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Hydrogeological Assessment – Durham Live! Tourist Destination Lands Re-Zoning Application

Pickering, ON

Palmer Project #
1805601

Prepared For
Pickering Developments Inc.

February 5, 2020

February 5, 2020

Steve Apostolopoulos,
Pickering Developments Inc.
186 Bartley Drive
North York, ON M4A 1E1

Dear Mr. Apostolopoulos:

Re: **Hydrogeological Assessment – Durham Live! Tourist Destination Re-Zoning Application, Pickering, ON Hydrogeological Assessment – Durham Live! Tourist Destination Lands Re-Zoning Application**
Project #: **1805601**

Palmer is pleased to submit the following report describing the results of our Hydrogeological Assessment to support a Re-Zoning Application for the proposed Durham Live Major Tourist Destination (MTD) project in Pickering, ON.

This report expands upon the Interim Hydrogeological Assessment (Palmer, May 2018) to include monitoring completed between August 2017 and November 2019 to establish long-term groundwater level trends and wetland hydroperiods at the site. This report includes a detailed assessment of the groundwater/ surface water interactions within the Lower Duffins Creek PSW and a Feature Based Water Budget Assessment for three individual wetland communities (Eastern SWD3-2, Central SWD3-2 and Western MAS2-1). A series of Low Impact Development (LID) measures have been proposed to maintain the water balance from pre-to-post development to avoid adverse effects to the PSW.

The results of this report indicate that development within the area zoned “Urban Reserve (UR)” to the east of Squires Beach Road will not adversely affect groundwater recharge or natural features on the site. A Feature Based Water Budget (FBWB) model and recommendations for mitigation, including LID measures have been provided to support this project.

Please let us know if you have question or comments on this submission. Thank you for the opportunity to work with your team on this project.

Yours truly,
Palmer Environmental Consulting Group Inc.

J. Cole

Jason Cole, M.Sc., P. Geo.
Principal, Senior Hydrogeologist

Distribution List

# of Hard Copies	PDF Required	Association / Company Name
	Yes	Toronto and Region Conservation Authority (TRCA)
	Yes	City of Pickering
	Yes	Malone Givens Parsons (MGP)
	Yes	Pickering Developments Inc.

Revision Log

Revision #	Revised By	Date	Issue / Revision Description

Signatures

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Principal, Senior Hydrogeologist

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1 Introduction

Palmer was retained by Pickering Developments (401) Inc., Pickering Developments (Bayly) Inc., and Pickering Developments (Squires) Inc. (collectively referred to as Pickering Developments) to complete a Hydrogeological Assessment for the Durham Live! project in Pickering, ON (**Figure 1**). The project lands are bounded by CN rail to the north, Church Street to the east, Bayly Street to the south and Squires Beach Road to the west. The central portion of the site host the Lower Duffins Creek Provincially Significant Wetland (PSW). The planned development consists of an entertainment complex, casino, hotels, film studios, restaurants, pedestrian spaces, and various tourist destination uses. The Concept Plan and Grading Plan is presented in **Appendix A**.

Presently, the lands located greater than 120 m to the east of the PSW wetlands are zoned as Major Tourist Destination (MTD) with two holding provisions (H-2 and H-3). The H-1 holding provision was lifted in October 2018. When Durham Live was first approved, only those lands 120 m east of the PSW wetlands were zoned MTD to ensure there were no adverse impacts on the PSW or groundwater resources. The purpose of this report is to provide a further hydrogeological assessment of the property in support of an application to re-zone the lands within 120 m of the PSW from Urban Reserve (UR) to MTD based on the Concept Plan and Grading Plan shown in **Appendix A**.

1.1 Background

Palmer hydrogeologists have been involved with the Durham Live! project since 2014. In September 2014, Palmer completed a preliminary hydrogeological investigation at the site, with a specific focus on characterizing groundwater and surface water interactions within the PSW communities present on the site. A series of groundwater monitoring wells were installed and each major wetland community within the PSW were instrumented with wetland mini-piezometers (MP) to measure groundwater and surface water levels. Surface water and groundwater levels at each MP were monitored monthly over a period of 1-year, between September 2014 and September 2015. The intent of this initial study was to assess each wetland from a hydrogeological perspective to characterize each as groundwater supported, surface water supported, or a combination of both.

In August 2017, the wetland and groundwater level monitoring program resumed and was expanded upon to meet the criteria of the Toronto and Region Conservation Authority (TRCA) Wetland Water Balance Monitoring Protocol (2016) and the Wetland Water Balance Risk Evaluation (2017). Five (5) additional MP locations were added, and dataloggers were added to each of the existing MP locations to collect continuous water level data at 1-hour intervals. Two (2) staff gauges, also instrumented with dataloggers, were added at the outlet and inlet of the PSW wetlands along Bayly Street to determine the spill over/ spill in water level elevations.

An “Interim Hydrogeological Assessment Report in Support of Lifting the H-1 Holding Provision” was prepared by Palmer on May 4, 2018 and was submitted to the City of Pickering and the TRCA. This report focused on characterizing the existing hydrogeological conditions at the site, and specifically to determine if the PSW wetlands were supported by groundwater, surface water or a combination of both. The key result from the Interim Hydrogeological Assessment Report was that *while upwards hydraulic gradients were measured in many of the PSW wetlands, the low hydraulic conductivity of the glaciolacustrine silt and clay underlying these features greatly limits the rate of volume of groundwater*

Legend

- ▭ Subject Site
- ⦸ Drumlin
- ⋯ Staked Dripline (Surveyor)
- - - Staked Wetland (Suveyor)
- — H1 Area 120 m Setback
- – – 30 m Setback
- — Watercourse
- ➤ Ephemeral Drainage Feature
- — Index Contour (1 m)
- — Contour (0.25 m)
- ▨ Test Pit
- ● Borehole
- ● Monitoring Well
- ● Mini-piezometer

Imagery (2017 - DigitalGlobe) provided by Esri basemap service.

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Key Map

0 50 100 150 200
metres

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DRAWN: BE/CV
CHECKED: A. Lo
PROJECT: 1805601
DATE: Jan 20, 2020

Scale 1:8000
UTM Zone 17N
NAD 1983

Palmer™

CLIENT: Pickering Developments
PROJECT: Durham Live

Site Map

FIGURE 1

Document Path: W:\Egnyte\Shared\Projects\Active\18056 - Pickering Developments Inc\1805601 - Durham Live - Geotechnical and Hydrogeological Study for H2 and EA\Mapping\mxd\Nov2019\1805601_1-1_Site Map.mxd *discharge. As such, the wetlands are considered to be surface water supported and not groundwater supported. Based on the limited groundwater discharge to the PSWs, the use of surface water based Low Impact Development (LID) measures to maintain the seasonal volume and timing of surface water entering the wetlands was recommended.*

The Interim Hydrogeological Assessment Report recommended that a series of additional studies be completed to support the re-zoning of lands within 120 m of the PSW to avoid or mitigate potential adverse effects to this feature. These studies included:

- Continued monitoring at each wetland MP and MW location. Continuous water level data will establish the high and low water levels at each location to support a future Feature Based Water Budget (FBWB) model.
- In-situ infiltration testing at the proposed LID locations to measure the infiltration rates prior to finalizing the LID design.
- Additional groundwater monitoring well installations, including shallow and deep nested wells, will be installed as part of the Environmental Assessment for the Notion Road Hwy 401 crossing. This will provide additional hydrogeological data on the western portion of the site to further refine groundwater flow interpretations at the site.

This Hydrogeological Assessment Report presents a summary of the hydrogeological investigations and the results of the above listed studies to demonstrate that the proposed Durham Live! development will not cause an adverse impact to groundwater quality or quality, or to natural heritage features on or adjacent to the site. The conclusions presented in this report are based on a multi-disciplinary consulting team including ecologists from Beacon Environmental (Beacon) and engineers from Sabourin Kimble & Associated (SKA).

1.2 Summary of Hydrogeological Field Investigations

In April 2013, Golder Associates (Golder) completed an Environmental Baseline Report focused on the future Casino lands north of Kellino Street. As part of this study, Golder completed the following field and laboratory investigations:

- Drilling of seven (7) boreholes and the installation of three (3) groundwater monitoring wells (BH13-1 to BH13-7);
- Grain size and hydrometer testing of four (4) soil samples; and
- Chemical testing of soil and groundwater.

Starting in 2014, Palmer expanded upon the Golder study to complete a hydrogeological assessment and wetland monitoring program, that included the following scope of work:

- Collection and review of background geology and hydrogeology data from published maps and reports, Ministry of the Environment, Conservation and Parks (MECP) water well records, and previously conducted hydrogeological studies in the area;
- Drilling of eight (8) boreholes and the installation of five (5) groundwater monitoring wells to expand upon the Golder borehole program (MW1 to MW3, BH4, MW5, and TH1 to TH3);

- Conducting single well response testing (i.e., slug tests) at each well to determine the hydraulic conductivity of the geological material;
- Collection of groundwater chemistry samples at two (2) locations;
- Review of Beacon Environmental (Beacon) ELC mapping and a hydrogeological wetland characterization to inform the installation of six (6) wetland mini-piezometers (MPs) (MP1 to MP6) within on-site watercourse and PSW wetland units, which provides flow and pre-development wetland hydroperiod data; and
- Completion of 1-year of monthly groundwater level and wetland water level monitoring between September 2014 and September 2015.

In August 2017, Palmer's hydrogeological and wetland monitoring resumed and was expanded upon to meet the criteria of the TRCA Wetland Water Balance Monitoring Protocol (2016), the Wetland Water Balance Risk Evaluation (2017), and to support a future Feature Based Water Budget (FBWB) model for the site. This expanded work program included:

- Installation of two (2) additional wetland MPs (MP7 and MP8);
- Installation of two (2) staff gauge (SG) piezometers (SG1 and SG2) at the outlet/ inlet of the PSW wetlands along Bayly Street to determine the spill over/ spill in water level elevations;
- Instrumentation of each MP, SG, and monitoring well (MW) with a Solinst level logger set to record water levels at 1-hour intervals;
- Resumption of the groundwater and wetland water level monitoring program;
- Elevation survey of each monitoring location and wetland community;
- Evaluation of the potential impacts from site development on groundwater levels, aquifer units and the hydroperiod of each wetland unit;
- Assessment of construction dewatering rates and potential impact of the proposed sanitary sewer alignment through the UR lands;
- Completion of a hydrogeological impact assessment for the H-1 lands; and
- Recommendations for mitigation and future monitoring requirements.

In November 2018, a hydrogeological investigation consisting of additional drilling and groundwater level measurements in support of a Schedule 'C' Municipal Class Environmental Assessment (EA) for the proposed Notion Road to Squires Beach Road Highway 401 Crossing was initiated. Palmer completed the drilling program in conjunction with the geotechnical investigation being completed by Palmer geotechnical staff and by Thurber Engineering. This work program includes:

- Drilling of fourteen (14) boreholes and the completion of eight (8) groundwater monitoring wells (BH18-1 to BH18-5, BH18-7 to BH18-12, BH18-14, TH18-05, and TH18-06);
- Development and hydraulic testing at multiple monitoring well locations to measure the permeability of the soils/ bedrock;
- Groundwater level monitoring to measure groundwater level fluctuations; and
- Hydrogeological reporting.

To support stormwater management planning and LID design, in September 2019 Palmer personnel revisited the site to complete in-situ infiltration rate testing of the unsaturated soil. The following work program was conducted:

- Excavation of ten (10) test pits (TPs) at the location and depth of the preliminary stormwater management plan and LID design by SKA;
- Perform Guelph Permeameter tests at each TP location to determine field saturated hydraulic conductivity (K_{fs}); and
- Provide recommendations for LID locations, depth and design based on the water table depth and soil percolation rates.

All borehole and test pit locations are shown on **Figure 1** and all borehole and test pit logs are provided in **Appendix B**.

In November 2019, Palmer staff downloaded the continuous groundwater and wetland water level data collected since August 2017 to provide a multi-year characterization of the high and low groundwater levels, and wetland hydroperiods for each community. These results will be used to support both the hydrological modelling by SKA, a FBWB completed by Palmer and SKA, and the ecological impact assessment completed by Beacon.

2 Study Methods

2.1 Drilling and Installation of Monitoring Wells

Fourteen (14) boreholes were drilled between November 27, 2018 and December 13, 2018, concurrently with a preliminary geotechnical investigation conducted by Palmer and Thurber Engineering to supplement the existing boreholes on the site (**Figure 1**). The new boreholes were drilled to depths ranging from 3.5 metres below ground surface (mbgs) to 12.6 mbgs using a combination of hollow and solid stem auger methods. Eight (8) of the 14 boreholes were completed as monitoring wells in accordance with Ontario Regulation 903. The monitoring wells are made of 5.1 cm (2 inch) diameter schedule 40 polyvinyl chloride (PVC) pipe, with a 1.5 m (5 foot) screened interval. Borehole logs are provided in **Appendix B**. Details of all boreholes and monitoring well investigated for this study can be seen in **Table 1** in chronological order based on drilling date. Elevations of the boreholes were taken from drawing “100-1-17Z- Sketch Illustrating Topographic Information of Part of Lots 15 and 16 Concession 1, City of Pickering, Regional Municipality of Durham” by David B. Searles Surveying Ltd.

Table 1. Borehole and Monitoring Well Installation Details

Year Drilled	Borehole/ Monitoring Well	Approximate Surface Elevation (masl)	Depth masl (mbgs)	Approx. Screened Interval masl (mbgs)	Screened Geology
2013	BH13-1	86.4	82.7 (3.7)	84.3 to 82.8 (2.1 to 3.6)	Silty Clay
	BH13-2	86.4	83.5 (2.9)	n/a – borehole only	n/a – borehole only
	BH13-3	87.6	83.9 (3.7)	85.5 to 84.0 (2.1 to 3.6)	Silty clay to silty sand and sand
	BH13-4	94.0	91.9 (2.1)	n/a – borehole only	n/a – borehole only
	BH13-5	89.9	86.2 (3.7)	87.8 to 86.3 (2.1 to 3.6)	Silt and clayey silt
	BH13-6	88.0	86.5 (1.5)	n/a – borehole only	n/a – borehole only
	BH13-7	86.7	84.6 (2.1)	n/a – borehole only	n/a – borehole only
2014	MW1	88.8	82.1 (6.7)	83.6 to 82.1 (5.2 to 6.7)	Sandy silty clay till
	MW2	88.5	81.8 (6.7)	83.3 to 81.8 (5.2 to 6.7)	Sandy silty clay till
	MW3	86.9	78.7 (8.2)	80.2 to 78.7 (6.7 to 8.2)	Silty fine sand and coarse grained sand
	BH4	89.7	84.4 (5.3)	n/a – borehole only	n/a – borehole only
	MW5	88.5	81.8 (6.7)	83.3 to 81.8 (5.2 to 6.7)	Sandy silty clay till
	TH1	92.6	82.8 (9.8)	n/a – borehole only	n/a – borehole only
	TH2	95.6	86.6 (9.0)	88.05 to 86.55 (7.5 to 9.0)	Sandy silty clay till
	TH3	95.0	96.8 (8.2)	n/a – borehole only	n/a – borehole only

Year Drilled	Borehole/ Monitoring Well	Approximate Surface Elevation (masl)	Depth masl (mbgs)	Approx. Screened Interval masl (mbgs)	Screened Geology
2018	BH18-1	91.6	84.6 (7.0)	n/a – borehole only	n/a – borehole only
	BH18-2	95.6	89.0 (6.6)	91.0 to 89.5 (4.6 to 6.1)	Sandy silt, silt, and clayey silt till
	BH18-3	97.1	90.4 (6.7)	n/a – borehole only	n/a – borehole only
	BH18-4	95.3	88.8 (6.6)	92.3 to 89.2 (3.0 to 6.1)	Sandy silt till to silty sand till
	BH18-5	90.1	86.7 (3.5)	n/a – borehole only	n/a – borehole only
	BH18-7	89.9	83.5 (6.3)	87.1 to 84.0 (2.8 to 5.9)	Sand and clayey silt till to silty clay till
	BH18-8	89.2	82.7 (6.5)	n/a – borehole only	n/a – borehole only
	BH18-9D	89.5	80.2 (9.3)	81.9 to 80.3 (7.6 to 9.2)	Clayey silt till to silty clay till and silty clay
	BH18-9S	89.5	84.9 (4.6)	87.9 to 84.9 (1.6 to 4.6)	Sandy silt till to clayey silt till
	BH18-10	89.8	80.1 (9.7)	83.7 to 80.7 (6.1 to 9.1)	Sandy silt till and clayey silt till
	BH18-11	88.6	82.4 (6.2)	84.0 to 82.5 (4.6 to 6.1)	Silty sand and sandy silt till
	BH18-12	89.3	82.6 (6.7)	84.7 to 83.2 (4.6 to 6.1)	Sandy silt till
	BH18-14	87.8	84.2 (3.7)	n/a – borehole only	n/a – borehole only
	TH18-05	87.2	74.6 (12.6)	79.6 to 76.6 (7.6 to 10.6)	Clayey silt till and fractured shale
	TH18-06	88.3	77.5 (10.8)	n/a – borehole only	n/a – borehole only

2.2 Hydrogeological Wetland Investigation and Instrumentation

On September 18, 2014, six (6) MPs (MP1 to MP6) were installed in identified wetlands at the site. The MPs are constructed from 1.9 cm (3/4 inch) diameter steel pipe and have a screened interval of 0.31 m (1.0 foot). The MPs were installed in each major wetland community type as identified by Beacon (**Figure 2**) during their 2014 wetland staking and were monitored for a period of one-year, from September 2014 to September 2015, to define a hydroperiod for the community.

In August 2017, two (2) additional piezometers (MP7 and MP8) and two (2) staff gauges (SG1 and SG2) were installed at the site to expand upon the existing monitoring network. Each wetland piezometer location was instrumented with a Solinst datalogger to collect continuous water level data on an hourly basis. In December 2017, three (3) additional MPs locations were added (MP9, MP10, and MP11) to monitoring groundwater and surface water interaction between the cattail mineral shallow marsh north and south of Kellino Street. Locations of the MPs can be found in **Figure 2**.

Each of these MPs were continued to be monitored through 2018 and 2019. This report presents the results of between 2 and 5-years of water level and wetland monitoring data at the site.

2.3 Infiltration Testing

The infiltration rate of the unsaturated in-situ soils were measured between September 23 and 25, 2019. Testing was completed using a constant head well permeameter method (Guelph Permeameter), and employed both the inner and combined reservoir techniques to optimize results depending on the soil type.

Ten (10) test pit (TPs) locations were selected based on preliminary stormwater planning input from SKA (**Figure 1**). At each location, soils were excavated to a shallow depth ranging from 0.65 - 1.10 m below ground surface (mbgs), and a deeper depth (1.60 - 2.60 mbgs) using an excavator. Within each test pit, a 6 cm diameter soil auger was then used to excavate an additional depth in the test pit ranging from 18 – 33 cm to place the Guelph Permeameter in, and to characterize the soils. This allowed for the infiltration of soils to be tested at approximately at a depth of 1 m (shallow) and 2 m (deep). At each test pit location (TP1 to TP10), a single head infiltration test was completed at each of the shallow and deep depths. A summary of the soil profiles logs is provided in **Appendix B.** A photo log of the soil profile at each location is provided in **Appendix C**.

Prior to the test, approximately 2.5 L of water was used to fill the Guelph Permeameter. For the single head test, a hydraulic head (H) of 0.20 m was applied in most cases as majority of the soils were low permeability and required a greater pressure for infiltration rates to be accurately recorded. However, at a few sites, a lower head pressure was applied (0.10 – 0.15 m) as the soils infiltrated quickly at 0.20 m head. The test was terminated at each TP once the rate of change was observed to remain stable over three consecutive time intervals, achieving a steady-state infiltration rate (R).

2.4 Hydraulic Conductivity Testing

Two separate hydraulic conductivity testing events were performed on the Durham Live! site. On February 25, 2015, Palmer personnel conducted in-situ testing of the hydraulic conductivity (K) of the geological material immediately surrounding MW1, MW2, MW3, and MW5. Additional in-situ testing was conducted on December 17, 2018, to determine the hydraulic conductivity (K) of the geological material at BH18-9, BH18-11, and TH18-05.

Both rising-head (RH) and falling-head (FH) tests were conducted for each monitoring well. The FH test began when a PVC slug with a diameter of 1.5 inches and length of 1 m was dropped into the well, causing a near-instantaneous rise in water level. The RH test began when the slug was removed from the well, causing a near-instantaneous drop in water level. Water levels in the well were recorded using a datalogger which was set to record water levels at two-second intervals for high permeability soils and five-second intervals for low permeability soils. Manual water-level measurements were also collected during the test to gauge recovery.

For MW1, MW3, MW5, and TH18-05, tests were terminated once 80% recovery had been attained. The test for MW2, BH18-9, and BH18-11 did not reach 80% recovery. K-values were calculated from the displacement-time data using the Hvorslev method as modelled by Aqtesolv^{TM} software. The results are provided in **Appendix E**.

Legend

- ● Borehole
- ● Monitoring Well
- ● Mini-piezometer
- ✚ Test Pit
- ⦰ Drumlin
- ········ Staked Dripline (Surveyor)
- - - - Staked Wetland (Suveyor)
- ▬ H1 Area 120 m Setback
- ‒ ‒ 30 m Setback
- ― Watercourse
- ‒▸ Ephemeral Drainage Feature
- ― Index Contour (1 m)
- ― Contour (0.25 m)
- ◯ Ecological Land Classification (Beacon, 2019)

Vegetation Communities

CUM1: Mineral Cultural Meadow
CUP3-3: Scotch Pine Coniferous Planation
CUT1: Mineral Cultural Thicket
CUT1-1: Sumac Mineral Cultural Thicket
CUW1: Mineral Cultural Woodland
FOC1-2: Dry-Fresh White-Red Pine C.F.
FOC2-2: Dry-Fresh White Cedar C.F.
FOD5-6: Dry-Fresh Sugar Maple-Basswood D.F.
MAM2: Mineral Meadow Marsh (Phragmites)
MAM2-2: Read-canary Grass Mineral Shallow Marsh
MAM2-10: Forb Mineral Meadow Marsh
MAS2-1: Cattail Mineral Shallow Marsh
MAS2-9: Forb Mineral Shallow Marsh
SWD3-2: Silver Maple Mineral Deciduous Swamp
SWD4-1: Willow Mineral Deciduous Swamp
SWT2-2: Willow Mineral Thicket Swamp
SWT2-5: Red-osler Mineral Thicket Swamp

Imagery (2017 - DigitalGlobe) provided by Esri basemap service.

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DRAWN: BE/CV
CHECKED: A. Lo
PROJECT: 1805601
DATE: Jan 20, 2020

Scale 1:5000
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CLIENT: Pickering Developments
PROJECT: Durham Live

Natural Environmental Features and Monitoring Locations

FIGURE 2

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3 Regional Conditions

3.1 Physiography and Drainage

The site is located within the Iroquois Plain physiographic region (Chapman and Putnam, 2007). This area is characterized by thin glaciolacustrine sediments (1 – 4 m) overlying till deposits to depths of up to 20 m. Gravel beaches and nearshore sands were deposited along the shore of former Glacial Lake Iroquois, while glaciolacustrine silts and clays were deposited away from the shoreline features in calmer water. In some areas, drumlins remained as islands even during the glacial lake’s highest stage, with glaciolacustrine materials deposited around them. These *till islands* are an important feature of the site that control much of the geological, hydrogeological, and ecological conditions.

The site is located in the subwatershed of Lower Duffins Creek (TRCA, 2002). The Duffins Creek watershed has an area of 283 km^2 and is one of the most comprehensively studied watersheds in Canada (TRCA, 2002). Headwaters of Duffins Creek originate on the Oak Ridges Moraine, and surface water flow is generally to the south, with waters discharging in Lake Ontario. Locally however, surface water flow follows topography.

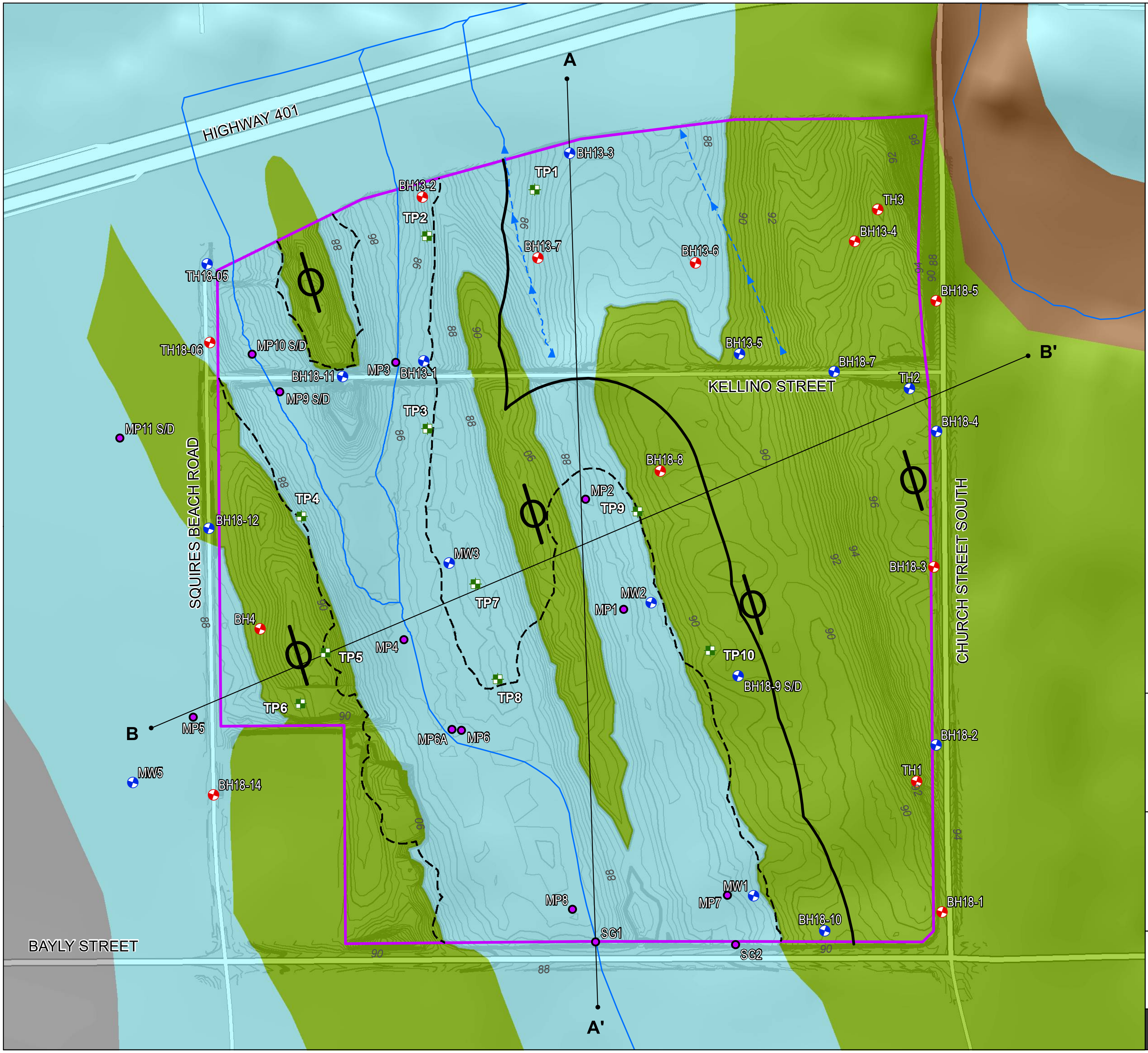
A series of ephemeral drainage swales are present on the site, located between the drumlins (**Figure 1**). With the exception of the drainage feature near MP2, these swales direct water internally within the agricultural fields or off-site.

3.2 Geological and Hydrogeological Setting

3.2.1 Quaternary Geology

The geology of the site consists of a succession of unconsolidated sediments, representing glacial and interglacial periods, overlying bedrock (Gerber, 2003). Surficial geology of the area as mapped by the Ontario Geological Survey (OGS) and modified based on the site-specific results of this study (further described in Section 4) are presented in **Figure 3**. The majority of the site is underlain by stone-poor sandy silt to silty clay-textured till of the Newmarket Till Formation (OGS, 2003). Within the central portion of the site the till is overlain by massive to well-laminated fine-textured glaciolacustrine deposits of silt and clay. These sediments were deposited during the last glaciation in offshore areas between till islands, present during the lake’s highest stage. Organic deposits of peat, muck, and marl are found in the wetland areas on the site.

The main branch of Duffins creek runs in general north-to-south direction just outside of the eastern boundary of the site. The sediments surrounding the watercourse consist of alluvial deposits of clay, silt, sand and gravel (OGS, 2003).



Legend

- Borehole
- Monitoring Well
- Mini-piezometer
- Test Pit
- Drumlin
- Cross Section
- H1 Area 120 m Setback
- 30 m Setback
- Watercourse
- Ephemeral Drainage Feature
- Index Contour (1 m)
- Contour (0.25 m)
- Road
- Subject Site

Surficial Geology Descriptions

- **Organic deposits:** peat, muck, and marl
- **Modern alluvial deposits:** sand and gravel
- **Newmarket Till:** sandy silt to sand till
- **Glaciolacustrine deposits:** silt and clay

Source: Ontario Geological Survey - Surficial Geology of Southern Ontario (2010) - modified.

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PROJECT: 1805601
DATE: Jan 20, 2020

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UTM Zone 17N
NAD 1983

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CLIENT: Pickering Developments
PROJECT: Durham Live

Surficial Geology

FIGURE 3

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3.2.2 Hydrogeology

The Newmarket Till forms a major regional aquitard within the study area, given its low hydraulic conductivity (10^{-11} to 10^{-6} m/s, Sharp *et al*., 1996) and consistent presence throughout the region. Where Newmarket Till is exposed at the surface, the water table is commonly high within the till because of the poorly drained till soils. In such areas, a well-developed surface drainage network can often be identified. Groundwater flow within till soils is typically towards more permeable, confined aquifers units downwards (i.e., the vertical hydraulic gradient is greater than the horizontal hydraulic gradient).

Closer to Lake Ontario, glaciolacustrine silts and clays from Glacial Lake Iroquois overlie the Newmarket Till. Within these deposits, the water table is typically at or near surface because the silt and clay soils, and the underlying Newmarket Till, inhibit drainage to depth. These low permeability silt and clay deposits inhibit both groundwater recharge and discharge. Precipitation and snowmelt in this area runs off the surface directly into stream channels and low-lying wetlands.

3.2.3 MECP Water Wells

Based on a review of the Ministry of the Environment, Conservation and Parks (MECP) water well record database, approximately 37 water wells are situated within 500 m of the project boundary (**Figure 4**). In this area, all residents have access to municipal water and the construction of the Durham Live project will not adversely affect water supplies.

3.2.4 Source Water Protection

In December 2015, a Source Water Protection Plan came into effect that encompasses the study area (CTCSPR, 2015). The Source Water Protection Plan identifies three main regulatory factors under the *Clean Water Act (2006)* relating to local hydrogeology to consider for site development: Significant Groundwater Recharge Areas (SGRAs), Highly Vulnerable Aquifers (HVAs), and Wellhead Protection Areas (WHPAs).

Based on available MECP Source Protection Information mapping, small isolated areas of the Durham Live project are situated on a HVA. A HVA can be described as an aquifer that is susceptible to contamination because of its location near the ground's surface, or the soil material is highly permeable. **Figure 5** details the location of the HVAs within the study area. The inclusion of these areas on the site is likely an artifact of the large-scale modelling work used to define the HVAs as the soil types on the site do not reflect an area that would hydrogeological be considered highly vulnerable (till drumlins <10 m in thickness). No SGRA and WHPA were found near the study area.

The results of the Source Water Protection mapping confirm that the Durham Live! site does not function as an important groundwater recharge area. In addition, given its location near the bottom of the Duffins Creek watershed and near Lake Ontario, regional aquifers or groundwater flow are not reliant on recharge from the site. Our assessment will therefore focus on groundwater/ surface water input to the *features* on site through a FBWB rather than overall groundwater recharge.

Legend

⊙ Water Well[1]

▭ Subject Site

⌜⌟ 500 m Buffer

— Watercourse

⇢ Ephemeral Drainage Feature

1 - Source: Ministry of Environment, Conservation and Parks (Water Well Information System)

Imagery (2017 - DigitalGlobe) provided by Esri basemap service.

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0 50 100 150 200
metres

N

DRAWN: B. Elder
CHECKED: A. Lo
PROJECT: 1805601
DATE: Jan 20, 2020

Scale 1:10000
UTM Zone 17N
NAD 1983

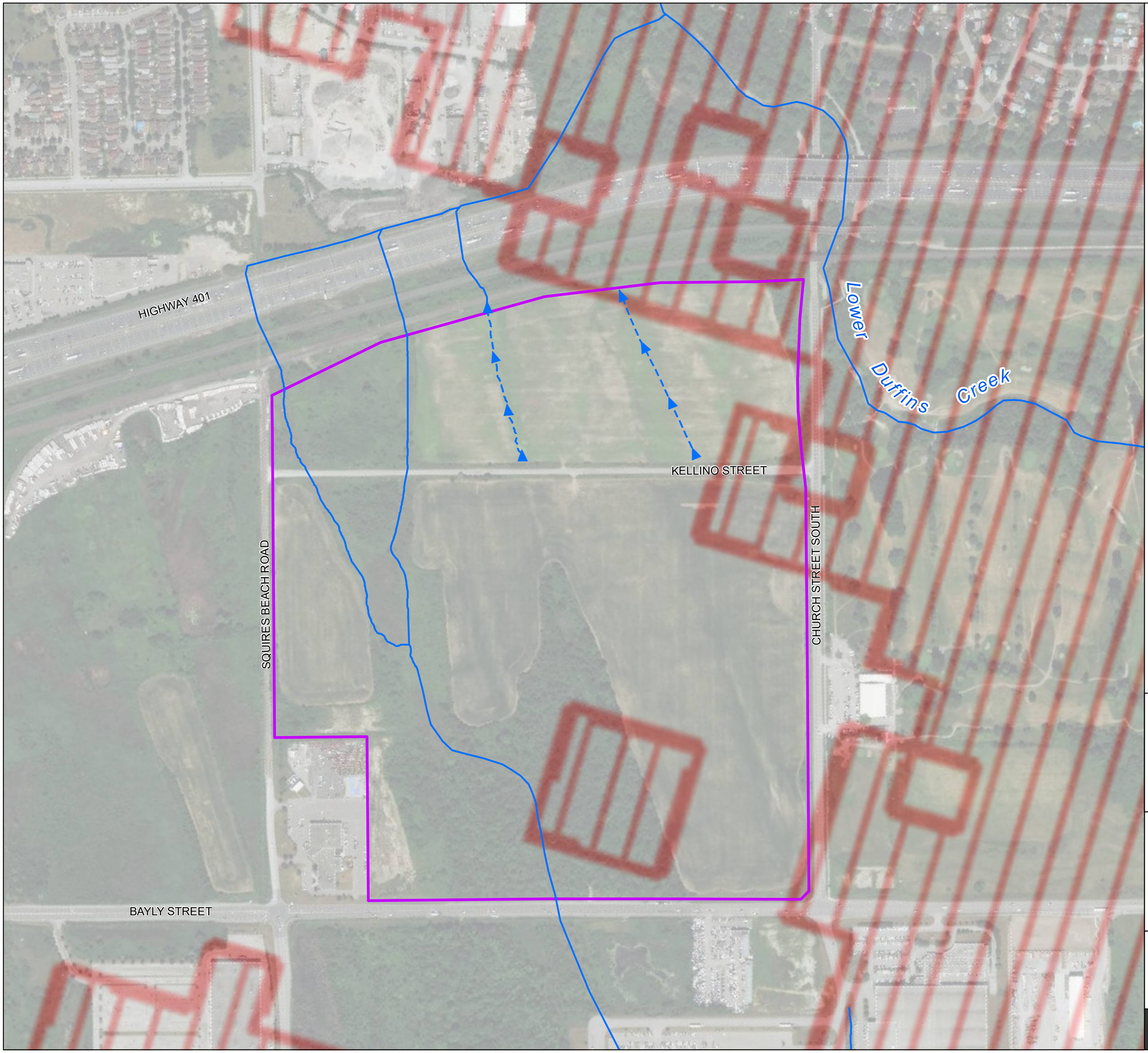
Palmer™

CLIENT: Pickering Developments
PROJECT: Durham Live

MECP Water Wells

FIGURE 4

Document Path: W:\Egnyte\Shared\Projects\Active\18056 - Pickering Developments Inc\1805601 - Durham Live - Geotechnical and Hydrogeological Study for H2 and EA\Mapping\mxd\Nov2019\1805601_4-1_Wells.mxd



Legend

- ▨ Highly Vulnerable Aquifer[1]
- □ Subject Site
- — Watercourse
- - ▸ Ephemeral Drainage Feature

1 - Source: Ministry of Environment, Conservation and Parks (Source Protection Information Atlas)

Imagery (2017 - DigitalGlobe) provided by Esri basemap service.

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0 50 100 150 200
metres

N

DRAWN: B. Elder
CHECKED: A. Lo
PROJECT: 1805601
DATE: Jan 20, 2020

Scale 1:8000
UTM Zone 17N
NAD 1983

Palmer™

CLIENT: Pickering Developments
PROJECT: Durham Live

Source Water Protection

FIGURE 5

Document Path: W:\Egnyte\Shared\Projects\Active\18056 - Pickering Development's Inc\1805601 - Durham Live - Geotechnical and Hydrogeological Study for H2 and EA\Mapping\mxd\Nov2019\1805601_5-1_SWP.mxd

4 Site-Specific Conditions

Having a conceptual model of groundwater flow at the Durham Live site is critical for completing a water budget and effects assessment. **Section 4** describes our understanding of geological and hydrogeological conditions, how groundwater flow supports the natural environment, and how and where mitigation measures could be applied to protect natural features and groundwater resources.

4.1 Surface Water Features and Drainage

Lower Duffins Creek is located immediately northeast and east of the study area, outside of the site boundary (**Figure 1**). Lower Duffins Creek is a natural warm water reach, which is a consequence of its size, and the low quantities of groundwater input into the creek (TRCA, 2002).

Overall, drainage at the site is highly complex and controlled by the undulating landscape and roadside drainage ditching. **Appendix A** presents the surface water flow direction and pre-development catchment areas on the site represented by Catchment C2 and C4 (also shown on **Figure 17**). On the eastern portion of the site, surface water flows south within the PSW wetland towards the Bayly Street drainage ditching. This area represents the <u>C2 Catchment</u>. Surface water then flows west in the drainage ditch and is joined by flow from the south side of Bayly Street, before turning north and re-entering the PSW. Surface water continues to flow north under Kellino Road and exits the site at a culvert under the CN rail corridor. This area represents the <u>C4 Catchment</u>. The FBWB assessment uses this understanding of surface water flow to assess the potential for impacts to the PSW wetlands.

The water levels at MP9 and MP10 were used to determine the flow direction of this tributary across Kellino Street. At MP9, flow is observed to be flowing to the south, ultimately connecting with the tributary and flowing to the north, back under Kellino Street and off-site. The flow at MP 19 assumed to be flowing in the north direction as the land generally slopes towards northwards. A culvert connection near MP9 and MP10 below Kellino Street was not observed.

4.2 Provincially Significant Wetlands

The central portion of the site contains the Lower Duffins Creek Provincially Significant Wetland (PSW). The C2 catchment includes PSW wetland communities on the eastern portion of the site adjacent to the “Fat Plan” and the C4 catchment includes PSW wetland communities on the central and western portions of the site adjacent to the “Film Studio” lands. The development plans are provided in **Appendix A**.

Ecological Land Classification (ELC) mapping completed by Beacon indicates that the PSW is dominated by the following swamp (SWD and SWT) and marsh (MAM and MAS) communities (**Figure 2**):

<u>C2 Catchment</u>

- SWD3-2
- SWT2-5
- MAM2-2
- MAS2-9

C4 Catchment

- SWD3-2
- SWT2-2
- MAS2-1

Based on our understanding of wetland function from Beacon (2019) the swamp communities (SWD and SWT) are generally more sensitive to hydrological change than the marsh communities as the require distinct periods of inundation and dry conditions. While still potentially sensitive, the marsh communities (MAM and MAS) are typically inundated year-round or for the majority of the year and often can adapt to small changes in surface water or groundwater inputs.

4.3 Geology

The surficial geological conditions were revised from the regional geology mapping (OGS, 2003) based on the results of borehole drilling, and an interpretation of shallow geological conditions assessed during site investigations using a 1 m long hand auger from within the wetland units. **Figure 3** presents a site-specific surficial geology map for the site and **Figure 6** and **Figure 7** present a north-south and east-west hydrostratigraphic cross section, respectively, that were constructed using the lithographic descriptions and depth from the borehole logs (**Appendix B**).

The OGS mapping identified a series of northwest-northeast trending drumlins bisecting the site and coinciding with upland areas. The presence of drumlins was confirmed during site investigations and their location was revised to more accurately reflect their location on the site.

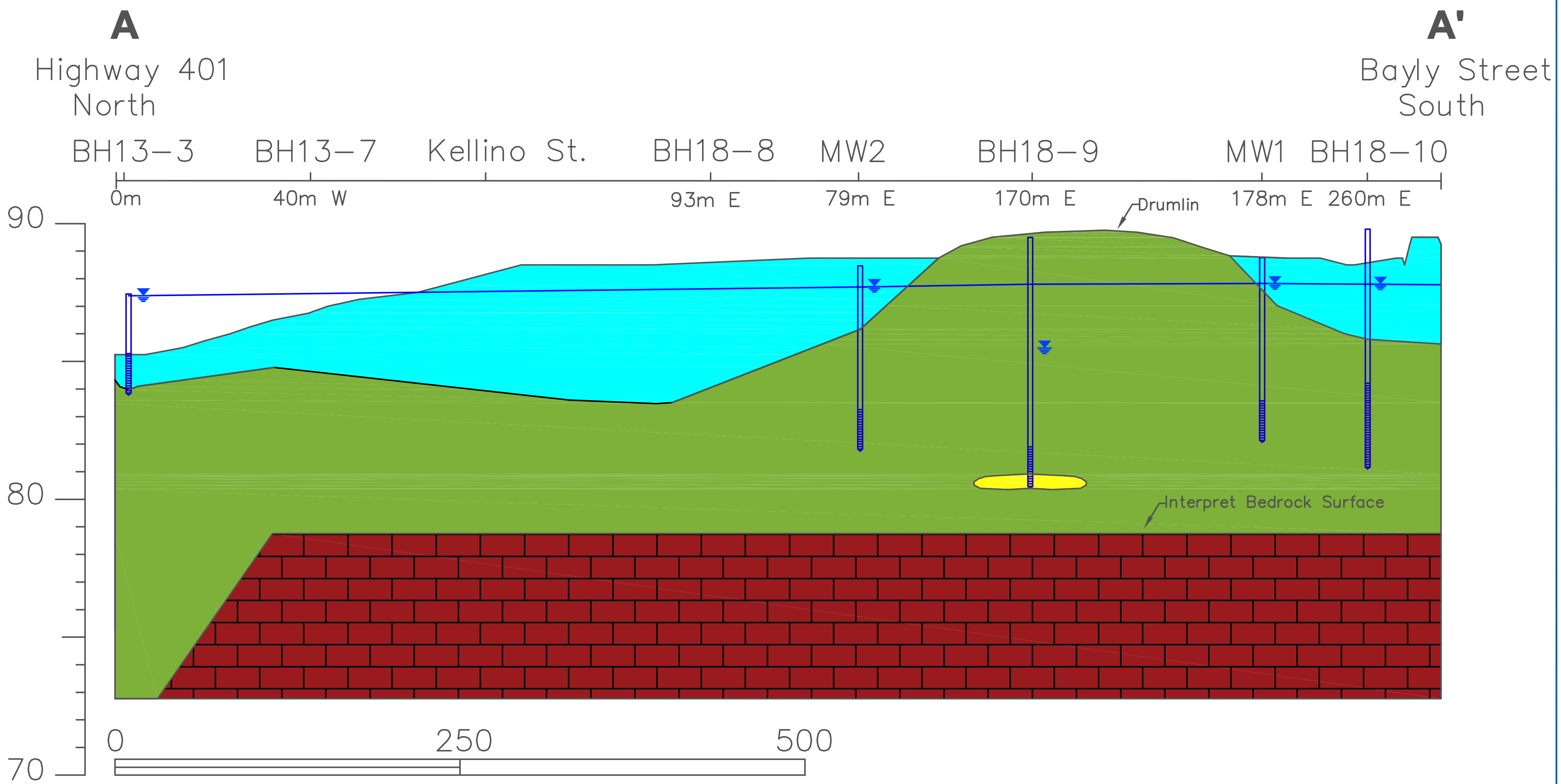
During the drilling program conducted in November and December 2018, boreholes encountered either a pavement structure or topsoil at surface. In boreholes where topsoil is present, it was found extending from the ground surface to depths ranging from 0.180 to 0.250 mbgs. Where fill deposits were encountered, they were found extending to depths ranging from 0.7 to 3.1 mbgs and consists of mainly clayey silt, silty clay, sand, and sandy silt with some rootlets and organics.

The native stratigraphy of the site as encountered during borehole drilling is described below:

Fine-Textured Glaciolacustrine Deposits (Clay, silt, clayey silt, silty clay, silty sand, and sandy silt):

Generally, the glaciolacustrine deposits were found in low-lying areas between the drumlins and are associated with the formation of wetlands (BH18-1, BH18-5, BH18-11, BH18-12, BH18-14, and TH18-6). The soils were found to be comprised of clay, silt, clayey silt, silty clay, silty sand, and sandy silt.

Throughout the site, most of the glaciolacustrine deposits are found below the surficial topsoil/fill/road structure and is found to reach depths ranging from 2.0 to 7.2 mbgs. In general, the glaciolacustrine silty clay deposits are present at an elevation less than 86 to 92 masl, which coincide with the low-lying areas between the drumlins.



Legend

🟦 Glaciolacustrine Sand, Silt, and Silty Clay

▨ Sand

🟩 Newmarket Till

🟥 Shale

▼ Piezometric Head

— Water Level

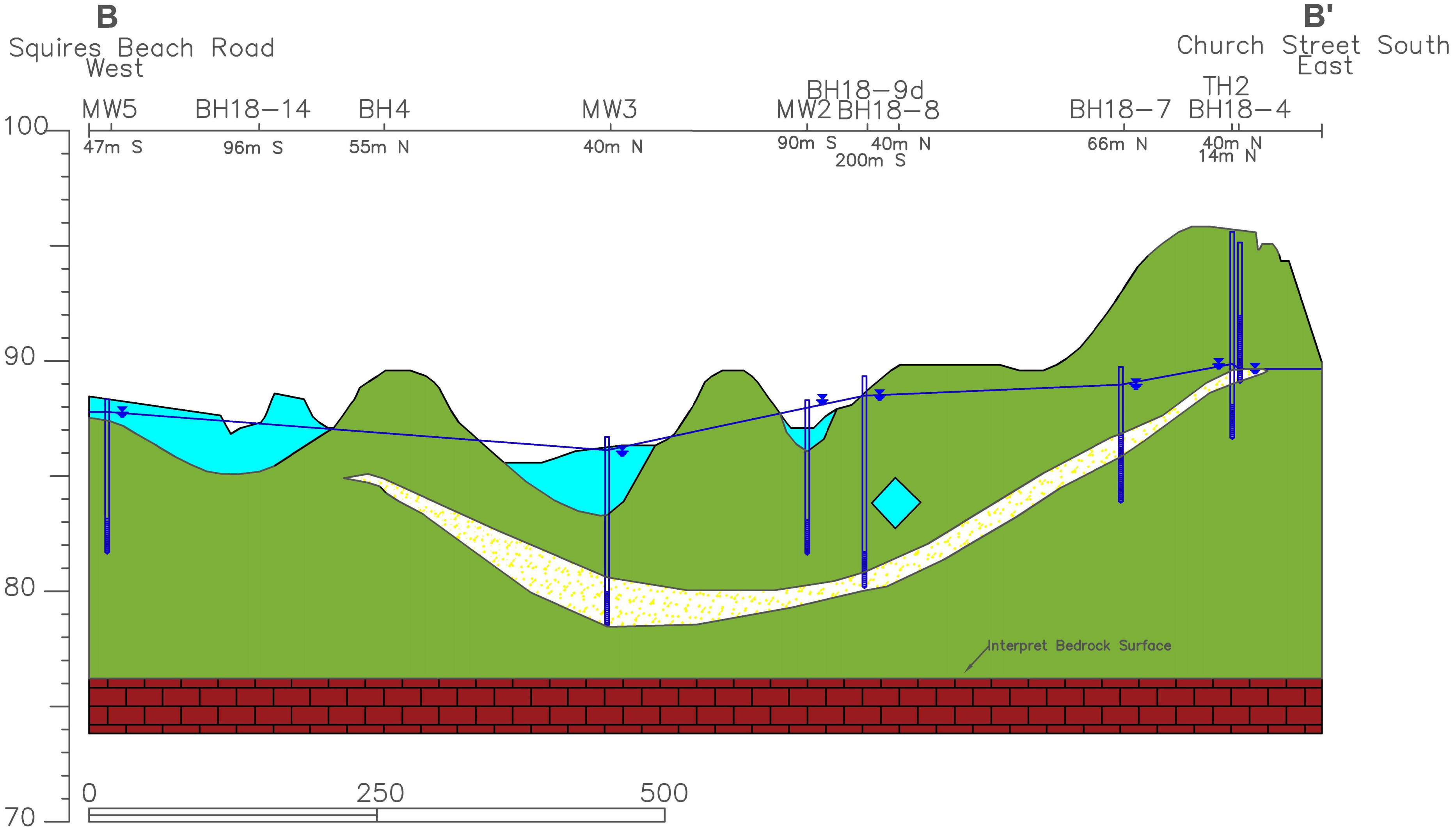
* water level data derived from November 15, 2014 (BH13-3), December 13, 2017 (TH2), December 17, 2018, and January 28, 2019 monitoring events

CLIENT: Pickering Developments Inc.
186 Bartley Drive
North York, ON
M4A 1E1

FIGURE: Figure 6

TITLE: A-A' North-South
Hydrostratigraphic Cross-Section

SCALE AT 11 X 8: See inset
DATE: Dec 16, 2019
DRAWN: AL
CHECKED: JC
PROJECT NO: 180561
SITE: Pickering, ON
REVISION: A



Legend

🟦 Glaciolacustrine Sand, Silt, and Silty Clay

▨ Sand

🟩 Newmarket Till

🟥 Shale

▼ Piezometric Head

— Water Level

* water level data derived from December 13, 2017 (TH2), December 17, 2018, and January 28, 2019 monitoring events

CLIENT: Pickering Developments Inc.
186 Bartley Drive
North York, ON
M4A 1E1

FIGURE: Figure 7

TITLE: B-B' East West
Hydrostratigraphic Cross-Section

SCALE AT 11 X 8:	DATE:	DRAWN:	CHECKED:
See inset	Dec 16, 2019	AL	JC
PROJECT NO:	SITE:		REVISION:
180561	Pickering, ON		A

Newmarket Till (Silty clay till, clayey silt till, and sandy silt till):

The Newmarket Till layer was found beneath the glaciolacustrine deposits and consists of silty clay till, clayey silt till, and sandy silt till with some gravel, cobbles and boulders. This deposit formed the drumlins which would have acted as *till* islands during the last glaciation. Thin sand lenses can be found throughout the Newmarket Till deposit. This layer was found either at the ground surface (at the till islands) or below the glaciolacustrine deposit and extends to depths ranging from 3.5 mbgs to 10.2 mbgs.

Occasional silt or sand layers were found within the till layer. These sand layers were found at a depth ranging from 2.4 mbgs to 5.6 mbgs and range in thickness from 0.6 m to 1.8 m (BH18-2, BH18-3, BH18-5, BH18-7, BH18-8, and BH18-10).

Ordovician Blue Mountain Formation (Shale):

Shale was evident in two deep boreholes (TH18-05 and TH18-06) at a depth of 9.6 and 10.2 mbgs and extends to the full extent of the borehole. This shale is grey and moderately to highly weathered, with multiple fracture zones. Groundwater flow within the fractured shale is expected to flow southwards towards Lake Ontario and act as the primary aquifer unit at this site.

4.4 Hydrogeology

Based on site-specific subsurface conditions as encountered during drilling, and supported by regional surficial geology mapping (OGS, 2003), the Newmarket Till aquitard is present over the entire site. Low permeability glaciolacustrine silt and clay deposits are encountered within low-lying areas between the drumlins (**Figure 3**). No major aquifers are expected to be present at the site at depths less than 10 mbgs. Small-scale units (i.e., lenses) are present within the till unit and the upper fractured bedrock has sufficient permeability to convey groundwater flow.

