REVISED REPORT

Hydrogeology Investigation, Terrain Analysis and Impact Assessment

Cavanagh Developments, 2596 Carp Road, Ottawa, Ontario

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APPENDICES

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by Cavanagh Developments (Cavanagh) to carry out a hydrogeology investigation, terrain analysis and impact assessment in support of the proposed development of a concrete plant at 2596 Carp Road (the Site) in Ottawa, Ontario (Figure 1).

This revised report incorporates the recommendations provided to Cavanagh by the City of Ottawa in documents dated November 21, 2018, January 15, 2019 and February 20, 2019. It also reflects the current anticipated water taking requirements for the proposed concrete plant. The first version of the report was submitted in September 2018 and a first revised version was submitted in January 2019.

The Site consists of a parcel of land measuring 28.8 hectares in size, within which the operating area of the concrete plant would measure approximately 3.7 hectares. The concrete plant would be privately serviced by two groundwater supply wells and a new septic system, while the administration building would be serviced by an existing groundwater supply well and an existing septic system. The remaining portion of the Site would remain undeveloped at this time.

The objectives of the hydrogeology investigation, terrain analysis and impact assessment were to:

- Determine the shallow subsurface soil and groundwater conditions;
- Investigate the potential quantity and quality of groundwater available from drilled wells for concrete production and for the office water supply;
- Assess the potential impact of the sewage systems in the proposed development on downgradient groundwater and/or surface water resources; and,
- Complete a water balance assessment for the proposed Site development.

1.1 Technical Guidance Documents

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

- Ministry of the Environment (MOE) Procedure D-5-4. Technical Guideline for Individual On-Site Sewage Systems: Water Quality Impact Risk Assessment (August 1996).
- Ministry of the Environment (MOE) Procedure D-5-5. Technical Guideline for Private Wells: Water Supply Assessment (August 1996).
- Ministry of the Environment and Energy (MOEE) Hydrogeological Technical Information Requirements for Land Development Applications (TIR; April 1995).
- MOE Stormwater Management Planning and Design Manual (2003), hereafter referred to as the MOE Manual.
- Hydrogeological Assessment Submissions (Conservation Authority Guidelines for Development Applications) (2013), hereafter referred to as the CA Guidelines.
- Low Impact Development Stormwater Management Planning and Design Guide (by Credit Valley Conservation and Toronto Region Conservation), hereafter referred to as the LID Guide.
- Carp River Watershed/Subwatershed Study, Volume I – Main Report (2004). Prepared for the City of Ottawa by Robinson Consultants Inc.

2.0 SITE BACKGROUND

2.1 Site Description

In this document, the “Site” refers to the 28.8-hectare total site area, while the “proposed concrete plant site” is the area in which development is currently proposed (see Figure 1).

The Site is primarily undeveloped grassy land with sparse bushes and some fill piles. Huntley Creek flows across the northern half of the Site, roughly from southwest to northeast (see Figure 1) and the area immediately surrounding the creek is more heavily treed. Also located within the Site are one residence and one small commercial enterprise. At the southern end of the Site, there are some commercial storage buildings and associated access roads.

The current land uses with 500 metres of the Site are varied. To the southeast of the Site, along Richardson Side Road, there is commercial and industrial development, rural residential development and an undeveloped area used for storage of aggregates. To the south and southwest of the Site, along Carp Road, there is primarily commercial and industrial development. The areas north and east of the Site consist primarily of forest, rural residential development and some agricultural lands.

The topography of the Site shows that the ground surface on both sides of Huntley Creek slopes toward the creek. South of the creek, the average slope is approximately 0.02 toward the northeast. North of the creek, the average slope is approximately 0.025 to the east (Figure 1). The Site surficial drainage is interpreted to follow the topography toward Huntley Creek. The Site is located within the Carp River watershed and Huntley Creek subwatershed.

2.2 Regional Geology

2.2.1 Surficial Geology

Based on published geology maps, the surficial geology at the Site consists primarily of glaciomarine sand and gravel deposits, with a zone of glacial till in the middle of the Site (see Figure 2). These units are also mapped beyond the Site boundaries, in addition to muck and peat and fine-textured glaciomarine deposits mapped to the north of the site.

2.2.2 Bedrock Geology

Based on published mapping, the upper bedrock units at the Site are mapped as the Bobcaygeon Formation and the Verulam Formation. A bedrock fault is mapped as crossing the Site from roughly west to east, separating the Bobcaygeon Formation to the south from the Verulam formation to the north (see Figure 3). As described in the Mississippi-Rideau Source Protection Region (MRSPR) Watershed Characterization Report, the Bobcaygeon Formation is limestone with varying shale content, and the thickness of the formation varies between approximately 80 to 90 metres in the northwestern portions of the MRSPR to 50 metres in the eastern portions (MRSPR, 2008). The Verulam Formation is interbedded limestone and shale, and its thickness varies from 30 metres near Ottawa to 65 metres in the east of the MRSPR (MRSPR, 2008).

2.3 Hydrogeology

2.3.1 Overburden Aquifers

Extensive deposits of coarse and permeable overburden capable of supplying sufficient quantities of groundwater do not appear on geological maps for the study area (see Figure 2). For this reason, the bedrock is considered the principal source for water supply within the vicinity of the Site for locations where municipal services are not available.

2.3.2 Bedrock Aquifers

The limestone and shale aquifer units in the MRSPR, including the Bobcaygeon and Verulam Formations that are the uppermost bedrock formations at the Site, are indicated to provide a poor or marginally moderate yield of potable water for domestic consumption (i.e., less than 10 to 15 L/min) (MRSPR, 2008). Groundwater flow in the Bobcaygeon and Verulam Formations is through bedrock fractures; however, the presence of shale content in the Verulam Formation may adversely affect the water quality and yield (MRSPR, 2008).

Regional groundwater flow is generally from southwest to northeast toward the Ottawa River (MRSPR, 2008).

2.3.3 Local Water Supply

The Ministry of the Environment, Conservation and Parks (MECP) 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 proposed water taking locations are plotted on Figure 3. Note that the water well records for the existing Site test wells and monitoring wells are not shown on Figure 3. In addition, some water well locations were adjusted based on a review of the original well records. All 7 well records within 500 metres of the Site are for water supply wells completed in limestone bedrock at depths ranging from 20 to 87 metres. The depth to bedrock encountered in the wells was 3 to 8 metres. The overburden material overlying the bedrock at these wells was variable and included clay, sand and gravel, and hardpan (interpreted to be glacial till). Water was found at a depth of 7 to 31 metres in the bedrock wells, and the static water level ranged from 1.1 to 8.2 metres below ground. Based on these data, the available drawdown (calculated as the difference between the static water level and the total well depth) was estimated to range from 15.8 to 84.1 metres. A summary of key information from the WWIS records within 500 metres of the site is provided in Appendix A.

2.4 Proposed Site Development

The development of the concrete plant site will include a concrete batching plant with surface parking areas, a vehicle refueling area and aggregate storage areas.

2.4.1 Water Supply

The proposed water supply for the concrete plant site will be groundwater taken from two on-site water supply wells referred to as TW5 and TW6 (see Figure 4). More information on these wells is provided in Section 4.1. Permit to Take Water Number 4753-B7NJXC was issued by the MECP to Cavanagh Concrete Ltd. on February 13, 2019 and allows groundwater taking from TW5 and TW6 (see Appendix C).

It is proposed that one water supply well will serve as the main water source for the plant, while the other well will serve as a backup well. The concrete plant will also have two 20,000-L water storage tanks to supplement production and ensure the plant can operate at full capacity, as well as a 6,000-L tank associated with the heating system. The plant will typically operate between 11 and 12 hours per day with an anticipated average water taking rate of 283 L/min. Under maximum production, a taking of up to 333 L/min for 12 hours/day may be required. In addition to the water taking for concrete production, test wells TW5 and TW6 will provide water supply for up to 50 employees at the concrete plant. A small portion of the water would also be used for equipment washing within

the concrete plant and for washing cement trucks after loading and at the end of the work day. The maximum total anticipated water taking rate from TW5 and/or TW6 is 245,000 L/day, or 340 L/min for 12 hours/day.

The required maximum number of days of water taking for the concrete plant per year is 365, although the concrete production rate (and the associated water taking) is expected to be decreased between the months of December to March due to lower demand.

The existing residence located immediately north of the concrete plant site will be repurposed as an administration building. It will be serviced by the existing water supply well for the house (referred to as House Well; see Figure 4). It is understood that the maximum number of employees using the water supply at the house would be 36 (separate from the maximum 50 employees at the concrete plant). Therefore, assuming a daily water usage of 75 L/day/employee, the maximum water taking from the House Well is expected to be 2,700 L/day.

The following rates of water taking are permitted by PTTW Number 4753-B7NJXC:

Source	Taking Purpose	Maximum Rate per Minute (L)	Maximum Number of Hours Taking per Day	Maximum Volume per Day (L)
TW5	Concrete Plant	340	12	245,000
TW6	Concrete Plant	340	12	245,000
			Total	**245,000**

As noted in the above table, TW5 and TW6 may be operated one at a time or simultaneously, but the total water taking rate will not exceed 245,000 L/day.

The maximum taking at the House Well (2,700 L/day) is approximately 1% of the maximum taking from TW5 and TW6 (245,000 L/day) and is well below the threshold of 50,000 L/day at which a PTTW is required for a single source. Given the relatively minor water taking rate from this source, it was proposed to the MECP to omit it from Table A in the PTTW application form, and as such, it is not subject to flow monitoring and reporting requirements.

2.4.2 Septic Systems

A new on-site septic system is proposed to provide treatment of all sewage flows generated from the concrete plant. Gemtec Consulting Engineers and Scientists Limited (Gemtec) has designed a new on-site septic system (submitted under a separate cover) which has been sized to adequately treat all sewage flows generated from the concrete mixing plant.

The existing residence (future administration building) will be serviced by the existing on-site sewage treatment system. The location of the existing septic leaching bed for the house is shown on Figure 1.

2.4.3 Stormwater Management

The stormwater management system will consist of two bioretention facilities across the concrete plant site to capture stormwater runoff and provide cleansing prior to discharge into Huntley Creek. Bioretention temporarily stores, treats and infiltrates/filtrates runoff. The proposed bioretention facilities will provide enhanced quality control via infiltration/filtration of stormwater through the various treatment layers within the facility if full infiltration of the runoff volume control target (RVCT) is achieved. The stormwater management system is described in detail by Robinson Land Development under separate cover (Robinson, 2019).

2.5 Additional Studies Completed by Golder

An Ontario Regulation 153/04 Phase One Environmental Site Assessment (ESA) was conducted at the Site in May 2016 by Golder, as documented in Golder (2016). Two Areas of Potential Environmental Concern (APECs) were identified due to 1) the historical importation of fill of unknown quality in several locations (the nearest of which was 20 metres north of the proposed concrete plant site) and 2) actively/formerly used diesel and gasoline tanks (located approximately 140 metres northwest of the proposed concrete plant site). Golder subsequently carried out a Phase One ESA Update in August 2018, and identified no new APECs for the site (Golder, 2018a). Based on the presence of the two APECs as described above, a Phase Two ESA was required and was carried out in August/September 2018 (Golder 2018b).

The Phase Two ESA was conducted to assess soil and groundwater conditions at both APECs. Analytical data was compared to the Table 8 generic site condition standards in a potable groundwater condition within 30 meters of a water body (SCS; residential/parkland/industrial/commercial property use, coarse soil texture) presented in the MECP "*Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act*", dated April 15, 2011. The analytical results from the sampling and analysis program identified the following soil and groundwater impacts:

- The cadmium concentration in crushed stone exceeded the MECP Table 8 Standard at one location near the existing residence (approximately 20 metres of the proposed concrete plant site). The exceedance appears to be limited to the imported fill used for creation of the residence's driveway and is not a Site-wide issue.
- The molybdenum concentration in soil exceeded the MECP Table 8 Standard at one location near a fill pile in the southwestern half of the Site. This exceedance is likely associated to a naturally elevated background concentration.
- Cobalt in groundwater exceeded the MECP Table 8 Standard at two locations: near the commercial enterprise north of Huntley Creek and near the commercial storage buildings at the southwest end of the site. These exceedances may be attributable to the presence of fill of poor quality but may also represent a naturally elevated background concentration.
- Petroleum hydrocarbon (PHC) Fraction F1 and PHC F2 and total xylene concentrations in soil exceeded the MECP Table 8 Standard at one location near the commercial enterprise north of Huntley Creek, approximately 140 metres from the proposed concrete plant site. In addition, ethylbenzene, PHC F2, 1-methylnaphtalene, 2-methylnaphtalene, and methylnaphtalene, 2-(1-) in groundwater exceeded the MECP Table 8 Standard in the same area. These exceedances may be due to a past petroleum hydrocarbon spill in that area.

As noted in the Phase Two ESA report (Golder, 2018b), APECs and locations where soil and groundwater impacts were identified are not located within the proposed concrete plant site.

3.0 TERRAIN ANALYSIS

3.1 Investigations by Golder (2015 to 2017)

A subsurface investigation was completed by Golder at the Site between December 7 and 8, 2015. During that time, a total of 5 boreholes (numbered 15-1, 15-2, 15-4, 15-5 and 15-6) were advanced at the approximate locations shown on Figure 4.

The boreholes were advanced using a track-mounted drill rig supplied and operated by CCC Geotechnical & Environmental Drilling of Ottawa, Ontario. The boreholes were advanced through the overburden to depths of about 4.8 to 7.4 metres below the existing ground surface. Practical auger refusal was encountered at boreholes except BH15-5. Standard penetration tests were carried out within the overburden at regular intervals of depth. Samples of the soils encountered were recovered using split-spoon sampling equipment. The borehole logs for these boreholes are included in Appendix B.

A test pit investigation was carried out at the Site on April 25 and 26, 2017. During that time, a total of 11 test pits (numbered 17-1, 17-2, 17-4 to 17-8, and 17-19 to 17-22) were advanced at the approximate locations shown on Figure 4.

The test pits were advanced using a backhoe supplied and operated by Cavanagh. The test pits were advanced through the overburden to depths of about 2.0 to 4.0 metres below the existing ground surface. A sample of each soil type encountered in each test pit was recovered and the presence and depth of groundwater inflow was noted. The test pit logs are included in Appendix B.

The fieldwork described above was supervised by Golder staff who directed the test pit excavation/borehole drilling operations, logged the test pits/boreholes and samples, and took custody of the soil samples retrieved. The soil samples were transported to Golder's laboratory for further examination.

Monitoring wells were sealed into all five boreholes to allow for groundwater sampling, hydraulic response testing, and measurements of the groundwater level. The hydraulic response testing was carried out on December 22, 2015, while groundwater level measurements were collected on December 22, 2015 and April 26, 2017. Groundwater samples were collected from monitoring wells installed in BH15-1, 15-2 and 15-4 on July 19, 2018 and submitted to Eurofins Environment Testing Canada Inc. (Eurofins) for nitrate analysis.

3.2 Investigation by Gemtec (2018)

In 2018**,** Gemtec carried out a geotechnical investigation at the Site, which included the drilling of 11 boreholes and the installation of 4 monitoring wells across the Site. The locations of the Gemtec boreholes are indicated on Figure 4 and borehole logs are included in Appendix B. Note that BH18-6 and BH18-11 are a nested well set located immediately adjacent to each other.

4.0 GROUNDWATER SUPPLY INVESTIGATION

The groundwater supply investigation for the site was based on procedures for the assessment of water supplies for developments with private individual wells as described in the MOE Procedure D-5-5 (MOE, 1996a).

As described in Section 2.4, test wells TW5 and TW6 are the proposed water supply wells for the operations at the concrete plant. Water taken from these wells will be used for concrete production and water supply for employees at the concrete plant. The House Well is the proposed water supply well at the future administration building. On behalf of Cavanagh, Golder obtained PTTW 4005-B3GKCQ for the aquifer testing program (see Appendix C). This PTTW allowed a maximum taking of 340 L/min for up to 3 days at each of the three wells. As described in the following sections, test wells TW5 and TW6 were tested at this rate; however, due to the smaller required water supply rate for the administration building, the House Well was tested at a lower rate.

4.1 Test Well Construction

The two water supply wells proposed for use for the concrete plant operations were drilled by Air Rock Drilling Co. Ltd. Test well TW5 was drilled on March 20, 2018 and TW6 was drilled on June 26, 2018, at the locations shown on Figure 4. Both wells were completed in the bedrock. The following table provides drilling details for TW5 and TW6:

Location	Depth to Bedrock (m)	Casing Depth (m)	Total Depth (m)	Water Bearing Zones (m)	Well Yield Estimated by Driller (L/min)
TW5	4.9	6.7	29.6	22.3, 26.5, 27.7	>75
TW6	5.5	7.3	36.6	20.7, 23.8, 34.7	>75

For reference, copies of the water well records for TW5 and TW6 are provided in Appendix D.

Prior to the pumping tests on TW5 and TW6, a step-test was performed on each well to estimate a sustainable pumping rate to use during the aquifer testing program.

The House Well was drilled at some time before this investigation began and a water well record could not be found. During the aquifer testing program, the total well depth was measured as 5.85 metres; however, this may have reflected an obstruction in the well that did not allow the measuring device to pass.

4.2 Monitoring Well Locations

4.2.1 On-Site Water Wells

Two drilled wells (TW1 and TW2) installed in 2017 were used as monitoring wells during the pumping tests at TW5 and TW6. Copies of the water well record for these wells are provided in Appendix D, while the following table provides construction details for TW1 and TW2:

Location	Depth to Bedrock (m)	Casing Depth (m)	Total Depth (m)	Water Bearing Zones (m)	Well Yield Estimated by Driller (L/min)
TW1	7.3	9.1	91.4	54.6, 79.2	11.4
TW2	2.4	6.1	91.4	58.2, 76.2	18.9

4.2.2 Shallow Monitoring Wells

In order to monitor the water level response adjacent to Huntley Creek during the pumping tests at TW5 and TW6, three shallow monitoring wells (labelled MW18-1, MW18-2 and MW18-3) were installed at the locations shown on Figure 4. The construction details for these shallow monitoring wells are provided in Appendix B.

4.2.3 Borehole Monitoring Wells

As described in Section 3.1, monitoring wells were sealed into five boreholes advanced by Golder across the Site. The monitoring wells nearest to the test wells TW5 and TW6 (i.e., BH15-4 and BH15-5) were monitored for water level response during the pumping tests.

Two monitoring wells (MW18-7 and MW18-11) installed as part of the Gemtec geotechnical investigation were also monitored during the pumping tests.

4.2.4 Off-Site Water Wells

As required by Condition 4.3 of PTTW 4005- B3GKCQ (see Appendix C), private well owners with 500 metres of TW5, TW6 and the House Well were notified of the proposed aquifer testing program, and written permission was requested to access their wells for the purpose of monitoring groundwater levels before, during and after the pumping tests. Golder attempted to contact the residents/tenants of the 9 residences or buildings within this area. The owner of one private well (located at 2060 Richardson Side Road) agreed to have a datalogger installed in his well for groundwater level monitoring during the pumping tests. The well record for the well was not provided by the owner and could not be found in the MECP database. Due to the presence of the pump and associated pipe and wiring, the depth of the well could not be measured at the time of monitoring. The homeowner did not provide information regarding the depth of the well. Based on the well records plotted nearest to the residence in the MECP databased (with WWR numbers 1523285, 1522656 and 1530395), the well at 2060 Richardson Side Road is assumed to have a depth in the range of 26 to 34 metres, which is consistent with the range for all nearby wells (see Section 2.3.3).

In addition, a well drilled in 2017 (TW4) located north of Richardson Side Road that is not currently in use was monitored during the aquifer testing program. A copy of the water well record for this well is included in Appendix D, while the following table provides construction details for TW4:

Location	Depth to Bedrock (m)	Casing Depth (m)	Total Depth (m)	Water Bearing Zones (m)	Well Yield Estimated by Driller (L/min)
TW4	6.1	7.9	36.9	15.2; 17.4; 34.4	75.7

4.3 Aquifer Testing Program

4.3.1 TW5 and TW6

Pumping tests were carried out at test wells TW5 and TW6 between August 22 and 30, 2018. Each pumping test consisted of a pumping phase (48.6 to 67.9 hours in duration) followed by a recovery period (up to 142 hours in duration).

The pumping tests were conducted at a rate of 340 L/min (i.e., maximum allowable rate under the PTTW) using a submersible pump supplied by Air-Rock Drilling Co. Ltd (Air-Rock). The discharge from each pumping test was directed through approximately 30 metres of flexible hose toward the east (from TW5) or northeast (from TW6). The water discharged to a well-vegetated area which was monitored to ensure that erosion did not occur.

Before, during and after the pumping tests, groundwater levels were recorded in the pumping well (TW5 or TW6) and observation wells (TW1, TW2, TW4, shallow wells MW18-1, MW18-2 and MW18-3, BH15-4, BH15-5, Gemtec wells MW18-7 and MW18-11, 2060 Richardson Side Road) at selected time intervals. 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. It was not possible to monitor the water level at the House Well during the TW5 and TW6 pumping tests, due to the configuration of pipes and cables in the well.

4.3.2 House Well

The pumping test on the House Well was carried out on September 5, 2018, and consisted of a constant rate pumping phase (18.9 L/min for 6.2 hours) followed by a recovery period of 90 minutes. In order to complete the test, the existing pump in the House Well was removed and a submersible pump was installed by Air-Rock. The discharge from the pumping test was directed through approximately 30 metres of flexible hose toward the south. The water discharged to a well-vegetated area which was monitored to ensure that erosion did not occur.

The water level monitoring program during this pumping test was the same as described for TW5 and TW6; however, manual water level measurements were collected at only the observation wells nearest the House Well (MW18-7, TW-2, TW-5 and shallow monitoring well MW18-1).

4.4 Groundwater Quality Investigation

During the pumping tests at test wells TW5 and TW6 and at the House Well, samples of the pump discharge were collected after approximately 1.3 to 2.8 hours of pumping at a constant rate and at the end of the pumping period, just before pump shut-off (i.e. after approximately 45.5 to 66.6 hours of pumping). At the time of sampling, field testing indicated that no chlorine residual was present in the discharge water. A field-measured chlorine residual of 0.01 mg/L was measured in the two samples collected at the House Well; however, this is considered an erroneous reading given that this well was not chlorinated before the pumping test.

The samples were preserved as necessary and submitted to Eurofins Environment Testing Canada Inc. (Eurofins) for the chemical, physical and bacteriological analyses listed in the MOE Procedure D-5-5 (MOE, 1996a). The results of the Phase Two ESA (see Section 2.5) were also considered in selecting the laboratory analyses. The cadmium and molybdenum concentrations in soil exceeded MECP Table 8 at one location each; however, the soil samples with the exceedances were collected above the groundwater table. The cobalt concentration in groundwater at two locations exceeded MECP Table 8; however, this parameter does not have an ODWQS standard. For these reasons, analysis of cadmium, molybdenum and cobalt in groundwater at the test wells and House Well were not warranted. Based on the presence of some BTEX compounds (benzene, toluene, ethylbenzene and xylenes), PHCs and polycyclic aromatic hydrocarbons (PAHs) in groundwater exceeding the MECP Table 8 Standard near the commercial enterprise north of Huntley Creek, the sample collected from the House Well at the end of the pumping test was analyzed for those parameters. The results of these analyses are summarized in Tables E-1A and E-1B (Appendix E).

Field measurements of temperature, pH, conductivity, chlorine residual and turbidity were taken periodically during the pumping tests and at the time of sampling (Table E-2, Appendix E). 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 E.

5.0 TERRAIN ANALYSIS RESULTS

5.1 Subsurface Conditions

This section provides a summary of the subsurface soils and shallow groundwater conditions on the site based on the information obtained from the test pits, boreholes and auger holes completed at the site between 2015 and 2018. Logs of the materials encountered at each investigation location are included in Appendix B. It is noted that, in some cases, the stratigraphic boundaries within the overburden represent a transition between soil types rather than an exact plane of geologic change.

In general, the subsurface conditions at the Site consist of surficial topsoil or fill, underlain by layers of sand, silty sand and clayey silt, followed by glacial till at some locations. In the southwestern portion of the Site (in the area of TP17-1, TP17-2, TP17-4 and BH15-1), there was generally fill or clayey silt from ground surface to a depth of 0.4 to 1.7 metres below ground surface (bgs), underlain by 1.1 to 1.9 metres of sand, followed by 2.2 to 2.4 metres of silty sand. At BH15-1, the silty sand was underlain by a thin (0.2 metre) layer of silt followed by silty sand and gravel starting at 6.9 metres bgs.

Just southwest of the concrete plant site (in the area of TP17-5, TP17-6, TP17-7, TP17-8, TP17-22 and BH15-2), the subsurface conditions consisted of topsoil or gravelly sand from ground surface to a depth of 0.1 to 0.7 metres bgs, underlain by 0.5 to 1.5 metres of sand or silty sand, followed by glacial till. The top of the glacial till was generally at 0.2 to 2.9 metres bgs. A layer of fill was also noted at or near ground surface and TP17-7, TP17-22 and BH15-2.

Along the northwestern and northern boundaries of the concrete plant site (in the area of TP17-19, TP17-20, TP17-21 and BH15-4), there was topsoil from ground surface to a depth of 0.1 to 0.5 metres bgs, underlain by 0.5 to 1.8 metres of sand or silty sand, followed by glacial till. The top of the glacial till was generally at 1.5 to 2.1 metres bgs. A 0.2 to 0.5 metre layer of silty clay was observed at TP17-21 and BH15-4.

At BH15-5 (located near the northeastern corner of the Site), the subsurface conditions consisted of 0.3 metre of topsoil, 0.6 metre of silty sand, 3.9 metres of silty clay, and glacial till below 4.75. At BH15-6 (located on the north side of Huntley Creek near the northern boundary of the Site), the subsurface conditions consisted of 0.3 metre of topsoil, and 4.5 metres of alternating layers of silt, silty sand, clayey silt and silty clay layers.

Bedrock was not encountered in any of the test pits, all of which were approximately 2.0 to 4.0 metres deep.

Practical refusal to augering was encountered at boreholes 15-1, 15-2, 15-4 and 15-6 at depths ranging from about 4.8 to 7.4 metres bgs. In general, these depths are consistent with the anticipated depth to bedrock in the area; however, because coring was not undertaken to prove the bedrock, auger refusal could also represent cobbles or a boulder within the fill or glacial till.

5.2 Hydrogeological Conditions

Monitoring wells were sealed into boreholes 15-1, 15-2, 15-4, 15-5 and 15-6 to allow for groundwater sampling, hydraulic response testing, and measurements of the groundwater level at the site. A summary of the groundwater levels measured in these wells and at selected Gemtec monitoring wells is provided in Appendix F. The detailed results of the hydraulic conductivity analyses are also provided in Appendix F. The groundwater levels measured in April 2017 and the estimated hydraulic conductivity values are summarized in the following table:

Well ID	Geologic Unit of Screened Interval	Depth of Screened Interval (mbgs)	Groundwater Levels April 26, 2017		Hydraulic Conductivity (m/s)
			Depth (mbgs)	Elevation (masl)	
15-1	Silty Sand over Silty Sand and Gravel	5.8 – 7.4	0.22	114.35	$5x10^{-5}$
15-2	Glacial Till	4.6 – 6.1	5.26	109.73	-
15-4	Glacial Till	3.7 – 5.3	1.52	108.79	$4x10^{-7}$
15-5	Silty Clay over Glacial Till	4.6 – 6.1	0.88	108.62	$3x10^{-7}$
15-6	Layers of Silty Sand and Silty Clay	4.1 – 5.6	3.13	106.41	$2x10^{-4}$

The groundwater levels are expected to fluctuate seasonally. Higher groundwater levels are expected during wet periods of the year, such as spring, as shown by the higher groundwater levels measured in April 2017.

Groundwater inflow was noted at depths of 1.5 to 1.7 mbgs at test pits TP17-1 and 17-4 located along the western boundary of the Site. Test pits TP17-19, TP17-20 and TP17-21, located along the northwestern boundary of the concrete plant site, indicated groundwater seepage at depths of 1.4 to 1.8 mbgs. Groundwater inflow was not observed in the remaining test pits.

The shallow groundwater flow direction is interpreted to be toward Huntley Creek, based on topography and groundwater level measurements collected at selected monitoring wells in August 2018 (see Figure 4).

5.3 Background Groundwater Nitrate Concentrations

Groundwater samples were collected from monitoring wells installed in BH15-1, 15-2 and 15-4 on July 19, 2017 and submitted to Eurofins for nitrate analysis. The nitrate concentration results are presented in the following table:

Monitoring Well	BH15-1	BH15-2	BH15-4
Nitrate Concentration (mg/L)	2.03	4.77	0.51

5.4 Sewage Disposal System

As previously mentioned, it is proposed to construct a new on-site septic system to provide treatment of all sanitary sewage generated from the concrete plant. The Gemtec design report provides details on this septic system.

The future administration building (currently used as a residence) will be serviced by the existing sewage disposal system. It is understood that the existing system was constructed in 1999. The Septic System Site Evaluation and Design Review for the existing system are included as Appendix G. Based on these documents, it is understood that the existing system was designed for a total daily design flow of 3,000 L/day. Assuming a water usage of 75 L/day/employee and a maximum of 36 employees, the maximum total flow would be 2,700 L/day, which is below the total daily design flow.

6.0 GROUNDWATER SUPPLY INVESTIGATION RESULTS

6.1 Groundwater Quantity

Pumping tests were carried out at test wells TW5, TW6 and the House Well between August 22 and September 5, 2018.

The results of the pumping tests are presented in the following sections. During each pumping test, the end of the discharge pipe was positioned approximately 30 metres from the pumping well to avoid ponding of the pumped groundwater in the vicinity of the pumping well. The drawdown and recovery data and the associated analyses are presented in Appendix H.

Test Well TW5

A pumping test was conducted at TW5 from August 22 to 24, 2018. The static water level before the start of the test was at 3.78 metres below the top of the casing. TW5 was pumped at a rate of 340 L/min for 48.6 hours, after which a drawdown of 2.73 metres was measured (see Figure H-1a). Approximately 200 minutes after pump shut-off, 95 percent recovery of the maximum imposed drawdown had been achieved. As shown on Figure H-1a, there was a slight increase in water level approximately 900 minutes after pumping began. It is interpreted this may have been related to slight variations in the pumping rate.

Based on data from the Environment Canada Ottawa CDA Meteorological Station (ID 6105976), located approximately 23 kilometres northeast of the Site, there was approximately 33 mm of precipitation on the day preceding and the first day of the pumping test at TW5 (August 21 and 22, 2018). There was also 1.4 mm of precipitation on August 26, 2018 (two days after pump shutoff).

During the pumping test at TW5, water levels were measured in the observation wells listed in Section 4.2 (see Figures H-1b through H-1e). The water level response at the observation wells is summarized as follows:

- The greatest water level drawdown, ranging from 0.58 to 0.75 metre, was observed at TW6 (proposed water supply well), TW2 (bedrock observation well) and MW15-4 (monitoring well screened in glacial till above bedrock) (see Figure H-1b). The end of the water level recovery at these wells appears to have been affected by a background decreasing water level trend (see next bullet point). As a result, the water level at TW6 achieved 95% recovery approximately 41 hours after pump shut-off, whereas the water level at TW2 and MW15-4 had not achieved 95% as of 68 hours after pump shut-off.
- Figure H-1c shows the water level response at the other overburden observation wells. At MW15-5 (screened in glacial till above bedrock), the water level appeared to respond to pumping at TW5 and exhibited approximately 0.18 m of drawdown. Monitoring wells MW18-7 (screened in glacial till above bedrock) and MW18-11 (likely screened in silty clay) did not appear to respond to pumping at TW5, based on the increasing water level trend during most of the pumping test. Starting at approximately 5 hours of before pump shut-off, these two wells exhibited a decreasing water level trend which continued for 74 hours, suggesting that there was a background decreasing trend in water level during the recovery period.
- Figure H-1d shows the water level response at the other bedrock observation wells. All three wells (TW1, TW4 and 2060 Richardson Side Road) exhibited a drawdown on the order of 0.1 metre during the pumping test at TW5, which may have been in response to the pumping from the bedrock at TW5. The water level at the supply well at 2060 Richardson Side Road was also affected by the operation of the pump in that well.
- Figure H-1e shows the water level response at the shallow monitoring wells adjacent to Huntley Creek. The datalogger installed in MW18-1 malfunctioned; therefore, only manual water level measurements were available for that well. Based on the datalogger measurements at MW18-2 and MW18-3, the shallow groundwater level did not respond to pumping at TW5 and either increased or stayed relatively consistent during the first 20 hours of the test. A decreasing trend began after 20 hours of pumping and continued until 5 hours after pump shut-off.

A composite drawdown plot showing the water level drawdown at the pumping well and selected observation wells is provided as Figure H-1f. This plot shows drawdown vs. t/r2, where t=time since pumping began and r=distance from the pumping well. The drawdown in any observation well in the water supply aquifer that responded to pumping at TW5 should have the same slope as the pumping well drawdown. Aquifer transmissivity of the pumped bedrock aquifer was estimated as $3x10^{-3}$ m^2/s using the Cooper and Jacob drawdown (Cooper and Jacob, 1946) based on the slope of the drawdown on the composite plot. The recovery data from the pumping well were also analyzed using the Theis recovery (Theis, 1935) method and yielded a transmissivity estimate of $4x10^{-3}$ m^2/s (see Figure H-1g). Although the assumptions on which these methods are based are not strictly met, these methods provide a reasonable estimate of aquifer transmissivity (T).

The composite plot also confirmed that the water level in the shallow monitoring wells adjacent to Huntley Creek (MW18-2 and MW18-3) did not respond to pumping at TW5.

Test Well TW6

A pumping test was conducted at TW6 from August 27 to 30, 2018. The static water level before the start of the test was at 3.33 metres below the top of the casing. TW6 was pumped at a rate of 340 L/min for 67.9 hours, after which a drawdown of 1.91 metres was measured (see Figure H-2a). Approximately 65 hours after pump shut-off, 91 percent recovery of the maximum imposed drawdown had been achieved. The water level then remained relatively steady for the next 77 hours. The fact that the water level did not fully recover suggests that there was a background decreasing water level trend throughout the pumping test, as discussed below.

Based on data from the Environment Canada Ottawa CDA Meteorological Station (ID 6105976), located approximately 23 kilometres northeast of the Site, there was approximately 1.4 mm of precipitation on the day preceding the pumping test at TW6 (August 26, 2018). There was also 4.0 mm of precipitation on September 2, 2018 (three days after pump shutoff).

During the pumping test at TW6, water levels were measured in the observation wells listed in Section 4.2 (see Figures H-2b through H-2e). The water level response at the observation wells is summarized as follows:

- The greatest water level drawdown, ranging from 0.61 to 0.93 metre, was observed at TW5 (proposed water supply well), TW2 (bedrock observation well) and MW15-4 (monitoring well screened in glacial till above bedrock) (see Figure H-2b). The end of the water level recovery at these wells appears to have been affected by a background decreasing water level trend (see next bullet point). As a result, the water level at these three wells had not achieved 95% recovery as of 142 hours after pump shut-off.
- Figure H-2c shows the water level response at the other overburden observation wells. At MW15-5 (monitoring well screened in glacial till above bedrock), the water level appeared to respond to pumping at TW6 and exhibited approximately 0.19 m of drawdown. Monitoring wells MW18-7 (screened in glacial till above bedrock) and MW18-11 (likely screened in silty clay) did not appear to respond to pumping at TW6, based on the decreasing water level trend that was apparent before the test began and continued after the end of the pumping test. It appears that there was a background decreasing trend in water level during the recovery period.
- Figure H-2d shows the water level response at the other bedrock observation wells. All three wells (TW1, TW4 and 2060 Richardson Side Road) exhibited a drawdown on the order of 0.1 to 0.4 metre during the pumping test at TW6, which may have been in response to the pumping from the bedrock at TW6. The water level at the supply well at 2060 Richardson Side Road was also affected by the operation of the pump in that well.
- Figure H-2e shows the water level response at the shallow monitoring wells adjacent to Huntley Creek. The datalogger installed in MW18-1 malfunctioned; therefore, only manual water level measurements were available for that well. Based on the datalogger measurements at MW18-2 and MW18-3, the shallow groundwater level was exhibiting a background decreasing trend in response to precipitation that began before the TW6 test and continued until 33 hours into the test. The water level then became steady and remained so for approximately 100 hours until it again appeared to respond to precipitation on September 2, 2018.

A composite drawdown plot showing the water level drawdown at the pumping well and selected observation wells is provided as Figure H-2f. This plot shows drawdown vs. t/r2, where t=time since pumping began and r=distance from the pumping well. The drawdown in any observation well in the water supply aquifer that responded to pumping at TW5 should have the same slope as the pumping well drawdown. Aquifer transmissivity of the pumped bedrock aquifer was estimated as $4x10^{-3}$ m^2/s using the Cooper and Jacob drawdown (Cooper and

Jacob, 1946) based on the slope of the drawdown on the composite plot. The recovery data from the pumping well were also analyzed using the Theis recovery (Theis, 1935) method and yielded a transmissivity estimate of $8x10^{-3}$ m^2/s (see Figure H-2g); however, as previously discussed, it is interpreted that the water level recovery at TW6 was likely affected by a background decreasing trend in groundwater level. Although the assumptions on which these methods are based are not strictly met, these methods provide a reasonable estimate of aquifer transmissivity (T).

The composite plot also confirmed that the water level in the shallow monitoring wells adjacent to Huntley Creek (MW18-2 and MW18-3) did not respond to pumping at TW6.

House Well

A pumping test was conducted at the House Well on September 5, 2018. The static water level before the start of the test was at 2.56 metres below the top of the casing. The House Well was pumped at a rate of 18.9 L/min for 6.2 hours, after which a drawdown of 0.31 metre was measured (see Figure H-3a). Approximately 90 minutes after pump shut-off, 93 percent recovery of the maximum imposed drawdown had been achieved.

During the pumping test at the House Well, water levels were measured in the observation wells listed in Section 4.2 (see Figures H-3b through H-3e). It is noted that in some of the observation wells, a sudden increase and decrease in water level was observed after approximately 385 minutes of pumping. At this time, there was a sudden increase in barometric pressure recorded at the site during the passage of a brief thunderstorm. The apparent change in water level is due to the change in barometric pressure reading used to correct the raw water level. The water level response noted at the observation wells is summarized as follows:

- Figure H-3b shows the water level response at the bedrock wells nearest the House Well (TW2, TW5 and TW6). Figure H-3c shows the water level response at the overburden wells (MW15-4, MW15-5, MW18-7, MW18-11). Both the bedrock well and overburden wells showed variations within 0.03 metre of the static level during the test, likely reflecting a background water level trend.
- Figure H-3d shows the water level response at the bedrock wells further from the House Well (TW1 and TW4). These wells did not appear to respond to pumping at the House Well.
- Figure H-3e shows the water level response at the shallow monitoring wells adjacent to Huntley Creek. The datalogger installed in MW18-1 malfunctioned; therefore, only manual water level measurements were available for that well. Based on the datalogger measurements, the shallow groundwater level at MW18-2 may have decreased by 0.01 metre during the pumping test, although this variation is within the range of measurement error. The water level at MW18-3 appeared to respond to precipitation events but not to pumping.

Summary of Hydraulic Response

The following table summarizes the estimated transmissivity (from drawdown and recovery data) and storativity based on the response at the bedrock wells showing the most significant response during pumping at TW5 and TW6.

Pumping Well	Observation Well	T (drawdown) (m^2/s)	T (recovery) (m^2/s)	S (-)
TW5	TW5	$4x10^{-3}$	$4x10^{-3}$	-
TW5	TW6	$7x10^{-3}$	$7x10^{-3}$	$1x10^{-5}$
TW5	TW2	$5x10^{-3}$	$5x10^{-3}$	$6x10^{-4}$
TW5	TW1	$4x10^{-2}$	$4x10^{-2}$	$1x10^{-3}$
TW6	TW6	$7x10^{-3}$	$9x10^{-3}$	-
TW6	TW5	$7x10^{-3}$	$7x10^{-3}$	$2x10^{-6}$
TW6	TW2	$4x10^{-3}$	$5x10^{-3}$	$3x10^{-4}$
TW6	TW1	$2x10^{-2}$	-	$5x10^{-3}$
Range		$4x10^{-3}$ – $4x10^{-2}$		$2x10^{-6}$ – $5x10^{-3}$
Geometric Mean		$8x10^{-3}$		$1x10^{-4}$

During the pumping tests at TW5 and TW6, the recovery at the pumping and observation wells at the end of the water level monitoring period ranged from 71 to more than 95%. The recovery at some wells of less than 95% corresponds to only 14 to 19 cm of residual drawdown. The ambient water level data collected at the observation wells before the start of pumping at TW5, as well as the water levels measured at MW18-7 and MW18-11 (which did not respond during the pumping tests), indicate that natural variations of up to 9 cm over two days were typical. Therefore, the apparent lack of recovery is interpreted to be at least partially related to natural water level variations.

Based on the change in slope of the water level response plots during pumping at TW6 (see Figure H-2f), it appears that there may be a hydraulic boundary at some distance from the site. The location of the hydraulic boundary was calculated using methods described in Domenico and Schwartz (1990); however, based on the range of response at the monitoring wells, and the range in aquifer parameters associated with each monitoring well, the estimated distance to the hydraulic boundary from TW6 ranged from 1,000 to 30,000 m, indicating a heterogeneous system. Calculations are provided in Appendix J.

6.2 Hydrogeological Conceptual Model

The conceptual model of the site consists of approximately 2.4 to 7.4 metres of overburden overlying limestone and shale bedrock. The overburden consists of varying thicknesses of surficial topsoil and fill, underlain by layers of sand, silty sand and clayey silt, followed by glacial till. The water table is within the surficial granular materials, at a depth of approximately 1 to 3 mbgs. Of the ten boreholes where auger refusal was encountered (potentially indicating the bedrock surface), glacial till was logged above the inferred bedrock surface at eight locations. Therefore, it is interpreted that the glacial till provides an extensive, low hydraulic conductivity ($4x10^{-7}$ m/s) separation between the surficial granular materials and the bedrock. The water bearing zone in the bedrock is interpreted to range from 15 to 79 mbgs based on the site well records; this depth corresponds to a separation of at least 15 metres between the base of the glacial till and the uppermost water-bearing zone in the bedrock.

The table below summarizes whether water level response to pumping at TW5 and TW6 was observed at the nearby monitoring locations.

Well	Geologic Unit	Response to Pumping
TW5	Bedrock (water-bearing zone 22-28 mbgs)	Yes
TW6	Bedrock (water-bearing zone 21-35 mbgs)	Yes
TW2	Bedrock (water-bearing zone 58-76 mbgs)	Yes
MW15-4	Glacial Till	Yes
MW15-5	Glacial Till	Yes
TW1	Bedrock (water-bearing zone 56-79 mbgs)	Yes
TW4	Bedrock (water-bearing zone 15-34 mbgs)	Yes
2060 Richardson	Bedrock (water-bearing zone unknown)	Yes
MW18-7	Glacial Till	No
MW18-11	Not logged – Assumed Glacial Till	No
MW18-1, 18-2, 18-3	Sand	No

Pumping from TW5 and TW6 caused a water level response at all bedrock wells being monitored, and at two nearby monitoring wells screened near the base of the glacial till. Two other monitoring wells in the glacial till did not respond to pumping. These results suggest some hydraulic connection between the bedrock aquifer and the base of the glacial till. Given the depth of the water-bearing zones and the lack of response in the other overburden monitoring wells, it is interpreted that the bedrock aquifer behaves as a leaky confined aquifer, and the use of the Cooper-Jacob solution for estimation of aquifer parameters is appropriate.

