Appendix G
Geotechnical Report

THURBER ENGINEERING LTD.

April 19, 2023 File No.: 19-1605-196

HATCH
2800 Speakman Drive
Mississauga, Ontario
L5K 2R7

Attention: Melissa Alexander, B.Sc., MCIP, RPP

FINAL THURBER ENGINEERING REPORTS
WINSTON CHURCHILL BOULEVARD CLASS EA STUDY
HIGHWAY 401 TO EMBLETON ROAD
REGION OF PEEL

Dear Ms. Alexander,

This letter accompanies the final reports submitted by Thurber Engineering Ltd. (Thurber) for the Winston Churchill Boulevard Class EA Study project from Highway 401 to Embleton Road.

As requested by HATCH, Thurber has finalized the following 4 reports, which were last issued in draft form in 2016:

- Contaminated Soil Assessment Report, Winston Churchill Boulevard Class EA Study, Highway 401 to Embleton Road, Region of Peel, Ontario” Report Submitted to Hatch Mott MacDonald, dated March 14, 2016. File No. 19-1605-196.
- Geotechnical Investigation Report, Winston Churchill Boulevard Class EA Study, Highway 401 to Embleton Road, Region of Peel” Report Submitted to Hatch Mott MacDonald, dated May 11, 2016. File No. 19-1605-196.
- Hydrogeology Investigation, Winston Churchill Boulevard, Highway 401 to Embleton Road, City of Brampton, Ontario” Report Submitted to Hatch Mott MacDonald, dated July 25, 2016. File No. 19-1605-196.
- Foundation Investigation and Design Report, Winston Churchill Boulevard Class EA Study, Highway 407 Bridge Widening, Region of Peel” Report Submitted to HATCH, dated August 10, 2016. File No. 19-1605-196.

It is a condition of each report that Thurber’s performance of its professional services is subject to the attached Statement of Limitations and Conditions.

The final reports are based on the site and subsurface conditions encountered at the time of Thurber’s original investigations in 2015 and 2016 and do not reflect any changes in site conditions that may have occurred since this time. The recommendations provided must be reviewed with respect to any changes in site conditions and updates to relevant specifications, standards, regulations, codes or guidelines that have occurred since 2016.

Furthermore, Thurber’s reports were produced prior to completion of the preferred design concept for the Winston Churchill Boulevard corridor and were based on existing site information and preliminary design information that was available at the time of preparation of each report. Accordingly, the factual information and foundation and hydrogeological recommendations (including Permit to Take Water requirements) must be reviewed for their completeness and applicability for the 100% design of the relevant works. Additional investigations may therefore be required to support the 100% design. Some dewatering works may require registration on the Environmental Activity and Sector Registry (EASR).

Thank you and please contact us if you should have any questions.

Yours truly,
Thurber Engineering Ltd.

P.K. Chatterji, P.Eng.
Review Principal

LICENSED PROFESSIONAL ENGINEER
M.E. FARRANT
100053767
4/19/2023
PROVINCE OF ONTARIO

Mark Farrant, P.Eng.
Associate, Senior Geotechnical Engineer

Attachment

- Statement of Limitations and Conditions

THURBER ENGINEERING LTD.

GEOTECHNICAL INVESTIGATION REPORT
WINSTON CHURCHILL BOULEVARD CLASS EA STUDY
HIGHWAY 401 TO EMBLETON ROAD
REGION OF PEEL

Report

to

Hatch Mott MacDonald

LICENSED PROFESSIONAL ENGINEER
M. J. POPIK
100050381
05/11/2016
PROVINCE OF ONTARIO

Mark Popik, P.Eng.
Review Principal

LICENSED PROFESSIONAL ENGINEER
M.E. FARRANT
100053767
5/11/2016
PROVINCE OF ONTARIO

Date: May 11, 2016
File: 19-1605-196

Mark Farrant, P.Eng.
Geotechnical Engineer

103, 2010 Winston Park Drive, Oakville, ON L6H 5R7 T: 905 829 8666 F: 905 829 1166
thurber.ca

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APPENDICES

1. INTRODUCTION

This report presents the results of a geotechnical investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed widening of Winston Churchill Boulevard between Highway 401 and Embleton Road (approximately 4.0 km), located on the border of the City of Brampton (Region of Peel) and the Town of Halton Hills (Halton Region). The geotechnical investigation was undertaken on behalf of Hatch Mott MacDonald (HMM) as part of a Schedule 'C' Class Environmental Assessment (EA) for the Regional Municipality of Peel.

The purpose of this investigation was to evaluate the existing pavement and subsurface conditions within the project limits and provide pavement/geotechnical recommendations to a 100% design level to assist in implementing the Region of Peel's updated Long Range Transportation Plan (LRTP). The geotechnical assessment was based on information provided by HMM for the 30% design of the project. The investigation was carried out in general accordance with Region of Peel's terms of reference (Document 2014-097P) and Thurber's proposal letter dated March 7, 2014.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

2. PROJECT AND SITE DESCRIPTION

2.1 Background

Winston Churchill Boulevard (Regional Road 19) is a major north-south arterial road that borders the City of Brampton (Region of Peel) and the Town of Halton Hills (Halton Region). It is understood that the Region of Peel is considering corridor improvements (with potential widening) along Winston Churchill Boulevard, from Highway 401 to Embleton Road. To implement the LRTP's recommendations; the roadway within the project limits is to be widened to a six lane facility in the year 2021 for the section south of Steeles Avenue, while the section north of Steeles Avenue is to be widened to six lanes in 2031. The ultimate design includes a 45 m wide Right-of-Way (ROW). Part of the widening works will require extensions of existing culverts, as well as new sewers or modifications to existing sewers. The project will also require widening of the bridge crossing Highway 407. Foundation recommendations for the Highway 407 bridge are presented in a separate Foundation Investigation and Design Report by Thurber.

It is understood that Winston Churchill Boulevard was last reconstructed in 2013, which included pavement widening from Steeles Avenue to just north of the entrance to the Maple Lodge Farms facility. Drawings from the 2013 construction also indicate that the roadway is constructed with a flexible pavement structure that comprises 185 mm of Hot Mix Asphalt, 150 mm of Granular A Base, and 500 mm of Granular B, Type I.

Project stationing for this assignment was synchronized with the 2010 construction drawings for the 2013 reconstruction provided by HMM, which extended from Steeles Avenue (Station 1+000) to Embleton Road (Station 4+000). As a point of reference, Station 1+000 was located at the intersection with Steeles Avenue. It should be noted that base plan and alignment drawing received from HMM in February 2016, following the field investigation, shows the project stationing to be offset by 292 m from the 2010 construction drawings. The 2010 stationing is used throughout this report, on the borehole location plan, and for identification of borehole and culvert locations.

2.2 Physiography

The site is located in the physiographic region known as the Peel Plain, which is characterized by beveled till plains (OGS Map P.2226, 1984).

The Quaternary geologic mapping for the site (OGS Map M.2223, 2005) indicates that the soil conditions mainly consist of red to brown glacial tills ranging in composition from gritty to clayey silt till (Halton Till). The bedrock in the area comprises Upper-Ordovician red shale of the Queenston Formation (Map 2337, 1976). Based on drift thickness mapping for the area (Map 2179, 1969), the depth to the bedrock ranges from approximately 4 to 15 m below the ground surface. Recently, agriculture and road construction activities in the area have likely resulted in placement of anthropogenic (fill) deposits in some areas.

Based on existing borehole logs included in a December 2009 geotechnical investigation report by Golder Associates for the portion of Winston Churchill Boulevard between Steeles Avenue and Embleton Road, the subsurface soil in the upper 5 m below the ground surface predominantly consists of fill and/or topsoil overlying very stiff to hard silty clay to clayey silt till.

2.3 Existing Conditions

The roadway currently consists of a five lane urban platform from Highway 401, northerly 2.2 km to the Maple Lodge Farms facility. The remaining 1.8 km of Winston Churchill Boulevard to the northern project limits (Embleton Road) is a three lane rural roadway with one lane in each direction and a centre median lane. Shoulders in this area are comprised of gravel shoulders adjacent to the northbound lane and a paved shoulder in the southbound direction.

At all signalized intersections, Winston Churchill Boulevard widens to include turn lanes and/or a secondary driving lane. The posted speed limit within the project area is 60 km/hr.

3. PAVEMENT INVESTIGATION METHODOLOGY

A field investigation was carried out in May to June 2015 and comprised of deflection testing, visual pavement condition survey, pavement coring, borehole drilling, and laboratory testing on recovered samples of granular base/subbase and subgrade soil.

The visual pavement surface condition survey was completed on May 6, 2015 to assess the condition of the existing pavement surface, and identify the type and severity of the specific pavement distresses present at that time. Typical photographs of existing conditions are provided in Appendix B.

A total of 41 boreholes were advanced in travelled lanes and shoulders along proposed improvement areas to depths of 1.5 to 2.1 m. Upon completion, all boreholes were backfilled with auger cuttings and patched with cold mix asphalt.

Prior to the start of the drilling investigation, public utility clearances were obtained through Ontario One-Call. A road occupancy permit was obtained prior to commencement of drilling. Traffic control was provided by Direct Traffic Management, while the boreholes were advanced using track-mounted CME-55 drill rigs supplied and operated by DBW Drilling Ltd. The field investigation was carried out under the full-time supervision of Thurber technical staff. All boreholes were logged in the field. The approximate borehole locations are shown on the Borehole Location Plan in Appendix A. The boreholes are identified with reference to the stationing on the 2010 construction drawings. All borehole logs are provided in Appendix C. Additional hand dug test pits were completed at the end of culverts to determine topsoil thickness and subgrade soil conditions.

Soil samples were identified, placed in labelled containers and transported back to Thurber’s laboratory for further examination and testing. Geotechnical laboratory testing consisted of natural moisture content determinations, visual classification and description of all soil samples. Grain size distribution and particle size analyses were carried out on selected samples of the pavement granular materials and subgrade soils. Results of the geotechnical laboratory testing are summarized in the Borehole logs and provided in detail in Appendix E.

Selected soil samples were also submitted to a qualified laboratory for analytical testing to assess disposal requirements for excess excavated materials and corrosivity potential of soils. The laboratory Certificates of Analysis are provided in Appendix F.

Falling Weight Deflectometer (FWD) testing of Winston Churchill Boulevard was completed on 100 m intervals throughout the project limits, with test locations staggered by direction. The testing was completed by Applied Research Associates Inc. (ARA), on May 6th, 2015, with the analysis of the collected data completed by Thurber. Further details of the FWD testing are provided in the ensuing section, with the results of the analysis provided in Appendix G.

4. PAVEMENT EVALUATION

4.1 Existing Pavement Condition

A visual pavement condition survey was completed within the project limits to assess the condition of the existing pavement surface, and identify the type and severity of the specific pavement distresses present. Pavement distresses were classified in accordance with the MTO Document SP-022, Flexible Pavement Condition Rating Guidelines for Municipalities, with a summary of the results provided in the ensuing paragraph.

The pavement surface on Winston Churchill Boulevard between Highway 401 and Embleton Road, which was reconstructed in 2013, was considered to be in excellent condition, with no significant distresses observed in the travelled lanes. The only noted distress was slight segregation/ ravelling along longitudinal construction joints. Overall the ride condition rating for this section of Winston Churchill Boulevard was considered to be excellent, as the ride was very smooth.

4.2 Existing Pavement Structure

4.2.1 Asphalt

The asphalt thickness of lanes and paved outer shoulders on Winston Churchill Boulevard typically varied from 170 to 220 mm, although an asphalt thickness of 100 mm was observed on the northbound right turn lane (station 0+800); 200 m south of the intersection with Steeles Avenue.

4.2.2 Granular Base/Subbase

Underlying the asphalt surface, the pavement structure on Winston Churchill Boulevard comprised a granular base/subbase, which consisted primarily of sandy gravel with trace silt over sand with some gravel and some silt. The granular base/subbase thicknesses generally varied from 700 to 900 mm, however thicknesses varying from 580 to 1,630 mm were observed. In areas with gravel shoulders, the total granular thickness typically ranged from 900 mm to 1.0 m; however, at Station 2+600, the observed granular thickness was 1.5 m.

During the drilling of the boreholes, the interface between the granular base and granular subbase could not always be distinguished. Grain size analysis was completed on selected samples of granular base/subbase material that indicate material collected near the asphalt generally conforms to OPSS Granular A gradation specifications, while samples extracted at lower depths were slightly finer than OPSS Granular B, Type I gradation requirements. Moisture contents in the retrieved samples ranged from 2 to 5 percent.

It is noteworthy that three of the four samples tested exceeded the specified percent passing on the 75 µm sieve size. This is common for samples collected from existing roadways, and could be the result of construction activities (i.e. compaction efforts), or the drilling operation.

4.2.3 Pavement Subgrade

Soils beneath the Winston Churchill Boulevard pavement structure and typically within the upper 1.5 to 2.1 m depth, were generally found to be fill material which varied from sandy silt with clay, to silt with sand with clay. The southern segment of the roadway (Station 0+000 to 3+100) fill was typically found to be stiff to very stiff, with Standard Penetration Test (SPT) 'N' values ranging from 10 to 25 blows per 0.3 m pf penetration, whereas in the northern segments (station 03+200 to 4+000) soils were generally found to be firm with 'N' values below 10 blows per 0.3 m of penetration.

All boreholes were dry upon completion of drilling, with no indication of groundwater within the drilling depth. Moisture conditions of the subgrade soils were typically found to be moist, with the natural moisture content typically between 10 and 20%.

Based on laboratory testing on selected samples, the subgrade soils were determined to have a moderate susceptibility to frost heaving as defined in the *MTO Pavement Design and Rehabilitation Manual*. Soil erodibility was determined using the *Wischmeier Nomograph*, with typical K-values between 0.27 and 0.31, indicating a low to moderate potential for soil erodibility.

4.3 Subgrade Soil

The subgrade soil conditions below the pavement subgrade, and outside of existing pavement areas, were identified based on previous borehole information available in a December 2009 report by Golder Associates entitled, “Supplementary Geotechnical Investigation, Proposed Watermain Installation, Winston Churchill Boulevard, Steeles Avenue to Embleton Road, Region of Peel, Ontario”, which was provided by HMM. The previous borehole information was supplemented by hand-dug test pits at the end of the concrete culverts. The previous borehole locations and the test pit locations are shown on the Borehole Location Plan in Appendix A, and the previous borehole logs are included in Appendix D. The test pit information is summarized on Table C1 in Appendix C. The December 2009 report included 31 boreholes, referred to as 08-1 to 08-20 and 09-1 to 09-11, which were drilled to depths ranging from 1.5 to 9.3 m below the existing ground surface (Elev. 207.0 to 196.4 m). Boreholes 09-7 and 09-8 were missing from the report provided by HMM. Based on the 2009 information, the subgrade soils at the site typically consist of silty clay to clayey silt till, with some zones of silt and sand till, and occasional sand and gravel layers. Shale bedrock was also encountered in some boreholes below Elev. 200 m. The subgrade soils outside of existing pavement areas are generally overlain by topsoil, or rip rap at the existing culvert locations. Since the 2009 information was obtained prior to the 2013 reconstruction work, the subsurface conditions are likely to have changed. Descriptions of the subgrade soils are provided below:

4.3.1 Rip Rap and Topsoil

A layer of limestone rip rap was observed at the ends of each of the existing concrete culverts. In the test pits, which were dug beyond or beside the rip rap, a layer of topsoil was encountered between stations 2+600 and 3+740. The topsoil generally varied in thickness from 50 mm to 200 mm, although as much as 350 mm was recorded at station 3+010. The topsoil thickness measurements are summarized in Table C1 in Appendix C.

4.3.2 Glacial Till

Glacial till deposits ranging in composition from silty clay to clayey silt with occasional silt and sand zones were noted throughout the site in the 2009 boreholes. Silty clay was also observed in all of the hand dug test pits below the topsoil layer or at the ground surface. All of the previous boreholes were terminated within the glacial till deposits except for Boreholes 09-4 and 09-5, where reddish brown weathered shale bedrock was reported at depths of 6.7 to 7.6 m (Elev. 199.4 to 198.4 m). The till deposits contained varying amounts of sand and gravel, as well as inferred cobbles and boulders based on grinding of the augers noted on the logs.

SPT 'N' values reported in the silty clay to clayey silt till deposits typically ranged from 12 to greater than 100 blows per 0.3 m of penetration, indicating a stiff to hard consistency. SPT 'N' values in the silt and sand till were typically greater than 50 blows per 0.3 m of penetration, indicating that the deposits are very dense.

Moisture contents of samples reported in the previous boreholes indicate natural moisture contents ranging from 6 to 22%.

4.3.3 Sand and Gravel

A layer of sand and gravel was shown on the logs within the silty clay till deposit in Boreholes 08-13 and 09-4, near the culvert at station 2+600. The sand and gravel layer is 0.3 to 0.4 m thick and was shown at depths of 1.8 to 4.0 m (Elev. 202.9 to 202.1 m)

SPT 'N' values of 57 and 68 blows per 0.3 m of penetration were noted in the sand and gravel, indicating a very dense relative density.

4.3.4 Groundwater

The December 2009 report reported the following groundwater level measurements in standpipe piezometers installed in three boreholes:

Borehole No.	Water Level Depth (m)	Date of Reading
08-6	0.1	Dec. 16, 2008
08-13	0.5 1.0	Dec. 16, 2008 Dec. 1, 2009
08-16	2.0	Dec. 16, 2008

The reported levels are short-term readings and seasonal fluctuations are to be expected. The groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

4.4 Falling Weight Deflection Testing

The structural adequacy of Winston Churchill Boulevard between Highway 401 and Embleton Road was evaluated by Falling Weight Deflectometer (FWD) pavement load/deflection testing. The FWD tests were completed on 100 m intervals, staggered by lane and direction. At each test location, a series of four load applications was applied to the pavement surface. The first application was a "seating" load to ensure the FWD load plate was firmly resting on the pavement surface. The next three loads were approximately 30, 40, and 65 kN. Pavement surface deflections under the load were measured by sensors (velocity transducers) placed at fixed spacing from the load plate in accordance with SHRP testing protocols. Asphalt granular base/subbase thicknesses from the borehole investigation were used in the analysis of the FWD data.

The analysis of the FWD deflection data was completed in accordance with the procedures outlined in the AASHTO Guide for Design of Pavement Structures (1993). The parameters calculated as part of this analysis include:

Normalized Deflection: The deflection (D_0) measured at the centre of the load plate is a good indicator of overall pavement strength. The deflection at this location is a function of the pavement layer stiffness and the support capacity of the subgrade soil. Because deflection is a function of load and because of slight variations in measured load at each test point, a linear extrapolation of the measured deflection is made to adjust deflections at all test locations to a “standard” load level of 40 kN.

Materials Characterization: The pavement thickness data from the boreholes was used in conjunction with the FWD results to estimate the stiffness (strength) of the existing pavement. Pavement layer stiffness back-calculation uses closed form models to estimate layer elastic modulus values, given the layer thickness and FWD data.

The procedure as outlined in the AASHTO 1993 Guide for Design of Pavement Structures, Part III, Chapter 5, was used to determine the properties of the as-constructed flexible pavements. The resultant data includes the composite elastic pavement modulus (E_p) for the combination of all bound layers above the subgrade (e.g., the asphalt concrete and granular bases), and the subgrade elastic modulus (E_s). The subgrade resilient modulus (M_R) is determined by reducing the value of E_s by a conversion factor of 3.

Effective Structural Number: Based on the back-calculated pavement moduli, the effective structural number (SN_{Eff}) of the existing pavement was calculated using the 1993 AASHTO Guide for Design of Pavement Structures procedure.

The summary of the FWD analysis is provided in Table 4.1, while detailed results are presented in Appendix G. The SN_{Eff} for each travel lane is plotted along the length of the project in Figure 4.1.

Table 4.1 – Summary of FWD Test Results

Direction	Station		D_0 (µm)		M_R (MPa)		E_P (MPa)		SN_{Eff} (mm)	
	From	To	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
NB Lane 1	0+000	4+000	170	45	63	16	1092	234	206	16
NB Lane 2	0+000	2+350	221	76	55	13	840	236	188	18
SB Lane 1	0+000	4+000	169	59	65	16	1106	252	206	19
SB Lane 2	0+000	2+350	199	73	58	17	948	248	196	19

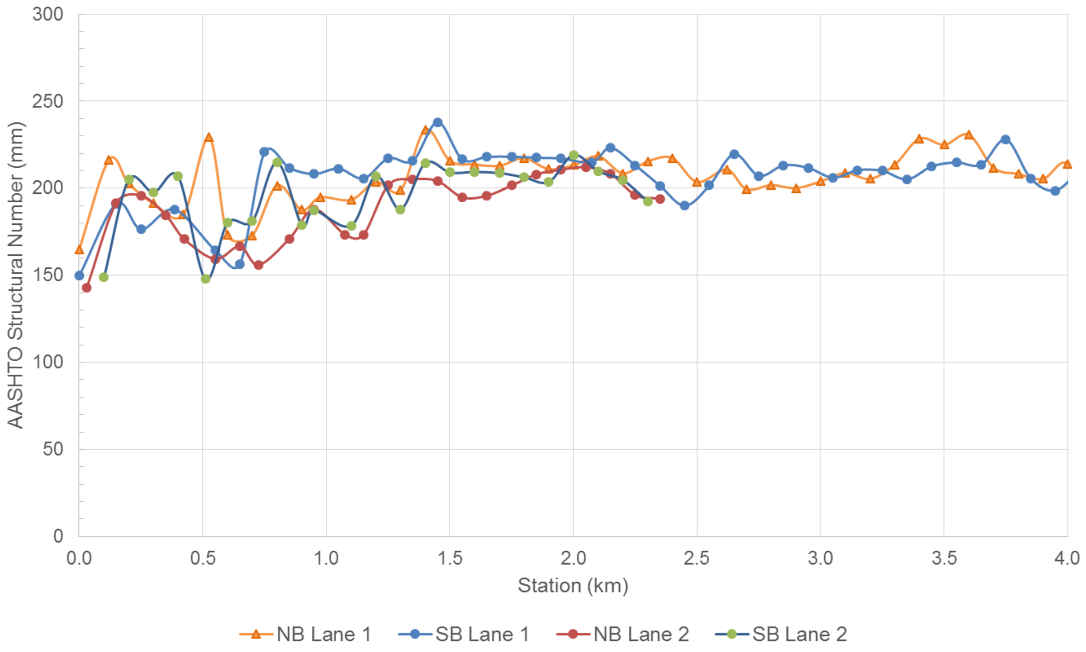

Figure 4.1 – Effective Structure Number on Winston Churchill Boulevard

The normalized deflections on Winston Churchill Boulevard were found to be somewhat variable from the southern project limits to Station 1+300, after which, deflection values become more consistent. The overall average subgrade strength along Winston Churchill Boulevard was found to be roughly 60 MPa, although localized subgrade strengths varied to values as low as 26 MPa.

5. PAVEMENT EVALUATION AND DESIGN

The pavement design analysis is based on the subsurface soil conditions encountered during the investigation, supplemented by FWD test results, and traffic data provided by others.

5.1 Traffic Analysis

Traffic information used for this investigation was provided by HMM in a technical memo entitled "AADT Volumes for Winston Churchill Boulevard Prepared for the Winston Churchill Boulevard Class EA - Highway 401 to Embleton Road" dated August 11, 2015. The traffic data used for the traffic analysis were obtained from 2012 and 2013 volume counts, as well as 2014 AADT obtained from the Region of Peel web-site. A summary of the two-way collected 2014 and forecasted 2021 and 2031 Average Annual Daily Traffic (AADT) are provided in Table 5.1.

Table 5.1 – Winston Churchill Boulevard – Two-way AADT

Segments	2014 AADT	2021 AADT	2031 AADT	Percentage Trucks
Highway 401 Ramps – Steeles Avenue	24,230	28,930	34,140	12
Steeles Avenue – Maple Lodge Farm Entrance	11,860	15,300	17,070	12
Maple Lodge Farm Entrance – Embleton Road	11,550	15,180	20,700	8

As indicated in the traffic study memo, a growth rate of 2 percent per annum was used for the pavement widening design analysis south of Steeles Avenue beyond 2021, with a 4 percent growth rate for the section north of Steeles Avenue beyond 2031.

5.2 ESALs Calculations

The traffic data was used to determine the pavement damage caused by the anticipated traffic volumes. Using axle load equivalency factors, the different axle loads and axle groups are converted to a standard axle load known as an Equivalent Single Axle Loads (ESALs). The ESALs calculation was completed in accordance with the MTO *Procedures for Estimating Traffic Loads for Pavement Designs*, with an average truck factor of 2.5. The 20-year design ESALs calculated for the ultimate 6-lane roadway platform between Highway 401 Ramps and Embleton Road are as follows.

Table 5.2 – Winston Churchill Boulevard ESALs

Segments	Anticipate Construction Year	ESALs (million)
Highway 401 – Steeles Avenue	2021	27.0
Steeles Avenue- Maple Lodge Farm	2031	19.5
Maple Lodge Farm - Embleton Road	2031	15.8

It is noted that the 20-year design life includes the forecasted traffic volumes for the anticipated construction year. For the purposes of developing a consistent pavement design through all widening areas, the design ESALs of 27 million were used.

5.3 AASHTO Pavement Design

The pavement design analysis was carried out using the methodology outlined in the 1993 AASHTO "*Guide for the Design of Pavement Structures*", as modified by the Ministry's "*Adaptation and Verification of AASHTO Pavement Design Guide for Ontario Conditions*", and the MTO "*Pavement Design and Rehabilitation Manual*". This analysis was completed to determine the structural requirements for the new pavement structure in the widening areas on Winston Churchill Boulevard.

The AASHTO procedure for the design of flexible pavements determines a required Structural Number that characterizes the structural capacity of the pavement layers, for a given set of inputs. The following design inputs were used in the AASHTO design analysis.

- Design ESALs = 27.0 Million
- Initial serviceability, (Pi) = 4.4
- Terminal serviceability (Pt) = 2.2
- Reliability level (R) = 90 percent
- Overall standard of deviation (So) = 0.44
- Mean soil resilient modulus (MR) = 35 MPa

It is noted that the results of the FWD testing indicated that the subgrade strengths on the existing pavement within the project area were generally competent, with the average back-calculated resilient modulus roughly 60 MPa. However, as localized test points were found to have lower subgrade strength, and considering that moderately frost susceptible soils were encountered within the project limits, a subgrade strength of 35 MPa was used as the subgrade strength in the design analysis.

