Hydrogeological Investigation West Orillia Neighbourhood Plan, Residential Development

Orillia, Ontario

FINAL REPORT

September 30, 2022

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First Submission: July 27, 2020
Second Submission: September 30, 2022

Project No. 121622652

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Glossary

AMSL	above mean sea level
ASTM	American Society for Testing and Materials
BGS	below ground surface
Charter	Charter Development LP
CVC	Credit Valley Conservation
EASR	Environmental Activity and Sector Registry
ESGRA	Ecologically Significant Groundwater Recharge Area
HDPE	high density polyethylene
HVA	Highly Vulnerable Aquifer
IPZ	Intake Protection Zone
Levelogger	Solinst Edge Levelogger®
MECP	Ministry of the Environment, Conservation and Parks
OGS	Ontario Geological Survey
O. Reg.	Ontario Regulation
PTTW	permit to take water
PVC	polyvinyl chloride
SGRA	Significant Groundwater Recharge Area
SPA	Source Protection Area
SPP	Source Protection Plan
Stantec	Stantec Consulting Limited
TRCA	Toronto and Region Conservation
SWM	stormwater management
WHPA	Wellhead Protection Area
WWIS	Water Well Information System

1.0 INTRODUCTION

Charter Development LP (Charter) retained Stantec Consulting Limited (Stantec) to complete a hydrogeological assessment for the subject lands located east of Line 15 North and south of Bass Lake Sideroad East, in the City of Orillia, Ontario (Site) (Figure 1). The Site covers an approximate area of 103 hectares (ha) and is bounded to the north by Bass Lake Sideroad East and rural residential areas to the north, a mixture of agricultural and wooded areas to the east (lands designated as future subdivision development), and predominantly agricultural lands to the south and west (Figure 1). A southwest to northeast running Trans-Canada Energy pipeline easement also bisects the Site. Stantec understands the proposed development concept for the Site is to include a mixture of low, medium and high-density residential housing, roadways, a stormwater management (SWM) pond, with site servicing including sanitary sewers, storms sewers, and municipal water supply.

Stantec (2019) also performed a geotechnical investigation for the Site at the same time as the hydrogeological investigation, with the results of this geotechnical work being provided under a separate cover.

Overall, the focus of this hydrogeological investigation is to evaluate potential effects of the proposed development on the hydrogeological form and function of the Site. Specifically, the hydrogeological investigation objectives are as follows:

1. Interpret the geological and hydrogeological conditions at the Site, including identifying hydrostratigraphic units, seasonal fluctuations in groundwater levels and hydraulic gradients, goundwater-surface water interactions (with regard to the onsite wetland), and soil infiltration potenital.
2. Identify those local aquifer systems from which nearby residences obtain their potable water supply (i.e., private wells) and provide commentary on whether future development could interfere with these groundwater quantities.
3. Preliminary assessment of whether proposed future buildings, stormwater management facilities, serciving (i.e., storm/sanitary sewers and watermains) and associated construction activities could intercept the groundwater table and evaluate if any measures are required to mitigate potential disturbances on pre-development groundwater elevations and flow patterns.
4. Review proposed land use activities for conformity with Source Water Protection requirements as stipulated in the *Clean Water Act*.
5. Identify potential hydrogeological constraints to the development of the Site and evaluate potential mitigation measures to alleviate these constraints.

This report is arranged into seven sections, including this introduction (Section 1). Section 2 presents the physical setting of the Site at a regional scale. Section 3 outlines the methods used to evaluate the Site hydrogeological conditions. Section 4 presents the results of the Site investigation, with Section 5 discussing the potential hydrogeological impacts of the project and recommended mitigation measures. Report conclusions and references are listed in Sections 6 and 7, respectively. All figures and tables referenced in this report are presented in Appendices A and B, respectively. Appendices C to E include Regional Groundwater Flow and Recharge and Discharge Area Mapping, Borehole Logs, and Hydraulic Conductivity Analytical Solutions, respectively.

2.0 PHYSICAL SETTING

2.1 PHYSIOGRAPHY, TOPOGRAPHY AND DRAINAGE

The Site is located predominantly within the physiographic region classified by Chapman and Putnam (1984) as the Simcoe Uplands (Figure 2). The Simcoe Uplands physiographic region extends northeast from Lake Simcoe to Severn Sound encompassing a series of upland features separated by a network of incised, steep-sided sandy floored valleys, which are typically occupied by perennial streams. Gently to steeply rolling plains of Newmarket Till characterize the upland areas, with this till deposit often being overlain by fine- to coarse-textured glaciolacustrine and outwash deposits of silt and sand. The uplands are commonly surrounded by well-defined shorelines and beaches formed by glacial Lake Algonquin, with organic deposits consisting of peat, muck and marl sometimes occurring within the low-lying areas. Typical surface elevations range from 220 to 250 meters above mean sea level (m AMSL) in the valleys and 280 to 350 m AMSL in the uplands (Figure 3).

The Site largely lies upon drumlinized till plain (Figure 2) and is situated approximately 1.8 kilometers (km) from the northeast flank of the Oro Moraine. The Oro Moraine is characterized by numerous local topographic highs and has been deeply incised by surface drainage, although there are currently no perennial streams. The moraine forms both a regional aquifer, recharge area, and the headwaters for three major watersheds within the South Georgian Bay-Lake Simcoe Watershed Region: the Lake Simcoe, Nottawasaga Valley, and Severn Sound watersheds. Most of the Site is located within the Severn Sound watershed, with the most southern portion of the Site (i.e., lands located to south of BH15; Figure 1) occurring within the Lake Simcoe watershed.

Within the Severn Sound watershed to the north and northwest of the Oro Moraine, the Simcoe Uplands are drained by streams in the valley network into Severn Sound. Bass Lake, which is positioned approximately 600 meters (m) to the northwest of the Site, occurs in this watershed (Figure 1).

As shown in Figure 3, the Site is characterized by hummocky topography, with the terrain generally sloping from the southwest and east towards a low-lying area located in the central to northern portion of the property. The topographic high points occur in the southwest, central east, and northeast corner of the Site, where elevations range from 280 to 286 m AMSL. These elevations decline to 258 to 264 m AMSL in the low-lying area of the Site, which is occupied by a wetland.

Two intermittent drainage swales occupy the Site, with Swale A entering along the western boundary in the south-central end of the property (Figure 1). Swale A is a grassy, undefined channel that drains a swamp located offsite to the west of Line 15 North and eventually connects to the existing onsite stormwater management (SWM) pond. Swale A functions as an intermittent drainage feature, capturing ground surface runoff during the wet season (i.e., winter-spring), but becomes dry (i.e., non-flowing) during the hot summer months. Swale B enters through the northwest end of the Site and is characterized by a predominantly dry, undefined channel that traverses an actively cropped field. Similarly, Swale B is reported to capture and convey surface water runoff from the Site during the spring freshet and possibly during notable precipitation events (Beacon Environmental, 2019).

A third watercourse is present onsite that is referred to as the Bass Lake Drain, which originates from the outlet of the SWM pond (Figure 1). This watercourse directs flows from the wetland to the northwest, exiting the Site at Bass lake Sideroad East, and eventually discharges to Bass Lake.

Charter notes that grading activities that have occurred in the south end of the Site has adjusted the landscape such that surface water drainage from this area is now directed northwards towards the SWM pond. As a result, the Lakes Simcoe and Couchiching-Black River Source Protection Area boundary, as shown on shown on Figure 1, may now be positioned further south than what is currently depicted (i.e., beyond the southern limits of the Site).

2.2 REGIONAL GEOLOGY AND HYDROSTRATIGRAPHY

Geological conditions within the region are summarized in the Severn Sound Source Protection Area (SGBLSSPA, 2015a) and Lakes Simcoe and Couchiching River Source Protection Area (SGBLSSPA, 2015b) Assessment Reports, with the interpretation of hydrostratigraphic conditions near the Site being further refined by Stantec using information presented in the Ontario Geological Survey report produced by Burt and Dodge (2011). The initial work completed by Burt and Dodge (2011) involved the development of a three-dimensional conceptual model in the Barrie-Oro Moraine area, taking geological formations having similar hydrogeological properties, textural characteristics, and stratigraphic position and grouping them together to form hydrostratigraphic units, which were further categorized into aquifers and aquitards. This initial work by Burt and Dodge (2011) was expanded upon by Earthfx (2013), which involved the development and calibration of an integrated surface water and groundwater flow model for the Oro Moraine area based on these hydrostratigraphic units. The units identified as occurring in the region where the Site resides, listed in order from youngest to oldest, are as follows:

Algonquin Aquifer: Surficial aquifer comprised of permeable ice-contact deposits (predominantly sand and gravel containing lenses of silt and clay left behind by the melting of enclosed ice blocks) (Figure 4; Unit 6) together with shallow water coarse-textured glaciolacustrine sediments (medium to fine sand and silty fine sand) deposited by glacial Lake Algonquin (Figure 4; Unit 9c). This aquifer typically ranges from 1 m to 20 m thick and locally can reach up to 35 m thick in buried tunnel valleys. Topographic low-lying areas underlain by this unit throughout the Simcoe Uplands and occupied by wetlands will also include modern organic deposits (i.e., peat, marl) (Figure 4; Unit 20). This aquifer is used for domestic water supply in the region. Although surficial deposits associated with this hydrostratigraphic unit appear to occur within the central to northwestern areas of the Site, as well as the southeast corner of the property, there is no evidence indicating that an aquifer system is present within these onsite deposits (i.e., groundwater table largely resides in the Newmarket Till / Aquitard; Section 4.2.1).

Oro Moraine Aquifer: Surficial ice-contact stratified drift (i.e., sand and gravel containing lenses of silt and clay) and outwash deposits associated with the Oro Moraine, which are thickest in the central portions of the moraine (up to 69 m) and become progressively thinner moving towards the edges of this feature (i.e., less than 1 m in thickness). This aquifer does not provide a key source of water for domestic and agricultural uses throughout the region, with a very small proportion of wells drawing water from this system (Burt and Dodge, 2011); however, the deposits comprising this aquifer do act as a notable groundwater recharge area for the three major watersheds (i.e., Lake Simcoe, Nottawasaga Valley, and Severn Sound). This hydrostratigraphic unit is not encountered beneath the Site.

Newmarket Aquitard: Composed primarily of the Newmarket Till (i.e., stony sandy silt to silty sand till), combined with deep-water glaciolacustrine deposits of interbedded silt to silty clay (Figure 4, Unit 5b). This aquitard is laterally extensive throughout the region, typically ranging from 1 m to 20 m in thickness, with this unit occurring at ground surface over much of the Simcoe Uplands. However, in low-lying areas, it is common to find sediments of the Algonquin Aquifer overlying the Newmarket Aquitard. The horizontal hydraulic conductivity of the aquitard is reported to be in the range of 10^{-8} metres per second (m/s) (10^{-6} m/s where the till is weathered), with the vertical hydraulic conductivity being in the range of 10^{-9} m/s (Kassenaar and Wexler, 2006). The Newmarket Till / Aquitard forms a horizontally continuous unit beneath the Site.

Upper Aquifer Complex: An aquifer complex consisting of a regionally significant upper aquifer (gravel, sand, and silty sand; AF1) and much smaller local aquifer (gravel, sand, and silty sand; AF2), separated by a local aquitard (silt, silty clay, and clay; AT1). The thickness of upper aquifer (AF1) can range from one meter to 78 m; however, its typical thickness is less than 40 m. The local aquitard (AT1) ranges from one meter to 45 m in thickness and is often less than 25 m thick, with the local aquifer (AF2) generally being less than 15 m thick. As per mapping presented in Burt and Dodge (2011), the local aquitard (AT1) and local aquifer (AF2) do not appear to be present in the subsurface near the Site. Where buried tunnel valleys are present, this aquifer complex can be hydraulically connected to the overlying Algonquin Aquifer (where present). The upper aquifer (AF1) is correlated with the Thorncliffe Aquifer Complex as modeled by Kassenaar and Wexler (2006), with the horizontal hydraulic conductivity of this unit being reported to be in the range of 10^{-5} m/s. Overall, this aquifer complex is an important supplier of domestic and agricultural water throughout the region. This hydrostratigraphic unit is encountered beneath the Site and is overlain by the Newmarket Aquitard.

Regional Aquitard: A fine textured diamicton[1] extending from Lake Simcoe and under the Oro Moraine that is comprised of both glacial till and deep-water glaciolacustrine deposits. This diamicton varies from slightly stony clayey silt till to a stony sandy silt till that typically ranges from one meter to 35 m in thickness; however, locally the diamicton can be in the range of 60 m thick. The regional aquitard is significant as this unit hydraulically separates the Upper Aquifer Complex from the Regional Aquifer. Drilling associated with the current investigation did not encounter this hydrostratigraphic unit beneath the

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[1] Diamicton is a general term used to describe a non-sorted or poorly sorted deposit containing a wide range of particle sizes derived from a broad range of sedimentary deposition processes (i.e., heterogenous mixture of clay, sand, gravel and boulders varying widely in size and shape). Often synonymous with the diamicton is the term “till”, but not all diamictons are tills.

Site; however, this is due to drilling being kept to depths of less than 10 m below ground surface (BGS). A review of drilling logs associated with local private water supply wells indicate that this aquitard occurs at an elevation of approximately 232.1 m AMSL beneath the Site.

As with the Regional Aquitard, the hydrostratigraphic units listed below were not encountered during drilling because the subsurface investigative work was confined to the upper 10 m of the overburden; however, previously mentioned regional investigations do indicate that these units do occur beneath the Site.

Regional Aquifer: Comprised of medium to coarse-textured sand, sandy gravel and boulder gravel beds deposited as a series of fining-upward pulses, which ranges from one meter to 54 m in thickness. Where buried tunnel valleys are present, this aquifer can be hydraulically connected to the overlying Upper Aquifer Complex. This aquifer complex is currently one of the most important aquifers in the region (Burt and Dodge, 2011).

Lower Drift: Sediment complex comprised of three aquitards: the lower drift upper aquitard (silty sand to sand till; one meter to 43 m thick, typically less than 25 m thick), the lower drift middle aquitard (clayey silt till; one meter to 53 m thick, typically less than 35 m thick), and the lower drift lower aquitard (sandy silt to silty sand till; one meter to 55 m thick, typically less than 35 m thick). The complex also contains two aquifer units: the lower drift local aquifer (glacial outwash deposit of sand and occasionally gravel; one meter to 32 m thick, typically less than 15 m thick) and the lower drift lower aquifer (fine-textured sand and silt; one meter to 45 m thick, typically less than 25 m thick). These aquifer units are reported to represent locally notable sources of water supply (Burt and Dodge, 2011). The West Orillia Well of the Orillia Water Supply System, which is located approximately 950 m to the east of the Site, is reported to draw its groundwater supply from this aquifer system (SGBLSSPC, 2015a) (Figure 5).

Basal Aquifer: Small isolated pockets of gravel and cobble that directly overlie the bedrock surface, raging from one meter to 22 m in thickness but typically less than 15 m thick.

Bedrock Aquifer: Bedrock of the Simcoe Group, consisting of the Bobcaygeon Formation (limestone with shale interbeds) forming the bedrock surface in the area containing the Site, which subsequently overlies the Gull River (thin- to medium-bedded limestone) and Shadow Lake (interbedded shale, siltstone, and sandstone) Formations. As per Singer *et al.* (2003), the water-yielding capacity for the bedrock formations of the Simcoe Group is fair (for domestic water supply purposes), with this hydrogeologic unit having a reported average transmissivity of 5.7 square metres per day (m^2/day).

2.3 REGIONAL HYDROGEOLOGY

2.3.1 Groundwater Flow, Recharge and Discharge Areas

As presented in the Severn Sound Source Protection Area Assessment Report (SGBLSSPC, 2015a) (Figure 3.1-20, Appendix C), simulated water table surface elevations produced via a calibrated steady-state groundwater flow model completed as part of the North Simcoe Municipal Groundwater Study (Golder Associates, 2004), suggests that groundwater near the Site moves to the north to northwest through the upper overburden (i.e., Newmarket Till and overlying glaciolacustrine and ice-contact deposits) in the area containing the Site towards Bass Lake.

Within the Severn Sound watershed, the key groundwater recharge area is the Oro Moraine, with river and creek valleys being the main receivers of groundwater discharge (SGBLSSPC, 2015a). As shown in Figure 3.1-22 (Appendix C), zones of groundwater recharge occur in the northwestern portions of the Site, coinciding with the topographic high areas where ice-contact deposits of sand and gravel are present. However, groundwater discharge conditions are mapped as occurring in the topographic low-lying areas of the Site where the wetland resides.

2.3.2 Water Supply

A review of the Ministry of the Environment, Conservation and Parks (MECP) Water Well Information System (2020a) indicates that there is a total of 59 water wells located within 500 m of the Site boundary (Figure 4). Most of these wells (54) are listed as being utilized for public or domestic water supply purposes, with two of the wells providing water for livestock, and remaining three locations representing test holes and/or monitoring wells (i.e., not used as water supply) (Appendix D). The casings of the previously mentioned public and domestic wells extend to elevations ranging from 260.6 m AMSL to 206.3 m AMSL, indicating that these wells either draw their groundwater supplies from the Upper Aquifer Complex or one of the deeper regional aquifer systems, noting that the top of the Upper Aquifer is estimated to occur at elevations ranging from 257.4 to 273.2 m AMSL beneath the Site (Section 4.1). In reviewing the reported lithology / stratigraphy associated with these domestic wells, it appears that a relatively thick aquitard unit(s) covers the aquifer systems in which these wells obtain their water supply (Appendix D), forming a natural protective barrier between the aquifer and potential activities occurring at ground surface across the Site.

2.4 SOURCE WATER PROTECTION

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 Severn Sound and Lakes Simcoe and Couchiching-Black River Source Protection Areas (SPA). Within each SPA, the MECP has designated the following types of vulnerable areas that apply to drinking water sources:

Wellhead Protection Areas (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: Time-of-travel to the municipal well is two years or less.
- WHPA-C: Time-of-travel to the municipal well is equal to or less than five years and greater than two years.
- WHPA-D: Time-of-travel to the municipal well is equal to or less than 25 years and greater than five years.

As shown in Figure 5, lands within the Site to the north of BH8 and BH10 are intercepted by WHPA-C of the West Orillia Well of the Orillia Water Supply System. The West Orillia Well is screened to a depth of 48.8 to 57.9 m BGS and is reported to draw its groundwater supply from a confined sand and gravel aquifer, specifically the Lower Drift Aquifer (SGBLSSPC, 2015a). As shown in Figure 6, WHPA-C that extends through the Site is assigned a vulnerability score of 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 the West Orillia Well draws its groundwater supply, is low.

Significant Groundwater Recharge Areas (SGRA): A local area where the annual groundwater recharge rate is 15% greater than the average annual recharge rate calculated for a given SPA. For the Severn Sound SPA, where most of the Site resides (Figure 1), modeling / calculation of the annual groundwater recharge rate for this SPA included those lands located within the Nottawasaga Valley and Severn Sound watersheds. Given that the average annual recharge rate calculated for the Severn Sound SPA is 202 millimeters per year (mm/year), a SGRA is delineated where the annual recharge rate is greater than 232 mm/year (SGBLSSPC, 2015a). For the Lakes Simcoe and Couchiching-Black River SPA, where the southernmost area of the Site resides (Figure 1), the average annual recharge rate for this SPA is 164 mm/year; therefore, a SGRA subsequently is identified as an area having an annual recharge rate exceeding 189 mm/year (SGBLSSPC, 2015b).

The location of SGRA within the Site are shown on Figure 7, with these areas generally coinciding with areas where ice-contact and coarse-textured glaciolacustrine deposits of medium to fine sand, silty fine sand, and gravel occur at ground surface (Figure 4). The SGRA occurring onsite are assigned with a range of vulnerability scores: 2 (Low), 4 (Medium), and 6 (High) (Figure 7).

Highly Vulnerable Aquifers (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. For both the Severn Sound SPA and Lakes Simcoe and Couchiching-Black River SPA, an HVA is assigned a vulnerability score of 6. The location of HVA within the Site is shown on Figure 8. As with the SGRA, the HVA coincide with where ice-contact and coarse-textured glaciolacustrine deposits of medium to fine sand, silty fine sand, and gravel occur at ground surface (Figure 4).

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. These zones also include land adjacent to streams and storm sewers where surface water runoff can quickly reach the intake. As per the SGBLSSPC (2015a, 2015b), no IPZ intercept the Site.

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 a drinking water quantity threat activity can occur and pose a drinking water quantity threat. 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 MECP (2020b) Source Water Protection mapping, the Site is not located in a WHPA-Q.

3.0 METHODOLOGY

The hydrogeological site investigation included the:

- drilling of boreholes
- installation of monitoring wells
- installation of drive-point piezometers
- monitoring of groundwater levels
- performing hydraulic response (hydraulic conductivity) testing
- performing soil permeability / infiltration testing.

The methodology for these tasks is described in Sections 3.1 to 3.5 below.

3.1 BOREHOLE DRILLING AND MONITORING WELL INSTALLATIONS

Between May 14 and 22, 2019 boreholes were advanced at 18 locations across the Site as part of the geotechnical investigation (Stantec, 2020) (Figure 1), supplementing the two boreholes drilled along the Trans-Canada Energy pipeline easement as documented in Stantec (2018). Seven of the locations involved the drilling of a borehole, which was then equipped with a single monitoring well (i.e., BH/MW06, BH/MW09, BH/MW10, BH/MW13, BH/MW15, BH/MW16, BH/MW18). Two of the locations involved the installation of a multi-level monitoring well (i.e., BH/MW02 and BH/MW04) where two boreholes (one shallow and one deep) were drilled within meters of each other, with each of these boreholes then being equipped with a single monitoring well. Overall, the boreholes were strategically positioned throughout the Site to obtain a spatially representative understanding of soil conditions, groundwater depths and fluctuations, and to evaluate local patterns of groundwater flow.

Stantec, on behalf of Charter, retained a qualified drilling contractor to complete the borehole drilling and monitoring well installations. The boreholes were drilled using a track-mounted drilling rig equipped with a hollow stem auger drilling system (i.e., to permit the installation of monitoring wells). Soil samples were collected using split-spoon sampling techniques. 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 3.8 m (12.5 feet) of drilling depth, followed by sample collection occurring at approximately every 1.5 m (5 feet) to the termination depth of the borehole. The completed depths of the boreholes ranged from 5.2 m to 9.8 m below ground surface (BGS). Stantec personnel directed the drilling and soil sampling operations and logged the borehole stratigraphy using the American Society for Testing and Materials (ASTM) guideline for the description and identification of soils (ASTM, 2009). 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. Copies of the borehole logs are provided in Appendix D.

The drilling contractor installed the monitoring wells adhering to the construction requirements as outlined under Ontario Regulation 903 (O. Reg. 903) (MOE, 1990). 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 to 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.

Following installation, Stantec personnel purged each monitoring well using dedicated 16 mm (2/3 inch) inside diameter high density polyethylene (HDPE) tubing connected to a D-25 Waterra™ foot valve. Using the dedicated tubing, Stantec personnel purged up to five standing column volumes from each well (where possible) to clear out any fine-grained sediments and, subsequently, establish a proper hydraulic connection with the native aquifer material.

Charter retained a surveyor to tie in the ground surface and top-of-pipe elevations at each monitoring well location to a geodetic benchmark.

3.2 DRIVE-POINT PIEZOMETER INSTALLATION

On June 14, 2019, Stantec personnel installed one multi-level drive-point piezometer, consisting of a shallow and a deep piezometer (i.e., DP1-19(S) and DP1-19(D)), along the southeastern limits of the wetland adjacent to the Trans-Canada Energy pipeline easement (Figure 1). The multi-level piezometer was installed to evaluate whether this wetland functions as a groundwater recharge feature (i.e., contributes water to subsurface), discharge feature (receives water from the subsurface), or a combination of both.

Each drive-point piezometer is constructed of a 0.42 m long steel screen (19 mm diameter) that is connected to 25 mm diameter steel riser pipes. Stantec personnel drove the drive-point piezometers into the substrate using a fence post driver, with shallow and deep pipes being constructed within one meter of each other and the mid-point of their screens being separated by a vertical distance of approximately 0.9 m. Construction details for the drive-point piezometers are summarized in Table 1.

3.3 GROUNDWATER LEVEL MONITORING

Groundwater levels were recorded at the monitoring well and piezometer locations from July 2019 to April 2020 using a combination of automated and manual measurement methods. Solinst® Edge Leveloggers® (Leveloggers) were installed at selected monitoring well and piezometer locations to allow automatic measurement of water levels. The Leveloggers were suspended into the water column at each monitoring well and drive-point piezometer 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 BH/MW10.

Groundwater levels were manually measured several times from the onsite monitoring wells (two to three events) and the multi-level drive-point piezometer (two events) between June 2019 and April 2020. The groundwater level measurements were recorded in metres to the nearest 0.01 m using a battery-operated water level indicator. Manual groundwater level measurements were used to verify data recorded by the Leveloggers. Manual water levels collected from the monitoring wells and drive-point piezometer are presented in Tables 2 and 3, respectively. Hydrographs presenting both the automatic and manually measured groundwater level data are provided in Figures 9 and 10.

3.4 HYDRAULIC RESPONSE TESTING

Stantec performed in-situ hydraulic response testing at BH/MW04(S), BH/MW06, BH/MW09, BH/MW10, and BH/MW16 between June 4 and July 11, 2019, to estimate the horizontal hydraulic conductivity of the deposits beneath the Site. The testing consisted of creating an instantaneous change in the well water level by removing a known volume of water followed by recording the time taken for the water level to return to static conditions (i.e., a rising head or bail test). Data were analyzed using the Bouwer and Rice (1976, 1989) solution for a bail test in an unconfined aquifer as provided in the software package AQTESOLV™ Pro Version 4.5 (Duffield, 2014). Testing provided an estimate of the horizontal hydraulic conductivity of the sediments within the screened interval for 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 E.

3.5 INFILTRATION TESTING

Assessment of the infiltration potential for the onsite soils involved the use of a Guelph Permeameter (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 0.2 to 0.5 m deep, 50 mm diameter cylindrical hole into the native soil at five locations for testing (i.e., GP1 to GP5, 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. 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 4 presents the results of this soil infiltration testing.

Stantec also used the in-situ hydraulic response testing results obtained at BH/MW04(S), BH/MW06, BH/MW09, BH/MW10, and BH/MW16 to estimate infiltration rates of the deeper overburden soils (i.e., between 1.3 m and 6.3 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 Credit Valley Conservation-Toronto and Region Conservation (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 4.

4.0 LOCAL GEOLOGY AND HYDROGEOLOGY

4.1 LOCAL GEOLOGY AND HYDROSTRATIGRAPHY

Figure 4 presents the surficial geology throughout the Site as mapped by the Ontario Geological Survey (OGS) (2010), with this mapping indicating that the central to northwestern portions of the property, including a small sliver in the southeast and northeast corners of the Site, is covered by coarse-textured glaciolacustrine or ice-contact deposits. The remaining areas of the Site are covered by stone-poor, silty to sandy glacial till (i.e., the Newmarket Till).

Figure 1 shows the locations of Cross-Section A-A’ (Figure 11) and B-B’ (Figure 12), which were constructed using geological information obtained from the onsite drilling completed at the Site by Stantec (Appendix D). Overall, the onsite drilling results validate the surficial soil mapping presented on Figure 4. The glaciolacustrine and ice-contact deposits of silty sand, sand, and gravel form a 0.3 to 3.8 m layer that directly overlies the Newmarket Till, except in those areas of the Site where this glacial till is exposed at ground surface. The Newmarket Till (i.e., stony sandy silt to silty sand till) ranges from 1.5 to 9.1 m in thickness and is underlain by a horizontally and vertically contiguous unit of sand and gravel that is interpreted to represent deposits associated with the Upper Aquifer Complex. The top of the Upper Aquifer Complex is interpreted to occur at elevations ranging from 257.4 to 273.2 m AMSL beneath the Site, extending to an elevation of 232.1 m AMSL, where this deposit potentially encounters the top of the Regional Aquitard (stony sandy to clayey silt till).

Boreholes completed by Stantec (2020) along the Trans-Canada Energy pipeline easement adjacent to the onsite wetland (i.e., BH18-01 and BH18-02) suggest that this feature is underlain by peat, some sand and gravel, followed by low permeability deposits of clay to silty clay and silt (Appendix D).

4.2 LOCAL HYDROGEOLOGY

4.2.1 Groundwater Levels and Flow

Figures 9 and 10 and Table 2 present the continuous and manual water levels recorded within the monitoring wells and drive-point piezometers between July 2019 and April 2020. Groundwater depths across the Site ranged from 0.4 m BGS (at BH/MW10) to greater than 9.2 m BGS (dry at BH/MW15) over the monitoring period, equating to elevations ranging from 260.0 m to 283.4 m AMSL. In general, the groundwater table largely resides in the Newmarket Till / Aquitard, with groundwater elevations found to be lowest in the topographic low areas of the Site and greatest within the topographic high areas of the Site.

As shown in the hydrographs (Figures 9 and 10), the water table demonstrated a similar pattern in fluctuations across the Site, with high groundwater conditions predominantly occurring in the spring (i.e., early March and April) as a result of lower evapotranspiration losses and a melting snowpack, which in turn provided a greater volume of water available to infiltrate and recharge the groundwater system. Moving into the summer months, the groundwater table begins to experience a steady decline, reaching its lowest elevation in late fall in response to more water being drawn from the subsurface over this period to meet evapotranspiration demands. This cyclical pattern of groundwater fluctuations is common within shallow groundwater systems in southern Ontario. Overall, the difference between the minimum and maximum groundwater elevations at the onsite monitoring wells ranged from 1.4 m (BH/MW04) to greater than 5.3 m (BH/MW06).

Throughout the Site, groundwater levels in those monitoring wells screened in the Newmarket Till / Aquitard (i.e., BH/MW06, BH/MW09, BH/MW10, BH/MW16) show a marked response to notable precipitation events (i.e., immediate spike/rise in the groundwater table). The response observed in these previously mentioned wells is largely a function of the smaller pore spaces associated with these finer-grained deposits, which 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 wells where the screen intervals are constructed into the overlying coarser-grained (i.e., larger pore) ice-contact and glaciolacustrine deposits of sand and gravel (e.g., BH/MW04; Figure 9). The low hydraulic conductivity associated with the Newmarket Till / Aquitard (i.e., 10^{-7} to 10^{-8} m/s; Table 1, Appendix E) also limits the ability of infiltrating water that reaches the groundwater table to horizontally move through these deposits, which will cause a potential mounding effect to occur at these locations during the wetter periods of the year. Overall, the physical characteristics of the Newmarket Till / Aquitard make this unit unsuitable for the use of Low Impact Development (LID) stormwater infiltration measures.

Figure 13 presents groundwater elevation contours and the interpreted direction of horizontal flow through the groundwater system beneath the Site using level measurements collected from the on-site monitoring wells in July 2019. In general, groundwater contours mimic the prevailing topography of the Site with groundwater flowing predominantly to the north and northeast through the Newmarket Till / Aquitard from the topographic high areas of the Site towards the onsite wetland, which represents the topographic low point of the Site and according to mapping shown on Figure 3.1-22 (Appendix C) as presented in the *Severn Sound Source Protection Area, Approved Assessment Report* (SGBLSSPC, 2015a) is identified as being a groundwater discharge area. However, Stantec notes that portions of the on-Site wetland may also act as groundwater recharge area, as suggested by the consistent downward vertical hydraulic gradients observed in DP1-19(S/D) (Table 3, Figure 10). Although no groundwater elevation data is available from the monitoring wells installed in the northeastern portion of the Site (i.e., groundwater elevation was consistently below the bottom of BH/MW02 over the monitoring period; 268.6 m AMSL), topographic contours suggest that groundwater is also flowing to the southwest from this area of the property towards the on-Site wetland. Overall, once reaching this topographic low point of the Site, groundwater flow is funnelled through the subsurface of the valley to the north/northwest and beyond the northern property boundary, with flow then continuing onward to Bass Lake. This interpretation agrees with regional groundwater flow mapping presented in Figure 3.1-20 (Appendix C).

Groundwater volume contributions to the wetland from the Newmarket Till / Aquitard are expected to be small, given that this hydrostratigraphic unit is characterized by low permeability. Horizontal hydraulic conductivity estimates calculated from in-situ hydraulic response testing completed at the on-Site monitoring wells screened in the sandy silt to silty sand till ranged from 1.5×10^{-7} m/s to 6.5×10^{-8} m/s (Table 1; Appendix E). These calculated values are consistent with the literature values of hydraulic conductivity provided for these deposits (Fetter, 1994) and with values provided for the Newmarket Till as reported in Kassenaar and Wexler (2006). Overall, the estimated bulk (i.e., geometric mean) horizontal hydraulic conductivity calculated for these overburden deposits is 1.1 x 10^{-7} m/s (Table 1).

