Hydrogeological Assessment,
220 Arkell Road, Guelph, ON

FINAL REPORT

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Prepared for:

Rockpoint Properties Inc.
195 Hanlon Creek Blvd.
Unit 100
Guelph ON N1C 0A1

Prepared by:

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

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PROFESSIONAL GEOSCIENTIST
TRACEY NICOLE SEMPER
PRACTISING MEMBER
0515
05/28/2019
ONTARIO

Prepared by _____
(signature)

T. Nicole Semper, B.Sc., P.Geo.
Senior Hydrogeologist

PROFESSIONAL GEOSCIENTIST
LIMITED MEMBER
GRANT S. WHITEHEAD
1774 MAY 28, 2019
ONTARIO

Reviewed by _____
(signature)

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

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Abbreviations

AMSL	above mean sea level
AO	Aesthetic Objectives
ASTM	American Society for Testing and Materials
BGS	below ground surface
EASR	Environmental Activity Sector Registry
GRCA	Grand River Conservation Area
GRIN	Grand River Information Network
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
GUDI	Groundwater Under the Direct Influence
HDPE	high-density polyethylene
HVA	Highly Vulnerable Aquifer
ID	inside diameter
IMAC	Interim Maximum Acceptable Criteria
IPZ	Intake Protection Zone
LID	Low Impact Development
LST	London Soil Test
MAC	Maximum Acceptable Criteria
Maxxam	Maxxam Analytics Inc.
MECP	Ontario Ministry of the Environment, Conservation and Parks

MNRF	Ministry of Natural Resources and Forestry
ODWS	Ontario Drinking Water Quality Standards
OG	Operational Guidelines
ORP	oxidation reduction potential
PSW	Provincially Significant Wetland
PTTW	Permit to Take Water
PVC	polyvinyl chloride
PWQOs	Provincial Water Quality Objectives
Site	220 Arkell Road, City of Guelph, Ontario
SGRA	Significant Groundwater Recharge Area
Stantec	Stantec Consulting Ltd.
SWM	stormwater management
WHPA	Well Head Protection Area
WWR	Water Well Record

1.0 INTRODUCTION

Rockpoint Properties Inc. retained Stantec Consulting Limited (Stantec) to complete a hydrogeological assessment for the lands located at 220 Arkell Road in the City of Guelph, Ontario (the Site) (Figure 1, Appendix A). The proposed Site development is to consist of single-family lots and a 1.72 hectare (ha) multiple-family residential block, which will be serviced by municipal sanitary sewer and water, utilities, storm drainage, and a stormwater management (SWM) facility. The Site covers an area of approximately 7.16 ha and is bounded by Victoria Park Village Subdivision to the north, existing woodlot and greenfield property to the east, Arkell Meadows Subdivision to the south, and the Torrance Creek Swamp to the west. A single-family residence and former horse pasture currently occupy the Site, which is accessed via a driveway connected to Arkell Road.

The information provided in this report is to support the Draft Plan Application. The objectives of the hydrogeological assessment are to:

- Characterize current geological and hydrogeological conditions at the Site, including a discussion of overburden and bedrock stratigraphy, hydrostratigraphic units, seasonal fluctuations in groundwater levels and hydraulic gradients, flow direction across the Site, soil infiltration potential, and groundwater quality conditions.
- Evaluate pre-development infiltration volumes at the Site and assess the impact that proposed land use changes could potentially have on these volumes under the post-development condition, including an evaluation of potential measures that could be employed throughout the Site under the post-development condition to mitigate these impacts.
- Assess whether proposed buildings, site servicing and associated construction activities will intercept the groundwater table and evaluate if any measures are required to mitigate potential disturbances to pre-development groundwater levels, flow patterns, and groundwater-surface water interactions.
- Evaluate whether proposed land use activities conform to Source Water Protection requirements as stipulated in the Clean Water Act, S.O. 2006, Chapter 22.

This report is arranged into eight sections, including this introduction (Section 1.0). Section 2.0 presents the Site's physical setting at a regional scale. Section 3.0 presents the methodology for investigations of site-specific hydrogeological conditions. Section 4.0 presents the result of the site-specific investigations. Section 5.0 presents a water balance analysis for the Site. Section 6.0 presents the potential impacts of the proposed development on the hydrogeological form and function of the Site and discusses potential mitigation measures for identified impacts. Report conclusions are provided in Section 7.0, with references listed in Section 8.0.

All figures and tables referenced in this report are presented in Appendices A and B, respectively. Appendices C to G include Regional Groundwater Flow Mapping, Vertical Hydraulic Gradient Mapping, Borehole Logs, Laboratory Certificates of Analysis, and Hydraulic Conductivity Testing Analytical Solutions, respectively.

2.0 PHYSICAL SETTING

2.1 PHYSIOGRAPHY AND TOPOGRAPHY

The Site is situated within the physiographic region referred to by Chapman and Putnam (1984) as the Guelph Drumlin Field. The Guelph Drumlin Field consists of a series of broad oval type hills with axes trending in a northwest to southeast direction (i.e., drumlins). The drumlins and associated till plain consist of stony, calcareous till derived from dolostone of the Goat Island and Gasport Formations (formerly referred to as the Amabel Formation) and consists of sand (50%; average content based on grain-size analysis completed on till samples), silt (35%) and clay (15%) (Chapman and Putnam, 1984). The drumlin groupings occur in swampy valleys that are flanked by terraced spillway channels of sand and gravel, which contain tributaries of the Grand River (e.g., Torrance Creek located north of the Site; Figure 2). Gravel ridges or eskers are also known to cut through the till plain in the same general direction of the drumlins.

The Site is located within the Torrance Creek subwatershed of the Grand River Watershed and within the boundary of the Grand River Conservation Authority (GRCA). The subwatershed is characterized by hummocky terrain associated with the drumlins and by the network of broad, relatively flat spillway channels that cut through the drumlin fields. As shown on in Figure 3, a topographic high point occurs within the southeastern portion of the Site at an elevation of 340 m AMSL (representing the peak of a drumlin), with the land sloping from this peak elevation to the north (337 m AMSL) and southwest (334 m AMSL) limits of the property. Surface water drainage from the Site follows two routes, with approximately 4.70 ha of the land draining to the southwest towards the Torrance Creek Swamp and the remaining land area (2.47 ha) flowing offsite via the northern corner of the property and discharging to an existing woodlot.

2.2 REGIONAL GEOLOGY AND HYDROSTRATIGRAPHY

Geological conditions within the region have been mapped and described by Matrix Solutions Inc. (2017), the Lake Erie Region Source Protection Committee (LERSPC, 2015a), Golder Associates Limited (2011), Totten Sims Hubicki Associates *et al.* (1998), and Jagger Hims Limited (1998). Based on these previous studies, overburden and bedrock geology near the Site is summarized as follows, listed from youngest to oldest:

Spillway Deposits: Glaciofluvial outwash and glaciolacustrine deposits of sand and gravel with minor silt and clay associated with the spillway channels (Figure 2; Unit 7).

Ice-Contact Deposits: Predominantly sand and gravel containing lenses of silt and clay left behind by the melting of enclosed ice blocks (i.e., eskers, kames) (Figure 2; Unit 6).

Port Stanley Till: An occasionally stony, silty sand to sandy silt till, forming the till plain and drumlins that characterize the region (Figure 2; Unit 5b). Some of the drumlins, however, can consist of an older clayey silt till core that is subsequently covered by a veneer of Port Stanley Till (Karrow, 1968). In areas south of the Speed River, the till plain is often covered by a layer of glaciofluvial and glaciolacustrine sediments (i.e., fine to silty sand, sandy silt, sand and gravel) deposited from melting glacier ice, with the till extending to the bedrock surface.

Bedrock: The Guelph Formation, representing the uppermost bedrock unit throughout the region is described as a light brown/beige coloured fossiliferous dolostone and an important aquifer in the Guelph area (Brunton, 2008).

2.3 REGIONAL HYDROGEOLOGY

Based on previous groundwater modeling work completed by Matrix Solutions Inc. (2017), the following aquifer and aquitard systems occur beneath the Site:

Upper Sand and Gravel Aquifer: an unconfined aquifer system consisting predominantly of outwash sand and gravel deposits. This unit is reported to have a horizontal hydraulic conductivity ranging from 7.0×10^{-4} m/s to 6.0×10^{-6} m/s, with the vertical hydraulic conductivity being one tenth (0.1) to an order (1.0) of magnitude lower than the horizontal hydraulic conductivity (Golder, 2011). Soil permeability testing using a Guelph Permeameter indicates that the sandy soils of this unit have vertical hydraulic conductivities in the range of 10^{-5} m/s (Totten Sims Hubicki Associates *et al.*, 1998).

Lower Till Aquitard: dense sandy to silty glacial till (i.e., Port Stanley Till) that is occasionally interbedded with discontinuous lenses of coarse sand and gravel. This unit is reported to have a horizontal hydraulic conductivity ranging from 1.0×10^{-4} m/s to 2.0×10^{-9} m/s, with the vertical hydraulic conductivity being one half (0.5) to an order (1.0) of magnitude lower than the horizontal hydraulic conductivity (Golder, 2011). Soil permeability testing using a Guelph Permeameter indicates that the silty to clayey soils of this unit have vertical hydraulic conductivities in the range of 10^{-5} m/s to 10^{-7} m/s (Totten Sims Hubicki Associates *et al.*, 1998).

Contact Zone Aquifer: coarse, unconsolidated granular deposits directly overlying, and hydraulically connected to, upper weathered/fractured bedrock. This unit typically forms a thin aquifer having an assumed thickness of four meters (two meters above and below bedrock surface) (Golder, 2011). This aquifer is reported to have a horizontal hydraulic conductivity ranging from 1.0×10^{-4} m/s to 1.0×10^{-5} m/s, with the vertical hydraulic conductivity being one half (0.5) to an order (1.0) of magnitude lower than the horizontal hydraulic conductivity (Golder, 2011).

Bedrock Aquifer: consisting of medium to thick bedded fossiliferous dolostone of the Guelph Formation. This unit is reported to have a horizontal hydraulic conductivity ranging from 8.0×10^{-3} m/s to 7.0×10^{-9} m/s, with the vertical hydraulic conductivity being one tenth (0.1) to an order (1.0) of magnitude lower than the horizontal hydraulic conductivity (Golder, 2011).

As presented in Figure 4.3 of Matrix Solutions Inc. (2017) (Appendix C), simulated water table surface elevations produced via a calibrated steady-state groundwater flow model suggests that groundwater moves to the northwest through the overburden aquifer located beneath the Site, eventually discharging to the Speed River.

Regionally, the lands containing the Site are characterized by groundwater recharge conditions. Mapping created using the Grand River Information Network (GRIN) (GRCA, 2018) indicates that downward vertical hydraulic gradients are present beneath the Site (Appendix D). According to the GRIN mapping, annual recharge rates across the Site range from 100 to 200 mm/year where surficial deposits of Port Stanley Till (silty sand to sandy silt till) are present and from 200 to 400 mm/year in those areas where spillway and/or ice-contact deposits of sand and gravel cover the property (Appendix D).

2.4 SOURCE WATER PROTECTION

As per the Approved Assessment Report for the Grand River Source Protection Area (LERSPC, 2015a), the Site is located within the Well Head Protection Area (WHPA) for the Burke Municipal Production Well (Burke Well), with this production well located approximately 200 m to the south of the Site (Figure 4; MECP, 2018). Specifically, the Site is intercepted by the Burke Well WHPA-B, representing an area where it takes two years or less for precipitation to infiltrate to the underlying aquifer system and flow through this aquifer to the production well intake. The WHPA-B has an assigned vulnerability score of eight (8), indicating that groundwater beneath the Site is at medium risk to contamination from drinking-water threats (i.e., an activity or existing 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 western portion of the Site lies within the WHPA-E (vulnerability score of 7.2; MECP, 2018) of the Carter Municipal Production Wells (Carter Wells), with these wells being classified as Groundwater Under the Direct Influence (GUDI) of surface water (i.e., a surface water source has a direct connection to the groundwater system and is drawn into the production well during pumping). The extents of the WHPA-E are equivalent to the area of an Intake Protection Zone (IPZ); that is, a capture zone delineated for those drinking-water systems that obtain their potable water from surface water bodies. The WHPA-E is equivalent to an IPZ-2 and for the Carter Wells, represents the upstream length of Torrance Creek where surface water will take less than two hours to travel along this watercourse to the intake of these production wells.

The Site is also designated as a Significant Groundwater Recharge Area (SGRA) having a medium vulnerability score of four (4); however, the Site is not classified as Highly Vulnerable Aquifer (HVA) (MECP, 2018).

3.0 METHODOLOGY

The hydrogeological site investigation included the:

- drilling of boreholes
- installing of monitoring wells
- installing of drive-point piezometers
- monitoring of groundwater levels
- collecting groundwater samples for quality testing
- performing of hydraulic response (hydraulic conductivity) testing

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

3.1 BOREHOLE DRILLING

Four boreholes (BH01-17 to BH04-17) were advanced at the Site on April 5, 2017 as part of the geotechnical (Stantec, 2017) and hydrogeological investigations. The boreholes were strategically located to obtain spatially representative soil and groundwater samples beneath the property. Borehole locations are shown on Figure 1.

Drilling services were provided by London Soil Test Limited (LST) who used a Diedrich D50 drill rig equipped with a hollow stem auger drilling system to advance the boreholes. Boreholes were advanced to maximum depths of 5.2 m to 8.2 m BGS, and soil samples were collected using a 0.6 m long stainless steel split spoon sampler at intervals of 0.76 m from the existing grade to at least 3.0 m BGS, and intervals of 1.5 m thereafter.

Stantec personnel were onsite during drilling to log soil samples using the *American Society for Testing and Materials (ASTM) Standard D2488 00 - Guidelines for the Manual Description and Identification of Soils* (ASTM, 2000). Borehole logs were prepared for each drilling location, containing descriptions of type, texture, colour, structure, consistency, plasticity, and moisture content of soil samples. Soil samples were collected in field for subsequent grain size analysis. Copies of the borehole logs are provided in Appendix E.

3.2 MONITORING WELL INSTALLATIONS

A single monitoring well was installed at each borehole location in accordance with *Revised Regulations of Ontario (R.R.O) 1990*, *Regulation 903: Wells* (MOE, 1990). The monitoring wells (i.e. MW01-17, MW02-17, MW03-17 and MW04-17) were installed to confirm local water table elevations, groundwater flow direction, and seasonal trends in groundwater fluctuations.

Each monitoring well is constructed with a 51 mm inside diameter (ID), Schedule 40 polyvinyl chloride (PVC) pipe, with a No. 10 slot screen (0.01 inch slot) that was 3.0 m long. The annular space between the monitoring well pipe and surrounding soil was backfilled with No.2 grade silica sand to approximately 0.3 m above the top of screen. The annular space was then filled with granular bentonite to 0.3 m BGS to prevent a hydraulic connection from occurring between the screened formation and those above. The monitoring wells were completed with above ground lockable protective steel casings that were cemented into place to 0.3 m BGS. The elevation of the existing grade and top-of-pipe at each monitoring well was surveyed to a geodetic benchmark by the Geomatics division of Stantec. Well construction details and survey data are summarized in Table 1 (Appendix B).

3.3 DRIVE-POINT PIEZOMETER INSTALLATIONS

On April 13, 2017, Stantec personnel installed one multi-level drive-point piezometer nest, consisting of a shallow and a deep piezometer (i.e. DP1-17(S) and DP1-17(D)), within a section of the Torrance Creek Swamp extending into south-central portion of the Site (Figure 1). The piezometer nest was installed to evaluate whether this wetland area 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 their screens being separated by a vertical distance of approximately 1.3 m. Construction details for the drive-point piezometers are summarized in Table 1.

3.4 GROUNDWATER LEVEL MONITORING

Groundwater levels were recorded at the monitoring well and piezometer locations from April 2017 to May 2018 using a combination of automated and manual measurement methods. Solinst® Edge Leveloggers® (Leveloggers) were installed at all monitoring well and piezometer locations in April 2017 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 MW03-17.

Groundwater levels were manually measured at the Site in April and September 2017, and in February and May 2018. 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 piezometers are presented in Tables 2 and 3, respectively. Hydrographs presenting both the automatic and manually measured groundwater level data are provided in Figure 6.

3.5 GROUNDWATER SAMPLING AND TESTING

The monitoring wells were developed following well installation between April 12 and 13, 2017. The purpose of well development was to remove drilling fluids, solids or other particulates that may have been introduced during drilling. Each monitoring well was developed using dedicated high-density polyethylene (HDPE) tubing and a Delrin Waterra foot valve. Where possible, at least ten well volumes of water were removed from each well.

Groundwater quality samples were collected from the monitoring wells following well development. between April 12 and 13, 2017. The samples were collected to help evaluate pre-development groundwater quality conditions at the Site. Groundwater sampling was completed using dedicated HDPE tubing and foot valve. Prior to collecting the samples, wells were purged and field parameters including pH, temperature, electrical conductivity, oxidation reduction potential (ORP), and dissolved oxygen (DO) were monitored periodically during the purging process using a Horiba U-52 multi-parameter water quality meter and a flow through cell. The meter was calibrated prior to use according to the manufacturer's specifications with the appropriate calibration standards. Groundwater sampling occurred after these field parameter concentrations had stabilized, indicating that water being pumped from the monitoring wells was representative of groundwater flowing into the well from surrounding geological formations.

The groundwater sample collected from each monitoring well consisted of pouring water directly from the HDPE tubing into lab supplied sample bottles. Groundwater samples collected for metals analysis were field-filtered using disposable in-line 0.45 µm (micron) filters attached to the HDPE tubing. The groundwater samples were carefully packed into coolers with ice, which was added to maintain sample temperatures below 10ºC during transport to the analytical laboratory. Samples were delivered to Maxxam Analytics Inc. (Maxxam) for analysis of general inorganic parameters and dissolved metals. Chain of custody forms were completed and included with the samples.

The results of the groundwater quality testing are summarized in Table 4 and illustrated in a piper diagram on Figure 8. A copy of the Laboratory Certificate of Analysis is presented in Appendix F.

3.6 HYDRAULIC RESPONSE TESTING

Stantec performed in-situ hydraulic response testing at each monitoring well between April 12 and 17, 2017 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) solution for a slug 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 G.

4.0 Local Geology and Hydrogeology

4.1 GEOLOGY

As shown in Figure 2, surficial geology mapping suggests the Site is covered by glaciofluvial sand and gravel, and stone-poor, silty to sandy till deposits representing the Port Stanley Till. These deposits are consistent with the subsurface materials encountered in the onsite boreholes BH01-17 through BH04-17 (Appendix E).

Cross-section A-A' (Figure 5), which traverses the Site from southwest to northeast, provides an interpretation of the subsurface stratigraphy based on onsite borehole data and nearby Ontario Ministry of the Environment, Conservation and Parks (MECP) water well records. The subsurface conditions at the borehole locations generally consist of a 0.4 m to 3.8 m thick layer of sand with trace to some gravel, overlying the Port Stanley Till (Figure 5). The till unit is encountered at depths ranging from approximately 0.7 m to at least 8.2 m BGS (the maximum depth of investigation), or elevations ranging from 339.3 m to 328.3 m AMSL. Surficial silty sand to sandy silty fill was encountered at BH03-17 and extended to a depth of 2.4 m BGS.

MECP Well No. 6712543 and No. 6702582, located approximately 20 m and 120 m to the south and north of the Site, respectively, indicate that the bedrock surface beneath the Site is found at an elevation ranging from 317.8 m to 322.8 m AMSL. Subsequently, overburden beneath the Site is estimated to range from 12 m to 17 m in thickness.

4.2 HYDROGEOLOGY

4.2.1 Groundwater Levels

Figure 6 and Table 2 present continuous and manual water level data measured within the onsite monitoring wells from April 2017 to May 2018, respectively. Available data indicate the depth to groundwater across the Site ranges from being positioned at ground surface (BH01-17, BH02-17) to 2.3 m BGS (BH04-17) under high water table conditions, with about 1.9 m to 3.5 m of seasonal fluctuation occurring based on the data collected throughout the monitoring period (Figure 6). Groundwater levels were highest in the spring, gradually declining over the summer and fall, after which water levels started to gradually increase again (Figure 6). This pattern in fluctuations is common within shallow groundwater systems throughout southern Ontario, where high water table conditions occur in the spring due to lower evapotranspiration losses and the infiltration of a melting snowpack and provide a greater volume of water for recharge. Low water table conditions occur in the late summer to fall as more water is drawn from the subsurface over this period to meet evapotranspiration demands.

4.2.2 Groundwater Flow

Groundwater elevations over the monitoring period ranged from a high of approximately 337.7 m AMSL at BH04-17 in the northeastern corner of the Site to lows of approximately 331.4 m AMSL at BH03-17 near the south-central property boundary (Figures 6 and 7). Groundwater elevation contours for May 2017, representing the period of highest groundwater levels measured at the Site, are shown on Figure 7. Based on the May 2017 data, the interpreted direction of groundwater flow through the overburden is to the south and southwest at an estimated average horizontal hydraulic gradient of approximately 0.017 m/m. A review of the groundwater level data shows no seasonal change in the groundwater flow direction throughout the monitoring period.

Figure 6 and Table 3 present continuous and manual water groundwater and surface water level data measured within drive-point piezometers DP1-17(S) (shallow) and DP1-17(D) (deep) installed within the wetland area from April 2017 to February 2018, respectively (Figure 1). Groundwater levels within DP1-17(D) remained lower than the observed levels recorded at DP1-17(S) throughout the monitoring period, with measured vertical hydraulic gradients being consistently downward and ranging from -0.61 m/m to -1.00 m/m (Table 3). These downward gradients indicate that the wetland functions as a groundwater recharge feature, which is consistent with GRCA (2017) mapping that shows downward hydraulic gradients to be present beneath the entire Site (Appendix D).

The hydraulic conductivities estimated from the single well hydraulic response testing are summarized in Table 1, with the solutions being provided in Appendix G. Calculated horizontal hydraulic conductivities range from 1.6×10^{-6} m/s to 2.8×10^{-5} m/s for wells screened within the silty sand deposits that characterize the subsurface of the Site (i.e., from depths of 1.3 m to 7.4 m BGS). The geometric mean of the hydraulic conductivity across the Site is estimated at 6.2×10^{-6} m/s.

Assuming a soil porosity of 0.3, an average horizontal hydraulic gradient of 0.017 m/m, and geometric mean hydraulic conductivity of 6.2×10^{-6} m/s, the estimated velocity of horizontal groundwater flow through the shallow overburden beneath the Site is calculated to be approximately 11 m/year.

4.2.3 Groundwater Quality

Results of the groundwater quality testing are summarized in Table 4. Groundwater quality data have been assessed against the Ontario Drinking Water Quality Standards (O. Reg 169/03) (ODWS) for health-related [i.e., Maximum Acceptable Criteria (MAC) and Interim Maximum Acceptable Criteria (IMAC)] and non-health related [i.e., Aesthetic Objectives (AO) and Operational Guidelines (OG)] parameters. Technical documentation of the ODWS is provided in Ministry of the Environment (2006)

The shallow groundwater system is characterized by calcium-bicarbonate type water (Figure 8).

No tested parameters were detected above applicable health-related criteria. The ODWS for hardness was exceeded in samples collected at all monitoring wells, with values ranging from 290 mg/L to 410 mg/L; and higher than the OG of 80 mg/L to 100 mg/L. ODWS OG exceedances are provided primarily for operators of drinking water systems to identify parameter levels that can lead to poor system performance and affect the appearance and taste of drinking water. The presence of elevated hardness concentrations is typical of groundwater in southern Ontario.

5.0 WATER BALANCE

Water balance calculations were completed to quantify infiltration volumes at the Site and confirm the recharge function. A comparison of water balance data under pre- and post-development conditions was completed to determine the potential impacts of development on the Site's recharge function. The methodology for the water balance calculations is provided in Section 5.1. Results of the pre-development water balance analysis are presented in Section 5.2. The comparison of pre- and post-development conditions is presented in Section 6.1.

5.1 METHODOLOGY

Within the hydrologic cycle, the flow of water into and out of system can be described through a simplified water balance equation as follows:

$$P = ET + S + R + I$$ **Equation 1**

Where:

P = precipitation
ET = evapotranspiration
S = change in groundwater storage
R = runoff
I = infiltration (groundwater recharge)

Equation 1 may be further simplified by ignoring the change in groundwater storage (S), which trends over time to zero. The various components of the hydrologic cycle may be estimated through calculations or based on measurements made in the field. Precipitation (P) is typically a measured value. Evapo-transpiration (ET) is calculated based on measured air temperatures. Infiltration (I) and Runoff (R) are calculated based on P and ET, where the difference between P and ET is the water surplus (WS) available for Infiltration (I) and Recharge (R) as follows:

$$WS = P - ET$$ **Equation 2**

Where WS is used to calculate I after applying an infiltration factor (IF),

$$I = WS \times IF$$ **Equation 3**

And R is estimated by subtracting I from WS,

$$R = WS - I$$ **Equation 4**

For this assessment, ET was calculated using the soil moisture balance model by Thornthwaite and Mather (1955). In the Thornthwaite and Mather model monthly potential evapotranspiration (PET) is calculated based on the measured average monthly daily temperature (T_a) and a heat index (H_i) value assuming 12 hours of daylight in a day and 30 days in a month, as follows:

$$PET = 16 \times \left(\frac{10T_a}{H_i}\right)^{\alpha}$$ **Equation 5**

Where T_a is taken as 0 degrees Celsius for months with negative temperatures, and H_i, the heat index is estimated as,

$$H_i = \sum_{i=1}^{12} \left(\frac{10T_a}{5}\right)^{1.514}$$ **Equation 6**

For α

$$\alpha = 0.49 + (0.0179 \times H_i) - \left(0.0000771 \times H_i^2\right) + \left(0.000000675 \times H_i^3\right)$$ **Equation 7**

PET values are then multiplied by an adjustment factor, after Thornthwaite and Mather (1957), which represents the average number of daylight hours per month at the latitude of the subject property to give the Adjusted Potential Evapotranspiration (PET_{adj}).

Actual Evapotranspiration (AET) is derived as,

$$AET = PET_{adj} - \Delta S$$ **Equation 8**

Where ΔS is the change in storage for the month, calculated as,

$$\Delta S = S_{mc} \times e^{\left(\frac{APWL}{S_{mc}}\right)}$$ **Equation 9**

Where:

S_{mc} = soil moisture capacity
APWL = accumulated potential water loss, calculated for $\Delta P < 0$ as $APWL = -\sum_{i=0}^{12} PET_i$, and for $\Delta P > 0$ by rearranging equation 8; with ΔP= net precipitation = P - PET_{adj}

WS is derived by subtracting AET from the monthly precipitation,

$$WS = P - AET$$ **Equation 10**

And the infiltration and runoff calculated per Equations 3 and 4 above.

The infiltration factor shown in Equation 3 is estimated based on the topography, soil type and land cover after MOE (2003) and the Ministry of the Environment and Energy (MOEE) (1995). To define appropriate infiltration factors, the Site was divided into three Sub-Areas based on similarities in soil type, topography and vegetation cover as follows:

Sub-Area A (0.83 ha)	Sand to silty sand, flat topography, woodland cover (wetland)
Sub-Area B (2.31 ha)	Sand to silty sand, flat to gently rolling topography, pasture and shrubs land cover
Sub-Area C (4.01 ha)	Sand to silty sand, rolling topography, cultivated land cover

The delineated Sub-Areas are shown on Figure 9 and the infiltration factors assigned for each Sub-Area pre- and post-development is presented in Tables 5 and 6, respectively.