Based on the above structural requirements, site considerations, and input from the design team, the following minimum pavement structure will be required for the pavement widening on Winston Churchill between Highway 401 and Embleton Road.

190 mm	Hot Mix Asphalt
150 mm	Granular ‘A’ Base
550 mm	Granular ‘B’, Type I Subbase

The details of the pavement design analysis from the AASHTO DARWin 3.0 software are provided in Appendix H.

5.4 Pavement Rehabilitations

The existing pavement on Winston Churchill Boulevard was evaluated to determine its functional and structural capacity of supporting the anticipated future traffic volumes for the new Winston Churchill Boulevard. The understanding of these requirements is critical for the development of future rehabilitation strategies.

5.4.1 Functional Requirements

A road’s functional capacity is a measure of how well the pavement serves the user. This serviceability index is often referred to as ‘Ride Comfort’, and is a reflection of the pavement condition at a particular time during the service life of the pavement. Pavement distresses that impact a pavement’s functional ability to serve the travelling public include: transverse cracking; potholes; ravelling; as well as heave and swells.

The existing pavement on Winston Churchill Boulevard was considered in excellent condition, with no distresses observed other than construction joint segregation/ ravelling. In consideration of the good functional condition of the existing pavement, rehabilitation treatments for the improvement of the overall rideability are not required at the present time.

However, it should be noted that deterioration of the existing pavement will occur in the interval up to the anticipated start of construction for the pavement widening. Although it is impossible to predict the quantity and severity of pavement distress in the future, it can be expected that the existing functional condition will deteriorate. It is strongly recommended that the pavement conditions on Winston Churchill Boulevard be reviewed prior to finalizing the future pavement widening to determine the extent of pavement rehabilitation required.

5.4.2 Structural Requirements

The structural capacity of a pavement is the physical condition of the roadway that adversely affects the load-carrying capability of the pavement structure. The structural assessment of any roadway is usually evaluated by identifying pavement distresses that indicate structural failure (such as alligator/fatigue cracking and pavement rutting), as well as load/deflection testing.

Although structural deficiencies were not observed during the 2015 pavement condition evaluation, it is expected that as the pavement ages, structural deficiencies will become visible. To determine the structural capacity of the existing pavement, a remaining life analysis was completed.

Remaining Life Analysis

Based on existing pavement structure and traffic volume, an analysis was completed to determine the remaining life of the in-place pavement. The remaining life analysis was completed by determining the structural capacity of the new pavement constructed in 2013 and calculating the amount of structural damage predicted by calculating the amount of ESALs supported since construction. The accumulated ESALs were determined to the anticipated construction years of 2021 and 2031 for the respective sections.

Based on an average pavement structure of 190 mm Asphalt, 150 mm Granular A Base, and 550 mm of Granular B Subbase, the effective structural number after construction was calculated to be 150 mm, which would be able to support 27 million ESALs. A summary of the remaining life analysis results is provided in Table 5.3.

Table 1.3 – Winston Churchill Boulevard Existing Pavement Remaining Life

Segments	Calculated Design ESALs (million)	Total ESALs to Construction Year (million)		Remaining Life
Highway 401 - Steeles Avenue	27.0	9.4	-	13 Years
Steeles Avenue – Maple Lodge Farms	27.0	-	13.3	15 Years
Maple Lodge Farms - Embleton Road	27.0	-	10.8	20 Years

The remaining life analysis indicates that the existing pavement section south of Steeles Avenue will have roughly 13 years of pavement life remaining in 2021. Therefore, pavement strengthening of the existing pavement should be included as part of the pavement widening construction for the existing pavement to provide similar performance as the new 20-year pavement in the widening area.

With the reduced traffic volumes on Winston Churchill Boulevard north of Steeles Avenue, it is expected that roughly half of the structural capacity will be available by the time of anticipated construction in the year 2031. As a results, slight pavement strengthening should be anticipated for the existing pavement as part of the pavement widening construction at that time.

5.4.3 Pavement Rehabilitation Alternatives

The results of the structural analysis found the existing condition of Winston Churchill Boulevard between Highway 401 and Embleton Road is currently in excellent condition; however, as noted above, pavement strengthening should be considered when construction of the pavement widening is completed.

2021 Pavement Rehabilitation – Highway 401 to Steeles Avenue

The results of the remaining life analysis indicate that roughly one third of the structural capacity will be used prior to the anticipated pavement widening construction in 2021. In order to increase the structural capacity of the existing pavement to match the 20-year design life in the widening area, it is recommended that a ‘Mill-and-Overlay’ strategy be implemented. The recommended pavement rehabilitation would include partial depth milling, followed by a two lift asphalt overlay. This strategy would improve the structural capacity of the existing pavement; however, asphalt base repairs may be required to address localized distresses.

2031 Pavement Rehabilitation – Steeles Avenue to Embleton Road

As indicated in Table 5.3, a significant amount of service life will remain in the existing pavement within this segment by the year of 2031 when construction of the 6-lane platform will commence. Therefore, to match the expected service life as the pavement in the widening area, slight pavement strengthening would be required. The recommended strengthening strategy anticipated in 2031 should include 40 mm partial depth milling, with 90 mm asphalt overlay. This strategy would improve the structural capacity of the existing pavement; however, asphalt base repairs may be required to address localized distresses, as described in Section 6.2.1.

6. PAVEMENT RECOMMENDATIONS

The recommendations for pavement rehabilitation and widening of Winston Churchill Boulevard are provided in the ensuing sections. The recommendations provided in this section were developed based on provided traffic information, and the results of the completed field investigation.

6.1 Pavement Widening

It is noted that in all pavement widening areas, the new pavement thickness should match or exceed the thickness of the existing pavement so that positive sub-surface drainage is maintained across the widening area. For this reason, the thickness of the granular subbase has been increased (over the design thickness) to ensure adequate drainage is maintained within the frost penetration depth.

The recommended new pavement structure for all pavement widening areas on Winston Churchill Boulevard should consist of:

40 mm	HL1
150 mm	HDBC (3 lifts)
150 mm	Granular ‘A’ Base
850 mm	Granular ‘B’, Type I Subbase

6.2 Pavement Rehabilitation

6.2.1 Highway 401 to Steeles Avenue

The recommended 2021 rehabilitation strategy for the existing pavement on Winston Churchill Boulevard between Highway 401 and Steeles Avenue include 20 mm partial depth milling followed by the placement of a two lift asphalt overlay. The recommended asphalt materials and layer thickness should consist of:

40 mm	HL1
50 mm	HDBC

As the future pavement condition cannot be predicted at this time, it is recommended that the contract include an item for asphalt base repairs and/or rout and sealing to be completed prior to the placement of the asphalt overlay. For estimating purposes, it is assumed that roughly 5 percent of the existing pavement area may require some sort of treatment. Actual repair quantities should be revised based on pavement inspection made during detailed design, prior to construction.

Steeles Avenue to Embleton Road

The recommended 2031 rehabilitation strategy for the existing pavement on Winston Churchill Boulevard between Steeles Avenue and Embleton Road should consist of 40 mm partial depth milling followed by the placement of a two-lift asphalt overlay. The recommended asphalt materials and layer thickness should consist of:

40 mm	HL1
50 mm	HDBC

As the future pavement condition cannot be predicted at this time, it is recommended that the contract include an item for asphalt base repairs to be completed prior to the placement of the asphalt overlay. For estimating purposes, it is assumed that roughly 10 percent of the existing pavement area may require some sort of treatment. Actual repair quantities should be revised during detailed design, prior to construction.

6.3 Driveways, Entrances, and Access Roads

It is understood that a number of driveways and access roads will be impacted by the construction of the new 6 lane roadway platform. Reinstatement of existing driveways and access roads should match existing conditions. All gravel driveways and residential entrances should be graded and compacted as required with new Granular A Base material. Paved residential entrances should be surfaced with 60 mm of HL1.

Further investigation and analysis should be completed for all commercial entrances to ensure reinstated pavements are adequate to support anticipated truck traffic.

6.4 Bridge Deck and Approach Slabs

It is understood that the existing Highway 407 underpass structure will need to be widened to accommodate the new 6-Lane pavement platform. The recommended pavement surface for the Highway 407 Underpass structure should consist of:

40 mm	HL1
40 mm	HL1
	Waterproofing Membrane

The recommended pavement for the Highway 407 Structure approach slabs (if required) should consist of:

40 mm	Hl1
50 mm	HDBC
	Concrete Base

The thickness of the concrete approach slabs should be determined by the structural team to meet the design requirements for the structure. For pavement design purposes, the minimum concrete thickness for the new approach slab is assumed to be 150 mm.

6.5 Multi-Use Path

It is understood that a multi-use path will be constructed along Winston Churchill Boulevard to accommodate pedestrian traffic and maintenance vehicles. The recommended pavement structure for the construction of this multi-use path is:

40 mm	HL1
50 mm	HDBC
300 mm	Granular A Base

As the location of this path is expected to be behind the curb and gutter along the roadway, the top of subgrade for this path should be slope 3% toward the roadway curbline for improved drainage.

6.6 New Pavement Materials

6.6.1 Asphalt Materials

All Hot Mix Asphalt (HMA) material should meet the requirements of OPSS 310, and Region of Peel Specifications. All asphalt lifts should be placed and compacted to levels between 92 and 96.5 percent of the Marshall Maximum Relative Density (MRD). The recommended asphalt cement grade for all mixes should be PG 64-28 and shall conform to OPSS.MUNI.1101. Aggregates for the asphalt mixes should be in accordance with OPSS.MUNI.1003.

Should the Region consider using Superpave asphalt mixes for this project, the recommended HL1 material should be substituted with a Superpave 12.5FC1 asphalt mix, and the HDBC asphalt material should be replaced with a Superpave 19 asphalt materials. As the 20-year design ESALs for Winston Churchill Boulevard was estimated to be 27 million, a Traffic Category D designation should be used in preparing all Superpave asphalt mix designs.

6.6.2 New Granular Material

All new granular subbase material should consist of OPSS Granular B Type I, while the granular base material should consist of OPSS Granular A. All new granular material should meet the requirements of OPSS.MUNI.1010, OPSS 501, and be compacted to 100 percent of the Standard Proctor Maximum Dry Density (SPMDD) within 2 percent of Optimum Moisture Content (OMC). Granular should be tied into the road drainage system to maintain appropriate drainage.

6.7 Transition Treatments

Smooth transitions are required in all areas where the new pavement meets the existing asphalt surface. All longitudinal and transverse joints should meet the requirements of OPSS 310. All longitudinal joints should be staggered between the asphalt lifts. The staggering of the longitudinal joints should be accomplished by offsetting the paving edge in the upper asphalt course by a minimum of 150 mm.

At the paving limits, the transverse tie-in should be trimmed to a depth of the surface course, full width, to provide a straight clean vertical surface so that the new asphalt material can be placed flush with the top of the existing pavement surface. At all transverse tie-ins to existing pavements, the top lift of asphalt should extend a minimum of 5 m in length beyond the transverse joint in the upper binder lift.

6.8 Pavement Drainage

The new pavement structure should be constructed to provide positive cross lateral drainage at the top of subgrade, as well as at the pavement surface. The top of subgrade should be sloped at a minimum 3 percent grade, while the pavement surface should be constructed with a minimum 2 percent crossfall.

Should curb and gutters be considered in the design of the new pavement platform, they should be constructed in accordance with OPSD 600.040, and Region of Peel standards. Subdrains should be included and conform to Regional standards. Drainage ditches in rural areas (if required) should be constructed in accordance with OPSD 200.010, and be suitable to provide drainage of the subgrade.

6.9 New Alignment Subgrade Preparation

In all areas of pavement widening, the surficial vegetation and topsoil should be removed. The underlying subgrade soils should be graded as required to accommodate the new pavement platform. The exposed subgrade should be compacted and proof-rolled with a heavy roller and examined to identify areas of unstable subgrade. Any soft/wet areas identified should be subexcavated and replaced with approved material within 2 percent of Optimum Moisture Content (OMC), and compacted to at least 98 percent of Standard Proctor Maximum Dry Density (SPMDD).

The sandy silt with clay subgrade soils are susceptible to softening when exposed to excessive moisture or disturbance. Accordingly, appropriate drainage should be provided to maintain a reasonable dry subgrade and construction traffic should not be allowed on any wet areas. Construction traffic on the approved subgrade should be avoided unless there is adequate granular cover to support the temporary loading.

Wet soils should be anticipated in the area of existing creeks, culverts, and ditches. A contingency should be made in the construction contract for additional subexcavation or alternatively scarifying, moisture conditioning, and re-compaction of any upper wet zones of soil.

6.10 Culverts

As part of the proposed road widening of Winston Churchill Boulevard, eleven (11) concrete culverts may require extension, as listed in Table 6.1 in Section 6.10.1.

The stratigraphy encountered at the subgrade level in the reference boreholes closest to each culvert is listed in Table 6.1, but generally consisted of stiff to hard silty clay to clayey silt till.

6.10.1 Foundation Design

The bases of the culvert extensions should be placed at the same level or lower than the existing culvert bases, and footings should be founded on native stiff to hard silty clay to clayey silt till. The concrete pipe culvert extensions should be placed on a minimum 300 m thick layer of bedding material consisting of OPSS Granular A or Granular B Type II, as per OPSD 802.010.

Concrete open box or headwall footings subject to freezing temperatures must be provided with a minimum earth cover of 1.2 m or equivalent thermal insulation as protection against frost action. During construction, the footing bases should be kept free of water and a 75 mm skim slab of concrete should be provided over the founding surface if structural concrete cannot be placed within 24 hours of excavation.

The culvert footings must be positioned below the maximum anticipated depth of scour or otherwise protected from undermining by stream erosion.

For installation of culvert and headwall footings placed on undisturbed till or compacted granular backfill, reference should be made to OPSS 400 series and OPSD 802 and 804 series, as appropriate.

All existing fill, topsoil, organic/streambed deposits and soft/loose soils should be removed from the culvert subgrade prior to placement of the culvert bedding material. Inspection and approval of the exposed base by a geotechnical engineer is recommended. The grade should be raised in sub-excavated areas if necessary using Granular A backfill, compacted to 100% of SPMDD.

The anticipated culvert subgrade conditions and recommended design bearing resistances for concrete culvert or headwall footings, if applicable, are presented in Table 6.1, based on minimum footing widths of 0.6 m for headwalls and 1.5 m for culverts. Footing widths should match the existing footings for uniform behaviour.

Table 6.1 – Recommended Culvert and Headwall Bearing Resistances

Culvert Location	Type and Dimensions	Existing Invert Elev. (m)	Reference Boreholes	Anticipated Footing Elev. (m)	Anticipated Subgrade	Factored Bearing Resistance at ULS (kPa)	Bearing Resistance at SLS (kPa)
Sta. 1+145	600 mm dia. concrete pipe, 35 m long	206.1 to 205.7	08-3	204.9 to 204.5*	Very stiff silty clay till	225	150
Sta. 1+432 (Mullet Creek)	10.4 x 2.4 m concrete open box	203.6 to 203.2	08-5, 08-6, 09-1, 09-2	202.4	Hard silty clay till	375	250
Sta. 2+300	500 mm dia. concrete pipe, 32 m long	207.5	08-11, 09-3	206.3*	Stiff to hard silty clay to clayey silt till	225	150
Sta. 2+415	600 mm dia. concrete pipe, 24.2 m long	206.3 to 206.2	09-3	205.1 to 205.0*	Hard silty clay till	375	250
Sta. 2+604 (Levi Creek South)	5.5 x 2.4 m concrete open box	204.4 to 204.0	08-12, 08-13, 09-4, 09-5	203.7	Stiff to hard silty clay to clayey silt till	150	100
Sta. 2+864	600 mm dia. concrete pipe, 20 m long	206.2 to 206.0	09-6	205.0 to 204.8*	Very stiff to hard silty clay till	225	150
Sta. 3+013	600 mm dia. concrete pipe, 20.2 m long	206.2 to 205.8	08-14, 08-15	205.0 to 204.6*	Hard silty clay till	375	250
Sta. 3+227	600 mm dia. concrete pipe, 20 m long	206.5 to 205.2	09-7 (log missing), 08-14	205.3 to 204.0*	Very stiff to hard silty clay till	225	150
Sta. 3+414	600 mm dia. concrete pipe, 23.2 m long	207.0 to 206.8	09-8 (log missing), 08-16	205.8 to 205.6*	Very stiff to hard silty clay to clayey silt till	225	150

Culvert Location	Type and Dimensions	Existing Invert Elev. (m)	Reference Boreholes	Anticipated Footing Elev. (m)	Anticipated Subgrade	Factored Bearing Resistance at ULS (kPa)	Bearing Resistance at SLS (kPa)
Sta. 3+533 (Levi Creek North)	11 x 2.4 m concrete open box	206.8 to 206.5	08-16, 08-17, 09-9	205.5	Very stiff to hard silty clay to clayey silt till	225	150
Sta. 3+745	1200 mm dia. concrete pipe, 23.7 m long	206.1 to 205.7	09-10	204.9 to 204.5*	Hard silty clay till	375	250

* Headwall

The bearing values provided are for vertical, concentric loads only. Effects of load inclination and eccentricity must be considered.

Horizontal resistance against sliding may be developed by frictional resistance between the concrete culvert base and the underlying soil. For cast-in-place concrete, an ultimate friction factor of 0.4 is recommended on stiff to hard silty clay till. A suitable safety factor should be applied to this value.

Frost tapers should be provided as per OPSD 803.030 and 803.031.

Applicable comments regarding excavation and groundwater control during culvert installation are presented in Section 6.11.

6.10.2 Backfill and Lateral Earth Pressures

Backfill to the culverts and any headwalls should consist of free-draining, non-frost susceptible granular materials conforming to OPS Granular A or Granular B Type II requirements. Reference should be made to the backfill arrangements stipulated in OPSD 802 series, 803.010, 3121.150 and 3190.100, as appropriate.

The lateral earth pressures acting on the culvert (and any headwalls), assuming full drainage from behind the walls, may be computed using the following pressure distribution:

$$p = K(\gamma H + q)$$

where p = lateral earth pressure acting at depth H, kPa

K = earth pressure coefficient (see Table 6.2 below)

γ = unit weight of retained soil or backfill, kN/m^3 (see Table 6.2 below)

H = depth below top of wall where pressure is computed, m

q = surcharge pressure including traffic loads, kPa

Table 6.2 lists the unfactored parameters recommended for design, for an essentially level ground surface or for sloping backfill (2H:1V) behind and in front of the culvert and walls:

Table 6.2 – Earth Pressure Parameters

Parameter	**Retained Material**			
	OPSS Granular A or Granular B Type II		**OPSS Granular B Type I**	
	Horizontal Surface Behind Wall	**Sloping Backfill (2H:1V)**	**Horizontal Surface Behind Wall**	**Sloping Backfill (2H:1V)**
Unit Weight, kN/m^3	22.8	22.8	21.2	21.2
Friction Angle, degrees	35	35	32	32
Active Pressure Coefficient, K_a	0.27	0.38	0.31	0.46
At-Rest Pressure Coefficient, K_0	0.43	-	0.47	-
Passive Pressure Coefficient, K_p	3.7	-	3.3	-

If lateral movement is not permissible and/or the wall is restrained from lateral yielding, the at-rest pressure coefficient, K_o, should be used. If the wall design allows lateral yielding (non-rigid structure), the active earth pressure coefficient, K_a, may be used.

The earth pressure coefficients in the table above do not include potential compaction effects that must be included in the design. Compaction effects should be considered as per the Canadian Highway Bridge Design Code (CHBDC).

Wall backfill should be placed in maximum 200 mm loose lifts and compacted to 95% of the material's SPMDD. The backfill should be placed and compacted in simultaneous equal lifts on both sides of the culvert, and the top of the backfill elevation should be the same on both sides of the culvert at all times. Heavy compaction equipment should not be used adjacent to the walls and roof of the culvert or headwalls.

Design of the culvert headwalls must incorporate measures such as weepholes as per OPSD 3190.100 to permit drainage of the backfill and avoid potential build-up of hydrostatic pressures behind the walls.

6.10.3 Erosion and Scour Protection

Erosion protection should be provided at the new culvert inlet and outlet areas. Rip rap or other protective measures should be established on the creek banks to protect against surficial erosion and seepage-induced material loss. Design of the scour and erosion protection measures must consider hydrologic/hydraulic factors. Slopes should be protected from erosion in accordance with OPSS 805.

A concrete/steel cut-off wall or clay seal should be installed at the culvert inlets to minimize the potential for seepage through the granular bedding and backfill material and avoid consequent erosion of these materials. The clay seal should have a minimum thickness of 0.5 m, completely surround the culverts, extend laterally the width of the granular backfill material, and extend above the high-water level. The material used for the clay seal should conform to the requirements of OPSS 1205. Frost treatment for the concrete culverts should be done as per OPSD 803.010.

6.11 Excavation and Groundwater Control

Excavations for culvert foundations and open cut installation of sewers will primarily extend through the existing roadway pavement structure and into native silty clay to clayey silt till deposits. Provision should be made for handling and removal of possible obstructions in the fill and cobbles or boulders in the till soils. Use of a suitable hydraulic excavator for excavation within these materials is required.

All temporary excavations must be carried out in accordance with the current Occupational Health and Safety Act (OHSA) of Ontario and regulations. In general, the pavement and fill is classified as Type 3 soil and the native silty clay to clayey silt till is classified as Type 2.

Where space restrictions preclude excavation of inclined slopes, sewer installation may be carried out using a trench box or temporary shoring. Where the trench depth exceeds 6 m, the support system must be designed by a Professional Engineer specifically for this project.

The design of all members of the support system should include the effects of surcharge loads such as those imposed by construction equipment and highway traffic. Soil should not be stockpiled within a horizontal distance from the excavation wall equal to the depth of excavation.

Groundwater was measured at depths of 0.1 to 2.0 m below the ground surface at piezometers installed near the creek crossings. Considering the predominantly cohesive soils on site, dewatering of shallow excavations should generally be feasible using sumps and pumps. However, concentrated seepage and instability of the trench walls and base may be experienced where cohesionless layers are encountered below the groundwater level. Further, localized zones of perched water may be encountered in the fill and at the culvert locations. Additional pumps or other dewatering measures may be required dependent on the conditions at a particular location.

Surface water runoff and stream flow should be diverted away from the culvert excavations at all times during construction.

6.12 Storm Sewer Installation

New storm sewers may be included along Winston Churchill Boulevard as part of the road widening. Excavations and control of groundwater for sewer installations should follow the recommendations provided in Section 6.11.

Prior to placement of the pipe bedding, the base of the sewer trench should be maintained in a dry condition, free of loose or disturbed material. The pipe must be placed on a uniformly competent subgrade. Pipe bedding materials, compaction and cover should follow OPSD 802.030 to 803.034, and/or Region of Peel specifications.

In areas where a less competent subgrade is encountered, it may be necessary to increase the sewer bedding thickness. Any excessively soft, loose or compressible materials at the pipe subgrade should be subexcavated and replaced with OPS Granular A material compacted to at least 95% of SPMDD.

Trench backfill materials should be placed and compacted as per OPSS.MUNI 401. Where the sewer trench is located beneath the roadway, compacted OPSS Granular A or B material, or unshrinkable fill should be employed as backfill.

Where the sewer trench is located outside of the roadway, the portion of the trench above the pipe cover can be backfilled with excavated till provided it is unfrozen and free of organics, debris and other deleterious materials. The placement moisture content should be within about 2% of the OMC for efficient compaction, and the till must be adequately broken down, spread in horizontal lifts, and compacted in the trench.

6.13 Corrosion Potential of Soils

A sample of the base/subbase fill soil (sand, some gravel, some silt) at station 2+000 was submitted to AGAT Laboratories for corrosivity analysis to evaluate the potential for corrosion to metal pipes and fittings, as well as sulphate attack on concrete. The sample ID for the laboratory test was BH15-08, 220-860. The results of the testing are included in Appendix F. The test results indicate the following:

- The potential for sulphate attack on concrete pipes and foundations from the surrounding soil is considered to be low due to the low concentration of sulphate in the sample tested.
- The low resistivity results indicate that there is a potential for corrosion to steel or other metals.
- If metal structural elements are used on the project, appropriate corrosion protection measures should be provided.

6.14 Management of Excess Materials

In order to assess the options for reuse or disposal of excess materials generated during construction, selected samples of the fill and native soils were submitted to AGAT Laboratories for analytical testing of metal and inorganic (M&I) parameters in Ontario Regulation 153/04, as amended, and for the toxicity characteristic leaching procedure (TCLP) analysis of Ontario Regulation 558/00. The results of the testing are included in Appendix F. The samples tested are outlined below:

Sample ID	Location and Depth	Soil Type	Test Conducted
BH15-04, 200-900	Sta. 1+200, 200-900 mm	Granular Fill	Reg 153 M&I
BH15-17, 1500-2100	Sta. 3+800, 1500-2100 mm	Sand silt with clay	Reg 153 M&I
BH15-12, 100-870	Sta. 2+900, 100-870 mm	Granular Fill	Reg 153 M&I
BH15-13, 430-900	Sta. 3+100, 430-900 mm	Granular Fill	Reg 153 M&I
BH15-30, 1500-2100	Sta. 1+600, 1500-2100 mm	Sandy silt, trace clay	Reg 153 M&I
BH15-08, 220-860	Sta. 2+000, 220-860 mm	Granular Fill	Reg 153 M&I
BH15-25, 1800-2100	Sta. 2+600, 1800-2100 mm	Sandy silt with clay	Reg 153 M&I
BH15-24, 1500-2100	Sta. 2+900, 1500-2100 mm	Sandy silt with clay	Reg 588 M&I
BH15-03, 190-1080	Sta. 1+100, 190-1080 mm	Granular Fill	Reg 588 M&I
BH15-18, 160-1200	Sta. 4+000, 160-1200 mm	Granular Fill	Reg 588 M&I

The applicable analytical results were compared to Table 2 (Full Depth Generic Site Condition Standards in a Potable Groundwater Condition) of O.Reg. 153/04, as amended. The concentrations of all parameters met the standards established in Table 2 of the Regulation for Industrial, Commercial and Community land use, with the exception of Electrical Conductivity (EC) and Sodium Adsorption Ratio (SAR) in three samples (BH15-17, BH 15-12, and BH 15-25). The EC and SAR values are believed to reflect the effects of road de-icing salt, and may impact vegetation growth if placed near the surface of a receiving site.

