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REPORT ON

Hydrogeological Study
Proposed Development
Part of Lot 26, Concession 4
Geographic Township of Goulbourn
City of Ottawa (Richmond Village), Ontario

Submitted to:
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REPORT

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Table of Contents

1.0 INTRODUCTION 1
1.1 Technical Guidance Documents 1
2.0 SITE BACKGROUND 2
2.1 Site Description 2
2.2 Regional Geology and Hydrogeology 2
2.3 Regional Groundwater Quality 2
3.0 STUDY PROCEDURES 3
3.1 Groundwater Supply Investigation 3
3.1.1 Test Well Construction 3
3.1.2 Hydraulic Testing 3
3.2 Groundwater Quality Investigation 4
3.3 Neighbouring Well Survey 4
4.0 WATER SUPPLY INVESTIGATION 5
4.1 Groundwater Quantity 5
4.1.1 TW15-1 5
4.1.2 TW15-2 5
4.1.3 TW15-3 6
4.1.4 Hydraulic Testing Summary 7
4.2 Groundwater Quality 7
4.2.1 TW15-1 7
4.2.2 TW15-2 8
4.2.3 TW15-3 8
4.3 Neighbouring Well Survey 9
4.4 Summary of Water Supply Investigation 9
5.0 IMPACT ASSESSMENT 10
5.1 Hydrogeological Sensitivity 10
5.2 Mutual Well Interference 10
5.3 Water Quality Impacts 10

6.0 CONCLUSIONS AND RECOMMENDATIONS 11

6.1 Conclusions 11

6.2 Recommendations 11

7.0 LIMITATIONS AND USE OF REPORT 13

8.0 CLOSURE 14

9.0 REFERENCES 15

TABLES

Table 1: Water Quality Data (Discharge Samples)

Table 2: Water Quality Data (Field Parameters)

FIGURES

Figure 1: Key Plan

Figure 2: Site Plan

Figure 3: Surficial Geology

Figure 4: Bedrock Geology

Figure 5: Stratigraphic Cross-Section A-A'

APPENDICES

APPENDIX A
Curricula Vitae

APPENDIX B
Summary of MOECC Water Well Records

APPENDIX C
Test Well MOECC Well Records On-Site Borehole Records

APPENDIX D
Laboratory Reports of Analysis

APPENDIX E
Neighbouring Well Survey Forms

APPENDIX F
Hydraulic Testing Data and Analyses

APPENDIX G
Calculations: Well Interference and Langelier Saturations Index

1.0 INTRODUCTION

Golder Associates Ltd. (Golder Associates) carried out a hydrogeological investigation for a proposed residential subdivision located on part of Lot 26, Concession 4, geographic Township of Goulbourn, City of Ottawa (hereafter referred to as the "site") as shown on Figure 1.

The site consists of a parcel of land measuring 4.0 hectares in size which is to be subdivided into 59 residential lots with lot sizes of 0.04 to 0.07 hectares (see Figure 2). The site is to be serviced by individual wells. The lots will be connected to residential waste water services, and as such, an impact assessment for septic services has not been conducted.

This study does not address the construction of earth energy systems, which require a building permit and may require approval from the Ministry of the Environment and Climate Change (MOECC).

Curricula vitae for the report authors are included as Appendix A.

1.1 Technical Guidance Documents

This study was carried out according to the following MOECC guidance documents:

- Procedure D-5-5. Technical Guideline for Private Wells: Water Supply Assessment (August 1996); and,
- MOEE Hydrogeological Technical Information Requirements for Land Development Applications (TIR; April 1995).

Golder Associates also considered the relevant sections of the City of Ottawa Official Plan (2003, as amended). In particular, Policy 1 of Section 4.4.2 stipulates that:

1. *"Anywhere development is proposed on the basis of private individual services and requires an application for an Official Plan or Zoning By-law amendment or involves a plan of subdivision, plan of condominium, severance or site plan approval, the City will require sufficient information with the application to assess the likelihood that:*

    a. *Sufficient quantity of groundwater exists on site to service the development;*
    b. *A water well can be constructed on the proposed lot(s) that will not be impacted by identified potential sources of groundwater contamination in the area;*
    c. *The quality of the groundwater meets or exceeds the Ontario Drinking Water Standards, Objectives and Guidelines;*
    d. *The operation of the on-site wastewater system on the new lot(s) will not adversely impact on a well to be constructed on the proposed lot(s) and on the wells of neighbouring properties;*
    e. *The development is within the reserve capacity of the municipal sewage system for hauled sewage."*

    [Amendment #76, August 04, 2010]

This hydrogeological study addresses parts a), b) and c) of Policy 1. Parts d) and e) are not applicable at this site because the lots will be connected to the municipal sewer system.

2.0 SITE BACKGROUND

2.1 Site Description

The site is located on Shea Road, and is bounded to the north by agricultural land and to the south by a rural commercial zone. Land to the east is a development reserve zone. On the west side of Shea Road is an existing village residential zone. The site is former agricultural land. Based on information from the site owner, the site was not used for agriculture in 2015.

The site surficial and subsurface drainage is interpreted to follow the topography, toward the Flowing Creek municipal drain located northeast of the site (see Figures 1 and 2).

Based on published geology maps, the surficial geology at the site consists of glaciomarine silt and clay deposits with minor sand and gravel (see Figure 3). The bedrock at the site, and for at least 3,000 metres beyond the site in all directions, is mapped as the Oxford Formation dolostone (see Figure 4).

2.2 Regional Geology and Hydrogeology

The site is located within the Ottawa Valley Clay Plains physiographic region, which is characterized by clay plains interrupted by ridges of rock or sand (Chapman and Putnam, 1984). Regional groundwater flow is generally from southwest to northeast (MVC and RVCA, 2011).

The MOECC Water Well Information System (WWIS) was reviewed for water well records in the vicinity of the site. Water well records within 500 metres of the site for which the UTM reliability code was 6 or less (i.e., 300 metres or less) are plotted on Figure 3. The WWIS search yielded records for 124 water supply wells. One well was completed in overburden, 105 wells were completed in bedrock and well completion information was unavailable for the remaining 18 wells. The total well depths range from 9 to 83 metres. The depth to bedrock, where encountered in the wells, was from 2 to 40 metres. At most wells, water was found at depths of 30 metres or less; at seven wells, the shallowest water-bearing zone was encountered at a depth of 43 to 74 metres. Water quality noted in the well records was consistently fresh. A summary of key information from the WWIS records within 500 metres of the site is provided in Appendix B.

Figure 5 shows a northwest-to-southeast hydrogeological cross-section through the site based on water well records within 500 metres of the site and test wells and boreholes advanced for this study (Section 3.2). The cross-section location is indicated on Figure 3. The cross-section indicates that the surficial topsoil layer across the site is underlain by 7 to 12 metres of clay, a thin layer (0.2 to 0.7 metres) of glacial till (not noted by water well drillers), followed by limestone bedrock. Water well record 7209314 extended 12 metres deeper than the on-site wells and boreholes, and indicated that the limestone is underlain by sandstone.

2.3 Regional Groundwater Quality

In general, groundwater quality from private wells in the Oxford Formation within the Village of Richmond is considered to be potable. Elevated concentrations of iron, hardness (as is typical for carbonate aquifers), sodium, total dissolved solids (TDS) and hydrogen sulphide occur locally (Golder Associates, 2003). The elevated concentrations of TDS are typically within the range that can be treated by conventional water softening (assuming the elevated TDS is related to hardness).

3.0 STUDY PROCEDURES

The objectives of the hydrogeological investigation were to investigate the potential quantity and quality of groundwater that would be expected from water supply wells that are drilled on site.

3.1 Groundwater Supply Investigation

Procedures for the assessment of water supplies for developments with individual private wells are described in the MOECC Procedure D-5-5 (MOE, 1996a).

3.1.1 Test Well Construction

Three test wells (TW15-1, TW15-2 and TW15-3) were used to determine the quality and quantity of groundwater available for water supply within the development. The test wells were drilled by Capital Water Supply Ltd. in August 2015 using air rotary equipment. Annular space around the casing was sealed with grouted cement and bentonite. Well construction details from the well records are summarized in the following table, while test well locations are shown on Figure 2 and water well records for the test wells are provided in Appendix C.

Test Well	Total Well Depth (mbgs)	Depth to Bedrock (mbgs)	Casing Depth (mbgs)	Water Found Depth (mbgs)	Bedrock Type	Overburden Material
TW15-1	29.9	11.9	13.5	14.0, 29.3	Limestone	Clay
TW15-2	37.5	10.4	11.3	24.4, 33.5	Limestone	Clay and gravel
TW15-3	29.0	7.9	9.4	10.7, 29.0	Limestone	Clay

Notes: mbgs = metres below ground surface

The locations of test wells TW15-1, TW15-2 and TW15-3 were chosen to provide geographic coverage of the site.

3.1.2 Hydraulic Testing

Pumping tests were carried out at test wells TW15-1, TW15-2 and TW15-3 on September 11, September 10 and September 9, 2015, respectively. Each pumping test consisted of a pumping phase (6 hours in duration) followed by a recovery period (up to 50 minutes in duration). The pumping tests were conducted using a submersible pump. The approximate pumping test discharge locations are shown on Figure 2.

The initial pumping rate for each well was based upon driller's estimate of well yield. Groundwater levels were recorded in the pumping well and the other test wells (which were used as observation wells) at selected time intervals. Groundwater levels were also measured in monitoring wells installed in overburden geotechnical boreholes at the site. The water levels were measured manually, using an electric water level tape, and electronically, using pressure transducer loggers which were set to take measurements every minute. A barometric pressure logger was left on-site for post-processing barometric compensation.

Aquifer transmissivity was estimated using the Cooper and Jacob drawdown (Cooper and Jacob, 1946) and Theis recovery (Theis, 1935) methods. The assumptions on which these methods are based are generally applicable to the tests undertaken (in terms of site conditions and pumping test design), therefore, analysis by these methods provides a reasonable estimate of aquifer transmissivity (T) and storativity (S).

3.2 Groundwater Quality Investigation

During the pumping tests at test wells TW15-1, TW15-2 and TW15-3, samples of the pump discharge were collected after approximately 3 hours of pumping at a constant rate and at the end of the pumping period, just before pump shut-off (i.e. after approximately 6 hours of pumping at a constant rate). All samples were collected after testing indicated that no chlorine residual was present.

The samples were preserved as necessary and submitted to Exova for the chemical, physical and bacteriological analyses listed in the MOECC Procedure D-5-5 (MOE, 1996a). The results of these analyses are summarized in Table 1.

Field measurements of temperature, pH, conductivity, chlorine residual and turbidity were taken periodically during the pumping tests and at the time of sampling (Table 2). All analyses were compared to the applicable maximum acceptable concentrations (MAC), interim maximum acceptable concentrations (IMAC), or aesthetic objectives (AO) found in the Technical Support Document for Ontario Drinking Water Quality Standards, Objectives and Guidelines (MOE, 2006). All laboratory method detection limits (MDLs) were less than, or equivalent to, the respective criteria. Laboratory Reports of Analysis are provided in Appendix D.

3.3 Neighbouring Well Survey

An attempt was made to contact property owners in the immediate vicinity of the site, in order to carry out a well survey and/or collect a sample of their water well. Packages including an introductory letter, a well survey and a stamped return envelope were hand-delivered on September 11, 2015 to each of the 14 residences closest to the proposed development, listed in the following table.

3290 Shea Road	3338 Shea Road
4 Hemphill Street	1 Moore Street
3310 Shea Road	3354 Shea Road
3316 Shea Road	3360 Shea Road
3318 Shea Road	3366 Shea Road
3326 Shea Road	3372 Shea Road
3330 Shea Road	3378 Shea Road

As of the date of preparation of this report, only the survey delivered to 3316 Shea Road had been returned to Golder Associates. The residents of 3316 Shea Road declined to allow Golder Associates to collect a groundwater sample. Therefore, no sampling of nearby water wells was carried out.

The well survey consisted of the completion of a questionnaire with the homeowner. The information documented/requested in the questionnaire included: the location of the well with respect to the dwelling; the well type (i.e., drilled, bored, dug, etc.) and depth; evidence of any water quantity issues (i.e., any dry well events, water shortages during laundry or car-washing, etc.); and supplementary sources of water (i.e., purchased water, etc.). The completed questionnaire is included in Appendix E.

4.0 WATER SUPPLY INVESTIGATION

4.1 Groundwater Quantity

Pumping tests were carried out at test wells TW15-1, TW15-2 and TW15-3 between September 9 and 11, 2015. The results of the pumping tests are presented in the following sections. During each pumping test, the end of the discharge pipe was positioned an adequate distance from the pumping well to avoid ponding of the pumped groundwater in the vicinity of the pumping well (as indicated on Figure 2). The drawdown and recovery data and the associated analyses are presented in Appendix F.

Regional groundwater level data prior to the pumping tests was collected by installing dataloggers in test wells TW15-1, TW15-2 and TW15-3 on August 27, 2015. Following the completion of the pumping tests, the dataloggers were left in the test wells until retrieval on September 14, 2015. The groundwater level data recorded during this 19 day period is summarized in Figure 6, along with daily precipitation recorded by Environment Canada at the Ottawa Airport.

Figure 6 indicates a declining trend in groundwater levels between August 27 and September 7, 2015. An increasing trend was recorded from September 8 to 10, 2015. Groundwater levels were then generally steady until an increasing trend was recorded from September 12 to 14, 2015.

4.1.1 TW15-1

A pumping test was conducted at TW15-1 on September 11, 2015. The static water level before the start of the test was at 3.12 metres below the top of the casing. TW15-1 was pumped at a constant discharge rate of 31 L/min for 372 minutes (6.2 hours). A maximum drawdown of 0.05 metres was measured in the first minute of pumping; the water level subsequently increased by 0.08 metres before the end of pumping. The water level at the end of the test was higher than the static water level (see Figure F-1).

During the pumping test at TW15-1, water levels were measured in observation wells TW15-2 (manual and datalogger measurements) and TW15-3 (manual and datalogger measurements) (see Figure F-1). Water levels were also measured manually in monitoring wells installed in overburden geotechnical boreholes BH15-1 and BH15-2. At TW15-2 and TW15-3, the water levels increased by approximately 0.03 metres and 0.06 metres, respectively, during pumping at TW15-1. This is interpreted to represent a regional groundwater level increase unrelated to the pumping test. At BH15-1 and BH15-2, the water levels were unchanged during the test.

Due to the increasing water level at TW15-1 during the test, and the lack of response at the monitoring wells, aquifer transmissivity was not estimated using these data.

Based on the data obtained during the pumping test, it can be concluded that TW15-1 is capable of supplying at least 31 L/min. During the course of the six-hour pumping test period, less than one percent of the available drawdown was utilized while pumping at a rate of 31 L/min. As such, the yield of TW15-1 substantially exceeds the required minimum specified in MOECC Procedure D-5-5.

4.1.2 TW15-2

A pumping test was conducted at TW15-2 on September 10, 2015. The static water level before the start of the test was at 3.18 metres below the top of the casing. The pumping rate was maintained at a constant rate of 32 L/min for 374 minutes (6.2 hours). A drawdown of 5.0 metres was measured at the end of the test. Approximately 5 minutes after pump shut-off, 95 percent recovery of the imposed drawdown had been achieved (see Figure F-2).

During the pumping test at TW15-2, water levels were measured in observation wells TW15-1 (manual and datalogger measurements) and TW15-3 (manual and datalogger measurements) (see Figure F-2). Water levels were also measured manually in monitoring wells installed in overburden geotechnical boreholes BH15-1 and BH15-2. At TW15-1 and TW15-3, the water levels increased by approximately 0.01 metres and 0.02 metres, respectively, during pumping at TW15-2. This is interpreted to represent a regional groundwater level increase unrelated to the pumping test. At BH15-1 and BH15-2, the water levels fell by less than 0.01 metres during the test.

Aquifer transmissivity was estimated using the Cooper and Jacob drawdown (Cooper and Jacob, 1946) and Theis recovery (Theis, 1935) methods to interpret drawdown and recovery data collected during the pumping test at TW15-2 using the pumping data only (see Appendix F). Due to the negligible response to pumping at observation wells TW15-1 and TW15-3, observation well data were not analyzed. Based on pumping well data, the aquifer transmissivity is approximately $2x10^{-3}$ to $3x10^{-3}$ m^2/s.

Based on the data obtained during the pumping test, it can be concluded that TW15-2 is capable of supplying at least 32 L/min. During the course of the six-hour pumping test period, approximately 14 percent of the available drawdown was utilized while pumping at a rate of 32 L/min. As such, the yield of TW15-2 substantially exceeds the required minimum specified in MOECC Procedure D-5-5.

4.1.3 TW15-3

A pumping test was conducted at TW15-3 on September 9, 2015. The static water level before the start of the test was at 3.22 metres below the top of the casing. The pumping rate was maintained at a constant rate of 31 L/min for 366 minutes (6.1 hours). A drawdown of 0.5 metres was measured at the end of the test. Approximately 3 minutes after pump shut-off, 100 percent recovery of the imposed drawdown had been achieved (see Figure F-4).

During the pumping test at TW15-3, water levels were measured in observation wells TW15-1 (manual and datalogger measurements) and TW15-2 (manual and datalogger measurements) (see Figure F-4). Water levels were also measured manually in monitoring wells installed in overburden geotechnical boreholes BH15-1 and BH15-2. At TW15-1 and TW15-2, the water levels increased by approximately 0.03 metres and 0.04 metres, respectively, during pumping at TW15-3. (see Figure F-4). At BH15-1 and BH15-2, the water levels fell by less than 0.01 metres during the test.

Aquifer transmissivity was estimated using the Cooper and Jacob drawdown (Cooper and Jacob, 1946) and Theis recovery (Theis, 1935) methods to interpret drawdown and recovery data collected during the pumping test at TW15-3 using the pumping data only (see Appendix F). Due to the negligible response to pumping at observation wells TW15-1 and TW15-2, observation well data were not analyzed. Based on pumping well data, the aquifer transmissivity is indicated to be approximately $4x10^{-3}$ to $5x10^{-3}$ m^2/s.

Based on the data obtained during the pumping test, it can be concluded that TW15-3 is capable of supplying at least 31 L/min. During the course of the six-hour pumping test period, approximately 2 percent of the available drawdown was utilized while pumping at a rate of 31 L/min. As such, the yield of TW15-3 substantially exceeds the required minimum specified in MOECC Procedure D-5-5.

4.1.4 Hydraulic Testing Summary

The transmissivity values calculated using the drawdown and recovery data from the pumping wells are summarized in the following table:

Pumping Well	Pumping Rate (L/min)	Maximum Drawdown (m)	Transmissivity (m^2/s)	
			Drawdown Data	Recovery Data
TW15-1	31	0.05	Could not be calculated	Could not be calculated
TW15-2	32	5.0	$2x10^{-3}$	$3x10^{-3}$
TW15-3	31	0.5	$9x10^{-3}$	$4x10^{-3}$

Based on these results, it is interpreted that a transmissivity ranging from $2x10^{-3}$ to $9x10^{-3}$ m^2/s is representative of the bedrock aquifer in which the three wells were completed.

4.2 Groundwater Quality

The field observations and the results of the laboratory microbiological, chemical and physical analyses for the groundwater samples collected from the test wells in September 2015 are summarized in Table 1 following the text of this report. The certificates of laboratory analyses are included in Appendix D. Field measurements of temperature, pH, conductivity, chlorine residual and turbidity collected periodically during the pumping tests are presented in Table 2.

All laboratory results were compared to the applicable maximum acceptable concentrations (MAC), interim maximum acceptable concentrations (IMAC), aesthetic objectives (AO) and operational guidelines (OG) found in the Technical Support Document for Ontario Drinking Water Quality Standards (MOE, 2006).

It should be noted that the OG of 80 to 100 mg/L for hardness has been established to aid in water source selection where a choice is available. Hardness concentrations in groundwater, particularly from bedrock aquifers, rarely if ever fall within this range. Groundwater samples collected from the test wells in this hydrogeological investigation had hardness concentrations in excess of the OG, but less than 500 mg/L, the value at which a water supply is considered unacceptable for domestic purposes (MOE, 2006). Hardness can be removed using common water softening equipment.

4.2.1 TW15-1

Analytical results of the groundwater samples collected from TW15-1 on September 11, 2015 exceeded the MAC for total coliforms (2 cts/100 mL), and exceeded the AO for TDS (545 mg/L).

As stated in Guideline D-5-5, “for the purposes of the assessment described by this Guideline, Total Coliform counts of less than 6 per 100 ml of sample (and 0 for E. coli and fecal coliforms) shall be considered as indicative of acceptable water quality.” Under Guideline D-5-5, the total coliforms results at TW15-3 (2 ct/100mL) are acceptable. The bacteriological quality of the groundwater from TW15-1 is typical of recently drilled wells.

The TDS concentration of 545 mg/L measured in both samples was higher than the AO of 500 mg/L. The potential for corrosion or encrustation problems associated with elevated TDS was assessed by calculating the Langelier Saturation Indices (LSI) for the 3-hour and 6-hour samples, which were -0.26 and -0.28, respectively. These LSI values are within the range generally considered stable (between -0.5 and +0.5) and indicate that corrosion or encrustation problems are unlikely (see Appendix G).

In addition, the hardness concentration at TW15-1 was 144 mg/L after 3 hours of pumping and 144 mg/L after 6 hours of pumping; these concentrations were higher than the OG.

All of the other results of chemical analysis for TW15-1 were below the respective MACs, AOs and OGs (see Table 1).

4.2.2 TW15-2

Analytical results of the groundwater samples collected from TW15-2 on September 10, 2015 exceeded the AO for TDS.

The TDS concentrations of 577 mg/L and 571 mg/L measured in the 3-hour and 6-hour samples, respectively, were higher than the AO of 500 mg/L. The potential for corrosion or encrustation problems associated with elevated TDS was assessed by calculating the Langelier Saturation Indices (LSI) for the 3-hour and 6-hour samples, which were -0.14 and -0.21, respectively. These LSI values are within the range generally considered stable (between -0.5 and +0.5) and indicate that corrosion or encrustation problems are unlikely (see Appendix G).

In addition, the hardness concentration at TW15-2 was 195 mg/L after 3 hours of pumping and 195 mg/L after 6 hours of pumping; these concentrations were higher than the OG.

All of the other results of chemical analysis for TW15-2 were below the respective MACs, AOs and OGs (see Table 1).