Soil moisture capacity was set between 150 mm to 300 mm among the Sub-Areas depending on the soil type and land cover as specified under MOE (2003). In Sub-Area A, where sand to silty sand and woodland/wetland cover is present, soil moisture was set at 300 mm corresponding to the soil moisture content for fine sandy loam in a mature forest. For Sub-Area B, where sand to silty sand soil and cultivated land cover is present, soil moisture content was set at 150 mm corresponding to a fine sandy loam with pasture and shrubs. For Sub-Area C, where sand to silty sand soil and cultivated land cover is present, soil moisture content was set at 150 mm corresponding to fine sandy loam with moderately rooted crops.

Under pre-development conditions, the Site (7.16 ha) is either covered by wetland/woodland, or cultivated fields and is deemed 92% pervious, with 8% impervious cover associated with the existing residential structures and driveways. Lands planned for residential use under the post-development condition is expected to have 80% of its area converted to impervious surfaces. Similarly, the land area being used for stormwater management purposes (i.e., pond) or roadways will have an impervious cover of 100% (i.e., no pervious area). Overall, the calculated percent imperviousness value assigned for each Sub-Area was based on the proportion of each previously mentioned land use area expected to occur in each Sub-Area under the post-development condition. Percent imperviousness values for the various land uses are consistent with those presented in the in the City of Guelph and Township of Guelph/Eramosa Tier Three Water Budget and Local Area Risk Assessment (Matrix Solutions Inc., 2017).

For this water balance assessment, climate normals (1981 to 2010) as recorded at the Waterloo Wellington A Climate Station were used to obtain monthly values of precipitation and temperature. The climate data were obtained from Environment Canada (2018) and are summarized in Table 7. The Waterloo Wellington A Climate Station is located approximately 15 km to the southwest of the Site. Although the Guelph Arboretum Climate Station is located approximately 1.5 km to the northwest of the Site, climate normals from 1971 to 2000 are only available from this station.

Water balance calculations were completed for each Sub-Area and then summed to provide results for the entire Site. The water balance calculations shown in Tables 5 and 6 generate a rounding error of less than 1%.

5.2 PRE-DEVELOPMENT WATER BALANCE

The average annual precipitation at the Site is estimated at 916 mm based on data obtained from the Waterloo Wellington A Climate Station (Environment Canada, 2018). In comparison, Matrix Solutions Inc. (2017) reported average annual precipitation in the Upper Speed Assessment Area is 923 mm/year as measured at the Guelph Arboretum Climate Station. In Sub-Areas A, B, and C, annual actual evapotranspiration is estimated as 620 mm, 592 mm and 592 mm, respectively. This means that 296 mm of surplus water is available for runoff and infiltration across Sub-Area A on an annual basis, with an annual surplus of 324 mm being available across both Sub-Areas B and C. Applying the estimated infiltration factors of 0.90 for Sub-Area A, 0.80 for Sub-Area B and 0.70 for Sub-Area C, the calculated annual infiltration for these sub-areas is 267 mm, 259 mm and 227 mm, respectively.

Overall, the average annual volume of infiltration to the Site under pre-development conditions is estimated at 15,946 m^3/year for a rate of 223 mm/year (Table 5). This infiltration rate falls within the 100 mm/year to 400 mm/year groundwater recharge rate range for the Site area as estimated by Matrix Solutions Inc. (2017) and GRIN mapping (Appendix D). The average annual volume of runoff under pre-development conditions at the Site is estimated to be 10,027 m^3/year (140 mm/year) (Table 5).

6.0 IMPACT ASSESSMENT AND MITIGATION MEASURES

6.1 GROUNDWATER RECHARGE

As per the proposed Draft Plan (Figure 9) the Site development is to include the construction of internal roadways, single-family lots and a multiple-family residential block, and a SWM facility. 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. The potential impacts associated with the introduction of impervious surfaces on the recharge function of the Site are discussed below.

Under the post-development condition, impervious surfaces are expected to cover 39% of the Site (2.82 ha of 7.16 ha), resulting in a projected infiltration volume deficit of 4,908 m^3/year (i.e., from 15,946 m^3/year to 11,038 m^3/year) (Table 6).

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 may still be effective. At the Site, the seasonally high groundwater table is deepest at the northeastern limits of the property (e.g., BH04-17), with the groundwater table becoming shallower moving to the southwest across the property towards the Torrance Creek Swamp (e.g., BH01-17 and BH03-17). As shown in Figure 6, the high groundwater table occurs at depths ranging from 0.1 m to 0.6 m BGS in the southwestern portion of the Site, whereas in the northeastern portion of the Site the high groundwater

table is in the range of 2.3 m BGS. As such, the use of post-development infiltration augmentation measures in the southwestern areas of the Site may be limited.

The suitability of using the previously mentioned infiltration augmentation options within the Site will be evaluated at the detailed design stage of the project. Overall, it is reasonable to conclude that the application of some or all the previously mentioned infiltration augmentation measures in those areas of the Site where the seasonal groundwater table is greater than one meter below final grades will assist in achieving the maximum groundwater recharge possible throughout the property under the post-development condition.

6.2 GROUNDWATER DEWATERING

The proposed development is to consist of residential housing that will be connected to underground utility infrastructure (e.g., watermain, storm and sanitary sewers). Invert levels of the site servicing are expected to be up to three to four meters below grade but could be as much as eight meters below grade. Groundwater levels measured in the onsite monitoring wells ranged from at ground surface to 2.3 m BGS under high water table conditions across the Site, with about 1.9 m to 3.5 m of seasonal fluctuation (Section 4.2.1). Subsequently, groundwater levels are expected to occur above the servicing invert levels throughout the Site and, consequently, construction dewatering will likely be required.

Under Ontario Regulation (O. Reg.) 64/16 and O. Reg. 63/16A, if construction dewatering volumes are projected to exceed 50,000 L/day, registration of an MECP Environmental Activity and Sector Registry (EASR) or Permit to Take Water (PTTW) will be required for dewatering to occur. A PTTW is required when daily dewatering volumes are expected to exceed 400,000 L, whereas an EASR is required for daily dewatering volumes ranging between 50,000 L and 400,000 L. A dewatering assessment can be completed during the detailed design phase of the project to determine dewatering and water taking permitting requirements.

If site servicing infrastructure is installed below the groundwater table, mitigation measures may be required to minimize the disturbance that this site servicing could have on pre-development groundwater flow patterns. Typically, the most common mitigation measure is the installation of anti-seepage (cut-off) collars to prevent the preferential movement of groundwater along the servicing alignments. An assessment for the need, total number and exact placements of anti-seepage collars along the servicing alignments can be explored in more detail during the detailed design phase of the project.

6.3 WETLAND ALTERATION

As per the proposed Draft Plan, the proposed development is expected to encroach into the wetland area located to the east of the existing access driveway to the Site, where DP1-17(S/D) is installed (Figure 1). However, as discussed in the Stantec (2019) *Environmental Impact Study*, existing Grand River Conservation Authority (GRCA) and Ministry of Natural Resources and Forestry (MNRF) wetland mapping for the Site does not appear to reflect recent updates to the Torrance Creek Swamp boundary in

this area of the property. In 2010, a portion of this wetland area was approved for removal and, subsequently, removed as part of the Arkell Meadows Subdivision development.

Pursuant to Ontario Regulation 150/06, the GRCA must first provide permission for any proposed alteration of a wetland to occur as part of a land development project. The GRCA will permit development to occur within, or result in the removal of, a naturally occurring wetland of less than 0.5 ha or an anthropogenic wetland covering an area less than 2.0 ha, if the wetland is not:

1. part of a Provincially Significant Wetland
2. located within a floodplain or riparian community
3. part of a Provincially or municipally designated natural heritage feature, a significant woodland, or hazard land
4. a bog or fen
5. fish habitat
6. significant wildlife habitat
7. confirmed habitat for a Provincially or regionally significant species as determined by the Ministry of Natural Resources and Forestry or as determined by the municipality
8. part of an ecologically functional corridor or linkage between larger wetlands or natural areas
9. part of a groundwater recharge area
10. a groundwater discharge area associated with any of the above

The hydrogeological information previously presented in this report will be used to address GRCA Criteria 9) and 10), with the remaining criteria being addressed in Stantec's accompanying *Environmental Impact Study* (Stantec, 2019) report.

Although it appears that wetland area located to the east of the access driveway has already been approved for removal by the GRCA, if additional permissions are required to remove the remaining portion of this wetland area, Stantec is of the opinion that this can occur for the reasons presented below.

9) The onsite wetland is not a notable groundwater recharge area

Under the pre-development condition, the predicted annual volume of infiltration provided to the shallow groundwater system by the onsite wetland only represents approximately 3% of the total annual volume of infiltration that occurs across the Site, noting that the subsurface deposits found beneath this wetland area are also present throughout the entire Site (i.e., the soils underlying the wetland are not unique to the Site) (Appendix E). Overall, it is reasonable to conclude that the loss of recharge function associated with the onsite wetland will not detrimentally impact the overall groundwater recharge function provided by the Site.

10) The onsite wetland is not a groundwater discharge feature

As discussed in Section 4.2.2, consistent downward vertical hydraulic gradients are present beneath the wetland area, indicating that the wetland functions as a groundwater recharge feature.

6.4 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*.
2. The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage.
3. The application of agricultural source material to land.
4. The storage of agricultural source material.
5. The management of agricultural source material.
6. The application of non-agricultural source material to land.
7. The handling and storage of non-agricultural source material.
8. The application of commercial fertilizer to land.
9. The handling and storage of commercial fertilizer.
10. The application of pesticide to land.
11. The handling and storage of pesticide.
12. The application of road salt.
13. The handling and storage of road salt.
14. The storage of snow.
15. The handling and storage of fuel.
16. The handling and storage of a dense non-aqueous phase liquid (DNAPL).
17. The handling and storage of an organic solvent.
18. The management of runoff that contains chemicals used in the de-icing of aircraft.

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

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

21. The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard. O. Reg. 385/08, s. 3.

The Site is intercepted by the Burke Well WHPA-B, with this area having an assigned vulnerability score of eight (8), indicating that groundwater beneath the Site is at medium risk to contamination from drinking-water threats (i.e., an activity or existing 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). As per the Approved Source Protection Plan (LERSPC, 2015b), the Site is subject to the protection policies specified under Significant Drinking Water Threat Policy Categories 1 (Waste Disposal), 2 (Sewage Systems), and 16 (DNAPLs). Since the planned use for the Site does not involve the operation or maintenance of a waste disposal facility or the onsite handling and storage of a DNAPL, the policies under Categories 1 and 16 do not apply.

Given that the Site will be serviced by municipal sanitary sewers and a SWM facility, the following protection policies under Category 2 (Sewage Systems) will apply and require discussion with the City of Guelph at the detailed design stage of the project:

Policy No. CG-MC-14 (Sanitary Sewers and Related Pipes): For existing and future sanitary sewers and pipes within vulnerable areas where this activity is or would be a significant drinking water threat, the MECP shall ensure that the Environmental Compliance Approval that governs sanitary sewer and related pipes includes appropriate terms and conditions to ensure the activity ceases to be and/or never becomes a significant drinking water threat.

Policy No. CG-MC-15 (Discharge of Stormwater from a Stormwater Management Facility): For existing and future discharge of stormwater from a stormwater management facility within vulnerable areas where this activity is or would be a significant drinking water threat, the MECP shall ensure that the Environmental Compliance Approval that governs the stormwater management facility includes appropriate terms and conditions to ensure the activity ceases to be and/or never becomes a significant drinking water threat.

No protection policies are specified in the *Approved Source Protection Plan* (LERSPC, 2015b) that apply to the Site's designation as a SGRA or WHPA-E (intercepts the western portion of the property).

6.5 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.

7.0 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. Subsurface conditions across the Site consist of 0.4 m to 3.8 m thick layer of sand with trace to some gravel, overlying stone-poor, silty to sandy till deposits representing the Port Stanley Till. The till unit is encountered at depths ranging from approximately 0.7 m to at least 8.2 m BGS (339.3 m to 328.3 m AMSL). Bedrock appears to be encountered at elevations ranging from 317.8 m to 322.8 m AMSL.

2. Groundwater depths across the Site range from being positioned at ground surface (BH01-17, BH02-17) to 2.3 m BGS (BH04-17) under high water table conditions, with about 1.9 m to 3.5 m of seasonal fluctuation occurring based on the data collected during the monitoring period (i.e., April 2017 to May 2018). The groundwater table is deepest in the northeastern corner of the Site, with groundwater levels becoming shallower moving to the southwest towards the Torrance Creek Swamp.

3. Groundwater flows horizontally through the subsurface overburden deposits to the south and southwest towards the Torrance Creek Swamp at an average rate of 11.1 m/year.

4. Downward vertical hydraulic gradients are consistently observed beneath the wetland area located in the future footprint of the development, indicating that this wetland is a groundwater recharge feature. Under the pre-development condition, the predicted annual volume of infiltration provided to the shallow groundwater system by this wetland area represents approximately 3% of the total annual volume of infiltration that occurs across the Site.

5. Groundwater in the shallow groundwater system is calcium-bicarbonate type water. No tested parameters having health-related ODWS were detected above their applicable standards. The ODWS for hardness was exceeded in samples collected at all wells. The presence of elevated hardness concentrations is typical of groundwater in southern Ontario.

6. The Site is located within the WHPA-B for the Burke Municipal Well. Given that the Site will be serviced by municipal sanitary sewers and a SWM facility, Policies CG-MC-14 (Sanitary Sewers and Related Pipes) and CG-MC-15 (Discharge of Stormwater from a Stormwater Management Facility) will apply to the Site as per the *Approved Source Protection Plan* (LERSPC, 2015b) and require discussion with the City of Guelph at the detailed design stage of the project.

7. A calculated 15,946 m^3 (223 mm) of annual infiltration occurs under pre-development conditions at the Site. Under post-development conditions, Stantec estimates that 39% of the land surface will be converted to impervious cover, reducing annual infiltration to 11,038 m^3 (154 mm), and resulting in an annual infiltration deficit of approximately 4,908 m^3.

8. The future development of the Site will increase the overall imperviousness of these lands, resulting in an overall reduction in infiltration under the post-development condition. The proposed development will require strategies to infiltrate as much stormwater as possible post-development to mimic the existing recharge function provided by these lands. Potential LID infiltration augmentation options available to the Site are roof downspout disconnection, soakaways / infiltration trenches, bioretention cells, vegetated filter strips and/or grassed swale or enhanced grassed swales. High

water table conditions may present a constraint for the using of LIDs in certain areas of the Site. The suitability of using these infiltration augmentation options will be evaluated further at the detailed design stage of the project.

9. Underground utility infrastructure (e.g., watermain, storm and sanitary sewers) is expected to occur below the groundwater table in certain areas of the Site and, consequently, groundwater dewatering will likely be required. A dewatering assessment should be completed during the detailed design phase of the project to determine dewatering and water taking permitting requirements.

10. Servicing (e.g., watermain, storm and sanitary sewers) is likely to occur below the groundwater table at the Site. Efforts may be required to minimize the disturbance that this servicing could have on pre-development groundwater flow patterns. Typically, the most common mitigation measure is the installation of anti-seepage (cut-off) collars to prevent the preferential movement of groundwater along the servicing alignments. An assessment for the need, total number and exact placements of anti-seepage collars along the servicing alignments can be explored in more detail during the detailed design phase of the project.

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APPENDIX A:
FIGURES

Stantec

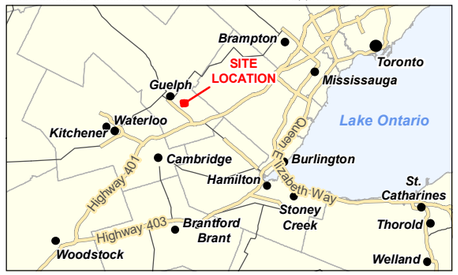
- Site Boundary
- Monitoring Well (Stantec, 2017)
- Drive-Point Piezometer (Stantec, 2017)
- MECP Water Well Record
- Proposed Subdivision
- Wetland Boundary (Stantec, June 2017)
- Wetland - Evaluated (Provincial)
- Wetland Boundary (GRCA)

0 50 100 metres

1:2,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2017.
3. Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
4. MECP water well record locations have been positioned based on published UTM coordinates and their locations should be considered approximate.



Project Location
Guelph, Ontario

161413338 REVA
Prepared by CMC on 2019-06-04
Technical Review by GW on 2018-12-03

Client/Project
ROCKPOINT PROPERTIES INC.
HYDROGEOLOGICAL ASSESSMENT
220 ARKELL ROAD, GUELPH, ONTARIO

Figure No.
1

Title
Site Plan

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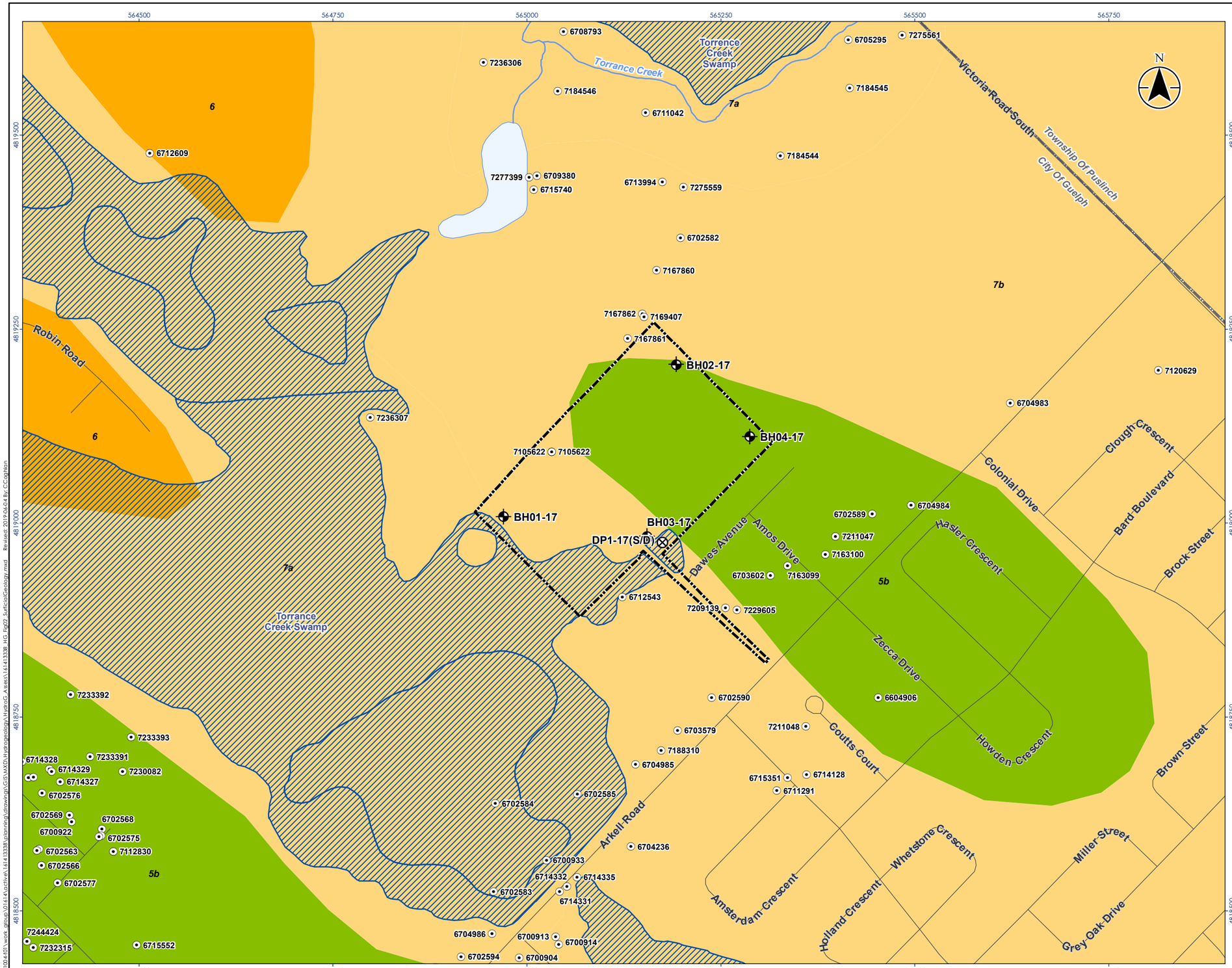

Stantec

- Site Boundary
- Monitoring Well (Stantec, 2017)
- Drive-Point Piezometer (Stantec, 2017)
- MOECC Water Well Record
- Road
- Watercourse
- Municipal Boundary - Lower Tier
- Waterbody
- Wetland - Evaluated (Provincial)

Surficial Geology

- 7a: Glaciofluvial deposits (Sandy deposits)
- 7b: Glaciofluvial deposits (Gravelly deposits)
- 6: Ice-contact stratified deposits
- 5b: Stone-poor, carbonate-derived silty to sandy till (Port Stanley Till)

0 100 200 metres

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

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2017.
3. 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
Guelph, Ontario

161413338 REVA
Prepared by CMC on 2019-06-04
Technical Review by GW on 2018-12-03

Client/Project
ROCKPOINT PROPERTIES INC.
HYDROGEOLOGICAL ASSESSMENT
220 ARKELL ROAD, GUELPH, ONTARIO

Figure No.
2

Title
Surficial Geology

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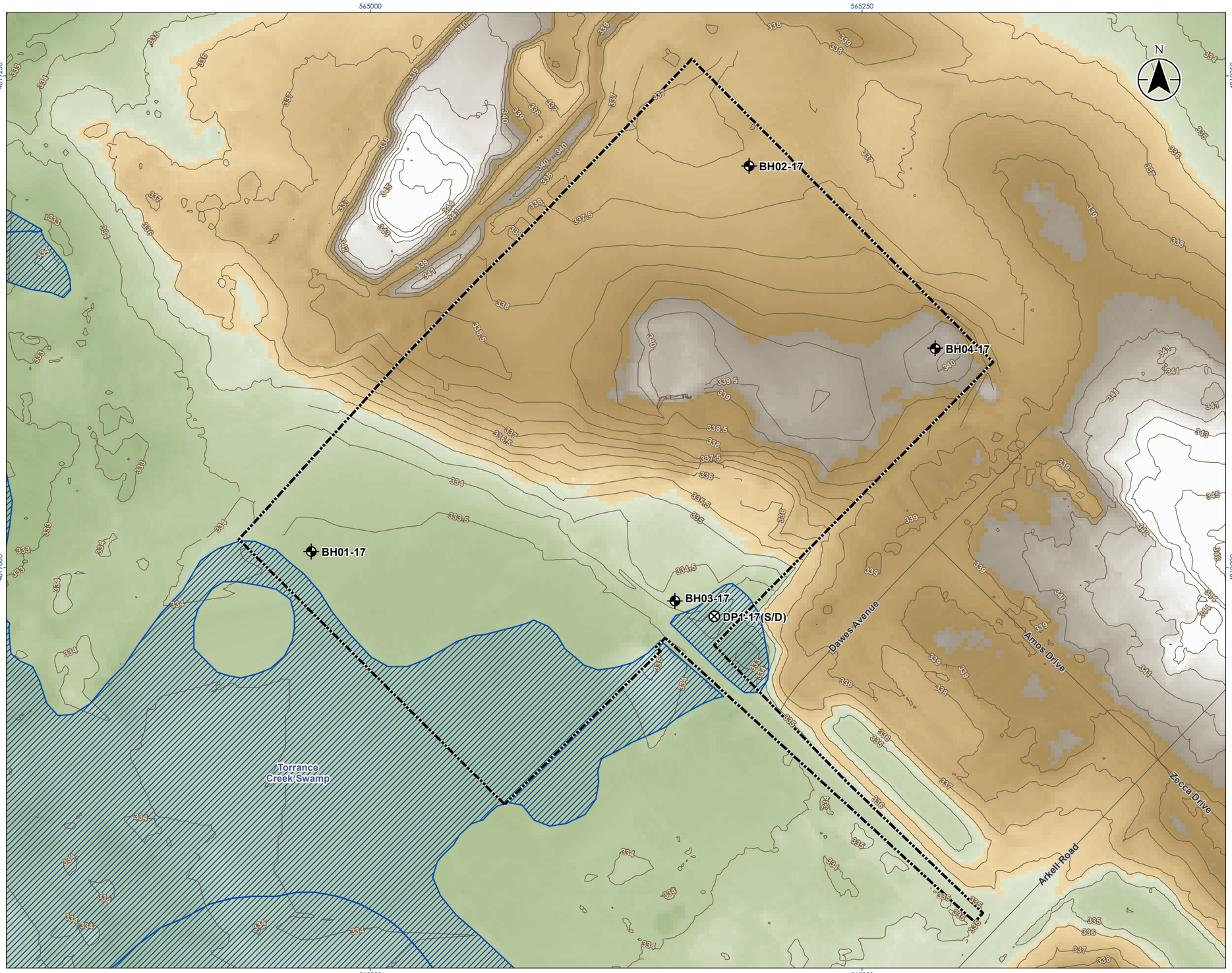

Stantec

Legend

- Site Boundary
- Monitoring Well (Stantec, 2017)
- Drive-Point Piezometer (Stantec, 2017)
- Road
- Topographic Contour (mAMSL)
- Wetland - Evaluated (Provincial)

Value

High : 346.46

Low : 332.05

0 50 100 metres

1:2,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2017.
3. Topographic contours presented on site as surveyed by Stantec (2017). Topographic data beyond the site boundaries should be considered approximate and for illustrative purposes only.
4. DEM from the Southwestern Ontario Orthophotography Project 2015 Digital Elevation Model (DEM) © Queen's Printer for Ontario, 2015. This product is a generalized representation of groud surface features and should be considered approximate.