The applicable TCLP analytical results were compared to the leachate quality criteria presented in Schedule 4 of O.Reg. 558/00. The concentrations of all parameters tested were below the criteria.

Based on the available subsurface information and the analytical results of selected samples, excess materials from the site may generally be classified as a “non-subject waste” in accordance with O.Reg. 558/00 and disposed of at a suitable receiving site or reused on-site.

Should materials require off-site disposal, the acceptance criteria stipulated by individual fill receivers may vary, and some receivers may require that all results meet the stringent Table 1 background standards of O.Reg. 153/04, as amended, or other specified criteria.

Excavated asphalt should be disposed of appropriately off-site. While disposing of off-site, asphalt should not be mixed with excess excavated soil; some fill receivers may not accept excess excavated soils if they contain asphalt.

Excavated native soils free from boulders, deleterious material, and organics may be reused on site for general fill purposes subject to geotechnical approval.

6.15 Construction Inspection and Testing

It is recommended that geotechnical inspection and testing by qualified personnel be provided during construction. The inspection and testing should include observation and inspection of sewer trench, culvert, and pavement subgrade conditions, compaction testing of backfill and pavement materials, as well as concrete and asphalt testing.

7. CLOSURE

Full time supervision of the field activities including obtaining utility clearances and direction of the drilling operations was provided by experienced Thurber personnel, while pavement coring, drilling and sampling equipment was supplied and operated by DBW Drilling Ltd. The FWD testing and analysis for this investigation was completed by Applied Research Associates Inc., with the pavement structure information provided by Thurber.

The analysis presented in this report is based on available information and design inputs provide by HMM and the Region of Peel. The provided information was supplemented by a field investigation program and Thurber's experience with the project area and similar projects of this type. We note any changes in materials, or construction procedures, may have a significant impact on assumptions made for the purposes of developing the recommended pavement designs. It is strongly suggested that all materials and construction practices be completed in accordance with Region of Peel and Ontario standards and specifications.

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of 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 THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

APPENDIX A

BOREHOLE LOCATION PLAN

LEGEND

- ⊕ APPROX. BOREHOLE LOCATION (CURRENT INVESTIGATION)
- ● APPROX. BOREHOLE LOCATION (PREVIOUS INVESTIGATIONS)
- ▲ APPROX. TESTPIT LOCATION (CURRENT INVESTIGATION)
- 1+000 CENTRELINE STATIONING BASED ON REGION OF PEEL'S 2010 AS-BUILT CONSTRUCTION DRAWINGS

HATCH MOTT MACDONALD

EA FOR WINSTON CHURCHILL
BOULEVARD WIDENING
BOREHOLE LOCATION PLAN

JOB# 19-1605-196

THURBER ENGINEERING LTD.

ENGINEER :	DRAWN :	APPROVED :
RI	MFA/AN	MRA
DATE :	SCALE :	DRAWING No.
MAY 2016	1:1000	19-1605-196-1

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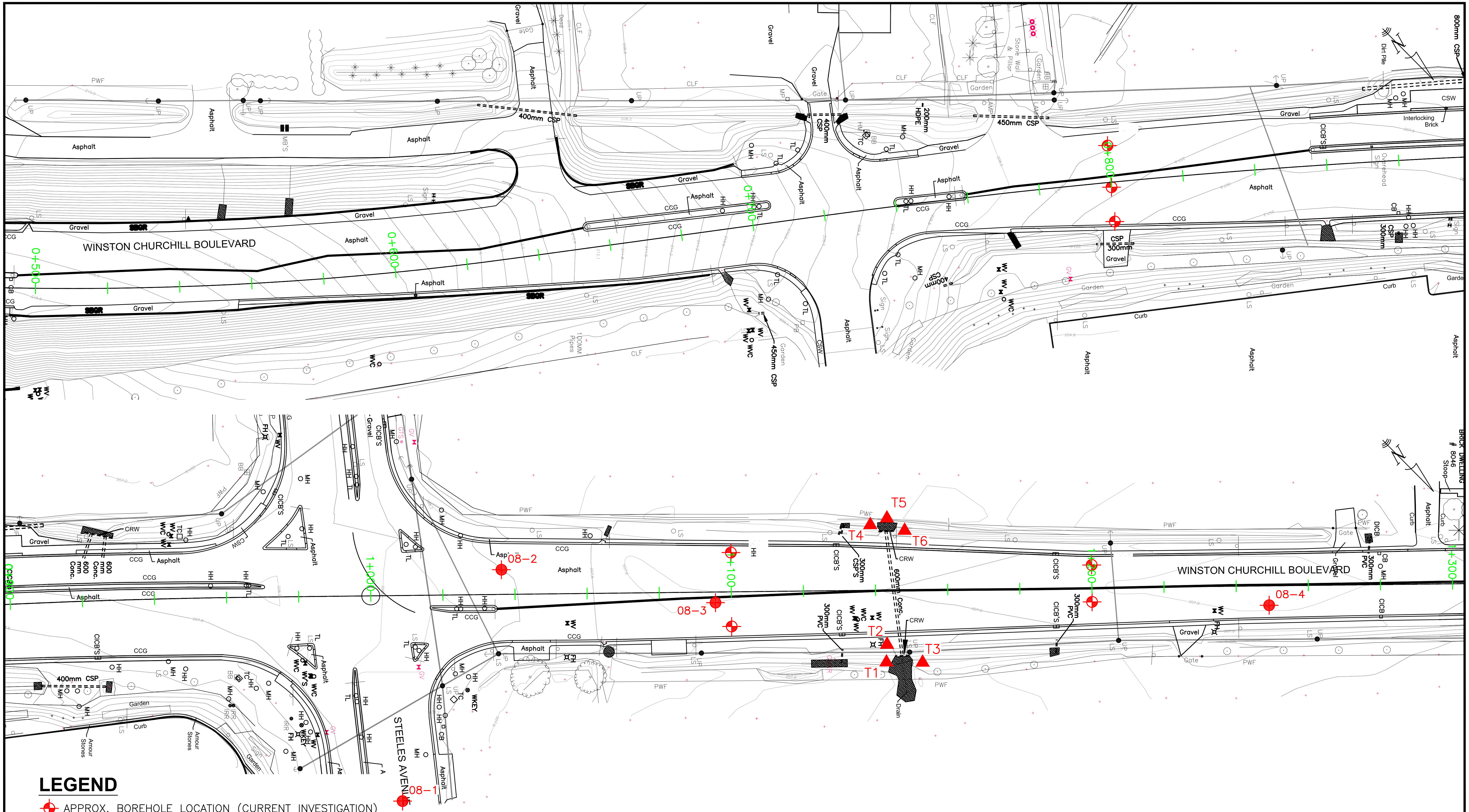
PLOTDATE: May 10, 2016 - 4:30 PM



LEGEND

APPROX. BOREHOLE LOCATION (CURRENT INVESTIGATION)

APPROX. BOREHOLE LOCATION (PREVIOUS INVESTIGATIONS)

APPROX. TESTPIT LOCATION (CURRENT INVESTIGATION)

1+000 CENTRELINE STATIONING BASED ON REGION OF PEEL'S 2010 AS–BUILT CONSTRUCTION DRAWINGS

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HATCH MOTT MACDONALD

EA FOR WINSTON CHURCHILL
BOULEVARD WIDENING
BOREHOLE LOCATION PLAN

JOB# 19-1605-196

THURBER ENGINEERING LTD.

ENGINEER :	DRAWN :	APPROVED :
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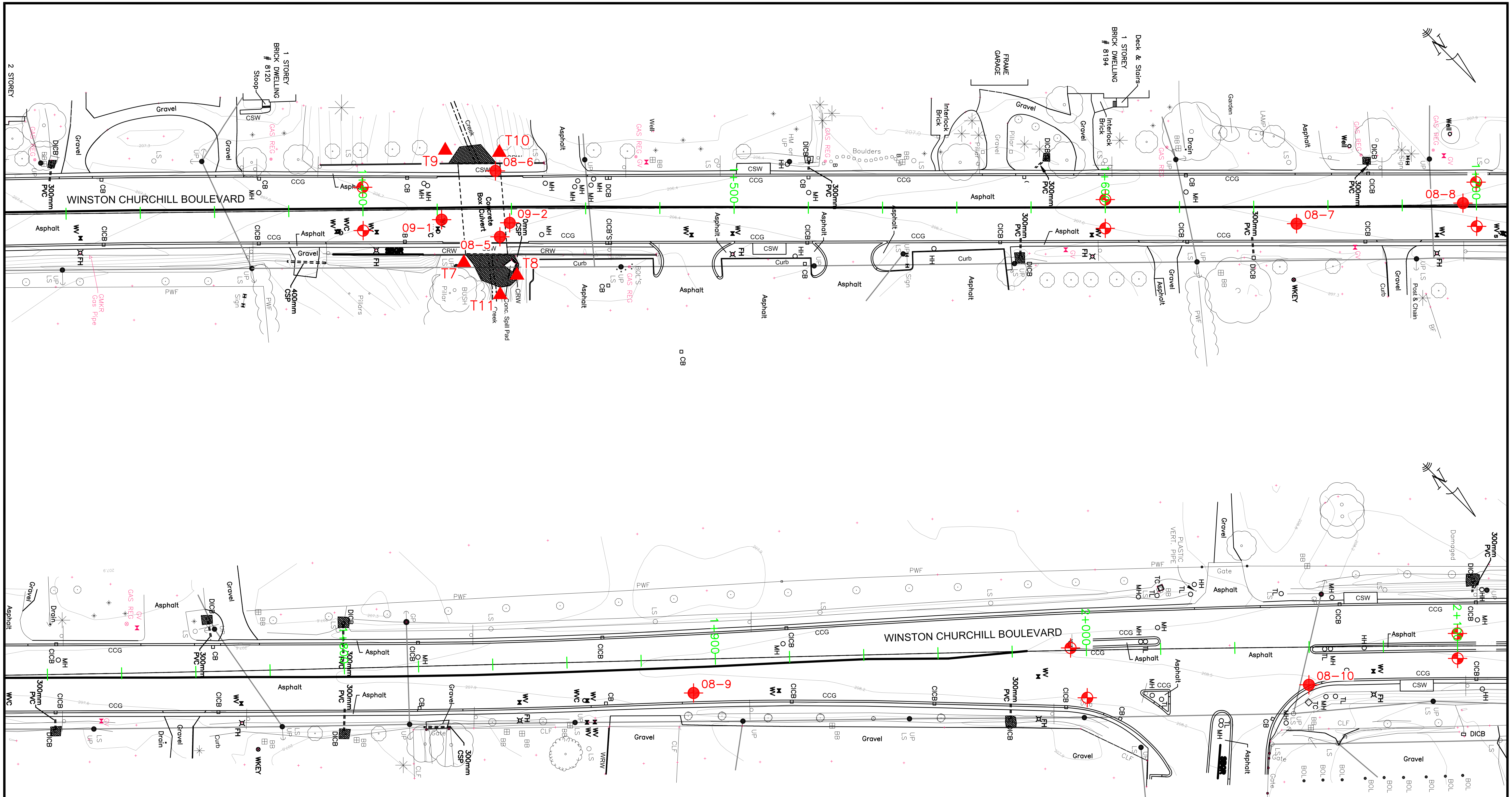

LEGEND

⊕ APPROX. BOREHOLE LOCATION (CURRENT INVESTIGATION)

● APPROX. BOREHOLE LOCATION (PREVIOUS INVESTIGATIONS)

▲ APPROX. TESTPIT LOCATION (CURRENT INVESTIGATION)

1+000 CENTRELINE STATIONING BASED ON REGION OF PEEL'S 2010 AS–BUILT CONSTRUCTION DRAWINGS

20 0 20 40m
SCALE 1:1000

HATCH MOTT MACDONALD

EA FOR WINSTON CHURCHILL
BOULEVARD WIDENING
BOREHOLE LOCATION PLAN

JOB# 19-1605-196

THURBER ENGINEERING LTD.

ENGINEER :	DRAWN :	APPROVED :
RI	MFA/AN	MRA
DATE :	SCALE :	DRAWING No.
MAY 2016	1:1000	19-1605-196-3

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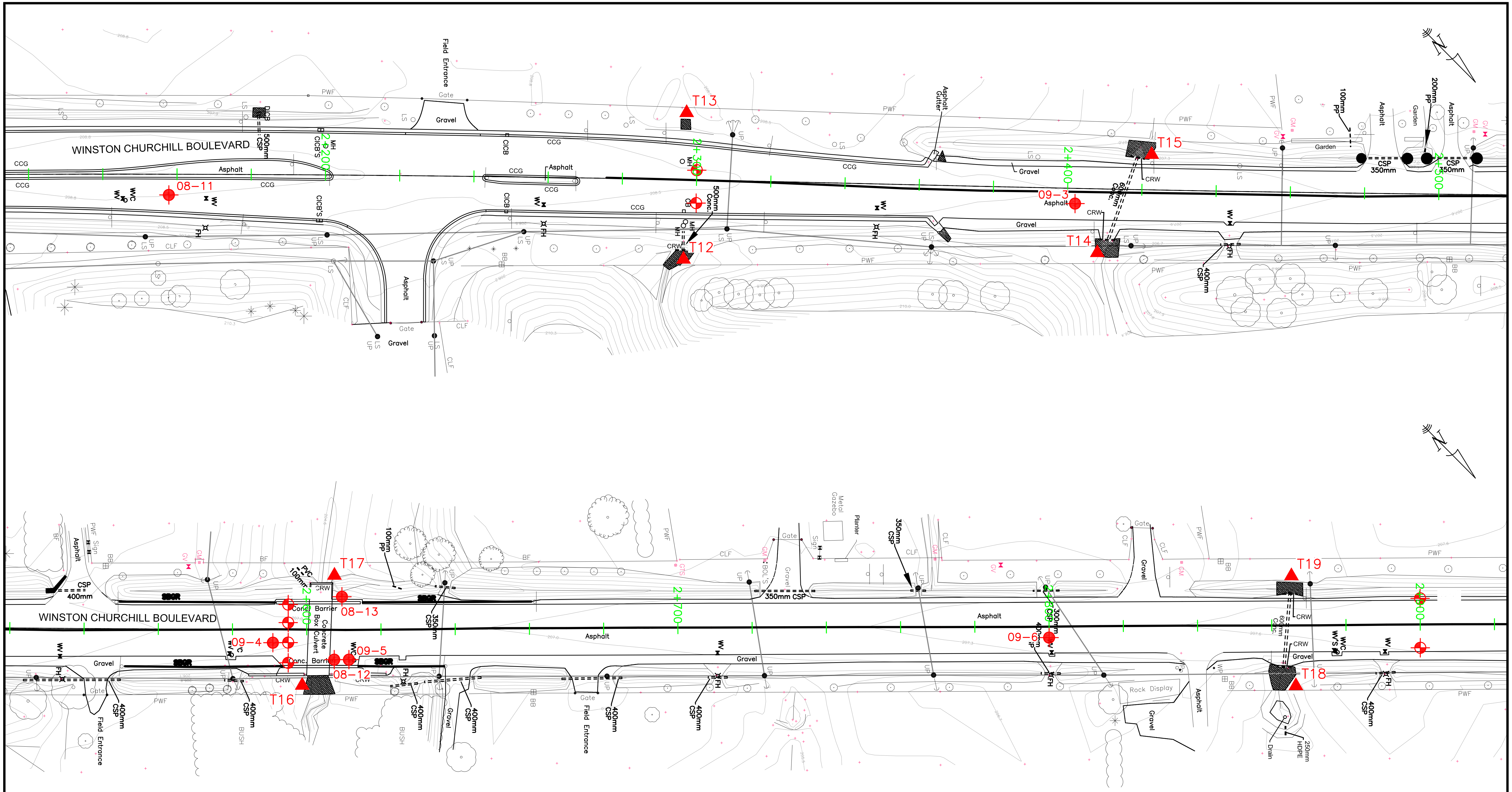

LEGEND

⊕ APPROX. BOREHOLE LOCATION (CURRENT INVESTIGATION)

● APPROX. BOREHOLE LOCATION (PREVIOUS INVESTIGATIONS)

▲ APPROX. TESTPIT LOCATION (CURRENT INVESTIGATION)

1+000 CENTRELINE STATIONING BASED ON REGION OF PEEL'S 2010 AS–BUILT CONSTRUCTION DRAWINGS

20 0 20 40m

SCALE 1:1000

HATCH MOTT MACDONALD

EA FOR WINSTON CHURCHILL
BOULEVARD WIDENING
BOREHOLE LOCATION PLAN

JOB# 19-1605-196

THURBER ENGINEERING LTD.

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RI	MFA/AN	MRA
DATE :	SCALE :	DRAWING No.
MAY 2016	1:1000	19-1605-196-4

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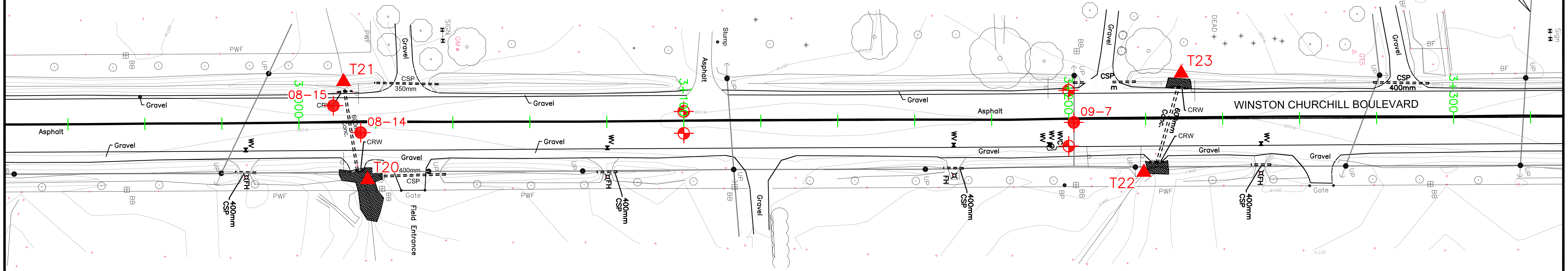

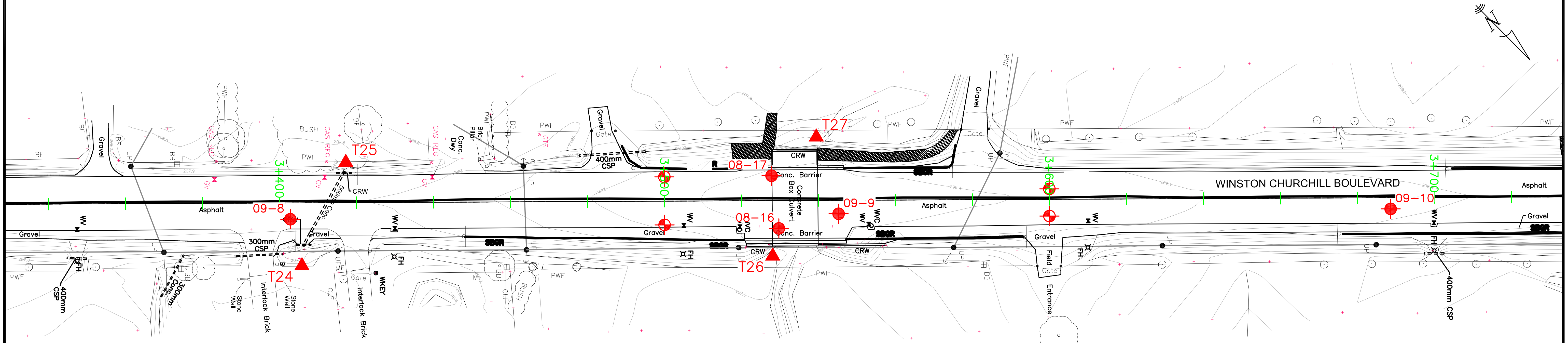

LEGEND

⊕ APPROX. BOREHOLE LOCATION (CURRENT INVESTIGATION)

● APPROX. BOREHOLE LOCATION (PREVIOUS INVESTIGATIONS)

▲ APPROX. TESTPIT LOCATION (CURRENT INVESTIGATION)

1+000 CENTRELINE STATIONING BASED ON REGION OF PEEL'S 2010 AS–BUILT CONSTRUCTION DRAWINGS

20 0 20 40m
SCALE 1:1000

HATCH MOTT MACDONALD

EA FOR WINSTON CHURCHILL
BOULEVARD WIDENING
BOREHOLE LOCATION PLAN

JOB# 19-1605-196

THURBER ENGINEERING LTD.

ENGINEER :	DRAWN :	APPROVED :
RI	MFA/AN	MRA
DATE :	SCALE :	DRAWING No.
MAY 2016	1:1000	19-1605-196-5

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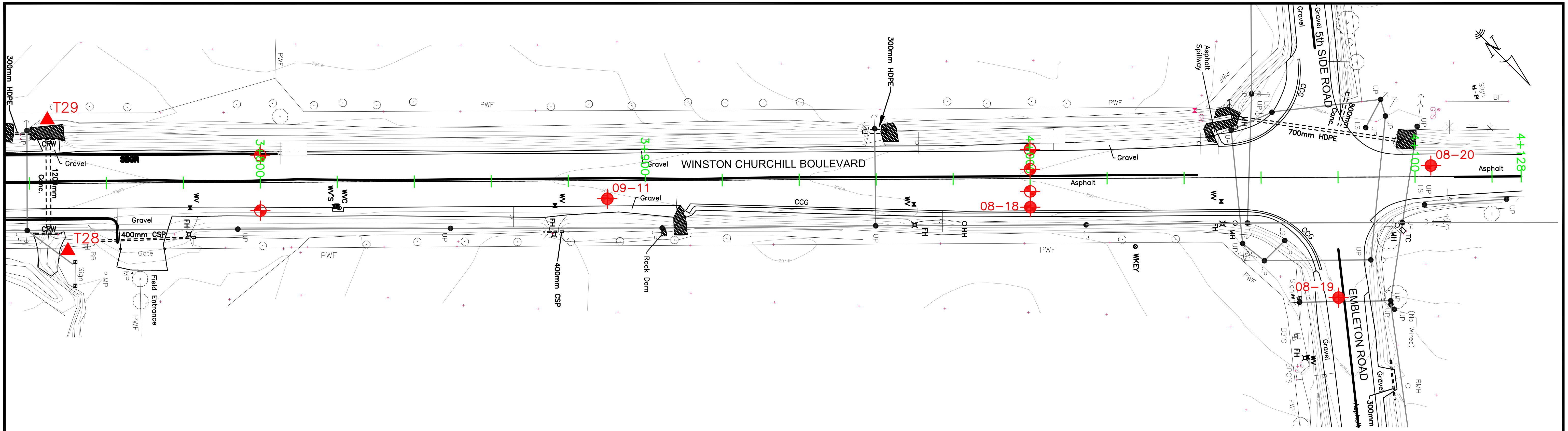
PLOTDATE: May 10, 2016 - 4:33 PM



LEGEND

⊕ APPROX. BOREHOLE LOCATION (CURRENT INVESTIGATION)

● APPROX. BOREHOLE LOCATION (PREVIOUS INVESTIGATIONS)

▲ APPROX. TESTPIT LOCATION (CURRENT INVESTIGATION)

1+000 CENTRELINE STATIONING BASED ON REGION OF PEEL'S 2010 AS–BUILT CONSTRUCTION DRAWINGS

20 0 20 40m
SCALE 1:1000

HATCH MOTT MACDONALD

EA FOR WINSTON CHURCHILL
BOULEVARD WIDENING
BOREHOLE LOCATION PLAN

JOB# 19-1605-196

THURBER ENGINEERING LTD.

ENGINEER :	DRAWN :	APPROVED :
RI	MFA/AN	MRA
DATE :	SCALE :	DRAWING No.
MAY 2016	1:1000	19-1605-196-6

FILENAME: H:\Drafting\19\1605\196\ted5196-BoreholePlans2.dwg
PLOTDATE: May 10, 2016 - 4:34 PM

THURBER

APPENDIX B

PHOTOGRAPHS OF TYPICAL CONDITIONS

Appendix B
Winston Churchill Boulevard Class EA Study
Highway 401 to Embleton Road
Photographs of Typical Conditions

Typical Photograph #1
Winston Churchill Boulevard Northbound at Station 0+944
(Looking Northerly)

Typical Photograph #2
Winston Churchill Boulevard Northbound at Station 1+400
(Looking Northerly)

Appendix B
Winston Churchill Boulevard Class EA Study
Highway 401 to Embleton Road
Photographs of Typical Conditions

Typical Photograph #3
Winston Churchill Boulevard Northbound at Station 2+900
(Looking Northerly)

Typical Photograph #4
Winston Churchill Boulevard Northbound at Station 3+750
(Looking Northerly)

Appendix B
Winston Churchill Boulevard Class EA Study
Highway 401 to Embleton Road
Photographs of Typical Conditions

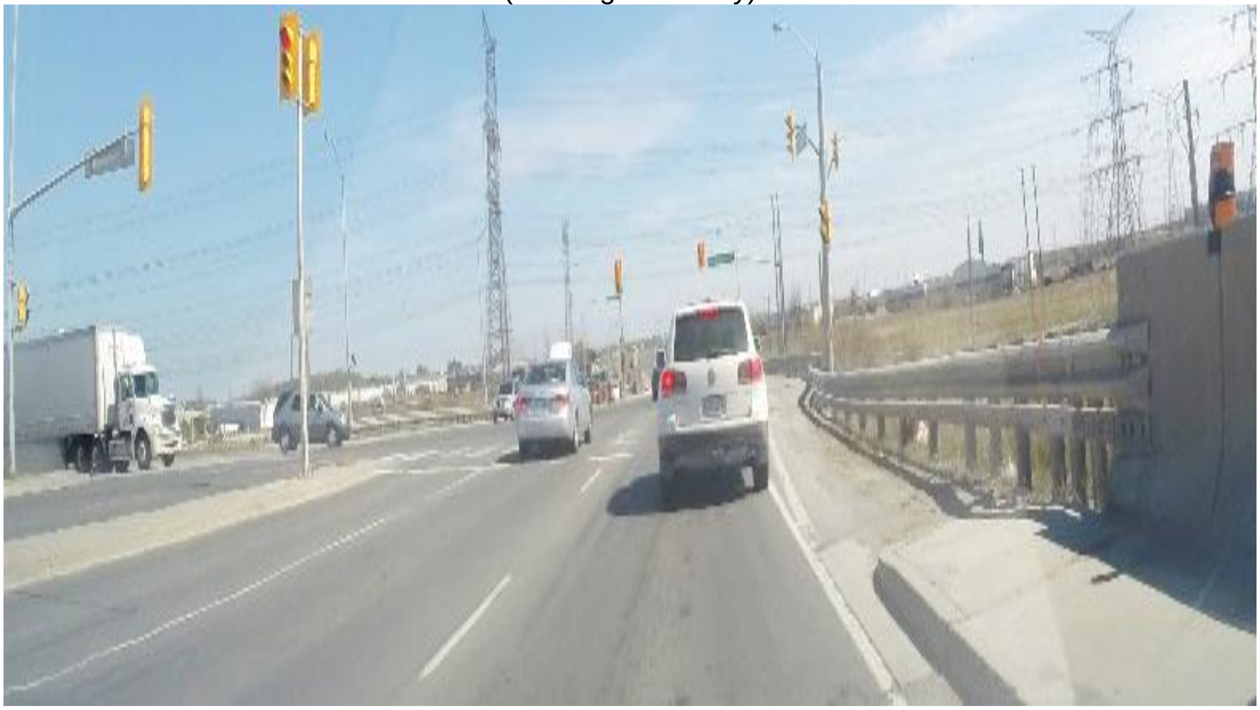
Typical Photograph #5
Winston Churchill Boulevard Southbound at Station 3+800
(Looking Southerly)

Typical Photograph #6
Winston Churchill Boulevard Southbound at Station 2+900
(Looking Southerly)

Appendix B
Winston Churchill Boulevard Class EA Study
Highway 401 to Embleton Road
Photographs of Typical Conditions

Typical Photograph #7
Winston Churchill Boulevard Southbound at Station 1+700
(Looking Southerly)

Typical Photograph #8
Winston Churchill Boulevard Southbound at Station 0+300
(Looking Southerly)



THURBER

APPENDIX C

PAVEMENT BOREHOLE LOGS AND TEST PIT SUMMARY

Appendix C
Winston Churchill Boulevard Class EA Study
Highway 401 to Embleton Road
Borehole Logs

January 14, 2016

Station 00+300 NB RTL

0- 200	Asph	

End of BH Due to Overhead Utility Conflict

Station 00+300 NB Lane 2

0- 170	Asph	

End of BH Due to Overhead Utility Conflict

Station 00+300 SB OSH

0- 220	Asph	
220- 920	Gry Sa(y) Gr Tr Si	Moist
920- 1.5	Br Sa(y) Si W Cl	Moist

Station 00+800 NB Lane 1

0- 200	Asph	
200- 780	Gry Sa(y) Gr Tr Si	Moist
780- 1.5	Br Si W Sa W Cl	Moist

Station 00+800 NB RTL

0- 100	Asph	
100- 870	Br Sa(y) Gr Tr Si	Dry
		w @ 0.6m = 4%
870- 1.5	Br Si W Sa W Cl	Dry
1.5- 2.1	Br Si W Sa W Cl (Stiff)	Dry
	Nvalue=9 blows / 300mm	
		w @ 1.8m = 20%

Station 00+800 SB Lane 2

0- 170	Asph	
170- 540	Gry Sa(y) Gr Tr Si	Dry
540- 1.0	Blk Gr(y) Sa Tr Si (Rap)	Moist
		w @ 0.8m = 5%
1.0 1.5	Br Sa(y) Si W Cl	Moist

Station 01+100 NB Lane 2

0- 190	Asph	
190- 1.1	Br Sa(y) Gr Tr Si	Dry
		w @ 0.5m = 3%
		Percent Passing 4.75 mm = 33%
		75 µm = 2%
		Slightly Coarser Than Granular A
1.1- 1.5	Br Si W Sa W Cl	Moist
1.5- 2.1	Br Si W Sa W Cl (V Stiff)	Moist
	Nvalue=20 blows / 300mm	
		w @ 1.8m = 13%
		Percent Passing 4.75 mm = 96%
		75 µm = 72%
		5 µm = 27%
		Frost Susceptibility = MFSH
		Soil Erodibility = 0.28

Station 01+100 SB RTL

0- 200	Asph	
200- 890	Br Sa(y) Gr Tr Si	Dry
		w @ 0.5m = 4%
890- 1.5	Br Sa(y) Si W Cl	Moist
1.5- 2.1	Br Sa(y) Si W Cl (Stiff)	Moist
	Nvalue=14 blows / 300mm	
		w @ 1.8m = 15%

Station 01+200 NB Lane 1

0- 200	Asph	
200- 900	Gry Sa(y) Gr Tr Si	Dry
		w @ 0.4m = 3%
900- 1.5	Br Si W Sa W Cl	Moist
1.5- 2.1	Br Si W Sa W Cl(V Stiff)	Moist
	Nvalue=20 blows / 300mm	
		w @ 1.8m = 13%

Station 01+200 SB Lane 2

0- 200	Asph	
200- 900	Gry Sa(y) Gr Tr Si	Dry
900- 1.5	Br Sa(y) Si W Cl	Moist

Station 01+400 NB Lane 2

0- 200	Asph	
200- 900	Gry Sa(y) Gr Tr Si	Dry
900- 1.5	Br Si W Sa W Cl	Moist

Station 01+400 SB Lane 2

0- 200	Asph	
200- 1.1	Gry Sa(y) Gr Tr Si	Dry
1.1- 1.5	Br Sa(y) Si W Cl	Moist

Station 01+600 NB Lane 2

0- 200	Asph	
200- 930	Gry Sa(y) Gr Tr Si	Dry
930- 1.5	Br Si W Sa W Cl	Moist

Station 01+600 SB Lane 1

0- 200	Asph	
200- 960	Gry Sa(y) Gr Tr Si	Dry
		w @ 0.6m = 3%
960- 1.5	Br Sa(y) Si Tr Cl	Moist
1.5- 2.1	Br Sa(y) Si Tr Cl (Compact)	Moist
	Nvalue=24 blows / 300mm	
		w @ 1.8m = 11%
		Percent Passing 4.75 mm = 94%
		75 µm = 53%
		5 µm = 9%
		Frost Susceptibility = MFSH
		Soil Erodibility = 0.31

THURBER

Appendix C
Winston Churchill Boulevard Class EA Study
Highway 401 to Embleton Road
Borehole Logs

January 14, 2016

Station 01+700 NB Lane 2

0- 200	Asph	
200- 930	Gry Sa(y) Gr Tr Si	Dry
930- 1.5	Br Sa(y) Si W Cl	Moist

Station 01+700 SB Lane 2

0- 190	Asph	
190- 920	Gry Sa(y) Gr Tr Si	Dry
920- 1.5	Br Sa(y) Si W Cl	Moist

Station 02+000 NB RTL

0- 220	Asph	
220- 860	Gry Sa Some Gr Some Si	Dry
		w @ 0.5m = 2%
		Percent Passing 4.75 mm = 87%
		75 µm = 15%
		Slightly Finer Than Granular B Type I
860- 1.5	Br Sa(y) Si W Cl	Dry
1.5- 2.1	Br Sa(y) Si W Cl (V Stiff)	Moist
	Nvalue=20 blows / 300mm	
		w @ 1.8m = 11%

Station 02+000 SB Lane 2

0- 200	Asph	
200- 960	Gry Sa(y) Gr Tr Si	Moist
		w @ 0.6m = 2%
960- 1.5	Br Sa(y) Si Tr Cl	Moist
1.5- 2.1	Br Sa(y) Si Tr Cl (Compact)	Moist
	Nvalue=25 blows / 300mm	
		w @ 1.8m = 11%

Station 02+100 NB Lane 1

0- 200	Asph	
200- 400	Br Sa(y) Gr Tr Si	Moist
400- 1.2	Gry Sa Some Gr Some Si	Moist
1.2- 1.5	Br Si W Sa W Cl Tr Gr	Moist
1.5- 2.1	Br Si W Sa W Cl (Stiff)	Moist
	Nvalue=11 blows / 300mm	
		w @ 1.8m = 11%

Station 02+100 SB Lane 1

0- 200	Asph	
200- 700	Gry Sa(y) Gr Tr Si	Dry
700- 1.0	Br Sa Some Gr Some Si	Dry
1.0- 1.5	Br Sa(y) Si W Cl	Moist
		w @ 1.5m = 21%

Station 02+300 NB Lane 2

0- 210	Asph	
210- 1.4	Gry Sa(y) Gr Tr Si	Moist
		w @ 1.0m = 3%
1.4- 1.5	Br Si W Sa W Cl Tr Gr	Moist

Station 02+300 SB Lane 1

0- 210	Asph	
210- 920	Gry Sa(y) Gr Tr Si	Dry
920- 1.5	Br Sa(y) Si W Cl	Moist

Station 02+600 NB OSH

0- 400	Br Gr W Sa Some Si	Moist
400- 1.5	Gry Sa Some Gr Some Si	Moist
1.5- 2.1	Br Si W Sa W Cl	Moist

Station 02+600 NB Lane 1

0- 190	Asph	
190- 390	Br Sa(y) Gr Tr Si	Dry
390- 1.4	Gry Sa Some Gr Some Si	Dry
		w @ 1.0m = 2%
1.4- 1.5	Br Gr(y) Sa Tr Si	Moist
1.5- 2.1	Br Gr(y) Sa Tr Si (Dense)	Moist
	Nvalue=42 blows / 300mm	
		w @ 1.8m = 6%

Station 02+600 SB Lane 1

0- 170	Asph	
170- 600	Gry Sa(y) Gr Tr Si	Dry
600- 1.8	Br Sa Some Gr Some Si	Dry
		w @ 1.0m = 3%
1.8- 2.1	Br Sa(y) Si W Cl (Farm)	Moist
	Nvalue=8 blows / 300mm	
		w @ 1.8m = 12%

Station 02+600 SB OSH

0- 190	Asph	
190- 600	Gry Sa(y) Gr Tr Si	Dry
600- 1.5	Br Sa Some Gr Some Si	Dry

Station 02+900 NB OSH

0- 450	Br Gr W Sa Some Si	Moist
450- 900	Gry Sa Some Gr Some Si	Moist
900- 1.5	Br Sa(y) Si W Cl	Moist

Station 02+900 SB OSH

0- 200	Asph	
200- 930	Gry Sa(y) Gr Tr Si	Dry
930- 1.5	Br Sa(y) Si W Cl	Moist
1.5- 2.1	Br Sa(y) Si W Cl (V Stiff)	Moist
	Nvalue=20 blows / 300mm	
		w @ 1.8m = 12%

Station 03+100 NB Lane 1

0- 200	Asph	
200- 430	Br Sa(y) Gr Tr Si	Moist
		w @ 0.4m = 2%
430- 900	Gry Sa Some Gr Some Si	Moist
		w @ 0.7m = 3%

900- 1.5 Br Sa(y) Si W Cl Tr Gr Moist
1.5- 2.1 Br Sa(y) Si W Cl (V Stiff) Moist
Nvalue=19 blows / 300mm
w @ 1.8m = 17%

Station 03+100 **SB** **Lane 1**
0- 200 Asph
200- 900 Gry Sa(y) Gr Tr Si Dry
900- 1.5 Br Sa(y) Si W Cl Moist

Station 03+200 **NB** **OSH**
0- 400 Br Gr W Sa Some Si Moist
400- 900 Gry Sa Some Gr Some Si Moist
900- 1.5 Br Sa(y) Si W Cl Moist

Station 03+200 **SB** **OSH**
0- 170 Asph
170- 900 Br Sa(y) Gr Tr Si Dry
900- 1.5 Br Sa(y) Si W Cl Moist

Station 03+500 **NB** **OSH**
0- 300 Gry Gr W Sa Some Si Moist
w @ 0.3m = 5%
Percent Passing 4.75 mm = 40%
75 µm =12%
Slightly Finer Than Granular B Type I
300- 900 Br Sa Some Gr Some Si Moist
w @ 0.6m = 3%
900- 1.5 Br Sa(y) Si W Cl Moist

Station 03+500 **SB** **OSH**
0- 180 Asph
180- 1.0 Gry Sa Some Gr Some Si Dry
w @ 0.6m = 3%
Percent Passing 4.75 mm = 87%
75 µm = 20%
Slightly Finer Than Granular B Type I
1.0- 1.5 Br Sa(y) Si W Cl Moist
1.5- 2.1 Br Sa(y) Si W Cl (Stiff) Moist
Nvalue=9 blows / 300mm
w @ 1.8m = 15%
Percent Passing 4.75 mm = 99%
75 µm = 64%
5 µm = 22%
Frost Susceptibility = MFSH
Soil Erodibility = 0.23
Plastic Limit = 17%
Liquid Limit = 32%
Plasticity Index = 15%
MTC Classification = CL

Station 03+600 **NB** **Lane 1**
0- 180 Asph
180- 1.2 Gry Sa Some Gr Some Si Dry
w @ 1.0m = 4%
1.2- 1.5 Br Sa(y) Si W Cl Moist

Station 03+600 **SB** **Lane 1**
0- 200 Asph
200- 900 Gry Sa Some Gr Some Si Dry
900- 1.5 Br Sa(y) Si W Cl Moist

Station 03+800 **NB** **OSH**
0- 400 Br Gr W Sa Some Si Dry
400- 1.1 Gry Sa Some Gr Some Si Dry
1.1- 1.5 Br Sa(y) Si W Cl Moist
1.5- 2.1 Br Sa(y) Si W Cl (Farm) Moist
Nvalue=8 blows / 300mm
w @ 1.8m = 13%

Station 03+800 **SB** **OSH**
0- 200 Asph
200- 1.0 Gry Sa Some Gr Some Si Dry
1.0- 1.5 Br Sa(y) Si W Cl Moist
1.5- 2.1 Br Sa(y) Si W Cl (Farm) Moist
Nvalue=8 blows / 300mm

Station 04+000 **NB** **Lane 1**
0- 180 Asph
180- 1.2 Br Sa Some Gr Some Si Moist
w @1.0m = 3%
1.2- 1.5 Br Sa(y) Si W Cl Moist
1.5- 2.1 Br Sa(y) Si W Cl (Stiff) Moist
Nvalue=10 blows / 300mm
w @ 1.8m = 8%
Percent Passing 4.75 mm = 99%
75 µm = 67%
5 µm = 25%
Frost Susceptibility = MFSH
Soil Erodibility = 0.27
Plastic Limit = 18%
Liquid Limit = 32%
Plasticity Index = 14%
MTC Classification = CL

Station 04+000 **SB** **OSH**
0- 1 Gry Sa Some Gr Some Si Moist
1.0- 1.5 Br Sa(y) Si W Cl Moist
1.5- 2.1 Br Sa(y) Si W Cl (Farm) Moist
Nvalue=8 blows / 300mm
w @ 1.8m = 20%

THURBER

Appendix C
Winston Churchill Boulevard Class EA Study
Highway 401 to Embleton Road
Borehole Logs

January 14, 2016

Station 04+000 **SB** **Lane 1**

0- 180	Asph	
180- 1.0	Gry Sa Some Gr Some Si	Moist
		w @ 0.6m = 3%
1- 1.5	Br Sa(y) Si W Cl	Moist
1.5- 2.1	Br Sa(y) Si W Cl (Stiff)	Moist
	Nvalue=9 blows / 300mm	
		w @ 1.8m = 19%

THURBER

APPENDIX D

PREVIOUS BOREHOLE INFORMATION

PROJECT: 08-1111-0038

RECORD OF BOREHOLE: BH08-1

SHEET 1 OF 1

LOCATION: See Figure 2

BORING DATE: November 21, 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 / SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 10 20 30 40	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} / WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 5 10 15 20	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		207.99							
0	Truck Mounted D-50 100 mm Solid Stem Augers	ASPHALT	■	0.00							
		Very dense, moist, brown, sand and gravel, some silt, trace clay (FILL)	▩	0.15	1	50 DO	145				
		Very stiff, brown, silty clay, trace sand and gravel, contains dark grey/black layers / pockets of organic matter (FILL)	▩	207.23 0.76							
1		Very stiff, brown, SILTY CLAY, some sand, trace to some gravel (TILL)	▨	0.91	2	50 DO	24				
			▨		3	50 DO	24				
2		END OF BOREHOLE		206.01 1.98							
		NOTE:									
		1. Borehole dry upon completion of drilling.									
3											
4											
5											
6											
7											
8											
9											
10											

MIS-BHS 001 08-1111-0038.GPJ GAL-MIS.GDT 3/25/09 SAC

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AM/BC

CHECKED: SLP

PROJECT: 08-1111-0038

RECORD OF BOREHOLE: BH08-2

SHEET 1 OF 1

LOCATION: See Figure 2

BORING DATE: November 25, 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (10 20 30 40)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (5 10 15 20)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		207.49							
0	Truck Mounted D-50 100 mm Solid Stem Augers	ASPHALT		0.00							
		Dense, moist, brown, sand and gravel, trace to some silt (FILL)		0.15	1	50 DO	50		○	MH	
		Very stiff, dark brown/grey, SILTY CLAY, trace to some sand, gravel and rootlets (TOPSOIL / Reworked TILL)		206.73 0.76					○		
1		Very stiff to hard, mottled brown/grey to brown, SILTY CLAY, some sand, trace gravel (TILL)		206.42 1.07	2	50 DO	25		○		
2					3	50 DO	28				
					4	50 DO	51				
3											
					5	50 DO	52				
		END OF BOREHOLE		203.83 3.66							
4		NOTE: 1. Borehole dry upon completion of drilling.									
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AM/BC
CHECKED: SLP

PROJECT: 08-1111-0038

RECORD OF BOREHOLE: BH08-3

SHEET 1 OF 1

LOCATION: See Figure 2

BORING DATE: November 21, 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 10 20 30 40	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 5 10 15 20	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m				
		GROUND SURFACE		207.47							
0	Truck Mounted D-50 100 mm Solid Stem Augers	ASPHALT	■	0.00 207.29							
		Very dense, moist, dark brown, sand and gravel, trace silt, slight petroleum hydrocarbon odour (FILL)	▨	0.18 206.71	1	50 DO	58				
1		Very stiff, mottled brown/grey, SILTY CLAY, some sand, trace gravel. Contains sand pockets (TILL)	▨	0.76	2	50 DO	22				
				205.49	3	50 DO	28				
2		END OF BOREHOLE NOTE: 1. Borehole dry upon completion of drilling.		1.98							
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AM/BC
CHECKED: SLP

PROJECT: 08-1111-0038

RECORD OF BOREHOLE: BH08-4

SHEET 1 OF 1

LOCATION: See Figure 2

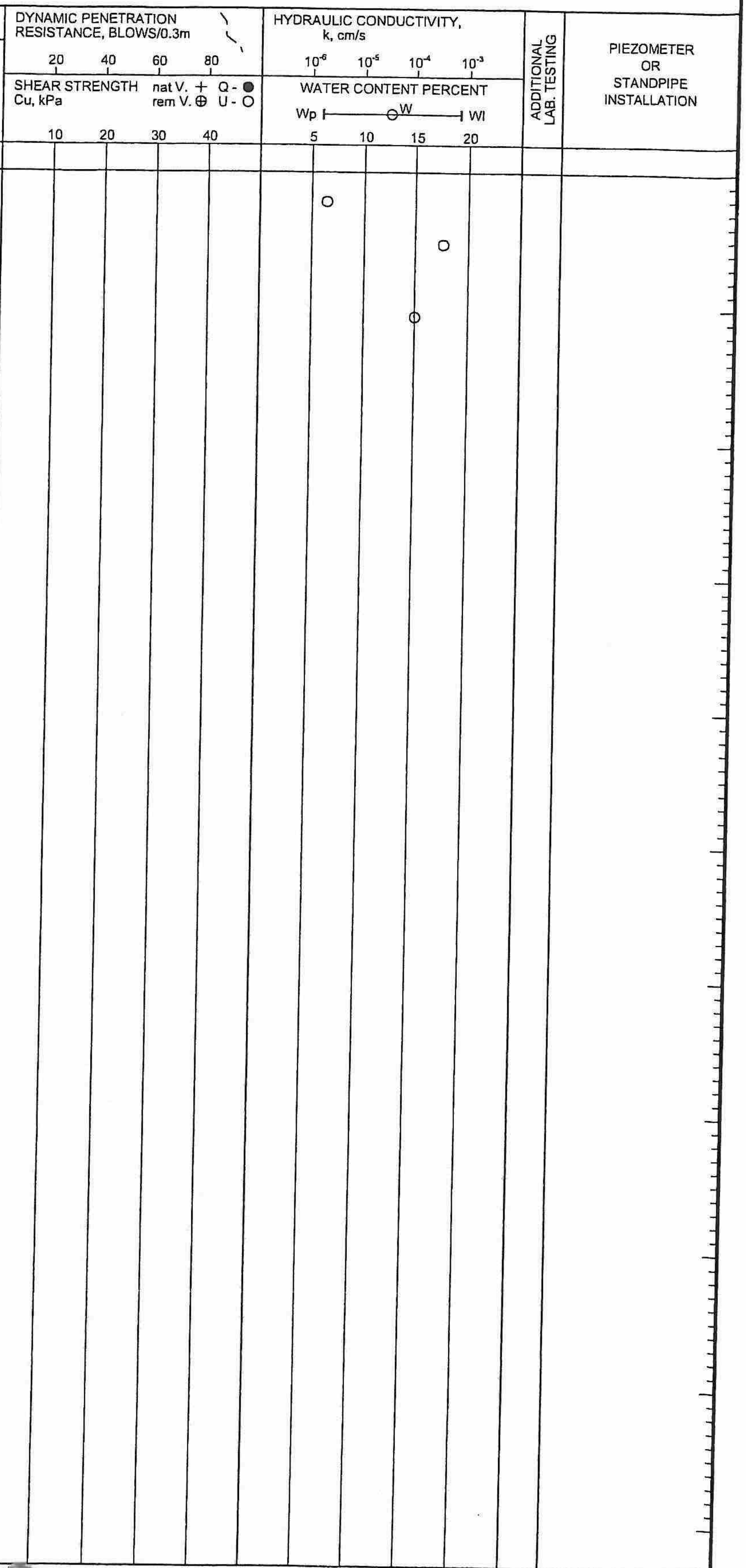
BORING DATE: November 21, 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
		GROUND SURFACE		207.86			
0	Truck Mounted D-50 100 mm Solid Stem Augers	ASPHALT		0.00			
		Compact, moist, dark brown, sand and gravel, trace silt (FILL)		0.15			
		Stiff, moist, brown and dark grey, silty clay, trace sand and gravel. Contains organic matter (Reworked TILL / FILL)		0.25	1	50 DO	11
		Hard, brown, SILTY CLAY, some sand, trace to some gravel (TILL)		207.25 0.61			
1					2	50 DO	32
2					3	50 DO	39
					4	50 DO	33
3					5	50 DO	52
4					6	50 DO	50/0.08
		Auger grinding at 4.1 m depth					
		Becoming grey and contains interlayers of sand and silt below 4.3 m depth					
5					7	50 DO	45
		END OF BOREHOLE		202.68 5.18			
		NOTE:					
		1. Borehole dry upon completion of drilling.					
6							
7							
8							
9							
10							



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DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AM/BC

CHECKED: SLP

PROJECT: 08-1111-0038

RECORD OF BOREHOLE: BH08-5

SHEET 1 OF 1

LOCATION: See Figure 2

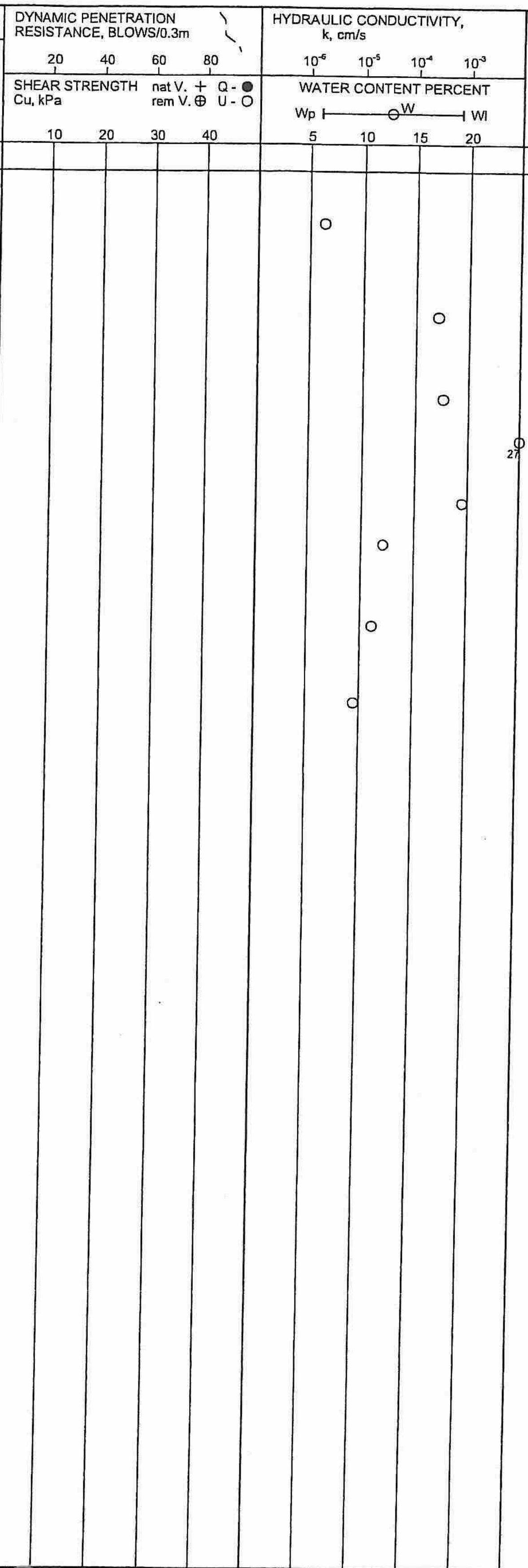
BORING DATE: November 21, 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m
		GROUND SURFACE		205.68			
0	Truck Mounted D-50 100 mm Solid Stem Augers	Gravel (ROAD SHOULDER FILL)		0.00			
		Compact, moist to wet, brown, sand, trace to some gravel. Contains clayey silt pockets (FILL)		0.08	1	50 DO	14
1					2	50 DO	15
		Loose, wet, brown, silty sand, trace to some gravel (FILL)		204.31 1.37			
		Firm, grey, Organic SILTY CLAY, trace to some sand, gravel, rootlets		203.85 1.83	3	50 DO	5
2							
		Hard, brown, SILTY CLAY, some sand, trace to some gravel (TILL)		203.24 2.44	4	50 DO	63
3					5	50 DO	40
4					6	50 DO	50/0.08
		Grinding of augers at 4.1 m depth					
		Auger Refusal END OF BOREHOLE		201.11 4.57			
5		NOTE: 1. Borehole dry upon completion of drilling.					
6							
7							
8							
9							
10							



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AM/BC
CHECKED: SLP

PROJECT: 08-1111-0038

RECORD OF BOREHOLE: BH08-6

SHEET 1 OF 1

LOCATION: See Figure 2

BORING DATE: November 24, 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

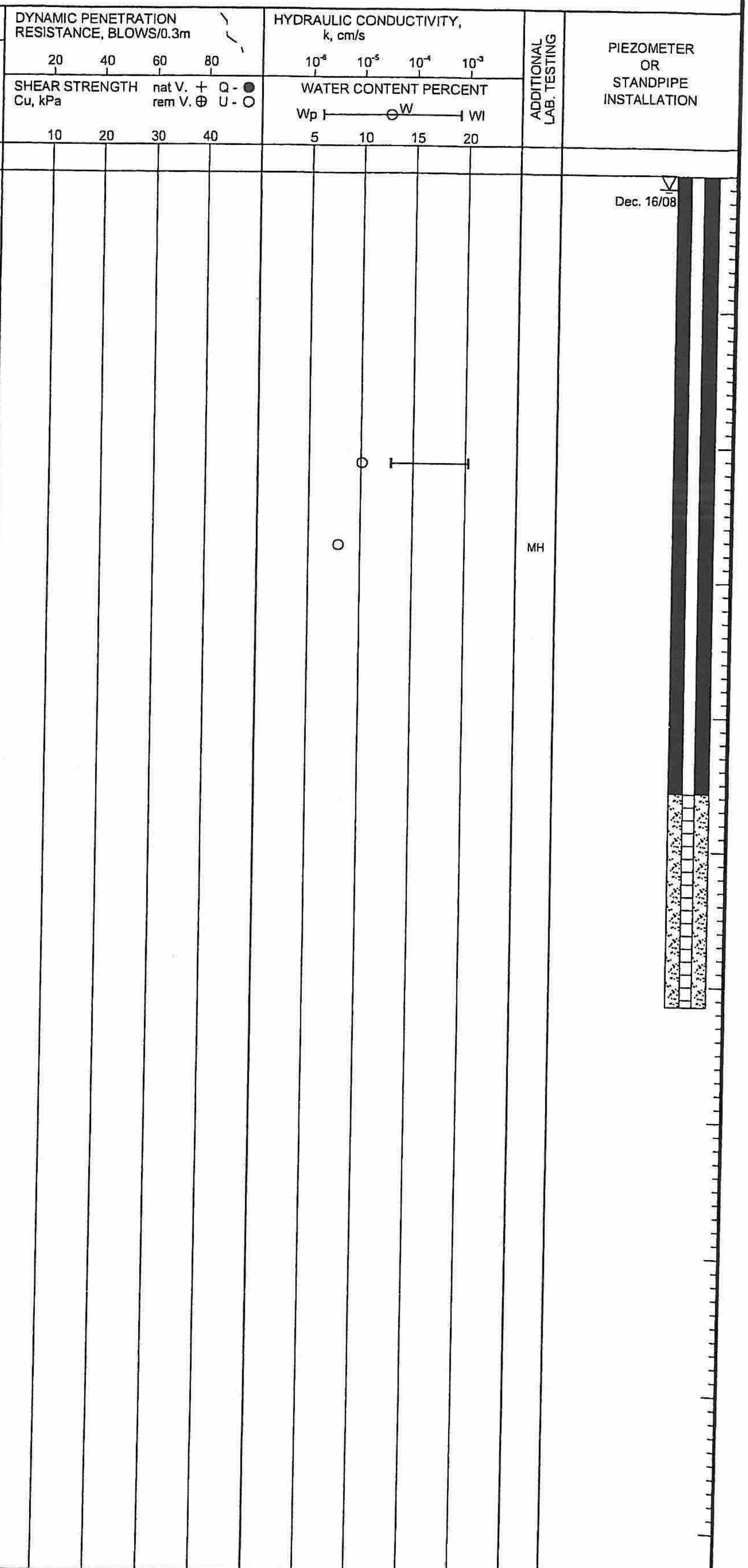
BORING METHOD: Big Beaver, 100 mm Solid Stem

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
GROUND SURFACE	204.71				
Stiff, brown, silty clay. Contains roots (TOPSOIL)	0.00	1	50 DO	9	
Firm, brown, silty clay, trace to some sand, gravel and topsoil (FILL)	204.25 0.46	2	50 DO	5	
Hard, brown, SILTY CLAY, some sand, trace to some gravel (TILL)	203.49 1.22	3	50 DO	33	
		4	50 DO	47	
Very dense, moist, grey, SILT and SAND, some gravel, trace to some clay (TILL)	202.27 2.44	5	50 DO	50	MH
Hard, grey, CLAYEY SILT, trace to some sand and gravel (TILL)	201.66 3.05	6	50 DO	50/0.13	
Very dense, moist, red/grey, Silty SAND to SILT and SAND, trace to some gravel, trace clay (TILL)	201.05 3.66	7	50 DO	50/0.05	
Contains shale and limestone fragments		8	50 DO	50/0.05	
END OF BOREHOLE	198.56 6.15	9	50 DO	50/0.05	

NOTE:

1. Borehole dry upon completion of drilling.

2. Water level in piezometer measured at 0.1 m depth (Elev. 204.6 m) on December 16, 2008.



DEPTH SCALE 1 : 50

LOGGED: AM/BC

CHECKED: SLP

PROJECT: 08-1111-0038

RECORD OF BOREHOLE: BH08-7

SHEET 1 OF 1

LOCATION: See Figure 2

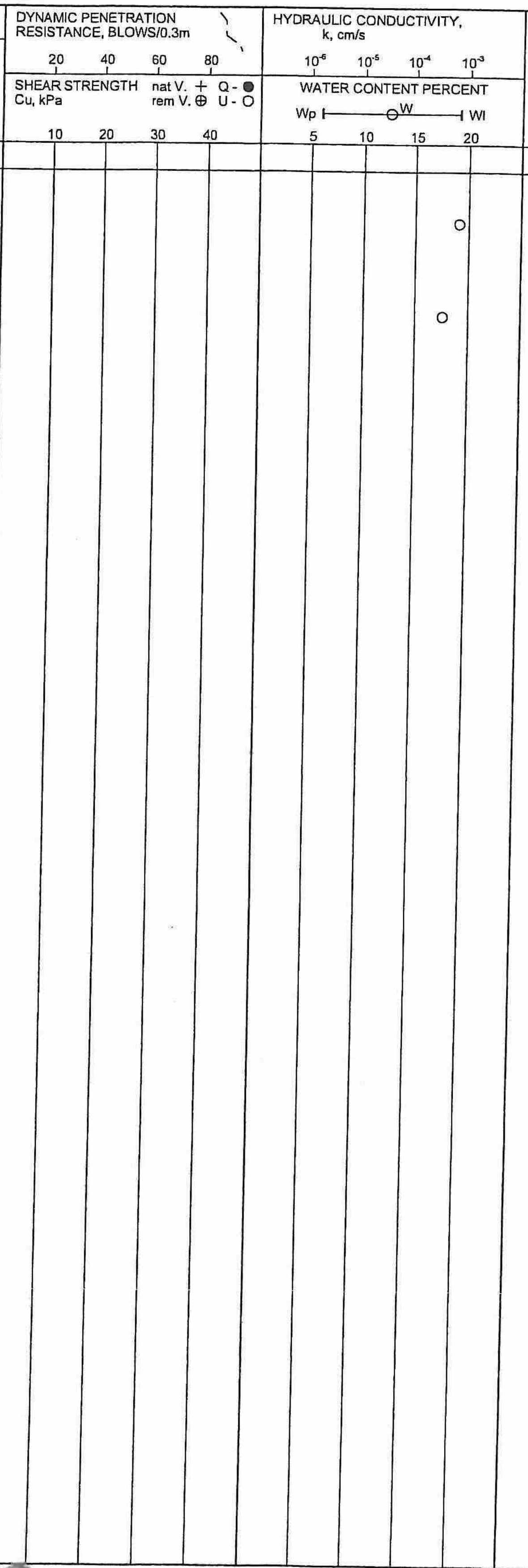
BORING DATE: November 21, 2009

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m
		GROUND SURFACE		207.52			
0	Truck Mounted D-50 100 mm Solid Stem Augers	ASPHALT		0.00			
		Stiff, moist, blackish brown, silty clay, some sand and gravel, black stained (TOPSOIL/Reworked TILL)		0.15	1	50 DO	14
1		Very stiff to hard, brown, SILTY CLAY, some sand, trace to some gravel (TILL)		206.76 0.76	2	50 DO	29
2					3	50 DO	39
					4	50 DO	65
3					5	50 DO	57
4					6	50 DO	86/0.28
		Very dense, moist, brown to grey, Sandy SILT, trace to some gravel, trace clay (TILL)		203.22 4.30	7	50 DO	50/0.10
		END OF BOREHOLE		202.87 4.65			
5		NOTE: 1. Borehole dry upon completion of drilling.					
6							
7							
8							
9							
10							



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AM/BC

CHECKED: SLP

PROJECT: 08-1111-0038

RECORD OF BOREHOLE: BH08-8

SHEET 1 OF 1

LOCATION: See Figure 2

BORING DATE: November 25, 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 10 20 30 40	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 5 10 15 20	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		207.89							
0	Truck Mounted D-50 100 mm Solid Stem Augers	ASPHALT		0.00							
		Compact, dark brown/black, sand and gravel, slight petroleum hydrocarbon odour. Contains topsoil (FILL)		0.15	1	50 DO	28				
		TOPSOIL, black		207.51 0.38							
1		Very stiff to hard, mottled brown and grey to brown, SILTY CLAY, some sand, trace gravel (TILL)		0.48	2	50 DO	16				
2					3	50 DO	45				
		END OF BOREHOLE		205.76 2.13							
3		NOTE: 1. Borehole dry upon completion of drilling.									
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AM/BC
CHECKED: SLP

PROJECT: 08-1111-0038

RECORD OF BOREHOLE: BH08-9

SHEET 1 OF 1

LOCATION: See Figure 2

BORING DATE: November 21, 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (10 20 30 40)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (5 10 15 20)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		208.21							
0	Truck Mounted D-50 100 mm Solid Stem Augers	Compact, moist, brown, sand and gravel, trace silt (FILL)	▩	0.00	1	50 DO	24		○		
1		Very stiff to hard, mottled brown and grey to brown, SILTY CLAY, trace to some sand and gravel (TILL)	▨	207.45 0.76	2	50 DO	20		○	MH	
2					3	50 DO	43				
					4	50 DO	50/ 0.15				
3					5	50 DO	55				
4		Becoming grey/red and auger grinding below 3.8 m depth			6	50 DO	50/ 0.10				
		END OF BOREHOLE		204.15 4.06							
5											
6											
7											
8											
9											
10											

NOTE:

1. Borehole dry upon completion of drilling.

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DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AM/BC
CHECKED: SLP

PROJECT: 08-1111-0038

RECORD OF BOREHOLE: BH08-10

SHEET 1 OF 1

LOCATION: See Figure 2

BORING DATE: November 24, 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80; SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 10 20 30 40	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3}; WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 5 10 15 20	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		208.23							
0	Truck Mounted D-50 100 mm Solid Stem Augers	Compact, brown, sand and gravel, trace silt (FILL)	▨	0.00	1	50 DO	19				
		Very stiff, brown, silty clay, trace sand and gravel, contains topsoil and rootlets (Possible FILL)	▨	207.77 0.46							
1		Very stiff to hard, mottled brown/grey to brown, SILTY CLAY, some sand, trace to some gravel (TILL)	▨	207.47 0.76	2	50 DO	23				
2					3	50 DO	41				
		Contains sand and silt interlayers below 2.3 m depth			4	50 DO	36				
3					5	50 DO	46				
		END OF BOREHOLE		204.57 3.66							
4		NOTE: 1. Borehole dry upon completion of drilling.									
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AM

CHECKED: SLP

PROJECT: 08-1111-0038

RECORD OF BOREHOLE: BH08-11

SHEET 1 OF 1

LOCATION: See Figure 2

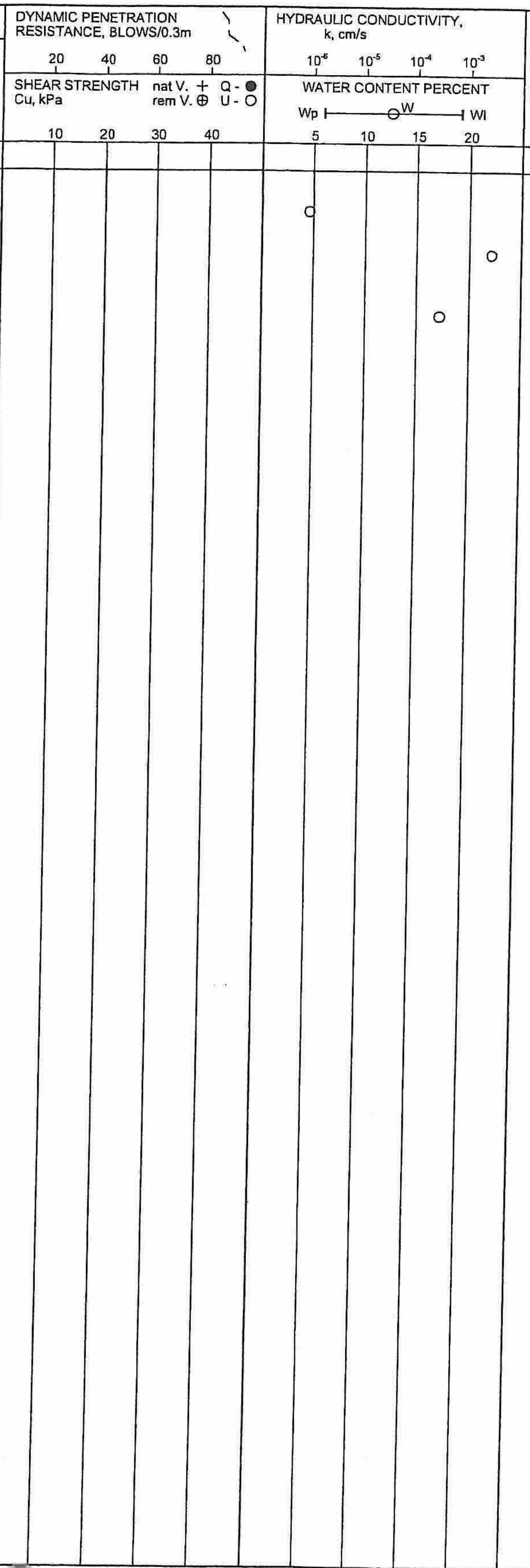
BORING DATE: November 25, 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
		GROUND SURFACE	208.37			
0	Truck Mounted D-50 100 mm Solid Stem Augers	ASPHALT	0.00			
		Compact, moist, brown, sand and gravel, trace silt (FILL)	0.15	1	50 DO	20
		Very stiff, brown/black, silty clay, trace to some sand and gravel (FILL)	207.76 0.61			
1		Very stiff to hard, mottled brown and grey to brown, SILTY CLAY to CLAYEY SILT, some sand, trace gravel (TILL)	0.76	2	50 DO	24
		Becoming brown below 1.5 m depth		3	50 DO	45
2				4	50 DO	42
3		Contains shale fragments		5	50 DO	58
		END OF BOREHOLE	204.71 3.66			
4		NOTE:				
		1. Borehole dry upon completion of drilling.				
5						
6						
7						
8						
9						
10						



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AM/BC

CHECKED: SLP

PROJECT: 08-1111-0038

RECORD OF BOREHOLE: BH08-12

SHEET 1 OF 1

LOCATION: See Figure 2

BORING DATE: November 25, 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Truck Mounted D-50, 100 mm Solid Stem Augers

SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)
GROUND SURFACE		206.02
ASPHALT	■	0.00
Very dense, moist, brown, sand and gravel, trace silt (FILL)	▩	0.15
Compact, moist to wet, sand, trace silt and gravel (FILL)	▩	205.41 0.61
Firm, brown and dark grey, Organic SILTY CLAY, trace to some sand, gravel and rootlets	▨	204.50 1.52
Hard, brown to grey, CLAYEY SILT with SAND to SILTY CLAY, some sand trace gravel. Contains silt pockets (TILL)	▨	203.73 2.29
Very dense, moist, brownish red, SILT and SAND, trace to some gravel, trace clay (Probable TILL)		199.92 6.10
END OF BOREHOLE		6.20

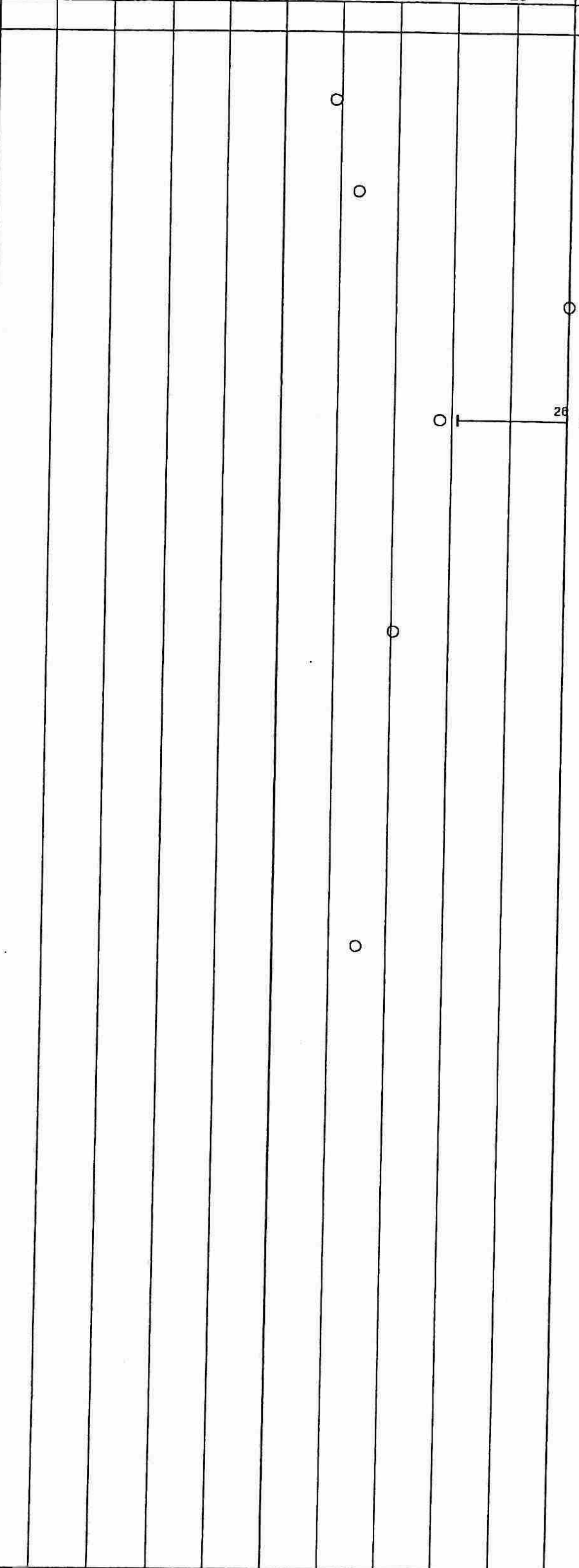
SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
1	50 DO	50/ 0.08	
2	50 DO	10	
3	50 DO	6	
4	50 DO	30	MH
5	50 DO	86	
6	50 DO	89/ 0.27	
7	50 DO	50/ 0.13	
8	50 DO	50/ 0.10	

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - O: 10 20 30 40

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

WATER CONTENT PERCENT: Wp ⊢—O W—⊣ Wl: 5 10 15 20



PIEZOMETER OR STANDPIPE INSTALLATION: ∇

NOTE:

1. Water level measured at 4.8 m depth upon completion of drilling.

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: AM/BC

CHECKED: SLP

PROJECT: 08-1111-0038

RECORD OF BOREHOLE: BH08-13

SHEET 1 OF 1

LOCATION: See Figure 2

BORING DATE: November 24, 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - O: 10 20 30 40

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

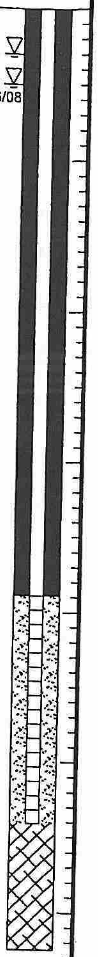
WATER CONTENT PERCENT Wp ⊢—O W—⊣ Wl: 5 10 15 20

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

BORING METHOD: Big Beaver, 100 mm Solid Stem Augers

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m
	GROUND SURFACE	204.76			
0	Firm, brown, SILTY CLAY, some sand, trace gravel. Contains organic matter including roots and grass (Possible FILL)	0.00	1	50 DO	5
1	Stiff to hard, brown CLAYEY SILT, some sand, trace to some gravel (TILL)	203.85 0.91	2	50 DO	12
			3	50 DO	34
2	Very dense, moist, brown, SAND and GRAVEL, trace to some silt and clay	202.94 1.82			
	Hard, brown to grey/red, CLAYEY SILT with SAND to CLAYEY SILT, some sand, trace to some gravel (TILL)	202.63 2.13	4	50 DO	57
			5	50 DO	57
3	Auger grinding from 3.0 m to 3.7 m depth Contains sandy silt pockets/interlayers and shale fragments		6	50 DO	50/0.10
			7	50 DO	50/0.08
4					
5			8	50 DO	50/0.08
6	Hard, moist, reddish brown, CLAYEY SILT, some sand and gravel, shale fragments (Residual Soil/TILL)	198.97 5.79	9	50 DO	120/0.15
	END OF BOREHOLE	198.51 6.25			



NOTE:

1. Water level in open borehole measured at 0.3 m depth (Elev. 204.5 m) upon completion of drilling.

2. Water level in piezometer measured at 0.5 m depth (Elev. 204.3 m) on December 16, 2008.

7

8

9

10

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: BC

CHECKED: SLP

PROJECT: 08-1111-0038

RECORD OF BOREHOLE: BH08-14

SHEET 1 OF 1

LOCATION: See Figure 2

BORING DATE: November 24, 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80; SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 10 20 30 40	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3}; WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 5 10 15 20	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		207.49							
	Truck Mounted D-50 100 mm Solid Stem Augers	ASPHALT		0.00							
		Compact, moist, dark brown, sand and gravel, trace silt (FILL)		0.13	1	50 DO	17				
		Very stiff, brown and black/grey, SILTY CLAY, trace to some sand and gravel, rootlets (TOPSOIL)		206.73 0.76	2	50 DO	18				
		Very stiff to hard, brown, SILTY CLAY, some sand, trace to some gravel (TILL) Sandy silt interlayers noted between 1.5 m and 2.1 m depth		205.97 1.52	3	50 DO	26				
					4	50 DO	41				
3											∇
					5	50 DO	51				
		END OF BOREHOLE NOTE: 1. Water level measured at 2.9 m depth upon completion of drilling.		203.83 3.66							

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DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AM
CHECKED: SLP

PROJECT: 08-1111-0038

RECORD OF BOREHOLE: BH08-15

SHEET 1 OF 1

LOCATION: See Figure 2

BORING DATE: November 25, 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

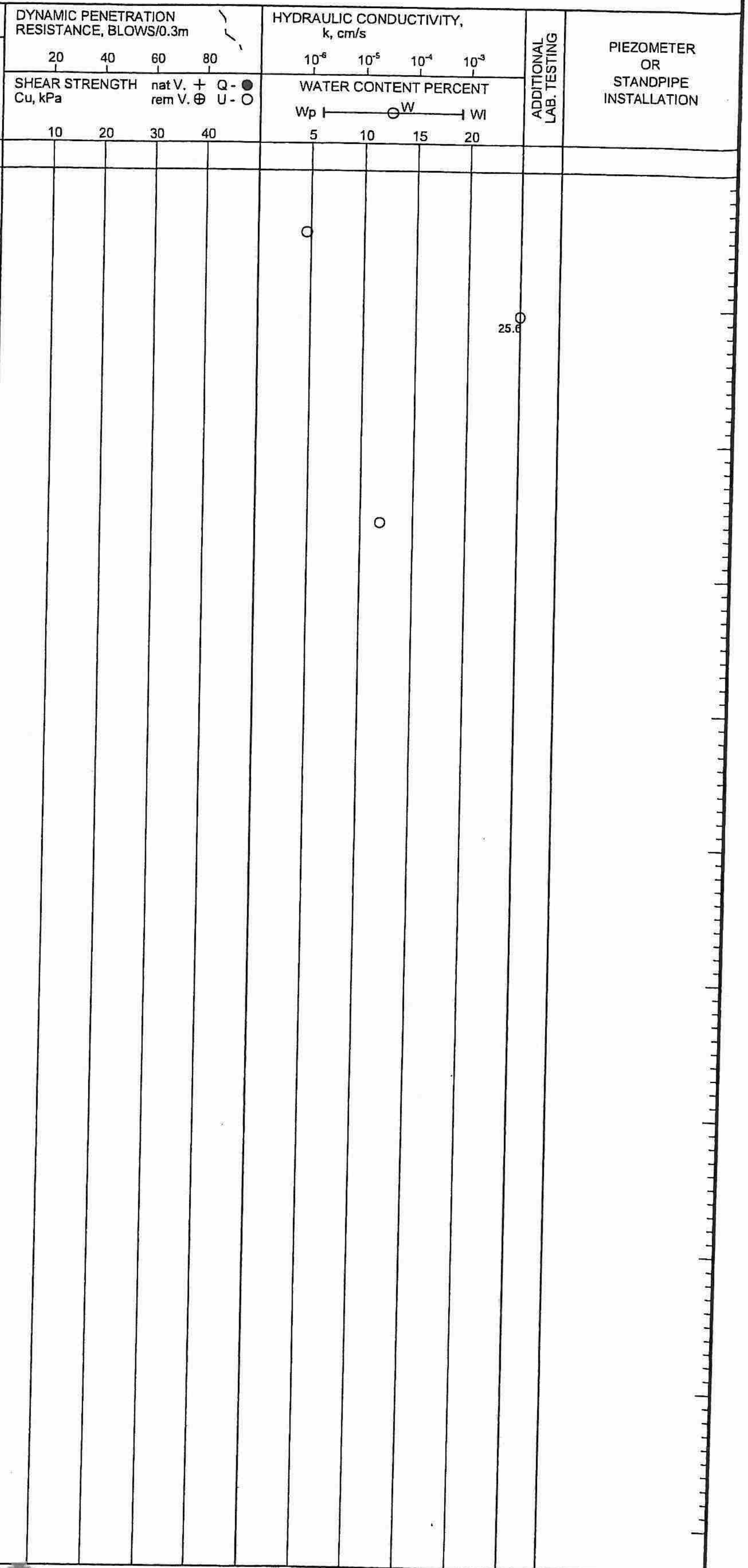
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Truck Mounted D-50, 100 mm Solid Stem Augers

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m
0	GROUND SURFACE	207.62			
	ASPHALT	0.00			
	Compact, moist, brown to dark brown, sand and gravel, trace silt (FILL)	0.15	1	50 DO	14
	Very stiff, grey/black to brown, silty clay, trace sand, gravel, rootlets. Contains clay tile fragments (FILL)	206.86 0.76	2	50 DO	15
1					
	Very stiff to hard, brown, SILTY CLAY, some sand, trace to some gravel (TILL)	205.92 1.70	3	50 DO	24
2			4	50 DO	36
3			5	50 DO	69
	END OF BOREHOLE	203.96 3.66			

NOTE:

1. Borehole dry upon completion of drilling.



DEPTH SCALE 1 : 50

Golder Associates

LOGGED: AM

CHECKED: SLP

PROJECT: 08-1111-0038

RECORD OF BOREHOLE: BH08-16

SHEET 1 OF 1

LOCATION: See Figure 2

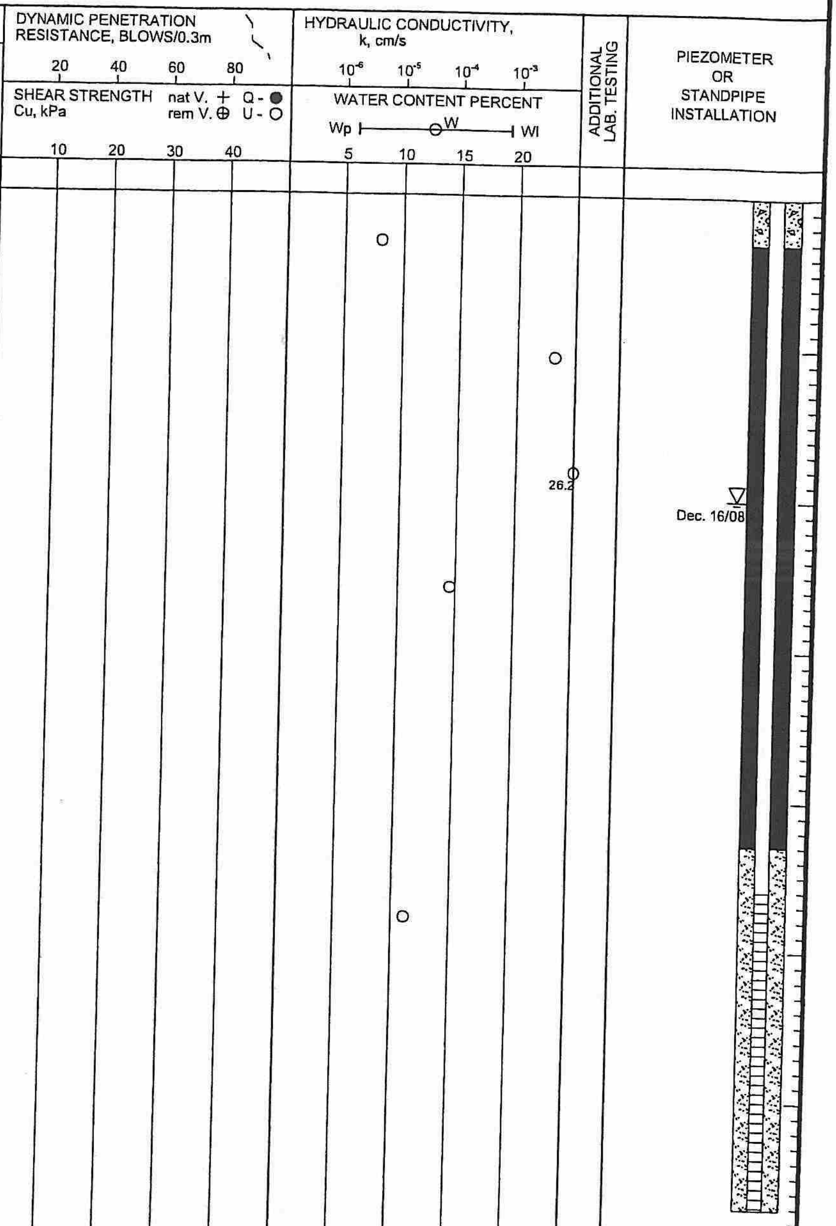
BORING DATE: November 24, 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m
		GROUND SURFACE		208.13			
0	Truck Mounted D-50 100 mm Solid Stem Augers	Loose, moist, dark brown, sand, some gravel, trace silt (FILL)	▩	0.00	1	50 DO	8
		Firm, brown, silty clay, trace to some sand and gravel. Contains pockets of topsoil (FILL)	▩	207.37 0.76	2	50 DO	7
1		Stiff, dark grey, Organic SILTY CLAY, trace to some sand, gravel, and rootlets	▨	206.76 1.37	3	50 DO	10
2		Very stiff to hard, mottled brown/grey to brown to grey, SILTY CLAY to CLAYEY SILT, some sand, trace to some gravel. Contains sandy silt pockets (TILL)	▨	205.84 2.29	4	50 DO	26
3		Becoming grey below 3.0 m depth			5	50 DO	36
4–5					6	50 DO	50/ 0.13
5–6					7	50 DO	52
6					8	50 DO	35
		END OF BOREHOLE		201.42 6.71			



NOTE:

1. Borehole dry upon completion of drilling.

2. Water level in piezometer measured at 2.0 m depth (Elev. 206.1 m) on December 16, 2008.

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AM
CHECKED: SLP

PROJECT: 08-1111-0038

LOCATION: See Figure 2

SAMPLER HAMMER, 64kg; DROP, 760mm

RECORD OF BOREHOLE: BH08-17

BORING DATE: November 25, 2008

SHEET 1 OF 1

DATUM: Geodetic

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

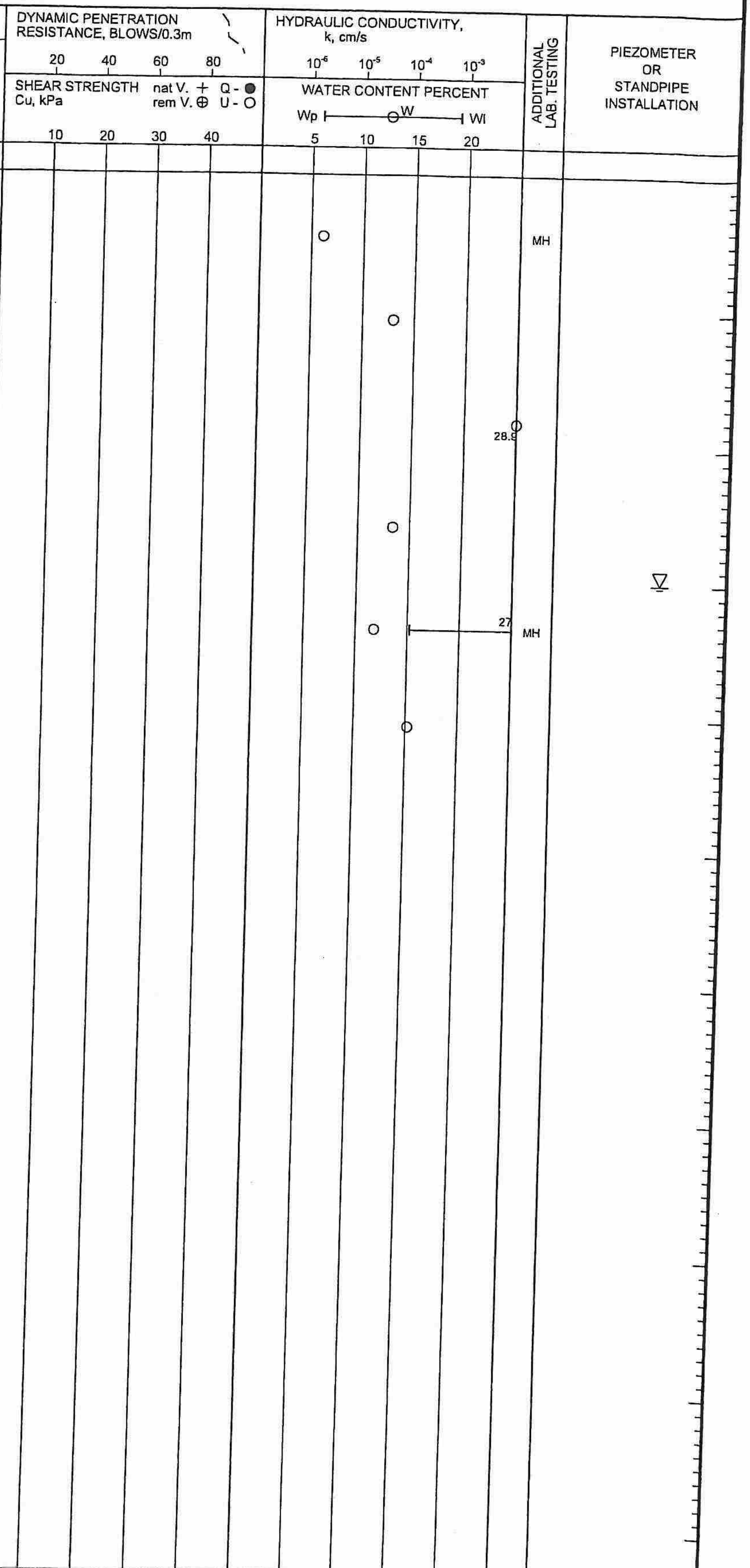
BORING METHOD: Truck Mounted D-50, 100 mm Solid Stem Augers

DEPTH SCALE METRES: 0 – 10

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
GROUND SURFACE	208.38				
ASPHALT	0.00				
Dense, moist, brown, gravelly sand, some silt. Contains clay pockets and asphalt fragments (FILL)	0.15	1	50 DO	31	MH
Stiff, dark brown, silty clay, trace to some sand, gravel, rootlets (TOPSOIL)	207.61 0.77	2	50 DO	11	
Stiff, brown, SILTY CLAY, some sand, trace to some gravel, trace topsoil (TILL)	206.65 1.73	3	50 DO	10	
Hard, brown, SILTY CLAY, some sand, to CLAYEY SILT with sand, trace to some gravel (TILL)	206.25 2.13	4	50 DO	30	
Contains interlayers of silt and sand		5	50 DO	42	MH
		6	50 DO	50/ 0.15	
		7	50 DO	50/ 0.15	
		8	50 DO	78/ 0.28	
END OF BOREHOLE	201.83 6.55				

NOTE:

1. Water seepage noted at 3.0 m depth upon completion of drilling.



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AM

CHECKED: SLP

PROJECT: 08-1111-0038

RECORD OF BOREHOLE: BH08-18

SHEET 1 OF 1

LOCATION: See Figure 2

BORING DATE: November 24, 2008

DATUM: Geodetic

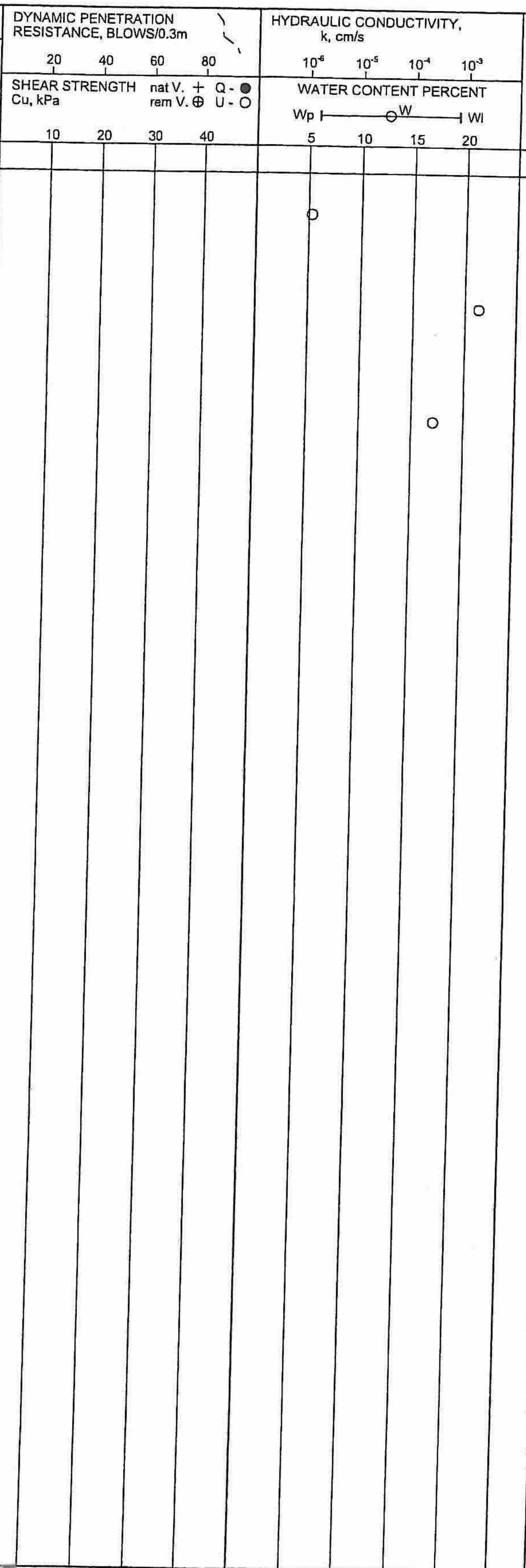
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m
		GROUND SURFACE		208.49			
0	Truck Mounted D-50 100 mm Solid Stem Augers	Compact, moist, brown, sand and gravel, trace silt (FILL)	▩	0.00	1	50 DO	19
		Stiff, grey/black turning brown, silty clay, trace to some sand, gravel and rootlets (TOPSOIL)	▤	207.88 0.61	2A	50 DO	15
1		Very stiff to hard, mottled brown and grey to brown, SILTY CLAY, some sand, trace to some gravel (TILL)	▨	207.27 1.22	2B	50 DO	
2					3	50 DO	19
3					4	50 DO	36
					5	50 DO	54
		END OF BOREHOLE		204.83 3.66			

NOTE:

1. Borehole dry upon completion of drilling.



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

MIS-BHS 001 08-1111-0038.GPJ GAL-MIS.GDT 3/25/09 SAC

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AM

CHECKED: SLP

PROJECT: 08-1111-0038

RECORD OF BOREHOLE: BH08-19

SHEET 1 OF 1

LOCATION: See Figure 2

BORING DATE: November 24, 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20, 40, 60, 80); SHEAR STRENGTH Cu, kPa (10, 20, 30, 40) nat V. + Q - ● rem V. ⊕ U - ○	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}); WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (5, 10, 15, 20)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	Truck Mounted D-50 100 mm Solid Stem Augers	ASPHALT		209.09 0.00							
		Very dense, moist, brown, sand and gravel, trace silt (FILL)		208.91 0.18	1	50 DO	57				
		Hard, brown/black, silty clay, trace to some sand, gravel and roots (FILL / TOPSOIL)		208.63 0.46							
1		Very dense, dark brown, sand and gravel, trace clay. Contains asphalt pieces (FILL)		208.40 0.69	2	50 DO	50/ 0.13				
2		Very stiff, mottled grey/brown, SILTY CLAY, some sand, trace gravel (TILL)		207.69 1.40	3	50 DO	18				
		END OF BOREHOLE		206.96 2.13							
3		NOTE: 1. Borehole dry upon completion of drilling.									
4											
5											
6											
7											
8											
9											
10											

MIS-BHS 001 08-1111-0038.GPJ GAL-MIS.GDT 3/25/09 SAC

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AM
CHECKED: SLP

PROJECT: 08-1111-0038

RECORD OF BOREHOLE: BH08-20

SHEET 1 OF 1

LOCATION: See Figure 2

BORING DATE: November 24, 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - O 10 20 30 40	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—O W—⊣ Wl 5 10 15 20	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		209.21							
0	Truck Mounted D-50 100 mm Solid Stem Augers	Compact, moist, dark brown, sand and gravel, trace silt (FILL)	▨	0.00							
		Stiff, dark brown/black, silty clay, trace to some sand, gravel, rootlets (TOPSOIL)	▤	208.91 0.30	1	50 DO	15				
1		Very stiff to hard, mottled brown/grey to brown, SILTY CLAY to CLAYEY SILT, some sand, trace to some gravel (TILL)	▨	208.45 0.76	2	50 DO	22				
2		Contains sand pockets	▨		3	50 DO	32				
			▨		4	50 DO	50				
3			▨		5	50 DO	39				
		END OF BOREHOLE		205.55 3.66							
4											
5											
6											
7											
8											
9											
10											

NOTE:

1. Borehole dry upon completion of drilling.

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AM
CHECKED: SLP

PROJECT: 08-1111-0038 (7000)

RECORD OF BOREHOLE: 09-1

SHEET 1 OF 1

LOCATION: N 829294.9 ;E 596719.2

BORING DATE: October 19, 2009

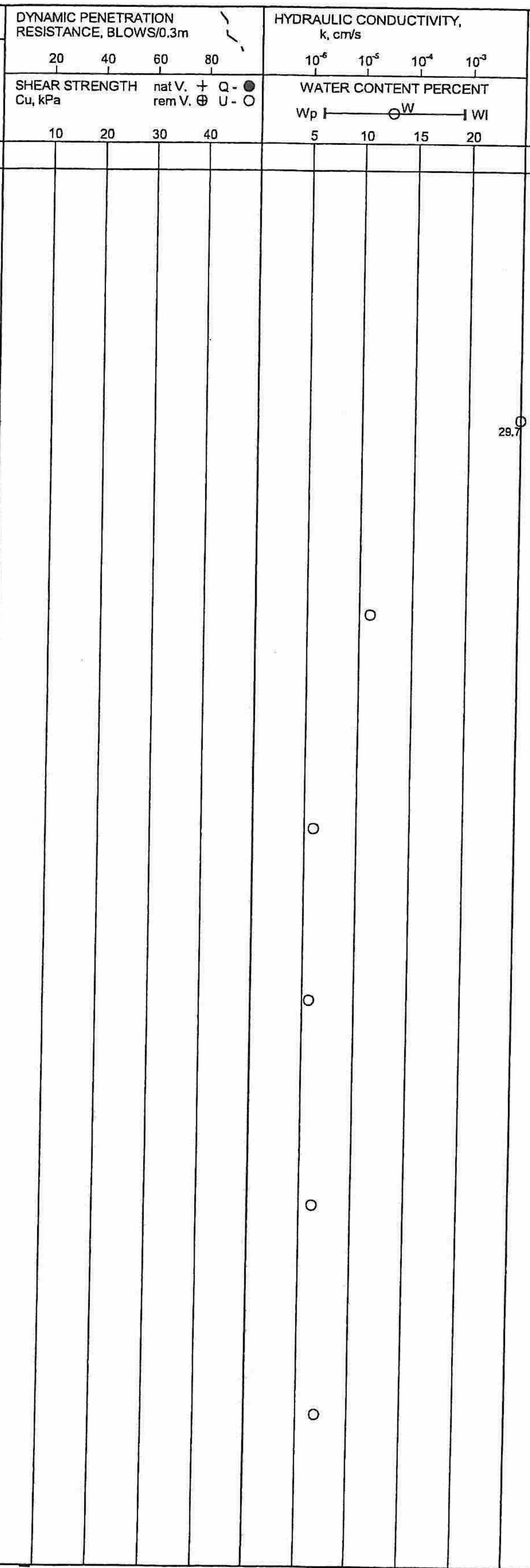
DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: CME 55 Truck Mount
150 mm Solid Stem Augers

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
0	GROUND SURFACE	205.68			
	ASPHALT	0.00			
	Stiff, moist, black, organic silty clay, some sand and gravel, contains rootlets (FILL)	205.43 0.25	1	50 DO	12
2			2	50 DO	8
3	Hard, brown, SILTY CLAY, some sand and gravel, contains cobbles and/or boulders (TILL)	202.94 2.74	3	50 DO	35
4	Hard, moist, brown, SILTY CLAY to CLAYEY SILT, some sand, some gravel (TILL) to very dense, brown, SILT and SAND, trace to some gravel, trace clay (TILL), contains cobbles/boulders	201.41 4.27			
5			4	50 DO	69/ 0.3
			5	50 DO	70/ 0.22
6			6	50 DO	65/ 0.10
7			7	50 DO	53/ 0.08
9		196.44	8	50 DO	65/ 0.10
	END OF BOREHOLE	9.24			



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

Upon completion of drilling the borehole was open with no free water; the borehole was wet at the bottom.

NOTE:
1. Augers were grinding between depths of 4.0 m and 4.3 m, suggesting possible presence of cobbles and/or boulders.

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: BC

CHECKED: CCG

PROJECT: 08-1111-0038 (7000)

RECORD OF BOREHOLE: 09-2

SHEET 1 OF 1

LOCATION: N 829308.5 ;E 596704.2

BORING DATE: October 19, 2009

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q- ● rem V. ⊕ U- ○ (10 20 30 40)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp ├──○W──┤ Wl (5 10 15 20)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		205.73							
0	CME 55 Truck Mount 150 mm Solid Stem Augers	ASPHALT		0.00							
		Very dense, moist, brown, sand and gravel, trace silt, contains asphalt fragments (FILL)		205.53 0.20	1	50 DO	52				
		Firm, moist, dark grey, organic silty clay, some sand and gravel, contains rootlets and wood fragments (FILL)		205.12 0.61							
1					2	50 DO	7				
		Very stiff to hard, moist, brown, SILTY CLAY, some sand and gravel, contains cobbles and/or boulders (TILL)		204.21 1.52	3	50 DO	22				
2											
3					4	50 DO	59				
4											
		Very dense, moist, brown, SAND and SILT, trace to some gravel and clay (TILL) to hard, brown, CLAYEY SILT (TILL). Contains cobbles and/or boulders.		201.46 4.27	5	50 DO	63/ 0.15				
5					6	50 DO	68/ 0.30				
6					7	50 DO	61/ 0.15		○ ├─┤	MH	
7					8	50 DO	50/ 0.25				
8											
9				196.49	9	50 DO	50/ 0.10				
		END OF BOREHOLE NOTE: 1. Augers were grinding at a depth of 4.3 m suggesting possible presence of cobbles and/or boulders.		9.24							Upon completion of drilling the borehole was open with no free water; the borehole was wet at the bottom.
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: BC

CHECKED: CCG

PROJECT: 08-1111-0038 (7000)

RECORD OF BOREHOLE: 09-3

SHEET 1 OF 1

LOCATION: N 829980.8 ;E 596019.4

BORING DATE: October 19, 2009

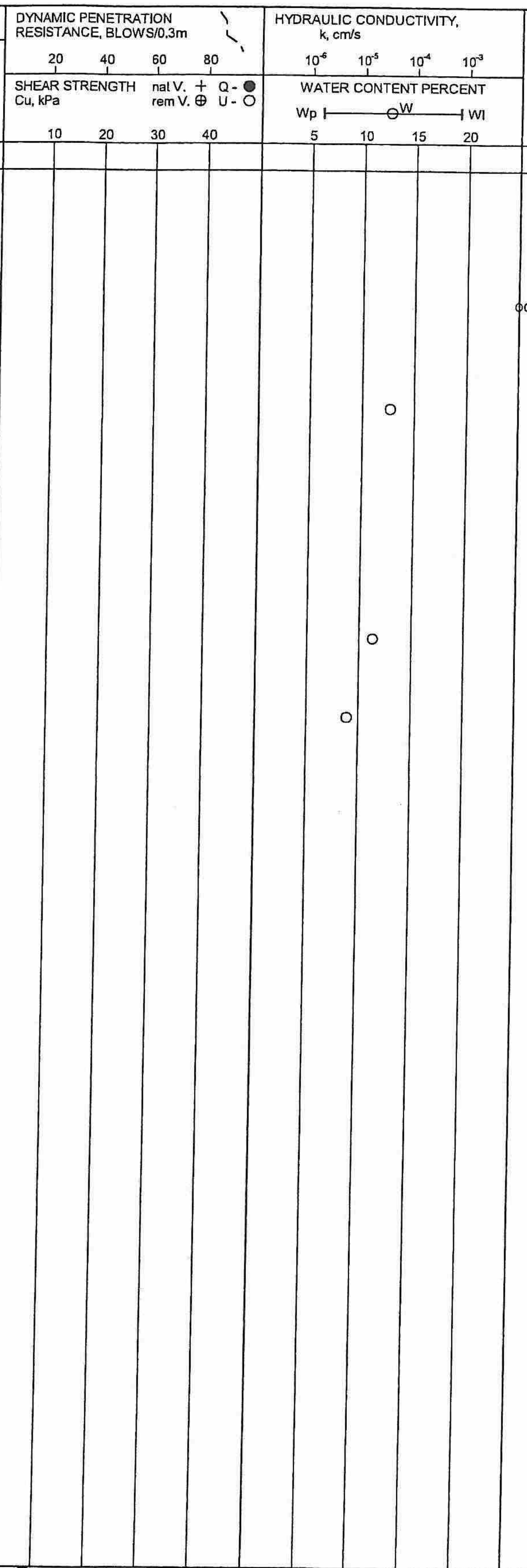
DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		207.70					
0	CME 55 Truck Mount 150 mm Solid Stem Augers	ASPHALT	■	0.00					
		Dense, moist, brown, sand and gravel, trace silt, contains asphalt fragments (FILL)	▨	0.15	1	50 DO	35		
1		Stiff, moist, dark grey to black, organic silty clay, some sand and gravel (FILL)	▨	207.09 0.61	2	50 DO	11	OC=7.1%	
2		Stiff to hard, moist, brown, SILTY CLAY, some sand and gravel (TILL)	▨	206.18 1.52	3 4 5	50 DO 50 DO 50 DO	10 45 56		
4		Hard, moist, brown to grey, SILTY CLAY to CLAYEY SILT, some sand and gravel (TILL)	▨	204.04 3.66	6	50 DO	57		
		END OF BOREHOLE		203.43 4.27					

NOTE:
1. Upon completion of drilling the borehole was open with no free water.