4.4.1 Groundwater Levels and Flow

Monthly water levels were originally collected between September 2014 and September 2015. Generally, horizontal groundwater flow within the overburden is towards the swamp and marsh wetland found in the western portion of the site. North of Kellino Street, groundwater within the overburden will flow towards Highway 401. The general piezometric surface and groundwater flow is depicted in **Figure 8**. The manual water level data from 2014 to 2015 is presented graphically on **Figure 9**.

Beginning in August 2017, MW1, MW2, and MW3 were instrumented with Solinst dataloggers to continuously measure groundwater levels, and a bi-monthly manual monitoring program for all wells in the study area was initiated. The continuous water level and manual data collected at all monitoring wells between August 2017 and November 2019 data are presented graphically in **Figure 10**. Manual data collected from the newly installed wells from 2018 are presented in **Figure 11**. Groundwater level monitoring results from all MWs at the site are found in **Table 2** and **Table 3**.

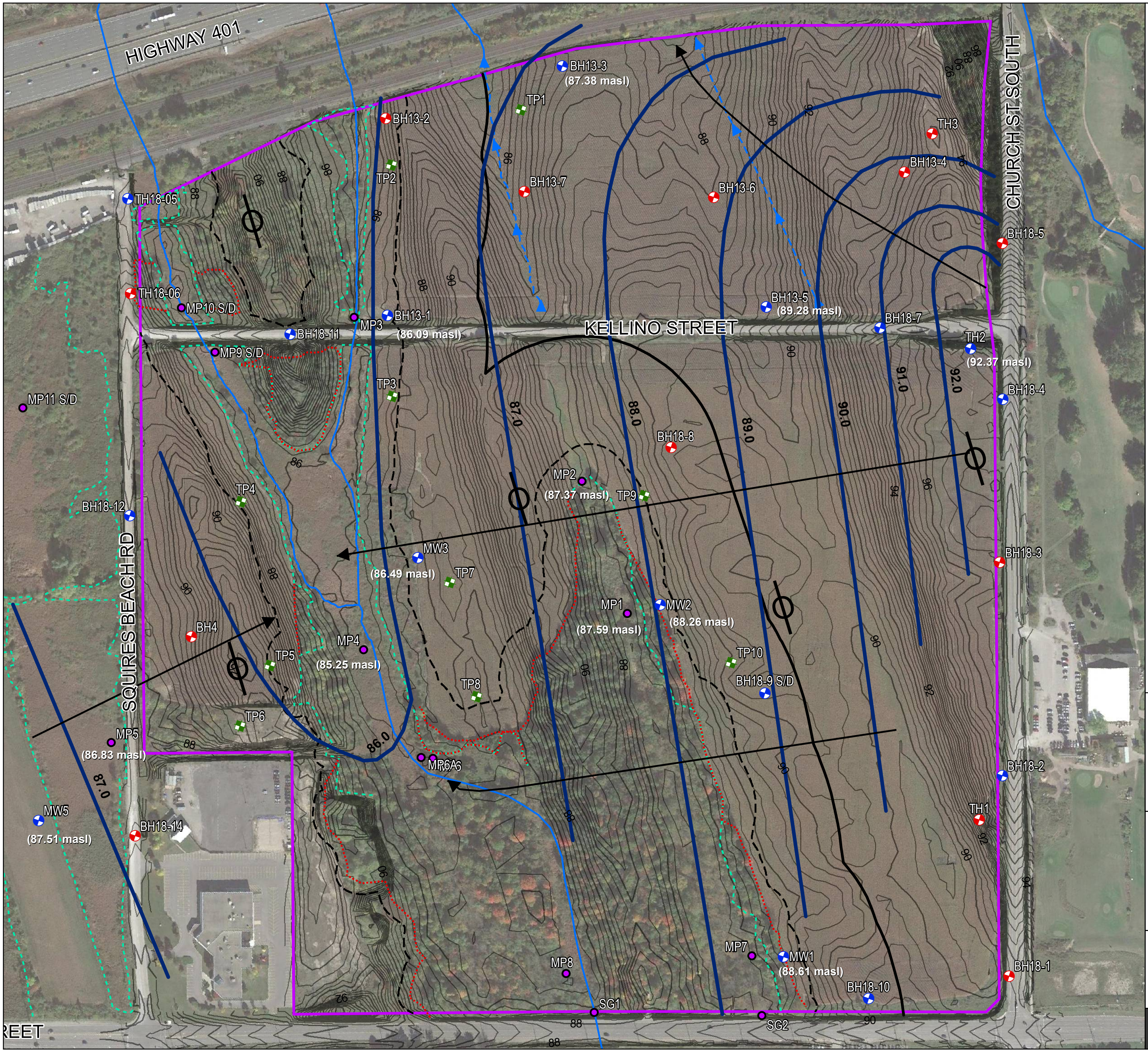
Water levels are plotted with monthly precipitation data, obtained from the Oshawa station (Climate ID: 6155875). The measured water levels generally follow the trends in precipitation. Water Levels are lowest during the late summer and winter months and rise during the spring indicating that water levels in the subsurface soils are controlled by local precipitation trends. In general, groundwater levels near wetland features and in low lying areas between the drumlins are found at around 2.3 mbgs. Deeper groundwater levels are found in upland areas. All groundwater levels show a similar seasonal change indicating they are hydraulically connected and no regional confined aquifers were encountered during drilling (i.e., Thorncliffe Fm). In particular, this interpretation applies to the 2.13 m thick sand unit encountered at MW3. This unit is interpreted to be a large lens within the Newmarket Till and not part of a larger aquifer unit.

Groundwater levels (excluding non stabilized water levels) were found to range from a low of 5.74 mbgs in TH2 to 0.43 metres above ground surface (mags) at MW2. Artesian conditions are expected to be localized and reflect the very low permeability of the confining upper till unit and the glaciolacustrine clay units. While localized artesian heads are observed, overall the hydraulic gradient at the site is downwards towards the bedrock, which is expected given the low permeability surficial soils and the absence of regional aquifer units. At nested wells BH18-9s and BH18-9d the vertical hydraulic gradient was generally downwards during monitoring events and was in the range of -0.13 m/m. The horizontal hydraulic gradient as determined from the potentiometric surface map in **Figure 7**, generally showed a horizontal hydraulic gradient in the range of 0.01 m/m. As expected, the vertical hydraulic gradient is more than an order of magnitude greater than the horizontal gradient and dominates groundwater flow at the site.

4.4.2 Hydraulic Conductivity

Single well response tests (i.e., slug tests) were completed at MW1, MW2, MW3, MW5, BH18-9D, BH18-11, and TH18-05. Slug test data and results can be found in **Appendix E**. To expand upon the results of the slug testing, grain size analysis estimates of hydraulic conductivity were made using the Puckett *et al.* (1985) method for fine grained soils. Sieve and hydrometer grain size curves from Golder (2015) were used for this assessment. The hydraulic conductivity estimates from grain size from soil at MW1, MW2 and MW4 were consistent with the slug test results.

The hydraulic conductivity of the glaciolacustrine silty clay in MW3 was calculated to be $3.7x10^{-9}$ using the Puckett et al. method. This is within the expected range for these types of soils. The calculated values of hydraulic conductivity for wells screened in Newmarket Till ranged from $2.0x10^{-7}$ m/s to $1.8x10^{-6}$ m/s, with a geometric mean of $4.5x10^{-7}$ m/s (**Table 4**), which is at the higher end of the range expected for till unit (Sharpe *et al*, 1996). The higher hydraulic relative to typical values is due to increased sand within the Till (e.g., sand silt to silty clay matrix). The calculated values of hydraulic conductivity for wells screened in sand layers or fractured shale ranged from $3.4x10^{-6}$ m/s to $8.0x10^{-6}$ m/s, with a geometric mean of $5.8x10^{-6}$ m/s (**Table 4**). The higher hydraulic relative to typical values is due to the monitoring wells being screened in the sandier facies of the till units and within the upper fractured portion of the shale bedrock.



Legend

- ● Mini-piezometer / Staff Gauge
- ● Borehole
- ● Monitoring Well
- ✚ Test Pit
- → Groundwater Flow
- — Equipotential Line (Nov 2014)
- Drumlin
- — H1 Area 120 m Setback
- - - 30 m Setback
- ····· Staked Dripline (Surveyor)
- - - Staked Wetland (Suveyor)
- — Watercourse
- - → Ephemeral Drainage Feature
- — Index Contour (1 m)
- — Contour (0.25 m)
- ▭ Subject Site
- **92.0** Groundwater Elevation (masl)

Imagery ©Google (DigitalGlobe - 2016)

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0 50 100 150

metres

N

DRAWN: B. Elder
CHECKED: J. Cole
PROJECT: 1805601
DATE: Jan 20, 2020

Scale 1:5000
UTM Zone 17N
NAD 1983

Palmer™

CLIENT: Pickering Developments
PROJECT: Durham Live

Piezometric Surface and Groundwater Flow

FIGURE 8

Document Path: W:\Egnyte\Shared\Projects\Active\18056 - Pickering Developments Inc\1805601 - Durham Live - Geotechnical and Hydrogeological Study for H2 and EA\Mapping\mxd\Nov2019\1805601_8-1_Equipotential.mxd

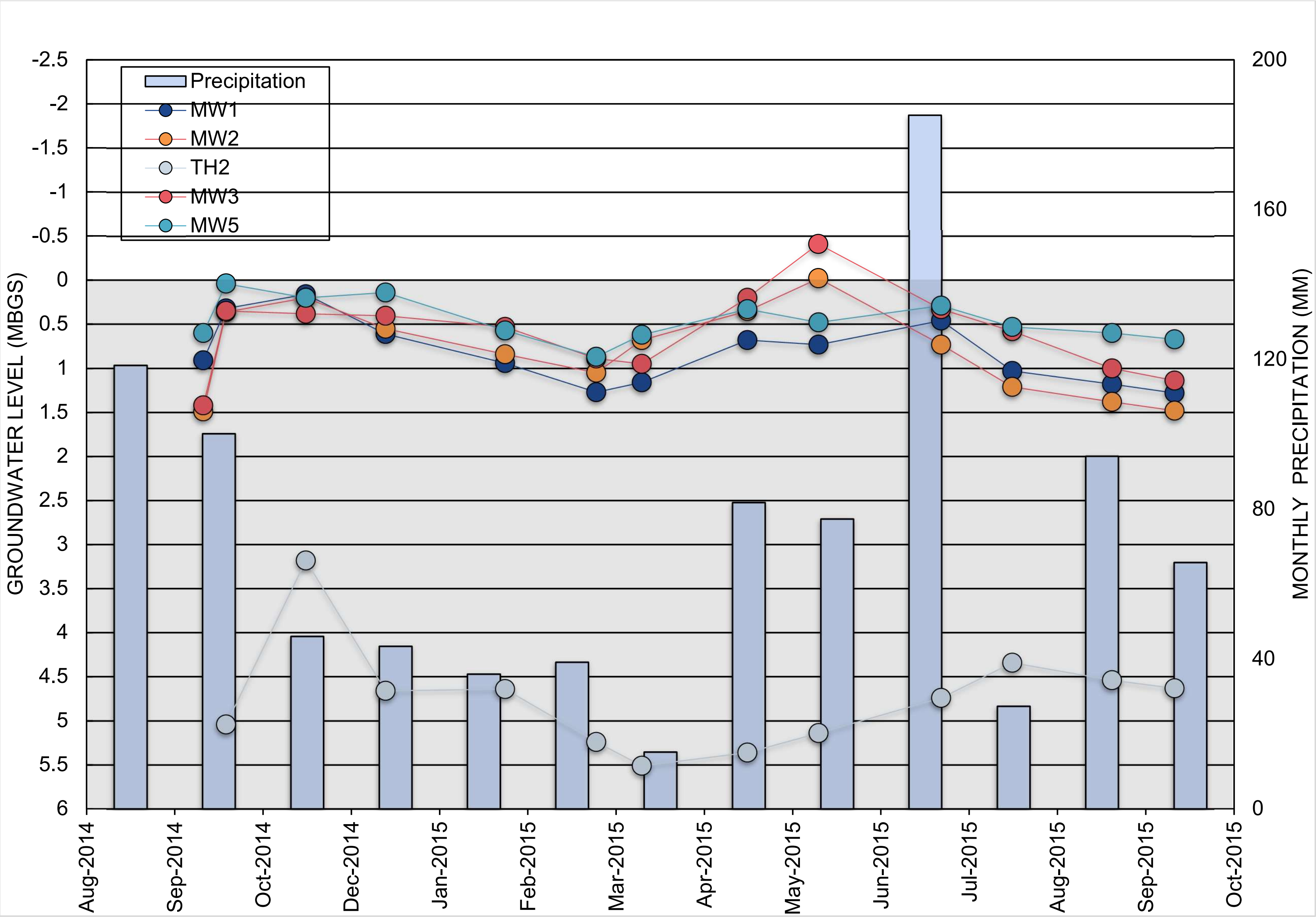


Figure 9. Manual Groundwater Levels (2014 – 2015)

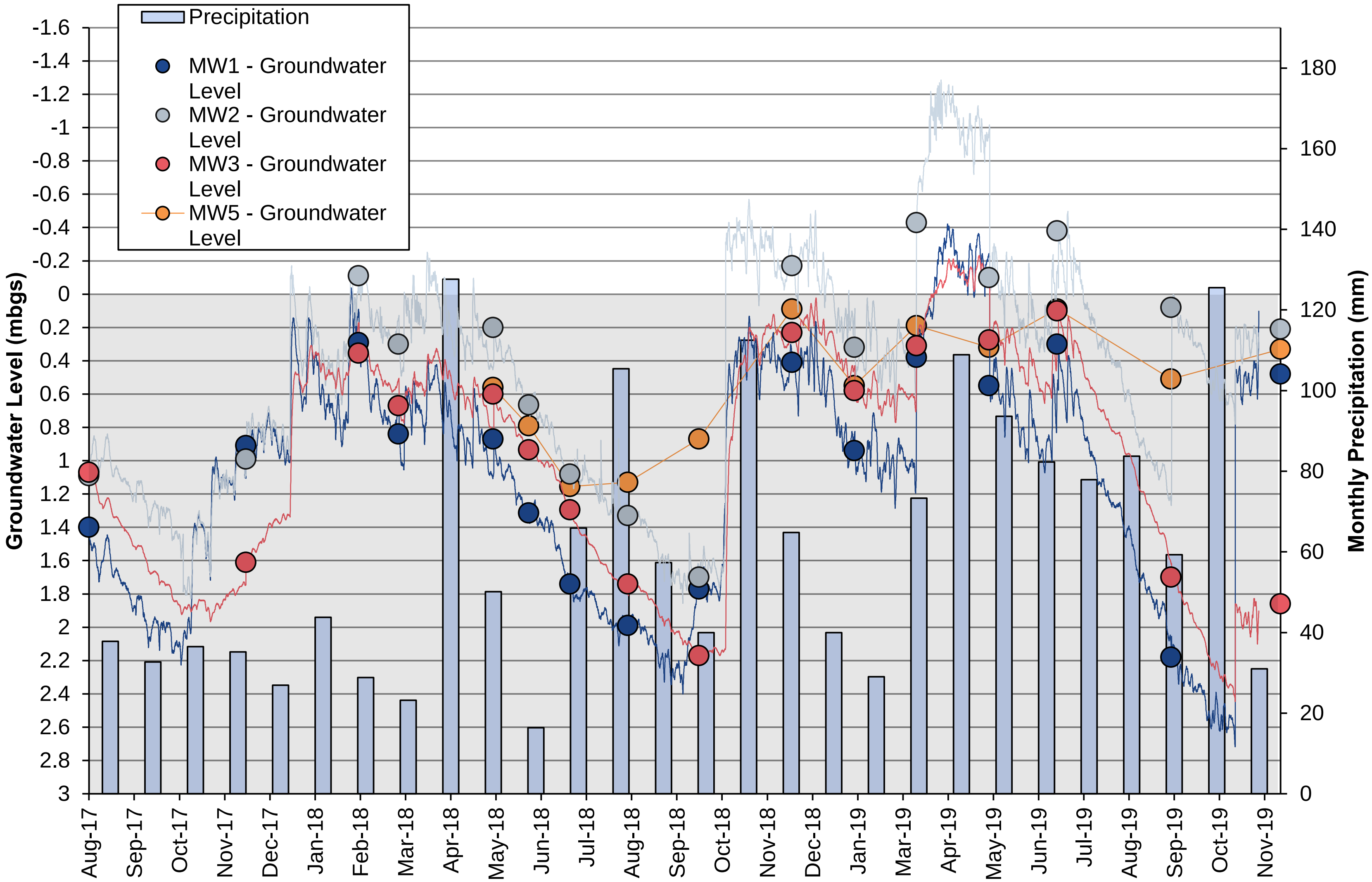


Figure 10. MW1, MW2, MW3, and MW5 Hydrograph (2017 – 2019)

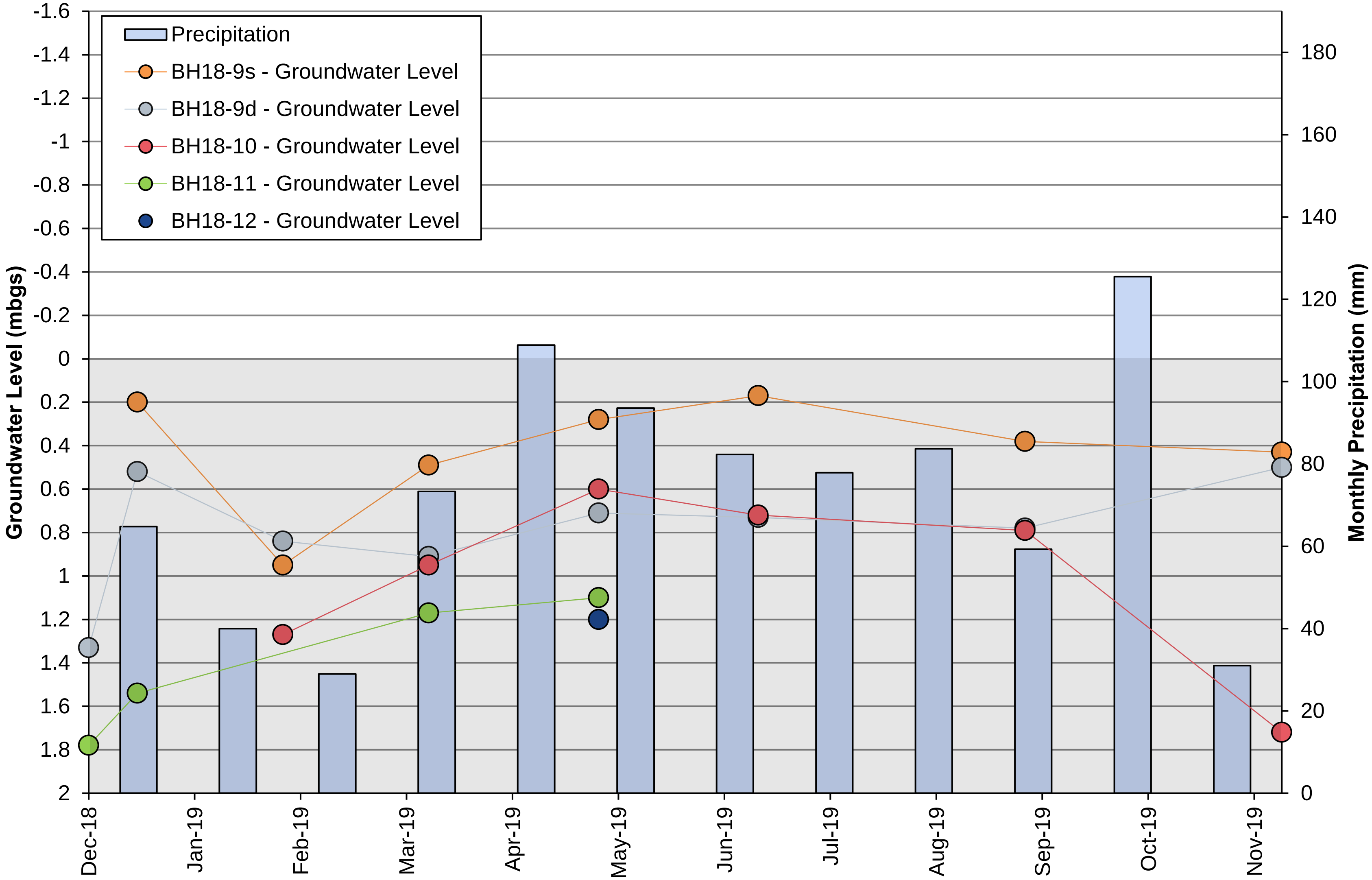


Figure 11. BH18-9s, BH18-9d, BH18-10, BH18-11, BH18-12 Manual Groundwater Levels (2018 – 2019)

Table 2. Monthly Water Level and Elevation (2014 – 2015)

					10-Oct-14	18-Oct-14	15-Nov-14	13-Dec-14	24-Jan-15	25-Feb-15	13-Mar-15	19-Apr-15	14-May-15	26-Jun-15	21-Jul-15	25-Aug-15	16-Sep-15
	Elevation (masl)	**Depth (mbgs)**	**Depth elevation (masl)**	**Stick UP (m)**	WL masl/mbgs	WL masl/mbgs	WL masl/mbgs	WL masl/mbgs	WL masl/mbgs	WL masl/mbgs	WL masl/mbgs	WL masl/mbgs	WL masl/mbgs	WL masl/mbgs	WL masl/mbgs	WL masl/mbgs	WL masl/mbgs
MW1	88.77	6.71	82.06	0.91	87.86 (0.91)	88.45 (0.32)	88.61 (0.16)	88.16 (0.61)	87.83 (0.94)	87.5 (1.27)	87.61 (1.16)	88.09 (0.68)	88.04 (0.73)	88.31 (0.46)	87.74 (1.03)	87.59 (1.18)	87.49 (1.28)
MW2	88.46	6.71	81.75	0.95	86.97 (1.49)	88.1 (0.36)	88.26 (0.2)	87.91 (0.55)	87.62 (0.84)	87.41 (1.05)	87.78 (0.68)	88.11 (0.35)	88.48 (-0.02)	87.73 (0.73)	87.25 (1.21)	87.08 (1.38)	86.98 (1.48)
TH2	95.55	9	86.55	0.88	96.43 (-0.88)	90.51 (5.04)	92.37 (3.18)	90.89 (4.66)	90.91 (4.64)	90.31 (5.24)	90.04 (5.51)	90.19 (5.36)	90.41 (5.14)	90.81 (4.74)	91.21 (4.34)	91.01 (4.54)	90.92 (4.63)
MW3	86.87	8.23	78.64	0.87	85.45 (1.42)	86.52 (0.35)	86.49 (0.38)	86.47 (0.41)	86.34 (0.53)	85.98 (0.89)	85.92 (0.95)	86.67 (0.2)	87.28 (-0.41)	86.54 (0.33)	86.29 (0.58)	85.87 (1)	85.73 (1.14)
MW5	88.5	6.71	81.79	0.92	87.9 (0.6)	88.46 (0.04)	88.3 (0.2)	88.36 (0.14)	87.93 (0.57)	87.63 (0.87)	87.88 (0.62)	88.17 (0.33)	88.02 (0.48)	88.21 (0.29)	87.97 (0.53)	87.9 (0.6)	87.83 (0.67)
BH13-1	86.40	3.66	82.74	0.85	85.33 (1.07)	85.93 (0.47)	86.09 (0.31)	wells decommissioned									
BH13-3	87.60	3.66	83.94	0.86	86.38 (1.22)	87.08 (0.52)	87.38 (0.22)										
BH13-5	89.95	3.66	86.29	0.79	88.18 (1.77)	89.08 (0.87)	89.88 (0.07)										

Table 3. Monthly Water Level and Elevation (2017 – 2019)

					29-Aug-17	13-Dec-17	27-Feb-18	26-Mar-18	29-May-18	22-Jun-18	20-Jul-18	28-Aug-18	15-Oct-18	3-Dec-18	17-Dec-18	28-Jan-19	11-Mar-19	29-Apr-19	14-Jun-19	30-Aug-19	12-Nov-19
	Elevation (masl)	**Depth (mbgs)**	**Depth Elevation (masl)**	**Stick Up (m)**	WL masl/ mbgs	WL masl/ mbgs	WL masl/ mbgs	WL masl/ mbgs	WL masl/ mbgs	WL masl/ mbgs	WL masl/ mbgs	WL masl/ mbgs	WL masl/ mbgs	WL masl/ mbgs	WL masl/ mbgs	WL masl/ mbgs	WL masl/ mbgs	WL masl/ mbgs	WL masl/ mbgs	WL masl/ mbgs	WL masl/ mbgs
MW1	88.77	6.71	82.06	0.91	87.37 (1.4)	87.86 (0.91)	88.48 (0.29)	87.93 (0.84)	87.9 (0.87)	87.46 (1.32)	87.03 (1.74)	86.78 (1.99)	87 (1.77)	-	88.36 (0.41)	87.83 (0.94)	88.39 (0.38)	88.22 (0.55)	88.47 (0.3)	86.59 (2.18)	88.29 (0.48)
MW2	88.46	6.71	81.75	0.95	87.37 (1.09)	87.83 (0.99)	88.13 (-0.11)	87.72 (0.3)	87.82 (0.2)	87.36 (0.67)	86.94 (1.08)	86.69 (1.33)	86.32 (1.7)	-	88.19 (-0.17)	87.7 (0.32)	88.45 (-0.43)	88.12 (-0.1)	88.4 (-0.38)	87.94 (0.09)	87.81 (0.21)
TH2	95.55	9	86.55	0.88	90.81 (4.74)	89.81 (5.74)	well blocked														
MW3	86.87	8.23	78.64	0.87	85.8 (1.07)	85.26 (1.61)	86.52 (0.36)	86.2 (0.67)	86.27 (0.6)	85.94 (0.94)	85.58 (1.3)	85.13 (1.74)	84.7 (2.17)	-	86.64 (0.23)	86.29 (0.58)	86.56 (0.31)	86.6 (0.28)	86.77 (0.1)	85.17 (1.7)	85.01 (1.86)
MW5	88.5	6.71	81.79	0.92	-	-	-	-	87.94 (0.56)	87.71 (0.79)	87.35 (1.16)	87.37 (1.13)	87.63 (0.87)	-	88.41 (0.09)	87.95 (0.55)	88.31 (0.19)	88.18 (0.32)	88.41 (0.09)	87.99 (0.51)	88.17 (0.33)
BH18-2	95.57	6.1	89.47	0	-	-	-	-	-	-	-	-	-	94.51 (1.06)	damaged						
BH18-4	95.30	6.12	89.18	0	-	-	-	-	-	-	-	-	-	89.82 (5.48)	damaged						
BH18-7	89.86	6	83.86	0	-	-	-	-	-	-	-	-	-	-	89.09 (0.77)	damaged					
BH18-9S	89.50	5.41	84.09	0.84	-	-	-	-	-	-	-	-	-	-	89.3 (0.2)	88.55 (0.95)	89.01 (0.49)	89.22 (0.28)	89.33 (0.17)	89.12 (0.38)	89.07 (0.43)
BH18-9D	89.50	10.85	78.65	0.84	-	-	-	-	-	-	-	-	-	88.17 (1.33)	88.98 (0.52)	88.66 (0.84)	88.59 (0.91)	88.79 (0.71)	88.77 (0.73)	88.72 (0.78)	89 (0.5)
BH18-10	89.83	9.96	79.87	0.81	-	-	-	-	-	-	-	-	-	-	-	88.56 (1.27)	88.88 (0.95)	89.23 (0.6)	89.11 (0.72)	89.04 (0.79)	88.11 (1.72)
BH18-11	88.61	6.2	82.41	0	-	-	-	-	-	-	-	-	-	86.83 (1.78)	87.07 (1.54)	-	87.44 (1.17)	87.51 (1.1)	-	-	-
BH18-12	89.27	6.1	83.17	0	-	-	-	-	-	-	-	-	-	-	83.77 (5.5)	-	-	88.07 (1.2)	damaged		
TH18-05	87.42	10.39	77.03	0	-	-	-	-	-	-	-	-	-	-	84.97 (2.45)	-	85.09 (2.33)	damaged			

Table 4. Calculated Hydraulic Conductivity

Well/ Borehole	Test	K (m/s)	Unit	Geometric Mean
MW3	Grain Size	3.7x10^{-9}	Glaciolacustrine Deposit (Silty Clay)	3.7x10^{-9}
MW1	FH-1	4.1x10^{-7}	Newmarket Till (Silty Clay Till, Clayey Silt Till, Sandy Silt Till)	4.5x10^{-7}
	RH-1	5.3x10^{-7}		
	Grain Size	3.8x10^{-7}		
MW2	FH-1	2.9x10^{-7}		
	RH-1	3.8x10^{-7}		
	Grain Size	2.3x10^{-7}		
MW4	Grain Size	2.0x10^{-7}		
MW5	FH-1	1.1x10^{-6}		
	RH-1	1.8x10^{-6}		
BH18-9D	FH-1	2.5x10^{-7}		
	RH-1	8.7x10^{-7}		
BH11	FH-1	2.7x10^{-7}		
	RH-1	5.6x10^{-7}		
MW3	FH-1	5.0x10^{-6}	Sand Layer/Fractured Shale	5.8x10^{-6}
	RH-1	8.0x10^{-6}		
TH18-05	FH-1	3.4x10^{-6}		
	RH-1	6.1x10^{-6}		
	FH-2	6.3x10^{-6}		
	RH-2	7.1x10^{-6}		

4.4.3 Recharge, Discharge and Groundwater Flow

Recharge is the term used to describe downward-flowing groundwater, that is, from the ground surface towards the water table. Of all precipitation that reaches the ground surface, much is lost to evapotranspiration (ET) and surface runoff directly into streams, and the remainder infiltrates into the ground. Discharge is defined as upward-flowing groundwater where the water table intersects the ground surface. Groundwater discharge is important because it sustains a minimum flow (baseflow) in some streams, moderates stream temperatures, and dampens stream temperature fluctuations during the summer and winter.

Surficial geology is the most important factor influencing groundwater recharge and discharge. Where high permeability sediments such as sand and gravel are present at surface, precipitation rapidly infiltrates to recharge the water table. In contrast, where low permeability soils such as clay and till are present at surface, the area will have a limited recharge potential and surface runoff will exceed infiltration.

Groundwater flow and the relationship between recharge and runoff are controlled by the specific geological and hydrogeological conditions found at the Durham Live site. Newmarket Till drumlins are found in upland areas of the site, with deposits of glaciolacustrine silt and clay found in the low-lying areas between the drumlins.

Horizontal groundwater movement is interpreted to flow from topographically high areas to topographically low areas as presented in the cross section in **Figure 6** and **Figure 7**. On the Casino Lands north of Kellino Street, groundwater flow is generally to the north, flowing off site and away from the PSW wetlands. South of Kellino Street, groundwater flow is interpreted to flow to the west towards the wetland at MP4 and into the Duffins Creek tributary. Measured artesian conditions at MW2 and MW3 suggest the potential for seasonal upwards hydraulic gradients at this location. West of Squires Beach Road, groundwater flow is interpreted to flow eastwards towards MP4 and into the Duffins Creek tributary by comparing the water levels at MW5 and BH18-12.

As discussed previously, horizontal hydraulic gradient of 0.01 m/m and a vertical hydraulic gradient of -0.13 m/m were calculated as being representative for overall groundwater flow at the site. For areas of localized artesian conditions, a vertical hydraulic gradient was calculated between MW2 and MP1, and MW3 and MP4. The vertical hydraulic gradient was upwards at both locations and ranged from 0.13 m/m at MW2/MP1 to 0.17 m/m at MW3/MP4. It is important to note that while upwards hydraulic gradients indicate groundwater discharge, the groundwater flux (Q) is highly dependent upon the hydraulic conductivity of the soils. This minor amount of groundwater discharge is not sufficient to sustain water levels in the wetlands, and seasonal trends in precipitation and surface runoff are the controlling factors for surface water levels in the wetlands. The same mechanism that limits groundwater discharge from the wetlands also limits the groundwater recharge potential from these features and allows for prolonged surface water inundation.

The water budget is expected to be dominated by surface water runoff rather than infiltration due to the presence of low permeability soils. Areas underlain by till soils are generally dryer as demonstrated by the presence of upland forest communities and active agriculture use, and therefore have some potential to infiltrate water. Low lying areas underlain by glaciolacustrine silt and clay trap water and limit the recharge and discharge potential of these areas.

4.4.4 Groundwater / Surface Water Interactions

Mini-piezometers (MPs) were used to assess groundwater/surface water interactions both in terms of measuring the vertical hydraulic gradients as well as to measure the hydroperiod of each wetland community. The TRCA Wetland Water Balance Monitoring Protocol (2016) was used to guide the development of the wetland monitoring program. Long-term groundwater and surface water information for each feature was obtained through the installation of a mix of sealed MPs and open standpipe MPs installed together at most locations. Key wetland locations were instrumented with Solinst dataloggers to continuously monitor wetland water levels. Two (2) staff gauges (SG) locations were installed in the drainage ditching along the north side of Bayly Street to capture surface water flow out of and into the wetland communities. **Figure 2** presents the location of each wetland MP and SG shown along with the ELC communities for the site as identified by Beacon (2019).

The MPs have been grouped based on the wetland community they represent so that the hydrology of the wetland can be defined and used to assess potential changes from site development. The initial monitoring results from September 2014 to September 2015 for the initial MP installation are presented in **Figure 12**.

The hydroperiod for each of the key wetland communities (**Figure 2**) has been defined through MP monitoring as follows:

- ***Eastern SWD3-2*** along the eastern portion of the site near the entertainment complex (includes SWT2-5, MAS2-9 and MAM2-2 communities) – MP1, MP2, MP7, and SG2 (**Figure 13**);
- ***Central SWD3-2*** within the central southern portion of the site, south of the film studios – MP8 and SG1 (**Figure 14**);
- ***MAS2-1 within the western portion*** of the site (includes SWT2-2 and SWT2-5) near the film studios –MP4, MP6, and MP9 (**Figure 15**); and
- MAS2-1 and SWD2-2 located on the west side of Squires Beach Road and north of Kellino Street – MP3, MP5, MP10, and MP11 (**Figure 16**).

The monthly monitoring data and gradient at each MP is found in **Table 5** and **Table 6**. A detailed description of the groundwater/ surface water interactions and hydroperiod at each MP is discussed below and is separated by key wetland community.

4.4.4.1 Eastern SWD3-2 Community Hydroperiod

MP1

MP1 was installed in September 2014 to measure both groundwater and wetland water levels in a Read-canary Grass Mineral Shallow Marsh community (MAM2-2) within the larger SWD3-2 wetland. The monthly monitoring data from September 2014 to September 2015 is presented in **Figure 12**. Continuous data from August 2017 to November 2019 is presented in **Figure 13**.

Between September and November 2014, the groundwater level was recovering suggesting very low permeability soils in the wetland. After reaching equilibrium, the monitoring results indicate seasonal variation between upwards and downwards hydraulic gradients, indicating seasonal groundwater discharge during the spring and summer months. Excluding the winter months when frozen conditions can lead to errors in the continuous data, the wetland water level ranges from approximately -0.60 m (i.e., dry to 0.60 m below ground) to approximately 0.30 m.

Based on the long-term monitoring results and the seasonal hydroperiod of the wetland, it is concluded that this wetland is primarily a surface water supported feature with limited groundwater contributions.

MP2

MP2 was installed in September 2014 to measure wetland water levels in a Red-Osier Mineral Thicket Swamp (SWT2-5) community at a point where an ephemeral drainage feature enters the eastern SWD3-2 wetland. In this type of feature, a period of inundation and a dry period would be expected. The monthly monitoring data from September 2014 to September 2015 is presented in **Figure 12**. Continuous data from August 2017 to November 2019 is presented in **Figure 13**.

From September 2014 to September 2015, the wetland water levels followed a typical seasonal pattern of being inundated between approximately mid-March and late June, and dry for the remaining times of the year. The wetland water levels ranged from -0.68 m to 0.19 m. The wetland is expected to be infrequently inundated between approximately March and July, and therefore, do not provide yearly amphibian breeding habitat.

Between August 2017 and November 2018, MP2 was dry (excluding frozen conditions in winter 2018). No inundation was measured during this time. Starting in December 2018 and continuing until July 2019, the wetland at MP2 was inundated with approximately 0.10 m of water on average. After July 2019, the wetland was again dry. The water level between August 2017 to October 2019 ranged from approximately -1.30 m (dry) to +0.10 m.

The hydroperiod measured at MP2 is representative of the SWT2-5 community with a small catchment area. The small catchment area limits the total volume of water that enters the feature causing the large range in seasonal water level changes. This pattern, along with a precipitation driven hydroperiod, and the swamp wetland community type, indicate a surface water supported feature.

MP7

MP7 was installed in August 2017 to measure wetland water levels in the deciduous swamp community (SWD3-2). Continuous data from August 2017 to November 2019 is presented in **Figure 13**.

During the monitoring period, the wetland water levels responded to seasonal precipitation and temperature trends. Between August 2017 and June 2018, the water level fluctuated in a relatively small range between approximately +0.10 m and -0.30 m (dry). Between July 2018 and November 2018, the water level was approximately -0.60 m, indicating a sustained dry condition. Similar to MP1 and MP2, starting in December 2018 and continuing until July 2019, the wetland at MP7 was inundated with approximately 0.30 m of water on average. After July 2019, the wetland was again dry.

This pattern of wetland water levels is considered typical for a swamp community where periods of inundation are observed in the spring, with the wetland being dry for much for the remaining portions of the year. Based upon this, it is expected that the wetland is typically inundated or near inundated between March and July consistent with surface water inputs. Based on the long-term monitoring results and the seasonal hydroperiod of the wetland, it is concluded that the SWD3-2 wetland is primarily a surface water supported feature with limited groundwater contributions.

SG2

SG2 was installed at a clearly defined outlet to the eastern PSW wetland on the north side of Bayly Street. A berm was historically created as part of installation of a natural gas pipeline and Bayly Street that controls water levels in this wetland. The purpose of this monitoring location is to measure water levels in the wetland to determine when the wetland ‘spills’ into the roadside ditching along Bayly Street. The monitoring location was installed so that the spill elevation is at 0.0 m (i.e., water levels above 0.0 m indicate some outflow from the wetland. Monitoring data is presented in on **Figure 13**.

When installed in August 2017, the wetland had a water level of -0.16 m. Between August 2017 and November 2019, excluding the frozen conditions in the winter months, the water level was typically below ground, indicating limited outflow from the wetland. Only during short periods in December 2017, March 2018 and May 2018 did the wetland spill to the ditch.

However, in winter 2019 and continuing until almost July 2019, the water levels in the SWD3-2 wetland were high and drainage at SG2 was measured. No drainage was measured after July 2019.

Overall Eastern SWD3-2 Wetland Hydrology Assessment

It is clear from the water level data at MP1, MP7 and SG2 that the eastern SWD3-2 wetland is a predominantly surface water supported feature with water levels fluctuating seasonally with precipitation and snow melt trends (**Figure 13**). Extended periods of dry conditions as observed during 2017 and 2018 are expected to be more typical than the extended period of inundation observed in 2019. Based on the continuous data collected to date, it is expected that the wetland is generally inundated between approximately March and July, during the amphibian breeding season.

As important observation from the monitoring data is that the water level in MP1, MP2 and MP7 did not exceed approximately 0.40 m (excluding frozen winter conditions). When comparing this pattern to the water level pattern of SG2, it is estimated that at a water level of approximately 0.30 mags the wetland spills into the drainage ditching on the north side of Bayly Street. Therefore, in years where the spring runoff or storm events are large, the wetland can drain which reduces the risk of long-term ponding or changes to the hydroperiod from increased surface water flow.

To estimate the limited volume of groundwater discharge to the wetland, the Darcy equation was used. Based on a hydraulic gradient or 0.13 m/m (maximum upwards gradient measured at MP1), a hydraulic conductivity of the glaciolacustrine clay of 3.7×10^{-9} m/s, and the area of the wetland (~1,650 m^2) the rate of groundwater discharge to the feature is 0.001 L/s. If the area of the entire marsh and swamp community along the eastern edge of the SWD3-2 wetland was used, the estimated groundwater discharge increases to 0.009 L/s. This groundwater discharge rate is insufficient to maintain a consistent water level in the wetland and indicates that the vast majority of the water in this feature would be derived from surface runoff rather than groundwater discharge. Lateral flow of shallow infiltration (i.e., interflow) is expected to contribute a source of shallow groundwater to the wetland, but this water is not connected to the site wide flow system and its effects are expected to be localized in area (i.e., less than 30 m based on site topography).

4.4.4.2 Central SWD3-2 Community Hydroperiod

MP8

MP8 was installed in August 2017 to measure wetland water levels in the deciduous swamp community (SWD3-2) within the central portion of the site. Continuous data from August 2017 to November 2019 is presented in **Figure 14**.

During the monitoring period, the wetland water levels responded to seasonal precipitation and temperature trends. This wetland has a large catchment area that includes direct precipitation to the feature, lands on the southside of Bayly Street and the drainage ditching along the north side of Bayly Street.

During the monitoring period, water levels ranged from approximately -0.60 m to +0.50 m (excluding winter months) but were generally in the range of -0.15 m to +0.20 m. Relative to the other swamp communities, this MP showed a smaller range of water level fluctuations potentially indicative of the large catchment area and the influence of surface water flow from the south and from the roadside ditching.

Between August 2017 and September 2018, excluding the winter months, the swamp was generally dry with a water level just below ground surface. Between October 2018 and June 2019, the wetland has a relatively stable water level at about +0.10 m. The water level falls below ground in summer 2019 and rises again in fall 2019, typical of a swamp community.

SG1

SG1 was installed within the deep roadside ditching north of Bayly Street at the point where a culvert from south of Bayly directs water to the north side of Bayly Street and into the central swamp wetland. The purpose of this monitoring location was to measure water levels in the ditch to determine when water from the ditch 'spills' into the watercourse and deciduous swamp wetland community.

The results from this MP were determined to be unreliable due to damage to the SG and heaving effects during the monitoring period. In general, this SG suggests that the water level in the ditch needs to rise to approximately 0.10 m in order to 'spill' into the wetland.

Overall Central SWD3-2 Wetland Hydrology Assessment

Overall, the measured pattern of wetland water levels are considered typical for a swamp community where periods of inundation are observed starting in the mid fall and continuing into the spring, with the wetland being dry for much of the summer and early fall. This is typical of a surface water supported feature and is influenced by the large drainage area.

4.4.4.3 Western MAS2-1 Community Hydroperiod

MP4

MP4 was installed in September 2014 to measure both groundwater and wetland water levels in the large Cattail Mineral Shallow Marsh community (MAS2-1). This MP was installed near the center of the wetland as was designed to represent the deepest water levels in the feature. It is also installed within the internal drainage feature that flows from south to north through the feature. The monthly monitoring data from September 2014 to September 2015 is presented in **Figure 12**. Continuous data from August 2017 to November 2019 is presented in **Figure 15**.

During the majority of the 2014 to 2015 monitoring period, the groundwater level at MP4 was recovering indicating very low permeability soils in the wetland. After reaching equilibrium, the monitoring results, primarily from August 2017 and November 2019, indicate a primary upwards hydraulic gradient indicating groundwater discharge, but alternates between being groundwater and surface water supported (**Table 5**). Generally, there is an upward gradient during the spring months.

During the monitoring period, the wetland water levels responded to seasonal precipitation and temperature trends. The hydroperiod pattern in this wetland is similar to that of MP8 (**Figure 14**), which is likely related to the connected catchment areas of both MP locations.

During the monitoring period, water levels were generally above ground surface (i.e., inundated) and in the range of +0.10 to +0.20 m (excluding the winter months). Periods of dry conditions were observed 2017, 2018 and 2019 in the summer and early fall months, with brief periods of inundation following significant summer storm events. The duration of inundation is longer at MP4 than the other MPs installed in the SWD3-2 wetlands, which is consistent with the differing vegetation communities.

Wetland water levels generally ranged from approximately -0.75 m to +0.30 m (excluding winter months) but were generally in the range of -0.10 m to +0.20 m. The effects of the south to north drainage feature (tributary to East Duffins Creek) are evident in the monitoring data. The water level in MP4 generally does not exceed +0.20 m except for short durations during storm events. This is interpreted to be due to drainage effects from the culvert below Kellino Street draining the wetland to the north. Therefore, this wetland functions more like a riverine wetland than a closed marsh community.

MP6

MP6 was installed in May 2015 to measure both groundwater and wetland water levels in the southern extent of the large cattail mineral shallow marsh community (MAS2-1) at the point where water from the SWD3-2 community enters. The monthly monitoring data from May 2015 to September 2015 is presented in **Figure 12**. Continuous data from August 2017 to November 2019 is presented in **Figure 15**.

From May 2015 to September 2015, the monitoring results a vertical hydraulic gradient ranging from -0.70 to 0.00 m/m. Between August 2017 and November 2019, the hydraulic gradient ranges from - 0.10 to 0.25 m/m. The gradient data from 2014 to 2015 suggest a strong downward gradient, however, more recent data from 2017 to 2019 suggests that the wetland may have seasonal upwards hydraulic gradients with groundwater discharge limited by the low permeability of the glaciolacustrine soils. Overall, it is interpreted that this wetland is predominantly surface water supported, and flow in the tributary from the south is a significant contributor to the water level fluctuations at this location.

The water level pattern at MP6 was very similar to MP4. During the monitoring period, water levels were generally above ground surface (i.e., inundated) and in the range of +0.05 to +0.20 m (excluding the winter months). Periods of dry conditions were observed 2017, 2018 and 2019 in the summer and early fall months, with brief periods of inundation following significant summer storm events.

Wetland water levels generally ranged from approximately -0.75 m to +0.30 m (excluding winter months) but were generally in the range of -0.15 m to +0.15 m. The effects of the south to north drainage feature (tributary to East Duffins Creek) are evident in the monitoring data. The water level in MP6 generally does not exceed +0.20 m except for short durations during storm events. This is interpreted to be due to drainage effects from the culvert below Kellino Street draining the wetland to the north. Therefore, this wetland functions more like a riverine wetland than a closed marsh community.

MP9

MP9 was installed in December 2017 to measure both groundwater and wetland water levels in a cattail mineral shallow marsh community (MAS2-1) at a point immediately south of Kellino Street. There is no culvert crossing at this location, so surface water flow is from north to south at MP9 towards the larger

MAS2-1 community and the primary drainage feature. Continuous data from December 2017 to November 2019 is presented in **Figure 15**.

Between December 2017 and November 2019, the hydraulic gradient for MP9 was -0.26 to 0.02 m/m. There is generally a strong downward gradient throughout the year for MP9. The wetland water level is controlled by surface water flow from a very small catchment near Kellino Street. The range in water level was found to be from -0.90 m to +0.20 m. This large range is likely indicative of the small catchment area. The maximum water level is similar to that of MP4 and MP6 and further supports that this wetland is drained to the north preventing sustained water levels greater than +0.20 m.

<u>Overall Eastern MAS2-1 Wetland Hydrology Assessment</u>

It is clear from the water level data at MP4, MP6 and MP9 that the western MAS2-1 wetland is a predominantly surface water supported feature with water levels generally above ground surface (i.e., inundated) both fluctuating seasonally with precipitation and snow melt trends (**Figure 15**). Based on the continuous data collected to date, it is expected that the wetland is generally inundated between approximately October and July.

As important observation from the monitoring data is that the water level in MP4, MP6 and MP9 did not exceed approximately 0.20 m for long durations (excluding frozen winter conditions). This is interpreted to reflect positive drainage through the wetland to the north within the tributary to East Duffins Creek. Therefore, this marsh wetland functions more like a riverine system than a closed marsh community. This makes the feature less sensitive to increase surface water flow as it has a natural mechanism to drain and prevent a significant increase in inundation extend and duration.

To estimate the volume of groundwater discharge to the wetland at MP4, the Darcy equation was used. Based on the highest upwards hydraulic gradient (0.21 m/m), the hydraulic conductivity of the glaciolacustrine clay (**Table 4**), and the area of the wetland (~23,800 m2) the rate of groundwater discharge is calculated as 0.018 L/s. This rate is insufficient to maintain a consistent water level in the wetland and indicates that a clear majority of the water in this feature would be derived from surface runoff rather than groundwater discharge. Lateral flow of shallow infiltration (i.e., interflow) is expected to contribute a source of shallow groundwater to the wetland, but this water is not connected to the site wide groundwater flow system and its effects are expected to be localized in area (i.e., less than 30 m based on site topography).

4.4.4.4 Wetlands West of Squires Beach Road and North of Kellino Street

<u>MP3</u>

MP3 was installed in September 2014 to measure groundwater and surface water levels in the East Duffins Creek Tributary north of Kellino Street. The monthly monitoring data from September 2014 to September 2015 is presented in **Figure 12**. Continuous data from August 2017 to August 2018 is presented in **Figure 16**.

Between October 2014 and at least January 2015, it appears that the groundwater level was recovering suggesting very low permeability soils in the wetland. After reaching equilibrium, the monitoring results indicate a strong downwards vertical hydraulic gradient ranging from -0.75 m/m to -0.12 m/m. Between August 2017 and November 2019, the hydraulic gradient ranges from -0.31 m/m to 0.10 m/m. There is generally a strong downward gradient with the strongest upward gradient being from May 2018. Water level measurements in MP3 are generally below +0.20 m consistent with the drainage observations at MP4, MP6 and MP9. The wetland water level is controlled by surface water levels in the tributary with only minor groundwater inputs during the spring freshet.

MP5

MP5 was installed in September 2014 to measure both groundwater and wetland water levels west of Squires Beach Road in a cattail mineral shallow marsh community (MAS2-1). The monthly monitoring data from September 2014 to September 2015 is presented in **Figure 12**. Manual water level data from May 2018 to November 2019 is presented in **Figure 16**.

Between October 2014 and at March 2015, it appears that the groundwater level was recovering suggesting very low permeability soils in the wetland. After reaching equilibrium, the monitoring results indicate a strong downwards vertical hydraulic gradient ranging from -0.60 m/m to -0.02 m/m. Between May 2018 and November 2019, the hydraulic gradient ranges from -0.05 m/m to 0.22 m/m. The gradient data from 2014 to 2015 suggest a strong downward gradient, however, more recent data from 2017 to 2019 shows a weaker downward gradient and suggests that the wetland may be seasonally groundwater supported. However, very poor drainage through the low permeability lacustrine clay soils may also explain the high water levels and gradient reversal between the 2014 to 2015 and 2018 to 2019 monitoring period at MP5.

The water levels at MP5 were generally consistent in 2018 and 2019 and ranged from +0.12 to +0.45 m above ground surface. This differs from the 2014 to 2015 monitoring period that showed periods of inundation and dry conditions.

Based on a drainage catchment assessment by SKA (2019, **Appendix A**), drainage on Squires Beach Road flows to the east and eventually enters the central MAS2-1 wetland. Water found in MP5 is derived from direction precipitation and runoff from the west side of Squires Beach Road. The catchment for this feature also extends south of Bayly Street. Tappendherefore, the hydrology of the wetland at MP5 will not be impacted by development of the entertainment complex and film studios east of Squires Beach Road.

MP10

MP10 was installed in December 2017 to measure both groundwater and wetland water levels in a cattail mineral shallow marsh community (MAS2-1) located north of Kellino and east of Squires Beach Road. Continuous data from December 2017 to November 2019 is presented in **Figure 16**.

Between December 2017 and November 2019, the hydraulic gradient for MP10 ranged from -0.48 m/m to 0.07 m/m. There is generally a strong downward gradient throughout the year for MP10, with some upwards gradients observed during the spring months. The wetland water level is controlled by surface water flow from a very small catchment near Kellino Street. The range in water level was found to be from -0.80 m to +0.40 m. This large range is likely indicative of the small catchment area and is related to direct precipitation entering the feature as well as localized stormwater runoff.

Based on a drainage catchment assessment by SKA (2019, **Appendix A**), drainage to this wetland is derived from direction precipitation and runoff from Squires Beach Road north of Kellino Street. Therefore, the hydrology of the wetland at MP10 will not be impacted by development of the entertainment complex and film studios east of Squires Beach Road and south of Kellino Street. Impacts to this wetland from the Notion Road to Squires Beach Road MTO crossing are addressed through the EA.

MP11

MP11 was installed in December 2017 to measure both groundwater and wetland water levels in the willow mineral thicket swamp (SWT2-2) found west of Squires Beach Road. Manual data from December 2017 to November 2019 is presented in **Figure 16**.

Between December 2017 and November 2019, the hydraulic gradient ranges from -0.07 m/m to 0.12 m/m. There is generally a mix of upward and downward gradient throughout the year and the wetland water level is controlled by surface water levels in the tributary and is not supported by groundwater discharge. The water level ranged from approximately -0.50 m to +0.35 m and fluctuated with seasonal trends in precipitation.