The velocity at which groundwater horizontally flows through the Newmarket Till / Aquitard is calculated through the application of Darcy's law, where:

$$v = \frac{K \nabla}{\theta}$$

where: v = velocity (m/yr)
K = hydraulic conductivity
∇ = hydraulic gradient
θ = effective porosity

Assuming a soil porosity of 0.2 for glacial till (Fetter, 1994), a calculated average horizontal hydraulic gradient of 0.05 m/m, and a geometric mean hydraulic conductivity of 1.1 x 10^{-7} m/s, the estimated velocity of groundwater flowing through the Newmarket Till / Aquitard towards the on-Site wetland is calculated to be approximately 0.9 m/year (i.e., one meter every 1.1 years).

A second potential source of groundwater inputs to the on-Site wetland may occur through the glaciolacustrine and ice-contact deposits of silty sand, sand, and gravel that overlies the Newmarket Till / Aquitard in the central to northwestern portions of the Site (Figure 4). Where the glacial till directly lies beneath these sand and gravel deposits, the bulk of precipitation infiltrating through these sands and gravels may flow along this interface with the till as interflow (i.e., horizontal movement of water through the unsaturated zone) and eventually discharge to the on-Site wetland. However, out of all the boreholes drilled in areas of the Site where these surficial sand and gravel deposits are present, only BH/MW04 was observed to have a saturated zone above the interface with the Newmarket Till / Aquitard (Figure 9, Appendix D). As such, there does not appear to be a horizontally continuous zone of saturation present in the ice-contact / glaciolacustrine deposits connecting this unit to the wetland, suggesting that potential groundwater volume inputs from these deposits to the onsite wetland may also be limited. Overall, surface water runoff contributions from the hummocky topographic landscape are expected to be the main source of water that maintains the form and function of the on-Site wetland.

As shown in Figure 3.1-22 (Appendix C), the glaciolacustrine and ice-contact deposits of silty sand, sand, and gravel in the central to northwestern portions of the Site represent the main groundwater recharge area for the property, with limited recharge occurring in those areas of the Site where the Newmarket Till occurs near or at ground surface. Vertical hydraulic gradients recorded at BH/MW04, located in the northwest corner of the Site, continuously remained downward throughout the monitoring period (i.e., -0.02 to -0.05, Figure 9) confirming this recharge area function.

4.2.2 Infiltration Potential

Estimated infiltration rates for the overburden deposits are provided in Table 4. 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 Guelph Permeameter testing of the surficial deposits (i.e., 0.5 to 0.6 m BGS) and in-situ hydraulic response testing completed at each monitoring well for the deeper deposits (1.3 to 6.3 m BGS) (Section 3.5).

Vertical hydraulic conductivities for the ice-contact and glaciolacustrine deposits of silty sand to fine sand that occupy the Site ranged from 7.1×10^{-6} to 3.1×10^{-7} m/s. Based on these values, the calculated infiltration rates for the previously mentioned deposits range from 34 mm/hour to 78 mm/hour (Table 4).

Vertical hydraulic conductivities for the Newmarket Till (sandy silt to silty sand till) ranged from 2.6×10^{-8} to 6.5×10^{-9} m/s. Based on these values, the calculated infiltration rates for the previously mentioned deposits range from 12 mm/hour to 17 mm/hour (Table 4).

5.0 IMPACT ASSESSMENT AND MITIGATION MEASURES

5.1 SITE SERVICING AND CONSTRUCTION DEWATERING

The proposed development (Figure 1) is to consist of residential housing (single family, medium density, and high density) that will be connected to municipal water and sanitary services. In general, invert levels of watermain, storm and sanitary sewers are expected to be up to three to four meters below finished grades. Groundwater levels measured in the monitoring wells ranged from 0.4 m BGS to greater than 9.2 m BGS across the Site over the monitoring period (i.e., July 2019 to April 2020). Overall, it is reasonable to assume that the groundwater table may rise above servicing levels within some portions of the Site, particularly if the construction works associated with these servicing installations are completed between the late fall to spring.

Under a scenario where the Site requires construction dewatering (e.g., construction grading results in servicing invert levels occurring below the groundwater table), a water taking permit to complete this work from the MECP will likely be required. Under O. Reg. 64/16 and O. Reg. 63/16, a Permit to Take Water (PTTW) is required when dewatering volumes are expected to exceed 400,000 L/day, whereas an Environmental Activity and Sector Registry (EASR) is required for daily dewatering volumes ranging between 50,000 litres (L) and 400,000 L. For registering an EASR, the MECP will require the preparation of a Water Taking Report and a Discharge Plan Report. Overall, the type and extent of dewatering system to be used at the excavations will be the responsibility of the Construction Contractor and may include the use of a vacuum well point system, sump/trash pumps located within the excavation, or an equivalent system.

Where required, construction dewatering performed to install site servicing will result in the lowering of groundwater table to the base of a given excavation for a short duration. The effects of local dewatering in general cannot be mitigated, since dewatering deliberately seeks to create an effect (i.e., temporary lowering of groundwater levels); however, the amount of drawdown is anticipated to be low and isolated to a small distance around the excavation, given that the excavations will be relatively shallow and generally completed into the Newmarket Till / Aquitard where hydraulic conductivities range from 10^{-7} m/s to 10^{-8} m/s (Table 1; Appendix E). Overall, a dewatering assessment is recommended for completion during the detailed design phase of the development to assess potential dewatering volumes and water taking permitting requirements.

The performing of short-term construction dewatering is not expected to interfere with the municipal water supply (i.e., West Orillia Well of the Orillia Water Supply System, Figure 5) seeing that this municipal well is screened in the Lower Drift Aquifer (SGBLSSPC, 2015a), which is separated from the shallow overburden where dewatering would occur by at least two regional aquitards (i.e., Newmarket and Regional Aquitards).

The potential interference effects on local private well quantities are also expected to be minimal, given that the private wells located within 500 m of the Site according to MECP WWIS (Figure 4, Appendix D) are constructed within the Upper Aquifer Complex, with groundwater quantities in this aquifer being protected by the overlying low permeability Newmarket Till / Aquitard. Stantec notes that if in the unlikely event on-Site construction dewatering were to interfere with offsite private well quantities, the residual effects of this dewatering will be reversible. Once pumping ceases, groundwater levels will recover as local groundwater levels re-equilibrate with the local groundwater table. Stantec also notes that the monitoring of water levels in offsite private wells is often a condition of a PTTW, should such a permit be required to complete construction dewatering activities at the Site.

Potential construction dewatering is also expected to have no detrimental effects on the hydrogeological function of the on-Site wetland, given that groundwater inputs to this feature from the Site appear to be minimal (Section 4.2.1).

If groundwater levels are expected to occur above servicing levels, mitigation measures may also be required to minimize the disturbance that this servicing may have on pre-development groundwater flow patterns (e.g., installation of anti-seepage collars in trenches to prevent the preferential movement of groundwater along the servicing alignments). The exact placement of the anti-seepage collars along the servicing alignments will be explored in more detail during the next design phase of the project.

5.2 GROUNDWATER RECHARGE

As per the proposed development plan (Figure 1) the Site will experience construction of single family, medium density, and high density residential and internal roadways. In the areas of the Site where this development is to occur, there will also be the introduction of impervious surfaces (e.g., rooftops, concrete/asphalt roadways and walkways) and, subsequently, a corresponding reduction in the volume of water infiltrating to the subsurface.

Water balance calculations presented in the Pearson Engineering (2022) *Functional Servicing and Preliminary Stormwater Management Report* indicate that under the pre-development condition, the annual volume of infiltration occurring across the Site is 124,925 m^3. Under the post-development condition, this annual infiltration volume is predicted to be reduced to 50,810 m^3, equating to an annual infiltration deficit of 74,115 m^3.

Low impact development (LID) is a stormwater management 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. Infiltration augmentation options (as described in CVC-TRCA Low Impact Development Stormwater Management Planning and Design Guide, 2010) that could potentially be available for use across the Site to assist in maximizing infiltration under the post-development condition include:

- roof downspout disconnection

- soakaways / infiltration trenches
- bioretention cells
- vegetated filter strips
- grass swales or enhanced grassed swales

A key constraint in using several of the mentioned infiltration augmentation measures (i.e., soakaways / infiltration trenches, bioretention, vegetated filter strips, grass swales) is the positioning of the seasonally high groundwater table. As per CVC-TRCA (2010), the recommended vertical separation between the base of the given infiltration augmentation option and the high groundwater table is at least one meter; however, distances of less than one meter of separation in soils having higher infiltration potential (e.g., sand and gravel soils) may still be effective.

If LIDs are considered for the Site, Stantec recommends that such strategies be best employed in the central to northwestern portions of the property where coarse-textured glaciolacustrine or ice-contact deposits of silty sand, sand, and gravel occur (Figure 4). As discussed previously, these deposits are characterized by higher infiltration potential (i.e., rates ranging from 34 to 78 mm/hour) and are preferable for post-development infiltration compared to those low infiltration potential areas of the Site where the Newmarket Till / Aquitard occurs at or near ground surface (i.e., rates ranging from 12 to 17 mm/hour). In addition, the central to northwestern portions of the Site appear to have greater depths of unsaturated soil to achieve the one meter of separation between the base of infiltration augmentation options and the high groundwater table.

As discussed in the Pearson Engineering (2022) *Functional Servicing and Preliminary Stormwater Management Report*, the incorporation of the following LID measures in those areas of the Site where favourable soils are present (i.e., coarse-textured glaciolacustrine or ice-contact deposits of silty sand, sand, and gravel) will be considered:

- The employment of a treatment train approach with precipitation captured by rooftop areas within the medium and high-density blocks, commercial block, and school block being directed to underground infiltration galleries and/or soakaway pits.
- Bioretention trenches.
- Lot grading designed to minimum City of Orillia grades.
- Permeable pavers to promote infiltration, filter storm runoff, and slow conveyance of runoff.
- Usage of filter strips, consisting of 5.0 m wide grassed areas, within the park and school blocks.

In addition, efforts will be made to locate the previously mentioned LIDs in areas of the Site where SGRA and ESGRA[2] are present.

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[2] Ecologically Significant Groundwater Recharge Area (ESGRA) are areas on the landscape that feed a particularly sensitive ecological feature such as a wetland, river, or stream. An area classified as ESGRA is not necessarily a SGRA. Where a SGRA is

As discussed in Sections 2.2 and 2.4, the regional groundwater supply aquifers beneath the Site are overlain by thick sections of the Newmarket Aquitard where development is proposed. As such, this aquitard provides a natural protective barrier that limits groundwater quantity (i.e., recharge) and quality interactions between the regional groundwater supply aquifer(s) and activities that will occur at ground surface throughout the Site. Consequently, the use of the previously mentioned LID options poses no threat to the quality of the underlying Upper Aquifer Complex, as these post-development infiltration augmentation structures will be constructed in the coarse-textured glaciolacustrine or ice-contact deposits that cover portions of the Site.

The suitability of using the previously mentioned infiltration augmentation options within the Site will be evaluated at the detailed design stage of the project. Once the locations of where LID measures will be constructed are finalized, Stantec recommends that additional infiltration testing be performed within the footprint of these proposed facilities to confirm the soil permeability potential of the underlying soils, which are to be used to confirm design infiltration rates. Overall, it is reasonable to conclude that the application of some or all these measures will assist in achieving the maximum groundwater recharge possible throughout the property under the post-development condition.

5.3 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.

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an area providing recharge volumes that are greater than an average annual rate calculated for a Source Protection Area, an ESGRA is defined as being an area important to providing groundwater recharge to a targeted ecological feature.

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. O. Reg. 385/08, s. 3.

As shown in Figure 5, lands within the Site to the north of BH8 and BH10 are intercepted by WHPA-C of the West Orillia Well of the Orillia Water Supply System. The WHPA-C has an assigned vulnerability score of four (4) (Figure 6), 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 the West Orillia Well draws its groundwater supply, is low.

As per the Source Protection Plan (SPP) (SGBLSSPC, 2019), the Site is only subject to the protection policies specified under Significant Drinking Water Threat Policy Category 16 (DNAPLs). Since the planned use for the Site does not involve the onsite handling and storage of a DNAPL, the policies under Category 16 do not apply.

No protection policies are specified in the SPP (SGBLSSPC, 2019) that apply to the areas of the Site that are designated as SGRA (Figure 7) or HVA (Figure 8).

5.4 SPILL CONTAINMENT AND RESPONSE

The potential exists for spills during any construction activity, with the most probable type of spill occurring being attributable to the refuelling of major construction equipment that cannot readily leave the Site (e.g., earth movers). The potential impacts of a spill could be the contamination of soils, groundwater, and/or surface water. By implementing proper protocols for the handling of fuels and lubricants during construction, the risk of a spill occurring will be greatly reduced. The procedures to be implemented to prevent onsite spills are as follows:

- all trucks or other road vehicles would be refuelled and maintained offsite, where practicable
- refuelling and lubrication of other construction equipment would not be allowed within 30 m of a drainage system or dewatering excavation
- regular inspections of hydraulic and fuel systems on machinery, with leaks being repaired immediately upon detection or the equipment being removed from Site
- spill kits containing absorbent materials would be kept on hand
- implement best management practices and develop an emergency spill response plan

Given that anticipated construction activities at the Site are not expected to involve the storage or use of bulk chemicals or fuels, any potential spill that does occur would be localized and involve a small volume of material. Standard containment facilities and emergency response materials are to be maintained onsite as required, with refuelling, equipment maintenance, and other potentially contaminating activities being confined to designated areas. As appropriate, spills are to be reported immediately to the MECP Spills Action Centre.

6.0 CONCLUSIONS

Based on the hydrogeological assessment, using the existing data collected at the Site and information obtained from a background review of regional data, the following conclusions are provided:

1. Newmarket Till / Aquitard (sandy silt to silty sand till) underlies the entire Site, ranging from 1.5 m to 9.1 m in thickness, and is overlain by a 0.3 to 3.8 m thick layer of glaciolacustrine and ice-contact silty sand, sand, and gravel in the central to northwestern portions of the property. The Newmarket Till / Aquitard is in turn underlain by a horizontally and vertically contiguous unit of sand and gravel that is interpreted to represent deposits associated with the Upper Aquifer Complex. The top of the Upper Aquifer Complex is interpreted to occur at elevations ranging from 257.4 to 273.2 m AMSL beneath the Site, extending to an elevation of 232.1 m AMSL, where this deposit appears to encounter the top of the Regional Aquitard (stony sandy to clayey silt till).

2. Groundwater depths across the Site ranged from 0.4 m to greater than 9.2 m BGS over the monitoring period (July 2019 to April 2020), equating to elevations ranging from 260.0 m AMSL to 283.4 m AMSL. In general, the groundwater table largely resides in the Newmarket Till / Aquitard, with groundwater elevations found to be lowest in the topographic low areas of the Site and greatest within the topographic high areas of the Site.

3. In general, groundwater contours mimic the prevailing topography of the Site, with groundwater flowing through the Newmarket Till / Aquitard from the topographic high areas of the Site towards the onsite wetland, which is identified as being a groundwater discharge area. Portions of the wetland may also function as groundwater recharge area as indicated by consistent downward vertical hydraulic gradients observed in the drive-point piezometers installed in this feature (i.e., DP1-19S/D). However, on-Site subsurface investigations (e.g., BH18-01, BH18-02; Appendix D) suggest that deposits underlying the wetland are associated with the Newmarket Till / Aquitard and, as such, recharge rates through these deposits will be low.

4. The estimated velocity of groundwater flowing through the Newmarket Till / Aquitard beneath the Site towards the onsite wetland is calculated to be approximately 0.9 m/year (i.e., one meter every 1.1 years), suggesting that groundwater volume contributions to the wetland from this low permeability unit will be limited compared to surface water inputs.

5. A second potential source of groundwater inputs to the onsite wetland may occur through the glaciolacustrine and ice-contact deposits of silty sand, sand, and gravel that overlies the Newmarket Till / Aquitard in the central to northwestern portions of the Site (via interflow along the interface of these deposits and the glacial till). However, there does not appear to be a horizontally continuous zone of saturation present in the ice-contact / glaciolacustrine deposits connecting this sand and gravel unit to the wetland, suggesting that potential groundwater volume inputs from these deposits to the onsite wetland are also likely limited.

6. Vertical hydraulic conductivities associated with the Newmarket Till / Aquitard range from 2.6 x 10^{-8} to 6.5 x 10^{-9} m/s, equating to infiltration rates of 12 mm/hour to 17 mm/hour. For the ice-contact and glaciolacustrine deposits of silty sand to fine sand, vertical hydraulic conductivities range from 7.1 x 10^{-6} to 3.1 x 10^{-7} m/s, equating to infiltration rates of 34 mm/hour to 78 mm/hour. These results indicate that the Newmarket Till / Aquitard is unsuitable for the use of Low Impact Development (LID) stormwater infiltration measures compared to those areas of the Site where sandy deposits are present.

7. Although the installation of servicing is expected to occur below the groundwater table within some portions of the Site, construction dewatering volumes are expected to be limited and confined to a small distance around open excavations due to the low permeability of the Newmarket Till / Aquitard (where the groundwater table is encountered throughout the Site). Overall, a dewatering assessment is recommended for completion during the detail design phase of the development to assess potential dewatering volumes and subsequent water taking permitting requirements.

8. The performing of short-term construction dewatering will not interfere with the water supply of the West Orillia Well, seeing that this municipal well is screened in the Lower Drift Aquifer (SGBLSSPC, 2015a), which is separated from the shallow overburden where dewatering would occur onsite by at least two regional aquitards (i.e., Newmarket and Regional Aquitards).

9. The potential interference effects on local private well quantities from potential onsite dewatering is expected to be minimal, given that the private wells located within 500 m of the Site are constructed within the Upper Aquifer Complex, with groundwater quantities in this aquifer being protected by the overlying low permeability Newmarket Till / Aquitard.

10. Potential construction dewatering is expected to have no detrimental effects on the hydrogeological function of the on-Site wetland, given that groundwater inputs to this feature from the Site already appear to be minimal.

11. If groundwater levels are expected to occur above servicing levels, mitigation measures may also be required to minimize the disturbance that this servicing may have on pre-development groundwater flow patterns (e.g., installation of anti-seepage collars in trenches to prevent the preferential movement of groundwater along the servicing alignments). The exact placement of the anti-seepage collars along the servicing alignments will be explored in more detail during the next design phase of the project.

12. The introduction of impervious surfaces associated with the development is expected to result in a corresponding reduction in the volume of water infiltrating to the subsurface. If Low Impact Development (LID) stormwater infiltration strategies are considered for the Site, such strategies will be best employed in the central to northwestern portions of the property where coarse-textured glaciolacustrine or ice-contact deposits of silty sand, sand, and gravel occur. As discussed previously, these deposits are characterized by higher infiltration potential (i.e., rates ranging from 34 to 78 mm/hour) and are preferable for post-development infiltration compared to those low infiltration potential areas of the Site where the Newmarket Till / Aquitard occurs at or near ground surface (i.e., rates ranging from 12 to 17 mm/hour). In addition, the central to northwestern portions of the Site appear to have greater depths of unsaturated soil to achieve the one meter of separation between the base of infiltration augmentation options and the high groundwater table.

13. The proposed development footprint for the Site is located within the WHPA-C for the West Orillia Well. Subsequently, as per the Source Protection Plan, the Site is only subject to the protection policies specified under Significant Drinking Water Threat Policy Category 16 (DNAPLs). Since the planned use for the Site does not involve the onsite handling and storage of a DNAPL, the policies under Category 16 do not apply to the development.

7.0 REFERENCES

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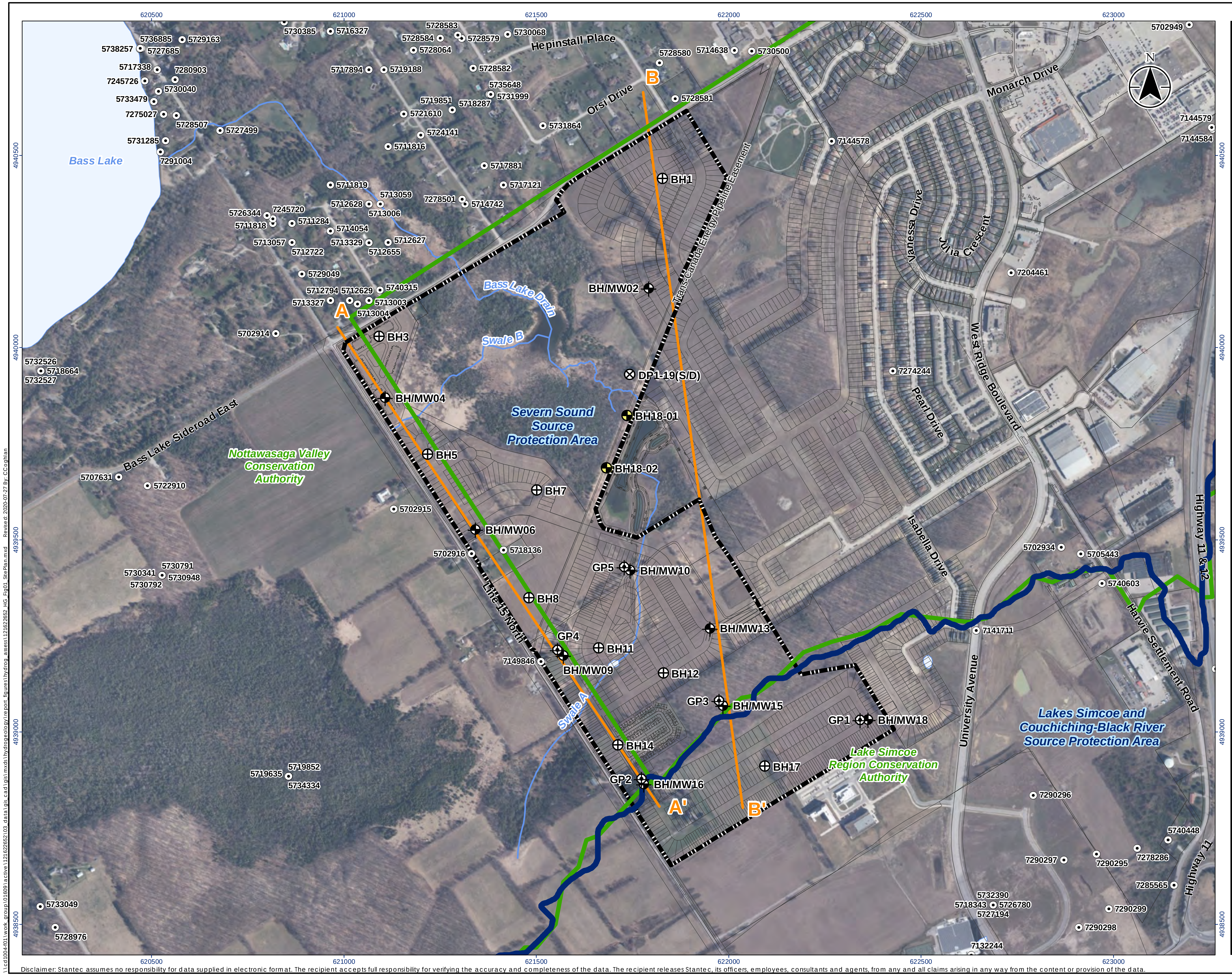
APPENDIX A:

FIGURES



Stantec

Legend

- ⬚ Site Boundary
- ⊕ Monitoring Well (Stantec, 2019)
- ⊕ Borehole (Stantec, 2019)
- ⊕ Borehole (Stantec, 2018)
- ⊗ Drive-Point Piezometer (Stantec, 2019)
- ⊕ Guelph Permeameter (Stantec, 2019)
- ⊙ MECP Water Well Record
- ― Cross-Section Location
- ― Development Plan
- ― Watercourse
- ▭ Waterbody
- ▭ Source Protection Area
- ▭ Conservation Authority Administrative Boundary

0 250 500 metres

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

Notes
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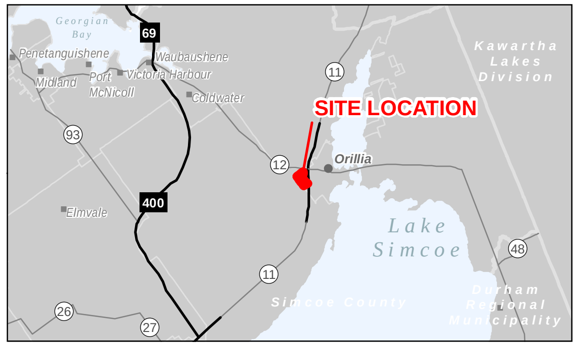
3. Orthoimagery © First Base Solutions, 2020. Imagery Date, 2016.
4. MECP water well record locations have been positioned based on published UTM coordinates and their locations should be considered approximate.



Project Location
Orillia, ON

121622652 REVA
Prepared by CMC on 2020-07-27
Technical Review by ABC on yyyy-mm-dd

Client/Project
CHARTER DEVELOPMENT LP.
WEST ORILLIA NEIGHBOURHOOD PLAN
ORILLIA, ONTARIO

Figure No.
1

Title
Site Plan

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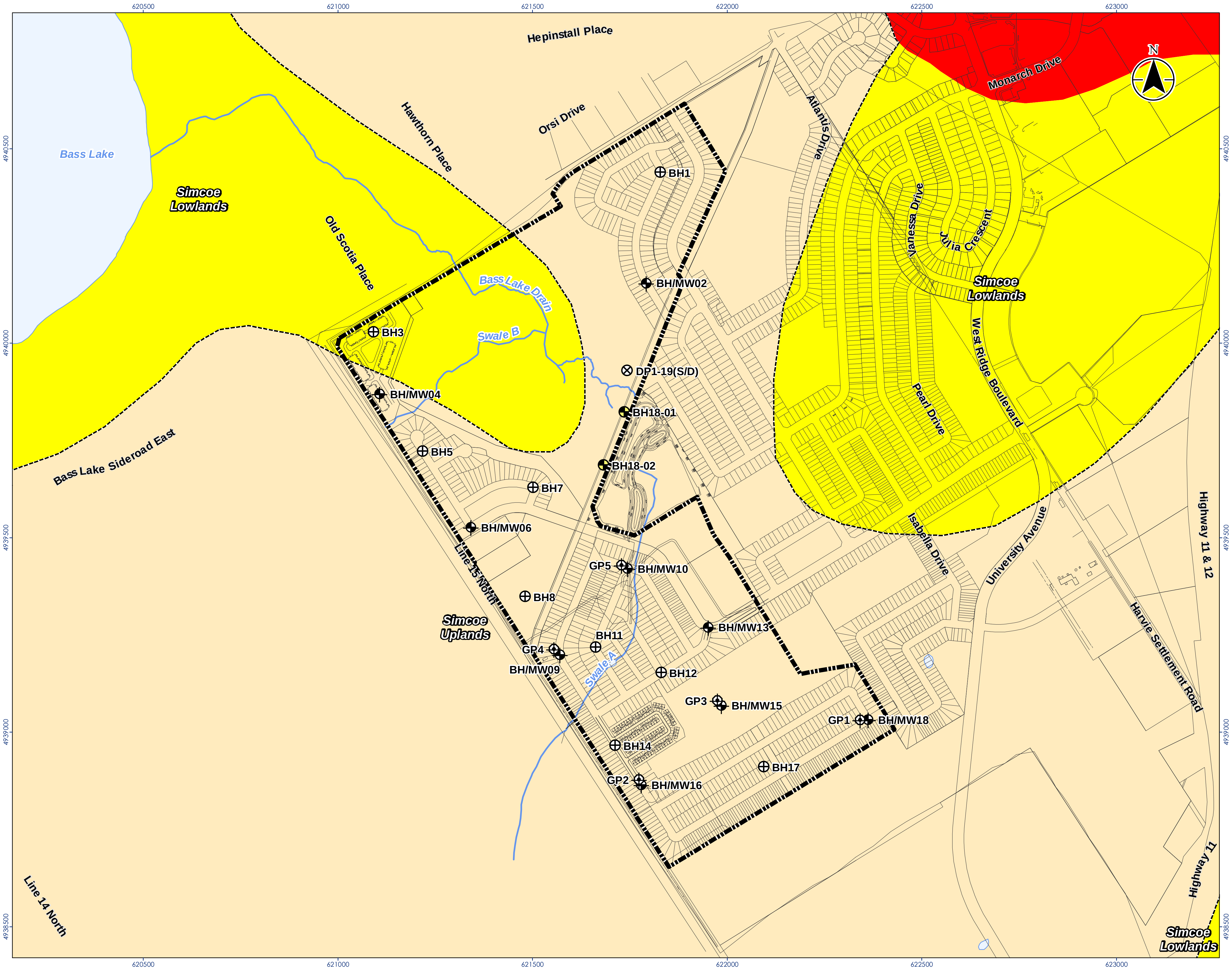


Stantec

Legend

⬚	Site Boundary
⊕	Monitoring Well (Stantec, 2019)
⊕	Borehole (Stantec, 2019)
●	Borehole (Stantec, 2018)
⊗	Drive-Point Piezometer (Stantec, 2019)
⊕	Guelph Permeameter (Stantec, 2019)
—	Development Plan
—	Watercourse
▭	Waterbody
⬚	Physiographic Region Boundary

Physiography

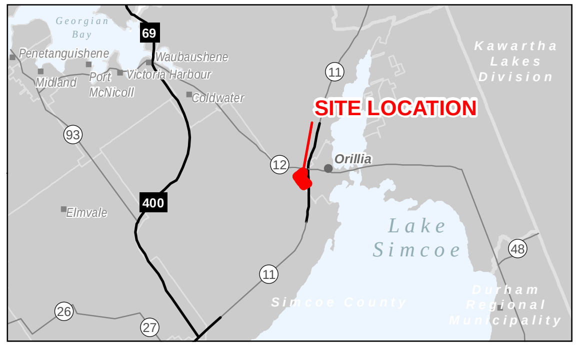
🟥	14: Beaches
🟨	11: Sand Plains
▭	6: Till Plains (Drumlinized)

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, 2020.
3. Chapman, L.J. and Putnam, D.F. 2007. Physiography of southern Ontario; Ontario Geological Survey, Miscellaneous Release—Data 228.



