HYDROGEOLOGICAL FOUNDATION INVESTIGATION REPORT FOR PRELIMINARY DESIGN

HIGHWAY 407 EAST EXTENSION – WESTERN SECTION

W.O. 07 – 20015

Geocres Number: 30M14-317

Prepared for:
Ministry of Transportation Ontario

Prepared by:

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Date:

June, 2009

Project Number:

107905-50613

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June 30, 2009

Project Number: 107904-50613

Mr. Dean Kemper
Senior Project Manager
Planning and Environmental Office
Ministry of Transportation Ontario
3rd Floor, Building D, 1201 Wilson Avenue
Downsview, ON M3M 1J8

Dear Mr. Kemper:

Re: Hydrogeological Foundation Investigation Report For Preliminary Design

We are pleased to convey this report on the Hydrogeological Investigations along the Western Mainline and West Durham Link of the Highway 407 East Extension to the Ministry of Transportation.

Shall you or any other technical reviewer have any questions please contact the undersigned.

Sincerely,
AECOM Canada Ltd.

Steve Usher, B.Sc., M.Sc., P.Eng., P.Geo
Steve.Usher@aecom.com

SU:mm
Attach.

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Part A

Hydrogeological Foundation Investigation Report for Preliminary Design

HIGHWAY 407 EAST EXTENSION – WESTERN SECTION

Ministry of Transportation Ontario

Date:

June, 2009

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1. Introduction

This report presents Part A of the Hydrogeological Investigations for the Preliminary Design for the Western Mainline and the West Durham Link of the Technically Preferred Route (TPR) of the Highway 407 East Extension. AECOM was retained by URS Canada Inc. (URS) to carry out this study for the Ministry of Transportation (MTO). The purpose of this report is to provide a summary of the geological / hydrogeological information in support of the foundation design, structural design and highway design teams. Interpretation and discussion of the results presented in Part A will be further discussed in Part B.

The study area of the hydrogeological investigations within the Western Section includes approximately 15 km the 407 mainline from Brock Road to Ashburn Road as well as approximately 10 km the West Durham Link from Highway 401 to Highway 407 (**Figure 1**). The majority of the field investigations were concentrated within one (1) km of the centreline of the TPR.

This report is designed to be a stand alone report that supersedes all previous hydrogeological foundations reports. The information presented here may only be used for planning and feasibility purposes. Additional, site-specific hydrogeologic data are required for preparation at the detailed design stage.

2. Report Structure

The Western Mainline and Link have been divided into sub-sections based upon differences in geology / hydrogeology that exist within the larger Western Section. The study area was divided into two parts: The West Mainline from Brock Road to Ashburn Road and West Link from the Highway 407 mainline to Highway 401. Further divisions were made to reflect the differences in geology across the mainline and link. The West Mainline was subdivided into *West 1* from Brock Road to Audley Road and *West 2* from Audley Road to Ashburn Road. *West 1* was further subdivided into *W1a* from Brock Road to east of East Duffins Creek; and *W1b* from east of East Duffins Creek to Kinsale Road. *West Link* was further subdivided into *WLa* from north of Highway 7 to south of Rossland Road; and *WLb* from south of Rossland Road to Highway 401.

2.1 Hydrogeological Conditions Summary Tables

Hydrogeological Conditions Summary Tables (**Tables 1 to 5**) were created for each subsection of the Western Mainline and Western Link [*West 1 (W1a and W1b), West 2 (W2a) and West Link (WLa and WLb)*]. The column on the left lists the associated tables and figures that accompany the summary table, the sources of field information used to draw conclusions, the engineering features of the subsection (structures, deep cuts, and high fills), and the general site physiography. The column on the right provides existing geological and hydrogeological conditions as interpreted from the desk top study, borehole drilling, hydrogeology field investigations, water well surveys and water quality sampling. These summary tables are designed to present the factual hydrogeological conditions along the West Mainline and West Link. Interpretation and discussion of the potential effects of the existing hydrogeological conditions will be presented in Report B.

2.2 Geological Cross-Sections

Geological Cross-Sections were created for Sections *West 1 (W1a and W1b), West 2 (W2a) and West Link (WLa and WLb)* using subsurface information collected from environmental borehole drilling by AECOM, geotechnical borehole drilling by Golder, historic geotechnical boreholes, MOE water well records and surficial geological mapping (**Figures A6, A7 and A8**). Cross-Section locations are shown on **Figures A1 to A5**. In cases where the geology interpreted from borehole drilling differed from the Provincial surficial geology mapping, the results of the borehole drilling were used. The central axis of the cross-section is the centre line of the highway corridor. A limit of ~500 m from the highway centre line was placed on MOE water wells and historic geotechnical boreholes to ensure accuracy, unless they were deep and continuous through multiple geological units. Wells were projected onto the cross-section at a 90^{o} angle between the well and the highway centre line. Surface topography was determined from surface elevation profiles along the centre line of the TPR using the Provincial digital elevation model (DEM) for the study area. The highway 407 Western Mainline and Western Link Profiles were provided by URS in December 2008, and were added to each cross-section. The profile is the most current profile at the time of reporting. Alterations to this profile may be made during detailed design.

3. Sources

The following geological / hydrogeological conditions outlined in this report are based upon a comprehensive review of existing regional information and on investigative field activities. The information and conclusions presented herein were derived from, but not limited to, hydrogeological field investigations by AECOM, geotechnical field investigations by Golder Associates (Golder), and preliminary bridge and highway profile designs provided by URS.

4. Investigation Methodology

4.1 Background Review

Secondary source information was comprehensively compiled and analyzed to develop a general understanding of the local geology, groundwater flow, groundwater quality, areas of groundwater recharge, areas of groundwater discharge, and aquifer vulnerability.

Secondary source information was reviewed from the following sources:

a) Information gathered from previous 407 Environmental Assessment studies (1989-1994)
b) Previous 407 East Geotechnical Foundation Design Reports (1994)
c) Ministry of the Environment water well records
d) York-Peel-Durham-Toronto Groundwater Study
e) 1:50,000 NTS maps and aerial photography and digital orthoimagery
f) 1:10,000 Ontario Base Maps (OBM)

g) Oak Ridges Moraine studies and 3D sections prepared by the Geological Survey of Canada[1]
h) Existing information residing with MNR, Conservation Authorities (CA) and local field naturalists
i) Durham local well data and Well Head Protection Zone studies

Field investigations were undertaken to augment secondary source information in support of the Foundation Engineering and Design Teams. The scope of field investigations enabled the Project Team to provide detailed and site-specific hydrogeological information to the Foundation Engineering Teams.

4.2 Air Photo Interpretation and Terrain/Drainage Mapping

Terrain/drainage mapping was completed along the entire Technically Recommended Route (TRR) corridor and within the proposed interchange footprints. This was done to refine existing surficial geology mapping (which is typically mapped at regional scale) and to better characterize the ground conditions along the proposed highway corridor. The results of the Terrain and Drainage Mapping conducted on the TRR are presented as an overlay to the Ontario Geological Survey (OGS) Surficial Geology Base mapping, within the current boundaries of the Transportation Corridor on **Figures A1 to A5** and on **Figure 1**. However, occasionally there is a difference between the TRR and the current Transportation Corridor, due to the timing of the field mapping, the difference between the terrain/ drainage conditions was considered negligible.

The mapping provided a basis for selecting the most representative and valuable sites for drilling boreholes and installing groundwater monitors. Additional information pertinent to the geotechnical desktop study was collected in conjunction with the terrain/drainage mapping: valley geomorphology and historic evidence of slope instability, valley bottom sediments and wetland characteristics, evidence of seepage areas, approximate meander belt width, and approximate depth of overburden (based on MOE well records).

The terrain/drainage mapping was completed using 1:10,000-scale, black-and-white aerial photograph stereopairs acquired specifically for this project in 2007. All interpretations were made using a track-mounted, 1.5- to 3-times magnifying mirror stereoscope, which facilitated efficient coverage of the study area. Regional-scale surficial geology mapping from OGS and Geological Survey of Canada (GSC), based primarily on 1:30,000-scale aerial photography, helped guide the detailed, route-specific interpretations. It was overlain with 5 m interval topographic contours to help illustrate regional physiographic character and highlight steep slopes with considerable relief.

Field reconnaissance was completed between October and November, 2007 to ‘ground truth’ the aerial photograph-based interpretations. Approximately 25% of map units (polygons) were examined in the field, resulting in the verification or refinement of boundary lines and supplementation of textural information. Field reconnaissance locations and descriptions associated with the original regional OGS/GSC mapping were obtained from Dr. David Sharpe (GSC) to help focus the field reconnaissance and reduce the effort necessary to satisfactorily check the mapping. Where possible, representative sites with existing natural (e.g., stream cut-bank) or anthropogenic (e.g., road cut) sediment exposures were visited. A hand auger was used to examine sediments in areas without sediment outcrops.

1. *Ontario Geologic Survey Maps M2562 (Barnett et al. 1999) and M2644 (Barnett et al. 1996); Geological Survey of Canada Maps OF3300 (Sharpe and Barnett, 1997) and OF3331 (Brennand, 1997).*

4.3 Drilling and Groundwater Monitor Installation

The general aims of the Hydrogeology drilling program in support of the 407 East foundation design and construction is as follows:

a) to geologically characterize subsurface soils;
b) to investigate the presence, extent and hydraulic characteristics of near-surface hydrostratigraphic units;
c) to determine the relative depth of the water table by hydrostratigraphic unit;
d) to determine the potential impacts of groundwater on foundation design and construction; and
e) to determine the potential impacts of foundation design and construction on the groundwater.

A total of 15 boreholes were installed at 11 locations along the Western Mainline and West Link (**Figures 1 and A1 to A5**). The borehole logs are presented in **Appendix B**. Many hydrogeology boreholes were completed as groundwater monitor nests consisting of a shallow and a deep monitor. These nests where designed to estimate vertical hydraulic gradients, assess soil permeability, determine seasonal changes in water table depth and to identify the potential for future groundwater contamination. Groundwater monitors installed as part of this study are shown on **Figures A1 to A5** and include: G1W-1, G1W-2, G2W-1, G2W-2, G3W-1, G3W-2, G4W-1, G4W-2, DM-1, DM-2, DM-3, DM-4, DM-5, DM-6, and DM-7. The internal nomenclature used to name the wells and well nests is based upon well location and whether or not it was completed as a nest or left single. Wells with the same base name but a different suffix (e.g., G1W-1 and G1W-2) mean that they are part of a monitoring well nest. The -1 suffix indicates the deep well at the nest and the -2 suffix indicates the shallow well at the nest. For the DM series, all wells were completed as single groundwater monitors.

All Terrain Drilling Limited (All Terrain) of Waterloo, Ontario was sub-contracted to drill boreholes and install groundwater monitors G1W-1, G1W-2, G2W-1, G2W-2, G3W-1, G3W-2, G4W-1, and G4W-2,. This was done using a CME 75 drilling rig with 6.25” ID (15.9 cm) hollow stem augers. Samples were collected every 2.5 ft (0.75 m) for the first 15 ft (4.6 m) and every 5 ft (1.5 m) thereafter using a split spoon core barrel. AtCost Drilling Limited (AtCost) of Concord, Ontario was sub-contracted to drill boreholes and install groundwater monitors DM-1, DM-2, DM-3, DM-4, DM-5, DM-6, and DM-7. This was done using a CME 75, or a CME 105, or a track mounted CME 75 drilling rig with 6.25” ID (15.9 cm) hollow stem augers. Samples were collected every 2.5 ft (0.75 m) for the first 10 ft (3.1 m) and every 5 ft (1.5 m) thereafter using a split spoon core barrel. These samples were laboratory tested[2] for moisture content, grain size, and Atterberg Limits, the results of which are shown on the borehole logs presented in **Appendix B**. Each borehole was logged to record geology, stratigraphy, and standard penetration (N) values.

Monitoring well nests were installed at each location of the G-series wells to determine vertical hydraulic gradients. The deep well at each nest was completed at approximately 40 ft (12.2 m) below ground surface (bgs) and screened in till, and the shallow well was competed at approximately 20 ft (6.1 m) bgs and screened in till or surficial sand. Deep wells have piezometer screen lengths of 5 ft (1.52 m). The shallow wells have longer screen lengths of 15 ft (4.57 m) and were designed to straddle the water table in a manner to pick up seasonal fluctuations. Single groundwater monitors (DM-series) were installed to specifically target important aquifer units with well screens 10 ft (3.10 m) long. Each groundwater monitor was instrumented with a 2-inch (51 mm) diameter riser pipe and a No. 10 slot screen. A silica sand pack (No. 2) was placed around the well screens to approximately 2 ft (0.6 m) above the well screen. For each groundwater monitor, the annular well space was sealed with approximately 2 ft (0.6 m) of bentonite chip (holeplug),

2. *100% of samples were tested for moisture content, 25% for grain size and where applicable, 25% for Atterberg Limits.*

and then grouted to within 1 ft (0.3 m) of the ground surface. Groundwater monitors were completed with protective steel casings embedded in concrete and lockable well caps. Several wells (DM-1, DM-2, DM-5, and DM-6) exhibited flowing artesian groundwater pressures and where the water level was above the stick-up well casing, were sealed with J-plugs to prevent aquifer depressurization and/ or leakage problems. Each well was surveyed using a GPS unit for lateral and vertical control. All monitors were tagged and labelled in accordance with MOE regulations by the well drillers and the Water Well Record was submitted to the MOE by the drilling sub-contractors. A summary of groundwater monitor construction detail is presented in **Appendix C**, **Table C1**.

Following completion, each monitor was developed to ensure a good hydraulic connection to the surrounding geological material to obtain representative water levels and groundwater samples. Development was conducted using 5/8" high density polyethylene (HDPE) tubing attached to a Waterra Electric Hydrolift pump powered by a gasoline generator. A minimum of 10 well casing volumes were removed as part of well development, unless the well was quickly purged dry.

Geotechnical field investigations conducted by Golder included borehole drilling at individual structure locations. The geotechnical borehole logs were provided by Golder in draft form and are presented in Appendix G. The location of all boreholes is presented on **Figures A1 to A5** and **Figure 1**.

4.3.1 Hydraulic Testing

Single well response tests (slug tests) were completed at each groundwater monitor between April and June, 2008 (additional monitors were slug tested shortly after completion). These tests were performed to obtain the horizontal component of the hydraulic conductivity of the geologic material in the vicinity of the well screen. For each well, a falling head test slug test was performed by raising a 1.0 m (3.1 ft) of water column by 2.54 cm (1.0-inch) solid slug down the well and measuring the water level recovery using a Solinst Gold Levelogger™ set to continuously record water levels at 1.0 second intervals. Once a minimum of 80% water level recovery was achieved, the slug was removed and rising head slug test was performed. Water level data was continuously recorded using a Solinst Gold Levelogger™. To confirm the results of the test, a bail test was conducted by removing a 1.0 L 'slug' of water using a disposable bailer. The water level recovery was manually measured using a Solinst Water Level Tape.

Slug test data was analyzed using the Hvorslev Method (Hvorslev, 1951) for confined aquifers, such as sand lenses, or more continuous buried sand with low permeability soils above. Hvorslev deals with the case of aquifer depressurization. The Bouwer-Rice Method for unconfined aquifers (Bouwer and Rice, 1976) was used for surficial aquifers where the test soil undergoes gravity drainage, whether it is the till or perched lacustrine sand. A summary of the single well response test activities and results is presented in **Table C2**. Based on slug test results, **Table A** in **Section 5.2** has been prepared which organizes the hydraulic conductivity information by stratigraphic unit. These values will be used when describing the physical properties of specific hydrogeological units.

4.3.2 Groundwater Sampling

Groundwater quality samples were collected at each monitor to establish baseline groundwater quality. Using these results the typical ranges for groundwater quality in different areas and different aquifer units could be characterized. This helps refine the conceptual understanding of the local and regional aquifer and aquitard units and allows a comparison with the results of the domestic well sampling.

All wells were purged a minimum of three well casing volumes prior to sampling, unless the well was purged dry, in which case the sample was collected after allowing the well to recover for several hours/ days. Samples for the G-series wells were submitted to AGAT Laboratories of Mississauga (AGAT), Ontario for analysis of microbiology (*E. coli*, Total Coliform, Heterotrophic Plate Count), total petroleum hydrocarbons (F1-F4), BTEX, and inorganics. Samples for the DM-series wells were submitted to AGAT Laboratories of Mississauga (AGAT), Ontario for analysis of inorganics. The results of groundwater sampling are shown on **Table C3**.

4.4 Mini-Piezometers

Mini-piezometers (MP) were installed in ecologically significant streams and wetland areas along the Transportation Corridor to establish the hydraulic relationship between shallow groundwater and surface water. Mini-piezometers installed as part of this study are shown on **Figures A1 to A5** and **Figure 1** and include: MP1, MP2, MP3s/d, MP4s/d, MP5, MP6, MP7, MP8, MP9s/d, MP10, MP11, MP12s/d, MP13, MP14, DMP1, DMP2, DMP3, DMP4, and DMP5,. Mini-piezometers were installed either as a single piezometer (in flowing streams) or as a piezometer nest consisting of two mini-piezometers, each installed at different depths. Mini-piezometer nests were primarily installed in wetland areas to characterize the vertical direction and magnitude of the hydraulic gradient within the subsurface (i.e., between mini-piezometers) to establish the relationship between shallow groundwater and surface water in the wetland. That is, to determine whether the wetland is groundwater fed, or surface water fed. Each mini-piezometer consists of a length of 12.7-mm diameter (0.5-inch ID) galvanized steel pipe with a slotted and screened drivepoint tip on the end. The surrounding geologic formation was allowed to collapse around the piezometer to seal the annular space around the pipe. Mini-piezometers were installed by hand using a post driver. Single mini-piezometer installations were installed to a depth of approximately 1.5 m below the bottom of the streambed, where permitted by subsurface conditions. Mini-piezometer nests consist of one piezometer installed to a depth of approximately 1.5 m below the bottom of the streambed and one piezometer installed deeper so that there was at least 1.0 m separating the bottom of the drivepoint in the shallow piezometer and the top of drivepoint in the deep piezometer. Galvanized steel screw caps were placed on each piezometer to prevent any rainwater inputs. Each piezometer was surveyed using a GPS unit for horizontal position and an estimate of vertical control. A summary of the mini-piezometer installation details is presented in **Table C4**. This table also includes the monitoring results. A number of the mini-piezometers needed to be replaced during the study period due to a variety of factors including: vandalism, frost heave, and strong spring stream flow. This is shown on **Table C4** as multiple installation dates and construction details under the same MP heading.

4.5 Stream Reconnaissance Network

The results of the terrain/ drainage mapping identified water courses within the study area that may potentially be impacted by highway construction and long-term operation. A series of stream reconnaissance sites were established, primarily at road crossings upstream and downstream of the Transportation Corridor, to provide a preliminary characterization of the yearly flow regime within significant drainage areas. By monitoring both upstream and downstream of the Transportation Corridor, preliminary indications of groundwater supplementation or loss from the stream could be understood. Stream reconnaissance stations monitored as part of this study are shown on **Figures A1 to A5** and **Figure 1** and includes: SR1a/b, SR2a/b, SR3a/b, SR4a/b, SR5a/b/c, SR6a/b/c, SR7, SR8a/b/c, SR9a/b, SR10a/b, SR12a/b/c, SR13a/b/c/d/e, SR14a/b, SR15a/b, and SR16a/b. Data acquisition at each stream reconnaissance location included: manual stream temperature and air temperature measurements, stream width and depth estimations, and estimations of the maximum stream flow velocity at the surface. Stream flow gauging has been deferred to subsequent design phases. The results of the stream reconnaissance data collection will provide additional information on groundwater discharge areas and will help determine the sensitivity of the creeks to highway construction. The results of the stream reconnaissance monitoring are presented in **Table C5.**

4.6 Hydrogeological Monitoring

4.6.1 Precipitation and Temperature

Total daily precipitation and mean air temperature records are obtained from the Blackstock Meteorological Station (Environment Canada, 2008) located near the town of Blackstock on a monthly basis. While this station is on the north side of the Oak Ridges Moraine, it is at a similar elevation to much of the Transportation Corridor, and is central to the east-west breadth of the study area. When necessary, stations closer to Lake Ontario (Oshawa) were used for comparison to results at the south end of the West Link. The Blackstock data are presented along side hydrographs for the groundwater monitors to visualize the potential effects of rainfall on water levels recorded in the wells. Mean air temperature data are used to supplement the air temperature data required for analysis of stream temperature results.

4.6.2 Groundwater Level

Groundwater levels were collected from each monitor on an approximately 4 to 6 week basis (8 times per year) beginning in December, 2007. This period of record may have been later for those monitors installed at a later time due to the timing of permission to entry. Monitoring at the DM-series wells began in March 2009 and continued until the end of April 2009. Some of the water levels in the wells (e.g., DM-6) are flowing artesian (i.e., the static water level is above the top of the casing). Down-hole J-plugs are installed in these locations to prevent continual groundwater flow over the top of the casing and to protect against freezing in winter. To measure the static water level in these wells, an additional section of PVC riser pipe is fitted to the top of the well casing and the groundwater level is allowed to equilibrate for several hours until the static water level is reached. Results of groundwater table monitoring and monthly hydraulic gradient calculations are shown on **Table C6**. Groundwater levels for the shallow and deep wells at each well nest, as well as daily precipitation data are presented in **Appendix E**.

4.6.3 Mini-Piezometers

Groundwater levels were collected from each mini-piezometer on an approximately 4 to 6 week basis (8 times per year) beginning in November, 2007 (this period of record may too have been late for those monitors installed at a later time due to the timing of permission to entry, or replacement of damaged/vandalized/lost equipment). Groundwater level measurements were collected within the mini-piezometers and surface water levels below the top of the mini-piezometer. The difference between the two measurements gives the difference in hydraulic head (**dh**) between the groundwater and the surface water. Expressed over the difference in length between the bottom of the creek and the top of the mini-piezometer screen (**dL**), the vertical hydraulic gradient was calculated (**dH/dL**). The direction of the hydraulic gradient indicate the upwards (discharge) or downwards (recharge) movement of water. Mini-piezometer measurements and hydraulic gradients are shown on **Table C4**.

4.7 Water Well Survey and Sampling

4.7.1 Residential Well Survey

A residential water well survey was undertaken in 2008 as part of the investigations. The study area for the water well survey was selected based upon the surficial geological conditions present along the TRR and was further refined to accommodate minor changes between the TRR and the Transportation Corridor. It was assumed that areas underlain by low permeability till deposits were less sensitive to impacts than areas underlain by high permeability sand deposits. The water well survey was conducted within a (1) km radius of the Transportation Corridor ROW centerline where sand deposits are present at surface and within a 500 m radius of the Transportation Corridor ROW centerline where till deposits are present at surface. The number of wells located within the selected survey area was estimated by a query of the 2002 version of the MOE water well database. Using reliability codes, the results from MOE database were filtered for accuracy. Only wells that were located within 300 m of their true location were used to assess subsurface soil type details, however all existing wells were inventoried for the purpose of knowing well use. It was found that there were ~320% more wells in the full 407 East study area, than were listed in the MOE database. This is for many reasons: multiple wells at a single home; significant positional survey error; wells drilled but not reported to the MOE; and older wells predating 1949 when records began to be kept. For these reasons every residence in the study area was visited and the identified wells are shown on **Figures A1 to A5.**

Information obtained during the residential water well survey included property owner information, well construction details, pump details, water use information, and a history of any previous water quality or quantity issues. Residents were asked to give consent to being contacted in the future by AECOM for water quality sampling. Upon completion of the water well survey questionnaire, wells were visited, visually inspected for condition, photographed, and surveyed for horizontal and vertical position using a portable Global Positioning System (GPS). Some wells are not able to be inspected due to thick snow cover or burial. Selected details were immediately entered into a handheld iPAQ © device, which was used to track the progress of the water well survey. Copies of the raw water well survey forms have been retained in the MTO and AECOM's electronic files.

4.7.2 Residential Well Sampling

Selected residential wells were sampled to gather information from upgradient and downgradient of the Transportation Corridor, from shallow and deep aquifer units, and from low sensitivity and high sensitivity aquifer units. All wells considered to be at risk were included in the program, if possible. Approximately 7% of the 1,328 surveyed wells across the full study area were sampled to establish pre-construction baseline conditions. Water samples were collected from a point "upflow" of any filters and/ or softeners that may be used on site, to ensure raw water samples were collected. Duplicate and blank samples were collected for QA/QC purposes. All collected samples were submitted to AGAT Laboratories of Mississauga Ontario for analysis. Samples were analyzed for microbiology (*E. coli*, Total Coliform, Heterotrophic Plate Count), total petroleum hydrocarbons (F1-F4), BTEX, and inorganics. The residents were notified by letter of their water quality results. Residences were promptly notified by telephone if any water quality results exceeded Ontario Drinking Water Standards (ODWS) as presented in Ontario Regulation 170/03, for any health related parameter (e.g., *E. coli*). The specific homes that were sampled will not be specifically identified in this public document due to privacy concerns. Water quality samples were collected at 19 residences (not including duplicates, blanks, or multiple samples at a single residence that had multiple wells) within the Western Section between July and August 2008. The results from the water well water quality sampling are shown in **Table C7** and are displayed as non-descriptive sample identifiers.

5. Regional Geology and Hydrogeology

5.1 Regional Physiography

The study area is characterized, from north to south, by three east-west trending physiographic regions: the Oak Ridges Moraine (ORM), the South Slope, and the Iroquois Plain. The ORM is a lateral moraine that forms the northern boundary of the analysis area. The South Slope is a gently rolling till plain, characterized by numerous drumlins oriented upslope. The Iroquois Plain physiographic region is found extending from the till plain of the South Slope Region down to Lake Ontario. This area is characterized by gravel beaches that formed along the shore of Glacial Lake Iroquois, while sand was deposited nearshore, grading to silts and clays in the more calm offshore areas.

5.2 Regional Geology and Hydrogeology

The **Newmarket Till** is a dense, stony, sandy silt diamicton, ranging in thickness from about 5 to 50 m. This unit is exposed at ground surface throughout much of the lower South Slope Physiographic Region. It is also present underneath the whole study area. The ***Newmarket Till Aquitard*** is a major regional aquitard, given its low hydraulic conductivity (10^{-10} to 10^{-6} m/s – refer to **Table A** below) and consistent presence throughout the analysis area. It separates the shallow aquifers from the deep aquifers (*Thorncliffe Aquifer*). Isolated lenses of silt, sand, and gravel are present within the till. Where Newmarket Till is exposed at the surface, the water table is often high because of the poorly drained nature of the soils.

The **Oak Ridges Moraine** was deposited about 13,300 years ago on the meltwater flood-scoured surface of the Newmarket Till in a deep glacial lake. Numerous “finger-like” protrusions of highly permeable ORM sediments extend southward toward Lake Ontario, but pinch out beneath the Halton Till. These are occasionally exposed at surface where valleys have incised the Halton till. The ***Oak Ridges Moraine Aquifer*** is a major regional aquifer and an important groundwater recharge area. Its sandy and gravelly composition gives it a high permeability (10^{-5} to 10^{-4} m/s – refer to **Table A** below) and, combined with the hummocky surface topography, facilitates infiltration. Coarse-grained sediments associated with the ORM extend southward, acting as important aquifers for residential use.

The **Halton Till** ranges in thickness from about 10 to 20 m and overlies the Newmarket Till in the south slope area. It has a predominantly clayey silt to silt matrix with isolated lenses of laminated sand, silt, and clay The ***Halton Till Aquitard*** has low hydraulic conductivities (approximately 10^{-9} m/s – refer to **Table A** below). On a regional scale, the Halton Till Aquitard acts as a surficial aquitard, inhibiting local groundwater recharge.

The Glacial Lake Iroquois Shoreline Sediments are characterized by gravelly beach sediments along the former shoreline. Nearshore glaciolacustrine deposits of sand and gravel overly the Newmarket Till and grade to the south into laminated silts and clays. The high permeability (approximately 10^{-5} m/s – refer to **Table A** below) of the sandy nearshore deposits of the Iroquois Plain Shallow Aquifer provides a pathway for local groundwater discharge. The water table is typically near surface because the low permeability of the underlying Newmarket Till. Numerous wetlands and lowland stream headwaters coincide with the Iroquois Shoreline. The low permeability (10^{-9} to 10^{-7} m/s – refer to **Table A** below) silt and clay plains farther south inhibit both groundwater recharge and discharge.

Table A summarizes the slug test results that provide a general overview of the relative hydraulic conductivity of the different stratigraphic units present under the full study area. For example the basal unit for the area, the Newmarket Till has a mean hydraulic conductivity that is 55 times higher than that for the more clayey Halton Till. The effect of weathering of the Newmarket Till in the shallow subsurface is an increase by a factor of about 6. Understandably, the silty sands of the Iroquois shoreline sediments are more permeable by about 70 times, reflecting the unconsolidated nature of these materials, as well as the lower silt fraction. The less silty ORM deposits, which are primarily sand with some gravel, have a geometric mean hydraulic conductivity about 360 times more permeable than the Newmarket till, reflecting the coarser particle size distribution. These general relationships hold true across the site and reflect values found in other studies, and can be used as a guide in assessing the ability of the soils to allow groundwater to move for the purposes of this work.

Table A. Hydraulic Conductivity Summary by Hydrostratigraphic Unit

Geological Unit	Monitors	Range of Hydraulic Conductivity (m/s)		Geometric Mean Hydraulic Conductivity	Relative to Newmarket Till*
		Low	High	(m/s)	Times greater
Lake Iroquois Shoreline Deposits	G2E-2, G11E-2	2.0E-05	3.2E-05	2.4E-05	***73***
Surficial Glaciolacustrine Silt and Fine Sand and Sand and Gravel	G2C-2, G1W-2, G3W-2, G4W-2, G3E-2, G10E-2	1.1E-06	5.2E-05	5.6E-06	***17***
Halton Till	G3C-2	5.8E-09	5.8E-09	5.8E-09	***0.02***
Oak Ridges Moraine Sand and Gravel	G8E-2, G9E	1.3E-05	7.7E-04	1.2E-04	***357***
Weathered Newmarket Till	G1C-2, G1E-2, G4E-2, G10E-1	2.6E-07	4.4E-06	2.0E-06	***6***
Newmarket Till	G1C-1, G3C-1, G2W-1, G2W-2, G3W-1, G1E-1, G2E-1, G3E-1, G4E-1, G7E-2, G8E-1	9.1E-11	4.6E-06	3.2E-07	***1***
Sand Lenses/ Layers	G2C-1, G5E-2, G6E-1	3.0E-06	2.8E-05	8.4E-06	***26***
Sandy Silt	G7E-1, G11E-1	1.4E-06	1.8E-05	5.2E-06	***16***
Glaciolacustrine Silty Clay and Clayey Silt	G1W-1, G5E-1	8.7E-09	2.4E-07	4.4E-08	***0.14***
Weathered Shale bedrock	G4W-1	2.4E-06	2.5E-06	2.4E-06	***8***
Construction Fill	G6E-2	5.0E-05	1.1E-04	7.4E-05	***229***

5.3 Regional Groundwater Flow

Water table contours and groundwater flow directions subtly reflect the topographic contours in the analysis area, indicating the influence of topography and soil type on the shallow groundwater flow system. Regional groundwater flow in the aquifers within the analysis area is downwards and south-southeast from the ORM towards Lake Ontario. Locally, horizontal groundwater flow paths bend into river valleys and isolated topographic depressions. Topographic highs are generally groundwater recharge zones. Groundwater discharge is predominant along the Iroquois shoreline and groundwater flow in the Iroquois Plain Shallow Aquifer is predominantly horizontal due to the Newmarket Till Aquitard below. Regionally, streams that originate from the ORM warm up as they flow over the South Slope till soils due to little thermal moderation by cool groundwater. Streams that originate on the low permeability till plain of the lower South Slope initially derive most of their water from surface runoff, but receive a significant proportion of their flow from groundwater discharge as they flow across the sandy Iroquois shoreline.

6. West Mainline – Geological and Hydrogeological Conditions

6.1 Physiography, Geology, Hydrogeology

The West Mainline area is located within the South Slope Physiographic Region (**Figures A1 to A3, and Figure 1**). The South Slope is a gently rolling till plain, characterized by numerous drumlins oriented upslope. This portion is primarily underlain by dense, stone-poor, carbonate-derived, silty to sandy Newmarket Till. Upland areas and north-south trending drumlins are often comprised of glaciolacustrine-derived, silty to clayey Halton Till, and where present overlies the Newmarket Till.

Although not exposed at surface, southerly oriented, “finger like” extensions of ice-contact stratified drift deposits characteristic of the Oak Ridges Moraine (ORM) Aquifer can often be found at the contact between the Halton and Newmarket till units. Deposits of fine and coarse textured glaciolacustrine materials are also present at surface, most notably near East Duffins Creek and Carruthers Creek, and south of the Transportation Corridor between Coronation Road and Ashburn Road. Deposits of Glacial Lake Iroquois Shoreline sands and gravels are present south of the Transportation Corridor between Sideline 14 Road and Sideline 16 Road (**Figure 1**).

Water table contours subtly reflect the topographic contours in the study area, indicating the influence of topography and soil type on the shallow groundwater flow system. The water table is generally high within this area due to poor drainage through the low permeability till units. Regional groundwater flow in the aquifers within the analysis area is downwards and south-southeast from the ORM towards Lake Ontario. Locally, horizontal groundwater flow paths in the shallow subsurface bend into river valleys and isolated topographic depressions. Topographic highs are generally groundwater recharge zones which dominate the study area for almost all of this 12 km stretch of the ROW.

Groundwater discharge occurs only locally in stream valleys and is often limited by the dense till soils at surface. It is also found east of Sideline 14 Road, along the Iroquois Shoreline, and groundwater flow in the Iroquois Plain Shallow Aquifer found there is predominantly horizontal due to the Newmarket Till Aquitard below. Regionally, streams that originate from the ORM warm up as they flow over the South Slope till soils due to little thermal moderation by cooler groundwater. Streams that originate on the low permeability till plain of the lower South Slope initially derive most of their water from surface runoff, but receive a significant proportion of their flow from groundwater discharge as they flow across the sandy Iroquois shoreline.

6.2 Results of Field Investigations

6.2.1 Borehole Drilling and Groundwater Monitors

As described in **Section 4.2**, terrain mapping was conducted using air photograph interpretation with field truthing of observations to accurately determine the surficial geology within the TRR (**Figures A1 to A3 and Figure 1**). The geology was further refined using the results of the hydrogeological and geotechnical borehole drilling, and by site specific field investigations. Examination of Figures **A2 and A3** show that the field truthing identified far less surficial sand than the OGS mapping in the vicinity of the creeks.

Borehole drilling was originally conducted at two (2) locations and all boreholes were completed as groundwater monitor nests consisting of two vertically separated monitors (G1W-1, G1W-2, G2W-1 and G2W-2). A further 7 boreholes, that were completed as monitoring wells, were drilled as part of the additional investigations near Sideline 16 Road in Pickering.

The location of G1W near Paddock Road was selected to obtain geological and hydrogeologic information from an area of coarse-textured glaciolacustrine sands that overlie low permeability deposits. Borehole G1W-1 encountered 6.1 m of glaciolacustrine sand and silty sand, underlain by silty clay to a depth of 13.7 m (**Appendix B**). Groundwater monitor G1W-1 was screened between 12.19 and 13.72 mbgs in silty clay (**Table C1**), for which a geometric mean hydraulic conductivity of 1.1×10^{-8} m/s was determined (**Table C2**). The shallow groundwater monitor G1W-2 was screened between 1.52 and 6.10 mbgs in glaciolacustrine silty sand (**Table C1**), for which a geometric mean hydraulic conductivity of 2.2×10^{-6} m/s was determined (**Table C2**).

The groundwater levels in G1W-1 range from 2.35 mbgs (May 2008) to 2.70 mbgs (March 2008) and groundwater levels in G1W-2 range from 0.29 mbgs (May 2008) to 1.19 mbgs (December 2007 - **Table C6**). The December 2007 water level for G1W-1 was discounted because it was taken right after well installation and the water level in the well had not yet reached equilibrium. These groundwater levels indicate that the shallow water table is at or near surface due to a lack of drainage through the low permeability materials below. Both the shallow and the deep water levels respond to seasonal changes in precipitation and therefore, water is likely derived from local infiltration (**Figure E1**). The shallow monitor has a greater seasonal fluctuation, which is typical of this setting. A downwards hydraulic gradient exists between the surficial glaciolacustrine aquifer and the deeper silty clay, indicating a groundwater recharge area.

The location of G2W near Halls Road was selected to obtain geological and hydrogeologic information from an area of thick Newmarket Till deposits near a proposed freeway to freeway interchange. Borehole G2W-1 encountered 10.7 m of sandy silt to silt sand Newmarket Till (**Appendix B**). Clayey silt was encountered between 10.7 and 12.3 mbgs. Groundwater monitor G2W-1 was screened between 10.59 and 12.12 mbgs in clayey silt (**Table C1**), for which a geometric mean hydraulic conductivity of 1.7×10^{-6} m/s was determined (**Table C2**). The shallow groundwater monitor G2W-2 was screened between 1.57 and 6.15 mbgs in Newmarket Till (**Table C1**), for which a geometric mean hydraulic conductivity of 6.1×10^{-7} m/s was determined (**Table C2**).

The groundwater levels in the deep monitor G2W-1 range from 0.16 m above ground surface (January 2008) to 1.54 mbgs (June 2008). Groundwater levels in G2W-2 range from 0.22 mbgs (March 2008) to 1.91 mbgs (June 2008 - **Table C6**). These groundwater levels indicate that the shallow water table is at or near surface because the water table in the weathered Newmarket Till is perched on the unweathered Newmarket Till. Both the shallow and the deep water levels respond to seasonal changes in precipitation and therefore, water is likely derived from local infiltration (**Figure E2**). Minor artesian pressure is found in G2W-1 and is derived from the deeper clayey silt unit indicating it may extend to under the higher ground to the north. An upwards hydraulic gradient exists between the shallow and the deep till because of this.

Additional Borehole Drilling at Sideline 16 Road

Several boreholes (DM-1 to DM-7) were drilled near the existing intersection of Sideline 16 Road and Highway 7 in Pickering to investigate the complex geology surrounding a spring fed irrigation pond and wetland area near Structures WM-5/ WM-6 (**Figure A1**). There was also a concern that the deep cut at DC-W1 would intercept a confined aquifer which may cause a significant groundwater impact. Additional boreholes beyond those originally scoped were completed to aid in determining the nature of the potential impacts in the area and to recommend specific mitigation options (if required) during preliminary design. The results of the borehole drilling and mini-piezometer installations are described below and the interpretation and discussion of the results is included in Report B.

Borehole DM-1 (**Figure A1** at the northwest edge of the pond) encountered 13.9 m of sandy silt Newmarket Till, underlain by a short interval of glaciolacustrine clayey silt, followed by sand to a depth of 15.1 m (**Appendix B**). Installation of the monitor at DM-1 was difficult due to heaving sands near the base. Although the screen tip is at 14.33 mbgs (opposite the Newmarket Till) it is believed that the sand unit below is the driving force for the potentiometric head in the well. The groundwater level in DM-1 was measured at 2.46 m above ground surface (mags) indicating that this well is artesian (**Table C6**). Hydraulic testing measured a horizontal hydraulic conductivity (K) of 6.5 x 10^{-6} m/s over the length of the screened interval. This value is more reflective of a silty sand unit than the Newmarket Till or clayey silt. It is speculated that the silty sand aquifer unit encountered below the glaciolacustrine clayey silt is the Upper Thorncliffe Aquifer. The elevation of the unit (~155 to 170 masl) fits the regional model and the high groundwater pressures are indicative of a regional aquifer that extends northwards to areas of higher elevation.

Borehole DM-2 (**Figure A1** at the north edge of the pond) encountered similar conditions to DM-1 with 12.2 m of sandy silt Newmarket Till, underlain by glaciolacustrine clayey silt to a depth of 15.2 m, followed by sand to a depth of 15.9 m (**Appendix B**). DM-2 also experienced heaving sands and it is believed that the sand unit below is the driving force for the potentiometric head in the well. The groundwater level in DM-2 was measured at 1.53 m mags in April 2009, indicating that this well is artesian (**Table C6**). Hydraulic testing measured a horizontal hydraulic conductivity (K) of 5.9 x 10^{-6} m/s over the length of the screened interval. Although the screened interval is mostly in clayey silt, it is believed that a hydraulic connection to the sand unit below exists which is causing the artesian pressure. The K value is more reflective of a silty sand unit than the clayey silt, which would be at least 2 -3 orders of magnitude lower. As with DM-1, it is speculated that the silty sand aquifer unit encountered below the glaciolacustrine clayey silt is the Upper Thorncliffe Aquifer.

Borehole DM-3 (**Figure A1** east of the pond) encountered a 1.5 m veneer of silty sand, underlain by reworked or weathered Newmarket Till to 4.6 m (**Appendix B**). Below, a thin deposit of clean sand and gravel was found to 5.6 m, followed by a thin deposit of Newmarket Till. Below the Newmarket Till, a thick deposit of loose, silty sand and large angular gravel was present to the bottom of the borehole at 12.3 m. Geologically, this unit appears to be a glacial ice contact margin sand and gravel deposit, similar to the ORM deposits, but because of where it lies in the stratigraphy (i.e., below the Newmarket Till and not above it), it is likely a local aquifer deposit and not ORM. The screen was placed within the silty sand and gravel aquifer. The groundwater level in DM-3 was measured at 1.81 mbgs (**Table C6**) and hydraulic testing provided a K-value of 3.0 x 10^{-5} m/s (**Table C2**), which is reflective of the coarse textured nature of the deposit.

Borehole DM-4 (**Figure A1** along the centreline of the Transportation Corridor between Sideline 16 and Sideline 14) encountered a surficial sequence of fine and course textured glaciolacustrine deposits and Newmarket Till to a depth of 6.1 mbgs. These units were generally dry and loose. Below these deposits, very dense Newmarket Till was encountered to a depth of 15.2 m, followed by a fine textured, well sorted sand to 15.9 mbgs (**Appendix B**). DM-4 was screened between 12.04 and 15.09 mbgs in the till but like DM-1 and DM-2, it is believed that the well is hydraulically connected to the sand unit. The groundwater level in DM-4 was measured at 6.18 mbgs (**Table C6**) and hydraulic testing provided a K-value of 2.8 x 10^{-5} m/s (**Table C2**). This value is greater than the other K-values measured in the same aquifer unit at DM-1 and DM-2 which may reflect the absence of the hydraulic influence of the fine-textured glaciolacustrine unit.

Borehole DM-5 lies in a similar setting to DM-3 (**Figure A1** east of the wetland near Highway 7 and within the ROW of the transportation corridor), and encountered 2.2 m of Newmarket Till at surface (**Appendix B**). The Till is underlain by deposits of sand and gravel to 7.9 m. Between 3.1 m and 4.6 a deposit of loose, silty sand and large angular gravel was encountered followed by a deposit of clean coarse sand to a depth of 7.9 m. The silty sand and gravel unit was very similar in character to the silty sand and gravel unit found in DM-3 and DM-7. Newmarket Till was encountered below the clean sand to the base of the borehole at 8.2 m. DM-5 was screened between 5.18 and 8.23 mbgs in sand and gravel and the groundwater level in DM-5 was measured at 0.25 mags indicating that this well is artesian (**Table C6**). The horizontal hydraulic conductivity of the aquifer around the well screen was determined to be 7.8 x 10^{-6} m/s (**Table C2**).

Borehole DM-6 (Figure A1 north along Sideline 16 Road) encountered a silty sand fill to a depth of 3.1 mbgs, underlain by Newmarket Till to 10.7 mbgs. Similar to DM-1 and DM-2, glaciolacustrine silt was encountered below the till and had fine horizontal laminations, often containing a very thin layer of silty fine sand to a depth of 20.4 m (**Appendix B**). DM-6 was screened between 7.62 and 10.67 mbgs in glaciolacustrine silt, although it is believed to be hydraulically connected to a deeper aquifer unit that was not found in the soil record. The groundwater level in DM-1 has not been measured at equilibrium (static) but a measurement taken near static using a pressure transducer was at ~9.5 m above ground surface (**Table C6**). It is believed that the static water level may still be a couple of metres higher. Hydraulic testing has not yet been completed for this well.

Borehole DM-7 (**Figure A1** along the alignment and east of the wetland) encountered 4.6 m of reworked till and trace organic deposits. This was underlain by Newmarket Till which was interpreted to be the surficial sediment prior to fill placement (**Appendix B**). Deposits of sand and gravel are present to 9.5 m, where Newmarket Till was again encountered to a depth of 10.7 m. A deposit of silty sand and gravel was found that extended to the base of the borehole at 15.9 m and was very similar in textural composition to the silty sands and gravels found in DM-3 and DM-5. DM-7 was screened between 6.10 and 9.14 mbgs in the sand and gravel (**Table C1**). The groundwater level in DM-7 was measured at 4.68 mbgs (**Table C6**) and hydraulic testing provided a K-value of 5.8 x 10^{-6} m/s (**Table C2**), which is similar to the K-value of the materials at DM-5.

6.2.2 Mini-Piezometers

Seven (7) mini-piezometers (MP1, MP2, MP3s/d, MP4, MP5, MP13 and MP14) were originally installed in this section (**Table C4, Figures A1 to A3**). A further five (5) mini-piezometers were installed as part of the additional investigations at Sideline 16 Road. MP1 (Brougham Creek), MP4 (East Duffins Creek tributary), and MP5 (Carruthers Creek tributary) generally show downwards hydraulic gradients indicating that the water courses are perched on low permeability till units and may be intermittent. Stream temperature measurements at MP1 and MP5 suggest that groundwater may be contributing to baseflow based upon the thermal buffering in the summer and winter months displayed as a difference between the air and water temperatures in **Figures D1 and D3.** MP2 shows a strong upwards gradient within a tributary of Brougham Creek, which indicates groundwater discharge. Stream temperature measurements (**Figure D2**) showing stream temperatures of about 4°C during winter periods of below zero air temperatures and summer water temperatures consistently below average daily air temperatures support this. In addition site observations of watercress and geologic factors such as the presence of the Iroquois near-shore shoreline deposits all confirm that cold groundwater discharge is occurring at this location. MP3s/d was installed in a small wetland area near East Duffins Creek and shows a downwards hydraulic gradient indicating that this wetland is perched on low permeability deposits below.

MP13 generally showed a downwards hydraulic gradient indicating that the water course is perched on low permeability till and may be intermittent. Only the October 2008 monitoring data showed an upwards gradient. MP14 generally showed an upwards hydraulic gradient, indicating groundwater discharge, except for November, May and September 2008, where a downwards gradient was measured. Stream temperature measurements contradict the mini-piezometer data as the stream temperature data are generally mimicking the air temperature (**Figure D9**). The outlet of a Stormwater Management Pond from a development in Brooklin near this mini-piezometer adds a degree of uncertainty to the groundwater discharge/ recharge relationship.

Five mini-piezometers (DMP1, DMP2, DMP3, DMP4, and DMP5) were installed as part of the additional investigations at Sideline 16 Road (**Table C4, Figure A1**). DMP1 and DMP3 were installed in tributaries of Brougham Creek that feed into the pond north of the ROW near structure WM-5/WM-6. These two mini-piezometers showed downwards hydraulic gradients indicating that groundwater discharge is not occurring in the tributaries to the north of the pond and wetland (**Table C4**). DMP2 was installed in the pond and shows an upwards hydraulic gradient, substantiating the assumption that the pond is groundwater fed. DMP4 and DMP5 where installed in the wetland area near WM-5/ WM-6. Both showed very strong upwards hydraulic gradients, indicating that groundwater is discharging into this wetland, which is consistent with the results at MP2.

6.2.3 Stream Reconnaissance

14 stream reconnaissance stations (SR1a/b, SR2a/b, SR3a/b, SR4a/b, SR5a/b/c, SR6a/b/c, SR7, SR8a/b/c, SR9a/b, SR10a/b, SR12a/b/c, SR14a/b, SR15a/b, and SR16a/b) were established in this area (**Table C5, Figures A1 to A3**). SR1a/b, SR2b, SR5c, SR8c, SR9b, SR10b and SR12a/b/c did not flow continuously over the duration of the study and suggest that these water courses are intermittent. Stream temperature measurements confirm this observation. SR2a, SR3a/b, SR4a/b, SR5a/b, SR6a/b/c, SR7, SR8a/b, SR9a, SR10a, SR14a/b, SR15a/b and SR16a/b flowed continuously over the duration of the study. Various temperature measurements and site observations of water cress and iron sheen confirm groundwater inputs to these water courses.

6.2.4 Water Wells

The results from the water well survey in the Western Mainline area show that 113 private water wells are present within the 407 East water well survey study area. Of these 113 wells, 30% (34 wells) are shallow dug wells, 25% (28 wells) are deep drilled wells, 1 well (1%) is a community well (no longer in use), and 44% (50 wells) have unknown construction details because the water well survey questionnaire was not completed at these residences. Water quality samples were collected from 11 wells that were selected to reflect the various aquifer units present in the study area, both upgradient and downgradient of the Transportation Corridor (**Table C7**). Concentrations of one or more of the following parameters were found to exceed Ontario Drinking Water Standards (ODWS) in all 11 of the wells: sodium, iron, manganese, nitrate, hardness, *E. coli*, total coliform, and Heterotrophic Plate Count (HPC). High concentrations of parameters such as iron, manganese and hardness are found naturally in local aquifer units, but exceedances of the other parameters indicate existing effects from surficial land use activities, such as road salt (sodium chloride), fertilizer applications (nitrate, bacteria), and/or improperly functioning septic beds (nitrate, sodium, bacteria). Exceedances of bacteriological parameters were found in 7 of the 11 wells, with 2 wells exceeding for *E. coli*. ODWS was exceeded for sodium in 6 of the 11 wells and elevated chloride was found in 3 wells. Well 1021 also exceeded for lead and nitrate. Well 1047 also exceeded for lead. The presence of lead is most likely derived from lead pipes or lead soldering in the household and is not derived from local groundwater. Samples collected from north of the Transportation Corridor along Paddock Road suggest existing effects from land use activities in the shallow, glaciolacustrine aquifer unit as shown by elevated levels of both sodium and chloride. Within the same aquifer unit, south of the Transportation Corridor along Paddock Road, impacts do not seem to have occurred in the wells tested. In the areas of the Newmarket Till aquitard at surface, there is little evidence of groundwater impairment from surface activities.

7. West Link – Geological and Hydrogeological Conditions

7.1 Physiography, Geology, Hydrogeology

The West Link area is located largely within the Iroquois Plain Physiographic Region (**Figure 1**). The Iroquois Plain Physiographic Region is characterized by lake sediments laid down upon the underlying Newmarket Till which provides a low permeability basement to the groundwater system. Gravel beaches formed along the shore of pre-historical Glacial Lake Iroquois and can be found between 15+400 and 16+100 (**Figures A4 and A5**). Flat lying deposits of sands and silts grade to silts and clays with depth, and were deposited in nearshore areas and comprise 35% of the alignment extending south to Rossland Road. They also grade laterally offshore from sand to silt to clay with southward distance (making up 39% of the alignment, largely south of Rossland Road). This happens because the more calm offshore areas towards present day Lake Ontario was an environment where the smaller clay particles could settle. The shoreline bluff is still easily identified[3] north of flat lying deposits of sand and provides a marked difference from the undulating till plains to the north. Glaciolacustrine sediments generally overlie till to a maximum depth of 20 m, and occasionally the till outcrops in the form of drumlins, flanked by glaciolacustrine sediment.

The north end of the West Link north of Taunton Road lies on the South Slope of the Oak Ridges Moraine, which is a gently rolling till plain and comprises the remaining 26% of the west link. This area is primarily underlain by deposits of fine and coarse textured glaciolacustrine deposits (as described above), that blanket the underlying layer of dense, stone-poor, carbonate-derived, silty to sandy Newmarket Till (**Figures A4, A5 and A8**). Below the Newmarket Till, lie older overburden deposits on top of the flat-lying Lindsay Formation Limestone and Shale (locally called the Whitby Shale). These older deposits are generally only present at the north end of the alignment and do not have any hydrogeologic significance to this project. The bedrock can be found at an elevation of approximately 100 mASL at the north end of the West Link and is about 85 m below ground surface. It dips to 73 mASL at the south end and is sometimes less than 10 m below ground surface. No bedrock outcrops are present in the study area.

Water table contours subtly reflect the topographic contours in the study area, indicating the influence of topography and soil type on the shallow groundwater flow system. The water table is generally high within this area due to higher recharge rates into high permeability surficial materials, but poor drainage through underlying, low permeability till units. Groundwater flow in the Iroquois Plain Shallow Aquifer is predominantly horizontal, due to low permeability till sediments restricting drainage below. Locally, groundwater flow paths bend into river valleys and isolated topographic depressions. The majority of this area is a groundwater recharge zone, but due to the underlying till units restricting flow to depth, the recharge is not regionally important. Where the recharge occurs in the sandy surficial soils, it is locally significant when there are nearby creeks that attract the groundwater. Groundwater discharge occurs along the Glacial Lake Iroquois Shoreline particularly were incised river valleys intercept the water table.

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3. *It can be clearly seen as one travels south from Highway 7 on Lakeridge Road.*

7.2 Results of Field Investigations

7.2.1 Borehole Drilling and Groundwater Monitors

As described in **Section 4.2**, terrain mapping was conducted using air photograph interpretation with field truthing of observations to accurately determine the surficial geology within the TRR (**Figures A4 and A5**). The geology was further refined using the results of the hydrogeological and geotechnical borehole drilling, and by site specific field investigations.

Borehole drilling was conducted at two locations (G3W, G4W) in typical settings along the West Link. Both were constructed as groundwater monitor nests consisting of two vertically separated monitors (G3W-1& G3W-2, and G4W-1 & G4W-2).

G3W, located about 1,500 m south of Highway 7, was selected to obtain geological and hydrogeologic information from an area of coarse-textured glaciolacustrine sands that overlie low permeability deposits within the Shallow Iroquois Plain Aquifer. Borehole G3W-1 encountered 1.7 m of sand grading finer with depth (to 4.6 m depth) to sandy silt. Below this lay 1.5 m of sand and gravel which may have been a remnant of beach deposits, as this location is very close to the old shoreline. Below, silty sandy Newmarket Till is present to a depth of 11.6 m (**Appendix B**), where the borehole finished.

Groundwater monitor G3W-1 was screened between 10.06 and 11.58 mbgs in Newmarket Till (**Table C1**), for which a hydraulic conductivity of 2.2 x 10^{-7} m/s was determined (**Table C2**). By contrast the geometric mean hydraulic conductivity of the surficial sand, measured in G3W-2, screened between 1.47 and 6.04 mbgs (**Table C1**), was 8.5 x 10^{-6} m/s (**Table C2**). The fact that the sand is almost 40 times more permeable than the till at this location is consistent with the findings for the rest of the study area (**Table A**).

The groundwater levels in G3W-1 average about 2.0 mbgs, and groundwater levels in the more permeable G3W-2 range from 0.16 mbgs (November 2008) to 0.93 mbgs (July 2008) (**Table C6**). These groundwater levels indicate that the shallow water table is at or near surface because it is perched in the sand on the low permeability till below (**Figure E3**). The shallow water levels in the surficial sand respond to seasonal changes in precipitation[4] which demonstrates that its water is derived from local infiltration. A downwards hydraulic gradient exists between the surficial glaciolacustrine aquifer and the deeper silty clay, indicating a groundwater recharge area (albeit slowly). It is however expected that horizontal groundwater flow dominates in the shallow aquifer.

The location of G4W-1 on Rossland Road near Halls Road was selected to obtain geological and hydrogeologic information from an area of fine-textured glaciolacustrine silts and clay that overlie low permeability deposits along the Iroquois Plain. Borehole G4W-1 encountered 2.6 m of silty clay, overlying 2.0 m of sand and gravel. Below, silty sandy Newmarket Till is present to a depth of 10.5 m at the bedrock surface (Whitby Shale) (**Appendix B**). Groundwater monitor G4W-1 was screened between 9.02 and 10.54 mbgs in the Newmarket Till (**Table C1**), for which a hydraulic conductivity of 2.4 x 10^{-6} m/s was determined (**Table C2**). The shallow groundwater monitor G4W-2 was a continuous standpipe screened between 1.52 and 6.10 mbgs across Newmarket Till, sand and gravel, and silty clay (**Table C1**) to identify the water table position. Permeability testing of G4W-2 yielded a geometric mean hydraulic conductivity of 4.3x10^{-5} m/s (**Table C2**), indicating that the sand and gravel was the prime contributor, as would be expected.

4. *For example the lowest water level is in July, and the higher levels are in the spring or late fall, Table B-6.*

The groundwater levels in the till at G4W-1 range from 2.88 mbgs (September 2008) to 3.27 mbgs (March 2008). The water table measured in G4W-2 ranged from 3.39 mbgs (March 2008) to 3.68 mbgs (October 2008) (**Table C6**). These groundwater levels indicate a subtle but persistent upwards gradient between the till and the surficial glaciolacustrine aquifer. Both the shallow and the deep water levels respond to seasonal changes in precipitation and therefore, water is likely derived from local infiltration (**Figure E4**). The water table is relatively low for the Iroquois Plain, suggesting that downwards groundwater movement is not restricted.

7.2.2 Mini-Piezometers

Nine (9) mini-piezometers (MP6, MP7, MP8, MP9s/d, MP10, MP11 and MP12s/d) were installed at seven locations in this section (**Table C4**). MP6, MP8, and MP11 were installed in West Lynde Creek. Each show downwards hydraulic gradients indicating that the water course is perched on low permeability till units, receives little groundwater inputs and is likely intermittent. This interpretation is consistent with the stream classification from the *Fish and Fish Habitat Impact Assessment Report*. Temperature measurements confirm this observation (**Figures D4, D6, and D8**). MP10 was installed in West Lynde Creek (between MP8 and MP11) and upward hydraulic gradients measured there (**Table C4**) show clear indications of groundwater discharge. While this indicates that West Lynde Creek does receive some groundwater inputs, it is still considered intermittent at times of the year. In fact, stream temperature measurements show it freezes in winter but is a cool water stream in summer suggesting significant surface water inputs (**Figure D7**).

MP9s/d and MP12s/d were each installed in small wetland areas and each generally shows downwards hydraulic gradients, indicating that the wetlands are perched on low permeability deposits. MP7 shows a generally upwards hydraulic gradient within a tributary of Lynde Creek along Coronation Road, which indicates groundwater discharge. However, stream temperature measurements (**Figure D5**) indicate little thermal buffering which may mean there is not much discharge to the creek, likely as a result of the glaciolacustrine sediments being fine grained (i.e., silt and clay).

7.2.3 Stream Reconnaissance

One set of stream reconnaissance stations, consisting of 5 monitoring points from north to south (SR13a/b/c/d/e), was established along this section (**Table C5**). SR13a/b/c/d/e all flowed continuously over the duration of the study. Stream temperatures measurements suggest both surface water and groundwater inputs into West Lynde Creek. For example, from July 2008 to September 2008 the surface water was up to 10°C cooler than the air temperature, although this difference was only 4 to 7 degrees cooler in the lower reach near Highway 401. This is consistent with the clayey nature of the soil substrate where there are greater surface flows and a natural warming up of the watercourse. It is believed that this reach is cooler only because of the cool water from upstream and not from local groundwater discharge. The *Fish and Fish Habitat Impact Assessment Report* classifies this water course as intermittent. Data collected as part of the hydrogeology field investigations was not detailed enough to firmly classify these water courses.

7.2.4 Water Wells

The results from the water well survey in the area along the West Durham Link (**Figures A4 and A5**) show that 211 private water wells are present within the 407 East water well survey study area. Of these 211 wells, 26% (54 wells) are shallow dug wells, 11% (23 wells) are deep drilled wells, and well construction details are unknown for 63% (134 wells). Water quality samples were collected from 8 wells that were selected to reflect the various aquifer units present in the study area, both upgradient and downgradient of the Transportation Corridor (**Table C7, Figures A4 and A5**).

Concentrations of one or more of the following parameters were found to exceed Ontario Drinking Water Standards (ODWS) in all 8 of the wells: sodium, iron, manganese, hardness, *E. coli*, total coliform, and Heterotrophic Plate Count (HPC). High concentrations of parameters such as iron, manganese and hardness are found naturally in local aquifer units, especially the bedrock aquifer. Exceedances of the other parameters indicate existing effects from surficial land use activities, such as road salt (sodium chloride), fertilizer applications (nitrate, bacteria), and improperly functioning septic beds (nitrate, sodium, bacteria). Exceedances of bacteriological parameters were found in 7 of the 8 wells, with 5 wells exceeding for *E. coli*. ODWS was exceeded for sodium in 6 of the 8 wells and elevated chloride was found in 3 wells. Samples collected from both shallow and deep wells showed concentrations of sodium above ODWS. Concentrations of sodium above 20 mg/L in deep wells are assumed to be derived from sodium rich aquifer units. In shallow wells, if the chloride concentration was also elevated along with the sodium, then road-salt or septic system impacts are assumed. The results of the water well sampling suggest pre-existing impacts from surficial land use activities as shown by the 75% of wells (6 of 8) that had elevated levels of sodium, chloride, or both in baseline sampling.

8. Acknowledgements

AECOM would like to thank Golder Associates for their contribution to the hydrogeological investigations. The geotechnical borehole logs provided by Golder aided AECOM in providing analysis of the geological / hydrogeologic conditions at each structure. Without these logs, the level of detail provided in this report would not have been possible.

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Figures – Part A

Map Document: (N:\projects\2005\50613\2009\Final\GISSpatial\MXDs\ReportMXDs\Hydrogeology\Foundations_april\50613RegionalGeology-24x36.mxd)
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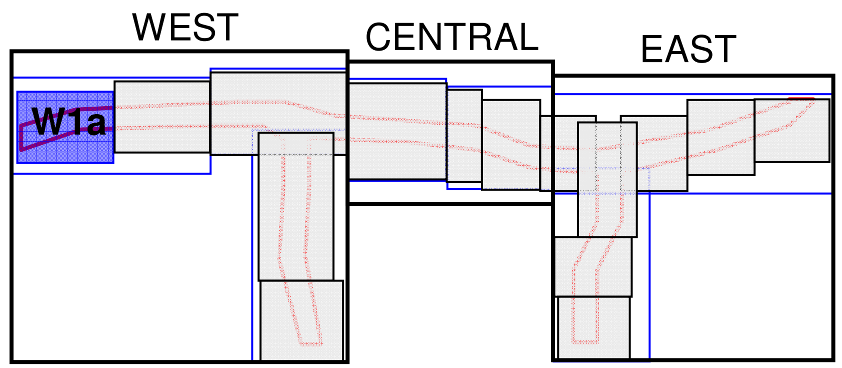
Tables – Part A

AECOM

407 East Extension – West Section
Summary Table 1 – Hydrogeological Conditions Summary (W1a)

Key Map



Map: West 1 – W1a

Section Boundaries: Brock Road to Westney Road

Figure(s): Figure A1 (Section W1a)

Cross-section(s): West 1: A – A' (Figure A6)

Assumed Proposed Structures: West Mainline – WM-A, WM-1, WM-2, WM-3, WM-4, WM-5, WM-6, WM-7, WM-8, WM-9, WM-10, WM-11, WM-11A, WM-12, WM-13

Assumed Deep Cuts: DC-W1 (13+225 to 13+580) – 18 m cut depth (drawdown curve – Figure F1)
DC-Hwy 7

Assumed High Fills: HF-W1/2 (11+725 to 11+975) – 5.5 m fill height
HF-W3 (12+475 to 12+930) – 17 m fill height
HF-W4 (13+625 to 13+900) – 10 m fill height
HF-W5 (14+400 to 14+975) – 14.5 m fill height

Hydrogeology Site Ranking Table: Table 6 (Section W1a)

FIELD DATA SOURCES:

Boreholes: P4, P5, P6, P7, WMa-1, WMa-2, WM1-1, WM3-1, WM3-2, WM5-1, WM8-1, WM11-1, WM11-2, WM11a-1, WM12-1

Monitoring Wells: G1W-1, G1W-2

Mini-Piezometers: MP1, MP2, MP3s/d, MP38

Stream Reconnaissance Sites: SR1a,b, SR2a,b, SR3a,b, SR4a,b, SR5a,b,c

Residential Water Wells: 47 private water wells. 34% dug, 15% drilled, 50% unknown, 1% community (drilled). Approximately 4 wells within the TPR boundary (May require decommissioning)

PHYSIOGRAPHIC SETTING:

- The northern and western portions of the greater study area consist of a level to rolling till plain, with numerous drumlins oriented up slope (north), typical of the South Slope physiographic region (Chapman and Putman, 1984). Meltwater streams have cut sharp valleys in the till (e.g., Duffins Creek) and deposited coarse-textured glaciofluvial sediments along their path. Modern alluvial silts, sands and gravels can be found in these valleys.
- The Iroquois Plain physiographic region is found south of Highway 7 and is characterized by flat lying deposits of coarse sand and gravel that are present along the shoreline bluff of Glacial Lake Iroquois. Glaciolacustrine sediments of sand, silt and clay overlie till to depths of 20m (Barnett, 1996).

Notes:
mBGS – metres below ground surface
GWT – groundwater table
ORM – Oak Ridges Moraine
PTTW – Permit To Take Water

TYPICAL STRATIGRAPHIC/ HYDROSTRATIGRAPHIC UNITS:
West 1 (W1a) Section

Thickness	Description
0 – 9 m	**Unit 1: Coarse-textured Glaciolacustrine Deposits including Glacial Lake Iroquois Shoreline** (surficial aquifer) – yellow and hatched yellow on figure A1 ▶ Sand and Gravel, loose (Nearshore Lake Iroquois deposits) – hatched yellow ▶ Fine to coarse sand and silty sand or sandy silt, well rounded, well sorted, compact - yellow ▶ Utilized for potable water from shallow dug wells ▶ Water table is often close to surface because till unit below restricts drainage to depth ▶ Unit is typically considered a recharge area, but local groundwater discharge can occur in the Lake Iroquois deposits along breaks in slope and in creeks ▶ Alluvial sediments are present in modern river valleys ▶ Hydraulic Conductivity (K) – 5.6x10^{-06} m/s (Table A) ▶ Infiltration is rapid but drainage to depth is poor due to till soils below ▶ The groundwater flow direction is lateral towards discharge areas alongside valleys ▶ Assumed downwards hydraulic gradient exists between coarse-textured glaciolacustrine deposits and underlying till deposits
0 – 5 m	**Unit 4: Newmarket Till** (aquitard) – light green on figure A1 and figure A6 (cross-section) ▶ Silty sand to sandy silt till, with gravel and occasional boulders, very dense ▶ In this stratigraphic position, the Newmarket Till is thin and often appears to be highly weathered or reworked ▶ See full description below
0 – 10 m	**Unit 3: Ice Contact Margin Sand and Gravel** (aquifer) – yellow and brown at the base of dark green (see cross section – figure A6) ▶ Silty to clean sand and gravel ▶ Significant local aquifer that contributes to groundwater discharge in local streams and wetlands ▶ Likely present between 12+100 and 13+000 ▶ Hydraulic Conductivity (K) – 1.2x10^{-04} to 6.3x10^{-06} m/s ▶ May exhibit flowing artesian groundwater pressures
0 – 50 m	**Unit 4: Newmarket Till** (aquitard) – light green on figure A1 and figure A6 (cross-section) ▶ Silty sand to sandy silt till, with gravel and occasional boulders, very dense ▶ Ranges in thickness from 10 to 50 m ▶ Unit is exposed at ground surface in places ▶ Water table is often close to surface (<1 mBGS) because unit is poorly drained ▶ Hydraulic Conductivity (K) – 3.2x10^{-07} m/s (Table A) ▶ Infiltration is poor and run-off exceeds infiltration ▶ The groundwater flow direction is downwards towards deep aquifer units ▶ Downwards hydraulic gradient exists between shallow and deep till deposits ▶ Contains discontinuous sand lenses that are utilized as individual potable water sources ▶ Hydraulic Conductivity (K) of sand lenses – 8.4x10^{-06} m/s (geometric mean of all hydrogeology monitors screened in sand lenses/layers) Shale Bedrock present at an elevation of 115 masl (30 to 70 mBGS)
0 - >10 m	**Unit 4: Fine to silty sand Thorncliffe Aquifer Deposits (aquifer)** – yellow below light green on figure A6 ▶ Silty to fine sand aquifer unit found at approximately 155 to 170 masl ▶ The sand aquifer is often overlain by a glaciolacustrine clayey silt that is characteristic of the Thorncliffe Aquifer ▶ Aquifer unit is confined and pressurized and has a high potential for very strong artesian groundwater pressures ▶ Hydraulic Conductivity (K) – 6.1x10^{-06} m/s (Table C2) ▶ Aquifer is utilized as source of potable groundwater, often for municipal supply

GROUNDWATER FLOW:

Distribution & Significance of Recharge/Discharge Areas:

- Shallow groundwater flow directions typically mimic the surface topography. That is, shallow lateral groundwater flow is from high ground towards discharge areas in perennial river valleys, mainly East Duffins Creek. Lateral groundwater flow is minor and regional groundwater flow is primarily downwards though the till
- Low rates of groundwater recharge occur in upland till plains as surface runoff often exceeds recharge due to the presence of low permeability till deposits. This caused dendritic drainage patterns to form on valley slopes and created numerous seasonal or ephemeral creeks that are perched on the surficial till. Where buried sand horizons are intersected by the creek valleys, significant local groundwater discharge may occur and facilitate perennial stream flow.
- Where present, surficial sand acts as a local recharge area and may have a high water table (<1 mBGS) perched on dense till below

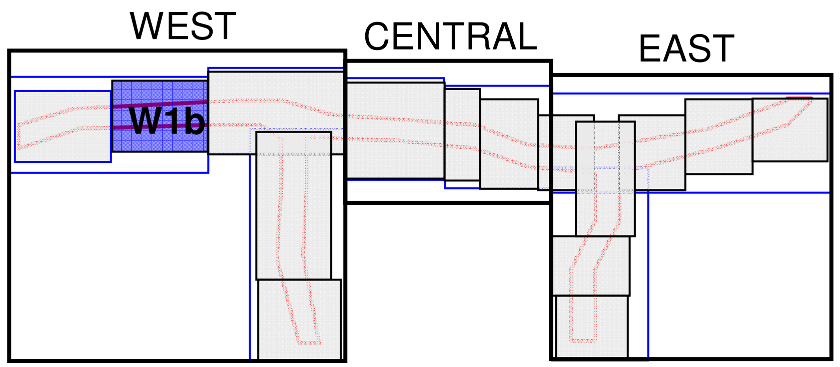
Groundwater Use:

- Majority of private wells obtain potable water from major aquifer units including the Thorncliffe Aquifer, the ORM Aquifer (or other glacial ice contact margin deposits) and surficial glaciolacustrine sand aquifers.
- Some private wells obtain potable water from thin, discontinuous sand lenses/ seams within till units
- 16 dug wells (~5 to ~12 m deep), 7 drilled wells (~10 to ~55 m deep), 1 community well, no commercial/ industrial wells, 23 other wells (unknown construction details)

407 East Extension – West Section

Summary Table 2 – Hydrogeological Conditions Summary (W1b)

Key Map



Map: West 1 – W1b

Section Boundaries: Westney Road to Kinsale Road

Figure(s): Figure A2

Cross-section(s): West 1: A – A' (Figure A6)

Assumed Proposed Structures: Western Mainline – WM-14, WM-15, WM-16, WM-17, WM-18, WM-19, WM-20, WM-21, WM-22, WM-23, WM-24, WM-25, WM-26, WM-27

Assumed Deep Cuts: DC-W2 (18+060 to 18+300) – 12 m cut depth (drawdown curve – Figure F2)

Assumed High Fills: HF-W6 (16+150 to 16+275) – 6.5 m fill height
HF-W7/ WM8 (16+525 to 17+625) – 6.5 m fill height
HF-W9 (18+450 to 18+550) – 5.5 m fill height

Hydrogeology Site Ranking Table: Table 7 (Section W1b)

FIELD DATA SOURCES:

Boreholes: P8, P9, WM17-1, WM17-2, WM22-1, WM25-1, WM27-1, WM27-2

Monitoring Wells: None

Mini-Piezometers: MP4, MP5

Stream Reconnaissance Sites: SR6a,b,c, SR7, SR8a,b,c, SR9a,b, SR10a,b

Residential Water Wells: 20 private water wells. 15% dug, 60% drilled, 25% unknown. Approximately 6 wells within the TPR boundary (may require decommissioning)

PHYSIOGRAPHIC SETTING:

- The eastern and western portions of the greater study area consist of a level to rolling till plain, with numerous drumlins oriented up slope (north), typical of the South Slope physiographic region (Chapman and Putman, 1984). Meltwater streams have cut sharp valleys in the till and deposited coarse-textured glaciofluvial sediments along their path. Modern alluvial silts, sands and gravels can be found in these valleys.
- This map sheet lies in the till plain, except the central area, which hosts overlying lacustrine deposits.