4.2.3 TW15-3

Analytical results of the groundwater samples collected from TW15-3 on September 11, 2105 exceeded the AOs for colour and TDS.

The colour concentration of 6 TCU after 6 hours of pumping was higher than the AO of 5 TCU but below the maximum concentration considered reasonably treatable (7 TCU). In the sample collected after 3 hours of pumping, the colour concentration was 4 TCU, below the AO. Although the field measured turbidity decreased from 2.79 NTU to 1.16 NTU between the 3 hour and 6 hour samples, the laboratory measured turbidity increased from 0.9 NTU to 1.7 NTU. There were no other significant changes in the water quality between the 3 hour and 6 hour samples; therefore, it is possible that the minor increase in colour was due to the minor increase in turbidity in the laboratory samples and not due to any change in groundwater quality.

The TDS concentrations of 634 mg/L and 629 mg/L measured in the 3-hour and 6-hour samples, respectively, were higher than the AO of 500 mg/L. The potential for corrosion or encrustation problems associated with elevated TDS was assessed by calculating the Langelier Saturation Indices (LSI) for the 3-hour and 6-hour samples, which were 0.29 and 0.23, respectively. These LSI values are within the range generally considered stable (between -0.5 and +0.5) and indicate that corrosion or encrustation problems are unlikely (see Appendix G).

In addition, the hardness concentration at TW15-3 was 316 mg/L after 3 hours of pumping and 317 mg/L after 6 hours of pumping; these concentrations were higher than the OG.

All of the other results of chemical analysis for TW15-3 were below the respective MACs, AOs and OGs (see Table 1).

4.3 Neighbouring Well Survey

A copy of the well survey received as of the date of preparation of this report at one residence in the vicinity of the site is included in Appendix E. An attempt was made to identify the MOECC well record associated with this home. Based on the site location and well depth, it is likely that the well at 3316 Shea Road is associated with MOECC well ID 1509751 (Appendix B). This well is 47 years old and no details regarding the grouting of the well are available.

The well survey for 3316 Shea Road indicated that groundwater is used for drinking water. A water softener is in use at this home, and the homeowner rated their water quality as good. The homeowner reported no problems with water quantity.

Based on the results of the neighbouring well survey, no water quality or quantity issues were identified.

4.4 Summary of Water Supply Investigation

Based on the results of the pumping tests carried out by Golder Associates, the test wells are interpreted to be capable of yielding at least 18.8 L/min, as required by Procedure D-5-5.

Groundwater quality in the samples collected at the end of the pumping tests satisfied the ODWQS, with the exception of the total coliforms result at one well, the colour result at one well, and the TDS concentration at three wells. The colour result is below the level considered treatable, while the TDS concentration is not anticipated to cause corrosion or encrustation. Under Guideline D-5-5, the total coliforms results at TW15-1 (2 ct/100mL) are acceptable.

The geological and hydrogeological conditions encountered at the three test wells used in the investigation were generally consistent. The bedrock type noted in the MOECC well records for the test wells was consistently limestone, overlain by 7 to 12 metres of clay and a thin layer of glacial till. Well depths range from 29 to 37 mbgs and water-bearing zones were noted at depths from 11 to 34 mbgs. The test wells are interpreted to represent the range of potential geological and hydrogeological conditions that may be encountered across the site.

Water quality and water quantity were determined to be consistently adequate across the site. It is Golder Associates' opinion that the three test wells adequately represent groundwater supply conditions at the site, that the number, areal distribution, depths and design of test wells are technically justifiable, and that the test wells were located and constructed in such a way to permit the prediction of the quantity and quality of groundwater which domestic wells will supply in the future, if constructed in a similar manner to the test wells.

It is Golder Associates' professional opinion that the well yields and groundwater quality demonstrated by the pumping tests at TW15-1, TW15-2 and TW15-3 are representative of the long term yields and groundwater quality that the future residents of the subdivision are likely to obtain from wells constructed in a similar manner to the test wells.

5.0 IMPACT ASSESSMENT

5.1 Hydrogeological Sensitivity

The site is not considered hydrogeologically sensitive, as none of the following have been identified: karstic areas, areas of fractured bedrock exposed at surface, areas of thin soil cover, or areas of highly permeable soils. As discussed in Section 2.2, at least 7 metres of overburden was encountered in all site test wells and boreholes. The overburden material consisted of a combination of clay and glacial till.

5.2 Mutual Well Interference

The effect of potential mutual well interference resulting from the simultaneous pumping of all wells in the subdivision and the 14 closest existing residences on the west side of Shea Road was investigated by calculating the potential cumulative drawdown in a well drilled on Lot 17 which is centrally located within the subdivision. The cumulative drawdown was calculated using the Cooper and Jacob equation (Cooper and Jacob, 1946) with an aquifer transmissivity of $2x10^{-3}$ m^2/s (the lowest value calculated from the pumping test data), an assumed storativity of $1x10^{-4}$, a pumping rate of 2,250 L/day/household and a time of 20 years. Calculations are provided in Appendix G.

A cumulative potential drawdown of 1.1 metre was calculated. Assuming that the well in Lot 17 would have an available drawdown similar to those in test wells TW15-1, TW15-2 and TW15-3 (at least 20 metres), this level of cumulative drawdown is considered acceptable with respect to the total drawdown available to the well.

It is important to note that the method used to evaluate mutual well interference is considered conservative due to the lack of aquifer recharge in the calculation, the intermittent (rather than continuous) nature of domestic water use, and the fact that the average pumping rate would likely be considerably less than 2,250 L/day/household.

Mutual well interference (water quantity) between wells within the proposed development is not indicated to be a concern. In addition, interference with existing nearby wells is not expected to result in any significant reduction in the availability of groundwater to on-site or off-site wells

5.3 Water Quality Impacts

Golder Associates prepared a Phase One Environmental Site Assessment for the site (Golder Associates, 2015). Based on the information obtained as part of this Phase One ESA, no areas of potential environmental concern were identified on the Site or within the Study Area. As such, potential interference on water quality in the development from nearby sources of groundwater contamination is not anticipated.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Based on the hydrogeology investigation and impact assessment carried out by Golder Associates at the site, the following conclusions are provided:

a) Pumping tests conducted at test wells TW15-1, TW15-2 and TW15-3 indicate that a sufficient quantity of water is available in the bedrock to satisfy the required daily water consumption of 2,250 L/day for four-bedroom single family homes. It is Golder Associates' professional opinion that the well yields demonstrated by the pumping tests at TW15-1, TW15-2 and TW15-3 are representative of the long term yields that the future residents of the subdivision are likely to obtain from their wells;

b) The groundwater quality analyses of samples from test wells TW15-1, TW15-2 and TW15-3 indicate that the water quality meets applicable maximum acceptable concentrations (MAC), interim maximum acceptable concentrations (IMAC) and aesthetic objectives (AO) for the analyzed parameters, with the exception of the total coliforms result at one well, the colour result at one well, and the TDS concentration at three wells. The colour result is below the level considered treatable, while the TDS concentration is not anticipated to cause corrosion or encrustation. Under Guideline D-5-5, the total coliforms results at TW15-3 (2 ct/100mL) are acceptable. Common techniques for colour treatment include carbon filter treatment systems;

c) Mutual well interference (water quantity) between wells within the proposed development is not indicated to be a concern. In addition, interference with existing nearby wells is not expected to result in any significant reduction in the availability of groundwater to on-site or off-site wells;

d) One surveyed neighbouring well owner rated their water quality as good. The homeowner reported no problems with water quantity. Based on this neighbouring well survey, existing sources of adverse impacts to groundwater quality or quantity in the vicinity of the site have not been identified;

e) It is Golder Associates' professional opinion that the proposed development satisfies Policy 1 of Section 4.4.2 of the City of Ottawa Official Plan with respect to water supply wells; and,

f) The test wells used in the hydrogeological investigation may be used as domestic supply wells and do not require decommissioning.

6.2 Recommendations

Golder Associates also offers the following recommendations regarding groundwater supply wells at the site:

a) **Water Quality** – Future homeowners should be notified that treatment of the groundwater supply for colour may be desirable. They should also be notified of the following potential effects caused by natural groundwater quality or by water treatment equipment:

- The sodium concentration in groundwater samples at the site exceeded 20 mg/L. Accordingly, the Local Medical Officer of Health should be informed and individuals on sodium-restricted diets should consult their physicians before using the well water as a potable water source; and,
- Treating water for hardness using a conventional sodium ion exchange water softener may increase the sodium content of the water.

b) **Well Construction** – All residential water wells should be drilled through the overburden and completed in the limestone bedrock. All wells should be constructed by appropriately licensed contractors and well technicians as per O.Reg. 903.

Installed steel casings should be grouted as per O. Reg. 903. The material used to seal the annular space could consist of either a cement grout or a commercially available bentonite grout product. Cement grout mixtures should be allowed to set for a minimum two day period for normal cement or twelve hours for a high early strength cement prior to advancing the well further into bedrock. Non-shrink cement such as V-3 Grout, CDP Non-shrink Construction Grout (premixed), or similar non-shrink cement grouts are recommended. If a bentonite grout product is used, drilling need only be suspended for a few hours depending on the product used.

Once the casing has been sealed into bedrock, the well should be advanced uncased in the bedrock until a water supply of sufficient quantity and quality is encountered. The completed well should then be developed to maximize the yield and sampled to characterize groundwater quality. As per O.Reg. 903, the well casings should be completed at least 0.4 metres above finished ground surface and should be fitted with a pitless adapter to facilitate below ground plumbing and electrical connections. Surface grading should direct surface water away from the well.

c) **Artesian Wells** – There is a potential for water supply wells at the proposed development to be flowing wells. In accordance with O. Reg. 903, a flowing well should be instrumented with an appropriate device that controls the discharge of water from within the well casing, is capable of stopping the discharge of water from within the well casing, and is capable of withstanding the freezing of water in the well casing. The well should be constructed so as to prevent any uncontrolled flow of water from the well and prevent backflow of water into the well or well casing.

d) **Test Well Depths** – It should be noted that the water bearing zones in the limestone bedrock encountered in test wells TW15-1, TW15-2 and TW15-3 are between approximately 11 to 34 metres below ground surface at the site. Water quality below a depth of 34 metres has not been tested.

e) **Well Setbacks** – The MOECC has indicated that wells must be located a minimum separation distance of 15 metres from any source of contaminant, including sewer lines and laterals.

f) **Supervision of Well Installation** – It is recommended that the well casing installation be supervised by qualified professional engineer or professional geoscientist, or a person under the direction of a professional engineer or professional geoscientist, to ensure that wells are constructed in accordance with the requirements.

g) **Best Management Practices** – Homeowners should refer to the following website for information on Best Management Practices for water wells from the Ontario Ministry of Agriculture and Food: www.omafra.gov.on.ca/english/environment/bmp/well.htm;

h) **Well Decommissioning** – Any test wells that will not be used as a supply well for the subdivision should be decommissioned.

i) **Earth Energy Systems** – This study does not address the construction of earth energy systems, which require a building permit and may require approval from the MOECC.

7.0 LIMITATIONS AND USE OF REPORT

This report was prepared for the exclusive use of Cardel Homes. Should additional parties require reliance on this report, written authorization from Golder Associates Ltd. (Golder Associates) will be required. The report, which specifically includes all tables, figures and appendices is based on data and information collected during the site investigation conducted by Golder Associates and is based solely on the conditions of the property at the time of the field investigation, supplemented by historical information and data obtained by Golder Associates and others as described in this report.

The services performed as described in this report were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and geoscience professions currently practising under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

Any use which a third party makes of this report, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The findings and conclusions of this report are valid only as of the date of this report. If new information is discovered in future work, including excavations, borings, or other studies, Golder Associates should be requested to re-evaluate the findings of this report, and to provide amendments as required.

8.0 CLOSURE

We trust this report meets with your current requirements. If you have any questions regarding this report, please contact the undersigned.

GOLDER ASSOCIATES LTD.

Caitlin Cooke, M.Sc., P.Geo.
Hydrogeologist

Brian Byerley, M.Sc., P.Eng.
Senior Hydrogeologist/Principal

CAMC/BTB/sg

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9.0 REFERENCES

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WATER QUALITY DATA (DISCHARGE SAMPLES)

Parameter	Unit	ODWQS(169/03)-Health [2] [1]	ODWQS-AO [4] [3]	ODWQS-OG [6] [5]	TW15-01 11-Sep-2015 TW15-01-3	TW15-01 11-Sep-2015 TW15-01-06
Bacterial						
Escherichia coli	CFU/100mL	0 [7]	--	--	0	0
Total Coliform	CFU/100mL	0 [7]	--	--	**2**	**2**
General Chemistry						
Alkalinity (Total as CaCO3)	mg/l	--	--	500	229	226
Ammonia Nitrogen	mg/l	--	--	--	0.23	0.23
Chloride	mg/l	--	250	--	102	104
Chlorine, Total Residual (Field)	mg/l	--	--	--	0	0
Color	color unit	--	5	--	4	<2
Conductivity	uS/cm	--	--	--	839	839
Conductivity (Field)	uS/cm	--	--	--	747	769
Dissolved Organic Carbon	mg/l	--	5	--	1.8	1.1
Fluoride	mg/l	1.5	--	--	1.10	1.10
Hardness, Calcium Carbonate	mg/l	--	--	100	*144*	*144*
Hydrogen Sulphide, field measured (Field)	mg/l	--	0.05	--	0	0
Nitrate as N	mg/l	10	--	--	<0.10	<0.10
Nitrite as N	mg/l	1	--	--	<0.10	<0.10
Nitrogen, Organic	mg/l	--	--	0.15	<0.08	<0.08
Nitrogen, Total Kjeldahl	mg/l	--	--	--	0.2	0.2
pH	-	--	--	8.5	8.16	8.21
pH (Field)	-	--	--	8.5	7.75	7.73
Phosphorus, Total Orthophosphate, dissolved	mg/l	--	--	--	<0.2	<0.2
Sulfate	mg/l	--	500 [8]	--	40	40
Tannin & Lignin	mg/l	--	--	--	<0.1	<0.1
Temperature (Field)	deg c	--	15	--	12.2	12.2
Total Dissolved Solids	mg/l	--	500	--	545	545
Turbidity	NTU	--	5 [9]	-- [10]	2.2	0.8
Turbidity (Field)	NTU	--	5 [9]	-- [10]	2.15	0.47
Metals						
Aluminum, dissolved	mg/l	--	--	0.1	0.01	<0.01
Antimony, dissolved	mg/l	0.006	--	--	<0.0005	<0.0005
Arsenic, dissolved	mg/l	0.025	--	--	0.001	0.001
Barium, dissolved	mg/l	1	--	--	0.06	0.06
Beryllium, dissolved	mg/l	--	--	--	<0.0005	<0.0005
Boron, dissolved	mg/l	5	--	--	0.37	0.36
Cadmium, dissolved	mg/l	0.005	--	--	<0.0001	<0.0001
Calcium	mg/l	--	--	--	28	28
Chromium, dissolved	mg/l	0.05	--	--	<0.001	<0.001
Copper, dissolved	mg/l	--	1	--	<0.001	<0.001
Iron, dissolved	mg/l	--	0.3	--	0.27	0.13
Lead, dissolved	mg/l	0.01	--	--	<0.001	<0.001
Magnesium	mg/l	--	--	--	18	18
Manganese, dissolved	mg/l	--	0.05	--	<0.01	<0.01
Mercury, dissolved	mg/l	0.001	--	--	<0.0001	<0.0001
Molybdenum, dissolved	mg/l	--	--	--	<0.005	<0.005
Nickel, dissolved	mg/l	--	--	--	<0.005	<0.005
Potassium	mg/l	--	--	--	7	7
Selenium, dissolved	mg/l	0.01	--	--	<0.001	<0.001
Silver, dissolved	mg/l	--	--	--	<0.0001	<0.0001
Sodium	mg/l	--	200 [11]	--	121	123
Strontium, dissolved	mg/l	--	--	--	3.98	3.97
Thallium, dissolved	mg/l	--	--	--	<0.0001	<0.0001
Uranium, dissolved	mg/l	0.02	--	--	<0.001	<0.001
Zinc, dissolved	mg/l	--	5	--	<0.01	<0.01
Phenols						
Phenolics, Total Recoverable	mg/l	--	--	--	<0.001	<0.001

WATER QUALITY DATA (DISCHARGE SAMPLES)

Parameter	Unit	[2] [1] ODWQS(169/03)-Health	[4] [3] ODWQS-AO	[6] [5] ODWQS-OG	TW15-02 10-Sep-2015 TW15-02-3	TW15-02 10-Sep-2015 TW15-02-6
Bacterial						
Escherichia coli	CFU/100m	0 [7]	--	--	0	0
Total Coliform	CFU/100m	0 [7]	--	--	0	0
General Chemistry						
Alkalinity (Total as CaCO3)	mg/l	--	--	500	244	251
Ammonia Nitrogen	mg/l	--	--	--	0.251	0.203
Chloride	mg/l	--	250	--	108	105
Chlorine, Total Residual (Field)	mg/l	--	--	--	0	0
Color	color unit	--	5	--	<2	<2
Conductivity	uS/cm	--	--	--	887	879
Conductivity (Field)	uS/cm	--	--	--	774	759
Dissolved Organic Carbon	mg/l	--	5	--	0.7	<0.5
Fluoride	mg/l	1.5	--	--	0.91	0.91
Hardness, Calcium Carbonate	mg/l	--	--	100	*195*	*195*
Hydrogen Sulphide, field measured (Field)	mg/l	--	0.05	--	0	0
Nitrate as N	mg/l	10	--	--	<0.10	<0.10
Nitrite as N	mg/l	1	--	--	<0.10	<0.10
Nitrogen, Organic	mg/l	--	--	0.15	<0.08	<0.08
Nitrogen, Total Kjeldahl	mg/l	--	--	--	0.29	0.25
pH	-	--	--	8.5	8.24	8.18
pH (Field)	-	--	--	8.5	7.67	7.61
Phosphate, dissolved	mg/l	--	--	--	<0.03	<0.03
Sulfate	mg/l	--	500 [8]	--	45	45
Tannin & Lignin	mg/l	--	--	--	6.4	0.1
Temperature (Field)	deg c	--	15	--	13.0	12.0
Total Dissolved Solids	mg/l	--	500	--	577	571
Turbidity	NTU	--	5 [9]	-- [10]	1.1	1.2
Turbidity (Field)	NTU	--	5 [9]	-- [10]	1.81	0.47
Metals						
Aluminum, dissolved	mg/l	--	--	0.1	<0.01	<0.01
Antimony, dissolved	mg/l	0.006	--	--	<0.0005	<0.0005
Arsenic, dissolved	mg/l	0.025	--	--	<0.001	<0.001
Barium, dissolved	mg/l	1	--	--	0.07	0.07
Beryllium, dissolved	mg/l	--	--	--	<0.0005	<0.0005
Boron, dissolved	mg/l	5	--	--	0.38	0.39
Cadmium, dissolved	mg/l	0.005	--	--	<0.0001	<0.0001
Calcium	mg/l	--	--	--	40	40
Chromium, dissolved	mg/l	0.05	--	--	<0.001	<0.001
Copper, dissolved	mg/l	--	1	--	<0.001	<0.001
Iron, dissolved	mg/l	--	0.3	--	0.19	0.16
Lead, dissolved	mg/l	0.01	--	--	<0.001	<0.001
Magnesium	mg/l	--	--	--	23	23
Manganese, dissolved	mg/l	--	0.05	--	0.01	<0.01
Mercury, dissolved	mg/l	0.001	--	--	<0.0001	<0.0001
Molybdenum, dissolved	mg/l	--	--	--	<0.005	<0.005
Nickel, dissolved	mg/l	--	--	--	<0.005	<0.005
Potassium	mg/l	--	--	--	6	6
Selenium, dissolved	mg/l	0.01	--	--	<0.001	<0.001
Silver, dissolved	mg/l	--	--	--	<0.0001	<0.0001
Sodium	mg/l	--	200 [11]	--	115	113
Strontium, dissolved	mg/l	--	--	--	3.93	3.88
Thallium, dissolved	mg/l	--	--	--	<0.0001	<0.0001
Uranium, dissolved	mg/l	0.02	--	--	<0.001	<0.001
Zinc, dissolved	mg/l	--	5	--	<0.01	<0.01
Phenols						
Phenolics, Total Recoverable	mg/l	--	--	--	<0.002	<0.002

WATER QUALITY DATA (DISCHARGE SAMPLES)

