Englobe
Soils Materials Environment

Reid's Heritage Homes

Scoped Hydrogeology Study
Lowes Road
Guelph, Ontario

Hydrogeology Study

Date: June 21, 2018
Ref. N°: 160-P-0010233-0-02-0300-HD-R-0001-02

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Scoped Hydrogeology Study
Lowes Road
Guelph, Ontario

Hydrogeology Study |160-P-0010233-0-02-300

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Property and Confidentiality

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REVISION AND PUBLICATION REGISTER		
Revision N°	Date	Modification And/Or Publication Details
00	2016/06/29	Final Report Issued
01	2017/05/30	Revised Final Report
02	2018/06/21	Second Revised Final Report

DISTRIBUTION	
1 electronic copy	Mr. Alfred Artinger, P.Eng., Reid's Heritage Homes
1 electronic copy	Mr. Peter Fitzgerald, Stantec Consulting Ltd.
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1 electronic copy	File

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INTRODUCTION

Englobe Corp. (Englobe) was retained in April 2016 to carry out a scoped hydrogeology study for the proposed residential redevelopment at the properties located at 19, 29, 35, 41, 51, and 59 Lowes Road in Guelph, Ontario as shown on the Location Plan, Drawing 1 in Appendix 1, herein referred to as the Site. This work was authorized by Mr. Alfred Artinger, P.Eng. of Reid's Heritage Homes following submission of a fee proposal.

The scope of work for this scoped hydrogeology study included a review of available topographic, geological and hydrogeological information for the Site and adjacent lands, and a subsurface investigation within the Site. The subsurface investigation was performed to identify the subsoil stratigraphy and hydrogeological properties, groundwater conditions and hydraulic gradients, and the relationship between groundwater and surface water features. It also includes long term continuous monitoring of groundwater levels in the monitoring wells installed on the site for approximately one year. A long-term monitoring program was implemented in order to obtain a seasonal high groundwater level across the site via barometrically corrected pressure transducers (datalogger) readings and manual measurements.

It was determined in April 2017 that the groundwater monitoring program would be continued in order to evaluate the long-term groundwater trends at the Site and establish the seasonally high groundwater elevation. This recommendation had been made by the City of Guelph Environmental Advisory Committee (EAC) draft comments in August 2017 and finalized in November 2017 as well as the City of Guelph Engineering and Planning Departments and Cole Engineering (City of Guelph's retained peer reviewer) in January 2018.

The objectives of this report are:

- To assess the geological and hydrogeological conditions beneath the Site;
- To calculate a pre-development water balance;
- To describe the soil physical properties;
- To identify water users and sensitive areas within the Site; and,
- To identify potential impacts and provide suggested mitigation measures.

It is noted that this report was not written to support the application or submittal of a Category 3 Permit to Take Water (PTTW) or Environmental Activity and Sector Registry (EASR).

A separate hydrogeology study in support of a Category 3 PTTW application or EASR submittal would be required at the detailed design stage. This report should include a more appropriate groundwater sampling program such as the City of Guelph Sanitary and Storm Sewer Use By-Law. It should also include a detailed comparison of the groundwater elevations to the proposed inverts for the servicing and drop structure infrastructure in order to determine an appropriate daily dewatering rate.

Concurrent with this scoped hydrogeology study, Englobe undertook a geotechnical investigation (Englobe Reference No. 160-P-0010233-0-01-100-GE-R-0001-00 dated May 24, 2016). As a result of comments received from the City of Guelph's Planning Department, an update to the Geotechnical Report (Englobe Reference No. 160-P-0010233-0-01-100-GE-R-0001-01, June 2018) was completed. Further, in 2016, MTE Consultants Inc. completed an environmental site assessment for the subject properties and the borehole drilling and installation of monitoring wells for this study were carried out concurrently by Englobe with the fieldwork for the geotechnical investigation.

1 OBJECTIVE OF THIS STUDY

1.1 SITE CONTEXT

The Site (1.7 ha) is located on the south side of the City of Guelph on Lowes Road West as illustrated on the appended Drawing 1 (Appendix 1). The Site is bounded by residential buildings in all directions. The Site is east and south of GRCA delineated wetlands. An unnamed contributing tributary interpreted to be Tributary D based on Figure 3.1.2 of the 1993 Hanlon Creek Watershed Plan completed by Marshall Macklin Monaghan Limited (October 1993) to Hanlon Creek lies about 640 m northwest of the Site. Tributary E East, identified on Drawing 1 (Appendix 1), is located approximately 415 m west of the site.

1.2 CURRENT AND PROPOSED LAND USE

The current land use of the Site is low density residential consisting of single residential dwellings. All subject properties face Lowes Road West with grassed areas and trees in the rear yards of the properties. A secondary building structure is located in the rear of 41 Lowes Road.

The project involves the redevelopment of the residential properties located at 19, 29, 35, 41, 51, and 59 Lowes Road West in Guelph, Ontario. The site layout of the proposed redevelopment has not been finalized at the time of writing this report, however; it is understood that the new residential development will comprise of 36 single family residential units and internal roadways. The appended Drawing 2 (Appendix 1), Site Plan depicts the proposed development layout. The stormwater management concept includes a dry pond that

is proposed to be lined. This is to ensure no inadvertent infiltration (that is not accounted for in the water balance calculations) will contribute to mounding beyond what has been calculated. In addition to the dry pond, a network of clean water collection (CWC) systems are proposed and lots that will be connected to the CWC are identified on Drawing 2 (Appendix 1) (identified as INFL on the appended drawing). These CWC systems are identified on Drawing 2 (Appendix 1) as CWC Trench 1, CWC Trench 2 and CWC Trench 3. The CWC systems will collect clean roof water from Lots 1-7, 10, 11, 14-33. The basements of the proposed development have been set 1.0 m above the measured seasonally high groundwater level (330.64 mASL). Therefore, it is expected that there will be minimal flow from the sump pumps. The sump pumps for these corresponding lots will also be connected to the CWC systems. Elsewhere, sump pumps will discharge to grade. As no basements are directly connected to the CWC system there is no need to locate the CWC system above the 100 year hydraulic grade line. The proposed development of the Site will be fully serviced with municipal sewers and water supply. We refer you to the Stantec Consulting Ltd. (Stantec) June 2018 Functional Servicing Report for more details pertaining to site specific servicing.

2 PHYSICAL SETTING OF THE SITE

2.1 TOPOGRAPHY AND PHYSIOGRAPHY

The Site is situated within the Guelph drumlin field physiographic region of Southern Ontario (Chapman and Putnam, 1984) and more specifically located within the spillways physiographic landform as described by Chapman and Putnam (2007).

The Site is also located within the Hanlon Creek Subwatershed. The Hanlon Creek Subwatershed boundaries are between the Hanlon Parkway on the west to just past Gordon Street on the east, from the north on Stone Road and south to Maltby Road. The underlying bedrock aquifer is part of a regional aquifer system which discharges to the Speed River (Stantec, 2008).

Ground surface elevations across the Site are found to be between 331 and 333 mASL. The topography is sloping to the northwest toward Hanlon Creek Wetland (HCW) with an approximate elevation of 328 mASL and several unnamed tributaries (Tributaries A-I) of the Hanlon Creek. Hanlon Creek discharges about 4.6 km east into the Speed River.

2.2 CLIMATE

Guelph's climate is characterized by variable annual temperatures and less variable total monthly precipitation. The average annual temperature was approximately 7.0°C and the inferred average total precipitation is 916 mm/yr[1]. Precipitation is typically lower in the fall and winter months, and late spring months experience higher amounts of runoff due to the effect of winter snow melt. Table 1 below lists monthly average precipitation and temperature data; from the Kitchener/Waterloo station located at the Region of Waterloo International Airport in Breslau (Latitude: 43°46'00" N Longitude: 80°38'00" W; Elevation: 321.60 m).

Table 1 Monthly Climate Summary data[1]

MONTH	PRECIPITATION mm/month	TEMPERATURE deg. Celsius
Jan	65.2	-6.5
Feb	54.9	-5.5
Mar	61.0	-1.0
Apr	74.5	6.2
May	82.3	12.5
Jun	82.4	17.6
Jul	98.6	20.0
Aug	83.9	18.9
Sep	87.8	14.5
Oct	67.4	8.2
Nov	87.1	2.5
Dec	71.2	-3.3
Total	916.3	--
Average	--	7.0

2.3 OVERBURDEN AND BEDROCK GEOLOGY

The Surficial Geology Map of the Guelph Area (GRCA, 2016) and the Quaternary (Pleistocene) Geology Map of the Guelph Area (Karrow, 1963) indicates that primarily outwash gravel deposits are found within the Site, as depicted on the appended Drawing 3 (Appendix 1), Surficial Geology.

[1] Canadian Climate Centre, 1981-2010, for Region of Waterloo International Airport

The overburden is underlain by a major carbonate bedrock formation, Guelph Formation, which consists of tan to brown sucrosic dolostone. The bedrock formation dates from the Upper Silurian Period, approximately 420 million years ago (Armstrong & Dodge, 2007; The Geological Society of America, 2012).

According to the Bedrock Topography of the Guelph Area (Karrow et al. 1979), depth to bedrock in the Site is between 320.0 - 323.1 mASL (1050 – 1060 fASL). According to WWR Nº 6702463, overburden thickness at the Site is estimated to be at 11.3 m.

2.3.1 Surface Water Features

The appended Drawing 1 (Appendix 1) depicts Hanlon Creek (and tributaries including Tributaries D and E as identified in the Hanlon Creek Watershed Plan, 1993) and Torrance Creek as surface water features in proximity to the Site. West and north of the Site are GRCA delineated wetland areas. To the northwest is the HCW, and to the north is the Torrance Creek Wetland Complex. The Torrance Creek Wetland Complex belongs to the Torrance Creek Subwatershed. A topographic divide occurs east of Gordon Street separating the two subwatersheds. Surface waters flowing from the Site will not affect the Torrance Creek (Dougan & Associates with Ecological Outlook, 2005).

3 HYDROGEOLOGICAL STUDY METHODOLOGY

The study methodology involved a number of tasks, which included:

- reviewing topographic, geological, and hydrogeological mapping and reports for the area; and the Ontario Ministry of the Environment and Climate Change (MOECC) Water Well Record (WWR) database;
- drilling of thirteen (13) boreholes, eight (8) of which were completed as 50 mm monitoring wells, for investigation of subsurface stratigraphy and hydrogeology;
- collecting soil samples for moisture content analysis, and for particle size distribution analysis to determine hydraulic conductivity values;
- collection of three (3) groundwater samples for analysis of general chemistry parameters;
- performing single response insitu (slug) tests in the monitoring wells to determine hydraulic conductivity values of the water-bearing deposits
- installation of four (4) mini piezometers for the measurement of surface water levels in three (3) locations and localized shallow groundwater levels in one (1) location; and,
- measurement of groundwater levels to establish the flow direction and horizontal gradient.

3.1 REVIEW OF PREVIOUS STUDIES

The review of previous studies for the Site included a Geotechnical Investigation completed by Englobe in May 2016 (Report Number 160-P-0010233-0-01-GE-R-0001-00) and updated in June 2018 (Report Number 160-P-0010233-0-01-GE-R-0001-01). Concurrent to the Geotechnical Investigation and Scoped Hydrogeology Study, MTE Consultants Inc. completed an environmental site assessment for the subject properties.

3.2 FIELD PROGRAM

3.2.1 Borehole Drilling

The present field program involved the advancement of thirteen (13) boreholes (BH-01-16 to BH-13-16) to depths ranging from 3.66 to 6.55 m to identify the subsurface soil and groundwater conditions at the locations shown on the appended Drawing 2 (Appendix 1). The boreholes were advanced between May 2 and May 4, 2016 by Geo-Environmental Drilling Inc. under the full-time observation of a senior technician from Englobe using a CME-75 track-mounted drill-rig equipped with continuous flight hollow stem augers.

Soil samples were recovered from the boreholes at regular 0.75 and 1.50 m depth intervals using a 50 mm diameter split-spoon sampler in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586). Soil samples obtained from the boreholes were submitted for moisture content analysis and seven (7) particle size distribution analyses. The laboratory results for moisture content are included on the borehole logs in Appendix 2. The laboratory results for the particle size distribution analyses are included in Appendix 3.

3.2.2 Monitoring Well and Mini Piezometer Installations

During the borehole drilling program, monitoring wells were installed in eight (8) boreholes (Boreholes BH-01-16, BH-02-16, BH-04-16, BH-06-16, BH-09-16, BH-10-16, BH-12-16 and BH-13-16) for measurement of groundwater levels and to determine saturated soil hydrogeological parameters.

The 50 mm diameter monitoring wells were constructed by inserting slotted, Schedule 40 PVC well screen and riser pipe into the open auger holes. Sand was added in order to place a filter pack around the screen, until the level of the sand was approximately 300 mm above the top of the screen. Bentonite seals were then placed above the sand pack to prevent the infiltration of surface water. The tops of all the well riser pipes were vented to allow accurate measurement of stabilized groundwater levels, and the flush mount wells were concreted in place to house each of the monitoring wells. Details of the monitoring well installations and soil and groundwater conditions encountered are provided on the borehole logs included in Appendix 2.

All of the monitoring wells were constructed in accordance with Ontario Regulation 903 (as amended) as administered by the Ontario MOECC. Well records were submitted to the MOECC based on the cluster system whereby one well record can be submitted on behalf of an entire property. Provincial Site Cluster Tag Identification Numbers were placed on the boreholes listed in Table 2. A licensed well technician must properly decommission the monitoring wells prior to construction.

Table 2 Borehole with Provincial Site Cluster Tag Identification Number

BOREHOLE	PROVINCIAL SITE CLUSTER TAG IDENTIFICATION NUMBER
BH-01-16	A192785

Manual measurements of stabilized groundwater levels in the monitoring wells on site were collected on May 12, 2016 and were collected on a quarterly basis for two years (May 2016 to May 2018) to determine seasonal changes of groundwater levels. Measured groundwater levels are summarized in Table 101 in Appendix 4.

Continuous groundwater monitoring was completed using electronic pressure transducers (dataloggers) installed in eight monitoring wells (Monitoring Wells BH-01-16, BH-02-16, BH-04-16, BH-06-16, BH-09-16, BH-10-16, BH-12-16 and BH-13-16), and a barologger has been installed in Monitoring Well BH-10-16 to continuously record barometric pressure fluctuations. All datalogger data has been barometrically compensated.

In April 2018, five hand holes were excavated and four mini piezometers were installed into the locations identified on Drawing 4 (Appendix 1). Mini Piezometer MP-01-18 was installed near storm water outlet 1 (SWO1) to record surface water levels. The PVC piping installed below ground surface is unscreened to measure surface water levels only.

A hand hole was excavated at the location identified as MP-02-18 to confirm whether there was a hydraulic connection between the surface water and shallow groundwater systems. The soils encountered were topsoil overlying brown silty sand with numerous cobbles. Mini Piezometer location MP-02-18 was advanced directly adjacent to Mini Piezometer MP-03-18. No groundwater was present during the time of excavation; therefore, a mini piezometer was not installed at this location. Mini Piezometer MP-03-18 was installed in the wetland identified on Drawing 4 (Appendix 1) to measure the surface water levels. The PVC piping installed below ground surface is unscreened to measure surface water levels only.

Mini Piezometer MP-04-18 was installed on land directly adjacent to Tributary E East to measure the shallow groundwater levels located within the vicinity of the surface water feature. Mini Piezometer MP-05-18 was installed within Tributary E East to measure changes in surface water levels. PVC piping installed below ground surface is unscreened to measure surface water levels only. It is noted that as Tributary E East is the closest branch of Tributary E to the site, the mini piezometers were installed in this location as it is expected that if there were increases to surface water levels, it would be noticed at Tributary E East first.

3.2.3 Surveying

The boreholes, monitoring wells and ground surface elevations were surveyed by Englobe using a Sokkia Model GXR 2 Global Navigation Satellite System (GNSS) rover. The previously mentioned feature locations were referenced to Universal Trans Mercator North American Datum of 1983 (UTM NAD83) coordinates; the zone reference (17T) has been excluded for the presentation purposes. The ground surface elevations are geodetic, based on GNSS and local base station telemetry with a vertical root mean squared error of less than 20 mm.

3.2.4 Insitu Infiltration Testing

Insitu infiltration testing utilizing the Guelph Permeameter was originally completed in August 2017 at the proposed CWC system locations to determine the design infiltration rate. In order to address comments from the City of Guelph and the City of Guelph's peer reviewer, additional insitu infiltration testing at these locations was completed in May 2018.

Insitu field saturated hydraulic conductivity values between 2.27 $x10^{-6}$ and 6.82 x 10^{-4} m/sec were obtained in the locations identified on the appended Drawing 2 (Appendix 1) in May 2018. A safety factor of 3.5 was applied to these figures resulting in factored design infiltration rates between 17 – 76 mm/hr. Based on these results, Englobe recommended using the factored design infiltration rates of 17 and 18 mm/hr corresponding to the measurements taken at GP-02-18 (at an approximate elevation of 330.8 mASL) and GP-03-18 (at an approximate elevation of 330.8 mASL). It is noted that at these two locations the base of the proposed CWC system (331.64 mASL) is above existing grade, and as such, the topsoil material was stripped back and the infiltration tests were completed on the native silty sand material. Englobe anticipates that the top silty layer encountered at these locations will hinder the infiltration into the underlying sand and gravel layers (which are considered to be very permeable); therefore, we advise that any topsoil and sandy silt soils found beneath the proposed infiltration facilities be removed and replaced with free draining material confirmed to have an appropriate hydraulic conductivity rate.

We refer you to Englobe Reference No. 160-P-0010233-0-07-304-HD-L-0002-00, dated June 2018 for more information pertaining to the insitu infiltration testing.

3.3 LABORATORY SOIL TESTING

All soil samples obtained during borehole drilling were returned to Englobe's laboratory facilities for visual examination, with selected samples undergoing physical testing. The soil moisture content test results obtained from borehole samples are plotted on the appended borehole logs, and the particle size analyses are plotted on Figures 1 and 2 in Appendix 3.

3.4 HYDRAULIC CONDUCTIVITY TESTING

Hydraulic conductivity estimates for the site soils were determined using two methods. The first method is applicable to saturated soils at depth and involves single response in-situ hydraulic (slug) tests at monitoring wells.

The second method involves a calculated estimation of hydraulic conductivity based on soil sample particle size analysis using the Kozeny-Carman and Kaubisch formulae where appropriate. The two methods used for this study are described in the following subsections.

3.4.1 Slug Testing

Hydraulic conductivity estimates were determined for the saturated soils at depth using single response slug tests for six (6) monitoring wells within and in proximity to the Site.

Each monitoring well was developed prior to slug testing. Well purging was implemented to remove silt and sand introduced into the well during construction, and to remove fine particles from the coarse sand pack placed around the outside of the well screen during construction.

The slug test procedure employs the hydrostatic time-lag method for groundwater recovery following the introduction of a slug of known volume into a monitoring well, and makes use of the theory of Hvorslev (1951), as described in Freeze and Cherry (1979). Hvorslev's method is expressed by the following equation:

$$K = \frac{r^2 \ln (L/R)}{2LT_0}$$

where:

K = hydraulic conductivity of the tested material (m/sec)
r = inner radius of the well riser pipe (m)
R = outer radius of the well riser pipe (m)
L = length of screen and sand pack (m)
T_o = time lag (sec), where $(H-h)/(H-H_o) = 0.37$
h = water level at each time of measurement (m)
H_o = initial water level (m, start of test)
H = stabilized water level prior to introducing slug (m)

The time lag, T_0, is defined as the time required for the water level to recover to 63 % of the stabilized level if the initial flow rate into the well is maintained. This time lag is determined graphically as the time for which (H-h) divided by ($H-H_o$) is equal to 0.37.

Slug test data was analyzed using MS Excel 2010 software. A summary of the hydraulic conductivity estimates is provided in the appended Table 102 (Appendix 4), and graphed results of the slug tests completed for the monitoring wells are included in Appendix 5.

3.4.2 Grain Size Analyses

Hydraulic conductivity values of seven (7) soil samples were derived empirically using the particle size distribution test and the Kozeny-Carman and Kaubisch formulae where the grain size analyses met the appropriate formulae criteria.

The particle size distribution analysis graphs are shown on Figures 1 and 2 in Appendix 3 and the calculated conductivity values for the samples from the boreholes are listed in the appended Table 102 (Appendix 4).

3.5 GROUNDWATER CHEMISTRY TESTING

Samples of groundwater were obtained from three (3) on-site monitoring wells (Monitoring Wells BH-02-16, BH-04-16 and BH-10-16) on May 13, 2016 and submitted to ALS Laboratories in Waterloo, Ontario for analysis of general chemistry parameters. Analysis results are summarized in the appended Table 103 (Appendix 4) with comparison to the Ontario Drinking Water Standards (ODWS) and the Provincial Water Quality Objectives (PWQO) where applicable. The laboratory Certificates of Analysis are included in Appendix 6.

4 HYDROGEOLOGICAL INVESTIGATION RESULTS

4.1 SUBSOILS

The borehole logs in Appendix 2 show that the soil composition varies across the Site. As shown in the cross section on the appended Drawing 5 (Appendix 1), the sediments of the Site consist mostly of sand and gravel deposits with trace to some silt. Some to numerous cobbles are found throughout the majority of the samples. Trace amounts of clay were encountered in Borehole BH-01-16 between 6.1 and 6.6 mBGS. Imported fill material was encountered at ground surface in seven boreholes (Boreholes BH-02-16 to BH-05-16, BH-07-16, BH-09-16 and BH-11-16). Native topsoil material consisting of mainly silts with some sand and gravel was encountered at ground surface in the remaining six boreholes. According to water well records in the vicinity of the Site (WWR Nº 6702440, 6703251), a discontinuous layer of clay is found overlying the dolostone bedrock.

Granular deposits encountered within the boreholes across the Site range in depth from approximately 3.4 to 6.4 m. Saturated conditions were encountered in the boreholes completed as monitoring wells ranging in depth from 1.4 to 2.8 mBGS.

The appended borehole logs (Appendix 2) describe soil types, lithological stratigraphy, results of STP testing, moisture content profiles, pocket penetrometer test results, details of the monitoring well construction, and groundwater level measurements and observations.

4.2 HYDRAULIC CONDUCTIVITY

Hydraulic conductivity estimates determined by the various testing methods are summarized in Table 102 in Appendix 4, with graphical analyses of slug test data included in Appendix 5, and particle size distribution graphs on Figures 1 and 2 in Appendix 3.

The analyzed soil types were sand and gravel with trace to some silt, a gravelly silt and sand, and a sandy silt with some gravel and trace clay. Based on the 13 calculated results for hydraulic conductivity (7 derived from grain size analysis and 6 derived from slug test analysis), Table 3 describes the geometric means of the two main soil types.

Table 3 Geometric Mean of Hydraulic Conductivities based on Soil Type

SOIL TYPE	GEOMETRIC MEAN [M/S]	NUMBER OF SAMPLES
Sand and gravel with trace to some silt	3.7×10^{-5}	11
Gravelly silt and sand	5.9×10^{-7}	2

4.3 GROUNDWATER ELEVATIONS AND FLOW DIRECTION

Groundwater is typically found within the granular deposits beneath the Site. The granular deposits occurring at varying depths across the Site are interpreted to be hydraulically connected and build an unconfined Shallow Overburden Aquifer.

The Site is a recharge zone belonging to the headwater area of Hanlon Creek subwatershed. Across the Site, groundwater in the Shallow Overburden Aquifer flows towards the HCW in a westerly direction. The general flow gradient slopes towards Hanlon Creek. The measured depth to water table in the monitoring wells varies across the site from approximately 1.1 to 3.6 mBGS. A map with seasonal high groundwater levels is shown on the appended Drawing 6 (Appendix 1). The depicted groundwater levels were recorded between May 5 and May 11, 2017. The shallow groundwater is interpreted to flow westerly toward the HCW.

4.4 SEASONAL FLUCTUATION OF GROUNDWATER ELEVATIONS

Englobe commenced a long term monitoring program in May 2016 for the duration of one year in order to observe seasonal fluctuations and determine the seasonal high groundwater level in the shallow groundwater aquifer across the site through the use of electronic pressure transducers (dataloggers). The location of the wells is depicted on the appended Drawing 2 (Appendix 1). In April 2017, it was determined that the monitoring program should continue for one more year (until May 2018) to confirm the depth to high groundwater during another spring freshet.

The program included quarterly site visits with manual groundwater level measurements at Monitoring Wells BH-01-16, BH-02-16, BH-04-16, BH-06-16, BH-09-16, BH-10-16, BH-12-16, BH-13-16. Dataloggers were installed in Monitoring Wells BH-01-16, BH-02-16, BH-04-16, BH-06-16, BH-09-16 and BH-10-16 for continuous monitoring of groundwater conditions across the Site between May 2016 and May 2017. In June 2017 dataloggers were also installed into Monitoring Wells BH-12-16 and BH-13-16. The manual measurements were used to verify the datalogger information which was downloaded, barometrically compensated using a barologger installed in Monitoring Well BH-10-16 and graphed on a quarterly basis. Measured groundwater levels are summarized in the appended Table 101 (Appendix 4).

The appended Figure 101 (Appendix 3) depicts barometrically corrected continuous groundwater level measurements in Monitoring Wells BH-01-16, BH-02-16, BH-06-16 and BH-10-16 and manual measurements for the previously mentioned monitoring wells and Monitoring Wells BH-04-16, BH-12-16 and BH-13-16 from May 12, 2016 to May 11, 2017. In June 2017 dataloggers were installed into Monitoring Wells BH-12-16 and BH-13-16, and the continuously recorded data from these dataloggers has been added to the appended Figure 101 (Appendix 3). Unfortunately, while a datalogger was installed in Monitoring Well BH-09-16, after the May 12, 2016 monitoring event, the monitoring well casing was damaged and as such, Englobe is unable to obtain the continuous readings and manual measurements from this monitoring well. It is noted that a wind storm occurred across Southwestern Ontario on May 4, 2018. As a result, a tree was downed and restricted access to Monitoring Well BH-04-16 during the May 9, 2018 monitoring event. Another monitoring event occurred on May 31, 2018 where it was noted water levels in all on site monitoring wells had decreased between 0.15 and 0.17 m. As the May 31, 2018 water level in Monitoring Well BH-04-16 was 2.45 mBGS, we estimated an approximate water level of 2.30 mBGS corresponding to an estimated groundwater elevation of 330.01 mASL for May 9, 2018. During the May 31, 2018 monitoring event, a car was parked on top of Monitoring Well BH-02-16 (a flushmount style well located in the driveway of 59 Lowes Road West). Therefore, a manual water level measurement and datalogger download could not be completed.

A review of both the continuously recorded and manually measured water levels to date show the seasonal high in all the wells occurred between May 5 and May 11, 2017 with the seasonal low occurring in the winter of 2017 into early 2018. At the end of the second year of groundwater monitoring (May 2018), it was determined that the highest measured water level occurred in Monitoring Well BH-13-16 corresponding to an elevation of 330.64 mASL on May 11, 2017, as previously discussed. A gradual increase in water levels in all monitoring wells is noted between May 2016 and May 2017; however, it is noted that water levels were lower in May 2018 when compared to May 2017. Measured groundwater levels were approximately 0.48 m higher on May 11, 2017 than May 12, 2016 in Monitoring Well BH-13-16. This is attributed to an early spring freshet and a more wet spring 2017. Measured groundwater levels were approximately 0.50 m lower on May 31, 2018 than May 11, 2017 in Monitoring Well BH-13-16.

Water levels in May 2018 were similar to those measured in May 2016 in the on site monitoring wells. This indicates that the water levels measured in 2016 and 2018 are typical baseline groundwater levels for the site and that the water levels measured in 2017 were higher than normal as depicted on Drawing 5 (Appendix 1) and described in Table 101 (Appendix 4). Based on the historical precipitation data received from the Environment Canada weather station (the closest station that records daily precipitation values) at the Region of Waterloo International Airport, Breslau, Ontario, by May 31, 2016, the amount of measured precipitation was 319 mm. By May 31, 2018, the amount of measured precipitation at this location was 303 mm. By May 31, 2017, the amount of measured precipitation at this location was 456 mm. This information further supports the belief that 2017 was a wet year and that a higher than average seasonal high groundwater level of 330.64 mASL has been used to set the elevations for the base of the CWC systems and basement elevations.

Based on the shallow groundwater contours depicted on the appended Drawing 7 (Appendix 1), shallow groundwater is interpreted to flow in a westerly direction toward the HWC. In order to better understand the local groundwater conditions, groundwater elevations measured at the adjacent site are included on the appended Drawing 7 (Appendix 1).

In response to a comment received by the City of Guelph's peer reviewer, a groundwater contour plan was created using the MOECC Water Well Records (WWRs) available within the vicinity of the site. It is noted that the area within the site has been developed for many years, and the water levels provided on the WWRs may not be consistent with water levels measured today. Based on the groundwater levels provided on the WWRs and assuming water levels were recorded below ground surface, groundwater levels were roughly 330 to 335 mASL. The 330 mASL contour line intersects the site and aligns well with the current groundwater elevations measured at the site. This information is provided on Drawing 8 (Appendix 1), appended.

Lastly, at the request of the City of Guelph's peer reviewer to understand the hydrogeological sensitivities that potentially exist at the site, the appended Drawing 9 (Appendix 1) depicts the minimum measured depth to groundwater for the site and adjacent site. It is noted that groundwater is measured at roughly 3.2 mBGS at the southern portion of the adjacent site and at the northwestern portion of the site groundwater is measured at approximately 1.5 mBGS. This plan is based on existing conditions, and that in order to achieve the appropriate separation, the site will be filled so that the base of the CWC systems will be at 331.64 mASL or higher, corresponding to 1.0 m above the measured high groundwater elevation of 330.64 mASL.

All dataloggers are still currently installed on site recording continuous water levels.

4.5 DEWATERING CONSIDERATIONS

To address a comment received from the City of Guelph, the potential preliminary dewatering estimates for the proposed site servicing and proposed external drop structure were calculated. It is noted that this hydrogeology study was not prepared to support dewatering activities and that once detailed design drawings are made available, more accurate and appropriate estimates related to dewatering will be made. A hydrogeology study in support of an Environmental Activity and Sector Registry (EASR) or Category 3 PTTW inclusive of appropriate water chemistry sampling would be required.

For the purpose of this assessment, it is assumed the installation of the sanitary, storm and watermain infrastructure will be completed using open cut methodologies. It is assumed the maximum depth for the servicing infrastructure is approximately 3.9 m.

The external drop structure located on Lowes Road would be excavated using vacuum excavation inside the formwork of the drop structure. The assumed maximum depth of the drop structure is approximately 6.2 m.

The Thiem Equation for unconfined radial flow into a circular excavation (Powers et al., 2007) was used to estimate the lateral flow into the excavation for the external drop structure. The Thiem Equation for unconfined flow into a long excavation (Powers et al., 2007) was used to estimate the lateral flow into the excavation. Please note the desktop calculations do not consider vertical flow from the bottom of the excavation. Further, the values calculated are for steady state dewatering rates and transient, initial dewatering rates are expected to be higher than the steady state dewatering in order to remove groundwater from storage within the surrounding soils.

The following assumptions were made for the proposed external drop structure:

- Groundwater elevation is the measured high groundwater level of 330.64 mASL;
- Aquifer bottom was set to an elevation of 317.8 mASL based on the MOECC WWR No. 6702457 and assuming the top 3 m of bedrock is permeable and an inferred ground surface elevation of 333.0;
- 0.6 m x 0.6 m excavation footprint;
- Assumed invert elevation of 329.1 mASL with a dewatering target of 328.1 mASL; and,
- A hydraulic conductivity of 3.7 x 10^{-5} m/sec.

The following assumptions were made for the currently proposed site servicing infrastructure:

- Groundwater elevation is the measured high groundwater level of 330.64 mASL;
- Aquifer bottom was set to an elevation of 317.8 mASL based on the MOECC WWR No. 6702457 and assuming the top 3 m of bedrock is permeable and an inferred ground surface elevation of 333.0;
- 40 m segment of trench 4 m wide to be dewatered at one time;
- Assumed invert elevation of 326.8 mASL with a dewatering target of 325.8 mASL; and,
- A hydraulic conductivity of 3.7 x 10^{-5} m/sec.

Based on the assumptions noted above, preliminary dewatering estimates for the proposed external drop structure are approximately 55,000 L/day, while the preliminary dewatering estimates for the proposed servicing infrastructure is approximately 1,780,000 L/day. Based on these numbers it is recommended that a Category 3 PTTW application be submitted for this work. It is noted that these numbers are based on preliminary inverts and are reflective of steady state dewatering conditions and that once detailed design drawings are available a more comprehensive analysis be completed to determine the appropriate dewatering rates.

To mitigate the potential impacts of dewatering, the following recommendations are provided and should be considered:

- Consideration for smaller excavations for linear works to reduce dewatering rates;
- A reduction in dewatering rates whenever possible;
- Appropriate filtration and treatment systems to be applied to the discharge pipe prior to discharging to the approved location;
- Completing construction that would require dewatering in summer or fall when groundwater levels are naturally lower; and,
- Directing discharge to the sanitary sewer if possible to avoid overland flow along Lowes Road and Dawn Avenue.

4.6 GROUNDWATER CHEMISTRY

Groundwater samples were obtained from three new monitoring wells (Monitoring Wells BH-02-16, BH-04-16 and BH-10-16) on May 13, 2016. Chemical parameters were compared to ODWS concentration limits in the appended Table 103 (Appendix 4). It is important to note that the ODWS was used for comparative purposes only as none of the monitoring wells are used to supply drinking water.

As shown on the appended Table 103 (Appendix 4), Monitoring Well BH-02-16 had measured exceedances of apparent colour, hardness, total dissolved solids, turbidity, total and dissolved aluminum, total iron, and total manganese. Monitoring Wells BH-04-16 and BH-10-16 had measured exceedances in hardness and total dissolved solids. In each case, these parameters are not health related, pertaining to aesthetic qualities or the effectiveness of water treatment systems.

It is noted that the general chemistry package was selected to gain a better understanding of the pre-development groundwater quality.

In response to the City of Guelph's peer reviewer's comment the chemistry results were also compared to the PWQOs. It is noted that in order to support a Category 3 PTTW application or EASR submission, resampling of the groundwater would be required as the chemistry results have exceeded the 18 month allowable limit for water chemistry results as set forth by the MOECC. Further, a more appropriate chemistry package (such as more comprehensive general chemistry package including parameters from City of Guelph Sanitary and Storm Sewer Use By-Law package) would need be selected if this study was for dewatering purposes.

Exceedances of the PWQO for ammonia were measured in all monitoring wells sampled. Total zinc exceedances were also measured in Monitoring Wells BH-02-16, BH-04-16 and BH-10-16. The detection limit for total cobalt was above the PWQO in Monitoring Wells BH-04-16 and BH-10-16. The detection limit for total and dissolved phosphorus was above the PWQO in all monitoring wells. Should these exceedances be measured under the sampling program for the hydrogeology study in support of a Category 3 PTTW or an EASR submittal, appropriate treatment and/or filtration will be required until the discharge meets the applicable criteria (City of Guelph Sanitary or Storm Sewer Use By-Law or PWQOs). Pilot testing the treatment and/or filtration system would be required prior to active dewatering and discharging activities to confirm the system is working effectively. It is also noted the total phosphorus would need to be analyzed apart from a total metals scan in order to achieve a lower detection limit. This should be completed under the sampling program for the hydrogeology study in support of a Category 3 PTTW or an EASR submittal.

It is recommended to discharge to the sanitary sewer to avoid overland flow down Lowes Road and Dawn Avenue, provided the sanitary sewer would be capable of handling the maximum dewatering rates provided, based on detailed drawings (to be determined at a later date). The groundwater would need to be sampled for the City of Guelph Sanitary Sewer Use By-Law and meet all the parameters prior to discharge. It is likely that treatment and/or filtration may be required prior to discharge.

It is understood that SWO1 has the capacity to handle flows up to 192 L/sec. Given the estimated daily dewatering rates of 1,835,000 L/day which is approximately 21 L/sec, an alternative discharge location would be to discharge to the SWO1. The groundwater would need to be sampled for the City of Guelph Storm Sewer Use By-Law and meet all the parameters prior to discharge. It is likely that treatment and/or filtration may be required prior to discharge.

Permission from the City of Guelph to discharge to either of these locations would also be required prior to discharge.

4.7 GROUNDWATER MOUNDING ASSESSMENT

To determine the potential groundwater mounding of the CWC systems, a groundwater mounding assessment was completing utilizing the volume of clean roof top water being directed to each corresponding CWC and the design rates provided in Englobe Reference Number 160-P-0010233-0-07-304-HD-L-0002-00, dated June 2018.

Based on the results, and assuming a field saturated hydraulic conductivity of 2.27×10^{-6} m/sec, minimal mounding is expected to occur at the site (>0.10 m directly below the CWC Trench 1). Based on the measured water levels at site, this amount is within the natural variation of the water table on site. Further, based on the recommendation to remove any topsoil and silty sand material underlying the infiltration facilities, it is anticipated that minimal, if any, mounding would occur on or off site.

We refer you to Englobe Reference Number 160-P-0010233-0-08-305-HD-L-0002-00, dated June 2018 for a more detailed discussion regarding the inputs and results of the anticipated groundwater mounding.

5 EXISTING CONDITIONS WATER BALANCE

The water balance accounts for all water in- and out-flows in the hydrologic cycle. Precipitation (P) falls as rain and snow. Then it can run off towards wetlands, ponds, lakes, and streams (R), infiltrate to the groundwater table (I), or evaporate from surface water and vegetation (ET).

When long-term average values of P, R, I, and ET are used then minimal or no net change to groundwater storage (ΔS) is assumed.

The annual water balance can be stated as:

$$P = ET + R + I + \Delta S$$

where:

P = Precipitation (mm/year)

ET = Evapo-transpiration (mm/year)

R = Runoff (mm/year)

I = Infiltration (mm/year)

ΔS = Change in groundwater storage (taken as zero) (mm/year)

For this site, Stantec has completed a pre and post feature based water balance and site level monthly water balance. While this hydrogeology study will outline key features of both pre and post feature based and site level monthly water balance, we refer you to the Preliminary Stormwater Management Report, 19-59 Lowes Road, Guelph ON, Revision #3 dated June 2018 (Reference Number 161413228) for more details pertaining to the water balance.

The site is part of the HCW which is approximately 2,640 ha and contains nine (9) tributaries in the area of the central wetland to which the site is discharging (Tributaries A – I). The site is part of the Tributary E subcatchment and drains to the east portion of Tributary E of the HCW. Based on the original GAWSER model completed for the Hanlon Creek Watershed Plan (HCWP) and then updated in the Hanlon Creek State of the Watershed Study (HCSOWS), the Tributary E subcatchment is approximately 667 ha. This subcatchment includes a large area of drainage south of Clair Road which does not generate surface water runoff as all water is assumed to infiltrate (pages B-15-16 of HCSOWS). According to the HCSOWS, the site is part of Catchment 1215 (previously catchments 211-215 from the HCWP) illustrated on Figure B1.13 of the HCSOWS report which drains to Tributary D in the GAWSER model; however, based on more recent topographic information and the local storm sewer network provided by the City of Guelph to Stantec, the site is part of a 62.1 ha subcatchment (as shown on Figure 4.0, in Appendix A of the Preliminary Stormwater Management Report). The 1.7 ha site represents 3% of this subcatchment.

5.1 FEATURE BASED WATER BALANCE

5.1.1 Precipitation and Evapotranspiration

The feature based water balance used average annual precipitation[2] for the Site of 916 mm/yr, based on the 30-year average annual rainfall for Waterloo-Wellington rain gauge.

The calculated annual actual evapotranspiration rate for the site is 478 mm/yr. Applying these figures to the pre-development feature based water balance for the subject property gives a water surplus of 438 mm/year (precipitation minus evapotranspiration), which then becomes the infiltration and runoff components of the budget.

5.1.2 Infiltration and Runoff

The pre-development recharge/infiltration rates from the GRCA dataset (shown on the appended Drawing 10 [Appendix 1]) indicate rates ranging from 200 - 300 mm/year across the Site. The average infiltration rate for the area provided by Stantec, 2018 is 256 mm/year.

It is important to consider that the localized infiltration rates commonly vary. The ability of soils to infiltrate under post-development conditions will change accordingly. It is important to note that infiltration rates may vary based on certain variables such as the saturated hydraulic conductivity of surface soils, land slope, rainfall intensity, relative soil moisture at the start of a rainfall event, and vegetative cover of the ground surface.

According to the appended Drawing 11 (Appendix 1), Average Annual Runoff, the area within the site has average runoff values ranging from less than 50 mm/yr of runoff and 125 to 250 mm/yr. The estimated runoff for the Site provided by Stantec, 2018 is 182 mm/year.

The average pre-development water balance inputs for the Site is presented in Table 4 below.

Table 4 Pre-Development Water Balance Inputs for the Site (SA)

HYDROLOGIC COMPONENT	SITE VOLUME BASED (mm/year)	SITE VOLUME BASED %
Total Precipitation	916	100.0
Evapotranspiration	478	52.0
Infiltration	256	28
Runoff	182	20.0

[2] Canadian Climate Centre Normals, 1981-2010 for Waterloo Wellington Airport.

These runoff and infiltration values are a result of the well-draining near surface soils typically sand and gravel with trace to some silt components resulting in a relatively high permeability which contributes to an increased infiltration rate for the water balance. As previously mentioned, based on the results of the insitu infiltration testing completed in May 2018 we advise that any topsoil and sandy silt soils found beneath the proposed infiltration facilities be removed and replaced with free draining material confirmed to have an appropriate hydraulic conductivity rate.

We refer you to Englobe Reference No. 160-P-0010233-0-07-304-HD-L-0002-00, dated June 2018 for more information pertaining to the insitu infiltration testing.

5.1.3 Post Development

The featured based water balance was checked against the natural variation in precipitation for the area to ensure negligible impact to Tributary E East. Provided runoff and recharge values remain within the historical range (1981-2010), minimal impacts are anticipated.

It is noted that the largest post development recharge deficit and surplus occur in April and July, respectively; however, the values remain well within the historical range for the natural variation of precipitation for these months. The largest post development runoff surpluses occur in October and April, respectively; however, these changes are also within the historical range for the natural variation of precipitation. Based on this information, from a hydrological perspective no significant change is anticipated to the downstream receiver.

As expected for a developed condition, there is an increase in surface runoff on an annual basis. The annual surface runoff following development of the site is calculated to be 187 mm or a surplus of 5 mm/year which represents a 3% increase. The total volume of runoff to the wetland is in the range of 116,000 m^3. Given the size of the overall catchment, this is considered a minor increase in surface water volume to the watercourse on an annual basis and no further analysis is recommended per the TRCA's feature-based water balance methodology.

A copy of the Monthly Feature Based Water Balance Analysis – Tributary E of Hanlon Creek Watershed spreadsheet completed by Stantec is provided in Appendix 7.

We refer you to Stantec's Preliminary Stormwater Management Report (June, 2018) for more details pertaining to the feature based water balance. Please refer to the EIS (Aboud, 2018) for details relating to the sensitivity of the terrestrial and aquatic features found within this wetland area.

5.2 SITE LEVEL MONTHLY WATER BALANCE

Stantec also completed a monthly water balance for the site under existing and proposed conditions given the proposed implementation of the CWC systems. As development will increase the amount of impervious surface on a site, the total volume of recharge (infiltration) and evapotranspiration volumes are decreased, consequently increasing the runoff volumes. As previously discussed, the proposed infiltration strategy outlined above and in the Stantec Preliminary Stormwater Management Report helps to maintain recharge to the groundwater system by infiltration the 25 mm rainfall event from the majority of rooftop areas. Under the proposed conditions, an infiltration surplus of 118 m^3/year (7mm/year) and a runoff surplus of 3,242 m^3/year (196 mm/year) will exist at the site. We refer you to the appended Drawing 2 (Appendix 1) which identifies the proposed lots that will contribute to the CWC systems.

The site level water balance analysis was also completed by Stantec for the monthly minimum and maximum precipitation values over the past 30 years of rainfall data (1981-2010). For each monthly input precipitation value in the water balance spreadsheet (please see Appendix 7), the average monthly precipitation value was replaced with the minimum and maximum monthly values for the past 30 years. The water balance calculations were then adjusted using each of these values to determine a range of monthly runoff and recharge values. The analysis was performed to check if the proposed site's annual runoff volume is within the natural hydrologic variation for the property. If so, the impact of the site's discharge on the downstream receiver is within the natural hydrologic regime; i.e., no negative impacts on a site level scale.