As presented in the previous section, it is interpreted that there is a hydraulic boundary at some distance from the site (1,000 to 30,000 m from TW6).

6.3 Groundwater Quality

The field observations and the results of the laboratory chemical, physical and bacteriological analyses for the groundwater samples collected from TW5, TW6 and the House Well are summarized in Tables E-1A and E-1B following the text of this report. The certificates of laboratory analyses are also included in Appendix E.
Field measurements of temperature, pH, conductivity, chlorine residual and turbidity collected periodically during the pumping tests are presented in Table E-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 (ODWQS) (MOE, 2006).

Test Wells TW5 and TW6

Based on the analytical results, test wells TW5 and TW6 have similar groundwater quality. Exceedances of the ODWQS at these wells included chloride concentration in the 1.3-hour sample at TW6 (but not the 66.6-hour sample), the hydrogen sulphide concentration in the 2.8-hour and 45.5-hour samples at TW5, and the TDS concentration in all samples from TW5 and TW6; all of these concentrations exceeded the applicable AO.
The hydrogen sulphide concentrations at TW5 were below the treatability limit established in Procedure D-5-5. There is no treatability limit for TDS. The potential for corrosion or encrustation problems associated with elevated TDS was assessed by calculating the Langelier Saturation Indices (LSI) for all of the samples from TW5 and TW6, which ranged from 0.1 to 0.6. These LSI values are within or just beyond the range generally considered stable (between -0.5 and +0.5) and indicate that corrosion or encrustation problems are unlikely (see Appendix E).

In addition, total coliforms were detected at both TW5 and TW6 (at concentrations of 51 ct/100 mL and 5 ct/100 mL, respectively, at or above the applicable MAC of 0 ct/100 mL and the 5 ct/100 mL level used to evaluate non-disinfected private water supplies (as described in Procedure D-5-5; MOE, 1996).

The hardness in all samples from TW5 and TW6 exceeded the applicable OG but is treatable by conventional water softening equipment.

There were no other exceedances of the applicable MACs, AOs or OGs for the parameters tested (see Table E-1).

TW5 was resampled for bacteriological parameters on March 31, 2019. Prior to resampling, the well was chlorinated and allowed to sit for approximately 40 hours. Afterward, the chlorinated water was flushed from the system by pumping at 95 L/min for 5 hours. Chlorine residual measurements were collected in the field and chlorine was not detected in the discharge at the time of sampling (see Table E-2). The analytical results indicated that the total coliform, fecal coliform and E. coli concentrations were 0 ct/100 mL (see Table E-1). On the basis of the March 31, 2019 results, it is interpreted that the chlorination and flushing of the TW5 was effective in addressing the bacteriological exceedances.

Test wells TW5 and TW6 will be used to supply water for concrete production and for employees at the concrete plant.

House Well

Based on the analytical results for the House Well, the colour and TDS concentrations in both the 2.2-hour and 4.7-hour samples exceeded the applicable AOs. The colour concentrations were at or below the treatability limit established in Procedure D-5-5. There is no treatability limit for TDS. The potential for corrosion or encrustation problems associated with elevated TDS was assessed by calculating the Langelier Saturation Indices (LSI) for 2.2-hour and 4.7-hour samples, which were 0.8 and 0.6, respectively. These LSI values are within or just beyond the range generally considered stable (between -0.5 and +0.5) and showed a decreasing trend, indicating that corrosion or encrustation problems are unlikely (see Appendix E).

In addition, the total coliform concentrations (4 and 10 ct/100 mL after 2.2 and 4.7 hours, respectively) exceeded the applicable MAC of 0 ct/100 mL, and the latter sample exceeded the 5 ct/100 mL level used to evaluate non-disinfected private water supplies (as described in Procedure D-5-5; MOE, 1996). Similarly, the E. coli concentration in the 4.7-hour sample (1 ct/100mL) exceeded the applicable MAC of 0 ct/100 mL.

The hardness in both samples exceeded the applicable OG but is treatable by conventional water softening equipment.

The House Well was resampled for bacteriological parameters on September 11, 2018. The sample was collected from an outside tap at the residence. The E. coli concentration was 0 ct/100 mL. The total coliform and fecal coliform concentrations were both 1 ct/100 mL. After the sample was collected on September 11, 2018, the House Well was chlorinated and the house plumbing was filled with chlorinated water and allowed to sit for 12 hours. Afterward, the chlorinated water was flushed from the system. The House Well was resampled on September 13, 2018 at the outside tap. The results indicated that the total coliform, fecal coliform and E. coli concentrations were 0 ct/100 mL and that free chlorine residual was not detected. On the basis of the September 13, 2018 results, it is interpreted that the chlorination and flushing of the House Well was effective in addressing the bacteriological exceedances.

There were no other exceedances of the applicable MACs, AOs or OGs for the parameters tested (see Table E-1).

The House Well will be used to supply water to the future administration building.

7.0 WATER BALANCE

A water balance assessment for current and proposed land uses, with and without LID mitigation measures, was carried out for the Site. The assessment was carried out with due consideration of the MOE Manual, the CA Guidelines and the LID Guide as described in Section 1.1. Golder also referred to the stormwater management design prepared by Robinson (2018). Note that the Site for which the water balance assessment was completed is the entire 28.8 hectare parcel of land, within which the concrete plant site will occupy approximately 3.7 hectares.

The water balance assessment was based on land use data, existing soil types and meteorological data. The water surplus for the site was based on water budget data from the Environment Canada Ottawa CDA Meteorological Station (ID 6105976), located approximately 23 kilometres northeast of the Site, from 1945 to 2013. The raw water budget data from Environment Canada (EC) are included in Appendix I.

Water balance calculations are based on the following equation:

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

Where: P = precipitation
S = change in soil water storage
ET = evapotranspiration
R = surface runoff
I = infiltration (groundwater recharge)

Precipitation data for the Ottawa CDA station indicate a mean annual precipitation (P) of 885 mm/yr.

Evapotranspiration (ET) refers to water lost to the atmosphere from vegetated surfaces. The term combines evaporation (i.e., water lost from soil or water surfaces) and transpiration (i.e., water lost from plants and trees) because of the difficulties in measuring these two processes separately. Potential evapotranspiration refers to the loss of water from a vegetated surface to the atmosphere under conditions of an unlimited water supply. The actual rate of evapotranspiration is typically less than the potential rate under dry conditions (e.g., during the summer months when there is a moisture deficit). The mean annual potential evapotranspiration for the study area is approximately 615 mm/yr based on data provided by EC.

Annual water surplus is the difference between precipitation and the actual evapotranspiration. The water surplus represents the total amount of water available for either surface runoff (R) or groundwater infiltration (I) on an annual basis. On a monthly basis, surplus water remains after actual evapotranspiration has been removed from the sum of rainfall and snow-melt, and maximum soil or snow pack storage is exceeded. Maximum soil storage is quantified using a water holding capacity (WHC) specific to the soil type and land use. Short-term or seasonal changes in soil water storage (S) occur as demonstrated by the dry conditions in the summer months and the wet or flooded conditions in the winter and spring. Long-term changes (e.g., year-to-year) in soil water storage are considered to be negligible.

The site-specific data required to use the water balance equation described above depend on soil type, land use, topography and vegetative cover. Soil type and land use are used to determine WHC based on Table 3.1 from the MOE Manual (2003), which in turn is used to determine actual evapotranspiration. Soil type, topography and ground cover are used to estimate an infiltration factor which represents the approximate annual percentage of surplus which can be infiltrated in an area with a sufficient downward groundwater gradient. Wetlands and water bodies are assumed to have a negligible downward gradient, resulting in all surpluses being contained in these areas, which provide increased evaporation and typically limited infiltration. Runoff is calculated as the difference between surplus and infiltration.

7.1 Pre-Development Conditions

The following data sources and assumptions were used in determining the infiltration factors for the water balance under pre-development conditions:

- For the purpose of determining WHC, land use at the Site under existing conditions was identified from Google Earth imagery (dated September 2016) and Golder's Site visits. In keeping with the vegetation cover types described in the MOE Manual (2003), land use was classified as follows (see Figure 5):
  - The lawn area immediately surrounding the existing residence was classified as "Urban Lawn".
  - Huntley Creek was assumed to measure 3 metres wide along its path within the Site and was classified as "Open Water".
  - The treed area on either side of Huntley Creek was classified as "Mature Forest", with the boundary of this area estimated based on Google Earth imagery.
  - The roadways and disturbed areas across the Site were classified as "Impervious Surface". These areas generally consist of a gravel surface, which is considered relatively impervious for the purpose of the water balance assessment.
  - The rest of the Site area was classified as "Pasture/Shrub", based on the presence of tall grasses and shrubs.
- For impervious surfaces, an infiltration factor of zero indicating no infiltration occurring on these surfaces was applied. It was assumed that 20% of precipitation on impervious surfaces would evaporate, while 80% would become runoff (Cuddy et al., 2013).
- Based on the results of the borehole and testpit investigations at the Site (refer to Section 5.0), the main surficial soils at the Site consist of surficial topsoil or fill, underlain by layers of sand, silty sand and clayey silt. For comparison to the MOE Manual (2003), this soil type was classified as sand loam, based on the U.S. Department of Agriculture classification system and the relative percentages of sand, silt and clay.
- Based on the average ground surface slope of 0.02 to 0.025, the topography was considered "hilly", as defined in the MOE Manual (2003).
- For the purpose of determining the infiltration factor, the type of cover was classified as "woodland" for the treed area along Huntley Creek and "cultivated land" for the urban lawn. The areas classified as "Pasture/Shrub" were assumed to have a land cover equivalent to the average between cultivated land use and woodland.
- Due to their small area relative to the overall Site area, the rooves of the existing residence and other commercial buildings on Site were not separately assessed as impermeable surfaces in the water balance.
- Water holding capacities (WHC) – WHC were taken from Table 3.1 of the MOE manual.
- The surplus to Huntley Creek was estimated as precipitation minus potential evapotranspiration. As described in the previous section, wetlands and water bodies are assumed to have a negligible downward gradient, resulting in all surpluses being contained in these areas, which provide increased evaporation and typically limited infiltration. Therefore, an infiltration factor of zero, indicating no infiltration occurring on this surface, was applied.

The following table presents the results of the water balance under pre-development conditions for average annual conditions.

Pre-Development Annual Water Balance Results

Land Use	Area (ha)	Precipitation *(mm/yr)* m³/yr	Evapo-transpiration *(mm/yr)* m³/yr	Surplus *(mm/yr)* m³/yr	Infiltration *(mm/yr)* m³/yr	Runoff *(mm/yr)* m³/yr
Impervious Surfaces	2.381	*(885)* 21,072	*(177)* 4,214	*(708)* 16,857	*(0)* 0	*(708)* 16,857
Water	0.501	*(885)* 4,434	*(615)* 3,081	*(270)* 1,353	*(0)* 0	*(270)* 1,353
Urban Lawn	0.410	*(885)* 3,629	*(534)* 2,189	*(351)* 1,439	*(211)* 865	*(140)* 574
Pasture/Shrub	19.968	*(885)* 176,717	*(579)* 115,615	*(306)* 61,102	*(199)* 39,736	*(107)* 21,366
Mature Forest	5.540	*(885)* 49,029	*(609)* 33,739	*(276)* 15,290	*(193)* 10,692	*(83)* 4,598
Total	**28.800**	**254,881**	**158,838**	**96,041**	**51,293**	**44,748**

The total estimated average annual pre-development runoff from the site is approximately 44,748 m^3 and the estimated infiltration is approximately 51,293 m^3.

Additional details of the hydrologic water balance are presented in Appendix I.

Based on site topography, it is interpreted that the shallow groundwater flow direction mirrors the topography and the surface water drainage. That is, shallow groundwater flow is toward Huntley Creek.

7.2 Proposed Post-Development Conditions

The post-development water balance excludes the LID features (bioretention facilities) proposed for the concrete plant site, which are addressed in the following section. The water balance was completed for the Site under post-development conditions using the same method presented for the pre-development conditions. The assumptions for post-development conditions were the same as described in the previous section for pre-development conditions, with the following exceptions:

- Within the area of the concrete plant site (approximately 3.7 ha), the land use was changed from “Urban Lawn” or “Pasture/Shrub” to “Impervious Surface” (see Figure 6).
- The area of the proposed access road to the concrete plant site was also changed to “Impervious Surface”.

The following table presents the results of the water balance under post-development conditions for average annual conditions.

Post-Development Annual Water Balance Results

Land Use	Area (ha)	Precipitation *(mm/yr)* m³/yr	Evapo-transpiration *(mm/yr)* m³/yr	Surplus *(mm/yr)* m³/yr	Infiltration *(mm/yr)* m³/yr	Runoff *(mm/yr)* m³/yr
Impervious Surfaces	6.556	*(885)* 58,021	*(177)* 11,604	*(708)* 46,416	*(0)* 0	*(708)* 46,416
Water	0.501	*(885)* 4,434	*(615)* 3,081	*(270)* 1,353	*(0)* 0	*(270)* 1,353
Urban Lawn	0.271	*(885)* 2,398	*(534)* 1,447	*(351)* 951	*(211)* 572	*(140)* 379
Pasture/Shrub	15.932	*(885)* 140,998	*(579)* 92,246	*(306)* 48,752	*(199)* 31,705	*(107)* 17,047
Mature Forest	5.540	*(885)* 49,029	*(609)* 33,739	*(276)* 15,290	*(193)* 10,692	*(83)* 4,598
Total	**28.800**	**254,880**	**142,117**	**112,762**	**42,969**	**69,793**

The total estimated average annual post-development runoff from the site is approximately 69,793 m^3 and the estimated infiltration is approximately 42,969 m^3.

Additional details of the hydrologic water balance are presented in Appendix I.

Under post-development conditions, it is assumed that shallow groundwater flow is toward Huntley Creek. Between pre- and post-development conditions, the infiltration on the site is estimated to decrease by 16% and the runoff is estimated to increase by 56%.

7.3 Mitigated Development Condition

The main LID feature consists of two bioretention facilities that will capture stormwater runoff and provide cleansing prior to discharge into Huntley Creek. The RVC_T (runoff volume control target) to be infiltrated by these facilities is 27 mm (i.e., this feature has been designed to capture runoff from the concrete plant site for precipitation events under 27 mm or the first 27 mm of higher intensity precipitation events). This precipitation amount corresponds to the 90th percentile rainfall event (Robinson, 2018). Therefore, as per the Robinson stormwater management design, 90% of the annual surplus from the concrete plant site (3.7 ha) will be available for infiltration through the bioretention facilities.

The following table presents the results of the water balance within the study area under post-development mitigated conditions for average annual conditions.

Mitigated Post-Development Annual Water Balance Results

Land Use	Area (ha)	Precipitation *(mm/yr)* m^3/yr	Evapo-transpiration *(mm/yr)* m^3/yr	Surplus *(mm/yr)* m^3/yr	Infiltration *(mm/yr)* m^3/yr	Runoff *(mm/yr)* m^3/yr
Impervious Surfaces – Other than Concrete Plant	2.866	*(885)* 25,634	*(177)* 5,073	*(708)* 20,291	*(0)* 0	*(708)* 20,291
Impervious Surfaces – Concrete Plant	3.690	*(885)* 32,657	*(177)* 6,531	*(708)* 26,125	*(637)* 23,513	*(71)* 2,613
Water	0.501	*(885)* 4,434	*(615)* 3,081	*(270)* 1,353	*(0)* 0	*(270)* 1,353
Urban Lawn	0.271	*(885)* 2,398	*(534)* 1,447	*(351)* 951	*(211)* 572	*(140)* 379
Pasture/Shrub	15.932	*(885)* 140,998	*(579)* 92,246	*(306)* 48,752	*(199)* 31,705	*(107)* 17,047
Mature Forest	5.540	*(885)* 49,029	*(609)* 33,739	*(276)* 15,290	*(193)* 10,692	*(83)* 4,598
Total	**28.800**	**254,880**	**142,117**	**112,762**	**66,482**	**46,281**

The total estimated overall annual mitigated development runoff from the site is approximately 46,281 m^3 and the estimated infiltration is approximately 66,482 m^3. Between pre- and post-development mitigated conditions, the infiltration on the site is estimated to increase by 30% and the runoff is estimated to increase by 3%.

Additional details of the hydrologic water balance are presented in Appendix I.

8.0 IMPACT ASSESSMENT

8.1 Hydrogeological Sensitivity

The site is not considered hydrogeologically sensitive, as none of the following have been identified: karstic areas, areas of thin soil cover, or areas of highly permeable soils. As discussed in Sections 3.0 and 4.0, at least 2.0 metres of overburden was encountered in all Site boreholes, test pits and test wells. The overburden material generally consists of surficial topsoil or fill, underlain by layers of sand, silty sand and clayey silt, followed by glacial till at some locations.

8.2 Water Quantity Impacts

This section addresses potential impacts to groundwater and surface water quality due to groundwater pumping at TW5, TW6 and House Well. As discussed in Section 2.4, the maximum water taking from TW5 and TW6 for concrete production and water supply would be 340 L/min for 12 hours per day under extreme conditions, while the average taking would be approximately 283 L/min for 11 to 12 hours per day. The maximum taking from the House Well would be 2,700 L/day.

It should be noted that the maximum instantaneous rate requested in the PTTW (340 L/min) is equal to the pumping rate used during the pumping tests at TW5 and TW6, while the requested duration of pumping is 12 hours/day, such that the requested total daily pumping rate is half of the rate used during the pumping tests.

8.2.1 Well Interference

The potential impact of pumping at TW5 or TW6 (for concrete production/water supply) and at the House Well (for water supply at the administration building) on off-site water supply wells was investigated by calculating the potential cumulative drawdown at the nearest supply well, which was identified as the well at the commercial/industrial building located north of Huntley Creek, approximately 70 metres west of the House Well (within the Site boundary; see Figure 1). The predicted drawdown was also calculated for the nearest off-site well (2087 Richardson Side Road, located approximately 340 metres southeast of TW6; see Figure 1). The cumulative drawdown was calculated using the Cooper and Jacob equation (Cooper and Jacob, 1946) using the parameters listed below. In addition, to account for a potential hydraulic boundary located 1,000 m from TW6, an "image well" was situated 1,000 m from TW6 (in line with TW6 and the nearest off-site water supply well). The image well was simulated to pump at the same rate as TW6. Sample calculations are provided in Appendix J.

- Transmissivity: range of $4x10^{-3}$ to $4x10^{-2}$ m^2/s
- Storativity: range of $2x10^{-6}$ to $5x10^{-3}$
- Pumping Rate: 245,000 L/day from TW6
- Distance: 70 metres for nearest on-site well; 340 metres for nearest off-site well (2087 Richardson Side Road)

After 20 years of simulated pumping at TW6 and the image well at the maximum daily rate for 365 days per year, drawdown was calculated to range from 0.1 to 2.0 m for nearest on-site well (at 70 metres distance) and 0.1 to 1.9 m for nearest off-site well (at 340 metres distance). Given a reported available drawdown of 15.8 to 84.1 m of local water supply wells (see Section 2.3.3), the predicted drawdown is considered acceptable.

8.2.2 Shallow Groundwater and Surface Water

The potential impact on the shallow groundwater and surface water levels at Huntley Creek due to groundwater pumping at the site was assessed based on the water level response at the shallow monitoring wells adjacent to the creek during the aquifer testing program.

As discussed in Section 6.1, the shallow groundwater level at MW18-2 and MW18-3 did not exhibit a response to pumping at TW5, TW6 or the House Well. The composite drawdown plot also confirmed that the water level in these did not respond to pumping at TW5 or TW6. The concrete supply wells TW5 and TW6 were each pumped at 340 L/min for at least 48 hours, which represents a higher taking than the anticipated average total pumping rate of 283 L/min for 11 to 12 hours/day. Therefore, the pumping rates used in the aquifer testing program are considered to represent a conservative water taking rate relative to the long-term average taking. Based on these results, it is not anticipated that the water taking from the bedrock aquifer for the operation of the concrete plant will adversely impact shallow groundwater levels or surface water level in the vicinity of Huntley Creek.

8.2.3 Water Balance

Based on the results of the water balance assessment, with mitigation measures proposed, the proposed site development is projected to increase the average annual infiltration by approximately 30% and decrease the average annual runoff by approximately 3% compared to existing conditions. In terms of LID infiltration targets, it is generally recommended that any post-development reduction in infiltration be within 10% of pre-development conditions. In this case, infiltration is projected to increase from pre-development to post-development.

8.3 Water Quality Impacts

8.3.1 Background Nitrate Concentration

As presented in Section 5.3, the nitrate concentration at monitoring wells BH15-1, BH15-2 and BH15-4 ranged from 0.51 mg/L at BH15-2 to 4.77 mg/L at BH15-4. The nitrate concentration at BH15-2 is interpreted to reflect the historical use of this area of the site (for agricultural or other purposes). It is noted that BH15-2 is located 90 metres from the proposed concrete plant site, and that the nitrate concentration at the monitoring well located within the proposed concrete plant site (BH15-4) was 0.51 mg/L.

8.3.2 Nitrate Attenuation

The assessment of potential groundwater impact due to the use of the existing on-site sewage system at the future administration building and the new on-site sewage system at the concrete plant site was based on the MOE Guideline entitled “Technical Guideline for Individual On-site Sewage Systems: Water Quality Impact Risk Assessment”, dated August 1996 (Guideline D-5-4). This guideline was developed for the assessment of privately serviced subdivisions. The groundwater impact assessment for the site followed the predictive assessment method (i.e., the nitrate dilution calculation). The following assumptions were made to apply this method:

- The shallow groundwater flow direction in the area of the septic systems is interpreted to be toward the north and northeast. Therefore, the area contributing infiltration to dilute the septic system effluent was assumed to consist of the concrete plant site, which is located immediately upgradient of the septic systems.
- As shown in Table I-3 (Appendix I), the infiltration volume from the concrete plant are is 23,513 m^3/year. This water will be infiltrated via the bioretention facilities.
- The daily sewage flow was estimated as 6,450 L/day, based on an individual rate of 75 L/day per employee and 86 employees (50 at the concrete plant and 36 at the administration building).
- The nitrate input was estimated as $9.417x10^7$ mg/year (40 mg/L x 6,450 L/day x 365 days/yr).
- The downgradient nitrate concentration is equal to the nitrate input divided by the volume of dilution water.

Based on these assumptions, the theoretical nitrate concentration at the location where the shallow groundwater discharges to Huntley Creek was calculated as 4.0 mg/L. As such, the proposed development complies with the requirements of Procedure D-5-4 related to nitrate impacts.

8.3.3 Surface Water Quality Impacts

The shallow groundwater flow direction is interpreted to be toward Huntley Creek, based on topography and groundwater level measurements collected at selected monitoring wells in August 2018 (see Figure 4). Therefore, effluent from the on-site sewage disposal systems will ultimately flow via shallow groundwater toward Huntley Creek. As described in the previous section, the on-site nitrate attenuation satisfies the requirements of Procedure D-5-4. With regards to other potential parameters found in septic effluent (e.g. phosphate), the new sewage systems will be constructed at an appropriate setback from the creek in accordance with the Ontario Building Code and City of Ottawa requirements. Therefore, adverse water quality impacts to surface water are not anticipated.

9.0 PROPOSED MONITORING AND CONTINGENCY PROGRAM

Based on the results of the impact assessment, the potential for impacting surrounding water supply wells and surface water features is considered low. Nonetheless, a groundwater level monitoring program was recommended in the Category 3 PTTW application to confirm that the extent of groundwater level drawdown in the bedrock does not differ significantly from the magnitude presented in the impact assessment.

The proposed monitoring locations, rationale for their inclusion and monitoring frequency are presented in the table below.

Monitor	Location	Rationale	Frequency
TW1	West of concrete plant site	Bedrock well to confirm that receptors west of the Site will not be adversely impacted.	Monthly manual water level measurements and daily datalogger measurements
TW2	Southern border of concrete plant site	Bedrock well to confirm that receptors south of the Site will not be adversely impacted.	
MW15-5	East of concrete plant site	Overburden well to confirm that receptors east of the Site will not be adversely impacted.	
TW7 (to be drilled)	East of concrete plant site (near MW15-5)	Bedrock well to confirm that receptors east of the Site will not be adversely impacted.	
MW18-1	Adjacent to Huntley Creek	Shallow monitoring wells to confirm that Huntley Creek will not be adversely affected.	Monthly manual water level measurements at all wells; daily datalogger measurements at one well
MW18-2	Adjacent to Huntley Creek		
MW18-3	Adjacent to Huntley Creek		

The monitoring program associated with PTTW Number 4753-B7NJXC, which permits water taking from TW5 and TW6, includes several of the monitoring wells listed above. Groundwater level monitoring will continue as long as required by the PTTW.

If groundwater level monitoring results indicate that the water taking for the concrete plant has caused bedrock groundwater levels to decline by more than 5 metres (approximately 1/3 of the smallest available drawdown in local water supply wells), the well interference assessment will be reviewed and revised in accordance with the monitoring data. If unacceptable interference with local water supply wells is anticipated, the water taking will be adjusted accordingly. If monitoring results indicate that the water taking for the concrete plant has caused groundwater levels at MW18-1, MW18-2 and MW18-3 to decline below the level of Huntley Creek, the shallow groundwater and surface water impact assessment will be reviewed and revised in accordance with the monitoring data. If unacceptable interference with Huntley Creek is anticipated, the water taking will be adjusted accordingly.

If the monitoring program indicates that groundwater pumping at the site has not caused groundwater level lowering to a degree that would adversely affect the nearby receptors, a reduction in the monitoring program may be proposed.

10.0 CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

Based on the hydrogeology investigation, terrain analysis and impact assessment carried out by Golder at the Site, the following conclusions are provided:

a) Pumping tests carried out at test wells TW5 and TW6 suggest that both wells can provide at least 340 L/min for concrete production, which represents a higher taking than the anticipated average pumping rate of 283 L/min for 11 to 12 hours/day. The pumping test carried out at the House Well indicates that the well can provide at least 18 L/min, which is greater than the anticipated water use at the future administration building of 75 L/day/employee (or 2,700 L/day).

b) Based on the analytical results, test wells TW5 and TW6 have exceedances of the ODWQS for chloride, hydrogen sulphide, TDS, hardness and total coliforms. However, the post-chlorination results at TW5 indicated that the total coliform, fecal coliform and E. coli concentrations were 0 ct/100 mL. Furthermore, the total coliform level at TW6 (5 ct/100 mL) was equal to the 5 ct/100 mL level used to evaluate non-disinfected private water supplies (as described in Procedure D-5-5; MOE, 1996). Therefore, TW5 and TW6 are considered to satisfy the ODWQS and Procedure D-5-5 for bacteriological parameters. Test wells TW5 and TW6 will be used to supply water for concrete production and for employees at the concrete plant.

c) Based on the analytical results, the House Well has exceedances of the ODWQS for colour and TDS. It also had exceedances for total coliforms, fecal coliforms and E.coli. However, the post-chlorination results indicated that the total coliform, fecal coliform and E. coli concentrations were 0 ct/100 mL. Therefore, the House Well is considered to satisfy the ODWQS for bacteriological parameters. The House Well will be used to supply water to the future administration building.

d) The shallow groundwater levels in the vicinity of Huntley Creek did not respond to pumping at TW5, TW6 and the House Well. Based on these results, it is not anticipated that the water taking for the operation of the concrete plant will adversely impact shallow groundwater levels or surface water level in the vicinity of Huntley Creek.

e) The use of the test wells and the House Well for the Site water supply is not anticipated to result in a significant impact on the available drawdown at nearby water supply wells.

f) Based on the results of the water balance assessment, with mitigation measures proposed, the proposed site development is projected to increase the average annual infiltration by approximately 30% and increase the average annual runoff volume by approximately 3% compared to existing conditions.

g) The theoretical nitrate concentration at the location of groundwater discharge to Huntley Creek was calculated as 4.0 mg/L. As such, the proposed development complies with the requirements of Procedure D-5-4 related to nitrate impacts. With regards to other potential parameters found in domestic sewage (e.g. phosphate), the new sewage system will be constructed at an appropriate setback from the creek in accordance with the Ontario Building Code and City of Ottawa requirements. Therefore, adverse water quality impacts to surface water are not anticipated.

10.2 Recommendations

a) Cavanagh is advised that treatment of the groundwater for colour, hydrogen sulphide and hardness may be desirable if it is used for drinking water. Cavanagh is also advised of the following:

- 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;
- Treating water for hardness using a conventional sodium ion exchange water softener may increase the sodium content of the water; and,
- If untreated, elevated sulphide concentrations may result in an unpleasant odour.

b) Regular water quality testing of all wells used to supply drinking water is recommended.

c) Septic systems at the site must be constructed in accordance with the Ontario Building Code (OBC, O.Reg. 350/06), which indicates minimum clearances between wells and septic system components (treatment units and distribution piping). The septic system designer and constructor shall ensure that the necessary approvals are obtained.

d) The groundwater monitoring program outlined in Section 9.0 should be implemented.

11.0 LIMITATIONS

This report was prepared for the exclusive use of Cavanagh Developments. The report, which specifically includes all tables, figures and appendices, is based on data and information collected by Golder Associates Ltd. and is based solely on the conditions of the properties at the time of the work, supplemented by historical information and data obtained by Golder Associates Ltd. as described in this report.

Electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore authenticity of any electronic media versions of Golder's report should be verified.

Golder Associates Ltd. has relied in good faith on all information provided and does not accept responsibility for any deficiency, misstatements, or inaccuracies contained in the report as a result of omissions, misinterpretation, or fraudulent acts of the persons contacted or errors or omissions in the reviewed documentation.

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 science professions currently practicing 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 Ltd. 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 Ltd. should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

12.0 CLOSURE

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

Golder Associates Ltd.

Loren Bekeris, M.Sc., P.Eng.
Environmental Engineer

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

LEB/BTB/sg

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13.0 REFERENCES

Domenico, P.A. and F.W. Schwartz. 1990. *Physical and Chemical Hydrogeology*, John Wiley & Sons, New York, 824 p.

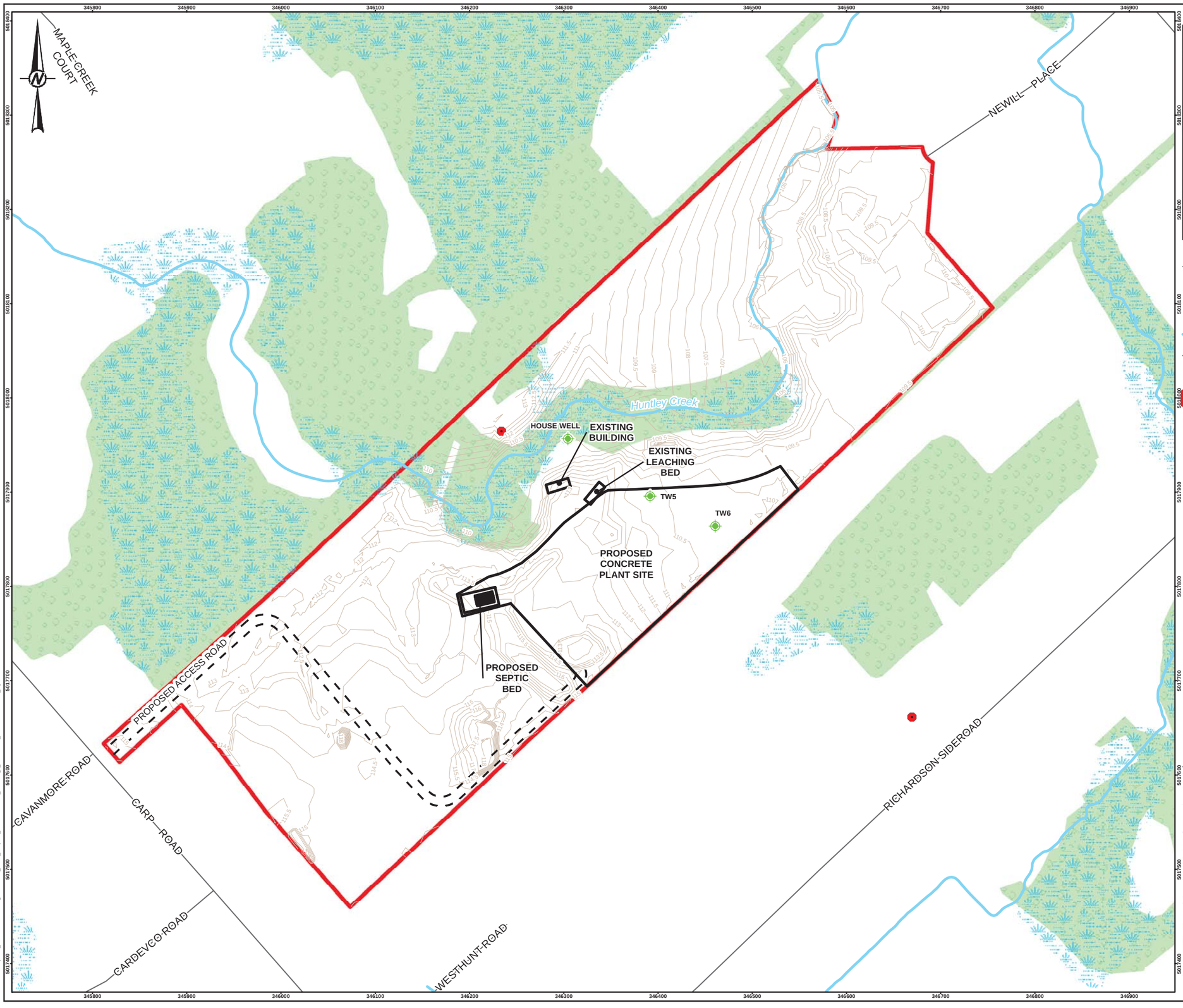
Golder Associates Ltd. 2016. Phase One Environmental Site Assessment, Part of Lot 6, Concession 2, Township of Huntley, Ottawa, Ontario. Project No. 1543767, May 2016.

Golder Associates Ltd. 2018a. Ontario Regulation 153/04 Phase One Environmental Site Assessment Update, 2596 Carp Road, Ottawa, Ontario. Project No. 1543767, September 2018.

Golder Associates Ltd. 2018b. Phase Two Environmental Site Assessment, 2596 Carp Road, Ottawa, Ontario. Project No. 1543767, September 2018.

Mississippi-Rideau Source Protection Region (MRSPR). 2008. Watershed Characterization Report. March 2008.

Robinson Land Development. 2019. 2596 Carp Road, Ottawa, Ontario, Industrial Development Servicing and Stormwater Management Report. Project No. 18047, revised April 2019.



KEY MAP

SCALE 1:100,000

LEGEND

- NEAREST ON-SITE AND OFF-SITE WATER WELLS (INTERPRETED)
- APPROXIMATE TEST WELL LOCATION
- WATERCOURSE
- ROADWAY
- WETLAND
- SITE BOUNDARY

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: MTM ZONE 9 VERTICAL DATUM: CGVD28

0 40 80 160

1:4,000 METRES

CLIENT
CAVANAGH DEVELOPMENTS

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
SITE PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-01
DESIGNED	----
PREPARED	ABD
REVIEWED	LEB
APPROVED	BTB

PROJECT NO.	PHASE	REV.	FIGURE
1543767	2001	0	1

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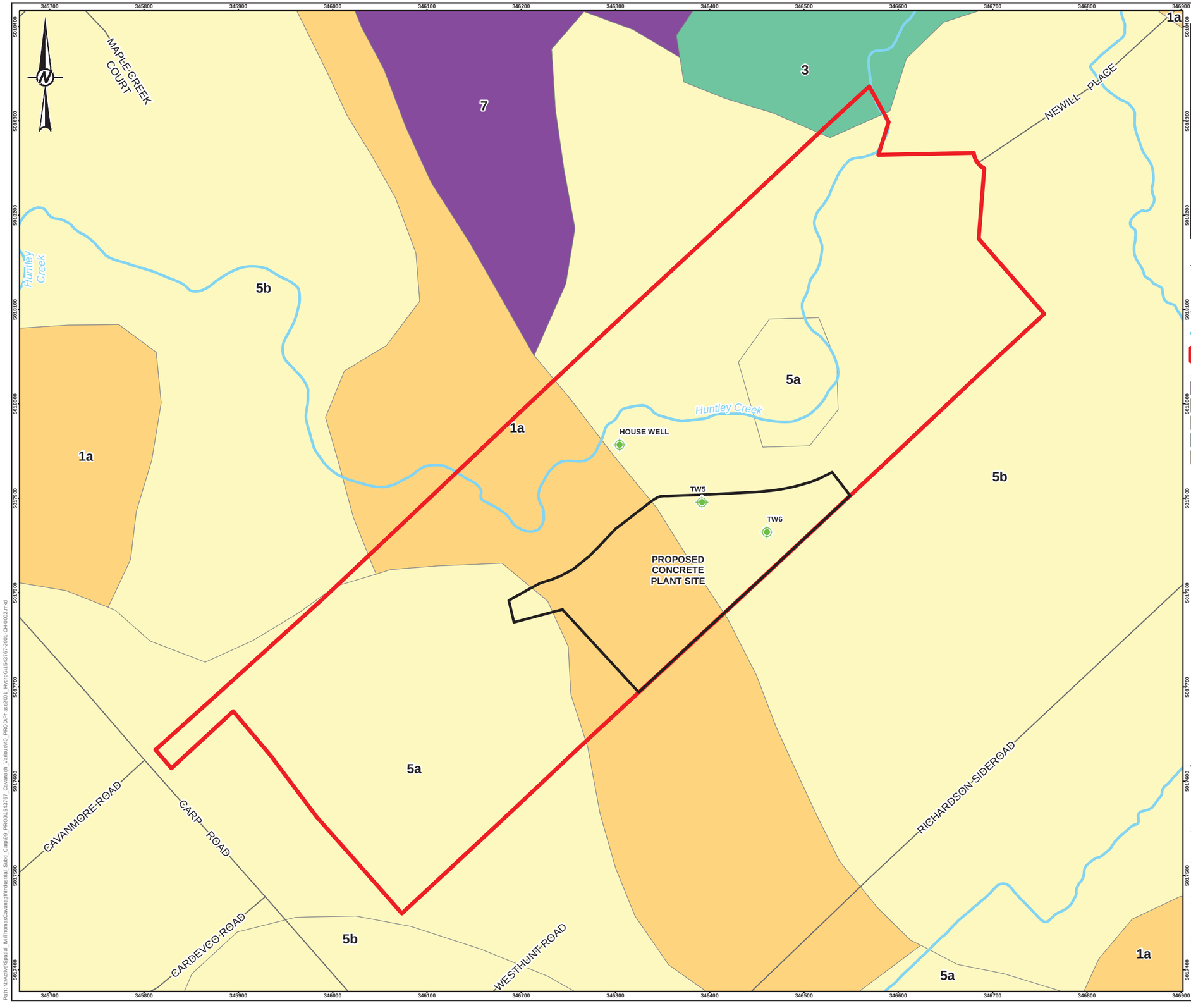

KEY MAP

SCALE 1:100,000

LEGEND

- APPROXIMATE TEST WELL LOCATION
- ROADWAY
- WATERCOURSE
- SITE BOUNDARY

SURFICIAL GEOLOGY

- 7. ORGANIC DEPOSITS: MUCK & PEAT
- 5a: NEARSHORE SEDIMENTS: GRAVEL, SAND & BOULDERS
- 5b: NEARSHORE SEDIMENTS: FINE TO MEDIUM GRAINED SAND
- 3. OFFSHORE MARINE DEPOSITS: CLAY, SILTY CLAY & SILT
- 1a. TILL, PLAIN WITH LOCAL RELIEF <5 m

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. BÉLANGER, J. R. 2008 URBAN GEOLOGY OF THE NATIONAL CAPITAL AREA, GEOLOGICAL SURVEY OF CANADA, OPEN FILE 5311, 1 DVD.
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: MTM ZONE 9 VERTICAL DATUM: CGVD28

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1:4,000 METRES

CLIENT
CAVANAGH DEVELOPMENTS

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
SURFICIAL GEOLOGY

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-01
DESIGNED	----
PREPARED	ABD
REVIEWED	LEB
APPROVED	BTB

PROJECT NO.	PHASE	REV.	FIGURE
1543767	2001	0	**2**

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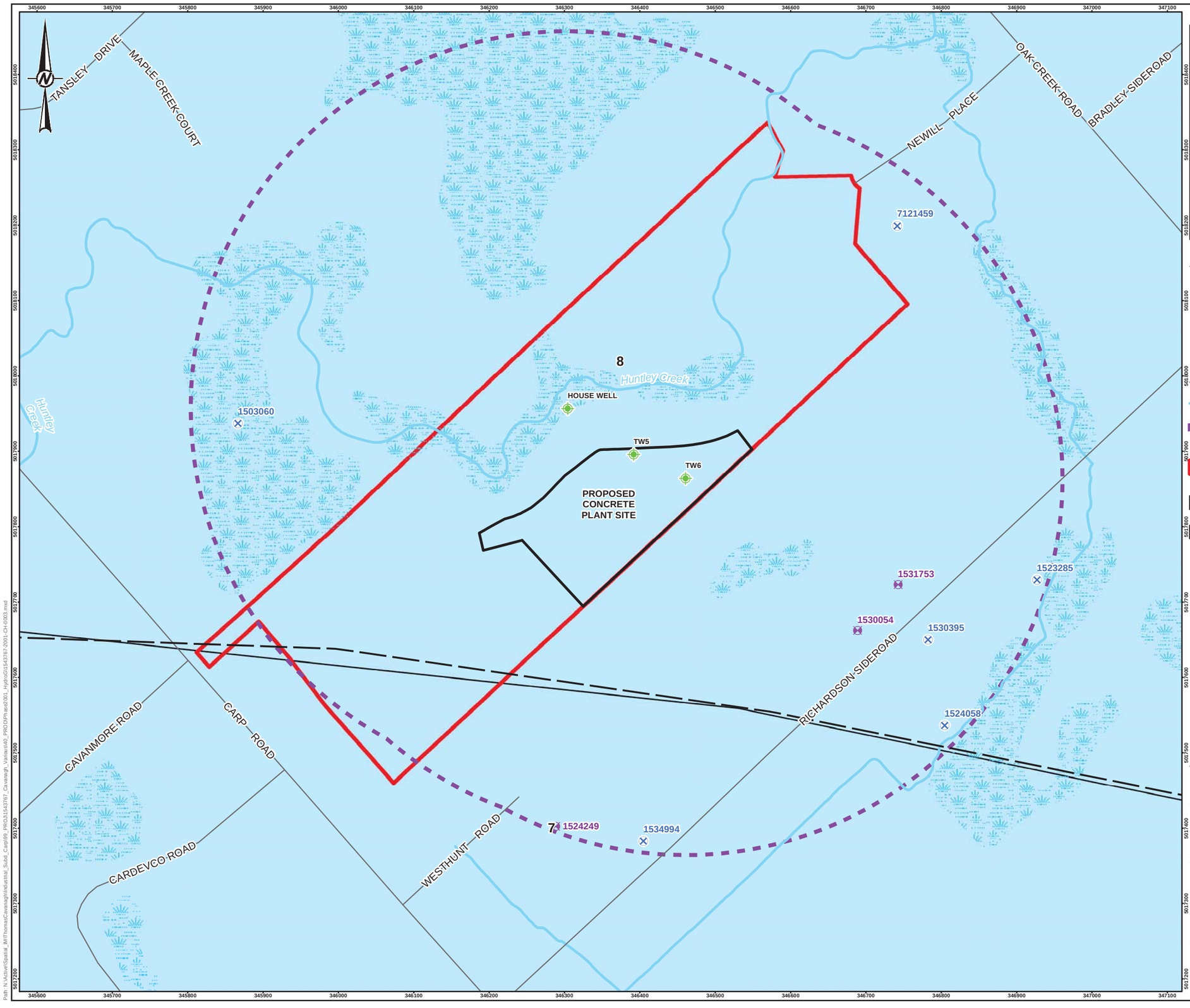