Parameter	Unit	[2] [1] ODWQS(169/03)-Health	[4] [3] ODWQS-AO	[6] [5] ODWQS-OG	TW15-03 09-Sep-2015 TW15-03-3	TW15-03 09-Sep-2015 TW15-03-6
Bacterial						
Escherichia coli	CFU/100mL	0 [7]	--	--	0	0
Total Coliform	CFU/100mL	0 [7]	--	--	0	0
General Chemistry						
Alkalinity (Total as CaCO3)	mg/l	--	--	500	265	268
Ammonia Nitrogen	mg/l	--	--	--	0.235	0.207
Chloride	mg/l	--	250	--	122	118
Chlorine, Total Residual (Field)	mg/l	--	--	--	0	0
Color	color unit	--	5	--	4	6
Conductivity	uS/cm	--	--	--	975	967
Conductivity (Field)	uS/cm	--	--	--	854	839
Dissolved Organic Carbon	mg/l	--	5	--	1.1	1.0
Fluoride	mg/l	1.5	--	--	0.59	0.59
Hardness, Calcium Carbonate	mg/l	--	--	100	*316*	*317*
Hydrogen Sulphide, field measured (Field)	mg/l	--	0.05	--	0	0
Nitrate as N	mg/l	10	--	--	<0.10	<0.10
Nitrite as N	mg/l	1	--	--	<0.10	<0.10
Nitrogen, Organic	mg/l	--	--	0.15	0.13	0.08
Nitrogen, Total Kjeldahl	mg/l	--	--	--	0.36	0.29
pH	-	--	--	8.5	8.18	8.13
pH (Field)	-	--	--	8.5	7.82	7.76
Phosphate, dissolved	mg/l	--	--	--	<0.03	<0.03
Sulfate	mg/l	--	500 [8]	--	63	61
Tannin & Lignin	mg/l	--	--	--	0.2	0.2
Temperature (Field)	deg c	--	15	--	12.6	13.0
Total Dissolved Solids	mg/l	--	500	--	634	629
Turbidity	NTU	--	5 [9]	-- [10]	0.9	1.7
Turbidity (Field)	NTU	--	5 [9]	-- [10]	2.79	1.16
Metals						
Aluminum, dissolved	mg/l	--	--	0.1	<0.01	<0.01
Antimony, dissolved	mg/l	0.006	--	--	<0.0005	<0.0005
Arsenic, dissolved	mg/l	0.025	--	--	0.001	0.001
Barium, dissolved	mg/l	1	--	--	0.07	0.07
Beryllium, dissolved	mg/l	--	--	--	<0.0005	<0.0005
Boron, dissolved	mg/l	5	--	--	0.20	0.20
Cadmium, dissolved	mg/l	0.005	--	--	<0.0001	<0.0001
Calcium	mg/l	--	--	--	72	71
Chromium, dissolved	mg/l	0.05	--	--	<0.001	<0.001
Copper, dissolved	mg/l	--	1	--	<0.001	<0.001
Iron, dissolved	mg/l	--	0.3	--	0.22	0.22
Lead, dissolved	mg/l	0.01	--	--	<0.001	<0.001
Magnesium	mg/l	--	--	--	33	34
Manganese, dissolved	mg/l	--	0.05	--	<0.01	<0.01
Mercury, dissolved	mg/l	0.001	--	--	<0.0001	<0.0001
Molybdenum, dissolved	mg/l	--	--	--	<0.005	<0.005
Nickel, dissolved	mg/l	--	--	--	<0.005	<0.005
Potassium	mg/l	--	--	--	6	6
Selenium, dissolved	mg/l	0.01	--	--	<0.001	<0.001
Silver, dissolved	mg/l	--	--	--	<0.0001	<0.0001
Sodium	mg/l	--	200 [11]	--	90	88
Strontium, dissolved	mg/l	--	--	--	2.25	2.17
Thallium, dissolved	mg/l	--	--	--	<0.0001	<0.0001
Uranium, dissolved	mg/l	0.02	--	--	0.001	0.001
Zinc, dissolved	mg/l	--	5	--	<0.01	<0.01
Phenols						
Phenolics, Total Recoverable	mg/l	--	--	--	<0.002	<0.002

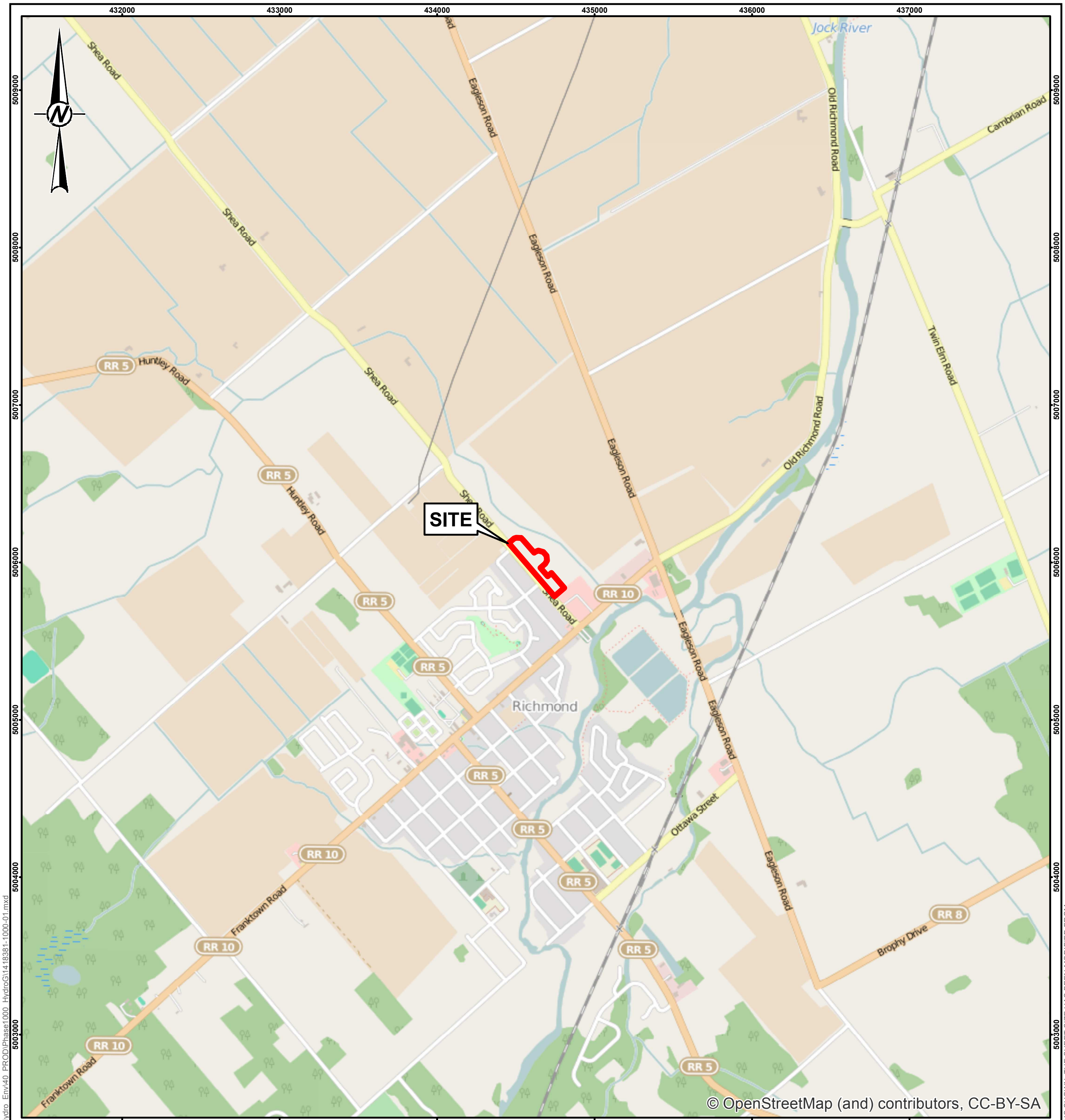
Footnotes:
Tables should be read in conjunction with the accompanying document.
< value = Indicates parameter not detected above laboratory method detection limit.
> value = Indicates parameter detected above equipment analytical range.
-- Chemical not analyzed or criteria not defined.
Grey background indicates exceedances.
(1) Ontario Drinking Water Quality Standards - Health Based Standards (June 2003, revised June 2006).
(2) Bold Font = Parameter concentration greater than ODWQS(169/03)-Health
(3) Ontario Drinking Water Quality Standards - Aesthetic Objectives. Aesthetic Objectives are established for parameters that may impair the taste, odour or colour of water or which may interfere with good water quality control practices. For certain parameters, both aesthetic objectives and health-related MACs have been derived (June 2003, revised June 2006).
(4) Underlined Font = Parameter concentration greater than ODWQS-AO
(5) Ontario Drinking Water Quality Standards - Operational Guidelines. Operational Guidelines are established for parameters that, if not controlled, may negatively affect the efficient and effective treatment, disinfection and distribution of the water (June 2003, revised June 2006).
(6) Italic Font = Parameter concentration greater than ODWQS-OG
(7) Reporting units and Guideline units are not convertible into each other.
(8) There may be a laxative effect in some individuals when sulphate levels exceed 500 mg/L.
(9) Applicable for all waters at the point of consumption.
(10) The Operational Guidelines for filtration processes are provided as performance criteria in the Procedure for Disinfection of Drinking Water in Ontario.
(11) The aesthetic objective for sodium in drinking water is 200 mg/L. The local Medical Officer of Health should be notified when the sodium concentration exceeds 20 mg/L so that this information may be communicated to local physicians for their use with patients on sodium restricted diets.

WATER QUALITY DATA (FIELD PARAMETERS)

Test Well	Date	Time (min)	pH	Temp (°C)	Cond (µs/cm)	Turb (ntu)	Hydrogen Sulphide (mg/L)	Free Chlorine (mg/L)	Sample
TW15-1	11-Sep-15	8:59	7.51	12.3	736	1.68	0	0	
TW15-1	11-Sep-15	9:44	7.70	12.6	746	2.06	0	0	
TW15-1	11-Sep-15	10:42	7.68	12.7	772	2.49	0	0	
TW15-1	11-Sep-15	11:12	7.75	12.2	747	2.16	0	0	TW15-01-3hr
TW15-1	11-Sep-15	12:04	7.71	11.9	742	1.97	0	0	
TW15-1	11-Sep-15	13:24	7.61	12.5	727	0.73	0	0	
TW15-1	11-Sep-15	14:08	7.73	12.2	769	0.50	0	0	TW15-01-6hr

Test Well	Date	Time (min)	pH	Temp (°C)	Cond (µs/cm)	Turb (ntu)	Hydrogen Sulphide (mg/L)	Free Chlorine (mg/L)	Sample
TW15-2	10-Sep-15	9:47	7.59	13.0	775	1.70	0	0	
TW15-2	10-Sep-15	10:10	7.68	12.5	775	1.77	0	0	
TW15-2	10-Sep-15	11:15	7.67	13.0	774	1.79	0	0	TW15-02-3hr
TW15-2	10-Sep-15	12:15	7.63	13.5	762	0.46	0	0	
TW15-2	10-Sep-15	13:20	7.69	12.6	767	0.45	0	0	
TW15-2	10-Sep-15	14:15	7.61	12.0	759	0.48	0	0	TW15-02-6hr

Test Well	Date	Time (min)	pH	Temp (°C)	Cond (µs/cm)	Turb (ntu)	Hydrogen Sulphide (mg/L)	Free Chlorine (mg/L)	Sample
TW15-3	9-Sep-15	9:25	8.21	12.9	860	2.63	not measured	not measured	
TW15-3	9-Sep-15	10:45	7.90	12.6	855	3.02	0	0	
TW15-3	9-Sep-15	11:20	7.82	12.6	854	2.64	0	0	TW15-03-3hr
TW15-3	9-Sep-15	12:17	7.76	13.3	851	1.40	0	0	
TW15-3	9-Sep-15	13:12	7.71	13.8	840	1.12	not measured	not measured	
TW15-3	9-Sep-15	14:20	7.76	13.0	839	1.16	0	0	TW15-03-6hr



DRAFT

0 350 700 1,400

1:35,000 METRES

NOTE(S)

1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1418381-1000

REFERENCE(S)

1. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 18 VERTICAL DATUM: CGVD28

CLIENT
CARDEL HOMES

PROJECT
SHEA ROAD DEVELOPMENT
RICHMOND (CITY OF OTTAWA), ONTARIO

TITLE
KEY PLAN

CONSULTANT

Golder Associates

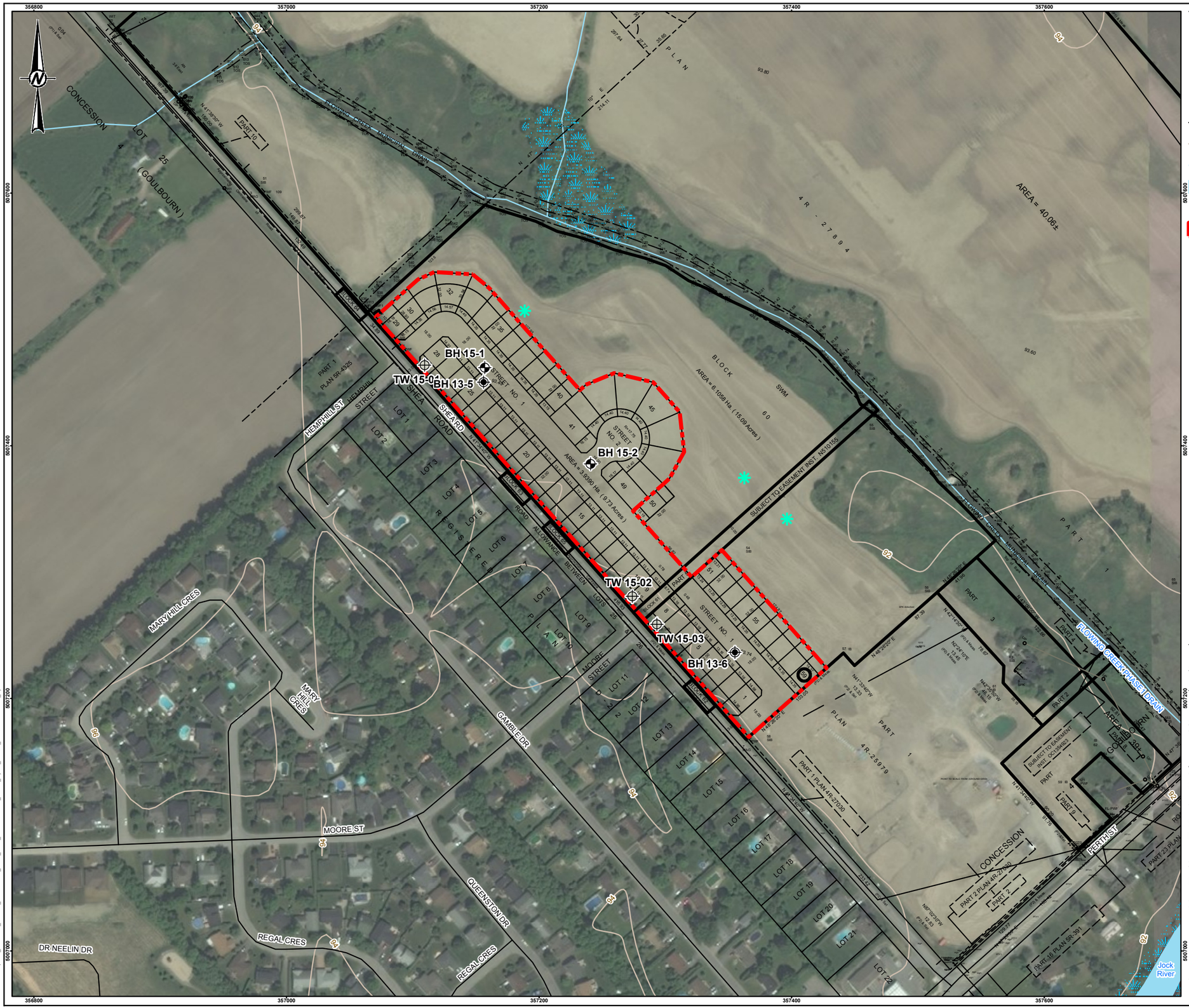
YYYY-MM-DD	2015-09-15
DESIGNED	----
PREPARED	JEM
REVIEWED	CAMC
APPROVED	BTB

PROJECT NO.	PHASE	REV.	FIGURE
1418381	1000	0	1

Path: N:\Active\Spatial_IM\Cardel_Custom_Homes\5873_Perth_St\99_PROJ\1418381_Cardel_Hydro_Env\40_PROD\Phase1000_HydroG\1418381-1000-01.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

25mm



LEGEND

- PUMPING TEST DISCHARGE LOCATION
- APPROXIMATE BOREHOLE LOCATION
- APPROXIMATE TEST WELL LOCATION
- APPROXIMATE BOREHOLE LOCATION, BY OTHERS
- ROADWAY
- TOPOGRAPHIC CONTOUR, 2 m
- WATERCOURSE
- WATERBODY
- WETLAND
- SITE

DRAFT

0 30 60 120
1:3,000 METRES

NOTE(S)
1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1418381-1000

REFERENCE(S)
1. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2014
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 18 VERTICAL DATUM: CGVD28

CLIENT
CARDEL HOMES

PROJECT
SHEA ROAD DEVELOPMENT
RICHMOND (CITY OF OTTAWA), ONTARIO

TITLE
SITE PLAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-09-15
DESIGNED	----
PREPARED	JEM
REVIEWED	CAMC
APPROVED	BTB

PROJECT NO.	PHASE	REV.	MAP
1418381	1000	0	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 0 25mm

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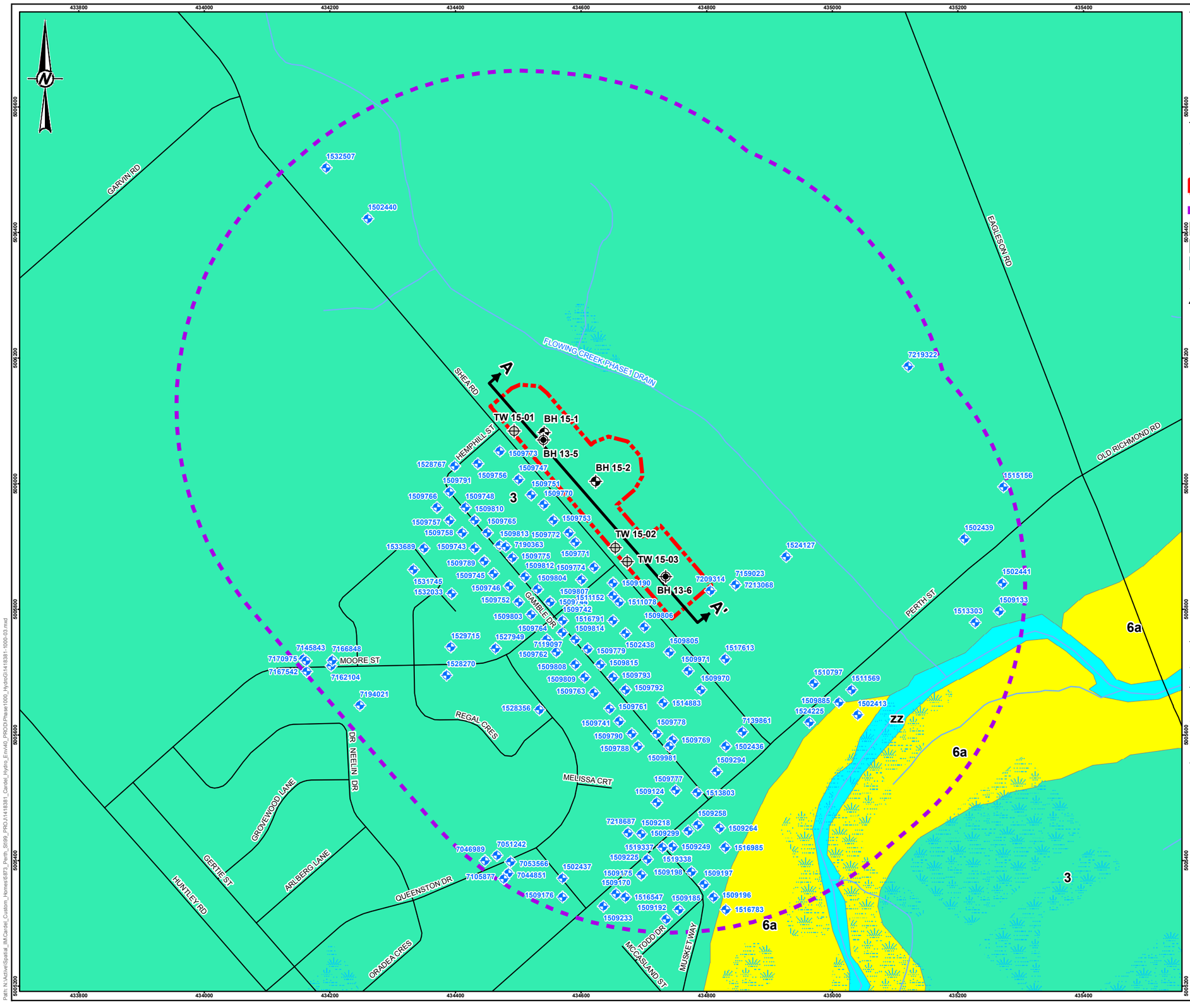

LEGEND

✦	MOECC LISTED WATER WELL
⊕	APPROXIMATE BOREHOLE LOCATION
⊕	APPROXIMATE TEST WELL LOCATION
⊕	APPROXIMATE BOREHOLE LOCATION, BY OTHERS
—	ROADWAY
—	WATERCOURSE
▨	WETLAND
🟥	SITE
🟪	500 m FROM SITE BOUNDARY
🟨	6a: ALLUVIAL DEPOSITS: SILTY SAND, SILT, SAND & CLAY
🟩	3. OFFSHORE MARINE DEPOSITS: CLAY, SILTY CLAY & SILT
🟦	zz. WATERBODY
A A'	CROSS-SECTION LOCATION (SEE FIGURE 5 FOR CROSS-SECTION DETAILS)

DRAFT

0 60 120 240

1:6,000 METRES

NOTE(S)

1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1418381-1000

REFERENCE(S)

1. BÉLANGER, J. R. 2008 URBAN GEOLOGY OF THE NATIONAL CAPITAL AREA, GEOLOGICAL SURVEY OF CANADA, OPEN FILE 5311, 1 DVD.
2. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2014
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18 VERTICAL DATUM: CGVD28

CLIENT
CARDEL HOMES

PROJECT
SHEA ROAD DEVELOPMENT
RICHMOND (CITY OF OTTAWA), ONTARIO

TITLE
SURFICIAL GEOLOGY

CONSULTANT

Golder Associates

YYYY-MM-DD	2015-09-15
DESIGNED	----
PREPARED	JEM
REVIEWED	CAMC
APPROVED	BTB

PROJECT NO.	PHASE	REV.	MAP
1418381	1000	0	3

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

25mm

0

LEGEND

- 🔹 MOECC LISTED WATER WELL
- ⊕ APPROXIMATE BOREHOLE LOCATION
- ⊕ APPROXIMATE TEST WELL LOCATION
- ⊕ APPROXIMATE BOREHOLE LOCATION, BY OTHERS
- — ROADWAY
- — WATERCOURSE
- ▨ WETLAND
- ▨ WATERBODY
- ⬚ SITE
- ⬚ 500 m FROM SITE BOUNDARY
- 🟦 5: OXFORD FORMATION - DOLOSTONE, MINOR SHALE AND SANDSTONE

DRAFT

0 60 120 240

1:6,000 METRES

NOTE(S)

1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1418381-1000

REFERENCE(S)

1. ARMSTRONG, D.K. AND DODGE, J.E.P. 2007. PALEOZOIC GEOLOGY OF SOUTHERN ONTARIO; ONTARIO GEOLOGICAL SURVEY, MISCELLANEOUS RELEASE--DATA 219
2. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2014
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18 VERTICAL DATUM: CGVD28

CLIENT
CARDEL HOMES

PROJECT
SHEA ROAD DEVELOPMENT
RICHMOND (CITY OF OTTAWA), ONTARIO

TITLE
BEDROCK GEOLOGY

CONSULTANT
Golder Associates

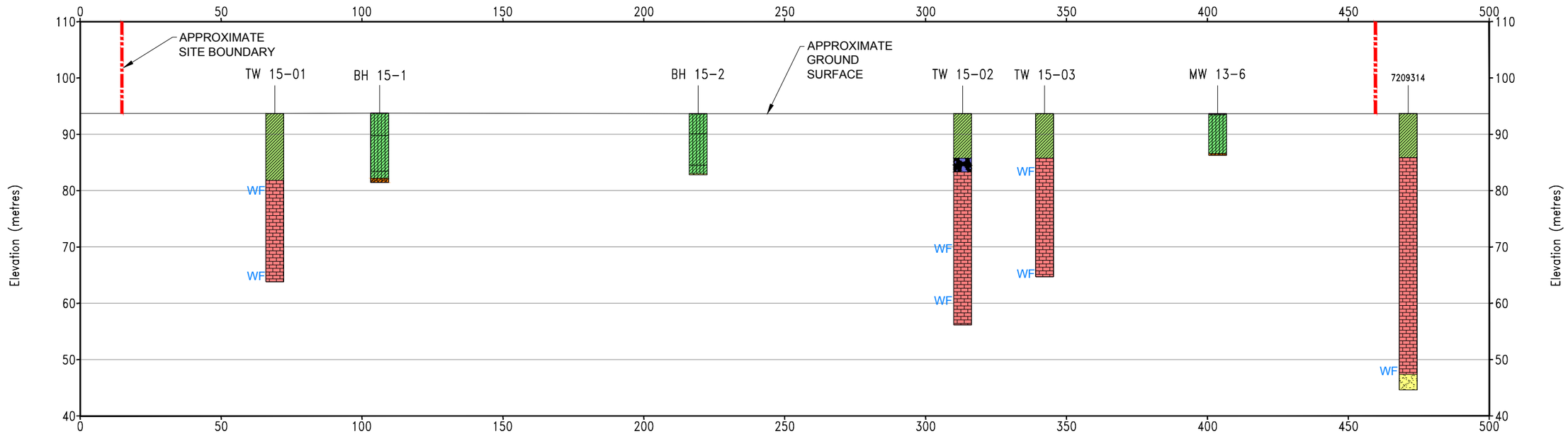
YYYY-MM-DD	2015-09-15
DESIGNED	----
PREPARED	JEM
REVIEWED	CAMC
APPROVED	BTB

PROJECT NO.	PHASE	REV.	MAP
1418381	1000	0	4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
25mm
0

A

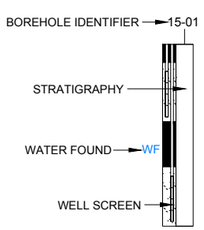
A'



Distance Along Baseline (metres)

LEGEND

- CLAY
- LIMESTONE
- SANDSTONE
- TOPSOIL
- SILTY CLAY
- BROKEN ROCK
- SILTY SAND
- GLACIAL TILL



NOTE(S)

FOR DETAILED SOIL STRATIGRAPHY AND OR GROUNDWATER CONDITIONS, REFER TO RECORD OF BOREHOLE SHEETS

SEE FIGURE 3 FOR CROSS-SECTION LOCATIONS

THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1418381-1000.