Project Location
Orillia, ON

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Technical Review by ABC on yyyy-mm-dd

Client/Project
CHARTER DEVELOPMENT LP.
WEST ORILLIA NEIGHBOURHOOD PLAN
ORILLIA, ONTARIO

Figure No.
2

Title
Physiography

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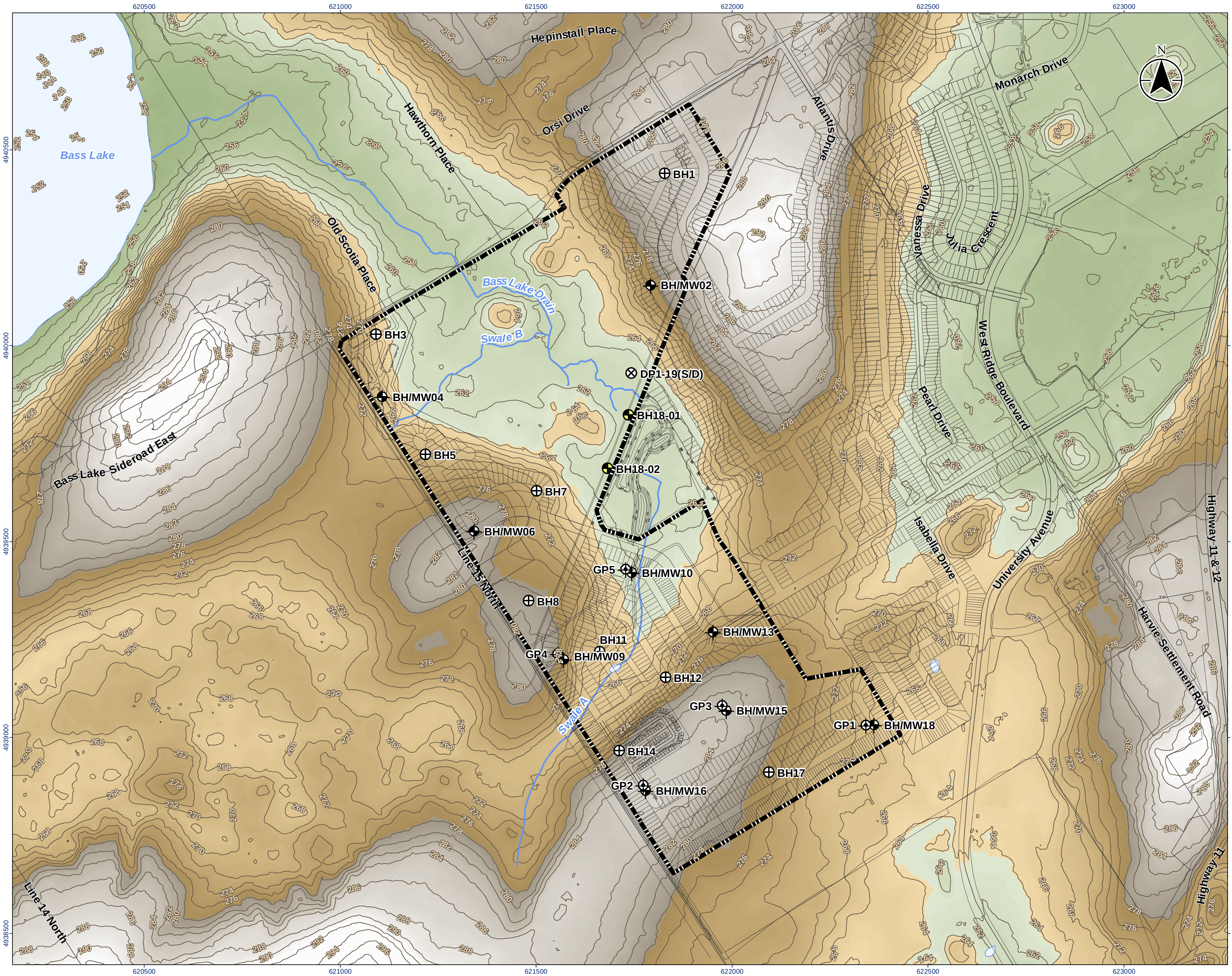

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Stantec

Legend

- ▭ Site Boundary
- ⊕ Monitoring Well (Stantec, 2019)
- ⊕ Borehole (Stantec, 2019)
- ● Borehole (Stantec, 2018)
- ⊗ Drive-Point Piezometer (Stantec, 2019)
- ⊕ Guelph Permeameter (Stantec, 2019)
- — Development Plan
- — Road
- — Topographic Contour (m AMSL)
- — Watercourse
- ▭ Waterbody

Ground Surface Elevation (m AMSL)

High : 298.96

Low : 234.82

0 250 500 metres

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

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
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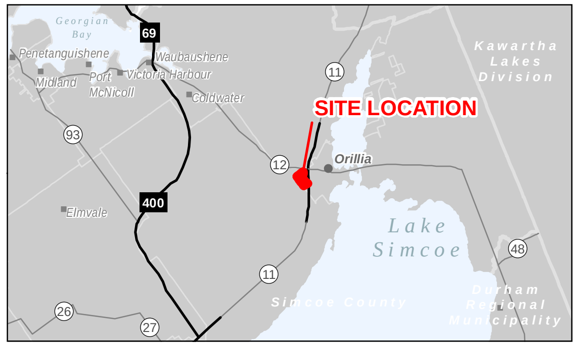
3. South Central Ontario Orthophotography Project (SCOOP) 2013 Digital Elevation Model.



Project Location
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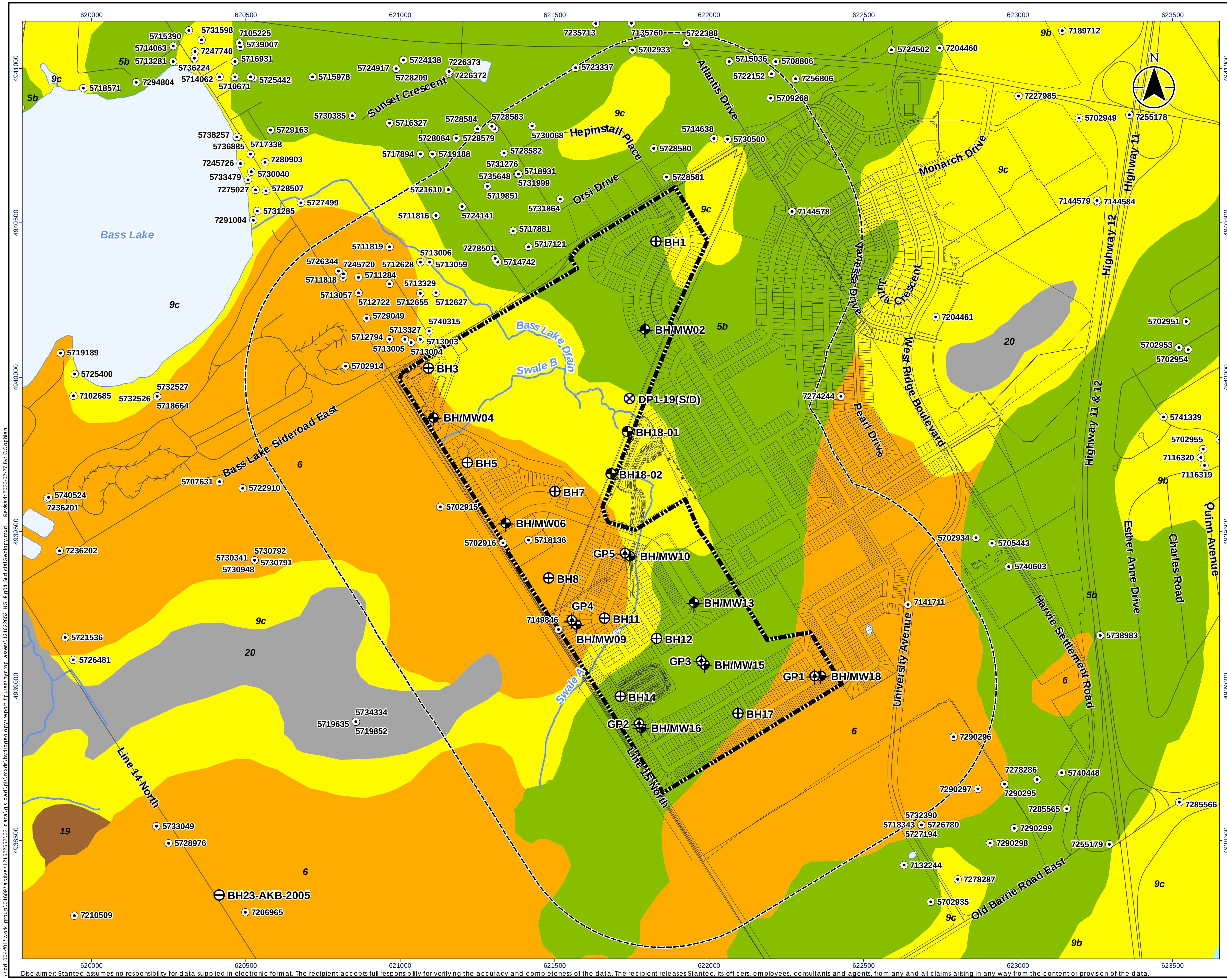
Client/Project
CHARTER DEVELOPMENT LP.
WEST ORILLIA NEIGHBOURHOOD PLAN
ORILLIA, ONTARIO

Figure No.
3

Title
Topography



Stantec

- ⬚ Site Boundary
- ⬚ 500m Buffer of Site
- ⊕ Monitoring Well (Stantec, 2019)
- ⊕ Borehole (Stantec, 2019)
- ⊕ Borehole (Stantec, 2018)
- ⊖ Borehole (Burt and Dodge, 2011)
- ⊗ Drive-Point Piezometer (Stantec, 2019)
- ⊕ Guelph Permeameter (Stantec, 2019)
- ⊙ MECP Water Well Record
- — Development Plan
- — Road
- — Watercourse
- ▭ Waterbody

Surficial Geology

- ■ 20: Organic deposits
- ■ 19: Modern alluvial deposits
- 🟨 9b: Coarse-textured glaciolacustrine deposits (Littoral-foreshore deposits)
- 🟨 9c: Coarse-textured glaciolacustrine deposits (Foreshore-basinal deposits)
- ■ 8a: Fine-textured glaciolacustrine deposits (Massive-well laminated)
- 🟧 6: Ice-contact stratified deposits
- 🟩 5b: Stone-poor, carbonate-derived silty to sandy till (Newmarket Till)

0 250 500 metres
1:12,500 (At original document size of 11x17)

Notes
1. Coordinate System: NAD 1983 UTM Zone 17N
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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. MECP water well record locations have been positioned based on published UTM coordinates and their locations should be considered approximate.

Project Location
Orillia, ON

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Technical Review by ABC on yyyy-mm-dd

Client/Project
CHARTER DEVELOPMENT LP.
WEST ORILLIA NEIGHBOURHOOD PLAN
ORILLIA, ONTARIO

Figure No.
4

Title
Surficial Geology

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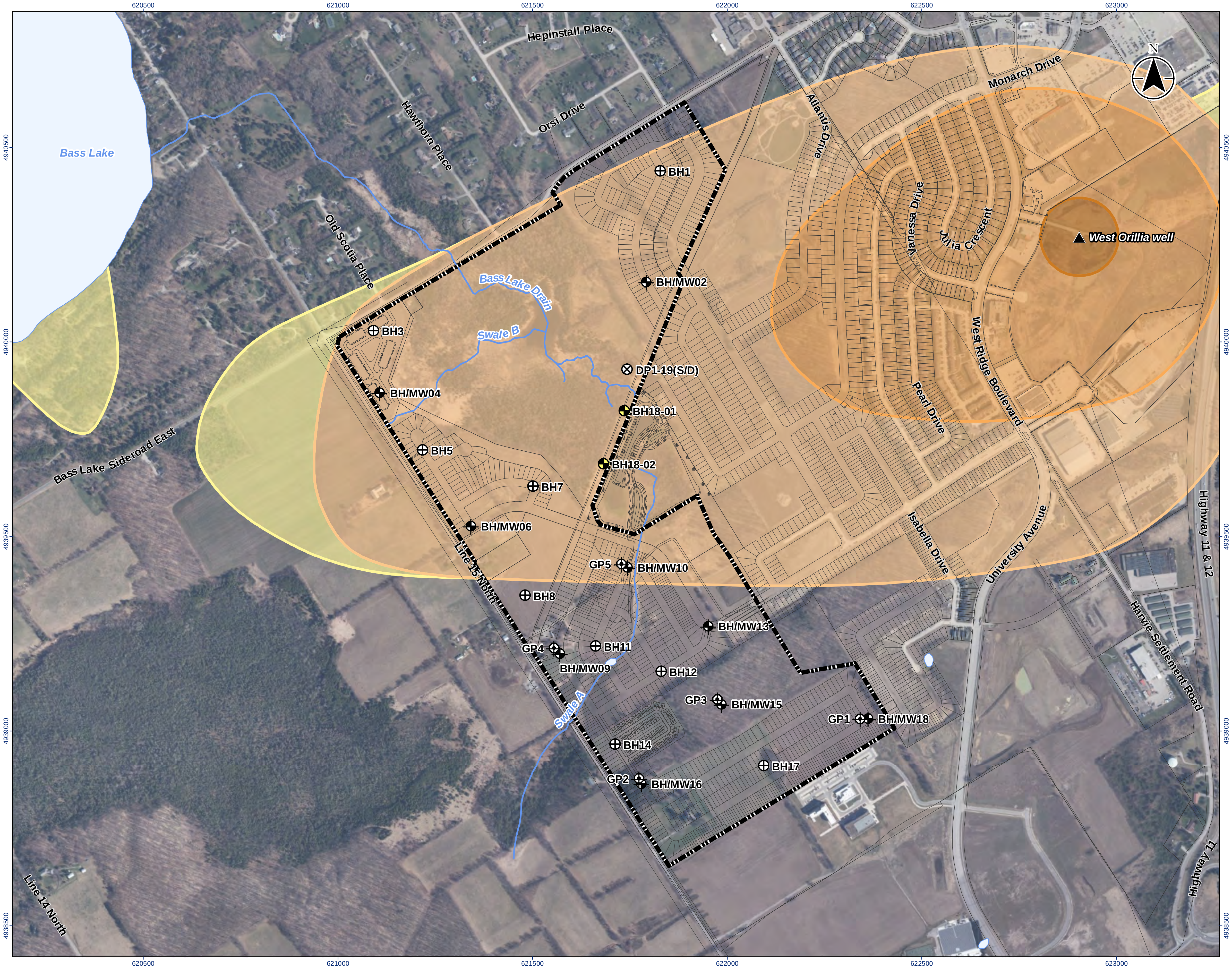

Stantec

Legend
- ⬚ Site Boundary
- ⌖ Monitoring Well (Stantec, 2019)
- ⊕ Borehole (Stantec, 2019)
- ⊕ Borehole (Stantec, 2018)
- ⊖ Borehole (Burt and Dodge, 2011)
- ⊗ Drive-Point Piezometer (Stantec, 2019)
- ⌖ Guelph Permeameter (Stantec, 2019)
- ▲ Municipal Supply Well
- — Development Plan
- — Watercourse
- ▭ Waterbody

Wellhead Protection Areas
- ▨ WHPA-A
- ▨ WHPA-B
- ▨ WHPA-C
- ▨ WHPA-D

0 250 500 metres

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

Notes
1. Coordinate System: NAD 1983 UTM Zone 17N
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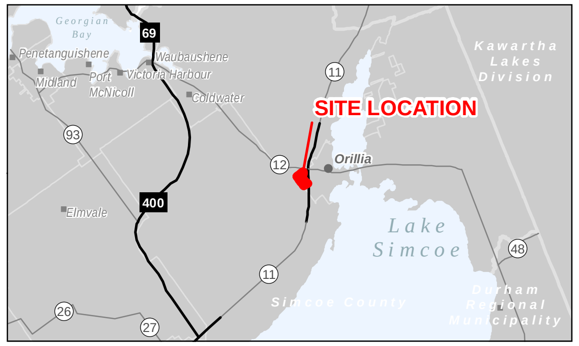

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Client/Project
CHARTER DEVELOPMENT LP.
WEST ORILLIA NEIGHBOURHOOD PLAN
ORILLIA, ONTARIO

Figure No.
5

Title
Wellhead Protection Areas

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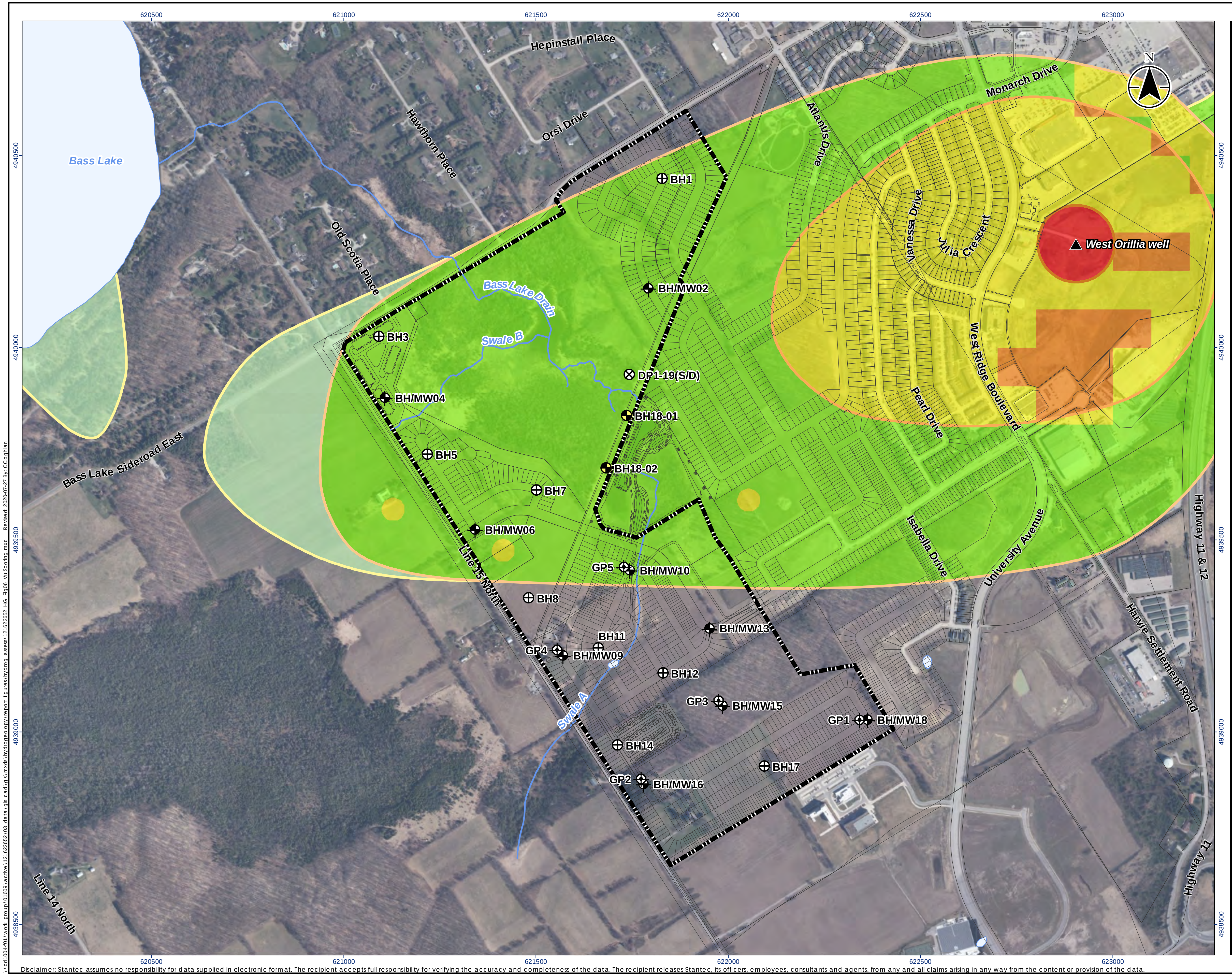

Stantec

- ⬚ Site Boundary
- ⊕ Monitoring Well (Stantec, 2019)
- ⊕ Borehole (Stantec, 2019)
- ● Borehole (Stantec, 2018)
- ⊖ Borehole (Burt and Dodge, 2011)
- ⊗ Drive-Point Piezometer (Stantec, 2019)
- ⊕ Guelph Permeameter (Stantec, 2019)
- ▲ Municipal Production Well
- — Development Plan
- — Watercourse
- ▭ Waterbody

Wellhead Protection Area

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

Vulnerability Score

- 🟩 2
- 🟩 4
- 🟨 6
- 🟧 8
- 🟥 10

0 250 500 metres

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

Notes

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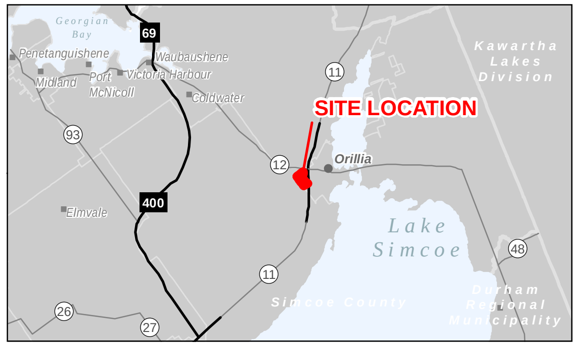

Project Location
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Technical Review by ABC on yyyy-mm-dd

Client/Project
CHARTER DEVELOPMENT LP.
WEST ORILLIA NEIGHBOURHOOD PLAN
ORILLIA, ONTARIO

Figure No.
6

Title
Vulnerability Scoring

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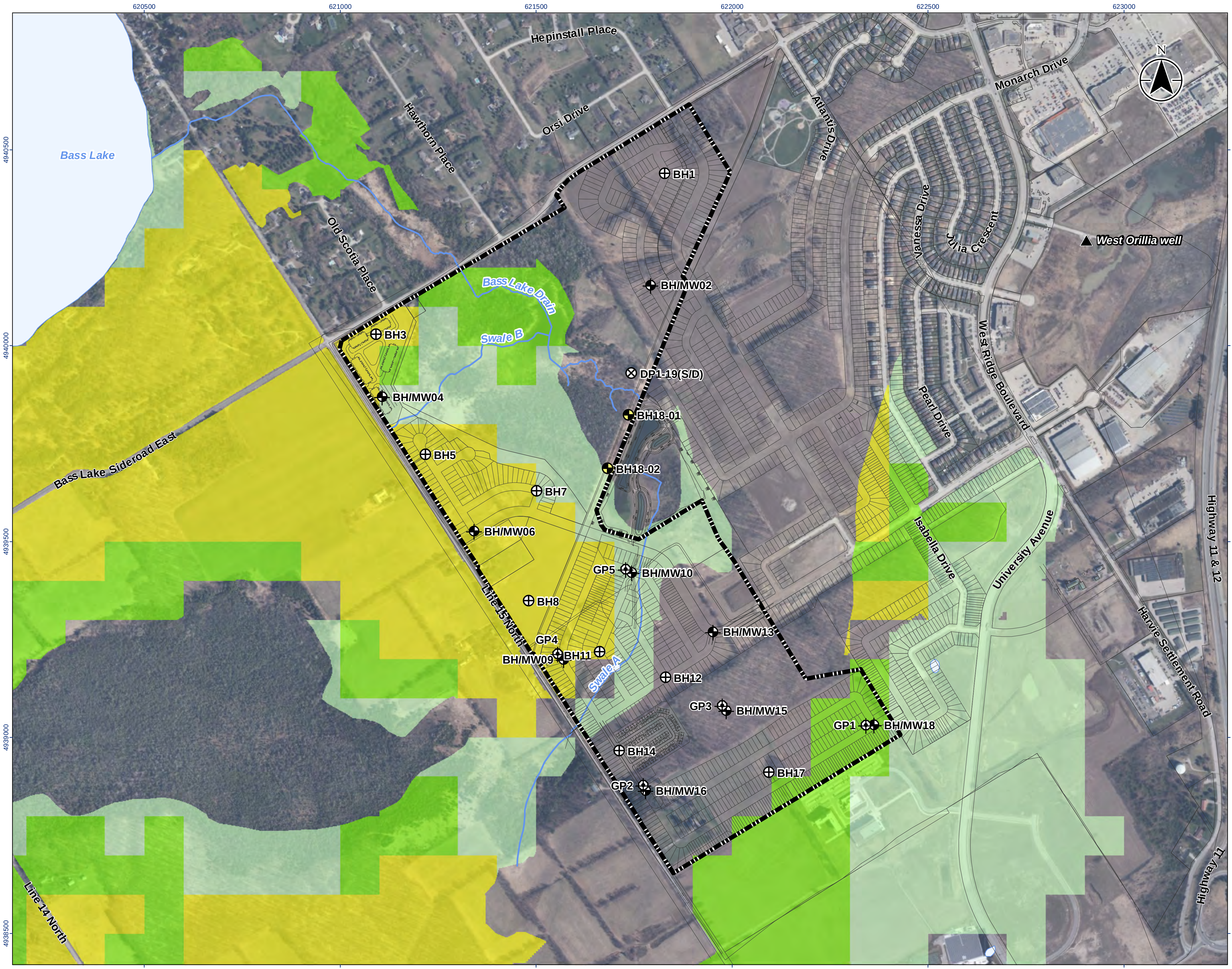

Stantec

Legend
▭ Site Boundary
⊕ Monitoring Well (Stantec, 2019)
⊕ Borehole (Stantec, 2019)
● Borehole (Stantec, 2018)
⊖ Borehole (Burt and Dodge, 2011)
⊗ Drive-Point Piezometer (Stantec, 2019)
⊕ Guelph Permeameter (Stantec, 2019)
▲ Municipal Supply Well
— Development Plan
— Watercourse
▭ Waterbody
Significant Groundwater Recharge Area
🟨 Vulnerability Score - 2
🟩 Vulnerability Score - 4
🟩 Vulnerability Score - 6

0 250 500 metres
1:10,000 (At original document size of 11x17)

Notes
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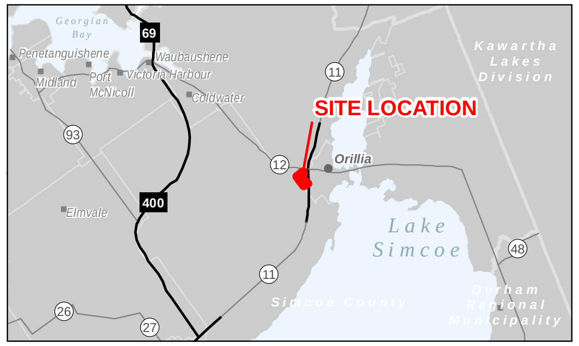

Project Location
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Technical Review by ABC on yyyy-mm-dd

Client/Project
CHARTER DEVELOPMENT LP.
WEST ORILLIA NEIGHBOURHOOD PLAN
ORILLIA, ONTARIO

Figure No.
7

Title
Significant Groundwater Recharge Areas

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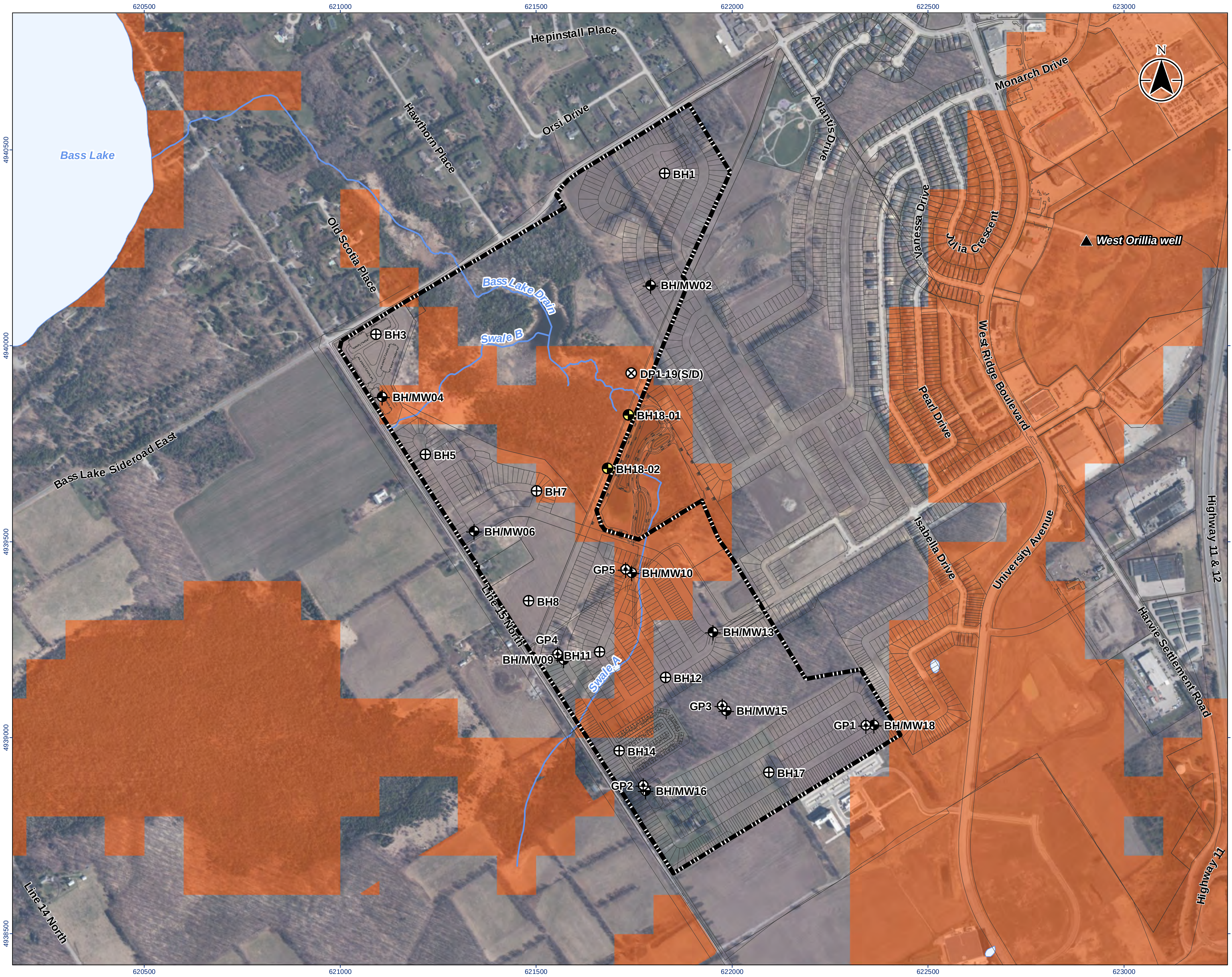

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Stantec

Legend
- ▭ Site Boundary
- ⊕ Monitoring Well (Stantec, 2019)
- ⊕ Borehole (Stantec, 2019)
- ● Borehole (Stantec, 2018)
- ⊖ Borehole (Burt and Dodge, 2011)
- ⊗ Drive-Point Piezometer (Stantec, 2019)
- ⊕ Guelph Permeameter (Stantec, 2019)
- ▲ Municipal Supply Well
- — Development Plan
- — Watercourse
- 🟧 Highly Vulnerable Aquifer
- ▭ Waterbody

0 250 500 metres

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

Notes
1. Coordinate System: NAD 1983 UTM Zone 17N
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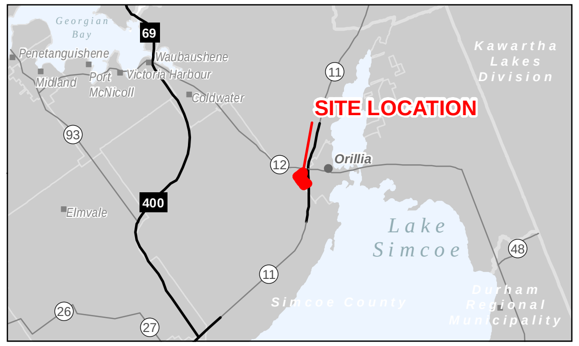

Project Location
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121622652 REVA
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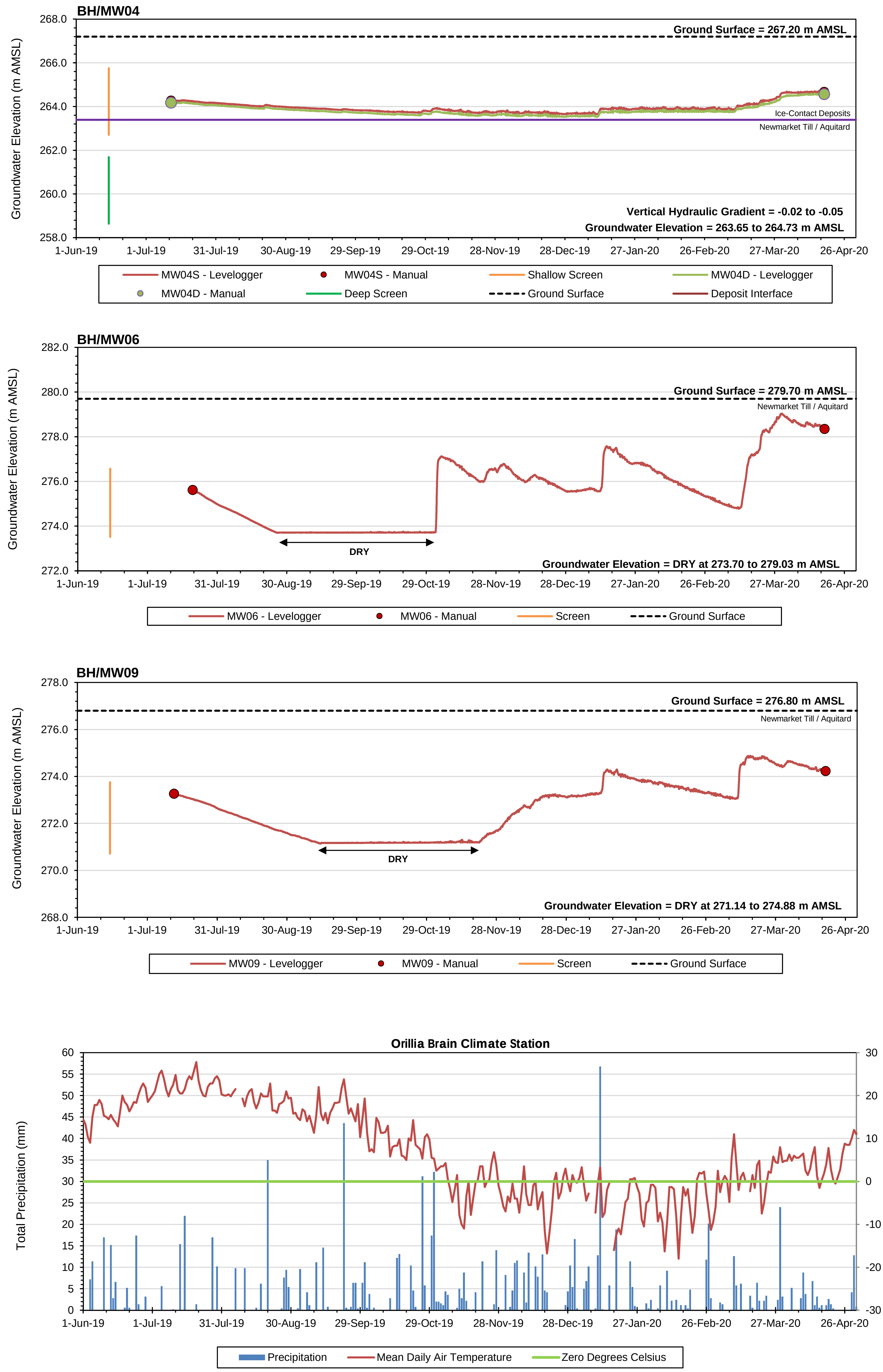
Technical Review by ABC on yyyy-mm-dd

Client/Project
CHARTER DEVELOPMENT LP.
WEST ORILLIA NEIGHBOURHOOD PLAN
ORILLIA, ONTARIO

Figure No.
8

Title
Highly Vulnerable Aquifer



Notes:

Precipitation and temperature data were obtained from Environment Canada for the Orillia Brain Climate Station (ID 6115811), accessed April 23, 2020.