Based on the site level monthly water balance and the historical variations in rainfall between 1981-2010, the largest post-development recharge deficit and surplus occur in April and July, respectively; however, the values remain well within the historical range for the natural hydrologic variation. Similarly, the smallest and largest post-development runoff surpluses occur in October and April, respectively; however, these changes also remain within the historical range for the natural hydrologic variation. As such, no significant change is anticipated downstream of the site outlets.

The Site water balance calculations prepared by Stantec (2018) are provided in Appendix 7.

6 POTENTIAL IMPACTS OF LAND DEVELOPMENT

6.1 WATER USERS

Well Records from the Ministry of the Environment and Climate Change (MOECC) Water Well Record (WWR) Database were reviewed to determine the number of wells present. One hundred fourteen (114) wells are located within an approximate radius of 600 m from the center of the Site according to the MOECC WWR database. Monitoring wells, abandoned wells, and wells that are classified as not in use are going to be excluded from further consideration, bringing the total amount of wells within the area to sixty-nine (69). Five (5) wells are completed in overburden soils, and sixty-four (64) wells have unknown completion details. The appended Drawing 12 (Appendix 1) depicts the sixty-nine (69) wells under consideration. It must be noted that all of these sixty-four (64) wells are drilled to bedrock approximately 11.3 to 13.1 mBGS, and it is assumed the screen is completed within the bedrock. A summary of the Water Well records is included in Appendix 8.

One municipal well, known as the Burke Well, is located along Arkell Road, approximately 1200 m north of the site. It is noted that the well record summary includes another municipal well (WWR Number 6702440); however, further investigation revealed this well no longer exists.

Maintaining the distribution of pre-development infiltration rates across the Site will help to preserve recharge to the Shallow Overburden Aquifer; therefore, no impacts to shallow overburden water supply wells would be expected. Wells screened in deeper overburden and bedrock aquifers are principally supplied by precipitation that infiltrates over a much broader area, and are unlikely reliant upon infiltration within the Site.

As discussed in Section 5.2, the post-development water balance will be designed with the intention to match pre-development conditions.

6.2 BURKE WELL

The City of Guelph has a municipal supply well located at 164 Arkell Road that is approximately 1200 m of the Site. According to the water well record, the Burke Well was drilled in June 1966 to a depth of 78.9 m (259 feet) and completed into blue shale bedrock. The screen depth and screen length of the production well is unknown.

6.2.1 Wellhead Protection Areas (WHPAs)

The Grand River Source Protection Area (GRSPA) Approved Assessment Report (2012) defines Wellhead Protection Areas (WHPAs) for the studied wellfields. WHPAs correspond to the travel time of groundwater flowing through an aquifer to a municipal well. The GRSPA identifies WHPA classes as follows:

- WHPA-A: 100 m radius from a municipal supply well;
- WHPA-B: between 100 m and the 2 year travel time;
- WHPA-C: Between the 2 year and 5 year travel time;
- WHPA-D: Between the 5 year and 25 year travel time;

As shown on the appended Drawing 13 (Appendix 1), the Site lies within WHPA-C of the Burke Well. It is noted that the WHPA corresponds to travel times for the City of Guelph's Burke Well (a deep bedrock well).

6.2.2 WHPA Vulnerability

Wellhead Protection Area adjusted vulnerability scoring mapping combines the WHPA and the intrinsic vulnerability to provide vulnerability scoring inside the WHPA. The adjusted vulnerability score for a WHPA accounts for both the rate of vertical and horizontal movement of water to the well and range from 2 to 10, with 10 being the highest score. Generally, vulnerability scores increase in proximity to a supply well. The appended Drawing 14 (Appendix 1) shows the majority of the Site has a vulnerability score of 8, with a small portion of the northwest corner of the property scoring a 6.

6.2.3 Aquifer Intrinsic Vulnerability

Mapping of the intrinsic vulnerability within WHPAs is based on the Intrinsic Susceptibility Index (ISI). The ISI is intended to reflect the intrinsic degree of protection of an aquifer based on the thickness and properties of the materials overlying the aquifer, which is analogous to the vertical travel time of a contaminant to the given aquifer.

The appended Drawing 15 (Appendix 1) depicts the intrinsic vulnerability mapping (GRCA, 2013) of the bedrock aquifer, indicating that the Site is in an area of medium intrinsic vulnerability.

6.2.4 Groundwater Recharge Vulnerability

The appended Drawing 16 (Appendix 1) illustrates groundwater recharge vulnerability for Significant Groundwater Recharge Areas (SGRAs) surrounding the Site. SGRAs correspond to areas where recharge is greater than or equal to 115% of the average recharge rate within a watershed. The Site is found to be within an area of medium vulnerability with a score of 4.

6.3 SENSITIVE AREAS

6.3.1 Wetlands

Wetlands are sensitive to changes in seasonal runoff volumes, and changes in shallow groundwater elevations. Runoff, coupled with groundwater inflows from the shallow overburden aquifer, increases the surface area of the wetlands.

Based on the general shallow groundwater flow direction and elevation, and the groundwater contours converging towards the HCW, it is concluded that Hanlon Creek and its associated wetlands are partially dependent on groundwater flowing (and discharging) from the Site. The groundwater contours on the appended Drawing 7 (Appendix 1) suggests that a portion of groundwater discharges into the tributary of Hanlon Creek.

As a result, any detrimental changes to the pre-development water balance, causing a reduction of the infiltration rates or long term lowering of groundwater levels in the Shallow Overburden Aquifer, would adversely impact the wetland ecosystem by shrinking the size of this habitat.

It is noted that during the installation of the mini piezometers, SWO1 outlet had been discharging due to a large rainfall event; therefore, Mini Piezometer MP-01-18 was installed within the existing flow path of the outlet to measure the surface water levels when the outlet is discharging as depicted in Photo 1 in Appendix 9. The mini piezometers were installed on April 12, 2018 when it was raining. The outlet was discharging and shortly after the rain had stopped, the outlet stopped discharging and the surface water infiltrated into the ground. On April 12, 2018 it was noted that the maximum distance the discharge from the outlet extended was approximately 7 meters. Water pooled around the outlet to an approximate distance of 7 meters before flowing west along the fence line between the HCW and the properties backing onto the HCW from Zess Court as depicted in Photos 2 and 3, appended. The rain had stopped around noon and by 13:10 the majority of the surface water had infiltrated with some pools remaining in low level areas.

Figure 103, (Appendix 3) depicts the water levels recorded within Mini Piezometer MP-01-18. It is noted that the mini piezometer was installed to measure surface water levels only, and that the PVC piping installed below ground surface is not screened; therefore, surface water may enter through the screened portion above ground surface but cannot infiltrate into the ground. As depicted on Figure 103 (Appendix 3) water levels within the mini piezometer respond quickly to precipitation events. It is noted that the drop in water levels within the mini piezometer appear exaggerated on May 9, 2018 due to the difference in manual measurements that were used to correct the data. During numerous site visits the area within the vicinity of the outlet discharge is dry.

Mini Piezometer MP-03-18 is installed within the surface water of the wetland as shown on Drawing 4, Appendix 1. It is understood that this wetland is a man-made feature and was created by the discharging of sump pumps at the end of Dawn Avenue. This coupled with the lack of groundwater found in Mini Piezometer MP-02-18 directly adjacent to Mini Piezometer MP-03-18 that this portion of the HCW is not supported by shallow groundwater.

The appended Figure 104 (Appendix 3) depicts the continuously recorded surface water levels within this man made wetland. Based on the hydrograph, surface water levels have remained stable. The surface water levels appear to respond to precipitation events as depicted on the appended figure.

6.3.2 Streams

Post-development runoff from the Site will be directed to either the on site dry pond (lined) or drain south onto Lowes Road and ultimately flowing toward Dawn Avenue and will not be directly discharged into a surface water feature. As previously mentioned the site falls within the catchment of Tributary E within the HCW. Two mini piezometers (Mini Piezometer MP-04-18 and MP-05-18) were installed on land and within the stream bed, respectively, to monitor the pre-development surface water levels and to understand the relationship between the shallow groundwater and surface water interactions. The GRCA has the area mapped as having an upward hydraulic gradient; however, based on the water levels within these two mini piezometers (328.37 and 328.30 on April 12, 2018 for MP-04-05 and MP-05-18 respectively), it is determined that the gradient in this location is downward, indicating recharging conditions are occurring.

Dataloggers were installed in both mini piezometers in April 2018. The data from these dataloggers are barometrically corrected using the barologger installed in Monitoring Well BH-10-16 located on site. We refer you to the appended Figures 105 and 106 located in Appendix 3 for the hydrographs.

Based on the hydrograph produced for Mini Piezometer MP-04-18 (Figure 105, Appendix 3), the shallow overburden aquifer responds quickly to precipitation events however the water quickly dissipates. Stream levels within Tributary E East remain fairly stable noting muted increases (>0.10 m) in the hydrograph coincide with precipitation events as depicted on the appended Figure 106 (Appendix 3). We note that Tributary E East flows through a forested area closest to the site, and as such, may not receive as much precipitation due to interception of the tree canopy.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

The geotechnical and hydrogeological studies conducted by Englobe have provided information about the subsurface stratigraphy across the Site. The subsurface stratigraphy across the Site is mainly sand and gravel with trace to minor silt. MOECC WWR in the vicinity of the Site indicates that a discontinuous layer of clay exists at depth overlying bedrock. The nature of the soils across the Site allow for high infiltration of water.

A long term monitoring program was completed for the duration of two years to gain a better understanding of the groundwater levels across the Site and to determine a seasonal high groundwater level. The highest measured groundwater level was in Monitoring Well BH-13-16 with a level of 330.64 mASL on May 11, 2017. Groundwater was measured in the near surface granular soils between 1.1 and 3.6 mBGS.

All proposed dwellings exceed the required minimum separation of 0.5 m and are set 1.0 m above the seasonal high groundwater level of 330.64 mASL. The bottom of the proposed CWC systems are set 1.0 m above the seasonal high groundwater elevation of 330.64 mASL. Please refer to Stantec's June 2018 Functional Servicing Report for more details.

Low impact development techniques have been implemented as part of the design and the site meets the stormwater parameters for the property as provided by the City. Stantec's Preliminary Stormwater Management Report Revision 3 (June 2018) for more details pertaining to the required stormwater parameters and low impact development techniques.

Surface water features within the vicinity of the Site include tributaries (Tributaries A-I) to the Hanlon Creek as well as the HCW, found northwest of the Site. The Site was found to be within the WHPA-C delineation for the City of Guelph's Burke Well, located approximately 1200 m north of the Site on Arkell Road. The Site has scored between 6- 8 on the WHPA vulnerability, and has a moderate level of intrinsic vulnerability. The Site is within a moderate significant groundwater recharge area scoring a level of 6.

A feature based water balance for existing and post development conditions was calculated by Stantec. Under post-development conditions, no increase to infiltration was calculated. As expected for a developed condition, a surplus of 5 mm/year which represents a 3% increase in surface runoff on an annual basis was calculated. The total volume of runoff to the wetland is in the range of 116,000 m^3. Given the size of the overall catchment, this is considered a minor increase in surface water volume to the watercourse on an annual basis and no further analysis is recommended per the TRCA's feature-based water balance methodology.

A site level water balance for existing and post development conditions was also calculated by Stantec. Under post-development conditions, a negligible (7 mm/year) increase in infiltration rates was calculated; however, due to the permeable nature of the soils and the results of the groundwater mounding assessment, groundwater mounding on and off site is expected to be minimal, if any. Runoff water chemistry can be addressed by SWM facilities through treatment of runoff from the Site prior to discharge to the unnamed tributary.

The pre to post balance is met for the site. By ensuring the water balance is maintained and that the water chemistry of infiltrated water is not significantly degraded, the potential impacts to the shallow overburden aquifer will be mitigated. Please refer to the Aboud & Associates Inc. Scoped EIS Addendum Report (June 2018) and Stantec's Preliminary Stormwater Management Report Revision 3 (June 2018) for more details pertaining to the feature based and site level pre to post water balance.

Based on Englobe's results of the groundwater mounding assessment (Englobe Reference 160-P-0010233-0-08-305-HD-L-0002-00, June 2018), groundwater mounding will not be an issue on the internal site structures or neighbouring properties. It is recommended that any topsoil and sandy silt / silty sand material found beneath the CWC systems (infiltration facilities) will be removed and replaced with free draining material confirmed to have an appropriate hydraulic conductivity rate. Based on this recommendation, the potential cumulative impact of all three trenches infiltrating that there would be no impact at the property line.

7.2 RECOMMENDATIONS

A combination of spatially distributed at-source and other infiltration measures may be applied where subsurface soils are adequately permeable and there is sufficient separation between groundwater and footing elevations.

During the design phase of the proposed development within the Site, grading and footing information were compared to groundwater monitoring data to achieve separation between the seasonally high groundwater table elevation and house footings. The fill material for grading should have similar (or improved) hydraulic properties to the existing permeable soils.

Additionally, the backfilled soils have to be clean materials to maintain the innocuous groundwater chemistry within the Site.

In order to keep the form and function of wetlands, the proposed residential development will need to conserve pre-development groundwater levels, and keep seasonal runoff volumes as low as possible.

It is recommended that any topsoil and sandy silt / silty sand material found beneath the CWC systems (infiltration facilities) will be removed and replaced with free draining material confirmed to have an appropriate hydraulic conductivity rate.

8 STATEMENT OF LIMITATIONS

The hydrogeology recommendations provided in this report are applicable only to the project described in the text and are intended for the use of the project designer. Any use which a contractor makes of this report, or decisions made based on it, are the responsibility of the contractor. The contractor must also accept the responsibility for means and methods of construction, seek additional information if required, and draw their own conclusions as to how the subsurface conditions may affect their work. Englobe accepts no responsibility and denies any liability whatsoever for any damages arising from improper or unauthorized use of the report or parts thereof.

It is important to note that this investigation involves a limited sampling of the Site gathered at specific test hole locations, and the conclusions in this report are based on this information gathered. The subsurface conditions between and beyond the boreholes may differ from those encountered at the boreholes. Should subsurface conditions be encountered which differ materially from those indicated in the borehole logs, we request that we be notified in order to assess the additional information and determine whether or not changes should be made as a result of the conditions.

Additionally, much of the information and conclusions presented in this report have been based on, and taken from, data and reports collected and prepared by other consultants. Englobe is not responsible for any errors or omissions in these third party reports.

The professional services provided for this project include only the hydrogeological aspects of the subsurface conditions at the Site, unless otherwise stated specifically in the report. The recommendations and opinions given in this report are based on our professional judgment and are for the guidance of the Client and Consultant in the design of the specific project. No other warranties or guarantees, expressed or implied, are made.

We trust that this report is suitable for your present requirements and we thank Reid's Heritage Homes for this opportunity to have provided hydrogeological engineering services. If you have any questions or require further hydrogeological or geotechnical consultation, please do not hesitate to contact our office.

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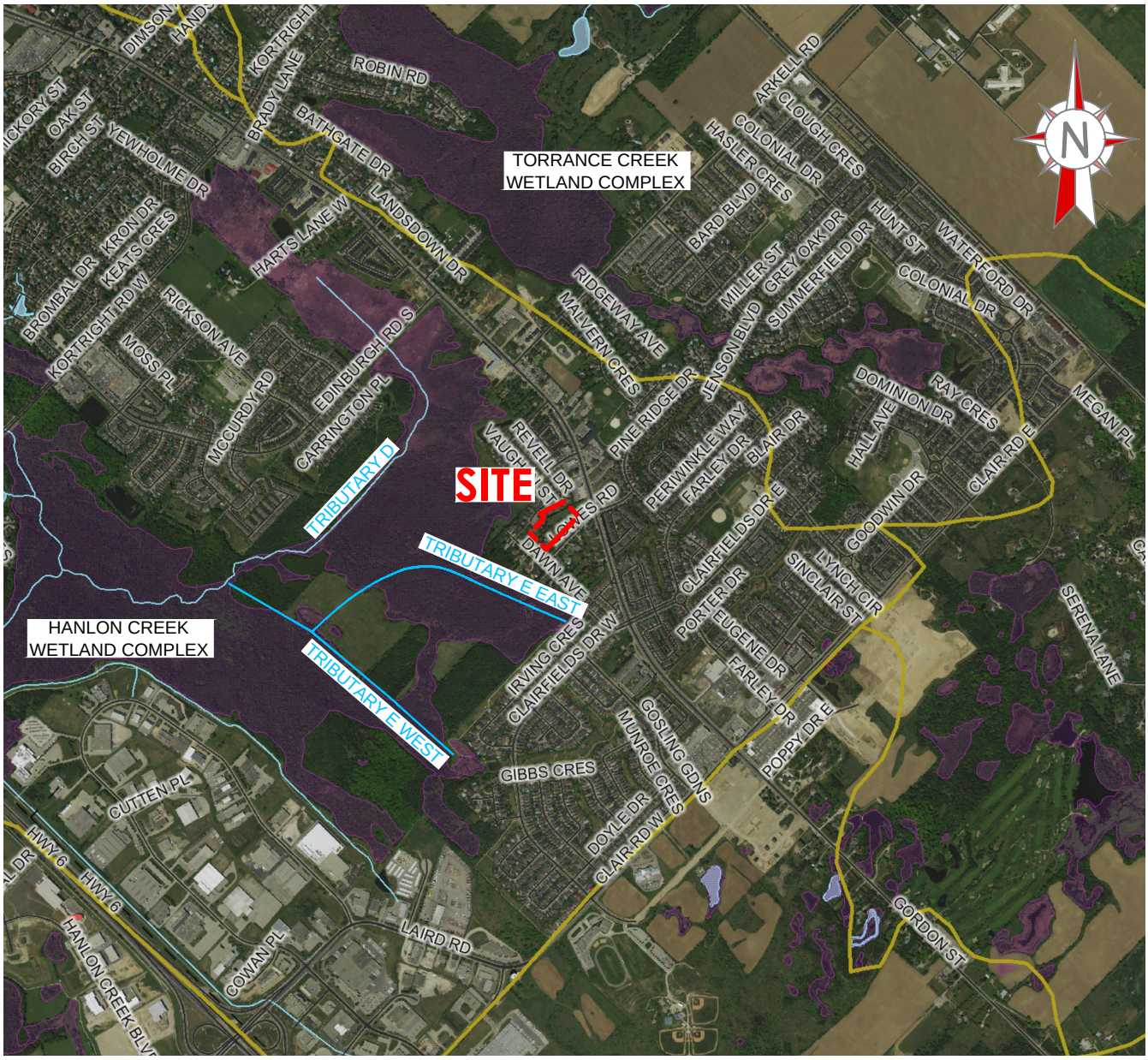
Appendix 1 Drawings

Drawing 1: Location Plan
Drawing 2: Site Plan
Drawing 3: Surficial Geology
Drawing 4: Mini Piezometer Location
Drawing 5: Cross Section A-A'
Drawing 6: Seasonal High Groundwater Levels May 2016 to May 2018
Drawing 7: Shallow Groundwater Contours
Drawing 8: MOECC Groundwater Contour Plan
Drawing 9: Minimum Measured Depth to Groundwater (Existing Conditions)
Drawing 10: Average Annual Recharge
Drawing 11: Average Annual Runoff
Drawing 12: MOECC Water Well Records
Drawing 13: Wellhead Protection Areas Map
Drawing 14: Wellhead Protection Area Vulnerability
Drawing 15: Intrinsic Vulnerability
Drawing 16: Significant Groundwater Recharge Area Vulnerability



LEGEND :

GRCA WETLANDS

GRCA SUBWATERSHED BOUNDARY

NOTES :

1-REFERENCES : GRAND RIVER CONSERVATION AUTHORITY, 2010 Aerial Photograph (2016).

2-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.

0 250 500 750 1000 m

SCALE 1:25000

Project

Lowes Road Development, Hydrogeology Study

Lowes Road, Guelph, Ontario

Title

LOCATION PLAN

Englobe Corp.
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon	Discipline	HYDROGEOLOGY	Project manager	E.Brears
Drawn	E.Ciochon	Scale	1 : 25000	Sequence no.	01 of 16
Checked	E.Brears	Date	2018-06-14		

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0010233-0-02-300	HD	001	02

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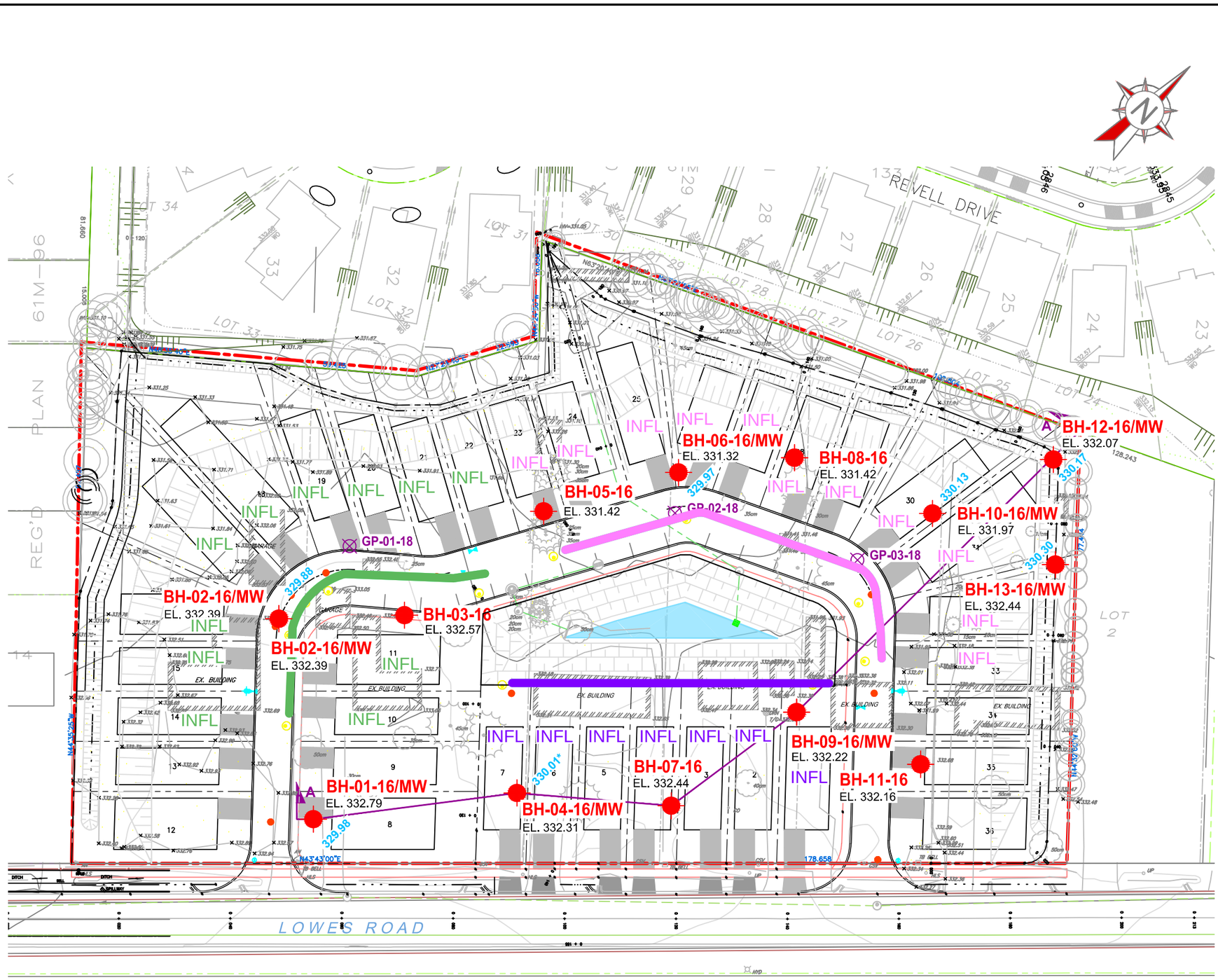

LEGEND :

- SITE OUTLINE
- BOREHOLE LOCATION
- EL. 331.32 — GROUND SURFACE ELEVATION (m)
- GUELPH PERMEAMETER TEST LOCATION (May 9, 2018)
- A A' — CROSS SECTION (Refer to Drawing 5)
- DRY POND (lined)
- INFL — INFILTRATION LOTS
- 330.08 — GROUNDWATER ELEVATION (mASL) (May 9, 2018)
- * — ESTIMATED WATER LEVEL IN MONITORING WELL BH-04-16 (May 9, 2018 due to downed tree)
- CWC TRENCH 1
- CWC TRENCH 2
- CWC TRENCH 3

NOTES :
1-REFERENCES: STANTEC, Project: Feature Water Balance Drainage Area Plan, Drawing: FIG.4, May 2018.
2-Borehole coordinates and elevations based on Sokkia network data.
3-Estimated water level in Monitoring Well BH-04-16 for May 9, 2018 due to downed tree.
4-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.
5-MW refers to monitoring well installed at borehole location.

Project
Lowes Road Development, Hydrogeology Study

Lowes Road, Guelph, Ontario

Title
SITE PLAN

Englobe Corp.
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon	Discipline	HYDROGEOLOGY
Drawn	E.Ciochon	Scale	1:750
Checked	E.Brears	Date	2018-06-14
Project manager	E.Brears	Sequence no.	02 of 16

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0010233-0-02-300	HD	002	02

10 cm 0 1 2 3 4 5

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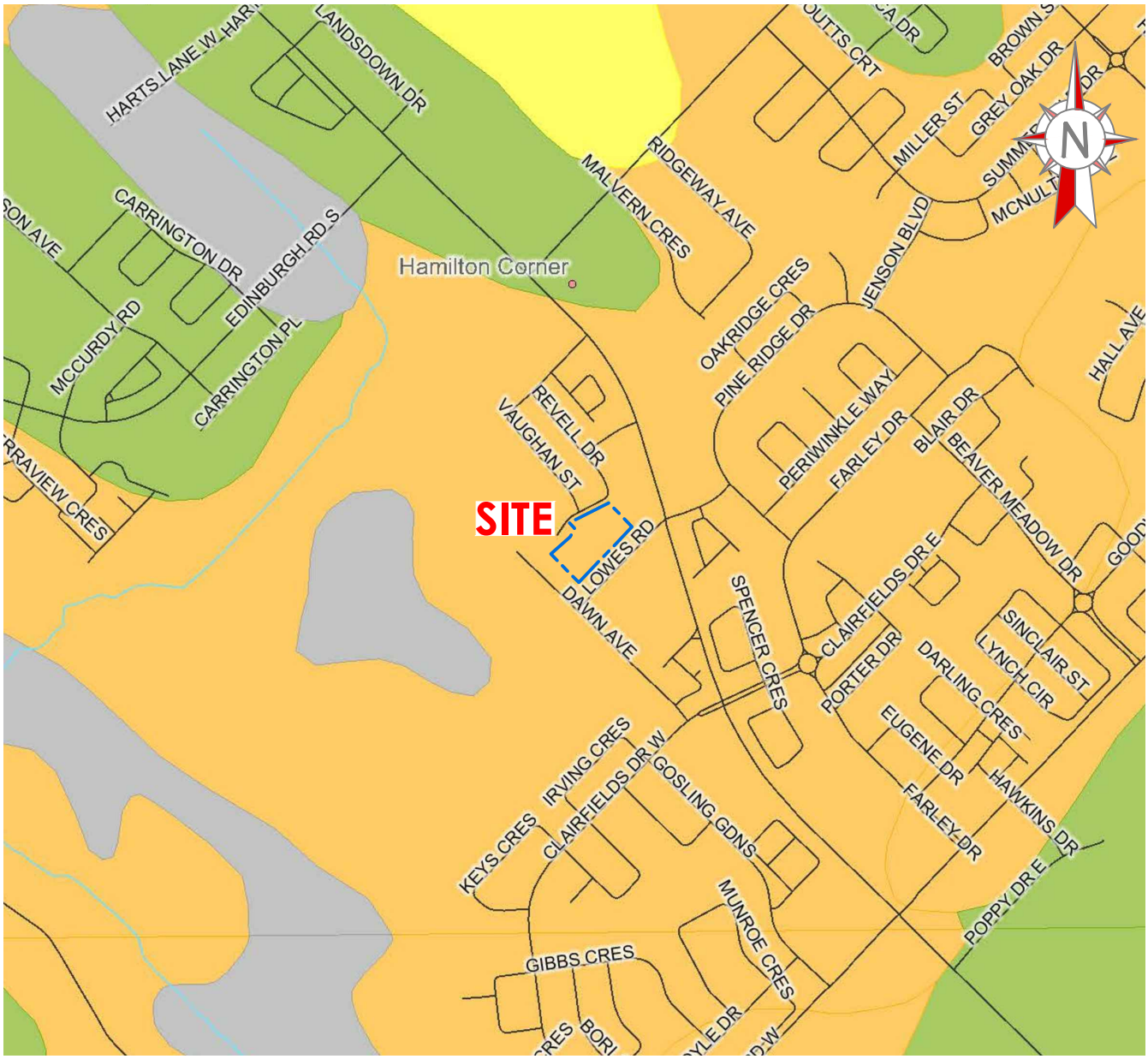

LEGEND :

- DIAMICTION
- GRAVEL
- ORGANIC DEPOSITS
- SAND

NOTES :

1-REFERENCES : GRAND RIVER CONSERVATION AUTHORITY, Surficial Geology, (2016).

2-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.

0 100 200 300 400 500 m

SCALE 1:15000

Project

Lowes Road Development Hydrogeology Study

Lowes Road, Guelph, Ontario

Title

SURFICIAL GEOLOGY

Englobe Corp.
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon	Discipline	HYDROGEOLOGY	Project manager	E.Brears
Drawn	E.Ciochon	Scale	1 : 15000	Sequence no.	03 of 16
Checked	E.Brears	Date	2018-06-14		

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0010233-0-02-300	HD	003	02

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LEGEND :

- SITE OUTLINE (Current Englobe Investigation, P-0010233-0-02-300, May 2016)
- SITE OUTLINE (Previous Englobe Investigation, P-0011540-0-02-300, June 2017)
- MINI PIEZOMETER LOCATION
- STORM OUTLET

0 20 40 60 80 100 m

SCALE 1:2000

NOTES :

1-REFERENCES: GRAND RIVER CONSERVATION AUTHORITY, 2015 Aerial Photograph (2018).

2-Mini Piezometer coordinates provided by Stantec.

3-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.

Project

Lowes Road Development, Hydrogeology Study

Lowes Road, Guelph, Ontario

Title

MINI PIEZOMETER LOCATION PLAN

Englobe Corp.
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon
Drawn	E.Ciochon
Checked	E.Brears
Discipline	HYDROGEOLOGY
Scale	1:1250
Date	2018-06-13
Project manager	E.Brears
Sequence no.	04 of 16

M. dept.	Project	Disc.	Dwg no.	Rev.
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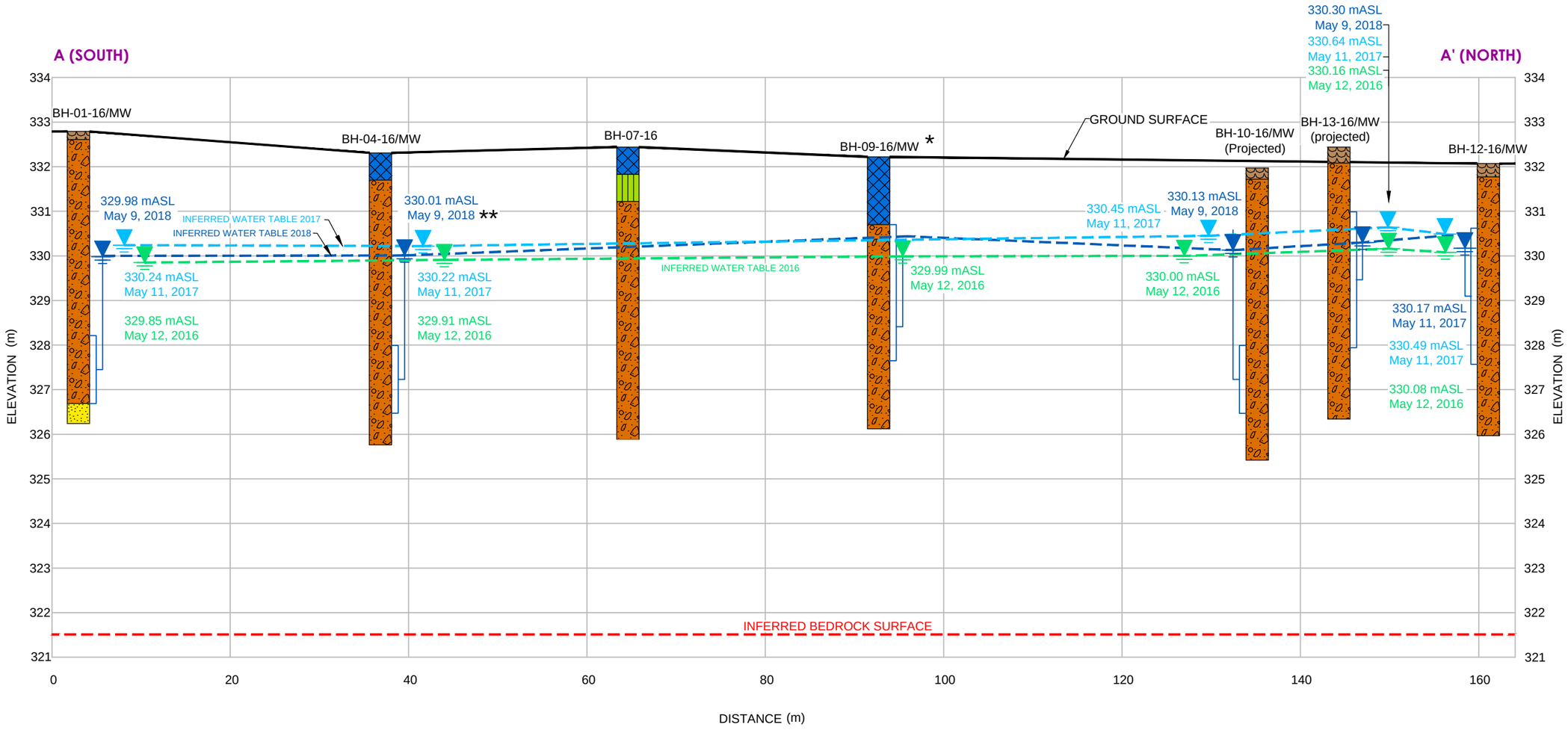

LEGEND :

- FILL
- TOPSOIL
- SILT
- SAND
- SAND AND GRAVEL
- SCREENED INTERVAL
- WATER LEVEL (May 9, 2018)
- WATER LEVEL (May 11, 2017)
- WATER LEVEL (May 12, 2016)

NOTES :

1-Seasonal fluctuations in groundwater levels would be expected.

2-The inferred stratigraphy shown on this cross-section is based on the subsurface stratigraphy contacted at the boreholes. The subsurface conditions between the boreholes will vary.

3-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.

* -Well casing damaged and unable to get into well past May 12, 2016.

** -Water level estimated for May 9, 2018 due to downed tree.

Lowes Road Development, Hydrogeology Study

Lowes Road, Guelph, Ontario

CROSS SECTION A - A'

Englobe Corp.
12-60 Meg Drive
London (Ontario) N6E 3T6
Telephone : 519.685.6400
Fax : 519.685.0943

Prepared	E.Ciochon	Discipline	HYDROGEOLOGY
Drawn	E.Ciochon	Scale	H=:500, V=1:100
Checked	E.Brears	Date	2018-06-14

Project manager: E.Brears
Sequence no.: 05 of 16

M. dept.	Project	Disc.	Dwg no.	Rev.
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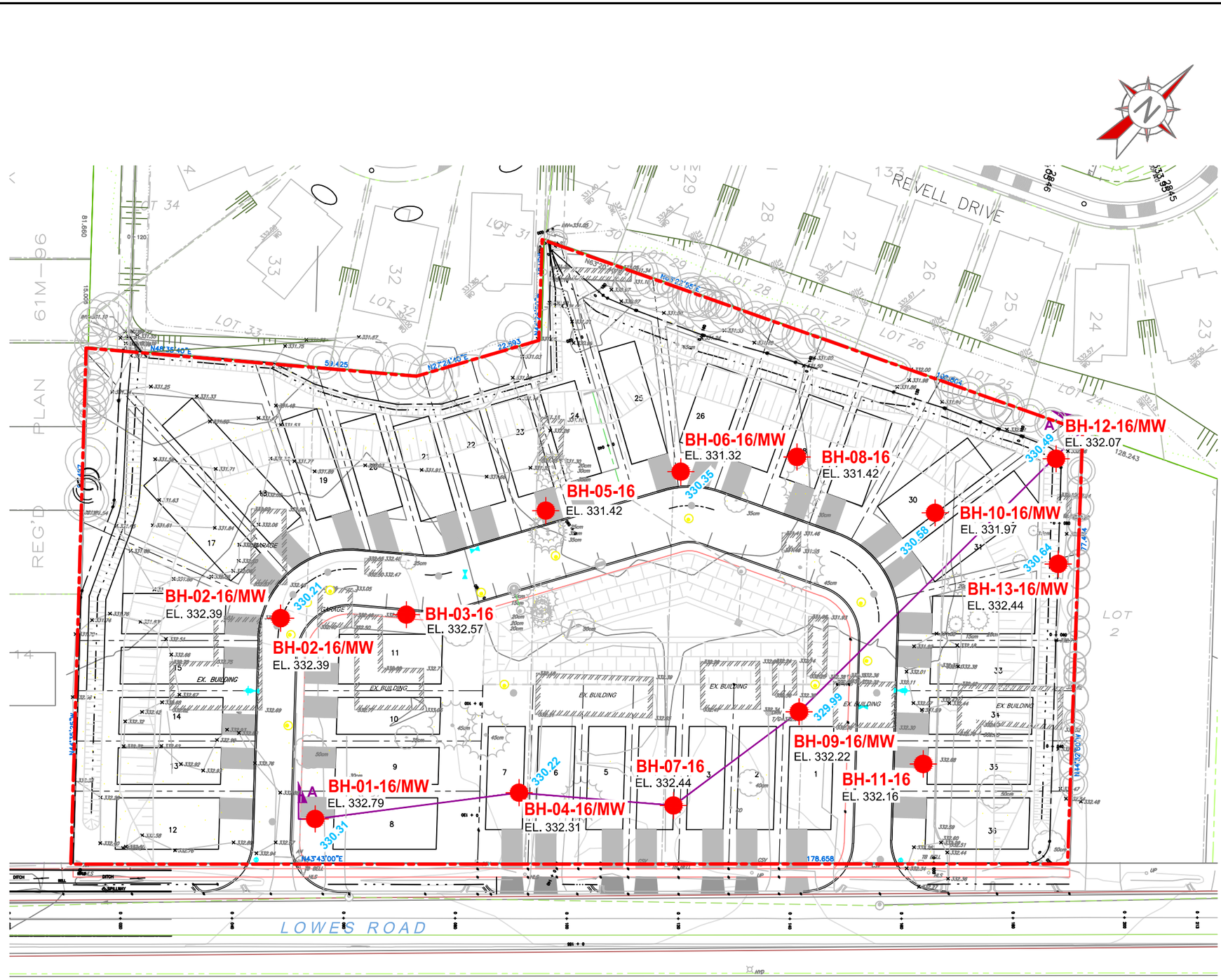

LEGEND :

- SITE OUTLINE
- BOREHOLE LOCATION
- EL. 331.32 — GROUND SURFACE ELEVATION (m)
- A A' — CROSS SECTION (Refer to Drawing 3)
- 329.86 — GROUNDWATER ELEVATION (mASL) (May, 2017)

0 10 20 30 m

SCALE 1:750

NOTES :

1-REFERENCES: STANTEC, Project: Feature Water Balance Drainage Area Plan, Drawing: FIG.4, May 2018.
2-Borehole coordinates and elevations based on Sokkia network data.
3-Estimated water level in Borehole BH-04-16 for May 9, 2018 due to downed tree.
4-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.
5-MW refers to monitoring well installed at borehole location.

Project

Lowes Road Development, Hydrogeology Study

Lowes Road, Guelph, Ontario

Title

SEASONAL HIGH GROUNDWATER LEVELS May 2016 to May 2018

Englobe Corp.
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon	Discipline	HYDROGEOLOGY
Drawn	E.Ciochon	Scale	1:750
Checked	E.Brears	Date	2018-06-14

Project manager: E.Brears

Sequence no.: 06 of 16

M. dept.	Project	Disc.	Dwg no.	Rev.
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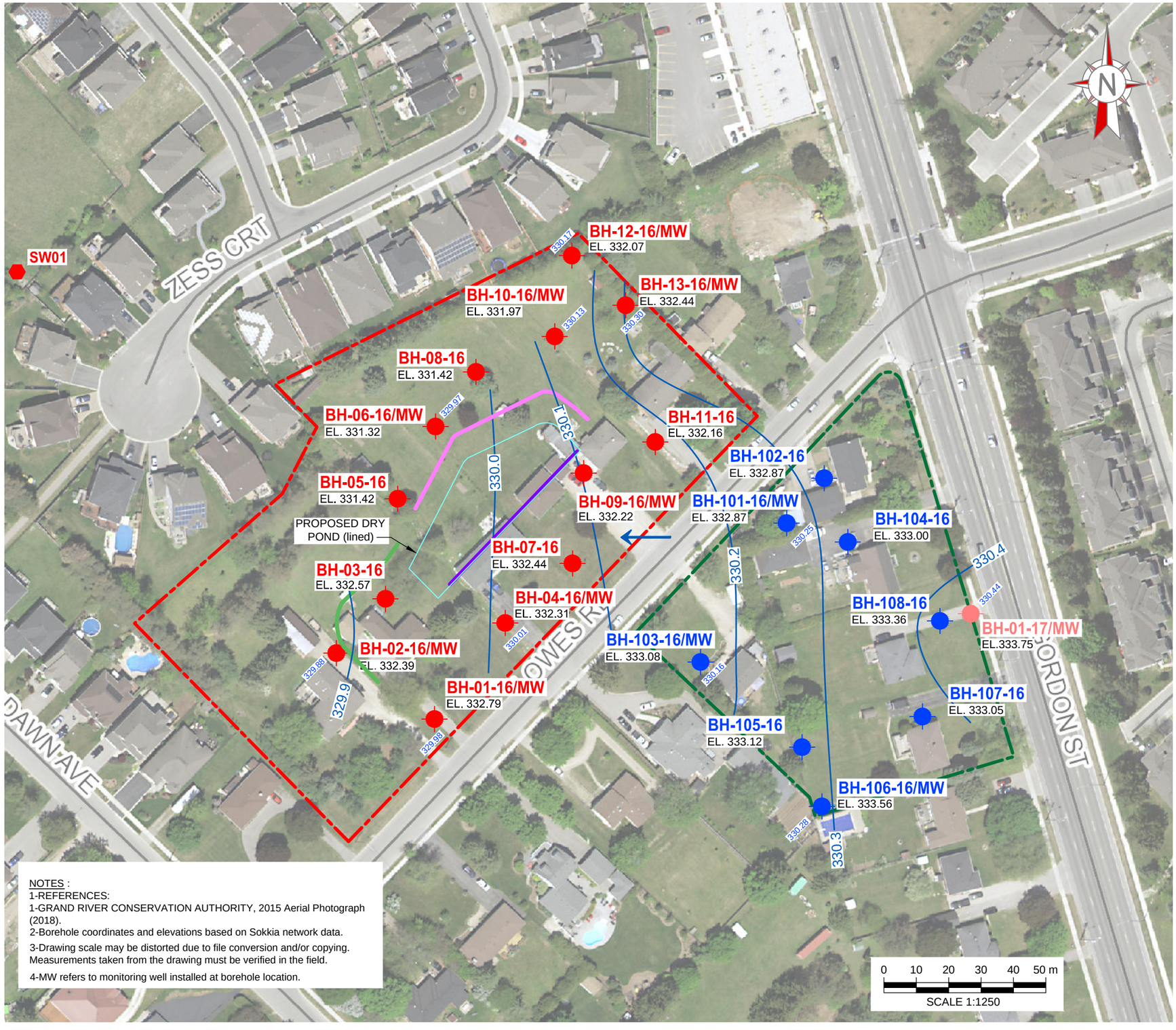
10 cm



NOTES :
1-REFERENCES:
1-GRAND RIVER CONSERVATION AUTHORITY, 2015 Aerial Photograph (2018).
2-Borehole coordinates and elevations based on Sokkia network data.
3-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.
4-MW refers to monitoring well installed at borehole location.