KEY MAP

SCALE 1:100,000

LEGEND

- APPROXIMATE TEST WELL LOCATION
- MECP LISTED WATER WELL (LOCATION ADJUSTED)
- MECP LISTED WATER WELL
- FAULT
- ROADWAY
- WATERCOURSE
- 500 m BUFFER FROM TEST WELLS
- WETLAND
- SITE BOUNDARY

BEDROCK GEOLOGY

- 8. VERULAM FORMATION: INTERBEDDED BIOCLASTIC LIMESTONE, SUBLITHOGRAPHIC TO FINE CRYSTALLINE LIMESTONE
- 7. BOBCAYGEON FORMATION: INTERBEDDED SILTY DOLOMITE, LITHOGRAPHIC TO FINE CRYSTALLINE LIMESTONE, OOLITIC LIMESTONE, SHALE, AND FINE-GRAINED CALCAREOUS QUARTZ SANDSTONE

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. BÉLANGER, J. R., URBAN GEOLOGY OF THE NATIONAL CAPITAL AREA, GEOLOGICAL SURVEY OF CANADA, OPEN FILE D3256, 2001
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: MTM ZONE 9 VERTICAL DATUM: CGVD28

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1:5,000 METRES

CLIENT
CAVANAGH DEVELOPMENTS

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
BEDROCK GEOLOGY

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-01
DESIGNED	----
PREPARED	ABD
REVIEWED	LEB
APPROVED	BTB

PROJECT NO.	PHASE	REV.	FIGURE
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KEY MAP

SCALE 1:100,000

LEGEND

99.99	OVERBURDEN GROUNDWATER ELEVATION, mASL (Aug. 22, 2018)
99.99	BEDROCK GROUNDWATER ELEVATION, mASL (Aug. 22, 2018)
	APPROXIMATE BOREHOLE LOCATION, GEMTEC, 2018
	APPROXIMATE TEST WELL LOCATION
	APPROXIMATE TEST WELL (MONITORING WELL) LOCATION
	APPROXIMATE TEST PIT LOCATION
	APPROXIMATE SHALLOW MONITORING WELL LOCATION
	APPROXIMATE BOREHOLE LOCATION
	SITE BOUNDARY

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: MTM ZONE 9 VERTICAL DATUM: CGVD28

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1:4,000 METRES

CLIENT
CAVANAGH DEVELOPMENTS

PROJECT
HYDROGEOLOGY INVESTIGATION
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
FIELD INVESTIGATION LOCATIONS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-01
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PREPARED	ABD
REVIEWED	LEB
APPROVED	BTB

PROJECT NO.	PHASE	REV.	FIGURE
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KEY MAP

SCALE 1:100,000

LEGEND

- INFILTRATION AREA
- SITE BOUNDARY

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: MTM ZONE 9 VERTICAL DATUM: CGVD28

0 40 80 160

1:4,000 METRES

CLIENT
CAVANAGH DEVELOPMENTS

PROJECT
HYDROGEOLOGY INVESTIGATION
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
WATER BALANCE - PRE-DEVELOPMENT CONDITIONS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-01
DESIGNED	----
PREPARED	ABD
REVIEWED	LEB
APPROVED	BTB

PROJECT NO.	PHASE	REV.	FIGURE
1543767	2001	0	**5**

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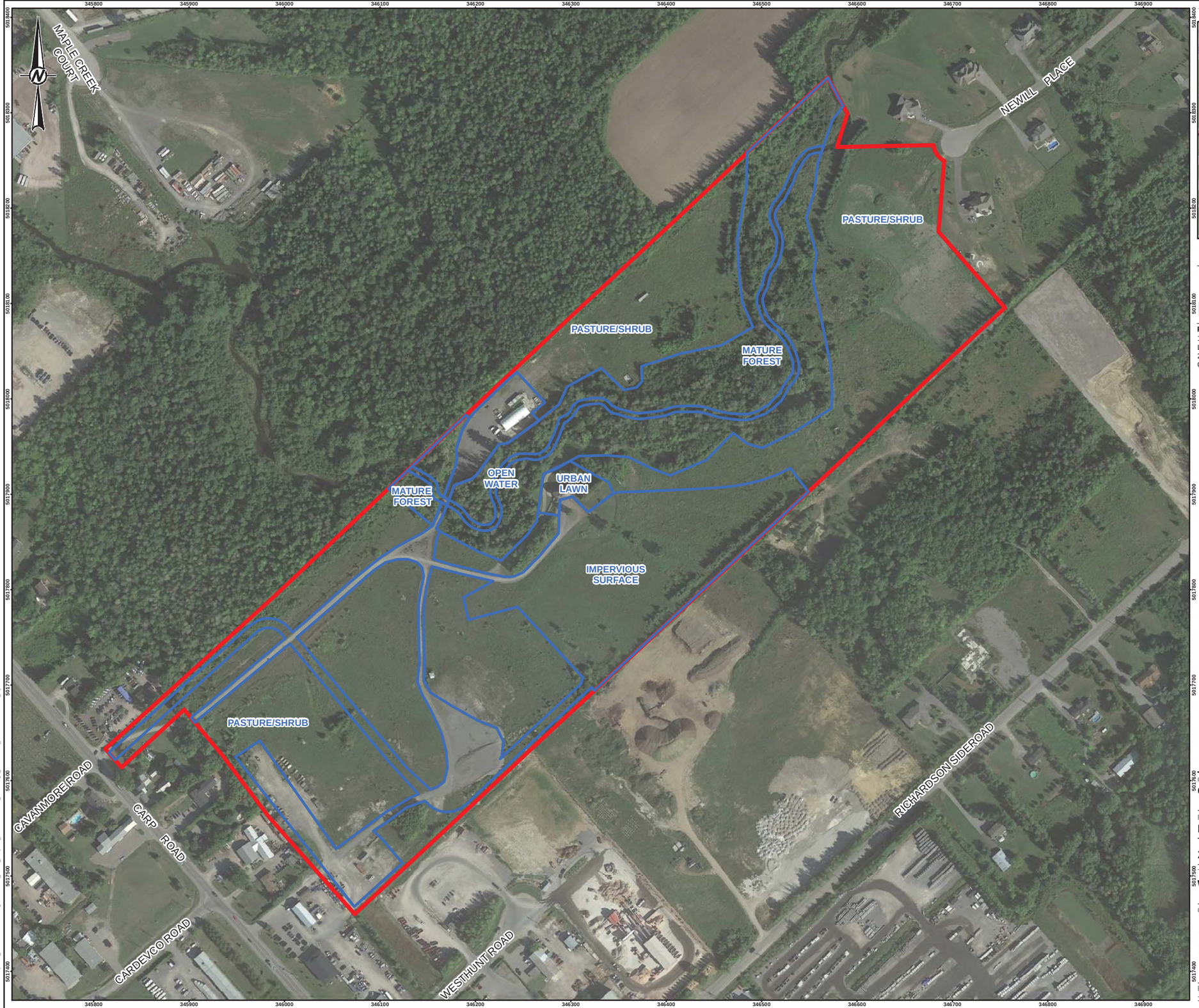


KEY MAP

SCALE 1:100,000

LEGEND

INFILTRATION AREA

SITE BOUNDARY

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: MTM ZONE 9 VERTICAL DATUM: CGVD28

0 40 80 160

1:4,000 METRES

CLIENT
CAVANAGH DEVELOPMENTS

PROJECT
HYDROGEOLOGY INVESTIGATION
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
WATER BALANCE - POST-DEVELOPMENT CONDITIONS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-01
DESIGNED	----
PREPARED	ABD
REVIEWED	LEB
APPROVED	BTB

PROJECT NO.	PHASE	REV.	FIGURE
1543767	2001	0	6

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

Path: N:\Active\Spatial_IM\Thomas\Cavanagh\Ind\astrial_Subd_Carp\dp_PRO\1543767_Cavanagh_Various\40_PROD\Phase\2001_Hydro\G1543767-2001-CH-0006.mxd

APPENDIX A

MECP Water Well Record Summary

Well ID	Easting	Northing	Elevation (m)	Date Completed	Well Type	Depth to Bedrock (ft)	Depth to Bedrock (m)	Well Depth (m)	Water found depth (ft)	Water Found Depth (m)	Static Water Level (m)	Overburden Type	Bedrock Type	UTMRC	Available Drawdown
7121459	424330	5017008	107.9	06-Feb-09	Bedrock	N/A	6.1	86.7	N/A	N/A	2.6	sandy clay/clay	limestone	3	84.1
1524249	424085	5016674	109.2	16-Oct-89	Bedrock	16	4.9	45.7	28; 87	8.5; 26.5	4.3	sand and gravel/hardpan	limestone	9	41.5
1530054	424085	5016674	109.2	05-May-98	Bedrock	15	4.6	30.5	80-95	24.3 - 29.0	1.5	sandy clay/sand and gravel	limestone	9	29.0
1531753	424081	5016676	109.2	19-Feb-01	Bedrock	12	3.7	30.5	26; 89	7.9; 27.1	1.1	sandy clay	limestone	9	29.4
1524058	424381	5016344	109.5	03-Nov-89	Bedrock	21	6.4	20.4	65	19.8	4.6	clay	limestone	5	15.8
1530395	424361	5016458	110.0	25-Sep-98	Bedrock	22	6.7	33.5	100	30.5	3.4	clay fill/sand	limestone	5	30.2
1523285	424507	5016535	108.1	11-Mar-89	Bedrock	26	7.9	25.9	83	25.3	8.2	sand and gravel/clay	limestone	5	17.7

Notes: N/A - not applicable
N/D - no data

APPENDIX B

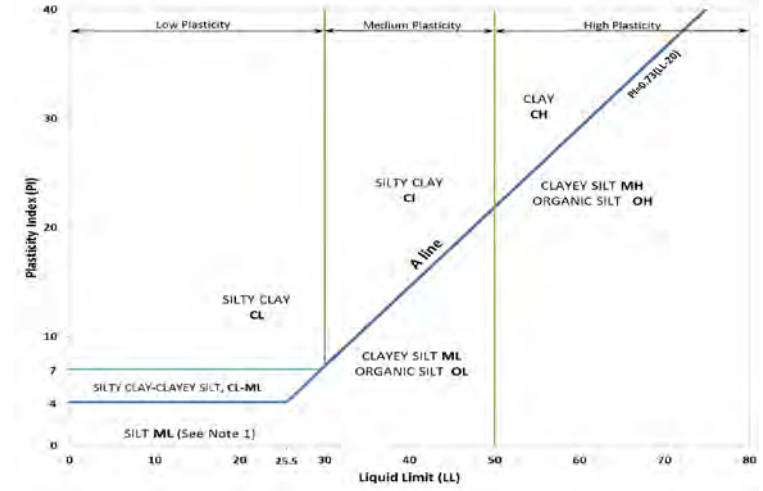
Borehole and Test Pit Logs

METHOD OF SOIL CLASSIFICATION

The Golder Associates Ltd. Soil Classification System is based on the Unified Soil Classification System (USCS)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10} x D_{60}}$	Organic Content	USCS Group Symbol	Group Name
INORGANIC (Organic Content ≤30% by mass)	COARSE-GRAINED SOILS (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Gravels with ≤12% fines (by mass)	Poorly Graded	<4	≤1 or ≥3	≤30%	GP	GRAVEL
				Well Graded	≥4	1 to 3		GW	GRAVEL
			Gravels with >12% fines (by mass)	Below A Line	n/a			GM	SILTY GRAVEL
				Above A Line	n/a			GC	CLAYEY GRAVEL
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Sands with ≤12% fines (by mass)	Poorly Graded	<6	≤1 or ≥3		SP	SAND
				Well Graded	≥6	1 to 3		SW	SAND
			Sands with >12% fines (by mass)	Below A Line	n/a			SM	SILTY SAND
				Above A Line	n/a			SC	CLAYEY SAND

Organic or Inorganic	Soil Group	Type of Soil	Laboratory Tests	Field Indicators					Organic Content	USCS Group Symbol	Primary Name
				Dilatancy	Dry Strength	Shine Test	Thread Diameter	Toughness (of 3 mm thread)			
INORGANIC (Organic Content ≤30% by mass)	FINE-GRAINED SOILS (≥50% by mass is smaller than 0.075 mm)	SILTS (Non-Plastic or PI and LL plot below A-Line on Plasticity Chart below)	Liquid Limit <50	Rapid	None	None	>6 mm	N/A (can't roll 3 mm thread)	<5%	ML	SILT
				Slow	None to Low	Dull	3mm to 6 mm	None to low	<5%	ML	CLAYEY SILT
				Slow to very slow	Low to medium	Dull to slight	3mm to 6 mm	Low	5% to 30%	OL	ORGANIC SILT
			Liquid Limit ≥50	Slow to very slow	Low to medium	Slight	3mm to 6 mm	Low to medium	<5%	MH	CLAYEY SILT
				None	Medium to high	Dull to slight	1 mm to 3 mm	Medium to high	5% to 30%	OH	ORGANIC SILT
		CLAYS (PI and LL plot above A-Line on Plasticity Chart below)	Liquid Limit <30	None	Low to medium	Slight to shiny	~ 3 mm	Low to medium	0% to 30% **(see Note 2)**	CL	SILTY CLAY
			Liquid Limit 30 to 50	None	Medium to high	Slight to shiny	1 mm to 3 mm	Medium		CI	SILTY CLAY
			Liquid Limit ≥50	None	High	Shiny	<1 mm	High		CH	CLAY
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures							30% to 75%	PT	SILTY PEAT, SANDY PEAT
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat							75% to 100%		PEAT



Note 1 – Fine grained materials with PI and LL that plot in this area are named (ML) SILT with slight plasticity. Fine-grained materials which are non-plastic (i.e. a PL cannot be measured) are named SILT.
Note 2 – For soils with <5% organic content, include the descriptor "trace organics" for soils with between 5% and 30% organic content include the prefix "organic" before the Primary name.

Dual Symbol — A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC and CL-ML.
For non-cohesive soils, the dual symbols must be used when the soil has between 5% and 12% fines (i.e. to identify transitional material between "clean" and "dirty" sand or gravel.
For cohesive soils, the dual symbol must be used when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart (see Plasticity Chart at left).

Borderline Symbol — A borderline symbol is two symbols separated by a slash, for example, CL/CI, GM/SM, CL/ML.
A borderline symbol should be used to indicate that the soil has been identified as having properties that are on the transition between similar materials. In addition, a borderline symbol may be used to indicate a range of similar soil types within a stratum.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

Percentage by Mass	Modifier
>35	Use 'and' to combine major constituents (*i.e.,* SAND and GRAVEL)
> 12 to 35	Primary soil name prefixed with "gravelly, sandy, SILTY, CLAYEY" as applicable
> 5 to 12	some
≤ 5	trace

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); N_d:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , w_L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, Gs)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

1. Tests anisotropically consolidated prior to shear are shown as CAD, CAU.

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT 'N' (blows/0.3m)[1]
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

1. SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.
2. Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grainsize. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1,2] (blows/0.3m)
Very Soft	<12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	>200	>30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
NP	non-plastic
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan \phi'$

2 shear strength = (compressive strength)/2

PROJECT: 1543767

RECORD OF BOREHOLE: 15-1

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 7, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	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		114.57							
0	Power Auger 200 mm Diam. (Hollow Stem)	(ML) CLAYEY SILT, some sand and gravel; dark brown; non-cohesive, moist, loose to compact		0.00							
1					1	SS	7				
				112.89							
		(SP) SAND, some gravel, trace fines; brown; non-cohesive, moist to wet, compact		1.68	2	SS	19				
2											Cuttings
					3	SS	16				
				111.67							
3		(SP) SAND, trace gravel; grey, contains cobbles; non-cohesive, wet, compact		2.90	4	SS	19				
				110.76							
4		(SM) SILTY SAND; brown; non-cohesive, wet, compact		3.81	5	SS	11				
					6	SS	14				
5											Bentonite Seal
					7	SS	17				Silica Sand
6											
					8	SS	17				
				107.95							51 mm Diam. PVC #10 Slot Screen
		(ML) SILT, some sand and gravel; grey; non-cohesive, wet, compact		6.62							
				107.71							
7		(SM/GM) SILTY SAND and GRAVEL; grey brown; non-cohesive, wet, compact		6.86	9	SS	>50				
				107.19							
		End of Borehole Auger Refusal		7.38							W.L. in Screen at Elev. 106.41 m on April 26, 2017
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: HEC

CHECKED: WAM

MIS-BHS 001 1543767.GPJ GAL-MIS.GDT 09/12/18 JEM

PROJECT: 1543767

RECORD OF BOREHOLE: 15-2

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 7, 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
		GROUND SURFACE		114.99							
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL - (SP) gravelly SAND, angular; grey; non-cohesive, moist, loose		0.00							
1					1	SS	7				Cuttings
				113.62							
		(SM) SILTY SAND, trace gravel; red brown; non-cohesive, moist, loose			2	SS	7				Bentonite Seal
2				112.86							
		(SM) SILTY SAND, some gravel; grey brown; non-cohesive, moist to wet, compact		2.13	3	SS	16				
				112.09							
3		(SM) gravelly SILTY SAND; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, very dense		2.90	4	SS	>50				Silica Sand
4					5	SS	71				
					6	SS	56				
5											51 mm Diam. PVC #10 Slot Screen
					7	SS	60				
6					8	SS	>50				Silica Sand
				108.61							
		End of Borehole Auger Refusal		6.38							W.L. in Screen at Elev. 109.74 m on April 26, 2017
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: HEC

CHECKED: WAM

MIS-BHS 001 1543767.GPJ GAL-MIS.GDT 09/12/18 JEM

PROJECT: 1543767

RECORD OF BOREHOLE: 15-3

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 12, 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. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	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		112.02							
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL - (SM) SILTY SAND, some gravel; brown, contains cobbles; non-cohesive, moist		0.00 / 111.33							
		(SM) SILTY SAND; brown; non-cohesive, moist, compact		0.69 / 111.03							Cuttings
1		(SM) gravelly SILTY SAND; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, very dense		0.99	1	SS	14				
					2	SS	47				Bentonite Seal
2											Silica Sand
					3	SS	86				
3					4	SS	>50				51 mm Diam. PVC #10 Slot Screen
				108.21							
4		End of Borehole Auger Refusal		3.81							W.L. in Screen at Elev. 111.74 m on April 26, 2017
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: HEC

CHECKED: WAM

MIS-BHS 001 1543767.GPJ GAL-MIS.GDT 09/12/18 JEM

PROJECT: 1543767

RECORD OF BOREHOLE: 15-4

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 7, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	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 - ○) (20 40 60 80)	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		110.31							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; non-cohesive, moist		0.00 109.90							
		(SM) SILTY SAND to sandy SILT; brown; non-cohesive, moist		0.41 109.55							
		(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff		0.76 0.91	1	SS	10				
1		(SM) SILTY SAND, fine, trace gravel; brown, contains organics; non-cohesive, moist, compact									Cuttings
					2	SS	17				
2		(SM) gravelly SILTY SAND; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, dense to very dense		108.25 2.06							
					3	SS	30				Bentonite Seal
3				107.26							
		(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL)		3.05	4	SS	53				Silica Sand
4					5	SS	82				
											51 mm Diam. PVC #10 Slot Screen
					6	SS	41				
5				105.05							
		End of Borehole Auger Refusal		5.26							W.L. in Screen at Elev. 108.79 m on April 26, 2017
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: HEC

CHECKED: WAM

MIS-BHS 001 1543767.GPJ GAL-MIS.GDT 09/12/18 JEM

PROJECT: 1543767

RECORD OF BOREHOLE: 15-5

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 8, 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. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	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		109.50							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND, fine; dark brown; non-cohesive, moist		0.00 / 109.19							
		(SM) SILTY SAND; brown; non-cohesive, moist		0.31 / 108.59							
1		(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff		0.91	1	SS	6				
					2	SS	15				Cuttings
2					3	SS	3				
		(CI/CH-ML) SILTY CLAY to CLAYEY SILT, trace sand; grey; cohesive, w>PL, firm to stiff		106.76 / 2.74				⊕ +			
3								⊕ +			
					4	SS	WH				Bentonite Seal
4				104.75							Silica Sand
		(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, dense to compact		4.75	5	SS	31				
5											51 mm Diam. PVC #10 Slot Screen
					6	SS	25				
6				103.40							
		End of Borehole		6.10							W.L. in Screen at Elev. 108.62 m on April 26, 2017
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: HEC

CHECKED: WAM

MIS-BHS 001 1543767.GPJ GAL-MIS.GDT 09/12/18 JEM

PROJECT: 1543767

RECORD OF BOREHOLE: 15-6

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 8, 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. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	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
0		GROUND SURFACE		109.54							
	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; moist		0.00 / 109.23							
		(SM) SILTY SAND; brown; non-cohesive, moist, compact		0.31	1	SS	8				Cuttings
1				108.24							
		(SM) SILTY SAND; grey brown; non-cohesive, moist, compact		1.30	2	SS	25				
2				107.25							
		(ML,CL & SM) layered SILT, CLAYEY SILT, SILTY CLAY and SILTY SAND; grey; brown; non-cohesive, moist, very loose		2.29	3	SS	2				Bentonite Seal
3				106.49							
		(SM) SILTY SAND, fine; brown; non-cohesive, moist to wet, loose		3.05	4	SS	4				Silica Sand
				105.73							
		(CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL, very stiff		3.81	5	SS	WH				51 mm Diam. PVC #10 Slot Screen
4				105.12							
		(SM) SILTY SAND, fine, some gravel; grey; non-cohesive, wet, compact		4.42	6	SS					
				104.72							
		End of Borehole Auger Refusal		4.82							W.L. in Screen at Elev. 106.41 m on April 26, 2017
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: HEC

CHECKED: WAM

MIS-BHS 001 1543767.GPJ GAL-MIS.GDT 09/12/18 JEM

RECORD OF BOREHOLE 18-1

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface		112.90						
0	Power Auger / Hollow Stem Auger (210mm OD)	TOPSOIL		0.05						
		Brown SAND, trace silt		112.49	1	GS			M	Bentonite seal
		Grey SILTY SAND, trace clay		0.41						Filter sand
1					2	GS				51 mm diametre, 1.52 m long well screen
2				110.77						
		End of borehole		2.13						
3										
4										
5										

● PENETRATION RESISTANCE (N), BLOWS/0.3m
▲ DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED
WATER CONTENT, %: W_P — W — W_L
10 20 30 40 50 60 70 80 90

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
18/08/17	0.69 ▽	112.21

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

RECORD OF BOREHOLE 18-2

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m ● / DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m ▲	SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED / WATER CONTENT, % W_P W W_L	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger Hollow Stem Auger (210mm OD)	Ground Surface		114.17								
		TOPSOIL FILL		0.03								
		Dark brown sandy silt, some clay, trace gravel (FILL MATERIAL)			1	GS			○		M	Backfilled with soil cuttings
1					2	GS						Groundwater seepage oberved in open borehole
				112.65								
		End of borehole		1.52								
2												
3												
4												
5												

10 20 30 40 50 60 70 80 90

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
18/08/08	1.35 ▽	112.82

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

RECORD OF BOREHOLE 18-3

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA (NATURAL, REMOULDED) / WATER CONTENT, %	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger, Hollow Stem Auger (210mm OD)	Ground Surface		114.76							
		TOPSOIL FILL		114.71 / 0.05	1	GS					
		Brown sandy silt, trace gravel and clay, with debris (rebar) (FILL MATERIAL)			2	GS					Backfilled with soil cuttings
1											
				113.24							No groundwater seepage observed upon completion of borehole
		End of borehole		1.52							
2											
3											
4											
5											

PENETRATION RESISTANCE (N), BLOWS/0.3m
DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA: + NATURAL, ⊕ REMOULDED
WATER CONTENT, %: W_P — W — W_L
10 20 30 40 50 60 70 80 90

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

RECORD OF BOREHOLE 18-4

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m ● / DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m ▲	SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED / WATER CONTENT, % W_P W W_L	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger Hollow Stem Auger (210mm OD)	Ground Surface		113.88					10 20 30 40 50 60 70 80 90			
		TOPSOIL FILL		0.05								
		Brown sandy silt, trace gravel and clay, with possible cobbles and boulders (FILL MATERIAL)			1	GS			○		M	Backfilled with soil cuttings
1												No groundwater seepage observed upon completion of borehole
		End of borehole		112.36 1.52								
2												
3												
4												
5												

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

RECORD OF BOREHOLE 18-5

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA (NATURAL, REMOULDED) / WATER CONTENT, %	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger Hollow Stem Auger (210mm OD)	Ground Surface		113.91							
		TOPSOIL FILL		0.03							
		Grey to brown sandy silt, some clay, trace gravel (FILL MATERIAL)			1	GS					Backfilled with soil cuttings
1					2	GS					
		End of borehole		112.39 / 1.52							No groundwater seepage observed upon completion of borehole
2											
3											
4											
5											

PENETRATION RESISTANCE (N), BLOWS/0.3m ●
DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m ▲
SHEAR STRENGTH (Cu), kPA: + NATURAL, ⊕ REMOULDED
WATER CONTENT, %: W_P — W — W_L
10 20 30 40 50 60 70 80 90

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

RECORD OF BOREHOLE 18-6

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger Hollow Stem Auger (210mm OD)	Ground Surface		110.86						Bentonite seal
		TOPSOIL		0.05						
		Dark brown SILTY SAND		110.56	1	GS				Filter sand
		Brown SAND, trace silt and gravel		0.30 / 110.35	2	GS				
		Grey brown SILTY SAND		0.51						
1					3	GS			M	51 mm diametre, 1.52 m long well screen
2				108.73						
		End of borehole		2.13						
3										
4										
5										

● PENETRATION RESISTANCE (N), BLOWS/0.3m
▲ DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED
WATER CONTENT, %: W_P — W — W_L
10 20 30 40 50 60 70 80 90

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
18/08/17	1.25 ▽	109.61

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

RECORD OF BOREHOLE 18-7

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m ● / DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m ▲	SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED / WATER CONTENT, % W_P W W_L	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface		112.68								
		TOPSOIL		0.05								
	Power Auger / Hollow Stem Auger (210mm OD)	Loose, brown SILTY SAND, trace gravel			1 1B	SS SS	430	7			M	Bentonite seal
1		very dense, grey brown silty sand, trace to some gravel with possible cobbles and boulders (GLACIAL TILL)		111.61 1.07	2	SS	480	10				Filter sand
					3	SS	610	54				
2					4	SS	410	>50 for 150 mm				51 mm diametre, 1.52 m long well screen
		End of borehole Auger refusal on inferred bedrock		109.78 2.90								
3												
4												
5												

10 20 30 40 50 60 70 80 90

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
18/08/17	1.52 ▽	111.16

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LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

RECORD OF BOREHOLE 18-8

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA (NATURAL, REMOULDED) / WATER CONTENT, % (W_P, W, W_L)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger / Hollow Stem Auger (210mm OD)	Ground Surface		111.57							
		TOPSOIL		0.05							
		Very loose, brown SILTY SAND, trace gravel			1A 1B	SS SS	480	4			Soil moist at about 0.8 metres below ground surface
				110.81							
1		Compact to very dense, grey brown silty sand, trace to some gravel with possible cobbles and boulders (GLACIAL TILL)		0.76	2	SS	460	21			Backfilled with soil cuttings
					3	SS	510	54		MH	
2					4	SS	510	>50 for 100 mm			
				108.88							
		End of borehole Auger refusal on inferred bedrock		2.69							
3											
4											
5											

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LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

RECORD OF BOREHOLE 18-9

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger, Hollow Stem Auger (210mm OD)	Ground Surface	111.79						
		TOPSOIL	0.05	1	SS	305	7		Soil moist at about 0.8 metres below ground surface
1		Loose to compact, brown SILTY SAND, trace gravel	110.72	2	SS	560	15		
		Compact to very dense, grey brown silty sand, trace to some gravel with possible cobbles and boulders (GLACIAL TILL)	1.07	3	SS	560	58		Backfilled with soil cuttings
2				4	SS	530	>50 for 130 mm		
3		End of borehole Auger refusal on inferred bedrock	108.92 2.87						
4									
5									

PENETRATION RESISTANCE (N), BLOWS/0.3m
DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA: NATURAL, REMOULDED
WATER CONTENT, %: W_P, W, W_L
10 20 30 40 50 60 70 80 90

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

RECORD OF BOREHOLE 18-10

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger Hollow Stem Auger (210mm OD)	Ground Surface		110.28						
		TOPSOIL		110.20 0.08						
		Very loose to loose dark brown to brown SANDY SILT, trace clay			1	SS	510	3		
1					2	SS	585	9	M	Soil moist at about 0.8 metres below ground surface
				108.76						Backfilled with soil cuttings
		Compact to very dense, grey brown silty sand, trace to some gravel with possible cobbles and boulders (GLACIAL TILL)		1.52	3	SS	560	18		
2					4	SS	280	>50 for 80 mm		
				107.38						
3		End of Borehole Auger refusal on inferred bedrock		2.90						
4										
5										

PENETRATION RESISTANCE (N), BLOWS/0.3m
DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED
WATER CONTENT, %: W_P — W — W_L
10 20 30 40 50 60 70 80 90

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

RECORD OF BOREHOLE 18-11

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m	SHEAR STRENGTH (Cu), kPA: NATURAL / REMOULDED; WATER CONTENT, % (W_P, W, W_L)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger, Hollow Stem Auger (210mm OD)	Ground Surface		110.87								
		Soil conditions not logged										Bentonite seal
1												Filter sand
2												51 mm diametre, 1.52 m long well screen
				108.08								
3		End of Borehole Auger refusal on inferred bedrock		2.79								
4												
5												

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
18/08/18	1.47 ▽	109.40

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

TP17-1	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.4	FILL - (GP) sandy GRAVEL; grey; non-cohesive, moist	SA-1 (0.3 m)
	0.4 – 2.0	(SP) SAND, some gravel; brown, contains cobbles; non-cohesive, moist to wet	SA-2 (1.5 m)
	2.0	End of test pit; groundwater seepage into test pit at 1.5 m, test pit caving	

TP17-2	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.5	FILL - (SP) gravelly SAND, some fines; grey; non-cohesive, moist	SA-1 (0.3 m)
	0.5 – 1.8	(SP) SAND, some gravel; brown; non-cohesive, moist	SA-2 (1.2 m)
	1.8 - 4.0	(SM) SILTY SAND; grey; non-cohesive, wet	SA-3 (3.0 m)
	4.0	End of test pit; no groundwater inflow noted	

TP17-4	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.1	(SM) SILTY SAND, some gravel; contains rootlets; non-cohesive	SA-1 (0.4 m)
	0.1 – 0.5	(ML) CLAYEY SILT, some sand, trace gravel; non-cohesive, moist	SA-2 (1.0 m)
	0.5 – 2.4	(SP) SAND, trace gravel; brown; non-cohesive, moist to wet	SA-3 (2.0 m)
	2.4	End of test pit; water at 1.7 m in test pit	

TP17-5	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.4	TOPSOIL - (SP) gravelly SAND, some fines; dark brown; non-cohesive	SA-1 (0.2 m)
	0.4 – 1.5	(SP) SAND, some fines, trace gravel; brown; non-cohesive, moist	SA-2 (1.0 m)
	1.5 – 2.0	(SM) SILTY SAND, some gravel; grey, contains cobbles (GLACIAL TILL); non-cohesive, moist	SA-3 (2.0 m)
	2.0	End of test pit; no groundwater inflow noted	

TP17-6	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.3	(SP) gravelly SAND, some fines; brown, contains organic matter; non-cohesive, moist	SA-1 (0.2 m)
	0.3 – 0.8	(SM) SILTY SAND, trace gravel; brown; non-cohesive, moist	SA-2 (0.7 m)
	0.8 – 2.0	(SM) SILTY SAND, some gravel; brown (GLACIAL TILL): non-cohesive, moist	SA-3 (1.6 m)
	2.0	End of test pit; no groundwater inflow noted	

TP17-7	Depth (m)	Description	Sample
	0.0 – 0.7	TOPSOIL - (SP) SAND, trace fines and gravel; dark	SA-1 (0.2 m)
25-Apr-17	0.7 - 1.4	FILL - (SP) SAND, some fines and gravel; brown, contains debris; non-cohesive, moist	SA-2 (1.2 m)
	1.4 - 2.8	(SM) SILTY SAND, some gravel; grey, contains cobbles (GLACIAL TILL); non-cohesive, moist	SA-3 (1.9 m)
	2.8	End of test pit; no groundwater inflow noted	

TP17-8	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.2	TOPSOIL - (SM) SILTY SAND, trace gravel; dark brown; non-cohesive, moist	SA-1 (0.1 m)
	0.2 - 2.0	(SM) SILTY SAND, some gravel; grey brown, contains cobbles (GLACIAL TILL); non-cohesive, moist	SA-2 (1.5 m)
	2.0	End of test pit; no groundwater inflow noted	

TP17-19	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.1	TOPSOIL - (SM) SILTY SAND, some gravel; non-cohesive	SA-1 (0.3 m)
	0.1 - 1.6	(SP) SAND, trace fines and gravel; brown; non-cohesive, moist	SA-2 (1.0 m)
	1.6 - 2.1	(SM) SILTY SAND, some gravel; brown, contains cobbles; non-cohesive, wet	SA-3 (2.0 m)
	2.1	End of test pit; groundwater seepage into test pit at 1.4 m, water level in pit at 2.0 m	

TP17-20	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.1	TOPSOIL - (SM) SILTY SAND, some gravel; dark brown; non-cohesive, moist	SA-1 (0.1 m)
	0.1 - 1.5	(SP-SM) SAND, some fines to SILTY, trace gravel; red brown; non-cohesive, moist to wet	SA-2 (1.0 m)
	1.5 - 2.0	(SM) SILTY SAND, some gravel; grey brown, contains cobbles (GLACIAL TILL); non-cohesive, moist	SA-2 (1.7 m)
	2.0	End of test pit; groundwater seepage into test pit at 1.4 m, water level in pit at 1.9 m	

TP17-21	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.5	TOPSOIL - (SM) SILTY SAND, some gravel; dark brown; non-cohesive, moist	SA-1 (0.1 m); SA2 (0.3 m)
	0.5 - 1.0	(CI/CH) SILTY CLAY to CLAY, trace to some sand; grey brown (WEATHERED CRUST); cohesive, w>PL	SA-3 (0.7 m)
	1.0 - 1.3	(SP) SAND, some fines, trace gravel; brown, non-cohesive, moist	SA-4 (1.1 m)
	1.3 - 2.8	(SM) SILTY SAND, some gravel; brown, contains cobbles; non-cohesive, moist to wet	SA-5 (1.7 m)
	2.8	End of test pit; groundwater seepage into test pit at 1.8 m, water level in pit at 2.7 m	

TP17-22	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.1	FILL/TOPSOIL - (SM) SILTY SAND, some gravel; brown; non-cohesive, moist	SA-1 (0.1 m)
	0.1 - 1.8	FILL - (SM) SILTY SAND, some gravel; brown, contains cobbles and boulders; non-cohesive, moist	SA-2 (1.0 m)
	1.8 - 2.4	(SM) SILTY SAND, some gravel; brown, contains cobbles; non-cohesive, moist	SA-3 (2.0 m); SA-4 (2.2 m)
	2.4	End of test pit; no groundwater inflow noted	

MW18-1	Depth (m)	Description	Ground Surface Elevation (m)
13-Aug-18	0.00 – 0.39	SAND, some gravel and cobbles; brown.	107.782

MW18-2	Depth (m)	Description	Ground Surface Elevation (m)
13-Aug-18	0.00 – 0.59	SAND, some gravel and cobbles; brown.	107.093

MW18-3	Depth (m)	Description	Ground Surface Elevation (m)
13-Aug-18	0.00 – 0.45	SAND, some gravel and cobbles; brown.	106.552

All monitoring wells were constructed using 19-mm PVC pipe. The wells were screened from the bottom of the well to approximately 8 cm below ground surface and sealed with bentonite between 8 cm below ground and ground surface.

APPENDIX C

Permits to Take Water 4005-B3GKCQ and 4753-B7NJXC

PERMIT TO TAKE WATER
Ground Water
NUMBER 4005-B3GKCQ

Pursuant to Section 34.1 of the Ontario Water Resources Act, R.S.O. 1990 this Permit To Take Water is hereby issued to:

1384341 Ontario Ltd.
9094 Cavanagh Rd Ashton
Ottawa, Ontario, K0A 1B0
Canada

For the water taking from: Pumping Test Wells TW5, TW6, and a House Well (approximately 20 metres from Huntley Creek) for future long-term ready-mix concrete production at the proposed Cavanagh Developments, Ready-mix Concrete Plant

Located at: 2596 Carp Rd
Ottawa

For the purposes of this Permit, and the terms and conditions specified below, the following definitions apply:

DEFINITIONS

(a) "Director" means any person appointed in writing as a Director pursuant to section 5 of the OWRA for the purposes of section 34.1, OWRA.

(b) "Provincial Officer" means any person designated in writing by the Minister as a Provincial Officer pursuant to section 5 of the OWRA.

(c) "Ministry" means Ontario Ministry of the Environment, Conservation and Parks.

(d) "District Office" means the Ottawa District Office.

(e) "Permit" means this Permit to Take Water No. 4005-B3GKCQ including its Schedules, if any, issued in accordance with Section 34.1 of the OWRA.

(f) "Permit Holder" means 1384341 Ontario Ltd..

(g) "OWRA " means the *Ontario Water Resources Act,* R.S.O. 1990, c. O. 40, as amended.

You are hereby notified that this Permit is issued subject to the terms and conditions outlined below:

TERMS AND CONDITIONS

1. Compliance with Permit

1.1 Except where modified by this Permit, the water taking shall be in accordance with the application for this Permit To Take Water, dated July 19, 2018 and signed by Jeff Cavanagh, and all Schedules included in this Permit.

1.2 The Permit Holder shall ensure that any person authorized by the Permit Holder to take water under this Permit is provided with a copy of this Permit and shall take all reasonable measures to ensure that any such person complies with the conditions of this Permit.

1.3 Any person authorized by the Permit Holder to take water under this Permit shall comply with the conditions of this Permit.

1.4 This Permit is not transferable to another person.

1.5 This Permit provides the Permit Holder with permission to take water in accordance with the conditions of this Permit, up to the date of the expiry of this Permit. This Permit does not constitute a legal right, vested or otherwise, to a water allocation, and the issuance of this Permit does not guarantee that, upon its expiry, it will be renewed.

1.6 The Permit Holder shall keep this Permit available at all times at or near the site of the taking, and shall produce this Permit immediately for inspection by a Provincial Officer upon his or her request.

1.7 The Permit Holder shall report any changes of address to the Director within thirty days of any such change. The Permit Holder shall report any change of ownership of the property for which this Permit is issued within thirty days of any such change. A change in ownership in the property shall cause this Permit to be cancelled.

2. General Conditions and Interpretation

2.1 Inspections

The Permit Holder must forthwith, upon presentation of credentials, permit a Provincial Officer to carry out any and all inspections authorized by the OWRA, the *Environmental Protection Act* , R.S.O. 1990, the *Pesticides Act* , R.S.O. 1990, or the *Safe Drinking Water Act,* S. O. 2002.

2.2 Other Approvals

The issuance of, and compliance with this Permit, does not:

(a) relieve the Permit Holder or any other person from any obligation to comply with any other applicable legal requirements, including the provisions of the *Ontario Water Resources Act* , and the *Environmental Protection Act* , and any regulations made thereunder; or

(b) limit in any way any authority of the Ministry, a Director, or a Provincial Officer, including the authority to require certain steps be taken or to require the Permit Holder to furnish any further information related to this Permit.

2.3 Information

The receipt of any information by the Ministry, the failure of the Ministry to take any action or require any person to take any action in relation to the information, or the failure of a Provincial Officer to prosecute any person in relation to the information, shall not be construed as:

(a) an approval, waiver or justification by the Ministry of any act or omission of any person that contravenes this Permit or other legal requirement; or

(b) acceptance by the Ministry of the information's completeness or accuracy.

2.4 Rights of Action

The issuance of, and compliance with this Permit shall not be construed as precluding or limiting any legal claims or rights of action that any person, including the Crown in right of Ontario or any agency thereof, has or may have against the Permit Holder, its officers, employees, agents, and contractors.

2.5 Severability

The requirements of this Permit are severable. If any requirements of this Permit, or the application of any requirements of this Permit to any circumstance, is held invalid or unenforceable, the application of such requirements to other circumstances and the remainder of this Permit shall not be affected thereby.

2.6 Conflicts

Where there is a conflict between a provision of any submitted document referred to in this Permit, including its Schedules, and the conditions of this Permit, the conditions in this Permit shall take precedence.

3. Water Takings Authorized by This Permit

3.1 **Expiry**

This Permit expires on **February 20, 2019**. No water shall be taken under authority of this Permit after the expiry date.

3.2 Amounts of Taking Permitted

The Permit Holder shall only take water from the source, during the periods and at the rates and amounts of taking specified in Table A. Water takings are authorized only for the purposes specified in Table A.

Table A

	Source Name / Description:	Source: Type:	Taking Specific Purpose:	Taking Major Category:	Max. Taken per Minute (litres):	Max. Num. of Hrs Taken per Day:	Max. Taken per Day (litres):	Max. Num. of Days Taken per Year:	Zone/ Easting/ Northing:
1	TW5	Well Drilled	Pumping Test	Miscellaneous	340	24	489,600	3	18 423975 5016711
2	TW6	Well Drilled	Pumping Test	Miscellaneous	340	24	489,600	3	18 424043 5016678
3	House Well	Well Drilled	Pumping Test	Miscellaneous	340	24	489,600	3	18 423888 5016774
						Total Taking:	489,600		

3.3 Purpose of Pumping Test

Water taken by the Permit Holder shall be used solely for the purpose of pumping tests in order to assess hydrogeological conditions.

4. Monitoring

4.1 Monitoring of Water Takings

The Permit Holder shall maintain a record of all water takings. This record shall include the dates and times of water takings, and the total measured amounts of water taken per day for each day that water is taken under the authorization of this Permit. A separate record shall be maintained for each source. The Permit Holder shall keep all required records up to date and available at or near the site of the taking and shall produce the records immediately for inspection by a Provincial Officer upon his or her request.

4.2 Type of Water Taking Measurement

The total amounts of water taken shall be measured using a calibrated flow meter and totalizer.

4.3 Area of Study

The Permit Holder shall contact all well owners within 500 metres of the test well(s) prior to commencing the pumping test and seek written permission to access their well(s).

4.4 Required Groundwater Pumping Test Results
Where written permission sought under Condition 4.3 has been obtained, the Permit Holder shall measure and record static water levels prior to the pumping test, pumping water levels at an appropriate frequency to allow for the calculation of aquifer conductivity and storativity values and water levels during the recovery period in the well(s) until 95% recovery occurs or for a period of time equal to the duration of the pumping test, whichever is less.

4.5 The Permit Holder shall monitor groundwater levels as described in Item #1 and Item #2, Schedule A of this Permit.

4.6 Water Interference Contingency Plan
Prior to commencing the pumping test, the Permit Holder shall develop a contingency plan to compensate other water users in the event that this water taking negatively impacts the area's water supply. The Permit Holder shall implement this contingency plan upon the validation of any water interference complaint and this plan shall remain in effect until the affected water supply recovers to a sustainable quality and quantity that may be considered usable for the normal use of the water.

5. Impacts of the Water Taking

5.1 Notification
The Permit Holder shall immediately notify the local District Office of any complaint arising from the taking of water authorized under this Permit and shall report any action which has been taken or is proposed with regard to such complaint. The Permit Holder shall immediately notify the local District Office if the taking of water is observed to have any significant impact on the surrounding waters. After hours, calls shall be directed to the Ministry's Spills Action Centre at 1-800-268-6060.

5.2 For Groundwater Takings
If the taking of water is observed to cause any negative impact to other water supplies obtained from any adequate sources that were in use prior to initial issuance of a Permit for this water taking, the Permit Holder shall take such action necessary to make available to those affected, a supply of water equivalent in quantity and quality to their normal takings, or shall compensate such persons for their reasonable costs of so doing, or shall reduce the rate and amount of taking to prevent or alleviate the observed negative impact. Pending permanent restoration of the affected supplies, the Permit Holder shall provide, to those affected, temporary water supplies adequate to meet their normal requirements, or shall compensate such persons for their reasonable costs of doing so.

If permanent interference is caused by the water taking, the Permit Holder shall restore the water supplies of those permanently affected.

5.3 Notification of the Director

The Permit Holder must immediately report to the Director all groundwater and surface water interference and surface water discharge impacts and adverse effects associated with the pumping test.

5.4 Prevention of Damage To Structures
The Permit Holder shall take all measures necessary to prevent damage to buildings, structures, roads and/or railway lines that may be impacted by this taking.

5.5 Discharge of Water Taken
The discharge of water shall be controlled in such a way as to avoid erosion and sedimentation in the receiving stream.

5.6 The Permit Holder shall ensure that any water discharged to the natural environment does not result in scouring, erosion or physical alteration of stream channels or banks and that there is no flooding in the receiving area or water body, downstream water bodies, ditches or properties caused or worsened by this discharge.

5.7 Any discharge to the land surface shall use a multi-barrier approach to control erosion and run-off and the discharge shall be to a well vegetated area to promote infiltration prior to entering Huntley Creek or any other watercourse.

5.8 The Permit Holder shall not discharge turbid water to any watercourse. Turbid water shall be defined as any discharge water or diverted water with a maximum increase of 8 NTUs above the receiving stream's background levels.

5.9 Siltation control measures shall be installed at the discharge site(s) and shall be sufficient to control the volumes. Continuous care shall be taken to properly maintain the siltation control devices.

6. Director May Amend Permit
The Director may amend this Permit by letter requiring the Permit Holder to suspend or reduce the taking to an amount or threshold specified by the Director in the letter. The suspension or reduction in taking shall be effective immediately and may be revoked at any time upon notification by the Director. This condition does not affect your right to appeal the suspension or reduction in taking to the Environmental Review Tribunal under the *Ontario Water Resources Act* , Section 100 (4).

The reasons for the imposition of these terms and conditions are as follows:

1. Condition 1 is included to ensure that the conditions in this Permit are complied with and can be enforced.

2. Condition 2 is included to clarify the legal interpretation of aspects of this Permit.

3. Conditions 3 through 6 are included to protect the quality of the natural environment so as to safeguard the ecosystem and human health and foster efficient use and conservation of waters. These conditions allow for the beneficial use of waters while ensuring the fair sharing,

conservation and sustainable use of the waters of Ontario. The conditions also specify the water takings that are authorized by this Permit and the scope of this Permit.

*In accordance with Section 100 of the Ontario Water Resources Act, R.S.O. 1990, you may by written notice served upon me, the Environmental Review Tribunal and the Environmental Commissioner, **Environmental Bill of Rights**, R.S.O. 1993, Chapter 28, within 15 days after receipt of this Notice, require a hearing by the Tribunal. The Environmental Commissioner will place notice of your appeal on the Environmental Registry. Section 101 of the Ontario Water Resources Act, as amended provides that the Notice requiring a hearing shall state:*

1. The portions of the Permit or each term or condition in the Permit in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

In addition to these legal requirements, the Notice should also include:

a. The name of the appellant;
b. The address of the appellant;
c. The Permit to Take Water number;
d. The date of the Permit to Take Water;
e. The name of the Director;
f. The municipality within which the works are located;

This notice must be served upon:

The Secretary
Environmental Review Tribunal
655 Bay Street, 15th Floor
Toronto ON
M5G 1E5
Fax: (416) 326-5370
Email:
ERTTribunalsecretary@ontario.ca

AND

The Environmental Commissioner
1075 Bay Street
6th Floor, Suite 605
Toronto, Ontario M5S 2W5

AND

The Director, Section 34.1,
Ministry of the Environment,
Conservation and Parks
1259 Gardiners Rd, PO Box 22032
Kingston, ON
K7P 3J6

Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal:

by Telephone at	by Fax at	by e-mail at
(416) 212-6349	(416) 326-5370	www.ert.gov.on.ca
Toll Free 1(866) 448-2248	Toll Free 1(844) 213-3474	

*This instrument is subject to Section 38 of the **Environmental Bill of Rights** that allows residents of Ontario to seek leave to appeal the decision on this instrument. Residents of Ontario may seek to appeal for 15 days from the date this decision is placed on the Environmental Registry. By accessing the Environmental Registry, you can determine when the leave to appeal period ends.*

Dated at Kingston this 16th day of August, 2018.

Peter Taylor

Peter Taylor
Director, Section 34.1

Ontario Water Resources Act , R.S.O. 1990

Schedule A

This Schedule “A” forms part of Permit To Take Water 4005-B3GKCQ, dated August 16, 2018.

Item #1

Section 2.6.5, Proposed Monitoring Program, of the report titled "Category 2 Permit To Take Water Application Proposed Cavanagh Ready-Mix Concrete Plant, Ottawa, Ontario", signed and stamped by Loren Bekeris, M.Sc., P.Eng., and signed by Kris Marentette, M.Sc., P.Geo., on July 20, 2018.

Item #2

Figure 1, Site Plan, Rev. A, dated July 16, 2018, of the report titled "Category 2 Permit To Take Water Application Proposed Cavanagh Ready-Mix Concrete Plant, Ottawa, Ontario", signed and stamped by Loren Bekeris, M.Sc., P.Eng., and signed by Kris Marentette, M.Sc., P.Geo., on July 20, 2018.

PERMIT TO TAKE WATER
Ground Water
NUMBER 4753-B7NJXC

Pursuant to Section 34.1 of the Ontario Water Resources Act, R.S.O. 1990 this Permit To Take Water is hereby issued to:

Cavanagh Concrete Ltd.
9094 Cavanagh Road
Ashton, Ontario K0A 1B0
Canada

For the water taking from: Wells TW5 and TW6

Located at: 2596 Carp Rd
Ottawa

For the purposes of this Permit, and the terms and conditions specified below, the following definitions apply:

DEFINITIONS

(a) "Director" means any person appointed in writing as a Director pursuant to section 5 of the OWRA for the purposes of section 34.1, OWRA.

(b) "Provincial Officer" means any person designated in writing by the Minister as a Provincial Officer pursuant to section 5 of the OWRA.

(c) "Ministry" means Ontario Ministry of the Environment, Conservation and Parks.

(d) "District Office" means the Ottawa District Office.

(e) "Permit" means this Permit to Take Water No. 4753-B7NJXC including its Schedules, if any, issued in accordance with Section 34.1 of the OWRA.

(f) "Permit Holder" means Cavanagh Concrete Ltd..

(g) "OWRA " means the *Ontario Water Resources Act*, R.S.O. 1990, c. O. 40, as amended.

You are hereby notified that this Permit is issued subject to the terms and conditions outlined below:

TERMS AND CONDITIONS

1. Compliance with Permit

1.1 Except where modified by this Permit, the water taking shall be in accordance with the application for this Permit To Take Water, dated November 2, 2018 and signed by Jeff Cavanagh, and all Schedules included in this Permit.

1.2 The Permit Holder shall ensure that any person authorized by the Permit Holder to take water under this Permit is provided with a copy of this Permit and shall take all reasonable measures to ensure that any such person complies with the conditions of this Permit.

1.3 Any person authorized by the Permit Holder to take water under this Permit shall comply with the conditions of this Permit.

1.4 This Permit is not transferable to another person.

1.5 This Permit provides the Permit Holder with permission to take water in accordance with the conditions of this Permit, up to the date of the expiry of this Permit. This Permit does not constitute a legal right, vested or otherwise, to a water allocation, and the issuance of this Permit does not guarantee that, upon its expiry, it will be renewed.

1.6 The Permit Holder shall keep this Permit available at all times at or near the site of the taking, and shall produce this Permit immediately for inspection by a Provincial Officer upon his or her request.

1.7 The Permit Holder shall report any changes of address to the Director within thirty days of any such change. The Permit Holder shall report any change of ownership of the property for which this Permit is issued within thirty days of any such change. A change in ownership in the property shall cause this Permit to be cancelled.

2. General Conditions and Interpretation

2.1 Inspections

The Permit Holder must forthwith, upon presentation of credentials, permit a Provincial Officer to carry out any and all inspections authorized by the OWRA, the *Environmental Protection Act* , R.S.O. 1990, the *Pesticides Act* , R.S.O. 1990, or the *Safe Drinking Water Act*, S. O. 2002.

2.2 Other Approvals

The issuance of, and compliance with this Permit, does not:

(a) relieve the Permit Holder or any other person from any obligation to comply with any other applicable legal requirements, including the provisions of the *Ontario Water Resources Act* , and the *Environmental Protection Act* , and any regulations made thereunder; or

(b) limit in any way any authority of the Ministry, a Director, or a Provincial Officer, including the authority to require certain steps be taken or to require the Permit Holder to furnish any further information related to this Permit.

2.3 Information

The receipt of any information by the Ministry, the failure of the Ministry to take any action or require any person to take any action in relation to the information, or the failure of a Provincial Officer to prosecute any person in relation to the information, shall not be construed as:

(a) an approval, waiver or justification by the Ministry of any act or omission of any person that contravenes this Permit or other legal requirement; or

(b) acceptance by the Ministry of the information's completeness or accuracy.

2.4 Rights of Action

The issuance of, and compliance with this Permit shall not be construed as precluding or limiting any legal claims or rights of action that any person, including the Crown in right of Ontario or any agency thereof, has or may have against the Permit Holder, its officers, employees, agents, and contractors.

2.5 Severability

The requirements of this Permit are severable. If any requirements of this Permit, or the application of any requirements of this Permit to any circumstance, is held invalid or unenforceable, the application of such requirements to other circumstances and the remainder of this Permit shall not be affected thereby.

2.6 Conflicts

Where there is a conflict between a provision of any submitted document referred to in this Permit, including its Schedules, and the conditions of this Permit, the conditions in this Permit shall take precedence.

3. Water Takings Authorized by This Permit

3.1 **Expiry**

This Permit expires on **December 18, 2028**. No water shall be taken under authority of this Permit after the expiry date.

3.2 Amounts of Taking Permitted

The Permit Holder shall only take water from the source, during the periods and at the rates and amounts of taking specified in Table A. Water takings are authorized only for the purposes specified in Table A.

Table A

	Source Name / Description:	Source: Type:	Taking Specific Purpose:	Taking Major Category:	Max. Taken per Minute (litres):	Max. Num. of Hrs Taken per Day:	Max. Taken per Day (litres):	Max. Num. of Days Taken per Year:	Zone/ Easting/ Northing:
1	TW5	Well Drilled	Manufacturing	Industrial	340	12	245,000	365	18 423975 5016711
2	TW6	Well Drilled	Manufacturing	Industrial	340	12	245,000	365	18 424043 5016678
						Total Taking:	245,000		

3.3 Water taken from wells TW5 and TW6 shall be used for concrete production and equipment washing. The total combined daily water taking from TW5 and TW6 shall not exceed 245,000 litres.

3.4 Water may be taken from the House Well for the purpose of an administration building water supply. Water from the House Well shall not be used for concrete production or equipment washing.

4. Monitoring

4.1 The Permit Holder shall maintain a record of all water takings from wells TW5 and TW6. This record shall include the dates and times of water takings and the total measured amounts of water pumped per day for each day that water is taken under the authorization of this Permit. A separate record shall be maintained for each source. The Permit Holder shall keep all required records up to date and available at or near the site of the taking and shall produce the records immediately for inspection by a Provincial Officer upon his or her request.

4.2 The total amounts of water pumped from wells TW5 and TW6 shall be measured using a calibrated flow meter and totalizer.

4.3 The proposed monitoring program specified in Schedule A shall be undertaken. If changes to this monitoring program are desired, an application for an amendment to this Permit To Take Water shall be submitted. Any application submitted to the Ministry for renewal or amendment of this Permit shall be accompanied by all records required by the conditions of this Permit.

5. Impacts of the Water Taking

5.1 Notification

The Permit Holder shall immediately notify the local District Office of any complaint arising from the taking of water authorized under this Permit and shall report any action which has been taken or is proposed with regard to such complaint. The Permit Holder shall immediately notify the local District Office if the taking of water is observed to have any significant impact on the surrounding waters. After hours, calls shall be directed to the Ministry's Spills Action Centre at 1-800-268-6060.

5.2 For Groundwater Takings

If the taking of water is observed to cause any negative impact to other water supplies obtained from any adequate sources that were in use prior to initial issuance of a Permit for this water taking, the Permit Holder shall take such action necessary to make available to those affected, a supply of water equivalent in quantity and quality to their normal takings, or shall compensate such persons for their reasonable costs of so doing, or shall reduce the rate and amount of taking to prevent or alleviate the observed negative impact. Pending permanent restoration of the affected supplies, the Permit Holder shall provide, to those affected, temporary water supplies adequate to meet their normal requirements, or shall compensate such persons for their reasonable costs of doing so.

If permanent interference is caused by the water taking, the Permit Holder shall restore the water supplies of those permanently affected.

6. Director May Amend Permit

The Director may amend this Permit by letter requiring the Permit Holder to suspend or reduce the taking to an amount or threshold specified by the Director in the letter. The suspension or reduction in taking shall be effective immediately and may be revoked at any time upon notification by the Director. This condition does not affect your right to appeal the suspension or reduction in taking to the Environmental Review Tribunal under the *Ontario Water Resources Act* , Section 100 (4).

The reasons for the imposition of these terms and conditions are as follows:

1. Condition 1 is included to ensure that the conditions in this Permit are complied with and can be enforced.

2. Condition 2 is included to clarify the legal interpretation of aspects of this Permit.

3. Conditions 3 through 6 are included to protect the quality of the natural environment so as to safeguard the ecosystem and human health and foster efficient use and conservation of waters. These conditions allow for the beneficial use of waters while ensuring the fair sharing, conservation and sustainable use of the waters of Ontario. The conditions also specify the water takings that are authorized by this Permit and the scope of this Permit.

*In accordance with Section 100 of the Ontario Water Resources Act, R.S.O. 1990, you may by written notice served upon me, the Environmental Review Tribunal and the Environmental Commissioner, **Environmental Bill of Rights**, R.S.O. 1993, Chapter 28, within 15 days after receipt of this Notice, require a hearing by the Tribunal. The Environmental Commissioner will place notice of your appeal on the Environmental Registry. Section 101 of the Ontario Water Resources Act, as amended provides that the Notice requiring a hearing shall state:*

1. The portions of the Permit or each term or condition in the Permit in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

In addition to these legal requirements, the Notice should also include:

a. The name of the appellant;
b. The address of the appellant;
c. The Permit to Take Water number;
d. The date of the Permit to Take Water;
e. The name of the Director;
f. The municipality within which the works are located;

This notice must be served upon:

The Secretary
Environmental Review Tribunal
655 Bay Street, 15th Floor
Toronto ON
M5G 1E5
Fax: (416) 326-5370
Email:
ERTTribunalsecretary@ontario.ca

AND

The Environmental Commissioner
1075 Bay Street
6th Floor, Suite 605
Toronto, Ontario M5S 2W5

AND

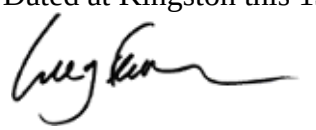
The Director, Section 34.1,
Ministry of the Environment,
Conservation and Parks
1259 Gardiners Rd, PO Box 22032
Kingston, ON
K7P 3J6

Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal:

by Telephone at	by Fax at	by e-mail at
(416) 212-6349	(416) 326-5370	www.ert.gov.on.ca
Toll Free 1(866) 448-2248	Toll Free 1(844) 213-3474	

*This instrument is subject to Section 38 of the **Environmental Bill of Rights** that allows residents of Ontario to seek leave to appeal the decision on this instrument. Residents of Ontario may seek to appeal for 15 days from the date this decision is placed on the Environmental Registry. By accessing the Environmental Registry, you can determine when the leave to appeal period ends.*

Dated at Kingston this 13th day of February, 2019.



Greg Faaren
Director, Section 34.1

Ontario Water Resources Act , R.S.O. 1990

Schedule A

This Schedule “A” forms part of Permit To Take Water 4753-B7NJXC, dated February 13, 2019.

Section 8.0 of the report entitled "Technical Study in Support of a Category 3 Permit To Take Water Application, Carp Road Concrete Plant, Ottawa, Ontario" completed by Golder Associates Ltd. and dated November 2018

- Petroleum hydrocarbon (PHC) Fraction F1 and PHC F2 and total xylene concentrations in soil exceeded the MECP Table 8 Standard at one location near the commercial enterprise north of Huntley Creek, approximately 140 metres from the proposed concrete plant site (see Figure 6). In addition, ethylbenzene, PHC F2, 1-methylnaphtalene, 2-methylnaphtalene, and methylnaphtalene, 2-(1-) in groundwater exceeded the MECP Table 8 Standard in the same area (see Figure 7). These exceedances may be due to a past petroleum hydrocarbon spill in that area.

The APECs and locations where soil and groundwater impacts were identified are not located within the proposed concrete plant site; however, they are located within the predicted zone of bedrock groundwater level lowering due to pumping at TW5, TW6 and the House Well.

The soil exceedances for molybdenum and cadmium were detected in fill samples collected above the water table; therefore, they are not considered to present a risk of groundwater contamination mobilization. With respect to the cobalt exceedance in groundwater at the southwest end of the Site, it is considered a very localized potential impact to groundwater quality. Soil and groundwater was sampled at four locations in that area of the Site, and the groundwater cobalt concentration at one location was the only exceedance. Therefore, the potential for mobilization of contamination in that area of the Site is considered minimal.

At the commercial enterprise north of Huntley Creek (approximately 70 metres west of the House Well and 180 metres west of TW5), soil impacts included PHC F1 and F2 and total xylenes. Groundwater impacts included ethylbenzene, PHC F2, some polycyclic aromatic hydrocarbons (PAHs) and cobalt. The monitoring well at this location was screened in the glacial till at a depth of 2.1 to 3.7 metres bgs. As previously described, the shallow groundwater flow at the Site is interpreted to be primarily horizontal toward Huntley Creek. It is not anticipated that the bedrock aquifer would have been impacted by the elevated concentrations of these parameters in the shallow groundwater. During the pumping test at the House Well, a discharge sample was collected after six hours of pumping and analyzed for PHC F1 to F4, benzene, toluene, ethylbenzene and xylenes (BTEX) and PAHS, all of which had non-detectable concentrations. Based on this information, it is interpreted that the groundwater contamination in the overburden across the creek from the proposed concrete plant would not be mobilized by pumping from the bedrock at the House Well, TW5 or TW6.

7.5 Potential Impacts to Structures

There are no deposits of sensitive clays identified within the zone of influence for the water taking from TW5 and TW6. Therefore, no impacts to structures are anticipated.

8.0 PROPOSED MONITORING PROGRAM

Based on the results of the impact assessment, the potential for impacting surrounding water supply wells, surface water features, areas of groundwater contamination and areas of sensitive soils is considered low. Nonetheless, a groundwater level monitoring program is recommended to confirm that the extent of groundwater level drawdown in the bedrock does not differ significantly from the magnitude presented in this assessment.

The proposed monitoring locations, rationale for their inclusion and monitoring frequency are presented in the table below.

Monitoring Point	Location	Rationale	Frequency
TW1	West of concrete plant site	Bedrock well to confirm that receptors west of the Site will not be adversely impacted.	Monthly Manual Water Level Measurements
TW2	Southern border of concrete plant site	Bedrock well to confirm that receptors south of the Site will not be adversely impacted.	
MW15-5	East of concrete plant site	Overburden well (no bedrock well available) to confirm that receptors east of the Site will not be adversely impacted.	

It is proposed to carry out the monthly groundwater level monitoring program for a period of two years following the start of water taking at the Site, after which the need for continued monitoring will be assessed. If the monitoring program indicates that groundwater pumping at the Site has not caused groundwater level lowering to a degree that would adversely affect the nearby receptors, a reduction in the monitoring program may be proposed.

9.0 CONCLUSIONS

The following conclusions are provided based on the aquifer testing program and impact assessment associated with the proposed water taking from the two concrete plant supply wells and the additional well at the administration building:

a) Pumping tests carried out at test wells TW5 and TW6 suggest that both wells can provide at least 340 L/min for concrete production, which represents a higher taking than the anticipated average pumping rate of 283 L/min for 12 hours/day and is equal to the anticipated maximum pumping rate of 340 L/min. The pumping test carried out at the House Well indicates that the well can provide at least 18 L/min, which is greater than the anticipated water use at the future administration building of 75 L/day/employee (or 2,700 L/day).

b) The predicted 1-metre groundwater level lowering radius of influence extends approximately 30 metres from the pumping locations.

c) The shallow groundwater levels in the vicinity of Huntley Creek did not respond to pumping at TW5, TW6 and the House Well. Based on these results, it is not anticipated that the water taking for the operation of the concrete plant will adversely impact shallow groundwater levels or surface water level in the vicinity of Huntley Creek.

d) The predicted drawdown at the nearest off-Site water supply well would be expected to be approximately 0.7 metres, which is acceptable with respect to the anticipated total drawdown available to the well. Interference with existing water supply wells as a result of the proposed water taking at the Site is not predicted.

e) It is interpreted that the groundwater contamination in the overburden across the creek from the proposed concrete plant would not be mobilized by pumping from the bedrock at the House Well, TW5 or TW6.

f) There are no deposits of sensitive clays identified within the zone of influence for the water taking from TW5 and TW6. Therefore, no impacts to structures are anticipated.

g) Although the potential is considered low for impacts to surrounding water supply wells, surface water features, areas of groundwater contamination and areas of sensitive soils, a groundwater level monitoring program is recommended to confirm that the extent of groundwater level drawdown in the bedrock does not differ significantly from the magnitude presented in this assessment.

APPENDIX D

Water Well Records for TW1, TW2, TW4, TW5 and TW6

TW1

Ontario — Ministry of the Environment and Climate Change

Tag#: A229217 (Print Below)

A229217

Well Record

Regulation 903 Ontario Water Resources Act

Measurements recorded in: ☐ Metric ☒ Imperial

Page ___ of ___

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	
	1384341 Ontario Limited (c/o Cavanagh Const)		☐ Well Constructed by Well Owner

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
9094 Cavanagh Road	Ashton	On	K0A 1B0	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
2596 Carp Road	West Carleton	P/L 6	2

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

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	18	423630	5016497	RP 4R-11656	Part 1

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 (mft) From	Depth (mft) To
	Sand & Gravel	& Stones		0'	24'
Grey	Limestone			24'	97'
Grey	Sandstone	w/ Grey Limestone	MIX	97'	179'
Grey	Sandstone	w/ Grey Limestone	MIX	179'	200'
Grey	Sandstone	w/ Grey Limestone	MIX	200'	260'
Grey	Sandstone	w/ Grey Limestone	MIX	260'	300'

* TEST WELL # 1 OF 4 *

Annular Space

Depth Set at (mft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (mft³)
30	0	Neat cement	12.5

Method of Construction

☐ Cable Tool ☐ Diamond ☐ Rotary (Conventional) ☐ Jetting ☐ Rotary (Reverse) ☐ Driving ☐ Boring ☐ Digging ☒ Air percussion ☐ Other, specify

Well Use

☐ Public ☐ Commercial ☐ Not used ☒ Domestic ☐ Municipal ☐ Dewatering ☐ Livestock ☐ 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 (mft) From	Depth (mft) To
6¼"	Steel	.188"	+2'	30'
6"	Open Hole		30'	300'

Status of Well

☒ 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

Construction Record - Screen

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

Water Details

Water found at Depth (mft)	Kind of Water	Hole Diameter Depth (mft) From	To	Diameter (cm/in)
179	☐ Fresh ☒ Untested ☐ Gas ☐ Other, specify	0'	30'	9¾"
260	☐ Fresh ☒ Untested ☐ Gas ☐ Other, specify	30'	300'	6"
	☐ Fresh ☐ Untested ☐ Gas ☐ Other, specify			

Results of Well Yield Testing

After test of well yield, water was: ☐ Clear and sand free ☐ Other, specify **Not tested**

If pumping discontinued, give reason: X

Pump intake set at (mft): 250

Pumping rate (l/min / GPM): 3

Duration of pumping: 1 hrs + 0 min

Final water level end of pumping (mft): 119.9'

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

Recommended pump depth (mft): 290'

Recommended pump rate (l/min / GPM): 3

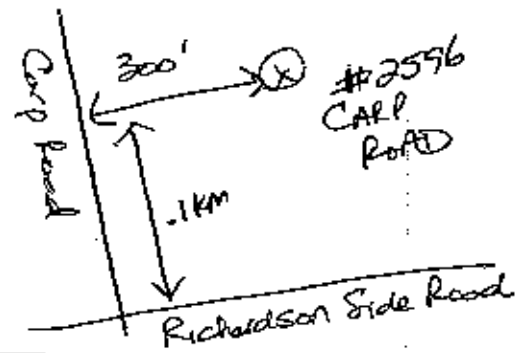
Well production (l/min / GPM): 3

Disinfected? ☒ Yes ☐ No

Draw Down Time (min)	Water Level (mft)	Recovery Time (min)	Water Level (mft)
Static Level	11'2"		119.9'
1	15.3	1	113.3
2	17.9	2	111.2
3	20.2	3	109.6
4	22.8	4	107.9
5	24.7	5	106.4
10	34.5	10	98.3
15	42.7	15	90.8
20	52.1	20	83
25	61.7	25	75.4
30	71.1	30	68
40	88.7	40	53.7
50	105.5	50	39.8
60	119.9	60	25'1"

Map of Well Location

Please provide a map below following instructions on the back.



Comments: 3/4HR 5GPM @ 290'

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Air Rock Drilling Co. Ltd.	1119

Business Address (Street Number/Name)	Municipality
6659 Frankford Road, RR#1	Richmond

Province	Postal Code	Business E-mail Address
ON	K0A 2Z0	air-rock@sympatico.ca

Business Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)
6138392170	Hanna, Jeremy

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
13652		2017 06 30 (Y Y Y Y M M D D)

Well owner's information package delivered	Date Package Delivered	Date Work Completed
☒ Yes ☐ No	2017 06 30	2017 06 27

Ministry Use Only

Audit No. Z237480

Received

0506E (2014/11)

Ministry's Copy

TW2

Ontario — Ministry of the Environment and Climate Change

Measurements recorded in: ☐ Metric ☒ Imperial

W Tag#: A 229219 (Below)

#229219

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
	1394341 Ontario Limited (c/o Cavanagh Const)		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
9094 Cavanagh Road	Ashton	On	K0A 1B0	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
2596 Carp Road	West Carleton	P/L 6	2

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

UTM Coordinates Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 8 3	18 423966	5016596	RP 4R-1165	Part 1

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	To
	Sand			0'	8'
Grey	Limestone			8'	52'
Grey	Sandstone	w/ Grey Limestone MIX		52'	130'
Grey	Limestone			130'	191'
Grey	Limestone			191'	250'
Grey	Limestone			250'	300'

TEST WELL 2 OF 4

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m³/ft³)
20'	0'	Neat cement	10.9

Method of Construction

☐ Cable Tool ☐ Diamond ☐ Rotary (Conventional) ☐ Jetting ☐ Rotary (Reverse) ☐ Driving ☐ Boring ☐ Digging ☒ Air percussion ☐ Other, specify

Well Use

☐ Public ☒ Domestic ☐ Livestock ☐ Irrigation ☐ Industrial ☐ Other, specify ☐ Commercial ☐ Municipal ☐ Test Hole ☐ Cooling & Air Conditioning ☐ Not used ☐ Dewatering ☐ Monitoring

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
6 1/4"	Steel	.188"	+2'	20'
6"	Open Hole		20'	300'

Status of Well

☒ 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

Construction Record - Screen

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

Water Details

Water found at Depth (m/ft)	Kind of Water	Gas	Other, specify
191	☐ Fresh ☒ Untested	☐	
250	☐ Fresh ☒ Untested	☐	
(m/ft)	☐ Fresh ☐ Untested	☐	

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0'	20'	9 3/4"
20'	300'	6"

Results of Well Yield Testing

After test of well yield, water was: ☐ Clear and sand free ☐ Other, specify — Mottested

If pumping discontinued, give reason: X

Pump intake set at (m/ft): 250

Pumping rate (l/min / GPM): 5

Duration of pumping: 1 hr + 0 min

Final water level end of pumping (m/ft): 49'9"

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

Recommended pump depth (m/ft): 290'

Recommended pump rate (l/min / GPM): 5

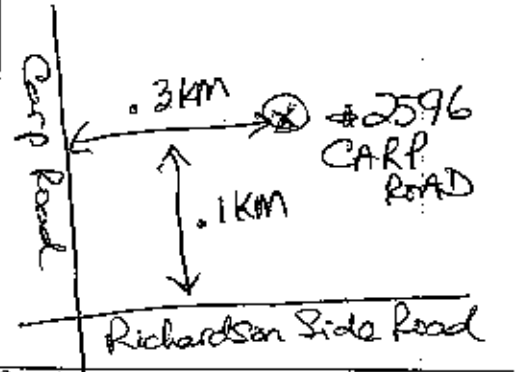
Well production (l/min / GPM): 5

Disinfected? ☒ Yes ☐ No

Draw Down Time (min)	Water Level (m/ft)	Recovery Time (min)	Water Level (m/ft)
Static Level	8'6"		49'8"
1	12.2	1	44
2	14.3	2	42
3	16.1	3	40.1
4	17.8	4	38.5
5	19.2	5	36.8
10	25.6	10	31.1
15	30.5	15	26.5
20	34.3	20	23.1
25	37.1	25	20.8
30	38.7	30	19.1
40	44.1	40	18.7
50	47.3	50	14.3
60	49'6"	60	12'8"

Map of Well Location

Please provide a map below following instructions on the back.



Comments: 3/4HP-5GPM@290'

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Air Rock Drilling Co. Ltd.	1119

Business Address (Street Number/Name)	Municipality	Province	Postal Code	Business E-mail Address
6859 Franktown Road, RR#1	Richmond	ON	K0A 2Z0	air-rock@sympatico.ca

Bus. Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)	Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
6138382170	Hanna, Jeremy	T3632		2017/08/30

Well owner's information package delivered: ☒ Yes ☐ No

Date Package Delivered: 2017/08/30

Date Work Completed: 2017/08/27

Ministry Use Only

Audit No. Z237481

Received

0502E (2014/12)

Ministry's Copy

TW4

Ontario — Ministry of the Environment and Climate Change

Tag#: A207595 (Below) — A207595

Well Record

Regulation 903 Ontario Water Resources Act

Page ____ of ____

Measurements recorded in: ☐ Metric ☒ Imperial

Well Owner's Information

First Name | Last Name / Organization: 1384341 Ontario Limited (c/o Cavanagh Const) | E-mail Address | ☐ Well Constructed by Well Owner

Mailing Address (Street Number/Name): 9094 Cavanagh Road | Municipality: Ashton | Province: On | Postal Code: K0A 1B0 | Telephone No. (incl. area code)

Well Location

Address of Well Location (Street Number/Name): 2115 Richardson Side Road | Township: West Carleton | Lot: 6 | Concession: 2

County/District/Municipality: Ottawa Carleton | City/Town/Village: Carp | Province: Ontario | Postal Code

UTM Coordinates: NAD 8 3 | Zone: 18 | Easting: 424183 | Northing: 5016364 | Municipal Plan and Sublot Number | Other: Test Well 4 of 4

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 (mBGL) From	To
	Boulders	& Hard Pan		0'	12'
	Sand & Gravel			12'	20'
Grey	Limestone			20'	50'
Grey	Limestone			50'	57'
Grey	Limestone			57'	113'
Grey	Limestone			113'	121'

* TEST WELL # 4 of 4 *

Annular Space

Depth Set at (mBGL) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m³)
26'	18'	Neat cement	10.9
18'	0'	Bentonite Slurry	8.4

Method of Construction

☐ Cable Tool ☐ Diamond ☐ Rotary (Conventional) ☐ Jetting ☐ Rotary (Reverse) ☐ Driving ☐ Boring ☐ Digging ☒ Air percussion ☐ Other, specify

Well Use

☐ Public ☐ Commercial ☐ Not used ☒ Domestic ☐ Municipal ☐ Dewatering ☐ Livestock ☐ Test Hole ☐ Monitoring ☐ Irrigation ☐ Cooling & Air Conditioning ☐ Industrial ☐ Other, specify

Construction Record - Casing

Inside Diameter (cm/mm)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/mm)	Depth (mBGL) From	To
6¼"	Steel	.188"	+2'	26'
6 1/8"	Open Hole		26'	121'

Status of Well

☒ 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

Construction Record - Screen

Outside Diameter (cm/mm)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (mBGL) From	To

Water Details

Water found at Depth	Kind of Water	Hole Diameter Depth (mBGL) From	To	Diameter (cm/mm)
50 (mBGL) ☐ Gas	☐ Fresh ☐ Untested ☐ Other, specify	0'	26'	9¾"
57 (mBGL) ☐ Gas	Water found at Depth ☐ Fresh ☐ Untested ☐ Other, specify	26'	121'	6⅛"
113 (mBGL) ☐ Gas	Water found at Depth ☐ Fresh ☐ Untested ☐ Other, specify			

Results of Well Yield Testing

After test of well yield, water was: ☐ Clear and sand free ☐ Other, specify Not tested

If pumping discontinued, give reason: X

Pump intake set at (mBGL): 100

Pumping rate (l/min / GPM): 20

Duration of pumping: 1 hrs + 0 min

Final water level end of pumping (mBGL): 79.5'

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

Recommended pump depth (mBGL): 100

Recommended pump rate (l/min / GPM): 20

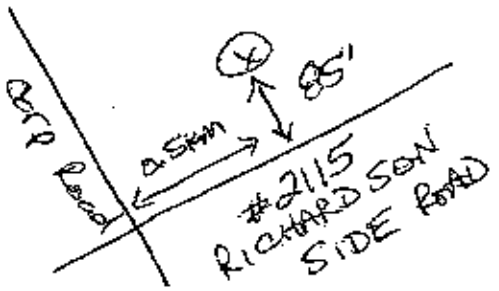
Well production (l/min / GPM): 20

Disinfected? ☒ Yes ☐ No

Draw Down Time (min)	Water Level (mBGL)	Recovery Time (min)	Water Level (mBGL)
Static Level	10.0		11.5'
1	15.9'	1	57.0
2	19.1	2	41.2
3	22.3	3	43.0
4	24.6	4	39.4
5	26.8	5	36.9
10	35'	10	28.4
15	40.5	15	23.3
20	44.6	20	19.7
25	47.7	25	14.4
30	50.0	30	10.0
40	58.8	40	10.0
50	62.9	50	10.0
60	79.5	60	10.0

Map of Well Location

Please provide a map below following instructions on the back.



Comments: 1/2 HP - 10 GPM SET @ 110 FT

Well Contractor and Well Technician Information

Business Name of Well Contractor: Air Rock Drilling Co. Ltd. | Well Contractor's Licence No.: 1119

Business Address (Street Number/Name): 6268 Franktown Road, RR#1 | Municipality: Richmond

Province: ON | Postal Code: K0A 2Z0 | Business E-mail Address: air-rock@sympatico.ca

Business Telephone No. (incl. area code): 6135832170 | Name of Well Technician (Last Name, First Name): Hanna, Jeremy

Well Technician's Licence No.: 15632 | Signature of Technician and/or Contractor | Date Submitted: 2017 05 31

Well owner's information package delivered: ☒ Yes ☐ No

Date Package Delivered: 2017 05 12

Date Work Completed: 2017 05 11

Ministry Use Only: Audit No. 2237402 | Received

0506E (2014/11)

Ministry's Copy

TW5

Ontario — Ministry of the Environment and Climate Change

Measurements recorded in: ☐ Metric ☒ Imperial

Well Tag#: A240646 (ow)

A240646

Well Record

Regulation 903 Ontario Water Resources Act

Page ____ of ____

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed ☐ Well Owner
1384341	ONTARIO LIMITED	(9o Colonagh Cons	

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
9094 Colonagh Road	Ashton	Ont	K0A1B0	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
#2596 CARP ROAD	West Carleton PT	L6	2

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

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	18	423975	5016711	RP 4R-1165 Part 1	TW#5

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
	Clay Gravel			0'	16'
	Grey Limestone		(Broken)	16'	97'

* TEST WELL #5 *

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m³/ft³)
22'	0'	Neat Cement Slurry	10.92

Method of Construction

☐ Cable Tool ☐ Diamond ☐ Rotary (Conventional) ☐ Jetting ☐ Rotary (Reverse) ☐ Driving ☐ Boring ☐ Digging ☒ Air percussion ☐ Other, specify

Well Use

☐ Public ☐ Commercial ☐ Not used ☒ Domestic ☐ Municipal ☐ Dewatering ☐ Livestock ☐ 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
6¼"	Steel	.188"	+2'	22'
6"	Open hole		22'	97'

Status of Well

☒ 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

Construction Record - Screen

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

Water Details

Water found at Depth	Kind of Water	Gas	Other, specify
73 (m/ft)	☐ Fresh ☒ Untested	☐	
87 (m/ft)	☐ Fresh ☒ Untested	☐	
91 (m/ft)	☐ Fresh ☒ Untested	☐	

Hole Diameter

Depth (m/ft) From	Depth (m/ft) To	Diameter (cm/in)
0'	22'	9¾"
22'	97'	6"

Results of Well Yield Testing

After test of well yield, water was: ☐ Clear and sand free ☐ Other, specify

If pumping discontinued, give reason: X

Pump intake set at (m/ft): 80'

Pumping rate (l/min / GPM): 20

Duration of pumping: 1 hrs 0 min

Final water level end of pumping (m/ft): 12'

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

Recommended pump depth (m/ft): 80'

Recommended pump rate (l/min / GPM): 20

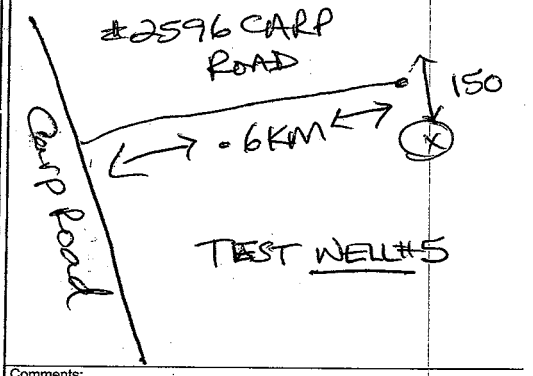
Well production (l/min / GPM): 20

Disinfected? ☒ Yes ☐ No

	Draw Down Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level		11'2"		12'
1	1	12'	1	11'2"
2	2	12'	2	11'2"
3	3		3	
4	4		4	
5	5		5	
10	10		10	
15	15		15	
20	20		20	
25	25		25	
30	30		30	
40	40		40	
50	50		50	
60	60		60	

Map of Well Location

Please provide a map below following instructions on the back.



Comments: 1/2HP-10GPM @ 80'

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
AIR ROCK DRILLING CO LTD	1119

Business Address (Street Number/Name)	Municipality	Province	Postal Code	Business E-mail Address
RR#1	RICHMOND	ONT	K0A2Z0	

Bus. Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)	Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
6138382170	HANNA JEREMY	T3632		2018/03/30

Well owner's information package delivered	Date Package Delivered	Date Work Completed
☒ Yes ☐ No	2018/03/22	2018/03/20

Ministry Use Only

Audit No. Z237000

Received

0506E (2014/11)

Ministry's Copy

TW6

Ontario — Ministry of the Environment and Climate Change

Measurements recorded in: ☐ Metric ☒ Imperial

Tag#: A229149 (see Below)

A229149

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
	1384341 Ontario Limited (c/o Cavanagh Const)		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
9094 Cavanagh Road	Ashton	On	K0A 1B0	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
2596 Carp Road	West Carleton	P/L 6	2

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

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	18	424043	5016678	RP-4R-1165	Part 1 - TEST WELL 6

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 From	Depth To
	Sandy	Clay,	Gravel & Sand	0'	18'
Grey	Limestone			18'	68'
Grey	Limestone			68'	78'
Grey	Limestone			78'	114'
Grey	Limestone			114'	120'

TEST WELL # 6

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m³/cu ft)
24'	14'	Neat cement	12.5
14'	0'	Bentonite slurry	8.4

Method of Construction

☐ Cable Tool ☐ Diamond ☐ Rotary (Conventional) ☐ Jetting ☐ Rotary (Reverse) ☐ Driving ☐ Boring ☐ Digging ☒ Air percussion ☐ Other, specify

Well Use

☐ Public ☐ Commercial ☐ Not used ☒ Domestic ☐ Municipal ☐ Dewatering ☐ Livestock ☐ 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 From	Depth To
6 1/4"	Steel	.188"	+2'	24'
6"	Open Hole		24'	120'

Construction Record - Screen

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

Status of Well

☒ 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 (m/ft)	Gas	Kind of Water: Fresh	Untested	Other, specify
68	☐	☐	☒	
78	☐	☐	☒	
114	☐	☐	☒	

Hole Diameter

Depth From	Depth To	Diameter (cm/in)
0'	24'	9 3/4"
24'	120'	6"

Results of Well Yield Testing

After test of well yield, water was: ☐ Clear and sand free ☐ Other, specify **Not tested**

If pumping discontinued, give reason: X

Pump intake set at (m/ft): 100

Pumping rate (l/min / GPM): 20

Duration of pumping: 1 hrs + 0 min

Final water level end of pumping (m/ft): 11.2'

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

Recommended pump depth (m/ft): 100'

Recommended pump rate (l/min / GPM): 20

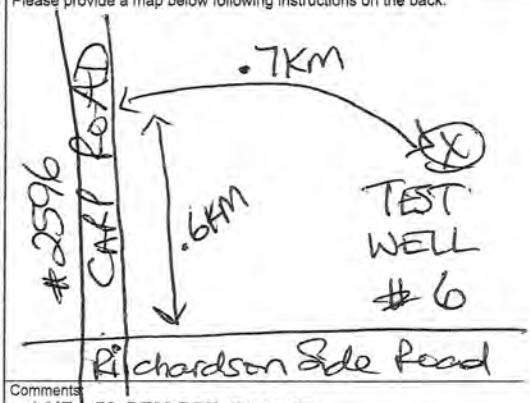
Well production (l/min / GPM): 20 +

Disinfected? ☒ Yes ☐ No

Draw Down Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level	10'.7"		11'.2"
1	11.2	1	10.7
2	11.2	2	10.7
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Map of Well Location

Please provide a map below following instructions on the back.