Based on a drainage catchment assessment by SKA (2019, **Appendix A**), water found in MP11 is derived from direction precipitation and runoff from the west side of Squires Beach Road. The catchment for this feature also extends south of Bayly Street. Therefore, the hydrology of the wetland at MP11 will not be impacted by development of the entertainment complex and film studios east of Squires Beach Road. Impacts to this wetland from the Notion Road to Squires Beach Road MTO crossing are addressed through the EA.

Table 5. Monthly MP Water Levels and Hydraulic Gradients (2014 – 2015)

Mini-Piezometer	**Water Level (mags)**	**Monitoring Date**												
		2014-09-18	**2014-10-18**	**2014-11-15**	**2014-12-13**	**2015-01-24**	**2015-02-25**	**2015-03-13**	**2015-04-19**	**2015-05-14**	**2015-06-26**	**2015-07-21**	**2015-08-25**	**2015-09-16**
MP1	GW	-1.47	-0.31	-0.04	0.05	0.25	0.10	0.12	0.11	0.15	0.38	0.33	0.13	-0.02
	SW	0.14	0.17	0.09	0.18	0.25	0.10	0.25	0.18	-	0.19	0.10	0.05	dry
	Gradient	-0.90	-0.27	-0.07	-0.07	0.00	0.00	-0.07	-0.04	-	0.11	0.13	0.04	-
MP2	GW	-0.58	-0.68	-0.52	-0.41	-0.29	-0.25	-0.09	0.16	0.12	0.19	0.00	-0.24	-0.42
	SW	-	-	-	-	-	-	-	-	-	-	-	-	-
	Gradient	-	-	-	-	-	-	-	-	-	-	-	-	-
MP3	GW	-0.32	-1.18	-1.02	-0.91	-0.79	-0.75	-0.74	-0.48	-0.57	-0.22	-0.16	-0.47	-0.35
	SW	0.06	0.14	0.15	0.06	0.22	0.20	0.29	0.07	0.14	0.05	0.00	0.03	-0.09
	Gradient	-0.28	-0.97	-0.86	-0.72	-0.75	-0.70	-0.76	-0.41	-0.52	-0.20	-0.12	-0.37	-0.19
MP4	GW	-0.92	-1.05	-0.83	-0.68	-0.52	-0.46	-0.45	-0.47	-0.19	-	-	0.11	0.13
	SW	0.03	0.25	0.20	0.25	0.28	0.21	0.47	0.38	0.21	-	-	0.15	0.06
	Gradient	-0.80	-1.10	-0.87	-0.79	-0.68	-0.57	-0.78	-0.72	-0.34	-	-	-0.03	0.06
MP5	GW	-	-1.18	-1.02	-0.88	-0.70	-0.68	0.07	-0.09	-0.36	-0.29	0.03	-0.04	-0.18
	SW	-	0.03	0.01	frozen	0.00	0.19	0.11	0.12	0.08	0.11	0.05	0.01	0.00
	Gradient	-	-1.14	-0.97	-	-0.66	-0.82	-0.04	-0.20	-0.41	-0.38	-0.02	-0.05	-0.17
MP6	GW	-	-	-	-	-	-	-	-	-0.49	-0.19	-0.21	-0.16	-0.18
	SW	-	-	-	-	-	-	-	-	0.13	0.01	dry	dry	dry
	Gradient	-	-	-	-	-	-	-	-	-0.70	-0.22	-	-	-

Table 6. Monthly MP Water Levels and Hydraulic Gradients (2017 – 2019)

Mini-Piezometer	Water Level (mags)	Monitoring Date															
		2017-08-29	**2017-12-13**	**2018-02-27**	**2018-03-26**	**2018-05-29**	**2018-06-22**	**2018-07-20**	**2018-08-20**	**2018-10-15**	**2018-12-17**	**2019-01-28***	**2019-03-29**	**2019-04-29**	**2019-06-14**	**2019-08-30**	**2019-10-12**
MP1	GW	0.24	0.04	-0.02	-0.18	0.32	0.13	-0.19	-0.40	dry	-0.11	0.14	0.25	0.40	0.42	-0.34	-0.58
	SW	0.07	dry	0.21	0.09	0.08	dry	dry	dry	dry	0.13	0.25	frozen	0.22	0.20	dry	0.14
	Gradient	0.10	-	-0.13	-0.15	0.13	-	-	-	-	-0.13	-0.06	-	0.10	0.12	-	-0.40
MP2	GW	-0.78	-0.74	-0.01	-0.30	-0.37	-0.74	-1.10	-1.12	dry	frozen	0.19	-0.15	0.15	0.12	dry	0.07
	SW	-0.47	dry	-0.01	-0.18	-0.37	dry	dry	dry	dry	0.02	0.21	0.04	0.16	0.12	dry	0.08
	Gradient	-3.10	-	0.00	-1.20	0.00	-	-	-	-	-0.20	-0.20	-1.90	-0.10	0.00	-	-0.10
MP3	GW	-0.12	-0.10	0.07	-0.01	0.10	-0.03	-0.37	-0.48	-0.52	-0.06	0.03	0.05	0.18	0.17	-0.46	-0.42
	SW	0.02	-0.03	0.05	-0.01	-0.04	dry	dry	dry	dry	0.02	0.02	0.10	0.08	0.11	dry	0.00
	Gradient	-0.10	-0.05	0.01	0.00	0.10	-	-	-	-	-0.06	0.01	-0.04	0.07	0.04	-	-0.31
MP4	GW	0.48	0.49	0.39	0.40	0.43	0.33	0.16	0.24	0.24	0.32	0.39	0.81	0.63	0.58	0.12	0.18
	SW	0.23	dry	0.56	0.42	0.26	0.23	dry	0.30	0.24	0.34	0.49	0.82	0.39	0.39	dry	0.34
	Gradient	0.21	-	-0.14	-0.02	0.14	0.09	-	-0.05	0.00	-0.02	-0.08	-0.01	0.20	0.16	-	-0.14
MP5	GW	-	-	-	-	0.24	0.29	0.13	0.17	0.15	0.16	0.19	0.13	0.26	0.34	0.12	0.45
	SW	-	-	-	-	0.08	0.05	dry	dry	dry	0.03	0.18	0.18	0.13	0.17	dry	0.46
	Gradient	-	-	-	-	0.15	0.22	-	-	-	0.12	0.01	-0.05	0.12	0.16	-	-0.01
MP6	GW	-0.09	-0.01	0.15	0.39	0.05	0.30	-0.52	-0.25	-0.22	0.01	0.07	0.18	0.17	0.13	-0.54	-0.18
	SW	dry	dry	0.20	0.17	dry	dry	dry	dry	dry	0.01	0.14	0.27	0.06	0.05	dry	-0.19
	Gradient	-	-	-0.06	0.25	-	-	-	-	-	0.00	-0.08	-0.10	0.12	0.09	-	0.01
MP7	GW	-0.02	-0.12	0.20	0.13	0.08	-0.21	-0.59	-0.48	-0.54	0.19	0.27	0.23	0.29	0.25	dry	-0.16
	SW	0.04	dry	0.22	0.13	0.08	dry	dry	0.03	dry	0.19	0.29	0.26	0.29	0.26	dry	-0.16
	Gradient	-0.06	-	-0.02	0.00	0.00	-	-	-0.47	-	0.00	-0.02	-0.03	0.00	-0.01	-	0.00
MP8	GW	-0.07	0.02	0.20	0.02	0.01	-0.35	-0.61	-0.02	-0.05	0.06	-0.05	0.16	0.14	0.13	0.03	0.00
	SW	dry	0.00	0.17	0.03	0.01	dry	dry	-0.02	-0.02	0.07	0.24	0.18	0.14	0.15	0.04	0.02
	Gradient	-	0.02	0.03	-0.01	0.00	-	-	-0.01	-0.03	-0.01	-0.32	-0.02	0.00	-0.02	-0.01	-0.02
MP9	GW	-	-0.21	-0.09	-0.04	-0.02	-0.23	-0.79	-0.68	-0.77	-0.28	-0.13	-0.04	0.00	-0.02	-	-0.06

Mini-Piezometer	Water Level (mags)	Monitoring Date															
		2017-08-29	2017-12-13	2018-02-27	2018-03-26	2018-05-29	2018-06-22	2018-07-20	2018-08-20	2018-10-15	2018-12-17	2019-01-28*	2019-03-29	2019-04-29	2019-06-14	2019-08-30	2019-10-12
	SW	-	dry	0.11	0.06	-0.04	dry	dry	dry	dry	0.00	0.11	0.18	0.02	0.03	-	-0.04
	Gradient	-	-	-0.19	-0.09	0.02	-	-	-	-	-0.26	-0.23	-0.21	-0.02	-0.05	-	-0.02
MP10	GW	-	-0.66	-0.21	-0.13	0.07	0.12	-0.19	-0.32	-0.36	0.01	0.06	0.05	0.14	0.18	-0.38	-0.43
	SW	-	dry	0.22	0.10	0.03	dry	dry	dry	dry	0.03	0.14	0.20	0.10	0.11	dry	0.04
	Gradient	-	-	-0.44	-0.24	0.04	-	-	-	-	-0.02	-0.08	-0.15	0.04	0.07	-	-0.48
MP11	GW	-	-0.13	0.23	0.25	0.40	0.24	-0.15	-0.22	-0.23	0.08	0.19	0.28	0.38	0.33	-0.47	-0.06
	SW	-	dry	0.29	0.25	0.32	0.13	dry	dry	dry	0.13	0.20	0.29	0.39	0.32	dry	-0.01
	Gradient	0.00	-	-0.07	0.00	0.09	0.12	-	-	-	-0.05	-0.01	-0.01	-0.01	0.01	-	-0.05
SG1	SW	1.26	1.3	0.97	1.04	1.05	1.419	1.825	dry	dry	0.99	0.91	0.94	0.893	0.92	dry	0.86
SG2	SW	-0.16	-0.20	0.13	0.06	0.05	-0.32	-0.73	dry	dry	0.11	0.19	0.16	0.21	0.18	dry	0.24

** All measurements on January 28, 2019 are frozen*

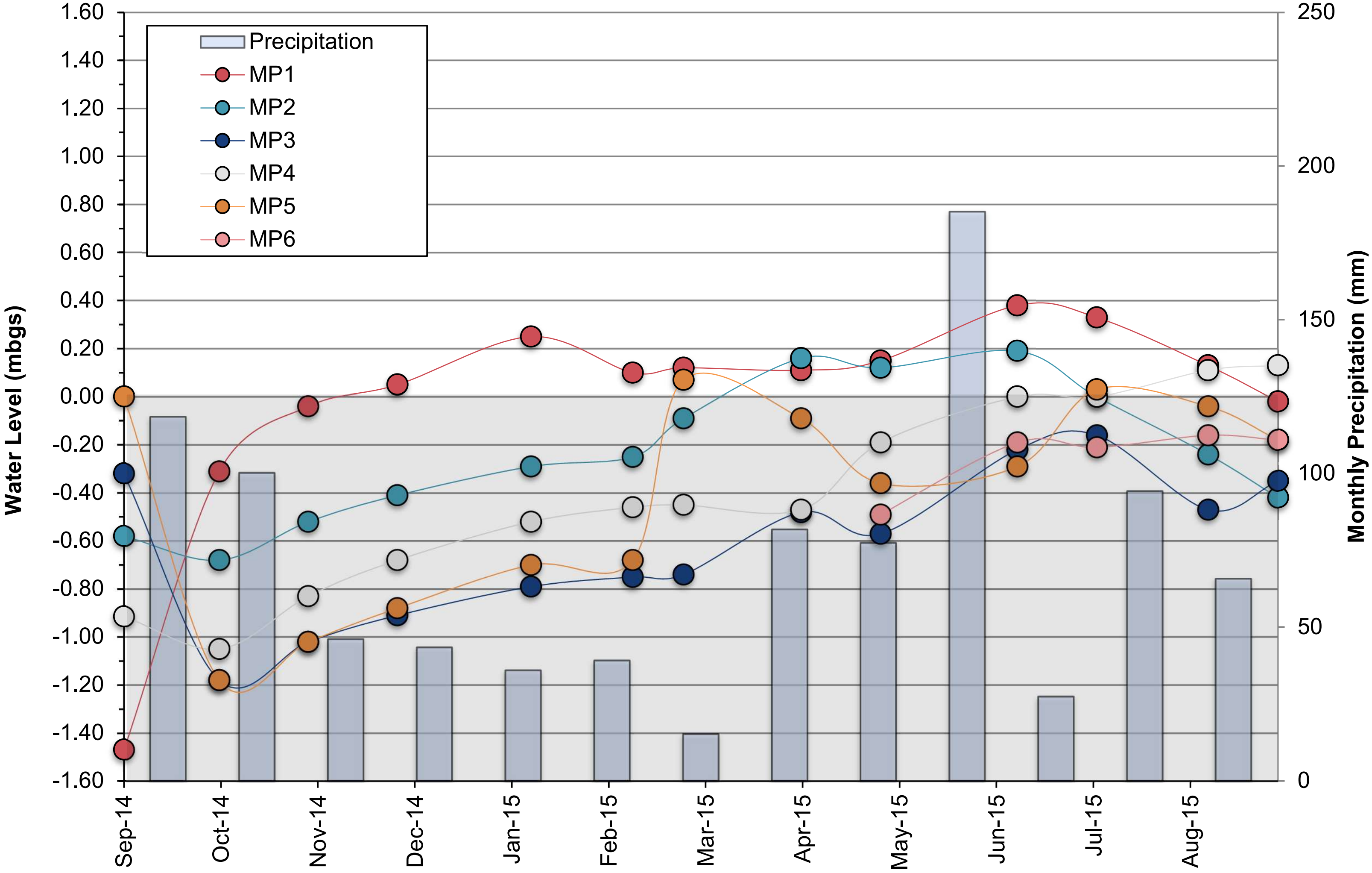


Figure 12. Wetland Hydrograph (MP1 to MP6) (2014 – 2015)

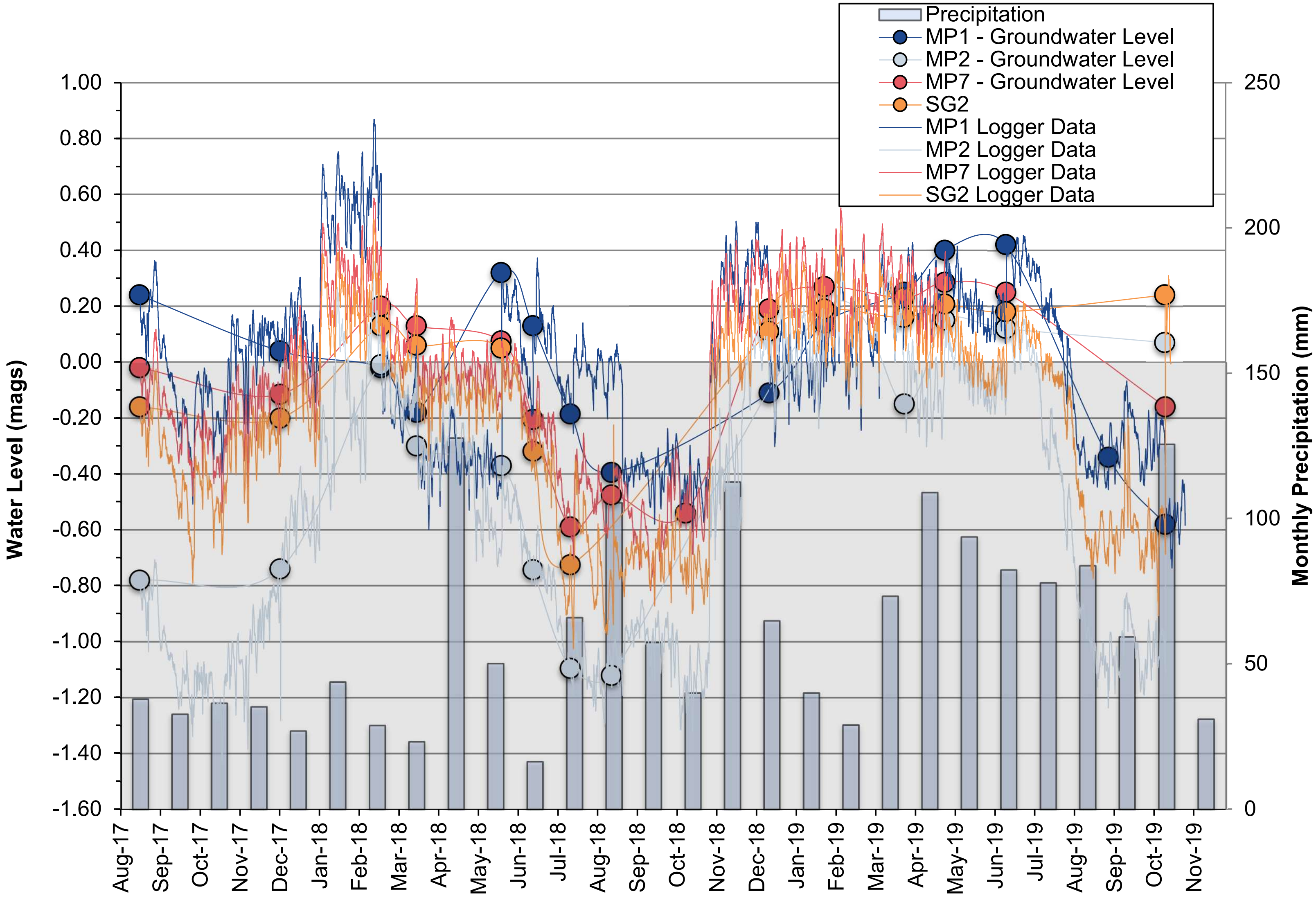


Figure 13. Wetland Hydrograph (MP1, MP2, MP7, and SG2) (2017 – 2019)

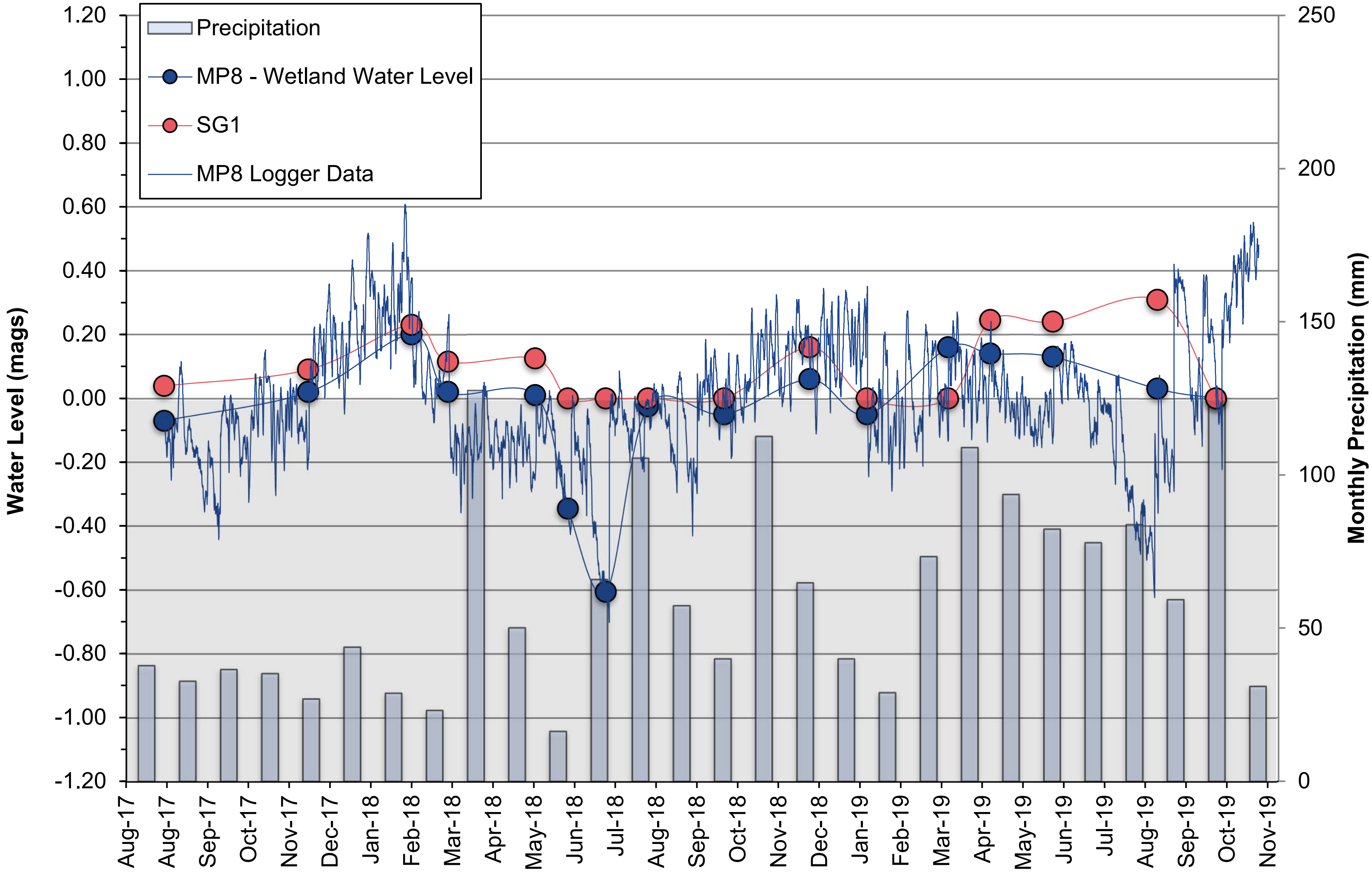


Figure 14. Wetland Hydrograph (MP8 and SG1) (2017 – 2019)

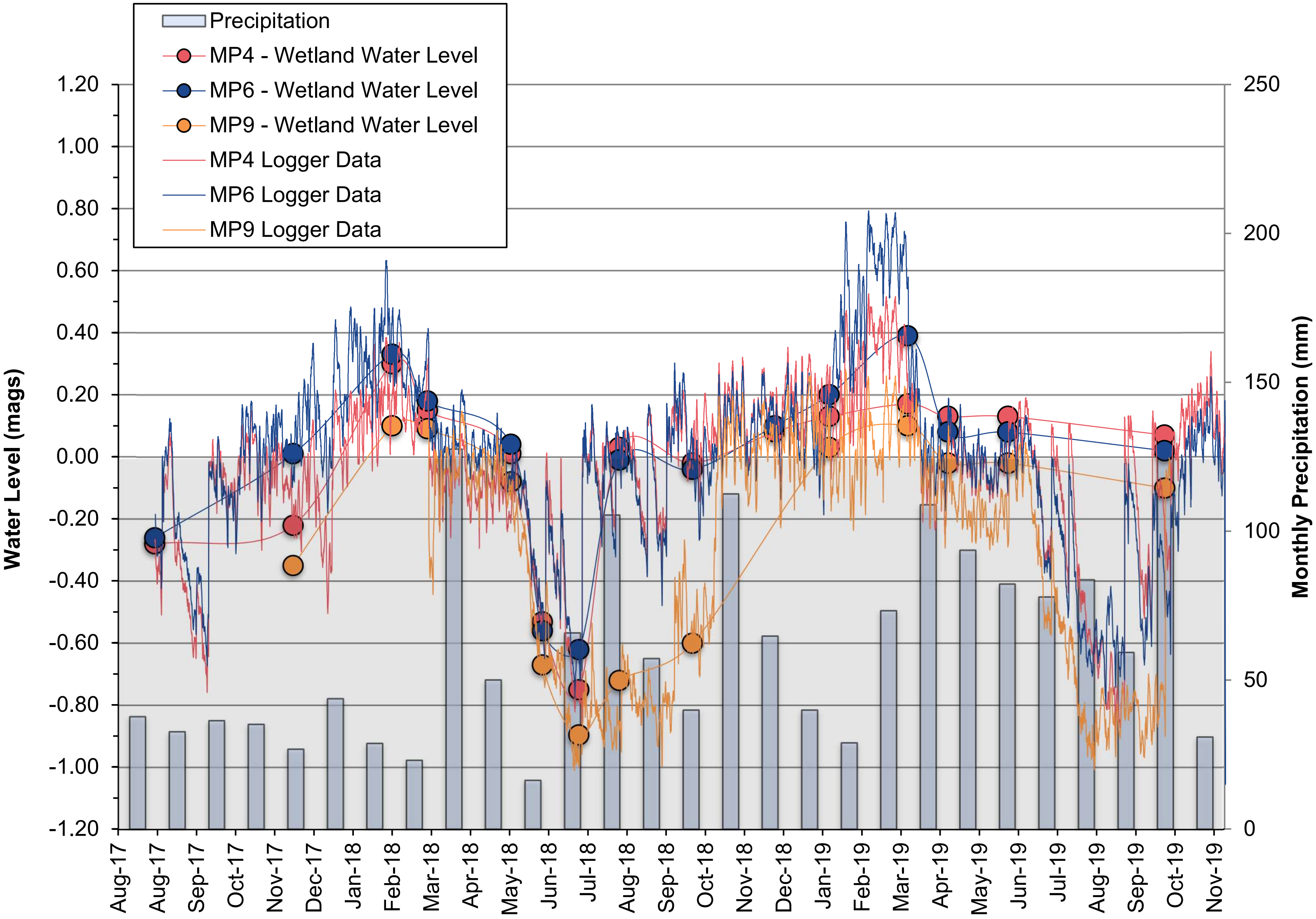


Figure 15. Wetland Hydrograph (MP4, MP6, and MP9) (2017 – 2019)

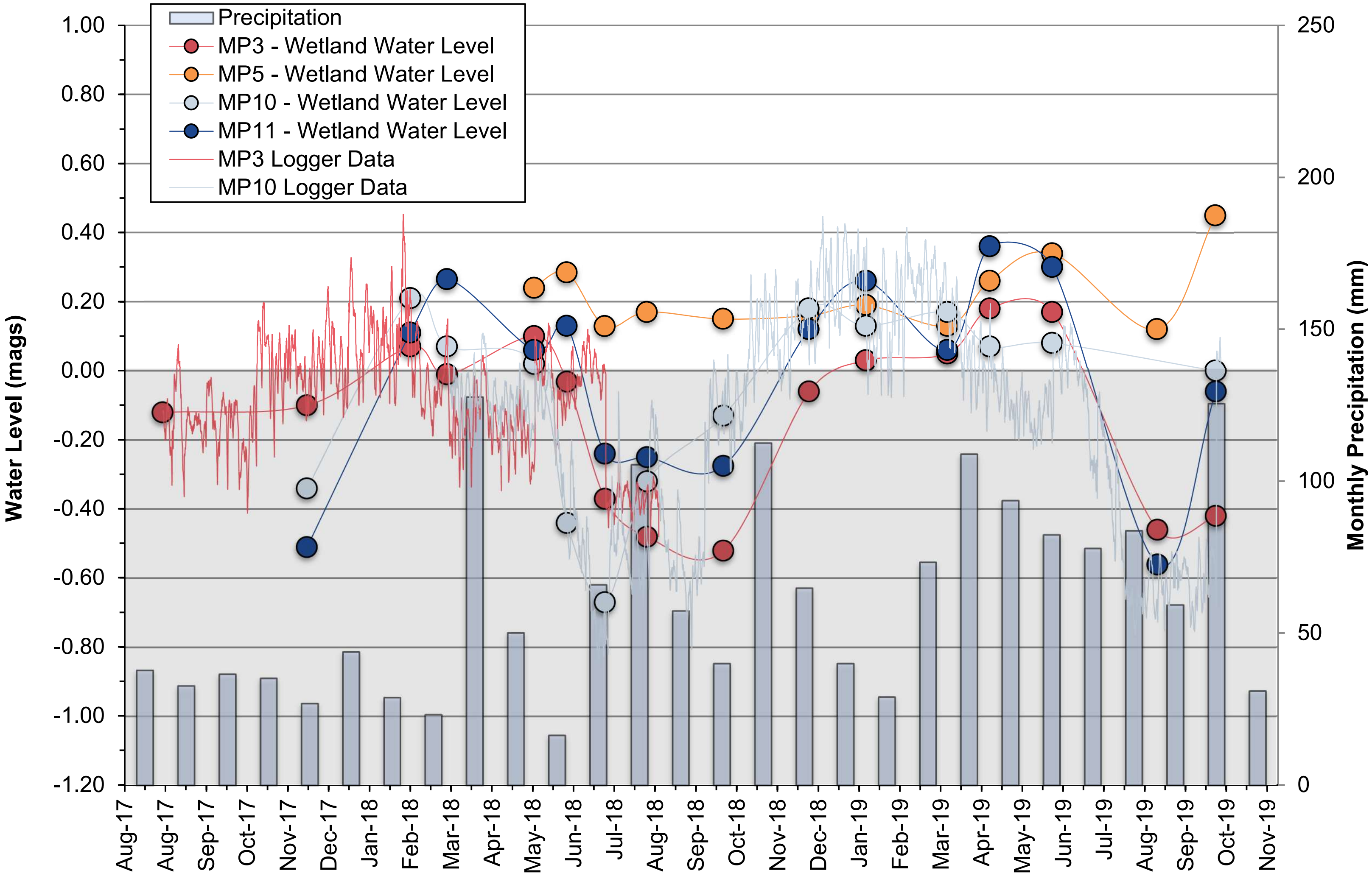


Figure 16. Wetland Hydrograph (MP3, MP5, MP10, and MP11) (2017 – 2019)

4.5 Infiltration Testing

4.5.1 Methodology

The infiltration rate of the unsaturated soils were measured by Palmer personnel between September 23 to 25, 2019 at the location and depth of the proposed LID locations. Testing was completed using a constant head well permeameter method (Guelph Permeameter), and employed both the inner and combined reservoir techniques to optimize results depending on the soil type. Field saturated hydraulic conductivity (K_{fs}) values were calculated using the Guelph Permeameter K-sat Calculator (2012) for the single head method at all TPs.

Measured infiltration rates were estimated from the K_{fs} values using the relationship provided by the "Low Impact Development Stormwater Management Planning and Design Guide, Appendix C (Figure C1)" (TRCA/CVC, 2010). Design infiltration rates (mm/hr) were determined by applying a safety correction factor of at least 2.5. Approximate water table depths were determined from correlations to nearby boreholes and wells, as well as through excavation and over excavation of the TPs.

4.5.2 Results

The soil profiles determined from the test pits are consistent with the regional geology of the study area, as the soils varied between fine-textured glaciolacustrine deposits of silt and clay (TP 1, TP 7, TP 8, TP9) and very dense silty sand to sandy silt Newmarket Till (TP 2, TP 3, TP 4, TP 5, TP6, TP 10) (**Appendix B**). Across the TPs, K_{fs} values ranged from 1.0 x 10^{-10} m/sec to 1.0 x 10^{-6} m/sec and infiltration rates ranged from 6 to 46 mm/hr.

The TPs were grouped for analysis to obtain a geometric mean K_{fs} value for distinct groupings based on the preliminary stormwater planning from SKA. TP1 (PL1 Storm Tech System) and TP6 (FS2 Storm Tech System) were evaluated individually for the potential design of underground stormwater facilities. TP2, TP3, TP4, TP5, TP7 and TP8 were grouped into "Buffer LID" to provide information on potential shallow stormwater management infrastructure in the buffer lands. TP9 and TP10 were grouped into "PSW LID" based on proximity to the eastern SWD3-2 PSW wetlands and similarity in soil characteristics.

The geometric mean of the Buffer LIDs were found to be 1.3 x 10^{-7} m/sec whereas the SWD3-2 PSW LID sites had an order of magnitude lower K_{fs} values (9.7 x 10^{-9} m/sec). The average infiltration with a factor of safety of 2.5 at the Buffer LID sites and SWD3-2 PSW LID sites are 11.1 mm/hr and 5.8 mm/hr respectively. K_{fs} values and infiltration rates for each TP is summarized in **Table 7.**

The results of the infiltration testing indicate that TP1 (PL1 Storm Tech System) is not a suitable location for a deep infiltration facility considering the high water table (1.2 mbgs) and relatively low infiltration rates across the site. The lowest water table was found at TP 6 (FS2 Storm Tech System), with a depth lower than 3.6 mbgs. The remaining TPs has similar water table depths ranging from 2.27 – 2.40 mbgs.

The results are consistent with the surficial geological mapping shown on **Figure 3** and the limited recharge capacity of this site as observed in the MP monitoring data. The location and design of the LID measures (SKA, 2019) take the observed groundwater table elevations and soil permeability into consideration to ensure that the LID's will function as designed.

Table 7. Summary of Infiltration Testing Results

LID			Depth of Pit (mbgs)	Approximate Surface Elevation (masl)	Estimated Water Table Depth (mbgs)	H (m)	K_{fs} (m/sec)	Infiltration Rate (mm/hr)	Infiltration Rate with 2.5 FOS (mm/hr)	Geomean K_{fs} (m/sec)	Average Infiltration Rate with 2.5 FOS (mm/hr)
TP 1	PL1 Storm Tech System	Shallow	0.94	87.28	1.2	0.15	1.0×10^{-6}	46	18.5	1.0×10^{-6}	18.5
TP 6	FS2 Storm Tech System	Deep	2.60	90.00	> 3.6	0.20	1.2×10^{-8}	14	5.6	1.2×10^{-8}	5.6
TP 2	Buffer LID	Shallow	0.80	86.10	1.3	0.20	7.2×10^{-8}	23	9.2	1.3×10^{-7}	11.1
TP 3		Shallow	0.80	86.54	2.27	0.20	1.2×10^{-7}	26	10.5		
		Deep	1.80			0.20	8.3×10^{-8}	24	9.5		
TP 4		Shallow	0.83	88.93	2.27	0.15	2.3×10^{-8}	17	6.8		
		Deep	1.74			0.15	8.3×10^{-7}	44	17.6		
TP 5		Shallow	0.93	91.50	2.27	0.15	5.5×10^{-7}	39	15.8		
		Deep	1.63			0.15	2.5×10^{-7}	32	12.8		
TP 7		Shallow	0.66	87.39	2.27	0.20	4.8×10^{-8}	21	8.4		
		Deep	1.60			0.20	1.2×10^{-7}	26	10.4		
TP 8		Shallow	0.75	87.16	2.27	0.20	2.4×10^{-7}	32	12.8		
		Deep	1.72			0.20	4.7×10^{-8}	20	8.0		
TP 9	SWD3-2 PSW LID	Shallow	0.65	88.93	2.40	0.20	6.0×10^{-8}	22	8.8	9.7×10^{-9}	5.8
		Deep	1.65			0.20	1.2×10^{-8}	14	5.6		
TP 10		Shallow	1.10	90.09	2.40	0.20	6.0×10^{-10}	6	2.4		
		Deep	1.80			0.10	2.1×10^{-8}	16	6.4		

5 Water Budget

5.1 Pre-to Post-Development Feature Based Water Budget

The Durham Live! site hosts a series of wetlands that are part of the Lower Duffins Creek Provincially Significant Wetland (PSW). As previously discussed, this PSW contains swamp (SDW3-2, SWT2-2, and SWT2-5) and marsh (MAS2-1 and MAM2-2) communities. Protection of the PSW wetland features is a key consideration for this project and as such, the following Feature Based Water Budget (FBWB) Assessments have been completed:

- Continuous and monthly spreadsheet based model for the Eastern SWD3-2 wetland;
- Monthly spreadsheet based model for the Central SWD3-2 wetland; and
- Monthly spreadsheet based model for the Western MAS2-1 wetland.

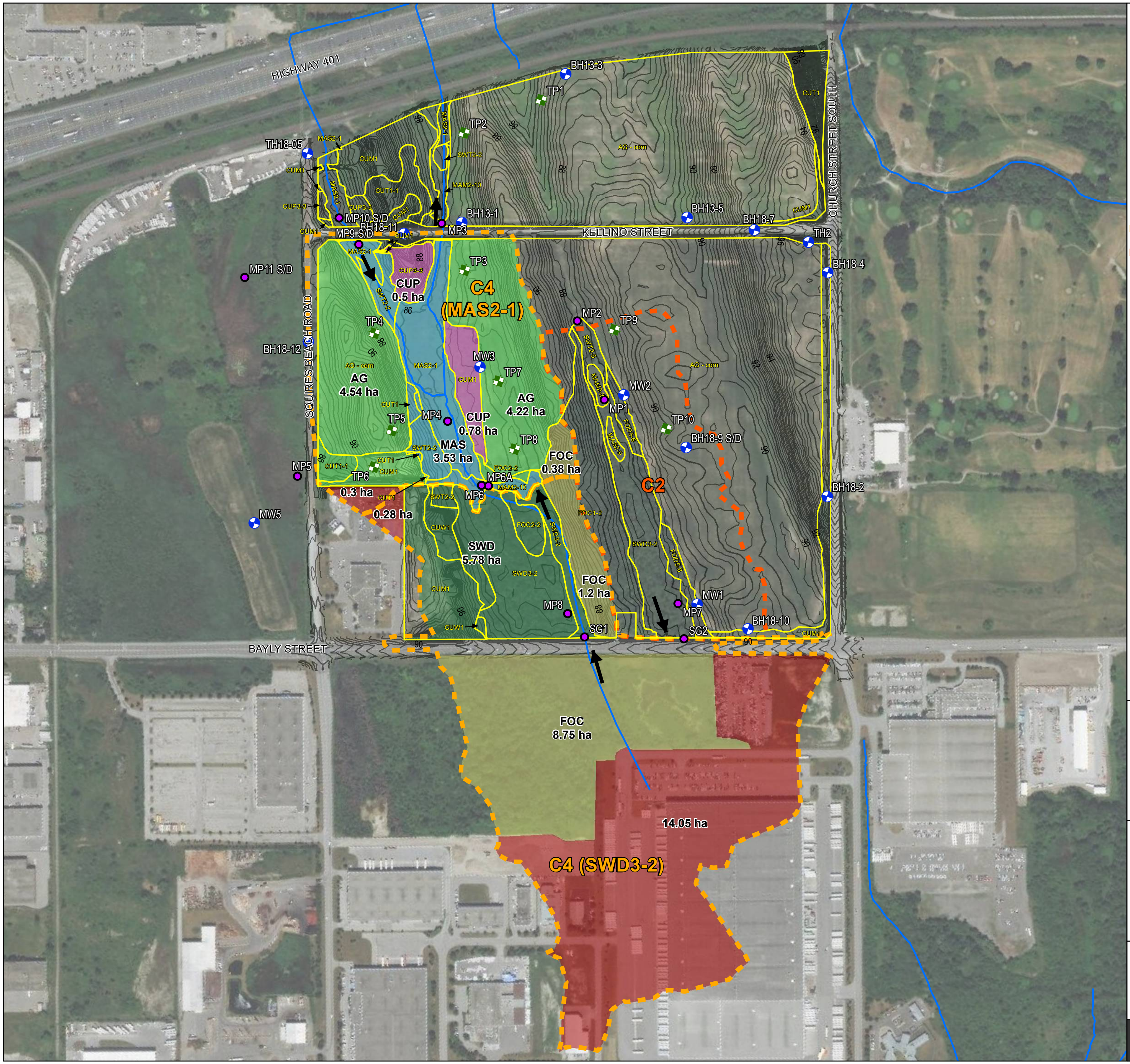
The pre- and post-development catchment areas, as delineated by SKA (2019), for each of the wetland features is presented in **Figures 17** and **18** (as well as **Appendix A**). The C2 Catchment Area captures the eastern SWD3-2 wetland and the C4 Catchment Area captures both the central SWD3-2 and the MAS2-1 wetlands. The C4 Catchment has been subdivided into the C4 (SWD3-2) Catchment and the C4 (MAS2-1) Catchment so that the effects to these two wetlands can be assessed individually.

The FBWB has been completed using the TRCA Wetland Water Balance Monitoring Protocol (2016) and the Wetland Water Balance Risk Evaluation (2017) as a guide. The type of analysis completed for each FBWB was selected based on ecological input from Beacon, stormwater input from SKA and hydrogeological/ hydrological input from Palmer. The long-term data set on groundwater water levels and wetland hydroperiod data is used to establish a baseline condition for each feature. The results of this hydrogeological assessment demonstrated the wetlands are considered to be predominantly surface water supported and not groundwater supported, and therefore groundwater inputs were not considered.

Both a continuous and non-continuous monthly spreadsheet based model was completed for the eastern SWD3-2 wetland in the C2 catchment due to its high sensitivity to change and the large change to the pre-development catchment area. The methods and results of the continuous model is presented in the FSR Report completed by SKA (2019). The non-continuous model is presented herein.

Even though it is considered to have a high sensitivity to change, a non-continuous monthly spreadsheet based model was completed for the central SWD3-2 wetland in the C4 catchment due to the little to no change in the pre-development catchment area or % imperviousness (i.e., low risk). The MAS2-1 community was demonstrated to function more like a riverine system and therefore it is considered to have a lower sensitivity to change. There will be a large change in the catchment area and the level of imperviousness adjacent to this feature, but it is our opinion that the potential effects can be effectively assessed through a monthly spreadsheet model.

The FBWB assessment also takes into consideration the Stormwater and LID measures proposed by the project team to mitigate the effects to the volume and timing of recharge and runoff. A brief summary of the LID measures is presented in this report to support the FBWB, but additional information can be found in the FSR report (SKA, 2019).



Legend

- 🔵 Monitoring Well
- ● Mini-piezometer
- ▨ Test Pit
- — Watercourse
- — Index Contour (1 m)
- — Contour (0.25 m)
- 🟨 Ecological Land Classification (Beacon, 2019)
- 🟧 Catchment 4 Pre Development
- 🟥 Catchment 2 Pre Development
- ← Surface Water Flow

Vegetation Communities

CUM1: Mineral Cultural Meadow
CUP3-3: Scotch Pine Coniferous Planation
CUT1: Mineral Cultural Thicket
CUT1-1: Sumac Mineral Cultural Thicket
CUW1: Mineral Cultural Woodland
FOC1-2: Dry-Fresh White-Red Pine C.F.
FOC2-2: Dry-Fresh White Cedar C.F.
FOD5-6: Dry-Fresh Sugar Maple-Basswood D.F.
MAM2: Mineral Meadow Marsh (Phragmites)
MAM2-2: Read-canary Grass Mineral Shallow Marsh
MAM2-10: Forb Mineral Meadow Marsh
MAS2-1: Cattail Mineral Shallow Marsh
MAS2-9: Forb Mineral Shallow Marsh
SWD3-2: Silver Maple Mineral Deciduous Swamp
SWD4-1: Willow Mineral Deciduous Swamp
SWT2-2: Willow Mineral Thicket Swamp
SWT2-5: Red-osler Mineral Thicket Swamp

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metres

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DRAWN: CV
CHECKED: A. Lo
PROJECT: 1805601
DATE: Jan 20, 2020

Scale 1:8500
UTM Zone 17N
NAD 1983

Palmer™

CLIENT: Pickering Developments
PROJECT: Durham Live

Feature Based Water Budget Catchment Pre - Development

FIGURE 17

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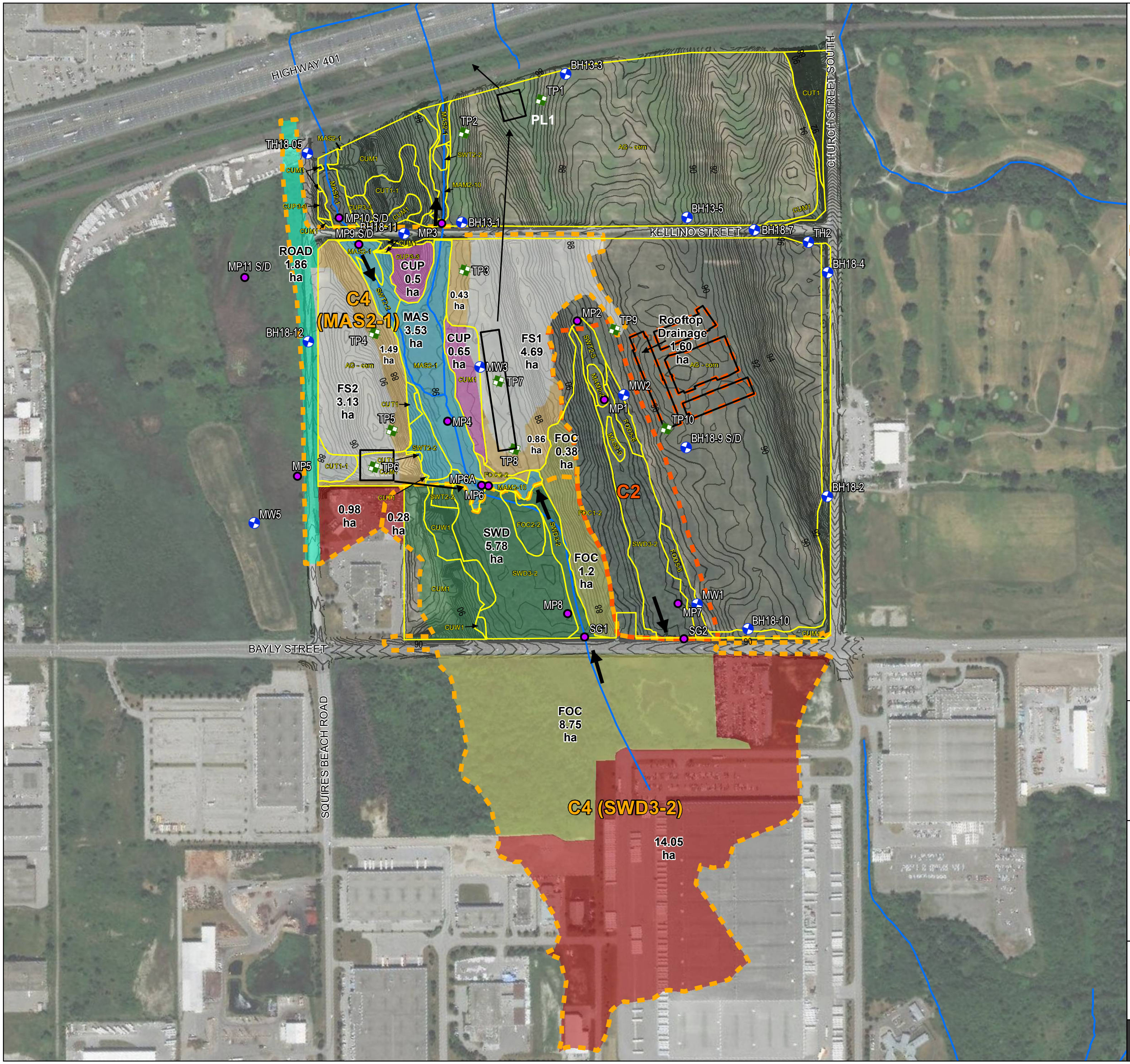

Legend

- ● Monitoring Well
- ● Mini-piezometer
- ✚ Test Pit
- Watercourse
- Index Contour (1 m)
- Contour (0.25 m)
- Ecological Land Classification (Beacon, 2019)
- Catchment 4 Post Development
- Catchment 2 Post Development
- ← Surface Water Flow
- ☐ LID
- 🟧 Buffer Land (2.79 ha)

Vegetation Communities

CUM1: Mineral Cultural Meadow
CUP3-3: Scotch Pine Coniferous Planation
CUT1: Mineral Cultural Thicket
CUT1-1: Sumac Mineral Cultural Thicket
CUW1: Mineral Cultural Woodland
FOC1-2: Dry-Fresh White-Red Pine C.F.
FOC2-2: Dry-Fresh White Cedar C.F.
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MAM2: Mineral Meadow Marsh (Phragmites)
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MAM2-10: Forb Mineral Meadow Marsh
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MAS2-9: Forb Mineral Shallow Marsh
SWD3-2: Silver Maple Mineral Deciduous Swamp
SWD4-1: Willow Mineral Deciduous Swamp
SWT2-2: Willow Mineral Thicket Swamp
SWT2-5: Red-osler Mineral Thicket Swamp

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metres

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CHECKED: A. Lo
PROJECT: 1805601
DATE: Jan 20, 2020

Scale 1:8500
UTM Zone 17N
NAD 1983

Palmer™

CLIENT: Pickering Developments
PROJECT: Durham Live

Feature Based Water Budget Catchment Post - Development

FIGURE 18

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5.1.1 Pre-Development Water Budget

A monthly pre-development water budget was calculated for the C2 and C4 Catchment Areas (**Figure 17**) using a monthly soil-moisture balance approach as described in Thornthwaite and Mather (1957) and focusing on the year, 2018. This year was a generally average climatic year where a complete set of continuous groundwater and wetland water level monitoring data was available for the assessment.

The climate data was obtained from the nearest meteorological station to the study area, the Oshawa WPCP (43^{0} 52’ 00” N, 78^{0} 50’ 00” W) which is approximately 18 km from the study area. The monthly available water surplus, which is the water available for infiltration and runoff, was calculated by subtracting the monthly evapotranspiration from the monthly precipitation. A soil moisture retention value of 200 mm was utilized to represent the glaciolacustrine silt and clay, clay and silt textured till, and agricultural land cover at the site, in accordance with the Ministry of the Environment (MOE) Stormwater Management Planning and Design Manual (MOE, 2003). Using the TSRPA Water Balance tool, precipitation and actual evapotranspiration values were found to be 0.872 m/year and 0.612 m/year, respectively for the Durham Live site.

The resulting monthly water surplus was then partitioned using infiltration coefficients based on MOE (1995) and modified based on site specific conditions. This approach takes into consideration three factors: topography/slope, soil type, and land cover, which are summed to provide a representative infiltration factor for the area. A summary of the infiltration factors for each descriptor used in the pre-development water balance assessment are provided in **Table 8**. The monthly infiltration and runoff values were then calculated by multiplying the applicable water surplus value by the sum of the three individual factors. Monthly runoff and infiltration values for the pre-development of the C2 Catchment Area (eastern SWD3-2 wetland), the C4 Catchment Area (central SWD3-2 wetland) and the C4 Catchment Area (western MAS2-1 wetland) are presented in **Table 8**.

Table 8. Summary of Pre-Development Infiltration and Runoff Factors

Area	Land Use	Area (ha)	Impervious Factor	Impervious area (ha)	Estimated Pervious Area (ha)	Infiltration Coefficient	Runoff Coefficient
C2 Catchment - SWD3-2 Wetland Catchment	Woodlot/Wetland	6.68	0	0	6.68	0.30	0.70
	Agricultural Lands	4.45	0	0	4.45	0.25	0.75
	Total and Averages	11.13	-	0	11.13	0.28	0.72
C4 Catchment - SWD3-2 Wetland Catchment	Woodlot/Wetland/SWD	15.73	0	0	17.38	0.30	0.70
	ROW/Buildings	14.33	1	14.05	0	0.00	1.00
	Total and Averages	30.06	-	14.05	17.38	0.16	0.84
C4 Catchment - MAS2-1 Wetland Catchment	Woodlot/Wetland/MAM	5.19	0	0	5.19	0.30	0.70
	Agricultural Lands	8.76	0	0	8.76	0.25	0.75
	ROW/Buildings	0.30	1	0.3	0	0.00	1.00
	Total and Averages	14.25	-	0.3	13.95	0.26	0.74

5.1.2 Post-Development Water Budget and LIDs

Similarly, to the pre-development condition, a post-development water budget was calculated for the C2 and C4 Catchment Areas (**Figure 17**) using a monthly soil-moisture balance approach as described in Thornthwaite and Mather (1957) and focusing on the year, 2018. Under the post-development condition, the C2 Catchment (SWD3-2 wetland) is reduced in size, while the C4 Catchment (SWD3-2) is maintained, and the C4 Catchment (MAS2-1 wetland) is increased in area.

A summary of the infiltration factors for the C2 Catchment Area (eastern SWD3-2 wetland), the C4 Catchment Area (central SWD3-2 wetland) and the C4 Catchment Area (western MAS2-1 wetland) are presented on **Table 9**.

Table 9. Summary of Post-Development Infiltration and Runoff Factors

Area	Land Use	Area (ha)	Impervious Factor	Impervious area (ha)	Estimated Pervious Area (ha)	Infiltration Coefficient	Runoff Coefficient
C2 Catchment - SWD3-2 Wetland Catchment	Woodlot/Wetland/Buffer	7.18	0.00	0.00	7.18	0.30	0.70
	Rooftop Drainage to C2 LID (see LID info)	1.60	1	1.60	0.00	0.0	1.0
	Total and Averages	8.78	-	1.60	7.18	0.25	0.75
C4 Catchment - SWD3-2 Wetland Catchment	Woodlot/Wetland/SWD	15.73	0.0	0.00	17.38	0.30	0.70
	ROW/Buildings	14.33	1.0	14.05	0.00	0.00	1.00
	Total and Averages	30.06	-	14.05	17.38	0.16	0.84
C4 Catchment - MAS2-1 Wetland Catchment	Woodlot/Wetland/MAM/ Buffer	7.46	0.0	0.00	3.53	0.30	0.70
	FS1	4.69	1.0	4.68	0.00	0.00	1.00
	FS2	3.13	1.0	3.13	0.00	0.00	1.00
	ROW/Buildings	2.84	1.0	1.83	0.00	0.00	1.00
	Total and Averages	18.12	-	9.64	3.53	0.12	0.88

A series of LIDs were proposed by Palmer and SKA to provide additional infiltration to the site to mitigate the effects of increased impervious surface area post-development. Based on the soil type and the surrounding land use two LID features have been proposed which are presented in **Figure 18** and **Appendix A**:

- The redirection of 1.6 ha of rooftop drainage to a Vegetative Swale LID in the C2 Catchment adjacent to the SWD3-2 Wetland; and
- A Stormwater Infiltration Trench LID in the FS1 lands on the east side of the C4 Catchment adjacent to the MAS2-1 Wetland.