Project Location
Guelph, Ontario

161413338 REVA
Prepared by CMC on 2019-06-04
Technical Review by GW on 2018-12-03

Client/Project
ROCKPOINT PROPERTIES INC.
HYDROGEOLOGICAL ASSESSMENT
220 ARKELL ROAD, GUELPH, ONTARIO

Figure No.
3

Title
Topography

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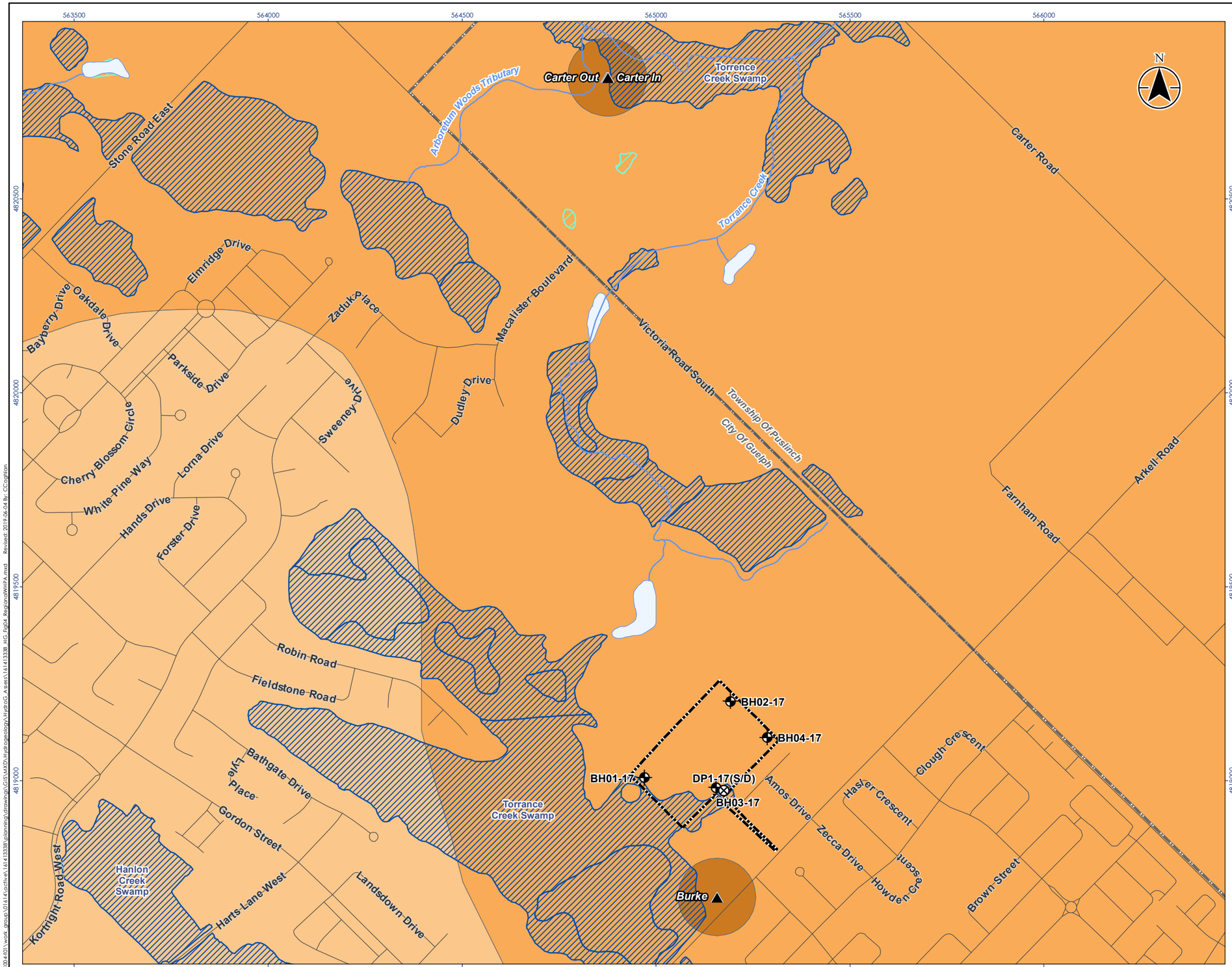

Stantec

- Site Boundary
- Monitoring Well (Stantec, 2017)
- Drive-Point Piezometer (Stantec, 2017)
- Municipal Production Well
- Road
- Watercourse
- Municipal Boundary - Lower Tier
- Waterbody
- Wetland - Evaluated (Provincial)
- Wetland - Not evaluated per Ontario Wetland Evaluation System

WHPA - Wellhead Protection Area (GRCA)

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

0 200 400 metres

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

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2017.
3. Regional WHPA zones and Production well locations © Grand River Conservation, 2017.

Project Location
Guelph, Ontario

161413338 REVA
Prepared by CMC on 2019-06-04
Technical Review by GW on 2018-12-03

Client/Project
ROCKPOINT PROPERTIES INC.
HYDROGEOLOGICAL ASSESSMENT
220 ARKELL ROAD, GUELPH, ONTARIO

Figure No.
4

Title
Regional Wellhead Protection Zones

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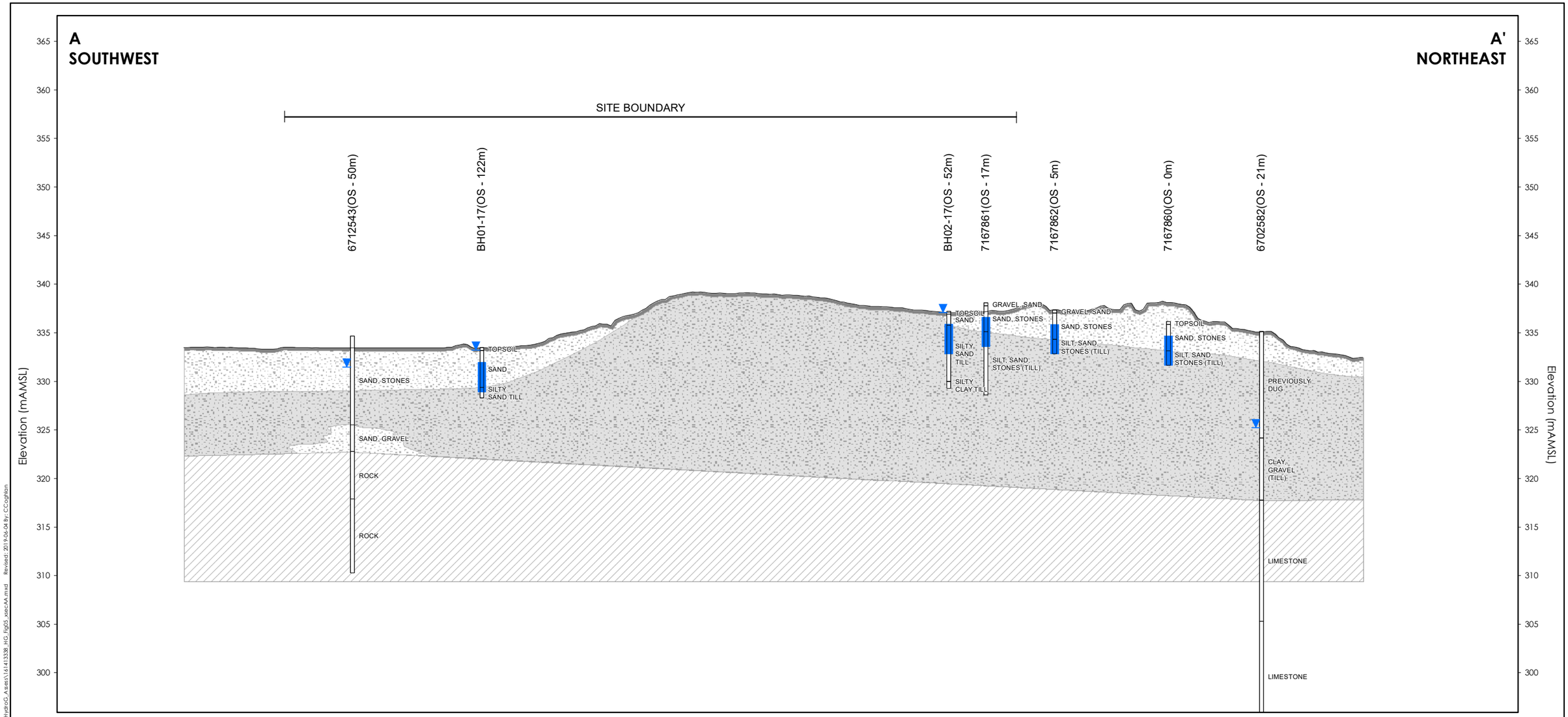

MW1-15 (OS m)

Well ID (Offset)

Sand Stratigraphy

Water Level

Well Screen

Topsoil and/or Fill

Glaciofluvial/Glaciolacustrine Deposit (Sand and Gravel, Silty Sand and Sandy Silt)

Port Stanley Till (Silty Sand to Sandy Silt Till)

Bedrock

5x Vertical Exaggeration

0 30 60 metres

1:2,000 (At original document size of 11x17)

Notes

1.Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

2. Groundwater elevations for Stantec monitoring wells from May 2017. All other water levels were taken at time of well drilling.

Stantec

Project Location
Guelph, Ontario

161413338 REVA
Prepared by CCoghlan on 2019-06-04
Technical Review by GW on 2018-12-03

Client/Project
ROCKPOINT PROPERTIES INC.
HYDROGEOLOGICAL ASSESSMENT
220 ARKELL ROAD, GUELPH, ONTARIO

Figure No.
5

Title
Cross-Section A-A'

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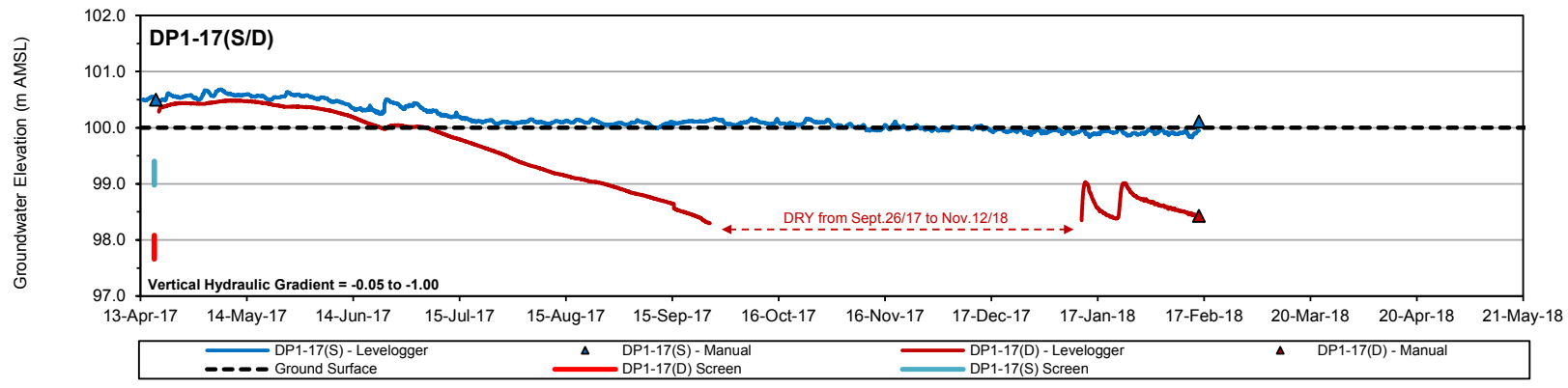

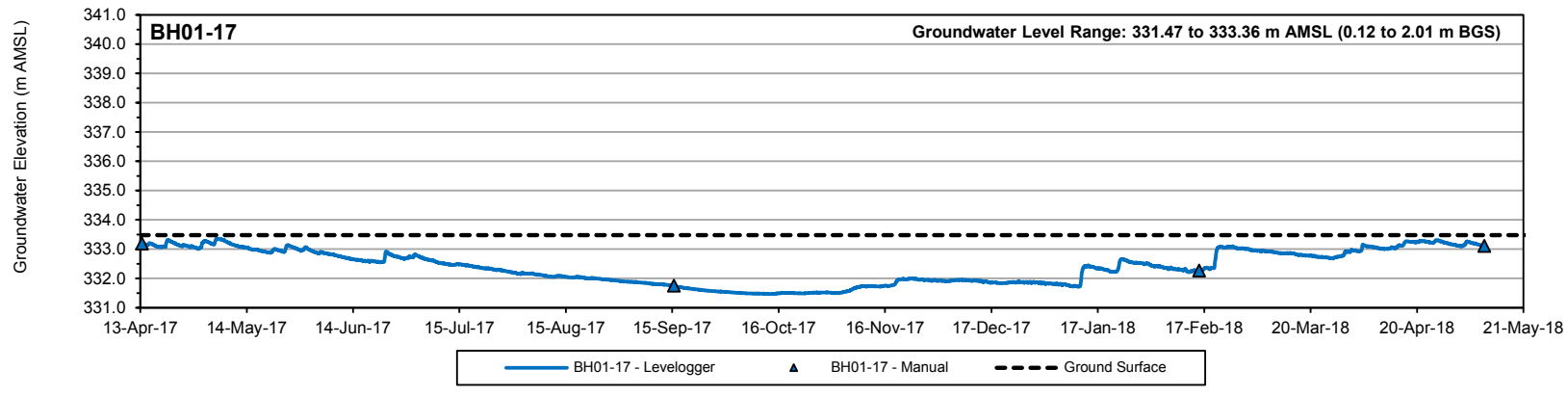

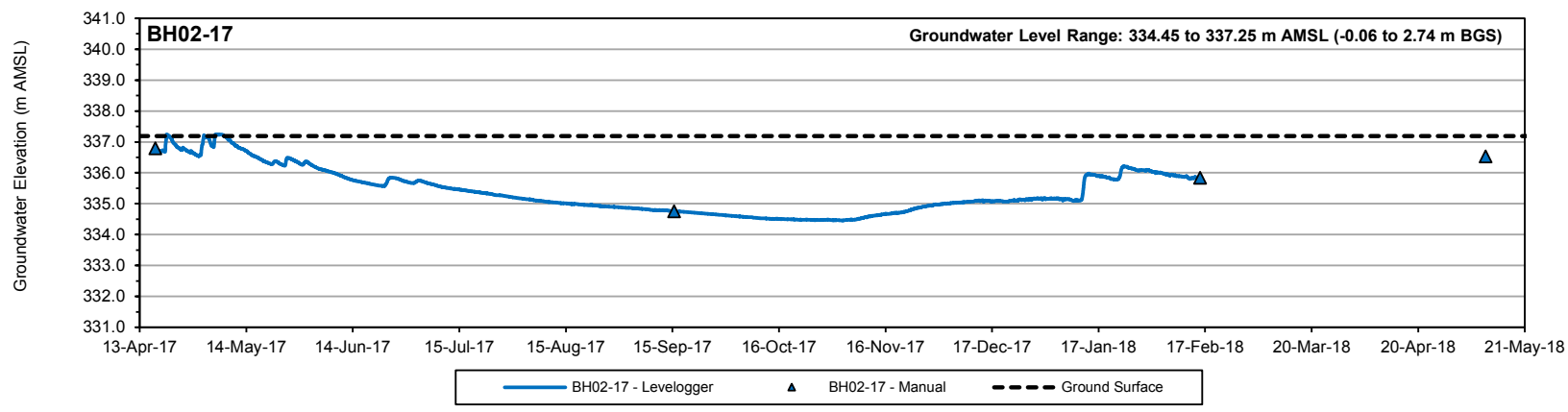

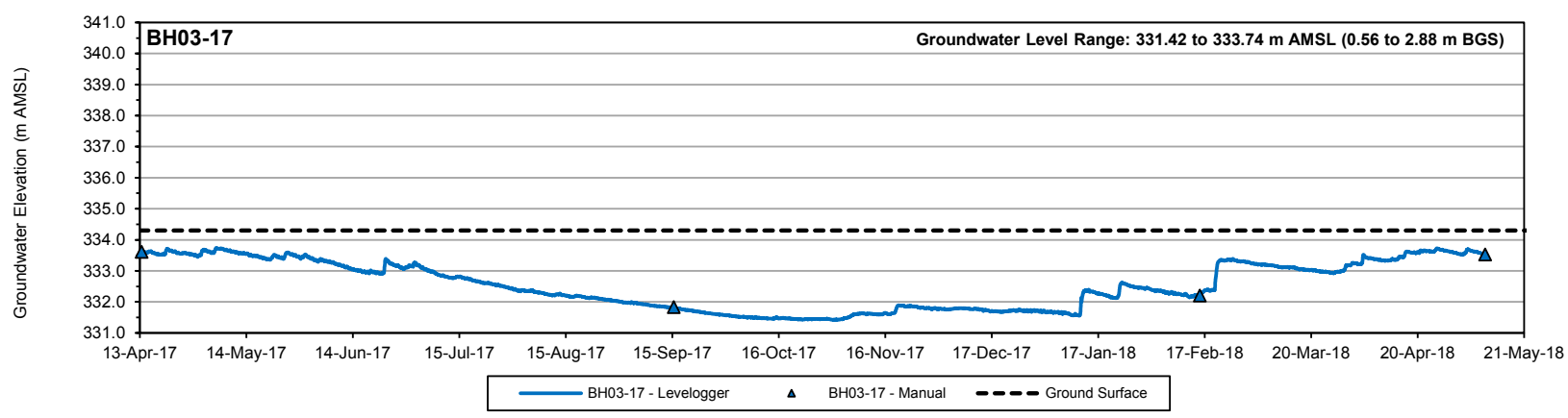

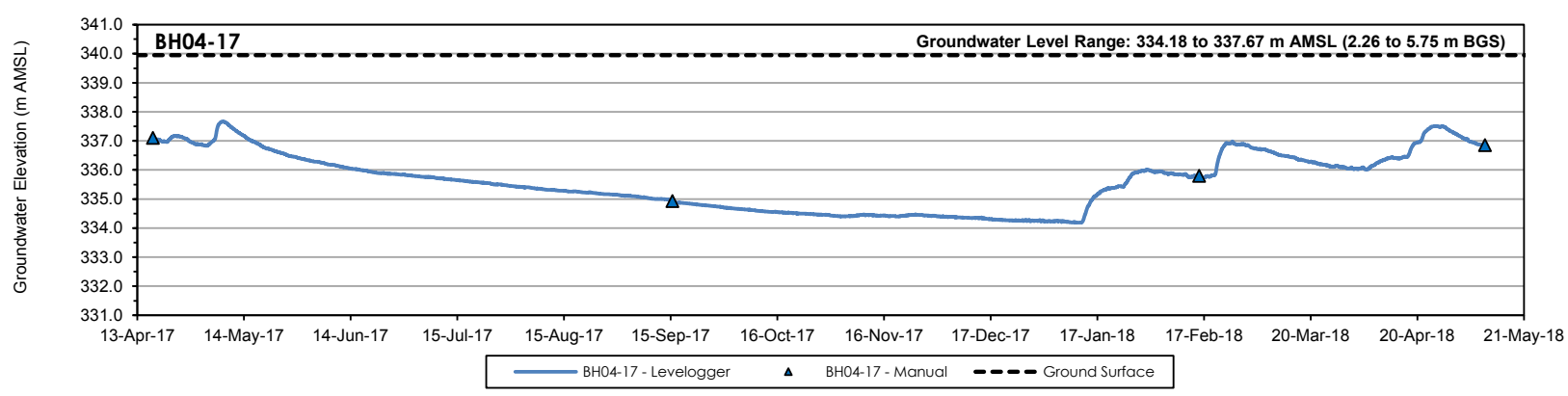

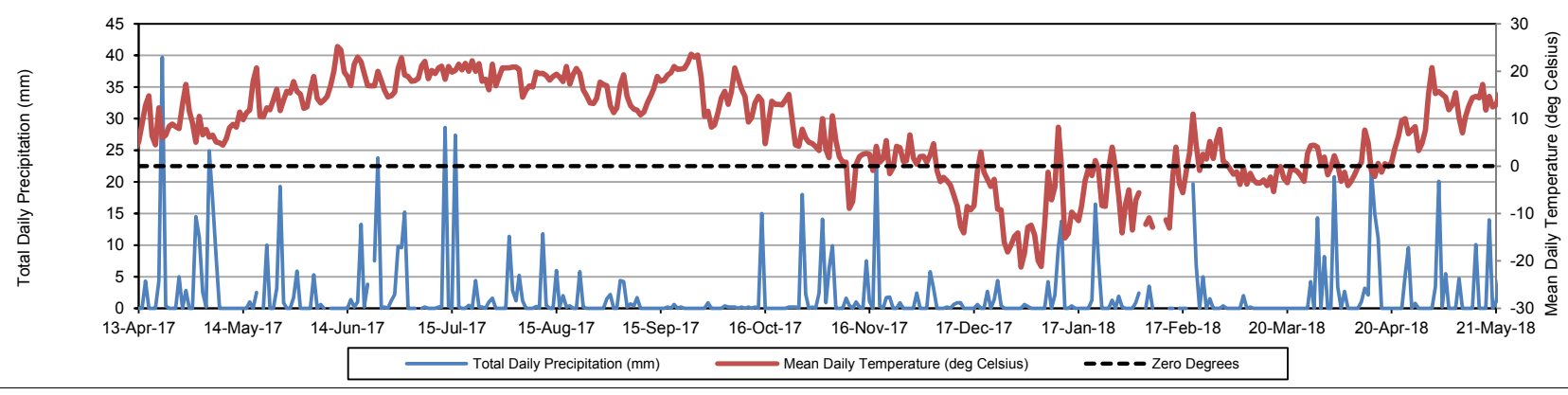

Stantec

Client/Project
ROCKPOINT PROPERTIES INC.
HYDROGEOLOGICAL ASSESSMENT
220 ARKELL ROAD, GUELPH, ONTARIO

Figure No.
6

Title **HYDROGRAPHS**
BH01-17 to BH04-17 and DP1-17(S/D)

Stantec

- Site Boundary
- Monitoring Well (Stantec, 2017)
- Drive-Point Piezometer (Stantec, 2017)
- Proposed Subdivision
- 337.10 Groundwater Elevation (mAMSL)
- Groundwater Contour (mAMSL)
- Interpreted Direction of Groundwater Flow

0 50 100 metres

1:2,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
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3. Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Project Location
Guelph, Ontario

161413338 REVA
Prepared by CMC on 2019-06-04
Technical Review by GW on 2018-12-03

Client/Project
ROCKPOINT PROPERTIES INC.
HYDROGEOLOGICAL ASSESSMENT
220 ARKELL ROAD, GUELPH, ONTARIO

Figure No.
7

Title
Groundwater Flow - May 2017

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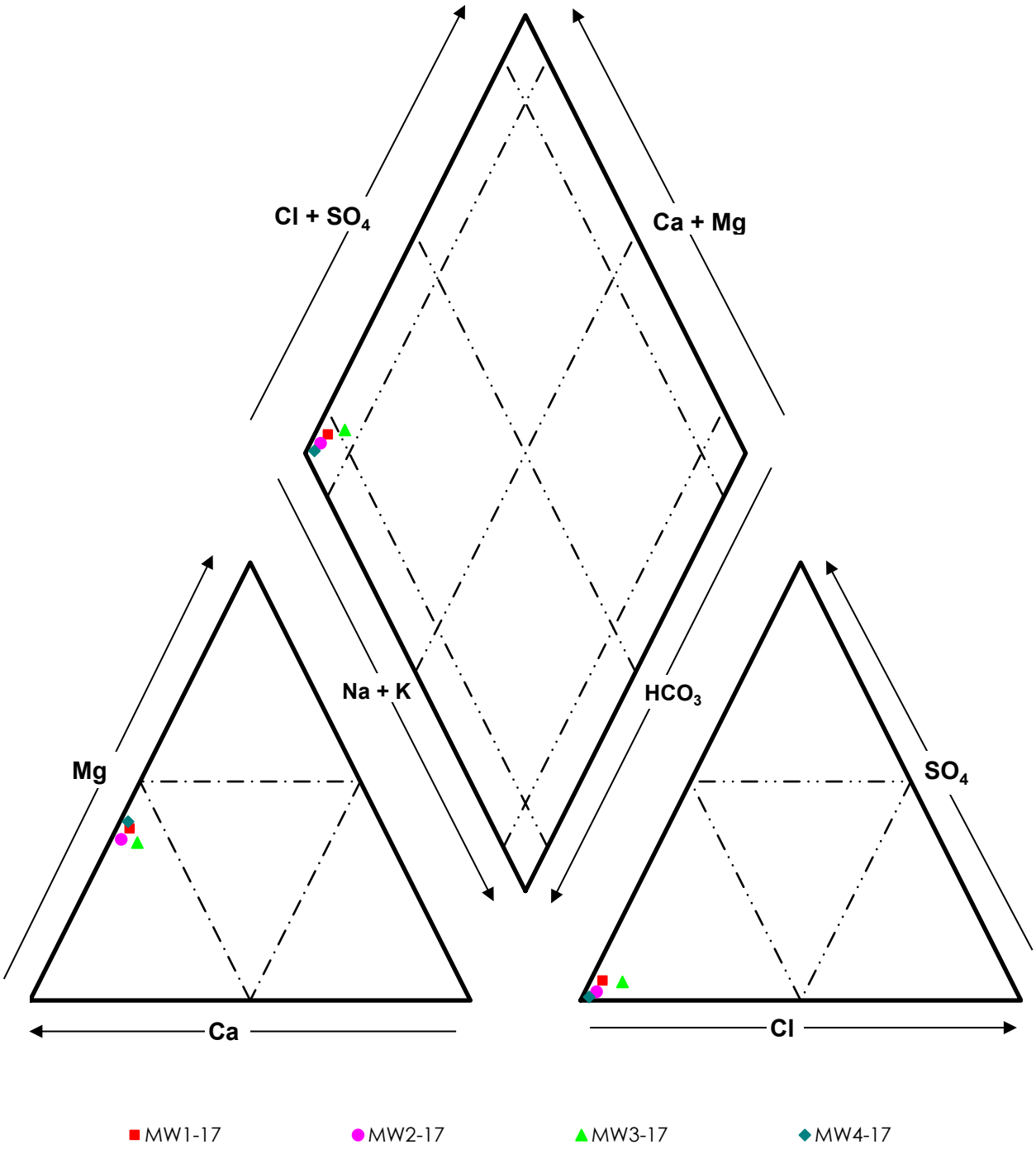


Stantec

ROCKPOINT PROPERTIES INC., 220 ARKELL RD, GUELPH
HYDROGEOLOGICAL ASSESSMENT

PIPER DIAGRAM

DATE:	SCALE:	PROJECT No.	FIGURE No.
		161413338	8

Stantec

Site Boundary
Monitoring Well (Stantec, 2017)
Drive-Point Piezometer (Stantec, 2017)
Proposed Subdivision
Wetland Boundary (Stantec, June 2017)

Proposed Land Use

Community Trail
Ecological Linkage
Open Space
Park
Residential
Road
SWM Pond
Wetland

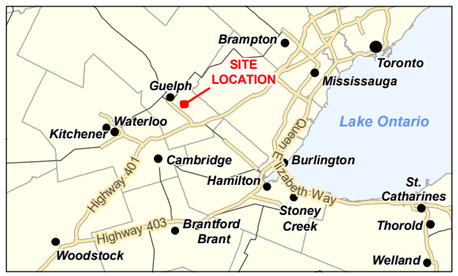
Water Balance Sub-Areas

Sub-Area A (0.83 ha)
Sub-Area B (2.31 ha)
Sub-Area C (4.02 ha)

0 50 100 metres
1:2,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2017.
3. Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Project Location
Guelph, Ontario

161413338 REVA
Prepared by CMC on 2019-06-04
Technical Review by GW on 2018-12-03

Client/Project
ROCKPOINT PROPERTIES INC.
HYDROGEOLOGICAL ASSESSMENT
220 ARKELL ROAD, GUELPH, ONTARIO

Figure No.
9

Title
Water Balance Sub-Areas

\\cal0240\1\work_group\01614\active\161413338\planning\drawings\GIS\MXD\HydroGeology\HydroG_Assess\161413338_HG_Fig09_WaterBalanceAreas.mxd Revised: 2019-06-04 By: CCrighton

APPENDIX B:
TABLES

TABLE 1
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)]	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														
BH01-17	4819008	564970	334.36	333.48	0.88	5.45	4.57	328.91	1.52	331.96	4.57	328.91	Sand / Silty Sand with Gravel TILL	2.8E-05
BH02-17	4819204	565193	338.12	337.19	0.93	5.30	4.37	332.82	1.32	335.87	4.37	332.82	Silty Sand TILL	2.4E-06
BH03-17	4818983	565155	335.26	334.30	0.96	5.28	4.32	329.98	1.27	333.03	4.32	329.98	Sandy Silty Clay FILL / Silty Sand with Gravel TILL	1.6E-06
BH04-17	4819111	565287	340.86	339.95	0.91	8.30	7.39	332.56	4.34	335.61	7.39	332.56	Silty Sand with Gravel TILL	1.4E-05
													GEOMEAN =	**6.2E-06**
DRIVE-POINT PIEZOMETERS														
DP1-17(S)	4818975	565175	-	-	1.15	1.75	0.60	-	0.18	-	0.60	-	-	-
DP1-17(D)	4818974	565169	-	-	1.14	3.06	1.92	-	1.50	-	1.92	-	-	-

Notes:

(a) Refer to **Appendix E** for borehole and well construction logs
(b) Refer to **Appendix G** hydraulic conductivity analytical solutions

m AMSL = meters above mean sea level
m BGS = meters below ground surface
m BTOC = meters below top of well casing
\- = data not available

TABLE 2
GROUNDWATER LEVEL DATA - MONITORING WELLS

Well ID	Date	Time	Well Depth			Screen Length	Top of Casing Elevation	Ground Surface Elevation	Pipe Stick-up	Groundwater Level		
			(m BTOC)	(m BGS)	(m AMSL)	(m)	(m AMSL)	(m AMSL)	(m)	(m BGS) (1)	(m BTOC)	(m AMSL)
BH01-17	13-Apr-17	11:38 AM	5.45	4.57	328.91	3.05	334.36	333.48	0.88	0.29	1.17	333.19
	15-Sep-17	11:33 AM								1.72	2.60	331.76
	15-Feb-18	12:30 PM								1.21	2.09	332.27
	9-May-18	3:09 PM								0.37	1.25	333.11
BH02-17	17-Apr-17	1:02 PM	5.30	4.37	332.82	3.05	338.12	337.19	0.93	0.40	1.33	336.79
	15-Sep-17	12:08 PM								2.44	3.37	334.75
	15-Feb-18	1:00 PM								1.35	2.28	335.84
	9-May-18	3:24 PM								0.66	1.59	336.53
BH03-17	13-Apr-17	1:12 PM	5.28	4.32	329.98	3.05	335.26	334.30	0.96	0.69	1.65	333.61
	15-Sep-17	11:18 AM								2.47	3.43	331.83
	15-Feb-18	1:30 PM								2.09	3.05	332.21
	9-May-18	4:03 PM								0.77	1.73	333.53
BH04-17	17-Apr-17	12:06 PM	8.30	7.39	332.56	3.05	340.86	339.95	0.91	2.85	3.76	337.10
	15-Sep-17	12:03 PM								5.02	5.93	334.93
	15-Feb-18	1:15 PM								4.16	5.07	335.79
	9-May-18	3:42 PM								3.10	4.01	336.85

Notes:

(1) A negative value indicates that the water level measured within the pipe is located above ground surface

m BGS = meters below ground surface
m BTOC = meters below top of casing
DRY = no groundwater or surface water was observed in the piezometer or watercourse, respectively
- = measurement not available

TABLE 3
GROUNDWATER LEVELS - DRIVE-POINT PIEZOMETERS

Piezometer ID	Depth (m BTOC)	Depth (m BGS)	Screen Length (m)	Screen Separation [1] (m)	Pipe Stick-up (m)	Ground Surface Elevation (m AMSL)	Top of Casing Elevation (m AMSL)	Date	Time	Groundwater Level (m BGS) [2]	Groundwater Level (m BTOC)	Groundwater Level (m AMSL)	Surface Water Level (m BTOC) [3]	Surface Water Level (m AMSL)	Vertical Hydraulic Gradient[4] (+) = Upward (-) = Downward
DP1-17(S)	1.75	0.60	0.42		1.15	100.00	101.15	17-Apr-17	-	-0.50	0.65	100.50	0.67	100.48	
								15-Sep-17	11:49 AM	-	DRY	-	DRY	-	
								15-Feb-18	12:00 PM	-0.11	1.04	100.11	DRY	-	
DP1-17(D)	3.06	1.92	0.42	1.32	1.14	100.00	101.14	17-Apr-17	-	0.30	1.44	99.70	0.72	100.42	-0.61
								15-Sep-17	11:48 AM	-	DRY	-	DRY	-	-
								15-Feb-18	12:02 PM	1.57	2.71	98.43	DRY	-	-1.00

Notes:
(1) Distance between the mid-point of the screened intervals of the shallow and deep piezometer.
(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 mid-points of the shallow and deep piezometer screen.
(5) Ground surface elevation set to an arbitrary elevation of 100 m AMSL.