Comments: 1 HP - 20 GPM SET @ 100 FT

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Air Rock Drilling Co. Ltd.	1119

Business Address (Street Number/Name)	Municipality
6058 Frankford Road, RR#1	Richmond

Province	Postal Code	Business E-mail Address
ON	K0A 2Z0	air-rock@sympatico.ca

Bus. Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)
6138382170	Hanna, [redacted] Jeremy

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted (Y Y Y Y M M D D)
T3632		2018 06 29

Well owner's information package delivered	Date Package Delivered (Y Y Y Y M M D D)	Ministry Use Only
☒ Yes ☐ No	2018 06 27	Audit No. Z276961
	Date Work Completed: 2018 06 26	Received

0506E (2014/11) Ministry's Copy

APPENDIX E

Water Quality Results

TABLE E-1A
GROUNDWATER QUALITY DATA
LABORATORY RESULTS

PARAMETER	ODWQS	TREATABILITY LIMIT [a]	TW5			TW6		House Well				MW15-1	MW15-2	MW15-4
			22-Aug-18	24-Aug-18	31-Mar-19	27-Aug-18	30-Aug-18	05-Sep-18	05-Sep-18	11-Sep-18	13-Sep-18	19-Jul-17	19-Jul-17	19-Jul-17
			2.8 hr	45.5 hr	5.2 hr	1.3 hr	66.6 hr	2.2 hr	4.7 hr	--	--	--		--
Alkalinity (as $CaCO_3$)	30-500 (OG)	--	300	306	--	314	281	378	280	--	--	--	--	--
Ammonia (as N)	--	--	0.07	0.12	--	0.05	0.06	0.03	0.04	--	--	--	--	--
Calcium	--	--	124	140	--	142	149	114	115	--	--	--	--	--
Chloride	250 (AO)	250	210	218	--	**262**	246	120	118	--	--	--	--	--
Chlorine Residual	--	--	0.04	0.00	--	0.03	0.00	0.01*	0.01*	--	<0.04	--	--	--
Colour (TCU)	5 (AO)	7	3	2	--	<2	3	7	6	--	--	--	--	--
Conductivity (field) (uS/cm)	--	--	1452	1451	--	1680	1500	1015	965	--	--	--	--	--
Conductivity (lab) (uS/cm)	--	--	1440	1440	--	1630	1530	956	956	--	--	--	--	--
Dissolved Organic Carbon	5 (AO)	10	1.3	1.7	--	2.0	3.1	2.5	2.5	--	--	--	--	--
Fluoride	1.5 [b] (MAC)	--	0.20	0.20	--	0.14	0.23	0.12	0.12	--	--	--	--	--
Hardness (as $CaCO_3$)	80-100 [c] (OG)	--	413	444	--	458	479	363	365	--	--	--	--	--
Iron	0.30 (AO)	10	0.18	0.05	--	0.03	<0.03	0.10	0.07	--	--	--	--	--
Magnesium	--	--	25	23	--	25	26	19	19	--	--	--	--	--
Manganese	0.05 (AO)	1	0.02	0.01	--	<0.01	<0.01	<0.01	<0.01	--	--	--	--	--
Nitrate (as N)	10 [d] (MAC)	--	1.18	1.27	--	1.90	1.41	0.19	0.19	--	--	2.03	4.77	0.51
Nitrite (as N)	1 [d] (MAC)	--	<0.10	<0.10	--	<0.10	<0.10	<0.10	<0.10	--	--	--	--	--
pH (field)	6.5-8.5 (OG)	--	7.33	7.55	--	7.63	7.86	7.90	7.87	--	--	--	--	--
pH (lab)	6.5-8.5 (OG)	--	8.01	8.19	--	7.72	7.82	7.97	7.99	--	--	--	--	--
Phenols	--	--	<0.001	<0.001	--	<0.001	<0.001	<0.001	<0.001	--	--	--	--	--
Potassium	--	--	4	3	--	4	4	2	2	--	--	--	--	--
Sodium	200 [e] (AO)	200	114	111	--	160	142	67	68	--	--	--	--	--
Sulphate	500 [f] (AO)	500	87	114	--	149	130	45	44	--	--	--	--	--
Sulphide (lab)	0.05 (AO)	2.5	0.07	0.06	--	<0.01	<0.01	<0.01	<0.01	--	--	--	--	--
Tannin and Lignin	--	--	<0.1	<0.1	--	<0.1	<0.1	<0.1	<0.1	--	--	--	--	--
Temperature (field)	15 (AO)	--	11.7	13.1	--	18.1	11.1	17.7	16.7	--	--	--	--	--
Total Dissolved Solids	500 (AO)	--	936	936	--	1060	994	621	621	--	--	--	--	--
Total Kjeldahl Nitrogen	--	--	0.3	0.4	--	0.3	0.3	0.1	0.1	--	--	--	--	--
Turbidity - field (NTU)	5 [g] (AO)	5	3.30	0.65	--	0.75	0.50	1.80	1.95	--	--	--	--	--
Turbidity - lab (NTU)	5 [g] (AO)	5	2.6	2.8	--	0.9	0.2	1.6	0.4	--	--	--	--	--
Total Coliforms (ct/100ml)	not detected [h] (MAC)	--	--	51	0	--	5	4	10	1	0	--	--	--
Escherichia coli (ct/100ml)	not detected (MAC)	--	--	0	0	--	0	0	1	0	0	--	--	--
Fecal Coliforms (ct/100ml)	--	--	--	0	0	--	1	0	0	1	0	--	--	--
Heterotrophic Plate Count (ct/ml)	--	--	--	34	0	--	43	89	176	>500	18	--	--	--

Notes:
* = measurement considered erroneous
Criteria from "Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines",
Ministry of the Environment, June 2003, Revised June 2006
OG = operational guideline
AO = aesthetic objective
MAC = maximum acceptable concentration
Values are reported in mg/L unless otherwise noted
nd = below detection limit
-- = not measured or no value derived

Exceeds ODWQS (MAC or AO)
Bold Exceeds Treatability Limit (MOE Guideline D-5-5)

a - Treatability Limit from MOE Guideline D-5-5
b - Where fluoride is added to drinking water, it is recommended that the concentration be adjusted to 0.5 – 0.8 mg/L, the optimum level for control of tooth decay. Where supplies contain naturally occurring fluoride at levels higher than 1.5 mg/L but less than 2.4 mg/L, the Ministry of Health and Long Term Care recommends an approach through local boards of health to raise public and professional awareness to control excessive exposure to fluoride from other sources.
c - Hardness in excess of 500 mg/L in drinking water is unacceptable for most domestic purposes.
d – Where both nitrate and nitrite are present, the total of the two should not exceed 10 mg/L (as nitrogen).
e -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.
f - When sulphate levels exceed 500 mg/L, water may have a laxative effect on some people.
g - Applicable for all waters at the point of consumption.
h - For private water wells Total Coliform counts of less than 6 per 100 ml of sample are considered indicative of acceptable water quality (Table 1 of MOE Guideline D-5-5).

TABLE E-1B
GROUNDWATER QUALITY DATA
LABORATORY RESULTS

PARAMETER	ODWQS	House Well
		05-Sep-18
		4.7 hr
F1 (C6-C10)	--	<20
F1-BTEX (C6-C10)	--	<20
F2 (C10-C16)	--	<20
F3 (C16-C34)	--	<50
F4 (C34-C50)	--	<50
Benzene	1 (MAC)	<0.5
Toluene	60 (MAC)	<0.5
Ethylbenzene	140 (MAC)	<0.5
m/p-Xylene	--	<0.4
o-Xylene	--	<0.4
Xylene, total	90 (MAC)	<0.5
1+2-Methylnaphthalene	--	<0.1
1-Methylnaphthalene	--	<0.1
2-Methylnaphthalene	--	<0.1
Acenaphthene	--	<0.1
Acenaphthylene	--	<0.1
Anthracene	--	<0.1
Benzo(a)anthracene	--	<0.1
Benzo(a)pyrene	0.01 (MAC)	<0.01
Benzo(g,h,i)perylene	--	<0.1
Benzo(k)fluoranthene	--	<0.05
Benzo(b)fluoranthene	--	<0.05
Chrysene	--	<0.05
Dibenzo(a,h)anthracene	--	<0.1
Fluoranthene	--	<0.1
Fluorene	--	<0.1
Indeno(1,2,3-c,d)pyrene	--	<0.1
Naphthalene	--	<0.1
Phenanthrene	--	<0.1
Pyrene	--	<0.1

Notes:
* = value in parentheses is from duplicate sample
Criteria from “Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines”, Ministry of the Environment, June 2003, Revised June 2006
OG = operational guideline
AO = aesthetic objective
MAC = maximum acceptable concentration
Values are reported in ug/L unless otherwise noted
nd = below detection limit
-- = not measured or no value derived

	Exceeds ODWQS (MAC or AO)
Bold	Exceeds Treatability Limit (MOE Guideline D-5-5)

a - Treatability Limit from MOE Guideline D-5-5
b - Where fluoride is added to drinking water, it is recommended that the concentration be adjusted to 0.5 – 0.8 mg/L, the optimum level for control of tooth decay. Where supplies contain naturally occurring fluoride at levels higher than 1.5 mg/L but less than 2.4 mg/L, the Ministry of Health and Long Term Care recommends an approach through local boards of health to raise public and professional awareness to control excessive exposure to fluoride from other sources.
c - Hardness in excess of 500 mg/L in drinking water is unacceptable for most domestic purposes.
d – Where both nitrate and nitrite are present, the total of the two should not exceed 10 mg/L (as nitrogen).
e -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.
f - When sulphate levels exceed 500 mg/L, water may have a laxative effect on some people.
g - Applicable for all waters at the point of consumption.
h - For private water wells Total Coliform counts of less than 6 per 100 ml of sample are considered indicative of acceptable water quality (Table 1 of MOE Guideline D-5-5).

TABLE E-2A
GROUNDWATER QUALITY DATA
FIELD-MEASURED RESULTS

Test Well	Date	Time (hr)	pH	Temp (°C)	Cond (µs/cm)	Turb (ntu)	Chlorine Residual (mg/L)	Sample
TW5	22-Aug-18	2.8	7.33	11.7	1452	3.30	0.04	SA#1
TW5	22-Aug-18	22.4	7.59	11.8	1430	0.85	0.04	
TW5	22-Aug-18	45.5	7.55	13.1	1451	0.65	0.00	SA#2

TW5	31-Mar-19	1.0					0.05	
TW5	31-Mar-19	3.0					0.03	
TW5	31-Mar-19	4.5					0.01	
TW5	31-Mar-19	5.2					0.00	SA#1

Test Well	Date	Time (hr)	pH	Temp (°C)	Cond (µs/cm)	Turb (ntu)	Total Chlorine (mg/L)	Sample
TW6	27-Aug-18	1.3	7.63	18.1	1680	0.75	0.03	SA#3
TW6	28-Aug-18	20.6	7.65	16.0	1550	0.68	0.05	
TW6	29-Aug-18	47.1	7.75	14.6	1525	0.62	0.00	
TW6	30-Aug-18	66.6	7.86	11.1	1520	0.50	0.00	SA#4

Test Well	Date	Time (min)	pH	Temp (°C)	Cond (µs/cm)	Turb (ntu)	Total Chlorine (mg/L)	Sample
House	05-Sep-18	2.2	7.90	17.7	1015	1.80	0.01[(1)]	SA#5
House	05-Sep-18	4.7	1.87	16.7	965	1.95	0.01[(1)]	SA#6

Notes:

1 Reading considered erroneous as there was no chlorination before pumping.

Certificate of Analysis

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

Report Number: 1815371
Date Submitted: 2018-08-27
Date Reported: 2018-08-30
Project: 1543767-5000
COC #: 199022

Dear Loren Bekeris:

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: Rebecca Koshy 2018.08.30 18:45:57 -04'00'

Rebecca Koshy, Project Manager

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

Eurofins 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.

Eurofins(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.

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. Eurofins recommends consulting the official provincial or federal guideline as required.

Certificate of Analysis

eurofins | Environment Testing

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

Report Number: 1815371
Date Submitted: 2018-08-27
Date Reported: 2018-08-30
Project: 1543767-5000
COC #: 199022

				Lab I.D.	1383513
				Sample Matrix	Water
				Sample Type	
				Sampling Date	2018-08-27
				Sample I.D.	SA#3
Group	**Analyte**	**MRL**	**Units**	**Guideline**	
Anions	Cl	1	mg/L	AO 250	262*
	N-NO2	0.10	mg/L	MAC 1.0	<0.10
	N-NO3	0.10	mg/L	MAC 10.0	1.90
	SO4	1	mg/L	AO 500	149
General Chemistry	Alkalinity as CaCO3	5	mg/L	OG 500	314
	Colour	2	TCU	AO 5	<2
	Conductivity	5	uS/cm		1630
	F	0.10	mg/L	MAC 1.5	0.14
	pH	1.00		6.5-8.5	7.72
	S2-	0.01	mg/L	AO 0.05	<0.01
	TDS (COND - CALC)	1	mg/L	AO 500	1060*
	Turbidity	0.1	NTU	AO 5.0	0.9
Hardness	Hardness as CaCO3	1	mg/L	OG 100	458*
Indices/Calc	Ion Balance	0.01			0.96
Metals	Ca	1	mg/L		142
	Fe	0.03	mg/L	AO 0.3	0.03
	K	1	mg/L		4
	Mg	1	mg/L		25
	Mn	0.01	mg/L	AO 0.05	<0.01
	Na	2	mg/L	AO 200	160
Subcontract	DOC	0.5	mg/L	AO 5	2.0
	N-NH3	0.01	mg/L		0.05
	Phenols	0.001	mg/L		<0.001
	Tannin & Lignin	0.1	mg/L		<0.1
	Total Kjeldahl Nitrogen	0.1	mg/L		0.3

Guideline = ODWSOG *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
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

Certificate of Analysis

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Ottawa, ON
K2H 5B7
Attention: Ms. Loren Bekeris
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Report Number: 1815371
Date Submitted: 2018-08-27
Date Reported: 2018-08-30
Project: 1543767-5000
COC #: 199022

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 342797 **Analysis/Extraction Date** 2018-08-30 **Analyst** H D **Method** C SM2120C			
Colour	<2 TCU	99	90-110
Run No 351667 **Analysis/Extraction Date** 2018-08-28 **Analyst** AET **Method** EPA 200.8			
Iron	<0.03 mg/L	92	91-109
Manganese	<0.01 mg/L	97	92.9-107
Run No 351752 **Analysis/Extraction Date** 2018-08-30 **Analyst** H F **Method** SM 4110			
Chloride	<1 mg/L	100	90-110
SO4	<1 mg/L	105	90-110
Run No 351793 **Analysis/Extraction Date** 2018-08-30 **Analyst** Z S **Method** C SM4500-NO3-F			
N-NO2	<0.10 mg/L	100	80-120
N-NO3	<0.10 mg/L	97	80-120
Run No 351794 **Analysis/Extraction Date** 2018-08-30 **Analyst** H F **Method** M SM3120B-3500C			
Calcium	<1 mg/L	99	90-110
Potassium	<1 mg/L	108	87-113

Guideline = ODWSOG *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
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

Certificate of Analysis

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Date Submitted: 2018-08-27
Date Reported: 2018-08-30
Project: 1543767-5000
COC #: 199022

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Magnesium	<1 mg/L	97	76-124
Sodium	<2 mg/L	96	82-118
Run No 351800 **Analysis/Extraction Date** 2018-08-30 **Analyst** AET **Method** C SM4500-S2-D			
S2-	<0.01 mg/L	113	
Run No 351819 **Analysis/Extraction Date** 2018-08-30 **Analyst** AET **Method** SM2320,2510,4500H/F			
Alkalinity (CaCO3)	<5 mg/L	96	90-110
Conductivity	<5 uS/cm	100	90-110
F	<0.10 mg/L	106	90-110
pH		100	90-110
Run No 351820 **Analysis/Extraction Date** 2018-08-30 **Analyst** AET **Method** C SM2340B			
Hardness as CaCO3			
Ion Balance			
TDS (COND - CALC)			
Run No 351838 **Analysis/Extraction Date** 2018-08-30 **Analyst** R K **Method** SUBCONTRACT P			
DOC	<0.5 mg/L	78	

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. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815371
Date Submitted: 2018-08-27
Date Reported: 2018-08-30
Project: 1543767-5000
COC #: 199022

QC Summary

Analyte	Blank	QC % Rec	QC Limits
N-NH3	<0.01 mg/L	100	
Phenols	<0.001 mg/L	92	
Tannin & Lignin	<0.1 mg/L	80	
Total Kjeldahl Nitrogen	<0.1 mg/L	97	
Run No 351840 **Analysis/Extraction Date** 2018-08-30 **Analyst** R K **Method** C SM2130B			
Turbidity	0.1 NTU		70-130

Guideline = ODWSOG *** = Guideline Exceedence**

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

Report Number: 1815147
Date Submitted: 2018-08-23
Date Reported: 2018-09-01
Project: 1543767
COC #: 198679

Dear Loren Bekeris:

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:

Addrine Thomas 2018.09.01 10:46:25 -04'00'

APPROVAL: _____
Addrine Thomas, Inorganics Supervisor

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

Eurofins 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.

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Certificate of Analysis

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

Report Number: 1815147
Date Submitted: 2018-08-23
Date Reported: 2018-09-01
Project: 1543767
COC #: 198679

				Lab I.D.	1382734
				Sample Matrix	Water
				Sample Type	
				Sampling Date	2018-08-22
				Sample I.D.	SA #1
Group	**Analyte**	**MRL**	**Units**	**Guideline**	
Anions	Cl	1	mg/L	AO 250	210
	N-NO2	0.10	mg/L	MAC 1.0	<0.10
	N-NO3	0.10	mg/L	MAC 10.0	1.18
	SO4	1	mg/L	AO 500	87
General Chemistry	Alkalinity as CaCO3	5	mg/L	OG 500	300
	Colour	2	TCU	AO 5	3
	Conductivity	5	uS/cm		1440
	F	0.10	mg/L	MAC 1.5	0.20
	pH	1.00		6.5-8.5	8.01
	S2-	0.01	mg/L	AO 0.05	0.07*
	TDS (COND - CALC)	1	mg/L	AO 500	936*
	Turbidity	0.1	NTU	AO 5.0	2.6
Hardness	Hardness as CaCO3	1	mg/L	OG 100	413*
Indices/Calc	Ion Balance	0.01			0.96
Metals	Ca	1	mg/L		124
	Fe	0.03	mg/L	AO 0.3	0.18
	K	1	mg/L		4
	Mg	1	mg/L		25
	Mn	0.01	mg/L	AO 0.05	0.02
	Na	2	mg/L	AO 200	114
Subcontract-Inorg	DOC	0.5	mg/L	AO 5	1.3
	N-NH3	0.01	mg/L		0.07
	Phenols	0.001	mg/L		<0.001
	Tannin & Lignin	0.1	mg/L		<0.1
	Total Kjeldahl Nitrogen	0.1	mg/L		0.3

Guideline = ODWSOG *** = Guideline Exceedence**

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Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815147
Date Submitted: 2018-08-23
Date Reported: 2018-09-01
Project: 1543767
COC #: 198679

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 351242 **Analysis/Extraction Date** 2018-08-31 **Analyst** YH **Method** C SM2120C			
Colour	<2 TCU	100	90-110
Run No 351471 **Analysis/Extraction Date** 2018-08-24 **Analyst** YH **Method** C SM2130B			
Turbidity	<0.1 NTU	103	70-130
Run No 351479 **Analysis/Extraction Date** 2018-08-24 **Analyst** SKH **Method** EPA 200.8			
Iron	<0.03 mg/L	93	91-109
Manganese	<0.01 mg/L	102	92.9-107
Run No 351517 **Analysis/Extraction Date** 2018-08-27 **Analyst** AET **Method** C SM4500-S2-D			
S2-	<0.01 mg/L	123	
Run No 351634 **Analysis/Extraction Date** 2018-08-27 **Analyst** AET **Method** SUBCONTRACT P-INORG			
DOC	<0.5 mg/L	89	
N-NH3	<0.01 mg/L	100	
Phenols	<0.001 mg/L	88	69-132
Tannin & Lignin	<0.1 mg/L	80	

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Report Number: 1815147
Date Submitted: 2018-08-23
Date Reported: 2018-09-01
Project: 1543767
COC #: 198679

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Total Kjeldahl Nitrogen	<0.1 mg/L	101	81-126
Run No 351673 **Analysis/Extraction Date** 2018-08-28 **Analyst** AET **Method** SM2320,2510,4500H/F			
Alkalinity (CaCO3)	<5 mg/L	96	90-110
Conductivity	<5 uS/cm	100	90-110
F	<0.10 mg/L	110	90-110
pH		102	90-110
Run No 351723 **Analysis/Extraction Date** 2018-08-29 **Analyst** Z S **Method** C SM4500-NO3-F			
N-NO2	<0.10 mg/L	93	80-120
N-NO3	<0.10 mg/L	88	80-120
Run No 351794 **Analysis/Extraction Date** 2018-08-30 **Analyst** H F **Method** M SM3120B-3500C			
Calcium	<1 mg/L	99	90-110
Potassium	<1 mg/L	108	87-113
Magnesium	<1 mg/L	97	76-124
Sodium	<2 mg/L	96	82-118
Run No 351871 **Analysis/Extraction Date** 2018-08-31 **Analyst** H F **Method** SM 4110			

Guideline = ODWSOG *** = Guideline Exceedence**

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K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815147
Date Submitted: 2018-08-23
Date Reported: 2018-09-01
Project: 1543767
COC #: 198679

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Chloride	<1 mg/L	100	90-110
SO4	<1 mg/L	105	90-110
Run No 351975 **Analysis/Extraction Date** 2018-09-01 **Analyst** AET **Method** C SM2340B			
Hardness as CaCO3			
Ion Balance			
TDS (COND - CALC)			

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. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815262
Date Submitted: 2018-08-24
Date Reported: 2018-09-04
Project: 1543767-5000
COC #: 198680

Dear Loren Bekeris:

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: Addrine Thomas 2018.09.04 15:25:58 -04'00'

Addrine Thomas, Inorganics Supervisor

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

Eurofins 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.

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Certificate of Analysis

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

Report Number: 1815262
Date Submitted: 2018-08-24
Date Reported: 2018-09-04
Project: 1543767-5000
COC #: 198680

				Lab I.D.	1383039
				Sample Matrix	Water
				Sample Type	
				Sampling Date	2018-08-24
				Sample I.D.	SA#2
Group	**Analyte**	**MRL**	**Units**	**Guideline**	
Anions	Cl	1	mg/L	AO 250	218
	N-NO2	0.10	mg/L	MAC 1.0	<0.10
	N-NO3	0.10	mg/L	MAC 10.0	1.27
	SO4	1	mg/L	AO 500	114
General Chemistry	Alkalinity as CaCO3	5	mg/L	OG 500	306
	Colour	2	TCU	AO 5	2
	Conductivity	5	uS/cm		1440
	F	0.10	mg/L	MAC 1.5	0.20
	pH	1.00		6.5-8.5	8.19
	S2-	0.01	mg/L	AO 0.05	0.06*
	TDS (COND - CALC)	1	mg/L	AO 500	936*
	Turbidity	0.1	NTU	AO 5.0	2.8
Hardness	Hardness as CaCO3	1	mg/L	OG 100	444*
Indices/Calc	Ion Balance	0.01			0.94
Metals	Ca	1	mg/L		140
	Fe	0.03	mg/L	AO 0.3	0.05
	K	1	mg/L		3
	Mg	1	mg/L		23
	Mn	0.01	mg/L	AO 0.05	0.01
	Na	2	mg/L	AO 200	111
Microbiology	Escherichia Coli	0	ct/100mL	MAC 0	0
	Faecal Coliforms	0	ct/100mL		0
	Faecal Streptococcus	0	ct/100mL		0
	Heterotrophic Plate Count	0	ct/1mL		34
	Total Coliforms	0	ct/100mL	MAC 0	51*

Guideline = ODWSOG *** = Guideline Exceedence**

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Certificate of Analysis

eurofins | Environment Testing

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

Report Number: 1815262
Date Submitted: 2018-08-24
Date Reported: 2018-09-04
Project: 1543767-5000
COC #: 198680

Group	Analyte	MRL	Units	Guideline	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.
					1383039 Water 2018-08-24 SA#2
Subcontract	DOC	0.5	mg/L	AO 5	1.7
	N-NH3	0.01	mg/L		0.12
	Phenols	0.001	mg/L		<0.001
	Tannin & Lignin	0.1	mg/L		<0.1
	Total Kjeldahl Nitrogen	0.1	mg/L		0.4

Guideline = ODWSOG *** = Guideline Exceedence**

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Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
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Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815262
Date Submitted: 2018-08-24
Date Reported: 2018-09-04
Project: 1543767-5000
COC #: 198680

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 351242 **Analysis/Extraction Date** 2018-08-31 **Analyst** YH **Method** C SM2120C			
Colour	<2 TCU	100	90-110
Run No 351495 **Analysis/Extraction Date** 2018-08-26 **Analyst** DRA **Method** AMBCOLM1			
Escherichia Coli			
Faecal Coliforms			
Faecal Streptococcus			
Heterotrophic Plate Count			
Total Coliforms			
Run No 351517 **Analysis/Extraction Date** 2018-08-27 **Analyst** AET **Method** C SM4500-S2-D			
S2-	<0.01 mg/L	123	
Run No 351521 **Analysis/Extraction Date** 2018-08-27 **Analyst** YH **Method** C SM2130B			
Turbidity	<0.1 NTU	103	70-130
Run No 351667 **Analysis/Extraction Date** 2018-08-28 **Analyst** AET **Method** EPA 200.8			
Iron	<0.03 mg/L	92	91-109

Guideline = ODWSOG *** = Guideline Exceedence**

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Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815262
Date Submitted: 2018-08-24
Date Reported: 2018-09-04
Project: 1543767-5000
COC #: 198680

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Manganese	<0.01 mg/L	97	92.9-107
Run No 351673 **Analysis/Extraction Date** 2018-08-29 **Analyst** AET **Method** SM2320,2510,4500H/F			
Alkalinity (CaCO3)	<5 mg/L	96	90-110
Conductivity	<5 uS/cm	100	90-110
F	<0.10 mg/L	110	90-110
pH		102	90-110
Run No 351794 **Analysis/Extraction Date** 2018-08-30 **Analyst** H F **Method** M SM3120B-3500C			
Calcium	<1 mg/L	99	90-110
Potassium	<1 mg/L	108	87-113
Magnesium	<1 mg/L	97	76-124
Sodium	<2 mg/L	96	82-118
Run No 351799 **Analysis/Extraction Date** 2018-08-30 **Analyst** Z S **Method** C SM4500-NO3-F			
N-NO2	<0.10 mg/L	100	80-120
N-NO3	<0.10 mg/L	102	80-120
Run No 351841 **Analysis/Extraction Date** 2018-08-28 **Analyst** R K **Method** SUBCONTRACT P			

Guideline = ODWSOG *** = Guideline Exceedence**

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PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815262
Date Submitted: 2018-08-24
Date Reported: 2018-09-04
Project: 1543767-5000
COC #: 198680

QC Summary

Analyte	Blank	QC % Rec	QC Limits
DOC	<0.5 mg/L	90	
N-NH3	<0.01 mg/L	100	
Phenols	<0.001 mg/L	92	
Tannin & Lignin	<0.1 mg/L	80	
Total Kjeldahl Nitrogen	<0.1 mg/L	101	
Run No 351979 **Analysis/Extraction Date** 2018-08-31 **Analyst** H F **Method** SM 4110			
Chloride	<1 mg/L	102	90-110
SO4	<1 mg/L	107	90-110
Run No 352013 **Analysis/Extraction Date** 2018-09-04 **Analyst** AET **Method** C SM2340B			
Hardness as CaCO3			
Ion Balance			
TDS (COND - CALC)			

Guideline = ODWSOG *** = Guideline Exceedence**

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

Report Number: 1815697
Date Submitted: 2018-08-30
Date Reported: 2018-09-05
Project: 1543767-5000
COC #: 199029

Dear Loren Bekeris:

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:

Rebecca Koshy
2018.09.05
06:12:07 -04'00'

APPROVAL: _____

Rebecca Koshy, Project Manager

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K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815697
Date Submitted: 2018-08-30
Date Reported: 2018-09-05
Project: 1543767-5000
COC #: 199029

				Lab I.D.	1384434
				Sample Matrix	Water
				Sample Type	
				Sampling Date	2018-08-30
				Sample I.D.	SA#4
Group	**Analyte**	**MRL**	**Units**	**Guideline**	
Anions	Cl	1	mg/L	AO 250	246
	N-NO2	0.10	mg/L	MAC 1.0	<0.10
	N-NO3	0.10	mg/L	MAC 10.0	1.41
	SO4	1	mg/L	AO 500	130
General Chemistry	Alkalinity as CaCO3	5	mg/L	OG 500	281
	Colour	2	TCU	AO 5	3
	Conductivity	5	uS/cm		1530
	F	0.10	mg/L	MAC 1.5	0.23
	pH	1.00		6.5-8.5	7.82
	S2-	0.01	mg/L	AO 0.05	<0.01
	TDS (COND - CALC)	1	mg/L	AO 500	994*
	Turbidity	0.1	NTU	AO 5.0	0.2
Hardness	Hardness as CaCO3	1	mg/L	OG 100	479*
Indices/Calc	Ion Balance	0.01			1.03
Metals	Ca	1	mg/L		149
	Fe	0.03	mg/L	AO 0.3	<0.03
	K	1	mg/L		4
	Mg	1	mg/L		26
	Mn	0.01	mg/L	AO 0.05	<0.01
	Na	2	mg/L	AO 200	142
Microbiology	Escherichia Coli	0	ct/100mL	MAC 0	0
	Faecal Coliforms	0	ct/100mL		1
	Heterotrophic Plate Count	0	ct/1mL		43
	Total Coliforms	0	ct/100mL	MAC 0	5*
Subcontract	DOC	0.5	mg/L	AO 5	3.1

Guideline = ODWSOG *** = Guideline Exceedence**

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Report Number: 1815697
Date Submitted: 2018-08-30
Date Reported: 2018-09-05
Project: 1543767-5000
COC #: 199029

Group	Analyte	MRL	Units	Guideline	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D. 1384434 Water 2018-08-30 SA#4
Subcontract	N-NH3	0.01	mg/L		0.06
	Phenols	0.001	mg/L		<0.001
	Tannin & Lignin	0.1	mg/L		<0.1
	Total Kjeldahl Nitrogen	0.1	mg/L		0.3

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. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815697
Date Submitted: 2018-08-30
Date Reported: 2018-09-05
Project: 1543767-5000
COC #: 199029

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 351242 **Analysis/Extraction Date** 2018-08-31 **Analyst** YH **Method** C SM2120C			
Colour	<2 TCU	100	90-110
Run No 351795 **Analysis/Extraction Date** 2018-08-31 **Analyst** L V **Method** AMBCOLM1			
Escherichia Coli			
Faecal Coliforms			
Heterotrophic Plate Count			
Total Coliforms			
Run No 351800 **Analysis/Extraction Date** 2018-08-30 **Analyst** AET **Method** C SM4500-S2-D			
S2-	<0.01 mg/L	113	
Run No 351840 **Analysis/Extraction Date** 2018-08-30 **Analyst** R K **Method** C SM2130B			
Turbidity	0.1 NTU		70-130
Run No 351871 **Analysis/Extraction Date** 2018-08-31 **Analyst** H F **Method** SM 4110			
Chloride	<1 mg/L	100	90-110
N-NO2	<0.10 mg/L	108	90-110

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Project: 1543767-5000
COC #: 199029

QC Summary

Analyte	Blank	QC % Rec	QC Limits
SO4	<1 mg/L	105	90-110
Run No 351898 **Analysis/Extraction Date** 2018-08-31 **Analyst** Z S **Method** C SM4500-NO3-F			
N-NO3	<0.10 mg/L	97	80-120
Run No 351901 **Analysis/Extraction Date** 2018-08-31 **Analyst** AET **Method** EPA 200.8			
Iron	<0.03 mg/L	94	91-109
Manganese	<0.01 mg/L	99	92.9-107
Run No 351940 **Analysis/Extraction Date** 2018-08-31 **Analyst** AET **Method** SM2320,2510,4500H/F			
Alkalinity (CaCO3)	<5 mg/L	99	90-110
Conductivity	<5 uS/cm	101	90-110
F	<0.10 mg/L	108	90-110
pH		100	90-110
Run No 352001 **Analysis/Extraction Date** 2018-09-04 **Analyst** H F **Method** M SM3120B-3500C			
Calcium	<1 mg/L	100	90-110
Potassium	<1 mg/L	107	87-113
Magnesium	<1 mg/L	97	76-124

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Report Number: 1815697
Date Submitted: 2018-08-30
Date Reported: 2018-09-05
Project: 1543767-5000
COC #: 199029

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Sodium	<2 mg/L	108	82-118
Run No 352034 **Analysis/Extraction Date** 2018-09-04 **Analyst** R K **Method** SUBCONTRACT P			
DOC	<0.5 mg/L	110	
N-NH3	<0.01 mg/L	111	
Phenols	<0.001 mg/L	80	
Tannin & Lignin	<0.1 mg/L	80	
Total Kjeldahl Nitrogen	<0.1 mg/L	102	
Run No 352035 **Analysis/Extraction Date** 2018-09-05 **Analyst** R K **Method** C SM2340B			
Hardness as CaCO3			
Ion Balance			
TDS (COND - CALC)			

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. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1816061
Date Submitted: 2018-09-06
Date Reported: 2018-09-10
Project: 1543767
COC #: 835480

Dear Loren Bekeris:

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:

Rebecca Koshy
2018.09.10
19:08:03 -04'00'

APPROVAL: _____

Rebecca Koshy, Project Manager

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

Eurofins 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.

Eurofins(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.

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. Eurofins recommends consulting the official provincial or federal guideline as required.

Certificate of Analysis

eurofins | Environment Testing

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

Report Number: 1816061
Date Submitted: 2018-09-06
Date Reported: 2018-09-10
Project: 1543767
COC #: 835480

Group	Analyte	MRL	Units	Guideline	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	1385665 GW 2018-09-05 SA#5	1385666 GW 2018-09-05 SA#6
Anions	Cl	1	mg/L	AO 250		120	118
	F	0.10	mg/L	MAC 1.5		0.12	0.12
	N-NO2	0.10	mg/L	MAC 1.0		<0.10	<0.10
	N-NO3	0.10	mg/L	MAC 10.0		0.19	0.19
	SO4	1	mg/L	AO 500		45	44
General Chemistry	Alkalinity as CaCO3	5	mg/L	OG 500		378	280
	Colour	2	TCU	AO 5		7*	6*
	Conductivity	5	uS/cm			956	956
	pH	1.00		6.5-8.5		7.97	7.99
	S2-	0.01	mg/L	AO 0.05		<0.01	<0.01
	TDS (COND - CALC)	1	mg/L	AO 500		621*	621*
	Turbidity	0.1	NTU	AO 5.0		1.6	0.4
Hardness	Hardness as CaCO3	1	mg/L	OG 100		363*	365*
Hydrocarbons	F1 (C6-C10)	20	ug/L				<20
	F1-BTEX (C6-C10)	20	ug/L				<20
	F2 (C10-C16)	20	ug/L				<20
	F3 (C16-C34)	50	ug/L				<50
	F4 (C34-C50)	50	ug/L				<50
Indices/Calc	Ion Balance	0.01				0.86	1.05
Metals	Ca	1	mg/L			114	115
	Fe	0.03	mg/L	AO 0.3		0.10	0.07
	K	1	mg/L			2	2
	Mg	1	mg/L			19	19
	Mn	0.01	mg/L	AO 0.05		<0.01	<0.01
	Na	2	mg/L	AO 200		67	68

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Report Number: 1816061
Date Submitted: 2018-09-06
Date Reported: 2018-09-10
Project: 1543767
COC #: 835480

Group	Analyte	MRL	Units	Guideline	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	1385665 GW 2018-09-05 SA#5	1385666 GW 2018-09-05 SA#6
Microbiology	Escherichia Coli	0	ct/100mL	MAC 0		0	1*
	Faecal Coliforms	0	ct/100mL			0	0
	Heterotrophic Plate Count	0	ct/1mL			89	176
	Total Coliforms	0	ct/100mL	MAC 0		4*	10*
PAH	1+2-methylnaphthalene	0.1	ug/L				<0.1
	1-methylnaphthalene	0.1	ug/L				<0.1
	2-methylnaphthalene	0.1	ug/L				<0.1
	Acenaphthene	0.1	ug/L				<0.1
	Acenaphthylene	0.1	ug/L				<0.1
	Anthracene	0.1	ug/L				<0.1
	Benzo(a)anthracene	0.1	ug/L				<0.1
	Benzo(a)pyrene	0.01	ug/L	MAC 0.01			<0.01
	Benzo(b)fluoranthene	0.05	ug/L				<0.05
	Benzo(g,h,i)perylene	0.1	ug/L				<0.1
	Benzo(k)fluoranthene	0.05	ug/L				<0.05
	Chrysene	0.05	ug/L				<0.05
	Dibenzo(a,h)anthracene	0.1	ug/L				<0.1
	Fluoranthene	0.1	ug/L				<0.1
	Fluorene	0.1	ug/L				<0.1
	Indeno(1,2,3-c,d)pyrene	0.1	ug/L				<0.1
	Naphthalene	0.1	ug/L				<0.1
	Phenanthrene	0.1	ug/L				<0.1
	Pyrene	0.1	ug/L				<0.1
PHC Surrogate	Alpha-androstrane	0	%				103
Subcontract-Inorg	DOC	0.5	mg/L	AO 5		2.5	2.5

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Report Number: 1816061
Date Submitted: 2018-09-06
Date Reported: 2018-09-10
Project: 1543767
COC #: 835480

Group	Analyte	MRL	Units	Guideline	1385665 GW 2018-09-05 SA#5	1385666 GW 2018-09-05 SA#6
	Lab I.D.				1385665	1385666
	Sample Matrix				GW	GW
	Sample Type					
	Sampling Date				2018-09-05	2018-09-05
	Sample I.D.				SA#5	SA#6
Subcontract-Inorg	N-NH3	0.01	mg/L		0.03	0.04
	Phenols	0.001	mg/L		<0.001	<0.001
	Tannin & Lignin	0.1	mg/L		<0.1	<0.1
	Total Kjeldahl Nitrogen	0.1	mg/L		0.1	0.1
VOCs Surrogates	Toluene-d8	0	%			94
Volatiles	Benzene	0.5	ug/L	MAC 1		<0.5
	Ethylbenzene	0.5	ug/L	MAC 140		<0.5
	m/p-xylene	0.4	ug/L			<0.4
	o-xylene	0.4	ug/L			<0.4
	Toluene	0.5	ug/L	MAC 60		<0.5
	Xylene; total	0.5	ug/L	MAC 90		<0.5

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Report Number: 1816061
Date Submitted: 2018-09-06
Date Reported: 2018-09-10
Project: 1543767
COC #: 835480

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 208523 **Analysis/Extraction Date** 2018-09-10 **Analyst** C M **Method** P 8270			
1+2-methylnaphthalene			
Run No 352169 **Analysis/Extraction Date** 2018-09-07 **Analyst** DRA **Method** AMBCOLM1			
Escherichia Coli			
Faecal Coliforms			
Heterotrophic Plate Count			
Total Coliforms			
Run No 352177 **Analysis/Extraction Date** 2018-09-06 **Analyst** Z S **Method** C SM4500-NO3-F			
N-NO2	<0.10 mg/L	100	80-120
N-NO3	<0.10 mg/L	103	80-120
Run No 352188 **Analysis/Extraction Date** 2018-09-06 **Analyst** SKH **Method** EPA 200.8			
Manganese	<0.01 mg/L	100	92.9-107
Run No 352206 **Analysis/Extraction Date** 2018-09-07 **Analyst** H F **Method** SM 4110			
Chloride	<1 mg/L	100	90-110

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COC #: 835480

QC Summary

Analyte	Blank	QC % Rec	QC Limits
SO4	<1 mg/L	105	90-110
Run No 352239 **Analysis/Extraction Date** 2018-09-07 **Analyst** AET **Method** C SM4500-S2-D			
S2-	<0.01 mg/L	110	
Run No 352240 **Analysis/Extraction Date** 2018-09-07 **Analyst** C F **Method** C SM2130B			
Turbidity	<0.1 NTU	100	70-130
Run No 352250 **Analysis/Extraction Date** 2018-09-07 **Analyst** SKH **Method** EPA 200.8			
Iron	<0.03 mg/L	94	91-109
Run No 352289 **Analysis/Extraction Date** 2018-09-07 **Analyst** AET **Method** SM 2320B			
Alkalinity (CaCO3)	<5 mg/L	101	95-105
Conductivity	<5 uS/cm	99	95-105
F	<0.10 mg/L	106	90-110
pH	5.99	100	90-110
Run No 352312 **Analysis/Extraction Date** 2018-09-06 **Analyst** TJB **Method** V 8260B			
Benzene	<0.5 ug/L	91	60-130

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Report Number: 1816061
Date Submitted: 2018-09-06
Date Reported: 2018-09-10
Project: 1543767
COC #: 835480

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Ethylbenzene	<0.5 ug/L	85	60-130
Petroleum Hydrocarbons F1	<20 ug/L	93	60-140
Petroleum Hydrocarbons F1-BTEX			
m/p-xylene	<0.4 ug/L	89	60-130
o-xylene	<0.4 ug/L	88	60-130
Toluene	<0.5 ug/L	92	60-130
Run No 352313 **Analysis/Extraction Date** 2018-09-10 **Analyst** TJB **Method** V 8260B			
Xylene Mixture			
Run No 352318 **Analysis/Extraction Date** 2018-09-10 **Analyst** YH **Method** C SM2120C			
Colour	<2 TCU	105	90-110
Run No 352321 **Analysis/Extraction Date** 2018-09-07 **Analyst** C M **Method** P 8270			
Methlynaphthalene, 1-	<0.1 ug/L	66	50-140
Methlynaphthalene, 2-	<0.1 ug/L	54	50-140
Acenaphthene	<0.1 ug/L	62	50-140
Acenaphthylene	<0.1 ug/L	64	50-140
Anthracene	<0.1 ug/L	70	50-140

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Report Number: 1816061
Date Submitted: 2018-09-06
Date Reported: 2018-09-10
Project: 1543767
COC #: 835480

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Benz[a]anthracene	<0.1 ug/L	60	50-140
Benzo[a]pyrene	<0.01 ug/L	64	50-140
Benzo[b]fluoranthene	<0.05 ug/L	78	50-140
Benzo[ghi]perylene	<0.1 ug/L	62	50-140
Benzo[k]fluoranthene	<0.05 ug/L	78	50-140
Chrysene	<0.05 ug/L	71	50-140
Dibenz[a h]anthracene	<0.1 ug/L	64	50-140
Fluoranthene	<0.1 ug/L	64	50-140
Fluorene	<0.1 ug/L	62	50-140
Indeno[1 2 3-cd]pyrene	<0.1 ug/L	62	50-140
Naphthalene	<0.1 ug/L	58	50-140
Phenanthrene	<0.1 ug/L	54	50-140
Pyrene	<0.1 ug/L	64	50-140
Run No 352371 **Analysis/Extraction Date** 2018-09-10 **Analyst** RRK **Method** CCME O.Reg 153/04			
Petroleum Hydrocarbons F2	<20 ug/L	80	60-140
Petroleum Hydrocarbons F3	<50 ug/L	80	60-140
Petroleum Hydrocarbons F4	<50 ug/L	80	60-140

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Report Number: 1816061
Date Submitted: 2018-09-06
Date Reported: 2018-09-10
Project: 1543767
COC #: 835480

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 352380 **Analysis/Extraction Date** 2018-09-10 **Analyst** SKH **Method** M SM3120B-3500C			
Calcium	<1 mg/L	107	90-110
Potassium	<1 mg/L	95	87-113
Magnesium	<1 mg/L	101	76-124
Sodium	<2 mg/L	91	82-118
Run No 352387 **Analysis/Extraction Date** 2018-09-07 **Analyst** SDC **Method** SUBCONTRACT P-INORG			
DOC	<0.5 mg/L	102	
N-NH3	<0.01 mg/L	99	
Phenols	<0.001 mg/L	84	69-132
Tannin & Lignin	<0.1 mg/L	80	
Total Kjeldahl Nitrogen	<0.1 mg/L	94	81-126
Run No 352388 **Analysis/Extraction Date** 2018-09-10 **Analyst** R K **Method** C SM2340B			
Hardness as CaCO3			
Ion Balance			
TDS (COND - CALC)			

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Date Submitted: 2018-09-06
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Certificate of Analysis

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

Report Number: 1816448
Date Submitted: 2018-09-11
Date Reported: 2018-09-13
Project: 1543767
COC #: 199103

Dear Loren Bekeris:

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: Krista Quantrill 2018.09.13 14:14:42 -04'00'

Krista Quantrill, Microbiology Supervisor

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

Eurofins 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.

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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. Eurofins recommends consulting the official provincial or federal guideline as required.

Certificate of Analysis

eurofins | Environment Testing

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

Report Number: 1816448
Date Submitted: 2018-09-11
Date Reported: 2018-09-13
Project: 1543767
COC #: 199103

Group	Analyte	MRL	Units	Guideline	Lab I.D. 1386680 Sample Matrix Water Sample Type Sampling Date 2018-09-11 Sample I.D. 2596 Carp
Microbiology	Heterotrophic Plate Count	0	ct/1mL		>500
Others	Escherichia Coli	0	ct/100mL	MAC 0	0
	Faecal Coliforms	0	ct/100mL		1
	Total Coliforms	0	ct/100mL	MAC 0	1*

Guideline = ODWSOG *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Analytical Method: AMBCOLM1
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

Certificate of Analysis

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

Report Number: 1816624
Date Submitted: 2018-09-13
Date Reported: 2018-09-17
Project: 1543767
COC #: 199023

Dear Loren Bekeris:

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: _____
Krista Quantrill, Microbiology Supervisor

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

Eurofins 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.

Eurofins (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.

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. Eurofins recommends consulting the official provincial or federal guideline as required.

Certificate of Analysis

eurofins | Environment Testing

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

Report Number: 1816624
Date Submitted: 2018-09-13
Date Reported: 2018-09-17
Project: 1543767
COC #: 199023

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.
					1387247 / GW / / 2018-09-13 / 2596 Carp Road
General Chemistry	Chlorine (free)	0.04	mg/L		<0.04
	Chlorine (total)	0.04	mg/L		0.09
Microbiology	Heterotrophic Plate Count	0	ct/1mL		18
Others	Escherichia Coli	0	ct/100mL	MAC 0	0
	Faecal Coliforms	0	ct/100mL		0
	Total Coliforms	0	ct/100mL	MAC 0	0

Guideline = ODWSOG *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Analytical Method: AMBCOLM1
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

Certificate of Analysis

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

Report Number: 1904541
Date Submitted: 2019-04-01
Date Reported: 2019-04-03
Project: 1543767
COC #: 199593

Dear Loren Bekeris:

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:

Steven Tosh
2019.04.03
11:57:41
-04'00'

APPROVAL: _____

Steven Tosh, Operations Manager

All analysis is completed at Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) unless otherwise indicated.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on the scope of accreditation. The scope is available at: http://www.cala.ca/scopes/2602.pdf.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is licensed by the Ontario Ministry of the Environment, Conservation, and Parks (MECP) for specific tests in drinking water (license #2318). A copy of the license is available upon request.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by the Ontario Ministry of Agriculture, Food, and Rural Affairs for specific tests in agricultural soils.

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. Eurofins recommends consulting the official provincial or federal guideline as required. Unless otherwise stated, measurement uncertainty is not taken into account when determining guideline or regulatory exceedances.

Certificate of Analysis

eurofins | Environment Testing

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

Report Number: 1904541
Date Submitted: 2019-04-01
Date Reported: 2019-04-03
Project: 1543767
COC #: 199593

				Lab I.D.	1417921
				Sample Matrix	Water
				Sample Type	
				Sampling Date	2019-03-31
				Sample I.D.	TW5
Group	**Analyte**	**MRL**	**Units**	**Guideline**	
Microbiology	Escherichia Coli	0	ct/100mL	MAC 0	0
	Faecal Coliforms	0	ct/100mL		0
	Faecal Streptococcus	0	ct/100mL		0
	Heterotrophic Plate Count	0	ct/1mL		0
	Total Coliforms	0	ct/100mL	MAC 0	0

Guideline = ODWSOG *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Analytical Method: AMBCOLM1
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

APPENDIX F

Water Level Measurements and Rising Head Test Analyses

Well ID	Ground Surface Elevation	Top of Casing Elevation	Geologic Unit of Screened Interval	Depth of Screened Interval	Groundwater Levels						Hydraulic Conductivity (m/s)
					22-Dec-15		26-Apr-17		22-Aug-18		
	(masl)	(masl)		(mbgs)	Depth (mbtoc)	Elevation (masl)	Depth (mbtoc)	Elevation (masl)	Depth (mbtoc)	Elevation (masl)	
15-1	114.57	115.45	Silty Sand over Silty Sand and Gravel	5.8 – 7.4	2.32	113.13	1.10	114.35	-	-	$5x10^{-5}$
15-2	114.99	115.79	Glacial Till	4.6 – 6.1	Dry	Dry	6.06	109.73	-	-	-
15-4	110.31	111.24	Glacial Till	3.7 – 5.3	3.60	107.64	2.45	108.79	3.43	107.81	$4x10^{-7}$
15-5	109.50	110.33	Silty Clay over Glacial Till	4.6 – 6.1	2.55	107.78	1.71	108.62	2.693	107.64	$3x10^{-7}$
15-6	109.54	110.34	Layers of Silty Sand and Silty Clay	4.1 – 5.6	4.16	106.18	3.93	106.41	-	-	$2x10^{-4}$
Gemtec 18-7	112.68	113.63	Glacial Till	1.4 - 2.9	-	-	-	-	2.795	110.84	-
Gemtec 18-11	110.87	111.82	Glacial Till	1.4 - 2.9	-	-	-	-	2.57	109.25	-
MW18-1 (Shallow)	107.782	109.391	Sand	0.1 - 0.39	-	-	-	-	1.7	107.69	-
MW18-2 (Shallow)	107.093	108.665	Sand	0.1 - 0.59	-	-	-	-	1.605	107.06	-
MW18-3 (Shallow)	106.552	108.182	Sand	0.1 - 0.45	-	-	-	-	1.6	106.58	-
TW1	-	-	Limestone Bedrock	9.1 - 91.4	-	-	-	-	4.153	-	-
TW2	-	-	Limestone Bedrock	6.1 - 91.4	-	-	-	-	4.178	-	-
TW4	111.513	112.109	Limestone Bedrock	7.9 - 36.9	-	-	-	-	3.943	108.17	-
TW5	111.215	111.785	Limestone Bedrock	6.7 - 29.6	-	-	-	-	3.61	108.18	-
TW6	110.414	111.034	Limestone Bedrock	7.3 - 36.6	-	-	-	-	3.16	107.87	-
House Well	-	110	Unknown	Unknown	-	-	-	-	-	-	-

HVORSLEV SLUG TEST ANALYSIS
FALLING HEAD TEST 15-1

INTERVAL (metres below ground surface)

Top of Interval =	**5.84**
Bottom of Interval =	**7.37**

$$K = \frac{r_c^2}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right] \left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

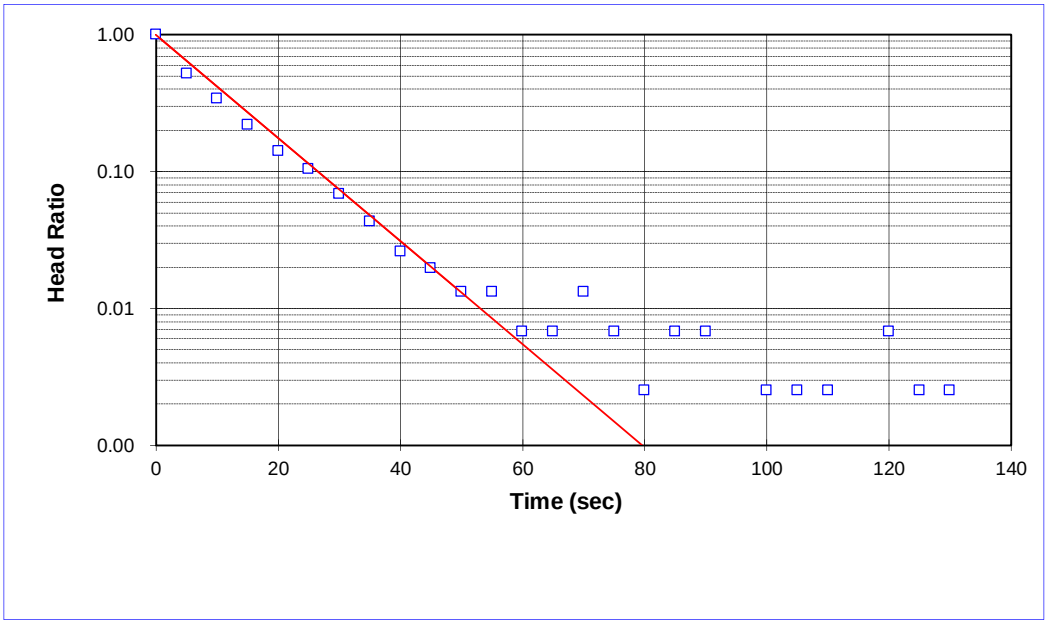
where:

r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS	
r_c =	**0.025**
R_e =	**0.102**
L_e =	**1.5**
t_1 =	**0**
t_2 =	**50**
h_1/h_0 =	**1.00**
h_2/h_0 =	**0.01**

RESULTS

K=	**5E-05**	**m/sec**
K=	**5E-03**	**cm/sec**



Project Name: Cavanagh/Carp Road
Project No.: 1543767
Test Date: 12/22/2015

Analysis By: CWT
Checked By: LEB
Analysis Date: 12/23/2015

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 15-1

INTERVAL (metres below ground surface)

Top of Interval =	**5.84**
Bottom of Interval =	**7.37**

$$K = \frac{r_c^2}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right] \left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

where:

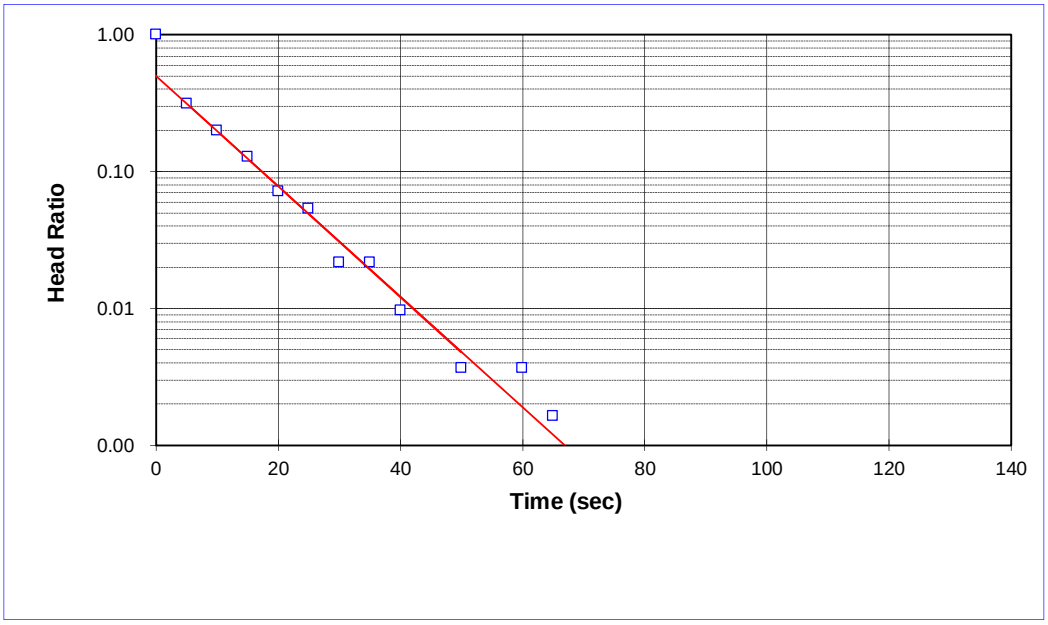
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS

r_c =	**0.025**
R_e =	**0.102**
L_e =	**1.5**
t_1 =	**5**
t_2 =	**50**
h_1/h_0 =	**0.31**
h_2/h_0 =	**0.00**

RESULTS

K=	**5E-05**	**m/sec**
K=	**5E-03**	**cm/sec**



Project Name: Cavanagh/Carp Road
Project No.: 1543767
Test Date: 12/22/2015

Analysis By: CWT
Checked By: LEB
Analysis Date: 12/23/2015

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 15-4

INTERVAL (metres below ground surface)

Top of Interval =	**3.73**
Bottom of Interval =	**5.26**

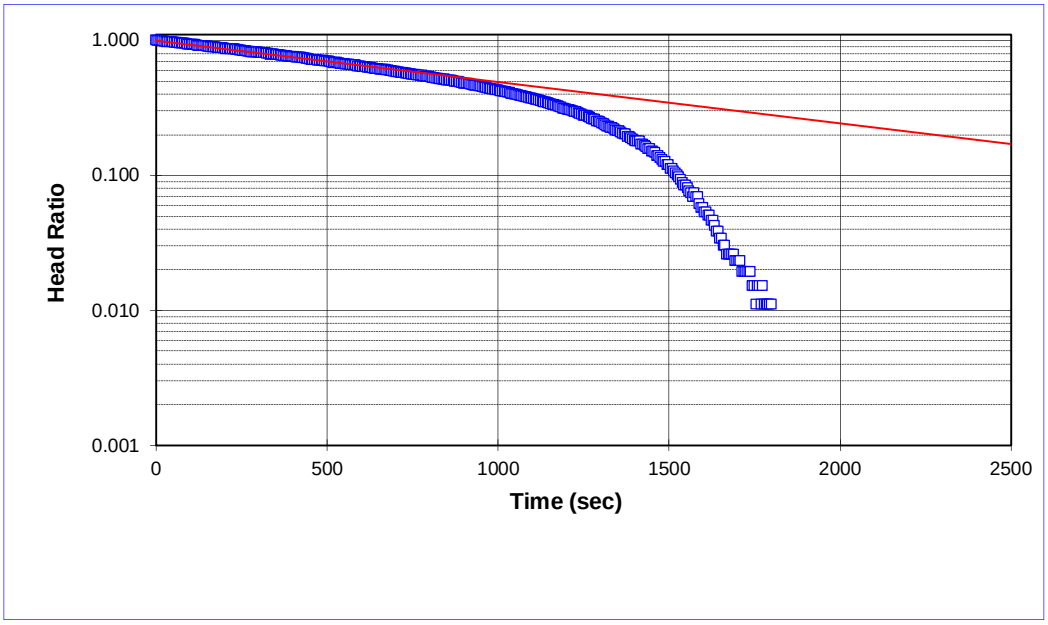
$$K = \frac{r_c^2}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right] \left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

where:
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS	
r_c =	**0.025**
R_e =	**0.102**
L_e =	**1.5**
t_1 =	**0**
t_2 =	**400**
h_1/h_0 =	**1.00**
h_2/h_0 =	**0.75**

RESULTS

K=	**4E-07**	**m/sec**
K=	**4E-05**	**cm/sec**



Project Name: Cavanagh/Carp Road
Project No.: 1543767
Test Date: 12/22/2015

Analysis By: CWT
Checked By: LEB
Analysis Date: 12/23/2015

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 15-5

INTERVAL (metres below ground surface)

Top of Interval =	**4.57**
Bottom of Interval =	**6.10**

$$K = \frac{r_c^2}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right] \left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

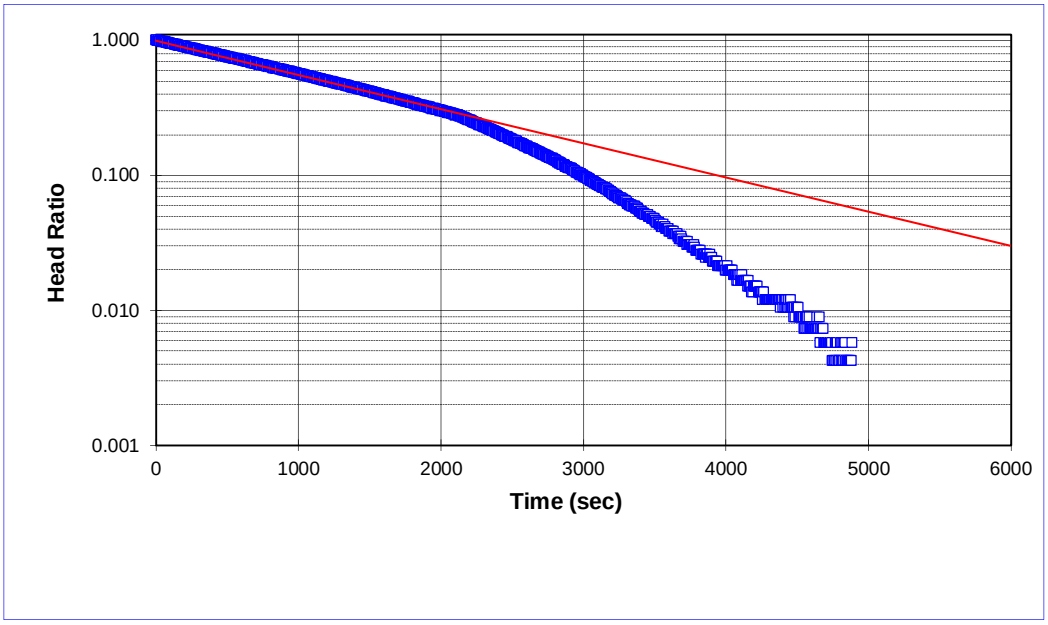
where:
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS

r_c =	**0.025**
R_e =	**0.102**
L_e =	**1.5**
t_1 =	**165**
t_2 =	**1475**
h_1/h_0 =	**0.91**
h_2/h_0 =	**0.42**

RESULTS

K=	**3E-07**	**m/sec**
K=	**3E-05**	**cm/sec**



Project Name: Cavanagh/Carp Road
Project No.: 1543767
Test Date: 12/22/2015

Analysis By: CWT
Checked By: LEB
Analysis Date: 12/23/2015

Golder Associates Ltd.

BOUWER AND RICE SLUG TEST ANALYSIS
RISING HEAD TEST 15-6

INTERVAL (metres below ground surface)

Top of Interval =	**3.30**
Bottom of Interval =	**4.82**

$$K = \frac{r_c^2 \ln\left(\frac{R_e}{r_w}\right)}{2L_e} \frac{1}{t} \ln\frac{y_0}{y_t}$$

where K=m/sec

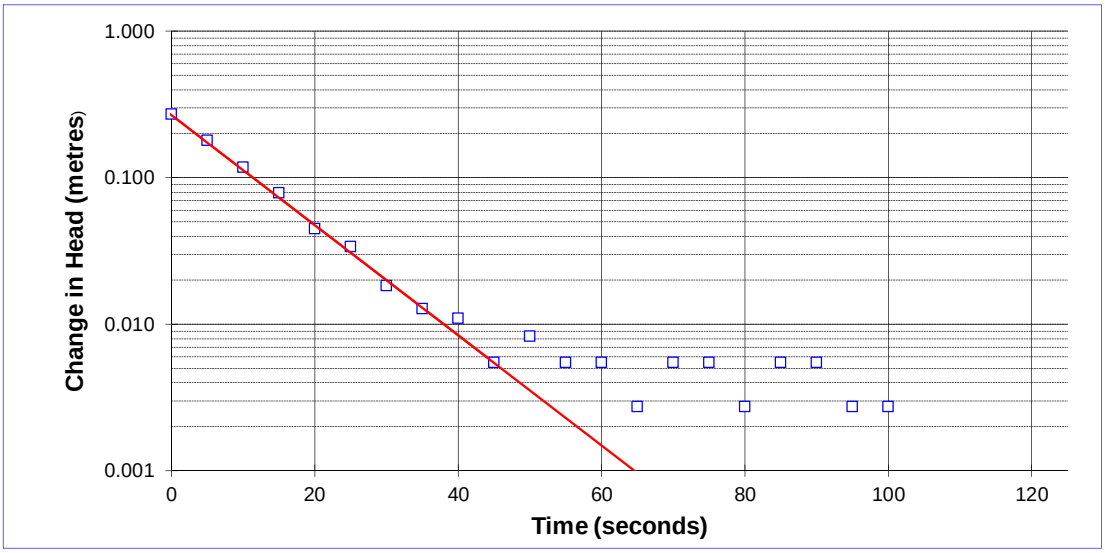
where:

r_c = casing radius (metres);
R_e = effective radius (metres);
L_e = length of screened interval (metres);
r_w = radial distance to undisturbed aquifer (metres)
y_0 = initial drawdown (metres)
y_t = drawdown (metres) at time t (seconds)

INPUT PARAMETERS	
r_c =	**0.060**
r_w =	**0.102**
L_e =	**1.47**
$\ln(R_e/r_w)$	**1.97**
y_0 =	**0.27**
y_t =	**0.01**
t =	**45.0**

RESULTS

K=	**2E-04**	**m/sec**
K=	**2E-02**	**cm/sec**



Project Name: Cavanagh/Carp Road
Project No.: 1543767
Test Date: 12/22/15

Analysis By: CWT
Checked By: LEB
Analysis Date: 12/23/2015

APPENDIX G

Septic System Information

WEST CARLETON

SEPTIC SYSTEM SITE EVALUATION

- ☐ CLASS 2 LEACHING PIT
- ☐ CLASS 3 CESS POOL
- ☒ CLASS 4 SYSTEMS
- ☒ ABSORPTION TRENCH CONVENTIONAL
- ☐ ABSORPTION TRENCH RAISED
- ☐ FILTER BED (ATTACH GRADING CERTIFICATE)
- ☐ PROPRIETARY SYSTEM

DESCRIBE

- ☐ CLASS 5 HOLDING TANK

TYPE OF ALARM ☐ AUDIO ☐ VISUAL

PUMP OUT CONTRACT ☐ ATTACH DOCUMENTATION

NAME Ken White Const LTD
(Name of Individual Preparing Site Evaluation)

ADDRESS P.O. Box 296

CITY Carp Ont

POSTAL CODE K0A 1L0

PHONE O ( ) 839-5460 H ( )

LICENCE # L1998-1654

DESIGN PARAMETERS

☐ NUMBER OF BEDROOMS - EXIST _____ PROPOSED 3

☐ BUILDING AREA GROSS

TOTAL ALL FLOORS - LIVING AREA 339 M²

☐ WATER SUPPLY - DUG WELL ☐

- SAND POINT ☐

- CASED WELL (min 6M) ☒ Proposed

SEPTIC SYSTEM DESIGN

6000L TANK SIZE

_____ PROPRIETARY TREATMENT SYSTEM

DESCRIBE _____
(ATTACH MANUFACTURERS INFORMATION)

18.75 LENGTH DISTRIBUTION PIPING EACH RUN

8 NUMBER OF RUNS

150 TOTAL LENGTH OF DISTRIBUTION PIPING

3000L DAILY FLOW RATE

MINIMUM LOADING AREA

MINIMUM CONTACT AREA

TANK TYPE CONCRETE ☐ MANUFACTURER

PLASTIC ☐ Boucher Pre-Cast

OTHER ☐ MODEL

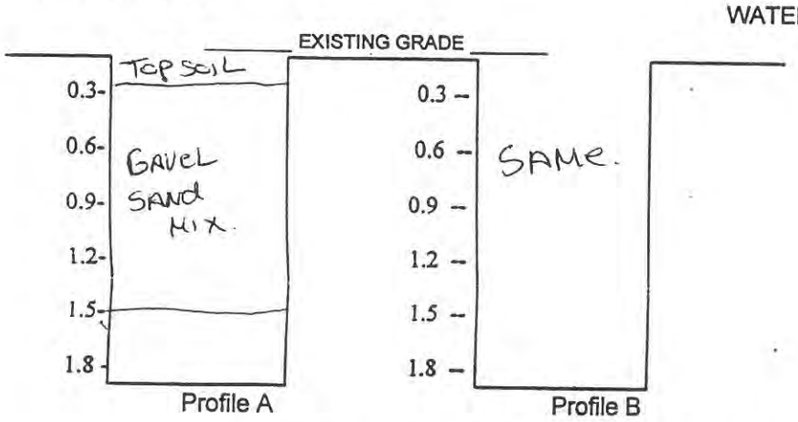
DESCRIBE _____

☐ PUMP REQUIRED MANUFACTURER
(ATTACH MANUFACTURER SPECS AND INSTALLATION INSTRUCTIONS)

PLUMBING FIXTURES	EXIST	PROPOSED		FIXTURE UN
Bathroom Group (3 PCs)		3	X 6	18
Bathtub/Shower		0	X 1.5	
Basin (Lavatory)		0	X 1.5	
Toilet		0	X 4	
Bidet		0	X 1.0	
Sink		1	X 1.5	1.5
Dishwasher		1	X 1.5	1.5
Laundry Tub		1	X 1.5	1.5
Auto Washer		1	X 1.5	1.5
Water Softener		0	X	
Other				
TOTALS		7		24

NOTICE: Depth to bedrock/watertable and description of soil type are to be shown for both profiles. TWO test locations are required of BURIED beds.

SOIL PROFILES



IDENTIFY SOIL TYPE, LAYERS AND DEPTHS, WATER TABLE AND ROCK

The percolation rate shall be determined by test **OR** soil classification, according to the unified soil classification syste

T Time .....

Native Soil .....10.....

Imported Soil .....10.....

TOWNSHIP OF WEST CARLETON

DESIGN REVIEW
CLASS 4 SEPTIC SYSTEM

Permit No. 99-0249 **Date** JULY 2/99
Plan review By T. USHER
Owner R. RUMP
Applicant copy _____ Office copy ✓

Calculate daily design flow Additional flows

1 bedroom 750 litre — additional bedrooms 500 litre each
2 bedroom 1100 litre — additional bldg area exceeding 200m2 100 litre / 10m2
(3) bedroom 1600 litre — additional fixture unite exceeding 20 50 litre each fixture unit
4 bedroom 2000 litre
5 bedroom 2500 litre

Daily design flow
< 10,000 litre/ day ✓ > 10,000 litre/ day _____

Number of bedrooms 3 — 1600 litres
Additional Flows Building Area 139 m2 — 1400 litres (339 m² > 200 m²)
Additional Flows Fixture Units 4 FU — 200 litres (24 > 20)
1600+1400

1 **Total daily design flow** 3000 litres

✓2 Size treatment unit septic tank — Proposed 6000
2 x daily design flow res ✓ 3x non-res ___

2 **Min Septic tank size** 6000 litres

3 Type of leaching bed (check one)
Absorption trench
Raised bed _ Partially raised bed _ (Buried Bed) _ Raised bed _ Partially raised bed _ Buried bed _

Filter media

Proprietary treatment units
Manufacturers installation Instructions or Ministry Guidelines, BMEC or Buildings Branch Opinion

✓4 Size distribution pipe
T time > 2 < 20 min / cm — L = QT / 200 — 1:10
T time >20 < 50 min / cm — L = QT / 300
Length of distribution pipe 150 m

Daily design flow
<5000 litre/ day _____ > 5000 litre/ day ___

Daily design flow
< 3000 litre > 3000 litre Secondary or tertiary treatment ___

Minimum 2 beds

5 Bed loading 6 litre / m2 **Bed loading Area** Proposed ____m2 500 m²
✓6 Bed size — No. of runs 8
Length of runs 18.75 m

✓7 Distribution piping > 150 metres
requires dosing pump and chamber
Determine dosage volume 75% of distribution piping Volume dia. X length — **Dosage Volume** _____ litres
PROPOSED 150 m > 150 m

4 Size bed effective area
Maximum 75 litre/ m2/ day ___ Maximum 50 litre/ m2/ day ___
proposed _____m2 **Min bed area** _____m2
Bed size minimum 10 m2 maximum 50 m2 area

✓8 Required — Proposed
900 mm to rock, water table or impervious soil — 900 mm
40 metre minimum total piping length — 150 mm
30 metre maximum run length — 18.75 mm
500mm to 1000mm trench width — 500 mm
600 to 900 depth of trench — 600 mm
1.6 metre minimum trench spacing — 1.6 mm

5 Size contact area A= QT / 850
Minimum contact area _____m2

6 750 mm x min bed area **Size volume of filter sand** _____m3
45.36 kg per ft3 1602kg per m3 _____kg
7 **Size mantel contact area** Daily design flow / 4 litre / m2 _____m2

Raised beds fill material mantel T time
minimum 75 % of leaching bed soil

8 Distribution piping maximum spacing 1.2 metre
evenly spaced with ½ space at bed edges
_____mm 750 mm filter sand below stone
_____mm 250 mm material depth below filter sand where on rock or impervious soil

BURIED BED

~~9 Raised beds mantel minimum 15 metre extension in direction of natural drainage~~
~~250 mm depth of material~~ **Length of Mantle Extension** _____m

10
300 to 600 mm topsoil over stone — 300 mm
Paper over stone — YES
50 mm stone over tiles — 50 mm
75 mm minimum tile diameter — 75 mm
150 mm minimum stone depth below tile — 150 mm
Slope of pipe minimum 30 mm maximum 50 mm / 10 metre — 36.25 mm to 73.75 mm
No slope required on filter beds

~~11 Increase clearances for raised beds~~ 2 x _____ _____ m

12 Clearances Required — Clearances Actual

Treatment unit to structure 1.5 metre — 1.5 m
2 x bed height above existing grade
Treatment unit to potable water supply
- drilled wells cased to 6 metre — 15 metres — 15 m
- Surface wells sand points and dug wells — 15 metres — ~~15~~ m
- drilled wells — 15 ~~30~~ metres — 15 m
- Surface wells, sand points and dug wells — 30 metres — ~~15~~ m

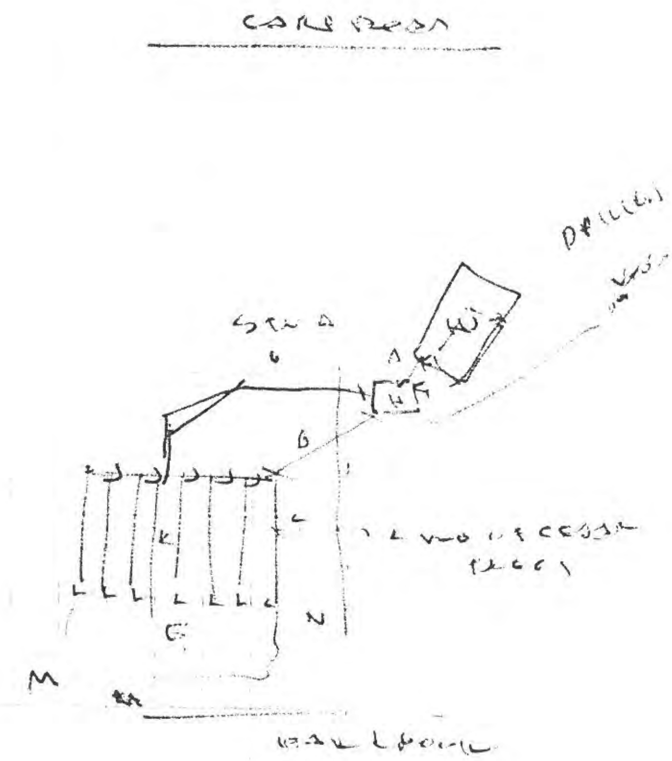
Tile bed to water supply
Tile bed to Property lines — 3 metres — 3 m
Tile bed to Bodies of water — 15 metres — 15 m
Tile bed to Trees — 3 metres — 3 m
Tile bed to structures 5 metres — 5 m
~~Mantel slopes minimum 4:1~~ BURIED — _____ m

Total Mantel width _____ m

13 Design conforms to regulation ✓ Design does not conform to regulation _____

14 Required Inspections
1. Test pit
2. Scarify clay
3. Septic system installation
4. Final grading

PUMP
CARR ROAD
DEC 8/99



TANK ~~[illegible]~~
MAX CONC
MANY BOULDERS
SIZE GOOD
BAFFLES

ABSORPTION TRENCH BED HIGH
8 RUNS
LENGTH OF TILE 18.8m

A HOUSE TO TANK 4.18m
B TANK TO TILE 13.94m
C TILE TO TREES 8.1m
D TANK TO WELL 155m +-
E MANTLE EXT — NOT INSTALLED

SLOPE 188 18.8
3 5
56.4 90.0
56.4 – 90 mm RANGE

END OF TILE 1.035
HEADER 0.96
.075 m

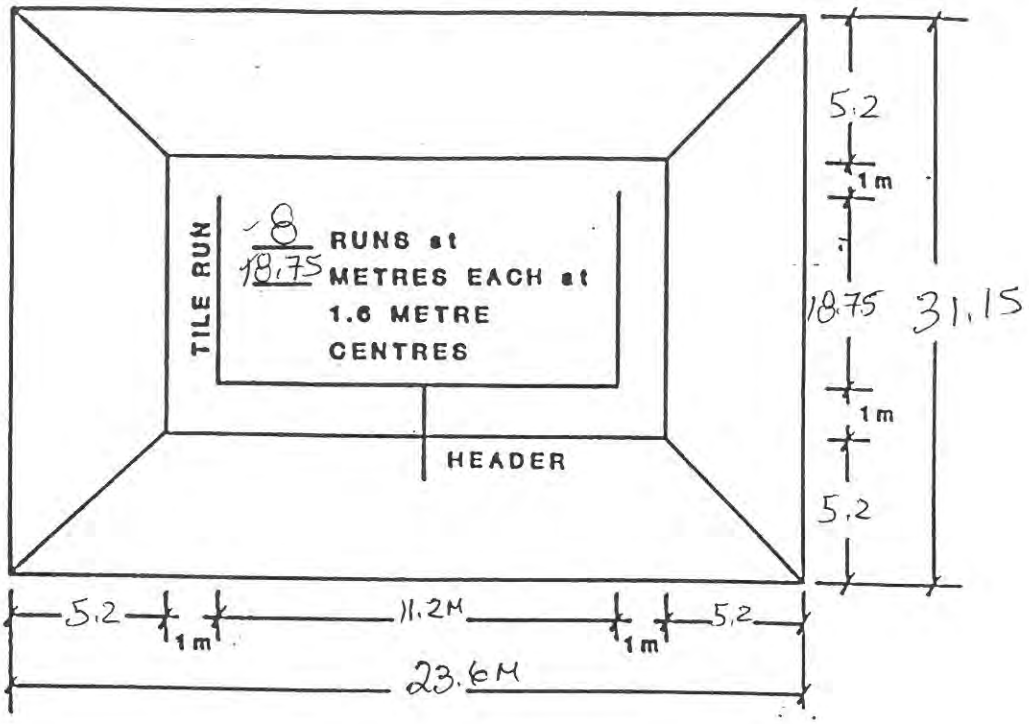
F TOP FOUND. 0.47
G TOP INLET — NOT INSTALLED
H TOP TANK 0.64
I TOP OUTLET 0.825
J TOP HEADER 0.96
K TOP SAND BED 1.235
L TOP END TILE 1.035
M TOP EXIST. GRADE 2.48
N EXIST. GRADE 1.965

DEPTH OF SAND
EXIST GRADE 2.48
TOP OF SAND 1.235
1.245 m

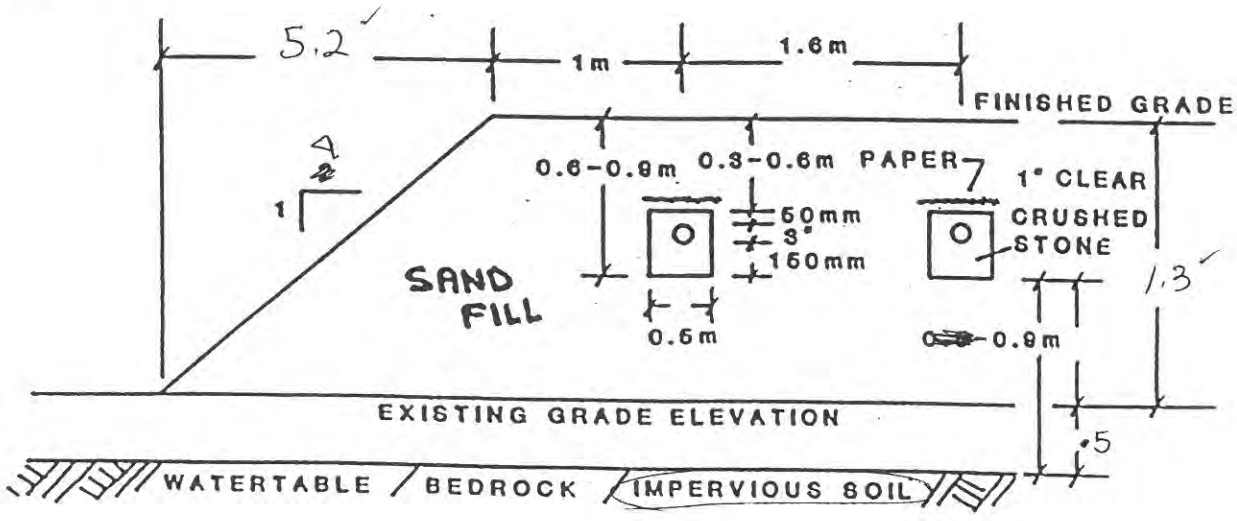
1.5 m MANTLE EXT
ACCESS TO TANK LIDS PLACE
INLET PVC TO TANK
REPAIR ON TILE

TYPICAL DRAWING B
RAISED TILE BED – ABSORPTION TRENCH METHOD

PLAN



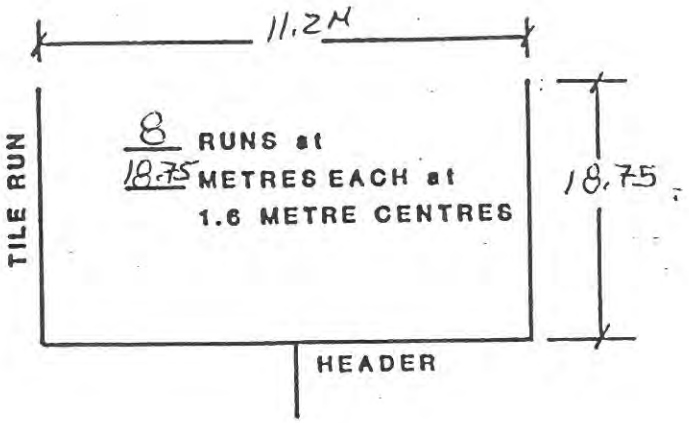
PROFILE



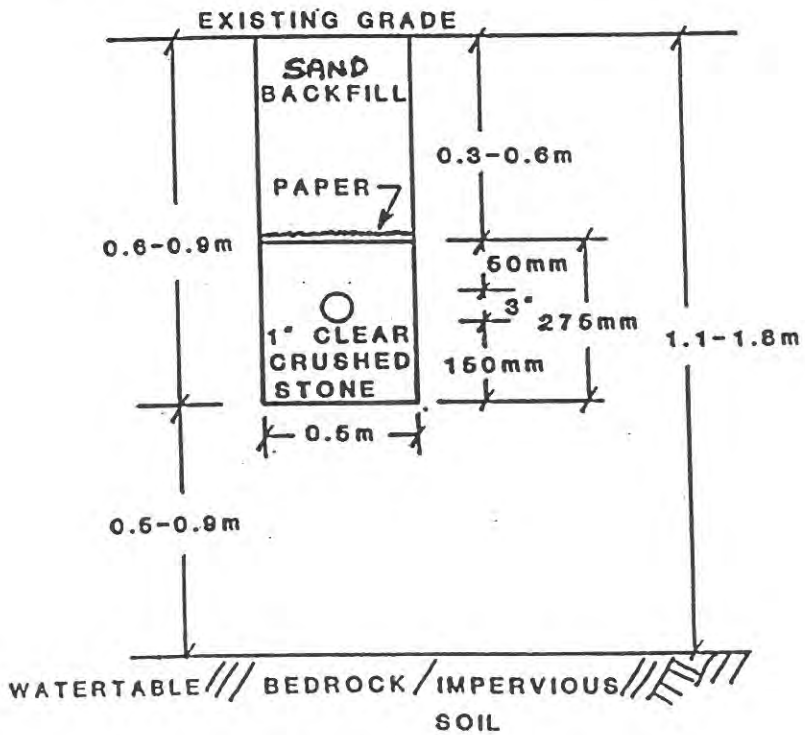
TYPICAL DRAWING A

BURIED BED-ABSORPTION TRENCH METHOD

PLAN



PROFILE



END VIEW

TOWNSHIP OF WEST CARLETON

Construction Site Inspection Report

Permit Number 99-0219 Date of Inspection DEC. 8, 1999
Civic Address 2596 CARP RD. Owner RUMP
Contractor K. WHITE CONST. LTD. Inspector R. MOORE
Weather _____ Time 9^45

Inspection

Building		Plumbing		Septic		Other	
Site	☐	Underground	☐	Site	☐	Pool Enclosure	☐
Excavation	☐	Sanitary Sewer	☐	Scarification	☐	Wood Appliance	☐
Foundation	☑ FO	Rough In	☐	Installation	☑	Chimney	☐
Framing	☐	Completion	☐	Final Grading	☐	Heating	☐
Insulation	☐						
Progress	☐						
Occupancy	☐						
Final	☐						

Inspection Status

Passed	☐
Passed with Conditions	☑ SEPTIC
Not passed	☑ FOUND
Do Not Cover	☐
Call For Reinspection	☐

832-5644 (224)

Inspection Remarks

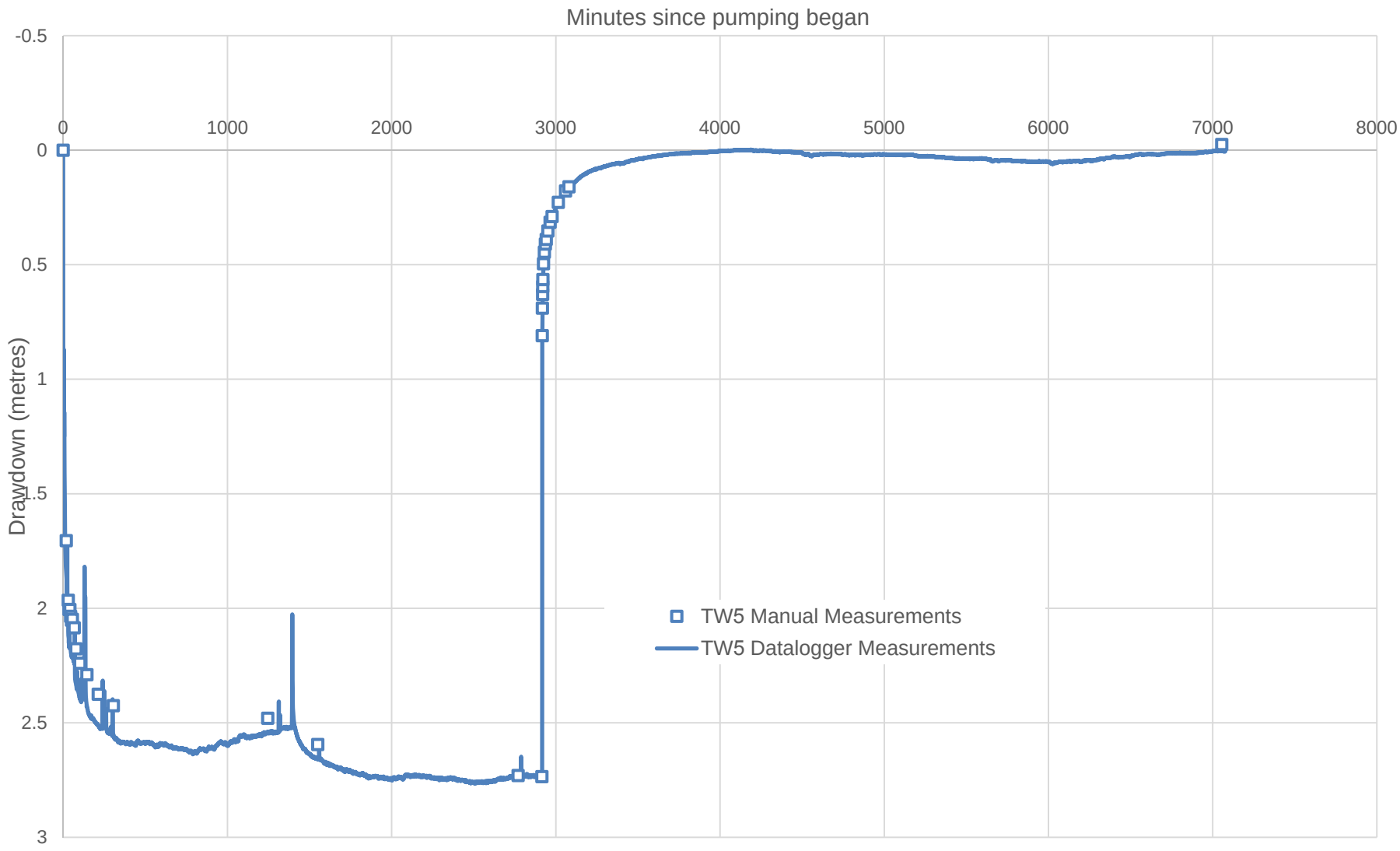
1. FOUNDATION INSPECTION NOT PASSED
ITEMS NOTED AUG 20/99 OUTSTANDING
2 ENG DWGS SIDE WALL OPENING
3 FILLING HONEYCOMBED CONCRETE
4 DAMPROOFING NOT INSTALLED
4 DRAINAGE TILE INSTALLATION
5 FROST PROTECTION FOOTING @ SIDE ENTRY

2 SEPTIC - MANTEL EXTENSION ISN
3 ACCESS TO TANK - LIDS FROZEN
4 PAPER ON TILE
5 INLET PIPE TO TANK NOT INSTALLED - FULLY BED, INSPECTION PRIOR TO COVER

BB.

APPENDIX H

Pumping Test Results and Analysis



CLIENT
CAVANAGH DEVELOPMENTS

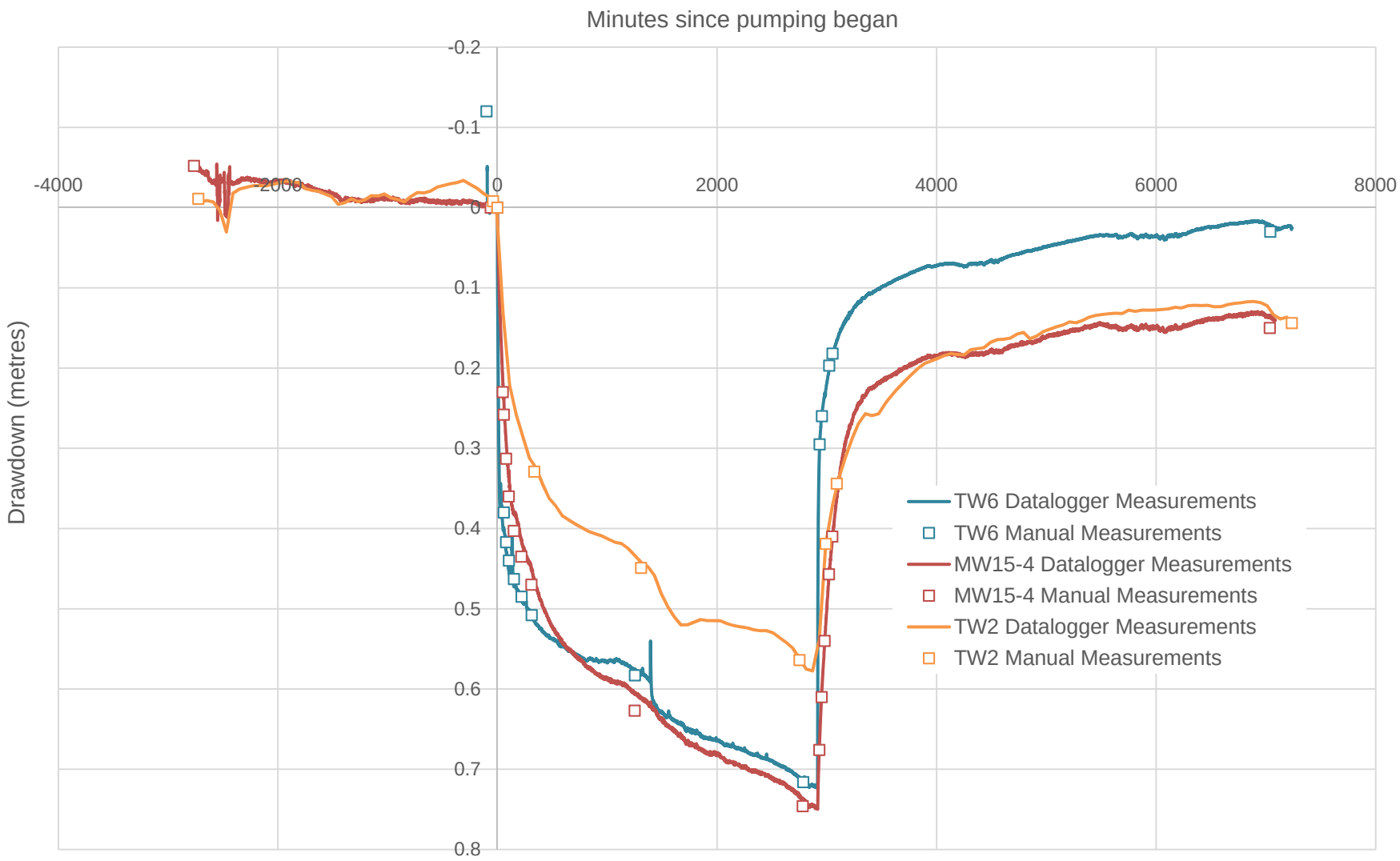
CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW5 (PUMPING WELL)

PROJECT No. **1543767**
Rev.
FIGURE **H-1a**



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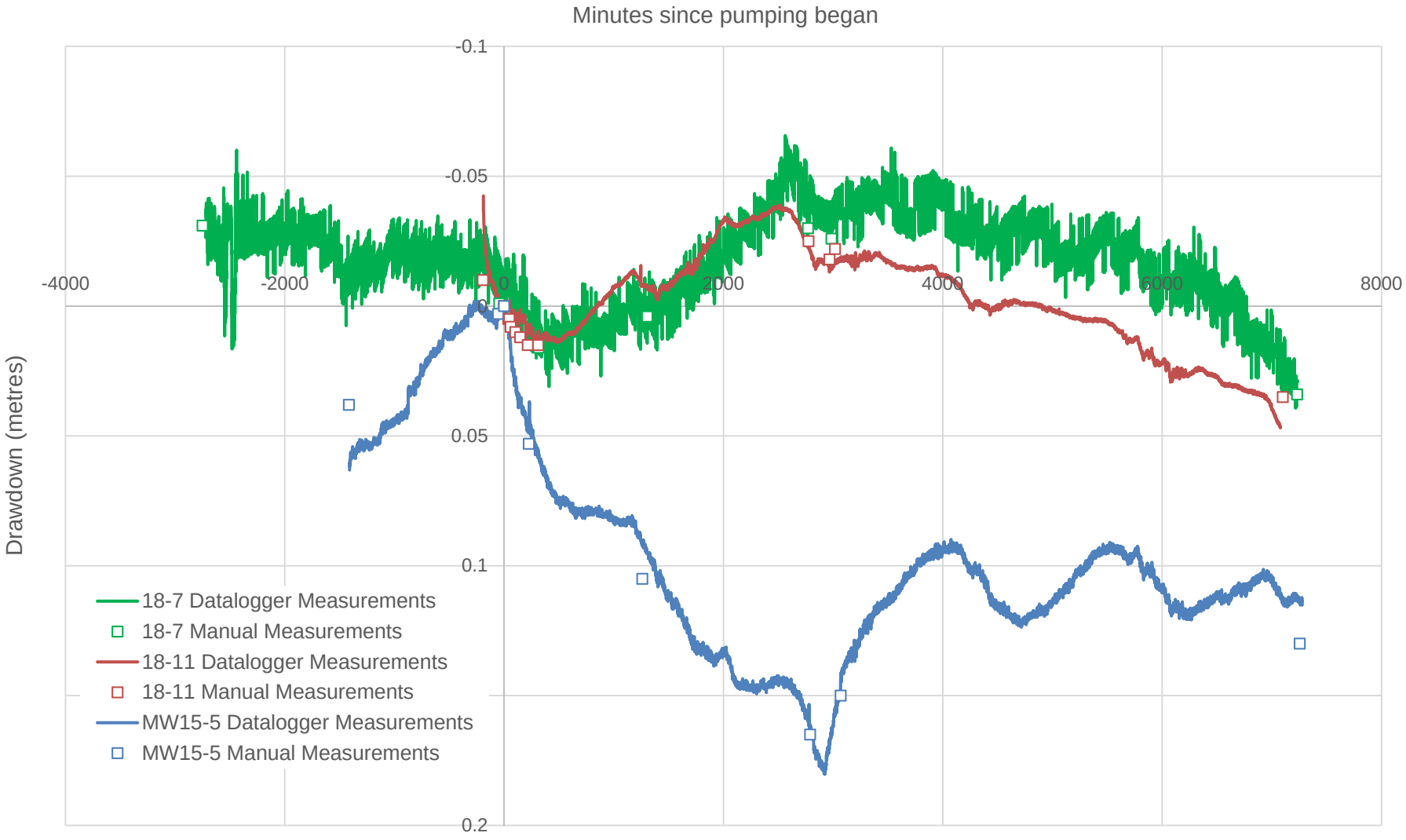
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW5 (TW2, TW6 AND MW15-4)

PROJECT No. **1543767**
Rev.
FIGURE **H-1b**



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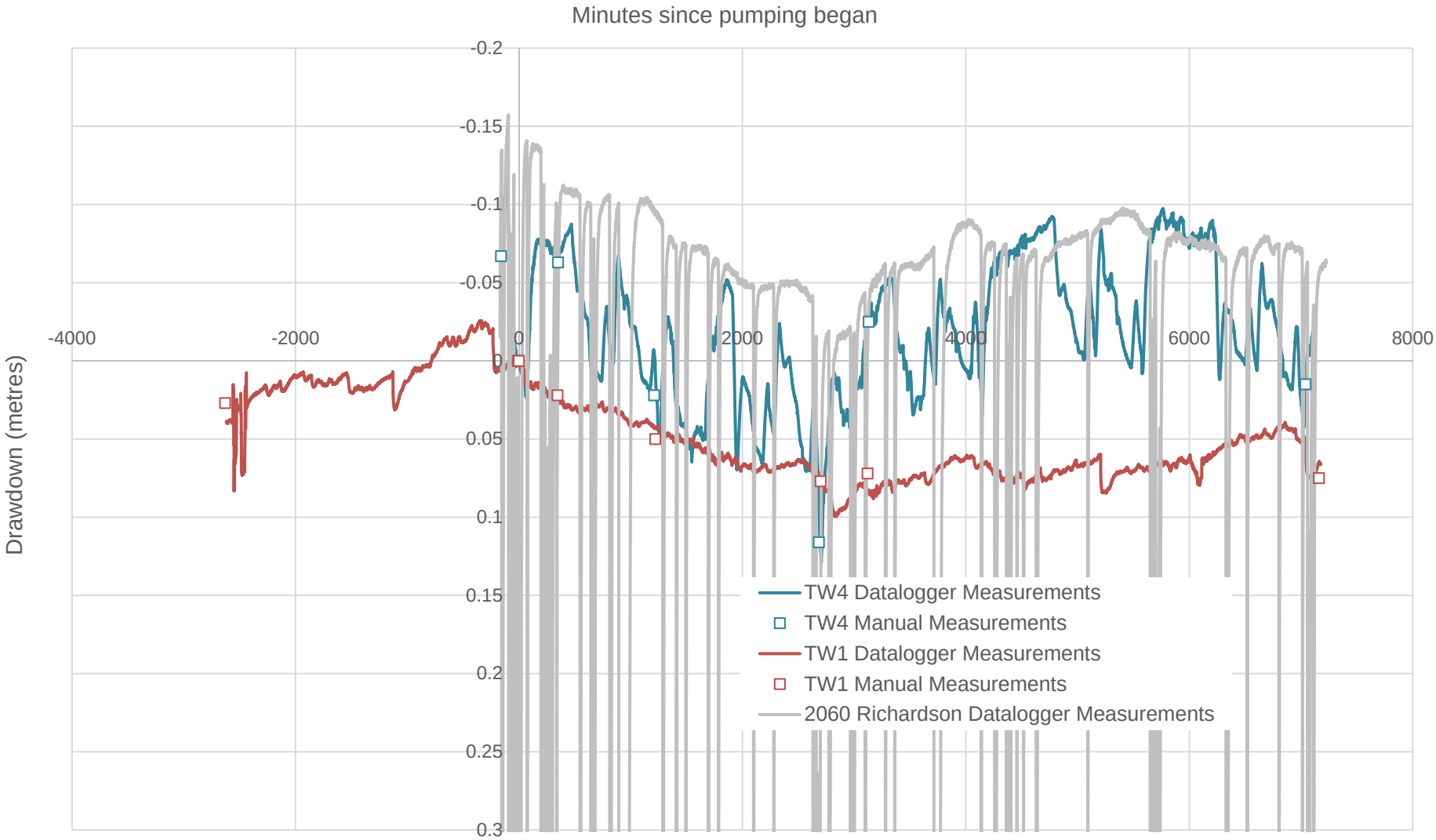
PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW5 (MW18-7, MW18-11 AND MW15-5)

PROJECT No. **1543767**
Rev.
FIGURE **H-1c**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



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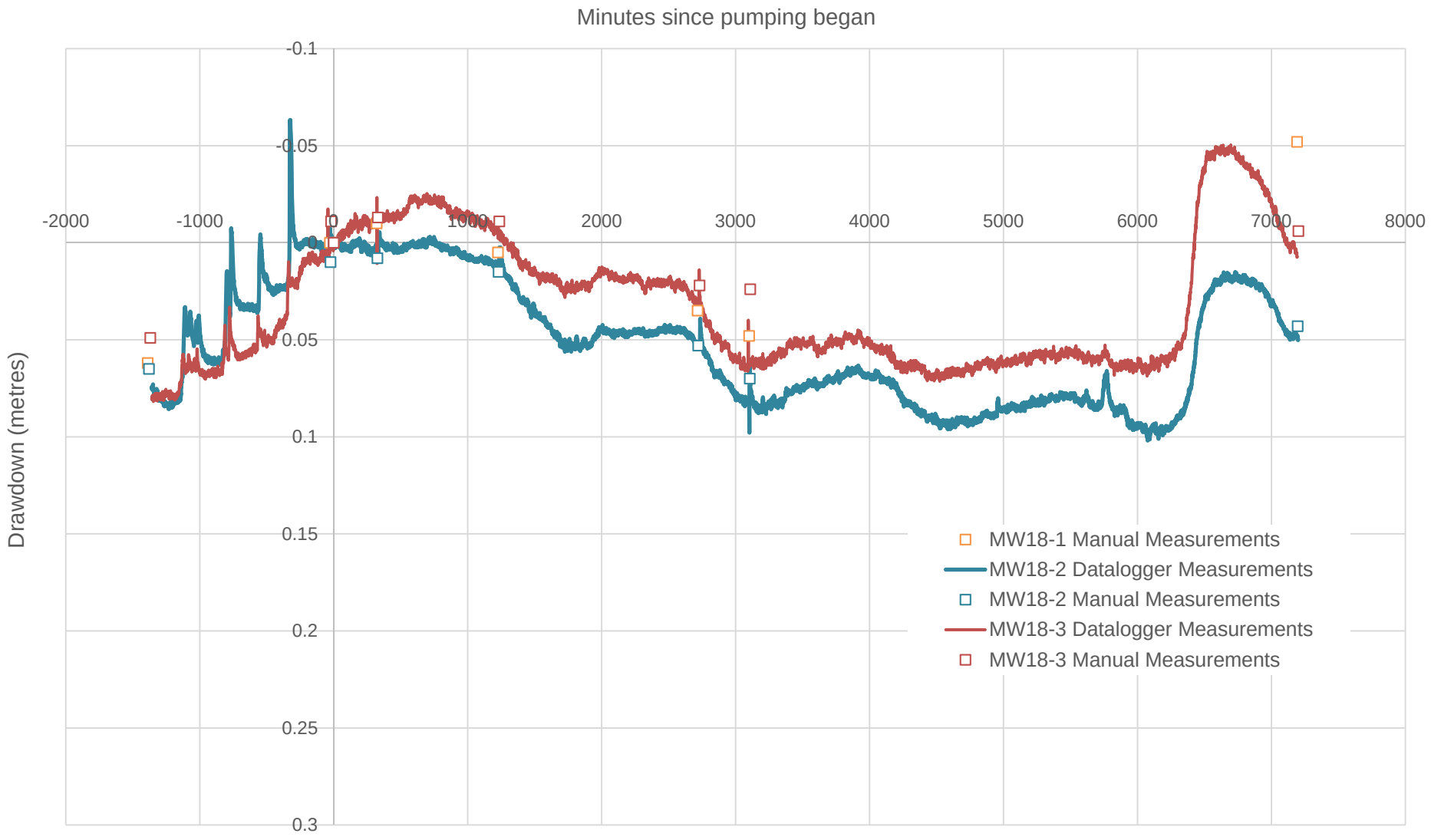
YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW5 (TW1, TW4 AND 2060 RICHARDSON SIDE ROAD)

PROJECT No. **1543767**
Rev.
FIGURE **H-1d**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0



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YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

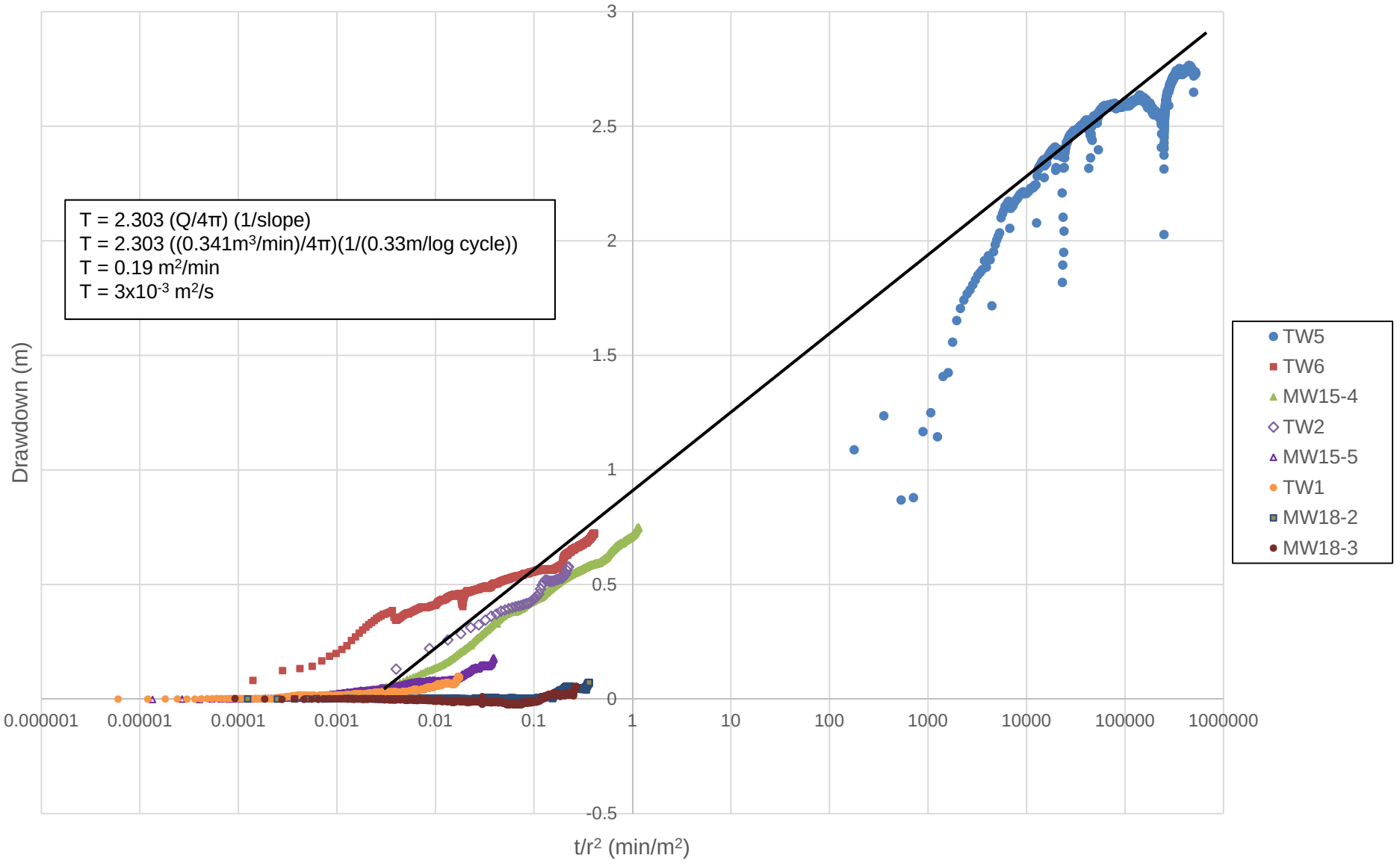
TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW5 (SHALLOW MONITORS MW18-1, MW18-2, MW18-3)

PROJECT No. **1543767**

Rev.

FIGURE **H-1e**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0



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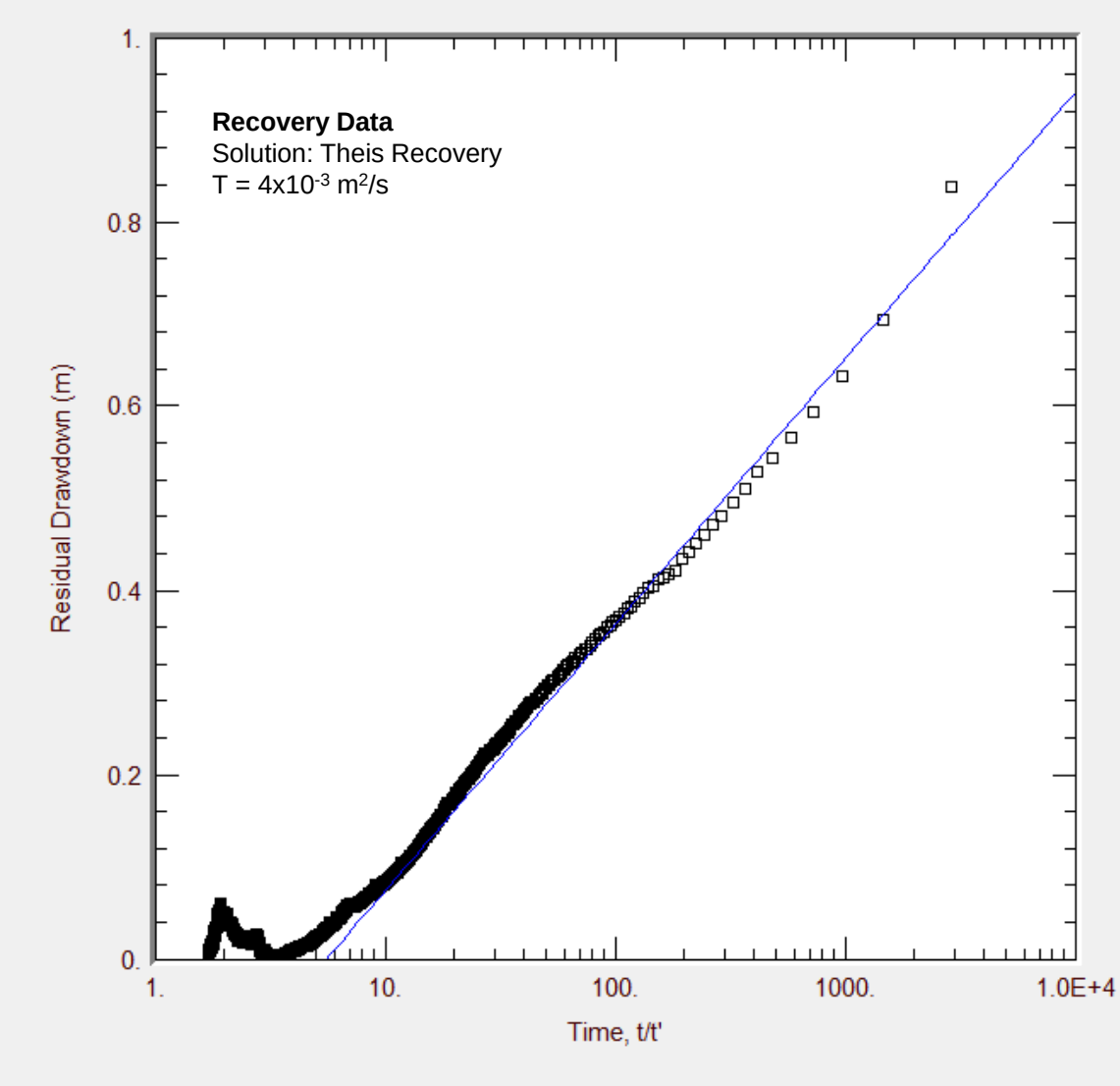
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
COOPER-JACOB STRAIGHT-LINE COMPOSIT ANALYSIS
WATER LEVEL RESPONSE DURING PUMPING AT TW5

PROJECT No. **1543767**
Rev.
FIGURE **H-1f**



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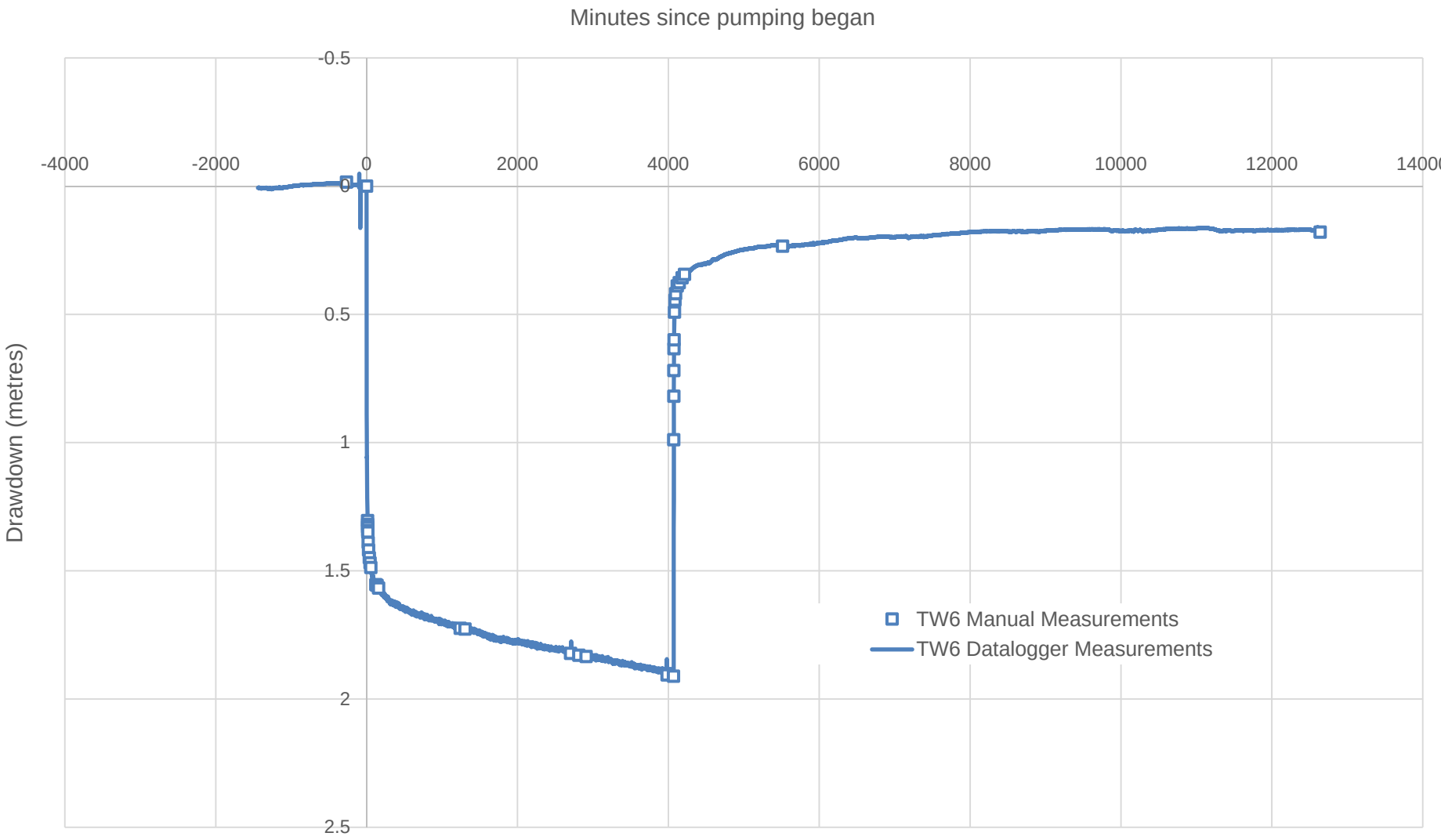
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
RECOVERY DATA ANALYSIS
PUMPING AT TW5

PROJECT No. **1543767**
Rev.
FIGURE **H-1g**



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CAVANAGH DEVELOPMENTS

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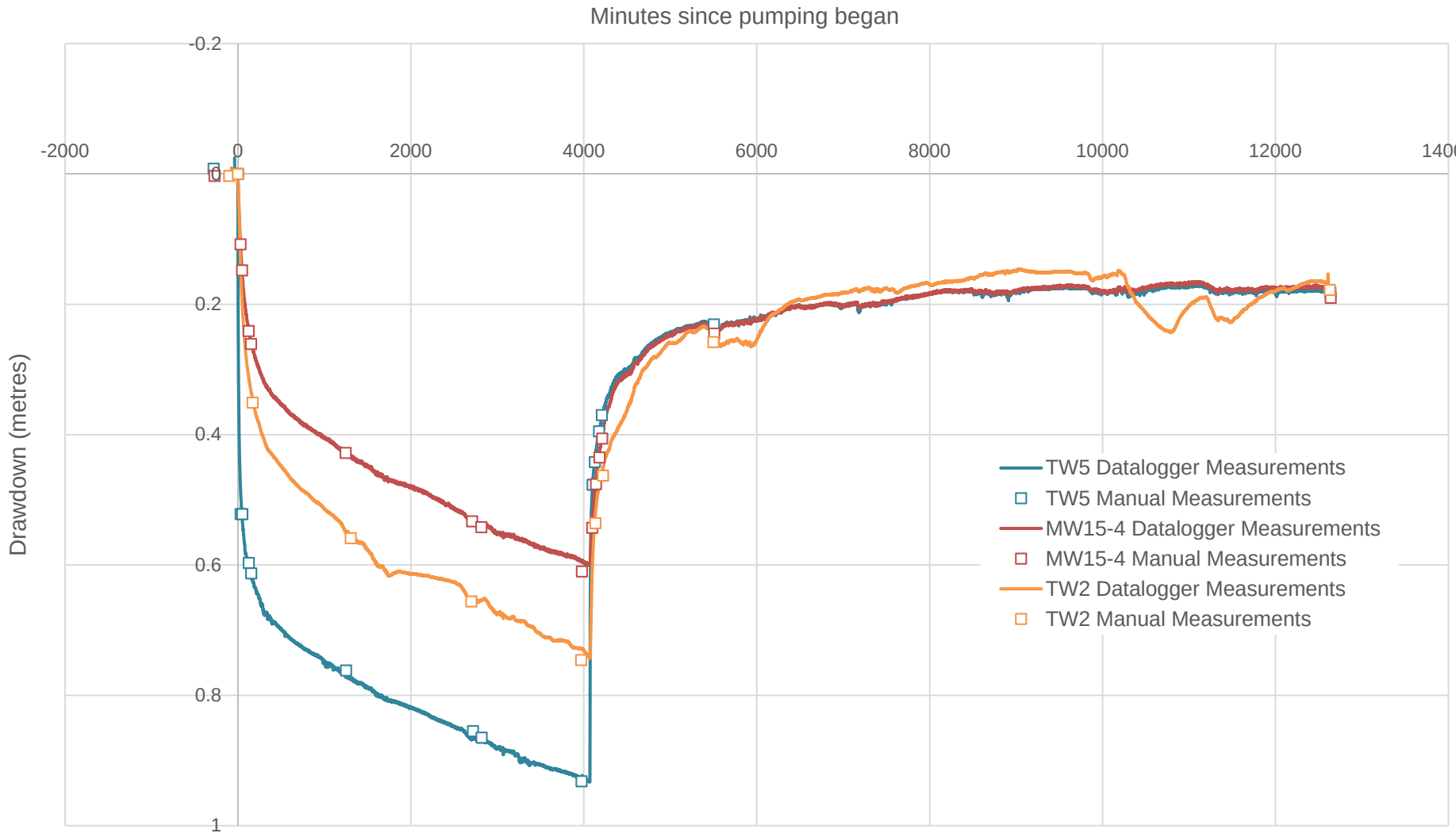
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW6 (PUMPING WELL)

PROJECT No. **1543767**
Rev.
FIGURE **H-2a**



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CAVANAGH DEVELOPMENTS

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GOLDER

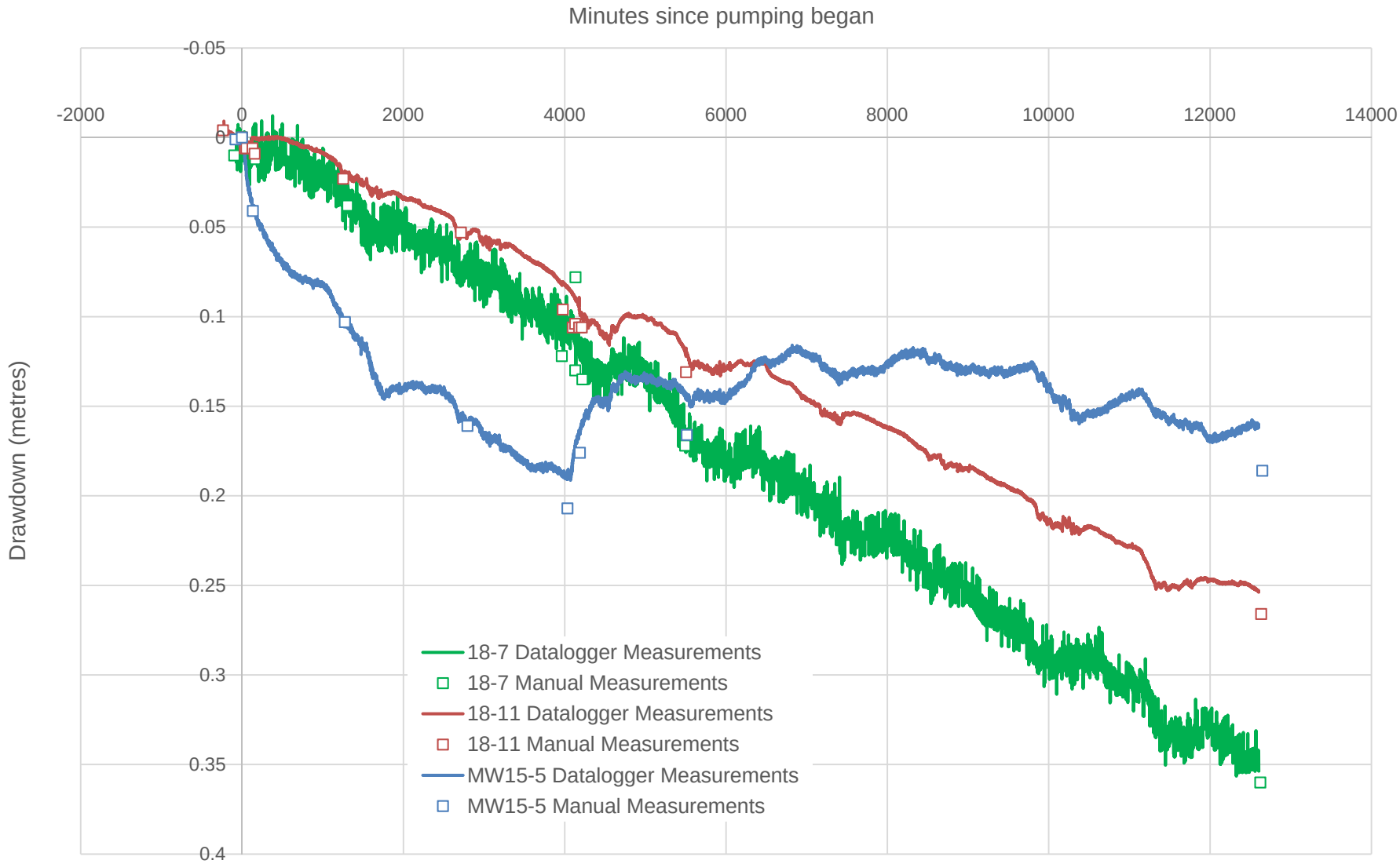
YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW6 (TW2, TW6 AND MW15-4)

PROJECT No. **1543767**
Rev.
FIGURE **H-2b**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: A/B/I/A
1 in
0



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CAVANAGH DEVELOPMENTS

CONSULTANT
GOLDER

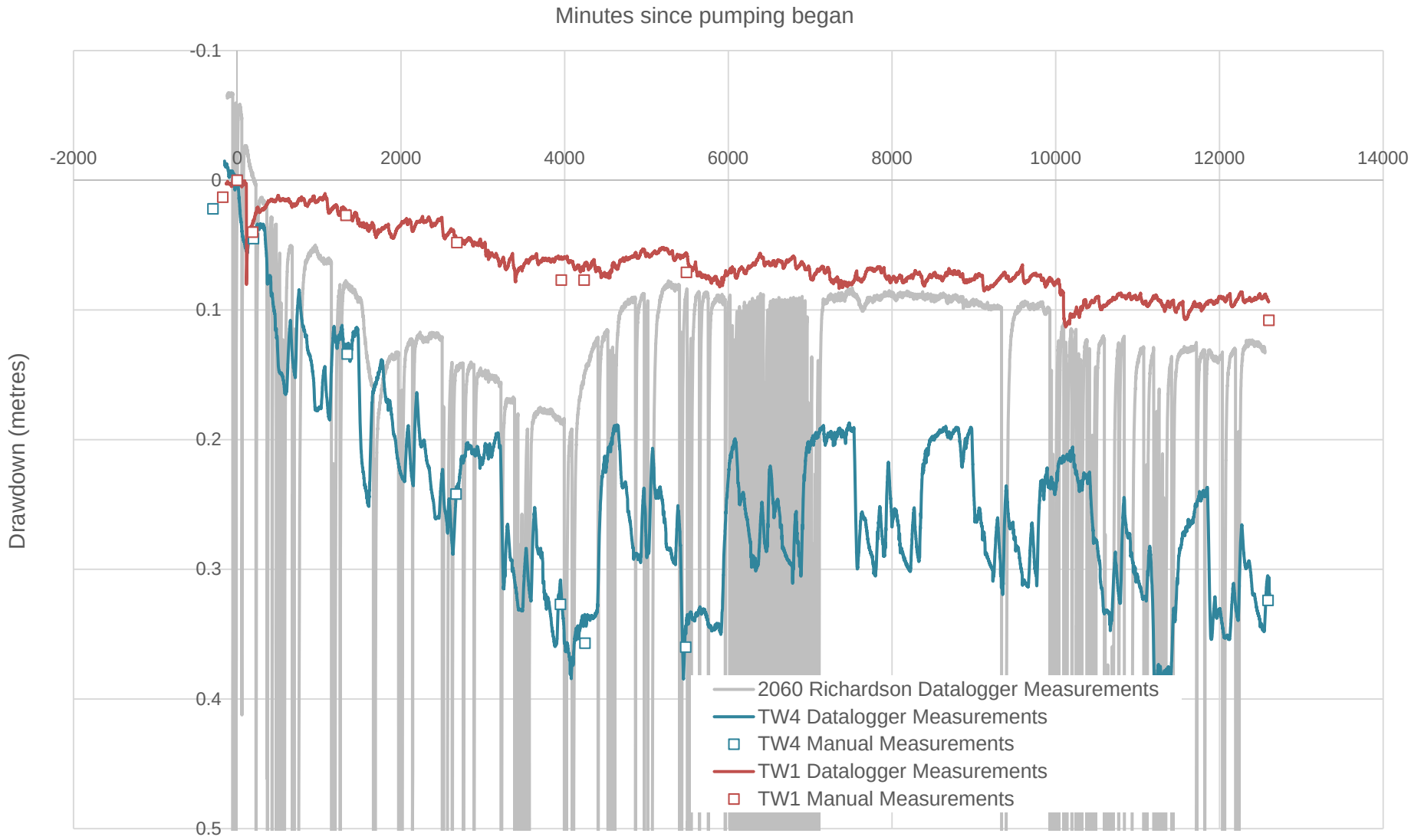
YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW6 (MW18-7, MW18-11 AND MW15-5)

PROJECT No. **1543767** | Rev. | FIGURE **H-2c**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



CLIENT
CAVANAGH DEVELOPMENTS

CONSULTANT
GOLDER

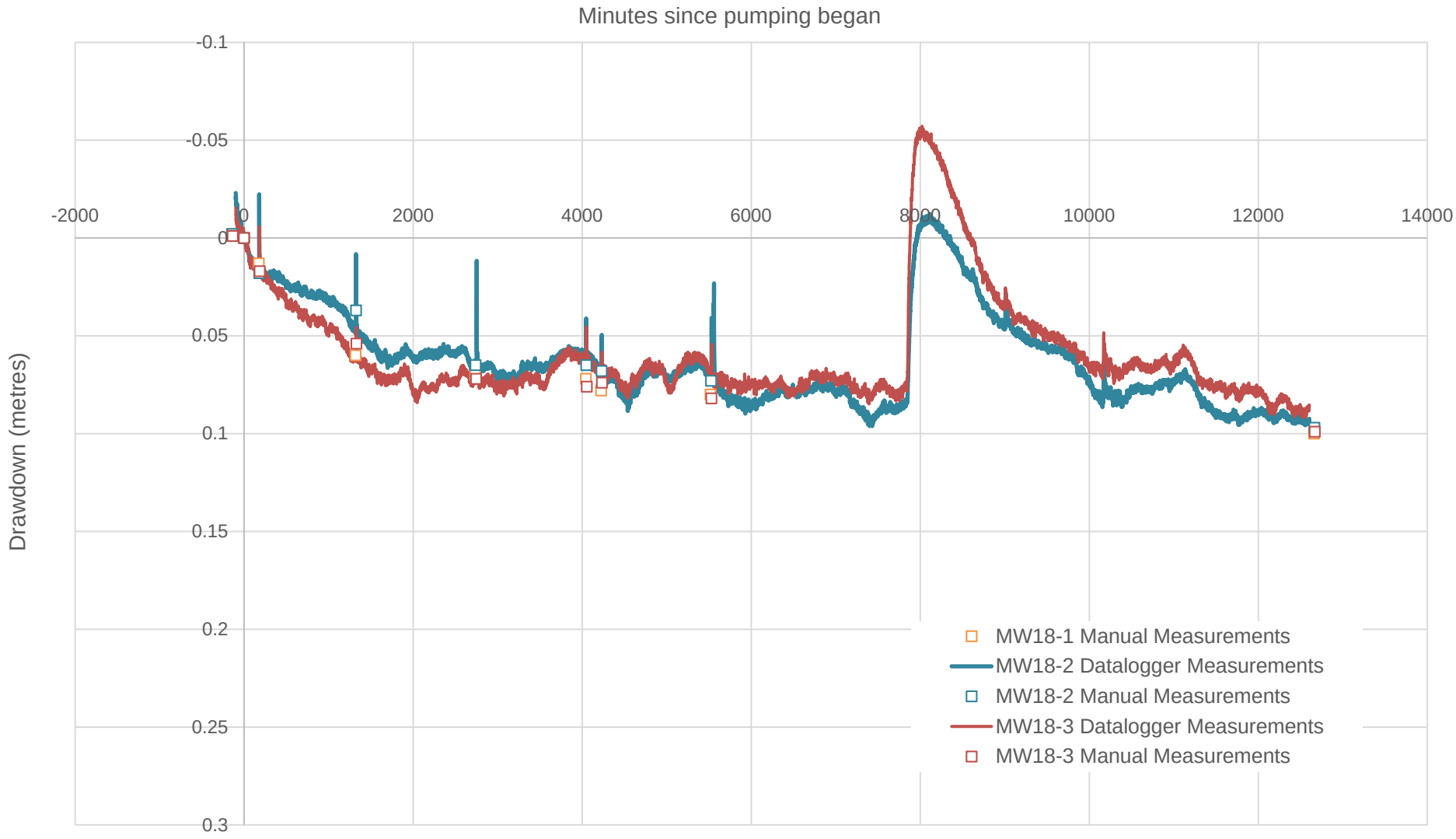
YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW6 (TW1, TW4 AND 2060 RICHARDSON SIDE ROAD)

PROJECT No. **1543767**
Rev.
FIGURE **H-2d**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0



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CAVANAGH DEVELOPMENTS

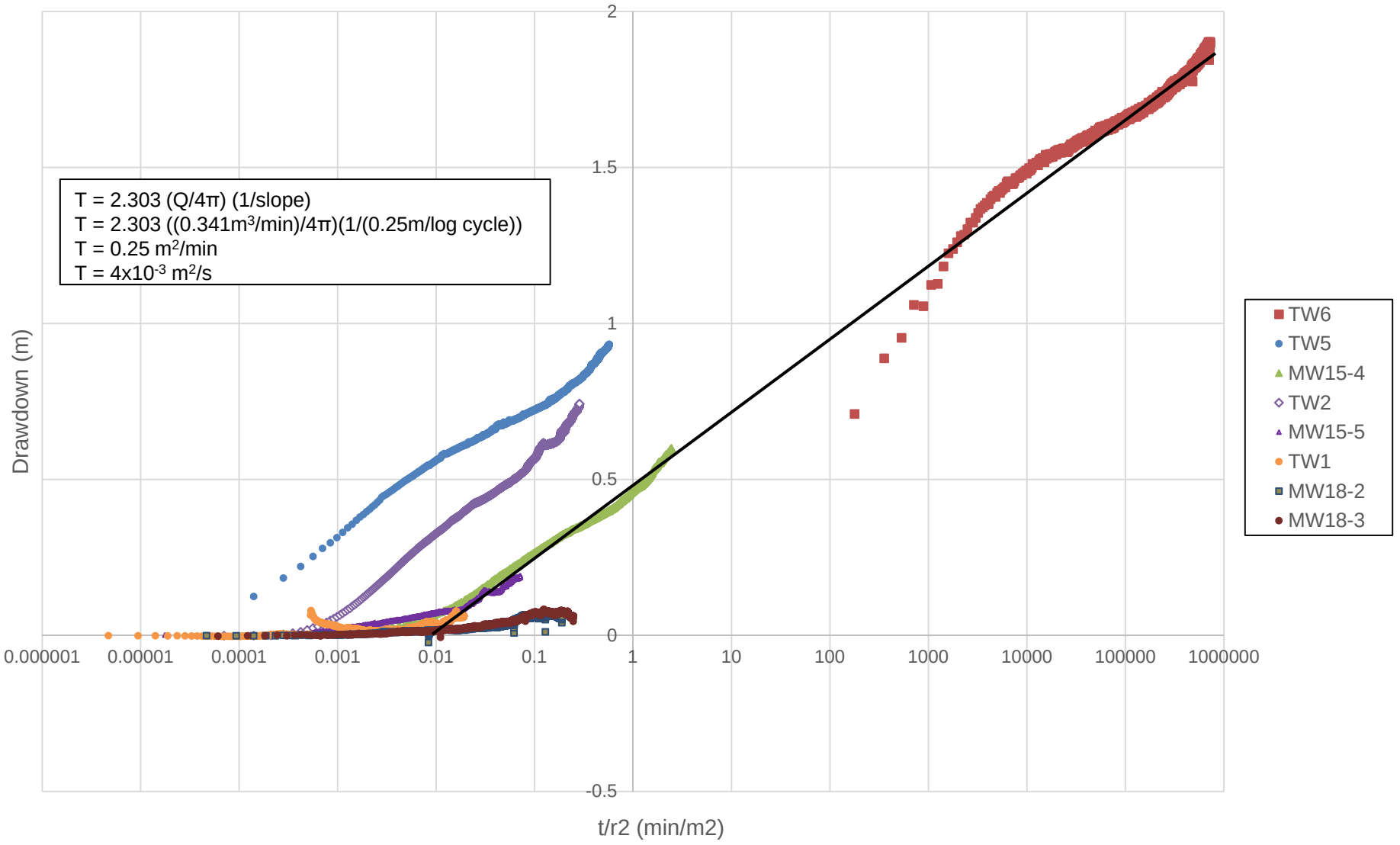
CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW6 (SHALLOW MONITORS MW18-1, MW18-2, MW18-3)

PROJECT No. **1543767**
Rev.
FIGURE **H-2e**



CLIENT
CAVANAGH DEVELOPMENTS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

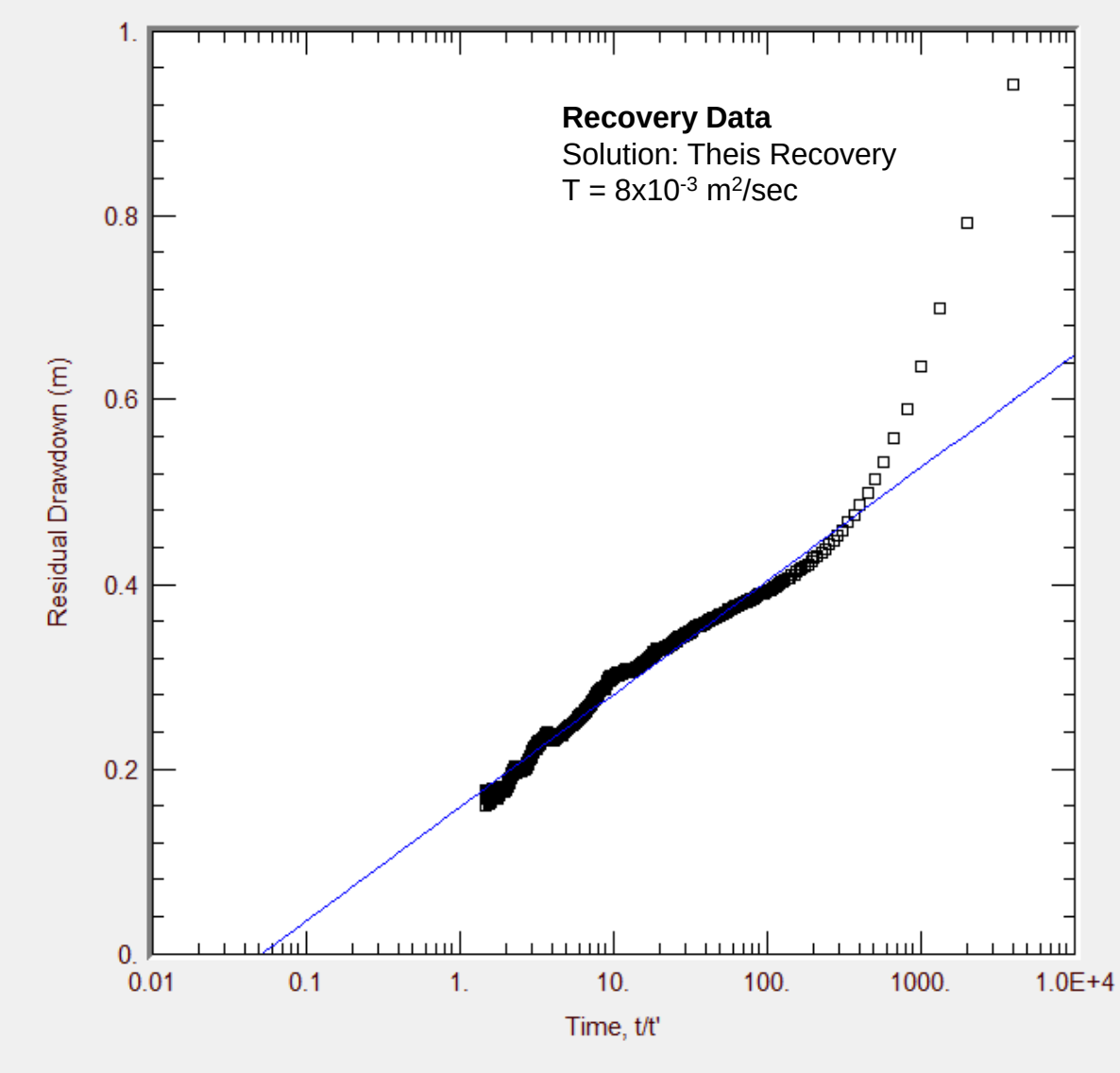
PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
COOPER-JACOB STRAIGHT-LINE COMPOSIT ANALYSIS WATER LEVEL RESPONSE DURING PUMPING AT TW6

PROJECT No. **1543767**

Rev.

FIGURE **H-2f**



CLIENT
CAVANAGH DEVELOPMENTS

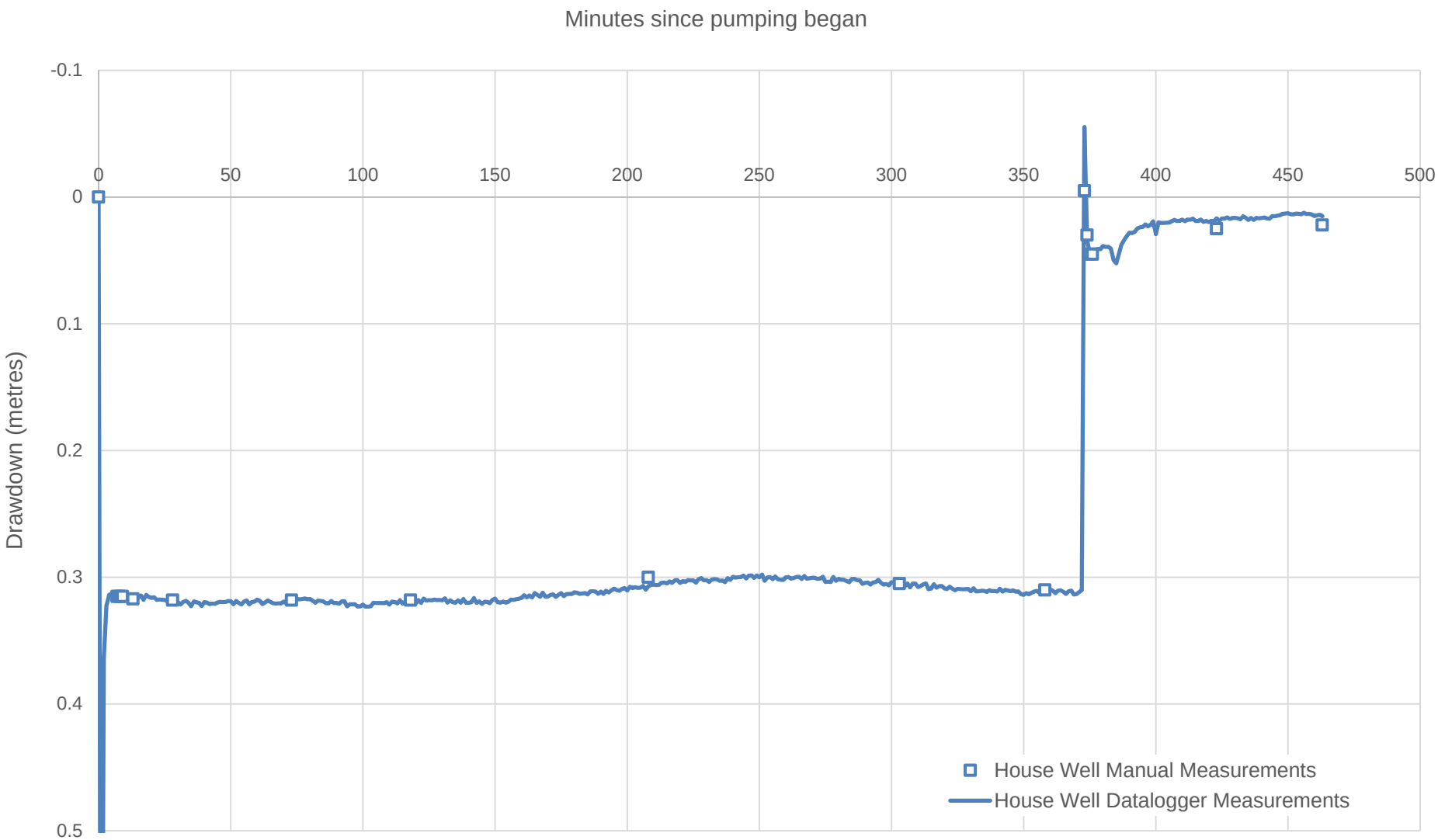
CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
RECOVERY DATA ANALYSIS
PUMPING AT TW6

PROJECT No. **1543767**
Rev.
FIGURE **H-2g**



CLIENT
CAVANAGH DEVELOPMENTS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT HOUSE WELL (PUMPING WELL)

PROJECT No. **1543767**

Rev.

FIGURE **H-3a**

CLIENT
CAVANAGH DEVELOPMENTS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT HOUSE WELL (TW2, TW5, TW6)

PROJECT No. **1543767**
Rev.
FIGURE **H-3b**

CLIENT
CAVANAGH DEVELOPMENTS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

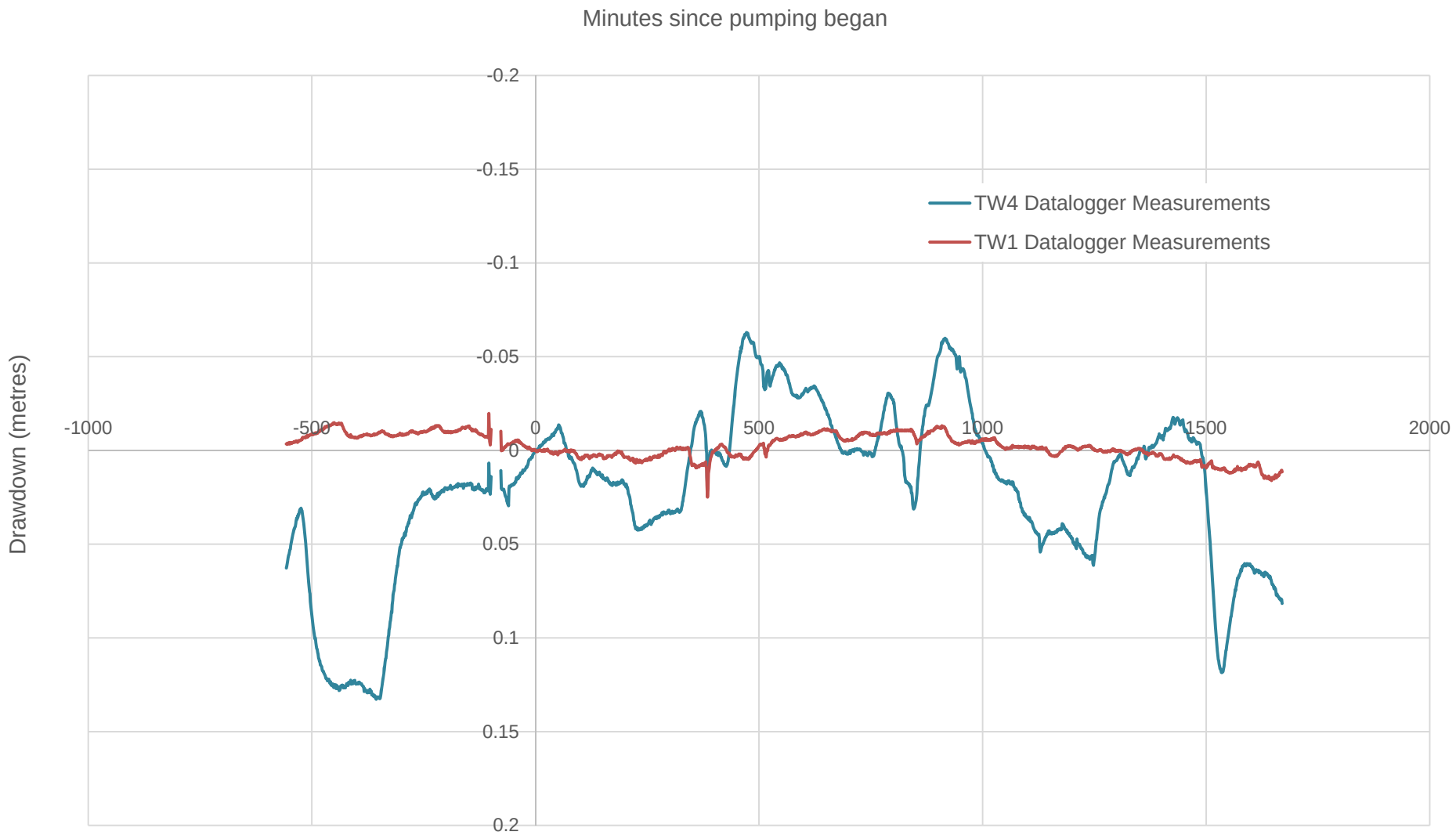
PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT HOUSE WELL (MW18-7, MW18-11, MW15-4 AND MW15-5)

PROJECT No. **1543767**

Rev.

FIGURE **H-3c**



CLIENT
CAVANAGH DEVELOPMENTS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT HOUSE WELL (TW1 AND TW4)

PROJECT No. **1543767**
Rev.
FIGURE **H-3d**

CLIENT
CAVANAGH DEVELOPMENTS

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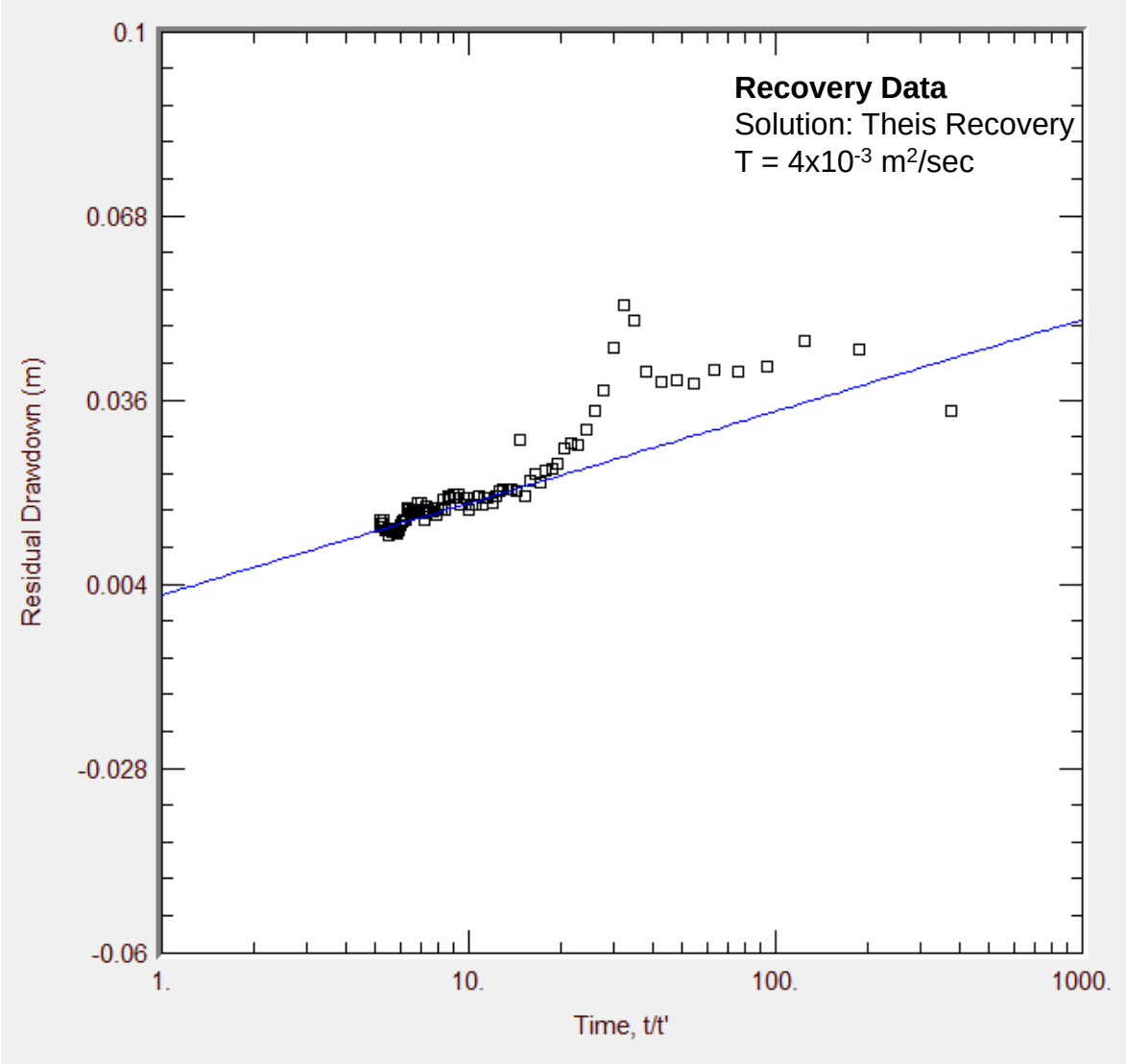
YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT HOUSE WELL (SHALLOW MONITORS MW18-1, MW18-2, MW18-3)

PROJECT No. **1543767**
Rev.
FIGURE **H-3e**



CLIENT
CAVANAGH DEVELOPMENTS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
RECOVERY DATA ANALYSIS
PUMPING AT HOUSE WELL

PROJECT No. **1543767**
Rev.
FIGURE **H-3f**

APPENDIX I

Water Balance Analysis

Table I-1: Environment Canada Precipitation and Surplus Data
Ottawa CDA Meteorological Station

Ottawa CDA Combined, ON WATER BUDGET MEANS FOR THE PERIOD 1945-2013 DC20492
LAT.... 45.38 WATER HOLDING CAPACITY... 75 MM HEAT INDEX... 37.10
LONG... 75.72 LOWER ZONE..... 45 MM A..... 1.085

Date	Temprature (˚C)	Precipiation (mm)	Rain (mm)	Melt (mm)	Potential Evaporation (mm)	Actual Evaporation (mm)	Deficit (mm)	Surplus (mm)	Snow (mm)	Soil (mm)	Accumulated Precipiation (mm)
31- 1	-10.4	59	11	16	0	0	0	26	71	74	284
28- 2	-8.8	52	10	18	1	1	0	27	94	75	335
31- 3	-2.5	61	31	74	6	6	0	99	50	75	396
30- 4	6	70	67	53	32	32	0	88	0	74	466
31- 5	13.1	77	77	0	80	80	0	14	0	58	542
30- 6	18.3	85	85	0	117	108	-8	3	0	32	627
31- 7	20.8	86	86	0	136	105	-30	1	0	11	714
31- 8	19.6	85	85	0	117	85	-33	1	0	11	798
30- 9	14.9	85	85	0	76	68	-8	3	0	26	883
31-10	8.6	75	75	0	38	37	-1	13	0	51	75
30-11	1.8	76	61	7	11	11	0	38	7	70	151
31-12	-6.6	73	25	16	1	1	0	35	39	75	224
AVE/TTL	6.3	885	698	184	615	534	-80	348			

Ottawa CDA Combined, ON WATER BUDGET MEANS FOR THE PERIOD 1945-2013 DC20492
LAT.... 45.38 WATER HOLDING CAPACITY... 100 MM HEAT INDEX... 37.10
LONG... 75.72 LOWER ZONE..... 60 MM A..... 1.085

Date	Temprature (˚C)	Precipiation (mm)	Rain (mm)	Melt (mm)	Potential Evaporation (mm)	Actual Evaporation (mm)	Deficit (mm)	Surplus (mm)	Snow (mm)	Soil (mm)	Accumulated Precipiation (mm)
31- 1	-10.4	59	11	16	0	0	0	25	71	98	284
28- 2	-8.8	52	10	18	1	1	0	27	94	99	335
31- 3	-2.5	61	31	74	6	6	0	98	50	100	396
30- 4	6	70	67	53	32	32	0	88	0	99	466
31- 5	13.1	77	77	0	80	80	0	14	0	83	542
30- 6	18.3	85	85	0	117	113	-4	3	0	52	627
31- 7	20.8	86	86	0	136	115	-20	1	0	21	714
31- 8	19.6	85	85	0	117	88	-30	1	0	18	798
30- 9	14.9	85	85	0	76	69	-7	2	0	33	883
31-10	8.6	75	75	0	38	37	-1	9	0	62	75
30-11	1.8	76	61	7	11	11	0	30	7	90	151
31-12	-6.6	73	25	16	1	1	0	32	39	97	224
AVE/TTL	6.3	885	698	184	615	553	-62	330			

Ottawa CDA Combined, ON WATER BUDGET MEANS FOR THE PERIOD 1945-2013 DC20492
LAT.... 45.38 WATER HOLDING CAPACITY... 150 MM HEAT INDEX... 37.10
LONG... 75.72 LOWER ZONE..... 90 MM A..... 1.085

Date	Temprature (˚C)	Precipiation (mm)	Rain (mm)	Melt (mm)	Potential Evaporation (mm)	Actual Evaporation (mm)	Deficit (mm)	Surplus (mm)	Snow (mm)	Soil (mm)	Accumulated Precipiation (mm)
31- 1 -	10.4	59	11	16	0	0	0	21	71	145	284
28- 2	-8.8	52	10	18	1	1	0	25	94	147	335
31- 3	-2.5	61	31	74	6	6	0	97	50	150	396
30- 4	6	70	67	53	32	32	0	88	0	149	466
31- 5	13.1	77	77	0	80	80	0	14	0	133	542
30- 6	18.3	85	85	0	117	116	0	3	0	98	627
31- 7	20.8	86	86	0	136	127	-8	1	0	56	714
31- 8	19.6	85	85	0	117	98	-19	1	0	42	798
30- 9	14.9	85	85	0	76	70	-6	2	0	56	883
31-10	8.6	75	75	0	38	37	0	7	0	87	75
30-11	1.8	76	61	7	11	11	0	19	7	125	151
31-12	-6.6	73	25	16	1	1	0	25	39	140	224
AVE/TTL	6.3	885	698	184	615	579	-33	303			

Table I-1: Environment Canada Precipitation and Surplus Data
Ottawa CDA Meteorological Station

Date	Temprature	Precipiation	Rain	Melt	Potential Evaporation	Actual Evaporation	Deficit	Surplus	Snow	Soil	Accumulated Precipiation

Ottawa CDA Combined, ON WATER BUDGET MEANS FOR THE PERIOD 1945-2013 DC20492
LAT.... 45.38 WATER HOLDING CAPACITY... 300 MM HEAT INDEX... 37.10
LONG... 75.72 LOWER ZONE..... 1280 MM A..... 1.085

Date	Temprature (˚C)	Precipiation (mm)	Rain (mm)	Melt (mm)	Potential Evaporation (mm)	Actual Evaporation (mm)	Deficit (mm)	Surplus (mm)	Snow (mm)	Soil (mm)	Accumulated Precipiation (mm)
31- 1	-10.4	59	11	16	0	0	0	17	71	280	284
28- 2	-8.8	52	10	18	1	1	0	20	94	288	335
31- 3	-2.5	61	31	74	6	6	0	89	50	298	396
30- 4	6	70	67	53	32	32	0	87	0	299	466
31- 5	13.1	77	77	0	80	80	0	14	0	283	542
30- 6	18.3	85	85	0	117	117	0	3	0	248	627
31- 7	20.8	86	86	0	136	135	0	1	0	198	714
31- 8	19.6	85	85	0	117	114	-3	1	0	168	798
30- 9	14.9	85	85	0	76	74	-2	2	0	178	883
31-10	8.6	75	75	0	38	38	0	7	0	208	75
30-11	1.8	76	61	7	11	11	0	15	7	251	151
31-12	-6.6	73	25	16	1	1	0	19	39	272	224
AVE/TTL	6.3	885	698	184	615	609	-5	275			

Table I-2: Estimation of Annual Water Balance Rates
2596 Carp Road
Ottawa, Ontario

Assigned Water Holding Capacity					
Soil Type	Fine Sandy Loam	Fine Sandy Loam	Fine Sandy Loam	Fine Sandy Loam	
Vegetation Type	Pasture/Shrub	Urban Lawn	Mature Forest	Gravel Surface	
Water Holding Capacity (mm)	150	75	300	10	

Annual Rates by Water Holding Capacity					
Water Holding Capacity (mm)	**Impervious**	**Water**	**75**	**150**	**300**
Precipitation	885	885	885	885	885
Actual Evapotranspiration	177	615	534	579	609
Surplus	708	270	351	306	276

Pre-Development - Estimated Infiltration Factor					
Land use		**Topography**	**Soils**	**Cover**	**Infiltration Factor**
Impervious Surfaces	n/a	n/a	0.00	0.00	0.00
Water	n/a	n/a	0.00	0.00	0.00
Urban Lawn	Fine Sandy Loam	0.1	0.40	0.10	0.60
Pasture/Shrub	Fine Sandy Loam	0.1	0.40	0.15	0.65
Mature Forest	Fine Sandy Loam	0.1	0.40	0.20	0.70

Post-Development - Estimated Infiltration Factor					
Land use		**Topography**	**Soils**	**Cover**	**Infiltration Factor**
Impervious Surfaces	n/a	n/a	0.00	0.00	0.00
Water	n/a	n/a	0.00	0.00	0.00
Urban Lawn	Fine Sandy Loam	0.1	0.40	0.10	0.60
Pasture/Shrub	Fine Sandy Loam	0.1	0.40	0.15	0.65
Mature Forest	Fine Sandy Loam	0.1	0.40	0.20	0.70

Pre-Development - Estimated Average Annual Infiltration Rates						
Land use	**Surficial Soil**	**WHC (mm)**	**Surplus (mm/a)**	**Infiltration Factor**	**Infiltration (mm/a)**	**Run-Off (mm/a)**
Impervious Surfaces	n/a	n/a	708	n/a	0	708
Water	n/a	n/a	270	0.00	0	270
Urban Lawn	Fine Sandy Loam	75	351	0.60	211	140
Pasture/Shrub	Fine Sandy Loam	150	306	0.65	199	107
Mature Forest	Fine Sandy Loam	300	276	0.70	193	83

Post-Development - Estimated Average Annual Infiltration Rates						
Land use	**Surficial Soil**	**WHC (mm)**	**Surplus (mm/a)**	**Infiltration Factor**	**Infiltration (mm/a)**	**Run-Off (mm/a)**
Impervious Surfaces	n/a	n/a	708	n/a	0	708
Water	n/a	n/a	270	0.00	0	270
Urban Lawn	Fine Sandy Loam	75	351	0.60	211	140
Pasture/Shrub	Fine Sandy Loam	150	306	0.65	199	107
Mature Forest	Fine Sandy Loam	300	276	0.70	193	83

Table I-3: Water Balance Calculation
2596 Carp Road
Ottawa, Ontario

Land use	Surficial Soil	Water Holding Capacity	Area	Precipitation		Evapotranspiration		Surplus		Infiltration		Runoff	
		(mm)	(m^2)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)
Impervious Surfaces	n/a	n/a	23,810	885	21,072	177	4,214	708	16,857	0	0	708	16,857
Water	n/a	n/a	5,010	885	4,434	615	3,081	270	1,353	0	0	270	1,353
Urban Lawn	Fine Sandy Loam	75	4,100	885	3,629	534	2,189	351	1,439	211	865	140	574
Pasture/Shrub	Fine Sandy Loam	150	199,680	885	176,717	579	115,615	306	61,102	199	39,736	107	21,366
Mature Forest	Fine Sandy Loam	300	55,400	885	49,029	609	33,739	276	15,290	193	10,692	83	4,598
TOTAL			**288,000**		**254,881**		**158,838**		**96,041**		**51,293**		**44,748**

Post-Development - Estimated Annual Average Water Balance

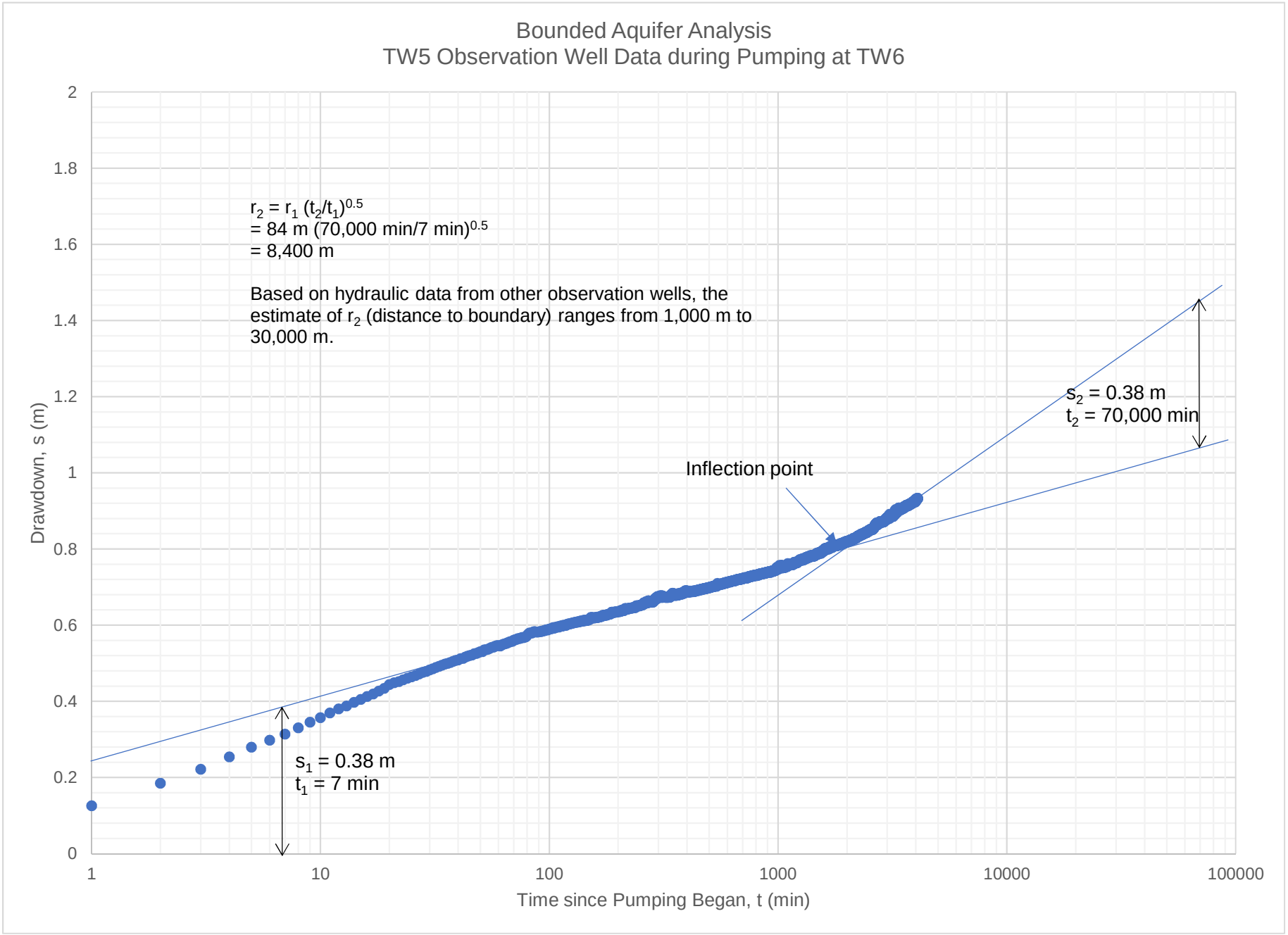
Land use	Surficial Soil	Water Holding Capacity	Area	Precipitation		Evapotranspiration		Surplus		Infiltration		Runoff	
		(mm)	(m^2)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)
Impervious Surfaces	n/a	n/a	65,560	885	58,021	177	11,604	708	46,416	0	0	708	46,416
Water	n/a	n/a	5,010	885	4,434	615	3,081	270	1,353	0	0	270	1,353
Urban Lawn	Fine Sandy Loam	75	2,710	885	2,398	534	1,447	351	951	211	572	140	379
Pasture/Shrub	Fine Sandy Loam	150	159,320	885	140,998	579	92,246	306	48,752	199	31,705	107	17,047
Mature Forest	Fine Sandy Loam	300	55,400	885	49,029	609	33,739	276	15,290	193	10,692	83	4,598
TOTAL			**288,000**		**254,880**		**142,117**		**112,762**		**42,969**		**69,793**
		% Change					-11%		17%		-16%		56%

Mitigated Post-Development - Estimated Annual Average Water Balance

Land use	Surficial Soil	Water Holding Capacity	Area	Precipitation		Evapotranspiration		Surplus		Infiltration		Runoff	
		(mm)	(m^2)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)
Impervious Surfaces - Other than Concrete Plant	n/a	n/a	28,660	885	25,364	177	5,073	708	20,291	0	0	708	20,291
Impervious Surfaces - Concrete Plant	n/a	n/a	36,900	885	32,657	177	6,531	708	26,125	637	23,513	71	2,613
Water	n/a	n/a	5,010	885	4,434	615	3,081	270	1,353	0	0	270	1,353
Urban Lawn	Fine Sandy Loam	75	2,710	885	2,398	534	1,447	351	951	211	572	140	379
Pasture/Shrub	Fine Sandy Loam	150	159,320	885	140,998	579	92,246	306	48,752	199	31,705	107	17,047
Mature Forest	Fine Sandy Loam	300	55,400	885	49,029	609	33,739	276	15,290	193	10,692	83	4,598
TOTAL			**288,000**		**254,880**		**142,117**		**112,762**		**66,482**		**46,281**
		% Change					-11%		17%		30%		3%

APPENDIX J

Bounded Aquifer Assessment and Well Interference Assessment


Bounded Aquifer Analysis
TW5 Observation Well Data during Pumping at TW6
$r_2 = r_1 (t_2/t_1)^{0.5}$
$= 84$ m $(70{,}000$ min$/7$ min$)^{0.5}$
$= 8{,}400$ m
Based on hydraulic data from other observation wells, the estimate of r_2 (distance to boundary) ranges from 1,000 m to 30,000 m.
$s_2 = 0.38$ m
$t_2 = 70{,}000$ min
Inflection point
$s_1 = 0.38$ m
$t_1 = 7$ min
Drawdown, s (m)
Time since Pumping Began, t (min)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
1
10
100
1000
10000
100000

S (-)	2.00E-06
t (years)	20
t (d)	7300
T (m^2/sec)	3.70E-03
T (m^2/day)	3.20E+02

s = (0.183*(Q/T))*LOG((2.25*T*t)/(S*r^2))

Drawdown due to TW5/TW6 pumping:

Q (L/day)	245000
Q (m^3/day)	245
r (m)	**Drawdown (m)**
20	1.38
25	1.35
30	1.33
35	1.31
40	1.29
70	1.22
100	1.18
150	1.13
200	1.10
340	1.03
1000	0.90

S (-)	2.00E-06
t (years)	20
t (d)	7300
T (m^2/sec)	3.70E-03
T (m^2/day)	3.20E+02

s = (0.183*(Q/T))*LOG((2.25*T*t)/(S*r^2))

Drawdown due to image well:

Q (L/day)	245000
Q (m^3/day)	245
r (m)	**Drawdown (m)**
1980	0.82
1975	0.82
1970	0.82
1965	0.82
1960	0.82
1930	0.82
1900	0.82
1850	0.83
1800	0.83
1660	0.84
1000	0.90

Total:

Drawdown (m)
2.19
2.17
2.15
2.13
2.11
2.04
2.00
1.96
1.93
1.87
1.80

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