The purpose of the C2 LID is to add additional surface water runoff from clean rooftop drainage to the SWD3-2 wetland to mitigate for the loss of drainage area. This LID has been designed to infiltrate a 5.0 mm storm event with all additional water directed out of the LID and into the Eastern SWD3-2 Wetland via overland flow. The purpose of the C4 FS1 Infiltration Trench is to also to infiltrate a 5.0 mm storm event, but also to direct additional runoff away from the MAS2-1 wetland and into an underground SWM facility located south of the MTO Right-Of-Way along the norther property boundary. This will help not only to increase infiltration but to also limit the excess surface water being directed to this feature.

The infiltration capacity of each LID is controlled by the LID volume, contributing area, runoff coefficient and the rainfall event storage. A summary of the preliminary design parameters of each LID is presented on **Table 10**. The design of the proposed LIDs has been investigated through site specific infiltration testing and water table delineation as presented in Section 4. The post-development runoff value with LID mitigation is calculated by subtracting the infiltration volume of the LID from post-development runoff. The post-development infiltration value with LID mitigation is calculated by adding the infiltration volume of the

LID to the post-development infiltration. The monthly change in pre- and post-development runoff and infiltration with LID mitigation is presented for each catchment area in **Tables 13**, **16** and **19**.

Table 10. LID Details

LID Number	C2	FS1
LID Location	C2 Catchment	C4 FS1 Catchment
Name	C2 LID	FS1 LID
Type	Vegetative Swale	Infiltration Trench
Existing Water Table Elevation (masl)	87.7	86.7
Post-construction Surface Elevation (masl)	89.9	89.0
Depth of water table below LID (mbgs)	2.2	2.3
Side Slope	1:1	1:1
LID Length (m)	500	188
LID Trench Width (m)	1.5	7.0
Area (m^2)	750.0	1,316.0
Depth of Water in LID (m)	0.27	0.45
Porosity	0.4	0.4
LID Volume (m^3)	81.0	236.9
LID Contributing Area (m^2)	16,000.0	46,900.0
Runoff Coefficient	1.0	1.0
Rainfall Event Storage Required (mm)	5.0	5.0
Storage Volume Required (m^3)	80.0	234.5
percolation Rate (mm/hr)	5.6	9.3
Drawdown Time (hr)	48	48

5.1.2.1 C2 Catchment FBWB – Eastern SWD3-2 Wetland

The eastern swamp wetland (SWD3-2) was characterized Beacon (2019) and instrumented by Palmer with MP1, MP2, and MP7 for wetland water level and groundwater monitoring (**Figure 13**). The area consists of primarily of Red-osler Mineral Thicket Swamp, Silver Maple Mineral Deciduous Swamp, Read-canary Grass Mineral Shallow Marsh, and Forb Mineral Shallow Marsh. The topographic water drainage to this wetland from within the proposed site area was delineated using topographical contours provided by SKA (2019) and is shown on **Figure 17** (pre-development) and **Figure 18** (post-development).

A pre-development water balance for 2018 was calculated over the site area using a monthly soil-moisture balance approach as described in Thornthwaite and Mather (1957). Precipitation and evapotranspiration values were taken from the TRSPA Water Balance Tool and found to be 0.872 m/year and 0.612 m/year, respectively. Pre-development, it was determined that for the C2 Catchment area, the Total Runoff Volume is 20,841 m^3/year and the Total Infiltration Volume is 8,105 m^3/year (**Table 11**).

For the post-development water balance, 1.60 ha of rooftop drainage to C2 LID has been proposed to balance the pre- and post-development runoff and infiltration to the swamp PSW wetland feature. Without LID mitigation, there is an anticipated increase of 23% in runoff and a decrease of 31% in infiltration (**Table 13**). This is primarily due to the increase in hard surfacing along the north-south roadway and a loss of drainage area to the east of the feature. To balance the water budget, an enhanced vegetative swale that is 500 m in length, 1.5 m in width, and 0.27 m in water storage depth that receives clean rooftop drainage from the development has been assessed (**Table 10**). As the purpose is to maintain surface water inputs through surface runoff and maintain or enhance groundwater infiltration, the LID has been designed to capture and infiltrate a 5.0 mm rainfall event storage volume consistent with the low pre-development infiltration rates. The results of this assessment demonstrate that the proposed LID will provide an additional infiltration volume of 5,338 m^3 and decrease runoff to the feature by the same amount. By incorporating LID mitigation, this is anticipated to result in an increase of 35% in infiltration and a decrease of 3% in infiltration (**Table 13**).

A continuous FBWB model has also been produced for this wetland by SKA (2019) and confirms the results of our assessment in that surface water input to this feature can be maintained post-development.

The FBWB for the C2 SDW3-2 Catchment demonstrates that the runoff for the wetland will be maintained post-development, through the proposed LID. It is evident that the volume and timing of runoff is directly correlated to the seasonal changes, as shown through the water level and hydroperiod of the swamp at MP1 and MP7 which has been continuously monitored during 2018. The monthly runoff volumes and the wetland hydroperiod at MP1 and MP7 is presented in **Figure 19**. This assessment confirms that the swamp wetland has a well-defined wet and dry period typical for this type of wetland community, and that this seasonal change in water level is based on runoff volumes. The FBWB confirms that the overall volume and timing of water entering the feature will be maintained post-development and that no adverse effects are expected.

The infiltration in the C2 Catchment has been increased by 35%, however this is not expected to have an overall benefit to the PSW feature as it was determined that it was not supported by significant groundwater discharge.

5.1.2.2 C4 Catchment FBWB – Central SWD3-2 Wetland

The central swamp wetland (SWD3-2) was characterized Beacon (2019) and instrumented by Palmer with MP8 wetland water level and groundwater monitoring (**Figure 14**). The area consists of primarily of Silver Maple Mineral Deciduous Swamp communities and it also conveys drainage from south to north. The topographic water drainage to this wetland is primarily derived from lands south of Bayly Street and from direct precipitation within the feature itself. The catchment area is presented on **Figure 17** (pre-development) and **Figure 18** (post-development).

Pre-development, the Total Runoff Volume is 141,098 m^3/year and the Total Infiltration Volume is 12,273 m^3/year to the SWD3-2 swamp wetland community (**Table 14**). The vast majority of water entering this wetland feature is derived from direct precipitation, from runoff off-site south of Bayly Street, and from runoff from the C2 catchment through the roadside ditch along Bayly Street.

Since it has been demonstrated that the runoff volumes can be maintained in the C2 SWD3-2 Catchment (Section 5.1.2.1), and no changes to the roadside ditching or to lands to the south of Bayly Street are proposed by the Durham Live development, no change to the water budget or wetland hydroperiod will occur for the SWD3-2 PSW (**Table 16**). **Figure 20** presents the monthly runoff volumes and the wetland hydroperiod as measured at MP8, both of which are not expected to change from the project.

5.1.2.3 *C4 Catchment FBWB – Western MAS2-1 Wetland*

The western marsh wetland (MAS2-1) was characterized Beacon (2019) and instrumented by Palmer with MP4, MP6 and MP9 to measure wetland water levels and for groundwater monitoring (**Figure 15**). The area consists of primarily of Cattail Mineral Shallow Marsh communities and it also conveys drainage from south to north along a fairly well defined drainage feature. This wetland receives drainage from the agricultural field to the east and west, from Squires Beach Road, and from drainage from the south. The catchment area is presented on **Figure 17** (pre-development) and **Figure 18** (post-development).

Pre-development, the Total Runoff Volume is 28,889 m^3/year and the Total Infiltration Volume is 9,745 m^3/year to the SWD3-2 swamp wetland community (**Table 17**). All of the landuse changes in the overall C4 Catchment for the Durham Live project are within the catchment of the MAS2-1 marsh wetland. This includes the addition of hard surfaces from the proposed film studios (FS1 and FS2), additional runoff from the upgraded Squires Beach Road and a small increase in the catchment area of FS1 to the east. Based on our calculations, without LID mitigation, there is an anticipated increase of 237% in runoff and a decrease of 40% in infiltration in the marsh catchment (**Table 18**).

As previously discussed, SKA has proposed an infiltration trench that is 188 m in length and 7 m in width within the FS1 catchment (**Table 10**) which will allow for an additional 15,646 m^3/year of infiltration, considering 5 mm rainfall event storage. No LID based infiltration is proposed in the FS2 Catchment and all rainfall will be assumed to be runoff from the site and from the closed bottom stormwater facility at FS2. By incorporating LID mitigation in the FS1 Catchment, the increase in runoff has been reduced to 182% and infiltration has been increased by 120% within the MAS2-1 catchment (**Table 19**).

Figure 21 presents the monthly runoff volumes and the wetland hydroperiod as measured at MP4 within the MAS2-1 marsh community. Based on the predicted increase in runoff volumes, the total water entering this feature will increase. The effect of this additional runoff was assessed based on the results of the wetland monitoring data from MP4, MP6 and MP9 (**Figure 15**). As important observation from the monitoring data is that the water level in MP4, MP6 and MP9 did not exceed approximately 0.20 m for long durations (excluding frozen winter conditions). This is interpreted to reflect positive drainage through the wetland to the north within the tributary to East Duffins Creek. Therefore, this marsh wetland functions more like a riverine system than a closed marsh community. This makes the feature less sensitive to increase surface water flow as it has a natural mechanism to drain and prevent a significant increase in inundation extend and duration.

The area that is interpreted to currently exhibit seasonal inundation in the MAS2-1 wetland is presented on **Figure 22**. This area of inundation is based on the existing drainage conditions to the wetland and matches observed MP monitoring data at MP4 and MP6.

We understand that the planned outlet for the FS2 SWM Facility is to the existing drainage channel that enters the wetland from the west (shown conceptually on **Figure 22**). Due to positive drainage through the culvert at Kellino Street, the overall area of inundation is not anticipated to increase post-development. Short duration backwatering effects could occur following large precipitation events but are expected to be short in duration; estimated at 1-2 days based on water level response at MP4 and MP6 to precipitation events (**Figure 15**).

However, as shown from the FBWB calculation and **Figure 21**, the duration of inundation in the MAS2-1 wetland is expected to increase post-development due to increased surface water volumes and increased release timing from the FS2 SWM facility. Dry periods within the wetland are still expected during the late summer and early fall when precipitation at the site is at it's lowest, but overall, the duration and frequency of these dry periods is expected to decrease.

It is important to note that no increase in frequency or duration to the SWD3-2 or SWT2-5 communities are expected as water that enters the marsh from the FS2 SWM facility through the existing drainage channel, will ultimately drain northwards towards Kellino Street. No impact to the water levels or hydroperiod for the Central SWD3-2 swamp wetland are expected.

Based on this assessment, 1.06 ha of MAS2-1 wetland is expected to have an increase to the duration of inundation. The overall water level is not expected to increase beyond approximately 0.20 m due to continued positive drainage northwards to the culvert at Kellino Street. Through discussions with the ecology team at Beacon we understand that these changes to the duration of inundation of the MAS2-1 wetland is not expected to create an adverse effect as vegetation communities in the marsh are adaptable to this type of change.

Table 11. C2 Catchment – Pre-Development FBWB

Pre-Development Water Budget – C2 Catchment	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**YEAR**
Precipitation (P) (m)	0.066	0.057	0.054	0.073	0.079	0.074	0.073	0.077	0.094	0.070	0.085	0.071	0.872
Temperature (T) (*C)	-4.8	-3.6	0.4	6.6	12.3	17.6	20.6	20	15.9	9.5	4.2	-1.2	8
Potential Evapotranspiration (PET) (m)	0.000	0.000	0.001	0.033	0.074	0.111	0.134	0.120	0.081	0.042	0.015	0.000	0.611
Change in Soil Moisture Storage (m)	0.000	0.000	-0.001	-0.030	-0.031	-0.024	-0.012	0.007	0.024	0.029	0.023	0.000	-0.015
Soil Moisture Storage (mm)	200	200	199	169	138	114	102	109	133	162	185	200	-
Actual Evapotranspiration (AET) (m)	0.000	0.000	0.001	0.033	0.074	0.111	0.134	0.120	0.081	0.042	0.015	0.000	0.612
Soil Moisture Deficit (m)	0.000	0.000	0.000	0.000	0.000	0.013	0.049	0.050	0.000	0.000	0.000	0.000	0.112
Surplus (P-AET) (m)	0.066	0.057	0.053	0.039	0.005	-0.037	-0.061	-0.043	0.013	0.028	0.070	0.071	0.260
Water Surplus on Impermeable Surfaces (m/a)	0.059	0.051	0.049	0.065	0.071	0.067	0.066	0.070	0.085	0.063	0.076	0.064	0.785
Run off from Impervious Area (m^3/a)	0	0	0	0	0	0	0	0	0	0	0	0	0
Water Surplus on Vegetated Pervious Areas (m/a)	0.066	0.057	0.053	0.039	0.005	-0.037	-0.061	-0.043	0.013	0.028	0.070	0.071	0.260
Runoff Volume From Pervious Area (m^3/a)	5257	4536	4231	3157	366	-2977	-4886	-3427	1035	2254	5629	5666	20841
Infiltration Volume from Pervious Area (m^3/a)	2044	1764	1646	1228	142	-1158	-1900	-1333	403	876	2189	2203	8105
Total Runoff Volume (m^3/a)	5257	4536	4231	3157	366	-2977	-4886	-3427	1035	2254	5629	5666	20841
Total Infiltration Volume (m^3/a)	2044	1764	1646	1228	142	-1158	-1900	-1333	403	876	2189	2203	8105

Table 12. C2 Catchment –Post-Development FBWB

Pre-Development Water Budget – C2 Catchment	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YEAR
Precipitation (P) (m)	0.066	0.057	0.054	0.073	0.079	0.074	0.073	0.077	0.094	0.070	0.085	0.071	0.872
Temperature (T) (*C)	-4.8	-3.6	0.4	6.6	12.3	17.6	20.6	20	15.9	9.5	4.2	-1.2	8
Potential Evapotranspiration (PET) (m)	0.000	0.000	0.001	0.033	0.074	0.111	0.134	0.120	0.081	0.042	0.015	0.000	0.611
Change in Soil Moisture Storage (m)	0.000	0.000	-0.001	-0.030	-0.031	-0.024	-0.012	0.007	0.024	0.029	0.023	0.000	-0.015
Soil Moisture Storage (mm)	200	200	199	169	138	114	102	109	133	162	185	200	-
Actual Evapotranspiration (AET) (m)	0.000	0.000	0.001	0.033	0.074	0.111	0.134	0.120	0.081	0.042	0.015	0.000	0.612
Soil Moisture Deficit (m)	0.000	0.000	0.000	0.000	0.000	0.013	0.049	0.050	0.000	0.000	0.000	0.000	0.112
Surplus (P-AET) (m)	0.066	0.057	0.053	0.039	0.005	-0.037	-0.061	-0.043	0.013	0.028	0.070	0.071	0.260
Water Surplus on Impermeable Surfaces (m/a)	0.059	0.051	0.049	0.065	0.071	0.067	0.066	0.070	0.085	0.063	0.076	0.064	0.785
Run off from Impervious Area (m^3/a)	945	815	780	1047	1136	1064	1053	1115	1354	1009	1221	1018	12557
Water Surplus on Vegetated Pervious Areas (m/a)	0.066	0.057	0.053	0.039	0.005	-0.037	-0.061	-0.043	0.013	0.028	0.070	0.071	0.260
Runoff Volume From Pervious Area (m^3/a)	3297	2845	2654	1980	230	-1867	-3065	-2149	649	1414	3530	3553	13071
Infiltration Volume from Pervious Area (m^3/a)	1413	1219	1137	849	98	-800	-1313	-921	278	606	1513	1523	5602
Total Runoff Volume (m^3/a)	4242	3660	3434	3027	1366	-803	-2012	-1035	2003	2423	4751	4571	25628
Total Infiltration Volume (m^3/a)	1413	1219	1137	849	98	-800	-1313	-921	278	606	1513	1523	5602

Table 13. C2 Catchment – Pre- and Post-Development Change

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Pre- to Post- Change	Potential Runoff (R) (mm)	-1015	-876	-797	-130	1000	2174	2874	2392	968	169	-877	-1094	4787
	Potential Runoff (R) (%)	-19%	-19%	-19%	-4%	273%	-73%	-59%	-70%	93%	8%	-16%	-19%	23%
	Potential Infiltration (I) (mm)	-631	-545	-508	-379	-44	358	587	412	-124	-271	-676	-680	-2503
	Potential Infiltration (I) (%)	-31%	-31%	-31%	-31%	-31%	-31%	-31%	-31%	-31%	-31%	-31%	-31%	-31%
Pre- to Post- Change W/ LIDs	Rainfall based on Event Storage	26	25.3	13.8	43.9	28.1	12.1	26.2	25.4	22	30.7	41.4	38.7	333.6
	Infiltration Volume (m^3/a)	416	405	221	702	450	194	419	406	352	491	662	619	5,338
	Total Runoff	3,826	3,255	3,214	2,325	916	-996	-2,431	-1,441	1,651	1,932	4,089	3,952	20,290
	Total Infiltration	1,829	1,624	1,358	1,551	548	-607	-894	-515	630	1,097	2,175	2,142	10,940
	Final % Change in Runoff	-27%	-28%	-24%	-26%	150%	-67%	-50%	-58%	59%	-14%	-27%	-30%	-3%
	Final % Change in Infiltration	-11%	-8%	-17%	26%	285%	-48%	-53%	-61%	57%	25%	-1%	-3%	35%

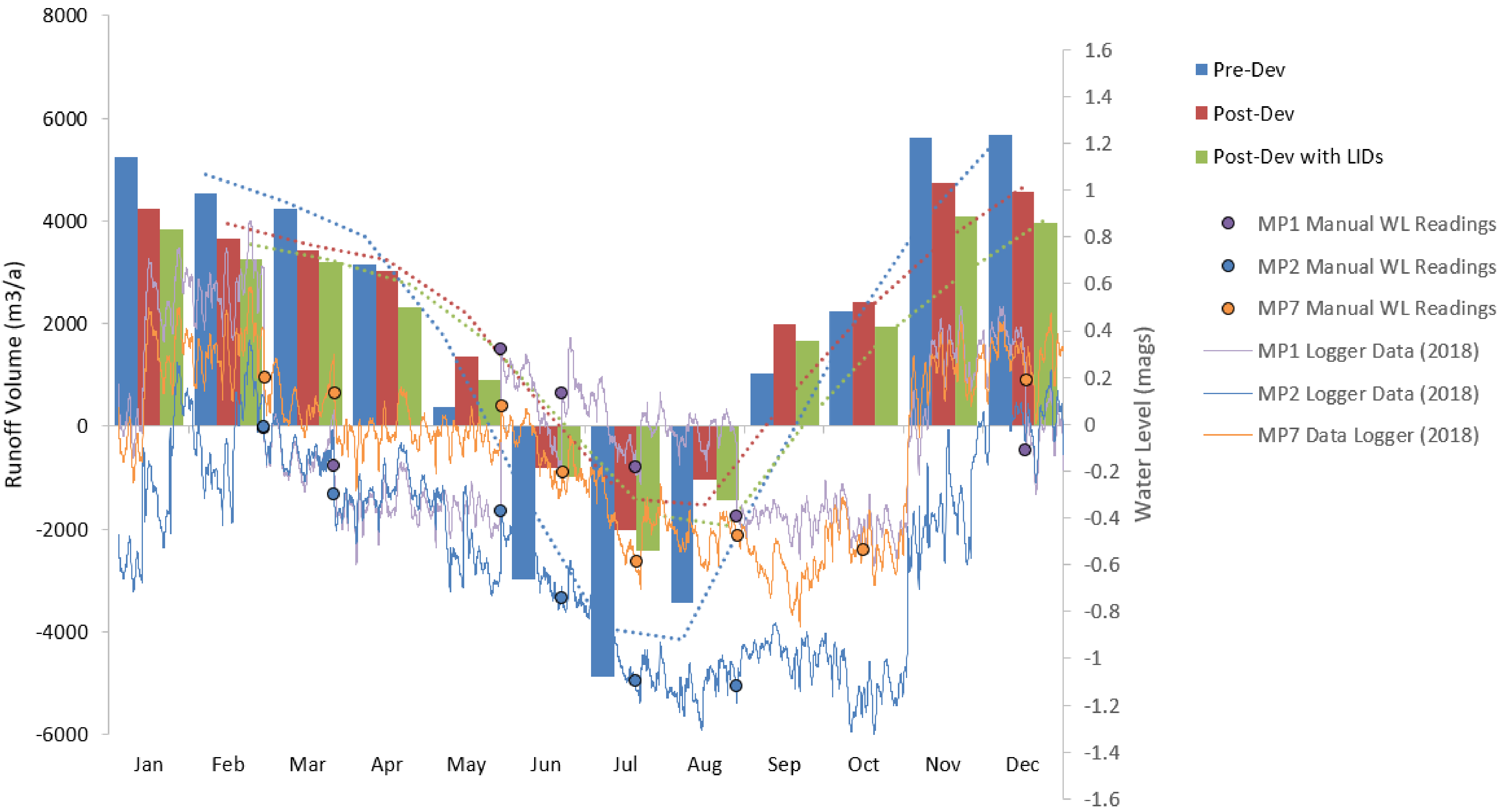

Figure 19. C2 Catchment – Eastern SWD3-2 Pre- and Post-Development Monthly Runoff Volume

Table 14. C4 Catchment - SWD3-2 – Pre-Development FBWB

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YEAR
Precipitation (P) (m)	0.066	0.057	0.054	0.073	0.079	0.074	0.073	0.077	0.094	0.070	0.085	0.071	0.872
Temperature (T) (*C)	-4.8	-3.6	0.4	6.6	12.3	17.6	20.6	20	15.9	9.5	4.2	-1.2	8
Potential Evapotranspiration (PET) (m)	0.000	0.000	0.001	0.033	0.074	0.111	0.134	0.120	0.081	0.042	0.015	0.000	0.611
Change in Soil Moisture Storage (m)	0.000	0.000	-0.001	-0.030	-0.031	-0.024	-0.012	0.007	0.024	0.029	0.023	0.000	-0.015
Soil Moisture Storage (mm)	200	200	199	169	138	114	102	109	133	162	185	200	-
Actual Evapotranspiration (AET) (m)	0.000	0.000	0.001	0.033	0.074	0.111	0.134	0.120	0.081	0.042	0.015	0.000	0.612
Soil Moisture Deficit (m)	0.000	0.000	0.000	0.000	0.000	0.013	0.049	0.050	0.000	0.000	0.000	0.000	0.112
Surplus (P-AET) (m)	0.066	0.057	0.053	0.039	0.005	-0.037	-0.061	-0.043	0.013	0.028	0.070	0.071	0.260
Water Surplus on Impermeable Surfaces (m/a)	0.059	0.051	0.049	0.065	0.071	0.067	0.066	0.070	0.085	0.063	0.076	0.064	0.785
Run off from Impervious Area (m^3/a)	8460	7300	6990	9376	10176	9531	9428	9982	12123	9041	10937	9118	112462
Water Surplus on Vegetated Pervious Areas (m/a)	0.066	0.057	0.053	0.039	0.005	-0.037	-0.061	-0.043	0.013	0.028	0.070	0.071	0.260
Runoff Volume From Pervious Area (m^3/a)	7223	6232	5814	4338	503	-4090	-6714	-4709	1423	3097	7734	7785	28636
Infiltration Volume from Pervious Area (m^3/a)	3096	2671	2492	1859	216	-1753	-2877	-2018	610	1327	3315	3336	12273
Total Runoff Volume (m^3/a)	15684	13532	12804	13715	10679	5441	2714	5274	13546	12138	18671	16903	141098
Total Infiltration Volume (m^3/a)	3096	2671	2492	1859	216	-1753	-2877	-2018	610	1327	3315	3336	12273

Table 15. C4 Catchment - SWD3-2 – Post-Development FBWB

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Precipitation (P) (m)	0.066	0.057	0.054	0.073	0.079	0.074	0.073	0.077	0.094	0.070	0.085	0.071	0.872
Temperature (T) (*C)	-4.8	-3.6	0.4	6.6	12.3	17.6	20.6	20	15.9	9.5	4.2	-1.2	8
Potential Evapotranspiration (PET) (m)	0.000	0.000	0.001	0.033	0.074	0.111	0.134	0.120	0.081	0.042	0.015	0.000	0.611
Change in Soil Moisture Storage (m)	0.000	0.000	-0.001	-0.030	-0.031	-0.024	-0.012	0.007	0.024	0.029	0.023	0.000	-0.015
Soil Moisture Storage (mm)	200	200	199	169	138	114	102	109	133	162	185	200	-
Actual Evapotranspiration (AET) (m)	0.000	0.000	0.001	0.033	0.074	0.111	0.134	0.120	0.081	0.042	0.015	0.000	0.612
Soil Moisture Deficit (m)	0.000	0.000	0.000	0.000	0.000	0.013	0.049	0.050	0.000	0.000	0.000	0.000	0.112
Surplus (P-AET) (m)	0.066	0.057	0.053	0.039	0.005	-0.037	-0.061	-0.043	0.013	0.028	0.070	0.071	0.260
Water Surplus on Impermeable Surfaces (m/a)	0.059	0.051	0.049	0.065	0.071	0.067	0.066	0.070	0.085	0.063	0.076	0.064	0.785
Run off from Impervious Area (m^3/a)	8460	7300	6990	9376	10176	9531	9428	9982	12123	9041	10937	9118	112462
Water Surplus on Vegetated Pervious Areas (m/a)	0.066	0.057	0.053	0.039	0.005	-0.037	-0.061	-0.043	0.013	0.028	0.070	0.071	0.260
Runoff Volume From Pervious Area (m^3/a)	7223	6232	5814	4338	503	-4090	-6714	-4709	1423	3097	7734	7785	28636
Infiltration Volume from Pervious Area (m^3/a)	3096	2671	2492	1859	216	-1753	-2877	-2018	610	1327	3315	3336	12273
Total Runoff Volume (m^3/a)	15684	13532	12804	13715	10679	5441	2714	5274	13546	12138	18671	16903	141098
Total Infiltration Volume (m^3/a)	3096	2671	2492	1859	216	-1753	-2877	-2018	610	1327	3315	3336	12273

Table 16. C4 Catchment - SWD3-2 – Pre- and Post-Development Change

		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Pre- to Post- Change	Potential Runoff (R) (mm)	0	0	0	0	0	0	0	0	0	0	0	0	0
	Potential Runoff (R) (%)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Potential Infiltration (I) (mm)	0	0	0	0	0	0	0	0	0	0	0	0	0
	Potential Infiltration (I) (%)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Pre- to Post- Change W/ LIDs	Rainfall based on Event Storage (mm/year)	26	25.3	13.8	43.9	28.1	12.1	26.2	25.4	22	30.7	41.4	38.7	333.6
	Infiltration Volume from FS1 (m3/a)	0	0	0	0	0	0	0	0	0	0	0	0	0
	Infiltration Volume from FS2 (m3/a)	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Runoff	15,684	13,532	12,804	13,715	10,679	5,441	2,714	5,274	13,546	12,138	18,671	16,903	141,098
	Total Infiltration	3,096	2,671	2,492	1,859	216	-1,753	-2,877	-2,018	610	1,327	3,315	3,336	12,273
	Final % Change in Runoff	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Final % Change in Infiltration	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

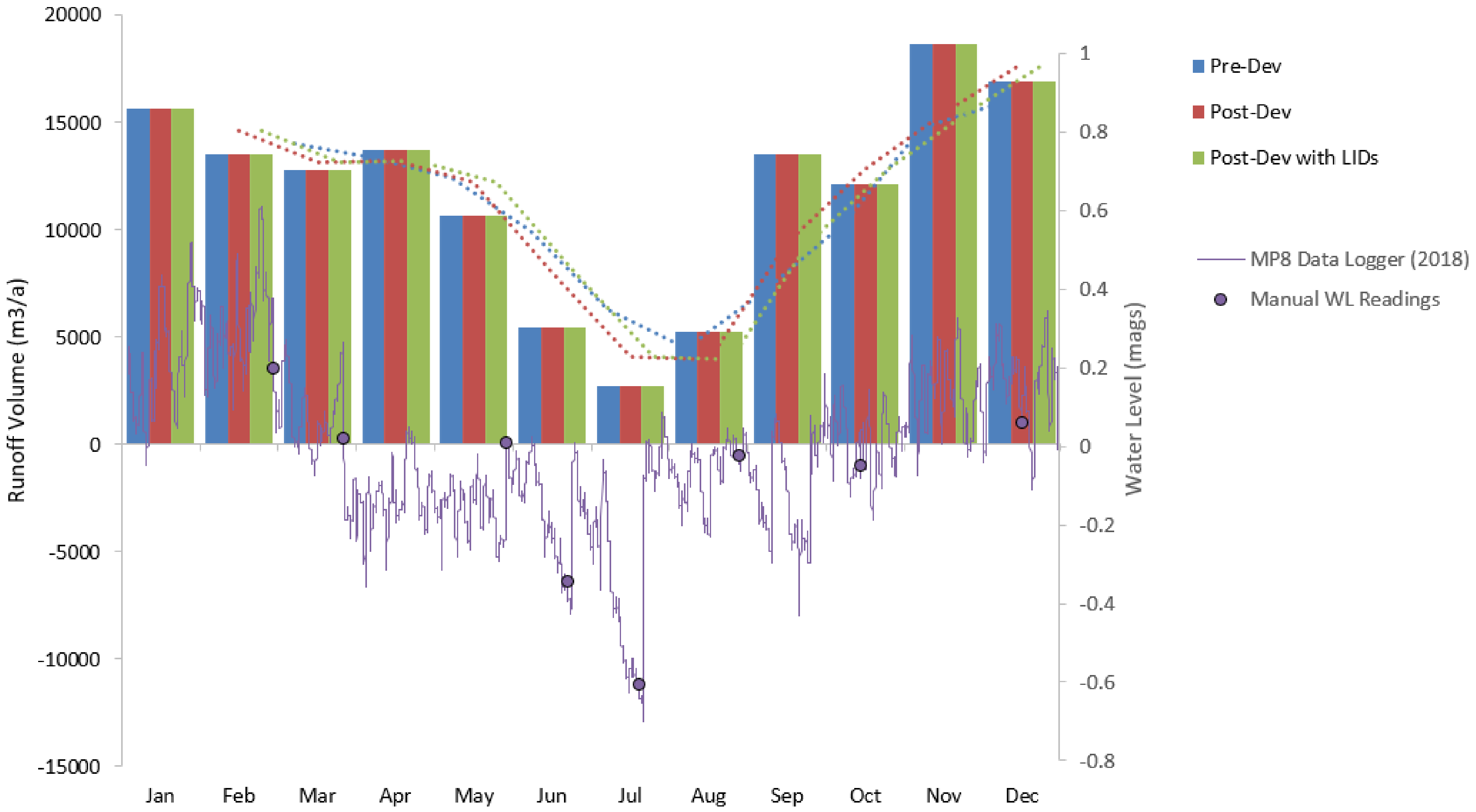

Figure 20. C4 Catchment – Central SWD3-2 Wetland Pre- and Post-Development Monthly Runoff Volume

Table 17. C4 Catchment - MAS2-1 – Pre-Development FBWB

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YEAR
Precipitation (P) (m)	0.066	0.057	0.054	0.073	0.079	0.074	0.073	0.077	0.094	0.070	0.085	0.071	0.872
Temperature (T) (*C)	-4.8	-3.6	0.4	6.6	12.3	17.6	20.6	20	15.9	9.5	4.2	-1.2	8
Potential Evapotranspiration (PET) (m)	0.000	0.000	0.001	0.033	0.074	0.111	0.134	0.120	0.081	0.042	0.015	0.000	0.611
Change in Soil Moisture Storage (m)	0.000	0.000	-0.001	-0.030	-0.031	-0.024	-0.012	0.007	0.024	0.029	0.023	0.000	-0.015
Soil Moisture Storage (mm)	200	200	199	169	138	114	102	109	133	162	185	200	-
Actual Evapotranspiration (AET) (m)	0.000	0.000	0.001	0.033	0.074	0.111	0.134	0.120	0.081	0.042	0.015	0.000	0.612
Soil Moisture Deficit (m)	0.000	0.000	0.000	0.000	0.000	0.013	0.049	0.050	0.000	0.000	0.000	0.000	0.112
Surplus (P-AET) (m)	0.066	0.057	0.053	0.039	0.005	-0.037	-0.061	-0.043	0.013	0.028	0.070	0.071	0.260
Water Surplus on Impermeable Surfaces (m/a)	0.059	0.051	0.049	0.065	0.071	0.067	0.066	0.070	0.085	0.063	0.076	0.064	0.785
Run off from Impervious Area (m^3/a)	177	153	146	196	213	200	197	209	254	189	229	191	2354
Water Surplus on Vegetated Pervious Areas (m/a)	0.066	0.057	0.053	0.039	0.005	-0.037	-0.061	-0.043	0.013	0.028	0.070	0.071	0.260
Runoff Volume From Pervious Area (m^3/a)	6693	5775	5387	4020	466	-3790	-6221	-4363	1318	2869	7167	7214	26535
Infiltration Volume from Pervious Area (m^3/a)	2458	2121	1978	1476	171	-1392	-2285	-1602	484	1054	2632	2649	9745
Total Runoff Volume (m^3/a)	6870	5928	5534	4216	679	-3591	-6024	-4154	1572	3059	7396	7404	28889
Total Infiltration Volume (m^3/a)	2458	2121	1978	1476	171	-1392	-2285	-1602	484	1054	2632	2649	9745

Table 18. C4 Catchment - MAS2-1 – Post-Development FBWB

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Precipitation (P) (m)	0.066	0.057	0.054	0.073	0.079	0.074	0.073	0.077	0.094	0.070	0.085	0.071	0.872
Temperature (T) (*C)	-4.8	-3.6	0.4	6.6	12.3	17.6	20.6	20	15.9	9.5	4.2	-1.2	8
Potential Evapotranspiration (PET) (m)	0.000	0.000	0.001	0.033	0.074	0.111	0.134	0.120	0.081	0.042	0.015	0.000	0.611
Change in Soil Moisture Storage (m)	0.000	0.000	-0.001	-0.030	-0.031	-0.024	-0.012	0.007	0.024	0.029	0.023	0.000	-0.015
Soil Moisture Storage (mm)	200	200	199	169	138	114	102	109	133	162	185	200	-
Actual Evapotranspiration (AET) (m)	0.000	0.000	0.001	0.033	0.074	0.111	0.134	0.120	0.081	0.042	0.015	0.000	0.612
Soil Moisture Deficit (m)	0.000	0.000	0.000	0.000	0.000	0.013	0.049	0.050	0.000	0.000	0.000	0.000	0.112
Surplus (P-AET) (m)	0.066	0.057	0.053	0.039	0.005	-0.037	-0.061	-0.043	0.013	0.028	0.070	0.071	0.260
Water Surplus on Impermeable Surfaces (m/a)	0.059	0.051	0.049	0.065	0.071	0.067	0.066	0.070	0.085	0.063	0.076	0.064	0.785
Run off from Impervious Area (m^3/a)	6294	5430	5200	6975	7570	7090	7013	7426	9018	6725	8136	6783	83660
Water Surplus on Vegetated Pervious Areas (m/a)	0.066	0.057	0.053	0.039	0.005	-0.037	-0.061	-0.043	0.013	0.028	0.070	0.071	0.260
Runoff Volume From Pervious Area (m^3/a)	3426	2956	2757	2057	239	-1940	-3184	-2233	675	1469	3668	3692	13581
Infiltration Volume from Pervious Area (m^3/a)	1468	1267	1182	882	102	-831	-1365	-957	289	629	1572	1582	5820
Total Runoff Volume (m^3/a)	9719	8386	7957	9032	7808	5150	3829	5193	9693	8194	11804	10475	97241
Total Infiltration Volume (m^3/a)	1468	1267	1182	882	102	-831	-1365	-957	289	629	1572	1582	5820

Table 19. C4 Catchment - MAS2-1 – Pre- and Post-Development Change

		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Pre- to Post- Change	Potential Runoff (R) (mm)	2849	2458	2424	4816	7129	8741	9853	9347	8121	5135	4408	3071	68351
	Potential Runoff (R) (%)	41%	41%	44%	114%	1049%	-243%	-164%	-225%	517%	168%	60%	41%	237%
	Potential Infiltration (I) (mm)	-990	-854	-797	-595	-69	561	920	645	-195	-424	-1060	-1067	-3924
	Potential Infiltration (I) (%)	-40%	-40%	-40%	-40%	-40%	-40%	-40%	-40%	-40%	-40%	-40%	-40%	-40%
Pre- to Post- Change W/ LIDs	Rainfall based on Event Storage (mm/year)	26	25.3	13.8	43.9	28.1	12.1	26.2	25.4	22	30.7	41.4	38.7	333.6
	Infiltration Volume from FS1 (m3/a)	1,219	1,187	647	2,059	1,318	567	1,229	1,191	1,032	1,440	1,942	1,815	15,646
	Infiltration Volume from FS2 (m3/a)	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Runoff	8,500	7,199	7,310	6,973	6,490	4,583	2,600	4,001	8,661	6,754	9,862	8,660	81,595
	Total Infiltration	2,688	2,453	1,829	2,941	1,420	-264	-136	234	1,321	2,069	3,514	3,397	21,466
	Final % Change in Runoff	24%	21%	32%	65%	855%	-228%	-143%	-196%	451%	121%	33%	17%	182%
	Final % Change in Infiltration	9%	16%	-8%	99%	729%	-81%	-94%	-115%	173%	96%	34%	28%	120%

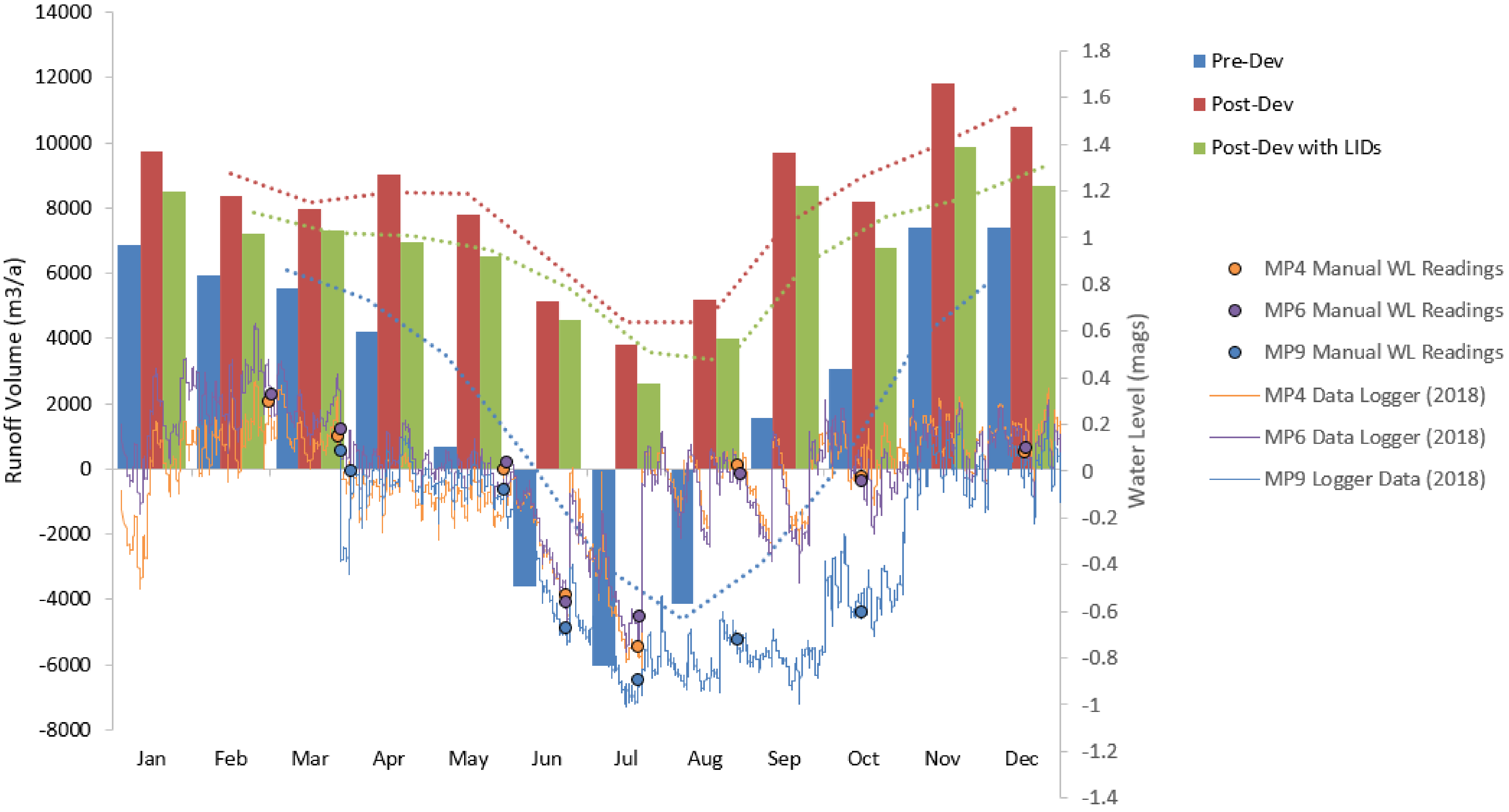

Figure 21. C4 Catchment – Wester MAS2-1 Wetland Pre- and Post-Development Monthly Runoff Volume

Legend

- Watercourse
- Ephemeral Drainage Feature
- Index Contour (1 m)
- Contour (0.25 m)
- Ecological Land Classification (Beacon, 2019)

Area of Inundation

- 🟦 below 86 m (0.798 ha)
- 🟦 86 - 86.25 m (1.059 ha)

Vegetation Communities

CUM1: Mineral Cultural Meadow
CUP3-3: Scotch Pine Coniferous Planation
CUT1: Mineral Cultural Thicket
CUT1-1: Sumac Mineral Cultural Thicket
CUW1: Mineral Cultural Woodland
FOC1-2: Dry-Fresh White-Red Pine C.F.
FOC2-2: Dry-Fresh White Cedar C.F.
FOD5-6: Dry-Fresh Sugar Maple-Basswood D.F.
MAM2: Mineral Meadow Marsh (Phragmites)
MAM2-2: Read-canary Grass Mineral Shallow Marsh
MAM2-10: Forb Mineral Meadow Marsh
MAS2-1: Cattail Mineral Shallow Marsh
MAS2-9: Forb Mineral Shallow Marsh
SWD3-2: Silver Maple Mineral Deciduous Swamp
SWD4-1: Willow Mineral Deciduous Swamp
SWT2-2: Willow Mineral Thicket Swamp
SWT2-5: Red-osler Mineral Thicket Swamp

Imagery (2017 - DigitalGlobe) provided by Esri basemap service.

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0 20 40 60 80
metres

DRAWN: BE/CV
CHECKED: JC
PROJECT: 1805601
DATE: Jan 20, 2020

Scale 1:3000
UTM Zone 17N
NAD 1983

Palmer™

CLIENT: Pickering Developments
PROJECT: Durham Live

Extent of Existing Inundation MAS2-1 Wetland

FIGURE 22

Document Path: W:\Egnyte\Shared\Projects\Active\18056 - Pickering Development's Inc\1805601 - Durham Live - Geotechnical and Hydrogeological Study for H2 and EA\Mapping\mxd\Nov2019\1805601_22-2_Wetland Inundation.mxd

5.2 Site Water Budget

Changes to land use from development of the Durham Live project will increase imperviousness at the site. This will lead to an increase in surface water runoff and a decrease of infiltration. The FSR completed by SKA (2019) addresses how the additional runoff volumes will be matched such that peak flows are maintained for all surface water features leaving the site. A decrease in infiltration from pre-to post-development is expected for areas that were not shown to support the PSW wetlands. The pre-to-post development water balance to the natural features was shown to be maintained or enhanced through the FBWB assessment complete as part of this study.

While it is often the goal to maintain infiltration pre-to post-development, based on our understanding of the site geology and hydrogeology, the function of natural environmental features, location of the site in the East Duffins Creek watershed and policy mechanisms, a decrease in infiltration is not considered to have a significant adverse effect on the local groundwater system. The following rationale supports this conclusion:

1. The site is underlain by low permeability till and glaciolacustrine clays and silts. Hydraulic conductivity values and infiltration rates were shown to be very low. Pre-development, infiltration accounts for 25% or less of the water budget.
2. The wetland features were shown to not be supported by groundwater discharge. In areas where seasonal upwards gradients were measured, the groundwater discharge rate was calculated to be very low (in the range of <0.02 L/s. A detailed FBWB was completed for each feature to ensure that the pre-to post-development water budget was maintained to these features.
3. The site is located in the lower Duffins Creek watershed less than 5 km from Lake Ontario in a low sensitivity part of the watershed. There are no private wells or other groundwater users located in the vicinity of the site that rely on groundwater.
4. The area was not identified as a Significant Groundwater Recharge Area (SGRA), Highly Vulnerable Aquifer (HVA) nor is it located in a Wellhead Protection Area (WHPA) or Recharge Management Area (WHPA-Q).

It has been our goal for this project to ensure that all natural features are protected and maintained as part of this project. We have demonstrated this through the nearly 4 years on monitoring, including long-term continuous monitoring of wetland water level and groundwater levels. While an overall decrease in groundwater infiltration from the site is expected, the water balance to the PSW wetlands has been maintained. No adverse impacts to groundwater are expected.

6 Summary and Conclusions

The following summarizes the results our Hydrogeological Investigation to support re-zoning for the Urban Reserve (UR) lands to Major Tourist Destination (MTD) for the proposed Durham Live project in Pickering, ON:

- Hydrogeological studies have been ongoing at the Durham Live site since 2014 to collect a long-term dataset for both groundwater levels and wetland hydroperiods. Detailed hydrogeological investigations and monitoring were completed between September 2014 to September 2015, and again between August 2017 to November 2019.
- The site is underlain by Newmarket Till that forms a series of northwest trending drumlins. Glaciolacustrine silt and clay deposits were deposited around these drumlins, that acted as 'till islands' during the highest extent of former Glacial Lake Iroquois and are now found in low lying areas on the site.
- The Lower Duffins Provincially Significant Wetland (PSW) is present on the site and is associated with areas underlain by low permeability glaciolacustrine silt and clay which limit groundwater/ surface water interactions and support longer periods of inundation through restricting drainage.
- Groundwater elevations range from 80.17 masl at BH18-15 in January 2019 to 94.60 masl at BH18-2 in March 2019. In general, groundwater levels are deepest in upland areas and found near ground surface in low lying areas and near wetlands.
- North of Kellino Street, groundwater flow is predominantly to the north, flowing below Highway 401 towards the Duffins Creek valley. South of Kellino, groundwater flow is to the west, flowing from the upland, drumlinized areas towards the low-lying wetlands.
- The vertical hydraulic gradient dominates over the horizontal hydraulic gradient by an order of magnitude.
- The geometric mean hydraulic conductivity the Newmarket Till was calculated from both slug tests and grain size analysis to be 4.6 x 10^{-7} m/s. The hydraulic conductivity of the glaciolacustrine silt and clay was calculated using the Puckett *et al. (1985)* method to be 3.7 x 10^{-9}. The results indicate that both unit act is aquitard materials restricting groundwater flow and promoting surface runoff.
- The infiltration rate of the unsaturated soils were measured at the location and depth of the proposed LID locations. Testing was completed using a constant head well permeameter method (Guelph Permeameter). The soil profiles determined from the test pits are consistent with the regional geology of the study area, as the soils varied between fine-textured glaciolacustrine deposits of silt and clay (TP 1, TP 7, TP 8, TP9) and very dense silty sand to sandy silt Newmarket Till (TP 2, TP 3, TP 4, TP 5, TP6, TP 10). The K_{fs} values ranged from 1.0 x 10^{-10} m/sec to 1.0 x 10^{-6} m/sec and infiltration rates ranged from 6 to 46 mm/hr.
- Drainage at the site is highly complex and controlled by the undulating landscape and roadside drainage ditching. On the eastern portion of the site, surface water flows south within the PSW wetland towards the Bayly Street drainage ditching (C2 Catchment). Surface water then flows west in the drainage ditch and is joined by flow from the south side of Bayly Street, before turning

north and re-entering the PSW. Surface water continues to flow north under Kellino Road and exits the site at a culvert under the CN rail corridor (C4 Catchment).

- Wetland mini-piezometers have been installed at eleven (11) locations within the PSW wetlands to assess groundwater/ surface water interactions and to establish a hydroperiod for each wetland. The results of between 2 and 5-years of wetland water level monitoring conclude that the wetlands are predominantly surface water support features. The low permeability glaciolacustrine soils limit groundwater discharge even where seasonal upwards gradients were measured.
    - For the Eastern SWD3-2 wetland hydrology assessment, it is clear from the water level data at MP1, MP7 and SG2 that the eastern SWD3-2 wetland is a predominantly surface water supported feature with water levels fluctuating seasonally with precipitation and snow melt trends.
    - For the Central SWD3-2 wetland hydrology assessment, the measured pattern of wetland water levels are considered typical for a swamp community where periods of inundation are observed starting in the fall and continuing into the spring, with the wetland being dry for much for the remaining portions of the year. This is typical of a surface water supported feature and is influenced by the large drainage area.
    - For the Eastern MAS2-1 wetland hydrology assessment it is clear from the water level data at MP4, MP6 and MP9 that the western MAS2-1 wetland is a predominantly surface water supported feature with water levels generally above ground surface (i.e., inundated) both fluctuating seasonally with precipitation and snow melt trends. It is expected that the wetland is generally inundated between approximately October and July and that the water level does not exceed approximately 0.20 m for long durations (excluding frozen winter conditions) due to positive drainage through the wetland to the culvert at Kellino Street the north within the tributary to East Duffins Creek. Therefore, this marsh wetland functions more like a riverine system than a closed marsh community.
- A series of Feature Based Water Budget (FBWB) Assessments have been completed focused on the following PSW communities:
    - Continuous and monthly spreadsheet based model for the Eastern SWD3-2 wetland;
    - Monthly spreadsheet based model for the Central SWD3-2 wetland; and
    - Monthly spreadsheet based model for the Western MAS2-1 wetland.
- The following LIDs were proposed by Palmer and SKA to provide additional infiltration to the site to mitigate the effects of increased impervious surface area post-development. Based on the soil type and the surrounding land use two LID features have been proposed at incorporated into the FBWB Assessment:
    - The redirection of 1.6 ha of rooftop drainage to a Vegetative Swale LID in the C2 Catchment adjacent to the Eastern SWD3-2 wetland; and
    - A Stormwater Infiltration Trench LID in the FS1 lands on the east side of the C4 Catchment adjacent to the Western MAS2-1 wetland.
- The Eastern SWD3-2 wetland within the C2 Catchment area was found to have a Total Runoff Volume of 20,841 m^3/year and a Total Infiltration Volume of 8,105 m^3/year, pre-development. Without LID mitigation, there is an anticipated increase of 23% in runoff and a decrease of 31% in infiltration to this feature. To balance the water budget an enhanced vegetative swale LID that is

500 m in length, 1.5 m in width, and 0.27 m in water storage depth that receives clean rooftop drainage from 1.6 ha of the entertainment areas development has been assessed. The results of this assessment demonstrate that the proposed LID will provide an additional infiltration volume of 5,338 m^3 and decrease runoff to the feature by the same amount. By incorporating LID mitigation, this is anticipated to result in an increase of 35% in infiltration and a decrease of 3% in infiltration.