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
GROUNDWATER QUALITY RESULTS

Sample Location			MW01-17	MW02-17	MW03-17	MW04-17
Sample Date			13-Apr-17	12-Apr-17	12-Apr-17	12-Apr-17
Sample ID			WG-161413338-20170413-AH04	WG-161413338-20170412-AH03	WG-161413338-20170412-AH01	WG-161413338-20170412-AH02
Sampling Company			STANTEC	STANTEC	STANTEC	STANTEC
Laboratory			MAXX	MAXX	MAXX	MAXX
Laboratory Work Order			B774848	B774848	B774848	B774848
Laboratory Sample ID	Units	ODWS	EFF795	EFF794	EFF792	EFF793
Calculated Parameters						
Anion Sum	me/L	n/v	6.88	5.66	8.51	7.25
Alkalinity, Bicarbonate (as CaCO3)	mg/L	n/v	310	270	370	350
Total Dissolved Solids (Calculated)	mg/L	500[C]	340	280	430	360
Alkalinity, Carbonate (as CaCO3)	mg/L	n/v	2.9	2.7	2.9	3.2
Cation Sum	me/L	n/v	6.91	5.84	8.7	7.68
Hardness (as CaCO3)	mg/L	80-100[E]	**340[E]**	**290[E]**	**410[E]**	**380[E]**
Ion Balance	%	n/v	0.17	1.58	1.08	2.89
Langelier Index (at 20 C)	none	n/v	0.972	0.892	1.03	1.05
Langelier Index (at 4 C)	none	n/v	0.723	0.642	0.784	0.798
Saturation pH (at 20 C)	none	n/v	7.03	7.13	6.88	6.94
Saturation pH (at 4 C)	none	n/v	7.27	7.38	7.13	7.19
Inorganics						
Total Ammonia-N	mg/L	n/v	<0.050	<0.050	<0.050	<0.050
Electrical Conductivity, Lab	µmhos/cm	n/v	610	520	740	640
Dissolved Organic Carbon (DOC)	mg/L	5[C]	1.3	1.2	1.8	1.4
Orthophosphate(as P)	mg/L	n/v	<0.010	<0.010	<0.010	<0.010
pH	S.U.	6.5-8.5[E]	8	8.02	7.91	7.99
Sulfate	mg/L	500[C] h	15	5.4	17	2.7
Alkalinity, Total (as CaCO3)	mg/L	30-500[E]	320	270	370	350
Chloride	mg/L	250[C]	6.8	5.3	22	4
Nitrite (as N)	mg/L	1.0 d[B]	<0.010	<0.010	<0.010	<0.010
Nitrate (as N)	mg/L	10.0 d[B]	0.73	<0.10	0.98	0.26
Nitrate + Nitrite (as N)	mg/L	10.0 d[B]	0.73	<0.10	0.98	0.26
Metals						
Aluminum	mg/L	0.1[E]	<0.0050	0.014	<0.0050	0.045
Antimony	mg/L	0.006[A]	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic	mg/L	0.025[A]	<0.0010	<0.0010	<0.0010	<0.0010
Barium	mg/L	1[B]	0.044	0.022	0.042	0.025
Beryllium	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00050
Boron	mg/L	5[A]	0.021	0.01	0.019	0.015
Cadmium	mg/L	0.005[B]	<0.00010	<0.00010	<0.00010	<0.00010
Calcium	mg/L	n/v	80	71	100	88
Chromium	mg/L	0.05[B]	<0.0050	<0.0050	<0.0050	<0.0050
Cobalt	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00050
Copper	mg/L	1[C]	0.0013	0.0012	0.0013	0.0012
Iron	mg/L	0.3[C]	<0.10	<0.10	<0.10	<0.10
Lead	mg/L	0.01 c[B]	<0.00050	<0.00050	<0.00050	<0.00050
Magnesium	mg/L	n/v	33	26	38	38
Manganese	mg/L	0.05[C]	0.0054	0.017	0.014	0.03
Molybdenum	mg/L	n/v	0.00068	<0.00050	<0.00050	<0.00050
Nickel	mg/L	n/v	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus	mg/L	n/v	<0.10	<0.10	<0.10	<0.10
Potassium	mg/L	n/v	0.9	0.8	1.1	1.1
Selenium	mg/L	0.01[B]	<0.0020	<0.0020	<0.0020	<0.0020
Silicon	mg/L	n/v	4.7	4.6	6.4	5.8
Silver	mg/L	n/v	<0.00010	<0.00010	<0.00010	<0.00010
Sodium	mg/L	200 g[C] 20 g[D]	4.3	2.6	12	2.6
Strontium	mg/L	n/v	0.15	0.097	0.13	0.1
Thallium	mg/L	n/v	<0.000050	<0.000050	<0.000050	<0.000050
Titanium	mg/L	n/v	<0.0050	<0.0050	<0.0050	<0.0050
Uranium	mg/L	0.02[B]	0.00069	0.00062	0.00048	0.00038
Vanadium	mg/L	n/v	<0.00050	<0.00050	<0.00050	<0.00050
Zinc	mg/L	5[C]	0.012	<0.0050	0.016	0.0056

Notes:

ODWS	Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines (MOE, 2006, revised January 2017)
A	ODWS Table 2 - Chemical Standards, Interim Maximum Acceptable Concentration
B	ODWS Table 2 - Chemical Standards, Maximum Acceptable Concentration
C	ODWS Table 4 - Chemical/Physical Objectives and Guidelines, Aesthetic Objectives
D	ODWS Table 4 - Medical Officer of Health Reporting Limit
E	ODWS Table 4 - Chemical/Physical Objectives and Guidelines, Operational Guidelines
6.5[A]	Concentration exceeds the indicated standard.
15.2	Measured concentration did not exceed the indicated standard.
<0.50	Laboratory reporting limit was greater than the applicable standard.
<0.03	Analyte was not detected at a concentration greater than the laboratory reporting limit.
n/v	No standard/guideline value.
-	Parameter not analyzed / not available.
c	This standard applies to water at the point of consumption. Since lead is a component in some plumbing systems, first flush water may contain higher concentrations of lead than water that has been flushed for five minutes.
d	Where both nitrate and nitrite are present, the total of the two should not exceed 10 mg/L (as nitrogen).
CD g	The aesthetic objective for sodium in drinking water is 200 mg/L. The local Medical Officer of Health should be notified when the sodium concentration exceeds 20 mg/L so that this information may be communicated to local physicians for their use with patients on sodium restricted diets.
h	When sulfate levels exceed 500 mg/L, water may have a laxative effect on some people.

TABLE 5
PRE-DEVELOPMENT MONTHLY WATER BALANCE
220 Arkell Road, Guelph, Ontario

Sub-Area Descriptions (topography, soils, cover)	
Sub-Area A (pre)	flat, silty sand, woodland (Wetland)
Sub-Area B (pre)	flat to gently rolling, silty sand, pastures and shrubs
Sub-Area C (pre)	rolling, silty sand, cultivated

Model Type: Thornthwaite and Mather (1955)
Client: Rockpoint Properties Inc.
Total Site Area (ha) 7.16

Land Description Factors	Sub-Area A (pre)	Sub-Area B (pre)	Sub-Area C (pre)											Total
Topography	0.30	0.25	0.20											
Soils	0.40	0.40	0.40											
Cover	0.20	0.15	0.10											
Sum (Infiltration Factor)†	0.90	0.80	0.70											
Soil Moisture Capacity (mm)	300	150	150											
Site area (ha)	0.83	2.31	4.01											7.16
Imperviousness Coefficient	0.00	0.00	0.15											
Impervious Area (ha)	0.00	0.00	0.60											0.60
Percentage of Total Site Area	0.0%	0.0%	8.4%											8%
Remaining Pervious Area (ha)	0.83	2.31	3.41											6.56
Total Pervious Site Area (ha)	0.83	2.31	3.41											6.56
Percentage of Total Site Area	11.6%	32.3%	47.7%											92%

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Climate Data ‡													
Average Daily Temperature (°C)	-6.5	-5.5	-1	6.2	12.5	17.6	20	18.9	14.5	8.2	2.5	-3.3	**7.0**
Precipitation (mm)	65.2	54.9	61	74.5	82.3	82.4	98.6	83.9	87.8	67.4	87.1	71.2	**916**

Potential Evapotranspiration Analysis for Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Heat Index	0.0	0.0	0.0	1.4	4.0	6.7	8.2	7.5	5.0	2.1	0.4	0.0	**35**
Unadjusted Potential Evapotranspiration (mm)	0.0	0.0	0.0	29.0	60.8	87.2	99.8	94.0	71.1	39.0	11.1	0.0	**492**
Potential Evapotranspiration Adjusting Factor for Latitude*	0.77	0.87	0.99	1.12	1.23	1.29	1.26	1.16	1.04	0.92	0.81	0.75	
Adjusted Potential Evapotranspiration (PET)(mm)	0	0	0	32	75	112	126	110	74	36	9	0	**573**
Precipitation - PET (mm)	65	55	61	42	8	-30	-27	-26	14	32	78	71	**343**

Evapotranspiration Analysis													
Sub-Area A (pre)	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
Precipitation (m^3)													**7,605**
Accumulated Potential Water Loss (APWL)	0	0	0	0	0	-30	-57	-82	-69	-37	0	0	
Storage (S)	300	300	300	300	300	272	225	171	185	216	300	300	
Change in Storage	0	0	0	0	0	-28	-47	-54	14	32	84	0	
Actual Evapotranspiration (mm)	0	0	0	32	75	111	145	138	74	36	9	0	**620**
Recharge/Runoff Analysis													
Water Surplus (mm)	65	55	61	42	8	0	0	0	0	0	-6	71	**296**
Potential Infiltration (I)	59	49	55	38	7	0	0	0	0	0	-5	64	267
Potential Direct Surface Water Runoff (R)	7	5	6	4	1	0	0	0	0	0	-1	7	30
Potential Infiltration (mm)	0	0	0	265	7	0	0	0	0	0	-5	0	267
Pervious Evapotranspiration (m^3)	0	0	0	270	620	919	1207	1144	615	297	75	0	5,147
Pervious Runoff (m^3)	54	46	51	35	6	0	0	0	0	0	-5	59	**246**
Pervious Infiltration (m^3)	0	0	0	2199	57	0	0	0	0	0	-43	0	**2,213**
Potential Impervious Evaporation (mm)	7	5	6	7	8	8	10	8	9	7	9	7	92
Potential Impervious Runoff (mm)	59	49	55	67	74	74	89	76	79	61	78	64	825
Impervious Runoff (m^3)	0	0	0	0	0	0	0	0	0	0	0	0	**0**

TABLE 5
PRE-DEVELOPMENT MONTHLY WATER BALANCE
220 Arkell Road, Guelph, Ontario

Evapotranspiration Analysis													
Sub-Area B (pre)	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
Precipitation (m^3)													**21,191**
Accumulated Potential Water Loss (APWL)	0	0	0	0	0	-30	-57	-82	-69	-37	0	0	
Storage (S)	150	150	150	150	150	123	84	49	62	94	150	150	
Change in Storage	0	0	0	0	0	-27	-39	-36	14	32	56	0	
Actual Evapotranspiration (mm)	0	0	0	32	75	109	137	120	74	36	9	0	**592**
Recharge/Runoff Analysis													
Water Surplus (mm)	65	55	61	42	8	0	0	0	0	0	22	71	**324**
Potential Infiltration (I)	52	44	49	34	6	0	0	0	0	0	18	57	259
Potential Direct Surface Water Runoff (R)	13	11	12	8	2	0	0	0	0	0	4	14	65
Potential Infiltration (mm)	0	0	0	235	6	0	0	0	0	0	18	0	259
Pervious Evapotranspiration (m^3)	0	0	0	751	1728	2529	3177	2764	1714	828	208	0	13,699
Pervious Runoff (m^3)	302	254	282	194	35	0	0	0	0	0	102	329	**1,499**
Pervious Infiltration (m^3)	0	0	0	5445	140	0	0	0	0	0	408	0	**5,994**
Potential Impervious Evaporation (mm)	7	5	6	7	8	8	10	8	9	7	9	7	92
Potential Impervious Runoff (mm)	59	49	55	67	74	74	89	76	79	61	78	64	825
Impervious Runoff (m^3)	0	0	0	0	0	0	0	0	0	0	0	0	**0**

Evapotranspiration Analysis													
Sub-Area C (pre)	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
Precipitation (m^3)													**36,787**
Accumulated Potential Water Loss (APWL)	0	0	0	0	0	-30	-57	-82	-69	-37	0	0	
Storage (S)	150	150	150	150	150	123	84	49	62	94	150	150	
Change in Storage	0	0	0	0	0	-27	-39	-36	14	32	56	0	
Actual Evapotranspiration (mm)	0	0	0	32	75	109	137	120	74	36	9	0	**592**
Recharge/Runoff Analysis													
Water Surplus (mm)	65	55	61	42	8	0	0	0	0	0	22	71	**324**
Potential Infiltration (I)	46	38	43	29	5	0	0	0	0	0	15	50	227
Potential Direct Surface Water Runoff (R)	20	16	18	13	2	0	0	0	0	0	7	21	97
Potential Infiltration (mm)	0	0	0	206	5	0	0	0	0	0	15	0	227
Pervious Evapotranspiration (m^3)	0	0	0	1108	2549	3732	4687	4078	2529	1222	307	0	20,213
Pervious Runoff (m^3)	667	562	624	430	78	0	0	0	0	0	226	729	**3,317**
Pervious Infiltration (m^3)	0	0	0	7031	181	0	0	0	0	0	527	0	**7,739**
Potential Impervious Evaporation (mm)	7	5	6	7	8	8	10	8	9	7	9	7	92
Potential Impervious Runoff (mm)	59	49	55	67	74	74	89	76	79	61	78	64	825
Impervious Evaporation (m^3)	39	33	37	45	50	50	59	51	53	41	52	43	**552**
Impervious Runoff (m^3)	353	298	331	404	446	447	534	455	476	365	472	386	**4,966**

Pre-Development Infiltration	**15,946**	**(m^3/yr)**	**223**	**mm/yr**	**0.5**	**L/s**
Pre-Development Runoff	10,027	(m^3/yr)	140	mm/yr	0.3	L/s

Notes:
† Infiltration factors after Ontario Ministry of the Environment, 2003. Stormwater Management Planning and Design Manual. March 2003.; and Ontario Ministry of Environment and Energy (MOEE). 1995. MOEE Hydrogeological Technical Information Requirements for Land Development Applications. April 1995.

* PET adjustment factors after Thornthwaite, C.W., and J.R. Mather, 1957. Instructions and Tables for Computing Potential Evapotranspiration and the water balance. Drexel Institute of Technology, Laboratory of Climatology, Publications in Climatology, Volume X, No. 3. Centerton, New Jersey.

‡ Climate Data after Environment Canada, 2018. Canadian Climate Normals 1981-2010, Waterloo Wellington A Climate Station, Climate ID 6149387. [Online] http://climate.weather.gc.ca/climate_normals/index_e.html

Assumptions:
[1] The monthly average precipitation collected at the Waterloo-Wellington A climate station is reflective of the precipitation trends that have historically occurred at the Site.
[2] Surplus water is not available for runoff and recharge during months where water losses from actual evapotranspiration exceed precipitation inputs.
[3] Runoff, infiltration and evapotranspiration do not occur in months where the average daily temperature is below 0°C, which is the case for the months of December through March at the Site.
[4] Precipitation during freezing months (i.e., December to March) is assumed to accumulate as snow and result in additional precipitation in the first month thereafter where the average temperature is greater than 0°C (i.e., April).
[5] Soil moisture capacity is at a maximum in April.

TABLE 6
POST-DEVELOPMENT MONTHLY WATER BALANCE
220 Arkell Road, Guelph, Ontario

Sub-Area Descriptions (topography, soils, cover)	
Sub-Area A (post)	flat, silty sand, woodland (Wetland)
Sub-Area B (post)	rolling, silty sand, cultivated
Sub-Area C (post)	rolling, silty sand, cultivated

Model Type: Thornthwaite and Mather (1955)
Client: Rockpoint Properties Inc.
Total Site Area (ha) 7.16

Land Description Factors	Sub-Area A (post)	Sub-Area B (post)	Sub-Area C (post)											Total
Topography	0.30	0.25	0.20											
Soils	0.40	0.40	0.40											
Cover	0.20	0.15	0.10											
Sum (Infiltration Factor)†	0.90	0.80	0.70											
Soil Moisture Capacity (mm)	300	150	100											
Site area (ha)	0.83	2.31	4.01											7.16
Imperviousness Coefficient	0.00	0.10	0.65											
Impervious Area (ha)	0.00	0.22	2.60											2.82
Percentage of Total Site Area	0.0%	3.1%	36.3%											39%
Remaining Pervious Area (ha)	0.83	2.09	1.42											4.34
Total Pervious Site Area (ha)	0.83	2.09	1.42											4.34
Percentage of Total Site Area	11.6%	29.2%	19.8%											61%

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Climate Data ‡													
Average Daily Temperature (°C)	-6.5	-5.5	-1	6.2	12.5	17.6	20	18.9	14.5	8.2	2.5	-3.3	**7.0**
Precipitation (mm)	65.2	54.9	61	74.5	82.3	82.4	98.6	83.9	87.8	67.4	87.1	71.2	**916**

Potential Evapotranspiration Analysis for Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Heat Index	0.0	0.0	0.0	1.4	4.0	6.7	8.2	7.5	5.0	2.1	0.4	0.0	**35**
Unadjusted Potential Evapotranspiration (mm)	0.0	0.0	0.0	29.0	60.8	87.2	99.8	94.0	71.1	39.0	11.1	0.0	**492**
Potential Evapotranspiration Adjusting Factor for Latitude*	0.77	0.87	0.99	1.12	1.23	1.29	1.26	1.16	1.04	0.92	0.81	0.75	
Adjusted Potential Evapotranspiration (PET)(mm)	0	0	0	32	75	112	126	110	74	36	9	0	**573**
Precipitation - PET (mm)	65	55	61	42	8	-30	-27	-26	14	32	78	71	**343**

Evapotranspiration Analysis													
Sub-Area A (post)	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
Accumulated Potential Water Loss (APWL)	0	0	0	0	0	-30	-57	-82	-69	-37	0	0	
Storage (S)	300	300	300	300	300	272	225	171	185	216	300	300	
Change in Storage	0	0	0	0	0	-28	-47	-54	14	32	84	0	
Actual Evapotranspiration (mm)	0	0	0	32	75	111	145	138	74	36	9	0	**620**
Recharge/Runoff Analysis													
Water Surplus (mm)	65	55	61	42	8	0	0	0	0	0	-6	71	**296**
Potential Infiltration (I)	59	49	55	38	7	0	0	0	0	0	-5	64	267
Potential Direct Surface Water Runoff (R)	7	5	6	4	1	0	0	0	0	0	-1	7	30
Potential Infiltration (mm)	0	0	0	265	7	0	0	0	0	0	-5	0	267
Pervious Evapotranspiration (m^3)	0	0	0	270	620	919	1207	1144	615	297	75	0	5,147
Pervious Runoff (m^3)	54	46	51	35	6	0	0	0	0	0	-5	59	**246**
Pervious Infiltration (m^3)	0	0	0	2199	57	0	0	0	0	0	-43	0	**2,213**
Potential Impervious Evaporation (mm)	7	5	6	7	8	8	10	8	9	7	9	7	92
Potential Impervious Runoff (mm)	59	49	55	67	74	74	89	76	79	61	78	64	825
Impervious Runoff (m^3)	0	0	0	0	0	0	0	0	0	0	0	0	**0**

TABLE 6
POST-DEVELOPMENT MONTHLY WATER BALANCE
220 Arkell Road, Guelph, Ontario

Evapotranspiration Analysis													
Sub-Area B (post)	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
Accumulated Potential Water Loss (APWL)	0	0	0	0	0	-30	-57	-82	-69	-37	0	0	
Storage (S)	150	150	150	150	150	123	84	49	62	94	150	150	
Change in Storage	0	0	0	0	0	-27	-39	-36	14	32	56	0	
Actual Evapotranspiration (mm)	0	0	0	32	75	109	137	120	74	36	9	0	**592**
Recharge/Runoff Analysis													
Water Surplus (mm)	65	55	61	42	8	0	0	0	0	0	22	71	**324**
Potential Infiltration (I)	52	44	49	34	6	0	0	0	0	0	18	57	259
Potential Direct Surface Water Runoff (R)	13	11	12	8	2	0	0	0	0	0	4	14	65
Potential Infiltration (mm)	0	0	0	235	6	0	0	0	0	0	18	0	259
Pervious Evapotranspiration (m^3)	0	0	0	679	1562	2287	2872	2499	1549	749	188	0	12,384
Pervious Runoff (m^3)	273	230	255	176	32	0	0	0	0	0	92	298	**1,355**
Pervious Infiltration (m^3)	0	0	0	4923	127	0	0	0	0	0	369	0	**5,419**
Potential Impervious Evaporation (mm)	7	5	6	7	8	8	10	8	9	7	9	7	92
Potential Impervious Runoff (mm)	59	49	55	67	74	74	89	76	79	61	78	64	825
Impervious Runoff (m^3)	130	110	122	149	164	165	197	168	175	135	174	142	**1,831**

Evapotranspiration Analysis													
Sub-Area C (post)	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
Accumulated Potential Water Loss (APWL)	0	0	0	0	0	-30	-57	-82	-69	-37	0	0	
Storage (S)	100	100	100	100	100	74	42	18	32	64	100	100	
Change in Storage	0	0	0	0	0	-26	-32	-24	14	32	36	0	
Actual Evapotranspiration (mm)	0	0	0	32	75	108	131	108	74	36	9	0	**573**
Recharge/Runoff Analysis													
Water Surplus (mm)	65	55	61	42	8	0	0	0	0	0	42	71	**344**
Potential Infiltration (I)	46	38	43	29	5	0	0	0	0	0	29	50	241
Potential Direct Surface Water Runoff (R)	20	16	18	13	2	0	0	0	0	0	13	21	103
Potential Infiltration (mm)	0	0	0	206	5	0	0	0	0	0	29	0	241
Pervious Evapotranspiration (m^3)	0	0	0	460	1057	1530	1851	1522	1049	507	127	0	8,104
Pervious Runoff (m^3)	277	233	259	178	32	0	0	0	0	0	178	302	**1,460**
Pervious Infiltration (m^3)	0	0	0	2916	75	0	0	0	0	0	415	0	**3,406**
Potential Impervious Evaporation (mm)	7	5	6	7	8	8	10	8	9	7	9	7	92
Potential Impervious Runoff (mm)	59	49	55	67	74	74	89	76	79	61	78	64	825
Impervious Runoff (m^3)	1525	1284	1427	1743	1925	1928	2307	1963	2054	1577	2038	1666	**21,435**

Post-Development Infiltration	**11,038**	**(m^3/yr)**	**154**	**mm/yr**	**0.3**	**L/s**
Post-Development Runoff	26,327	(m^3/yr)	368	mm/yr	0.8	L/s
Infiltration Deficit	**4,908**	**(m^3/yr)**	**69**	**mm/yr**	**0.2**	**L/s**

Sub-Area Descriptions (topography, soils, cover)	
Sub-Area A (post)	flat, silty sand, woodland (Wetland)
Sub-Area B (post)	rolling, silty sand, cultivated
Sub-Area C (post)	rolling, silty sand, cultivated

Notes:
† Infiltration factors after Ontario Ministry of the Environment, 2003. Stormwater Management Planning and Design Manual. March 2003.; and Ontario Ministry of Environment and Energy (MOEE). 1995. MOEE Hydrogeological Technical Information Requirements for Land Development Applications. April 1995.

* PET adjustment factors after Thornthwaite, C.W., and J.R. Mather, 1957. Instructions and Tables for Computing Potential Evapotranspiration and the water balance. Drexel Institute of Technology, Laboratory of Climatology, Publications in Climatology, Volume X, No. 3. Centerton, New Jersey.