Notes:
mBGS – metres below ground surface
GWT – groundwater table
ORM – Oak Ridges Moraine
PTTW – Permit To Take Water

TYPICAL STRATIGRAPHIC/ HYDROSTRATIGRAPHIC UNITS:
West 1 (W1b) Section

Limited glaciolacustrine silts and clays are present in this section (blue on figure A2)	**Fine-textured Glaciolacustrine Sediments** – blue on figure A2 ▶ Silt and clay, laminated ▶ Derived from glaciolacustrine sedimentation coinciding with deposition of the ORM ▶ Potential to confine aquifer materials. Minor groundwater discharge may occur at the contact between the glaciolacustrine silt and clay and the Newmarket Till ▶ Hydraulic Conductivity (K) – 4.4×10^{-08} m/s (Table A) **Other:** ▶ Modern Alluvial sediments have been mapped in many low lying areas associated with ephemeral streams – brown on figure A2 ▶ Hydraulic Conductivity (K) – 1×10^{-04} m/s (estimated from Freeze and Cherry, 1979) ▶ Evidence of ORM glaciofluvial sand deposits at surface or near surface. May suggest a thin veneer of Halton Till in some locations – orange on figure A2
0 – 70 m	**Unit 1: Newmarket Till** (aquitard) – light green on figure A2 ▶ Silty sand to sandy silt till, with gravel and occasional boulders, very dense ▶ May be up to 70 m thick ▶ Unit is exposed at ground surface. ▶ Contains discontinuous sand lenses that are utilized as individual potable water sources ▶ Water table is often close to surface (<1 mBGS) because unit is poorly drained ▶ Hydraulic Conductivity (K) – 3.2×10^{-07} m/s (Table A) ▶ Infiltration is poor and run-off exceeds infiltration ▶ The groundwater flow direction is downwards towards deep aquifer units ▶ Downwards hydraulic gradient exists between shallow and deep till deposits ▶ Contains discontinuous sand lenses that are utilized as individual potable water sources ▶ Hydraulic Conductivity (K) of sand lenses – 8.4×10^{-06} m/s (Table A) Shale Bedrock present at an elevation of ~115 masl (30 to 70 mBGS)

GROUNDWATER FLOW:

Distribution & Significance of Recharge/Discharge Areas:

- Shallow groundwater flow directions typically mimic the surface topography. That is, shallow lateral groundwater flow is from high ground towards discharge areas in perennial river valleys, mainly Carruthers Creek. Lateral flow in minor and regional groundwater flow is primarily downwards through the till.
- Low rates of groundwater recharge occur in upland till plains, although surface runoff often exceeds recharge due to the presence of low permeability till of glaciolacustrine silt and clay deposits. This caused dendritic drainage patterns to form on valley slopes and created numerous seasonal or ephemeral creeks that are perched on the surficial till. Where buried sand horizons are intersected by the creek valleys, significant local groundwater discharge may occur and facilitate perennial stream flow. Groundwater discharge is predominant along the Lake Iroquois shoreline deposits south of Highway 7.

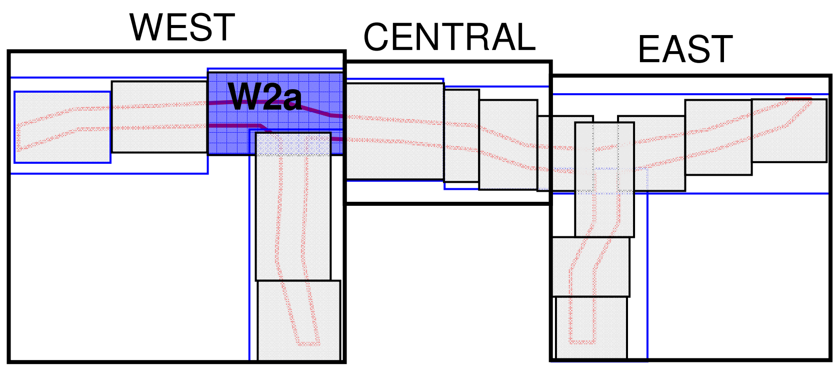
Groundwater Use:

- Majority of private wells are drilled and obtain potable water from thin, discontinuous sand lenses/ seams within till units.
- 3 dug wells (~5 to ~12 m deep), 12 drilled wells (~10 to ~55 m deep), no commercial/ industrial wells, 5 other wells (unknown construction details)

AECOM

407 East Extension – West Section
Summary Table 3 – Hydrogeological Conditions Summary (W2a)

Key Map



Map: West 2 – W2a

Section Boundaries: Kinsale Road to Ashburn Road

Figure(s): Figure A3

Cross-section(s): West 2: B – B' (Figure A7)

Assumed Proposed Structures: West Mainline – WM-28, WM29, WM-30, WM-31, WM-32, WM-33, WM-34, WM-35, WM-36, WM-37, WM-38, WM-39, WM-40, WM-41, WM-42, WM-43, WL-25, WL-26, WL-27, WL-28, WL-29, WL-30, WL-31, WL-32, WL-33

Assumed Deep Cuts: DC-W4 (19+560 to 19+700) – 8.0 m cut depth (drawdown curve – Figure F4)
DC-W5 (20+275 to 20+700) – 8.0 m cut depth (drawdown curve – Figure F5)
DC-W6 (21+450 to 21+590) – 11.5 m cut depth (drawdown curve – Figure F6)
DC-W7 (22+325 to 22+625) – 7.5 m cut depth (drawdown curve – Figure F7)

Assumed High Fills: HF-W10 (20+885 to 21+225) – 11.5 m fill height
HF-W11 (21+675 to 22+075) – 7.0 m fill height
HF-W12 (22+930 to 23+000) – 6.5 m fill height

Hydrogeology Site Ranking Table: Table 8 (Section W2a)

FIELD DATA SOURCES:

Boreholes: BH8, P10, P11, P12, WM28-1, WM29-1, WM29-2, WM35-1, WM35-2, WM36-1, WM37-1, WM38-1, WM38-2, WM39-1, WM40-1, WM41-1, WM41-2, WM43-1, WM43-2, WL26-1, WL26-2, WL27-1, WL27-2, WL28-1, WL28-2, WL31-1

Monitoring Wells: G2W-1, G2W-2

Mini-Piezometers: MP13, MP14

Stream Reconnaissance Sites: SR12a,b,c, SR14a,b, SR15a,b, SR16a,b

Residential Water Wells: 46 private water wells. 33% dug, 20% drilled, 47% unknown. Approximately 9 wells within the TPR boundary (may require decommissioning)

PHYSIOGRAPHIC SETTING:

- Level to rolling till plain, with numerous drumlins oriented up slope (north), typical of the South Slope physiographic region (Chapman and Putman, 1984). Most of W2a lies in this setting. Meltwater streams have cut sharp valleys in the till (e.g., Lynde Creek) and deposited coarse-textured glaciofluvial sediments along their path. Modern alluvial silts, sands and gravels can be found in these valleys
- The Iroquois Plain physiographic region is found south of Highway 7 and is characterized by flat lying deposits of coarse sand and gravel that are present along the shoreline bluff of Glacial Lake Iroquois. Glaciolacustrine sediments of sand, silt and clay overlie till to depths of 20 m (Barnett, 1996). GWT is often shallow due to poor drainage below

Notes:
mBGS – metres below ground surface
GWT – groundwater table
ORM – Oak Ridges Moraine
PTTW – Permit To Take Water

TYPICAL STRATIGRAPHIC/ HYDROSTRATIGRAPHIC UNITS:
West 2 (W2a) Section

Few surficial sand deposits are present in this section (yellow and brown on figure A3)	Exceptions: ▸ Glaciofluvial sand found at surface at the tributaries of Lynde Creek ▸ Thin deposits of modern alluvial sediments are present in modern river valleys ○ Hydraulic Conductivity (K) – $1x10^{-04}$ m/s (estimated from Freeze and Cherry, 1979) ▸ Isolated deposits of coarse grained glaciolacustrine sediments are present in this Section, mostly near Ashburn Road and Highway 7. ○ Hydraulic Conductivity (K) – $5.6x10^{-06}$ m/s (Table A)
0 – 70 m	**Unit 1: Newmarket Till** (aquitard) – light green on figure A3) ▸ Silty sand to sandy silt till, with gravel and occasional boulders, very dense ▸ May be up to 70 m thick ▸ Unit is exposed at ground surface. ▸ Water table is often close to surface (<1 mBGS) because unit is poorly drained ▸ Hydraulic Conductivity (K) – $3.2x10^{-07}$ m/s (Table A) ▸ Infiltration is poor and run-off exceeds infiltration ▸ The groundwater flow direction is downwards towards deep aquifer units ▸ Downwards hydraulic gradient exists between shallow and deep till deposits ▸ Contains discontinuous sand lenses that are utilized as individual potable water sources ▸ Hydraulic Conductivity (K) of sand lenses – $8.4x10^{-06}$ m/s (Table A)

GROUNDWATER FLOW:

Distribution & Significance of Recharge/Discharge Areas:

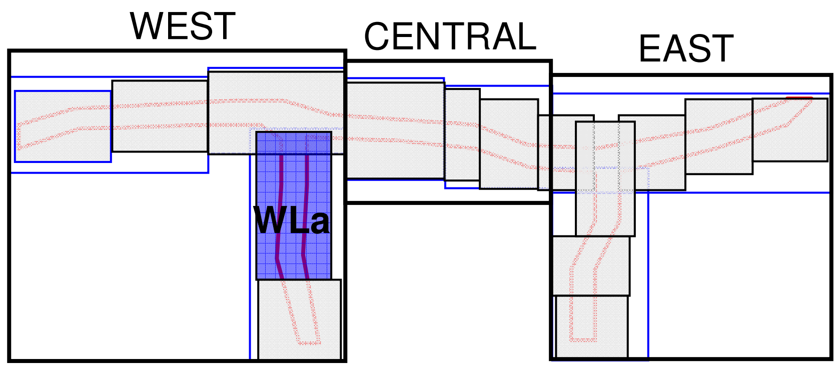
- Shallow groundwater flow directions typically mimic the surface topography. That is, shallow lateral groundwater flow is from high ground towards discharge areas in perennial river valleys, mainly Lynde Creek tributaries. Lateral flow in minor and regional groundwater flow is primarily downwards through the till.
- Low rates of groundwater recharge occur in upland till plains, although surface runoff often exceeds recharge due to the presence of low permeability till deposits. This caused dendritic drainage patterns to form on valley slopes and created numerous seasonal or ephemeral creeks that are perched on the surficial till. Where buried sand horizons are intersected by the creek valleys, significant local groundwater discharge may occur and facilitate perennial stream flow.

Groundwater Use:

- Majority of private wells obtain potable water from thin, discontinuous sand lenses/ seams within till units.
- 15 dug wells (~5 to ~12 m deep), 9 drilled wells (~10 to ~55 m deep), no commercial/ industrial wells, 22 other wells (unknown construction details).

407 East Extension – West Section
Summary Table 4 – Hydrogeological Conditions Summary (WLa)

Key Map



Map: West Link – WLa

Section Boundaries: Highway 407 Mainline to Rossland Road between Audley Road and Country Lane.

Figure(s): Figure A4

Cross-section(s): West Link: C – C' (Figure A8)

Assumed Proposed Structures: West Link – WL-16, WL-17, WL-18, WL-19, WL-19a, WL-20, WL-21, WL-22, WL-23, WL-24, WL-25, WL-26, WL-27, WL-28, WL-29, WL-30, WL-31, WL-32, WL-33

Assumed Deep Cuts: DC-W8 (12+400 to 12+890) – 6.5 m cut depth (drawdown curve – Figure F8)

Assumed High Fills: HF-W13 (18+050 to 18+490) – 10.0 m fill height
HF-W14 (17+325 to 17+700) – 7.5 m fill height
HF-W15 (14+350 to 15+075) – 8.0 m fill height

Hydrogeology Site Ranking Table: Table 9 (Section WLa)

FIELD DATA SOURCES:

Boreholes: BH3, BH4, BH5, BH6, BH7, BH8, WL16-1, WL20-1, WL20-2, WL23-1, WL24-1, WL24-2, WL26-1, WL26-2, WL27-1, WL27-2, WL28-1, WL28-2

Monitoring Wells: G3W-1, G3W-2, G4W-1, G4W-2

Mini-Piezometers: MP6, MP7, MP8, MP9s/d, MP10

Stream Reconnaissance Sites: SR13c,d,e

Residential Water Wells: 201 private water wells. 25% dug, 11% drilled, 64% unknown. Approximately 8 wells within the TPR boundary (may require decommissioning)

PHYSIOGRAPHIC SETTING:

- Gently sloping southward from the South Slope physiographic region to Lake Ontario is the Iroquois Plain physiographic region (Chapman and Putman, 1984). Boulder pavements and sand and gravel beach deposits characterize the shoreline of Glacial Lake Iroquois, which is found south of Highway 7. Nearshore deposits of sand, that grade to silts and clays characterize the area between the glacial shoreline and Lake Ontario. These shallow deposits overlie the Newmarket Till. Modern alluvial silts, sands and gravels can be found in recent alluvial valley of Lynde Creek and its tributaries

Notes:
mBGS – metres below ground surface
GWT – groundwater table
ORM – Oak Ridges Moraine
PTTW – Permit To Take Water

TYPICAL STRATIGRAPHIC/ HYDROSTRATIGRAPHIC UNITS:
West Link (WLa) Section

Depth	Unit
0 – 20 m	**Unit 1: Fine to Coarse-textured Glaciolacustrine Deposits including Glacial Lake Iroquois Shoreline** - figure A4 and figure A8 ▶ Lake Iroquois Shoreline deposits - Sand and Gravel, loose (hatched yellow) ○ Up to 20 m in thickness ○ Present from 17+400 to 18+100 ▶ Coarse Textured Glaciolacustrine deposits - fine to coarse sand and silty sand or sandy silt, well rounded, well sorted, compact (yellow) ○ Form the unconfined Iroquois Plain Shallow Aquifer ○ Utilized for potable water from shallow dug wells. ○ Water table is often close to surface because till unit below restricts drainage to depth ▶ Hydraulic Conductivity (K) – 5.6x10^{-06} m/s (Table A) ▶ Fine Textured Glaciolacustrine deposits (blue on figure A4) – clayey silt grading to sandy silt with depth ○ Hydraulic Conductivity (K) – 4.4x10^{-08} m/s (Table A) ▶ Unit is typically considered a recharge Area, but local groundwater discharge can occur in the Lake Iroquois deposits along breaks in slope and in watercourses ▶ Alluvial sediments are present in modern river valleys ▶ Hydraulic Conductivity (K) – 1x10^{-04} m/s (estimated from Freeze and Cherry, 1979) ▶ Upward hydraulic gradient (groundwater discharge) measured in a tributary of Lynde Creek at WM-42
0 – 55 m	**Unit 2: Newmarket Till** (aquitard) – light green in figure A4 and figure A8 ▶ Silty sand to sandy silt till, with gravel and occasional boulders, very dense ▶ Ranges in thickness from 5 to 55 m ▶ Unit is exposed at ground surface in many places ▶ Water table is often close to surface (<1 mBGS) because unit is poorly drained ▶ Hydraulic Conductivity (K) – 3.2x10^{-07} m/s (Table A) ▶ Infiltration is poor and run-off exceeds infiltration ▶ The groundwater flow direction is downwards towards deep aquifer units ▶ Downwards hydraulic gradient exists between shallow and deep till deposits ▶ Contains discontinuous sand lenses that are utilized as individual potable water sources ▶ Hydraulic Conductivity (K) of sand lenses – 8.4x10^{-06} m/s (Table A) Sand unit at the base of Newmarket Till may be the Thorncliffe Aquifer (see cross section – figure A8). Based upon MOE water well records this may only be present at the north end of the TPR along the West Link and is too deep to be influenced by highway construction
>7.5 - >65 m	**Unit 3: Bedrock** (aquifer) – figure A8 ▶ Flat-lying Paleozoic (Upper Ordovician) limestone and shale ▶ Lindsay Formation Limestone and Blue Mountain (locally Whitby Formation) Shale ▶ Dips from an elevation of ~100 to 90 masl (between 65 and 7.5 mBGS) for the WLa area ▶ No outcrops present in study area ▶ Utilized as a source of potable water by deep drilled wells, but is known to contain high concentrations of iron, manganese, iron reducing bacteria, and hydrogen sulphide gas. ▶ Hydraulic Conductivity (K) – 2.4x10^{-06} m/s (Table A)

GROUNDWATER FLOW:

Distribution & Significance of Recharge/Discharge Areas:

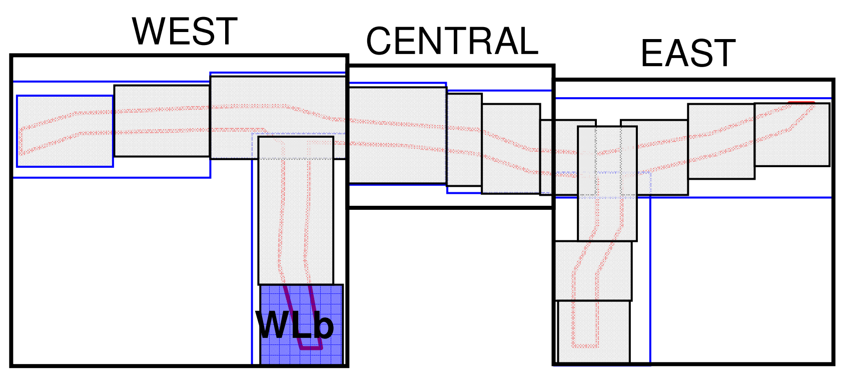
- Shallow groundwater flow directions typically mimic the surface topography. Groundwater flow in the Iroquois Plain Shallow Aquifer is predominantly horizontal, due to low permeability till sediments restricting flow below, and flows to the southeast or southwest towards perennial river valleys of Lynde Creek and its tributaries. Deep groundwater flow within the bedrock aquifer is south towards Lake Ontario
- Groundwater recharge occurs locally within areas of the Iroquois Sand Plain Aquifer. Minor groundwater recharge also occurs on upland till deposits, although run-off exceeds recharge in these areas. Groundwater discharge is predominant along the Lake Iroquois shoreline deposits and where incised river valleys intercept the water table in the surficial Iroquois Plain Aquifer

Groundwater Use:

- Majority of private wells obtain potable water either from unconfined glaciolacustrine sand aquifers or from deep bedrock aquifers.
- Some private wells obtain potable water from thin, discontinuous sand lenses/ seams within the Newmarket Till
- 50 dug wells (~5 to ~12 m deep), 23 drilled wells (~10 to ~55 m deep), no commercial/ industrial wells, 128 other wells (unknown construction details)

407 East Extension – West Section
Summary Table 5 – Hydrogeological Conditions Summary (WLb)

Key Map



Map: West Link – WLb

Section Boundaries: Rossland Road to Highway 401.

Figure(s): Figure A5

Cross-section(s): West Link: C – C' (Figure A8)

Assumed Proposed Structures: West Link – WL-1, WL-2, WL-3, WL-4, WL-5, WL-6, WL-7, WL-8, WL-9, WL-10, WL-11, WL-12, WL-13, WL-14, WL-15

Assumed Deep Cuts: None

Assumed High Fills: None

Hydrogeology Site Ranking Table: Table 10 (Section WLb)

FIELD DATA SOURCES:

Boreholes: BH1, BH3, BH9, WL2-1, WL2-2, WL3-1, WL3-2, WL3-3, WL4-1, WL5-2, WL7-1, WL7-2, WL8-1, WL8-2, WL8-3, WL9-1, WL10-1, WL11-1, WL12-1

Monitoring Wells: None

Mini-Piezometers: MP11, MP12s/d

Stream Reconnaissance Sites: SR13a,b

Residential Water Wells: 10 private water wells. 40% dug, 0% drilled, 60% unknown. Municipal water is utilized in this area. Approximately 8 wells within the TPR boundary (may require decommissioning)

PHYSIOGRAPHIC SETTING:

- Gently sloping southward from the South Slope physiographic region to Lake Ontario is the Iroquois Plain physiographic region (Chapman and Putman, 1984). Boulder pavements and sand and gravel beach deposits characterize the shoreline of Glacial Lake Iroquois. Nearshore deposits of silts and clays characterize the area. Modern alluvial silts, sands and gravels can be found in recent alluvial valley of Lynde Creek and its tributaries.

Notes:
mBGS – metres below ground surface
GWT – groundwater table
ORM – Oak Ridges Moraine
PTTW – Permit To Take Water

TYPICAL STRATIGRAPHIC/ HYDROSTRATIGRAPHIC UNITS:
West Link (WLb) Section

Depth	Unit
0 – 9 m	**Unit 1: Fine-textured Glaciolacustrine Sediments** (surficial aquitard) – blue on figure A5 ▸ Silt and clay, massive, well laminated ▸ Derived from glaciolacustrine sedimentation in calm offshore waters of Glacial Lake Iroquois ▸ May contain interbedded fine sand layers ▸ Minor glaciolacustrine silt and sand present at surface ▸ Water table is often close to surface (<1 mBGS) because unit is poorly drained ▸ Hydraulic Conductivity (K) – 4.4x10^{-08} m/s (Table A) ▸ Upwards hydraulic gradient exists between the underlying till deposits and the fine-textured glaciolacustrine deposits
0 – 12 m	**Unit 2: Newmarket Till** (aquitard) – light green on figure A5 ▸ Silty sand to sandy silt till, with gravel and occasional boulders, very dense ▸ Ranges in thickness from 6 to 12 m ▸ Unit is exposed at ground surface in places ▸ Water table is often close to surface (<1 mBGS) because unit is poorly drained ▸ Hydraulic Conductivity (K) – 3.2x10^{-07} m/s (Table A) ▸ Infiltration is poor and run-off exceeds infiltration ▸ The groundwater flow direction is downwards towards deep aquifer units ▸ Downwards hydraulic gradient exists between shallow and deep till deposits ▸ Contains discontinuous sand lenses that are utilized as individual potable water sources ▸ Hydraulic Conductivity (K) of sand lenses – 8.4x10^{-06} m/s (Table A)
>12 m	**Unit 3: Bedrock** (aquifer) – figure A8 ▸ Flat-lying Paleozoic (Upper Ordovician) limestone and shale ▸ Lindsay Formation Limestone and Blue Mountain (locally Whitby Formation) Shale ▸ Present at an elevation of ~100 masl dropping to 73 masl at Dundas Street (between 20 and 7.5 mBGS) ▸ No outcrops present in study area ▸ Utilized as a source of potable water by deep drilled wells, but is known to contain high concentrations of iron, manganese, iron reducing bacteria, and methane. ▸ Hydraulic Conductivity (K) – 2.4x10^{-06} m/s (Table A)

GROUNDWATER FLOW:

Distribution & Significance of Recharge/Discharge Areas:

- Shallow groundwater flow directions typically mimic the surface topography. Groundwater flow in the Iroquois Plain Shallow Aquifer is predominantly horizontal, due to low permeability till sediments restricting flow below, and flows to the southeast or southwest towards perennial river valleys of Lynde Creek and its tributaries. Deep groundwater flow within the bedrock aquifer is south towards Lake Ontario.

Groundwater Use:

- Majority of private wells obtain potable water either from unconfined glaciolacustrine sand aquifers or from deep bedrock aquifers.
- Some private wells obtain potable water from thin, discontinuous sand lenses/ seams within the Newmarket Till
- 4 dug wells (~5 to ~12 m deep), 0 drilled wells (~10 to ~55 m deep), no commercial/ industrial wells, 6 other wells (unknown construction details).
- Majority of this Section obtains potable water from the local municipality and no longer wells for potable water.

Part B

Hydrogeological Foundation Investigation Report for Preliminary Design

HIGHWAY 407 EAST EXTENSION – WESTERN SECTION

Ministry of Transportation Ontario

Date:

June, 2009

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Appendices for Parts A and B

1. Introduction

Report B presents a discussion of the potential impacts and mitigation options for the Western Mainline and the West Durham Link of the Technically Preferred Route (TPR) of the Highway 407 East Extension. AECOM was retained by URS Canada Inc. (URS) to carry out this study for the Ministry of Transportation (MTO). The purpose of this report is to provide an analysis of the potential effect that groundwater may have on foundation design and construction in support of the foundation design, structural design and highway design teams.

The study area of the hydrogeological investigations within the Western Section includes the 407 mainline from Brock Road to Ashburn Road (approx. 15 km) as well as the West Durham Link from Highway 401 to the Highway 407 mainline (approx. 10 km). This section of highway is shown on **Figure 1**. The majority of the field investigations were concentrated within one (1) km of the centreline of the TPR. An interpretation of the geological and hydrogeological conditions at each structure and at each deep cut location in this section is provided based upon existing information. A preliminary assessment has been made that highlights areas of potential concern, locations that require additional information during detailed design, opportunities for mitigation, and the priorities for detailed design.

This report is designed to be a stand alone report that supersedes all previous hydrogeology foundations reports. The information presented here may only be used for planning and feasibility purposes. Additional, site-specific hydrogeologic data are required for preparation at the detailed design stage.

2. Report Structure

The Western Mainline and Link have been divided into sub-sections based upon differences in geology / hydrogeology that exist within the larger Western Section. The divisions were designed to be compatible with both the Foundation Investigation Report and the Impact Assessment Report. The study area was divided into three parts: *West 1* from Brock Road to Kinsale Road; *West 2* from Kinsale Road to Ashburn Road; and West Link from the Highway 407 mainline to Highway 401. *West 1* was further subdivided into *W1a* from Brock Road to Westney Road; and *W1b* from Westney Road to Kinsale Road. *West Link* was further subdivided into *WLa* from north of Highway 7 to south of Rossland Road; and *WLb* from south of Rossland Road to Highway 401.

2.1 Numbering System

To maintain consistency with the engineering Design Teams, hydrogeological information is presented on a structure bases using their structure nomenclature:

WM - xx represents a structure along the Western Mainline
WL - xx represents a structure along the Western Link

The structure summary tables also present the drainage crossing identification numbers along side the structure locations, to allow ease of cross reference.

3. Sources

The following geological / hydrogeological conditions outlined in this report are based upon a comprehensive review of existing regional information and on investigative field activities. The information and conclusions presented herein were derived from, but not limited too, hydrogeological field investigations by AECOM, geotechnical field investigations by Golder Associates (Golder), and preliminary bridge and highway profile designs provided by URS.

4. Hydrogeological Foundation Investigation

4.1 Hydrogeology Summary Tables

Hydrogeological Conditions Summary Tables were created for each subsection of the Western Mainline and Western Link [*West 1 (W1a and W1b), West 2 (W2a) and West Link (WLa and WLb)*]. The column on the left lists the associated tables and figures that accompany the summary table, the sources of field information used to draw conclusions, the engineering features of the subsection (structures, deep cuts, and high fills), and the general site physiography. The location of the deep cuts and high fills are for illustrative purposes only and should be considered approximate. The column on the right provides a summary of the effects of groundwater on foundation design and construction, and the potential impacts to the natural environment. A summary of the avoidance/ mitigation/ compensation measures, and the recommended priorities for detailed design are also shown. Foundation design should consider each of the recommendations presented. Potential Impacts and Mitigation Summaries are presented on Tables 1 to 5.

4.2 Structure Summary Tables

The Structure Summary Tables are modified versions of the Hydrogeology Foundation Design Tables that have been submitted monthly by AECOM to URS. They provide a summary at each structure along the Western Mainline and Link, including a discussion of the hydrogeologic conditions in its vicinity and hydrogeology site ranking (low, medium, high). They have been expanded to include information gathered from geotechnical boreholes and to include recommendations for watercourse crossings, based upon known or interpreted groundwater-surface water interactions at stream locations. Structure Summary Tables are shown on Tables 6 to 10.

The Hydrogeology Site Ranking denotes the degree of impact that groundwater may have on construction activities, in terms of design, construction and environmental sensitivity.

- **Low Hydrogeology Site Ranking**

  Typical conditions include areas where thick sequences of low permeability, highly consolidated geologic materials are present at surface (e.g., glacial till). Geologic materials transmit water poorly and generally have hydraulic conductivities of <1.0x10^{-7} m/s. The water table may be close to surface (<1.0 mbgs) but dewatering is not anticipated for excavations, even below the water table due to the poor ability of the soils to transmit water. No wetland areas or perennial cold water streams are present. No restrictions based upon hydrogeology are placed on foundation design at these locations.

- **Medium Hydrogeology Site Ranking**

  Typical conditions include areas where thin bands of permeable material are present at surface and excavations below the water table may require localized groundwater control. Surficial sediments may also have a moderate hydraulic conductivity generally between $1.0x10^{-5}$ and $1.0x10^{-07}$ m/s. There is small potential to require a Permit To Take Water (PTTW), but it is not anticipated. Seasonal groundwater discharge may have been measured in the local water body and therefore ecological concerns may need to be addressed. Deep foundations are most often recommended to minimizing dewatering. Open bottom culverts or bridges are the preferable water course crossing so seasonal groundwater discharge is not impacted.

- **High Hydrogeology Site Ranking**

  Typical conditions include areas where thick sequences of high permeability sediments (generally K = $>1.0x10^{-5}$ m/s) are present at surface (e.g., alluvial sand and gravel). The water table is often at or near ground surface (<1.0 mbgs) and excavations below the water table have a high potential to require a PTTW. Groundwater discharge has been measured in the local water body which is classified as a permanent cold water stream that supports sensitive fish or fish habitat. Where feasible, deep foundations are recommended to minimizing dewatering and impacts to cold groundwater discharge. Span bridges are the preferable water course crossing, although depending upon the individual situation and bank width, an open bottom culvert may also be acceptable.

4.3 Deep Cuts Analysis

Excavations below the water table related to Deep Highway Cuts (Deep Cuts) will permanently lower the water table elevation near the cut. A deep highway cut is defined as any excavation lower than 4.5 m below original grade (OG). The radius and extent of water table drawdown is dictated by the depth of the cut below the water table, the hydraulic conductivity of the surrounding material, and the lateral extent of the geologic unit. Permanent reductions in water table elevation have the potential to lower water levels in private wells and reduce baseflow to steams and wetlands, and should be addressed at detailed design. To estimate the radius of permanent water table drawdown (x) related to deep highway cuts, the following differential equation[5] for calculating flow towards an excavation in an unconfined aquifer was used,

$$\frac{\partial h}{\partial t} = \frac{KD}{\mu}\frac{\partial^2 h}{\partial x^2}$$

Where, ∂h = change in head (m)
∂t = change in time (s)
K = hydraulic conductivity (m/s)
D = Unconfined Unit Thickness (m)
μ = Porosity
x = Distance (m) from excavation

5. *Equation derived from Drainage Principles and Applications (1973), Pub 16 – Vol II – Theories of field drainage and water shed run-off. e.d. J. Kessler. Chapter 13.3.1. Page 203. Equation #33.*

This equation assumes that the change in water level (Δh) is << D, that flow in the aquifer is horizontal so the Dupuit assumptions are valid, and that by continuity (water-in equals water-out) the flow into the excavation (Q) = the Recharge Rate (R), which was estimated from regional averages. ∂t was assumed to be 1 year. K, D, and μ were estimated based upon site-specific conditions. The modeled results also assume that drawdown is confined to a single heterogeneous and isotropic hydrogeological unit. **Appendix F, Figures F1 to F8** shows the estimated extent of water table drawdown at each deep highway cut location in the Western Section. The radius is based upon preliminary estimations of the water table drawdown at the maximum cut depth which is typically found at the edge or toe of the cut. The theoretical radius of drawdown should begin at the edge of the cut and extend outwards. A permanent lowering of the water table of <1.0 m was not considered significant for most private wells, and therefore the radius of drawdown or influence was estimated to this point. The extent of the water table drawdown is presented as the radius from the edge of the cut where the drawdown is anticipated to be <1.0 m.

This preliminary analysis is based upon drawdown in a single soil layer and hydrogeological judgement was used to interpret conditions where site-specific information was absent. Site specific borehole drilling and pumping tests have not yet been completed and may be required at detailed design. The radius of water table drawdown was estimated based upon the principles of groundwater flow towards a linear cut or ditch for each deep cut location Additional information on geology, seasonal water table fluctuations, hydraulic conductivity, and the presence/ absence of high permeability units within low permeability till soils, must be acquired prior to finalizing these ranges.

5. Description of the Hydrogeological Regime – West 1 (Brock Road to Kinsale Road)

5.1 Groundwater Flow

Groundwater flow in this section is generally downwards, indicating groundwater recharge. Since most of the area (89%) is underlain by till units, as estimated from **Figures A1 and A2**, runoff exceeds infiltration making groundwater recharge rates low. Groundwater level measurements from G1W-1 and G1W-2 indicate that groundwater flow between surficial aquifer units towards the deep till is downwards (**Figure E1**). There is likely a significant component of eastward lateral groundwater flow in the unconfined glaciolacustrine aquifer unit found east of Sideline 14 Road (~13+700 to 14+600), towards East Duffins Creek.

The groundwater table is generally shallow and can be anticipated to be within ~2.0 m of ground surface throughout the section due to poor drainage through the dense till soils. Following major recharge events (i.e., spring melt) the groundwater table within coarse textured glaciolacustrine materials can be very close ground surface (0.29 mbgs in G1W-2 in May 2008, **Table C6**).

According to the Provincial OGS surficial geological mapping, coarse textured deposits of the remnant Glacial Lake Iroquois Shoreline are present south of the ROW between ~12+500 and 13+800. These deposits are found at a large break in slope between the Iroquois Plain and the South Slope upland area and constitute a significant groundwater discharge area. Mini-piezometer MP2 is located in these deposits and shows a strong upwards gradient within Brougham Creek.

Between ~12+100 to ~12+800 recent borehole drilling has confirmed that a sand and gravel aquifer unit is present within 2.0 to 3.0 of surface, underlain only by a thin layer of clayey silt (Appendix B – Borehole DM-5). Groundwater monitor DM-5 which is screened near the base of the sand and gravel aquifer unit is flowing artesian (Table C6). Groundwater springs and seeps have been observed near ~12+650 on the table lands to the west of the valley at WM-5/ WM-6. This sand and gravel aquifer unit may be hydraulically connected to the Lake Iroquois Shoreline deposits found south of the ROW, which may further increase the significance of the discharge function of these sediments.

5.1.1 Recharge

Groundwater recharge is known to occur where Newmarket and Halton till units are present at surface, although recharge rates are generally low (60 to 100 mm/a). Small footprints within these areas are not considered regionally significant recharge areas because of the low rates. Mini-piezometer measurements at MP1, MP4, and MP5 indicate that these water courses are "losing" streams, meaning that they recharge the water table. High rates of infiltration (>200 mm/a) are expected between ~13+700 and 14+600 (**Figure A1**) where glaciolacustrine silts and sands are present at surface. The water that infiltrates here is anticipated to both flow relatively slowly downward into the underlying till , but also rapidly eastwards discharging into East Duffins Creek.

5.1.2 Discharge

Groundwater discharge generally occurs at specific points within this section. Cold groundwater discharge was measured at MP2 within Brougham Creek. Site specific observations of the wetland areas both north and south of Highway 7 along the Glacial Lake Iroquois Shoreline showed an abundance of groundwater springs and seeps, as well as other indicators of groundwater upwelling (discharge) such as water cress. Groundwater springs and seeps are found near ~12+650 on the table lands to the west of the valley at WM-5/ WM-6. Manual temperature measurements from this area confirm these observations. Groundwater discharge is also anticipated in Spring Creek (SR4a/b), East Duffins Creek (SR5a/b), Carruthers Creek (SR6a/b/c), Carruthers Creek tributaries (SR8a/b, SR9a) and West Lynde Creek tributary (SR10a)(**Figures A1 and A2**). Spring seepage was noted along Sideline 14 Road, north of Highway 7, but south of the Transportation Corridor, again within the deposits mapped as Lake Iroquois Shoreline deposits. While these sites represent a very small percentage of Section 1, the groundwater discharge can be significant for the specific location.

5.2 Significant Aquifer Units

The coarse textured glaciolacustrine deposit between ~13+700 and 14+600 is approximately 6.1 m thick and constitutes a significant local aquifer unit (**Figures A1 and A6**). At G1W-1, the unit is comprised of 2.3 m of fine to coarse sand, underlain by 3.8 m of sandy silt, but could be thicker to the west (**Appendix B**). Although the measured hydraulic conductivity of this unit was 2.2×10^{-6} m/s (**Table C2**), the gradational nature of the deposit means that it will be more permeable at surface, decreasing with depth. This unit is utilized by local residences as a source of potable water in shallow dug wells, but is only a local aquifer unit as shown on **Figure A1**. This unit becomes finer grained with depth and is underlain by soft, silty clay that restricts drainage to depth and therefore maintains a high water table (**Figure A6**).

Many private wells obtain potable water from thin, discontinuous sand lenses found within the Newmarket Till. These units are confined, which provide a degree of protection from surface contamination, but may only yield enough water for single residential use.

5.2.1 Site Specific Investigation Near Sideline 16 Road

A site specific investigation was conducted near Sideline 16 Road and Highway 7 to determine the hydrogeological conditions in the area (**Figure A1**). Hydrogeological field observations indicated that significant groundwater discharge was occurring within a wetland area north of Highway 7 within the 407 East Transportation Corridor and that the setting hosted an active irrigation pond. Investigations focused on delineating the distribution of aquifer units in the area and how they contribute to groundwater discharge. A total of 7 boreholes were drilled, and completed as groundwater monitors as shown on **Figure A1**. Five mini-piezometers were installed in various water courses and water bodies at the site to characterize groundwater discharge relationships.

Two separate aquifer units were identified from subsurface investigations. Boreholes DM-1, DM-2, DM-4 and DM-6 appear to be tapping the same hydrogeologic unit below the Newmarket Till. Boreholes DM-3, DM-5 and DM-7 appear to tap a separate sand and gravel deposit that is hydraulically connected to the wetland, but are stratigraphically above the Newmarket Till which locally appears to thin to the south. The following description deals with each group separately.

Boreholes DM-3, DM-5 and DM-7 encountered a ~5.0 – 10.0 m thick sand and gravel aquifer unit that is interpreted to consist of glacial ice contact margin deposits due to the sequences of the clean and silty sands and gravels that have been identified. This unit is interpreted to be present between ~12+100 and 12+800 (**Figure A1 and A6**). Geologically, this unit appears to be a glacial ice contact margin sand and gravel deposit, similar to the ORM deposits, but because of where it lies in the stratigraphy (i.e., below the Newmarket Till and not above it), it is likely a local aquifer deposit and not regional like the ORM. Groundwater discharge from this aquifer unit is likely responsible for the upwelling (MP2) and spring seepage observed in the wetland area near structure *WM-5 / WM-6* on both the north and south side of Highway 7. This aquifer unit is likely hydraulically connected to the Lake Iroquois deposits and adds to their discharge function. As shown on **Figure A6**, this aquifer unit was not encountered in borehole drilling within the ROW past ~12+900. It likely trends in an east-west direction and is present close to surface near the Iroquois Shoreline scarp. On the east side of the valley near WM-5/ WM-6, groundwater pressure has been reduced due to the large flux of groundwater discharge into the valley area. Conversely, on the west side of the valley, groundwater pressures have been maintained and groundwater levels are at or above ground surface (i.e., DM-5). Groundwater seeps were observed within the ROW near DM-5 at ~12+650, and there is significant upwelling in the creek and seepage from the valley walls in the wetland.

Borehole drilling at DM-1, DM-2, DM-4, and DM-6 identified a highly pressurized silty sand aquifer unit that is confined below unweathered Newmarket Till and glaciolacustrine clayey silt at an elevation of approximately ~160 to 165 masl. This unit has very strong artesian pressures (DM-6 has ~9.5 m of head above ground surface) which are derived from groundwater recharge at higher elevations and maintained by the competency of the confining units. There are strong arguments that suggest that this aquifer unit may correlate to the Thorncliffe Aquifer. For example, the glaciolacustrine silt found above the sand at DM-1, DM-2 and DM-6 are characteristic of the Thorncliffe Aquifer. The very strong artesian pressures suggest a large regional aquifer that is extensive northwards and the elevation of the deposits is consistent with the regional elevation of the Thorncliffe Aquifer (~155 to 170 masl). The stratigraphic sequence of glaciolacustrine silts and clays that overlies a fine sand to silty sand aquifer are also consistent with the regional description of the Thorncliffe Aquifer. It appears that this aquifer unit extends in a northwest to south east direction but may not be ubiquitously present across the entire area. This aquifer unit appears to be separate from the glacial ice contact margin sand and gravel deposits described above due to the large difference in groundwater pressures and sediment characteristics. There is a potential that valley incision in the wetland at WM-5/ WM-6 has caused a hydraulic connection between the two aquifer units in this area. This hypothesis will require further study at detailed design to confirm impacts from bridge construction.

The results of the investigations at Sideline 16 Road indicate that an irregularly layered aquifer/ aquitard system exists at this location that is contributing to strong upwards groundwater pressures as typified by the artesian wells DM-1, DM-2, DM-5, and DM-6. The source of the artesian pressure is a confined fine to medium sand aquifer that is present at approximately 15.2 mbgs within the 407 East ROW. The confining units are the Newmarket Till and a finely laminated glaciolacustrine clayey silt to silt. Heading southward from the pond located at ~12+800 to where the 407 East ROW crosses the area, deposits of sand and gravel overlie the Newmarket Till. The hydrostratigraphy of the area suggests that the source of the groundwater discharge to the wetland area north of Highway 7 is from the sand and gravel deposits that overlies the Newmarket Till. Strong upwards groundwater flow (pressure) from the confined sand aquifer below, may contribute a significant amount of water to the sand and gravel aquifer above, from upwards leakage through the glaciolacustrine material and Newmarket Till. The Newmarket Till and the clayey silt aquitard units may have been naturally breached by the deeply incised valley, exposing the fine to medium sand aquifer below. This explains the significant amount of groundwater springs, seeps, and watercress found with the wetland areas to the north and south of Highway 7.

6. Description of the Hydrogeological Regime – West 2 (Kinsale Road to Ashburn Road)

6.1 Groundwater Flow

Groundwater flow in this section is generally downwards, indicating groundwater recharge. Since most of the area is underlain by till units, runoff exceeds infiltration making groundwater recharge rates low. Groundwater level measurements from G2W-1 and G2W-2 indicate that groundwater flow between the shallow and the deep till is upwards at that location, due to confined groundwater pressure in the silt lens, rather than a significant discharge area (**Figure E2**). Groundwater flow within surficial, coarse textured sand in the creek valleys is likely lateral towards each creek.

The groundwater table is generally shallow and can be anticipated to be within ~2.0 m of ground surface throughout the section due to poor drainage through the dense till soils. Minor artesian pressure can be expected from confined units at depth with the till blanket, however the vast majority of the area is a recharge feature.

6.1.1 Recharge

Groundwater recharge is known to occur where Newmarket Till units are present at surface, although recharge rates are generally low (60 to 100 mm/a). Small footprints within these areas are not considered regionally significant recharge areas because of the low rates. Mini-piezometer measurements at MP13 in the tributary near Hall's Road indicate that this water course is a "losing" stream, meaning that surface water enters the groundwater.

6.1.2 Discharge

No discrete groundwater springs or seeps were observed in this section. Stream reconnaissance measurements of increased stream flow under baseflow conditions and other observations such as the presence of watercress indicate that diffuse groundwater discharge is occurring along Lynde Creek (SR14a/b) and Lynde Creek tributaries (SR15a/b and SR16a/b, **Figure A3**). This groundwater is seasonal in nature from the shallow weathered zone of the surrounding till soils and is insufficient to sustain stream flow, other than to augment what comes downstream from the north.

6.2 Significant Aquifer Units

No significant aquifer units were identified in this section. Some private wells obtain potable water from thin, discontinuous sand lens found within the Newmarket Till. These units are confined, which provide a degree of protection from surface contamination, but may only yield enough water for single residential use. Thin deposits of glaciolacustrine sands and silts are found near Lynde Creek tributaries at ~20+900 and ~23+000, but are too thin to be considered local aquifer units (**Figure A3**). Indeed, the air photo interpretation and ground truthing found these units to be smaller than the OGS mapping suggested, as described earlier.

7. Description of the Hydrogeological Regime – West Link (407 Mainline to Highway 401)

7.1 Groundwater Flow

Groundwater flow in this section is generally downwards and southwards, indicating groundwater recharge and flow towards Lake Ontario. Where till units exist at surface (26% of the west link, as estimated from **Figure A5**), runoff exceeds infiltration causing groundwater recharge rates to be low. Infiltration occurs where coarse textured glaciolacustrine materials are present at surface (35% of the West Link, between ~11+250 and 18+100, **Figure A4).** Groundwater flow between bedrock units and overburden is upwards (G4W-1 and G4W-2, **Figure E4**). There is likely a significant component of lateral groundwater flow in the glaciolacustrine aquifer unit eastward towards Lynde Creek and its tributaries.

The groundwater table is shallow and can be anticipated to be within ~2.0 m of ground surface throughout the section due to poor drainage through till units. If drainage to depth is good, the water table will occur at a deeper depth (~3.0 – 4.0 mbgs). Following major recharge events (i.e., spring melt) the groundwater table within the coarse textured glaciolacustrine materials can be at ground surface (e.g., 0.25 mbgs in G3W-2 in April 2008).

7.1.1 Recharge

High rates of infiltration (>200 mm/a) are expected between ~11+250 and 18+100 where glaciolacustrine silts and sands are present at surface (**Figure A4**). Further to the south where these sediments become finer grained the rate of infiltration will be much less. The water that infiltrates here is anticipated to flow primarily laterally to discharge into surface water. A lesser component will flow downward into the underlying till in the higher areas, but where there is an upward gradient from the bedrock in low-lying areas; there will be only a minor upward flux due to the low permeability till soils. Minor groundwater recharge occurs where Newmarket Till is present at surface, although recharge rates are generally low (60 to 100 mm/a). Mini-piezometer measurements at MP9s/d and MP12s/d indicate that these wetland areas are perched and are providing recharge to the water table.

7.1.2 Discharge

Groundwater discharge occurs infrequently within the study area along the West Durham Link. Groundwater discharge is anticipated to occur along the Glacial Lake Iroquois Shoreline (~17+600 to 17+900, **Figure A4**) although no water courses are present where the West Link crosses this feature. Upward hydraulic gradients were measured in MP7 and MP10, however discharge to surface water is expected to be diffuse as seems to be demonstrated by the stream temperature measurements that do not suggest significant groundwater inputs (**Figures D5 and D7**).

7.2 Significant Aquifer Units

Most private wells are located east of the Transportation Corridor within a larger portion of the Shallow Iroquois Plain Aquifer (~14+250 to 17+400, **Figure A4**). Borehole G3W-2 was drilled along the western edge of this unit and encountered a sand and gravel aquifer unit above the till between 4.6 and 6.1 mbgs. The hydraulic conductivity of this unit is 8.5×10^{-6} m/s (**Table C2**). Deposits similar to this are utilized by local residences as a source of potable water, but are only important as a local aquifer unit. These deposits are susceptible to effects from land use, including road de-icing compounds if nearby. This unit is underlain by sandy silt Newmarket Till that restricts drainage to depth (**Figure A8**).

The Whitby Formation shale is also utilized as a sporadic source of potable water for domestic use. This unit is confined below the Newmarket Till. Those few residents who obtain water from this unit report high concentrations of iron, manganese, and a sulphurous odour in their water.

Many private wells also obtain potable water from thin, discontinuous sand lens aquifers found within the Newmarket Till. These units are confined, which provide a degree of protection from surface contamination.

8. Construction and Operational Effects – West 1 (Brock Road to Kinsale Road)

8.1 Aquifer and Well Vulnerability

Of the 7.1 km for the proposed Transportation Corridor right-of-way, 6.3 km lies on low permeability Newmarket Till or Halton Till aquitard deposits (**Figure A1 and Figure A2**). These thick deposits of till act as a hydraulic barrier (aquitard) restricting the interaction between surface water and groundwater. The potential effects to groundwater from construction and long-term operation are low due to till soils at surface restricting infiltration and protecting aquifer units below.

An unconfined glaciolacustrine silt and sand aquifer unit is present between ~13+700 and 14+600 (**Figure A1**) and is an important source of potable water for local residences. This unit has a moderate hydraulic conductivity (5.6×10^{-6} m/s, **Table C2**) and infiltration is relatively rapid. Groundwater flow in this unit is downwards and eastward towards discharge areas in East Duffins Creek. The water table is shallow due to poor drainage through the Newmarket Till below. Most private wells in this area are shallow and dug, and are therefore susceptible to surficial contaminants. Potential adverse effects from long-term road salt applications were identified within this area.

8.2 Artesian Conditions

Significant artesian groundwater pressures are likely to be found between ~12+100 to ~12+800. The source of the artesian pressure is from two aquifer units: The first is a shallow sand and gravel aquifer unit that is confined below a thin veneer of Newmarket Till (often less than 2.2 m in thickness) and interpreted to have been deposited at the ice contact margin during the last glaciation. The second is a confined and highly pressurized fine to silty sand aquifer present between ~160 to 165 masl, which is interpreted to be the Thorncliffe Aquifer. Excavations below the Newmarket Till between ~12+100 to ~12+800 have a high potential to encounter a saturated, pressurized aquifer. Permanent groundwater control may be required and should be assessed on a site specific basis at detailed design. Deep foundations may intercept the highly pressurized Thorncliffe aquifer at ~165 masl. Design of the deep foundations will need to account for this pressure and should be assessed at detailed design.

8.3 Impacts From Structures

Structures *WM-A* (Urfe Creek), *WM-1/ WM-2* (Brougham Creek), SITE 3A (Brougham Creek), *WM-9/ WM-10* (Spring Creek), *WM-12/ WM-13* (East Duffins Creek), *WM-18/ WM-19* (Carruthers Creek), and *WM-20/ WM-21* (Carruthers Creek) are bridge crossings over water courses (**Figures A1 and A2**). Although the span lengths and the number of piers differ, they each have similar potential effects related to groundwater. Permeable alluvial materials are present at surface, but vary in extent and thickness, and the water table is generally at ground surface (<1.0 mbgs) being lowest in the late summer. Stream reconnaissance data suggests that groundwater discharge is contributing to flow at *WM-9/ WM-10, WM-12/ WM-13, WM-18/ WM-19, and WM-20/ WM-21.* Site observations at *WM-A*, suggest that groundwater discharge is occurring at this location as well. It is anticipated that temporary construction dewatering may be required at WM-9/WM-10 and WM-12/WM-13 crossings to facilitate construction of bridge foundations. Significant dewatering is not anticipated at WM-18/WM-19 and WM-20/WM-21 due to the presence of low permeability soils at surface; however some low yielding pumping may be locally required.

Structure *WM-5/ WM-6* is a bridge crossing over Brougham Creek and the outlet water course from the irrigation pond to the north of the transportation corridor at ~12+800 (**Figure A1**). **Chapter 5.1.2** details the site specific hydrogeological investigations near this crossing. Significant groundwater discharge was identified within the footprint of this structure from mini-piezometer data (Table C4), artesian groundwater conditions at DM-5, and site observations of water cress and groundwater seeps. Approximately 15 m of fill placement is required within the valley that may impact groundwater discharge to the water course within the valley. Mitigation measures to convey groundwater below the fill will likely be required to maintain the groundwater discharge function of this valley and should be assessed at detailed design. It is anticipated that dewatering will be required for excavations within the valley, although no estimates have been made towards the dewatering rate. There is also a potential that dewatering could temporarily reduce groundwater discharge into the pond, located directly north of the transportation corridor over the duration of the water taking. This reduction in groundwater discharge is not anticipated to significantly impact the amount of groundwater discharge to the pond, due to the temporary nature of construction dewatering and the small amount of water taking relative to the anticipated rate of natural discharge. If deep foundations are used in this area, they will likely encounter a highly pressurized aquifer at ~165 masl. Mitigation measures though foundation design will be required and should be assessed at detailed design.

SITE 4 (Brougham Creek tributary within transportation corridor), SITE 5 (Brougham Creek tributary at Sideline 16 south of the transportation corridor), *WM-14/ WM-15/ WM-16* (East Duffins Creek tributary), *WM-23* (Carruthers Creek tributary), *WM-24* (Carruthers Creek tributary), *WM-26* (West Lynde Creek tributary), *SITE 101* (Brougham Creek tributary at Highway 7)*, and SITE 102* (Brougham Creek tributary north of Highway 7 for Brock Road realignment) are all culverts across water courses (**Figures A1 and A2**). Each of these water courses is intermittent and perched on low permeability till deposits. Groundwater discharge was not observed within the ROW at these crossings although minor seasonal discharge could be contributing to stream flow. No construction or long-term effects are anticipated at these Structures.

Structures *WM-3* (Brock Road) and *WM-4* (re-aligned Highway 7) are both bridges that carry secondary roads over 407 East (both underpasses). Both these locations are underlain by Till deposits (**Figure A1**). A sand and gravel aquifer unit is present at ~3.1 mbgs and the water table is estimated to be <5.0 mbgs (**Figure A6**). Shallow groundwater control may be required if shallow excavations intercept the saturated aquifer that is present at ~3.1 mbgs.

Structures *WM-17* (Westney Road), *WM-22* (Salem Road), *WM-25* (Balsam Road), and *WM-27* (Kinsale Road), are all underpasses or overpasses that carry a secondary road over or under 407 East (**Figure A2**). Each of these structures is underlain by low permeability Newmarket Till. No construction effects on groundwater are anticipated at these Structures.

Structure *WM-7* is an overpass over re-aligned Highway 7 (**Figure A1**). Excavations below the Newmarket Till between ~12+100 to ~12+800 have a high potential to encounter a saturated, pressurized aquifer. If this occurs, dewatering will likely be required and there is a potential to require a PTTW. If deep foundations are used in this area, they will likely encounter a highly pressurized aquifer at ~165 masl. Mitigation measures though foundation design will be required and should be assessed at detailed design.

Structure *WM-8* is an underpass at Sideline 14 Road (**Figure A1**). A thin veneer of alluvial materials is likely present at surface. Due to their limited extent, dewatering is not anticipated at this crossing. Temporary groundwater control may be required if shallow excavations intercept a saturated aquifer that is present at ~7.6 mbgs (**Figure A6).** Construction fill placement is planned for a raised alignment at this location (*HF-W3*), which has the potential to block lateral groundwater flow and potentially disrupt spring seepage along Sideline 14 Road. Mitigation measures may be required for fill placement at this location and should be assessed at detailed design.

Structure *WM-11/ WM-11A* is an overpass at Paddock Road (**Figure A1**). This area is underlain by coarse-textured glaciolacustrine materials and the groundwater table is shallow (<1.0 mbgs). Temporary construction dewatering may be required at this location to facilitate construction of bridge foundations.

8.4 Impacts From Deep Highway Cuts

Deep Cut *DC-W1* has a maximum cut depth of approximately 18 m below original ground (OG) and is located between Sideline 16 Road and Sideline 14 Road (~13+225 to 13+580, **Figure A1 and Figure A6**). Stratigraphic correlation between DM-4, WM8-1, and MOE well #4604783 suggests that excavations for DC-W1 will be confined to the Newmarket Till and potentially a layer of glaciolacustrine clayey silt and have a low potential to encounter any major regional aquifer units (**Figure A6**). Because the cut will likely be confined to low permeability materials, the anticipated maximum water table drawdown caused by the deep cut is estimated to be ~84 m (**Figure F1**). Groundwater discharge to the valley at WM-5 / WM-6 or at WM-9 / WM-10) is not anticipated to be affected. Additional borehole drilling is still required and has been recommended as a priority for detailed design at the deepest part of the cut at approximately 13+400 to confirm this analysis.

Deep Cut *DC-W2* has a maximum cut depth of approximately 12 m below original ground, and is located between Balsam Road and Kinsale Road (~18+060 to 18+300, **Figure A2 and Figure A6**). It is anticipated that this deep cut is underlain by Newmarket Till over the complete extent (**Table 11**). Excavations within the Newmarket Till are anticipated to permanently lower the groundwater table within a 52 m radius of *DC-W2* (**Figure F2**). No private wells are anticipated to be impacted. Temporary groundwater control may be required if shallow excavations intercept saturated sand lenses.

There is a deep highway cut required for the Highway 7 realignment near existing Brock Road (Figure A1). This deep cut is not mapped but will be referred to as *DC-Hwy 7*. Analysis of the preliminary highway profile for the realignment shows that *DC-Hwy 7* will be approximately 5.0 m below original ground, and is located between Sideline 16 and the realigned Brock Road (~9+355 to 9+610 – Hwy 7 realignment). There is a potential for this deep cut to encounter the shallow sand and gravel aquifer that is present below the thin layer of Newmarket Till at surface. This aquifer unit is highly permeable and may have upwards groundwater pressures in the vicinity of the cut. Borehole drilling will be required at detailed design along the length and transverse to this deep cut. There is a potential that excavations below the water table for this cut will require permanent groundwater control. One option that could be explored to convey groundwater would be to use a gravity drain system to pipe the seepage to the Brougham Creek crossing and wetland area at WM-5/ WM-6. This is a cold water stream that would benefit from additional cold groundwater inputs. Mitigation options related to conveyance of groundwater seepage should be assessed at detailed design.

9. Construction and Operational Effects – West 2 (Kinsale Road to Ashburn Road)

9.1 Aquifer and Well Vulnerability

Of the 4.9 km for the proposed Transportation Corridor right-of-way between Kinsale Road and Ashburn Road, virtually all overlies low permeability Newmarket Till aquitard deposits (**Figures A3 and A7**). These thick deposits of till act as a hydraulic barrier (aquitard) restricting groundwater flow. The potential effects to groundwater from construction and long-term operation are low due to till soils at surface restricting infiltration and protecting aquifer units below.

9.2 Artesian Conditions

There are no significant artesian conditions anticipated within this Section.

9.3 Impact From Structures

Structures *WM-30/ WM-31* (Lynde Creek tributary), *WM-33/ WM-34* (Lynde Creek), *WM-36/ WM-37* (Lynde Creek tributary) and *WM-39/ WM-40/ WM-41* (Lynde Creek tributary) are bridge crossings over water courses (**Figures A3**

and A7). Although the span lengths and the number of piers differ, they each have similar potential effects related to groundwater. Permeable alluvial materials are present at surface, but vary in extent and thickness, and the water table is generally at ground surface. Stream reconnaissance and mini-piezometer data suggests that shallow groundwater discharge, likely from the weathered till soils or thin alluvium is contributing to baseflow at *WM-33/ WM-34, WM-36/ WM-37*, and *WM-39/ WM-40/ WM-41.* It is anticipated that temporary construction dewatering will be required within the valleys of each of these crossings to facilitate construction of bridge foundations.

Structures *WM-28* (Lake Ridge Road), *WM-29* (Halls Road), *WM-32* (Coronation Road), *WM-35* (Country Lane), *WM-38* (Cochrane Street), and *WM-43* (Ashburn Road) are all underpasses or overpasses that carry a secondary road over or under 407 East (**Figures A3 and A7**). Each of these structures is underlain by low permeability Newmarket Till. No construction effects are anticipated at these structures.

Structure *WM-42* is an underpass below Winchester Road (Highway 7) near a tributary to Lynde Creek (**Figure A2**). Thin deposits of permeable alluvial materials are present at surface within the Lynde Creek tributary valley and the water table is shallow (<1.0 mbgs). Seasonal groundwater discharge is occurring in this water course that contributes to flow. It is anticipated that temporary construction dewatering will be required for any construction activities within the Lynde Creek tributary valley to facilitate construction of bridge foundations. The remainder of the area is underlain by low permeability Newmarket Till.

9.4 Impacts From Deep Highway Cuts

Deep cut *DC-W3* has a maximum cut depth of 7.0 m below original ground and is located at Kinsale Road between ~18+700 and 19+200 (**Figure A3 and A7**). It is anticipated that this deep cut is underlain by Newmarket Till over the complete extent (**Table 11**). Excavations within the Newmarket Till are anticipated to permanently lower the groundwater table within a 28 m radius of *DC-W3* (**Figure F3**). No private wells are anticipated to be impacted. Temporary groundwater control may be required if shallow excavations intercept saturated sand lenses.

Deep cut *DC-W4* has a maximum cut depth of 8.0 m below original ground and is located at Lake Ridge Road between ~19+560 and 19+700 (**Figure A3 and A7**). It is anticipated that this deep cut is underlain by Newmarket Till over the complete extent (**Table 11**). Excavations within the Newmarket Till are anticipated to permanently lower the groundwater table within a 26 m radius of *DC-W4* (**Figure F4**). No private wells are anticipated to be impacted. Temporary groundwater control may be required if shallow excavations intercept saturated sand lenses.

Deep cut *DC-W5* has a maximum cut depth of 8.0 m below original ground and is located at Coronation Road between ~20+275 and 20+700 (**Figure A3 and A7**). It is anticipated that this deep cut is underlain by Newmarket Till over the complete extent (**Table 11**). Excavations within the Newmarket Till are anticipated to permanently lower the groundwater table within a 34 m radius of *DC-W5* (**Figure F5**). No private wells are anticipated to be impacted. Temporary groundwater control may be required if shallow excavations intercept saturated sand lenses.

Deep cut *DC-W6* (has a maximum cut depth of 11.5 m below original ground and is located at Country Lane between ~21+450 and 21+590 (**Figure A3 and A7**). It is anticipated that this deep cut is underlain by Newmarket Till over the complete extent (**Table 11**). Excavations within the Newmarket Till are anticipated to permanently lower the groundwater table within a 50 m radius of *DC-W6* (**Figure F6**). No private wells are anticipated to be impacted. Temporary groundwater control may be required if shallow excavations intercept saturated sand lenses.

Deep cut *DC-W7* has a maximum cut depth of 7.5 m below original ground and is located at Cochrane Street between ~22+325 and 22+625 (**Figure A3 and A7**). It is anticipated that this deep cut is underlain by Newmarket Till over the complete extent (**Table 11**). Excavations within the Newmarket Till are anticipated to permanently lower the groundwater table within a 12 m radius of *DC-W7* (**Figure F7**). No private wells are anticipated to be impacted. Temporary groundwater control may be required if shallow excavations intercept saturated sand lenses.

10. Construction and Operational Effects – West Link

10.1 Aquifer and Well Vulnerability

Of the 10.1 km for the proposed Transportation Corridor right-of-way, 5.5 km overlies low permeability Newmarket Till or glaciolacustrine silt and clay aquitard deposits (**Figure 1 and Figures A4 and A5**). These thick deposits of low permeability material act as a hydraulic barrier (aquitard) restricting groundwater flow. The potential effects to groundwater from construction and long-term operation are low where low permeability soils are present at surface to restrict infiltration and protect aquifer units below. The remaining 3.6 km overlies coarse-textured glaciolacustrine silts and sands that are part of the Iroquois Plain Shallow Aquifer. These shallow aquifer deposits are utilized as a potable water supply and are susceptible to contamination from road runoff.

The Glacial Lake Iroquois Shoreline (nearshore beach) deposit is present along the West Durham Link between ~17+600 and 17+800 (**Figure A4**). Within the boundaries of the Transportation Corridor, this deposit is not a significant groundwater discharge feature and it is quarried for sand and gravel resources to the east of the ROW near the intersection of Coronation Road and Highway 7. Construction of the West Durham Link is not anticipated to affect the Lake Iroquois Shoreline deposits and their limited local groundwater discharge function at the crossing location.

An unconfined glaciolacustrine silt and sand aquifer unit is present east of the West Durham Link ROW between ~14+200 and 17+400 (**Figure A4**) and is an important source of potable water for local residences in Macedonian Village. This unit has a relatively high hydraulic conductivity and infiltration is rapid. Groundwater flow in this unit is downwards and eastward towards discharge areas in Lynde Creek. The water table is shallow due to poor drainage through the Newmarket Till below. Many private wells in this area are shallow and dug, and are therefore susceptible to surficial contaminants. Based on the water well survey, many homeowners have drilled deeper wells due to commonly low summer water table levels, even thought the groundwater quality of the deeper aquifer is not as good as the shallow one in terms of iron and sulphur content. Potential adverse effects from long-term road salt applications were identified within this area.

10.2 Artesian Conditions

There are no significant artesian conditions anticipated along the West Durham Link.

10.3 Impacts From Structures

SITE 43 (small crossing at ~17+300), Structure WL-21, SITE 45 (Lynde Creek tributary crossing at Taunton Road), Structure WL-17, Structure WL-6, Site 97 (Lynde Creek tributary crossing at Rossland Road), Structure WL-25/ WL-26

(Lynde Creek tributary), *Structure WL-27* (Lynde Creek tributary), *Structure WL-30* (Lynde Creek tributary), *Structure WL-32* (Lynde Creek), *and CP railway crossing (near CP crossing at ~12+750)* are all bridge crossings over water courses (**Figures A4 and A5**). With the exception of *WL-32*, there are no anticipated adverse impacts to construction or long-term operation of these structures. Stream reconnaissance data suggests that groundwater discharge is contributing minor amounts of groundwater to the Lynde Creek tributary that flow north to south along the West Link, even though most of the Lynde Creek tributaries are classified as intermittent. It is anticipated that temporary construction dewatering will be required at *WL-32* to facilitate construction of bridge foundations, although minor water taking may be required at the others.

Structure *WL-10/ WL-11* is a bridge crossing at Highway 401 over Lynde Creek and the Lynde Creek Coastal Wetland Complex (**Figure A5**). Permeable alluvial deposits and organic soils are anticipated to be present at surface and the water table will be shallow (<1.0 mbgs). Although not directly measured, slow groundwater discharge is expected at this location. It is anticipated that temporary dewatering will be required at this crossing to facilitate construction of bridge foundations. Construction fill placement should be minimized in this wetland to maintain its groundwater function.

Structures WL-1 (West Lynde Creek tributary), *Structure WL-14* (West Lynde Creek), *Structure WL-18* (West Lynde Creek tributary), *SITE 49 (Lynde Creek tributary at Dundas Street), and SITE 99A (West Lynde Creek tributary at Lake Ridge Road)* are all culverts across water courses (**Figures A4 and A5**). Each of these water courses is intermittent and perched on low permeability till deposits. Little to no groundwater discharge was observed within the ROW at these crossings although minor seasonal discharge could be contributing to stream flow. No construction or long-term effects are anticipated at these Structures.

Structures WL-2 (Interchange Ramp), *WL-3* (Interchange Ramp), *WL-4* (Interchange Ramp), *WL-5* (Interchange Ramp), *WL-7* (Interchange Ramp), *WL-8* (Interchange Ramp), *WL-9* (Interchange Ramp), *WL-12* (Dundas Street), *WL-15* (Structure Cancelled), *WL-16* (Rossland Road), *WL-20* (Taunton Road), *WL-23* (Highway 7), *WL-28/ WL-29* (Interchange Ramp), *WL-31* (Interchange Ramp), *and WL-33* (Interchange Ramp), are all underpasses or overpasses or interchange ramps that carry a secondary road or an interchange over or under 407 East or the West Durham Link (**Figures A4 and A5**). Each of these structures except *WL-20* is underlain by low permeability Newmarket Till or fine-textured glaciolacustrine silt and clay. No construction effects are anticipated at these Structures. *WL-20* at Taunton Road is underlain by coarse-textured glaciolacustrine silt and sand and that water table is anticipated to be perched on till soils below. Temporary construction dewatering may be required at this location if excavations are conducted below the water table.

Structure *WL-19/ WL19A* is a subway that passes the West Durham Link under the CPR Railway (**Figure A4**). This area is underlain by a glaciolacustrine silty to clayey aquitard that grades to sandy silt towards the contact with the Newmarket Till below (**Figure A8**). The results of the air photo interpretation show that fill placement for the current CPR railway bridge has impeded shallow, southwards groundwater flow. This is recognized by mottled textured[6] soils on the north side and clean textured soils on the south side. Fill placement for the reconstructed CPR subway at WL-19/ WL-19A should be designed with a permeable sub-base to convey shallow, southwards groundwater flow.

6. *Mottled texture refers to soils with a blocky pattern of light and dark spots that indicates a high water table in poorly drained materials.*

10.4 Impacts From Deep Highway Cuts

Deep Cut *DC-W8* has a maximum cut depth of approximately 6.5 m below original ground and is located north of Rossland Road at the CPR crossing (~12+400 to 12+890, **Figures A4 and A8**). This area is underlain by fine-textured glaciolacustrine silty clay to a depth of ~3.0 mbgs and grades to sandy silt at the contact with the Newmarket Till below. There is a potential for continuous side-wall seepage at the contact between the Newmarket Till and the fine-textured glaciolacustrine materials. Permanent groundwater control may be required to maintain slope stability and to convey seepage. Flow rates are estimated to be very low (0.3 – 3.0 L/s) and can be drained into the surface water drainage system for the transportation corridor. Changes to the groundwater table due to excavations within the Newmarket Till and seepage along the cut slope are anticipated to permanently lower the groundwater table within a 26 m radius of *DC-W8* (**Figure F8**). No private wells are anticipated to be impacted. Shallow groundwater control may be required if excavations intercept a saturated aquifer and/ or to install a drainage system to convey side wall seepage.

The possibility of continual groundwater seepage at *DC-W8* presents a compensation opportunity that could add additional cold groundwater to West Lynde Creek. It is recommended that the possibility of piping the cold groundwater collected from the sidewall seepage underground to be discharged into Lynde Creek to the east, be explored during detailed design. This would add additional cold groundwater baseflow to the creek. Although West Lynde Creek is intermittent and is not considered a significant groundwater discharge area, the potential to add cold groundwater should at least be explored.

11. Opportunities for Mitigation

11.1 West 1 (Brock Road to Kinsale Road)

The majority of potential changes to the groundwater flow regime are a result of temporary construction dewatering. Mitigation measures are designed to minimize dewatering rates, to ensure that groundwater discharge will not be disrupted during critical environmental periods (i.e., cold water fish spawning), and to discharge extracted water into the receptor water course following temperature and clarity controls to maintain baseflow. Although impacts may occur, the temporary nature of the impact means that there are no residual effects anticipated. Construction of the following Structures will likely require dewatering and have a high potential to require a PTTW: *WM-A* (Urfe Creek), *WM-1/ WM-2* (Brougham Creek), *WM-5/ WM-6* (Brougham Creek), *WM-9/ WM-10* (Spring Creek), *WM-11/ WM-11A* (Paddock Road), *WM-12/ WM-13* (East Duffins Creek), *WM-18/ WM-19* (Carruthers Creek), and *WM-20/ WM-21 (Carruthers Creek).*

WM-5/ WM-6 (Brougham Creek) is fed by groundwater discharge from an ice contact margin sand and gravel aquifer unit within the Newmarket Till that has been exposed by valley incision. Excavations within the valley will require dewatering and potentially a PTTW. Artesian groundwater pressures were encountered at borehole DM-5 to the west of the valley, confined below a thin (~2.2 m,) layer of sandy silt till (Newmarket Till). Even shallow excavations between ~12+100 to ~12+800 may required groundwater control and may encounter groundwater pressure from below. The placement of 15 m of fill at HF-W2 within the valley, will likely block groundwater discharge and may create slope stability problems with the embankment. The use of a permeable sub-base is recommended for fill placement within the valley to maintain current groundwater flow conditions and to convey groundwater seepage. The use of drains below the fill should be explored as an additional mitigation option to direct groundwater discharge to a specific location within the valley. Deep foundations are recommended at this crossing to minimize dewatering, although the effects of artesian pressure originating at ~165 masl will need to be accounted for in the foundation design.

Deep Cut DC-W1 is estimated to permanently lower the groundwater table within a ~84 m radius of the cut (**Figure E1**). Excavations for this cut are anticipated to be within low permeability till units and should not encounter the aquifer unit that is present below the base of the cut (**Figure A6)**. No wells are anticipated to be affected because wells in the area draw water from the aquifer unit that has been avoided. Groundwater discharge to local creeks or springs is also not anticipated to be affected. The need for construction dewatering is not anticipated, unless a saturated sand lens is encountered within the till unit.

Deep Cut *DC-W2* is estimated to permanently lower the groundwater table within about a 52 m radius of the cut (**Figure F2**). The need for construction dewatering is not anticipated, unless a saturated sand lens is encountered within the till unit.

Deep Cut DC-Hwy 7 has a potential to cut into a saturated and pressurized aquifer unit between ~9+355 to 9+610 (Hwy 7 realignment). Permanent groundwater control may be required to convey groundwater flow and should be assessed at detailed design. One option of conveyance of groundwater would be to use a gravity drain system to pipe the seepage to the Brougham Creek crossing at WM-5/ WM-6. This is a cold water stream that would likely benefit from additional cold groundwater inputs. Mitigation options related to conveyance of groundwater seepage should be assessed at detailed design.

To minimize reductions in groundwater quality, the MTO Road Salt Management Plan should be followed over the entire section. Between ~13+700 and 14+600, runoff must be collected in the stormwater management system and consideration should be given to drainage alternatives including liners and drainage separation to minimize infiltration to the groundwater table. If long-term impacts do occur, homeowners could be compensated by providing a temporary or permanent alternative water supply.

11.2 West 2 (Kinsale Road to Ashburn Road)

The majority of potential changes to the groundwater flow regime are a result of temporary construction dewatering. Mitigation measures are designed to minimize dewatering rates, to ensure that groundwater discharge will not be disrupted during critical environmental periods (i.e., cold water fish spawning), and to discharge extracted water into the receptor water course following temperature and clarity controls to maintain baseflow. Although impacts may occur, the temporary nature of the impact means that there are no residual effects anticipated. Construction of the following Structures will likely require dewatering and may require a PTTW: Structures *WM-33/ WM-34* (Lynde Creek), *WM-36/ WM-37* (Lynde Creek tributary) and *WM-39/ WM-40/ WM-41* (Lynde Creek tributary).