DEPTH SCALE
1 : 50

Golder Associates

LOGGED: BC

CHECKED: CCG

PROJECT: 08-1111-0038 (7000)

RECORD OF BOREHOLE: 09-4

SHEET 1 OF 1

LOCATION: N 595884.6 ;E 830114.0

BORING DATE: October 20, 2009

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger 150 mm O.D. Solid Stem Augers	GROUND SURFACE	206.07					
		ASPHALT	0.00					
		Compact to loose, moist, brown, sand and gravel, trace clay, contains organics (FILL)	205.87 0.20	1	50 DO	26		
1								
		Firm, moist, grey, silty clay, trace to some sand and gravel, contains organics (FILL)	204.47 1.60	2	50 DO	7		
2								
		Stiff, brown to grey, SILTY CLAY, some sand and gravel (TILL)	203.63 2.44					
3				3	50 DO	12		
4		Very dense, wet, brown, SAND and GRAVEL, trace silt and clay	202.11 3.96	4A	50 DO	68		
		Hard, moist, brown to reddish brown, SILTY CLAY, some sand and gravel, contains cobbles and/or boulders (TILL)	201.67 4.40	4B				
5				5	50 DO	100/0.25		
6		Very dense, moist to wet, reddish brown, SILT and SAND, some gravel, trace clay, contains cobbles and/or boulders (TILL) Laboratory testing indicates Sample 6 is non-plastic.	200.29 5.78	6	50 DO	100/0.43	MH	
7		Reddish brown, weathered SHALE	199.36 6.71	7	50 DO	90/0.30		∇
8								
9				8	50 DO	50/0.05		
		END OF BOREHOLE NOTE: 1. Augers were grinding at various depths within the till.	196.87 9.20					Water level in open borehole at a depth of 7.2 m below ground surface upon completion of drilling.
10								

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - O; 10 20 30 40

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

WATER CONTENT PERCENT: Wp ⊢—O W—⊣ Wl; 5 10 15 20

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: TZ

CHECKED: CCG

MIS-BHS 001 08-1111-0038.GPJ GAL-MIS.GDT 1/25/10 SAC

PROJECT: 08-1111-0038 (7000)

RECORD OF BOREHOLE: 09-5

SHEET 1 OF 1

LOCATION: N 595869.7 ;E 830128.3

BORING DATE: October 20, 2009

DATUM: Geodetic

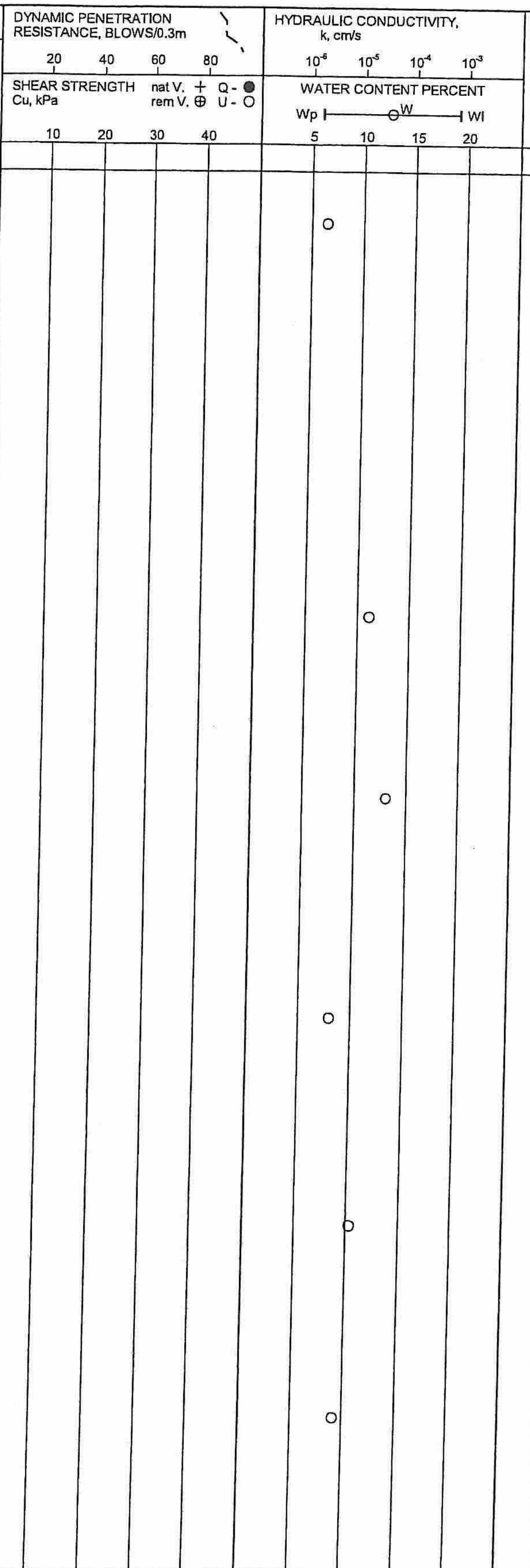
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 150 mm O.D. Solid Stem Augers

SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES – NUMBER	TYPE	BLOWS/0.3m
GROUND SURFACE	206.01			
ASPHALT	0.00			
Dense, moist, brown, sand and gravel, contains organics matter and rootlets (FILL)	0.15	1	50 DO	31
Stiff, moist, grey, silty clay, trace to some gravel and sand, contains organics matter and rootlets (FILL)	204.79 1.22	2	50 DO	10
Hard, moist, brown to reddish brown, SILTY CLAY, some sand and gravel, contains silt seams, cobbles and/or boulders (TILL)	203.57 2.44	3	50 DO	52
		4	50 DO	75/ 0.10
		5	50 DO	78/ 0.15
		6	50 DO	75/ 0.30
Reddish brown, weathered SHALE	198.39 7.62	7	50 DO	65/ 0.30
	196.81	8	50 DO	70/ 0.05
END OF BOREHOLE	9.20			

NOTE:
1. Augers were grinding at various depths within the till.



PIEZOMETER OR STANDPIPE INSTALLATION

▽

Water level in open borehole at a depth of 7.8 m below ground surface upon completion of drilling.

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: TZ

CHECKED: CCG

PROJECT: 08-1111-0038 (7000)

RECORD OF BOREHOLE: 09-6

SHEET 1 OF 1

LOCATION: N 595737.2 ;E 830258.4

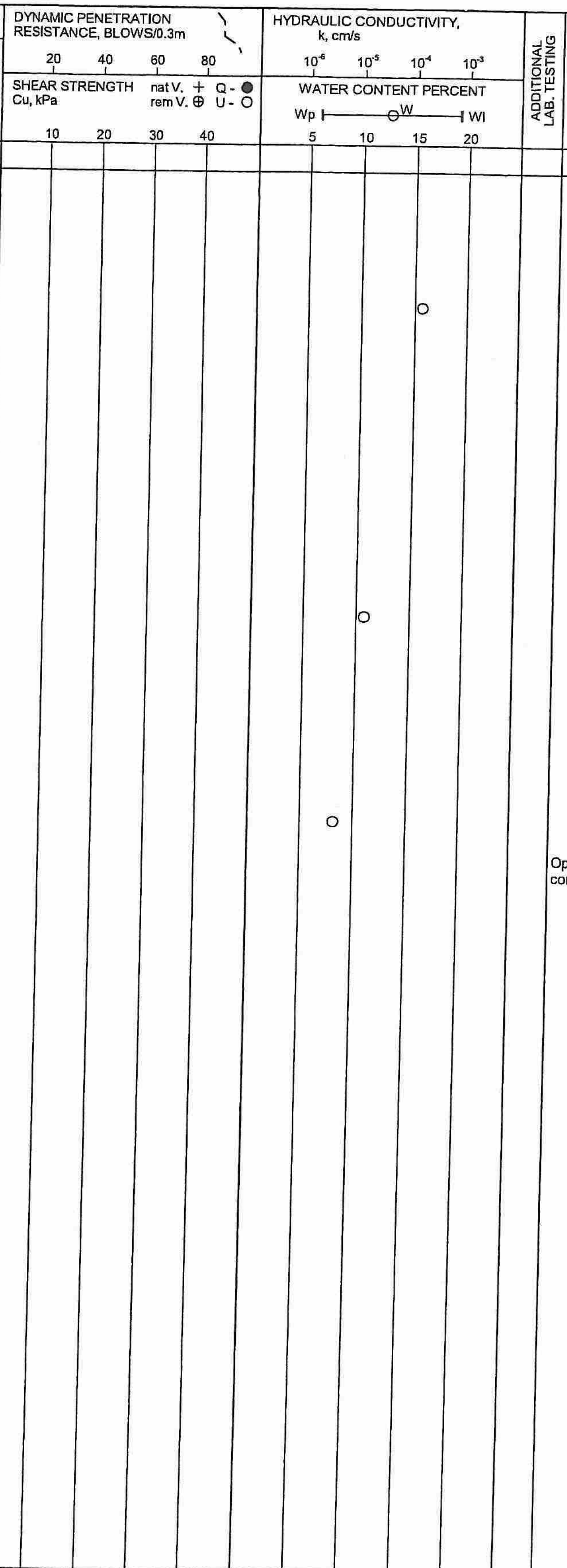
BORING DATE: October 20, 2009

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger 150 mm O.D. Solid Stem Augers	GROUND SURFACE		207.54				
		ASPHALT	■	0.00				
		Compact, moist, brown, sand, some gravel, contains asphalt fragments (FILL)	▨	207.34 0.20	1	50 DO	29	
1		Stiff to hard, moist, brown with grey spots, SILTY CLAY, some sand and gravel (TILL)	▨	206.95 0.59	2	50 DO	14	
2					3	50 DO	23	
3					4	50 DO	34	
4								
5		Becoming grey, contains grey shale fragments			5	50 DO	51	
		END OF BOREHOLE		202.51 5.03				Open borehole dry upon completion of drilling.
6								
7								
8								
9								
10								



DEPTH SCALE

1 : 50

LOGGED: TZ

CHECKED: CCG

PROJECT: 08-1111-0038 (7000)

RECORD OF BOREHOLE: 09-9

SHEET 1 OF 1

LOCATION: N 595205.0 ;E 830781.0

BORING DATE: October 21, 2009

DATUM: Geodetic

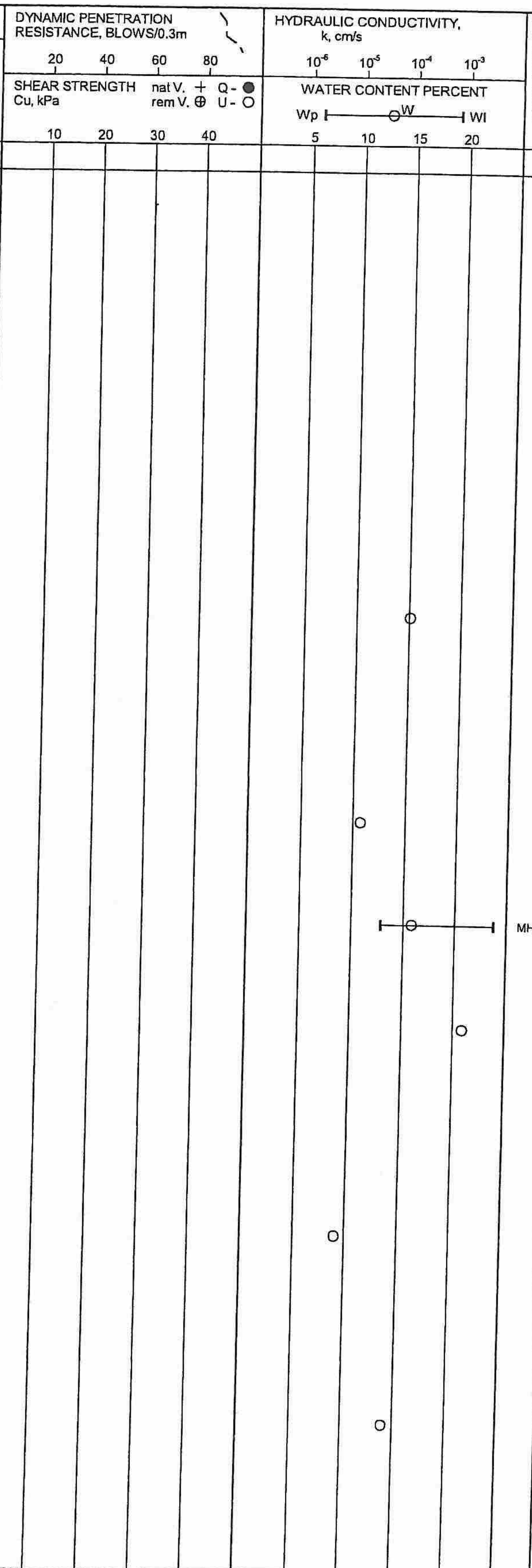
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 150 mm O.D. Solid Stem Augers

SOIL PROFILE – DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	208.25
ASPHALT	0.00
Dense, moist, brown, sand and gravel, contains silty clay inclusions (FILL)	208.05 0.20
Firm to hard, moist, brown with grey spot, SILTY CLAY, some sand, trace to some gravel, contains sandy silt seams, cobbles and/or boulders (TILL)	207.34 0.91
Becoming grey	
Becoming reddish brown and wet	
END OF BOREHOLE	198.95 9.30

SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
1	50 DO	47	
2	50 DO	7	
3	50 DO	33	
4	50 DO	55	
5	50 DO	29	MH
6	50 DO	31	
7	50 DO	70	
8	50 DO	50/ 0.15	



PIEZOMETER OR STANDPIPE INSTALLATION

∇

NOTE:

1. No recovery for Sample 2.

Groundwater in open borehole encountered at a depth of about 2.1 m below ground surface upon completion of drilling.

DEPTH SCALE

1 : 50

LOGGED: TZ

CHECKED: CCG

PROJECT: 08-1111-0038 (7000)

RECORD OF BOREHOLE: 09-9A

SHEET 1 OF 1

LOCATION: Approximately 0.5 m south-west of Borehole 09-9

BORING DATE: October 21, 2009

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 10 20 30 40	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 5 10 15 20	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m				
0		GROUND SURFACE									
	Power Auger 150 mm O.D. Solid Stem Augers	ASPHALT	■	0.00							
				0.20							
1											
		Moist, brown, SILTY CLAY, some sand and gravel (TILL)	▨	1.52	1	50 DO	9				
2		END OF BOREHOLE		1.98							
		NOTE: 1. Augered from 0 m to 1.52 m to obtain Sample 1 (same depth as missed Sample 2 from Borehole 09-9).									
3											
4											
5											
6											
7											
8											
9											
10											

MIS-BHS 001 08-1111-0038.GPJ GAL-MIS.GDT 1/25/10 SAC

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: TZ

CHECKED: CCG

PROJECT: 08-1111-0038 (7000)

RECORD OF BOREHOLE: 09-10

SHEET 1 OF 1

LOCATION: N 830881.2 ;E 595103.4

BORING DATE: October 21, 2009

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (10 20 30 40)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (5 10 15 20)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		207.82							
0	Power Auger 150 mm O.D. Solid Stem Augers	ASPHALT	■	0.00							
		Compact, moist, brown, sand and gravel (FILL)	▩	207.62 0.20	1	50 DO	22				
		Stiff to hard, moist, brown with grey spots, SILTY CLAY, some sand, some gravel (TILL)	▨	207.16 0.66							
1					2	50 DO	24		○		
2					3	50 DO	28				
3					4	50 DO	57		○		
		END OF BOREHOLE NOTE: 1. Open borehole dry upon completion of drilling.		204.32 3.50							
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: TZ

CHECKED: CCG

PROJECT: 08-1111-0038 (7000)

RECORD OF BOREHOLE: 09-11

SHEET 1 OF 1

LOCATION: N 831025.4 ;E 594957.6

BORING DATE: October 21, 2009

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - O (10 20 30 40)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (5 10 15 20)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		207.98							
0	Power Auger 150 mm O.D. Solid Stem Augers	ASPHALT	■	0.00							
		Loose, moist, brown, sand and gravel (FILL)	▨	207.75 0.23	1A	50 DO	9				
		Firm, moist, dark grey to black, organic silty clay, some sand, some gravel (FILL)	▨	207.50 0.48	1B						
1		Firm, light grey, silty clay, some sand and gravel (FILL)	▨	207.29 0.69	2	50 DO	8				
2		Very stiff, brown, SILTY CLAY to CLAYEY SILT with sand, some gravel (TILL)	▨	206.76 1.22	3	50 DO	24				
3					4	50 DO	39		○	MH	
		END OF BOREHOLE		204.48 3.50							

NOTE:
1. Open borehole dry upon completion of drilling.

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: TZ

CHECKED: CCG

MIS-BHS 001 08-1111-0038.GPJ GAL-MIS.GDT 1/25/10 SAC

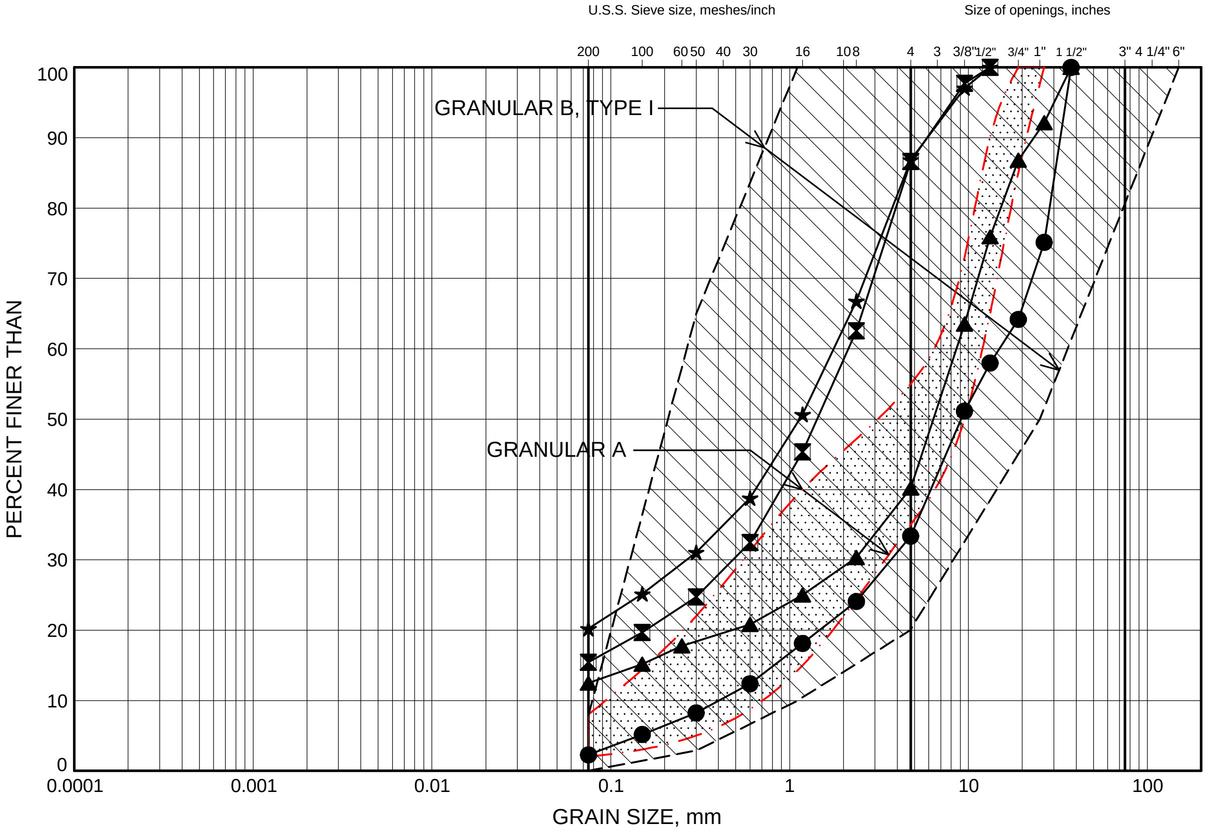
APPENDIX E

GEOTECHNICAL LABORATORY TEST RESULTS

Winston Chruchill Boulevard Class EA Study

GRAIN SIZE DISTRIBUTION

FIGURE 1



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	1+100 SB RTL	0.61	
⧗	2+000 NB RTL	0.54	
▲	3+500 NB OSH	0.61	
★	3+500 SB OSH	0.59	

Date January 2016

Project 19-1605-196

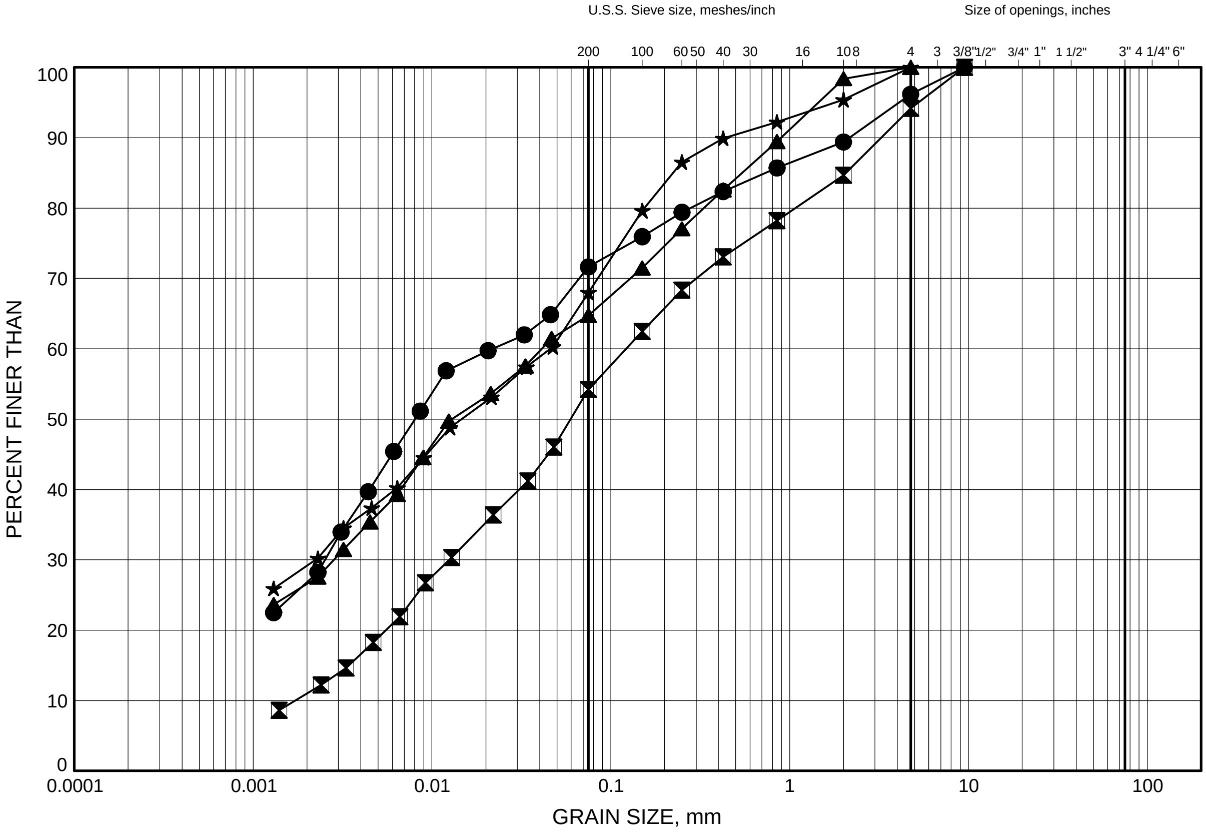
Prep'd AN

Chkd. RI

Winston Chruchill Boulevard Class EA Study

GRAIN SIZE DISTRIBUTION

FIGURE 2



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	1+100 NB Lane 1	1.80	
⧗	1+600 SB Lane 1	1.80	
▲	3+500 SB OSH	1.80	
★	4+000 NB Lane 1	1.80	

Date January 2016

Project 19-1605-196

THURBER

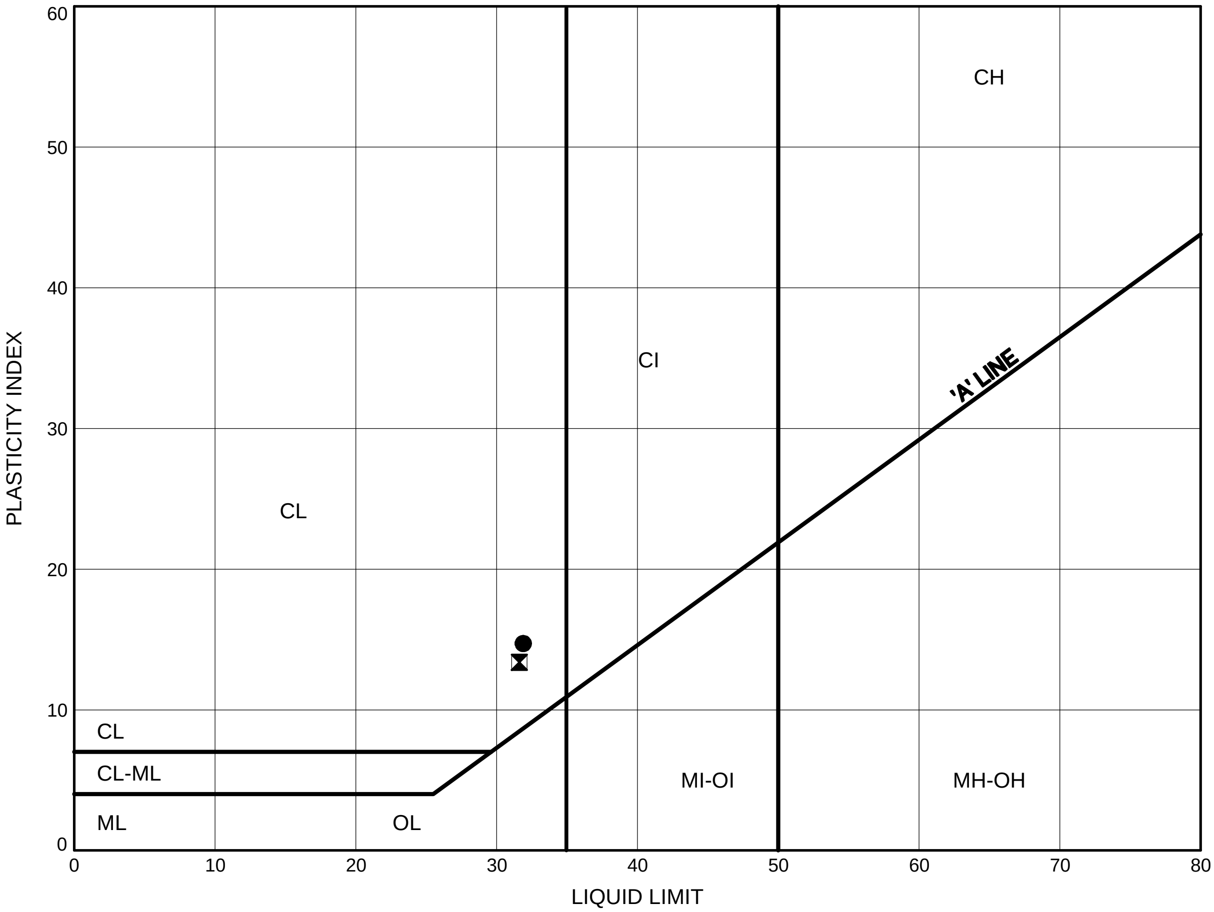
Prep'd AN

Chkd. RI

Winston Chruchill Boulevard Class EA Study

ATTERBERG LIMITS TEST RESULTS

FIGURE 3



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	3+500 SB OSH	1.80	
⧗	4+000 NB Lane 1	1.80	

Date January 2016

Project 19-1605-196

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THURBALT 19-1605-196.GPJ 1/5/16

APPENDIX F

ANALYTICAL LABORATORY TEST RESULTS

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 15T981110
PROJECT: 19-1605-196

CLIENT NAME: THURBER ENGINEERING LTD
ATTENTION TO: MARK FARRANT
SAMPLING SITE:
SAMPLED BY:Deanna Pizycki

Corrosivity Package

DATE RECEIVED: 2015-06-04
DATE REPORTED: 2015-06-12

			SAMPLE DESCRIPTION:	BH15-08, 220-860
			SAMPLE TYPE:	Soil
			DATE SAMPLED:	6/1/2015
Parameter	**Unit**	**G / S**	**RDL**	**6623117**
Sulfide	%		0.01	0.01
Chloride (2:1)	µg/g	NA	2	305
Sulphate (2:1)	µg/g		2	112
pH (2:1)	pH Units		NA	9.26
Electrical Conductivity (2:1)	mS/cm	1.4	0.005	0.635
Resistivity (2:1)	ohm.cm		1	1570
Redox Potential (2:1)	mV		5	217

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to ON T2 S ICC CT

6623117 * Sulphide analysis was performed at AGAT Laboratories Vancouver.

EC/Resistivity, pH, Chloride, Sulphate and Redox Potential were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil).

DR. ANTHONY R. K. DAPAAH

Certified By:

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 15T981110

PROJECT: 19-1605-196

CLIENT NAME: THURBER ENGINEERING LTD

SAMPLING SITE:

ATTENTION TO: MARK FARRANT

SAMPLED BY:Deanna Pizycki

O. Reg. 153(511) - Metals & Inorganics (Soil)

DATE RECEIVED: 2015-06-04

DATE REPORTED: 2015-06-12

			SAMPLE DESCRIPTION:	BH15-04, 200-900	BH15-17, 1500-2100	BH15-12, 100-870	BH15-13, 430-900	BH15-30, 1500-2100	BH15-08, 220-860	BH15-25, 1800-2100
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	6/1/2015	6/1/2015	6/1/2015	6/1/2015	6/1/2015	6/1/2015	6/1/2015
Parameter	**Unit**	**G / S**	**RDL**	**6623111**	**6623112**	**6623113**	**6623114**	**6623115**	**6623117**	**6623120**
Antimony	µg/g	40	0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8
Arsenic	µg/g	18	1	3	5	5	3	3	4	4
Barium	µg/g	670	2	8	70	87	5	7	6	81
Beryllium	µg/g	8	0.5	<0.5	0.6	<0.5	<0.5	<0.5	<0.5	<0.5
Boron	µg/g	120	5	8	7	8	6	7	7	7
Boron (Hot Water Soluble)	µg/g	2	0.10	0.20	0.26	0.15	0.11	0.19	0.15	0.35
Cadmium	µg/g	1.9	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5
Chromium	µg/g	160	2	<2	17	8	3	2	<2	15
Cobalt	µg/g	80	0.5	1.4	10.1	4.9	1.3	1.5	1.7	7.4
Copper	µg/g	230	1	4	31	35	3	4	5	34
Lead	µg/g	120	1	27	14	32	19	24	39	16
Molybdenum	µg/g	40	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Nickel	µg/g	270	1	3	19	8	3	4	5	15
Selenium	µg/g	5.5	0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Silver	µg/g	40	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Thallium	µg/g	3.3	0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Uranium	µg/g	33	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Vanadium	µg/g	86	1	2	27	14	2	3	4	22
Zinc	µg/g	340	5	153	56	192	78	113	254	69
Chromium VI	µg/g	8	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cyanide	µg/g	0.051	0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
Mercury	µg/g	3.9	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Electrical Conductivity	mS/cm	1.4	0.005	0.604	**1.89**	**1.78**	0.814	0.709	0.635	**2.36**
Sodium Adsorption Ratio	NA	12	NA	2.26	**19.7**	**23.6**	2.28	2.16	3.28	**27.6**
pH, 2:1 CaCl2 Extraction	pH Units		NA	8.51	7.76	8.19	8.42	8.57	8.56	8.29

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to ON T2 S ICC CT

6623111-6623120 EC & SAR were determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil). pH was determined on the 0.01M CaCl2 extract prepared at 2:1 ratio.

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
DR. ANTHONY R. K. DAPAAH
CHEMIST

Certified By:

Certificate of Analysis

AGAT WORK ORDER: 15T981110
PROJECT: 19-1605-196

CLIENT NAME: THURBER ENGINEERING LTD
ATTENTION TO: MARK FARRANT
SAMPLING SITE:
SAMPLED BY:Deanna Pizycki

O. Reg. 558 Metals and Inorganics

DATE RECEIVED: 2015-06-04
DATE REPORTED: 2015-06-12

			SAMPLE DESCRIPTION:	BH15-24, 1500-2100	BH15-03, 190-1080	BH15-18, 160-1200
			SAMPLE TYPE:	Soil	Soil	Soil
			DATE SAMPLED:	6/1/2015	6/1/2015	6/1/2015
Parameter	Unit	G / S	RDL	6623109	6623116	6623119
Arsenic Leachate	mg/L	2.5	0.010	<0.010	<0.010	<0.010
Barium Leachate	mg/L	100	0.100	0.934	0.272	0.117
Boron Leachate	mg/L	500	0.050	<0.050	<0.050	0.053
Cadmium Leachate	mg/L	0.5	0.010	<0.010	<0.010	<0.010
Chromium Leachate	mg/L	5.0	0.010	<0.010	<0.010	<0.010
Lead Leachate	mg/L	5.0	0.010	<0.010	0.022	0.182
Mercury Leachate	mg/L	0.1	0.01	<0.01	<0.01	<0.01
Selenium Leachate	mg/L	1.0	0.010	<0.010	<0.010	<0.010
Silver Leachate	mg/L	5.0	0.010	<0.010	<0.010	<0.010
Uranium Leachate	mg/L	10.0	0.050	<0.050	<0.050	<0.050
Fluoride Leachate	mg/L	150	0.05	0.32	0.30	0.41
Cyanide Leachate	mg/L	20.0	0.05	<0.05	<0.05	<0.05
(Nitrate + Nitrite) as N Leachate	mg/L	1000	0.70	<0.70	<0.70	<0.70

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to Regulation 558

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
DR. ANTHONY R. K. DAPAAH
CHEMIST

Certified By:

AGAT Laboratories

Guideline Violation

AGAT WORK ORDER: 15T981110

PROJECT: 19-1605-196

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: THURBER ENGINEERING LTD **ATTENTION TO: MARK FARRANT**

SAMPLEID	SAMPLE TITLE	GUIDELINE	ANALYSIS PACKAGE	PARAMETER	GUIDEVALUE	RESULT
6623112	BH15-17, 1500-2100	ON T2 S ICC CT	O. Reg. 153(511) - Metals & Inorganics (Soil)	Electrical Conductivity	1.4	1.89
6623112	BH15-17, 1500-2100	ON T2 S ICC CT	O. Reg. 153(511) - Metals & Inorganics (Soil)	Sodium Adsorption Ratio	12	19.7
6623113	BH15-12, 100-870	ON T2 S ICC CT	O. Reg. 153(511) - Metals & Inorganics (Soil)	Electrical Conductivity	1.4	1.78
6623113	BH15-12, 100-870	ON T2 S ICC CT	O. Reg. 153(511) - Metals & Inorganics (Soil)	Sodium Adsorption Ratio	12	23.6
6623120	BH15-25, 1800-2100	ON T2 S ICC CT	O. Reg. 153(511) - Metals & Inorganics (Soil)	Electrical Conductivity	1.4	2.36
6623120	BH15-25, 1800-2100	ON T2 S ICC CT	O. Reg. 153(511) - Metals & Inorganics (Soil)	Sodium Adsorption Ratio	12	27.6

THURBER

APPENDIX G

FWD TEST RESULTS

Appendix G
Winston Churchill Boulevard Class EA Study
Highway 401 to Embleton Road

Station (km)	Direction	Lane	Normalized Deflection (μm)	M_R (MPa)	E_P (MPa)	SN_{Eff} (mm)
0.000	NB	1	324	29	554	165
0.120	NB	1	150	58	1,248	216
0.200	NB	1	163	73	1,026	203
0.300	NB	1	212	42	863	191
0.420	NB	1	226	45	777	185
0.525	NB	1	139	50	1,483	229
0.600	NB	1	278	35	641	173
0.700	NB	1	271	39	637	173
0.800	NB	1	175	57	1,009	202
0.900	NB	1	219	45	813	188
0.975	NB	1	178	70	911	195
1.100	NB	1	191	58	891	193
1.200	NB	1	164	66	1,040	204
1.300	NB	1	172	65	969	199
1.400	NB	1	107	108	1,571	234
1.500	NB	1	142	68	1,237	216
1.600	NB	1	138	82	1,203	214
1.700	NB	1	138	85	1,190	213
1.800	NB	1	137	75	1,264	217
1.900	NB	1	148	71	1,158	211
2.000	NB	1	151	62	1,195	213
2.100	NB	1	148	55	1,284	218
2.200	NB	1	161	57	1,118	209
2.300	NB	1	146	63	1,234	215
2.400	NB	1	145	63	1,265	217
2.500	NB	1	170	58	1,041	204
2.620	NB	1	150	72	1,153	211
2.700	NB	1	180	58	977	199
2.800	NB	1	170	62	1,013	202
2.900	NB	1	176	59	988	200
3.000	NB	1	168	60	1,045	204
3.100	NB	1	159	61	1,121	209
3.200	NB	1	164	63	1,068	205
3.300	NB	1	149	65	1,200	214
3.400	NB	1	121	81	1,471	229
3.500	NB	1	122	91	1,404	225
3.600	NB	1	114	93	1,513	231
3.700	NB	1	148	71	1,171	212
3.800	NB	1	157	67	1,113	208
3.900	NB	1	165	62	1,068	205
4.000	NB	1	146	68	1,206	214
4.100	NB	1	254	34	719	180
Minimum Value			**107**	**29**	**554**	**165**
Maximum Value			**324**	**108**	**1,571**	**234**
Average Value			**170**	**63**	**1,092**	**206**

Appendix G
Winston Churchill Boulevard Class EA Study
Highway 401 to Embleton Road

Station (km)	Direction	Lane	Normalized Deflection (µm)	M_R (MPa)	E_P (MPa)	SN_{Eff} (mm)
0.030	NB	2	449	30	359	143
0.150	NB	2	196	57	869	192
0.250	NB	2	182	63	926	196
0.350	NB	2	218	51	776	185
0.425	NB	2	273	42	613	171
0.550	NB	2	334	36	500	159
0.650	NB	2	295	38	571	167
0.725	NB	2	350	35	468	156
0.850	NB	2	265	47	617	171
0.950	NB	2	191	78	818	188
1.075	NB	2	256	48	643	173
1.150	NB	2	262	43	642	173
1.250	NB	2	173	59	1,012	202
1.350	NB	2	161	66	1,064	205
1.450	NB	2	158	77	1,049	204
1.550	NB	2	189	55	911	195
1.650	NB	2	185	59	925	196
1.750	NB	2	170	64	1,010	202
1.850	NB	2	155	70	1,109	208
1.950	NB	2	150	68	1,153	211
2.050	NB	2	146	72	1,177	212
2.150	NB	2	160	60	1,114	208
2.250	NB	2	185	57	930	196
2.350	NB	2	196	49	900	194
		Minimum Value	**146**	**30**	**359**	**143**
		Maximum Value	**449**	**78**	**1,177**	**212**
		Average Value	**221**	**55**	**840**	**188**

THURBER

Appendix G
Winston Churchill Boulevard Class EA Study
Highway 401 to Embleton Road

Station (km)	Direction	Lane	Normalized Deflection	M_R	E_P	SN_{Eff}
			(µm)	(MPa)	(MPa)	(mm)
0.000	SB	1	385	33	414	150
0.150	SB	1	209	44	860	191
0.250	SB	1	237	56	677	176
0.385	SB	1	212	47	817	188
0.550	SB	1	312	33	548	164
0.650	SB	1	356	30	473	157
0.750	SB	1	138	65	1,326	221
0.850	SB	1	155	60	1,168	212
0.950	SB	1	153	72	1,112	208
1.050	SB	1	146	74	1,163	211
1.150	SB	1	162	63	1,071	206
1.250	SB	1	135	80	1,263	217
1.350	SB	1	137	79	1,239	216
1.450	SB	1	101	113	1,662	238
1.550	SB	1	138	73	1,253	217
1.650	SB	1	129	88	1,278	218
1.750	SB	1	133	80	1,279	218
1.850	SB	1	135	78	1,269	218
1.950	SB	1	134	81	1,261	217
2.075	SB	1	137	83	1,224	215
2.150	SB	1	130	74	1,371	223
2.250	SB	1	143	74	1,194	213
2.350	SB	1	185	45	1,007	201
2.450	SB	1	201	53	845	190
2.550	SB	1	166	65	1,010	202
2.650	SB	1	133	77	1,306	220
2.750	SB	1	159	62	1,095	207
2.850	SB	1	145	68	1,194	213
2.950	SB	1	149	67	1,170	212
3.050	SB	1	163	60	1,079	206
3.150	SB	1	154	64	1,148	210
3.250	SB	1	152	65	1,142	210
3.350	SB	1	169	54	1,063	205
3.450	SB	1	143	77	1,185	213
3.550	SB	1	154	55	1,222	215
3.650	SB	1	146	69	1,201	214
3.750	SB	1	125	72	1,462	228
3.850	SB	1	167	57	1,073	206
3.950	SB	1	185	50	967	199
4.050	SB	1	154	62	1,158	211
Minimum Value			**101**	**30**	**414**	**150**
Maximum Value			**385**	**113**	**1,662**	**238**
Average Value			**169**	**65**	**1,106**	**206**

THURBER

Appendix G
Winston Churchill Boulevard Class EA Study
Highway 401 to Embleton Road

Station (km)	Direction	Lane	Normalized Deflection (μm)	M_R (MPa)	E_P (MPa)	SN_{Eff} (mm)
0.100	SB	2	383	37	405	149
0.200	SB	2	147	96	1,062	205
0.300	SB	2	173	72	949	197
0.400	SB	2	172	49	1,090	207
0.510	SB	2	423	26	399	148
0.600	SB	2	247	39	722	180
0.700	SB	2	237	44	732	181
0.800	SB	2	137	87	1,222	215
0.900	SB	2	232	55	706	179
0.950	SB	2	210	54	810	187
1.100	SB	2	242	44	701	179
1.200	SB	2	157	66	1,095	207
1.300	SB	2	214	47	818	188
1.400	SB	2	139	81	1,216	215
1.500	SB	2	153	70	1,126	209
1.600	SB	2	158	58	1,131	209
1.700	SB	2	152	70	1,121	209
1.800	SB	2	162	62	1,082	206
1.900	SB	2	170	57	1,041	204
2.000	SB	2	139	65	1,298	219
2.100	SB	2	154	64	1,138	210
2.200	SB	2	176	48	1,057	205
2.300	SB	2	200	49	878	192
		Minimum Value	**137**	**26**	**399**	**148**
		Maximum Value	**423**	**96**	**1,298**	**219**
		Average Value	**199**	**58**	**948**	**196**

THURBER

APPENDIX H

DARWIN PAVEMENT DESIGN ANALYSIS

1997 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Thurber Engineering Ltd.

Flexible Structural Design Module

Winston Churchill Boulevard Class EA Study
Highway 401 to Steeles Avenue Widening 2021
Flexible Pavement Design

Flexible Structural Design

80-kN ESALs Over Initial Performance Period	26,957,972
Initial Serviceability	4.4
Terminal Serviceability	2.2
Reliability Level	90 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	35,000 kPa
Stage Construction	1
Calculated Design Structural Number	150 mm

Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	28,930
Number of Lanes in Design Direction	3
Percent of All Trucks in Design Lane	70 %
Percent Trucks in Design Direction	50 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	12 %
Average Initial Truck Factor (ESALs/truck)	2.5
Annual Truck Factor Growth Rate	0 %
Annual Truck Volume Growth Rate	2 %
Growth	Compound
Total Calculated Cumulative ESALs	26,957,972

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(mm)	Width (m)	Calculated SN (mm)
1	HMA	0.42	1	190	3.6	80
2	Granular A	0.14	1	150	3.6	21
3	Granular B	0.09	1	550	3.6	50
Total	-	-	-	890	-	150

Layered Thickness Design

Thickness precision Actual

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Spec Thickness (Di)(mm)	Min Thickness (Di)(mm)	Elastic Modulus (kPa)	Width (m)	Calculated Thickness (mm)	Calculated SN (mm)
1	HMA	0.42	1	-	100	2,750,000	3.6	189	79
2	Granular A	0.14	1	150	-	250,000	3.6	150	21
3	Granular B	0.09	1	-	300	150,000	3.6	551	50
Total	-	-	-	-	-	-	-	890	150

1997 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

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Computer Software Product

Thurber Engineering Ltd.

Flexible Structural Design Module

Winston Churchill Boulevard Class EA Study
Steeles Avenue to Maple Lodge Farm Widening 2031
Flexible Pavement Design

Flexible Structural Design

80-kN ESALs Over Initial Performance Period	19,494,393
Initial Serviceability	4.4
Terminal Serviceability	2.2
Reliability Level	90 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	35,000 kPa
Stage Construction	1
Calculated Design Structural Number	144 mm

Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	17,070
Number of Lanes in Design Direction	3
Percent of All Trucks in Design Lane	70 %
Percent Trucks in Design Direction	50 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	12 %
Average Initial Truck Factor (ESALs/truck)	2.5
Annual Truck Factor Growth Rate	0 %
Annual Truck Volume Growth Rate	4 %
Growth	Compound
Total Calculated Cumulative ESALs	19,494,393

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(mm)	Width (m)	Calculated SN (mm)
1	HMA	0.42	1	185	3.6	78
2	Granular A	0.14	1	150	3.6	21
3	Granular B	0.09	1	525	3.6	47
Total	-	-	-	860	-	146

Layered Thickness Design

Thickness precision Actual

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Spec Thickness (Di)(mm)	Min Thickness (Di)(mm)	Elastic Modulus (kPa)	Width (m)	Calculated Thickness (mm)	Calculated SN (mm)
1	HMA	0.42	1	-	100	2,750,000	3.6	180	76
2	Granular A	0.14	1	150	-	250,000	3.6	150	21
3	Granular B	0.09	1	-	300	150,000	3.6	526	47
Total	-	-	-	-	-	-	-	856	144

1997 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Thurber Engineering Ltd.

Flexible Structural Design Module

Winston Churchill Boulevard Class EA Study
Maple Lodge Farm to Embleton Road Widening 2031
Flexible Pavement Design

Flexible Structural Design

80-kN ESALs Over Initial Performance Period	15,759,966
Initial Serviceability	4.4
Terminal Serviceability	2.2
Reliability Level	90 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	35,000 kPa
Stage Construction	1
Calculated Design Structural Number	140 mm

Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	20,700
Number of Lanes in Design Direction	3
Percent of All Trucks in Design Lane	70 %
Percent Trucks in Design Direction	50 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	8 %
Average Initial Truck Factor (ESALs/truck)	2.5
Annual Truck Factor Growth Rate	0 %
Annual Truck Volume Growth Rate	4 %
Growth	Compound
Total Calculated Cumulative ESALs	15,759,966

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(mm)	Width (m)	Calculated SN (mm)
1	HMA	0.42	1	180	3.6	76
2	Granular A	0.14	1	150	3.6	21
3	Granular B	0.09	1	525	3.6	47
Total	-	-	-	855	-	144

Layered Thickness Design

Thickness precision Actual

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Spec Thickness (Di)(mm)	Min Thickness (Di)(mm)	Elastic Modulus (kPa)	Width (m)	Calculated Thickness (mm)	Calculated SN (mm)
1	HMA	0.42	1	-	100	2,750,000	3.6	174	73
2	Granular A	0.14	1	150	-	250,000	3.6	150	21
3	Granular B	0.09	1	-	300	150,000	3.6	509	46
Total	-	-	-	-	-	-	-	833	140

1997 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Thurber Engineering Ltd.

Overlay Design Module

Winston Churchill Boulevard Class EA Study
Highway 401 to Steeles Avenue
2021 Pavement Strengthening - Flexible Pavement Design

AC Overlay of AC Pavement

Structural Number for Future Traffic	150 mm

Design Method	Effective Existing Structural Number (mm)	Overlay Structural Number (mm)
Component Analysis	-	-
Remaining Life	121	29
Non-Destructive Testing	-	-

Effective Structural Number - Remaining Life Method

Past Traffic Lane ESALs	9,400,000
ESALs to Terminal Serviceability of 1.5	13,000,000
SN of New Existing Pavement After Milling (SNo)	150 mm

Calculated Results

Remaining Life	27.69 %
Condition Factor	0.81
Effective Existing Pavement SN (SNEff)	121 mm

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(mm)	Width (m)	Calculated SN (mm)
1	New HMA	0.42	1	70	3.6	29
Total	-	-	-	70	-	29

1997 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Thurber Engineering Ltd.

Overlay Design Module

Winston Churchill Boulevard Class EA Study
Steeles Aenue to MLF
2031 Pavement Strengthening - Flexible Pavement Design

AC Overlay of AC Pavement

Structural Number for Future Traffic	150 mm

Design Method	Effective Existing Structural Number (mm)	Overlay Structural Number (mm)
Component Analysis	-	-
Remaining Life	134	16
Non-Destructive Testing	-	-

Effective Structural Number - Remaining Life Method

Past Traffic Lane ESALs	13,300,000
ESALs to Terminal Serviceability of 1.5	27,000,000
SN of New Existing Pavement After Milling (SNo)	150 mm

Calculated Results

Remaining Life	50.74 %
Condition Factor	0.89
Effective Existing Pavement SN (SNEff)	134 mm

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(mm)	Width (m)	Calculated SN (mm)
1	New HMA	0.42	1	50	3.6	21
Total	-	-	-	50	-	21

*Note: This value is not represented by the inputs or an error occurred in calculation.

1997 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Thurber Engineering Ltd.

Overlay Design Module

Winston Churchill Boulevard Class EA Study
Maple Lodge Farm to Embleton Road
2031 Pavement Strengthening - Flexible Pavement Design

AC Overlay of AC Pavement

Structural Number for Future Traffic	150 mm

Design Method	Effective Existing Structural Number (mm)	Overlay Structural Number (mm)
Component Analysis	-	-
Remaining Life	138	12
Non-Destructive Testing	-	-

Effective Structural Number - Remaining Life Method

Past Traffic Lane ESALs	10,800,000
ESALs to Terminal Serviceability of 1.5	27,000,000
SN of New Existing Pavement After Milling (SNo)	150 mm

Calculated Results

Remaining Life	60.00 %
Condition Factor	0.92
Effective Existing Pavement SN (SNEff)	138 mm

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(mm)	Width (m)	Calculated SN (mm)
1	New HMA	0.42	1	50	3.6	21
Total	-	-	-	50	-	21