‡ Climate Data after Environment Canada, 2018. Canadian Climate Normals 1981-2010, Waterloo Wellington A Climate Station, Climate ID 6149387. [Online] http://climate.weather.gc.ca/climate_normals/index_e.html

Assumptions:
[1] The monthly average precipitation collected at the Waterloo-Wellington A climate station is reflective of the precipitation trends that have historically occurred at the Site.
[2] Surplus water is not available for runoff and recharge during months where water losses from actual evapotranspiration exceed precipitation inputs.
[3] Runoff, infiltration and evapotranspiration do not occur in months where the average daily temperature is below 0°C, which is the case for the months of December through March at the Site.
[4] Precipitation during freezing months (i.e., December to March) is assumed to accumulate as snow and result in additional precipitation in the first month thereafter where the average temperature is greater than 0°C (i.e., April).
[5] Soil moisture capacity is at a maximum in April.

TABLE 7
1981 TO 2010 CANADIAN CLIMATE NORMALS (WATERLOO WELLINGTON A)
HYDROGEOLOGICAL ASSESSMENT
220 ARKELL ROAD, GUELPH, ONTARIO

Climate Normals 1981-2010 Station Data
Metadata including Station Name, Province, Latitude, Longitude, Elevation, Climate ID, WMO ID, TC ID

STATION_NAME	PROVINCE	LATITUDE	LONGITUDE	ELEVATION	CLIMATE_ID	WMO_ID	TC_ID
WATERLOO WELLINGTON A	ON	43°27'00.000" N	80°23'00.000" W	317.0 m	6149387		

Legend
A = WMO "3 and 5 rule" (i.e. no more than 3 consecutive and no more than 5 total missing for either temperature or precipitation)
B = At least 25 years
C = At least 20 years
D = At least 15 years

1981 to 2010 Canadian Climate Normals Station Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
Temperature														
Daily Average (°C)	-6.5	-5.5	-1	6.2	12.5	17.6	20	18.9	14.5	8.2	2.5	-3.3	7	C
Standard Deviation	2.9	2.5	2	1.4	2.1	1.3	1.3	1.3	1.2	1.4	1.5	2.9	0.9	C
Daily Maximum (°C)	-2.6	-1.2	3.6	11.5	18.5	23.6	26	24.8	20.4	13.5	6.3	0.2	12	C
Daily Minimum (°C)	-10.3	-9.7	-5.6	0.8	6.4	11.5	14	12.9	8.6	2.9	-1.4	-6.8	2	C
Extreme Maximum (°C)	14.2	13.7	24.4	29.2	32	36.1	36	36.5	33.3	29.4	21.7	18.7		
Date (yyyy/dd)	1995/14	2000/26	2000/08	1990/25	1987/28	1988/25	1988/07	2001/08	1973/03	1971/02	1974/01	1982/03		
Extreme Minimum (°C)	-31.9	-29.2	-25.4	-16.1	-3.9	-0.6	5	1.1	-3.7	-8.3	-15.4	-27.2		
Date (yyyy/dd)	1984/16	1979/18	1980/02	1972/08	1970/07	1972/11	1971/03	1982/29	1989/27	1976/27	2000/23	1980/25		
Precipitation														
Rainfall (mm)	28.7	29.7	36.8	68	81.8	82.4	98.6	83.9	87.8	66.1	75	38	776.8	C
Snowfall (cm)	43.7	30.3	26.5	7.3	0.4	0	0	0	0	1.4	13	37.2	159.7	C
Precipitation (mm)	65.2	54.9	61	74.5	82.3	82.4	98.6	83.9	87.8	67.4	87.1	71.2	916.5	C
Average Snow Depth (cm)	11	11	6	0	0	0	0	0	0	0	1	5	3	C
Median Snow Depth (cm)	11	11	4	0	0	0	0	0	0	0	0	3	3	C
Snow Depth at Month-end (cm)	12	9	1	0	0	0	0	0	0	0	1	9	3	C
Extreme Daily Rainfall (mm)	43	47	36.8	53.4	51.8	54.2	89.8	73.7	74.4	39.2	56	36.8		
Date (yyyy/dd)	1995/15	2001/09	1991/27	1992/16	1996/20	1984/17	1985/15	1975/24	1986/10	1977/08	1992/12	1990/29		
Extreme Daily Snowfall (cm)	16.8	17.8	21.2	22.9	6	0	0	0	0	6	16.6	22.4		
Date (yyyy/dd)	1992/14	1985/12	1980/08	2002/02	1984/13	1970/01	1970/01	1970/01	1970/01	1997/26	1986/20	1971/30		
Extreme Daily Precipitation (mm)	43	47	53.8	53.4	51.8	54.2	89.8	73.7	74.4	39.2	56	36.8		
Date (yyyy/dd)	1995/15	2001/09	1976/02	1992/16	1996/20	1984/17	1985/15	1975/24	1986/10	1977/08	1992/12	1990/29		
Extreme Snow Depth (cm)	58	74	77	18	0	0	0	0	0	2	19	50		
Date (yyyy/dd)	1976/24	1982/14	1982/10	1975/04	1970/01	1970/01	1970/01	1970/01	1970/01	1989/21	1986/21	2000/31		
Days with Maximum Temperature														
<= 0 °C	20.7	15.7	9.2	0.64	0	0	0	0	0	0	3.2	14	63.5	C
> 0 °C	10.3	12.5	21.8	29.4	31	30	31	31	30	31	26.8	17	301.7	C
> 10 °C	0.45	0.5	4.9	17.3	29.3	29.9	31	31	29.6	22.5	7.4	1.6	205.4	C
> 20 °C	0	0	0.29	2.9	11.6	23.5	29.7	28.1	15.9	3.6	0.15	0	115.7	C
> 30 °C	0	0	0	0	0.32	2.1	3.6	1.9	0.45	0	0	0	8.4	C
> 35 °C	0	0	0	0	0	0.05	0.23	0.05	0	0	0	0	0.33	C
Days with Minimum Temperature														
> 0 °C	1.5	1.9	4	15.5	28.9	30	31	31	29.2	21.7	10.4	2.5	207.6	C
<= 2 °C	30.5	27.9	29.2	19.6	6.1	0.23	0	0.09	2.6	14.6	24.2	29.8	184.7	C
<= 0 °C	29.5	26.4	27	14.5	2.1	0	0	0	0.77	9.3	19.7	28.5	157.6	C
< -2 °C	27.2	23.6	21.9	8.3	0.18	0	0	0	0.18	3.8	13.1	23.1	121.3	C
< -10 °C	15.1	13.4	6.7	0.18	0	0	0	0	0	0	0.85	9.1	45.4	C
< -20 °C	2.9	2	0.41	0	0	0	0	0	0	0	0	0.67	6	C
< - 30 °C	0.05	0	0	0	0	0	0	0	0	0	0	0	0.05	C
Days with Rainfall														
>= 0.2 mm	5.6	5	6.9	11.5	12.4	12	10.6	10.7	12.2	13.7	11.6	6.9	118.7	C
>= 5 mm	1.8	1.8	2.5	4.1	5.1	5.2	5.1	4.4	5	4.4	4.7	2.8	46.9	C
>= 10 mm	0.95	1	1.4	2.1	2.9	3.1	3.4	2.8	2.8	2.4	2.4	1.2	26.4	C
>= 25 mm	0.09	0.14	0.09	0.32	0.45	0.36	0.95	0.77	0.68	0.14	0.48	0.14	4.6	C
Days With Snowfall														
>= 0.2 cm	16.1	11.9	9	3.3	0.18	0	0	0	0	0.91	6.5	14.4	62.2	C
>= 5 cm	2.5	1.8	1.9	0.36	0.05	0	0	0	0	0.05	0.67	2.3	9.6	C
>= 10 cm	0.64	0.5	0.64	0.09	0	0	0	0	0	0	0.05	0.57	2.5	C
>= 25 cm	0	0	0	0	0	0	0	0	0	0	0	0	0	C
Days with Precipitation														
>= 0.2 mm	18.2	14.2	13.8	13.7	12.4	12	10.6	10.7	12.2	13.9	16.4	18.1	166	C
>= 5 mm	4.3	3.2	4	4.5	5.2	5.2	5.1	4.4	5	4.5	5.3	4.5	55.1	C
>= 10 mm	1.5	1.6	1.8	2.3	2.9	3.1	3.4	2.8	2.8	2.4	2.5	2.1	29.2	C
>= 25 mm	0.09	0.18	0.27	0.32	0.45	0.36	0.95	0.77	0.68	0.14	0.48	0.38	5.1	C
Days with Snow Depth														
>= 1 cm	26.9	24.3	17.2	1.7	0	0	0	0	0	0.18	5.6	19.4	95.3	C
>= 5 cm	20.6	17.5	9.7	0.41	0	0	0	0	0	0	1.1	10.5	59.8	C
>= 10 cm	13.7	11.2	6.5	0.05	0	0	0	0	0	0	0.33	4.5	36.2	C
>= 20 cm	6.8	5.1	1.5	0	0	0	0	0	0	0	0	1.4	14.7	C

TABLE 7
1981 TO 2010 CANADIAN CLIMATE NORMALS (WATERLOO WELLINGTON A)
HYDROGEOLOGICAL ASSESSMENT
220 ARKELL ROAD, GUELPH, ONTARIO

Climate Normals 1981-2010 Station Data
Metadata including Station Name, Province, Latitude, Longitude, Elevation, Climate ID, WMO ID, TC ID

STATION_NAME	PROVINCE	LATITUDE	LONGITUDE	ELEVATION	CLIMATE_ID	WMO_ID	TC_ID
WATERLOO WELLINGTON A	ON	43°27'00.000" N	80°23'00.000" W	317.0 m	6149387		

Legend
A = WMO "3 and 5 rule" (i.e. no more than 3 consecutive and no more than 5 total missing for either temperature or precipitation)
B = At least 25 years
C = At least 20 years
D = At least 15 years

1981 to 2010 Canadian Climate Normals Station Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
Wind														
Speed (km/h)	15.2	14.3	14.9	14.6	12.3	10.4	9.6	8.5	9.8	11.7	14.5	14.8	12.6	C
Most Frequent Direction	W	W	W	NW	NW	NW	NW	NW	NW	W	W	SW	W	C
Maximum Hourly Speed (km/h)	70	67	74	72	71	52	52	45	53	63	66	61	74	
Date (yyyy/dd)	1982/04	2002/01	2002/09	1984/30	1976/05	1998/02	2001/01	1966/09	1967/26	2001/26	1975/10	1972/13	2002/09	
Direction of Maximum Hourly Speed	SW	W	W	S	SW	W	NW	W	S	SW	SW	SW	W	
Maximum Gust Speed (km/h)	113	113	120	98	106	89	111	98	89	96	100	96	120	
Date (yyyy/dd)	1978/26	2002/01	1981/30	1984/30	1976/05	1998/02	1997/14	1990/27	1997/29	2001/25	1998/11	1982/28	1981/30	
Direction of Maximum Gust	S	W	SW	SW	SW	W	W	N	W	SW	SW	SW	SW	
Days with Winds >= 52 km/h														
Days with Winds >= 63 km/h														
Degree Days														
Above 24 °C	0	0	0	0	0.1	1.6	5.2	2.5	0.3	0	0	0	9.8	C
Above 18 °C	0	0	0	1	10.2	40.9	77.2	54.7	16.6	0.7	0	0	201.4	C
Above 15 °C	0	0	0.1	3.7	30.2	94.1	157.3	125	46.3	4.5	0	0	461.2	C
Above 10 °C	0	0	2.3	20.3	103.6	227.6	310.8	275.6	145.8	33	3.8	0.6	1123.2	C
Above 5 °C	1.2	0.9	13.4	75.1	234.7	376.8	465.8	430.5	286.4	115.6	28.1	5	2033.3	C
Above 0 °C	11	13.9	55.4	190.6	388.6	526.8	620.8	585.5	436.2	255.6	100.1	26.1	3210.6	C
Below 0 °C	211.7	168	89.7	6.1	0	0	0	0	0	0.2	23.6	129.4	628.8	C
Below 5 °C	356.8	296.1	202.7	40.7	1.1	0	0	0	0.1	15.2	101.7	263.3	1277.6	C
Below 10 °C	510.7	436.4	346.7	135.8	25	0.8	0	0.2	9.6	87.5	227.3	413.8	2193.7	C
Below 15 °C	665.7	577.5	499.4	269.3	106.6	17.2	1.5	4.6	60.1	214.1	373.6	568.3	3357.8	C
Below 18 °C	758.7	662.2	592.4	356.6	179.7	54	14.4	27.2	120.4	303.3	463.6	661.3	4193.6	C
Humidex														
Extreme Humidex	13.4	13	28	33.7	39.6	43.2	47.7	48.3	41.2	34.5	24.4	22.1		
Date (yyyy/dd)	1995/14	1997/21	1998/30	2002/16	1987/30	1988/25	1995/14	1988/02	1983/10	1971/02	1987/03	1982/03		
Wind Chill														
Extreme Wind Chill	-40.5	-37.1	-30.2	-20.6	-8.1	0	0	0	-4.1	-11.9	-22.2	-31.2		
Date (yyyy/dd)	1982/17	1979/17	1989/07	1982/04	1978/01	1966/13	1966/01	1966/01	1989/27	1969/23	1976/29	1983/26		
Humidity														
Average Relative Humidity - 0600LST (%)	86.4	83.4	84.8	84.4	84.7	87	90.1	93.6	94.3	90.6	87.6	87.1	87.8	D
Average Relative Humidity - 1500LST (%)	78.2	75.4							66.5	69.7		81.7		

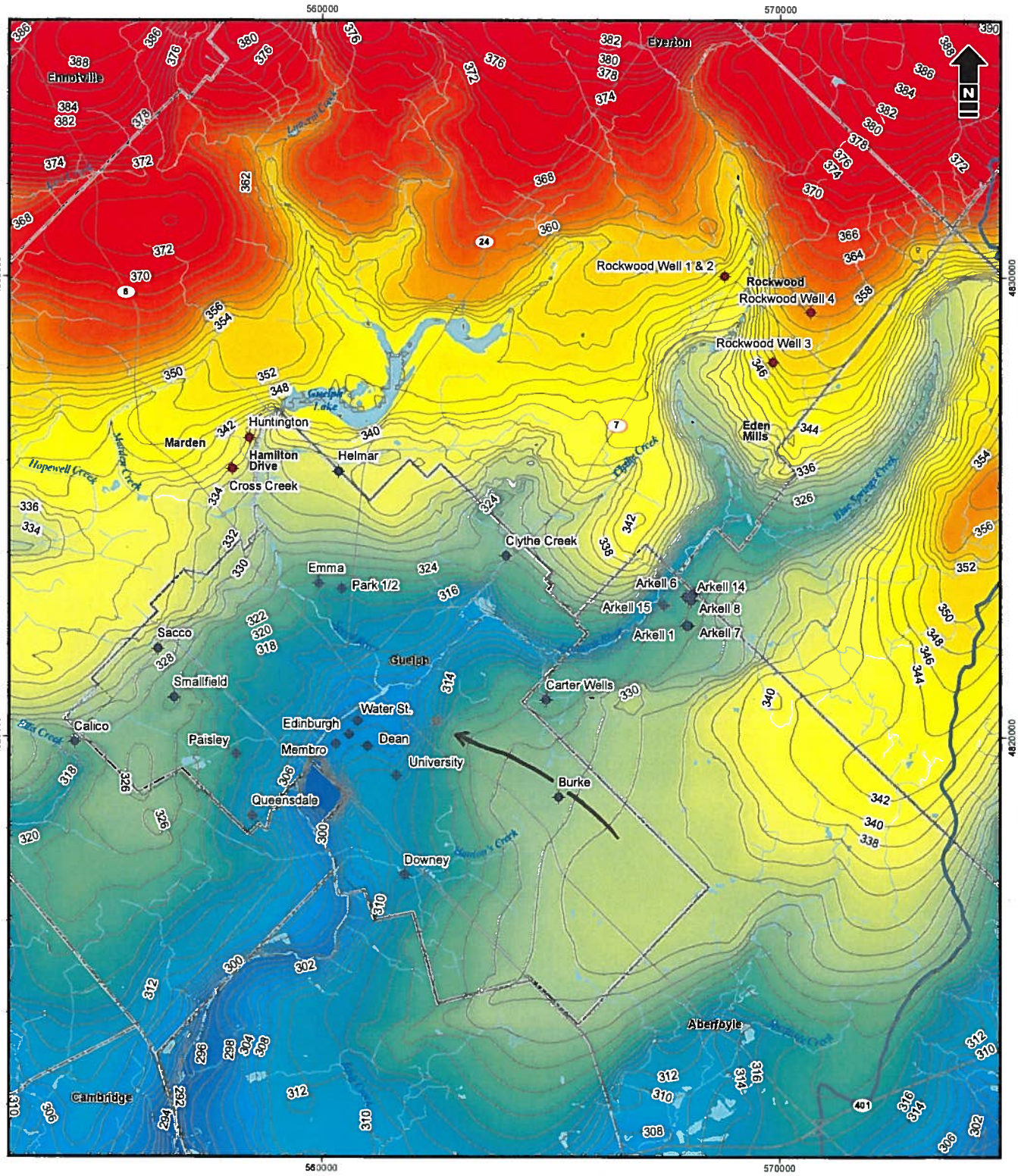
1981 to 2010 Canadian Climate Normals station data (Frost-Free)

	Frost-Free:	Code
Average Date of Last Spring Frost	7-May	D
Average Date of First Fall Frost	2-Oct	D
Average Length of Frost-Free Period	147 Days	D

Probability of last temperature in spring of 0 °C or lower on or after indicated dates	10%	25%	33%	50%	66%	75%	90%
Date	18-May	15-May	13-May	8-May	4-May	30-Apr	28-Apr
Probability of first temperature in fall of 0 °C or lower on or after indicated dates	10%	25%	33%	50%	66%	75%	90%
Date	19-Sep	24-Sep	25-Sep	30-Sep	3-Oct	8-Oct	16-Oct
Probability of frost-free period equal to or less than indicated period (Days)	10%	25%	33%	50%	66%	75%	90%
Days	128	135	136	144	152	157	169

Source: Environment Canada, 2018. Canadian Climate Normals 1981-2010. Online [http://climate.weather.gc.ca/climate_normals/index_e.html] Last Accessed February 2018

APPENDIX C:
REGIONAL GROUNDWATER FLOW MAPPING



Reference: Base Data - City of Guelph, 2009; GRCA, 2008; CVC, 2008; Ministry of Natural Resources, 2008. Produced using information provided by the Grand River Conservation Authority. Copyright © Grand River Conservation Authority, 2013. Produced using information provided by the Ministry of Natural Resource. Copyright © Ministry of Natural

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

City of Guelph and Township of Guelph/Eramosa
Tier 3 Water Budget and Local Area Risk Assessment

Model Predicted Water Table Elevation (Area of Interest)

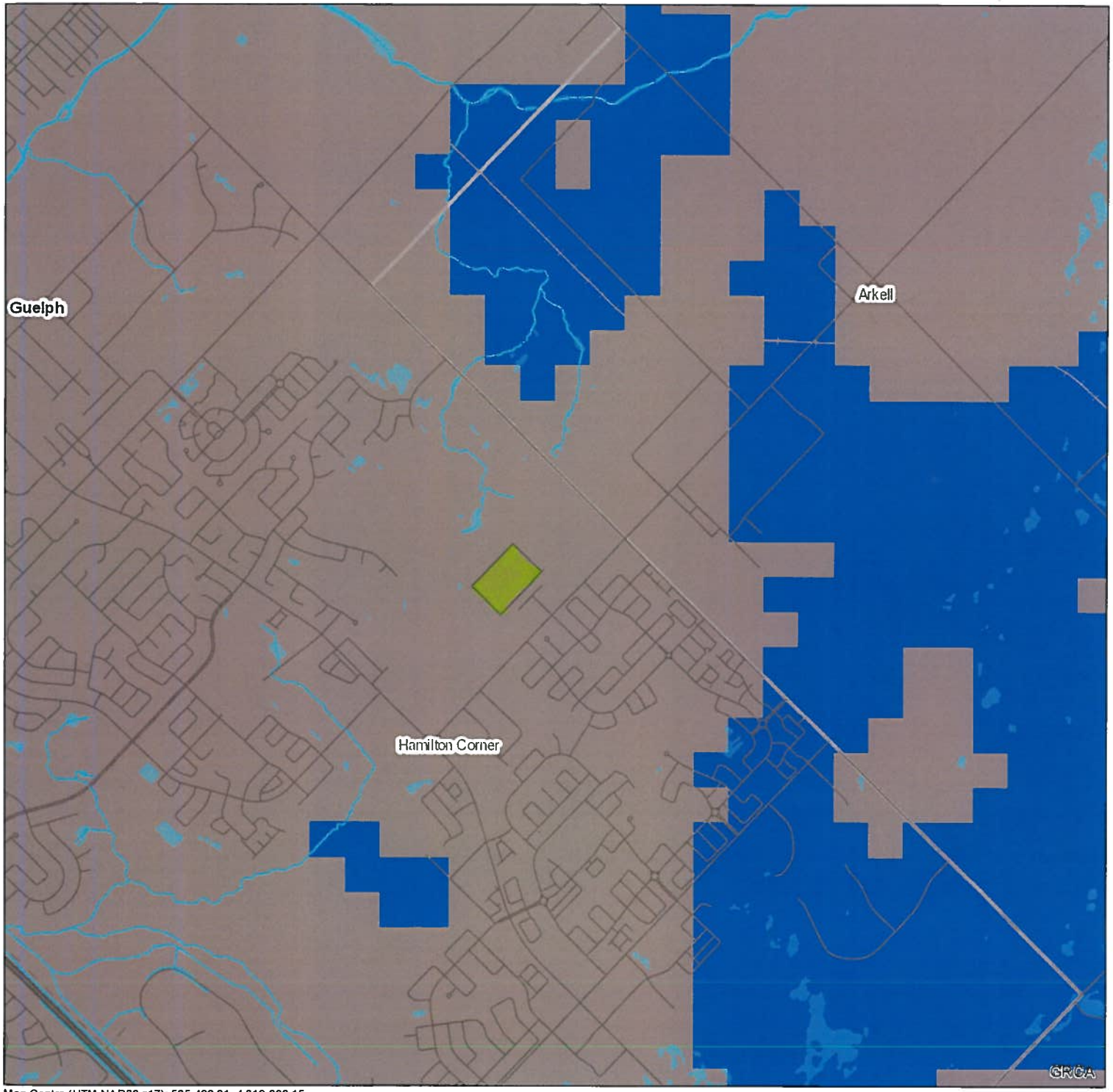
Date	Project	Technical	Reviewer	Drawn
23 Mar 2017	15072-527	P. Chin	D. VanVliet	M. Urtheil

Disclaimer: Prepared solely for the use of City of Guelph as specified in the accompanying report. No representation of any kind is made to other parties with which City of Guelph has not entered into contract.

Figure 4-3

I:\CityofGuelph\15072\Figures\Tables\QH\2013\Report\RiskAssessment\Figure_4-3_Model_Predicted_Water_Table_Elevation_CityofGuelph.mxd

APPENDIX D:
VERTICAL HYDRAULIC GRADIENT MAPPING



Grand River Conservation Authority

Date: Mar 23, 2017

Legend

- Municipal Boundary (GRCA)
- Watercourse - Local (GRCA)
- Park - Local (GRCA)
- Waterbody - Local (GRCA)
- Great Lakes - Local (GRCA)
- Upward
- Downward

0 190 380 760 1,140 Metres

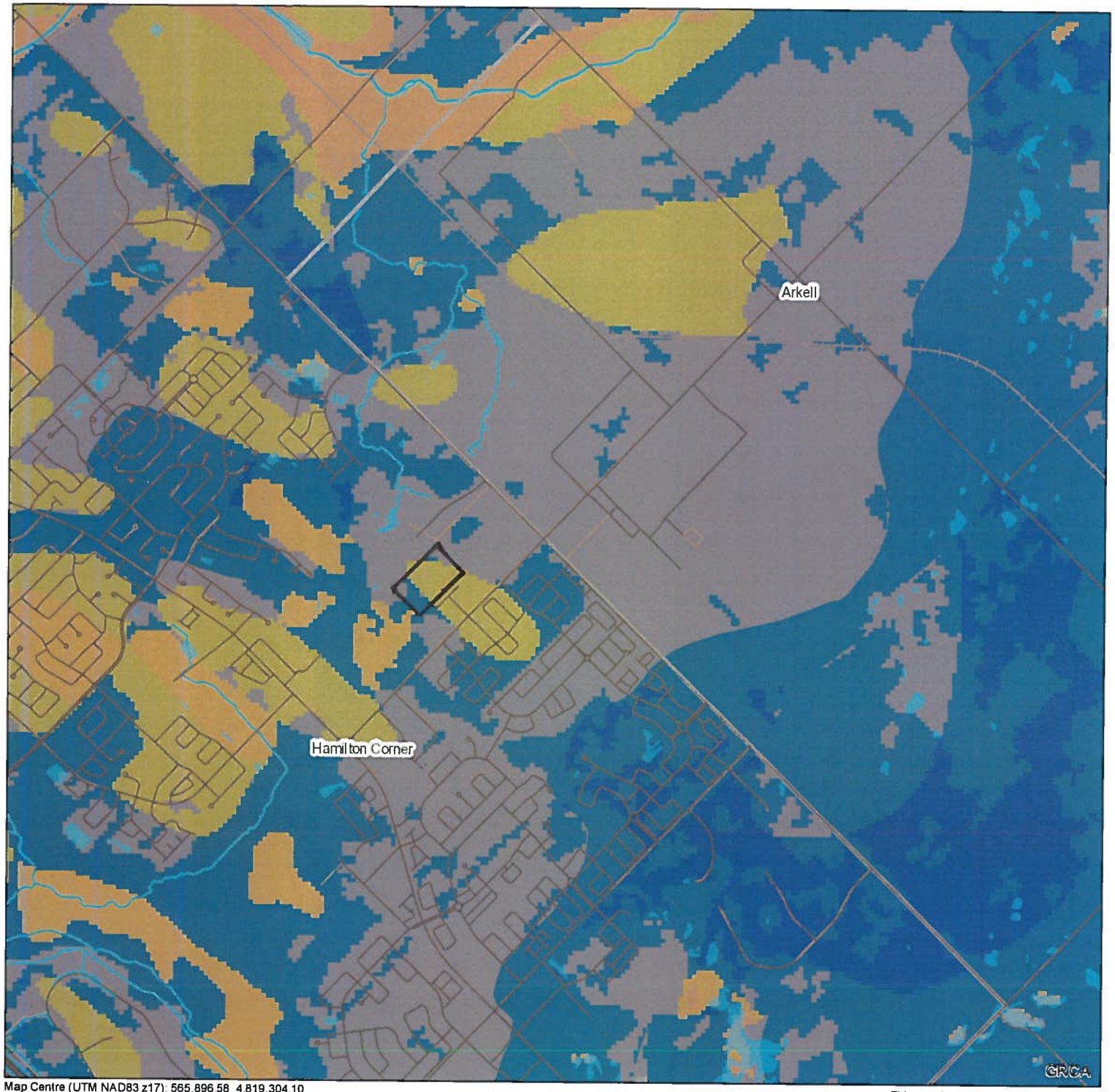
N

Map Centre (UTM NAD83 z17): 565,422.01 4,819,298.15

This map is not to be used for navigation

NAD 1983 UTM Zone 17N

Scale: 31,728



Map Centre (UTM NAD83 z17): 565,896.58 4,819,304.10

This map is not to be used for navigation

Grand River Conservation Authority

Date: Nov 21, 2018

Legend

- Municipal Boundary (GRCA)
- Watercourse - Local (GRCA)
- Park - Local (GRCA)
- Waterbody - Local (GRCA)

Average Annual Recharge (GRCA)

- less than 50 mm/yr
- 50 - 100
- 100 - 200
- 200 - 300
- 300 - 400
- > 400
- Great Lakes - Local (GRCA)

The source for each data layer is shown in parentheses in the map legend. For a complete listing of sources and citations go to: https://maps.grandriver.ca/Sources-and-Citations.pdf

0 187.5 375 750 1,125 Metres

N

NAD 1983 UTM Zone 17N

Scale: 31,000

APPENDIX E:
BOREHOLE LOGS

Stantec

BOREHOLE RECORD

N: 4 819 008 E: 564 970

BH01-17

CLIENT Carson Reid Homes Ltd. PROJECT No. 161413338

LOCATION 220 Arkell Road, Guelph, ON DATUM Geodetic

DATES: BORING April 5, 2017 WATER LEVEL TPC ELEVATION 334.36

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION
0	333.5	**Grass Field**
	333.2	300 mm TOPSOIL
1, 2		Loose to compact, brown, SAND (SM) - trace gravel and silt - wet
3		- grey, some silt
4	329.4	Very dense, grey, Silty Sand with Gravel (SM) TILL - wet
5	328.3	END OF BOREHOLE at approximately 5.2 m below existing grade. Water level measured at 2.1 m below grade on completion of drilling. Monitoring well installed with 50 mm screen from approximately 1.5 m to 4.6 m below grade.
6, 7, 8, 9, 10, 11, 12		

STRATA PLOT

WATER LEVEL

SAMPLES

DEPTH (ft)	TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
1	SS	1	280/610	6
4	SS	2	250/610	9
6	SS	3	100/610	17
9	SS	4	230/610	21
11	SS	5	460/610	5
16	SS	6	380/610	54

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

Stantec

BOREHOLE RECORD

N: 4 819 204 E: 565 193

BH02-17

CLIENT Carson Reid Homes Ltd. PROJECT No. 161413338

LOCATION 220 Arkell Road, Guelph, ON DATUM Geodetic

DATES: BORING April 5, 2017 WATER LEVEL TPC ELEVATION 338.12

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION
0	337.2	**Grass Field**
	336.9	280 mm TOPSOIL
1		Compact, brown, SAND (SM) - trace gravel and silt - moist
	335.8	
2		Loose, brown, Silty Sand (SM) TILL - wet
		- very dense, moist
3		- grey
4		- auger grinding
5		- auger grinding
6		- moist to wet
7	330.0	
		Hard, grey, Silty Clay (CL) TILL - trace gravel
8	329.3	- moist
		END OF BOREHOLE at approximately 7.9 m below existing grade. Water level measured at 2.3 below grade on completion of drilling. Monitoring well installed with 50 mm screen from approximately 1.5 m to 4.6 m below grade.
9		
10		
11		
12		

STRATA PLOT

WATER LEVEL

DEPTH (ft): 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39

SAMPLES

TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
SS	1	200/610	5
SS	2	51/610	11
SS	3	100/610	7
SS	4	250/250	50/100
SS	5	230/230	50/76
SS	6	250/280	50/130
SS	7	76/76	50/76
SS	8	280/280	50/130

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
6	38	42	14

□ Field Vane Test, kPa

■ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

N: 4 818 983 E: 565 155

BH03-17

CLIENT Carson Reid Homes Ltd.

