sep-14	-	-	-	-	-	-	-	-	-	-	-	-	121.1	0.34	4.4	-	-	-
28-Oct-14	57.1	0.30	3.50	58.3	0.26	2.80	68.1	0.20	3.70	-	-	-	116.7	0.36	4.5	119.7	0.26	5.85
15-Dec-14	54.5	0.22	2.60	70.2	0.23	2.75	67.6	0.18	3.60	-	-	-	132.7	0.36	4.8	145.6	0.24	5.80
13-Apr-15	104.5	0.38	3.75	131.3	0.28	3.40	134.7	0.19	3.45	-	-	-	307.6	0.39	4.95	319.9	0.30	5.95
28-Sep-15	4.3	0.11	1.80	4.7	0.09	1.80	4.4	0.08	2.40	-	-	-	30.7	0.21	3.6	28.1	0.08	4.40
27-Nov-15	89.0	0.31	3.00	113.5	0.27	2.80	121.4	0.24	3.90	-	-	-	228.3	0.37	5.3	236.0	0.32	5.90
28-Mar-16	385.1	0.62	5.00	483.2	0.62	4.10	541.0	0.50	4.40	-	-	-	694.1	0.5	6.9	691.0	0.50	5.85
25-Aug-16	22.4	0.15	2.25	25.5	0.15	2.35	27.5	0.10	2.90	-	-	-	78.1	0.28	4	75.6	0.12	5.70
7-Nov-16	33.5	0.18	3.20	33.9	0.15	2.35	36.0	0.16	3.45	-	-	-	82.8	0.32	4.6	75.1	0.20	5.75
7-Apr-17	384.6	0.50	4.60	422.3	0.55	3.95	438.0	0.45	4.45	-	-	-	851.1	0.58	7.5	-	-	-
10-Apr-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	278.2	0.28	6.00
6-Sep-17	30.9	0.14	3.30	41.2	0.16	2.45	43.5	0.10	3.00	-	-	-	115.9	0.3	4.4	116.3	0.14	5.80
17-Nov-17	84.9	0.23	3.20	95.8	0.22	2.70	92.0	0.21	3.70	-	-	-	142.6	0.35	5.2	164.3	0.25	5.90
3-May-18	117.3	0.26	3.80	114.2	0.30	2.85	143.0	0.23	4.50	-	-	-	168.8	0.4	5.1	155.7	0.30	4.90
23-Aug-18	46.0	0.15	3.20	43.1	0.18	2.40	51.6	0.18	4.10	-	-	-	136.1	0.27	3.6	131.1	0.21	5.00
29-Nov-18	68.6	0.23	4.00	93.4	0.26	2.50	95.4	0.21	4.20	-	-	-	182.0	0.46	4.8	202.0	0.42	5.50
14-May-19	160.7	0.30	3.60	183.3	0.30	2.90	147.9	0.21	4.00	-	-	-	504.6	0.42	5	490.2	0.49	5.80
20-Aug-19	25.0	0.13	2.40	19.9	0.14	2.00	17.9	0.12	3.60	-	-	-	124.0	0.3	4.2	92.8	0.13	5.50
4-Nov-19	80.1	0.31	3.60	87.6	0.24	2.40	92.6	0.20	4.00	-	-	-	162.3	0.35	4.5	178.2	0.35	5.70
5-May-20	69.9	0.20	3.00	80.5	0.20	2.60	68.6	0.20	4.75	-	-	-	147.5	0.3	4	122.4	0.22	5.75
26-Aug-20	9.9	0.10	2.20	8.0	0.10	2.20	9.4	0.12	3.90	-	-	-	31.8	0.22	3.2	37.8	0.13	4.50
20-Nov-20	30.4	0.18	3.20	34.2	0.16	2.50	23.2	0.14	4.00	-	-	-	73.8	0.36	3.8	65.8	0.24	5.60
13-May-21	20.5	0.11	2.80	24.1	0.14	2.50	23.8	0.14	4.00	-	-	-	64.7	0.23	3.6	78.6	0.20	5.60
1-Sep-21	8.4	0.12	2.50	18.4	0.14	2.60	18.4	0.14	4.10	-	-	-	75.9	0.2	3.6	85.1	0.16	5.20
30-Nov-21	60.8	0.30	3.20	62.2	0.26	3.20	82.7	0.20	4.60	-	-	-	124.1	0.3	4	124.9	0.39	5.80
8-Aug-22	13.7	0.10	2.80	11.8	0.15	2.30	5.6	0.15	4.40	-	-	-	25.2	0.28	3.75	32.1	0.14	5.40
13-Sep-22	12.7	0.10	2.90	12.7	0.12	2.10	7.1	0.16	4.20	-	-	-	36.6	0.28	3.7	23.9	0.13	5.50
16-Dec-22	54.6	0.20	3.30	66.1	0.24	3.00	65.5	0.13	4.30	-	-	-	122.1	0.3	4.3	105.4	0.32	4.90
29-Mar-23	151.0	0.32	3.80	223.1	0.41	3.30	177.8	0.27	4.80	-	-	-	404.0	0.53	5	449.3	0.57	5.40
10-Jul-23	17.3	0.12	3.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30-Nov-23	25.1	0.14	3.60	35.9	0.20	3.00	-	-	-	-	-	-	90.6	0.29	4.2	86.3	0.22	6.10
1-Dec-23	-	-	-	-	-	-	100.8	0.20	4.80	-	-	-	-	-	-	-	-	-

Table 3
Summary of Groundwater Analytical Results
Waterloo North Hydrogeological Assessment

Sample Location			MW1-10		MW2-10												MW3-10D				
Sample Date			18-May-10	26-Oct-10	17-May-10	25-Oct-10	21-Aug-14	28-Sep-15	25-Aug-16	31-Aug-17	21-Aug-18	20-Aug-19	26-Aug-20	24-Aug-21	29-Aug-22	16-Nov-23	20-May-10	27-Oct-10	21-Aug-14	28-Sep-15	25-Aug-16
Sample ID			WG-160340875-20100518-AV09	WG-160340875-20101026-JK8	WG-160340875-20100517-AV05	WG-160340875-20101025-JK2	WG-160310875-20140821-AV02	WG-160310875-20150928-AV04	WG-160310875-20160825-AV07	WG-160310875-20170831-AV02	WG-150310875-20180821-DS04	WG-161450875-20190820-DS02	WG-161450875-20200826-DS-03	WG-161450875-20210824-AV01	WG-161450875-20220829-JM02	MW2-10	WG-160340875-20100520-AV17	WG-160340875-20101027-JK 12	WG-160310875-20140821-AV03	WG-160310875-20150928-AV03	WG-160310875-20160825-AV08
Sampling Company			STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC
Laboratory			MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	BV	BV	BV	BV	BV	MAXX	MAXX	MAXX	MAXX	MAXX
Laboratory Work Order			B062483	B0F2316	B062483	B0F1430	B4F3646	B5J8856	B6I3010	B7J0582	B8L6839	B9N2253	C0M1964	C1O3272	C2P0302	C3AC977	B064180	B0F3108	B4F3646	B5J8856	B6I3010
Laboratory Sample ID			FX4449	HQ0824	FX4445	HP6282	XG4185	BBU089	CYS143	FBA581	HNX849	KOP306	NMK092	QMC301	TPN285	XQK216	FY2702	HQ4300	XG4186	BBU088	CYS144
Sample Type	Units	ODWS																			
Field Parameters																					
Dissolved Oxygen, Field	mg/L	n/v	3.9	1.0	5.9	-	-	-	-	5.20	9.3	4.8	-	-	-	-	-	2.3	-	2.38	5.90
General Chemistry																					
Alkalinity, Bicarbonate (as CaCO3)	mg/L	n/v	349	355	138	154	170	180	170	160	160	160	170	140	160	170	155	158	180	200	180
Alkalinity, Carbonate (as CaCO3)	mg/L	n/v	5	3	2	1	1.3	1.1	1.6	1.5	1.5	1.7	1.0	1.3	1.7	1.6	3	2	2.6	1.1	2.5
Alkalinity, Total (as CaCO3)	mg/L	30-500[D]	353	358	140	155	170	180	170	170	160	170	170	140	170	170	158	160	180	200	190
Ammonia (as N)	mg/L	n/v	0.06	0.16	<0.05	0.06	0.051	<0.050	<0.050	0.087	<0.050	<0.050	<0.050	<0.050	0.16	<0.050	0.11	0.23	0.29	0.18	0.14
Anion Sum	me/L	n/v	8.45	8.47	3.91	4.79	4.84	4.75	4.76	4.07	4.36	5.02	4.20	5.83	4.31	4.41	3.58	4.31	4.45	5.03	4.60
Cation Sum	me/L	n/v	8.84	8.29	3.93	4.95	5.03	4.86	4.64	4.08	4.07	5.12	4.04	5.48	4.45	4.38	3.31	4.42	4.57	4.46	4.40
Chloride	mg/L	250[B]	12	13	4	6	14	3.5	1.8	1.0	19	15	16	44	9.3	13	6	12	7	8.4	7.2
Dissolved Organic Carbon (DOC)	mg/L	5[B]	2.0	2.3	1.4	1.7	1.1	1.4	1.1	1.3	1.3	1.3	1.2	1.1	1.5	1.3	**5.1[B]**	**5.7[B]**	**6.5[B]**	4.8	3.4
Electrical Conductivity, Lab	µmhos/cm	n/v	755	760	388	473	480	460	470	380	420	500	410	590	400	440	342	432	410	440	450
Hardness (as CaCO3)	mg/L	80-100[D]	**430[D]**	**400[D]**	**190[D]**	**240[D]**	**240[D]**	**240[D]**	**230[D]**	**200[D]**	**200[D]**	**250[D]**	**200[D]**	**270[D]**	**220[D]**	**210[D]**	**43[D]**	**66[D]**	**64[D]**	**78[D]**	83
Ion Balance	%	n/v	2.29	1.12	0.270	1.58	1.95	1.10	1.23	0.0900	3.43	1.00	1.88	3.08	1.55	0.390	3.91	1.26	1.35	5.98	2.30
Langelier Index (at 20 C)	none	n/v	1.25	0.973	0.653	0.559	0.599	0.490	0.656	0.577	0.574	0.720	0.409	0.607	0.685	0.658	0.140	0.128	0.275	-0.0170	0.355
Langelier Index (at 4 C)	none	n/v	0.996	0.725	0.404	0.310	0.350	0.241	0.408	0.327	0.324	0.470	0.159	0.358	0.435	0.408	-0.110	-0.121	0.0260	-0.267	0.106
Nitrate (as N)	mg/L	10.0_g[A]	<0.1	<0.1	**12[A]**	**19[A]**	**12.0[A]**	**12.1[A]**	**17.3[A]**	6.57	6.18	**15.0[A]**	3.01	**21.5[A]**	6.18	5.75	<0.1	<0.1	<0.10	<0.10	0.52
Nitrate + Nitrite (as N)	mg/L	10.0_g[A]	<0.1	<0.1	**12[A]**	**19[A]**	**12.0[A]**	**12.1[A]**	**17.3[A]**	6.57	6.18	**15.0[A]**	3.01	**21.5[A]**	6.18	5.75	<0.1	<0.1	<0.10	<0.10	0.52
Nitrite (as N)	mg/L	1.0_g[A]	0.03	<0.01	<0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.01	<0.01	<0.010	0.021	<0.010
Orthophosphate (as P)	mg/L	n/v	<0.01	<0.01	<0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.08	0.06	0.068	0.021	0.019
pH, lab	S.U.	6.5-8.5[D]	8.1	7.88	8.1	7.92	7.90	7.79	8.00	7.97	7.99	8.03	7.80	7.99	8.05	8.00	8.3	8.09	8.20	7.78	8.15
Saturation pH (at 20 C)	none	n/v	6.89	6.90	7.49	7.36	7.30	7.30	7.35	7.39	7.42	7.31	7.39	7.39	7.37	7.34	8.15	7.96	7.93	7.80	7.80
Saturation pH (at 4 C)	none	n/v	7.14	7.15	7.74	7.61	7.55	7.54	7.60	7.64	7.67	7.56	7.64	7.63	7.62	7.59	8.40	8.21	8.17	8.05	8.05
Sulfate	mg/L	500_h[B]	50	47	6	6	5	4.6	3.6	12	5.7	10	3.7	14	14	7.0	12	37	33	37	30
Total Dissolved Solids (Calculated)	mg/L	500[B]	441	433	226	289	280	270	280	220	230	290	220	340	240	240	194	250	260	270	250
Metals																					
Aluminum	mg/L	0.1[D]	<0.005	<0.005	0.006	0.012	0.0080	<0.0050	<0.0050	0.0054	<0.0050	<0.0050	0.0059	<0.0049	0.0053	<0.0049	0.011	0.011	0.020	0.012	<0.0050
Antimony	mg/L	0.006[A]	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005	0.0010	<0.00050	<0.00050
Arsenic	mg/L	0.01[A]	<0.001	<0.001	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.003	0.002	0.0020	0.0018	0.0015
Barium	mg/L	1[A]	0.087	0.083	0.012	0.016	0.011	0.011	0.010	0.0068	0.0080	0.0099	0.0079	0.013	0.010	0.012	0.012	0.015	0.025	0.034	0.024
Beryllium	mg/L	n/v	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050
Boron	mg/L	5[A]	<0.01	<0.01	<0.01	0.01	0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.14	0.16	0.16	0.14	0.13
Cadmium	mg/L	0.005[A]	<0.0001	0.0001	<0.0001	0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010
Calcium	mg/L	n/v	100	99	57	73	75	71	69	60	59	77	59	80	65	66	11	17	17	20	22
Chromium	mg/L	0.05[A]	<0.005	<0.005	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050
Cobalt	mg/L	n/v	0.0025	0.0019	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.0008	<0.0005	0.0010	<0.00050	<0.00050
Copper	mg/L	1[B]	0.002	0.001	0.003	0.002	0.0020	0.0013	0.0069	0.0030	0.0016	0.0015	0.0014	0.0014	0.0013	0.0013	<0.001	<0.001	0.0010	<0.0010	<0.0010
Iron	mg/L	0.3[B]	<0.1	<0.1	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10	<0.10
Lead	mg/L	0.01[A]	<0.0005	<0.0005	0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050
Magnesium	mg/L	n/v	41	37	12	14	14	15	13	12	13	14	12	16	13	12	3.8	5.5	5.2	6.6	7.0
Manganese	mg/L	0.05[B]	**0.33[B]**	**0.34[B]**	0.005	0.003	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.010	<0.0020	**0.080[B]**	**0.097[B]**	**0.055[B]**	0.049	0.040
Molybdenum	mg/L	n/v	0.003	0.003	<0.001	<0.001	0.0010	0.00068	0.00053	<0.00050	<0.00050	<0.00050	<0.00050	0.00054	0.00059	0.00056	0.042	0.039	0.038	0.031	0.029
Nickel	mg/L	n/v	0.002	<0.001	0.001	<0.001	0.0070	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.001	0.002	0.0030	<0.0010	<0.0010
Phosphorus	mg/L	n/v	<0.1	<0.1	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.2	0.1	<0.10	<0.10	<0.10
Potassium	mg/L	n/v	3.0	2.6	2.6	3.3	3.6	3.6	3.3	2.2	2.3	2.0	2.6	3.7	3.3	2.9	1.1	1.1	0.96	0.90	0.88
Selenium	mg/L	0.05[A]	<0.002	<0.002	<0.002	<0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.002	<0.002	<0.0020	<0.0020	<0.0020
Silicon	mg/L	n/v	6.5	7.0	2.0	2.5	2.5	2.6	2.3	2.3	2.2	2.5	2.3	2.1	2.4	2.3	4.6	4.9	5.1	4.7	4.4
Silver	mg/L	n/v	<0.0001	<0.0001	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010
Sodium	mg/L	200_g[B] 20_g[C]	5.9	5.1	1.4	1.6	1.6	1.1	0.99	0.90	0.90	1.0	0.87	0.97	1.1	1.2	**55[C]**	**70[C]**	**75[C]**	**66[C]**	**62[C]**
Strontium	mg/L	n/v	0.26	0.22	0.069	0.092	0.092	0.095	0.088	0.075	0.074	0.093	0.071	0.11	0.085	0.093	0.19	0.26	0.29	0.38	0.37
Thallium	mg/L	n/v	<0.00005	<0.00005	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050
Titanium	mg/L	n/v	<0.005	<0.005	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050
Uranium	mg/L	0.02[A]	0.0059	0.0049	0.0002	0.0002	<0.00010	0.00015	0.00013	0.00012	0.00011	0.00014	0.00012	0.00012	0.00014	0.00013	0.0009	0.0013	0.0020	0.0022	0.0014
Vanadium	mg/L	n/v	<0.001	<0.001	<0.001	<0.001	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.001	0.001	0.0020	0.0013	0.00065
Zinc	mg/L	5[B]	0.14	0.009	0.016	0.017	0.0080	<0.0050	0.0070	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.017	0.013	0.0070	<0.0050	<0.0050

See notes on last page.

Table 3
Summary of Groundwater Analytical Results
Waterloo North Hydrogeological Assessment

Sample Location			MW3-10D (Contd.)							MW3-10S				MW3-16S						MW4-10	
Sample Date			31-Aug-17	22-Aug-18	21-Aug-19	27-Aug-20	24-Aug-21	30-Aug-22	17-Nov-23	19-May-10	25-Oct-10	21-Aug-14	29-Sep-15	31-Aug-17	21-Aug-18	20-Aug-19	26-Aug-20	29-Aug-22	16-Nov-23	17-May-10	25-Oct-10
Sample ID			WG-160310875-20170831-AV03	WG-160310875-20180822-DS05	WG-161450875-20190821-DS07	WG-161450875-20200827-DS-07	WG-161450875-20210824-AV05	WG-161450875-20220830-JM05	MW3-10D	WG-160340875-20100519-AV13	WG-160340875-20101025-JK1	WG-160310875-20140821-AV01	WG-160310875-20150929-AV06	WG-160310875-20170831-AV01	WG-160310875-20180821-DS03	WG-161450875-20190820-DS01	WG-161450875-20200826-DS-02	WG-161450875-20220829-JM01	MW3-16S	WG-160340875-20100517-AV04	WG-160340875-20101025-JK3
Sampling Company			STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC
Laboratory			MAXX	MAXX	BV	BV	BV	BV	BV	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	BV	BV	BV	BV	MAXX	MAXX
Laboratory Work Order			B7J0582	B8L6839	B9N2253	C0M1964	C1O3272	C2P0302	C3AC977	B064180	B0F1430	B4F3646	B5J8856	B7J0582	B8L6839	B9N2253	C0M1964	C2P0302	C3AC977	B062483	B0F1430
Laboratory Sample ID			FBA582	HNX850	KOP311	NMK096	QMC305	TPN288	XQK218	FY2698	HP6281	XG4184	BBU091	FBA580	HNX848	KOP305	NMK091	TPN284	XQK215	FX4444	HP6283
Sample Type	Units	ODWS																			
Field Parameters																					
Dissolved Oxygen, Field	mg/L	n/v	7.60	1.5	1.1	-	2.0	-	-	6.6	-	-	19.08	11.29	6.9	8.8	-	-	-	2.9	-
General Chemistry																					
Alkalinity, Bicarbonate (as CaCO3)	mg/L	n/v	170	170	170	160	170	150	360	223	229	240	250	260	270	260	270	270	240	309	338
Alkalinity, Carbonate (as CaCO3)	mg/L	n/v	2.6	2.6	4.2	2.2	3.3	3.3	8.1	3	2	1.7	1.7	2.1	2.8	3.1	2.0	2.7	3.1	4	2
Alkalinity, Total (as CaCO3)	mg/L	30-500[D]	170	170	170	170	170	150	360	226	231	240	250	270	270	260	270	270	250	313	340
Ammonia (as N)	mg/L	n/v	0.19	0.31	0.26	0.22	0.17	0.39	0.55	0.09	0.07	0.082	<0.050	<0.050	<0.050	<0.050	0.051	0.11	<0.050	0.09	0.15
Anion Sum	me/L	n/v	3.81	3.69	3.77	3.52	3.72	3.33	7.93	8.65	7.96	7.62	7.99	8.11	8.62	8.43	8.88	8.21	7.96	6.76	7.33
Cation Sum	me/L	n/v	3.30	3.20	3.32	3.30	3.12	3.35	3.64	8.18	7.69	7.86	7.84	7.75	7.93	8.28	8.22	8.34	7.97	7.18	7.52
Chloride	mg/L	250[B]	4.7	4.4	8.1	3.9	4.4	4.8	<20 DB	28	23	15	17	17	20	22	24	29	31	6	6
Dissolved Organic Carbon (DOC)	mg/L	5[B]	3.2	**5.2[B]**	3.5	3.1	3.1	3.3	**5.9[B]**	1.7	1.7	1.6	1.9	1.5	1.6	1.3	1.3	1.2	1.4	1.4	1.7
Electrical Conductivity, Lab	µmhos/cm	n/v	340	330	300	300	300	300	340	847	774	720	760	760	800	790	820	760	780	625	667
Hardness (as CaCO3)	mg/L	80-100[D]	**44[D]**	**41[D]**	**40[D]**	**42[D]**	**40[D]**	**39[D]**	**44[D]**	**390[D]**	**360[D]**	**360[D]**	**360[D]**	**360[D]**	**380[D]**	**390[D]**	**380[D]**	**390[D]**	**370[D]**	**350[D]**	**370[D]**
Ion Balance	%	n/v	7.17	7.11	6.47	3.26	8.67	0.240	37.1	2.78	1.70	1.54	0.950	2.26	4.18	0.890	3.83	0.730	0.0700	2.99	1.29
Langelier Index (at 20 C)	none	n/v	0.122	0.0910	0.289	0.0380	0.183	0.177	0.578	0.989	0.733	0.780	0.787	0.853	0.991	1.03	0.838	0.987	1.05	1.13	0.896
Langelier Index (at 4 C)	none	n/v	-0.128	-0.159	0.0390	-0.212	-0.0670	-0.0730	0.329	0.741	0.485	0.532	0.539	0.605	0.743	0.781	0.590	0.739	0.806	0.883	0.647
Nitrate (as N)	mg/L	10.0_d[A]	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	**37[A]**	**28[A]**	**22.5[A]**	**24.3[A]**	**24.9[A]**	**28.2[A]**	**28.0[A]**	**30.2[A]**	**22.2[A]**	**24.1[A]**	2.1	2.9
Nitrate + Nitrite (as N)	mg/L	10.0_d[A]	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	**37[A]**	**28[A]**	**22.5[A]**	**24.3[A]**	**24.9[A]**	**28.2[A]**	**28.0[A]**	**30.2[A]**	**22.2[A]**	**24.1[A]**	2.1	2.9
Nitrite (as N)	mg/L	1.0_d[A]	<0.010	<0.010	<0.010	<0.010	<0.010	0.029	0.014	0.03	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.02	<0.01
Orthophosphate (as P)	mg/L	n/v	0.10	0.081	0.13	0.12	0.14	0.094	0.34	<0.01	0.03	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.01	0.01
pH, lab	S.U.	6.5-8.5[D]	8.22	8.21	8.42	8.16	8.31	8.36	8.38	8.1	7.86	7.89	7.87	7.94	8.05	8.10	7.90	8.04	8.13	8.1	7.80
Saturation pH (at 20 C)	none	n/v	8.09	8.12	8.13	8.12	8.13	8.18	7.80	7.13	7.13	7.11	7.08	7.08	7.05	7.07	7.06	7.05	7.08	6.95	6.90
Saturation pH (at 4 C)	none	n/v	8.34	8.37	8.38	8.37	8.38	8.43	8.05	7.38	7.37	7.36	7.33	7.33	7.30	7.32	7.31	7.30	7.33	7.20	7.15
Sulfate	mg/L	500_h[B]	10	7.9	2.9	4.6	4.6	5.3	30	35	34	35	37	26	30	26	30	21	21	9	8
Total Dissolved Solids (Calculated)	mg/L	500[B]	200	190	200	190	190	190	340	**519[B]**	469	450	470	460	490	490	**510[B]**	470	460	349	375
Metals																					
Aluminum	mg/L	0.1[D]	0.0086	0.0088	0.056	0.076	0.058	0.018	0.052	<0.005	0.024	0.0050	<0.0050	0.0067	<0.0050	0.0059	0.0053	0.0086	<0.0049	<0.005	<0.005
Antimony	mg/L	0.006[A]	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.0006	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005
Arsenic	mg/L	0.01[A]	0.0033	0.0034	0.0043	0.0042	0.0040	0.0042	0.0046	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.001	<0.001
Barium	mg/L	1[A]	0.017	0.017	0.018	0.014	0.015	0.017	0.030	0.067	0.050	0.074	0.074	0.067	0.054	0.056	0.050	0.048	0.043	0.047	0.058
Beryllium	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.0005	<0.0005
Boron	mg/L	5[A]	0.15	0.14	0.16	0.15	0.15	0.15	0.13	0.02	0.02	0.024	0.020	0.021	0.012	0.019	0.017	0.020	0.021	<0.01	0.01
Cadmium	mg/L	0.005[A]	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001
Calcium	mg/L	n/v	11	11	10	11	10	10	12	96	94	92	96	90	96	95	94	97	97	96	100
Chromium	mg/L	0.05[A]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005
Cobalt	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005
Copper	mg/L	1[B]	<0.0010	<0.0010	<0.0010	<0.00090	0.0015	<0.00090	<0.00090	0.003	0.002	0.0020	0.0021	<0.0010	<0.0010	<0.0010	0.0015	0.0013	<0.00090	0.002	0.002
Iron	mg/L	0.3[B]	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1
Lead	mg/L	0.01[A]	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005
Magnesium	mg/L	n/v	3.7	3.4	3.4	3.4	3.4	3.3	3.6	35	31	31	29	33	33	37	36	36	32	26	27
Manganese	mg/L	0.05[B]	0.021	0.021	0.017	0.019	0.022	0.014	0.015	0.047	0.008	<0.0020	<0.0020	0.0032	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.028	0.036
Molybdenum	mg/L	n/v	0.038	0.038	0.040	0.038	0.037	0.037	0.030	0.001	<0.001	0.0010	<0.00050	0.00071	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.001	<0.001
Nickel	mg/L	n/v	<0.0010	<0.0010	0.0017	<0.0010	<0.0010	<0.0010	<0.0010	0.002	<0.001	0.0010	<0.0010	<0.0010	0.0015	<0.0010	<0.0010	<0.0010	<0.0010	0.002	0.001
Phosphorus	mg/L	n/v	0.19	0.19	0.18	0.18	0.18	0.10	<0.10	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1
Potassium	mg/L	n/v	0.64	0.60	0.59	0.56	0.63	0.67	0.90	2.9	1.8	1.8	1.7	5.0	3.4	5.1	4.2	5.0	2.6	1.4	1.9
Selenium	mg/L	0.05[A]	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.002	<0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.002	<0.002
Silicon	mg/L	n/v	4.6	4.4	5.0	5.0	4.2	4.6	4.5	6.8	6.6	7.3	6.8	6.0	6.3	7.0	6.9	6.9	6.8	4.4	5.0
Silver	mg/L	n/v	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001
Sodium	mg/L	200_g[B] 20_g[C]	**55[C]**	**54[C]**	**57[C]**	**56[C]**	**53[C]**	**58[C]**	**62[C]**	8.9	9.0	14	14	9.4	7.9	9.0	10	8.9	10	3.7	3.8
Strontium	mg/L	n/v	0.22	0.22	0.21	0.21	0.22	0.22	0.25	0.22	0.16	0.14	0.15	0.20	0.16	0.19	0.17	0.18	0.17	0.17	0.20
Thallium	mg/L	n/v	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00005	<0.00005
Titanium	mg/L	n/v	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005
Uranium	mg/L	0.02[A]	0.00032	0.00042	0.00039	0.00031	0.00033	0.0016	0.0035	0.0032	0.0009	0.0010	0.00081	0.00098	0.00049	0.00052	0.00049	0.00047	0.00048	0.0012	0.0013
Vanadium	mg/L	n/v	<0.00050	<0.00050	0.0015	0.0015	0.0017	0.0036	0.0032	<0.001	<0.001	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.001	<0.001
Zinc	mg/L	5[B]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.086	0.017	0.0050	0.020	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.009	0.006

See notes on last page.