Stantec

Client/Project

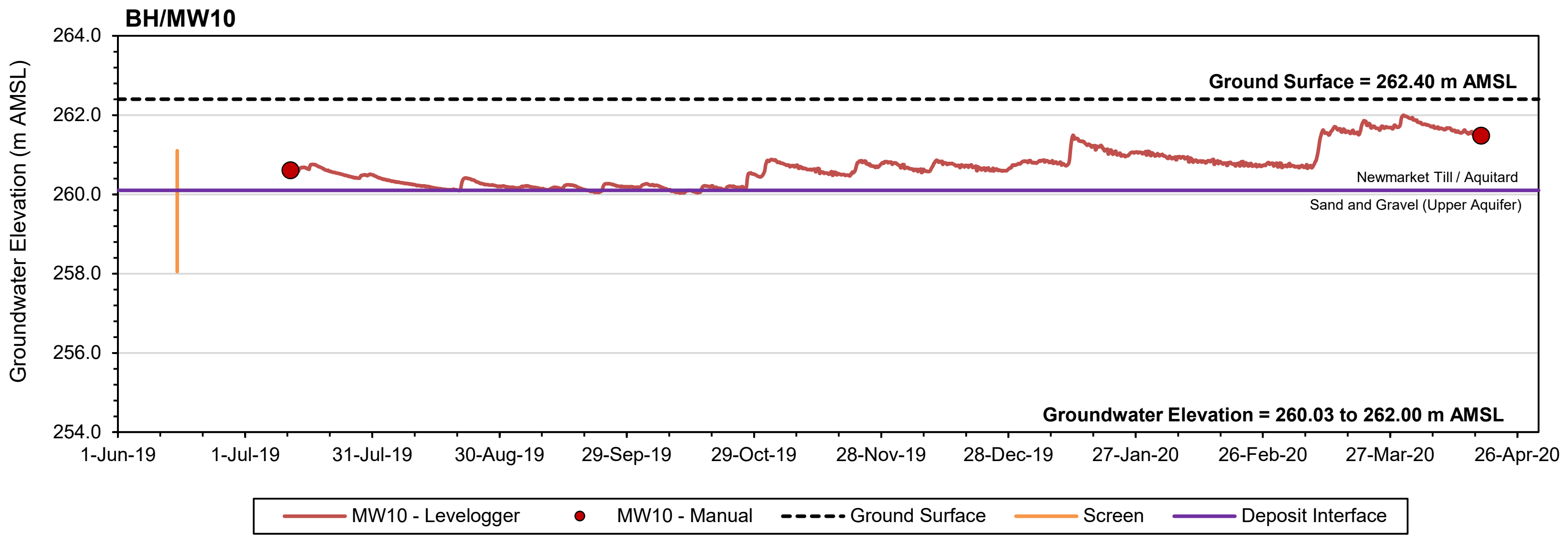
Charter Development LP
West Orillia Neighbourhood Plan
Hydrogeological Assessment

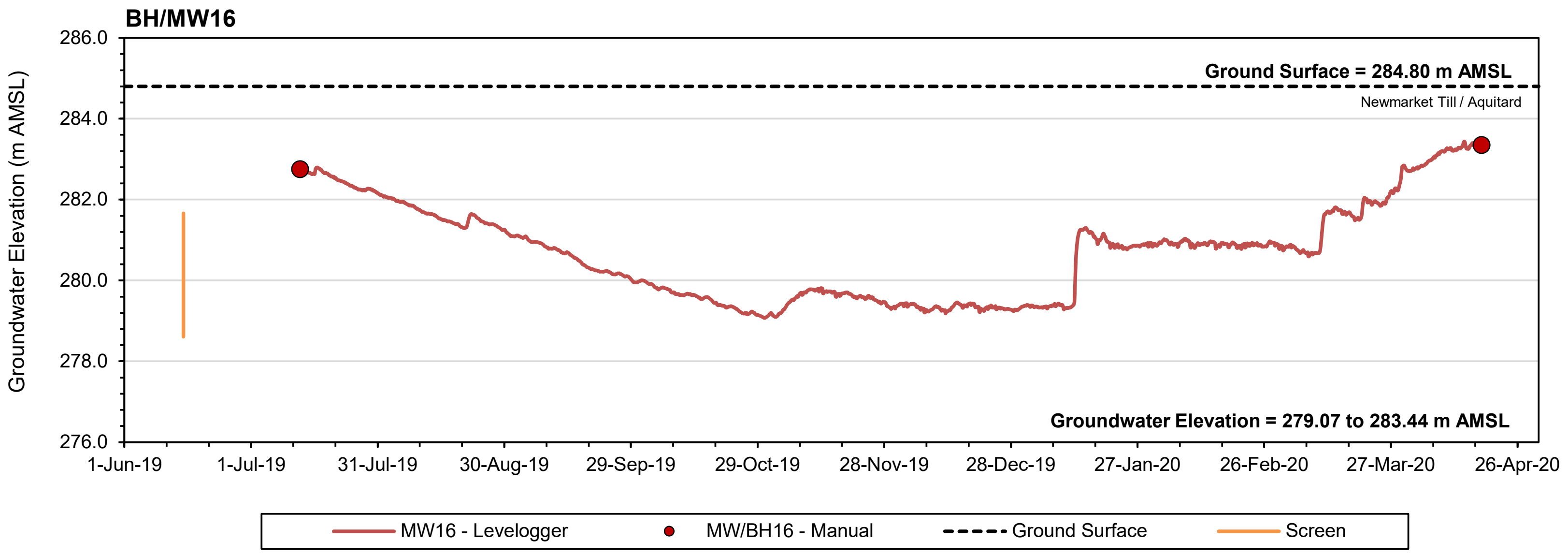
Figure No.

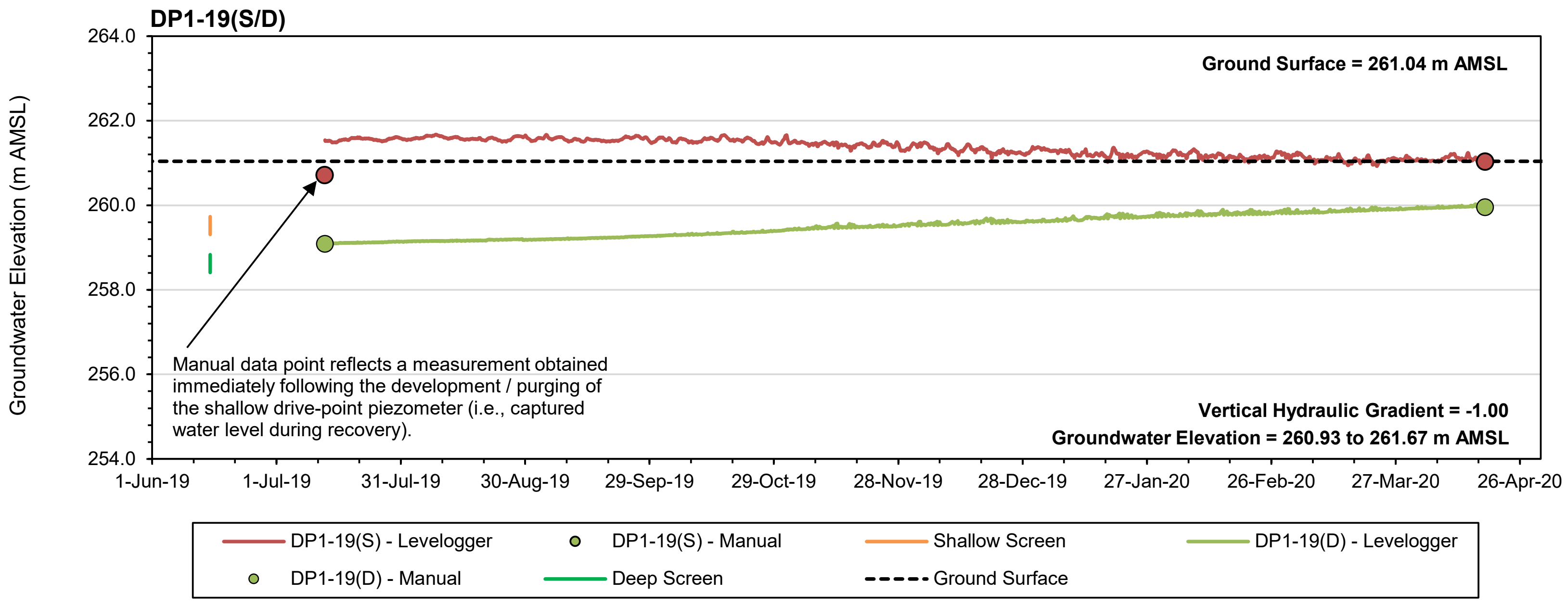
9

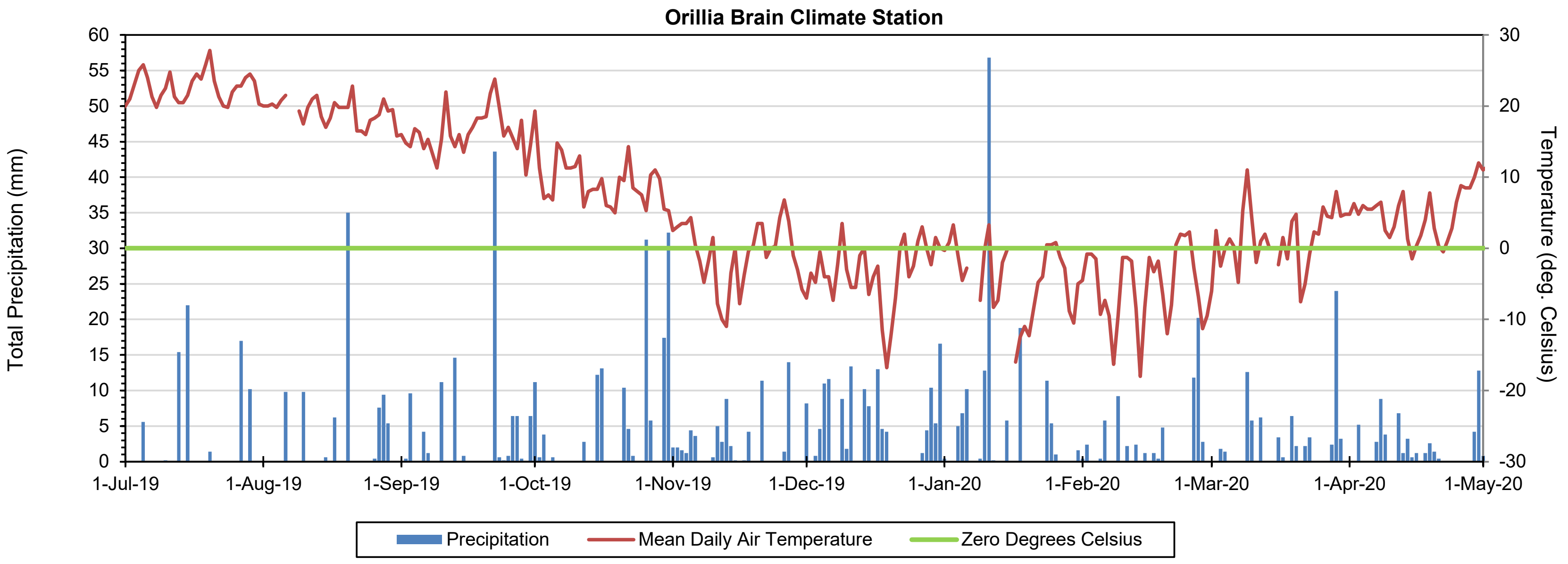
Title

HYDROGRAPHS
BH/MW04, BH/MW06, and BH/MW09









Notes:

Precipitation and temperature data were obtained from Environment Canada for the Orillia Brain Climate Station (ID 6115811), accessed April 23, 2020.

Client/Project

Charter Development LP
West Orillia Neighbourhood Plan
Hydrogeological Assessment

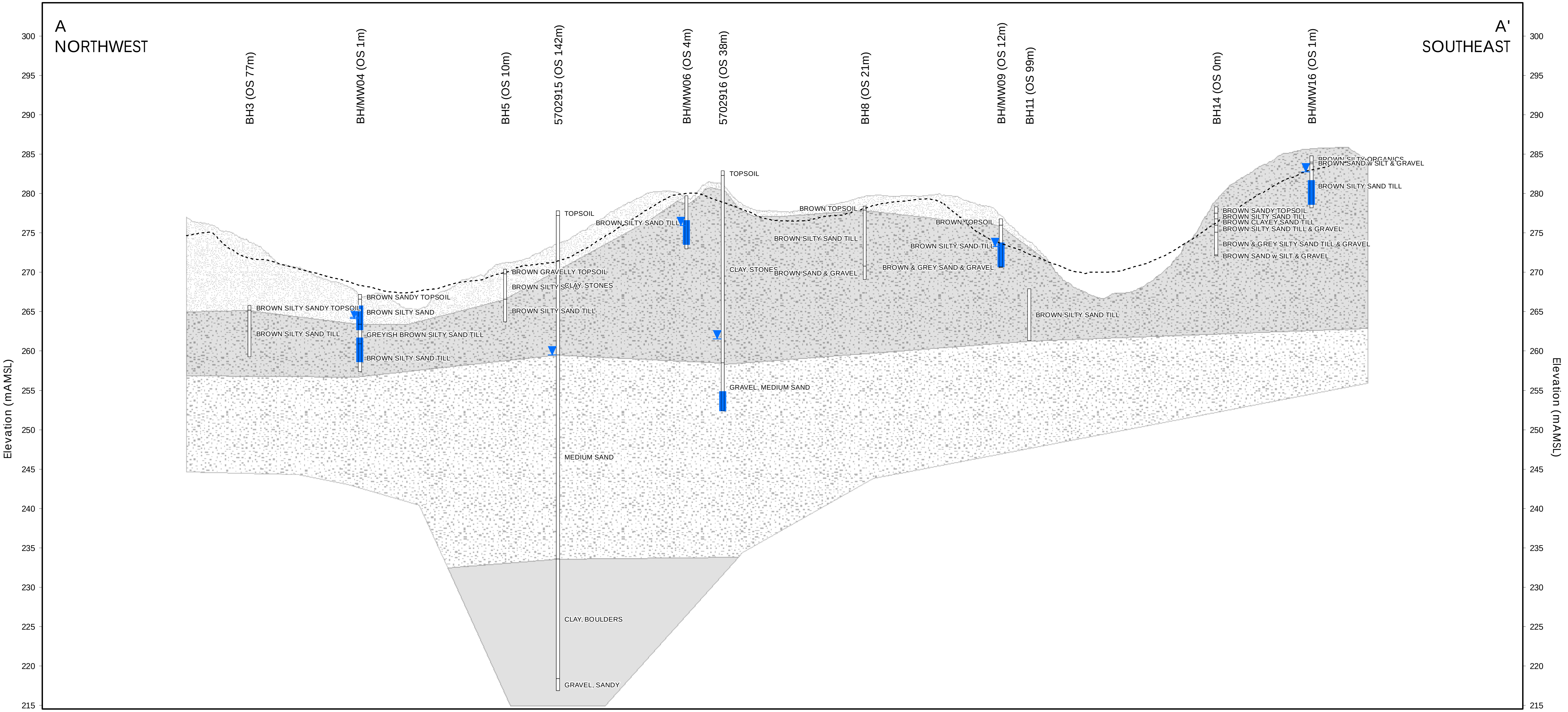
Figure No.

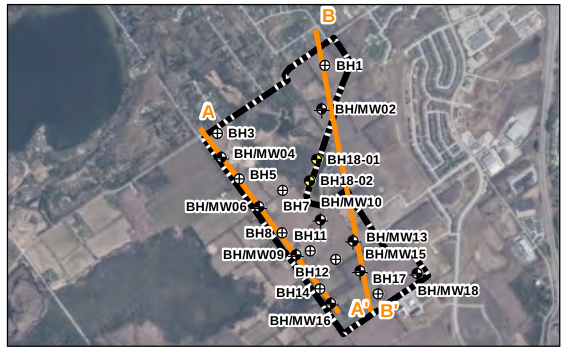
10

Title

HYDROGRAPHS
BH/MW10, BH/MW16, and DP1-19(S/D)

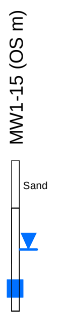
Stantec





Notes

1. Orthoimagery © First Base Solutions, 2020. Imagery Date, 2016.
2. Groundwater elevations shown for Stantec monitoring wells measured in July 2019.
3. Groundwater elevations shown for MECP water wells recorded at time of their installation.



Well ID (Offset)

Stratigraphy

▼ Water Level (July 2019)

■ Well Screen

- - - - - Proposed Grade

░ Glaciolacustrine and/or Ice-Contact Deposit (gravel, sand, silty sand)

▒ Newmarket Aquitard (stony sandy silt to silty sand till)

░ Upper Aquifer Complex (gravel, sand, silty sand)

▒ Regional Aquitard (stony sandy to clayey silt till)

10x Vertical Exaggeration

0 90 180 metres

1:5,000 (At original document size of 11x17)

Project Location
Orillia, ON

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Technical Review by XX on XXXX-XX-XX

Client/Project
CHARTER DEVELOPMENT LP.
WEST ORILLIA NEIGHBOURHOOD PLAN
ORILLIA, ONTARIO

Figure No.
11

Title
Cross-Section A-A'

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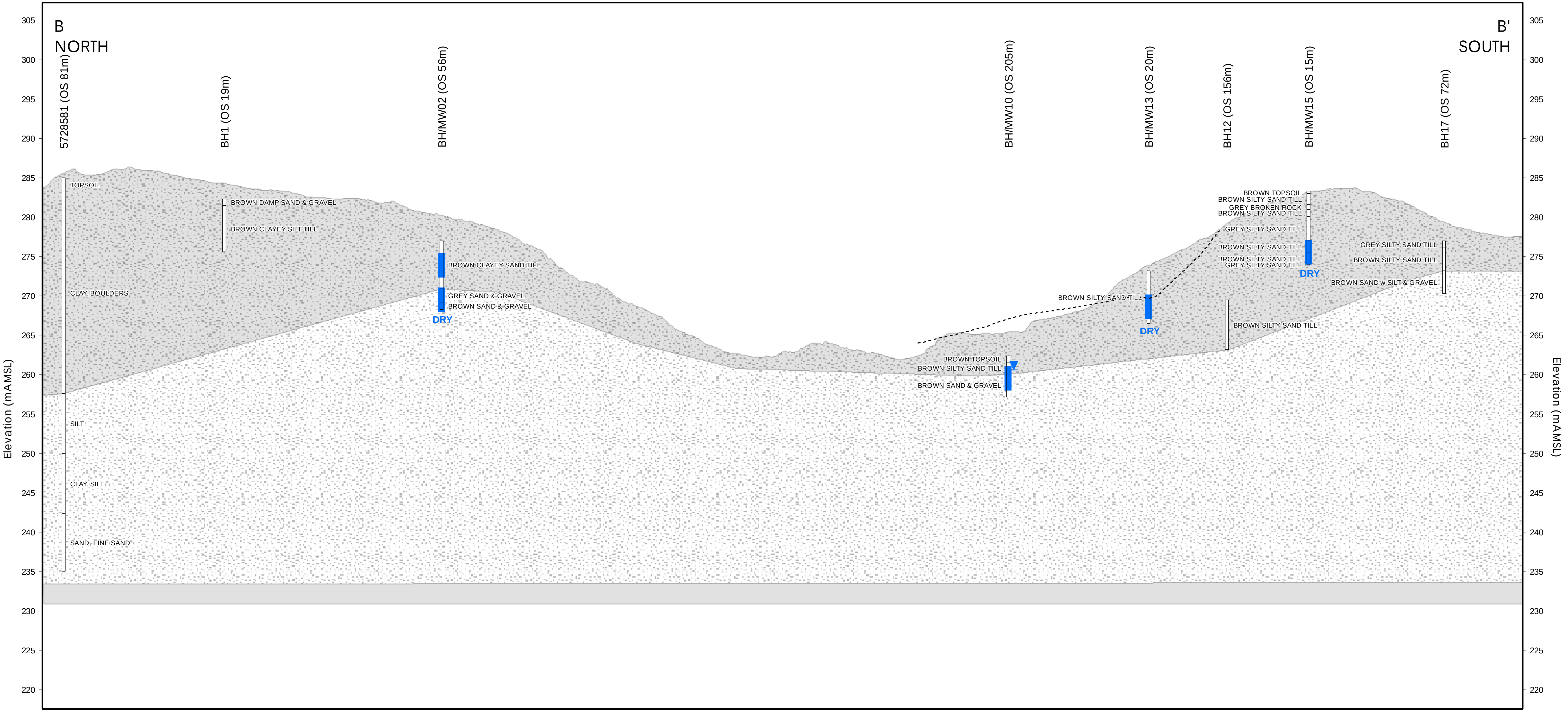
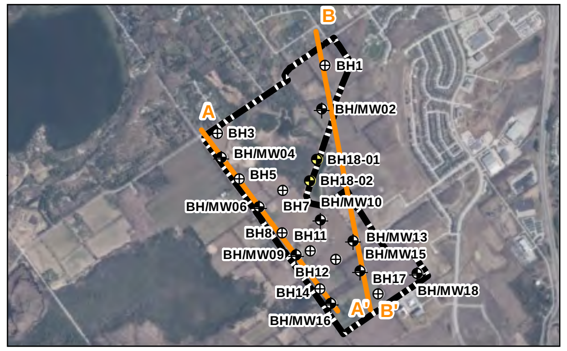




Notes
1. Orthoimagery © First Base Solutions, 2020. Imagery Date, 2016.

MW1-15 (OS m)
Well ID (Offset)

Sand
Stratigraphy

▼ Water Level

■ Well Screen

DRY Water Level Below Well Screen

------ Proposed Grade

▨ Newmarket Aquitard (stony sandy silt to silty sand till)

░ Upper Aquifer Complex (gravel, sand, silty sand)

▭ Regional Aquitard (stony sandy to clayey silt till)

10x Vertical Exaggeration
0 90 180 metres
1:5,000 (At original document size of 11x17)

Stantec

Project Location
Orillia, ON

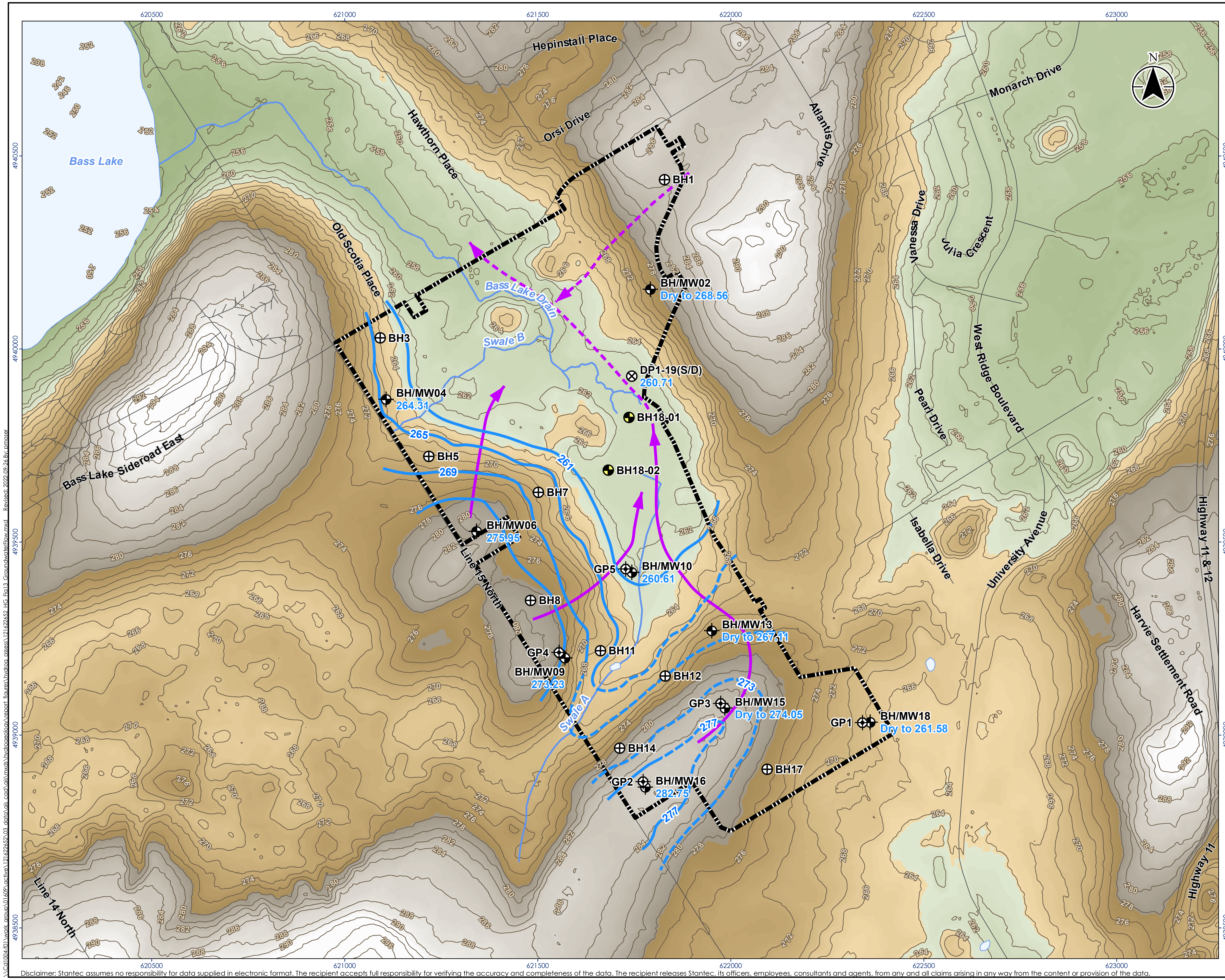
121622652 REVA
Prepared by CCoghlan on 2020-07-27
Technical Review by XX on XXXX-XX-XX

Client/Project
CHARTER DEVELOPMENT LP.
WEST ORILLIA NEIGHBOURHOOD PLAN
ORILLIA, ONTARIO

Figure No.
12

Title
Cross-Section B-B'

\\cd1004-f01\work_group\01609\active\121622652\03_data\gis_cad\gis\mxds\hydrogeology\report_figures\hydrog_assess\121622652_HG_Fig12_xsecBB.mxd Revised: 2020-07-27 By: CCoghlan



Stantec

Legend

- ⬚ Site Boundary
- ⊕ Monitoring Well (Stantec, 2019)
- ⊕ Borehole (Stantec, 2019)
- ● Borehole (Stantec, 2018)
- ⊗ Drive-Point Piezometer (Stantec, 2019)
- ⊕ Guelph Permeameter (Stantec, 2019)
- 261.54 Groundwater Elevation (mAMSL)
- — Groundwater Contour (mAMSL)
- → Interpreted Direction of Groundwater Flow
- — Road
- — Topographic Contour (m AMSL)
- — Watercourse
- ▭ Waterbody

Ground Surface Elevation (m AMSL)

High : 298.96

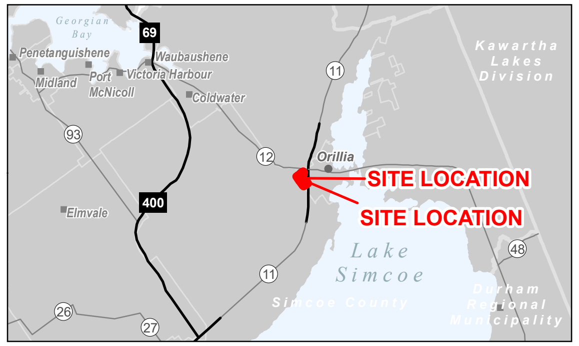
Low : 234.82

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, 2020.
3. South Central Ontario Orthophotography Project (SCOOP) 2013 Digital Elevation Model.



Project Location
Orillia, ON

121622652 REVA
Prepared by PRM on 2022-09-26
Technical Review by GW on 2022-09-26

Client/Project
CHARTER DEVELOPMENT LP.
WEST ORILLIA NEIGHBOURHOOD PLAN
ORILLIA, ONTARIO

Figure No.
13

Title
Groundwater Flow - July 2019

APPENDIX B:
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 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															
BH/MW02(S)	4940155	621792	277.88	277.00	*0.88*	5.50	4.62	272.38	1.57	275.43	4.62	272.38	Clayey SAND TILL (100%)	Newmarket Aquitard	-
BH/MW02(D)	4940155	621792	277.83	277.00	*0.83*	9.90	9.07	267.93	6.02	270.98	9.07	267.93	Clayey SAND TILL (15%) / SAND & GRAVEL (85%)	Newmarket Aquitard / Upper Aquifer	-
BH/MW04(S)	4939870	621107	268.09	267.20	0.89	5.38	4.49	262.71	1.44	265.76	4.49	262.71	Silty SAND (78%) / Silty SAND TILL (22%)	Ice-Contact/Glaciolacustrine Deposits	5.2E-06
BH/MW04(D)	4939870	621107	267.96	267.20	0.76	9.32	8.56	258.64	5.51	261.69	8.56	258.64	Silty SAND TILL (100%)	Newmarket Aquitard	-
BH/MW06	4939527	621341	280.62	279.70	0.92	7.10	6.18	273.52	3.13	276.57	6.18	273.52	Silty SAND TILL (100%)	Newmarket Aquitard	6.7E-08
BH/MW09	4939200	621570	277.61	276.80	0.81	6.90	6.09	270.71	3.04	273.76	6.09	270.71	Silty SAND TILL (97%) / SAND & GRAVEL (3%)	Newmarket Aquitard	1.5E-07
BH/MW10	4939421	621744	263.33	262.40	0.93	5.28	4.35	258.05	1.30	261.10	4.35	258.05	Silty SAND TILL (33%) / Silty SAND & GRAVEL (67%)	Newmarket Aquitard / Upper Aquifer	2.6E-07
BH/MW13	4939270	621951	274.18	273.20	0.98	7.07	6.09	267.11	3.04	270.16	6.09	267.11	Silty SAND TILL with sand layers (100%)	Newmarket Aquitard	-
BH/MW15	4939069	621985	284.07	283.30	0.77	10.02	9.25	274.05	6.20	277.10	9.25	274.05	Silty SAND TILL (100%)	Newmarket Aquitard	-
BH/MW16	4938865	621779	285.79	284.80	0.99	7.18	6.19	278.61	3.14	281.66	6.19	278.61	Silty SAND TILL (100%)	Newmarket Aquitard	6.5E-08
BH/MW18	4939033	622361	268.64	267.80	0.84	7.10	6.26	261.54	3.21	264.59	6.26	261.54	SAND with SILT and GRAVEL	Ice-Contact/Glaciolacustrine Deposits	-
DRIVE-POINT PIEZOMETERS														**GEOMEAN (Newmarket Aquitard) =**	**1.1E-07**
DP1-19(S)	4939929	621744	261.86	261.04	0.82	2.55	1.73	259.31	1.31	259.73	1.73	259.31	-		-
DP1-19(D)	4939929	621744	261.91	261.04	0.87	3.50	2.63	258.41	2.21	258.83	2.63	258.41	-		-

Notes:

(a) Refer to **Appendix D** for borehole and well construction logs

(b) Refer to **Appendix E** hydraulic conductivity analytical solutions

(c) Ground surface elevation for DP1-19(S/D) not surveyed. Elevation estimated using data provided by the South Central Ontario Orthophotography project DEM (2013), Queen's Printer for Ontario, 2013.

m AMSL = meters above mean sea level
m BGS = meters below ground surface
m BTOC = meters below top of well casing
\- = data not available
(S) = shallow
(D) = deep

TABLE 2: GROUNDWATER LEVEL DATA - MONITORING WELLS

Monitoring Well ID	Date	Time	Well Depth			Screen Length	Screen Separation (1)	Top of Casing Elevation	Ground Surface Elevation	Pipe Stick-up	Groundwater Level			Vertical Hydraulic Gradient (3)
			(m BTOC)	(m BGS)	(m AMSL)	(m)	(m)	(m AMSL)	(m AMSL)	(m)	(m BGS) (2)	(m BTOC)	(m AMSL)	(+) = Upward (-) = Downward
BH/MW02(S)	11-Jul-19 17-Apr-20	10:58 AM 12:50 PM	5.50	4.62	272.38	3.05		277.88	277.00	0.88	DRY to 4.62 DRY to 4.62	DRY to 5.50 DRY to 5.50	DRY to 272.38 DRY to 272.38	
BH/MW02(D)	11-Jul-19 17-Apr-20	10:55 AM 12:55 PM	9.32	8.44	268.56	3.05	3.82	277.88	277.00	0.88	DRY to 8.44 DRY to 8.44	DRY to 9.32 DRY to 9.32	DRY to 268.56 DRY to 268.56	- -
BH/MW04(S)	4-Jun-19 11-Jul-19 17-Apr-20	4:04 PM 5:04 PM 10:11 AM	5.38	4.49	262.71	3.05		268.09	267.20	0.89	2.80 2.89 2.52	3.69 3.78 3.41	264.40 264.31 264.68	
BH/MW04(D)	4-Jun-19 11-Jul-19 17-Apr-20	4:06 PM 5:07 PM 10:18 AM	9.32	8.56	258.64	3.05	4.07	267.96	267.20	0.76	2.92 3.05 2.63	3.68 3.81 3.39	264.28 264.15 264.57	-0.03 -0.04 -0.03
BH/MW06	12-Jul-19 17-Apr-20	9:35 AM 10:40 AM	7.10	6.18	273.52	3.05		280.62	279.70	0.92	3.75 1.35	4.67 2.27	275.95 278.35	
BH/MW09	11-Jul-19 17-Apr-20	2:53 PM 11:35 AM	6.90	6.09	270.71	3.05		277.61	276.80	0.81	3.54 2.57	4.35 3.38	273.26 274.23	
BH/MW10	4-Jun-19 11-Jul-19 17-Apr-20	11:22 AM 4:28 PM 10:57 AM	5.28	4.35	258.05	3.05		263.33	262.40	0.93	1.28 1.79 0.92	2.21 2.72 1.85	261.12 260.61 261.48	
BH/MW13	4-Jun-19 17-Apr-20	12:21 PM 11:15 AM	7.07	6.09	267.11	3.05		274.18	273.20	0.98	DRY to 6.09 DRY to 6.09	DRY to 7.07 DRY to 7.07	DRY to 267.11 DRY to 267.11	
BH/MW15	4-Jun-19 17-Apr-20	1:42 PM 12:01 PM	10.02	9.25	274.05	3.05		284.07	283.30	0.77	DRY to 9.25 DRY to 9.25	DRY to 10.02 DRY to 10.02	DRY to 274.05 DRY to 274.05	
BH/MW16	4-Jun-19 12-Jul-19 17-Apr-20	1:16 PM 2:24 PM 11:49 AM	7.18	6.19	278.61	3.05		285.79	284.80	0.99	1.14 2.05 1.45	2.13 3.04 2.44	283.66 282.75 283.35	
BH/MW18	11-Jul-19 17-Apr-20	12:12 PM 12:18 PM	7.10	6.22	261.58	3.05		268.68	267.80	0.88	DRY to 6.22 DRY to 6.22	DRY to 7.10 DRY to 7.10	DRY to 261.58 DRY to 261.58	

Notes:

(1) Distance between the screen mid-points in the deep and shallow monitoring wells.
(2) A negative value indicates that the water level measured within the pipe is located above ground surface
(3) Negative and positive values indicate downward and upward gradients, respectively.