LOCATION 220 Arkell Road, Guelph, ON

DATES: BORING April 5, 2017

WATER LEVEL

PROJECT No. 161413338

DATUM Geodetic

TPC ELEVATION 335.26

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION	STRATA PLOT	WATER LEVEL	DEPTH (ft)	SAMPLES TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)	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 ●	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0	334.3	**Grass Field**			0						
	334.0	FILL: 300 mm TOPSOIL			1	SS	1	460/610	8	●	
1	332.9	FILL: brown silty sand, some clay, trace gravel - moist			3	SS	2	200/610	8	●	
2	331.9	FILL: brown sandy silty clay, trace gravel - moist			6	SS	3	250/610	6	●	
3		Compact, brown, Silty Sand with Gravel (SM) TILL - moist to saturated		▽	8	SS	4	25/610	25	●	
					11	SS	5	300/610	26	●	23 28 41 8
5	329.1				16	SS	6	430/610	28	●	
6		END OF BOREHOLE at approximately 5.2 m below existing grade.									
7		Water level measured at 2.4 m below grade on completion of drilling.									
8		Monitoring well installed with 50 mm screen from approximately 1.5 m to 4.6 m below grade.									
9											
10											
11											
12											

□ Field Vane Test, kPa

■ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

Stantec

BOREHOLE RECORD

N: 4 819 111 E: 565 287

BH04-17

CLIENT Carson Reid Homes Ltd.

LOCATION 220 Arkell Road, Guelph, ON

DATES: BORING April 5, 2017

WATER LEVEL

PROJECT No. 161413338

DATUM Geodetic

TPC ELEVATION 340.86

DEPTH (m)	ELEVATION (m)	STRATA DESCRIPTION
0	340.0	**Grass Field**
	339.7	280 mm TOPSOIL
	339.3	Loose, brown, SAND (SM) - some gravel, trace silt - wet
1		Compact to very dense, brown, Silty Sand with Gravel (SM) TILL - moist
2		
3		
4		
5		
6		- wet
7		
8	331.8	
		END OF BOREHOLE at approximately 8.2 m below existing grade. Water level measured at 6.4 m below grade on completion of drilling. Monitoring well installed with 50 mm screen from approximately 4.6 m to 7.6 m below grade.
9		
10		
11		
12		

STRATA PLOT

WATER LEVEL

DEPTH (ft): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39

SAMPLES

TYPE	NUMBER	RECOVERY (mm) TCR(%) / SCR(%)	N-VALUE OR RQD(%)
SS	1	230/610	8
SS	2	460/610	11
SS	3	430/610	26
SS	4	460/610	67
SS	5	460/610	87
SS	6	250/250	50/100
SS	7	130/130	50/130
SS	8	460/610	84

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
18	36	37	9
27	32	32	9

□ Field Vane Test, kPa

■ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

APPENDIX F:
LABORATORY CERTIFICATES OF ANALYSIS

Maxxam
A Bureau Veritas Group Company

Your Project #: 161413338
Your C.O.C. #: 606049-01-01

Attention:Grant Whitehead

Stantec Consulting Ltd
300 Hagey Blvd
Suite 100
Waterloo, ON
N2L 0A4

Report Date: 2017/04/24
Report #: R4436105
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B774848
Received: 2017/04/13, 16:00

Sample Matrix: Water
Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Alkalinity	4	N/A	2017/04/21	CAM SOP-00448	SM 22 2320 B m
Carbonate, Bicarbonate and Hydroxide	4	N/A	2017/04/21	CAM SOP-00102	APHA 4500-CO2 D
Chloride by Automated Colourimetry	4	N/A	2017/04/19	CAM SOP-00463	EPA 325.2 m
Conductivity	4	N/A	2017/04/21	CAM SOP-00414	SM 22 2510 m
Dissolved Organic Carbon (DOC) (1)	4	N/A	2017/04/18	CAM SOP-00446	SM 22 5310 B m
Hardness (calculated as CaCO3)	4	N/A	2017/04/19	CAM SOP 00102/00408/00447	SM 2340 B
Dissolved Metals by ICPMS	4	N/A	2017/04/19	CAM SOP-00447	EPA 6020B m
Ion Balance (% Difference)	4	N/A	2017/04/21		
Anion and Cation Sum	4	N/A	2017/04/21		
Total Ammonia-N	4	N/A	2017/04/20	CAM SOP-00441	EPA GS I-2522-90 m
Nitrate (NO3) and Nitrite (NO2) in Water (2)	4	N/A	2017/04/19	CAM SOP-00440	SM 22 4500-NO3I/NO2B
pH	4	N/A	2017/04/21	CAM SOP-00413	SM 4500H+ B m
Orthophosphate	4	N/A	2017/04/19	CAM SOP-00461	EPA 365.1 m
Sat. pH and Langelier Index (@ 20C)	4	N/A	2017/04/21		
Sat. pH and Langelier Index (@ 4C)	4	N/A	2017/04/21		
Sulphate by Automated Colourimetry	4	N/A	2017/04/19	CAM SOP-00464	EPA 375.4 m
Total Dissolved Solids (TDS calc)	4	N/A	2017/04/21		

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported: unless indicated otherwise, associated sample data are not blank corrected.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing.

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel (905) 817-5700 Toll Free 800 563 6266 Fax (905) 817-5777 www.maxxam.ca

Maxxam
A Bureau Veritas Group Company

Your Project #: 161413338
Your C.O.C. #: 606049-01-01

Attention:Grant Whitehead

Stantec Consulting Ltd
300 Hagey Blvd
Suite 100
Waterloo, ON
N2L 0A4

Report Date: 2017/04/24
Report #: R4436105
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B774848
Received: 2017/04/13, 16:00

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) Dissolved Organic Carbon (DOC) present in the sample should be considered as non-purgeable DOC.
(2) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

Encryption Key

Augustyna Dobosz
Project Manager
24 Apr 2017 14:46:56

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Augustyna Dobosz, Project Manager
Email: ADobosz@maxxam.ca
Phone# (905)817-5700 Ext:5798
==========
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel (905) 817-5700 Toll Free 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B774848
Report Date: 2017/04/24

Stantec Consulting Ltd
Client Project #: 161413338
Sampler Initials: AW

RCAP - COMPREHENSIVE (WATER)

Maxxam ID		EFF792	EFF793	EFF794		
Sampling Date		2017/04/12 13:43	2017/04/12 16:17	2017/04/12 17:14		
COC Number		606049-01-01	606049-01-01	606049-01-01		
	UNITS	WG-161413338-20170412-AH01	WG-161413338-20170412-AH02	WG-161413338-20170412-AH03	RDL	QC Batch
Calculated Parameters						
Anion Sum	me/L	8.51	7.25	5.66	N/A	4941389
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	370	350	270	1.0	4941386
Calculated TDS	mg/L	430	360	280	1.0	4941392
Carb. Alkalinity (calc. as CaCO3)	mg/L	2.9	3.2	2.7	1.0	4941386
Cation Sum	me/L	8.70	7.68	5.84	N/A	4941389
Hardness (CaCO3)	mg/L	410	380	290	1.0	4941387
Ion Balance (% Difference)	%	1.08	2.89	1.58	N/A	4941388
Langelier Index (@ 20C)	N/A	1.03	1.05	0.892		4941390
Langelier Index (@ 4C)	N/A	0.784	0.798	0.642		4941391
Saturation pH (@ 20C)	N/A	6.88	6.94	7.13		4941390
Saturation pH (@ 4C)	N/A	7.13	7.19	7.38		4941391
Inorganics						
Total Ammonia-N	mg/L	<0.050	<0.050	<0.050	0.050	4945156
Conductivity	umho/cm	740	640	520	1.0	4945858
Dissolved Organic Carbon	mg/L	1.8	1.4	1.2	0.20	4941671
Orthophosphate (P)	mg/L	<0.010	<0.010	<0.010	0.010	4944394
pH	pH	7.91	7.99	8.02		4945861
Dissolved Sulphate (SO4)	mg/L	17	2.7	5.4	1.0	4944392
Alkalinity (Total as CaCO3)	mg/L	370	350	270	1.0	4945849
Dissolved Chloride (Cl)	mg/L	22	4.0	5.3	1.0	4944387
Nitrite (N)	mg/L	<0.010	<0.010	<0.010	0.010	4943872
Nitrate (N)	mg/L	0.98	0.26	<0.10	0.10	4943872
Nitrate + Nitrite (N)	mg/L	0.98	0.26	<0.10	0.10	4943872
Metals						
Dissolved Aluminum (Al)	mg/L	<0.0050	0.045	0.014	0.0050	4942980
Dissolved Antimony (Sb)	mg/L	<0.00050	<0.00050	<0.00050	0.00050	4942980
Dissolved Arsenic (As)	mg/L	<0.0010	<0.0010	<0.0010	0.0010	4942980
Dissolved Barium (Ba)	mg/L	0.042	0.025	0.022	0.0020	4942980
Dissolved Beryllium (Be)	mg/L	<0.00050	<0.00050	<0.00050	0.00050	4942980
Dissolved Boron (B)	mg/L	0.019	0.015	0.010	0.010	4942980
Dissolved Cadmium (Cd)	mg/L	<0.00010	<0.00010	<0.00010	0.00010	4942980
Dissolved Calcium (Ca)	mg/L	100	88	71	0.20	4942980
Dissolved Chromium (Cr)	mg/L	<0.0050	<0.0050	<0.0050	0.0050	4942980
Dissolved Cobalt (Co)	mg/L	<0.00050	<0.00050	<0.00050	0.00050	4942980

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable

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Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B774848
Report Date: 2017/04/24

Stantec Consulting Ltd
Client Project #: 161413338
Sampler Initials: AW

RCAP - COMPREHENSIVE (WATER)

Maxxam ID		EFF792	EFF793	EFF794		
Sampling Date		2017/04/12 13:43	2017/04/12 16:17	2017/04/12 17:14		
COC Number		606049-01-01	606049-01-01	606049-01-01		
	UNITS	WG-161413338-20170412-AH01	WG-161413338-20170412-AH02	WG-161413338-20170412-AH03	RDL	QC Batch
Dissolved Copper (Cu)	mg/L	0.0013	0.0012	0.0012	0.0010	4942980
Dissolved Iron (Fe)	mg/L	<0.10	<0.10	<0.10	0.10	4942980
Dissolved Lead (Pb)	mg/L	<0.00050	<0.00050	<0.00050	0.00050	4942980
Dissolved Magnesium (Mg)	mg/L	38	38	26	0.050	4942980
Dissolved Manganese (Mn)	mg/L	0.014	0.030	0.017	0.0020	4942980
Dissolved Molybdenum (Mo)	mg/L	<0.00050	<0.00050	<0.00050	0.00050	4942980
Dissolved Nickel (Ni)	mg/L	<0.0010	<0.0010	<0.0010	0.0010	4942980
Dissolved Phosphorus (P)	mg/L	<0.10	<0.10	<0.10	0.10	4942980
Dissolved Potassium (K)	mg/L	1.1	1.1	0.80	0.20	4942980
Dissolved Selenium (Se)	mg/L	<0.0020	<0.0020	<0.0020	0.0020	4942980
Dissolved Silicon (Si)	mg/L	6.4	5.8	4.6	0.050	4942980
Dissolved Silver (Ag)	mg/L	<0.00010	<0.00010	<0.00010	0.00010	4942980
Dissolved Sodium (Na)	mg/L	12	2.6	2.6	0.10	4942980
Dissolved Strontium (Sr)	mg/L	0.13	0.10	0.097	0.0010	4942980
Dissolved Thallium (Tl)	mg/L	<0.000050	<0.000050	<0.000050	0.000050	4942980
Dissolved Titanium (Ti)	mg/L	<0.0050	<0.0050	<0.0050	0.0050	4942980
Dissolved Uranium (U)	mg/L	0.00048	0.00038	0.00062	0.00010	4942980
Dissolved Vanadium (V)	mg/L	<0.00050	<0.00050	<0.00050	0.00050	4942980
Dissolved Zinc (Zn)	mg/L	0.016	0.0056	<0.0050	0.0050	4942980

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Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B774848
Report Date: 2017/04/24

Stantec Consulting Ltd
Client Project #: 161413338
Sampler Initials: AW

RCAP - COMPREHENSIVE (WATER)

Maxxam ID		EFF795		
Sampling Date		2017/04/13 10:55		
COC Number		606049-01-01		
	UNITS	WG-161413338-20170413-AH04	RDL	QC Batch
Calculated Parameters				
Anion Sum	me/L	6.88	N/A	4941389
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	310	1.0	4941386
Calculated TDS	mg/L	340	1.0	4941392
Carb. Alkalinity (calc. as CaCO3)	mg/L	2.9	1.0	4941386
Cation Sum	me/L	6.91	N/A	4941389
Hardness (CaCO3)	mg/L	340	1.0	4941387
Ion Balance (% Difference)	%	0.170	N/A	4941388
Langelier Index (@ 20C)	N/A	0.972		4941390
Langelier Index (@ 4C)	N/A	0.723		4941391
Saturation pH (@ 20C)	N/A	7.03		4941390
Saturation pH (@ 4C)	N/A	7.27		4941391
Inorganics				
Total Ammonia-N	mg/L	<0.050	0.050	4945156
Conductivity	umho/cm	610	1.0	4945858
Dissolved Organic Carbon	mg/L	1.3	0.20	4941671
Orthophosphate (P)	mg/L	<0.010	0.010	4944394
pH	pH	8.00		4945861
Dissolved Sulphate (SO4)	mg/L	15	1.0	4944392
Alkalinity (Total as CaCO3)	mg/L	320	1.0	4945849
Dissolved Chloride (Cl)	mg/L	6.8	1.0	4944387
Nitrite (N)	mg/L	<0.010	0.010	4943872
Nitrate (N)	mg/L	0.73	0.10	4943872
Nitrate + Nitrite (N)	mg/L	0.73	0.10	4943872
Metals				
Dissolved Aluminum (Al)	mg/L	<0.0050	0.0050	4942980
Dissolved Antimony (Sb)	mg/L	<0.00050	0.00050	4942980
Dissolved Arsenic (As)	mg/L	<0.0010	0.0010	4942980
Dissolved Barium (Ba)	mg/L	0.044	0.0020	4942980
Dissolved Beryllium (Be)	mg/L	<0.00050	0.00050	4942980
Dissolved Boron (B)	mg/L	0.021	0.010	4942980
Dissolved Cadmium (Cd)	mg/L	<0.00010	0.00010	4942980
Dissolved Calcium (Ca)	mg/L	80	0.20	4942980
Dissolved Chromium (Cr)	mg/L	<0.0050	0.0050	4942980
Dissolved Cobalt (Co)	mg/L	<0.00050	0.00050	4942980

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QC Batch = Quality Control Batch
N/A = Not Applicable

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Maxxam
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Maxxam Job #: B774848
Report Date: 2017/04/24

Stantec Consulting Ltd
Client Project #: 161413338
Sampler Initials: AW

RCAP - COMPREHENSIVE (WATER)

Maxxam ID		EFF795		
Sampling Date		2017/04/13 10:55		
COC Number		606049-01-01		
	UNITS	WG-161413338-20170413-AH04	RDL	QC Batch
Dissolved Copper (Cu)	mg/L	0.0013	0.0010	4942980
Dissolved Iron (Fe)	mg/L	<0.10	0.10	4942980
Dissolved Lead (Pb)	mg/L	<0.00050	0.00050	4942980
Dissolved Magnesium (Mg)	mg/L	33	0.050	4942980
Dissolved Manganese (Mn)	mg/L	0.0054	0.0020	4942980
Dissolved Molybdenum (Mo)	mg/L	0.00068	0.00050	4942980
Dissolved Nickel (Ni)	mg/L	<0.0010	0.0010	4942980
Dissolved Phosphorus (P)	mg/L	<0.10	0.10	4942980
Dissolved Potassium (K)	mg/L	0.90	0.20	4942980
Dissolved Selenium (Se)	mg/L	<0.0020	0.0020	4942980
Dissolved Silicon (Si)	mg/L	4.7	0.050	4942980
Dissolved Silver (Ag)	mg/L	<0.00010	0.00010	4942980
Dissolved Sodium (Na)	mg/L	4.3	0.10	4942980
Dissolved Strontium (Sr)	mg/L	0.15	0.0010	4942980
Dissolved Thallium (Tl)	mg/L	<0.000050	0.000050	4942980
Dissolved Titanium (Ti)	mg/L	<0.0050	0.0050	4942980
Dissolved Uranium (U)	mg/L	0.00069	0.00010	4942980
Dissolved Vanadium (V)	mg/L	<0.00050	0.00050	4942980
Dissolved Zinc (Zn)	mg/L	0.012	0.0050	4942980

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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Maxxam Job #: B774848
Report Date: 2017/04/24

Stantec Consulting Ltd
Client Project #: 161413338
Sampler Initials: AW

TEST SUMMARY

Maxxam ID: EFF792
Sample ID: WG-161413338-20170412-AH01
Matrix: Water

Collected: 2017/04/12
Shipped:
Received: 2017/04/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	4945849	N/A	2017/04/21	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	4941386	N/A	2017/04/21	Automated Statchk
Chloride by Automated Colourimetry	KONE	4944387	N/A	2017/04/19	Alina Dobreanu
Conductivity	AT	4945858	N/A	2017/04/21	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	4941671	N/A	2017/04/18	Anastasia Hamanov
Hardness (calculated as CaCO3)		4941387	N/A	2017/04/19	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	4942980	N/A	2017/04/19	Cristina Petran
Ion Balance (% Difference)	CALC	4941388	N/A	2017/04/21	Automated Statchk
Anion and Cation Sum	CALC	4941389	N/A	2017/04/21	Automated Statchk
Total Ammonia-N	LACH/NH4	4945156	N/A	2017/04/20	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	4943872	N/A	2017/04/19	Chandra Nandlal
pH	AT	4945861	N/A	2017/04/21	Surinder Rai
Orthophosphate	KONE	4944394	N/A	2017/04/19	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	4941390	N/A	2017/04/21	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	4941391	N/A	2017/04/21	Automated Statchk
Sulphate by Automated Colourimetry	KONE	4944392	N/A	2017/04/19	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	4941392	N/A	2017/04/21	Automated Statchk

Maxxam ID: EFF793
Sample ID: WG-161413338-20170412-AH02
Matrix: Water

Collected: 2017/04/12
Shipped:
Received: 2017/04/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	4945849	N/A	2017/04/21	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	4941386	N/A	2017/04/21	Automated Statchk
Chloride by Automated Colourimetry	KONE	4944387	N/A	2017/04/19	Alina Dobreanu
Conductivity	AT	4945858	N/A	2017/04/21	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	4941671	N/A	2017/04/18	Anastasia Hamanov
Hardness (calculated as CaCO3)		4941387	N/A	2017/04/19	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	4942980	N/A	2017/04/19	Cristina Petran
Ion Balance (% Difference)	CALC	4941388	N/A	2017/04/21	Automated Statchk
Anion and Cation Sum	CALC	4941389	N/A	2017/04/21	Automated Statchk
Total Ammonia-N	LACH/NH4	4945156	N/A	2017/04/20	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	4943872	N/A	2017/04/19	Chandra Nandlal
pH	AT	4945861	N/A	2017/04/21	Surinder Rai
Orthophosphate	KONE	4944394	N/A	2017/04/19	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	4941390	N/A	2017/04/21	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	4941391	N/A	2017/04/21	Automated Statchk
Sulphate by Automated Colourimetry	KONE	4944392	N/A	2017/04/19	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	4941392	N/A	2017/04/21	Automated Statchk

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Maxxam Job #: B774848
Report Date: 2017/04/24

Stantec Consulting Ltd
Client Project #: 161413338
Sampler Initials: AW

TEST SUMMARY

Maxxam ID: EFF794
Sample ID: WG-161413338-20170412-AH03
Matrix: Water

Collected: 2017/04/12
Shipped:
Received: 2017/04/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	4945849	N/A	2017/04/21	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	4941386	N/A	2017/04/21	Automated Statchk
Chloride by Automated Colourimetry	KONE	4944387	N/A	2017/04/19	Alina Dobreanu
Conductivity	AT	4945858	N/A	2017/04/21	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	4941671	N/A	2017/04/18	Anastasia Hamanov
Hardness (calculated as CaCO3)		4941387	N/A	2017/04/19	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	4942980	N/A	2017/04/19	Cristina Petran
Ion Balance (% Difference)	CALC	4941388	N/A	2017/04/21	Automated Statchk
Anion and Cation Sum	CALC	4941389	N/A	2017/04/21	Automated Statchk
Total Ammonia-N	LACH/NH4	4945156	N/A	2017/04/20	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	4943872	N/A	2017/04/19	Chandra Nandlal
pH	AT	4945861	N/A	2017/04/21	Surinder Rai
Orthophosphate	KONE	4944394	N/A	2017/04/19	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	4941390	N/A	2017/04/21	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	4941391	N/A	2017/04/21	Automated Statchk
Sulphate by Automated Colourimetry	KONE	4944392	N/A	2017/04/19	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	4941392	N/A	2017/04/21	Automated Statchk

Maxxam ID: EFF795
Sample ID: WG-161413338-20170413-AH04
Matrix: Water

Collected: 2017/04/13
Shipped:
Received: 2017/04/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	4945849	N/A	2017/04/21	Surinder Rai
Carbonate, Bicarbonate and Hydroxide	CALC	4941386	N/A	2017/04/21	Automated Statchk
Chloride by Automated Colourimetry	KONE	4944387	N/A	2017/04/19	Alina Dobreanu
Conductivity	AT	4945858	N/A	2017/04/21	Surinder Rai
Dissolved Organic Carbon (DOC)	TOCV/NDIR	4941671	N/A	2017/04/18	Anastasia Hamanov
Hardness (calculated as CaCO3)		4941387	N/A	2017/04/19	Automated Statchk
Dissolved Metals by ICPMS	ICP/MS	4942980	N/A	2017/04/19	Cristina Petran
Ion Balance (% Difference)	CALC	4941388	N/A	2017/04/21	Automated Statchk
Anion and Cation Sum	CALC	4941389	N/A	2017/04/21	Automated Statchk
Total Ammonia-N	LACH/NH4	4945156	N/A	2017/04/20	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	4943872	N/A	2017/04/19	Chandra Nandlal
pH	AT	4945861	N/A	2017/04/21	Surinder Rai
Orthophosphate	KONE	4944394	N/A	2017/04/19	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	4941390	N/A	2017/04/21	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	4941391	N/A	2017/04/21	Automated Statchk
Sulphate by Automated Colourimetry	KONE	4944392	N/A	2017/04/19	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	4941392	N/A	2017/04/21	Automated Statchk

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Maxxam Job #: B774848
Report Date: 2017/04/24

Stantec Consulting Ltd
Client Project #: 161413338
Sampler Initials: AW

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	7.0°C

Results relate only to the items tested.