Table 3
Summary of Groundwater Analytical Results
Waterloo North Hydrogeological Assessment

Sample Location			MW5-10		MW6-10												MW7-10				
Sample Date			17-May-10	26-Oct-10	17-May-10	27-Oct-10	22-Aug-14	28-Sep-15	26-Aug-16	5-Sep-17	21-Aug-18	20-Aug-19	26-Aug-20	24-Aug-21	30-Aug-22	16-Nov-23	17-May-10	26-Oct-10	22-Aug-14	28-Sep-15	26-Aug-16
Sample ID			WG-160340875-20100517-AV08	WG-160340875-20101026-JK9	WG-160340875-20100517-AV01	WG-160340875-20101027-JK 15	WG-160310875-20140822-AV11	WG-160310875-20150928-AV05	WG-160310875-20160826-AV09	WG-160310875-20170905-AV10	WG-160310875-20180821-DS01	WG-161450875-20190820-DS03	WG-161450875-20200826-DS-04	WG-161450875-20210824-AV02	WG-161450875-20220830-JM06	MW6-10	WG-160340875-20100517-AV02	WG-160340875-20101026-JK11	WG-160310875-20140822-AV12	WG-160310875-20150928-AV02	WG-160310875-20160826-AV10
Sampling Company			STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC
Laboratory			MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	BV	BV	BV	BV	BV	MAXX	MAXX	MAXX	MAXX	MAXX
Laboratory Work Order			B062483	B0F2316	B062483	B0F3108	B4F3646	B5J8856	B6I3010	B7J2479	B8L6839	B9N2253	C0M1964	C1O3272	C2P0302	C3AC977	B062483	B0F2316	B4F3646	B5J8856	B6I3010
Laboratory Sample ID			FX4448	HQ0825	FX4441	HQ4303	XG4194	BBU090	CYS145	FBK361	HNX846	KOP307	NMK093	QMC302	TPN289	XQK217	FX4442	HQ0827	XG4195	BBU087	CYS146
Sample Type	Units	ODWS																			
Field Parameters																					
Dissolved Oxygen, Field	mg/L	n/v	4.9	2.5	7.7	1.0	-	32.43	10.33	11.57	7.7	8.2	-	7.5	-	-	6.9	1.2	-	-	11.48
General Chemistry																					
Alkalinity, Bicarbonate (as CaCO3)	mg/L	n/v	252	317	130	153	160	180	180	180	180	180	190	170	180	180	267	313	250	280	280
Alkalinity, Carbonate (as CaCO3)	mg/L	n/v	2	2	1	2	1.3	<1.0	1.8	1.6	2.7	2.0	1.5	1.6	1.8	1.6	2	3	2.1	1.9	2.5
Alkalinity, Total (as CaCO3)	mg/L	30-500[D]	254	319	132	155	170	180	180	180	190	180	200	170	180	180	269	316	260	280	280
Ammonia (as N)	mg/L	n/v	0.07	0.19	<0.05	0.05	<0.050	0.11	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.06	0.09	<0.050	<0.050	<0.050
Anion Sum	me/L	n/v	5.51	6.85	4.53	5.28	5.27	5.23	5.02	4.89	4.67	5.08	4.94	5.75	5.37	4.93	6.23	7.18	5.55	6.24	6.35
Cation Sum	me/L	n/v	6.28	7.10	4.63	5.40	5.23	4.91	5.06	4.81	4.31	5.14	4.68	5.46	5.48	4.92	7.31	7.23	5.79	6.24	6.34
Chloride	mg/L	250[B]	7	7	4	14	12	11	6.8	4.9	7.4	11	12	28	23	14	10	10	6	8.7	12
Dissolved Organic Carbon (DOC)	mg/L	5[B]	0.8	1.3	1.2	1.6	0.79	1.1	1.0	1.1	1.3	1.1	0.92	0.93	0.93	1.0	0.9	1.2	0.48	0.69	0.56
Electrical Conductivity, Lab	µmhos/cm	n/v	508	621	469	531	530	510	500	480	430	500	470	570	510	490	571	654	510	570	590
Hardness (as CaCO3)	mg/L	80-100[D]	**310[D]**	**340[D]**	**230[D]**	**260[D]**	**250[D]**	**240[D]**	**240[D]**	**230[D]**	**210[D]**	**250[D]**	**230[D]**	**270[D]**	**260[D]**	**240[D]**	**350[D]**	**350[D]**	**280[D]**	**300[D]**	**310[D]**
Ion Balance	%	n/v	6.60	1.75	1.07	1.06	0.400	3.24	0.450	0.800	4.02	0.580	2.69	2.64	1.06	0.160	8.00	0.350	2.05	0.0100	0.0700
Langelier Index (at 20 C)	none	n/v	0.923	0.902	0.564	0.767	0.626	0.429	0.743	0.692	0.871	0.826	0.661	0.730	0.788	0.708	0.936	1.02	0.846	0.808	0.954
Langelier Index (at 4 C)	none	n/v	0.674	0.654	0.315	0.518	0.376	0.180	0.494	0.442	0.621	0.577	0.412	0.481	0.539	0.459	0.687	0.769	0.597	0.559	0.705
Nitrate (as N)	mg/L	10.0_d[A]	1.1	1.1	**23[A]**	**23[A]**	**20.3[A]**	**15.9[A]**	**15.1[A]**	**12.8[A]**	8.29	**12.9[A]**	7.40	**18.8[A]**	**11.9[A]**	9.30	2.6	3.0	1.87	2.56	3.54
Nitrate + Nitrite (as N)	mg/L	10.0_d[A]	1.1	1.1	**23[A]**	**23[A]**	**20.3[A]**	**15.9[A]**	**15.1[A]**	**12.8[A]**	8.29	**12.9[A]**	7.40	**18.8[A]**	**11.9[A]**	9.30	2.6	3.0	1.87	2.56	3.54
Nitrite (as N)	mg/L	1.0_d[A]	<0.01	<0.01	<0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.01	<0.01	<0.010	<0.010	<0.010
Orthophosphate (as P)	mg/L	n/v	<0.01	<0.01	<0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.01	<0.01	<0.010	<0.010	<0.010
pH, lab	S.U.	6.5-8.5[D]	8.0	7.82	8.0	8.10	7.93	7.71	8.02	7.97	8.19	8.08	7.92	8.01	8.03	7.98	7.9	7.96	7.95	7.85	7.99
Saturation pH (at 20 C)	none	n/v	7.07	6.91	7.45	7.33	7.30	7.28	7.27	7.28	7.32	7.25	7.26	7.28	7.24	7.27	7.01	6.94	7.11	7.04	7.04
Saturation pH (at 4 C)	none	n/v	7.32	7.16	7.70	7.58	7.55	7.53	7.52	7.53	7.57	7.50	7.51	7.53	7.49	7.52	7.25	7.19	7.36	7.29	7.29
Sulfate	mg/L	500_h[B]	7	10	6	7	8	7.0	6.1	7.6	8.3	9.8	7.8	12	11	9.5	18	18	7	9.9	9.0
Total Dissolved Solids (Calculated)	mg/L	500[B]	296	355	283	323	310	300	290	280	250	290	260	330	310	270	344	373	290	320	330
Metals																					
Aluminum	mg/L	0.1[D]	<0.005	<0.005	0.007	0.006	0.013	<0.0050	<0.0050	0.0063	<0.0050	<0.0050	<0.0049	<0.0049	<0.0049	<0.0049	<0.005	<0.005	<0.0050	<0.0050	<0.0050
Antimony	mg/L	0.006[A]	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050
Arsenic	mg/L	0.01[A]	<0.001	<0.001	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.001	<0.001	<0.0010	<0.0010	<0.0010
Barium	mg/L	1[A]	0.024	0.032	0.017	0.015	0.020	0.016	0.019	0.017	0.014	0.019	0.018	0.019	0.038	0.017	0.025	0.021	0.015	0.015	0.014
Beryllium	mg/L	n/v	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050
Boron	mg/L	5[A]	0.01	0.01	<0.01	<0.01	0.010	<0.010	<0.010	<0.010	<0.010	0.012	0.010	0.013	0.011	0.011	<0.01	<0.01	<0.010	<0.010	<0.010
Cadmium	mg/L	0.005[A]	<0.0001	<0.0001	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	0.0001	<0.00010	<0.00010	<0.00010
Calcium	mg/L	n/v	89	100	69	80	80	74	77	73	66	80	71	83	84	76	99	100	80	86	88
Chromium	mg/L	0.05[A]	<0.005	<0.005	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050
Cobalt	mg/L	n/v	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050
Copper	mg/L	1[B]	0.002	0.002	0.002	0.002	0.0020	0.0012	0.0034	0.0038	0.0018	0.0024	0.0027	0.0026	0.0047	0.0012	0.002	0.001	0.0010	<0.0010	0.0010
Iron	mg/L	0.3[B]	<0.1	<0.1	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10	<0.10
Lead	mg/L	0.01[A]	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.0012	<0.0005	<0.00050	<0.00050	<0.00050
Magnesium	mg/L	n/v	20	21	13	15	13	13	13	12	11	12	12	14	13	12	26	24	20	21	21
Manganese	mg/L	0.05[B]	0.028	**0.059[B]**	<0.002	<0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.0023	<0.0020	<0.0020	<0.0020	<0.0020	0.012	<0.002	<0.0020	<0.0020	<0.0020
Molybdenum	mg/L	n/v	0.002	<0.001	<0.001	<0.001	0.0010	<0.00050	0.00054	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00054	<0.00050	<0.001	<0.001	<0.00050	<0.00050	<0.00050
Nickel	mg/L	n/v	<0.001	0.001	<0.001	<0.001	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.001	<0.001	0.0010	<0.0010	<0.0010
Phosphorus	mg/L	n/v	<0.1	<0.1	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10	<0.10
Potassium	mg/L	n/v	1.5	1.8	2.2	1.9	4.6	2.5	4.9	4.5	2.8	5.3	4.6	2.9	5.2	3.4	0.8	0.8	0.68	0.72	0.71
Selenium	mg/L	0.05[A]	<0.002	<0.002	<0.002	<0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.002	<0.002	<0.0020	<0.0020	<0.0020
Silicon	mg/L	n/v	5.1	5.8	2.6	3.3	2.7	3.1	2.9	2.8	2.7	2.8	2.7	2.9	3.0	2.9	5.8	5.8	5.3	5.3	5.3
Silver	mg/L	n/v	<0.0001	<0.0001	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010
Sodium	mg/L	200_g[B] 20_g[C]	3.4	3.6	1.6	2.7	1.7	1.3	1.5	1.3	1.1	1.3	1.2	1.4	1.6	1.4	5.1	5.3	3.5	3.6	3.8
Strontium	mg/L	n/v	0.15	0.16	0.081	0.10	0.099	0.10	0.11	0.10	0.088	0.11	0.098	0.12	0.11	0.11	0.11	0.12	0.086	0.10	0.10
Thallium	mg/L	n/v	<0.00005	<0.00005	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050
Titanium	mg/L	n/v	<0.005	<0.005	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050
Uranium	mg/L	0.02[A]	0.0009	0.0007	0.0002	<0.0001	<0.00010	0.00019	0.00018	0.00017	0.00018	0.00018	0.00019	0.00016	0.00018	0.00017	0.0002	0.0002	<0.00010	0.00019	0.00019
Vanadium	mg/L	n/v	<0.001	0.004	<0.001	0.001	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.001	<0.001	<0.00050	<0.00050	<0.00050
Zinc	mg/L	5[B]	0.043	0.044	0.006	0.006	0.0070	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.014	0.006	0.0080	<0.0050	<0.0050

See notes on last page.

Table 3
Summary of Groundwater Analytical Results
Waterloo North Hydrogeological Assessment

Sample Location			MW7-10 (Contd.)							MW8-10D											
Sample Date			5-Sep-17	21-Aug-18	20-Aug-19	26-Aug-20	25-Aug-21	29-Aug-22	17-Nov-23	18-May-10	26-Oct-10	22-Aug-14	29-Sep-15	24-Aug-16	5-Sep-17	22-Aug-18	20-Aug-19	26-Aug-20	25-Aug-21	6-Sep-22	17-Nov-23
Sample ID			WG-160310875-20170905-AV11	WG-160310875-20180821-DS02	WG-161450875-20190820-DS04	WG-161450875-20200826-DS-01	WG-161450875-20210825-AV10	WG-161450875-20220829-JM03	MW7-10	WG-160340875-20100518-AV11	WG-160340875-20101026-JK5	WG-160310875-20140822-AV08	WG-160310875-20150929-AV010	WG-160310875-20160824-AV03	WG-160310875-20170905-AV08	WG-160310875-20180822-DS07	WG-161450875-20190820-DS05	WG-161450875-20200826-DS-06	WG-161450875-20210825-AV09	WG-161459875-20220906-JM11	MW8-10D
Sampling Company			STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC
Laboratory			MAXX	MAXX	BV	BV	BV	BV	BV	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	BV	BV	BV	BV	BV
Laboratory Work Order			B7J2479	B8L6839	B9N2253	C0M1964	C1O3272	C2P0302	C3AC977	B064180	B0F2316	B4F3646	B5J8856	B6I3010	B7J2479	B8L6839	B9N2253	C0M1964	C1O3272	C2P6965	C3AC977
Laboratory Sample ID			FBK362	HNX847	KOP308	NMK090	QMC310	TPN286	XQK223	FY2696	HQ0821	XG4191	BBU095	CYS139	FBK359	HNX852	KOP309	NMK095	QMC309	TQZ171	XQK219
Sample Type	Units	ODWS																			
Field Parameters																					
Dissolved Oxygen, Field	mg/L	n/v	9.67	6.6	7.2	-	7.64	-	-	0.7	0.8	-	1.65	3.83	2.82	0.2	0.5	-	0.34	-	-
General Chemistry																					
Alkalinity, Bicarbonate (as CaCO3)	mg/L	n/v	300	320	320	360	360	340	380	238	233	240	240	240	240	240	230	230	230	230	230
Alkalinity, Carbonate (as CaCO3)	mg/L	n/v	2.4	2.6	2.4	2.4	3.2	2.6	2.3	3	2	2.1	1.8	2.9	2.2	2.5	2.7	1.7	2.2	2.8	1.9
Alkalinity, Total (as CaCO3)	mg/L	30-500[D]	310	320	320	360	360	340	380	241	235	240	240	240	240	240	240	240	240	230	230
Ammonia (as N)	mg/L	n/v	<0.050	<0.050	0.060	0.10	<0.050	<0.050	<0.050	0.11	0.18	0.12	0.087	0.12	0.10	0.11	0.14	0.14	0.072	0.087	0.12
Anion Sum	me/L	n/v	7.06	7.68	7.67	8.61	8.69	8.34	9.14	7.50	7.25	6.94	7.00	7.02	6.98	6.89	6.88	6.73	7.16	6.69	7.04
Cation Sum	me/L	n/v	7.15	7.48	8.03	8.61	8.28	8.70	9.23	7.17	7.43	7.17	6.92	7.01	7.20	6.34	6.93	6.70	7.28	6.97	7.26
Chloride	mg/L	250[B]	16	18	12	15	17	16	15	11	7	26	26	23	20	12	20	14	23	23	18
Dissolved Organic Carbon (DOC)	mg/L	5[B]	0.69	0.79	0.64	0.71	0.64	0.91	0.70	**7.1[B]**	**7.5[B]**	0.74	0.86	0.62	0.70	0.67	0.54	0.55	0.57	0.51	0.64
Electrical Conductivity, Lab	µmhos/cm	n/v	660	690	710	770	760	740	850	688	673	660	660	670	650	620	640	590	660	610	680
Hardness (as CaCO3)	mg/L	80-100[D]	**350[D]**	**360[D]**	**390[D]**	**410[D]**	**390[D]**	**420[D]**	**440[D]**	**290[D]**	**320[D]**	**290[D]**	**290[D]**	**300[D]**	**310[D]**	**280[D]**	**300[D]**	**300[D]**	**310[D]**	**300[D]**	**320[D]**
Ion Balance	%	n/v	0.660	1.31	2.25	0.0300	2.39	2.15	0.500	2.23	1.26	1.59	0.550	0.0400	1.55	4.17	0.360	0.250	0.840	2.00	1.53
Langelier Index (at 20 C)	none	n/v	0.963	1.01	1.01	1.02	1.12	1.07	1.04	0.977	0.804	0.818	0.756	0.965	0.858	0.880	0.937	0.746	0.876	0.959	0.816
Langelier Index (at 4 C)	none	n/v	0.715	0.760	0.766	0.770	0.869	0.821	0.789	0.729	0.556	0.569	0.508	0.716	0.610	0.631	0.688	0.498	0.627	0.709	0.568
Nitrate (as N)	mg/L	10.0_g[A]	5.04	6.06	9.14	9.04	7.25	8.54	8.72	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Nitrate + Nitrite (as N)	mg/L	10.0_g[A]	5.04	6.06	9.14	9.08	7.25	8.54	8.72	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Nitrite (as N)	mg/L	1.0_g[A]	<0.010	<0.010	<0.010	0.043	<0.010	<0.010	<0.010	<0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Orthophosphate (as P)	mg/L	n/v	<0.050 DB	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
pH, lab	S.U.	6.5-8.5[D]	7.93	7.93	7.90	7.85	7.97	7.91	7.81	8.1	7.93	7.98	7.91	8.11	7.99	8.05	8.09	7.90	8.01	8.11	7.94
Saturation pH (at 20 C)	none	n/v	6.96	6.92	6.89	6.83	6.85	6.84	6.77	7.17	7.13	7.16	7.16	7.15	7.13	7.17	7.15	7.15	7.13	7.15	7.12
Saturation pH (at 4 C)	none	n/v	7.21	7.17	7.14	7.08	7.10	7.09	7.02	7.41	7.38	7.41	7.40	7.39	7.38	7.42	7.40	7.40	7.38	7.40	7.37
Sulfate	mg/L	500_h[B]	6.9	15	13	18	19	20	21	110	110	69	72	77	77	80	77	78	86	68	89
Total Dissolved Solids (Calculated)	mg/L	500[B]	370	400	420	460	450	450	490	423	419	390	390	390	400	370	390	380	410	380	400
Metals																					
Aluminum	mg/L	0.1[D]	<0.0050	<0.0050	<0.0050	<0.0049	<0.0049	0.022	<0.0049	<0.005	0.007	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0049	<0.0049	<0.0049	<0.0049
Antimony	mg/L	0.006[A]	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic	mg/L	0.01[A]	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.004	0.004	0.0040	0.0046	0.0043	0.0044	0.0044	0.0045	0.0043	0.0044	0.0044	0.0044
Barium	mg/L	1[A]	0.016	0.017	0.018	0.020	0.021	0.023	0.025	0.049	0.045	0.039	0.041	0.044	0.044	0.042	0.044	0.044	0.046	0.048	0.049
Beryllium	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040
Boron	mg/L	5[A]	<0.010	<0.010	<0.010	<0.010	0.011	<0.010	0.010	0.04	0.03	0.036	0.030	0.029	0.036	0.030	0.035	0.033	0.043	0.035	0.037
Cadmium	mg/L	0.005[A]	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090
Calcium	mg/L	n/v	98	100	110	120	110	120	130	80	90	81	81	83	86	77	83	83	88	84	90
Chromium	mg/L	0.05[A]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Cobalt	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Copper	mg/L	1[B]	<0.0010	0.0012	<0.0010	<0.00090	0.0015	<0.00090	<0.00090	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.00090	<0.00090	<0.00090	<0.00090
Iron	mg/L	0.3[B]	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	**0.5[B]**	**0.6[B]**	**0.73[B]**	**0.69[B]**	**0.76[B]**	**0.84[B]**	**0.80[B]**	**0.79[B]**	**0.77[B]**	**0.95[B]**	**0.93[B]**	**0.93[B]**
Lead	mg/L	0.01[A]	<0.00050	<0.00050	<0.00050	<0.00050	0.0012	<0.00050	<0.00050	<0.0005	<0.0005	0.0020	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Magnesium	mg/L	n/v	25	25	26	29	29	29	30	22	23	23	22	22	23	22	22	22	22	22	23
Manganese	mg/L	0.05[B]	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.0047	<0.0020	**0.075[B]**	**0.12[B]**	**0.11[B]**	**0.097[B]**	**0.099[B]**	**0.090[B]**	**0.076[B]**	**0.077[B]**	**0.072[B]**	**0.086[B]**	**0.069[B]**	**0.066[B]**
Molybdenum	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.004	0.004	0.0010	0.0014	0.0013	0.0012	0.0011	0.0012	0.0011	0.0013	0.0013	0.0012
Nickel	mg/L	n/v	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus	mg/L	n/v	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.12	<0.10
Potassium	mg/L	n/v	0.78	0.79	0.77	0.89	0.92	0.97	1.0	1.3	1.3	1.0	0.94	0.92	0.96	0.86	0.87	0.87	0.90	0.89	0.93
Selenium	mg/L	0.05[A]	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.002	<0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicon	mg/L	n/v	5.9	5.5	6.1	6.3	5.7	6.3	6.8	9.1	9.4	9.4	9.1	8.8	9.6	8.4	9.2	9.2	8.8	9.3	9.4
Silver	mg/L	n/v	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090
Sodium	mg/L	200_g[B] 20_g[C]	4.9	5.2	5.6	6.7	8.7	6.2	8.1	**30[C]**	**24[C]**	**28[C]**	**23[C]**	**23[C]**	**22[C]**	15	20	16	**23[C]**	**21[C]**	19
Strontium	mg/L	n/v	0.12	0.13	0.13	0.14	0.15	0.15	0.17	1.6	1.7	1.5	1.3	1.3	1.5	1.5	1.5	1.3	1.5	1.4	1.4
Thallium	mg/L	n/v	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Titanium	mg/L	n/v	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Uranium	mg/L	0.02[A]	0.00021	0.00023	0.00024	0.00025	0.00026	0.00024	0.00023	0.0006	0.0005	<0.00010	0.00030	0.00029	0.00026	0.00019	0.00023	0.00022	0.00025	0.00021	0.00019
Vanadium	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.001	<0.001	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc	mg/L	5[B]	<0.0050	<0.0050	0.0075	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050

See notes on last page.

Table 3
Summary of Groundwater Analytical Results
Waterloo North Hydrogeological Assessment

Sample Location			MW8-10S												MW9-10D		MW9-10S		MW10-10		
Sample Date			18-May-10	26-Oct-10	22-Aug-14	29-Sep-15	24-Aug-16	5-Sep-17	21-Aug-18	20-Aug-19	26-Aug-20	25-Aug-21	30-Aug-22	17-Nov-23	20-May-10	27-Oct-10	18-May-10	26-Oct-10	17-May-10	27-Oct-10	21-Aug-14
Sample ID			WG-160340875-20100518-AV12	WG-160340875-20101026-JK4	WG-160310875-20140822-AV09	WG-160310875-20150929-AV011	WG-160310875-20160824-AV04	WG-160310875-20170905-AV09	WG-150310875-20180821-SB01	WG-161450875-20190820-DS06	WG-161450875-20200826-DS-05	WG-161450875-20210825-AV11	WG-161450875-20220830-JM07	MW8-10S	WG-160340875-20100520-AV18	WG-160340875-20101027-JK 14	WG-160340875-20100518-AV10	WG-160340875-20101026-JK10	WG-160340875-20100517-AV06	WG-160340875-20101027-JK 16	WG-160310875-20140821-AV05
Sampling Company			STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC
Laboratory			MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	BV	BV	BV	BV	BV	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX
Laboratory Work Order			B064180	B0F2316	B4F3646	B5J8856	B6I3010	B7J2479	B8L6839	B9N2253	C0M1964	C1O3272	C2P0302	C3AC977	B064180	B0F3108	B064180	B0F2316	B062483	B0F3108	B4F3646
Laboratory Sample ID			FY2697	HQ0820	XG4192	BBU096	CYS140	FBK360	HNX842	KOP310	NMK094	QMC311	TPN290	XQK220	FY2703	HQ4302	FY2695	HQ0826	FX4446	HQ4304	XG4188
Sample Type	Units	ODWS																			
Field Parameters																					
Dissolved Oxygen, Field	mg/L	n/v	0	-	-	3.64	6.91	3.08	0.9	0.6	-	-	-	-	2.2	0.8	0	0.5	0	-	-
General Chemistry																					
Alkalinity, Bicarbonate (as CaCO3)	mg/L	n/v	278	307	350	310	300	310	250	300	320	310	300	290	228	217	238	235	239	248	250
Alkalinity, Carbonate (as CaCO3)	mg/L	n/v	3	2	3.0	2.1	2.0	2.5	1.5	2.2	2.1	2.2	2.2	1.5	4	4	3	2	4	3	2.4
Alkalinity, Total (as CaCO3)	mg/L	30-500[D]	281	309	350	320	310	310	260	300	330	310	310	290	232	221	241	237	243	251	260
Ammonia (as N)	mg/L	n/v	0.09	<0.05	0.065	<0.050	<0.050	<0.050	0.079	0.088	0.051	<0.050	<0.050	0.077	<0.05	0.19	0.17	0.27	0.23	0.34	0.32
Anion Sum	me/L	n/v	29.3	34.3	21.7	22.2	26.9	28.9	33.2	32.1	30.1	28.5	29.9	27.9	6.08	5.74	7.66	6.01	5.26	5.51	5.49
Cation Sum	me/L	n/v	30.6	36.1	23.6	22.7	27.0	29.2	33.7	32.4	31.3	27.5	31.5	35.4	5.89	6.43	7.04	6.14	5.40	5.53	5.48
Chloride	mg/L	250[B]	**800[B]**	**970[B]**	**500[B]**	**550[B]**	**720[B]**	**790[B]**	**980[B]**	**910[B]**	**810[B]**	**770[B]**	**820[B]**	**760[B]**	11	8	13	14	2	2	2
Dissolved Organic Carbon (DOC)	mg/L	5[B]	2.1	2.1	2.4	1.5	1.3	1.8	2.2	1.3	1.7	1.4	1.4	2.0	1.6	3.9	1.2	1.4	1.0	1.5	2.2
Electrical Conductivity, Lab	µmhos/cm	n/v	3,330	3,680	2,400	2,400	2,900	3,100	3,600	3,300	3,300	2,900	3,200	3,200	569	542	714	558	474	489	480
Hardness (as CaCO3)	mg/L	80-100[D]	**530[D]**	**600[D]**	**280[D]**	**290[D]**	**410[D]**	**480[D]**	**600[D]**	**590[D]**	**530[D]**	**480[D]**	**520[D]**	**840[D]**	**230[D]**	**240[D]**	**230[D]**	**220[D]**	**250[D]**	**260[D]**	**250[D]**
Ion Balance	%	n/v	2.16	2.57	4.12	1.06	0.0700	0.440	0.620	0.500	2.05	1.67	2.58	11.9	1.57	5.67	4.22	1.02	1.33	0.210	0.0900
Langelier Index (at 20 C)	none	n/v	1.05	0.849	0.871	0.723	0.824	0.979	0.846	0.996	0.932	0.911	0.944	0.986	0.896	0.906	0.734	0.679	0.979	0.902	0.726
Langelier Index (at 4 C)	none	n/v	0.808	0.606	0.626	0.478	0.579	0.734	0.602	0.752	0.688	0.667	0.700	0.742	0.647	0.657	0.486	0.430	0.730	0.653	0.477
Nitrate (as N)	mg/L	10.0_d[A]	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.13
Nitrate + Nitrite (as N)	mg/L	10.0_d[A]	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.14
Nitrite (as N)	mg/L	1.0_d[A]	0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.01	0.02	0.02	0.01	<0.01	0.12	0.013
Orthophosphate (as P)	mg/L	n/v	<0.01	<0.01	<0.010	<0.010	<0.010	<0.050 DB	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.010
pH, lab	S.U.	6.5-8.5[D]	8.0	7.74	7.96	7.85	7.84	7.93	7.81	7.88	7.83	7.87	7.88	7.75	8.2	8.24	8.1	8.01	8.3	8.16	8.00
Saturation pH (at 20 C)	none	n/v	6.97	6.89	7.09	7.13	7.01	6.95	6.97	6.89	6.90	6.96	6.94	6.76	7.32	7.34	7.35	7.34	7.29	7.26	7.28
Saturation pH (at 4 C)	none	n/v	7.22	7.13	7.33	7.38	7.26	7.20	7.21	7.13	7.15	7.21	7.18	7.00	7.57	7.59	7.59	7.59	7.54	7.51	7.52
Sulfate	mg/L	500_h[B]	50	40	24	21	24	16	19	22	28	24	24	23	55	53	120	42	17	20	15
Total Dissolved Solids (Calculated)	mg/L	500[B]	**1,680[B]**	**1,980[B]**	**1,300[B]**	**1,300[B]**	**1,500[B]**	**1,600[B]**	**1,900[B]**	**1,800[B]**	**1,700[B]**	**1,600[B]**	**1,700[B]**	**1,700[B]**	327	326	425	330	279	293	290
Metals																					
Aluminum	mg/L	0.1[D]	0.006	0.017	0.0080	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0049	<0.0049	<0.0049	**0.42[D]**	<0.005	<0.005	0.006	0.081	<0.005	<0.005	0.0050
Antimony	mg/L	0.006[A]	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	0.0007	0.0008	<0.0005	<0.0005	<0.0005	<0.00050
Arsenic	mg/L	0.01[A]	<0.001	<0.005	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.002	0.001	0.003	0.005	**0.011[A]**	**0.012[A]**	**0.015[A]**
Barium	mg/L	1[A]	0.20	0.15	0.11	0.098	0.13	0.16	0.17	0.18	0.17	0.13	0.18	0.15	0.082	0.078	0.12	0.071	0.068	0.068	0.10
Beryllium	mg/L	n/v	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050
Boron	mg/L	5[A]	0.02	0.02	0.011	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.03	0.04	0.03	0.03	0.02	0.03	0.030
Cadmium	mg/L	0.005[A]	<0.0001	0.0002	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.00010
Calcium	mg/L	n/v	160	180	88	89	130	150	180	180	160	150	160	250	55	56	53	52	55	57	54
Chromium	mg/L	0.05[A]	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.0050
Cobalt	mg/L	n/v	0.0012	<0.0005	0.0010	<0.00050	<0.00050	<0.00050	<0.00050	0.00054	<0.00050	<0.00050	<0.00050	0.00070	<0.0005	<0.0005	0.0008	0.0007	0.0010	0.0007	<0.00050
Copper	mg/L	1[B]	0.003	0.002	0.0030	<0.0010	<0.0020 MI	<0.0010	<0.0010	<0.0010	0.0043	0.0028	0.0032	0.0035	<0.001	<0.001	0.001	<0.001	0.001	0.001	0.0010
Iron	mg/L	0.3[B]	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	**1.4[B]**	0.1	<0.1	<0.1	0.2	<0.1	<0.1	0.17
Lead	mg/L	0.01[A]	<0.0005	0.0011	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.0016	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00050
Magnesium	mg/L	n/v	32	35	16	16	23	27	35	32	30	28	30	51	22	24	24	22	27	28	28
Manganese	mg/L	0.05[B]	**0.28[B]**	**0.21[B]**	**0.056[B]**	**0.066[B]**	0.037	**0.087[B]**	0.042	**0.064[B]**	**0.058[B]**	0.012	0.020	**0.21[B]**	**0.070[B]**	**0.13[B]**	**0.13[B]**	**0.20[B]**	**0.070[B]**	**0.067[B]**	0.025
Molybdenum	mg/L	n/v	0.004	0.004	0.0010	0.00051	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.006	0.009	0.007	0.004	0.001	0.001	0.0010
Nickel	mg/L	n/v	0.004	0.001	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0011	0.0010	<0.0010	<0.0010	0.0016	0.001	0.010	0.002	<0.001	0.001	0.001	0.0010
Phosphorus	mg/L	n/v	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.31	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10
Potassium	mg/L	n/v	5.8	5.9	3.0	3.1	3.1	3.4	3.7	3.3	3.3	3.0	3.2	3.2	1.3	1.8	2.1	1.7	1.4	1.3	1.5
Selenium	mg/L	0.05[A]	<0.002	<0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.0020
Silicon	mg/L	n/v	4.3	4.8	4.4	4.2	4.0	4.5	4.1	4.4	4.5	4.0	4.3	4.9	6.7	6.2	7.0	8.3	11	12	12
Silver	mg/L	n/v	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.00010
Sodium	mg/L	200_g[B] 20_g[C]	**460[BC]**	**550[BC]**	**410[BC]**	**390[BC]**	**430[BC]**	**450[BC]**	**490[BC]**	**470[BC]**	**470[BC]**	**410[BC]**	**480[BC]**	**430[BC]**	**30[C]**	**37[C]**	**54[C]**	**37[C]**	8.1	8.1	9.2
Strontium	mg/L	n/v	0.50	0.46	0.19	0.19	0.28	0.31	0.40	0.39	0.32	0.32	0.35	0.44	0.35	0.63	0.31	0.30	0.29	0.32	0.32
Thallium	mg/L	n/v	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050	<0.000050	0.000054	0.000056	<0.000050	<0.000050	0.000061	0.000062	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.000050
Titanium	mg/L	n/v	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.027	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.0050
Uranium	mg/L	0.02[A]	0.0079	0.0048	0.0010	0.00075	0.00082	0.00094	0.00065	0.00083	0.00074	0.00068	0.00075	0.00094	0.0013	0.0017	0.0029	0.0022	0.0013	0.0005	<0.00010
Vanadium	mg/L	n/v	<0.001	<0.005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.0020	<0.001	0.001	<0.001	<0.001	<0.001	0.001	<0.00050
Zinc	mg/L	5[B]	0.010	0.009	0.012	0.0066	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	0.008	<0.005	0.006	<0.005	0.0090

See notes on last page.

Table 3
Summary of Groundwater Analytical Results
Waterloo North Hydrogeological Assessment

Sample Location			MW10-10 (Contd.)									MW11-10			MW12-10D						
Sample Date			29-Sep-15	24-Aug-16	1-Sep-17	22-Aug-18	20-Aug-19	26-Aug-20	24-Aug-21	30-Aug-22	1-Dec-23	19-May-10	27-Oct-10	22-Aug-14	19-May-10	26-Oct-10	22-Aug-14	29-Sep-15	24-Aug-16	31-Aug-17	22-Aug-18
Sample ID			WG-160310875-20150929-AV07	WG-160310875-20160824-AV05	WG-160310875-20170901-AV07	WG-160310875-20180822-SB03	WG-161450875-20190820-SB02	WG-161450875-20200826-SB-02	WG-161450875-20210824-AV04	WG-161450875-20220830-JM10	MW10-10	WG-160340875-20100519-AV16	WG-160340875-20101027-JK 17	WG-160310875-20140822-AV10	WG-160340875-20100519-AV14	WG-160340875-20101026-JK6	WG-160310875-20140822-AV06	WG-160310875-20150929-AV08	WG-160310875-20160824-AV01	WG-160310875-20170831-AV04	WG-160310875-20180822-DS06
Sampling Company			STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC
Laboratory			MAXX	MAXX	MAXX	MAXX	BV	BV	BV	BV	BV	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX
Laboratory Work Order			B5J8856	B6I3010	B7J0582	B8L6839	B9N2253	C0M1964	C1O3272	C2P0302	C3AT024	B064180	B0F3108	B4F3646	B064180	B0F2316	B4F3646	B5J8856	B6I3010	B7J0582	B8L6839
Laboratory Sample ID			BBU092	CYS141	FBA586	HNX844	KOP302	NMK088	QMC304	TPN293	XTW489	FY2701	HQ4305	XG4193	FY2699	HQ0822	XG4189	BBU093	CYS137	FBA583	HNX851
Sample Type	Units	ODWS																			
Field Parameters																					
Dissolved Oxygen, Field	mg/L	n/v	1.67	0.94	1.76	0.5		-	0.7	-	-	-	-	-	0.7	-	-	1.40	2.60	0.17	0.4
General Chemistry																					
Alkalinity, Bicarbonate (as CaCO3)	mg/L	n/v	250	260	250	260	260	270	260	250	250	241	231	230	271	244	250	250	240	250	250
Alkalinity, Carbonate (as CaCO3)	mg/L	n/v	2.2	3.2	4.1	2.9	3.2	2.1	3.4	3.0	2.0	4	3	2.1	2	1	1.6	1.3	1.8	1.8	2.1
Alkalinity, Total (as CaCO3)	mg/L	30-500[D]	250	260	260	260	260	270	260	250	250	245	234	230	273	245	250	250	250	250	250
Ammonia (as N)	mg/L	n/v	0.27	<0.050	0.20	0.38	0.15	0.19	0.20	0.32	0.18	<0.05	0.08	0.075	0.08	0.29	0.15	0.16	0.15	0.14	0.13
Anion Sum	me/L	n/v	5.45	5.54	5.45	5.54	5.80	5.89	5.69	5.62	5.25	7.47	7.22	6.87	13.0	13.2	12.4	13.9	14.1	13.7	14.0
Cation Sum	me/L	n/v	5.25	5.53	5.47	5.22	5.92	5.81	5.27	11.0	5.60	7.56	7.52	6.77	12.5	13.9	13.5	14.2	14.1	14.0	14.1
Chloride	mg/L	250[B]	1.9	2.3	1.9	1.8	4.9	4.2	2.9	2.4	<1.0	24	33	27	21	20	20	20	20	22	24
Dissolved Organic Carbon (DOC)	mg/L	5[B]	1.0	0.84	0.88	0.87	0.91	0.85	0.87	0.77	0.88	2.0	3.2	1.9	**14.4[B]**	2.8	0.63	0.86	0.79	0.88	0.85
Electrical Conductivity, Lab	µmhos/cm	n/v	480	520	480	480	530	500	490	480	490	739	705	670	1,140	1,210	1,200	1,200	1,300	1,200	1,200
Hardness (as CaCO3)	mg/L	80-100[D]	**240[D]**	**260[D]**	**250[D]**	**240[D]**	**270[D]**	**270[D]**	**240[D]**	**520[D]**	**260[D]**	**190[D]**	**270[D]**	**300[D]**	**560[D]**	**650[D]**	**630[D]**	**660[D]**	**660[D]**	**660[D]**	**660[D]**
Ion Balance	%	n/v	1.89	0.130	0.190	2.93	1.04	0.650	3.87	32.6	3.23	0.610	2.02	0.670	1.80	2.81	4.08	0.820	0.140	1.24	0.460
Langelier Index (at 20 C)	none	n/v	0.684	0.873	0.948	0.794	0.895	0.710	0.847	1.18	0.660	0.832	0.907	0.852	0.991	0.901	0.975	0.897	1.05	1.06	1.12
Langelier Index (at 4 C)	none	n/v	0.435	0.624	0.699	0.545	0.646	0.461	0.598	0.927	0.411	0.584	0.658	0.604	0.745	0.654	0.728	0.650	0.802	0.809	0.872
Nitrate (as N)	mg/L	10.0_g[A]	0.11	<0.10	<0.10	0.15	0.11	0.12	<0.10	0.27	<0.10	**11[A]**	**13[A]**	**16.1[A]**	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10
Nitrate + Nitrite (as N)	mg/L	10.0_g[A]	0.16	0.12	<0.10	0.16	0.14	0.14	<0.10	0.31	<0.10	**11[A]**	**13[A]**	**16.1[A]**	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10
Nitrite (as N)	mg/L	1.0_g[A]	0.056	0.042	<0.010	0.017	0.025	0.029	<0.010	0.036	0.015	0.02	0.08	<0.010	0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010
Orthophosphate (as P)	mg/L	n/v	0.010	0.010	0.013	0.011	<0.010	<0.010	0.017	0.012	<0.010	<0.01	<0.01	0.046	<0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010
pH, lab	S.U.	6.5-8.5[D]	7.97	8.12	8.24	8.08	8.12	7.93	8.13	8.10	7.94	8.2	8.14	7.99	7.9	7.75	7.82	7.74	7.89	7.89	7.95
Saturation pH (at 20 C)	none	n/v	7.29	7.25	7.29	7.29	7.23	7.22	7.29	6.93	7.28	7.37	7.23	7.14	6.87	6.84	6.84	6.84	6.85	6.83	6.83
Saturation pH (at 4 C)	none	n/v	7.54	7.50	7.54	7.54	7.48	7.47	7.54	7.18	7.52	7.62	7.48	7.39	7.12	7.09	7.09	7.09	7.09	7.08	7.08
Sulfate	mg/L	500_h[B]	14	13	14	14	20	19	15	25	12	55	32	18	330	370	330	410	420	380	400
Total Dissolved Solids (Calculated)	mg/L	500[B]	280	290	290	290	310	310	290	400	280	437	422	390	**767[B]**	**810[B]**	**760[B]**	**850[B]**	**860[B]**	**830[B]**	**850[B]**
Metals																					
Aluminum	mg/L	0.1[D]	<0.0050	<0.0050	0.0064	<0.0050	0.0078	<0.0049	<0.0049	**1.7[D]**	0.015	0.007	0.007	0.010	0.005	<0.005	0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Antimony	mg/L	0.006[A]	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0005	<0.0005	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic	mg/L	0.01[A]	**0.015[A]**	**0.016[A]**	**0.015[A]**	**0.015[A]**	**0.015[A]**	**0.014[A]**	**0.014[A]**	**0.019[A]**	**0.013[A]**	<0.001	<0.001	<0.0010	0.003	0.003	0.0030	0.0032	0.0028	0.0031	0.0032
Barium	mg/L	1[A]	0.099	0.11	0.11	0.10	0.13	0.11	0.11	0.14	0.10	0.039	0.047	0.047	0.042	0.039	0.024	0.027	0.025	0.023	0.022
Beryllium	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040	<0.0005	<0.0005	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron	mg/L	5[A]	0.025	0.020	0.029	0.019	0.026	0.023	0.027	0.027	0.021	0.01	0.01	0.012	0.06	0.06	0.053	0.051	0.050	0.052	0.051
Cadmium	mg/L	0.005[A]	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.00010	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Calcium	mg/L	n/v	53	57	52	52	60	59	51	130	55	50	71	88	160	190	190	200	200	190	200
Chromium	mg/L	0.05[A]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Cobalt	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00050	0.00076	<0.00050	<0.00050	0.0035	<0.00050	<0.0005	<0.0005	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Copper	mg/L	1[B]	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.00090	<0.00090	0.010	<0.00090	0.003	0.008	0.0030	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Iron	mg/L	0.3[B]	0.20	0.11	0.20	0.24	**0.78[B]**	0.30	0.30	**4.3[B]**	0.29	<0.1	<0.1	<0.10	**1.2[B]**	**1.3[B]**	**1.3[B]**	**1.3[B]**	**1.3[B]**	**1.3[B]**	**1.3[B]**
Lead	mg/L	0.01[A]	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.0070	<0.00050	<0.0005	<0.0005	<0.00050	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Magnesium	mg/L	n/v	27	28	30	27	30	30	28	45	30	16	22	21	38	40	41	42	41	42	41
Manganese	mg/L	0.05[B]	0.022	0.024	0.019	0.021	0.021	0.017	0.016	**0.28[B]**	0.022	0.014	0.017	0.014	**0.13[B]**	**0.089[B]**	0.036	0.037	0.035	0.032	0.033
Molybdenum	mg/L	n/v	0.0010	0.0010	0.00097	0.00093	0.00091	0.00087	0.0011	0.00084	0.0011	0.003	0.002	0.0010	0.003	<0.001	0.0010	0.00073	0.00068	0.00064	0.00069
Nickel	mg/L	n/v	<0.0010	<0.0010	<0.0010	<0.0010	0.0011	<0.0010	<0.0010	0.0048	0.0039	0.002	0.001	0.0010	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus	mg/L	n/v	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.46	<0.10	<0.1	<0.1	<0.10	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10
Potassium	mg/L	n/v	1.4	1.4	1.4	1.3	1.4	1.4	1.3	1.8	1.3	3.6	4.8	4.9	1.7	1.5	1.4	1.5	1.4	1.4	1.4
Selenium	mg/L	0.05[A]	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.002	<0.002	<0.0020	<0.002	<0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicon	mg/L	n/v	12	12	12	12	12	12	11	15	12	5.1	5.9	5.3	8.0	7.7	7.8	7.6	7.1	7.6	7.0
Silver	mg/L	n/v	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.0001	<0.0001	<0.00010	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Sodium	mg/L	200_g[B] 20_g[C]	7.8	7.7	8.2	7.8	8.1	8.2	7.6	8.0	8.3	**85[C]**	**46[C]**	13	**28[C]**	18	19	18	19	19	20
Strontium	mg/L	n/v	0.35	0.36	0.37	0.35	0.38	0.36	0.39	0.48	0.38	0.13	0.18	0.13	2.8	3.2	3.0	3.1	2.9	2.9	3.0
Thallium	mg/L	n/v	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000068	<0.000050	<0.00005	<0.00005	<0.000050	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Titanium	mg/L	n/v	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.065	<0.0050	<0.005	<0.005	<0.0050	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Uranium	mg/L	0.02[A]	0.00012	0.00017	0.00014	0.00014	0.00015	0.00012	0.00014	0.0012	0.00010	0.0048	0.0035	0.0020	0.0007	0.0005	<0.00010	0.00030	0.00030	0.00027	0.00028
Vanadium	mg/L	n/v	<0.00050	0.00066	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.0059	<0.00050	<0.001	0.001	<0.00050	<0.001	<0.001	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc	mg/L	5[B]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.022	<0.0050	0.006	0.008	0.0070	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050

See notes on last page.

Table 3
Summary of Groundwater Analytical Results
Waterloo North Hydrogeological Assessment

Sample Location			MW12-10D (Contd.)							MW12-10S											
Sample Date			20-Aug-19	27-Aug-20	25-Aug-21	6-Sep-22	17-Nov-23	17-Nov-23		19-May-10	26-Oct-10	22-Aug-14	29-Sep-15	24-Aug-16	31-Aug-17	22-Aug-18	20-Aug-19	26-Aug-20	25-Aug-21	30-Aug-22	17-Nov-23
Sample ID			WG-161450875-20190820-SB03	WG-161450875-20200827-DS-08	WG-161450875-20210825-AV06	WG-161459875-20220906-JM12	MW12-10D	DUPLICATE		WG-160340875-20100519-AV15	WG-160340875-20101026-JK7	WG-160310875-20140822-AV07	WG-160310875-20150929-AV09	WG-160310875-20160824-AV02	WG-160310875-20170831-AV05	WG-160310875-20180822-SB04	WG-161450875-20190820-SB04	WG-161450875-20200826-SB-03	WG-161450875-20210825-AV08	WG-161450875-20220830-JM08	MW12-10S
Sampling Company			STANTEC BV	STANTEC BV	STANTEC BV	STANTEC BV	STANTEC BV	STANTEC BV		STANTEC MAXX	STANTEC MAXX	STANTEC MAXX	STANTEC MAXX	STANTEC MAXX	STANTEC MAXX	STANTEC MAXX	STANTEC BV	STANTEC BV	STANTEC BV	STANTEC BV	STANTEC BV
Laboratory			B9N2253	C0M1964	C1O3272	C2P6965	C3AC977	C3AC977		B064180	B0F2316	B4F3646	B5J8856	B6I3010	B7J0582	B8L6839	B9N2253	C0M1964	C1O3272	C2P0302	C3AC977
Laboratory Work Order			KOP303	NMK097	QMC306	TQZ172	XQK221	XQK224		FY2700	HQ0823	XG4190	BBU094	CYS138	FBA584	HNX845	KOP304	NMK089	QMC308	TPN291	XQK222
Sample Type	Units	ODWS						Field Duplicate	RPD (%)												
Field Parameters																					
Dissolved Oxygen, Field	mg/L	n/v	0.7	-	0.42	-	-	-	-	6.6	1.2	-	1.57	3.48	4.83	1.2	1.3	-	-	-	-
General Chemistry																					
Alkalinity, Bicarbonate (as CaCO3)	mg/L	n/v	240	240	240	240	240	240	0%	434	459	430	410	420	420	420	410	410	410	390	410
Alkalinity, Carbonate (as CaCO3)	mg/L	n/v	1.6	1.5	2.4	2.0	1.5	1.7	nc	5	2	2.5	2.2	3.5	3.4	3.7	3.3	2.7	3.4	3.2	2.3
Alkalinity, Total (as CaCO3)	mg/L	30-500[D]	250	250	250	240	240	240	0%	439	461	430	420	420	420	420	410	410	410	400	410
Ammonia (as N)	mg/L	n/v	0.22	0.17	0.11	0.14	0.17	0.19	nc	0.11	0.11	0.095	<0.050	<0.050	<0.050	0.077	0.16	0.090	<0.050	0.12	0.054
Anion Sum	me/L	n/v	13.3	14.1	14.2	14.2	14.3	14.3	nc	9.87	10.3	9.61	9.24	9.29	9.27	9.32	9.07	9.02	9.01	8.71	8.83
Cation Sum	me/L	n/v	14.8	14.9	14.8	15.3	14.9	14.9	nc	9.98	10.3	9.92	9.64	9.26	9.30	8.76	9.40	8.81	8.44	9.05	8.72
Chloride	mg/L	250[B]	24	25	28	27	25	25	0%	18	18	14	15	14	13	11	11	9.3	9.2	10	7.9
Dissolved Organic Carbon (DOC)	mg/L	5[B]	0.78	0.79	0.80	0.74	0.76	0.75	nc	1.5	1.7	0.96	0.85	0.70	0.80	0.78	0.84	0.72	0.57	0.57	0.74
Electrical Conductivity, Lab	µmhos/cm	n/v	1,200	1,300	1,200	1,200	1,300	1,300	0%	878	908	850	830	820	810	790	800	790	760	740	790
Hardness (as CaCO3)	mg/L	80-100[D]	**690[D]**	**700[D]**	**680[D]**	**710[D]**	**690[D]**	**690[D]**	0%	**480[D]**	**490[D]**	**480[D]**	**460[D]**	**440[D]**	**450[D]**	**420[D]**	**450[D]**	**420[D]**	**410[D]**	**440[D]**	**420[D]**
Ion Balance	%	n/v	5.12	2.94	1.93	3.64	2.30	1.95	nc	0.560	0.100	1.59	2.12	0.120	0.160	3.05	1.76	1.19	3.25	1.91	0.620
Langelier Index (at 20 C)	none	n/v	1.02	0.980	1.19	1.12	0.997	1.04	nc	1.30	0.931	1.02	0.974	1.15	1.14	1.16	1.14	1.02	1.11	1.11	0.965
Langelier Index (at 4 C)	none	n/v	0.775	0.734	0.939	0.877	0.751	0.789	nc	1.05	0.683	0.769	0.726	0.904	0.889	0.912	0.894	0.769	0.866	0.862	0.717
Nitrate (as N)	mg/L	10.0_g[A]	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	nc	0.5	0.4	1.19	0.95	0.75	1.56	1.46	1.33	1.89	2.04	1.91	1.60
Nitrate + Nitrite (as N)	mg/L	10.0_g[A]	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	nc	0.5	0.4	1.19	0.97	0.76	1.56	1.51	1.52	1.89	2.04	1.91	1.60
Nitrite (as N)	mg/L	1.0_g[A]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	nc	0.02	0.01	<0.010	0.013	0.014	<0.010	0.055	0.192	<0.010	<0.010	<0.010	<0.010
Orthophosphate (as P)	mg/L	n/v	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	nc	<0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
pH, lab	S.U.	6.5-8.5[D]	7.85	7.80	8.02	7.95	7.83	7.87	nc	8.1	7.66	7.79	7.75	7.95	7.94	7.98	7.94	7.84	7.95	7.94	7.78
Saturation pH (at 20 C)	none	n/v	6.82	6.82	6.83	6.83	6.83	6.83	nc	6.76	6.73	6.77	6.77	6.80	6.80	6.82	6.80	6.82	6.84	6.83	6.82
Saturation pH (at 4 C)	none	n/v	7.07	7.07	7.08	7.07	7.08	7.08	nc	7.01	6.98	7.02	7.02	7.05	7.05	7.06	7.04	7.07	7.09	7.07	7.06
Sulfate	mg/L	500_h[B]	370	410	410	420	420	420	0%	27	26	22	20	21	19	19	18	18	18	18	15
Total Dissolved Solids (Calculated)	mg/L	500[B]	**830[B]**	**870[B]**	**870[B]**	**890[B]**	**880[B]**	**880[B]**	0%	500	**520[B]**	490	480	470	470	460	460	450	440	450	440
Metals																					
Aluminum	mg/L	0.1[D]	<0.0050	<0.0049	<0.0049	0.015	<0.0049	<0.0049	nc	0.014	<0.005	<0.0050	<0.0050	<0.0050	0.0058	<0.0050	<0.0050	<0.0049	<0.0049	0.013	<0.0049
Antimony	mg/L	0.006[A]	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	nc	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic	mg/L	0.01[A]	0.0031	0.0033	0.0035	0.0032	0.0034	0.0031	nc	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Barium	mg/L	1[A]	0.023	0.025	0.025	0.024	0.024	0.023	4%	0.087	0.078	0.10	0.092	0.097	0.10	0.093	0.098	0.098	0.082	0.10	0.090
Beryllium	mg/L	n/v	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	nc	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040
Boron	mg/L	5[A]	0.060	0.054	0.057	0.059	0.056	0.056	0%	0.02	0.02	0.018	0.011	0.015	0.016	<0.010	0.016	0.014	0.012	0.015	0.017
Cadmium	mg/L	0.005[A]	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	nc	<0.0001	0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090
Calcium	mg/L	n/v	210	210	200	210	210	210	0%	120	120	110	120	110	110	100	110	100	100	110	110
Chromium	mg/L	0.05[A]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	nc	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Cobalt	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	nc	0.0006	0.0009	0.0010	<0.00050	0.0013	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Copper	mg/L	1[B]	<0.0010	<0.00090	<0.00090	<0.00090	<0.00090	<0.00090	nc	0.002	0.001	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.00090	0.0028	<0.00090	0.0018
Iron	mg/L	0.3[B]	**1.2[B]**	**1.3[B]**	**1.3[B]**	**1.3[B]**	**1.2[B]**	**1.2[B]**	0%	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Lead	mg/L	0.01[A]	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	nc	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Magnesium	mg/L	n/v	42	43	43	44	41	42	2%	46	46	46	42	42	42	40	42	39	38	40	37
Manganese	mg/L	0.05[B]	0.033	0.033	0.034	0.035	0.034	0.033	3%	**0.18[B]**	**0.22[B]**	**0.11[B]**	**0.061[B]**	**0.11[B]**	**0.077[B]**	0.026	0.027	0.033	0.020	0.023	0.018
Molybdenum	mg/L	n/v	0.00068	0.00066	0.00073	0.00081	0.00076	0.00071	nc	0.002	0.002	0.0010	<0.00050	0.00088	0.00061	<0.00050	<0.00050	<0.00050	<0.00050	0.00054	<0.00050
Nickel	mg/L	n/v	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	nc	0.002	<0.001	0.0010	<0.0010	0.0014	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus	mg/L	n/v	<0.10	<0.10	<0.10	0.13	<0.10	<0.10	nc	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Potassium	mg/L	n/v	1.5	1.4	1.5	1.5	1.5	1.6	6%	3.4	3.1	2.9	2.5	2.9	2.6	2.2	2.4	2.2	1.6	2.3	1.9
Selenium	mg/L	0.05[A]	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	nc	<0.002	<0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicon	mg/L	n/v	8.2	8.1	7.4	7.9	7.7	7.6	1%	8.0	8.5	8.0	8.2	7.4	7.8	7.2	7.9	7.5	7.0	7.9	7.7
Silver	mg/L	n/v	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090	<0.000090	nc	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090
Sodium	mg/L	200_g[B] 20_g[C]	**22[C]**	**22[C]**	**23[C]**	**23[C]**	**24[C]**	**24[C]**	0%	8.0	9.1	8.0	6.7	7.3	6.9	6.1	7.0	6.6	5.5	6.3	5.8
Strontium	mg/L	n/v	3.2	3.2	3.3	3.3	3.2	3.2	0%	0.46	0.45	0.44	0.35	0.39	0.40	0.34	0.37	0.33	0.30	0.37	0.33
Thallium	mg/L	n/v	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	nc	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Titanium	mg/L	n/v	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	nc	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Uranium	mg/L	0.02[A]	0.00028	0.00028	0.00026	0.00029	0.00025	0.00023	nc	0.0064	0.0044	0.0020	0.0014	0.0016	0.0016	0.0014	0.0014	0.0013	0.0011	0.0013	0.0011
Vanadium	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	nc	<0.001	<0.001	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00050
Zinc	mg/L	5[B]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	nc	0.013	<0.005	0.0060	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0079

See notes on last page.

Table 3
Summary of Groundwater Analytical Results
Waterloo North Hydrogeological Assessment

Sample Location			MW13-10											
Sample Date			17-May-10	27-Oct-10	21-Aug-14	28-Sep-15	25-Aug-16	1-Sep-17	22-Aug-18	20-Aug-19	26-Aug-20	24-Aug-21	30-Aug-22	1-Dec-23
Sample ID			WG-160340875-20100517-AV07	WG-160340875-20101027-JK 13	WG-160310875-20140821-AV04	WG-160310875-20150928-AV01	WG-160310875-20160825-AV06	WG-160310875-20170901-AV06	WG-160310875-20180822-SB02	WG-161450875-20190820-SB01	WG-161450875-20200826-SB-01	WG-161450875-20210824-AV03	WG-161450875-20220830-JM09	MW13-10
Sampling Company			STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC
Laboratory			MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	BV	BV	BV	BV	BV
Laboratory Work Order			B062483	B0F3108	B4F3646	B5J8856	B6I3010	B7J0582	B8L6839	B9N2253	C0M1964	C1O3272	C2P0302	C3AT024
Laboratory Sample ID			FX4447	HQ4301	XG4187	BBU085	CYS142	FBA585	HNX843	KOP301	NMK087	QMC303	TPN292	XTW488
Sample Type	Units	ODWS												
Field Parameters														
Dissolved Oxygen, Field	mg/L	n/v	0.6	0.7	-	-	-	1.92	1.1	2.8	-	0.6	-	-
General Chemistry														
Alkalinity, Bicarbonate (as CaCO3)	mg/L	n/v	276	314	340	320	320	340	300	330	340	310	330	330
Alkalinity, Carbonate (as CaCO3)	mg/L	n/v	2	3	2.3	2.0	3.0	2.3	2.5	2.9	2.4	2.4	2.5	1.9
Alkalinity, Total (as CaCO3)	mg/L	30-500[D]	279	318	340	320	330	340	310	330	340	320	330	340
Ammonia (as N)	mg/L	n/v	0.07	0.14	<0.050	<0.050	<0.050	<0.050	0.058	0.068	0.075	<0.050	0.14	<0.050
Anion Sum	me/L	n/v	6.80	7.64	8.31	7.73	7.56	8.05	7.49	7.91	8.26	7.79	8.08	7.98
Cation Sum	me/L	n/v	8.04	8.59	8.30	7.60	7.93	7.85	7.81	8.35	7.93	8.01	8.43	8.61
Chloride	mg/L	250[B]	11	12	12	14	9.9	12	14	15	17	16	18	13
Dissolved Organic Carbon (DOC)	mg/L	5[B]	0.7	1.4	1.1	0.66	0.53	0.65	0.54	0.53	0.51	0.43	0.42	0.51
Electrical Conductivity, Lab	µmhos/cm	n/v	629	705	710	700	710	710	660	710	700	690	700	740
Hardness (as CaCO3)	mg/L	80-100[D]	**390[D]**	**420[D]**	**400[D]**	**370[D]**	**380[D]**	**380[D]**	**380[D]**	**410[D]**	**390[D]**	**390[D]**	**410[D]**	**420[D]**
Ion Balance	%	n/v	8.40	5.85	0.0800	0.870	2.38	1.24	2.06	2.75	2.05	1.44	2.08	3.80
Langelier Index (at 20 C)	none	n/v	0.979	1.13	0.978	0.896	1.08	0.947	0.988	1.09	0.972	0.985	1.03	0.910
Langelier Index (at 4 C)	none	n/v	0.731	0.883	0.730	0.648	0.826	0.699	0.739	0.843	0.724	0.736	0.780	0.662
Nitrate (as N)	mg/L	10.0_g[A]	1.8	0.9	3.37	3.36	3.21	2.80	2.52	4.00	4.28	2.45	4.05	2.29
Nitrate + Nitrite (as N)	mg/L	10.0_g[A]	1.8	0.9	3.37	3.36	3.21	2.80	2.52	4.00	4.28	2.45	4.05	2.29
Nitrite (as N)	mg/L	1.0_g[A]	0.02	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Orthophosphate (as P)	mg/L	n/v	<0.01	<0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.030 MI
pH, lab	S.U.	6.5-8.5[D]	8.0	8.03	7.86	7.83	7.99	7.86	7.94	7.98	7.87	7.91	7.91	7.78
Saturation pH (at 20 C)	none	n/v	6.98	6.90	6.88	6.93	6.91	6.91	6.95	6.89	6.90	6.93	6.89	6.87
Saturation pH (at 4 C)	none	n/v	7.22	7.15	7.13	7.18	7.16	7.16	7.20	7.14	7.15	7.17	7.13	7.12
Sulfate	mg/L	500_h[B]	37	42	40	33	25	34	38	28	30	39	31	35
Total Dissolved Solids (Calculated)	mg/L	500[B]	379	416	440	400	400	410	400	420	430	410	430	430
Metals														
Aluminum	mg/L	0.1[D]	<0.005	0.010	<0.0050	<0.0050	0.023	<0.0050	<0.0050	<0.0050	<0.0049	<0.0049	0.0069	<0.0049
Antimony	mg/L	0.006[A]	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic	mg/L	0.01[A]	<0.001	<0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Barium	mg/L	1[A]	0.070	0.086	0.088	0.075	0.077	0.075	0.070	0.070	0.073	0.070	0.092	0.078
Beryllium	mg/L	n/v	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00040	<0.00040	<0.00040	<0.00040
Boron	mg/L	5[A]	<0.01	0.01	0.011	<0.010	<0.010	0.010	<0.010	0.010	<0.010	0.011	<0.010	<0.010
Cadmium	mg/L	0.005[A]	<0.0001	0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090
Calcium	mg/L	n/v	100	110	110	100	100	100	100	110	100	110	110	110
Chromium	mg/L	0.05[A]	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Cobalt	mg/L	n/v	<0.0005	<0.0005	<0.00050	<0.00050	0.0014	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Copper	mg/L	1[B]	0.002	0.002	0.0020	0.0010	<0.0010	<0.0010	<0.0010	0.0011	0.0025	0.0014	0.0038	0.0023
Iron	mg/L	0.3[B]	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Lead	mg/L	0.01[A]	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Magnesium	mg/L	n/v	32	33	32	28	29	31	31	32	31	31	33	33
Manganese	mg/L	0.05[B]	**0.055[B]**	**0.052[B]**	0.0070	0.0058	0.0093	0.0068	0.0082	0.0033	<0.0020	0.025	<0.0020	<0.0020
Molybdenum	mg/L	n/v	<0.001	<0.001	0.0020	0.00054	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Nickel	mg/L	n/v	0.002	0.001	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0014	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus	mg/L	n/v	<0.1	<0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Potassium	mg/L	n/v	1.0	1.4	1.0	1.0	1.3	1.1	0.94	0.86	0.86	0.87	0.84	0.91
Selenium	mg/L	0.05[A]	<0.002	<0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicon	mg/L	n/v	6.2	7.0	6.8	6.4	6.2	6.4	6.1	7.1	6.6	6.2	6.6	6.9
Silver	mg/L	n/v	<0.0001	<0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000090	<0.000090	<0.000090	<0.000090
Sodium	mg/L	200_g[B] 20_g[C]	3.6	5.3	4.6	3.2	6.1	4.0	4.1	3.7	3.7	3.7	3.3	3.8
Strontium	mg/L	n/v	0.15	0.18	0.15	0.15	0.15	0.15	0.15	0.15	0.14	0.16	0.16	0.17
Thallium	mg/L	n/v	<0.00005	<0.00005	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Titanium	mg/L	n/v	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Uranium	mg/L	0.02[A]	0.0010	0.0012	0.0010	0.00079	0.00087	0.00076	0.00079	0.00074	0.00066	0.00081	0.00071	0.00077
Vanadium	mg/L	n/v	<0.001	<0.001	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc	mg/L	5[B]	0.013	0.010	0.016	0.040	0.0081	0.0071	0.0088	0.015	0.011	0.010	0.011	0.016

See notes on last page.

Table 3
Summary of Groundwater Analytical Results
Waterloo North Hydrogeological Assessment

Notes:

ODWS	Ontario Drinking Water Quality Standards (January 1, 2018)
[A]	Schedule 2 - Chemical Standards (expressed as a maximum acceptable concentration)
[B]	ODWS Table 4 - Chemical/Physical Objectives and Guidelines, Aesthetic Objectives
[C]	ODWS Table 4 - Medical Officer of Health Reporting Limit
[D]	ODWS Table 4 - Chemical/Physical Objectives and Guidelines, Operational Guidelines
6.5[A]	Concentration exceeds the indicated standard.
15.2	Measured concentration did not exceed the indicated standard.
<0.50	Laboratory reporting limit was greater than the applicable standard.
<0.03	Analyte was not detected at a concentration greater than the laboratory reporting limit.
n/v	No standard/guideline value.
-	Parameter not analyzed / not available.
[d]	Where both nitrate and nitrite are present, the total of the two should not exceed 10 mg/L (as nitrogen).
[g]	The aesthetic objective for sodium in drinking water is 200 mg/L. The local Medical Officer of Health should be notified when the sodium concentration exceeds 20 mg/L so that this information may be communicated to local physicians for their use with patients on sodium restricted diets.
[h]	When sulfate levels exceed 500 mg/L, water may have a laxative effect on some people.
DB	Due to the sample matrix, sample required dilution. Detection limit was adjusted accordingly.
MI	Detection limits raised due to matrix interference.
RPD	Relative Percent Difference.
61%	RPD exceeds data quality objective of 30%.
nc	RPD is not calculated if one or more values is non detect or if one or more values is less than five times the reportable detection limit.

APPENDIX C:
Phase Monitoring Program

NORTH WATERLOO
PROPOSED PHASE 1 MONITORING PROGRAM
2014

1.0 STUDY AREA AND CONTEXT

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

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

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

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

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

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

2.0 MONITORING STUDY APPROACH

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

2.1 SURFACE WATER MONITORING

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

2.1.1 Surface Water Flow Monitoring

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

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

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

2.1.2 Water Level Monitoring

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

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

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

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

2.2 GROUNDWATER MONITORING

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

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

2.2.1 Water Level Monitoring

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

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

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

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

2.2.2 Water Chemistry Monitoring

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

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

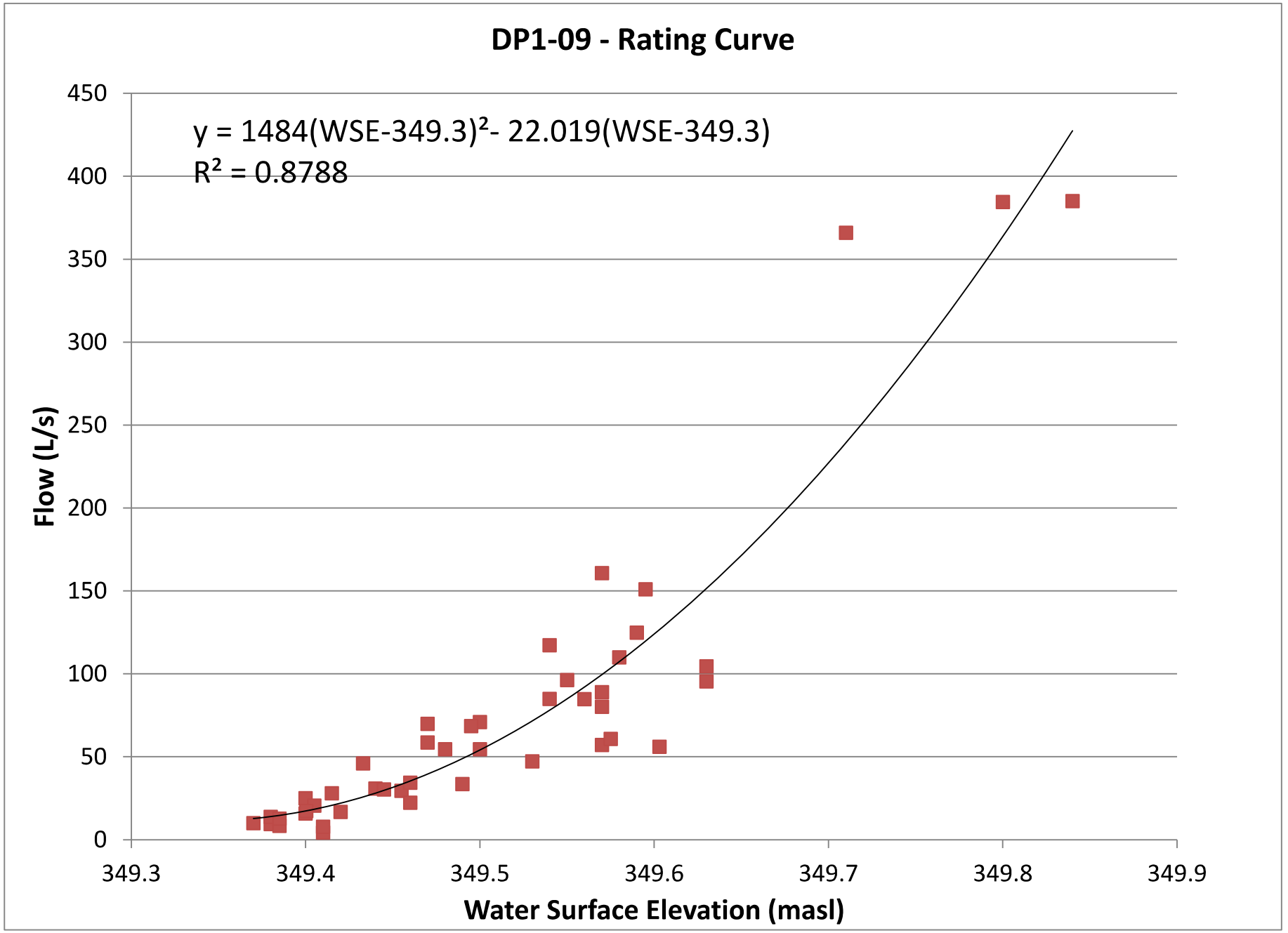
Timing. Water quality samples will be collected once per year in the spring. The 2014 sampling will be completed in August 2014.

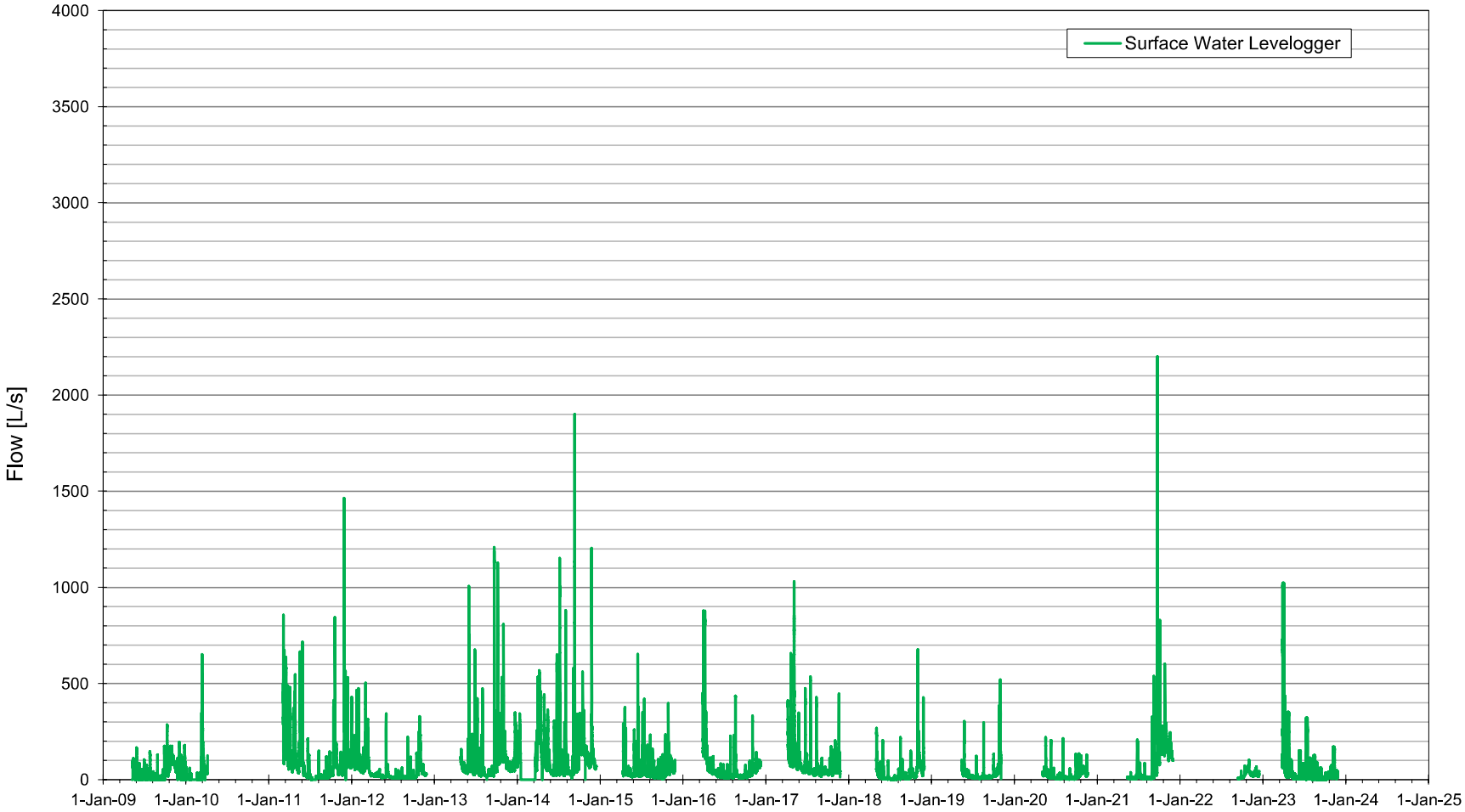
Methodology. Groundwater samples will be collected using foot valve / tubing or submersible pump depending on the location. Each well will be purged of three (3) casing volumes prior to sampling. Groundwater samples for metals analysis will be field filtered. Water quality samples would be analyzed for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

3.0 REPORTING

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

APPENDIX D:
Surface Water Flow Data


DP1-09 - Rating Curve
y = 1484(WSE-349.3)²- 22.019(WSE-349.3)
R² = 0.8788
Flow (L/s)
450
400
350
300
250
200
150
100
50
0
349.3
349.4
349.5
349.6
349.7
349.8
349.9
Water Surface Elevation (masl)

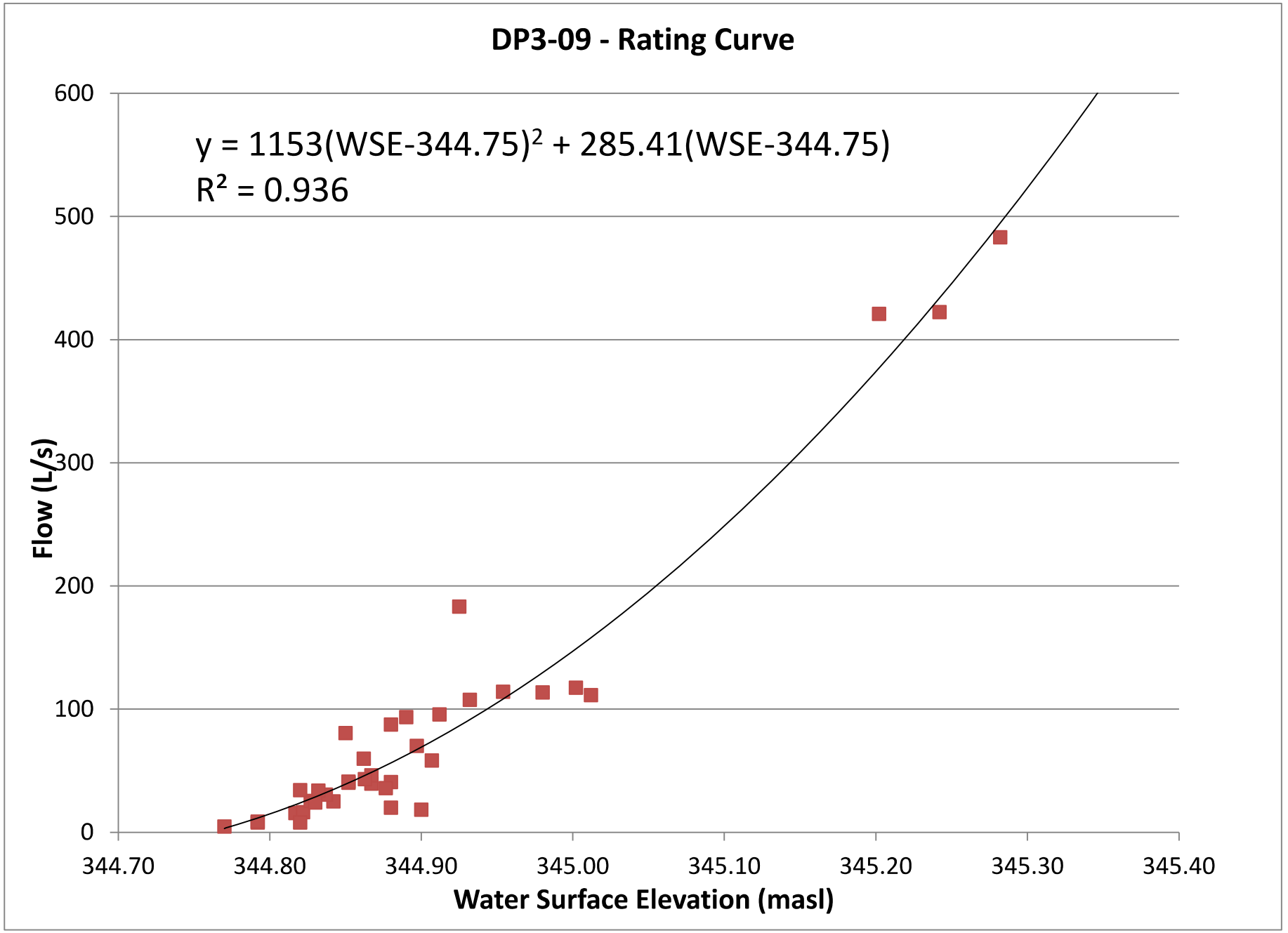


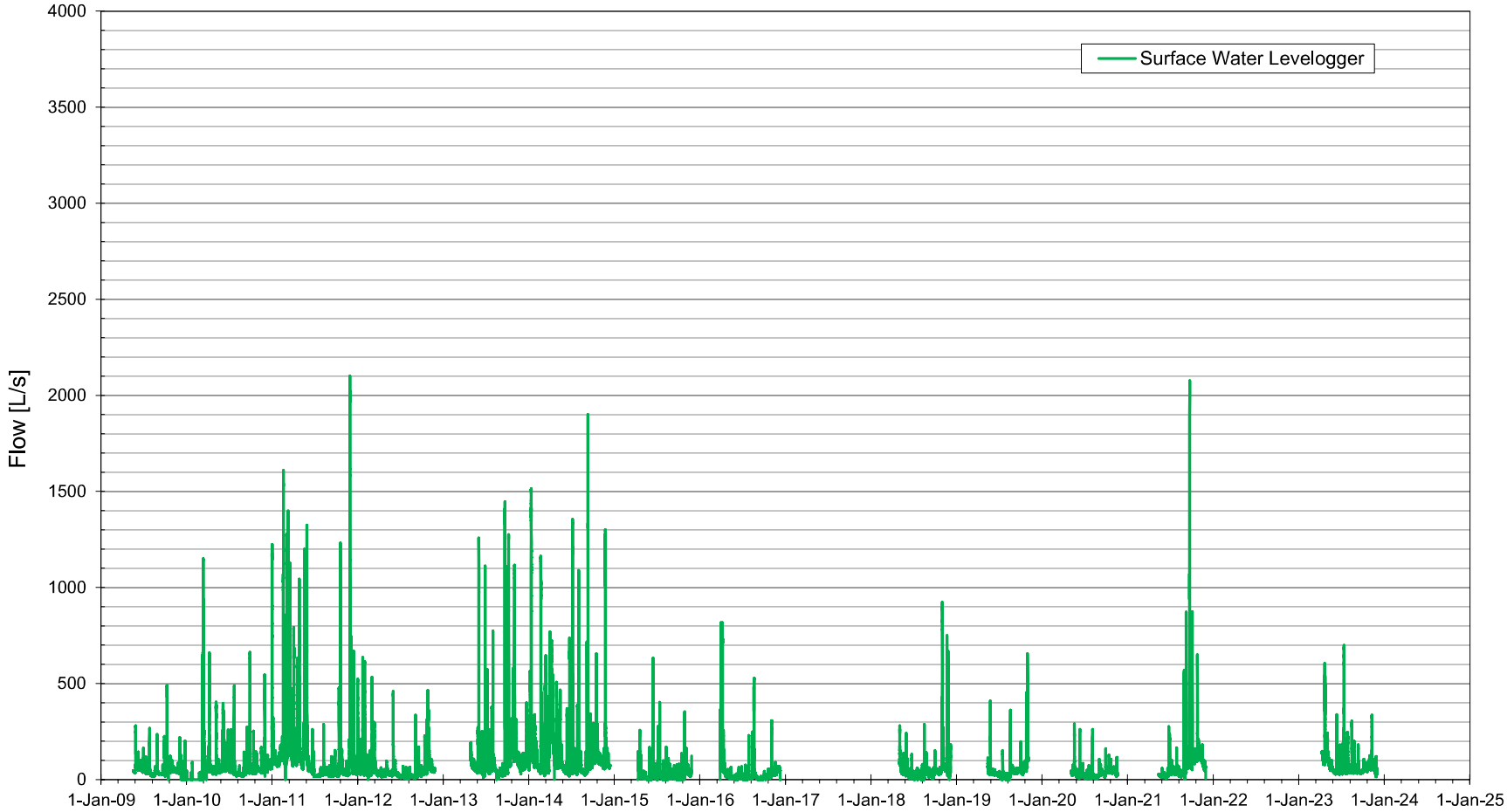
Note: Surface water logger removed for winters 2013-2023

Project: North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program

Stantec

Title: DP1-09 (Hydrograph)


DP3-09 - Rating Curve
y = 1153(WSE-344.75)² + 285.41(WSE-344.75)
R² = 0.936
600
500
400
300
200
100
0
Flow (L/s)
344.70
344.80
344.90
345.00
345.10
345.20
345.30
345.40
Water Surface Elevation (masl)

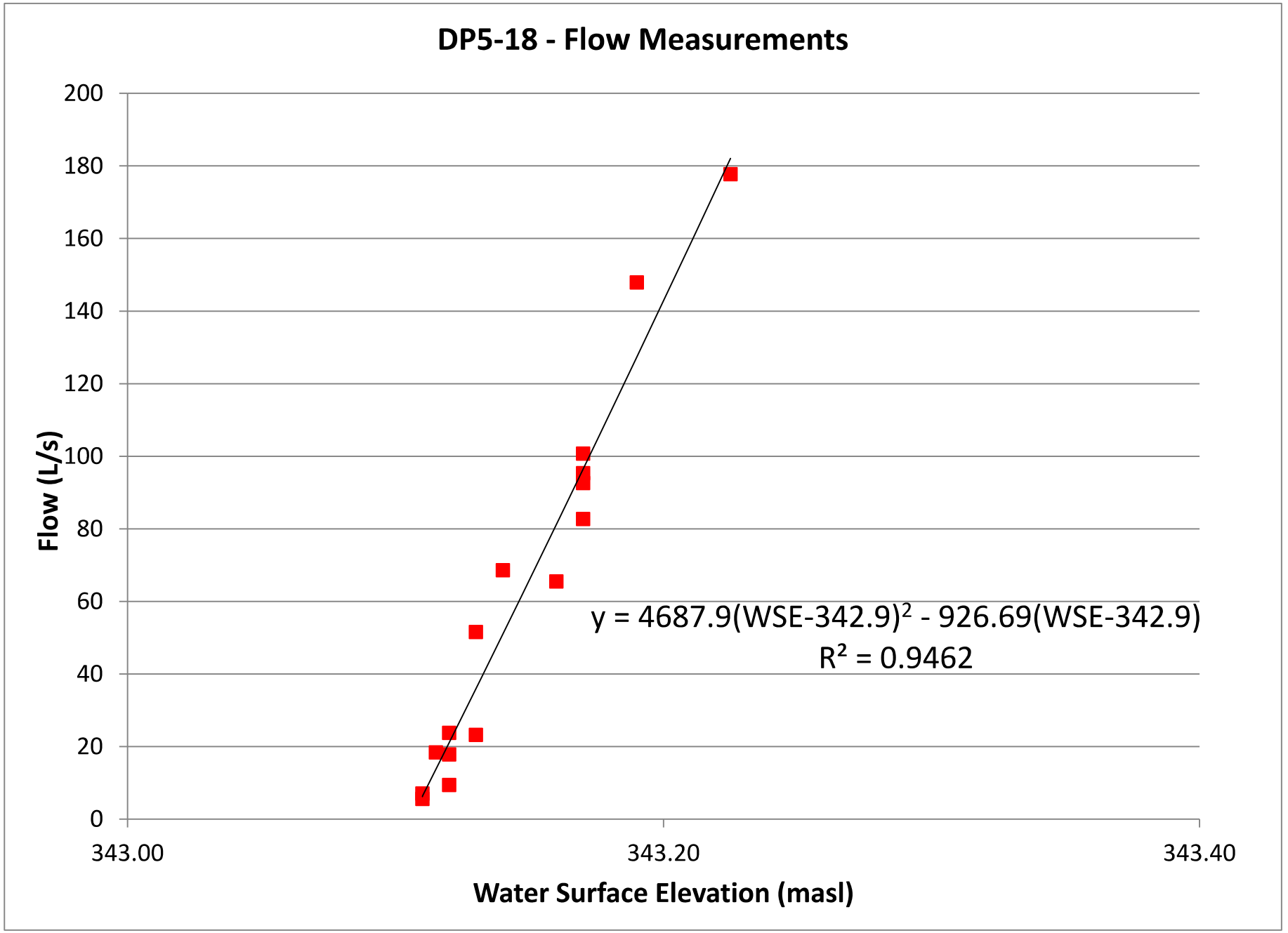


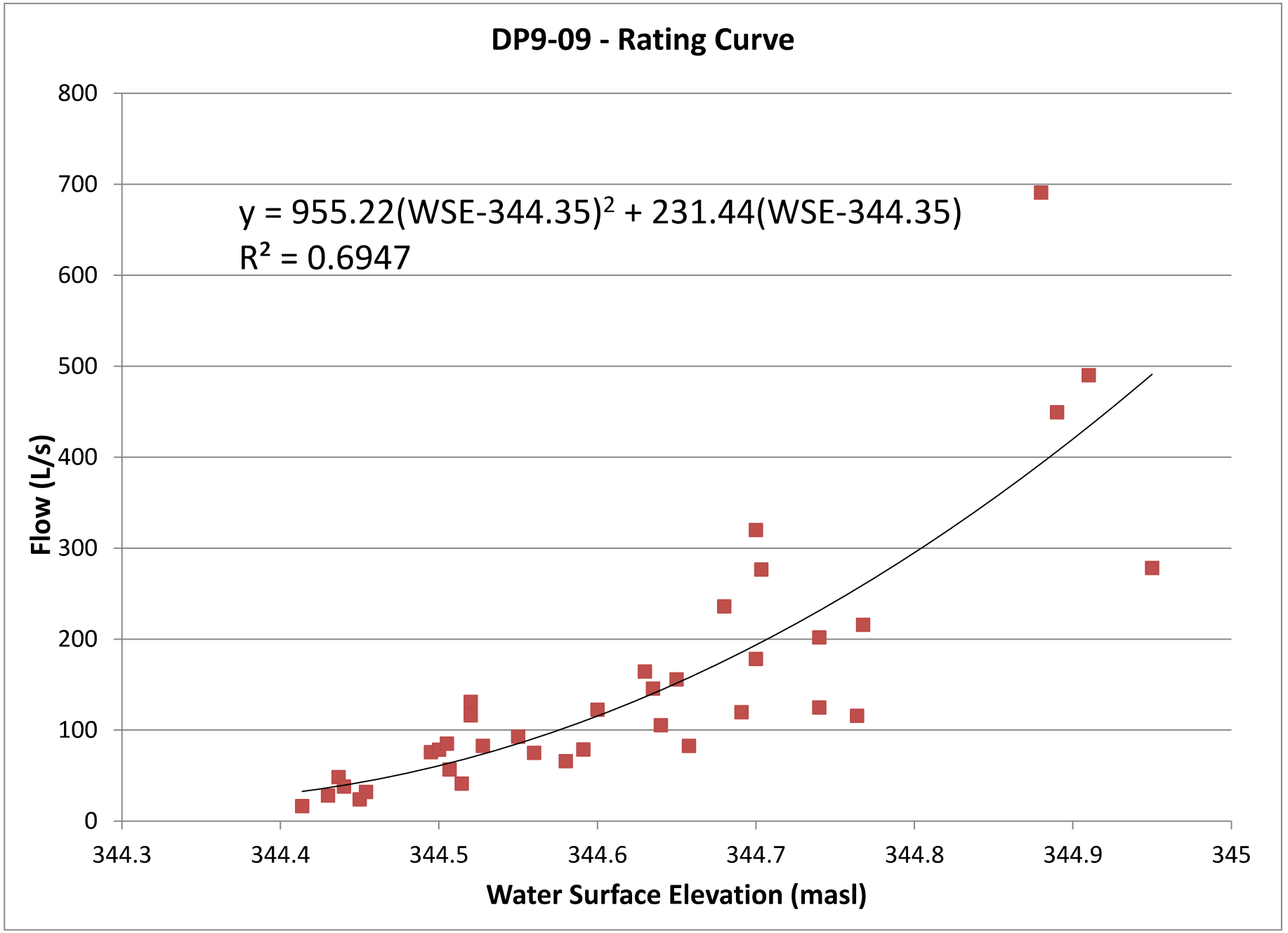
Note: Surface water logger removed for winters 2013 and 2015-2023, logger malfunction in 2022

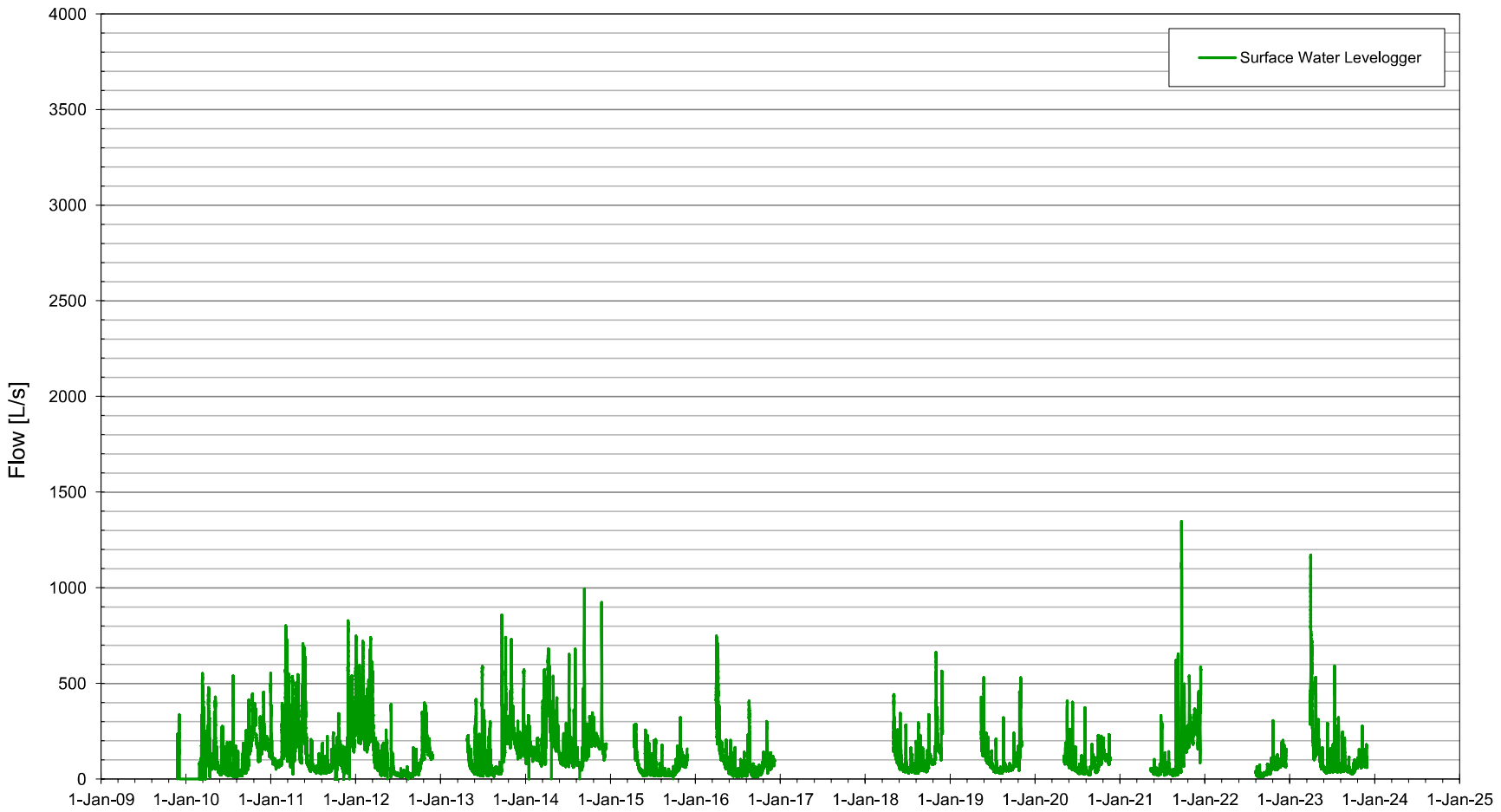
Project: North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program

Stantec

Title: DP3-09 (Hydrograph)


DP5-18 - Flow Measurements
200
180
160
140
120
100
80
60
40
20
0
Flow (L/s)
343.00
343.20
343.40
Water Surface Elevation (masl)
y = 4687.9(WSE-342.9)² - 926.69(WSE-342.9)
R² = 0.9462


DP9-09 - Rating Curve
y = 955.22(WSE-344.35)² + 231.44(WSE-344.35)
R² = 0.6947
800
700
600
500
400
300
200
100
0
Flow (L/s)
344.3
344.4
344.5
344.6
344.7
344.8
344.9
345
Water Surface Elevation (masl)

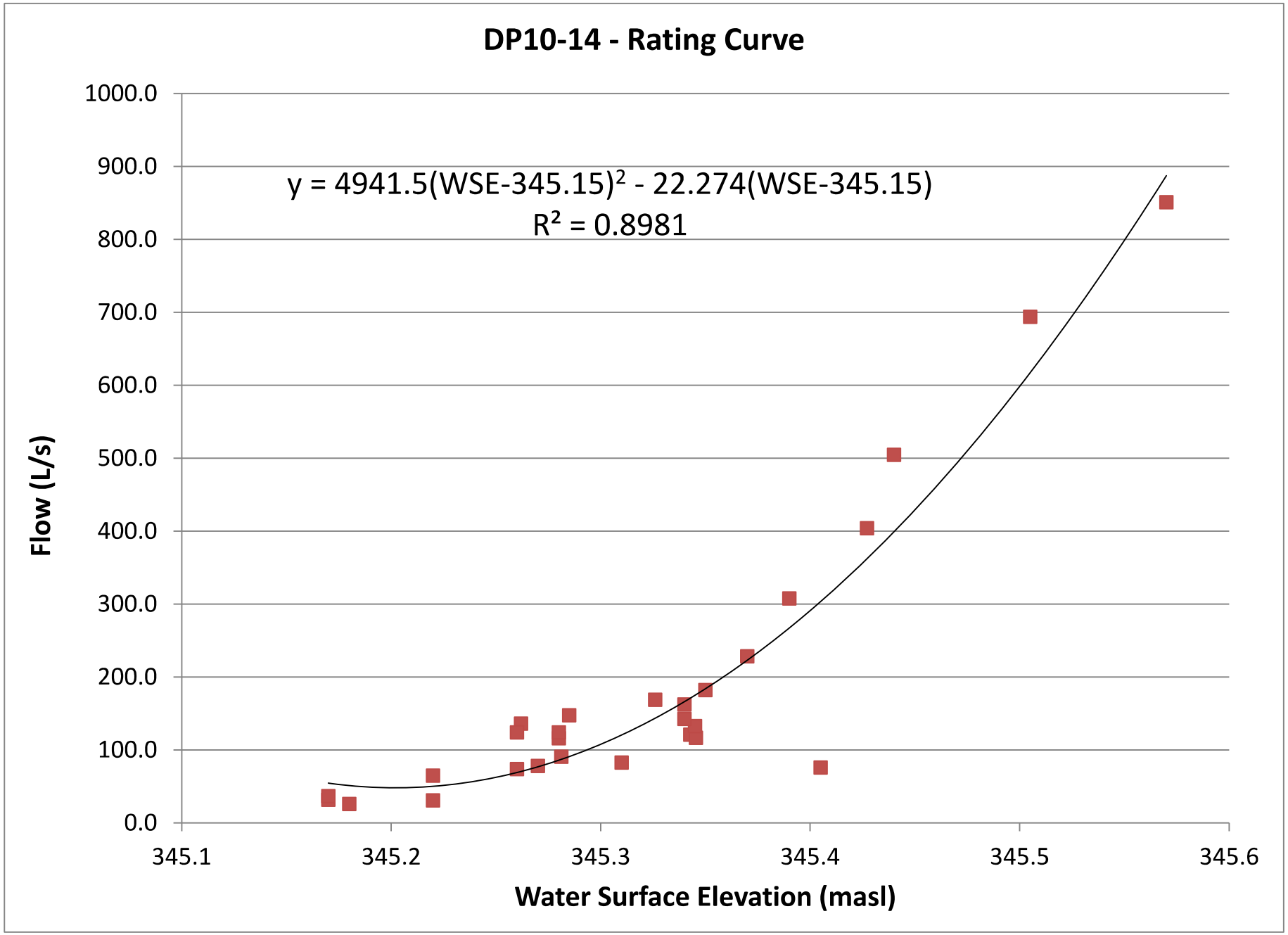


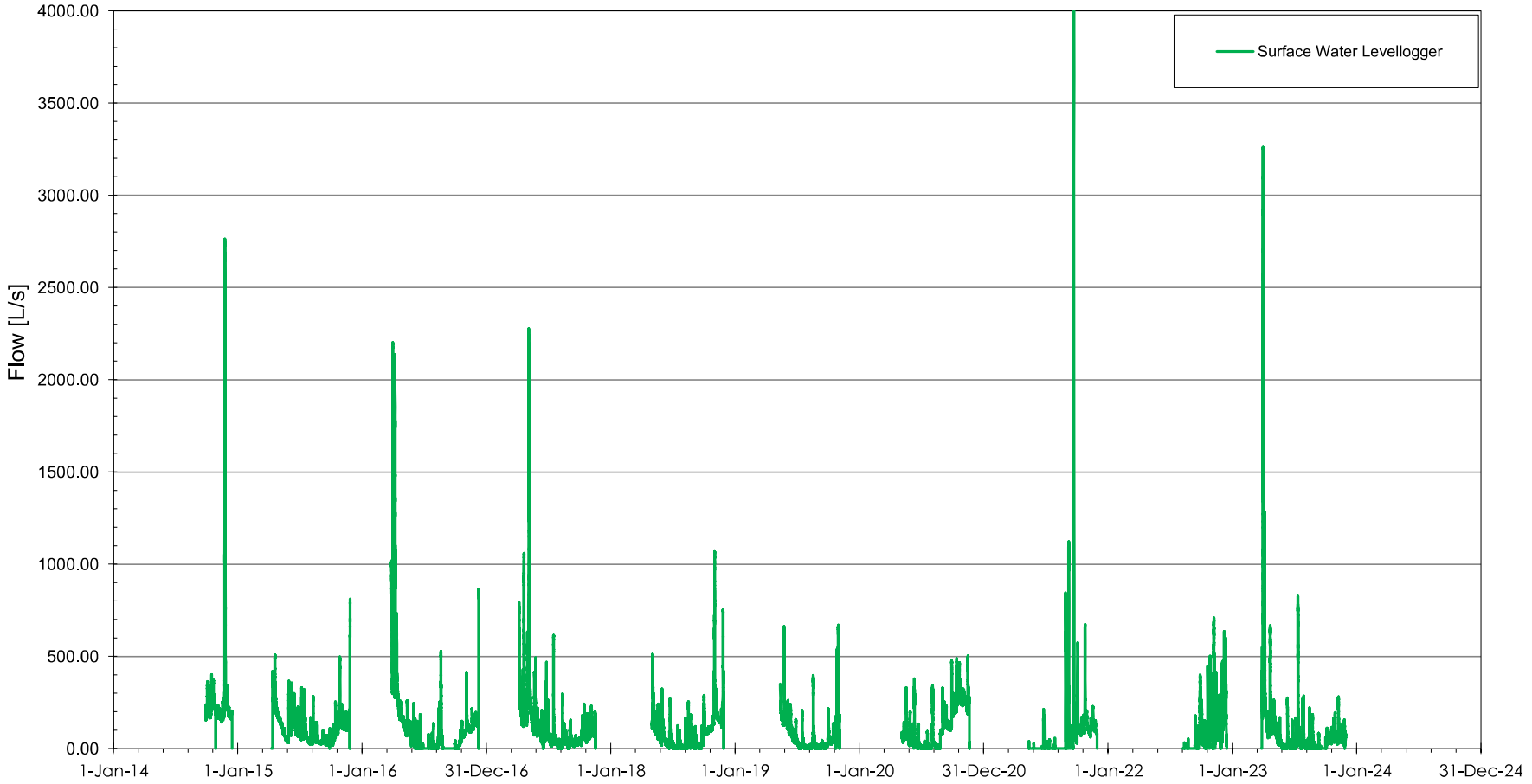
Note: Surface water logger removed for winter 2013, 2015, 2016, 2017, 2020-2023

Project: North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program

Stantec

Title: DP9-09 (Hydrograph)


DP10-14 - Rating Curve
y = 4941.5(WSE-345.15)² - 22.274(WSE-345.15)
R² = 0.8981
1000.0
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
Flow (L/s)
345.1
345.2
345.3
345.4
345.5
345.6
Water Surface Elevation (masl)



Note: Loggers removed in winters 2015-2023

Project

North Waterloo, Phase 1 Groundwater and Surface Water Monitoring Program

Stantec

Title DP10-14 (Hydrograph)

LAUREL CREEK WATERSHED
CITY SAMPLE STATION #: 17
SITE DESCRIPTION: BEAVER CREEK @ CONSERVATION DRIVE

Date	Site	Time	Classification	1 Day Antecedant + Current Morning Precipitation (mm)	Daily Total Precipitation (mm)	3 Day Antecedant Precipitation (mm)	7 Day Antecedent Precipitation (mm)	Q (m^3/sec)	Spec Cond (uS/cm)	DO (mg/L)	Temp (C)	pH	TSS (mg/L)	TP (ug/L)
March 25, 2023	17	11:13	Agricultural	12.4	12.4	3.8	3.8	0.2200	552	12.36	1.1	7.84	7.2	35.2
March 28, 2023	17	12:20	Agricultural	4.5	0.0	16.9	20.7	0.2127	512	13.70	3.0	7.94	<3	29.1
April 2, 2023	17	13:55	Agricultural	13.4	0.0	36.9	43.4	0.2700	299	15.22	3.7	8.00	12.2	66.2
May 2, 2023	17	18:25	Agricultural	12.5	8.1	13.0	16.2	0.1645	554	9.92	7.1	7.86	<3	46.1
May 18, 2023	17	18:40	Agricultural	0.0	0.0	0.0	0.0	0.0432	593	10.49	13.3	8.37	3.3	18.3
May 30, 2023	17	14:22	Agricultural	0.0	0.0	0.0	0.0	0.0233	611	9.30	17.5	7.99	5.3	35.1
June 13, 2023	17	14:30	Agricultural	22	1.7	34.7	35.9	0.0572	653	8.35	13.8	7.91	<3	36.6
June 27, 2023	17	12:30	Agricultural	20.6	9.2	18.4	21.3	0.0734	645	7.77	16.8	7.87	<3	52.6
July 11, 2023	17	10:34	Agricultural	14.8	7.3	5.7	29.2	0.0265	653	7.79	17.5	7.96	4.9	66.5
July 25, 2023	17	11:40	Agricultural	0.0	0.0	0.0	13.6	0.0102	635	7.85	17.4	7.95	<3	56.6
July 27, 2023	17	15:40	Agricultural	26.0	3.8	22.2	35.8	0.0980	613	7.38	20.4	7.73	4.2	64.1
August 8, 2023	17	11:15	Agricultural	2.2	0.2	5.0	8.0	0.0275	622	7.55	16.4	8.01	6.5	60.0
August 16, 2023	17	15:46	Agricultural	29.6	0	29.6	45.4	0.0883	630	7.61	18.2	7.87	5.3	68.3
August 22, 2023	17	11:05	Agricultural	0.0	0.0	0.0	50.6	0.0290	630	8.29	15.1	7.93	<3	59.0
September 5, 2023	17	09:35	Agricultural	0.0	0.0	0.0	6.0	0.0165	610	7.51	17.6	7.87	<3	62.8
September 19, 2023	17	16:45	Agricultural	0.8	0.0	7.5	18.4	0.0123	606	8.85	13.3	8.12	<3	50.9

APPENDIX E:
Laboratory Certificate of Analysis

Your Project #: 160310875
Your C.O.C. #: N/A

Attention: Lesley Veale

Stantec Consulting Ltd
300 Hagey Blvd
Suite 100
Waterloo, ON
CANADA N2L 0A4

Report Date: 2023/11/30
Report #: R7934680
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C3AC977
Received: 2023/11/18, 12:15

Sample Matrix: Water
Samples Received: 10

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity	9	N/A	2023/11/23	CAM SOP-00448	SM 24 2320 B m
Alkalinity	1	N/A	2023/11/28	CAM SOP-00448	SM 24 2320 B m
Carbonate, Bicarbonate and Hydroxide	10	N/A	2023/11/24	CAM SOP-00102	APHA 4500-CO2 D
Chloride by Automated Colourimetry	9	N/A	2023/11/22	CAM SOP-00463	SM 23 4500-Cl E m
Chloride by Automated Colourimetry	1	N/A	2023/11/27	CAM SOP-00463	SM 23 4500-Cl E m
Conductivity	9	N/A	2023/11/23	CAM SOP-00414	SM 23 2510 m
Conductivity	1	N/A	2023/11/29	CAM SOP-00414	SM 23 2510 m
Dissolved Organic Carbon (DOC) (1)	10	N/A	2023/11/21	CAM SOP-00446	SM 24 5310 B m
Hardness (calculated as CaCO3)	10	N/A	2023/11/23	CAM SOP 00102/00408/00447	SM 2340 B
Dissolved Metals by ICPMS	9	N/A	2023/11/22	CAM SOP-00447	EPA 6020B m
Dissolved Metals by ICPMS	1	N/A	2023/11/29	CAM SOP-00447	EPA 6020B m
Ion Balance (% Difference)	10	N/A	2023/11/24		
Anion and Cation Sum	10	N/A	2023/11/24		
Total Ammonia-N	10	N/A	2023/11/22	CAM SOP-00441	USGS I-2522-90 m
Nitrate & Nitrite as Nitrogen in Water (2)	10	N/A	2023/11/22	CAM SOP-00440	SM 23 4500-NO3I/NO2B
pH	9	2023/11/21	2023/11/23	CAM SOP-00413	SM 24th - 4500H+ B
pH	1	2023/11/28	2023/11/29	CAM SOP-00413	SM 24th - 4500H+ B
Orthophosphate	10	N/A	2023/11/22	CAM SOP-00461	SM 23 4500-P E m
Sat. pH and Langelier Index (@ 20C)	10	N/A	2023/11/24		Auto Calc
Sat. pH and Langelier Index (@ 4C)	10	N/A	2023/11/24		Auto Calc
Sulphate by Automated Turbidimetry	9	N/A	2023/11/22	CAM SOP-00464	SM 23 4500-SO42- E m
Sulphate by Automated Turbidimetry	1	N/A	2023/11/27	CAM SOP-00464	SM 23 4500-SO42- E m
Total Dissolved Solids (TDS calc)	10	N/A	2023/11/24		Auto Calc

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCCFP, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in

Your Project #: 160310875
Your C.O.C. #: N/A

Attention: Lesley Veale

Stantec Consulting Ltd
300 Hagey Blvd
Suite 100
Waterloo, ON
CANADA N2L 0A4

Report Date: 2023/11/30
Report #: R7934680
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C3AC977
Received: 2023/11/18, 12:15

writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) Dissolved Organic Carbon (DOC) present in the sample should be considered as non-purgeable DOC.
(2) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to:
Julie Clement, Technical Account Manager
Email: Julie.CLEMENT@bureauveritas.com
Phone# (613)868-6079

==========

This report has been generated and distributed using a secure automated process.
Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Rodney Major, General Manager responsible for Ontario Environmental laboratory operations.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK215			XQK215			XQK216		
Sampling Date		2023/11/16 15:00			2023/11/16 15:00			2023/11/16 15:25		
COC Number		N/A			N/A			N/A		
	UNITS	MW3-16S	RDL	QC Batch	MW3-16S Lab-Dup	RDL	QC Batch	MW2-10	RDL	QC Batch
Calculated Parameters										
Anion Sum	me/L	7.96	N/A	9059962				4.41	N/A	9059962
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	240	1.0	9059958				170	1.0	9059958
Calculated TDS	mg/L	460	1.0	9059965				240	1.0	9059965
Carb. Alkalinity (calc. as CaCO3)	mg/L	3.1	1.0	9059958				1.6	1.0	9059958
Cation Sum	me/L	7.97	N/A	9059962				4.38	N/A	9059962
Hardness (CaCO3)	mg/L	370	1.0	9059711				210	1.0	9059711
Ion Balance (% Difference)	%	0.0700	N/A	9059961				0.390	N/A	9059961
Langelier Index (@ 20C)	N/A	1.05		9059963				0.658		9059963
Langelier Index (@ 4C)	N/A	0.806		9059964				0.408		9059964
Saturation pH (@ 20C)	N/A	7.08		9059963				7.34		9059963
Saturation pH (@ 4C)	N/A	7.33		9059964				7.59		9059964
Inorganics										
Total Ammonia-N	mg/L	<0.050	0.050	9063571				<0.050	0.050	9063571
Conductivity	umho/cm	780	1.0	9062429	790	1.0	9062429	440	1.0	9062429
Dissolved Organic Carbon	mg/L	1.4	0.40	9062077				1.3	0.40	9062077
Orthophosphate (P)	mg/L	<0.010	0.010	9063531				<0.010	0.010	9063531
pH	pH	8.13		9062437	8.08		9062437	8.00		9062437
Dissolved Sulphate (SO4)	mg/L	21	1.0	9063527				7.0	1.0	9063527
Alkalinity (Total as CaCO3)	mg/L	250	1.0	9062424	250	1.0	9062424	170	1.0	9062424
Dissolved Chloride (Cl-)	mg/L	31	1.0	9063521				13	1.0	9063521
Nitrite (N)	mg/L	<0.010	0.010	9062426				<0.010	0.010	9062426
Nitrate (N)	mg/L	24.1	0.50	9062426				5.75	0.10	9062426
Nitrate + Nitrite (N)	mg/L	24.1	0.50	9062426				5.75	0.10	9062426
Metals										
Dissolved Aluminum (Al)	mg/L	<0.0049	0.0049	9061821				<0.0049	0.0049	9061821
Dissolved Antimony (Sb)	mg/L	<0.00050	0.00050	9061821				<0.00050	0.00050	9061821
Dissolved Arsenic (As)	mg/L	<0.0010	0.0010	9061821				<0.0010	0.0010	9061821
Dissolved Barium (Ba)	mg/L	0.043	0.0020	9061821				0.012	0.0020	9061821
Dissolved Beryllium (Be)	mg/L	<0.00040	0.00040	9061821				<0.00040	0.00040	9061821
Dissolved Boron (B)	mg/L	0.021	0.010	9061821				<0.010	0.010	9061821

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK215			XQK215			XQK216		
Sampling Date		2023/11/16 15:00			2023/11/16 15:00			2023/11/16 15:25		
COC Number		N/A			N/A			N/A		
	UNITS	MW3-16S	RDL	QC Batch	MW3-16S Lab-Dup	RDL	QC Batch	MW2-10	RDL	QC Batch
Dissolved Cadmium (Cd)	mg/L	<0.000090	0.000090	9061821				<0.000090	0.000090	9061821
Dissolved Calcium (Ca)	mg/L	97	0.20	9061821				66	0.20	9061821
Dissolved Chromium (Cr)	mg/L	<0.0050	0.0050	9061821				<0.0050	0.0050	9061821
Dissolved Cobalt (Co)	mg/L	<0.00050	0.00050	9061821				<0.00050	0.00050	9061821
Dissolved Copper (Cu)	mg/L	<0.00090	0.00090	9061821				0.0013	0.00090	9061821
Dissolved Iron (Fe)	mg/L	<0.10	0.10	9061821				<0.10	0.10	9061821
Dissolved Lead (Pb)	mg/L	<0.00050	0.00050	9061821				<0.00050	0.00050	9061821
Dissolved Magnesium (Mg)	mg/L	32	0.050	9061821				12	0.050	9061821
Dissolved Manganese (Mn)	mg/L	<0.0020	0.0020	9061821				<0.0020	0.0020	9061821
Dissolved Molybdenum (Mo)	mg/L	<0.00050	0.00050	9061821				0.00056	0.00050	9061821
Dissolved Nickel (Ni)	mg/L	<0.0010	0.0010	9061821				<0.0010	0.0010	9061821
Dissolved Phosphorus (P)	mg/L	<0.10	0.10	9061821				<0.10	0.10	9061821
Dissolved Potassium (K)	mg/L	2.6	0.20	9061821				2.9	0.20	9061821
Dissolved Selenium (Se)	mg/L	<0.0020	0.0020	9061821				<0.0020	0.0020	9061821
Dissolved Silicon (Si)	mg/L	6.8	0.050	9061821				2.3	0.050	9061821
Dissolved Silver (Ag)	mg/L	<0.000090	0.000090	9061821				<0.000090	0.000090	9061821
Dissolved Sodium (Na)	mg/L	10	0.10	9061821				1.2	0.10	9061821
Dissolved Strontium (Sr)	mg/L	0.17	0.0010	9061821				0.093	0.0010	9061821
Dissolved Thallium (Tl)	mg/L	<0.000050	0.000050	9061821				<0.000050	0.000050	9061821
Dissolved Titanium (Ti)	mg/L	<0.0050	0.0050	9061821				<0.0050	0.0050	9061821
Dissolved Uranium (U)	mg/L	0.00048	0.00010	9061821				0.00013	0.00010	9061821
Dissolved Vanadium (V)	mg/L	<0.00050	0.00050	9061821				<0.00050	0.00050	9061821
Dissolved Zinc (Zn)	mg/L	<0.0050	0.0050	9061821				<0.0050	0.0050	9061821

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

Bureau Veritas Job #: C3AC977
Report Date: 2023/11/30

Stantec Consulting Ltd
Client Project #: 160310875
Sampler Initials: JM

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK216			XQK217			XQK217		
Sampling Date		2023/11/16 15:25			2023/11/16 17:05			2023/11/16 17:05		
COC Number		N/A			N/A			N/A		
	UNITS	MW2-10 Lab-Dup	RDL	QC Batch	MW6-10	RDL	QC Batch	MW6-10 Lab-Dup	RDL	QC Batch
Calculated Parameters										
Anion Sum	me/L				4.93	N/A	9059962			
Bicarb. Alkalinity (calc. as CaCO3)	mg/L				180	1.0	9059958			
Calculated TDS	mg/L				270	1.0	9059965			
Carb. Alkalinity (calc. as CaCO3)	mg/L				1.6	1.0	9059958			
Cation Sum	me/L				4.92	N/A	9059962			
Hardness (CaCO3)	mg/L				240	1.0	9059711			
Ion Balance (% Difference)	%				0.160	N/A	9059961			
Langelier Index (@ 20C)	N/A				0.708		9059963			
Langelier Index (@ 4C)	N/A				0.459		9059964			
Saturation pH (@ 20C)	N/A				7.27		9059963			
Saturation pH (@ 4C)	N/A				7.52		9059964			
Inorganics										
Total Ammonia-N	mg/L				<0.050	0.050	9063571			
Conductivity	umho/cm				490	1.0	9062429			
Dissolved Organic Carbon	mg/L				1.0	0.40	9062077	0.91	0.40	9062077
Orthophosphate (P)	mg/L	<0.010	0.010	9063531	<0.010	0.010	9063531			
pH	pH				7.98		9062437			
Dissolved Sulphate (SO4)	mg/L	6.8	1.0	9063527	9.5	1.0	9063527			
Alkalinity (Total as CaCO3)	mg/L				180	1.0	9062424			
Dissolved Chloride (Cl-)	mg/L	13	1.0	9063521	14	1.0	9063521			
Nitrite (N)	mg/L				<0.010	0.010	9062426			
Nitrate (N)	mg/L				9.30	0.10	9062426			
Nitrate + Nitrite (N)	mg/L				9.30	0.10	9062426			
Metals										
Dissolved Aluminum (Al)	mg/L				<0.0049	0.0049	9061821			
Dissolved Antimony (Sb)	mg/L				<0.00050	0.00050	9061821			
Dissolved Arsenic (As)	mg/L				<0.0010	0.0010	9061821			
Dissolved Barium (Ba)	mg/L				0.017	0.0020	9061821			
Dissolved Beryllium (Be)	mg/L				<0.00040	0.00040	9061821			
Dissolved Boron (B)	mg/L				0.011	0.010	9061821			

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK216			XQK217			XQK217		
Sampling Date		2023/11/16 15:25			2023/11/16 17:05			2023/11/16 17:05		
COC Number		N/A			N/A			N/A		
	UNITS	MW2-10 Lab-Dup	RDL	QC Batch	MW6-10	RDL	QC Batch	MW6-10 Lab-Dup	RDL	QC Batch
Dissolved Cadmium (Cd)	mg/L				<0.000090	0.000090	9061821			
Dissolved Calcium (Ca)	mg/L				76	0.20	9061821			
Dissolved Chromium (Cr)	mg/L				<0.0050	0.0050	9061821			
Dissolved Cobalt (Co)	mg/L				<0.00050	0.00050	9061821			
Dissolved Copper (Cu)	mg/L				0.0012	0.00090	9061821			
Dissolved Iron (Fe)	mg/L				<0.10	0.10	9061821			
Dissolved Lead (Pb)	mg/L				<0.00050	0.00050	9061821			
Dissolved Magnesium (Mg)	mg/L				12	0.050	9061821			
Dissolved Manganese (Mn)	mg/L				<0.0020	0.0020	9061821			
Dissolved Molybdenum (Mo)	mg/L				<0.00050	0.00050	9061821			
Dissolved Nickel (Ni)	mg/L				<0.0010	0.0010	9061821			
Dissolved Phosphorus (P)	mg/L				<0.10	0.10	9061821			
Dissolved Potassium (K)	mg/L				3.4	0.20	9061821			
Dissolved Selenium (Se)	mg/L				<0.0020	0.0020	9061821			
Dissolved Silicon (Si)	mg/L				2.9	0.050	9061821			
Dissolved Silver (Ag)	mg/L				<0.000090	0.000090	9061821			
Dissolved Sodium (Na)	mg/L				1.4	0.10	9061821			
Dissolved Strontium (Sr)	mg/L				0.11	0.0010	9061821			
Dissolved Thallium (Tl)	mg/L				<0.000050	0.000050	9061821			
Dissolved Titanium (Ti)	mg/L				<0.0050	0.0050	9061821			
Dissolved Uranium (U)	mg/L				0.00017	0.00010	9061821			
Dissolved Vanadium (V)	mg/L				<0.00050	0.00050	9061821			
Dissolved Zinc (Zn)	mg/L				<0.0050	0.0050	9061821			

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK218			XQK219		XQK220		
Sampling Date		2023/11/17 10:15			2023/11/17 12:20		2023/11/17 13:35		
COC Number		N/A			N/A		N/A		
	UNITS	MW3-10D	RDL	QC Batch	MW8-10D	RDL	MW8-10S	RDL	QC Batch
Calculated Parameters									
Anion Sum	me/L	7.93	N/A	9059962	7.04	N/A	27.9	N/A	9059962
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	360	1.0	9059958	230	1.0	290	1.0	9059958
Calculated TDS	mg/L	340	1.0	9059965	400	1.0	1700	1.0	9059965
Carb. Alkalinity (calc. as CaCO3)	mg/L	8.1	1.0	9059958	1.9	1.0	1.5	1.0	9059958
Cation Sum	me/L	3.64	N/A	9059962	7.26	N/A	35.4	N/A	9059962
Hardness (CaCO3)	mg/L	44	1.0	9059711	320	1.0	840	1.0	9059711
Ion Balance (% Difference)	%	37.1	N/A	9059961	1.53	N/A	11.9	N/A	9059961
Langelier Index (@ 20C)	N/A	0.578		9059963	0.816		0.986		9059963
Langelier Index (@ 4C)	N/A	0.329		9059964	0.568		0.742		9059964
Saturation pH (@ 20C)	N/A	7.80		9059963	7.12		6.76		9059963
Saturation pH (@ 4C)	N/A	8.05		9059964	7.37		7.00		9059964
Inorganics									
Total Ammonia-N	mg/L	0.55	0.050	9063571	0.12	0.050	0.077	0.050	9063571
Conductivity	umho/cm	340	1.0	9077212	680	1.0	3200	1.0	9062429
Dissolved Organic Carbon	mg/L	5.9	0.40	9062077	0.64	0.40	2.0	0.40	9062077
Orthophosphate (P)	mg/L	0.34	0.20	9063531	<0.010	0.010	<0.010	0.010	9063531
pH	pH	8.38		9077215	7.94		7.75		9062437
Dissolved Sulphate (SO4)	mg/L	30	20	9072078	89	1.0	23	1.0	9063527
Alkalinity (Total as CaCO3)	mg/L	360	1.0	9071842	230	1.0	290	1.0	9062424
Dissolved Chloride (Cl-)	mg/L	<20 (1)	20	9072076	18	1.0	760	9.0	9063521
Nitrite (N)	mg/L	0.014	0.010	9062426	<0.010	0.010	<0.010	0.010	9062426
Nitrate (N)	mg/L	<0.10	0.10	9062426	<0.10	0.10	<0.10	0.10	9062426
Nitrate + Nitrite (N)	mg/L	<0.10	0.10	9062426	<0.10	0.10	<0.10	0.10	9062426
Metals									
Dissolved Aluminum (Al)	mg/L	0.052	0.0049	9078870	<0.0049	0.0049	0.42	0.0049	9061821
Dissolved Antimony (Sb)	mg/L	<0.00050	0.00050	9078870	<0.00050	0.00050	<0.00050	0.00050	9061821
Dissolved Arsenic (As)	mg/L	0.0046	0.0010	9078870	0.0044	0.0010	<0.0010	0.0010	9061821
Dissolved Barium (Ba)	mg/L	0.030	0.0020	9078870	0.049	0.0020	0.15	0.0020	9061821
Dissolved Beryllium (Be)	mg/L	<0.00040	0.00040	9078870	<0.00040	0.00040	<0.00040	0.00040	9061821
Dissolved Boron (B)	mg/L	0.13	0.010	9078870	0.037	0.010	<0.010	0.010	9061821

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable
(1) Due to the sample matrix, sample required dilution. Detection limit was adjusted accordingly.

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK218			XQK219		XQK220		
Sampling Date		2023/11/17 10:15			2023/11/17 12:20		2023/11/17 13:35		
COC Number		N/A			N/A		N/A		
	UNITS	MW3-10D	RDL	QC Batch	MW8-10D	RDL	MW8-10S	RDL	QC Batch
Dissolved Cadmium (Cd)	mg/L	<0.000090	0.000090	9078870	<0.000090	0.000090	<0.000090	0.000090	9061821
Dissolved Calcium (Ca)	mg/L	12	0.20	9078870	90	0.20	250	0.20	9061821
Dissolved Chromium (Cr)	mg/L	<0.0050	0.0050	9078870	<0.0050	0.0050	<0.0050	0.0050	9061821
Dissolved Cobalt (Co)	mg/L	<0.00050	0.00050	9078870	<0.00050	0.00050	0.00070	0.00050	9061821
Dissolved Copper (Cu)	mg/L	<0.00090	0.00090	9078870	<0.00090	0.00090	0.0035	0.00090	9061821
Dissolved Iron (Fe)	mg/L	<0.10	0.10	9078870	0.93	0.10	1.4	0.10	9061821
Dissolved Lead (Pb)	mg/L	<0.00050	0.00050	9078870	<0.00050	0.00050	0.0016	0.00050	9061821
Dissolved Magnesium (Mg)	mg/L	3.6	0.050	9078870	23	0.050	51	0.050	9061821
Dissolved Manganese (Mn)	mg/L	0.015	0.0020	9078870	0.066	0.0020	0.21	0.0020	9061821
Dissolved Molybdenum (Mo)	mg/L	0.030	0.00050	9078870	0.0012	0.00050	<0.00050	0.00050	9061821
Dissolved Nickel (Ni)	mg/L	<0.0010	0.0010	9078870	<0.0010	0.0010	0.0016	0.0010	9061821
Dissolved Phosphorus (P)	mg/L	<0.10	0.10	9078870	<0.10	0.10	0.31	0.10	9061821
Dissolved Potassium (K)	mg/L	0.90	0.20	9078870	0.93	0.20	3.2	0.20	9061821
Dissolved Selenium (Se)	mg/L	<0.0020	0.0020	9078870	<0.0020	0.0020	<0.0020	0.0020	9061821
Dissolved Silicon (Si)	mg/L	4.5	0.050	9078870	9.4	0.050	4.9	0.050	9061821
Dissolved Silver (Ag)	mg/L	<0.000090	0.000090	9078870	<0.000090	0.000090	<0.000090	0.000090	9061821
Dissolved Sodium (Na)	mg/L	62	0.10	9078870	19	0.10	430	0.10	9061821
Dissolved Strontium (Sr)	mg/L	0.25	0.0010	9078870	1.4	0.0010	0.44	0.0010	9061821
Dissolved Thallium (Tl)	mg/L	<0.000050	0.000050	9078870	<0.000050	0.000050	0.000062	0.000050	9061821
Dissolved Titanium (Ti)	mg/L	<0.0050	0.0050	9078870	<0.0050	0.0050	0.027	0.0050	9061821
Dissolved Uranium (U)	mg/L	0.0035	0.00010	9078870	0.00019	0.00010	0.00094	0.00010	9061821
Dissolved Vanadium (V)	mg/L	0.0032	0.00050	9078870	<0.00050	0.00050	0.0020	0.00050	9061821
Dissolved Zinc (Zn)	mg/L	<0.0050	0.0050	9078870	<0.0050	0.0050	<0.0050	0.0050	9061821

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK221			XQK221		
Sampling Date		2023/11/17 15:15			2023/11/17 15:15		
COC Number		N/A			N/A		
	UNITS	MW12-10D	RDL	QC Batch	MW12-10D Lab-Dup	RDL	QC Batch
Calculated Parameters							
Anion Sum	me/L	14.3	N/A	9059962			
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	240	1.0	9059958			
Calculated TDS	mg/L	880	1.0	9059965			
Carb. Alkalinity (calc. as CaCO3)	mg/L	1.5	1.0	9059958			
Cation Sum	me/L	14.9	N/A	9059962			
Hardness (CaCO3)	mg/L	690	1.0	9059711			
Ion Balance (% Difference)	%	2.30	N/A	9059961			
Langelier Index (@ 20C)	N/A	0.997		9059963			
Langelier Index (@ 4C)	N/A	0.751		9059964			
Saturation pH (@ 20C)	N/A	6.83		9059963			
Saturation pH (@ 4C)	N/A	7.08		9059964			
Inorganics							
Total Ammonia-N	mg/L	0.17	0.050	9063571	0.17	0.050	9063571
Conductivity	umho/cm	1300	1.0	9062429			
Dissolved Organic Carbon	mg/L	0.76	0.40	9062077			
Orthophosphate (P)	mg/L	<0.010	0.010	9063531			
pH	pH	7.83		9062437			
Dissolved Sulphate (SO4)	mg/L	420	2.0	9063527			
Alkalinity (Total as CaCO3)	mg/L	240	1.0	9062424			
Dissolved Chloride (Cl-)	mg/L	25	1.0	9063521			
Nitrite (N)	mg/L	<0.010	0.010	9062426			
Nitrate (N)	mg/L	<0.10	0.10	9062426			
Nitrate + Nitrite (N)	mg/L	<0.10	0.10	9062426			
Metals							
Dissolved Aluminum (Al)	mg/L	<0.0049	0.0049	9061821			
Dissolved Antimony (Sb)	mg/L	<0.00050	0.00050	9061821			
Dissolved Arsenic (As)	mg/L	0.0034	0.0010	9061821			
Dissolved Barium (Ba)	mg/L	0.024	0.0020	9061821			
Dissolved Beryllium (Be)	mg/L	<0.00040	0.00040	9061821			
Dissolved Boron (B)	mg/L	0.056	0.010	9061821			

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK221			XQK221		
Sampling Date		2023/11/17 15:15			2023/11/17 15:15		
COC Number		N/A			N/A		
	UNITS	MW12-10D	RDL	QC Batch	MW12-10D Lab-Dup	RDL	QC Batch
Dissolved Cadmium (Cd)	mg/L	<0.000090	0.000090	9061821			
Dissolved Calcium (Ca)	mg/L	210	0.20	9061821			
Dissolved Chromium (Cr)	mg/L	<0.0050	0.0050	9061821			
Dissolved Cobalt (Co)	mg/L	<0.00050	0.00050	9061821			
Dissolved Copper (Cu)	mg/L	<0.00090	0.00090	9061821			
Dissolved Iron (Fe)	mg/L	1.2	0.10	9061821			
Dissolved Lead (Pb)	mg/L	<0.00050	0.00050	9061821			
Dissolved Magnesium (Mg)	mg/L	41	0.050	9061821			
Dissolved Manganese (Mn)	mg/L	0.034	0.0020	9061821			
Dissolved Molybdenum (Mo)	mg/L	0.00076	0.00050	9061821			
Dissolved Nickel (Ni)	mg/L	<0.0010	0.0010	9061821			
Dissolved Phosphorus (P)	mg/L	<0.10	0.10	9061821			
Dissolved Potassium (K)	mg/L	1.5	0.20	9061821			
Dissolved Selenium (Se)	mg/L	<0.0020	0.0020	9061821			
Dissolved Silicon (Si)	mg/L	7.7	0.050	9061821			
Dissolved Silver (Ag)	mg/L	<0.000090	0.000090	9061821			
Dissolved Sodium (Na)	mg/L	24	0.10	9061821			
Dissolved Strontium (Sr)	mg/L	3.2	0.0010	9061821			
Dissolved Thallium (Tl)	mg/L	<0.000050	0.000050	9061821			
Dissolved Titanium (Ti)	mg/L	<0.0050	0.0050	9061821			
Dissolved Uranium (U)	mg/L	0.00025	0.00010	9061821			
Dissolved Vanadium (V)	mg/L	<0.00050	0.00050	9061821			
Dissolved Zinc (Zn)	mg/L	<0.0050	0.0050	9061821			

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK222	XQK223			XQK223		
Sampling Date		2023/11/17 16:35	2023/11/17 17:30			2023/11/17 17:30		
COC Number		N/A	N/A			N/A		
	UNITS	MW12-10S	MW7-10	RDL	QC Batch	MW7-10 Lab-Dup	RDL	QC Batch
Calculated Parameters								
Anion Sum	me/L	8.83	9.14	N/A	9059962			
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	410	380	1.0	9059958			
Calculated TDS	mg/L	440	490	1.0	9059965			
Carb. Alkalinity (calc. as CaCO3)	mg/L	2.3	2.3	1.0	9059958			
Cation Sum	me/L	8.72	9.23	N/A	9059962			
Hardness (CaCO3)	mg/L	420	440	1.0	9059711			
Ion Balance (% Difference)	%	0.620	0.500	N/A	9059961			
Langelier Index (@ 20C)	N/A	0.965	1.04		9059963			
Langelier Index (@ 4C)	N/A	0.717	0.789		9059964			
Saturation pH (@ 20C)	N/A	6.82	6.77		9059963			
Saturation pH (@ 4C)	N/A	7.06	7.02		9059964			
Inorganics								
Total Ammonia-N	mg/L	0.054	<0.050	0.050	9063571			
Conductivity	umho/cm	790	850	1.0	9062429			
Dissolved Organic Carbon	mg/L	0.74	0.70	0.40	9062077			
Orthophosphate (P)	mg/L	<0.010	<0.010	0.010	9063531			
pH	pH	7.78	7.81		9062437			
Dissolved Sulphate (SO4)	mg/L	15	21	1.0	9063527			
Alkalinity (Total as CaCO3)	mg/L	410	380	1.0	9062424			
Dissolved Chloride (Cl-)	mg/L	7.9	15	1.0	9063521			
Nitrite (N)	mg/L	<0.010	<0.010	0.010	9062426	<0.010	0.010	9062426
Nitrate (N)	mg/L	1.60	8.72	0.10	9062426	8.84	0.10	9062426
Nitrate + Nitrite (N)	mg/L	1.60	8.72	0.10	9062426	8.84	0.10	9062426
Metals								
Dissolved Aluminum (Al)	mg/L	<0.0049	<0.0049	0.0049	9061821			
Dissolved Antimony (Sb)	mg/L	<0.00050	<0.00050	0.00050	9061821			
Dissolved Arsenic (As)	mg/L	<0.0010	<0.0010	0.0010	9061821			
Dissolved Barium (Ba)	mg/L	0.090	0.025	0.0020	9061821			
Dissolved Beryllium (Be)	mg/L	<0.00040	<0.00040	0.00040	9061821			
Dissolved Boron (B)	mg/L	0.017	0.010	0.010	9061821			

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK222	XQK223			XQK223		
Sampling Date		2023/11/17 16:35	2023/11/17 17:30			2023/11/17 17:30		
COC Number		N/A	N/A			N/A		
	UNITS	MW12-10S	MW7-10	RDL	QC Batch	MW7-10 Lab-Dup	RDL	QC Batch
Dissolved Cadmium (Cd)	mg/L	<0.000090	<0.000090	0.000090	9061821			
Dissolved Calcium (Ca)	mg/L	110	130	0.20	9061821			
Dissolved Chromium (Cr)	mg/L	<0.0050	<0.0050	0.0050	9061821			
Dissolved Cobalt (Co)	mg/L	<0.00050	<0.00050	0.00050	9061821			
Dissolved Copper (Cu)	mg/L	0.0018	<0.00090	0.00090	9061821			
Dissolved Iron (Fe)	mg/L	<0.10	<0.10	0.10	9061821			
Dissolved Lead (Pb)	mg/L	<0.00050	<0.00050	0.00050	9061821			
Dissolved Magnesium (Mg)	mg/L	37	30	0.050	9061821			
Dissolved Manganese (Mn)	mg/L	0.018	<0.0020	0.0020	9061821			
Dissolved Molybdenum (Mo)	mg/L	<0.00050	<0.00050	0.00050	9061821			
Dissolved Nickel (Ni)	mg/L	<0.0010	<0.0010	0.0010	9061821			
Dissolved Phosphorus (P)	mg/L	<0.10	<0.10	0.10	9061821			
Dissolved Potassium (K)	mg/L	1.9	1.0	0.20	9061821			
Dissolved Selenium (Se)	mg/L	<0.0020	<0.0020	0.0020	9061821			
Dissolved Silicon (Si)	mg/L	7.7	6.8	0.050	9061821			
Dissolved Silver (Ag)	mg/L	<0.000090	<0.000090	0.000090	9061821			
Dissolved Sodium (Na)	mg/L	5.8	8.1	0.10	9061821			
Dissolved Strontium (Sr)	mg/L	0.33	0.17	0.0010	9061821			
Dissolved Thallium (Tl)	mg/L	<0.000050	<0.000050	0.000050	9061821			
Dissolved Titanium (Ti)	mg/L	<0.0050	<0.0050	0.0050	9061821			
Dissolved Uranium (U)	mg/L	0.0011	0.00023	0.00010	9061821			
Dissolved Vanadium (V)	mg/L	0.00050	<0.00050	0.00050	9061821			
Dissolved Zinc (Zn)	mg/L	0.0079	<0.0050	0.0050	9061821			

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK224		
Sampling Date		2023/11/17		
COC Number		N/A		
	UNITS	DUPLICATE	RDL	QC Batch
Calculated Parameters				
Anion Sum	me/L	14.3	N/A	9059962
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	240	1.0	9059958
Calculated TDS	mg/L	880	1.0	9059965
Carb. Alkalinity (calc. as CaCO3)	mg/L	1.7	1.0	9059958
Cation Sum	me/L	14.9	N/A	9059962
Hardness (CaCO3)	mg/L	690	1.0	9059711
Ion Balance (% Difference)	%	1.95	N/A	9059961
Langelier Index (@ 20C)	N/A	1.04		9059963
Langelier Index (@ 4C)	N/A	0.789		9059964
Saturation pH (@ 20C)	N/A	6.83		9059963
Saturation pH (@ 4C)	N/A	7.08		9059964
Inorganics				
Total Ammonia-N	mg/L	0.19	0.050	9063571
Conductivity	umho/cm	1300	1.0	9062429
Dissolved Organic Carbon	mg/L	0.75	0.40	9062077
Orthophosphate (P)	mg/L	<0.010	0.010	9063531
pH	pH	7.87		9062437
Dissolved Sulphate (SO4)	mg/L	420	2.0	9063527
Alkalinity (Total as CaCO3)	mg/L	240	1.0	9062424
Dissolved Chloride (Cl-)	mg/L	25	1.0	9063521
Nitrite (N)	mg/L	<0.010	0.010	9062426
Nitrate (N)	mg/L	<0.10	0.10	9062426
Nitrate + Nitrite (N)	mg/L	<0.10	0.10	9062426
Metals				
Dissolved Aluminum (Al)	mg/L	<0.0049	0.0049	9061821
Dissolved Antimony (Sb)	mg/L	<0.00050	0.00050	9061821
Dissolved Arsenic (As)	mg/L	0.0031	0.0010	9061821
Dissolved Barium (Ba)	mg/L	0.023	0.0020	9061821
Dissolved Beryllium (Be)	mg/L	<0.00040	0.00040	9061821
Dissolved Boron (B)	mg/L	0.056	0.010	9061821
Dissolved Cadmium (Cd)	mg/L	<0.000090	0.000090	9061821

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XQK224		
Sampling Date		2023/11/17		
COC Number		N/A		
	UNITS	DUPLICATE	RDL	QC Batch
Dissolved Calcium (Ca)	mg/L	210	0.20	9061821
Dissolved Chromium (Cr)	mg/L	<0.0050	0.0050	9061821
Dissolved Cobalt (Co)	mg/L	<0.00050	0.00050	9061821
Dissolved Copper (Cu)	mg/L	<0.00090	0.00090	9061821
Dissolved Iron (Fe)	mg/L	1.2	0.10	9061821
Dissolved Lead (Pb)	mg/L	<0.00050	0.00050	9061821
Dissolved Magnesium (Mg)	mg/L	42	0.050	9061821
Dissolved Manganese (Mn)	mg/L	0.033	0.0020	9061821
Dissolved Molybdenum (Mo)	mg/L	0.00071	0.00050	9061821
Dissolved Nickel (Ni)	mg/L	<0.0010	0.0010	9061821
Dissolved Phosphorus (P)	mg/L	<0.10	0.10	9061821
Dissolved Potassium (K)	mg/L	1.6	0.20	9061821
Dissolved Selenium (Se)	mg/L	<0.0020	0.0020	9061821
Dissolved Silicon (Si)	mg/L	7.6	0.050	9061821
Dissolved Silver (Ag)	mg/L	<0.000090	0.000090	9061821
Dissolved Sodium (Na)	mg/L	24	0.10	9061821
Dissolved Strontium (Sr)	mg/L	3.2	0.0010	9061821
Dissolved Thallium (Tl)	mg/L	<0.000050	0.000050	9061821
Dissolved Titanium (Ti)	mg/L	<0.0050	0.0050	9061821
Dissolved Uranium (U)	mg/L	0.00023	0.00010	9061821
Dissolved Vanadium (V)	mg/L	<0.00050	0.00050	9061821
Dissolved Zinc (Zn)	mg/L	<0.0050	0.0050	9061821

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

TEST SUMMARY

Bureau Veritas ID: XQK215
Sample ID: MW3-16S
Matrix: Water

Collected: 2023/11/16
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9061821	N/A	2023/11/22	Azita Fazaeli
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas ID: XQK215 Dup
Sample ID: MW3-16S
Matrix: Water

Collected: 2023/11/16
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai

Bureau Veritas ID: XQK216
Sample ID: MW2-10
Matrix: Water

Collected: 2023/11/16
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9061821	N/A	2023/11/22	Azita Fazaeli
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

TEST SUMMARY

Bureau Veritas ID: XQK216
Sample ID: MW2-10
Matrix: Water

Collected: 2023/11/16
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas ID: XQK216 Dup
Sample ID: MW2-10
Matrix: Water

Collected: 2023/11/16
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu

Bureau Veritas ID: XQK217
Sample ID: MW6-10
Matrix: Water

Collected: 2023/11/16
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9061821	N/A	2023/11/22	Azita Fazaeli
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas ID: XQK217 Dup
Sample ID: MW6-10
Matrix: Water

Collected: 2023/11/16
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

Bureau Veritas Job #: C3AC977
Report Date: 2023/11/30

Stantec Consulting Ltd
Client Project #: 160310875
Sampler Initials: JM

TEST SUMMARY

Bureau Veritas ID: XQK218
Sample ID: MW3-10D
Matrix: Water

Collected: 2023/11/17
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9071842	N/A	2023/11/28	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9072076	N/A	2023/11/27	Massarat Jan
Conductivity	AT	9077212	N/A	2023/11/29	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9078870	N/A	2023/11/29	Arefa Dabhad
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9077215	2023/11/28	2023/11/29	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9072078	N/A	2023/11/27	Massarat Jan
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas ID: XQK219
Sample ID: MW8-10D
Matrix: Water

Collected: 2023/11/17
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9061821	N/A	2023/11/22	Azita Fazaeli
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

TEST SUMMARY

Bureau Veritas ID: XQK220
Sample ID: MW8-10S
Matrix: Water

Collected: 2023/11/17
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9061821	N/A	2023/11/22	Azita Fazaeli
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas ID: XQK221
Sample ID: MW12-10D
Matrix: Water

Collected: 2023/11/17
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9061821	N/A	2023/11/22	Azita Fazaeli
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

TEST SUMMARY

Bureau Veritas ID: XQK221 Dup
Sample ID: MW12-10D
Matrix: Water

Collected: 2023/11/17
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru

Bureau Veritas ID: XQK222
Sample ID: MW12-10S
Matrix: Water

Collected: 2023/11/17
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9061821	N/A	2023/11/22	Azita Fazaeli
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas ID: XQK223
Sample ID: MW7-10
Matrix: Water

Collected: 2023/11/17
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9061821	N/A	2023/11/22	Azita Fazaeli
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

TEST SUMMARY

Bureau Veritas ID: XQK223
Sample ID: MW7-10
Matrix: Water

Collected: 2023/11/17
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas ID: XQK223 Dup
Sample ID: MW7-10
Matrix: Water

Collected: 2023/11/17
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal

Bureau Veritas ID: XQK224
Sample ID: DUPLICATE
Matrix: Water

Collected: 2023/11/17
Shipped:
Received: 2023/11/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9062424	N/A	2023/11/23	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	9059958	N/A	2023/11/24	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9063521	N/A	2023/11/22	Alina Dobreanu
Conductivity	AT	9062429	N/A	2023/11/23	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9062077	N/A	2023/11/21	Gyulshen Idriz
Hardness (calculated as CaCO3)		9059711	N/A	2023/11/23	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9061821	N/A	2023/11/22	Azita Fazaeli
Ion Balance (% Difference)	CALC	9059961	N/A	2023/11/24	Automated Statchk
Anion and Cation Sum	CALC	9059962	N/A	2023/11/24	Automated Statchk
Total Ammonia-N	LACH/NH4	9063571	N/A	2023/11/22	Viorica Rotaru
Nitrate & Nitrite as Nitrogen in Water	LACH	9062426	N/A	2023/11/22	Chandra Nandlal
pH	AT	9062437	2023/11/21	2023/11/23	Surinder Rai
Orthophosphate	KONE	9063531	N/A	2023/11/22	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	9059963	N/A	2023/11/24	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9059964	N/A	2023/11/24	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9063527	N/A	2023/11/22	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9059965	N/A	2023/11/24	Automated Statchk

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	5.3°C

Sample XQK218 [MW3-10D] : Total Phosphorus < ortho-Phosphate: Both values fall within the method uncertainty for duplicates and are likely equivalent.

Results relate only to the items tested.

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

Bureau Veritas Job #: C3AC977
Report Date: 2023/11/30

QUALITY ASSURANCE REPORT

Stantec Consulting Ltd
Client Project #: 160310875
Sampler Initials: JM

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
9061821	Dissolved Aluminum (Al)	2023/11/22	99	80 - 120	99	80 - 120	<0.0049	mg/L		
9061821	Dissolved Antimony (Sb)	2023/11/22	107	80 - 120	103	80 - 120	<0.00050	mg/L	NC	20
9061821	Dissolved Arsenic (As)	2023/11/22	99	80 - 120	98	80 - 120	<0.0010	mg/L	NC	20
9061821	Dissolved Barium (Ba)	2023/11/22	99	80 - 120	99	80 - 120	<0.0020	mg/L	0.063	20
9061821	Dissolved Beryllium (Be)	2023/11/22	99	80 - 120	99	80 - 120	<0.00040	mg/L	NC	20
9061821	Dissolved Boron (B)	2023/11/22	99	80 - 120	98	80 - 120	<0.010	mg/L	1.2	20
9061821	Dissolved Cadmium (Cd)	2023/11/22	100	80 - 120	99	80 - 120	<0.000090	mg/L	NC	20
9061821	Dissolved Calcium (Ca)	2023/11/22	NC	80 - 120	101	80 - 120	<0.20	mg/L		
9061821	Dissolved Chromium (Cr)	2023/11/22	97	80 - 120	96	80 - 120	<0.0050	mg/L	NC	20
9061821	Dissolved Cobalt (Co)	2023/11/22	95	80 - 120	95	80 - 120	<0.00050	mg/L	0.95	20
9061821	Dissolved Copper (Cu)	2023/11/22	98	80 - 120	96	80 - 120	<0.00090	mg/L	0.14	20
9061821	Dissolved Iron (Fe)	2023/11/22	99	80 - 120	99	80 - 120	<0.10	mg/L		
9061821	Dissolved Lead (Pb)	2023/11/22	98	80 - 120	99	80 - 120	<0.00050	mg/L	NC	20
9061821	Dissolved Magnesium (Mg)	2023/11/22	NC	80 - 120	97	80 - 120	<0.050	mg/L		
9061821	Dissolved Manganese (Mn)	2023/11/22	97	80 - 120	96	80 - 120	<0.0020	mg/L		
9061821	Dissolved Molybdenum (Mo)	2023/11/22	105	80 - 120	102	80 - 120	<0.00050	mg/L	8.2	20
9061821	Dissolved Nickel (Ni)	2023/11/22	95	80 - 120	95	80 - 120	<0.0010	mg/L	0.48	20
9061821	Dissolved Phosphorus (P)	2023/11/22	106	80 - 120	101	80 - 120	<0.10	mg/L		
9061821	Dissolved Potassium (K)	2023/11/22	100	80 - 120	100	80 - 120	<0.20	mg/L		
9061821	Dissolved Selenium (Se)	2023/11/22	100	80 - 120	99	80 - 120	<0.0020	mg/L	NC	20
9061821	Dissolved Silicon (Si)	2023/11/22	100	80 - 120	102	80 - 120	<0.050	mg/L		
9061821	Dissolved Silver (Ag)	2023/11/22	99	80 - 120	98	80 - 120	<0.000090	mg/L	NC	20
9061821	Dissolved Sodium (Na)	2023/11/22	96	80 - 120	98	80 - 120	<0.10	mg/L	0.77	20
9061821	Dissolved Strontium (Sr)	2023/11/22	99	80 - 120	99	80 - 120	<0.0010	mg/L		
9061821	Dissolved Thallium (Tl)	2023/11/22	99	80 - 120	100	80 - 120	<0.000050	mg/L	NC	20
9061821	Dissolved Titanium (Ti)	2023/11/22	100	80 - 120	98	80 - 120	<0.0050	mg/L		
9061821	Dissolved Uranium (U)	2023/11/22	91	80 - 120	91	80 - 120	<0.00010	mg/L	0.44	20
9061821	Dissolved Vanadium (V)	2023/11/22	99	80 - 120	98	80 - 120	<0.00050	mg/L	10	20
9061821	Dissolved Zinc (Zn)	2023/11/22	95	80 - 120	97	80 - 120	<0.0050	mg/L	4.3	20
9062077	Dissolved Organic Carbon	2023/11/21	88	80 - 120	93	80 - 120	<0.40	mg/L	11	20
9062424	Alkalinity (Total as CaCO3)	2023/11/23			99	85 - 115	<1.0	mg/L	2.9	20

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
9062426	Nitrate (N)	2023/11/22	94	80 - 120	101	80 - 120	<0.10	mg/L	1.4	20
9062426	Nitrite (N)	2023/11/22	102	80 - 120	104	80 - 120	<0.010	mg/L	NC	20
9062429	Conductivity	2023/11/23			102	85 - 115	<1.0	umho/cm	2.3	10
9062437	pH	2023/11/23			102	98 - 103			0.71	N/A
9063521	Dissolved Chloride (Cl-)	2023/11/22	90	80 - 120	97	80 - 120	<1.0	mg/L	0.51	20
9063527	Dissolved Sulphate (SO4)	2023/11/22	91	75 - 125	97	80 - 120	<1.0	mg/L	3.1	20
9063531	Orthophosphate (P)	2023/11/22	94	75 - 125	94	80 - 120	<0.010	mg/L	NC	20
9063571	Total Ammonia-N	2023/11/22	102	75 - 125	98	80 - 120	<0.050	mg/L	1.1	20
9071842	Alkalinity (Total as CaCO3)	2023/11/28			102	85 - 115	<1.0	mg/L	1.5	20
9072076	Dissolved Chloride (Cl-)	2023/11/27	86	80 - 120	94	80 - 120	<1.0	mg/L	0.59	20
9072078	Dissolved Sulphate (SO4)	2023/11/27	NC	75 - 125	96	80 - 120	<1.0	mg/L	0.11	20
9077212	Conductivity	2023/11/29			102	85 - 115	<1.0	umho/cm	0.96	10
9077215	pH	2023/11/29			102	98 - 103			1.9	N/A
9078870	Dissolved Aluminum (Al)	2023/11/29	102	80 - 120	103	80 - 120	<0.0049	mg/L		
9078870	Dissolved Antimony (Sb)	2023/11/29	106	80 - 120	105	80 - 120	<0.00050	mg/L		
9078870	Dissolved Arsenic (As)	2023/11/29	102	80 - 120	100	80 - 120	<0.0010	mg/L		
9078870	Dissolved Barium (Ba)	2023/11/29	103	80 - 120	99	80 - 120	<0.0020	mg/L		
9078870	Dissolved Beryllium (Be)	2023/11/29	96	80 - 120	102	80 - 120	<0.00040	mg/L		
9078870	Dissolved Boron (B)	2023/11/29	92	80 - 120	99	80 - 120	<0.010	mg/L		
9078870	Dissolved Cadmium (Cd)	2023/11/29	103	80 - 120	102	80 - 120	<0.000090	mg/L		
9078870	Dissolved Calcium (Ca)	2023/11/29	NC	80 - 120	104	80 - 120	<0.20	mg/L		
9078870	Dissolved Chromium (Cr)	2023/11/29	97	80 - 120	97	80 - 120	<0.0050	mg/L		
9078870	Dissolved Cobalt (Co)	2023/11/29	99	80 - 120	102	80 - 120	<0.00050	mg/L		
9078870	Dissolved Copper (Cu)	2023/11/29	105	80 - 120	105	80 - 120	<0.00090	mg/L		
9078870	Dissolved Iron (Fe)	2023/11/29	NC	80 - 120	101	80 - 120	<0.10	mg/L	1.1	20
9078870	Dissolved Lead (Pb)	2023/11/29	100	80 - 120	103	80 - 120	<0.00050	mg/L		
9078870	Dissolved Magnesium (Mg)	2023/11/29	99	80 - 120	101	80 - 120	<0.050	mg/L		
9078870	Dissolved Manganese (Mn)	2023/11/29	NC	80 - 120	99	80 - 120	<0.0020	mg/L	1.4	20
9078870	Dissolved Molybdenum (Mo)	2023/11/29	106	80 - 120	103	80 - 120	<0.00050	mg/L		
9078870	Dissolved Nickel (Ni)	2023/11/29	102	80 - 120	99	80 - 120	<0.0010	mg/L		
9078870	Dissolved Phosphorus (P)	2023/11/29	103	80 - 120	104	80 - 120	<0.10	mg/L		

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
9078870	Dissolved Potassium (K)	2023/11/29	106	80 - 120	103	80 - 120	<0.20	mg/L		
9078870	Dissolved Selenium (Se)	2023/11/29	102	80 - 120	102	80 - 120	<0.0020	mg/L		
9078870	Dissolved Silicon (Si)	2023/11/29	NC	80 - 120	102	80 - 120	<0.050	mg/L		
9078870	Dissolved Silver (Ag)	2023/11/29	56 (1)	80 - 120	101	80 - 120	<0.000090	mg/L		
9078870	Dissolved Sodium (Na)	2023/11/29	108	80 - 120	103	80 - 120	<0.10	mg/L		
9078870	Dissolved Strontium (Sr)	2023/11/29	102	80 - 120	101	80 - 120	<0.0010	mg/L		
9078870	Dissolved Thallium (Tl)	2023/11/29	103	80 - 120	106	80 - 120	<0.000050	mg/L		
9078870	Dissolved Titanium (Ti)	2023/11/29	105	80 - 120	101	80 - 120	<0.0050	mg/L		
9078870	Dissolved Uranium (U)	2023/11/29	99	80 - 120	102	80 - 120	<0.00010	mg/L		
9078870	Dissolved Vanadium (V)	2023/11/29	100	80 - 120	99	80 - 120	<0.00050	mg/L		
9078870	Dissolved Zinc (Zn)	2023/11/29	101	80 - 120	100	80 - 120	<0.0050	mg/L		

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

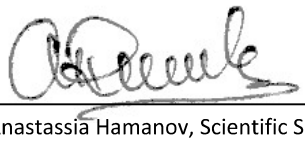
(1) Matrix Spike exceeds acceptance limits, probable matrix interference

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:



Anastassia Hamanov, Scientific Specialist



Cristina Carriere, Senior Scientific Specialist

Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Rodney Major, General Manager responsible for Ontario Environmental laboratory operations.

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

www.BVNA.com

6740 Campobello Road, Mississauga, Ontario L5N 2L8
Phone: 905-817-5700 Fax: 905-817-5779 Toll Free: 800-563-6266

CHAIN OF CUSTODY RECORD

ENV COC - 00014v3

Page 1 of 1

Invoice Information	Invoice to (requires report) ☐	Report Information (if differs from invoice)		Project Information	
Company:	Stantec Consulting Ltd.	Company:		Quotation #:	
Contact Name:	Accounts Payable	Contact Name:		P.O. #/ AFE#:	
Street Address:	300 Hagey Blvd suite 100	Street Address:		Project #:	160310875
City:	Waterloo Prov: ON Postal Code: N2L0A4	City:	Prov: Postal Code:	Site #:	
Phone:	1 519 579 4410	Phone:		Site Location:	
Email:	accounts.payable@stantec.com	Email:		Site Location Province:	
Copies:	lesley.vowell@stantec.com	Copies:		Sampled By:	Julian Murray

NONT-2023-11-492

Regulatory Criteria

REG 153: ☐ Table 1 ☐ Table 2 ☐ Table 3 ☐ Table _____ ☐ Res/Park ☐ Ind/Comm ☐ Agri/other ☐ Med/Fine ☐ Course ☐ For RSC

OTHER: ☐ CCME ☐ Reg 558* ☐ *min 3 day TAT ☐ MISA ☐ PWQO ☐ Reg 406, Table: _____ ☐ Sanitary Sewer Bylaw ☐ Storm Sewer Bylaw Municipality ☒ Other: OWRS

Include Criteria on Certificate of Analysis (check if yes): ☐

SAMPLES MUST BE KEPT COOL (<10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BUREAU VERITAS

Regular Turnaround Time (TAT)

☒ 5 to 7 Day ☐ 10 Day

Rush Turnaround Time (TAT) Surcharges apply

☐ Same Day ☐ 1 Day ☐ 2 Day ☐ 3 Day ☐ 4 Day

Date Required: YY MM DD

Comments

	Sample Identification	Date Sampled YY	MM	DD	Time (24hr) HH	MM	Matrix	1 FIELD FILTERED (Metals)	2 FIELD PRESERVED (Metals, Ammonia)	3 LAB FILTRATION REQUIRED	4 BTEX/ F1	5 F2 - F4	6 VOCs	7 Reg 153 metals and inorganics	8 Reg 153 ICPMS metals	9 Reg 153 metals (Hg, Cr VI, ICPMS metals, HWS - B)	10 RCAP - comprehensive	11	12	13	14	15	16	17	18	19	20	21 # OF CONTAINERS SUBMITTED	22 HOLD - DO NOT ANALYZE
1	MW3-16S	23	11	16	15	00	GW	X	X								X										4	
2	MW2-10	23	11	16	15	29	GW	X	X								X										4	
3	MW6-10	23	11	16	17	05	GW	X	X								X										4	
4	MW3-10D	23	11	17	10	15	GW	X	X								X										4	
5	MW8-10D	23	11	17	12	20	GW	X	X								X										4	
6	MW8-10S	23	11	17	13	35	GW	X	X								X										4	
7	MW12-10D	23	11	17	15	15	GW	X	X								X										4	
8	MW12-10S	23	11	17	16	35	GW	X	X								X										4	
9	MW7-10	23	11	17	17	30	GW	X	X								X										4	
10																												
11																												
12																												

*UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BUREAU VERITAS STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS AND CONDITIONS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVNA.COM/TERMS-AND-CONDITIONS OR BY CALLING THE LABORATORY LISTED ABOVE TO OBTAIN A COPY

LAB USE ONLY	Yes	No	°C	1	2	3
Seal present	✓					
Seal intact	✓					
Cooling media present	✓					
				5	6	5

LAB USE ONLY	Yes	No	°C	1	2	3
Seal present						
Seal intact						
Cooling media present						

LAB USE ONLY	Yes	No	°C	1	2	3
Seal present						
Seal intact						
Cooling media present						

Temperature reading by:

	Relinquished by: (Signature/ Print)	Date YY	MM	DD	Time HH	MM	Received by: (Signature/ Print)	Date YY	MM	DD	Time HH	MM	Special instructions
1	Julian Murray	2023	11	17	18	15	1 AVISHEK SHRESTHA	2023	11	18	12	15	
2							2						

Your Project #: 161450875
Your C.O.C. #: 959584-02-01

Attention: Lesley Veale

Stantec Consulting Ltd
300 Hagey Blvd
Suite 100
Waterloo, ON
CANADA N2L 0A4

Report Date: 2023/12/08
Report #: R7946167
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C3AT024
Received: 2023/12/02, 11:40

Sample Matrix: Water
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity	2	N/A	2023/12/05	CAM SOP-00448	SM 24 2320 B m
Carbonate, Bicarbonate and Hydroxide	2	N/A	2023/12/05	CAM SOP-00102	APHA 4500-CO2 D
Chloride by Automated Colourimetry	2	N/A	2023/12/05	CAM SOP-00463	SM 24 4500-Cl E m
Conductivity	2	N/A	2023/12/05	CAM SOP-00414	SM 24 2510 m
Dissolved Organic Carbon (DOC) (1)	2	N/A	2023/12/05	CAM SOP-00446	SM 24 5310 B m
Hardness (calculated as CaCO3)	2	N/A	2023/12/06	CAM SOP 00102/00408/00447	SM 2340 B
Dissolved Metals by ICPMS	2	N/A	2023/12/05	CAM SOP-00447	EPA 6020B m
Ion Balance (% Difference)	2	N/A	2023/12/06		
Anion and Cation Sum	2	N/A	2023/12/06		
Total Ammonia-N	2	N/A	2023/12/07	CAM SOP-00441	USGS I-2522-90 m
Nitrate & Nitrite as Nitrogen in Water (2)	2	N/A	2023/12/05	CAM SOP-00440	SM 24 4500-NO3I/NO2B
pH	2	2023/12/04	2023/12/05	CAM SOP-00413	SM 24th - 4500H+ B
Orthophosphate	2	N/A	2023/12/04	CAM SOP-00461	SM 24 4500-P E
Sat. pH and Langelier Index (@ 20C)	2	N/A	2023/12/06		Auto Calc
Sat. pH and Langelier Index (@ 4C)	2	N/A	2023/12/06		Auto Calc
Sulphate by Automated Turbidimetry	2	N/A	2023/12/05	CAM SOP-00464	SM 24 4500-SO42- E m
Total Dissolved Solids (TDS calc)	2	N/A	2023/12/06		Auto Calc

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCCFP, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report.