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: GROUNDWATER LEVELS - DRIVE-POINT PIEZOMETERS

Piezometer ID	Depth		Screen Length	Screen Separation (1)	Pipe Stick-up	Ground Surface Elevation (5)	Top of Casing Elevation	Date	Time	Groundwater Level			Surface Water Level		Vertical Hydraulic Gradient(4)
	(m BTOC)	(m BGS)	(m)	(m)	(m)	(m AMSL)	(m AMSL)			(m BGS) (2)	(m BTOC)	(m AMSL)	(m BTOC) (3)	(m AMSL)	(+) = Upward (-) = Downward
DP1-19(S)	2.55	1.73	0.42		0.82	261.04	261.86	12-Jul-19 17-Apr-20	4:04 PM 1:27 PM	0.33 0.01	1.15 0.83	260.71 261.03	- -	- -	
DP1-19(D)	3.50	2.63	0.42	0.90	0.87	261.04	261.91	12-Jul-19 17-Apr-20	4:05 PM 1:34 PM	1.95 1.08	2.82 1.95	259.09 259.96	- -	- -	-1.00 -1.00

Notes:
(1) Distance between the screen mid-points in the deep and shallow piezometers.
(2) A negative value indicates that the water level measured within the pipe is located above ground surface.
(3) A negative value indicates that the surface water level is above the top of the piezometer.
(4) Vertical hydraulic gradient between the shallow and deep piezometer screened intervals. Negative and positive values indicate downward and upward gradients, respectively.
(5) Ground surface elevation not surveyed. Elevation estimated using data provided by the South Central Ontario Orthophotography project DEM (2013), Queen's Printer for Ontario, 2013.

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 4 - INFILTRATION TESTING RESULTS

Testing Location ID	Horizontal Hydraulic Conductivity	Vertical Hydraulic Conductivity$^{(2)}$		Infiltration Rate$^{(1)}$	Pit Depth	Screened Interval	Soil Substrate Tested (% of screened interval)	Hydrostratigraphic Unit
	(m/s)	(cm/s)	(m/s)	(mm/hr)	(m BGS)	(m BGS)		
Guelph Permeameter Testing$^{(3)}$								
GP1	-	4.5E-04	4.5E-06	69	0.52	-	FINE SAND, trace silt	Ice-Contact/Glaciolacustrine Deposits
GP2	-	4.1E-04	4.1E-06	67	0.58	-	Silty FINE SAND, some medium to coarse sand	Ice-Contact/Glaciolacustrine Deposits
GP3	-	7.1E-04	7.1E-06	78	0.50	-	Silty FINE SAND, some medium to coarse sand	Ice-Contact/Glaciolacustrine Deposits
GP4	-	2.6E-04	2.6E-06	60	0.50	-	FINE SAND, trace silt	Ice-Contact/Glaciolacustrine Deposits
GP5	-	3.1E-05	3.1E-07	34	0.50	-	Silty FINE SAND, some silty clay	Ice-Contact/Glaciolacustrine Deposits
In-situ Hydraulic Response Testing$^{(4)}$								
BH/MW04(S)	5.2E-06	-	5.2E-07	39	-	1.5 - 4.5	Silty SAND	Ice-Contact/Glaciolacustrine Deposits
BH/MW06	6.7E-08	-	6.7E-09	12	-	3.1 - 6.1	Silty SAND TILL	Newmarket Aquitard
BH/MW09	1.5E-07	-	1.5E-08	15	-	3.0 - 6.0	Silty SAND TILL / SAND & GRAVEL	Newmarket Aquitard
BH/MW10	2.6E-07	-	2.6E-08	17	-	1.3 - 4.3	Silty SAND TILL / Silty SAND & GRAVEL	Newmarket Aquitard
BH/MW16	6.5E-08	-	6.5E-09	12	-	3.3 - 6.3	Silty SAND TILL	Newmarket Aquitard
Average (Ice-Contact/Glaciolacustrine Deposits) $^{(3)}$ =				62				
Average (Newmarket Aquitard) $^{(4)}$ =				19				
Average (All Soils) =				40				

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.*

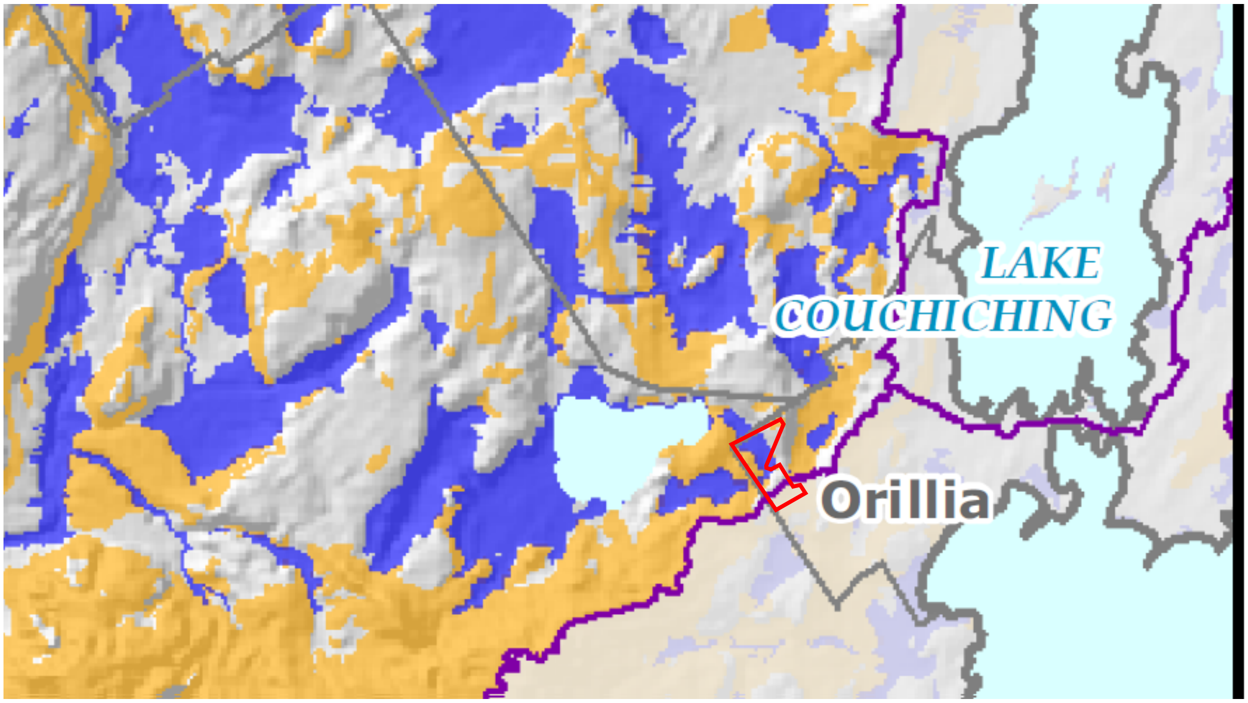
(2) Vertical hydraulic conductivities assumed to be one order of magnitude lower than in-situ measured horizontal hydraulic conductivities.

(3) Based on Guelph Permeameter testing performed on upper 0.6 m of overburden deposits (i.e., surficial deposits).

(4) Based on wells screened in deposits located from depths of 1.3 m to 6.3 m BGS.

APPENDIX C:

REGIONAL GROUNDWATER FLOW AND RECHARGE AND DISCHARGE MAPPING



🟧 Recharge Areas
🟦 Discharge Areas
☐ SWP Watershed Region
☐ SWP Watershed Area
☐ Upper Tier Municipality
☐ Lower Tiers Municipality
🟦 Water Body

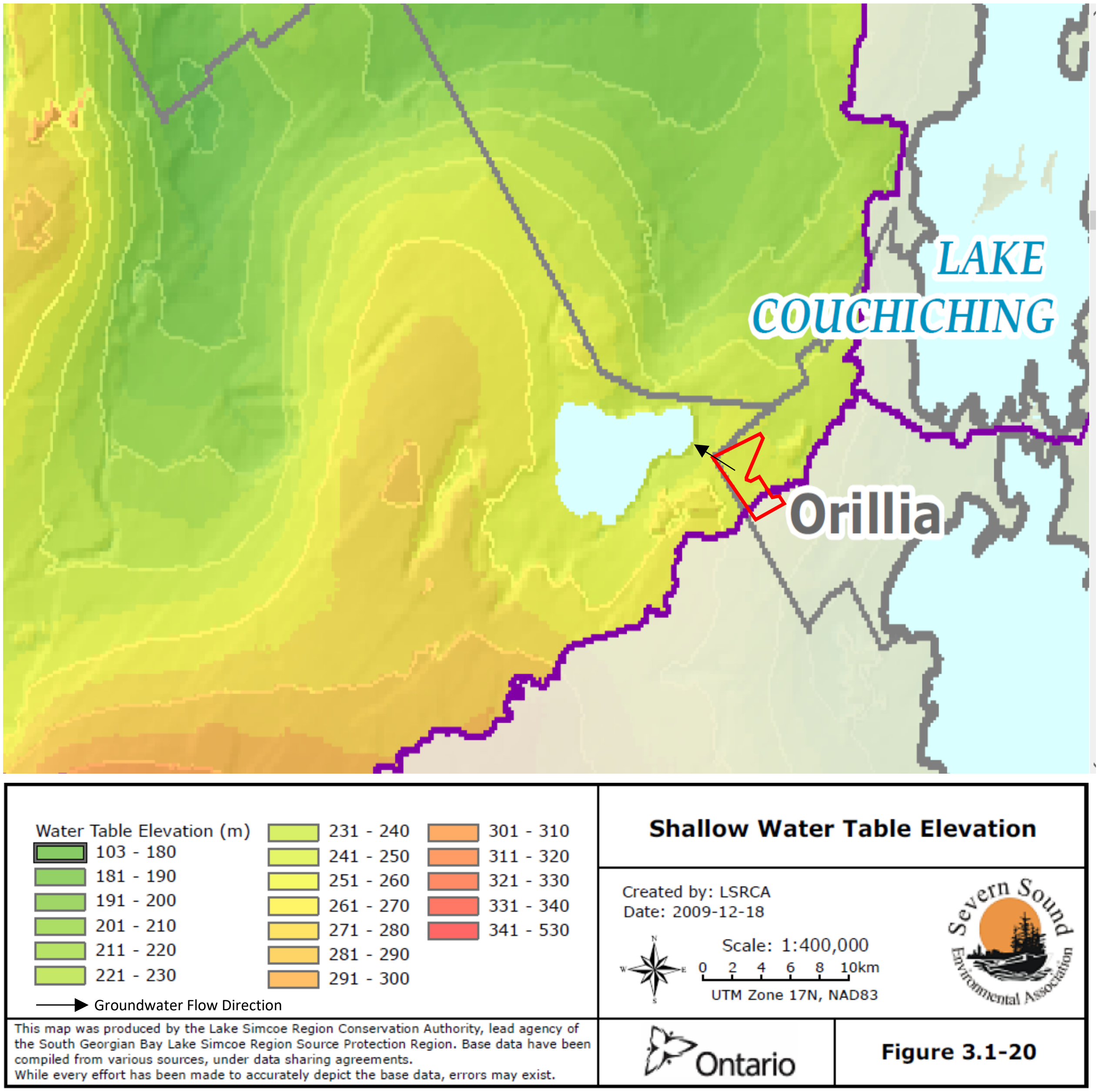
Groundwater Recharge and Discharge Areas

Created by: LSRCA
Date: 2009-12-21

Scale: 1:400,000
0 2 4 6 8 10km
UTM Zone 17N, NAD83

This map was produced by the Lake Simcoe Region Conservation Authority, lead agency of the South Georgian Bay Lake Simcoe Region Source Protection Region. Base data have been compiled from various sources, under data sharing agreements.
While every effort has been made to accurately depict the base data, errors may exist.

Figure 3.1-22



Shallow Water Table Elevation

Figure 3.1-20

This map was produced by the Lake Simcoe Region Conservation Authority, lead agency of the South Georgian Bay Lake Simcoe Region Source Protection Region. Base data have been compiled from various sources, under data sharing agreements.
While every effort has been made to accurately depict the base data, errors may exist.

Source: South Georgian Bay-Lake Simcoe Source Protection Committee (SGBLSSPC). 2015a. Severn Sound Source Protection Area, Approved Assessment Report. January 26, 2015.

APPENDIX D:

BOREHOLE LOGS AND MECP WATER WELL RECORDS

Stantec

BOREHOLE RECORD

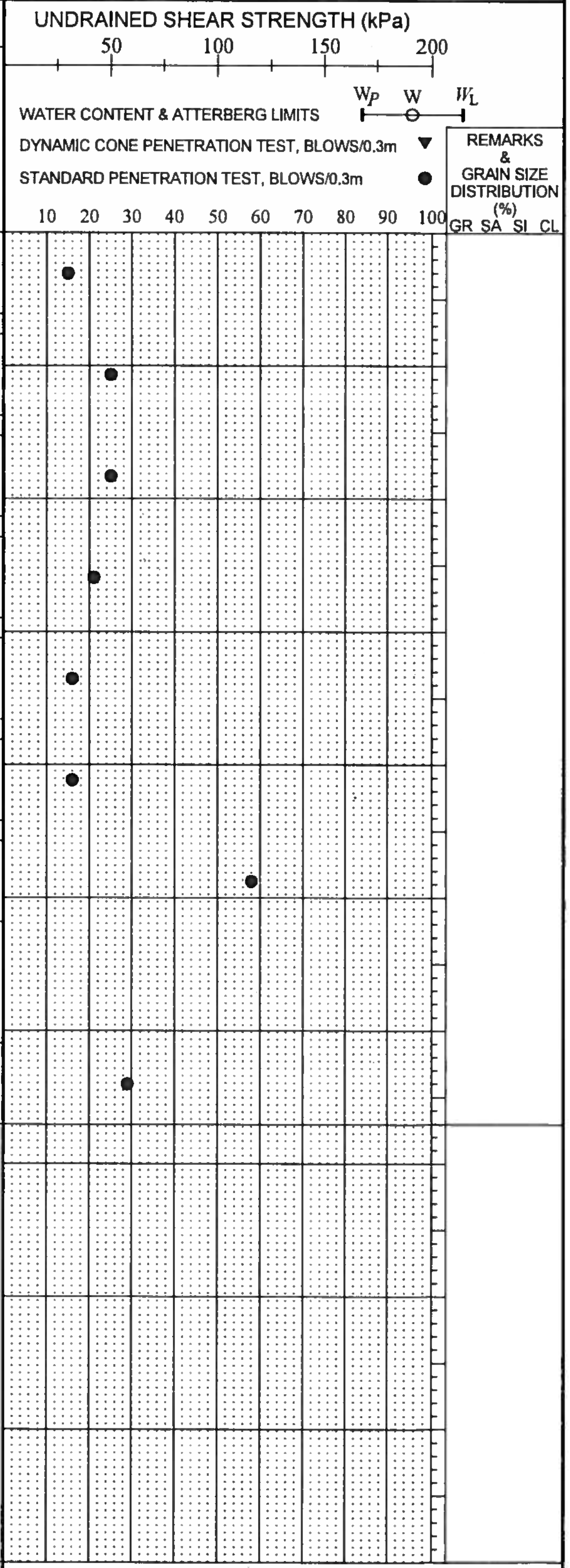
BH 1

Sheet 1 of 1

CLIENT Charter Consruction
LOCATION Orillia
DATES: BORING 21/05/2019
WATER LEVEL 21/05/2019
PROJECT No. 121622652
DATUM Geodetic
TPC ELEVATION 282.3m

DEPTH (ft)	ELEVATION (m)	STRATA DESCRIPTION	WATER LEVEL	TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
0	282.3	Compact, Light Brown, Damp SAND & Gravel					
1				SS	1	410/610	15
2	281.5						
3		Compact, Brown, Damp Clayey Silt (SC) Till					
4				SS	2	460/610	25
6				SS	3	610/610	25
8–9				SS	4	610/610	21
11				SS	5	580/610	16
13–14		-Trace Gravel		SS	6	610/610	16
16		-Very Dense, Moist -No Gravel	∇	SS	7	460/610	58
21				SS	8	460/610	29
22	275.6	-End of Borehole at 6.71m					

DEPTH (m): 0 1 2 3 4 5 6 7 8 9 10



□ Field Vane Test, kPa
◘ Remoulded Vane Test, kPa
△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

BH 2

Sheet 1 of 2

CLIENT Charter Consruction

LOCATION Orillia

DATES: BORING 22/05/2019

WATER LEVEL 11/07/2019

PROJECT No. 121622652

DATUM Geodetic

TPC ELEVATION 277.0m

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION
0	277.0	Loose, Brown, Moist Clayey SAND (SC) Till -Compact, Light Brown, Some Gravel -Brown, Trace Gravel -Some Gravel -With Gravel -Some Gravel and Cobbles
6	270.9	Very Dense, Light Grey, Dry Poorly Graded SAND and GRAVEL (SP) -Brown, Moist
8.69	268.3	-End of Borehole at 8.69m -A 50mm groundwater monitoring well was installed at a depth of 8.69m. Screened from 8.69m to 5.64m. The well was dry on July 11th, 2019.

Continued Next Page

SAMPLES

DEPTH (ft)	TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)	GR	SA	SI	CL
1	SS	1	280/610	5				
3.5	SS	2	410/610	22				
6	SS	3	610/610	18	2	54	31	13
8.5	SS	4	510/610	20				
11	SS	5	560/610	18				
13.5	SS	6	560/610	32				
16	SS	7		26				
21	SS	8		50/130				
26	SS	9		50/100				

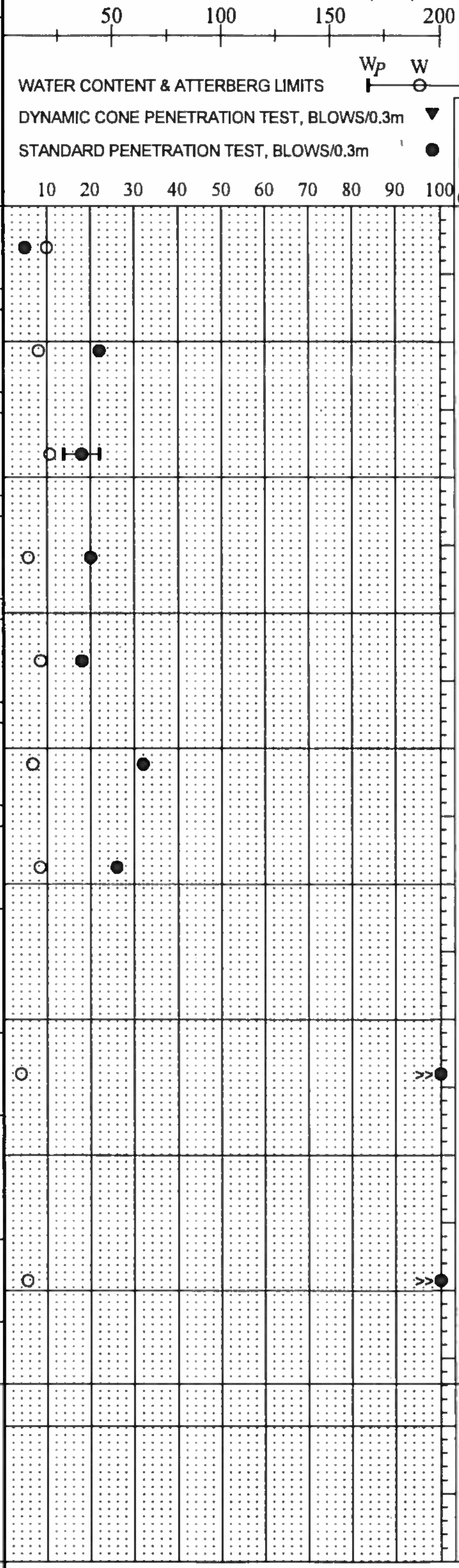
UNDRAINED SHEAR STRENGTH (kPa)

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC CONE PENETRATION TEST, BLOWS/0.3m ▼

STANDARD PENETRATION TEST, BLOWS/0.3m ●

REMARKS & GRAIN SIZE DISTRIBUTION (%)



☐ Field Vane Test, kPa

◘ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

BH 2

Sheet 2 of 2

CLIENT Charter Consruction
LOCATION Orillia
DATES: BORING 22/05/2019 WATER LEVEL 11/07/2019

PROJECT No. 121622652
DATUM Geodetic
TPC ELEVATION 277.0m

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	STRATA PLOT	WATER LEVEL	DEPTH (ft)	SAMPLES				UNDRAINED SHEAR STRENGTH (kPa)	REMARKS & GRAIN SIZE DISTRIBUTION (%)
						TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)	50 100 150 200 WATER CONTENT & ATTERBERG LIMITS W_P W W_L DYNAMIC CONE PENETRATION TEST, BLOWS/0.3m ▼ STANDARD PENETRATION TEST, BLOWS/0.3m ● 10 20 30 40 50 60 70 80 90 100	GR SA SI CL
	267.0										
10 11 12 13 14 15 16 17 18 19 20		-A 50mm auxillary well was also installed at a depth of 4.57m. Screened from 4.57m to 1.52m. The well was dry on July 11th, 2019.			33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65						

☐ Field Vane Test, kPa
◘ Remoulded Vane Test, kPa
△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

BH 3

Sheet 1 of 1

CLIENT Charter Consruction

LOCATION Orillia

DATES: BORING 14/05/2019

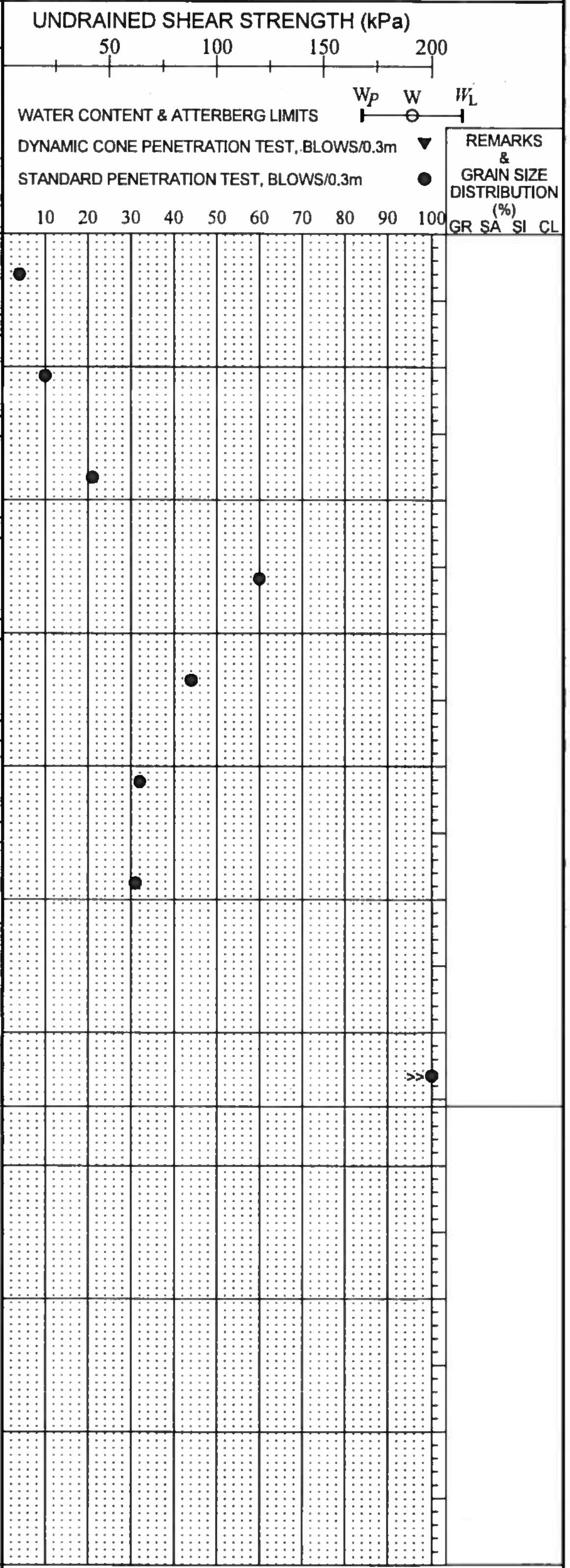
WATER LEVEL

PROJECT No. 121622652

DATUM Geodetic

TPC ELEVATION 265.8m

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	DEPTH (ft)	SAMPLES TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
0	265.8		0				
		Loose, Brown, Moist Silty Sandy TOPSOIL organics	1	SS	1	330/610	4
	265.2	Compact, Brown, Moist Silty SAND (SM) Till	3–4	SS	2	460/610	10
		-Trace Gravel	6	SS	3	510/610	21
		-Very Dense	8–9	SS	4	610/610	60
		-Dense	11	SS	5	580/610	44
		-Wet	13–14	SS	6	510/610	32
			16	SS	7	610/610	31
	259.2	-Very Dense	21	SS	8	460/460	50/150
		-End of bore hole at 6.55m -Caving at 3.35m					



□ Field Vane Test, kPa

◘ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

BH 4

Sheet 1 of 2

CLIENT Charter Consruction

LOCATION Orillia

DATES: BORING 14/05/2019

WATER LEVEL 11/07/2019

PROJECT No. 121622652

DATUM Geodetic

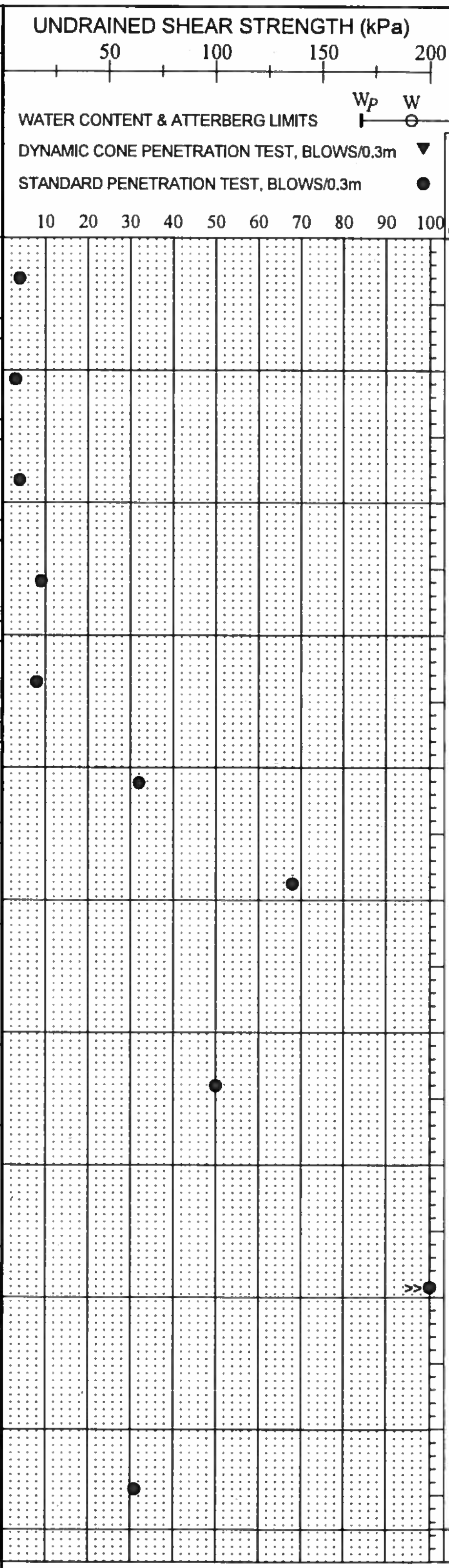
TPC ELEVATION 267.2m

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION
0	267.2	Very Loose, Brown, Moist Sandy TOPSOIL
	266.6	Very Loose, Brown, Moist Silty SAND (SM) -Loose -Wet
	263.4	Dense, Greyish Brown, Wet Silty SAND (SM) Till -Blowback in Augurs at 12.5' -Very Dense, Very Wet -Brown -Approx. 5' blowback in augurs -Dense
	257.4	-End of Borehole at 9.75m.
10		

Continued Next Page

WATER LEVEL: ∇ at approx. 3 m (10 ft)

DEPTH (ft)	TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
1	SS	1	300/610	4
3–4	SS	2	380/610	3
6	SS	3	430/610	4
8–9	SS	4	430/610	9
11	SS	5	530/610	8
13–14	SS	6	580/610	32
16	SS	7	530/610	68
21	SS	8	560/610	50
26	SS	9	460/610	50/150
31	SS	10	510/610	31



REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

☐ Field Vane Test, kPa

◘ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

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BOREHOLE RECORD

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CLIENT Charter Consruction

LOCATION Orillia

DATES: BORING 14/05/2019

WATER LEVEL 11/07/2019

PROJECT No. 121622652

DATUM Geodetic

TPC ELEVATION 267.2m

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	STRATA PLOT	WATER LEVEL	DEPTH (ft)	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm) TCR(%) / SCR(%)	SAMPLES N-VALUE OR RQD(%)
10	257.2	-Water level measured at 2.44m. -A 50mm groundwater monitoring well was installed at 8.84m. Screened from 8.84m to 5.79m. Groundwater level measured at 3.05m below ground surface on July 11th, 2019. -A 50mm groundwater monitoring well was also installed at 4.57m. Screened from 4.57m to 1.52m. Groundwater level measured at 2.89m below ground surface on July 11th, 2019.			33				