DRAFT

0 12.5 25
1:750 VERTICAL METRES

0 25 50
1:1,500 HORIZONTAL METRES

CLIENT
CARDEL HOMES

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-09-16
DESIGNED	----
PREPARED	JEM
REVIEWED	CAMC
APPROVED	BTB

PROJECT
SHEA ROAD DEVELOPMENT
RICHMOND (CITY OF OTTAWA), ONTARIO

TITLE
STRATIGRAPHIC CROSS-SECTION A-A'

PROJECT NO.	PHASE	REV.	FIGURE
1418381	1000	0	5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25 mm

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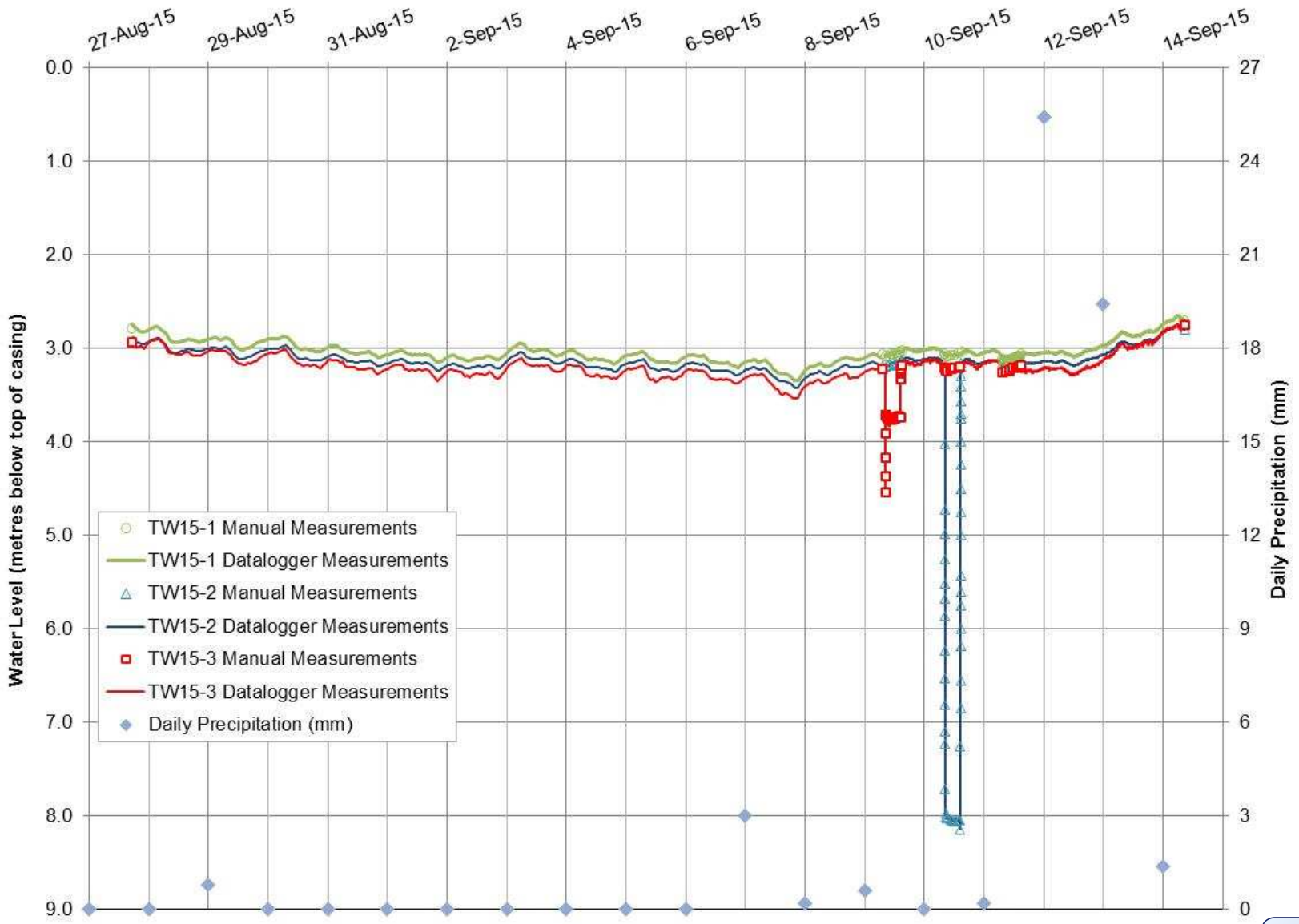


DRAFT

Golder Associates	Date: October 2015 Drawn: CAMC Project: 1418381-1000 Chkd: BTB	Water Level Measurements at Test Wells Before, During and After the Pumping Tests	FIGURE 6

APPENDIX A

Curricula Vitae

Education

M.Sc. Earth Sciences-Hydrogeology Option, University of Waterloo, Waterloo, Ontario, 1995

B.Sc. Geological Engineering , Queen's University, Kingston, Ontario, 1989

Certifications

Registered Professional Engineer, Ontario, 1997

Golder Associates Ltd. – Ottawa

Career Summary

Brian Byerley has over 23 years of experience as a hydrogeologist, geophysicist and project manager. Brian has been involved in a wide range of environmental engineering and hydrogeology projects involving construction dewatering for sewers, watermains and other infrastructure; landfill investigations and monitoring; water supply assessments and investigations; source water protection; contaminant site investigations; and Class Environmental Assessments. He is skilled in the evaluation of contaminant and physical hydrogeological information and the development of hydrogeological conceptual models. He is experienced in the areas of pump test design and analysis, geochemical, groundwater and landfill modeling. He has significant experience with the Ontario Permit to Take Water program and has obtained Environmental Compliance Approvals for landfills and sewage works. He is an experienced public presenter, possessing the necessary combination of technical and public communication skills. Brian has provided peer review services for a number of municipalities and conservation authorities and has provided expert witness testimony as a hydrogeologist to the Ontario Municipal Board.

Employment History

Golder Associates Ltd. – Ottawa, Ontario

Hydrogeologist then Associate (2003) and Principal (2012) (1996 to Present)

Involved in groundwater resources studies; construction dewatering projects; wellhead protection studies; on-site sewage system investigations; landfill groundwater, surface water and gas investigations; contaminant site investigations; contaminated site monitoring; and, remediation programs as a hydrogeologist, project manager and as a technical reviewer.

Was the hydrogeologist for three Class EA projects involving water and sewage services in three Eastern Ontario villages. Two of the projects involved extensive water well sampling and assessment of on-site sewage systems. All three projects involved multiple public presentations and consultations.

Was the hydrogeologist and project manager for a project involving the characterizing of over 300 private water supply wells, located within a chlorinated solvent groundwater plume, and the design and installation of water treatment systems for these supply wells.

Involved in many construction dewatering projects: assessing rates of groundwater inflow, evaluating potential environmental impacts, preparing groundwater control specifications, and obtaining associated water taking permits and sewage works approvals.

Involved in numerous Phase II and Phase III Environmental Site Assessments and landfill monitoring programs. Conducted and analysed pumping tests and other hydraulic tests. Completed groundwater and landfill modeling. Participated in the design and permitting of on-site sewage systems.

Managed a pump-and-treat system to remediate a potable water supply aquifer, and developed design recommendations that were implemented and achieved site remediation and decommissioning of the system.

Waterloo Centre for Groundwater Research – Waterloo, Ontario
Research Hydrogeologist (1995 to 1996)

Involved in the application and evaluation of soil and groundwater sampling and remediation technologies developed at WCGR. Responsible for the collection, compilation and interpretation of field data for a research project studying enhanced in-situ bioremediation of BTEX contaminated groundwater using passive release of oxygen from ORC (oxygen release compound) in wells. Was the lead hydrogeologist for a detailed DNAPL source zone soil and groundwater investigation at a US Superfund site.

University of Waterloo – Waterloo, Ontario
Research Assistant (1993 to 1994)

Designed, built and maintained an experimental on-site landfill leachate treatment system. Monitored the system over two years and applied geochemical and flow modeling to evaluate system treatment effectiveness. Assisted in the installation and monitoring of other experimental septic systems.

Geoterrex Ltd. – Ottawa, Ontario
Geophysicist and Project Manager (1989 to 1991)

Managed collection and processing of airborne electromagnetic and magnetic data.

Education

M.Sc. Earth Sciences, University of Waterloo, Waterloo, Ontario, 2004

B.Sc. Earth Sciences, University of Waterloo, Waterloo, Ontario, 2002

Certifications

Registered Professional Geoscientist, Association of Professional Geoscientists, Ontario, 2007

Golder Associates Ltd. – Ottawa

Career Summary

Caitlin Cooke, P.Geo., is a hydrogeologist with Golder Associates in Ottawa. She holds B.Sc. and M.Sc. degrees, both from the department of Earth Science at the University of Waterloo. She manages hydrogeological and environmental investigations including monitoring of groundwater and surface water quality at landfills and quarries, borehole drilling and groundwater monitoring well installation, and groundwater modeling in support of construction dewatering projects and permit to take water applications.

Employment History

Golder Associates Ltd. – Ottawa, Ontario
Hydrogeologist/Environmental Scientist (2004 to Present)

Performs scheduling, technical analysis, data management and report generation for a variety of hydrogeological and environmental projects. Duties include: residential groundwater sampling; groundwater and surface water analysis at municipal waste disposal and quarry sites and assessment of their performance; hydrogeological and environmental investigations including borehole drilling and groundwater monitoring well installations; groundwater elevation monitoring at waste disposal sites, quarries and construction sites; and preparation of Permit To Take Water (PTTW) applications. Performs groundwater modeling for wellhead protection studies, construction-related groundwater control and quarry PTTW applications.

University of Waterloo – Waterloo, Ontario
Teaching Assistant (2002)

Instructed undergraduate students in geophysical field exercises, corrected assignments.

Gorrell Resource Investigations – Oxford Mills, Ontario
Intermediate Hydrogeologist (2001)

Produced hydrogeological reports and environmental assessment reports for clients; measured water levels and collected water samples at quarries and waste disposal sites.

Grace Bioremediation Technologies – Mississauga, Ontario
Laboratory Assistant (1999 to 2000)

Established, maintained, and disposed of lab-scale soil research studies which proved innovative bioremediation methods for hydrocarbon-contaminated soils; operated liquid scintillation counter for analysis of CO2 samples from radio-labeled soil studies; extracted organic compounds from soil samples for gas chromatograph analysis.

APPENDIX B

Summary of MOECC Water Well Records

Summary of MOECC Water Well Records

Well ID	Date Completed	Easting	Northing	UTMRC	Elevation (m)	CODEOB	Depth to Bedrock (m)	Well Depth (m)	Bottom of Well Elevation (m)	Static Water Elevation (m)	USE_1ST	USE_2ND
1502413	20-Nov-63	435041	5005632	5	91.7	r	9.8	15.2	76.4	88.6	Domestic	
1502436	30-Jun-50	434831	5005582	5	94.0	r	8.5	18.9	75.1	91.6	Domestic	
1502437	04-Oct-54	434571	5005372	5	94.2	r	9.1	15.2	78.9	90.5	Domestic	
1502438	28-Jun-66	434671	5005762	5	94.6	r	18.3	25.3	69.3	86.4	Livestock	Domestic
1502439	12-May-56	435211	5005912	5	93.0	r	9.1	19.8	73.2	90.0	Domestic	
1502440	27-Nov-57	434261	5006422	5	92.9	r	18.6	25.9	67.0	89.9	Livestock	Domestic
1502441	02-Dec-65	435271	5005842	5	92.7	r	11.6	20.7	72.0	90.9	Livestock	Domestic
1509124	11-Dec-53	434721	5005492	5	94.3	r	11.6	15.2	79.0	91.2	Domestic	
1509133	11-Oct-55	435266	5005797	5	91.2	r	5.8	13.4	77.8	87.6	Domestic	
1509170	14-May-58	434656	5005347	5	94.6	r	6.1	12.5	82.1	91.5	Domestic	
1509175	20-Jun-58	434696	5005377	5	94.5	r	7.3	12.2	82.3	92.7	Domestic	
1509176	24-Jun-58	434571	5005342	5	94.3	r	8.8	15.5	78.8	92.8	Domestic	
1509185	10-Jun-59	434756	5005322	5	94.1	r	7.3	15.2	78.8	92.2	Domestic	
1509190	30-Jul-59	434651	5005842	5	94.4	r	6.7	18.9	75.5	91.3	Domestic	
1509192	06-Aug-59	434736	5005307	5	93.8	r	6.4	24.4	69.4	91.4	Domestic	
1509196	22-Aug-59	434811	5005342	5	93.2	r	6.7	15.2	78.0	90.5	Domestic	
1509197	26-Aug-59	434796	5005362	5	93.7	r	7.9	14.0	79.7	90.3	Domestic	
1509198	29-Aug-59	434776	5005382	5	94.0	r	8.5	12.2	81.8	90.3	Domestic	
1509218	18-Nov-59	434696	5005442	5	94.5	r	10.4	18.6	75.9	92.6	Domestic	
1509225	24-May-60	434706	5005402	5	94.6	r	8.2	12.5	82.1	93.1	Domestic	
1509233	01-Aug-60	434636	5005327	5	94.4	r	6.4	19.8	74.6	93.2	Domestic	
1509249	03-Jul-61	434746	5005422	5	94.2	r	9.1	15.2	78.9	89.6	Domestic	
1509258	19-Apr-62	434786	5005457	5	93.4	r	8.2	18.3	75.2	90.7	Domestic	
1509264	01-Aug-62	434821	5005452	5	94.2	r	8.8	42.7	51.5	92.4	Commerical	
1509294	03-May-65	434816	5005542	5	94.1	r	8.8	24.1	70.0	91.6	Commerical	
1509299	18-Jun-66	434771	5005447	5	94.0	r	6.4	17.1	76.9	90.9	Domestic	
1509741	30-Sep-68	434661	5005622	4	94.4	r	8.2	8.5	85.9	92.6	Domestic	
1509742	28-Sep-68	434571	5005782	4	94.4	o		11.3	83.1	91.4	Domestic	
1509743	27-Sep-68	434431	5005897	4	94.4	r	12.8	16.5	77.9	91.3	Domestic	
1509744	27-Sep-68	434551	5005812	4	94.5	r	11.3	12.5	82.0	92.1	Domestic	
1509745	26-Sep-68	434461	5005857	4	94.4	r	11.9	19.5	74.9	88.3	Domestic	
1509746	25-Sep-68	434486	5005837	4	94.3	r	12.2	15.5	78.7	92.8	Domestic	
1509747	24-Sep-68	434501	5006007	4	94.3	r	12.5	14.6	79.6	91.2	Domestic	
1509748	24-Sep-68	434416	5005962	4	94.2	r	13.7	15.2	78.9	91.1	Domestic	
1509751	25-Sep-68	434521	5005982	4	94.3	r	12.8	15.8	78.4	89.7	Domestic	
1509752	25-Sep-68	434501	5005812	4	94.4	r	11.6	15.2	79.2	89.2	Domestic	
1509753	24-Sep-68	434556	5005942	4	94.3	r	12.2	15.2	79.1	89.7	Domestic	
1509756	14-Aug-68	434436	5006032	4	94.2	r	13.1	26.2	68.0	90.8	Domestic	
1509757	14-Aug-68	434391	5005942	4	94.5	r	13.7	14.3	80.1	92.9	Domestic	
1509758	16-Aug-68	434411	5005922	4	94.4	r	13.7	15.2	79.1	92.5	Domestic	
1509761	16-Aug-68	434646	5005642	4	94.4	r	8.8	9.1	85.2	92.8	Domestic	
1509762	30-Aug-68	434561	5005732	4	94.5	r	9.8	11.3	83.3	94.5	Domestic	
1509763	29-Aug-68	434621	5005667	4	94.4	r	9.1	10.7	83.8	92.3	Domestic	
1509764	29-Aug-68	434546	5005752	4	94.5	r	10.4	15.5	79.0	92.4	Domestic	
1509765	28-Aug-68	434451	5005922	4	94.3	r	13.7	16.8	77.6	91.3	Domestic	
1509766	27-Aug-68	434371	5005962	4	94.3	r	14.3	16.2	78.2	92.2	Domestic	
1509769	10-Oct-68	434746	5005592	4	94.4	r	8.5	10.7	83.8	92.3	Domestic	
1509770	28-Oct-68	434541	5005967	4	94.3	r	12.2	13.4	80.8	91.2	Domestic	
1509771	26-Oct-68	434591	5005907	4	94.1	r	10.4	11.9	82.2	91.0	Domestic	
1509772	24-Oct-68	434581	5005922	4	94.1	r	11.9	12.2	81.9	91.1	Domestic	
1509773	24-Oct-68	434471	5006052	4	94.1	r	14.0	18.0	76.1	86.5	Domestic	
1509774	24-Oct-68	434621	5005867	4	94.5	r	9.1	10.1	84.4	89.9	Domestic	
1509775	23-Oct-68	434491	5005882	4	94.5	r	12.8	15.2	79.2	91.4	Domestic	
1509777	08-Oct-68	434751	5005512	4	93.8	r	7.0	8.8	85.0	91.7	Domestic	
1509778	09-Oct-68	434721	5005602	4	94.3	r	8.2	9.4	84.9	91.6	Domestic	
1509779	05-Oct-68	434611	5005737	4	94.5	r	10.1	12.2	82.3	92.7	Domestic	
1509788	10-Jul-68	434691	5005582	4	94.3	r	9.1	10.4	84.0	93.1	Domestic	
1509789	08-Jul-68	434446	5005877	4	94.5	r	13.4	15.2	79.2	93.2	Domestic	
1509790	09-Jul-68	434681	5005602	4	94.4	r	9.1	10.7	83.7	93.1	Domestic	
1509791	27-Jun-68	434391	5005987	4	94.2	r	13.7	15.2	78.9	92.9	Domestic	
1509792	06-Jun-68	434671	5005672	4	94.5	r	9.4	11.0	83.5	92.7	Domestic	
1509793	07-Jun-68	434651	5005692	4	94.5	r	8.8	9.8	84.7	92.6	Domestic	
1509803	31-Jul-68	434521	5005792	4	94.5	r	11.0	12.2	82.3	91.4	Domestic	
1509804	30-Jul-68	434531	5005832	4	94.4	r	11.0	13.1	81.3	93.2	Domestic	
1509805	29-Jul-68	434741	5005732	4	94.4	r	8.8	10.4	84.0	93.1	Domestic	
1509806	26-Jul-68	434701	5005772	4	94.3	r	8.2	9.8	84.6	93.1	Domestic	
1509807	25-Jul-68	434601	5005847	4	94.4	r	8.2	10.1	84.3	93.2	Domestic	
1509808	23-Jul-68	434591	5005712	4	94.5	r	9.8	13.7	80.7	93.2	Domestic	
1509809	22-Jul-68	434606	5005692	4	94.5	r	9.8	11.0	83.5	93.3	Domestic	
1509810	02-Jul-68	434431	5005942	4	94.3	r	13.7	15.5	78.7	93.1	Domestic	
1509812	17-May-68	434511	5005852	4	94.3	r	12.2	14.6	79.7	93.1	Domestic	

Well ID	Date Completed	Easting	Northing	UTMRC	Elevation (m)	CODEOB	Depth to Bedrock (m)	Well Depth (m)	Bottom of Well Elevation (m)	Static Water Elevation (m)	USE_1ST	USE_2ND
1509813	16-May-68	434471	5005902	4	94.4	r	12.8	14.6	79.7	93.1	Domestic	
1509814	14-May-68	434591	5005752	4	94.5	r	9.1	12.2	82.3	93.0	Domestic	
1509815	13-May-68	434631	5005712	4	94.4	r	8.8	18.3	76.2	93.2	Domestic	
1509885	07-Oct-68	435011	5005652	4	92.8	r	11.0	17.1	75.7	88.2	Domestic	
1509970	23-Jan-69	434791	5005672	4	94.4	r	8.5	10.7	83.8	89.9	Domestic	
1509971	22-Jan-69	434771	5005702	4	94.3	r	7.6	12.2	82.1	91.3	Domestic	
1509981	09-Jan-69	434741	5005582	4	94.4	r	8.5	10.7	83.7	92.5	Domestic	
1510797	31-Aug-70	434971	5005682	4	93.1	r	9.4	17.4	75.8	91.3	Domestic	
1511078	29-Jan-71	434661	5005812	4	94.4	r	6.7	9.4	85.0	92.6	Domestic	
1511152	21-Apr-71	434651	5005822	4	94.5	r	7.6	9.4	85.0	93.5	Domestic	
1511569	06-Dec-71	435031	5005672	4	92.0	r	6.7	19.2	72.8	88.4	Domestic	
1513303	19-Jun-73	435228	5005779	4	91.8	r	11.3	16.8	75.0	90.5	Domestic	
1513803	10-Mar-73	434785	5005508	4	93.7	r	7.0	9.4	84.2	92.5	Domestic	
1514883	25-Jun-75	434731	5005651	4	94.6	r	10.1	12.5	82.1	93.1	Domestic	
1515156	18-Nov-75	435273	5005995	4	93.1	r	10.7	16.8	76.4	90.7	Domestic	
1516547	24-Apr-78	434671	5005342	4	94.5	r	8.8	19.5	75.0	93.0	Domestic	
1516783	21-Sep-78	434831	5005322	4	93.3	r	6.7	13.4	79.8	90.2	Domestic	
1516791	03-Oct-78	434651	5005782	4	94.6	r	7.9	19.5	75.1	91.5	Domestic	
1516985	09-May-79	434830	5005421	4	93.9	r	1.8	10.7	83.2	91.7	Domestic	
1517613	21-Jul-81	434830	5005721	4	93.9	r	14.0	14.6	79.2	91.4	Domestic	
1518017	01-Oct-82	434730	5005421	4	94.4	r	9.8	22.9	71.6	92.9	Domestic	
1519337	26-Sep-84	434730	5005421	4	94.4	r	11.9	12.8	81.6	91.4	Domestic	
1519338	13-Sep-84	434730	5005421	4	94.4	r	12.8	27.4	67.0	88.9	Domestic	
1524127	26-Oct-89	434927	5005884	5	92.7	r	10.1	19.5	73.2	90.9	Domestic	
1524225	08-Aug-89	434964	5005620	5	93.4	r	9.8	22.9	70.5	90.9	Domestic	
1527949	25-May-94	434464	5005738	5	94.3	r	11.6	19.2	75.1	90.7	Domestic	
1528270	07-Oct-94	434386	5005695	5	94.5	r	10.4	19.2	75.3	90.5	Domestic	
1528356	30-Nov-94	434534	5005640	5	94.3	r	11.3	19.2	75.1	91.9	Domestic	
1528767	05-Sep-95	434399	5006028	5	94.1	r	14.0	14.3	79.7	91.6	Domestic	
1529715	24-Oct-97	434393	5005740	5	94.5	r	14.6	83.2	11.3	89.3	Domestic	
1531745	11-Jan-01	434333	5005863	3	94.2	r	15.8	74.7	19.6	90.6	Domestic	
1532033	20-Jun-01	434394	5005825	3	94.4	r	14.6	74.7	19.7	90.7	Domestic	
1532507	28-Nov-01	434194	5006503	3	93.5	r	18.6	30.5	63.0	88.9	Domestic	
1533689	06-Mar-03	434350	5005897	6	94.2	r	11.6	22.3	72.0	88.7	Domestic	
7044851	11-Apr-07	434484	5005380	3	94.1	r	40.0	75.6	18.5	91.8	Domestic	
7046989	14-Jun-07	434447	5005400	3	94.2			68.0	26.3	90.9	Domestic	
7051242	13-Aug-07	434466	5005408	3	94.2			68.0	26.2	88.6	Domestic	
7053566	23-Oct-07	434488	5005398	3	94.1			71.6	22.5	90.8	Domestic	
7105877	13-May-08	434477	5005371	3	94.1			53.3	40.8	91.2	Domestic	
7119097	02-Oct-08	434570	5005763	4	94.5			19.8	74.7	90.2		
7139861	29-Oct-09	434857	5005605	4	93.8			45.1	48.7	91.6	Public	Domestic
7145843	25-Mar-10	434158	5005721	4	94.6			73.2	21.5	91.4	Domestic	
7159023	22-Dec-10	434846	5005839	3				61.9			Domestic	
7162104	14-Mar-11	434202	5005710	3				73.1			Domestic	
7166848	30-May-11	434204	5005719	3				70.1			Domestic	
7167542	13-Jul-11	434163	5005701	3				73.2			Domestic	
7170975	05-Jul-11	434162	5005718	4				73.1			Domestic	
7190363	05-Oct-12	434480	5005900	4							Domestic	
7194021	05-Nov-12	434248	5005647	5				73.2			Domestic	
7209314	15-Aug-13	434806	5005830	4				49.1			Commerical	
7213068	21-Oct-13	434846	5005839	4								
7218687	13-Aug-13	434675	5005444	4				70.1			Domestic	
7219322	06-Aug-13	435121	5006187	4								

APPENDIX C

Test Well MOECC Well Records
On-Site Borehole Records

Ontario — Ministry of the Environment

Well Tag No. *(Place Sticker and/or Print Below)* A165020

Tag #: A165020

Well Record

Regulation 903 Ontario Water Resources Act

Measurements recorded in: [X] Metric [ ] Imperial

Page _____ of _____

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	[ ] Well Constructed by Well Owner
	1470424 Ontario Inc.		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. *(inc. area code)*
301 Moodie Dr. Suite 100	Nepean	Ontario	K2H 9C4	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
TW15-01 Shea Road	Goulbourn		

County/District/Municipality	City/Town/Village	Province	Postal Code
Ottawa Carleton	Richmond	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	18	434498	5006085		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	Depth (m/ft) To
Brown	Clay		Packed	0	3.35
Grey	Clay		Sticky	3.35	11.88
Grey	Limestone		Medium	11.88	29.86

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m^3/ft^3)
13.10	0	Grouted Cement & Bentonite	.42m^3

Method of Construction

[ ] Cable Tool [ ] Diamond
[X] Rotary (Conventional) [ ] Jetting
[ ] Rotary (Reverse) [ ] Driving
[ ] Boring [ ] Digging
[X] Air percussion
[ ] Other, *specify* _____

Well Use

[ ] Public [ ] Commercial [ ] Not used
[X] Domestic [ ] Municipal [ ] Dewatering
[ ] Livestock [X] Test Hole [ ] Monitoring
[ ] Irrigation [ ] Cooling & Air Conditioning
[ ] Industrial
[ ] Other, *specify* _____

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	To
27.13	Open		0	13.10
15.86	Steel	.48	+.45	13.10

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To

Status of Well

[X] Water Supply
[ ] Replacement Well
[ ] Test Hole
[ ] Recharge Well
[ ] Dewatering Well
[ ] Observation and/or Monitoring Hole
[ ] Alteration (Construction)
[ ] Abandoned, Insufficient Supply
[ ] Abandoned, Poor Water Quality
[ ] Abandoned, other, *specify*
[ ] Other, *specify*

Water Details

Water found at Depth	Kind of Water	
14.02 (m/ft) [ ] Gas	[ ] Fresh [X] Untested [ ] Other, *specify*	
29.25 (m/ft) [ ] Gas	[ ] Fresh [X] Untested [ ] Other, *specify*	
(m/ft) [ ] Gas	[ ] Fresh [ ] Untested [ ] Other, *specify*	

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0	13.10	15.86
13.10	29.86	15.55

Results of Well Yield Testing

After test of well yield, water was:
[X] Clear and sand free
[ ] Other, *specify* _____

If pumping discontinued, give reason:

Pump intake set at (m/ft): 15.23

Pumping rate (l/min / GPM): 45.5

Duration of pumping: 6 hrs + 10 min

Final water level end of pumping (m/ft): 3.08

If flowing give rate (l/min / GPM):

Recommended pump depth (m/ft): 12.19

Recommended pump rate (l/min / GPM): 45.5

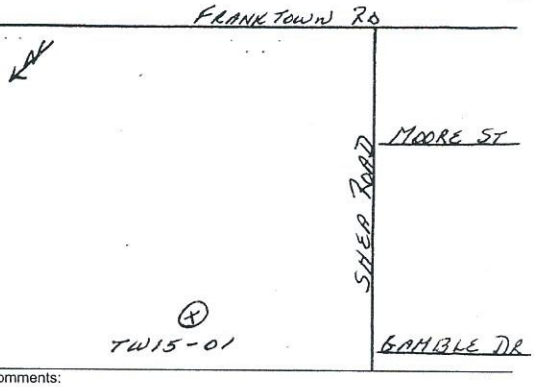
Well production (l/min / GPM):

Disinfected? [X] Yes [ ] No

Draw Down Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level	3.11		
1	3.16	1	3.08
2	3.14	2	3.08
3	3.14	3	3.08
4	3.13	4	3.08
5	3.14	5	3.08
10	3.13	10	3.08
15	3.13	15	3.08
20	3.13	20	3.08
25	3.13	25	3.05
30	3.13	30	
40	3.13	40	
50	3.12	50	
60	3.12	60	

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Capital Water Supply Ltd.	1558

Business Address (Street Number/Name)	Municipality
Box 490	Stittsville

Province	Postal Code	Business E-mail Address
Ontario	K2S1A6	office@capitalwater.ca

Bus. Telephone No. *(inc. area code)*	Name of Well Technician (Last Name, First Name)
6138361766	Miller, Stephen

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
0097		2015091 5

Well owner's information package delivered	Date Package Delivered	Date Work Completed
[X] Yes [ ] No	2015091 1	20150818

Ministry Use Only

Audit No. Z 188470

Received

0506E (2007/12)

Ministry's Copy

Ontario — Ministry of the Environment

Measurements recorded in: [X] Metric [ ] Imperial

Well Tag No. *(Place Sticker and/or Print Below)* A165021

Tag #: A165021

Well Record

Regulation 903 Ontario Water Resources Act

Page _____ of _____

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	[ ] Well Constructed by Well Owner
	1470424 Ontario Inc.		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. *(inc. area code)*
301 Moodie Dr. Suite 100	Nepean	Ontario	K2H9C4	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
TW15-02 Shea Rd.	Goulbourn		

County/District/Municipality	City/Town/Village	Province	Postal Code
Ottawa Carleton	Richmond	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	18	434657	5005896		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	Depth (m/ft) To
Brown	Clay		Packed	0	3.04
Grey	Clay		Sticky	3.04	7.92
Grey	Gravel	Broken Rock	Wet	7.92	10.36
Grey	Limestone		Soft	10.36	24.38
Grey	Limestone		Badly Broken	24.38	31.39
Grey	Limestone		Medium	31.39	37.48

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m^3/ft^3)
11.27	0	Grouted Cement & Bentonite	1.392m^3

Method of Construction

[ ] Cable Tool [ ] Diamond
[X] Rotary (Conventional) [ ] Jetting
[ ] Rotary (Reverse) [ ] Driving
[ ] Boring [ ] Digging
[X] Air percussion
[ ] Other, specify _____

Well Use

[ ] Public [ ] Commercial [ ] Not used
[X] Domestic [ ] Municipal [ ] Dewatering
[ ] Livestock [X] Test Hole [ ] Monitoring
[ ] Irrigation [ ] Cooling & Air Conditioning
[ ] Industrial
[ ] Other, specify _____

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	Depth (m/ft) To
27.13	Open		0	11.27
15.86	Steel	.48	+.45	11.27

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	Depth (m/ft) To

Status of Well

[X] Water Supply
[ ] Replacement Well
[ ] Test Hole
[ ] Recharge Well
[ ] Dewatering Well
[ ] Observation and/or Monitoring Hole
[ ] Alteration (Construction)
[ ] Abandoned, Insufficient Supply
[ ] Abandoned, Poor Water Quality
[ ] Abandoned, other, specify _____
[ ] Other, specify _____

Water Details

Water found at Depth	Kind of Water	
24.38 (m/ft) [ ] Gas	[ ] Fresh [X] Untested [ ] Other, specify	
Water found at Depth	Kind of Water	
33.52 (m/ft) [ ] Gas	[ ] Fresh [X] Untested [ ] Other, specify	
Water found at Depth (m/ft) [ ] Gas	Kind of Water: [ ] Fresh [ ] Untested [ ] Other, specify	

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0	11.27	15.86
11.27	37.48	15.55

Results of Well Yield Testing

After test of well yield, water was:
[X] Clear and sand free
[ ] Other, specify _____

If pumping discontinued, give reason:

Pump intake set at (m/ft): 21.33

Pumping rate (l/min / GPM): 36.40

Duration of pumping: 6 hrs + 10 min

Final water level end of pumping (m/ft): 8.15

If flowing give rate (l/min / GPM):

Recommended pump depth (m/ft): 15.23

Recommended pump rate (l/min / GPM): 36.40

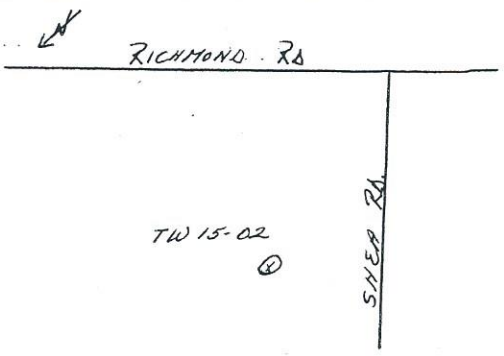
Well production (l/min / GPM):

Disinfected? [X] Yes [ ] No

Draw Down Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level	3.18		
1	5.26	1	6.55
2	5.68	2	5.43
3	6.23	3	4.50
4	6.53	4	4.00
5	6.80	5	3.57
10	7.23	10	3.16
15	7.71	15	3.15
20	7.97	20	3.15
25		25	3.15
30	8.00	30	3.15
40	8.02	40	3.15
50		50	3.15
60	8.15	60	3.15

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Capital Water Supply Ltd.	1558

Business Address (Street Number/Name)	Municipality
Box 490	Stittsville

Province	Postal Code	Business E-mail Address
Ontario	K2S1A6	office@capitalwater.ca

Bus. Telephone No. *(inc. area code)*	Name of Well Technician (Last Name, First Name)
6138361766	Miller, Stephen

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
0097		2015091 5

Well owner's information package delivered	Date Package Delivered	Ministry Use Only
[X] Yes [ ] No	2015091 0	Audit No. Z 188465
	Date Work Completed: 2015081 9	Received

Ontario — Ministry of the Environment

Measurements recorded in: [X] Metric [ ] Imperial

Well Tag No. (Place Sticker and/or Print Below): A165022

Tag #: A165022

Well Record

Regulation 903 Ontario Water Resources Act

Page ____ of ____

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	[ ] Well Constructed by Well Owner
	1470424 Ontario Inc.		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
301 Moodie Dr. Suite 100	Nepean	Ontario	K2H 9C4	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
TW15-03 Shea Road	Goulbourn		

County/District/Municipality	City/Town/Village	Province	Postal Code
Ottawa Carleton	Richmond	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	18	434675	5005878		

Overburden and Bedrock Materials/Abandonment Sealing Record (see instructions on the back of this form)

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	Depth (m/ft) To
Brown	Clay		Packed	0	3.04
Grey	Clay		Sticky	3.04	7.92
Grey	Limestone		Medium Hard	7.92	10.66
Grey	Limestone		Badly Layered & Broken	10.66	28.95

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m^3/ft^3)
9.44	0	Grouted Cement & Bentonite	.252m^3

Method of Construction

[ ] Cable Tool [ ] Diamond
[X] Rotary (Conventional) [ ] Jetting
[ ] Rotary (Reverse) [ ] Driving
[ ] Boring [ ] Digging
[X] Air percussion
[ ] Other, specify ____

Well Use

[ ] Public [ ] Commercial [ ] Not used
[X] Domestic [ ] Municipal [ ] Dewatering
[ ] Livestock [X] Test Hole [ ] Monitoring
[ ] Irrigation [ ] Cooling & Air Conditioning
[ ] Industrial
[ ] Other, specify ____

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	Depth (m/ft) To
27.13	Open		0	9.44
15.86	Steel	.48	+.45	9.44

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	Depth (m/ft) To

Status of Well

[X] Water Supply
[ ] Replacement Well
[ ] Test Hole
[ ] Recharge Well
[ ] Dewatering Well
[ ] Observation and/or Monitoring Hole
[ ] Alteration (Construction)
[ ] Abandoned, Insufficient Supply
[ ] Abandoned, Poor Water Quality
[ ] Abandoned, other, specify ____
[ ] Other, specify ____

Water Details

Water found at Depth	Kind of Water	
10.66 (m/ft) [ ] Gas	[ ] Fresh [X] Untested	[ ] Other, specify ____
28.95 (m/ft) [ ] Gas	[ ] Fresh [X] Untested	[ ] Other, specify ____
(m/ft) [ ] Gas	[ ] Fresh [ ] Untested	[ ] Other, specify ____

Hole Diameter

Depth (m/ft) From	Depth (m/ft) To	Diameter (cm/in)
0	9.44	15.86
9.44	28.95	15.55

Results of Well Yield Testing

After test of well yield, water was:
[X] Clear and sand free
[ ] Other, specify ____

If pumping discontinued, give reason:

Pump intake set at (m/ft): 9.14

Pumping rate (l/min / GPM): 36.40

Duration of pumping: 6 hrs + ____ min

Final water level end of pumping (m/ft): 3.74

If flowing give rate (l/min / GPM):

Recommended pump depth (m/ft): 9.14

Recommended pump rate (l/min / GPM): 36.40

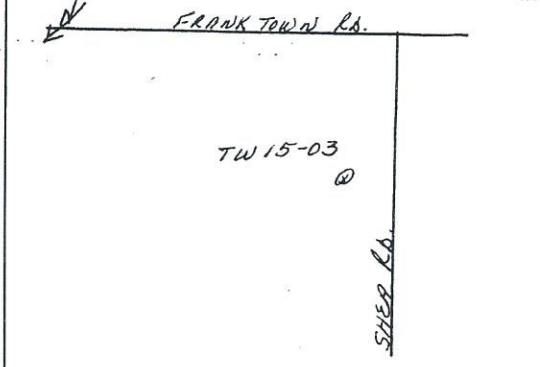
Well production (l/min / GPM):

Disinfected? [X] Yes [ ] No

	Draw Down Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level	3.22			
1	4.54	1	3.24	
2	3.91	2	3.22	
3		3	3.22	
4	3.71	4	3.22	
5	3.71	5	3.22	
10	3.71	10	3.22	
15	3.72	15	3.22	
20	3.72	20	3.22	
25	3.73	25	3.22	
30	3.74	30	3.22	
40	3.74	40	3.22	
50	3.74	50	3.22	
60	3.75	60	3.22	

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Capital Water Supply Ltd.	1558

Business Address (Street Number/Name)	Municipality
Box 490	Stittsville

Province	Postal Code	Business E-mail Address
Ontario	K2S1A6	office@capitalwater.ca

Bus. Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)
6138361766	Miller, Stephen

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
0097		2015091 5

Well owner's information package delivered	Date Package Delivered	Ministry Use Only
[X] Yes [ ] No	2015091 0	Audit No. Z 188460
	Date Work Completed: 2015082 0	Received

0506E (2007/12)

Ministry's Copy

PROJECT: 1418381

RECORD OF BOREHOLE: 15-1

SHEET 1 OF 1

LOCATION: N 5006081.4 ;E 434541.2

BORING DATE: August 13, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		93.72							
		TOPSOIL		0.05							
		(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown, highly fissured, (Weathered Crust); cohesive, w>PL, very stiff to stiff			1	SS	10				
1											
					2	SS	6				
2											
					3	SS	5				
3											Bentonite and Cuttings
				89.84							
4		(CI/CH) SILTY CLAY to CLAY; grey with black mottling; cohesive, w>PL, soft to firm		3.88							
					4	SS	1				
5											
	Power Auger 200 mm Diam. (Hollow Stem)				5	SS	WH				
6											
											Bentonite Seal
7											
					6	TP	PH			C	Silica Sand
8											
											51 mm Diam. PVC #10 Slot Screen
9											
					7	TP	PH				
10											
				83.43							
		(CI and ML) SILTY CLAY and CLAYEY SILT; grey, laminated to thinly bedded; cohesive, w>PL		10.29							
											Bentonite and Sand
11					8	SS	WH				
				82.14							
		(SM) SILTY SAND, some gravel; grey, (GLACIAL TILL); non-cohesive, wet		11.58					>96		
12											
				81.43	9	SS	>50				
		End of Borehole Sampler Refusal		12.29							W.L. in Screen at Elev. 91.39 m on August 24, 2015
13											
14											
15											

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: HEC

CHECKED: SD

PROJECT: 1418381

RECORD OF BOREHOLE: 15-2

SHEET 1 OF 1

LOCATION: N 5005998.2 ;E 434616.1

BORING DATE: August 13, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		93.57							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.05							
		(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown, highly fissured, (Weathered Crust); cohesive, w>PL, very stiff			1	SS	13				
1											
					2	SS	7				
2											Bentonite and Cuttings
					3	SS	4				
3											
					4	SS	3				
				89.84							
		(CI/CH) SILTY CLAY; grey, with black mottling; cohesive, w>PL, firm		3.73	5	TP	PH			FALL CONE	
4											
											Bentonite Seal
					6	SS	WH				
5											Silica Sand
6					7	SS	WH				51 mm Diam. PVC #10 Slot Screen
7											
8					8	SS	WH				
				84.43							Bentonite and Sand
9		(CI and ML) SILTY CLAY and CLAYEY SILT; grey, laminated to thinly bedded; cohesive, w>PL, firm to stiff		9.14	9	SS	WR				
10											W.L. in Screen at Elev. 91.73 m on August 24, 2015
				82.90							
		(SM) SILTY SAND, some gravel; grey, (GLACIAL TILL); non-cohesive, wet, compact to dense		10.67	10	SS	>50				
11		End of Borehole Sampler Refusal		10.87							
12											
13											
14											
15											

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: HEC

CHECKED: SD

MIS-BHS 001 1418381.GPJ GAL-MIS.GDT 09/30/15 JEM

LOG OF BOREHOLE BH13-6

PROJECT: Geotechnical Investigation - 5831/5873 Perth St. & 2770 Eagleson Rd.
CLIENT: Cardel Homes
PROJECT LOCATION: 5831/ 5873 Perth St. and 2770 Eagleson Rd., Ottawa
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan N 5005854 E 434736

DRILLING DATA
Method: Hollow Stem Augers
Diameter: 203mm
Date: Aug/06/2013

REF. NO.: 1776-710
ENCL NO.:

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS/0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	NATURAL UNIT WT (KN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
93.7								
93.6	**Topsoil** 200 mm							
0.2	**Silty Clay**, brown, moist, firm to stiff, (weathered crust)	1	SS	9				
		2	SS	5			17.9	
		3	SS	3				
		4	SS	3				
90.7								
3.1	**Silty Clay** grey, wet, firm	5	TW					
			VANE					
			VANE				16.9	
		6	SS	WH				
			VANE					
			VANE					
		7	SS	3				
			VANE					
86.6								
7.1	**Sand and Gravel** trace silt, grey, wet, very dense	8		50/12mm				37 56 (8)
86.3								
7.4	**END OF BOREHOLE**							

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
25 50 75 100 125

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
25 50 75

POCKET PEN. (Cu) (kPa)

93
91
90
89
88
87

W. L. 92.6 m Jan 17, 2014
W. L. 92.1 m Aug 28, 2013

Notes:
1) Upon completion, standing water level 3.6 m BSL
2) DCPT refusal at 7.4 m
3) Auger refusal at 7.4 m
4) 19mm dia. piezometer was installed in the borehole upon completion
5) Depth of Water

Date	Depth
28/08/2013	1.6 m
17/01/2014	1.1 m

GROUNDWATER ELEVATIONS
Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES: + 3, × 3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

APPENDIX D

Laboratory Reports of Analysis

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Caitlin Cooke
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1518119
Date Submitted: 2015-09-11
Date Reported: 2015-09-21
Project: 1418381
COC #: 506592

Dear Caitlin Cooke:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

Revised report - Rerun for DOC

APPROVAL: Shyla Monette 2015.09.23 14:13:48 -04'00'

Shyla Monette
Team Leader, Inorganics

All analysis is completed in Ottawa, Ontario (unless otherwise indicated).

Exova Ottawa is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on our CALA scope of accreditation. It can be found at http://www.cala.ca/scopes/2602.pdf.

Exova (Ottawa) is certified and accredited for specific parameters by OMAFRA, Ontario Ministry of Agriculture, Food and Rural Affairs (for farm soils). Licensed by Ontario MOE for specific tests in drinking water.

Exova (Mississauga) is accredited for specific parameters by SCC, Standards Council of Canada (to ISO 17025)

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Certificate of Analysis

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1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Caitlin Cooke
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1518119
Date Submitted: 2015-09-11
Date Reported: 2015-09-21
Project: 1418381
COC #: 506592

Group	Analyte	MRL	Units	Guideline	Lab I.D. 1201077 Sample Matrix Groundwater Sample Type Sampling Date 2015-09-11 Sample I.D. TW15-01-3	Lab I.D. 1201078 Sample Matrix Groundwater Sample Type Sampling Date 2015-09-11 Sample I.D. TW15-01-06
Calculations	Hardness as CaCO3	1	mg/L	OG-100	144*	144*
	TDS (COND - CALC)	1	mg/L	AO-500	545*	545*
General Chemistry	Alkalinity as CaCO3	5	mg/L	OG-500	229	226
	Cl	1	mg/L	AO-250	102	104
	Colour	2	TCU	AO-5	4	<2
	Conductivity	5	uS/cm		839	839
	F	0.10	mg/L	MAC-1.5	1.10	1.10
	N-NO2	0.10	mg/L	MAC-1.0	<0.10	<0.10
	N-NO3	0.10	mg/L	MAC-10.0	<0.10	<0.10
	pH	1.00		6.5-8.5	8.16	8.21
	SO4	1	mg/L	AO-500	40	40
	Turbidity	0.1	NTU	AO-5.0	2.2	0.8
Mercury	Hg	0.0001	mg/L	MAC-0.001	<0.0001	<0.0001
Metals	Ag	0.0001	mg/L		<0.0001	<0.0001
	Al	0.01	mg/L	OG-0.1	0.01	<0.01
	As	0.001	mg/L	IMAC-0.025	0.001	0.001
	B	0.01	mg/L	IMAC-5.0	0.37	0.36
	Ba	0.01	mg/L	MAC-1.0	0.06	0.06
	Be	0.0005	mg/L		<0.0005	<0.0005
	Ca	1	mg/L		28	28
	Cd	0.0001	mg/L	MAC-0.005	<0.0001	<0.0001
	Cr	0.001	mg/L	MAC-0.05	<0.001	<0.001
	Cu	0.001	mg/L	AO-1.0	<0.001	<0.001
	Fe	0.03	mg/L	AO-0.3	0.27	0.13
	K	1	mg/L		7	7
	Mg	1	mg/L		18	18

Guideline = ODWSOG *** = Guideline Exceedence**

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MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Caitlin Cooke
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1518119
Date Submitted: 2015-09-11
Date Reported: 2015-09-21
Project: 1418381
COC #: 506592

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.	
					1201077 Groundwater 2015-09-11 TW15-01-3	1201078 Groundwater 2015-09-11 TW15-01-06
Metals	Mn	0.01	mg/L	AO-0.05	<0.01	<0.01
	Mo	0.005	mg/L		<0.005	<0.005
	Na	2	mg/L	AO-200	121	123
	Ni	0.005	mg/L		<0.005	<0.005
	Pb	0.001	mg/L	MAC-0.010	<0.001	<0.001
	Sb	0.0005	mg/L	IMAC-0.006	<0.0005	<0.0005
	Se	0.001	mg/L	MAC-0.01	<0.001	<0.001
	Sr	0.001	mg/L		3.98	3.97
	Tl	0.0001	mg/L		<0.0001	<0.0001
	U	0.001	mg/L	MAC-0.02	<0.001	<0.001
	Zn	0.01	mg/L	AO-5.0	<0.01	<0.01
Nutrients	Organic Nitrogen	0.08	mg/L	OG-0.15	<0.08	<0.08
	PO4 as P	0.2	mg/L		<0.2	<0.2
	Tannin & Lignin	0.1	mg/L		<0.1	<0.1
	Total Kjeldahl Nitrogen	0.1	mg/L		0.2	0.2
Phenols	Phenols	0.001	mg/L		<0.001	<0.001
Subcontract	DOC	0.5	mg/L	AO-5	1.8	1.1
	N-NH3	0.01	mg/L		0.23	0.23

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Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Caitlin Cooke
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1518119
Date Submitted: 2015-09-11
Date Reported: 2015-09-21
Project: 1418381
COC #: 506592

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 294517 **Analysis/Extraction Date** 2015-09-12 **Analyst** C F			
Method C SM2130B			
Turbidity	<0.1 NTU	100	73-127
Run No 294568 **Analysis/Extraction Date** 2015-09-14 **Analyst** SKH			
Method M SM3120B-3500C			
Calcium	<1 mg/L	99	90-110
Potassium	<1 mg/L	100	87-113
Magnesium	<1 mg/L	94	76-124
Sodium	<2 mg/L	99	82-118
Run No 294615 **Analysis/Extraction Date** 2015-09-14 **Analyst** AET			
Method C SM4500-H+B			
Alkalinity (CaCO3)	<5 mg/L	101	90-110
Conductivity	<5 uS/cm	101	90-110
F	<0.10 mg/L	99	90-110
pH	6.00	100	90-110
Run No 294678 **Analysis/Extraction Date** 2015-09-15 **Analyst** K A			
Method EPA 200.8			
Silver	<0.0001 mg/L	95	94-106

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K2H 5B7
Attention: Ms. Caitlin Cooke
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Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1518119
Date Submitted: 2015-09-11
Date Reported: 2015-09-21
Project: 1418381
COC #: 506592

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Aluminum	<0.01 mg/L	99	89-111
Arsenic	<0.001 mg/L	98	93-106
Boron (total)	<0.01 mg/L	100	88-112
Barium	<0.01 mg/L	97	91-109
Beryllium	<0.0005 mg/L	97	93-107
Cadmium	<0.0001 mg/L	98	93-107
Chromium Total	<0.001 mg/L	95	94-106
Copper	<0.001 mg/L	95	93-106
Iron	<0.03 mg/L	96	92-107
Manganese	<0.01 mg/L	96	94-106
Molybdenum	<0.005 mg/L	101	94-106
Nickel	<0.005 mg/L	97	94-106
Lead	<0.001 mg/L	101	70-130
Antimony	<0.0005 mg/L	95	80-120
Selenium	<0.001 mg/L	99	91-108
Strontium	<0.001 mg/L	99	89-110
Thallium	<0.0001 mg/L	99	95-105
Uranium	<0.001 mg/L	98	94-106

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Client: Golder Associates Ltd. (Ottawa)
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Attention: Ms. Caitlin Cooke
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Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1518119
Date Submitted: 2015-09-11
Date Reported: 2015-09-21
Project: 1418381
COC #: 506592

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Zinc	<0.01 mg/L	99	94-106
Run No 294697 **Analysis/Extraction Date** 2015-09-15 **Analyst** NP			
Method C SM4500-NO3-F			
N-NO2	<0.10 mg/L	117	80-120
N-NO3	<0.10 mg/L	95	80-120
Run No 294768 **Analysis/Extraction Date** 2015-09-15 **Analyst** NP			
Method SM 4110			
SO4	<1 mg/L	103	90-110
Run No 294782 **Analysis/Extraction Date** 2015-09-16 **Analyst** AET			
Method C SM2120C			
Colour	<2 TCU	95	90-110
Run No 294830 **Analysis/Extraction Date** 2015-09-16 **Analyst** NP			
Method SM 4110C			
Chloride	<1 mg/L	101	90-112
Run No 294930 **Analysis/Extraction Date** 2015-09-17 **Analyst** JDT			
Method M SM3112B-3500B			
Mercury	<0.0001 mg/L	89	76-123
Run No 295020 **Analysis/Extraction Date** 2015-09-15 **Analyst** CON			
Method SUBCONTRACT P			

Guideline = ODWSOG *** = Guideline Exceedence**
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1931 Robertson Road
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K2H 5B7
Attention: Ms. Caitlin Cooke
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1518119
Date Submitted: 2015-09-11
Date Reported: 2015-09-21
Project: 1418381
COC #: 506592

QC Summary

Analyte	Blank	QC % Rec	QC Limits
N-NH3	<0.01 mg/L		
Run No 295022 **Analysis/Extraction Date** 2015-09-15 **Analyst** CON			
Method SUBCONTRACT P			
DOC	<0.5 mg/L		
Run No 295023 **Analysis/Extraction Date** 2015-09-17 **Analyst** CON			
Method SUBCONTRACT P			
Phenols	0.001 mg/L		
Run No 295024 **Analysis/Extraction Date** 2015-09-16 **Analyst** CON			
Method C SM5550B			
Tannin & Lignin	<0.1 mg/L		80-120
Run No 295026 **Analysis/Extraction Date** 2015-09-18 **Analyst** CON			
Method SUBCONTRACT P			
Total Kjeldahl Nitrogen	<0.1 mg/L		
Run No 295035 **Analysis/Extraction Date** 2015-09-15 **Analyst** R K			
Method C SM4500-PE			
PO4 as P	<0.2 mg/L	102	
Run No 295053 **Analysis/Extraction Date** 2015-09-21 **Analyst** SCM			
Method C SM2340B			
Hardness as CaCO3			

Guideline = ODWSOG *** = Guideline Exceedence**
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Attention: Ms. Caitlin Cooke
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Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1518119
Date Submitted: 2015-09-11
Date Reported: 2015-09-21
Project: 1418381
COC #: 506592

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 295054 **Analysis/Extraction Date** 2015-09-21 **Analyst** SCM			
Method C SM2540			
TDS (COND - CALC)			
Run No 295055 **Analysis/Extraction Date** 2015-09-21 **Analyst** SCM			
Method C SM2340B			
Hardness as CaCO3			
Run No 295056 **Analysis/Extraction Date** 2015-09-21 **Analyst** SCM			
Method C SM2540			
TDS (COND - CALC)			
Run No 295057 **Analysis/Extraction Date** 2015-09-21 **Analyst** SCM			
Method C SM4500-Norg-C			
Organic Nitrogen			

Guideline = ODWSOG *** = Guideline Exceedence**
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EXOVA ENVIRONMENTAL ONTARIO

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Caitlin Cooke
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1518126
Date Submitted: 2015-09-11
Date Reported: 2015-09-13
Project:
COC #: 506592

Dear Caitlin Cooke:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

Dragana Dzeletovic 2015.09.13 12:27:26 -04'00'

APPROVAL: _____

Dragana Dzeletovic
Team Leader, Microbiology

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EXOVA ENVIRONMENTAL ONTARIO

Certificate of Analysis

Exova

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Caitlin Cooke
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1518126
Date Submitted: 2015-09-11
Date Reported: 2015-09-13
Project:
COC #: 506592

				Lab I.D.	1201115	1201116
				Sample Matrix	Water	Water
				Sample Type		
				Sampling Date	2015-09-11	2015-09-11
				Sample I.D.	TW15-01-03	TW15-01-6
Group	**Analyte**	**MRL**	**Units**	**Guideline**		
Microbiology	Escherichia Coli	0	ct/100mL	MAC-0	0	0
	Total Coliforms	0	ct/100mL	MAC-0	2*	2*

Guideline = ODWSOG *** = Guideline Exceedence**

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EXOVA ENVIRONMENTAL ONTARIO

Certificate of Analysis

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1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Caitlin Cooke
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1518028
Date Submitted: 2015-09-10
Date Reported: 2015-09-18
Project: 1418381
COC #: 506591

Dear Caitlin Cooke:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

APPROVAL: Shyla Monette 2015.09.18 16:03:31 -04'00'

Shyla Monette
Team Leader, Inorganics

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Attention: Ms. Caitlin Cooke
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1518028
Date Submitted: 2015-09-10
Date Reported: 2015-09-18
Project: 1418381
COC #: 506591

				Lab I.D.	1200759	1200760
				Sample Matrix	Groundwater	Groundwater
				Sample Type		
				Sampling Date	2015-09-10	2015-09-10
				Sample I.D.	TW15-02-3	TW15-02-6
Group	**Analyte**	**MRL**	**Units**	**Guideline**		
Calculations	Hardness as CaCO3	1	mg/L	OG-100	195*	195*
	TDS (COND - CALC)	1	mg/L	AO-500	577*	571*
General Chemistry	Alkalinity as CaCO3	5	mg/L	OG-500	244	251
	Cl	1	mg/L	AO-250	108	105
	Colour	2	TCU	AO-5	<2	<2
	Conductivity	5	uS/cm		887	879
	DOC	0.5	mg/L	AO-5	0.7	<0.5
	F	0.10	mg/L	MAC-1.5	0.91	0.91
	N-NO2	0.10	mg/L	MAC-1.0	<0.10	<0.10
	N-NO3	0.10	mg/L	MAC-10.0	<0.10	<0.10
	pH	1.00		6.5-8.5	8.24	8.18
	SO4	1	mg/L	AO-500	45	45
	Tannin & Lignin	0.1	mg/L		6.4	0.1
	Turbidity	0.1	NTU	AO-5.0	1.1	1.2
Mercury	Hg	0.0001	mg/L	MAC-0.001	<0.0001	<0.0001
Metals	Ag	0.0001	mg/L		<0.0001	<0.0001
	Al	0.01	mg/L	OG-0.1	<0.01	<0.01
	As	0.001	mg/L	IMAC-0.025	<0.001	<0.001
	B	0.01	mg/L	IMAC-5.0	0.38	0.39
	Ba	0.01	mg/L	MAC-1.0	0.07	0.07
	Be	0.0005	mg/L		<0.0005	<0.0005
	Ca	1	mg/L		40	40
	Cd	0.0001	mg/L	MAC-0.005	<0.0001	<0.0001
	Cr	0.001	mg/L	MAC-0.05	<0.001	<0.001
	Cu	0.001	mg/L	AO-1.0	<0.001	<0.001
	Fe	0.03	mg/L	AO-0.3	0.19	0.16

Guideline = ODWSOG *** = Guideline Exceedence**

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Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Caitlin Cooke
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1518028
Date Submitted: 2015-09-10
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Group	Analyte	MRL	Units	Guideline	1200759 Groundwater 2015-09-10 TW15-02-3	1200760 Groundwater 2015-09-10 TW15-02-6
	Lab I.D.				1200759	1200760
	Sample Matrix				Groundwater	Groundwater
	Sample Type					
	Sampling Date				2015-09-10	2015-09-10
	Sample I.D.				TW15-02-3	TW15-02-6
Metals	K	1	mg/L		6	6
	Mg	1	mg/L		23	23
	Mn	0.01	mg/L	AO-0.05	0.01	<0.01
	Mo	0.005	mg/L		<0.005	<0.005
	Na	2	mg/L	AO-200	115	113
	Ni	0.005	mg/L		<0.005	<0.005
	Pb	0.001	mg/L	MAC-0.010	<0.001	<0.001
	Sb	0.0005	mg/L	IMAC-0.006	<0.0005	<0.0005
	Se	0.001	mg/L	MAC-0.01	<0.001	<0.001
	Sr	0.001	mg/L		3.93	3.88
	Tl	0.0001	mg/L		<0.0001	<0.0001
	U	0.001	mg/L	MAC-0.02	<0.001	<0.001
	Zn	0.01	mg/L	AO-5.0	<0.01	<0.01
Nutrients	N-NH3	0.025	mg/L		0.251	0.203
	Organic Nitrogen	0.08	mg/L	OG-0.15	<0.08	<0.08
	Total Kjeldahl Nitrogen	0.07	mg/L		0.29	0.25
Phenols-4AAP	Phenols	0.002	mg/L		<0.002	<0.002
Subcontract	PO4	0.03	mg/L		<0.03	<0.03

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Date Submitted: 2015-09-10
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Project: 1418381
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QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 294465 **Analysis/Extraction Date** 2015-09-11 **Analyst** AET			
Method C SM2130B			
Turbidity	<0.1 NTU	100	73-127
Run No 294480 **Analysis/Extraction Date** 2015-09-11 **Analyst** SKH			
Method M SM3120B-3500C			
Calcium	<1 mg/L	100	90-110
Potassium	<1 mg/L	99	87-113
Magnesium	<1 mg/L	96	76-124
Sodium	<2 mg/L	95	82-118
Run No 294521 **Analysis/Extraction Date** 2015-09-11 **Analyst** AET			
Method C SM2510B			
Conductivity	<5 uS/cm	100	95-105
Method C SM4500-FC			
F	<0.10 mg/L	99	90-110
Method C SM4500-H+B			
pH	6.15	100	90-110
Method SM 2320B			
Alkalinity (CaCO3)	<5 mg/L	100	95-105
Run No 294529 **Analysis/Extraction Date** 2015-09-11 **Analyst** NP			

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Date Submitted: 2015-09-10
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Project: 1418381
COC #: 506591

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Method C SM4500-NO3-F			
N-NO2	<0.10 mg/L	97	80-120
N-NO3	<0.10 mg/L	90	80-120
Run No 294678 **Analysis/Extraction Date** 2015-09-15 **Analyst** K A			
Method EPA 200.8			
Silver	<0.0001 mg/L	95	94-106
Aluminum	<0.01 mg/L	99	89-111
Arsenic	<0.001 mg/L	98	93-106
Boron (total)	<0.01 mg/L	100	88-112
Barium	<0.01 mg/L	97	91-109
Beryllium	<0.0005 mg/L	97	93-107
Cadmium	<0.0001 mg/L	98	93-107
Chromium Total	<0.001 mg/L	95	94-106
Copper	<0.001 mg/L	95	93-106
Iron	<0.03 mg/L	96	92-107
Manganese	<0.01 mg/L	96	94-106
Molybdenum	<0.005 mg/L	101	94-106
Nickel	<0.005 mg/L	97	94-106

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Date Submitted: 2015-09-10
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Project: 1418381
COC #: 506591

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Lead	<0.001 mg/L	101	70-130
Antimony	<0.0005 mg/L	95	80-120
Selenium	<0.001 mg/L	99	91-108
Strontium	<0.001 mg/L	99	89-110
Thallium	<0.0001 mg/L	99	95-105
Uranium	<0.001 mg/L	98	94-106
Zinc	<0.01 mg/L	99	94-106
Run No 294752 **Analysis/Extraction Date** 2015-09-15 **Analyst** NP			
Method SM 4110C			
SO4	<1 mg/L	106	90-110
Run No 294782 **Analysis/Extraction Date** 2015-09-16 **Analyst** AET			
Method C SM2120C			
Colour	<2 TCU	95	90-110
Run No 294830 **Analysis/Extraction Date** 2015-09-16 **Analyst** NP			
Method SM 4110C			
Chloride	<1 mg/L	101	90-112
Run No 294930 **Analysis/Extraction Date** 2015-09-17 **Analyst** JDT			
Method M SM3112B-3500B			
Mercury	<0.0001 mg/L	89	76-123

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Date Submitted: 2015-09-10
Date Reported: 2015-09-18
Project: 1418381
COC #: 506591

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 294961 **Analysis/Extraction Date** 2015-09-16 **Analyst** CON			
Method Exova Edmonton-SM4500-NH3-G			
N-NH3	<0.025 mg/L	100	
Run No 294964 **Analysis/Extraction Date** 2015-09-15 **Analyst** CON			
Method Exova Edmonton-ISO/TR 11905-2			
Total Kjeldahl Nitrogen	<0.07 mg/L	88	
Run No 294983 **Analysis/Extraction Date** 2015-09-16 **Analyst** CON			
Method Exova Edmonton-SM5310B			
DOC	<0.5 mg/L	101	
Run No 294985 **Analysis/Extraction Date** 2015-09-15 **Analyst** CON			
Method Exova Surrey-SM5550B			
Tannin & Lignin	<0.1 mg/L		
Run No 294987 **Analysis/Extraction Date** 2015-09-14 **Analyst** CON			
Method Exova Edmonton-SM5530D			
Phenols	<0.002 mg/L	100	
Run No 295006 **Analysis/Extraction Date** 2015-09-16 **Analyst** SCM			
Method SUBCONTRACT-E-INORG			
PO4	<0.03 mg/L	103	
Run No 295009 **Analysis/Extraction Date** 2015-09-18 **Analyst** SCM			

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Report Number: 1518028
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Date Reported: 2015-09-18
Project: 1418381
COC #: 506591

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Method C SM2340B			
Hardness as CaCO3			
Run No 295010 **Analysis/Extraction Date** 2015-09-18 **Analyst** SCM			
Method C SM2540			
TDS (COND - CALC)			
Run No 295011 **Analysis/Extraction Date** 2015-09-18 **Analyst** SCM			
Method C SM2340B			
Hardness as CaCO3			
Method C SM4500-Norg-C			
Organic Nitrogen			
Run No 295012 **Analysis/Extraction Date** 2015-09-18 **Analyst** SCM			
Method C SM2540			
TDS (COND - CALC)			
Run No 295013 **Analysis/Extraction Date** 2015-09-18 **Analyst** SCM			
Method C SM4500-Norg-C			
Organic Nitrogen			

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EXOVA ENVIRONMENTAL ONTARIO

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
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Attention: Ms. Caitlin Cooke
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1518032
Date Submitted: 2015-09-10
Date Reported: 2015-09-13
Project: 1418381
COC #: 506591

Dear Caitlin Cooke:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

APPROVAL: Dragana Dzeletovic 2015.09.13 12:26:58 -04'00'

Dragana Dzeletovic
Team Leader, Microbiology

All analysis is completed in Ottawa, Ontario (unless otherwise indicated).