Your Project #: 161450875
Your C.O.C. #: 959584-02-01

Attention: Lesley Veale

Stantec Consulting Ltd
300 Hagey Blvd
Suite 100
Waterloo, ON
CANADA N2L 0A4

Report Date: 2023/12/08
Report #: R7946167
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C3AT024
Received: 2023/12/02, 11:40

Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) Dissolved Organic Carbon (DOC) present in the sample should be considered as non-purgeable DOC.
(2) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to:
Julie Clement, Technical Account Manager
Email: Julie.CLEMENT@bureauveritas.com
Phone# (613)868-6079

==========

This report has been generated and distributed using a secure automated process.
Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Rodney Major, General Manager responsible for Ontario Environmental laboratory operations.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XTW488			XTW488		
Sampling Date		2023/12/01 15:40			2023/12/01 15:40		
COC Number		959584-02-01			959584-02-01		
	UNITS	MW13-10	RDL	QC Batch	MW13-10 Lab-Dup	RDL	QC Batch
Calculated Parameters							
Anion Sum	me/L	7.98	N/A	9087967			
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	330	1.0	9087962			
Calculated TDS	mg/L	430	1.0	9087968			
Carb. Alkalinity (calc. as CaCO3)	mg/L	1.9	1.0	9087962			
Cation Sum	me/L	8.61	N/A	9087967			
Hardness (CaCO3)	mg/L	420	1.0	9087958			
Ion Balance (% Difference)	%	3.80	N/A	9087965			
Langelier Index (@ 20C)	N/A	0.910		9087963			
Langelier Index (@ 4C)	N/A	0.662		9087966			
Saturation pH (@ 20C)	N/A	6.87		9087963			
Saturation pH (@ 4C)	N/A	7.12		9087966			
Inorganics							
Total Ammonia-N	mg/L	<0.050	0.050	9094508			
Conductivity	umho/cm	740	1.0	9089367			
Dissolved Organic Carbon	mg/L	0.51	0.40	9088929			
Orthophosphate (P)	mg/L	<0.030 (1)	0.030	9088781			
pH	pH	7.78		9089366			
Dissolved Sulphate (SO4)	mg/L	35	1.0	9088805			
Alkalinity (Total as CaCO3)	mg/L	340	1.0	9089363			
Dissolved Chloride (Cl-)	mg/L	13	1.0	9088799			
Nitrite (N)	mg/L	<0.010	0.010	9088873			
Nitrate (N)	mg/L	2.29	0.10	9088873			
Nitrate + Nitrite (N)	mg/L	2.29	0.10	9088873			
Metals							
Dissolved Aluminum (Al)	mg/L	<0.0049	0.0049	9091730	<0.0049	0.0049	9091730
Dissolved Antimony (Sb)	mg/L	<0.00050	0.00050	9091730	<0.00050	0.00050	9091730
Dissolved Arsenic (As)	mg/L	<0.0010	0.0010	9091730	<0.0010	0.0010	9091730
Dissolved Barium (Ba)	mg/L	0.078	0.0020	9091730	0.077	0.0020	9091730
Dissolved Beryllium (Be)	mg/L	<0.00040	0.00040	9091730	<0.00040	0.00040	9091730

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable
(1) Detection Limit was raised due to matrix interferences.

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XTW488			XTW488		
Sampling Date		2023/12/01 15:40			2023/12/01 15:40		
COC Number		959584-02-01			959584-02-01		
	UNITS	MW13-10	RDL	QC Batch	MW13-10 Lab-Dup	RDL	QC Batch
Dissolved Boron (B)	mg/L	<0.010	0.010	9091730	<0.010	0.010	9091730
Dissolved Cadmium (Cd)	mg/L	<0.000090	0.000090	9091730	<0.000090	0.000090	9091730
Dissolved Calcium (Ca)	mg/L	110	0.20	9091730	120	0.20	9091730
Dissolved Chromium (Cr)	mg/L	<0.0050	0.0050	9091730	<0.0050	0.0050	9091730
Dissolved Cobalt (Co)	mg/L	<0.00050	0.00050	9091730	<0.00050	0.00050	9091730
Dissolved Copper (Cu)	mg/L	0.0023	0.00090	9091730	0.0018	0.00090	9091730
Dissolved Iron (Fe)	mg/L	<0.10	0.10	9091730	<0.10	0.10	9091730
Dissolved Lead (Pb)	mg/L	<0.00050	0.00050	9091730	<0.00050	0.00050	9091730
Dissolved Magnesium (Mg)	mg/L	33	0.050	9091730	34	0.050	9091730
Dissolved Manganese (Mn)	mg/L	<0.0020	0.0020	9091730	<0.0020	0.0020	9091730
Dissolved Molybdenum (Mo)	mg/L	<0.00050	0.00050	9091730	<0.00050	0.00050	9091730
Dissolved Nickel (Ni)	mg/L	<0.0010	0.0010	9091730	<0.0010	0.0010	9091730
Dissolved Phosphorus (P)	mg/L	<0.10	0.10	9091730	<0.10	0.10	9091730
Dissolved Potassium (K)	mg/L	0.91	0.20	9091730	0.90	0.20	9091730
Dissolved Selenium (Se)	mg/L	<0.0020	0.0020	9091730	<0.0020	0.0020	9091730
Dissolved Silicon (Si)	mg/L	6.9	0.050	9091730	7.1	0.050	9091730
Dissolved Silver (Ag)	mg/L	<0.000090	0.000090	9091730	<0.000090	0.000090	9091730
Dissolved Sodium (Na)	mg/L	3.8	0.10	9091730	3.8	0.10	9091730
Dissolved Strontium (Sr)	mg/L	0.17	0.0010	9091730	0.17	0.0010	9091730
Dissolved Thallium (Tl)	mg/L	<0.000050	0.000050	9091730	<0.000050	0.000050	9091730
Dissolved Titanium (Ti)	mg/L	<0.0050	0.0050	9091730	<0.0050	0.0050	9091730
Dissolved Uranium (U)	mg/L	0.00077	0.00010	9091730	0.00079	0.00010	9091730
Dissolved Vanadium (V)	mg/L	<0.00050	0.00050	9091730	<0.00050	0.00050	9091730
Dissolved Zinc (Zn)	mg/L	0.016	0.0050	9091730	0.017	0.0050	9091730

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XTW489		
Sampling Date		2023/12/01 15:20		
COC Number		959584-02-01		
	UNITS	MW10-10	RDL	QC Batch
Calculated Parameters				
Anion Sum	me/L	5.25	N/A	9087967
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	250	1.0	9087962
Calculated TDS	mg/L	280	1.0	9087968
Carb. Alkalinity (calc. as CaCO3)	mg/L	2.0	1.0	9087962
Cation Sum	me/L	5.60	N/A	9087967
Hardness (CaCO3)	mg/L	260	1.0	9087958
Ion Balance (% Difference)	%	3.23	N/A	9087965
Langelier Index (@ 20C)	N/A	0.660		9087963
Langelier Index (@ 4C)	N/A	0.411		9087966
Saturation pH (@ 20C)	N/A	7.28		9087963
Saturation pH (@ 4C)	N/A	7.52		9087966
Inorganics				
Total Ammonia-N	mg/L	0.18	0.050	9094908
Conductivity	umho/cm	490	1.0	9089367
Dissolved Organic Carbon	mg/L	0.88	0.40	9088929
Orthophosphate (P)	mg/L	<0.010	0.010	9088781
pH	pH	7.94		9089366
Dissolved Sulphate (SO4)	mg/L	12	1.0	9088805
Alkalinity (Total as CaCO3)	mg/L	250	1.0	9089363
Dissolved Chloride (Cl-)	mg/L	<1.0	1.0	9088799
Nitrite (N)	mg/L	0.015	0.010	9088873
Nitrate (N)	mg/L	<0.10	0.10	9088873
Nitrate + Nitrite (N)	mg/L	<0.10	0.10	9088873
Metals				
Dissolved Aluminum (Al)	mg/L	0.015	0.0049	9091730
Dissolved Antimony (Sb)	mg/L	<0.00050	0.00050	9091730
Dissolved Arsenic (As)	mg/L	0.013	0.0010	9091730
Dissolved Barium (Ba)	mg/L	0.10	0.0020	9091730
Dissolved Beryllium (Be)	mg/L	<0.00040	0.00040	9091730
Dissolved Boron (B)	mg/L	0.021	0.010	9091730
Dissolved Cadmium (Cd)	mg/L	<0.000090	0.000090	9091730

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

RCAP - COMPREHENSIVE (WATER)

Bureau Veritas ID		XTW489		
Sampling Date		2023/12/01 15:20		
COC Number		959584-02-01		
	UNITS	MW10-10	RDL	QC Batch
Dissolved Calcium (Ca)	mg/L	55	0.20	9091730
Dissolved Chromium (Cr)	mg/L	<0.0050	0.0050	9091730
Dissolved Cobalt (Co)	mg/L	<0.00050	0.00050	9091730
Dissolved Copper (Cu)	mg/L	<0.00090	0.00090	9091730
Dissolved Iron (Fe)	mg/L	0.29	0.10	9091730
Dissolved Lead (Pb)	mg/L	<0.00050	0.00050	9091730
Dissolved Magnesium (Mg)	mg/L	30	0.050	9091730
Dissolved Manganese (Mn)	mg/L	0.022	0.0020	9091730
Dissolved Molybdenum (Mo)	mg/L	0.0011	0.00050	9091730
Dissolved Nickel (Ni)	mg/L	0.0039	0.0010	9091730
Dissolved Phosphorus (P)	mg/L	<0.10	0.10	9091730
Dissolved Potassium (K)	mg/L	1.3	0.20	9091730
Dissolved Selenium (Se)	mg/L	<0.0020	0.0020	9091730
Dissolved Silicon (Si)	mg/L	12	0.050	9091730
Dissolved Silver (Ag)	mg/L	<0.000090	0.000090	9091730
Dissolved Sodium (Na)	mg/L	8.3	0.10	9091730
Dissolved Strontium (Sr)	mg/L	0.38	0.0010	9091730
Dissolved Thallium (Tl)	mg/L	<0.000050	0.000050	9091730
Dissolved Titanium (Ti)	mg/L	<0.0050	0.0050	9091730
Dissolved Uranium (U)	mg/L	0.00010	0.00010	9091730
Dissolved Vanadium (V)	mg/L	<0.00050	0.00050	9091730
Dissolved Zinc (Zn)	mg/L	<0.0050	0.0050	9091730

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

TEST SUMMARY

Bureau Veritas ID: XTW488
Sample ID: MW13-10
Matrix: Water

Collected: 2023/12/01
Shipped:
Received: 2023/12/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9089363	N/A	2023/12/05	Nachiketa Gohil
Carbonate, Bicarbonate and Hydroxide	CALC	9087962	N/A	2023/12/05	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9088799	N/A	2023/12/05	Alina Dobreanu
Conductivity	AT	9089367	N/A	2023/12/05	Nachiketa Gohil
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9088929	N/A	2023/12/05	Gyulshen Idriz
Hardness (calculated as CaCO3)		9087958	N/A	2023/12/06	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9091730	N/A	2023/12/05	Prempal Bhatti
Ion Balance (% Difference)	CALC	9087965	N/A	2023/12/06	Automated Statchk
Anion and Cation Sum	CALC	9087967	N/A	2023/12/06	Automated Statchk
Total Ammonia-N	LACH/NH4	9094508	N/A	2023/12/07	Shivani Shivani
Nitrate & Nitrite as Nitrogen in Water	LACH	9088873	N/A	2023/12/05	Chandra Nandlal
pH	AT	9089366	2023/12/04	2023/12/05	Nachiketa Gohil
Orthophosphate	KONE	9088781	N/A	2023/12/04	Massarat Jan
Sat. pH and Langelier Index (@ 20C)	CALC	9087963	N/A	2023/12/06	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9087966	N/A	2023/12/06	Automated Statchk
Sulphate by Automated Turbidimetry	SKAL	9088805	N/A	2023/12/05	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9087968	N/A	2023/12/06	Automated Statchk

Bureau Veritas ID: XTW488 Dup
Sample ID: MW13-10
Matrix: Water

Collected: 2023/12/01
Shipped:
Received: 2023/12/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Dissolved Metals by ICPMS	ICP/MS	9091730	N/A	2023/12/05	Prempal Bhatti

Bureau Veritas ID: XTW489
Sample ID: MW10-10
Matrix: Water

Collected: 2023/12/01
Shipped:
Received: 2023/12/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	9089363	N/A	2023/12/05	Nachiketa Gohil
Carbonate, Bicarbonate and Hydroxide	CALC	9087962	N/A	2023/12/05	Automated Statchk
Chloride by Automated Colourimetry	SKAL	9088799	N/A	2023/12/05	Alina Dobreanu
Conductivity	AT	9089367	N/A	2023/12/05	Nachiketa Gohil
Dissolved Organic Carbon (DOC)	TOCV/NDIR	9088929	N/A	2023/12/05	Gyulshen Idriz
Hardness (calculated as CaCO3)		9087958	N/A	2023/12/06	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	9091730	N/A	2023/12/05	Prempal Bhatti
Ion Balance (% Difference)	CALC	9087965	N/A	2023/12/06	Automated Statchk
Anion and Cation Sum	CALC	9087967	N/A	2023/12/06	Automated Statchk
Total Ammonia-N	LACH/NH4	9094908	N/A	2023/12/07	Shivani Shivani
Nitrate & Nitrite as Nitrogen in Water	LACH	9088873	N/A	2023/12/05	Chandra Nandlal
pH	AT	9089366	2023/12/04	2023/12/05	Nachiketa Gohil
Orthophosphate	KONE	9088781	N/A	2023/12/04	Massarat Jan
Sat. pH and Langelier Index (@ 20C)	CALC	9087963	N/A	2023/12/06	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	9087966	N/A	2023/12/06	Automated Statchk

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

Bureau Veritas Job #: C3AT024
Report Date: 2023/12/08

Stantec Consulting Ltd
Client Project #: 161450875
Sampler Initials: JM

TEST SUMMARY

Bureau Veritas ID: XTW489
Sample ID: MW10-10
Matrix: Water

Collected: 2023/12/01
Shipped:
Received: 2023/12/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Sulphate by Automated Turbidimetry	SKAL	9088805	N/A	2023/12/05	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	9087968	N/A	2023/12/06	Automated Statchk

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	0.0°C

Results relate only to the items tested.

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

QUALITY ASSURANCE REPORT

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
9088781	Orthophosphate (P)	2023/12/04	89	75 - 125	89	80 - 120	<0.010	mg/L	NC	20
9088799	Dissolved Chloride (Cl-)	2023/12/05	92	80 - 120	94	80 - 120	<1.0	mg/L	0.61	20
9088805	Dissolved Sulphate (SO4)	2023/12/05	NC	75 - 125	94	80 - 120	<1.0	mg/L	1.1	20
9088873	Nitrate (N)	2023/12/05	91	80 - 120	94	80 - 120	<0.10	mg/L	NC	20
9088873	Nitrite (N)	2023/12/05	100	80 - 120	103	80 - 120	<0.010	mg/L	NC	20
9088929	Dissolved Organic Carbon	2023/12/05	87	80 - 120	97	80 - 120	<0.40	mg/L	2.0	20
9089363	Alkalinity (Total as CaCO3)	2023/12/05			97	85 - 115	<1.0	mg/L	0.36	20
9089366	pH	2023/12/05			101	98 - 103			1.2	N/A
9089367	Conductivity	2023/12/05			101	85 - 115	<1.0	umho/cm	0.38	10
9091730	Dissolved Aluminum (Al)	2023/12/05	106	80 - 120	115	80 - 120	<0.0049	mg/L	NC	20
9091730	Dissolved Antimony (Sb)	2023/12/05	111	80 - 120	103	80 - 120	<0.00050	mg/L	NC	20
9091730	Dissolved Arsenic (As)	2023/12/05	106	80 - 120	102	80 - 120	<0.0010	mg/L	NC	20
9091730	Dissolved Barium (Ba)	2023/12/05	107	80 - 120	103	80 - 120	<0.0020	mg/L	1.3	20
9091730	Dissolved Beryllium (Be)	2023/12/05	103	80 - 120	100	80 - 120	<0.00040	mg/L	NC	20
9091730	Dissolved Boron (B)	2023/12/05	101	80 - 120	98	80 - 120	<0.010	mg/L	NC	20
9091730	Dissolved Cadmium (Cd)	2023/12/05	107	80 - 120	100	80 - 120	<0.000090	mg/L	NC	20
9091730	Dissolved Calcium (Ca)	2023/12/05	NC	80 - 120	107	80 - 120	<0.20	mg/L	2.4	20
9091730	Dissolved Chromium (Cr)	2023/12/05	107	80 - 120	103	80 - 120	<0.0050	mg/L	NC	20
9091730	Dissolved Cobalt (Co)	2023/12/05	105	80 - 120	102	80 - 120	<0.00050	mg/L	NC	20
9091730	Dissolved Copper (Cu)	2023/12/05	109	80 - 120	103	80 - 120	<0.00090	mg/L	NC	20
9091730	Dissolved Iron (Fe)	2023/12/05	109	80 - 120	104	80 - 120	<0.10	mg/L	NC	20
9091730	Dissolved Lead (Pb)	2023/12/05	105	80 - 120	101	80 - 120	<0.00050	mg/L	NC	20
9091730	Dissolved Magnesium (Mg)	2023/12/05	NC	80 - 120	105	80 - 120	<0.050	mg/L	0.38	20
9091730	Dissolved Manganese (Mn)	2023/12/05	106	80 - 120	102	80 - 120	<0.0020	mg/L	NC	20
9091730	Dissolved Molybdenum (Mo)	2023/12/05	114	80 - 120	105	80 - 120	<0.00050	mg/L	NC	20
9091730	Dissolved Nickel (Ni)	2023/12/05	101	80 - 120	99	80 - 120	<0.0010	mg/L	NC	20
9091730	Dissolved Phosphorus (P)	2023/12/05	117	80 - 120	109	80 - 120	<0.10	mg/L	NC	20
9091730	Dissolved Potassium (K)	2023/12/05	112	80 - 120	107	80 - 120	<0.20	mg/L	1.5	20
9091730	Dissolved Selenium (Se)	2023/12/05	104	80 - 120	99	80 - 120	<0.0020	mg/L	NC	20
9091730	Dissolved Silicon (Si)	2023/12/05	110	80 - 120	106	80 - 120	<0.050	mg/L	2.0	20
9091730	Dissolved Silver (Ag)	2023/12/05	106	80 - 120	100	80 - 120	<0.000090	mg/L	NC	20

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
9091730	Dissolved Sodium (Na)	2023/12/05	109	80 - 120	106	80 - 120	<0.10	mg/L	1.6	20
9091730	Dissolved Strontium (Sr)	2023/12/05	107	80 - 120	102	80 - 120	<0.0010	mg/L	0.49	20
9091730	Dissolved Thallium (Tl)	2023/12/05	106	80 - 120	103	80 - 120	<0.000050	mg/L	NC	20
9091730	Dissolved Titanium (Ti)	2023/12/05	109	80 - 120	102	80 - 120	<0.0050	mg/L	NC	20
9091730	Dissolved Uranium (U)	2023/12/05	107	80 - 120	103	80 - 120	<0.00010	mg/L	2.8	20
9091730	Dissolved Vanadium (V)	2023/12/05	108	80 - 120	103	80 - 120	<0.00050	mg/L	NC	20
9091730	Dissolved Zinc (Zn)	2023/12/05	104	80 - 120	101	80 - 120	<0.0050	mg/L	1.5	20
9094508	Total Ammonia-N	2023/12/07	82	75 - 125	100	80 - 120	<0.050	mg/L	0.53	20
9094908	Total Ammonia-N	2023/12/07	98	75 - 125	99	80 - 120	<0.050	mg/L	2.4	20

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

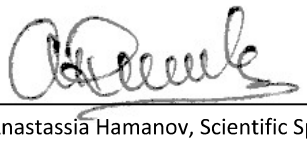
NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:

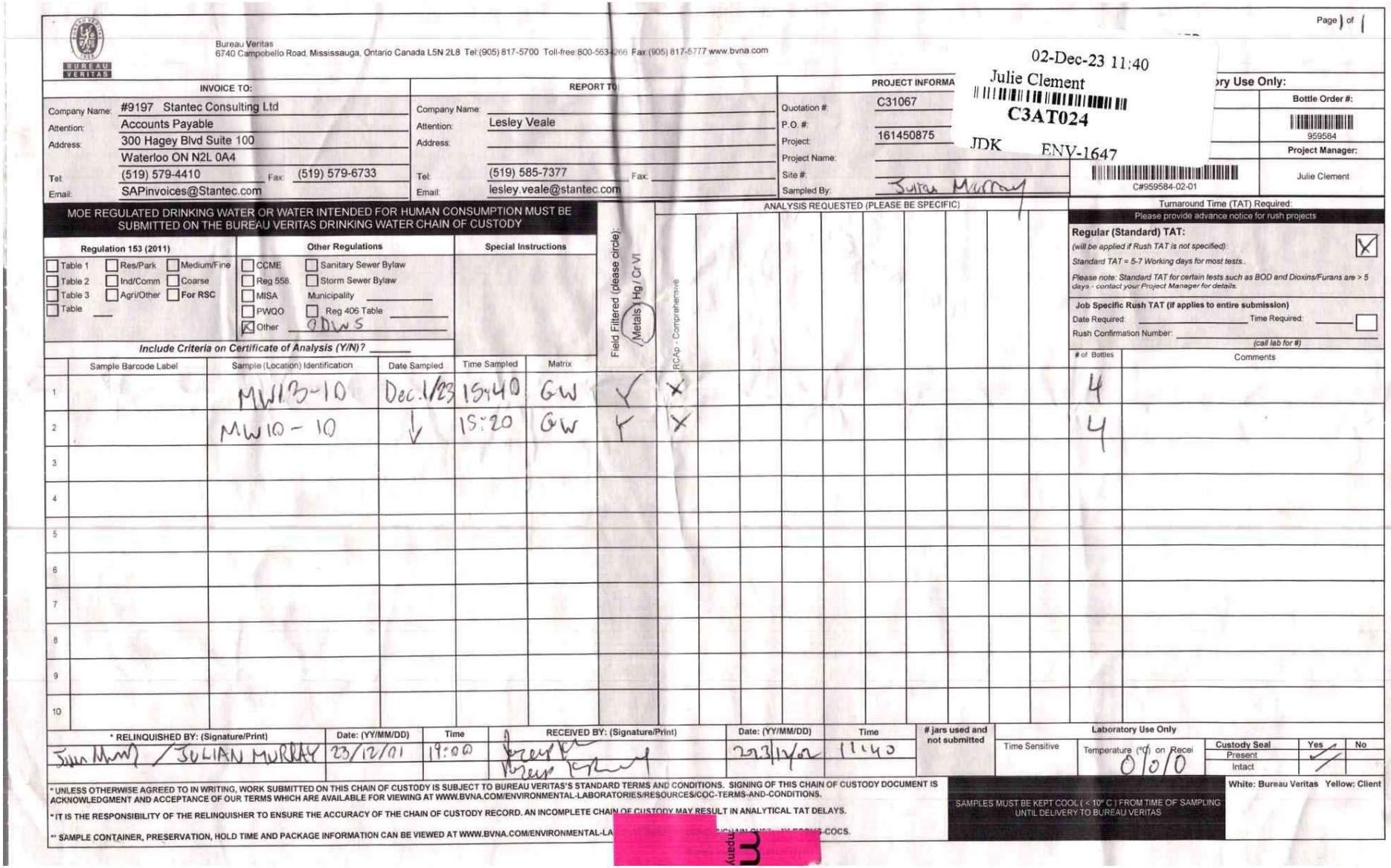


Anastassia Hamanov, Scientific Specialist

Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Rodney Major, General Manager responsible for Ontario Environmental laboratory operations.

Bureau Veritas 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvna.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.



Bureau Veritas
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel:(905) 817-5700 Toll-free:800-563-6266 Fax (905) 817-5777 www.bvna.com

Page 1 of 1

02-Dec-23 11:40
Julie Clement
C3AT024
JDK ENV-1647

C#959584-02-01

INVOICE TO:

Company Name: #9197 Stantec Consulting Ltd
Attention: Accounts Payable
Address: 300 Hagey Blvd Suite 100
Waterloo ON N2L 0A4
Tel: (519) 579-4410 Fax: (519) 579-6733
Email: SAPinvoices@Stantec.com

REPORT TO:

Company Name:
Attention: Lesley Veale
Address:
Tel: (519) 585-7377 Fax:
Email: lesley.veale@stantec.com

PROJECT INFORMA

Quotation #: C31067
P.O. #: 161450875
Project:
Project Name:
Site #:
Sampled By: Julian Murray

Bureau Veritas Use Only:

Bottle Order #: 959584
Project Manager: Julie Clement

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BUREAU VERITAS DRINKING WATER CHAIN OF CUSTODY

Regulation 153 (2011)
☐ Table 1 ☐ Res/Park ☐ Medium/Fine
☐ Table 2 ☐ Ind/Comm ☐ Coarse
☐ Table 3 ☐ Agri/Other ☐ For RSC
☐ Table ___

Other Regulations
☐ CCME ☐ Sanitary Sewer Bylaw
☐ Reg 558 ☐ Storm Sewer Bylaw
☐ MISA Municipality
☐ PWQO ☐ Reg 406 Table
☒ Other ODWS

Special Instructions

Include Criteria on Certificate of Analysis (Y/N)? ___

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Field Filtered (please circle): (Metals / Hg / Cr VI)
RCAp - Comprehensive

Turnaround Time (TAT) Required:
Please provide advance notice for rush projects

Regular (Standard) TAT: ☒
(will be applied if Rush TAT is not specified)
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: Time Required: ☐
Rush Confirmation Number:
(call lab for #)

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	# of Bottles	Comments
1		MW13-10	Dec.1/23	15:40	GW	4	
2		MW10-10	↓	15:20	GW	4	
3							
4							
5							
6							
7							
8							
9							
10							

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
JULIAN MURRAY	23/12/01	19:00		23/12/02	11:40	

Laboratory Use Only
Time Sensitive
Temperature (°C) on Recei: 0 | 0 | 0
Custody Seal Present ✓ Intact ✓ Yes ✓ No

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BUREAU VERITAS'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVNA.COM/ENVIRONMENTAL-LABORATORIES/RESOURCES/COC-TERMS-AND-CONDITIONS.

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT WWW.BVNA.COM/ENVIRONMENTAL-LA -COCS.

SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BUREAU VERITAS

White: Bureau Veritas Yellow: Client

Meritech Engineering 1315 Bishop Street North Suite 202 Cambridge ON N1R 6Z2 t 519.623.1140 f 519.623.7334