Deep Cuts *DC-W3, DC-W4, DC-W5*, and *DC-W6* are estimated to permanently lower the groundwater table within a <50 m radius (**Figures F3, F4, F5 and F6**). The need for construction dewatering is not anticipated, unless a saturated sand lens is encountered within the till unit.

Deep Cut *DC-W7* is not anticipated to lower the groundwater table near the cut (**Figure F7**), unless a saturated sand lens is encountered. If the sand lens is saturated, the radius of drawdown will be confined to the small aquifer unit and will likely only propagate a small distance. The need for construction dewatering is otherwise not anticipated.

Given the low permeability till soils in this section, effects on groundwater quality are not anticipated, but the MTO Road Salt Management Plan should still be followed over the entire section. In most cases, runoff should be collected in SWM Ponds that provide both quality and quantity controls. If long-term impacts do occur, homeowners could be compensated by providing a temporary or permanent alternative water supply.

There is a small sand and gravel pit located south of WM-28 on the west side of Lakeridge Road within the Transportation Corridor (**Figure A3**). Any SWM ponds located near this location may need to be lined prevent infiltration, should the presence of permeable soils at surface be confirmed during detailed design.

11.3 West Link

Like with the other sections, the majority of the anticipated changes to the groundwater flow regime are a result of temporary construction dewatering. Mitigation measures are designed to minimize dewatering rates, to ensure that groundwater discharge will not be disrupted during critical environmental periods (i.e., cold water fish spawning), and to discharge extracted water into the receptor water course following temperature and clarity controls to maintain baseflow. Although impacts may occur, the temporary nature of the impact means that there are not residual effects associated with it. Construction of the following Structures will likely require dewatering and may require a PTTW: *WL-10/WL-11* (Lynde Creek) and *WL-32* (Lynde Creek).

Deep Cut *DC-W8* is estimated to permanently lower the groundwater table within a 26 m radius of the cut (**Figure F8**). Although permanent side wall seepage is anticipated from the contact between the glaciolacustrine materials and the till, this will have a negligible effect to the natural environment beyond what *DC-W8* will already create, due to the very low seepage rates anticipated. The increase to the radius of water table drawdown will be minimal and the changes to the local groundwater flow regime negligible. Deep Cut DC-W8 has a potential to require a PTTW for dewatering during excavation and for construction of the lateral groundwater collector drains.

To minimize reductions in groundwater quality, the MTO Road Salt Management Plan should be followed over the entire section. Between ~12+100 and 17+800, runoff must be collected in the stormwater management system and consideration should be given to drainage design alternatives including liners and drainage separation to minimize infiltration to the groundwater table. If long-term impacts do occur, homeowners could be compensated by providing a temporary or permanent alternative water supply.

12. Well Monitoring Program

Due to the need for construction below the water table at a number of structures and deep highway cuts and the potential slow recovery time for the local water table to reach a new equilibrium, it is recognized that construction activities could have an adverse effect on nearby wells from both a water quality and interference (quantity) perspective. It is also recognized that potential impacts to groundwater quality could result from both spills during construction and long-term operation. The release of deleterious materials into the environment due to spills during construction is largely limited to petroleum products from machinery (fuels and lubricants). In the longer term, effects to groundwater quality are typically associated with spills associated with accidents and the use of de-icing salts. The risk from spills and accidents is low because of the MTO spills response protocols that will be in place. It is recognized that road salt will dissolve in highway runoff and can infiltrate into the underlying groundwater system from roadside ditches. As a result, down-gradient shallow residential wells and/ or groundwater discharge into surface water bodies have the potential to be affected.

The collection of baseline domestic water well information during the water well survey conducted in 2008 (see **Report A – Table C7**) has provided a database of all private water wells within the 407 East water well survey study area and a snap-shot of the water quality in a representative group of wells. Nineteen water quality samples were collected from wells both up gradient and down gradient of the Transportation Corridor and from shallow and deep aquifer units. This inventory and sampling provides the first data set required to develop a domestic well monitoring program. This monitoring program will need to be developed during subsequent design phases once site specific investigations have been conducted and construction methods and details are established. The details of this monitoring program will need to address future works and other approvals (e.g., PTTW).

Monitoring at each of the domestic wells selected is subject to permission from the homeowners. The Contract Administrator will retain a Qualified Groundwater Engineer or Hydrogeologist to carry out the monitoring program which shall consist of:

Groundwater level monitoring with the following frequency:

Pre-Construction: .... at least once within one month prior to construction, depending upon site specific hydrogeologic conditions

During Construction:.... minimum weekly depending upon the length of the construction period, site specific hydrogeologic conditions and whether impacts are detected

Post-Construction: .... at least once within one month after construction is complete, depending upon site specific hydrogeologic conditions. If dewatering is not required for the full duration of construction activities and no impacts were detected to the groundwater levels after the one month of post-dewatering monitoring, monitoring can be considered complete.

Groundwater quality monitoring with the following frequency:

Pre-Construction: .... once within one week before construction begins

During Construction:.... once during the construction period, unless impacts are detected at which time additional investigations will be carried out by a Qualified Person(s)

Post-Construction: .... once after construction is complete, unless impacts are detected at which time additional investigations will be carried out by a Qualified Person(s). If dewatering is not required for the full duration of construction activities and no impacts were detected from the sample collected during the post-dewatering period, monitoring can be considered complete.

The wells should be sampled and the samples analyzed for a suite of parameters that includes general inorganic water quality, metals, bacterial water quality and petroleum hydrocarbons in the F1 to F4 range (including BTEX parameters). This is consistent with the background water quality collected as part of the Environmental Assessment.

Site specific geological conditions and individual well locations will need to be taken into consideration when designing the monitoring program. Modifications can be made to frequency of monitoring depending upon the length of the construction period, the site specific geological conditions (i.e., till soils or sandy soils), anticipated well vulnerability (i.e., shallow wells vs. deep wells), and whether or not impacts are detected.

13. Priorities for Detailed Design

Additional investigations will be required during detailed design to confirm the results of this preliminary hydrogeological analysis. Site-specific stratigraphic and groundwater level information is a priority at all structure locations, deep highway cuts and high fills. Collection of the following information is a priority to fully evaluate the hydrogeological impacts of construction of Highway 407 East.

a) Determination of the potential dewatering requirements and the potential need for a PTTW at the following structures: *WM-A* (Urfe Creek), *WM-1/ WM-2* (Brougham Creek), *WM-5/ WM-6* (Brougham Creek), *WM-9/ WM-10* (Spring Creek), *WM-11/ WM-11A* (Paddock Road), *WM-12/ WM-13* (East Duffins Creek), *WM-18/ WM-19* (Carruthers Creek), *WM-20/ WM-21 (Carruthers Creek),* Structures *WM-33/ WM-34* (Lynde Creek), *WM-36/ WM-37* (Lynde Creek tributary), *WM-39/ WM-40/ WM-41* (Lynde Creek tributary), *WL-10/WL-11* (Lynde Creek) and *WL-32* (Lynde Creek).

b) Collection of geological and hydrogeological information along the length of and transverse to each deep cut location to confirm geological and hydrogeological interpretations and estimations of the extent of local drawdown. Hydraulic testing may also be required.

c) Where permeable sediments are present at surface and are being used for potable water supply, consider various drainage alignment alternatives, liners or runoff separation to further minimize infiltration to the water table to help minimize impacts to groundwater. The specific areas in the West Section are: between ~13+700 and 14+600 and between ~12+100 and 17+800 (West Link)

d) The extent of the confined aquifer and artesian pressure needs to be delineated between ~12+100 to ~12+800 so that deep foundations do not unexpectedly encounter a highly pressurized aquifer.

e) Once dewatering requirements have been confirmed, the well monitoring program will need to be revised to include specific wells particularly in sensitive areas. The most sensitive areas are: between ~13+700 and 14+600 and between ~12+100 and 17+800 (West Link).

f) Assess the need for additional mitigation strategies to convey groundwater discharge and seepage under fill placement in the wetland area near WM-5/ WM-6. These strategies could include but not limited to groundwater collection drains and permeable sub-base materials.

g) Assess the need for permanent groundwater control at DC-Hwy 7, as there is a potential that this cut may encounter a confined sand and gravel aquifer unit. Collected groundwater can likely be discharged into Brougham Creek following proper sediment and temperature mitigation.

14. Acknowledgements

AECOM would like to thank Golder Associates for their contribution to the hydrogeological investigations. The geotechnical borehole logs provided by Golder aided AECOM in providing analysis of the geological / hydrogeological conditions at each structure. Without these logs, the level of detail provided in this report would not have been possible.

Figures – Part B

Map Document: (N:\projects\2005\50613\2009\Final\GISSpatial\MXDs\ReportMXDs\Hydrogeology\Foundations_april\50613RegionalGeology-24x36.mxd)
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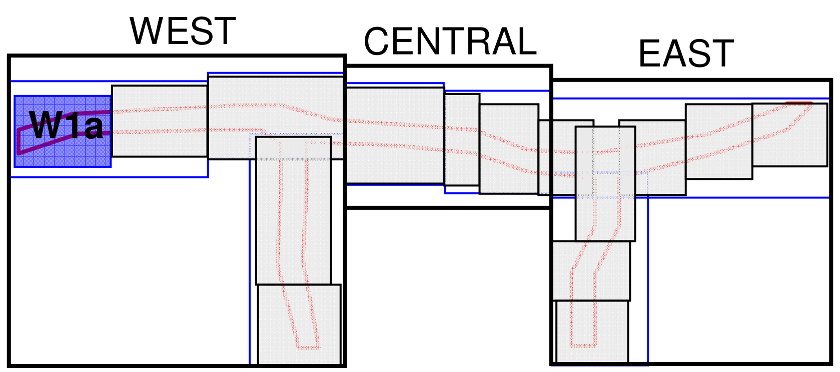
Tables – Part B

AECOM

407 East Extension – West Section

Summary Table 1 – Potential Impacts and Mitigation Summary (W1a)

Key Map



Map: West 1 – W1a

Section Boundaries: Brock Road to Westney Road

Figure(s): Figure A1 (Section W1a)

Cross-section(s): West 1: A – A' (Figure A6)

Assumed Proposed Structures: West Mainline – WM-A, WM-1, WM-2, WM-3, WM-4, WM-5, WM-6, WM-7, WM-8, WM-9, WM-10, WM-11, WM-11A, WM-12, WM-13

Assumed Deep Cuts: DC-W1 (13+225 to 13+580) – 18 m cut depth (drawdown curve – Figure F1)
DC-Hwy 7 (along Highway 7 realignment) – 5.0 m cut depth (not mapped)

Assumed High Fills: HF-W1/2 (11+725 to 11+975) – 5.5 m fill height
HF-W3 (12+475 to 12+930) – 17 m fill height
HF-W4 (13+625 to 13+900) – 10 m fill height
HF-W5 (14+400 to 14+975) – 14.5 m fill height

Hydrogeology Site Ranking Table: Table 6 (Section W1a)

FIELD DATA SOURCES:

Boreholes: P4, P5, P6, P7, WMa-1, WMa-2, WM1-1, WM3-1, WM3-2, WM5-1, WM8-1, WM11-1, WM11-2, WM11a-1, WM12-1

Monitoring Wells: G1W-1, G1W-2

Mini-Piezometers: MP1, MP2, MP3s/d, MP38

Stream Reconnaissance Sites: SR1a,b, SR2a,b, SR3a,b, SR4a,b, SR5a,b,c

Residential Water Wells: 47 private water wells. 34% dug, 15% drilled, 50% unknown, 1% community (drilled). Approximately 4 wells within the TPR boundary (May require decommissioning)

PHYSIOGRAPHIC SETTING:

- The northern and western portions of the greater study area consist of a level to rolling till plain, with numerous drumlins oriented up slope (north), typical of the South Slope physiographic region (Chapman and Putman, 1984). Meltwater streams have cut sharp valleys in the till (e.g., Duffins Creek) and deposited coarse-textured glaciofluvial sediments along their path. Modern alluvial silts, sands and gravels can be found in these valleys.
- The Iroquois Plain physiographic region is found south of Highway 7 and is characterized by flat lying deposits of coarse sand and gravel that are present along the shoreline bluff of Glacial Lake Iroquois. Glaciolacustrine sediments of sand, silt and clay overlie till to depths of 20m (Barnett, 1996).

Notes:
mBGS – metres below ground surface
GWT – groundwater table
ORM – Oak Ridges Moraine
PTTW – Permit To Take Water

POTENTIAL IMPACTS:

Groundwater Effects on Foundation Design and Construction:

- Thick deposits of silty sand, and sand and gravel are present at or near the surface in this Section
  - Between ~12+100 to 13+000 – thin deposits of Newmarket Till at surface overlie a sand and gravel aquifer that may exhibit artesian groundwater pressures
  - Between ~13+600 and 14+400 – a thick glaciolacustrine silty sand aquifer is present at surface
  - Temporary groundwater control is anticipated if excavating below the water table in the above listed areas. Further assessment is needed during Detailed Design
  - Where practical, consideration should be given to minimizing excavations below the water table
- Shallow GWT (<1.0 mBGS) within till units because the unit is poorly drained or because groundwater upwards pressures keep shallow sediments saturated. Flow into excavations is anticipated to be minimal
- Significant flowing artesian conditions are expected at two locations within this Section. Additional investigations are required at detailed design
  - At ~30 mBGS (~120 masl) between ~13+600 and 14+750 near East Duffins Creek valley (deep confined aquifer)
  - At ~15 - 30 mBGS (155 - 170 masl) between ~12+800 and 13+000 near WM-5/ WM-6 and north of the ROW and the irrigation pond (Thorncliffe Aquifer)
  - At ~3.0 mBGS (170 – 180 masl) between ~12+000 to ~12+800 west of WM-5 / WM-6 (glacial ice contact margin sand and gravel aquifer)
- Significant groundwater discharge and side slope seepage was observed at Structures WM-5/6 and WM-8
  - Fill placement in these areas has the potential to disrupt groundwater flow, groundwater discharge and spring seepage and should be assessed at detailed design
- Anticipate encountering discontinuous sand lenses below the groundwater table within till units. Will drain in the short term
- Structures WM-1, WM-2, WM-3, WM-4, WM-7, WM-8 – Temporary groundwater control is anticipated
- Structures WM-A, WM-5, WM-6, WM-9, WM-10, WM-11, WM-12, WM-13 – Temporary groundwater control is anticipated for excavations in permeable sediments. A PTTW may be required. Further assessment is needed during Detailed Design
- Deep Cut DC-W1 (18 m deep cut) – additional site investigations are required during Detailed Design to confirm hydrogeological conditions and impacts
  - Low potential to encounter a confined aquifer unit in excavation. Borehole drilling suggests that the aquifer unit is present ~5 – 15 m below the base of the cut
  - Groundwater water table anticipated at ~4.0 mBGS due to poor drainage through the till
- Deep Cut DC-Hwy 7 (5.0 m deep cut) – additional site investigations are required during Detailed Design to determine hydrogeological conditions, impacts and mitigation strategies
  - Potential to encounter a pressurized sand and gravel aquifer

Surface Water Features:

- A wetland area and an irrigation pond are present near the TPR at WM-5 / WM-6
  - Temporary dewatering may reduce groundwater inputs to these features over the dewatering period. Fill placement may block known groundwater seeps. Will require further assessment at detailed design
- Dewatering for bridge abutments in the valleys near Spring Creek (WM-9, WM-10) and East Duffins Creek (WM-11, WM-12, WM-13) may reduce groundwater discharge into the creeks over the dewatering period
  - A PTTW and a site specific investigation may be required for these locations
- Groundwater seepage was observed along Sideline 14 Rd south of the TPR and may be related to a confined aquifer
- Ecoplans reports the presence of Redside Dace, which rely on continuous groundwater discharge within creeks at structures WM-9, WM-10, WM-12, and WM-13

Aquifer/Well Vulnerability:

- A local ice contact margin sand and gravel aquifer was identified between ~12+000 to 12+800
  - Significant dewatering and/ or impacts to private wells may occur if unit is encountered in excavation
- Glacial Lake Iroquois Shoreline sediments are found south of the TPR in this section (12+600 to 15+000).
  - This shallow aquifer unit is downgradient of the highway and is highly sensitive to surficial contamination due to high permeability
- Deep Cut DC-W1(18 m deep cut) – Excavations estimated to be 14.0 m below the water table
  - Preliminary geologic interpretations of the area (figure A6) suggest that this deep cut will be above any significant aquifer units
  - Radius of water table drawdown is conservatively estimated to be ~84 m in till (figure F1)
  - Low potential to impact wells/ aquifers unless continuous sand lenses are encountered
- West Mainline (W1a) – Highway constructed primarily on or near high permeability aquifer deposits
  - Between ~13+600 and 14+750 and ~12+000 to 12+800 - potential for impacts to groundwater quality from de-icing compounds and mitigative measures should be assessed during Detailed Design
  - No reduction in groundwater recharge is anticipated due to the linear nature and small surface area of the highway

OPPORTUNITIES FOR MITIGATION:

- Structures WM-A, WM-5, WM-6, WM-9, WM-10, WM-11, WM-12, WM-13 – dewatering may be required for construction of bridge footings. A PTTW may be required. Further assessment is needed during Detailed Design
  - Where practical, deep foundations are recommended to minimize dewatering (high permeability units at surface in this Section)
  - Time the dewatering period to avoid fish spawning seasons
  - Discharge water into receptor stream following temperature and clarity controls to maintain baseflow
  - Monitor stream flow and groundwater discharge into adjacent wetlands
- Deep Cut DC-W1 – Estimated permanent lowering of water table within ~84 m of the cut
  - Not anticipated to impact private water wells or the natural environment
  - Due to the large depth of the cut and the unconfirmed geological conditions, at this time it may be necessary to establish GW monitoring program to monitor quality and quantity prior to, during and following construction
  - Compensation for impacts may be considered in the form of alternative water supplies on a case-by-case basis
- Irrigation pond has been avoided by a change in the route alignment.
- West Mainline (West 1 – W1a) – Potential for reduction in groundwater quality from road run-off
- Between 13+600 and 14+750 and ~12+000 to 12+800 – potential for impacts to groundwater quality from de-icing compounds. Consideration should be given to mitigation measures during detailed design such as drainage design alternatives including liners and drainage separation to minimize infiltration to the water table
- Compensation for impacts by may be considered in the form of alternative water supplies on a case-by-case basis

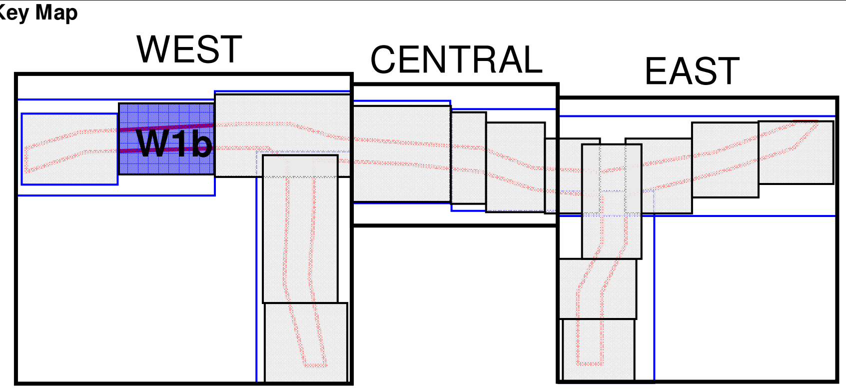
PRIORITIES FOR DETAILED DESIGN:

- A PTTW may be required for setting bridge foundations at WM-A,WM-5, WM-6,WM-9,WM-10,WM-11,WM-12,WM-13 and the need for a PTTW should be assessed during Detailed Design
- To determine potential dewatering requirements, confirm depth of excavation for bridge abutments in East Duffins Creek valley (Structures WM12/13). Hydraulic testing may be required to establish potential impacts
- Collection of geological and hydrogeological information along the length of and transverse to DC-W1 to confirm preliminary geological condition and estimation of the extent of local drawdown will be required during Detailed Design. Hydraulic testing may be required to confirm impacts
- The extent of the confined aquifer and artesian pressure needs to be delineated between ~12+100 to ~12+800 so that deep foundations do not unexpectedly encounter a highly pressurized aquifer
- Assess the need for additional mitigation strategies to convey groundwater discharge and seepage under fill placement in the wetland area near WM-5/ WM-6. These strategies could include but not limited to groundwater collection drains and permeable sub-base materials.
- Assess the need for permanent groundwater control at DC-Hwy 7, as there is a potential that this cut may encounter a confined sand and gravel aquifer unit. Collected groundwater can likely be discharged into Brougham Creek following proper sediment and temperature mitigation.

407 East Extension – West Section

Summary Table 2 – Potential Impacts and Mitigation Summary (W1b)

Key Map



Map: West 1 – W1b

Section Boundaries: Westney Road to Kinsale Road

Figure(s): Figure A2

Cross-section(s): West 1: A – A' (Figure A6)

Assumed Proposed Structures: Western Mainline – WM-14, WM-15, WM-16, WM-17, WM-18, WM-19, WM-20, WM-21, WM-22, WM-23, WM-24, WM-25, WM-26, WM-27

Assumed Deep Cuts: DC-W2 (18+060 to 18+300) – 12 m cut depth (drawdown curve – Figure F2)

Assumed High Fills: HF-W6 (16+150 to 16+275) – 6.5 m fill height
HF-W7/ WM8 (16+525 to 17+625) – 6.5 m fill height
HF-W9 (18+450 to 18+550) – 5.5 m fill height

Hydrogeology Site Ranking Table: Table 7 (Section W1b)

FIELD DATA SOURCES:

Boreholes: P8, P9, WM17-1, WM17-2, WM22-1, WM25-1, WM27-1, WM27-2

Monitoring Wells: None

Mini-Piezometers: MP4, MP5

Stream Reconnaissance Sites: SR6a,b,c, SR7, SR8a,b,c, SR9a,b, SR10a,b

Residential Water Wells: 20 private water wells. 15% dug, 60% drilled, 25% unknown. Approximately 6 wells within the TPR boundary (may require decommissioning)

PHYSIOGRAPHIC SETTING:

- The eastern and western portions of the greater study area consist of a level to rolling till plain, with numerous drumlins oriented up slope (north), typical of the South Slope physiographic region (Chapman and Putman, 1984). Meltwater streams have cut sharp valleys in the till and deposited coarse-textured glaciofluvial sediments along their path. Modern alluvial silts, sands and gravels can be found in these valleys.
- This map sheet lies in the till plain, except the central area, which hosts overlying lacustrine deposits.

Notes:
mBGS – metres below ground surface
GWT – groundwater table
ORM – Oak Ridges Moraine
PTTW – Permit To Take Water

POTENTIAL IMPACTS:

- **Groundwater Effects on Foundation Design and Construction:**
- Thick deposits of silty sand till (Newmarket Till) are most often present at or near surface in this Section
- Shallow groundwater control may be required at Structures WM-18, WM-19, WM-20, WM-21, WM-23, and WM-27. Further assessment is needed during Detailed Design
- Soft silty clay soils present at surface between 16+125 and 16+525. Further assessment may be needed during Detailed Design
- Shallow GWT (<1.0 mBGS) within till units because the unit is poorly drained. Flow into excavations anticipated to be minimal
- Significant flowing artesian conditions are not expected
- Anticipate encountering discontinuous sand lenses below the groundwater table within till units. Will drain in the short term
- Deep Cut DC-W2 (12 m cut depth) may encounter the groundwater table at ~2.2 mBGS. Isolated sand lenses in till are anticipated and should drain in the short term. Low potential for dewatering

Surface Water Features:
- Groundwater discharge within tributaries of Carruthers Creek is inferred from the observation of water cress near structures WM-18, WM-19, WM-20, and WM-21
- Potential groundwater springs at the contact between the glaciolacustrine silt and clay and the Newmarket Till south of the TPR
- Ecoplans reports the presence of Redside Dace within creeks at structures WM-18, WM-19, WM-20, and WM-21, which indicates thermal buffering by groundwater. Temperature records at SR6a,b,c indicate both groundwater and surface water inputs between upstream and downstream stream monitoring locations.

Aquifer/Well Vulnerability:
- ORM aquifer units are not likely present in this Section
- No significant aquifer units were encountered by drilling activities to date, although no boreholes were drilled at the deep cut location. Further assessment is needed during Detailed Design
- Deep Cut DC-W2 (12 m cut depth) – Excavations estimated to be 9.8 m below the water table
  - Radius of water table drawdown is conservatively estimated to be ~52 m in till (figure F2)
  - Low potential to impact wells/ aquifers unless continuous sand lenses are encountered
- West Mainline (W1b) – Highway constructed primarily on low permeability till and glaciolacustrine deposits
  - Low potential for impact to groundwater quality from de-icing compounds
  - No reduction in groundwater recharge due to the linear nature and small surface area of the highway

OPPORTUNITIES FOR MITIGATION

- Deep Cut DC-W2 – Estimated permanent lowering of water table within ~52 of the cut
  - No mitigation anticipated
- West Mainline (West 1 – W1b) – Low potential for reduction in groundwater quality from road run-off
  - Low potential for long-term impact to groundwater quality from de-icing compounds
  - Most SWM ponds will not require lining because low permeability materials present at surface
- No reduction in groundwater recharge due to the small surface area of the highway

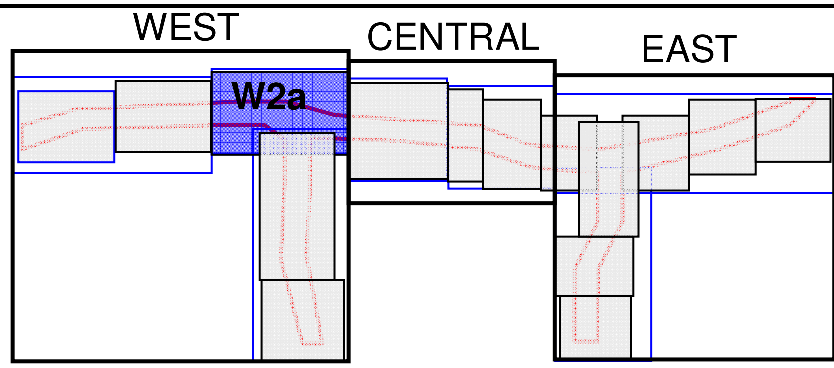
PRIORITIES FOR DETAILED DESIGN:

- Collection of geological and hydrogeological information along the length of and transverse to deep cut location DC-W2 to confirm the presence of till to depth and estimation of the extent of local drawdown will be required during Detailed Design. Hydraulic testing may be required to establish potential impacts
- Collection of geologic and hydrogeologic information at structures WM-18, WM-19, WM-20 and WM-21 will be required during Detailed Design to confirm the absence of high permeability units near surface (as suggested by the surface water features)

407 East Extension – West Section

Summary Table 3 – Potential Impacts and Mitigation Summary (W2a)

Key Map



Map: West 2 – W2a

Section Boundaries: Kinsale Road to Ashburn Road

Figure(s): Figure A3

Cross-section(s): West 2: B – B' (Figure A7)

Assumed Proposed Structures: West Mainline – WM-28, WM29, WM-30, WM-31, WM-32, WM-33, WM-34, WM-35, WM-36, WM-37, WM-38, WM-39, WM-40, WM-41, WM-42, WM-43, WL-25, WL-26, WL-27, WL-28, WL-29, WL-30, WL-31, WL-32, WL-33

Assumed Deep Cuts: DC-W4 (19+560 to 19+700) – 8.0 m cut depth (drawdown curve – Figure F4)
DC-W5 (20+275 to 20+700) – 8.0 m cut depth (drawdown curve – Figure F5)
DC-W6 (21+450 to 21+590) – 11.5 m cut depth (drawdown curve – Figure F6)
DC-W7 (22+325 to 22+625) – 7.5 m cut depth (drawdown curve – Figure F7)

Assumed High Fills: HF-W10 (20+885 to 21+225) – 11.5 m fill height
HF-W11 (21+675 to 22+075) – 7.0 m fill height
HF-W12 (22+930 to 23+000) – 6.5 m fill height

Hydrogeology Site Ranking Table: Table 8 (Section W2a)

FIELD DATA SOURCES:

Boreholes: BH8, P10, P11, P12, WM28-1, WM29-1, WM29-2, WM35-1, WM35-2, WM36-1, WM37-1, WM38-1, WM38-2, WM39-1, WM40-1, WM41-1, WM41-2, WM43-1, WM43-2, WL26-1, WL26-2, WL27-1, WL27-2, WL28-1, WL28-2, WL31-1

Monitoring Wells: G2W-1, G2W-2

Mini-Piezometers: MP13, MP14

Stream Reconnaissance Sites: SR12a,b,c, SR14a,b, SR15a,b, SR16a,b

Residential Water Wells: 46 private water wells. 33% dug, 20% drilled, 47% unknown. Approximately 9 wells within the TPR boundary (may require decommissioning)

PHYSIOGRAPHIC SETTING:

- Level to rolling till plain, with numerous drumlins oriented up slope (north), typical of the South Slope physiographic region (Chapman and Putman, 1984). Most of W2a lies in this setting. Meltwater streams have cut sharp valleys in the till (e.g., Lynde Creek) and deposited coarse-textured glaciofluvial sediments along their path. Modern alluvial silts, sands and gravels can be found in these valleys
- The Iroquois Plain physiographic region is found south of Highway 7 and is characterized by flat lying deposits of coarse sand and gravel that are present along the shoreline bluff of Glacial Lake Iroquois. Glaciolacustrine sediments of sand, silt and clay overlie till to depths of 20 m (Barnett, 1996). GWT is often shallow due to poor drainage below

Notes:
mBGS – metres below ground surface
GWT – groundwater table
ORM – Oak Ridges Moraine
PTTW – Permit To Take Water

POTENTIAL IMPACTS:

Groundwater Effects on Foundation Design and Construction:

- Thick deposits of silty sand till are present at surface in this Section
  - Dewatering is not anticipated at majority of structures
  - Structures WM-28, WM-39, WM-40, WM-41, and WM-42 may require dewatering if excavating in river valley. A PTTW may be required. Further assessment is needed during Detailed Design
- Shallow GWT (<1 mBGS) within till units because the unit is poorly drained. Flow into excavations will likely be minimal
- Flowing artesian conditions are not expected
- Anticipate encountering discontinuous sand lenses below the groundwater table within till units. Will drain in the short term
- Deep Cut DC-W4 (8.0 m cut depth) may encounter the groundwater table at ~3.4 mBGS. Low potential for dewatering
- Deep Cut DC-W5 (8.0 m cut depth) may encounter the groundwater table at <2.0 mBGS. Low potential for dewatering
- Deep Cut DC-W6 (11.5 m cut depth) may encounter the groundwater table at <2.0 mBGS. Low potential for dewatering
- Deep Cut DC-W7 (7.5 m deep cut) may encounter the groundwater table at <5.0 mBGS. Isolated sand lenses are present in the upper 5.0 m. Lenses should drain in the short term. Low potential for dewatering

Surface Water Features:

- If dewatering for bridge abutments is required in the Lynde Creek tributary (WM-39, WM-40, WM-41) it is anticipated that groundwater discharge will be reduced into the creek over the dewatering period
- Ecoplans reports the presence of Brook Trout south of Highway 7 between Coronation Road and Cochrane Street. Groundwater discharge in these areas is unlikely to be affected if construction is restricted to the TPR boundaries and on-site erosion control measures are implemented
- Ecoplans reports the presence of Redside Dace within creeks at structures WM-36, WM-37, WM-39, and WM-40, and WM-41. Dewatering activities will need to be timed to not interfere with cold water discharge during spawning

Aquifer/Well Vulnerability:

- ORM aquifer units are not likely present in this Section
- No significant aquifer units were encountered by drilling activities in this section
- Deep Cut DC-W4 (8.0 m cut depth) – Excavations estimated to be 4.6 m below the water table
  - Radius of water table drawdown is conservatively estimated to be ~26 m (figure F4)
  - Low potential to impact wells/ aquifers unless continuous sand lenses are encountered.
- Deep Cut DC-W5 (8.0 m cut depth) – Excavations estimated to be 6.0 m below the water table
  - Radius of water table drawdown is conservatively estimated to be ~34 m (figure F5)
  - Low potential to impact wells/ aquifers unless continuous sand lenses are encountered.
- Deep Cut DC-W6 (11.5 m cut depth) – Excavations estimated to be 9.5 m below the water table
  - Radius of water table drawdown is conservatively estimated to be ~50 m (figure F6)
  - Low potential to impact wells/ aquifers unless continuous sand lenses are encountered.
- Deep Cut DC-W7 (7.5 m cut depth) – Excavations estimated to be 2.5 m below the water table
  - Radius of water table drawdown is conservatively estimated to be ~12 m if till is continuous. May be greater if saturated sand lenses are encountered (figure F7)
  - Low potential to impact wells/ aquifers due to discontinuous nature of sand lenses
- West Mainline (W2a) – Highway constructed primarily on low permeability till deposits
  - Low potential for impact to groundwater quality from de-icing compounds
  - No reduction in groundwater recharge due to the linear nature and small surface area of the highway

OPPORTUNITIES FOR MITIGATION

- Structure WM-28, WM-39, WM-40, WM-41, and WM-42 – dewatering may be required for construction of bridge footings. The need for a PTTW should be assessed during Detailed Design
  - Where practical, consideration should be given to minimizing excavations below the water table
  - Where practical, deep foundations are recommended to minimize dewatering
  - Time the dewatering period to avoid fish spawning seasons
  - Discharge water into receptor stream following temperature and clarity controls to maintain baseflow
- Deep Cut DC-W4 –Permanent lowering of water table within ~26 of cut. No wells are anticipated to be affected
- Deep Cut DC-W5 –Permanent lowering of water table within ~34of cut. No wells are anticipated to be affected
- Deep Cut DC-W6 –Permanent lowering of water table within ~50 of cut. No wells are anticipated to be affected
- Deep Cut DC-W7 –Permanent lowering of water table within ~12 of cut. No wells are anticipated to be affected
- West Mainline (West 1 – W1b) – Low potential for reduction in groundwater quality from road run-off
  - Low potential for long-term impact to groundwater quality from de-icing compounds
  - Most SWM ponds will not require lining because low permeability materials present at surface
- No reduction in GW recharge due to the small surface area of the highway

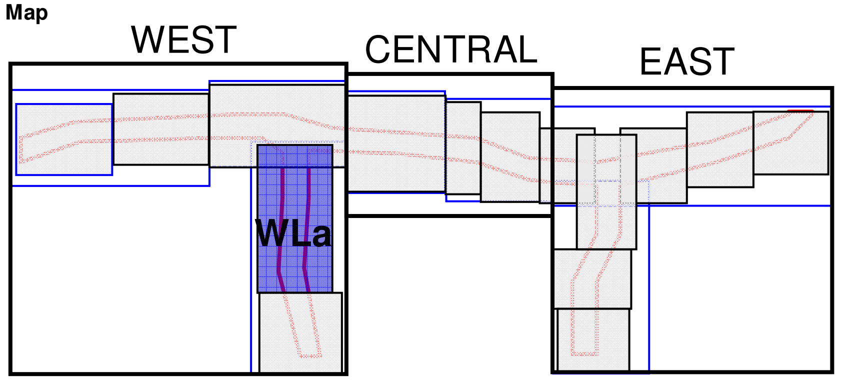
PRIORITIES FOR DETAILED DESIGN:

- A PTTW may be required for constructing bridge foundations at WM-28, WM-39, WM-40, WM-41, WM-42, and should be assessed during Detailed Design
- Collection of geological and hydrogeological information along the length of and transverse to each deep cut location to confirm the presence of till to depth and estimation of the extent of local drawdown will be required during Detailed Design. Hydraulic testing may be required to establish potential impacts

407 East Extension – West Section

Summary Table 4 – Potential Impacts and Mitigtion Summary (WLa)

Key Map



Map: West Link – WLa

Section Boundaries: Highway 407 Mainline to Rossland Road between Audley Road and Country Lane.

Figure(s): Figure A4

Cross-section(s): West Link: C – C' (Figure A8)

Assumed Proposed Structures: West Link – WL-16, WL-17, WL-18, WL-19, WL-19a, WL-20, WL-21, WL-22, WL-23, WL-24, WL-25, WL-26, WL-27, WL-28, WL-29, WL-30, WL-31, WL-32, WL-33

Assumed Deep Cuts: DC-W8 (12+400 to 12+890) – 6.5 m cut depth (drawdown curve – Figure F8)

Assumed High Fills: HF-W13 (18+050 to 18+490) – 10.0 m fill height
HF-W14 (17+325 to 17+700) – 7.5 m fill height
HF-W15 (14+350 to 15+075) – 8.0 m fill height

Hydrogeology Site Ranking Table: Table 9 (Section WLa)

FIELD DATA SOURCES:

Boreholes: BH3, BH4, BH5, BH6, BH7, BH8, WL16-1, WL20-1, WL20-2, WL23-1, WL24-1, WL24-2, WL26-1, WL26-2, WL27-1, WL27-2, WL28-1, WL28-2

Monitoring Wells: G3W-1, G3W-2, G4W-1, G4W-2

Mini-Piezometers: MP6, MP7, MP8, MP9s/d, MP10

Stream Reconnaissance Sites: SR13c,d,e

Residential Water Wells: 201 private water wells. 25% dug, 11% drilled, 64% unknown. Approximately 8 wells within the TPR boundary (may require decommissioning)

PHYSIOGRAPHIC SETTING:

- Gently sloping southward from the South Slope physiographic region to Lake Ontario is the Iroquois Plain physiographic region (Chapman and Putman, 1984). Boulder pavements and sand and gravel beach deposits characterize the shoreline of Glacial Lake Iroquois, which is found south of Highway 7. Nearshore deposits of sand, that grade to silts and clays characterize the area between the glacial shoreline and Lake Ontario. These shallow deposits overlie the Newmarket Till. Modern alluvial silts, sands and gravels can be found in recent alluvial valley of Lynde Creek and its tributaries

Notes:
mBGS – metres below ground surface
GWT – groundwater table
ORM – Oak Ridges Moraine
PTTW – Permit To Take Water

POTENTIAL IMPACTS:

Groundwater Effects on Foundation Design and Construction:

- Thin deposits of glaciolacustrine sands and silts are present over most of this Section
  - Local dewatering may be required for excavations in glaciolacustrine materials, probably at low rates
  - Where practical, consideration should be given to minimizing excavations below the water table
  - Bedrock is generally within 30 m of surface in the southern portion of the Section
- Shallow GWT (<1.0 mBGS) may be encountered within till units because the unit is poorly drained
- Anticipate encountering discontinuous sand lenses below the groundwater table within till units. Will drain in the short term
- Structures WL-16, WL-17, WL-19, WL-21, WL-22, WL-23, WL-24, WL-32, WL-33 – Shallow dewatering may be required for excavations below the water table. Further assessment is needed during Detailed Design
- The TPR crosses the Lake Iroquois Shoreline sand and gravel sediments between 17+400 to 18+100 (West Link) on raised fill
  - Groundwater discharge was not identified along the Iroquois Shoreline at this location
- Deep Cut DC-W8 (6.5 m deep cut may encounter the groundwater table at 2.0 mBGS.
  - High potential for side slope seepage at the contact between upper glaciolacustrine materials and lower till
  - May require permanent groundwater control to convey seepage. Should be assessed during detailed design

Surface Water Features:

- Only minor groundwater discharge was recorded within Lynde Creek tributary along the TPR. This water course is often intermittent and is generally considered a warm water stream
- Anecdotal evidence of groundwater seepage in wetland area near WL-18. May require assessment during detailed design
- No significant impacts to surface water bodies are anticipated

Aquifer/Well Vulnerability:

- The TPR crosses the Glacial Lake Iroquois Shoreline sediments at 17+400 to 18+100 (West Link).
  - Aquifer unit is highly sensitive to surficial contamination due to high permeability, however groundwater discharge was not identified at this Shoreline location
  - The presence across the TPR is not confirmed and requires further investigation
- Deep Cut DC-W8 (6.5 m deep cut) – Excavations estimated to be 4.5 m below the water table
  - Radius of water table drawdown is conservatively estimated to be ~26 m (figure F8)
  - Low potential to impact wells/ aquifers unless continuous sand lenses are encountered
- West Link (WLa) – Highway constructed primarily on or near high permeability aquifer deposits
  - Between 11+250 and 18+100 - potential for impacts to groundwater quality from de-icing compounds and mitigative measures should be assessed during Detailed Design

OPPORTUNITIES FOR MITIGATION:

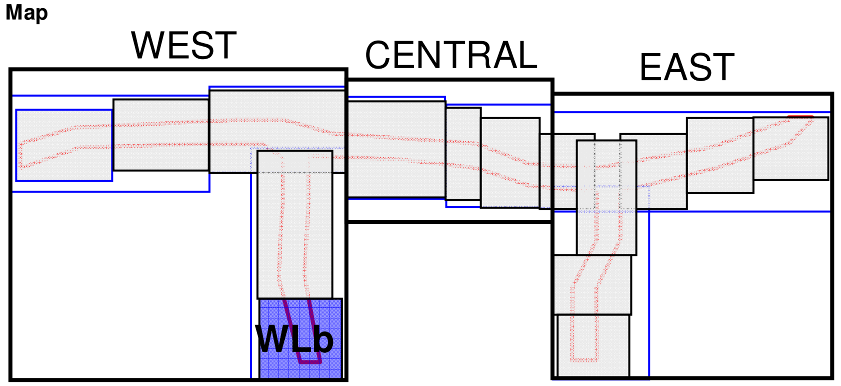
- Structures WL-16, WL-17, WL-19, WL-21, WL-22, WL-23, WL-24, WL-32, WL-33 – local dewatering may be required for excavations in permeable sediments. The need for a PTTW will be assessed during Detailed Design
  - Where practical, consideration should be given to minimizing excavations below the water table
  - Where practical, deep foundations are recommended to minimize dewatering
  - Time the dewatering period to avoid fish spawning seasons
  - Discharge water into receptor stream following temperature and clarity controls to maintain baseflow
- Deep Cut DC-W8 – Estimated permanent lowering of water table within ~26 m of cut
  - Area may require passive groundwater control at the contact between glaciolacustrine sediment and till to convey seepage through gravity drainage to discharge point in Lynde Creek tributary.
  - May require a PTTW to construct groundwater drains. Further assessment is needed during Detailed Design. Performance monitoring may also be required
- West Link (West Link – WLa) – Potential for reduction in groundwater quality from road run-off
- Between 11+250 and 18+100 - potential for impacts to groundwater quality from de-icing compounds. Consideration should be given to mitigation measures during detailed design such as drainage design alternatives including liners and drainage separation to minimize infiltration to the water table
- Compensation for impacts by may be considered in the form of alternative water supplies on a case-by-case basis

PRIORITIES FOR DETAILED DESIGN:

- Collection of geological and hydrogeological information along the length and transverse of the deep cut location DC-W8 to confirm the presence of permeable glaciolacustrine deposits and estimation of the extent of local drawdown will be required during Detailed Design. Hydraulic testing may be required to establish potential impacts.
- To determine potential dewatering requirements, confirm depth of excavation for bridge abutments at WL-16, WL-17, WL-19, WL-21, WL-22, WL-23, WL-24, WL-32, and WL-33. Hydraulic testing may be required to establish potential impacts. The need for a PTTW should be assessed
- Further assessment and potentially design of passive groundwater control system at DC-W8
- Additional investigations where the TPR crosses the Lake Iroquois Shoreline (17+400 to 18+100)
- Assess the need for drainage design alternatives including liners and drainage separation to minimize infiltration to the water table between 11+250 and 18+100

407 East Extension – West Section
Summary Table 5 – Potential Impacts and Mitigation Summary (WLb)

Key Map



Map: West Link – WLb

Section Boundaries: Rossland Road to Highway 401.

Figure(s): Figure A5

Cross-section(s): West Link: C – C' (Figure A8)

Assumed Proposed Structures: West Link – WL-1, WL-2, WL-3, WL-4, WL-5, WL-6, WL-7, WL-8, WL-9, WL-10, WL-11, WL-12, WL-13, WL-14, WL-15

Assumed Deep Cuts: None

Assumed High Fills: None

Hydrogeology Site Ranking Table: Table 10 (Section WLb)

FIELD DATA SOURCES:

Boreholes: BH1, BH3, BH9, WL2-1, WL2-2, WL3-1, WL3-2, WL3-3, WL4-1, WL5-2, WL7-1, WL7-2, WL8-1, WL8-2, WL8-3, WL9-1, WL10-1, WL11-1, WL12-1

Monitoring Wells: None

Mini-Piezometers: MP11, MP12s/d

Stream Reconnaissance Sites: SR13a,b

Residential Water Wells: 10 private water wells. 40% dug, 0% drilled, 60% unknown. Municipal water is utilized in this area. Approximately 8 wells within the TPR boundary (may require decommissioning)

PHYSIOGRAPHIC SETTING:

- Gently sloping southward from the South Slope physiographic region to Lake Ontario is the Iroquois Plain physiographic region (Chapman and Putman, 1984). Boulder pavements and sand and gravel beach deposits characterize the shoreline of Glacial Lake Iroquois. Nearshore deposits of silts and clays characterize the area. Modern alluvial silts, sands and gravels can be found in recent alluvial valley of Lynde Creek and its tributaries.

Notes:
mBGS – metres below ground surface
GWT – groundwater table
ORM – Oak Ridges Moraine
PTTW – Permit To Take Water

POTENTIAL IMPACTS:

Groundwater Effects on Foundation Design and Construction:
- Thin deposits of glaciolacustrine silts and clays are present over most of this Section
  - Bedrock is generally within 12 m of surface
- Shallow ground water table (<1.0 mBGS) may be encountered within till units because the unit is poorly drained
- Anticipate encountering discontinuous sand lenses below the GWT within till units. Will drain in the short term
- Structure WL-6 – Shallow dewatering may be required for excavations below the water table. Further assessment is needed during Detailed Design
- Structure WL-10 and WL-11
  - Temporary construction dewatering may be required for excavations within alluvial sediments WL-10 / WL-11. A PTTW may be required. Further assessment is needed during Detailed Design

Surface Water Features:
- Only minor groundwater discharge was recorded within Lynde Creek tributary along the TPR. The water course is often intermittent and is generally considered a warm water stream
- Some seepage areas may be present at the contact between the surficial silts and clays and the underlying till
- The small wetland areas present are perched on top of the low permeability silt and clay units
- Dewatering for bridge abutments in the Lynde Creek valley (WL-10, WL-11) may reduce groundwater discharge into the creek over the dewatering period
  - The need for a PTTW will need to be assessed during Detailed Design

Aquifer/Well Vulnerability:
- No impacts to local water wells or aquifer units are anticipated
- West Link (WLb) – Highway constructed primarily on low permeability till and glaciolacustrine deposits
  - Low potential for impact to groundwater quality from de-icing compounds
  - No reduction in GW recharge due to the linear nature and small surface area of the highway

OPPORTUNITIES FOR MITIGATION:

- West Link (West Link – WLb) – Low potential for reduction in groundwater quality from road run-off
  - Low potential for long-term impact to groundwater quality from de-icing compounds
  - Most SWM ponds will not require lining because low permeability materials present at surface
- No reduction in GW recharge due to the small surface area of the highway

PRIORITIES FOR DETAILED DESIGN:

- Confirm highway design for Interchange Ramps connecting Hwy 407 with Hwy 401. New deep cut and high fill locations are anticipated. Further assessment is needed during Detailed Design
- Collection of geologic and hydrogeologic information at structures WL-10 and WL-11 so dewatering rates can be estimated. Hydraulic testing may be required to establish potential impacts

TABLE 6
Hydrogeology Site Ranking Table (W1a)

SECTION	Structure		Assumed Structure Type	Asumed Structure Category	Name	Data Source(s) at Structure	Groundwater Comments		SITE RANKING	Assumed Watercourse Crossing	Valley Geomorphology Based on Air Photo Interpretation	Valley Sediments & Wetlands Based on Air Photo Interpretation	Approx. Overburden Thickness (m), based on interpolation from geotechnical borehole and water well records
	ID	Drainage Crossing ID					SUBSURFACE CONDITIONS	REMARKS	HYDROGEOLOGY				
WEST SECTION - Subsection W1a	WM - A	WM-2	Bridge	Overpass	Urfe Creek	WMa-1, WMa-2, MP38	Surficial aquifer to 8.8 mBGS in valley - alluvial sediments (sand and gravel), and glaciolacustrine silty sand. Water table near surface (<1.0 mBGS) and upwards hydraulic gradient within stream (i.e., groundwater discharge). Sand and silt till (Newmarket Till) aquitard below surficial aquifer to a depth of 10.7 mBGS.	Shallow water table (<1.0 mBGS) and surficial sand aquifer. Dewatering may be required if excavating in alluvial sediments for foundations. PTTW may be required for dewatering.	Medium	Expand Existing Span Bridge	Narrow, shallow valley with no geomorphic evidence of significant valleyside instability	Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	75
	WM - 1	WM-3	Bridge	Overpass	Brougham Creek	WM1-1	Surficial sand and gravel aquifer interbedded with sand and silt till units to a depth of 14.0 mBGS. Cobbles and boulders were noted in the geotech borehole logs, which suggests fluvial deposition. Water table is expected to be <5.0 mBGS.	Surficial sand and gravel aquifer. Potential for dewatering if excavating alluvial sediments in valley.	Medium	Closed Bottom Culvert	Narrow, moderately deep valley with no geomorphic evidence of significant valleyside instability	Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	70
	WM - 2	WM-3	Bridge	Overpass	Brougham Creek	WM1-1	Surficial sand and gravel aquifer interbedded with sand and silt till units to a depth of 14.0 mBGS. Cobbles and boulders were noted in the geotech borehole logs, which suggests fluvial deposition. Water table is expected to be <5.0 mBGS.	Surficial sand and gravel aquifer. Potential for dewatering if excavating below the water table.	Medium	Closed Bottom Culvert	Narrow, moderately deep valley with no geomorphic evidence of significant valleyside instability	Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	70
	WM - 3	WM-5	Bridge	Underpass	Realigned Brock Rd	WM3-1, WM3-2	Thin till aquitard present at surface to a depth of 2.3 m. Sand and gravel aquifer to a depth of between 4.6 and 11.6 mBGS. Underlying the aquifer is a sand and silt till (Newmarket Till) aquitard to a depth of 12.3mBGS. Cobbles and boulders were noted in the geotech borehole logs, which suggests fluvial deposition. Water table is expected to be <5.0 mBGS.	Thin deposit of till underlain by sand and gravel aquifer. Potential for dewatering if excavating below the water table.	Medium	No Watercourse (Street Crossing)			70
	WM - 4	WM-101	Bridge	Crossing Road Overpass	Highway 7	WM3-1, WM3-2	Thin till aquitard present at surface to a depth of 2.3 m. Sand and gravel aquifer to a depth of between 4.6 and 11.6 mBGS. Underlying the aquifer is a sand and silt till (Newmarket Till) aquitard to a depth of 12.3mBGS. Cobbles and boulders were noted in the geotech borehole logs, which suggests fluvial deposition. Water table is expected to be <5.0 mBGS.	Thin deposit of till underlain by sand and gravel aquifer. Potential for dewatering if excavating below the water table.	Medium	No Watercourse (Street Crossing)			75
	WM - 5	WM-6	Bridge	Overpass	Brougham Creek	WM5-1, MP2	Sand and gravel to a depth of 12.3 mBGS. Overlies till. Artesian groundwater pressures are anticipated if the saturated sand and gravel aquifer is encountered in excavation. The wetland area and Irrigation Pond are fed by groundwater discharge from a local sand and gravel aquifer. Site investigations show an abundance of groundwater seeps within the valley and to the west of the valley. Shallow water table and evidence of groundwater discharge within stream south of Hwy 7. Mapped Lake Iroquois Shoreline sediments present south of Hwy 7	Shallow water table (<1.0 mBGS) within valley and surficial sand and gravel aquifer. Significant artesian groundwater pressures are anticipated. Dewatering may be required if excavating in alluvial sediments for foundations. PTTW may be required for dewatering. Mitigation measures will need to be assessed during detailed design to account for groundwater seepage below fill placement and the effects of groundwater pressure on deep foundations.	High	Span Bridge	Narrow, moderately deep valley with approx. 20° steep valleysides; potential for localized valleyside instability due to saturated conditions	Valley bottom sediments >0.5 m deep and dominantly silty gravelly sand alluvium	55
	WM - 6	WM-7	Bridge	Overpass	Brougham Creek	WM5-1, MP2	Sand and gravel to a depth of 12.3 mBGS. Overlies till. Artesian groundwater pressures are anticipated if the saturated sand and gravel aquifer is encountered in excavation. The wetland area and Irrigation Pond are fed by groundwater discharge from a local sand and gravel aquifer. Site investigations show an abundance of groundwater seeps within the valley and to the west of the valley. Shallow water table and evidence of groundwater discharge within stream south of Hwy 7. Mapped Lake Iroquois Shoreline sediments present south of Hwy 7	Shallow water table (<1.0 mBGS) within valley and surficial sand and gravel aquifer. Significant artesian groundwater pressures are anticipated. Dewatering may be required if excavating in alluvial sediments for foundations. PTTW may be required for dewatering. Mitigation measures will need to be assessed during detailed design to account for groundwater seepage below fill placement and the effects of groundwater pressure on deep foundations.	High	Span Bridge	Narrow, moderately deep valley with approx. 20° steep valleysides; potential for localized valleyside instability due to saturated conditions	Valley bottom sediments >0.5 m deep and dominantly silty gravelly sand alluvium	55
	WM - 7	-	Bridge	Overpass	Highway 7	WM5-1, MP2	Thin till aquitard present at surface to a depth of 2.3 m. Sand and gravel aquifer to a depth of between 4.6 and 11.6 mBGS. Exhibits artesian groundwater pressures. Underlying the aquifer is a sand and silt till (Newmarket Till) aquitard to a depth of 12.3mBGS. Cobbles and boulders were noted in the geotech borehole logs, which suggests fluvial deposition. Water table is expected to be <5.0 mBGS.	Thin deposit of till underlain by sand and gravel aquifer that has minor artesian groundwater pressures. Potential for dewatering if excavating below the water table. Fill placement shoould be assessed during detailed design to accommodate the potential of seepage below raised alignment.	Medium	No Watercourse (Street Crossing)	Narrow, moderately deep valley with approx. 20° steep valleysides; potential for localized valleyside instability due to saturated conditions	Valley bottom sediments >0.5 m deep and dominantly silty gravelly sand alluvium	55
	WM - 8	-	Bridge	Underpass	Sideline 14	WM8-1, P6	Surficial silty to clayey till (Halton Till) aquitard to a depth of 7.6 mBGS underlain by silty sand to sandy materials (potential ORM Aquifer deposits) to a depth of at least 16.8 mBGS. Shallow water table (<1.0 mBGS). Seeps observed near the base of the large hill.	Shallow water table (<1.0 mBGS) and potential ORM aquifer deposits confined below till. Potential for dewatering if excavating for foundations. Groundwater flow feeding observed seeps may be altered due to construction activities.	High	No Watercourse (Street Crossing)			55
	WM - 9	WM-8	Bridge	Overpass	Spring Creek	None (WM11-1)	Surficial sand to silty-sand aquifer to a depth of 9.8 mBGS underlain by clayey silt to 15.9 mBGS. Water table likely close to ground surface (<2.0 mBGS). Evidence of groundwater discharge into stream. Pond is partially fed by groundwater.	Shallow water table (<2.0 mBGS) and surficial sand aquifer. Dewatering may be required if excavating in alluvial sediments for foundations. PTTW may be required for dewatering.	High	Open Bottom Culvert or Span Bridge	Moderately wide, shallow valley with no geomorphic evidence of significant valleyside instability	Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	45
	WM - 10	WM-8	Bridge	Overpass	Spring Creek	None (WM11-1)	Surficial sand to silty-sand aquifer to a depth of 9.8 mBGS underlain by clayey silt to 15.9 mBGS. Water table likely close to ground surface (<2.0 mBGS). Evidence of groundwater discharge into stream. Pond is partially fed by groundwater.	Shallow water table (<2.0 mBGS) and surficial sand aquifer. Dewatering may be required if excavating in alluvial sediments for foundations. PTTW may be required for dewatering.	High	Open Bottom Culvert or Span Bridge	Moderately wide, shallow valley with no geomorphic evidence of significant valleyside instability	Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	45
	WM - 11	-	Bridge	Overpass	Paddock Road	G1W-1, G1W-2, WM11-1, WM11-2, WM11a-1	Surficial silty-sand aquifer to a depth of 9.8 mBGS. Underlain by a clayey silt aquitard. Shallow water table (0.8 - 1.9 mbgs) measured at G1W. Downwards hydraulic gradient observed between surficial sand and underlying till. Seeps observed at break in slope along valley wall. Bedrock encountered at 37.4 mBGS.	Shallow water table (<1.0 mBGS) and surficial sand aquifer. Dewatering may be required if excavating in alluvial sediments for foundations. PTTW may be required for dewatering.	Medium	No Watercourse (Street Crossing)	Wide, deep valley with approx. 30° steep western valleyside; proposed bridge footprint within meander bend of early post-glacial river; potential for localized valleyside instability due to saturated conditions at slope toe	Valley bottom sediments >2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material	40
	WM - 11A	-	Bridge	Overpass	Paddock Road	G1W-1, G1W-2, WM11-1, WM11-2, WM11a-1	Surficial silty-sand aquifer to a depth of 9.8 mBGS. Underlain by a clayey silt aquitard. Shallow water table (0.8 - 1.9 mbgs) measured at G1W. Downwards hydraulic gradient observed between surficial sand and underlying till. Seeps observed at break in slope along valley wall. Bedrock encountered at 37.4 mBGS.	Shallow water table (<1.0 mBGS) and surficial sand aquifer. Dewatering may be required if excavating in alluvial sediments for foundations. PTTW may be required for dewatering.	Medium	No Watercourse (Street Crossing)	Wide, deep valley with approx. 30° steep western valleyside; proposed bridge footprint within meander bend of early post-glacial river; potential for localized valleyside instability due to saturated conditions at slope toe	Valley bottom sediments >2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material	40
	WM - 12	WM-9	Bridge	Overpass	East Duffins Creek	WM12-1	Geotech borehole was not drilled in the valley of East Duffins Creek. Surficial sand and gravel aquifer underlain by a clayey silt aquitard is anticipated. Shallow water table (0.8 - 1.9 mbgs) measured at G1W. Groundwater discharge anticipated in valley. Seeps observed at break in slope along valley wall. Bedrock encountered at 37.4 mBGS.	Shallow water table (<1.0 mBGS) and surficial sand aquifer. Dewatering may be required if excavating in alluvial sediments for foundations. PTTW may be required for dewatering. From a hydrogeology perspective, a permeable sub-base may be required below any fill placed in the valley to maintain groundwater discharge.	High	Span Bridge	Wide, deep valley with old channel scars across floodplain	Valley bottom sediments >2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material	30
	WM - 13	WM-9	Bridge	Overpass	East Duffins Creek	WM13-1	Geotech borehole was not drilled in the valley of East Duffins Creek. Surficial sand and gravel aquifer underlain by a clayey silt aquitard is anticipated. Shallow water table (0.8 - 1.9 mbgs) measured at G1W. Groundwater discharge anticipated in valley. Seeps observed at break in slope along valley wall. Bedrock encountered at 37.4 mBGS.	Shallow water table (<1.0 mBGS). Dewatering may not be required if surficial clayey silt unit is continuous within the valley. From a hydrogeology perspective, a permeable sub-base may be required below any fill placed in the valley to maintain groundwater discharge.	High	Span Bridge	Wide, deep valley with old channel scars across floodplain	Valley bottom sediments >2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material	30

Site ranking for Hydrogeology: Low/Medium/High risk -in terms of sensitivity of the environment to construction, e.g. High risk - highly sensitive environment.

TABLE 7
Hydrogeology Site Ranking Table (W1b)

SECTION	Structure		Assumed Structure Type	Asumed Structure Category	Name	Data Source(s) at Structure	Groundwater Comments		SITE RANKING	Assumed Watercourse Crossing	Valley Geomorphology Based on Air Photo Interpretation	Valley Sediments & Wetlands Based on Air Photo Interpretation	Approx. Overburden Thickness (m), based on interpolation from geotechnical borehole and water well records
	ID	Drainage Crossing ID					SUBSURFACE CONDITIONS	REMARKS	HYDROGEOLOGY				
WEST SECTION - Subsection W1b	WM - 14	WM-10	Culvert	Overpass	East Duffins Creek tributary	WM17-1, WM17-2	Surficial silty to clayey till aquitard, interbedded with sand/silt units to a depth of >16.5 mBGS . Strong downwards hydraulic gradient measured in stream indicating groundwater recharge.	Depth to water table is likely <5.0 mBGS. Watercourse perched on till and is intermittent. Culvert installation should occur when stream bed is dry.	Low	Closed Bottom Culvert	Poorly defined, shallow valley with no geomorphic evidence of significant valleyside instability	Valley bottom mostly organic material (<1 m) overlying till, with discontinuous sandy alluvial deposits	40
	WM - 15	WM-10	Culvert	Overpass	East Duffins Creek tributary	WM17-1, WM17-2	Surficial silty to clayey till aquitard, interbedded with sand/silt units to a depth of >16.5 mBGS . Strong downwards hydraulic gradient measured in stream indicating groundwater recharge.	Depth to water table is likely <5.0 mBGS. Watercourse perched on till and is intermittent. Culvert installation should occur when stream bed is dry.	Low	Closed Bottom Culvert	Poorly defined, shallow valley with no geomorphic evidence of significant valleyside instability	Valley bottom mostly organic material (<1 m) overlying till, with discontinuous sandy alluvial deposits	45
	WM - 16	WM-10	Culvert	Overpass	East Duffins Creek tributary	WM17-1, WM17-2	Surficial silty to clayey till aquitard, interbedded with sand/silt units to a depth of >16.5 mBGS . Strong downwards hydraulic gradient measured in stream indicating groundwater recharge.	Depth to water table is likely <5.0 mBGS. Watercourse perched on till and is intermittent. Culvert installation should occur when stream bed is dry.	Low	Closed Bottom Culvert	Poorly defined, shallow valley with no geomorphic evidence of significant valleyside instability	Valley bottom mostly organic material (<1 m) overlying till, with discontinuous sandy alluvial deposits	45
	WM - 17	-	Bridge	Underpass	Westney Road	WM17-1, WM17-2	Surficial silty to clayey till aquitard, interbedded with sand/silt units to a depth of >16.5 mBGS . Strong downwards hydraulic gradient measured in stream indicating groundwater recharge.	Water table perched on till unit. Depth to water table is likely <5.0 mBGS.	Low	No Watercourse (Street Crossing)			45
	WM - 18	WM-11	Bridge	Overpass	Carruthers Creek West	None	Surficial silty to clayey till aquitard, overlain by alluvial and lacustrine clayey-silt sediments. Groundwater table is likely < 2.5 mbgs in alluvial sediment and lacustrine clayey-silts. Water table is possibly perched. Ecoplans reports some localized groundwater inputs. Possible sand deposits below surficial aquitard.	Water table perched on low permeability sediments. Depth to water table is likely <2.5 mBGS.	Medium	Span Bridge	Narrow, shallow valley with no geomorphic evidence of significant valleyside instability	Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	40
	WM - 19	WM-11	Bridge	Overpass	Carruthers Creek West	None	Surficial silty to clayey till aquitard, overlain by alluvial and lacustrine clayey-silt sediments. Groundwater table is likely < 2.5 mbgs in alluvial sediment and lacustrine clayey-silts. Water table is possibly perched. Ecoplans reports some localized groundwater inputs. Possible sand deposits below surficial aquitard.	Water table perched on low permeability sediments. Depth to water table is likely <2.5 mBGS.	Medium	Span Bridge	Narrow, shallow valley with no geomorphic evidence of significant valleyside instability	Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	40
	WM - 20	WM-12	Bridge	Overpass	Carruthers Creek East	None	Surficial silty to clayey till aquitard, overlain by alluvial and lacustrine clayey-silt sediments. Groundwater table is likely < 2.5 mbgs in alluvial sediment and lacustrine clayey-silts. Water table is possibly perched. Ecoplans reports some localized groundwater inputs. Possible sand deposits below surficial aquitard.	Water table perched on low permeability sediments. Depth to water table is likely <2.5 mBGS.	Medium	Span Bridge	Narrow, shallow valley; meandering channel has locally undercut valleysides upstream of proposed bridge footprint	Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	40
	WM - 21	WM-12	Bridge	Overpass	Carruthers Creek East	None	Surficial silty to clayey till aquitard, overlain by alluvial and lacustrine clayey-silt sediments. Groundwater table is likely < 2.5 mbgs in alluvial sediment and lacustrine clayey-silts. Water table is possibly perched. Ecoplans reports some localized groundwater inputs. Possible sand deposits below surficial aquitard.	Water table perched on low permeability sediments. Depth to water table is likely <2.5 mBGS.	Medium	Span Bridge	Narrow, shallow valley; meandering channel has locally undercut valleysides upstream of proposed bridge footprint	Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	40
	WM - 22	-	Bridge	Underpass	Salem Road	WM22-1, P8	Surficial clayey-silt till aquitard to a depth of 6.4 mBGS. Silty sand deposits from 6.4 to 11.6 mBGS. Silt and clayey silt from 11.6 to 20.0 mBGS. Water table depth is likely <5.0 mBGS.	Water table perched on low permeability sediments. Depth to water table is likely <5.0 mBGS.	Low	No Watercourse (Street Crossing)			45
	WM - 23	WM-14	Culvert	Overpass	Carruthers Creek tributary	MP5	Surficial sand and silt till (Newmarket Till) aquitard to a depth of 20.0 mBGS. Water table is perched and encountered at <2.0 mBGS. Evidence of seasonal groundwater discharge. Some evidence of groundwater seeps.	Water table perched on low permeability sediments. Depth to water table is likely <2.0 mBGS. Low potential for dewatering if excavating in alluvial valley.	Medium	Open Bottom Culvert	Narrow, shallow valley with no geomorphic evidence of significant valleyside instability	Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	55
	WM - 24	WM-15	Culvert	Overpass	Carruthers Creek tributary	WM25-1, P9	Surficial sand and silt till (Newmarket Till) aquitard to a depth of 20.0 mBGS. Water table is perched and encountered at <2.0 mBGS.	Water table perched on low permeability sediments. Depth to water table is likely <2.0 mBGS. Low potential for dewatering if excavating in alluvial valley.	Low	Closed Bottom Culvert	Narrow, shallow valley; meandering channel has eroded road embankment material	Valley bottom sediments approx. 0.5 m deep silty gravelly sand alluvium overlying silt till, containing boulders	55
	WM - 25	-	-	Cul de Sac	Sideline 4 (Balsam Road)	WM25-1, P9	Surficial sand and silt till (Newmarket Till) aquitard to a depth of 20.0 mBGS. Water table is perched and encountered at <2.0 mBGS.	Water table perched on low permeability sediments. Depth to water table is likely <2.0 mBGS.	Low	No Watercourse (Street Crossing)			55
	WM - 26	WM-16	Culvert	Overpass	Lynde Creek tributary	None	Surficial sand and silt till (Newmarket Till) aquitard to a depth of 9.3 mBGS. Water table is perched and encountered at <1.0 mBGS.	Water table perched on low permeability sediments. Depth to water table is likely <2.0 mBGS. Low potential for dewatering if excavating in alluvial valley.	Low	Closed Bottom Culvert	Narrow, shallow valley with no geomorphic evidence of significant valleyside instability	Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	65
	WM - 27	-	Bridge	Underpass	Audley Road (Kinsale Road)	WM27-1, WM27-2	Surficial sand and silt till (Newmarket Till) aquitard to a depth of 9.3 mBGS. Water table is perched and encountered at <1.0 mBGS.	Water table perched on low permeability sediments. Depth to water table is likely <1.0 mBGS.	Low	No Watercourse (Street Crossing)			70

Site ranking for Hydrogeology: Low/Medium/High risk -in terms of sensitivity of the environment to construction, e.g. High risk - highly sensitive environment.