- The Central SWD3-2 wetland within the C4 Catchment was found to have a Total Runoff Volume of 141,098 m^3/year and a Total Infiltration Volume of 12,273 m^3/year, pre-development. The vast majority of water entering this wetland feature is derived from direct precipitation, from runoff off-site south of Bayly Street, and from runoff from the C2 catchment through the roadside ditch along Bayly Street. Since it has been demonstrated that the runoff volumes can be maintained in the C2 SWD3-2 Catchment, and no changes to the roadside ditching or to lands to the south of Bayly Street are proposed by the Durham Live development, no change to the water budget or wetland hydroperiod will occur for the SWD3-2 PSW.
- The Western MAS2-1 wetland within the C4 Catchment was found to have a Total Runoff Volume of 28,889 m^3/year and a Total Infiltration Volume of 9,745 m^3/year, pre-development. Due to the increase in drainage area and hard surfaces in the catchment, without LID mitigation, there is an anticipated increase of 237% in runoff and a decrease of 40% in infiltration to this wetland. To mitigate, SKA has proposed an infiltration trench that is 180 m in length and 6.1 m in width within the FS1 catchment which will allow for an additional 14,051 m^3/year of infiltration, considering 5 mm rainfall event storage. By incorporating LID mitigation in the FS1 Catchment, the increase in runoff has been reduced to 182% and infiltration has been increased by 120% within the MAS2-1 catchment.
- The duration of inundation in the Western MAS2-1 wetland is expected to increase post-development over an area of 1.06 ha due to increased surface water volumes and increased release timing from the FS2 SWM facility. Dry periods within the wetland are still expected during the late summer and early fall when precipitation at the site is at it's lowest, but overall, the duration and frequency of these dry periods is expected to decrease. The overall water level is not expected to increase beyond approximately 0.20 m due to continued positive drainage northwards to the culvert at Kellino Street.
- The site is not within a Significant Groundwater Recharge Area (SGRA), Highly Vulnerable Aquifer (HVA) nor is it located in a Wellhead Protection Area (WHPA) or Recharge Management Area (WHPA-Q). The site is located within the lower reaches of the Duffins Creek Watershed and no natural features or groundwater users that rely on groundwater were identified near the site. Changes to the overall infiltration at the site is not expected to cause an adverse impact to groundwater resources or groundwater supported features, as long at the FBWB to the PSW is maintained.

Statement of Limitations

The extent of this study was limited to the specific scope of work for which we were retained and that is described in this report. PALMER has assumed that the information provided by the client or any secondary sources of information are factual and accurate. PALMER accepts no responsibility for any deficiency, misstatement or inaccuracy contained in this report as a result of omissions, misinterpretations or negligent acts from relied upon data. Judgment has been used by PALMER in the interpretation of the information provided but subsurface physical and chemical characteristics may differ from regional scale geology mapping and vary between or beyond well/borehole locations given the inherent variability in geological conditions.

PALMER is not a guarantor of the geological or groundwater conditions at the subject site, but warrants only that its work was undertaken and its report prepared in a manner consistent with the level of skill and diligence normally exercised by competent geoscience professionals practicing in the Province of Ontario. Our findings, conclusions and recommendations should be evaluated in light of the limited scope of our work.

The information and opinions expressed in the Report are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT PALMER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS PALMER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belongs to PALMER. Any use which a third party makes of the Report is the sole responsibility of such third party. PALMER accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without PALMER's express written permission. Should the project design change following issuance of the Report, PALMER must be provided the opportunity to review and revise the Report in light of such alteration or variation.

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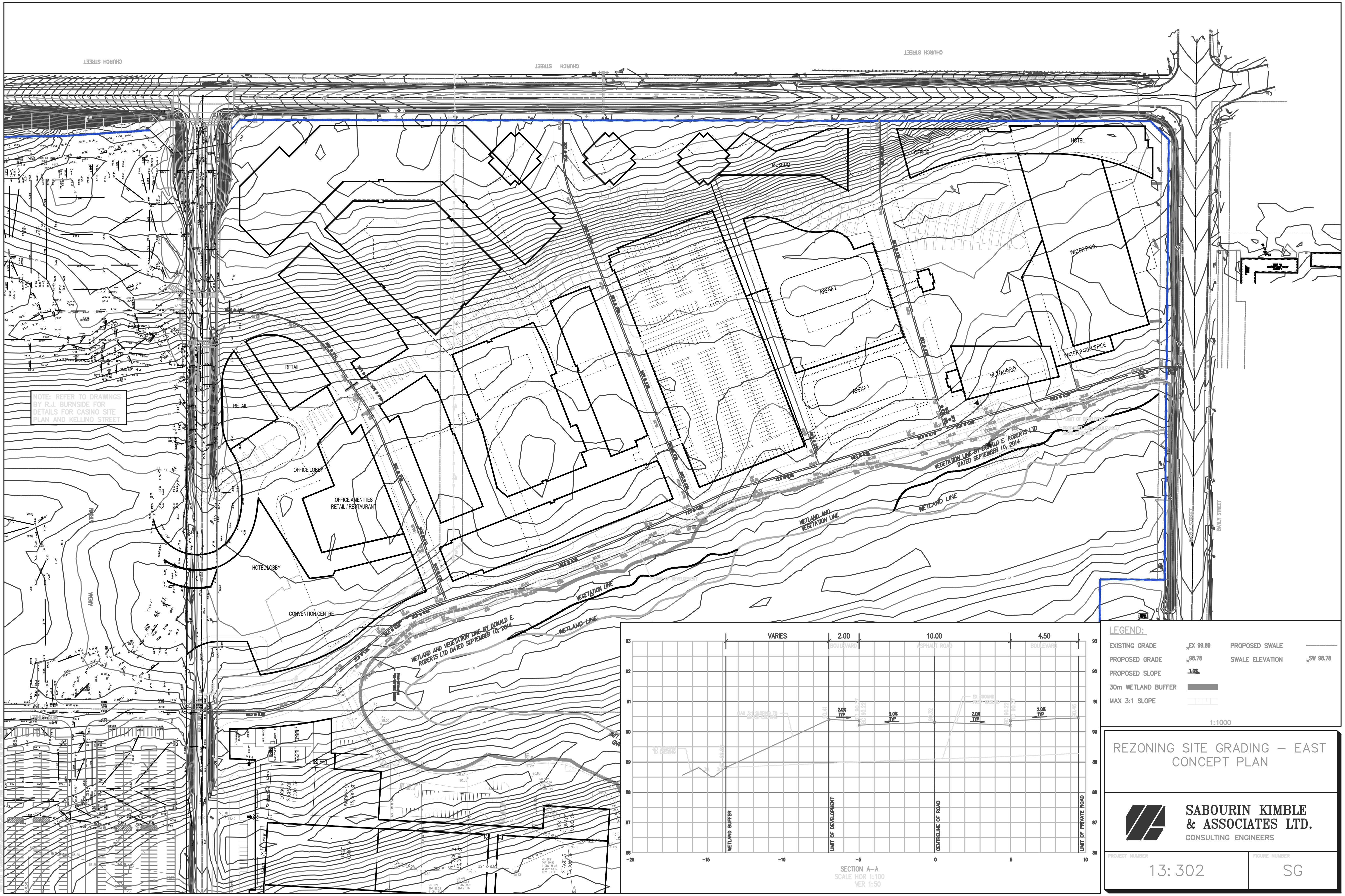
Appendix A

Site Drawings

A1. Re-Zoning Site Grading Plans – East and West Concept Plan

(SKA, 2019)

A2. Pre- and Post-Development Drainage Areas (SKA, 2019)



NOTE: REFER TO DRAWINGS BY R.J. BURNSIDE FOR DETAILS FOR CASINO SITE PLAN AND KELLINO STREET

SECTION A–A
SCALE HOR 1:100
VER 1:50

LEGEND:

EXISTING GRADE	×EX 99.89	PROPOSED SWALE	------
PROPOSED GRADE	×98.78	SWALE ELEVATION	×SW 98.78
PROPOSED SLOPE	1.0% →		
30m WETLAND BUFFER	▬		
MAX 3:1 SLOPE	┬┬┬		

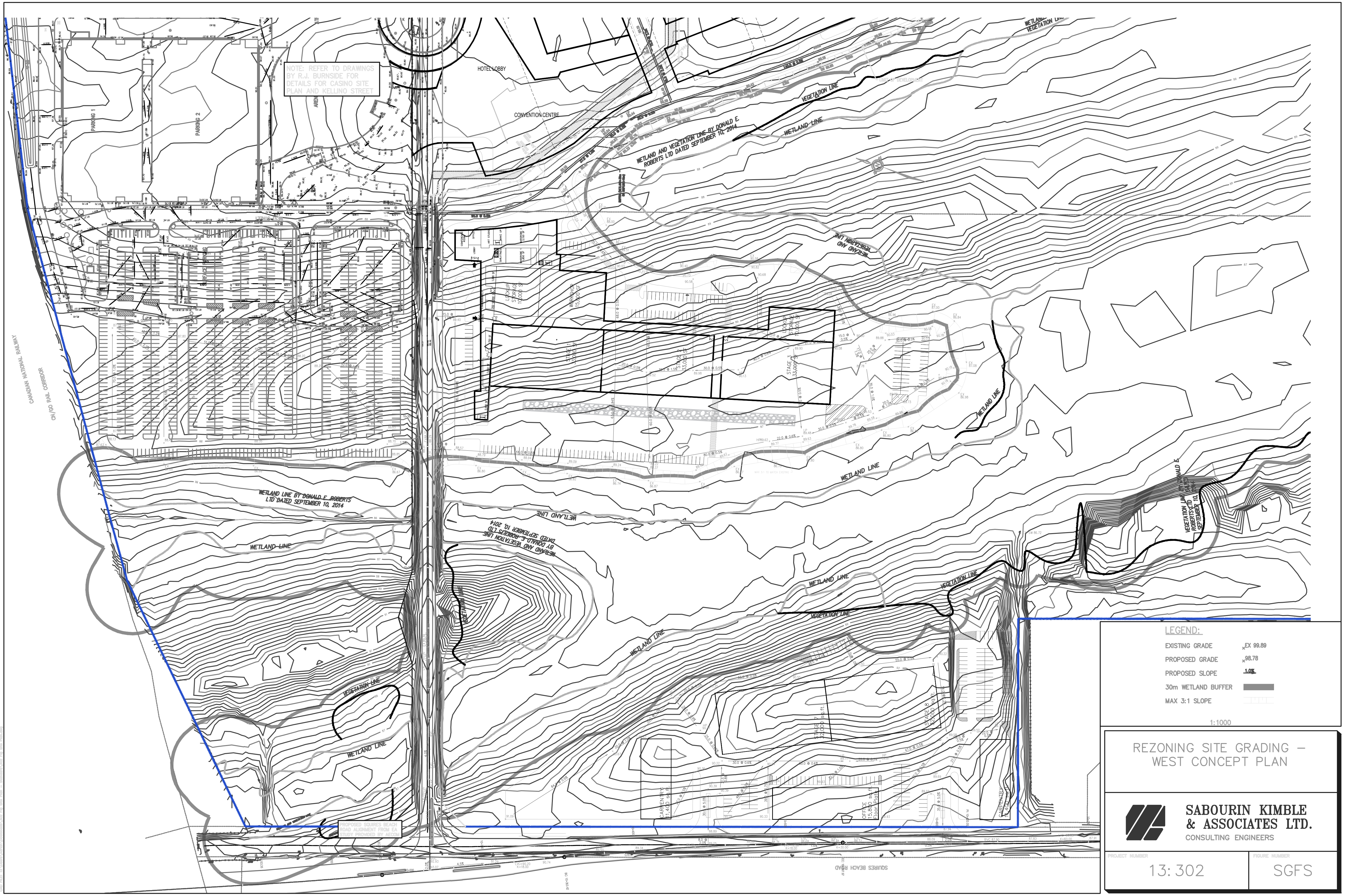
1:1000

REZONING SITE GRADING – EAST
CONCEPT PLAN

SABOURIN KIMBLE
& ASSOCIATES LTD.
CONSULTING ENGINEERS

PROJECT NUMBER
13: 302

FIGURE NUMBER
SG



NOTE: REFER TO DRAWINGS BY R.J. BURNSIDE FOR DETAILS FOR CASINO SITE PLAN AND KELLINO STREET

PROPOSED SQUIRES BEACH ROAD ALIGNMENT FROM EA STUDY PROVIDED BY AECOM

LEGEND:

EXISTING GRADE	×EX 99.89
PROPOSED GRADE	×98.78
PROPOSED SLOPE	1.0%
30m WETLAND BUFFER	▬
MAX 3:1 SLOPE	▭

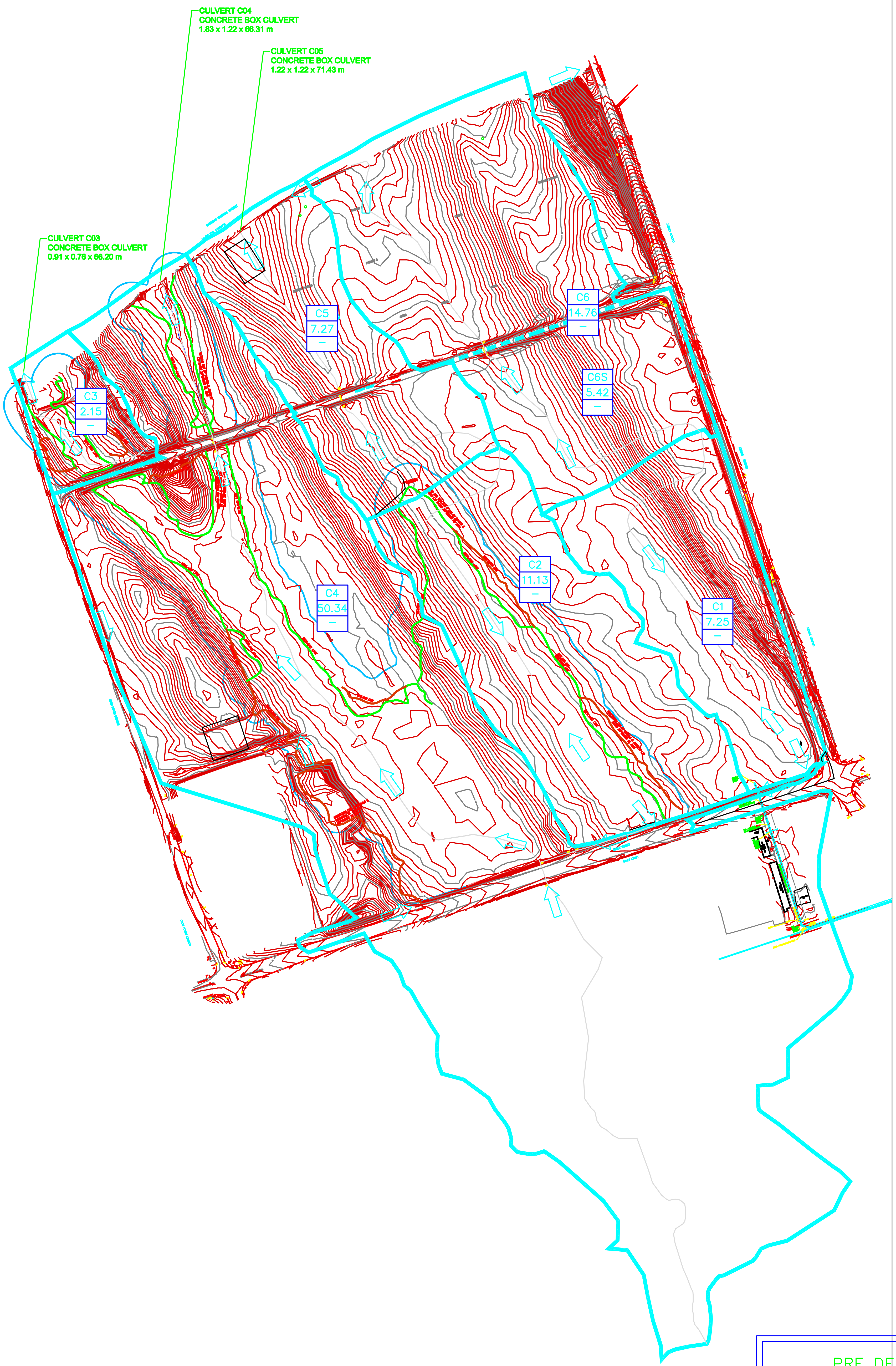
1:1000

REZONING SITE GRADING – WEST CONCEPT PLAN

SABOURIN KIMBLE & ASSOCIATES LTD.
CONSULTING ENGINEERS

PROJECT NUMBER
13: 302

FIGURE NUMBER
SGFS



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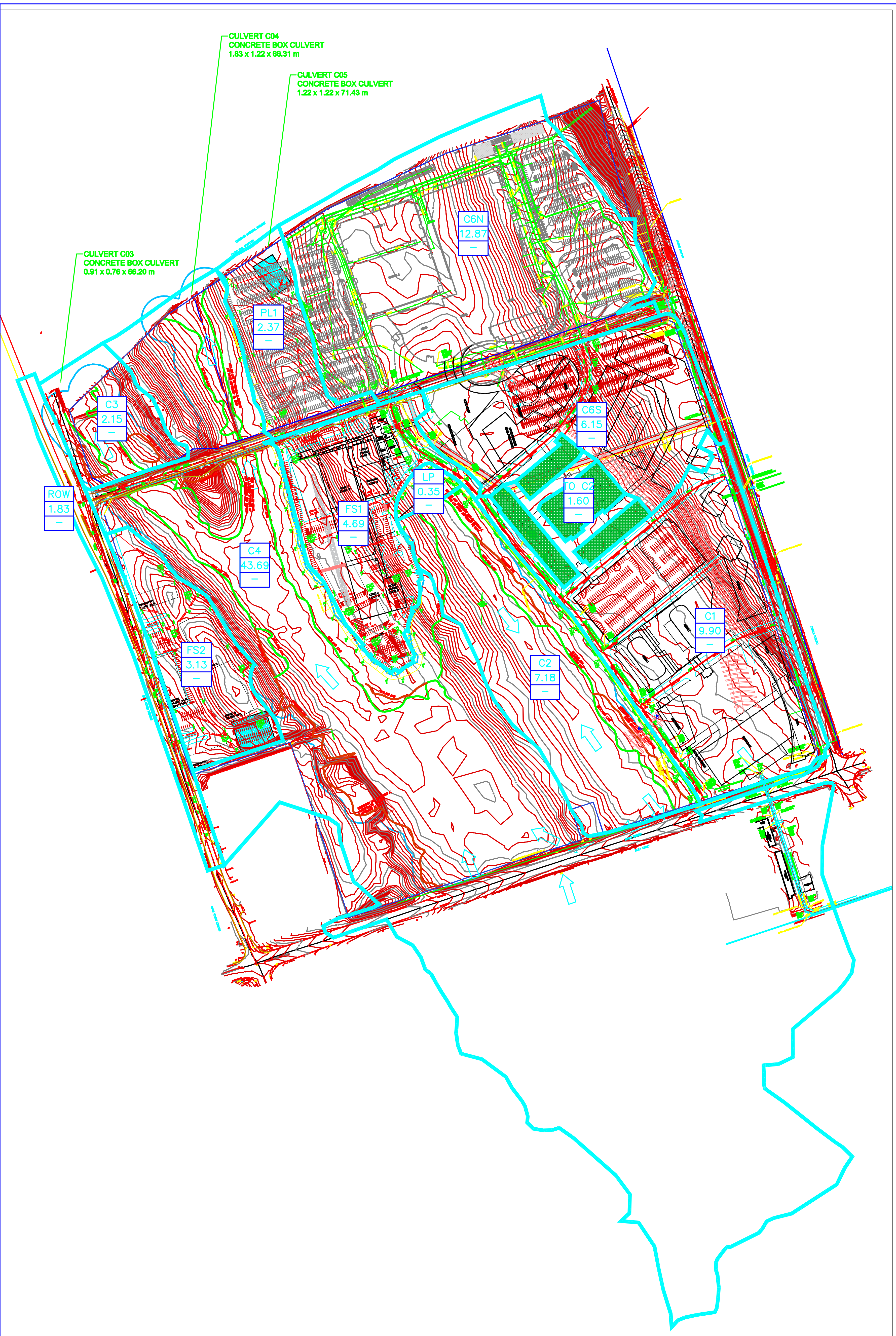
PRE DEVELOPMENT
DRAINAGE AREAS

SABOURIN KIMBLE
& ASSOCIATES LTD.
CONSULTING ENGINEERS

PROJECT NUMBER	FIGURE NUMBER
13:302	PRE



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POST DEVELOPMENT
DRAINAGE AREAS

SABOURIN KIMBLE
& ASSOCIATES LTD.
CONSULTING ENGINEERS

PROJECT NUMBER	FIGURE NUMBER
13:302	POST

Appendix B

Borehole Logs and Test Pit Logs

(Golder, 2013; Thurber 2018; and Palmer, 2014, ,2018, & 2019)

PROJECT: 13-1185-0057

RECORD OF BOREHOLE: BH13-1

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: April 4, 2013

DATUM:

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected 100 200 300 400 ☐ 100 200 300 400	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	RUBBER TRACK MOUNTED CME 75 200 mm Diameter Hollow Stem Augers	Moist, dark brown to brown, clayey silt, some sand, some organics (rootlets), NO OD/ST (FILL)	▩	0.00	1	60 DO	7	⊕			50 mm Diameter Monitoring Well
1		Moist, brown, SILTY CLAY, trace sand, NO OD/ST	▥	0.61	2	60 DO	11	⊕			Bentonite Seal
2		Soft, moist to wet, CLAY, trace silt, NO OD/ST	▨	1.37	3	60 DO	2	⊕ ND			
					4	60 DO	3	⊕ ND			
3					5	60 DO	1	⊕			Silica Sand Filter
		END OF BOREHOLE		3.66							
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: KS
CHECKED:

PROJECT: 13-1185-0057

RECORD OF BOREHOLE: BH13-2

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: April 4, 2013

DATUM:

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕ *ND = Not Detected* 100 200 300 400 □ 100 200 300 400	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	RUBBER TRACK MOUNTED CME 75 100 mm O.D. Solid Stem Augers	Moist, dark brown, clayey silt, some sand, some organics (rootlets), NO OD/ST (FILL)		0.00	1	60 DO	6	⊕			
1					2	60 DO	23	⊕			
2		Moist, brown, SILTY SAND, some gravel, NO OD/ST (TILL)		1.37	3	60 DO	30	⊕ *ND*			
		Moist, brown to grey, SAND, some gravel, trace silt, NO OD/ST		2.29	4	60 DO	23	⊕			
3		END OF BOREHOLE		2.90							
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: KS
CHECKED:

PROJECT: 13-1185-0057

RECORD OF BOREHOLE: BH13-3

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: April 4, 2013

DATUM:

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

BORING METHOD: RUBBER TRACK MOUNTED CME 75
200 mm Diameter Hollow Stem Augers

HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕
ND = Not Detected
100 200 300 400

HYDRAULIC CONDUCTIVITY, k, cm/s
10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT
Wp ⊢—○W—⊣ Wl
10 20 30 40

SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	HEADSPACE	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE								
Moist, dark brown, clayey silt, trace sand, some organics (rootlets), NO OD/ST (FILL)		0.00	1	60 DO	5	⊕		50 mm Diameter Monitoring Well
Moist, brown, SILTY CLAY, trace sand, NO OD/ST		0.61	2	60 DO	10	⊕		Bentonite Seal
			3	60 DO	19	⊕		
Moist, brown, SILTY CLAY to SILTY SAND, trace gravel, NO OD/ST		2.13	4	60 DO	14	⊕ ND		Silica Sand Filter
Moist to wet, grey, SAND, some silt, some gravel, NO OD/ST		3.05	5	60 DO	30	⊕ ND		
END OF BOREHOLE		3.66						

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: KS
CHECKED:

PROJECT: 13-1185-0057

RECORD OF BOREHOLE: BH13-4

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: April 4, 2013

DATUM:

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected 100 200 300 400 □ 100 200 300 400	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	RUBBER TRACK MOUNTED CME 75 100 mm O.D. Solid Stem Augers	Moist, dark brown, clayey silt, some sand, some organics (rootlets), NO OD/ST		0.00	1	60 DO	50/.03	⊕ ND			
1					2	60 DO	6	⊕ ND			
		Moist, brown, SILTY SAND, trace gravel, NO OD/ST (TILL)		1.37	3	60 DO	32	⊕ ND			
2											
		END OF BOREHOLE		2.13							
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: KS

CHECKED:

PROJECT: 13-1185-0057

RECORD OF BOREHOLE: BH13-5

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: April 4, 2013

DATUM:

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕ *ND = Not Detected* 100 200 300 400 □ 100 200 300 400	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	RUBBER TRACK MOUNTED CME 75 200 mm Diameter Hollow Stem Augers	Moist, dark brown, clayey silt, some organics (rootlets), trace sand, NO OD/ST (FILL)	▩	0.00	1	60 DO	10	⊕ *ND*			50 mm Diameter Monitoring Well
1		Moist, loose, brown, SILTY CLAY, some clay, trace gravel, NO OD/ST	▨	0.61	2	60 DO	8	⊕ *ND*			Bentonite Seal
2		Moist, stiff, brown, SANDY SILT, trace gravel, trace clay, NO OD/ST	▒	1.37	3	60 DO	35	⊕			
		Moist, hard, brown to grey, SILT, trace sand, trace gravel, NO OD/ST	▥	2.13	4	60 DO	51	⊕			
3		Moist, grey, CLAYEY SILT, NO OD/ST	▨	2.90	5	60 DO	35	⊕ *ND*			Silica Sand Filter
		END OF BOREHOLE		3.66							
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: KS

CHECKED:

PROJECT: 13-1185-0057

RECORD OF BOREHOLE: BH13-6

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: April 4, 2013

DATUM:

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected 100 200 300 400 ☐ 100 200 300 400	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp W Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	RUBBER TRACK MOUNTED CME 75 100 mm O.D. Solid Stem Augers	Moist, dark brown to brown, clayey silt, some organics (rootlets), some sand, NO OD/ST (FILL)	▨	0.00	1	60 DO	8	⊕ ND			
1		Moist, brown, SILTY SAND, trace gravel, NO OD/ST		0.61	2	60 DO	24	⊕ ND			
		END OF BOREHOLE		1.52							
2											
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: KS

CHECKED:

PROJECT: 13-1185-0057

RECORD OF BOREHOLE: BH13-7

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: April 4, 2013

DATUM:

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected 100 200 300 400 □ 100 200 300 400	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m				
		GROUND SURFACE									
0	RUBBER TRACK MOUNTED CME 75 100 mm O.D. Solid Stem Augers	Moist, dark brown to brown, clayey silt, some sand, some organics (rootlets), NO OD/ST (FILL)		0.00	1	60 DO	6	⊕ ND			
1		Moist, brown, SILTY SAND, some gravel, NO OD/ST (TILL)		0.66	2	60 DO	12	⊕ ND			
					3	60 DO	27	⊕ ND			
2		END OF BOREHOLE		2.13							
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

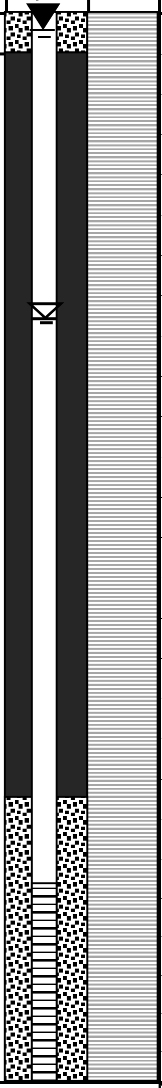
Golder Associates

LOGGED: KS

CHECKED:

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Project: Pickering		Project Number: 14121	Client: Triple Group	Boring No. **MW1**
Address, City, State Bayly Street and Squires Beach Road, Pickering, ON			Drilling Contractor: Pontil Drilling	Drill Rig Type: CME 75
Logged By: D. Turner	Checked By: J. Cole	Date Started: 06/10/2014	Auger Type: HSA	Diameter: 8.5"
Coordinates: 656688, 4855677		Date Completed: 06/10/2014	Screened Interval: 5.21 - 6.71 mbgs	Stick Up Height: 0.91 m
Groundwater upon Completion 1.82 m		Static Groundwater Depth: 0.16 m	Elevation:	Total Depth of Boring: 6.71 m



Depth (metres)	Sample Type	Sample Number	Well Completion	Geology Log	**Lithology** **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	N - Value	Moisture Content (%)
					0 - 0.15 m: TOPSOIL, dark brown, weathered, loose		
	SS	1			0.15 - 0.61 m: (CL) sandy SILTY CLAY, dark brown, W>PL,	7	21.4
					firm, some gravel, organic staining, rootlets, angular gneiss		
1	SS	2			boulder encountered	10	10.6
					0.76 - 6.71 m: (CL) sandy SILTY CLAY (TILL), dark brown to		
					light brown, becoming grey at 2.29m, W>PL to W<PL, stiff		
	SS	3			to hard, some gravel, oxidation stains to 2.29m, occational	15	12.3
					clasts and sand lenses below 2.29m		
2							
	SS	4				>50 for 0.13 m	8.9
3							
	SS	5			- two large clasts at 3.35 m	48	12.4
4							
	SS	6				42	15.5
5							
6							
	SS	7				57	12.9
					- 1 to 5 cm thick sand lens at 6.4 m		

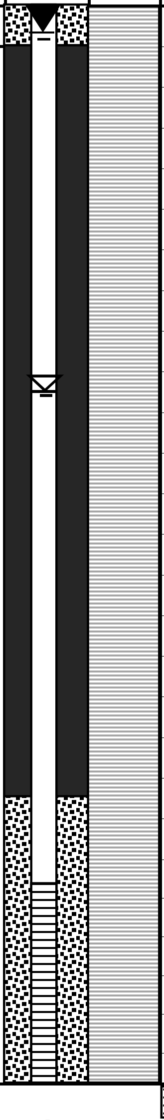
Notes:

- ■ Bentonite Seal
- ▩ Sand Pack
- ⬚ Sand
- ▩ Gravel
- ▤ Clay / Clay Till
- ▨ Silt / Silty till
- ▨ Sandy till
- ▼ Stabilized groundwater
- ▽ Groundwater upon completion

Sheet _1_of _1_

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Project: Pickering	Project Number: 14121	Client: Triple Group	Boring No. **MW2**
Address, City, State Bayly Street and Squires Beach Road, Pickering, ON		Drilling Contractor: Pontil Drilling	Drill Rig Type: CME 75
Logged By: D. Turner	Checked By: J. Cole	Auger Type: SSA	Diameter: 6"
Date Started: 06/10/2014	Date Completed: 06/10/2014	Screened Interval: 5.21 - 6.71 mbgs	Stick Up Height: 0.95 m
Coordinates: 656478, 4855945			
Groundwater upon Completion 2.44 m	Static Groundwater Depth: 0.20 m	Elevation:	Total Depth of Boring: 6.71 m



Depth (metres)	Sample Type	Sample Number	Well Completion	Geology Log	**Lithology** **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	N - Value	Moisture Content (%)
					0 - 0.025 m: TOPSOIL, dark brown, dry, weathered		
	SS	1			0.025 - 0.61 m: (CL) silty CLAY, dark brown, W>PL, firm to stiff, some gravel, organic staining, organic inclusions	8	22.7
1	SS	2			0.76 - 1.37 m: (CL) silty CLAY, dark brown, cohesive, laminated, W>PL, firm	6	38.9
2	SS	3			1.52 - 2.13 m: (CL) sandy SILTY CLAY, grey-brown, W>PL, firm, some gravel	5	13.6
3	SS	4			2.29 - 2.90 m: (CL-ML) SILTY CLAY to CLAYEY SILT and SAND (TILL), brown, W<PL, hard, some gravel, large clast at 2.6m	62	10.4
4	SS	5			3.05 - 6.71 m: (CL) sandy SILTY CLAY (TILL), light grey becoming dark grey at 4.57m, W>PL, hard, some gravel, gleyed to 3.66m	42	14.4
5	SS	6				67/0.29m	11.8
6	SS	7				64	10.8

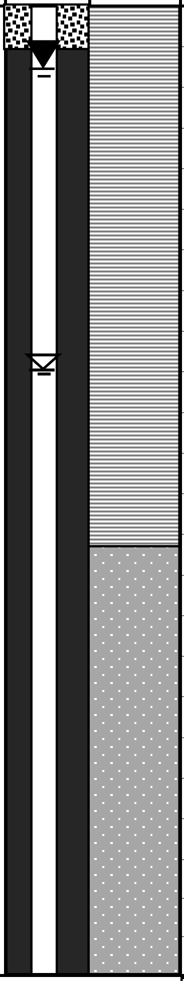
Notes:

■ Bentonite Seal	⬚ Sand	▒ Silt / Silty till	▼ Stabilized groundwater
▩ Sand Pack	▩ Gravel	▒ Sandy till	⩡ Groundwater upon completion
	▤ Clay / Clay Till		

Sheet _1_of _1_

PALMER
ENVIRONMENTAL
CONSULTING
GROUP INC.

Project: Pickering	Project Number: 14121	Client: Triple Group	Boring No. **MW3**
Address, City, State Bayly Street and Squires Beach Road, Pickering, ON		Drilling Contractor: Pontil Drilling	Drill Rig Type: CME 75
Logged By: D. Turner	Checked By: J. Cole	Date Started: 07/10/2014	Auger Type: HSA
Coordinates: 656245, 4855915		Date Completed: 07/10/2014	Screened Interval: 6.70 - 8.23 mbgs
Diameter: 8.5"	Stick Up Height: 0.87 m		
Groundwater upon Completion: 2.29 m	Static Groundwater Depth: 0.38 m	Elevation:	Total Depth of Boring: 8.23 m



Depth (metres)	Sample Type	Sample Number	**Lithology** **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	N - Value	Moisture Content (%)
	SS	1A	0 - 0.24 m: (CL) SILTY CLAY (FILL), dark brown, W>PL,	6	30.5
			firm, some sand, organic inclusions, organic staining,		
	SS	1B	rootlets, wood debris		26.2
1			0.24 - 0.61 m: (CL) SILTY CLAY (FILL), light brown,		
	SS	2	W>PL, firm, some sand, organic inclusions	15	21.8
			0.76 - 2.30 m: (CL) SILTY CLAY, light brown, W>PL,		
	SS	3	stiff to very stiff, some sand, laminated, oxidized along	12	22.9
2			laminations		
	SS	4	2.30 - 3.40 m: (CL) SILTY CLAY, light grey, W>PL, firm	5	13.1
			to very stiff, some sand, some gravel		
3					
	SS	5		23	8.0
			3.40 - 5.18 m: (ML) sandy SILT (TILL), light grey, moist,		
			compact to very dense, trace gravel		
4					
			- Hole caving at ~4.5 m		
	SS	6		72	7.0
5					

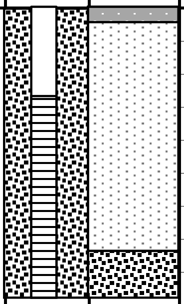
Notes:

- ■ Bentonite Seal
- ▩ Sand Pack
- ░ Sand
- ▩ Gravel
- ▤ Clay / Clay Till
- ▒ Silt / Silty till
- ▒ Sandy till
- ▼ Stabilized groundwater
- ▽ Groundwater upon completion

Sheet _1_of _2_

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Project: Pickering	Project Number: 14121	Client: Triple Group	Boring No. **MW3**
Address, City, State Bayly Street and Squires Beach Road, Pickering, ON		Drilling Contractor: Pontil Drilling	Drill Rig Type: CME 75
Logged By: D. Turner / Checked By: J. Cole	Date Started: 07/10/2014	Auger Type: HSA	Diameter: 8.5"
Coordinates: 656245, 4855915	Date Completed: 07/10/2014	Screened Interval: 6.70 - 8.23 mbgs	Stick Up Height: 0.87 m
Groundwater upon Completion: 2.29 m	Static Groundwater Depth: 2.27 m	Elevation:	Total Depth of Boring: 8.23 m



Depth (metres)	Sample Type	Sample Number	Well Completion	Geology Log	**Lithology** **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	N - Value	Moisture Content (%)
	SS	7			6.10 - 6.71 m: (SM) silty fine SAND, light grey, compact, well sorted, saturated, massive, trace pebbles	28	10.4
7							
	SS	8			7.62 - 8.23 m: (SP-SM)coarse-grained SAND, light grey, dense, saturated, well sorted, some silt - well sorted pebble GRAVEL @ 8.10 m	48	5.2
8							
9							
10							
11							

Notes:

■ Bentonite Seal

▨ Sand Pack

░ Sand

▨ Gravel

▤ Clay / Clay Till

▒ Silt / Silty till

▒ Sandy till

▼ Stabilized groundwater

▽ Groundwater upon completion

Sheet _2_of _2_

PALMER
ENVIRONMENTAL
CONSULTING
GROUP INC.

Project: Pickering	Project Number: 14121	Client: Triple Group	Boring No. **MW4**
Address, City, State Bayly Street and Squires Beach Road, Pickering, ON		Drilling Contractor: Pontil Drilling	Drill Rig Type: CME 75
Logged By: D. Turner / Checked By: J. Cole	Date Started: 08/10/2014	Auger Type: SSA	Diameter: 6"
Coordinates: 656035, 4855816	Date Completed: 08/10/2014	Screened Interval:	Stick Up Height:
Groundwater upon Completion: 3.05 m	Static Groundwater Depth:	Elevation:	Total Depth of Boring: 5.33 m

Depth (metres)	Sample Type	Sample Number	Well Completion	Geology Log	Lithology **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	N - Value	Moisture Content (%)
	SS	1		▤	0 - 0.80 m: (CL) SILTY CLAY (FILL), dark brown, W>PL, firm, some sand, organic inclusions, organic staining, rootlets, woody debris and corn husks	7	20.9
1	SS	2		▤	0.80 - 1.50 m: (CL) sandy SILTY CLAY (TILL), light brown, W>PL, very stiff to hard, some gravel, oxidation staining	30	13.0
2	SS	3		▒	1.50 - 2.90 m: (ML) sandy SILT (TILL), light brown, dense to very dense, some gravel, moist, trace to some silt, heavily oxidized, some gravel, massive, consolidated	43	14.8
	SS	4		▒		72 / 0.23m	9.2
3	SS	5	▽	▤	3.05 - 4.85 m: (CL-ML) sandy SILTY CLAY to CLAYEY SILT (TILL), dark grey, W<PL, hard, strong fissility, trace to some gravel and clasts, oxidized along fractures	30	9.1
4				▤			
	SS	6A		▤		38	9.0
5	SS	6B		░	4.85 - 5.33 m: (SP) fine to medium SAND, dark grey, wet, well sorted, some gravel, dense		9.5
					- Auger refusal at 5.33 m on boulder		

Notes:

■ Bentonite Seal

▦ Sand Pack

░ Sand

▩ Gravel

▤ Clay / Clay Till

▒ Silt / Silty till

▓ Sandy till

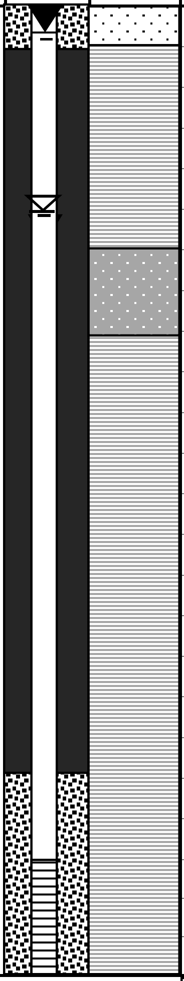
▼ Stabilized groundwater

▽ Groundwater upon completion

Sheet _1_of _1_

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Project: Pickering	Project Number: 14121	Client: Triple Group	Boring No. **MW5**
Address, City, State Bayly Street and Squires Beach Road, Pickering, ON		Drilling Contractor: Pontil Drilling	Drill Rig Type: CME 75
Logged By: D. Turner	Checked By: J. Cole	Auger Type: SSA	Diameter: 6"
Date Started: 08/10/2014	Date Completed: 08/10/2014	Screened Interval: 5.18 - 6.71 mbgs	Stick Up Height: 0.92
Coordinates: 656027, 4855541			
Groundwater upon Completion: 1.52 m	Static Groundwater Depth: 0.20 m	Elevation:	Total Depth of Boring: 6.71 m

Depth (metres)	Sample Type	Sample Number	Well Completion	Geology Log	Lithology **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	N - Value	Moisture Content (%)
	SS	1			0 - 0.23 m: silty sand TOPSOIL, dark brown, damp, some woody debris and roots, weathered, oxidized, no clasts	6	25.7
1	SS	2			0.23 - 0.80 m: (CL) SILTY CLAY (FILL), brown-dark brown, mottled, W>PL, firm, organic inclusions, organic staining, rootlets	6	15.3
	SS	3			0.80 - 1.52 m: (CL) sandy SILTY CLAY (TILL), brown, W<PL, firm, some gravel, strong fissility, massive, heavily oxidized	16	11.1
2	SS	4			1.52 - 2.01 m: (ML) sandy SILT (TILL), brown-grey, wet, compact, trace gravel - large clast @ 2.15 m	40	8.6
3	SS	5			2.30 - 6.71 m: (CL) sandy SILTY CLAY (TILL), dark grey, W<PL, hard, trace to some gravel	41	9.3
4							
	SS	6				31	10.2
5							

Notes:

■ Bentonite Seal	░ Sand	▒ Silt / Silty till
▩ Sand Pack	▩ Gravel	▒ Sandy till
	▤ Clay / Clay Till	

▼ Stabilized groundwater

▽ Groundwater upon completion

Sheet _1_of _2_

PALMER
ENVIRONMENTAL
CONSULTING
GROUP INC.

Project: Pickering		Project Number: 14121	Client: Triple Group	Boring No. **MW5**
Address, City, State Bayly Street and Squires Beach Road, Pickering, ON			Drilling Contractor: Pontil Drilling	Drill Rig Type: CME 75
Logged By: D. Turner	Checked By: J. Cole	Date Started: 08/10/2014	Auger Type: SSA	Diameter: 6"
Coordinates: 656027, 4855541		Date Completed: 08/10/2014	Screened Interval: 5.18 - 6.71 mbgs	Stick Up Height: 0.92
Groundwater upon Completion: 1.52 m		Static Groundwater Depth: 0.20 m	Elevation:	Total Depth of Boring: 6.71 m

Depth (metres)	Sample Type	Sample Number	Well Completion	Geology Log	**Lithology** **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	N - Value	Moisture Content (%)
	SS	7	▩ ▤ ▩	▤		33	9.8
7							
8							
9							
10							
11							

Notes:

■	Bentonite Seal
▩	Sand Pack
⬚	Sand
▩	Gravel
▤	Clay / Clay Till
▦	Silt / Silty till
▦	Sandy till
▼	Stabilized groundwater
▽	Groundwater upon completion

Sheet _2_of _2_

Project: Pickering	Project Number: 14121	Client: Triple Group	Boring No. **TH1**
Address, City, State Bayly Street and Squires Beach Road, Pickering, ON		Drilling Contractor: Pontil Drilling	Drill Rig Type: CME 75
Logged By: D. Turner / Checked By: J. Cole	Date Started: 06/10/2014	Auger Type: SSA	Diameter: 6"
Coordinates: 656807, 4855922	Date Completed: 08/10/2014	Screened Interval:	Stick Up Height:
Groundwater upon Completion: 4.42 m	Static Groundwater Depth:	Elevation:	Total Depth of Boring: 9.75 m

Depth (metres)	Sample Type	Sample Number	Well Completion	Geology Log	**Lithology** **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	N - Value	Moisture Content (%)
	SS	1		▤	0 - 0.80 m: (CL) SILTY CLAY, dark brown, W>PL, firm,	6	16.9
				▤	some sand, organic staining, organic inclusions, rootlets		
				▤			
1	SS	2		▤	0.80 - 2.10 m: (CL) sandy SILTY CLAY (TILL), light to	36	11.1
				▤	dark brown, moist, dense, some gravel, oxidation staining		
				▤	- large clast @ 1.4 m		
	SS	3		▤		32	10.4
2				▤			
				▒	2.30 - 3.70 m: (ML) some sand to sandy SILT, brown,		
	SS	4		▒	moist to wet, very dense, trace gravel, moderately well	85 / 0.29m	9.0
				▒	sorted		
3				▒			
	SS	5		▒		50 / 0.1m	18.1
				▒			
				▒			
4				▤			
				▤			
			▽	▤			
	SS	6		▤	4.57 - 9.52 m: (CL) sandy SILTY CLAY (TILL), light to	86 / 0.23m	8.0
5				▤	dark grey, W<PL, hard, some gravel, over consolidated,		
				▤	sand lenses @ 4.6 m		
				▤			
				▤			

Notes:

■	Bentonite Seal
▩	Sand Pack
⬚	Sand
▩	Gravel
▤	Clay / Clay Till
▒	Silt / Silty till
▦	Sandy till
▼	Stabilized groundwater
▽	Groundwater upon completion

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GROUP INC.

Project: Pickering	Project Number: 14121	Client: Triple Group	Boring No. **TH1**
Address, City, State Bayly Street and Squires Beach Road, Pickering, ON		Drilling Contractor: Pontil Drilling	Drill Rig Type: CME 75
Logged By: D. Turner Checked By: J. Cole	Date Started: 06/10/2014	Auger Type: SSA	Diameter: 6"
Coordinates: 656807, 4855922	Date Completed: 06/10/2014	Screened Interval:	Stick Up Height:
Groundwater upon Completion: 4.42 m	Static Groundwater Depth:	Elevation:	Total Depth of Boring: 9.75 m

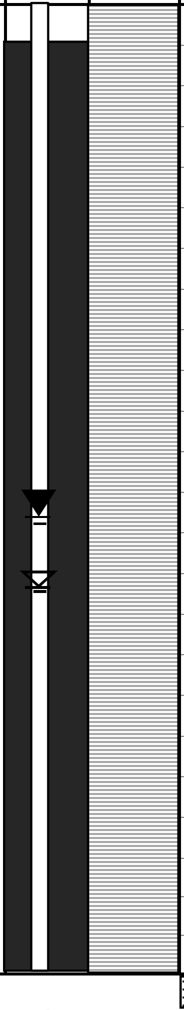
Depth (metres)	Sample Type	Sample Number	Well Completion	Geology Log	**Lithology** **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	N - Value	Moisture Content (%)
	SS	7		▤		62	7.4
7				▤			
	SS	8		▤		60	7.4
8				▤			
9	SS	9		▤		41	7.8
	SS	10		⛆	9.52 - 9.75 m: (SP) fine to medium SAND, dark grey, wet, well sorted, some gravel, pockets of sandy silt		12.4
10							
11							

Notes:

■	Bentonite Seal
▩	Sand Pack
⛆	Sand
▩	Gravel
▤	Clay / Clay Till
▦	Silt / Silty till
▩	Sandy till
▼	Stabilized groundwater
▽	Groundwater upon completion

Sheet _2_of _2_

Project: Pickering	Project Number: 14121	Client: Triple Group	Boring No. **TH2**
Address, City, State Bayly Street and Squires Beach Road, Pickering, ON		Drilling Contractor: Pontil Drilling	Drill Rig Type: CME 75
Logged By: D. Turner	Checked By: J. Cole	Date Started: 06/10/2014	Auger Type: SSA
Coordinates: 656627, 4854241	Date Completed: 07/10/2014	Screened Interval: 7.5 - 9.0 m	Diameter: 6"
			Stick Up Height:
Groundwater upon Completion: 3.66 m	Static Groundwater Depth: 3.18 m	Elevation:	Total Depth of Boring: 9.0 m



Depth (metres)	Sample Type	Sample Number	Well Completion	Geology Log	**Lithology** **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	N - Value	Moisture Content (%)
	SS	1			0 - 0.61 m: (CL) sandy SILTY CLAY, dark brown, W<PL,	7	17.2
					firm, organic staining, organic inclusions, rootlets		
1	SS	2			0.76 - 5.70 m: (CL) sandy SILTY CLAY (TILL), light brown	20	12.5
					becoming grey at 4.6 m, very stiff to hard, some gravel,		
					oxidation staining to 3.6m		
	SS	3				38	8.5
2							
	SS	4				40	8.5
3	SS	5				32	9.3
					- wet at 3.66 m		
4							
	SS	6				42	6.9
5							
					- large clast @ 5.0 - 5.15		

Notes:

■ Bentonite Seal

▩ Sand Pack

░ Sand

▩ Gravel

▤ Clay / Clay Till

▒ Silt / Silty till

▓ Sandy till

▼ Stabilized groundwater

▽ Groundwater upon completion

Sheet _1_of _2_

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Project: Pickering	Project Number: 14121	Client: Triple Group	Boring No. **TH2**
Address, City, State Bayly Street and Squires Beach Road, Pickering, ON		Drilling Contractor: Pontil Drilling	Drill Rig Type: CME 75
Logged By: D. Turner	Checked By: J. Cole	Date Started: 06/10/2014	Auger Type: SSA
Coordinates: 656627, 4854241		Date Completed: 07/10/2014	Screened Interval: 7.5 - 9.0 m
Diameter: 6"	Stick Up Height: 0.88 m		
Groundwater upon Completion: 3.66 m	Static Groundwater Depth: 3.18 m	Elevation:	Total Depth of Boring: 9.0 m

Depth (metres)	Sample Type	Sample Number	Well Completion	Geology Log	**Lithology** **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	N - Value	Moisture Content (%)
	SS	7	■	▨	6.10 - 6.51 m: (ML) sandy SILT, grey, moist, very dense, trace gravel	98 / 0.23	13.7
			■	░	6.51 - 6.71 m: (SP) medium to coarse SAND, grey, very dense, some gravel, well sorted		
7			■	☰			
	SS	8	▩	☰		50 / 0.02m	12.5
8			▩	☰	7.62 - 8.23 m: (CL) sandy SILTY CLAY (TILL), dark grey, W<PL, hard, some gravel		
9					- Auger refusal at 9 m on boulder		
10							
11							

Notes:

■ Bentonite Seal

▩ Sand Pack

░ Sand

▩ Gravel

☰ Clay / Clay Till

▨ Silt / Silty till

▩ Sandy till

▼ Stabilized groundwater

▽ Groundwater upon completion

Sheet _2_of _2_

PALMER
ENVIRONMENTAL
CONSULTING
GROUP INC.

Project: Pickering	Project Number: 14121	Client: Triple Group	Boring No. **TH3**
Address, City, State Bayly Street and Squires Beach Road, Pickering, ON		Drilling Contractor: Pontil Drilling	Drill Rig Type: CME 75
Logged By: D. Pizycki	Checked By: J. Cole	Date Started: 07/10/2014	Auger Type: SSA	Diameter: 6"
Coordinates: 656546, 4856437		Date Completed: 07/10/2014	Screened Interval:	Stick Up Height:
Groundwater upon Completion: 4.8 m	Static Groundwater Depth:	Elevation:	Total Depth of Boring: 8.23 m

Depth (metres)	Sample Type	Sample Number	Well Completion	Geology Log	**Lithology** **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	N - Value	Moisture Content (%)
	SS	1		▤	0 - 0.61 m: (CL) SILTY CLAY (FILL), dark brown, W>PL,	4	24.0
				▤	soft to stiff, some sand, organic staining, organic		
				▤	inclusions, rootlets		
1	SS	2		▤	0.76 - 3.7 m: (CL) sandy SILTY CLAY (TILL), light brown,	11	13.1
				▤	W>PL to W<PL @1.5m, still to hard, some gravel,		
				▤	oxidation staining		
	SS	3		▤		12	10.3
2				▤			
				▤			
	SS	4		▤		43	8.0
				▤			
3				▤			
	SS	5		▤		66	8.2
				▤		for 0.13 m	
				▤			
4				▤			
				▤			
				▤	4.57 - 4.65 m: (SP) medium SAND, brown, dense,		
	SS	6A	⊻	░	moist, well sorted	50 for	5.8
5	SS	6B		▨	4.65 - 6.10 m: (ML) sandy CLAYEY SILT (TILL), brown	0.13 m	7.3
				▨	becoming grey at 4.8 m, moist, very dense, some gravel,		
				▨	oxidation staining		
				▨			
				▨			

Notes:

■ Bentonite Seal

▦ Sand Pack

░ Sand

▦ Gravel

▤ Clay / Clay Till

▨ Silt / Silty till

▒ Sandy till

▼ Stabilized groundwater

⊻ Groundwater upon completion

Sheet _1_of _2_

PALMER
ENVIRONMENTAL
CONSULTING
GROUP INC.