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Maxxam
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Maxxam Job #: B774848
Report Date: 2017/04/24

QUALITY ASSURANCE REPORT

Stantec Consulting Ltd
Client Project #: 161413338
Sampler Initials: AW

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
4941671	Dissolved Organic Carbon	2017/04/17	94	80 - 120	98	80 - 120	<0.20	mg/L	0.24	20
4942980	Dissolved Aluminum (Al)	2017/04/19	101	80 - 120	101	80 - 120	<0.0050	mg/L		
4942980	Dissolved Antimony (Sb)	2017/04/19	102	80 - 120	100	80 - 120	<0.00050	mg/L		
4942980	Dissolved Arsenic (As)	2017/04/19	101	80 - 120	98	80 - 120	<0.0010	mg/L		
4942980	Dissolved Barium (Ba)	2017/04/19	101	80 - 120	100	80 - 120	<0.0020	mg/L		
4942980	Dissolved Beryllium (Be)	2017/04/19	104	80 - 120	102	80 - 120	<0.00050	mg/L		
4942980	Dissolved Boron (B)	2017/04/19	104	80 - 120	103	80 - 120	<0.010	mg/L	1.5	20
4942980	Dissolved Cadmium (Cd)	2017/04/19	101	80 - 120	97	80 - 120	<0.00010	mg/L		
4942980	Dissolved Calcium (Ca)	2017/04/19	98	80 - 120	97	80 - 120	<0.20	mg/L	0.47	20
4942980	Dissolved Chromium (Cr)	2017/04/19	99	80 - 120	97	80 - 120	<0.0050	mg/L		
4942980	Dissolved Cobalt (Co)	2017/04/19	98	80 - 120	96	80 - 120	<0.00050	mg/L		
4942980	Dissolved Copper (Cu)	2017/04/19	102	80 - 120	99	80 - 120	<0.0010	mg/L		
4942980	Dissolved Iron (Fe)	2017/04/19	101	80 - 120	98	80 - 120	<0.10	mg/L	NC	20
4942980	Dissolved Lead (Pb)	2017/04/19	94	80 - 120	94	80 - 120	<0.00050	mg/L		
4942980	Dissolved Magnesium (Mg)	2017/04/19	99	80 - 120	99	80 - 120	<0.050	mg/L	1.2	20
4942980	Dissolved Manganese (Mn)	2017/04/19	NC	80 - 120	98	80 - 120	<0.0020	mg/L		
4942980	Dissolved Molybdenum (Mo)	2017/04/19	102	80 - 120	99	80 - 120	<0.00050	mg/L		
4942980	Dissolved Nickel (Ni)	2017/04/19	98	80 - 120	96	80 - 120	<0.0010	mg/L		
4942980	Dissolved Phosphorus (P)	2017/04/19	108	80 - 120	115	80 - 120	<0.10	mg/L		
4942980	Dissolved Potassium (K)	2017/04/19	102	80 - 120	101	80 - 120	<0.20	mg/L		
4942980	Dissolved Selenium (Se)	2017/04/19	100	80 - 120	98	80 - 120	<0.0020	mg/L		
4942980	Dissolved Silicon (Si)	2017/04/19	101	80 - 120	101	80 - 120	<0.050	mg/L		
4942980	Dissolved Silver (Ag)	2017/04/19	84	80 - 120	95	80 - 120	<0.00010	mg/L		
4942980	Dissolved Sodium (Na)	2017/04/19	100	80 - 120	99	80 - 120	<0.10	mg/L		
4942980	Dissolved Strontium (Sr)	2017/04/19	100	80 - 120	97	80 - 120	<0.0010	mg/L		
4942980	Dissolved Thallium (Tl)	2017/04/19	94	80 - 120	94	80 - 120	<0.000050	mg/L		
4942980	Dissolved Titanium (Ti)	2017/04/19	101	80 - 120	102	80 - 120	<0.0050	mg/L		
4942980	Dissolved Uranium (U)	2017/04/19	99	80 - 120	96	80 - 120	<0.00010	mg/L		
4942980	Dissolved Vanadium (V)	2017/04/19	99	80 - 120	97	80 - 120	<0.00050	mg/L		
4942980	Dissolved Zinc (Zn)	2017/04/19	99	80 - 120	96	80 - 120	<0.0050	mg/L		
4943872	Nitrate (N)	2017/04/19	108	80 - 120	104	80 - 120	<0.10	mg/L	3.1	20

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B774848
Report Date: 2017/04/24

QUALITY ASSURANCE REPORT(CONT'D)

Stantec Consulting Ltd
Client Project #: 161413338
Sampler Initials: AW

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
4943872	Nitrite (N)	2017/04/19	100	80 - 120	94	80 - 120	<0.010	mg/L	NC	20
4944387	Dissolved Chloride (Cl)	2017/04/19	NC	80 - 120	103	80 - 120	<1.0	mg/L	0.82	20
4944392	Dissolved Sulphate (SO4)	2017/04/19	119	75 - 125	104	80 - 120	<1.0	mg/L	1.7	20
4944394	Orthophosphate (P)	2017/04/19	115	75 - 125	100	80 - 120	<0.010	mg/L	NC	25
4945156	Total Ammonia-N	2017/04/20	NC	80 - 120	98	85 - 115	<0.050	mg/L	3.8	20
4945849	Alkalinity (Total as CaCO3)	2017/04/21			97	85 - 115	<1.0	mg/L	1.5	20
4945858	Conductivity	2017/04/21			100	85 - 115	<1.0	umho/cm	0.23	25
4945861	pH	2017/04/21			101	98 - 103			0.86	N/A

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

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Maxxam Job #: B774848
Report Date: 2017/04/24

Stantec Consulting Ltd
Client Project #: 161413338
Sampler Initials: AW

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Cristina Carriere

Cristina Carriere, Scientific Services

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

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6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel (905) 817-5700 Toll free 800-563-6266 Fax (905) 817-5777 www.maxxam.ca

STANTEC CHAIN OF CUSTODY RECORD

Page 1 of 1

IMMEDIATE

INVOICE INFORMATION:

Company Name: #9197 Stantec Consulting Ltd
Contact Name: Accounts Payable
Address: 300 Hagey Blvd Suite 100, Waterloo ON N2L 0A4
Phone: (519) 579-4410 x Fax: (519) 579-6733 x
Email: accounts.payable.invoices@stantec.com

REPORT INFORMATION (if differs from invoice):

Company Name:
Contact Name: Grant Whitehead
Address:
Phone: (519) 585-7400 x Fax:
Email: grant.whitehead@stantec.com

PROJECT INFORMATION:

Quotation #: 851646
Task #:
Project #: 161413338
Profit Centre: 1614
Site #:
Sampled By: Allison Healey

Laboratory Use Only:

Maxxam Job #:
Bottle Order #: 606049
COC #: C606049-01-01
Project Manager: Augustyna Dobosz

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY

Regulation 153 (2011): ☐ Table 1 ☐ Res/Park ☐ Medium/Fine ☐ Table 2 ☐ Ind/Comm ☐ Coarse ☐ Table 3 ☐ Agr/Other ☐ For RSC ☐ Table ___

Other Regulations: ☐ CCME ☐ Sanitary Sewer Bylaw ☐ Reg 558 ☐ Storm Sewer Bylaw ☐ MISA Municipality ___ ☐ PWQO ☒ Other ODWS

Special Instructions: gw samples non-reportable

Include Criteria on Certificate of Analysis (Y/N)? ___

ANALYSIS REQUESTED (PLEASE BE SPECIFIC): Field Filtered (please circle): Metals / Hg / Cr VI; RCAp - Comprehensive

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered (Metals / Hg / Cr VI)	RCAp - Comprehensive	# of Bottles	Comments
1	WG-161413338-	20170412-AH01	12-Apr-17	3:43	GW	Y	X	4	
2	↓	-AH02	↓	16:17	GW	Y	X	4	
3	↓	-AH03	↓	17:14	GW	Y	X	4	
4	WG-161413338-	20170413-AH04	13 Apr-17	10:55	GW	Y	X	4	
5					GW			4	
6									
7									
8									
9									
10									

13-Apr-17 16:00
Augustyna Dobosz
B774848
AKP FXV-1159

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
Allison Healey	17/04/13	16:10	[illegible]	2017/04/13	16:00	
			Matthew Taylor	2017/04/13	16:42	

Time Sensitive

Laboratory Use Only

Temperature (°C) on Receipt	Custody Seal Present	Yes	No
7 7 7	Intact		

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS
* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.
** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT HTTP://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC.PDF

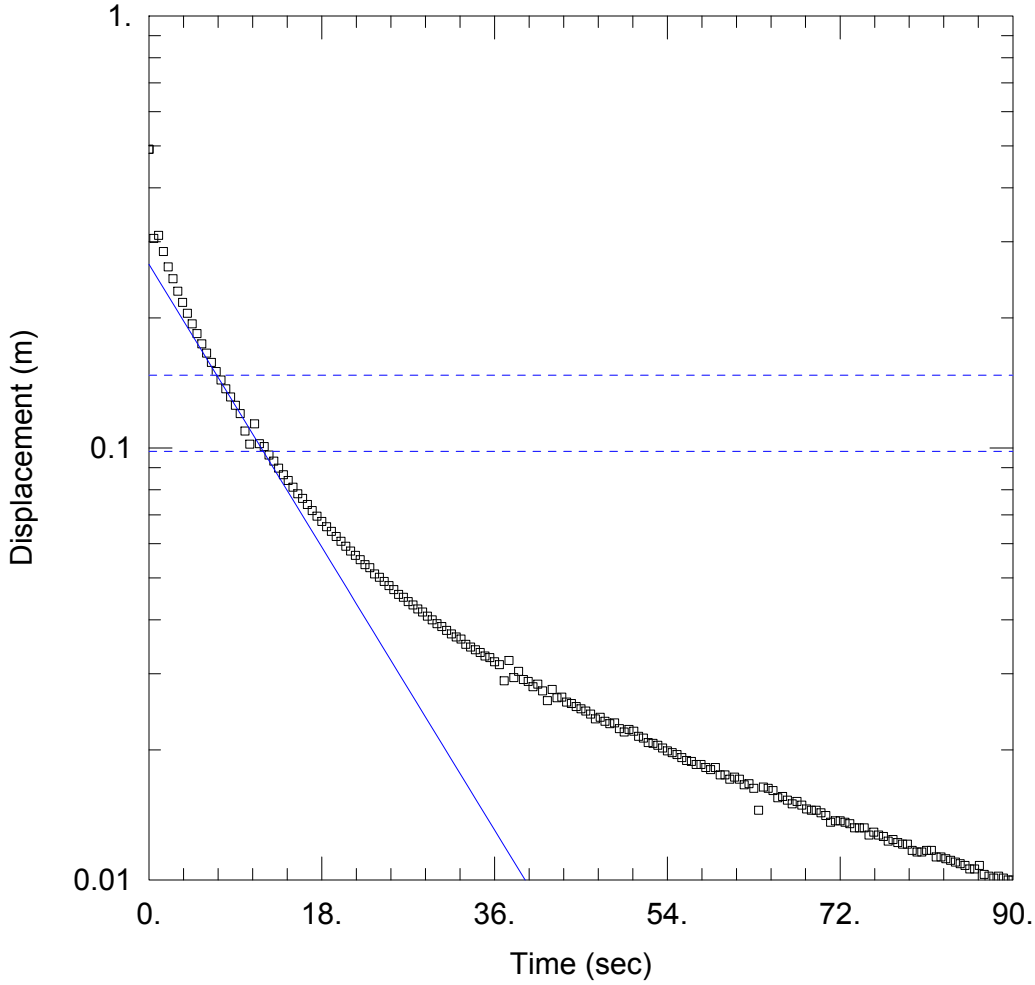
SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

White: Maxxam Yellow: Client

3/12

Maxxam Analytics International Corporation o/a Maxxam Analytics

APPENDIX G:
HYDRAULIC CONDUCTIVITY TESTING ANALYTICAL SOLUTIONS



TEST 1

Data Set: \...\MW01-17test1_ah_JK.aqt
Date: 04/21/17 Time: 09:31:06

PROJECT INFORMATION

Company: Stantec Consulting
Client: Carson Reid Homes
Project: 161413339
Test Well: MW01-17
Test Date: 13-Apr-17

AQUIFER DATA

Saturated Thickness: 4.28 m Anisotropy Ratio (Kz/Kr): 0.5

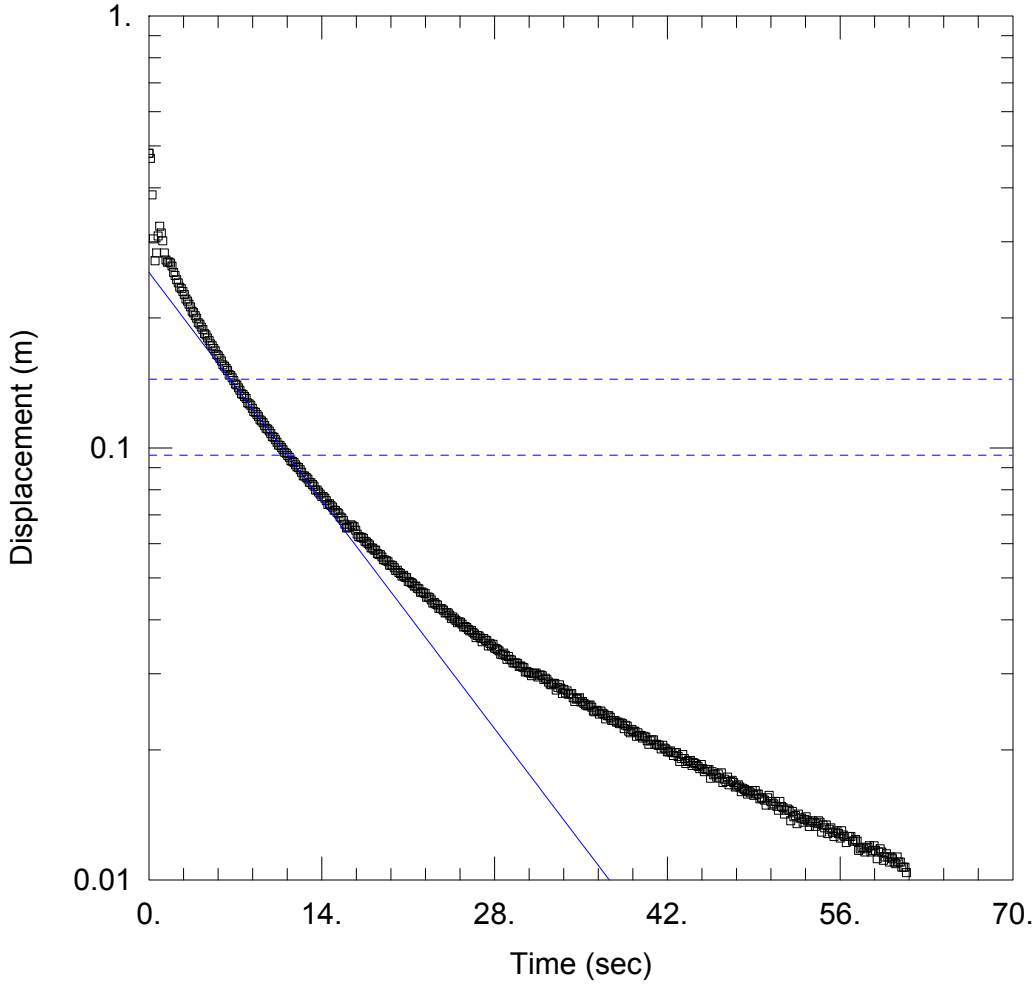
WELL DATA (MW01-17)

Initial Displacement: 0.4911 m Static Water Column Height: 4.28 m
Total Well Penetration Depth: 4.28 m Screen Length: 3.05 m
Casing Radius: 0.0254 m Well Radius: 0.1048 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 2.7E-5 m/sec y0 = 0.266 m



TEST 2

Data Set: \...\MW01-17test2_ah_JK.aqt
Date: 04/21/17 Time: 09:38:52

PROJECT INFORMATION

Company: Stantec Consulting
Client: Carson Reid Homes
Project: 161413339
Test Well: MW01-17
Test Date: 13-Apr-17

AQUIFER DATA

Saturated Thickness: 4.28 m Anisotropy Ratio (Kz/Kr): 0.5

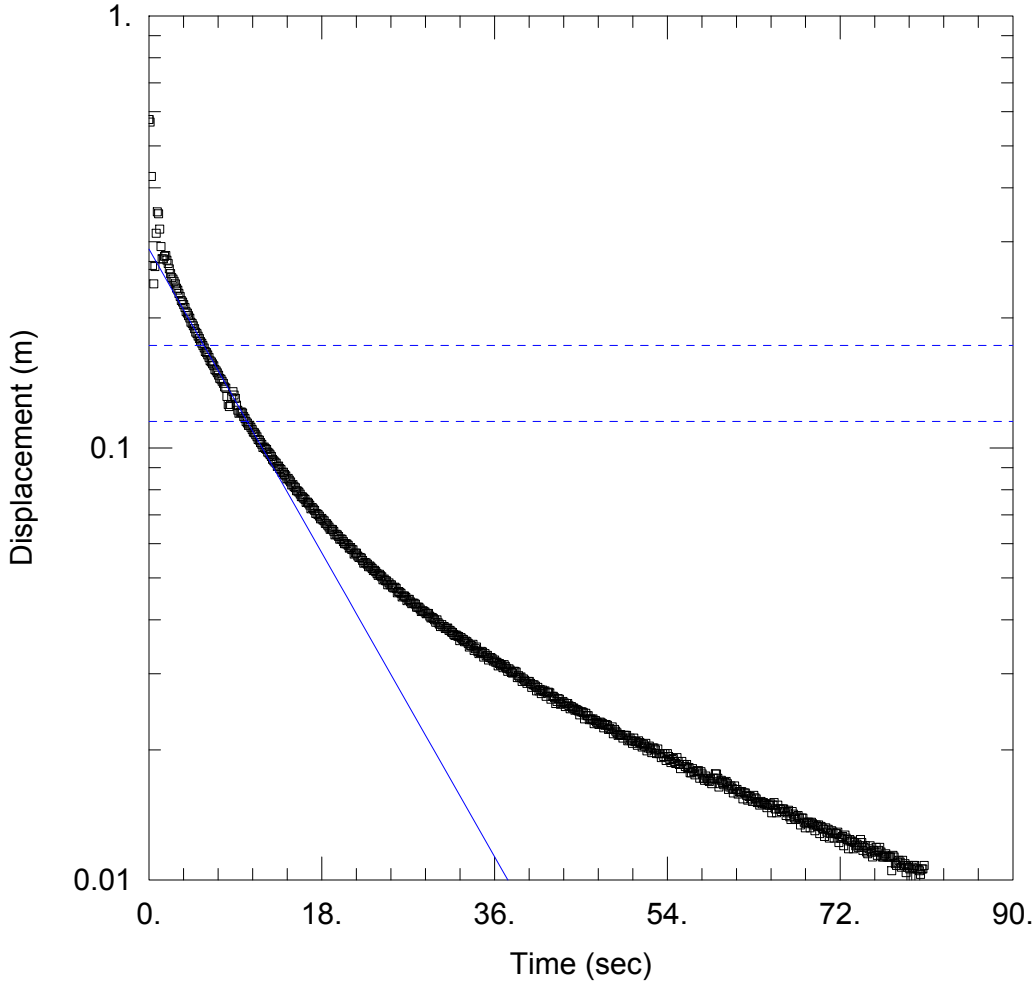
WELL DATA (MW01-17)

Initial Displacement: 0.4808 m Static Water Column Height: 4.28 m
Total Well Penetration Depth: 4.28 m Screen Length: 3.05 m
Casing Radius: 0.0254 m Well Radius: 0.1048 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 2.8E-5 m/sec y0 = 0.2548 m



TEST 3

Data Set: \...\MW01-17test3_ah_JK.aqt
Date: 04/21/17 Time: 09:42:15

PROJECT INFORMATION

Company: Stantec Consulting
Client: Carson Reid Homes
Project: 161413339
Test Well: MW01-17
Test Date: 13-Apr-17

AQUIFER DATA

Saturated Thickness: 4.28 m Anisotropy Ratio (Kz/Kr): 0.5

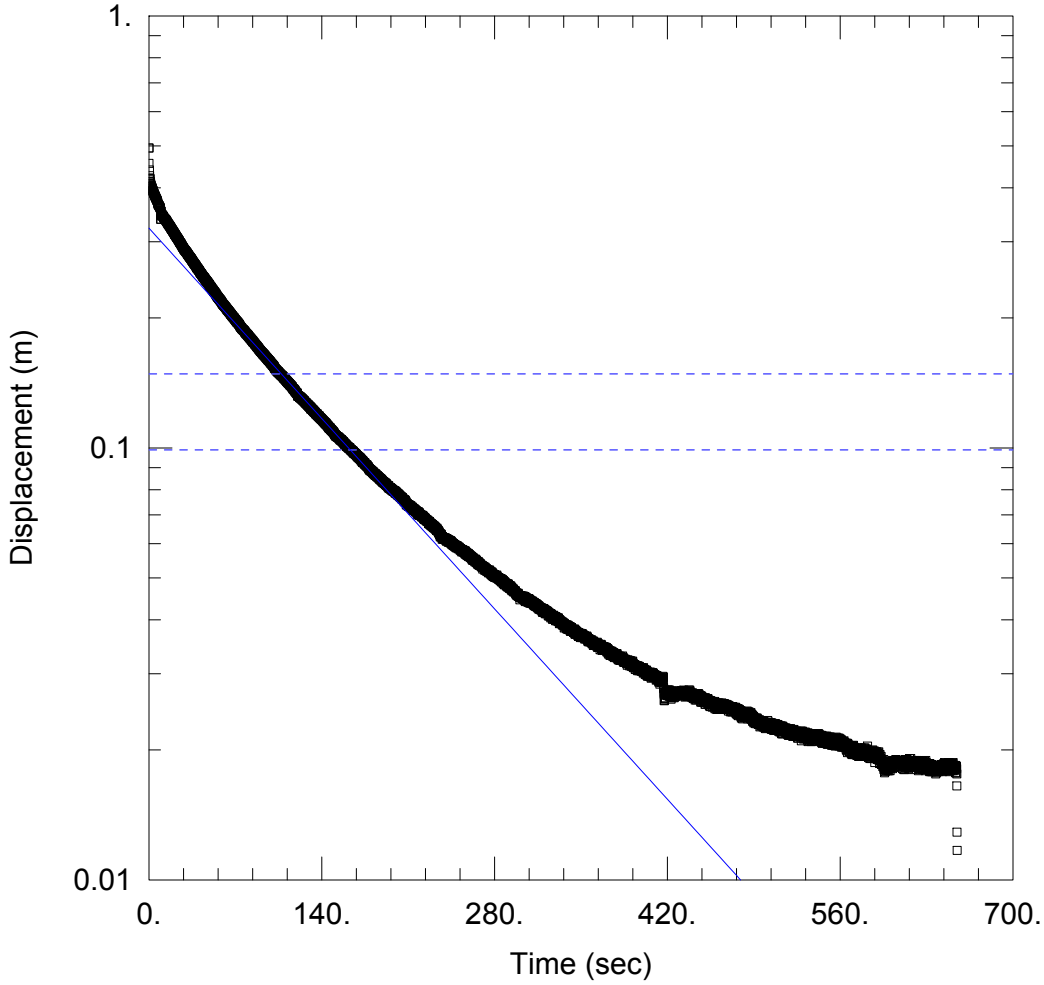
WELL DATA (MW01-17)

Initial Displacement: 0.5757 m Static Water Column Height: 4.28 m
Total Well Penetration Depth: 4.28 m Screen Length: 3.05 m
Casing Radius: 0.0254 m Well Radius: 0.1048 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 2.9E-5 m/sec y0 = 0.2886 m



TEST 1

Data Set: \...\MW02-17test1_ah_JK.aqt
Date: 04/21/17 Time: 09:53:11

PROJECT INFORMATION

Company: Stantec Consulting
Client: Carson Reid Homes
Project: 161413339
Test Well: MW02-17
Test Date: 17-Apr-17

AQUIFER DATA

Saturated Thickness: 3.96 m Anisotropy Ratio (Kz/Kr): 0.5

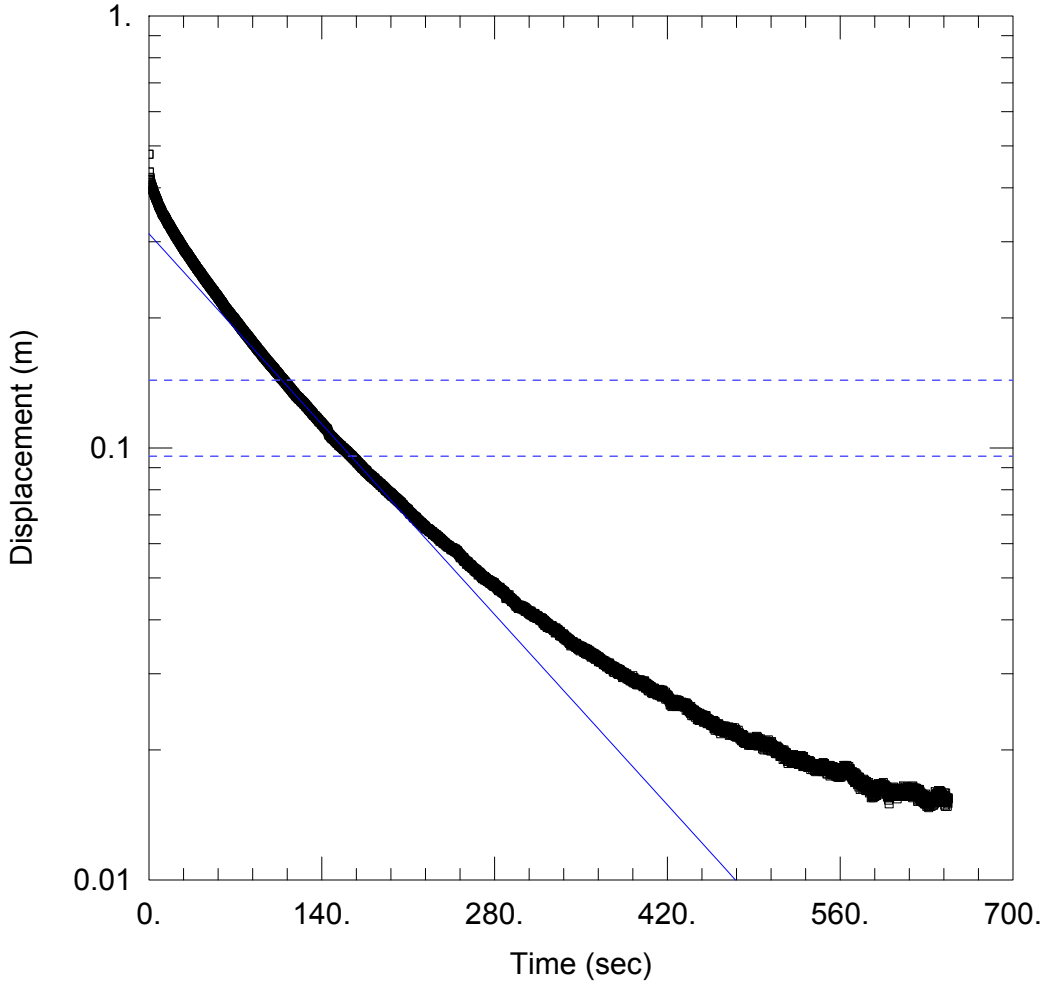
WELL DATA (MW02-17)

Initial Displacement: 0.4945 m Static Water Column Height: 3.96 m
Total Well Penetration Depth: 3.96 m Screen Length: 3.05 m
Casing Radius: 0.0254 m Well Radius: 0.1048 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 2.3E-6 m/sec y0 = 0.3226 m



TEST 2

Data Set: \...\MW02-17test2_ah_JK.aqt
Date: 04/21/17 Time: 10:00:17

PROJECT INFORMATION

Company: Stantec Consulting
Client: Carson Reid Homes
Project: 161413339
Test Well: MW02-17
Test Date: 17-Apr-17