TABLE 8
Hydrogeology Site Ranking Table (W2a)

SECTION	Structure		Assumed Structure Type	Asumed Structure Category	Name	Data Source(s) at Structure	Groundwater Comments		SITE RANKING	Assumed Watercourse Crossing	Valley Geomorphology Based on Air Photo Interpretation	Valley Sediments & Wetlands Based on Air Photo Interpretation	Approx. Overburden Thickness (m), based on interpolation from geotechnical borehole and water well records
	ID	Drainage Crossing ID					SUBSURFACE CONDITIONS	REMARKS	HYDROGEOLOGY				
WEST SECTION - Subsection W2a	WM - 28	-	Bridge	Underpass	Lake Ridge Road	WM28-1, P10	Surficial sand and silt till (Newmarket Till) aquitard to a depth of 7.8 mBGS.	Water table perched on low permeability sediments. Depth to water table is ~3.4 mBGS.	Low	No Watercourse (Street Crossing)			80
	WM - 29	-	Bridge	Underpass	Halls Road North	WM29-1, WM29-2	Surficial sand and silt till (Newmarket Till) aquitard to a depth of 7.8 mBGS.	Water table perched on low permeability sediments. Depth to water table is ~3.4 mBGS.	Low	No Watercourse (Street Crossing)			75
	WM - 30	WM-17	Bridge	Cancelled	Highway 407 over West Lynde Creek	None	Surficial sand and silt till (Newmarket Till) aquitard.	Water table perched on low permeability sediments. Depth to water table is likely <2.0 mBGS. Watercourse perched on till and is intermittent. Culvert installation should occur when stream bed is dry.	Low	Structure Cancelled	Narrow, shallow valley with no geomorphic evidence of significant valleyside instability	Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	70
	WM - 31	WM-17	Bridge	Cancelled	Highway 407 over West Lynde Creek	None	Surficial sand and silt till (Newmarket Till) aquitard.	Water table perched on low permeability sediments. Depth to water table is likely <2.0 mBGS. Watercourse perched on till and is intermittent. Culvert installation should occur when stream bed is dry.	Low	Structure Cancelled	Narrow, shallow valley with no geomorphic evidence of significant valleyside instability	Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	70
	WM - 32	WM-18	Bridge	Cancelled	Proposed Realigned Coronation Road	None	Surficial sand and silt till (Newmarket Till) aquitard.	Water table perched on low permeability sediments. Depth to water table is likely <2.0 mBGS.	Low	No Watercourse (Street Crossing)		Sediments within proposed structure footprint include >1 m deep silty gravelly sand alluvium and glaciolacustrine silt, locally interbedded with buried organic material; sediments saturated and very loose	50
	WM - 33	WM-19	Bridge	Overpass	Highway 407 over West Lynde Creek Valley	None	Surficial sand to silty-sand aquifer within valley underlain by sandy silt till (Newmarket Till). Water table likely close to ground surface (<1.0 mBGS). Evidence of groundwater discharge into stream.	Shallow water table (<1.0 mBGS) and surficial sand aquifer. Dewatering may be required if excavating in alluvial sediments for foundations. PTTW may be required for dewatering.	Medium	Span Bridge	Narrow, moderately deep valley with comparatively steep east valleyside, but no geomorphic evidence of significant valleyside instability	Valley bottom sediments possibly >2 m deep and likely dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	45
	WM - 34	WM-19	Bridge	Overpass	Highway 407 over West Lynde Creek Valley	None	Surficial sand to silty-sand aquifer within valley underlain by sandy silt till (Newmarket Till). Water table likely close to ground surface (<1.0 mBGS). Evidence of groundwater discharge into stream.	Shallow water table (<1.0 mBGS) and surficial sand aquifer. Dewatering may be required if excavating in alluvial sediments for foundations. PTTW may be required for dewatering.	Medium	Span Bridge	Narrow, moderately deep valley with comparatively steep east valleyside, but no geomorphic evidence of significant valleyside instability	Valley bottom sediments possibly >2 m deep and likely dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	45
	WM - 35	-	-	Cul de Sac	County Lane	WM35-1, WM35-2	Surficial sand and silt till (Newmarket Till) aquitard to a depth of 9.3 mBGS. Water table is perched and encountered at <2.0 mBGS.	Water table perched on low permeability sediments. Depth to water table is likely <2.0 mBGS.	Low	No Watercourse (Street Crossing)			55
	WM - 36	WM-20	Bridge	Overpass	Lynde Creek	WM36-1, WM37-1	Surficial silt and sand till (Newmarket Till) aquitard to a depth of 15.4 mBGS within valley. Water table close to ground surface (<1.0 mBGS). Evidence of groundwater discharge into stream.	Shallow water table (<1.0 mBGS) perched on till. Low potential for dewatering if excavating in till deposits for foundations.	Low	Open Bottom Culvert	Narrow, well defined valley with no geomorphic evidence of significant valleyside instability	Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	45
	WM - 37	WM-20	Bridge	Overpass	Lynde Creek	WM36-1, WM37-1	Surficial silt and sand till (Newmarket Till) aquitard to a depth of 15.4 mBGS within valley. Water table close to ground surface (<1.0 mBGS). Evidence of groundwater discharge into stream.	Shallow water table (<1.0 mBGS) perched on till. Low potential for dewatering if excavating in till deposits for foundations.	Low	Open Bottom Culvert	Narrow, well defined valley with no geomorphic evidence of significant valleyside instability	Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	45
	WM - 38	-	Bridge	Underpass	Cochrane Street	WM38-1, WM38-2	Surficial sand and silt till (Newmarket Till) aquitard. Sand unit encountered in WM38-1 between 4.6 and 9.1 mBGS. Till unit continues below. Water table depth is likely <5.0 mBGS	Water table expected at <5.0 mBGS. Sand lens encountered in WM38-1 at 4.6 mBGS. Due to deep cut (DC-W7), excavations may encounter sand lens. Should drain in the short term, but may require a PTTW.	Medium	No Watercourse (Street Crossing)			60
	WM - 39	WM-21	Bridge	Cancelled	Highway 407 over Lynde Creek Tributary	WM39-1, WM40-1, WM42-1, WM42-2, P12, MP14	Surficial silty to clayey till (possibly Halton Till) aquitard to a depth of between 7.6 and 9.8 mBGS. Underlain by sand and sandy gravel to 13.7 mBGS (possibly ORM Aquifer). Sandy silt till (Newmarket Till) aquitard found below to a depth of 17.0 mBGS. Shallow water table in alluvial sediments around stream (<1.0 mBGS). Evidence of groundwater discharge into stream.	Potential for dewatering if sandy gravel sediments are encountered in excavation. Depth to water table is likely <1.0 mBGS. A PTTW may be required.	Medium	Span Bridge	Narrow, well defined valley (once a glacial meltwater spillway) with no geomorphic evidence of significant valleyside instability	Valley bottom sediments >1 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material; presence of boulders in channel suggests till locally at or close to streambed elevation	55
	WM - 40	WM-21	Bridge	Overpass	Highway 407 over Lynde Creek Tributary	WM39-1, WM40-1, WM42-1, WM42-2, P12, MP14	Surficial silty to clayey till (possibly Halton Till) aquitard to a depth of between 7.6 and 9.8 mBGS. Underlain by sand and sandy gravel to 13.7 mBGS (possibly ORM Aquifer). Sandy silt till (Newmarket Till) aquitard found below to a depth of 17.0 mBGS. Shallow water table in alluvial sediments around stream (<1.0 mBGS). Evidence of groundwater discharge into stream.	Potential for dewatering if sandy gravel sediments are encountered in excavation. Depth to water table is likely <1.0 mBGS. A PTTW may be required.	Medium	Span Bridge	Narrow, well defined valley (once a glacial meltwater spillway) with no geomorphic evidence of significant valleyside instability	Valley bottom sediments >1 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material; presence of boulders in channel suggests till locally at or close to streambed elevation	55
	WM - 41	WM-21	Bridge	Cancelled	Ramp over Lynde Creek Tributary	WM39-1, WM40-1, WM42-1, WM42-2, P12, MP14	Surficial silty to clayey till (possibly Halton Till) aquitard to a depth of between 7.6 and 9.8 mBGS. Underlain by sand and sandy gravel to 13.7 mBGS (possibly ORM Aquifer). Sandy silt till (Newmarket Till) aquitard found below to a depth of 17.0 mBGS. Shallow water table in alluvial sediments around stream (<1.0 mBGS). Evidence of groundwater discharge into stream.	Potential for dewatering if sandy gravel sediments are encountered in excavation. Depth to water table is likely <1.0 mBGS. A PTTW may be required.	Medium	Span Bridge	Narrow, well defined valley (once a glacial meltwater spillway) with no geomorphic evidence of significant valleyside instability	Valley bottom sediments >1 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material; presence of boulders in channel suggests till locally at or close to streambed elevation	55
	WM - 42	-	Bridge	Underpass	Winchester Road West (Highway 7)	WM39-1, WM40-1, WM42-1, WM42-2, P12, MP14	Surficial silty to clayey till (possibly Halton Till) aquitard to a depth of between 7.6 and 9.8 mBGS. Underlain by sand and sandy gravel to 13.7 mBGS (possibly ORM Aquifer). Sandy silt till (Newmarket Till) aquitard found below to a depth of 17.0 mBGS. Shallow water table in alluvial sediments around stream (<1.0 mBGS). Evidence of groundwater discharge into stream.	Potential for dewatering if sandy gravel sediments are encountered in excavation. Depth to water table is likely <1.0 mBGS. A PTTW may be required.	Medium	No Watercourse (Street Crossing)			55
	WM - 43	-	Bridge	Underpass	Ashburn Rd	WM43-1, WM43-2	Surficial organic clayey silt to a depth of 1.5 mBGS, underlain by sand and silt till (Newmarket Till) aquitard to a depth of 9.6 mBGS. Water table is close to surface (<1.0 mBGS).	Water table perched on till unit. Depth to water table ranges from 1.2 to 2.3 mBGS.	Low	No Watercourse (Street Crossing)			60

Site ranking for Hydrogeology: Low/Medium/High risk -in terms of sensitivity of the environment to construction, e.g. High risk - highly sensitive environment.

TABLE 9
Hydrogeology Site Ranking Table (WLa)

SECTION	Structure		Assumed Structure Type	Asumed Structure Category	Name	Data Source(s) at Structure	Groundwater Comments		SITE RANKING	Assumed Watercourse Crossing	Valley Geomorphology Based on Air Photo Interpretation	Valley Sediments & Wetlands Based on Air Photo Interpretation	Approx. Overburden Thickness (m), based on interpolation from geotechnical borehole and water well records
	ID	Drainage Crossing ID					SUBSURFACE CONDITIONS	REMARKS	HYDROGEOLOGY				
WEST LINK SECTION - Subsection WLa	WL - 16	WL-47	Bridge	Underpass	Rossland Road East	G4G-1, G4W-2, WL16-1, MP10	Surficial silty to clayey aquitard to a depth of 2.6 to 3.1 mBGS. Silty sand and sand and gravel present from 3.1 to 4.6 mBGS. Silty sand till (Newmarket Till) aquitard below to a depth 10.5 mBGS. Shale bedrock encountered below till. Water table at 3.6 mBGS. Upward hydraulic gradient from bedrock to overburden. Evidence of groundwater discharge.	Potential for dewatering if excavating below water table or encounter sand and gravel units below silty clay aquitard. Water table expected to be at 3.5 mBGS.	Medium	No Watercourse (Street Crossing)			8
	WL - 17	WL-47	Culvert	Overpass	Lynde Creek tributary	G4G-1, G4W-2, WL16-1, MP10	Surficial silty to clayey aquitard to a depth of 2.6 to 3.1 mBGS. Silty sand and sand and gravel present from 3.1 to 4.6 mBGS. Silty sand till (Newmarket Till) aquitard below to a depth 10.5 mBGS. Shale bedrock encountered below till. Water table at 3.6 mBGS. Upward hydraulic gradient from bedrock to overburden. Evidence of groundwater discharge.	Potential for dewatering if excavating below water table or encounter sand and gravel units below silty clay aquitard. Water table expected to be at 3.5 mBGS.	Medium	Open Bottom Culvert	Moderately wide, well defined valley with old meander scars and 20-35 degree steep valleysides; meandering channel has undercut valleysides, which has led to localized slumps	Valley bottom sediments >1 m deep and dominantly gravelly silty sand alluvium with some clay, locally interbedded with buried organic material	8
	WL - 18	-	Bridge	Cancelled	CPR at Proposed Realigned Halls Rd	BH4	Surficial clayey silt aquitard underlain by silt till (Newmarket Till) aquitard. Shale bedrock encountered below till.	Potential for perched water table close to ground surface (<2.0 mBGS) in low permeability clays and till.	Medium	Open Bottom Culvert		Existing OGS/GSC mapping indicates alluvial deposits in within proposed bridge footprint	10
	WL - 19	-	Bridge	Subway	CPR at West Durham Link	None	Surficial glaciolacustrine clayey silt to a depth of 2.5 m, grading to sandy silt at the contact with till deposits. Silty sand till (Newmarket Till) aquitard below. Shale bedrock encountered below till. Water table expected at <2.0 mBGS.	Permanent groundwater control due to side wall seepage may be required. Needs to be assessed at detailed design. One option could be to use a passive gravity drain system to convey groundwater into storm water collection system or into Lynde Creek Tributary. Potential for dewatering and a PTTW due construction of groundwater collectors.. Water table expected to be at <2.0 mBGS.	High	No Watercourse (Street Crossing)			9
	WL - 19A	-	Bridge	Subway	CPR at West Durham Link	None	Surficial glaciolacustrine clayey silt to a depth of 2.5 m, grading to sandy silt at the contact with till deposits. Silty sand till (Newmarket Till) aquitard below. Shale bedrock encountered below till. Water table expected at <2.0 mBGS.	Permanent groundwater control due to side wall seepage may be required. Needs to be assessed at detailed design. One option could be to use a passive gravity drain system to convey groundwater into storm water collection system or into Lynde Creek Tributary. Potential for dewatering and a PTTW due construction of groundwater collectors.. Water table expected to be at <2.0 mBGS.	High	No Watercourse (Street Crossing)			9
	WL - 20	-	Bridge	Underpass	Taunton Rd	WL20-1, WL20-2, MP8	Surficial sandy silt to a depth of 3.1 mBGS. Sandy silt to clayey silt till (Newmarket Till) below to a depth of 17.2 mBGS. Water table expected to be close to ground surface (<2.0 mBGS).	Potential for perched water table close to ground surface (<2.0 mBGS) in low permeability clays and till.	Medium	No Watercourse (Street Crossing)			15
	WL - 21	WL-44	Culvert	Overpass	Lynde Creek tributary	None	No subsurface information at this stream crossing. Surficial silty sand and sand and gravel aquifer units may be underlain by silty sand till (Newmarket Till) aquitard. Water table expected to be close to ground surface within alluvial valley.	Perched water table (<1.0 mBGS) due to poor drainage through till unit. If excavating in permeable sediments, dewatering is anticipated.	Medium	Open Bottom Culvert	Moderately wide, well defined valley with old meander scars and 25-40 degree steep valleysides; meandering channel has undercut valleysides, which has led to localized slumps	Valley bottom sediments >1 m deep and dominantly gravelly silty sand alluvium with some clay, locally interbedded with buried organic material; presence of boulders in channel suggests till locally at or close to streambed elevation	20
	WL - 22	-	Bridge	Cancelled	Halls Road North	None	No subsurface information at this stream crossing. Surficial silty sand and sand and gravel aquifer units may be underlain by silty sand till (Newmarket Till) aquitard. Water table expected to be close to ground surface within alluvial valley.	Perched water table (<1.0 mBGS) due to poor drainage through till unit. If excavating in permeable sediments, dewatering is anticipated.	Medium	No Watercourse (Street Crossing)			20
	WL - 23	-	Bridge	Overpass	Winchester Rd West (Hwy 7)	WL23-1	Surficial sandy silt till (Newmarket Till) aquitard to a depth of 12.3 mBGS. Water table expected to be close to ground surface (<1.0 mBGS).	Potential for perched water table close to ground surface (<1.0 mBGS) in low permeability till.	Low	No Watercourse (Street Crossing)			55
	WL - 24	WL-42	Bridge	Crossing Road Overpass	Proposed Realigned Coronation Rd over Lynde Creek Tributary	WL24-1, WL24-2	Surficial aquitard, lacustrine and alluvial silts and fine sand. GWT <1 mbgs (water well records). Stream reconnaissance shows that the creek is intermittent.	Slight potential for dewatering (water table near surface at stream)	Low	Span Bridge	Narrow, well defined valley (once a glacial meltwater spillway) with 30 degree steep valleysides; meandering channel has undercut valleysides, which has led to localized slumps	Valley bottom sediments approx. 1 m deep silty gravelly sand alluvium overlying silt till, containing boulders	40
	WL - 25	WL-41	Bridge	Overpass	WL IC Ramp over far West Lynde Creek Tributary	None	Surficial sand and silt till (Newmarket Till) aquitard. Water table is perched and likely encountered at <2.0 mBGS.	Depth to water table is likely <2.0 mBGS. Watercourse perched on till and is intermittent.	Low	Span Bridge	Narrow, well defined valley (once a glacial meltwater spillway) with moderately steep valleysides and no geomorphic evidence of significant valleyside instability	Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	55
	WL - 26	WL-41	Bridge	Overpass	WL IC Ramp over far West Lynde Creek Tributary	WL26-1, WL26-2	Surficial sandy silt to clayey silt till (Newmarket Till) aquitard to a depth of 23.0 mBGS. Water table is perched and likely encountered at <2.0 mBGS.	Depth to water table is likely <2.0 mBGS. Watercourse perched on till and is intermittent.	Low	Span Bridge	Narrow, well defined valley (once a glacial meltwater spillway) with moderately steep valleysides and no geomorphic evidence of significant valleyside instability	Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	55
	WL - 27	WL-41	Bridge	Cancelled	407/WL IC Ramp W-S over far West Lynde Creek Tributary	WL27-1, WL27-2	Surficial sandy silt to clayey silt till (Newmarket Till) aquitard to a depth of 6.5 mBGS. Water table is perched and likely encountered at <2.0 mBGS.	Depth to water table is likely <2.0 mBGS. Watercourse perched on till and is intermittent.	Low	Span Bridge	Narrow, shallow valley with no geomorphic evidence of significant valleyside instability	Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	65
	WL - 28	-	Bridge	Underpass - IC Ramp	407/WL E-S	WL28-1, WL28-2	Surficial sandy silt to clayey silt till (Newmarket Till) aquitard to a depth of 6.3 mBGS. Water table is perched and likely encountered at <2.0 mBGS.	Depth to water table is likely <2.0 mBGS.	Low	No Watercourse (Street Crossing)			70
	WL - 29	-	Bridge	Underpass - IC Ramp	407/WL S-W	None	Surficial sand and silt till (Newmarket Till) aquitard. Water table is perched and encountered at <2.0 mBGS.	Depth to water table is likely <2.0 mBGS.	Low	No Watercourse (Street Crossing)			70
	WL - 30	WM-17	Bridge	Overpass	407/WL IC Ramp S-W over far West Lynde Creek Tributary	None	Surficial sand and silt till (Newmarket Till) aquitard. Water table is perched and encountered at <2.0 mBGS.	Depth to water table is likely <2.0 mBGS. Watercourse perched on till and is intermittent.	Low	Span Bridge	Narrow, shallow valley with no geomorphic evidence of significant valleyside instability	Valley bottom sediments likely <2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	75
	WL - 31	WM-17	Bridge	Overpass	407/WL IC Ramp S-W over Halls Road	WL31-1	Surficial sandy silt to clayey silt till (Newmarket Till) aquitard to a depth of 6.3 mBGS. Water table is perched and likely encountered at <2.0 mBGS.	Depth to water table is likely <2.0 mBGS. Watercourse perched on till and is intermittent.	Low	Span Bridge	Narrow, shallow valley with no geomorphic evidence of significant valleyside instability	Valley bottom sediments <1 m deep silty gravelly sand alluvium overlying silt till	75
	WL - 32	WM-19	Bridge	Overpass	407/WL IC Ramp E-S over West Lynde Creek Valley	None	Surficial sand to silty-sand aquifer within valley underlain by sandy silt till (Newmarket Till). Water table likely close to ground surface (<1.0 mBGS). Evidence of groundwater discharge into stream.	Shallow water table (<1.0 mBGS) and surficial sand aquifer. Dewatering may be required if excavating in alluvial sediments for foundations. PTTW may be required for dewatering.	Medium	Span Bridge	Narrow, moderately deep valley with comparatively steep east valleyside, but no geomorphic evidence of significant valleyside instability	Valley bottom sediments possibly >2 m deep and likely dominantly silty gravelly sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	45
	WL - 33	WM-19	Bridge	Underpass	Proposed Realigned Coronation Road over 407/WDL IC Ramp E-S	None	Surficial sand and silt till (Newmarket Till) aquitard. Potential to encounter a surficial sand aquifer. Water table is perched and encountered at <2.0 mBGS.	Depth to water table is likely <2.0 mBGS. Watercourse perched on till and is intermittent. A PTTW may be required for excavations if surficial sand aquifer is present.	Low	Span Bridge	Narrow, shallow valley with no geomorphic evidence of significant valleyside instability	Valley bottom sediments >1 m deep silty gravelly sand alluvium and glaciolacustrine silt, locally interbedded with buried organic material; sediments saturated and very loose	50

Site ranking for Hydrogeology: Low/Medium/High risk -in terms of sensitivity of the environment to construction, e.g. High risk - highly sensitive environment.

TABLE 10
Hydrogeology Site Ranking Table (WLb)

SECTION	Structure		Assumed Structure Type	Asumed Structure Category	Name	Data Source(s) at Structure	Groundwater Comments		SITE RANKING	Assumed Watercourse Crossing	Valley Geomorphology Based on Air Photo Interpretation	Valley Sediments & Wetlands Based on Air Photo Interpretation	Approx. Overburden Thickness (m), based on interpolation from geotechnical borehole and water well records
	ID	Drainage Crossing ID					SUBSURFACE CONDITIONS	REMARKS	HYDROGEOLOGY				
WEST LINK SECTION - Subsection WLb	WL - 1	WL-99	Culvert	Overpass	Lynde Creek tributary	Geological Mapping	Surficial clayey silt underlain by silt till (Newmarket Till) aquitard to a depth of between 9.1 and 16.8 mBGS. Shale bedrock encountered below till.	Potential for perched water table close to ground surface (<2.0 mBGS) in low permeability clays and till.	Low	Closed Bottom Culvert	Narrow, shallow, channelized valley with no geomorphic evidence of significant valleyside instability	Likely no appreciable alluvial deposits, based on field checks of similar valleys	6
	WL - 2	-	Bridge	Underpass	Lake Ridge Road	WL2-1, WL2-2	Surficial clayey silt aquitard underlain by silt till (Newmarket Till) aquitard to a depth of between 9.1 and 16.8 mBGS. Shale bedrock encountered below till.	Potential for perched water table close to ground surface (<2.0 mBGS) in low permeability clays and till.	Low	No Watercourse (Street Crossing)			6
	WL - 3	-	Bridge	Crossing Road Subway	CNR & GO at Lake Ridge Road	WL3-1, WL3-2, WL3-3	Surficial clayey silt aquitard underlain by silt till (Newmarket Till) aquitard to a depth of between 9.1 and 18.3 mBGS. Shale bedrock encountered below till.	Potential for perched water table close to ground surface (<2.0 mBGS) in low permeability clays and till.	Low	No Watercourse (Street Crossing)			6
	WL - 4	-	Bridge	Crossing Road	WL/401 W-N over Lake Ridge Road Ramp	WL4-1	Surficial clayey silt aquitard underlain by silt till (Newmarket Till) aquitard to a depth of 6.1 mBGS. Gravelly sand encountered below till.	Potential for perched water table close to ground surface (<2.0 mBGS) in low permeability clays and till.	Low	No Watercourse (Street Crossing)			6
	WL - 5	-	Bridge	Crossing Road	WL/401 W-N over Lake Ridge Road Ramp	WL5-2	Surficial clayey silt aquitard underlain by silt till (Newmarket Till) aquitard to a depth of 7.2 mBGS. Shale bedrock encountered below till.	Potential for perched water table close to ground surface (<2.0 mBGS) in low permeability clays and till.	Low	No Watercourse (Street Crossing)			4
	WL - 6	WL-50/51	Culvert	Overpass	WL/401 W-N over West Lynde Creek	WL5-2	Surficial clayey silt aquitard underlain by silt till (Newmarket Till) aquitard to a depth of 7.2 mBGS. Shale bedrock encountered below till. Ecoplans reports that Lynde Creek is intermittent at times.	Potential for perched water table close to ground surface (<2.0 mBGS) in low permeability clays and till. Some evidence of groundwater discharge. May require minor groundwater control.	Medium	Span Bridge (due to geomorphic size of crossing)	Moderately wide, shallow valley with no geomorphic evidence of significant valleyside instability	Valley bottom sediments may be >2 m deep and likely dominantly gravelly silty sand alluvium, locally interbedded with buried organic material, based on field checks of similar valleys	4
	WL - 7	-	Bridge	Underpass - IC Ramp	WL/401 W-N	WL7-1, WL7-2	Surficial clayey silt aquitard underlain by silt till (Newmarket Till) aquitard to a depth of between 7.7 and 8.6 mBGS. Shale bedrock encountered below till.	Potential for perched water table close to ground surface (<2.0 mBGS) in low permeability clays and till.	Low	No Watercourse (Street Crossing)			5
	WL - 8	-	Bridge	Crossing Road Overpass	WL/401 W-N over N-E ramp	WL8-1, WL8-2, WL8-3, BH9	Surficial clayey silt aquitard underlain by silt till (Newmarket Till) aquitard to a depth of between 6.4 and 6.7 mBGS. Shale bedrock encountered below till.	Potential for perched water table close to ground surface (<2.0 mBGS) in low permeability clays and till.	Low	No Watercourse (Street Crossing)			5
	WL - 9	-	Bridge	Underpass - IC Ramp	WL/401 N-E	WL9-1	Surficial clayey silt aquitard underlain by silt till (Newmarket Till) aquitard to a depth of 6.7 mBGS. Shale bedrock encountered below till.	Potential for perched water table close to ground surface (<2.0 mBGS) in low permeability clays and till.	Low	No Watercourse (Street Crossing)			5
	WL - 10	WL-100	Bridge	Overpass	Lynde Creek	WL10-1, WL11-1	Surficial clayey silt aquitard underlain by silt till (Newmarket Till) aquitard to a depth of 6.1 mBGS. Silty sand encountered below till. Water table at or near surface. Silty-sand alluvial deposit with organics. Provincially significant wetland present. Potential for significant groundwater discharge.	Water table likely <1.0 mBGS. Permeable sediments present in Lynde Creek valley wetland. A PTTW may be required for excavations.	High	Expand Existing Span Bridge	Moderately wide, shallow valley with old meander scars and no geomorphic evidence of significant valleyside instability	Valley bottom sediments >1 m deep and dominantly gravelly silty sand alluvium with some clay, locally interbedded with buried organic material	1
	WL - 11	WL-100	Bridge	Overpass	Lynde Creek	WL10-1, WL11-1	Surficial clayey silt aquitard underlain by silt till (Newmarket Till) aquitard to a depth of 6.1 mBGS. Silty sand encountered below till. Water table at or near surface. Silty-sand alluvial deposit with organics. Provincially significant wetland present. Potential for significant groundwater discharge.	Water table likely <1.0 mBGS. Permeable sediments present in Lynde Creek valley wetland. A PTTW may be required for excavations.	High	Expand Existing Span Bridge	Moderately wide, shallow valley with old meander scars and no geomorphic evidence of significant valleyside instability	Valley bottom sediments >1 m deep and dominantly gravelly silty sand alluvium with some clay, locally interbedded with buried organic material	1
	WL - 12	-	Bridge	Underpass	Dundas Street West	WL12-1	Surficial clayey silt aquitard underlain by silt till (Newmarket Till) aquitard to a depth of 9.1 mBGS. Shale bedrock encountered below till.	Potential for perched water table close to ground surface (<2.0 mBGS) in low permeability clays and till.	Low	No Watercourse (Street Crossing)			6
	WL - 13	-	Culvert	Overpass	drainage swale	None	Surficial clayey silt aquitard underlain by silt till (Newmarket Till) aquitard. Shale bedrock encountered below till.	Potential for perched water table close to ground surface (<2.0 mBGS) in low permeability clays and till.	Low	No Watercourse (Street Crossing)	Narrow, shallow swale	Likely no appreciable alluvial deposits, based on field checks of similar valleys	4
	WL - 14	WL-48	Culvert	Cancelled	Proposed Realigned Halls Road	None	Surficial clayey silt aquitard underlain by silt till (Newmarket Till) aquitard. Shale bedrock encountered below till.	Potential for perched water table close to ground surface (<2.0 mBGS) in low permeability clays and till.	Low	Open Bottom Culvert	Moderately wide, shallow valley with old meander scars, 20^{o} steep valleysides, and no geomorphic evidence of significant valleyside instability	Valley bottom sediments >1 m deep and dominantly gravelly silty sand alluvium with some clay, locally interbedded with buried organic material	3
	WL - 15	-	Bridge	Cancelled	Halls Road North	None	Surficial clayey silt aquitard underlain by silt till (Newmarket Till) aquitard. Shale bedrock encountered below till.	Potential for perched water table close to ground surface (<2.0 mBGS) in low permeability clays and till.	Low	No Watercourse (Street Crossing)			4

Site ranking for Hydrogeology: Low/Medium/High risk -in terms of sensitivity of the environment to construction, e.g. High risk - highly sensitive environment.

Table 11
Highway 407 East Extension
Western Section
Deep Cuts Water Table Drawdown Analysis

AECOM ID	Drawdown Curve Figure	Location	Chainage	Maximum Depth of Cut	Data Sources	Geology/ Hydrogeology	Depth to Groundwater	Estimated Hydraulic Conductivity K (m/s)	Estimated Radius of Influence (Drawdown) (m)	Potentially Affected Private Wells	Proposed Mitigation/ Compensation Measures	Comments
DC-W1	F1	Brougham Creek Tributary to Sideline 14	13+225 to 13+580 (Mainline)	18 m	MOE Well# 4604783, 4604674, WM5-1, WM8-1	Newmarket Till and Glaciolacustrine clayey silt aquitard units. No significant aquifer units are anticipated over the extent of the deep cut. May encounter a seasonal shallow, perched water table if thin surficial sand deposits are present.	~4.0 m	3.2E-07 (5.6E-06)	84 m (270 m)	No wells are anticipated to be affected by deep cut	None	Site specific data is required to confirm analysis. Although, information infoirmation from preliminary deisgn suggest that aquifer units will be avoided, the values in brackets are the estimated values and effects if a significant aquifer unit is encountered. Encountering these features will significantly increase the radius of influence. Dewatering and a PTTW will be required if a confined aquifer unit is found.
DC-W2	F2	Between Balsam Road and Kinsale/Audley Road	18+060 to 18+300 (Mainline)	12 m	WM25-1, WM27-1, WM27-2	Newmarket Till Aquitard to a depth of at least 9.3 m -sandy silt till	2.2 to 9.1 mBGS	3.2E-07	52 m	No wells are anticipated to be affected by deep cut	None	Site specific data is required to confirm analysis.
DC-W3	F3	Between Kinsale Road and Lake Ridge Road	18+700 to 19+200 (Mainline)	7 m	WM27-1, WM27-2	Newmarket Till Aquitard to a depth of at least 9.3 m -sandy silt till	2.2 to 9.1 mBGS	3.2E-07	28 m	No wells are anticipated to be affected by deep cut	None	Site specific data is required to confirm analysis.
DC-W4	F4	Lake Ridge Road	19+560 to 19+700 (Mainline)	8 m	WM28-1, WM29-1, WM29-2, WL31-1, P10	Newmarket Till Aquitard to a depth of at least 7.8 m -sandy silt till	~3.4 mBGS	3.2E-07	26 m	No wells are anticipated to be affected by deep cut	None	Site specific data is required to confirm analysis.
DC-W5	F5	West of Coronation Road	20+275 to 20+700	8 m	WL28-1, WL28-2, P11	Newmarket Till Aquitard to a depth of at least 6.3 m -sandy silt till	<2.0 mBGS	3.2E-07	34 m	No wells are anticipated to be affected by deep cut	None	Site specific data is required to confirm analysis.
DC-W6	F6	Country Lane	21+450 to 21+590 (Mainline)	11.5 m	WM35-1, WM35-2	Newmarket Till Aquitard to a depth of at least 9.3 m -sandy silt till	<2.0 mBGS	3.2E-07	50 m	No wells are anticipated to be affected by deep cut	None	Site specific data is required to confirm analysis.
DC-W7	F7	Cochrane Street	22+325 to 22+625 (Mainline)	7.5 m	WM38-1, WM38-2	Surficial sand and silt till (Newmarket Till) aquitard. Sand unit encountered in WM38-1 between 4.6 and 9.1 mBGS. Till unit continues below.	<5.0 mBGS	3.2E-07	12 m	No wells are anticipated to be affected by deep cut even if sand lens in encountered and drained.	None	Site specific data is required to confirm analysis.
DC-W8	F8	Rossland Road West and Lynde Creek Tributary	12+400 to 12+890 (Westlink)	6.5 m	G4W-1, G4W-2, WL20-1, BH3, BH4	Surficial glaciolacustrine clayey silt to a depth of 2.5 m, grading to sandy silt at the contact with till deposits. Silty sand till (Newmarket Till) aquitard below. Shale bedrock encountered below till.	<2.0 m	3.2E-07 (5.6E-06)	26 m (88 m)	No wells are anticipated to be affected by deep cut.	None	The vertical geometry of this cut creates a "bowl" strcuture at the base of the cut, where surface water and groundwater will accumulate. Sandy deposits at the contact between the glaciolacustrine materials and the till may cause permanent side wall seepage. Permanent passive groundwater control may be required.

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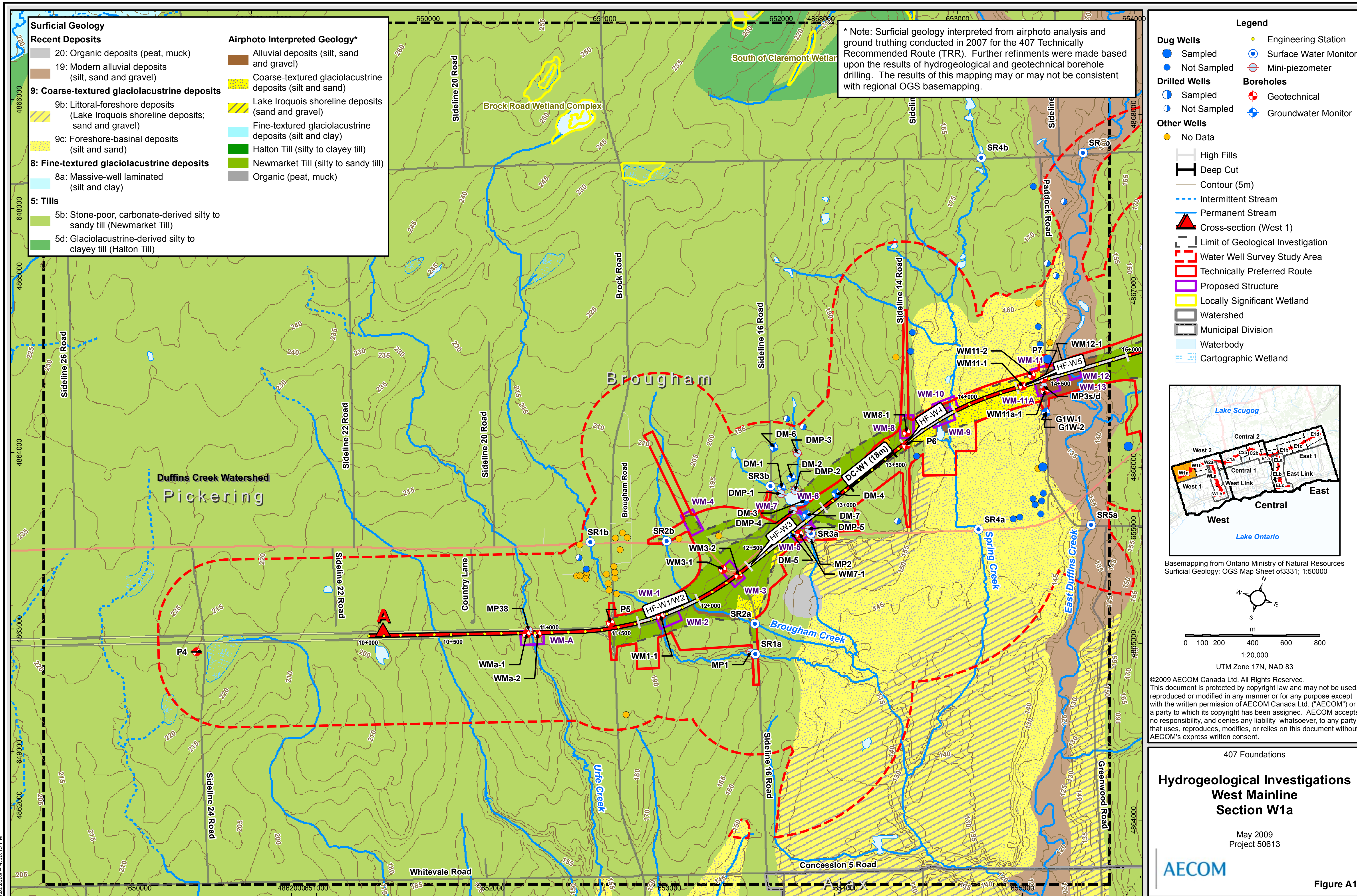
Appendix A

Hydrogeological Figures and Cross-Sections


Surficial Geology
Recent Deposits
20: Organic deposits (peat, muck)
19: Modern alluvial deposits (silt, sand and gravel)
9: Coarse-textured glaciolacustrine deposits
9b: Littoral-foreshore deposits (Lake Iroquois shoreline deposits; sand and gravel)
9c: Foreshore-basinal deposits (silt and sand)
8: Fine-textured glaciolacustrine deposits
8a: Massive-well laminated (silt and clay)
5: Tills
5b: Stone-poor, carbonate-derived silty to sandy till (Newmarket Till)
5d: Glaciolacustrine-derived silty to clayey till (Halton Till)
Airphoto Interpreted Geology*
Alluvial deposits (silt, sand and gravel)
Coarse-textured glaciolacustrine deposits (silt and sand)
Lake Iroquois shoreline deposits (sand and gravel)
Fine-textured glaciolacustrine deposits (silt and clay)
Halton Till (silty to clayey till)
Newmarket Till (silty to sandy till)
Organic (peat, muck)
* Note: Surficial geology interpreted from airphoto analysis and ground truthing conducted in 2007 for the 407 Technically Recommended Route (TRR). Further refinements were made based upon the results of hydrogeological and geotechnical borehole drilling. The results of this mapping may or may not be consistent with regional OGS basemapping.
Legend
Dug Wells
Sampled
Not Sampled
Drilled Wells
Sampled
Not Sampled
Other Wells
No Data
Engineering Station
Surface Water Monitor
Mini-piezometer
Boreholes
Geotechnical
Groundwater Monitor
High Fills
Deep Cut
Contour (5m)
Intermittent Stream
Permanent Stream
Cross-section (West 1)
Limit of Geological Investigation
Water Well Survey Study Area
Technically Preferred Route
Proposed Structure
Locally Significant Wetland
Watershed
Municipal Division
Waterbody
Cartographic Wetland
Brougham
Pickering
Duffins Creek Watershed
Brock Road Wetland Complex
South of Claremont Wetland
Sideline 26 Road
Sideline 24 Road
Sideline 22 Road
Sideline 20 Road
Sideline 16 Road
Sideline 14 Road
Brock Road
Brougham Road
Country Lane
Paddock Road
Greenwood Road
Whitevale Road
Concession 5 Road
Urfe Creek
Brougham Creek
Spring Creek
East Duffins Creek
Ajax
Lake Scugog
Lake Ontario
West
Central
East
Basemapping from Ontario Ministry of Natural Resources
Surficial Geology: OGS Map Sheet of3331; 1:50000
1:20,000
UTM Zone 17N, NAD 83
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Hydrogeological Investigations
West Mainline
Section W1a
May 2009
Project 50613
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Figure A1
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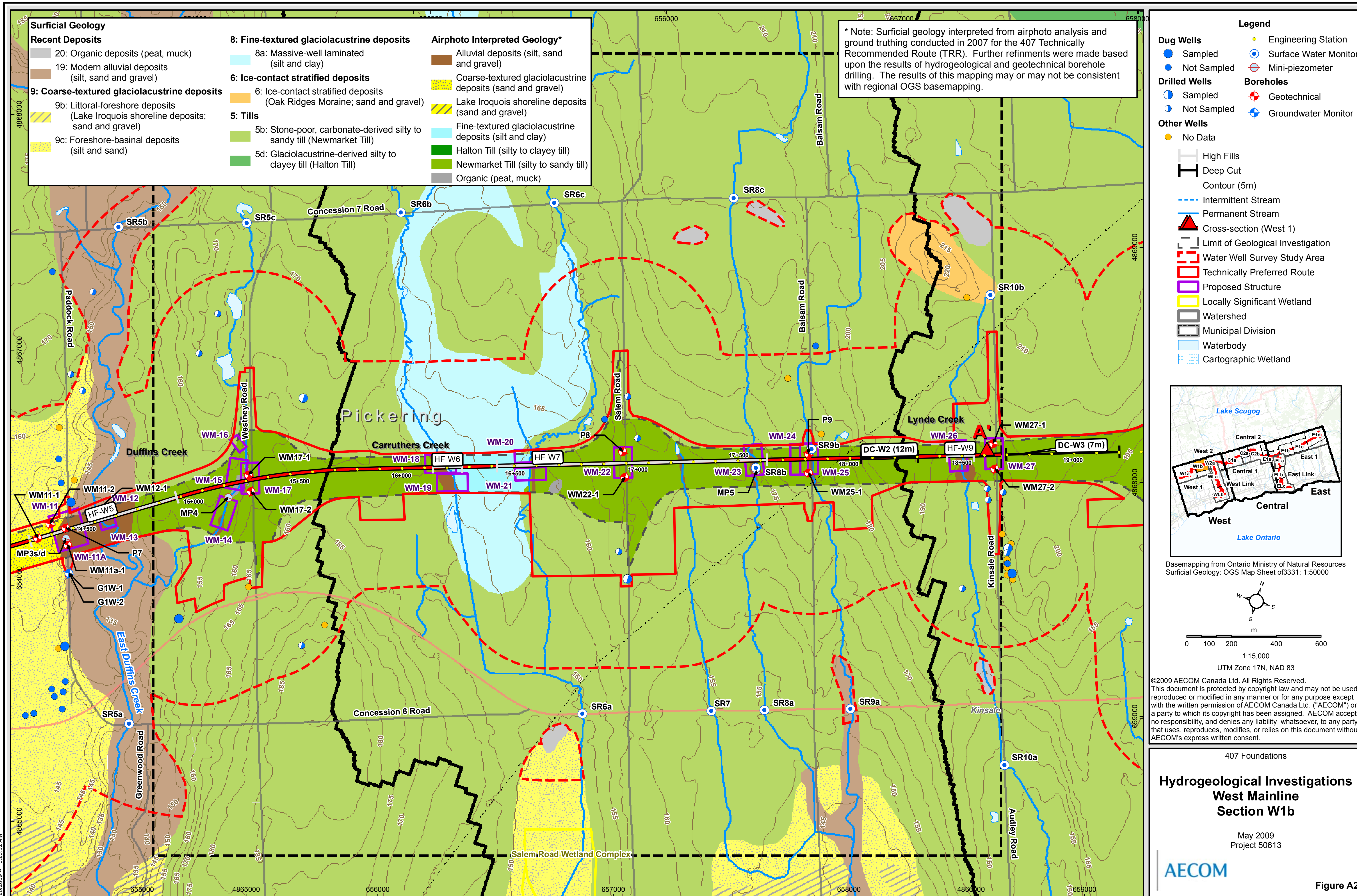

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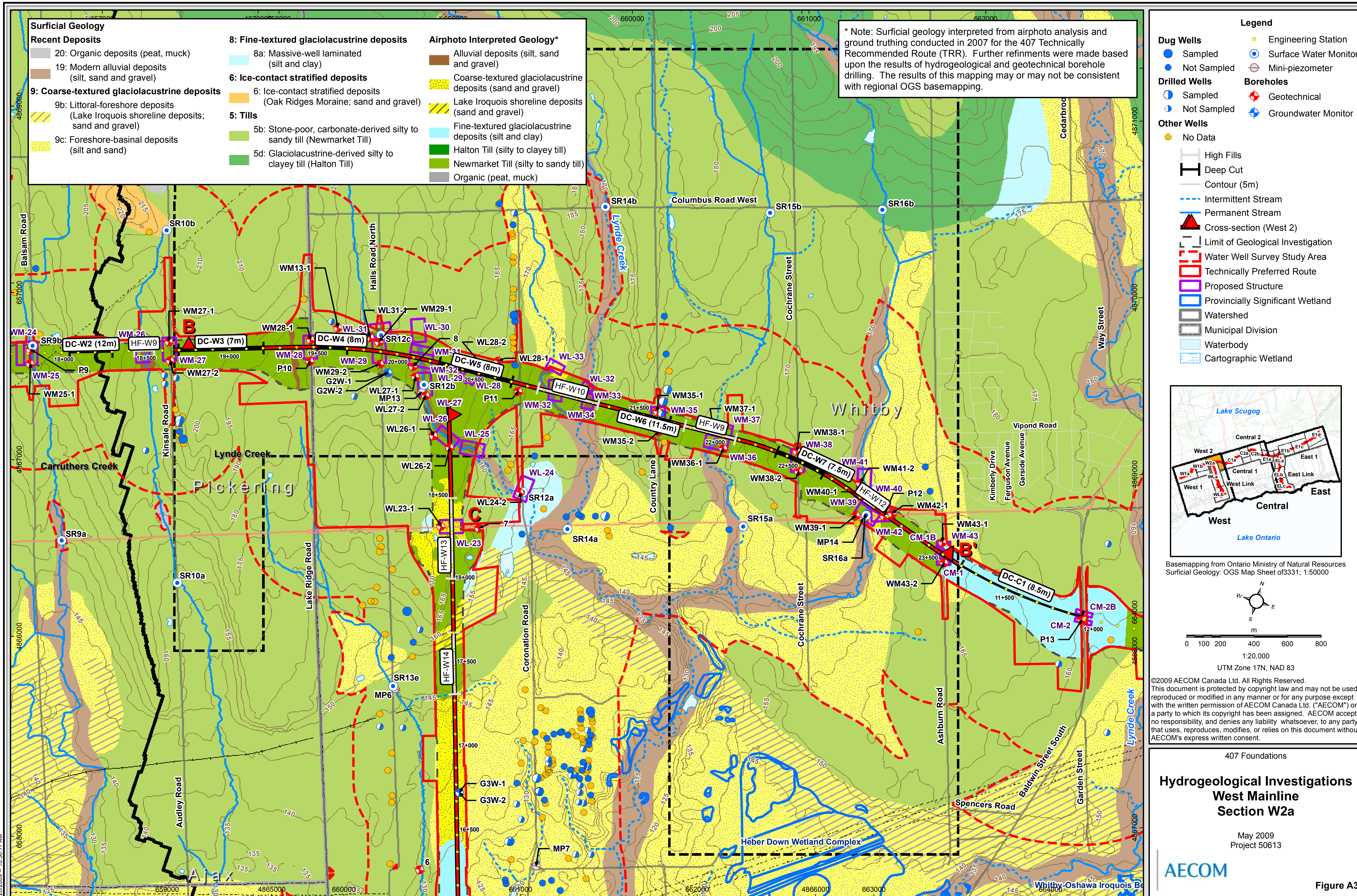
Surficial Geology
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9: Coarse-textured glaciolacustrine deposits
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8: Fine-textured glaciolacustrine deposits
8a: Massive-well laminated (silt and clay)
6: Ice-contact stratified deposits
6: Ice-contact stratified deposits (Oak Ridges Moraine; sand and gravel)
5: Tills
5b: Stone-poor, carbonate-derived silty to sandy till (Newmarket Till)
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Organic (peat, muck)
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Legend
Dug Wells
Sampled
Not Sampled
Drilled Wells
Sampled
Not Sampled
Other Wells
No Data
Engineering Station
Surface Water Monitor
Mini-piezometer
Boreholes
Geotechnical
Groundwater Monitor
High Fills
Deep Cut
Contour (5m)
Intermittent Stream
Permanent Stream
Cross-section (West 2)
Limit of Geological Investigation
Water Well Survey Study Area
Technically Preferred Route
Proposed Structure
Provincially Significant Wetland
Watershed
Municipal Division
Waterbody
Cartographic Wetland
Lake Scugog
Lake Ontario
West
Central
East
Basemapping from Ontario Ministry of Natural Resources
Surficial Geology: OGS Map Sheet of3331; 1:50000
0 100 200 400 600 800 m
1:20,000
UTM Zone 17N, NAD 83
Whitby
Pickering
Ajax
Lynde Creek
Carruthers Creek
Balsam Road
Kinsale Road
Halls Road North
Lake Ridge Road
Audley Road
Coronation Road
Columbus Road West
Country Lane
Cochrane Street
Ashburn Road
Vipond Road
Kimberly Drive
Ferguson Avenue
Garside Avenue
Way Street
Cedarbrook
Baldwin Street South
Garden Street
Spencers Road
Heber Down Wetland Complex
Whitby-Oshawa Iroquois Be
DC-W2 (12m)
DC-W3 (7m)
DC-W4 (8m)
DC-W5 (8m)
DC-W6 (11.5m)
DC-W7 (7.5m)
DC-C1 (8.5m)
HF-W9
HF-W10
HF-W12
HF-W13
HF-W14
B
B'
C
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Hydrogeological Investigations
West Mainline
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May 2009
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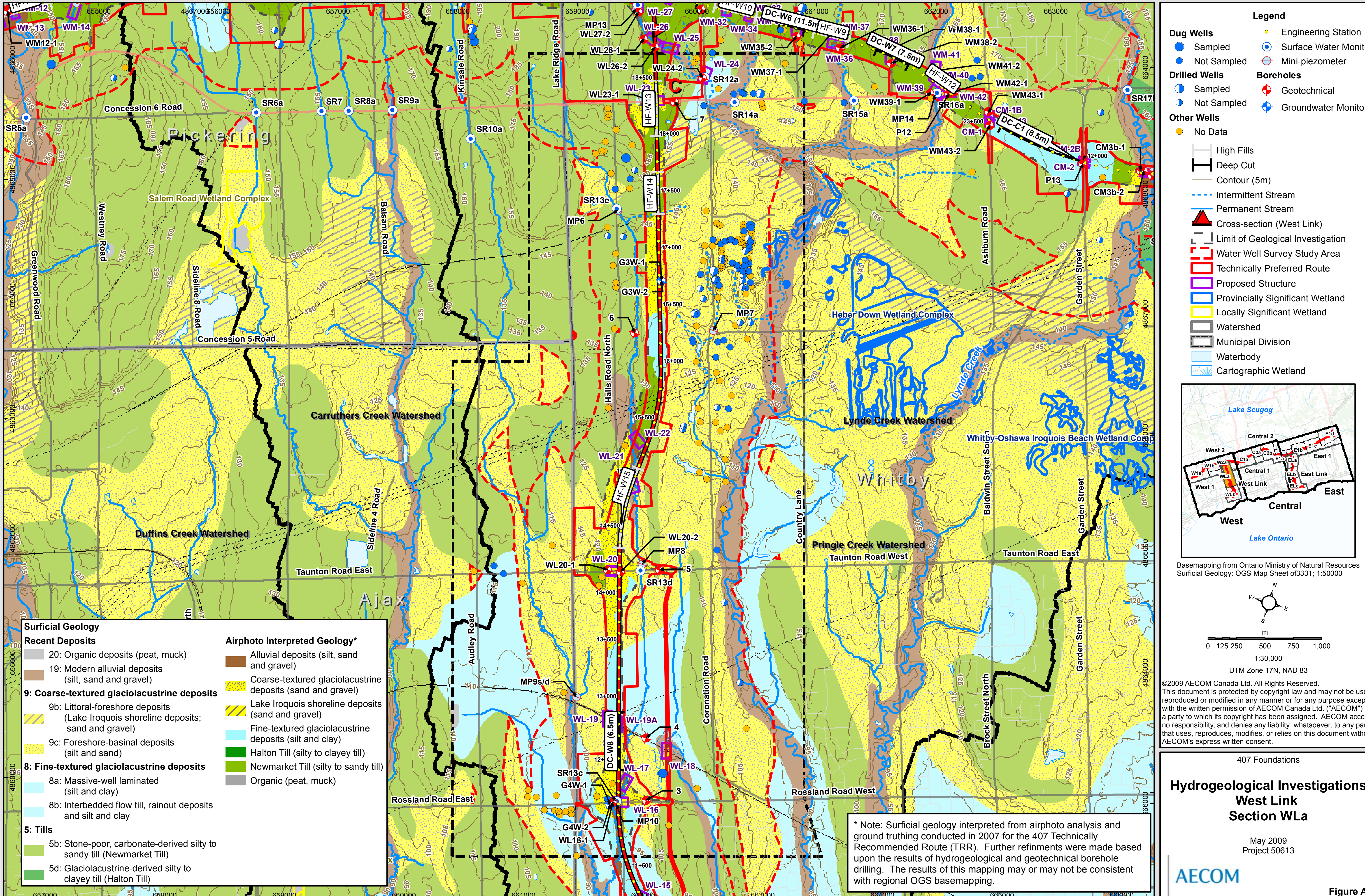
Figure A3



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Hydrogeological Investigations West Link Section WLa

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Figure A4

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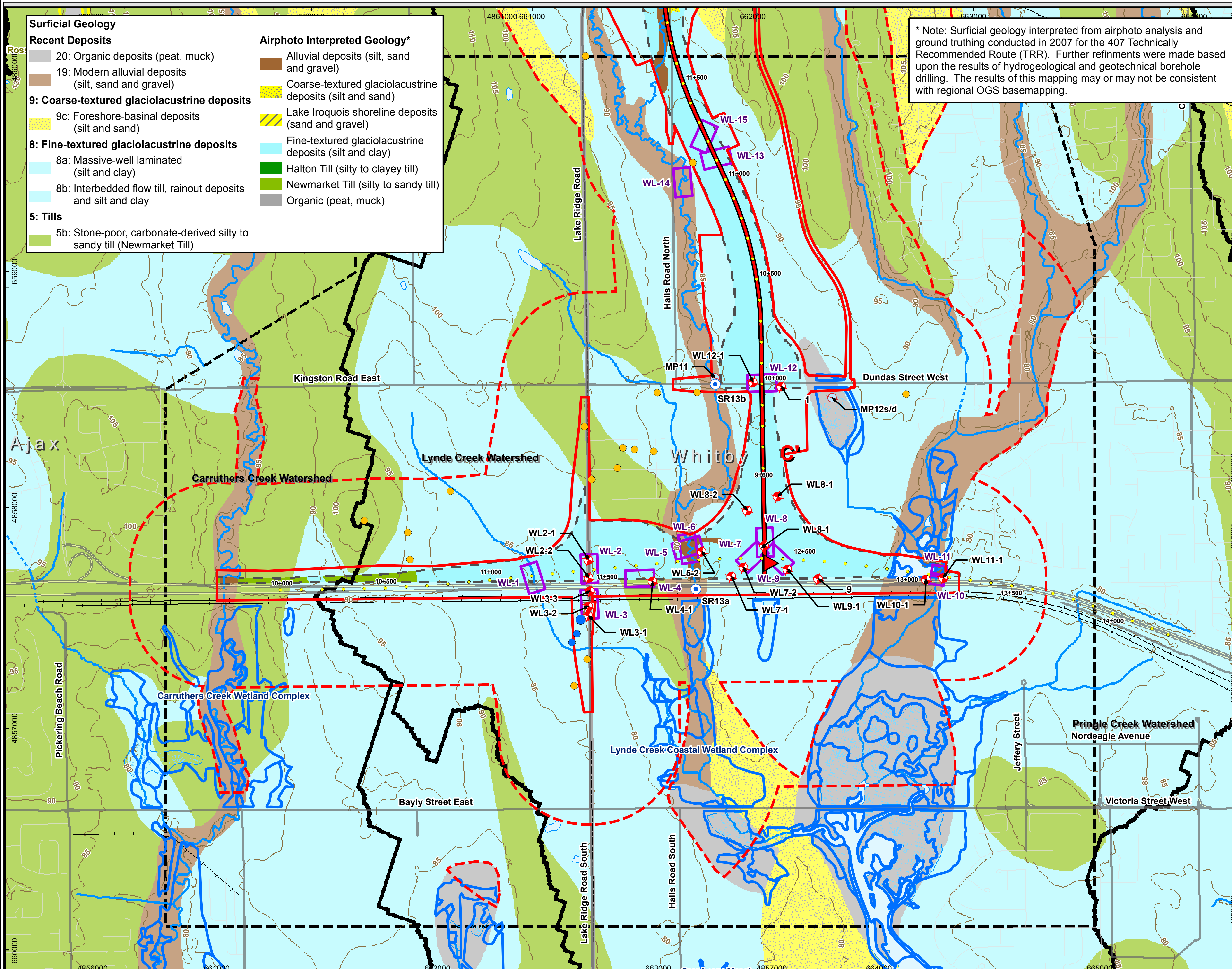

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Hydrogeological Investigations West Link Section WLb

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Figure A5

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Legend

- Sand and Gravel
- Sand
- Clayey Silt Till (Halton Till)
- Silty Sand to Sandy Silt Till (Newmarket Till)
- Silt and Clay
- Bedrock (Shale)
- Potential Oak Ridges Moraine

WM26 DC-W1 — PROPOSED STRUCTURE OR DEEP CUT LOCATION
4600545 — BOREHOLE LOCATION AND IDENTIFICATION
GROUND SURFACE
PROPOSED ROAD PROFILE
INFERRED STRATIGRAPHIC CONTACT
WATER LEVEL
SCREENED INTERVAL
OPEN BOREHOLE

Notes:
- Stratigraphy inferred from MOE water well records, geotechnical borehole logs completed by Golder Associates (2007-2008), geotechnical borehole logs from the MTO Foundation Investigation and Design Report (1994), and from Gartner Lee Limited (acting as AECOM) groundwater monitor borehole logs (2008), within 500m of the cross-section line and refined from the Ontario Geological Survey's regional geological model.
- Ground surface derived from 10m digital elevation model.

Horizontal 1 : 10,000
Vertical 1 : 500

File Name:	50613-X01-R5.dwg		
Reviewed by:	SJU	Prepared by:	JEP
Date Issued:	May, 2009	Project Number:	50613

407 East EA

West Mainline
Section W1
Geological Cross Section A-A'

May, 2009
Project 50613

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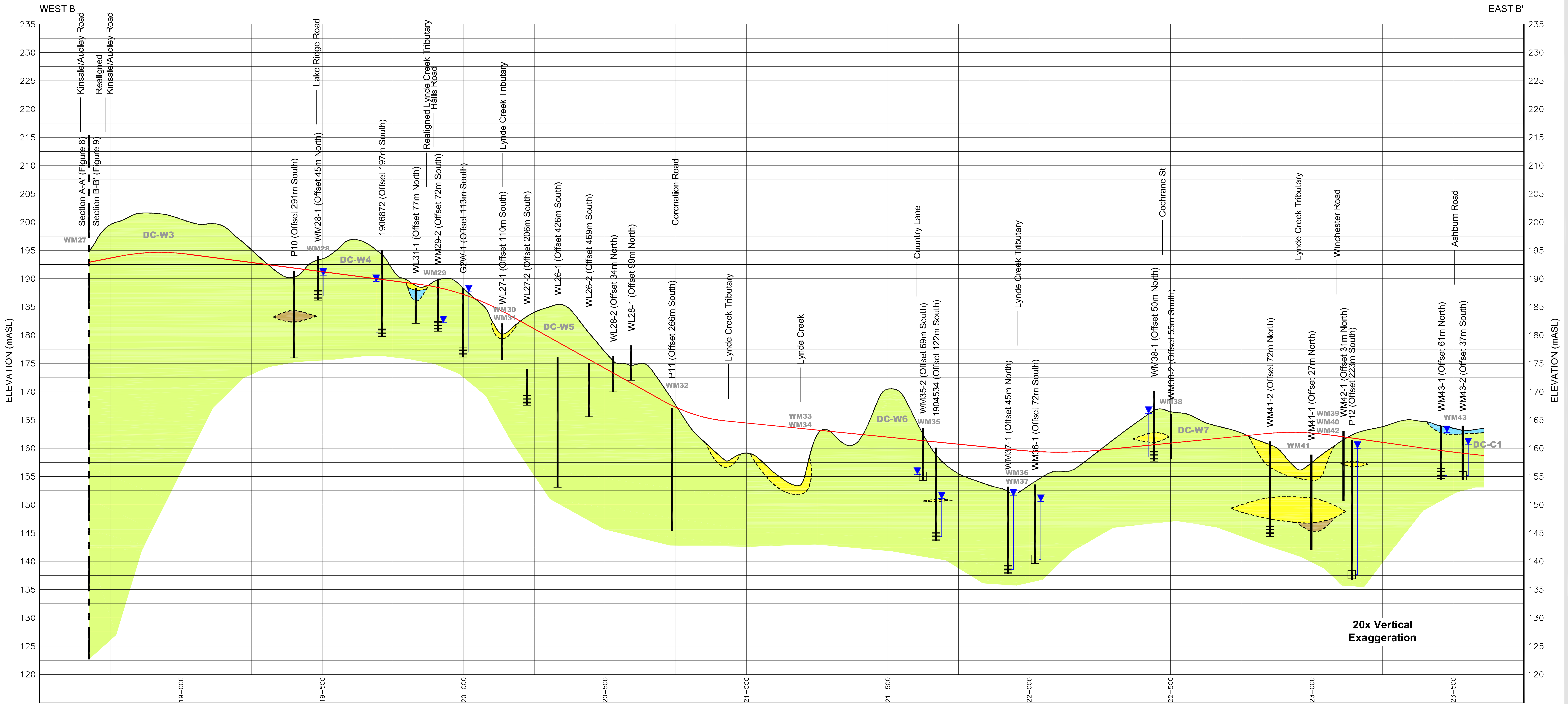
Figure A6



Legend

- Sand and Gravel
- Sand
- Clayey Silt Till (Halton Till)
- Silty Sand to Sandy Silt Till (Newmarket Till)
- Silt and Clay
- Bedrock (Shale)
- Potential Oak Ridges Moraine

- WM26 / DC-W1 — PROPOSED STRUCTURE OR DEEP CUT LOCATION
- 4600545 — BOREHOLE LOCATION AND IDENTIFICATION
- GROUND SURFACE
- PROPOSED ROAD PROFILE
- INFERRED STRATIGRAPHIC CONTACT
- WATER LEVEL
- SCREENED INTERVAL
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Horizontal 1 : 10,000
0 50 100 200 300 400 m
0 2.5 5 10 15 20 m
Vertical 1 : 500

File Name:	50613-X01-R5.dwg		
Reviewed by:	SJU	Prepared by:	JEP
Date Issued:	May, 2009	Project Number:	50613

407 East EA

West Mainline
Section W2
Geological Cross Section B-B'

May, 2009
Project 50613

AECOM

Figure A7

Legend

- Sand and Gravel
- Sand
- Clayey Silt Till (Halton Till)
- Silty Sand to Sandy Silt Till (Newmarket Till)
- Silt and Clay
- Bedrock (Shale)
- Potential Oak Ridges Moraine

- WL12 / DC-W1 — PROPOSED STRUCTURE OR DEEP CUT LOCATION
- 4600545 — BOREHOLE LOCATION AND IDENTIFICATION
- GROUND SURFACE
- PROPOSED ROAD PROFILE
- INFERRED STRATIGRAPHIC CONTACT
- WATER LEVEL
- SCREENED INTERVAL
- OPEN BOREHOLE

Notes:
- Stratigraphy inferred from MOE water well records, geotechnical borehole logs completed by Golder Associates (2007-2008), geotechnical borehole logs from the MTO Foundation Investigation and Design Report (1994), and from Gartner Lee Limited (acting as AECOM) groundwater monitor borehole logs (2008), within 500m of the cross-section line and refined from the Ontario Geological Survey's regional geological model.
- Ground surface derived from 10m digital elevation model.

Horizontal 1 : 10,000
Vertical 1 : 500

File Name:	50613-X01-R5.dwg		
Reviewed by:	SJU	Prepared by:	JEP
Date Issued:	May, 2009	Project Number:	50613

407 East EA

Section West Link Geological Cross Section C-C'

May, 2009
Project 50613

AECOM

Figure A8

Appendix B

Hydrogeology Borehole Logs

Ministry of Transportation Ontario

Gartner Lee Limited

RECORD OF BOREHOLE No G1W-1

 METRIC

G.W.P. 50-613 LOCATION N 4866140 & E 654244 ORIGINATED BY HSA

HWY 407 BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID) COMPILED BY CRC

DATUM Geodetic DATE 12.11.07 - 12.11.07 CHECKED BY TLC

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
144.0 / 0.0	**FILL** Brown fine sand, some gravel, moist, compact.	1	SS	19	144	
143.4 / 0.6	**SAND** Brown fine to coarse sand, trace silt and clay, saturated, compact to dense.	2	SS	28	143	1 84 8 7
		3	SS	32	142	
141.7 / 2.3	**SANDY SILT** Brown sandy silt becoming, some clay, saturated, soft to very stiff.	4	SS	13	141	
	-Increase in sand content (fine to medium) from about 3.1 to 4.6 m.	5	SS	8		
	-Becoming grey in colour below about 3.8 m.	6	SS	15	140	0 23 64 13
		7	SS	53	139	
137.9 / 6.1	**SILTY CLAY** Light grey to grey silty clay, saturated, loose to compact.	8	SS	13	138 / 137	
	-Trace gravel encountered with increasing sand content below about 7.6 and 9.0 m.	9	SS	3	136	
		10	SS	25	135 / 134	

Continued Next Page

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

+³, ×³: Numbers refer to Sensitivity   20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Gartner Lee Limited

RECORD OF BOREHOLE No G1W-1

 METRIC

G.W.P. 50-613 LOCATION N 4866140 & E 654244 ORIGINATED BY HSA

HWY 407 BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID) COMPILED BY CRC

DATUM Geodetic DATE 12.11.07 - 12.11.07 CHECKED BY TLC

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
144.0					134	8 5 40 47
		11	SS	3	133 / 132 / 131	
130.3 / 13.7	Borehole terminated at 13.72 m in silty clay. Water level: 2.48 metres below ground measured July, 2008.					

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

+³, ×³: Numbers refer to Sensitivity   20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Gartner Lee Limited

RECORD OF BOREHOLE No G1W-2

1 OF 1 **METRIC**

G.W.P. 50-613 | LOCATION N 4866138 & E 654544 | ORIGINATED BY HSA

HWY 407 | BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID) | COMPILED BY CRC

DATUM Geodetic | DATE 12.11.07 - 12.11.07 | CHECKED BY TLC

ELEV / DEPTH	DESCRIPTION	ELEVATION SCALE
143.9 / 0.0	**FILL** Brown fine sand, some gravel, moist, compact.	
143.3 / 0.6	**SAND** Brown fine to coarse sand, trace silt and clay, saturated, compact to dense.	143, 142
141.6 / 2.3	**SANDY SILT** Brown sandy silt becoming, some clay, saturated, compact to dense. -Increase in sand content (fine to medium) from about 3.1 to 4.6 m. -Becoming grey in colour below about 3.8 m.	141, 140, 139, 138
137.8 / 6.1	Borehole terminated at 6.10 m in sandy silt. Water level: 0.62 metres below ground measured July, 2008. *Please note borehole was augered without sampling. Lithology inferred from soils sampled at adjacent borehole G1W-1.*	

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+ ³, × ³ : Numbers refer to Sensitivity   20 / 15 ◆ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 407 HYDROGEOLOGY.GPJ 5/28/09

Ministry of Transportation Ontario

Gartner Lee Limited

RECORD OF BOREHOLE No G2W-1

1 OF 2 **METRIC**

G.W.P. 50-613 | LOCATION N 4868197 & E 659315 | ORIGINATED BY HSA

HWY 407 | BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID) | COMPILED BY CRC

DATUM Geodetic | DATE 1.15.08 - 1.15.08 | CHECKED BY TLC

ELEV / DEPTH	DESCRIPTION
189.0 / 0.0	**TOPSOIL** Dark grey clayey silt, organics, moist, loose.
188.2 / 0.8	**SANDY SILT TO SILTY SAND TILL** (Newmarket Till) Brown sandy silt to silty sand till, some clay, trace to some fine gravel, massive, moist, compact to dense. -Becoming saturated below about 4.6 m.
181.4 / 7.6	**SILT TILL** (Newmarket Till) Grey silt till, some fine sand, trace clay, trace gravel, saturated, very dense.
179.9 / 9.1	**SILTY SAND TILL** (Newmarket Till) Grey silty sand till, some clay, some sub-rounded to sub-angular gravel, massive, saturated, very dense.

NUMBER	TYPE	"N" VALUES	GR SA SI CL
1	SS	8	
2	SS	20	5 36 48 11
3	SS	78/ 0.28m	
4	SS	69	
5	SS	83/ 0.28m	28 34 26 12
6	SS	50/ 0.10m	
7	SS	50/ 0.10m	
8	SS	50/ 0.13m	
9	SS	50/ 0.10m	
10	SS	50/ 0.13m	21 36 29 14

Elevation scale: 189, 188, 187, 186, 185, 184, 183, 182, 181, 180, 179

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

+ ³, × ³ : Numbers refer to Sensitivity   20 / 15 ◆ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 407 HYDROGEOLOGY.GPJ 5/28/09

Ministry of Transportation Ontario

Gartner Lee Limited

RECORD OF BOREHOLE No G2W-1

METRIC

G.W.P. 50-613 | LOCATION N 4868197 & E 659315 | ORIGINATED BY HSA

HWY 407 | BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID) | COMPILED BY CRC

DATUM Geodetic | DATE 1.15.08 - 1.15.08 | CHECKED BY TLC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)
189.0					179	
178.3 / 10.7	**CLAYEY SILT** Grey clayey silt, some fine to medium sand, trace gravel, saturated, hard.	11	SS	50/ 0.13m	178	o
176.7		12	SS	50/ 0.15m	177	o
12.3	Borehole terminated at 12.30 m in clayey silt. Water level: 1.54 metres below ground measured July, 2008.					

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+³, ×³: Numbers refer to Sensitivity; 20 / 15 ◆ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 407 HYDROGEOLOGY.GPJ 5/28/09

Ministry of Transportation Ontario

Gartner Lee Limited

RECORD OF BOREHOLE No G2W-2

METRIC

G.W.P. 50-613 | LOCATION N 4868198 & E 659316 | ORIGINATED BY HSA

HWY 407 | BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID) | COMPILED BY CRC

DATUM Geodetic | DATE 1.16.08 - 1.16.08 | CHECKED BY TLC

ELEV / DEPTH	DESCRIPTION	ELEVATION SCALE
188.9 / 0.0	**TOPSOIL** Dark grey clayey silt, organics, moist, loose.	
188.1 / 0.8	**SANDY SILT TO SILTY SAND TILL** (Newmarket Till) Brown sandy silt to silty sand till, some clay, trace to some fine gravel, massive, moist, compact to dense. -Becoming saturated below about 4.6 m.	188, 187, 186, 185, 184, 183
182.6 / 6.3	Borehole terminated at 6.3 m in sandy silt to silty sand till. Water level: 1.905 metres below ground measured July, 2008. *Please note borehole was augered without sampling. Lithology inferred from soils sampled at adjacent borehole G2W-1.*	

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+³, ×³: Numbers refer to Sensitivity; 20 / 15 ◆ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 407 HYDROGEOLOGY.GPJ 5/28/09

Ministry of Transportation Ontario — Gartner Lee Limited

RECORD OF BOREHOLE No G3W-1 — 1 OF 2 — METRIC

G.W.P. 50-613 | LOCATION N 4865864 & E 660389 | ORIGINATED BY HSA

HWY 407 | BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID) | COMPILED BY CRC

DATUM Geodetic | DATE 3.27.08 - 3.27.08 | CHECKED BY TLC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
137.0								
136.8 / 0.0	**TOPSOIL** Brown silty sand, trace gravel, rich organics, loose, moist.	1	SS	12				
0.2	**SAND** Dark brown fine with some medium sand, trace gravel, trace clay, saturated, compact to dense.	2	SS	56				
135.3 / 1.7	**SANDY SILT** Grey sandy silt, some gravel, trace clay, moist to saturated, compact to very dense.	3	SS	24				
		4	SS	32	17	27	41	15
		5	SS	21				
		6	SS	69				
132.4 / 4.6	**SAND and GRAVEL** Grey sand and gravel, trace silt, trace clay, saturated, compact to dense.	7	SS	51	52	36	9	3
		8	SS	50/ 0.13m				
130.9 / 6.1	**SILTY SAND TILL** (Newmarket Till) Grey silty sand till, some clay, trace gravel, massive, moist, very dense.	9	SS	50/ 0.10m				
		10	SS	50/ 0.13m				
		11	CS					
		12	CS					

Elevation scale: 137 – 127

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity — 15 ⊕ 5 (20 / 10) (%) STRAIN AT FAILURE

ONTMT4S 407 HYDROGEOLOGY.GPJ 5/28/09

Ministry of Transportation Ontario — Gartner Lee Limited

RECORD OF BOREHOLE No G3W-1 — 2 OF 2 — METRIC

G.W.P. 50-613 | LOCATION N 4865864 & E 660389 | ORIGINATED BY HSA

HWY 407 | BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID) | COMPILED BY CRC

DATUM Geodetic | DATE 3.27.08 - 3.27.08 | CHECKED BY TLC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
137.0								
		13	CS		9	39	37	15
125.4 / 11.6	Borehole terminated at 11.58 m in silty sand till. Water level: 7.12 metres below ground measured July, 2008.							

Elevation scale: 127 – 126

+ 3, × 3: Numbers refer to Sensitivity — 15 ⊕ 5 (20 / 10) (%) STRAIN AT FAILURE

ONTMT4S 407 HYDROGEOLOGY.GPJ 5/28/09

Ministry of Transportation Ontario — Gartner Lee Limited

RECORD OF BOREHOLE No G3W-2

METRIC

G.W.P. 50-613	LOCATION N 4865864 & E 660389	ORIGINATED BY HSA	
HWY 407	BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID)	COMPILED BY CRC	
DATUM Geodetic	DATE 3.27.08 - 3.27.08	CHECKED BY TLC	

SOIL PROFILE / SAMPLES (NUMBER, TYPE, "N" VALUES) / GROUND WATER CONDITIONS / ELEVATION SCALE / DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100) / PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60 / UNIT WEIGHT γ kN/m³ / REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR SA SI CL
136.7					
136.5 / 0.0 – 0.2	**TOPSOIL** Brown silty sand, trace gravel, rich organics, loose, moist.				
	SAND Dark brown fine with some medium sand, trace gravel, trace clay, saturated, compact to dense.				
135.0 / 1.7	**SANDY SILT** Grey sandy silt, some gravel, trace clay, moist to saturated, compact to very dense.				
132.1 / 4.6	**SAND and GRAVEL** Grey sand and gravel, trace silt, trace clay, saturated, compact to dense.				
130.7 / 6.0	Borehole terminated at 6.04 m in sand and gravel. Water level: 0.93 metres below ground measured July, 2008. *Please note borehole was augered without sampling. Lithology inferred from soils sampled at adjacent borehole G3W-1.*				

Elevation scale: 136, 135, 134, 133, 132, 131

$+^3, \times^3$: Numbers refer to Sensitivity — 20 / 15 ◊ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario — Gartner Lee Limited

RECORD OF BOREHOLE No G4W-1

METRIC

G.W.P. 50-613	LOCATION N 4861387 & E 661441	ORIGINATED BY HSA	
HWY 407	BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID)	COMPILED BY CRC	
DATUM Geodetic	DATE 3.28.08 - 3.28.08	CHECKED BY TLC	

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR SA SI CL
97.2 / 0.0	**TOPSOIL** Brown silty clay, rootlets, very loose, moist.	1	SS	9	
96.2 / 1.0	**SILTY CLAY** Brown silty clay, trace sand, moist, firm.	2	SS	6	0 3 59 38
		3	SS	10	
94.7 / 2.6	**SAND and GRAVEL** Dark grey sand and gravel, trace silt, wet to saturated, compact.	4	SS	6	
		5	SS	10	28 65 5 2
		6	SS	35	
92.6 / 4.6	**SILTY SAND TILL** (Newmarket Till) Dark grey silty sand till with clay and gravel, saturated, compact to dense.	7	SS	30	
		8	SS	24	
		9	SS	30	
		10	SS	12	4 59 23 14
	- increasing clay content below 8.4 m				10 18 32 40
		11	SS	38	

Elevation scale: 97, 96, 95, 94, 93, 92, 91, 90, 89, 88

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity — 20 / 15 ◊ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario — Gartner Lee Limited

RECORD OF BOREHOLE No G4W-1 — 2 OF 2 — METRIC

G.W.P. 50-613 | LOCATION N 4861387 & E 661441 | ORIGINATED BY HSA

HWY 407 | BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID) | COMPILED BY CRC

DATUM Geodetic | DATE 3.28.08 - 3.28.08 | CHECKED BY TLC

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS
97.2						
					87	
86.7 / 10.5	**SHALE** Dark grey shale, weathered, very hard.	12	SS	50 /0.02m		
86.6 / 10.6	Borehole terminated at 10.57 m in shale. Water level: 3.25 metres below ground measured July, 2008.					

