190 – 216 ARKELL ROAD
GUELPH, ONTARIO

Final

Hydrogeological Investigation

Project Location:
190 - 216 Arkell Road
Guelph, Ontario

Prepared for:
Crescent Homes
3-180 Frobisher Drive
Waterloo ON N2V 2A2

Prepared by:
MTE Consultants Inc.
520 Bingemans Centre Drive
Kitchener, ON N2B 3X9

October 5, 2018

MTE File No.: 42063-104

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1.0 INTRODUCTION

MTE Consultants Inc. (MTE) was retained by Crescent Homes to conduct a hydrogeological investigation for a proposed residential development at municipal addresses 190-216 Arkell Road in Guelph, Ontario (herein referred to as the 'Subject Lands'). Currently, the Subject Lands are comprised of residential lots with associated residences and landscaped areas. **Figure 1** illustrates the Subject Lands Key Map.

MTE understands that the proposed development includes 33 townhouse units and two three-storey apartment buildings with a combined total of 32 apartment units. Also included are 46 parking spaces, a 20 m right-of-way for a roadway ('Street A') and an amenity area. The Subject Lands are to be serviced with municipal water and storm and sanitary sewers.

1.1 Scope and Methodology

The objectives of this report have been to investigate the suitability of the Subject Lands for the proposed development and to evaluate potential hydrogeological impacts on groundwater resources. In order to meet these objectives, the following scope of work was implemented:

1) Site Identification:
   - Site description.
   - Current and past land use summary.
   - Neighboring land uses.
   - Development Features.
   - Review of:
     - Quaternary geology maps; and
     - Bedrock geology.
   - Ministry of the Environment and Climate Change (MOECC) well records review.
   - Review of existing geology and hydrogeological reports.
2) Field Investigation:
   - Advance six overburden boreholes and install four overburden groundwater monitoring wells on-Site overseen by Peto MacCallum Ltd (PML).
   - Measurement of groundwater levels to determine groundwater flow direction.
   - Field testing of monitoring wells to determine hydraulic conductivity and average linear groundwater velocity.
   - Collection of groundwater level measurements to document groundwater level fluctuations.
3) Analysis and Reporting:
   - Geologic and hydrogeological summary.
   - Preparation of geological cross-sections through the Subject Lands.
   - Assess potential hydrogeological impacts from the proposed development on the Site.

- Determine shallow groundwater system properties:
  - Horizontal hydraulic gradient;
  - Average linear groundwater velocity; and
  - Shallow groundwater flow patterns.
- Determine potential impacts on the Torrance Creek Subwatershed.

This report should be read in conjunction with the following reports that have also been completed for the Subject Lands:

- Draft Geotechnical Investigation; Proposed Arkell Road Subdivision, Guelph, Ontario for Crescent Homes Inc. - Peto MacCallum Ltd., April, 2017.

2.0 SUBJECT LANDS DESCRIPTION

The Subject Lands comprise an area of approximately 2.5 hectares (6.3 acres) and are located north of the Arkell Road and Summerfield Drive intersection. The Study Area for the Subject Lands, including the property boundary, geological cross-section locations, monitoring wells and existing features is illustrated on **Figure 2**.

The land use within the Subject Lands is residential. Currently, residential dwellings and associated landscaped and parking areas are present within the southern portion of the property. The City of Guelph Official Plan identifies the Subject Lands as within a 'Greenfield Area' and classifies the property as 'Low Density Greenfield Residential'. The City of Guelph Official Plan does not identify the Subject Lands as a Regulatory Floodplain; however a Significant Natural Area is illustrated along the northwest boundary of the Subject Lands. The Ministry of Natural Resources and Forestry (MNRF) identifies this feature as the Torrence Creek Swamp Provincially Significant Wetland (PSW).

2.1 Adjacent Land Use

The Subject Lands are bounded to the southwest by a rural residential property and the Torrence Creek Swamp PSW is present further beyond. The Torrence Creek Swamp PSW is present to the north, a residential development is present to the east and Arkell Road is present to the south, with residential developments present further south.

2.2 Topography and Drainage

The ground surface at the Subject Lands is generally flat with elevations typically ranging between 333 to 335.5 m above mean sea level (amsl) across the property, decreasing towards the northeast. Surface water runoff therefore drains from south to north, towards the PSW.

A storm sewer is present along Arkell Road to the south, with three catch basins located within the roadway.

GRCA and MNRF online mapping illustrate a PSW north of the property, extending south and traversing the north property boundary. In addition, GRCA mapping illustrates a small surface water body within the west portion of the Subject Lands, presumed to be a landscaped feature. No other surface water bodies/courses are illustrated within or transecting the property.

The Subject Lands are located within the Speed River Subwatershed. Tributaries of the Eramosa River (Torrance Creek) are located approximately 575 m north of the property. The Eramosa River flows to the Speed River which drains directly into the Grand River.

According to the GRCA, a large portion of the Subject Lands is located within a Regulation Limit, as defined by Ontario Regulation 150/06: *Grand River Conservation Authority: Regulation Of Development, Interference With Wetlands And Alterations To Shorelines And Watercourses.*

2.3 Development Proposal

A Preliminary Concept Plan for the proposed development has been prepared by MHBC Planning Ltd. (Kitchener, ON), dated May 17, 2018 and forms the basis for the hydrogeological investigation. The Preliminary Concept Plan includes 33 townhouse units and two three-storey apartment buildings with a combined total of 32 apartment units. Also included are 46 parking spaces, a 20 m right-of-way for a roadway ('Street A') and an amenity area. The southern extent of the PSW, as determined by an Environmental Impact Study conducted by Natural Resource Solutions Inc. (NRSI) is illustrated, as is a 30 m buffer. A road widening buffer of 5 m is also shown, extending north from Arkell Road.

The net area of the proposed development comprises approximately 1.24 hectares and excludes the wetland, buffer zone, roadway widening and right-of-way. The Preliminary Concept Plan is enclosed in **Appendix A**.

Municipal Servicing

It is understood that the townhouses may be constructed with full basements. The Subject Lands will be serviced by municipal water, sanitary sewers and storm sewers which are anticipated to be installed to conventional depths (1.5 to 3 mbgs).

For further servicing information refer to MTE's Functional Servicing Report under separate cover.

Stormwater Management (SWM)

The proposed SWM system includes the collection of stormwater runoff from the right-of-way and the front half of the on-street townhome roofs. Stormwater runoff from the right-of way will be collected via storm sewers draining to an oil/grit separator (OGS) for pre-treatment which will then discharge to a dry pond for quantity and additional quality control and ultimately discharge to an infiltration gallery north of the proposed right-of-way.

Stormwater runoff from the apartment rooftops will discharge directly to an on-site infiltration gallery. Surface runoff from the apartment block will discharge to the dry pond which will be pre-treated with an OGS.

Stormwater from the rear yards of the townhomes located west of the proposed right-of-way will discharge, un-attenuated, directly to the wetland.

For further stormwater management information refer to MTE's Stormwater Management Report under separate cover.

3.0 FIELD PROGRAM

3.1 Borehole Advancement and Monitoring Well Construction

A total of six boreholes (BH1 to BH6) were advanced at the Subject Lands between February 13 and March 21, 2017 as part of a geotechnical investigation completed by PML. Boreholes were advanced to depths ranging between approximately 6.6 to 8.1 m bgs and were observed by PML. Four of these boreholes were completed as groundwater monitoring wells.

These boreholes and monitoring wells allow for the assessment of the overburden geology and hydrogeological characteristics at the Subject Lands, including stabilized groundwater elevations and groundwater flow direction interpretations. The borehole locations and ground elevations were surveyed by MTE to a geodetic benchmark. Borehole and monitoring well locations are illustrated on **Figure 3**. Borehole logs are provided in **Appendix B**.

Following installation, monitoring wells were developed using Waterra^{TM} Surge Blocks to remove any accumulated sediments from the bottom of the well and to remove fine materials from the well screen and sand pack.

Soil conditions observed during borehole advancement at the Subject Lands generally consist of topsoil ranging in thickness from 0.1 to 0.3 m underlain by native silt, sand, and sand and gravel to the maximum investigated depth of 8.1 m bgs. Fill was encountered at borehole locations BH1 and BH6 underlying the topsoil material. The fill material was observed to extend to approximately 0.5 to 0.7 m bgs and was comprised of sand and gravel or silt.

Bedrock was not encountered in any of the boreholes advanced at the Subject Lands; however, it is anticipated to be approximately 18 to 30 m bgs (refer to **Section 4.3**).

Representative samples of the overburden were collected from the boreholes by PML at regular depth intervals. All recovered samples were returned to PML's laboratory for detailed visual inspection, classification, and select particle size distribution analysis. Particle distribution size analyses charts have been provided in **Appendix E**.

3.2 Water Well Record Search

Private Wells

Hydrogeological data related to private supply wells within 500 m of the Subject Lands were obtained from water well records on file with the MOECC. Based on data in the MOECC well database, a total of 71 well records were located within 500 m of the Subject Lands. Of the 71 wells:

- 40 wells were identified as being livestock or domestic water supply wells;
- 16 wells were identified as test holes, observation or monitoring wells;
- One was identified as a municipal supply well;
- Five wells were identified as “not used”;
- Four wells were identified as “abandoned”; and
- Five well records did not specify the well use.

Municipal Supply Well

The Burke Well and Pumping Station is located approximately 60 m southwest of the Subject Lands and houses one municipal well (Burke Well), representing the closest municipal well to the Subject Lands. This well is described by the City of Guelph as an “important current and future water source” for the City of Guelph as it provides 8% of the City’s water supply. The Burke Well is a bedrock well, drawing from the deep aquifer system (Jagger Hims, 1998). The well depth is 79.6 m bgs within the Guelph – Middle Gasport Formation.

The Carter Wellfield is located approximately 1.8 km northeast of the Subject Lands and houses two wells (the Carter Wells) located approximately 3 m apart. The wells are bedrock wells, drawing from the shallow bedrock; however, the shallow bedrock in this area is interpreted to be hydraulically connected to the water table and therefore some water is supplied by Torrence Creek (LERSPC, 2015). As a result, the Carter Wells are classified as Groundwater Under the Direct Influence of Surface Water (GUDI) wells as outlined in Ontario Regulation 170/03: *Drinking Water Systems.* The well depths are 20.7 m bgs within the Guelph Formation.

3.3 Groundwater Levels

MTE completed multiple rounds of manual groundwater level measurements between March 2, 2017 and June 26, 2018. Manually measured groundwater levels and elevations within the monitoring wells are presented in **Table 1** and **Table 2**. In addition, electronic pressure transducers (data loggers) were installed within each of the monitoring wells on March 27, 2017. Data loggers measure the pressure (in centimeters of water) above the logger at a predetermined time interval, which can then be used to calculate a groundwater level and elevation. The data loggers installed at the Subject Lands were set to record a pressure at a time interval of every 1 hour.

Therefore, hydrographs illustrating continuous groundwater elevations within the monitoring wells at the Subject Lands for a period of 15 months are provided in **Appendix C**.

Groundwater elevations measured by data loggers were observed to range between 330.38 mAMSL (MW2 & MW5) and 333.99 mAMSL (MW4). It is noted that the ground surface elevation at MW4 is 333.24 mAMSL and therefore the measured groundwater elevations in the monitoring well represent saturated soil conditions at ground surface.

3.4 Hydraulic Conductivity Testing

Qualitatively, hydraulic conductivity (K) is a parameter describing the ease with which groundwater flows through a porous medium. Relatively large K values are attributed to permeable units, i.e. sand and gravel, while small values are attributed to less permeable material, i.e. silt or clay. Representative values for hydraulic conductivity for various soil types are presented in Freeze and Cherry (1979).

MTE conducted single well hydraulic response tests on the four on-Site monitoring wells in March 2017 (MW2 and MW3) and May 2017 (MW4 and MW5). A slug of known displacement was rapidly introduced (falling head test) and removed (rising head test) from the well as a means of inducing an immediate groundwater level response. Groundwater level recovery was monitored using a data logger programmed to collect groundwater levels every half second. Where possible, response tests were carried out three times using solid slugs of different displacement volumes to assess the viability of assumptions underlying the slug test analysis methods.

Prior to analysis, recovery data was normalized by dividing the observed head change (H_o) by the expected head change (H_o*) for the solid slug used during testing. Normalized data plots from repeat tests (at the same well) were compared to determine coincidence between tests. Coincidence between tests suggests assumptions underlying conventional analysis methods can be considered valid at that well (Butler et. al., 1996; Butler et. al., 2003). A single representative test from the each well was selected and analyzed using the Bouwer & Rice model using the AquiferTest© Pro software package (Waterloo Hydrogeologic Inc., 2016) to estimate the horizontal hydraulic conductivity (K) of the unconfined saturated materials beneath the Subject Lands.

3.5 Groundwater Sampling

MTE collected groundwater samples from two on-Site monitoring wells (one hydraulically up-gradient and one hydraulically down-gradient) on June 26, 2018. Prior to sample collection, a minimum of three well volumes was purged from the well based on the recorded water levels. The samples were placed in laboratory supplied sample containers and transported on ice, under chain-of-custody, to ALS Laboratories in Waterloo, Ontario. Standard QA/QC protocols were followed as outlined by the (MOECP) guidance documents.

4.0 REGIONAL GEOLOGY AND HYDROGEOLOGY

4.1 Physiography

The Subject Lands are located within the physiographic region known as the Guelph Drumlin Field, as shown on **Figure 4a**. This region primarily consists of stoney till within the drumlins and deep gravel terraces in the intervening areas (*Chapman and Putnam*, 1984). **Figure 4b** illustrates the Subject Lands as being located within a drumlin field, and, in this area, the drumlins are almost entirely comprised of sandy Wentworth Till (Karrow, 1967).

4.2 Quaternary Geology

Geology throughout the City of Guelph is comprised of three distinct till units identified from youngest to oldest as the Wentworth Till, the Middle Maryhill Till and the Catfish Creek Till, overlying bedrock attaining thicknesses of 75 m. The Wentworth Till is described as a coarse-grained sandy to silty sand till which is often bouldery or stony (Karrow, 1968). This unit is generally found at ground surface throughout the City of Guelph and includes glacial features such as drumlins, found within the Guelph drumlin field, and the Galt and Paris moraines. The till thickness is described as variable, ranging between 15 to 30 m below drumlins and moraines, while thicknesses are much lower within low-lying areas.

The Quaternary Geology Map (**Figure 5**) identifies regional surface deposits of sand and gravel within the area of the Subject Lands, which is consistent with the drumlin field landform surrounding the Subject Lands, as shown on **Figure 4b**.

4.3 Paleozoic Bedrock Geology

The City of Guelph is underlain by the Guelph Formation, characterized as sandstone, shale, dolostone and siltstone, as shown by **Figure 6**.

Bedrock was not encountered during the on-Site drilling program (Section 3); however, according to the depth to bedrock reported in MOECC well records in the area (namely MOECC Well ID No.'s 6702585 and 6702584, located approximately 160 m and 240 m west, respectively) it is anticipated that bedrock is approximately 18 to 30 m bgs.

4.4 Regional Hydrogeology Setting

The City of Guelph relies almost exclusively on groundwater for its potable water supply (LERSPC, 2015). In total, 25 municipal supply wells are located throughout the City of Guelph, the majority of which draw water from the deep confined bedrock of the Gasport (formerly Amabel), Guelph, Eramosa and Goat Island Formations. A regional aquitard is present within the Eramosa Formation (the Vinemount Member), which confines the Gasport Formation (LERSPC, 2015).

The regional groundwater flow direction was determined based on the following:

- Regional groundwater elevations provided from the GRCA;
- The presence of a PSW north of the Subject Lands;
- The presence of Torrence Creek located approximately 575 m northeast of the Subject Lands; and
- Ground surface topography in the area surrounding the Subject Lands generally slopes to the north.

Based on these factors, the regional groundwater flow is expected to be generally northerly in the vicinity of the Subject Lands, as shown on **Figure 7**.

5.0 LOCAL HYDROGEOLOGICAL SETTING

Boreholes and monitoring wells installed by PML were used to interpret local hydrostratigraphic units and generate two geological cross-sections. Local geological cross-sections (Cross-section A-A' and Cross-section B-B') are presented on **Figures 8 and 9**.

*Geological Cross-Section A-A' (**Figure 8**):*

- Extends approximately 217.5 m from northwest to southeast through the Subject Lands;
- Illustrates topography generally slopes towards the northwest;
- Portrays a generally coarse-grained subsurface comprised of sand and sand and gravel units;
- Illustrates the presence of a silt units at approximately 0.3 m bgs and 8.3 m bgs within the southeast portion of the Subject Lands; and
- Infers the shallow groundwater table at the Subject Lands generally slopes from the northwest to the southeast, ranging in elevations from approximately 333 mamsl in the vicinity of the wetland, to approximately 332.5.

*Geological Cross-Section B-B' (**Figure 9**):*

- Extends approximately 190 m from west to east through the Subject Lands.
- Illustrates topography generally slopes towards the west.
- Portrays a coarse grained subsurface beneath the west portion of the Subject Lands extending westward where it meets a fine-grained silt unit. The fine-grained silt unit is illustrated underlying the coarse grained materials within the west portion of the Subject Lands at a depth of approximately 7.8 m bgs.
- Infers the shallow groundwater table at the Subject Lands is located at an elevation of approximately 332.5 mamsl.

5.1 Hydraulic Conductivity

The normalized plots for MW2 through MW5 show an acceptable coincidence, suggesting the assumptions underlying conventional analysis methods are valid.

Based on the results of the in-situ response tests, horizontal hydraulic conductivity (K-value) estimates throughout the Subject Lands were calculated to range from 2.1 x 10^{-6} m/sec (0.18 m/day) to 2.1 x 10^{-4} m/sec (17.7 m/day) with a geometric mean of 2.5 x 10^{-5} m/sec (2.14 m/day), which is consistent with average published values for sand and gravel soil (Freeze and Cherry, 1979). **Table 6.1** summarizes the K-value estimates for each analyzed data set. A summary of the analyses carried out in AquiferTest© Pro are provided in **Appendix E**.

TABLE 5.1: SUMMARY OF HYDRAULIC CONDUCTIVITY ESTIMATES

Well ID	Estimated Hydraulic Conductivity (m/sec)
BH/MW2	5.52 x 10^{-5}
BH/MW3	1.62 x 10^{-5}
BH/MW4	2.06 x 10^{-6}
BH/MW5	2.05 x 10^{-4}
Geometric Mean	2.48 x 10^{-5}

5.2 Groundwater Flow and Average Linear Groundwater Velocity

Groundwater flow mapping was conducted for the Subject Lands using the June 26, 2018 groundwater elevation data. Groundwater contours and flow patterns are illustrated in **Figure 10** which suggests that shallow overburden groundwater generally flows in a southwesterly direction. It is recognized that this is inconsistent with MTE's interpretation of the regional groundwater flow direction (Section 4.4); this is interpreted to result from the separation distance between monitoring wells being small and therefore localized inconsistencies may exist. An average horizontal hydraulic gradient was calculated to be 0.005 m/m based on the June 26, 2018 groundwater levels.

Assuming an average horizontal conductivity of 2.5 x 10^{-5} m/s (Section 6.1) and using the horizontal hydraulic gradient of 0.005 m/m calculated above, the average linear groundwater velocity was calculated using Darcy's Law in the following equation:

$$q = (-Ki)/n_e$$

Where:

q = groundwater flux (m^3/m^2/time)
K = effective hydraulic conductivity (2.5 x 10^{-5} m/s)
i = horizontal hydraulic gradient (0.005 m/m)
n_e = effective soil porosity (0.3 typical for a sandy soil, Freeze and Cherry, 1979)

Using the above values, the average linear groundwater velocity at the Subject Lands is estimated to be approximately 13.0 m/year (4.13 x10^{-7} m/sec).

5.3 On-Site Infiltration

The geotechnical report completed by PML provides infiltration rates for the "major near surface soil units" at the Subject Lands. The report states an infiltration rate of 30 mm/hr for the sand/sand and gravel units beneath the Subject Lands.

Any soils brought to the Subject Lands for grading are required to have the same or better infiltration rates as current conditions.

5.4 Groundwater Chemistry

Groundwater samples were submitted and analyzed for general chemistry parameters in order to document the groundwater chemistry prior to development. The analytical results are summarized in **Table 3**. Laboratory Certificates of Analysis are provided in **Appendix F**.

Anions and Nutrients

As shown, detectable concentrations of Ammonia, Chloride, Fluoride, Nitrate, and Sulfate were reported for the samples collected from the two monitoring wells. The highest concentration of Nitrate (6.29 mg/L) was reported for monitoring location MW-4, which is located hydraulically up-gradient within the Subject Lands, adjacent to the PSW at the north end of the property. A nitrate concentration of 1.59 mg/L was reported at monitoring location MW-2 which is interpreted as hydraulically down-gradient.

Dissolved Metals

The following parameters were detected in one or both of the groundwater samples collected from the Subject Lands:

- Barium
- Calcium
- Copper
- Magnesium
- Potassium
- Silicon
- Sodium
- Strontium
- Zinc

Sodium and Chloride concentrations reported from monitoring location MW-2 were 60.4 mg/L and 76.0 mg/L, respectively. These concentrations were interpreted to results from road salt application on the roadway south of the Subject Lands. Concentrations of these parameters at monitoring location MW-4 were reported as 21.6 mg/L and 35.9 mg/L, respectively, indicating a reduction of the concentrations across the Subject Lands from south to north.

6.0 SOURCE WATER PROTECTION

The identification and assessment of vulnerable areas required through the Source Water Protection process has been completed for the Grand River Source Protection Area through a series of technical studies undertaken by the Lake Erie Region Source Protection Committee (LERSPC), the Grand River Conservation Authority, and the City of Guelph, which have delineated the areas requiring protection and identifying land use activities that could pose potential threats. The results of those studies are summarized in Chapter 8 of the Grand River Source Protection Area Assessment Report (LERSPC, 2015).

6.1 Wellhead Protection Area (WHPA) Vulnerability Assessment

With respect to source water protection, Wellhead Protection Areas (WHPA) are established for each municipal supply well through the delineation of well "capture zones." Part V of the Clean Water Act (CWA) Technical Rules (MOE, 2006) provides specific details for WHPA delineation.

The March 2010 City of Guelph Source Protection Project Groundwater and Surface Water Vulnerability Report defines a capture zone as:

> *"the projection onto the land surface of the portion of the three-dimensional volume through which groundwater travels towards a water supply well within a defined period of time."* (AquaResource Inc., 2010)

WHPAs are divided into four categories based on travel time to the well, and are summarized in the table below.

Category	Description
WHPA-A	A radius of 100 m from the outer boundary of the well
WHPA-B	Time-of-travel to the well ≤2 years (not including WHPA-A)
WHPA-C	Time-of-travel to the well is >2 years, but ≤ 5 years
WHPA-D	Time-of-travel to the well is >5 years, but ≤ 25 years

Based on data from GRCA Web-Mapping software, the majority of the Subject Lands are located within WHPA-B (≤ 2 year time-of-travel) of the nearby Burke municipal supply well. The southwest corner of the Subject Lands is observed to be located within WHPA-A (100 m zone), as shown on **Figure 11**.

The category of the WHPA and the characterization of the aquifer in terms of its susceptibility to surface/near surface sources of contamination allows for the calculation of a vulnerability score within a WHPA, which ranges from 2 to 10 (where 10 represents the highest vulnerability) (AquaResource Inc., 2010). Preferential pathways are also taken into consideration during the establishment of vulnerability scores, as they can allow contaminants to bypass natural features which protect the aquifer.