Exova Ottawa is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on our CALA scope of accreditation. It can be found at http://www.cala.ca/scopes/2602.pdf.

Exova (Ottawa) is certified and accredited for specific parameters by OMAFRA, Ontario Ministry of Agriculture, Food and Rural Affairs (for farm soils). Licensed by Ontario MOE for specific tests in drinking water.

Exova (Mississauga) is accredited for specific parameters by SCC, Standards Council of Canada (to ISO 17025)

Please note: Field data, where presented on the report, has been provided by the client and is presented for informational purposes only. Guideline values listed on this report are provided for ease of use (informational purposes) only. Exova recommends consulting the official provincial or federal guideline as required.

Certificate of Analysis

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Attention: Ms. Caitlin Cooke
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Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1518032
Date Submitted: 2015-09-10
Date Reported: 2015-09-13
Project: 1418381
COC #: 506591

				Lab I.D.	1200764	1200765
				Sample Matrix	Water	Water
				Sample Type		
				Sampling Date	2015-09-10	2015-09-10
				Sample I.D.	TW-15-02-3	TW15-02-06
Group	**Analyte**	**MRL**	**Units**	**Guideline**		
Microbiology	Escherichia Coli	0	ct/100mL	MAC-0	0	0
	Total Coliforms	0	ct/100mL	MAC-0	0	0

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EXOVA ENVIRONMENTAL ONTARIO

Certificate of Analysis

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1931 Robertson Road
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Attention: Ms. Caitlin Cooke
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1517883
Date Submitted: 2015-09-09
Date Reported: 2015-09-16
Project: 1418381
COC #: 179289

Dear Caitlin Cooke:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

APPROVAL: Shyla Monette 2015.09.16 15:55:42 -04'00'

Shyla Monette
Team Leader, Inorganics

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Report Number: 1517883
Date Submitted: 2015-09-09
Date Reported: 2015-09-16
Project: 1418381
COC #: 179289

				Lab I.D.	1200445	1200446
				Sample Matrix	Groundwater	Groundwater
				Sample Type		
				Sampling Date	2015-09-09	2015-09-09
				Sample I.D.	TW15-03-3	TW15-03-6
Group	**Analyte**	**MRL**	**Units**	**Guideline**		
Calculations	Hardness as CaCO3	1	mg/L	OG-100	316*	317*
	TDS (COND - CALC)	1	mg/L	AO-500	634*	629*
General Chemistry	Alkalinity as CaCO3	5	mg/L	OG-500	265	268
	Cl	1	mg/L	AO-250	122	118
	Colour	2	TCU	AO-5	4	6*
	Conductivity	5	uS/cm		975	967
	DOC	0.5	mg/L	AO-5	1.1	1.0
	F	0.10	mg/L	MAC-1.5	0.59	0.59
	N-NO2	0.10	mg/L	MAC-1.0	<0.10	<0.10
	N-NO3	0.10	mg/L	MAC-10.0	<0.10	<0.10
	pH	1.00		6.5-8.5	8.18	8.13
	SO4	1	mg/L	AO-500	63	61
	Tannin & Lignin	0.1	mg/L			0.2
	Turbidity	0.1	NTU	AO-5.0	0.9	1.7
Mercury	Hg	0.0001	mg/L	MAC-0.001	<0.0001	<0.0001
Metals	Ag	0.0001	mg/L		<0.0001	<0.0001
	Al	0.01	mg/L	OG-0.1	<0.01	<0.01
	As	0.001	mg/L	IMAC-0.025	0.001	0.001
	B	0.01	mg/L	IMAC-5.0	0.20	0.20
	Ba	0.01	mg/L	MAC-1.0	0.07	0.07
	Be	0.0005	mg/L		<0.0005	<0.0005
	Ca	1	mg/L		72	71
	Cd	0.0001	mg/L	MAC-0.005	<0.0001	<0.0001
	Cr	0.001	mg/L	MAC-0.05	<0.001	<0.001
	Cu	0.001	mg/L	AO-1.0	<0.001	<0.001
	Fe	0.03	mg/L	AO-0.3	0.22	0.22

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Date Submitted: 2015-09-09
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Project: 1418381
COC #: 179289

Group	Analyte	MRL	Units	Guideline	1200445 Groundwater 2015-09-09 TW15-03-3	1200446 Groundwater 2015-09-09 TW15-03-6
	Lab I.D.				1200445	1200446
	Sample Matrix				Groundwater	Groundwater
	Sample Type					
	Sampling Date				2015-09-09	2015-09-09
	Sample I.D.				TW15-03-3	TW15-03-6
Metals	K	1	mg/L		6	6
	Mg	1	mg/L		33	34
	Mn	0.01	mg/L	AO-0.05	<0.01	<0.01
	Mo	0.005	mg/L		<0.005	<0.005
	Na	2	mg/L	AO-200	90	88
	Ni	0.005	mg/L		<0.005	<0.005
	Pb	0.001	mg/L	MAC-0.010	<0.001	<0.001
	Sb	0.0005	mg/L	IMAC-0.006	<0.0005	<0.0005
	Se	0.001	mg/L	MAC-0.01	<0.001	<0.001
	Sr	0.001	mg/L		2.25	2.17
	Tl	0.0001	mg/L		<0.0001	<0.0001
	U	0.001	mg/L	MAC-0.02	0.001	0.001
	Zn	0.01	mg/L	AO-5.0	<0.01	<0.01
Nutrients	N-NH3	0.025	mg/L		0.235	0.207
	Organic Nitrogen	0.08	mg/L	OG-0.15	0.13	0.08
	Total Kjeldahl Nitrogen	0.07	mg/L		0.36	0.29
Phenols-4AAP	Phenols	0.002	mg/L		<0.002	<0.002
Subcontract	PO4	0.03	mg/L		<0.03	<0.03
	Tannin & Lignin	0.1	mg/L		0.2	

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Date Submitted: 2015-09-09
Date Reported: 2015-09-16
Project: 1418381
COC #: 179289

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 294357 **Analysis/Extraction Date** 2015-09-10 **Analyst** AET			
Method C SM2130B			
Turbidity	<0.1 NTU	100	73-127
Run No 294426 **Analysis/Extraction Date** 2015-09-10 **Analyst** NP			
Method C SM4500-NO3-F			
N-NO2	<0.10 mg/L	97	80-120
N-NO3	<0.10 mg/L	92	80-120
Run No 294467 **Analysis/Extraction Date** 2015-09-11 **Analyst** AET			
Method C SM2120C			
Colour	<2 TCU	100	90-110
Run No 294480 **Analysis/Extraction Date** 2015-09-11 **Analyst** SKH			
Method M SM3120B-3500C			
Calcium	<1 mg/L	100	90-110
Potassium	<1 mg/L	99	87-113
Magnesium	<1 mg/L	96	76-124
Sodium	<2 mg/L	95	82-118
Run No 294521 **Analysis/Extraction Date** 2015-09-11 **Analyst** AET			
Method C SM2510B			

Guideline = ODWSOG *** = Guideline Exceedence**
All analysis completed in Ottawa, Ontario (unless otherwise indicated by ** which indicates analysis was completed in Mississauga, Ontario).
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Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Caitlin Cooke
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1517883
Date Submitted: 2015-09-09
Date Reported: 2015-09-16
Project: 1418381
COC #: 179289

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Conductivity	<5 uS/cm	100	95-105
Method C SM4500-FC			
F	<0.10 mg/L	99	90-110
Method C SM4500-H+B			
pH	6.15	100	90-110
Method SM 2320B			
Alkalinity (CaCO3)	<5 mg/L	100	95-105
Run No 294551 **Analysis/Extraction Date** 2015-09-11 **Analyst** NP			
Method SM 4110			
SO4	<1 mg/L	106	90-110
Run No 294563 **Analysis/Extraction Date** 2015-09-14 **Analyst** K A			
Method EPA 200.8			
Silver	<0.0001 mg/L	98	94-106
Aluminum	<0.01 mg/L	98	89-111
Arsenic	<0.001 mg/L	97	93-106
Boron (total)	<0.01 mg/L	103	88-112
Barium	<0.01 mg/L	100	91-109
Beryllium	<0.0005 mg/L	97	93-107
Cadmium	<0.0001 mg/L	97	93-107

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Date Reported: 2015-09-16
Project: 1418381
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QC Summary

Analyte	Blank	QC % Rec	QC Limits
Chromium Total	<0.001 mg/L	97	94-106
Copper	<0.001 mg/L	97	93-106
Iron	<0.03 mg/L	98	92-107
Manganese	<0.01 mg/L	99	94-106
Molybdenum	<0.005 mg/L	100	94-106
Nickel	<0.005 mg/L	99	94-106
Lead	<0.001 mg/L	100	70-130
Antimony	<0.0005 mg/L	94	80-120
Selenium	<0.001 mg/L	100	91-108
Strontium	<0.001 mg/L	100	89-110
Thallium	<0.0001 mg/L	96	95-105
Uranium	<0.001 mg/L	98	94-106
Zinc	<0.01 mg/L	98	94-106
Run No 294596 **Analysis/Extraction Date** 2015-09-14 **Analyst** JDT			
Method M SM3112B-3500B			
Mercury	<0.0001 mg/L	91	76-123
Run No 294752 **Analysis/Extraction Date** 2015-09-15 **Analyst** NP			
Method SM 4110C			

Guideline = ODWSOG *** = Guideline Exceedence**
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Project: 1418381
COC #: 179289

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Chloride	<1 mg/L	101	90-112
Run No 294757 **Analysis/Extraction Date** 2015-09-14 **Analyst** CON			
Method Exova Edmonton-SM5530D			
Phenols	<0.002 mg/L	100	
Run No 294758 **Analysis/Extraction Date** 2015-09-11 **Analyst** CON			
Method Exova Edmonton-SM4500-NH3-G			
N-NH3	<0.025 mg/L	100	
Run No 294764 **Analysis/Extraction Date** 2015-09-14 **Analyst** CON			
Method Exova Edmonton-ISO/TR 11905-2			
Total Kjeldahl Nitrogen	<0.07 mg/L	95	
Run No 294787 **Analysis/Extraction Date** 2015-09-14 **Analyst** CON			
Method Exova Edmonton-SM5310B			
DOC	<0.5 mg/L	109	
Run No 294800 **Analysis/Extraction Date** 2015-09-14 **Analyst** CON			
Method Exova Surrey-SM5550B			
Tannin & Lignin			
Method SUBCONTRACT-SU-INORG			
Tannin & Lignin	<0.1 mg/L		
Run No 294807 **Analysis/Extraction Date** 2015-09-14 **Analyst** SCM			

Guideline = ODWSOG *** = Guideline Exceedence**
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Ottawa, ON
K2H 5B7
Attention: Ms. Caitlin Cooke
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1517883
Date Submitted: 2015-09-09
Date Reported: 2015-09-16
Project: 1418381
COC #: 179289

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Method SUBCONTRACT-E-INORG			
PO4	<0.03 mg/L	103	
Run No 294812 **Analysis/Extraction Date** 2015-09-16 **Analyst** SCM			
Method C SM2340B			
Hardness as CaCO3			
Run No 294813 **Analysis/Extraction Date** 2015-09-16 **Analyst** SCM			
Method C SM2540			
TDS (COND - CALC)			
Run No 294814 **Analysis/Extraction Date** 2015-09-16 **Analyst** SCM			
Method C SM2340B			
Hardness as CaCO3			
Method C SM4500-Norg-C			
Organic Nitrogen			
Run No 294816 **Analysis/Extraction Date** 2015-09-16 **Analyst** SCM			
Method C SM2540			
TDS (COND - CALC)			
Run No 294817 **Analysis/Extraction Date** 2015-09-16 **Analyst** SCM			
Method C SM4500-Norg-C			
Organic Nitrogen			

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EXOVA ENVIRONMENTAL ONTARIO

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Caitlin Cooke
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1517882
Date Submitted: 2015-09-09
Date Reported: 2015-09-10
Project: 1418381
COC #: 179289

Dear Caitlin Cooke:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

Krista Quantrill
2015.09.10
15:39:05 -04'00'

APPROVAL: _____

Krista Quantrill
Laboratory Supervisor, Microbiology

All analysis is completed in Ottawa, Ontario (unless otherwise indicated).

Exova Ottawa is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on our CALA scope of accreditation. It can be found at http://www.cala.ca/scopes/2602.pdf.

Exova (Ottawa) is certified and accredited for specific parameters by OMAFRA, Ontario Ministry of Agriculture, Food and Rural Affairs (for farm soils). Licensed by Ontario MOE for specific tests in drinking water.

Exova (Mississauga) is accredited for specific parameters by SCC, Standards Council of Canada (to ISO 17025)

Please note: Field data, where presented on the report, has been provided by the client and is presented for informational purposes only. Guideline values listed on this report are provided for ease of use (informational purposes) only. Exova recommends consulting the official provincial or federal guideline as required.

EXOVA ENVIRONMENTAL ONTARIO

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Caitlin Cooke
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1517882
Date Submitted: 2015-09-09
Date Reported: 2015-09-10
Project: 1418381
COC #: 179289

				Lab I.D.	1200443	1200444
				Sample Matrix	Groundwater	Groundwater
				Sample Type	-	-
				Sampling Date	2015-09-09	2015-09-09
				Sample I.D.	TW15-03-3	TW15-03-6
Group	**Analyte**	**MRL**	**Units**	**Guideline**		
Microbiology	Escherichia Coli	0	ct/100mL	MAC-0	0	0
	Total Coliforms	0	ct/100mL	MAC-0	0	0

Guideline = ODWSOG *** = Guideline Exceedence**

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APPENDIX E

Neighbouring Well Survey Forms

WATER WELL SYSTEM SURVEY QUESTIONNAIRE

TYPE OF DWELLING: ☒ Residential ☐ Commercial ☐ Institutional ☐ Other

I. OWNER/OCCUPANT INFORMATION AND GENERAL QUESTIONS:

OWNER/OCCUPANT:

Name: [redacted] Telephone No. (business)

Address: 3316 SHEARA Telephone No. (home) [redacted]

Number of Bedrooms 3 Number of Occupants 2

GENERAL QUESTIONS

How long have you owned/occupied this dwelling? 44 years

Is well water used for drinking water supply? Yes ☒ No ☐

If no, why not?

If no, how long has it been since well water was used for drinking?

If no, what is the origin of drinking water?

II. WATER WELL

A. WELL CONSTRUCTION DETAILS:

Date or year constructed Approx 1967-68 Contractor N/A

Well record number (if known) unknown

Type of well: Drilled ☒ Dug ☐ Well diameter (inches) unknown

Location of well (e.g. front yard, back yard, etc.) FRONT YARD

Present well depth Approx 40 ft Original well depth ☒ Same as present

Is the well accessible? Yes ☐ No ☒

Is well vented and how? Vented thru basement wall

B. WATER QUANTITY

Does your well supply enough water for your use? Yes ☒ No ☐

If no, is this is the case: all the time ☐ some of the time ☐ seasonally ☐ other .....

Use: Domestic: No ☐ Yes ☒ No. of persons using water from well ...3...

Lawn Watering: No ☐ Yes ☒ Other Uses .....

Have you ever experienced any problems with your well? ...No...

What was the cause of the problem? ☐ Drought ☐ Pump Failure ☐ Plugging

☐ Increased Usage ☐ Interference ☐ Other (Please Specify) .....

Did you ever have your well deepened or cleaned, or a new well constructed? .....

If so, why? ...Foot Valve ~~repaired~~ replaced...

C. WATER QUALITY

Water Treatment equipment in use (if any)...WATER SOFTENER...

Has your well recently been chlorinated and, if so, when? ...No...

How would you describe quality of your water? ☐Poor ☒Good ☐Excellent

Has your water quality previously been tested? No ☐ Yes ☒

If yes, for what and how often? (bacteriological, chemical analyses, etc.) .....

...Bacteriological...

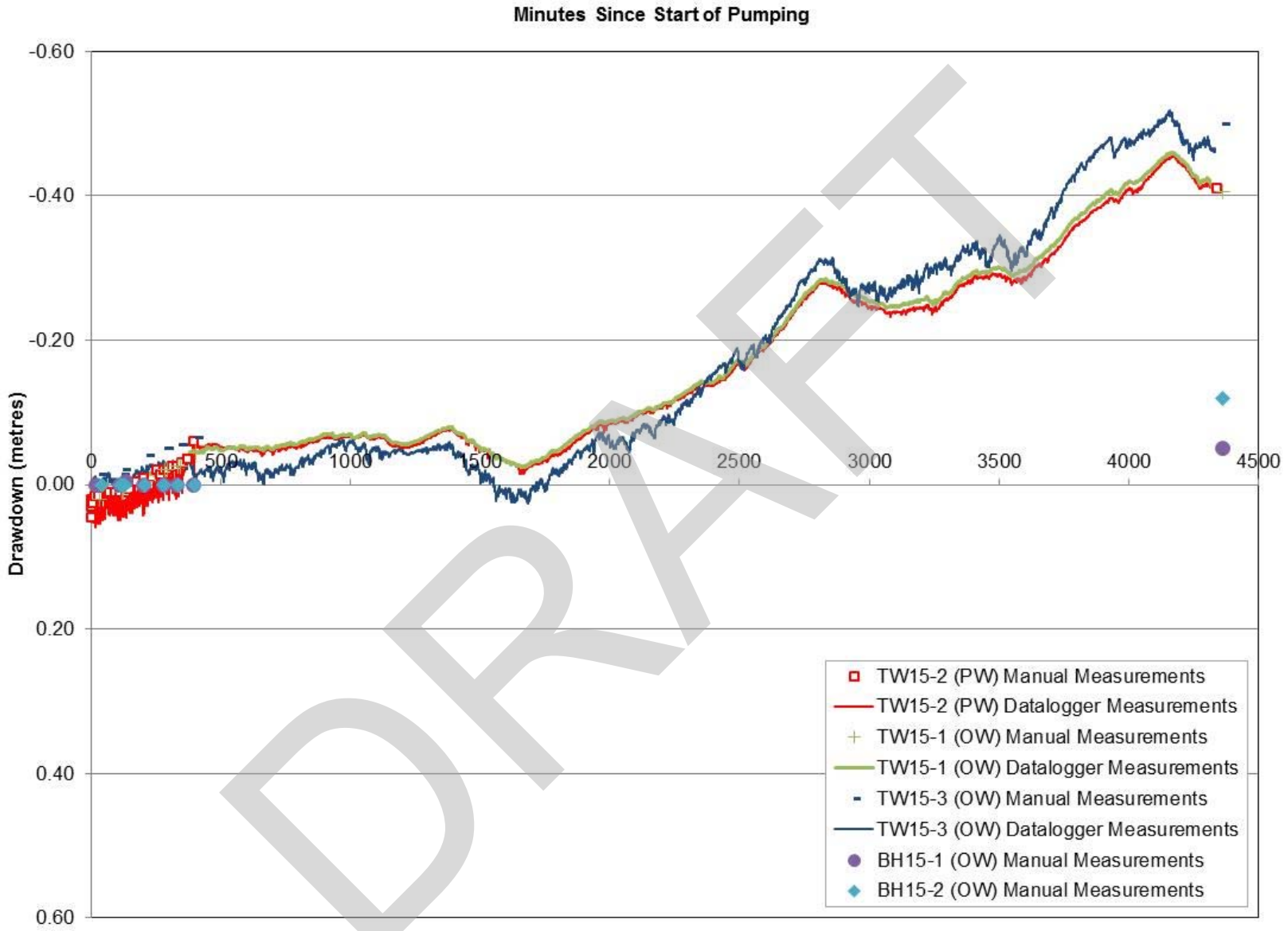
D. WATER SAMPLING INFORMATION

Would you be interested in having a water sample collected? ☒No ☐Yes

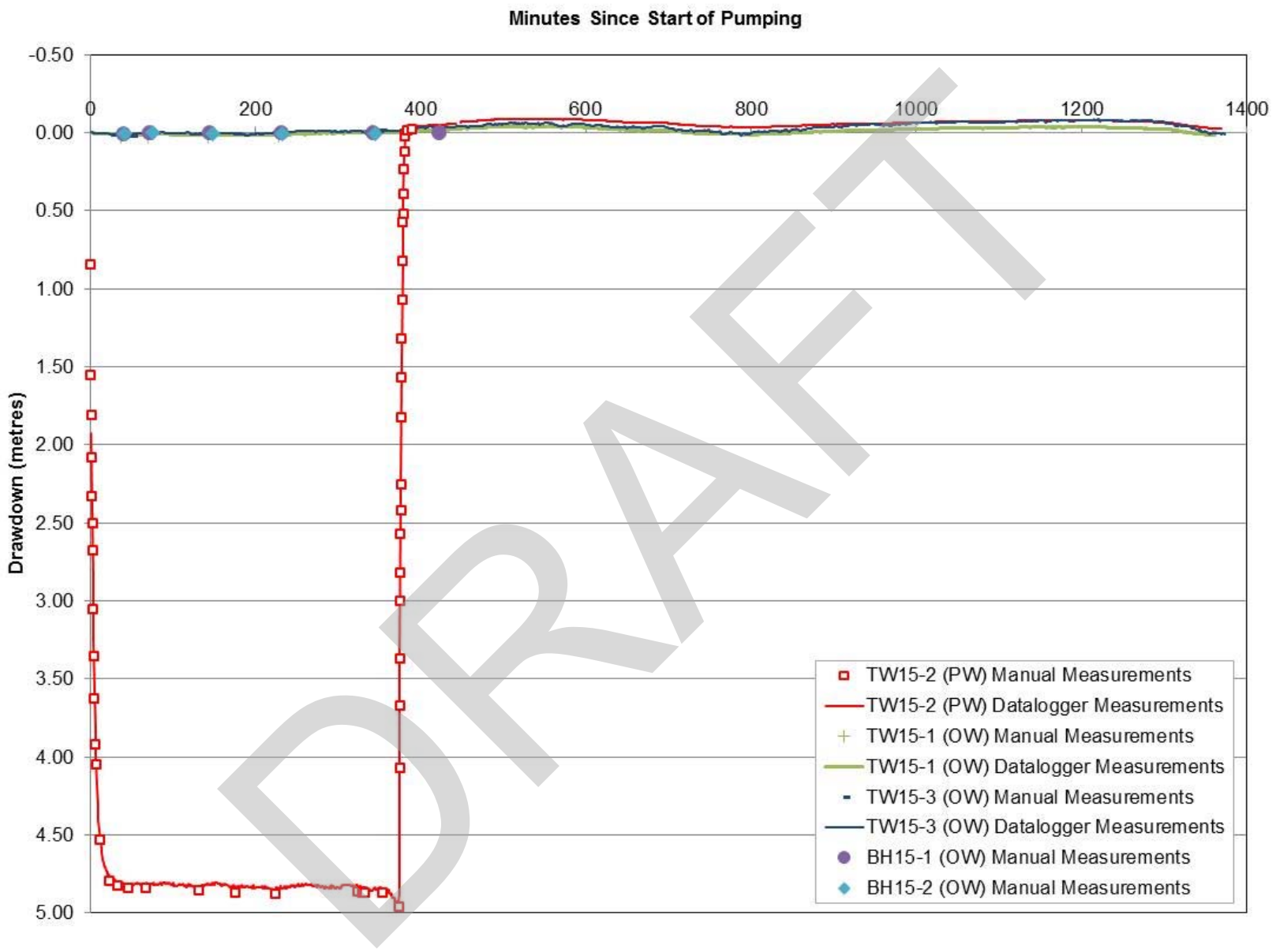
Please return this questionnaire in the included pre- addressed, stamped envelope.