+ ³, × ³ Numbers refer to Sensitivity — (%) STRAIN AT FAILURE

ONTMT4S 407 HYDROGEOLOGY.GPJ 5/28/09

Ministry of Transportation Ontario — Gartner Lee Limited

RECORD OF BOREHOLE No G4W-2 — 1 OF 1 — METRIC

G.W.P. 50-613 | LOCATION N 4861387 & E 661441 | ORIGINATED BY HSA

HWY 407 | BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID) | COMPILED BY CRC

DATUM Geodetic | DATE 3.28.08 - 3.28.08 | CHECKED BY TLC

ELEV DEPTH	DESCRIPTION
97.2 / 0.0	**TOPSOIL** Brown silty clay, rootlets, very loose, moist.
96.2 / 1.0	**SILTY CLAY** Brown silty clay, trace sand, moist, firm.
94.7 / 2.6	**SAND and GRAVEL** Dark grey sand and gravel, trace silt, wet to saturated, compact.
92.6 / 4.6	**SILTYSAND TILL** (Newmarket Till) Dark grey silty sand till with clay and gravel, saturated, compact to dense.
91.1 / 6.1	Borehole terminated at 6.10 m in silty sand till. Water level: 3.67 metres below ground measured July, 2008. *Please note borehole was augered without sampling. Lithology inferred from soils sampled at adjacent borehole G4W-1.*

Elevation scale: 97, 96, 95, 94, 93, 92

Column headings: SOIL PROFILE; SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+ ³, × ³ Numbers refer to Sensitivity — (%) STRAIN AT FAILURE

ONTMT4S 407 HYDROGEOLOGY.GPJ 5/28/09

Ministry of Transportation Ontario — Gartner Lee Limited

RECORD OF BOREHOLE No DM1

METRIC

G.W.P. 50-613 | LOCATION N 4864998 & E 337280 | ORIGINATED BY JED
HWY 407 | BOREHOLE TYPE Hollow Stem | COMPILED BY JC
DATUM Geodetic | DATE 3.18.09 - 3.18.09 | CHECKED BY TLC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
177.3 / 0.0	**TOPSOIL** Dark brown clayey silt topsoil, some small stones, rootlets, moist, soft	1	SS	3	177				
176.1		2	SS	7					
1.2	**FILL** Reworked till. Light brown silty sand fill, moist, loose				176				
175.8 / 1.5	**silty SAND TILL** (Newmarket Till) Light brown to beige silty sand till, with small to medium sub-angular gravel, trace clay, occational pebbles, moist, compact	3	SS	13					
		4	SS	21	175				
		5	SS	22	174				
		6	SS	14					
					173	4	38	37	21
		7	SS	18					
		8	SS	32	172				
		9	SS	41	171				
	- becoming grey at 6.55 mbgs				170				
		10	SS	71	169				
						1	29	32	38
		11	SS	50/0.13	168				

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity; 20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S SIDELINE 16 ANB LESKARD RD BOREHOLE LOGS.GPJ 6/2/09

Ministry of Transportation Ontario — Gartner Lee Limited

RECORD OF BOREHOLE No DM1

METRIC

G.W.P. 50-613 | LOCATION N 4864998 & E 337280 | ORIGINATED BY JED
HWY 407 | BOREHOLE TYPE Hollow Stem | COMPILED BY JC
DATUM Geodetic | DATE 3.18.09 - 3.18.09 | CHECKED BY TLC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
177.3					167				
		12	SS	71	166				
		13	SS	36	165				
					164				
163.4 / 13.9	**clayey SILT** (Glaciolacustrine) Grey, clayey silt to silt, finely laminated, occational very fine sand seems, moist, very stiff	14	SS	47	163				
162.8 / 14.5	**SAND** Grey medium to fine sand, saturated, very loose	15	SS	4			75	10	15
162.2 / 15.1	Borehole terminated at 15.09 mbgs in sand.				162				
	Water level: 2.26 metres above ground (artesian) measured March 20, 2009.								

+ 3, × 3: Numbers refer to Sensitivity; 20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S SIDELINE 16 ANB LESKARD RD BOREHOLE LOGS.GPJ 6/2/09

Ministry of Transportation Ontario

Gartner Lee Limited

RECORD OF BOREHOLE No DM2

METRIC

G.W.P. 50-613	LOCATION N 4865070 & E 337319	ORIGINATED BY CC	HWY 407	BOREHOLE TYPE Hollow Stem	COMPILED BY JC
DATUM Geodetic	DATE 3.17.09 - 3.17.09	CHECKED BY TLC			

ELEV / DEPTH (178.3)	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0.0	**FILL** Black to dark brown sity, clayey, sandy fill, trace gravel, moist, rootlets, brick fragments, wood	1	SS	8	178	
		2	SS	3	177	
		3	SS	3	176	
175.3		4	SS	11		
3.1	**silty SAND TILL** (Newmarket Till) Brown, silty sand till, some clay, some sub-angular gravel, cobbles, moist, compact	5	SS	6	175	
		6	SS	14	174	
	- becoming grey brown at 4.57 mbgs	7	SS	20		3 47 32 18
		8	SS	61	173	
		9	SS	50/0.13	172	
					171	
		10	SS	79	170	
		11	SS	54	169	

Continued Next Page

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+ 3, × 3: Numbers refer to Sensitivity; 20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S SIDELINE 16 ANB LESKARD RD BOREHOLE LOGS.GPJ 6/2/09

Ministry of Transportation Ontario

Gartner Lee Limited

RECORD OF BOREHOLE No DM2

METRIC

G.W.P. 50-613	LOCATION N 4865070 & E 337319	ORIGINATED BY CC	HWY 407	BOREHOLE TYPE Hollow Stem	COMPILED BY JC
DATUM Geodetic	DATE 3.17.09 - 3.17.09	CHECKED BY TLC			

ELEV / DEPTH (178.3)	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
					168	10 38 28 24
		12	SS	55	167	
166.1						
12.2	**clayey SILT** (Glaciolacustrine) Grey, clayey silt to silt, finely laminated, occational very fine sand seems, moist, very stiff	13	SS	25	166	
					165	
		14	SS	19	164	
163.1						1 73 16 10
15.2	**SAND** Grey fine to silty sand, saturated, very loose	15	SS	2	163	
162.5 / 15.9	Borehole terminated at 15.85 m in sand. Water level: 1.38 metres above ground (artesian) measured March 18, 2009.					

+ 3, × 3: Numbers refer to Sensitivity; 20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S SIDELINE 16 ANB LESKARD RD BOREHOLE LOGS.GPJ 6/2/09

Ministry of Transportation Ontario

Gartner Lee Limited

RECORD OF BOREHOLE No DM3

METRIC

G.W.P. 50-613	LOCATION N 4864966 & E 337433	ORIGINATED BY JED/ CC
HWY 407	BOREHOLE TYPE Hollow Stem	COMPILED BY JC
DATUM Geodetic	DATE 3.16.09 - 3.17.09	CHECKED BY TLC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
172.6						
0.0	**Silty SAND** Brown silty sand, with some clay and small sub-rounded pebbles, trace clay and organics, wet, loose	1	SS	3		
					172	
		2	SS	10		
171.1 / 1.5	**silty SAND TILL** (Newmarket Till) Reworked or highly weathered till. Light, orangy-brown, fine sand and silt, some medium sand, with small sub-angular gravel (Till), moist, very dense				171	
		3	SS	7		
		4	SS	74	170	
						10 51 27 12
		5	SS	58		
					169	
		6	SS	50/0.05		
168.0 / 4.6	**SAND and GRAVEL** Dark grey medium sand and gravel, clean, wet, dense				168	
		7	SS	33		
167.0 / 5.6	**silty SAND TILL** Grey/ brown, silty sand till, some angular gravel, trace clay, wet, very dense	8	SS	63	167	
166.5 / 6.1	**SAND and GRAVEL** Grey, course sand and gravel, trace cobbles, silty, saturated, dense Ice contact stratified drift silty sand and gravel	9	SS	54/0.15		
					166	
		10	SS	76		
		11	SS	86	165	45 50 3 2
					164	
		12	SS	72		
					163	

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity — 20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

Ministry of Transportation Ontario

Gartner Lee Limited

RECORD OF BOREHOLE No DM3

METRIC

G.W.P. 50-613	LOCATION N 4864966 & E 337433	ORIGINATED BY JED/ CC
HWY 407	BOREHOLE TYPE Hollow Stem	COMPILED BY JC
DATUM Geodetic	DATE 3.16.09 - 3.17.09	CHECKED BY TLC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
172.6						
					162	6 12 82 (SI+CL)
		13	SS	68		
					161	
160.3		14	SS	44		
12.3	Borehole terminated at 12.34 m in sand and gravel. Water level: 1.81 metres below ground measured March 23, 2009.					

+ 3, × 3: Numbers refer to Sensitivity — 20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Gartner Lee Limited

RECORD OF BOREHOLE No DM4

METRIC

G.W.P. 50-613 | LOCATION N 4865058 & E 337608 | ORIGINATED BY JED

HWY 407 | BOREHOLE TYPE Hollow Stem | COMPILED BY JC

DATUM Geodetic | DATE 3.16.09 - 3.16.09 | CHECKED BY TLC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
176.7									
0.0 / 176.2	**TOPSOIL** Dark brown silty sandy topsoil, some small gravel, organinc, moist	1	SS	5	176				
0.5 / 175.8	**silty SAND** Brown, silty sand, some small gravel, moist, loose								
0.9 / 175.2	**SAND** Brown, fine sand, some small gravel, moist, loose	2	SS	5	175				
1.5 / 173.7	**sandy SILT TILL** (Newmarket Till) Highly weathered or reworked till. Lighy brown, sandy silt, some clay, trace fine sand, trace small sub-rounded gravel, very moist, stiff	3	SS	36	174				
		4	SS	31					
3.1 / 172.9	**SILT** Light brown, silt, some very fine to fine sand, trace gravel, moist, compact	5	SS	32	173				
3.8 / 170.8	**SAND** Light brown to light grey, fine to mediun sand, trace gravel, well sorted, moist, compact	6	SS	26	172				
		7	SS	39		92	3	5	
		8	SS	37	171				
5.9 / 170.6	**SAND**								
6.1	Fine sand, coarsening downwards to a brown, sand and gravel, moist to wet, hard; water perched on Till unit below	9	SS	50/0.15	170				
	silty SAND TILL (Newmarket Till) Light grey, silt till, some fine sand, with medium to large sub-angular gravel, moist. very dense				169				
	Becoming grey and wet at 12.19 mbgs	10	SS	76	168				
		11	SS	34	167				

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity | 20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Gartner Lee Limited

RECORD OF BOREHOLE No DM4

METRIC

G.W.P. 50-613 | LOCATION N 4865058 & E 337608 | ORIGINATED BY JED

HWY 407 | BOREHOLE TYPE Hollow Stem | COMPILED BY JC

DATUM Geodetic | DATE 3.16.09 - 3.16.09 | CHECKED BY TLC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
176.7									
		12	SS	50/0.10	166	11	35	34	20
		13	SS	50/0.13	165, 164				
		14	SS	50/0.15	163, 162				
161.5									
15.2 / 160.9	**SAND** Dark grey, fine sand, well sorted, saturated, compact	15	SS	21	161	80	14	6	
15.9	Borehole terminated at 15.85 m in sand. Water level: 6.07 metres below ground measured March 16, 2009.								

+ 3, × 3: Numbers refer to Sensitivity | 20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Gartner Lee Limited

RECORD OF BOREHOLE No DM5

1 OF 1 **METRIC**

G.W.P.	50-613	LOCATION	N 4864754 & E 337413	ORIGINATED BY	JED
HWY	407	BOREHOLE TYPE	Hollow Stem	COMPILED BY	JC
DATUM	Geodetic	DATE	3.20.09 - 3.20.09	CHECKED BY	TLC

ELEV / DEPTH	DESCRIPTION
169.0	
0.0	**TOPSOIL** Brown, silty sandy topsoil, some gravel, wet, loose
168.4 / 0.6	**sandy SILT TILL** (Newmarket Till) Brown, clayey silt, trace fine sand, trace small gravel, moist, soft
166.8 / 2.2	**SAND** Beige fine to medium sand
166.6 / 2.4	**sandy SILT TILL** (Newmarket Till) Beige, sandy silt, some small sub-angular gravel, trace clay, saturated, loose
165.9 / 3.1	**SAND and GRAVEL** Dark brown, coarse sand and gravel, trace cobbles, silty, saturated, compact. Gravel is very coarse, angular, and made up of mainly carbonate rocks. Ice contact stratified drift sand and gravel
164.4 / 4.6	**SAND** Brown, coarse sand, well sorted, clean, saturated, compact
161.1 / 7.9	**sandy SILT TILL** (Newmarket Till) Grey, sandy silt till, with medium to large sub-rounded to sub-angular gravel, saturated, very dense
160.8 / 8.2	Borehole terminated at 8.23 m in till. Water level: 0.25 metres above ground (artesian) measured March 23, 2009.

SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	7	
2	SS	4	6 35 40 19
3	SS	13	
4	SS	13	
5	SS	33	
6	SS	29	
7	SS	18	
8	SS	28	2 90 5 3
9	SS	71	14 50 28 8

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (168, 167, 166, 165, 164, 163, 162, 161); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+ ³, × ³: Numbers refer to Sensitivity   20 / 15 ⌖ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S SIDELINE 16 ANB LESKARD RD BOREHOLE LOGS.GPJ 6/2/09

Ministry of Transportation Ontario

Gartner Lee Limited

RECORD OF BOREHOLE No DM6

1 OF 3 **METRIC**

G.W.P.	50-613	LOCATION	N 4865142 & E 337165	ORIGINATED BY	JED
HWY	407	BOREHOLE TYPE	Hollow Stem	COMPILED BY	JC
DATUM	Geodetic	DATE	3.18.09 - 3.19.09	CHECKED BY	TLC

ELEV / DEPTH	DESCRIPTION
185.6	
0.0	**FILL** Light to dark brown, sand and gravel to silty sand fill, moist to wet, compact
184.8 / 0.8	**FILL** Reworked Till. Beige to light grey, silty sand till, some medium sand, some gravel, trace clay, wet, loose to compact
182.5 / 3.1	**silty SAND TILL** (Newmarket Till) Grey, silty sand till, with large to medium sub-angular gravel, occational cobbles, moist, very dense
	At 9.75 m, a thin, fine to medium silty

SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	6	
2	SS	6	
3	SS	9	
4	SS	27	
5	SS	43	3 47 39 11
6	SS	50/0.13	
7	SS	50/0.13	
8	SS	50/0.13	
9	SS	57	
10	SS	73	
11	SS	50/0.13	

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (185, 184, 183, 182, 181, 180, 179, 178, 177, 176); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity   20 / 15 ⌖ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S SIDELINE 16 ANB LESKARD RD BOREHOLE LOGS.GPJ 6/2/09

Ministry of Transportation Ontario

Gartner Lee Limited

RECORD OF BOREHOLE No DM6 — 2 OF 3 — METRIC

G.W.P. 50-613 — LOCATION N 4865142 & E 337165 — ORIGINATED BY JED

HWY 407 — BOREHOLE TYPE Hollow Stem — COMPILED BY JC

DATUM Geodetic — DATE 3.18.09 - 3.19.09 — CHECKED BY TLC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
185.6									
174.9	sand seem was encountered				175				
10.7	**SILT** (Glaciolacustrine) Grey, silt, some clay, finly laminated, interbedded fine sand layers, saturated, very dense. Breaks along horizontal bedding plane fractures where very thin layers of brown, fine to silty sand exist.	12	SS	69					
					174		3	51	46
		13	SS	49	173				
					172				
		14	SS	45	171				
		15	SS	27	170				
					169				
		16	SS	25	168		1	26	73
		17	SS	26	167				
					166				

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity. 20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Gartner Lee Limited

RECORD OF BOREHOLE No DM6 — 3 OF 3 — METRIC

G.W.P. 50-613 — LOCATION N 4865142 & E 337165 — ORIGINATED BY JED

HWY 407 — BOREHOLE TYPE Hollow Stem — COMPILED BY JC

DATUM Geodetic — DATE 3.18.09 - 3.19.09 — CHECKED BY TLC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
185.6					
165.2		18	SS	24	
20.4	Borehole terminated at 20.42 mbgs in silt. Water level: Approximately 9.5 m above ground surface (artesian) May 28, 2009. Measured with a pressure transducer.				165

+ 3, × 3: Numbers refer to Sensitivity. 20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario — Gartner Lee Limited

RECORD OF BOREHOLE No DM7 — 1 OF 2 — METRIC

G.W.P. 50-613 | LOCATION N 4864890 & E 337466 | ORIGINATED BY JED
HWY 407 | BOREHOLE TYPE Hollow Stem | COMPILED BY JC
DATUM Geodetic | DATE 3.20.09 - 3.23.09 | CHECKED BY TLC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
169.2 / 0.0	**FILL** Brown to dark grey sand and sandy silt fill, moist to wet, peat	1	SS	5				
		2	SS	2				
167.7 / 1.5	**FILL** (reworked till and organic deposits) Grey, silty with some sand and clay, some small gravel, wood bits, occational peat and rootlets, wet, firm	3	SS	6				
		4	SS	4				
		5	SS	7				
		6	SS	9				
164.6 / 4.6	**silty SAND TILL** (Newmarket Till) Grey, silty sand till, with medium sub-angular to angular gravel, occational rootlets, wet, very dense Old till ground surface prior to fill placement	7	SS	5	4	49	32	15
163.1 / 6.1	**SAND and GRAVEL** Brown, sand and gravel, clean, saturated, compact	8	SS	20	41	39	15	5
161.6 / 7.6	**SAND** Grey, fine to medium sand, well sorted, clean, saturated, compact	9	SS	22				
		10	SS	42				
159.6 / 9.5	**silty SAND TILL** (Newmarket Till) Grey, silty sand till, with medium sub-angular to angular gravel,							

Continued Next Page

Elevation scale: 169, 168, 167, 166, 165, 164, 163, 162, 161, 160

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE: 20 40 60 80 100
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%): 20 40 60
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

+ ³, × ³: Numbers refer to Sensitivity — 20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S SIDELINE 16 ANB LESKARD RD BOREHOLE LOGS.GPJ 6/2/09

Ministry of Transportation Ontario — Gartner Lee Limited

RECORD OF BOREHOLE No DM7 — 2 OF 2 — METRIC

G.W.P. 50-613 | LOCATION N 4864890 & E 337466 | ORIGINATED BY JED
HWY 407 | BOREHOLE TYPE Hollow Stem | COMPILED BY JC
DATUM Geodetic | DATE 3.20.09 - 3.23.09 | CHECKED BY TLC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
	saturated, very dense							
158.5 / 10.7	**SAND and GRAVEL** Grey medium to coarse sand and gravel, gravel is sub-angular to angular, silty, saturated, dense Ice contact stratified drift sand and gravel	11	SS	74				
		12	SS	65/0.15				
					7	82	7	4
		13	SS	98				
		14	SS	100				
153.3 / 15.9	Borehole terminated at 15.85 m in sand and gravel. Water level: 4.68 metres below ground measured March 23, 2009.							

Elevation scale: 159, 158, 157, 156, 155, 154

+ ³, × ³: Numbers refer to Sensitivity — 20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S SIDELINE 16 ANB LESKARD RD BOREHOLE LOGS.GPJ 6/2/09

AECOM

Appendix C

Data Tables

Table C1: Monitoring Well Construction Details

AECOM

Monitor	MOE Well ID #	Easting	Northing	Completion Date	Ground Elevation	Top of Pipe Elevation	Well Diameter	Well Stick Up	Well Depth	Well Screen Length	Depth of Well Screen (mBGL)			Depth of Sand Pack (mBGL)			Depth of Seal (mBGL)		
		m	m	dd-mmm-yy	mASL	mASL	m	mAGL	mBGL	m	Top	-	Bottom	Top	-	Bottom	Top	-	Bottom
WEST																			
G1W-1	A067428	654243	4866140	11-Dec-07	144.00	144.00	0.051	0.00	13.72	1.52	12.20	-	13.72	11.55	-	12.19	0.00	-	11.55
G1W-2		654244	4866138	11-Dec-07	143.90	143.90	0.051	0.00	6.10	4.57	1.52	-	6.10	0.91	-	6.10	0.00	-	0.91
G2W-1	A072148	659315	4868197	15-Jan-08	187.94	188.82	0.051	0.89	12.34	1.52	10.59	-	12.12	10.29	-	12.34	0.00	-	10.29
G2W-2		659316	4868198	16-Jan-08	187.83	188.77	0.051	0.96	9.30	4.57	1.57	-	6.15	1.22	-	6.30	0.00	-	1.22
G3W-1	A072153	660389	4865864	27-Mar-08	137.03	137.79	0.051	0.84	11.58	1.52	10.06	-	11.58	9.78	-	11.58	0.00	-	9.78
G3W-2		660389	4865864	27-Mar-08	136.72	137.61	0.051	0.74	6.04	4.57	1.47	-	6.04	1.22	-	6.04	0.00	-	1.22
G4W-1	A072154	661441	4861387	28-Mar-08	97.21	98.15	0.051	0.88	10.57	1.52	9.02	-	10.54	9.02	-	10.54	0.00	-	10.54
G4W-2		661441	4861387	28-Mar-08	97.23	98.16	0.051	0.83	6.10	4.57	1.52	-	6.10	1.27	-	1.52	0.00	-	1.27
DM-1		337280	4864998	18-Mar-09	177.30	178.09	0.051	0.79	15.85	3.10	11.23	-	14.33	10.92	-	11.23	0.00	-	10.92
DM-2		337319	4865070	17-Mar-09	178.32	179.07	0.051	0.75	15.85	1.52	13.72	-	15.24	14.93	-	15.24	0.00	-	14.93
DM-3		337433	4864966	17-Mar-09	172.60	173.50	0.051	0.90	12.34	3.10	9.09	-	12.19	8.78	-	9.09	0.00	-	8.78
DM-4		337608	4865058	16-Mar-09	176.70	177.40	0.051	0.70	15.85	3.10	12.04	-	15.09	11.73	-	12.04	0.00	-	11.73
DM-5		337413	4864754	20-Mar-09	168.98	169.73	0.051	0.75	8.23	3.10	5.18	-	8.23	4.87	-	5.18	0.00	-	4.87
DM-6		337165	4865142	19-Mar-09	185.58	185.51	0.051	-0.07	20.42	3.10	7.62	-	10.67	7.31	-	7.62	0.00	-	7.31
DM-7		337466	4864890	23-Mar-09	169.17	169.92	0.051	0.75	15.85	3.10	6.10	-	9.14	5.79	-	6.10	0.00	-	5.79

NOTES:
1. Coordinates at UTM NAD83, Zn 17 N. Coordinates measured to with handheld GPS to within +/- 10 m.
Bold font coordinates measured to +/- 1m accuracy by Golder/Thurber. Elevations from BTM with 300 - 600 mm accuracy.
2. On Jan 31, 2008 BH nomenclature was changed from BH1W-S or BH1W-D to G1W-2 (shallow), G1W-1 (deep).
3. mASL - metres above sea level; mBGL - meters below ground level
4. mAGL - metres above ground level, Top of pipe elevation calculated from ground elevation
6. Seal (from top of sand pack to ground surface) consists of a layer of holeplug, bentonite and/or cement.

Table C2 – Hydraulic Testing Results

AECOM

Monitor	Well Stick Up	Well Depth	Well Screen Length	Depth of Well Screen (mBGL)			Lithology of Screened Interval	Geologic Unit	Aqufier Model	Solution Method	K1[1]	K2[2]	K Geometric Mean	Remarks
	mAGL	mBGL	m	Top	-	Bottom					(m/sec)	(m/sec)	(m/sec)	
G1W-1	0.00	13.72	1.52	12.19	-	13.72	Silty Clay	Glaciolacustrine	Confined	Hvorslev	1.4E-08	8.7E-09	1.1E-08	-
G1W-2	0.00	6.10	4.57	1.52	-	6.10	Glaciolacustrine Fine to Coarse Sand	Glaciolacustrine	Unconfined	B&R	2.3E-06	2.1E-06	2.2E-06	-
G2W-1	0.89	12.34	1.52	10.59	-	12.12	Clayey Silt / Newmarket Till	Newmarket Till	Confined	Hvorslev	1.6E-06	1.8E-06	1.7E-06	-
G2W-2	0.955	9.30	4.57	1.57	-	6.15	Newmarket Till	Newmarket Till	Unconfined	B&R	7.9E-07	4.7E-07	6.1E-07	-
G3W-1	0.84	11.58	1.52	10.06	-	11.58	Newmarket Till	Newmarket Till	Unconfined	B&R	2.2E-07	-	2.2E-07	
G3W-2	0.74	6.04	4.57	1.47	-	6.04	Glaciolacustrine (Sand and Gravel / Sandy Silt / Sand)	Glaciolacustrine	Unconfined	B&R	1.1E-05	6.5E-06	8.5E-06	-
G4W-1	0.88	10.57	1.52	9.02	-	10.54	Shale Bedrock / Newmarket Till	Weathered Shale Bedrock	Confined	Hvorslev	2.4E-06	2.5E-06	2.4E-06	-
G4W-2	0.83	6.10	4.57	1.52	-	6.10	Glaciolacustrine Sand and Gravel	Glaciolacustrine	Unconfined	B&R	5.2E-05	3.5E-05	4.3E-05	Very fast response
DM1	0.79	15.85	3.10	11.23	-	14.33	Sand / Glaciolacustrine Clayey Silt / Newmarket Till	Upper Thorncliffe Aquifer/ clayey silt / Newmarket Till	Confined	Hvorslev	6.5E-06	-	6.5E-06	very small portion of screen is in aquifer unit
DM2	0.75	15.85	1.52	13.72	-	15.24	Sand / Glaciolacustrine Clayey Silt	Upper Thorncliffe Aquifer / clayey silt / Newmarket Till	Confined	Hvorslev	5.9E-06	-	5.9E-06	very small portion of screen is in aquifer unit
DM3	0.90	12.34	3.10	9.09	-	12.19	clean Sand and Gravel	Ice Contact Sand and Gravel	Confined	Hvorslev	4.4E-05	2.1E-05	3.0E-05	-
DM4	0.70	15.85	3.10	12.04	-	15.09	Sand / Glaciolacustrine Silt	Upper Thorncliffe Aquifer / Newmarket Till	Confined	Hvorslev	4.1E-05	2.0E-05	2.8E-05	-
DM5	0.75	8.23	3.10	5.18	-	8.23	silty Sand and Gravel	Ice Contact Sand and Gravel	Confined	Hvorslev	9.1E-06	7.8E-06	8.4E-06	-
DM6	-0.07	20.42	3.10	7.62	-	10.67	silty fine to medium sand / Newmarket Till	Upper Thorncliffe Aquifer / clayey silt	Confined	Hvorslev	-	-	-	Very strong artesian pressure gave unreliable results for hydraulic testing
DM7	0.75	15.85	3.10	6.10	-	9.14	silty Sand and Gravel	Ice Contact Sand and Gravel	Confined	Hvorslev	6.9E-06	5.8E-06	6.3E-06	-

NOTES:

1 - Falling Head Test

2 - Rising Head Test

mBGL - Meters Below Ground Level

mAGL - Meters Above Ground Level

Hvorslev - Hvorslev method of slug test analysis for confined aquifers

B&R - Bower and Rice method of slug test analysis for unconfined aquifers

Table C3 - Groundwater Monitor Sampling Results

AECOM

Parameter	Unit	RDL	ODWS	G1W-1 15-Jan-08	G1W-2 11-Jan-08	G2W-1 21-Apr-08	G2W-2 21-Apr-08	G3W-1 24-Apr-08	G3W-2 22-Apr-08	G4W-1 22-Apr-08	G4W-2 22-Apr-08	DM-1 18-Mar-09	DM-2 17-Mar-09	DM-3 17-Mar-09	DM-4 16-Mar-09	DM-5 20-Mar-09	DM-6 19-Mar-09	DM-7 23-Mar-09	Sample Blank** 28-Apr-08
ORGANICS																			
C>10 - C16 (F2)	µg/L	100	NA	<100	<100	<100	<100	<100	<100	<100	<100	-	-	-	-	-	-	-	<0.2
C>16 - C34 (F3)	µg/L	500	NA	<500	<500	<500	<500	<500	<500	<500	<500	-	-	-	-	-	-	-	<100
C>16 - C50 (F3 + F4)	µg/L	500	NA	<500	<500	<500	<500	<500	<500	<500	<500	-	-	-	-	-	-	-	<500
C>34 - C50	µg/L	500	NA	<500	<500	<500	<500	<500	<500	<500	<500	-	-	-	-	-	-	-	<500
C6 - C10 (F1 minus BTEX)	µg/L	100	NA	<100	<100	<100	<100	<100	<100	<100	<100	-	-	-	-	-	-	-	<500
C6 - C10 (F1)	µg/L	100	NA	<100	<100	<100	<100	<100	<100	<100	<100	-	-	-	-	-	-	-	<100
C6 - C16 (F1 + F2)	µg/L	100	NA	<100	<100	<100	<100	<100	<100	<100	<100	-	-	-	-	-	-	-	<100
Benzene	µg/L	0.2	5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-	-	-	-	<100
Ethylbenzene	µg/L	0.1	2.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-	-	-	-	<0.1
Toluene	µg/L	0.2	NA	0.51	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-	-	-	-	NA
Xylenes (Total)	µg/L	0.14	300	0.59	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	0.42	-	-	-	-	-	-	-	2.40
Gravimetric Heavy Hydrocarbons	µg/L	500	NA	NA	NA	NA	NA	NA	NA	NA	NA	-	-	-	-	-	-	-	<0.14
MICROBIOLOGY																			
Total Coliforms	CFU/100mL	1	< 1	**160**	**88**	**114**	**93**	**320**	**1,500**	**103**	**83**	-	-	-	-	-	-	-	<1
Escherichia coli	CFU/100ml	1	< 1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-	-	-	<1
Heterotrophic Plate Count (HPC) (CFU/ml)	CFU/ml	10	< 500	**2,400**	**630**	450	480	**880**	**4,900**	**610**	**450**	-	-	-	-	-	-	-	40
INORGANICS AND METALS																			
Alkalinity (as CaCO3)	mg/L	5	30-500	149	204	224	162	204	164	362	288	-	-	-	-	-	-	-	**<10**
Aluminum	mg/L	0.004	0.1	0.006	0.006	0.005	0.006	0.007	0.015	<0.004	0.010	-	-	-	-	-	-	-	<0.004
Ammonia (as N)	mg/L	0.02	NA	0.58	<0.02	0.20	0.17	0.16	<0.02	0.29	1.73	-	-	-	-	-	-	-	<0.02
Arsenic	mg/L	0.003	0.025	0.01	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	-	-	-	-	-	-	-	<0.003
Barium	mg/L	0.002	1.0	0.05	0.017	0.069	0.092	0.133	0.053	0.117	0.079	-	-	-	-	-	-	-	<0.002
Bicarbonate (as CaCO3)	mg/L	5	NA	144	204	223	155	204	164	362	288	-	-	-	-	-	-	-	<10
Boron	mg/L	0.01	5.0	0.26	<0.010	0.14	0.07	0.03	**7.30**	0.03	0.56	-	-	-	-	-	-	-	0.023
Bromide	mg/L	0.05	NA	<0.05	<0.05	<0.05	<0.05	<0.05	0.10	<0.05	0.23	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	mg/L	0.002	0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	-	-	-	-	-	<0.002
Calcium	mg/L	0.05	NA	24.7	87.4	68.7	29.4	61.2	40.5	186.0	45.4	34.4	26.0	49.6	24.3	98.3	66.4	90.4	0.3
Calculated Total Dissolved Solids	mg/L	5	NA	289	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbonate (as CaCO3)	mg/L	5	NA	5	<10	<10	<10	<5	<10	<5	<5	-	-	-	-	-	-	-	<10
Chloride	mg/L	0.1	250	4.60	8.54	9.65	9.14	26.30	52.30	**304**	37.30	2.08	1.95	16.4	4.6	48.8	5.9	42.7	0.58
Colour	TCU	5	5	**20**	<5	<5	**5**	<5	**25**	<5	**5**	-	-	-	-	-	-	-	<5
Copper	mg/L	0.003	1.0	0.007	<0.003	0.006	<0.003	0.004	0.005	0.003	<0.003	-	-	-	-	-	-	-	<0.003
Electrical Conductivity	uS/cm	2	NA	450	480	5.90	5.30	5.70	8.70	2.80	3.50	-	-	-	-	-	-	-	16
Field Conductivity	uS/cm	N/A	NA	411	434	488	388	507	659	1,680	621	-	-	-	-	-	-	-	-
Fluoride	mg/L	0.05	1.5	0.22	<0.05	0.14	0.24	0.05	0.26	0.09	0.19	0.22	0.23	0.16	0.27	0.07	0.10	0.08	<0.05
Hydroxide	mg/L	5	NA	<5	<10	<10	<10	<5	<10	<5	<5	-	-	-	-	-	-	-	<10
Iron	mg/L	0.005	0.3	<0.005	<0.005	<0.005	0.01	<0.005	<0.005	<0.005	0.193	-	-	-	-	-	-	-	<0.005
Langelier Index	N/A	N/A	NA	0.80	0.96	1.14	0.89	0.81	0.77	1.12	0.97	-	-	-	-	-	-	-	-4.59
Lead	mg/L	0.002	0.01	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	-	-	-	-	-	<0.002
Magnesium	mg/L	0.05	NA	7.45	8.92	21.30	24.30	20.30	10.70	19.90	17.50	12.8	10.4	17.8	13.8	21.4	17.8	17.7	0.05
Manganese	mg/L	0.002	0.05	0.018	0.006	0.022	0.007	0.023	0.009	**0.212**	0.090	-	-	-	-	-	-	-	<0.002
Molybdenum	mg/L	0.002	NA	0.131	<0.002	0.002	0.005	<0.002	0.085	<0.002	0.003	-	-	-	-	-	-	-	<0.002
Nickel	mg/L	0.003	NA	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	-	-	-	-	-	-	-	<0.003
Nitrate as N	mg/L	0.05	10	<0.05	9.17	3.63	<0.05	<0.05	0.06	5.74	<0.05	0.09	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Nitrite as N	mg/L	0.05	1.0	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Orthophosphate as P	mg/L	0.1	NA	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
pH	N/A	N/A	6.5-8.5	**8.52**	8.10	8.21	8.27	7.99	8.25	7.72	8.10	-	-	-	-	-	-	-	**6.3**
Field pH	N/A	N/A	NA	8.50	7.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium	mg/L	0.05	NA	1.20	0.80	2.48	4.77	2.66	7.34	3.21	6.16	1.54	0.89	2.19	2.73	2.02	1.70	4.13	0.1
Reactive Silica	mg/L	0.05	NA	15.20	6.59	13.90	14.50	19.50	7.92	14.00	14.50	-	-	-	-	-	-	-	<0.05
Saturation pH	N/A	N/A	NA	7.72	7.14	7.07	7.38	7.18	7.48	6.60	7.13	-	-	-	-	-	-	-	10.9
Selenium	mg/L	0.004	0.01	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	-	-	-	-	-	-	-	<0.004
Silver	mg/L	0.002	NA	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	-	-	-	-	-	-	-	<0.002
Sodium	mg/L	0.05	20 (200)	**64.80**	2.96	9.60	15.50	13.20	**83.20**	**126**	**54.50**	**32.7**	**39.8**	**23.5**	**43.1**	19.5	14.8	**39.6**	1.06
Strontium	mg/L	0.005	NA	0.208	0.156	0.574	0.670	0.365	0.342	0.416	0.564	-	-	-	-	-	-	-	<0.005
Sulphate	mg/L	0.1	500	81.80	28.40	27.40	41.20	43.80	102	72.60	6.69	4.49	0.13	2.11	10.7	56.8	50.0	34.0	0.17
Thallium	mg/L	0.006	NA	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	-	-	-	-	-	-	-	<0.006
Titanium	mg/L	0.002	NA	<0.002	<0.002	<0.002	<0.002	<0.002	0.002	<0.002	<0.002	-	-	-	-	-	-	-	<0.002
Total Dissolved Solids	mg/L	20	500	392	302	232	216	320	424	**1,200**	350	-	-	-	-	-	-	-	**516**
Total Hardness (as CaCO3)	mg/L	10	80-100	92	**255**	**259**	**173**	**236**	**145**	**546**	**185**	-	-	-	-	-	-	-	<10
Total Organic Carbon	mg/L	0.5	NA	49.40	3.40	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Phosphorus	mg/L	0.05	NA	0.15	0.61	<0.05	<0.05	<0.05	<0.05	4.91	2.41	-	-	-	-	-	-	-	<0.05
Turbidity	NTU	0.5	5.0	**800**	**400**	3.2	3.7	**9.7**	**15.0**	**6.9**	**23.0**	-	-	-	-	-	-	-	**112**
Uranium	mg/L	0.002	0.02	0.011	<0.002	<0.002	<0.002	<0.002	0.004	0.002	<0.002	-	-	-	-	-	-	-	<0.002
Vanadium	mg/L	0.002	NA	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.002	<0.002	-	-	-	-	-	-	-	<0.002
Zinc	mg/L	0.005	5.0	0.008	<0.005	0.034	<0.005	0.031	0.009	0.022	<0.005	-	-	-	-	-	-	-	<0.005
Field Temp	ºC	N/A	NA	-	7.60	-		-	-	-	-	-	-	-	-	-	-	-	-

NOTES:
- paramter not analyzed
RDL - Reportable Detection Limit;
NA = Not Applicable
ODWS - Ontario Drinking Water Standards
Bold and highlighted font indicates ODWS exceedence
** Field Dups: BH600 = G1C-2; BH25 = G3E-1; BH99 = G11E-1*
*** Sample Blank: Collected during sampling of G8E-2*
TNTC - To Numerous To Count

Table C4 - Mini-Piezometer Data and Construction

Location		MP1					MP2		MP3-Shallow	MP3-Deep	MP4-Shallow	MP4-Deep	
		Original		*Replacement*		*Replacement*	*Original*		*Original*	*Original*	*Original*	Original	
Date Installed		2-Nov-07		13-May-08		3-Sep-08	2-Nov-07		14-May-08	14-May-08	14-May-08	14-May-08	
Stick Up (m above stream bed or surface)		1.35		1.68		1.37	0.82		0.67	0.35	0.71	0.94	
Depth of Top of Screen (m below stream bed or surface)		1.21		1.21		1.52	1.73		1.22	2.50	1.22	2.86	
Depth of Bottom of Screen (m below stream bed or surface)		1.51		1.51		1.82	2.04		1.52	2.80	1.52	3.16	
Depth of Mid Screen (m below stream bed or surface)		1.36		1.36		1.67	1.88		1.37	2.65	1.37	3.01	
Depth of Top of Screen (m below top of pipe)		2.56		2.89		2.89	2.55		1.89	2.85	1.93	3.80	
Depth of Bottom of Screen (m below top of pipe)		2.86		3.19		3.19	2.85		2.19	3.15	2.23	4.10	
Depth of Mid Screen (m below top of pipe)		2.71		3.04		3.04	2.70		2.04	3.00	2.08	3.95	
Water Depth (m below top of pipe)													
On Installation	Date	2-Nov-07	-	-	-	-	2-Nov-07	-	14-May-08	14-May-08	14-May-08	14-May-08	-
	Depth to Water (MP) (mbtop)	1.61	-	-	-	-	2.25 **	-	1.77 **	2.77 **	1.67 **	3.22 **	-
	Depth to Water (Water Body) (mbtop)	0.75	-	-	-	-	0.71	-	0.63	0.31	0.59	0.88	-
	Vertical Separation (DL[1])	1.21	-	-	-	-	1.73	-	1.22	2.50	1.22	2.86	-
	Water Level Difference (DH[2])	-0.86	-	-	-	-	-1.54	-	-1.14	-2.46	-1.08	-2.34	-
	Hydraulic Gradient (DH/DL)	-0.71	-	-	-	-	-0.89	-	-0.93	-0.98	-0.89	-0.82	-
Nov-07	Date	30-Nov-07	-	-	-	-	30-Nov-07	-	-	-	-	-	-
	Depth to Water (MP) (mbtop)	1.08	-	-	-	-	0.13 *	-	-	-	-	-	-
	Depth to Water (Water Body) (mbtop)	0.73	-	-	-	-	0.70	-	-	-	-	-	-
	Vertical Separation (DL[1])	1.21	-	-	-	-	1.73	-	-	-	-	-	-
	Water Level Difference (DH[2])	-0.35	-	-	-	-	0.57	-	-	-	-	-	-
	Hydraulic Gradient (DH/DL)	-0.29	-	-	-	-	**0.33**	-	-	-	-	-	-
Feb-08	Date	8-Feb-08	-	-	-	-	7-Feb-08	-	-	-	-	-	-
	Depth to Water (MP) (mbtop)	1.01	-	-	-	-	0.22 *	-	-	-	-	-	-
	Depth to Water (Water Body) (mbtop)	0.71	-	-	-	-	0.71	-	-	-	-	-	-
	Vertical Separation (DL[1])	1.21	-	-	-	-	1.73	-	-	-	-	-	-
	Water Level Difference (DH[2])	-0.30	-	-	-	-	0.49	-	-	-	-	-	-
	Hydraulic Gradient (DH/DL)	-0.25	-	-	-	-	**0.30**	-	-	-	-	-	-
Mar-08	Date	4-Mar-08	31-Mar-08	-	-	-	4-Mar-08	31-Mar-08	-	-	-	-	-
	Depth to Water (MP) (mbtop)	0.99	0.83	-	-	-	0.09	0.03	-	-	-	-	-
	Depth to Water (Water Body) (mbtop)	0.68 *	0.58	-	-	-	0.65	0.50	-	-	-	-	-
	Vertical Separation (DL[1])	1.21	1.21	-	-	-	1.73	1.73	-	-	-	-	-
	Water Level Difference (DH[2])	-0.31	-0.25	-	-	-	0.56	0.47	-	-	-	-	-
	Hydraulic Gradient (DH/DL)	-0.26	-0.21	-	-	-	**0.32**	**0.27**	-	-	-	-	-
Apr-08	Date	-	-	-	-	-	-	-	-	-	-	-	-
	Depth to Water (MP) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-
	Depth to Water (Water Body) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-
	Vertical Separation (DL[1])	-	-	-	-	-	-	-	-	-	-	-	-
	Water Level Difference (DH[2])	-	-	-	-	-	-	-	-	-	-	-	-
	Hydraulic Gradient (DH/DL)	-	-	-	-	-	-	-	-	-	-	-	-
May-08	Date	-	-	14-May-08	16-May-08	-	16-May-08	-	-	-	-	-	-
	Depth to Water (MP) (mbtop)	-	-	2.24	1.71	-	0.16	-	-	-	-	-	-
	Depth to Water (Water Body) (mbtop)	-	-	1.36 **	1.66	-	0.73	-	-	-	-	-	-
	Vertical Separation (DL[1])	-	-	1.21	1.21	-	1.73	-	-	-	-	-	-
	Water Level Difference (DH[2])	-	-	-0.88	-0.05	-	0.57	-	-	-	-	-	-
	Hydraulic Gradient (DH/DL)	-	-	-0.73	-0.05	-	**0.33**	-	-	-	-	-	-
Jun-08	Date	-	-	10-Jun-08	-	-	10-Jun-08	-	10-Jun-08	10-Jun-08	19-Jun-08	10-Jun-08	19-Jun-08
	Depth to Water (MP) (mbtop)	-	-	1.74	-	-	0.17	-	0.65	0.35	1.34	3.02	2.93
	Depth to Water (Water Body) (mbtop)	-	-	1.34	-	-	0.71	-	0.64	0.31	0.61	0.89	0.89
	Vertical Separation (DL[1])	-	-	1.21	-	-	1.73	-	1.22	2.50	1.22	2.86	2.86
	Water Level Difference (DH[2])	-	-	-0.39	-	-	0.54	-	-0.02	-0.04	-0.73	-2.12	-2.04
	Hydraulic Gradient (DH/DL)	-	-	-0.33	-	-	**0.31**	-	-0.02	-0.02	-0.59	-0.74	-0.71

*NOTES: * indicates that water level taken to top of ice*
*** indicates new stick up added*
****indicates measurement taken after installation*
> indicates measurement taken to dry ground
MP = Mini Piezometer mbtop = metres below top of pipe
***Bold** font indicates an upwards hydraulic gradient*
1 - Equals the Depth to the Top of the Screen (m below ground stream bed)
2 - Equals the difference between the Depth to Water (Water Body) and the Depth to Water (MP)

Table C4 - Mini-Piezometer Data and Construction

Location		MP1					MP2		MP3-Shallow	MP3-Deep	MP4-Shallow	MP4-Deep	
		Original		*Replacement*		*Replacement*	*Original*		*Original*	*Original*	*Original*	Original	
Date Installed		2-Nov-07		13-May-08		3-Sep-08	2-Nov-07		14-May-08	14-May-08	14-May-08	14-May-08	
Stick Up (m above stream bed or surface)		1.35		1.68		1.37	0.82		0.67	0.35	0.71	0.94	
Depth of Top of Screen (m below stream bed or surface)		1.21		1.21		1.52	1.73		1.22	2.50	1.22	2.86	
Depth of Bottom of Screen (m below stream bed or surface)		1.51		1.51		1.82	2.04		1.52	2.80	1.52	3.16	
Depth of Mid Screen (m below stream bed or surface)		1.36		1.36		1.67	1.88		1.37	2.65	1.37	3.01	
Depth of Top of Screen (m below top of pipe)		2.56		2.89		2.89	2.55		1.89	2.85	1.93	3.80	
Depth of Bottom of Screen (m below top of pipe)		2.86		3.19		3.19	2.85		2.19	3.15	2.23	4.10	
Depth of Mid Screen (m below top of pipe)		2.71		3.04		3.04	2.70		2.04	3.00	2.08	3.95	
Water Depth (m below top of pipe)													
Jul-08	Date	-	-	18-Jul-08	-	-	18-Jul-08	-	18-Jul-08	18-Jul-08	31-Jul-08	31-Jul-08	-
	Depth to Water (MP) (mbtop)	-	-	1.75	-	-	0.21	-	0.68	0.38	1.15	2.74	-
	Depth to Water (Water Body) (mbtop)	-	-	1.38	-	-	0.74	-	0.68	0.35	0.69	0.77	-
	Vertical Separation (DL[1])	-	-	1.21	-	-	1.73	-	1.22	2.50	1.22	2.86	-
	Water Level Difference (DH[2])	-	-	-0.37	-	-	0.53	-	0.00	-0.03	-0.46	-1.97	-
	Hydraulic Gradient (DH/DL)	-	-	-0.31	-	-	**0.31**	-	0.00	-0.01	-0.38	-0.69	-
Aug-08	Date												
	Depth to Water (MP) (mbtop)												
	Depth to Water (Water Body) (mbtop)												
	Vertical Separation (DL[1])												
	Water Level Difference (DH[2])												
	Hydraulic Gradient (DH/DL)												
Sep-08	Date	-	-	-	-	3-Sep-08	3-Sep-08	-	3-Sep-08	3-Sep-08	3-Sep-08	3-Sep-08	-
	Depth to Water (MP) (mbtop)	-	-	-	-	0.87	0.27	-	0.57	0.30	1.07	2.56	-
	Depth to Water (Water Body) (mbtop)	-	-	-	-	0.87	0.76 >	-	0.52	0.19	0.59	0.87	-
	Vertical Separation (DL[1])	-	-	-	-	1.52	1.73	-	1.22	2.50	1.22	2.86	-
	Water Level Difference (DH[2])	-	-	-	-	0.00	0.49	-	-0.05	-0.11	-0.48	-1.69	-
	Hydraulic Gradient (DH/DL)	-	-	-	-	0.00	**0.28**	-	-0.04	-0.04	-0.39	-0.59	-
Oct-08	Date	-	-	-	-	8-Oct-08	8-Oct-08	-	8-Oct-08	8-Oct-08	8-Oct-08	8-Oct-08	-
	Depth to Water (MP) (mbtop)	-	-	-	-	0.86	0.27	-	0.60	0.31	1.00	2.40	-
	Depth to Water (Water Body) (mbtop)	-	-	-	-	0.89	0.79	-	0.00	0.00	0.59	0.88	-
	Vertical Separation (DL[1])	-	-	-	-	1.52	1.73	-	1.22	2.50	1.22	2.86	-
	Water Level Difference (DH[2])	-	-	-	-	0.03	0.52	-	-0.60	-0.31	-0.41	-1.52	-
	Hydraulic Gradient (DH/DL)	-	-	-	-	**0.02**	**0.30**	-	-0.49	-0.12	-0.33	-0.53	-
Nov-08	Date	-	-	-	-	24-Nov-08	24-Nov-08	-	24-Nov-08	24-Nov-08	24-Nov-08	24-Nov-08	-
	Depth to Water (MP) (mbtop)	-	-	-	-	0.87	0.36	-	0.59	0.39	0.94	2.22	-
	Depth to Water (Water Body) (mbtop)	-	-	-	-	0.89	0.78	-	0.51	0.19	0.53	0.84	-
	Vertical Separation (DL[1])	-	-	-	-	1.52	1.73	-	1.22	2.50	1.22	2.86	-
	Water Level Difference (DH[2])	-	-	-	-	0.01	0.43	-	-0.09	-0.20	-0.41	-1.38	-
	Hydraulic Gradient (DH/DL)	-	-	-	-	**0.01**	**0.25**	-	-0.06	-0.08	-0.34	-0.48	-
Dec-08	Date	-	-	-	-	-	-	-	-	-	-	-	-
	Depth to Water (MP) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-
	Depth to Water (Water Body) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-
	Vertical Separation (DL[1])	-	-	-	-	-	-	-	-	-	-	-	-
	Water Level Difference (DH[2])	-	-	-	-	-	-	-	-	-	-	-	-
	Hydraulic Gradient (DH/DL)	-	-	-	-	-	-	-	-	-	-	-	-
Jan to Mar 2009	Date	-	-	-	-	-	-	-	-	-	-	-	-
	Depth to Water (MP) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-
	Depth to Water (Water Body) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-
	Vertical Separation (DL[1])	-	-	-	-	-	-	-	-	-	-	-	-
	Water Level Difference (DH[2])	-	-	-	-	-	-	-	-	-	-	-	-
	Hydraulic Gradient (DH/DL)	-	-	-	-	-	-	-	-	-	-	-	-

*NOTES: * indicates that water level taken to top of ice*
*** indicates new stick up added*
****indicates measurement taken after installation*
> indicates measurement taken to dry ground
MP = Mini Piezometer
***Bold** font indicates an upwards hydraulic gradient*
1 - Equals the Depth to the Top of the Screen (m below ground stream bed)
2 - Equals the difference between the Depth to Water (Water Body) and the Depth to Water (MP)

Table C4 - Mini-Piezometer Data and Construction

Location		MP5		MP6			MP7		MP8		MP9-Shallow		MP9-Deep		MP10	
		Original		*Original*		*Replacement*	*Original*		*Original*		*Original*		*Original*		*Original*	
Date Installed		9-Nov-07		2-Nov-07		13-May-08	2-Nov-07		8-Nov-07		8-Nov-07		8-Nov-07		7-Nov-07	
Stick Up (m above stream bed or surface)		1.65		0.94		1.81	0.77		1.29		0.96		0.57		1.44	
Depth of Top of Screen (m below stream bed or surface)		1.48		1.63		1.03	1.78		1.54		1.53		2.87		1.09	
Depth of Bottom of Screen (m below stream bed or surface)		1.78		1.93		1.33	2.09		2.17		1.83		3.17		1.39	
Depth of Mid Screen (m below stream bed or surface)		1.63		1.78		1.18	1.93		1.69		1.68		3.02		1.24	
Depth of Top of Screen (m below top of pipe)		3.12		2.57		2.84	2.55		2.83		2.49		3.43		2.52	
Depth of Bottom of Screen (m below top of pipe)		3.42		2.87		3.14	2.86		3.45		2.79		3.73		2.83	
Depth of Mid Screen (m below top of pipe)		3.27		2.72		2.99	2.70		2.98		2.64		3.58		2.67	
Water Depth (m below top of pipe)																
On Installation	Date	9-Nov-07	-	2-Nov-07	-	-	2-Nov-07	-	8-Nov-07	-	-	-	-	-	7-Nov-07	-
	Depth to Water (MP) (mbtop)	2.46	-	1.23	-	-	2.35 **	-	2.56 **	-	-	-	-	-	2.17**	-
	Depth to Water (Water Body) (mbtop)	1.28	-	0.88	-	-	0.67	-	1.14	-	-	-	-	-	1.33	-
	Vertical Separation (DL[1])	1.48	-	1.63	-	-	1.78	-	1.54	-	-	-	-	-	1.09	-
	Water Level Difference (DH[2])	-1.19	-	-0.35	-	-	-1.68	-	-1.42	-	-	-	-	-	-0.84	-
	Hydraulic Gradient (DH/DL)	-0.80	-	-0.22	-	-	-0.95	-	-0.92	-	-	-	-	-	-0.78	-
Nov-07	Date	30-Nov-07	-	30-Nov-07	-	-	30-Nov-07	-	30-Nov-07	-	30-Nov-07	-	30-Nov-07	-	30-Nov-07	-
	Depth to Water (MP) (mbtop)	2.44	-	2.14	-	-	0.58 *	-	2.38	-	1.86	-	3.09	-	1.31 *	-
	Depth to Water (Water Body) (mbtop)	1.28	-	0.83	-	-	0.66	-	1.13	-	0.94	-	0.54	-	1.36	-
	Vertical Separation (DL[1])	1.48	-	1.63	-	-	1.78	-	1.54	-	1.53	-	2.87	-	1.09	-
	Water Level Difference (DH[2])	-1.16	-	-1.30	-	-	0.09	-	-1.25	-	-0.91	-	-2.55	-	0.06	-
	Hydraulic Gradient (DH/DL)	-0.79	-	-0.80	-	-	**0.05**	-	-0.81	-	-0.50	-	-0.89	-	**0.06**	-
Feb-08	Date	7-Feb-08	-	7-Feb-08	-	-	7-Feb-08	-	7-Feb-08	-	7-Feb-08	-	7-Feb-08	-	7-Feb-08	-
	Depth to Water (MP) (mbtop)	1.37	-	1.90	-	-	0.44 *	-	2.06	-	1.08	-	2.66	-	1.14*	-
	Depth to Water (Water Body) (mbtop)	1.16	-	0.57	-	-	0.58 *	-	1.06	-	0.36	-	0.78	-	1.25	-
	Vertical Separation (DL[1])	1.48	-	1.63	-	-	1.78	-	1.54	-	1.53	-	2.87	-	1.09	-
	Water Level Difference (DH[2])	-0.21	-	-1.33	-	-	0.14	-	-1.00	-	-0.72	-	-1.89	-	1.10	-
	Hydraulic Gradient (DH/DL)	-0.14	-	-0.82	-	-	**0.08**	-	-0.67	-	-0.39	-	-0.66	-	**1.01**	-
Mar-08	Date	4-Mar-08	31-Mar-08	4-Mar-08	31-Mar-08	-	4-Mar-08	31-Mar-08	4-Mar-08	31-Mar-08	4-Mar-08	31-Mar-08	4-Mar-08	31-Mar-08	4-Mar-08	31-Mar-08
	Depth to Water (MP) (mbtop)	1.36	1.35	1.77	1.72	-	0.56 *	0.47	1.94	1.85	0.97	0.88	2.55	2.47	1.17	1.18
	Depth to Water (Water Body) (mbtop)	1.07	0.95	0.48	0.52	-	0.47 *	0.55	0.76	0.87	0.76*	0.78	0.35 *	0.38	1.15 *	1.00
	Vertical Separation (DL[1])	1.48	1.48	1.63	1.63	-	1.78	1.78	1.54	1.54	1.53	1.53	2.87	2.87	1.09	1.09
	Water Level Difference (DH[2])	-0.29	-0.40	-1.29	-1.20	-	-0.09	0.07	-1.18	-0.98	-0.21	-0.09	-2.20	-2.09	-0.02	-0.18
	Hydraulic Gradient (DH/DL)	-0.20	-0.27	-0.79	-0.74	-	-0.05	**0.04**	-1.18	-0.64	-0.13	-0.05	-0.77	-0.73	-0.02	-0.17
Apr-08	Date	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Depth to Water (MP) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Depth to Water (Water Body) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Vertical Separation (DL[1])	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Water Level Difference (DH[2])	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Hydraulic Gradient (DH/DL)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May-08	Date	16-May-08	-	-	-	13-May-08	22-May-08	-	16-May-08	-	16-May-08	-	16-May-08	-	16-May-08	-
	Depth to Water (MP) (mbtop)	1.25	-	-	-	2.48	0.36	-	1.71	-	0.86	-	2.33	-	1.19	-
	Depth to Water (Water Body) (mbtop)	1.27	-	-	-	1.62	0.64	-	1.21	-	0.87	-	0.45	-	1.36	-
	Vertical Separation (DL[1])	1.48	-	-	-	1.03	1.78	-	1.54	-	1.53	-	2.87	-	1.09	-
	Water Level Difference (DH[2])	0.02	-	-	-	-0.86	0.28	-	-0.50	-	0.01	-	-1.88	-	0.17	-
	Hydraulic Gradient (DH/DL)	**0.01**	-	-	-	-0.83	**0.16**	-	-0.38	-	**0.01**	-	-0.66	-	**0.16**	-
Jun-08	Date	10-Jun-08	-	-	-	10-Jun-08	10-Jun-08	-	10-Jun-08	-	10-Jun-08	-	10-Jun-08	-	10-Jun-08	-
	Depth to Water (MP) (mbtop)	1.27	-	-	-	2.37	0.40	-	1.69	-	0.90	-	2.31	-	1.14	-
	Depth to Water (Water Body) (mbtop)	1.28	-	-	-	1.58	0.64	-	1.20	-	0.87	-	0.45	-	1.36	-
	Vertical Separation (DL[1])	1.48	-	-	-	1.03	1.78	-	1.54	-	1.53	-	2.87	-	1.09	-
	Water Level Difference (DH[2])	0.00	-	-	-	-0.79	0.24	-	-0.49	-	-0.03	-	-1.86	-	0.23	-
	Hydraulic Gradient (DH/DL)	0.00	-	-	-	-0.77	**0.13**	-	-0.36	-	-0.02	-	-0.65	-	**0.21**	-

*NOTES: * indicates that water level taken to top of ice*
*** indicates new stick up added*
****indicates measurement taken after installation*
> indicates measurement taken to dry ground
MP = Mini Piezometer mbtop = metres below top of pipe
***Bold** font indicates an upwards hydraulic gradient*
1 - Equals the Depth to the Top of the Screen (m below ground stream bed)
2 - Equals the difference between the Depth to Water (Water Body) and the Depth to Water (MP)

AECOM

Table C4 - Mini-Piezometer Data and Construction

Location	MP5		MP6			MP7		MP8		MP9-Shallow		MP9-Deep		MP10	
	Original		*Original*		*Replacement*	*Original*		*Original*		*Original*		*Original*		*Original*	
Date Installed	9-Nov-07		2-Nov-07		13-May-08	2-Nov-07		8-Nov-07		8-Nov-07		8-Nov-07		7-Nov-07	
Stick Up (m above stream bed or surface)	1.65		0.94		1.81	0.77		1.29		0.96		0.57		1.44	
Depth of Top of Screen (m below stream bed or surface)	1.48		1.63		1.03	1.78		1.54		1.53		2.87		1.09	
Depth of Bottom of Screen (m below stream bed or surface)	1.78		1.93		1.33	2.09		2.17		1.83		3.17		1.39	
Depth of Mid Screen (m below stream bed or surface)	1.63		1.78		1.18	1.93		1.69		1.68		3.02		1.24	
Depth of Top of Screen (m below top of pipe)	3.12		2.57		2.84	2.55		2.83		2.49		3.43		2.52	
Depth of Bottom of Screen (m below top of pipe)	3.42		2.87		3.14	2.86		3.45		2.79		3.73		2.83	
Depth of Mid Screen (m below top of pipe)	3.27		2.72		2.99	2.70		2.98		2.64		3.58		2.67	
Water Depth (m below top of pipe)															
Jul-08 Date	31-Jul-08	-	-	-	18-Jul-08	31-Jul-08	-	18-Jul-08	-	18-Jul-08	-	18-Jul-08	-	-	-
Depth to Water (MP) (mbtop)	1.28	-	-	-	2.26	0.41	-	1.61	-	0.93	-	2.24	-	-	-
Depth to Water (Water Body) (mbtop)	1.10	-	-	-	1.71	0.58	-	1.21	-	0.86	-	0.42	-	-	-
Vertical Separation (DL[1])	1.48	-	-	-	1.03	1.78	-	1.54	-	1.53	-	2.87	-	-	-
Water Level Difference (DH[2])	-0.18	-	-	-	-0.55	0.18	-	-0.40	-	-0.07	-	-1.82	-	-	-
Hydraulic Gradient (DH/DL)	-0.12	-	-	-	-0.53	**0.10**	-	-0.30	-	-0.04	-	-0.63	-	-	-
Aug-08 Date															
Depth to Water (MP) (mbtop)															
Depth to Water (Water Body) (mbtop)															
Vertical Separation (DL[1])															
Water Level Difference (DH[2])															
Hydraulic Gradient (DH/DL)															
Sep-08 Date	3-Sep-08	-	-	-	3-Sep-08	3-Sep-08	-	3-Sep-08	-	3-Sep-08	-	3-Sep-08	-	3-Sep-08	-
Depth to Water (MP) (mbtop)	1.27	-	-	-	2.17	0.40	-	1.47	-	0.93	-	2.21	-	1.30	-
Depth to Water (Water Body) (mbtop)	1.27	-	-	-	1.62	0.64	-	1.19	-	0.93	-	0.51	-	1.39	-
Vertical Separation (DL[1])	1.48	-	-	-	1.03	1.78	-	1.54	-	1.53	-	2.87	-	1.09	-
Water Level Difference (DH[2])	0.00	-	-	-	-0.55	0.24	-	-0.28	-	-0.01	-	-1.69	-	0.09	-
Hydraulic Gradient (DH/DL)	0.00	-	-	-	-0.53	**0.13**	-	-0.22	-	0.00	-	-0.59	-	**0.09**	-
Oct-08 Date	8-Oct-08	-	-	-	8-Oct-08	8-Oct-08	-	8-Oct-08	-	8-Oct-08	-	8-Oct-08	-	8-Oct-08	-
Depth to Water (MP) (mbtop)	1.28	-	-	-	2.10	0.40	-	1.41	-	0.96	-	2.15	-	1.32	-
Depth to Water (Water Body) (mbtop)	1.26	-	-	-	1.58	0.62	-	1.17	-	0.93	-	0.51	-	1.37	-
Vertical Separation (DL[1])	1.48	-	-	-	1.03	1.78	-	1.54	-	1.53	-	2.87	-	1.09	-
Water Level Difference (DH[2])	-0.01	-	-	-	-0.53	0.23	-	-0.24	-	-0.03	-	-1.64	-	0.06	-
Hydraulic Gradient (DH/DL)	-0.01	-	-	-	-0.51	**0.13**	-	-0.19	-	-0.02	-	-0.57	-	**0.05**	-
Nov-08 Date	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Depth to Water (MP) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Depth to Water (Water Body) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vertical Separation (DL[1])	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Level Difference (DH[2])	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydraulic Gradient (DH/DL)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dec-08 Date	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Depth to Water (MP) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Depth to Water (Water Body) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vertical Separation (DL[1])	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Level Difference (DH[2])	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydraulic Gradient (DH/DL)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jan to Mar 2009 Date	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Depth to Water (MP) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Depth to Water (Water Body) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vertical Separation (DL[1])	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Level Difference (DH[2])	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydraulic Gradient (DH/DL)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

*NOTES: * indicates that water level taken to top of ice*

*** indicates new stick up added*

****indicates measurement taken after installation*

> indicates measurement taken to dry ground

MP = Mini Piezometer

***Bold** font indicates an upwards hydraulic gradient*

1 - Equals the Depth to the Top of the Screen (m below ground stream bed)

2 - Equals the difference between the Depth to Water (Water Body) and the Depth to Water (MP)

Table C4 - Mini-Piezometer Data and Construction

Location		MP11	MP12-Shallow		MP12-Deep		MP13		MP14			DMP1	DMP2	DMP3	DMP4	DMP5
		Original	*Original*		*Original*		*Original*		*Original*		*Replacement*	*Original*	*Original*	*Original*	*Original*	*Original*
Date Installed		1-Nov-07	1-May-08		1-May-08		12-Nov-07		1-Nov-07		20-May-08	24-Mar-09	24-Mar-09	24-Mar-09	24-Mar-09	24-Mar-09
Stick Up (m above stream bed or surface)		1.17	0.96		1.04		1.52		0.87		1.14	1.31	1.29	1.27	1.30	1.24
Depth of Top of Screen (m below stream bed or surface)		1.98	0.94		2.75		1.33		1.65		1.36	1.28	1.29	1.31	1.29	1.35
Depth of Bottom of Screen (m below stream bed or surface)		2.28	1.24		3.05		1.63		1.94		1.66	1.51	1.52	1.54	1.52	1.58
Depth of Mid Screen (m below stream bed or surface)		2.13	1.09		2.90		1.48		1.79		1.51	1.39	1.40	1.42	1.40	1.46
Depth of Top of Screen (m below top of pipe)		3.15	1.90		3.79		2.85		2.52		2.49	2.59	2.58	2.58	2.59	2.58
Depth of Bottom of Screen (m below top of pipe)		3.45	2.20		4.09		3.15		2.81		2.79	2.82	2.81	2.81	2.82	2.81
Depth of Mid Screen (m below top of pipe)		3.30	2.05		3.94		3.00		2.66		2.64	2.71	2.69	2.70	2.70	2.70
Water Depth (m below top of pipe)																
On Installation	Date	30-Nov-07	-	-	-	-	-	-	01-Nov-07	-	-	-	-	-	-	-
	Depth to Water (MP) (mbtop)	2.19	-	-	-	-	-	-	2.23	-	-	-	-	-	-	-
	Depth to Water (Water Body) (mbtop)	0.85	-	-	-	-	-	-	0.78	-	-	-	-	-	-	-
	Vertical Separation (DL[1])	1.98	-	-	-	-	-	-	1.65	-	-	-	-	-	-	-
	Water Level Difference (DH[2])	-1.34	-	-	-	-	-	-	-1.45	-	-	-	-	-	-	-
	Hydraulic Gradient (DH/DL)	-0.67	-	-	-	-	-	-	-0.88	-	-	-	-	-	-	-
Nov-07	Date	-	-	-	-	-	30-Nov-07	-	29-Nov-07	-	-	-	-	-	-	-
	Depth to Water (MP) (mbtop)	-	-	-	-	-	3.04	-	1.65	-	-	-	-	-	-	-
	Depth to Water (Water Body) (mbtop)	-	-	-	-	-	1.55	-	0.71	-	-	-	-	-	-	-
	Vertical Separation (DL[1])	-	-	-	-	-	1.33	-	1.65	-	-	-	-	-	-	-
	Water Level Difference (DH[2])	-	-	-	-	-	-1.50	-	-0.95	-	-	-	-	-	-	-
	Hydraulic Gradient (DH/DL)	-	-	-	-	-	-1.13	-	-0.57	-	-	-	-	-	-	-
Feb-08	Date	7-Feb-08	-	-	-	-	7-Feb-08	-	7-Feb-08	-	-	-	-	-	-	-
	Depth to Water (MP) (mbtop)	0.89	-	-	-	-	2.76	-	0.22 *	-	-	-	-	-	-	-
	Depth to Water (Water Body) (mbtop)	0.48 *	-	-	-	-	1.55	-	0.61	-	-	-	-	-	-	-
	Vertical Separation (DL[1])	1.98	-	-	-	-	1.33	-	1.65	-	-	-	-	-	-	-
	Water Level Difference (DH[2])	-0.42	-	-	-	-	-1.21	-	0.39	-	-	-	-	-	-	-
	Hydraulic Gradient (DH/DL)	-0.21	-	-	-	-	-0.91	-	**0.24**	-	-	-	-	-	-	-
Mar-08	Date	4-Mar-08	-	-	-	-	4-Mar-08	31-Mar-08	15-Mar-08	31-Mar-08	-	-	-	-	-	-
	Depth to Water (MP) (mbtop)	0.61 *	-	-	-	-	2.67	2.58	0.42	0.44	-	-	-	-	-	-
	Depth to Water (Water Body) (mbtop)	0.18 *	-	-	-	-	1.55	1.56	0.68	0.26	-	-	-	-	-	-
	Vertical Separation (DL[1])	1.98	-	-	-	-	1.33	1.33	1.65	1.65	-	-	-	-	-	-
	Water Level Difference (DH[2])	-0.43	-	-	-	-	-1.12	-1.03	0.26	-0.17	-	-	-	-	-	-
	Hydraulic Gradient (DH/DL)	-0.22	-	-	-	-	-0.85	-0.78	**0.16**	-0.11	-	-	-	-	-	-
Apr-08	Date	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Depth to Water (MP) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Depth to Water (Water Body) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Vertical Separation (DL[1])	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Water Level Difference (DH[2])	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Hydraulic Gradient (DH/DL)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May-08	Date	-	14-May-08	16-May-08	14-May-08	16-May-08	-	-	-	-	20-May-08	-	-	-	-	-
	Depth to Water (MP) (mbtop)	-	1.78	1.12	2.82	2.68	-	-	-	-	2.20	-	-	-	-	-
	Depth to Water (Water Body) (mbtop)	-	0.96	0.93	1.04	1.04	-	-	-	-	0.95	-	-	-	-	-
	Vertical Separation (DL[1])	-	0.94	0.94	2.75	2.75	-	-	-	-	1.36	-	-	-	-	-
	Water Level Difference (DH[2])	-	-0.82	-0.19	-1.78	-1.65	-	-	-	-	-1.25	-	-	-	-	-
	Hydraulic Gradient (DH/DL)	-	-0.87	-0.20	-0.65	-0.60	-	-	-	-	-0.92	-	-	-	-	-
Jun-08	Date	10-Jun-08	10-Jun-08	-	10-Jun-08	-	10-Jun-08	-	-	-	10-Jun-08	-	-	-	-	-
	Depth to Water (MP) (mbtop)	0.75	1.04	-	2.67	-	2.45	-	-	-	0.88	-	-	-	-	-
	Depth to Water (Water Body) (mbtop)	0.70	0.95	-	1.04	-	1.58	-	-	-	0.90	-	-	-	-	-
	Vertical Separation (DL[1])	1.98	0.94	-	2.75	-	1.33	-	-	-	1.36	-	-	-	-	-
	Water Level Difference (DH[2])	-0.05	-0.09	-	-1.63	-	-0.87	-	-	-	0.02	-	-	-	-	-
	Hydraulic Gradient (DH/DL)	-0.03	-0.10	-	-0.59	-	-0.65	-	-	-	**0.01**	-	-	-	-	-

*NOTES: * indicates that water level taken to top of ice*
*** indicates new stick up added*
****indicates measurement taken after installation*
> indicates measurement taken to dry ground
MP = Mini Piezometer   mbtop = metres below top of pipe
***Bold** font indicates an upwards hydraulic gradient*

1 - Equals the Depth to the Top of the Screen (m below ground stream bed)
2 - Equals the difference between the Depth to Water (Water Body) and the Depth to Water (MP)

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Table C4 - Mini-Piezometer Data and Construction