Both the vertical movement (intrinsic vulnerability) and horizontal movement (WHPA time-of-travel) of groundwater were incorporated into the establishment of the WHPA vulnerability scores. Usually, the most vulnerable areas in a WHPA (score of 8 to 10) are in WHPA-B (≤2 year time-of-travel) (Lake Erie Region Source Protection Committee, 2015).

As illustrated in **Figure 12**, the Subject Lands have been designated with three different WHPA vulnerability scores. A vulnerability score of 8 (considered moderate to high) has been assigned to more than half of the Subject Lands area, which is shown to extend toward the northern portion of the Subject Lands and beyond, into the wetland. The southeast corner of the Subject Lands has been assigned a moderate vulnerability score of 6, which implies that groundwater sources are adequately protected from surface contamination. Due to the close proximity to the Burke municipal supply well (approximately 60 m southwest of the Subject Lands), the southwest portion of the Subject Lands has been assigned a WHPA vulnerability score of 10, which represents the highest vulnerability.

6.1.1 Intrinsic Aquifer Vulnerability (IAV)

Intrinsic vulnerability of an aquifer is based on the idea that the natural environment (i.e. properties of the surface and subsurface including the unsaturated zone material, topography, depth to water table or depth to aquifer, preferential pathways, etc.) can provide some degree of protection against groundwater contamination from the surface, but does not take into consideration the properties of the contaminant itself (Liggett, Lapcevic, & Miller, May 2011). A map of intrinsic vulnerability is generated based on interpolating data between associated wells to generate a numerical score or index, with consideration given to observed static water levels, the overburden soil type, and the thickness of the unit above the aquifer. The generated maps are based on contaminant travel time from the ground surface through the subsurface and to the underlying contributing aquifer (AquaResource Inc., 2010).

Figure 13 illustrates the Subject Lands in relation to the City of Guelph with respect to intrinsic vulnerability. According to the GRCA, the intrinsic vulnerability of the aquifer at the Subject Lands has been designated a score of medium, which represents the susceptibility of the aquifer to contamination.

6.2 Significant Groundwater Recharge Areas (SGRA)

Groundwater recharge occurs where precipitation and snowmelt infiltrate into the ground to feed aquifers, watercourses, and wetlands. Significant Groundwater Recharge Areas (SGRAs) are typically associated with coarse-grained soils (i.e. sands and gravels) covering upland areas on the landscape. SGRA vulnerability scores of 2, 4, or 6 are assigned to areas which are designated as low, medium, or high SGRA vulnerability areas, respectively.

Based on the available GRCA online GIS data, the Subject Lands are depicted within an SGRA with an assigned medium vulnerability score of 4, on shown on **Figure 14.**

6.3 Potential Groundwater Quality Impacts

According to the Grand River Source Protection Plan, the analysis of the historical raw groundwater chemistry in each municipal well system for the City of Guelph has been used to determine whether any contaminants are present, and whether they have contributed to a decline in drinking water quality (Grand River Conservation Authority, 2015). Subsequently, zones of Issue Contributing Areas (ICA) were developed to define areas where past or current activities have or are likely to adversely affect the quality of drinking water in a given municipal well in which contaminants have already been measured at elevated levels.

An ICA is defined by the Grand River Source Protection Plan as:

> *"The area within which activities have or are likely to contribute to the elevated contaminant at the well...in most cases, an ICA is the 25 year time-of-travel capture zone."* (Grand River Conservation Authority, 2015)

According to GRCA online GIS data, the Subject Lands are not located within an Issue Contributing Area (ICA).

Within the Study Area are lands designated as being within the ICA (**Figure 15**) of the Membro municipal supply well, located approximately 5 km northwest of the Subject Lands. The primary groundwater contaminant of concern within the Membro well was identified to be trichloroethylene (TCE), at which concentrations have been measured to be approximately half of the Ontario Drinking Water Quality Standard (ODWSQ) of 5 µg/L, with an increasing trend (Lake Erie Region Source Protection Committee, 2015). Based on the intended redevelopment into residential land use, TCE will be not be used or stored on-Site and therefore no adverse impacts to groundwater quality are anticipated.

In addition, elevated concentrations of contaminants associated with road salt application were identified as a concern to groundwater quality within the ICA (Lake Erie Region Source Protection Committee, 2015). The application of road salt and the handling and storage of road salt are prescribed drinking water threats under the Clean Water Act (CWA). Road salt as a drinking water threat refers to any product containing sodium and/or chloride that is used to maintain roads and pedestrian areas.

The MOECC Tables of Drinking Water Threats identify sodium and chloride as contaminants that could make their way into surface and groundwater from road salt application, storage and handling. At typical concentrations in drinking water, sodium and chloride are not risks to human health. However, at concentrations greater than 20 mg/L, sodium intake may pose a health concern for people with dietary restrictions. At a concentration of 250 mg/L, chloride imparts a salty taste to drinking water.

Classifying the application of road salt as a significant drinking water threat is dependent on vulnerability zones, vulnerability score and the total impervious surface area. Although the Subject Lands are not located within an ICA, it is anticipated that the imperviousness of the Subject Lands will increase as a result of the proposed residential development and that road salt application will be required thereafter. Because the Subject Lands are located within an SGRA of medium vulnerability (i.e. vulnerability score of 6), it is reasonable to conclude that a Salt Management Plan (SMP) may be required. The need for a SMP, however, should be re-visited once a development plan for the Subject Lands has been finalized in order to help mitigate the effect of road salt on groundwater quality.

7.0 IMPACT ASSESSMENT

7.1 Potential Private Well Interference

An MOECC well record search indicates the presence of 40 domestic or livestock private water supply wells within a 500 m radius of the Subject Lands. A review of available well records determined that the shallowest depth at which water was encountered during the drilling of a domestic well was approximately 15.5 m bgs (51 feet), within a gravel unit (at MOECC#: 6702583, located approximately 330 m southwest of the Subject Lands). Based on the distance from the Subject lands to this shallow domestic supply well (>300 m), MTE does not anticipate any unreasonable well interference during construction activities.

Two municipal wells fields, Burke and Carter, are located within a 2 km radius of the Subject Lands. In particular, the Burke well is located approximately 60 m southwest of the Subject Lands. GRCA online GIS mapping indicates that the majority of the Subject Lands is categorized within WHPA-B, where a small portion of the southwest corner of the Subject Lands is located within the Burke well WHPA-A. A review of available well records determined the Burke and Carter wells to be screened within bedrock at depths of approximately 79.9 m bgs and 20.7 m bgs, respectively. Construction of basements, if included in the development, will not extend to these depths, and therefore it is unlikely that any well interference will occur within the municipal wells located near the Subject Lands during the construction process.

7.2 Groundwater Impacts

Static groundwater levels were measured at a depths ranging from above ground surface (representing saturated conditions at ground surface) (MW-4) to 3.7 m bgs (MW-2). The maximum groundwater elevation measured during this investigation was approximately 334.0 mAMLS which was observed at MW-4 in May 2017 during the spring freshet. MW4 is located in the northeast corner of the Subject Lands in the vicinity of the PSW. It is noted that the proposed development includes a 30 m horizontal separation from the limit of the PSW, as determined by NRSI, and MW-4 is located within this buffer zone; therefore the maximum groundwater elevation from

MW-3 was used, which is located approximately 30 m south of the buffer zone. The maximum groundwater elevation measured in MW-3 was 333.3 mAMSL, representing high spring time water levels measured in 2017 and 2018.

It is understood that additional fill will be introduced to further raise the grade on Subject Lands to an elevation of approximately 336.7 mAMSL prior to the construction of the proposed development. This provides an anticipated total separation of 3.4 m between the ground surface and top of the high water table. The lowest basement floor is anticipated to be at an approximate elevation of 334.22mAMSL. This provides a 0.89m separation distance between the high ground water table and the basement floor elevation which exceeds the City of Guelph Development Engineering Manual minimum separation distance of 0.5 m between basement elevations and the seasonal high groundwater elevation (COGECIS, 2016).

If, upon final confirmation of building design and Site grading, it is anticipated that the water table may be intercepted during construction activities, the need for construction dewatering will have to be assessed, which may result in the need for a Permit to take Water (PTTW) or Environmental Activity Sector Registry (EASR).

Further assessment may be required once design details are finalized and could be conducted during the detailed design stage of the development process.

7.3 Wetland Impacts

The groundwater flow direction across the Subject Lands was inferred as southwesterly, with the wetland along the north property boundary representing an expression of the groundwater table at ground surface. Therefore, it is apparent that the wetland contributes to the shallow groundwater flow.

During construction, cut-off collars may be used in excavated utility trenches to maintain natural flow regimes across the property and preserve flow conditions to the existing wetland feature.

8.0 CONCLUSIONS

Based on this hydrogeological investigation, MTE offers the following findings:

Geology

- Stratigraphic conditions beneath the Subject Lands consist of coarse-grained (sand or sand and gravel) materials characteristic of a drumlin landform; and
- Bedrock is anticipated to be approximately 18 to 30 m bgs.

Hydrogeology

- The groundwater table was encountered at a depth ranging between above ground surface (representing saturated conditions at ground surface) to 3.7 m bgs, at a maximum elevation of approximately 334.0 mAMSL during this investigation;
- The wetland located along the north property boundary appears to contribute to the local shallow groundwater flow;
- The local groundwater flow direction is inferred to be south-southwesterly while the regional groundwater flow direction is inferred as northerly;
- The horizontal hydraulic gradient of the groundwater table beneath the Subject Lands is estimated to be 0.005 m/m;
- Maximum and minimum hydraulic conductivity values for the shallow, unconfined groundwater aquifer beneath the Subject Lands were calculated to range between 2.1×10^{-6} m/sec (0.18 m/day) to 2.1×10^{-4} m/sec (17.7 m/day), with a geometric mean of 2.5×10^{-5} m/sec (2.14 m/day); and
- The groundwater velocity of the shallow groundwater aquifer beneath the Subject Lands was estimated to be approximately 13.0 m/year.

Impact Assessment and Construction Considerations

- Based on the measured depths to groundwater at the Subject Lands during this investigation, and the understanding that the grade of the Subject Lands is expected to be raised to approximately 336.7 mAMSL;
- Basement floors will have a minimum 0.89m separation distance to the high ground water table;
- If, upon final confirmation of building design and Site grading, it is anticipated that the water table may be intercepted during construction activities, the need for construction dewatering will have to be assessed, which may result in the need for a Permit to take Water (PTTW) or Environmental Activity Sector Registry (EASR);
- The geotechnical report completed by PML for the Subject Lands reports a infiltration rate of 30 mm/hr for the sand/sand and gravel units beneath the Subject Lands; and
- Impacts to the municipal aquifer from the proposed development are not anticipated due to the shallow depth of construction and the depth of completion of the closest municipal well.

As construction details were not available at the time of this report, assumptions were made for preliminary calculations. Further assessment may be required once design details are finalized.

8.1 Recommendations and Monitoring

Based on findings of this hydrogeological investigation, MTE offers the following recommendations:

- Continuous groundwater monitoring should be ongoing, updated and utilized during final design of the development as well as updated information utilized during the design of the site plan;
- During the development application process, existing on-site groundwater monitoring wells be maintained in accordance with Ontario Regulation 903 (as amended);
- Monitoring wells located within proposed construction areas will need to be decommissioned in accordance with Ontario Regulation 903 (as amended);
- Soils brought to the Subject Lands for grading must have the same or better infiltration rates as the current conditions;
- Based on policies outlined in the GRSPP, a Salt Management Plan is required for the Subject Lands, which will be undertaken by MTE during the final development design stages; and
- The use of cut-off collars during construction will assist in maintaining natural flow patterns across the property and preserve flow conditions to the existing wetland feature.

9.0 LIMITATIONS

Services performed by **MTE Consultants Inc.** (MTE) were conducted in a manner consistent with the level of care and skill ordinarily exercised by members of the Environmental Engineering & Consulting profession. No other warranty or representation expressed or implied as to the accuracy of the information, conclusions or recommendations is included or intended in this report.

This report was completed for the sole use of MTE and Crescent Homes. The assignment was carried out in accordance with the Scope of Work described in Section 1.1 as reviewed with and agreed to by the Client. MTE makes no representation that the present report has dealt with all of the important environmental issues, except as provided in the Scope of Work. This report is not intended to be exhaustive in scope or to imply a risk-free facility. As such, this report may not deal with all issues potentially applicable to the Site and may omit aspects which are or may be of interest to the reader.

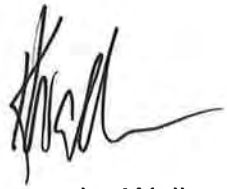
In addition, it should be recognized that a soil sample or groundwater level measurement represents one discrete portion of the Site at the time it is collected, and that the findings of this report are based on conditions as they existed during the time period of the investigation.

Any use which another party makes of this report, or any reliance on, or decisions to be made based upon it, are the responsibility of such parties. MTE accepts no responsibility for liabilities incurred by or damages, if any, suffered by another party as a result of decisions made or actions taken, based upon this report. Others with interest in the Site should undertake their own investigations and studies to determine how or if the condition affects them or their plans.

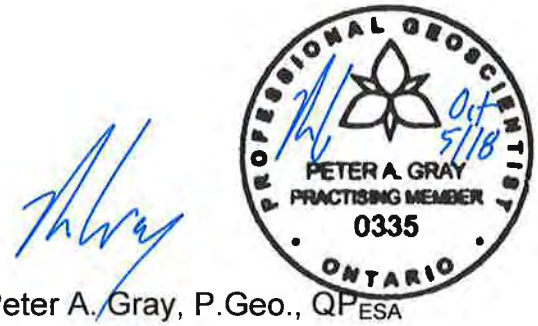
It should be recognized that the passage of time may affect the views, conclusions and recommendations (if any) provided in this report because environmental conditions of a property can change, along with regulatory requirements. Should additional or new information become available, MTE recommends that it be brought to our attention in order that we may determine whether it affects the contents of this report.

Respectfully Submitted,

MTE CONSULTANTS INC.



Kassandra Wallace, B.B.R.M.
Environmental Scientist



Peter A. Gray, P.Geo., QP$_{ESA}$
VP, Senior Hydrogeologist

KLW:dem

10.0 REFERENCES

Armstrong, D.K. and Carter, T.R, 2010: *The subsurface Paleozoic stratigraphy of southern Ontario:* Ontario Geological Survey, Special Volume 7, 301 p;

Butler, J.J., McElwee, C.D., & Liu, W., 1996: Improving the Quality of Parameter Estimates from Slug Tests. Ground Water, 34(3), 480-490;

Butler, J.J., Garnett, E.J., & Healey, J.M., 2003: Analysis of Slug Tests in Formations of High Hydraulic Conductivity. Groundwater Water 41(5), 620-630;

City of Guelph Engineering and Capital Infrastructure Services (COGECIS), 2016: Development Engineering Manual, Version 1, p. 28;

Credit Valley Conservation and Toronto and Region Conservation, 2010: *Low Impact Development Stormwater Management Planning and Design Guide – Version 1.0*, Table C1

Freeze, R.A. and Cherry, J.A., 1979: *Groundwater;* Prentice-Hall Inc. Englewood Cliffs, New Jersey;

Grand River Conservation Authority and City of Guelph, 1999, *Torrance Creek Subwatershed Study Management Study;*

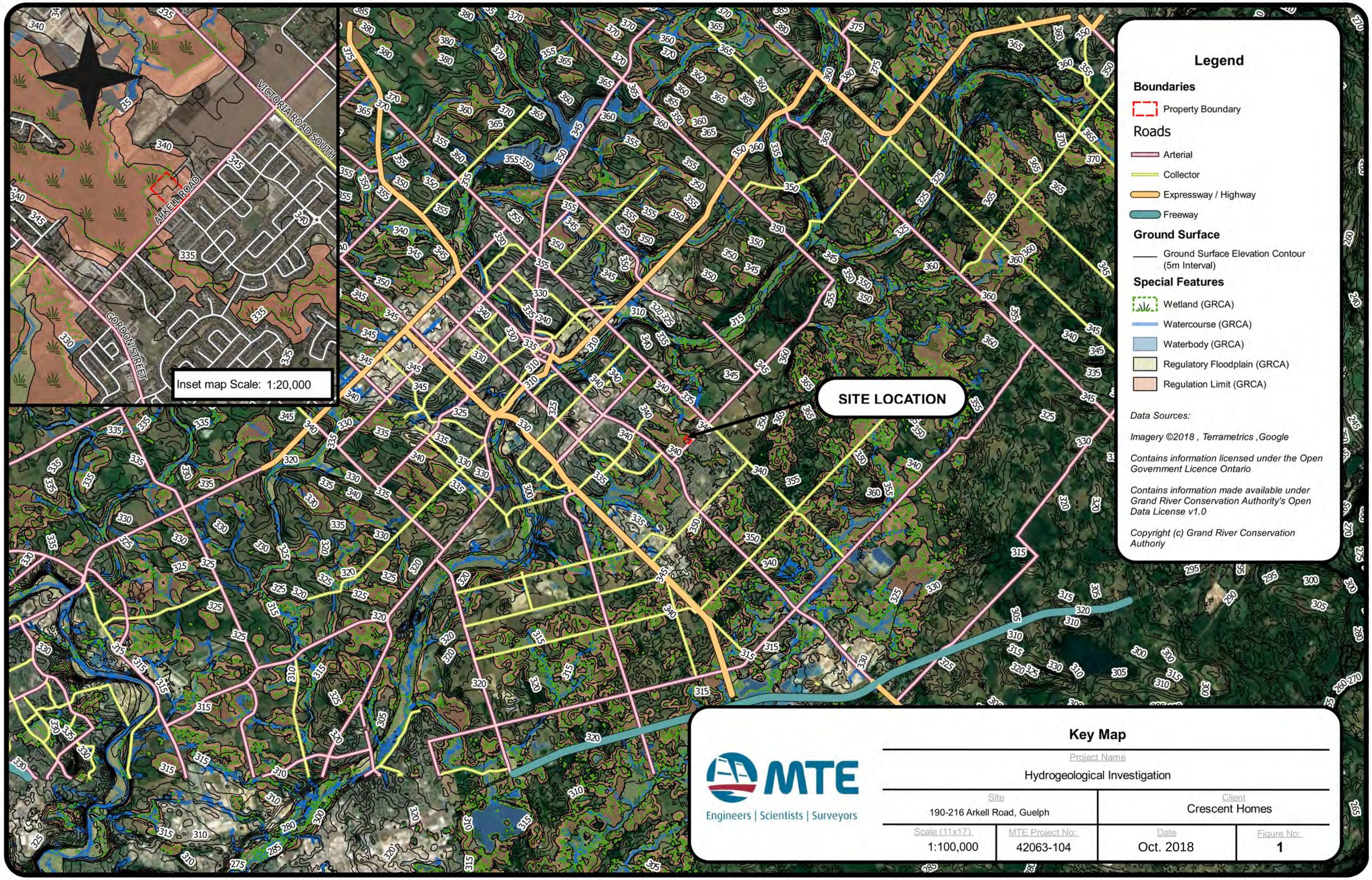
Karrow, P.F., 1983: Quaternary Geology of the Hamilton-Cambridge Area. Ontario Geological Survey. Report 255, 95p;

Lake Erie Region Source Protection Committee (LERSPC), 2015, *Grand River Source Protection Area Approved Assessment Report;*

Peto MacCallum Ltd., 2017, Geotechnical Investigation, Proposed Arkell Road Subdivision, Guelph, Ontario; For Crescent Homes c/o MTE Consultants Inc.; and

Waterloo Hydrogeologic, 2015, *Aquifer Test Pro Software*

FIGURES



Legend

Boundaries

- Property Boundary

Roads

- Arterial
- Collector
- Expressway / Highway
- Freeway

Ground Surface

- Ground Surface Elevation Contour (5m Interval)

Special Features

- Wetland (GRCA)
- Watercourse (GRCA)
- Waterbody (GRCA)
- Regulatory Floodplain (GRCA)
- Regulation Limit (GRCA)

Data Sources:

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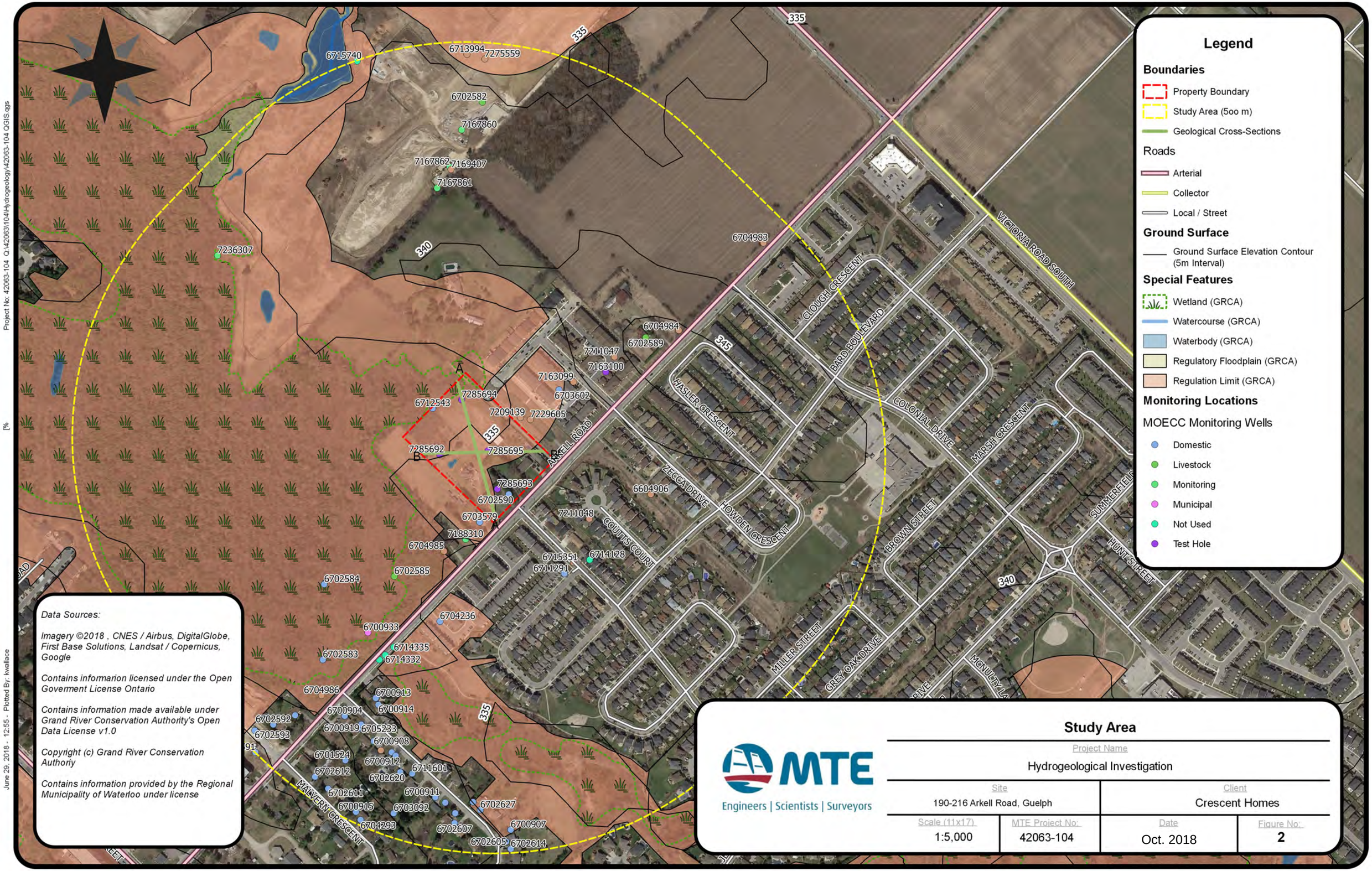
Key Map