DEPTH (m) scale: 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

DEPTH (ft) scale: 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65

UNDRAINED SHEAR STRENGTH (kPa)

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC CONE PENETRATION TEST, BLOWS/0.3m ▼

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90 100

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

☐ Field Vane Test, kPa

▣ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

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BOREHOLE RECORD

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CLIENT Charter Consruction

LOCATION Orillia

DATES: BORING

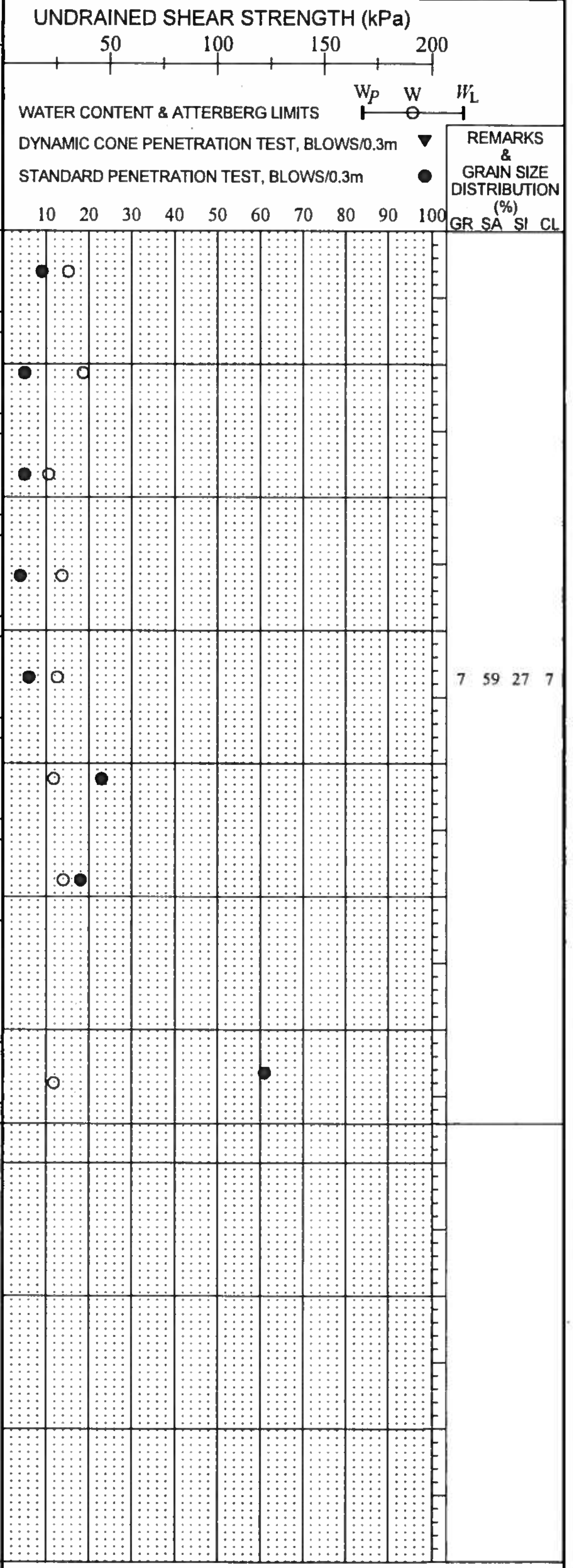
WATER LEVEL

PROJECT No. 121622652

DATUM Geodetic

TPC ELEVATION 270.4m

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	DEPTH (ft)	TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0	270.4	Loose, Brown, Moist Gravelly TOPSOIL	1	SS	1	300/610	9	
	269.8	Loose, Brown, Moist Silty SAND (SM)	3–4	SS	2	360/610	5	
			6	SS	3	510/610	5	
			8–9	SS	4	510/610	4	
			11	SS	5	530/610	6	7 59 27 7
	266.6	Compact, Brown, Moist Silty SAND (SM) Till	13–14	SS	6	580/610	23	
		-Wet	16	SS	7	580/610	18	
		-Very Dense, Very Wet	21	SS	8	510/460	61	
	263.7	-End of Borehole at 6.71m						



☐ Field Vane Test, kPa

▣ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

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BOREHOLE RECORD

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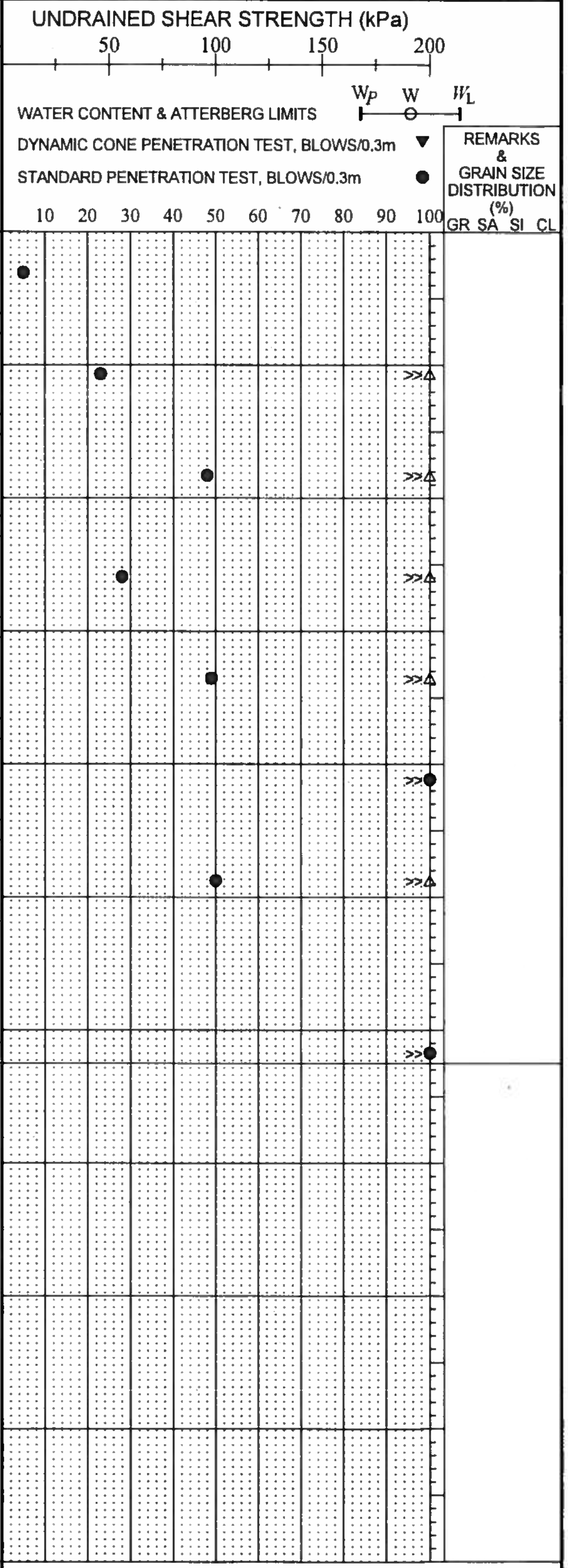
CLIENT Charter Consruction
PROJECT No. 121622652
LOCATION Orillia
DATUM Geodetic
DATES: BORING 15/05/2019
WATER LEVEL 11/07/2019
TPC ELEVATION 279.7m

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	WATER LEVEL	DEPTH (ft)	TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
0	279.7	Loose, Brown, Moist Silty SAND (SM) Till		1	SS	1	410/610	5
1		-Compact		3–4	SS	2	460/610	23
		-Dense		6	SS	3	580/610	48
2		-Compact		8–9	SS	4	580/610	28
3		-Dense		11	SS	5	530/610	49
			∇	12				
4		-Very Dense -Trace Gravel		13–14	SS	6	300/610	50/150
5				16	SS	7	580/610	50
6	273.5			20	SS	8	280/150	50/150
		-End of borehole at 6.71m -A 50mm groundwater monitoring well was installed at a depth of 6.10m. Screened from 6.10m to 3.05m. Groundwater level measured at 3.75m below ground surface on July 11th, 2019.						



□ Field Vane Test, kPa
▣ Remoulded Vane Test, kPa
△ Pocket Penetrometer Test, kPa

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BOREHOLE RECORD

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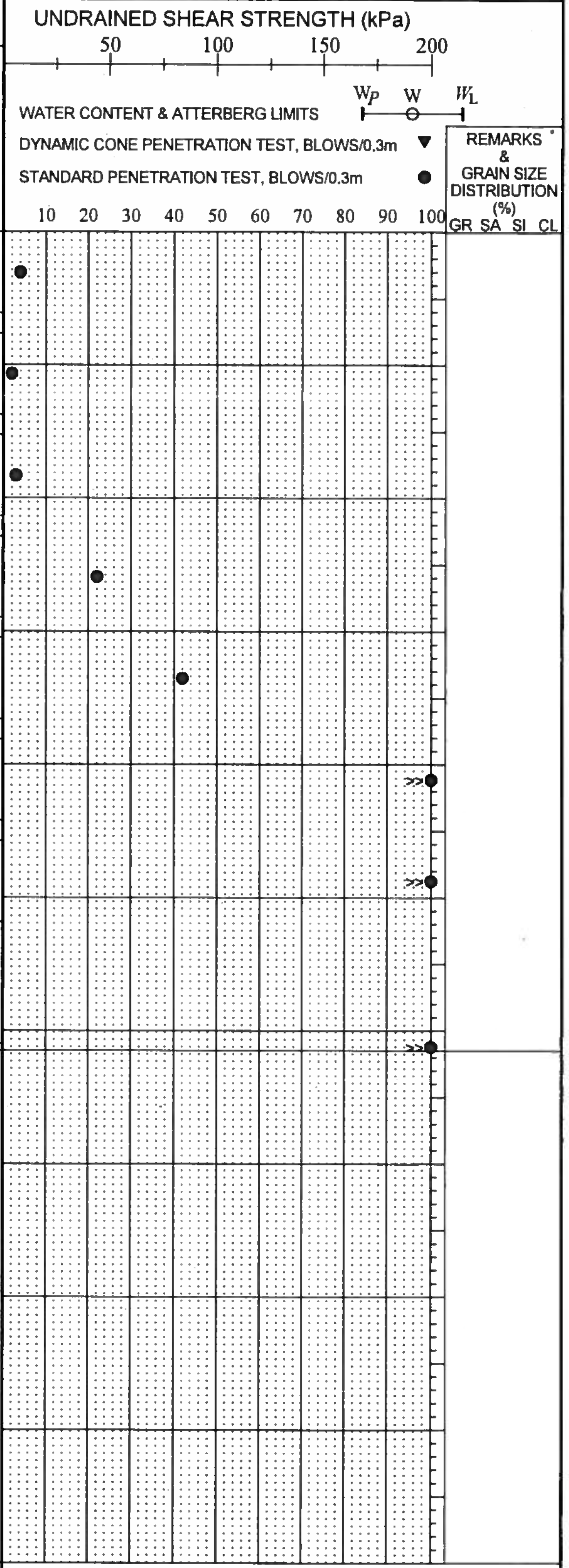
CLIENT Charter Consruction
LOCATION Orillia
DATES: BORING 15/05/2019
WATER LEVEL
PROJECT No. 121622652
DATUM Geodetic
TPC ELEVATION 270.7m

ELEVATION (m)	STRATA DESCRIPTION
270.7	Loose, Brown, Moist Silty Sandy Organic TOPSOIL
270.1	Very Loose, Brown, Moist Silty SAND (SM) -Coarse sand
268.4	Compact, Brown, Moist Silty SAND (SM) Till -Dense -Very Dense
264.6	-No recovery in last spoon -Borehole ends at 6.15m

TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
SS	1	460/610	4
SS	2	200/610	2
SS	3	580/610	3
SS	4	510/610	22
SS	5	480/610	42
SS	6	460/610	50/150
SS	7	460/610	50/150
SS	8	0.0/51	50/51



☐ Field Vane Test, kPa
■ Remoulded Vane Test, kPa
△ Pocket Penetrometer Test, kPa

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BOREHOLE RECORD

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CLIENT Charter Consruction

LOCATION Orillia

DATES: BORING 15/05/2019

WATER LEVEL

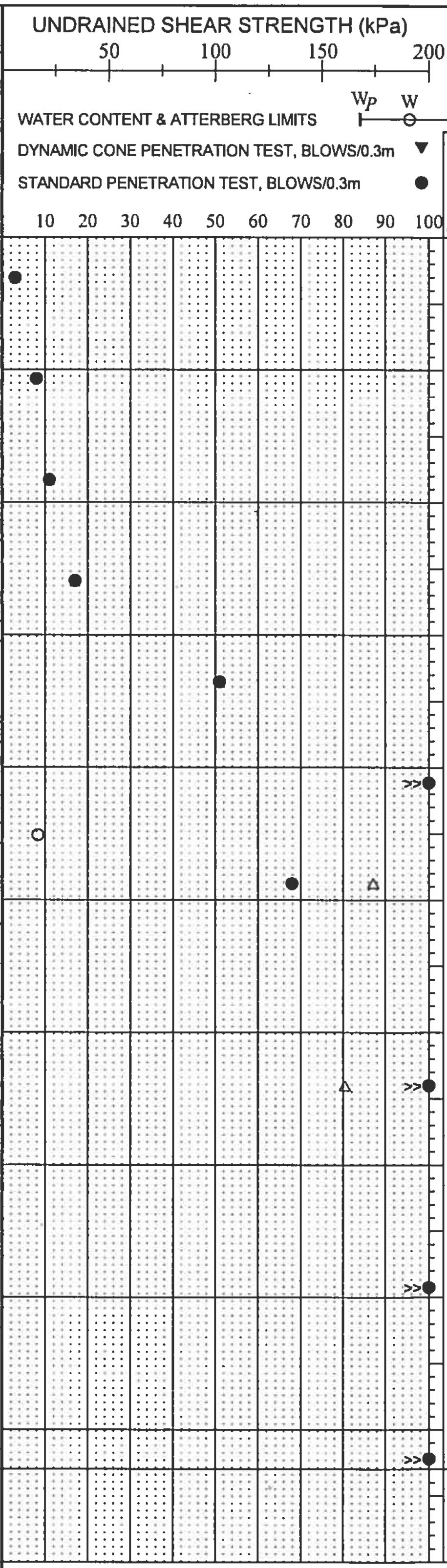
PROJECT No. 121622652

DATUM Geodetic

TPC ELEVATION 278.4m

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION
0	278.4	
	277.9	Very Loose, Brown, Moist Organic TOPSOIL
		Very Loose, Brown, Moist Silty SAND (SM) Till -Loose -Compact -Very Dense
	270.8	Very Dense, Brown, Very Wet Poorly Graded SAND & GRAVEL (SP)
	269.1	-End of Borehole at 9.3m

DEPTH (ft)	TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
0–2	SS	1	460/610	3
2.5–4.5	SS	2	360/610	8
5–7	SS	3	510/610	11
7.5–9.5	SS	4	580/610	17
10–12	SS	5	560/610	51
12.5–14.5	SS	6	100/610	50/100
15–17	SS	7	560/610	68
20–22	SS	8	360/610	50/150
25–27	SS	9	150/610	50/150
30–30.5	SS	10	150/150	50/150



REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
5	55	26	14

☐ Field Vane Test, kPa

◘ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

BOREHOLE RECORD

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CLIENT Charter Consruction

LOCATION Orillia

DATES: BORING 15/05/2019

WATER LEVEL 11/07/2019

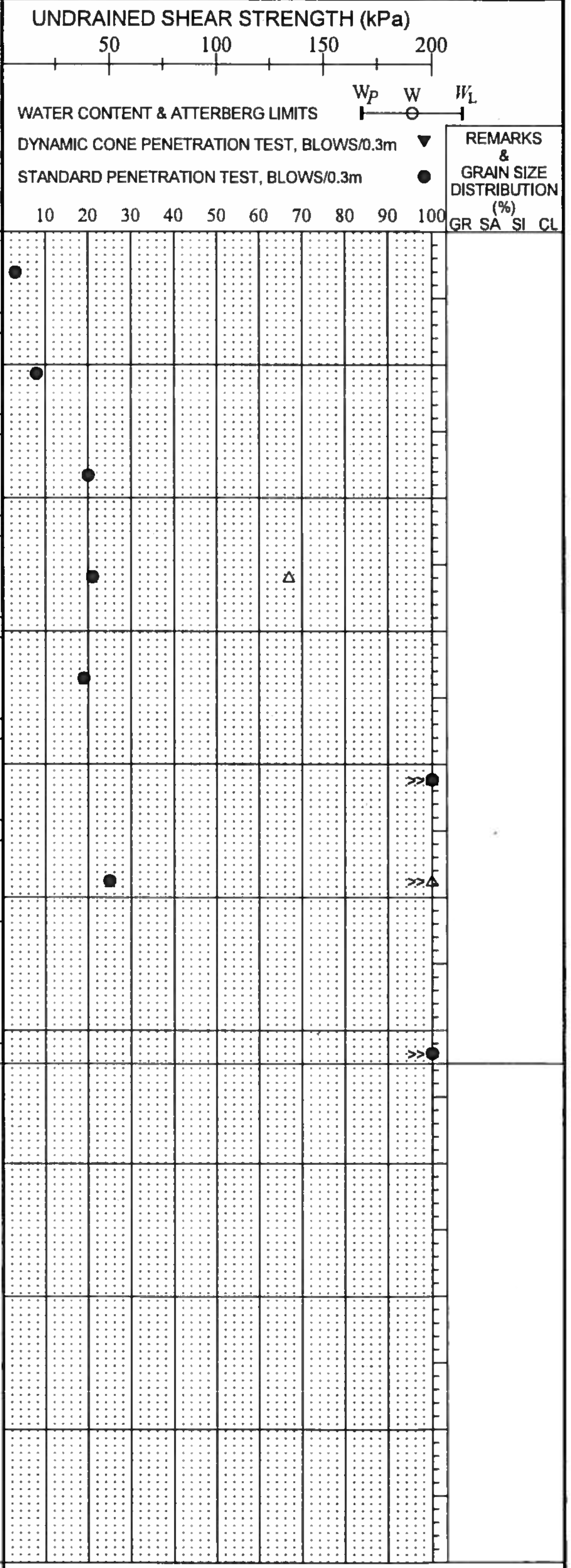
PROJECT No. 121622652

DATUM Geodetic

TPC ELEVATION 276.8m

ELEVATION (m)	STRATA DESCRIPTION	WATER LEVEL	DEPTH (ft)	TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
276.8	Very Loose, Brown, Moist Organic TOPSOIL		1	SS	1	180/610	3
276.0	Loose, Brown, Moist Silty SAND (SM) Till		3–4	SS	2	460/610	8
	-Compact		6	SS	3	460/610	20
			8–9	SS	4	530/610	21
	-Wet	∇	11	SS	5	560/610	19
	-Very Dense		13–14	SS	6	200/610	50/150
	-Compact, Moist		16	SS	7	430/610	25
270.7 270.6	Very Dense, Brown & Grey, Moist Poorly Graded SAND & GRAVEL (SP)		20	SS	8	100/150	50/150

-End of Borehole at 6.25m
-No cave
-A 50mm groundwater monitoring well was installed at a depth of 6.10m. Screened from 6.10m to 3.05m. Groundwater level measured at 3.54m below ground surface on July 11th, 2019.



☐ Field Vane Test, kPa

◘ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

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BOREHOLE RECORD

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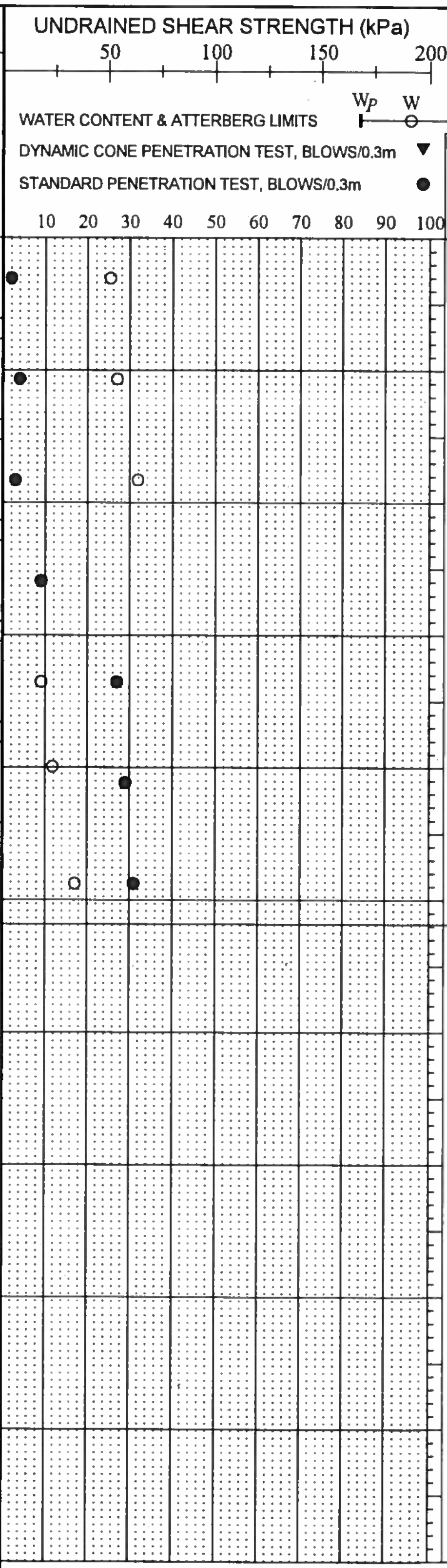
CLIENT Charter Consruction
PROJECT No. 121622652
LOCATION Orillia
DATUM Geodetic
DATES: BORING 16/05/2019
WATER LEVEL 11/07/2019
TPC ELEVATION 262.4m

ELEVATION (m)	STRATA DESCRIPTION	WATER LEVEL	TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)	GR	SA	SI	CL
262.4	Very Loose, Brown, Wet Organics, TOPSOIL trace Silt		SS	1	250/610	2				
261.6	Very Loose, Brown, Moist Silty SAND (SM) Till trace Organics		SS	2	510/610	4				
	-No more Organics	∇	SS	3	510/610	3				
260.1	Loose, Brown, Wet Poorly Graded SAND with GRAVEL (SP)		SS	4	410/610	9				
	-Compact, Very Wet		SS	5	510/610	27				
			SS	6	580/610	29	23	73	2	2
	-Dense -No more trace gravel		SS	7	580/610	31				
257.2	-End of Borehole at 5.18m -Cave to 4.89m -Drilled to 20' to open hole for well - Blow Back (7' Sand Blowback in Augurs) -A 50mm groundwater monitoring well was installed at a depth of 4.88m. Screened from 4.88m to 1.83m. Groundwater level measured at 1.79m below ground surface on July 11th, 2019.									



☐ Field Vane Test, kPa
◘ Remoulded Vane Test, kPa
△ Pocket Penetrometer Test, kPa

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BOREHOLE RECORD

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CLIENT Charter Consruction

LOCATION Orillia

DATES: BORING 16/05/2019

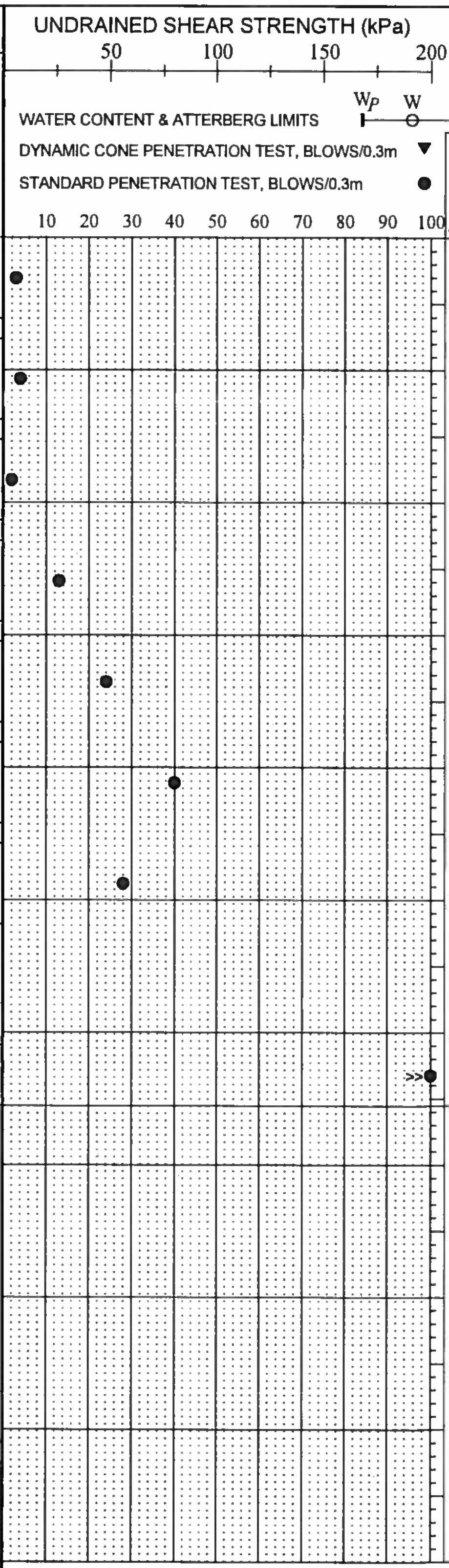
WATER LEVEL

PROJECT No. 121622652

DATUM Geodetic

TPC ELEVATION 267.9m

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	DEPTH (ft)	TYPE	NUMBER	RECOVERY (mm) / TCR(%) / SCR(%)	N-VALUE OR RQD(%)
0	267.9	Very Loose, Brown, Moist Silty SAND (SM) Till and Organic Topsoil	1	SS	1	410/610	3
1		-Loose, Moist -No Organics	3–4	SS	2	360/610	4
2		-Very Loose, Wet	6	SS	3	530/610	2
		-Compact -Some Sand in Tip	8–9	SS	4	560/610	13
3			11	SS	5	560/610	24
4		-Dense -With Gravel	13–14	SS	6	560/610	40
5		-Compact	16	SS	7	710/610	28
6	261.3	-Very Dense	21	SS	8	460/460	50/150
		-End of Borehole at 6.55m					



REMARKS & GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

☐ Field Vane Test, kPa

◘ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

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BOREHOLE RECORD

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CLIENT Charter Consruction

LOCATION Orillia

DATES: BORING 17/05/2019

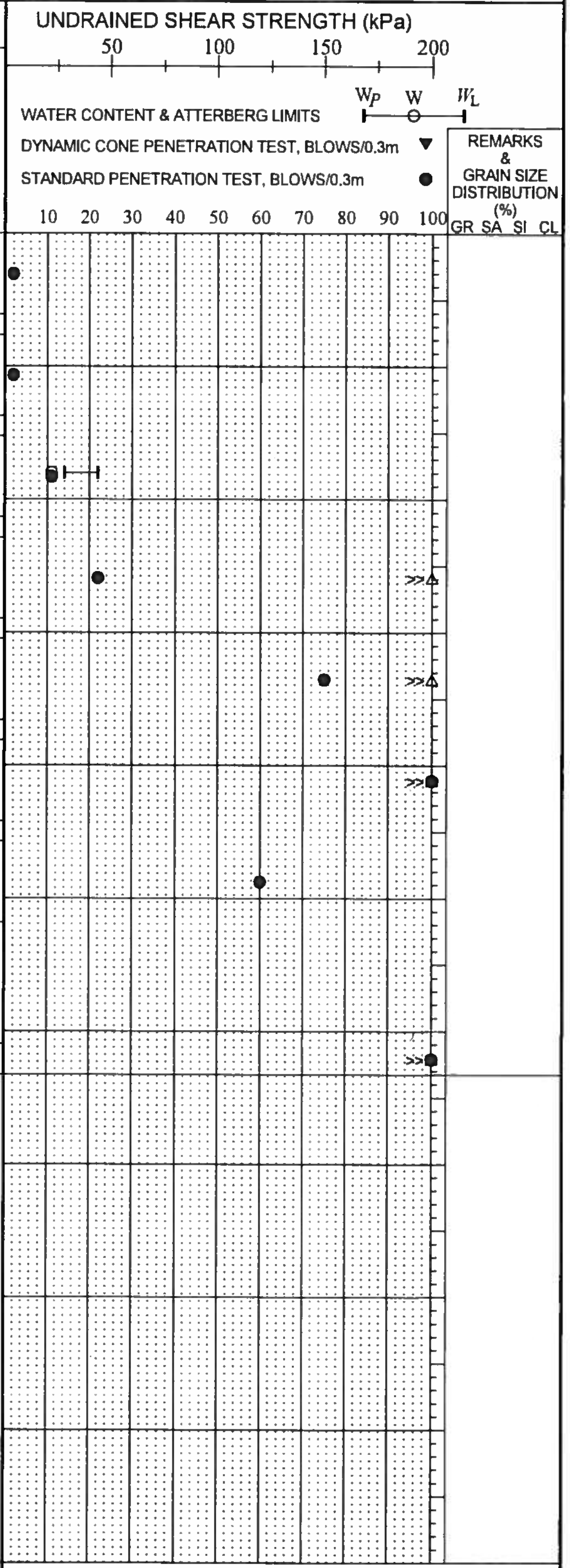
WATER LEVEL

PROJECT No. 121622652

DATUM Geodetic

TPC ELEVATION 269.5m

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	STRATA PLOT	WATER LEVEL	DEPTH (ft)	TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
0	269.5	Very Loose, Brown, Moist Silty SAND (SM) Till trace Organics			1	SS	1	300/610	2
1		-Wet, no Organics			3–4	SS	2	360/610	2
2		-Compact			6	SS	3	230/610	11
		-Moist			8–9	SS	4	530/610	22
3		-Very Dense			11	SS	5	580/610	75
4					13–14	SS	6	150/610	50/150
5		-Very Wet			16	SS	7	580/610	60
6	263.2	-Brown to Grey, Moist			20	SS	8	200/230	50/76
		-End of Borehole at 6.35m							



☐ Field Vane Test, kPa

◘ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

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BOREHOLE RECORD

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CLIENT Charter Consruction

LOCATION Orillia

DATES: BORING 17/05/2019

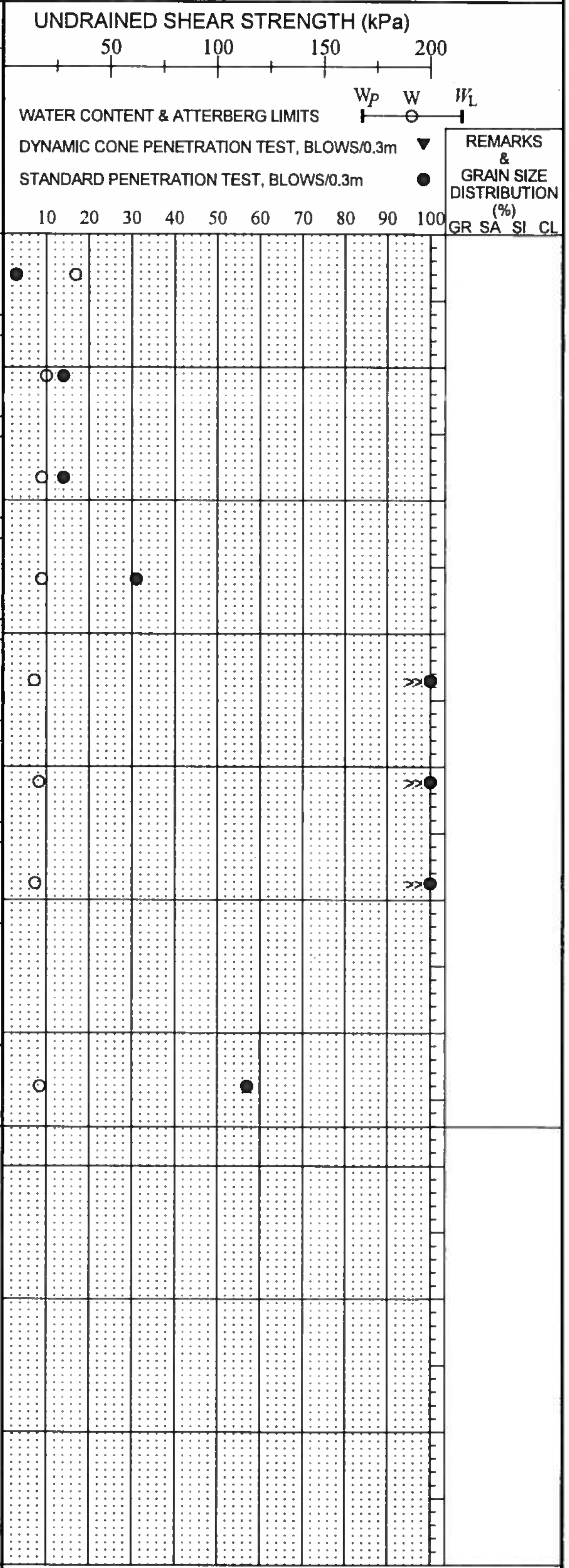
WATER LEVEL 04/06/2019

PROJECT No. 121622652

DATUM Geodetic

TPC ELEVATION 273.2m

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	DEPTH (ft)	SAMPLES TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
0	273.2	Very Loose, Brown, Moist Silty SAND (SM) Till and Organics	1	SS	1	360/610	3
1		-Compact	3–4	SS	2	330/610	14
2			6	SS	3	430/610	14
		-Dense	8–9	SS	4	560/610	31
3		-Very Dense	11	SS	5	250/610	50/150
4			13–14	SS	6	460/610	50/150
5			16	SS	7	300/610	50/150
6		-Imbedded with layers of Sand	21	SS	8	580/610	57
7	266.5	-End of Borehole at 6.71m -A 50mm groundwater monitoring well was intalled at a depth of 6.10m. Screened from 6.10m to 3.05m. The well was dry on June 4th, 2019.	22				