Location	MP11	MP12-Shallow		MP12-Deep		MP13		MP14			DMP1	DMP2	DMP3	DMP4	DMP5
	Original	*Original*		*Original*		*Original*		*Original*		*Replacement*	*Original*	*Original*	*Original*	*Original*	*Original*
Date Installed	1-Nov-07	1-May-08		1-May-08		12-Nov-07		1-Nov-07		20-May-08	24-Mar-09	24-Mar-09	24-Mar-09	24-Mar-09	24-Mar-09
Stick Up (m above stream bed or surface)	1.17	0.96		1.04		1.52		0.87		1.14	1.31	1.29	1.27	1.30	1.24
Depth of Top of Screen (m below stream bed or surface)	1.98	0.94		2.75		1.33		1.65		1.36	1.28	1.29	1.31	1.29	1.35
Depth of Bottom of Screen (m below stream bed or surface)	2.28	1.24		3.05		1.63		1.94		1.66	1.51	1.52	1.54	1.52	1.58
Depth of Mid Screen (m below stream bed or surface)	2.13	1.09		2.90		1.48		1.79		1.51	1.39	1.40	1.42	1.40	1.46
Depth of Top of Screen (m below top of pipe)	3.15	1.90		3.79		2.85		2.52		2.49	2.59	2.58	2.58	2.59	2.58
Depth of Bottom of Screen (m below top of pipe)	3.45	2.20		4.09		3.15		2.81		2.79	2.82	2.81	2.81	2.82	2.81
Depth of Mid Screen (m below top of pipe)	3.30	2.05		3.94		3.00		2.66		2.64	2.71	2.69	2.70	2.70	2.70
Water Depth (m below top of pipe)															
Jul-08 Date	18-Jul-08	18-Jul-08	-	18-Jul-08	-	-	-	-	-	21-Jul-2008	-	-	-	-	-
Depth to Water (MP) (mbtop)	0.84	1.01	-	2.46	-	-	-	-	-	0.21	-	-	-	-	-
Depth to Water (Water Body) (mbtop)	0.89	0.96	-	1.04	-	-	-	-	-	1.21	-	-	-	-	-
Vertical Separation (DL[1])	1.98	0.94	-	2.75	-	-	-	-	-	1.36	-	-	-	-	-
Water Level Difference (DH[2])	0.05	-0.05	-	-1.42	-	-	-	-	-	1.00	-	-	-	-	-
Hydraulic Gradient (DH/DL)	**0.03**	-0.05	-	-0.52	-	-	-	-	-	**0.74**	-	-	-	-	-
Aug-08 Date	-	-	-	-	-	-	-	-	-	-					
Depth to Water (MP) (mbtop)	-	-	-	-	-	-	-	-	-	-					
Depth to Water (Water Body) (mbtop)	-	-	-	-	-	-	-	-	-	-					
Vertical Separation (DL[1])	-	-	-	-	-	-	-	-	-	-					
Water Level Difference (DH[2])	-	-	-	-	-	-	-	-	-	-					
Hydraulic Gradient (DH/DL)	-	-	-	-	-	-	-	-	-	-					
Sep-08 Date	3-Sep-08	3-Sep-08	-	3-Sep-08	-	3-Sep-08	-	-	-	3-Sep-08					
Depth to Water (MP) (mbtop)	0.69	0.93	-	2.27	-	2.30	-	-	-	1.15					
Depth to Water (Water Body) (mbtop)	1.81	0.95	-	1.03	-	1.46	-	-	-	1.05					
Vertical Separation (DL[1])	1.98	0.94	-	2.75	-	1.33	-	-	-	1.36					
Water Level Difference (DH[2])	1.13	0.02	-	-1.24	-	-0.84	-	-	-	-0.10					
Hydraulic Gradient (DH/DL)	0.57	**0.02**	-	-0.45	-	-0.63	-	-	-	-0.07					
Oct-08 Date	8-Oct-08	8-Oct-08	-	8-Oct-08	-	8-Oct-08	-	-	-	8-Oct-08					
Depth to Water (MP) (mbtop)	0.71	0.94	-	2.14	-	1.25	-	-	-	0.37					
Depth to Water (Water Body) (mbtop)	0.62	0.95	-	0.00	-	1.48	-	-	-	1.02					
Vertical Separation (DL[1])	1.98	0.94	-	2.75	-	1.33	-	-	-	1.36					
Water Level Difference (DH[2])	-0.09	0.01	-	-2.14	-	0.23	-	-	-	0.66					
Hydraulic Gradient (DH/DL)	-0.04	**0.01**	-	-0.78	-	**0.17**	-	-	-	**0.48**					
Nov-08 Date	-	24-Nov-08	-	24-Nov-08	-	-	-	-	-	-					
Depth to Water (MP) (mbtop)	-	0.96	-	2.01	-	-	-	-	-	-					
Depth to Water (Water Body) (mbtop)	-	0.94	-	1.03	-	-	-	-	-	-					
Vertical Separation (DL[1])	-	0.94	-	2.75	-	-	-	-	-	-					
Water Level Difference (DH[2])	-	-0.01	-	-0.98	-	-	-	-	-	-					
Hydraulic Gradient (DH/DL)	-	-0.01	-	-0.36	-	-	-	-	-	-					
Dec-08 Date	-	-	-	-	-	-	-	-	-	-					
Depth to Water (MP) (mbtop)	-	-	-	-	-	-	-	-	-	-					
Depth to Water (Water Body) (mbtop)	-	-	-	-	-	-	-	-	-	-					
Vertical Separation (DL[1])	-	-	-	-	-	-	-	-	-	-					
Water Level Difference (DH[2])	-	-	-	-	-	-	-	-	-	-					
Hydraulic Gradient (DH/DL)	-	-	-	-	-	-	-	-	-	-					
Jan to Mar 2009 Date	-	-	-	-	-	-	-	-	-	-	29-Apr-09	29-Apr-09	29-Apr-09	29-Apr-09	29-Apr-09
Depth to Water (MP) (mbtop)	-	-	-	-	-	-	-	-	-	-	1.79	0.857	1.375	0.12	0.634
Depth to Water (Water Body) (mbtop)	-	-	-	-	-	-	-	-	-	-	1.10	0.90	1.24	0.90	1.03
Vertical Separation (DL[1])	-	-	-	-	-	-	-	-	-	-	1.28	1.29	1.31	1.29	1.35
Water Level Difference (DH[2])	-	-	-	-	-	-	-	-	-	-	-0.69	0.05	-0.14	0.78	0.40
Hydraulic Gradient (DH/DL)	-	-	-	-	-	-	-	-	-	-	-0.54	0.04	-0.10	0.61	0.29

*NOTES: * indicates that water level taken to top of ice*
*** indicates new stick up added*
****indicates measurement taken after installation*
> indicates measurement taken to dry ground
MP = Mini Piezometer
***Bold** font indicates an upwards hydraulic gradient*
1 - Equals the Depth to the Top of the Screen (m below ground stream bed)
2 - Equals the difference between the Depth to Water (Water Body) and the Depth to Water (MP)

Table C5 - Stream Reconnaissance Data

AECOM

Site	Date (mm/dd/yr)	Time (24 hrs)	Steam Flow Q (m^3/s)	Water Temp (°C)	Air Temp (°C)	Temp Difference (°C)	Soil	GW Indicator
SR1b	12/07/2007	08:45:00	WF	WF	-4	-	C	n/a: too much snow to see
SR1a	12/07/2007	10:00:00	WF	WF	-3	-	C	-
SR1b	02/11/2008	02:35:00	WF	1	-6	-7	-	too much slush to see bottom of streambed
SR1a	02/11/2008	03:15:00	WF	WF	-9	-	-	-
SR1b	04/15/2008	09:15:00	0.053	4	1	-3	C,G	WC
SR1a	04/15/2008	10:10:00	NFW	NFW	3	-	C,G	-
SR1b	05/16/2008	10:08:00	NFW	13	14	1	C, ST	-
SR1a	05/16/2008	11:00:00	NFW	NFW	14.7	-	C,ST	-
SR1b	09/03/2008	09:40:00	NFW	0	18	18	G,C	-
SR1a	09/03/2008	09:20:00	NFW	NFW	18	-	G,C	-
SR1b	10/06/2008	09:25:00	0.020	8	8	0	G	WC
SR1a	10/06/2008	10:00:00	NFW	0	8	8	-	-
SR1b	11/24/2008	09:45:00	0.015	1	3	-	C	-
SR1a	11/24/2008	10:25:00	NFW	NFW	3	NFW	C	-
SR2b	12/07/2007	10:25:00	WF	WF	-3	-	C	-
SR2a	12/07/2007	09:30:00	0.003	1	-4	-5	C, G	WC
SR2b	02/11/2008	02:42:00	WF	WF	-6	-	-	-
SR2a	02/11/2008	03:20:00	0.075	10	-9	-19	S,C	-
SR2b	04/15/2008	09:25:00	NFW	NFW	1	-	C,B	-
SR2a	04/15/2008	10:00:00	0.045	5	3	-2	G,C	-
SR2b	05/16/2008	10:15:00	NFW	NFW	14.7	-	ST, CL	-
SR2a	05/16/2008	10:45:00	0.008	11.2	14.5	3.3	C,S	WC
SR2b	09/03/2008	09:30:00	NFW	NFW	18	-	G,C	-
SR2a	09/03/2008	09:00:00	0.014	14	18	4	G,C	WC
SR2b	10/06/2008	09:35:00	NFW	NFW	8	-	G	-
SR2a	10/06/2008	09:50:00	0.014	9	8	-1	G	WC
SR2b	11/24/2008	09:55:00	NFW	NFW	3	NFW	C	-
SR2a	11/24/2008	10:18:00	0.031	1	3	-	C	WC
SR3b	12/07/2007	10:40:00	0.006	2.5	-3	-5.5	ST,G	-
SR3a	12/07/2007	11:40:00	0.030	5.5	-2	-7.5	ST	-
SR3b	02/11/2008	02:58:00	WF	WF	-8	-	-	-
SR3a	02/11/2008	03:28:00	0.030	3	-9	-12	S,G,C	-
SR3b	04/15/2008	09:35:00	0.011	5	1	-4	C,G	-
SR3a	04/15/2008	10:25:00	0.035	8	6	-2	S, G	-
SR3b	05/16/2008	10:30:00	0.004	11.9	14.7	2.8	G,S,ST	-
SR3a	05/16/2008	11:15:00	0.020	12.2	14.5	2.3	S	-
SR3b	09/03/2008	10:00:00	0.007	16	18	2	S,C	-
SR3a	09/03/2008	10:15:00	0.020	11	18	7	S, G	-
SR3b	10/06/2008	09:40:00	0.030	9	8	-1	G	-
SR3a	10/06/2008	10:05:00	0.044	9	8	-1	S	-
SR3b	11/24/2008	10:00:00	0.005	2	3	-	C	-
SR3a	11/24/2008	10:40:00	0.034	4	3	-	S	-
SR4a	12/07/2007	12:00:00	WF	WF	-1	-	-	-
SR4b	12/18/2007	10:45:00	0.027	1.5	-4	-5.5	ST,G	-
SR4a	12/18/2007	08:35:00	WF	WF	-5	-	-	-
SR4b	02/11/2008	04:15:00	0.002	1	-8	-9	S,G	-
SR4a	02/11/2008	03:40:00	0.113	0	-9	-9	C	-
SR4b	04/15/2008	11:15:00	0.126	8	8	0	G	-
SR4a	04/15/2008	10:45:00	0.096	6	7	1	G	-
SR4b	05/16/2008	11:30:00	0.013	16	15	-1	C,S	-
SR4a	05/16/2008	12:26:00	0.028	14.2	18	3.8	S	-
SR4b	09/03/2008	11:30:00	0.010	19	19	0	S, ST	staining
SR4a	09/03/2008	10:40:00	0.021	16	18	2	S,G	-
SR4b	10/06/2008	12:30:00	0.018	12	10	-2	G	WC
SR4a	10/06/2008	12:20:00	0.030	10	10	0	C,G	WC
SR4b	11/24/2008	11:25:00	0.027	3	3	-	C	-
SR4a	11/24/2008	11:15:00	0.050	2	3	-	C	-
SR5c	12/07/2007	15:15:00	WF	WF	-1	-	MU	-
SR5b	12/07/2007	14:50:00	39.600	2	-1	-3	C,S	-
SR5a	12/07/2007	12:20:00	0.717	2.5	-1	-3.5	C,G	-
SR5c	02/11/2008	04:30:00	WF	WF	-9	-	MU	-
SR5b	02/11/2008	04:25:00	WF	WF	-9	-	-	-
SR5a	02/11/2008	03:55:00	6.000	2	-8	-10	C,B	-
SR5c	04/15/2008	11:50:00	0.003	7	9	2	MU	-
SR5b	04/15/2008	11:30:00	2.640	5	8	3	G.B	-
SR5a	04/15/2008	11:00:00	2.310	5	7	2	C,G,B	-
SR5c	05/16/2008	13:00:00	NFW	NFW	18	-	ST,S	-
SR5b	05/16/2008	11:45:00	0.456	12	15	3	S,C	-
SR5a	05/16/2008	12:30:00	0.840	12.9	18	5.1	C,S	iron staining on cobbles and bank seeps
SR5c	09/03/2008	11:50:00	NFW	17	19	2	ST	GW sheen
SR5b	09/03/2008	11:40:00	1.782	15	19	4	C,G	-
SR5a	09/03/2008	11:15:00	1.254	15	18	3	S,G,C	-
SR5c	10/06/2008	12:45:00	0.002	13	10	-3	ST	groundwater sheen
SR5b	10/06/2008	12:40:00	0.360	8	10	2	C,G	-
SR5a	10/06/2008	11:55:00	0.640	9	10	1	C,G	-
SR5c	11/24/2008	11:44:00	0.002	2	3	-	ST	iron staining
SR5b	11/24/2008	11:35:00	0.750	2	3	-	C,G	-
SR5a	11/24/2008	10:55:00	0.612	1	3	-	G,C,S	-

NOTES:

** indicates that water is too turbid to see bottom of stream*

NM - not measured.

ABBREVIATIONS:

WF = water frozen
NFW = no flowing water
B = boulder
G = gravel
C = cobble
S = sand
ST = silt
CL = clay
MU = muck
US = upstream
DS = downstream
RB = right bank
LB = left bank

Table C5 - Stream Reconnaissance Data

AECOM

Site	Date (mm/dd/yr)	Time (24 hrs)	Steam Flow Q (m^3/s)	Water Temp (°C)	Air Temp (°C)	Temp Difference (°C)	Soil	GW Indicator
SR6c	12/07/2007	14:00:00	0.004	2.5	-1	-3.5	C	-
SR6b	12/07/2007	14:25:00	0.017	2	-1	-3	C	WC
SR6a	12/07/2007	13:30:00	WF	WF	-1	-	-	-
SR6c	02/14/2008	01:15:00	WF	WF	-5	-	-	-
SR6b	02/14/2008	01:10:00	WF	WF	-5	-	-	-
SR6a	02/14/2008	12:54:00	WF	WF	-5	-	-	-
SR6c	04/15/2008	12:25:00	0.026	8	9	1	C	-
SR6b	04/15/2008	12:15:00	0.020	8	9	1	C,G	-
SR6a	04/15/2008	12:35:00	0.210	8	9	1	ST	Bulrushes
SR6c	05/16/2008	13:15:00	0.004	14.3	18	3.7	ST,S	wetland marigolds
SR6b	05/16/2008	13:10:00	0.006	13.5	18	4.5	C,S	WC
SR6a	05/16/2008	13:25:00	0.039	15.1	18	2.9	ST	-
SR6c	09/03/2008	12:20:00	0.001	15	20	5	ST,G	WC
SR6b	09/03/2008	12:10:00	0.013	15	19	4	G	-
SR6a	09/03/2008	13:05:00	0.021	19	23	4	ST	-
SR6c	10/06/2008	13:00:00	0.008	9	10	1	rip-rap	-
SR6b	10/06/2008	12:55:00	0.010	11	10	-1	C,G	WC
SR6a	10/06/2008	11:45:00	0.078	9	10	1	ST	-
SR6c	11/24/2008	12:10:00	0.020	1	3	2	G,C	-
SR6b	11/24/2008	12:00:00	0.027	5	3	-2	C	WC
SR6a	11/24/2008	12:20:00	0.141	2	3	1	ST	-
SR7	12/18/2007	09:05:00	WF	WF	-5	-	-	-
SR7	02/14/2008	12:41:00	0.020	1	-6	-7	ST,S	-
SR7	04/15/2008	01:00:00	0.016	9	10	1	S,C	-
SR7	05/16/2008	13:30:00	0.001	16	19	3	MU	-
SR7	07/08/2008	08:22:00	0.006	14	22	8	MU	some WC
SR7	09/03/2008	13:22:00	0.001	16	23	7	S,ST	-
SR7	10/06/2008	11:35:00	0.001	11	10	-1	G,ST	-
SR8c	12/18/2007	10:30:00	WF	WF	-4	-	WF	-
SR8b	12/18/2007	10:15:00	0.001	1.5	-4	-5.5	ST	WC
SR8a	12/18/2007	09:10:00	WF	WF	-5	-	-	-
SR8c	02/14/2008	01:18:00	WF	WF	-5	-	WF	-
SR8b	02/14/2008	01:30:00	WF	WF	-5	-	-	-
SR8a	02/14/2008	12:31:00	WF	WF	-6	-	-	-
SR8c	04/15/2008	02:20:00	0.074	8	10	2	C	WC
SR8b	04/15/2008	01:55:00	0.085	8	10	2	S	WC
SR8a	04/15/2008	01:15:00	0.150	9	10	1	S,C	W/C
SR8c	05/16/2008	16:26:00	0.001	17	18	1	ST,S	-
SR8b	05/16/2008	16:40:00	0.007	15.8	17	1.2	ST,S	-
SR8a	05/16/2008	13:40:00	0.007	14.4	19	4.6	ST,S	WC
SR8c	07/08/2008	08:51:00	NFW	18	24	6	-	crayfish
SR8b	07/08/2008	09:15:00	0.002	14	25	11	-	WC
SR8a	07/08/2008	09:37:00	0.002	14	25	11	-	crayfish in pool
SR8c	09/03/2008	12:25:00	0.001	16	20	4	ST	-
SR8b	09/03/2008	12:50:00	0.006	16	23	7	C,ST	WC
SR8a	09/03/2008	13:30:00	0.008	15	24	9	CL	WC
SR8c	10/06/2008	13:05:00	0.012	10	10	0	G	-
SR8b	10/06/2008	13:20:00	0.019	10	10	0	G,ST	WC
SR8a	10/06/2008	11:26:00	0.018	8	10	2	G	WC
SR9b	12/18/2007	09:56:00	WF	WF	-5	-	WF	-
SR9a	12/18/2007	09:40:00	0.009	1	-5	-6	ST,C	WC
SR9b	02/14/2008	01:20:00	WF	WF	-5	-	WF	-
SR9a	02/14/2008	12:23:00	0.020	1	-6	-7	ST	LB,US ditch iron staining
SR9b	04/15/2008	02:10:00	0.090	9	10	1	S,C	WC
SR9a	04/15/2008	01:30:00	0.075	9	10	1	C,G	-
SR9b	05/16/2008	16:49:00	NFW	16.1	19	2.9	sand	WC
SR9a	05/16/2008	14:00:00	0.023	13.5	19.5	6	S,G	WC
SR9b	07/08/2008	09:05:00	NFW	16	25	9	-	-
SR9a	07/08/2008	09:37:00	0.002	14	25	11		crayfish
SR9b	09/03/2008	12:35:00	0.002	20	21	1	S	-
SR9a	09/03/2008	13:45:00	0.011	16	24	8	C,G	WC
SR9b	10/06/2008	13:10:00	0.003	14	10	-4	ST	-
SR9a	10/06/2008	11:16:00	0.011	9	10	1	G	WC
SR10b	12/18/2007	11:05:00	WF	WF	-4	-	-	-
SR10a	12/18/2007	09:30:00	0.003	0.5	5	4.5	-	-
SR10b	02/14/2008	01:51:00	WF	WF	-5	-	-	-
SR10a	02/14/2008	12:14:00	WF	WF	-6	-	-	-
SR10b	04/15/2008	02:35:00	0.048	12	10	-2	S,G	WC
SR10a	04/15/2008	02:50:00	0.100	9	10	1	S,G	-
SR10b	05/16/2008	16:20:00	0.004	15	18	3	S,G	-
SR10a	05/16/2008	16:54:00	0.012	14.1	20.3	6.2	S	-
SR10b	09/03/2008	14:05:00	NFW	18	24	6	S	-
SR10a	09/03/2008	13:50:00	0.012	19	24	5	S,G	WC
SR10b	10/06/2008	13:40:00	0.019	11	10	-1	G	
SR10a	10/06/2008	11:10:00	0.015	10	9	-1	S,G	
SR10b	11/24/2008	12:50:00	WF	WF	3	-	C,S	-
SR10a	11/24/2008	13:00:00	0.040	3	3	0	C,S	-

NOTES:
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NM - not measured.
ABBREVIATIONS:

WF = water frozen | *CL = clay*
NFW = no flowing water | *MU = muck*
B = boulder | *US = upstream*
G = gravel | *DS = downstream*
C = cobble | *RB = right bank*
S = sand | *LB = left bank*
ST = silt

Table C5 - Stream Reconnaissance Data

AECOM

Site	Date (mm/dd/yr)	Time (24 hrs)	Steam Flow Q (m^3/s)	Water Temp (°C)	Air Temp (°C)	Temp Difference (°C)	Soil	GW Indicator
SR12c	12/18/2007	11:20:00	WF	WF	-4	-	-	-
SR12b	12/18/2007	11:40:00	WF	WF	-4	-	-	-
SR12a	12/18/2007	14:30:00	WF	WF	-2	-	-	-
SR12c	02/14/2008	02:00:00	WF	WF	-5	-	-	-
SR12b	02/14/2008	02:15:00	WF	WF	-5	-	-	-
SR12a	02/14/2008	02:33:00	WF	WF	-5	-	-	-
SR12c	04/15/2008	03:15:00	0.052	8	10	2	S,G	-
SR12b	04/15/2008	03:30:00	0.080	9	10	1	C,G	-
SR12a	04/15/2008	03:00:00	0.150	9	10	1	C,G	-
SR12c	05/16/2008	15:50:00	0.001	14.5	17	2.5	S	-
SR12b	05/16/2008	16:00:00	0.001	14.2	18	3.8	C	-
SR12a	05/16/2008	15:40:00	0.010	14.2	18	3.8	S	WC
SR12c	07/08/2008	10:06:00	NFW	-	27	-	-	-
SR12b	07/08/2008	10:30:00	NFW	-	27	-	-	-
SR12a	07/08/2008	12:25:00	0.001	16	27	11	-	WC
SR12c	09/03/2008	14:15:00	0.001	17	24	7	S,MU	-
SR12b	09/03/2008	14:30:00	0.001	19	24	5	S,G	-
SR12a	09/03/2008	15:35:00	0.002	16	26	10	G	WC, GW sheen
SR12c	10/06/2008	13:50:00	0.017	9	10	1	S,MU	
SR12b	10/06/2008	14:00:00	0.048	9	10	1	G	
SR12a	10/06/2008	11:00:00	0.004	9	9	0	G,ST	WC
SR13e	12/06/2007	08:15:00	0.004	0.1	-7	-7.1	S	-
SR13d	12/06/2007	08:40:00	NFW	0.1	-7	-7.1	C,S	-
SR13c	12/06/2007	09:00:00	WF	WF	-7	-	-	-
SR13b	12/06/2007	09:15:00	WF	WF	-7	-	-	-
SR13a	12/06/2007	09:45:00	0.053	0.1	-7	-7.1	S	-
SR13e	02/14/2008	03:20:00	WF	WF	-5	-	-	-
SR13d	02/14/2008	03:35:00	WF	WF	-5	-	-	-
SR13c	02/14/2008	03:51:00	WF	WF	-5	-	-	-
SR13b	02/14/2008	04:15:00	WF	WF	-5	-	-	-
SR13a	02/14/2008	04:25:00	WF	WF	-5	-	-	-
SR13e	04/15/2008	04:25:00	0.280	10	10	0	S, ST	-
SR13d	04/15/2008	04:15:00	0.129	9	10	1	C	-
SR13c	04/15/2008	03:55:00	0.039	9	10	1	G,S	-
SR13b	04/15/2008	04:40:00	0.637	11	10	-1	S, ST	WC
SR13a	04/15/2008	05:00:00	0.563	9	10	1	S	-
SR13e	05/16/2008	17:00:00	0.014	14.9	19	4.1	C,S	WC, iron staining
SR13d	05/16/2008	17:20:00	0.025	15.7	19	3.3	G,S	iron staining
SR13c	05/16/2008	17:40:00	0.074	16.1	18	1.9	ST	-
SR13b	05/16/2008	18:00:00	0.032	14.8	15	0.2	ST	-
SR13a	05/16/2008	18:30:00	NFW	16	17	1	ST	-
SR13e	07/08/2008	10:45:00	0.038	21	26	5	-	-
SR13d	07/08/2008	10:55:00	0.030	18	26	8	-	minnows
SR13c	07/08/2008	11:11:00	0.003	17	27	10	-	minnows
SR13b	07/08/2008	11:31:00	0.090	21	27	6	-	WC, iron sheen
SR13a	07/08/2008	11:50:00	0.012	20	27	7	-	-
SR13e	09/03/2008	16:30:00	0.008	18	26	8	S, C	-
SR13d	09/03/2008	17:20:00	0.031	18	26	8	C,G	WC
SR13c	09/03/2008	17:55:00	0.035	17	26	9	ST,C	-
SR13b	09/03/2008	18:10:00	0.049	22	26	4	ST	WC
SR13a	09/03/2008	18:31:00	0.020	19	26	7	ST	-
SR13e	10/08/2008	11:20:00	0.012	9	10	1	G	
SR13d	10/08/2008	12:10:00	0.031	9	10	1	G,CL	WC
SR13c	10/08/2008	12:40:00	0.028	9	10	1	ST,G	
SR13b	10/08/2008	13:10:00	0.030	11	10	-1	ST	WC
SR13a	10/08/2008	13:20:00	0.010	11	10	-1	ST,MU	-
SR14b	12/18/2007	14:35:00	0.135	0	-2	-2	G,C	-
SR14a	12/18/2007	14:15:00	WF	WF	-2	-	-	-
SR14b	02/14/2008	02:40:00	WF	WF	-5	-	-	-
SR14a	02/14/2008	12:08:00	WF	WF	-6	-	-	-
SR14b	04/17/2008	08:25:00	0.612	4	4	0	S	-
SR14a	04/17/2008	09:30:00	0.600	5	6	1	G	-
SR14b	05/16/2008	15:30:00	0.081	14.4	16.2	1.8	CL,ST	-
SR14a	05/16/2008	14:10:00	0.126	12.8	19.5	6.7	S, G	iron staining on cobbles
SR14b	07/08/2008	01:30:00	0.280	16	25	9	-	small fish
SR14a	07/08/2008	12:34:00	0.203	18	27	9	-	groundwater seeps
SR14b	09/03/2008	16:00:00	0.510	18	26	8	C,G	WC
SR14a	09/03/2008	15:25:00	0.246	17	26	9	S,C,G	-
SR14b	10/06/2008	14:15:00	0.640	8	10	2	C,G,ST	-
SR14a	10/06/2008	10:50:00	0.372	8	9	1	G	WC
SR15b	12/18/2007	14:45:00	WF	WF	-2	-	-	-
SR15a	12/18/2007	14:05:00	WF	WF	-2	-	-	-
SR15b	02/14/2008	02:45:00	WF	1	-5	-6	-	-
SR15a	02/14/2008	12:00:00	WF	WF	-6	-	-	-
SR15b	04/17/2008	08:45:00	0.125	6	4	-2	G	-
SR15a	04/17/2008	09:20:00	0.235	5	5	0	C,G	-
SR15b	05/16/2008	15:15:00	0.150	15.5	16	0.5	S	WC
SR15a	05/16/2008	14:30:00	0.165	12.6	19	6.4	S,G	-
SR15b	07/08/2008	01:15:00	NFW	22	27	5	-	-
SR15a	07/08/2008	12:47:00	0.012	20	27	7	-	-
SR15b	09/03/2008	16:05:00	0.011	18	26	8	C	WC
SR15a	09/03/2008	15:15:00	0.016	18	25	7	S,C,G	-
SR15b	10/06/2008	14:20:00	0.017	12	10	-2	G	WC
SR15a	10/06/2008	10:40:00	0.186	8	9	1	G,C	-

NOTES:
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ABBREVIATIONS:

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NFW = no flowing water	*MU = muck*
B = boulder	*US = upstream*
G = gravel	*DS = downstream*
C = cobble	*RB = right bank*
S = sand	*LB = left bank*
ST = silt	

Table C5 - Stream Reconnaissance Data

AECOM

Site	Date (mm/dd/yr)	Time (24 hrs)	Steam Flow Q (m^3/s)	Water Temp (°C)	Air Temp (°C)	Temp Difference (°C)	Soil	GW Indicator
SR16b	12/18/2007	14:55:00	WF	WF	-2	-	-	-
SR16a	12/18/2007	13:50:00	0.015	0.5	-2	-2.5	G	WC
SR16b	02/14/2008	02:53:00	WF	WF	-6	-	-	-
SR16a	02/14/2008	11:49:00	WF	WF	-6	-	-	DS, RB culvert open and flowing
SR16b	04/17/2008	08:55:00	0.138	6	4	-2	S, G	-
SR16a	04/17/2008	09:05:00	0.112	5	5	0	G,C	-
SR16b	05/16/2008	15:00:00	0.005	15.6	16	0.4	C	iron staining
SR16a	05/16/2008	14:40:00	0.032	14.5	19	4.5	ST,S	WC
SR16b	07/08/2008	01:05:00	NFW	14	27	13	-	-
SR16a	07/08/2008	12:55:00	0.001	20	27	7	-	-
SR16b	09/03/2008	16:10:00	0.002	17	26	9	C,ST	gw sheen
SR16a	09/03/2008	15:00:00	0.027	18	25	7	G,C	WC
SR16b	10/06/2008	14:30:00	0.003	11	10	-1	G	WC, GW sheen
SR16a	10/06/2008	10:30:00	0.026	9	9	0	G	WC

NOTES:

** indicates that water is too turbid to see bottom of stream*

NM - not measured.

ABBREVIATIONS:

WF = water frozen
NFW = no flowing water
B = boulder
G = gravel
C = cobble
S = sand
ST = silt
CL = clay
MU = muck
US = upstream
DS = downstream
RB = right bank
LB = left bank

Table C6 – Groundwater Levels and Hydraulic Gradients

AECOM

Date	G1W-1 (mbgs)	G1W-2 (mbgs)	Gradient (dh/dl)	G2W-1 (mbgs)	G2W-2 (mbgs)	Gradient (dh/dl)	G3W-1 (mbgs)	G3W-2 (mgbs)	Gradient (dh/dl)	G4W-1 (mgbs)	G4W-2 (mbgs)	Gradient (dh/dl)	DM-1 (mbgs)	DM-2 (mbgs)	DM-3 (mbgs)	DM-4 (mbgs)	DM-5 (mbgs)	DM-6 (mbgs)	DM-7 (mbgs)
12/12/07	8.77	1.19	-1.23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12/13/07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12/20/07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1/7/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1/10/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1/11/08	2.63	0.84	-0.28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1/14/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1/15/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1/16/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1/17/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1/21/08	-	-	-	-0.16	0.55	0.18	-	-	-	-	-	-	-	-	-	-	-	-	-
1/30/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2/7/08	-	-	-	0.01 *	0.48	0.13	-	-	-	-	-	-	-	-	-	-	-	-	-
2/8/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2/27/08	2.59	0.67	-0.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3/4/08	-	-	-	0.23 *	0.57	0.10	-	-	-	-	-	-	-	-	-	-	-	-	-
3/11/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3/13/08	2.70	0.67	-0.32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3/27/08	-	-	-	-	-	-	-0.06	0.57	0.18	-	-	-	-	-	-	-	-	-	-
3/28/08	-	-	-	-	-	-	-	-	-	3.27	3.47	0.05	-	-	-	-	-	-	-
3/31/08	2.47	0.31	-0.34	-0.03	0.22	0.08	-	-	-	3.08	3.39	0.09	-	-	-	-	-	-	-
4/1/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4/2/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4/21/08	-	-	-	0.16	0.59	0.12	-	-	-	-	-	-	-	-	-	-	-	-	-
4/22/08	-	-	-	-	-	-	0.05	0.25	0.07	3.22	3.59	0.22	-	-	-	-	-	-	-
4/23/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4/28/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5/7/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5/8/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5/13/08	2.35	0.29	-0.32	0.97	1.53	0.15	-	-	-	-	-	-	-	-	-	-	-	-	-
5/14/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5/14/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6/3/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6/9/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6/10/08	2.44	0.39	-0.32	1.54	1.91	0.11	9.73	0.49	-2.28	3.25	3.64	0.13	-	-	-	-	-	-	-
6/19/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/18/08	2.48	0.62	-0.29	0.36	0.98	0.16	7.12	0.93	-1.52	2.96	3.67	0.13	-	-	-	-	-	-	-
7/21/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/28/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7/29/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8/21/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9/3/08	2.44	**	-	-	-	-	4.72	0.52	-1.03	2.88	3.65	0.21	-	-	-	-	-	-	-
9/4/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10/8/08	2.42	0.44	-0.31	0.47	0.93	0.01	3.47	0.41	-0.74	3.18	3.68	0.15	-	-	-	-	-	-	-
10/9/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10/16/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11/11/08	-	-	-	-	-	-	-	-	-	-	-	-							
11/24/08	-	-	-	-	-	-	2.25	0.16	-0.50	-	-	-	-	-	-	-	-	-	-
12/5/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12/14/08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3/23/09	-	-	-	-	-	-	-	-	-	-	-	-	-2.46	-0.80	1.81	6.18	-0.25	> 2.00	4.68
4/9/09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04/29/09	-	-	-	-	-	-	-	-	-	-	-	-	-2.38	-1.53	1.76	6.05	-0.37	> 2.00	4.90

Table C7 - Domestic Well Chemical Results

AECOM

Parameter	Unit	RDL	ODWS	1021	1022	1025	1042	1047	1062	1077	1081	1118	1152	1164	1201	1248	1255	6013	6245	6246
				West	West	West	West	West	West	West	West	West	West	West	West	West	West	West	West	West
				21-Jul-08	21-Jul-08	22-Jul-08	23-Jul-08	31-Jul-08	24-Jul-08	30-Jul-08	22-Jul-08	22-Jul-08	28-Jul-08	21-Jul-08	22-Jul-08	21-Jul-08	30-Jul-08	07-Aug-08	08-Aug-08	25-Jul-08
ORGANICS																				
C>10 - C16 (F2)	µg/L	100	na	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100
C>16 - C34 (F3)	µg/L	500	na	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500
C>16 - C50 (F3 + F4)	µg/L	500	na	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500
C>34 - C50	µg/L	500	na	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500	< 500
C6 - C10 (F1 minus BTEX)	µg/L	100	na	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100
C6 - C10 (F1)	µg/L	100	na	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100
C6 - C16 (F1 + F2)	µg/L	100	na	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100
Benzene	µg/L	0.2	5	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Ethylbenzene	µg/L	0.1	2.4	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Toluene	µg/L	0.2	na	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Xylenes (Total)	µg/L	0.14	300	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14
Gravimetric Heavy Hydrocarbons	µg/L	500	na	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MICROBIOLOGY																				
Total Coliforms	CFU/100mL	1	< 1	300	100	10	<1	4	30	<1	<1	1400	133	200	<1	25	469	300	9	4
Escherichia coli	CFU/100ml	1	< 1	<1	<1	5	<1	<1	5	<1	<1	35	<1	3	<1	<1	1	60	1	<1
Heterotrophic Plate Count (HPC) (CFU/ml)	CFU/ml	10	< 500	2400	33	22	7	760	90	<10	<1	5000	4600	30	<1	20	200	420	<1	26
INORGANICS AND METALS																				
Alkalinity (as CaCO3)	mg/L	5	30-500	351	239	250	208	286	275	185	218	227	310	196	229	311	153	364	284	259
Aluminum	mg/L	0.004	0.1	0.01	0.015	0.007	<0.004	0.03	<0.004	<0.004	<0.004	0.058	<0.004	<0.004	0.005	<0.004	0.004	<0.004	0.01	<0.004
Ammonia (as N)	mg/L	0.02	na	<0.02	<0.02	<0.02	1.63	<0.02	<0.02	<0.02	0.66	<0.02	3.47	<0.02	<0.02	0.46	<0.02	0.04	<0.02	<0.02
Arsenic	mg/L	0.003	0.025	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Barium	mg/L	0.002	1	0.124	0.024	0.171	0.056	0.02	0.042	0.073	0.076	0.055	0.108	0.053	0.046	0.12	0.025	0.26	0.04	<0.002
Bicarbonate (as CaCO3)	mg/L	5	na	351	239	234	195	247	275	171	157	227	310	187	223	301	153	336	272	224
Boron	mg/L	0.01	5	0.055	0.019	0.026	0.149	0.01	<0.01	0.086	0.032	0.014	0.148	0.013	0.013	0.203	0.013	0.2	0.02	0.047
Bromide	mg/L	0.05	na	0.12	<0.05	<0.05	0.1	<0.05	<0.05	0.1	<0.05	<0.05	0.15	<0.05	0.05	0.2	0.06	0.17	<0.05	0.06
Cadmium	mg/L	0.002	0.005	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Calcium	mg/L	0.05	na	0.057	0.033	0.009	0.017	0.11	0.025	<0.003	0.03	0.047	0.009	0.009	0.178	0.157	0.056	0.01	0.01	0.061
Carbonate (as CaCO3)	mg/L	5	na	<5	<5	16	13	39	<5	14	61	<5	<5	9	5	10	<5	28	12	35
Chloride	mg/L	0.1	250	183	9.42	120	6.07	11.9	6.49	19.3	0.87	16.8	10.2	6.01	134	15.6	141	114	37.8	12.2
Colour	TCU	5	5	<5	<5	<5	8	<5	<5	<5	<5	<5	15	<5	<5	5	<5	<5	<5	<5
Copper	mg/L	0.003	1	0.057	0.033	0.009	0.017	0.11	0.025	<0.003	0.03	0.047	0.009	0.009	0.178	0.157	0.056	0.01	0.01	0.061
Electrical Conductivity	uS/cm	2	na	1320	542	866	374	584	581	409	366	535	571	441	908	636	798	980	639	479
Field Conductivity	uS/cm	N/A	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fluoride	mg/L	0.05	1.5	<0.05	<0.05	0.08	0.26	<0.05	0.05	0.41	0.14	0.16	0.21	0.05	<0.05	0.14	<0.05	0.16	0.09	0.15
Hydroxide	mg/L	5	na	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Iron	mg/L	0.005	0.3	0.683	<0.01	<0.01	0.65	1.19	<0.01	2.08	0.197	0.064	1.95	<0.01	<0.01	0.8	0.024	1.54	0.35	0.02
Langelier Index	N/A	N/A	na	1.49	1.26	1.69	1.04	1.43	1.2	1.1	1.37	1.02	1.18	1.27	1.34	1.31	0.89	1.86	1.43	-1.91
Lead	mg/L	0.002	0.01	0.016	<0.002	<0.002	0.004	0.06	0.005	<0.002	0.002	<0.002	<0.002	<0.002	0.007	0.003	<0.002	<0.002	<0.002	<0.002
Magnesium	mg/L	0.05	na	13.6	7.07	37.5	13.7	9.16	13.4	8.58	19.8	8.85	19.3	9.26	9.35	14	9.73	43.4	8.15	<0.05
Manganese	mg/L	0.002	0.05	0.01	0.003	0.017	0.025	0.01	<0.002	0.094	0.022	<0.002	0.193	<0.002	<0.002	0.065	0.004	0.04	0.03	<0.002
Molybdenum	mg/L	0.002	na	<0.002	<0.002	<0.002	0.005	<0.002	<0.002	0.002	<0.002	<0.002	0.004	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Nickel	mg/L	0.003	na	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Nitrate as N	mg/L	0.05	10	12.4	8.81	0.12	<0.05	4.33	0.93	<0.05	<0.05	6.28	<0.05	0.66	1.12	<0.05	4.65	0.55	0.09	<0.05
Nitrite as N	mg/L	0.05	1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Orthophosphate as P	mg/L	0.1	na	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
pH	N/A	N/A	6.5-8.5	8.19	8.28	8.55	8.45	8.35	8.11	8.51	8.63	8.1	8.23	8.44	8.32	8.36	8.14	8.55	8.39	8.44
Field pH	N/A	N/A	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium	mg/L	0.05	na	12.4	0.58	2.52	1.19	0.65	1	1.06	1.19	0.81	3.01	2.01	1.13	3.4	1.11	5.01	0.49	0.12
Reactive Silica	mg/L	0.05	na	11.8	9.26	22.1	19.2	11.9	16.3	13.1	23.7	12.7	20.1	9.37	9.14	14.9	10.5	24.4	10.2	22.7
Saturation pH	N/A	N/A	na	6.7	7.02	6.86	7.41	6.92	6.91	7.41	7.26	7.08	7.05	7.17	6.98	7.05	7.25	6.69	6.96	10.4
Selenium	mg/L	0.004	0.01	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Silver	mg/L	0.002	na	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Sodium	mg/L	0.05	20 (200)	106	2.2	19.1	38.9	6.98	5.93	33.2	16.4	13.6	49.6	3.19	53.4	66.8	47.2	44.9	35.1	122
Strontium	mg/L	0.005	na	0.329	0.169	0.471	0.464	0.19	0.175	0.261	0.633	0.168	0.909	0.168	0.216	0.629	0.203	1.04	0.23	<0.005
Sulphate	mg/L	0.1	500	29.5	11	28.4	0.19	18.4	19.5	16	2.37	13.1	<0.1	28.7	36.9	13.3	21	3.93	16.9	2.52
Thallium	mg/L	0.006	na	<0.006	<0.006	<0.006	<0.006	<0.01	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.01	<0.01	<0.006
Titanium	mg/L	0.002	na	<0.002	<0.002	<0.002	<0.002	0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Total Dissolved Solids	mg/L	20	500	800	356	622	230	338	352	240	212	348	352	282	610	382	542	580	374	314
Total Hardness (as CaCO3)	mg/L	10	80-100	443	291	432	127	307	322	143	170	265	207	234	353	208	285	431	282	0.125
Total Organic Carbon	mg/L	0.5	na	2.8	1.8	1.0	2.2	1.8	1.2	1.3	1.3	2.2	5.4	1.1	1.3	3.9	1.4	1.3	2.8	1.8
Total Phosphorus	mg/L	0.05	na	<0.05	<0.05	0.14	<0.05	<0.05	<0.05	0.08	0.15	<0.05	0.43	<0.05	<0.05	0.07	<0.05	0.06	0.06	0.12
Turbidity	NTU	0.5	5	0.8	<0.5	<0.5	1.6	0.7	<0.5	13	1.2	1.7	4.3	<0.5	<0.5	4.1	<0.5	<0.5	0.7	0.5
Uranium	mg/L	0.002	0.02	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Vanadium	mg/L	0.002	na	<0.002	<0.002	<0.002	<0.002	0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Zinc	mg/L	0.005	5	0.044	0.008	0.014	0.025	0.14	0.01	<0.005	0.024	<0.005	0.007	<0.005	0.036	0.013	<0.005	0.05	<0.01	0.013
Field Temp	ºC	N/A	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

NOTES:
RDL - Reportable Detection Limit;
N/A or na = Not Applicable
ODWS - Ontario Drinking Water Standards
Bold font indicates ODWS exceedence

Table C7 - Domestic Well Chemical Results

AECOM

Parameter	Unit	RDL	ODWS	6257 West 25-Jul-08	6303 West 30-Jul-08
ORGANICS					
C>10 - C16 (F2)	µg/L	100	na	< 100	< 100
C>16 - C34 (F3)	µg/L	500	na	< 500	< 500
C>16 - C50 (F3 + F4)	µg/L	500	na	< 500	< 500
C>34 - C50	µg/L	500	na	< 500	< 500
C6 - C10 (F1 minus BTEX)	µg/L	100	na	< 100	< 100
C6 - C10 (F1)	µg/L	100	na	< 100	< 100
C6 - C16 (F1 + F2)	µg/L	100	na	< 100	< 100
Benzene	µg/L	0.2	5	< 0.2	< 0.2
Ethylbenzene	µg/L	0.1	2.4	< 0.1	< 0.1
Toluene	µg/L	0.2	na	< 0.2	< 0.2
Xylenes (Total)	µg/L	0.14	300	<0.14	<0.14
Gravimetric Heavy Hydrocarbons	µg/L	500	na	NA	NA
MICROBIOLOGY					
Total Coliforms	CFU/100mL	1	< 1	94	<1
Escherichia coli	CFU/100ml	1	< 1	<1	<1
Heterotrophic Plate Count (HPC) (CFU/ml)	CFU/ml	10	< 500	<1	<10
INORGANICS AND METALS					
Alkalinity (as CaCO3)	mg/L	5	30-500	262	193
Aluminum	mg/L	0.004	0.1	<0.004	<0.004
Ammonia (as N)	mg/L	0.02	na	3.21	<0.02
Arsenic	mg/L	0.003	0.025	<0.003	<0.003
Barium	mg/L	0.002	1	0.218	0.174
Bicarbonate (as CaCO3)	mg/L	5	na	262	166
Boron	mg/L	0.01	5	0.087	0.061
Bromide	mg/L	0.05	na	0.18	0.19
Cadmium	mg/L	0.002	0.005	<0.002	<0.002
Calcium	mg/L	0.05	na	<0.003	<0.003
Carbonate (as CaCO3)	mg/L	5	na	<5	26
Chloride	mg/L	0.1	250	11.4	61.3
Colour	TCU	5	5	20	<5
Copper	mg/L	0.003	1	<0.003	<0.003
Electrical Conductivity	uS/cm	2	na	498	608
Field Conductivity	uS/cm	N/A	na	-	-
Fluoride	mg/L	0.05	1.5	0.22	0.2
Hydroxide	mg/L	5	na	<5	<5
Iron	mg/L	0.005	0.3	1.65	1.39
Langelier Index	N/A	N/A	na	1.04	1.27
Lead	mg/L	0.002	0.01	<0.002	<0.002
Magnesium	mg/L	0.05	na	19.5	27.2
Manganese	mg/L	0.002	0.05	0.07	0.031
Molybdenum	mg/L	0.002	na	<0.002	<0.002
Nickel	mg/L	0.003	na	<0.003	<0.003
Nitrate as N	mg/L	0.05	10	<0.05	<0.05
Nitrite as N	mg/L	0.05	1	<0.05	<0.05
Orthophosphate as P	mg/L	0.1	na	<0.1	<0.1
pH	N/A	N/A	6.5-8.5	8.16	8.41
Field pH	N/A	N/A	na	-	-
Potassium	mg/L	0.05	na	1.92	2.16
Reactive Silica	mg/L	0.05	na	23	22.7
Saturation pH	N/A	N/A	na	7.12	7.14
Selenium	mg/L	0.004	0.01	<0.004	<0.004
Silver	mg/L	0.002	na	<0.002	<0.002
Sodium	mg/L	0.05	20 (200)	36.8	21.5
Strontium	mg/L	0.005	na	0.772	0.468
Sulphate	mg/L	0.1	500	0.39	42.3
Thallium	mg/L	0.006	na	<0.006	<0.006
Titanium	mg/L	0.002	na	<0.002	<0.002
Total Dissolved Solids	mg/L	20	500	284	378
Total Hardness (as CaCO3)	mg/L	10	80-100	195	269
Total Organic Carbon	mg/L	0.5	na	3.4	1.1
Total Phosphorus	mg/L	0.05	na	0.25	<0.05
Turbidity	NTU	0.5	5	4.6	12
Uranium	mg/L	0.002	0.02	<0.002	<0.002
Vanadium	mg/L	0.002	na	<0.002	<0.002
Zinc	mg/L	0.005	5	<0.005	0.007
Field Temp	ºC	N/A	na	-	-

NOTES:
RDL - Reportable Detection Limit;
N/A or na = Not Applicable
ODWS - Ontario Drinking Water Standards
Bold font indicates ODWS exceedence

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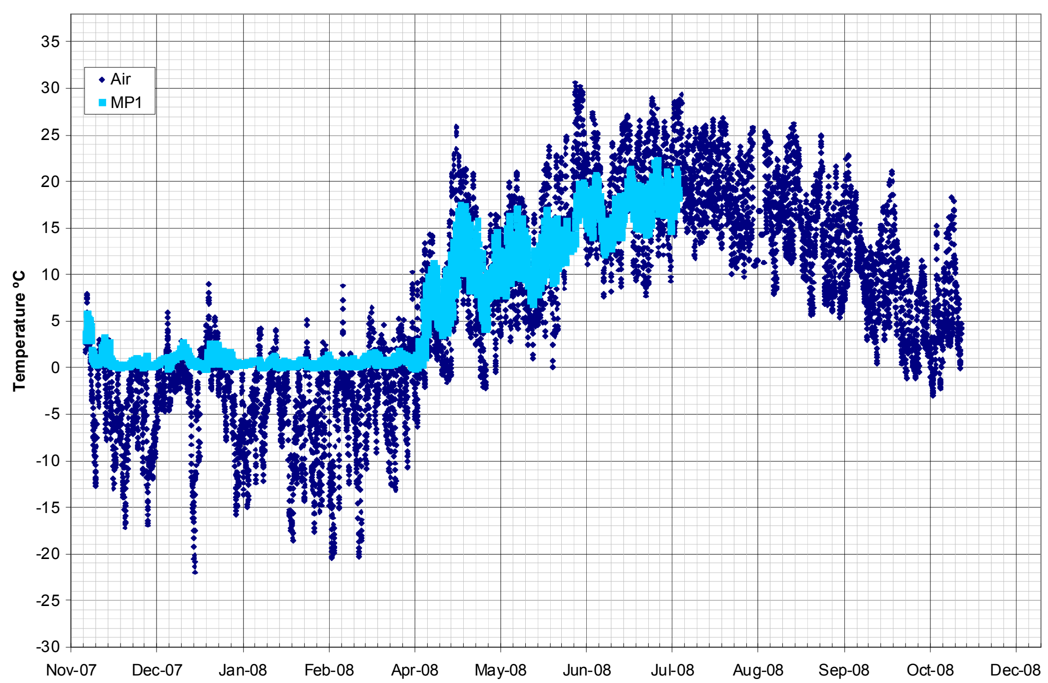
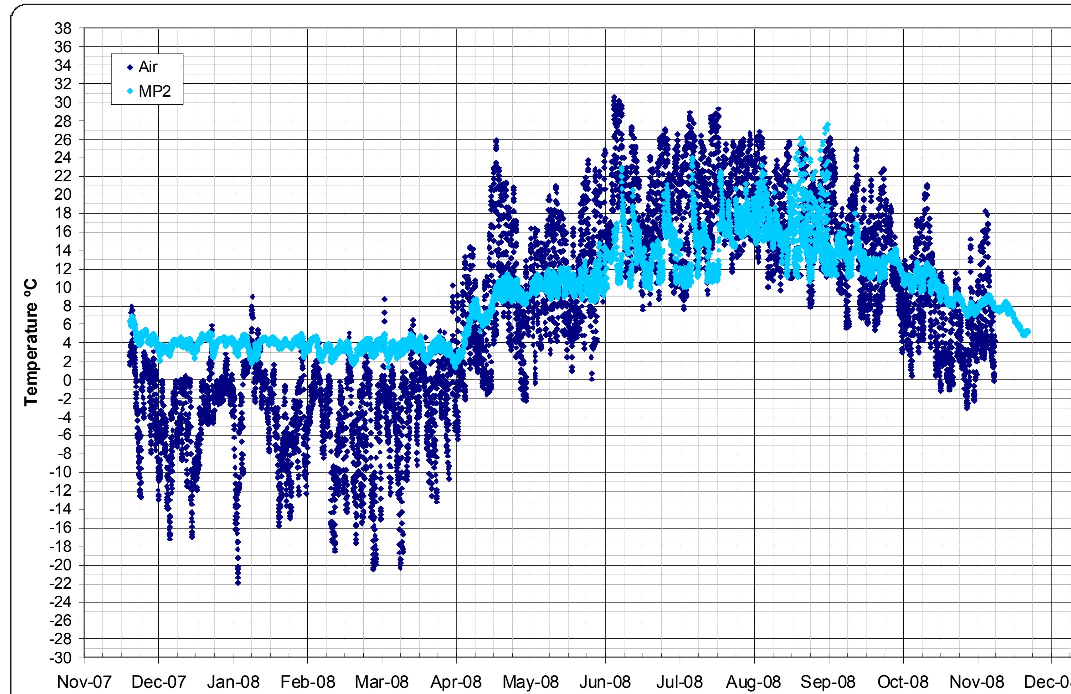
Appendix D

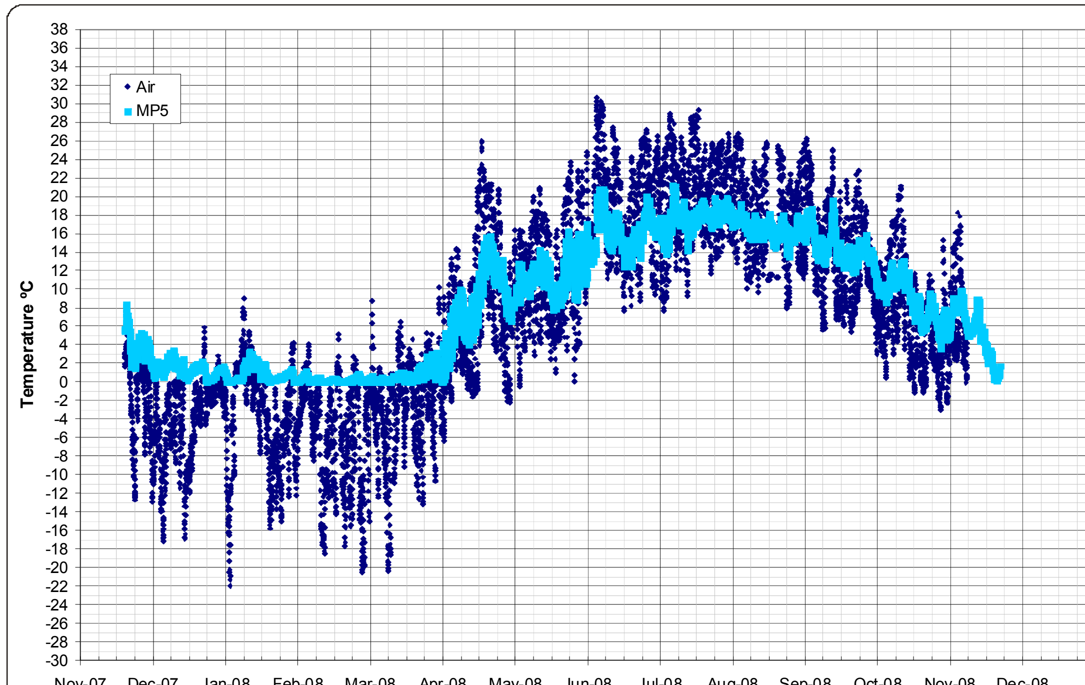
Stream Temperature Monitoring Results



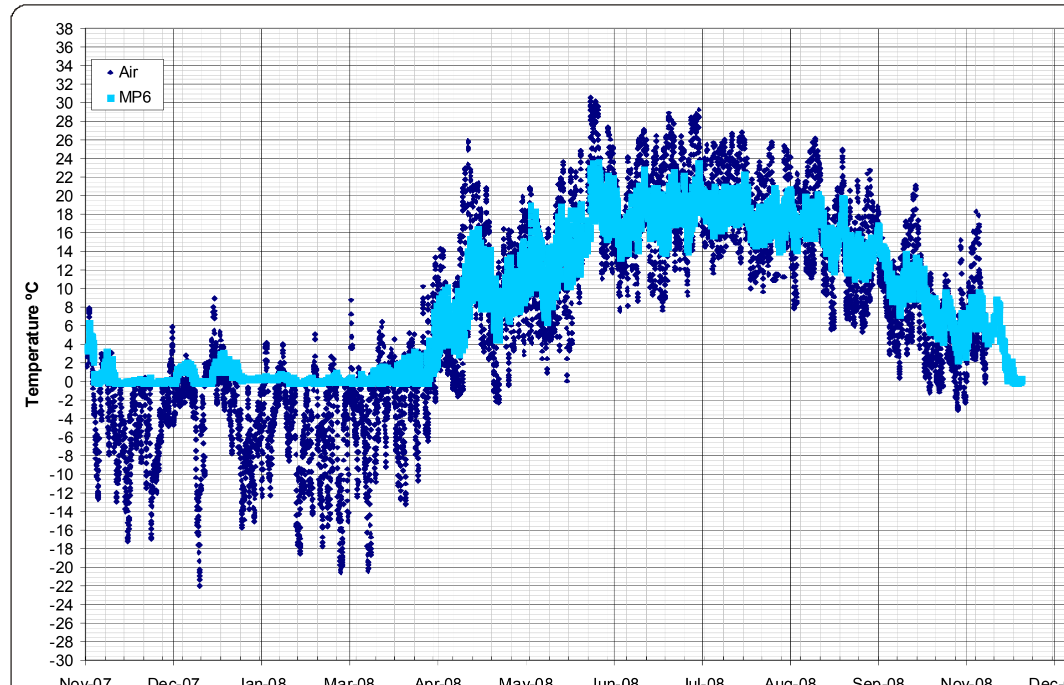
AECOM	MP1 Stream Temperature 407 EAST Foundations Seasonal Monitoring - Hydrogeology	**FIGURE D1** Project 50613



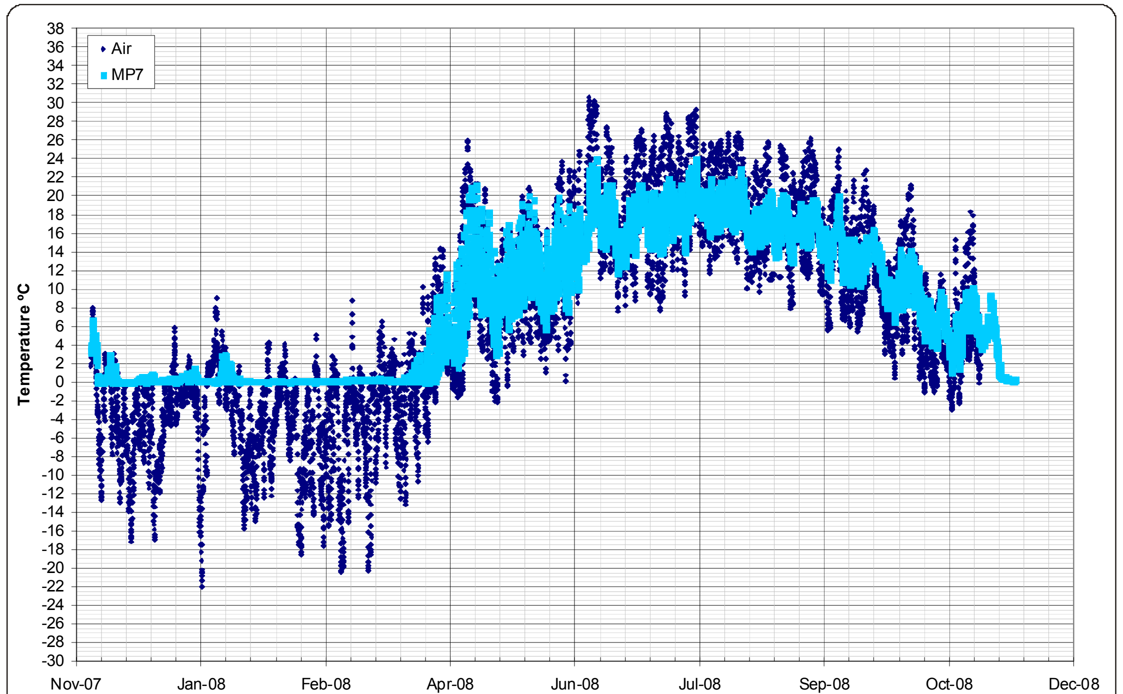
AECOM	MP2 Stream Temperature 407 EAST Foundations Seasonal Monitoring - Hydrogeology	**FIGURE D2** Project 50613



AECOM	MP5 Stream Temperature 407 EAST Foundations Seasonal Monitoring - Hydrogeology	**FIGURE D3** Project 50613



AECOM	MP6 Stream Temperature 407 EAST Foundations Seasonal Monitoring - Hydrogeology	**FIGURE D4** Project 50613



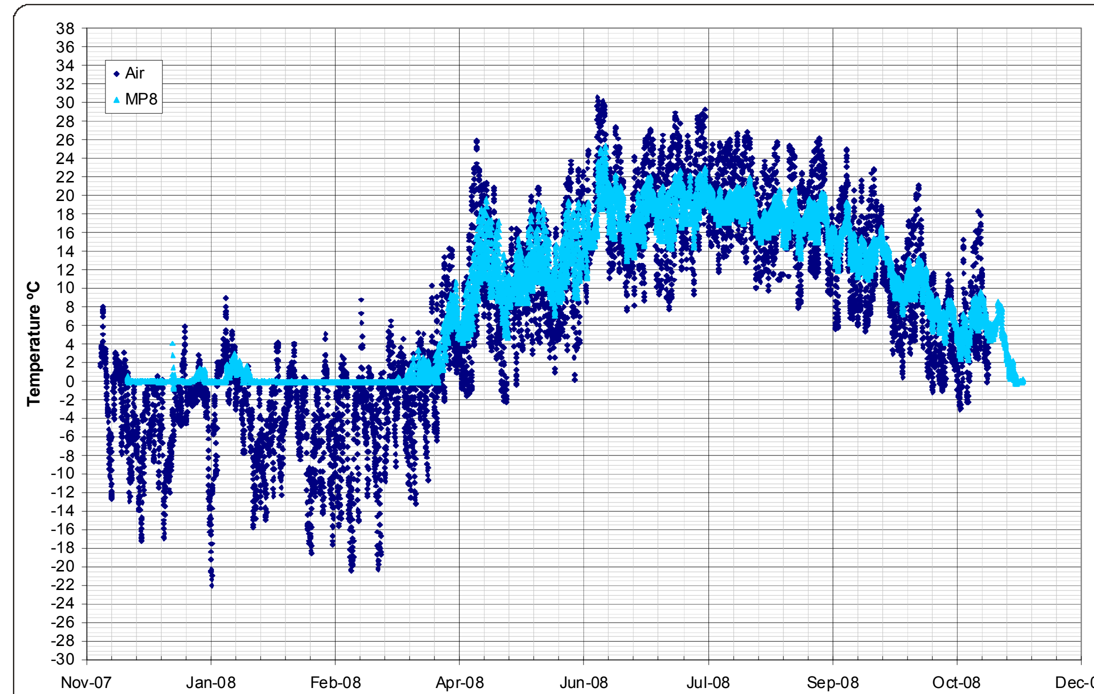
AECOM

MP7 Stream Temperature

407 EAST Foundations
Seasonal Monitoring - Hydrogeology

FIGURE D5

Project 50613



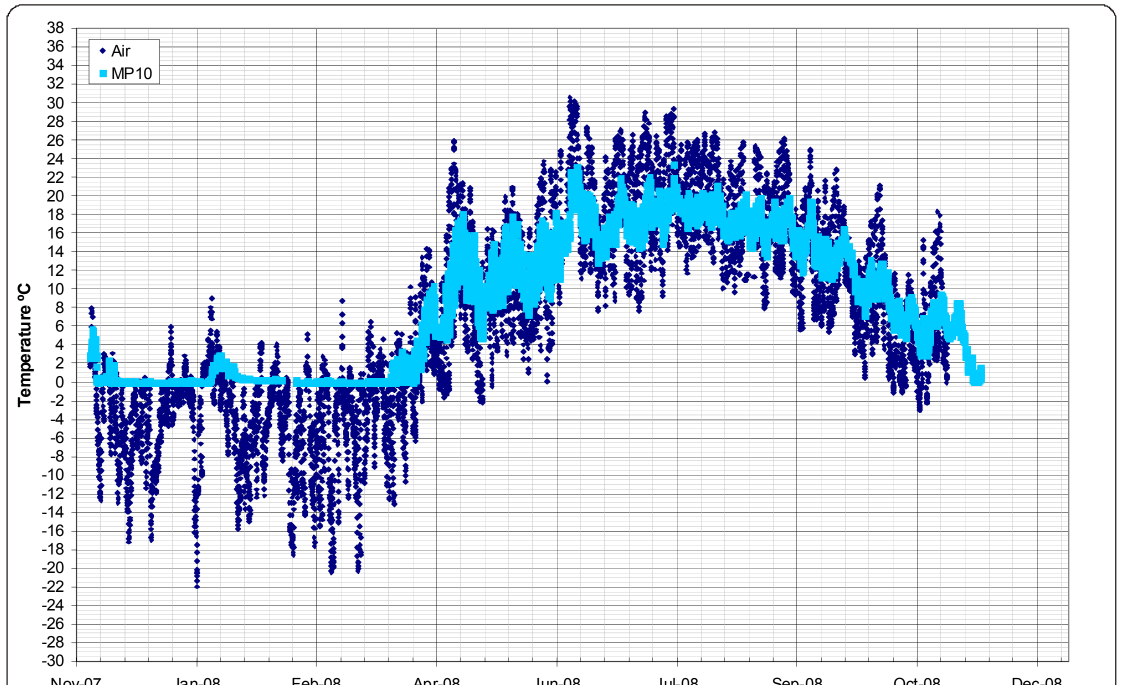
AECOM

MP8 Stream Temperature

407 EAST Foundations
Seasonal Monitoring - Hydrogeology

FIGURE D6

Project 50613



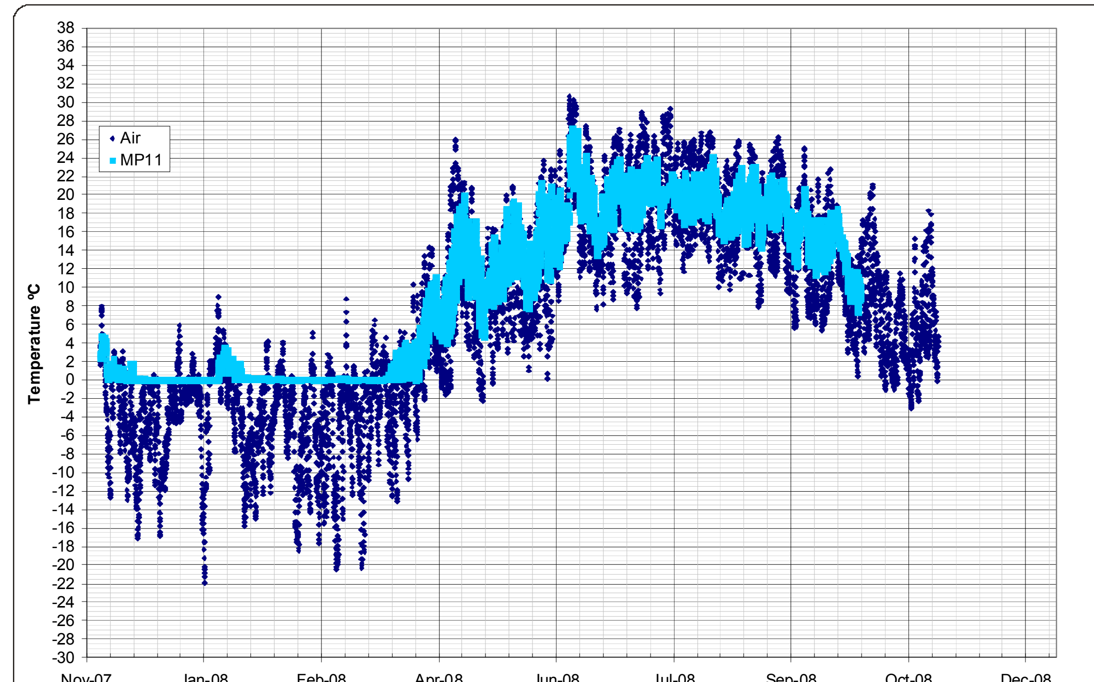
AECOM

MP10 Stream Temperature

407 EAST Foundations
Seasonal Monitoring - Hydrogeology

FIGURE D7

Project 50613



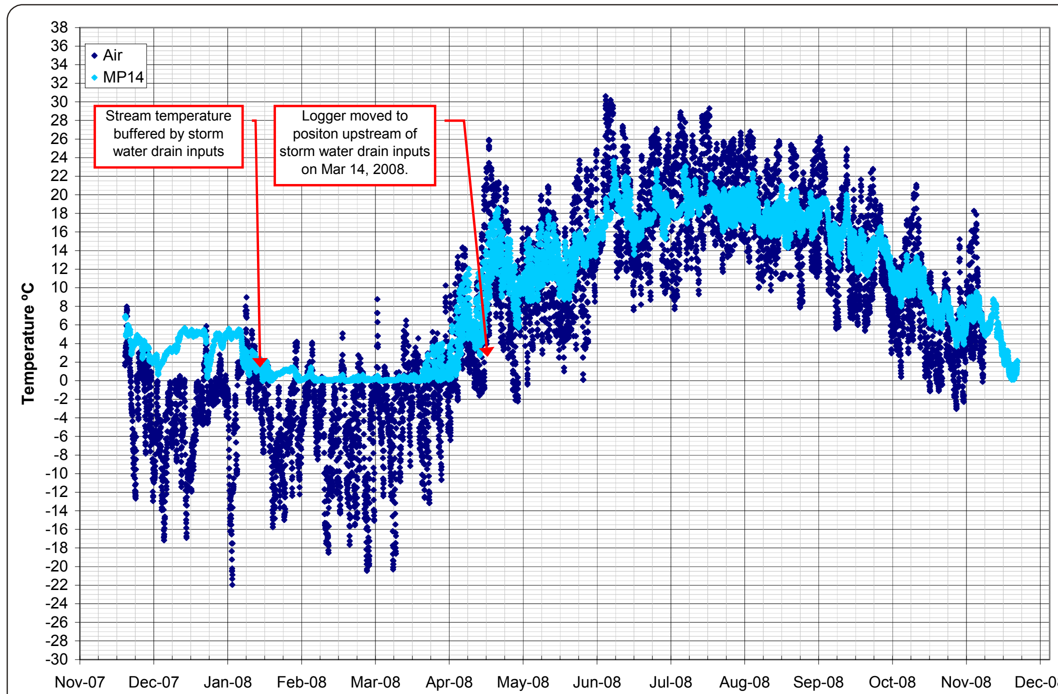
AECOM

MP11 Stream Temperature

407 EAST Foundations
Seasonal Monitoring - Hydrogeology

FIGURE D8

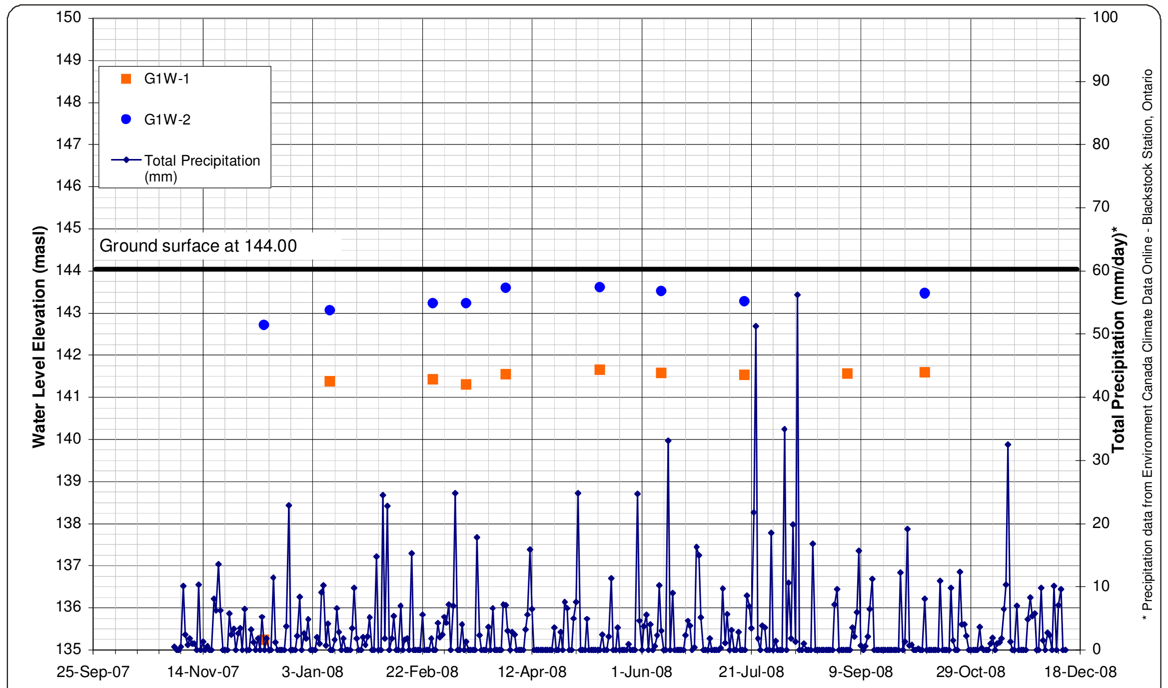
Project 50613



AECOM	MP14 Stream Temperature	FIGURE D9
	407 EAST Foundations Seasonal Monitoring - Hydrogeology	Project 50613