Project Name			
Hydrogeological Investigation			
Site: 190-216 Arkell Road, Guelph		Client: Crescent Homes	
Scale (11x17): 1:100,000	MTE Project No: 42063-104	Date: Oct. 2018	Figure No: 1



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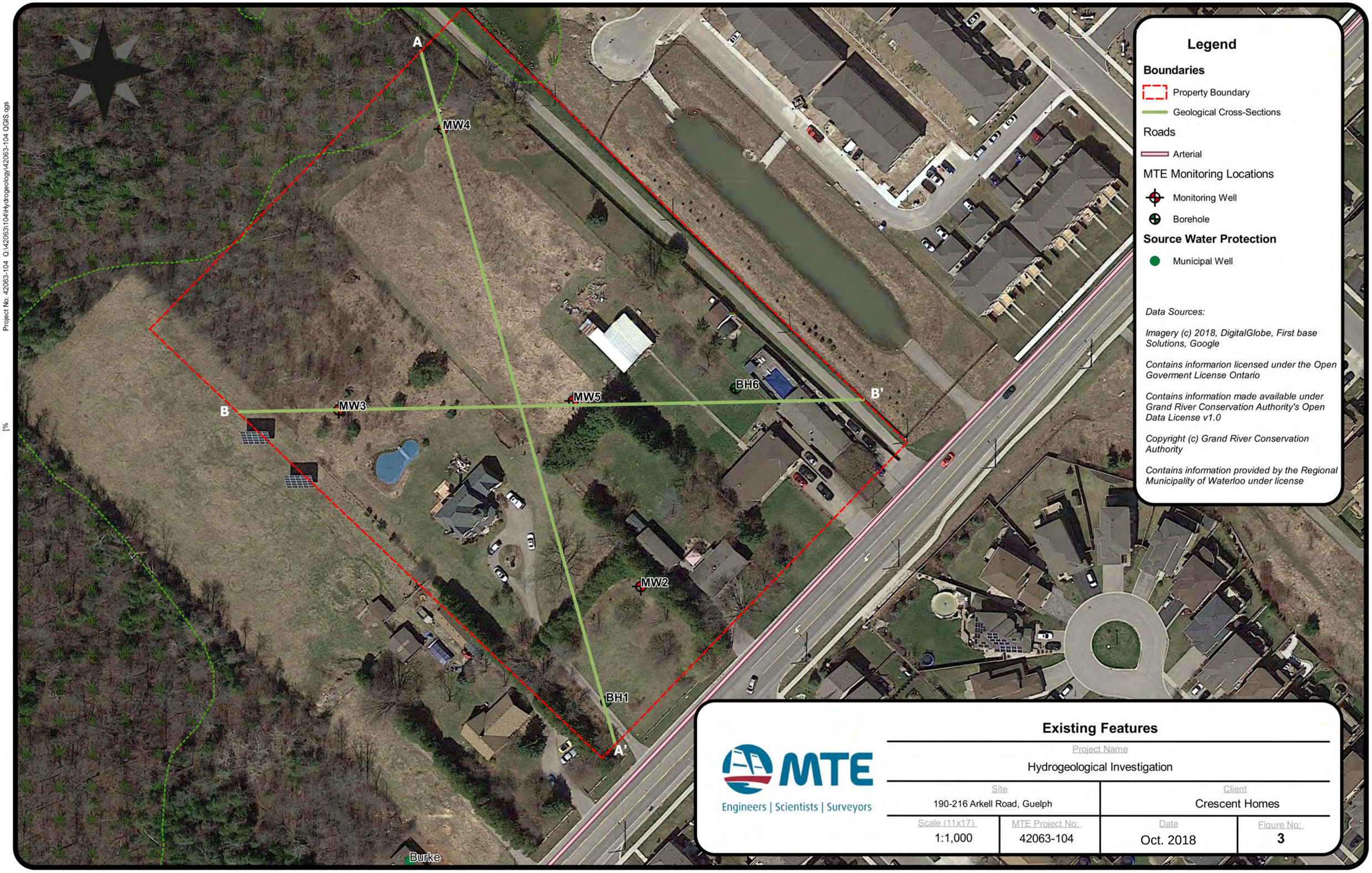

Legend

Boundaries

- Property Boundary
- Geological Cross-Sections

Roads

- Arterial

MTE Monitoring Locations

- Monitoring Well
- Borehole

Source Water Protection

- Municipal Well

Data Sources:

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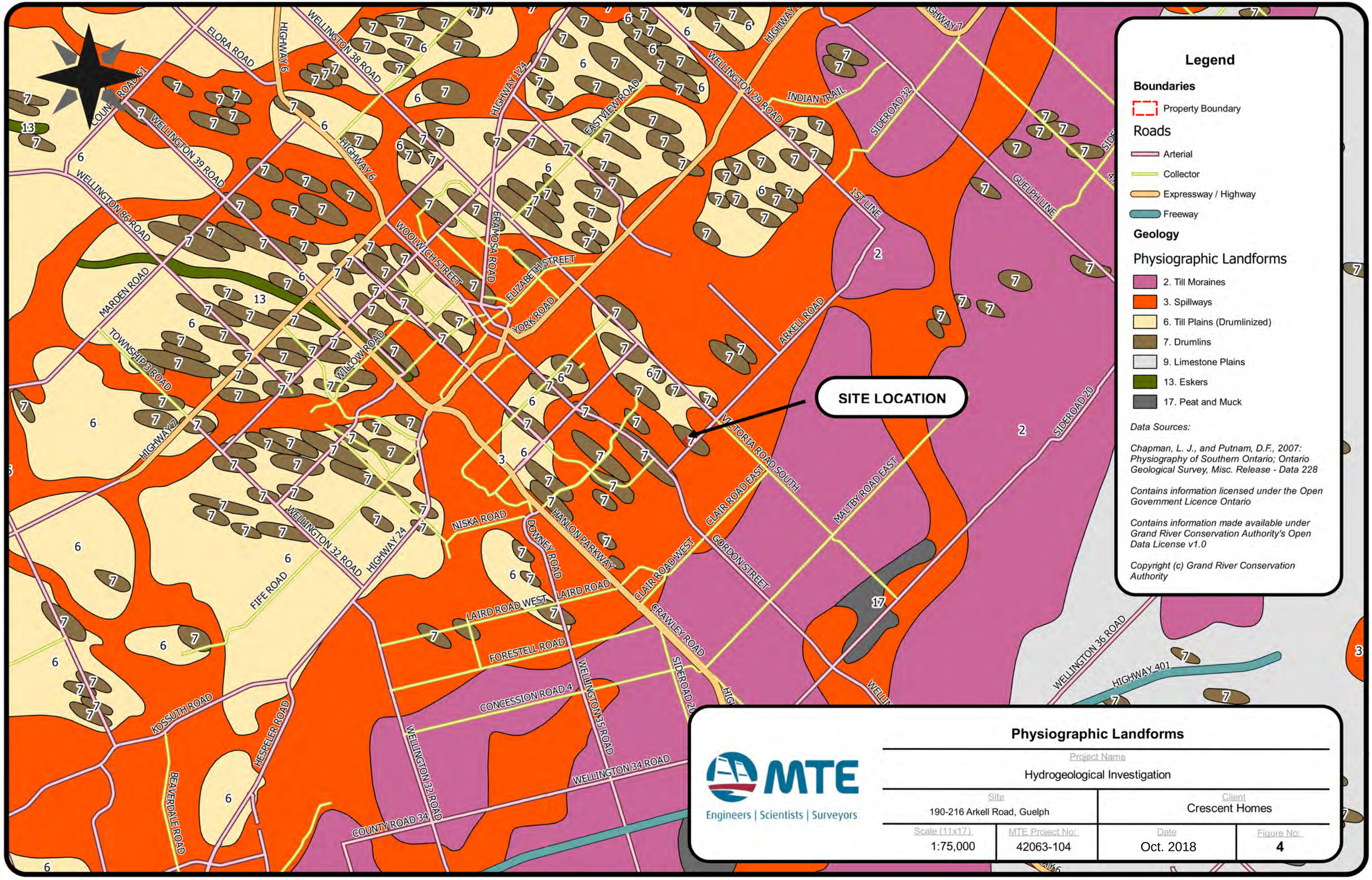
Existing Features

Project Name			
Hydrogeological Investigation			
Site: 190-216 Arkell Road, Guelph		Client: Crescent Homes	
Scale (11x17): 1:1,000	MTE Project No: 42063-104	Date: Oct. 2018	Figure No: 3



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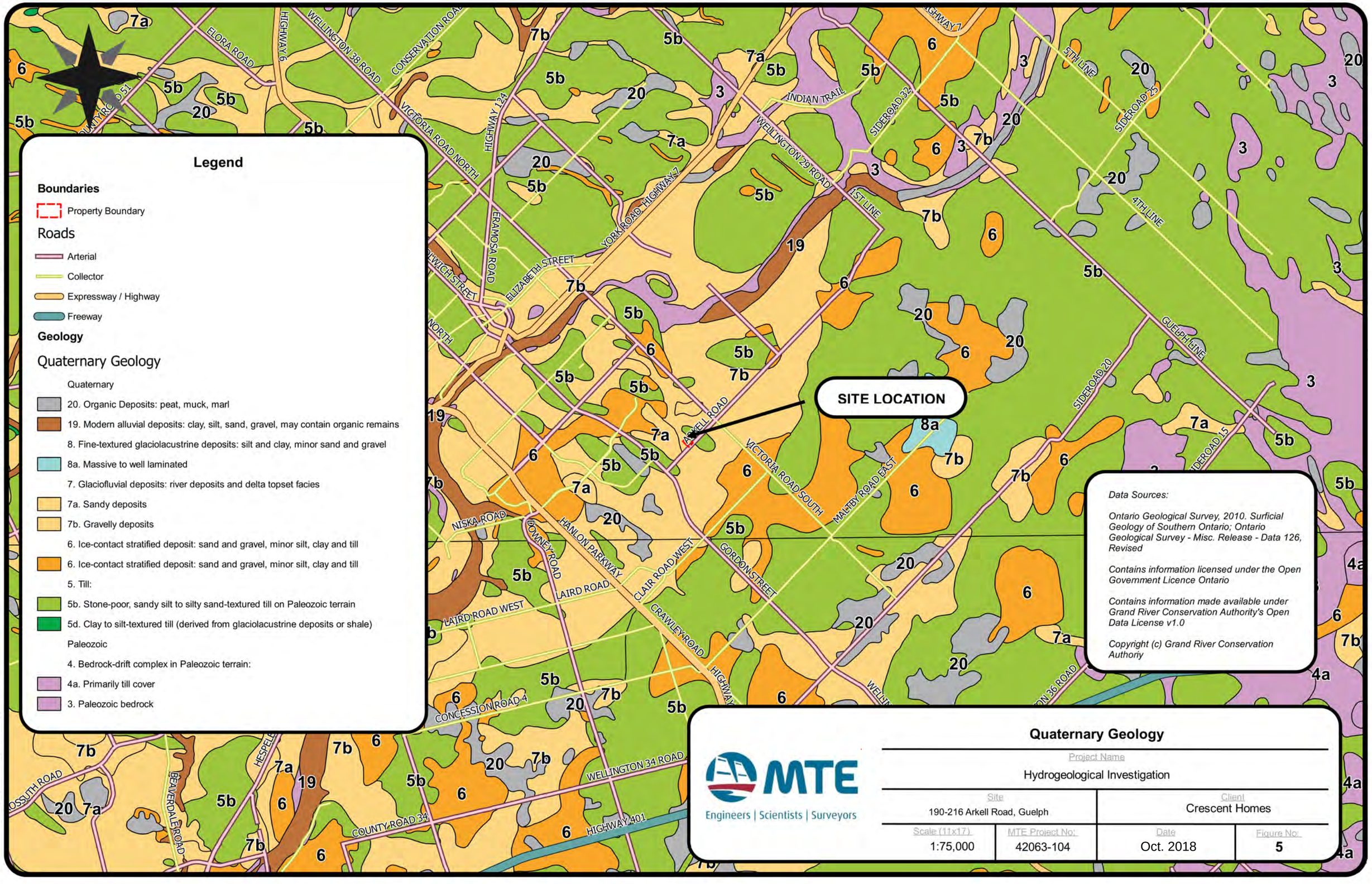
Physiographic Landforms

Project Name			
Hydrogeological Investigation			
Site: 190-216 Arkell Road, Guelph		Client: Crescent Homes	
Scale (11x17): 1:75,000	MTE Project No: 42063-104	Date: Oct. 2018	Figure No: 4



Legend

Boundaries

- Property Boundary

Roads

- Arterial
- Collector
- Expressway / Highway
- Freeway

Geology

Quaternary Geology

Quaternary

- 20. Organic Deposits: peat, muck, marl
- 19. Modern alluvial deposits: clay, silt, sand, gravel, may contain organic remains
- 8. Fine-textured glaciolacustrine deposits: silt and clay, minor sand and gravel
- 8a. Massive to well laminated
- 7. Glaciofluvial deposits: river deposits and delta topset facies
- 7a. Sandy deposits
- 7b. Gravelly deposits
- 6. Ice-contact stratified deposit: sand and gravel, minor silt, clay and till
- 6. Ice-contact stratified deposit: sand and gravel, minor silt, clay and till
- 5. Till:
- 5b. Stone-poor, sandy silt to silty sand-textured till on Paleozoic terrain
- 5d. Clay to silt-textured till (derived from glaciolacustrine deposits or shale)

Paleozoic

- 4. Bedrock-drift complex in Paleozoic terrain:
- 4a. Primarily till cover
- 3. Paleozoic bedrock

Data Sources:

Ontario Geological Survey, 2010. Surficial Geology of Southern Ontario; Ontario Geological Survey - Misc. Release - Data 126, Revised

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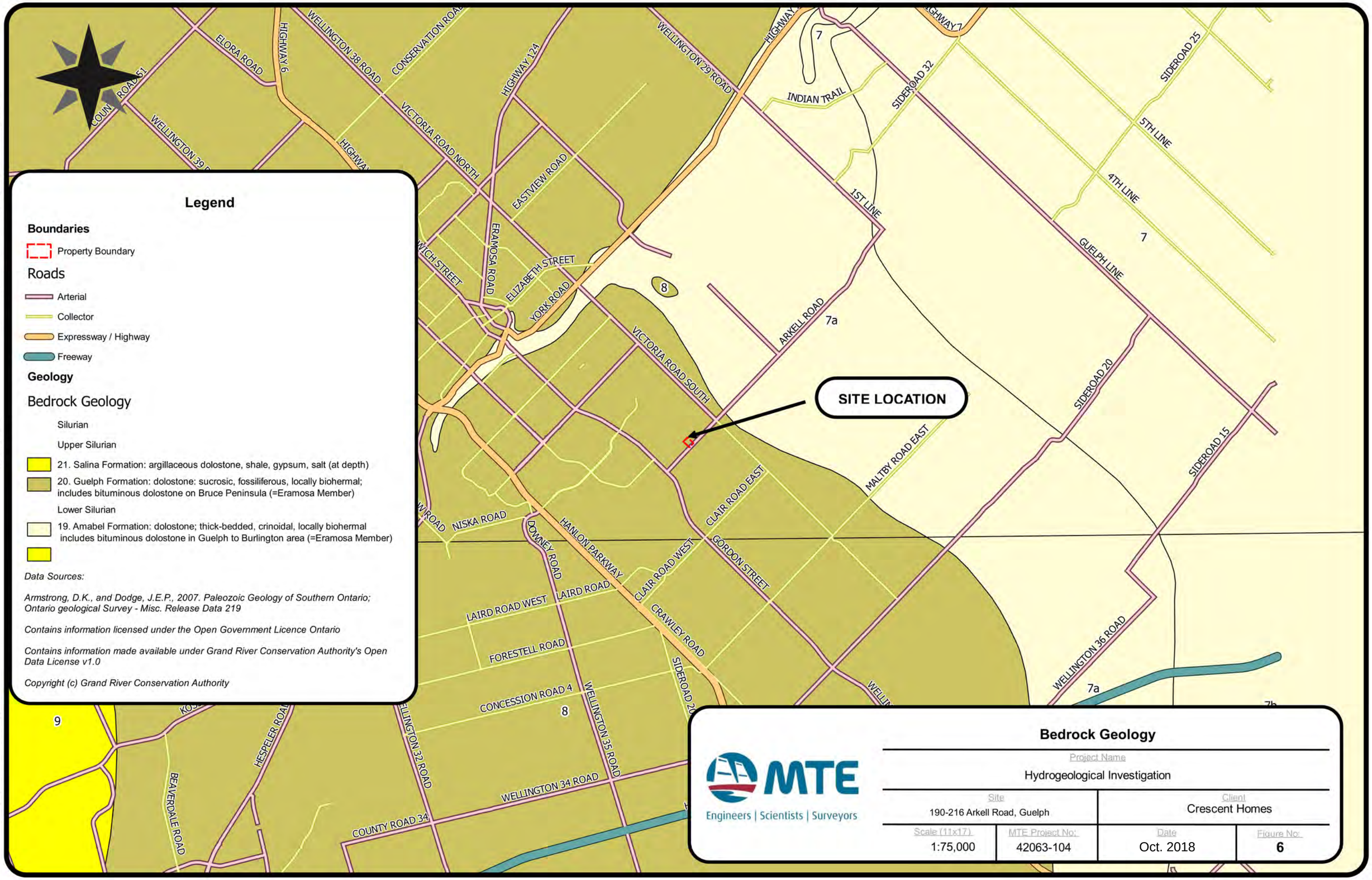
Quaternary Geology

Project Name			
Hydrogeological Investigation			
Site: 190-216 Arkell Road, Guelph		Client: Crescent Homes	
Scale (11x17): 1:75,000	MTE Project No: 42063-104	Date: Oct. 2018	Figure No: 5



Legend

Boundaries

- Property Boundary

Roads

- Arterial
- Collector
- Expressway / Highway
- Freeway

Geology

Bedrock Geology

Silurian

Upper Silurian

- 21. Salina Formation: argillaceous dolostone, shale, gypsum, salt (at depth)
- 20. Guelph Formation: dolostone: sucrosic, fossiliferous, locally biohermal; includes bituminous dolostone on Bruce Peninsula (=Eramosa Member)

Lower Silurian

- 19. Amabel Formation: dolostone; thick-bedded, crinoidal, locally biohermal includes bituminous dolostone in Guelph to Burlington area (=Eramosa Member)

Data Sources:

Armstrong, D.K., and Dodge, J.E.P., 2007. Paleozoic Geology of Southern Ontario; Ontario geological Survey - Misc. Release Data 219

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Bedrock Geology

Project Name			
Hydrogeological Investigation			
Site: 190-216 Arkell Road, Guelph		Client: Crescent Homes	
Scale (11x17): 1:75,000	MTE Project No: 42063-104	Date: Oct. 2018	Figure No: 6

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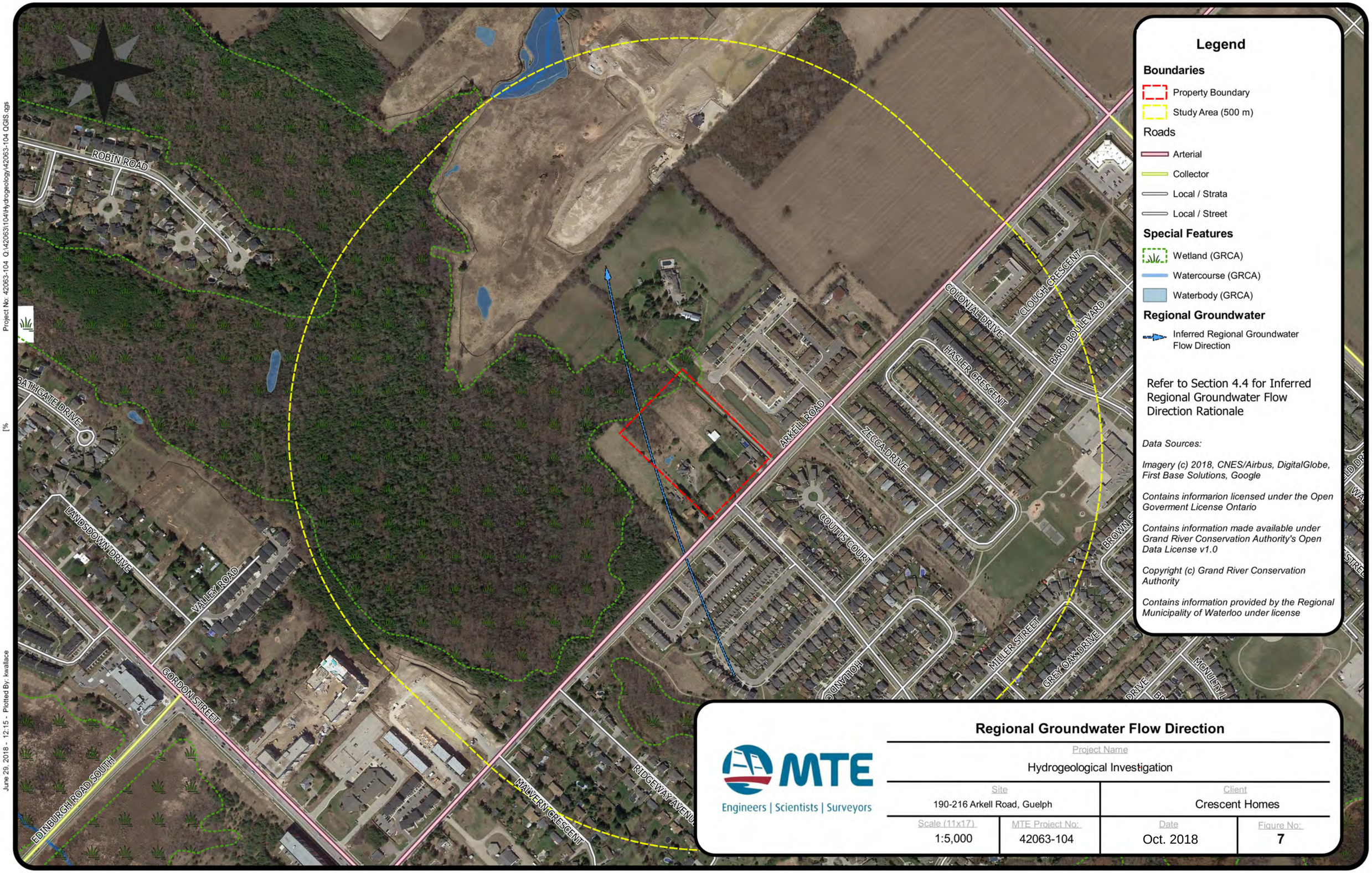

Legend

Boundaries

- Property Boundary
- Study Area (500 m)

Roads

- Arterial
- Collector
- Local / Strata
- Local / Street

Special Features

- Wetland (GRCA)
- Watercourse (GRCA)
- Waterbody (GRCA)

Regional Groundwater

- Inferred Regional Groundwater Flow Direction

Refer to Section 4.4 for Inferred Regional Groundwater Flow Direction Rationale

Data Sources:

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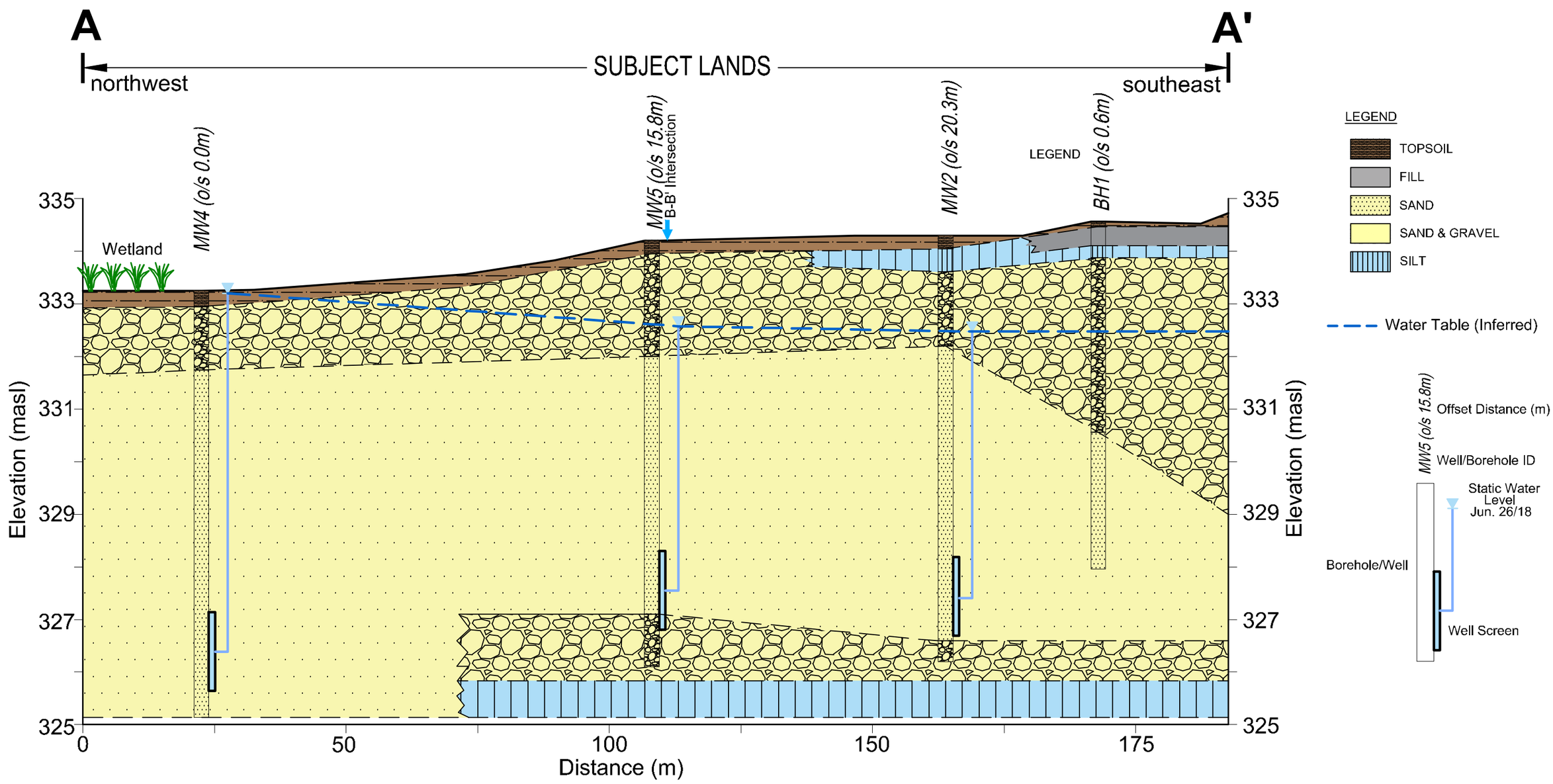
Regional Groundwater Flow Direction

Project Name			
Hydrogeological Investigation			
Site: 190-216 Arkell Road, Guelph		Client: Crescent Homes	
Scale (11x17): 1:5,000	MTE Project No: 42063-104	Date: Oct. 2018	Figure No: 7



Vertical Exaggeration (10X)

Notes:

Geological sequence is based on professional interpretation from the soils encountered during drilling and the geological descriptions provided from the geotechnical consultant. Actual geological conditions may vary between the tested locations.

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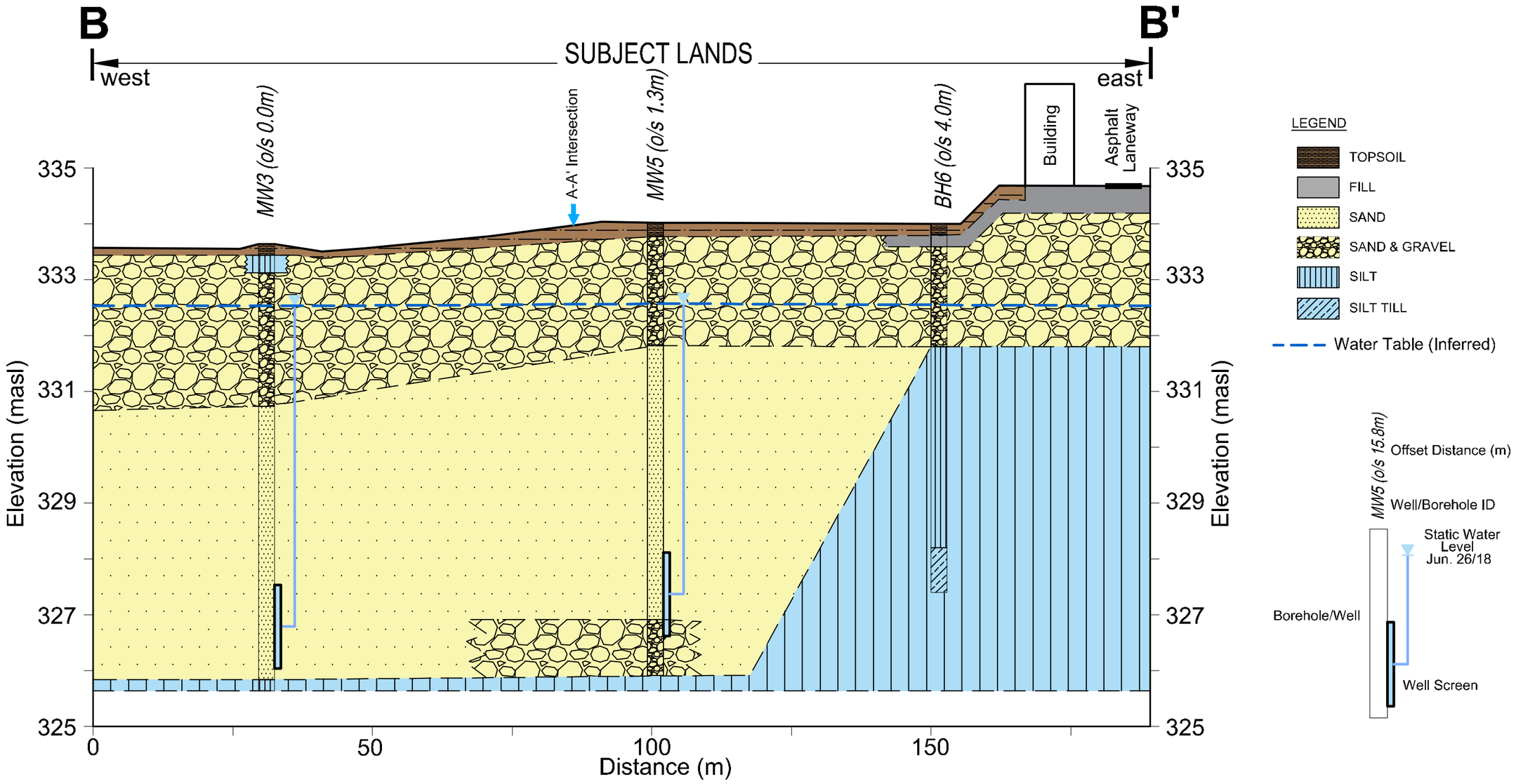
GEOLOGIC CROSS-SECTION A-A'

Project Name			
Hydrogeological Investigation			
Site: 190 - 216 Arkell Road, Guelph, ON		Client: Crescent Homes	
Scale (11x17): As shown	MTE Project No.: 42063-104	Date: Oct. 2018	Figure No.: 8



Vertical Exaggeration (10X)

Notes:

Geological sequence is based on professional interpretation from the soils encountered during drilling and the geological descriptions provided from the geotechnical consultant. Actual geological conditions may vary between the tested locations.

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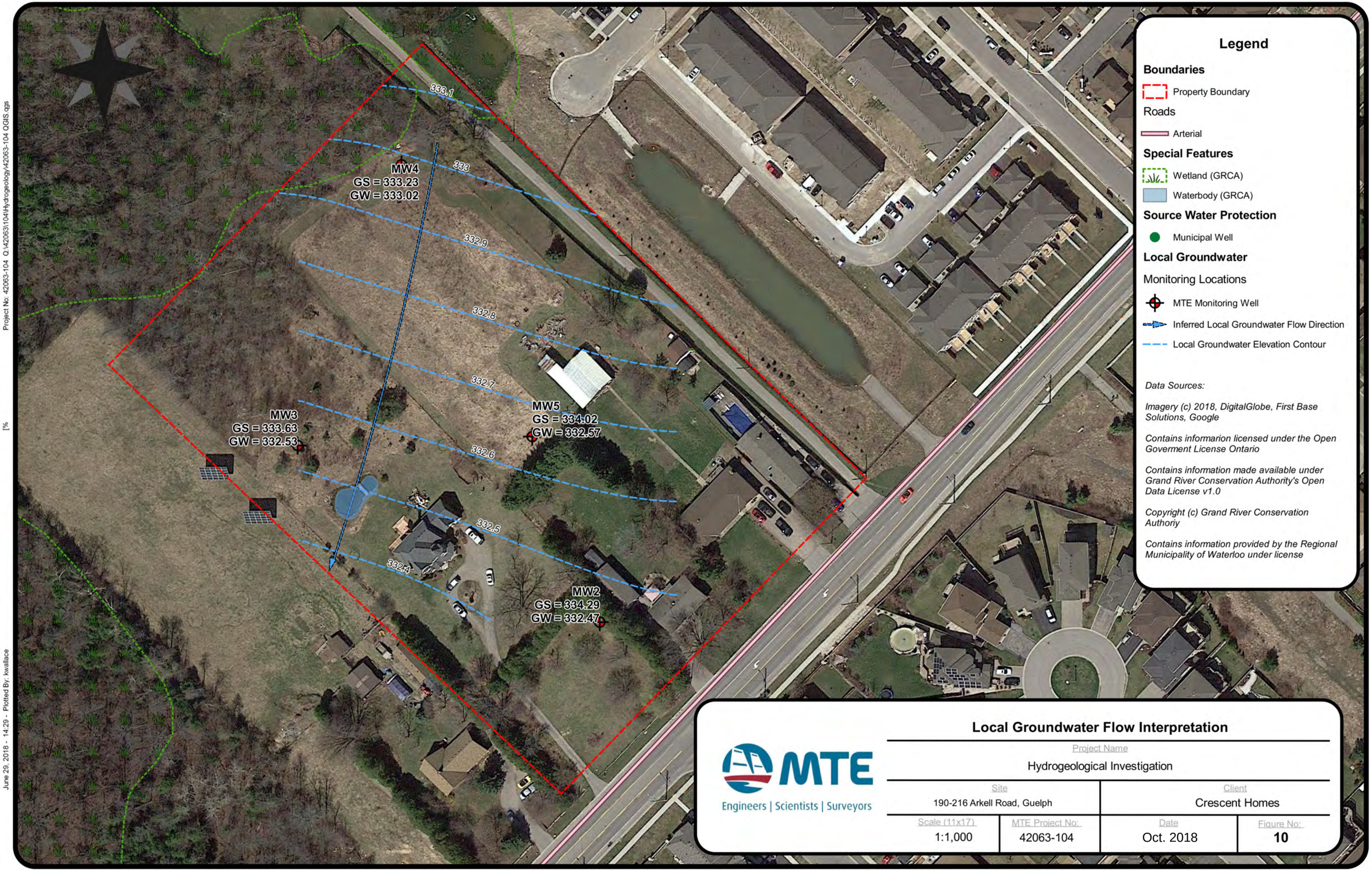
GEOLOGIC CROSS-SECTION B-B'

Project Name			
Hydrogeological Investigation			
Site: 190 - 216 Arkell Road, Guelph, ON		Client: Crescent Homes	
Scale (11x17): As shown	MTE Project No.: 42063-104	Date: Oct. 2018	Figure No.: **9**



Legend

Boundaries

- Property Boundary

Roads

- Arterial

Special Features

- Wetland (GRCA)
- Waterbody (GRCA)

Source Water Protection

- Municipal Well

Local Groundwater

Monitoring Locations

- MTE Monitoring Well
- Inferred Local Groundwater Flow Direction
- Local Groundwater Elevation Contour

Data Sources:

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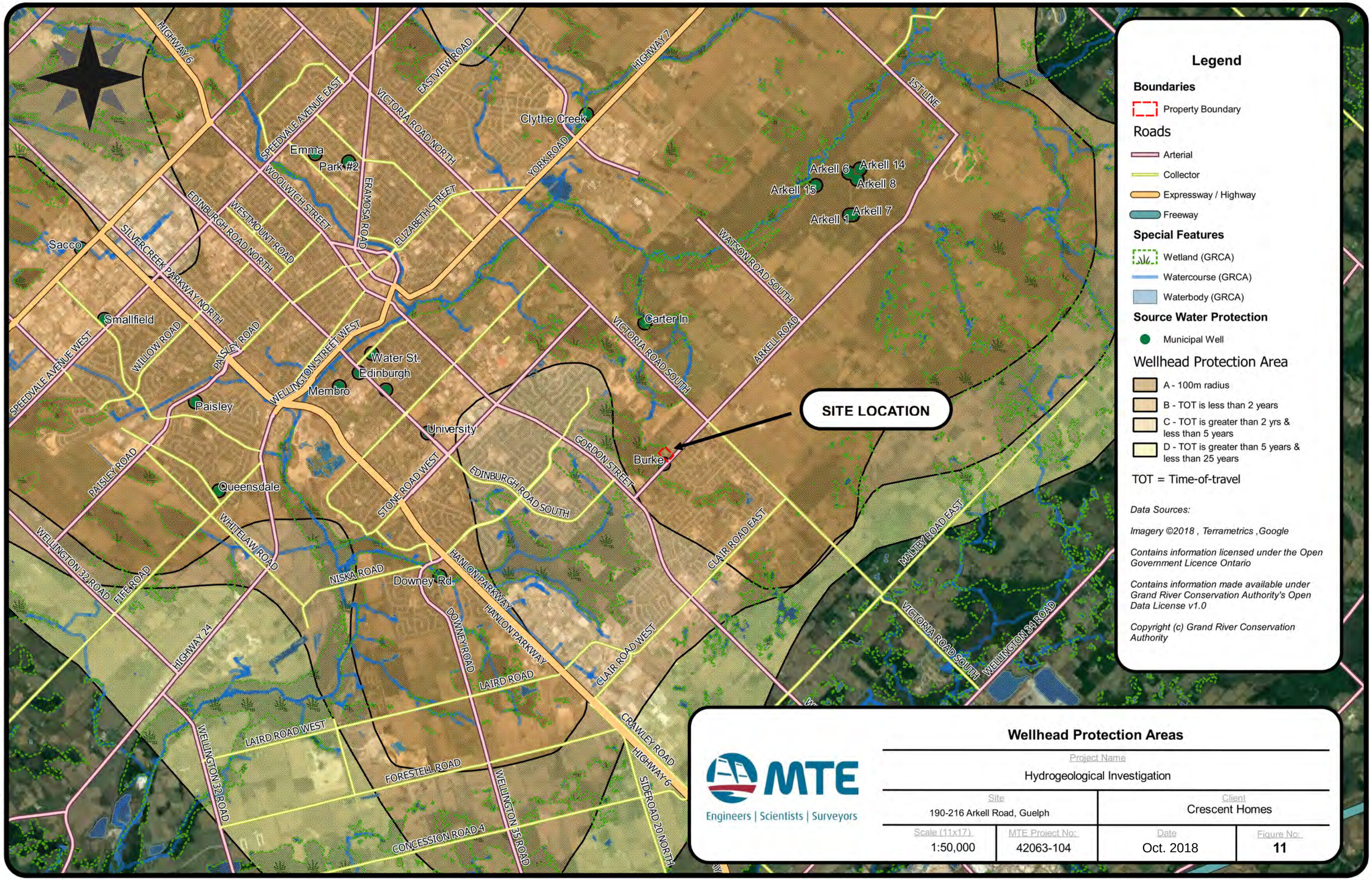
Local Groundwater Flow Interpretation

Project Name			
Hydrogeological Investigation			
Site: 190-216 Arkell Road, Guelph		Client: Crescent Homes	
Scale (11x17): 1:1,000	MTE Project No: 42063-104	Date: Oct. 2018	Figure No: **10**



Legend

Boundaries

- Property Boundary

Roads

- Arterial
- Collector
- Expressway / Highway
- Freeway

Special Features

- Wetland (GRCA)
- Watercourse (GRCA)
- Waterbody (GRCA)

Source Water Protection

- Municipal Well

Wellhead Protection Area

- A - 100m radius
- B - TOT is less than 2 years
- C - TOT is greater than 2 yrs & less than 5 years
- D - TOT is greater than 5 years & less than 25 years

TOT = Time-of-travel

Data Sources:

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Wellhead Protection Areas

Project Name			
Hydrogeological Investigation			
Site: 190-216 Arkell Road, Guelph		Client: Crescent Homes	
Scale (11x17): 1:50,000	MTE Project No: 42063-104	Date: Oct. 2018	Figure No: 11

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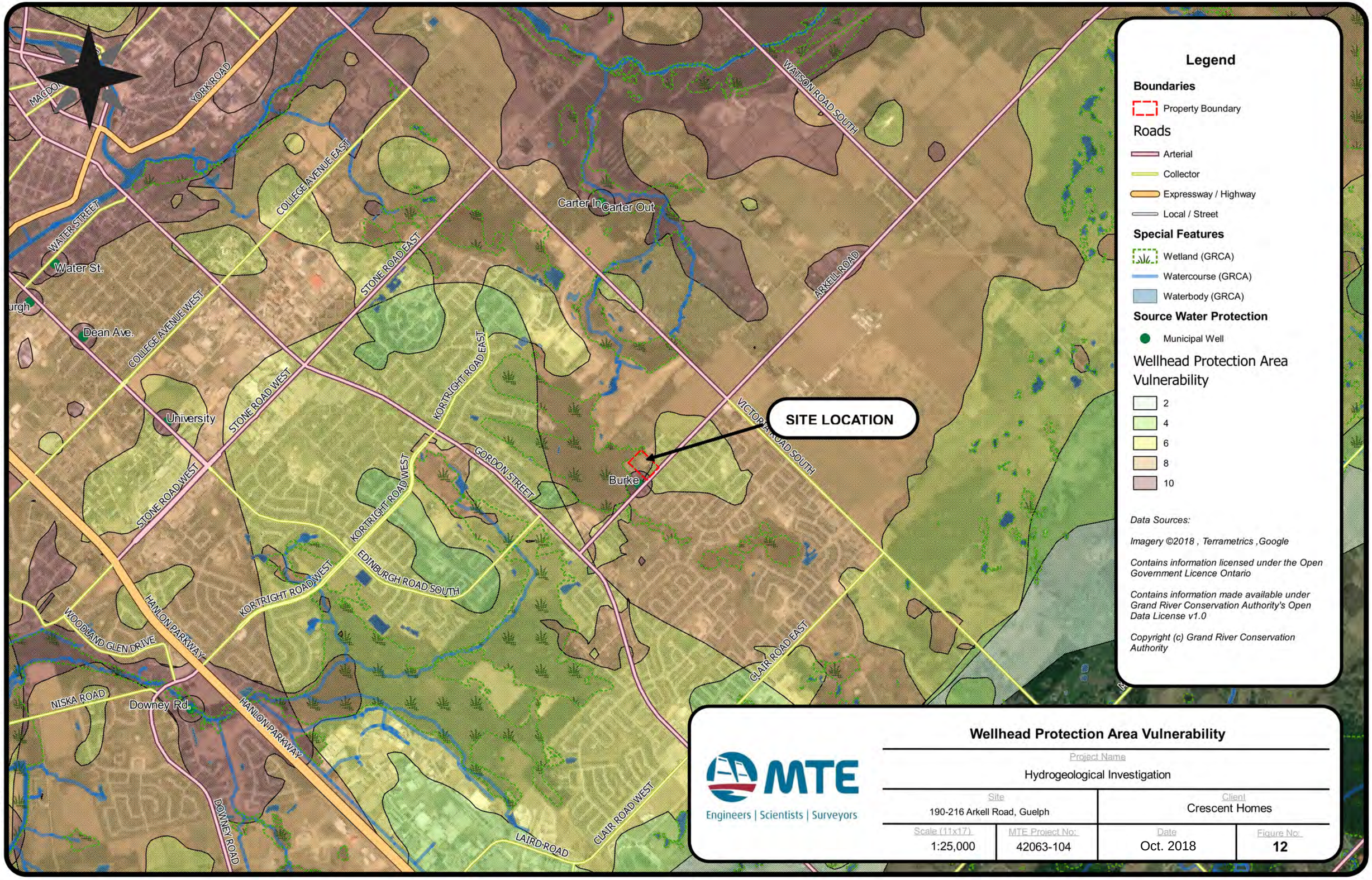