APPENDIX F

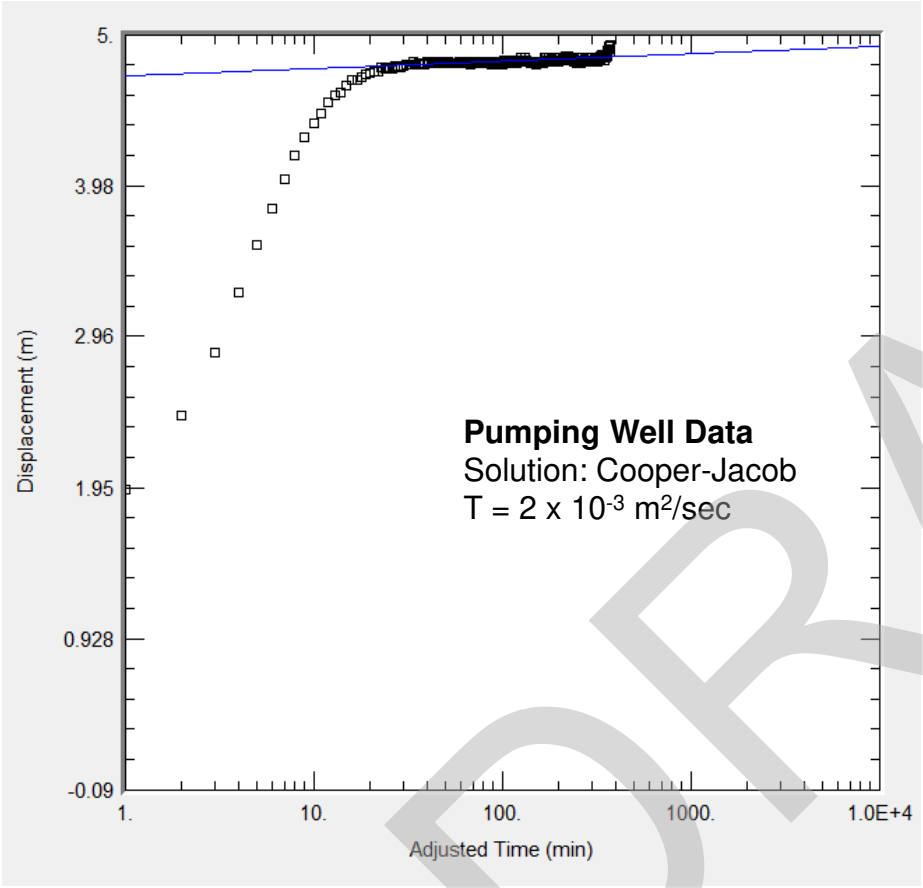
Hydraulic Testing Data and Analyses

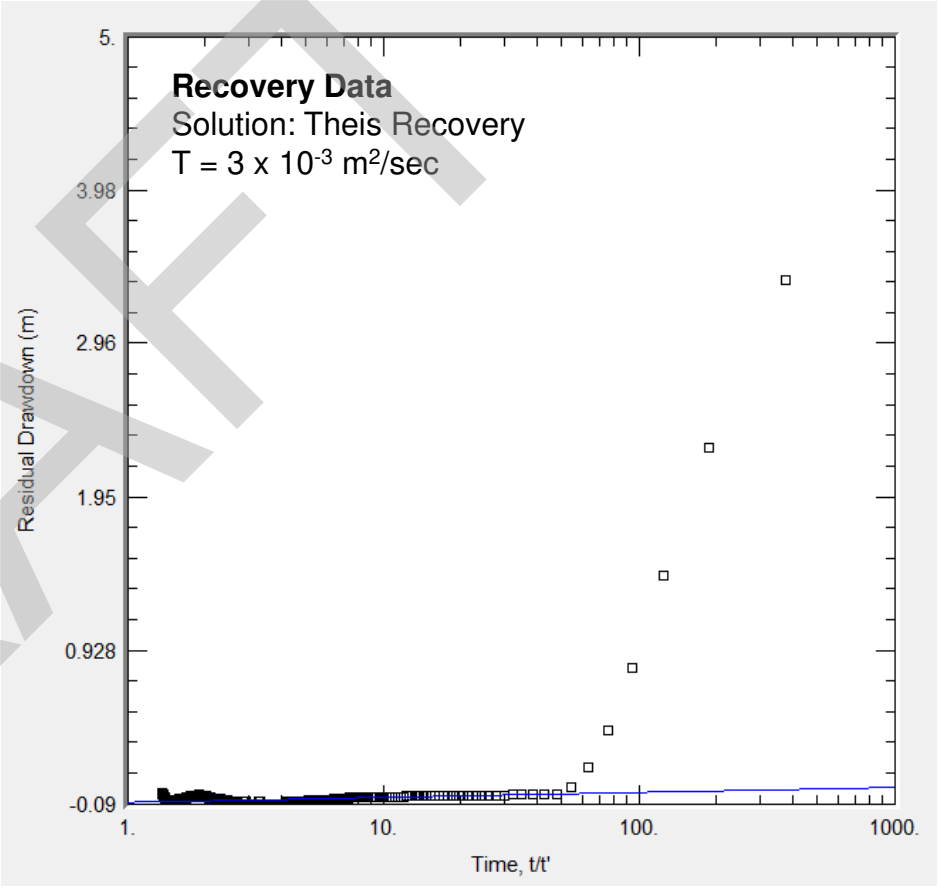


Golder Associates	Date: October 2015 Drawn: CAMC Project: 1418381-1000 Chkd: BTB	Water Level Response during Pumping at TW15-1	FIGURE F-1

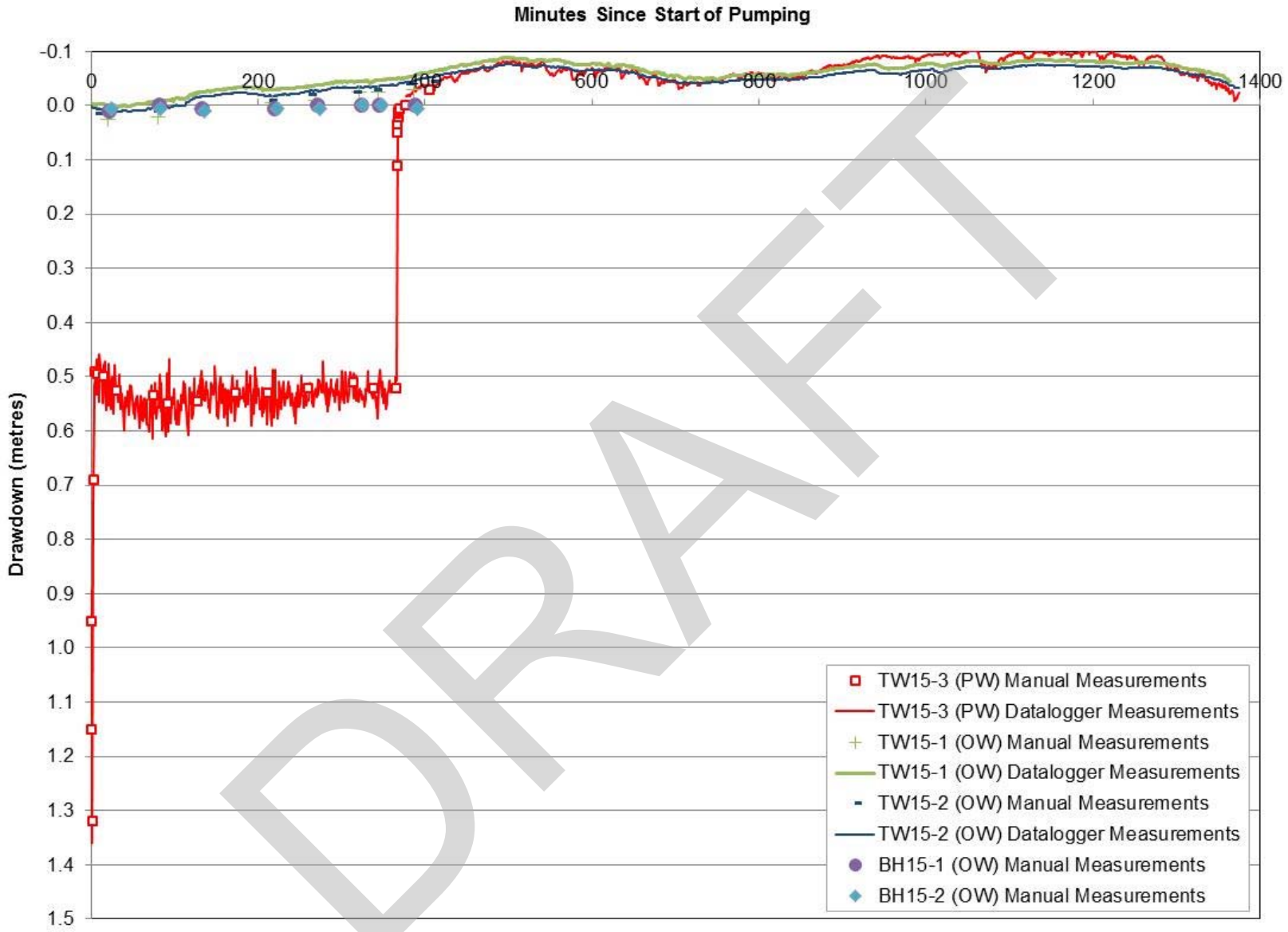


Golder Associates	Date: October 2015 Drawn: CAMC Project: 1418381-1000 Chkd: BTB	Water Level Response during Pumping at TW15-2	FIGURE F-2





Golder Associates	Date: October 2015 Drawn: CAMC Project: 1418381-1000 Chkd: BTB	Analysis of Hydraulic Response during Pumping at TW15-2	FIGURE F-3



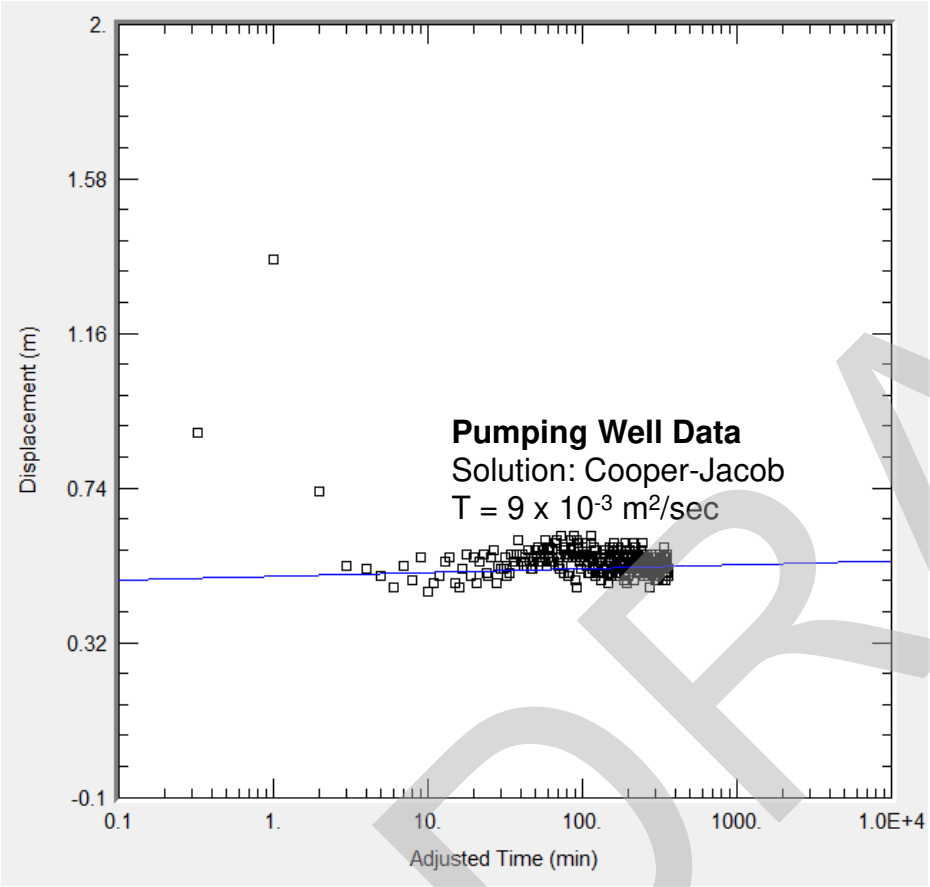
Golder Associates

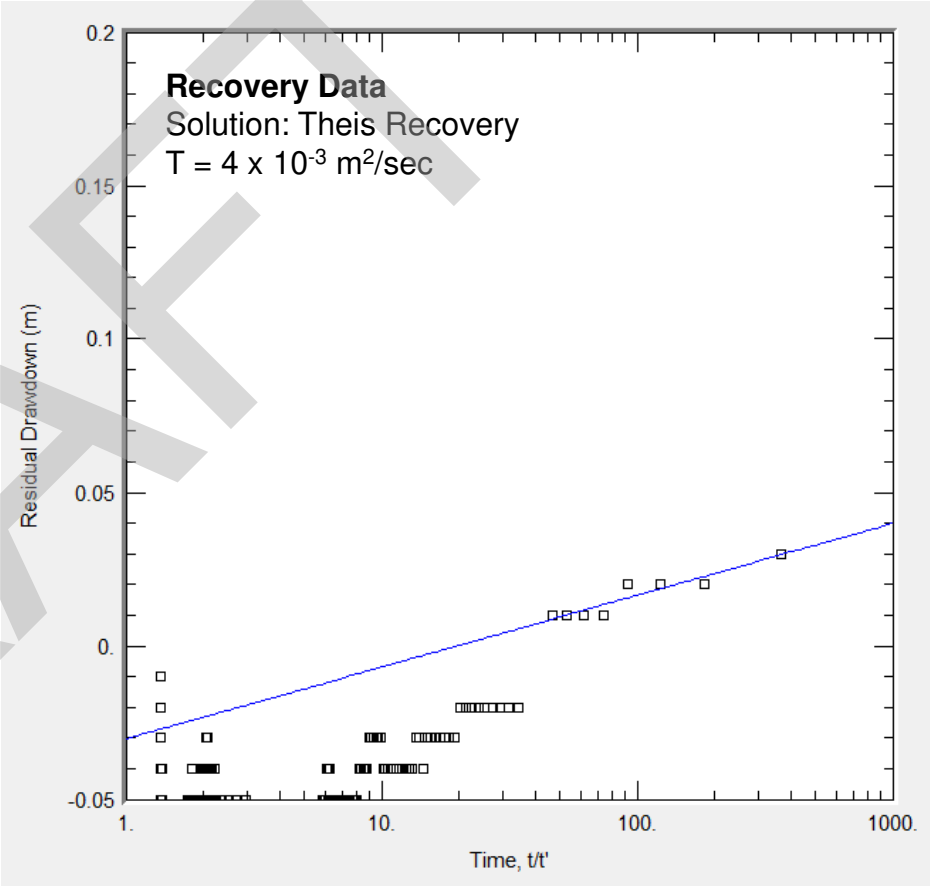
Date: October 2015 Drawn: CAMC

Project: 1418381-1000 Chkd: BTB

Water Level Response during Pumping at TW15-3

FIGURE F-4





Golder Associates	Date: October 2015 Drawn: CAMC Project: 1418381-1000 Chkd: BTB	Analysis of Hydraulic Response during Pumping at TW15-3	FIGURE F-5

APPENDIX G

Calculations: Well Interference and Langelier Saturations Index

ASSESSMENT OF MUTUAL WELL INTERFERENCE

Assumptions:

Centre point:	Lot 17	
S (-) =	1.0E-04	
T (m^2/s) =	2.0E-03	m2/d
Q (L/d) =	2250	
Q (m^3/s) =	2.604E-05	
Duration (yrs) =	20	
Duration (s) =	630720000	

From Lot	Distance (m)	20 Year Drawdown (m)
1	219	0.014
2	206	0.014
3	193	0.014
4	180	0.014
5	167	0.014
6	154	0.014
7	140	0.015
8	127	0.015
9	105	0.015
10	92	0.016
11	79	0.016
12	66	0.016
13	52	0.017
14	39	0.017
15	26	0.018
16	13	0.020
17	0	0.030
18	13	0.020
19	26	0.018
20	39	0.017
21	52	0.017
22	66	0.016
23	79	0.016
24	92	0.016
25	105	0.015
26	118	0.015
27	131	0.015
28	144	0.015
29	201	0.014
30	201	0.014
31	204	0.014
32	197	0.014
33	181	0.014
34	160	0.014
35	148	0.015
36	136	0.015
37	123	0.015
38	110	0.015
39	101	0.015
40	91	0.016
41	67	0.016
42	84	0.016
43	102	0.015
44	117	0.015
45	122	0.015
46	117	0.015
47	101	0.015
48	76	0.016
49	61	0.016
50	94	0.016
51	150	0.015
52	160	0.014
53	172	0.014
54	184	0.014
55	198	0.014
56	212	0.014
57	224	0.014
58	239	0.014
59	251	0.013
3290 Shea Road	192	0.014
4 Hemphill Street	153	0.014
3310 Shea Road	90	0.016
3316 Shea Road	69	0.016
3318 Shea Road	45	0.017
3326 Shea Road	32	0.018
3330 Shea Road	39	0.017
3338 Shea Road	55	0.017
1 Moore Street	115	0.015
3354 Shea Road	148	0.015
3360 Shea Road	171	0.014
3366 Shea Road	203	0.014
3372 Shea Road	228	0.014
3378 Shea Road	260	0.013
Cumulative aquifer drawdown at lot 17 (central lot) =		**1.128**

Note: Drawdowns calculated using methods of Theis (1935)

LANGELIER SATURATION INDEX CALCULATIONS

Sample	pH	TDS (mg/L)	Temp (deg C)	Ca (mg/L)	Ca as CaCO3 (mg/L)	Alkalinity as CaCO3 (mg/L)	A	B	C	D	pHs	Langelier Saturation Index (pH-pHs)	Comment
TW15-1 - 3 hours	7.75	545	12.2	28	70	229	0.17364	2.338438	1.445098	2.359835	8.007144	-0.26	Acceptable Range
TW15-1 - 6 hours	7.73	545	12.2	28	70	226	0.17364	2.338438	1.445098	2.354108	8.012871	-0.28	Acceptable Range
TW15-2 - 3 hours	7.67	577	13.0	40	100	244	0.176118	2.322478	1.6	2.38739	7.811205	-0.14	Acceptable Range
TW15-2 - 6 hours	7.61	571	12.0	40	100	251	0.175664	2.342435	1.6	2.399674	7.818425	-0.21	Acceptable Range
TW15-3 - 3 hours	7.82	634	12.6	72	180	265	0.180209	2.330452	1.855273	2.423246	7.532143	0.29	Acceptable Range
TW15-3 - 6 hours	7.76	629	13.0	71	177.5	268	0.179865	2.322478	1.849198	2.428135	7.52501	0.23	Acceptable Range

An acceptable range is -0.5 to +0.5

Notes:

$LSI = pH - pH_s$

$pH_s = (9.3 + A + B) - (C + D)$

$A = (Log_{10} [TDS] - 1) / 10$

$B = -13.12 \times Log_{10} (^{o}C + 273) + 34.55$

$C = Log_{10} [Ca^{2+} \text{ as } CaCO_3] - 0.4$

$D = Log_{10} [\text{alkalinity as } CaCO_3]$

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

For more information, visit golder.com

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