Appendix E

Groundwater Monitor Hydrographs



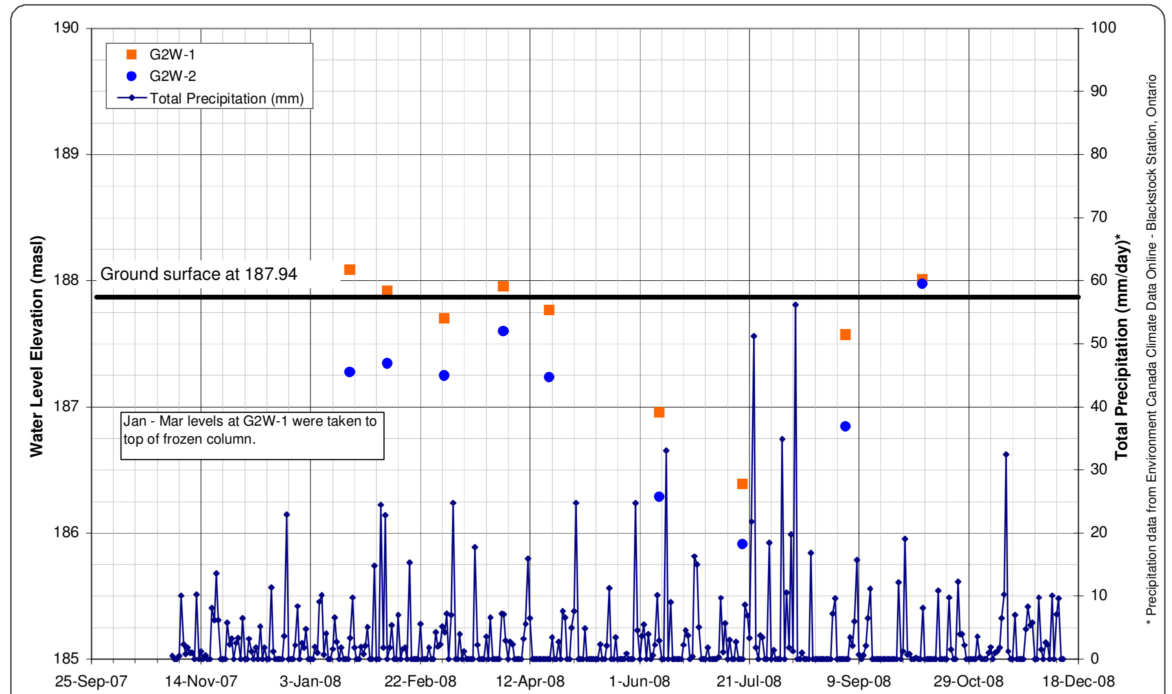
AECOM

Water Levels G1W

407 EAST Foundations
Seasonal Monitoring - Hydrogeology

FIGURE E1

Project 50613



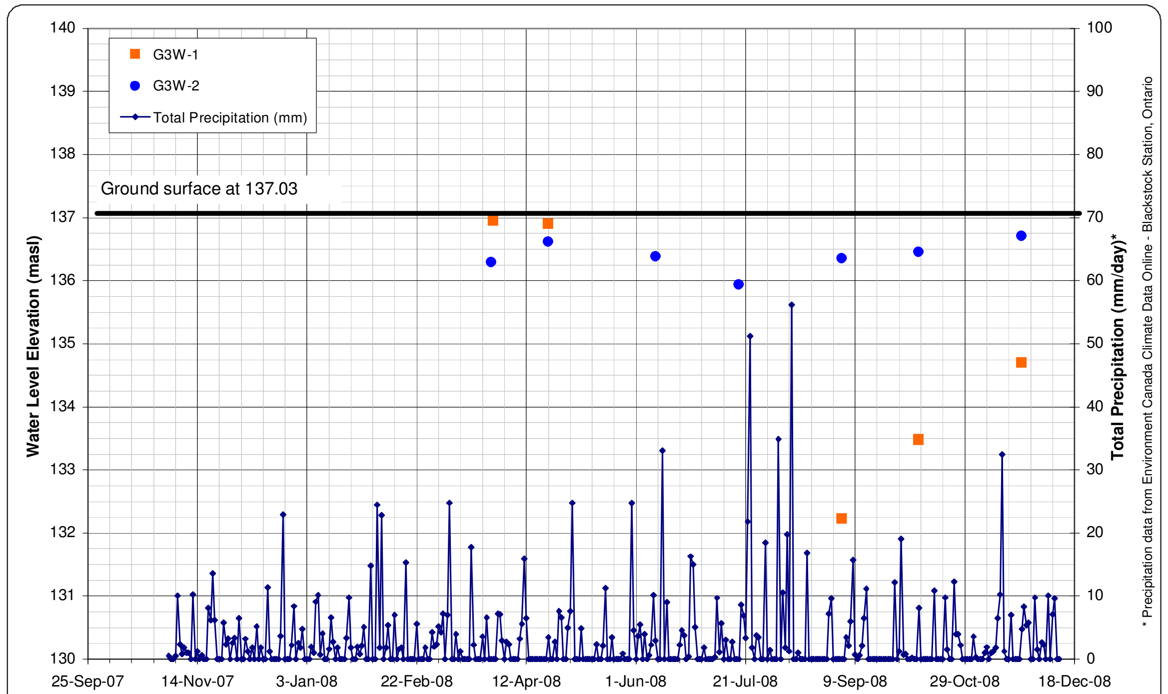
AECOM

Water Levels G2W

407 EAST Foundations
Seasonal Monitoring - Hydrogeology

FIGURE E2

Project 50613



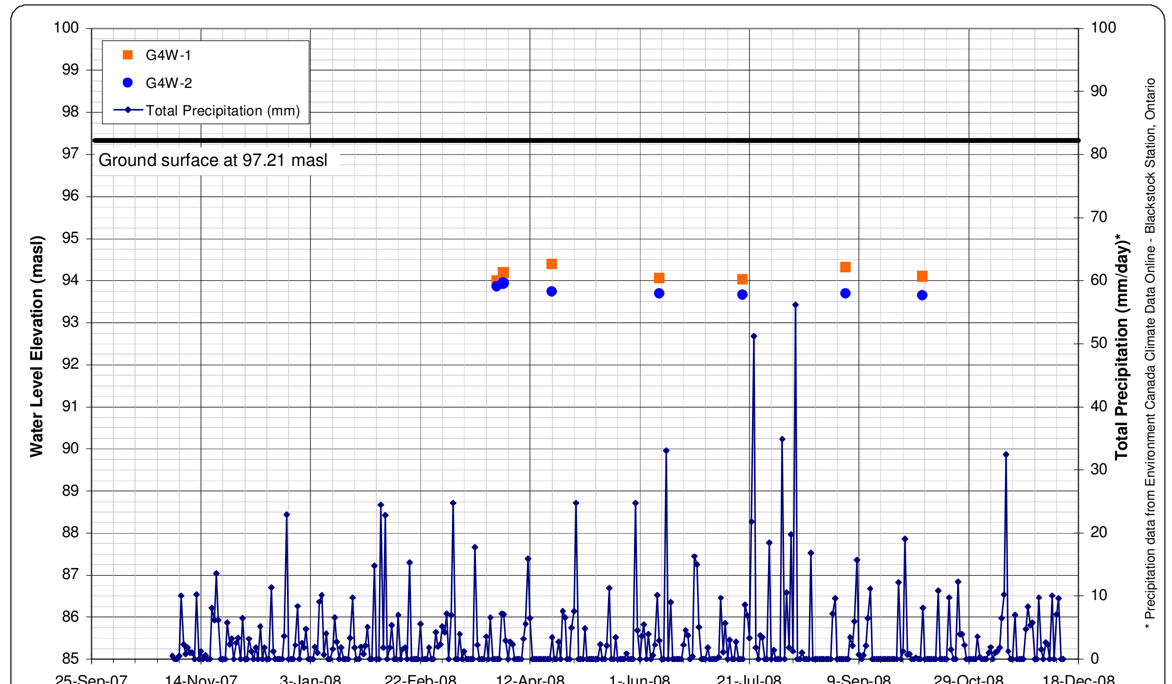
AECOM

Water Levels G3W

407 EAST Foundations
Seasonal Monitoring - Hydrogeology

FIGURE E3

Project 50613



AECOM

Water Levels G4W

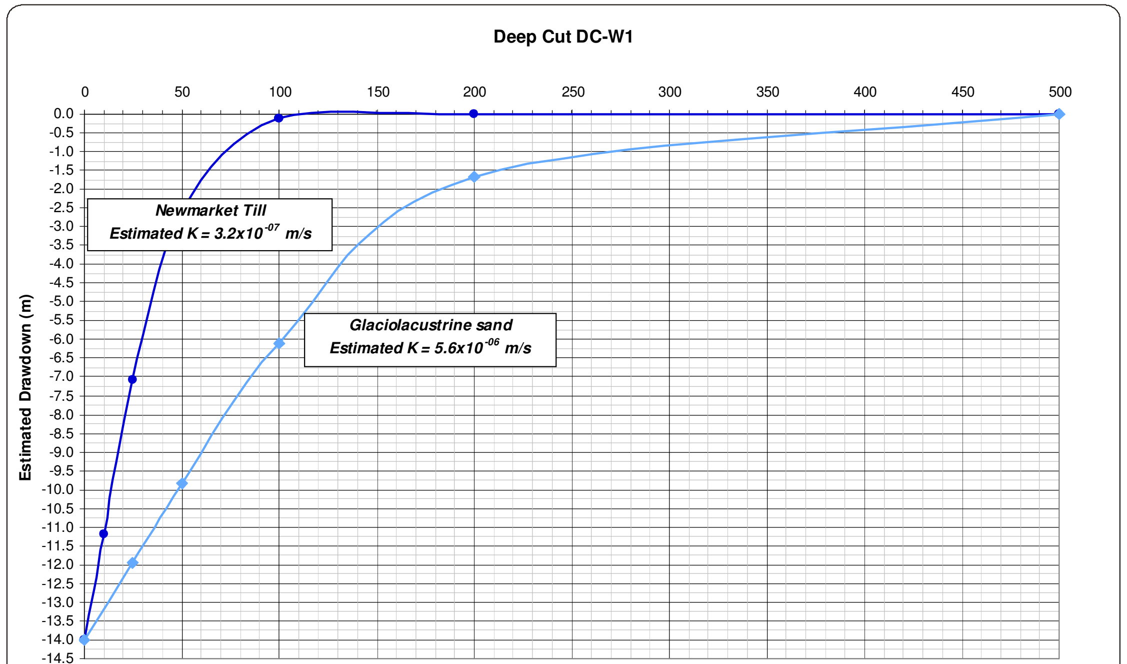
407 EAST Foundations
Seasonal Monitoring - Hydrogeology

FIGURE E4

Project 50613

Appendix F

Deep Cut Drawdown Analysis



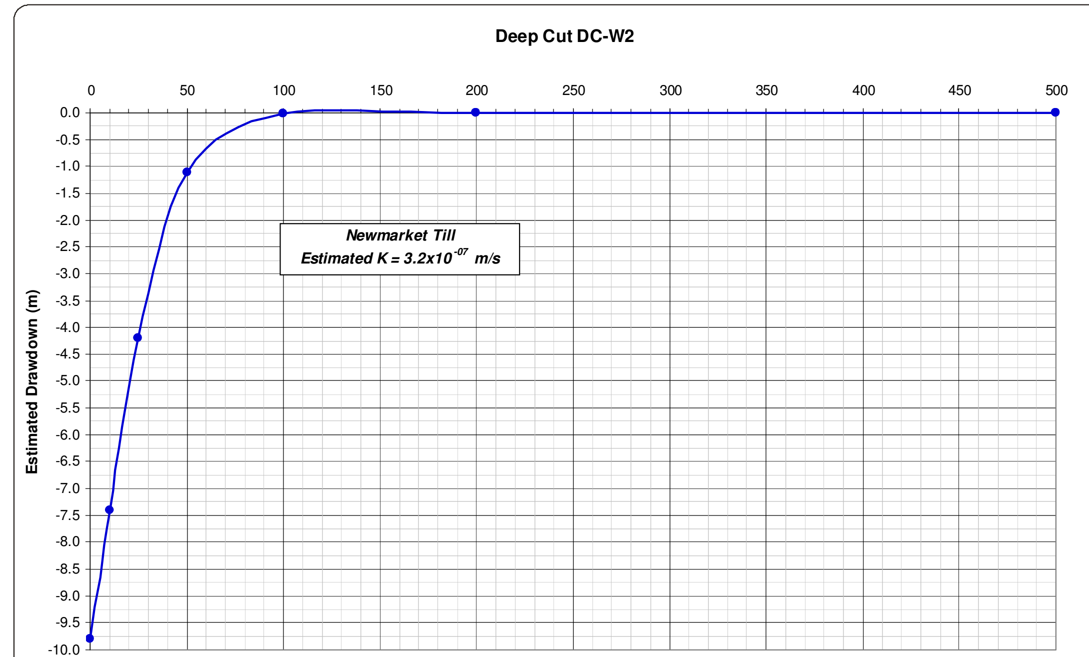
AECOM

Estimated Drawdown at Deep Cut DC-W1

407 EAST Foundations - Hydrogeology

FIGURE F1

Project 50613



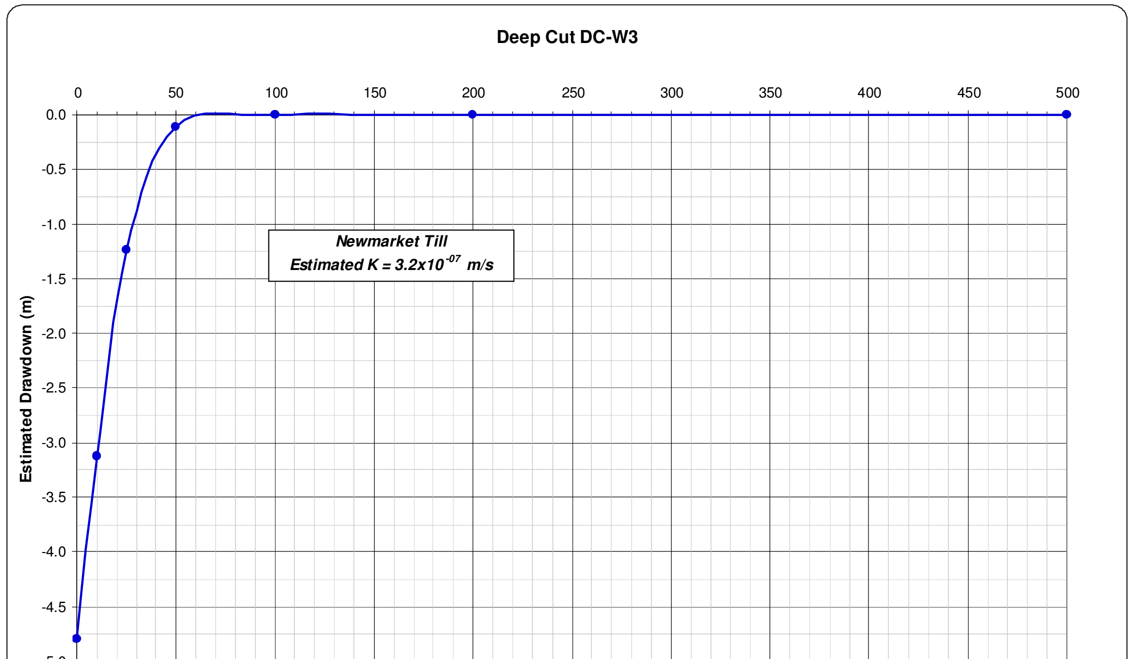
AECOM

Estimated Drawdown at Deep Cut DC-W2

407 EAST Foundations - Hydrogeology

FIGURE F2

Project 50613



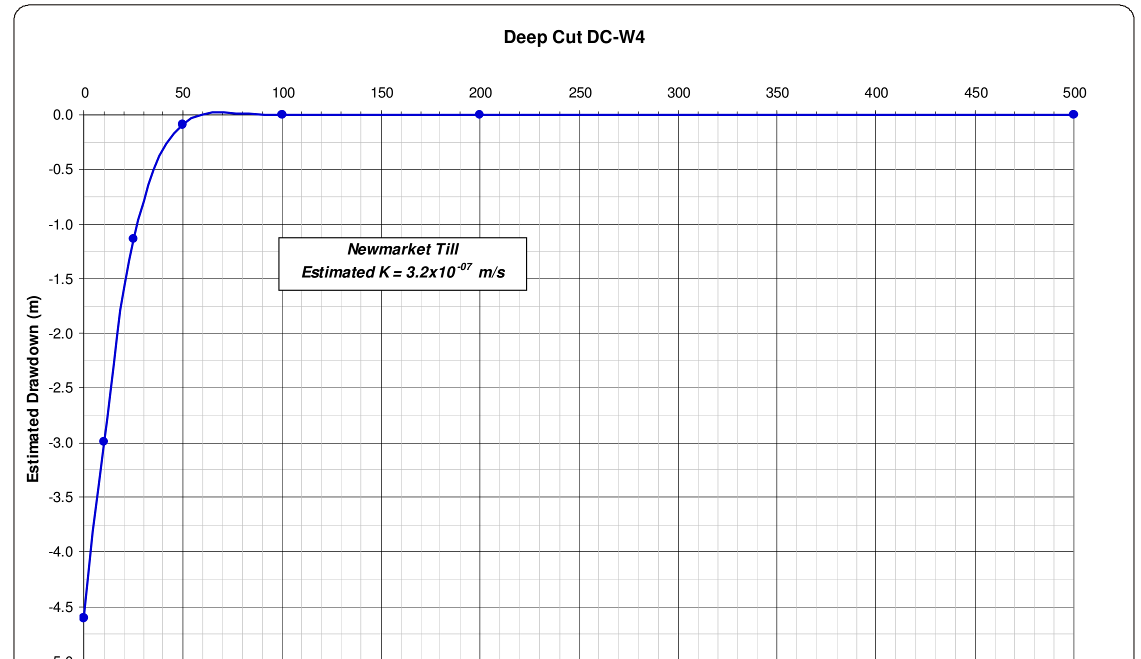
AECOM

Estimated Drawdown at Deep Cut DC-W3

407 EAST Foundations - Hydrogeology

FIGURE F3

Project 50613



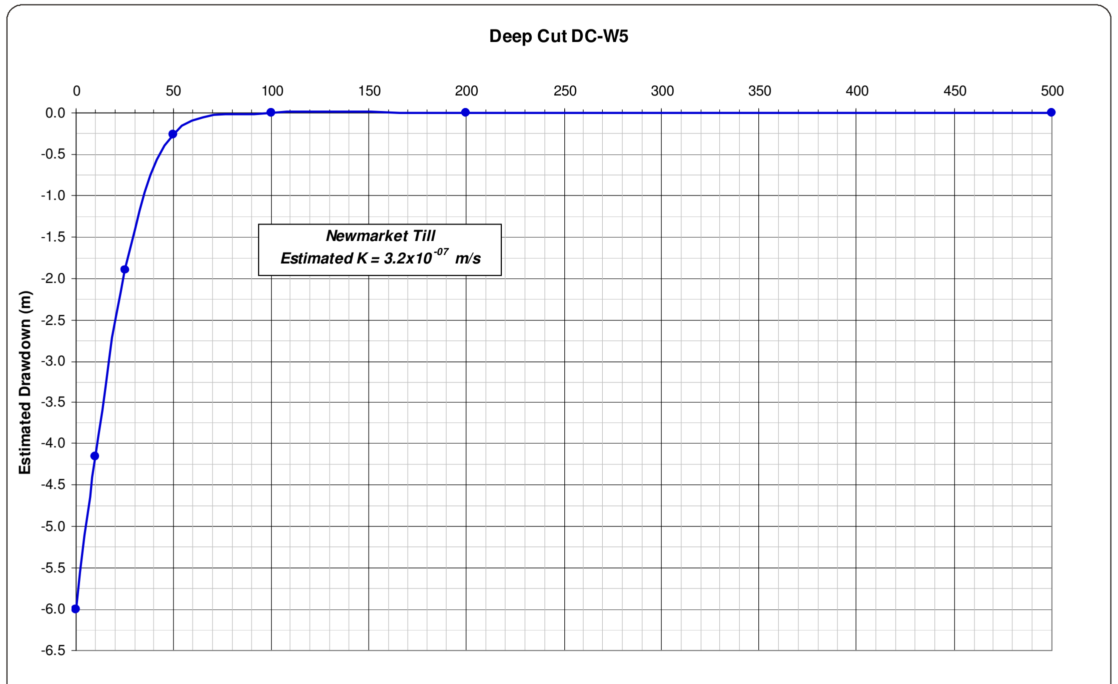
AECOM

Estimated Drawdown at Deep Cut DC-W4

407 EAST Foundations - Hydrogeology

FIGURE F4

Project 50613



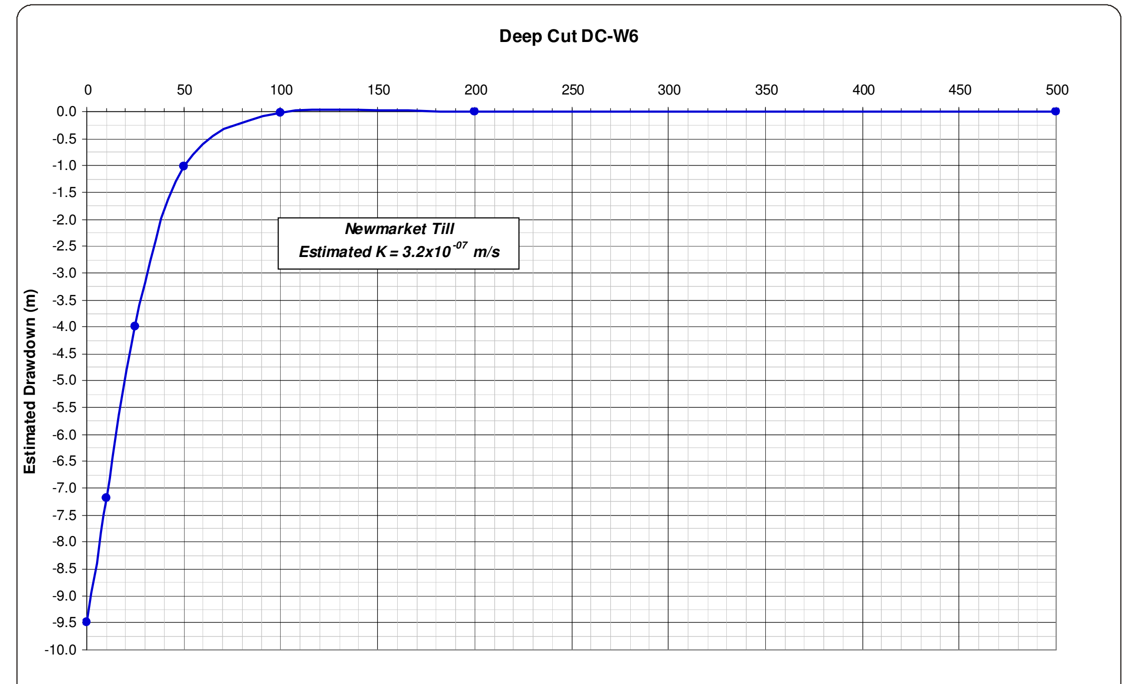
AECOM

Estimated Drawdown at Deep Cut DC-W5

407 EAST Foundations - Hydrogeology

FIGURE F5

Project 50613



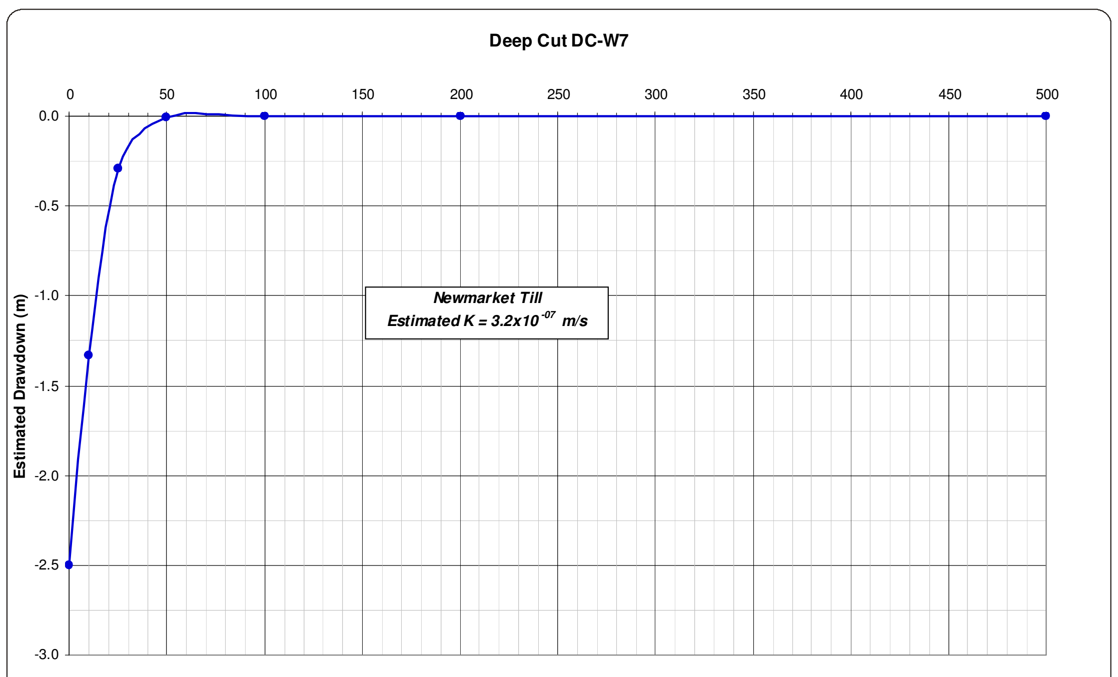
AECOM

Estimated Drawdown at Deep Cut DC-W6

407 EAST Foundations - Hydrogeology

FIGURE F6

Project 50613



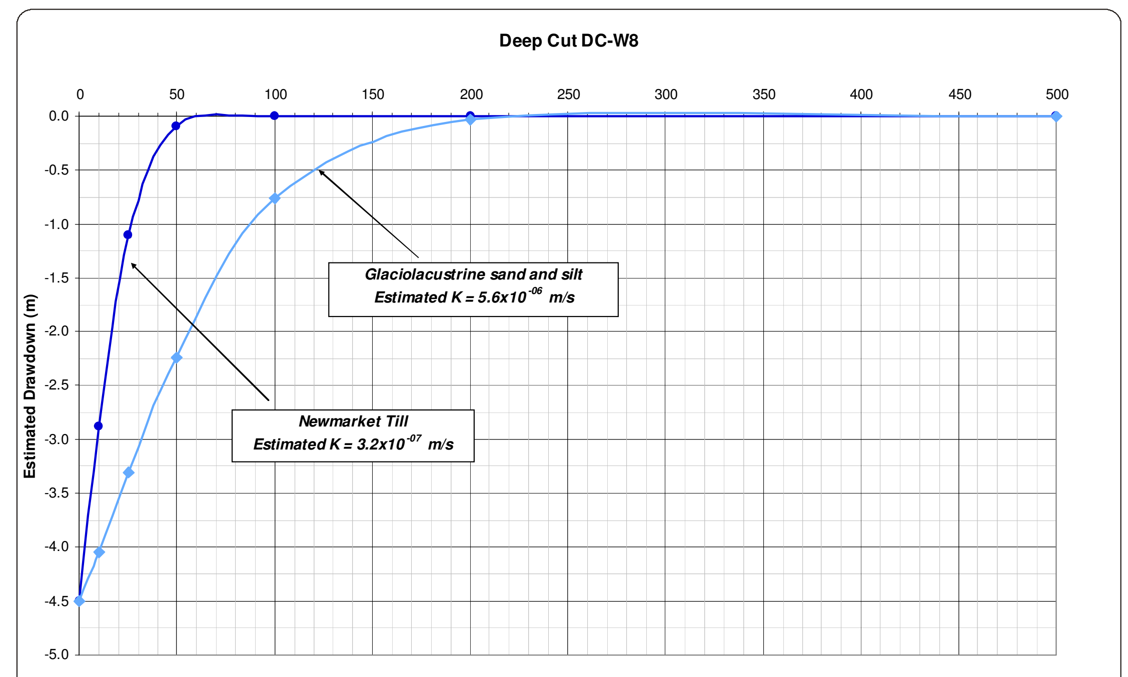
AECOM

Estimated Drawdown at Deep Cut DC-W7

407 EAST Foundations - Hydrogeology

FIGURE F7

Project 50613



AECOM

Estimated Drawdown at Deep Cut DC-W8

407 EAST Foundations - Hydrogeology

FIGURE F8

Project 50613

AECOM

Appendix G

Geotechnical Borehole Logs

Golder Associates

RECORD OF BOREHOLE No WMA-1

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015
LOCATION N 4863719.6 ;E 336079.0
ORIGINATED BY GD/JZ
DIST Central HWY 407
BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers
COMPILED BY DD
DATUM Geodetic
DATE January 31 and February 4, 2008
CHECKED BY TZ/HJ

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 | SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100 | PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%)

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
196.3	GROUND SURFACE							
196.0 0.0	Sandy silt, trace clay, containing organics (FILL) Loose Dark brown Moist	1	SS	9				
0.3	Sand and gravel (FILL) Loose Brown Moist	2	SS	4				
194.8 1.5	Silty sand, trace to some clay, trace gravel (FILL) Compact to loose Brown Moist	3	SS	20	3	68	22	7
		4	SS	8				
193.3 3.1	SAND, trace to some silt, occasional cobbles Dense Brown Moist	5	SS	34				
191.7 4.6	SAND and GRAVEL, some silt, trace clay, occasional cobbles Very dense Brown Moist Boulder at 5.5 m depth	6	SS	61/0.15				
		7	SS	61/0.07	44	37	16	3
188.7 7.6	SAND, trace to some silt Very dense Brown Moist	8	SS	87				
187.5 8.8	SAND and SILT, trace to some clay and gravel (TILL) Very dense Brown to grey Moist	9	SS	75/0.15	10	45	39	6
		10	SS	50/0.13	8	43	43	6
184.1	SAND and GRAVEL Very dense Brown Moist to wet	11	SS	50/0.25				
12.3	END OF BOREHOLE							

Elevation scale: 196, 195, 194, 193, 192, 191, 190, 189, 188, 187, 186, 185, 184

NOTES:

1. Water level measured in open borehole upon completion of drilling at a depth of 6.4 m below ground surface (Elevation 189.9 m).

+ ³, × ³: Numbers refer to Sensitivity ○ ³% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WMA-2

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015
LOCATION N 4863738.8 ;E 336142.1
ORIGINATED BY JZ/HM
DIST Central HWY 407
BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers
COMPILED BY DD
DATUM Geodetic
DATE February 8 and 11, 2008
CHECKED BY TZ/HJ

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 | SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100 | PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%)

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
196.0	GROUND SURFACE							
0.0	Sandy silt, trace clay and gravel, containing organics (FILL) Loose to compact Brown Moist	1	SS	5				
		2	SS	12				
194.5 1.5	SAND and SILT, trace to some clay, trace gravel (TILL) Compact Brown Moist to wet	3	SS	20				
		4	SS	17	6	42	40	12
		5	SS	34				
192.5 3.5	SAND, some silt, trace clay Dense Brown Moist	6	SS	42	0	80	17	3
	Wet below 6.1 m depth	7	SS	47				
189.3 6.7	SAND and SILT, some gravel, trace clay, containing cobbles and boulders (TILL) Very dense Grey Wet to moist	8	SS	50/0.13				
		9	SS	50/0.13	22	39	32	7
185.3	Sand seams at a depth of 10.7 m	10	SS	50/0.07				
10.7	END OF BOREHOLE							

Elevation scale: 195, 194, 193, 192, 191, 190, 189, 188, 187, 186

NOTES:

1. Water level measured in piezometer at a depth of 5.4 m below ground surface (Elevation 190.6 m) on April 4, 2008.

+ ³, × ³: Numbers refer to Sensitivity ○ ³% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WM1-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4864055.5 ;E 336810.0 ORIGINATED BY GD
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 25, 2008 CHECKED BY VO/HJ

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
185.4	GROUND SURFACE					
0.0	Topsoil (FILL)					
0.2	Sandy silt to silty sand, some clay, some gravel, containing cobbles, rootlets and wood fragments (FILL) Very loose to compact Brown Moist	1	SS	3		
		2	SS	13		
		3	SS	8		
183.2 / 2.2	SAND and SILT, some gravel, trace to some clay, containing cobbles/boulders (TILL) Compact Brown Moist to wet	4	SS	21	∇	19 40 34 7
182.4 / 3.0	SAND and GRAVEL, trace silt, containing cobbles/boulders Dense Brown Wet	5	SS	38		
181.3 / 4.1	SAND and SILT, trace to some clay and gravel, containing cobbles/boulders (TILL) Very dense Grey Moist to wet	6	SS	50/0.13		10 45 35 8
		7	SS	50/0.08		
178.4 / 7.0	SAND and GRAVEL, some silt, containing cobbles/boulders Very dense Grey Wet	8	SS	51		45 43 11 1
		9	SS	50/0.08		
		10	SS	50/0.08		
173.7 / 11.7	SAND and SILT, trace to some gravel and clay, containing cobbles (TILL) Very dense Grey Wet	11	SS	50/0.08		
172.0 / 13.4	SAND, trace to some silt Very dense Grey Wet	12	SS	50/0.15		
171.4 / 14.0	END OF BOREHOLE					

ELEVATION SCALE: 185, 184, 183, 182, 181, 180, 179, 178, 177, 176, 175, 174, 173, 172

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WM1-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4864055.5 ;E 336810.0 ORIGINATED BY GD
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 25, 2008 CHECKED BY VO/HJ

SOIL PROFILE — ELEV/DEPTH, DESCRIPTION, STRAT PLOT; SAMPLES — NUMBER, TYPE, "N" VALUES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

--- CONTINUED FROM PREVIOUS PAGE ---

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 2.9 m below ground surface (Elevation 182.5 m).

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WM2-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4864046.9 ;E 336863.8 ORIGINATED BY GD
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 24, 2008 CHECKED BY VO/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
187.6	GROUND SURFACE							
0.0	Topsoil (FILL)							
0.3	Sandy silt to silty sand, trace clay, trace to some gravel, containing rootlets and organic matter (FILL) Very loose to compact Brown Moist	1	SS	2				
		2	SS	14				
185.4		3	SS	10				
2.2	Silty sand, some gravel, trace to some clay, trace organic matter and wood fragments, containing clayey silt interlayers (FILL) Loose Brown Moist	4	SS	4	23	38	28	11
183.5		5	SS	4				
4.1	SAND and SILT, trace to some clay and gravel, containing cobbles/boulders (TILL) Compact to very dense Brown to grey Moist	6	SS	26				
180.4		7	SS	50/0.28	11	39	37	13
7.2	Silty SAND and GRAVEL, containing silty sand layer and cobbles/boulders Very dense Gey Wet	8	SS	50/0.25				
		9	SS	50/0.25	41	32	24	3
176.8		10	SS	50/0.10				
10.8	END OF BOREHOLE							

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (187 to 177); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTES:

1. Water level measured in piezometer at depth of 9.7m below ground surface (Elevation 177.9 m) upon completion of installation.

2. Water level measured in piezometer at depth of 5.0 m below ground surface (Elevation 182.6 m) on February 28, 2008.

3. Water level measured in piezometer at depth of 4.5 m below ground surface (Elevation 183.1 m) on April 4, 2008.

+ 3, × 3 Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WM3-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4864430.5 ;E 337084.4 ORIGINATED BY VO
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE May 15, 2008 CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
181.0	GROUND SURFACE							
0.0	Silty sand, trace gravel, containing organics (FILL) Loose Brown Moist	1	SS	8				
180.2 / 0.8	Clayey silt layer at 0.46 m depth SAND and GRAVEL, trace to some silt, trace clay, containing rootlets, cobbles and occasional boulders Very dense Brownish grey Moist to wet	2	SS	90				
		3	SS	93	49	35	11	5
		4	SS	51/0.15				
178.0		5	SS	51/0.08				
3.1	SAND, trace gravel and silt Very dense Brown Wet							
176.4								
4.6	SAND and SILT, some clay, trace gravel (TILL) Very dense Grey Moist	6	SS	110/0.23				
		7	SS	129	1	48	34	17
172.9		8	SS	100/0.13				
8.1	END OF BOREHOLE							

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (180 to 173); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 1.2 m below ground surface (Elevation 179.8 m).

+ 3, × 3 Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WM3-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
LOCATION N 4864424.0 ;E 337183.0
ORIGINATED BY GD
DIST Central HWY 407
BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers
COMPILED BY DD
DATUM Geodetic
DATE January 30, 2008
CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION
181.0	GROUND SURFACE
0.0	Silty sand, containing organics (FILL) Compact Dark brown to brown Moist
180.2 / 0.8	SAND and SILT, some gravel, trace to some clay, containing sand seams and occasional boulders (TILL) Dense to very dense Brown Moist Boulder encountered at 5.5 m depth
174.9 / 6.1	SAND and GRAVEL, some silt, trace clay Very dense Brown Wet to moist
172.3 / 8.7	SAND, some silt, trace gravel, containing cobbles Very dense Brown Moist
169.4 / 11.6	SAND and SILT, some gravel, trace to some clay (TILL) Very dense Grey Moist
168.7 / 12.3	END OF BOREHOLE

SAMPLE NUMBER	TYPE	"N" VALUES	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	11	
2	SS	29	
3	SS	54	
4	SS	36	
5	SS	53	17 46 29 8
6	SS	44	
7	SS	58	32 51 14 3
8	SS	69	
9	SS	65/0.13	
10	SS	50/0.02	
11	SS	100/0.10	23 33 32 12

NOTES:

1. Water level measured in open borehole upon completion of drilling at a depth of 4.9 m below ground surface (Elevation 176.1 m).
2. Water level measured in piezometer at a depth of 4.1 m and 3.9 m below ground surface (Elev. 176.9 m and Elev. 177.1 m) on February 28 and April 4, 2008, respectively.

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WM7-1A

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
LOCATION N 4864799.5 ;E 337267.5
ORIGINATED BY VO
DIST Central HWY 407
BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers
COMPILED BY DD
DATUM Geodetic
DATE September 8, 2008
CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION
177.2	GROUND SURFACE
0.0	Sand and gravel (FILL) Compact Brown and grey Moist
176.6 / 0.6	Silty sand, some gravel (FILL) Dense Brown Moist Wet below 2.7 m depth
173.9 / 3.4	SAND, trace to some silt, trace gravel Very dense brown Moist
170.7 / 6.6	SILT, trace to some sand, trace clay Very dense Brown Moist
169.1 / 8.1	Silty SAND to SAND, some silt, trace gravel and clay Very dense Brown Wet
163.2 / 14.0	END OF BOREHOLE

SAMPLE NUMBER	TYPE	"N" VALUES	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	23	
2	SS	33	
3	SS	46	
4	SS	49	
5	SS	55	
6	SS	59	
7	SS	57	
8	SS	52	0 8 90 2
9	SS	88	
10	SS	115	2 78 17 3
11	SS	113	
12	SS	140	

Continued Next Page

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No WM7-1A

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4864799.5 ;E 337267.5 ORIGINATED BY VO
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE September 8, 2008 CHECKED BY TZ/BLT

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	NOTE: 1. Water level measured in open borehole upon completion of drilling at a depth of 1.8 m below ground surface (Elevation 175.4 m).										

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No WM7-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4864765.1 ;E 337459.7 ORIGINATED BY GD
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 28 and 29, 2008 CHECKED BY TZ/HJ

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR SA SI CL
166.4	GROUND SURFACE				
0.0	Silty sand, trace gravel, containing organics (FILL) Loose Dark brown Moist	1	SS	4	
165.9 0.5	SAND and SILT, some clay, trace to some gravel (TILL) Compact Brown Moist	2	SS	18	
		3	SS	12	8 38 40 14
164.1 2.3	SAND and GRAVEL, trace to some silt, trace clay Dense to very dense Brown Wet	4	SS	38	
		5	SS	56	52 39 7 2
		6	SS	59	
		7	SS	77	
		8	SS	48	50 39 9 2
		9	SS	141	
		10	SS	100/0.15	
154.5	SAND, trace to some silt and gravel Very dense Grey Moist	11	SS	100/0.1	
154.1 12.3	END OF BOREHOLE NOTES: 1. Water level measured in open borehole upon completion of drilling at a depth of 0.9 m below ground surface (Elevation 165.5 m).				

Elevation scale: 166, 165, 164, 163, 162, 161, 160, 159, 158, 157, 156, 155

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WM7-2

 METRIC

PROJECT 07-1111-0053			
W.O. 07-20015	LOCATION N 4864765.1 ;E 337459.7	ORIGINATED BY GD	
DIST Central HWY 407	BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers	COMPILED BY DD	
DATUM Geodetic	DATE January 28 and 29, 2008	CHECKED BY TZ/HJ	

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---							
	2. Water level measured in piezometer at a depth of 2.2 m below ground surface (Elevation 164.2 m) on February 28, 2008.							
	3. Water level measured in piezometer at a depth of 2.1 m below ground surface (Elevation 164.3 m) on April 4, 2008.							

Column headings: SOIL PROFILE; SAMPLES; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

$+^3, \times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WM8-1

 METRIC

PROJECT 07-1111-0053			
W.O. 07-20015	LOCATION N 4865531.0 ;E 337893.6	ORIGINATED BY PKS	
DIST Central HWY 407	BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers	COMPILED BY DD	
DATUM Geodetic	DATE December 10 and 11, 2007	CHECKED BY TZ/HJ	

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
168.1	GROUND SURFACE								
0.0	Crushed sand and gravel (FILL)				168				
0.1	Silty sand, containing organics (FILL) Compact Brown Moist	1	SS	20					
167.3 / 0.8	Clayey silt with sand pockets, trace gravel (FILL) Firm Brown Moist	2	SS	9	167				
166.6 / 1.5	CLAYEY SILT with sand, trace gravel, occasional cobbles and silty sand seams (TILL) Hard Brown to grey Moist	3	SS	35	166				
		4	SS	45		1	41	41	17
		5	SS	46	165				
		6	SS	55	164				
	Wet below 4.6 m depth	7	SS	70	163				
		8	SS	55	162				
					161				
160.5 / 7.6	Silty SAND to SAND, some silt, trace clay Compact to very dense Grey Wet	9	SS	23	160				
		10	SS	48	159	0	74	22	4
		11	SS	13	158 / 157				
		12	SS	68	156	0	82	17	1
		13	SS	100/0.13	155 / 154				

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

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MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

$+^3, \times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WM8-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4865531.0 ;E 337893.6 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE December 10 and 11, 2007 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	--- CONTINUED FROM PREVIOUS PAGE ---									
	Silty SAND to SAND, some silt, trace clay Compact to very dense Grey Wet	14	SS	100/0.03	153	○				
					152					
151.2 / 16.9		15	SS	100/0.13		○	1	81	14	4
	END OF BOREHOLE									

NOTES:

1. Water level measured in open borehole upon completion of drilling at a depth of 2.4 m below ground surface (Elevation 165.7 m).

2. Water level measured in piezometer at a depth of 0.7 m below ground surface (Elevation 167.4 m) on April 4, 2008.

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+ ³, × ³: Numbers refer to Sensitivity ○ ³% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WM11-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4865995.6 ;E 338473.7 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers, Wash Boring from 6.1 m to 17.4 m depth COMPILED BY DD
DATUM Geodetic DATE March 20, 2008 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER	ELEVATION SCALE	SHEAR STRENGTH	WATER CONTENT (%)	GR	SA	SI	CL
153.5	GROUND SURFACE											
0.0	TOPSOIL Compact Brown Moist	1	SS	14		153						
152.7 / 0.8	SAND and SILT, trace clay to SILT, some sand, trace clay Loose to compact Brown Moist	2	SS	9		152		○				
		3	SS	20								
		4	SS	20		151		○	0 NP	40	58	2
	Wet below 3.1 m depth	5	SS	21		150						
					∇	149						
		6	SS	15		148		○				
		7	SS	22		147						
		8	SS	30		146 / 145		○	0	18	79	3
143.8		9	SS	9		144		○				
9.8	CLAYEY SILT, trace to some sand, trace gravel (TILL-Like) Stiff to very stiff Grey Wet					143						
		10	SS	9				├─○─┤	0	2	51	47
		11	TO	PH		142	+ 2.3					
		12	SS	8		141		○				
						140	>96					
		13	SS	11		139		├○┤	2	21	49	28

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity ○ ³% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WM11-1

 METRIC

PROJECT 07-1111-0053			
W.O. 07-20015	LOCATION N 4865995.6 ;E 338473.7		ORIGINATED BY PKS
DIST Central	HWY 407	BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers, Wash Boring from 6.1 m to 17.4 m depth	COMPILED BY DD
DATUM Geodetic	DATE March 20, 2008		CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---					
		14	SS	23	138	
137.7 / 15.9	Silty SAND Compact Grey Wet				137	
		15	SS	29		
136.1 / 17.4	END OF BOREHOLE					

NOTES:

1. "Blowing" sand was encountered during drilling at about a depth of 9.7 m below ground surface (Elev. 143.8 m).

2. Water level measured in open borehole upon completion of drilling at a depth of 4.0 m below ground surface (Elevation 149.5).

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3, \times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

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RECORD OF BOREHOLE No WM11-2

 METRIC

PROJECT 07-1111-0053			
W.O. 07-20015	LOCATION N 4866073.0 ;E 338507.6		ORIGINATED BY PKS
DIST Central	HWY 407	BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers, Wash Boring from 9.1 m to 38.4 m depth	COMPILED BY DD
DATUM Geodetic	DATE March 12 to 18, 2008		CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
152.4	GROUND SURFACE					
0.0	TOPSOIL Loose Brown Moist	1	SS	7	152	
151.6 / 0.8	Silty SAND, trace gravel Compact to very dense Brown Moist	2	SS	25	151	
		3	SS	70	150	
		4	SS	28		
149.5 / 2.9	SAND and SILT, trace clay Loose to dense Brown Moist	5	SS	33	149	0 50 48 2
					148	
	Wet below 4.6 m depth	6	SS	10	147	
		7	SS	7	146	
					145	
		8	SS	19	144	0 60 39 1
143.3 / 9.1	CLAYEY SILT with sand to trace sand, trace to some gravel (TILL-Like) Firm to hard Grey Wet	9	SS	5	143	
					142	
		10	SS	9	141	0 3 63 34
		11	SS	9	140	
					139	
		12	SS	10	138	

Shear strength plot: 2.6 (at approx. elev. 141)

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$+^3, \times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

PROJECT 07-1111-0053

RECORD OF BOREHOLE No WM11-2

 METRIC

W.O. 07-20015 LOCATION N 4866073.0 ;E 338507.6 ORIGINATED BY PKS

DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers, Wash Boring from 9.1 m to 38.4 m depth COMPILED BY DD

DATUM Geodetic DATE March 12 to 18, 2008 CHECKED BY TZ/HJ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	CLAYEY SILT with sand to trace sand, trace to some gravel (TILL-Like) Firm to hard Grey Wet Cobbles encountered at 15.6 m depth	13	SS	60/0.18	137	
					136	
		14	SS	16	135	10 28 45 17
		15	SS	32	134	
					133	
132.6 / 19.8	Silty SAND Loose Grey Wet	16	SS	6	132	
131.1 / 21.3	CLAYEY SILT, containing sand seams Hard Grey Wet	17	SS	58	131	
130.5 / 22.0	Silty SAND to SILT and SAND, containing clayey silt seams Dense to very dense Grey Wet				130	
		18	SS	100/0.27	129	0 3 83 14
		19	SS	61	128 / 127	
		20	SS	76	126	
		21	SS	74	125 / 124	
		22	SS	52	123	

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+ 3, × 3: Numbers refer to Sensitivity; ○ 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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PROJECT 07-1111-0053

RECORD OF BOREHOLE No WM11-2

 METRIC

W.O. 07-20015 LOCATION N 4866073.0 ;E 338507.6 ORIGINATED BY PKS

DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers, Wash Boring from 9.1 m to 38.4 m depth COMPILED BY DD

DATUM Geodetic DATE March 12 to 18, 2008 CHECKED BY TZ/HJ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty SAND to SILT and SAND, containing clayey silt seams Dense to very dense Grey Wet	23	SS	57	122	1 79 17 3
		24	SS	100/0.23	121 / 120	
		25	SS	100/0.25	119	7 31 45 17
		26	SS	38	118 / 117	
		27	SS	64	116	
115.0 / 37.4	Grey SHALE (BEDROCK) Wet	28	SS	100/0.15	115	
114.0 / 38.4	END OF BOREHOLE AUGER REFUSAL	29	SS	100/0.0	114	

NOTES:

1. "Blowing" sand was encountered during drilling at a depth of 9.1 m below ground surface (Elev. 143.3 m).

2. Water level measured in open borehole upon completion of drilling at a depth of 1.5 m below ground surface (Elevation 150.9 m).

3. Water level measured in piezometer at 2.4 m above ground surface (Elev. 154.8 m) on March 24, 2008.

4. Piezometer was decommissioned in accordance with O. Reg. 903 on March 24, 2008.

+ 3, × 3: Numbers refer to Sensitivity; ○ 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WM11A-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4866005.9 ;E 338609.9 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers, Wash Boring from 12.2 m to 28.0 m depth COMPILED BY DD
DATUM Geodetic DATE December 13, 2007 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
143.9	GROUND SURFACE					
0.0	Sand and gravel (FILL) Compact to dense Brown Moist	1	SS	22		
		2	SS	35		
142.5 / 1.4	Organic SILT to PEAT, occasional sand seams Very soft to soft Brown Moist	3	SS	4		
		4	SS	WH		
141.0 / 2.9	Silty SAND and GRAVEL Dense Brown Wet	5	SS	32	∇	
139.8 / 4.1	CLAYEY SILT with SAND, trace gravel, containing sand seams Firm Grey Wet	6	SS	13		1 42 42 15
		7	SS	WH		
136.3 / 7.6	SILTY CLAY, trace to some sand, trace gravel Soft to firm Grey Wet	8	SS	WH		
		9	SS	WH		
	Silty sand seam from 11.2 m to 11.3 m depth	10	SS	8		
131.7 / 12.2	CLAYEY SILT, trace to some sand, containing sand and silt seams Soft to hard Grey Wet	11	SS	9		0 24 54 22
		12	SS	5		

Plot annotations: field vane sensitivity values 1.7, 3.2, 1.4, 2; 55.2 OC = 30.7%

Elevation scale: 143 – 129

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DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L
WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WM11A-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4866005.9 ;E 338609.9 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers, Wash Boring from 12.2 m to 28.0 m depth COMPILED BY DD
DATUM Geodetic DATE December 13, 2007 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---					
	CLAYEY SILT, trace to some sand, containing sand and silt seams Soft to hard Grey Wet	13	SS	63		0 2 76 22
		14	SS	37		0 11 49 40
		15	SS	30		
	Silt seam encountered at 20.0 m depth	16	SS	2		
		17	SS	16		
	Silt seam encountered at 23.2 m depth	18	SS	22		0 11 75 14 NP (Silt Seam)
		19	SS	15		
		20	SS	10		
116.5 / 27.4	SAND and SILT, trace to some clay, trace gravel Compact Wet Grey	21	SS	13		2 49 43 6
115.9 / 28.0	Dynamic Cone Penetration Test (DCPT)					

Elevation scale: 128 – 114

Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WM11A-1

3 OF 3 **METRIC**

PROJECT 07-1111-0053			
W.O. 07-20015	LOCATION N 4866005.9 ;E 338609.9	ORIGINATED BY PKS	
DIST Central HWY 407	BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers, Wash Boring from 12.2 m to 28.0 m depth	COMPILED BY DD	
DATUM Geodetic	DATE December 13, 2007	CHECKED BY TZ/HJ	

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---							
	Dynamic Cone Penetration Test (DCPT)						113	
112.4 / 31.6	END OF DCPT UPON REFUSAL END OF BOREHOLE NOTES: 1. "Blowing" sand was encountered during drilling at approximately a depth of 12.2 m below ground surface (Elev. 131.7 m). 2. Water level measured in open borehole upon completion of drilling at a depth of 3.0 m below ground surface (Elevation 140.9 m).							

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WM12-1

1 OF 2 **METRIC**

PROJECT 07-1111-0053			
W.O. 07-20015	LOCATION N 4866170.2 ;E 338678.7	ORIGINATED BY PKS	
DIST Central HWY 407	BOREHOLE TYPE Portable (Tripod), wash boring from 0 m to 22 m depth	COMPILED BY DD/TZ	
DATUM Geodetic	DATE April 15 to 18 and April 21 to 23, 2008	CHECKED BY BLT	

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
141.3	GROUND SURFACE					
0.0 / 0.1	TOPSOIL Compact Brown Moist	1	SS	11	141	
	Silty SAND, some gravel Compact to very dense Brown Moist to wet Wet below 1.2 m depth	2	SS	50	140	
139.8 / 1.5	CLAYEY SILT, trace to some sand, trace gravel Firm to very stiff Grey Wet	3	SS	11		
		4	SS	11	139	
		5	SS	9	138	1 14 56 29
					137	
		6	SS	7	136	
		7	SS	10	135	
					134	
		8	SS	12	133	
		9	SS	16	132	0 3 50 47
					131	
		10	SS	6	130	
129.1 / 12.2	SAND and SILT, trace gravel and clay, containing clayey silt seams Loose to very dense Grey Wet	11	SS	7	129	4 38 53 5
					128	
		12	SS	60	127	

Field vane readings: 3.8 (near elev. 137.6), 5.3 (near elev. 136)

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

RECORD OF BOREHOLE No WM12-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 | LOCATION N 4866170.2 ;E 338678.7 | ORIGINATED BY PKS
DIST Central HWY 407 | BOREHOLE TYPE Portable (Tripod), wash boring from 0 m to 22 m depth | COMPILED BY DD/TZ
DATUM Geodetic | DATE April 15 to 18 and April 21 to 23, 2008 | CHECKED BY BLT

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND and SILT, trace gravel and clay, containing clayey silt seams Loose to very dense Grey Wet	13	SS	31	126	
					125	
		14	SS	80	124	0 55 43 2
		15	SS	160	123	
					122	
121.5 / 19.8	Sandy SILT, trace to some gravel and clay Compact Grey Wet	16	SS	17	121	6 23 61 10
		17	SS	16	120	
119.4 / 22.0	END OF BOREHOLE					

NOTES:

1. Artesian conditions encountered at a depth of 16.8 m below ground surface (Elevation 124.5 m) on April 17, 2008.

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No WM13-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 | LOCATION N 4866246.2 ;E 338899.0 | ORIGINATED BY PKS
DIST Central HWY 407 | BOREHOLE TYPE 108 mm O.D. Solid Stem Augers, Wash Boring from 12.2 m to 36.6 m depth | COMPILED BY DD/TZ
DATUM Geodetic | DATE April 30, May 4 to 7, 2008 | CHECKED BY BLT

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
140.1	GROUND SURFACE					
0.0	TOPSOIL Loose Brown Moist	1	SS	8	140	
139.3 / 0.8	CLAYEY SILT, trace to some sand, trace gravel, containing sandy silt to silty sand seams Firm to hard Brown to grey Moist to wet	2	SS	8	139	
		3	SS	12	138	
		4	SS	14	137	
		5	SS	8	136	
		6	SS	15	135	0 0 60 40
		7	SS	14	134	
	Wet below 7.9 m depth	8	SS	7	133 / 132	
		9	SS	9	131	
		10	SS	14	130 / 129	
		11	SS	17	128 / 127	3 8 49 40
126.4 / 13.7	SAND and SILT, containing clayey silt seams Loose to dense Grey Wet	12	SS	41	126	

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No WM13-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
LOCATION N 4866246.2 ;E 338899.0
ORIGINATED BY PKS
DIST Central HWY 407
BOREHOLE TYPE 108 mm O.D. Solid Stem Augers, Wash Boring from 12.2 m to 36.6 m depth
COMPILED BY DD/TZ
DATUM Geodetic
DATE April 30, May 4 to 7, 2008
CHECKED BY BLT

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND and SILT, containing clayey silt seams Loose to dense Grey Wet	13	SS	27	
		14	SS	9	
		15	SS	4	0 49 51 0 NP
		16	SS	7	
118.8 21.3	SAND, trace to some gravel, trace silt Loose to compact Grey Wet	17	SS	17	
		18	SS	7	10 86 4 0
115.7 24.4	SAND and SILT, trace gravel and clay Loose to very dense Grey Wet	19	SS	18	
		20	SS	60	0 52 47 1 NP
		21	SS	28	
		22	SS	27	

Elevation scale: 125, 124, 123, 122, 121, 120, 119, 118, 117, 116, 115, 114, 113, 112, 111

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+ 3, × 3: Numbers refer to Sensitivity   ○ 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WM13-1

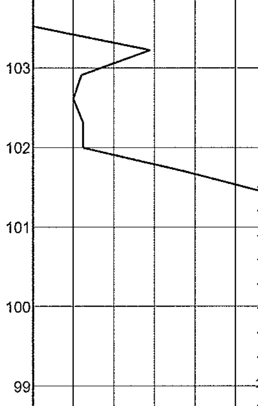
 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
LOCATION N 4866246.2 ;E 338899.0
ORIGINATED BY PKS
DIST Central HWY 407
BOREHOLE TYPE 108 mm O.D. Solid Stem Augers, Wash Boring from 12.2 m to 36.6 m depth
COMPILED BY DD/TZ
DATUM Geodetic
DATE April 30, May 4 to 7, 2008
CHECKED BY BLT

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND and SILT, trace gravel and clay Loose to very dense Grey Wet	23	SS	25	1 67 30 2 NP
		24	SS	8	
		25	SS	46	
105.1 35.1	SAND and GRAVEL Grey Wet	26	AS	-	
103.6 36.5	Dynamic Cone Penetration Test (DCPT)				
98.7 41.5	END OF BOREHOLE END OF DCPT NOTES: 1. Artesian conditions encountered at a depth of 15.2 m below ground surface (Elevation 124.9 m) on April 30, 2008.				

Elevation scale: 110, 109, 108, 107, 106, 105, 104, 103, 102, 101, 100, 99



+ 3, × 3: Numbers refer to Sensitivity   ○ 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

RECORD OF BOREHOLE No WM17-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4866540.5 ;E 339291.5 ORIGINATED BY SB
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE December 17, 2007 CHECKED BY TZ/HJ

SOIL PROFILE / SAMPLES / GROUND WATER CONDITIONS / ELEVATION SCALE / DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100) / PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30 / UNIT WEIGHT γ kN/m³ / REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV / DEPTH	DESCRIPTION
155.0	GROUND SURFACE
0.0	Sand and gravel, trace silt (FILL) Dense Brown Moist
154.2 / 0.8	Organic CLAYEY SILT, trace sand and gravel Firm Black Moist
153.5 / 1.5	CLAYEY SILT, some sand, trace gravel Very stiff to firm Brown Moist Becoming grey at 3.1 m depth
150.4 / 4.6	SILT, some sand, trace clay Very loose to compact Grey Wet
143.4 / 11.6	CLAYEY SILT, trace sand and gravel Firm to very stiff Grey Moist

NUMBER	TYPE	"N" VALUES	GR SA SI CL
1	SS	50/0.15	
2	SS	8	
3	SS	29	3 23 37 37
4	SS	20	
5	SS	5	
6	SS	8	
7	SS	15	0 15 74 11
8	SS	4	
9	SS	9	
10	SS	19	
11	SS	12	0 1 78 21
12	SS	8	

Elevation scale: 154, 153, 152, 151, 150, 149, 148, 147, 146, 145, 144, 143, 142, 141

Field vane: 2.0, 2.2

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE

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RECORD OF BOREHOLE No WM17-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4866540.5 ;E 339291.5 ORIGINATED BY SB
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE December 17, 2007 CHECKED BY TZ/HJ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION
	CLAYEY SILT, trace sand and gravel Firm to very stiff Grey Moist
138.5 / 16.5	Sandy SILT, trace to some gravel, trace clay Very loose to loose Grey Wet
132.4 / 22.6	SAND and SILT, trace to some clay, containing clayey silt lenses Compact to very dense Grey Moist to wet

NUMBER	TYPE	"N" VALUES	GR SA SI CL
13	SS	16	
14	SS	WH	
15	SS	9	
16	SS	9	8 24 63 5
17	SS	8	
18	SS	53	3 56 36 5
19	SS	44	0 50 46 4
20	SS	34	
21	SS	12	0 27 59 14
22	SS	24	

Elevation scale: 139, 138, 137, 136, 135, 134, 133, 132, 131, 130, 129, 128, 127, 126

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

RECORD OF BOREHOLE No WM17-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 | LOCATION N 4866540.5 ;E 339291.5 | ORIGINATED BY SB
DIST Central HWY 407 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers | COMPILED BY DD
DATUM Geodetic | DATE December 17, 2007 | CHECKED BY TZ/HJ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND and SILT, trace to some clay, containing clayey silt lenses Compact to very dense Grey Moist to wet	23	SS	41	124	4 65 29 2
		24	SS	101	123	
		25	SS	100/0.25	122, 121	
		26	SS	35	120, 119	
118.4 / 36.6	SILT, trace to some sand and clay, trace gravel, containing occasional silty sand seams Very dense Grey Wet	27	SS	154	118	3 10 78 9
		28	SS	100/0.25	117, 116	
		29	SS	100/0.28	115	
114.9 / 40.1	END OF BOREHOLE					

NOTES:

1. Water level measured in piezometer at a depth of 4.3 m below ground surface (Elevation 150.7 m) on January 7, 2008.

1. Water level measured in piezometer at a depth of 2.5 m below ground surface (Elevation 152.5 m) on April 4, 2008.

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+ 3, × 3: Numbers refer to Sensitivity   ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WM17-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 | LOCATION N 4866473.4 ;E 339324.1 | ORIGINATED BY PKS
DIST Central HWY 407 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers | COMPILED BY DD
DATUM Geodetic | DATE January 10, 16 and 17, 2008 | CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
156.4	GROUND SURFACE						
0.0	Sand and gravel (FILL) Loose to compact Brown Moist	1	SS	14		156	
		2	SS	6			
155.2 / 1.2	Organic CLAYEY SILT, some sand Stiff Black Moist	3	SS	9		155	
154.1 / 2.3	Silty SAND with clayey silt seams Compact Brown Moist	4	SS	10	∇	154	
153.3 / 3.1	CLAYEY SILT, trace to some sand, trace gravel Soft to stiff Grey Wet	5	SS	WH		153, 152	
		6	SS	4		151	
		7	SS	6		150, 149	1 10 43 46
		8	SS	14		148	
		9	SS	2		147, 146	
145.7 / 10.7	SILT, some sand, trace clay Loose to compact Grey Wet	10	SS	2		145	
		11	SS	5		144, 143	0 12 78 10
		12	SS	15		142	

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MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+ 3, × 3: Numbers refer to Sensitivity   ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WM17-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4866473.4 ;E 339324.1 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 10, 16 and 17, 2008 CHECKED BY TZ/HJ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
141.1					
15.2	CLAYEY SILT, some sand Very stiff Grey Wet	13	SS	20	
		14	SS	26	0 16 44 40
		15	SS	15	
136.6 / 19.8	SILT to Sandy SILT, trace gravel, containing clayey silt seams Compact Grey Wet	16	SS	14	0 8 83 9
		17	SS	14	
		18	SS	16	
		19	SS	13	3 33 58 6
		20	SS	22	
128.9 / 27.4	CLAYEY SILT, some sand, trace gravel Stiff to very stiff Grey Wet	21	SS	17	
		22	SS	14	

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No WM17-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4866473.4 ;E 339324.1 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 10, 16 and 17, 2008 CHECKED BY TZ/HJ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	CLAYEY SILT, some sand, trace gravel Stiff to very stiff Grey Wet	23	SS	14	
124.4 / 32.0	Sandy SILT to SILT, some sand, trace to some clay and gravel Compact to very dense Grey Wet	24	SS	48	
		25	SS	29	0 26 66 8
		26	SS	28	
		27	SS	36	4 16 63 17
		28	SS	100/0.18	
116.8 / 39.6	Silty SAND, trace to some gravel, trace clay Very dense Grey Wet	29	SS	100/0.25	
115.0		30	SS	100/0.20	10 70 17 3
41.4	END OF BOREHOLE				

NOTES:

1. Shelby tube sample (SA 6A) obtained between a depth of 4.6 m and 5.2 m below ground surface (Elevation 151.8 m and Elevation 151.2 m) in an adjacent borehole for laboratory consolidation testing.

2. Wet samples noted at a depth of 4.6 m below ground surface (Elevation 151.8 m).

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WM22-1

 METRIC

PROJECT 07-1111-0053			
W.O. 07-20015	LOCATION N 4867019.3 ;E 340901.0	ORIGINATED BY PKS	
DIST Central HWY 407	BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers	COMPILED BY DD	
DATUM Geodetic	DATE December 14, 18, 2007	CHECKED BY TZ/HJ	

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
169.0	GROUND SURFACE					
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	17		
168.2 / 0.8	CLAYEY SILT, with sand, trace gravel (TILL) Stiff to very stiff Brown Moist to wet	2	SS	11	168	
		3	SS	25	167	
		4	SS	21	166	4 30 47 19
		5	SS	23	165	
		6	SS	13	164	
					163	
162.6 / 6.4	Silty SAND to SAND some silt, trace to some gravel, trace clay, occasional cobbles Compact to very dense Grey Wet	7	SS	66	162	6 56 33 5
		8	SS	16	161	
		9	SS	44	160 / 159	
		10	SS	57	158	0 87 11 2
157.4 / 11.6	SILT, trace to some sand and clay, trace gravel Very dense Grey Wet	11	SS	93	157 / 156	
		12	SS	138	155	1 6 85 8

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

+ [3], × [3]: Numbers refer to Sensitivity ○ [3%] STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

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RECORD OF BOREHOLE No WM22-1

 METRIC

PROJECT 07-1111-0053			
W.O. 07-20015	LOCATION N 4867019.3 ;E 340901.0	ORIGINATED BY PKS	
DIST Central HWY 407	BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers	COMPILED BY DD	
DATUM Geodetic	DATE December 14, 18, 2007	CHECKED BY TZ/HJ	

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---					
	SILT, trace to some sand and clay, trace gravel Very dense Grey Wet	13	SS	52	153	
152.0		14	SS	100/0.1[illegible]	152	
17.0	CLAYEY SILT, containing sand seams Hard Grey Wet				151	
		15	SS	100/0.2[illegible]	150	
149.0		16	SS	100/0.2[illegible]	149	0 0 65 35
20.0	END OF BOREHOLE					

NOTES:

1. Water level measured in open borehole upon completion of drilling at a depth of 4.0 m below ground surface (Elevation 165.0 m).

2. Water level measured in piezometer at a depth of 5.6 m (Elevation 163.4 m) on January 7, 2008.

3. Water level measured in piezometer at a depth of 4.8 m (Elevation 164.2 m) on April 4, 2008.

+ [3], × [3]: Numbers refer to Sensitivity ○ [3%] STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

RECORD OF BOREHOLE No WM25-1

 METRIC

PROJECT 07-1111-0053

W.O. 07-20015 LOCATION N 4867278.2 ;E 341679.9 ORIGINATED BY PKS

DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD

DATUM Geodetic DATE December 19, 2007 CHECKED BY TZ/HJ

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.1	GROUND SURFACE				180	
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	22		
179.3 0.8	SAND and SILT, some clay, trace gravel, occasional cobbles (TILL) Compact to very dense Brown to gey Moist to wet	2	SS	15	179	
		3	SS	37	178	
		4	SS	32		10 39 37 14
		5	SS	31	177	
	Wet below 3.7 m depth				176	
		6	SS	31	175	12 43 32 13
		7	SS	62	174	
		8	SS	36	173 / 172	
		9	SS	45	171 / 170	
		10	SS	50	169	2 39 43 16
		11	SS	41	168 / 167	
		12	SS	52	166	

Column headings also include: STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³.

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+ ³, × ³: Numbers refer to Sensitivity ○ ³% STRAIN AT FAILURE

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Foundation Design

RECORD OF BOREHOLE No WM25-1

 METRIC

PROJECT 07-1111-0053

W.O. 07-20015 LOCATION N 4867278.2 ;E 341679.9 ORIGINATED BY PKS

DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD

DATUM Geodetic DATE December 19, 2007 CHECKED BY TZ/HJ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND and SILT, some clay, trace gravel, occasional cobbles (TILL) Compact to very dense Brown to gey Moist to wet	13	SS	74	165 / 164	1 50 37 12
		14	SS	100/0.2	163 / 162	
		15	SS	100/0.20	161	
160.1		16	SS	100/0.20		
20.0	END OF BOREHOLE					

NOTES:

1. Water level measured in open borehole upon completion of drilling at a depth of 6.1 m below ground surface (Elevation 174.0 m).

2. Water level measured in piezometer at a depth of 9.1 m below ground surface (Elevation 171.0 m) on January 7, 2008.

2. Water level measured in piezometer at a depth of 2.2 m below ground surface (Elevation 177.9 m) on April 4, 2008.

+ ³, × ³: Numbers refer to Sensitivity ○ ³% STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WM27-1

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015 | LOCATION N 4867644.3 ;E 342430.1 | ORIGINATED BY PKS
DIST Central HWY 407 | BOREHOLE TYPE 108 mm O.D. Solid Stem Augers | COMPILED BY DD
DATUM Geodetic | DATE December 20, 2007 | CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
195.8	GROUND SURFACE					
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	24		
195.0 / 0.8	SAND and SILT, trace to some clay and gravel (TILL) Compact to very dense Brown to grey Moist to wet	2	SS	16	195	
		3	SS	88	194	16 49 30 5 NP
		4	SS	100/0.15	193	
		5	SS	100/0.20	192	
		6	SS	100/0.20	191	
		7	SS	100/0.15	190, 189	
		8	SS	100/0.20	188, 187	
186.5		9	SS	100/0.18		4 37 44 15
9.3	END OF BOREHOLE					

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTE:

1. Borehole dry upon completion of drilling, however wet soil samples were noted at a depth of 6.4 m below ground surface (Elevation 189.4 m).

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No WM27-2

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015 | LOCATION N 4867538.3 ;E 342470.7 | ORIGINATED BY PKS
DIST Central HWY 407 | BOREHOLE TYPE 108 mm O.D. Solid Stem Augers | COMPILED BY DD
DATUM Geodetic | DATE December 20, 2007 | CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
191.8	GROUND SURFACE					
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	17		
191.0 / 0.8	SAND and SILT, trace to some clay and gravel, occasional cobbles (TILL) Compact to very dense Brown to grey Moist to wet	2	SS	29	191	
		3	SS	38	190	
		4	SS	81	189	
		5	SS	100/0.1	188	7 46 37 10
		6	SS	100/0.1	187, 186	
		7	SS	100/0.15	185	
		8	SS	100/0.15	184, 183	
182.5		9	SS	100/0.13		8 41 36 15
9.3	END OF BOREHOLE					

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTES:

1. Water level measured in piezometer at a depth of 0.6 m below ground surface (Elevation 191.2 m) on February 26, 2008.

2. Water level measured in piezometer at depth of 0.3 m below ground surface (Elevation 191.5 m) on April 4, 2008.

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WM28-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
DIST Central HWY 407
DATUM Geodetic
LOCATION N 4867900.8 ;E 343233.6
BOREHOLE TYPE 114 mm O.D. Hollow Stem Augers
DATE January 29, 2008
ORIGINATED BY PKS
COMPILED BY DD
CHECKED BY TZ/HJ

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
194.0	GROUND SURFACE								
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	22					
193.2 / 0.8	SAND and SILT, trace to some gravel and clay (TILL) Compact to very dense Brown to grey Moist	2	SS	13	193				
		3	SS	46	192				
		4	SS	88		23	43	28	6
		5	SS	95	191				
					190				
	Wet below 4.6 m depth	6	SS	100/0.25	189				
		7	SS	100/0.15	188	3	47	41	9
					187				
186.3 / 7.8	END OF BOREHOLE	8	SS	100/0.13					

SOIL PROFILE / SAMPLES / STRAT PLOT / GROUND WATER CONDITIONS / DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100 / PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30 / UNIT WEIGHT γ kN/m³ / REMARKS & GRAIN SIZE DISTRIBUTION (%)

NOTES:

1. Water level in open borehole upon completion of drilling at a depth of 0.4 m below ground surface (Elevation 193.6 m).

2. Water level measured in piezometer at a depth of 0.4 m below ground surface (Elevation 193.6 m) on February 28, 2008.

3. Water level measured in piezometer at a depth of 3.4 m below ground surface (Elevation 190.6 m) on April 4, 2008.

$+^3, \times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WM29-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
DIST Central HWY 407
DATUM Geodetic
LOCATION N 4868006.6 ;E 343626.2
BOREHOLE TYPE 108 mm O.D. Solid Stem Augers
DATE December 21, 2007
ORIGINATED BY PKS
COMPILED BY DD
CHECKED BY TZ/HJ

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
189.0	GROUND SURFACE								
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	23					
		2	SS	24	188				
187.5 / 1.5	SAND and SILT, some clay, trace to some gravel, occasional cobbles (TILL) Compact to to very dense Brown Moist	3	SS	12	187				
		4	SS	24	186				
		5	SS	50	185	17	36	36	11
		6	SS	100/0.13	184				
		7	SS	100/0.13	183	8	40	36	16
					182				
181.3	Clayey silt seam at 7.6 m depth	8	SS	100/0.13					
7.8	END OF BOREHOLE								

SOIL PROFILE / SAMPLES / STRAT PLOT / GROUND WATER CONDITIONS / DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100 / PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30 / UNIT WEIGHT γ kN/m³ / REMARKS & GRAIN SIZE DISTRIBUTION (%)

NOTE:

1. Open borehole dry upon completion of drilling.

$+^3, \times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WM29-2

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867883.6 ;E 343671.2 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 108 mm O.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE December 21, 2007 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
190.0	GROUND SURFACE							
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	15				
189.2 / 0.8	SAND and SILT, some clay, trace to some gravel, occasional cobbles (TILL) Loose to very dense Brown to grey Moist to wet	2	SS	9				
		3	SS	18	3	41	45	11
		4	SS	28				
		5	SS	33				
		6	SS	28	4	42	42	12
		7	SS	100/0.1[illegible]				
		8	SS	100/0.25	7	43	38	12
180.7		9	SS	100/0.1[illegible]				
9.3	END OF BOREHOLE							

NOTES:

1. Open borehole dry upon completion of drilling.

2. Water level measured in piezometer at a depth of 8.7 m below ground surface (Elevation 181.3 m) on January 7, 2008.

3. Water level measured in piezometer at a depth 7.8 m below ground surface (Elevation 182.2 m) on April 4, 2008.

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WM35-1

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4868095.8 ;E 345333.7 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 108 mm O.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 2, 2008 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
165.0	GROUND SURFACE							
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	AS				
		2	SS	20				
163.5 / 1.5	SAND and SILT, trace to some clay, trace gravel (TILL) Compact to very dense Brown to grey Moist	3	SS	15				
		4	SS	76				
		5	SS	65	3	44	46	7
		6	SS	116				
	Wet below 6.1 m depth	7	SS	100/0.1[illegible]				
		8	SS	110	1	37	44	18
155.7		9	SS	100/0.18				
9.3	END OF BOREHOLE							

NOTES:

1. Water level measured in piezometer at a depth of 3.9 m below ground surface (Elevation 161.1 m) on January 7, 2008.

2. Water level measured in piezometer at a depth of 2.5 m below ground surface (Elevation 162.6 m) on April 4, 2008.

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WM35-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
DIST Central HWY 407
DATUM Geodetic
LOCATION N 4867982.7 ;E 345375.8
BOREHOLE TYPE 108 mm O.D. Solid Stem Augers
DATE January 2, 2008
ORIGINATED BY PKS
COMPILED BY DD
CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
163.6	GROUND SURFACE				
0.0	Sand and gravel (FILL) Brown Moist	1	SS	AS	
162.9 / 0.8	CLAYEY SILT, some sand, trace gravel, containing rootlets, topsoil and wood pieces Stiff Brown Moist	2	SS	10	
162.4 / 1.2	SAND and SILT, trace to some clay, trace to some gravel (TILL) Compact to very dense Brown Moist	3	SS	17	
		4	SS	59	
		5	SS	53	
		6	SS	105	6 42 39 13
	Becoming gravelly at 6.1 m depth	7	SS	100/0.13	
		8	SS	100/0.13	23 36 32 9
		9	SS	100/0.15	
154.3 / 9.3	END OF BOREHOLE				

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 8.2 m below ground surface (Elevation 155.4 m).