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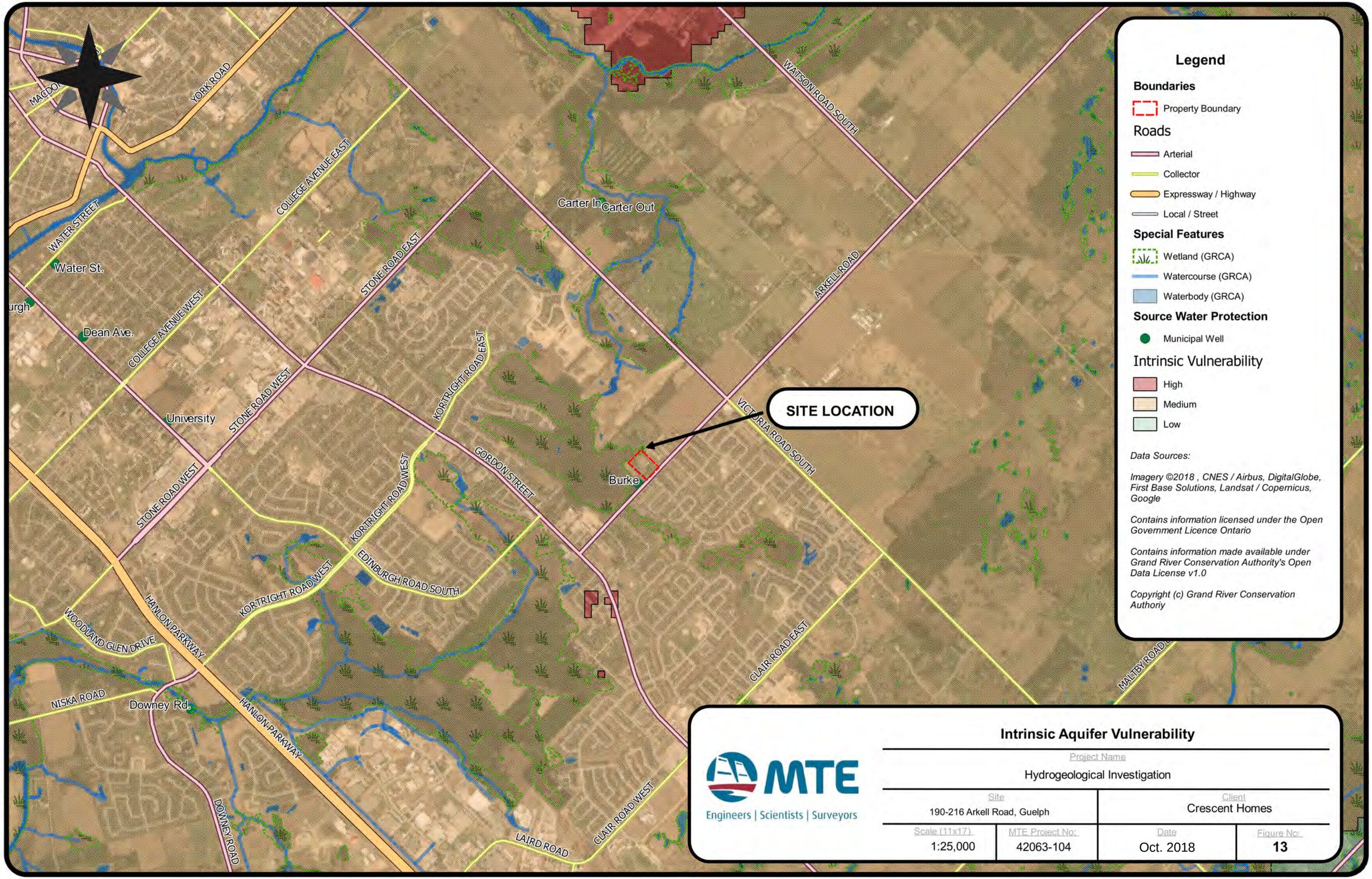
Wellhead Protection Area Vulnerability

Project Name			
Hydrogeological Investigation			
Site: 190-216 Arkell Road, Guelph		Client: Crescent Homes	
Scale (11x17): 1:25,000	MTE Project No: 42063-104	Date: Oct. 2018	Figure No: **12**



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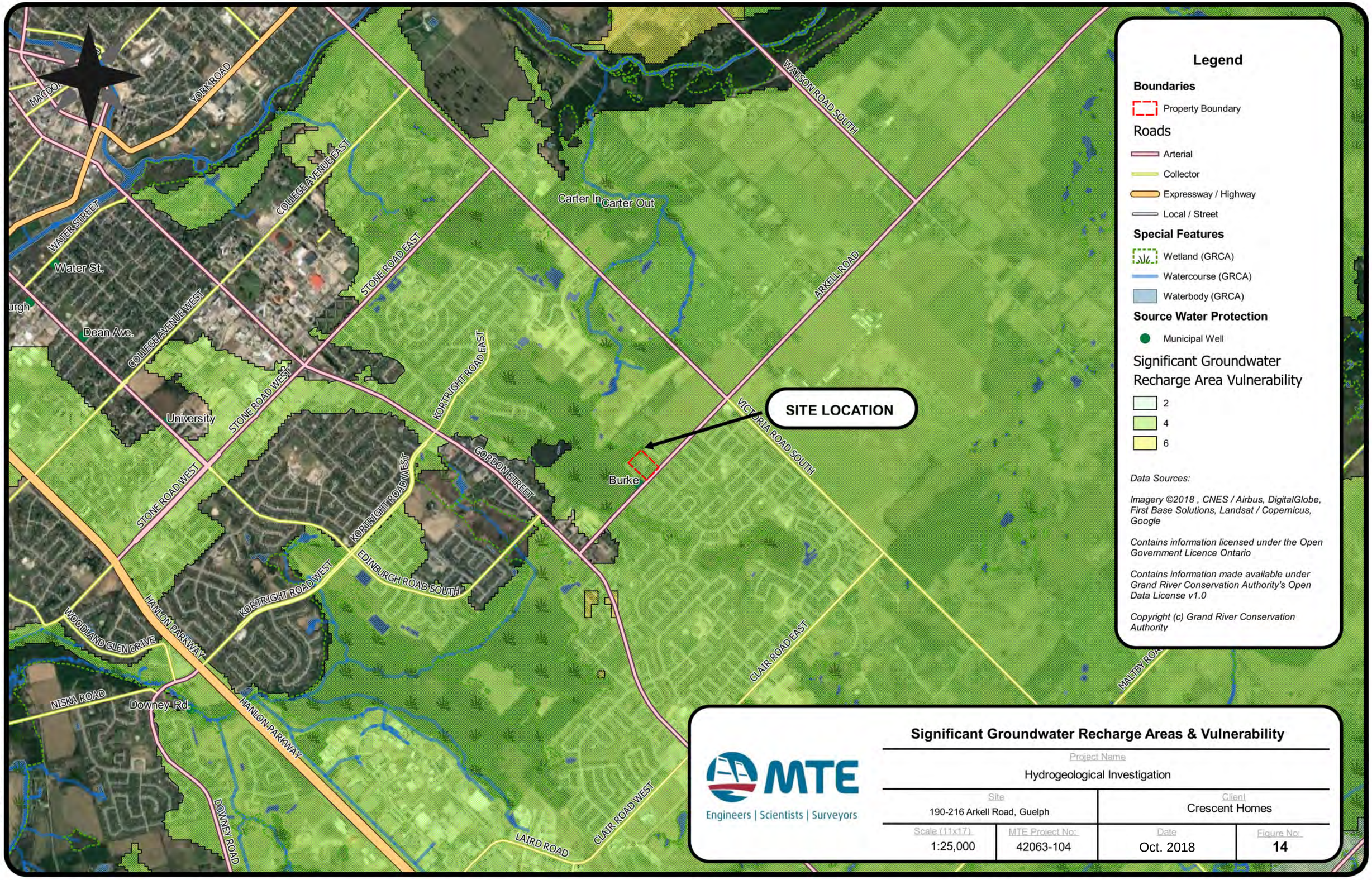
Intrinsic Aquifer Vulnerability

Project Name			
Hydrogeological Investigation			
Site: 190-216 Arkell Road, Guelph		Client: Crescent Homes	
Scale (11x17): 1:25,000	MTE Project No: 42063-104	Date: Oct. 2018	Figure No: **13**



Legend

Boundaries

- Property Boundary

Roads

- Arterial
- Collector
- Expressway / Highway
- Local / Street

Special Features

- Wetland (GRCA)
- Watercourse (GRCA)
- Waterbody (GRCA)

Source Water Protection

- Municipal Well

Significant Groundwater Recharge Area Vulnerability

- 2
- 4
- 6

Data Sources:

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Significant Groundwater Recharge Areas & Vulnerability

Project Name			
Hydrogeological Investigation			
Site: 190-216 Arkell Road, Guelph		Client: Crescent Homes	
Scale (11x17): 1:25,000	MTE Project No: 42063-104	Date: Oct. 2018	Figure No: **14**

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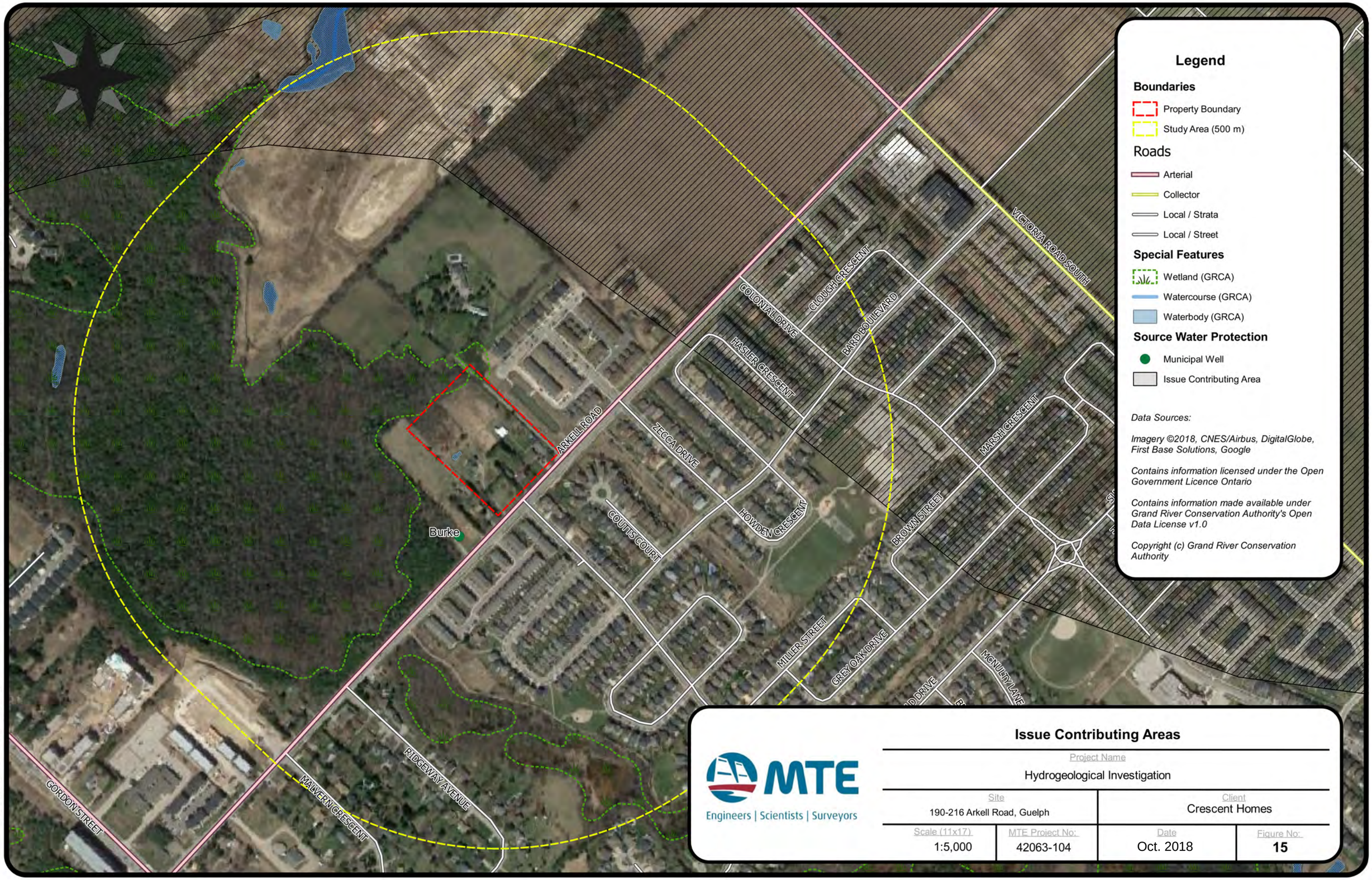

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Issue Contributing Areas

Project Name			
Hydrogeological Investigation			
Site: 190-216 Arkell Road, Guelph		Client: Crescent Homes	
Scale (11x17): 1:5,000	MTE Project No: 42063-104	Date: Oct. 2018	Figure No: **15**

TABLES

Table 1: Groundwater Levels

ID	MW-2		MW-3		MW-4		MW-5	
TOC Elevation (mAMSL)	335.04		334.31		333.99		334.83	
Stickup (m)	0.75		0.67		0.75		0.81	
Date	mbtoc	mbgs	mbtoc	mbgs	mbtoc	mbgs	mbtoc	mbgs
2-Mar-17	2.77	2.02	1.77	1.10	N.I.	-	N.I.	-
27-Mar-17	2.71	1.96	1.75	1.08	0.58	-0.17	2.32	1.51
10-May-17	1.95	1.20	1.17	0.50	0.04	-0.71	1.57	0.76
7-Jun-17	2.38	1.63	1.56	0.89	0.51	-0.24	2.06	1.25
2-Nov-17	4.4	3.65	3.51	2.84	2.81	2.06	4.12	3.31
26-Mar-18	2.97	2.22	2.09	1.42	1.15	0.40	2.62	1.81
26-Jun-18	2.57	1.82	1.79	1.11	0.98	0.22	2.26	1.45

Notes:

N.I. = not installed

mAMSL = metres above mean sea level

Negative values indicate saturated soil conditions at ground surface

Table 2: Groundwater Elevations (mAMSL)

ID	MW2	MW3	MW4	MW5
TOC Elevation (mAMSL)	335.04	334.31	333.99	334.83
2-Mar-17	332.27	332.54	-	-
27-Mar-17	332.33	332.56	333.41	332.51
10-May-17	333.09	333.14	333.95	333.26
7-Jun-17	332.66	332.75	333.48	332.77
2-Nov-17	330.64	330.80	331.18	330.71
26-Mar-18	332.07	332.22	332.84	332.21
26-Jun-18	332.47	332.53	333.02	332.57

Notes:

mAMSL = metres above mean sea level

Table 3: Groundwater Chemistry Summary - 2018

Parameter	Units	DL	MW-2	MW-4
			5-Oct-18	
			L2119092-1	L2119092-2
Physical Tests				
Colour, Apparent	CU	2	77.6	455
Conductivity	umhos/cm	3	712	770
Hardness (as CaCO3)	mg/L	10	250	380
pH	pH units	0.1	7.89	7.63
Total Dissolved Solids	mg/L	20	546	452
Turbidity	NTU	0.1	>4000	>4000
Anions and Nutrients				
Alkalinity, Total (as CaCO3)	mg/L	10	230	313
Ammonia, Total (as N)	mg/L	0.02	0.035	0.041
Chloride (Cl)	mg/L	0.5	76	35.9
Fluoride (F)	mg/L	0.02	0.062	0.051
Nitrate (as N)	mg/L	0.02	1.59	6.29
Nitrite (as N)	mg/L	0.01	<0.010	<0.010
Orthophosphate-Dissolved (as P)	mg/L	0.003	<0.0030	<0.0030
Sulfate (SO4)	mg/L	0.3	13.6	14.2
Dissolved Metals				
Dissolved Metals Filtration Location			FIELD	FIELD
Aluminum (Al)-Dissolved	mg/L	0.01	<0.010	<0.010
Antimony (Sb)-Dissolved	mg/L	0.005	<0.0050	<0.0050
Arsenic (As)-Dissolved	mg/L	0.001	<0.0010	<0.0010
Barium (Ba)-Dissolved	mg/L	0.01	0.028	0.058
Beryllium (Be)-Dissolved	mg/L	0.001	<0.0010	<0.0010
Bismuth (Bi)-Dissolved	mg/L	0.001	<0.0010	<0.0010
Boron (B)-Dissolved	mg/L	0.05	<0.050	<0.050
Cadmium (Cd)-Dissolved	mg/L	0.00009	<0.000090	<0.000090
Calcium (Ca)-Dissolved	mg/L	0.5	67.5	98.6
Chromium (Cr)-Dissolved	mg/L	0.0005	<0.00050	<0.00050
Cobalt (Co)-Dissolved	mg/L	0.0005	<0.00050	<0.00050
Copper (Cu)-Dissolved	mg/L	0.001	0.0034	0.0043
Iron (Fe)-Dissolved	mg/L	0.05	<0.050	<0.050
Lead (Pb)-Dissolved	mg/L	0.001	<0.0010	<0.0010
Magnesium (Mg)-Dissolved	mg/L	0.5	19.7	32.5
Manganese (Mn)-Dissolved	mg/L	0.001	<0.0010	<0.0010
Molybdenum (Mo)-Dissolved	mg/L	0.001	<0.0010	<0.0010
Nickel (Ni)-Dissolved	mg/L	0.002	<0.0020	<0.0020
Phosphorus (P)-Dissolved	mg/L	0.05	<0.050	<0.050
Potassium (K)-Dissolved	mg/L	1	1.9	7.5
Selenium (Se)-Dissolved	mg/L	0.0004	<0.00040	<0.00040
Silicon (Si)-Dissolved	mg/L	1	2.4	4.6
Silver (Ag)-Dissolved	mg/L	0.0001	<0.00010	<0.00010
Sodium (Na)-Dissolved	mg/L	0.5	60.4	21.6
Strontium (Sr)-Dissolved	mg/L	0.001	0.0735	0.111
Thallium (Tl)-Dissolved	mg/L	0.0003	<0.00030	<0.00030
Tin (Sn)-Dissolved	mg/L	0.001	<0.0010	<0.0010
Titanium (Ti)-Dissolved	mg/L	0.002	<0.0020	<0.0020
Tungsten (W)-Dissolved	mg/L	0.01	<0.010	<0.010
Uranium (U)-Dissolved	mg/L	0.005	<0.0050	<0.0050
Vanadium (V)-Dissolved	mg/L	0.001	<0.0010	<0.0010
Zinc (Zn)-Dissolved	mg/L	0.003	0.0132	0.0293
Zirconium (Zr)-Dissolved	mg/L	0.004	<0.0040	<0.0040

Notes:

DL = Detection Limit

APPENDIX A

CONCEPT PLAN

Preliminary Concept Plan

Arkell Road Properties
City of Guelph
County of Wellington

LEGEND

Subject Lands

	Proposed
Gross Area	25,443 m² (2.54 ha)
Net Area	12,410 m² (1.24 ha)
Number of Units	65
No. of Storeys	3
Gross Area Density	25.6 units/ha
Net Area Density	52.4 units/ha
Parking Required	39 spaces
Parking Provided	46 spaces

Notes:
1. Net Area excludes: NRSI wetland limit, 30m buffer from NRSI wetland, 20m wide right of way and 5m road widening.
2. Standards for Residential Townhouse (R.3) Zone used for Concept Plan.
3. Parking Required includes 1 space/unit and 20% visitor parking requirement.
4. Site Boundary is approximate and should be verified by Survey.
5. Natural feature limits from NRSI (July 28, 2016) and verified by GRCA and City of Guelph staff.
6. Density to be confirmed through City review.

Sources:
- Vumap/ First Base Solutions Aerial Imagery 2017
- Parcel Fabric - Grand River Conservation Authority (GRIN) 2010
- Dripline Limits - Natural Resource Solutions Inc. (NRSI) June 2016
- Wetland Limits - Natural Resource Solutions Inc. (NRSI) July 28, 2016
- City of Guelph Zoning By-law (1995) 14864

DATE: July 11, 2018

FILE: 15246A

SCALE Ñ1:1,500

DRAWN: DGS/ GC

north

K:\15246A-CRESCENT HOMES-ARKELL ROAD-GUELPH\CONCEPT\CONCEPT PLAN JULY 11 2018.DWG

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

APPENDIX B

BOREHOLE LOGS

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 1

PROJECT Proposed Arkell Road Subdivision
LOCATION Arkell Road, Guelph, Ontario
BORING METHOD Continuous Flight Hollow Stem Augers
BORING DATE: 2017 02 13
PML REF.: 17KF002
ENGINEER K. Hanes
TECHNICIAN H. Shinwary

GROUND ELEVATION 334.56

DEPTH in METRES	DESCRIPTION	NUMBER	TYPE	BLOWS/0.3m N - VALUES	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	GROUND WATER OBSERVATIONS AND REMARKS
0.10	TOPSOIL: Dark brown silt, trace sand, numerous rootlets, damp	1	SS	7			GR SA SI&CL
0.46							
0.69	FILL: Brown sand and gravel, trace silt, moist						
333.87	SILT: Loose brown silt, trace sand, occasional rootlets, damp	2	SS	42	334		
	SAND AND GRAVEL: Dense to very dense brown sand and gravel, trace to some silt, numerous cobbles, damp	3	SS	50/150mm	333		
2.1							
332.5	becoming moist	4	SS	39	332		
2.9							
331.7	becoming compact, no cobbles, saturated, contains saturated silt layers	5	SS	23	331		Sampler wet from SS5
4.0							
330.6	SAND: Compact brown sand, trace to some silt, trace gravel, saturated	6	SS	12	330		
					329		
6.6		7	SS	16	328		
328.0	BOREHOLE TERMINATED AT 6.6 m						Upon completion of augering Wet cave to 3.1 m

SHEAR STRENGTH C_u (kPa) 50 100 150 200
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
BLOWS/0.3M 20 40 60 80

LIQUID LIMIT ____ W_L
PLASTIC LIMIT ____ W_P
WATER CONTENT ___ W
W_P W W_L
WATER CONTENT % 10 20 30

NOTES: Headspace: SS1 0ppm, SS2 0ppm, SS3 0ppm, SS4 0ppm, SS5 0ppm, SS6 0ppm, SS7 0ppm

WATER LEVEL OBSERVED DURING / UPON COMPLETION OF DRILLING
WATER LEVEL MEASURED IN MONITORING WELL

UNDISTURBED FIELD VANE
REMOLDED FIELD VANE
LAB SHEAR TEST
POCKET PENETROMETER
POCKET TORVANE

CHECKED BY KH

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 2

PROJECT Proposed Arkell Road Subdivision
LOCATION Arkell Road, Guelph, Ontario
BORING METHOD Continuous Flight Hollow Stem Augers
BORING DATE: 2017 02 13
PML REF.: 17KF002
ENGINEER K. Hanes
TECHNICIAN H. Shinwary

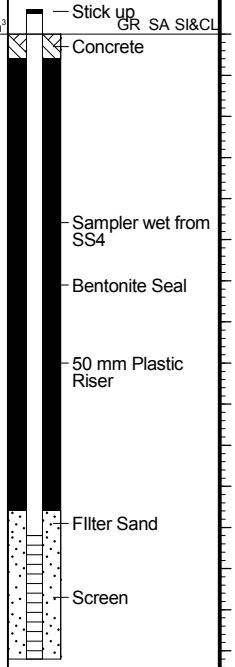
DEPTH in METRES	DESCRIPTION	LEGEND	NUMBER	TYPE	BLOWS/0.3m N - VALUES	ELEVATION SCALE
	GROUND ELEVATION 335.16					
0.25 / 334.91	TOPSOIL: Dark brown silt, trace sand, numerous rootlets, damp		1	SS	3	335
0.69 / 334.47	SILT: Loose dark brown silt, some sand, trace gravel, occasional rootlets, damp					
	SAND AND GRAVEL: Very dense sand and gravel, trace to some silt, numerous cobbles, damp		2	SS	57	334
			3	SS	64	
2.1 / 333.1	SAND: Compact to dense brown sand, trace to some silt, trace gravel, occasional cobbles, saturated		4	SS	34	333
			5	SS	31	332
			6	SS	30	331
			7	SS	26	330
7.7						329
8.1 / 327.1	SILT: Dense brown silt, trace sand, trace gravel, wet		8	SS	39	328
	BOREHOLE TERMINATED AT 8.1 m					

SHEAR STRENGTH C_u (kPa) 50 100 150 200
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
BLOWS/0.3M 20 40 60 80

LIQUID LIMIT ____ W_L
PLASTIC LIMIT ____ W_P
WATER CONTENT ___ W
W_P W W_L
WATER CONTENT % 10 20 30

UNIT WEIGHT γ kN/m³

GROUND WATER OBSERVATIONS AND REMARKS



Water Level Readings:
Initial: 3.40 m
Elevation: 331.76

2017-04: 2.51 m
Elevation: 332.45

NOTES: Headspace: SS1 0ppm, SS2 0ppm, SS3 0ppm, SS4 0ppm, SS5 5ppm, SS6 0ppm, SS7 0ppm, SS8 0ppm

WATER LEVEL OBSERVED DURING / UPON COMPLETION OF DRILLING
WATER LEVEL MEASURED IN MONITORING WELL

UNDISTURBED FIELD VANE
REMOLDED FIELD VANE
LAB SHEAR TEST
POCKET PENETROMETER
POCKET TORVANE

CHECKED BY KH

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 3

PROJECT Proposed Arkell Road Subdivision
LOCATION Arkell Road, Guelph, Ontario
BORING METHOD Continuous Flight Hollow Stem Augers
BORING DATE: 2017 02 13
PML REF.: 17KF002
ENGINEER K. Hanes
TECHNICIAN H. Shinwary

DEPTH in METRES	DESCRIPTION	NUMBER	TYPE	BLOWS/0.3m N - VALUES	ELEVATION SCALE
	GROUND ELEVATION 334.42				
0.20	TOPSOIL: Dark brown silt, trace sand, numerous rootlets, moist	1	SS	5	334
0.51					
333.91	SILT: Loose dark brown silt, some sand, occasional rootlets	2	SS	3	
1.4	SAND AND GRAVEL: Very loose brown sand and gravel, trace to some silt, occasional cobbles, damp				333
333.1	becoming compact, saturated	3	SS	35	
		4	SS	31	332
2.9					
331.5	SAND: Compact to dense brown sand, trace to some silt, trace gravel, occasional cobbles, saturated	5	SS	24	331
		6	SS	42	330
		7	SS	27	329
7.8					328
8.0	SILT: Compact brown silt, trace sand, trace gravel, wet	8	SS	21	327
326.4	BOREHOLE TERMINATED AT 8.0 m				

SHEAR STRENGTH C_u (kPa): 50 100 150 200
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
BLOWS/0.3M: 20 40 60 80

LIQUID LIMIT ____ W_L
PLASTIC LIMIT ____ W_P
WATER CONTENT ___ W
W_P W W_L
WATER CONTENT %: 10 20 30

UNIT WEIGHT γ kN/m³

GROUND WATER OBSERVATIONS AND REMARKS

Stick up
Concrete
Sampler wet from SS3
Bentonite Seal
50 mm Plastic Riser
FIlter Sand
Screen

Water Level Readings:
Initial: 1.95 m
Elevation: 332.47

2017-04: 1.86 m
Elevation: 332.56

NOTES: Headspace: SS1 0ppm, SS2 0ppm, SS3 0ppm, SS4 0ppm, SS5 5ppm, SS6 0ppm, SS7 5ppm, SS8 0ppm

WATER LEVEL OBSERVED DURING / UPON COMPLETION OF DRILLING
WATER LEVEL MEASURED IN MONITORING WELL

UNDISTURBED FIELD VANE
REMOLDED FIELD VANE
LAB SHEAR TEST
POCKET PENETROMETER
POCKET TORVANE

CHECKED BY KH

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 4

PROJECT Proposed Arkell Road Subdivision
LOCATION Arkell Road, Guelph, Ontario
BORING METHOD Continuous Flight Hollow Stem Augers
BORING DATE: 2017 03 21
PML REF.: 17KF002
ENGINEER K. Hanes
TECHNICIAN H. Shinwary

DEPTH in METRES	DESCRIPTION	NUMBER	TYPE	BLOWS/0.3m N - VALUES	ELEVATION SCALE
	GROUND ELEVATION 334.13				
0.30	TOPSOIL: Dark brown silt, trace sand, numerous rootlets, moist	1	SS	6	334
0.69 / 333.44	SAND AND GRAVEL: Compact brown sand and gravel, trace to some silt, occasional cobbles, moist	2	SS	13	333
1.5	becoming saturated				
332.7	SAND: Compact brown sand, trace to some silt, trace gravel, saturated	3	SS	14	332
		4	SS	11	
		5	SS	12	331
		6	SS	18	330
		7	SS	10	329
		8	SS	25	328
8.1 / 326.0	BOREHOLE TERMINATED AT 8.1 m				327

SHEAR STRENGTH C_u (kPa) 50 100 150 200
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
BLOWS/0.3M 20 40 60 80

LIQUID LIMIT _____ W_L
PLASTIC LIMIT ____ W_P
WATER CONTENT ___ W
W_P W W_L
WATER CONTENT % 10 20 30

UNIT WEIGHT γ kN/m³

GROUND WATER OBSERVATIONS AND REMARKS

Stick up
GR SA SI&CL
Concrete
Sampler wet from SS2
Bentonite Seal
FIlter Sand
Screen

Water Level Readings:
Initial: 0.75 m
Elevation: 333.38

2017-04: 0.44 m
Elevation: 333.55

NOTES: Headspace: SS1 0ppm, SS2 5ppm, SS3 0ppm, SS4 5ppm, SS5 0ppm, SS6 0ppm, SS7 0ppm, SS8 0ppm

WATER LEVEL OBSERVED DURING / UPON COMPLETION OF DRILLING
WATER LEVEL MEASURED IN MONITORING WELL

UNDISTURBED FIELD VANE
REMOLDED FIELD VANE
LAB SHEAR TEST
POCKET PENETROMETER
POCKET TORVANE

CHECKED BY KH

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 5

PROJECT Proposed Arkell Road Subdivision
LOCATION Arkell Road, Guelph, Ontario
BORING METHOD Continuous Flight Hollow Stem Augers
BORING DATE: 2017 03 21
PML REF.: 17KF002
ENGINEER K. Hanes
TECHNICIAN H. Shinwary

DEPTH in METRES	DESCRIPTION	NUMBER	TYPE	BLOWS/0.3m N - VALUES	ELEVATION SCALE
	GROUND ELEVATION 334.97				
0.25 / 334.72	TOPSOIL: Dark brown silt, trace sand, trace gravel, numerous rootlets, damp	1	SS	13	
	SAND AND GRAVEL: Dense brown sand and gravel, trace to some silt, numerous cobbles, damp	2	SS	49	334
		3	SS	31	333
2.2 / 332.8	SAND: Compact brown sand, some gravel, trace to some silt, occasional cobbles, saturated	4	SS	24	
		5	SS	27	332
		6	SS	14	331
5.6 / 329.4	becoming very dense				330
		7	SS	51	329
7.1 / 327.9	SAND AND GRAVEL: Very dense brown sand and gravel, trace silt, numerous cobbles, saturated				328
8.1 / 326.9	BOREHOLE TERMINATED AT 8.1 m	8	SS	52	327

SHEAR STRENGTH C_u (kPa) 50 100 150 200
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
BLOWS/0.3M 20 40 60 80

LIQUID LIMIT ____ W_L
PLASTIC LIMIT ____ W_P
WATER CONTENT ___ W
W_P W W_L
WATER CONTENT % 10 20 30

UNIT WEIGHT γ kN/m³

GROUND WATER OBSERVATIONS AND REMARKS

Stick up
GR SA SI&CL
Concrete
Sampler wet from SS4
Bentonite Seal
FIlter Sand
Screen

Water Level Readings:
Initial: 2.3 m
Elevation: 332.67

2017-04: 2.18 m
Elevation: 332.65

NOTES: Headspace: SS1 0ppm, SS2 0ppm, SS3 5ppm, SS4 5ppm, SS5 0ppm, SS6 0ppm, SS7 0ppm, SS8 0ppm

WATER LEVEL OBSERVED DURING / UPON COMPLETION OF DRILLING
WATER LEVEL MEASURED IN MONITORING WELL

UNDISTURBED FIELD VANE
REMOLDED FIELD VANE
LAB SHEAR TEST
POCKET PENETROMETER
POCKET TORVANE

CHECKED BY KH

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 6

PROJECT Proposed Arkell Road Subdivision
LOCATION Arkell Road, Guelph, Ontario
BORING METHOD Continuous Flight Hollow Stem Augers
BORING DATE: 2017 03 21
PML REF.: 17KF002
ENGINEER K. Hanes
TECHNICIAN H. Shinwary

GROUND ELEVATION 334.0

DEPTH in METRES	DESCRIPTION	NUMBER	TYPE	BLOWS/0.3m N - VALUES	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	GROUND WATER OBSERVATIONS AND REMARKS
0.20	TOPSOIL: Dark brown silt, trace sand, numerous rootlets, damp	1	SS	18			GR SA SI&CL
0.41							
0.69	FILL: Dark brown silt, some sand, trace gravel, occasional rootlets, damp						
333.31		2	SS	45	333		
1.5	SAND AND GRAVEL: Dense brown sand and gravel, trace to some silt, numerous cobbles, damp						
332.6	becoming moist	3	SS	36			Sampler wet from SS3
2.2	becoming saturated				332		
331.8	SILT: Compact brown silt, trace sand, trace gravel, trace clay, wet to saturated	4	SS	12			
		5	SS	10	331		
					330		
		6	SS	16			
5.8					329		
328.2	SILT TILL: Very dense brown silt, some sand, some gravel, occasional cobbles, damp				328		
6.6		7	SS	50/75mm			
327.4	BOREHOLE TERMINATED AT 6.6 m						Upon completion of augering Cave to 2.0 m Free water at 1.83 m

SHEAR STRENGTH C_u (kPa) 50 100 150 200
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
BLOWS/0.3M 20 40 60 80

LIQUID LIMIT _____ W_L
PLASTIC LIMIT ____ W_P
WATER CONTENT ___ W
W_P W W_L
WATER CONTENT % 10 20 30

NOTES: Headspace: SS1 0ppm, SS2 0ppm, SS3 0ppm, SS4 5ppm, SS5 0ppm, SS6 0ppm, SS7 0ppm

WATER LEVEL OBSERVED DURING / UPON COMPLETION OF DRILLING
WATER LEVEL MEASURED IN MONITORING WELL

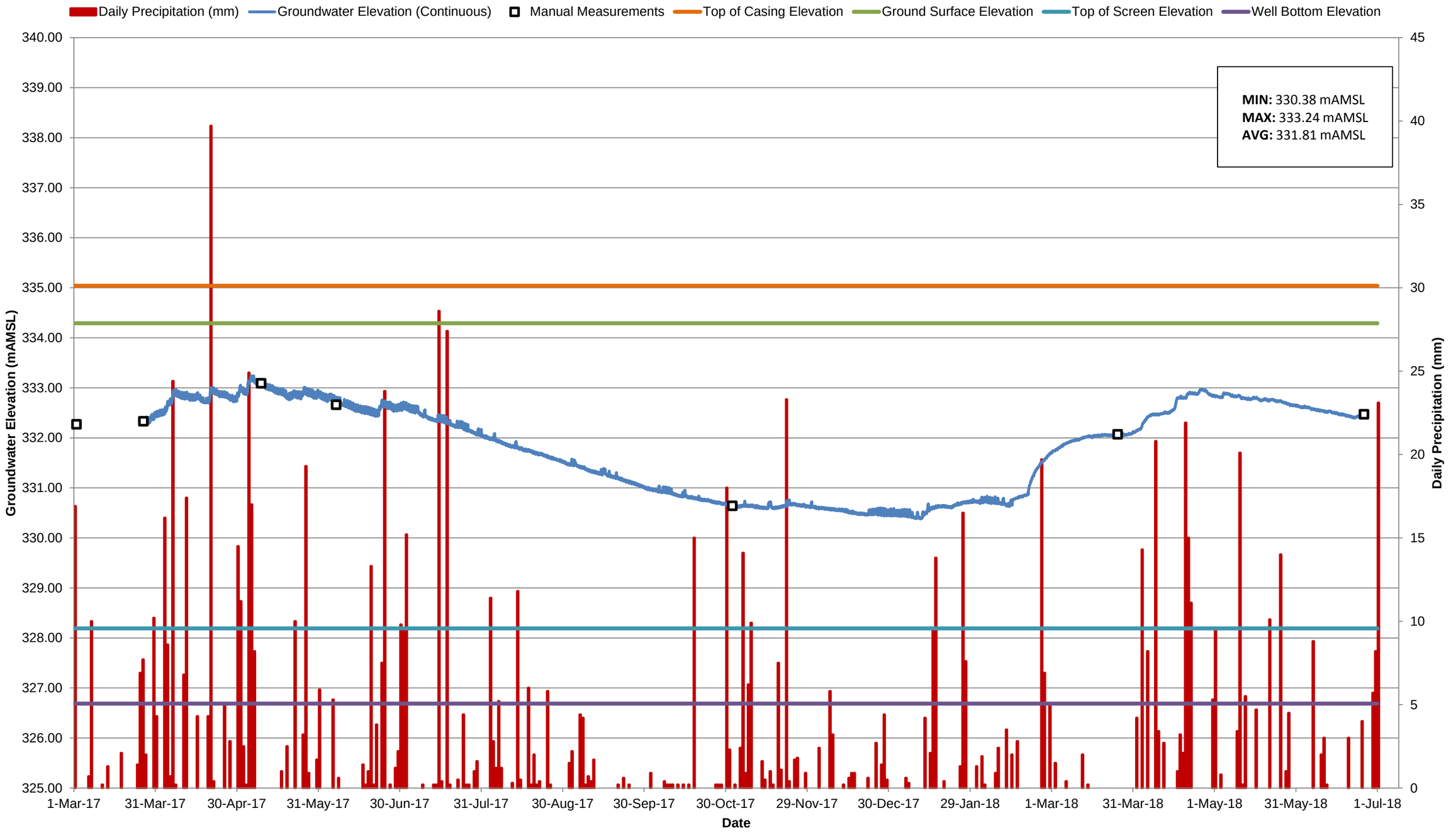
+ UNDISTURBED FIELD VANE
⊕ REMOLDED FIELD VANE
⊛ LAB SHEAR TEST
▲ POCKET PENETROMETER
◆ POCKET TORVANE

CHECKED BY KH

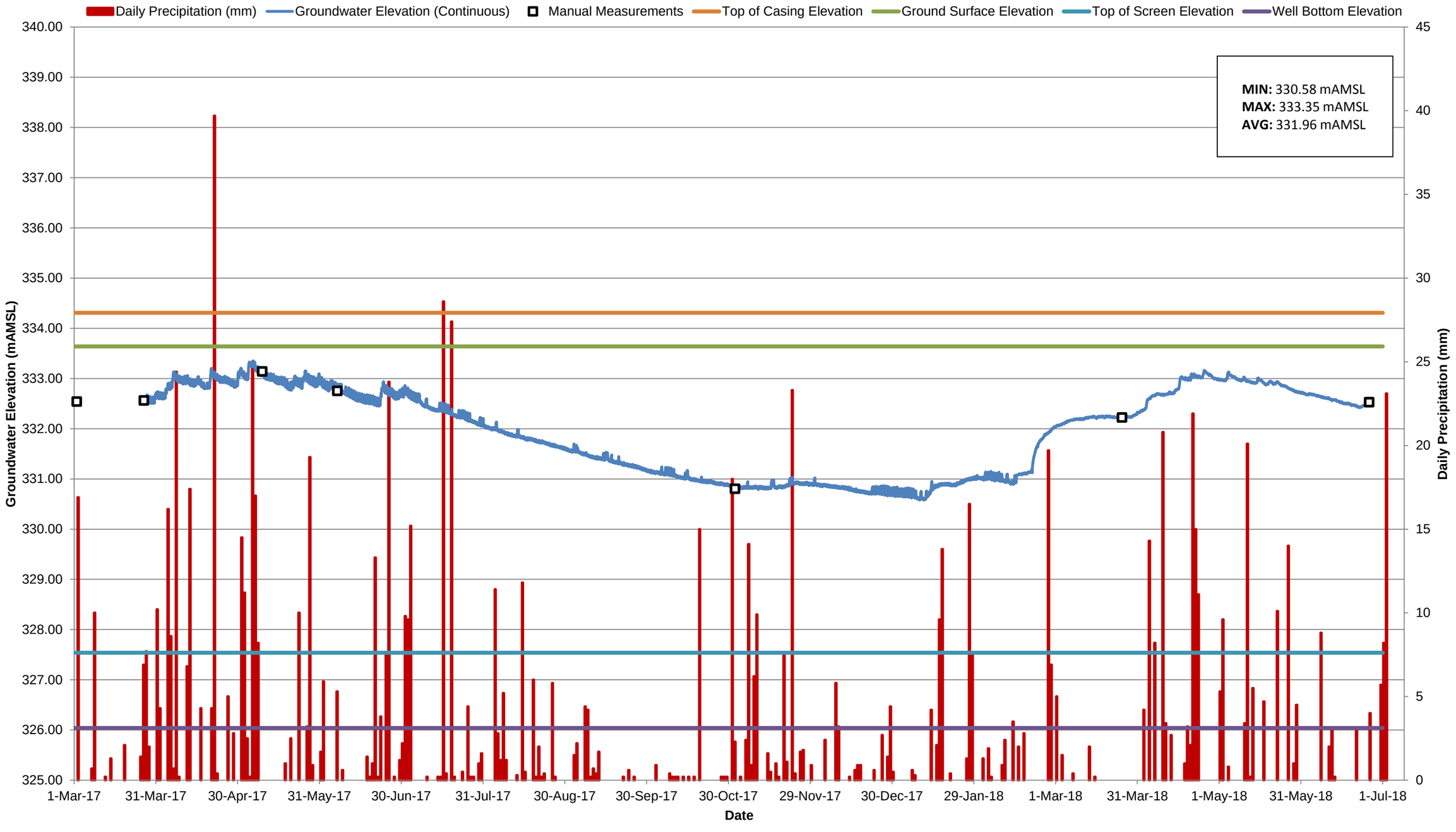
APPENDIX C

HYDROGRAPHS

Hydrograph 1: Groundwater Elevations (mAMSL) - MW2-17



Hydrograph 2: Groundwater Elevations (mAMSL) - MW3-17



Hydrograph 3: Groundwater Elevations (mAMSL) - MW4-17

Daily Precipitation (mm) | Groundwater Elevation (Continuous) | Manual Measurements | Tof of Casing Elevation | Ground Surface Elevation | Top of Screen Elevation | Well Bottom Elevation

MIN: 331.02 mAMSL
MAX: 333.99 mAMSL
AVG: 332.54 mAMSL

Groundwater Elevation (mAMSL)

340.00
339.00
338.00
337.00
336.00
335.00
334.00
333.00
332.00
331.00
330.00
329.00
328.00
327.00
326.00
325.00

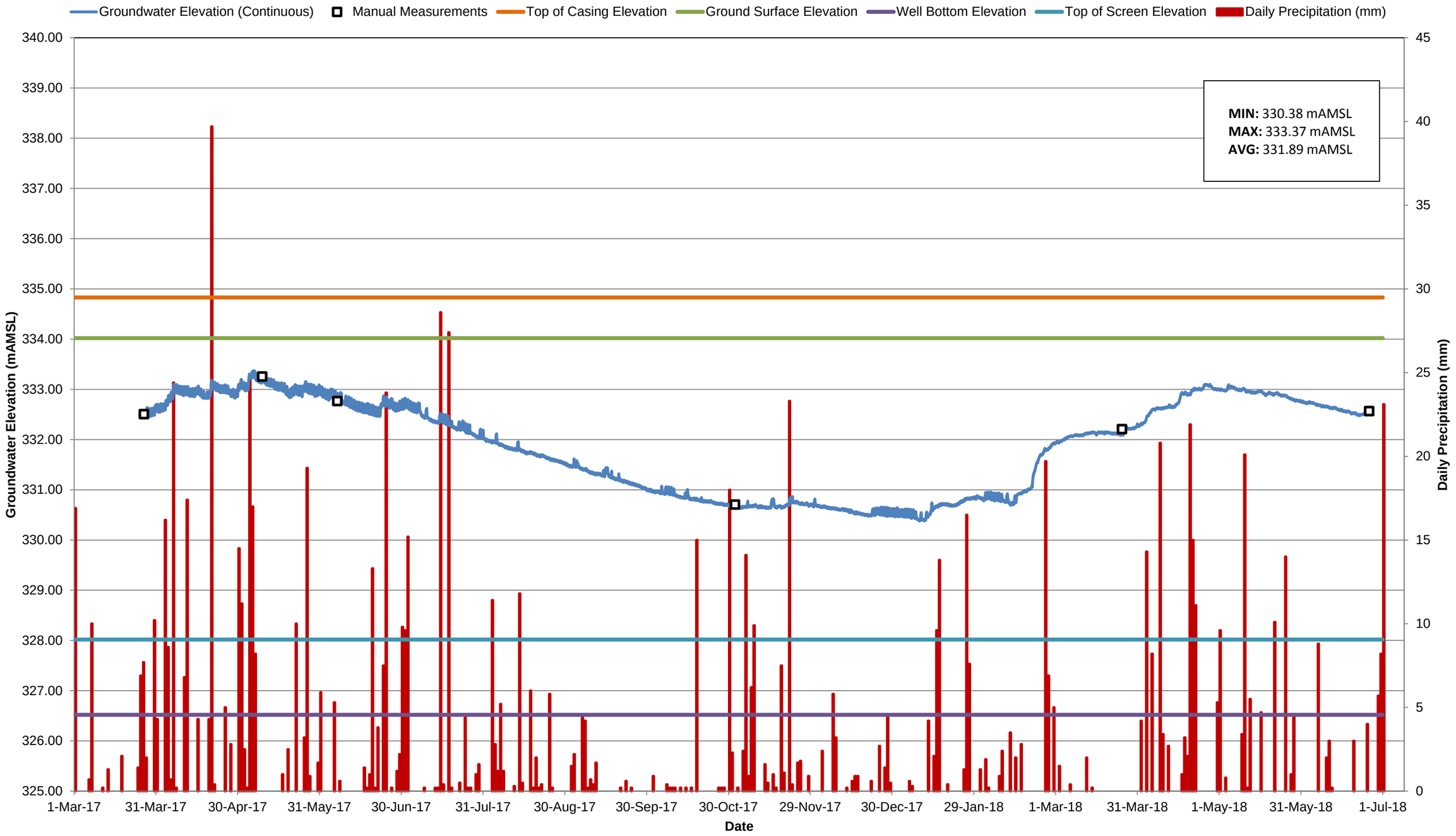
Daily Precipitation (mm)

45
40
35
30
25
20
15
10
5
0

1-Mar-17
31-Mar-17
30-Apr-17
31-May-17
30-Jun-17
31-Jul-17
30-Aug-17
30-Sep-17
30-Oct-17
29-Nov-17
30-Dec-17
29-Jan-18
1-Mar-18