☐ Field Vane Test, kPa

■ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

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BOREHOLE RECORD

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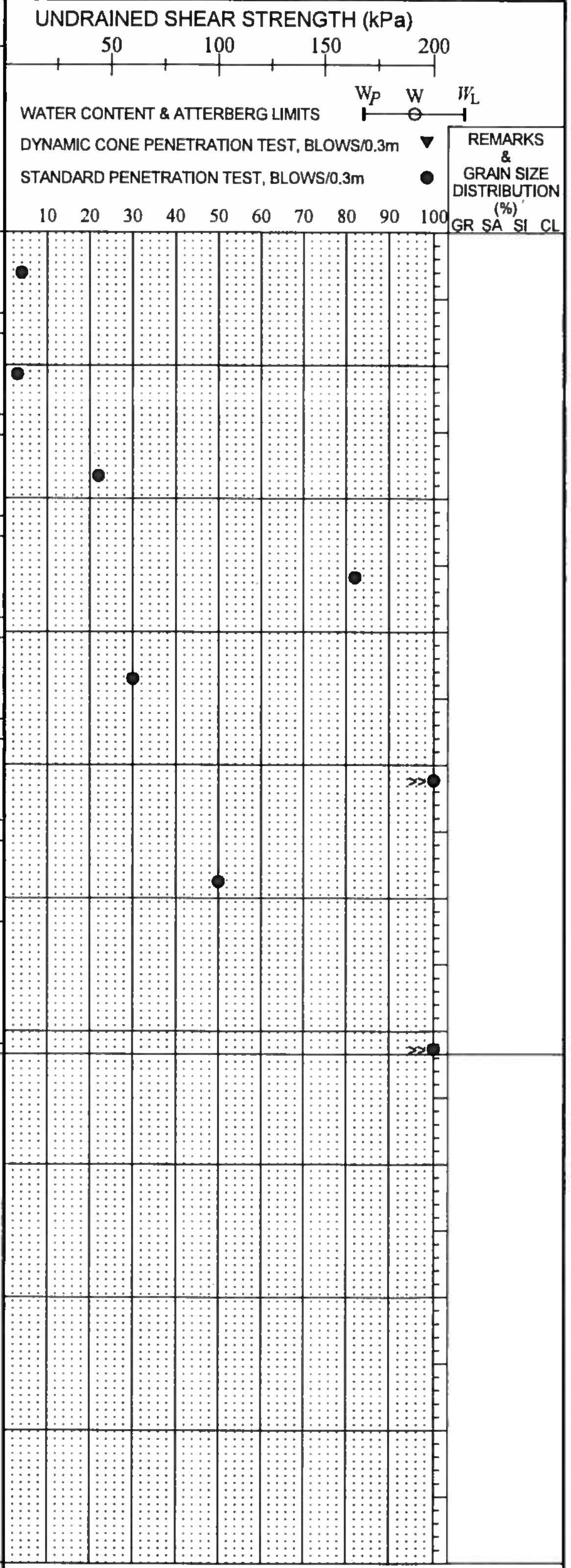
CLIENT Charter Consruction
LOCATION Orillia
DATES: BORING 17/05/2019
WATER LEVEL
PROJECT No. 121622652
DATUM Geodetic
TPC ELEVATION 278.3m

ELEVATION (m)	STRATA DESCRIPTION
278.3	
277.5	Very Loose, Brown, Moist Sandy TOPSOIL
276.8	Very Loose, Brown, Moist Silty SAND (SM) Till
276.0	Compact, Brown, Moist Clayey SAND (SC) Till
272.2	Very Dense, Brown, Moist Silty SAND (SM) Till & Gravel -Dense, Brown & Grey -Very Dense, Moist, No Gravel -Trace Gravel
	-Very Dense, Brown, Very Wet Well Graded SAND with SILT and Gravel
	-End of Borehole at 6.17m -Augur Refusal on Boulder

SAMPLES

TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
SS	1	150/610	4
SS	2	410/610	3
SS	3	330/610	22
SS	4	300/610	82
SS	5	580/610	30
SS	6	230/610	50/150
SS	7	580/610	50
SS	8	76/76	50/76



☐ Field Vane Test, kPa
■ Remoulded Vane Test, kPa
△ Pocket Penetrometer Test, kPa

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BOREHOLE RECORD

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CLIENT Charter Consruction

LOCATION Orillia

DATES: BORING 21/05/2019

WATER LEVEL 04/06/2019

PROJECT No. 121622652

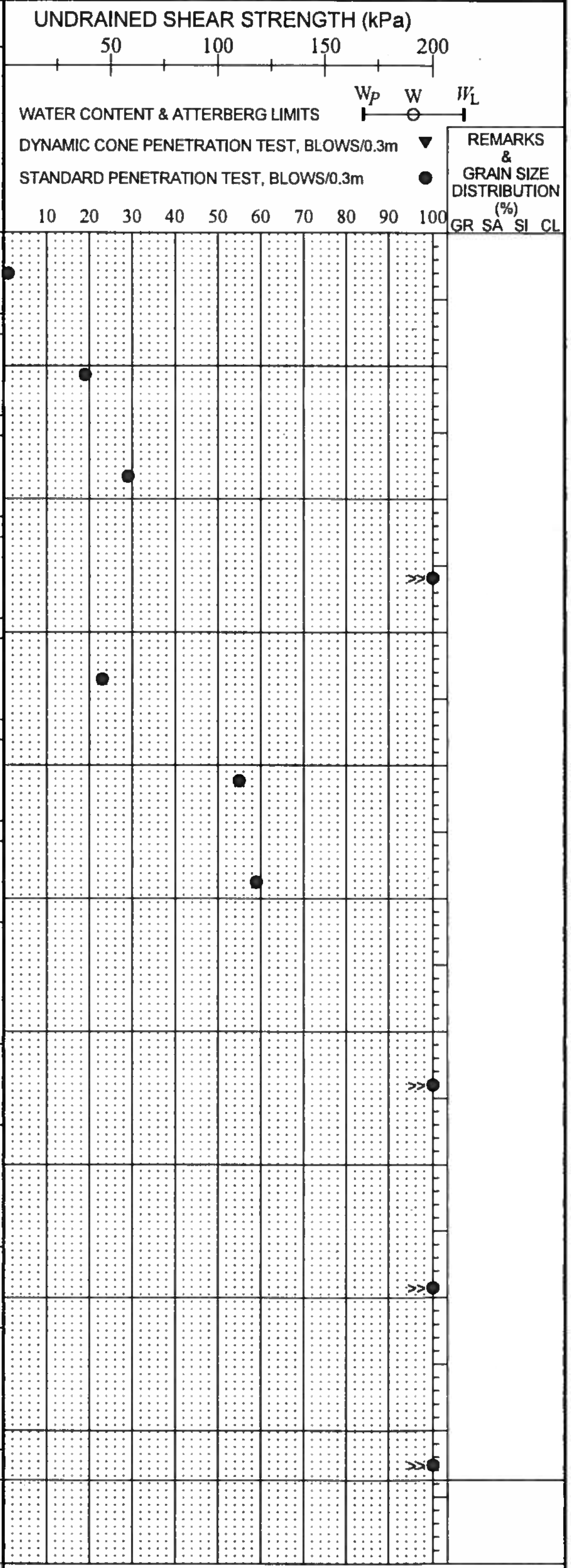
DATUM Geodetic

TPC ELEVATION 283.3m

ELEVATION (m)	STRATA DESCRIPTION
283.3	
283.0	Very Loose, Brown, Moist TOPSOIL
	Very Loose, Dark Brown, Moist Silty SAND (SM) Till -Compact, Organics
281.6	-Trace Gravel
281.0	Compact, Light Grey, Dry Broken pieces of ROCK
	Very Dense, Light Brown, Moist Silty SAND (SM) Till some Gravel -Compact, Light Grey to Grey, Damp -Very Dense, Trace Gravel -Light Brown, Damp -Brown, No Gravel -Very Dense, Light Brown
273.9	-Light Grey, Moist
	-End of Borehole at 9.37m

SAMPLES

TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
SS	1	300/610	1
SS	2	520/610	19
SS	3	430/610	29
SS	4	280/610	50/130
SS	5	610/610	23
SS	6	610/610	55
SS	7	580/610	59
SS	8	430/610	50/130
SS	9	410/610	50/100
SS	10	230/230	50/76



Continued Next Page

☐ Field Vane Test, kPa

◘ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

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BOREHOLE RECORD

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CLIENT Charter Consruction

LOCATION Orillia

DATES: BORING 21/05/2019

WATER LEVEL 04/06/2019

PROJECT No. 121622652

DATUM Geodetic

TPC ELEVATION 283.3m

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	STRATA PLOT	WATER LEVEL	DEPTH (ft)	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm) TCR(%) / SCR(%)	SAMPLES N-VALUE OR RQD(%)	UNDRAINED SHEAR STRENGTH (kPa) 50 100 150 200	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
10	273.3	-A 50mm groundwater monitoring well was installed at a depth of 9.14m. Screened from 9.14m to 6.10m. The well was dry on June 4th, 2019.			33						
					34						
					35						
11					36						
					37						
					38						
					39						
12					40						
					41						
					42						
13					43						
					44						
					45						
14					46						
					47						
					48						
					49						
15					50						
					51						
					52						
16					53						
					54						
					55						
17					56						
					57						
					58						
18					59						
					60						
					61						
					62						
19					63						
					64						
					65						
20											

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC CONE PENETRATION TEST, BLOWS/0.3m ▼

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90 100

☐ Field Vane Test, kPa

◘ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

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BOREHOLE RECORD

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CLIENT Charter Consruction

LOCATION Orillia

DATES: BORING 17/05/2019

WATER LEVEL 11/07/2019

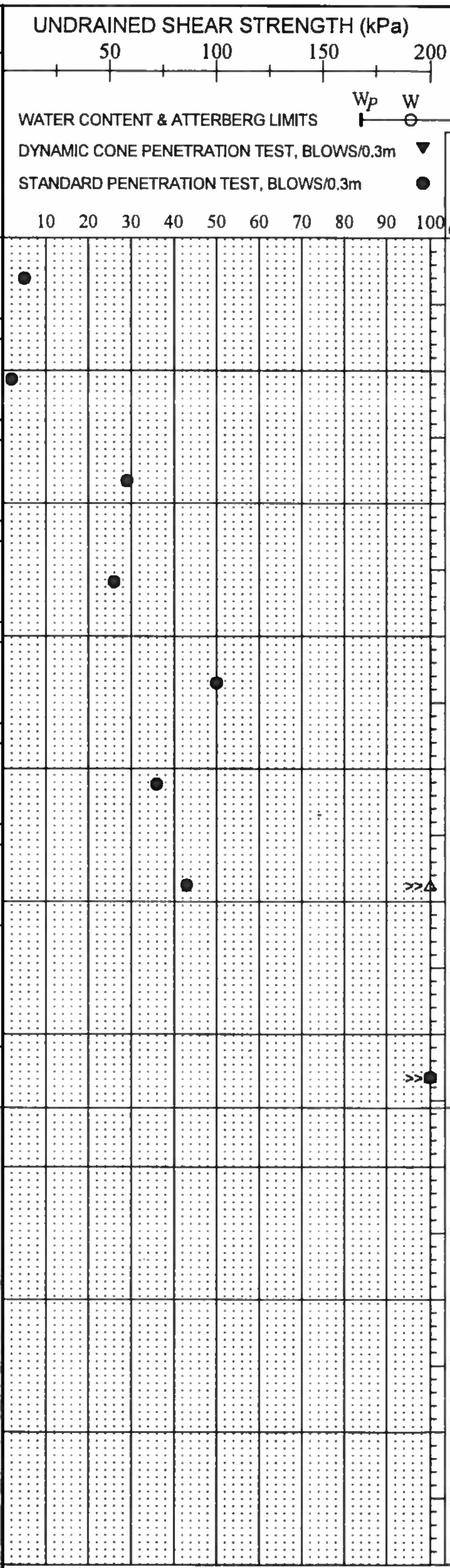
PROJECT No. 121622652

DATUM Geodetic

TPC ELEVATION 284.8m

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	WATER LEVEL
0	284.8	Loose, Brown Silty Organics	
	284.0 283.8	Very Loose, Brown, Very Wet Well-Graded SAND with Silt and Gravel	
		Very Loose, Brown, Moist Silty SAND (SM) Till some Organics -Compact, Wet -Moist -Dense -Sand seam extends from 10'9" to 11'1" -Very Dense	▽
	278.2	-End of Borehole at 6.55m -A 50mm groundwater monitoring well was installed at a depth of 6.10m. Screened from 6.10m to 3.05m. Groundwater level measured at 2.05m below ground surface on July 11th, 2019.	

TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)	GR	SA	SI	CL
SS	1	330/610	5				
SS	2	410/610	2	2	67	25	6
SS	3	530/610	29				
SS	4	560/610	26				
SS	5	430/610	50				
SS	6	560/610	36				
SS	7	580/610	43				
SS	8	410/460	50/130				



REMARKS & GRAIN SIZE DISTRIBUTION (%)

☐ Field Vane Test, kPa

◘ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

BH 17

Sheet 1 of 1

CLIENT Charter Consruction

LOCATION Orillia

DATES: BORING 21/05/2019

WATER LEVEL

PROJECT No. 121622652

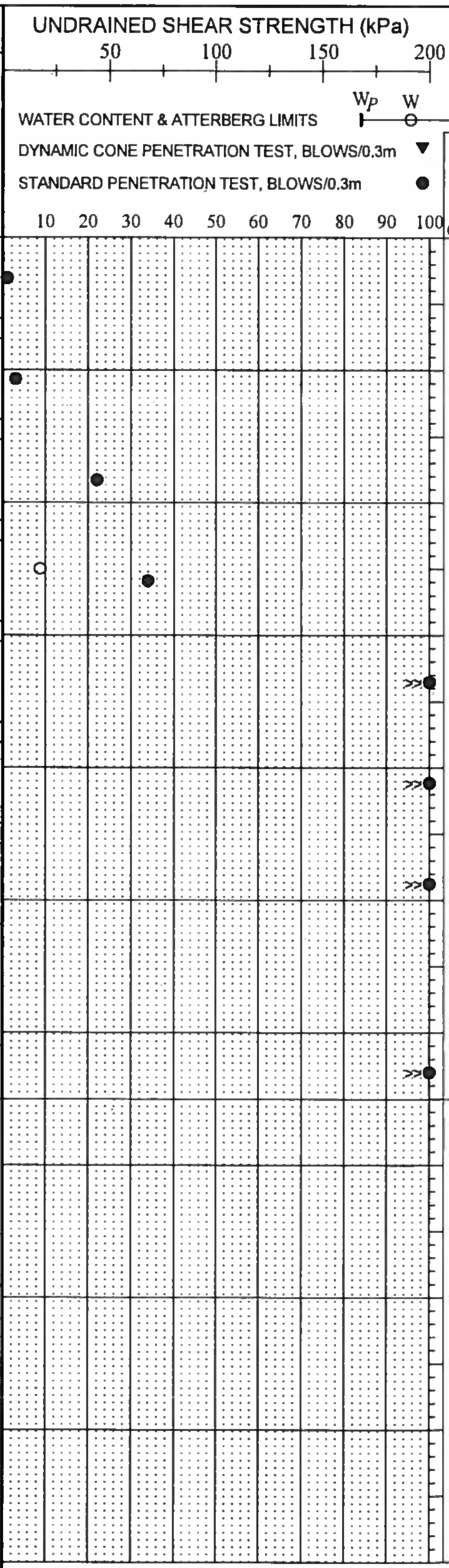
DATUM Geodetic

TPC ELEVATION 277.0m

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION
0	277.0	Very Loose, Dark Grey, Moist Silty SAND (SM) Till
		-Dark Brown
		-No Sample
		-Dense, Light Brown, Dry to Damp -Broken rock fragments
		-Very Dense, Wet
	273.2	Very Dense, Brown, Wet Well-Graded SAND with Silt and Gravel
		-Light Brown, Moist
	270.3	-End of borehole at 6.50m

SAMPLES

TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
SS	1	460 / 610	1	
SS	2	410 / 610	3	
SS	3	0.0 / 610	22	
SS	4	430 / 610	34	7 56 29 8
SS	5	430 / 610	50/ 130	
SS	6	230 / 610	50/ 76	
SS	7	89 / 610	50/ 76	
SS	8	410 / 410	50/ 100	



☐ Field Vane Test, kPa

◘ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

BH 18

Sheet 1 of 1

CLIENT Charter Consruction

LOCATION Orillia

DATES: BORING 21/05/2019

WATER LEVEL 11/07/2019

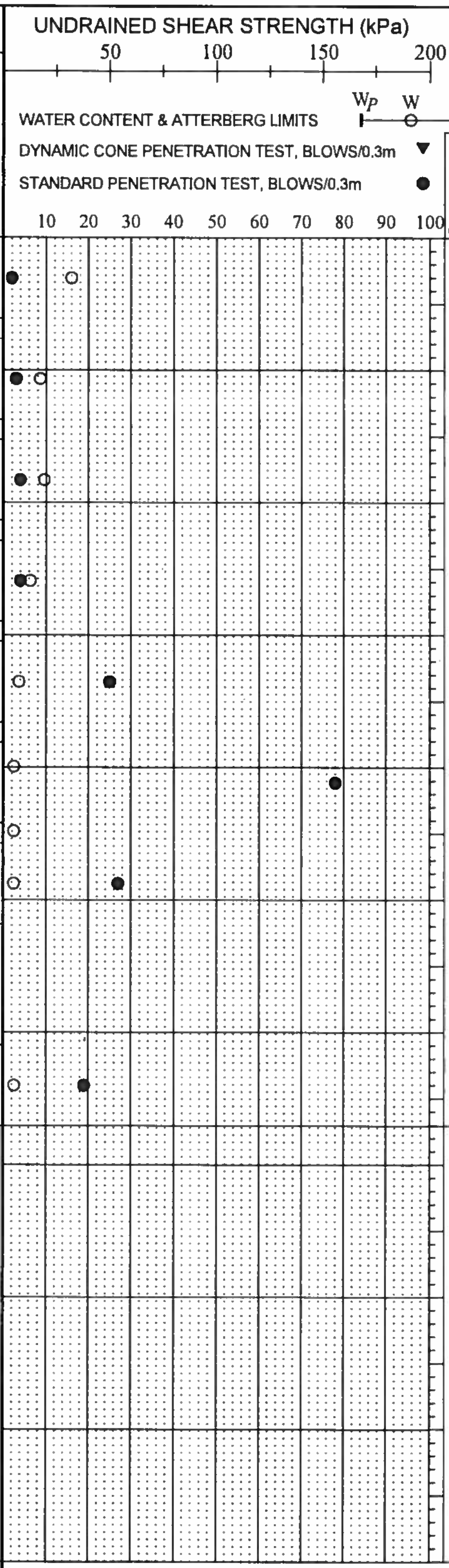
PROJECT No. 121622652

DATUM Geodetic

TPC ELEVATION 267.8m

ELEVATION (m)	STRATA DESCRIPTION
267.8	Very Loose, Dark Grey, Damp Silty SAND (SM) Till with Organics -Light Brown
266.3	Very Loose, Brown, Damp Well Graded SAND with SILT and GRAVEL (SW-SM) -Trace Cobbles -Compact -Very Dense -Compact, Dark Brown -Brown, Moist
261.1	End of Borehole at 6.71m -A groundwater monitoring well was installed at a depth of 6.10m. Screened from 6.10m to 3.05m. The well was dry on July 11th, 2019.

DEPTH (ft)	TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	1	200/610	2	
3.5	SS	2	410/610	3	
6	SS	3	460/610	4	
8.5	SS	4	430/610	4	
11	SS	5	410/610	25	
13.5	SS	6	460/610	78	39 52 7 2
16	SS	7	410/610	27	
21	SS	8	410/610	19	



☐ Field Vane Test, kPa

◘ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

BH18-01

CLIENT TransCanada Corporation

LOCATION Orillia, Ontario

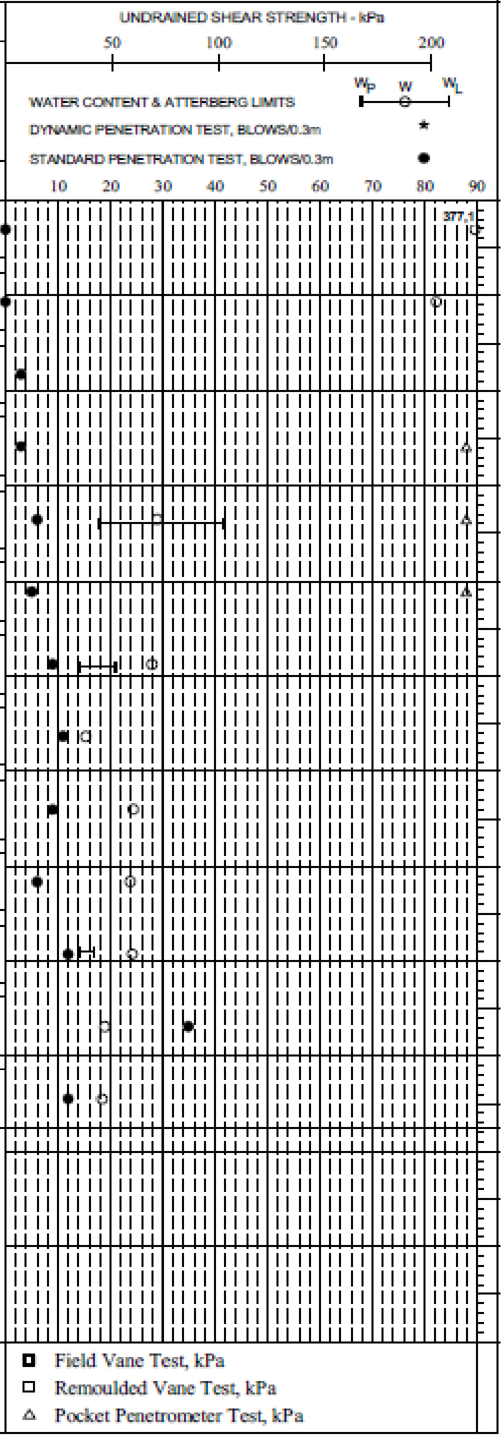
DATES: BORING September 27, 2018 WATER LEVEL September 27, 2018

BOREHOLE No. BH18-01

PROJECT No. 121622413

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD
0		Very loose black PEAT			SS	1	76	0
1					SS	2	76	0
2		152 mm thick sand layer at 2.0 m			SS	3	330	3
		~~Firm~~ to stiff grey LEAN CLAY (CL) to SILTY CLAY (CL-ML)			SS	4	356	3
3					SS	5	559	6
4					SS	6	584	5
5					SS	7	584	9
		Loose to dense brown SILT (ML)			SS	8	584	11
6					SS	9	584	9
7		Wet below 7.2 m		▽	SS	10	584	6
8					SS	11	584	12
9					SS	12	533	35
		51 mm thick layer of coarse sand at 9.7 m			SS	13	533	12
10		End of Borehole						
11								
12								



▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

Stantec

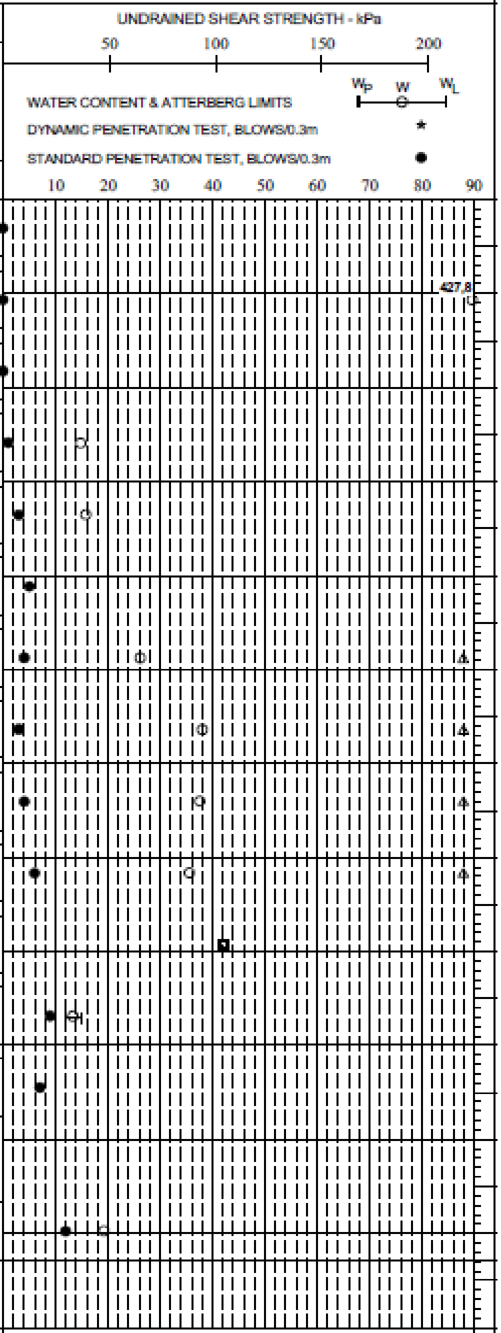
BOREHOLE RECORD

1 of 1

BH18-02

CLIENT TransCanada Corporation
LOCATION Orillia, Ontario
DATES: BORING September 27, 2018 WATER LEVEL September 27, 2018
BOREHOLE No. BH18-02
PROJECT No. 121622413
DATUM Geodetic

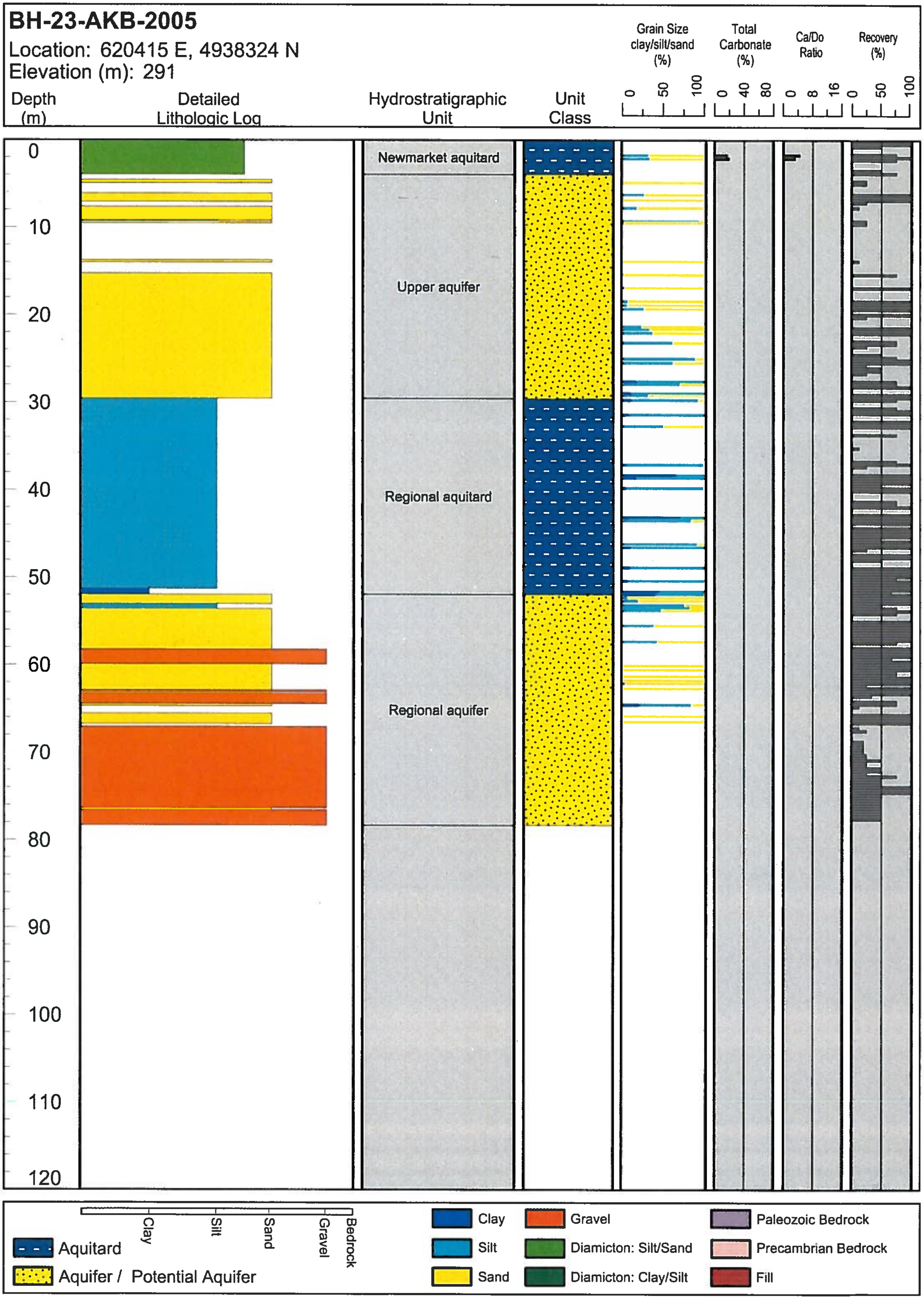
DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD
0		Loose brown PEAT - Wet	SS	1	76	0
1			SS	2	-	0
2			SS	3	127	0
		- Clay seam at 2.3 m Very loose grey SILTY GRAVEL with sand (GM) - Wet	SS	4	330	1
3		Very loose to loose silty clayey SAND (SC-SM) - Wet	SS	5	406	3
4			SS	6	432	5
5		Soft grey LEAN CLAY (CL) - Moist	SS	7	457	4
			SS	8	457	3
6			SS	9	508	4
7		Loose to compact grey sandy SILT (ML) - Wet Shear Strength > 106 kPa at 7.9 m depth	SS	10	559	6
8			SS	11	-	-
			SS	12	584	9
9			SS	13	533	7
10						
11			SS	14	584	12
		End of Borehole				
12						



Inferred Groundwater Level
Groundwater Level Measured in Standpipe

Field Vane Test, kPa
Remoulded Vane Test, kPa
Pocket Penetrometer Test, kPa

STN13-STAN-GEO 121622413 STONE RIDGE REPLACEMENT.GPJ SMART.GDT 10/22/18


BH-23-AKB-2005
Location: 620415 E, 4938324 N
Elevation (m): 291
Depth (m)
Detailed Lithologic Log
Hydrostratigraphic Unit
Unit Class
Grain Size clay/silt/sand (%)
0 50 100
Total Carbonate (%)
0 40 80
Ca/Do Ratio
0 8 16
Recovery (%)
0 50 100
0
10
20
30
40
50
60
70
80
90
100
110
120
Newmarket aquitard
Upper aquifer
Regional aquitard
Regional aquifer
Clay
Silt
Sand
Gravel
Bedrock
Aquitard
Aquifer / Potential Aquifer
Clay
Silt
Sand
Gravel
Diamicton: Silt/Sand
Diamicton: Clay/Silt
Paleozoic Bedrock
Precambrian Bedrock
Fill

MECP Water Well Records

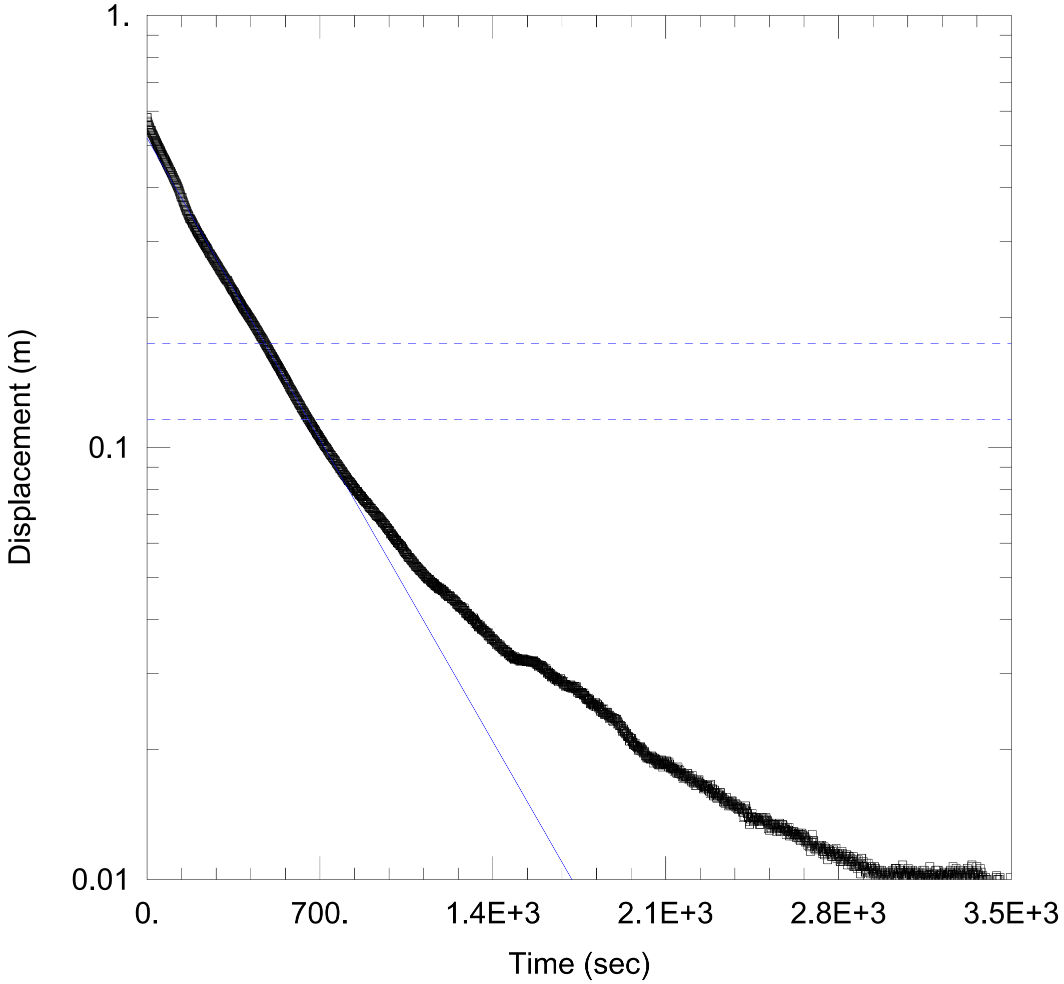
Well ID	Distance From Site (m)	Easting	Northing	Ground Elevation (m AMSL)	Well Depth		Casing Depth		Well Use	Date Constructed	**Lithology - base depth of deposit in brackets (m BGS)** Note: boded text highlighted in red interpreted to represent an aquitard unit
					(m BGS)	(m AMSL)	(m BGS)	(m AMSL)			
5702914	182	620823	4940037	288.8	74.7	214.1	74.7	214.1	Public	30-May-59	TPSL (0.3), CLAY (33.5), FSND (45.7), CLAY CSND (72.5), GRVL (74.7)
5702915	110	621129	4939581	277.8	61.0	216.9	61.0	216.9	Livestock	12-Mar-60	TPSL (0.6), CLAY STNS (18.3), MSND (44.2), CLAY BLDRS (59.4), SANDY GRVL (61)
5702916	1	621332	4939465	282.9	30.5	252.4	28.0	254.9	Domestic	29-Aug-62	TPSL (0.6), CLAY STNS (24.4), GRVL MSND (30.5)
5702933	467	621751	4941061	283.9	66.8	217.1	66.8	217.1	Domestic	19-Apr-67	N/A
5709268	423	622199	4940905	283.1	52.4	230.7	50.9	232.2	Domestic	07-Apr-72	N/A
5711284	338	620865	4940324	273.6	49.1	224.6	48.2	225.5	Domestic	25-May-74	TPSL (0.9), SILTY SAND BLDRS (13.7), SILT CLAY (39.6), CLAY GRVL (48.2), SAND (49.1)
5711816	381	621115	4940524	258.7	41.1	217.6	39.6	219.1	Domestic	27-Aug-74	CLAY STNS (6.4), GRVL SAND (41.1)
5711818	364	620815	4940324	276.5	59.7	216.7	57.6	218.9	Domestic	10-Jul-74	CLAY STNS (12.8), GRVL SAND (30.5), SILT CLAY (56.1), SAND GRVL (59.7)
5711819	371	620965	4940424	258.1	53.0	205.0	51.8	206.3	Domestic	05-Aug-74	CLAY STNS (4.6), SAND CLAY (11), GRVL CLAY (18.9), CLAY SILT (43.3), CLAY STNS (45.7), SAND GRVL (53)
5712627	166	621115	4940274	260.0	21.3	238.7	20.4	239.6	Domestic	17-Nov-75	TPSL (1.5), FSND (19.5), SAND CLAY (20.4), CLAY HARD PACKED (21.3)
5712628	277	621065	4940374	256.6	21.9	234.6	20.4	236.2	Domestic	25-Nov-75	TPSL (1.5), FSND (19.5), SAND CLAY (20.4), CLAY HARD PACKED (21.9)
5712629	89	621015	4940124	275.4	36.6	238.8	36.0	239.4	Domestic	04-Dec-75	SAND BLDRS (5.5), FSND (32), CLAY HARD PACKED (36.6)
5712655	190	621065	4940274	263.1	28.7	234.5	27.4	235.7	Domestic	08-Dec-75	TPSL (1.5), FSND (25), SAND CLAY (27.4), CLAY HARD PACKED (28.7)
5712722	296	620865	4940274	278.1	39.9	238.2	39.3	238.8	Domestic	31-Dec-75	SAND GRVL (6.4), FSND (34.1), CLAY HARD PACKED (39.9)
5712794	115	620965	4940124	279.4	39.9	239.4	39.0	240.4	Domestic	28-Jan-76	SAND GRVL (35.1), CLAY SAND HARD (39.9)
5713003	63	621065	4940124	269.3	41.1	228.2	41.1	228.2	Domestic	12-Mar-76	SAND GRVL (16.5), CLAY SILT LAYERED (36.6), SAND (39.9), GRVL (41.1)
5713004	70	621035	4940114	273.2	47.2	226.0	46.3	226.9	Domestic	31-Mar-76	FSND (18.9), SILT CLAY LAYERED (41.8), SAND (47.2)
5713005	89	621015	4940124	275.4	53.6	221.8	53.0	222.4	Domestic	26-Mar-76	PREV. DRILLED (36.6), CLAY HARD PACKED (46.6), SILT CLAY (53), FSND GRVL (53.6)
5713006	277	621065	4940374	256.6	41.8	214.8	40.8	215.8	Domestic	19-Mar-76	PREV. DRILLED (21.9), SILT CLAY (36.6), SAND (41.8)
5713057	296	620865	4940274	278.1	63.1	215.0	62.2	215.9	Domestic	28-Apr-76	PREV. DRILLED (39.9), CLAY SILT (57.9), SAND GRVL (63.1)
5713059	262	621095	4940374	255.3	42.1	213.2	41.8	213.5	Domestic	10-May-76	SAND GRVL STNS (7.6), CLAY GRVL (39.6), SAND GRVL (42.1)
5713327	115	620965	4940124	279.4	53.9	225.4	53.0	226.4	Domestic	15-Apr-76	PREV. DRILLED (39.9), CLAY (46.3), SAND GRVL (53.9)
5713329	190	621065	4940274	263.1	48.8	214.4	47.2	215.9	Domestic	23-Jul-76	PREV. DRILLED (28.7), FSND CLAY (36.6), CLAY FSND (41.1), SAND GRVL (48.8)
5714054	269	620965	4940304	267.4	16.2	251.2	16.2	251.2	Domestic	21-Oct-76	HARDPAN (16.2)
5714638	202	622015	4940774	283.3	55.2	228.2	55.2	228.1	Domestic	14-Sep-77	SAND GRVL (14.9), CLAY GRVL (20.4), FSND (39.6), CLAY SAND LAYERED (54.3), SAND GRVL (55.2)
5714742	150	621315	4940374	260.7	40.5	220.2	39.3	221.4	Domestic	05-Oct-77	CLAY GRVL (17.1), CLAY (33.5), STNS SAND (36.6), SAND (40.5)
5715036	444	622065	4941024	283.4	74.4	209.0	73.8	209.6	Public	21-Feb-78	N/A
5717121	142	621415	4940424	264.4	44.5	219.9	44.5	219.9	Domestic	03-Oct-80	HARDPAN (36.6), SAND (43.9), FGRVL (44.5)
5717881	207	621365	4940474	264.6	33.5	231.1	33.5	231.1	Domestic	18-Aug-81	CLAY BLDRS (18.3), CLAY GRVL (32.9), SAND GRVL (33.5)
5718136	0	621415	4939474	279.6	64.0	215.6	64.0	215.6	Domestic	02-Jul-82	CLAY GRVL (18.3), CLAY SAND SILT (22.9), SILT SAND (63.4), FGRVL (64)
5718287	311	621382	4940660	277.7	57.9	219.8	57.9	219.8	Domestic	31-Dec-82	TPSL (0.3), FSND (7.9), CLAY SILT (53.3), CLAY STNS (57.9)
5718931	311	621382	4940660	277.7	34.1	243.5	34.1	243.5	Domestic	25-Aug-83	SANDY BLDRS (16.8), HARDPAN (27.4), SAND (32), CLAY (33.8), GRVL (34.1)
5719851	355	621282	4940619	268.2	35.7	232.5	35.7	232.5	Domestic	25-Apr-85	CLAY STNS (22.3), CLAY (35.7)
5720534	311	621382	4940660	277.7	36.6	241.1	36.6	241.1	Domestic	28-Nov-83	HARDPAN (35.1), SAND GRVL (36.6)
5721610	433	621156	4940609	262.7	39.6	223.1	38.7	224.0	Domestic	17-Dec-86	GRVL CLAY (21.3), CLAY (38.1), GRVL SAND (39.6)
5722152	481	622201	4940983	280.2	36.6	243.7	35.4	244.9	Domestic	30-Jul-87	N/A
5722388	470	621926	4941084	283.7	53.9	229.8	52.7	231.0	Domestic	25-Sep-87	N/A
5724141	364	621200	4940554	262.6	54.3	208.3	54.3	208.3	Domestic	28-Sep-88	HARDPAN (24.4), CLAY 36.6), HARDPAN (52.4), SAND GRVL (54.3)
5726344	390	620800	4940345	276.1	19.2	256.9	18.0	258.1	Domestic	08-Feb-90	TPSL (0.3), SAND GRVL (14), CLAY SILT (16.8), SAND GRVL (19.2)
5728579	471	621306	4940805	281.2	51.8	229.3	48.8	232.4	Domestic	04-Oct-91	TPSL (1.8), GRVL BLDRS (13.7), CLAY CEMENTED (45.7), SAND (51.8)
5728580	145	621820	4940742	282.8	47.2	235.5	46.0	236.8	Domestic	24-Sep-91	TPSL (0.3), CLAY (29.9), SAND (36.9), CLAY (42.7), SAND (47.2)
5728581	44	621861	4940649	285.0	50.0	235.0	48.8	236.3	Livestock	26-Sep-91	TPSL (1.8), CLAY BLDRS (27.4), CLAY SILT (42.7), SAND (50)
5728582	391	621336	4940727	280.0	51.5	228.5	50.3	229.7	Domestic	27-Sep-91	TPSL (0.3), CLAY STNS (7.6), GRVL CLAY CEMENTED (45.1), SAND (51.5)

MECP Water Well Records

Well ID	Distance From Site (m)	Easting	Northing	Ground Elevation (m AMSL)	Well Depth		Casing Depth		Well Use	Date Constructed	Lithology - base depth of deposit in brackets (m BGS) Note: boded text highlighted in red interpreted to represent an aquitard unit
					(m BGS)	(m AMSL)	(m BGS)	(m AMSL)			
5728583	484	621296	4940814	281.5	56.4	225.1	49.7	231.8	Domestic	30-Sep-91	TPSL (0.3), GRVL BLDRS HARD (12.2), CLAY CEMENTED (45.1), SAND (56.4)
5729049	212	620891	4940192	282.7	54.3	228.5	53.3	229.4	Domestic	20-Jan-92	SAND CLAY (41.1), CLAY (49.1), CLAY SAND (52.7), SAND (54.3)
5730068	413	621426	4940815	279.5	48.8	230.8	47.5	232.0	Domestic	27-Jul-93	FILL (1.2), CLAY (11.6), GRAVEL (18.3), CLAY (38.4), SAND (48.8)
5730500	230	622059	4940772	283.7	78.3	205.4	77.4	206.3	Public	13-Dec-93	TPSL (0.3), SAND (40.2), CLAY SAND (47.5), FSND (58.8), GRVL CEMENTED (65.2), FSND (70.7), CLAY (73.5), GRVL (78.3)
5730679	311	621382	4940660	277.7	48.8	228.9	48.2	229.5	Domestic	12-Nov-93	HARDPAN (7.6), CLAY (42.7), CLAY HARDPAN (47.5), SAND GRVL (48.8)
5731276	311	621382	4940660	277.7	27.7	249.9	25.3	252.4	Domestic	27-Sep-94	TPSIL (0.6), CLAY GRVL BLDRS (21.3), SAND SILT (27.7)
5731864	164	621517	4940578	275.7	52.7	223.0	48.8	227.0	Domestic	10-Jul-95	GRVL CLAY CEMENTED (25.3), FSND (26.2), CLAY (36.6), GRVL (39.3), CLAY (47.2), SAND (51.5), GRVL CLAY (52.7)
5731999	311	621382	4940660	277.7	18.6	259.1	17.1	260.6	Domestic	03-Nov-95	DUG (6.1), SAND CLAY (16.8), SAND (18.6)
5735648	313	621378	4940660	277.7	38.1	239.6	-	-	Domestic	01-Oct-00	CLAY STNS (10.7), SAND GRVL (12.2), HARDPAN (36.6), SANDSTONE (38.1)
5740315	71	621093	4940151	265.9	41.8	224.1	40.3	225.6	Domestic	07-Oct-05	SAND SILT (15.8), CLAY SILT LAYERED (34.1), SAND GRVL (41.8)
7149846	0	621512	4939185	280.6	43.3	237.3	41.8	238.8	Domestic	23-Jul-10	CLAY BLDRS GRVL (3.7), CLAY GRVL (41.8), SAND (43.3)
7278501	165	621307	4940387	260.8	41.5	219.4	40.5	220.3	Domestic	24-Nov-16	TPSL (0.3), CLAY STNS (4), GRVL (5.2), CLAY (19.8), SILT (27.4), CLAY (33.2), GRVL SAND CEMENTED (40.2), SAND (41.5)
7245720	374	620815	4940336	275.7	11.3	264.5	10.4	265.3	Domestic	09-Jul-15	SAND CLAY (7.9), SAND (11.3)
7144578	288	622267	4940538	283.2	85.4	197.8	45.2 / 78.0	238.0	Monitoring	14-Feb-10	SAND TILL (21.4), FSND (37.5), CLAY (44.2), SAND CLAY (51.5), GRVL FSND (61.6), SAND GRVL CEMENTED (67.7), CLAY (70.7), FSND (85), CLAY DENSE (85.4)
7141711	316	622643	4939265	269.3	-	-	-	-	Test Hole	30-Nov-09	N/A
7290296	399	622791	4938837	267.2	4.6	262.6	3.0	264.2	Test Hole	18-May-17	TPSL (0.2), SAND SILT (4.6)

APPENDIX E:

HYDRAULIC CONDUCTIVITY ANALYTICAL SOLUTIONS



MW8-19S

Data Set: \...\MW8-19S_SB_JK.aqt
Date: 08/28/19 Time: 11:44:28

PROJECT INFORMATION

Company: Stantec Consulting Ltd.
Client: Charter Development LP
Project: 121622652
Location: Orillia ON
Test Well: MW8-19S
Test Date: 4-June-19

AQUIFER DATA

Saturated Thickness: 1.69 m
Anisotropy Ratio (Kz/Kr): 0.3

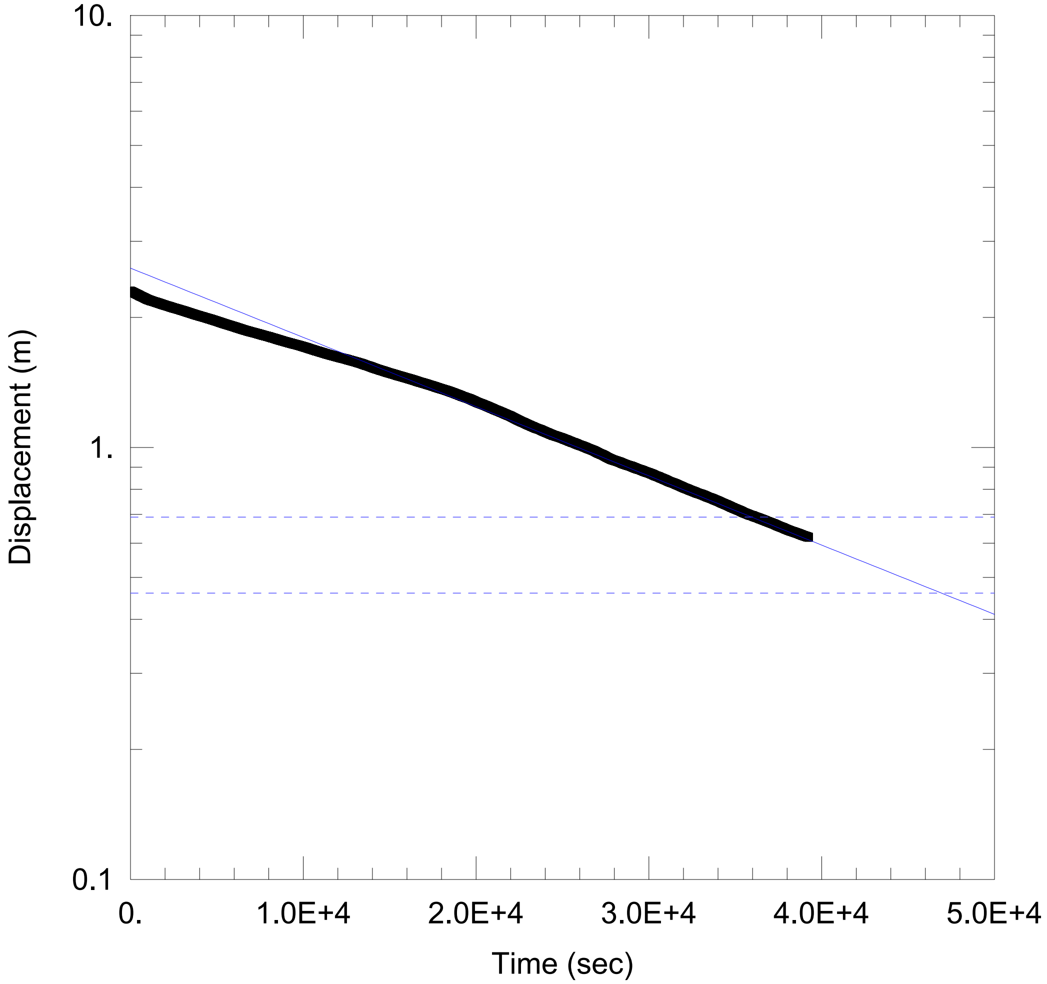
WELL DATA (MW8-19S)

Initial Displacement: 0.5804 m
Total Well Penetration Depth: 1.69 m
Casing Radius: 0.0254 m
Static Water Column Height: 1.69 m
Screen Length: 1.69 m
Well Radius: 0.105 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 5.2E-6 m/sec
y0 = 0.52 m



MW7-19

Data Set: \...\MW7-19_SB_JK.aqt
Date: 08/28/19
Time: 11:34:28

PROJECT INFORMATION

Company: Stantec Consulting Ltd.
Client: Charter Development LP
Project: 121622652
Location: Orillia ON
Test Well: MW7-19
Test Date: 11-July-19

AQUIFER DATA

Saturated Thickness: 2.43 m
Anisotropy Ratio (Kz/Kr): 0.2

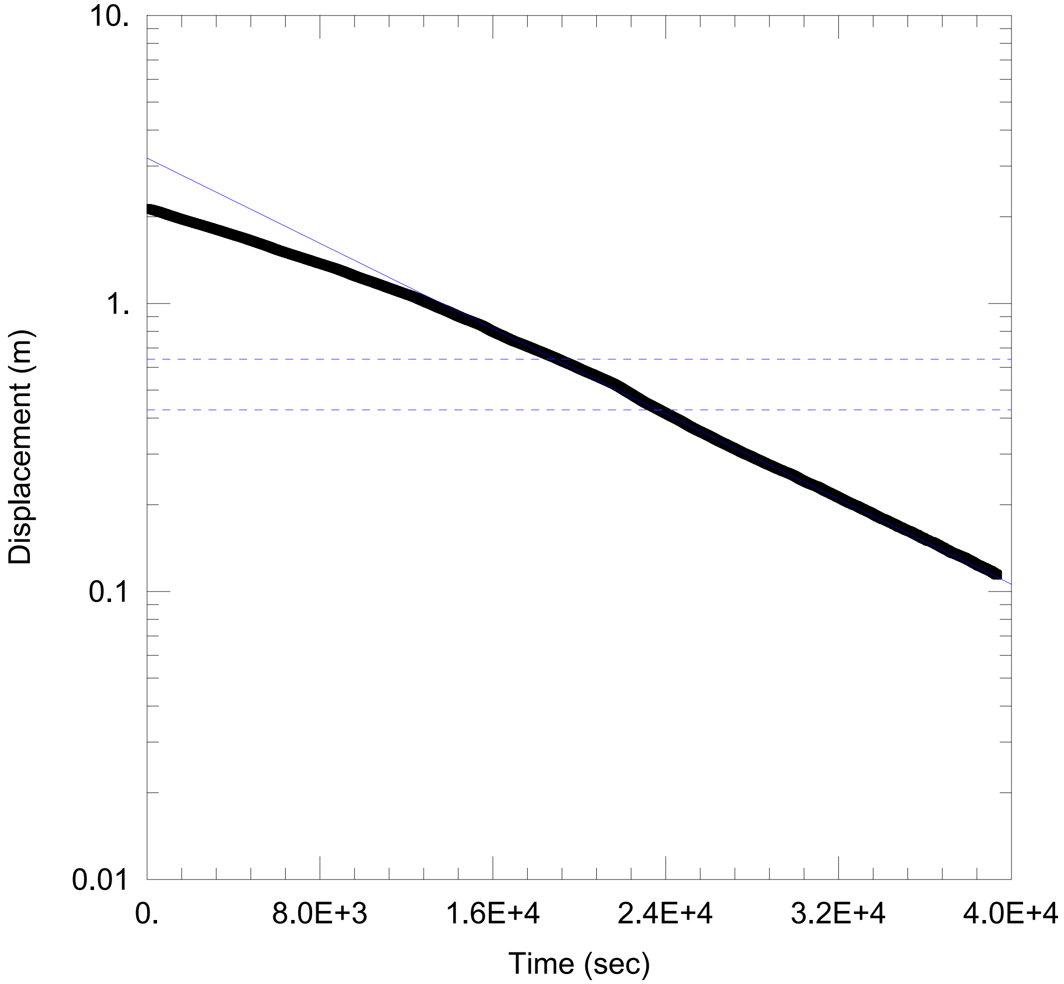
WELL DATA (MW7-19)

Initial Displacement: 2.3 m
Total Well Penetration Depth: 2.43 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.43 m
Screen Length: 2.43 m
Well Radius: 0.105 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 6.7E-8 m/sec
y0 = 2.6 m



MW5-19

Data Set: \...\MW5-19_SB_JK.aqt
Date: 08/28/19 Time: 09:37:34

PROJECT INFORMATION

Company: Stantec Consulting Ltd.
Client: Charter Development LP
Project: 121622652
Location: Orillia ON
Test Well: MW5-19
Test Date: 11-July-19

AQUIFER DATA

Saturated Thickness: 2.55 m
Anisotropy Ratio (Kz/Kr): 0.2

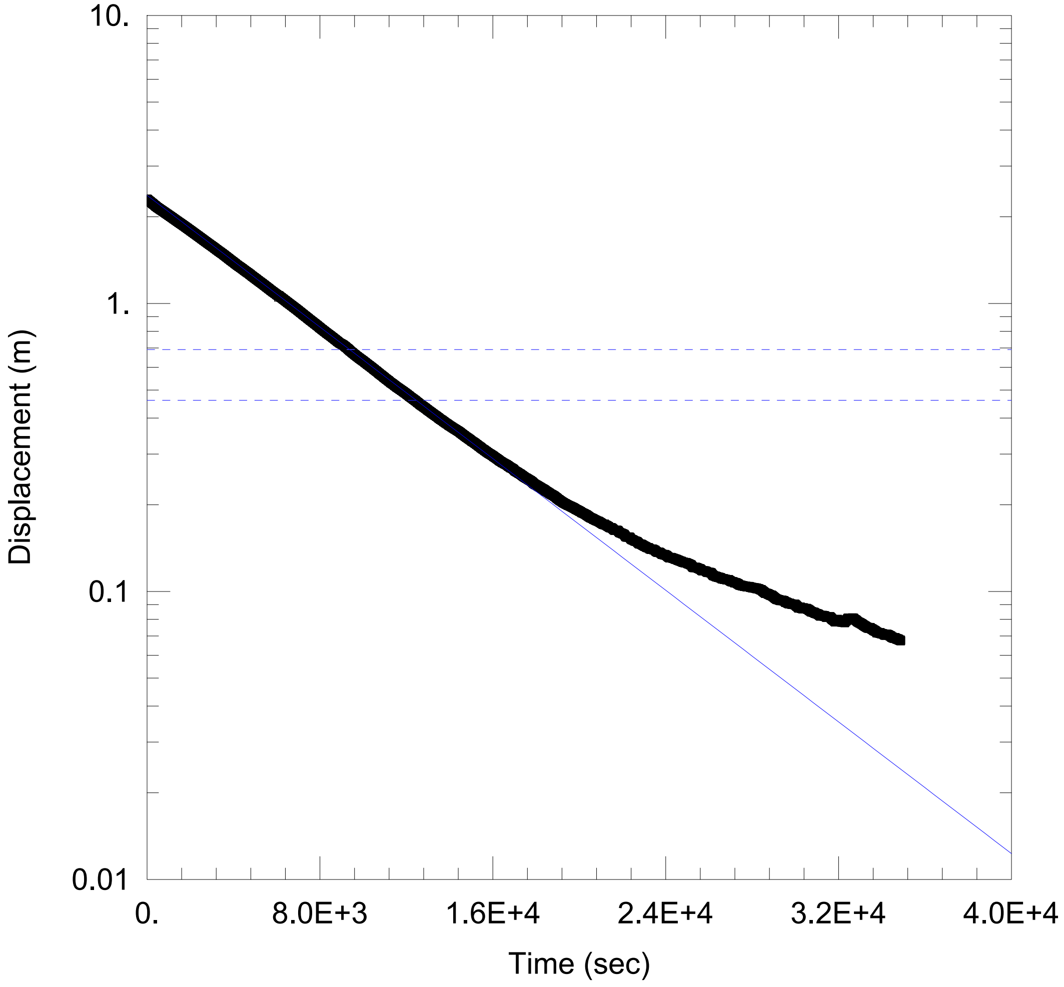
WELL DATA (MW5-19)

Initial Displacement: 2.135 m
Total Well Penetration Depth: 2.55 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.55 m
Screen Length: 2.55 m
Well Radius: 0.105 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 1.5E-7 m/sec
y0 = 3.196 m



MW6-19

Data Set: \...\MW6-19_SB_JK.aqt
Date: 08/28/19 Time: 09:59:14

PROJECT INFORMATION

Company: Stantec Consulting Ltd.
Client: Charter Development LP
Project: 121622652
Location: Orillia ON
Test Well: MW6-19
Test Date: 4-June-19

AQUIFER DATA

Saturated Thickness: 3.07 m
Anisotropy Ratio (Kz/Kr): 0.2

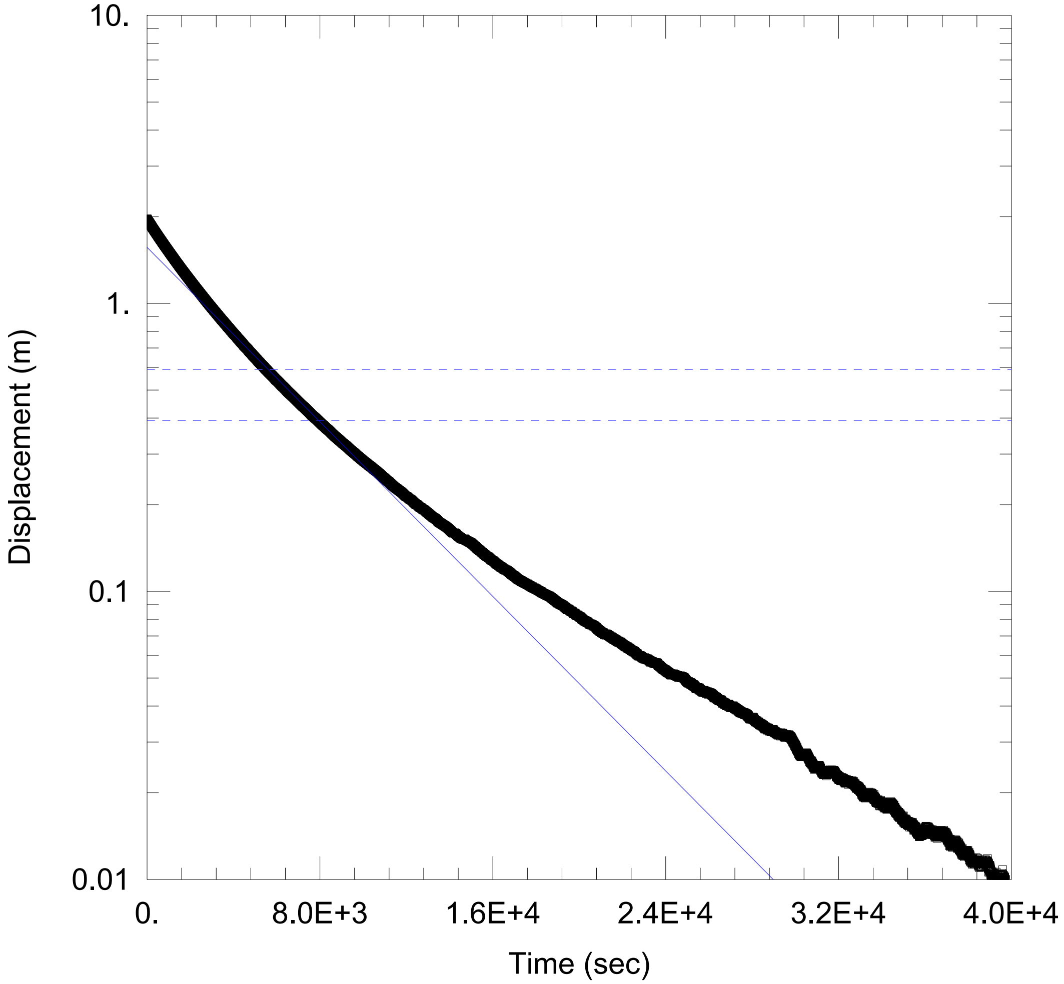
WELL DATA (MW6-19)

Initial Displacement: 2.305 m
Total Well Penetration Depth: 3.07 m
Casing Radius: 0.0254 m
Static Water Column Height: 3.07 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 = 2.6E-7 m/sec
y0 = 2.373 m



MW2-19

Data Set: \...\MW2-19_SB_JK.aqt
Date: 08/28/19 Time: 09:13:38

PROJECT INFORMATION

Company: Stantec Consulting Ltd.
Client: Charter Development LP
Project: 121622652
Location: Orillia ON
Test Well: MW2-19
Test Date: 4-June-19

AQUIFER DATA

Saturated Thickness: 5.05 m Anisotropy Ratio (Kz/Kr): 0.2

WELL DATA (MW2-19)

Initial Displacement: 1.965 m Static Water Column Height: 5.05 m
Total Well Penetration Depth: 5.05 m Screen Length: 3.05 m
Casing Radius: 0.0254 m Well Radius: 0.105 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 6.5E-8 m/sec y0 = 1.566 m