Project: Pickering	Project Number: 14121	Client: Triple Group	Boring No. **TH3**
Address, City, State Bayly Street and Squires Beach Road, Pickering, ON		Drilling Contractor: Pontil Drilling	Drill Rig Type: CME 75
Logged By: D. Pizycki / Checked By: J. Cole	Date Started: 07/10/2014	Auger Type: SSA	Diameter: 6"
Coordinates: 656546, 4856437	Date Completed: 07/10/2014	Screened Interval:	Stick Up Height:
Groundwater upon Completion: 4.8 m	Static Groundwater Depth:	Elevation:	Total Depth of Boring: 8.23 m

Depth (metres)	Sample Type	Sample Number	Well Completion	Geology Log	**Lithology** **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	N - Value	Moisture Content (%)
	SS	7A			6.10 - 8.08 m: (SP) SAND, dark grey with white pockets,	83	3.2
					dry, some gravel, trace silt and cobbles, cemented, very		6.2
	SS	7B			dense, pockets of moist sandy silt at 6.6-6.7m		
7							
	SS	8				91 / 0.28m	4.5
8							
					- Auger refusal at 8.23 m on boulder		
9							
10							
11							

Notes:

■ Bentonite Seal

▩ Sand Pack

⬚ Sand

▩ Gravel

▤ Clay / Clay Till

▨ Silt / Silty till

▦ Sandy till

▼ Stabilized groundwater

▽ Groundwater upon completion

Sheet _2_of _2_

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

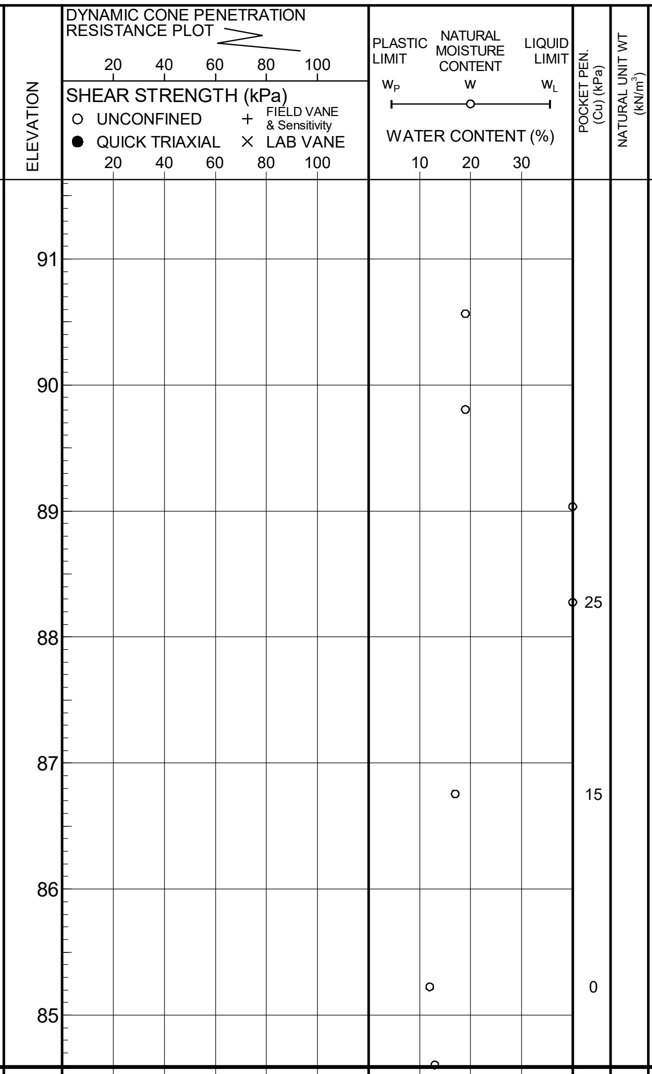
LOG OF BOREHOLE BH18-1

PROJECT: Durham Live, Pickering, ON
CLIENT: Pickering Developments Inc.
PROJECT LOCATION: Pickering, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan (UTM 17T)

Method: Solid Stem Auger
Diameter: 150
Date: Nov-27-2018

REF. NO.: 180561
ENCL NO.: 1

(m) ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	TYPE	"N" BLOWS / 0.3 m	GROUND WATER CONDITIONS	POCKET PEN. (Cu) (kPa)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
91.6	Ground Surface						
0.0	**GRANULAR BASE:** 300 mm						
91.3 0.3	**GRANULAR SUBBASE:** 350 mm	1	AS				38 54 (8)
91.0 90.9 0.8	**FILL:** sand, trace silt, trace gravel, trace rootlets, brown, moist						
	FILL: clayey silt, some sand, trace gravel, contains pockets of organics, contains organic odour, dark brown to dark grey, moist, firm	2	SS	5			
	contains hydrocarbon odour	3	SS	8			
89.4 2.2	**CLAYEY SILT TO SILTY CLAY:** trace to some sand, trace gravel, brown to grey, wet to moist, firm to very soft	4	SS	8			Spoon Wet
		5	SS	5		25	
	grey below 4.6 m	6	SS	6		15	
		7	SS	1		0	
	contains cobbles and boulders	8	SS	50/ Initial 25mm			Auger Grinding
84.6 7.0	**END OF BOREHOLE DUE TO AUGER REFUSAL** Notes: 1. Borehole caved to 3.7m below ground surface (mBGS) upon completion of drilling. 2. Water was at 1.8 mBGS upon completion of drilling.						



GROUNDWATER ELEVATIONS

Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ 3 =3% Strain at Failure

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

LOG OF BOREHOLE BH18-2

1 OF 1

PROJECT: Durham Live, Pickering, ON
CLIENT: Pickering Developments Inc.
PROJECT LOCATION: Pickering, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan (UTM 17T)

Method: Solid Stem Auger
Diameter: 150
Date: Nov-27-2018

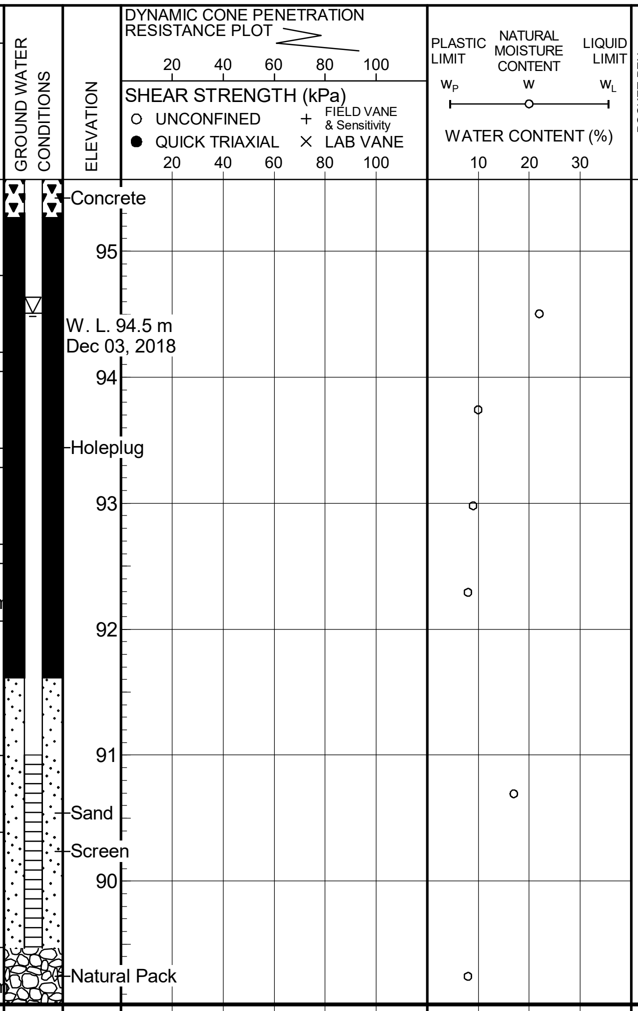
REF. NO.: 180561
ENCL NO.: 2

SOIL PROFILE

(m) ELEV	DEPTH	DESCRIPTION
95.6		Ground Surface
	0.0	**GRANULAR BASE:** 310 mm
95.3	0.3	**GRANULAR SUBBASE:** 240 mm
95.0	0.6	**FILL:** clayey silt, some sand, trace gravel, trace rootlets, trace organics, dark brown to brown, moist, firm
94.3	1.3	**FILL:** sandy silt, some clay, trace gravel, brown, moist, loose
94.1	1.5	**SANDY SILT TILL:** trace to some clay, trace gravel, contains sand seams, contains cobbles and boulders, brown, moist, compact to very dense
91.5	4.0	**SANDY SILT:** trace clay, trace gravel, grey, wet, compact
90.6	5.0	**SILT:** trace clay, trace sand, trace gravel, grey wet, compact
89.9	5.6	**CLAYEY SILT TILL:** sandy, trace gravel, contains sand seams, contains hydrocarbon odour, grey, moist, hard
89.0	6.6	**END OF BOREHOLE**

SAMPLES

NUMBER	TYPE	"N" BLOWS/0.3 m	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS		
2	SS	8	
3	SS	29	
4	SS	42	
5	SS	80/300mm	Auger Grinding
6	SS	25	Spoon Wet
7	SS	79/300mm	4 26 54 16



Notes:
1. Water was at 4.0 mBGS upon completion of drilling.
2. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole.
3. Water Level Readings:
Date W.L. Depth (mBGS)
Dec 3, 2018 1.06

SOIL-ROCK-JAN11-2019_PM_ROCK_HYDROG FORM_20190111 - COPY.GLB PALMER SOIL 2018 LOG 180561 - DURHAM LIVE 20181221.GPJ 19-1-11

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity ○ ^{8}=3% Strain at Failure

LOG OF BOREHOLE BH18-3

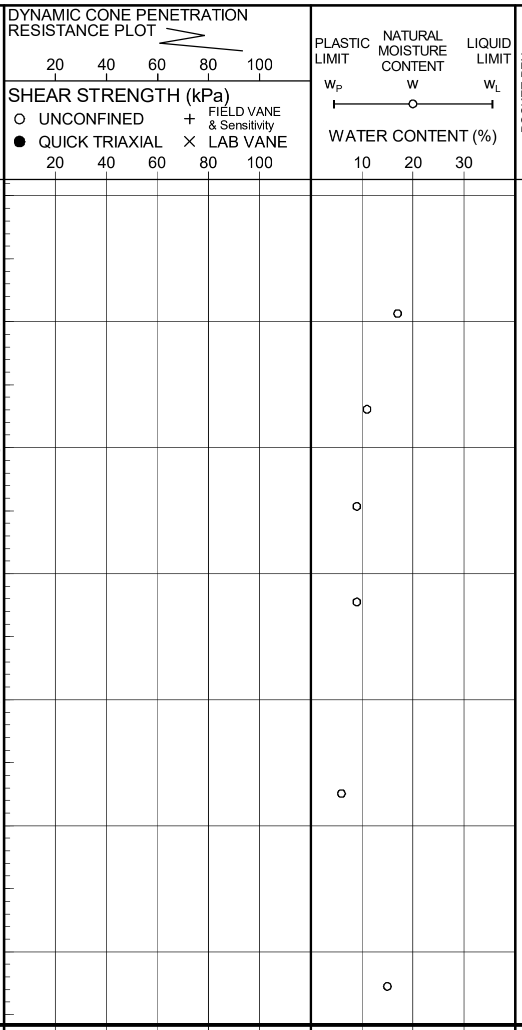
PROJECT: Durham Live, Pickering, ON
CLIENT: Pickering Developments Inc.
PROJECT LOCATION: Pickering, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan (UTM 17T)

Method: Solid Stem Auger
Diameter: 150
Date: Nov-27-2018

REF. NO.: 180561
ENCL NO.: 3

(m) ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" BLOWS / 0.3 m	GROUND WATER CONDITIONS	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
97.1	Ground Surface					
97.0 / 0.0	**ASPHALT:** 170 mm					
96.8 / 0.2	**GRANULAR BASE:** 160 mm	1	SS			
96.6 / 0.3	**GRANULAR SUBBASE:** 160 mm					
0.5	**FILL:** clayey silt, trace to some sand, trace gravel, some organics, trace rootlets, contains organic odour, dark grey to dark brown, moist, stiff	2	SS	10		
95.7 / 1.5	**SANDY SILT TILL:** trace clay, trace gravel, contains sand seams, contains cobbles, brown, moist, dense	3	SS	36		
		4	SS	34		
		5	SS	50		
93.6 / 3.5	**CLAYEY SILT TILL:** some sand, trace gravel, contains sand seams, brown, moist, hard					
93.0 / 4.1	**SANDY SILT TILL:** trace clay, trace gravel, brown to grey, moist, very dense grey below 4.9 m	6	SS	61		Spoon Wet
91.5 / 5.6	**SANDY SILT:** some clay, trace gravel, grey, wet, dense	7	SS	47		
90.4 / 6.7	**END OF BOREHOLE**					

Notes:
1. Borehole was open upon completion of drilling.
2. Water was at 5.8 mBGS upon completion of drilling.



GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES
+ 3, × 3: Numbers refer to Sensitivity
○ 8 =3% Strain at Failure

LOG OF BOREHOLE BH18-4

PROJECT: Durham Live, Pickering, ON

CLIENT: Pickering Developments Inc.

PROJECT LOCATION: Pickering, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan (UTM 17T)

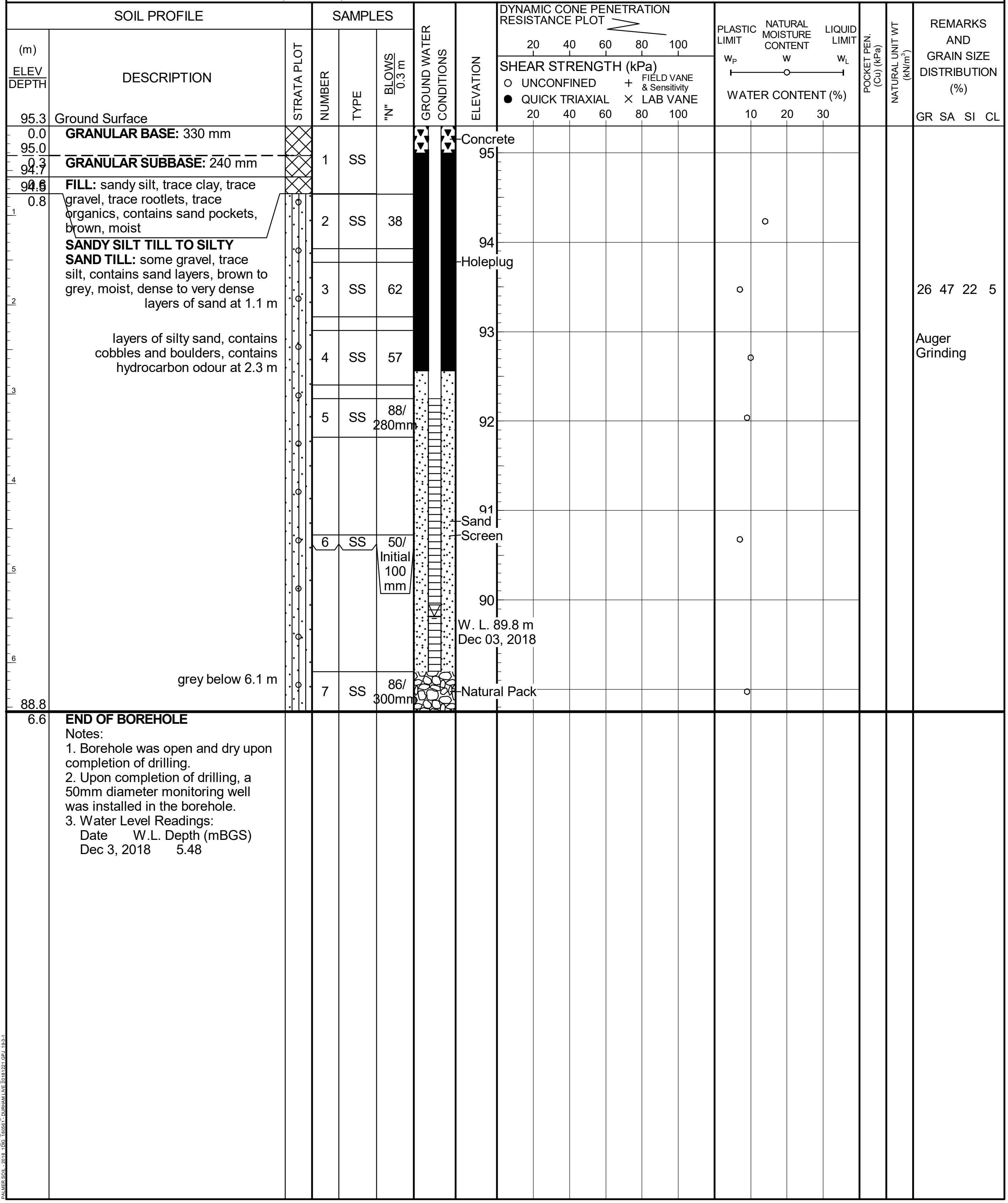
Method: Solid Stem Auger

Diameter: 150

Date: Nov-27-2018

REF. NO.: 180561

ENCL NO.: 4



(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS/0.3 m	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.3	Ground Surface				
0.0	**GRANULAR BASE:** 330 mm				
95.0 0.3	**GRANULAR SUBBASE:** 240 mm	1	SS		
94.7 94.5 0.6 0.8	**FILL:** sandy silt, trace clay, trace gravel, trace rootlets, trace organics, contains sand pockets, brown, moist	2	SS	38	
	SANDY SILT TILL TO SILTY SAND TILL: some gravel, trace silt, contains sand layers, brown to grey, moist, dense to very dense layers of sand at 1.1 m	3	SS	62	26 47 22 5
	layers of silty sand, contains cobbles and boulders, contains hydrocarbon odour at 2.3 m	4	SS	57	Auger Grinding
		5	SS	88/ 280mm	
		6	SS	50/ Initial 100 mm	
	grey below 6.1 m	7	SS	86/ 300mm	
88.8 6.6	**END OF BOREHOLE**				

Notes:
1. Borehole was open and dry upon completion of drilling.
2. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole.
3. Water Level Readings:
   Date W.L. Depth (mBGS)
   Dec 3, 2018 5.48

GROUNDWATER ELEVATIONS

Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ^{8}=3% Strain at Failure

LOG OF BOREHOLE BH18-5

1 OF 1

PROJECT: Durham Live, Pickering, ON

CLIENT: Pickering Developments Inc.

PROJECT LOCATION: Pickering, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan (UTM 17T)

Method: Solid Stem Auger

Diameter: 150

Date: Nov-27-2018

REF. NO.: 180561

ENCL NO.: 5

SOIL PROFILE

(m) ELEV / DEPTH	DESCRIPTION
90.1	Ground Surface
89.9 0.2	**ASPHALT:** 170 mm
89.8 0.3	**GRANULAR BASE:** 130 mm
89.6 0.5	**GRANULAR SUBBASE:** 210 mm
89.3 0.8	**FILL:** silty sand, trace clay, trace gravel, contains pockets of sandy silt, brown, moist
87.9 2.2	**SILTY SAND:** trace gravel, contains silt seams, brown, moist, dense to very dense contains layers of sandy silt 1.5 m
87.7 2.4	**SANDY SILT TILL:** trace clay, trace gravel, contains layers of sand, contains cobbles, contains hydrocarbon odour, brown, moist, very dense
87.1 3.0	**SAND:** trace silt, trace gravel, contains pockets of sandy silt, contains hydrocarbon odour, brown, moist, very dense
86.7 3.5	**SANDY SILT TILL:** trace clay, trace gravel, contains sand seams, contains hydrocarbon odour, brown to grey, moist, very dense grey below 3.4 m

END OF BOREHOLE

Notes:

1. Borehole was open and dry upon completion of drilling.

SAMPLES

NUMBER	TYPE	"N" BLOWS/0.3 m
1	AS	
2	SS	33
3	SS	61
4	SS	55
5	SS	92/255mm

GROUND WATER CONDITIONS

ELEVATION

DYNAMIC CONE PENETRATION RESISTANCE PLOT

20 40 60 80 100

SHEAR STRENGTH (kPa)

○ UNCONFINED + FIELD VANE & Sensitivity

● QUICK TRIAXIAL × LAB VANE

20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%)

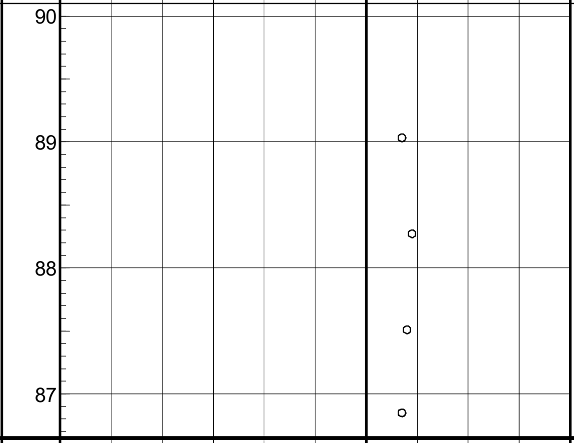
10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m^3)

REMARKS AND GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL



GROUNDWATER ELEVATIONS

Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES + 3, × 3: Numbers refer to Sensitivity ○ 8=3% Strain at Failure

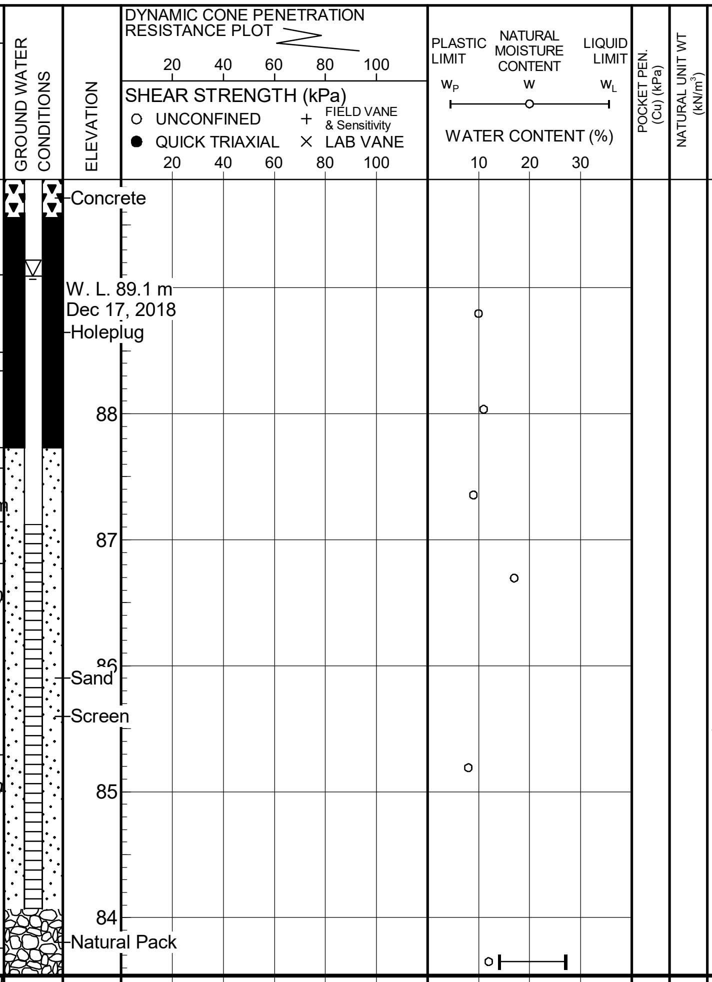
LOG OF BOREHOLE BH18-7

PROJECT: Durham Live, Pickering, ON
CLIENT: Pickering Developments Inc.
PROJECT LOCATION: Pickering, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan (UTM 17T)

Method: Solid Stem Auger
Diameter: 150
Date: Nov-27-2018

REF. NO.: 180561
ENCL NO.: 6

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS / 0.3 m	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
89.9	Ground Surface				
89.9 0.0	**ASPHALT:** 30 mm	1	AS		
89.5	**GRANULAR BASE:** 370 mm				
0.4	**GRANULAR SUBBASE:** 300 mm				
89.2 0.7	**FILL:** sandy silt, trace clay, trace gravel, trace rootlets, trace organics, brown, moist, compact	2	SS	13	
89.0 0.9	**SANDY SILT TILL:** trace to some clay, trace gravel, contains sand seams, brown, moist, compact to very dense some clay at 2.2 m	3 4	SS SS	19 90/ 280mm	
87.0 2.9	**SAND:** trace silt, trace gravel, brown, moist, very dense	5	SS	50/ 75mm	
85.9 3.9	**CLAYEY SILT TILL TO SILTY CLAY TILL:** trace sand, trace gravel, grey, moist, hard	6 7	SS SS	50/ 50mm 50/ 75mm	Spoon Wet
83.5 6.3	**END OF BOREHOLE**				



Notes:
1. Borehole was open upon completion of drilling.
2. Water was at 1.5mBGS upon completion of drilling.
3. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole.
4. Water Level Readings:

Date	W.L. Depth (mBGS)
Dec 17, 2018	0.77

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES: + 3, × 3: Numbers refer to Sensitivity ○ 8=3% Strain at Failure

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

LOG OF BOREHOLE BH18-8

1 OF 1

PROJECT: Durham Live, Pickering, ON
CLIENT: Pickering Developments Inc.
PROJECT LOCATION: Pickering, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan (UTM 17T)

Method: Solid Stem Auger
Diameter: 150
Date: Nov-30-2018

REF. NO.: 180561
ENCL NO.: 7

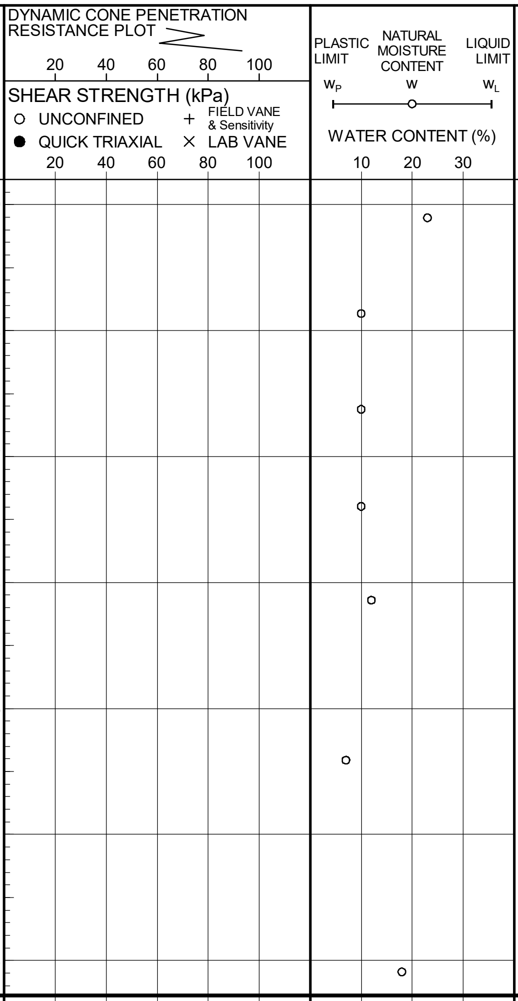
SOIL PROFILE

(m) ELEV DEPTH	DESCRIPTION
89.2	Ground Surface
89.0 0.0	**TOPSOIL:** 180 mm
0.2	**FILL:** sandy silt, some clay, trace gravel, some organics, trace rootlets, dark brown to brown, moist, loose
88.5 0.7	**CLAYEY SILT TILL:** some sand, trace gravel, contains layers of clayey silt, brown, moist, very stiff contains layers of sand at 1.5 m
87.0 2.2	**SANDY SILT TILL:** some clay, trace gravel, brown to grey, moist, dense grey at 2.5 m
86.2 3.0	**CLAYEY SILT TILL:** trace sand, trace gravel, grey, moist, hard
85.1 4.1	**SANDY SILT:** trace clay, grey, moist, very dense
83.8 5.4	**SILTY SAND:** trace clay, grey, wet, very dense
82.9 82.7 6.3	**SILTY CLAY TILL:** trace sand, trace gravel, grey, moist, hard
6.5	**END OF BOREHOLE** Notes: 1. Borehole caved to 4.0mBGS upon completion of drilling.

SAMPLES

NUMBER	TYPE	"N" BLOWS/0.3 m	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	7	
2	SS	18	
3	SS	23	
4	SS	46	
5	SS	45	
6	SS	50/ Initial 80mm	Spoon Wet
7	SS	92/ 230mm	

GROUND WATER CONDITIONS



POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

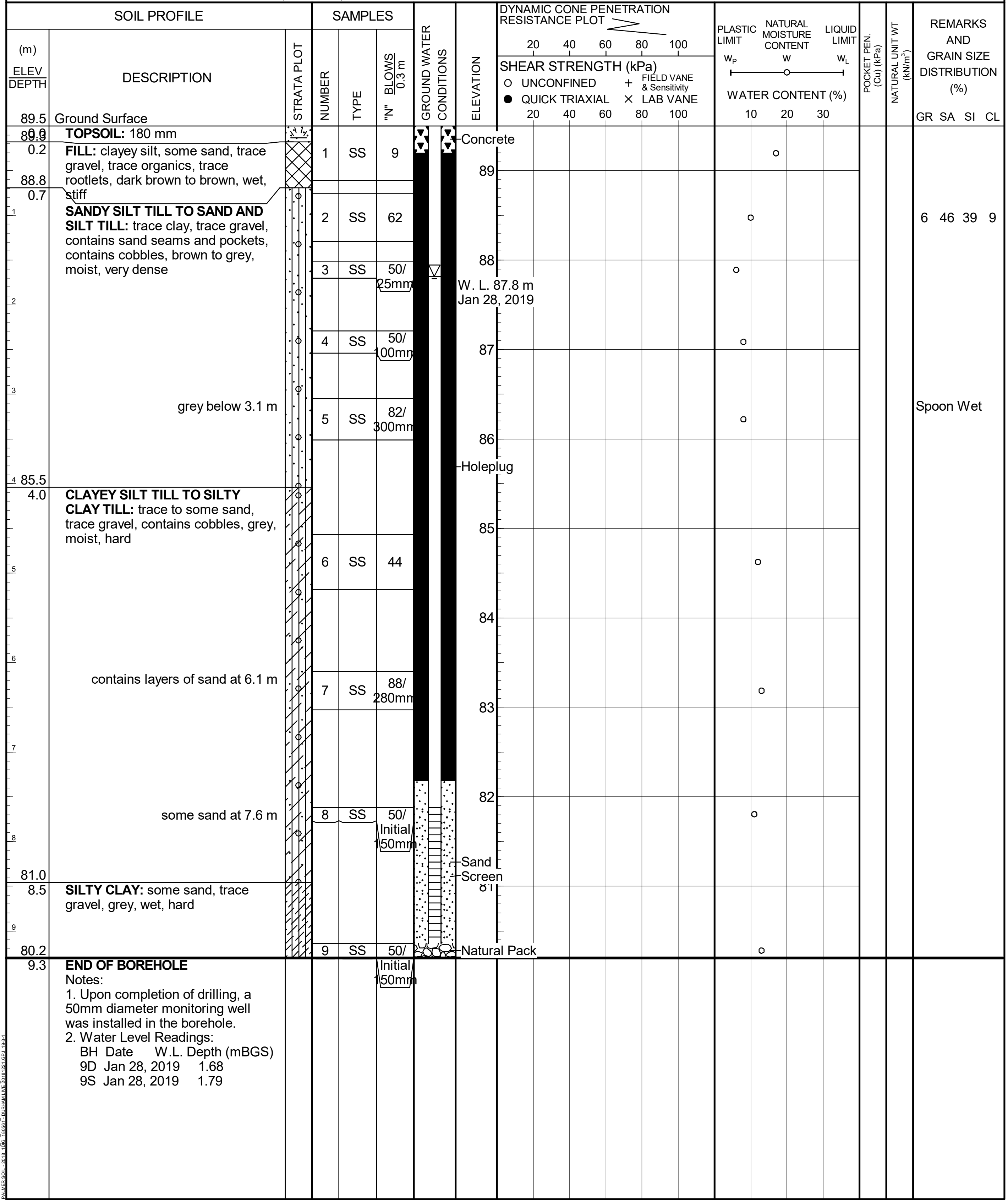
GRAPH NOTES
+³, ×³: Numbers refer to Sensitivity
○ ³=3% Strain at Failure

LOG OF BOREHOLE BH18-9

PROJECT: Durham Live, Pickering, ON
CLIENT: Pickering Developments Inc.
PROJECT LOCATION: Pickering, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan (UTM 17T)

Method: Solid Stem Auger
Diameter: 150
Date: Nov-30-2018

REF. NO.: 180561
ENCL NO.: 8



(m) ELEV / DEPTH	DESCRIPTION
89.5	Ground Surface
89.3 / 0.0	**TOPSOIL:** 180 mm
0.2	**FILL:** clayey silt, some sand, trace gravel, trace organics, trace rootlets, dark brown to brown, wet, stiff
88.8 / 0.7	**SANDY SILT TILL TO SAND AND SILT TILL:** trace clay, trace gravel, contains sand seams and pockets, contains cobbles, brown to grey, moist, very dense grey below 3.1 m
85.5 / 4.0	**CLAYEY SILT TILL TO SILTY CLAY TILL:** trace to some sand, trace gravel, contains cobbles, grey, moist, hard contains layers of sand at 6.1 m some sand at 7.6 m
81.0 / 8.5	**SILTY CLAY:** some sand, trace gravel, grey, wet, hard
80.2 / 9.3	**END OF BOREHOLE**

NUMBER	TYPE	"N" BLOWS / 0.3 m	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	9	
2	SS	62	6 46 39 9
3	SS	50/ 25mm	
4	SS	50/ 100mm	
5	SS	82/ 300mm	Spoon Wet
6	SS	44	
7	SS	88/ 280mm	
8	SS	50/ Initial 150mm	
9	SS	50/ Initial 150mm	

Notes:
1. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole.
2. Water Level Readings:

BH	Date	W.L. Depth (mBGS)
9D	Jan 28, 2019	1.68
9S	Jan 28, 2019	1.79

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES
+³, ×³: Numbers refer to Sensitivity
○ ⁸=3% Strain at Failure

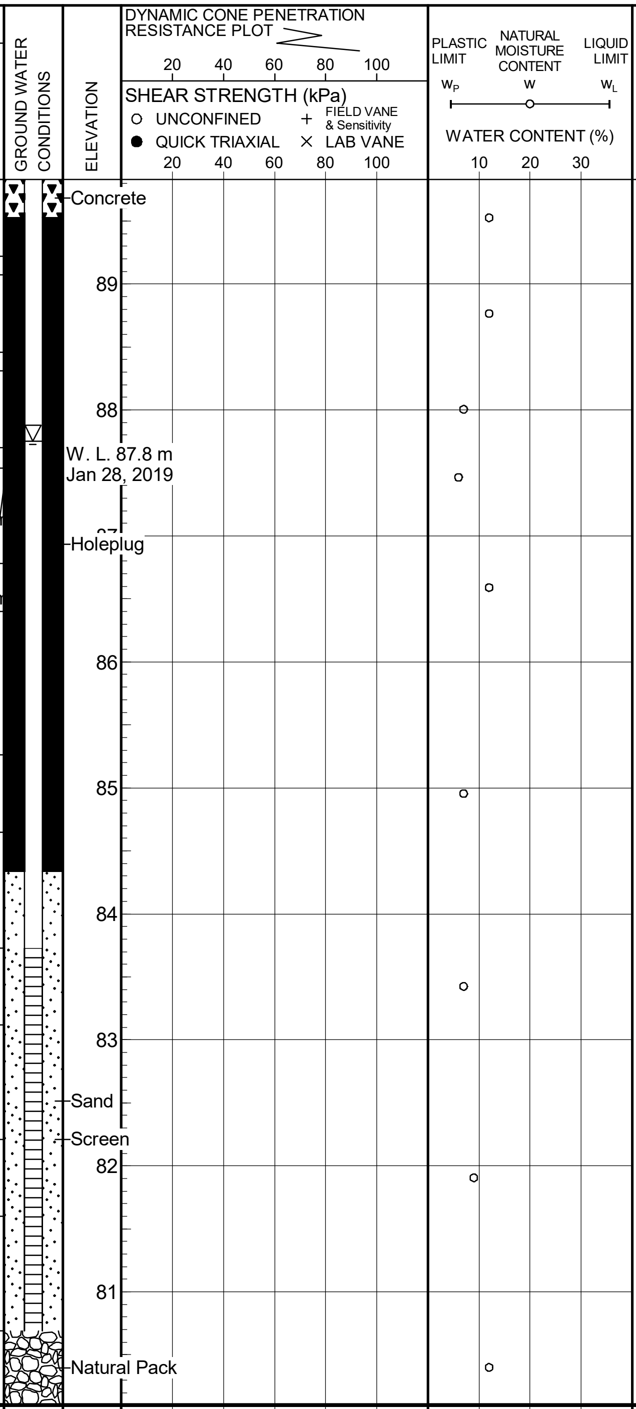
LOG OF BOREHOLE BH18-10

1 OF 1

PROJECT: Durham Live, Pickering, ON
CLIENT: Pickering Developments Inc.
PROJECT LOCATION: Pickering, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan (UTM 17T)
Method: Solid Stem Auger
Diameter: 150
Date: Nov-30-2018
REF. NO.: 180561
ENCL NO.: 9

ELEV (m)	DEPTH (m)	DESCRIPTION
89.8		Ground Surface
	0.0	**TOPSOIL:** 250 mm
89.6	0.3	**FILL:** clayey silt, trace sand, trace gravel, trace rootlets, trace organics, dark brown to brown, wet, stiff
89.1	0.7	**FILL:** sandy silt, some clay, trace gravel, trace organics, brown, wet, compact
88.7	1.1	**SANDY SILT TILL:** trace clay, trace gravel, contains sand seams, contains cobbles, brown, moist, compact to dense
87.6	2.2	**SANDY SILT:** trace to some clay, trace gravel, grey, moist to wet, very dense
85.8	4.0	**SANDY SILT TILL:** trace to some clay, trace gravel, grey, moist, dense to very dense contains cobbles at 6.1 m
81.1	8.7	**CLAYEY SILT TILL:** sandy, trace gravel, grey, moist, hard
80.1	9.7	**END OF BOREHOLE**

NUMBER	TYPE	"N" BLOWS / 0.3 m	GR	SA	SI	CL
1	SS	9				
2	SS	24				
3	SS	40				
4	SS	50/ Initial 150mm				
5	SS	84/ 230mm				
6	SS	46				
7	SS	61				
8	SS	45				
9	SS	53	1	22	44	33



POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (kN/m^3) | REMARKS AND GRAIN SIZE DISTRIBUTION (%)

Notes:
1. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole.
2. Water Level Readings:

Date	W.L. Depth (mBGS)
Jan 28, 2018	2.08

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ^{8}=3% Strain at Failure

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

LOG OF BOREHOLE BH18-11

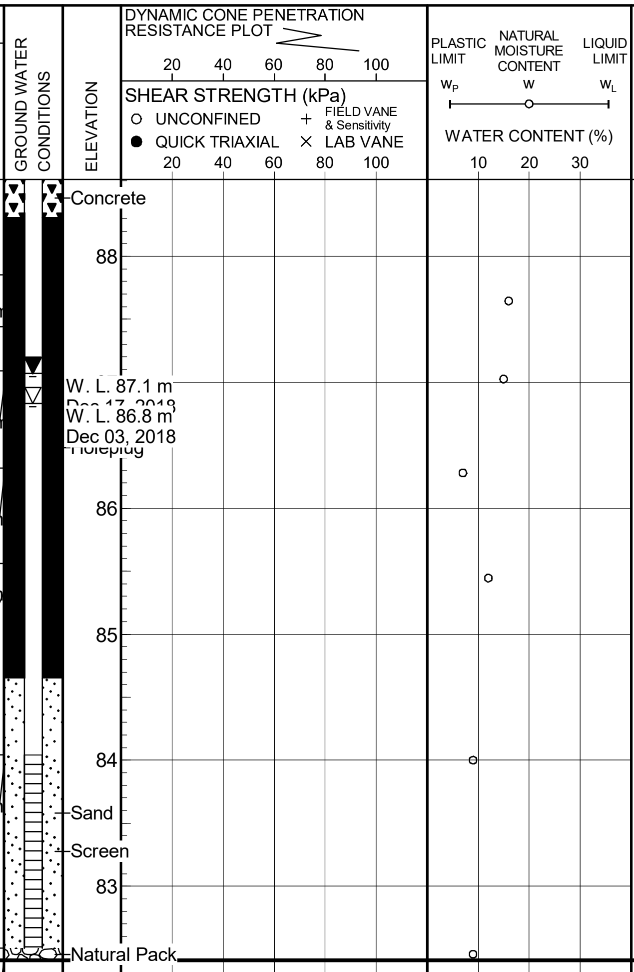
1 OF 1

PROJECT: Durham Live, Pickering, ON
CLIENT: Pickering Developments Inc.
PROJECT LOCATION: Pickering, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan (UTM 17T)

Method: Solid Stem Auger
Diameter: 150
Date: Nov-28-2018

REF. NO.: 180561
ENCL NO.: 10

SOIL PROFILE		SAMPLES			REMARKS AND GRAIN SIZE DISTRIBUTION (%)			
(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS/0.3 m	GR	SA	SI	CL
88.6	Ground Surface							
0.0	**GRANULAR BASE:** 310 mm							
88.3 0.3	**GRANULAR SUBBASE:** 450 mm	1	AS		34	59	(7)	
87.9 0.8	**SILT:** trace sand, contains sand seams, brown, moist, very dense	2	SS	72/ 255mm				
		3	SS	50/ Initial 125mm				
86.6 2.0	**SANDY SILT TO SAND AND SILT:** trace clay, trace gravel, contains layers of sand, brown, moist, very dense contains cobbles at 2.3 m	4	SS	50/ Initial 75mm				
		5	SS	50/ 75mm	1	43	48	8
					Spoon and Auger Wet			
84.7 3.9	**SILTY SAND:** trace clay, trace gravel, grey, moist, very dense	6	SS	50/ Initial 75mm				
83.2 5.4	**SANDY SILT TILL:** trace clay, trace gravel, grey, moist, very dense							
82.4 6.2	**END OF BOREHOLE**	7	SS	50/ Initial 100mm				



POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

Notes:
1. Water was at 3.1mBGS upon completion of drilling.
2. Water Level Readings:

Date	W.L. Depth (mBGS)
Dec 3, 2018	1.78
Dec 17, 2018	1.54

SOIL-ROCK-JAN11-2019_PM_ROCK_HYDROG FORM_20190111 - COPY.GLB
PALMER SOIL - 2018 1DIG 180561 - DURHAM LIVE 20181221.GPJ 19-3-1

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

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

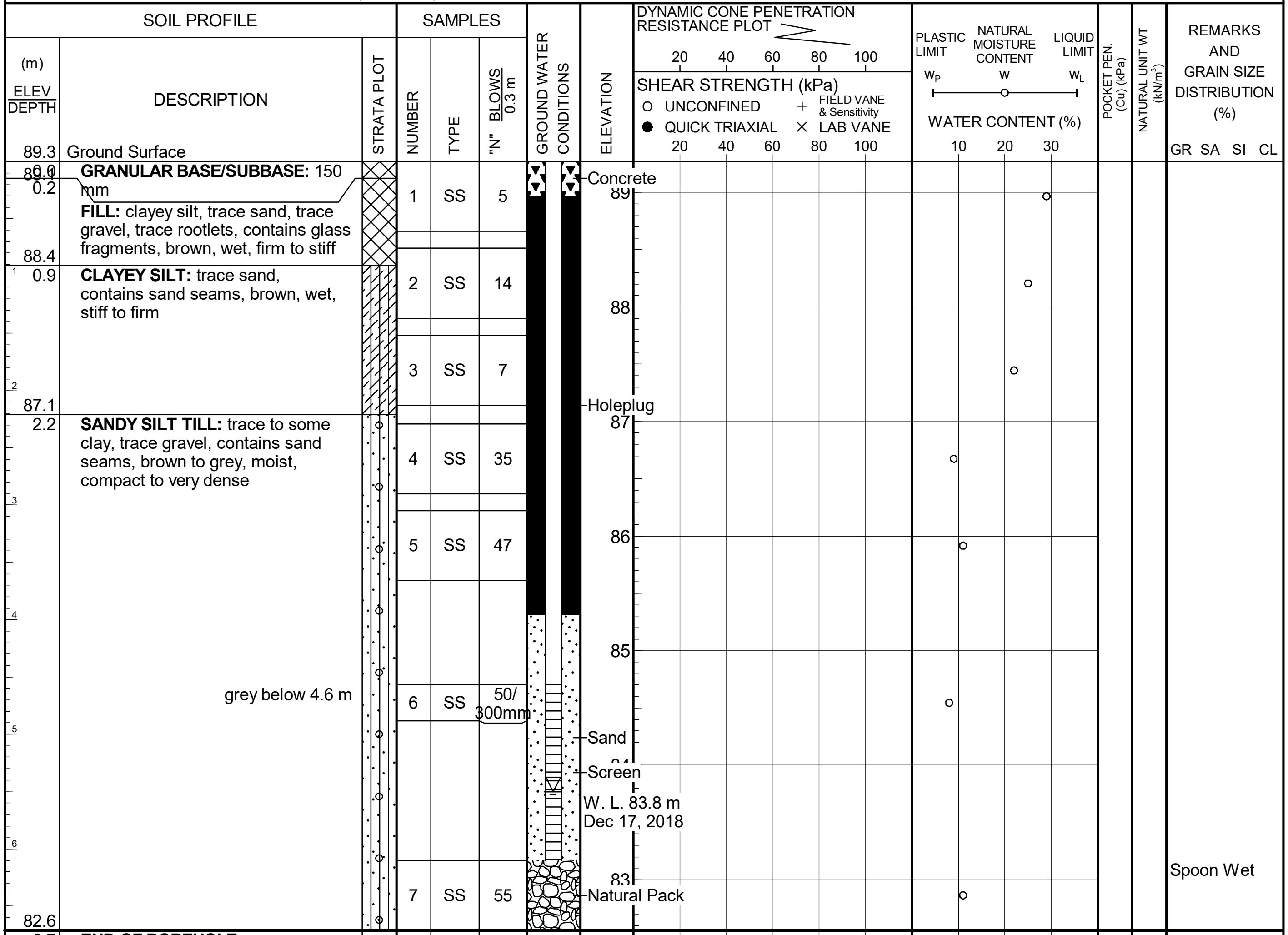
PALMER ENVIRONMENTAL CONSULTING GROUP INC.

LOG OF BOREHOLE BH18-12

PROJECT: Durham Live, Pickering, ON
CLIENT: Pickering Developments Inc.
PROJECT LOCATION: Pickering, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan (UTM 17T)

Method: Solid Stem Auger
Diameter: 150
Date: Dec-13-2018

REF. NO.: 180561
ENCL NO.: 11



(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS/0.3 m	REMARKS AND GRAIN SIZE DISTRIBUTION (%)
89.3	Ground Surface				
89.1 0.0 0.2	**GRANULAR BASE/SUBBASE:** 150 mm				
	FILL: clayey silt, trace sand, trace gravel, trace rootlets, contains glass fragments, brown, wet, firm to stiff	1	SS	5	
88.4 0.9	**CLAYEY SILT:** trace sand, contains sand seams, brown, wet, stiff to firm	2	SS	14	
		3	SS	7	
87.1 2.2	**SANDY SILT TILL:** trace to some clay, trace gravel, contains sand seams, brown to grey, moist, compact to very dense	4	SS	35	
		5	SS	47	
	grey below 4.6 m	6	SS	50/ 300mm	
		7	SS	55	Spoon Wet
82.6 6.7	**END OF BOREHOLE**				

Notes:
1. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole.
2. Water Level Readings:

Date	W.L. Depth (mBGS)
Dec 17, 2018	5.50

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

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

LOG OF BOREHOLE BH18-14

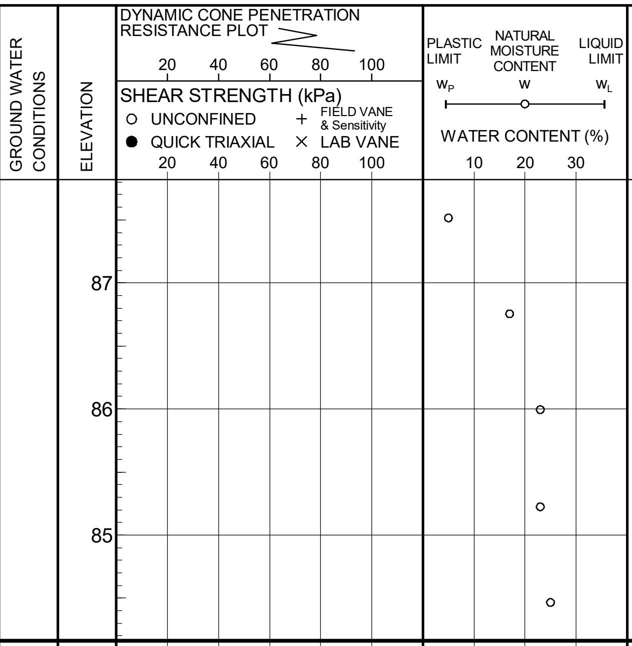
PROJECT: Durham Live, Pickering, ON
CLIENT: Pickering Developments Inc.
PROJECT LOCATION: Pickering, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan (UTM 17T)

Method: Solid Stem Auger
Diameter: 150
Date: Dec-13-2018

REF. NO.: 180561
ENCL NO.: 12

(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT
87.8	Ground Surface	
87.7 0.1	**ASPHALT:** 100 mm	■
87.5 0.3	**GRANULAR BASE:** 200 mm	⊠
87.1 0.7	**GRANULAR SUBBASE:** 400 mm	⊠
86.7 1.2	**FILL:** sand, some gravel, trace silt, brown, wet, loose	⊠
86.4 1.5	**FILL:** clayey silt, some sand, trace gravel, some organics, trace rootlets, contains pockets of organics, dark brown to dark grey, wet, stiff	⊠
84.2 3.7	**CLAYEY SILT TO SILTY CLAY:** trace to some sand, trace gravel, contains sand seams and pockets, brown to grey, wet, stiff to firm grey below 2.6 m	
	END OF BOREHOLE Notes: 1. Borehole caved to 2.4 mBGS upon completion of drilling. 2. Water was at 1.5 mBGS upon completion of drilling.	

SAMPLES NUMBER	TYPE	"N" BLOWS / 0.3 m	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	30	
2	SS	9	
3	SS	9	Spoon Wet
4	SS	8	
5	SS	5	



POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m^3)

GROUNDWATER ELEVATIONS

Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ^{8}=3% Strain at Failure

SOIL-ROCK-JAN11-2019_PM_ROCK_HYDROG FORM_20190111 - COPY.GLB
PALMER SOIL - 2018 1DIG 180561 - DURHAM LIVE 20181221.GPJ 19-3-1

RECORD OF BOREHOLE No 18-05

1 OF 2

METRIC

W.P. ______ LOCATION Notion Rd. & Squires Beach Rd., Pickering, MTM Zone 10: N 4 855 876.0 E 340 115.5 ORIGINATED BY BL

DIST ______ HWY 401 BOREHOLE TYPE Hollow Stem Augers 108mm I.D./HQ Coring COMPILED BY AN

DATUM Geodetic DATE 2018.12.11 - 2018.12.12 LATITUDE 43.842009 LONGITUDE -79.060811 CHECKED BY CR

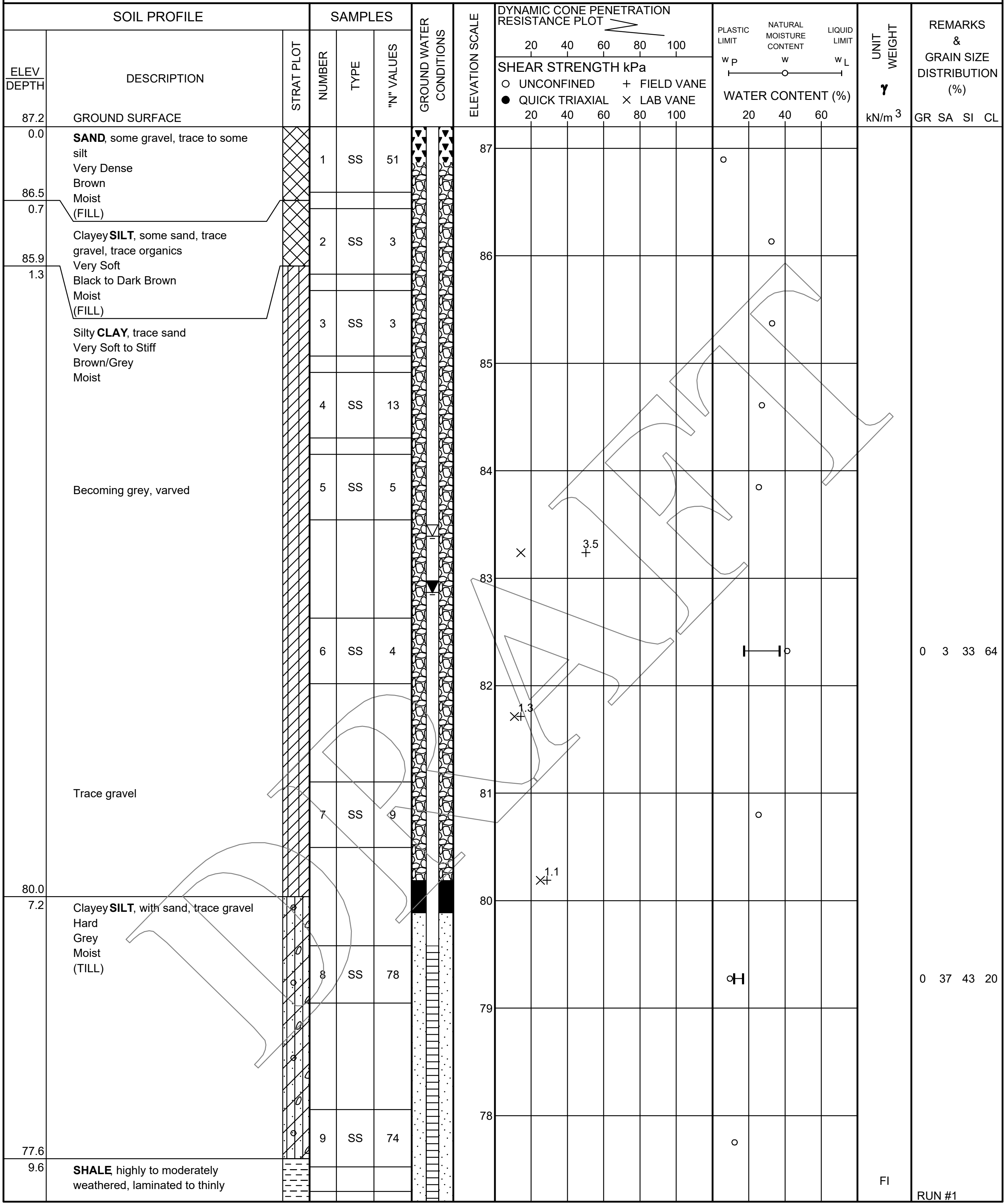
SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
87.2	GROUND SURFACE
0.0	**SAND**, some gravel, trace to some silt Very Dense Brown Moist (FILL)
86.5 0.7	Clayey **SILT**, some sand, trace gravel, trace organics Very Soft Black to Dark Brown Moist (FILL)
85.9 1.3	Silty **CLAY**, trace sand Very Soft to Stiff Brown/Grey Moist Becoming grey, varved Trace gravel
80.0 7.2	Clayey **SILT**, with sand, trace gravel Hard Grey Moist (TILL)
77.6 9.6	**SHALE**, highly to moderately weathered, laminated to thinly

Continued Next Page

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	51				
2	SS	3				
3	SS	3				
4	SS	13				
5	SS	5				
6	SS	4	0	3	33	64
7	SS	9				
8	SS	78	0	37	43	20
9	SS	74				



$+^3, \times^3$: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-05 2 OF 2 METRIC

W.P. ______ LOCATION Notion Rd. & Squires Beach Rd., Pickering, MTM Zone 10: N 4 855 876.0 E 340 115.5 ORIGINATED BY BL
DIST ______ HWY 401 BOREHOLE TYPE Hollow Stem Augers 108mm I.D./HQ Coring COMPILED BY AN
DATUM Geodetic DATE 2018.12.11 - 2018.12.12 LATITUDE 43.842009 LONGITUDE -79.060811 CHECKED BY CR

SOIL PROFILE: ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	bedded, grey, weak to medium strong with medium strong limestone interbeds: (Whitby Formation) Clayey silt seam (250mm) at 9.9m and (50mm) at 10.5m Highly fractured zone from 10.2m to 10.4m and 10.9m to 11.1m Clayey seam (75mm) at 11.2m, (25mm) at 12.2m and (175mm) at 12.7m		1	RUN			77			>5 >10 >10 >10	TCR=100% SCR=54% RQD=10% UCS=15.5MPa (Shale)
74.6	Highly fractured zone (75mm) at 11.3m, (25mm) at 11.4m, (100mm) at 11.6m and (50mm) at 12.2m Limestone interbed at 11.3m		2	RUN			76 75			>10 >10 >10 >10 >10	RUN #2 TCR=100% SCR=75% RQD=23% UCS=43MPa (Limestone) UCS=11.8MPa (Shale)
12.6	END OF BOREHOLE AT 12.6m. WATER LEVEL AT 3.8m UPON COMPLETION OF AUGERING BEFORE CORING. Piezometer installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2019.01.28	4.3	82.9

NOTE:
Water level measured on 01/28/2019 by PECL

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-06

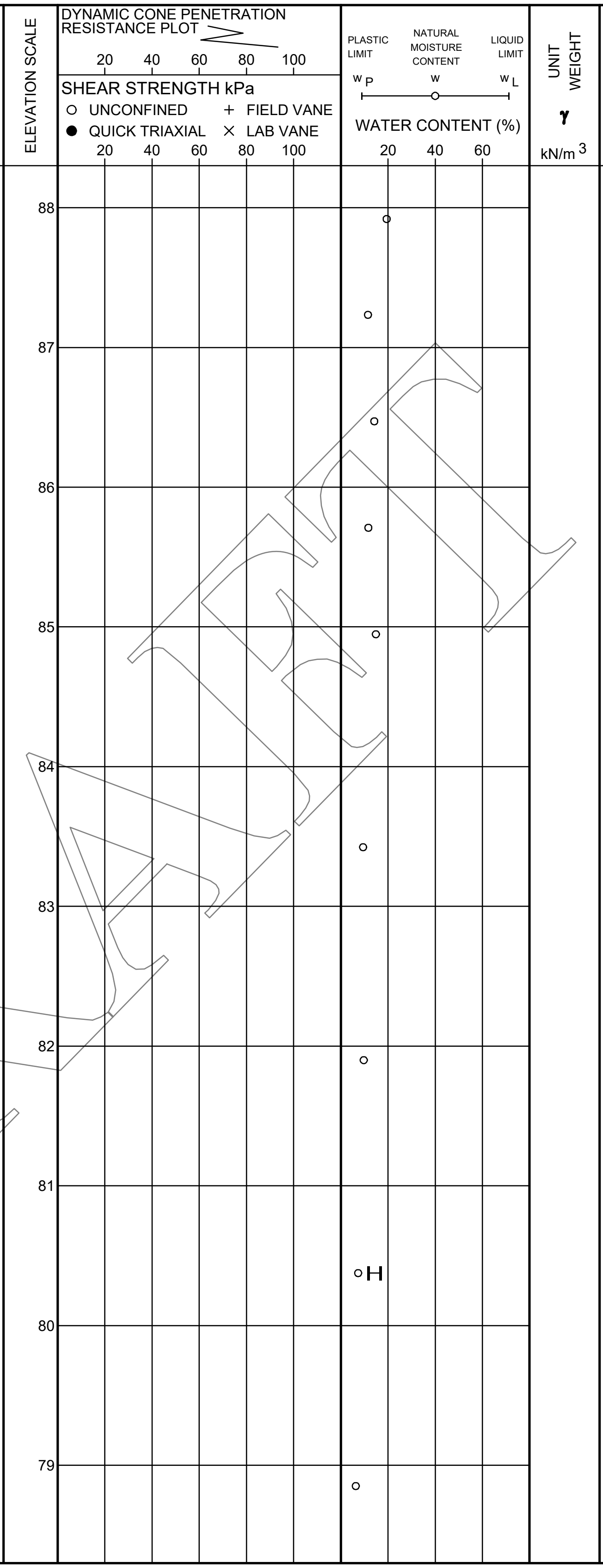
1 OF 2 **METRIC**

W.P. ______ LOCATION Notion Rd. & Squires Beach Rd., Pickering, MTM Zone 10: N 4 855 787.4 E 340 149.9 ORIGINATED BY BL

DIST ______ HWY 401 BOREHOLE TYPE Hollow Stem Augers 108mm I.D. COMPILED BY AN

DATUM Geodetic DATE 2018.12.10 - 2018.12.10 LATITUDE 43.841210 LONGITUDE -79.060389 CHECKED BY CR

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
88.3	GROUND SURFACE								
0.0	Clayey **SILT**, some sand, trace gravel, trace organics Brown Moist (FILL)	1	GS						
87.6 0.7	Clayey **SILT**, with sand, trace gravel Stiff to Hard Brown Moist (TILL)	1	SS	20					
		2	SS	21					
		3	SS	9					
		4	SS	41		0	12	74	14
		5	SS	63					
		6	SS	63					
		7	SS	41		4	35	39	22
	Occasional shale fragments	8	SS	100/ 0.175	▽				



Continued Next Page

+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 18-06

2 OF 2 **METRIC**

W.P. ______ LOCATION Notion Rd. & Squires Beach Rd., Pickering, MTM Zone 10: N 4 855 787.4 E 340 149.9 ORIGINATED BY BL

DIST ______ HWY 401 BOREHOLE TYPE Hollow Stem Augers 108mm I.D. COMPILED BY AN

DATUM Geodetic DATE 2018.12.10 - 2018.12.10 LATITUDE 43.841210 LONGITUDE -79.060389 CHECKED BY CR

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
78.1											
10.2	**SHALE**, highly weathered, grey: (Whitby Formation)						78				
77.5			9	SS	100/				○		
10.8	END OF BOREHOLE AT 10.8m. WATER LEVEL AT 9.1m AND BOREHOLE OPEN TO 10.7m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 3.0m, THEN CUTTINGS TO SURFACE.				0.150						

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

PALMER
ENVIRONMENTAL
CONSULTING
GROUP INC.

LOG OF BOREHOLE TP 1

1 OF 1

PROJECT: Durham Live

CLIENT: Pickering Developments Inc.

PROJECT LOCATION: Kellino Street and Squires Beach Road, Pickering

DATUM: Geodetic

BH LOCATION: Refer to Test Pit Map

Method: Excavation

Diameter:

Date: Sep-24-2019 to Sep-24-2019

REF. NO.: 180561

ENCL NO.: 1

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
(m) ELEV/DEPTH	DESCRIPTION Ground Surface	STRATA PLOT	NUMBER	TYPE	"N" BLOWS/0.3 m							
0.0	**TOPSOIL:**											
0.2	**SANDY SILT:** brown, weathered											
0.6	**CLAYEY SILT:** brown, weathered, trace sand											Infiltration Test at 0.94 m, TP1 Shallow
1.2	**SILTY CLAY:** grey											
1.8	**END OF TEST PIT**											

1

GROUNDWATER ELEVATIONS

Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity

○ ^{8}=3% Strain at Failure

LOG OF BOREHOLE TP 2

PROJECT: Durham Live
CLIENT: Pickering Developments Inc.
PROJECT LOCATION: Kellino Street and Squires Beach Road, Pickering
DATUM: Geodetic
BH LOCATION: Refer to Test Pit Map

Method: Excavation
Diameter:
Date: Sep-23-2019 to Sep-23-2019

REF. NO.: 180561
ENCL NO.: 2

SOIL PROFILE (m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" BLOWS / 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Ground Surface											
0.0	**CLAYEY SILT TILL:** brown, weathered											
0.4	**CLAYEY SILT TILL:** brown, unweathered											Infiltration Test at 0.80 m, TP 2 Shallow
1.5	**SILTY CLAY:** brown, unweathered											
1.8	**SILTY CLAY** grey, unweathered, water table											
1.9	**END OF TEST PIT**											

1

SOIL-ROCK-JAN11-2019_PM_ROCK_HYDROG FORM_20190111 - COPY.GLB
PALMER SOIL - 2018 1DIG 180561- DURHAM LIVE INFILTRATION TEST.GPJ 19-10-9

GROUNDWATER ELEVATIONS

Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ^{8}=3% Strain at Failure

LOG OF BOREHOLE TP 3

PROJECT: Durham Live
CLIENT: Pickering Developments Inc.
PROJECT LOCATION: Kellino Street and Squires Beach Road, Pickering
DATUM: Geodetic
BH LOCATION: Refer to Test Pit Map

Method: Excavation
Diameter:
Date: Sep-24-2019 to Sep-24-2019

REF. NO.: 180561
ENCL NO.: 3

SOIL PROFILE (m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	SAMPLES TYPE	"N" BLOWS / 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L / WATER CONTENT (%) 10 20 30	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Ground Surface											
0.0	**TOPSOIL:**											
0.2	**SANDY SILT TILL:** brown, weathered											
0.4	**SANDY SILT TILL:** brown 20 cm sand lens at 0.41 m											Infiltration Test at 0.80 m, TP 3 Shallow
1.8	**END OF TEST PIT**											

GROUNDWATER ELEVATIONS

Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES: $+^3, \times^3$: Numbers refer to Sensitivity ○ ^{8}=3% Strain at Failure

LOG OF BOREHOLE TP 4

PROJECT: Durham Live
CLIENT: Pickering Developments Inc.
PROJECT LOCATION: Kellino Street and Squires Beach Road, Pickering
DATUM: Geodetic
BH LOCATION: Refer to Test Pit Map

Method: Excavation
Diameter:
Date: Sep-25-2019 to Sep-25-2019

REF. NO.: 180561
ENCL NO.: 4

SOIL PROFILE (m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	SAMPLES TYPE	"N" BLOWS/0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Ground Surface											
0.0	**TOPSOIL:**											
0.2	**SANDY SILT TILL:** brown 30 cm sand lens at 1.13 m											Infiltration Test at 0.83 m, TP 4 Shallow
1.5	**CLAYEY SILT TILL:** brown											
1.7	**END OF TEST PIT**											

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

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

LOG OF BOREHOLE TP 5

PROJECT: Durham Live
CLIENT: Pickering Developments Inc.
PROJECT LOCATION: Kellino Street and Squires Beach Road, Pickering
DATUM: Geodetic
BH LOCATION: Refer to Test Pit Map

Method: Excavation
Diameter:
Date: Sep-25-2019 to Sep-25-2019

REF. NO.: 180561
ENCL NO.: 5

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): ○ UNCONFINED; + FIELD VANE & Sensitivity; ● QUICK TRIAXIAL; × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%): 10 20 30

SOIL PROFILE (m) ELEV DEPTH	DESCRIPTION (Ground Surface)	STRATA PLOT	SAMPLES NUMBER	TYPE	"N" BLOWS/0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION / SHEAR STRENGTH (kPa)	WATER CONTENT (%)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0.0	**TOPSOIL:**											
0.4	**SANDY SILT TILL:** brown, weathered											
0.8	**SANDY SILT TILL:** brown, unweathered											Infiltration Test at 0.93 m, TP 5 Shallow
1.6	**END OF TEST PIT**											

1

SOIL-ROCK-JAN11-2019_PM_ROCK_HYDROG FORM_20190111 - COPY.GLB
PALMER SOIL - 2018 1DIG 180561- DURHAM LIVE INFILTRATION TEST.GPJ 19-10-9

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES
$+^3, \times^3$: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

LOG OF BOREHOLE TP 6

PROJECT: Durham Live
CLIENT: Pickering Developments Inc.
PROJECT LOCATION: Kellino Street and Squires Beach Road, Pickering
DATUM: Geodetic
BH LOCATION: Refer to Test Pit Map

Method: Excavation
Diameter:
Date: Sep-25-2019 to Sep-25-2019

REF. NO.: 180561
ENCL NO.: 6

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): ○ UNCONFINED; + FIELD VANE & Sensitivity; ● QUICK TRIAXIAL; × LAB VANE: 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%): 10 20 30

SOIL PROFILE (m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	SAMPLES TYPE	"N" BLOWS/0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION / SHEAR STRENGTH (kPa)	WATER CONTENT (%)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Ground Surface											
0.0	**TOPSOIL:** 160 mm											
0.2	**SANDY SILT:** brown, trace clay 35 cm sand lens at 0.65 m 21 cm sand lens at 1.16 m 30 cm sand lens at 1.4 m											
1.6	**CLAYEY SILT:** grey, trace sand											
2.0	**SANDY SILT TILL:** grey, trace clay, trace gravel, contains sand and silt seams											
2.6	**END OF TEST PIT**											

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES
$+^3, \times^3$: Numbers refer to Sensitivity
○ ^{8}=3% Strain at Failure

PALMER
ENVIRONMENTAL
CONSULTING
GROUP INC.

LOG OF BOREHOLE TP 7

1 OF 1

PROJECT: Durham Live
CLIENT: Pickering Developments Inc.
PROJECT LOCATION: Kellino Street and Squires Beach Road, Pickering
DATUM: Geodetic
BH LOCATION: Refer to Test Pit Map

Method: Excavation
Diameter:
Date: Sep-24-2019 to Sep-24-2019

REF. NO.: 180561
ENCL NO.: 7

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%): 10 20 30

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa)	WATER CONTENT (%)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS / 0.3 m							
	Ground Surface											
0.0	**TOPSOIL:**											
0.1	**CLAYEY SILT:** brown, weathered											
0.7	**CLAYEY SILT:** brown/grey											Infiltration Test at 0.66 m, TP 7 Shallow
1.6	**END OF TEST PIT**											

SOIL-ROCK-JAN11-2019_PM_ROCK_HYDROG FORM_20190111 - COPY.GLB
PALMER SOIL - 2018 1DIG 180561- DURHAM LIVE INFILTRATION TEST.GPJ 19-10-9

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES
$+^3, \times^3$: Numbers refer to Sensitivity
○ $^{\varepsilon}$=3% Strain at Failure

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

LOG OF BOREHOLE TP 8

1 OF 1

PROJECT: Durham Live

CLIENT: Pickering Developments Inc.

PROJECT LOCATION: Kellino Street and Squires Beach Road, Pickering

DATUM: Geodetic

BH LOCATION: Refer to Test Pit Map

Method: Excavation

Diameter:

Date: Sep-24-2019 to Sep-24-2019

REF. NO.: 180561

ENCL NO.: 8

SOIL PROFILE (m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	TYPE	"N" BLOWS / 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Ground Surface											
0.0	**CLAYEY SILT:** brown, weathered	▨										
0.5	**CLAYEY SILT:** brown/grey	▨										Infiltration Test at 0.75 m, TP 8 Shallow
1.7	**END OF TEST PIT**											

SOIL-ROCK-JAN11-2019_PM_ROCK_HYDROG FORM_20190111 - COPY.GLB
PALMER SOIL - 2018 1DIG 180561- DURHAM LIVE INFILTRATION TEST.GPJ 19-10-9

GROUNDWATER ELEVATIONS

Measurement 1st ∇ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity

○ ^{8}=3% Strain at Failure

PALMER
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GROUP INC.

LOG OF BOREHOLE TP 9

PROJECT: Durham Live
CLIENT: Pickering Developments Inc.
PROJECT LOCATION: Kellino Street and Squires Beach Road, Pickering
DATUM: Geodetic
BH LOCATION: Refer to Test Pit Map

Method: Excavation
Diameter:
Date: Sep-23-2019 to Sep-23-2019

REF. NO.: 180561
ENCL NO.: 9

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT W_L / WATER CONTENT (%) 10 20 30	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
(m) ELEV / DEPTH	DESCRIPTION Ground Surface	STRATA PLOT	NUMBER	TYPE	"N" BLOWS / 0.3 m							
0.0	**SILTY CLAY:** brown, weathered	▨										
0.6	**SILTY CLAY:** brown, unweathered	▨										Infiltration Test at 0.65 m, TP 9 Shallow
1.7	**END OF TEST PIT**											

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ^{8}=3% Strain at Failure

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

LOG OF BOREHOLE TP 10

1 OF 1

PROJECT: Durham Live

CLIENT: Pickering Developments Inc.

Method: Excavation

PROJECT LOCATION: Kellino Street and Squires Beach Road, Pickering

Diameter:

REF. NO.: 180561

DATUM: Geodetic

Date: Sep-23-2019 to Sep-23-2019

ENCL NO.: 10

BH LOCATION: Refer to Test Pit Map

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
(m) ELEV / DEPTH	DESCRIPTION Ground Surface	STRATA PLOT	NUMBER	TYPE	"N" BLOWS / 0.3 m	GROUND WATER CONDITIONS	ELEVATION					
0.0	**CLAYEY SILT TILL:** brown, weathered											
1												Infiltration Test at 1.10 m, TP 10 Shallow
1.3	**CLAYEY SILT TILL:** brown, unweathered											
1.8	**END OF TEST PIT**											

GROUNDWATER ELEVATIONS

Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ^{8}=3% Strain at Failure

Appendix C

Soil Profile for Test Pits (Palmer, 2019)

Photograph Log

Client Name:	Project No.	Site Location:
Pickering Developments Inc.	180561	Durham Live!

Photo #: 1	**Date.** 9/24/2019
Direction Photo Taken	

Description

TP 1 Shallow (PL1 Storm Tech System)

Depth of Pit: 0.94 m

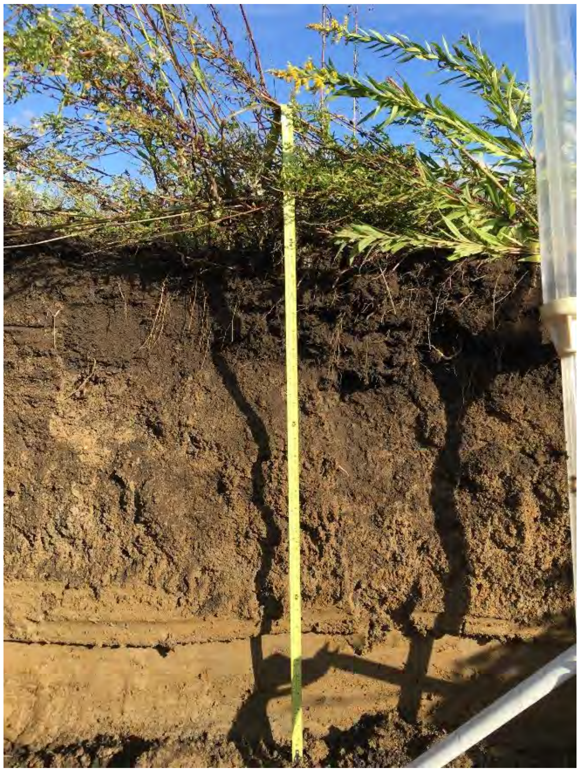


Photo #: 2	**Date.** Click here to enter a date.
Direction Photo Taken	

Description

TP 1 Deep (PL1 Storm Tech System)

Water Table at 1.2 m

Depth of Pit: 1.9 m

Photo #:	*Date.*
3	9/23/2019
Direction Photo Taken	

Description

TP 2 Shallow

Depth of Pit: 0.80 m

Photo #:	*Date.*
4	9/24/2019
Direction Photo Taken	

Description

TP 3 Shallow

Depth of Pit: 0.80 m

Photograph Log

Client Name:	Project No.	Site Location:
Pickering Developments Inc.	180561	Durham Live!

Photo #:	Date.
5	9/24/2019
Direction Photo Taken	

Description

TP 3 Deep

Depth of Pit: 1.8 m

Photo #:	Date.
6	9/25/2019
Direction Photo Taken	

Description

TP 4 Shallow

Depth of Pit: 0.83 m

Photograph Log

Client Name: Pickering Developments Inc.	*Project No.* 180561	*Site Location:* Durham Live!

Photo #: 7	*Date.* 9/25/2019
Direction Photo Taken	

Description

TP 4 Deep

Depth of Pit: 1.7 m

Photo #: 8	*Date.* 9/25/2019
Direction Photo Taken	

Description

TP 5 Shallow

Depth of Pit: 0.93 m

Photo #:	Date.
9	9/25/2019
Direction Photo Taken	

Description

TP 5 Deep

Depth of Pit: 1.6 m

Photo #:	Date.
10	9/25/2019
Direction Photo Taken	

Description

TP 6 Deep (FS2 Storm Tech System)

Depth of Pit: 2.6 m

Photo #:	*Date.*
11	9/24/2019
Direction Photo Taken	

Description

TP 7 Shallow

Depth of Pit: 0.66 m

Photo #:	*Date.*
12	9/24/2019
Direction Photo Taken	

Description

TP 7 Deep

Depth of Pit: 1.6 m

Photograph Log

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Client Name:	*Project No.*	*Site Location:*
Pickering Developments Inc.	180561	Durham Live!

Photo #:	*Date.*
13	9/24/2019
Direction Photo Taken	

Description

TP 8 Shallow

Depth of Pit: 0.75 m

Photo #:	*Date.*
14	9/24/2019
Direction Photo Taken	

Description

TP 8 Deep

Depth of Pit: 1.7 m

Photograph Log

Client Name:	Project No.	Site Location:
Pickering Developments Inc.	180561	Durham Live!

Photo #:	Date.
15	9/23/2019
Direction Photo Taken	

Description

TP 9 Shallow

Depth of Pit: 0.65 m

Photo #:	Date.
16	9/23/2019
Direction Photo Taken	

Description

TP 9 Deep

Depth of Pit: 1.7 m

Photograph Log

Client Name:	Project No.	Site Location:
Pickering Developments Inc.	180561	Durham Live!

Photo #:	Date.
17	9/23/2019
Direction Photo Taken	

Description

TP 10 Shallow

Depth of Pit: 1.10 m

Photo #:	Date.
18	9/23/2019
Direction Photo Taken	

Description

TP 10 Deep

Depth of Pit: 1.8 m

Appendix D

Chemistry Certificate of Analysis

(ALS, 2015)

CASH CLIENTS - RICHMOND HILL
ATTN: JASON COLE
65 FRONT STREET EAST
TORONTO ON M5E 1B5

Date Received:	27-FEB-15
Report Date:	16-MAR-15 07:47 (MT)
Version:	FINAL REV. 2

Client Phone: 416-795-8153

Certificate of Analysis

Lab Work Order #:	**L1582391**
Project P.O. #:	NOT SUBMITTED
Job Reference:	
C of C Numbers:	
Legal Site Desc:	

Comments: MAR-16-15:
Conductivity units changed.

Mathumai Ganeshakumar
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1582391-1 MW2							
Sampled By: J. COLE on 24-FEB-15 @ 14:00							
Matrix: GROUND WATER							
Physical Tests							
Color, Apparent	46.2		1.0	C.U.		03-MAR-15	R3154631
Conductivity	646		3.0	umhos/cm		03-MAR-15	R3154668
Hardness (as CaCO3)	248		10	mg/L		03-MAR-15	
pH	7.91	PEHT	0.10	pH units		03-MAR-15	R3154665
Total Dissolved Solids	400		40	mg/L		04-MAR-15	R3154714
Turbidity	8.05	PEHR	0.10	NTU	03-MAR-15	03-MAR-15	R3154363
Anions and Nutrients							
Alkalinity, Total (as CaCO3)	258		10	mg/L		04-MAR-15	R3155279
Ammonia, Total (as N)	<0.050		0.050	mg/L		03-MAR-15	R3154299
Chloride (Cl)	22.0		0.50	mg/L		03-MAR-15	R3155193
Fluoride (F)	0.174		0.020	mg/L		03-MAR-15	R3155193
Nitrate (as N)	2.15		0.020	mg/L		03-MAR-15	R3155193
Nitrite (as N)	<0.010		0.010	mg/L		03-MAR-15	R3155193
Phosphate-P (ortho)	0.0061		0.0030	mg/L		03-MAR-15	R3154641
Sulfate (SO4)	73.5		0.30	mg/L		03-MAR-15	R3155193
Total Metals							
Aluminum (Al)-Total	<0.010		0.010	mg/L	02-MAR-15	03-MAR-15	R3154346
Antimony (Sb)-Total	<0.0050		0.0050	mg/L	02-MAR-15	03-MAR-15	R3154346
Arsenic (As)-Total	<0.0010		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346
Barium (Ba)-Total	0.077		0.010	mg/L	02-MAR-15	03-MAR-15	R3154346
Beryllium (Be)-Total	<0.0010		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346
Bismuth (Bi)-Total	<0.0010		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346
Boron (B)-Total	0.081		0.050	mg/L	02-MAR-15	03-MAR-15	R3154346
Cadmium (Cd)-Total	<0.000090		0.000090	mg/L	02-MAR-15	03-MAR-15	R3154346
Calcium (Ca)-Total	64.1		0.50	mg/L	02-MAR-15	03-MAR-15	R3154346
Chromium (Cr)-Total	<0.00050		0.00050	mg/L	02-MAR-15	03-MAR-15	R3154346
Cobalt (Co)-Total	<0.00050		0.00050	mg/L	02-MAR-15	03-MAR-15	R3154346
Copper (Cu)-Total	0.0016		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346
Iron (Fe)-Total	<0.050		0.050	mg/L	02-MAR-15	03-MAR-15	R3154346
Lead (Pb)-Total	<0.0010		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346
Magnesium (Mg)-Total	21.3		0.50	mg/L	02-MAR-15	03-MAR-15	R3154346
Manganese (Mn)-Total	0.0163		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346
Molybdenum (Mo)-Total	0.0415		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346
Nickel (Ni)-Total	<0.0020		0.0020	mg/L	02-MAR-15	03-MAR-15	R3154346
Phosphorus (P)-Total	<0.050		0.050	mg/L	02-MAR-15	03-MAR-15	R3154346
Potassium (K)-Total	3.6		1.0	mg/L	02-MAR-15	03-MAR-15	R3154346
Selenium (Se)-Total	0.00109		0.00040	mg/L	02-MAR-15	03-MAR-15	R3154346
Silicon (Si)-Total	4.6		1.0	mg/L	02-MAR-15	03-MAR-15	R3154346
Silver (Ag)-Total	<0.00010		0.00010	mg/L	02-MAR-15	03-MAR-15	R3154346
Sodium (Na)-Total	48.5		0.50	mg/L	02-MAR-15	03-MAR-15	R3154346
Strontium (Sr)-Total	0.546		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1582391-1 MW2 Sampled By: J. COLE on 24-FEB-15 @ 14:00 Matrix: GROUND WATER							
Total Metals							
Thallium (Tl)-Total	<0.00030		0.00030	mg/L	02-MAR-15	03-MAR-15	R3154346
Tin (Sn)-Total	<0.0010		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346
Titanium (Ti)-Total	<0.0020		0.0020	mg/L	02-MAR-15	03-MAR-15	R3154346
Tungsten (W)-Total	<0.010		0.010	mg/L	02-MAR-15	03-MAR-15	R3154346
Uranium (U)-Total	<0.0050		0.0050	mg/L	02-MAR-15	03-MAR-15	R3154346
Vanadium (V)-Total	0.0019		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346
Zinc (Zn)-Total	0.0050		0.0030	mg/L	02-MAR-15	03-MAR-15	R3154346
Zirconium (Zr)-Total	<0.0040		0.0040	mg/L	02-MAR-15	03-MAR-15	R3154346
L1582391-2 MW5 Sampled By: J. COLE on 24-FEB-15 @ 14:00 Matrix: GROUND WATER							
Physical Tests							
Color, Apparent	142		1.0	C.U.		03-MAR-15	R3154631
Conductivity	454		3.0	umhos/cm		03-MAR-15	R3154668
Hardness (as CaCO3)	199		10	mg/L		03-MAR-15	
pH	8.11	PEHT	0.10	pH units		03-MAR-15	R3154665
Total Dissolved Solids	286		40	mg/L		04-MAR-15	R3154714
Turbidity	31.0	PEHR	0.10	NTU	03-MAR-15	03-MAR-15	R3154363
Anions and Nutrients							
Alkalinity, Total (as CaCO3)	251		10	mg/L		04-MAR-15	R3155279
Ammonia, Total (as N)	0.394		0.050	mg/L		03-MAR-15	R3154299
Chloride (Cl)	9.02		0.50	mg/L		03-MAR-15	R3155193
Fluoride (F)	0.181		0.020	mg/L		03-MAR-15	R3155193
Nitrate (as N)	0.034		0.020	mg/L		03-MAR-15	R3155193
Nitrite (as N)	<0.010		0.010	mg/L		03-MAR-15	R3155193
Phosphate-P (ortho)	<0.0030		0.0030	mg/L		03-MAR-15	R3154641
Sulfate (SO4)	11.8		0.30	mg/L		03-MAR-15	R3155193
Total Metals							
Aluminum (Al)-Total	0.011		0.010	mg/L	02-MAR-15	03-MAR-15	R3154346
Antimony (Sb)-Total	<0.0050		0.0050	mg/L	02-MAR-15	03-MAR-15	R3154346
Arsenic (As)-Total	0.0017		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346
Barium (Ba)-Total	0.144		0.010	mg/L	02-MAR-15	03-MAR-15	R3154346
Beryllium (Be)-Total	<0.0010		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346
Bismuth (Bi)-Total	<0.0010		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346
Boron (B)-Total	0.111		0.050	mg/L	02-MAR-15	03-MAR-15	R3154346
Cadmium (Cd)-Total	<0.000090		0.000090	mg/L	02-MAR-15	03-MAR-15	R3154346
Calcium (Ca)-Total	41.4		0.50	mg/L	02-MAR-15	03-MAR-15	R3154346
Chromium (Cr)-Total	<0.00050		0.00050	mg/L	02-MAR-15	03-MAR-15	R3154346
Cobalt (Co)-Total	<0.00050		0.00050	mg/L	02-MAR-15	03-MAR-15	R3154346
Copper (Cu)-Total	0.0010		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346
Iron (Fe)-Total	<0.050		0.050	mg/L	02-MAR-15	03-MAR-15	R3154346
Lead (Pb)-Total	<0.0010		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1582391-2 MW5 Sampled By: J. COLE on 24-FEB-15 @ 14:00 Matrix: GROUND WATER							
Total Metals							
Magnesium (Mg)-Total	23.3		0.50	mg/L	02-MAR-15	03-MAR-15	R3154346
Manganese (Mn)-Total	0.0180		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346
Molybdenum (Mo)-Total	0.0085		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346
Nickel (Ni)-Total	<0.0020		0.0020	mg/L	02-MAR-15	03-MAR-15	R3154346
Phosphorus (P)-Total	<0.050		0.050	mg/L	02-MAR-15	03-MAR-15	R3154346
Potassium (K)-Total	2.7		1.0	mg/L	02-MAR-15	03-MAR-15	R3154346
Selenium (Se)-Total	<0.00040		0.00040	mg/L	02-MAR-15	03-MAR-15	R3154346
Silicon (Si)-Total	9.7		1.0	mg/L	02-MAR-15	03-MAR-15	R3154346
Silver (Ag)-Total	<0.00010		0.00010	mg/L	02-MAR-15	03-MAR-15	R3154346
Sodium (Na)-Total	26.0		0.50	mg/L	02-MAR-15	03-MAR-15	R3154346
Strontium (Sr)-Total	0.574		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346
Thallium (Tl)-Total	<0.00030		0.00030	mg/L	02-MAR-15	03-MAR-15	R3154346
Tin (Sn)-Total	<0.0010		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346
Titanium (Ti)-Total	<0.0020		0.0020	mg/L	02-MAR-15	03-MAR-15	R3154346
Tungsten (W)-Total	<0.010		0.010	mg/L	02-MAR-15	03-MAR-15	R3154346
Uranium (U)-Total	<0.0050		0.0050	mg/L	02-MAR-15	03-MAR-15	R3154346
Vanadium (V)-Total	<0.0010		0.0010	mg/L	02-MAR-15	03-MAR-15	R3154346
Zinc (Zn)-Total	0.0038		0.0030	mg/L	02-MAR-15	03-MAR-15	R3154346
Zirconium (Zr)-Total	<0.0040		0.0040	mg/L	02-MAR-15	03-MAR-15	R3154346

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

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Calcium (Ca)-Total	MS-B	L1582391-1, -2
Matrix Spike	Magnesium (Mg)-Total	MS-B	L1582391-1, -2
Matrix Spike	Manganese (Mn)-Total	MS-B	L1582391-1, -2
Matrix Spike	Potassium (K)-Total	MS-B	L1582391-1, -2
Matrix Spike	Sodium (Na)-Total	MS-B	L1582391-1, -2
Matrix Spike	Strontium (Sr)-Total	MS-B	L1582391-1, -2
Matrix Spike	Sulfate (SO4)	MS-B	L1582391-1, -2

Qualifiers for Sample Submission Listed:

Qualifier	Description
SRPF	Sample received partially frozen

Sample Parameter Qualifier key listed:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
PEHR	Parameter Exceeded Recommended Holding Time On Receipt: Proceed With Analysis As Requested.
PEHT	Parameter Exceeded Recommended Holding Time Prior to Analysis

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-WT	Water	Alkalinity, Total (as CaCO3)	EPA 310.2
CL-IC-WT	Water	Chloride by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection. Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).			
COLOUR-WT	Water	Colour	APHA 2120
Apparent colour is determined by analysis of the decanted sample using the platinum-cobalt colourimetric method.			
EC-WT	Water	Conductivity	APHA 2510 B
Water samples can be measured directly by immersing the conductivity cell into the sample.			
ETL-HARDNESS-CALC-WT	Water	Hardness (as CaCO3)	APHA 2340 B
F-IC-N-WT	Water	Fluoride in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
MET-T-MS-WT	Water	Total Metals in Water by ICPMS	EPA 200.8
This analysis involves preliminary sample treatment by hotblock acid digestion (APHA 3030E). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).			
NH3-WT	Water	Ammonia, Total as N	EPA 350.1
Sample is measured colorimetrically. When sample is turbid a distillation step is required, sample is distilled into a solution of boric acid and measured colorimetrically.			
NO2-IC-WT	Water	Nitrite in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
NO3-IC-WT	Water	Nitrate in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
PH-WT	Water	pH	APHA 4500 H-Electrode
Water samples are analyzed directly by a calibrated pH meter. Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).			
PO4-DO-COL-WT	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P PHOSPHORUS
This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.			
SO4-IC-N-WT	Water	Sulfate in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			

Reference Information

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

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

TURBIDITY-WT	Water	Turbidity	APHA 2130 B

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

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

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

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

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.

mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid weight of sample
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Quality Control Report

Workorder: L1582391 Report Date: 16-MAR-15

Client: CASH CLIENTS - RICHMOND HILL
65 FRONT STREET EAST
TORONTO ON M5E 1B5
Contact: JASON COLE

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-WT	**Water**							
Batch R3155279								
WG2049079-3 CRM		**WT-ALK-CRM**						
Alkalinity, Total (as CaCO3)			90.3		%		80-120	04-MAR-15
WG2049079-2 CVS								
Alkalinity, Total (as CaCO3)			96.8		%		85-115	04-MAR-15
WG2049079-4 DUP		**L1581414-1**						
Alkalinity, Total (as CaCO3)		88	88		mg/L	0.6	20	04-MAR-15
WG2049079-1 MB								
Alkalinity, Total (as CaCO3)			<10		mg/L		10	04-MAR-15
CL-IC-WT	**Water**							
Batch R3155193								
WG2048491-4 DUP		**WG2048491-3**						
Chloride (Cl)		58.3	58.2		mg/L	0.0	25	03-MAR-15
WG2048491-2 LCS								
Chloride (Cl)			100.9		%		70-130	03-MAR-15
WG2048491-1 MB								
Chloride (Cl)			<0.50		mg/L		0.5	03-MAR-15
WG2048491-5 MS		**WG2048491-3**						
Chloride (Cl)			95.8		%		70-130	03-MAR-15
COLOUR-WT	**Water**							
Batch R3154631								
WG2048354-3 CRM		**WT-COLOUR-CRM**						
Color, Apparent			98.4		%		80-120	03-MAR-15
WG2048354-2 CVS								
Color, Apparent			100.4		%		85-115	03-MAR-15
WG2048354-4 DUP		**L1582391-1**						
Color, Apparent		46.2	51.8		C.U.	11	20	03-MAR-15
WG2048354-1 MB								
Color, Apparent			<1.0		C.U.		1	03-MAR-15
EC-WT	**Water**							
Batch R3154668								
WG2048384-4 DUP		**WG2048384-3**						
Conductivity		2150	2150		umhos/cm	0.0	10	03-MAR-15
WG2048384-2 LCS								
Conductivity			100.4		%		90-110	03-MAR-15
WG2048384-1 MB								
Conductivity			<3.0		umhos/cm		3	03-MAR-15
F-IC-N-WT	**Water**							

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
F-IC-N-WT	**Water**							
Batch R3155193								
WG2048491-4 DUP		**WG2048491-3**						
Fluoride (F)		0.595	0.597		mg/L	0.4	20	03-MAR-15
WG2048491-2 LCS								
Fluoride (F)			101.6		%		90-110	03-MAR-15
WG2048491-1 MB								
Fluoride (F)			<0.020		mg/L		0.02	03-MAR-15
WG2048491-5 MS		**WG2048491-3**						
Fluoride (F)			101.0		%		75-125	03-MAR-15
MET-T-MS-WT	**Water**							
Batch R3154346								
WG2048388-1 CVS								
Aluminum (Al)-Total			100.3		%		80-120	03-MAR-15
Antimony (Sb)-Total			100.5		%		80-120	03-MAR-15
Arsenic (As)-Total			100.2		%		80-120	03-MAR-15
Barium (Ba)-Total			101.4		%		80-120	03-MAR-15
Beryllium (Be)-Total			102.0		%		80-120	03-MAR-15
Bismuth (Bi)-Total			99.5		%		80-120	03-MAR-15
Boron (B)-Total			102.4		%		80-120	03-MAR-15
Cadmium (Cd)-Total			100.7		%		80-120	03-MAR-15
Calcium (Ca)-Total			98.2		%		80-120	03-MAR-15
Chromium (Cr)-Total			100.4		%		80-120	03-MAR-15
Cobalt (Co)-Total			102.6		%		80-120	03-MAR-15
Copper (Cu)-Total			99.4		%		80-120	03-MAR-15
Iron (Fe)-Total			100.9		%		80-120	03-MAR-15
Lead (Pb)-Total			99.5		%		80-120	03-MAR-15
Magnesium (Mg)-Total			100.2		%		80-120	03-MAR-15
Manganese (Mn)-Total			101.1		%		80-120	03-MAR-15
Molybdenum (Mo)-Total			99.97		%		80-120	03-MAR-15
Nickel (Ni)-Total			101.3		%		80-120	03-MAR-15
Phosphorus (P)-Total			98.7		%		80-120	03-MAR-15
Potassium (K)-Total			99.7		%		80-120	03-MAR-15
Selenium (Se)-Total			99.5		%		80-120	03-MAR-15
Silicon (Si)-Total			97.8		%		80-120	03-MAR-15
Silver (Ag)-Total			102.1		%		80-120	03-MAR-15
Sodium (Na)-Total			100.1		%		80-120	03-MAR-15

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-MS-WT	**Water**							
Batch R3154346								
WG2048388-1 CVS								
Strontium (Sr)-Total			102.0		%		80-120	03-MAR-15
Thallium (Tl)-Total			98.8		%		80-120	03-MAR-15
Tin (Sn)-Total			99.8		%		80-120	03-MAR-15
Titanium (Ti)-Total			101.6		%		80-120	03-MAR-15
Tungsten (W)-Total			98.7		%		80-120	03-MAR-15
Uranium (U)-Total			99.5		%		80-120	03-MAR-15
Vanadium (V)-Total			99.7		%		80-120	03-MAR-15
Zinc (Zn)-Total			95.9		%		80-120	03-MAR-15
Zirconium (Zr)-Total			100.3		%		80-120	03-MAR-15
WG2048316-4 DUP		**WG2048316-3**						
Aluminum (Al)-Total		0.036	0.034		mg/L	5.9	20	03-MAR-15
Antimony (Sb)-Total		0.00172	0.00171		mg/L	0.8	20	03-MAR-15
Arsenic (As)-Total		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	03-MAR-15
Barium (Ba)-Total		0.0367	0.0368		mg/L	0.3	20	03-MAR-15
Beryllium (Be)-Total		<0.00050	<0.00050	RPD-NA	mg/L	N/A	20	03-MAR-15
Bismuth (Bi)-Total		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	03-MAR-15
Boron (B)-Total		0.027	0.026		mg/L	3.1	20	03-MAR-15
Cadmium (Cd)-Total		<0.000090	<0.000090	RPD-NA	mg/L	N/A	20	03-MAR-15
Calcium (Ca)-Total		55.3	55.3		mg/L	0.1	20	03-MAR-15
Chromium (Cr)-Total		0.00053	<0.00050	RPD-NA	mg/L	N/A	20	03-MAR-15
Cobalt (Co)-Total		0.00066	0.00063		mg/L	4.6	20	03-MAR-15
Copper (Cu)-Total		0.0012	0.0012		mg/L	3.7	20	03-MAR-15
Iron (Fe)-Total		0.207	0.207		mg/L	0.0	20	03-MAR-15
Lead (Pb)-Total		<0.00050	<0.00050	RPD-NA	mg/L	N/A	20	03-MAR-15
Magnesium (Mg)-Total		10.8	10.7		mg/L	0.5	20	03-MAR-15
Manganese (Mn)-Total		0.400	0.401		mg/L	0.1	20	03-MAR-15
Molybdenum (Mo)-Total		0.00099	0.00101		mg/L	2.7	20	03-MAR-15
Nickel (Ni)-Total		0.0041	0.0041		mg/L	0.8	20	03-MAR-15
Phosphorus (P)-Total		0.148	0.157		mg/L	5.8	20	03-MAR-15
Potassium (K)-Total		2.5	2.5		mg/L	0.3	20	03-MAR-15
Selenium (Se)-Total		<0.00040	<0.00040	RPD-NA	mg/L	N/A	20	03-MAR-15
Silicon (Si)-Total		2.2	2.2		mg/L	0.6	20	03-MAR-15
Silver (Ag)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	03-MAR-15

Quality Control Report

Workorder: L1582391 Report Date: 16-MAR-15

Client: CASH CLIENTS - RICHMOND HILL
65 FRONT STREET EAST
TORONTO ON M5E 1B5
Contact: JASON COLE

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-MS-WT	**Water**							
Batch R3154346								
WG2048316-4 DUP		**WG2048316-3**						
Sodium (Na)-Total		96.1	95.4		mg/L	0.7	20	03-MAR-15
Strontium (Sr)-Total		0.292	0.292		mg/L	0.3	20	03-MAR-15
Thallium (Tl)-Total		<0.00030	<0.00030	RPD-NA	mg/L	N/A	20	03-MAR-15
Tin (Sn)-Total		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	03-MAR-15
Titanium (Ti)-Total		<0.0020	<0.0020	RPD-NA	mg/L	N/A	20	03-MAR-15
Tungsten (W)-Total		<0.010	<0.010	RPD-NA	mg/L	N/A	20	03-MAR-15
Uranium (U)-Total		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	03-MAR-15
Vanadium (V)-Total		<0.00050	<0.00050	RPD-NA	mg/L	N/A	20	03-MAR-15
Zinc (Zn)-Total		0.0183	0.0194		mg/L	5.8	20	03-MAR-15
Zirconium (Zr)-Total		<0.0040	<0.0040	RPD-NA	mg/L	N/A	20	03-MAR-15
WG2048316-2 LCS								
Aluminum (Al)-Total			103.6		%		80-120	03-MAR-15
Antimony (Sb)-Total			98.6		%		80-120	03-MAR-15
Arsenic (As)-Total			100.2		%		80-120	03-MAR-15
Barium (Ba)-Total			98.1		%		80-120	03-MAR-15
Beryllium (Be)-Total			95.4		%		80-120	03-MAR-15
Bismuth (Bi)-Total			98.2		%		80-120	03-MAR-15
Boron (B)-Total			96.5		%		80-120	03-MAR-15
Cadmium (Cd)-Total			96.6		%		80-120	03-MAR-15
Calcium (Ca)-Total			100.5		%		80-120	03-MAR-15
Chromium (Cr)-Total			95.9		%		80-120	03-MAR-15
Cobalt (Co)-Total			98.3		%		80-120	03-MAR-15
Copper (Cu)-Total			96.9		%		80-120	03-MAR-15
Iron (Fe)-Total			98.6		%		80-120	03-MAR-15
Lead (Pb)-Total			97.1		%		80-120	03-MAR-15
Magnesium (Mg)-Total			97.7		%		80-120	03-MAR-15
Manganese (Mn)-Total			97.6		%		80-120	03-MAR-15
Molybdenum (Mo)-Total			97.8		%		80-120	03-MAR-15
Nickel (Ni)-Total			98.2		%		80-120	03-MAR-15
Phosphorus (P)-Total			104.2		%		80-120	03-MAR-15
Potassium (K)-Total			103.2		%		80-120	03-MAR-15
Selenium (Se)-Total			98.6		%		80-120	03-MAR-15
Silicon (Si)-Total			102.1		%		80-120	03-MAR-15

Quality Control Report

Client: CASH CLIENTS - RICHMOND HILL
65 FRONT STREET EAST
TORONTO ON M5E 1B5
Contact: JASON COLE

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-MS-WT	**Water**							
Batch R3154346								
WG2048316-2 LCS								
Silver (Ag)-Total			99.4		%		80-120	03-MAR-15
Sodium (Na)-Total			100.3		%		80-120	03-MAR-15
Strontium (Sr)-Total			98.4		%		80-120	03-MAR-15
Thallium (Tl)-Total			95.5		%		80-120	03-MAR-15
Tin (Sn)-Total			97.3		%		80-120	03-MAR-15
Titanium (Ti)-Total			97.6		%		80-120	03-MAR-15
Tungsten (W)-Total			97.2		%		80-120	03-MAR-15
Uranium (U)-Total			96.0		%		80-120	03-MAR-15
Vanadium (V)-Total			99.4		%		80-120	03-MAR-15
Zinc (Zn)-Total			100.5		%		80-120	03-MAR-15
Zirconium (Zr)-Total			97.0		%		80-120	03-MAR-15
WG2048316-1 MB								
Aluminum (Al)-Total			<0.010		mg/L		0.01	03-MAR-15
Antimony (Sb)-Total			<0.00050		mg/L		0.0005	03-MAR-15
Arsenic (As)-Total			<0.0010		mg/L		0.001	03-MAR-15
Barium (Ba)-Total			<0.0020		mg/L		0.002	03-MAR-15
Beryllium (Be)-Total			<0.00050		mg/L		0.0005	03-MAR-15
Bismuth (Bi)-Total			<0.0010		mg/L		0.001	03-MAR-15
Boron (B)-Total			<0.010		mg/L		0.01	03-MAR-15
Cadmium (Cd)-Total			<0.000090		mg/L		0.00009	03-MAR-15
Calcium (Ca)-Total			<0.50		mg/L		0.5	03-MAR-15
Chromium (Cr)-Total			<0.00050		mg/L		0.0005	03-MAR-15
Cobalt (Co)-Total			<0.00050		mg/L		0.0005	03-MAR-15
Copper (Cu)-Total			<0.0010		mg/L		0.001	03-MAR-15
Iron (Fe)-Total			<0.050		mg/L		0.05	03-MAR-15
Lead (Pb)-Total			<0.00050		mg/L		0.0005	03-MAR-15
Magnesium (Mg)-Total			<0.50		mg/L		0.5	03-MAR-15
Manganese (Mn)-Total			<0.0010		mg/L		0.001	03-MAR-15
Molybdenum (Mo)-Total			<0.00050		mg/L		0.0005	03-MAR-15
Nickel (Ni)-Total			<0.0010		mg/L		0.001	03-MAR-15
Phosphorus (P)-Total			<0.050		mg/L		0.05	03-MAR-15
Potassium (K)-Total			<1.0		mg/L		1	03-MAR-15
Selenium (Se)-Total			<0.00040		mg/L		0.0004	03-MAR-15
Silicon (Si)-Total			<1.0		mg/L		1	03-MAR-15

Quality Control Report

Client: CASH CLIENTS - RICHMOND HILL
65 FRONT STREET EAST
TORONTO ON M5E 1B5
Contact: JASON COLE

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-MS-WT	**Water**							
Batch R3154346								
WG2048316-1 MB								
Silver (Ag)-Total			<0.00010		mg/L		0.0001	03-MAR-15
Sodium (Na)-Total			<0.50		mg/L		0.5	03-MAR-15
Strontium (Sr)-Total			<0.0010		mg/L		0.001	03-MAR-15
Thallium (Tl)-Total			<0.00030		mg/L		0.0003	03-MAR-15
Tin (Sn)-Total			<0.0010		mg/L		0.001	03-MAR-15
Titanium (Ti)-Total			<0.0020		mg/L		0.002	03-MAR-15
Tungsten (W)-Total			<0.010		mg/L		0.01	03-MAR-15
Uranium (U)-Total			<0.0010		mg/L		0.001	03-MAR-15
Vanadium (V)-Total			<0.00050		mg/L		0.0005	03-MAR-15
Zinc (Zn)-Total			<0.0030		mg/L		0.003	03-MAR-15
Zirconium (Zr)-Total			<0.0040		mg/L		0.004	03-MAR-15
WG2048316-5 MS		**WG2048316-3**						
Aluminum (Al)-Total			101.6		%		70-130	03-MAR-15
Antimony (Sb)-Total			100.8		%		70-130	03-MAR-15
Arsenic (As)-Total			102.4		%		70-130	03-MAR-15
Barium (Ba)-Total			95.4		%		70-130	03-MAR-15
Beryllium (Be)-Total			93.1		%		70-130	03-MAR-15
Bismuth (Bi)-Total			95.8		%		70-130	03-MAR-15
Boron (B)-Total			93.9		%		70-130	03-MAR-15
Cadmium (Cd)-Total			94.4		%		70-130	03-MAR-15
Calcium (Ca)-Total			N/A	MS-B	%		-	03-MAR-15
Chromium (Cr)-Total			96.2		%		70-130	03-MAR-15
Cobalt (Co)-Total			94.3		%		70-130	03-MAR-15
Copper (Cu)-Total			91.6		%		70-130	03-MAR-15
Iron (Fe)-Total			95.9		%		70-130	03-MAR-15
Lead (Pb)-Total			93.2		%		70-130	03-MAR-15
Magnesium (Mg)-Total			N/A	MS-B	%		-	03-MAR-15
Manganese (Mn)-Total			N/A	MS-B	%		-	03-MAR-15
Molybdenum (Mo)-Total			98.3		%		70-130	03-MAR-15
Nickel (Ni)-Total			92.6		%		70-130	03-MAR-15
Phosphorus (P)-Total			100.9		%		70-130	03-MAR-15
Potassium (K)-Total			N/A	MS-B	%		-	03-MAR-15
Selenium (Se)-Total			100.3		%		70-130	03-MAR-15
Silicon (Si)-Total			101.4		%		70-130	03-MAR-15

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-MS-WT	**Water**							
Batch R3154346								
WG2048316-5 MS		**WG2048316-3**						
Silver (Ag)-Total			98.2		%		70-130	03-MAR-15
Sodium (Na)-Total			N/A	MS-B	%		-	03-MAR-15
Strontium (Sr)-Total			N/A	MS-B	%		-	03-MAR-15
Thallium (Tl)-Total			92.5		%		70-130	03-MAR-15
Tin (Sn)-Total			99.8		%		70-130	03-MAR-15
Titanium (Ti)-Total			96.6		%		70-130	03-MAR-15
Tungsten (W)-Total			98.3		%		70-130	03-MAR-15
Uranium (U)-Total			95.6		%		70-130	03-MAR-15
Vanadium (V)-Total			98.5		%		70-130	03-MAR-15
Zinc (Zn)-Total			94.0		%		70-130	03-MAR-15
Zirconium (Zr)-Total			96.1		%		70-130	03-MAR-15
NH3-WT	**Water**							
Batch R3154299								
WG2048412-2 CVS								
Ammonia, Total (as N)			102.8		%		85-115	03-MAR-15
WG2048412-3 DUP		**L1581761-1**						
Ammonia, Total (as N)		0.865	0.872		mg/L	0.8	20	03-MAR-15
WG2048412-1 MB								
Ammonia, Total (as N)			<0.050		mg/L		0.05	03-MAR-15
WG2048412-4 MS		**L1581761-1**						
Ammonia, Total (as N)			110.3		%		75-125	03-MAR-15
NO2-IC-WT	**Water**							
Batch R3155193								
WG2048491-4 DUP		**WG2048491-3**						
Nitrite (as N)		0.016	0.016		mg/L	0.0	25	03-MAR-15
WG2048491-2 LCS								
Nitrite (as N)			99.4		%		70-130	03-MAR-15
WG2048491-1 MB								
Nitrite (as N)			<0.010		mg/L		0.01	03-MAR-15
WG2048491-5 MS		**WG2048491-3**						
Nitrite (as N)			99.6		%		70-130	03-MAR-15
NO3-IC-WT	**Water**							

Quality Control Report

Workorder: L1582391 Report Date: 16-MAR-15

Client: CASH CLIENTS - RICHMOND HILL
65 FRONT STREET EAST
TORONTO ON M5E 1B5
Contact: JASON COLE

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO3-IC-WT	**Water**							
Batch R3155193								
WG2048491-4 DUP		**WG2048491-3**						
Nitrate (as N)		1.57	1.57		mg/L	0.2	25	03-MAR-15
WG2048491-2 LCS								
Nitrate (as N)			99.8		%		70-130	03-MAR-15
WG2048491-1 MB								
Nitrate (as N)			<0.020		mg/L		0.02	03-MAR-15
WG2048491-5 MS		**WG2048491-3**						
Nitrate (as N)			95.3		%		70-130	03-MAR-15
PH-WT	**Water**							
Batch R3154665								
WG2048383-3 DUP		**WG2048383-2**						
pH		7.92	7.88	J	pH units	0.04	0.2	03-MAR-15
WG2048383-1 LCS								
pH			6.96		pH units		6.9-7.1	03-MAR-15
PO4-DO-COL-WT	**Water**							
Batch R3154641								
WG2048351-3 DUP		**L1582391-1**						
Phosphate-P (ortho)		0.0061	0.0065		mg/L	7.0	20	03-MAR-15
WG2048351-2 LCS								
Phosphate-P (ortho)			103.7		%		80-120	03-MAR-15
WG2048351-1 MB								
Phosphate-P (ortho)			<0.0030		mg/L		0.003	03-MAR-15
WG2048351-4 MS		**L1582391-1**						
Phosphate-P (ortho)			94.9		%		70-130	03-MAR-15
SO4-IC-N-WT	**Water**							
Batch R3155193								
WG2048491-4 DUP		**WG2048491-3**						
Sulfate (SO4)		970	968		mg/L	0.2	20	03-MAR-15
WG2048491-2 LCS								
Sulfate (SO4)			101.4		%		90-110	03-MAR-15
WG2048491-1 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	03-MAR-15
WG2048491-5 MS		**WG2048491-3**						
Sulfate (SO4)			N/A	MS-B	%		-	03-MAR-15
SOLIDS-TDS-WT	**Water**							

Quality Control Report

Client:
CASH CLIENTS - RICHMOND HILL
65 FRONT STREET EAST
TORONTO ON M5E 1B5

Contact: JASON COLE

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
SOLIDS-TDS-WT	**Water**							
Batch R3154714								
WG2048391-3 DUP		**L1582391-2**						
Total Dissolved Solids		286	291		mg/L	1.6	20	04-MAR-15
WG2048391-2 LCS								
Total Dissolved Solids			98.9		%		85-115	04-MAR-15
WG2048391-1 MB								
Total Dissolved Solids			<20		mg/L		20	04-MAR-15
TURBIDITY-WT	**Water**							
Batch R3154363								
WG2048375-3 DUP		**L1582786-1**						
Turbidity		3.29	3.31		NTU	0.6	15	03-MAR-15
WG2048375-2 LCS								
Turbidity			102.0		%		85-115	03-MAR-15
WG2048375-1 MB								
Turbidity			<0.10		NTU		0.1	03-MAR-15

Legend:

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

Sample Parameter Qualifier Definitions:

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

Quality Control Report

Workorder: L1582391 Report Date: 16-MAR-15

Client: CASH CLIENTS - RICHMOND HILL
65 FRONT STREET EAST
TORONTO ON M5E 1B5
Contact: JASON COLE

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
Colour							
	1	24-FEB-15 14:00	03-MAR-15 00:21	48	154	hours	EHTR
	2	24-FEB-15 14:00	03-MAR-15 04:52	48	159	hours	EHTR
Total Dissolved Solids							
	1	24-FEB-15 14:00	04-MAR-15 10:36	7	8	days	EHT
	2	24-FEB-15 14:00	04-MAR-15 10:36	7	8	days	EHT
Turbidity							
	1	24-FEB-15 14:00	03-MAR-15 14:28	48	168	hours	EHTR
	2	24-FEB-15 14:00	03-MAR-15 14:29	48	168	hours	EHTR
pH							
	1	24-FEB-15 14:00	03-MAR-15 14:20	4	7	days	EHTL
	2	24-FEB-15 14:00	03-MAR-15 14:20	4	7	days	EHTL

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1582391 were received on 27-FEB-15 15:55.