LEGEND :

- SITE OUTLINE (Current Englobe Investigation, P-0010233-0-02-300, May 2016)
- SITE OUTLINE (Previous Englobe Investigation, P-0011540-0-02-300, June 2017
- BOREHOLE LOCATION (Current Investigation)
- BOREHOLE LOCATION (Previous Englobe Investigation P-0011540-0-01-100, September 2016)
- BOREHOLE LOCATION (Previous Englobe Investigation, P-0011540-0-02-300, June 2017)
- EL. 331.32 GROUND SURFACE ELEVATION (mASL)
- GROUNDWATER CONTOURS (mASL)
- FLOW DIRECTION
- 330.00 GROUNDWATER ELEVATION (mASL) (May 9,2018)
- CWC TRENCH 1
- CWC TRENCH 2
- CWC TRENCH 3
- STORM OUTLET

Project
Lowes Road Development, Hydrogeology Study

Lowes Road, Guelph, Ontario

Title
SHALLOW GROUNDWATER CONTOURS

Englobe Corp.
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon	Discipline	HYDROGEOLOGY
Drawn	E.Ciochon	Scale	1:1250
Checked	E.Brears	Date	2018-06-13
Project manager	E.Brears	Sequence no.	07 of 16

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0010233-0-02-300	HD	007	02

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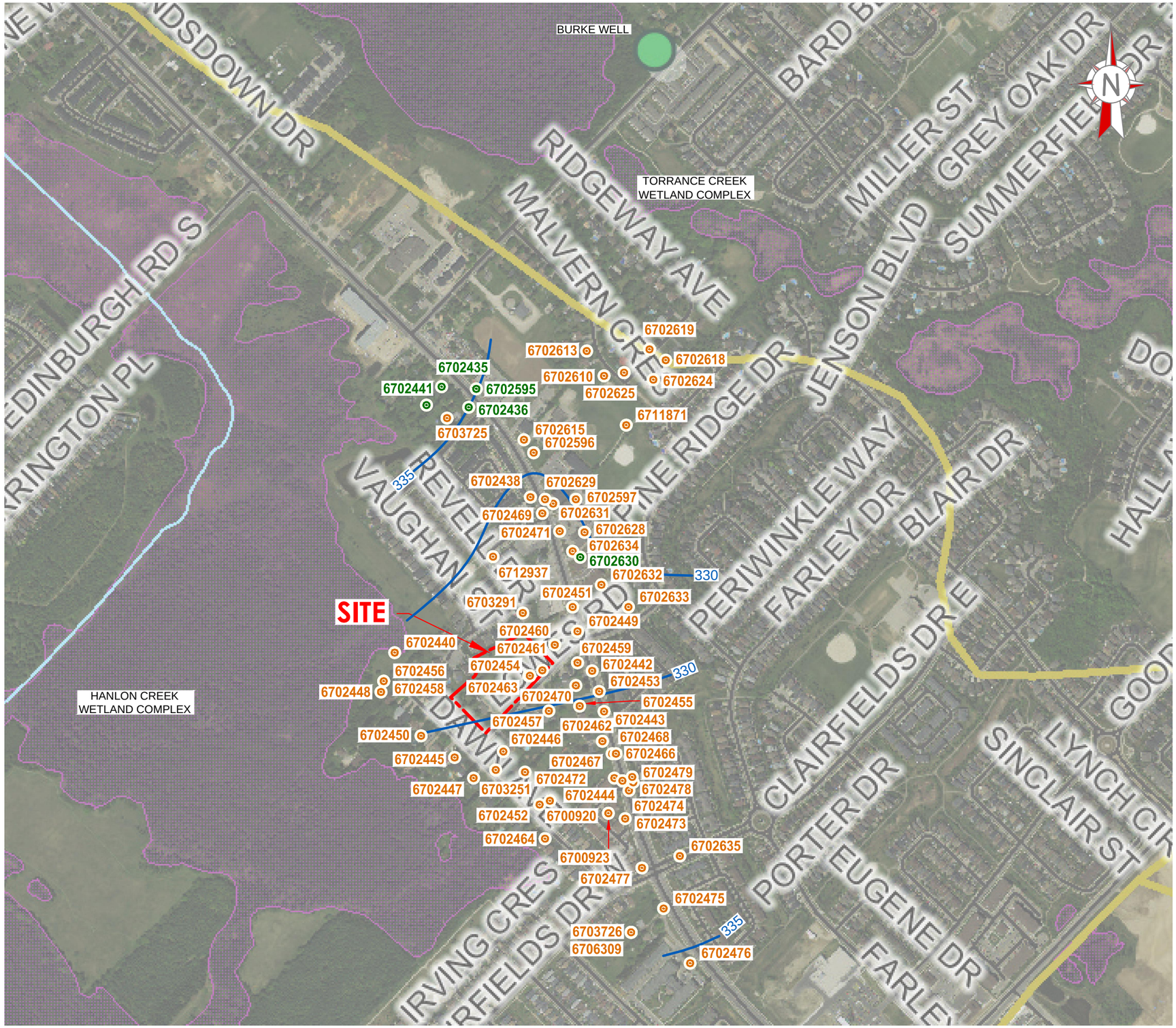

LEGEND :

- MOECC WATER WELL LOCATION - Overburden
- MOECC WATER WELL LOCATION - Bedrock
- GRCA SUBWATERSHED BOUNDARY
- INFERRED GROUNDWATER CONTOUR (mASL)

0 100 200 300 m

SCALE 1:7500

NOTES :

1-REFERENCES :

- GRAND RIVER CONSERVATION AUTHORITY, 2010 Aerial Photograph (2016).
- MOECC - MINISTRY OF ENVIRONMENT AND CLIMATE CHANGE Water Well Record, 2016.

2-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.

Project

Lowes Road Development, Hydrogeology Study

Lowes Road, Guelph, Ontario

Title

MOECC GROUNDWATER CONTOUR PLAN

Englobe Corp.
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon	Discipline	HYDROGEOLOGY
Drawn	E.Ciochon	Scale	1:7500
Checked	E.Brears	Date	2018-06-14

Project manager: E.Brears

Sequence no.: 08 of 16

M. dept.	Project	Disc.	Dwg no.	Rev.
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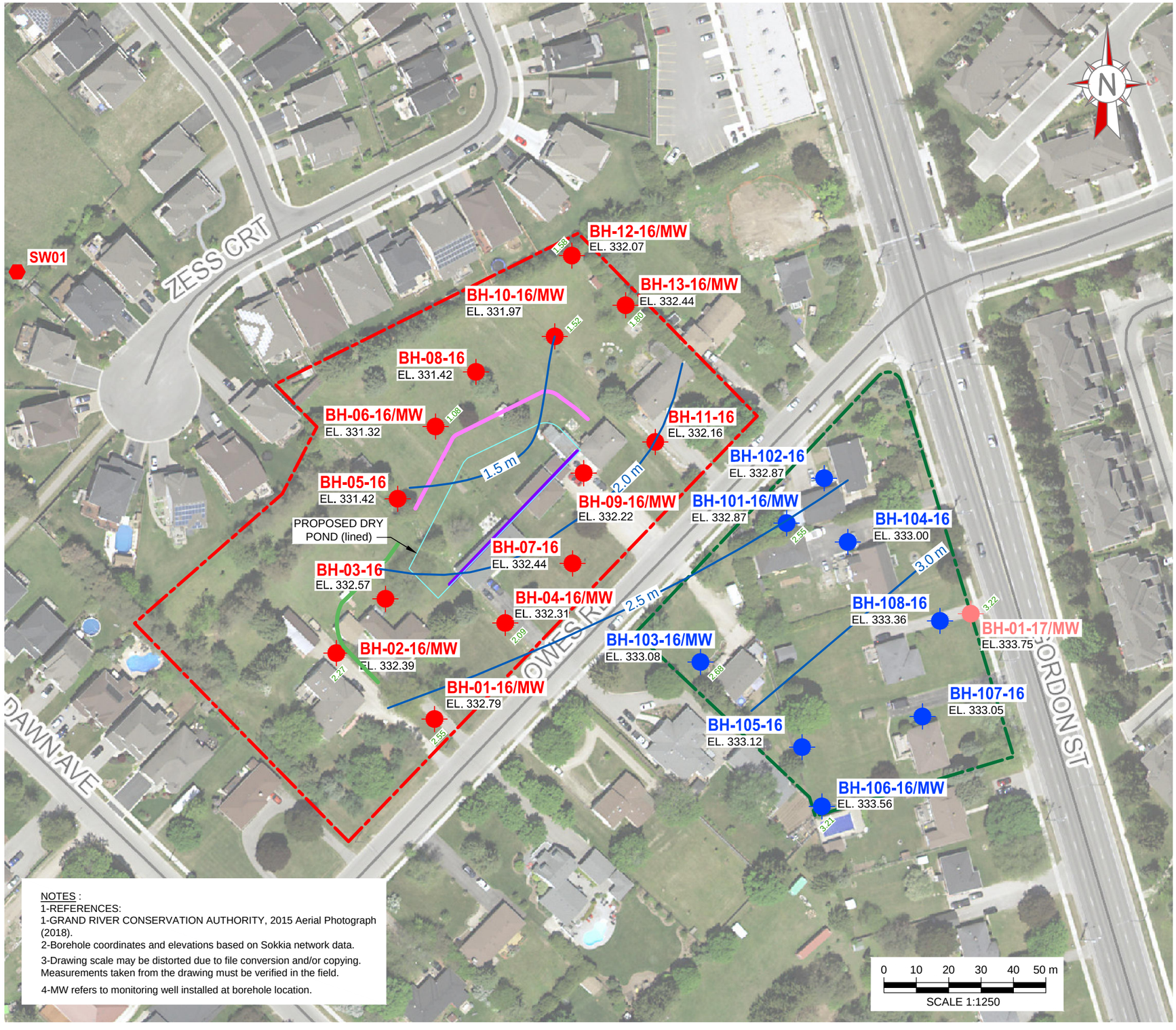

NOTES :
1-REFERENCES:
1-GRAND RIVER CONSERVATION AUTHORITY, 2015 Aerial Photograph (2018).
2-Borehole coordinates and elevations based on Sokkia network data.
3-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.
4-MW refers to monitoring well installed at borehole location.

LEGEND :

- SITE OUTLINE (Current Englobe Investigation, P-0010233-0-02-300, May 2016)
- SITE OUTLINE (Previous Englobe Investigation, P-0011540-0-02-300, June 2017
- BOREHOLE LOCATION (Current Investigation)
- BOREHOLE LOCATION (Previous Englobe Investigation P-0011540-0-01-100, September 2016)
- BOREHOLE LOCATION (Previous Englobe Investigation, P-0011540-0-02-300, June 2017)
- EL. 331.32 GROUND SURFACE ELEVATION (mASL)
- GROUNDWATER CONTOURS (mASL)
- 330.00 GROUNDWATER ELEVATION (mASL) (May 31,2018)
- 1.08 MINIMUM DEPTH TO GROUNDWATER (mbgs) VARIOUS DATES
- STORM OUTLET
- CWC TRENCH 1
- CWC TRENCH 2
- CWC TRENCH 3

Project

Lowes Road Development, Hydrogeology Study

Lowes Road, Guelph, Ontario

Title

MINIMUM MEASURED DEPTH TO GROUNDWATER (Existing Conditions Prior to Site Infill)

Englobe Corp.
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon	Discipline	HYDROGEOLOGY
Drawn	E.Ciochon	Scale	1:1250
Checked	E.Brears	Date	2018-06-13

Project manager: E.Brears

Sequence no.: 09 of 16

M. dept.	Project	Disc.	Dwg no.	Rev.
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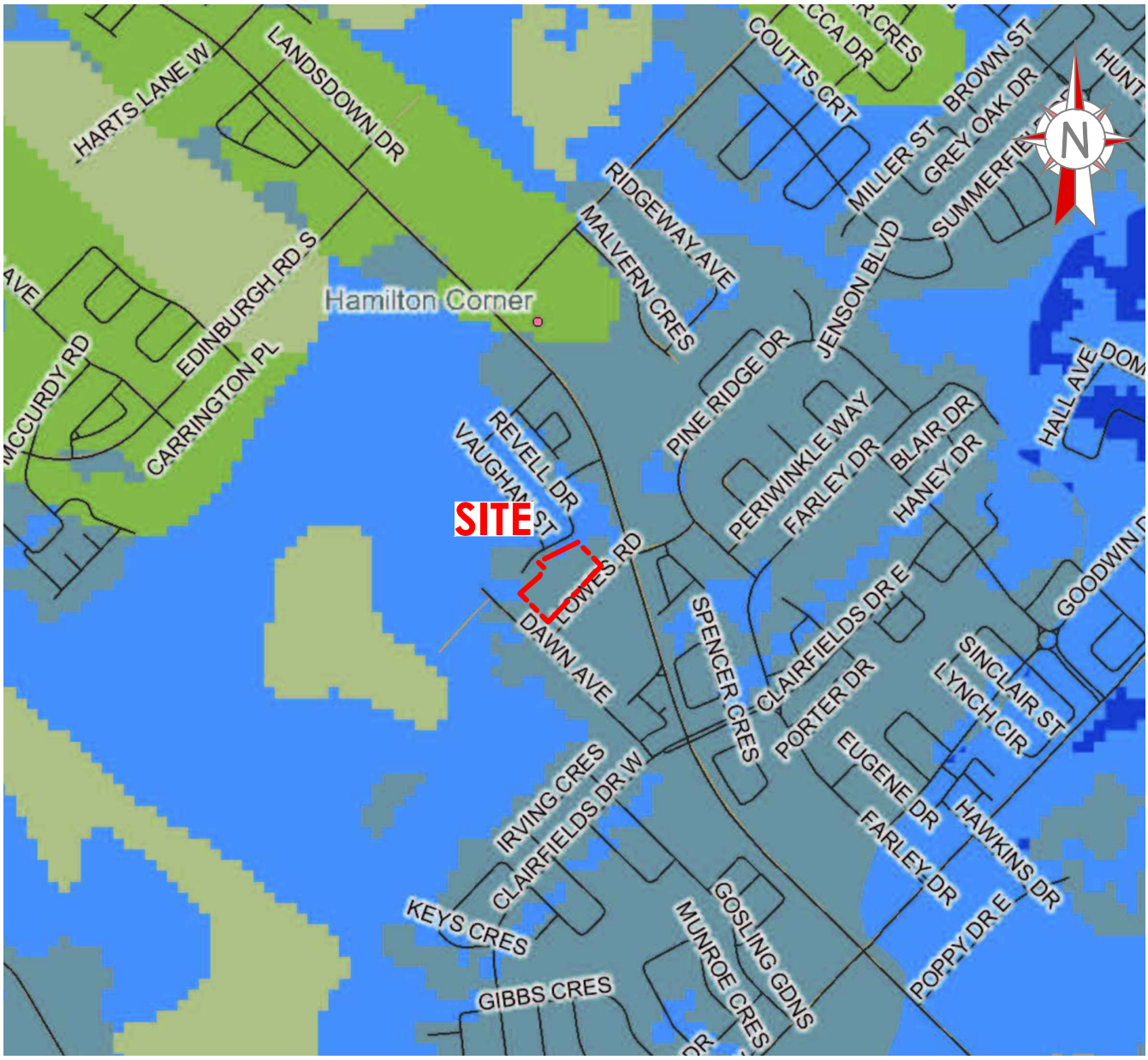

LEGEND :

- less than 50 mm/yr
- 50 - 100
- 100 - 200
- 200 - 300
- 300 - 400
- > 400

NOTES :

1-REFERENCES : GRAND RIVER CONSERVATION AUTHORITY, Average Annual Recharge, (2016).

2-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.

0 100 200 300 400 500 m

SCALE 1:15000

Project

Lowes Road Development Hydrogeology Study

Lowes Road, Guelph, Ontario

Title

AVERAGE ANNUAL RECHARGE

Englobe Corp.
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon	Discipline	HYDROGEOLOGY	Project manager	E.Brears
Drawn	E.Ciochon	Scale	1 : 15000	Sequence no.	10 of 16
Checked	E.Brears	Date	2018-06-14		

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0010233-0-02-300	HD	010	02

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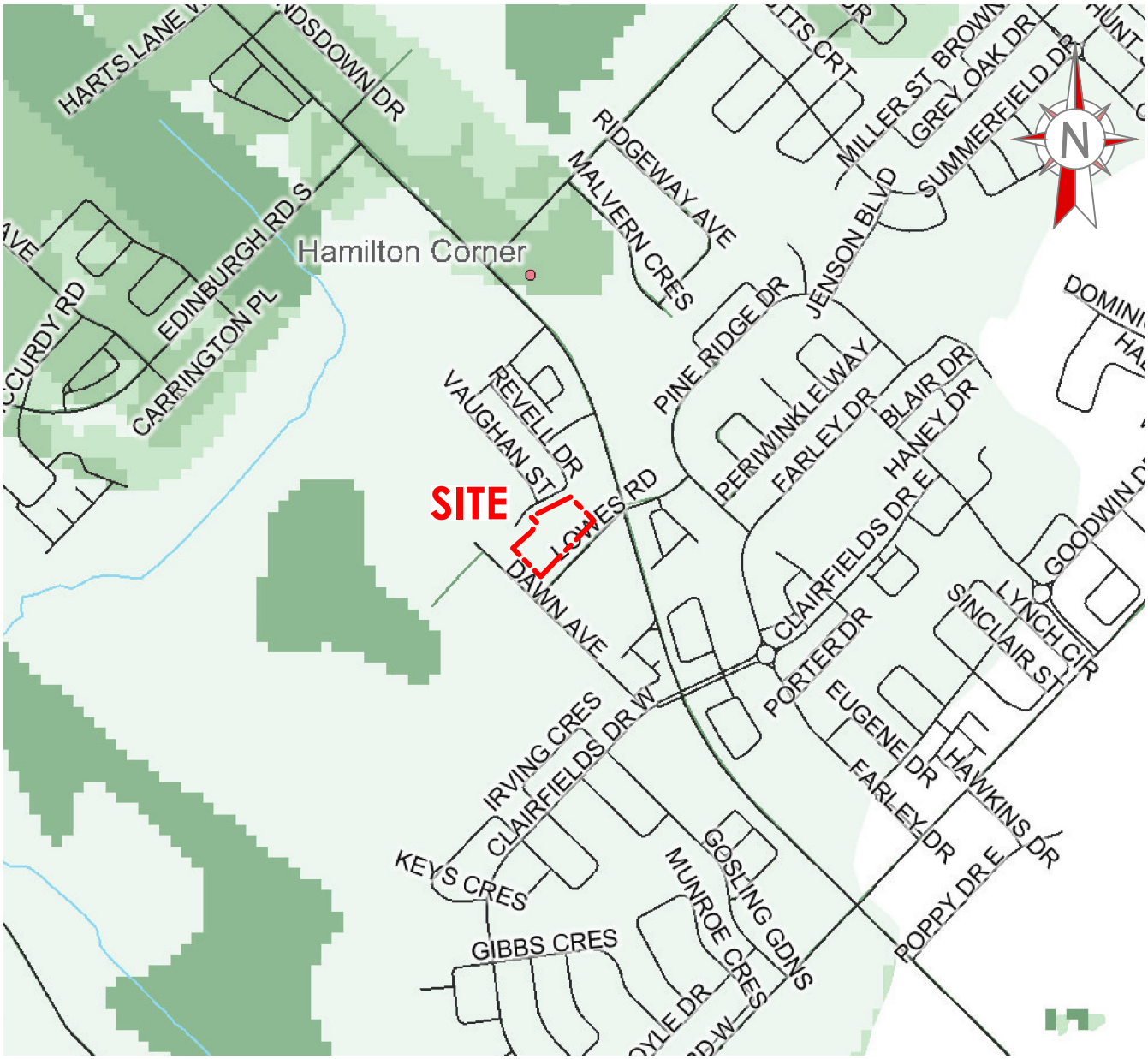

LEGEND :

- less than 50 mm/yr
- 50 - 125
- 125 - 250
- 250 - 400
- > 400

NOTES :

1-REFERENCES : GRAND RIVER CONSERVATION AUTHORITY, Average Annual Runoff, (2016).

2-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.

0 100 200 300 400 500 m

SCALE 1:15000

Project

Lowes Road Development Hydrogeology Study

Lowes Road, Guelph, Ontario

Title

AVERAGE ANNUAL RUNOFF

Englobe Corp.
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon	Discipline	HYDROGEOLOGY
Drawn	E.Ciochon	Scale	1 : 15000
Checked	E.Brears	Date	2018-06-14

Project manager: E.Brears
Sequence no.: 11 of 16

M. dept.	Project	Disc.	Dwg no.	Rev.
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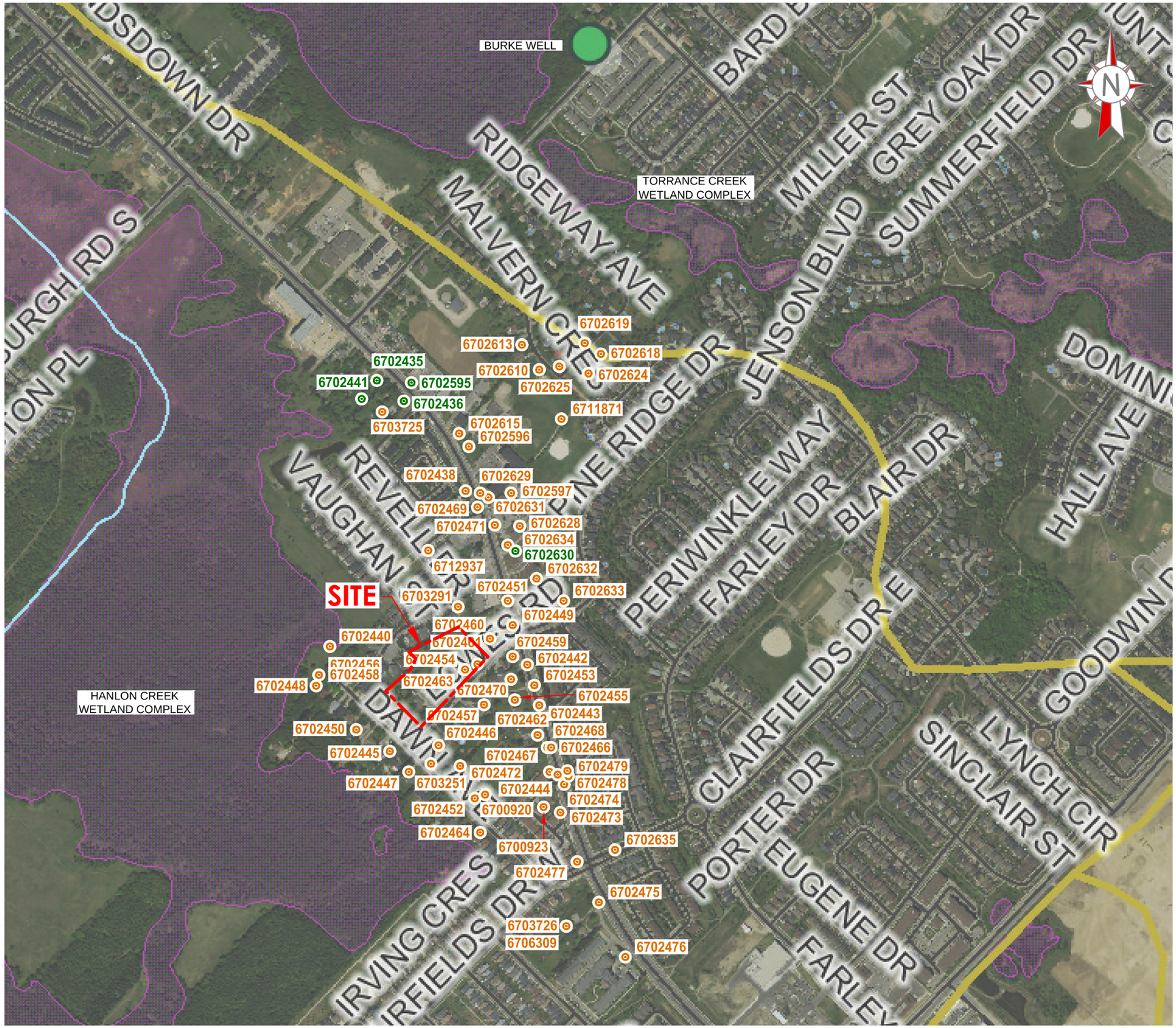

LEGEND :

- MOECC WATER WELL LOCATION - Overburden
- MOECC WATER WELL LOCATION - Bedrock
- GRCA SUBWATERSHED BOUNDARY

0 100 200 300 m

SCALE 1:7500

NOTES :

1-REFERENCES :

- GRAND RIVER CONSERVATION AUTHORITY, 2010 Aerial Photograph (2016).
- MOECC - MINISTRY OF ENVIRONMENT AND CLIMATE CHANGE Water Well Record, 2016.

2-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.

Project

Lowes Road Development, Hydrogeology Study

Lowes Road, Guelph, Ontario

Title

MOECC WATER WELL RECORD

Englobe Corp.
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon	Discipline	HYDROGEOLOGY
Drawn	E.Ciochon	Scale	1:7500
Checked	E.Brears	Date	2018-06-14
Project manager	E.Brears	Sequence no.	12 of 16

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0010233-0-02-300	HD	012	02

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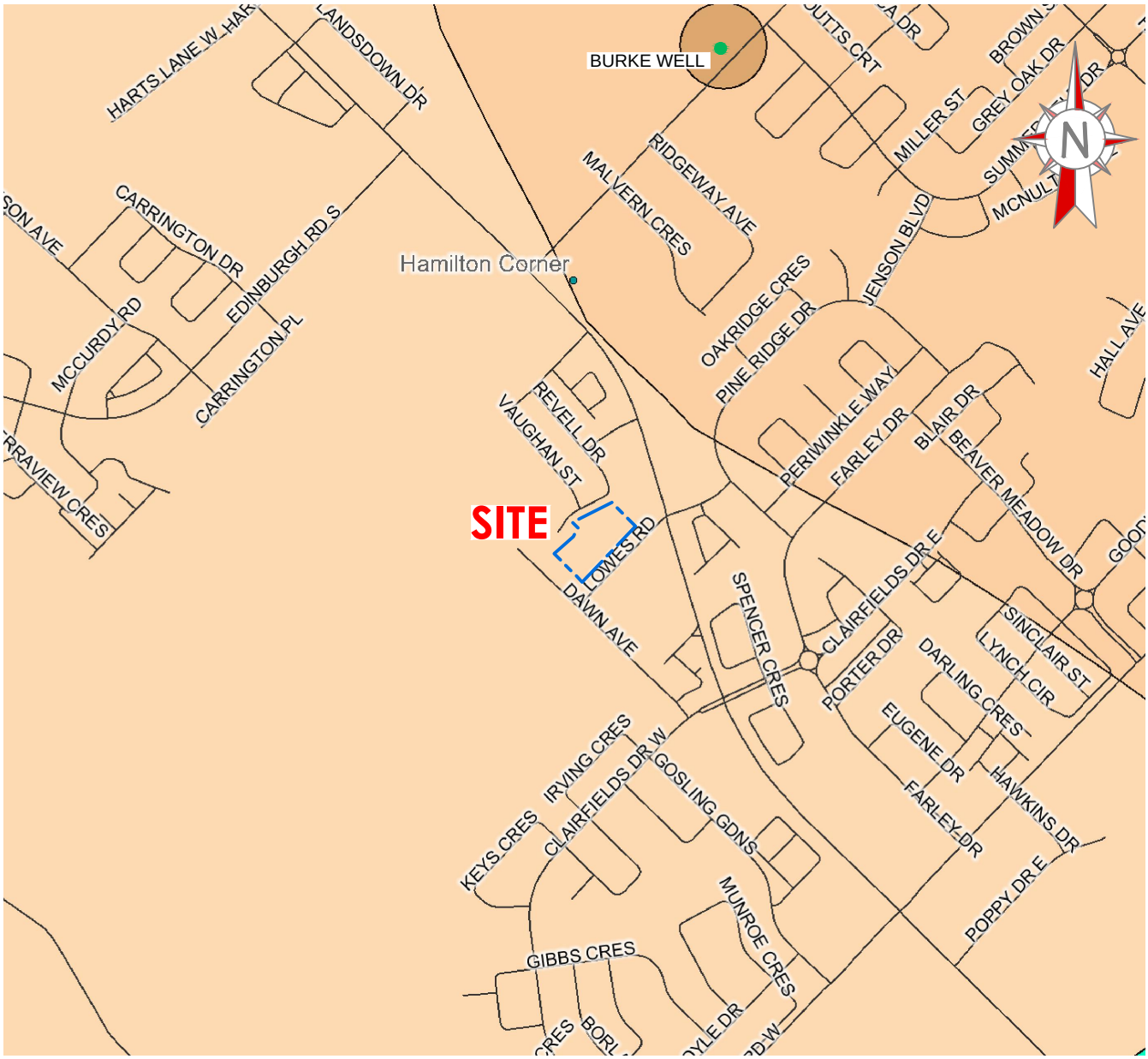

LEGEND :

- WHPA-A
- WHPA-B
- WHPA-C
- WHPA-D
- MUNICIPAL WATER WELL

NOTES :

1-REFERENCES : GRAND RIVER CONSERVATION AUTHORITY, WHPA Protection Area, (2016).

2-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.

0 100 200 300 400 500 m

SCALE 1:15000

Project

Lowes Road Development Hydrogeology Study

Lowes Road, Guelph, Ontario

Title

WELL HEAD PROTECTION AREA

Englobe Corp.
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon	Discipline	HYDROGEOLOGY	Project manager	E.Brears
Drawn	E.Ciochon	Scale	1 : 15000	Sequence no.	13 of 16
Checked	E.Brears	Date	2018-06-04		

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0010233-0-02-300	HD	013	02

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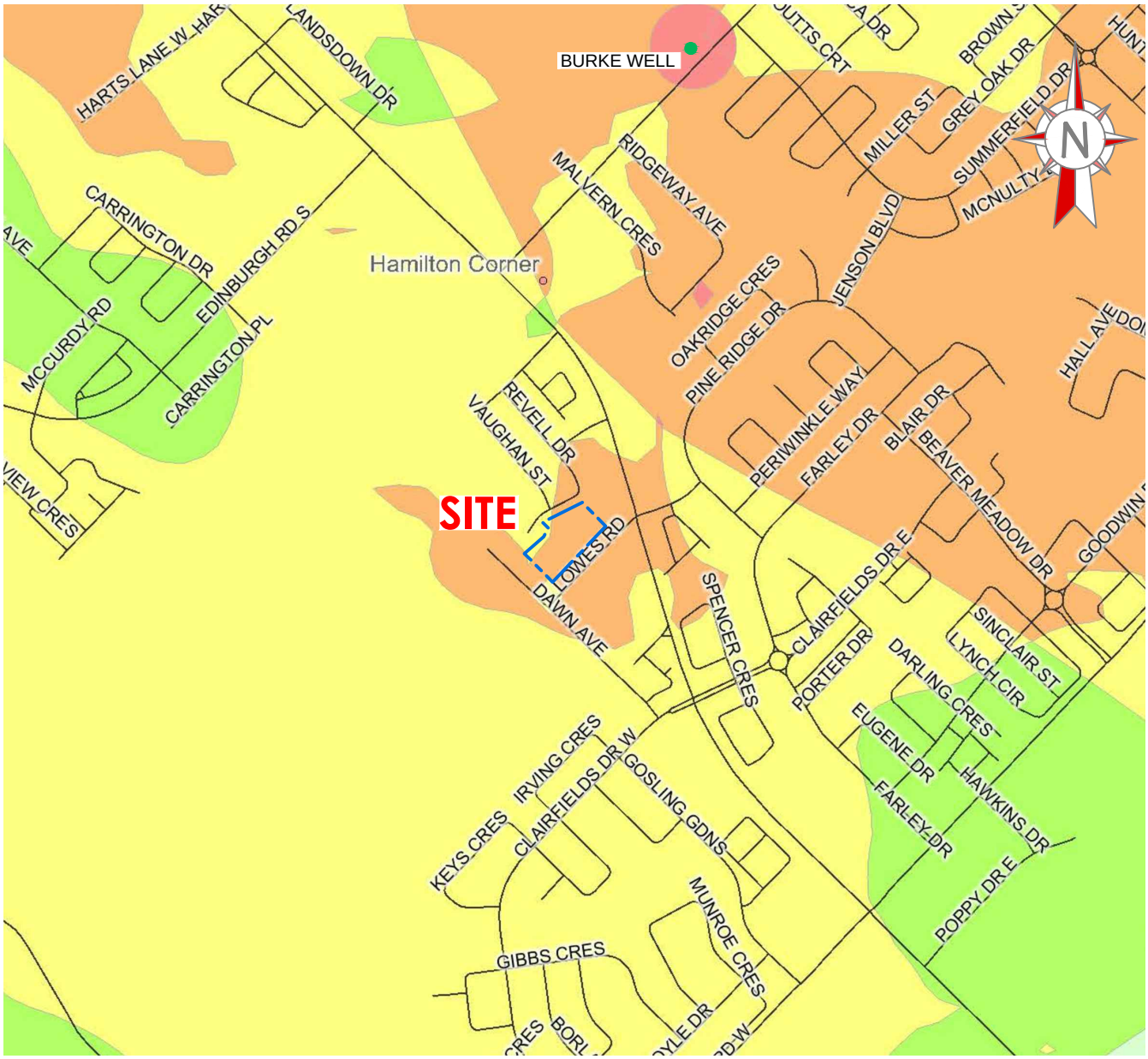

LEGEND :

10	MUNICIPAL WATER WELL
8	
6	
4	
2	

NOTES :

1-REFERENCES : GRAND RIVER CONSERVATION AUTHORITY, Wellhead Protection Area Vulnerability, (2016).

2-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.

0 100 200 300 400 500 m

SCALE 1:15000

Project

Lowes Road Development Hydrogeology Study

Lowes Road, Guelph, Ontario

Title

WELLHEAD PROTECTION AREA VULNERABILITY

Englobe Corp.
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon	Discipline	HYDROGEOLOGY	Project manager	E.Brears
Drawn	E.Ciochon	Scale	1 : 15000	Sequence no.	14 of 16
Checked	E.Brears	Date	2018-06-04		

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0010233-0-02-300	HD	014	02

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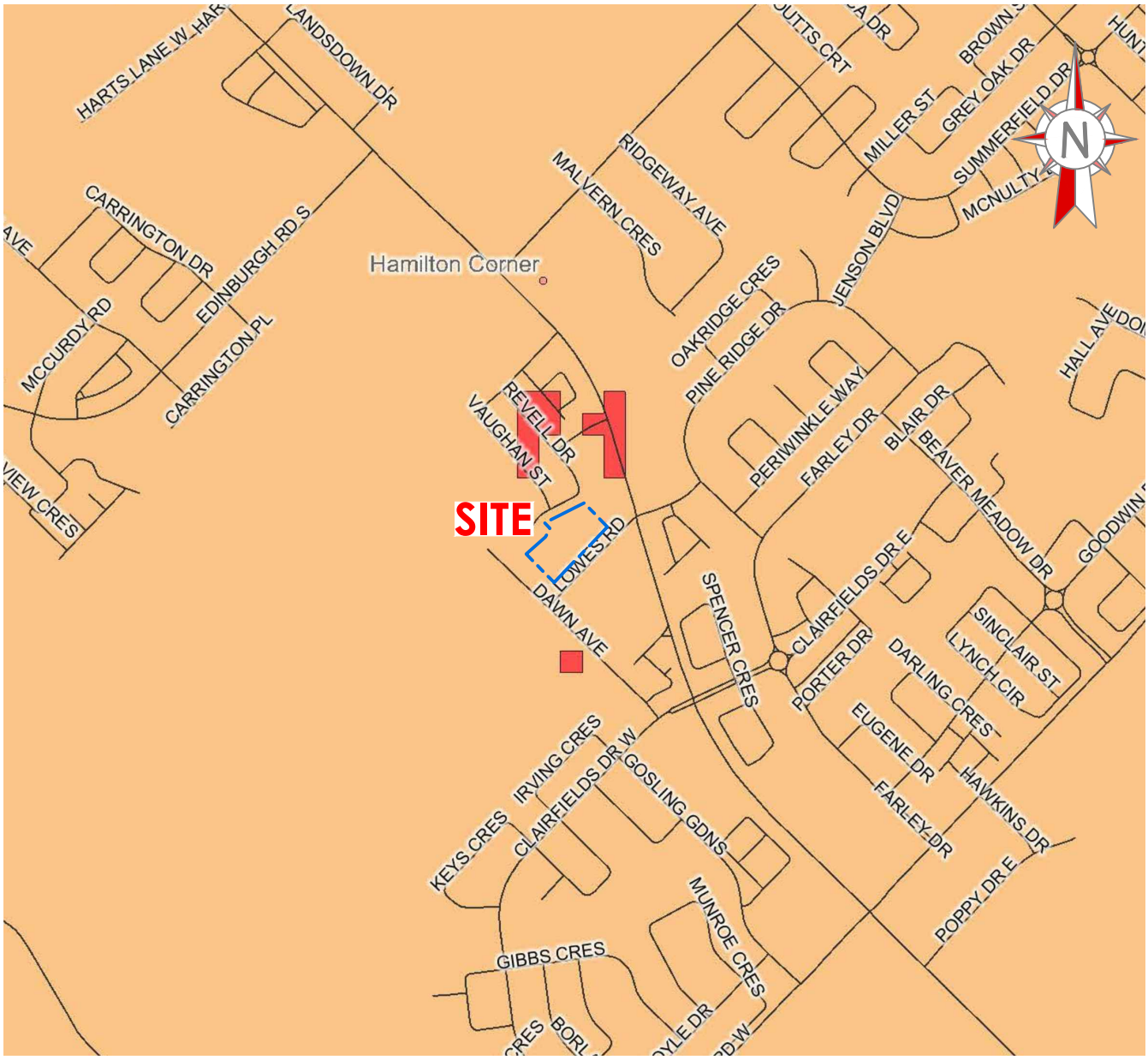

LEGEND :

- HIGH
- MEDIUM

NOTES :

1-REFERENCES : GRAND RIVER CONSERVATION AUTHORITY, Intrinsic Vulnerability, (2016).

2-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.

0 100 200 300 400 500 m

SCALE 1:15000

Project

Lowes Road Development Hydrogeology Study

Lowes Road, Guelph, Ontario

Title

INTRINSIC VULNERABILITY

Englobe Corp.
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon	Discipline	HYDROGEOLOGY	Project manager	E.Brears
Drawn	E.Ciochon	Scale	1 : 15000	Sequence no.	15 of 16
Checked	E.Brears	Date	2018-06-14		

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0010233-0-02-300	HD	015	02

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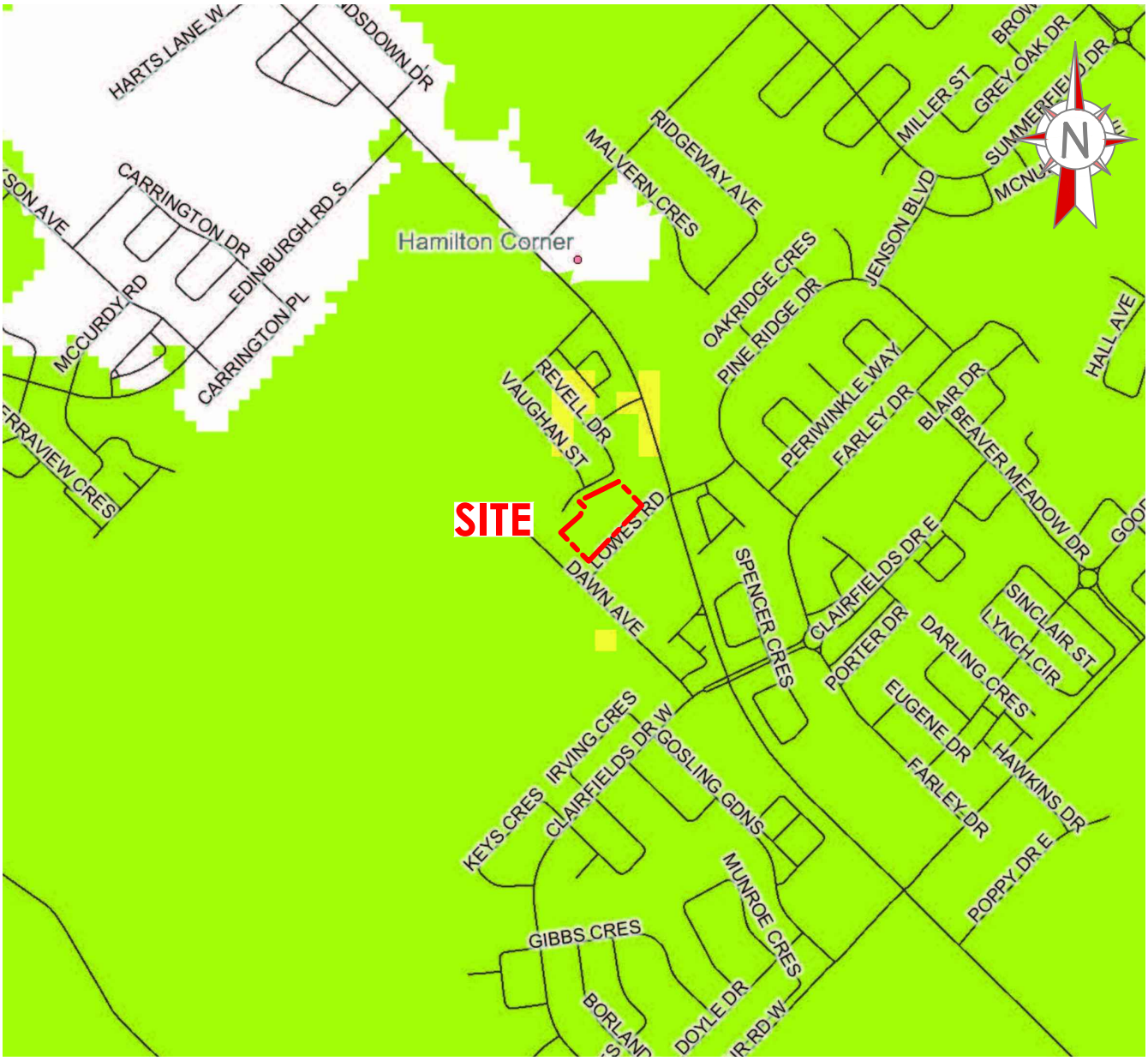

LEGEND :

6	HIGH
4	MEDIUM
2	LOW

NOTES :

1-REFERENCES : GRAND RIVER CONSERVATION AUTHORITY, Intrinsic Vulnerability, (2016).

2-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.

0 100 200 300 400 500 m

SCALE 1:15000

Project

Lowes Road Development Hydrogeology Study

Lowes Road, Guelph, Ontario

Title

SIGNIFICANT GROUNDWATER RECHARGE AREA VULNERABILITY

Englobe Corp.
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon	Discipline	HYDROGEOLOGY	Project manager	E.Brears
Drawn	E.Ciochon	Scale	1 : 15000	Sequence no.	16 of 16
Checked	E.Brears	Date	2018-06-14		

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0010233-0-02-300	HD	016	02

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Appendix 2 Borehole Logs

List of Abbreviations
Boreholes BH-01-16 to BH-13-16

LIST OF ABBREVIATIONS

The abbreviations commonly employed on the borehole logs, on the figures, and in the text of the report, are as follows:

Sample Types		Soil Tests and Properties	
AS	Auger Sample	SPT	Standard Penetration Test
CS	Core Sample	UC	Unconfined Compression
RC	Rock Core	FV	Field Vane Test
SS	Split Spoon	ø	Angle of internal friction
TW	Thinwall, Open	γ	Unit weight
WS	Wash Sample	w_p	Plastic limit
BS	Bulk Sample	w	Water content
GS	Grab Sample	w_L	Liquid limit
WC	Water Content Sample	I_L	Liquidity index
TP	Thinwall, Piston	I_p	Plasticity index
		PP	Pocket penetrometer

Penetration Resistances	
Dynamic Penetration Resistance	The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) diameter 60º cone a distance 300 mm (12 in.). The cone is attached to 'A' size drill rods and casing is not used.
Standard Penetration Resistance, N (ASTM D1586)	The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) required to drive a standard split spoon sampler 300 mm (12 in.)
WH	sampler advanced by static weight of hammer
PH	sampler advanced by hydraulic pressure
PM	sampler advanced by manual pressure

Soil Description		
Cohesionless Soils	**SPT N-Value**	**Relative Density (D_r)**
Compactness Condition	(blows per 0.3 m)	(%)
Very Loose	0 to 4	0 to 20
Loose	4 to 10	20 to 40
Compact	10 to 30	40 to 60
Dense	30 to 50	60 to 80
Very Dense	over 50	80 to 100
Cohesive Soils	**Undrained Shear Strength (C_u)**	
Consistency	**kPa**	**psf**
Very Soft	less than 12	less than 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1000
Stiff	50 to 100	1000 to 2000
Very Stiff	100 to 200	2000 to 4000
Hard	over 200	over 4000
DTPL	Drier than plastic limit	Low Plasticity, W_L <30
APL	About plastic limit	Medium Plasticity, 30 < W_L < 50
WTPL	Wetter than plastic limit	High Plasticity, W_L > 50

Englobe

Ground Elevation:	*332.79 m*	**Borehole Number:**	**BH-01-16**
Northing:	*4817479.66 m*	**Job N°:**	*P-0010233-0-01-100*
Easting:	*564870.78 m*	**Drill Date:**	*2016-05-02*
Project:	*Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*Lowes Road, Guelph, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE								
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration	Shear Strength (PP) kPa / Shear Strength (FV) kPa	Water Content (%)	Groundwater Observations and Standpipe Details
	Ground Elevation		332.79							
	TOPSOIL: dark brown silt, some sand and gravel, numerous cobbles, moist		0.00 / 332.61 / 0.18							flushmount cover and concrete
	SAND AND GRAVEL: dense brown sand and gravel, trace silt, occasional cobbles, moist			SS-1	8-18 20	38				
	very dense, numerous cobbles		331.27 / 1.52	SS-2	23-33 35	68				
				SS-3	50 /150 mm					bentonite seal
	dense, saturated		329.74 / 3.05	SS-4	20-31 17	48				el. 329.85 m 2016-05-12
	compact, occasional cobbles		328.22 / 4.57	SS-5	10-12 10	22				sand pack
										50 mm pipe 1.52 m slotted screen
	SILT AND SAND: compact brown gravelly silty fine sand, trace clay, wet to saturated		326.69 / 6.10	SS-6	4-6 10	16				native cave
	Borehole terminated at 6.55 m		326.24 / 6.55							

Dynamic Cone: 20 40 60 80 — Std Penetration: 20 40 60 80

Shear Strength (PP) kPa: 50 100 150 200 — Initial / Remold — Shear Strength (FV) kPa: 50 100 150 200

WP WL — Water Content (%): 10 20 30

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Notes: *MOECC Well Tag No.A192785.*
Well Record for Well Cluster: C27745.

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Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011

Englobe

Ground Elevation:	*332.39 m*	**Borehole Number:**	**BH-02-16**
Northing:	*4817500.03 m*	**Job N°:**	*P-0010233-0-01-100*
Easting:	*564840.49 m*	**Drill Date:**	*2016-05-02*
Project:	*Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*Lowes Road, Guelph, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE							
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration	Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa	WP WL / Water Content (%)	Groundwater Observations and Standpipe Details
	Ground Elevation		332.39							
	FILL: loose brown silty sand and gravel, very moist		0.00 / 332.24	SS-1	5-5 3-3	8				flushmount cover and concrete
	loose dark brown silt, some topsoil, trace sand and organics, moist		0.15 / 332.11							
	brown sandy silt, trace gravel, very moist		0.28 / 331.48	SS-2	4-6 9-9	15				bentonite seal
1	***SAND AND GRAVEL:*** compact brown sand and gravel, some silt, occasional cobbles, moist		0.91 / 330.87	SS-3	18-20 30-26	50				
	very dense, numerous cobbles		1.52							
2				SS-4	46-23 21-16	44				el. 329.76 m 2016-05-12
	dense, wet		329.65 / 2.74							
3	compact, saturated		329.34 / 3.05	SS-5	13-14 14-12	28				sand pack
	very dense to dense		328.58 / 3.81	SS-6	27-30 35-30	65				50 mm pipe 3.05 m slotted screen
4										
5				SS-7	12-19 21-20	40				
	compact, occasional cobbles		327.06 / 5.33	SS-8	17-13 12-10	25				native cave
6	Borehole terminated 5.94 m		326.45 / 5.94							
7										
8										

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Notes:

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Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011

Englobe

Ground Elevation:	*332.57 m*	**Borehole Number:**	**BH-03-16**
Northing:	*4817516.77 m*	**Job N°:**	*P-0010233-0-01-100*
Easting:	*564855.63 m*	**Drill Date:**	*2016-05-02*
Project:	*Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*Lowes Road, Guelph, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE							
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration	Shear Strength (PP) kPa / Shear Strength (FV) kPa	Water Content (%)	Groundwater Observations and Standpipe Details
	Ground Elevation		332.57							
	FILL: dark brown silt (topsoil), trace gravel, moist		0.00 332.26	SS-1	2-2 4-6	6				
	SAND AND GRAVEL: dense brown sand and gravel, some silt, numerous cobbles, moist		0.30	SS-2	7-24 16-20	40				native backfill
	very dense		331.05 1.52	SS-3	17-60 /150 mm					
				SS-4	46-45 50	95				
	wet		329.67 2.90							native cave
	dense, occasional cobbles, saturated		329.52 3.05	SS-5	14-17 20-27	37				
	Borehole terminated at 3.66 m		328.91 3.66							At drilling completion, dry cave at 2.24 m.

Dynamic Cone / Std Penetration: 20 40 60 80

Shear Strength (PP) kPa / Shear Strength (FV) kPa: 50 100 150 200 (Initial / Remold)

Water Content (%): WP WL; 10 20 30

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Notes:

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Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011

Englobe

Ground Elevation:	*332.31 m*	**Borehole Number:**	**BH-04-16**
Northing:	*4817509.32 m*	**Job N°:**	*P-0010233-0-01-100*
Easting:	*564892.64 m*	**Drill Date:**	*2016-05-02*
Project:	*Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*Lowes Road, Guelph, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE							
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration	Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa	WP WL / Water Content (%)	Groundwater Observations and Standpipe Details
	Ground Elevation		332.31							
	FILL: dark brown silt (topsoil), trace sand and gravel, moist		0.00 / 332.16 / 0.15							flushmount cover and concrete
	brown sandy silt, some gravel, trace topsoil, very moist		331.70 / 0.61							
1	***SAND AND GRAVEL:*** dense brown sand and gravel, some silt, occasional cobbles, moist			SS-1	6-15 25	40				
				SS-2	12-22 25	47				el. 329.91 m 2016-05-12
2	saturated		330.02 / 2.29							bentonite seal
				SS-3	7-13 19	32				
3				SS-4	9-16 16	32				
4										
				SS-5	12-20 24	44				sand pack
5										50 mm pipe 1.52 m slotted screen
6	compact		326.21 / 6.10	SS-6	12-12 12	24				native cave
	Borehole terminated at 6.55 m		325.76 / 6.55							
7										
8										

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Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011

Englobe

Ground Elevation:	*331.42 m*	**Borehole Number:**	**BH-05-16**
Northing:	*4817547.70 m*	**Job N°:**	*P-0010233-0-01-100*
Easting:	*564859.41 m*	**Drill Date:**	*2016-05-02*
Project:	*Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*Lowes Road, Guelph, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE							
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration	Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa	WP WL / Water Content (%)	Groundwater Observations and Standpipe Details
	Ground Elevation		331.42							
	FILL: loose dark brown silt (topsoil), trace sand and gravel, very moist		0.00 331.19 0.23	SS-1	1-2 3-5	5				native backfill
	SAND: loose brown sand, some silt, trace gravel, moist		330.66 0.76	SS-2	7-11 17-20	28				
1	***SAND AND GRAVEL:*** compact to dense brown sand and gravel, some silt, moist									bentonite seal
	dense, saturated		329.90 1.52	SS-3	10-14 21	35				
2										
	trace silt		329.13 2.29	SS-4	11-15 15	30				
3				SS-5	6-17 19	36				
4										native cave
	compact		326.85 4.57	SS-6	8-10 14	24				
5										
6				SS-7	7-8 9	17				
	Borehole terminated at 6.55 m		324.87 6.55							At drilling completion, dry cave at 2.13 m.
7										
8										

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Notes:

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Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011

Englobe

Ground Elevation:	*331.32 m*	**Borehole Number:**	**BH-06-16**
Northing:	*4817570.01 m*	**Job N°:**	*P-0010233-0-01-100*
Easting:	*564871.12 m*	**Drill Date:**	*2016-05-03*
Project:	*Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*Lowes Road, Guelph, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE							
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration	Shear Strength (PP) kPa / Shear Strength (FV) kPa	Water Content (%)	Groundwater Observations and Standpipe Details
	Ground Elevation		331.32							
	TOPSOIL: dark brown silt, moist		0.00 / 331.12							
	SAND: loose brown/dark brown silty sand, trace gravel and topsoil, very moist		0.20 / 330.56	SS-1	2-3 5-5	8				
1	compact, brown, some gravel, occasional cobbles, moist		0.76 / 329.80	SS-2	9-7 6-6	13				
	SAND AND GRAVEL: very dense grey/brown sand and gravel, trace silt, numerous cobbles, saturated		1.52 / 329.03	SS-3	16-24 39-20	63				
2	dense		2.29 / 328.27	SS-4	31-20 23-32	43				
3	compact		3.05 / 327.51	SS-5	12-13 14-16	27				
	very dense		3.81 / 326.75	SS-6	17-15 /75 mm					
4	compact, brown, occasional cobbles		4.57 / 326.14	SS-7	9-11 15-19	26				
5	Borehole terminated at 5.18 m		5.18							
6										
7										
8										

Dynamic Cone / Std Penetration: 20 40 60 80

Shear Strength (PP) kPa / Shear Strength (FV) kPa: 50 100 150 200 — Initial / Remold

Water Content (%): WP WL — 10 20 30

Groundwater Observations and Standpipe Details:
- flushmount cover and concrete
- bentonite seal
- el. 329.86 m 2016-05-12
- sand pack
- 50 mm pipe
- 3.05 m slotted screen
- native cave

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Notes:

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Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011

Englobe

Ground Elevation:	*332.44 m*	**Borehole Number:**	**BH-07-16**
Northing:	*4817527.72 m*	**Job N°:**	*P-0010233-0-01-100*
Easting:	*564913.43 m*	**Drill Date:**	*2016-05-04*
Project:	*Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*Lowes Road, Guelph, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE							
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration	Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa	Water Content (%) WP WL	Groundwater Observations and Standpipe Details
	Ground Elevation		332.44							
	FILL: dark brown silt (topsoil), trace sand and gravel, occasional cobbles, moist		0.00 / 331.83							topsoil; native backfill
1	***SILT:*** compact brown/dark brown sandy silt, some gravel and topsoil, trace clay, occasional cobbles, moist		0.61 / 331.22	SS-1	1-3 12	15				bentonite seal
	SAND AND GRAVEL: compact brown sand and gravel, some silt, numerous cobbles, moist		1.22	SS-2	9-11 15	26				
2	dense		330.15 / 2.29	SS-3	12-22 20	42				
	wet		329.85 / 2.59							
3	compact, saturated		329.39 / 3.05	SS-4	10-13 13	26				
4										native cave
5				SS-5	8-9 17	26				
6				SS-6	11-12 15	27				
	Borehole terminated at 6.55 m		325.89 / 6.55							At drilling completion, dry cave at 1.52 m.
7										
8										

Dynamic Cone / Std Penetration: 20 40 60 80

Shear Strength (PP) kPa / Shear Strength (FV) kPa: 50 100 150 200 — Initial, Remold

Water Content (%): 10 20 30 — WP, WL

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Notes:

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Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011

Englobe

Ground Elevation:	*331.42 m*	**Borehole Number:**	**BH-08-16**
Northing:	*4817586.89 m*	**Job N°:**	*P-0010233-0-01-100*
Easting:	*564883.60 m*	**Drill Date:**	*2016-05-03*
Project:	*Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*Lowes Road, Guelph, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE							
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration	Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa	Water Content (%)	Groundwater Observations and Standpipe Details
	Ground Elevation		331.42							
	TOPSOIL: loose dark brown silt, moist		0.00 / 331.22	SS-1	2-2 3	5				topsoil
	SAND: loose brown silty sand, some gravel, trace topsoil, moist		0.20 / 330.66							native backfill
1	***SAND AND GRAVEL:*** very dense brown sand and gravel, some silt, numerous cobbles, moist		0.76	SS-2	9-23 35	58				bentonite seal
	dense, saturated		329.90 / 1.52	SS-3	13-15 15	30				
2			329.13							
	very dense		2.29	SS-4	16-31 35	66				
3			328.37							
	dense		3.05	SS-5	16-18 24	42				
4										native cave
5				SS-6	14-17 20	37				
6				SS-7	8-14 17	31				
	Borehole terminated at 6.55 m		324.87 / 6.55							At drilling completion, wet cave at 1.52 m.
7										
8										

Dynamic Cone / Std Penetration: 20 40 60 80

Shear Strength (PP) kPa / Shear Strength (FV) kPa: 50 100 150 200 — Initial, Remold

Water Content (%): WP, WL; 10 20 30

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Notes:

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Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011

Englobe

Ground Elevation:	*332.22 m*	**Borehole Number:**	**BH-09-16**
Northing:	*4817555.61 m*	**Job N°:**	*P-0010233-0-01-100*
Easting:	*564916.85 m*	**Drill Date:**	*2016-05-04*
Project:	*Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*Lowes Road, Guelph, Ontario*	**Drill Method:**	*Hollow Stem Auger*

Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value
	Ground Elevation		332.22			
	FILL: compact brown silty sand and gravel, some topsoil, moist		0.00 / 331.99			
	dark brown silt, some sand, trace gravel and organics, moist		0.23 / 331.46	SS-1	6-10 9-8	19
1	loose brown/dark brown mottled silt, some sand, topsoil and gravel, occasional cobbles, moist		0.76 / 330.70	SS-2	4-3 5-9	8
	SAND AND GRAVEL: dense brown sand and gravel, some silt, numerous cobbles, moist		1.52	SS-3	16-20 22-22	42
2	very dense, saturated		329.93 / 2.29	SS-4	23-50 /150 mm	
3	compact, some medium sand layers		329.17 / 3.05	SS-5	9-10 17-18	27
4				SS-6	15-10 18-21	28
	dense		327.65 / 4.57	SS-7	10-19 17-12	36
5						
6				SS-8	14-16 20-31	36
	Borehole terminated at 6.10 m		326.12 / 6.10			
7						
8						

Dynamic Cone / Std Penetration: 20 40 60 80

Shear Strength (PP) kPa / Shear Strength (FV) kPa: 50 100 150 200 — Initial / Remold

Water Content (%): WP WL — 10 20 30

Groundwater Observations and Standpipe Details

- flushmount cover and concrete
- bentonite seal
- Tel. 329.99 m 2016-05-12
- sand pack
- 50 mm pipe
- 3.05 m slotted screen
- native cave

Reviewed by: *K.Thrams* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes:

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Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011

Englobe

Ground Elevation:	*331.97 m*	**Borehole Number:**	**BH-10-16**
Northing:	*4817597.87 m*	**Job N°:**	*P-0010233-0-01-100*
Easting:	*564907.94 m*	**Drill Date:**	*2016-05-03*
Project:	*Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*Lowes Road, Guelph, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE		SAMPLE							
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration	Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa	Water Content (%) WP WL	Groundwater Observations and Standpipe Details
	Ground Elevation		331.97							
	TOPSOIL: dark brown silt, trace sand and gravel, occasional cobbles, moist		0.00 331.72 0.25							protective cover and concrete
1	***SAND AND GRAVEL:*** compact brown silty sand and gravel, trace topsoil, moist			SS-1	3-5 6	11				
	very dense, trace silt, numerous cobbles		330.45 1.52	SS-2	9-29 35	64				
2	saturated		329.68 2.29	SS-3	60 /150 mm					el. 330.00 m 2016-05-12
3	compact		328.92 3.05	SS-4	7-11 15	26				sand pack
4										50 mm pipe 1.52 m slotted screen
5				SS-5	8-10 12	22				
6	dense		325.87 6.10	SS-6	8-21 26	47				native cave
	Borehole terminated at 6.55 m		325.42 6.55							
7										
8										

Dynamic Cone / Std Penetration: 20 40 60 80

Shear Strength (PP) kPa / Shear Strength (FV) kPa: 50 100 150 200 — Initial, Remold

Water Content (%): 10 20 30

Reviewed by: *K.Thrams* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes:

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Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011

Englobe

Ground Elevation:	*332.16 m*	**Borehole Number:**	**BH-11-16**
Northing:	*4817565.23 m*	**Job N°:**	*P-0010233-0-01-100*
Easting:	*564938.99 m*	**Drill Date:**	*2016-05-04*
Project:	*Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*Lowes Road, Guelph, Ontario*	**Drill Method:**	*Hollow Stem Auger*

SOIL PROFILE			SAMPLE							
Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value	Dynamic Cone / Std Penetration	Shear Strength (PP) kPa / Initial / Remold / Shear Strength (FV) kPa	Water Content (%)	Groundwater Observations and Standpipe Details
	Ground Elevation		332.16							
	FILL: dark brown silt (topsoil), trace sand and roots, moist		0.00							topsoil
	compact brown silty sand, some gravel, very moist		331.75 / 0.41							native backfill
1				SS-1	4-9 10	19				
	SAND AND GRAVEL: very dense brown sand and gravel, trace silt, numerous cobbles, moist to very moist		330.94 / 1.22							bentonite seal
2				SS-2	23-29 29	58				
	dense, saturated		329.87 / 2.29	SS-3	10-23 18	41				
3										
				SS-4	10-13 18	31				
4										native cave
	compact, occasional cobbles, some sand layers		327.59 / 4.57	SS-5	10-11 10	21				
5										
6				SS-6	11-16 12	28				
	Borehole terminated at 6.55 m		325.61 / 6.55							At drilling completion, wet cave at 2.29 m.
7										
8										

Dynamic Cone / Std Penetration: 20 40 60 80

Shear Strength (PP) kPa / Shear Strength (FV) kPa: 50 100 150 200 — Initial / Remold

Water Content (%): WP WL — 10 20 30

Reviewed by: *K.Thrams* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes:

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Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011

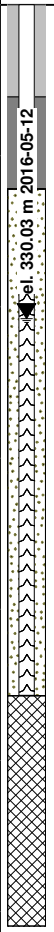
Englobe

Ground Elevation:	*332.07 m*	**Borehole Number:**	**BH-12-16**
Northing:	*4817620.24 m*	**Job N°:**	*P-0010233-0-01-100*
Easting:	*564915.94 m*	**Drill Date:**	*2016-05-03*
		Field Tech:	*D.Souter*
Project:	*Proposed Residential Development*		
Location:	*Lowes Road, Guelph, Ontario*	**Drill Method:**	*Hollow Stem Auger*

Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value
	Ground Elevation		332.07			
	TOPSOIL: loose dark brown silt, trace sand and gravel, moist		0.00 / 331.76	SS-1	1-2 7-10	9
	SAND AND GRAVEL: compact brown sand and gravel, trace silt, numerous cobbles, moist		0.30 / 331.31			
1	very dense, grey/brown		0.76	SS-2	21-25 45-45	70
				SS-3	14-50 /75 mm	
2			329.78			
	dense, saturated		2.29	SS-4	12-20 18-14	38
3			329.02			
	compact		3.05	SS-5	8-11 12-16	23
			328.26			
4	dense		3.81	SS-6	12-14 19-12	33
				SS-7	13-17 18-20	35
5			326.58			
	compact		5.49	SS-8	11-13 15-16	28
6			325.97			
	Borehole terminated at 6.10 m		6.10			
7						
8						

Dynamic Cone: 20 40 60 80
Std Penetration: 20 40 60 80
Shear Strength (PP) kPa: 50 100 150 200
Initial
Remold
Shear Strength (FV) kPa: 50 100 150 200
WP WL
Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details



Reviewed by: *K.Thrams* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes:

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Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011

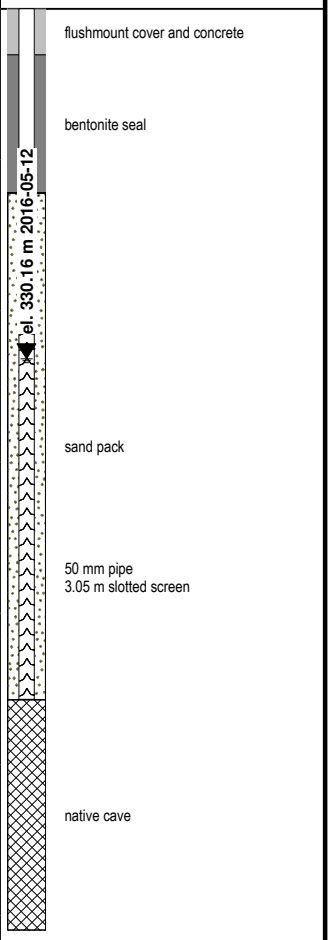
Englobe

Ground Elevation:	*332.44 m*	**Borehole Number:**	**BH-13-16**
Northing:	*4817607.48 m*	**Job N°:**	*P-0010233-0-01-100*
Easting:	*564929.82 m*	**Drill Date:**	*2016-05-04*
Project:	*Proposed Residential Development*	**Field Tech:**	*D.Souter*
Location:	*Lowes Road, Guelph, Ontario*	**Drill Method:**	*Hollow Stem Auger*

Depth (m)	Description	Symbol	Elevation (m) / Depth (m)	Type and Number	"Blows" /150 mm	SPT 'N' Value
	Ground Elevation		332.44			
	TOPSOIL: loose dark brown silt, trace sand, moist		0.00 / 332.08	SS-1	1-2 5-5	7
	SAND AND GRAVEL: loose brown sand and gravel, some silt, numerous cobbles, moist		0.36 / 331.68			
1	dense		0.76 / 330.92	SS-2	23-17 24-50	41
	very dense		1.52 / 330.15	SS-3	23-22 33-45	55
2	compact, occasional cobbles, saturated		2.29	SS-4	10-12 14-15	26
3				SS-5	8-9 10-10	19
	dense		3.81 / 328.63	SS-6	9-15 15-20	30
4						
				SS-7	13-14 16-17	30
5						
	compact		5.49 / 326.95	SS-8	10-11 8-8	19
6			326.34			
	Borehole terminated at 6.10 m		6.10			
7						
8						

Dynamic Cone: 20 40 60 80
Std Penetration: 20 40 60 80
Shear Strength (PP) kPa: 50 100 150 200
Initial
Remold
Shear Strength (FV) kPa: 50 100 150 200
WP WL
Water Content (%): 10 20 30

Groundwater Observations and Standpipe Details



Reviewed by: *K.Thrams* **Drafted by:** *E.Ciochon* **Sheet:** *1 of 1*

Notes:

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Vertical Scale = 1 : 50.0

EQ-09-Ge-72 R.1 18.02.2011

Appendix 3 Figures

Figures 1 and 2 (Particle Size Distribution Curves)
Figure 101: Continuous Groundwater Level Measurements
Figure 102: Manual Groundwater Level Measurements
Figure 103: Mini Piezometer MP-01-18 Hydrograph
Figure 104: Mini Piezometer MP-03-18 Hydrograph
Figure 105: Mini Piezometer MP-04-18 Hydrograph
Figure 106: Mini Piezometer MP-05-18 Hydrograph

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PARTICLE SIZE ANALYSIS

Project: **Proposed Residential Development**

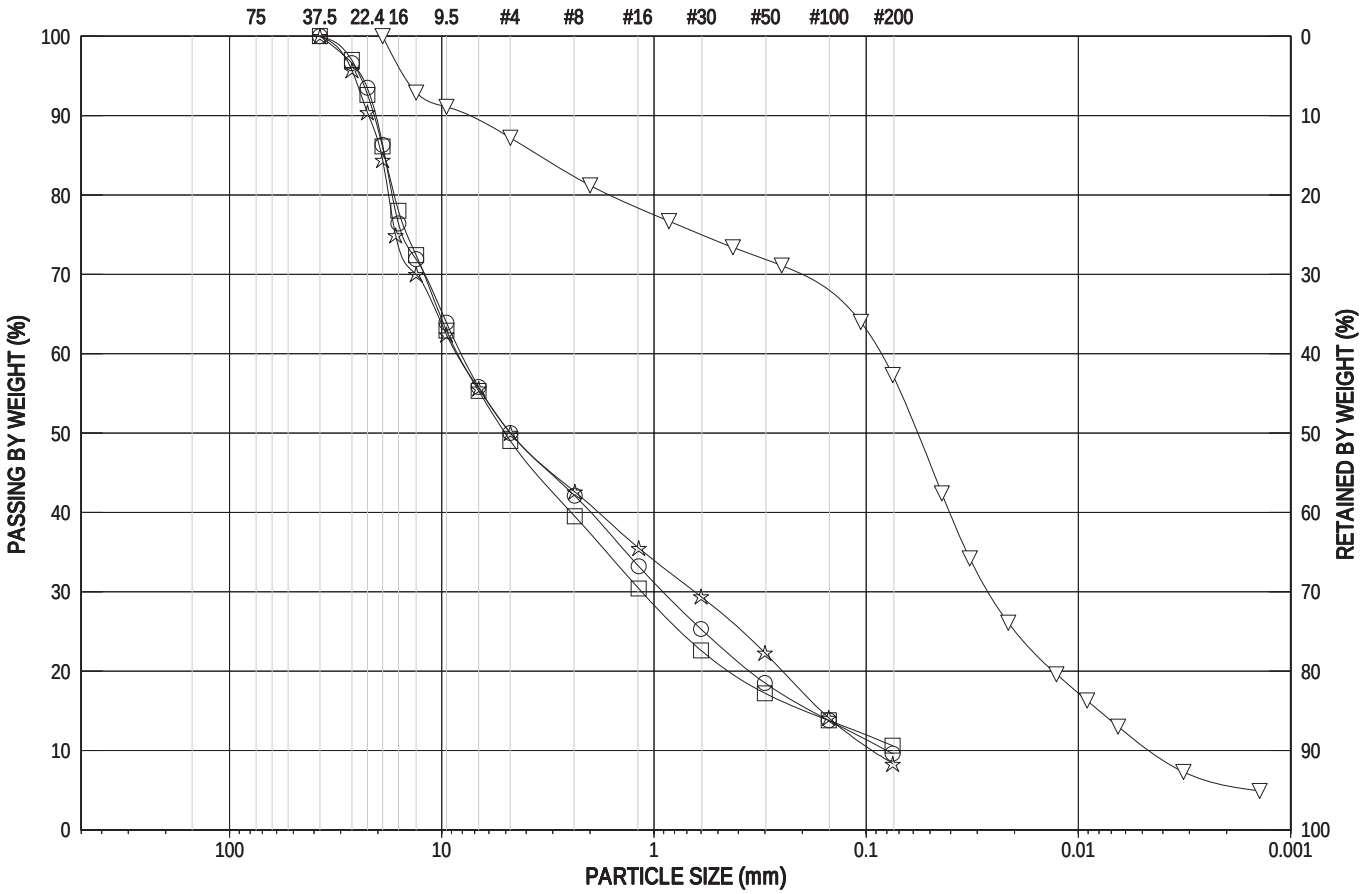
Figure No : **1**

Location: **Lowes Road, Guelph, Ontario**

File No : **P-0010233-0-02-300**

UNIFIED SOIL CLASSIFICATION

COBBLES	*GRAVEL*		*SAND*			*SILT OR CLAY*
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN MILLIMETRES			*U.S. STANDARD SIEVE No.*			*HYDROMETER*



Symbol	Borehole n°	Sample n°	Depth (m)	Description
○	BH-01-16	SS-1 to SS-5	0.76 - 1.22	SAND and GRAVEL, trace Silt
□	BH-02-16	SS-3 to SS-6	1.52 - 2.13	SAND and GRAVEL, some Silt
▽	BH-07-16	SS-1	0.76 - 1.22	Sandy SILT, some Gravel, trace Clay
☆	BH-11-16	SS-2 to SS-6	1.52 - 1.98	SAND and GRAVEL, trace Silt

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PARTICLE SIZE ANALYSIS

Project: **Proposed Residential Development**

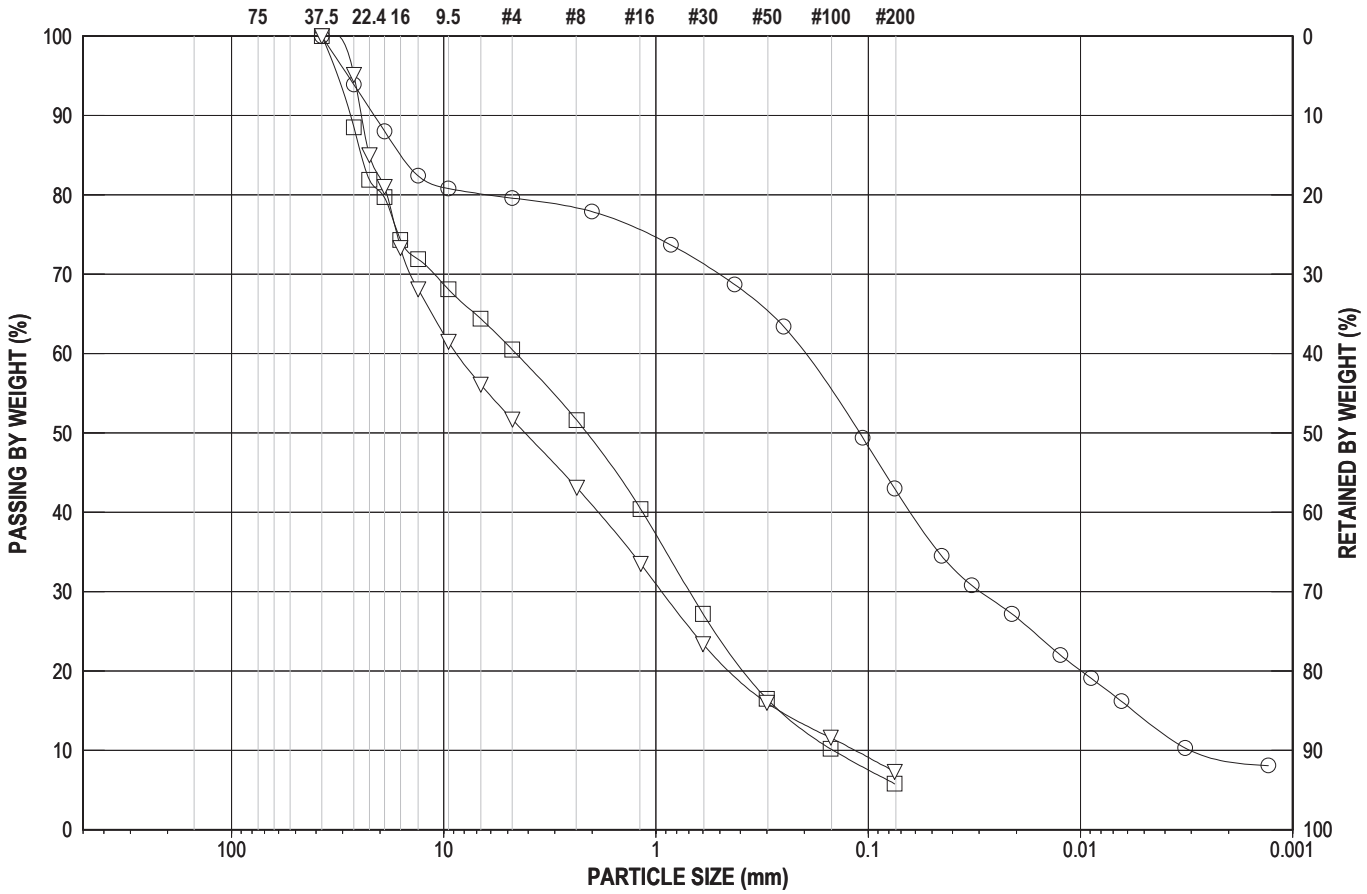
Location: **Lowes Road, Guelph, Ontario**

Figure No : **2**

File No : **P-0010233-0-02-300**

UNIFIED SOIL CLASSIFICATION

COBBLES	*GRAVEL*		*SAND*			*SILT OR CLAY*
	COARSE	FINE	COARSE	MEDIUM	FINE	
U.S. SIEVE SIZE IN MILLIMETRES			*U.S. STANDARD SIEVE No.*			*HYDROMETER*



Symbol	Borehole n°	Sample n°	Depth (m)	Description
○	BH-01-16	SS-6	6.10 - 6.55	Gravelly SILT and SAND, trace Clay
□	BH-06-16	SS-4 to SS-7	2.29 - 2.90	SAND and GRAVEL, trace Silt
▽	BH-10-16	SS-2 to SS-6	1.52 - 1.98	SAND and GRAVEL, trace Silt

FIGURE 101
CONTINUOUS GROUNDWATER LEVEL MEASUREMENTS

Hydrogeology Study Report
19-59 Lowes Road
Guelph, Ontario

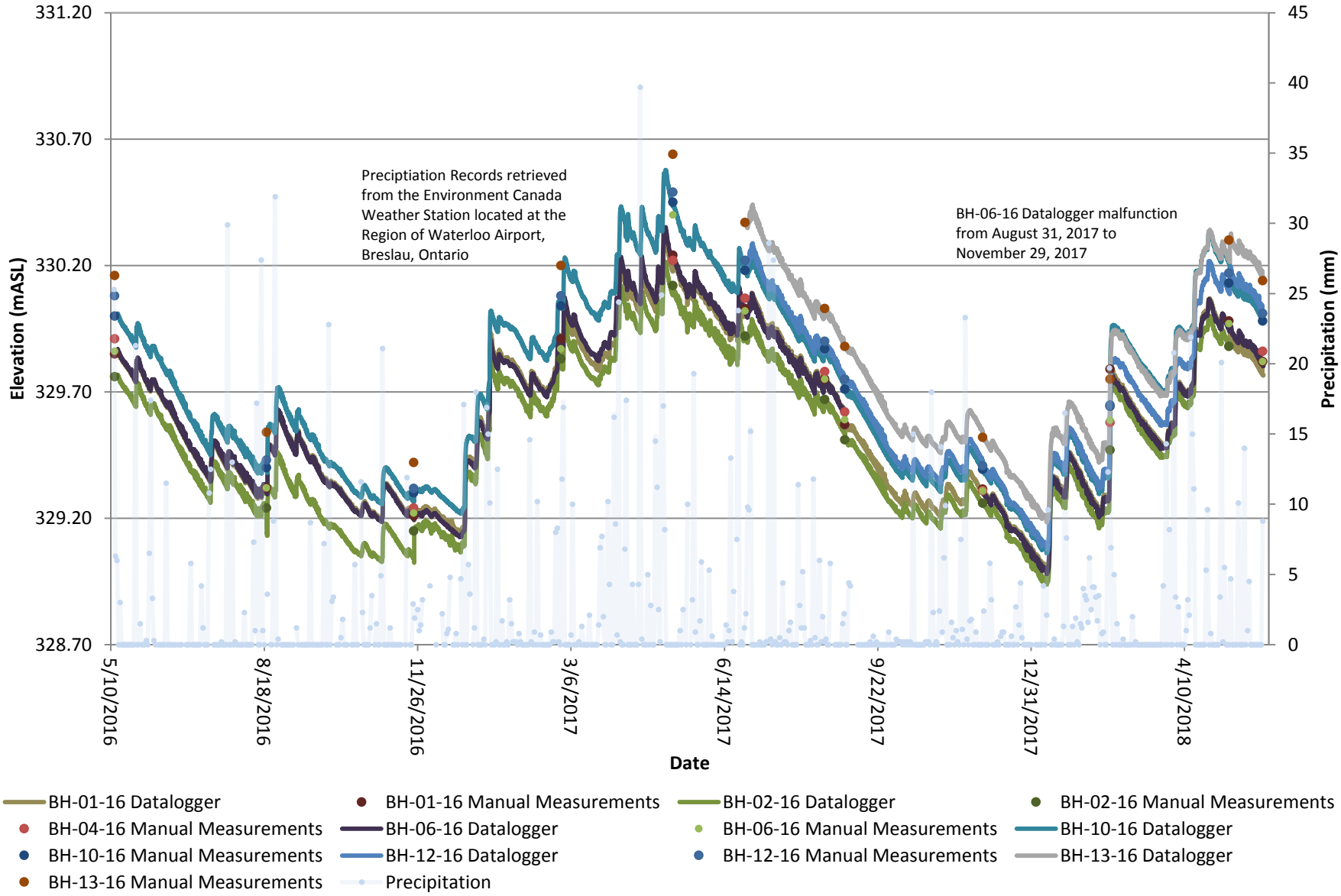


FIGURE 102
MANUAL WATER LEVEL MEASUREMENTS

Hydrogeology Study Report
19-59 Lowes Road
Guelph, Ontario

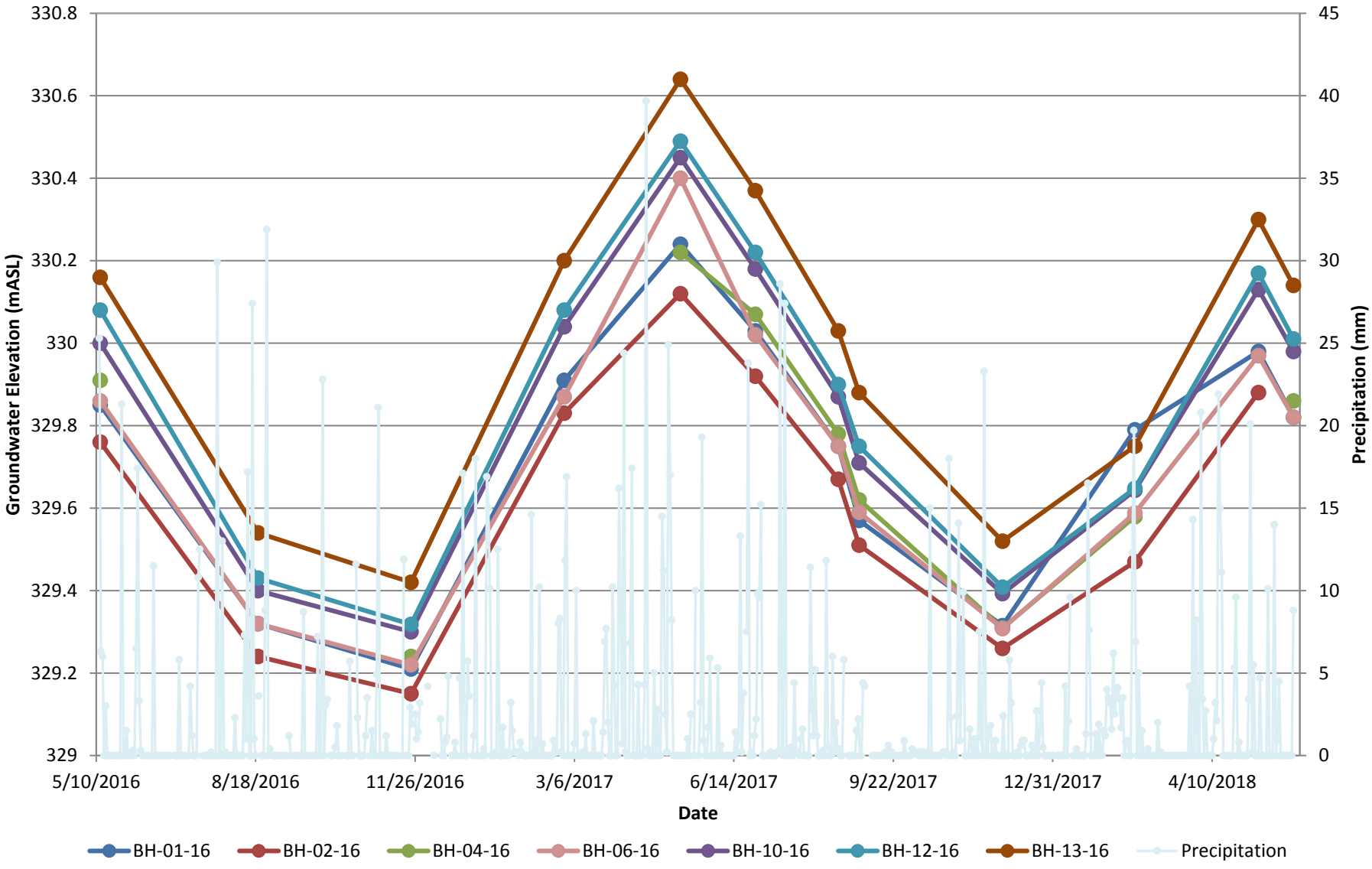


FIGURE 103
CONTINUOUSLY RECORDED WATER ELEVATIONS MINI PIEZOMETER MP-01-18

Scoped Hydrogeology Study
19-59 Lowes Road
Guelph, Ontario

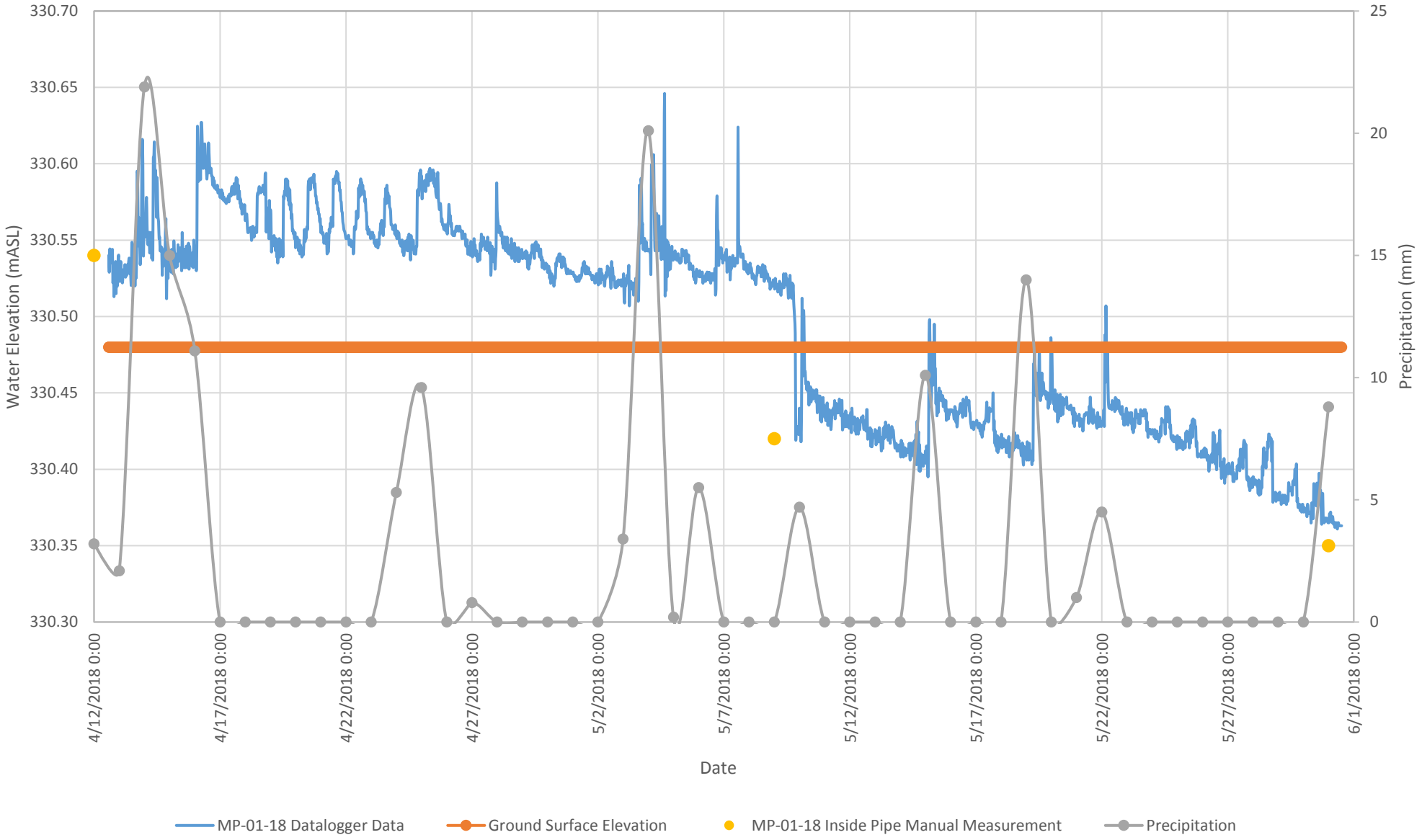


FIGURE 104
CONTINUOUSLY RECORDED GROUNDWATER ELEVATIONS MINI PIEZOMETER MP-03-18

Scoped Hydrogeology Study
19-59 Lowes Road
Guelph, Ontario

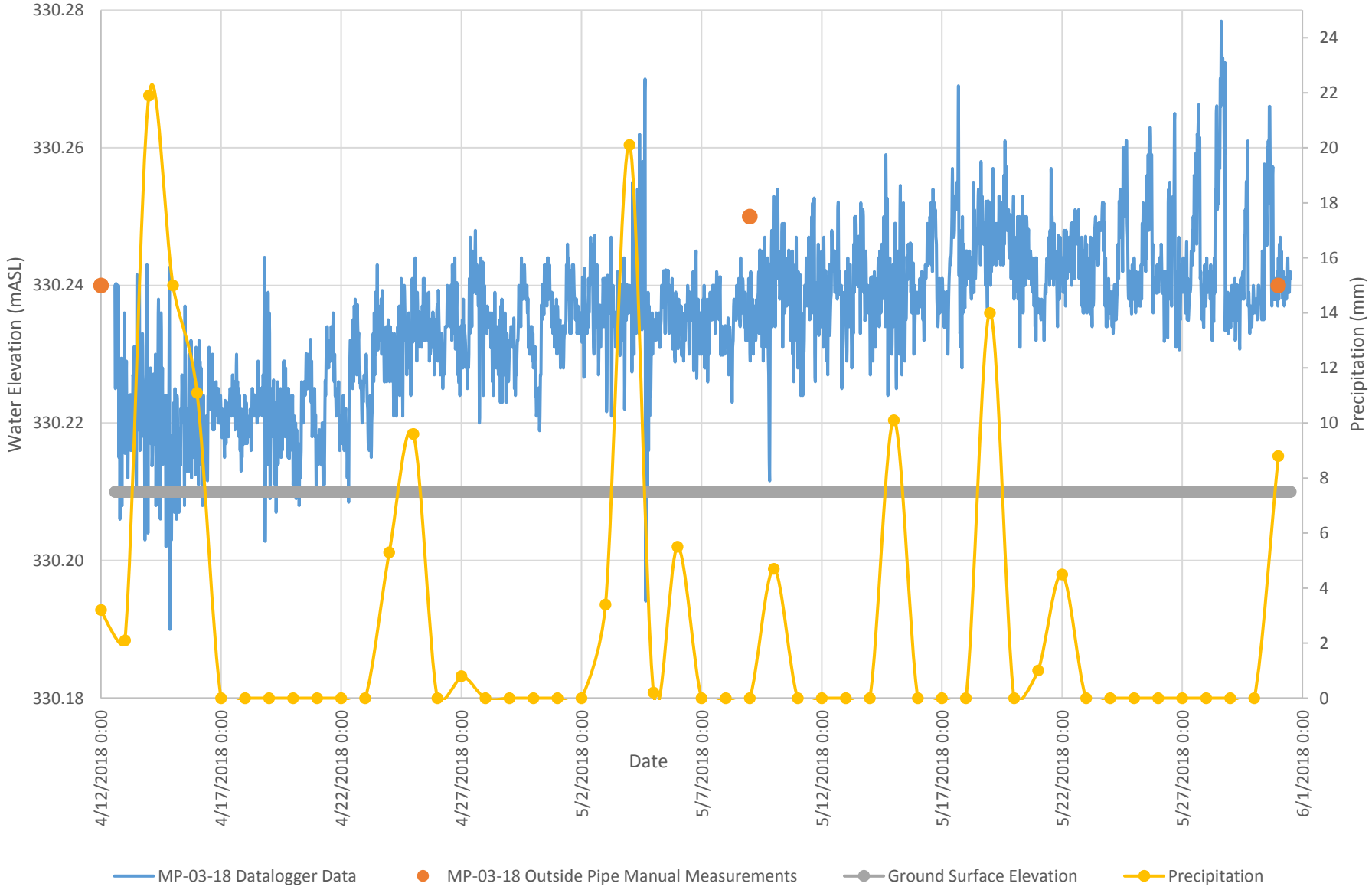


FIGURE 105
CONTINUOUSLY RECORDED GROUNDWATER ELEVATIONS MINI PIEZOMETER MP-04-18

Scoped Hydrogeology Study
19-59 Lowes Road
Guelph, Ontario

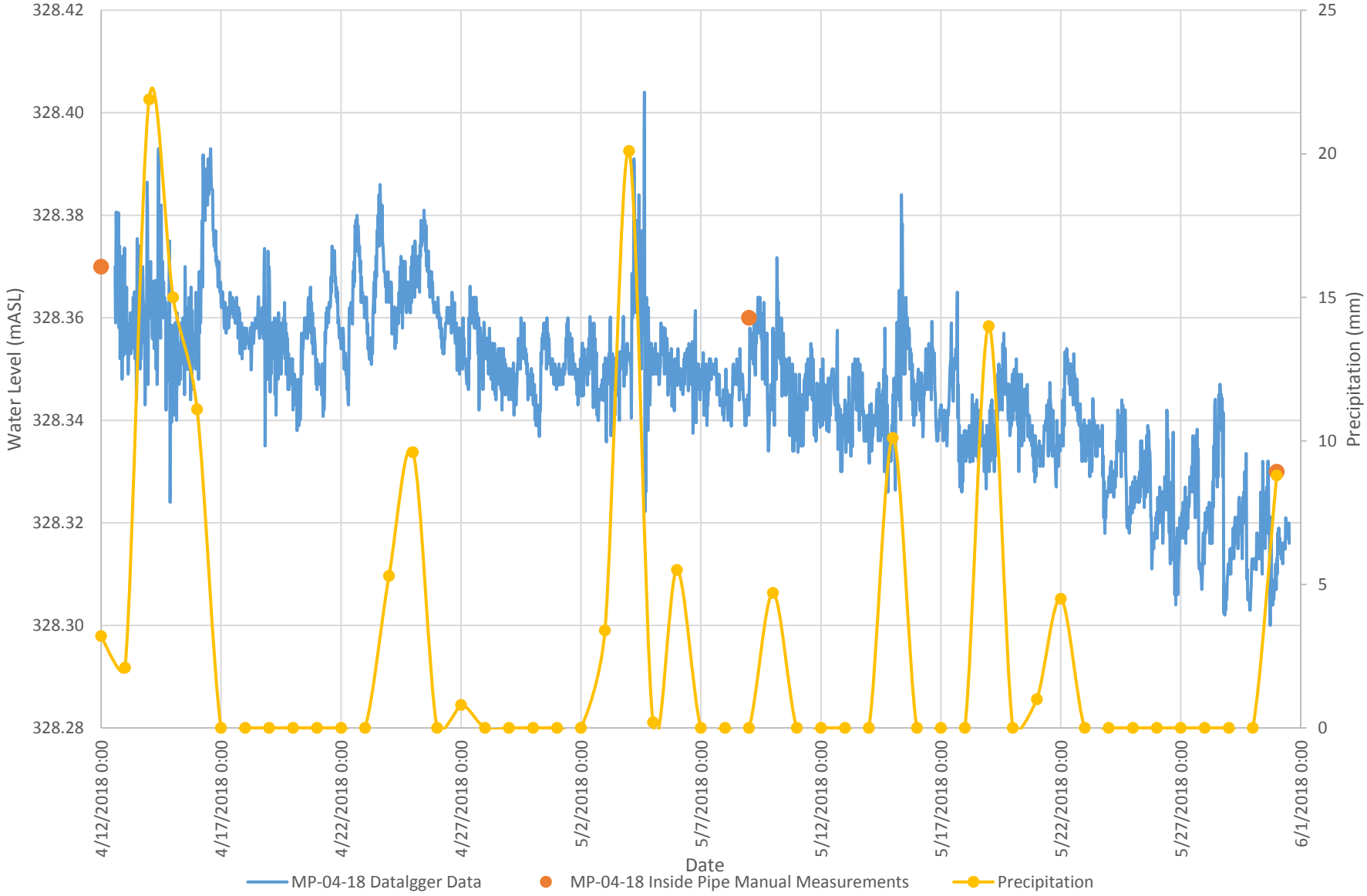
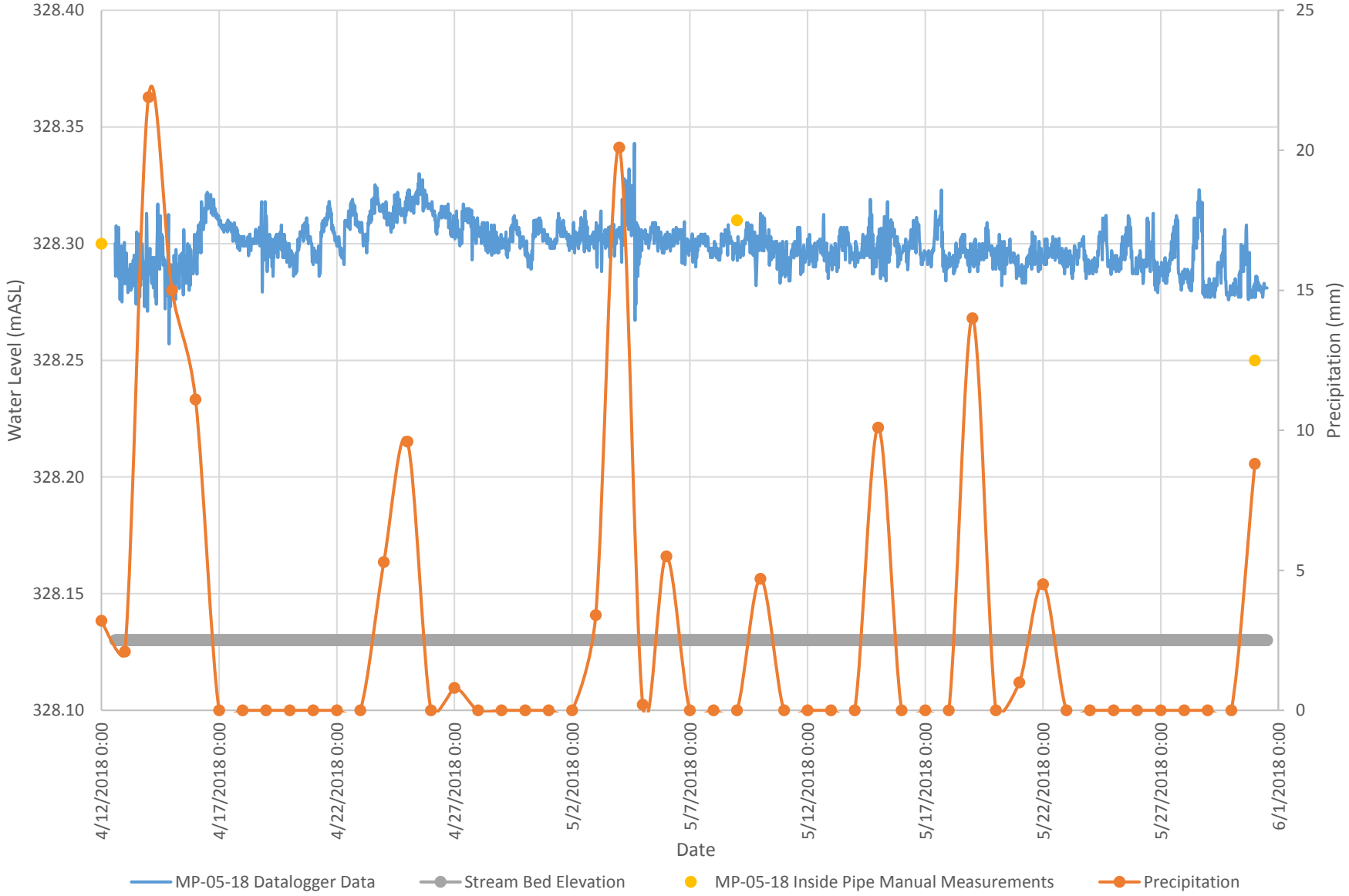


FIGURE 106
CONTINUOUSLY RECORDED WATER ELEVATIONS MINI PIEZOMETER MP-05-18

Scoped Hydrogeology Study
19-59 Lowes Road
Guelph, Ontario



Appendix 4 Tables

Englobe

TABLE 101

MEASURED GROUNDWATER ELEVATIONS

Scoped Hydrogeology Study
19-59 Lowes Road
Guelph, Ontario

					May-12-16			August-19-16			November-23-16			February-27-17		
WELL NAME	GROUND SURFACE ELEVATION (mASL)	TOP OF PIPE ELEVATION (mASL)	TOP OF CASING ELEVATION (mASL)	STICK-UP (m)	DEPTH TO WL (mBTOP)	DEPTH TO WL (mBGS)	WL ELEVATION (mASL)	DEPTH TO WL (mBTOP)	DEPTH TO WL (mBGS)	WL ELEVATION (mASL)	DEPTH TO WL (mBTOP)	DEPTH TO WL (mBGS)	WL ELEVATION (mASL)	DEPTH TO WL (mBTOP)	DEPTH TO WL (mBGS)	WL ELEVATION (mASL)
BH-01-16	332.79	--	332.79	--	--	2.94	329.85	--	3.47	329.32	--	3.58	329.21	--	2.88	329.91
BH-02-16	332.39	--	332.39	--	--	2.63	329.76	--	3.15	329.24	--	3.24	329.15	--	2.56	329.83
BH-04-16	332.31	--	332.31	--	--	2.40	329.91	--	NA	NA	--	3.07	329.24	--	NA	NA
BH-06-16	331.32	--	331.32	--	--	1.46	329.86	--	2.00	329.32	--	2.10	329.22	--	1.45	329.87
BH-09-16	332.22	--	332.22	--	--	2.23	329.99	--	NA	NA	--	NA	NA	--	NA	NA
BH-10-16	331.97	332.83	--	0.86	2.83	1.97	330.00	3.43	2.57	329.40	3.53	2.67	329.30	2.79	1.93	330.04
BH-12-16	332.07	332.80	--	0.73	2.72	1.99	330.08	3.37	2.64	329.43	3.48	2.75	329.32	2.72	1.99	330.08
BH-13-16	332.44	--	332.44	--	--	2.28	330.16	--	2.90	329.54	--	3.02	329.42	--	2.24	330.20

					May-11-17			June-27-17			August-18-17			August-31-17		
WELL NAME	GROUND SURFACE ELEVATION (mASL)	TOP OF PIPE ELEVATION (mASL)	TOP OF CASING ELEVATION (mASL)	STICK-UP (m)	DEPTH TO WL (mBTOP)	DEPTH TO WL (mBGS)	WL ELEVATION (mASL)	DEPTH TO WL (mBTOP)	DEPTH TO WL (mBGS)	WL ELEVATION (mASL)	DEPTH TO WL (mBTOP)	DEPTH TO WL (mBGS)	WL ELEVATION (mASL)	DEPTH TO WL (mBTOP)	DEPTH TO WL (mBGS)	WL ELEVATION (mASL)
BH-01-16	332.79	--	332.79	--	--	2.55	330.24	--	2.76	330.03	--	3.04	329.75	--	3.22	329.57
BH-02-16	332.39	--	332.39	--	--	2.27	330.12	--	2.47	329.92	--	2.72	329.67	--	2.88	329.51
BH-04-16	332.31	--	332.31	--	--	2.09	330.22	--	2.24	330.07	--	2.53	329.78	--	2.69	329.62
BH-06-16	331.32	--	331.32	--	--	1.08	330.24	--	1.30	330.02	--	1.57	329.75	--	1.73	329.59
BH-09-16	332.22	--	332.22	--	--	NA	NA	--	NA	NA	--	NA	NA	--	NA	NA
BH-10-16	331.97	332.83	--	0.86	2.38	1.52	330.45	2.65	1.79	330.18	2.96	2.10	329.87	3.12	2.26	329.71
BH-12-16	332.07	332.80	--	0.73	2.31	1.58	330.49	2.58	1.85	330.22	2.9	2.17	329.90	3.05	2.32	329.75
BH-13-16	332.44	--	332.44	--	--	1.80	330.64	--	2.07	330.37	--	2.41	330.03	--	2.56	329.88

					November-29-17			February-20-18			May-09-18			May-31-18		
WELL NAME	GROUND SURFACE ELEVATION (mASL)	TOP OF PIPE ELEVATION (mASL)	TOP OF CASING ELEVATION (mASL)	STICK-UP (m)	DEPTH TO WL (mBTOP)	DEPTH TO WL (mBGS)	WL ELEVATION (mASL)	DEPTH TO WL (mBTOP)	DEPTH TO WL (mBGS)	WL ELEVATION (mASL)	DEPTH TO WL (mBTOP)	DEPTH TO WL (mBGS)	WL ELEVATION (mASL)	DEPTH TO WL (mBTOP)	DEPTH TO WL (mBGS)	WL ELEVATION (mASL)
BH-01-16	332.79	--	332.79	--	--	3.47	329.32	--	3.00	329.79	--	2.81	329.98	--	2.97	329.82
BH-02-16	332.39	--	332.39	--	--	3.13	329.26	--	2.92	329.47	--	2.51	329.88	Car Parked Over Well		
BH-04-16	332.31	--	332.31	--	--	3.00	329.31	--	2.73	329.58	Buried Under Tree			--	2.45	329.86
BH-06-16	331.32	--	331.32	--	--	2.01	329.31	--	1.73	329.59	--	1.35	329.97	--	1.5	329.82
BH-09-16	332.22	--	332.22	--	--	NA	NA	--	NA	NA	--	NA	NA	--	NA	NA
BH-10-16	331.97	332.83	--	0.86	3.44	2.58	329.39	3.19	2.33	329.64	2.70	1.84	330.13	2.85	1.99	329.98
BH-12-16	332.07	332.80	--	0.73	3.39	2.66	329.41	3.15	2.42	329.65	2.63	1.90	330.17	2.79	2.06	330.01
BH-13-16	332.44	--	332.44	--	--	2.92	329.52	--	2.69	329.75	--	2.14	330.30	--	2.30	330.14

TABLE 101

MEASURED GROUNDWATER ELEVATIONS

Scoped Hydrogeology Study
19-59 Lowes Road
Guelph, Ontario

				April-12-18		May-09-18		May-31-18	
WELL NAME	GROUND SURFACE ELEVATION (mASL)	STICK-UP (m)	TOP OF PIPE ELEVATION (mASL)	DEPTH TO WL (mBTOP)	WL ELEVATION (mASL)	DEPTH TO WL (mBTOP)	WL ELEVATION (mASL)	DEPTH TO WL (mBTOP)	WL ELEVATION (mASL)
MP-01-18 (in)	330.48	1.45	331.93	1.39	330.54	1.51	330.42	1.58	330.35
MP-01-18 (out)	330.48	1.45	331.93	1.49	330.44	Dry		Dry	
MP-03-18 (in)	330.21	1.41	331.62	1.36	330.26	1.37	330.25	1.42	330.20
MP-03-18 (out)	330.21	1.41	331.62	1.38	330.24	1.37	330.25	1.38	330.24
MP-04-18 (in)	328.52	1.30	329.82	1.45	328.37	1.46	328.36	1.49	328.33
MP-04-18 (out)	328.52	1.30	329.82	Dry		Dry		Dry	
MP-05-18 (in)	328.13	1.44	329.57	1.27	328.30	1.26	328.31	1.32	328.25
MP-05-18 (out)	328.13	1.44	329.57	1.27	328.30	1.26	328.31	1.28	328.29

1. mBTOP – metres below top of pipe.
2. mASL – metres above sea level.
3. WL – water level.
4. NA – unable to open lid
5. Wind storm occurred on May 4, 2018. Tree fell on Monitoring Well BH-04-16
6. Mini Piezometer ground surface elevations and top of pipe elevation obtained from Stantec Engineering
7. MP-05-18 ground surface elevation is actually stream bed elevation

TABLE 102

HYDRAULIC CONDUCTIVITY ESTIMATES

Scoped Hydrogeology Study
19-59 Lowes Road,
Guelph, Ontario

Borehole Name / Location	Ground Surface Elevation (mASL)	Grain Size Analyses			
		Soil Description	Sample Depth (mBGS)	Hydraulic Conductivity (m/sec)	Method
BH-01-16	332.79	Sand and gravel, trace silt, occasional cobbles	SS-1 – SS-5 0.8-5.0	1.2×10^{-5}	Kozeny- Carman, C_u = 104.9
BH-01-16	332.79	Gravelly Silt and Sand, occasional cobbles	SS-6, 6.1-6.6	4.2×10^{-7}	Kaubisch, P = 26
BH-02-16	332.39	Sand and gravel, some silt, occasional cobbles	SS-3 – SS- 6, 1.5 - 4.3	9.0×10^{-6}	Kozeny- Carman, C_u = 114.3
BH-06-16	331.32	Sand and gravel, trace silt, numerous cobbles	SS-4 – SS-7, 2.3 - 5.2	4.8×10^{-5}	Kozeny- Carman, C_u = 30
BH-07-16	332.44	Sandy Silt and gravel, numerous cobbles	SS-1 0.8-1.2	8.2×10^{-7}	Kaubisch, P = 23
BH-10-16	331.97	Sand and gravel, trace Topsoil, trace Silt, occasional cobbles	SS-2 – SS-6, 1.5 - 6.6	3.1×10^{-5}	Kozeny- Carman, C_u = 69.2
BH-11-16	332.16	Sand and gravel, trace silt, numerous cobbles	SS-2 – SS-6 1.5 – 6.6	1.7×10^{-5}	Kozeny- Carman, C_u = 17.3

Borehole Name / Location	Ground Surface Elevation (mASL)	Slug Tests			
		Soil Description	Screened Interval (mBGS)	Hydraulic Conductivity (m/sec)	Method
BH-01-16	332.79	Sand and gravel, trace Silt, occasional cobbles	4.6 – 6.1	4.8×10^{-5}	Pneumatic (rising head)
BH-02-16	332.39	Sand and gravel, some silt, occasional cobbles	1.5 - 4.6	2.3×10^{-5}	Water In (rising head)
BH-04-16	332.31	Sand and gravel, some silt, occasional cobbles	4.5 – 6.0	$> 2.0 \times 10^{-4}$	Pneumatic (rising head)
BH-06-16	331.32	Sand and gravel, trace silt, numerous cobbles	0.9 – 4.0	2.4×10^{-4}	Slug Out (rising head)
BH-09-16	332.22	Sand and gravel, some silt, numerous cobbles	1.5 - 4.6	1.3×10^{-4}	Slug Out (rising head)
BH-10-16	331.97	Sand and gravel, trace Topsoil, trace Silt, occasional cobbles	3.9 – 5.5	8.7×10^{-5}	Pneumatic (rising head)

Notes:
1. mASL – metres Above Sea Level
2. C_u = coefficient of uniformity value
3. P = percent of soil smaller than 0.02 mm
4. * = Insufficient data to determine the time lag

TABLE 103

GROUNDWATER CHEMISTRY ANALYSIS RESULTS

Scoped Hydrogeology Study
19- 59 Lowes Road
Guelph, Ontario

					13-May-16		
SAMPLE ID	UNITS	TYPE OF OBJECTIVE	ODWS LIMIT	PWQO LIMIT	BH-02-16	BH-04-16	BH-10-16
Colour, Apparent	TCU	AO	5	-	**30.7**	<1.0	2.4
Conductivity	umhos/cm	-	-	-	1150	1120	1080
Hardness (as $CaCO_3$)	mg/L	OG	80-100	-	**372**	**341**	**359**
pH	pH units	OG	6.5-8.5	6.5-8.5	8.08	8.03	8.14
Total Dissolved Solids	mg/L	AO	500	-	**635**	**604**	**578**
Turbidity	NTU	AO	5	(*)	**37.2**	0.17	0.93
Alkalinity, Total (as $CaCO_3$)	mg/L	OG	30-500	-	271	246	256
Ammonia, Total (as N)	mg/L	-	-	0.02	**0.075**	**0.033**	**0.184**
Chloride (Cl)	mg/L	AO	250	-	185	197	167
Fluoride (F)	mg/L	MAC	1.5	-	<0.10	<0.10	<0.10
Nitrate (as N)	mg/L	MAC	10	-	4.39	4.6	5.65
Nitrite (as N)	mg/L	MAC	1	-	<0.050	<0.050	<0.050
Phosphate-P (ortho)	mg/L	-	-	-	<0.0030	<0.0030	0.0056
Sulfate (SO_4)	mg/L	AO	500	-	26.1	29.9	34.4
Aluminum (Al)-Total	mg/L	OG	0.1	0.015	**0.33**	<0.010	0.02
Antimony (Sb)-Total	mg/L	IMAC	0.006	0.02	<0.00010	<0.00010	<0.00010
Arsenic (As)-Total	mg/L	IMAC	0.025	0.005	0.00042	0.00011	0.00028
Barium (Ba)-Total	mg/L	MAC	1	-	0.0681	0.062	0.0507
Beryllium (Be)-Total	mg/L	-	-	0.001	<0.00010	<0.00010	<0.00010
Bismuth (Bi)-Total	mg/L	-	-	-	<0.000050	<0.000050	<0.000050
Boron (B)-Total	mg/L	IMAC	5.00	0.20	0.021	0.02	0.02
Cadmium (Cd)-Total	mg/L	MAC	0.005	0.005	0.000132	0.000119	0.000057
Calcium (Ca)-Total	mg/L	-	-	-	92.8	85.3	93
Cesium (Cs)-Total	mg/L	-	-	-	0.000042	<0.000010	<0.000010
Chromium (Cr)-Total	mg/L	MAC	0.05	0.001(**)	0.00068	<0.00050	<0.00050
Cobalt (Co)-Total	mg/L	-	-	0.0009	0.00031	**<0.00010**	**<0.00010**
Copper (Cu)-Total	mg/L	AO	1	0.005	0.0022	<0.0010	0.0015
Iron (Fe)-Total	mg/L	AO	0.3	0.3	**0.447**	<0.050	<0.050
Lead (Pb)-Total	mg/L	MAC	0.01	0.005	0.00704	0.00012	0.0004
Lithium (Li)-Total	mg/L	-	-	-	0.0022	0.0018	0.0022
Magnesium (Mg)-Total	mg/L	-	-	-	33.7	28.9	32.3
Manganese (Mn)-Total	mg/L	AO	0.05	-	**0.0599**	0.00176	0.0161
Molybdenum (Mo)-Total	mg/L	-	-	0.04	0.000769	0.000284	0.0007
Nickel (Ni)-Total	mg/L	-	-	0.025	0.00123	<0.00050	0.00083
Phosphorus (P)-Total	mg/L	-	-	0.01	**<0.050**	**<0.050**	**<0.050**
Potassium (K)-Total	mg/L	-	-	-	2.9	1.95	2.22
Rubidium (Rb)-Total	mg/L	-	-	-	0.00383	0.0019	0.00164
Selenium (Se)-Total	mg/L	MAC	0.01	0.1	0.000331	0.000324	0.00036
Silicon (Si)-Total	mg/L	-	-	-	3.94	3.35	3.44
Silver (Ag)-Total	mg/L	-	-	0.0001	<0.000050	<0.000050	<0.000050
Sodium (Na)-Total	mg/L	AO	200	-	116	109	87
Strontium (Sr)-Total	mg/L	-	-	-	0.12	0.105	0.117
Sulfur (S)-Total	mg/L	-	-	-	10	10.6	12.7
Tellurium (Te)-Total	mg/L	-	-	-	<0.00020	<0.00020	<0.00020
Thallium (Tl)-Total	mg/L	-	-	0.0003	0.000054	0.000016	0.000035
Thorium (Th)-Total	mg/L	-	-	-	<0.00010	<0.00010	<0.00010
Tin (Sn)-Total	mg/L	-	-	-	0.00016	<0.00010	<0.00010
Titanium (Ti)-Total	mg/L	-	-	-	0.0135	<0.00030	<0.00050
Tungsten (W)-Total	mg/L	-	-	0.3	<0.00010	<0.00010	<0.00010
Uranium (U)-Total	mg/L	MAC	0.02	0.005	0.000498	0.000454	0.000794
Vanadium (V)-Total	mg/L	-	-	0.006	0.00075	<0.00050	<0.00050
Zinc (Zn)-Total	mg/L	AO	5	0.02	**0.0542**	**0.0395**	0.0188
Zirconium (Zr)-Total	mg/L	-	-	0.004	<0.00030	<0.00030	<0.00030
Aluminum (Al)-Dissolved	mg/L	OG	0.1	0.015	**0.161**	<0.010	0.012
Antimony (Sb)-Dissolved	mg/L	IMAC	0.006	0.02	<0.0050	<0.0050	<0.0050
Arsenic (As)-Dissolved	mg/L	IMAC	0.025	0.005	<0.0010	<0.0010	<0.0010
Barium (Ba)-Dissolved	mg/L	MAC	1	-	0.068	0.063	0.053
Beryllium (Be)-Dissolved	mg/L	-	-	0.001	<0.0010	<0.0010	<0.0010
Bismuth (Bi)-Dissolved	mg/L	-	-	-	<0.0010	<0.0010	<0.0010
Boron (B)-Dissolved	mg/L	IMAC	5	0.2	<0.050	<0.050	<0.050
Cadmium (Cd)-Dissolved	mg/L	MAC	0.005	0.005	0.000141	0.000134	<0.000090
Calcium (Ca)-Dissolved	mg/L	-	-	-	94.3	87.6	91.8
Chromium (Cr)-Dissolved	mg/L	MAC	0.05	0.001(**)	<0.00050	<0.00050	<0.00050
Cobalt (Co)-Dissolved	mg/L	-	-	0.0009	<0.00050	<0.00050	<0.00050
Copper (Cu)-Dissolved	mg/L	AO	1	0.005	0.0018	<0.0010	0.0015
Iron (Fe)-Dissolved	mg/L	AO	0.3	0.3	**0.189**	<0.050	<0.050
Lead (Pb)-Dissolved	mg/L	MAC	0.01	0.005	**0.0069**	<0.0010	<0.0010
Magnesium (Mg)-Dissolved	mg/L	-	-	-	33.2	29.6	31.6
Manganese (Mn)-Dissolved	mg/L	AO	0.05	-	0.0584	0.0017	0.0155
Molybdenum (Mo)-Dissolved	mg/L	-	-	0.04	<0.0010	<0.0010	<0.0010
Nickel (Ni)-Dissolved	mg/L	-	-	0.025	<0.0020	<0.0020	<0.0020
Phosphorus (P)-Dissolved	mg/L	-	-	0.01	**<0.050**	**<0.050**	**<0.050**
Potassium (K)-Dissolved	mg/L	-	-	-	2.8	2	2.3
Selenium (Se)-Dissolved	mg/L	MAC	0.01	0.1	0.00043	0.00041	0.00045
Silicon (Si)-Dissolved	mg/L	-	-	-	3.5	3.3	3.4
Silver (Ag)-Dissolved	mg/L	-	-	0.0001	<0.00010	<0.00010	<0.00010
Sodium (Na)-Dissolved	mg/L	AO	200	-	107	108	84.6
Strontium (Sr)-Dissolved	mg/L	-	-	-	0.122	0.109	0.119
Thallium (Tl)-Dissolved	mg/L	-	-	0.0003	<0.00030	<0.00030	<0.00030
Tin (Sn)-Dissolved	mg/L	-	-	-	<0.0010	<0.0010	<0.0010
Titanium (Ti)-Dissolved	mg/L	-	-	-	<0.0080	<0.0020	<0.0020
Tungsten (W)-Dissolved	mg/L	-	-	0.3	<0.010	<0.010	<0.010
Uranium (U)-Dissolved	mg/L	MAC	0.02	0.005	<0.0050	<0.0050	<0.0050
Vanadium (V)-Dissolved	mg/L	-	-	0.006	<0.0010	<0.0010	<0.0010
Zinc (Zn)-Dissolved	mg/L	AO	5	0.02	**0.0505**	**0.0423**	0.0185
Zirconium (Zr)-Dissolved	mg/L	-	-	0.004	<0.0040	<0.0040	<0.0040

Notes:

1. Criteria from Ontario Drinking Water Standards (MOE, 2006).
2. Analytical analysis performed by ALS Laboratories, Waterloo, Ontario
3. Results in **bold and highlighted** in yellow exceed Ontario Drinking Water Quality System criteria limits
4. Results in **bold and highlighted** in purple exceed the Provincial Water Quality Objective (PWQO)
5. Results in **bold and highlighted** in blue exceed the City of Guelph Sanitary Sewer Use By-Law (1996)-15202
6. Results in **bold and highlighted** in green exceed the City of Guelph Storm Sewer Use By-Law (1996)-15202
7. Results in **bold and highlighted** in orange exceed more than one Standard/Objective/By-Law
8. Results in **bold and highlighted** in red indicate detection limit was above Standard, Objective or By-Law
9. The AO for sodium is 200 mg/L however; if this was drinking water the Medical Officer of Health would be notified to pass the information on to physicians working with patients with sodium reduced diets.
10. (*) Suspended matter should not be added to surface water in concentrations that will change the natural Secchi disc reading by more than 10%. In accordance with O. Reg 63/16 Part III Section 9.5.5 if construction site dewatering is within 30 m of a surface water body, turbidity shall not exceed 8 NTU above the background concentration
11. (**) PWQO for Hexavalent Chromium (Cr VI) which is most stringent

MAC - Maximum Acceptable Concentration (health related)
IMAC - Interim Maximum Acceptable Concentration (health related)
OG - Operational Guideline (parameters which must be controlled for effective treatment)
AO - Aesthetic Objective
TCU - True Colour Units
NTU - Nephelometric Turbidity Units

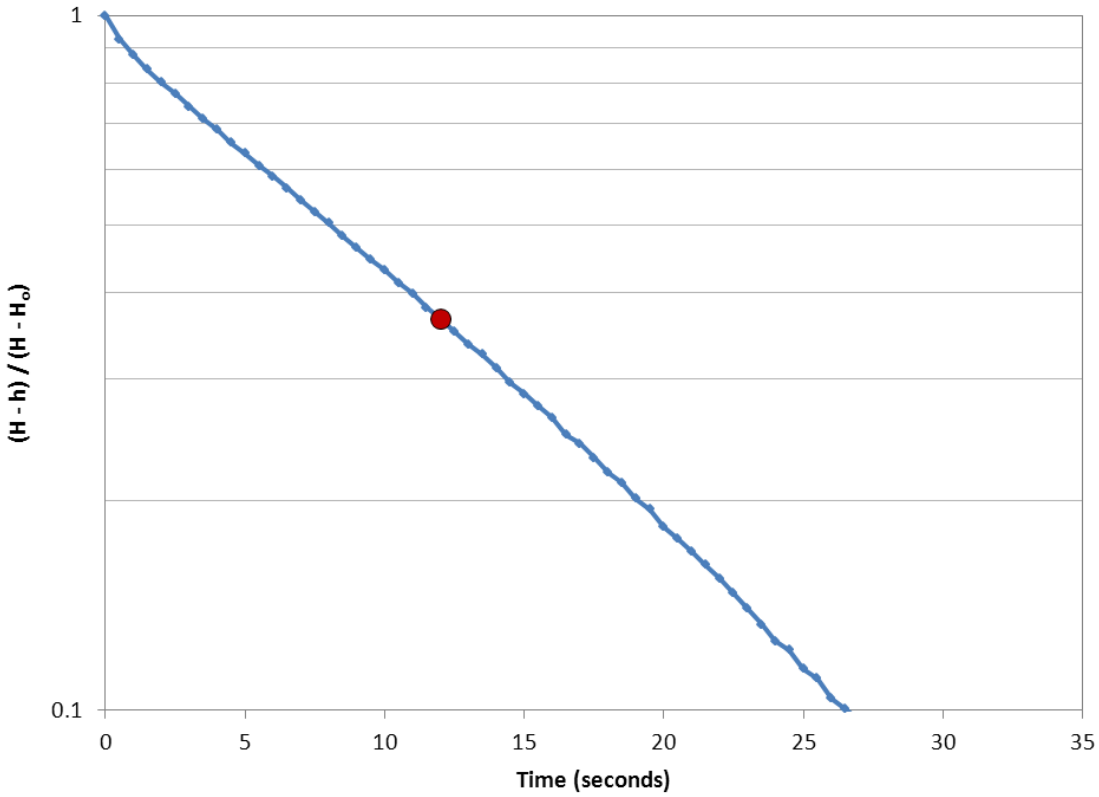
Appendix 5 Slug Test Analysis

Boreholes BH-01-16-BH-13-16

Slug Test Analysis Report

Project: Lowes Road Development – Hydrogeology Study
Project No.: P-0010233-0-02-300-01
Location: Lowes Road, Guelph, Ontario

Test Well: BH-01-16
Test Date(s): May 12, 2016
Analysis Date: June 8, 2016
Test Conducted by: D. Souter
Analysis Performed by: S. Meteer



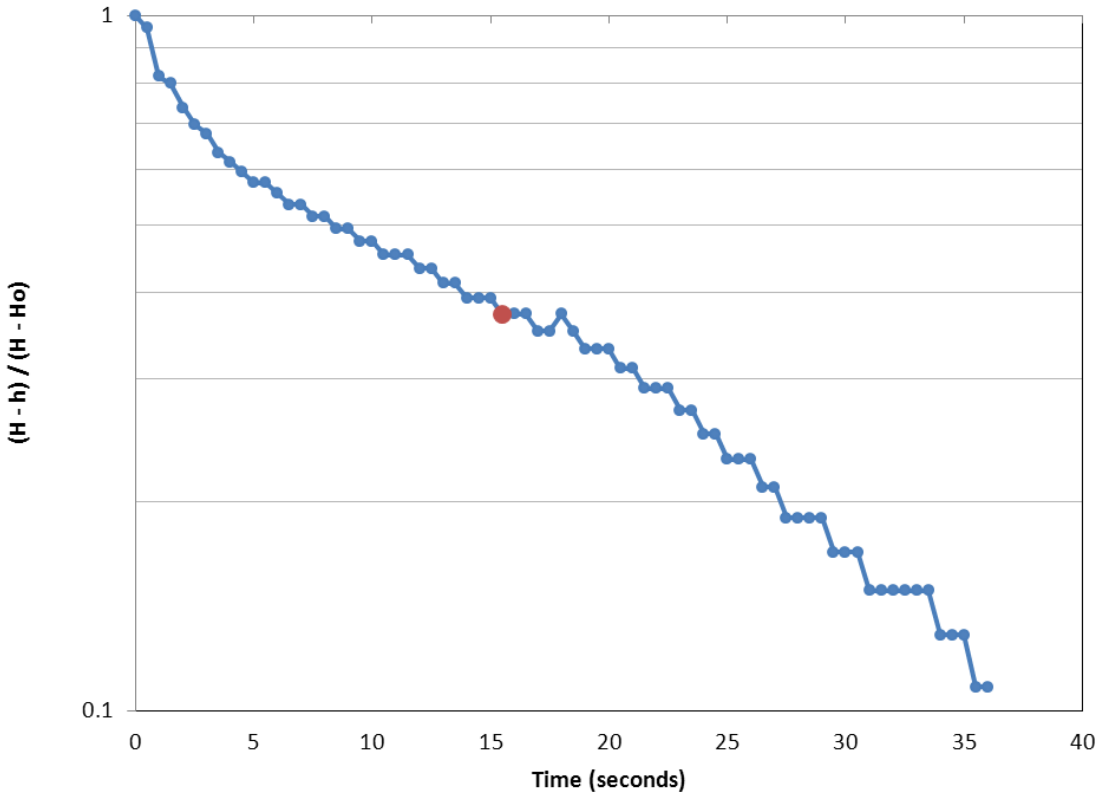
Time Lag: 11.5 seconds
Hydraulic Conductivity (m/s): 4.8×10^{-5}
Soil Type: Sand and gravel, trace silt, occasional cobbles
Notes:
Calculated using Hvorslev: pneumatic, rising head

Englobe

Slug Test Analysis Report

Project: Lowes Road Development – Hydrogeology Study
Project No.: P-0010233-0-02-300-01
Location: Lowes Road, Guelph, Ontario

Test Well: BH-02-16
Test Date(s): May 12, 2016
Analysis Date: June 8, 2016
Test Conducted by: D. Souter
Analysis Performed by: S. Meteer



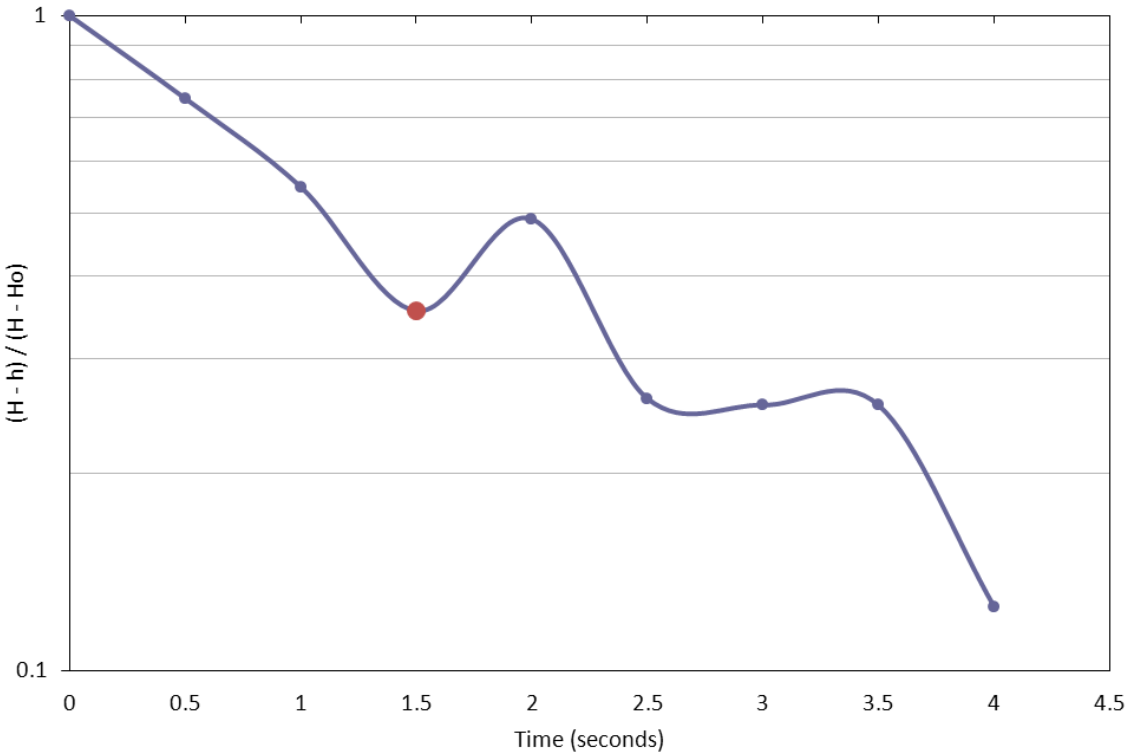
Time Lag: 15.5 seconds
Hydraulic Conductivity (m/s): 2.3×10^{-5}
Soil Type: Sand and gravel, some silt, occasional cobbles
Notes:
Calculated using Hvorslev: Water in, rising head

Englobe

Slug Test Analysis Report

Project: Lowes Road Development – Hydrogeology Study
Project No.: P-0010233-0-02-300-01
Location: Lowes Road, Guelph, Ontario

Test Well: BH-06-16
Test Date(s): May 12, 2016
Analysis Date: June 8, 2016
Test Conducted by: D. Souter
Analysis Performed by: E. Brears



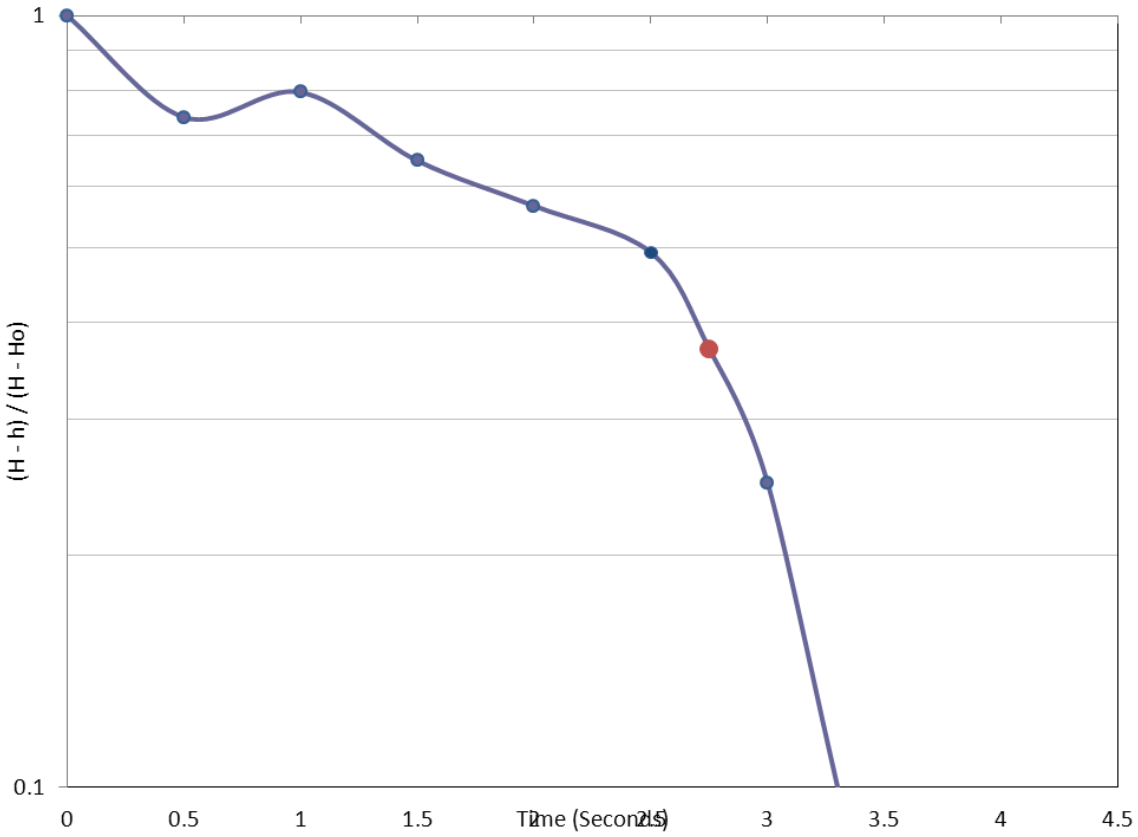
Time Lag: 1.5 seconds
Hydraulic Conductivity (m/s): 2.4×10^{-4}
Soil Type: Sand and gravel, trace silt, numerous cobbles
Notes:
Calculated using Hvorslev: Slug out, rising head

Englobe

Slug Test Analysis Report

Project: Lowes Road Development – Hydrogeology Study
Project No.: P-0010233-0-02-300-01
Location: Lowes Road, Guelph, Ontario

Test Well: BH-09-16
Test Date(s): May 12, 2016
Analysis Date: June 8, 2016
Test Conducted by: D. Souter
Analysis Performed by: E. Brears



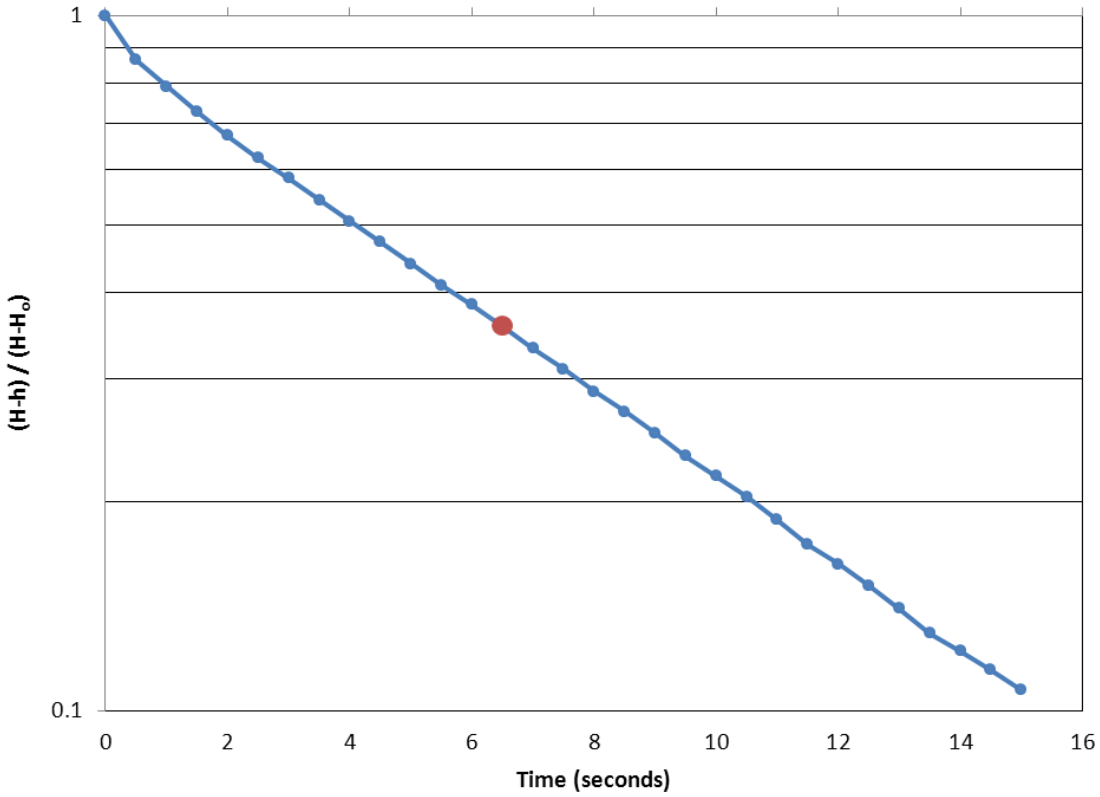
Time Lag: 2.75 seconds
Hydraulic Conductivity (m/s): 1.2×10^{-4}
Soil Type: Sand and gravel, some silt, numerous cobbles
Notes:
Calculated using Hvorslev: Slug out, rising head

Englobe

Slug Test Analysis Report

Project: Lowes Road Development – Hydrogeology Study
Project No.: P-0010233-0-02-300-01
Location: Lowes Road, Guelph, Ontario

Test Well: BH-10-16
Test Date(s): May 12, 2016
Analysis Date: June 13, 2016
Test Conducted by: D. Souter
Analysis Performed by: E. Brears



Time Lag: 6.5 seconds
Hydraulic Conductivity (m/s): 8.7×10^{-5}
Soil Type: Sand and gravel, trace topsoil, trace silt, occasional cobbles
Notes:
Calculated using Hvorslev: pneumatic, rising head

Englobe

Appendix 6 Laboratory Certificate of Analysis

ALS Environmental, Laboratory Work Order No. L1768544

EnGlobe Corp.
ATTN: Susanna Meteer
353 BRIDGE ST. E.
KITCHENER ON N2K 2Y5

Date Received: 13-MAY-16
Report Date: 24-MAY-16 08:47 (MT)
Version: FINAL

Client Phone: 519-741-1313

Certificate of Analysis

Lab Work Order #: L1768544

Project P.O. #: A03742
Job Reference: P-0010233-0-02-300
C of C Numbers: 14-457702
Legal Site Desc:

Mary-Lynn Pires
Client Services Supervisor

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1768544-1 02-16 Sampled By: D. SOUTER on 13-MAY-16 @ 09:00 Matrix: WATER							
Physical Tests							
Color, Apparent	30.7		1.0	C.U.		13-MAY-16	R3458963
Conductivity	1150		3.0	umhos/cm		15-MAY-16	R3458806
Hardness (as CaCO3)	372		10	mg/L		17-MAY-16	
pH	8.08		0.10	pH units		15-MAY-16	R3458799
Total Dissolved Solids	635	DLDS	20	mg/L		17-MAY-16	R3459879
Turbidity	37.2		0.10	NTU		14-MAY-16	R3457445
Anions and Nutrients							
Alkalinity, Total (as CaCO3)	271		10	mg/L		18-MAY-16	R3460560
Ammonia, Total (as N)	0.075		0.020	mg/L		17-MAY-16	R3459966
Chloride (Cl)	185	DLDS	2.5	mg/L		17-MAY-16	R3460229
Fluoride (F)	<0.10	DLDS	0.10	mg/L		17-MAY-16	R3460229
Nitrate (as N)	4.39	DLDS	0.10	mg/L		17-MAY-16	R3460229
Nitrite (as N)	<0.050	DLDS	0.050	mg/L		17-MAY-16	R3460229
Phosphate-P (ortho)	<0.0030		0.0030	mg/L		17-MAY-16	R3459547
Sulfate (SO4)	26.1	DLDS	1.5	mg/L		17-MAY-16	R3460229
Total Metals							
Aluminum (Al)-Total	0.330		0.010	mg/L	13-MAY-16	13-MAY-16	R3458293
Antimony (Sb)-Total	<0.00010		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Arsenic (As)-Total	0.00042		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Barium (Ba)-Total	0.0681		0.00020	mg/L	13-MAY-16	13-MAY-16	R3458293
Beryllium (Be)-Total	<0.00010		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Bismuth (Bi)-Total	<0.000050		0.000050	mg/L	13-MAY-16	13-MAY-16	R3458293
Boron (B)-Total	0.021		0.010	mg/L	13-MAY-16	13-MAY-16	R3458293
Cadmium (Cd)-Total	0.000132		0.000010	mg/L	13-MAY-16	13-MAY-16	R3458293
Calcium (Ca)-Total	92.8		0.50	mg/L	13-MAY-16	13-MAY-16	R3458293
Cesium (Cs)-Total	0.000042		0.000010	mg/L	13-MAY-16	13-MAY-16	R3458293
Chromium (Cr)-Total	0.00068		0.00050	mg/L	13-MAY-16	13-MAY-16	R3458293
Cobalt (Co)-Total	0.00031		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Copper (Cu)-Total	0.0022		0.0010	mg/L	13-MAY-16	13-MAY-16	R3458293
Iron (Fe)-Total	0.447		0.050	mg/L	13-MAY-16	13-MAY-16	R3458293
Lead (Pb)-Total	0.00704		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Lithium (Li)-Total	0.0022		0.0010	mg/L	13-MAY-16	13-MAY-16	R3458293
Magnesium (Mg)-Total	33.7		0.050	mg/L	13-MAY-16	13-MAY-16	R3458293
Manganese (Mn)-Total	0.0599		0.00050	mg/L	13-MAY-16	13-MAY-16	R3458293
Molybdenum (Mo)-Total	0.000769		0.000050	mg/L	13-MAY-16	13-MAY-16	R3458293
Nickel (Ni)-Total	0.00123		0.00050	mg/L	13-MAY-16	13-MAY-16	R3458293
Phosphorus (P)-Total	<0.050		0.050	mg/L	13-MAY-16	13-MAY-16	R3458293
Potassium (K)-Total	2.90		0.050	mg/L	13-MAY-16	13-MAY-16	R3458293
Rubidium (Rb)-Total	0.00383		0.00020	mg/L	13-MAY-16	13-MAY-16	R3458293
Selenium (Se)-Total	0.000331		0.000050	mg/L	13-MAY-16	13-MAY-16	R3458293
Silicon (Si)-Total	3.94		0.050	mg/L	13-MAY-16	13-MAY-16	R3458293

* 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
L1768544-1 02-16 Sampled By: D. SOUTER on 13-MAY-16 @ 09:00 Matrix: WATER							
Total Metals							
Silver (Ag)-Total	<0.000050		0.000050	mg/L	13-MAY-16	13-MAY-16	R3458293
Sodium (Na)-Total	116	DLHC	5.0	mg/L	13-MAY-16	13-MAY-16	R3458293
Strontium (Sr)-Total	0.120		0.0010	mg/L	13-MAY-16	13-MAY-16	R3458293
Sulfur (S)-Total	10.0		0.50	mg/L	13-MAY-16	13-MAY-16	R3458293
Tellurium (Te)-Total	<0.00020		0.00020	mg/L	13-MAY-16	13-MAY-16	R3458293
Thallium (Tl)-Total	0.000054		0.000010	mg/L	13-MAY-16	13-MAY-16	R3458293
Thorium (Th)-Total	<0.00010		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Tin (Sn)-Total	0.00016		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Titanium (Ti)-Total	0.0135		0.00030	mg/L	13-MAY-16	13-MAY-16	R3458293
Tungsten (W)-Total	<0.00010		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Uranium (U)-Total	0.000498		0.000010	mg/L	13-MAY-16	13-MAY-16	R3458293
Vanadium (V)-Total	0.00075		0.00050	mg/L	13-MAY-16	13-MAY-16	R3458293
Zinc (Zn)-Total	0.0542		0.0030	mg/L	13-MAY-16	13-MAY-16	R3458293
Zirconium (Zr)-Total	<0.00030		0.00030	mg/L	13-MAY-16	13-MAY-16	R3458293
Dissolved Metals							
Dissolved Metals Filtration Location	FIELD					13-MAY-16	R3457419
Aluminum (Al)-Dissolved	0.161		0.010	mg/L	13-MAY-16	13-MAY-16	R3459470
Antimony (Sb)-Dissolved	<0.0050		0.0050	mg/L	13-MAY-16	13-MAY-16	R3459470
Arsenic (As)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Barium (Ba)-Dissolved	0.068		0.010	mg/L	13-MAY-16	13-MAY-16	R3459470
Beryllium (Be)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Bismuth (Bi)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Boron (B)-Dissolved	<0.050		0.050	mg/L	13-MAY-16	13-MAY-16	R3459470
Cadmium (Cd)-Dissolved	0.000141		0.000090	mg/L	13-MAY-16	13-MAY-16	R3459470
Calcium (Ca)-Dissolved	94.3		0.50	mg/L	13-MAY-16	13-MAY-16	R3459470
Chromium (Cr)-Dissolved	<0.00050		0.00050	mg/L	13-MAY-16	13-MAY-16	R3459470
Cobalt (Co)-Dissolved	<0.00050		0.00050	mg/L	13-MAY-16	13-MAY-16	R3459470
Copper (Cu)-Dissolved	0.0018		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Iron (Fe)-Dissolved	0.189		0.050	mg/L	13-MAY-16	13-MAY-16	R3459470
Lead (Pb)-Dissolved	0.0069		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Magnesium (Mg)-Dissolved	33.2		0.50	mg/L	13-MAY-16	13-MAY-16	R3459470
Manganese (Mn)-Dissolved	0.0584		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Molybdenum (Mo)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Nickel (Ni)-Dissolved	<0.0020		0.0020	mg/L	13-MAY-16	13-MAY-16	R3459470
Phosphorus (P)-Dissolved	<0.050		0.050	mg/L	13-MAY-16	13-MAY-16	R3459470
Potassium (K)-Dissolved	2.8		1.0	mg/L	13-MAY-16	13-MAY-16	R3459470
Selenium (Se)-Dissolved	0.00043		0.00040	mg/L	13-MAY-16	13-MAY-16	R3459470
Silicon (Si)-Dissolved	3.5		1.0	mg/L	13-MAY-16	13-MAY-16	R3459470
Silver (Ag)-Dissolved	<0.00010		0.00010	mg/L	13-MAY-16	13-MAY-16	R3459470
Sodium (Na)-Dissolved	107	DLHC	5.0	mg/L	13-MAY-16	13-MAY-16	R3459470
Strontium (Sr)-Dissolved	0.122		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470

* 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
L1768544-1 02-16 Sampled By: D. SOUTER on 13-MAY-16 @ 09:00 Matrix: WATER							
Dissolved Metals							
Thallium (Tl)-Dissolved	<0.00030		0.00030	mg/L	13-MAY-16	13-MAY-16	R3459470
Tin (Sn)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Titanium (Ti)-Dissolved	<0.0080	DLUI	0.0080	mg/L	13-MAY-16	13-MAY-16	R3459470
Tungsten (W)-Dissolved	<0.010		0.010	mg/L	13-MAY-16	13-MAY-16	R3459470
Uranium (U)-Dissolved	<0.0050		0.0050	mg/L	13-MAY-16	13-MAY-16	R3459470
Vanadium (V)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Zinc (Zn)-Dissolved	0.0505		0.0030	mg/L	13-MAY-16	13-MAY-16	R3459470
Zirconium (Zr)-Dissolved	<0.0040		0.0040	mg/L	13-MAY-16	13-MAY-16	R3459470
L1768544-2 10-16 Sampled By: D. SOUTER on 13-MAY-16 @ 11:00 Matrix: WATER							
Physical Tests							
Color, Apparent	2.4		1.0	C.U.		13-MAY-16	R3458963
Conductivity	1080		3.0	umhos/cm		15-MAY-16	R3458806
Hardness (as CaCO3)	359		10	mg/L		17-MAY-16	
pH	8.14		0.10	pH units		15-MAY-16	R3458799
Total Dissolved Solids	578	DLDS	20	mg/L		18-MAY-16	R3462610
Turbidity	0.93		0.10	NTU		14-MAY-16	R3457445
Anions and Nutrients							
Alkalinity, Total (as CaCO3)	256		10	mg/L		18-MAY-16	R3460560
Ammonia, Total (as N)	0.184		0.020	mg/L		17-MAY-16	R3459966
Chloride (Cl)	167	DLDS	2.5	mg/L		17-MAY-16	R3460229
Fluoride (F)	<0.10	DLDS	0.10	mg/L		17-MAY-16	R3460229
Nitrate (as N)	5.65	DLDS	0.10	mg/L		17-MAY-16	R3460229
Nitrite (as N)	<0.050	DLDS	0.050	mg/L		17-MAY-16	R3460229
Phosphate-P (ortho)	0.0056		0.0030	mg/L		17-MAY-16	R3459547
Sulfate (SO4)	34.4	DLDS	1.5	mg/L		17-MAY-16	R3460229
Total Metals							
Aluminum (Al)-Total	0.020		0.010	mg/L	13-MAY-16	13-MAY-16	R3458293
Antimony (Sb)-Total	<0.00010		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Arsenic (As)-Total	0.00028		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Barium (Ba)-Total	0.0507		0.00020	mg/L	13-MAY-16	13-MAY-16	R3458293
Beryllium (Be)-Total	<0.00010		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Bismuth (Bi)-Total	<0.000050		0.000050	mg/L	13-MAY-16	13-MAY-16	R3458293
Boron (B)-Total	0.020		0.010	mg/L	13-MAY-16	13-MAY-16	R3458293
Cadmium (Cd)-Total	0.000057		0.000010	mg/L	13-MAY-16	13-MAY-16	R3458293
Calcium (Ca)-Total	93.0		0.50	mg/L	13-MAY-16	13-MAY-16	R3458293
Cesium (Cs)-Total	<0.000010		0.000010	mg/L	13-MAY-16	13-MAY-16	R3458293
Chromium (Cr)-Total	<0.00050		0.00050	mg/L	13-MAY-16	13-MAY-16	R3458293
Cobalt (Co)-Total	<0.00010		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Copper (Cu)-Total	0.0015		0.0010	mg/L	13-MAY-16	13-MAY-16	R3458293
Iron (Fe)-Total	<0.050		0.050	mg/L	13-MAY-16	13-MAY-16	R3458293

* 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
L1768544-2 10-16 Sampled By: D. SOUTER on 13-MAY-16 @ 11:00 Matrix: WATER							
Total Metals							
Lead (Pb)-Total	0.00040		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Lithium (Li)-Total	0.0022		0.0010	mg/L	13-MAY-16	13-MAY-16	R3458293
Magnesium (Mg)-Total	32.3		0.050	mg/L	13-MAY-16	13-MAY-16	R3458293
Manganese (Mn)-Total	0.0161		0.00050	mg/L	13-MAY-16	13-MAY-16	R3458293
Molybdenum (Mo)-Total	0.000700		0.000050	mg/L	13-MAY-16	13-MAY-16	R3458293
Nickel (Ni)-Total	0.00083		0.00050	mg/L	13-MAY-16	13-MAY-16	R3458293
Phosphorus (P)-Total	<0.050		0.050	mg/L	13-MAY-16	13-MAY-16	R3458293
Potassium (K)-Total	2.22		0.050	mg/L	13-MAY-16	13-MAY-16	R3458293
Rubidium (Rb)-Total	0.00164		0.00020	mg/L	13-MAY-16	13-MAY-16	R3458293
Selenium (Se)-Total	0.000360		0.000050	mg/L	13-MAY-16	13-MAY-16	R3458293
Silicon (Si)-Total	3.44		0.050	mg/L	13-MAY-16	13-MAY-16	R3458293
Silver (Ag)-Total	<0.000050		0.000050	mg/L	13-MAY-16	13-MAY-16	R3458293
Sodium (Na)-Total	87.0		0.50	mg/L	13-MAY-16	13-MAY-16	R3458293
Strontium (Sr)-Total	0.117		0.0010	mg/L	13-MAY-16	13-MAY-16	R3458293
Sulfur (S)-Total	12.7		0.50	mg/L	13-MAY-16	13-MAY-16	R3458293
Tellurium (Te)-Total	<0.00020		0.00020	mg/L	13-MAY-16	13-MAY-16	R3458293
Thallium (Tl)-Total	0.000035		0.000010	mg/L	13-MAY-16	13-MAY-16	R3458293
Thorium (Th)-Total	<0.00010		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Tin (Sn)-Total	<0.00010		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Titanium (Ti)-Total	<0.00050	DLUI	0.00050	mg/L	13-MAY-16	13-MAY-16	R3458293
Tungsten (W)-Total	<0.00010		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Uranium (U)-Total	0.000794		0.000010	mg/L	13-MAY-16	13-MAY-16	R3458293
Vanadium (V)-Total	<0.00050		0.00050	mg/L	13-MAY-16	13-MAY-16	R3458293
Zinc (Zn)-Total	0.0188		0.0030	mg/L	13-MAY-16	13-MAY-16	R3458293
Zirconium (Zr)-Total	<0.00030		0.00030	mg/L	13-MAY-16	13-MAY-16	R3458293
Dissolved Metals							
Dissolved Metals Filtration Location	FIELD					13-MAY-16	R3457419
Aluminum (Al)-Dissolved	0.012		0.010	mg/L	13-MAY-16	13-MAY-16	R3459470
Antimony (Sb)-Dissolved	<0.0050		0.0050	mg/L	13-MAY-16	13-MAY-16	R3459470
Arsenic (As)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Barium (Ba)-Dissolved	0.053		0.010	mg/L	13-MAY-16	13-MAY-16	R3459470
Beryllium (Be)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Bismuth (Bi)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Boron (B)-Dissolved	<0.050		0.050	mg/L	13-MAY-16	13-MAY-16	R3459470
Cadmium (Cd)-Dissolved	<0.000090		0.000090	mg/L	13-MAY-16	13-MAY-16	R3459470
Calcium (Ca)-Dissolved	91.8		0.50	mg/L	13-MAY-16	13-MAY-16	R3459470
Chromium (Cr)-Dissolved	<0.00050		0.00050	mg/L	13-MAY-16	13-MAY-16	R3459470
Cobalt (Co)-Dissolved	<0.00050		0.00050	mg/L	13-MAY-16	13-MAY-16	R3459470
Copper (Cu)-Dissolved	0.0015		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Iron (Fe)-Dissolved	<0.050		0.050	mg/L	13-MAY-16	13-MAY-16	R3459470
Lead (Pb)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470

* 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
L1768544-2 10-16 Sampled By: D. SOUTER on 13-MAY-16 @ 11:00 Matrix: WATER							
Dissolved Metals							
Magnesium (Mg)-Dissolved	31.6		0.50	mg/L	13-MAY-16	13-MAY-16	R3459470
Manganese (Mn)-Dissolved	0.0155		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Molybdenum (Mo)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Nickel (Ni)-Dissolved	<0.0020		0.0020	mg/L	13-MAY-16	13-MAY-16	R3459470
Phosphorus (P)-Dissolved	<0.050		0.050	mg/L	13-MAY-16	13-MAY-16	R3459470
Potassium (K)-Dissolved	2.3		1.0	mg/L	13-MAY-16	13-MAY-16	R3459470
Selenium (Se)-Dissolved	0.00045		0.00040	mg/L	13-MAY-16	13-MAY-16	R3459470
Silicon (Si)-Dissolved	3.4		1.0	mg/L	13-MAY-16	13-MAY-16	R3459470
Silver (Ag)-Dissolved	<0.00010		0.00010	mg/L	13-MAY-16	13-MAY-16	R3459470
Sodium (Na)-Dissolved	84.6		0.50	mg/L	13-MAY-16	13-MAY-16	R3459470
Strontium (Sr)-Dissolved	0.119		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Thallium (Tl)-Dissolved	<0.00030		0.00030	mg/L	13-MAY-16	13-MAY-16	R3459470
Tin (Sn)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Titanium (Ti)-Dissolved	<0.0020		0.0020	mg/L	13-MAY-16	13-MAY-16	R3459470
Tungsten (W)-Dissolved	<0.010		0.010	mg/L	13-MAY-16	13-MAY-16	R3459470
Uranium (U)-Dissolved	<0.0050		0.0050	mg/L	13-MAY-16	13-MAY-16	R3459470
Vanadium (V)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Zinc (Zn)-Dissolved	0.0185		0.0030	mg/L	13-MAY-16	13-MAY-16	R3459470
Zirconium (Zr)-Dissolved	<0.0040		0.0040	mg/L	13-MAY-16	13-MAY-16	R3459470
L1768544-3 04-16 Sampled By: D. SOUTER on 13-MAY-16 @ 12:00 Matrix: WATER							
Physical Tests							
Color, Apparent	<1.0		1.0	C.U.		13-MAY-16	R3458963
Conductivity	1120		3.0	umhos/cm		15-MAY-16	R3458806
Hardness (as CaCO3)	341		10	mg/L		17-MAY-16	
pH	8.03		0.10	pH units		15-MAY-16	R3458799
Total Dissolved Solids	604	DLDS	20	mg/L		18-MAY-16	R3462610
Turbidity	0.17		0.10	NTU		14-MAY-16	R3457445
Anions and Nutrients							
Alkalinity, Total (as CaCO3)	246		10	mg/L		18-MAY-16	R3460560
Ammonia, Total (as N)	0.033		0.020	mg/L		17-MAY-16	R3459966
Chloride (Cl)	197	DLDS	2.5	mg/L		17-MAY-16	R3460229
Fluoride (F)	<0.10	DLDS	0.10	mg/L		17-MAY-16	R3460229
Nitrate (as N)	4.60	DLDS	0.10	mg/L		17-MAY-16	R3460229
Nitrite (as N)	<0.050	DLDS	0.050	mg/L		17-MAY-16	R3460229
Phosphate-P (ortho)	<0.0030		0.0030	mg/L		17-MAY-16	R3459547
Sulfate (SO4)	29.9	DLDS	1.5	mg/L		17-MAY-16	R3460229
Total Metals							
Aluminum (Al)-Total	<0.010		0.010	mg/L	13-MAY-16	13-MAY-16	R3458293
Antimony (Sb)-Total	<0.00010		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Arsenic (As)-Total	0.00011		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293

* 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
L1768544-3 04-16 Sampled By: D. SOUTER on 13-MAY-16 @ 12:00 Matrix: WATER							
Total Metals							
Barium (Ba)-Total	0.0617		0.00020	mg/L	13-MAY-16	13-MAY-16	R3458293
Beryllium (Be)-Total	<0.00010		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Bismuth (Bi)-Total	<0.000050		0.000050	mg/L	13-MAY-16	13-MAY-16	R3458293
Boron (B)-Total	0.021		0.010	mg/L	13-MAY-16	13-MAY-16	R3458293
Cadmium (Cd)-Total	0.000119		0.000010	mg/L	13-MAY-16	13-MAY-16	R3458293
Calcium (Ca)-Total	85.3		0.50	mg/L	13-MAY-16	13-MAY-16	R3458293
Cesium (Cs)-Total	<0.000010		0.000010	mg/L	13-MAY-16	13-MAY-16	R3458293
Chromium (Cr)-Total	<0.00050		0.00050	mg/L	13-MAY-16	13-MAY-16	R3458293
Cobalt (Co)-Total	<0.00010		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Copper (Cu)-Total	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3458293
Iron (Fe)-Total	<0.050		0.050	mg/L	13-MAY-16	13-MAY-16	R3458293
Lead (Pb)-Total	0.00012		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Lithium (Li)-Total	0.0018		0.0010	mg/L	13-MAY-16	13-MAY-16	R3458293
Magnesium (Mg)-Total	28.9		0.050	mg/L	13-MAY-16	13-MAY-16	R3458293
Manganese (Mn)-Total	0.00176		0.00050	mg/L	13-MAY-16	13-MAY-16	R3458293
Molybdenum (Mo)-Total	0.000284		0.000050	mg/L	13-MAY-16	13-MAY-16	R3458293
Nickel (Ni)-Total	<0.00050		0.00050	mg/L	13-MAY-16	13-MAY-16	R3458293
Phosphorus (P)-Total	<0.050		0.050	mg/L	13-MAY-16	13-MAY-16	R3458293
Potassium (K)-Total	1.95		0.050	mg/L	13-MAY-16	13-MAY-16	R3458293
Rubidium (Rb)-Total	0.00194		0.00020	mg/L	13-MAY-16	13-MAY-16	R3458293
Selenium (Se)-Total	0.000324		0.000050	mg/L	13-MAY-16	13-MAY-16	R3458293
Silicon (Si)-Total	3.35		0.050	mg/L	13-MAY-16	13-MAY-16	R3458293
Silver (Ag)-Total	<0.000050		0.000050	mg/L	13-MAY-16	13-MAY-16	R3458293
Sodium (Na)-Total	109	DLHC	5.0	mg/L	13-MAY-16	13-MAY-16	R3458293
Strontium (Sr)-Total	0.105		0.0010	mg/L	13-MAY-16	13-MAY-16	R3458293
Sulfur (S)-Total	10.6		0.50	mg/L	13-MAY-16	13-MAY-16	R3458293
Tellurium (Te)-Total	<0.00020		0.00020	mg/L	13-MAY-16	13-MAY-16	R3458293
Thallium (Tl)-Total	0.000016		0.000010	mg/L	13-MAY-16	13-MAY-16	R3458293
Thorium (Th)-Total	<0.00010		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Tin (Sn)-Total	<0.00010		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Titanium (Ti)-Total	<0.00030		0.00030	mg/L	13-MAY-16	13-MAY-16	R3458293
Tungsten (W)-Total	<0.00010		0.00010	mg/L	13-MAY-16	13-MAY-16	R3458293
Uranium (U)-Total	0.000454		0.000010	mg/L	13-MAY-16	13-MAY-16	R3458293
Vanadium (V)-Total	<0.00050		0.00050	mg/L	13-MAY-16	13-MAY-16	R3458293
Zinc (Zn)-Total	0.0395		0.0030	mg/L	13-MAY-16	13-MAY-16	R3458293
Zirconium (Zr)-Total	<0.00030		0.00030	mg/L	13-MAY-16	13-MAY-16	R3458293
Dissolved Metals							
Dissolved Metals Filtration Location	FIELD					13-MAY-16	R3457419
Aluminum (Al)-Dissolved	<0.010		0.010	mg/L	13-MAY-16	13-MAY-16	R3459470
Antimony (Sb)-Dissolved	<0.0050		0.0050	mg/L	13-MAY-16	13-MAY-16	R3459470
Arsenic (As)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470

* 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
L1768544-3 04-16 Sampled By: D. SOUTER on 13-MAY-16 @ 12:00 Matrix: WATER							
Dissolved Metals							
Barium (Ba)-Dissolved	0.063		0.010	mg/L	13-MAY-16	13-MAY-16	R3459470
Beryllium (Be)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Bismuth (Bi)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Boron (B)-Dissolved	<0.050		0.050	mg/L	13-MAY-16	13-MAY-16	R3459470
Cadmium (Cd)-Dissolved	0.000134		0.000090	mg/L	13-MAY-16	13-MAY-16	R3459470
Calcium (Ca)-Dissolved	87.6		0.50	mg/L	13-MAY-16	13-MAY-16	R3459470
Chromium (Cr)-Dissolved	<0.00050		0.00050	mg/L	13-MAY-16	13-MAY-16	R3459470
Cobalt (Co)-Dissolved	<0.00050		0.00050	mg/L	13-MAY-16	13-MAY-16	R3459470
Copper (Cu)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Iron (Fe)-Dissolved	<0.050		0.050	mg/L	13-MAY-16	13-MAY-16	R3459470
Lead (Pb)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Magnesium (Mg)-Dissolved	29.6		0.50	mg/L	13-MAY-16	13-MAY-16	R3459470
Manganese (Mn)-Dissolved	0.0017		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Molybdenum (Mo)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Nickel (Ni)-Dissolved	<0.0020		0.0020	mg/L	13-MAY-16	13-MAY-16	R3459470
Phosphorus (P)-Dissolved	<0.050		0.050	mg/L	13-MAY-16	13-MAY-16	R3459470
Potassium (K)-Dissolved	2.0		1.0	mg/L	13-MAY-16	13-MAY-16	R3459470
Selenium (Se)-Dissolved	0.00041		0.00040	mg/L	13-MAY-16	13-MAY-16	R3459470
Silicon (Si)-Dissolved	3.3		1.0	mg/L	13-MAY-16	13-MAY-16	R3459470
Silver (Ag)-Dissolved	<0.00010		0.00010	mg/L	13-MAY-16	13-MAY-16	R3459470
Sodium (Na)-Dissolved	108	DLHC	5.0	mg/L	13-MAY-16	13-MAY-16	R3459470
Strontium (Sr)-Dissolved	0.109		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Thallium (Tl)-Dissolved	<0.00030		0.00030	mg/L	13-MAY-16	13-MAY-16	R3459470
Tin (Sn)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Titanium (Ti)-Dissolved	<0.0020		0.0020	mg/L	13-MAY-16	13-MAY-16	R3459470
Tungsten (W)-Dissolved	<0.010		0.010	mg/L	13-MAY-16	13-MAY-16	R3459470
Uranium (U)-Dissolved	<0.0050		0.0050	mg/L	13-MAY-16	13-MAY-16	R3459470
Vanadium (V)-Dissolved	<0.0010		0.0010	mg/L	13-MAY-16	13-MAY-16	R3459470
Zinc (Zn)-Dissolved	0.0423		0.0030	mg/L	13-MAY-16	13-MAY-16	R3459470
Zirconium (Zr)-Dissolved	<0.0040		0.0040	mg/L	13-MAY-16	13-MAY-16	R3459470

* 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	Barium (Ba)-Total	MS-B	L1768544-1, -2, -3
Matrix Spike	Calcium (Ca)-Total	MS-B	L1768544-1, -2, -3
Matrix Spike	Magnesium (Mg)-Total	MS-B	L1768544-1, -2, -3
Matrix Spike	Silicon (Si)-Total	MS-B	L1768544-1, -2, -3
Matrix Spike	Sodium (Na)-Total	MS-B	L1768544-1, -2, -3
Matrix Spike	Strontium (Sr)-Total	MS-B	L1768544-1, -2, -3
Matrix Spike	Sulfur (S)-Total	MS-B	L1768544-1, -2, -3
Matrix Spike	Uranium (U)-Total	MS-B	L1768544-1, -2, -3
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1768544-1, -2, -3
Matrix Spike	Boron (B)-Dissolved	MS-B	L1768544-1, -2, -3
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1768544-1, -2, -3
Matrix Spike	Iron (Fe)-Dissolved	MS-B	L1768544-1, -2, -3
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1768544-1, -2, -3
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1768544-1, -2, -3
Matrix Spike	Potassium (K)-Dissolved	MS-B	L1768544-1, -2, -3
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1768544-1, -2, -3
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1768544-1, -2, -3
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1768544-1, -2, -3
Matrix Spike	Uranium (U)-Dissolved	MS-B	L1768544-1, -2, -3
Matrix Spike	Nitrate (as N)	MS-B	L1768544-1, -2, -3

Qualifiers for Sample Submission Listed:

Qualifier	Description
CINT	Cooling initiated. Samples were received packed with ice or ice packs and were sampled the same day as received.

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).
DLUI	Detection Limit Raised: Unknown Interference generated an apparent false positive test result.
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
CL-IC-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-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.

Reference Information

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).

MET-T-MS-WT	Water	Total Metals in Water by ICPMS	EPA 200.8

This analysis involves preliminary sample treatment by hotblock acid digestion (APHA 3030E). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).

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).

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

A well-mixed sample is filtered though glass fibres filter. A known volume of the filtrate is evaporated and dried at 105–5°C overnight and then 180–10°C for 1hr.

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:

14-457702

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

Workorder: L1768544 Report Date: 24-MAY-16

Client: EnGlobe Corp.
353 BRIDGE ST. E.
KITCHENER ON N2K 2Y5
Contact: Susanna Meteer

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-WT	**Water**							
Batch R3460560								
WG2311187-3 CRM		**WT-ALK-CRM**						
Alkalinity, Total (as CaCO3)			90.3		%		80-120	18-MAY-16
WG2311187-7 CRM		**WT-ALK-CRM**						
Alkalinity, Total (as CaCO3)			94.1		%		80-120	18-MAY-16
WG2311187-4 DUP		**L1767977-1**						
Alkalinity, Total (as CaCO3)		218	220		mg/L	1.0	20	18-MAY-16
WG2311187-8 DUP		**L1768309-5**						
Alkalinity, Total (as CaCO3)		24	23		mg/L	2.9	20	18-MAY-16
WG2311187-2 LCS								
Alkalinity, Total (as CaCO3)			105.4		%		85-115	18-MAY-16
WG2311187-6 LCS								
Alkalinity, Total (as CaCO3)			107.6		%		85-115	18-MAY-16
WG2311187-1 MB								
Alkalinity, Total (as CaCO3)			<10		mg/L		10	18-MAY-16
WG2311187-5 MB								
Alkalinity, Total (as CaCO3)			<10		mg/L		10	18-MAY-16
CL-IC-WT	**Water**							
Batch R3460229								
WG2309840-4 DUP		**WG2309840-3**						
Chloride (Cl)		7.33	7.32		mg/L	0.1	25	17-MAY-16
WG2309840-2 LCS								
Chloride (Cl)			99.9		%		70-130	17-MAY-16
WG2309840-1 MB								
Chloride (Cl)			<0.50		mg/L		0.5	17-MAY-16
WG2309840-5 MS		**WG2309840-3**						
Chloride (Cl)			100.9		%		70-130	17-MAY-16
COLOUR-WT	**Water**							
Batch R3458963								
WG2308283-3 CRM		**WT-COLOUR-CRM**						
Color, Apparent			93.4		%		80-120	13-MAY-16
WG2308283-4 DUP		**L1768501-1**						
Color, Apparent		3.7	4.2		C.U.	13	20	13-MAY-16
WG2308283-1 MB								
Color, Apparent			<1.0		C.U.		1	13-MAY-16
EC-WT	**Water**							

Quality Control Report

Client: EnGlobe Corp.
353 BRIDGE ST. E.
KITCHENER ON N2K 2Y5
Contact: Susanna Meteer

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
EC-WT	**Water**							
Batch R3458806								
WG2308731-4 DUP		**WG2308731-3**						
Conductivity		1190	1190		umhos/cm	0.6	10	15-MAY-16
WG2308731-2 LCS								
Conductivity			100.4		%		90-110	15-MAY-16
WG2308731-1 MB								
Conductivity			<3.0		umhos/cm		3	15-MAY-16
F-IC-N-WT	**Water**							
Batch R3460229								
WG2309840-4 DUP		**WG2309840-3**						
Fluoride (F)		0.055	0.054		mg/L	1.3	20	17-MAY-16
WG2309840-2 LCS								
Fluoride (F)			100.5		%		90-110	17-MAY-16
WG2309840-1 MB								
Fluoride (F)			<0.020		mg/L		0.02	17-MAY-16
WG2309840-5 MS		**WG2309840-3**						
Fluoride (F)			100.3		%		75-125	17-MAY-16
MET-D-CCMS-WT	**Water**							
Batch R3459470								
WG2308317-4 DUP		**WG2308317-3**						
Aluminum (Al)-Dissolved		0.0673	0.0689		mg/L	2.4	20	13-MAY-16
Antimony (Sb)-Dissolved		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	13-MAY-16
Arsenic (As)-Dissolved		0.00047	0.00048		mg/L	1.6	20	13-MAY-16
Barium (Ba)-Dissolved		0.0654	0.0665		mg/L	1.6	20	13-MAY-16
Beryllium (Be)-Dissolved		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	13-MAY-16
Bismuth (Bi)-Dissolved		<0.000050	<0.000050	RPD-NA	mg/L	N/A	20	13-MAY-16
Boron (B)-Dissolved		0.171	0.167		mg/L	2.6	20	13-MAY-16
Cadmium (Cd)-Dissolved		<0.000010	<0.000010	RPD-NA	mg/L	N/A	20	13-MAY-16
Calcium (Ca)-Dissolved		72.2	71.3		mg/L	1.3	20	13-MAY-16
Chromium (Cr)-Dissolved		<0.00050	<0.00050	RPD-NA	mg/L	N/A	20	13-MAY-16
Cobalt (Co)-Dissolved		0.00030	0.00029		mg/L	2.8	20	13-MAY-16
Copper (Cu)-Dissolved		0.00239	0.00236		mg/L	1.1	20	13-MAY-16
Iron (Fe)-Dissolved		0.241	0.247		mg/L	2.4	20	13-MAY-16
Lead (Pb)-Dissolved		0.000830	0.000829		mg/L	0.2	20	13-MAY-16
Magnesium (Mg)-Dissolved		19.0	18.6		mg/L	1.9	20	13-MAY-16
Manganese (Mn)-Dissolved		0.108	0.108		mg/L	0.7	20	13-MAY-16

Quality Control Report

Client: EnGlobe Corp.
353 BRIDGE ST. E.
KITCHENER ON N2K 2Y5
Contact: Susanna Meteer

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-D-CCMS-WT	**Water**							
Batch R3459470								
WG2308317-4 DUP		**WG2308317-3**						
Molybdenum (Mo)-Dissolved		0.00222	0.00225		mg/L	1.1	20	13-MAY-16
Nickel (Ni)-Dissolved		0.00108	0.00107		mg/L	0.6	20	13-MAY-16
Phosphorus (P)-Dissolved		<0.050	<0.050	RPD-NA	mg/L	N/A	20	13-MAY-16
Potassium (K)-Dissolved		4.40	4.38		mg/L	0.5	20	13-MAY-16
Selenium (Se)-Dissolved		0.000326	0.000348		mg/L	6.4	20	13-MAY-16
Silicon (Si)-Dissolved		7.51	7.63		mg/L	1.6	20	13-MAY-16
Silver (Ag)-Dissolved		<0.000050	<0.000050	RPD-NA	mg/L	N/A	20	13-MAY-16
Sodium (Na)-Dissolved		60.7	60.6		mg/L	0.1	20	13-MAY-16
Strontium (Sr)-Dissolved		0.369	0.369		mg/L	0.1	20	13-MAY-16
Thallium (Tl)-Dissolved		<0.000010	<0.000010	RPD-NA	mg/L	N/A	20	13-MAY-16
Tin (Sn)-Dissolved		0.00153	0.00154		mg/L	0.5	20	13-MAY-16
Titanium (Ti)-Dissolved		0.00304	0.00306		mg/L	0.5	20	13-MAY-16
Tungsten (W)-Dissolved		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	13-MAY-16
Uranium (U)-Dissolved		0.000474	0.000476		mg/L	0.2	20	13-MAY-16
Vanadium (V)-Dissolved		<0.00050	<0.00050	RPD-NA	mg/L	N/A	20	13-MAY-16
Zinc (Zn)-Dissolved		0.0072	0.0071		mg/L	1.3	20	13-MAY-16
Zirconium (Zr)-Dissolved		<0.00030	<0.00030	RPD-NA	mg/L	N/A	20	13-MAY-16
WG2308317-2 LCS								
Aluminum (Al)-Dissolved			100.5		%		80-120	13-MAY-16
Antimony (Sb)-Dissolved			98.6		%		80-120	13-MAY-16
Arsenic (As)-Dissolved			95.0		%		80-120	13-MAY-16
Barium (Ba)-Dissolved			96.4		%		80-120	13-MAY-16
Beryllium (Be)-Dissolved			102.2		%		80-120	13-MAY-16
Bismuth (Bi)-Dissolved			98.7		%		80-120	13-MAY-16
Boron (B)-Dissolved			102.3		%		80-120	13-MAY-16
Cadmium (Cd)-Dissolved			94.8		%		80-120	13-MAY-16
Calcium (Ca)-Dissolved			100.1		%		80-120	13-MAY-16
Chromium (Cr)-Dissolved			96.4		%		80-120	13-MAY-16
Cobalt (Co)-Dissolved			96.6		%		80-120	13-MAY-16
Copper (Cu)-Dissolved			95.8		%		80-120	13-MAY-16
Iron (Fe)-Dissolved			95.0		%		80-120	13-MAY-16
Lead (Pb)-Dissolved			99.3		%		80-120	13-MAY-16
Magnesium (Mg)-Dissolved			105.7		%		80-120	13-MAY-16

Quality Control Report

Client: EnGlobe Corp.
353 BRIDGE ST. E.
KITCHENER ON N2K 2Y5
Contact: Susanna Meteer

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-D-CCMS-WT	**Water**							
Batch R3459470								
WG2308317-2 LCS								
Manganese (Mn)-Dissolved			97.6		%		80-120	13-MAY-16
Molybdenum (Mo)-Dissolved			98.3		%		80-120	13-MAY-16
Nickel (Ni)-Dissolved			96.3		%		80-120	13-MAY-16
Phosphorus (P)-Dissolved			107.9		%		80-120	13-MAY-16
Potassium (K)-Dissolved			101.7		%		80-120	13-MAY-16
Selenium (Se)-Dissolved			94.1		%		80-120	13-MAY-16
Silicon (Si)-Dissolved			101.3		%		80-120	13-MAY-16
Silver (Ag)-Dissolved			101.7		%		80-120	13-MAY-16
Sodium (Na)-Dissolved			101.1		%		80-120	13-MAY-16
Strontium (Sr)-Dissolved			95.1		%		80-120	13-MAY-16
Thallium (Tl)-Dissolved			98.7		%		80-120	13-MAY-16
Tin (Sn)-Dissolved			94.3		%		80-120	13-MAY-16
Titanium (Ti)-Dissolved			95.4		%		80-120	13-MAY-16
Tungsten (W)-Dissolved			98.8		%		80-120	13-MAY-16
Uranium (U)-Dissolved			98.9		%		80-120	13-MAY-16
Vanadium (V)-Dissolved			98.2		%		80-120	13-MAY-16
Zinc (Zn)-Dissolved			91.6		%		80-120	13-MAY-16
Zirconium (Zr)-Dissolved			95.6		%		80-120	13-MAY-16
WG2308317-1 MB								
Aluminum (Al)-Dissolved			<0.0050		mg/L		0.005	13-MAY-16
Antimony (Sb)-Dissolved			<0.00010		mg/L		0.0001	13-MAY-16
Arsenic (As)-Dissolved			<0.00010		mg/L		0.0001	13-MAY-16
Barium (Ba)-Dissolved			<0.00010		mg/L		0.0001	13-MAY-16
Beryllium (Be)-Dissolved			<0.00010		mg/L		0.0001	13-MAY-16
Bismuth (Bi)-Dissolved			<0.000050		mg/L		0.00005	13-MAY-16
Boron (B)-Dissolved			<0.010		mg/L		0.01	13-MAY-16
Cadmium (Cd)-Dissolved			<0.000010		mg/L		0.00001	13-MAY-16
Calcium (Ca)-Dissolved			<0.050		mg/L		0.05	13-MAY-16
Chromium (Cr)-Dissolved			<0.00050		mg/L		0.0005	13-MAY-16
Cobalt (Co)-Dissolved			<0.00010		mg/L		0.0001	13-MAY-16
Copper (Cu)-Dissolved			<0.00020		mg/L		0.0002	13-MAY-16
Iron (Fe)-Dissolved			<0.010		mg/L		0.01	13-MAY-16
Lead (Pb)-Dissolved			<0.000050		mg/L		0.00005	13-MAY-16
Magnesium (Mg)-Dissolved			<0.050		mg/L		0.05	13-MAY-16

Quality Control Report

Client: EnGlobe Corp.
353 BRIDGE ST. E.
KITCHENER ON N2K 2Y5
Contact: Susanna Meteer

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-D-CCMS-WT	**Water**							
Batch R3459470								
WG2308317-1 MB								
Manganese (Mn)-Dissolved			<0.00050		mg/L		0.0005	13-MAY-16
Molybdenum (Mo)-Dissolved			<0.000050		mg/L		0.00005	13-MAY-16
Nickel (Ni)-Dissolved			<0.00050		mg/L		0.0005	13-MAY-16
Phosphorus (P)-Dissolved			<0.050		mg/L		0.05	13-MAY-16
Potassium (K)-Dissolved			<0.050		mg/L		0.05	13-MAY-16
Selenium (Se)-Dissolved			<0.000050		mg/L		0.00005	13-MAY-16
Silicon (Si)-Dissolved			<0.050		mg/L		0.05	13-MAY-16
Silver (Ag)-Dissolved			<0.000050		mg/L		0.00005	13-MAY-16
Sodium (Na)-Dissolved			<0.50		mg/L		0.5	13-MAY-16
Strontium (Sr)-Dissolved			<0.0010		mg/L		0.001	13-MAY-16
Thallium (Tl)-Dissolved			<0.000010		mg/L		0.00001	13-MAY-16
Tin (Sn)-Dissolved			<0.00010		mg/L		0.0001	13-MAY-16
Titanium (Ti)-Dissolved			<0.00030		mg/L		0.0003	13-MAY-16
Tungsten (W)-Dissolved			<0.00010		mg/L		0.0001	13-MAY-16
Uranium (U)-Dissolved			<0.000010		mg/L		0.00001	13-MAY-16
Vanadium (V)-Dissolved			<0.00050		mg/L		0.0005	13-MAY-16
Zinc (Zn)-Dissolved			<0.0010		mg/L		0.001	13-MAY-16
Zirconium (Zr)-Dissolved			<0.00030		mg/L		0.0003	13-MAY-16
WG2308317-5 MS		**WG2308317-3**						
Aluminum (Al)-Dissolved			120.8		%		70-130	13-MAY-16
Antimony (Sb)-Dissolved			101.6		%		70-130	13-MAY-16
Arsenic (As)-Dissolved			112.0		%		70-130	13-MAY-16
Barium (Ba)-Dissolved			N/A	MS-B	%		-	13-MAY-16
Beryllium (Be)-Dissolved			107.8		%		70-130	13-MAY-16
Bismuth (Bi)-Dissolved			90.0		%		70-130	13-MAY-16
Boron (B)-Dissolved			N/A	MS-B	%		-	13-MAY-16
Cadmium (Cd)-Dissolved			103.9		%		70-130	13-MAY-16
Calcium (Ca)-Dissolved			N/A	MS-B	%		-	13-MAY-16
Chromium (Cr)-Dissolved			101.9		%		70-130	13-MAY-16
Cobalt (Co)-Dissolved			97.1		%		70-130	13-MAY-16
Copper (Cu)-Dissolved			93.8		%		70-130	13-MAY-16
Iron (Fe)-Dissolved			N/A	MS-B	%		-	13-MAY-16
Lead (Pb)-Dissolved			93.1		%		70-130	13-MAY-16
Magnesium (Mg)-Dissolved			N/A	MS-B	%		-	13-MAY-16

Quality Control Report

Client: EnGlobe Corp.
353 BRIDGE ST. E.
KITCHENER ON N2K 2Y5
Contact: Susanna Meteer

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-D-CCMS-WT	**Water**							
Batch R3459470								
WG2308317-5 MS		**WG2308317-3**						
Manganese (Mn)-Dissolved			N/A	MS-B	%		-	13-MAY-16
Molybdenum (Mo)-Dissolved			99.6		%		70-130	13-MAY-16
Nickel (Ni)-Dissolved			94.9		%		70-130	13-MAY-16
Phosphorus (P)-Dissolved			123.9		%		70-130	13-MAY-16
Potassium (K)-Dissolved			N/A	MS-B	%		-	13-MAY-16
Selenium (Se)-Dissolved			119.6		%		70-130	13-MAY-16
Silicon (Si)-Dissolved			N/A	MS-B	%		-	13-MAY-16
Silver (Ag)-Dissolved			82.2		%		70-130	13-MAY-16
Sodium (Na)-Dissolved			N/A	MS-B	%		-	13-MAY-16
Strontium (Sr)-Dissolved			N/A	MS-B	%		-	13-MAY-16
Thallium (Tl)-Dissolved			94.5		%		70-130	13-MAY-16
Tin (Sn)-Dissolved			99.6		%		70-130	13-MAY-16
Titanium (Ti)-Dissolved			100.1		%		70-130	13-MAY-16
Tungsten (W)-Dissolved			99.6		%		70-130	13-MAY-16
Uranium (U)-Dissolved			N/A	MS-B	%		-	13-MAY-16
Vanadium (V)-Dissolved			104.5		%		70-130	13-MAY-16
Zinc (Zn)-Dissolved			94.4		%		70-130	13-MAY-16
Zirconium (Zr)-Dissolved			100.1		%		70-130	13-MAY-16
MET-T-MS-WT	**Water**							
Batch R3458293								
WG2308159-4 DUP		**WG2308159-3**						
Aluminum (Al)-Total		0.025	0.030		mg/L	17	20	13-MAY-16
Antimony (Sb)-Total		0.00014	0.00012		mg/L	10	20	13-MAY-16
Arsenic (As)-Total		0.00019	0.00021		mg/L	7.2	20	13-MAY-16
Barium (Ba)-Total		0.0446	0.0422		mg/L	5.5	20	13-MAY-16
Beryllium (Be)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	13-MAY-16
Bismuth (Bi)-Total		<0.000050	<0.000050	RPD-NA	mg/L	N/A	20	13-MAY-16
Boron (B)-Total		0.020	0.020		mg/L	1.3	20	13-MAY-16
Cadmium (Cd)-Total		0.000014	0.000014		mg/L	0.2	20	13-MAY-16
Calcium (Ca)-Total		102	104		mg/L	2.1	20	13-MAY-16
Cesium (Cs)-Total		<0.000010	<0.000010	RPD-NA	mg/L	N/A	20	13-MAY-16
Chromium (Cr)-Total		<0.00050	<0.00050	RPD-NA	mg/L	N/A	20	13-MAY-16
Cobalt (Co)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	13-MAY-16

Quality Control Report

Client: EnGlobe Corp.
353 BRIDGE ST. E.
KITCHENER ON N2K 2Y5
Contact: Susanna Meteer

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-MS-WT	**Water**							
Batch R3458293								
WG2308159-4 DUP		**WG2308159-3**						
Copper (Cu)-Total		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	13-MAY-16
Iron (Fe)-Total		<0.050	<0.050	RPD-NA	mg/L	N/A	20	13-MAY-16
Lead (Pb)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	13-MAY-16
Lithium (Li)-Total		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	13-MAY-16
Magnesium (Mg)-Total		18.5	18.1		mg/L	2.5	20	13-MAY-16
Manganese (Mn)-Total		0.00764	0.00742		mg/L	2.9	20	13-MAY-16
Molybdenum (Mo)-Total		0.000274	0.000283		mg/L	3.1	20	13-MAY-16
Nickel (Ni)-Total		0.00060	0.00056		mg/L	7.1	20	13-MAY-16
Phosphorus (P)-Total		<0.050	<0.050	RPD-NA	mg/L	N/A	20	13-MAY-16
Potassium (K)-Total		2.50	2.43		mg/L	2.8	20	13-MAY-16
Rubidium (Rb)-Total		0.00064	0.00066		mg/L	2.2	20	13-MAY-16
Selenium (Se)-Total		0.000813	0.000777		mg/L	4.4	20	13-MAY-16
Silicon (Si)-Total		2.73	2.63		mg/L	3.6	20	13-MAY-16
Silver (Ag)-Total		<0.000050	<0.000050	RPD-NA	mg/L	N/A	20	13-MAY-16
Sodium (Na)-Total		31.0	30.1		mg/L	2.9	20	13-MAY-16
Strontium (Sr)-Total		0.223	0.227		mg/L	1.4	20	13-MAY-16
Sulfur (S)-Total		7.67	7.16		mg/L	6.9	20	13-MAY-16
Tellurium (Te)-Total		<0.00020	<0.00020	RPD-NA	mg/L	N/A	20	13-MAY-16
Thallium (Tl)-Total		<0.000010	<0.000010	RPD-NA	mg/L	N/A	20	13-MAY-16
Thorium (Th)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	13-MAY-16
Tin (Sn)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	13-MAY-16
Titanium (Ti)-Total		0.00072	0.00086		mg/L	18	20	13-MAY-16
Tungsten (W)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	13-MAY-16
Uranium (U)-Total		0.00131	0.00127		mg/L	3.6	20	13-MAY-16
Vanadium (V)-Total		0.00052	0.00051		mg/L	1.8	20	13-MAY-16
Zinc (Zn)-Total		<0.0030	<0.0030	RPD-NA	mg/L	N/A	20	13-MAY-16
Zirconium (Zr)-Total		<0.00030	<0.00030	RPD-NA	mg/L	N/A	20	13-MAY-16
WG2308159-2 LCS								
Aluminum (Al)-Total			93.8		%		80-120	13-MAY-16
Antimony (Sb)-Total			102.0		%		80-120	13-MAY-16
Arsenic (As)-Total			97.5		%		80-120	13-MAY-16
Barium (Ba)-Total			98.2		%		80-120	13-MAY-16
Beryllium (Be)-Total			92.3		%		80-120	13-MAY-16

Quality Control Report

Client: EnGlobe Corp.
353 BRIDGE ST. E.
KITCHENER ON N2K 2Y5
Contact: Susanna Meteer

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-MS-WT	**Water**							
Batch R3458293								
WG2308159-2 LCS								
Bismuth (Bi)-Total			98.5		%		80-120	13-MAY-16
Boron (B)-Total			88.9		%		80-120	13-MAY-16
Cadmium (Cd)-Total			100.2		%		80-120	13-MAY-16
Calcium (Ca)-Total			97.4		%		80-120	13-MAY-16
Cesium (Cs)-Total			98.8		%		80-120	13-MAY-16
Chromium (Cr)-Total			96.9		%		80-120	13-MAY-16
Cobalt (Co)-Total			97.0		%		80-120	13-MAY-16
Copper (Cu)-Total			96.7		%		80-120	13-MAY-16
Iron (Fe)-Total			96.4		%		80-120	13-MAY-16
Lead (Pb)-Total			101.2		%		80-120	13-MAY-16
Lithium (Li)-Total			89.7		%		80-120	13-MAY-16
Magnesium (Mg)-Total			98.4		%		80-120	13-MAY-16
Manganese (Mn)-Total			96.3		%		80-120	13-MAY-16
Molybdenum (Mo)-Total			99.8		%		80-120	13-MAY-16
Nickel (Ni)-Total			96.1		%		80-120	13-MAY-16
Phosphorus (P)-Total			100.5		%		80-120	13-MAY-16
Potassium (K)-Total			96.1		%		80-120	13-MAY-16
Rubidium (Rb)-Total			97.0		%		80-120	13-MAY-16
Selenium (Se)-Total			97.6		%		80-120	13-MAY-16
Silicon (Si)-Total			99.1		%		80-120	13-MAY-16
Silver (Ag)-Total			99.0		%		80-120	13-MAY-16
Sodium (Na)-Total			99.0		%		80-120	13-MAY-16
Strontium (Sr)-Total			99.8		%		80-120	13-MAY-16
Sulfur (S)-Total			93.6		%		80-120	13-MAY-16
Tellurium (Te)-Total			91.7		%		80-120	13-MAY-16
Thallium (Tl)-Total			98.6		%		80-120	13-MAY-16
Thorium (Th)-Total			97.7		%		80-120	13-MAY-16
Tin (Sn)-Total			99.8		%		80-120	13-MAY-16
Titanium (Ti)-Total			93.5		%		80-120	13-MAY-16
Tungsten (W)-Total			102.1		%		80-120	13-MAY-16
Uranium (U)-Total			99.0		%		80-120	13-MAY-16
Vanadium (V)-Total			98.5		%		80-120	13-MAY-16
Zinc (Zn)-Total			92.0		%		80-120	13-MAY-16

Quality Control Report

Client: EnGlobe Corp.
353 BRIDGE ST. E.
KITCHENER ON N2K 2Y5
Contact: Susanna Meteer

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-MS-WT	**Water**							
Batch R3458293								
WG2308159-2 LCS								
Zirconium (Zr)-Total			96.4		%		80-120	13-MAY-16
WG2308159-1 MB								
Aluminum (Al)-Total			<0.010		mg/L		0.01	13-MAY-16
Antimony (Sb)-Total			<0.00010		mg/L		0.0001	13-MAY-16
Arsenic (As)-Total			<0.00010		mg/L		0.0001	13-MAY-16
Barium (Ba)-Total			<0.00020		mg/L		0.0002	13-MAY-16
Beryllium (Be)-Total			<0.00010		mg/L		0.0001	13-MAY-16
Bismuth (Bi)-Total			<0.000050		mg/L		0.00005	13-MAY-16
Boron (B)-Total			<0.010		mg/L		0.01	13-MAY-16
Cadmium (Cd)-Total			<0.000010		mg/L		0.00001	13-MAY-16
Calcium (Ca)-Total			<0.50		mg/L		0.5	13-MAY-16
Cesium (Cs)-Total			<0.000010		mg/L		0.00001	13-MAY-16
Chromium (Cr)-Total			<0.00050		mg/L		0.0005	13-MAY-16
Cobalt (Co)-Total			<0.00010		mg/L		0.0001	13-MAY-16
Copper (Cu)-Total			<0.0010		mg/L		0.001	13-MAY-16
Iron (Fe)-Total			<0.050		mg/L		0.05	13-MAY-16
Lead (Pb)-Total			<0.00010		mg/L		0.0001	13-MAY-16
Lithium (Li)-Total			<0.0010		mg/L		0.001	13-MAY-16
Magnesium (Mg)-Total			<0.050		mg/L		0.05	13-MAY-16
Manganese (Mn)-Total			<0.00050		mg/L		0.0005	13-MAY-16
Molybdenum (Mo)-Total			<0.000050		mg/L		0.00005	13-MAY-16
Nickel (Ni)-Total			<0.00050		mg/L		0.0005	13-MAY-16
Phosphorus (P)-Total			<0.050		mg/L		0.05	13-MAY-16
Potassium (K)-Total			<0.050		mg/L		0.05	13-MAY-16
Rubidium (Rb)-Total			<0.00020		mg/L		0.0002	13-MAY-16
Selenium (Se)-Total			<0.000050		mg/L		0.00005	13-MAY-16
Silicon (Si)-Total			<0.050		mg/L		0.05	13-MAY-16
Silver (Ag)-Total			<0.000050		mg/L		0.00005	13-MAY-16
Sodium (Na)-Total			<0.50		mg/L		0.5	13-MAY-16
Strontium (Sr)-Total			<0.0010		mg/L		0.001	13-MAY-16
Sulfur (S)-Total			<0.50		mg/L		0.5	13-MAY-16
Tellurium (Te)-Total			<0.00020		mg/L		0.0002	13-MAY-16
Thallium (Tl)-Total			<0.000010		mg/L		0.00001	13-MAY-16
Thorium (Th)-Total			<0.00010		mg/L		0.0001	13-MAY-16

Quality Control Report

Client: EnGlobe Corp.
353 BRIDGE ST. E.
KITCHENER ON N2K 2Y5
Contact: Susanna Meteer

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-MS-WT	**Water**							
Batch R3458293								
WG2308159-1 MB								
Tin (Sn)-Total			<0.00010		mg/L		0.0001	13-MAY-16
Titanium (Ti)-Total			<0.00030		mg/L		0.0003	13-MAY-16
Tungsten (W)-Total			<0.00010		mg/L		0.0001	13-MAY-16
Uranium (U)-Total			<0.000010		mg/L		0.00001	13-MAY-16
Vanadium (V)-Total			<0.00050		mg/L		0.0005	13-MAY-16
Zinc (Zn)-Total			<0.0030		mg/L		0.003	13-MAY-16
Zirconium (Zr)-Total			<0.00030		mg/L		0.0003	13-MAY-16
WG2308159-5 MS		**WG2308159-3**						
Aluminum (Al)-Total			105.6		%		70-130	13-MAY-16
Antimony (Sb)-Total			96.8		%		70-130	13-MAY-16
Arsenic (As)-Total			95.0		%		70-130	13-MAY-16
Barium (Ba)-Total			N/A	MS-B	%		-	13-MAY-16
Beryllium (Be)-Total			88.0		%		70-130	13-MAY-16
Bismuth (Bi)-Total			90.4		%		70-130	13-MAY-16
Boron (B)-Total			88.1		%		70-130	13-MAY-16
Cadmium (Cd)-Total			92.3		%		70-130	13-MAY-16
Calcium (Ca)-Total			N/A	MS-B	%		-	13-MAY-16
Cesium (Cs)-Total			94.5		%		70-130	13-MAY-16
Chromium (Cr)-Total			95.9		%		70-130	13-MAY-16
Cobalt (Co)-Total			93.0		%		70-130	13-MAY-16
Copper (Cu)-Total			95.8		%		70-130	13-MAY-16
Lead (Pb)-Total			92.8		%		70-130	13-MAY-16
Lithium (Li)-Total			94.0		%		70-130	13-MAY-16
Magnesium (Mg)-Total			N/A	MS-B	%		-	13-MAY-16
Manganese (Mn)-Total			93.4		%		70-130	13-MAY-16
Molybdenum (Mo)-Total			97.8		%		70-130	13-MAY-16
Nickel (Ni)-Total			90.4		%		70-130	13-MAY-16
Phosphorus (P)-Total			103.2		%		70-130	13-MAY-16
Potassium (K)-Total			97.0		%		70-130	13-MAY-16
Rubidium (Rb)-Total			95.6		%		70-130	13-MAY-16
Selenium (Se)-Total			90.4		%		70-130	13-MAY-16
Silicon (Si)-Total			N/A	MS-B	%		-	13-MAY-16
Silver (Ag)-Total			90.1		%		70-130	13-MAY-16
Sodium (Na)-Total			N/A	MS-B	%		-	13-MAY-16

Quality Control Report

Client: EnGlobe Corp.
353 BRIDGE ST. E.
KITCHENER ON N2K 2Y5
Contact: Susanna Meteer

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-MS-WT	**Water**							
Batch R3458293								
WG2308159-5 MS		**WG2308159-3**						
Strontium (Sr)-Total			N/A	MS-B	%		-	13-MAY-16
Sulfur (S)-Total			N/A	MS-B	%		-	13-MAY-16
Tellurium (Te)-Total			82.6		%		70-130	13-MAY-16
Thallium (Tl)-Total			91.6		%		70-130	13-MAY-16
Thorium (Th)-Total			93.8		%		70-130	13-MAY-16
Tin (Sn)-Total			94.6		%		70-130	13-MAY-16
Titanium (Ti)-Total			98.0		%		70-130	13-MAY-16
Tungsten (W)-Total			97.9		%		70-130	13-MAY-16
Uranium (U)-Total			N/A	MS-B	%		-	13-MAY-16
Vanadium (V)-Total			97.8		%		70-130	13-MAY-16
Zinc (Zn)-Total			92.1		%		70-130	13-MAY-16
Zirconium (Zr)-Total			95.5		%		70-130	13-MAY-16
NH3-WT	**Water**							
Batch R3459966								
WG2309656-3 DUP		**L1768465-1**						
Ammonia, Total (as N)		<0.020	<0.020	RPD-NA	mg/L	N/A	20	17-MAY-16
WG2309656-2 LCS								
Ammonia, Total (as N)			101.8		%		85-115	17-MAY-16
WG2309656-1 MB								
Ammonia, Total (as N)			<0.020		mg/L		0.02	17-MAY-16
WG2309656-4 MS		**L1768465-1**						
Ammonia, Total (as N)			95.0		%		75-125	17-MAY-16
NO2-IC-WT	**Water**							
Batch R3460229								
WG2309840-4 DUP		**WG2309840-3**						
Nitrite (as N)		<0.010	<0.010	RPD-NA	mg/L	N/A	25	17-MAY-16
WG2309840-2 LCS								
Nitrite (as N)			100.1		%		70-130	17-MAY-16
WG2309840-1 MB								
Nitrite (as N)			<0.010		mg/L		0.01	17-MAY-16
WG2309840-5 MS		**WG2309840-3**						
Nitrite (as N)			100.7		%		70-130	17-MAY-16
NO3-IC-WT	**Water**							

Quality Control Report

Workorder: L1768544 Report Date: 24-MAY-16

Client: EnGlobe Corp.
353 BRIDGE ST. E.
KITCHENER ON N2K 2Y5
Contact: Susanna Meteer

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO3-IC-WT	**Water**							
Batch R3460229								
WG2309840-4 DUP		**WG2309840-3**						
Nitrate (as N)		<0.020	<0.020	RPD-NA	mg/L	N/A	25	17-MAY-16
WG2309840-2 LCS								
Nitrate (as N)			98.4		%		70-130	17-MAY-16
WG2309840-1 MB								
Nitrate (as N)			<0.020		mg/L		0.02	17-MAY-16
WG2309840-5 MS		**WG2309840-3**						
Nitrate (as N)			99.4		%		70-130	17-MAY-16
PH-WT	**Water**							
Batch R3458799								
WG2308727-6 DUP		**WG2308727-5**						
pH		7.98	7.99	J	pH units	0.01	0.2	15-MAY-16
WG2308727-4 LCS								
pH			6.98		pH units		6.9-7.1	15-MAY-16
PO4-DO-COL-WT	**Water**							
Batch R3459547								
WG2309825-3 DUP		**L1768554-1**						
Phosphate-P (ortho)		<0.0030	<0.0030	RPD-NA	mg/L	N/A	20	17-MAY-16
WG2309825-2 LCS								
Phosphate-P (ortho)			91.7		%		80-120	17-MAY-16
WG2309825-1 MB								
Phosphate-P (ortho)			<0.0030		mg/L		0.003	17-MAY-16
WG2309825-4 MS		**L1768554-1**						
Phosphate-P (ortho)			104.5		%		70-130	17-MAY-16
SO4-IC-N-WT	**Water**							
Batch R3460229								
WG2309840-4 DUP		**WG2309840-3**						
Sulfate (SO4)		5.22	5.22		mg/L	0.1	20	17-MAY-16
WG2309840-2 LCS								
Sulfate (SO4)			101.0		%		90-110	17-MAY-16
WG2309840-1 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	17-MAY-16
WG2309840-5 MS		**WG2309840-3**						
Sulfate (SO4)			100.9		%		75-125	17-MAY-16
SOLIDS-TDS-WT	**Water**							

Quality Control Report

Client: EnGlobe Corp.
353 BRIDGE ST. E.
KITCHENER ON N2K 2Y5
Contact: Susanna Meteer

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
SOLIDS-TDS-WT	**Water**							
Batch R3459879								
WG2309574-3 DUP		**L1768258-4**						
Total Dissolved Solids		280	272		mg/L	2.7	20	17-MAY-16
WG2309574-2 LCS								
Total Dissolved Solids			100.5		%		85-115	17-MAY-16
WG2309574-1 MB								
Total Dissolved Solids			<10		mg/L		10	17-MAY-16
Batch R3462610								
WG2310337-3 DUP		**L1768544-2**						
Total Dissolved Solids		578	584		mg/L	0.9	20	18-MAY-16
WG2310337-2 LCS								
Total Dissolved Solids			99.9		%		85-115	18-MAY-16
WG2310337-1 MB								
Total Dissolved Solids			<10		mg/L		10	18-MAY-16
TURBIDITY-WT	**Water**							
Batch R3457445								
WG2308348-3 DUP		**L1768544-2**						
Turbidity		0.93	0.87		NTU	7.2	15	14-MAY-16
WG2308348-2 LCS								
Turbidity			101.0		%		85-115	14-MAY-16
WG2308348-1 MB								
Turbidity			<0.10		NTU		0.1	14-MAY-16

Quality Control Report

Workorder: L1768544 Report Date: 24-MAY-16

Client: EnGlobe Corp.
353 BRIDGE ST. E.
KITCHENER ON N2K 2Y5
Contact: Susanna Meteer

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

Sample Parameter Qualifier Definitions:

Qualifier	Description
J	Duplicate results and limits are expressed in terms of absolute difference.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

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 (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1768544-COFC

COC Number: 14 - 457702

Page 1 of 1

Report To		Report Format / Distribution		Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
Company:	Englobe	Select Report Format:	PDF EXCEL EDD (DIGITAL)	R Regular (Standard TAT if received by 3pm)
Contact:	Sue Meteer	Quality Control (QC) Report with Report	Yes No	P Priority (2-4 business days if received by 3pm)
Address:	353 Bridge Street	Criteria on Report - provide details below if box checked		E Emergency (1-2 business days if received by 3pm)
		Select Distribution:	EMAIL MAIL FAX	E2 Same day or weekend emergency if received by 10am – contact ALS for surcharge.
Phone:	519 741 1313	Email 1 or Fax	Sue Meteer	Specify Date Required for E2,E or P:
		Email 2		

Invoice To	Same as Report To	Yes No	Invoice Distribution		Analysis Request
	Copy of Invoice with Report	Yes No	Select Invoice Distribution:	EMAIL MAIL FAX	Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below
Company:			Email 1 or Fax	Sue Meteer	
Contact:			Email 2		

Project Information		Oil and Gas Required Fields (client use)	
ALS Quote #:		Approver ID:	Cost Center:
Job #:	P-0010233-0-02-300	GL Account:	Routing Code:
PO / AFE:	A03742	Activity Code:	
LSD:		Location:	

ALS Lab Work Order # (lab use only): L1768544 13C

ALS Contact: ML

Sampler: Dan Soute

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	(Gen Chem Pkg)	Number of Containers
	~~BH16~~	13-May-16				5
1	02-16	"	9:00	water	✓	5
	~~BH16~~					5
2	10-16	"	11:00	Water	✓	5
3	04-16	"	12:00	Water	✓	5

Drinking Water (DW) Samples[1] (client use)	Special Instructions / Specify Criteria to add on report (client Use)
Are samples taken from a Regulated DW System? ☐ Yes ☑ No	
Are samples for human drinking water use? ☐ Yes ☑ No	

SAMPLE CONDITION AS RECEIVED (lab use only)

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

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
			11.9		

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date:	Time:	Received by:	Date:	Time:
Dan Soute	May 13/16	1524				RH	13MAY16	1530

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

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**.

Appendix 7 Stantec Water Balances

Monthly Feature Based Water Balance Analysis – Tributary E of Hanlon Creek Watershed
Monthly Water Balance Analysis

Update cells with red text. See cell comments for additional notes.

Monthly Feature Based Water Balance Analysis - Tributary E of Hanlon Creek Watershed
161413228 - Lowes Road
Current Conditions

Land Cover Descriptions
Urban Lawn, Forest, Pasture | Fine Sandly Loam | Rolling Land

Main Site Area (ha)[1]	62.1
Impervious[2]	5.9%

Land Description Factors[3]			**Impervious**	**Perm. Pool[5]**
Topography	0.20		-	-
Soils	0.30		-	-
Cover[4]	0.17		-	-
Sum (Infiltration Factor)	0.67		-	-
Soil Moisture Capacity (mm)	241		-	-
Site Area	58.4		3.66	0
Percentage of Total Site Area	94%		6%	0%

100% **OK**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Comment
Climate Data (Data from Waterloo-Wellington Station - Climate Normals from 1981-2010)														
Average Daily Temperature (°C)	-6.5	-5.5	-1.0	6.2	12.5	17.6	20.0	18.9	14.5	8.2	2.5	-3.3		Daily average temperature in each month
Precipitation (mm)	65.2	54.9	61.0	74.5	82.3	82.4	98.6	83.9	87.8	67.4	87.1	71.2	**916.3**	
Evapotranspiration Analysis														
Saturation Vapour Pressure (mb)	3.75	4.05	5.68	9.49	14.52	20.17	23.45	21.89	16.55	10.89	7.32	4.79		
PET (Malstrom, 1969) (mm/month)	0.00	0.00	0.00	38.82	59.39	82.51	95.89	89.54	67.67	44.54	29.93	0.00	**508.3**	Expected ET for 916 mm of annual rainfall per unit area of pervious area (zero impervious coverage)
Infiltration - PET (mm)	65.20	54.90	61.00	35.68	22.91	-0.11	2.71	-5.64	20.13	22.86	57.17	71.20		
Weighted Soil Storage Capacity (mm)	240.75	240.75	240.75	240.75	240.75	240.75	240.75	240.75	240.75	240.75	240.75	240.75		
Actual Soil Moisture (mm)	240.75	240.75	240.75	240.75	240.75	240.64	240.75	235.11	240.75	240.75	240.75	240.75		Assume April soil moisture is at max capacity (i.e., saturated)
Change in Soil Moisture (mm)	0.00	0.00	0.00	0.00	0.00	-0.11	0.11	-5.64	5.64	0.00	0.00	0.00		
Actual Evapotranspiration (mm)	**0.00**	**0.00**	**0.00**	**38.82**	**59.39**	**82.51**	**95.89**	**89.54**	**67.67**	**44.54**	**29.93**	**0.00**	508.3	
Recharge/Runoff Analysis														
Surplus	65.2	54.9	61.0	35.7	22.9	0.0	2.6	0.0	14.5	22.9	57.2	71.2	**408.0**	
Deficit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	
Weighted Infiltration Factor	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		Based on MOE SWM Manual (2003)
Runoff (mm)	**0.00**	**0.00**	**0.00**	**95.75**	**7.62**	**0.00**	**0.86**	**0.00**	**4.82**	**7.60**	**19.01**	**0.00**	135.7	Assume no runoff in sub-zero months
Recharge (mm)	**0.00**	**0.00**	**0.00**	**192.23**	**15.29**	**0.00**	**1.73**	**0.00**	**9.67**	**15.26**	**38.16**	**0.00**	272.3	

Volume-Based Balance (m^3)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	
Precipitation	40,489	34,093	37,881	46,265	51,108	51,170	61,231	52,102	54,524	41,855	54,089	44,215	**569,022**	**916 mm/year**
Evapotranspiration	0	0	0	22,686	34,707	48,219	56,035	52,325	39,546	26,025	17,489	0	**297,030**	**478 mm/year**
Pervious Runoff	0	0	0	55,954	4,451	0	504	0	2,814	4,442	11,108	0	79,274	128 mm/year
Impervious Runoff	0	0	0	11,974	3,015	3,019	3,613	3,074	3,217	2,469	3,191	0	33,572	54 mm/year
Total Runoff	0	0	0	67,928	7,466	3,019	4,117	3,074	6,031	6,912	14,300	0	**112,847**	**182 mm/year**
Groundwater Recharge	0	0	0	112,329	8,935	0	1,012	0	5,650	8,918	22,300	0	**159,145**	**256 mm/year**

Tributary E Catchment Area Summary (Existing Conditions)

Precipitation =	569,022	m^3/yr	
Evapotranspiration =	297,030	m^3/yr	478 mm/year
Infiltration/Recharge =	159,145	m^3/yr	256 mm/year
Runoff =	112,847	m^3/yr	182 mm/year

Monthly Feature Based Water Balance Analysis - Tributary E of Hanlon Creek Watershed
161413228 - Lowes Road
Post-Development of 19-59 Lowes Road

Land Cover Descriptions
Urban Lawn, Forest, Pasture | Fine Sandy Loam | Rolling Land

Main Site Area (ha)	62.1
Impervious Cover[6]	7.0%

Land Description Factors			**Impervious**	**Perm. Pool**
Topography	0.20		-	-
Soils	0.30		-	-
Cover	0.17		-	-
Sum (Infiltration Factor)	0.67		-	-
Soil Moisture Capacity (mm)	241		-	-
Site Area	57.8		4.32	0.00
Percentage of Total Site Area[2]	93%		7%	0%

100% **OK**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Comment
Climate Data (Data from Waterloo-Wellington Station - Climate Normals from 1981-2010)														
Average Daily Temperature (°C)	-6.5	-5.5	-1.0	6.2	12.5	17.6	20.0	18.9	14.5	8.2	2.5	-3.3		Daily average temperature in each month
Precipitation (mm)	65.2	54.9	61.0	74.5	82.3	82.4	98.6	83.9	87.8	67.4	87.1	71.2	**916.3**	
Evapotranspiration Analysis														
Saturation Vapour Pressure (mb)	3.75	4.05	5.68	9.49	14.52	20.17	23.45	21.89	16.55	10.89	7.32	4.79		
PET (Malstrom, 1969) (mm/month)	0.00	0.00	0.00	38.82	59.39	82.51	95.89	89.54	67.67	44.54	29.93	0.00	**508.3**	
Infiltration - PET (mm)	65.20	54.90	61.00	35.68	22.91	-0.11	2.71	-5.64	20.13	22.86	57.17	71.20		
Weighted Soil Storage Capacity (mm)	240.75	240.75	240.75	240.75	240.75	240.75	240.75	240.75	240.75	240.75	240.75	240.75		
Actual Soil Moisture (mm)	240.75	240.75	240.75	240.75	240.75	240.64	240.75	235.11	240.75	240.75	240.75	240.75		Assume April soil moisture is at max capacity (i.e., saturated)
Change in Soil Moisture (mm)	0.00	0.00	0.00	0.00	0.00	-0.11	0.11	-5.64	5.64	0.00	0.00	0.00		
Actual Evapotranspiration (mm)	**0.00**	**0.00**	**0.00**	**38.82**	**59.39**	**82.51**	**95.89**	**89.54**	**67.67**	**44.54**	**29.93**	**0.00**	508.3	

Recharge/Runoff Analysis - Pervious Areas														
Surplus	65.2	54.9	61.0	35.7	22.9	0.0	2.6	0.0	14.5	22.9	57.2	71.2	**408.0**	
Deficit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	
Weighted Infiltration Factor	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67		Based on MOE SWM Manual (2003)
Runoff (mm)	**0.00**	**0.00**	**0.00**	**95.75**	**7.62**	**0.00**	**0.86**	**0.00**	**4.82**	**7.60**	**19.01**	**0.00**	**135.7**	Assume no runoff in sub-zero months
Recharge (mm)	**0.00**	**0.00**	**0.00**	**192.23**	**15.29**	**0.00**	**1.73**	**0.00**	**9.67**	**15.26**	**38.16**	**0.00**	**272.3**	

Pond														
Pond Evaporation (mm)	0.00	0.00	0.00	75.00	105.40	123.00	133.30	108.50	66.00	27.00	0.00	0.00	**638.2**	
Runoff (mm)	0.0	0.0	0.0	251.8	-23.1	-40.6	-34.7	-24.6	21.8	40.4	87.1	0.0	**278.1**	

Volume-Based Balance (m^3)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	
Precipitation	**40,489**	**34,093**	**37,881**	**46,265**	**51,108**	**51,170**	**61,231**	**52,102**	**54,524**	**41,855**	**54,089**	**44,215**	**569,022**	
Evapotranspiration	0	0	0	22,430	34,316	47,675	55,403	51,735	39,100	25,732	17,292	0	293,685	
Pond Evaporation	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total Evap	**0**	**0**	**0**	**22,430**	**34,316**	**47,675**	**55,403**	**51,735**	**39,100**	**25,732**	**17,292**	**0**	**293,685**	**473 mm/year**
Pervious Runoff	0	0	0	55,324	4,401	0	498	0	2,783	4,392	10,983	0	78,381	126 mm/year
Impervious Runoff	0	0	0	14,125	3,557	3,561	4,262	3,626	3,795	2,913	3,765	0	39,604	64 mm/year
Pond Runoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0 mm/year
Total Runoff	**0**	**0**	**0**	**69,449**	**7,958**	**3,561**	**4,760**	**3,626**	**6,578**	**7,305**	**14,748**	**0**	**117,985**	190 mm/year
Groundwater Recharge from Pervious Areas	**0**	**0**	**0**	**111,064**	**8,835**	**0**	**1,001**	**0**	**5,586**	**8,818**	**22,049**	**0**	**157,352**	253 mm/year

Infiltration Augmentation														
Rooftop Recharge from site[7]	0	0	0	667	168	168	201	171	179	138	178	0	1,871	3 mm/year - Assuming 80% of roof top runoff is captured and infiltrated and 25 mm of runoff infiltrates from the roof (assume 80% of the annual rainfall volume)
Final Recharge[8]	**0**	**0**	**0**	**111,731**	**9,003**	**168**	**1,202**	**171**	**5,766**	**8,955**	**22,227**	**0**	**159,223**	**256 mm/year - Sum of groundwater recharge from pervious areas and recharge from rooftop areas on 1.65 ha site**
Final Runoff[9]	**0**	**0**	**0**	**68,782**	**7,790**	**3,393**	**4,559**	**3,455**	**6,398**	**7,168**	**14,570**	**0**	**116,115**	**187 mm/year - Assuming infiltration of rooftop areas occurs for all storms up to and including the 25 mm event**
Final Recharge Surplus	0	0	0	-598	67	168	190	171	116	37	-73	0	78	0 mm/year
Final Runoff Surplus	0	0	0	854	324	374	442	381	367	256	270	0	3,268	5 mm/year

Tributary E Catchment Area Summary (Proposed Conditions)

Precipitation =	569,022	m^3/yr	
Evapotranspiration =	293,685	m^3/yr	473 mm/year
Infiltration/Recharge =	159,223	m^3/yr	256 mm/year
Runoff =	116,115	m^3/yr	187 mm/year

Notes:

1. Total catchment area to Tributary E East measured using SWOOP data and City of Guelph storm sewer network information; area roughly matches GAWSER model information from Hanlon Creek Watershed Plan
2. Impervious coverage assumed based on aerial imagery from GRCA mapping service; approximately 23% impervious coverage for 16 ha of developed land on west side of Gordon and north of the Clairfields subdivision to the south
3. Infiltration factors based on measured areas from aerial imagery from GRCA mapping service; majority of catchment is woodland with small pockets of pasture in wetland area; any pervious, developed area is lawn; soils considered sand and gravel; total is a weighted average of all coverage
4. Land cover a weighted average of various land uses within the catchment; these are broken down by percentage: 69% mature forest, 14% pasture and shrubs, 17% urban lawns
5. It is assumed there is no standing water or permanent waterbodies within the catchment area
6. Post-development impervious coverage based on increase of 1.65 ha site from 20% impervious coverage (current) to 60% post-development; increase of 0.66 ha of impervious area
7. Rooftop recharge based on average rooftop area of 110 sq. m; assumes 80% of rooftop reaches infiltration (safety factor); total number of homes to infiltration is 29
8. Final recharge a sum of all infiltration from pervious areas on the site and rooftop recharge
9. Final runoff is the difference between total runoff volume and rooftop infiltration volumes

Other:

- All infiltration and soil retention values taken from Table 3.1 of the MOECC SWM Planning and Design Manual (2003)
- 25 mm of runoff assumed to represent 80% of annual rainfall volume
- No active infiltration occurs within the existing development areas
- Groundwater catchment area to Tributary E East may be larger than suface water catchment due to large amounts of active infiltration occurring within development areas in the Hanlon Creek Watershed; this analysis focuses on surface water only

Update cells with red text. See cell comments for additional notes.

Monthly Water Balance Analysis
161413228 - Lowes Road
Existing Conditions

Land Cover Descriptions
Lawns with some trees | Fine Sandy Loam | Flat land

Main Site Area (ha)	1.65
Impervious	20%

Land Description Factors			**Impervious**	**Perm. Pool**
Topography	0.30		-	-
Soils	0.30		-	-
Cover	0.05		-	-
Sum (Infiltration Factor)	0.65		-	-
Soil Moisture Capacity (mm)	50		-	-
Site Area	1.32		0.33	0
Percentage of Total Site Area	80%		20%	0%

100% **OK**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Comment
Climate Data (Data from Waterloo-Wellington Station - Climate Normals from 1981-2010)														
Average Daily Temperature (°C)	-6.5	-5.5	-1.0	6.2	12.5	17.6	20.0	18.9	14.5	8.2	2.5	-3.3		Daily average temperature in each month
Precipitation (mm)	65.2	54.9	61.0	74.5	82.3	82.4	98.6	83.9	87.8	67.4	87.1	71.2	**916.3**	
Evapotranspiration Analysis														
Saturation Vapour Pressure (mb)	3.75	4.05	5.68	9.49	14.52	20.17	23.45	21.89	16.55	10.89	7.32	4.79		
PET (Malstrom, 1969) (mm/month)	0.00	0.00	0.00	38.82	59.39	82.51	95.89	89.54	67.67	44.54	29.93	0.00	**508.3**	Expected ET for 916 mm of annual rainfall per unit area of pervious area (zero impervious coverage)
Infiltration - PET (mm)	65.20	54.90	61.00	35.68	22.91	-0.11	2.71	-5.64	20.13	22.86	57.17	71.20		
Weighted Soil Storage Capacity (mm)	40.03	40.03	40.03	40.03	40.03	40.03	40.03	40.03	40.03	40.03	40.03	40.03		
Actual Soil Moisture (mm)	40.03	40.03	40.03	40.03	40.03	39.92	40.03	34.39	40.03	40.03	40.03	40.03		Assume April soil moisture is at max capacity (i.e., saturated)
Change in Soil Moisture (mm)	0.00	0.00	0.00	0.00	0.00	-0.11	0.11	-5.64	5.64	0.00	0.00	0.00		
Actual Evapotranspiration (mm)	**0.00**	**0.00**	**0.00**	**38.82**	**59.39**	**82.51**	**95.89**	**89.54**	**67.67**	**44.54**	**29.93**	**0.00**	**508.3**	
Recharge/Runoff Analysis														
Surplus	65.2	54.9	61.0	35.7	22.9	0.0	2.6	0.0	14.5	22.9	57.2	71.2	**408.0**	
Deficit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	
Weighted Infiltration Factor	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65		Based on MOE SWM Manual (2003)
Runoff (mm)	**0.00**	**0.00**	**0.00**	**100.79**	**8.02**	**0.00**	**0.91**	**0.00**	**5.07**	**8.00**	**20.01**	**0.00**	**142.8**	Assume no runoff in sub-zero months
Recharge (mm)	**0.00**	**0.00**	**0.00**	**187.19**	**14.89**	**0.00**	**1.69**	**0.00**	**9.42**	**14.86**	**37.16**	**0.00**	**265.2**	

Volume-Based Balance (m^3)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	
Precipitation	1,076	906	1,007	1,229	1,358	1,360	1,627	1,384	1,449	1,112	1,437	1,175	**15,119**	**916 mm/year**
Evapotranspiration[1]	0	0	0	513	785	1,090	1,267	1,183	894	588	395	0	**6,715**	**407 mm/year**
	0	0	0	31	48	66	77	72	54	36	24	0		
Pervious Runoff	0	0	0	1,331	106	0	12	0	67	106	264	0	1,886	114 mm/year
Impervious Runoff	0	0	0	1,075	271	271	324	276	289	222	287	0	3,015	183 mm/year
Total Runoff	0	0	0	2,407	377	271	336	276	356	327	551	0	**4,901**	**297 mm/year**
Groundwater Recharge	0	0	0	2,473	197	0	22	0	124	196	491	0	**3,503**	**212 mm/year**

Monthly Water Balance Analysis
161413228 - Lowes Road
Post-Development

Land Cover Descriptions
Urban lawn | Fine Sandy Loam | Flat land

Main Site Area (ha)	1.65
Impervious Cover	60%

Land Description Factors			**Impervious**	**Perm. Pool**
Topography	0.30		-	-
Soils	0.30		-	-
Cover	0.05		-	-
Sum (Infiltration Factor)	0.65		-	-
Soil Moisture Capacity (mm)	50		-	-
Site Area	0.66		0.99	0.00
Percentage of Total Site Area[2]	40%		60%	0%

100% **OK**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Comment
Climate Data (Data from Waterloo-Wellington Station - Climate Normals from 1981-2010)														
Average Daily Temperature (°C)	-6.5	-5.5	-1.0	6.2	12.5	17.6	20.0	18.9	14.5	8.2	2.5	-3.3		Daily average temperature in each month
Precipitation (mm)	65.2	54.9	61.0	74.5	82.3	82.4	98.6	83.9	87.8	67.4	87.1	71.2	**916.3**	
Evapotranspiration Analysis														
Saturation Vapour Pressure (mb)	3.75	4.05	5.68	9.49	14.52	20.17	23.45	21.89	16.55	10.89	7.32	4.79		
PET (Malstrom, 1969) (mm/month)	0.00	0.00	0.00	38.82	59.39	82.51	95.89	89.54	67.67	44.54	29.93	0.00	**508.3**	
Infiltration - PET (mm)	65.20	54.90	61.00	35.68	22.91	-0.11	2.71	-5.64	20.13	22.86	57.17	71.20		
Weighted Soil Storage Capacity (mm)	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00		
Actual Soil Moisture (mm)	50.00	50.00	50.00	50.00	50.00	49.89	50.00	44.36	50.00	50.00	50.00	50.00		Assume April soil moisture is at max capacity (i.e., saturated)
Change in Soil Moisture (mm)	0.00	0.00	0.00	0.00	0.00	-0.11	0.11	-5.64	5.64	0.00	0.00	0.00		
Actual Evapotranspiration (mm)	**0.00**	**0.00**	**0.00**	**38.82**	**59.39**	**82.51**	**95.89**	**89.54**	**67.67**	**44.54**	**29.93**	**0.00**	**508.3**	
Recharge/Runoff Analysis - Pervious Areas														
Surplus	65.2	54.9	61.0	35.7	22.9	0.0	2.6	0.0	14.5	22.9	57.2	71.2	**408.0**	
Deficit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	
Weighted Infiltration Factor	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65		Based on MOE SWM Manual (2003)
Runoff (mm)	**0.00**	**0.00**	**0.00**	**100.79**	**8.02**	**0.00**	**0.91**	**0.00**	**5.07**	**8.00**	**20.01**	**0.00**	**142.8**	Assume no runoff in sub-zero months
Recharge (mm)	**0.00**	**0.00**	**0.00**	**187.19**	**14.89**	**0.00**	**1.69**	**0.00**	**9.42**	**14.86**	**37.16**	**0.00**	**265.2**	

Pond														
Pond Evaporation (mm)	0.00	0.00	0.00	75.00	105.40	123.00	133.30	108.50	66.00	27.00	0.00	0.00	**638.2**	
Runoff (mm)	0.0	0.0	0.0	251.8	-23.1	-40.6	-34.7	-24.6	21.8	40.4	87.1	0.0	**278.1**	

Volume-Based Balance (m^3)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	
Precipitation	**1,076**	**906**	**1,007**	**1,229**	**1,358**	**1,360**	**1,627**	**1,384**	**1,449**	**1,112**	**1,437**	**1,175**	**15,119**	
Evapotranspiration	0	0	0	256	392	545	633	591	447	294	198	0	3,355	
Pond Evaporation	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total Evap	**0**	**0**	**0**	**256**	**392**	**545**	**633**	**591**	**447**	**294**	**198**	**0**	**3,355**	**203 mm/year**
	0	**0**	**0**	**16**	**24**	**33**	**38**	**36**	**27**	**18**	**12**	**0**		
	0	**0**	**0**	**-16**	**-24**	**-33**	**-38**	**-36**	**-27**	**-18**	**-12**	**0**		
Pervious Runoff	0	0	0	665	53	0	6	0	33	53	132	0	942	57 mm/year
Impervious Runoff	0	0	0	3,235	815	816	976	831	869	667	862	0	9,071	550 mm/year
Pond Runoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0 mm/year
Total Runoff	**0**	**0**	**0**	**3,901**	**868**	**816**	**982**	**831**	**903**	**720**	**994**	**0**	**10,014**	607 mm/year
Groundwater Recharge from Pervious Areas	**0**	**0**	**0**	**1,235**	**98**	**0**	**11**	**0**	**62**	**98**	**245**	**0**	**1,750**	106 mm/year

Infiltration Augmentation														
Rooftop Recharge[3]	0	0	0	667	168	168	201	171	179	138	178	0	1,871	113 mm/year - Assuming 80% of roof top runoff is captured and infiltrated and 25 mm of runoff infiltrates from the roof (assume 80% of the annual rainfall volume)
Final Recharge[4]	**0**	**0**	**0**	**1,903**	**266**	**168**	**212**	**171**	**241**	**236**	**423**	**0**	**3,621**	**219 mm/year - Sum of groundwater recharge from pervious areas and recharge from rooftops and other impervious areas**
	0	**0**	**0**	**115**	**16**	**10**	**13**	**10**	**15**	**14**	**26**	**0**		
Final Runoff[5]	**0**	**0**	**0**	**3,233**	**700**	**648**	**781**	**659**	**723**	**582**	**817**	**0**	**8,143**	**494 mm/year - Assuming infiltration of rooftop areas and non-rooftop areas to SWM facility**
	0	0	0	196	42	39	47	40	44	35	49	0		
Final Recharge Surplus[6]	0	0	0	-570	70	168	190	171	117	39	-68	0	118	7 mm/year
Final Runoff Surplus[7]	0	0	0	827	323	376	444	383	368	255	266	0	3,242	196 mm/year

Notes:
1. Total ET from site based on total pervious area on-site; i.e., 80% of 1.64 ha site
2. Assumed 40% of site is pervious coverage based on measurements from site plan; includes all lawn areas, rear yards, boulevards, and dry SWM facility coverage
3. Rooftop recharge based on average rooftop area of 110 sq. m; assumes 80% of rooftop reaches infiltration (safety factor); total number of homes to infiltration is 29
4. Final recharge a sum of all infiltration from pervious areas on the site and rooftop recharge
5. Final runoff is the difference between total runoff volume and rooftop infiltration volumes
6. Final recharge surplus is the difference between post-development and pre-development annual recharge volumes
7. Final runoff surplus is the difference between post-development and pre-development annual runoff volumes

Other:
- Geotechnical Investigation results show mainly medium - coarse sand and gravel (based on grain size distribution); however, based on factored infiltration rate, assume fine sandy loam with infiltration factor of 0.3
- Existing conditions includes some development; original assumption was 10%, more accurate measurement is 20%, therefore assumption has been adjusted
- Geotechnical Investigation identifies the site as sand and gravel (one horizon), some silt located at south end of site
- Site is very flat with little discharge/outlet
- Existing ground coverage is lawn
- Proposed SWM facility is a dry facility
- Approximately 0.45 ha of non-rooftop area to SWM facility (including roadway, lawns, boulevard, driveways)
- 25 mm of runoff assumed to represent 85% of annual rainfall volume
- Water balance ignores end-of-pipe infiltration in perforated outlet pipes; it is anticipated additional infiltration will occur prior to discharging to the downstream wetland area

Appendix 8 MOECC Water Well Records

TOWNSHIP CONCESSION (LOT)	UTM[1]	DATE [2] CNTR [3]	CASING DIA [4]	WATER[5,6] DETAIL	STAT LVL/PUMP LVL[7] RATE[8]/TIME HR:MIN	WATER USE[9]	SCREEN INFO[10]	WELL # (AUDIT#) WELL TAG # STATE[12] DEPTHS TO WHICH FORMATIONS EXTEND[5,11]
ERIN TOWNSHIP CON 07(009)	17 565133 4817188 W	2001/10 2663						6714024 (235127) A
PUSLINCH TOWNSHIP CON 07(008)	17 564906 4817339 W	2012/10 2663						7191242 (Z152021) A
PUSLINCH TOWNSHIP CON 07(008)	17 564886 4817321 W	2012/10 2663						7191240 (Z158929) A
PUSLINCH TOWNSHIP CON 07(008)	17 564906 4817243 W	2012/10 2663						7191245 (Z152022) A
PUSLINCH TOWNSHIP CON 07(008)	17 564902 4817121 W	2012/10 2663						7191243 (Z158930) A
PUSLINCH TOWNSHIP CON 07(008)	17 564974 4817644 W	2015/05 2663						7244796 (Z202468) A
PUSLINCH TOWNSHIP CON 07(008)	17 564888 4817315 W	2012/10 2663						7191246 (Z152023) A
PUSLINCH TOWNSHIP CON 07(008)	17 564940 4817379 W	2012/10 2663						7191244 (Z158931) A
PUSLINCH TOWNSHIP CON 07(009)	17 565159 4816993 W	2009/11 7238	02			TH	5 10	7134620 (Z105836) A091542 BRWN SAND GRVL 0015
PUSLINCH TOWNSHIP CON 07(009)	17 565251 4816982 W	2009/11 7238				TH	4 10	7134622 (Z105834) A091541 BRWN SAND GRVL 0014
PUSLINCH TOWNSHIP CON 07(009)	17 565200 4817001 W	2004/05 2336				NU		6714925 (Z10313) A
PUSLINCH TOWNSHIP CON 07(009)	17 565191 4817017 W	2004/05 2336				NU		6714924 (Z10312) A
PUSLINCH TOWNSHIP CON 07(009)	17 565214 4816969 W	2004/05 2336				NU		6714922 (Z10314) A
PUSLINCH TOWNSHIP CON 07(009)	17 565152 4817041 W	2004/05 2336				NU		6714923 (Z10311) A
PUSLINCH TOWNSHIP CON 08(006)	17 564755 4818105 W	2013/09 2663						7211045 (Z172128) A
PUSLINCH TOWNSHIP ()	17 564893 4817732 W	2013/01 7238	02	0010		MO	8 10	7202892 (Z160057) A143057 BRWN SAND GRVL LOOS 0010 BRWN SAND GRVL LOOS 0018

TOWNSHIP CONCESSION (LOT)	UTM[1]	DATE[2] CNTR[3]	CASING DIA[4]	WATER[5,6] DETAIL	STAT LVL/PUMP LVL[7] RATE[8]/TIME HR:MIN	WATER USE[9]	SCREEN INFO[10]	WELL # (AUDIT#) WELL TAG # STATE[12] DEPTHS TO WHICH FORMATIONS EXTEND[5,11]
PUSLINCH TOWNSHIP ()	17 564904 4817740 W	2013/01 7238	02			MO	8 10	7202891 (Z160056) A143071 BRWN SAND GRVL LOOS 0010 BRWN SAND GRVL LOOS 0018
GUELPH CITY (002)	17 564788 4817616 W	2006/04 2663			004 / / :0			6715815 (Z43935) A
GUELPH CITY ()	17 564884 4817933 W	2006/02 6607	02	0007			8 4	6715673 (Z44180) A037794 BRWN SILT LOAM 0001 BRWN SILT SAND 0002 BRWN SAND GRVL 0012
GUELPH CITY ()	17 564851 4818070 W	2006/01 7190	02	0004		NU	5 10	6715670 (Z31480) A029377 BRWN LOAM SOFT 0007 BRWN GRVL DNSE SILT STNS SOFT 0015
GUELPH CITY ()	17 564908 4817726 W	2006/04 2663						6715814 (Z43936) A
GUELPH CITY 08(007)	17 564799 4818094 W	2006/06 6607	02	FR 0006			4 10	6715765 (Z49028) A037753 BRWN SAND 0001 BRWN SAND GRVL SILT 0008 GREY SILT CLAY SAND 0014
GUELPH CITY (002)	17 565012 4817783 W	2006/09 2663				DO		6715960 (Z44000) A
GUELPH CITY ()	17 564848 4818098 W	2007/09 2336				MO		7050884 (Z68546) A029377 A
GUELPH CITY ()	17 565114 4817073 W	1976/09 1906	05	UK 0100	012 / 019 015 / 3:0	DO		6706309 () LOAM 0001 BRWN CLAY STNS 0022 GRVL SAND 0045 LMSN 0100 BRWN ROCK FCRD 0105
GUELPH CITY ()	17 564936 4817737 W	2006/07 1129	02				9 10	7039963 (Z48781) A039897 0001 BRWN SAND CLAY 0003 BRWN SAND GRVL 0012 GREY SAND GRVL 0021 SAND GRVL 0024 GREY SAND 0025 BRWN SILT TILL 0027
GUELPH CITY ()	17 564875 4817931 W	2006/11 2336				NU		6716016 (Z49330) A037794 A
GUELPH CITY ()	17 564824 4817889 W	2006/11 2336				NU		6716017 (Z49329) A
GUELPH CITY ()	17 564790 4817930 W	2006/11 2336				NU		6716018 (Z49328) A

TOWNSHIP CONCESSION (LOT)	UTM[1]	DATE [2] CNTR [3]	CASING DIA [4]	WATER[5,6] DETAIL	STAT LVL/PUMP LVL[7] RATE[8]/TIME HR:MIN	WATER USE[9]	SCREEN INFO[10]	WELL # (AUDIT#) WELL TAG # STATE[12] DEPTHS TO WHICH FORMATIONS EXTEND[5,11]
GUELPH CITY ()	17 564900 4817880 W	2006/11 2336				NU		6716020 (Z49326) A 0029
GUELPH CITY ()	17 564858 4817914 W	2006/11 2336				NU		6716021 (Z49325) A 0009
GUELPH CITY ()	17 564835 4817968 W	2006/11 2336				NU		6716022 (Z49324) A 0042
GUELPH CITY ()	17 564767 4817913 W	2007/01 2336				NU		7040683 (Z49336) A
GUELPH CITY ()	17 564914 4817663 W	1968/06 2521	04 04	FR 0100	009 / 015 015 / 2:0	DO		6703291 () GRVL 0040 BRWN LMSN 0100
GUELPH CITY ()	17 564859 4817767 W	1999/04 2336	06 06	FR 0047	015 / 020 010 / 1:0	DO		6712937 (196621) BRWN CLAY GRVL 0015 GREY CLAY GRVL 0043 BRWN ROCK 0047
GUELPH CITY ()	17 564843 4817873 W	2006/11 2336				NU		6716015 (Z49331) A
GUELPH CITY ()	17 564955 4817729 W	2007/02 6875	02	FR 0009			7 11	7046594 (Z50945) A044685 BRWN SAND GRVL STNS 0018
GUELPH CITY ()	17 564626 4818171 W	2007/12 6607	02	0002		MO		7101752 (M00745) A062421 BRWN SILT LOAM 0001 BRWN SILT 0002 BRWN SAND GRVL 0007 BRWN SAND SILT 0008 BLCK SILT CLAY 0010 GREY SILT SAND 0010
GUELPH CITY ()	17 564847 4818097 W	2007/08 2336				NU		7049247 (Z59195) A
GUELPH CITY ()	17 564924 4817707 W	2008/12 6607	02	UK 0008		MO		7118256 (M04268) A081364 BRWN SAND SILT GRVL 0004 BRWN SAND GRVL SILT 0014
GUELPH CITY ()	17 564951 4817784 W	2009/03 6607	02			MO		7122484 (M04570) A081324 BRWN SAND GRVL SILT 0002 BRWN SILT LOAM 0003 BRWN SAND GRVL SILT 0012 BRWN SILT SAND GRVL 0014
GUELPH CITY ()	17 564949 4817782 W	2009/04 6607				MO		7124643 (M04623) A081324 A

TOWNSHIP CONCESSION (LOT)	UTM[1]	DATE [2] CNTR [3]	CASING DIA [4]	WATER[5,6] DETAIL	STAT LVL/PUMP LVL[7] RATE[8]/TIME HR:MIN	WATER USE[9]	SCREEN INFO[10]	WELL # (AUDIT#) WELL TAG # STATE[12] DEPTHS TO WHICH FORMATIONS EXTEND[5,11]
GUELPH CITY ()	17 564978 4817864 W	2011/08 7190	04 01	0010		MO	15 10	7168694 (Z133798) A105800 BRWN LOAM LOOS 0006 BRWN SAND GRVL LOOS 0010 GREY SILT SAND GRVL 0025
GUELPH CITY ()	17 564690 4817485 W	2013/10 7238						7210045 (Z174751) A BRWN SAND GRVL 0003 GREY 0007
GUELPH CITY (PUSLINC CON 07(007)	17 564814 4818043 W	1961/02 2414	04	FR 0042	008 / 013 012 / 2:45	DO	39 5	6702436 () LOAM 0001 GRVL STNS 0018 BRWN CLAY GRVL 0040 CSND 0042 GRVL 0045
GUELPH CITY (PUSLINC CON 07(007)	17 564928 4817877 W	1962/03 2414	04 04	FR 0058	005 / 023 015 / 2:30	DO		6702438 () PRDG 0010 CSND GRVL 0016 BRWN CLAY GRVL 0040 GRVL CSND 0046 BRWN LMSN 0058
GUELPH CITY (PUSLINC CON 07(007)	17 564677 4817589 W	1966/11 2414	12 12	FR 0200 FR 0271	005 / 192 103 / 5:30	MN		6702440 () STNS GRVL 0020 GRVL 0023 CLAY MSND STNS 0043 BRWN LMSN 0135 GREY LMSN 0235 BLUE LMSN 0270 BLUE SHLE 0271
GUELPH CITY (PUSLINC CON 07(007)	17 564774 4818023 W	1970/07 1906	04	UK 0097	004 / 080 005 / 2:0	DO		6703725 () CLAY STNS GRVL 0030 CLAY GRVL 0040 GRVL CLAY 0055 GREY CLAY 0082 BRWN ROCK 0100
GUELPH CITY (PUSLINC CON 07(007)	17 564764 4818081 W	1959/09 2521	04	FR 0050	006 / 010 008 / 3:0	DO	47 3	6702435 () CLAY FILL 0008 GRVL 0050
GUELPH CITY (PUSLINC CON 07(007)	17 564736 4818047 W	1964/03 1906	05	FR 0039	003 / 015 010 / 5:0	DO		6702441 () FILL 0003 CLAY STNS 0015 MSND CLAY 0037 GRVL 0039
GUELPH CITY (PUSLINC CON 07(008)	17 565083 4817358 W	1962/03 2414	04 04	FR 0075	014 / 030 010 / 1:0	DO		6702444 () LOAM 0002 BRWN CLAY GRVL 0019 BRWN CLAY CSND 0029 GREY CLAY GRVL 0038 BRWN LMSN 0075
GUELPH CITY (PUSLINC CON 07(008)	17 565012 4817529 W	1962/08 2521	04 04	FR 0095	012 / 070 006 / 1:0	DO		6702470 () GRVL 0043 BRWN LMSN 0095
GUELPH CITY (PUSLINC CON 07(008)	17 565064 4817481 W	1961/07 2414	04 04	FR 0069	015 / 019 015 / 2:0	DO		6702443 () LOAM 0001 GRVL STNS 0012 BRWN CLAY GRVL 0037 BRWN LMSN 0070

TOWNSHIP CONCESSION (LOT)	UTM[1]	DATE[2] CNTR[3]	CASING DIA[4]	WATER[5,6] DETAIL	STAT LVL/PUMP LVL[7] RATE[8]/TIME HR:MIN	WATER USE[9]	SCREEN INFO[10]	WELL # (AUDIT#) WELL TAG # STATE[12] DEPTHS TO WHICH FORMATIONS EXTEND[5,11]
GUELPH CITY (PUSLINC CON 07(008)	17 564788 4817396 W	1962/07 2414	05 05 05	FR 0093	009 / 009 010 / 1:0	DO		6702445 () LOAM 0001 GRVL BLDR 0022 HPAN GRVL ROCK 0055 BRWN LMSN 0093
GUELPH CITY (PUSLINC CON 07(008)	17 564823 4817358 W	1963/11 2521	04 04	FR 0081	012 / 040 010 / 1:0	DO		6702447 () PRDG 0011 GRVL 0032 GREY LMSN 0081
GUELPH CITY (PUSLINC CON 07(008)	17 565015 4817629 W	1964/01 2521	04 04	FR 0092	010 / 025 010 / 2:0	DO		6702449 () GRVL MSND 0038 GREY LMSN 0092
GUELPH CITY (PUSLINC CON 07(008)	17 564726 4817436 W	1964/01 2521	04 04	FR 0095	005 / 035 006 / 2:0	DO		6702450 () GRVL 0040 GREY LMSN 0095
GUELPH CITY (PUSLINC CON 07(008)	17 564945 4817309 W	1965/05 1906	04 04	FR 0052 FR 0075	008 / 019 020 / 2:0	DO		6702452 () STNS GRVL 0015 MSND CLAY 0035 BRWN LMSN 0075
GUELPH CITY (PUSLINC CON 07(008)	17 564925 4817547 W	1954/09 2521	04 04	FR 0080	007 / 023 007 / 1:0	DO		6702454 () GRVL 0031 GREY LMSN 0080
GUELPH CITY (PUSLINC CON 07(008)	17 564863 4817405 W	1955/04 2521	04 04	FR 0081	006 / 015 020 / 1:0	DO		6702456 () GRVL 0032 GREY LMSN 0081
GUELPH CITY (PUSLINC CON 07(008)	17 564657 4817537 W	1956/03 2521	04 04	FR 0093	009 / 030 010 / 1:0	DO		6702458 () GRVL 0038 FSND 0041 GREY LMSN 0093
GUELPH CITY (PUSLINC CON 07(008)	17 564973 4817604 W	1958/04 2414	04 04	FR 0080	006 / 008 012 / 1:30	DO		6702460 () GRVL STNS 0012 GRVL CSND 0030 CLAY GRVL 0037 BRWN LMSN 0097
GUELPH CITY (PUSLINC CON 07(008)	17 564950 4817557 W	1958/04 2414	04 04	FR 0080	005 / 008 012 / 2:0	DO		6702461 () LOAM 0002 STNS GRVL 0028 GRVL CLAY 0036 BRWN LMSN 0098
GUELPH CITY (PUSLINC CON 07(008)	17 564927 4817547 W	1958/10 2414	04 04	FR 0075	008 / 020 010 / 2:0	DO		6702463 () LOAM 0002 GRVL STNS 0030 MSND 0037 BRWN LMSN 0088 BLCK LMSN 0090
GUELPH CITY (PUSLINC CON 07(008)	17 565079 4817403 W	1959/06 2414	04 04	FR 0077	010 / 015 010 / 2:30	DO		6702467 () BLDR GRVL 0018 GRVL 0034 BRWN LMSN 0077

TOWNSHIP CONCESSION (LOT)	UTM[1]	DATE [2] CNTR [3]	CASING DIA [4]	WATER[5,6] DETAIL	STAT LVL/PUMP LVL[7] RATE[8]/TIME HR:MIN	WATER USE[9]	SCREEN INFO[10]	WELL # (AUDIT#) WELL TAG # STATE[12] DEPTHS TO WHICH FORMATIONS EXTEND[5,11]
GUELPH CITY (PUSLINC CON 07(008)	17 564950 4817847 W	1961/10 4208	06 06	FR 0049	009 / 040 016 / 0:30	DO CO		6702469 () CLAY STNS 0010 LOAM MSND GRVL 0040 GRVL 0049 LMSN 0053
GUELPH CITY (PUSLINC CON 07(008)	17 564918 4817369 W	1967/07 2521	04 04	FR 0085	008 / 040 015 / 1:0	DO		6702472 () GRVL STNS 0034 GREY LMSN 0085
GUELPH CITY (PUSLINC CON 07(008)	17 564864 4817373 W	1968/11 1906	04 04	FR 0060 FR 0086	007 / 070 008 / 1:0	DO		6703251 () STNS CLAY 0034 LMSN 0080 WHIT LMSN 0087
GUELPH CITY (PUSLINC CON 07(008)	17 564878 4817407 W	1967/08 1906	04 04	FR 0061 FR 0052	010 / 015 015 / 2:0	DO		6702446 () STNS GRVL 0028 BRWN LMSN 0061
GUELPH CITY (PUSLINC CON 07(008)	17 564652 4817517 W	1964/01 2521	04 04	FR 0085	010 / 020 012 / 2:0	DO		6702448 () GRVL 0036 BRWN LMSN 0085
GUELPH CITY (PUSLINC CON 07(008)	17 565006 4817674 W	1964/02 2521	04 04	FR 0093	011 / 025 010 / 2:0	DO		6702451 () GRVL STNS 0040 BRWN LMSN 0093
GUELPH CITY (PUSLINC CON 07(008)	17 565055 4817518 W	1965/06 2521	04 04	FR 0094	011 / 040 010 / 2:0	DO		6702453 () GRVL STNS 0040 BRWN LMSN 0094
GUELPH CITY (PUSLINC CON 07(008)	17 565019 4817491 W	1955/02 2414	05 05	FR 0060	008 / 024 005 / :0	DO		6702455 () PRDG 0012 GRVL STNS 0032 BRWN LMSN 0085
GUELPH CITY (PUSLINC CON 07(008)	17 564962 4817482 W	1955/07 2411	04 04	FR 0116	016 / 020 010 / 1:0	DO		6702457 () GRVL BLDR 0040 LMSN 0117
GUELPH CITY (PUSLINC CON 07(008)	17 565015 4817571 W	1957/01 2521	04 04	FR 0093	012 / 022 010 / 1:0	DO		6702459 () GRVL 0044 GREY LMSN 0093
GUELPH CITY (PUSLINC CON 07(008)	17 565061 4817426 W	1958/06 2414	04 04	FR 0055	010 / 013 010 / 3:0	DO		6702462 () CLAY GRVL BLDR 0017 HPAN 0028 BRWN LMSN 0074
GUELPH CITY (PUSLINC CON 07(008)	17 564955 4817246 W	1958/11 2414	04 04	FR 0070	008 / 022 008 / 2:0	DO		6702464 () PRDG 0015 MSND CLAY 0028 BRWN LMSN 0087 BLCK LMSN 0090

TOWNSHIP CONCESSION (LOT)	UTM[1]	DATE[2] CNTR[3]	CASING DIA[4]	WATER[5,6] DETAIL	STAT LVL/PUMP LVL[7] RATE[8]/TIME HR:MIN	WATER USE[9]	SCREEN INFO[10]	WELL # (AUDIT#) WELL TAG # STATE[12] DEPTHS TO WHICH FORMATIONS EXTEND[5,11]
GUELPH CITY (PUSLINC CON 07(008)	17 565098 4817353 W	1959/03 2521	04 04	FR 0092	015 / 025 010 / 1:0	DO		6702466 () GRVL 0033 BRWN LMSN 0092
GUELPH CITY (PUSLINC CON 07(008)	17 565086 4817403 W	1960/06 2414	04 04	FR 0050	012 / 012 012 / 1:0	DO		6702468 () BRWN CLAY STNS 0033 BRWN LMSN 0073
GUELPH CITY (PUSLINC CON 07(008)	17 564982 4817814 W	1962/03 2414	04 04	FR 0058	010 / 045 010 / 0:30	DO		6702471 () LOAM 0002 BRWN CLAY GRVL 0034 GREY HPAN GRVL 0049 BRWN LMSN 0058
GUELPH CITY (PUSLINC CON 07(008)	17 565042 4817556 W	1961/02 2414	04 04	FR 0045	008 / 013 012 / 1:30	DO		6702442 () LOAM 0001 GRVL STNS 0023 BRWN CLAY GRVL 0035 BRWN LMSN 0100
GUELPH CITY (PUSLINC CON 07(009)	17 565110 4817335 W	1963/10 2521	04 04	FR 0087	016 / 075 004 / 1:0	DO		6702474 () PRDG 0015 GRVL 0031 GREY LMSN 0087
GUELPH CITY (PUSLINC CON 07(009)	17 565174 4817117 W	1964/08 2521	04 04	FR 0084	011 / 035 019 / 1:0	DO		6702475 () PRDG 0009 CLAY 0032 BRWN LMSN 0084
GUELPH CITY (PUSLINC CON 07(009)	17 565114 4817073 W	1970/06 1906	04	FR 0079	011 / 020 010 / 3:0	DO		6703726 () CLAY STNS 0021 GRVL 0025 GRVL CLAY 0034 GREY CLAY 0039 GRVL 0049 LMSN 0079
GUELPH CITY (PUSLINC CON 07(009)	17 565118 4817350 W	1958/08 2414	04 04	FR 0070	013 / 030 006 / :0	DO		6702478 () PRDG 0013 CLAY BLDR 0020 HPAN 0028 BRWN LMSN 0084
GUELPH CITY (PUSLINC CON 07(009)	17 565134 4817192 W	1958/09 2414	04 04	FR 0080	013 / 020 006 / :0	DO		6702477 () PRDG 0013 BLDR CLAY 0039 GRVL CLAY 0052 BRWN LMSN 0100
GUELPH CITY (PUSLINC CON 07(009)	17 565103 4817283 W	1963/10 2521	04 04	FR 0090	015 / 070 004 / 1:0	DO		6702473 () PRDG 0014 GRVL 0029 GREY LMSN 0090
GUELPH CITY (PUSLINC CON 07(009)	17 565116 4817360 W	1956/03 2521	04 04	FR 0119	008 / 008 008 / 2:0	DO		6702479 () GRVL STNS 0032 FSND 0051 GREY LMSN 0119
GUELPH CITY (PUSLINC CON 07(009)	17 565223 4817016 W	1959/05 2414	04 04	FR 0110	007 / 017 007 / 3:0	DO		6702476 () PRDG 0009 STNS GRVL 0021 BRWN CLAY 0043 HPAN GRVL 0051 BRWN LMSN 0117

TOWNSHIP CONCESSION (LOT)	UTM[1]	DATE [2] CNTR [3]	CASING DIA [4]	WATER[5,6] DETAIL	STAT LVL/PUMP LVL[7] RATE[8]/TIME HR:MIN	WATER USE[9]	SCREEN INFO[10]	WELL # (AUDIT#) WELL TAG # STATE[12] DEPTHS TO WHICH FORMATIONS EXTEND[5,11]
GUELPH CITY (PUSLINC CON 08(007)	17 565101 4818107 W	1965/08 1906	04 04	UK 0052 FR 0073 FR 0075	006 / 015 010 / 3:0	DO		6702625 () STNS GRVL CLAY 0042 BRWN LMSN 0073 BLCK LMSN 0075
GUELPH CITY (PUSLINC CON 08(007)	17 565155 4818094 W	1965/07 2521	04 04	FR 0072	007 / 045 012 / 2:0	DO		6702624 () GRVL STNS 0043 BRWN LMSN 0072
GUELPH CITY (PUSLINC CON 08(007)	17 565178 4818130 W	1964/12 1906	04 04	FR 0060	012 / 020 010 / 4:0	DO		6702618 () STNS CLAY 0015 CLAY GRVL 0040 BRWN LMSN 0060
GUELPH CITY (PUSLINC CON 08(007)	17 565032 4818147 W	1963/08 2521	04 04	FR 0103	018 / 065 008 / 3:0	DO		6702613 () CLAY BLDR 0058 BRWN LMSN 0103
GUELPH CITY (PUSLINC CON 08(007)	17 564934 4817959 W	1954/06 2414	04 04	FR		DO		6702596 () LOAM 0001 CLAY STNS 0051 BRWN LMSN 0086
GUELPH CITY (PUSLINC CON 08(007)	17 565148 4818150 W	1964/12 1906	04 04	FR 0054 FR 0072	013 / 025 010 / 5:0	DO		6702619 () CLAY STNS 0015 STNS GRVL CLAY 0049 BRWN LMSN 0072
GUELPH CITY (PUSLINC CON 08(007)	17 564916 4817983 W	1963/12 2521	04 04	FR 0102	010 / 040 010 / 2:0	DO		6702615 () GRVL STNS MSND 0067 BRWN LMSN 0102
GUELPH CITY (PUSLINC CON 08(007)	17 565064 4818101 W	1961/11 2414	04 04	FR 0112	009 / 060 008 / 1:0	DO		6702610 () CLAY BLDR STNS 0058 BRWN LMSN 0095 BLCK LMSN 0114
GUELPH CITY (PUSLINC CON 08(007)	17 564828 4818077 W	1953/09 2411	04	FR	007 / 010 010 / 2:0	DO		6702595 () GRVL 0060
GUELPH CITY (PUSLINC CON 08(008)	17 565059 4817715 W	1961/07 2414	04 04	FR 0060	015 / 040 006 / 2:30	DO		6702632 () LOAM 0001 STNS GRVL 0020 GREY CLAY GRVL 0034 HPAN 0038 BRWN LMSN 0060
GUELPH CITY (PUSLINC CON 08(008)	17 565109 4817674 W	1962/02 2414	05 05	FR 0082	016 / 035 015 / 3:30	ST DO		6702633 () LOAM 0002 STNS GRVL SILT 0018 BRWN CLAY GRVL 0030 BRWN CLAY BLDR 0032 BRWN HPAN GRVL 0046 BRWN LMSN 0095
GUELPH CITY (PUSLINC CON 08(008)	17 565006 4817777 W	1963/04 2414	04 04 04	FR 0088	010 / 040 007 / 2:30	CO		6702634 () LOAM 0001 BRWN CLAY STNS 0018 BRWN CLAY GRVL 0072 BRWN LMSN 0088

TOWNSHIP CONCESSION (LOT)	UTM[1]	DATE [2] CNTR [3]	CASING DIA [4]	WATER[5,6] DETAIL	STAT LVL/PUMP LVL[7] RATE[8]/TIME HR:MIN	WATER USE[9]	SCREEN INFO[10]	WELL # (AUDIT#) WELL TAG # STATE[12] DEPTHS TO WHICH FORMATIONS EXTEND[5,11]
GUELPH CITY (PUSLINC CON 08(008)	17 565020 4817766 W	1949/11 2414	06	FR 0022	009 / 013 010 / 2:0	CO DO		6702630 () PRDG 0008 GRVL 0019 CLAY 0021 GRVL 0022
GUELPH CITY (PUSLINC CON 08(008)	17 564970 4817865 W	1964/03 2521	04 04	FR 0101	021 / 080 004 / 1:0	ST DO		6702631 () GRVL 0049 BRWN LMSN 0101
GUELPH CITY (PUSLINC CON 08(008)	17 564955 4817873 W	1953/09 2521	04 04	FR 0100	010 / 025 010 / 0:30	DO		6702629 () CLAY 0010 GRVL 0045 MSND 0059 LMSN 0100
GUELPH CITY (PUSLINC CON 08(008)	17 565012 4817873 W	1958/09 2414	05 05	FR 0080	006 / 016 012 / 3:30	PS		6702597 () PRDG 0017 GRVL 0036 MSND HPAN 0048 BRWN LMSN 0100
GUELPH CITY (PUSLINC CON 08(008)	17 565028 4817812 W	1955/04 2414	04 04	FR 0052	001 / 025 015 / :0	DO		6702628 () FILL GRVL 0008 STNS CLAY 0052 BRWN LMSN 0086
GUELPH CITY (PUSLINC CON 08(009)	17 565204 4817214 W	1962/02 2414	05 05	FR 0118	019 / 060 008 / 2:30	ST DO		6702635 () BRWN FILL 0006 GRVL BLDR 0024 GREY CLAY STNS 0039 BRWN LMSN 0120 LMSN 0130
GUELPH CITY (PUSLINC (007)	17 565105 4818010 W	1995/10 2336	06 06	FR 0055	/ 090 004 / 1:30			6711871 (163121) BRWN CLAY GRVL 0020 GREY CLAY GRVL 0040 BRWN ROCK 0060 BRWN ROCK 0075 BRWN ROCK 0100
GUELPH CITY (PUSLINC ()	17 565056 4817346 W	2003/12 2336				NU		6714788 (Z01892) A
GUELPH CITY (PUSLINC ()	17 565072 4818151 W	1966/10 2406	04 04	FR 0120	021 / 080 008 / 1:0	DO		6700923 () BRWN CLAY STNS 0015 BRWN CLAY GRVL 0054 BRWN LMSN 0102 BLCK LMSN 0120
GUELPH CITY (PUSLINC ()	17 565063 4817293 W	2003/12 2336				NU		6714786 (Z01893) A
GUELPH CITY (PUSLINC ()	17 564964 4817316 W	1966/06 1906	04 04	FR 0076	010 / 040 015 / 8:0	DO		6700920 () STNS GRVL 0016 MSND 0030 GRVL CLAY 0036 LMSN 0076
GUELPH CITY (PUSLINC ()	17 564925 4817794 W	2003/11 2336				NU		6714757 (Z01889) A

TOWNSHIP CONCESSION (LOT)	UTM[1]	DATE [2] CNTR [3]	CASING DIA [4]	WATER[5,6] DETAIL	STAT LVL/PUMP LVL[7] RATE[8]/TIME HR:MIN	WATER USE[9]	SCREEN INFO[10]	WELL # (AUDIT#) WELL TAG # STATE[12] DEPTHS TO WHICH FORMATIONS EXTEND[5,11]
GUELPH CITY (PUSLINC ())	17 565137 4818048 W	1974/01 2336	05		013 / / 0:5			6704987 () BRWN LOAM 0002 BRWN GRVL CLAY SAND 0014 BRWN GRVL CLAY BLDR 0019 BRWN CLAY STNS 0020

Notes:
1. UTM in Zone, Easting, Northing and Datum is NAD83; L: UTM estimated from Centroid of Lot; W: UTM not from Lot Centroid
2. Date Work Completed
3. Well Contractor Licence Number
4. Casing diameter in inches
5. Unit of Depth in Feet
6. See Table 4 for Meaning of Code
7. STAT LVL: Static Water Level in Feet ; PUMP LVL: Water Level After Pumping in Feet
8. Pump Test Rate in GPM, Pump Test Duration in Hour : Minutes
9. See Table 3 for Meaning of Code
10. Screen Depth and Length in feet
11. See Table 1 and 2 for Meaning of Code
12. A: Abandonment; P: Partial Data Entry Only

1. Core Material and Descriptive terms

Code	Description	…	Code	Description	…	Code	Description	…	Code	Description	…	Code	Description
BLDR	BOULDERS		FCRD	FRACTURED		IRFM	IRON FORMATION		PORS	POROUS		SOFT	SOFT
BSLT	BASALT		FGRD	FINE-GRAINED		LIMY	LIMY		PRDG	PREVIOUSLY DUG		SPST	SOAPSTONE
CGRD	COARSE-GRAINED		FGVL	FINE GRAVEL		LMSN	LIMESTONE		PRDR	PREV. DRILLED		STKY	STICKY
CGVL	COARSE GRAVEL		FILL	FILL		LOAM	TOPSOIL		QRTZ	QUARTZITE		STNS	STONES
CHRT	CHERT		FLDS	FELDSPAR		LOOS	LOOSE		QSND	QUICKSAND		STNY	STONEY
CLAY	CLAY		FLNT	FLINT		LTCL	LIGHT-COLOURED		QTZ	QUARTZ		THIK	THICK
CLN	CLEAN		FOSS	FOSILIFEROUS		LYRD	LAYERED		ROCK	ROCK		THIN	THIN
CLYY	CLAYEY		FSND	FINE SAND		MARL	MARL		SAND	SAND		TILL	TILL
CMTD	CEMENTED		GNIS	GNEISS		MGRD	MEDIUM-GRAINED		SHLE	SHALE		UNKN	UNKNOWN TYPE
CONG	CONGLOMERATE		GRNT	GRANITE		MGVL	MEDIUM GRAVEL		SHLY	SHALY		VERY	VERY
CRYS	CRYSTALLINE		GRSN	GREENSTONE		MRBL	MARBLE		SHRP	SHARP		WBRG	WATER-BEARING
CSND	COARSE SAND		GRVL	GRAVEL		MSND	MEDIUM SAND		SHST	SCHIST		WDFR	WOOD FRAGMENTS
DKCL	DARK-COLOURED		GRWK	GREYWACKE		MUCK	MUCK		SILT	SILT		WTHD	WEATHERED
DLMT	DOLOMITE		GVLY	GRAVELLY		OBDN	OVERBURDEN		SLTE	SLATE			
DNSE	DENSE		GYPS	GYPSUM		PCKD	PACKED		SLTY	SILTY			
DRTY	DIRTY		HARD	HARD		PEAT	PEAT		SNDS	SANDSTONE			
DRY	DRY		HPAN	HARDPAN		PGVL	PEA GRAVEL		SNDY	SANDY			

2. Core Color

Code	Description
WHIT	WHITE
GREY	GREY
BLUE	BLUE
GREN	GREEN
YLLW	YELLOW
BRWN	BROWN
RED	RED
BLCK	BLACK
BLGY	BLUE-GREY

3. Water Use

Code	Description	Code	Description
DO	Domestic	OT	Other
ST	Livestock	TH	Test Hole
IR	Irrigation	DE	Dewatering
IN	Industrial	MO	Monitoring
CO	Commercial	MT	Monitoring & Test Hole
MN	Municipal		
PS	Public		
AC	Cooling And A/C		
NU	Not Used		

4. Water Detail

Code	Description	Code	Description
FR	Fresh	GS	Gas
SA	Salty	IR	Iron
SU	Sulphur		
MN	Mineral		
UK	Unknown		

Appendix 9 Photographs

Photo 1: Mini Piezometer MP-01-18, 12:21 (April 12, 2018).

Photo 2: Mini Piezometer MP-01-18, 13:07 (April 12, 2018).

Photo 3: SW01 discharge flow path along fence line, 13:08 (April 12, 2018).

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June 14, 2018