AQUIFER DATA

Saturated Thickness: 3.96 m Anisotropy Ratio (Kz/Kr): 0.5

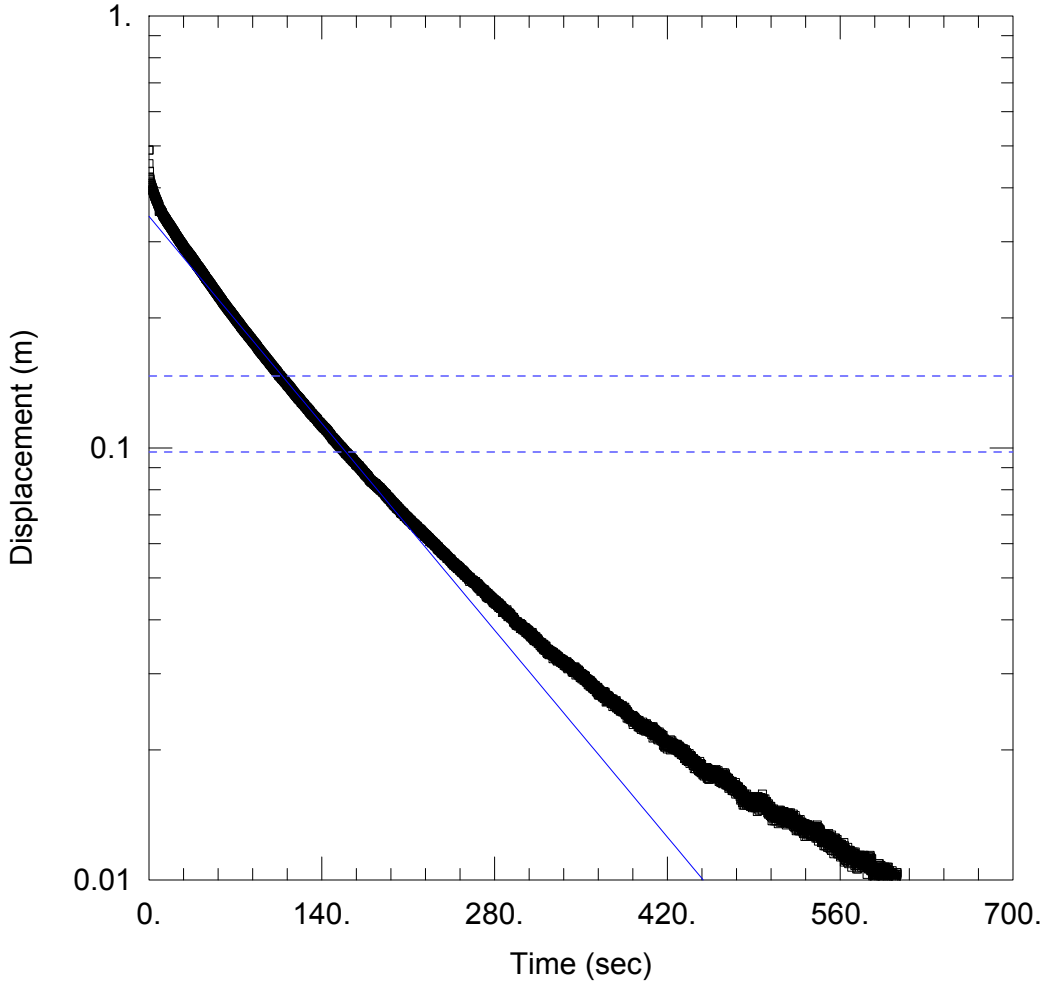
WELL DATA (MW02-17)

Initial Displacement: 0.4785 m Static Water Column Height: 3.96 m
Total Well Penetration Depth: 3.96 m Screen Length: 3.05 m
Casing Radius: 0.0254 m Well Radius: 0.1048 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 2.3E-6 m/sec y0 = 0.313 m



TEST 3

Data Set: \...\MW02-17test3_ah_JK.aqt
Date: 04/21/17 Time: 10:05:53

PROJECT INFORMATION

Company: Stantec Consulting
Client: Carson Reid Homes
Project: 161413339
Test Well: MW02-17
Test Date: 17-Apr-17

AQUIFER DATA

Saturated Thickness: 3.96 m Anisotropy Ratio (Kz/Kr): 0.5

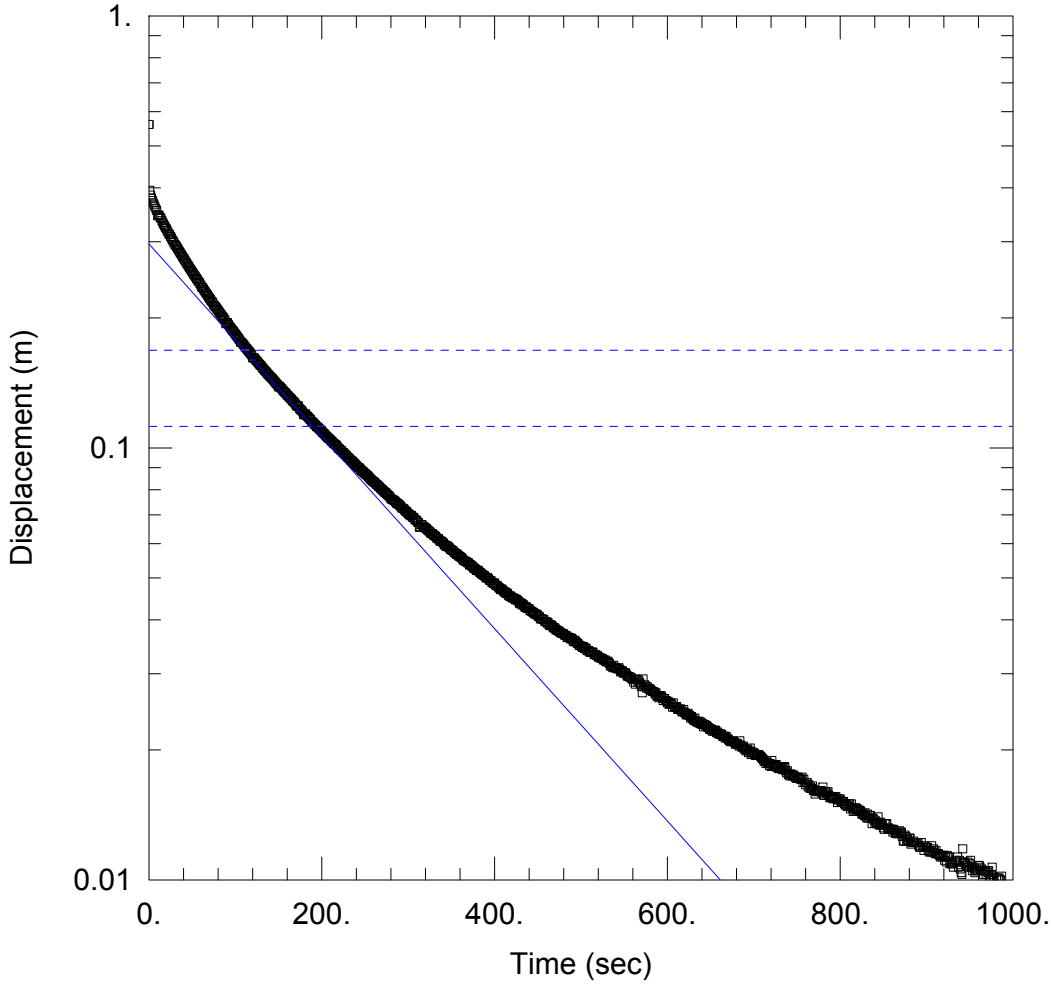
WELL DATA (MW02-17)

Initial Displacement: 0.4892 m Static Water Column Height: 3.96 m
Total Well Penetration Depth: 3.96 m Screen Length: 3.05 m
Casing Radius: 0.0254 m Well Radius: 0.1048 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 2.5E-6 m/sec y0 = 0.3435 m



TEST 1

Data Set: \...\MW03-17test1_ah_JK.aqt
Date: 04/21/17 Time: 10:19:45

PROJECT INFORMATION

Company: Stantec Consulting
Client: Carson Reid Homes
Project: 161413339
Test Well: MW03-17
Test Date: 13-Apr-17

AQUIFER DATA

Saturated Thickness: 3.66 m Anisotropy Ratio (Kz/Kr): 0.5

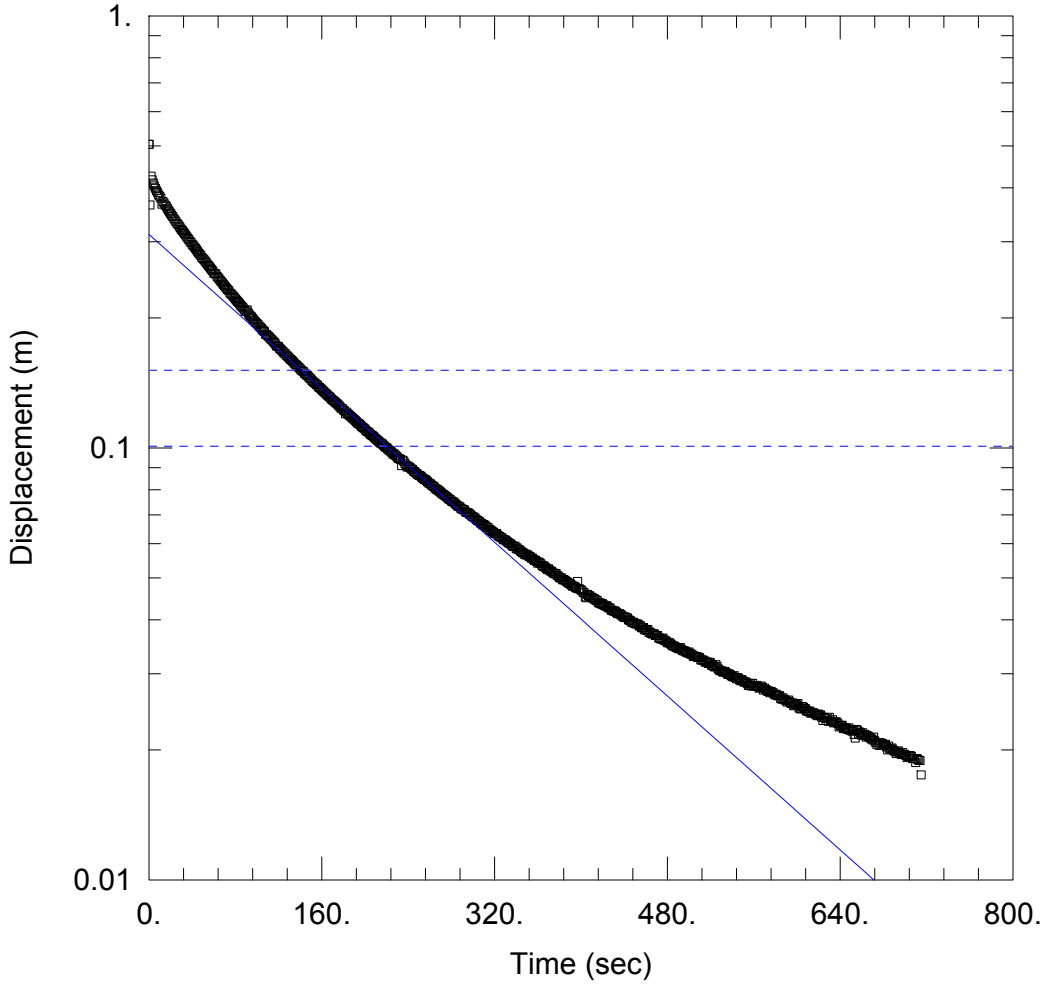
WELL DATA (MW03-17)

Initial Displacement: 0.5608 m Static Water Column Height: 3.66 m
Total Well Penetration Depth: 3.66 m Screen Length: 3.05 m
Casing Radius: 0.0254 m Well Radius: 0.1048 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 1.6E-6 m/sec y0 = 0.2965 m



TEST 2

Data Set: \...\MW03-17test2_ah_JK.aqt
Date: 04/21/17 Time: 10:21:46

PROJECT INFORMATION

Company: Stantec Consulting
Client: Carson Reid Homes
Project: 161413339
Test Well: MW03-17
Test Date: 13-Apr-17

AQUIFER DATA

Saturated Thickness: 3.66 m Anisotropy Ratio (Kz/Kr): 0.5

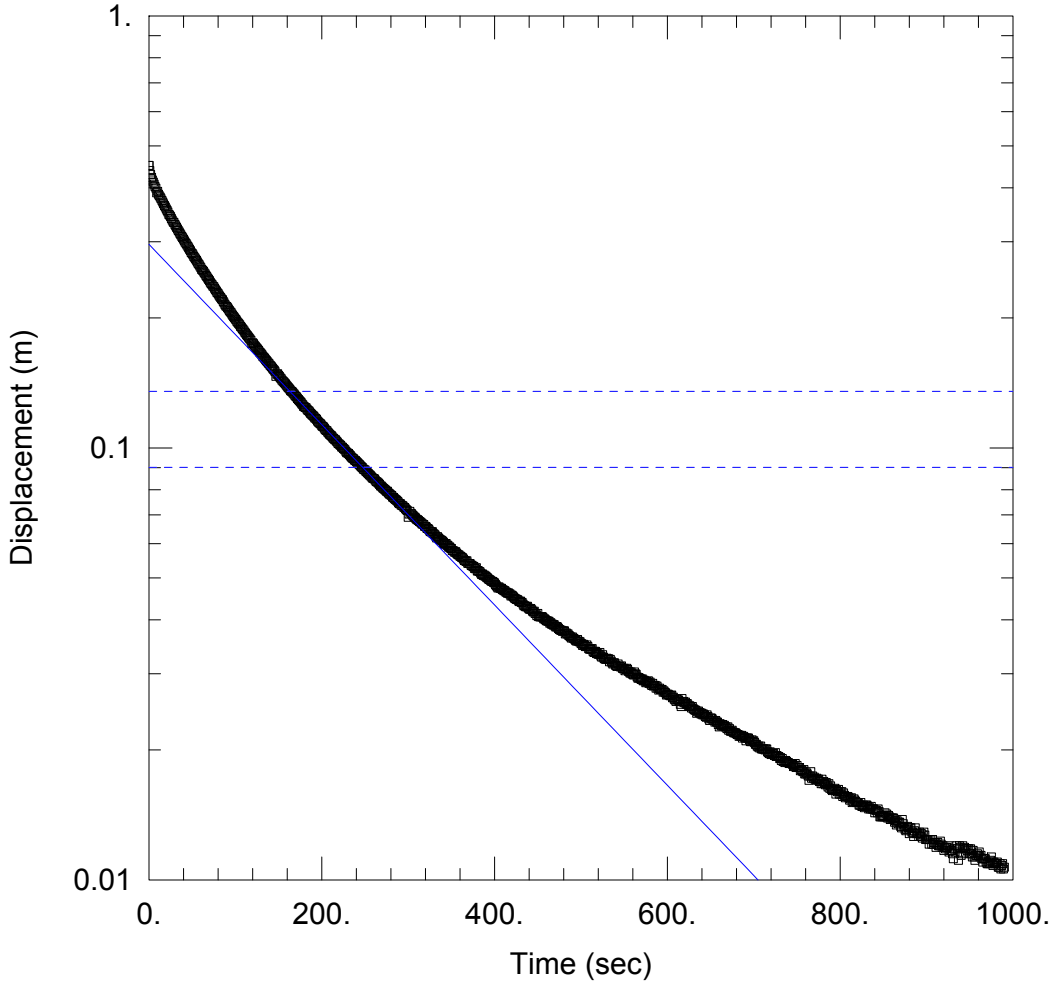
WELL DATA (MW03-17)

Initial Displacement: 0.5044 m Static Water Column Height: 3.66 m
Total Well Penetration Depth: 3.66 m Screen Length: 3.05 m
Casing Radius: 0.0254 m Well Radius: 0.1048 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 1.6E-6 m/sec y0 = 0.312 m



TEST 3

Data Set: \...\MW03-17test3_ah_JK.aqt
Date: 04/21/17 Time: 10:23:46

PROJECT INFORMATION

Company: Stantec Consulting
Client: Carson Reid Homes
Project: 161413339
Test Well: MW03-17
Test Date: 13-Apr-17

AQUIFER DATA

Saturated Thickness: 3.66 m Anisotropy Ratio (Kz/Kr): 0.5

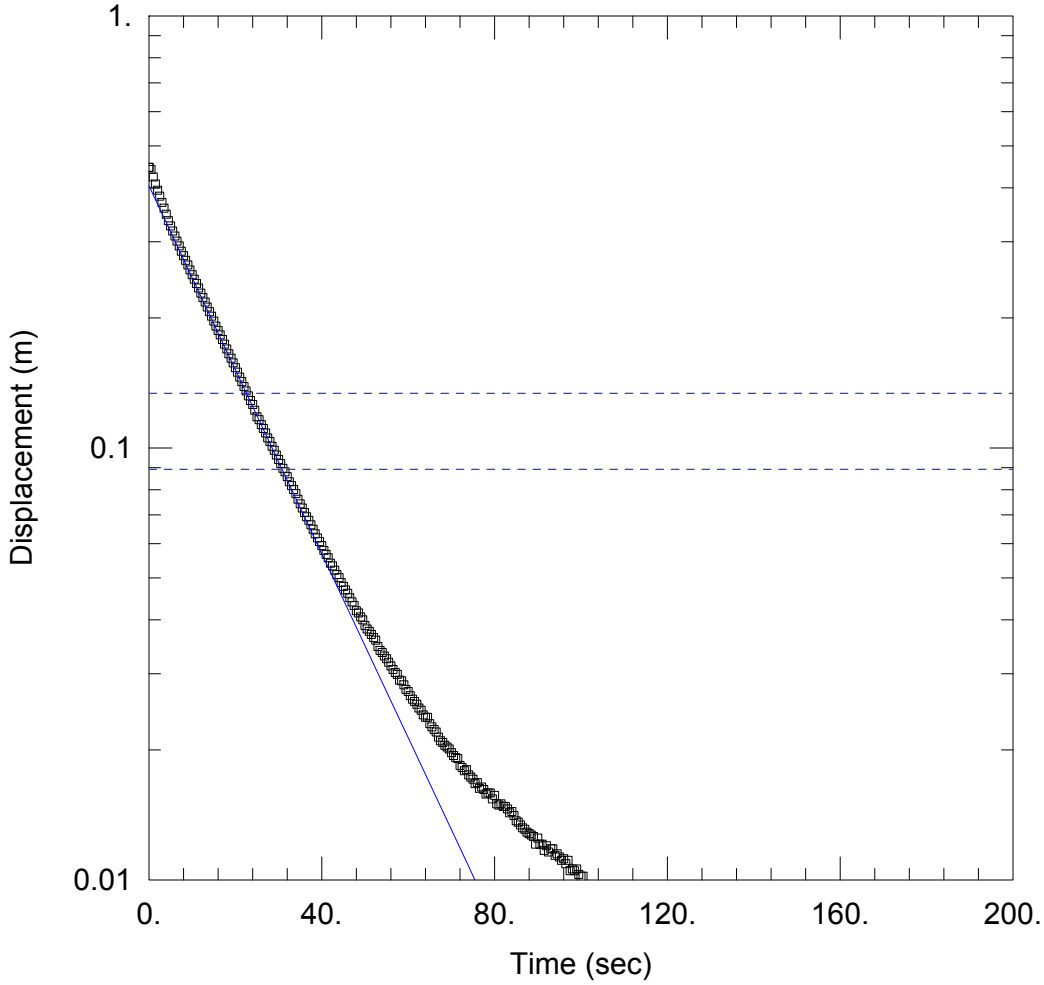
WELL DATA (MW03-17)

Initial Displacement: 0.4507 m Static Water Column Height: 3.66 m
Total Well Penetration Depth: 3.66 m Screen Length: 3.05 m
Casing Radius: 0.0254 m Well Radius: 0.1048 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 1.5E-6 m/sec y0 = 0.2959 m



TEST 1

Data Set: \...\MW04-17test1_ah_JK.aqt
Date: 04/21/17 Time: 10:39:03

PROJECT INFORMATION

Company: Stantec Consulting
Client: Carson Reid Homes
Project: 161413339
Test Well: MW04-17
Test Date: 17-Apr-17

AQUIFER DATA

Saturated Thickness: 4.54 m Anisotropy Ratio (Kz/Kr): 0.5

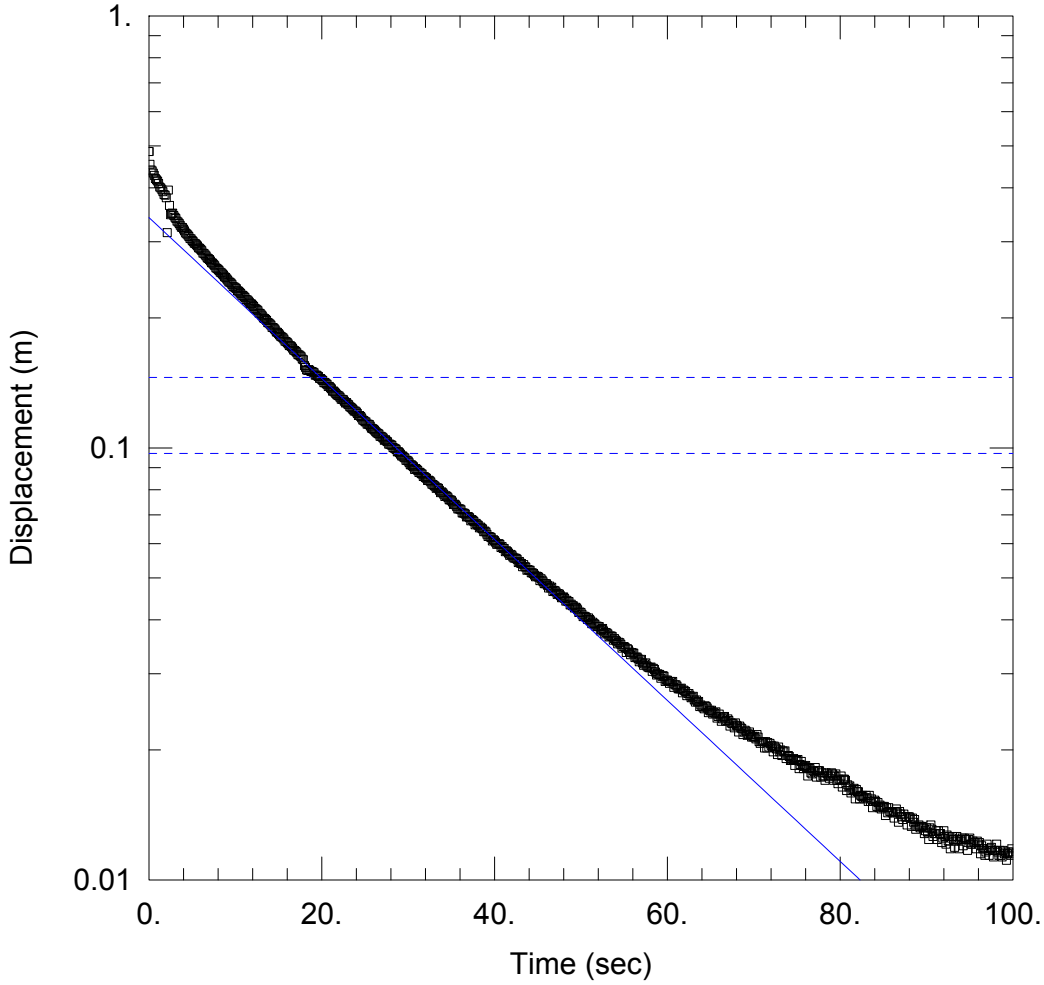
WELL DATA (MW04-17)

Initial Displacement: 0.4462 m Static Water Column Height: 4.54 m
Total Well Penetration Depth: 4.54 m Screen Length: 3.05 m
Casing Radius: 0.0254 m Well Radius: 0.1048 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 1.6E-5 m/sec y0 = 0.4043 m



TEST 2

Data Set: \...\MW04-17test2_ah_JK.aqt
Date: 04/21/17 Time: 10:42:17

PROJECT INFORMATION

Company: Stantec Consulting
Client: Carson Reid Homes
Project: 161413339
Test Well: MW04-17
Test Date: 17-Apr-17

AQUIFER DATA

Saturated Thickness: 4.54 m Anisotropy Ratio (Kz/Kr): 0.5

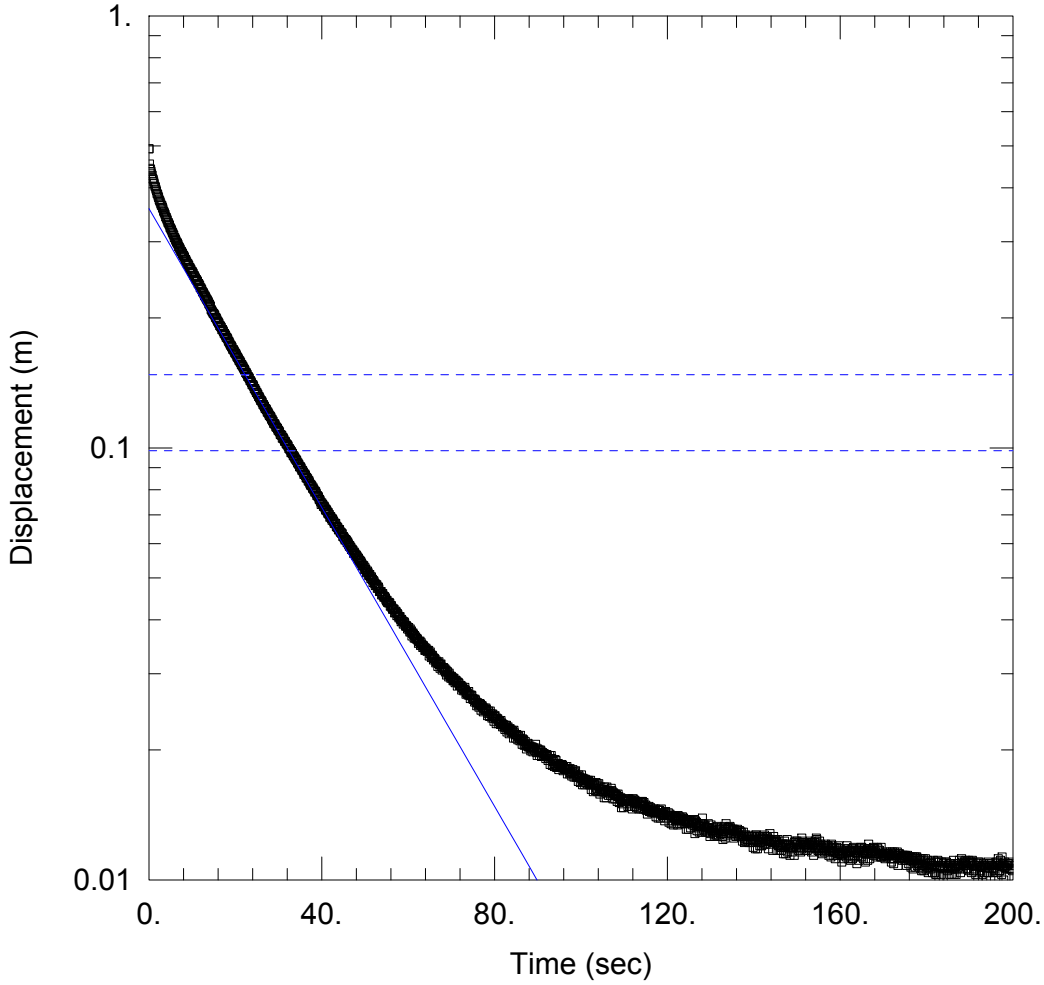
WELL DATA (MW04-17)

Initial Displacement: 0.4854 m Static Water Column Height: 4.54 m
Total Well Penetration Depth: 4.54 m Screen Length: 3.05 m
Casing Radius: 0.0254 m Well Radius: 0.1048 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 1.4E-5 m/sec y0 = 0.3413 m



TEST 3

Data Set: \...\MW04-17test3_ah_JK.aqt
Date: 04/21/17 Time: 10:54:42

PROJECT INFORMATION

Company: Stantec Consulting
Client: Carson Reid Homes
Project: 161413339
Test Well: MW04-17
Test Date: 17-Apr-17

AQUIFER DATA

Saturated Thickness: 4.54 m Anisotropy Ratio (Kz/Kr): 0.5

WELL DATA (MW04-17)

Initial Displacement: 0.4926 m Static Water Column Height: 4.54 m
Total Well Penetration Depth: 4.54 m Screen Length: 3.05 m
Casing Radius: 0.0254 m Well Radius: 0.1048 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 1.3E-5 m/sec y0 = 0.3581 m