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

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

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

ALS Environmental

www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here
(lab use only)

COC Number: 14 -

Page 1 of 1

Report To
Company: Palmer Environmental
Contact: Jason Cole
Address: ~~357 Bay Street, Suite 800~~ 65 Front St. East.
~~Toronto, ON, M5H 2T7~~ Toronto, ON, M5E 1B5
Phone: 416-795-8153

Report Format / Distribution
Select Report Format: ☒ PDF ☒ EXCEL ☐ EDD (DIGITAL)
Quality Control (QC) Report with Report ☒ Yes ☐ No
☒ Criteria on Report - provide details below if box checked
Select Distribution: ☐ EMAI ☐ MAI ☐ FAX
Email 1 or Fax jason@pecg.ca
Email 2

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
R ☒ Regular (Standard TAT if received by 3 pm - business days)
P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Specify Date Required for E2,E or P:

Invoice To
Same as Report To ☒ Yes ☐ No
Copy of Invoice with Report ☐ Yes ☐ No
Company: Palmer Environmental
Contact: Jason Cole

Invoice Distribution
Select Invoice Distribution: ☐ EMAI ☐ MAIL ☐ FAX
Email 1 or Fax jason@pecg.ca
Email 2

Project Information
ALS Quote #: Q48134
Job #:
PO / AFE:
LSD:

Oil and Gas Required Fields (client use)
Approver ID:
Cost Center:
GL Account:
Routing Code:
Activity Code:
Location:

ALS Lab Work Order # (lab use only) L1582391 NC 27-Feb-15
ALS Contact: Mathy G.
Sampler:

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

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	GENCHEM1-P-WT	Number of Containers
-1	MW2	feb24/2015	2:00	GW	X	4
-2	MW5	feb24/2015	4:00	GW	X	4

Drinking Water (DW) Samples[1] (client use)
Are samples taken from a Regulated DW System?
☐ Yes ☒ No
Are samples for human drinking water use?
☐ Yes ☒ No

Special Instructions / Specify Criteria to add on report (client Use)
Criteria: PLEASE specify below:
ODWS

SAMPLE CONDITION AS RECEIVED (lab use only)
Frozen ☐
SIF Observations Yes ☐ No ☒
Ice packs Yes ☐ No ☐
Custody seal intact Yes ☐ No ☐
Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
2.8					

SHIPMENT RELEASE (client use)
Released by: J.Cole
Date: feb26/2015
Time: 3:53

INITIAL SHIPMENT RECEPTION (lab use only)
Received by:
Date: 27-Feb-15
Time: 15:55

FINAL SHIPMENT RECEPTION (lab use only)
Received by:
Date:
Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

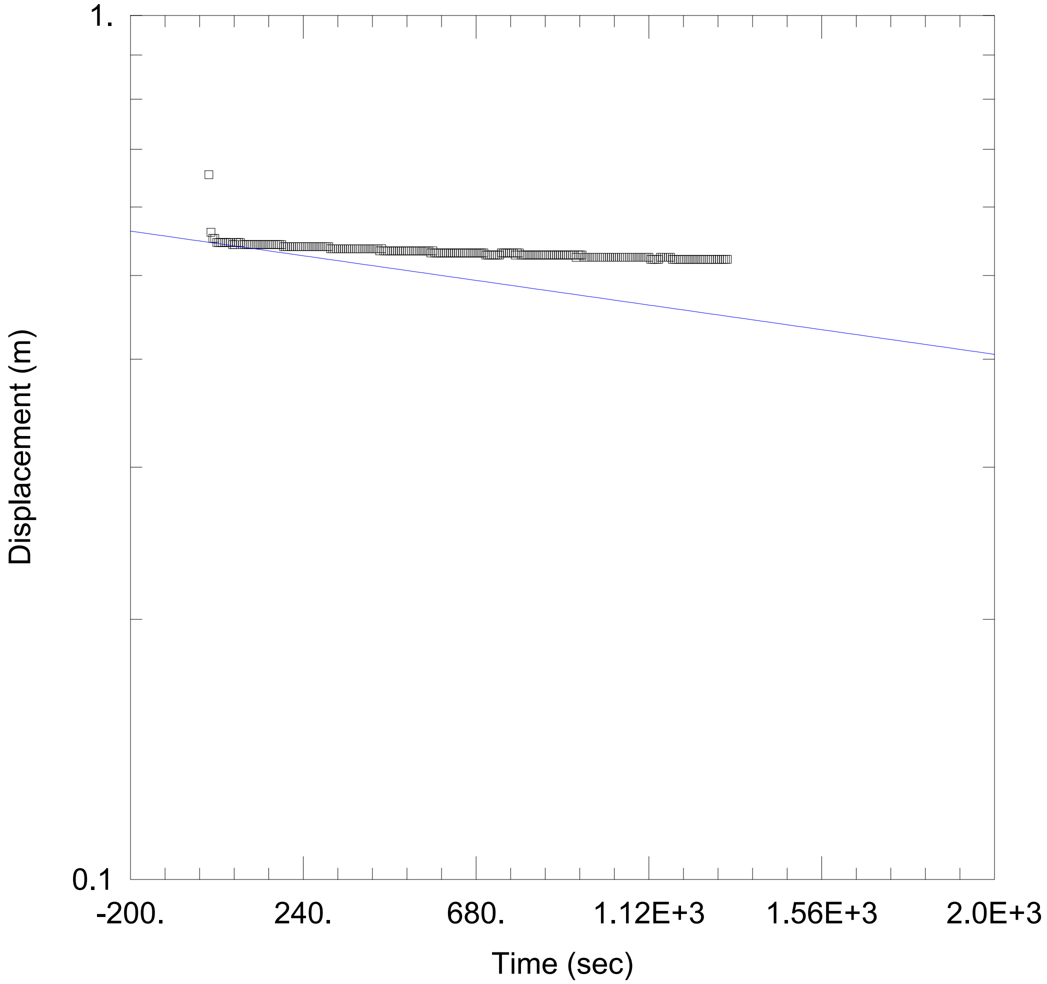
NA-FM-0326e v09 Front/04 January 2014

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

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

Appendix E

Slug Test Results (Palmer, 2018)



WELL TEST ANALYSIS

Data Set: \\EgnyteDrive\pecg\Private\adrian\Projects\Durham Live\BH 9D Slug Test.aqt
Date: 01/03/19 Time: 14:31:30

PROJECT INFORMATION

Company: PECG
Client: Pickering Developments Inc
Project: 180561
Location: Durham Live
Test Well: BH 9D
Test Date: December 17, 2018

AQUIFER DATA

Saturated Thickness: 0.8 m
Anisotropy Ratio (Kz/Kr): 0.1

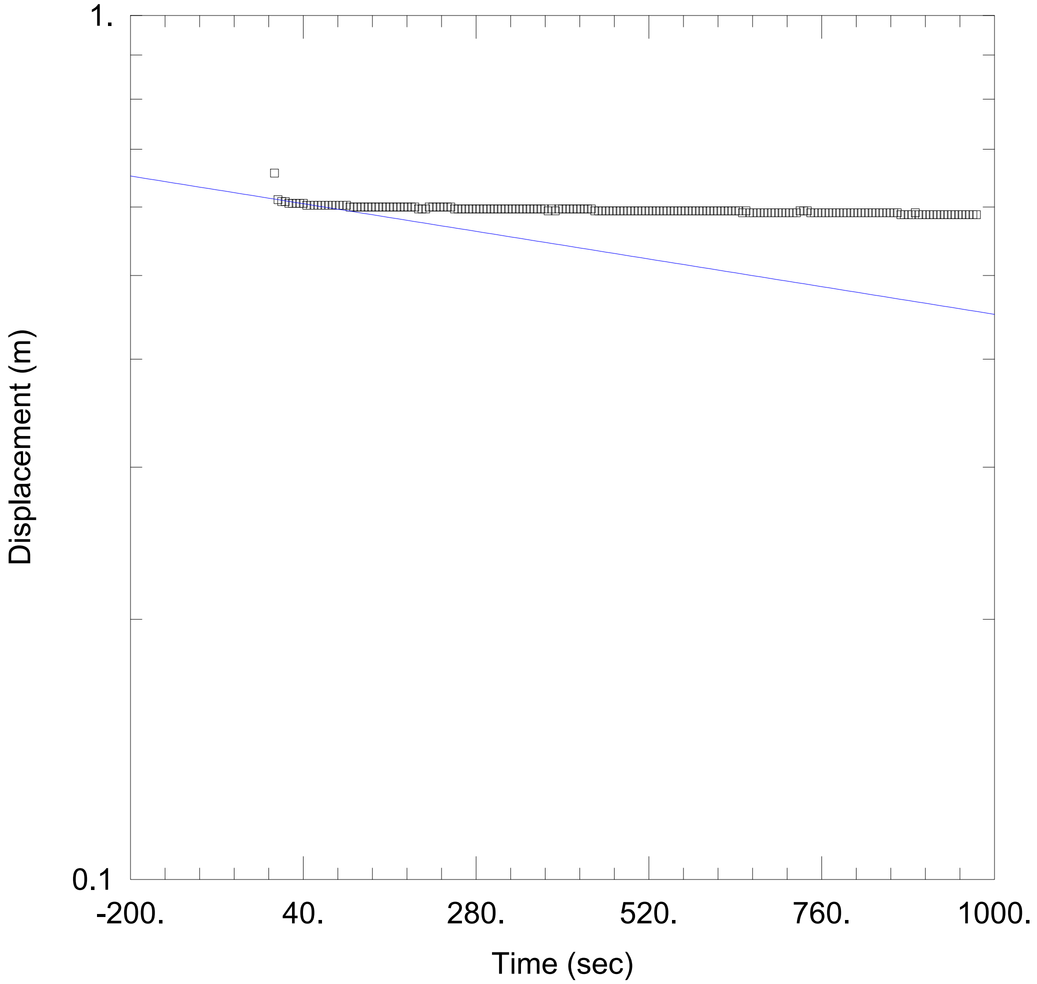
WELL DATA (BH 9D Falling Head)

Initial Displacement: 0.654 m
Static Water Column Height: 1.36 m
Total Well Penetration Depth: 9.3 m
Screen Length: 1.9 m
Casing Radius: 0.025 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 3.089E-7 m/sec
y0 = 0.5462 m



WELL TEST ANALYSIS

Data Set: \\EgnyteDrive\pecg\Private\adrian\Projects\Durham Live\BH 11 Slug Test Falling Head.aqt
Date: 01/03/19 Time: 14:29:31

PROJECT INFORMATION

Company: PECG
Client: Pickering Developments Inc
Project: 180561
Location: Durham Live
Test Well: BH 11
Test Date: December 17, 2018

AQUIFER DATA

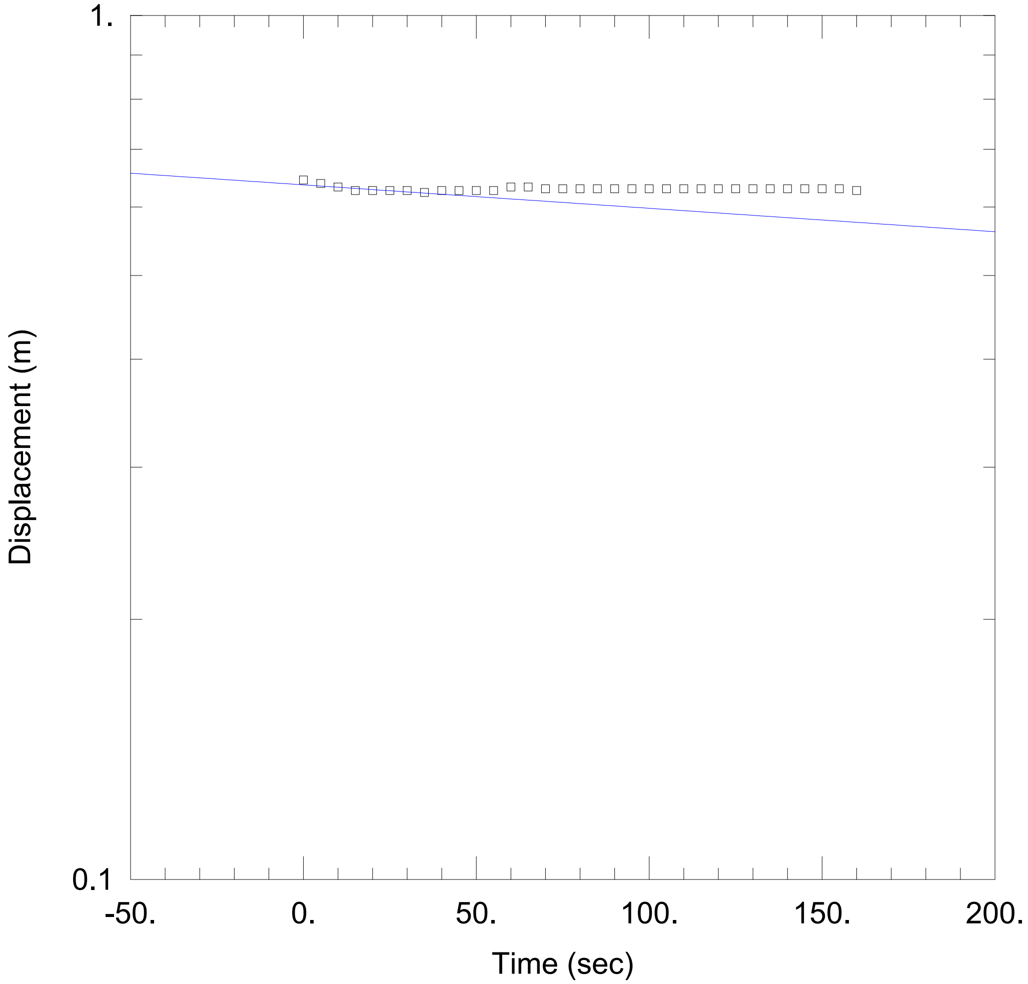
Saturated Thickness: 4.66 m
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (BH 11 Falling Head)

Initial Displacement: 0.657 m
Static Water Column Height: 1.54 m
Total Well Penetration Depth: 6.2 m
Screen Length: 2.2 m
Casing Radius: 0.025 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev
K = 2.757E-7 m/sec
y0 = 0.6129 m



WELL TEST ANALYSIS

Data Set: \\EgnyteDrive\pecg\Private\adrian\Projects\Durham Live\BH 11 Slug Test Rising Head.aqt
Date: 01/03/19 Time: 14:27:50

PROJECT INFORMATION

Company: PECG
Client: Pickering Developments Inc
Project: 180561
Location: Durham Live
Test Well: BH 11
Test Date: December 17, 2018

AQUIFER DATA

Saturated Thickness: 4.66 m
Anisotropy Ratio (Kz/Kr): 0.1

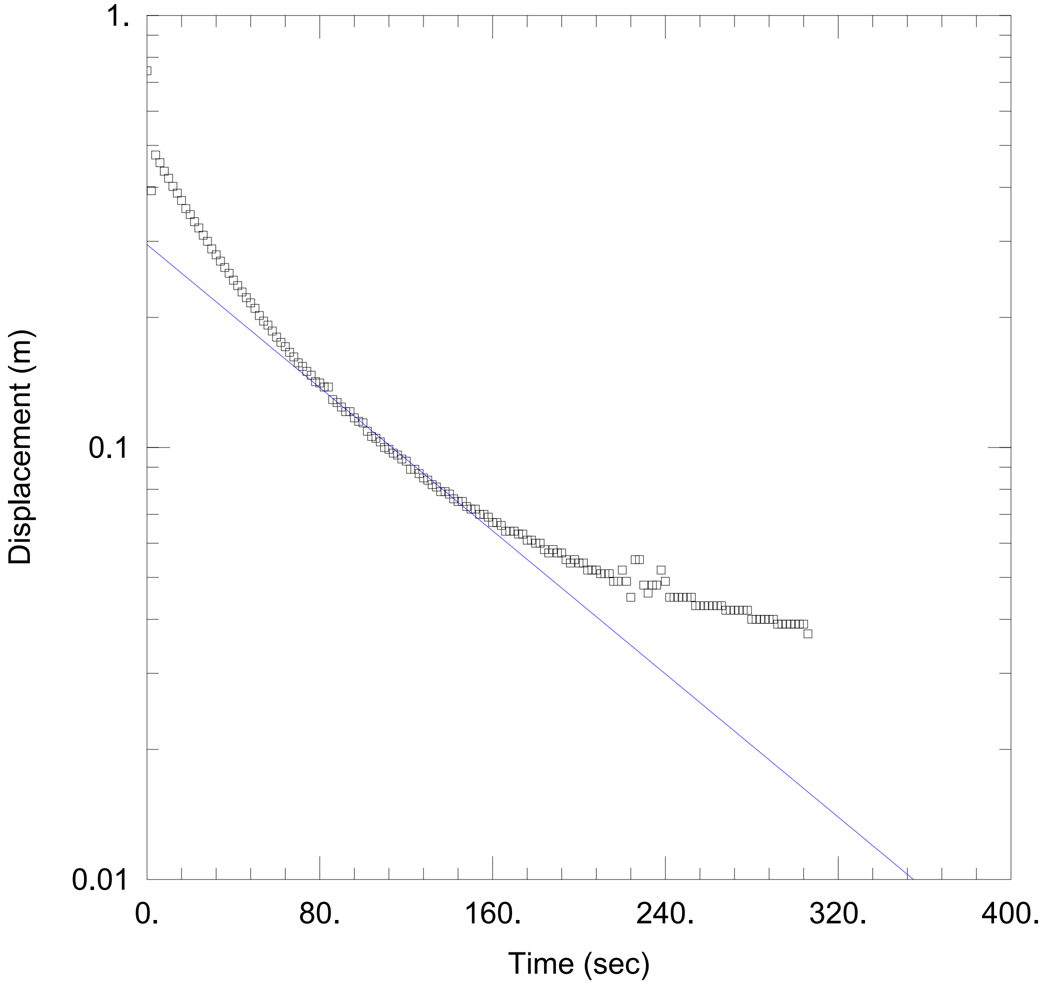
WELL DATA (BH 11 Rising Head)

Initial Displacement: 0.645 m
Static Water Column Height: 1.54 m
Total Well Penetration Depth: 6.2 m
Screen Length: 2.2 m
Casing Radius: 0.025 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 5.602E-7 m/sec
y0 = 0.6366 m



WELL TEST ANALYSIS

Data Set:
Date: 01/03/19 Time: 15:50:15

PROJECT INFORMATION

Company: PECG
Client: Pickering Developments Inc
Project: 180561
Location: Durham Live
Test Well: TH18-02
Test Date: December 17, 2018

AQUIFER DATA

Saturated Thickness: 3. m
Anisotropy Ratio (Kz/Kr): 0.1

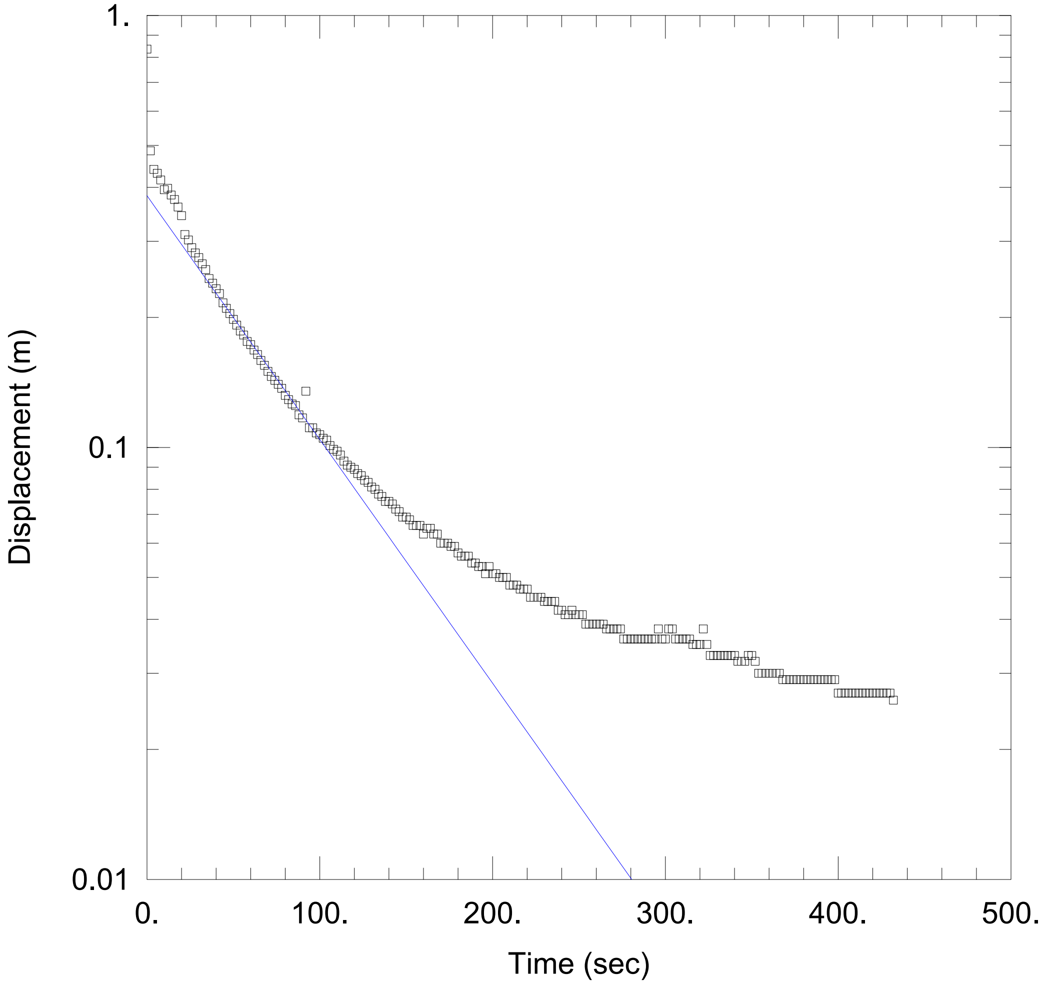
WELL DATA (TH18-02 Falling Head Test 1)

Initial Displacement: 0.744 m
Static Water Column Height: 13.38 m
Total Well Penetration Depth: 15.2 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 5.263E-6 m/sec
y0 = 0.2948 m



WELL TEST ANALYSIS

Data Set: \...\TH18-02 Slug Test Falling Head Test 2.aqt
Date: 01/03/19
Time: 15:53:16

PROJECT INFORMATION

Company: PECG
Client: Pickering Developments Inc
Project: 180561
Location: Durham Live
Test Well: TH18-02
Test Date: December 17, 2018

AQUIFER DATA

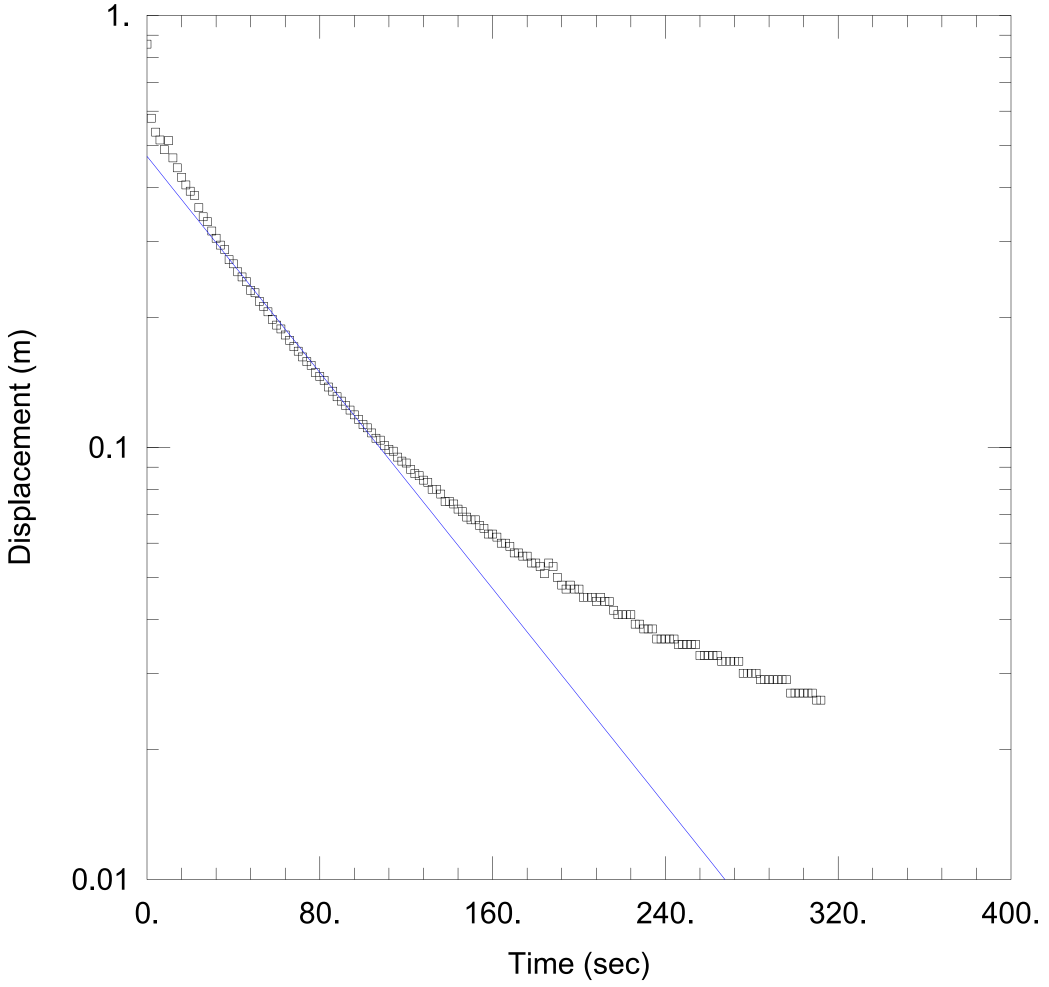
Saturated Thickness: 3. m
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (TH18-02 Falling Head Test 2)

Initial Displacement: 0.836 m
Static Water Column Height: 13.38 m
Total Well Penetration Depth: 15.2 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev
K = 7.171E-6 m/sec
y0 = 0.3825 m



WELL TEST ANALYSIS

Data Set: \...\TH18-02 Slug Test Rising Head Test 1.aqt
Date: 01/03/19
Time: 15:59:08

PROJECT INFORMATION

Company: PECG
Client: Pickering Developments Inc
Project: 180561
Location: Durham Live
Test Well: TH18-02
Test Date: December 17, 2018

AQUIFER DATA

Saturated Thickness: 3. m
Anisotropy Ratio (Kz/Kr): 0.1

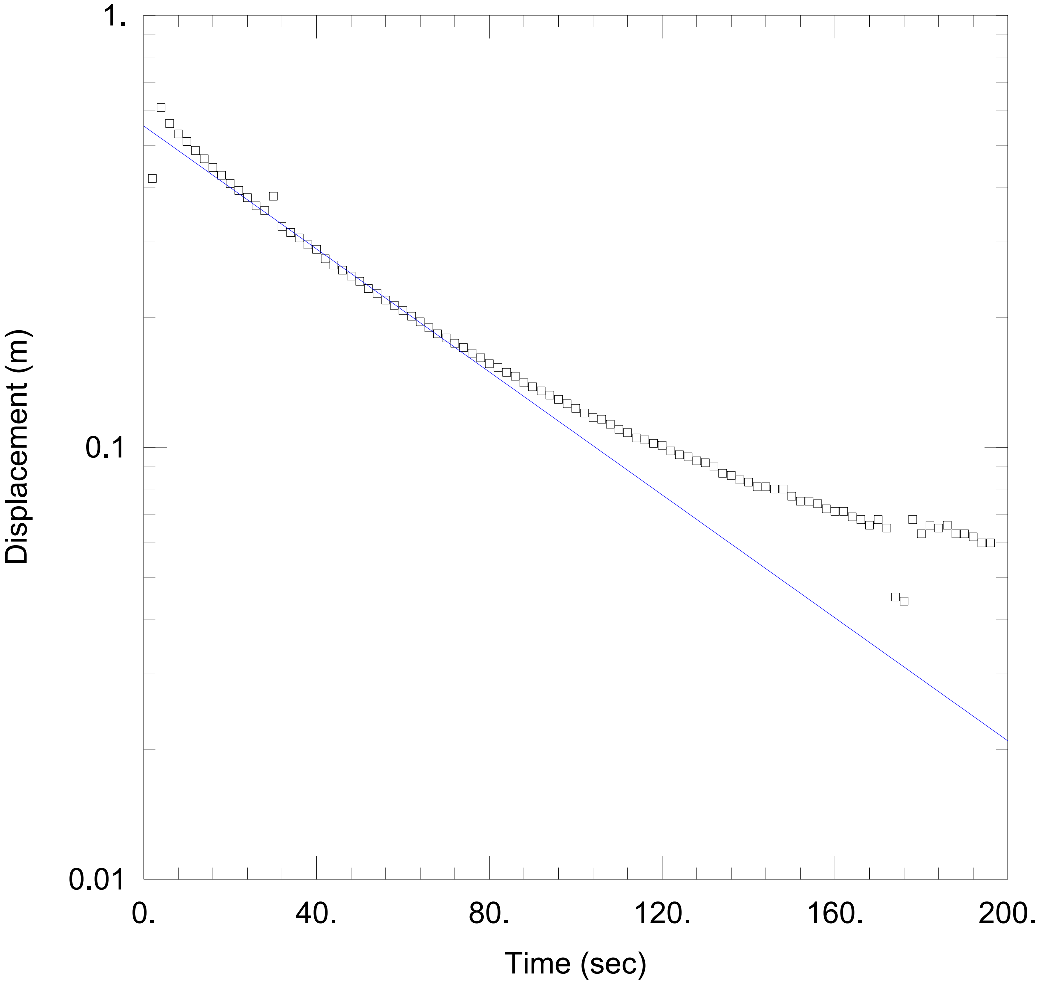
WELL DATA (TH18-02 Rising Head Test 1)

Initial Displacement: 0.858 m
Static Water Column Height: 13.38 m
Total Well Penetration Depth: 15.2 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 7.95E-6 m/sec
y0 = 0.472 m



WELL TEST ANALYSIS

Data Set: \...\TH18-02 Slug Test Rising Head Test 2.aqt
Date: 01/03/19 Time: 16:02:00

PROJECT INFORMATION

Company: PECG
Client: Pickering Developments Inc
Project: 180561
Location: Durham Live
Test Well: TH18-02
Test Date: December 17, 2018

AQUIFER DATA

Saturated Thickness: 3. m
Anisotropy Ratio (Kz/Kr): 0.1

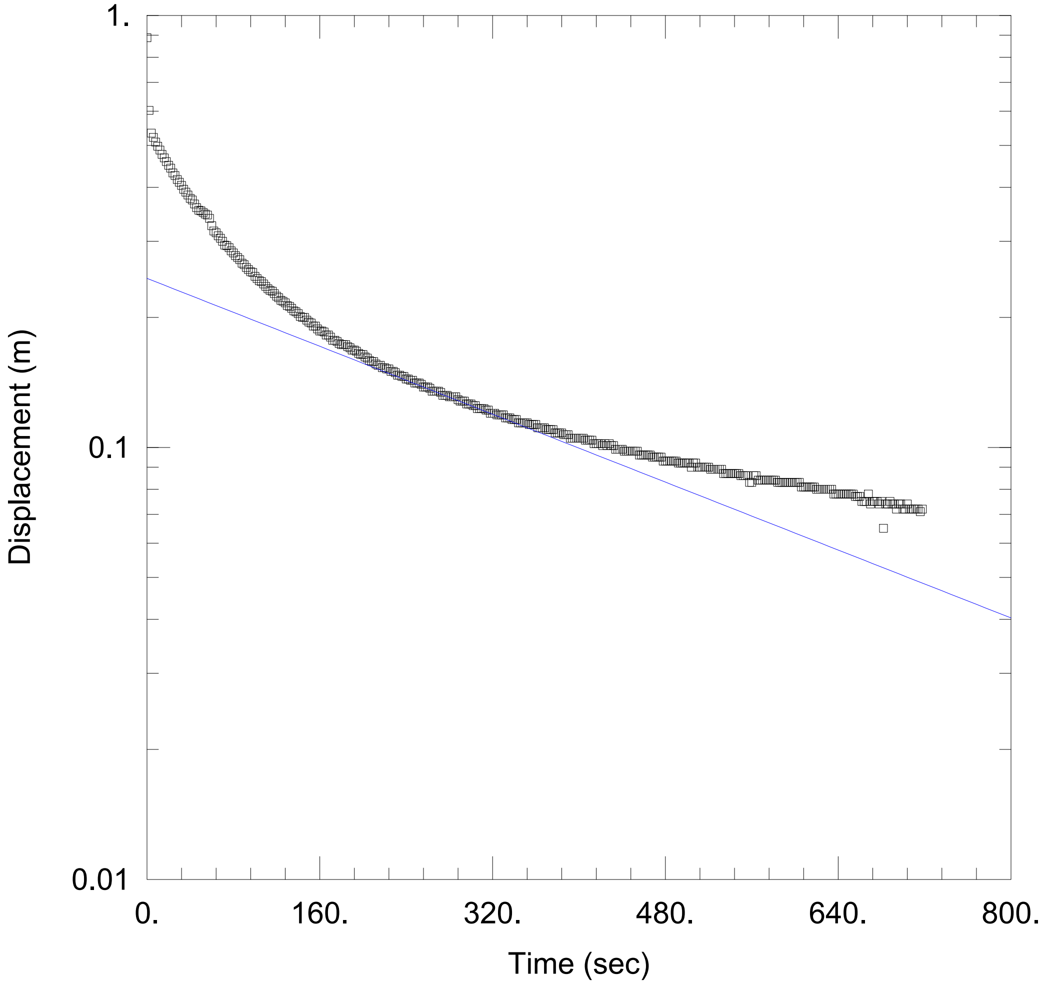
WELL DATA (TH18-02 Rising Head Test 2)

Initial Displacement: 0. m
Static Water Column Height: 13.38 m
Total Well Penetration Depth: 15.2 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 9.043E-6 m/sec
y0 = 0.554 m



WELL TEST ANALYSIS

Data Set: \...\TH18-05 Slug Test Falling Head Test 1.aqt
Date: 01/03/19 Time: 15:26:45

PROJECT INFORMATION

Company: PECG
Client: Pickering Developments Inc
Project: 180561
Location: Durham Live
Test Well: TH18-05
Test Date: December 17, 2018

AQUIFER DATA

Saturated Thickness: 1.1 m
Anisotropy Ratio (Kz/Kr): 0.1

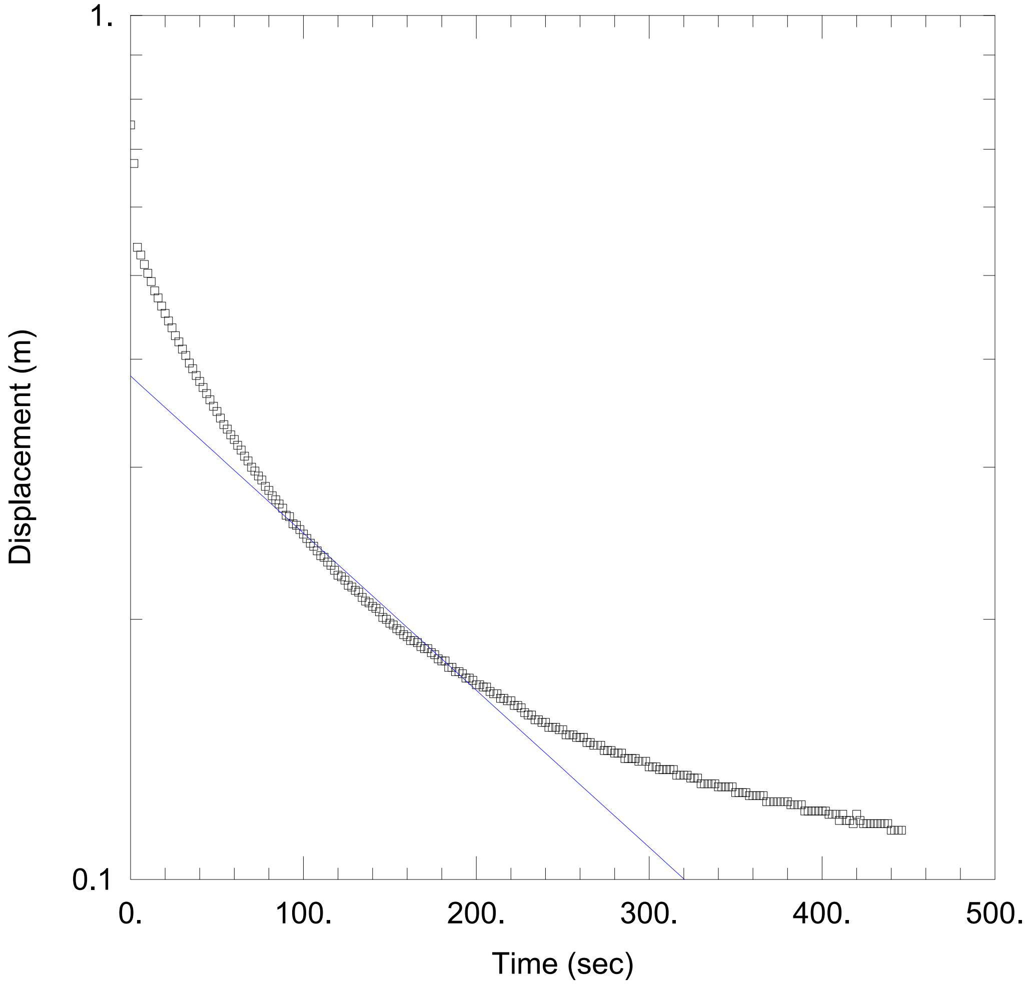
WELL DATA (TH18-05 Falling Head Test #1)

Initial Displacement: 0.888 m
Static Water Column Height: 10.15 m
Total Well Penetration Depth: 10.6 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 3.405E-6 m/sec
y0 = 0.2462 m



WELL TEST ANALYSIS

Data Set: \...\TH18-05 Slug Test Falling Head Test 2.aqt
Date: 01/03/19 Time: 15:28:37

PROJECT INFORMATION

Company: PECG
Client: Pickering Developments Inc
Project: 180561
Location: Durham Live
Test Well: TH18-05
Test Date: December 17, 2018

AQUIFER DATA

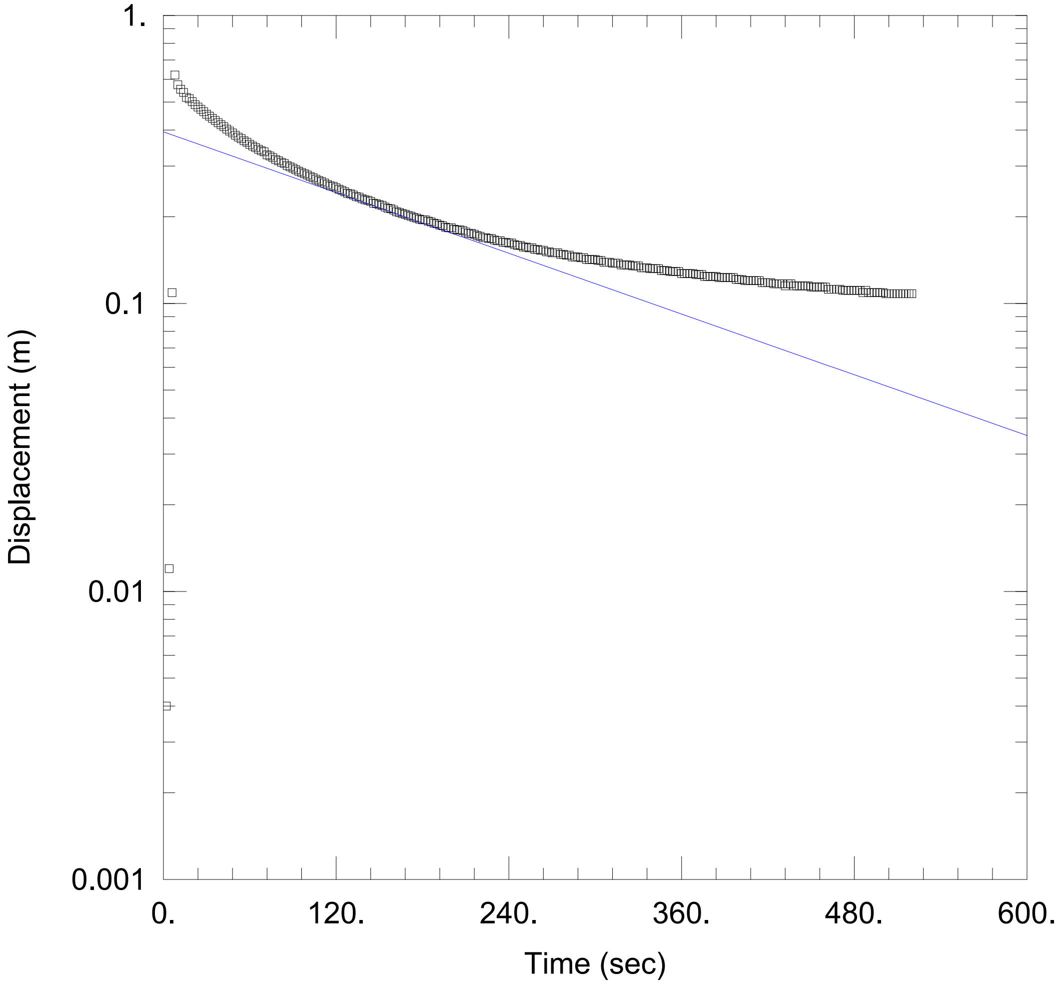
Saturated Thickness: 1.1 m
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (TH18-05 Falling Head Test #2)

Initial Displacement: 0.747 m
Static Water Column Height: 10.15 m
Total Well Penetration Depth: 10.6 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev
K = 6.303E-6 m/sec
y0 = 0.3825 m



WELL TEST ANALYSIS

Data Set: \...\TH18-05 Slug Test Rising Head Test 1.aqt
Date: 01/03/19 Time: 15:36:22

PROJECT INFORMATION

Company: PECG
Client: Pickering Developments Inc
Project: 180561
Location: Durham Live
Test Well: TH18-05
Test Date: December 17, 2018

AQUIFER DATA

Saturated Thickness: 1.1 m
Anisotropy Ratio (Kz/Kr): 0.1

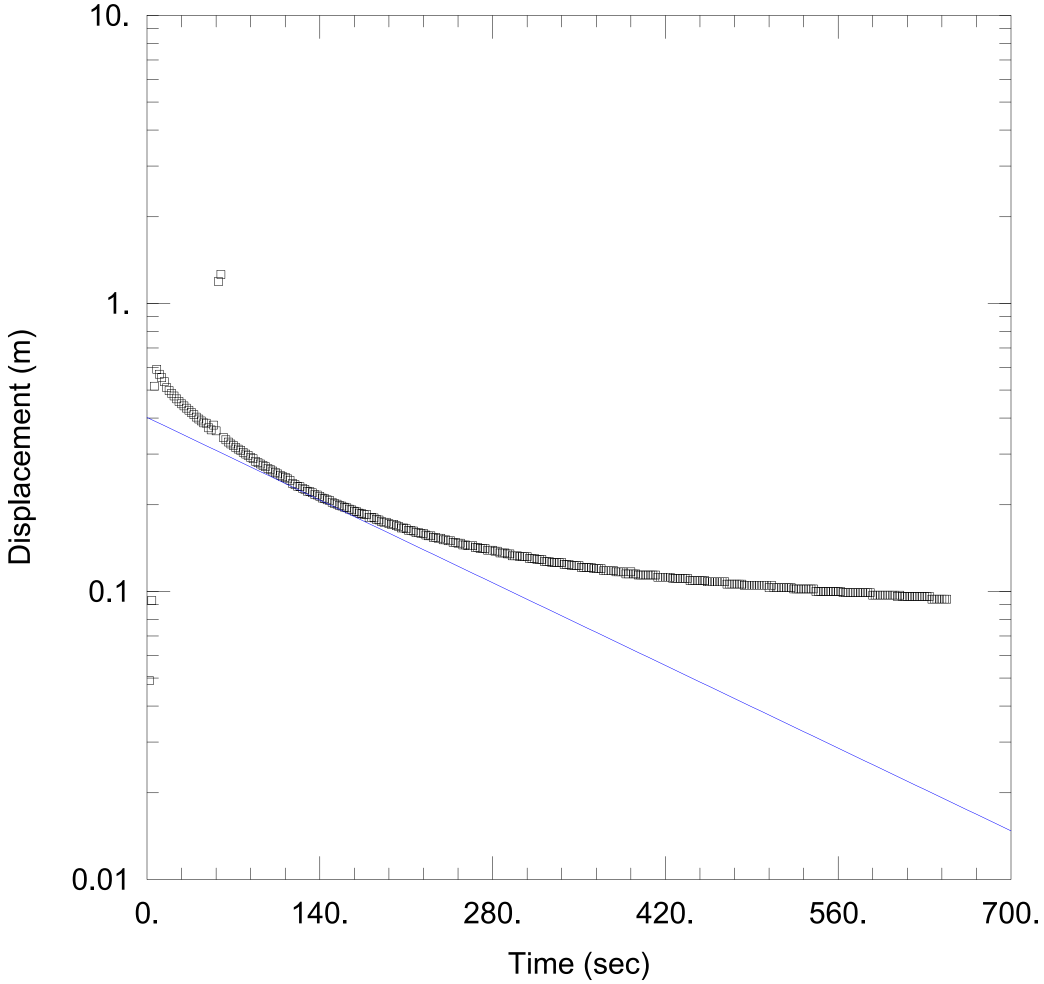
WELL DATA (TH18-05 Falling Head Test #2)

Initial Displacement: 0. m
Static Water Column Height: 10.15 m
Total Well Penetration Depth: 10.6 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 6.09E-6 m/sec
y0 = 0.3941 m



WELL TEST ANALYSIS

Data Set: \...\TH18-05 Slug Test Rising Head Test 2.aqt
Date: 01/03/19 Time: 15:40:18

PROJECT INFORMATION

Company: PECG
Client: Pickering Developments Inc
Project: 180561
Location: Durham Live
Test Well: TH18-05
Test Date: December 17, 2018

AQUIFER DATA

Saturated Thickness: 1.1 m
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (TH18-05 Falling Head Test #2)

Initial Displacement: 0. m
Static Water Column Height: 10.15 m
Total Well Penetration Depth: 10.6 m
Screen Length: 3. m
Casing Radius: 0.025 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 7.108E-6 m/sec
y0 = 0.4021 m