Date

Hydrograph 4: Groundwater Elevations (mAMSL) - MW5-17

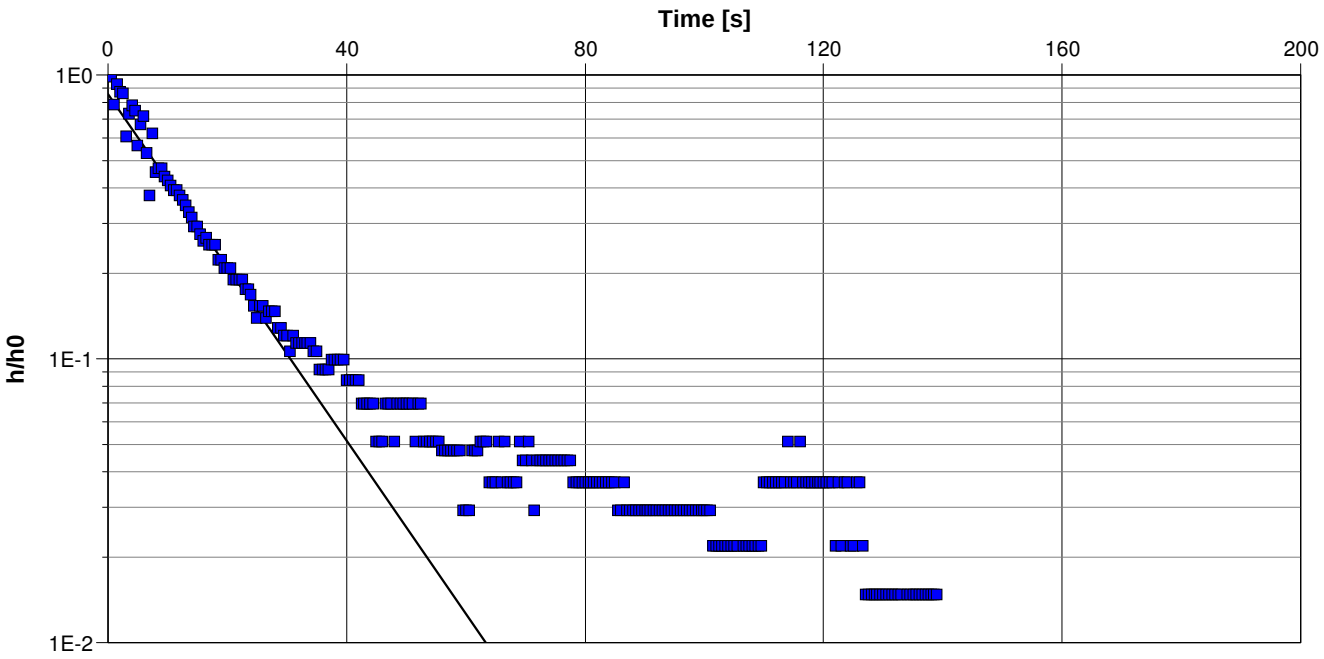


APPENDIX D

AQUIFER TEST© DATA SHEETS

	Slug Test Analysis Report	D
	Project: Arkell Road Properties	
	Number: 42063-104	
	Client: Crescent Homes	

Location: 202 Arkel Road, Guelph, ON	Slug Test: MW2-17	Test Well: MW2-17
Test Conducted by: YXM		Test Date: 3/3/2017
Analysis Performed by: MDE	Bouwer and Rice	Analysis Date: 5/12/2017
Aquifer Thickness: 5.67 m		

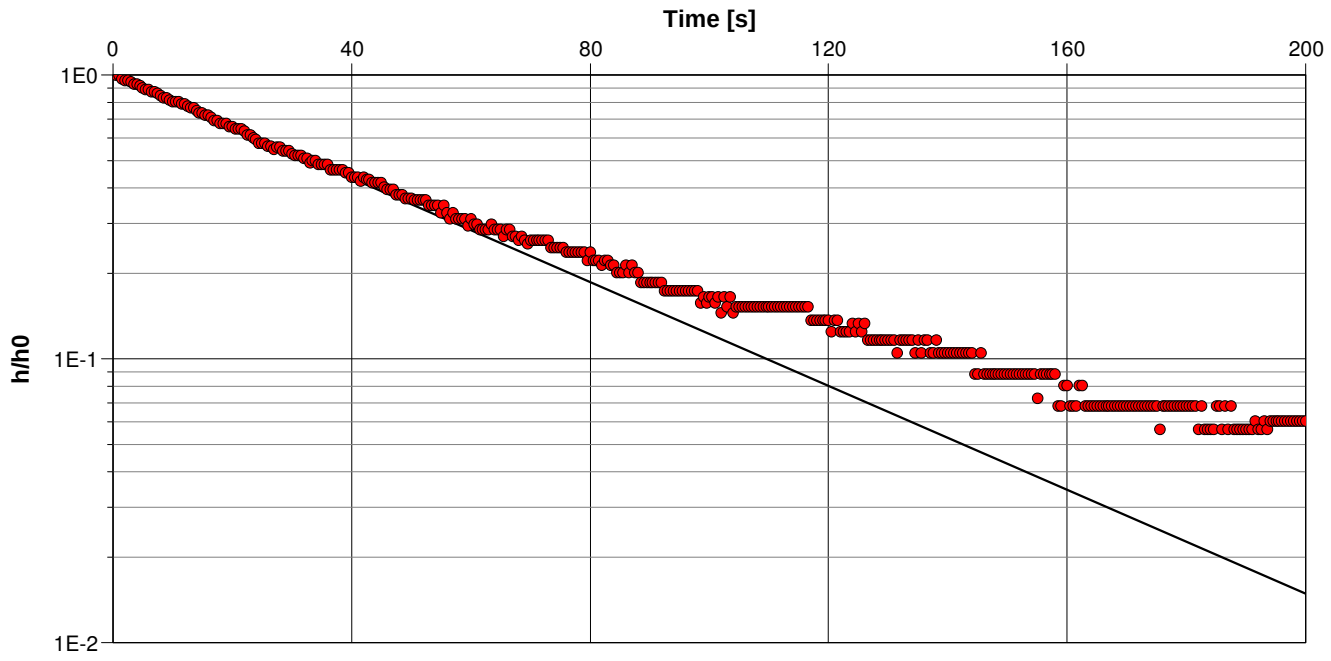


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/s]	
MW2-17	5.52×10^{-5}	

	Slug Test Analysis Report	D
	Project: Arkell Road Properties	
	Number: 42063-104	
	Client: Crescent Homes	

Location: 202 Arkel Road, Guelph, ON	Slug Test: MW3-17	Test Well: MW3-17
Test Conducted by: YXM		Test Date: 3/2/2017
Analysis Performed by: MDE	Bouwer and Rice	Analysis Date: 5/12/2017
Aquifer Thickness: 6.88 m		

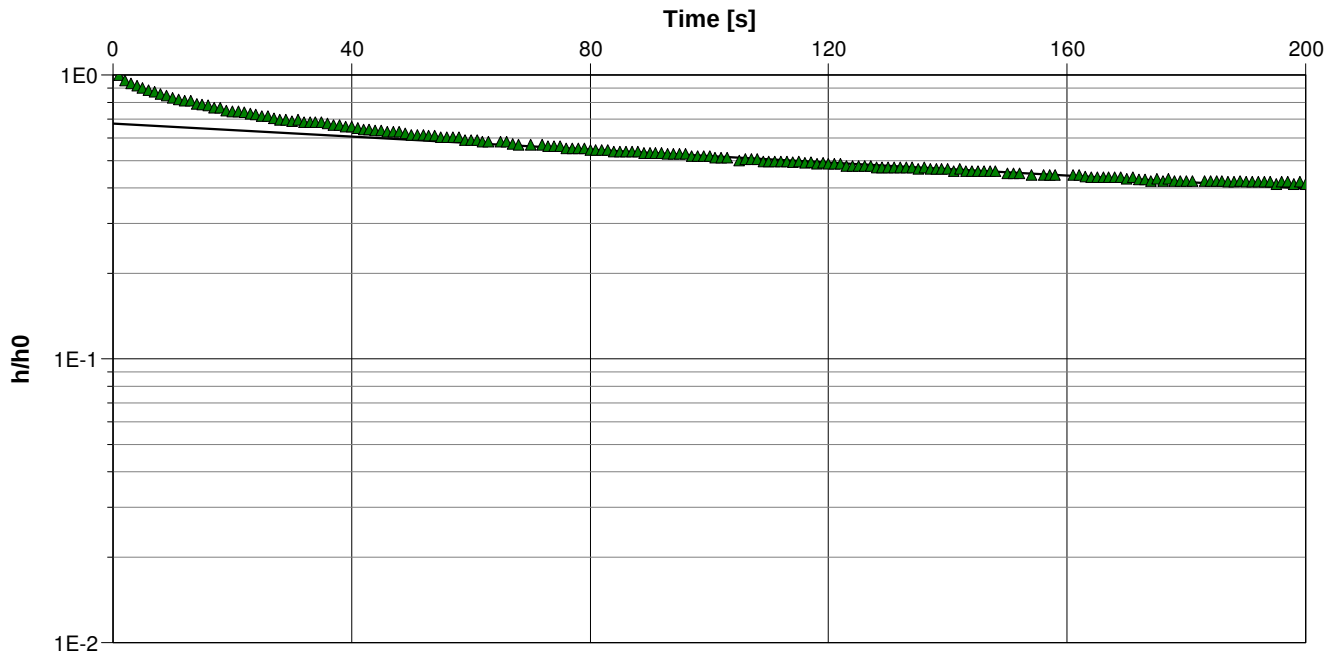


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/s]	
MW3-17	1.62×10^{-5}	

	Slug Test Analysis Report	D
	Project: Arkell Road Properties	
	Number: 42063-104	
	Client: Crescent Homes	

Location: 202 Arkel Road, Guelph, ON	Slug Test: MW4-17	Test Well: MW4-17
Test Conducted by: MDE		Test Date: 5/10/2017
Analysis Performed by: MDE	Bouwer and Rice	Analysis Date: 5/12/2017
Aquifer Thickness: 8.10 m		

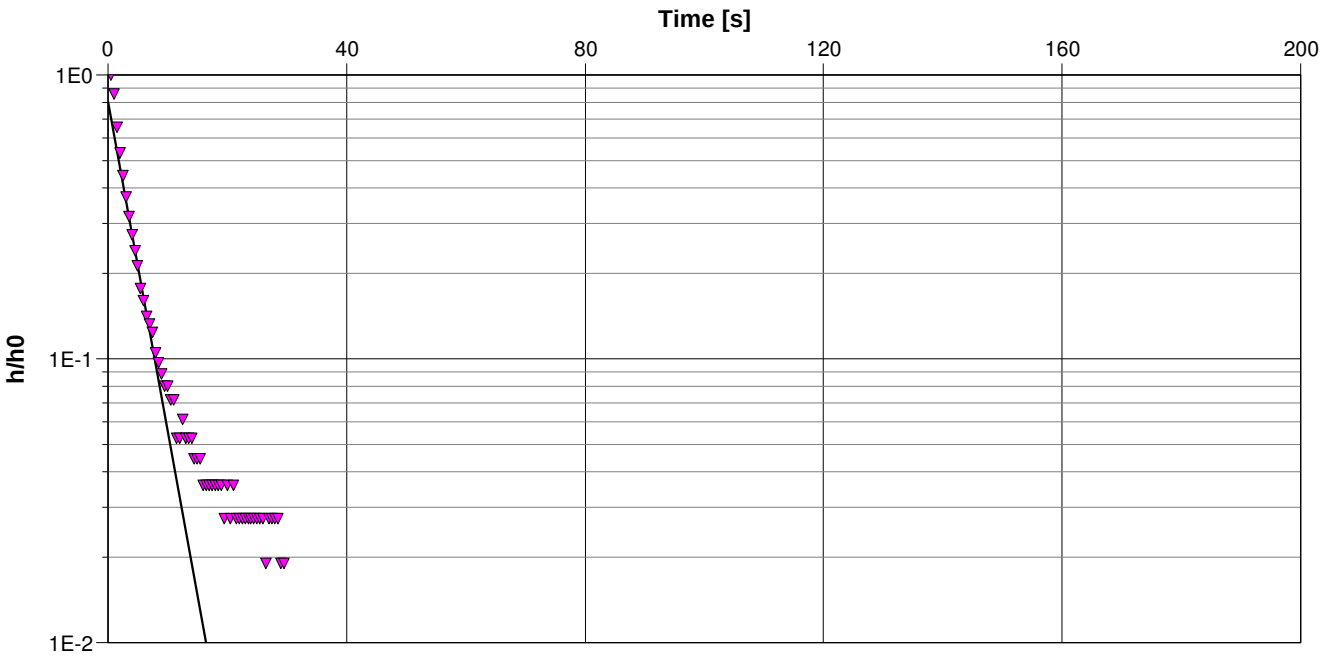


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/s]	
MW4-17	2.06×10^{-6}	

	Slug Test Analysis Report	D
	Project: Arkell Road Properties	
	Number: 42063-104	
	Client: Crescent Homes	

Location: 202 Arkel Road, Guelph, ON	Slug Test: MW5-17	Test Well: MW5-17
Test Conducted by: MDE		Test Date: 5/10/2017
Analysis Performed by: MDE	Bouwer and Rice	Analysis Date: 5/12/2017
Aquifer Thickness: 7.30 m		



Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/s]	
MW5-17	2.05×10^{-4}	

APPENDIX E

PARTICLE SIZE DISTRIBUTION CHARTS

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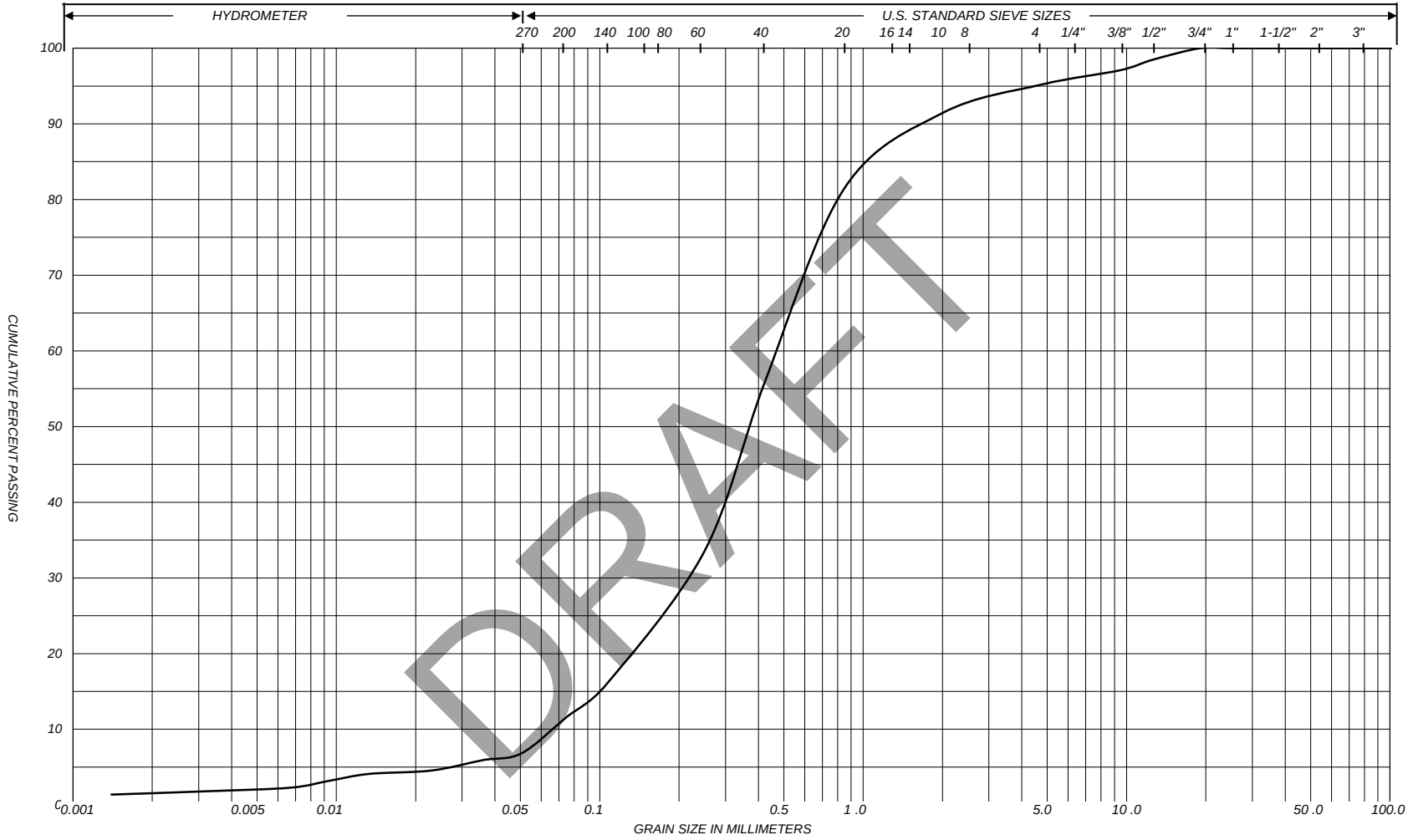
CONSULTING ENGINEERS

PML REF. 17KF002
REPORT NO. 1
FIGURE. 1

PARTICLE SIZE DISTRIBUTION CHART



SILT & CLAY			FINE	MEDIUM	COARSE	GRAVEL	COBBLES	UNIFIED					
			SAND										
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	GRAVEL	COBBLES	M.I.T.				
	SILT			SAND									
CLAY	SILT		VERY FINE	FINE	MEDIUM	COARSE	GRAVEL		U.S. BUREAU				
			SAND										

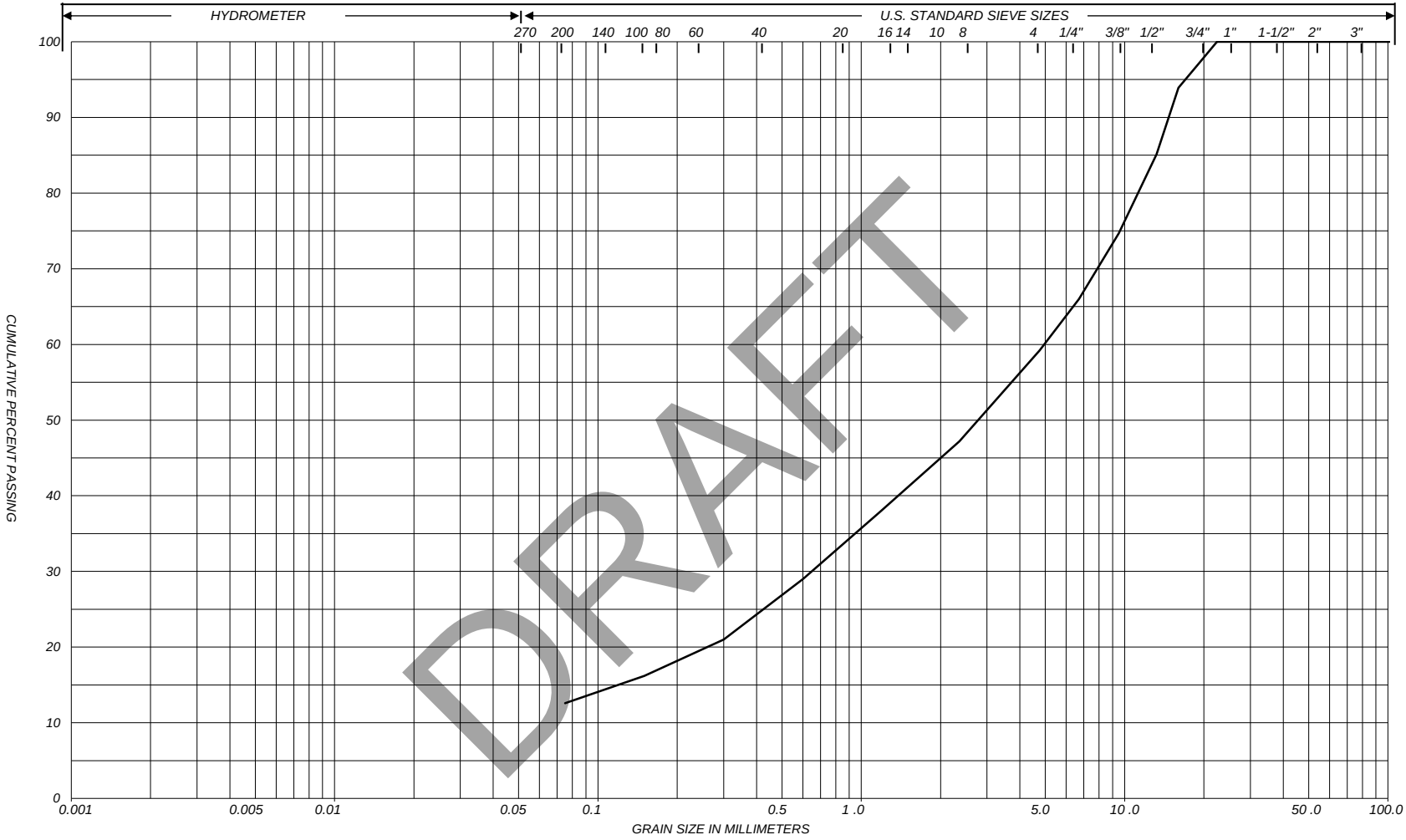
REMARKS Borehole 1, Sample SS6, Depth 4.5 to 5.0 m

SAND, SOME SILT, TRACE GRAVEL

Peto MacCallum Ltd.
CONSULTING ENGINEERS

PML REF.	17KF002
REPORT NO.	1
FIGURE.	2

PARTICLE SIZE DISTRIBUTION CHART



SILT & CLAY			FINE	MEDIUM	COARSE	GRAVEL		COBBLES	UNIFIED				
			SAND										
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	GRAVEL		COBBLES	M.I.T.			
	SILT			SAND									
CLAY	SILT		VERY FINE	FINE	MEDIUM	COARSE	GRAVEL			U.S. BUREAU			
			SAND										

REMARKS Borehole 2, Sample SS2, Depth 0.7 to 1.2 m

SAND AND GRAVEL, SOME SILT

APPENDIX F

LABORATORY CERTIFICATES OF ANALYSIS

MTE CONSULTANTS INC.
ATTN: ANDREW BINGEMAN
520 BINGEMANS CENTRE DRIVE
KITCHENER ON N2B 3X9

Date Received: 26-JUN-18
Report Date: 04-JUL-18 14:43 (MT)
Version: FINAL

Client Phone: 519-743-6500

Certificate of Analysis

Lab Work Order #: L2119092

Project P.O. #: NOT SUBMITTED
Job Reference: 42063-104
C of C Numbers: 17-624726
Legal Site Desc:

Mary-Lynn Pike
Client Services Supervisor

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2119092-1 MW-2 Sampled By: CLIENT on 26-JUN-18 @ 12:00 Matrix: WATER							
Physical Tests							
Colour, Apparent	77.6		2.0	CU		27-JUN-18	R4099703
Conductivity	712		3.0	umhos/cm		27-JUN-18	R4099089
Hardness (as CaCO3)	250		10	mg/L		28-JUN-18	
pH	7.89		0.10	pH units		27-JUN-18	R4099089
Total Dissolved Solids	546	DLDS	20	mg/L		29-JUN-18	R4110482
Turbidity	>4000		0.10	NTU		27-JUN-18	R4098100
Anions and Nutrients							
Alkalinity, Total (as CaCO3)	230		10	mg/L		28-JUN-18	R4101190
Ammonia, Total (as N)	0.035		0.020	mg/L		27-JUN-18	R4100330
Chloride (Cl)	76.0		0.50	mg/L		28-JUN-18	R4104567
Fluoride (F)	0.062		0.020	mg/L		28-JUN-18	R4104567
Nitrate (as N)	1.59		0.020	mg/L		28-JUN-18	R4104567
Nitrite (as N)	<0.010		0.010	mg/L		28-JUN-18	R4104567
Orthophosphate-Dissolved (as P)	<0.0030		0.0030	mg/L		27-JUN-18	R4100351
Sulfate (SO4)	13.6		0.30	mg/L		28-JUN-18	R4104567
Dissolved Metals							
Dissolved Metals Filtration Location	FIELD					27-JUN-18	R4097954
Aluminum (Al)-Dissolved	<0.010		0.010	mg/L	27-JUN-18	27-JUN-18	R4099009
Antimony (Sb)-Dissolved	<0.0050		0.0050	mg/L	27-JUN-18	27-JUN-18	R4099009
Arsenic (As)-Dissolved	<0.0010		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009
Barium (Ba)-Dissolved	0.028		0.010	mg/L	27-JUN-18	27-JUN-18	R4099009
Beryllium (Be)-Dissolved	<0.0010		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009
Bismuth (Bi)-Dissolved	<0.0010		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009
Boron (B)-Dissolved	<0.050		0.050	mg/L	27-JUN-18	27-JUN-18	R4099009
Cadmium (Cd)-Dissolved	<0.000090		0.000090	mg/L	27-JUN-18	27-JUN-18	R4099009
Calcium (Ca)-Dissolved	67.5		0.50	mg/L	27-JUN-18	27-JUN-18	R4099009
Chromium (Cr)-Dissolved	<0.00050		0.00050	mg/L	27-JUN-18	27-JUN-18	R4099009
Cobalt (Co)-Dissolved	<0.00050		0.00050	mg/L	27-JUN-18	27-JUN-18	R4099009
Copper (Cu)-Dissolved	0.0034		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009
Iron (Fe)-Dissolved	<0.050		0.050	mg/L	27-JUN-18	27-JUN-18	R4099009
Lead (Pb)-Dissolved	<0.0010		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009
Magnesium (Mg)-Dissolved	19.7		0.50	mg/L	27-JUN-18	27-JUN-18	R4099009
Manganese (Mn)-Dissolved	<0.0010		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009
Molybdenum (Mo)-Dissolved	<0.0010		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009
Nickel (Ni)-Dissolved	<0.0020		0.0020	mg/L	27-JUN-18	27-JUN-18	R4099009
Phosphorus (P)-Dissolved	<0.050		0.050	mg/L	27-JUN-18	27-JUN-18	R4099009
Potassium (K)-Dissolved	1.9		1.0	mg/L	27-JUN-18	27-JUN-18	R4099009
Selenium (Se)-Dissolved	<0.00040		0.00040	mg/L	27-JUN-18	27-JUN-18	R4099009
Silicon (Si)-Dissolved	2.4		1.0	mg/L	27-JUN-18	27-JUN-18	R4099009
Silver (Ag)-Dissolved	<0.00010		0.00010	mg/L	27-JUN-18	27-JUN-18	R4099009
Sodium (Na)-Dissolved	60.4		0.50	mg/L	27-JUN-18	27-JUN-18	R4099009

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2119092-1 MW-2 Sampled By: CLIENT on 26-JUN-18 @ 12:00 Matrix: WATER							
Dissolved Metals							
Strontium (Sr)-Dissolved	0.0735		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009
Thallium (Tl)-Dissolved	<0.00030		0.00030	mg/L	27-JUN-18	27-JUN-18	R4099009
Tin (Sn)-Dissolved	<0.0010		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009
Titanium (Ti)-Dissolved	<0.0020		0.0020	mg/L	27-JUN-18	27-JUN-18	R4099009
Tungsten (W)-Dissolved	<0.010		0.010	mg/L	27-JUN-18	27-JUN-18	R4099009
Uranium (U)-Dissolved	<0.0050		0.0050	mg/L	27-JUN-18	27-JUN-18	R4099009
Vanadium (V)-Dissolved	<0.0010		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009
Zinc (Zn)-Dissolved	0.0132		0.0030	mg/L	27-JUN-18	27-JUN-18	R4099009
Zirconium (Zr)-Dissolved	<0.0040		0.0040	mg/L	27-JUN-18	27-JUN-18	R4099009
L2119092-2 MW-4 Sampled By: CLIENT on 26-JUN-18 @ 13:04 Matrix: WATER							
Physical Tests							
Colour, Apparent	455	DLHC	4.0	CU		27-JUN-18	R4099703
Conductivity	770		3.0	umhos/cm		27-JUN-18	R4099089
Hardness (as CaCO3)	380		10	mg/L		28-JUN-18	
pH	7.63		0.10	pH units		27-JUN-18	R4099089
Total Dissolved Solids	452	DLDS	20	mg/L		29-JUN-18	R4110482
Turbidity	>4000		0.10	NTU		27-JUN-18	R4098100
Anions and Nutrients							
Alkalinity, Total (as CaCO3)	313		10	mg/L		28-JUN-18	R4101190
Ammonia, Total (as N)	0.041		0.020	mg/L		27-JUN-18	R4100330
Chloride (Cl)	35.9		0.50	mg/L		28-JUN-18	R4104567
Fluoride (F)	0.051		0.020	mg/L		28-JUN-18	R4104567
Nitrate (as N)	6.29		0.020	mg/L		28-JUN-18	R4104567
Nitrite (as N)	<0.010		0.010	mg/L		28-JUN-18	R4104567
Orthophosphate-Dissolved (as P)	<0.0030		0.0030	mg/L		27-JUN-18	R4100351
Sulfate (SO4)	14.2		0.30	mg/L		28-JUN-18	R4104567
Dissolved Metals							
Dissolved Metals Filtration Location	FIELD					27-JUN-18	R4097954
Aluminum (Al)-Dissolved	<0.010		0.010	mg/L	27-JUN-18	27-JUN-18	R4099009
Antimony (Sb)-Dissolved	<0.0050		0.0050	mg/L	27-JUN-18	27-JUN-18	R4099009
Arsenic (As)-Dissolved	<0.0010		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009
Barium (Ba)-Dissolved	0.058		0.010	mg/L	27-JUN-18	27-JUN-18	R4099009
Beryllium (Be)-Dissolved	<0.0010		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009
Bismuth (Bi)-Dissolved	<0.0010		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009
Boron (B)-Dissolved	<0.050		0.050	mg/L	27-JUN-18	27-JUN-18	R4099009
Cadmium (Cd)-Dissolved	<0.000090		0.000090	mg/L	27-JUN-18	27-JUN-18	R4099009
Calcium (Ca)-Dissolved	98.6		0.50	mg/L	27-JUN-18	27-JUN-18	R4099009
Chromium (Cr)-Dissolved	<0.00050		0.00050	mg/L	27-JUN-18	27-JUN-18	R4099009
Cobalt (Co)-Dissolved	<0.00050		0.00050	mg/L	27-JUN-18	27-JUN-18	R4099009
Copper (Cu)-Dissolved	0.0043		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2119092-2 MW-4 Sampled By: CLIENT on 26-JUN-18 @ 13:04 Matrix: WATER							
Dissolved Metals							
Iron (Fe)-Dissolved	<0.050		0.050	mg/L	27-JUN-18	27-JUN-18	R4099009
Lead (Pb)-Dissolved	<0.0010		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009
Magnesium (Mg)-Dissolved	32.5		0.50	mg/L	27-JUN-18	27-JUN-18	R4099009
Manganese (Mn)-Dissolved	<0.0010		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009
Molybdenum (Mo)-Dissolved	<0.0010		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009
Nickel (Ni)-Dissolved	<0.0020		0.0020	mg/L	27-JUN-18	27-JUN-18	R4099009
Phosphorus (P)-Dissolved	<0.050		0.050	mg/L	27-JUN-18	27-JUN-18	R4099009
Potassium (K)-Dissolved	7.5		1.0	mg/L	27-JUN-18	27-JUN-18	R4099009
Selenium (Se)-Dissolved	<0.00040		0.00040	mg/L	27-JUN-18	27-JUN-18	R4099009
Silicon (Si)-Dissolved	4.6		1.0	mg/L	27-JUN-18	27-JUN-18	R4099009
Silver (Ag)-Dissolved	<0.00010		0.00010	mg/L	27-JUN-18	27-JUN-18	R4099009
Sodium (Na)-Dissolved	21.6		0.50	mg/L	27-JUN-18	27-JUN-18	R4099009
Strontium (Sr)-Dissolved	0.111		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009
Thallium (Tl)-Dissolved	<0.00030		0.00030	mg/L	27-JUN-18	27-JUN-18	R4099009
Tin (Sn)-Dissolved	<0.0010		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009
Titanium (Ti)-Dissolved	<0.0020		0.0020	mg/L	27-JUN-18	27-JUN-18	R4099009
Tungsten (W)-Dissolved	<0.010		0.010	mg/L	27-JUN-18	27-JUN-18	R4099009
Uranium (U)-Dissolved	<0.0050		0.0050	mg/L	27-JUN-18	27-JUN-18	R4099009
Vanadium (V)-Dissolved	<0.0010		0.0010	mg/L	27-JUN-18	27-JUN-18	R4099009
Zinc (Zn)-Dissolved	0.0293		0.0030	mg/L	27-JUN-18	27-JUN-18	R4099009
Zirconium (Zr)-Dissolved	<0.0040		0.0040	mg/L	27-JUN-18	27-JUN-18	R4099009

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Chloride (Cl)	MS-B	L2119092-1, -2
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L2119092-1, -2
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L2119092-1, -2
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L2119092-1, -2
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L2119092-1, -2
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L2119092-1, -2
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L2119092-1, -2
Matrix Spike	Uranium (U)-Dissolved	MS-B	L2119092-1, -2
Matrix Spike	Ammonia, Total (as N)	MS-B	L2119092-1, -2
Matrix Spike	Nitrate (as N)	MS-B	L2119092-1, -2

Sample Parameter Qualifier key listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-WT	Water	Alkalinity, Total (as CaCO3)	EPA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

CL-IC-N-WT	Water	Chloride by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

COLOUR-APPARENT-WT	Water	Colour	APHA 2120

Apparent Colour is measured spectrophotometrically by comparison to platinum-cobalt standards using the single wavelength method after sample decanting. Colour measurements can be highly pH dependent, and apply to the pH of the sample as received (at time of testing), without pH adjustment. Concurrent measurement of sample pH is recommended.

EC-WT	Water	Conductivity	APHA 2510 B

Water samples can be measured directly by immersing the conductivity cell into the sample.

F-IC-N-WT	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

HARDNESS-CALC-WT	Water	Hardness	APHA 2340 B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

MET-D-CCMS-WT	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

NH3-WT	Water	Ammonia, Total as N	EPA 350.1

Sample is measured colorimetrically. When sample is turbid a distillation step is required, sample is distilled into a solution of boric acid and measured colorimetrically.

NO2-IC-WT	Water	Nitrite in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-IC-WT	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-WT	Water	pH	APHA 4500 H-Electrode

Water samples are analyzed directly by a calibrated pH meter.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011). Holdtime for samples under this regulation is 28 days

Reference Information

PO4-DO-COL-WT	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

SO4-IC-N-WT	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

SOLIDS-TDS-WT	Water	Total Dissolved Solids	APHA 2540C

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TURBIDITY-WT	Water	Turbidity	APHA 2130 B

Sample result is based on a comparison of the intensity of the light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. Sample readings are obtained from a Nephelometer.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

Chain of Custody Numbers:

17-624726

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid weight of sample
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: MTE CONSULTANTS INC.
520 BINGEMANS CENTRE DRIVE
KITCHENER ON N2B 3X9
Contact: ANDREW BINGEMAN

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-WT	**Water**							
Batch R4101190								
WG2809810-11 CRM		**WT-ALK-CRM**						
Alkalinity, Total (as CaCO3)			92.5		%		80-120	28-JUN-18
WG2809810-3 CRM		**WT-ALK-CRM**						
Alkalinity, Total (as CaCO3)			93.4		%		80-120	28-JUN-18
WG2809810-12 DUP		**L2119092-2**						
Alkalinity, Total (as CaCO3)		313	318		mg/L	1.7	20	28-JUN-18
WG2809810-10 LCS								
Alkalinity, Total (as CaCO3)			96.3		%		85-115	28-JUN-18
WG2809810-2 LCS								
Alkalinity, Total (as CaCO3)			97.9		%		85-115	28-JUN-18
WG2809810-1 MB								
Alkalinity, Total (as CaCO3)			<10		mg/L		10	28-JUN-18
WG2809810-9 MB								
Alkalinity, Total (as CaCO3)			<10		mg/L		10	28-JUN-18
CL-IC-N-WT	**Water**							
Batch R4104567								
WG2809480-2 LCS								
Chloride (Cl)			101.2		%		90-110	28-JUN-18
WG2809480-1 MB								
Chloride (Cl)			<0.50		mg/L		0.5	28-JUN-18
COLOUR-APPARENT-WT	**Water**							
Batch R4099703								
WG2808121-2 LCS								
Colour, Apparent			106.7		%		85-115	27-JUN-18
WG2808121-1 MB								
Colour, Apparent			<2.0		CU		2	27-JUN-18
EC-WT	**Water**							
Batch R4099089								
WG2808019-10 LCS								
Conductivity			99.9		%		90-110	27-JUN-18
WG2808019-6 LCS								
Conductivity			99.7		%		90-110	27-JUN-18
WG2808019-5 MB								
Conductivity			<3.0		umhos/cm		3	27-JUN-18
WG2808019-9 MB								
Conductivity			<3.0		umhos/cm		3	27-JUN-18
F-IC-N-WT	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
F-IC-N-WT	**Water**							
Batch R4104567								
WG2809480-2 LCS								
Fluoride (F)			101.3		%		90-110	28-JUN-18
WG2809480-1 MB								
Fluoride (F)			<0.020		mg/L		0.02	28-JUN-18
MET-D-CCMS-WT	**Water**							
Batch R4099009								
WG2807911-2 LCS								
Aluminum (Al)-Dissolved			105.6		%		80-120	27-JUN-18
Antimony (Sb)-Dissolved			101.3		%		80-120	27-JUN-18
Arsenic (As)-Dissolved			104.9		%		80-120	27-JUN-18
Barium (Ba)-Dissolved			102.5		%		80-120	27-JUN-18
Beryllium (Be)-Dissolved			103.7		%		80-120	27-JUN-18
Bismuth (Bi)-Dissolved			102.5		%		80-120	27-JUN-18
Boron (B)-Dissolved			99.6		%		80-120	27-JUN-18
Cadmium (Cd)-Dissolved			99.8		%		80-120	27-JUN-18
Calcium (Ca)-Dissolved			103.8		%		80-120	27-JUN-18
Chromium (Cr)-Dissolved			103.0		%		80-120	27-JUN-18
Cobalt (Co)-Dissolved			103.1		%		80-120	27-JUN-18
Copper (Cu)-Dissolved			103.0		%		80-120	27-JUN-18
Iron (Fe)-Dissolved			97.6		%		80-120	27-JUN-18
Lead (Pb)-Dissolved			102.6		%		80-120	27-JUN-18
Magnesium (Mg)-Dissolved			107.9		%		80-120	27-JUN-18
Manganese (Mn)-Dissolved			103.5		%		80-120	27-JUN-18
Molybdenum (Mo)-Dissolved			103.7		%		80-120	27-JUN-18
Nickel (Ni)-Dissolved			102.4		%		80-120	27-JUN-18
Phosphorus (P)-Dissolved			106.0		%		80-120	27-JUN-18
Potassium (K)-Dissolved			101.3		%		80-120	27-JUN-18
Selenium (Se)-Dissolved			102.8		%		80-120	27-JUN-18
Silicon (Si)-Dissolved			100.7		%		60-140	27-JUN-18
Silver (Ag)-Dissolved			99.3		%		80-120	27-JUN-18
Sodium (Na)-Dissolved			109.4		%		80-120	27-JUN-18
Strontium (Sr)-Dissolved			97.7		%		80-120	27-JUN-18
Thallium (Tl)-Dissolved			105.6		%		80-120	27-JUN-18
Tin (Sn)-Dissolved			100.3		%		80-120	27-JUN-18
Titanium (Ti)-Dissolved			101.6		%		80-120	27-JUN-18

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-D-CCMS-WT	**Water**							
Batch R4099009								
WG2807911-2 LCS								
Tungsten (W)-Dissolved			98.1		%		80-120	27-JUN-18
Uranium (U)-Dissolved			102.5		%		80-120	27-JUN-18
Vanadium (V)-Dissolved			106.6		%		80-120	27-JUN-18
Zinc (Zn)-Dissolved			97.8		%		80-120	27-JUN-18
Zirconium (Zr)-Dissolved			99.5		%		80-120	27-JUN-18
WG2807911-1 MB								
Aluminum (Al)-Dissolved			<0.0050		mg/L		0.005	27-JUN-18
Antimony (Sb)-Dissolved			<0.00010		mg/L		0.0001	27-JUN-18
Arsenic (As)-Dissolved			<0.00010		mg/L		0.0001	27-JUN-18
Barium (Ba)-Dissolved			<0.00010		mg/L		0.0001	27-JUN-18
Beryllium (Be)-Dissolved			<0.00010		mg/L		0.0001	27-JUN-18
Bismuth (Bi)-Dissolved			<0.000050		mg/L		0.00005	27-JUN-18
Boron (B)-Dissolved			<0.010		mg/L		0.01	27-JUN-18
Cadmium (Cd)-Dissolved			<0.000005C		mg/L		0.000005	27-JUN-18
Calcium (Ca)-Dissolved			<0.050		mg/L		0.05	27-JUN-18
Chromium (Cr)-Dissolved			<0.00050		mg/L		0.0005	27-JUN-18
Cobalt (Co)-Dissolved			<0.00010		mg/L		0.0001	27-JUN-18
Copper (Cu)-Dissolved			<0.00020		mg/L		0.0002	27-JUN-18
Iron (Fe)-Dissolved			<0.010		mg/L		0.01	27-JUN-18
Lead (Pb)-Dissolved			<0.000050		mg/L		0.00005	27-JUN-18
Magnesium (Mg)-Dissolved			<0.0050		mg/L		0.005	27-JUN-18
Manganese (Mn)-Dissolved			<0.00050		mg/L		0.0005	27-JUN-18
Molybdenum (Mo)-Dissolved			<0.000050		mg/L		0.00005	27-JUN-18
Nickel (Ni)-Dissolved			<0.00050		mg/L		0.0005	27-JUN-18
Phosphorus (P)-Dissolved			<0.050		mg/L		0.05	27-JUN-18
Potassium (K)-Dissolved			<0.050		mg/L		0.05	27-JUN-18
Selenium (Se)-Dissolved			<0.000050		mg/L		0.00005	27-JUN-18
Silicon (Si)-Dissolved			<0.050		mg/L		0.05	27-JUN-18
Silver (Ag)-Dissolved			<0.000050		mg/L		0.00005	27-JUN-18
Sodium (Na)-Dissolved			<0.050		mg/L		0.05	27-JUN-18
Strontium (Sr)-Dissolved			<0.0010		mg/L		0.001	27-JUN-18
Thallium (Tl)-Dissolved			<0.000010		mg/L		0.00001	27-JUN-18
Tin (Sn)-Dissolved			<0.00010		mg/L		0.0001	27-JUN-18
Titanium (Ti)-Dissolved			<0.00030		mg/L		0.0003	27-JUN-18

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-D-CCMS-WT	**Water**							
Batch R4099009								
WG2807911-1 MB								
Tungsten (W)-Dissolved			<0.00010		mg/L		0.0001	27-JUN-18
Uranium (U)-Dissolved			<0.000010		mg/L		0.00001	27-JUN-18
Vanadium (V)-Dissolved			<0.00050		mg/L		0.0005	27-JUN-18
Zinc (Zn)-Dissolved			<0.0010		mg/L		0.001	27-JUN-18
Zirconium (Zr)-Dissolved			<0.00030		mg/L		0.0003	27-JUN-18
NH3-WT	**Water**							
Batch R4100330								
WG2808125-6 LCS								
Ammonia, Total (as N)			98.7		%		85-115	27-JUN-18
WG2808125-5 MB								
Ammonia, Total (as N)			<0.020		mg/L		0.02	27-JUN-18
NO2-IC-WT	**Water**							
Batch R4104567								
WG2809480-2 LCS								
Nitrite (as N)			100.7		%		70-130	28-JUN-18
WG2809480-1 MB								
Nitrite (as N)			<0.010		mg/L		0.01	28-JUN-18
NO3-IC-WT	**Water**							
Batch R4104567								
WG2809480-2 LCS								
Nitrate (as N)			100.7		%		70-130	28-JUN-18
WG2809480-1 MB								
Nitrate (as N)			<0.020		mg/L		0.02	28-JUN-18
PH-WT	**Water**							
Batch R4099089								
WG2808019-10 LCS								
pH			7.00		pH units		6.9-7.1	27-JUN-18
WG2808019-6 LCS								
pH			6.99		pH units		6.9-7.1	27-JUN-18
PO4-DO-COL-WT	**Water**							
Batch R4100351								
WG2808131-2 LCS								
Orthophosphate-Dissolved (as P)			106.3		%		70-130	27-JUN-18
WG2808131-1 MB								
Orthophosphate-Dissolved (as P)			<0.0030		mg/L		0.003	27-JUN-18
SO4-IC-N-WT	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
SO4-IC-N-WT	**Water**							
Batch R4104567								
WG2809480-2 LCS								
Sulfate (SO4)			101.9		%		90-110	28-JUN-18
WG2809480-1 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	28-JUN-18
SOLIDS-TDS-WT	**Water**							
Batch R4110482								
WG2810907-3 DUP		**L2119092-1**						
Total Dissolved Solids		546	543		mg/L	0.5	20	29-JUN-18
WG2810907-2 LCS								
Total Dissolved Solids			97.0		%		85-115	29-JUN-18
WG2810907-1 MB								
Total Dissolved Solids			<10		mg/L		10	29-JUN-18
TURBIDITY-WT	**Water**							
Batch R4098100								
WG2807987-2 LCS								
Turbidity			104.0		%		85-115	27-JUN-18
WG2807987-1 MB								
Turbidity			<0.10		NTU		0.1	27-JUN-18

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental
www.alsglobal.com

Chain of Custody (C Request

L2119092-COFC

Canada Toll Free: 1

e label here

COC Number: 17 - 624726

Page 1 of 1

Report To	Contact and company name below will appear on the final report
Company:	MTE Consultants Inc.
Contact:	
Phone:	
	Company address below will appear on the final report
Street:	
City/Province:	
Postal Code:	

Report Format / Distribution	
Select Report Format:	☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report	☐ YES ☐ NO
☐ Compare Results to Criteria on Report - provide details below if box checked	
Select Distribution:	☐ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax	ddinsmore@mte85.com
Email 2	kwallace@mte85.com
Email 3	

Invoice To		
	Same as Report To	☑ YES ☐ NO
	Copy of Invoice with Report	☐ YES ☐ NO
Company:		
Contact:		

Invoice Distribution	
Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax	
Email 2	

Project Information	
ALS Account # / Quote #:	
Job #:	42063-104
PO / AFE:	
LSD:	
ALS Lab Work Order # (lab use only):	L2119092 Rev 96B

Oil and Gas Required Fields (client use)		
AFE/Cost Center:	PO#	
Major/Minor Code:	Routing Code:	
Requisitioner:		
Location:		
ALS Contact: ML	Sampler: KW	

Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4-20%] ☐ | 3 day [P3-25%] ☐ | 2 day [P2-50%] ☐

EMERGENCY: 1 Business day [E-100%] ☐ | Same Day, Weekend or Statutory holiday [E2-200% (Laboratory opening fees may apply)] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Genchem	SAMPLES ON HOLD	Sample is hazardous (please provide further details)	NUMBER OF CONTAINERS
	MW-2	26/06/18	12:00	W	X			4
	MW-4	1	13:04	1	X			4

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System?
☐ YES ☑ NO

Are samples for human consumption/ use?
☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen	☐	SIF Observations	Yes ☐	No	☐
Ice Packs	☑	Ice Cubes ☑	Custody seal intact	Yes ☐	No ☐
Cooling Initiated	☐				

INITIAL COOLER TEMPERATURES °C				FINAL COOLER TEMPERATURES °C			
				12.1°C			

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Kassandra Wallace	Date: 26/06/18	Time:	Received by:	Date:	Time:	Received by:	Date: JUNE 26/18	Time: 15:50

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JULY 2017 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.