Elevation scale: 163, 162, 161, 160, 159, 158, 157, 156, 155

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED: 20 40 60 80 100
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%): 10 20 30
UNIT WEIGHT γ kN/m³

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WM36-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
DIST Central HWY 407
DATUM Geodetic
LOCATION N 4867998.0 ;E 345772.3
BOREHOLE TYPE 108 mm O.D. Solid Stem Augers; 210 mm O.D. Hollow Stem Augers
DATE March 4 and 6, 2008
ORIGINATED BY PKS
COMPILED BY DD
CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
153.6	GROUND SURFACE				
0.0	Sandy TOPSOIL Loose Brown Moist	1	SS	4	
152.8 / 0.8	SAND and SILT, trace to some clay, trace to some gravel, containing sand seams and cobbles (TILL) Compact to very dense Brown to grey Moist	2	SS	13	
		3	SS	22	
	Wet below 2.3 m depth	4	SS	54	
		5	SS	18	
		6	SS	16	1 32 56 11
		7	SS	76	
		8	SS	50	13 46 33 8
144.5 / 9.1	SILT, some clay, trace to some sand Compact to very dense Grey Wet	9	SS	25	
		10	SS	108	
		11	SS	100/0.18	0 7 80 13
		12	SS	100/0.25	
139.6 / 14.0					

Continued Next Page

Elevation scale: 153, 152, 151, 150, 149, 148, 147, 146, 145, 144, 143, 142, 141, 140

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED: 20 40 60 80 100
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%): 10 20 30
UNIT WEIGHT γ kN/m³

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WM36-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867998.0 ;E 345772.3 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 108 mm O.D. Solid Stem Augers; 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE March 4 and 6, 2008 CHECKED BY TZ/BLT

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	END OF BOREHOLE										
	NOTE:										
	1. Water level measured in open borehole upon completion of drilling at a depth of 3.0 m below the ground surface (Elevation 150.6 m).										

+ 3, × 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WM37-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4868110.8 ;E 345670.5 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE March 6, 2008 CHECKED BY TZ/BLT

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
153.2	GROUND SURFACE				
0.0	Sandy TOPSOIL Loose Brown Moist	1	SS	8	
152.4 0.8	CLAYEY SILT, some sand, trace to some gravel (TILL) Firm to very stiff Brown to grey Moist	2	SS	8	
		3	SS	14	8 15 54 23
	Wet below 2.3 m depth	4	SS	16	
		5	SS	15	
		6	SS	17	
147.1 6.1	SAND and SILT, trace to some clay, trace to some gravel (TILL) Dense to very dense Grey Wet	7	SS	49	5 36 47 12
		8	SS	39	
		9	SS	51	
142.5 10.7	CLAYEY SILT, trace to some sand Stiff Grey Wet	10	SS	14	
141.9 11.3	SAND and SILT, some clay, trace to some gravel (TILL) Very dense Grey Wet	11	SS	100/0.1[illegible]	
		12	SS	100/0.1[illegible]	8 35 42 15

Elevation scale: 153, 152, 151, 150, 149, 148, 147, 146, 145, 144, 143, 142, 141, 140, 139

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

RECORD OF BOREHOLE No WM37-1

 METRIC

PROJECT 07-1111-0053			
W.O. 07-20015	LOCATION N 4868110.8 ;E 345670.5		ORIGINATED BY PKS
DIST Central	HWY 407	BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers	COMPILED BY DD
DATUM Geodetic	DATE March 6, 2008		CHECKED BY TZ/BLT

SOIL PROFILE / SAMPLES / GROUND WATER CONDITIONS / ELEVATION SCALE / DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100) / PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30) / UNIT WEIGHT γ kN/m³ / REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---					
137.8 / 15.4		13	SS	100/0.15	138	
	END OF BOREHOLE					

NOTES:

1. Water level measured in open borehole upon completion of drilling at a depth of 9.1 m below ground surface (Elevation 144.1 m).

2. Water level measured in piezometer at a depth of 1.6 m below ground surface (Elevation 151.6 m) on April 4, 2008.

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+ 3, × 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WM38-1

 METRIC

PROJECT 07-1111-0053			
W.O. 07-20015	LOCATION N 4868111.0 ;E 346196.0		ORIGINATED BY PLS
DIST Central	HWY 407	BOREHOLE TYPE 108 mm O.D. Solid Stem Augers	COMPILED BY DD
DATUM Geodetic	DATE January 3 and 7, 2008		CHECKED BY TZ/HJ

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR SA SI CL
170.1	GROUND SURFACE				
0.0	Sand and gravel (FILL) Compact Brown Moist	1	AS		
169.0 / 1.1	SAND and SILT, trace to some clay and gravel (TILL) Compact to very dense Brown Moist to wet	2	SS	29	
		3	SS	43	
		4	SS	51	8 39 48 5
		5	SS	85	
165.5 / 4.6	SAND, some silt, trace gravel Dense to very dense Brown Wet	6	SS	61	
		7	SS	34	
		8	SS	39	0 86 13 1
161.0 / 9.1	CLAYEY SILT with SAND, some gravel (TILL) Hard Brown to grey Wet	9	SS	112	
		10	SS	50/0.05	12 39 37 12
		11	SS	60/0.07	
157.7 / 12.4	END OF BOREHOLE				

Elevation scale: 170, 169, 168, 167, 166, 165, 164, 163, 162, 161, 160, 159, 158

NOTE:

1. Water level measured in piezometer at depth of 3.9 m below ground surface (Elevation 166.2 m) on April 4, 2008.

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+ 3, × 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WM38-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867998.9 ;E 346240.4 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 108 mm O.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 3, 2008 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
166.0	GROUND SURFACE					
0.0	Sand and gravel (FILL) Compact Brown Moist	1	AS			
165.2 / 0.8	SAND and SILT, some clay and gravel (TILL) Compact to very dense Brown Moist	2	SS	17	165	
		3	SS	64	164	
		4	SS	78		14 37 36 13
		5	SS	84	163	
					162	
161.4 / 4.6	CLAYEY SILT with SAND, some gravel (TILL) Hard Grey Moist to wet	6	SS	100/0.18	161	
					160	
		7	SS	103		13 27 37 23
					159	
		8	SS	100/0.23		
158.1 / 7.9	END OF BOREHOLE					

NOTE:

1. Wet soil samples noted at a depth of 7.6 m below ground surface (Elevation 158.4 m).

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WM39-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867846.2 ;E 346644.0 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 108 mm O.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 9, 2008 CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
159.0	GROUND SURFACE					
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	15		
158.2 / 0.8	SAND and SILT to Sandy SILT, some clay, trace gravel (TILL) Compact to dense Brown to grey Moist to wet	2	SS	14	158	
		3	SS	34	157	
	Wet below 2.3 m depth	4	SS	24		5 26 57 12
		5	SS	30	156	
					155	
154.7 / 4.3	CLAYEY SILT to SILTY CLAY, trace sand and gravel Very stiff Grey Wet	6	SS	21	154	
					153	
		7	SS	23	152	
151.4 / 7.6	SAND and GRAVEL to SAND, some gravel, trace to some silt, trace clay Dense to very dense Grey Wet	8	SS	42	151	
					150	
		9	SS	75	149	
		10	SS	44	148	18 70 11 1
					147	
		11	SS	60	146	54 38 7 1
145.6 / 13.4	SAND and SILT, trace to some gravel (TILL) Very dense Grey Wet	12	SS	100/0.20	145	

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DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WM39-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867846.2 ;E 346644.0 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 108 mm O.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 9, 2008 CHECKED BY TZ/BLT

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
	SAND and SILT, trace to some gravel (TILL) Very dense Grey Wet	13	SS	100/0.30	143				
142.0 17.0		14	SS	100/0.23					
	END OF BOREHOLE								

NOTE:

1. Water level measured in piezometer at a depth of 1.6 m below ground surface (Elevation 157.4 m) on April 4, 2008.

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

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RECORD OF BOREHOLE No WM40-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867951.9 ;E 346735.8 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers; Wash boring from 7.3 m to 13.8 m depth COMPILED BY DD
DATUM Geodetic DATE February 27 and 29, 2008 CHECKED BY TZ/BLT

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
159.4	GROUND SURFACE							
0.0	TOPSOIL Loose Brown Moist	1	SS	4				
158.6 0.8	CLAYEY SILT with SAND, trace to some gravel (TILL) Stiff to very stiff Brown to grey Moist	2	SS	9				
		3	SS	11	9	36	42	13
		4	SS	29				
		5	SS	23				
		6	SS	18	4	35	45	16
153.9 5.5	SILTY CLAY Stiff Grey Wet	7	SS	12				
151.8 7.6	SILT Very loose Grey Wet	8	SS	3				
150.3 9.1	SAND and SILT, some clay and gravel, containing clayey silt seams (TILL) Compact to very dense Grey Wet	9	SS	17	4	32	55	9
		10	SS	108				
		11	SS	100/0.28				
145.6		12	SS	100/0.13	10	37	39	14
13.8	END OF BOREHOLE							

ELEVATION SCALE: 159, 158, 157, 156, 155, 154, 153, 152, 151, 150, 149, 148, 147, 146

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WM40-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 — LOCATION N 4867951.9 ;E 346735.8 — ORIGINATED BY PKS
DIST Central HWY 407 — BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers; Wash boring from 7.3 m to 13.8 m depth — COMPILED BY DD
DATUM Geodetic — DATE February 27 and 29, 2008 — CHECKED BY TZ/BLT

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	NOTE: 1. Water level measured in open borehole upon completion of drilling at a depth of 3.0 m below ground surface (Elevation 156.4 m).										

Legend: PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED

+ 3, × 3: Numbers refer to Sensitivity — ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WM41-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 — LOCATION N 4868117.0 ;E 346637.4 — ORIGINATED BY GD
DIST Central HWY 407 — BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers — COMPILED BY DD
DATUM Geodetic — DATE February 26, 2008 — CHECKED BY TZ/BLT

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
158.9	GROUND SURFACE					
0.0	TOPSOIL Very loose Brown Moist	1	SS	3		
158.4 0.5	CLAYEY SILT, some sand, trace gravel Firm Brown Moist	2	SS	5	∇	
157.4 1.5	Sandy SILT to SILT, trace to some clay, trace sand, occasional sand seams Compact Brown to grey Wet	3	SS	20		
		4	SS	20		0 4 88 8
		5	SS	10		
154.3 4.6	CLAYEY SILT to SILTY CLAY, trace sand and gravel Very stiff to stiff Grey Wet	6	SS	20		
		7	SS	11		
151.3 7.6	SAND and SILT, some gravel, trace to some clay Very loose to loose Grey Wet	8	SS	WH*		
		9	SS	8*		18 30 45 7
		10	SS	9*		
146.7 12.2	SAND and GRAVEL Compact Brown Wet	11	SS	29		
145.2 13.7	SAND and SILT, some clay, trace to some gravel (TILL) Very dense Grey Moist	12	SS	88/0.15		

Elevation scale: 158, 157, 156, 155, 154, 153, 152, 151, 150, 149, 148, 147, 146, 145, 144

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

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity — ○ 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No WM41-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4868117.0 ;E 346637.4 ORIGINATED BY GD
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE February 26, 2008 CHECKED BY TZ/BLT

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
	SAND and SILT, some clay, trace to some gravel (TILL) Very dense Grey Moist	13	SS	103/0.15		9	40	37	14
					143				
142.0 / 16.9	END OF BOREHOLE	14	SS	82/0.15	142				

NOTES:

1. Artesian conditions encountered at a depth of 12.2 m below ground surface (Elevation 146.7).

2. Water level measured in open borehole upon completion of drilling at a depth of 0.9 m below ground surface (Elevation 158.0 m).

* "N" Values are lower than expected as a result of loosening due to groundwater pressures.

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

+ 3, × 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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Foundation Design

RECORD OF BOREHOLE No WM41-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4868039.3 ;E 346610.4 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers; Wash boring from 10.7 m to 16.8 m COMPILED BY DD
DATUM Geodetic DATE March 3, 2008 CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
161.2	GROUND SURFACE							
0.0	TOPSOIL Compact Brown Moist	1	SS	14				
160.4 / 0.8	CLAYEY SILT, some sand, trace gravel Stiff Brown Moist	2	SS	14				
		3	SS	15				
158.9 / 2.3	CLAYEY SILT with SAND, trace to some gravel (TILL) Very stiff Brown Moist	4	SS	18	11	28	35	26
		5	SS	24				
	Wet below 3.7 m depth							
156.6 / 4.6	SAND and SILT, trace to some clay, trace gravel (TILL) Compact Grey Wet	6	SS	23				
		7	SS	20	3	41	47	9
153.6 / 7.6	CLAYEY SILT to SILTY CLAY Very stiff Grey Wet	8	SS	18				
		9	SS	18				
151.5 / 9.8	Silty SAND to SAND, some silt, trace clay and gravel Loose to dense Grey Wet	10	SS	5	1	80	17	2
		11	SS	37				
147.5 / 13.7	CLAYEY SILT with SAND, trace to some gravel (TILL) Hard Grey Wet	12	SS	100/0.1[illegible]				

ELEVATION SCALE: 161, 160, 159, 158, 157, 156, 155, 154, 153, 152, 151, 150, 149, 148, 147

Continued Next Page

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

+ 3, × 3: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

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RECORD OF BOREHOLE No WM41-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 | LOCATION N 4868039.3 ;E 346610.4 | ORIGINATED BY PKS
DIST Central HWY 407 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers; Wash boring from 10.7 m to 16.8 m | COMPILED BY DD
DATUM Geodetic | DATE March 3, 2008 | CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
	--- CONTINUED FROM PREVIOUS PAGE ---								
	CLAYEY SILT with SAND, trace to some gravel (TILL) Hard Grey Wet	13	SS	100/0.15	146	9	34	40	17
					145				
144.4 / 16.8	END OF BOREHOLE	14	SS	100/0.07					

NOTE:

1. Water level measured in piezometer at a depth of 1.7 m below ground surface (Elevation 159.5 m) on April 4, 2008.

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+3, ×3: Numbers refer to Sensitivity   ○3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No WM42-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 | LOCATION N 4867921.5 ;E 346845.3 | ORIGINATED BY PKS
DIST Central HWY 407 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers | COMPILED BY DD
DATUM Geodetic | DATE January 9, 2008 | CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL
163.0	GROUND SURFACE									
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	22						
162.4 / 0.6	Silty sand, some gravel (FILL) Compact Brown Moist	2	SS	23		162				
161.6 / 1.4	Silty SAND, trace gravel and clay, containing organics Very dense Brown Moist	3	SS	50		161				
		4	SS	58						
160.0 / 3.0	Silty SAND to SAND and SILT, trace clay Compact to very dense Brown to grey Moist to wet	5	SS	80		160				
						159				
	Wet below 4.6 m depth	6	SS	25		158	0	62	37	1
					∇	157				
		7	SS	65		156				
		8	SS	65		155				
154.2 / 8.8	CLAYEY SILT with sand, trace gravel (TILL) Hard Grey Wet	9	SS	100/0.15		154	4	32	44	20
						153				
		10	SS	100/0.25		152				
						151				
150.7 / 12.3	END OF BOREHOLE	11	SS	100/0.13						

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 6.1 m below ground surface (Elevation 156.9 m).

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+3, ×3: Numbers refer to Sensitivity   ○3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No WM43-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
DIST Central HWY 407
DATUM Geodetic
LOCATION N 4867845.2 ;E 347182.7
BOREHOLE TYPE 108 mm O.D. Solid Stem Augers
DATE January 4, 2008
ORIGINATED BY PKS
COMPILED BY DD
CHECKED BY TZ/HJ

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
164.0	GROUND SURFACE
0.0	Sand and gravel (FILL) Brown Moist
163.2 / 0.8	Organic CLAYEY SILT, some sand, trace gravel Stiff Black/grey Moist
162.5 / 1.5	SAND and SILT to Sandy SILT, some clay, trace gravel (TILL) Compact to very dense Brown to grey Moist
154.4 / 9.6	END OF BOREHOLE

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	AS	-	
2	SS	14	
3	SS	13	
4	SS	28	1 46 40 13
5	SS	100/0.1[illegible]	
6	SS	100/0.1[illegible]	
7	SS	100/0.2[illegible]	
8	SS	131	0 27 61 12
9	SS	100	

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (163, 162, 161, 160, 159, 158, 157, 156, 155); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³

NOTES:

1. Water level measured in open borehole upon completion of drilling at a depth of 2.1 m below ground surface (Elevation 161.9 m).

2. Water level measured in piezometer at at a depth of 2.3 m below ground surface (Elevation 161.7 m) on January 7, 2008.

3. Water level measured in piezometer at at a depth of 1.2 m below ground surface (Elevation 162.8 m) on April 4, 2008.

+ 3, × 3: Numbers refer to Sensitivity ○ 3%: STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

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RECORD OF BOREHOLE No WM43-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
DIST Central HWY 407
DATUM Geodetic
LOCATION N 4867730.5 ;E 347228.7
BOREHOLE TYPE 108 mm O.D. Solid Stem Augers
DATE January 4, 2008
ORIGINATED BY PKS
COMPILED BY DD
CHECKED BY TZ/HJ

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
164.0	GROUND SURFACE
0.0	Sand and gravel (FILL) Brown Moist
163.2 / 0.8	Organic CLAYEY SILT, some sand, trace gravel Stiff Black/brown Moist
162.6 / 1.4	SAND and SILT, trace to some clay and gravel (TILL) Compact to very dense Grey Wet Wet below 6.6 m depth
154.4 / 9.6	END OF BOREHOLE

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	AS	-	
2	SS	12	
3	SS	26	
4	SS	38	
5	SS	43	
6	SS	70	9 42 38 11
7	SS	102	11 49 32 8
8	SS	108	
9	SS	100/0.25	

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (163, 162, 161, 160, 159, 158, 157, 156, 155); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 3.4 m below ground surface (Elevation 160.6 m).

+ 3, × 3: Numbers refer to Sensitivity ○ 3%: STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WL2-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 — LOCATION N 4858235.2 ;E 346342.8 — ORIGINATED BY PKS
DIST Central HWY 407 — BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers — COMPILED BY DD
DATUM Geodetic — DATE February 4, 2008 — CHECKED BY TZ/BLT

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS (GR SA SI CL)
89.0	GROUND SURFACE				
0.0	ASPHALT				
0.2	Sand and gravel (FILL) Compact Brown Moist	1	SS	27	
88.2 / 0.8	Clayey silt with sand, trace gravel (FILL) Stiff to hard Brown/grey Moist	2	SS	10	
		3	SS	19	
		4	SS	20	
		5	SS	33	5 26 41 28
84.4 / 4.6	Organic silty SAND, trace clay Compact Black Moist	6	SS	13	OC = 6.6%
82.9 / 6.1	CLAYEY SILT, some sand, trace to some gravel (TILL) Very stiff to hard Brown to grey Moist to wet	7	SS	20	
	Wet below 7.6 m depth	8	SS	50	11 19 43 27
79.9 / 9.1	Grey/black, weathered SHALE (BEDROCK)	9	SS	100/0.23	
78.3 / 10.7	END OF BOREHOLE AUGER REFUSAL	10	SS	100/0.05	

NOTE:

1. Samples were noted to be wet at a depth of 7.6 m below ground surface (Elevation 81.4 m).

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Elevation scale: 88, 87, 86, 85, 84, 83, 82, 81, 80, 79

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+ 3, × 3: Numbers refer to Sensitivity — O 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No WL2-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 — LOCATION N 4858153.9 ;E 346368.2 — ORIGINATED BY PKS
DIST Central HWY 407 — BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers — COMPILED BY DD
DATUM Geodetic — DATE February 4, 2008 — CHECKED BY TZ/BLT

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS (GR SA SI CL)
93.2	GROUND SURFACE				
0.0	ASPHALT				
0.2	Sand and gravel (FILL) Compact to dense Brown Moist	1	SS	27	
		2	SS	34	
		3	SS	29	
90.6 / 2.6	Clayey silt with sand, trace gravel (FILL) Very stiff Brown/grey Moist	4	SS	19	
		5	SS	22	
		6	SS	24	
		7	SS	19	0 33 45 22
		8	SS	20	
84.1 / 9.1	Organic silty SAND, trace clay Compact Black Moist	9	SS	29	OC = 4.8%
82.6 / 10.7	CLAYEY SILT with sand, trace to some gravel (TILL) Very stiff Brown Moist	10	SS	25	
81.0 / 12.2	SAND and SILT, trace to some clay, trace gravel, containing shale pieces (TILL) Dense to very dense Grey Wet	11	SS	100/0.28	
		12	SS	37	3 39 51 7

Elevation scale: 93, 92, 91, 90, 89, 88, 87, 86, 85, 84, 83, 82, 81, 80, 79

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MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+ 3, × 3: Numbers refer to Sensitivity — O 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No WL2-2

2 OF 2 **METRIC**

PROJECT 07-1111-0053

W.O. 07-20015 | LOCATION N 4858153.9 ;E 346368.2 | ORIGINATED BY PKS

DIST Central HWY 407 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers | COMPILED BY DD

DATUM Geodetic | DATE February 4, 2008 | CHECKED BY TZ/BLT

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---						
78.0						78	
15.2	CLAYEY SILT with sand, trace to some gravel (TILL) Hard Grey Wet	13	SS	60			17 33 38 12
						77	
76.5 16.8	Grey/black SHALE (BEDROCK)	14	SS	100/0.07			
						76	
74.9 18.3	END OF BOREHOLE NOTE: 1. Water level measured in open borehole upon completion of drilling at a depth of 13.7 m below ground surface (Elevation 79.5 m).	15	SS	100/0.02		75	

+3, ×3: Numbers refer to Sensitivity　　○3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WL3-1

1 OF 2 **METRIC**

PROJECT 07-1111-0053

W.O. 07-20015 | LOCATION N 4857980.3 ;E 346420.5 | ORIGINATED BY PKS

DIST Central HWY 407 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers | COMPILED BY DD

DATUM Geodetic | DATE January 30, 2008 | CHECKED BY TZ/BLT

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
91.3	GROUND SURFACE						
0.0	ASPHALT						
0.2	Sand and gravel (FILL) Compact Brown Moist	1	SS	26		91	
90.4 0.9	Clayey silt to silty clay, some sand, trace gravel, containing shale pieces (FILL) Very stiff to hard Brown/grey Moist	2	SS	21		90	
		3	SS	16		89	
		4	SS	24			
		5	SS	17		88	
						87	
		6	SS	20			4 19 43 34
						86	
		7	SS	41		85	
						84	
83.5 7.8	SAND and SILT, some gravel, trace to some clay (TILL) Compact to very dense Brown to grey Moist	8	SS	28		83	
		9	SS	55		82	16 40 34 10
						81	
	Wet below 10.7 m depth	10	SS	100/0.13		80	
		11	SS	101	∇	79	25 32 34 9
						78	
		12	SS	103			
77.1 14.2	END OF BOREHOLE						

Continued Next Page

+3, ×3: Numbers refer to Sensitivity　　○3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

RECORD OF BOREHOLE No WL3-1

 METRIC

PROJECT	07-1111-0053		
W.O.	07-20015	LOCATION	N 4857980.3 ;E 346420.5
ORIGINATED BY	PKS		
DIST	Central	HWY	407
BOREHOLE TYPE	210 mm O.D. Hollow Stem Augers	COMPILED BY	DD
DATUM	Geodetic	DATE	January 30, 2008
CHECKED BY	TZ/BLT		

SOIL PROFILE: ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	NOTE: 1. Water level measured in open borehole upon completion of drilling at a depth of 12.2 m below ground surface (Elevation 79.1 m) .										

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

$+^{3}, \times^{3}$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No WL3-2

 METRIC

PROJECT	07-1111-0053		
W.O.	07-20015	LOCATION	N 4858023.6 ;E 346406.4
ORIGINATED BY	PKS		
DIST	Central	HWY	407
BOREHOLE TYPE	210 mm O.D. Hollow Stem Augers	COMPILED BY	DD
DATUM	Geodetic	DATE	January 31, 2008
CHECKED BY	TZ/BLT		

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.0	GROUND SURFACE				
0.0	ASPHALT				
0.2	Sand and gravel, trace to some silt, trace clay (FILL) Compact Brown Moist	1	SS	30	
		2	SS	28	
		3	SS	18	50 41 8 1
		4	SS	27	
		5	SS	23	
89.4 / 4.6	Clayey silt with sand, trace gravel, containing shale pieces (FILL) Stiff to very stiff Brown Moist	6	SS	14	
		7	SS	27	
		8	SS	25	3 29 41 27
		9	SS	28	
83.6 / 10.4	Organic silty SAND, trace clay Compact Black Moist	10	SS	25	
82.1 / 11.9	SAND and SILT, trace to some clay and gravel (TILL) Very dense to compact Brown to grey Moist to wet	11	SS	71	18 40 34 8
	Wet below 13.7 m depth	12	SS	100	

Elevation scale: 93, 92, 91, 90, 89, 88, 87, 86, 85, 84, 83, 82, 81, 80

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MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

$+^{3}, \times^{3}$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No WL3-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 | LOCATION N 4858023.6 ;E 346406.4 | ORIGINATED BY PKS
DIST Central HWY 407 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers | COMPILED BY DD
DATUM Geodetic | DATE January 31, 2008 | CHECKED BY TZ/BLT

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---					
	SAND and SILT, trace to some clay and gravel (TILL) Very dense to compact Brown to grey Moist to wet	13	SS	21		10 40 38 12
		14	SS	49	∇	
75.7 / 18.3	Grey/black, weathered SHALE (BEDROCK)	15	SS	100/0.07		
74.1 / 19.9	END OF BOREHOLE	16	SS	100/0.10		

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 16.8 m below ground surface (Elevation 77.2 m) .

Elevation scale: 78, 77, 76, 75

+ [3], × [3]: Numbers refer to Sensitivity ○ [3%] STRAIN AT FAILURE

RECORD OF BOREHOLE No WL3-3

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 | LOCATION N 4858095.1 ;E 346393.7 | ORIGINATED BY GD
DIST Central HWY 407 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers | COMPILED BY DD
DATUM Geodetic | DATE March 26, 2008 | CHECKED BY TZ/BLT

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
88.0	GROUND SURFACE				
0.0	ASPHALT				
0.2	Sand and gravel, trace silt (FILL) Compact Brown Moist	1	SS	23	
87.2 / 0.8	Silty clay, some sand, trace gravel (FILL) Stiff to very stiff Grey / black Moist	2	SS	16	
		3	SS	11	
85.7 / 2.3	CLAYEY SILT with sand, trace gravel (TILL) Very stiff Brown Moist	4	SS	16	
		5	SS	23	3 30 44 23
83.4 / 4.6	SAND and SILT, some gravel, trace clay (TILL) Very dense Brown to grey Moist	6	SS	101	
		7	SS	54/0.16	16 42 37 5
		8	SS	66	
78.9 / 9.1	Dark grey, weathered, SHALE (BEDROCK)	9	SS	61/0.15	
77.3 / 10.7	Grey, SHALE (BEDROCK) Bedrock cored from 10.7 m to 14.6 m depth For bedrock coring detail see Record of Drillhole WL3-3	10	SS	61/0.02	
		1	RC	REC 78%	RQD = 34%
		2	RC	REC 100%	RQD = 57%
		3	RC	REC 100%	RQD = 90%
73.5 / 14.6					

Elevation scale: 87, 86, 85, 84, 83, 82, 81, 80, 79, 78, 77, 76, 75, 74

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+ [3], × [3]: Numbers refer to Sensitivity ○ [3%] STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WL3-3

2 OF 2 **METRIC**

PROJECT 07-1111-0053

W.O. 07-20015 LOCATION N 4858095.1 ;E 346393.7 ORIGINATED BY GD

DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD

DATUM Geodetic DATE March 26, 2008 CHECKED BY TZ/BLT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
	END OF BOREHOLE										
	NOTES:										
	1. Water level measured in open borehole upon completion of drilling at a depth of 5.8 m below ground surface (Elevation 82.2 m).										
	2. Water level measured in piezometer at a depth of 3.1 m below ground surface (Elevation 84.9 m) on April 5, 2008.										

+ 3, × 3 Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

RECORD OF DRILLHOLE: WL3-3

SHEET 1 OF 1

PROJECT: 07-1111-0053

LOCATION: N 4858095.1 ;E 346393.7

INCLINATION: -90° AZIMUTH: —

DRILLING DATE: March 26, 2008

DRILL RIG:

DRILLING CONTRACTOR:

DATUM: Geodetic

JN - Joint, FLT - Fault, SHR - Shear, VN - Vein, CJ - Conjugate, BD - Bedding, FO - Foliation, CO - Contact, OR - Orthogonal, CL - Cleavage, PL - Planar, CU - Curved, UN - Undulating, ST - Stepped, IR - Irregular, PO - Polished, K - Slickensided, SM - Smooth, Ro - Rough, MB - Mechanical Break, BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE min/(m)	FLUSH / COLOUR % RETURN	RECOVERY: TOTAL CORE % / SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle / DIP w.r.t. CORE AXIS / TYPE AND SURFACE DESCRIPTION / Jr Ja Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q AVG.	NOTES WATER LEVELS INSTRUMENTATION
		GROUND SURFACE		77.31											
11	HQ Coring Uncased	SHALE (BEDROCK) Moderately to slightly weathered Grey Thinly bedded		10.69	1									5	
12					2										
13															
14				73.45	3									21	
		END OF DRILLHOLE		14.55											
15															
16															
17															
18															
19															
20															

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: GD

CHECKED: TZ/BLT

MIS-RCK 004 07-1111-0053.GPJ GAL-MISS.GDT 3/27/09 DD/SAC

Golder Associates

RECORD OF BOREHOLE No WL4-1

 METRIC

PROJECT 07-1111-0053

W.O. 07-20015 | LOCATION N 4858226.4 ;E 346664.1 | ORIGINATED BY PKS

DIST Central HWY 407 | BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers | COMPILED BY DD

DATUM Geodetic | DATE March 25, 2008 | CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
83.0	GROUND SURFACE								
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	16					
82.2 / 0.8	CLAYEY SILT, some sand, trace gravel Firm to stiff Brown to grey Moist	2	SS	9					
		3	SS	4	∇				
80.7 / 2.3	CLAYEY SILT with sand, some gravel, containing shale fragments (TILL) Very stiff to hard Brown to grey Moist	4	SS	20					
		5	SS	15		17	41	31	11
	Wet below 4.6 m depth	6	SS	74					
76.9 / 6.1	Gravelly SAND, some silt, trace clay, containing shale fragments Very dense Grey Wet	7	SS	100/0.13					
		8	SS	100/0.28		27	56	13	4
73.8 / 9.2	END OF BOREHOLE	9	SS	100/0.05					

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 1.8 m below ground surface (Elevation 81.2 m).

Column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%). ELEVATION SCALE 82 to 74.

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WL5-2

 METRIC

PROJECT 07-1111-0053

W.O. 07-20015 | LOCATION N 4858430.0 ;E 346847.3 | ORIGINATED BY HM

DIST Central HWY 407 | BOREHOLE TYPE 108 mm O.D. Solid Stem Augers | COMPILED BY DD

DATUM Geodetic | DATE February 15, 2008 | CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
80.0	GROUND SURFACE							
0.0	TOPSOIL Brown Moist	1	AS	-				
79.5 / 0.5	Silty SAND Very loose Brown Moist							
79.1 / 0.9	CLAYEY SILT, trace sand Firm to stiff Brown Moist to wet	2	SS	5				
		3	SS	11				
77.8 / 2.2	SILTY CLAY, trace sand Soft to firm Brown to grey Wet	4	SS	4				
		5	SS	3				
75.5 / 4.5	CLAYEY SILT with sand, trace to some gravel Stiff Grey Wet	6	SS	WH	7	34	37	22
74.2 / 5.8	Silty SAND, some gravel, trace to some clay (TILL) Dense Grey Wet	7	SS	42	12	49	32	7
72.8 / 7.2	Dark grey SHALE							
72.3 / 7.7	END OF BOREHOLE	8	SS	50/0.05				

NOTES:

1. Water level measured in piezometer at a depth of 0.7 m below ground surface (Elevation 79.3 m) on April 5, 2008.

Column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%). ELEVATION SCALE 79 to 73.

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

Golder Associates

RECORD OF BOREHOLE No WL7-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4858358.5 ;E 347017.2 ORIGINATED BY HM
DIST Central HWY 407 BOREHOLE TYPE 108 mm I.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE February 12, 2008 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
82.0	GROUND SURFACE					
0.0	CLAYEY SILT, trace sand (TOPSOIL) Firm Dark brown Moist	1	SS	5		
81.2 / 0.8	SILTY CLAY, trace sand, containing sand seams Stiff Brown Moist	2	SS	15		
		3	SS	11		
79.9 / 2.1	CLAYEY SILT with sand, trace to some gravel, occasional sand seams (TILL) Stiff Brown to grey Wet	4	SS	10		
		5	SS	11	∇	
78.2 / 3.8	SILT, trace to some sand, trace clay (TILL) Dense to very dense Grey Wet	6	SS	32		1 16 78 5
		7	SS	54		0 3 92 5
		8	SS	47		
73.4 / 8.6	Dark grey SHALE (BEDROCK)	9	SS	50/0.10		
		10	SS	50/0.05		
		11	SS	50/0.02		
69.8 / 12.2	END OF BOREHOLE					

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 3.7 m below ground surface (Elevation 78.3 m).

Plot columns: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; ELEVATION SCALE 81–70.

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WL7-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4858415.1 ;E 347060.1 ORIGINATED BY HM
DIST Central HWY 407 BOREHOLE TYPE 108 mm I.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE February 12, 2008 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
82.0	GROUND SURFACE					
0.0	CLAYEY SILT, trace sand, organics (TOPSOIL) Stiff Dark brown Moist	1	SS	9		
81.3 / 0.7	CLAY to SILTY CLAY, trace sand and gravel, containing sand seams Firm Brown Moist	2	SS	6		
80.3 / 1.7	CLAYEY SILT with sand, trace to some gravel (TILL) Stiff to very stiff Brown to grey Wet Occasional sandy silt interlayers	3	SS	19	∇	
		4	SS	8		
78.8 / 3.2	SAND and SILT, trace to some clay and gravel (TILL) Compact to very dense Grey Wet	5	SS	14		9 44 39 8
		6	SS	34		
		7	SS	75		10 43 39 8
		8	SS	50/0.13		
74.3 / 7.7	Dark grey SHALE (BEDROCK) Moist to dry	9	SS	50/0.02		
71.3 / 10.7	END OF BOREHOLE	10	SS	50/0.05		

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 2.1 m below ground surface (Elevation 79.9 m).

Plot columns: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; ELEVATION SCALE 81–72.

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WL8-1

 METRIC

PROJECT 07-1111-0053

W.O. 07-20015 | LOCATION N 4858786.2 ;E 347117.0 | ORIGINATED BY HM

DIST Central HWY 407 | BOREHOLE TYPE 108 mm I.D. Solid Stem Augers | COMPILED BY DD

DATUM Geodetic | DATE February 13, 2008 | CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION
83.9	GROUND SURFACE
0.0	SILTY CLAY, trace sand, containing organics (TOPSOIL) Firm Dark brown Moist
83.4 / 0.5	SILTY CLAY, trace to some sand, trace gravel Firm to very stiff Brown Moist
82.5 / 1.4	CLAYEY SILT with sand, some gravel (TILL) Very stiff to hard Brown to grey Moist
77.5 / 6.4	Dark grey SHALE (BEDROCK) Moist to dry
74.7 / 9.2	END OF BOREHOLE

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 1.5 m below ground surface (Elevation 82.4 m).

SAMPLE NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	7				
2	SS	21				
3	SS	26				
4	SS	48	15	40	32	13
5	SS	50/0.05				
6	SS	48	10	42	36	12
7	SS	81/0.28				
~~8~~	~~SS~~	~~50/0.02~~				
~~9~~	~~SS~~	~~50/0.02~~				

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (83 to 75); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+3, ×3: Numbers refer to Sensitivity   ○3% STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WL8-2

 METRIC

PROJECT 07-1111-0053

W.O. 07-20015 | LOCATION N 4858681.3 ;E 346998.0 | ORIGINATED BY HM

DIST Central HWY 407 | BOREHOLE TYPE 108 mm I.D. Solid Stem Augers | COMPILED BY DD

DATUM Geodetic | DATE February 12, 2008 | CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION
82.3	GROUND SURFACE
0.0	SILTY CLAY, trace sand, containing organics and rootlets (TOPSOIL) Firm to stiff Dark brown Moist
81.7 / 0.6	CLAY to SILTY CLAY, trace to some sand, trace gravel, occasional sand seams Very soft to firm Brown to grey Moist to wet
79.0 / 3.3	CLAYEY SILT with sand, trace to some gravel (TILL-Like) Firm to stiff Grey Wet
75.6 / 6.7	Dark grey SHALE (BEDROCK) Wet
71.6 / 10.7	END OF BOREHOLE

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 1.5 m below ground surface (Elevation 80.8 m).

SAMPLE NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	8				
2	SS	4				
3	SS	4				
4	SS	1				
5	SS	WH				
6	SS	WH	11	33	44	12
7	SS	WH				
~~8~~	~~SS~~	~~50/0.02~~				
~~9~~	~~SS~~	~~50/0.02~~				
~~10~~	~~SS~~	~~50/0.02~~				

Field vane sensitivity noted on plot: 2.4 (at approx. elevation 77)

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (82 to 72); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+3, ×3: Numbers refer to Sensitivity   ○3% STRAIN AT FAILURE

Foundation Design

RECORD OF BOREHOLE No WL8-3

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4858543.9 ;E 347124.0 ORIGINATED BY HM
DIST Central HWY 407 BOREHOLE TYPE 108 mm I.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE February 14, 2008 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
82.0	GROUND SURFACE				
0.0	CLAYEY SILT, trace sand (TOPSOIL)	1	SS	4	
81.7 / 0.3	Soft, Dark brown, Wet				
	CLAY to SILTY CLAY, trace sand, containing occasional sand seams, Stiff to very stiff, Brown, Moist to wet	2	SS	5	
80.2 / 1.8	CLAYEY SILT with sand, trace to some gravel (TILL-Like), Soft to stiff, Brown to grey, Wet	3	SS	5	0 2 50 48
		4	SS	WH	
		5	SS	WH	
77.4 / 4.6	SAND and SILT, trace to some gravel and clay (TILL-Like), Very loose to compact, Grey, Wet	6	SS	WH	10 47 36 7
		7	SS	19	
75.4 / 6.6	SHALE (BEDROCK) Bedrock cored from 7.2 m to 10.4 m depth. For bedrock coring detail see Record of Drillhole WL8-3	1	RC	REC 43%	RQD = 0%
		-	AS	-	
		2	RC	REC 93%	RQD = 73%
71.6 / 10.4	END OF BOREHOLE				

Dynamic cone penetration / shear strength plot: >100 (samples 2, 3 and at approx. elev. 76.4); field vane 3.1 (elev. approx. 78.0), 3.4. Water content: 53 (liquid limit, sample 2–3).

Elevation scale: 81, 80, 79, 78, 77, 76, 75, 74, 73, 72

NOTES:

1. Water level measured in open borehole upon completion of drilling at a depth of 1.4 m below ground surface (Elevation 80.6 m).

2. Shelby tube sample (SA 4A) obtained between a depth of 1.8 m and 2.4 m in an adjacent borehole for laboratory consolidation testing.

3. Water level measured in piezometer at a depth of 0.7 m below ground surface (Elevation 81.3 m) on April 5, 2008.

$+^{3}, \times^{3}$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF DRILLHOLE: WL8-3

PROJECT: 07-1111-0053
LOCATION: N 4858543.9 ;E 347124.0 DRILLING DATE: February 14, 2008 DATUM: Geodetic
INCLINATION: -90° AZIMUTH: —
DRILL RIG:
DRILLING CONTRACTOR:

JN - Joint, FLT - Fault, SHR - Shear, VN - Vein, CJ - Conjugate, BD - Bedding, FO - Foliation, CO - Contact, OR - Orthogonal, CL - Cleavage, PL - Planar, CU - Curved, UN - Undulating, ST - Stepped, IR - Irregular, PO - Polished, K - Slickensided, SM - Smooth, Ro - Rough, MB - Mechanical Break, BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. / DEPTH (m)	RUN No.
		Continued from soil log	74.79	
8	HQ Coring, Uncased	Highly to moderately weathered, thinly bedded, grey, SHALE (BEDROCK)	7.21	1
9–10				2
		END OF DRILLHOLE	71.56 / 10.44	

Columns (no data other than graphical bars): PENETRATION RATE min/(m); COLOUR % RETURN; FLUSH; RECOVERY (TOTAL CORE %, SOLID CORE %); R.Q.D. %; FRACT. INDEX PER 0.3 m; DISCONTINUITY DATA (B Angle, DIP w.r.t. CORE AXIS, TYPE AND SURFACE DESCRIPTION, Jr, Ja, Jn); HYDRAULIC CONDUCTIVITY K cm/sec; Diametral Point Load Index (MPa); RMC -Q' AVG.; NOTES WATER LEVELS INSTRUMENTATION.

NOTE:

1. Corehole augered from Elevation 74.79 m to 71.56 m.

Depth scale: 8, 9, 10, 11, 12, 13, 14, 15, 16, 17

DEPTH SCALE 1 : 50   LOGGED: HM   CHECKED: TZ/HJ

RECORD OF BOREHOLE No WL9-1

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4858468.3 ;E 347261.8 ORIGINATED BY HM
DIST Central HWY 407 BOREHOLE TYPE 108 mm I.D. Solid Stem Augers COMPILED BY DD
DATUM Geodetic DATE February 13, 2008 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	SHEAR STRENGTH kPa	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
82.0	GROUND SURFACE										
0.0	CLAYEY SILT to SILTY CLAY (TOPSOIL) Firm Dark brown Moist	1	SS	4		4.6					
81.2 / 0.8	CLAY to SILTY CLAY, trace sand Stiff to very stiff Brown Moist	2	SS	6	∇	>100					
		3	SS	12							
79.7 / 2.3	CLAYEY SILT with sand, trace to some gravel (TILL-Like) Soft to firm Brown to grey Wet	4	SS	4				4	31	42	23
		5	SS	WH							
77.6 / 4.4	SAND and SILT, some gravel, trace to some clay (TILL) Compact to very dense Grey Wet	6	SS	17				16	45	34	5
		7	SS	50/0.07							
75.3 / 6.7	Dark grey SHALE (BEDROCK) Wet	8	SS	50/0.07							
72.8 / 9.2	END OF BOREHOLE	9	SS	50/0.05							

Water content plot: liquid limit 51 at sample 2.

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 1.1 m below ground surface (Elevation 80.9 m).

RECORD OF BOREHOLE No WL10-1

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4858615.2 ;E 347908.1 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE March 27, 2008 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	SHEAR STRENGTH kPa	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
79.1	GROUND SURFACE										
0.0	ASPHALT										
0.2	Sand and gravel (FILL) Compact Brown Moist	1	SS	20							
78.3 / 0.8	CLAYEY SILT with sand, trace gravel, containing seams of organics Stiff Grey/black Moist	2	SS	10							
		3	SS	14			OC=5.6%	2	48	32	18
76.8 / 2.3	CLAYEY SILT with sand, trace gravel Firm Grey Wet	4	SS	6							
		5	SS	4							
	Occasional silty sand and organic seams										
74.5 / 4.6	SAND and SILT, trace gravel, containing clayey silt seams Loose Grey Wet	6	SS	4		3.0; 2.9		0	48	45	7
73.0 / 6.1	Silty SAND, some gravel, trace clay Compact Grey Wet	7	SS	12	∇						
		8	SS	17							
	Containing shale pieces below 9.1 m depth	9	SS	17				29	45	21	5
69.0 / 10.1	Black SHALE (BEDROCK)	10	SS	100/0.07							
68.4 / 10.7	END OF BOREHOLE										

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 6.1 m below ground surface (Elevation 73.0 m).

Golder Associates

RECORD OF BOREHOLE No WL11-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 — LOCATION N 4858644.9 ;E 347984.2 — ORIGINATED BY PKS
DIST Central HWY 407 — BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers — COMPILED BY DD
DATUM Geodetic — DATE March 26, 2008 — CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
79.0	GROUND SURFACE				
78.7 / 0.0	Sandy TOPSOIL				
0.3	Loose, Brown, Moist	1	SS	7	
	CLAYEY SILT with sand, trace gravel, Firm to stiff, Brown to grey	2	SS	8	
		3	SS	5	
		4	SS	WH	4 38 36 22
	Occasional layers of silty sand, trace gravel	5	SS	7	
74.4 / 4.6	Silty SAND, some gravel, trace clay, Compact to dense, Grey, Wet	6	SS	45	
		7	SS	25	
		8	SS	35	16 59 23 2
69.9	Black, weathered SHALE (BEDROCK)	9	SS	100/0.10	
69.6 / 9.4	END OF BOREHOLE				

Shear strength (field vane) 2.6 recorded near elevation 76.

NOTES:

1. Water level measured in open borehole upon completion of drilling at a depth of 5.5 m below ground surface (Elevation 73.5 m).

2. Water level measured in piezometer at ground surface (Elevation 79.0 m) on April 5, 2008.

+ 3, × 3: Numbers refer to Sensitivity — ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WL12-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 — LOCATION N 4859272.4 ;E 346845.2 — ORIGINATED BY PKS
DIST Central HWY 407 — BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers — COMPILED BY DD
DATUM Geodetic — DATE February 8, 2008 — CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
87.0	GROUND SURFACE				
0.0	ASPHALT				
0.2	Sand and gravel (FILL), Compact, Brown, Moist	1	SS	13	
86.1 / 0.9	CLAYEY SILT with sand, trace to some gravel, containing shale fragments (TILL), Stiff to hard, Brown, Moist	2	SS	12	
		3	SS	19	
		4	SS	35	
		5	SS	26	15 38 37 10
82.4 / 4.6	Silty SAND, trace gravel, containing shale fragments (TILL), Very dense, Grey, Wet	6	SS	85	
81.5 / 5.5	CLAYEY SILT with sand, trace to some gravel, containing shale fragments (TILL), Hard, Grey, Wet	7	SS	64	
		8	SS	88	10 41 37 12
77.9 / 9.1	Grey, weathered, SHALE (BEDROCK)	9	SS	100/0.10	
77.2 / 9.8	END OF BOREHOLE				

NOTES:

1. Water level measured in open borehole upon completion of drilling at 8.8 m depth below ground surface (Elevation 78.2 m).

2. Water level measured in piezometer at a depth of 0.6 m below ground surface (Elevation 86.4 m) on August 15, 2008.

+ 3, × 3: Numbers refer to Sensitivity — ○ 3% STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WL16-1

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015
DIST Central HWY 407
DATUM Geodetic
LOCATION N 4861073.2 ;E 345796.6
BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers
DATE January 23, 2008
ORIGINATED BY PKS
COMPILED BY DD
CHECKED BY TZ/HJ/SH

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
97.0	GROUND SURFACE						
0.0	Sand and gravel (FILL) Compact to very dense Brown Moist	1	SS	15			
		2	SS	70			
95.6 / 1.4	Clayey silt, some sand, trace gravel, containing organics (FILL) Stiff Brown to grey Moist	3	SS	14			
		4	SS	14			
94.0 / 3.1	Silty SAND, trace to some gravel, containing organics Compact Grey Wet	5	SS	19		OC = 4.9%	
93.3 / 3.7	SILTY CLAY, trace sand Very stiff to hard Grey Wet				∇		
		6	SS	30			
		7	SS	25			
89.7 / 7.3	SAND, some silt, trace to some clay and gravel Dense Grey Wet	8	SS	41			6 73 16 7 NP
87.8 / 9.2	Grey to black SHALE (BEDROCK)	9	SS	100/0.07			
	Bedrock cored from 9.2 m to 13.1 m depth	1	RC	REC 100%			RQD = 0%
	For bedrock coring detail see Record of Drillhole WL16-1	2	RC	REC 100%			RQD = 27%
		3	RC	REC 100%			RQD = 53%
83.9 / 13.1	END OF BOREHOLE NOTE: 1. Water level measured in open borehole upon completion of drilling at a depth of 4.6 m below ground surface (Elevation 92.4 m).						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30
ELEVATION SCALE: 96, 95, 94, 93, 92, 91, 90, 89, 88, 87, 86, 85, 84

+³, ×³ Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

RECORD OF DRILLHOLE: WL16-1

SHEET 1 OF 1

PROJECT: 07-1111-0053
LOCATION: N 4861073.2 ;E 345796.6
INCLINATION: -90° AZIMUTH: —
DRILLING DATE: January 23, 2008
DRILL RIG:
DRILLING CONTRACTOR:
DATUM: Geodetic

JN - Joint, FLT - Fault, SHR - Shear, VN - Vein, CJ - Conjugate, BD - Bedding, FO - Foliation, CO - Contact, OR - Orthogonal, CL - Cleavage, PL - Planar, CU - Curved, UN - Undulating, ST - Stepped, IR - Irregular, PO - Polished, K - Slickensided, SM - Smooth, Ro - Rough, MB - Mechanical Break, BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. / DEPTH (m)	RUN No.	NOTES WATER LEVELS INSTRUMENTATION
		GROUND SURFACE	87.78		
	HQ Coring Uncased	SHALE, containing limestone seams (BEDROCK) Completely to highly weathered Grey Very thinly to thinly bedded	9.22	1	
10					
11				2	
12				3	
13			83.89 / 13.11		
		END OF DRILLHOLE			
14					
15					
16					
17					
18					
19					

Other columns: SYMBOLIC LOG, PENETRATION RATE min/(m), COLOUR % RETURN, FLUSH, RECOVERY (TOTAL CORE %, SOLID CORE %), R.Q.D. %, FRACT. INDEX PER 0.3 m, DISCONTINUITY DATA (B Angle, DIP w.r.t. CORE AXIS, TYPE AND SURFACE DESCRIPTION, Jr, Ja, Jn), HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}), Diametral Point Load Index (MPa), RMC -Q' AVG.

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PKS
CHECKED: TZ/HJ/SH

MIS-RCK 004 07-1111-0053.GPJ GAL-MISS.GDT 3/27/09 DD/SAC

RECORD OF BOREHOLE No WL19-2A

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 | LOCATION N 4861761.3 ;E 345567.1 | ORIGINATED BY TZ
DIST Central HWY 407 | BOREHOLE TYPE Portable (Tripod); Wash boring from 3.5 m to 9.6 m depth | COMPILED BY DD
DATUM Geodetic | DATE September 5 and 8, 2008 | CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
105.8	GROUND SURFACE							
0.0	TOPSOIL Loose Black Moist	1	SS	4				
104.9 / 0.9	SAND, some silt, trace clay Loose Brown Moist	2	SS	14				
	CLAYEY SILT, trace to some gravel and clay Stiff to hard Brown Wet	3	SS	33				
		4	SS	56	10	42	36	12
102.8 / 3.1	SAND and SILT, some gravel, trace to some clay (TILL) Very dense Brown to grey Wet	5	SS	236				
102.3 / 3.5	SAND, trace to some silt and gravel Very dense Grey Wet	6	SS	62				
101.6 / 4.2	SAND and SILT, some gravel, trace to some clay (TILL) Dense to very dense Brown to grey Wet	7	SS	43				
		8	SS	52	30	32	29	9
		9	SS	95				
		10	SS	191				
96.3 / 9.6	SHALE (BEDROCK) END OF BOREHOLE							

NOTE:

1. Water level measured in open borehole before wash boring at a depth of 1.1 m below ground surface. (Elevation 104.7 m).

2. Water level measured in piezometer at a depth of 2.5 m below ground surface (Elevation 103.3 m) on March 23, 2009.

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No WL19-3A

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 | LOCATION N 4861734.3 ;E 345611.8 | ORIGINATED BY TZ
DIST Central HWY 407 | BOREHOLE TYPE Portable (Tripod); Wash boring from 3.8 m to 8.4 m depth | COMPILED BY DD
DATUM Geodetic | DATE September 9, 2008 | CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
104.8	GROUND SURFACE							
0.0 / 0.1	TOPSOIL Loose Black Moist	1	SS	7				
103.8 / 1.0	SAND, some silt, containing organics Loose Brown Moist	2	SS	6				
	CLAYEY SILT to SILTY CLAY, trace sand Firm to hard Brown Moist	3	SS	57	0	2	61	37
101.8 / 3.1	SAND and SILT, trace to some gravel, trace clay (TILL) Very dense Brown Wet	4	SS	75				
100.2 / 4.6	CLAYEY SILT with sand, trace to some gravel (TILL) Stiff Grey Wet	5	SS	12	11	25	33	31
98.7 / 6.1	SAND and GRAVEL, containing shale pieces Compact Grey/black Wet	6	SS	29				
98.1 / 6.7	SAND and SILT, trace to some gravel, trace clay (TILL) Very dense Brown to grey Wet	7	SS	152				
		8	SS	100/0.10	10	52	33	5
96.4 / 8.4	END OF BOREHOLE							

Shear strength (field vane): >120, >120 (at approx. Elev. 103)

NOTE:

1. Wet soil samples noted at a depth of 3.1 m below ground surface (Elev. 101.8 m) during drilling.

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No WL19A-1A

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015 | LOCATION N 4861744.1 ;E 345677.9 | ORIGINATED BY TZ
DIST Central HWY 407 | BOREHOLE TYPE Portable (Tripod); Wash boring from 3.8 m to 7.0 m depth | COMPILED BY DD
DATUM Geodetic | DATE September 4 and 5, 2008 | CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
101.0	GROUND SURFACE									
0.0 / 0.1	TOPSOIL Loose Black Moist	1	SS	9						
99.8	SAND, some silt, trace clay Loose to compact Brown Wet	2	SS	10			0	6	62	32
99.5 / 1.5	CLAYEY SILT, trace to some sand Stiff Grey Wet	3	SS	9						
98.8 / 2.3	SAND, some silt, trace clay Loose Brown Wet	4	SS	5			0	78	19	3
98.2 / 2.8	CLAYEY SILT, trace to some sand Stiff Grey Wet	5	SS	4	∇		0	15	36	49
	SAND, trace clay Loose Brown Wet	6	TO	PM		17.9				
96.4 / 4.6	SILTY CLAY, some sand Soft to firm Grey Wet	7	SS	13						
	SAND and SILT, trace to some gravel and clay (TILL) Compact to very dense Grey Wet Clayey silt with gravel seam from 5.8 m to 6.0 m depth	8	SS	95						
94.0		9	SS	100/0.15						
7.0	END OF BOREHOLE									

NOTE:

1. Water level measured in open borehole before wash boring at a depth of 3.8 m below ground surface (Elevation 97.2 m).

Elevation scale: 100, 99, 98, 97, 96, 95, 94

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

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WL19A-2A

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015 | LOCATION N 4861716.4 ;E 345690.7 | ORIGINATED BY TZ
DIST Central HWY 407 | BOREHOLE TYPE Portable (Tripod); Wash boring from 3.0 m to 7.5 m depth | COMPILED BY DD
DATUM Geodetic | DATE September 10, 2008 | CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
102.0	GROUND SURFACE									
0.0 / 0.2	TOPSOIL Loose Black Moist	1	SS	53						
	SAND, some silt, trace clay Compact to very dense Brown Wet	2	SS	15						
		3	SS	7						
100.1 / 1.9	CLAYEY SILT, some sand Firm to very stiff Brown Wet	4	SS	17						
99.0 / 3.1	SILTY CLAY, trace to some sand Soft to firm Grey Wet	5	SS	6						
		6	SS	4			0	9	39	52
95.9 / 6.1	SAND and SILT, trace to some gravel and clay (TILL) Very dense Grey Wet	7	SS	100/0.15			9	41	39	11
94.5		8	SS	100/0.15						
7.5	END OF BOREHOLE									

NOTE:

1. Wet soil samples noted at a depth of 0.5 m below ground surface (Elev. 101.5 m) during drilling.

Elevation scale: 101, 100, 99, 98, 97, 96, 95

Field vane sensitivity values: 1.9, 2., 1.7, 2.6

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

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WL20-1

 METRIC

PROJECT 07-1111-0053 | W.O. 07-20015 | LOCATION N 4863012.2 ;E 345154.0 | ORIGINATED BY PKS

DIST Central HWY 407 | BOREHOLE TYPE 108 mm O.D. Solid Stem Augers; 210 mm O.D. Hollow Stem Augers below 12.2 m | COMPILED BY DD

DATUM Geodetic | DATE January 11, 2008 | CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	Plot annotations	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
116.4	GROUND SURFACE							
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	12				
115.6 / 0.8	Silty sand, trace gravel (FILL) Loose to compact Brown Moist	2	SS	22				
		3	SS	9				
114.1 / 2.3	Sandy SILT, containing organics Loose Brown to black Moist	4	SS	10				OC=5.7%
113.4 / 3.1	CLAYEY SILT, some sand and gravel (TILL-Like) Firm to stiff Brown to grey Wet	5	SS	WH		7.5		
		6	SS	4		>96		
		7	SS	5		2.0		
		8	SS	4		>96		15 23 35 27
		9	SS	4				
106.2 / 10.2	SAND and SILT, some gravel, trace to some clay (TILL) Very dense Grey Wet	10	SS	100/0.15				19 44 31 6
104.2 / 12.2	CLAYEY SILT with SAND, trace gravel (TILL) Hard Grey Wet	11	SS	47	∇			
		12	SS	105				

Column headings of the plots: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30. ELEVATION SCALE 116 to 102.

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WL20-1

 METRIC

PROJECT 07-1111-0053 | W.O. 07-20015 | LOCATION N 4863012.2 ;E 345154.0 | ORIGINATED BY PKS

DIST Central HWY 407 | BOREHOLE TYPE 108 mm O.D. Solid Stem Augers; 210 mm O.D. Hollow Stem Augers below 12.2 m | COMPILED BY DD

DATUM Geodetic | DATE January 11, 2008 | CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---						
	CLAYEY SILT with SAND, trace gravel (TILL) Hard Grey Wet	13	SS	100			0 37 42 21
		14	SS	102			
99.2 / 17.2	END OF BOREHOLE NOTE: 1. Water level measured in open borehole upon completion of drilling at a depth of 12.2 m below ground surface (Elevation 104.2 m).						

ELEVATION SCALE 101 to 100.

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

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RECORD OF BOREHOLE No WL20-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4863027.8 ;E 345272.1 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 25, 2008 CHECKED BY TZ/HJ

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
115.0	GROUND SURFACE				
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	24	
114.2 / 0.8	CLAYEY SILT, some sand, trace gravel, contains organics Stiff Brown to black Moist	2	SS	15	
113.4 / 1.6	CLAYEY SILT, trace sand Firm to very stiff Brown Moist	3	SS	4	
		4	TO	PH	
	Wet below 3.1 m depth	5	SS	24	0 1 79 20
		6	SS	4	
109.3 / 5.7	CLAYEY SILT with sand, trace gravel (TILL) Hard Grey Wet	7	SS	32	
		8	SS	39	5 44 38 13
		9	SS	45	
		10	SS	160	
		11	SS	100	
		12	SS	100/0.25	5 26 55 14

Field vane shear strength values plotted: 6.0 (near elev. 113), 2.9 (near elev. 110).

Chart columns: GROUND WATER CONDITIONS; ELEVATION SCALE (114 – 101); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L – WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³.

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

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RECORD OF BOREHOLE No WL20-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4863027.8 ;E 345272.1 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 25, 2008 CHECKED BY TZ/HJ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
99.5		13	SS	100/0.25	
15.5	END OF BOREHOLE				

NOTE:

1. Water level measured in piezometer at a depth of 7.4 m below ground surface (Elevation 107.6 m) on April 5, 2008.

$+^3, \times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

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RECORD OF BOREHOLE No WL23-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867065.4 ;E 344299.7 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE January 28, 2008 CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
166.3	GROUND SURFACE								
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	17	166				
		2	SS	30	165				
164.8 / 1.5	SAND and SILT, trace to some gravel and clay (TILL) Very dense Brown to grey Moist	3	SS	87					
		4	SS	65	164				
		5	SS	89	163				
					162				
	Wet below 4.6 m depth	6	SS	90		6	43	42	9
					161				
		7	SS	100/0.2	160				
					159				
		8	SS	81	158				
		9	SS	100/0.2	157				
					156				
		10	SS	100/0.2	155	20	40	31	9
154.0 / 12.3	END OF BOREHOLE	11	SS	100/0.1	154				

NOTE:

1. Water level measured in piezometer at a depth of 1.3 m below ground surface (Elevation 165.0 m) on April 4, 2008.

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No WL24-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867462.1 ;E 344744.7 ORIGINATED BY PKS/JB
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE March 11, 2008 CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
149.3	GROUND SURFACE								
0.0	TOPSOIL Loose Brown Moist	1	SS	8	149				
148.6 / 0.8	CLAYEY SILT, some sand, trace gravel Very stiff Brown Moist	2	SS	20	148				
147.8 / 1.5	Silty SAND, trace clay and gravel Dense Brown Wet	3	SS	32					
147.1 / 2.3	SAND and SILT, trace to some clay and gravel (TILL) Very dense Brown to grey Wet	4	SS	107	147	7	38	43	12
		5	SS	100/0.1	146				
					145				
		6	SS	100/0.1		8	45	38	9
					144				
143.1 / 6.3	END OF BOREHOLE	7	SS	100/0.1					

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 3.0 m below ground surface (Elevation 146.3 m).

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No WL24-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
LOCATION N 4867394.5 ;E 344690.9
ORIGINATED BY GD
DIST Central HWY 407
BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers
COMPILED BY DD
DATUM Geodetic
DATE January 28, 2008
CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
150.0	GROUND SURFACE				
0.0 / 149.6 / 0.4	Silty sand, containing organics (FILL) Very loose Dark brown Moist	1	SS	2	
148.5 / 1.5	Sand and gravel, trace to some silt (FILL) Compact Brown Moist	2	SS	19	
147.7 / 2.3	CLAYEY SILT, some sand, trace gravel (TILL) Hard Brown Moist	3	SS	48	
	SAND and SILT, some clay, trace to some gravel (TILL) Very dense Brown to grey Moist	4	SS	50/0.07	
		5	SS	50/0.10	
		6	SS	50/0.13	9 40 36 15
144.5 / 5.5		7	SS	50/0.13	
	END OF BOREHOLE				

NOTE:

1. Water level measured in piezometer at a depth of 0.7 m below ground surface (Elevation 149.3 m) on February 28, 2008.

2. Water level measured in piezometer at a depth of 0.3 m below ground surface (Elevation 149.7 m) on April 14, 2008.

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (149, 148, 147, 146, 145); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

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RECORD OF BOREHOLE No WL26-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
LOCATION N 4867568.0 ;E 344100.9
ORIGINATED BY PKS
DIST Central HWY 407
BOREHOLE TYPE Power Auger, 114 mm O.D. Solid Stem Augers
COMPILED BY DD
DATUM Geodetic
DATE February 20, 2008
CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
176.1	GROUND SURFACE				
0.0 / 175.5 / 0.6	TOPSOIL Soft Brown Moist	1	SS	4	
174.6 / 1.5	Silty SAND, trace clay Compact Brown Wet	2	SS	12	
	SAND and SILT, some gravel, trace to some clay (TILL) Compact to very dense Brown to grey Wet	3	SS	34	
		4	SS	40	19 38 43 0
		5	SS	48	
		6	SS	100/0.15	
	Grey below 6.1 m depth	7	SS	24	
		8	SS	33	2 47 40 11
166.9 / 9.2	CLAYEY SILT, some sand (TILL) Stiff to hard Grey Wet	9	SS	52	
		10	SS	14	
		11	SS	14	0 19 48 33
		12	SS	25	

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (176, 175, 174, 173, 172, 171, 170, 169, 168, 167, 166, 165, 164, 163, 162); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

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RECORD OF BOREHOLE No WL26-1

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
LOCATION N 4867568.0 ;E 344100.9
ORIGINATED BY PKS
DIST Central HWY 407
BOREHOLE TYPE Power Auger, 114 mm O.D. Solid Stem Augers
COMPILED BY DD
DATUM Geodetic
DATE February 20, 2008
CHECKED BY TZ/HJ

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
	CLAYEY SILT, some sand (TILL) Stiff to hard Grey Wet	13	SS	14				
159.3 / 16.8	SAND and GRAVEL Very dense Grey Moist	14	SS	58				
157.8 / 18.3	SAND and SILT, some gravel, trace to some clay (TILL) Very dense Grey Wet	15	SS	61	15	36	41	8
		16	SS	100/0.18				
		17	SS	100/0.13	12	36	43	9
		18	SS	100/0.13				
153.1 / 23.0	END OF BOREHOLE							

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 1.8 m below ground surface (Elevation 174.3 m).

Elevation scale: 161, 160, 159, 158, 157, 156, 155, 154

Chart column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3, \times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

Golder Associates

Foundation Design

RECORD OF BOREHOLE No WL26-2

 METRIC

PROJECT 07-1111-0053
W.O. 07-20015
LOCATION N 4867529.7 ;E 344213.2
ORIGINATED BY PKS
DIST Central HWY 407
BOREHOLE TYPE Power Auger, 114 mm O.D. Solid Stem Augers
COMPILED BY DD
DATUM Geodetic
DATE February 21, 2008
CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
175.0	GROUND SURFACE							
0.0	TOPSOIL Loose Brown Moist	1	SS	4				
174.2 / 0.8	SAND and SILT, some clay, trace to some gravel (TILL) Compact to very dense Brown to grey Moist to wet	2	SS	21				
		3	SS	63				
		4	SS	61				
		5	SS	80				
		6	SS	65	3	38	46	13
	Wet below 6.1 m depth	7	SS	50				
		8	SS	100/0.13	10	41	38	11
		9	SS	100/0.23				
165.6 / 9.4	END OF BOREHOLE							

NOTE:

1. Borehole dry upon completion of drilling.

Elevation scale: 174, 173, 172, 171, 170, 169, 168, 167, 166

Chart column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3, \times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

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RECORD OF BOREHOLE No WL27-1

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867872.5 ;E 343894.5 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE February 19, 2008 CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
182.1	GROUND SURFACE				182					
0.0	TOPSOIL, Loose, Black/brown, Moist	1	SS	6		42.1				
181.3 / 0.8	SAND and SILT, some gravel and clay (TILL), Compact to very dense, Brown to grey, Moist	2	SS	15	181					
		3	SS	45	180					
		4	SS	100/0.28			9	42	40	9
		5	SS	100/0.25	179					
					178					
		6	SS	100/0.28	177					
175.6		7	SS	100/0.23	176		10	44	34	12
6.5	END OF BOREHOLE									

Column headings also printed: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%).

NOTE:

1. Open borehole dry upon completion of drilling.

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No WL27-2

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015 LOCATION N 4867782.7 ;E 343985.7 ORIGINATED BY PKS
DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD
DATUM Geodetic DATE February 20, 2008 CHECKED BY TZ/BLT

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
174.0	GROUND SURFACE								
0.0	CLAYEY SILT, some sand, containing organics, Soft, Brown, Moist	1	SS	4					
173.4 / 0.6	Silty SAND, trace gravel and clay, Compact, Brown, Wet	2	SS	10	173				
172.5 / 1.5	SAND and SILT, trace to some clay and gravel (TILL), Very dense, Brown to grey, Wet	3	SS	55	172	19	36	34	11
		4	SS	100/0.2					
		5	SS	100/0.2	171				
					170				
		6	SS	100/0.28	169	17	33	34	16
167.7		7	SS	100/0.2	168				
6.4	END OF BOREHOLE								

NOTE:

1. Water level measured in open borehole upon completion of drilling at a depth of 1.5 m below ground surface (Elevation 172.5 m).

2. Water level measured in piezometer at a depth of 0.3 m below ground surface (Elevation 173.7 m) on April 4, 2008.

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No WL28-1

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015
DIST Central HWY 407
DATUM Geodetic
LOCATION N 4868104.2 ;E 344337.6
BOREHOLE TYPE 114 mm O.D. Hollow Stem Augers
DATE February 25, 2008
ORIGINATED BY GD
COMPILED BY DD
CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
178.2	GROUND SURFACE								
0.0	TOPSOIL Very loose Brown Moist	1	SS	2					
177.6 / 0.6	SAND and SILT, some gravel and clay (TILL) Compact to very dense Brown Moist	2	SS	11					
		3	SS	42		19	38	31	12
		4	SS	101					
		5	SS	65/0.15	∇				
		6	SS	50/0.07		11	38	37	14
172.0 / 6.2	END OF BOREHOLE	7	SS	100/0.07					

NOTE:

Water level measured in open borehole upon completion of drilling ata depth of 3.5 m below ground surface (Elevation 174.7 m).

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (178, 177, 176, 175, 174, 173); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10 20 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No WL28-2

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015
DIST Central HWY 407
DATUM Geodetic
LOCATION N 4868036.2 ;E 344277.3
BOREHOLE TYPE 114 mm O.D. Hollow Stem Augers
DATE February 25, 2008
ORIGINATED BY GD
COMPILED BY DD
CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
176.3	GROUND SURFACE							
0.0	TOPSOIL Very loose Brown Moist	1	SS	2				
175.8 / 0.5	SAND and SILT, some gravel and clay (TILL) Compact to very dense Brown to grey Moist	2	SS	14				
		3	SS	25				
		4	SS	47	8	38	41	13
		5	SS	108				
	Grey below 4.6 m depth	6	SS	100/0.13	16	36	35	13
170.0 / 6.3	END OF BOREHOLE	7	SS	50/0.07				

NOTE:

1. Water level measured in open borehole upon completion of drilling ata depth of 5.2 m below ground surface (Elevation 171.1 m).

2. Water level measured in piezometer at a depth of 0.3 m below ground surface (Elevation 176.0 m) on April 4, 2008.

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (176, 175, 174, 173, 172, 171, 170); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10 20 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 3/26/09 DD/SAC

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No WL31-1

 METRIC

PROJECT 07-1111-0053

W.O. 07-20015 — LOCATION N 4868016.8 ;E 343568.7 — ORIGINATED BY GD

DIST Central HWY 407 — BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers — COMPILED BY DD

DATUM Geodetic — DATE February 22, 2008 — CHECKED BY TZ/HJ

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
188.4	GROUND SURFACE					
0.0	Silty SAND, containing organics Very loose Dark brown Moist	1	SS	2	188	
187.9 / 0.5	CLAYEY SILT, trace sand Firm to stiff Brown Wet to moist	2	SS	5	187	
		3	SS	12		0 3 65 32
186.0 / 2.4	Silty SAND, some gravel, trace to some clay (TILL) Very dense Brown to grey Moist	4	SS	55	186	
		5	SS	100/0.1[illegible]	185	
	Boulder at 3.7 m depth				184	
	Grey below 4.6 m depth	6	SS	50/0.07	183	21 39 29 11
182.1 / 6.3	END OF BOREHOLE	7	SS	50/0.07		

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED — 20 40 60 80 100

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

UNIT WEIGHT γ kN/m³

NOTE:

1. Water level measured in open borehole upon completion of drilling ata depth of 2.1 m below ground surface (Elevation 186.3 m).

2. Water level measured in piezometer at a depth of 0.2 m below ground surface (Elevation 188.2 m) on April 5, 2008.

+³, ×³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE