

# **HYDROGEOLOGICAL FOUNDATION INVESTIGATION REPORT FOR PRELIMINARY DESIGN**

## **HIGHWAY 407 EAST EXTENSION – CENTRAL SECTION**

**W.O. 07 – 20016**

**Geocres Number: 30M15-104**

**Prepared for:  
Ministry of Transportation Ontario**

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**Date:**

**June, 2009**

**Project Number:**

**109407-50613**



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June 30, 2009

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Dear Mr. Kemper:

**Re: Hydrogeological Foundation Investigation Report For Preliminary Design**

We are pleased to convey this report on the Hydrogeological Investigations along the Central Mainline 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  
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SU:pc  
Attach.

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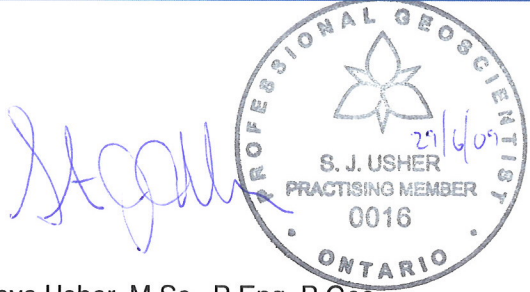
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# Part A

## Hydrogeological Foundation Investigation Report for Preliminary Design

### HIGHWAY 407 EAST EXTENSION – CENTRAL SECTION

Ministry of Transportation Ontario

Date:

June, 2009



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# 1. Introduction

This report presents Part A of the Hydrogeological Investigations Report for Preliminary Design for the Central Mainline of the Technically Preferred Route (TPR) of the Highway 407 East Extension. AECOM was retained by the Ministry of Transportation of Ontario (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 along the Central Mainline covers approximately 15 km between Ashburn Road in the west and Enfield Road in the east (**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 hydrogeology 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 Central Mainline has been divided into sub-sections based upon differences in geology / hydrogeology that exist within the larger Central Section. The study area was divided into two parts: *Central 1 (C1a)* from Ashburn Road to Simcoe Street; and *Central 2* from Simcoe Street to Enfield Road. *Central 2* was further subdivided into *C2a* from Simcoe Street to Wilson Road; and *C2b* from Wilson Road to Enfield Road.

## 2.1 Hydrogeology Conditions Summary Tables

Hydrogeological Conditions Summary Tables (**Tables 1 to 3**) were created for each subsection of the Central Mainline [*Central 1 (C1a)* and *Central 2 (C2a and C2b)*]. 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 and deep cuts), 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 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 Central Mainline. 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 *Central 1 (C1a)* and *Central 2 (C2a and C2b)* using subsurface information collected from environmental borehole drilling by AECOM, geotechnical borehole drilling by Thurber, historic geotechnical boreholes, MOE water well records and surficial geological mapping (**Figures A4 to A5**). Cross-

Section locations are shown on **Figures A1 to A3**. In cases where the geology interpreted from borehole drilling differed from the surficial geology, 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° 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 Central Mainline Profile was provided by the engineering team and was added to each cross-section. The profile used was provided to AECOM in April 2009 and 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, preliminary geotechnical field investigations by Thurber Engineering Limited (Thurber), and preliminary bridge and highway profile designs provided by the engineering design teams at AECOM.

# 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) Numerous Oak Ridges Moraine studies and 3D sections prepared by the Geological Survey of Canada<sup>1</sup>;
- h) Existing information residing with MNR, Conservation Authorities (CA) and local field naturalists; and
- i) Durham local well data and Well Head Protection Zone studies.

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).



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 A3** 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 the 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.

#### 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 six (6) boreholes at three (3) locations were installed along the Central Mainline (**Figures 1 and A1 to A3**). The borehole logs are presented in **Appendix B**. Each hydrogeology borehole was completed as a groundwater monitor nest consisting of a shallow and a deep monitor. These nests were 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 A3** and include: G1C-1, G1C-2, G2C-1, G2C-2, G3C-1 and G3C-2. 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., G1C-1, G1C-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.

All Terrain Drilling Limited (All Terrain) of Waterloo, Ontario was sub-contracted to drill boreholes and install groundwater monitors. 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. These samples were laboratory tested<sup>2</sup> 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.

Groundwater monitors were installed in a nest of separate boreholes, to prevent inadvertent leakage down the borehole. Monitoring well nests were installed at each location to determine the direction of the 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 or available sand lens, and the shallow well was completed at approximately 20 ft (6.1 m) bgs and screened in till or surficial sand. Each groundwater monitor was instrumented with a 2-inch (51 mm) diameter riser pipe and a No. 10 slot screen. 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. 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), 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. 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.

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

Geotechnical field investigations conducted by Thurber included borehole drilling for individual sites. The geotechnical borehole logs were provided by Thurber and are presented in **Appendix G**. The location of all boreholes is presented on **Figures A1 to A3**.

#### 4.3.1 Hydraulic Testing

Single well hydraulic response tests (slug tests) were completed at each groundwater monitor between April and June, 2008. 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 1.0 m (3.1 ft) of water column by a 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 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. 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 A3** and on **Figure 1** and include: MP15, MP16, MP17, MP18, MP19s/d and MP20s/d. 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-piezometers 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 A3** and **Figure 1** and include: SR17a/b, SR18a/b, SR19a/b, SR20a/b, SR21, SR22a/b, SR23a/b, SR24a/b, SR25a/b and SR26a/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. 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. Water levels in G2C-1 are flowing artesian (i.e., the static water level is above the top of the casing). Down-hole J-plugs are installed in this location 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 this well, 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 later 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. 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**.

Continuous stream temperature and air temperature measurements were collected at MP15, MP16, MP17, and MP18 (**Appendix D**). Because groundwater maintains an approximate year round temperature of 100<sup>o</sup>C where as air temperature varies widely, analysis of the difference between water and air temperature can help determine if groundwater discharge is occurring in a particular stream or reach of stream.

### 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 for 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 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 A3**.

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 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 20 residences (not including duplicates, blanks, or multiple samples at a single residence that had multiple wells) within the Central 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 (*Thornccliffe 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.

The following **Table A** summarized 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 50 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 (m/s)	Relative to Newmarket Till* Times greater
		Low	High		
Lake Iroquois Shoreline Deposits	G2E-2, G11E-2	2.0E-05	3.2E-05	2.4E-05	73
Surficial Glaciolacustrine	G2C-2, G1W-2, G3W-2, G4W-2, G3E-2, G10E-2	1.1E-06	5.2E-05	5.6E-06	17
Silt and Fine Sand and Sand and Gravel					
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, 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. Central Mainline – Geological and Hydrogeological Conditions

6.1 Physiography, Geology, Hydrogeology

The Central Mainline area is located within the South Slope Physiographic Region, and is adjacent to the Oak Ridges Moraine briefly near Grandview Road. 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 (**Figures A1 to A4**) particularly west of Baldwin Street. To the east of here the Newmarket till is capped with the

clayey silt Halton Till (**Figures A1, A2 and A4**) 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 be found on occasion at the contact between the Halton and Newmarket till units. Examination of the cross-section in **Figure A4** shows one such deposit near Thornton Road. Upland areas are comprised of glaciolacustrine-derived, silty to clayey Halton Till and where present, overlies the Newmarket Till (**Figure A5**). Deposits of fine and coarse textured glaciolacustrine materials are also present at surface, most notably near Lynde Creek west of Baldwin Street, West Oshawa Creek between Garrard and Thornton roads, Oshawa Creek at Ritson Road, Harmony Creek west of Langmaid Road, and Harmony Creek at Enfield Road. The ORM regulatory boundary extends to within <100 m of the Transportation Corridor as it crosses Grandview Road (~21+500) (**Figure 1**). Deposits of Glacial Lake Iroquois Shoreline sands and gravels are present south of the Transportation Corridor but do not encroach upon the ROW for this section.

Water table contours in the Central Mainline area subtly reflect the topographic contours in the analysis 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 underlying, 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 12.9 km of this 14.5 km section of ROW (or about 89%). Regionally, streams that originate from the ORM in this section, 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.

## 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, Figure 1**). The geology was further refined using the results of the hydrogeological and geotechnical borehole drilling, and by site specific field investigations where necessary. The extent of the glaciolacustrine sand at Oshawa Creek near Ritson Road was confirmed. Significantly, the Halton Till was found in the geotechnical borings to be more extensive, west of Thornton Road and east of Harmony Road to about 22+500, than anticipated by the provincial geologic mapping<sup>3</sup>. Valley deposits were roughly the same as the OGS mapping. Most significantly, the presence of a fine grained cap of silty fine sand to clay (exhibiting little surficial drainage, but a high water table) was identified between Ashburn Road and Baldwin Street at the west end of the section (shown in light blue on **Figure A1**). There was also a different distribution of glaciolacustrine sand at Harmony Creek and Langmaid Road, plus the presence of significant alluvial deposits in the creek valley.

Boreholes was drilled at three locations and were all completed as groundwater monitor nests consisting of two vertically separated monitors (G1C-1, G1C-2, G2C-1, G2C-2, G3C-1, and G3C-2).

The location of G1C-1 was selected to obtain geological and hydrogeologic information from an area of thick till sequences where the OGS Base Mapping showed Halton Till overlying Newmarket Till. As discussed above, borehole

G1C-1 encountered 12.8 m of silty sand to sandy silt Newmarket Till (**Appendix B**). Groundwater monitor G1C-1 was screened between 11.28 and 12.80 mbgs in the unweathered Newmarket Till (**Table C1**), exhibited a geometric mean hydraulic conductivity of  $4.4 \times 10^{-7}$  m/s (**Table C2**). The shallow groundwater monitor G1C-2 was screened between 1.45 and 6.02 mbgs in the weathered Newmarket Till (**Table C1**). The geometric mean hydraulic conductivity for G1C-2 is higher as should be anticipated, at  $2.3 \times 10^{-6}$  m/s (**Table C2**). These values are consistent with the weathered and unweathered till soils found across the full study area (**Table A**).

The groundwater levels in G1C-1 range from 0.51 mbgs (March 2008) to 1.95 mbgs (July 2008) and groundwater levels in G1C-2 range from 0.19 mbgs (March 2008) to 1.85 mbgs (July 2008) (**Table C6**). These groundwater levels indicate that the shallow water table is at or near surface because of the poorly drained low permeability host soils. 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**). A small downwards hydraulic gradient exists between the shallow and deep till indicating a groundwater recharge area. However, since water levels are very similar, lateral flow may be significant at this location.

The location of G2C-1 was selected to obtain geological and hydrogeologic information from an area of coarse-textured glaciolacustrine sands that overlie low permeability deposits near Oshawa Creek. Borehole G2C-1 encountered 7.6 m of glaciolacustrine sand, underlain by 1.8 m of sand and gravel (**Appendix B**). Below this, the silty sand Newmarket Till was encountered between 9.4 and 13.8 mbgs. A grey, fine sand lens is present between 12.2 and 12.9 mbgs and is confined within the Newmarket Till. Clayey silt till was found below the silty sand till to a depth of 15.2 mbgs. Groundwater monitor G2C-1 was screened between 12.19 and 13.72 mbgs in Newmarket Till and across the sand layer (**Table C1**), and exhibits a geometric mean hydraulic conductivity of  $5.0 \times 10^{-6}$  m/s (**Table C2**). The shallow groundwater monitor G2C-2 at this location was screened between 1.52 and 6.10 mbgs in glaciolacustrine sand (**Table C1**) with a geometric mean hydraulic conductivity of  $1.3 \times 10^{-5}$  m/s (**Table C2**).

The groundwater level in G2C-1 is flowing artesian and ranges from 0.95 m above ground surface in June 2008 to 0.87 m above ground surface in July 2008. Conversely, groundwater levels in the shallow monitor, G2C-2 range from 1.42 mbgs (December 2008) to 2.76 mbgs (June 2008) (**Table C6**). These groundwater levels indicate that while the shallow water table is at or near surface, the deeper monitor has a higher water pressure. A strong upwards gradient exists between the shallow and deep monitors, however the water pressure in G2C-1 reflects the sand lens rather than the underlying till unit (**Figure E2**). Only the shallow water levels respond to seasonal changes in precipitation and therefore, groundwater at G2C-2 is likely derived from local infiltration, while groundwater in G2C-1 is derived from an upgradient source.

The location of borehole G3C-1 was selected to investigate for the presence of ORM Aquifer materials at the contact between Halton Till and Newmarket Till. Borehole G3C-1 encountered a clayey silt till (the Halton Till) to a depth of 10.7 m (**Appendix B**), although the upper 3.1 m was not as clayey. No ORM deposits were found. The Halton Till is underlain by a silty sand till (the Newmarket Till) to the full borehole depth of 13.7 mbgs. Groundwater monitor G3C-1 was screened between 12.19 and 13.72 mbgs in Newmarket Till (**Table C1**), for which a geometric mean hydraulic conductivity of  $2.3 \times 10^{-6}$  m/s was determined (**Table C2**). Groundwater monitor G3C-2 was screened in the Halton Till between 4.57 and 9.14 (**Table C1**), which exhibited a geometric mean hydraulic conductivity of  $5.8 \times 10^{-9}$  m/s (**Table C2**). This lower value of hydraulic conductivity is consistent with the greater clay content of the Halton Till as shown in **Table A**.

3. In particular, the hydrogeological boring at G1C clearly showed Newmarket Till, yet the four geotechnical boreholes (CM6-1, CM6-2, CM6b-1, CN6b-2, CM9-1, C<9-2) clearly showed the clayey silt till characteristic of the Halton Till.

The groundwater level in G3C-1 ranges from 3.13 mbgs (October 2008) to 7.31 mbgs (January 2008)<sup>4</sup> and the groundwater level in G3C-2 ranges from 1.62 mbgs (December 2008) to 4.84 mbgs (January 2008) (**Table C6**). These groundwater levels indicate that the shallow water table is at or near surface which is consistent with a dense glacial till soil. A strong downwards hydraulic gradient exists between the shallow and deep till indicating a groundwater recharge area (**Figure E3**). Both the shallow and the deep water levels respond to seasonal changes in precipitation and therefore, water is likely derived from local infiltration.

### 6.2.2 Mini-Piezometers

Six mini-piezometers (MP15, MP16, MP17, MP18, MP19s/d and MP20s/d) were installed in this section (**Table C4**).

Although measurements at MP15 and MP16 were continuously disrupted by having the mini-piezometers either lost, stolen or inaccessible, both provide clear evidence of upward gradients and hence groundwater discharge into Lynde Creek and West Oshawa Creek. Indicators of groundwater discharge from thermal buffering for stream temperature measurements at MP15 (**Figure D1**) are inconclusive due to a lack of recorded data. Stream temperature measurements at MP16 (**Figure D2**) clearly show a thermal buffering regime consistent with groundwater discharge.

Water level measurements at MP17 indicated downwards hydraulic gradients between November 2007 and May 2008 at this station in Oshawa creek at Ritson Road some 300 m north of the alignment. However, upwards hydraulic gradients were measured in June and July 2008, more consistent with the groundwater springs and water cress were observed there. Stream temperature measurements clearly show significant buffering by cold groundwater (**Figure D3**).

MP18 (**Figure A3**) was originally installed on the east side of Harmony Road in East Oshawa Creek, and between November 2007 and July 2008 showed downwards hydraulic gradients. MP18 was reinstalled on the in East Oshawa Creek on the west side of Harmony Road in September 2008 and showed upwards hydraulic gradients on all subsequent measurements. Stream temperature measurements and observations at SR24b (at MP18) suggest that downwards hydraulic gradients exist at this location as the stream was frozen in the winter, showing no thermal buffering (**Figure D4**).

MP19s/d was installed in a small wetland area near Townline Road (**Figure A3**). The deep mini-piezometer MP19d showed downwards hydraulic gradients at each monitoring event. Beginning in May 2008, the shallow monitor (MP19s) showed upwards hydraulic gradients indicating groundwater discharge. Overall, there is a downwards hydraulic gradient between the shallow and deep mini-piezometers, suggesting that this area is predominantly surface water fed. Because MP19s showed an upwards gradient, it is suspected that some minor shallow groundwater discharge is occurring in the wetland, possibly through the weathered till. Overall groundwater recharge dominates, which is consistent to the results found at nearby monitor location G3C.

MP20s/d was installed in Farewell Creek just east of Enfield Road (**Figure A3**). Visual observations from 2008 indicate that this area is prone to flooding, which suggests that fine grained materials are present at surface. Water level measurements at MP20s and MP20d generally showed downwards hydraulic gradients indicating downwards hydraulic gradients. A strong downwards hydraulic gradient exists between the shallow and deep mini-piezometers which further suggest that groundwater discharge is not occurring over this portion of Farewell Creek.

4. This excludes the measurement taken right after installation, as that simply reflects the ground water monitor recovering from the drilling process, as water levels equilibrate in the monitor with those in the formation.

### 6.2.3 Stream Reconnaissance

Ten stream reconnaissance stations (SR17a/b, SR18a/b, SR19a/b, SR20a/b, SR21, SR22a/b, SR23a/b, SR24a/b, SR25s/b and SR26a/b) were established in this section (**Table C5, Figures A1 to A2**).

SR18a/b along St Thomas Street in Brooklin and SR21 west of Simcoe Street, did not flow continuously over the duration of the study and suggest that these water courses are intermittent or potentially ephemeral. Manual stream temperature measurements confirm this observation in that water temperatures (when present) closely followed air temperatures. SR17a/b, SR19a/b, and SR20a/b flowed continuously over the duration of the study. At SR17a/b and SR20a/b manual and continual temperature measurements confirm groundwater inputs to these water courses. SR19a/b would likely be an intermittent water course if it was not continuously sustained by the outlet of a stormwater management pond from the town of Brooklin. Manual stream temperature measurements confirm that water temperatures for the SR19 stations are dominated by surface water inputs. SR22a/b, SR25a/b and SR26b did not flow continuously over the duration of the study and suggest that these water courses are intermittent. Manual stream temperature measurements confirm this observation. SR23a/b (Oshawa Creek), SR24a/b (Oshawa Creek, east tributary) and SR26a (Harmony Creek) flowed continuously over the duration of the study and manual temperature measurements confirm groundwater inputs to these water courses.

### 6.2.4 Water Wells

The results from the water well survey in the Central Mainline area show that 207 private water wells are present within the 407 East water well survey study area. Of these 207 wells, 29% (59 wells) are shallow dug wells, 21% (44 wells) are deep drilled wells, 1 well is a community well, and 50% (103 wells) have unknown construction details. Water quality samples were collected from 20 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 and Figures A1 to A3**). Concentrations of one or more of the following parameters were found to exceed Ontario Drinking Water Standards (ODWS) in all 20 of the wells: sodium, iron, nitrate, hardness, *E. coli*, total coliform, and Heterotrophic Plate Count (HPC). High concentrations of parameters such as iron 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 improperly functioning septic beds (nitrate, sodium, bacteria). Exceedances of bacteriological parameters were found in 13 of the 20 wells, with 8 wells exceeding for *E. coli*. ODWS was exceeded for sodium in 9 of the 20 wells. Elevated chloride was found in 9 wells, and ODWS was exceeded for chloride in 3 wells. Well 6371 also exceeded for nitrate. Wells 2103 and 6350 also exceeded for lead. The presence of lead is most likely derived from lead pipes or lead soldering in the household and is unlikely derived from local groundwater. Samples collected from both shallow and deep wells showed impacts from surficial activities. This is uncommon for deep wells that are typically protected below thick till units, but improperly functioning seals around the wells may be one explanation. These impacts are generally identified by elevated levels of both sodium and chloride. Nine of the 20 wells (45%) showed elevated levels of sodium, chloride, or both in baseline sampling, suggesting pre-existing impacts.

One community well, that is no longer in use, was identified north of Conlin Road West on the west side of Thornton Road North at 666 Bickle Road but was slightly outside of the water well survey study area. This well does not have a well head protection area or a capture zone according to the Region of Durham Wellhead Protection Areas mapping. Although it is downgradient of the 407 East Transportation Corridor, it does not draw water towards it as it is not in use, and will not be impacted.

## 7. Acknowledgements

AECOM would like to thank Thurber Engineering Limited for their contribution to the hydrogeological investigations. The geotechnical borehole logs provided by Thurber 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.

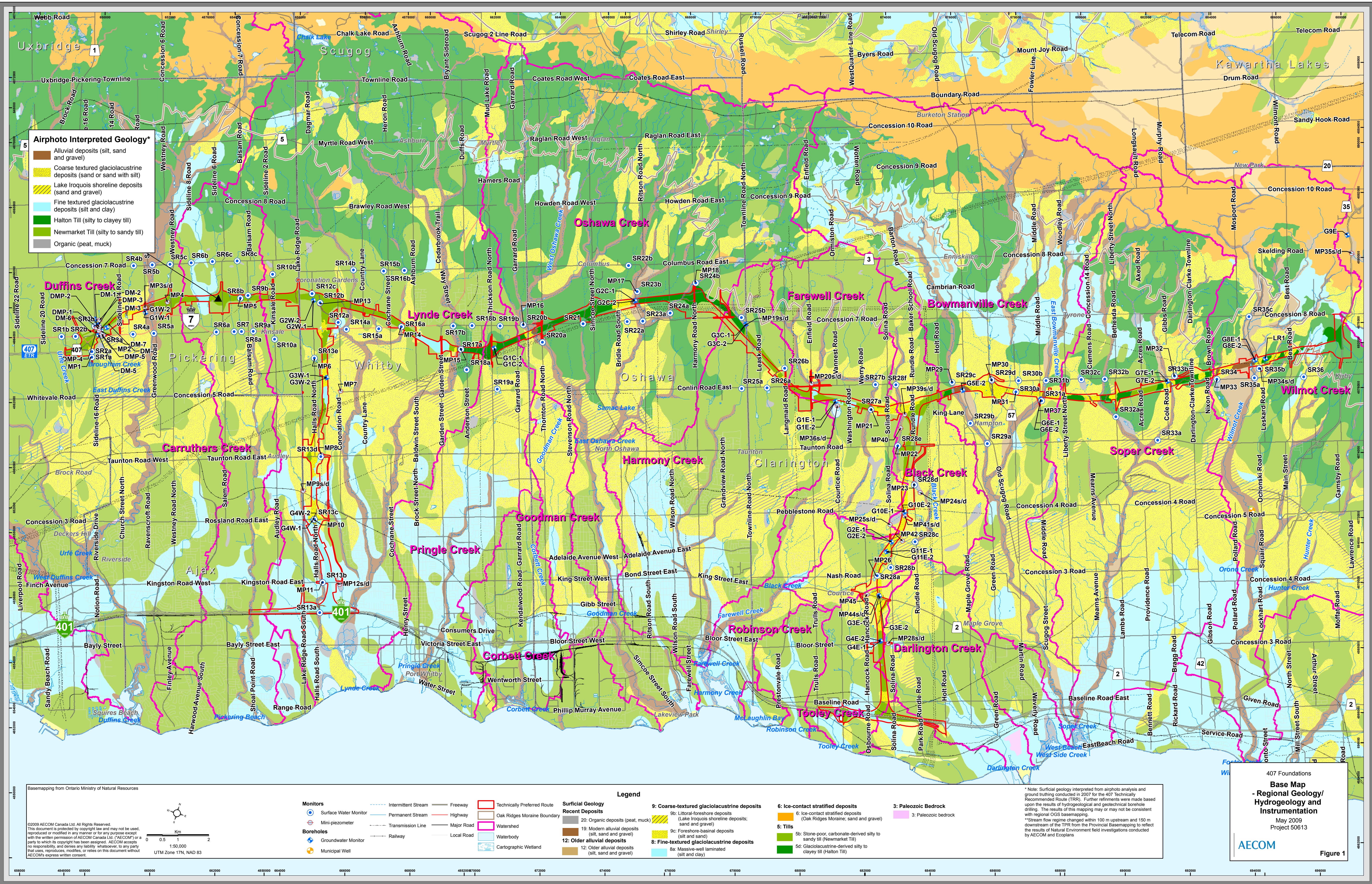


# Figures – Part A

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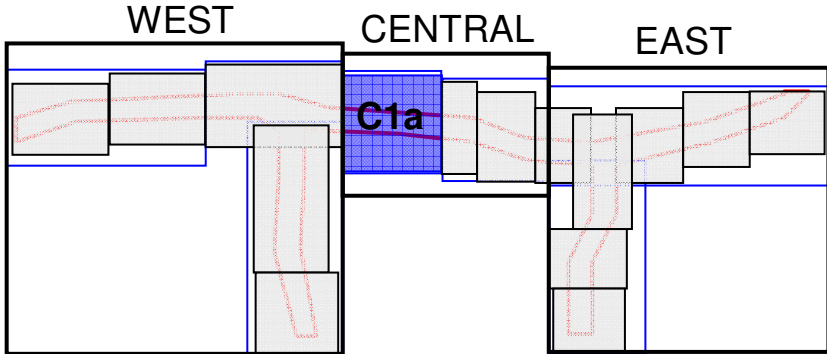


# Tables – Part A

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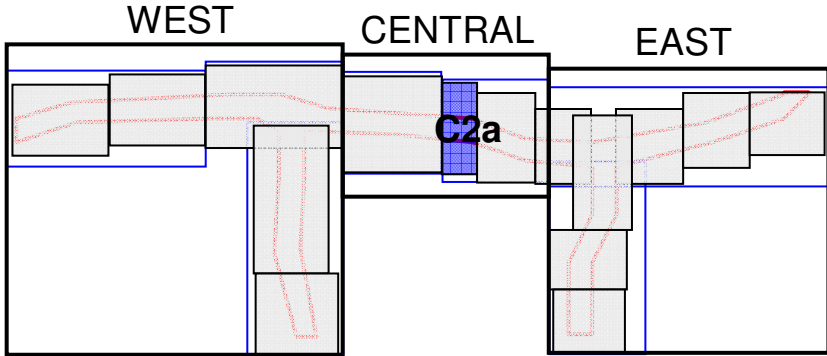
**407 East Extension – Central Section**  
**Summary Table 1 – Hydrogeological Conditions Summary (C1a)**

<b>Key Map</b> 		<b>TYPICAL STRATIGRAPHIC/ HYDROSTRATIGRAPHIC UNITS: Central 1 (C1a) Section</b>	
<b>Map:</b> Central 1 – C1a <b>Section Boundaries:</b> Ashburn Road to Simcoe Street <b>Figure(s):</b> Figure A1 <b>Cross-section(s):</b> Central 1 (Figure A4) <b>Assumed Proposed Structures:</b> Central Mainline CM-1,CM-2,CM-3,CM-4, CM-5,CM-6,CM-7,CM-8,CM-9,CM-10,CM 10b,CM-11,CM-12,CM-12b,CM-13,CM-13b,CM-14		<i>Few surficial sand deposits are present in this section (yellow and brown on Figure A1)</i>	<b>Exceptions:</b> <ul style="list-style-type: none"><li>▶ Glaciolacustrine clayey silt found at surface between 11+000 to 12+300<ul style="list-style-type: none"><li>○ Approximately 1.5 m in thickness and underlain by Newmarket Till</li><li>○ Grading to sandy silt at the contact with Newmarket Till</li><li>○ Hydraulic Conductivity (K) – <math>4.4 \times 10^{-08}</math> m/s (Table A)</li></ul></li><li>▶ Glaciolacustrine sand found at surface west of West Oshawa Creek and west of Lynde Creek</li><li>▶ Thin deposits of modern alluvial sediments are present in modern river valleys<ul style="list-style-type: none"><li>○ Hydraulic Conductivity (K) – <math>1 \times 10^{-04}</math> m/s (estimated from Freeze and Cherry, 1979)</li></ul></li></ul>
		0 – 20 m	<b>Unit 1: Halton Till</b> (aquitard) – dark green on figure A1 <ul style="list-style-type: none"><li>▶ Clayey silt till, compact to very dense</li><li>▶ Ranges in thickness from 0 to 20 m</li><li>▶ Water table is often close to surface (&lt;1 mBGS) because unit is poorly drained</li><li>▶ ORM sand and gravel deposits are occasionally encountered at the base of the Halton Till.</li><li>▶ Hydraulic Conductivity (K) – <math>5.8 \times 10^{-09}</math> m/s (Table A)</li><li>▶ Infiltration is poor and run-off exceeds infiltration</li><li>▶ The groundwater flow direction is downwards towards deep aquifer units</li><li>▶ Downwards hydraulic gradient exists between Halton Till and underlying Newmarket Till</li><li>▶ Contains discontinuous sand lenses that are utilized as individual potable water sources</li><li>▶ Hydraulic Conductivity (K) of sand lenses – <math>8.4 \times 10^{-06}</math> m/s (Table A)</li></ul>
<b>Assumed Deep Cuts:</b> DC-C1 (11+200 to 11+980) – 8.5 m cut depth (drawdown curve – Figure F1) DC-C2 (13+250 to 13+430) – 8 m cut depth (drawdown curve – Figure F2) DC-C3 (14+490 to 14+660) – 5.5 m cut depth (drawdown curve – Figure F3) <b>Assumed High Fills:</b> HF-C1 (12+680 to 12+750) – 7 m fill height HF-C2 (15+180 to 15+300) – 15.5 m fill height HF-C3 (15+500 to 16+000) – 7 m fill height HF-C4 (16+750 to 17+000) – 5.5 m fill height		0 – 50 m	<b>Unit 2: Newmarket Till</b> (aquitard) – light green on figure A1 <ul style="list-style-type: none"><li>▶ Silty sand to sandy silt till, with gravel and occasional boulders, very dense</li><li>▶ Ranges in thickness from 10 to 50 m</li><li>▶ Unit is exposed at ground surface in places</li><li>▶ Contains discontinuous sand lenses that are utilized as individual potable water sources</li><li>▶ Water table is often close to surface (&lt;1 mBGS) because unit is poorly drained</li><li>▶ Hydraulic Conductivity (K) – <math>3.2 \times 10^{-07}</math> m/s (Table A)</li><li>▶ Infiltration is poor and run-off exceeds infiltration</li><li>▶ The groundwater flow direction is downwards towards deep aquifer units</li><li>▶ Downwards hydraulic gradient exists between shallow and deep till deposits</li><li>▶ Contains discontinuous sand lenses that are utilized as individual potable water sources</li><li>▶ Hydraulic Conductivity (K) of sand lenses – <math>8.4 \times 10^{-06}</math> m/s (Table A)</li></ul>
<b>Hydrogeology Site Ranking Table:</b> Table 4 (Section C1a)		<b>GROUNDWATER FLOW:</b>	
<b>FIELD DATA SOURCES:</b>		<b>Distribution &amp; Significance of Recharge/Discharge Areas:</b> <ul style="list-style-type: none"><li>▶ 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 and West Oshawa Creek. Lateral flow in minor and regional groundwater flow is primarily downwards through the till.</li><li>▶ Low amounts of groundwater recharge occur in upland till plains and surficial sand deposits, 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.</li><li>▶ Where present, surficial sand acts as a local recharge area and may have a high water table (&lt;1 mBGS) perched on dense till below.</li></ul>	
<b>Boreholes:</b> P13,P14,P15,P21,P22, CM3-1,CM3-2,CM3b-1,CM3b-2,CM6-1,CM6-2,CM6b-1, CM6b-2,CM9-1,CM9-2,CM9b-1,CM9b-2,CM10-1,CM10-2,CM10b-1,CM10b-2,CM11-1,CM11-2, WM43-1, WM43-2 <b>Monitoring Wells:</b> G1C-1, G1C-2 <b>Mini-Piezometers:</b> MP15,MP16		<b>Groundwater Use:</b> <ul style="list-style-type: none"><li>▶ Private wells obtain potable water from thin, discontinuous sand lenses/ seams within till units</li><li>▶ 20 dug wells (~5 to ~12 m deep), 18 drilled wells (~10 to ~55 m deep), 1 community well, no commercial/ industrial wells, 35 other wells (unknown construction details)</li></ul>	
<b>Stream Reconnaissance Sites:</b> SR17a,b, SR18a,b, SR19a,b, SR20a,b, SR21			
<b>Residential Water Wells:</b> 74 private water wells. 27% dug, 24% drilled, 52% unknown, 1% community (drilled). Between 7 and 10 wells within the TPR boundary (may require decommissioning)			
<b>PHYSIOGRAPHIC SETTING:</b> <ul style="list-style-type: none"><li>▶ 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., West Oshawa Creek) and deposited coarse-textured glaciofluvial sediments along their path. Modern alluvial silts, sands and gravels can be found in these valleys.</li></ul>			
<b>Notes:</b> mBGS – metres below ground surface GWT – groundwater table ORM – Oak Ridges Moraine PTTW – Permit To Take Water			



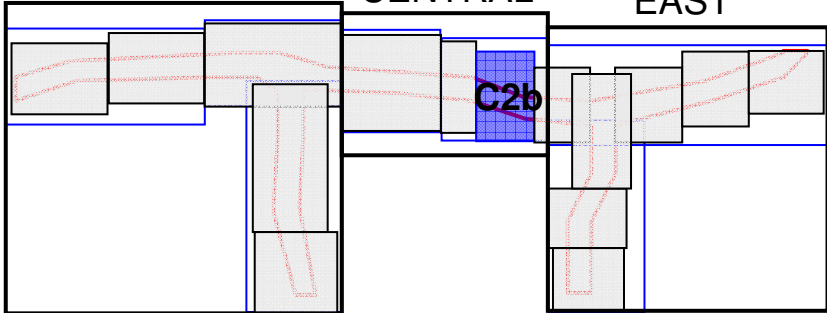


**407 East Extension – Central Section**  
**Summary Table 2 – Hydrogeological Conditions Summary (C2a)**

<div>Key Map</div> <div></div>	TYPICAL STRATIGRAPHIC/ HYDROSTRATIGRAPHIC UNITS: Central 2 (C2a) Section	
	0 - 3 m	<b>Unit 1: Modern Alluvial Deposits</b> (surficial aquifer) – brown colour on figure A2 <ul style="list-style-type: none"><li>▶ Silt, Sand and Gravel</li><li>▶ Modern alluvial deposits are derived from modern, post-glacial rivers (e.g., Oshawa Creek)</li></ul>
	0 - 10 m	<b>Unit 2: Glaciolacustrine Deposits</b> (surficial aquifer) – yellow colour on figure A2 <ul style="list-style-type: none"><li>▶ Fine to coarse sand and silty sand or sandy silt, moderately rounded, well sorted</li><li>▶ Utilized for potable water from shallow, dug wells.</li><li>▶ Water table is often close to surface because till unit below restricts drainage to depth</li><li>▶ Hydraulic Conductivity (K) – <math>5.6 \times 10^{-06}</math> m/s (Table A)</li><li>▶ Infiltration is rapid but drainage to depth is poor due to till soils below</li><li>▶ The groundwater flow direction is lateral towards discharge areas alongside valleys</li><li>▶ Assumed downwards hydraulic gradient exists between coarse-textured glaciolacustrine deposits and underlying till deposits</li></ul>
	0 – 20 m	<b>Unit 3: Halton Till</b> (aquitard) – dark green colour on figure A2 <ul style="list-style-type: none"><li>▶ Clayey silt till, compact to very dense</li><li>▶ Ranges in thickness from 0 to 20 m</li><li>▶ Water table is often close to surface (&lt;1 mBGS) because unit is poorly drained</li><li>▶ ORM sand and gravel deposits are occasionally encountered at the base of the Halton Till</li><li>▶ Hydraulic Conductivity (K) – <math>5.8 \times 10^{-09}</math> m/s (Table A)</li><li>▶ Infiltration is poor and run-off exceeds infiltration</li><li>▶ The groundwater flow direction is downwards towards deep aquifer units</li><li>▶ Downwards hydraulic gradient exists between Halton Till and underlying Newmarket Till</li><li>▶ Contains discontinuous sand lenses that are utilized as individual potable water sources</li><li>▶ Hydraulic Conductivity (K) of sand lenses – <math>8.4 \times 10^{-06}</math> m/s (Table A)</li></ul>
	0 – 50 m	<b>Unit 4: Newmarket Till</b> (aquitard) – light green colour on figure A2 <ul style="list-style-type: none"><li>▶ Silty sand to sandy silt till, with gravel and occasional boulders, very dense</li><li>▶ Ranges in thickness from 10 to 50 m</li><li>▶ Unit is exposed at ground surface in places</li><li>▶ Water table is often close to surface (&lt;1 mBGS) because unit is poorly drained</li><li>▶ Hydraulic Conductivity (K) – <math>3.2 \times 10^{-07}</math> m/s (Table A)</li><li>▶ Infiltration is poor and run-off exceeds infiltration</li><li>▶ The groundwater flow direction is downwards towards deep aquifer units</li><li>▶ Downwards hydraulic gradient exists between shallow and deep till deposits</li><li>▶ Contains discontinuous sand lenses that are utilized as individual potable water sources</li><li>▶ Confined aquifers may be flowing artesian (e.g., G2C-1)</li><li>▶ Hydraulic Conductivity (K) of sand lenses – <math>8.4 \times 10^{-06}</math> m/s (Table A)</li></ul>
<b>Map:</b> Central 2 – C2a	<b>GROUNDWATER FLOW:</b>	
<b>Section Boundaries:</b> Simcoe Street to Wilson Road		
<b>Figure(s):</b> Figure A2		
<b>Cross-section(s):</b> Central 2 (Figure A5)		
<b>Assumed Proposed Structures:</b> Central Mainline CM-15, CM-15B, CM-15C, CM-16, CM-16B, CM-17, CM-17B, CM-18, CM-19, CM-19B		
<b>Assumed Deep Cuts:</b> None	<b>Distribution &amp; Significance of Recharge/Discharge Areas:</b> <ul style="list-style-type: none"><li>▶ Shallow groundwater flow directions typically mimic the surface topography. That is, shallow lateral groundwater flow is from high ground towards discharge areas in the perennial river valley of Oshawa Creek. Local groundwater flow within the unconfined aquifer sandy deposits is horizontal towards Oshawa Creek. Regional groundwater flow is primarily downwards through the till. Lateral groundwater flow is minor</li><li>▶ Groundwater recharge occurs locally within areas of the surficial sand aquifer. Minor groundwater recharge also occurs on upland till deposits, although run-off exceeds recharge in these areas. Groundwater discharge is predominant where incised river valleys intercept the water table, creating perennial streams</li></ul>	
<b>Assumed High Fills:</b> HF-C5 (18+380 to 18+500) – 9 m fill height		
<b>Hydrogeology Site Ranking Table:</b> Table 5 (Section C2a)		
<b>FIELD DATA SOURCES:</b>		
<b>Boreholes:</b> P22, P23, CM17-1, CM17-1a, CM17-2, CM17-3, CM17-3a, CM17b-1, CM17b-2, CM17b-3		
<b>Monitoring Wells:</b> G2C-1, G2C-2	<b>Groundwater Use:</b> <ul style="list-style-type: none"><li>▶ Majority of private wells obtain potable water from surficial alluvial or glaciolacustrine aquifer units</li><li>▶ Some private wells obtain potable water from thin, discontinuous sand lenses/ seams within till units</li><li>▶ 14 dug wells (~5 to ~12 m deep), 4 drilled wells (~10 to ~55 m deep), no commercial/ industrial wells, 19 other wells (unknown construction details)</li></ul>	
<b>Mini-Piezometers:</b> MP17		
<b>Stream Reconnaissance Sites:</b> SR22a,b, SR23a,b		
<b>Residential Water Wells:</b> 37 private water wells. 38% dug, 11% drilled, 51% unknown. Approximately 11 wells within the TPR boundary (may require decommissioning)		
<b>PHYSIOGRAPHIC SETTING:</b> <ul style="list-style-type: none"><li>▶ 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., Oshawa Creek) and deposited coarse-textured glaciofluvial sediments along their path. Modern alluvial silts, sands and gravels can be found in these valleys.</li></ul>		
<b>Notes:</b> mBGS – metres below ground surface GWT – groundwater table ORM – Oak Ridges Moraine PTTW – Permit To Take Water		



**407 East Extension – Central Section**  
**Summary Table 3 – Hydrogeological Conditions Summary (C2b)**

<div>Key Map</div> <div><div>WESTCENTRALEAST</div><div></div></div>		<div>TYPICAL STRATIGRAPHIC/ HYDROSTRATIGRAPHIC UNITS:</div> <div>Central 2 (C2b) Section</div>	
<div>Map: Central 2 – C2b)</div> <div>Section Boundaries: Wilson Road to Enfield Road</div> <div>Figure(s): Figure A3</div> <div>Cross-section(s): Central 2 (Figure A5)</div> <div>Assumed Proposed Structures: Central Mainline CM-20, CM-20B, CM-20C, CM-21, CM-21B, CM-22, CM-22B, CM-23, CM-24, CM-26, CM-26B, CM-27, CM-27B, CM-28, CM-28B, CM-29, CM-29B</div> <div>Assumed Deep Cuts: DC-C4 (20+850 to 21+100) – 5.5 m cut depth (drawdown curve – Figure F4) DC-C5 (21+460 to 22+060) – 9 m cut depth (drawdown curve – Figure F5) DC-C6 (23+400 to 23+670) – 5.5 m cut depth (drawdown curve – Figure F6) DC-C7 (24+350 to 25+080) – 7 m cut depth (drawdown curve – Figure F7)</div> <div>Assumed High Fills: HF-C6 (20+200 to 20+630) – 14 m fill height HF-C7 (24+030 to 24+220) – 8.5 m fill height HF-C8 (25+260 to 25+440) – 7 m fill height</div>		<div>Few surficial sand deposits are present in this section (yellow and brown on Figure 5)</div> <div>0 – 20 m</div>	<div>Exceptions:</div> <div>▶ Thin deposits of modern alluvial sediments are present in modern river valleys of Oshawa Creek and Harmony Creek tributaries</div> <div>▶ Hydraulic Conductivity (K) of alluvial deposits – 1x10<sup>-04</sup> m/s (estimated from Freeze and Cherry, 1979)</div> <div>▶ A small deposit of glaciolacustrine sand is found at surface north of Concession 6 Road and Enfield Road</div> <div>▶ Hydraulic Conductivity (K) – 5.6x10<sup>-06</sup> m/s (Table A)</div> <div>Unit 1: Halton Till (aquitard) – dark green on figure A3</div> <div>▶ Clayey silt till, compact to very dense</div> <div>▶ Ranges in thickness from 0 to 20 m</div> <div>▶ Water table is often close to surface (&lt;1 mBGS) because unit is poorly drained</div> <div>▶ ORM sand and gravel deposits are occasionally encountered at the base of the Halton Till</div> <div>▶ Hydraulic Conductivity (K) – 5.8x10<sup>-09</sup> m/s (Table A)</div> <div>▶ Infiltration is poor and run-off exceeds infiltration</div> <div>▶ The groundwater flow direction is downwards towards deep aquifer units</div> <div>▶ Downwards hydraulic gradient exists between Halton Till and underlying Newmarket Till</div> <div>▶ Contains discontinuous sand lenses that are utilized as individual potable water sources</div> <div>▶ Hydraulic Conductivity (K) of sand lenses – 8.4x10<sup>-06</sup> m/s (Table A)</div>
		<div>2 - 5 m</div>	<div>Unit 2: Interstadial Sand and Gravel Deposits (aquifer) – yellow or brown at the base of dark green (see cross section – figure A5)</div> <div>▶ Silty sand, compact, waterbearing</div> <div>▶ Possibly “finger-like” protrusions of ORM oriented southwards</div> <div>▶ Encountered near Harmony Road and Grandview Road</div> <div>▶ Where present, used as a source of potable water for local residences</div>
<div>Hydrogeology Site Ranking Table: Table 6 (Section C2b)</div> <div>FIELD DATA SOURCES:</div> <div>Boreholes: P25, P26, P27, CM20b-2, CM20b-3, CM21-1, CM21-2, CM21b-1, CM21b-3, CM23b-2, CM24-1, CM24-2, CM24-3, CM24-4</div> <div>Monitoring Wells: G3C-1, G3C-2</div> <div>Mini-Piezometers: MP18, MP19s/d, MP20s/d</div> <div>Stream Reconnaissance Sites: SR24a,b, SR25a,b, SR26a,b,</div> <div>Residential Water Wells: 96 private water wells. 26% dug, 23% drilled, 51% unknown. Approximately 12 wells within the TPR boundary (will require decommissioning)</div> <div>PHYSIOGRAPHIC SETTING:</div> <div>▶ 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.</div> <div>Notes:</div> <div>mBGS – metres below ground surface</div> <div>GWT – groundwater table</div> <div>ORM – Oak Ridges Moraine</div> <div>PTTW – Permit To Take Water</div>		<div>0 – &gt;30 m</div>	<div>Unit 3: Newmarket Till (aquitard) – light green on figure A3</div> <div>▶ Silty sand to sandy silt till, with gravel and occasional boulders, very dense</div> <div>▶ Ranges in thickness from 10 to &gt;30 m</div> <div>▶ Unit is exposed at ground surface in places</div> <div>▶ Water table is often close to surface (&lt;1 mBGS) because unit is poorly drained</div> <div>▶ Hydraulic Conductivity (K) – 3.2x10<sup>-07</sup> m/s (Table A)</div> <div>▶ Infiltration is poor and run-off exceeds infiltration</div> <div>▶ The groundwater flow direction is downwards towards deep aquifer units</div> <div>▶ Downwards hydraulic gradient exists between shallow and deep till deposits</div> <div>▶ Contains discontinuous sand lenses that are utilized as individual potable water sources</div> <div>▶ Hydraulic Conductivity (K) of sand lenses – 8.4x10<sup>-06</sup> m/s (Table A)</div> <div>GROUNDWATER FLOW:</div> <div>Distribution &amp; Significance of Recharge/Discharge Areas:</div> <div>▶ 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 Oshawa Creek and tributaries of Harmony Creek. Lateral groundwater flow is minor and regional groundwater flow is primarily downwards though the till</div> <div>▶ Low amounts 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</div> <div>▶ Where present, surficial sand acts as a local recharge area and may have a high water table (&lt;1 mBGS) perched on dense till below</div> <div>Groundwater Use:</div> <div>▶ Private wells near Harmony Road obtain potable water from sand deposits at the base of the Halton Till that may be ORM deposits</div> <div>▶ Other private wells obtain potable water from thin, discontinuous sand lenses/ seams within till units</div> <div>▶ 25 dug wells (~5 to ~12 m deep), 22 drilled wells (~8 to ~55 m deep), no commercial/ industrial wells, 49 other wells (unknown construction details)</div>



# Part B

## Hydrogeological Foundation Investigation and Design Report for Preliminary Design

### HIGHWAY 407 EAST EXTENSION – CENTRAL SECTION

Ministry of Transportation Ontario

Date:

June, 2009





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# 1. Introduction

Report B presents a discussion of the potential impacts and mitigation options for the Central Mainline of the Technically Preferred Route (TPR) of the 407 East Extension. AECOM was retained 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 along the Central Mainline covers approximately 15 km between Ashburn Road in the west and Enfield Road in the east (**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

As in Report A, the Central Mainline has been divided into sub-sections based upon differences in geology / hydrogeology that exist within the larger Central Section. The study area was divided into two parts: *Central 1 (C1a)* from Ashburn Road to Simcoe Street; and *Central 2* from Simcoe Street to Enfield Road. *Central 2* was further subdivided into *C2a* from Simcoe Street to Wilson Road; and *C2b* from Wilson Road to Enfield Road.

## 2.1 Numbering System

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

- CM- XX represents a structure along the Central Mainline.

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 discussion outlined in this report is based upon a comprehensive review of existing regional information and on investigative field activities as documented in Report A. The information and conclusions presented herein were derived from, but not limited too, hydrogeological field investigations by AECOM, geotechnical field investigations by Thurber Engineering Limited (Thurber), and preliminary bridge and highway profile designs provided by AECOM.

# 4. Hydrogeological Foundation Investigation

## 4.1 Hydrogeology Summary Tables

Hydrogeological Conditions Summary Tables were created for each subsection of the Central Mainline [*Central 1 (C1a)* and *Central 2 (C2a and C2b)*]. 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 3**.

## 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 Thurber. They provide a summary at each structure along the Central Mainline, 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 3 to 6**.

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 have hydraulic conductivities of  $<1.0 \times 10^{-07}$  m/s. The water table may be close to surface ( $<1.0$  mbgs) but dewatering may not be required for excavations, even below the water table due to the poor ability of the till unit 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 between  $1.0 \times 10^{-05}$  and  $1.0 \times 10^{-07}$  m/s. There is 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 ( $K = >1.0 \times 10^{-05}$  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 will require a PTTW. Groundwater discharge have been measured in the local water body which is classified as a permanent cold water stream that supports sensitive fish or fish habitat. Deep foundations are recommended to minimizing dewatering and impacts to cold water discharge. Span bridges are the preferable water course crossing, although depending upon the individual situation and bank width, an open bottom culvert may 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 streams 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<sup>5</sup> 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,  $\partial h$  = change in head (m)  
 $\partial t$  = change in time (s)  
K = hydraulic conductivity (m/s)  
D = Unconfined Unit Thickness (m)  
 $\mu$  = Porosity  
x = Distance (m)

This equation assumes that the change in water level ( $\Delta h$ ) is  $\ll D$ , 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.  $\partial t$  was assumed to be 1 year. K, D, and  $\mu$  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 F7** shows the estimated extent of water table drawdown at each deep highway cut location in the Central 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. Therefore, 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 – Central 1 (Ashburn Road to Simcoe Street)**

**5.1 Groundwater Flow**

Groundwater flow in this section is generally downwards, indicating groundwater recharge. Since most of the area (91%) is underlain by till units, runoff exceeds infiltration making groundwater recharge rates low. Groundwater level measurements from G1C-1 and G1C-2 indicate that groundwater flow between shallow and deep till is downwards and lateral (**Figure E1**). There is likely a significant component of lateral groundwater flow towards Lynde Creek and West Oshawa Creek.

The groundwater table is generally considered shallow and can be anticipated to be within ~2.0 m of ground surface throughout the section due to poor drainage through the till soils. Following major recharge events (i.e., spring melt) the groundwater table within the till can be found very nearly at ground surface (0.19 mbgs in G1C-2 in March 2008) (**Table C6**).

**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 these low rates. Stream Reconnaissance measurements at SR18a/b, SR19a/b and SR21 indicate that these water courses are “losing” streams, meaning that they recharge the water table. High rates of infiltration are expected during the drier months within the valleys of Lynde Creek and West Oshawa Creek where glaciolacustrine and alluvial soils are present at surface (**Figure A1**). The water that infiltrates here is anticipated to flow downward to the underlying till as well as laterally towards discharge areas in the associated creeks.

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.

### 5.1.2 Discharge

Groundwater discharge occurs at specific points within this section. Cold groundwater discharge will occur, based on the upward hydraulic gradients measured at MP15 and MP16 within Lynde Creek and West Oshawa Creek (**Figure A1**). No discrete groundwater springs or seeps were observed in this section. Stream reconnaissance measurements and observations confirm mini-piezometer results, as there is some thermal buffering by groundwater.

## 5.2 Significant Aquifer Units

No significant aquifer units were identified in this section. Private wells generally obtain potable water from thin, discontinuous sand lens aquifers found within the Newmarket and Halton tills. These units are confined, which provide a degree of protection from surface contamination (**Figure A4**). Thin deposits of glaciolacustrine sands and silts are found near Lynde Creek at ~12+500 and West Oshawa Creek at ~15+100 (**Figure A1**), but are not considered important local aquifer units.

An extension of the ORM Aquifer unit may be present below the Halton Till at ~14+500 and ~15+375 (**Figure A4**). The ORM deposits appear very small in extent at these locations and if they occur elsewhere, may be used as a supply of potable water for local residences. If these units are encountered in excavation, they will not drain in the short term like a sand lens, but will constantly flow because their water source is from a major regional recharge area located north of the Study Area.

## 6. Description of the Hydrogeological Regime – Central 2 (Simcoe Street to Enfield Road)

### 6.1 Groundwater Flow

Groundwater flow in this section is generally downwards, indicating groundwater recharge. Since most of the area (87%) is underlain by low permeability till units, runoff exceeds infiltration indicating low groundwater recharge rates. Groundwater level measurements from G3C-1 and G3C-2, on the Townline Road allowance, demonstrate downward hydraulic gradients, and therefore groundwater flow between the shallow and deep till is downwards (**Figure A3**). Groundwater flow at G2C-1 and G2C-2 in the Oshawa Creek valley (~17+900 to 18+650) is generally upwards, with discharge into Oshawa Creek (**Figure A2**). Flowing artesian conditions may be encountered at ~12.0 m deep due to the presence of confined aquifer units (**Figure A5**). There is likely a significant component of lateral groundwater flow in the glaciolacustrine aquifer unit eastward towards Oshawa 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) increases in the water table were observed (2.5 mbgs in February to 1.90 mbgs in May), which supports the fact that runoff exceeds infiltration.

### 6.1.1 Recharge

Similar to the Central 1 area, 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. Stream Reconnaissance measurements at SR25a/b and SR26b indicate that these water courses are “losing” streams, meaning that they recharge the water table. Higher rates of infiltration (>200 mm/a) are expected north and south of the transportation corridor along Enfield Road where glaciolacustrine soils are present at surface. High rates of infiltration are also expected between ~17+900 and 18+650 where glaciolacustrine silts and sands are present at surface, although much of this water will flow eastwards to discharge in Oshawa Creek (**Figure A2**).

### 6.1.2 Discharge

Groundwater discharge only occurs at specific points within this section. Cold groundwater discharge was observed at MP17 within Oshawa Creek (**Figure A2**). Data collected for this study indicates that groundwater discharge is not occurring in East Oshawa Creek near MP18 (**Figure A3**). Shallow groundwater discharge may occur in the wetland area at MP19s although the general flow is downwards. Groundwater springs and seeps were observed within the Oshawa Creek valley, which is consistent with the upward gradient at G2C. Stream reconnaissance data generally confirm mini-piezometer results.

## 6.2 Significant Aquifer Units

The coarse textured glaciolacustrine and alluvial deposit between ~17+900 and 18+650 is approximately 9.4 m thick and constitutes a significant local aquifer unit (**Figure A2**). This unit is comprised of 7.6 m of fine sand, underlain by 1.8 m of sand and gravel. The hydraulic conductivity of this unit is about  $1.3 \times 10^{-5}$  m/s. This unit is utilized by local residences as a source of potable water. This unit is underlain by silty sand till (Newmarket Till) that restricts drainage to depth and maintains a high water table (**Figure A5**).

An extension of the ORM Aquifer unit may be present below the Halton Till at Harmony Road (~20+500) and at Grandview Road (~21+625) (**Figure A5**). If the ORM deposits are encountered in excavation, they will not drain in the short term like an isolated sand lens, but will constantly flow because their water source is from an extensive recharge area. While, deposits of glaciolacustrine sands and silts are found north of the transportation corridor along Enfield Road and are considered an important local aquifer unit for local residences, the highway construction will not intercept these.

In the areas along this section where there is extensive till, private wells generally obtain potable water from thin, discontinuous sand lens aquifers found within the Newmarket and Halton tills. These units are confined, which provide a degree of protection from surface contamination.



## 7. Construction and Operational Effects – Central 1 (Ashburn Road to Simcoe Street)

### 7.1 Aquifer and Well Vulnerability

Of the 6.1 km for the proposed transportation corridor right-of-way between Ashburn Road and Simcoe Street, 5.6 km overlies low permeability Newmarket Till, Halton Till or fine-textured glaciolacustrine silt and clay aquitard deposits (**Figure A1**). These thick deposits of aquitard materials act as a hydraulic barrier 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.

Two, small unconfined glaciolacustrine silt and sand aquifer units are present within this section. The first is located at ~12+500 east of Baldwin Street, but west of Lynde Creek (**Figure A1**) and the second is located at ~14+900 east of Garrard Road (**Figure A1**). Both of these aquifer units are too small in thickness and extent to constitute significant aquifer units.

### 7.2 Artesian Conditions

No significant artesian conditions are anticipated in the Central 1 Section.

### 7.3 Impact From Structures

Structures *CM-3/ CM-3B* (Lynde Creek) and *CM-10/ CM-10B* (West Oshawa Creek) are bridge crossings over water courses (**Figure A1**). 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 cold groundwater discharge is occurring within the ROW at both *CM-3/CM-3B* and *CM-10/CM-10B*. Temporary construction dewatering may be required within the valleys of each of these crossings to facilitate construction of bridge foundations. Construction fill placement at *HF-C2* is a 15 m high placement that is required within the West Oshawa Creek valley for construction of the eastern bridge abutment. A site specific investigation at this location confirmed that groundwater discharge is not occurring below the proposed footprint of the fill. However, the water table is shallow and alluvial deposits are present at surface, and large amounts of fill still may create a barrier to lateral groundwater flow. Additional analysis of fill placement at this location will need to be assessed at detailed design.

Culverts across water courses are planned at structures *CM-4* (drainage swale), *CM-7* (Pringle Creek), *CM-8* (drainage swale), and *CM-13/ CM-13B* (West Oshawa Creek tributary). Each of these water courses is intermittent or ephemeral and perched on low permeability till soils. Significant groundwater input to these water courses is not expected. No construction effects are anticipated at these Structures. Although Structure *CM-7* is mapped as intermittent, the results of the stream reconnaissance monitoring suggest that it flows year round due to input from a stormwater management pond from a housing development in the town of Brooklin.

Bridges that carry secondary roads over or under 407 East are planned for structures *CM-1/ CM-1B* (Ashburn Road), *CM-2/ CM-2B* (Baldwin Street), *CM-5/ CM-5B* (Anderson Street), *CM-6/ CM-6B* (Thickson Road), *CM-11* (Thornton Road), *CM-12/ CM-12B* (Winchester Road), and *CM-14/ CM-14B* (Simcoe Street) (**Figure A1**). Each of these structures is underlain by low permeability Newmarket or Halton till. No construction effects are anticipated at these Structures. Structure *CM-9* was previously an underpass below Garrard Road. Recent refinements to the transportation corridor have now eliminated this road crossing (Garrard Road will be a cul-de-sac) and it will not be discussed further.

### 7.4 Impacts From Deep Highway Cuts

Deep Cut *DC-C1* has a maximum cut depth of approximately 8.5 m below original ground and is located between Ashburn Road and Lynde Creek (~11+200 to 11+980, **Figure A1 and Figure A4**). This area is underlain by fine-textured glaciolacustrine silty clay to a depth of ~1.5 mbgs and may grade to sandy silt at the contact with the Newmarket Till below. There is a high potential for continuous side wall seepage at the contact between the Newmarket Till and the fine-textured glaciolacustrine materials. Permanent dewatering 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 one possible solution is to convey seepage in the existing surface water drainage system for the transportation corridor. Mitigation options should be explored during detailed design. Changes to the groundwater table due to excavation within the Newmarket Till is anticipated to permanently lower the groundwater table within a ~39 m radius of *DC-C1* (**Figure F1 and Table 7**). No private wells or groundwater discharge into Lynde Creek are anticipated to be impacted. Shallow groundwater control may be required if excavations intercept a saturated sand lens.

The possibility of continual groundwater seepage at *DC-C1* presents a potential compensation opportunity that could add additional cold groundwater to Lynde Creek. It is recommended that the possibility of collecting and conveying the cold groundwater from the sidewall seepage into Lynde Creek to the east, be explored during detailed design. This would add additional cold groundwater baseflow to the creek that would provide downstream benefits to fish species, while resolving a chronic seepage problem.

Deep Cut *DC-C2* has a maximum cut depth of approximately 8.0 m below original ground and is located between Anderson Street and Thickson Road (~13+250 to 13+430, **Figure A1 and Figure A4**). It is anticipated that this deep cut is underlain by Newmarket and Halton till over the complete extent. Excavations within the Newmarket/ Halton tills are anticipated to permanently lower the groundwater table within an 8.0 m radius of *DC-C2* (**Figure F2 and Table 7**). No private wells are anticipated to be affected. Shallow groundwater control may be required if shallow excavations intercept a localized saturated aquifer.

Deep Cut *DC-C3* has a maximum cut depth of approximately 5.5 m below original ground and is located at Garrard Road (~14+490 to 14+660, **Figure A1 and Figure A4**). It is anticipated that this deep cut is underlain by Halton Till to a depth of 8.7 mbgs. Below this, a gravelly sand aquifer was encountered, that may be a “finger” of the ORM Aquifer. It is anticipated that excavations will be confined to the Halton Till, and therefore, the potential effects will be low. The groundwater table is expected to be permanently lowered within a radius of 3.0 m of *DC-C3* (**Figure F3 and Table 7**). One private well may be impacted by *DC-C3* and will require construction monitoring. If the ORM Aquifer is encountered, permanent groundwater control may be required.

## 8. Construction and Operational Effects – Central 2 (Simcoe Street to Enfield Road)

### 8.1 Aquifer and Well Vulnerability

Of the 8.4 km for the proposed transportation corridor right-of-way, 7.3 km overlies low permeability Newmarket Till or Halton Till aquitard deposits (**Figures A2 and A3**). These thick deposits of aquitard material act as a hydraulic barrier 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. Elevated concentrations of nitrate, sodium and chloride in a confined aquifer unit in the area between Harmony Road and Grandview Road along Winchester Road (**Figure A3**) suggest that this area may be susceptible to surficial effects although the aquifer unit is overlain by Halton Till. This study was not detailed enough to determine the source of contaminants in these confined wells, but it is recommended that wells in this area are monitored during the construction phase.

An unconfined glaciolacustrine aquifer unit is present with the ROW between ~17+900 and 18+650 (**Figure A2**). This unit is ~ 9.4 m thick, has a hydraulic conductivity of  $1.3 \times 10^{-5}$  m/s, and is an important local aquifer unit. There is an upwards gradient to the glaciolacustrine aquifer from the confined sand aquifer below, which is consistent with other measurements of groundwater discharge in the area. The water table is shallow due to poor drainage through the Newmarket Till that underlies the surficial sand. Although few private wells utilize this aquifer near the ROW, it is still susceptible to impacts from roadway contaminants due to its high permeability. Groundwater flow in this unit is anticipated to be eastwards towards Oshawa Creek and therefore, private wells that utilize this aquifer unit south of the ROW (specifically along Winchester Road and Given Road) have a low potential to be impacted from long-term highway operations.

A second unconfined glaciolacustrine aquifer unit is present in this section along Enfield Road (25+500) to the north and to the south of the transportation corridor (**Figure A3**). A small portion of the re-aligned Enfield Road and the Enfield Road expansion north of Concession 6 Road will be constructed on this aquifer unit. The hydraulic properties of this unit are anticipated to be consistent with other glaciolacustrine aquifer units in the area and it is assumed that infiltration rates are high and the water table is shallow due to poor drainage through till units below. The results of the water well survey and well sampling indicate potential pre-existing impacts from road salt in aquifer units both north and south of the transportation corridor as typified by levels of sodium and chloride above the aesthetic ODWS limits. The path of 407 East is through the topographic low in the area and the elevation north and south of the transportation corridor slopes downwards towards the highway. Because of this, impacts to either aquifer unit, is unlikely from long-term operation or construction of the highway, due to groundwater flow towards the highway and not away from it. Road runoff may still impact the water quality of the shallow groundwater discharge to Farewell Creek, and therefore mitigation measures may still be required and should be assessed at detailed design.

### 8.2 Artesian Conditions

Groundwater levels from monitors (G2C) at *CM-17/ CM-17B* show strong upwards gradients and flowing artesian conditions in the sand aquifer at ~11.0 mbgs (**Figures A2 and A5**). Artesian pressure is derived from a thin, confined aquifer that does not appear to be a regionally significant aquifer unit. The potential exists for deep foundations to intercept this confined aquifer unit and create a direct path to the surface. However, even if this aquifer unit is

breached, there is little risk to groundwater quality or quantity. The upwards groundwater pressures will keep surficial contaminants from entering the deep aquifer and the small area breached will have a negligible effect on groundwater pressures, and therefore flow in the aquifer. No effects to the natural environment are anticipated.

### 8.3 Impacts From Structures

Structures *CM-17/ CM-17B* (Ritson Road and Oshawa Creek), *CM-20/ CM-20B/ CM-20C* (East Oshawa Creek), *CM-24* (Harmony Creek), and *SITE 57* (Farewell Creek at Enfield Road) are bridge crossings over water courses (**Figures A2 and A3**). 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 suggest that cold groundwater discharge is occurring within the ROW at *CM-17/ CM-17B* and may be occurring seasonally at *CM-20/ CM-20B/ CM-20C* and *SITE 57*. Stream flow at *CM-24* west of Leask road is intermittent, however evidence was collected from stream reconnaissance measurements that suggests cold groundwater discharge may be occurring at this location (**Figure A3**). Temporary construction dewatering may be required within the valleys of each of the above listed crossings to facilitate construction of bridge foundations. Construction dewatering at *CM-17/ CM-17B* may temporarily impact groundwater levels in two private wells near the structure that utilize the shallow aquifer unit for potable water. Construction fill placement may also be required within the valleys for construction of bridge abutments, which may create a barrier to lateral groundwater flow and groundwater discharge, specifically near Ritson road at *CM-17/CM-17B* where groundwater seeps were observed on the eastern slope of the valley crossing. These impacts should be further assessed at detailed design.

Structures *CM-15/ CM-15B/ CM-15C* (Oshawa Creek tributary) and *CM-18* (Oshawa Creek tributary) are culverts across water courses (**Figure A2**). Both of these water courses are intermittent or ephemeral and perched on low permeability till deposits. No construction effects are anticipated at these Structures. Structures *CM-16/ CM-16B* (Oshawa Creek tributary) and *CM-26/ CM-26B* (Harmony Creek) are open bottom culverts across water courses. Both of these water courses are intermittent, but may seasonally derive some groundwater inputs from shallow groundwater discharge from underlying glaciolacustrine aquifer units. These Structures are open bottomed to convey seasonal groundwater discharge to the creek. Temporary construction dewatering may be required at *CM-26/CM-26B* to facilitate construction of bridge foundations. There is also some potential for shallow groundwater control at *CM-16/CM-16B*. The need for dewatering at both these crossings will need to be assessed at detailed design.

Structure *CM-19/ CM-19B* (Wilson Road), *CM-21/ CM-21B* (Harmony Road), *CM-22/ CM-22B* (Grandview Road), *CM-23/ CM-23B* (Winchester Road), *CM-27/ CM-27B* (Langmaid Road), *CM-28/ CM-28B* (Concession 6 Road), and *CM-29/ CM-29B* (Enfield Road) are all bridges that carry secondary roads over or under 407 East. Each of these structures is underlain by low permeability Newmarket or Halton till (**Figures A2 and A3**). No construction effects are anticipated at these Structures.

### 8.4 Impacts From Deep Highway Cuts

Deep Cut *DC-C4* has a maximum cut depth of approximately 5.5 m below original ground and is located between Harmony Road and Grandview Road (~20+850 to 21+100, **Figures A3 and A5**). It is anticipated that this deep cut is underlain by Halton till over the complete extent. There is a potential that ORM Aquifer deposits are present at a depth of ~7.3 mbgs. This unit is sufficiently below *DC-C4* to alleviate potential impacts. Excavations within the Halton Till are

anticipated to permanently lower the groundwater table within a 7.0 m radius of *DC-C4* (**Figure F4**). No private wells are anticipated to be impacted. Shallow groundwater control may be required if shallow excavations intercept a saturated aquifer.

Deep Cut *DC-C5* has a maximum cut depth of approximately 9.0 m below original ground and is located at Grandview Road and Winchester Road (~21+460 and 22+060, **Figures A3 and A5**). It is anticipated that this deep cut is underlain by Halton till over the complete extent. There is a potential that ORM Aquifer deposits are present at a depth of ~12.2 mbgs. Although intercepting the ORM Aquifer is not anticipated, if it is encountered in excavation, the potentiometric head in the aquifer would likely be lowered. This may impact up to 9 private wells that are screened in this aquifer unit. If the ORM aquifer is not encountered, excavations within the Halton Till are anticipated to permanently lower the groundwater table within a <10 m radius of *DC-C5* (**Figure F5**). No private wells are anticipated to be impacted. Shallow groundwater control may be required if shallow excavations intercept a saturated aquifer. The results of the water well survey and sampling indicated that deep water wells in this area may be susceptible to surficial contaminants, although they are confined (or possibly semi-confined). Although no impacts are anticipated, it is recommended that water levels in this area be carefully monitored during construction phases, by using representative wells.

Deep Cut *DC-C6* has a maximum cut depth of 5.5 m below original ground and is located at Leask Road (~23+400 and 23+670, **Figures A3 and A5**), and Deep Cut *DC-C7* has a maximum cut depth of 7.0 m below original ground and is located at Langmaid Road and Concession 6 Road (~24+350 and 25+080, **Figures A3 and A5**). It is anticipated that each of these deep cuts are underlain by Newmarket Till over their complete extent. Excavations within the till are anticipated to permanently lower the groundwater table within a 26.5 m radius of the cut at *DC-C6* and within a 17 m radius of the cut at *DC-C7* (**Figures F6 and F7**). No private wells are anticipated to be impacted, but due to the large number of homes in the area, the monitoring strategy should include a number of representative wells. Shallow groundwater control may be required if shallow excavations intercept a saturated aquifer.

## 9. Opportunities for Mitigation

### 9.1 Central 1 (Ashburn Road to Simcoe Street)

The majority of the potential changes to the groundwater flow regime are a result of temporary construction dewatering. These 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 associated with it. Construction of the following Structures will likely require dewatering and have a high potential to require a PTTW: Structures *CM-3/ CM-3B* (Lynde Creek) and *CM-10/ CM-10B* (West Oshawa Creek). Dewatering may also be required for construction of the passive groundwater control system at *DC-C1*.

The use of a permeable sub-base for fill placement in creek valleys where groundwater seepage was observed is important to maintain groundwater flow towards the creeks. These mitigation options may be required for fill placement in the West Oshawa Creek valley at HF-C3.

Deep Cut *DC-C1* is estimated to permanently lower the groundwater table within a ~39 m radius of the cut (**Figure F1**). The influence of the glaciolacustrine unit has not been accounted for in this estimation, but it is anticipated that due to the thin nature of this unit, effects will be minimal. Although permanent side wall seepage is anticipated from the contact between the glaciolacustrine materials and the lower till, this will have a negligible effect to the natural environment beyond what *DC-C1* 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. The need for dewatering may be required for the construction of drains to convey the side wall seepage and should be assessed at detailed design.

Deep Cuts *DC-C2* and *DC-C3* are estimated to permanently lower the groundwater table within a <10 m radius of the cut (**Figures F2 and F3**). The need for dewatering is not anticipated based upon the results of this preliminary analysis.

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

### 9.2 Central 2 (Simcoe Street to Enfield Road)

Majority of the changes to the groundwater flow regime are a result of temporary construction dewatering. These 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 from construction dewatering, the temporary nature of the impact means that there are no residual effects associated with it. Construction of the following Structures will likely require dewatering and have a high potential to require a PTTW: Structures *CM-16/ CM-16B* (Oshawa Creek tributary), *CM-17/ CM-17B* (Ritson Road and Oshawa Creek), *CM-20/ CM-20B/ CM-20C* (East Oshawa Creek), *CM-24* (Harmony Creek), and *CM-26/ CM-26B* (Harmony Creek).

The use of a permeable sub-base for fill placement in creek valleys where groundwater seepage was observed is important to maintain groundwater flow towards the creeks and to maintain slope stability of the fill. The use of a permeable sub-base and design measures to deal with groundwater seepage and potential flowing artesian groundwater conditions at depth should be considered between ~17+900 and 18+650 near Oshawa Creek.

Deep Cut *DC-C4* is estimated to permanently lower the groundwater table within a <10 m radius of the cut (**Figure F4**). The need for dewatering is not anticipated, but may temporarily be required if a saturated sand lens is encountered.

Deep Cut *DC-C5* is estimated to permanently lower the groundwater table within a <10 m radius of the cut (**Figure F5**). The need for dewatering is not anticipated, but may temporarily be required if a saturated sand lens is encountered. There is a potential to encounter ORM Aquifer deposits at the base of the cut, although it is believed that this risk is low.

Deep Cut *DC-C6* is estimated to permanently lower the groundwater table within a 26.5 m radius of the cut (**Figure F6**). The need for dewatering is not anticipated, but may temporarily be required if a saturated sand lens is encountered.

Deep Cut *DC-C7* is estimated to permanently lower the groundwater table within an 17 m radius of the cut (**Figure F7**). The need for dewatering is not anticipated, but may temporarily be required if a saturated sand lens is encountered.



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, where feasible. Between ~17+900 and 18+650 a surficial sand aquifer exists that hosts nearby private wells. Runoff should be collected in the stormwater management system and consideration should be given to drainage design alternatives including liners and drainage separation. This would 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.

10. 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 private water wells and water use within the 407 East water well survey study area. Sampling at twenty representative wells provides a snap-shot of the water quality in the area. The twenty water quality samples were collected from wells both up gradient and down gradient of the Transportation Corridor in the Central Section 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 the frequency of monitoring depending upon the length of the construction period, the site specific geological conditions (i.e., till soils or sandy soils), the anticipated well vulnerability (i.e., shallow wells vs. deep wells), and whether or not impacts are detected.

11. 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 in the Central Section.

- a) Determination of the potential dewatering requirements and the potential need for a PTTW at the following structures: Structures CM-3/ CM-3B (Lynde Creek), CM-10/ CM-10B (West Oshawa Creek), Structures CM-17/ CM-17B (Ritson Road and Oshawa Creek), CM-20/ CM-20B/ CM-20C (East Oshawa Creek), CM-24 (Harmony Creek), and SITE 57 (Farewell Creek at Enfield Road).
- 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 and runoff separation to further minimize infiltration to the water table to help minimize impacts to groundwater. The specific area in the Central Section is that is potentially vulnerable is the Oshawa Creek valley (~17+900 to 18+700).
- d) 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 ~17+900 to 18+700, between ~21+460 and 22+060 (near Winchester Road and Grandview Road), and between ~23+400 and 23+670 (near Concession 6 Road and Langmaid Road).

## 12. Acknowledgements

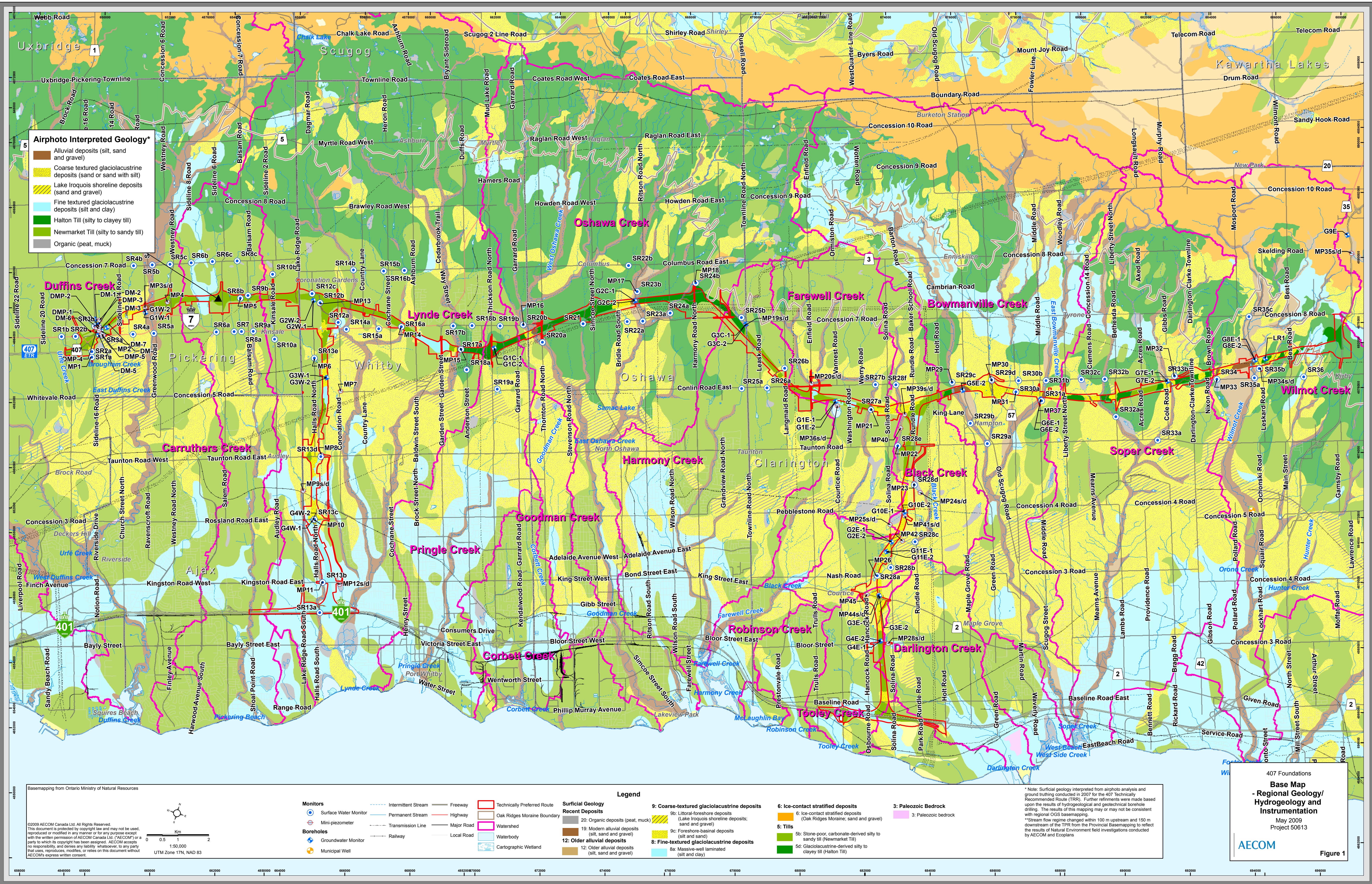
AECOM would like to thank Thurber Engineering Limited for their contribution to the hydrogeological investigations. The geotechnical borehole logs provided by Thurber aided AECOM in providing analysis of the geological / hydrogeologic conditions at each structure. Without these logs, the level of detail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

# Figures – Part B

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# Tables – Part B

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407 East Extension – Central Section

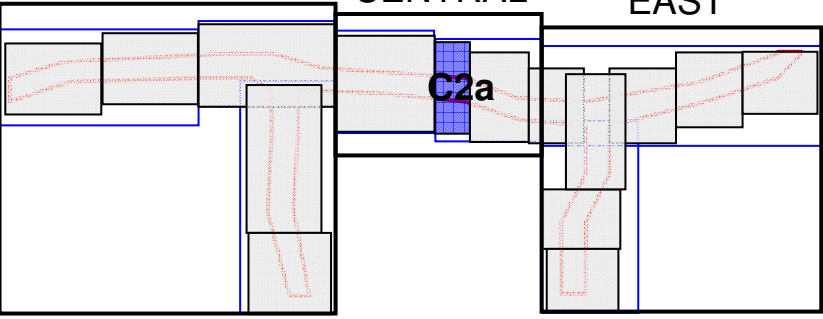
Summary Table 1 – Potential Impacts and Mitigation Summary (C1a)

<div><div>Key Map</div><div><div>WEST</div><div>CENTRAL</div><div>EAST</div><div></div></div></div>		POTENTIAL IMPACTS:
<div><div>Map: Central 1 – C1a</div><div>Section Boundaries: Ashburn Road to Simcoe Street</div><div>Figure(s): Figure A1</div><div>Cross-section(s): Central 1 (Figure A4)</div><div>Assumed Proposed Structures: Central Mainline CM-1,CM-2,CM-3,CM-4, CM-5,CM-6,CM-7,CM-8,CM-9,CM-10,CM 10b,CM-11,CM-12,CM-12b,CM-13,CM-13b,CM-14</div><div>Assumed Deep Cuts: DC-C1 (11+200 to 11+980) – 8.5 m cut depth (drawdown curve – Figure F1) DC-C2 (13+250 to 13+430) – 8 m cut depth (drawdown curve – Figure F2) DC-C3 (14+490 to 14+660) – 5.5 m cut depth (drawdown curve – Figure F3) Assumed High Fills: HF-C1 (12+680 to 12+750) – 7 m fill height HF-C2 (15+180 to 15+300) – 15.5 m fill height HF-C3 (15+500 to 16+000) – 7 m fill height HF-C4 (16+750 to 17+000) – 5.5 m fill height</div><div>Hydrogeology Site Ranking Table: Table 4 (Section C1a)</div></div>		<div><div>Groundwater Effects on Foundation Design and Construction:</div><div><div>▶ Shallow groundwater table (&lt;1.0 mBGS) may be encountered within till units because the unit is poorly drained.</div><div>▶ No significant flowing artesian conditions are expected to be encountered in this section</div><div>▶ Anticipate encountering discontinuous sand lenses below the groundwater table within till units. Will drain in the short term.</div><div>▶ Structures CM-3/ CM-3B and CM-10/ CM-10B<ul style="list-style-type: none"><li>◦ Temporary groundwater control is anticipated for excavations within alluvial sediments. A PTTW may be required. Further assessment is needed during Detailed Design</li></ul></div><div>▶ Deep Cut DC-C1 (8.5 m deep cut) anticipated to encounter the groundwater table at ~1.2 mBGS. A potential for side slope seepage may exist at the contact between upper glaciolacustrine materials and lower till. Further assessment is needed during Detailed Design</div><div>▶ Deep Cut DC-C2 (8 m deep cut) anticipated to encounter the groundwater table at ~1.0 mBGS. Isolated sand lenses are expected in the upper 6 m. Lenses should drain in the short term. Low potential for dewatering</div><div>▶ Deep Cut DC-C3 (5.5 m cut depth) anticipated to encounter the groundwater table at ~4.0 mBGS. Low potential for dewatering. Permeable ORM sediments may be within 3 m of bottom of cut and may have upwards groundwater pressures. Further assessment is needed during Detailed Design</div></div></div> <div><div>Surface Water Features:</div><div><div>▶ The Whitby-Oshawa Iroquois Wetland Complex is present south of the TPR<ul style="list-style-type: none"><li>◦ Construction activities primarily occur in low permeability till units are not expected to adversely affect these wetlands due to a lack of hydraulic connection and separation distance</li></ul></div><div>▶ Temporary dewatering for bridge abutments in the valleys near Lynde Creek (CM-3) and West Oshawa Creek (CM-10) may reduce groundwater discharge into the creeks over the dewatering period<ul style="list-style-type: none"><li>◦ A PTTW may be required. A site specific investigation will be required during Detailed Design to confirm potential impacts</li></ul></div></div></div>
<div><div>FIELD DATA SOURCES:</div><div><div>Boreholes: P13,P14,P15,P21,P22, CM3-1,CM3-2,CM3b-1,CM3b-2,CM6-1,CM6-2,CM6b-1, CM6b-2,CM9-1,CM9-2,CM9b-1,CM9b-2,CM10-1,CM10-2,CM10b-1,CM10b-2,CM11-1,CM11-2</div><div>Monitoring Wells: G1C-1, G1C-2</div><div>Mini-Piezometers: MP15,MP16</div><div>Stream Reconnaissance Sites: SR17a,b, SR18a,b, SR19a,b, SR20a,b, SR21</div><div>Residential Water Wells: 74 private water wells. 27% dug, 24% drilled, 52% unknown, 1% community (drilled). Between 7 and 10 wells within the TPR boundary (may require decommissioning)</div></div></div>		<div><div>Aquifer/Well Vulnerability:</div><div><div>▶ The ORM sand and gravel aquifer is occasionally present within Section C1a as southerly oriented “finger” like intrusions at the contact between the Halton and Newmarket till units<ul style="list-style-type: none"><li>◦ Significant dewatering and/ or impacts to private wells may occur if unit is encountered in excavation</li></ul></div><div>▶ The Thorncliffe Aquifer was not encountered in Section C1a</div><div>▶ Glacial Lake Iroquois Shoreline sediments are found along the southern boundary of this section. Construction activities are not expected to adversely impact these features due to the separation distance</div><div>▶ Deep Cut DC-C1 (8.5 m deep cut) – Excavations estimated to be 7.3 m below the water table<ul style="list-style-type: none"><li>◦ Radius of water table drawdown is conservatively estimated to be 39 m (figure F1)</li><li>◦ Low potential to impact wells/ aquifers unless continuous sand lenses are encountered</li></ul></div><div>▶ Deep Cut DC-C2 (8 m deep cut) – Excavations estimated to be 7.0 m below the water table<ul style="list-style-type: none"><li>◦ Radius of water table drawdown is conservatively estimated to be 8.0 m (figure F2)</li><li>◦ Low potential to impact wells/ aquifers unless continuous sand lenses are encountered</li></ul></div><div>▶ Deep Cut DC-C3 (5.5 m cut depth) – Excavations estimated to be 1.5 m below the water table<ul style="list-style-type: none"><li>◦ Potential ORM sand and gravel deposit present at 8.7 mBGS. If encountered in excavation, dewatering may be required</li><li>◦ Radius of water table drawdown in till is conservatively estimated to be 3.0 m (figure F3)</li><li>◦ Monitoring should be conducted at one (1) well north of the ROW along Garrard Road due to its very close proximity – Well ID 2106</li></ul></div><div>▶ Central Mainline (C1a) – Highway constructed primarily on low permeability till deposits<ul style="list-style-type: none"><li>◦ Low potential for impact to groundwater quality from de-icing compounds</li><li>◦ No reduction in GW recharge due to the linear nature and small surface area of the highway</li></ul></div></div></div>
<div><div>PHYSIOGRAPHIC SETTING:</div><div><div>▶ 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., West Oshawa Creek) and deposited coarse-textured glaciofluvial sediments along their path. Modern alluvial silts, sands and gravels can be found in these valleys.</div></div></div>		<div><div>OPPORTUNITIES FOR MITIGATION:</div><div><div>▶ Structure CM-3/ CM-3B and CM-10/ CM-10B – dewatering may be required for construction of footings. The need for a PTTW should be assessed during Detailed Design<ul style="list-style-type: none"><li>◦ Where practical, consideration should be given to minimizing excavations below the water table</li><li>◦ Where practical, deep foundations are recommended to minimize dewatering</li><li>◦ Time the dewatering period to avoid fish spawning seasons</li><li>◦ Discharge water into receptor stream following temperature and clarity controls to maintain baseflow</li></ul></div><div>▶ Deep Cut DC-C1 – Estimated permanent lowering of water table within ~39 m of cut<ul style="list-style-type: none"><li>◦ 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.</li><li>◦ May require a PTTW to construct groundwater drains. Further assessment is needed during Detailed Design. Performance monitoring may also be required</li></ul></div><div>▶ Deep Cut DC-C2 – Estimated permanent lowering of water table within ~8.0 m of cut<ul style="list-style-type: none"><li>◦ No mitigation anticipated</li></ul></div><div>▶ Deep Cut DC-C2 – Estimated permanent lowering of water table within ~3.0 m of cut. Potential to encounter ORM aquifer deposits near the base of the cut<ul style="list-style-type: none"><li>◦ Preliminary analysis suggests the potential to affect one (1) private well</li><li>◦ Establish a groundwater monitoring program to monitor quality and quantity prior to, during and following construction</li><li>◦ Compensation for impacts may be considered in the form of alternative water supplies on a case-by-case basis</li></ul></div><div>▶ Central Mainline (Central 1 – C1a) – Low potential for reduction in groundwater quality from road run-off<ul style="list-style-type: none"><li>◦ Low potential for long-term impact to groundwater quality from de-icing compounds</li><li>◦ Most SWM ponds will not require lining because low permeability materials present at surface</li><li>◦ No reduction in GW recharge due to the small surface area of the highway</li></ul></div></div></div>
<div><div>Notes:</div><div>mBGS – metres below ground surface</div><div>GWT – groundwater table</div><div>ORM – Oak Ridges Moraine</div><div>PTTW – Permit To Take Water</div></div>		<div><div>PRIORITIES FOR DETAILED DESIGN:</div><div><div>▶ A PTTW may be required for constructing bridge foundations at CM-3/ CM-3B and CM10/ CM-10B and should be assessed during Detailed Design</div><div>▶ Determine potential dewatering requirements. Confirm depth of excavation for bridge abutments in the valleys of Lynde Creek and West Oshawa Creek. Hydraulic testing may be required to establish potential impacts and to obtain a PTTW</div><div>▶ Collection of geological and hydrogeological information along the length of and transverse to DC-C1, DC-C2, DC-C3 to confirm the presence of discontinuous aquifer units. Further estimation of the extent of local drawdown will be required during Detailed Design. Hydraulic testing may be required to confirm</div><div>▶ The need for a passive groundwater control system at DC-C1 and detailed calculations of groundwater flow rates should be assessed during Detailed Design</div></div></div>



407 East Extension – Central Section

Summary Table 2 – Potential Impacts and Mitigation Summary (C2a)

<div>Key Map</div> <div></div> <div>Map: Central 2 – C2a</div> <div>Section Boundaries: Simcoe Street to Wilson Road</div> <div>Figure(s): Figure A2</div> <div>Cross-section(s): Central 2 (Figure A5)</div> <div>Assumed Proposed Structures: Central Mainline CM-15, CM-15B, CM-15C, CM-16, CM-16B, CM-17, CM-17B, CM-18, CM-19, CM-19B</div> <div>Assumed Deep Cuts: None</div> <div>Assumed High Fills: HF-C5 (18+380 to 18+500) – 9 m fill height</div> <div>Hydrogeology Site Ranking Table: Table 5 (Section C2a)</div> <div>FIELD DATA SOURCES:</div> <div>Boreholes: P22, P23, CM17-1, CM17-1a, CM17-2, CM17-3, CM17-3a, CM17b-1, CM17b-2, CM17b-3</div> <div>Monitoring Wells: G2C-1, G2C-2</div> <div>Mini-Piezometers: MP17</div> <div>Stream Reconnaissance Sites: SR22a,b, SR23a,b</div> <div>Residential Water Wells: 37 private water wells. 38% dug, 11% drilled, 51% unknown. Approximately 11 wells within the TPR boundary (may require decommissioning)</div> <div>PHYSIOGRAPHIC SETTING:</div> <div>► 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., Oshawa Creek) and deposited coarse-textured glaciofluvial sediments along their path. Modern alluvial silts, sands and gravels can be found in these valleys.</div> <div>Notes: mBGS – metres below ground surface GWT – groundwater table ORM – Oak Ridges Moraine PTTW – Permit To Take Water</div>	<div>POTENTIAL IMPACTS:</div> <div>Groundwater Effects on Foundation Design and Construction:<ul style="list-style-type: none"><li>► Shallow GWT (&lt;1.0 mBGS) may be encountered in alluvial sediments near Oshawa Creek (~17+900 to 18+650).<ul style="list-style-type: none"><li>◦ Excavations in these deposits may require dewatering and a PTTW. Further assessment is needed during Detailed Design</li></ul></li><li>► Shallow GWT (&lt;1.0 mBGS) may be encountered within till units because the unit is poorly drained</li><li>► Flowing artesian conditions encountered at monitor G2C-1 at a depth of 12.2 mBGS</li><li>► Anticipate encountering discontinuous sand lenses below the groundwater table within till units. Will drain in the short term</li><li>► Structure CM-17/ CM-17B<ul style="list-style-type: none"><li>◦ Temporary groundwater control is anticipated for excavations within alluvial sediments. A PTTW may be required. Further assessment is needed during Detailed Design</li><li>◦ Anticipate artesian conditions at 12.2 mBGS</li><li>◦ Groundwater seepage is occurring in the Oshawa Creek valley, especially along the east cut slope. Mitigation options for fill placement in this area may be needed and should be assessed at Detailed Design</li></ul></li></ul></div> <div>Surface Water Features:<ul style="list-style-type: none"><li>► No PSW are located within this Section</li><li>► Temporary dewatering for bridge abutments in the valley Oshawa Creek (CM-17) may reduce groundwater discharge into the creeks over the dewatering period<ul style="list-style-type: none"><li>◦ A PTTW may be required</li><li>◦ A site specific investigation will be required during Detailed Design</li></ul></li></ul></div>
	<div>Aquifer/Well Vulnerability:<ul style="list-style-type: none"><li>► The ORM sand and gravel aquifer is occasionally present within Section C2a as southerly oriented “finger” like intrusions at the contact between the Halton and Newmarket till units.<ul style="list-style-type: none"><li>◦ Significant dewatering and/ or impacts to private wells may occur if unit is encountered</li></ul></li><li>► The Thornccliffe Aquifer was not encountered in Section C1a.</li><li>► Central Mainline (C2a) – Between 17+900 and 18+700 highway constructed on high permeability alluvial and glaciolacustrine aquifer sediments<ul style="list-style-type: none"><li>◦ Potential for impact to groundwater quality from de-icing compounds</li><li>◦ 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</li><li>◦ No reduction in GW recharge due to the linear nature and small surface area of the highway</li></ul></li></ul></div> <div>Opportunities for Mitigation:</div> <div>► Structure CM-16/ CM-16B – There is a low potential to require dewatering for culvert construction that should be assessed at Detailed Design.</div> <div>► Structure CM-17/ CM-17B – Dewatering may be required for construction of footings. The need for a PTTW should be assessed during Detailed Design<ul style="list-style-type: none"><li>◦ Where practical, consideration should be given to minimizing excavations below the water table</li><li>◦ Where practical, deep foundations are recommended to minimize dewatering</li><li>◦ Time the dewatering period to avoid fish spawning seasons</li><li>◦ Discharge water into receptor stream following temperature and clarity controls to maintain baseflow</li><li>◦ Preliminary analysis suggests that dewatering has a potential to affect two (2) private wells over the dewatering period – Well IDs 2033 and 2034</li><li>◦ Establish a groundwater monitoring program to monitor quality and quantity prior to, during and following construction</li><li>◦ Compensation for impacts may be considered in the form of alternative water supplies on a case-by-case basis</li></ul></div> <div>► Central Mainline (Central 2 – C2a) – Potential for reduction in groundwater quality from road run-off<ul style="list-style-type: none"><li>◦ Between 17+900 and 18+700 - 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</li><li>◦ Compensation for impacts by may be considered in the form of alternative water supplies on a case-by-case basis</li></ul></div> <div>► No reduction in groundwater recharge due to the linear nature and small surface area of the highway</div> <div>PRIORITIES FOR DETAILED DESIGN:</div> <div>► A PTTW may be required for constructing bridge foundations at CM-17/ CM-17B and should be assessed during Detailed Design.</div> <div>► Collection of geological and hydrogeological information at CM-16/CM-16B to confirm geologic interpretations and the need for shallow dewatering will be required during Detailed Design. A PTTW may be required and should be assessed during Detailed Design</div> <div>► Determine potential dewatering requirements. Confirm depth of excavation for bridge abutments in the valley of Oshawa Creek . Hydraulic testing may be required to establish potential impacts and to obtain a PTTW.</div> <div>► The two (2) wells near Structure CM-17/ CM-17B should be monitored for water level and quality for 1 month before construction, during construction and for 1 month following construction</div> <div>► Assess the need for drainage design alternatives including liners and drainage separation to minimize infiltration to the water table between 17+900 and 18+700</div>



407 East Extension – Central Section

Summary Table 3 – Potential Impacts and Mitigation Summary (C2b)

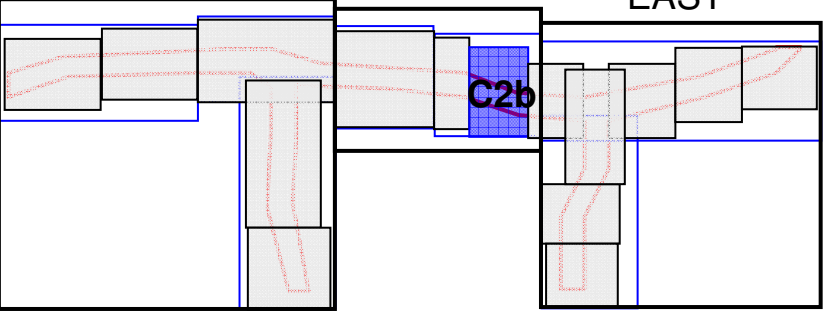
<div>Key Map</div> <div></div> <div>Map: Central 2 – C2b)</div> <div>Section Boundaries: Wilson Road to Enfield Road</div> <div>Figure(s): Figure A3</div> <div>Cross-section(s): Central 2 (Figure A5)</div> <div>Assumed Proposed Structures: Central Mainline CM-20, CM-20B, CM-20C, CM-21, CM-21B, CM-22, CM-22B, CM-23, CM-24, CM-26, CM-26B, CM-27, CM-27B, CM-28, CM-28B, CM-29, CM-29B</div> <div>Assumed Deep Cuts:DC-C4 (20+850 to 21+100) – 5.5 m cut depth (drawdown curve – Figure F4) DC-C5 (21+460 to 22+060) – 9 m cut depth (drawdown curve – Figure F5) DC-C6 (23+400 to 23+670) – 5.5 m cut depth (drawdown curve – Figure F6) DC-C7 (24+350 to 25+080) – 7 m cut depth (drawdown curve – Figure F7)</div> <div>Assumed High Fills: HF-C6 (20+200 to 20+630) – 14 m fill height HF-C7 (24+030 to 24+220) – 8.5 m fill height HF-C8 (25+260 to 25+440) – 7 m fill height</div> <div>Hydrogeology Site Ranking Table: Table 6 (Section C2b)</div> <div>FIELD DATA SOURCES:</div> <div>Boreholes: P25, P26, P27, CM20b-2, CM20b-3, CM21-1, CM21-2, CM21b-1, CM21b-3, CM23b-2, CM24-1, CM24-2, CM24-3, CM24-4</div> <div>Monitoring Wells: G3C-1, G3C-2</div> <div>Mini-Piezometers: MP18, MP19s/d, MP20s/d</div> <div>Stream Reconnaissance Sites: SR24a,b, SR25a,b, SR26a,b,</div> <div>Residential Water Wells: 96 private water wells. 26% dug, 23% drilled, 51% unknown. Approximately 12 wells within the TPR boundary (may require decommissioning)</div> <div>PHYSIOGRAPHIC SETTING: <ul style="list-style-type: none"><li>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.</li></ul></div> <div>Notes: mBGS – metres below ground surface GWT – groundwater table ORM – Oak Ridges Moraine PTTW – Permit To Take Water</div>	<div>POTENTIAL IMPACTS:</div> <div>Groundwater Effects on Foundation Design and Construction:<ul style="list-style-type: none"><li>Shallow GWT (&lt;1.0 mBGS) may be encountered within till units because the unit is poorly drained</li><li>Flowing artesian conditions possible near Harmony Road at a depth of 7.3 mBGS</li><li>Anticipate encountering discontinuous sand lenses below the GWT within till units. Will drain in the short term</li><li>Structures CM-20/ CM-20B/ CM-20C and CM-26/ CM-26B<ul style="list-style-type: none"><li>Temporary groundwater control is anticipated for excavations within alluvial sediments. A PTTW may be required. Further assessment is needed during Detailed Design</li></ul></li><li>Deep Cut DC-C4 (5.5 m deep cut) may encounter the GWT at ~2.0 mBGS. Potential confined ORM deposits at 7.3 mBGS. Temporary groundwater control and a PTTW may be required if unit is encountered</li><li>Deep Cut DC-C5 (9 m cut depth) will likely encounter the GWT at ~2.0 mBGS. Potential ORM deposits at &gt;7.3 mBGS. Temporary groundwater control and a PTTW may be required if unit is encountered</li><li>Deep Cut DC-C6 (5.5 m cut depth) may encounter the GWT at ~1.0 – 7.0 mBGS. Sand lenses will drain in the short term. Low potential for dewatering</li><li>Deep Cut DC-C7 (7 m cut depth) may encounter the GWT at &lt;7.0 mBGS. Sand lenses will drain in the short term. Low potential for dewatering</li></ul></div> <div>Surface Water Features:<ul style="list-style-type: none"><li>Dewatering for bridge abutments in the valleys near Oshawa Creek tributary (CM-20) and Harmony Creek (CM-26) may reduce GW discharge into the creeks over the dewatering period. A PTTW may be required. Further assessment is needed during Detailed Design</li><li>The Solina Bog Wetland Complex is located east of Enfield Road and is a PSW<ul style="list-style-type: none"><li>There is no hydraulic connection anticipated between Farewell Creek and the Solina Bog</li><li>Highway construction or operation is not anticipated to impact this wetland with storm water management facilities in place</li></ul></li></ul></div> <div>Aquifer/Well Vulnerability:<ul style="list-style-type: none"><li>The ORM sand and gravel aquifer is occasionally present within Section C2b as southerly oriented “finger” like intrusions at the contact between the Halton and Newmarket till units<ul style="list-style-type: none"><li>Significant dewatering and/ or impacts to private wells may occur if unit is encountered</li></ul></li><li>The Thorncliffe Aquifer may have been encountered in MOE well records in Section C2b near Enfield Road. This unit is deep and confined and has a very low potential to be impacted.</li><li>Deep Cut DC-C4 (5.5 m deep cut) – Excavations estimated to be 3.5 m below the water table<ul style="list-style-type: none"><li>Radius of water table drawdown is conservatively estimated to be 7.0 m (figure F4)</li><li>Low potential to encounter a significant aquifer unit and to impact local wells.</li></ul></li><li>Deep Cut DC-C5 (9 m cut depth) – Excavations estimated to be 7.0 m below the water table<ul style="list-style-type: none"><li>Radius of water table drawdown is conservatively estimated to be 7.5 m (figure F5)</li><li>Potential to encounter a saturated sand deposit near the base of the cut. Further assessment is required at detailed design.</li><li>Many private wells located within 250 m of cut and may be impacted if a confined aquifer unit is breached</li></ul></li><li>Deep Cut DC-C6 (5.5 m cut depth) – Excavations estimated to be 4.5 m below the water table<ul style="list-style-type: none"><li>Radius of water table drawdown is conservatively estimated to be 26.5 m (figure F6). Low potential to impact wells/ aquifers unless continuous sand lenses are encountered</li><li>Many private wells located within 250 m of cut and may be impacted if a confined aquifer unit is breached</li></ul></li><li>Deep Cut DC-C7 (7 m cut depth) – Excavations estimated to be 3.0 m below the water table<ul style="list-style-type: none"><li>Radius of water table drawdown is conservatively estimated to be 17 m (figure F7). Low potential to impact wells/ aquifers unless continuous sand lenses are encountered</li><li>Many private wells located within 250 m of cut and may be impacted if a confined aquifer unit is breached</li></ul></li><li>Central Mainline (C2b) – Highway constructed primarily on low permeability till deposits<ul style="list-style-type: none"><li>Low potential for impact to groundwater quality from de-icing compounds</li><li>No reduction in GW recharge due to the linear nature and small surface area of the highway</li></ul></li></ul></div> <div>Opportunities for Mitigation:</div> <div>Structures CM-20/ CM-20B/ CM-20C and CM-26/ CM-26B – dewatering may be required for construction of bridge footings. The need for a PTTW should be assessed during Detailed Design<ul style="list-style-type: none"><li>Where practical, consideration should be given to minimizing excavations below the water table</li><li>Where practical, deep foundations are recommended to minimize dewatering</li><li>Time the dewatering period to avoid fish spawning seasons</li><li>Discharge water into receptor stream following temperature and clarity controls to maintain baseflow</li></ul></div> <div>Deep Cut DC-C4 – Limiting excavation to a maximum of 7.0 m below grade is recommended to avoid ORM deposits<ul style="list-style-type: none"><li>No mitigation anticipated</li></ul></div> <div>Deep Cut DC-C5 – Estimated permanent lowering of water table within 7.5 m of cut . Further assessment is required at detailed design to confirm depth of aquifer unit below DC-C5<ul style="list-style-type: none"><li>Representative wells near the deep cut should be monitored prior to, during and following construction for both quality and quantity to confirm the absence of impacts</li><li>Compensation for impacts may be considered in the form of alternative water supplies on a case-by-case basis</li></ul></div> <div>Deep Cut DC-C6 – Estimated permanent lowering of water table within 26.5 m of cut<ul style="list-style-type: none"><li>Representative wells near the deep cut should be monitored prior to, during and following construction for both quality and quantity to confirm the absence of impacts</li><li>Compensation for impacts may be considered in the form of alternative water supplies on a case-by-case basis</li></ul></div> <div>Deep Cut DC-C7 – Estimated permanent lowering of water table within 17 m of cut<ul style="list-style-type: none"><li>Representative wells near the deep cut should be monitored prior to, during and following construction for both quality and quantity to confirm the absence of impacts</li><li>Compensation for impacts may be considered in the form of alternative water supplies on a case-by-case basis</li></ul></div> <div>Central Mainline (Central 2 – C2b) – Low potential for reduction in groundwater quality from road run-off<ul style="list-style-type: none"><li>Low potential for long-term impact to groundwater quality from de-icing compounds</li><li>Most SWM ponds will not require lining because low permeability materials present at surface</li><li>No reduction in GW recharge due to the small surface area of the highway</li></ul></div> <div>PRIORITIES FOR DETAILED DESIGN:</div> <div>A PTTW may be required for constructing bridge foundations at CM-20/ CM-20B/ CM-20C and CM-26/ CM-26B. The need for a PTTW should be assessed during Detailed Design</div> <div>To determine potential dewatering requirements, confirm depth of excavation for bridge abutments in the valley of the Oshawa Creek tributary (CM-20). Hydraulic testing may be required to establish potential impacts and to obtain a PTTW</div> <div>Representative wells near deep cuts DC-C5, DC-C6, DC-C7 should be monitored for water level and quality for 1 month before construction, during construction and for 1 month following construction</div> <div>Collection of geological and hydrogeological information along the length of and transverse to DC-C4, DC-C5, DC-C6, DC-C7 to confirm so the presence of aquifer units and estimation of the extent of local drawdown will be required during Detailed Design. Hydraulic testing may be required</div>
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TABLE 4  
Hydrogeology Site Ranking Table (C1a)

SECTION	Structures			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	Previous ID	Drainage Crossing ID					SUBSURFACE CONDITIONS	REMARKS	HYDROGEOLOGY				
CENTRAL SECTION - Subsection C1a	CM - 1			Bridge	Underpass	Ashburn Road	WM43-1, WM43-2	Surficial sandy silt till (Newmarket Till) aquitard to 9.6 mBGS. Overlain by 1.5 m of glaciolacustrine clayey silt.	Water table perched in till unit. Depth to water table ranges from 1.2 to 2.3 mBGS.	Low	No Watercourse (Street Crossing)			60
	CM - 1b			Bridge	Underpass	Ashburn Road	WM43-1, WM43-2	Surficial sandy silt till (Newmarket Till) aquitard to 9.6 mBG. Overlain by 1.5 m of glaciolacustrine clayey silt.	Water table perched in till unit. Depth to water table ranges from 1.2 to 2.3 mBGS.	Low	No Watercourse (Street Crossing)			60
	CM - 2	CM-3		Bridge	Underpass	Baldwin Street	P13	Surficial glaciolacustrine clayey silt that grades to sandy silt. Below, sandy silty till (Newmarket Till) aquitard to 12.4 mBGS. Potential confined aquifer at >45.0 mBGS.	Groundwater seepage anticipated at constack between glaciolacustrine materials and Newmarket Till due to deep cut. Watertable perched on till unit. Depth to water table is <3.0 mBGS.	High	No Watercourse (Street Crossing)			60
	CM - 2b	CM-3		Bridge	Underpass	Baldwin Street	P13	Surficial glaciolacustrine clayey silt that grades to sandy silt. Below, sandy silty till (Newmarket Till) aquitard to 12.4 mBGS. Potential confined aquifer at >45.0 mBGS.	Groundwater seepage anticipated at constack between glaciolacustrine materials and Newmarket Till due to deep cut. Watertable perched on till unit. Depth to water table is <3.0 mBGS.	High	No Watercourse (Street Crossing)			60
	CM - 3	CM-5	CM-LC-24	Bridge	Overpass	Lynde Creek	CM3-1, CM3-2, CM3b-1, CM3b-2, MP15	Surficial aquifer to 9.4 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 16.9 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.	High	Span Bridge	Wide, moderately deep valley with 15-25° steep valley sides, except where meandering channel is undercutting and steepening slope, which has lead to localized slumps	Valley bottom sediments >2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material (e.g., a 0.15 m thick organic layer, evidence of previous floodplain elevation, exists approx. 1.5 m below current floodplain)	55
	CM - 3b	CM-5	CM-LC-24	Bridge	Overpass	Lynde Creek	CM3-1, CM3-2, CM3b-1, CM3b-2, MP15	Surficial aquifer to 9.4 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 16.9 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.	High	Span Bridge	Wide, moderately deep valley with 15-25° steep valley sides, except where meandering channel is undercutting and steepening slope, which has lead to localized slumps	Valley bottom sediments >2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material (e.g., a 0.15 m thick organic layer, evidence of previous floodplain elevation, exists approx. 1.5 m below current floodplain)	55
	CM - 4	CM-6	CM-TBLC-25	Culvert	Overpass	Creek	P14	Surficial silty to clayey till aquitard to a depth of at least 11.4 mBGS.	Depth to water table is <3.0 mBGS. Watercourse perched on till. Culvert installation should occur when stream bed is dry.	Low	Closed Bottom Box Culvert	Narrow, shallow, channelized valley with no geomorphic evidence of significant valley side instability	Likely no appreciable alluvial deposits, based on field checks of similar valleys	55
	CM - 5	CM-7		Bridge	Underpass	Anderson Street	None	Surficial silty to clayey till aquitard to a depth of at least 11.4 mBGS (P14).	Water table perched in till unit. Depth to water table is <3.0 mBGS.	Low	No Watercourse (Street Crossing)			60
	CM - 5b	CM-7		Bridge	Underpass	Anderson Street	None	Surficial silty to clayey till aquitard to a depth of at least 11.4 mBGS (P14).	Water table perched in till unit. Depth to water table is <3.0 mBGS.	Low	No Watercourse (Street Crossing)			60
	CM - 6	CM-9		Bridge	Underpass	Thickson Road	G1C-1, G1C-2, CM6-1, CM6-2, CM6b-1, CM6b-2	Surficial silty sand to sandy silt till (Newmarket Till) aquitard to a depth of at least 12.8 mBGS. Isolated lenses of silt and sand in upper 12.8 m. Water table near surface (<1.0 to 2.0 mBGS) and downward hydraulic gradient measured in groundwater monitors indicating a groundwater recharge area.	Water table perched in till unit. Depth to water table ranges from <1.0 to 2.0 mBGS. Low potential for dewatering due to shallow water table in low permeability till soils.	Low	No Watercourse (Street Crossing)			60
	CM - 6b	CM-9		Bridge	Underpass	Thickson Road	G1C-1, G1C-2, CM6-1, CM6-2, CM6b-1, CM6b-2	Surficial silty sand to sandy silt till (Newmarket Till) aquitard to a depth of at least 12.8 mBGS. Isolated lenses of silt and sand in upper 12.8 m. Water table near surface (<1.0 to 2.0 mBGS) and downward hydraulic gradient measured in groundwater monitors indicating a groundwater recharge area.	Water table perched in till unit. Depth to water table ranges from <1.0 to 2.0 mBGS. Low potential for dewatering due to shallow water table in low permeability till soils.	Low	No Watercourse (Street Crossing)			60
	CM - 7	CM-10	CM-TBPC-27	Culvert	Overpass	Pringle Creek	None	Surficial silty sand to sandy silt till (Newmarket Till) aquitard to a depth of at least 12.8 mBGS.	Watercourse is perched on till. Low potential for dewatering due to shallow water table in low permeability till soils. Culvert installation should occur when stream flow is low.	Low	Closed Bottom Box Culvert	Narrow, shallow valley with no geomorphic evidence of significant valley side 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	60
	CM - 8			Culvert	Overpass	Creek / Pond	None	Surficial silty sand to sandy silt till (Newmarket Till) aquitard to a depth of at least 12.8 mBGS.	Watercourse is perched on till. Low potential for dewatering due to shallow water table in low permeability till soils. Culvert installation should occur when stream flow is low.	Low	No Watercourse (Small Pond Located to the North of the TPR)	Narrow, shallow swale with no geomorphic evidence of significant valley side instability	Small pond located to the north of the TPR. Likely no appreciable alluvial deposits, based on field checks of similar ponds and swales	60
	CM - 9			Cul-De-Sac	Underpass	Garrard Road	CM9-1, CM9-2, P15	Surficial silty to clayey till (Halton Till) aquitard to a depth of 7.6 mBGS. Sandy silt till (Newmarket Till) to a depth of between 8.7 and 17.6 mBGS. Gravelly sand aquifer unit encountered between 8.7 and 17.6 mBGS in geotechnical boreholes. Newmarket Till encountered below aquifer unit.	Water table is likely perched in till. Estimated depth to groundwater is <5.0 mBGS. Gravelly sand aquifer unit may be Oak Ridges Moraine (ORM) sediments. Low potential for dewatering unless excavating to a depth of >8.7 mBGS.	Medium	No Watercourse. No Street Crossing. Cul-De-Sac			55
	CM - 10	CM-12	CM-OCE-28	Bridge	Overpass	West Oshawa Creek	CM10-2, CM10b-2, MP16	Surficial coarse-textured sandy and alluvial aquifer deposits in West Oshawa Creek to a depth of 7.2 mBGS. Water table near surface (<1.0 mBGS), evidence of upward gradients along creek bed indicating groundwater discharge	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.	High	Span Bridge	Wide, deep valley with 30° steep valley sides, except where meandering channel is undercutting and steepening slope, which has lead to localized slumps (bridge abutment locations should take into account potential for continued down-valley migration of meander immediately northwest of proposed footprints); thin soil cover and minor irregularities on east valley side suggest localized erosion and instability	Valley bottom sediments >2 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material; riparian wetlands likely contain <1 m deep organic material	35

Site ranking for Hydrogeology: Low/Medium/High - Ranking denotes the degree of impact that groundwater will have on construction activities, both in terms of design and environmental sensitivity.



TABLE 5  
Hydrogeology Site Ranking Table (C2a)

SECTION	Structures			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	Previous ID	Drainage Crossing ID					SUBSURFACE CONDITIONS	REMARKS	HYDROGEOLOGY				
CENTRAL SECTION - Subsection C2a	CM - 15	CM-20	CM-TBOCW-33	Culvert	Overpass	Oshawa Creek Tributary	None	Surficial silty to clayey till (Halton Till) aquitard to a depth of 5.5 mBGS, overlying silty sand till (Newmarket Till) aquitard to a depth of 12.6 mBGS. Potential for thin alluvial sediments in valley.	Depth to water table is likely <3.0 mBGS. Watercourse perched on till and is intermittent. Culvert installation should occur when stream bed is dry.	NA	Stream Realigned to the North	Narrow, moderately deep valley with no geomorphic evidence of significant valley side 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
	CM - 15b	CM-20	CM-TBOCW-33	Culvert	Overpass	Oshawa Creek Tributary	None	Surficial silty to clayey till (Halton Till) aquitard to a depth of 5.5 mBGS, overlying silty sand till (Newmarket Till) aquitard to a depth of 12.6 mBGS. Potential for thin alluvial sediments in valley.	Depth to water table is likely <3.0 mBGS. Watercourse perched on till and is intermittent. Culvert installation should occur when stream bed is dry.	NA	Stream Realigned to the North	Narrow, moderately deep valley with no geomorphic evidence of significant valley side 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
	CM - 15c	CM-20	CM-TBOCW-33	Culvert	Overpass	Oshawa Creek Tributary	None	Surficial silty to clayey till (Halton Till) aquitard to a depth of 5.5 mBGS, overlying silty sand till (Newmarket Till) aquitard to a depth of 12.6 mBGS. Potential for thin alluvial sediments in valley.	Depth to water table is likely <3.0 mBGS. Watercourse perched on till and is intermittent. Culvert installation should occur when stream bed is dry.	NA	Stream Realigned to the North	Narrow, moderately deep valley with no geomorphic evidence of significant valley side 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
	CM - 16	CM-21	CM-TA1OCW-34	Bridge	Overpass	Oshawa Creek Tributary	None (Ecoplans provided comments on groundwater discharge)	Surficial coarse textured sandy aquifer deposits (unknown thickness - estimated to be <5.0 m). Ecoplans reports no indicators of groundwater discharge within TPR boundary. Surficial sand aquifer underlain by silty sand till (Newmarket Till) aquitard to depth.	Water table estimated to be close to ground surface (<1.0 mBGS) due to poor drainage below. Potential for dewatering if excavating alluvial sediments.	Medium	Open Bottom Culvert	Narrow, shallow valley with no geomorphic evidence of significant valley side 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	50
	CM - 16b	CM-21	CM-TA1OCW-34	Bridge	Overpass	Oshawa Creek Tributary	None (Ecoplans provided comments on groundwater discharge)	Surficial coarse textured sandy aquifer deposits (unknown thickness - estimated to be <5.0 m). Ecoplans reports no indicators of groundwater discharge within TPR boundary. Surficial sand aquifer underlain by silty sand till (Newmarket Till) aquitard to depth.	Water table estimated to be close to ground surface (<1.0 mBGS) due to poor drainage below. Potential for dewatering if excavating alluvial sediments.	Medium	Open Bottom Culvert	Narrow, shallow valley with no geomorphic evidence of significant valley side 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	50
	CM - 17	CM-22	CM-TCEBOC-35	Bridge	Overpass	Ritson Road and Oshawa Creek	G2C-1, G2C-2, CM17-1, CM17-2, CM17-3, CM17b-1, CM17b-3, MP17	Surficial aquifer up to 11.0 mBGS in valley - alluvial sediments (sand and gravel), and glaciolacustrine silty sand. Silty sand and sand units up to 4.0 m thick found between units of silty sand till (Newmarket Till) aquitard to a depth of 20.1 mBGS. Water table near surface (<1.0 mBGS) and upwards hydraulic gradient within stream (i.e., groundwater discharge).	Groundwater level at G2C ranges between - 1.3 and 2.3 bmgs. Deep well (15 mBGS) is flowing artesian. Strong upwards hydraulic gradient between shallow and deep well. Spring seepage and cattails at toe of steep east valley side. Potential to intercept flowing artesian conditions at 12mBGS. Dewatering may be required if excavating alluvial sediments in valley. A PTTW may be required.	High	Span Bridge	Wide, deep valley (old glacial meltwater spillway and early post-glacial river valley) with gentle west valley side and 35° steep east valley side, except where meandering channel is undercutting and steepening slope, which has lead to localized slumps.	Modern valley bottom sediments >1.5 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material; early post-glacial alluvial sediments comprising terrace on west side valley dominantly sandy gravel	40
	CM - 17b	CM-22	CM-TCEBOC-35	Bridge	Overpass	Ritson Road and Oshawa Creek	G2C-1, G2C-2, CM17-1, CM17-2, CM17-3, CM17b-1, CM17b-3, MP17	Surficial aquifer up to 11.0 mBGS in valley - alluvial sediments (sand and gravel), and glaciolacustrine silty sand. Silty sand and sand units up to 4.0 m thick found between units of silty sand till (Newmarket Till) aquitard to a depth of 20.1 mBGS. Water table near surface (<1.0 mBGS) and upwards hydraulic gradient within stream (i.e., groundwater discharge).	Groundwater level at G2C ranges between - 1.3 and 2.3 bmgs. Deep well (15 mBGS) is flowing artesian. Strong upwards hydraulic gradient between shallow and deep well. Spring seepage and cattails at toe of steep east valley side. Potential to intercept flowing artesian conditions at 12mBGS. Dewatering may be required if excavating alluvial sediments in valley. A PTTW may be required.	High	Span Bridge	Wide, deep valley (old glacial meltwater spillway and early post-glacial river valley) with gentle west valley side and 35° steep east valley side, except where meandering channel is undercutting and steepening slope, which has lead to localized slumps.	Modern valley bottom sediments >1.5 m deep and dominantly silty gravelly sand alluvium, locally interbedded with buried organic material; early post-glacial alluvial sediments comprising terrace on west side valley dominantly sandy gravel	40
	CM - 18	CM-23	CM-TCEBOC-36	Culvert	Overpass	Oshawa Creek Tributary	None	Surficial silty to clayey till (Halton Till) aquitard to overlying silty sand till (Newmarket Till) aquitard. Potential to encounter ORM aquifer deposits at the base of the Halton Till.	Depth to water table is likely <10.0 mBGS. Watercourse perched on till. Culvert installation should occur when stream bed is dry.	Low	Closed Bottom Box Culvert	Narrow, shallow swale with no geomorphic evidence of significant valley side instability	Likely no appreciable alluvial deposits, based on field checks of similar swales	45
	CM - 19			Bridge	Overpass	Wilson Road	None	Surficial silty to clayey till (Halton Till) aquitard to overlying silty sand till (Newmarket Till) aquitard. Potential to encounter ORM aquifer deposits at the base of the Halton Till.	Depth to water table is likely <10.0 mBGS.	Low	No Watercourse (Street Crossing)			65
	CM -19b			Bridge	Overpass	Wilson Road	None	SSurficial silty to clayey till (Halton Till) aquitard to overlying silty sand till (Newmarket Till) aquitard. Potential to encounter ORM aquifer deposits at the base of the Halton Till.	Depth to water table is likely <10.0 mBGS.	Low	No Watercourse (Street Crossing)			65





SECTION	Structures			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	Previous ID	Drainage Crossing ID					SUBSURFACE CONDITIONS	REMARKS	HYDROGEOLOGY				
CENTRAL SECTION - Subsection C2b	CM - 20	CM-26	CM-TEEBOC-38	Bridge	Overpass	East Oshawa Creek	CM20b-2, MP18	Surficial silty sand alluvial aquifer and organic material underlain by silty to clayey till (Halton Till) aquitard. Surficial aquifer likely limited to <5.0 in thickness. Groundwater table near surface in river valley (<1.0 mBGS). Upwards hydraulic gradients measured in East Oshawa Creek river valley indicating groundwater discharge.	Stream Reconnaissance data suggests that creek flows year round. Shallow dewatering may be required if excavating alluvial sediments in valley. A PTTW may be required.	Medium	Span Bridge	Narrow, moderately deep valley; meandering channel is undercutting valley side, which has lead to localized slumps	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
	CM - 20b	CM-26	CM-TEEBOC-38	Bridge	Overpass	East Oshawa Creek	CM20b-2, MP18	Surficial silty sand alluvial aquifer and organic material underlain by silty to clayey till (Halton Till) aquitard. Surficial aquifer likely limited to <5.0 in thickness. Groundwater table near surface in river valley (<1.0 mBGS). Upwards hydraulic gradients measured in East Oshawa Creek river valley indicating groundwater discharge.	Stream Reconnaissance data suggests that creek flows year round. Shallow dewatering may be required if excavating alluvial sediments in valley. A PTTW may be required.	Medium	Span Bridge	Narrow, moderately deep valley; meandering channel is undercutting valley side, which has lead to localized slumps	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
	CM - 20c	CM-28	CM-TEEBOC-39	Bridge	Overpass	East Oshawa Creek	CM20b-2, MP18	Surficial silty sand alluvial aquifer and organic material underlain by silty to clayey till (Halton Till) aquitard. Surficial aquifer likely limited to <5.0 in thickness. Groundwater table near surface in river valley (<1.0 mBGS). Upwards hydraulic gradients measured in East Oshawa Creek river valley indicating groundwater discharge.	Stream Reconnaissance data suggests that creek flows year round. Shallow dewatering may be required if excavating alluvial sediments in valley. A PTTW may be required.	Medium	Span Bridge	Narrow, moderately deep valley; meandering channel is undercutting valley side, which has lead to localized slumps	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
	CM - 21	CM-27		Bridge	Overpass	Harmony Road	CM21-1, CM21b-1, CM21-2	Surficial silty to clayey till (Halton Till) aquitard. Sand unit encountered at between 7.3 and 8.7 mBGS (likely ORM Aquifer deposits). Below sand, silty sand till (Newmarket Till) is present to a depth of 15.4 mBGS.	Water table depth likely <3.0 mBGS. Low potential for dewatering due to shallow water table in low permeability till soils. If ORM deposits are encountered in excavation, dewatering may be required.	Medium	No Watercourse (Street Crossing)			85
	CM - 21b	CM-27		Bridge	Overpass	Harmony Road	CM21-1, CM21b-1, CM21-2	Surficial silty to clayey till (Halton Till) aquitard. Sand unit encountered at between 7.3 and 8.7 mBGS (likely ORM Aquifer deposits). Below sand, silty sand till (Newmarket Till) is present to a depth of 15.4 mBGS.	Water table depth likely <3.0 mBGS. Low potential for dewatering due to shallow water table in low permeability till soils. If ORM deposits are encountered in excavation, dewatering may be required.	Medium	No Watercourse (Street Crossing)			85
	CM - 22			Bridge	Overpass	Grandview Street	None	Surficial silty clay to clayey silt till (Halton Till) aquitard to a depth of 8.3 mBGS. Boulder encountered at 8.3 mBGS according to geotech borehole log. Sandy silt till (Newmarket Till) aquitard is present below to a depth of 10.8 mBGS.	Water table perched on till unit. Depth to water table is expected to be <3.0 mBGS.	Medium	No Watercourse (Street Crossing)			105
	CM - 22b			Bridge	Overpass	Grandview Street	None	Surficial silty clay to clayey silt till (Halton Till) aquitard to a depth of 8.3 mBGS. Boulder encountered at 8.3 mBGS according to geotech borehole log. Sandy silt till (Newmarket Till) aquitard is present below to a depth of 10.8 mBGS.	Water table perched on till unit. Depth to water table is expected to be <3.0 mBGS.	Medium	No Watercourse (Street Crossing)			105
	CM - 23	CM-31		Bridge	Underpass	Winchester Road	CM23b-2	Surficial silty clay to clayey silt till (Halton Till) aquitard to a depth of 8.3 mBGS. Boulder encountered at 8.3 mBGS according to geotech borehole log. Sandy silt till (Newmarket Till) aquitard is present below to a depth of 10.8 mBGS.	Water table perched on till unit. Depth to water table is expected to be <5.0 mBGS.	Medium	No Watercourse (Street Crossing)			105
	CM - 23b	CM-31		Bridge	Underpass	Winchester Road	CM23b-2	Surficial silty clay to clayey silt till (Halton Till) aquitard to a depth of 8.3 mBGS. Boulder encountered at 8.3 mBGS according to geotech borehole log. Sandy silt till (Newmarket Till) aquitard is present below to a depth of 10.8 mBGS.	Water table perched on till unit. Depth to water table is expected to be <3.0 mBGS.	Medium	No Watercourse (Street Crossing)			105
	CM - 24	CM-32	CM-HC-53(54)	Culvert	Overpass	Harmony Creek tributary	G3C-1, G3C-2, CM24-1, CM24-2, CM24-3, CM24-4	Surficial silty clay to clayey silt till (Halton Till) aquitard to a depth of 10.7 mBGS. Sandy silt till (Newmarket Till) aquitard is present below to a depth of 29.0 mBGS. Silty clay and silty sand deposits interbedded within Till units.	Water table perched on till unit. Shallow water table ranges from 1.9 to 2.5 mBGS. Deep water level indicates a downwards gradient (recharge area) Moderate potential for dewatering if excavating alluvial sediments in valley. A PTTW may be required.	Medium	Closed Bottom Box Culvert	Narrow, shallow, channelized valley with no geomorphic evidence of significant valley side instability	Valley bottom sediments likely <1 m deep and dominantly silty gravelly sand alluvium, based on field checks of similar valleys	95
	CM - 26	CM-35	CM-HC-56	Bridge	Overpass	Harmony Creek	None	Surficial silt till and sandy silt glaciolacustrine plain with silty sand alluvial plain. Likely <5.0 m in thickness. Groundwater table near surface in river valley (<1.0 mBGS). Evidence of year round groundwater discharge (stream temperature logs)	Stream reconnaissance data suggests that groundwater discharge occurs in the creek along the distance of the TPR. Water table likely <1.90 mBGS. Moderate potential for dewatering if excavating alluvial sediments in valley. A PTTW may be required.	Medium	Open Bottom Culvert	Narrow, shallow valley with no geomorphic evidence of significant valley side 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	80
	CM - 26b	CM-35	CM-HC-56	Bridge	Overpass	Harmony Creek	None	Surficial silt till and sandy silt glaciolacustrine plain with silty sand alluvial plain. Likely <5.0 m in thickness. Groundwater table near surface in river valley (<1.0 mBGS). Evidence of year round groundwater discharge (stream temperature logs)	Stream reconnaissance data suggests that groundwater discharge occurs in the creek along the distance of the TPR. Water table likely <1.90 mBGS. Moderate potential for dewatering if excavating alluvial sediments in valley. A PTTW may be required.	Medium	Open Bottom Culvert	Narrow, shallow valley with no geomorphic evidence of significant valley side 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	80



**Table 7**  
**Deep Highway Cuts Summary**

AECOM Name	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-C1	F1	Ashburn Road to east of Baldwin Street	11+200 to 11+980	8.5 m	WM43-1, WM42-2, P13	Glaciolacustrine silty clay grading to sandy silt to 1.5 mBGS. Newmarket Till below.	1.2 to 2.3 mBGS	3.2E-07	39 m	No wells are anticipated to be affected by deep cut.	None	The vertical geometry of this cut creates a "bowl" structure 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 require permanent drainage to prevent continual seepage.
DC-C2	F2	Anderson Street to Thickson Road	13+250 to 13+430	8 m	G1C-1, G1C-2, CM6-1, CM6b-1, CM6-2, CM6b-2	Newmarket Till and Halton Till Aquitard - sandy silt till to clayey silt till	1.0 to 2.5 mBGS	5.8E-09	8 m	No wells are anticipated to be affected by deep cut.	None	Site specific data is required to confirm analysis. Estimation does not account for potential sand lenses/ seams. Encountering these features will significantly increase the radius of influence.
DC-C3	F3	Garrard Road	14+490 to 14+660	5.5 m	G1C-1, G1C-2, CM9-1, CM9-2	Halton Till Aquitard - clayey silt till. Potential ORM Gravelly Sand Aquifer at ~9.0 mBGS	~4.0 mBGS	5.8E-09	3 m	One (1) shallow, dug well within 50 m of excavation.	One (1) well requires monitoring prior to, during and following excavations for both water quality and quantity.	Water level obtained from CM9-1. Water level may possibly be higher. Estimation does not account for potential sand lenses/ seams. Encountering these features will significantly increase the radius of influence.
DC-C4	F4	Harmony Road to Grandview Street	20+850 to 21+100	5.5 m	G3C-1, G3C-2, CM21-1, CM21-2, CM21b-1, CM21b-3, CM23b-2	Newmarket Till Aquitard - sandy silt till. Potential ORM Silty Sand to Sand Aquifer at ~7.3 m BGS	~1.0 - 3.0 mBGS. Potential to encounter perched water table within areas of ablation moraine on east side of Harmony Rd.	5.8E-09	7 m	No wells are anticipated to be affected by deep cut	None	Site specific data is required to confirm analysis. Most wells in this area are drilled wells, but homeowners report that wells are sensitive to changes in the local water table (i.e., drilling of a new well)
DC-C5	F5	Grandview Street and Winchester Road E.	21+460 to 22+060	9 m	G3C-1, G3C-2, CM21-1, CM21-2, CM21b-1, CM21b-3, CM23b-2	Newmarket Till Aquitard - sandy silt till. Potential ORM Silty Sand to Sand Aquifer at ~7.3 m BGS	~2.0 - 3.0 mBGS. Potential to encounter perched water table within areas of ablation moraine on east side of Harmony Rd.	5.8E-09	7.5 m	Potential to encounter aquifer unit at base of cut. Nine (9) wells within 250 m of the cut.	Nine (9) wells require monitoring prior to, during and following excavations for both water quality and quantity.	Site specific data is required to confirm analysis. Most wells in this area are drilled wells, but homeowners report that wells are sensitive to changes in the local water table (i.e., drilling of a new well)
DC-C6	F6	Leask Road	23+400 to 23+670	5.5 m	G3C-1, G3C-2, CM24-1, CM24-2, CM24-3, CM24-4, P25, P26	Newmarket Till Aquitard - sandy silt till	1.0 to 7.0 mBGS	3.2E-07	26.5 m	Two (2) shallow, dug wells within 250 m of maximum cut elevation. Deep Cut may intercept sand lenses used for potable water supply.	Two (2) wells require monitoring prior to, during and following excavations for both water quality and quantity. Raising highway grade would reduce cut depth.	Site specific data is required to confirm analysis. Estimation does not account for potential sand lenses/ seams. Encountering these features will significantly increase the radius of influence.
DC-C7	F7	Landmaid Road and Concession 6 Road	24+350 to 25+080	7 m	CM29-1, CM29-2, P26, P27	Newmarket Till Aquitard - sandy silt till	< 7.0 mBGS	3.2E-07	17 m	No wells are anticipated to be affected by deep cut	Seven (7) wells require monitoring prior to, during and following excavations for both water quality and quantity. Raising highway grade would reduce cut depth.	Site specific data is required to confirm analysis. Estimation does not account for potential sand lenses/ seams. Encountering these features will significantly increase the radius of influence.

Profile Reviewed: Provided by TSH (April, 2009)





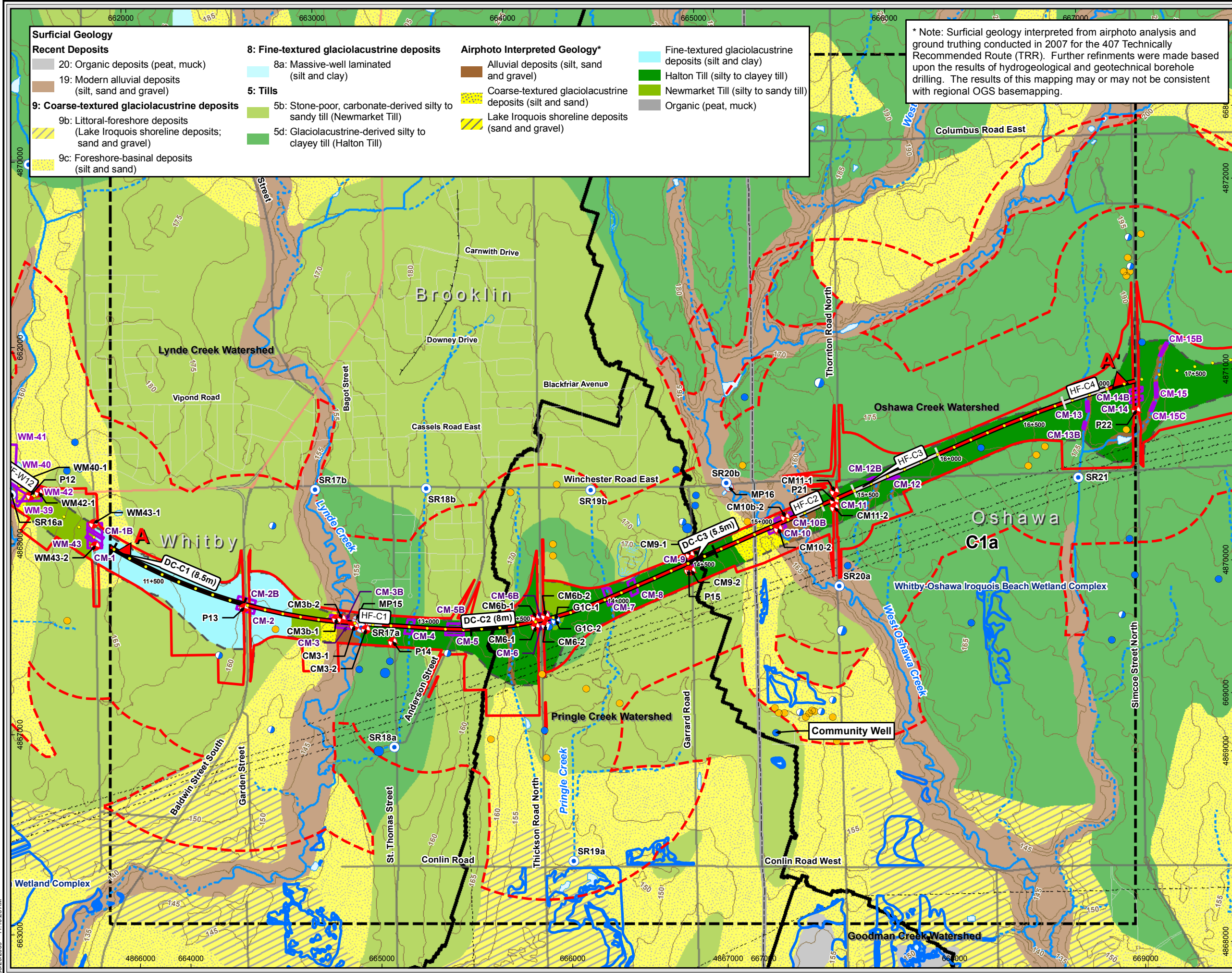
# Appendix A

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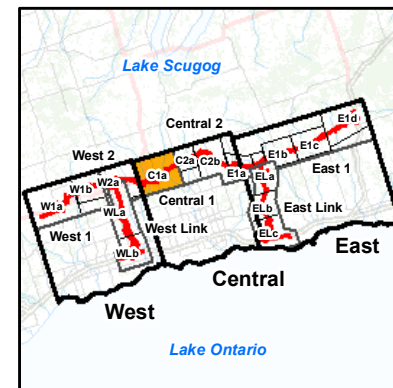
## Hydrogeological Figures and Cross-Sections



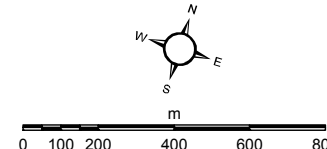
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- Legend**
- Dug Wells**
- Sampled
  - Not Sampled
- Drilled Wells**
- Sampled
  - Not Sampled
- Other Wells**
- No Data
- Boreholes**
- Geotechnical
  - Groundwater Monitor
- Engineering Station**
- Surface Water Monitor
  - Mini-piezometer
- High Fills**
- Deep Cut**
- Contour (5m)**
- Intermittent Stream**
- Permanent Stream**
- Cross-section**
- Limit of Geological Investigation**
- Water Well Survey Study Area**
- Technically Preferred Route**
- Proposed Structure**
- Provincially Significant Wetland**
- Locally Significant Wetland**
- Watershed**
- Municipal Division**
- Waterbody**
- Cartographic Wetland**



Basemapping from Ontario Ministry of Natural Resources  
Surficial Geology: OGS Map Sheet of3331; 1:50000



UTM Zone 17N, NAD 83

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407 Foundations

**Hydrogeological Investigations  
Central Mainline  
Section C1a**

May 2009  
Project 50613

**AECOM**

Figure A1



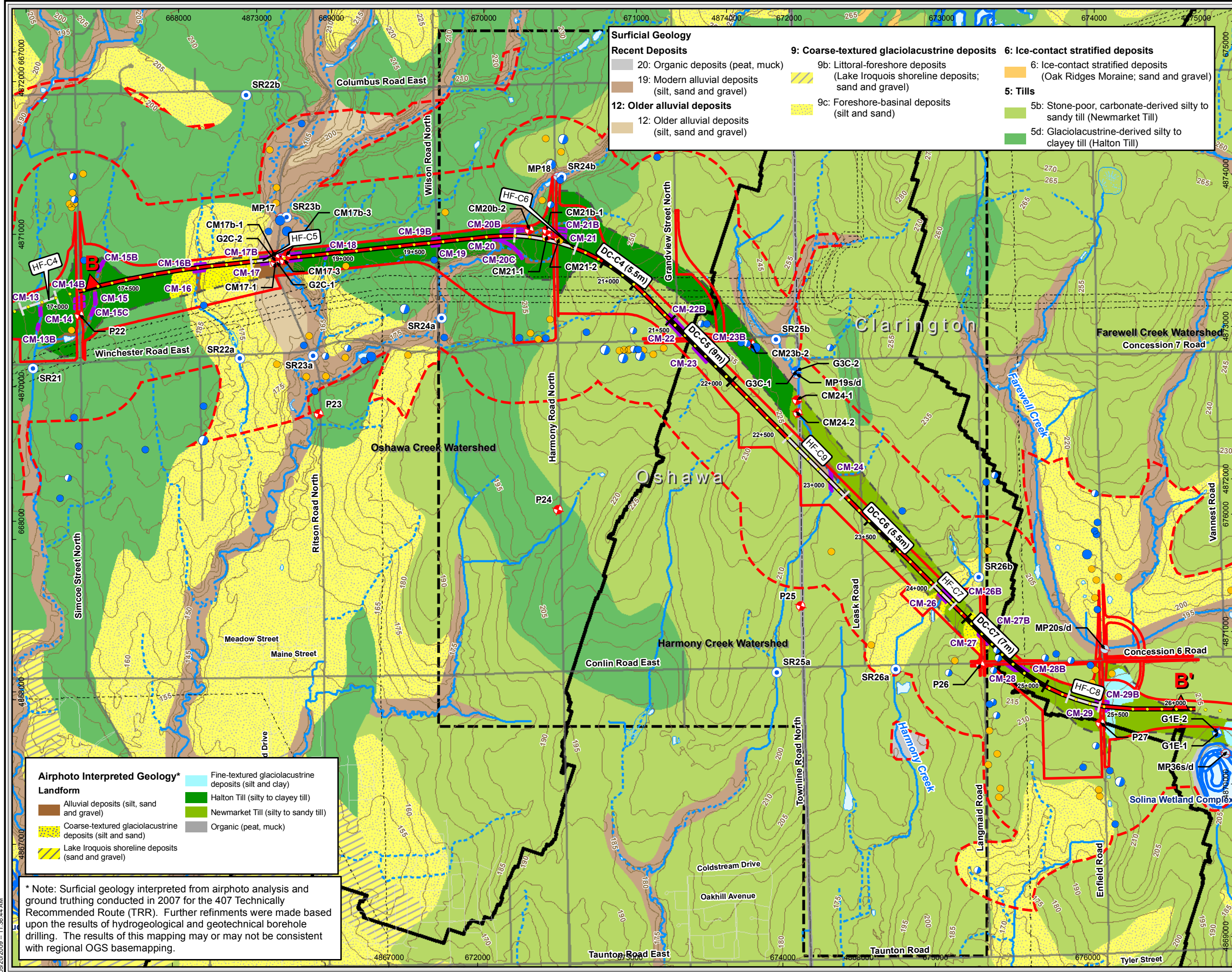








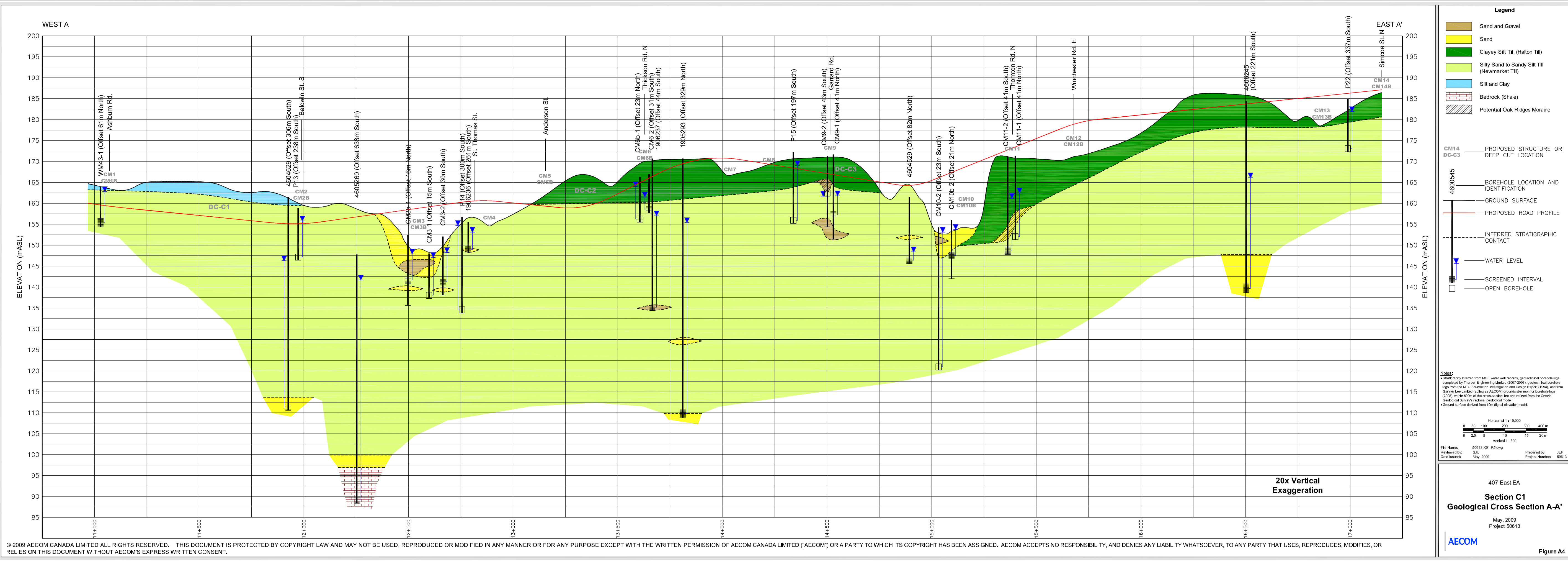
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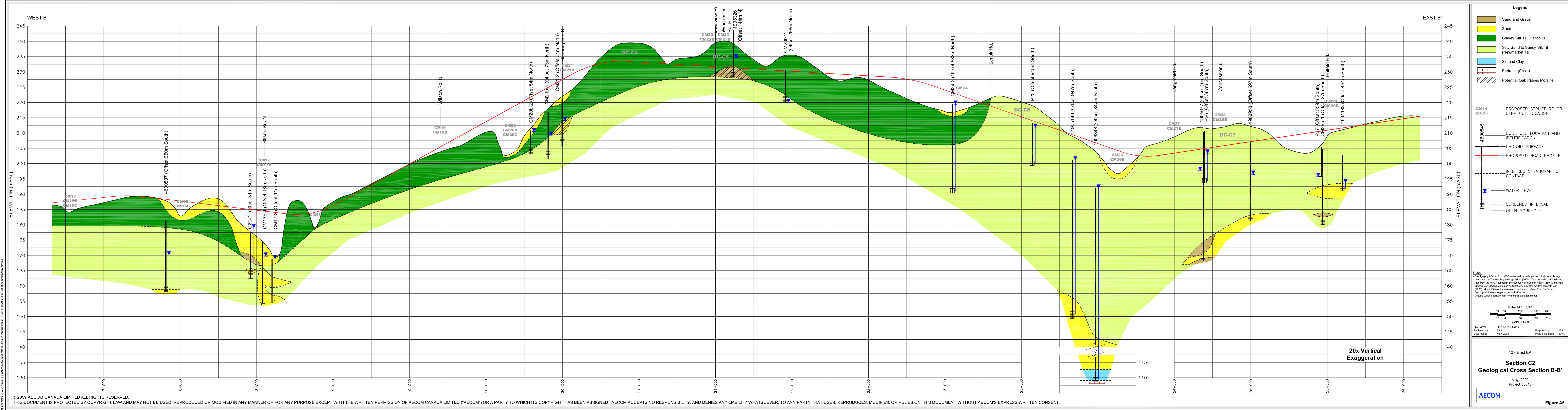




\\proj01\proj005\50613\2009\EA\A-Cross\13X01-RS.dwg Layout:Central 1 FIG A4 Plot:Jun 03, 2009 @ 12:00pm by prwsej











# Appendix B

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## Hydrogeology Borehole Logs



G.W.P. 50-613				LOCATION N 4868516 & E 665333		1 OF 2		METRIC				
HWY 407				BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID)		ORIGINATED BY RBC		COMPILED BY JC				
DATUM Geodetic				DATE 12.6.07 - 12.7.07		CHECKED BY SJU						
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT		UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	"N" VALUES	SHEAR STRENGTH kPa	W P			W
171.0	0.0		1	SS	31	171						7 46 38 9 4 30 53 13 14 41 32 13
170.0	1.0		2	SS	68/	170						
			3	SS	70	169						
			4	SS	50/	168						
					0.13m							
			5	SS	50/	167						
					0.13m							
			6	SS	50/	166						
					0.10m							
			7	SS	50/	165						
					0.08m							
			8	SS	50/	164						
					0.13m							
			9	SS	50/	163						
					0.05m							
			10	CS		162						
			11	CS		161						

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

RECORD OF BOREHOLE No G1C-1										2 OF 2		METRIC				
G.W.P. 50-613		LOCATION N 4868516 & E 665333		ORIGINATED BY RBC												
HWY 407		BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID)		COMPILED BY JC												
DATUM Geodetic		DATE 12.6.07 - 12.7.07		CHECKED BY SJU												
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				W P W W L				
171.0	SILTY SAND TO SANDY SILT TILL (continued)					○ UNCONFINED + FIELD VANE				WATER CONTENT (%)			γ	GR SA SI CL		
			12	CS	● QUICK TRIAXIAL × LAB VANE											
			13	CS												
158.2	Borehole terminated at 12.8 m in silty sand fill.  Water Level : 0.83 mBGS, measured January 14, 2008													10 38 35 17		
12.8																

+ 3, X 3: Numbers refer to Sensitivity

RECORD OF BOREHOLE No G1C-2										1 OF 1		METRIC	
G.W.P. 50-613		LOCATION N 4868514 & E 665332		ORIGINATED BY RBC									
HWY 407		BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID)		COMPILED BY JC									
DATUM Geodetic		DATE 12.10.07 - 12.10.07		CHECKED BY SJU									
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		WATER CONTENT (%)		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
171.0	TOPSOIL Brown topsoil, grass, rootlets.						771						
170.0	SILTY SAND TO SANDY SILT TILL (Newmarket Till) Brown silty sand to sandy silt till, trace to some clay, trace to some fine sub-angular gravel, dry to moist, very dense.						170						
165.0	Borehole terminated at 6.02 m in silty sand till.  Water Level : 0.535 mBGS, measured January 14, 2008  <i>Please note borehole was augered without sampling. Lithology inferred from soils sampled at adjacent borehole G1C-1.</i>						165						

+ 3, × 3: Numbers refer to Sensitivity

G.W.P. 60-613				LOCATION N 4868516 & E 665333		1 OF 2		METRIC	
HWY 407		BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID)		ORIGINATED BY HSA		COMPILED BY JC			
DATUM Geodetic		DATE 1.14.08 - 1.14.08		CHECKED BY SJU					
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	RESISTANCE (MPa)	WATER CONTENT (%)	UNIT WEIGHT (kN/m <sup>3</sup> )
175.0 0.0	TOPSOIL Dark grey to black topsoil, rootlets	[Strat Plot]	1	SS	9				
174.0 1.0	SAND Brown fine sand interbedded with fine to coarse well rounded gravel, trace medium to coarse sand, trace clay, saturated, compact.	[Strat Plot]	2	SS	5				
172.7 2.3	-Silty sand encountered from about 2.3 to 3.1 m.	[Strat Plot]	3	SS	42				
171.9 3.1		[Strat Plot]	4	SS	17				
		[Strat Plot]	5	SS	24				
		[Strat Plot]	6	SS	18				
		[Strat Plot]	7	SS	15				
		[Strat Plot]	8	SS	17				
167.4 7.6	SAND AND GRAVEL Grey sand and gravel, trace to some silt, trace clay, saturated, compact.	[Strat Plot]	9	SS	22				
165.6 9.4	SILTY SAND TILL (Newmarket Till) Grey silty sand till, trace angular to sub-angular gravel, trace clay,	[Strat Plot]	10	SS	76				

Continued Next Page

Numbers refer to Sensitivity



RECORD OF BOREHOLE No G2C-1															2 OF 2		METRIC	
G.W.P. 50-613			LOCATION N 4868516 & E 665333			ORIGINATED BY HSA												
HWY 407			BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID)			COMPILED BY JC												
DATUM Geodetic			DATE 1.14.08 - 1.14.08			CHECKED BY SJU												
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	20 40 60	W P W W L	UNIT WEIGHT	GR SA SI CL					
175.0	saturated, dense to very dense.						105											
			11	SS	50/		164											
					0.13m													
			12	SS	24		163											
162.8																		
12.2	-Grey fine sand, some silt, trace clay from about 12.2 to 12.9 m.		13	SS			162											
162.1																		
12.9			14	SS	50/		161											
					0.13m													
161.2			15	SS	50/		160											
13.8	CLAYEY SILT TILL Grey clayey silt till, trace angular to subangular gravel, saturated, hard.				0.13m													
			16	SS	50/													
					0.10m													
159.8																		
15.2	Borehole terminated at 15.24 m in clayey silt till.  Water level: flowing above top of pipe to 1.04 mAGS, measured June, 2008.																	

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

ONTMT/4S 407 HYDROGEOLOGY.GPJ 5/28/09

RECORD OF BOREHOLE No G2C-2															1 OF 1		METRIC	
G.W.P. 50-613			LOCATION N 4868514 & E 665332			ORIGINATED BY HSA												
HWY 407			BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID)			COMPILED BY JC												
DATUM Geodetic			DATE 1.15.08 - 1.15.08			CHECKED BY SJU												
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	20 40 60	W P W W L	UNIT WEIGHT	GR SA SI CL					
175.1	TOPSOIL Dark grey to black topsoil, rootlets						175											
174.1																		
1.0	SAND Brown fine sand interbedded with fine to coarse well rounded gravel, trace medium to coarse sand, trace clay, saturated, compact.						174											
172.8							173											
2.3	-Silty sand encountered from about 2.3 to 3.1 m.																	
172.0							172											
3.1																		
169.0							171											
6.1	Borehole terminated at 6.1 m in sand and gravel  Water level: 2.13 mBGS, measured February 8, 2008.  Please note borehole was augered without sampling. Lithology inferred from soils sampled at adjacent borehole G2C-1.						170											

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

ONTMT/4S 407 HYDROGEOLOGY.GPJ 5/28/09

G.W.P. 50-613				LOCATION N 4871770 & E 672817		1 OF 2		METRIC					
HWY 407				BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID)		ORIGINATED BY RBC/JED		COMPILED BY JC					
DATUM Geodetic				DATE 12.14.07 - 12.18.07		CHECKED BY SJU							
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID UNIT MOISTURE CONTENT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W p W W L	W p W W L	UNIT WEIGHT	GR SA SI CL	
220.4	TOPSOIL, Brown topsoil, rootlets, lens of brown fine sand at 0.03m		1	SS	7		220						
219.6	CLAYEY SILT AND SAND TILL (Halton Till) Brown, clayey silt to silty clay till, with sand, trace fine sub-angular gravel, wet, stiff to hard.		2	SS	16		219						5 38 37 20
0.8			3	SS	16		218						
			4	SS	16		217						4 36 36 24
217.3	CLAYEY SILT AND SAND TILL (Halton Till) Brown to grey, clayey silt to silty clay till, with sand, trace fine sub-angular gravel, wet, stiff to hard.		5	SS	29		216						
3.1			6	SS	51		215						
			7	SS	55		214						2 25 38 35
214.3	SANDY SILT AND CLAY TILL (Halton Till) Brownish grey trending to grey, sandy silt and clay silt, fine and coarse sand, trace fine to coarse sub-angular gravel, saturated, very stiff to hard.		8	SS	56		213						
6.1			9	SS	37		212						
							211						

[illegible]

RECORD OF BOREHOLE No G3C-2														1 OF 2		METRIC	
G.W.P. 50-613		LOCATION N 4871774 & E 675817				ORIGINATED BY RBC/JED											
HWY 407		BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID)				COMPILED BY JC											
DATUM Geodetic		DATE 12.18.07 - 12.18.07				CHECKED BY SJU											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID UNIT MOISTURE CONTENT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60	W P W W L	WATER CONTENT (%)	20 40 60	UNIT WEIGHT	GR SA SI CL			
220.4	0.0 TOPSOIL Brown topsoil, rootlets, lens of brown fine sand at 0.03m						220										
219.6	0.8 CLAYEY SILT AND SAND TILL (Halton Till) Brown, clayey silt to silty clay till, with sand, trace fine sub-angular gravel, wet, stiff to hard.						219										
217.3	3.1 CLAYEY SILT AND SAND TILL (Halton Till) Brown to grey, clayey silt to silty clay till, with sand, trace fine sub-angular gravel, wet, stiff to hard.						218										
214.3	6.1 SANDY SILT AND CLAY TILL (Halton Till) Brownish grey trending to grey, sandy silt and clay silt, fine and coarse sand, trace fine to coarse sub-angular gravel, saturated, very stiff to hard.						217										
211.3	9.1 Borehole terminated at 9.14 m in silty clay till.  Water Level: 4.84 mBGS, measured January 14, 2008.						216										

Continued Next Page

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

ONTMT4S 407 HYDROGEOLOGY GPJ 5/28/09

RECORD OF BOREHOLE No G3C-2														2 OF 2		METRIC	
G.W.P. 50-613		LOCATION N 4871774 & E 675817				ORIGINATED BY RBC/JED											
HWY 407		BOREHOLE TYPE Hollow Stem Auger - 6.25" Diameter (ID)				COMPILED BY JC											
DATUM Geodetic		DATE 12.18.07 - 12.18.07				CHECKED BY SJU											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID UNIT MOISTURE CONTENT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60	W P W W L	WATER CONTENT (%)	20 40 60	UNIT WEIGHT	GR SA SI CL			
220.4	Please note borehole was augered without sampling. Lithology inferred from soils sampled at adjacent borehole G3C-1.																

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

ONTMT4S 407 HYDROGEOLOGY GPJ 5/28/09





# Appendix C

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## Data Tables



**Table C1: Monitoring Well Construction Details**

Monitor	MOE Well ID #	Easting m	Northing m	Completion Date dd-mmm-yy	Ground Elevation mASL	Top of Pipe Elevation mASL	Well Diameter m	Well Stick Up mAGL	Well Depth mBGL	Well Screen Length m	Depth of Well Screen (mBGL) Top - Bottom	Depth of Sand Pack (mBGL) Top - Bottom	Depth of Seal (mBGL) Top - Bottom
<b>CENTRAL</b>													
G1C-1	A060933	665333	4868516	10-Dec-07	170.98	171.78	0.051	0.77	12.80	1.52	11.28 - 12.80	10.67 - 12.80	0.00 - 10.67
G1C-2		665332	4868514	10-Dec-07	170.99	171.84	0.051	0.85	6.02	4.57	1.45 - 6.02	0.91 - 6.02	0.00 - 0.91
G2C-1	A072147	669154	4871357	14-Jan-08	175.05	175.89	0.051	0.91	15.24	1.52	12.19 - 13.72	11.58 - 14.02	0.00 - 11.58
G2C-2		669150	4871363	14-Jan-08	175.06	175.96	0.051	0.84	6.10	4.57	1.52 - 6.10	1.22 - 6.10	0.00 - 1.22
G3C-1		672817	4871770	19-Dec-07	220.37	221.32	0.051	0.82	13.72	1.52	12.19 - 13.72	11.73 - 13.72	0.00 - 11.73
G3C-2	A060932	672817	4871774	19-Dec-07	220.35	221.12	0.051	0.79	9.14	4.57	4.57 - 9.14	4.27 - 9.14	0.00 - 4.27

**NOTES:**

- 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.
- On Jan 31, 2008 BH nomenclature was changed from BH1W-S or BH1W-D to G1W-2 (shallow), G1W-1 (deep).
- mASL - metres above sea level; mBGL - meters below ground level
- mAGL - metres above ground level, Top of pipe elevation calculated from ground elevation
- Seal (from top of sand pack to ground surface) consists of a layer of holeplug, bentonite and/or cement.

Table C2 – Hydraulic Testing Results

Monitor	Well Stick Up	Well Depth	Well Screen Length	Depth of Well Screen (mBGL)			Lithology of Screened Interval	Geologic Unit	Aquifer Model	Solution Method	K1 <sup>1</sup>	K2 <sup>2</sup>	K Geometric Mean	Remarks
	mAGL	mBGL	m	Top	-	Bottom					(m/sec)	(m/sec)	(m/sec)	
G1C-1	0.77	12.80	1.52	11.28	-	12.80	Newmarket Till	Newmarket Till	Confined	Hvorslev	6.3E-07	3.1E-07	4.4E-07	-
G1C-2	0.85	6.02	4.57	1.45	-	6.02	Weathered Newmarket Till	Newmarket Till	Unconfined	B&R	2.5E-06	2.1E-06	2.3E-06	-
G2C-1	0.91	15.24	1.52	12.19	-	13.72	Fine Sand Layer Confined within Newmarket Till	Sand Lens	Confined	Hvorslev	5.0E-06	5.0E-06	5.0E-06	-
G2C-2	0.84	6.10	4.57	1.52	-	6.10	Glaciolacustrine Fine Sand Interbedded with Gravel	Glaciolacustrine	Unconfined	B&R	1.1E-05	1.5E-05	1.3E-05	-
G3C-1	0.82	13.72	1.52	12.19	-	13.72	Newmarket Till	Newmarket Till	Confined	Hvorslev	1.6E-06	3.2E-06	2.3E-06	-
G3C-2	0.79	9.14	4.57	4.57	-	9.14	Halton Till	Halton Till	Confined	Hvorslev	5.8E-09	-	5.8E-09	Very slow response

NOTES:  
<sup>1</sup> - Falling Head Test  
<sup>2</sup> - 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	G1C-1 14-Jan-08	G1C-2 14-Jan-08	BH600* 14-Jan-08	G2C-1 22-Apr-08	G2C-2 16-Jan-08	G3C-1 15-Jan-08	G3C-2 15-Jan-08	Sample Blank** 28-Apr-08
ORGANICS											
C>10 - C16 (F2)	µg/L	100	NA	< 100	< 100	< 100	< 100	< 100	< 100	< 100	<0.2
C>16 - C34 (F3)	µg/L	500	NA	< 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
C>34 - C50	µg/L	500	NA	< 500	< 500	< 500	< 500	< 500	< 500	< 500	<500
C6 - C10 (F1 minus BTEX)	µg/L	100	NA	< 100	< 100	< 100	< 100	< 100	< 100	< 100	<500
C6 - C10 (F1)	µg/L	100	NA	< 100	< 100	< 100	< 100	< 100	< 100	< 100	<100
C6 - C16 (F1 + F2)	µg/L	100	NA	< 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	<100
Ethylbenzene	µg/L	0.1	2.4	0.11	0.11	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	<0.1
Toluene	µg/L	0.2	NA	0.39	0.35	0.41	< 0.2	0.45	0.41	0.57	NA
Xylenes (Total)	µg/L	0.14	300	0.50	0.30	0.48	0.15	0.70	0.18	0.56	2.40
Gravimetric Heavy Hydrocarbons	µg/L	500	NA	NA	NA	NA	NA	NA	NA	NA	<0.14
MICROBIOLOGY											
Total Coliforms	CFU/100mL	1	< 1	38	103	51	240	14	21	74	<1
Escherichia coli	CFU/100ml	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	<1
Heterotrophic Plate Count (HPC) (CFU/ml)	CFU/ml	10	< 500	160	3,200	310	585	220	280	1,040	40
INORGANICS AND METALS											
Alkalinity (as CaCO3)	mg/L	5	30-500	553	250	245	220	217	292	303	<10
Aluminum	mg/L	0.004	0.1	0.008	0.005	0.004	< 0.004	0.004	0.005	0.005	<0.004
Ammonia (as N)	mg/L	0.02	NA	1.73	0.17	0.09	0.50	0.26	0.59	0.57	<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
Barium	mg/L	0.002	1.0	0.081	0.130	0.140	0.051	0.104	0.078	0.049	<0.002
Bicarbonate (as CaCO3)	mg/L	5	NA	553	250	245	220	217	292	303	<10
Boron	mg/L	0.01	5.0	0.069	0.042	0.040	0.364	0.035	0.051	0.133	0.023
Bromide	mg/L	0.05	NA	< 0.05	0.55	0.61	< 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
Calcium	mg/L	0.05	NA	175.0	127.0	132.0	142.0	71.5	153.0	117.0	0.3
Calculated Total Dissolved Solids	mg/L	5	NA	-	-	-	-	-	645	450	-
Carbonate (as CaCO3)	mg/L	5	NA	< 5	< 5	< 5	< 5	< 5	< 5	< 5	<10
Chloride	mg/L	0.1	250	265	426	470	18.20	8.98	29.60	55.50	0.58
Colour	TCU	5	5	20	15	< 5	10	< 5	15	< 5	<5
Copper	mg/L	0.003	1.0	0.01	< 0.003	< 0.003	0.00	< 0.003	< 0.003	< 0.003	<0.003
Electrical Conductivity	uS/cm	2	NA	2,310	1,730	1,740	730	1.4	951	767	16
Field Conductivity	uS/cm	N/A	NA	2,340	1,845	1,845	704	484	815	722	-
Fluoride	mg/L	0.05	1.5	< 0.05	0.07	0.09	< 0.05	0.05	0.06	0.07	<0.05
Hydroxide	mg/L	5	NA	< 5	< 5	< 5	< 5	< 5	< 5	< 5	<10
Iron	mg/L	0.005	0.3	0.274	0.439	0.396	< 0.005	0.381	< 0.005	< 0.005	<0.005
Langelier Index	N/A	N/A	NA	1.65	1.45	1.45	1.24	(5.99)	1.21	1.21	-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
Magnesium	mg/L	0.05	NA	91.6	110.0	116.0	8.8	15.1	30.9	15.8	0.05
Manganese	mg/L	0.002	0.05	0.265	0.080	0.087	0.004	0.019	0.615	0.080	<0.002
Molybdenum	mg/L	0.002	NA	0.008	0.007	0.007	0.003	<0.002	0.014	0.004	<0.002
Nickel	mg/L	0.003	NA	0.010	0.008	0.008	< 0.003	< 0.003	0.016	< 0.003	<0.003
Nitrate as N	mg/L	0.05	10	7.60	< 0.05	< 0.05	14.90	< 0.05	0.44	1.56	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
Orthophosphate as P	mg/L	0.1	NA	< 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	7.90	8.07	8.05	8.20	8.15	7.93	8.04	6.3
Field pH	N/A	N/A	NA	6.79	7.05	7.05	7.11	-	7.68	7.64	-
Potassium	mg/L	0.05	NA	197	6.70	6.32	2.09	1.35	2.40	1.85	0.1
Reactive Silica	mg/L	0.05	NA	15.40	27.10	26.90	6.34	18.10	13.40	13.30	<0.05
Saturation pH	N/A	N/A	NA	6.25	6.62	6.60	6.96	7.14	6.72	6.83	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
Silver	mg/L	0.002	NA	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	<0.002
Sodium	mg/L	0.05	20 (200)	97.30	54.70	55.60	7.35	6.09	12.60	25.50	1.06
Strontium	mg/L	0.005	NA	0.659	1.32	1.37	0.297	0.206	0.491	0.315	<0.005
Sulphate	mg/L	0.1	500	274	121	126	76.2	45.5	227	37.4	0.17
Thallium	mg/L	0.006	NA	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	<0.006
Titanium	mg/L	0.002	NA	0.006	0.003	0.003	< 0.002	< 0.002	0.006	< 0.002	<0.002
Total Dissolved Solids	mg/L	20	500	1,610	1,400	1,350	548	308	506	462	516
Total Hardness (as CaCO3)	mg/L	10	80-100	814	770	807	391	241	509	357	<10
Total Organic Carbon	mg/L	0.5	NA	24.3	19.2	27.4	140	-	5.8	5.3	-
Total Phosphorus	mg/L	0.05	NA	3.06	5.66	2.76	2.15	8.77	6.40	4.95	<0.05
Turbidity	NTU	0.5	5.0	50	60	34	120	8	50	35	112
Uranium	mg/L	0.002	0.02	0.015	< 0.002	< 0.002	0.002	< 0.002	0.011	0.003	<0.002
Vanadium	mg/L	0.002	NA	0.003	0.002	0.002	< 0.002	< 0.002	< 0.002	< 0.002	<0.002
Zinc	mg/L	0.005	5.0	0.023	0.018	< 0.005	0.017	< 0.005	0.013	0.008	<0.005
Field Temp	°C	N/A	NA	8.00	7.90	7.90	7.60	-	6.30	5.10	-

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  
\*\* Sample Blank: Collected during sampling of G8E-2  
NTNC - To Numerous To Count

Table C4 - Mini-Piezometer Data and Construction

Location	MP15		MP16		MP17		MP18		MP19-Shallow		MP19-Deep		MP20-Shallow		MP20-Deep	
	Original	Replacement	Original	Replacement	Original	Replacement	Original	Replacement	Original	Replacement	Original	Replacement	Original	Replacement	Original	Replacement
Date Installed	1-Nov-07	03-Sep-08	2-Nov-07	14-May-08	1-Nov-07	30-Apr-08	1-Nov-07	19-Jun-08	4-Nov-07	4-Nov-07	2-Nov-07	30-Apr-08	2-Nov-07	30-Apr-08	2-Nov-07	30-Apr-08
Stick Up (m above stream bed or surface)	1.47	1.46	1.53	1.64	1.09	1.84	1.19	1.01	0.91	1.39	0.80	1.62	0.81	1.23		
Depth of Top of Screen (m below stream bed or surface)	1.68	1.38	1.61	1.21	1.42	2.23	1.32	1.55	1.61	2.95	0.89	1.51	2.64	2.80		
Depth of Bottom of Screen (m below stream bed or surface)	1.98	1.68	1.91	1.51	1.72	2.53	1.61	1.86	1.90	3.25	1.18	1.81	2.93	3.10		
Depth of Mid Screen (m below stream bed or surface)	1.83	1.53	1.76	1.36	1.57	2.38	1.47	1.71	0.76	3.10	1.03	1.66	2.78	2.95		
Depth of Top of Screen (m below top of pipe)	3.14	2.83	3.14	2.85	2.51	4.07	2.51	2.56	2.52	4.34	1.68	3.13	3.45	4.03		
Depth of Bottom of Screen (m below top of pipe)	3.44	3.14	3.44	3.15	2.80	4.37	2.81	2.87	2.81	4.64	1.98	3.43	3.74	4.33		
Depth of Mid Screen (m below top of pipe)	3.29	2.98	3.29	3.00	2.65	4.22	2.66	2.72	2.66	4.49	1.83	3.28	3.59	4.18		
<b>Water Depth (m below top of pipe)</b>																
On Installation	Date	1-Nov-07	-	-	2-Nov-07	-	-	1-Nov-07	-	-	-	-	-	-	-	-
Depth to Water (MP) (mbtop)		2.51 ***	-	-	2.28	-	-	1.95 ***	-	-	1.39	-	-	-	-	-
Depth to Water (Water Body) (mbtop)		1.28	-	-	1.15	-	-	0.74	-	-	0.74	-	-	-	-	-
Vertical Separation (DL)		1.68	-	-	1.61	-	-	1.42	-	-	1.32	-	-	-	-	-
Water Level Difference (Df)		-1.23	-	-	-1.13	-	-	-1.21	-	-	-0.66	-	-	-	-	-
Hydraulic Gradient (DH/DL)		-0.74	-	-	-0.70	-	-	-0.85	-	-	-0.50	-	-	-	-	-
Nov-07	Date	29-Nov-07	-	-	29-Nov-07	-	-	29-Nov-07	-	-	-	-	-	-	-	-
Depth to Water (MP) (mbtop)		1.17	-	-	0.99	-	-	1.80	-	-	1.37	-	-	-	-	-
Depth to Water (Water Body) (mbtop)		1.20	-	-	1.15	-	-	0.71	-	-	0.70	-	-	-	-	-
Vertical Separation (DL)		1.68	-	-	1.61	-	-	1.42	-	-	1.32	-	-	-	-	-
Water Level Difference (Df)		0.03	-	-	0.16	-	-	-1.09	-	-	-0.67	-	-	-	-	-
Hydraulic Gradient (DH/DL)		0.02	-	-	0.10	-	-	-0.77	-	-	-0.50	-	-	-	-	-
Feb-08	Date	8-Feb-08	-	-	8-Feb-08	-	-	8-Feb-08	-	-	8-Feb-08	-	-	8-Feb-08	-	8-Feb-08
Depth to Water (MP) (mbtop)		0.96 *	-	-	1.08 *	-	-	1.67	-	-	1.27	-	-	2.23	-	4.41
Depth to Water (Water Body) (mbtop)		1.12	-	-	1.20	-	-	0.78	-	-	0.46 *	-	-	0.82	-	1.33
Vertical Separation (DL)		1.68	-	-	1.61	-	-	1.42	-	-	1.32	-	-	1.61	-	2.95
Water Level Difference (Df)		0.16	-	-	0.12	-	-	-0.89	-	-	-0.81	-	-	-1.41	-	-3.08
Hydraulic Gradient (DH/DL)		0.10	-	-	0.07	-	-	-0.63	-	-	-0.61	-	-	-0.88	-	-1.04
Mar-08	Date	15-Mar-08	31-Mar-08	-	15-Mar-08	31-Mar-08	-	15-Mar-08	31-Mar-08	-	15-Mar-08	31-Mar-08	15-Mar-08	31-Mar-08	31-Mar-08	-
Depth to Water (MP) (mbtop)		1.12	1.03	-	1.56	1.31	-	1.82	1.60	-	1.25	1.25	1.96	1.86	4.22	4.13
Depth to Water (Water Body) (mbtop)		1.15	0.92	-	1.45	1.23	-	0.72	0.67	-	0.49	0.49	0.85	0.59	1.32	1.07
Vertical Separation (DL)		1.68	1.68	-	1.61	1.61	-	1.42	1.42	-	1.32	1.32	1.61	1.61	2.95	2.95
Water Level Difference (Df)		0.03	-0.12	-	-0.11	-0.08	-	-0.91	-0.93	-	-0.83	-0.77	-	-1.11	-1.27	-2.90
Hydraulic Gradient (DH/DL)		0.02	-0.07	-	-0.07	-0.05	-	-0.64	-0.65	-	-0.63	-0.58	-	-0.69	-0.79	-0.98
Apr-08	Date	-	-	-	-	-	-	-	30-Apr-08	30-Apr-08	-	-	-	-	-	-
Depth to Water (MP) (mbtop)		-	-	-	-	-	-	-	3.22***	-	-	-	-	-	-	2.74 **, ***
Depth to Water (Water Body) (mbtop)		-	-	-	-	-	-	-	1.49	MP Broken	-	-	-	-	-	1.33
Vertical Separation (DL)		-	-	-	-	-	-	-	2.23	-	-	-	-	-	-	1.51
Water Level Difference (Df)		-	-	-	-	-	-	-	-1.73	-	-	-	-	-	-	-1.41
Hydraulic Gradient (DH/DL)		-	-	-	-	-	-	-	-0.78	-	-	-	-	-	-	-0.94
May-08	Date	-	-	14-May-08	-	-	14-May-08	-	8-May-08	-	8-May-08	14-May-08	-	14-May-08	-	8-May-08
Depth to Water (MP) (mbtop)		-	-	1.14***	-	-	1.47***	-	1.67	-	-	1.33	-	3.85	-	3.56
Depth to Water (Water Body) (mbtop)		-	-	1.20	-	-	1.22	-	1.47	-	-	1.26 >	-	1.26 >	-	1.3
Vertical Separation (DL)		-	-	1.68	-	-	1.21	-	2.23	-	-	2.95	-	2.95	-	1.51
Water Level Difference (Df)		-	-	0.06	-	-	-0.26	-	-0.20	-	-	1.07	-	-2.59	-	-0.03
Hydraulic Gradient (DH/DL)		-	-	0.04	-	-	-0.21	-	-0.09	-	-	0.67	-	-0.88	-	-0.02
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)		-	-	-	-	-	1.09	-	1.42	-	-	0.26	-	3.83	-	1.39
Depth to Water (Water Body) (mbtop)		-	-	MP Stolen	-	-	1.20	-	1.50	-	-	0.85 >	-	1.26 >	-	1.36
Vertical Separation (DL)		-	-	MP Replaced	-	-	1.21	-	2.23	-	-	1.61	-	2.95	-	1.51
Water Level Difference (Df)		-	-	-	-	-	0.11	-	0.08	-	-	0.59	-	-2.57	-	-0.03
Hydraulic Gradient (DH/DL)		-	-	-	-	-	0.09	-	0.04	-	-	0.37	-	-0.87	-	-0.02

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

\*\* indicates new stick up added

\*\*\* indicates measurement taken after installation

&gt; 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 (M

Table C4 - Mini-Piezometer Data and Construction

Location	MP15		MP16		MP17		MP18		MP19-Shallow		MP19-Deep		MP20-Shallow		MP20-Deep	
	Original	Replacement	Original	Replacement	Original	Replacement	Original	Replacement	Original	Replacement	Original	Replacement	Original	Replacement	Original	Replacement
Date Installed	1-Nov-07	03-Sep-08	2-Nov-07	14-May-08	1-Nov-07	30-Apr-08	1-Nov-07	19-Jun-08	4-Nov-07	4-Nov-07	2-Nov-07	30-Apr-08	2-Nov-07	30-Apr-08	2-Nov-07	30-Apr-08
Stick Up (m above stream bed or surface)	1.47	1.46	1.53	1.64	1.09	1.84	1.19	1.01	0.91	1.39	0.80	1.62	0.81	1.23		
Depth of Top of Screen (m below stream bed or surface)	1.68	1.38	1.61	1.21	1.42	2.23	1.32	1.55	1.61	2.95	0.89	1.51	2.64	2.80		
Depth of Bottom of Screen (m below stream bed or surface)	1.98	1.68	1.91	1.51	1.72	2.53	1.61	1.86	1.90	3.25	1.18	1.81	2.93	3.10		
Depth of Mid Screen (m below stream bed or surface)	1.83	1.53	1.76	1.36	1.57	2.38	1.47	1.71	0.76	3.10	1.03	1.66	2.78	2.95		
Depth of Top of Screen (m below top of pipe)	3.14	2.83	3.14	2.85	2.51	4.07	2.51	2.56	2.52	4.34	1.68	3.13	3.45	4.03		
Depth of Bottom of Screen (m below top of pipe)	3.44	3.14	3.44	3.15	2.80	4.37	2.81	2.87	2.81	4.64	1.98	3.43	3.74	4.33		
Depth of Mid Screen (m below top of pipe)	3.29	2.98	3.29	3.00	2.65	4.22	2.66	2.72	2.66	4.49	1.83	3.28	3.59	4.16		
<b>Water Depth (m below top of pipe)</b>																
Jul-08	Date	-	-	21-Jul-08	-	-	21-Jul-08	-	-	21-Jul-08	31-Jul-08	-	31-Jul-08	-	-	21-Jul-08
	Depth to Water (MP) (mbtop)	-	-	-	-	-	1.42	-	-	1.16	0.01	-	3.67	-	-	1.29
	Depth to Water (Water Body) (mbtop)	-	-	MP Stolen	-	-	1.50	-	-	0.65	0.66	-	1.16	-	-	0.96
	Vertical Separation (DL)	-	-	MP Replaced	-	-	2.23	-	-	1.55	1.61	-	2.95	-	-	1.51
	Water Level Difference (DH)	-	-	-	-	-	0.08	-	-	-0.51	0.65	-	-2.51	-	-	0.05
Aug-08	Hydraulic Gradient (DH/DL)	-	-	-	-	-	<b>0.04</b>	-	-	-0.57	<b>0.40</b>	-	-0.85	-	-	<b>0.03</b>
	Date	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Depth to Water (MP) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Depth to Water (Water Body) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Vertical Separation (DL)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sep-08	Water Level Difference (DH)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Hydraulic Gradient (DH/DL)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Date	-	-	3-Sep-08	-	-	3-Sep-08	-	-	3-Sep-08	3-Sep-08	-	3-Sep-08	-	-	-
	Depth to Water (MP) (mbtop)	-	-	-	-	-	1.15	-	-	0.09	0.14	-	3.56	-	-	-
	Depth to Water (Water Body) (mbtop)	-	-	MP Stolen	-	-	1.21	-	MP Stolen	-	0.76	0.85 >	1.26 >	-	-	-
Oct-08	Vertical Separation (DL)	-	-	MP Replaced	-	-	1.21	-	-	1.80	1.61	-	2.95	-	-	-
	Water Level Difference (DH)	-	-	-	-	-	0.06	-	-	0.67	0.71	-	-2.30	-	-	-
	Hydraulic Gradient (DH/DL)	-	-	-	-	-	<b>0.05</b>	-	-	<b>0.75</b>	<b>0.44</b>	-	-0.78	-	-	-
	Date	-	-	15-Oct-08	-	-	15-Oct-08	-	-	15-Oct-08	15-Oct-08	-	15-Oct-08	-	-	15-Oct-08
	Depth to Water (MP) (mbtop)	-	-	0.53	-	-	0.90	-	-	0.08	0.40	-	3.34	-	-	1.25
Nov-08	Depth to Water (Water Body) (mbtop)	-	-	0.38	-	-	1.22	-	-	0.78	0.83 >	-	1.33 >	-	-	1.30
	Vertical Separation (DL)	-	-	1.38	-	-	1.21	-	-	1.80	1.61	-	2.95	-	-	1.51
	Water Level Difference (DH)	-	-	-0.15	-	-	0.32	-	-	0.70	0.43	-	-2.01	-	-	0.05
	Hydraulic Gradient (DH/DL)	-	-	-0.11	-	-	<b>0.26</b>	-	-	<b>0.79</b>	<b>0.28</b>	-	-0.68	-	-	<b>0.03</b>
	Date	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dec-08	Depth to Water (MP) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Depth to Water (Water Body) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Vertical Separation (DL)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Water Level Difference (DH)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Hydraulic Gradient (DH/DL)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jan to Mar 2009	Date	-	-	5-Dec-08	-	-	-	-	-	5-Dec-08	5-Dec-08	-	5-Dec-08	-	-	5-Dec-08
	Depth to Water (MP) (mbtop)	-	-	-	-	-	0.02 *	-	-	0.02 *	0.62	-	3.42	-	-	1.08 *
	Depth to Water (Water Body) (mbtop)	-	-	Water Too Deep to Enter	-	-	-	-	-	0.61 **	0.73	-	1.20	-	-	1.08 *
	Vertical Separation (DL)	-	-	-	-	-	-	-	-	1.80	1.61	-	2.95	-	-	1.51
	Water Level Difference (DH)	-	-	-	-	-	-	-	-	0.59	0.11	-	-2.22	-	-	0.00
	Hydraulic Gradient (DH/DL)	-	-	-	-	-	-	-	-	<b>0.66</b>	<b>0.07</b>	-	-0.75	-	-	<b>0.12</b>
	Date	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Depth to Water (MP) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Depth to Water (Water Body) (mbtop)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Vertical Separation (DL)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Water Level Difference (DH)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Hydraulic Gradient (DH/DL)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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

\*\* indicates new stick up added

\*\*\* indicates measurement taken after installation

&gt; 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

Site	Date (mm/dd/yr)	Time (24 hrs)	Steam Flow Q (m³/s)	Water Temp (°C)	Air Temp (°C)	Temp Difference (°C)	Soil	GW Indicator
SR17b	18-Dec-07	13:30:00	0.15	0.5	-3.0	-3.5	C,G	none
SR17a	18-Dec-07	13:10:00	0.23	0.5	-3.0	-3.5	S,G	-
SR17b	14-Feb-08	11:37:00	WF	WF	-6.0	-	C,B	WF
SR17a	14-Feb-08	11:15:00	0.34	2.0	-6.0	-8.0	G,C,S	-
SR17b	17-Apr-08	09:50:00	0.95	6.0	7.0	1.0	C,P	-
SR17a	17-Apr-08	10:10:00	0.75	6.0	8.0	2.0	S,C	
SR17b	14-May-08	14:25:00	0.40	13.0	9.0	-4.0	S,B	no
SR17a	14-May-08	14:25:00	0.50	15.0	9.0	-6.0	G,C, MU	-
SR17b	27-Jun-08	14:40:00	NM	10.8	31.0	20.2	*	-
SR17a	27-Jun-08	15:20:00	NM	11.0	31.0	20.0	*	-
SR17b	15-Oct-08	01:50:00	0.44	12.0	16.0	4.0	S,C,	-
SR17a	15-Oct-08	02:30:00	0.53	12.0	16.0	4.0	*	-
SR17b	05-Dec-08	10:15:00	4.02	2.0	-5.0	-7.0	ST,B	some WC DS on LB
SR17a	05-Dec-08	10:34:00	3.50	1.0	-5.0	-6.0	ST	-
SR18b	18-Dec-07	13:00:00	WF	WF	-3.0	-	WF	-
SR18a	18-Dec-07	12:30:00	WF	WF	-4.0	-	WF	-
SR18b	14-Feb-08	11:32:00	WF	WF	-6.0	-	WF	-
SR18a	14-Feb-08	10:58:00	WF	WF	-6.0	-	WF	cattails with iron staining US and DS
SR18b	17-Apr-08	10:00:00	NFW	NFW	8.0	-	-	-
SR18a	17-Apr-08	10:25:00	0.03	9.0	9.0	0.0	S	
SR18b	14-May-08	14:40:00	NFW	NFW	9.0	-	-	-
SR18a	14-May-08	14:10:00	0.01	15.0	9.0	-6.0	MU	-
SR18b	15-Jul-08	11:20:00	NFW	NFW	27.0	-	-	-
SR18a	15-Jul-08	11:05:00	NFW	11.0	27.0	16.0	CL,ST	-
SR18b	15-Oct-08	01:30:00	NFW	-	16.0	-	CL	-
SR18a	15-Oct-08	02:05:00	NFW	-	16.0	-	CL	-
SR18b	05-Dec-08	10:00:00	WF	WF	-5.0	WF	MU	-
SR18a	05-Dec-08	10:43:00	0.01	4.0	-5.0	-9.0	C, ST	-
SR19b	18-Dec-07	15:09:00	0.02	4.0	-2.0	-6.0	S,ST	-
SR19a	18-Dec-07	15:25:00	WF	WF	-2.0	-	WF	-
SR19b	13-Feb-08	13:06:00	0.04	5.0	-8.0	-13.0	C,ST	-
SR19a	13-Feb-08	12:46:00	WF	WF	-8.0	-	WF	-
SR19b	17-Apr-08	10:45:00	0.03	9.0	10.0	1.0	G,S	-
SR19a	17-Apr-08	10:35:00	0.06	8.0	9.0	1.0	G,S	-
SR19b	14-May-08	13:40:00	0.02	14.5	9.0	-5.5	G,C,CL/ST	-
SR19a	14-May-08	13:55:00	0.03	15.7	9.0	-6.7	G, MU	-
SR19b	15-Jul-08	12:10:00	0.03	19.0	27.0	8.0	ST, S,CL	-
SR19a	15-Jul-08	12:30:00	0.02	18.0	26.0	8.0	ST, S,CL	-
SR19b	03-Sep-08	10:20:00	0.02	20.0	29.0	9.0	-	-
SR19a	03-Sep-08	10:08:00	0.02	15.0	29.0	14.0	-	-
SR19b	15-Oct-08	01:26:00	0.01	13.8	16.5	2.7	CL	-
SR19a	15-Oct-08	01:17:00	0.01	13.5	16.5	3.0	CL	-
SR20b	02-Jan-08	13:51:00	WF	1.0	-13.0	-14.0	B	-
SR20a	02-Jan-08	14:05:00	0.84	1.0	-13.0	-14.0	G,C	-
SR20b	13-Feb-08	13:16:00	2.45	2.0	-18.0	-20.0	C,B	-
SR20a	13-Feb-08	13:26:00	2.40	1.0	-8.0	-9.0	G,C	-
SR20b	17-Apr-08	10:55:00	1.10	8.0	11.0	3.0	G,C	-
SR20a	17-Apr-08	11:10:00	1.00	7.0	11.0	4.0	G	-
SR20b	14-May-08	13:20:00	0.50	12.0	9.0	-3.0	G,S,C	-
SR20a	14-May-08	13:30:00	0.65	12.8	9.0	-3.8	G,C,ST	some iron stain on water edge US LB
SR20b	08-Jul-08	14:20:00	0.20	18.0	25.0	7.0	-	-
SR20a	08-Jul-08	14:30:00	0.25	17.0	25.0	8.0	-	-
SR20b	03-Sep-08	10:40:00	0.70	15.0	29.0	14.0	C,S	WC US on LB
SR20a	03-Sep-08	11:00:00	1.39	15.0	29.0	14.0	C	-
SR20b	15-Oct-08	12:44:00	0.72	11.4	16.6	5.2	C	Salmon
SR20a	15-Oct-08	01:05:00	0.54	11.0	16.3	5.3	S,C	-
SR20b	05-Dec-08	10:55:00	15.00	3.0	-5.0	-8.0	*	-
SR20a	05-Dec-08	11:10:00	6.00	2.0	-5.0	-7.0	*	-
SR21	02-Jan-08	13:42:00	WF	WF	-12.0	-	WF	-
SR21	13-Feb-08	13:33:00	WF	WF	-8.0	-	WF	-
SR21	17-Apr-08	11:30:00	0.05	9.0	12.0	3.0	G,ST	-
SR21	08-May-08	15:50:00	0.01	16.1	13.0	-3.1	MU	-
SR21	15-Jul-08	12:58:00	NFW	18.0	25.0	7.0	S,ST	-
SR21	03-Sep-08	11:10:00	NFW	18.0	29.0	11.0	S,ST	GW sheen
SR21	15-Oct-08	12:37:00	0.01	12.8	17.0	4.2	CL	-
SR21	05-Dec-08	11:05:00	0.10	4.0	-5.0	-9.0	ST,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

Site	Date (mm/dd/yr)	Time (24 hrs)	Steam Flow Q (m³/s)	Water Temp (°C)	Air Temp (°C)	Temp Difference (°C)	Soil	GW Indicator
SR22b	02-Jan-08	13:10:00	WF	WF	-11.0	-	WF	-
SR22a	02-Jan-08	13:36:00	WF	WF	-12.0	-	WF	-
SR22b	13-Feb-08	14:18:00	WF	WF	-7.0	-	WF	-
SR22a	13-Feb-08	13:42:00	WF	WF	-8.0	-	WF	-
SR22b	17-Apr-08	12:20:00	0.05	8.0	13.0	5.0	ST	-
SR22a	17-Apr-08	11:40:00	0.03	8.0	12.0	4.0	G,S	-
SR22b	08-May-08	15:40:00	NFW	12.1	13.0	0.9	MU	-
SR22a	08-May-08	16:00:00	0.01	12.0	13.0	1.0	MU	-
SR22b	15-Jul-08	16:34:00	NFW	NFW	24.0	-	G,S	-
SR22a	15-Jul-08	13:18:00	0.01	15.0	25.0	10.0	ST/S	-
SR22b	03-Sep-08	12:10:00	NFW	18.0	29.0	11.0	MU	some iron stain
SR22a	03-Sep-08	11:18:00	NFW	16.0	29.0	13.0	G,S	specs of GW sheen
SR22b	15-Oct-08	11:52:00	NFW	16.0	16.2	0.2	CI	-
SR22a	15-Oct-08	12:30:00	NFW	13.0	16.6	3.6	CL	-
SR23b	02-Jan-08	13:16:00	0.59	0.0	-11.0	-11.0	B,G,C	-
SR23a	02-Jan-08	13:28:00	0.44	1.0	-11.0	-12.0	G,C,S	-
SR23b	13-Feb-08	14:03:00	WF	WF	-8.0	-	WF	-
SR23a	13-Feb-08	13:50:00	WF	WF	-8.0	-	C,ST,CL	-
SR23b	17-Apr-08	12:10:00	0.28	13.0	7.0	-6.0	G,S	-
SR23a	17-Apr-08	12:00:00	0.41	7.0	13.0	6.0	C,S	-
SR23b	08-May-08	15:20:00	0.20	10.4	13.0	2.6	S,C	US LB seep
SR23a	08-May-08	14:43:00	0.45	10.3	10.0	-0.3	B,C,ST/MU	iron stain on silt
SR23b	15-Jul-08	15:11:00	0.45	14.0	25.0	11.0	G,S	-
SR23a	15-Jul-08	13:25:00	0.30	15.0	24.0	9.0	S	-
SR23b	03-Sep-08	11:55:00	0.30	15.0	29.0	14.0	S,C	-
SR23a	03-Sep-08	11:30:00	0.38	14.0	29.0	15.0	ST,MU	WC ds on lb
SR23b	15-Oct-08	12:05:00	0.15	11.2	16.5	5.3	S	-
SR23a	15-Oct-08	12:23:00	0.43	11.0	16.6	5.6	C,S	-
SR24b	02-Jan-08	12:58:00	0.22	1.0	-11.0	-12.0	G,C	-
SR24a	02-Jan-08	14:18:00	0.19	1.0	-13.0	-14.0	G,C	-
SR24b	20-Feb-08	15:00:00	WF	1.0	-10.0	-11.0	WF	-
SR24a	20-Feb-08	15:10:00	0.30	1.0	-10.0	-11.0	G,S,C	-
SR24b	17-Apr-08	12:50:00	0.70	9.0	14.0	5.0	C	-
SR24a	17-Apr-08	12:35:00	0.37	8.0	14.0	6.0	G,C	-
SR24b	08-May-08	14:20:00	0.07	11.0	9.0	-2.0	G,C	WC DS in culvert
SR24a	08-May-08	14:37:00	0.12	11.6	10.0	-1.6	G,C	watercress US RB
SR24b	15-Jul-08	15:31:00	0.05	19.0	27.0	8.0	B,C	-
SR24a	15-Jul-08	03:49:00	0.08	16.0	26.0	10.0	B,C,S	-
SR24b	03-Sep-08	12:40:00	0.17	16.0	29.0	13.0	B,C,ST	-
SR24a	03-Sep-08	12:20:00	0.33	16.0	29.0	13.0	B,C,ST	iron on bank
SR24b	15-Oct-08	11:16:00	0.08	11.0	16.0	5.0	C,S	-
SR24a	15-Oct-08	11:39:00	0.13	12.2	16.0	3.8	ST, S	-
SR25b	02-Jan-08	12:51:00	WF	WF	-11.0	-	WF	-
SR25a	02-Jan-08	14:25:00	WF	WF	-13.0	-	WF	-
SR25b	13-Feb-08	14:32:00	WF	WF	-8.0	-	WF	-
SR25a	13-Feb-08	12:28:00	WF	WF	-8.0	-	WF	-
SR25b	17-Apr-08	13:05:00	0.06	10.0	14.0	4.0	G,S	-
SR25a	17-Apr-08	13:35:00	0.06	10.0	14.0	4.0	G,S	-
SR25b	08-May-08	16:10:00	0.05	13.2	13.0	-0.2	G	iron stain on rocks
SR25a	08-May-08	14:00:00	0.03	11.2	9.0	-2.2	C,S and CL outcrop US RB	iron stain on rocks
SR25b	15-Jul-08	15:24:00	NFW	NFW	26.0	-	G,S	-
SR25a	15-Jul-08	14:30:00	NFW	18.0	28.0	10.0	S/ST	-
SR25b	03-Sep-08	12:50:00	NFW	16.0	29.0	13.0	MU	specs of GW Sheen, iron tint on algae
SR25a	03-Sep-08	14:00:00	NFW	19.0	29.0	10.0	C	-
SR25b	15-Oct-08	10:36:00	0.05	11.0	15.0	4.0	C	-
SR25a	15-Oct-08	10:46:00	0.02	11.2	15.0	3.8	C	-
SR25b	05-Dec-08	11:48:00	0.10	3.0	-5.0	-8.0	S,C	-
SR25a	05-Dec-08	12:10:00	0.41	4.0	-6.0	-10.0	C,S	-
SR26b	02-Jan-08	12:34:00	WF	WF	-11.0	-	WF	-
SR26a	02-Jan-08	14:37:00	0.04	1.0	-13.0	-14.0	ST,MU	-
SR26b	13-Feb-08	12:00:00	WF	1.0	-8.0	-9.0	WF	-
SR26a	13-Feb-08	12:15:00	0.10	1.0	-8.0	-9.0	S,ST	-
SR26b	17-Apr-08	13:20:00	0.01	12.0	14.0	2.0	S/ST	-
SR26a	17-Apr-08	13:29:00	0.05	12.0	14.0	2.0	S,ST	-
SR26b	08-May-08	13:45:00	0.01	9.3	9.0	-0.3	MU	-
SR26a	08-May-08	01:55:00	0.04	9.2	9.0	-0.2	MU	-
SR26b	15-Jul-08	14:10:00	NFW	NFW	27.0	-	S	-
SR26a	15-Jul-08	02:18:00	NFW	16.0	25.0	9.0	S	-
SR26b	03-Sep-08	13:30:00	NFW	19.0	29.0	10.0	G,S	-
SR26a	03-Sep-08	13:56:00	0.06	18.0	29.0	11.0	C,S,	-
SR26b	15-Oct-08	10:17:00	NFW	13.0	15.0	2.0	CL,ST	-
SR26a	15-Oct-08	10:28:00	0.02	12.4	15.0	2.6	CL,ST	-

NOTES:  
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NM - not measured.  
ABBREVIATIONS:  
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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 C7 - Domestic Well Chemical Results

Parameter	Unit	RDL	ODWS	2033	2042	2046	2057	2060	2064	2078	2103	2104	2105	2106	2107	6267	6274	6317	6350		
				Central	Central	Central	Central	Central	Central	Central	Central	Central	Central	Central	Central	Central	Central	Central	Central	Central	Central
				21-Jul-08	23-Jul-08	23-Jul-08	23-Jul-08	21-Jul-08	22-Jul-08	24-Jul-08	21-Jul-08	21-Jul-08	22-Jul-08	23-Jul-08	24-Jul-08	07-Aug-08	08-Aug-08	25-Jul-08	21-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		
C>16 - C34 (F3)	µg/L	500	na	< 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		
C>34 - C50	µg/L	500	na	< 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		
C6 - C10 (F1)	µg/L	100	na	< 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		
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		
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		
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		
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		
Gravimetric Heavy Hydrocarbons	µg/L	500	na	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
MICROBIOLOGY																					
Total Coliforms	CFU/100mL	1	< 1	533	1	400	<1	50	3	100	<1	<1	<1	16	2000	300	1	<1	552		
Escherichia coli	CFU/100ml	1	< 1	81	<1	3	<1	1	<1	75	<1	<1	<1	<1	500	2	1	<1	48		
Heterotrophic Plate Count (HPC) (CFU/ml)	CFU/ml	10	< 500	1260	10	400	140	90	2	7600	<1	<1	<1	13	3200	13	23	6	1270		
INORGANICS AND METALS																					
Alkalinity (as CaCO3)	mg/L	5	30-500	256	232	330	142	210	318	308	285	124	134	264	291	285	322	325	347		
Aluminum	mg/L	0.004	0.1	0.05	<0.004	0.006	0.022	<0.004	<0.004	0.026	<0.004	0.038	<0.004	0.029	0.019	<0.004	0.01	<0.004	<0.004		
Ammonia (as N)	mg/L	0.02	na	0.23	0.05	<0.02	0.43	<0.02	<0.02	<0.02	<0.02	0.06	0.03	<0.02	0.53	<0.02	<0.02	<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	0.005	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003		
Barium	mg/L	0.002	1	0.045	0.127	0.057	0.054	0.089	0.212	0.053	0.168	0.2	0.078	0.062	0.12	0.04	0.13	<0.002	0.166		
Bicarbonate (as CaCO3)	mg/L	5	na	256	223	272	130	196	312	308	285	117	134	207	291	271	291	325	347		
Boron	mg/L	0.01	5	0.045	0.019	0.015	0.056	0.033	0.014	0.014	<0.01	0.093	0.085	0.012	0.031	0.04	0.03	0.04	0.015		
Bromide	mg/L	0.05	na	<0.05	<0.05	0.06	<0.05	<0.05	0.06	<0.05	<0.05	0.05	<0.05	0.12	<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	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002		
Calcium	mg/L	0.05	na	0.077	<0.003	0.034	0.026	0.008	0.005	0.042	0.14	<0.003	0.007	<0.003	0.043	0.02	0.15	0.057	0.104		
Carbonate (as CaCO3)	mg/L	5	na	<5	9	58	12	14	6	<5	<5	7	<5	57	<5	14	31	<5	<5		
Chloride	mg/L	0.1	250	11.1	16.2	119	1.82	5.46	610	34.4	41.1	183	49.2	50.7	16.3	25.1	120	96.2	377		
Colour	TCU	5	5	10	<5	<5	<5	<5	<5	<5	<5	<5	5	<5	15	<5	<5	<5	<5		
Copper	mg/L	0.003	1	0.077	<0.003	0.034	0.026	0.008	0.005	0.042	0.14	<0.003	0.007	<0.003	0.043	0.02	0.15	0.057	0.104		
Electrical Conductivity	uS/cm	2	na	579	531	1040	264	525	255	789	698	847	472	662	646	636	1080	994	1880		
Field Conductivity	uS/cm	N/A	na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Fluoride	mg/L	0.05	1.5	0.07	0.07	<0.05	0.18	0.12	<0.05	<0.05	<0.05	0.25	0.23	0.05	0.09	0.06	0.07	<0.05	<0.05		
Hydroxide	mg/L	5	na	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5		
Iron	mg/L	0.005	0.3	0.095	0.891	0.014	0.54	0.043	0.085	<0.01	1.69	1.5	0.034	0.047	0.508	<0.01	2.12	0.049	0.017		
Langelier Index	N/A	N/A	na	1.16	1.38	1.77	1.15	1.45	1.71	1.09	1.39	1.13	0.32	1.63	1.3	1.53	1.89	-1.63	1.55		
Lead	mg/L	0.002	0.01	<0.002	<0.002	<0.002	0.006	<0.002	<0.002	<0.002	0.013	<0.002	<0.002	<0.002	0.003	<0.002	0.01	0.004	0.015		
Magnesium	mg/L	0.05	na	7.3	16.6	11.6	17.5	26.8	20.7	12.2	22.9	40.1	18.6	21.5	6.86	7.44	22	<0.05	27.9		
Manganese	mg/L	0.002	0.05	0.012	0.024	0.003	0.016	0.006	<0.002	<0.002	0.02	0.034	0.011	0.008	0.003	<0.002	0.02	<0.002	0.003		
Molybdenum	mg/L	0.002	na	0.003	<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		
Nickel	mg/L	0.003	na	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003									

Table C7 - Domestic Well Chemical Results

AECOM

Parameter	Unit	RDL	ODWS	6354	6371	6405	6452
				Central	Central	Central	Central
				22-Jul-08	31-Jul-08	06-Aug-08	23-Jul-08
ORGANICS							
C>10 - C16 (F2)	µg/L	100	na	< 100	< 100	< 100	< 100
C>16 - C34 (F3)	µg/L	500	na	< 500	< 500	< 500	< 500
C>16 - C50 (F3 + F4)	µg/L	500	na	< 500	< 500	< 500	< 500
C>34 - C50	µg/L	500	na	< 500	< 500	< 500	< 500
C6 - C10 (F1 minus BTEX)	µg/L	100	na	< 100	< 100	< 100	< 100
C6 - C10 (F1)	µg/L	100	na	< 100	< 100	< 100	< 100
C6 - C16 (F1 + F2)	µg/L	100	na	< 100	< 100	< 100	< 100
Benzene	µg/L	0.2	5	< 0.2	< 0.2	< 0.2	< 0.2
Ethylbenzene	µg/L	0.1	2.4	< 0.1	< 0.1	< 0.1	< 0.1
Toluene	µg/L	0.2	na	< 0.2	< 0.2	< 0.2	< 0.2
Xylenes (Total)	µg/L	0.14	300	<0.14	<0.14	<0.14	<0.14
Gravimetric Heavy Hydrocarbons	µg/L	500	na	NA	NA	NA	NA
MICROBIOLOGY							
Total Coliforms	CFU/100mL	1	< 1	<1	2	225	<1
Escherichia coli	CFU/100ml	1	< 1	<1	<1	<1	<1
Heterotrophic Plate Count (HPC) (CFU/ml)	CFU/ml	10	< 500	<1	<10	870	<1
INORGANICS AND METALS							
Alkalinity (as CaCO3)	mg/L	5	30-500	216	264	374	251
Aluminum	mg/L	0.004	0.1	0.004	<0.004	<0.004	0.005
Ammonia (as N)	mg/L	0.02	na	<0.02	<0.02	<0.02	0.02
Arsenic	mg/L	0.003	0.025	<0.003	<0.003	<0.003	<0.003
Barium	mg/L	0.002	1	0.054	0.06	0.23	0.114
Bicarbonate (as CaCO3)	mg/L	5	na	201	255	374	190
Boron	mg/L	0.01	5	0.011	0.01	0.02	0.022
Bromide	mg/L	0.05	na	<0.05	<0.05	0.06	<0.05
Cadmium	mg/L	0.002	0.005	<0.002	<0.002	<0.002	<0.002
Calcium	mg/L	0.05	na	0.015	<0.003	0.06	0.043
Carbonate (as CaCO3)	mg/L	5	na	15	10	<5	61
Chloride	mg/L	0.1	250	5.87	18.4	417	26.1
Colour	TCU	5	5	<5	<5	<5	<5
Copper	mg/L	0.003	1	0.015	<0.003	0.06	0.043
Electrical Conductivity	uS/cm	2	na	485	744	2140	578
Field Conductivity	uS/cm	N/A	na	-	-	-	-
Fluoride	mg/L	0.05	1.5	0.05	0.06	<0.05	0.07
Hydroxide	mg/L	5	na	<5	<5	<5	<5
Iron	mg/L	0.005	0.3	0.127	<0.01	0.16	0.084
Langelier Index	N/A	N/A	na	1.49	1.54	1.57	1.51
Lead	mg/L	0.002	0.01	<0.002	<0.002	0.002	0.003
Magnesium	mg/L	0.05	na	18	26.6	30.7	15.3
Manganese	mg/L	0.002	0.05	0.008	0.02	<0.002	0.011
Molybdenum	mg/L	0.002	na	<0.002	<0.002	<0.002	<0.002
Nickel	mg/L	0.003	na	<0.003	<0.003	<0.003	<0.003
Nitrate as N	mg/L	0.05	10	3.91	16.6	6.78	3.11
Nitrite as N	mg/L	0.05	1	<0.05	<0.05	<0.05	<0.05
Orthophosphate as P	mg/L	0.1	na	<0.1	<0.1	<0.1	<0.1
pH	N/A	N/A	6.5-8.5	8.58	8.39	8.07	8.53
Field pH	N/A	N/A	na	-	-	-	-
Potassium	mg/L	0.05	na	1.1	1.34	2.39	1.63
Reactive Silica	mg/L	0.05	na	14.7	7.79	16.8	17.5
Saturation pH	N/A	N/A	na	7.09	6.85	6.5	7.02
Selenium	mg/L	0.004	0.01	<0.004	<0.004	<0.004	<0.004
Silver	mg/L	0.002	na	<0.002	<0.002	<0.002	<0.002
Sodium	mg/L	0.05	20 (200)	5.22	6.88	206	15.2
Strontium	mg/L	0.005	na	0.163	0.28	0.44	0.302
Sulphate	mg/L	0.1	500	29.3	54.6	34.7	29
Thallium	mg/L	0.006	na	<0.006	<0.01	<0.01	<0.006
Titanium	mg/L	0.002	na	<0.002	<0.002	<0.002	<0.002
Total Dissolved Solids	mg/L	20	500	312	466	1440	364
Total Hardness (as CaCO3)	mg/L	10	80-100	271	392	678	278
Total Organic Carbon	mg/L	0.5	na	1.4	1.2	1.3	1.3
Total Phosphorus	mg/L	0.05	na	<0.05	<0.05	<0.05	<0.05
Turbidity	NTU	0.5	5	<0.5	<0.5	<0.5	1.3
Uranium	mg/L	0.002	0.02	<0.002	0.01	<0.002	<0.002
Vanadium	mg/L	0.002	na	<0.002	<0.002	0.002	<0.002
Zinc	mg/L	0.005	5	0.007	0.01	0.03	0.335
Field Temp	°C	N/A	na	-	-	-	-

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

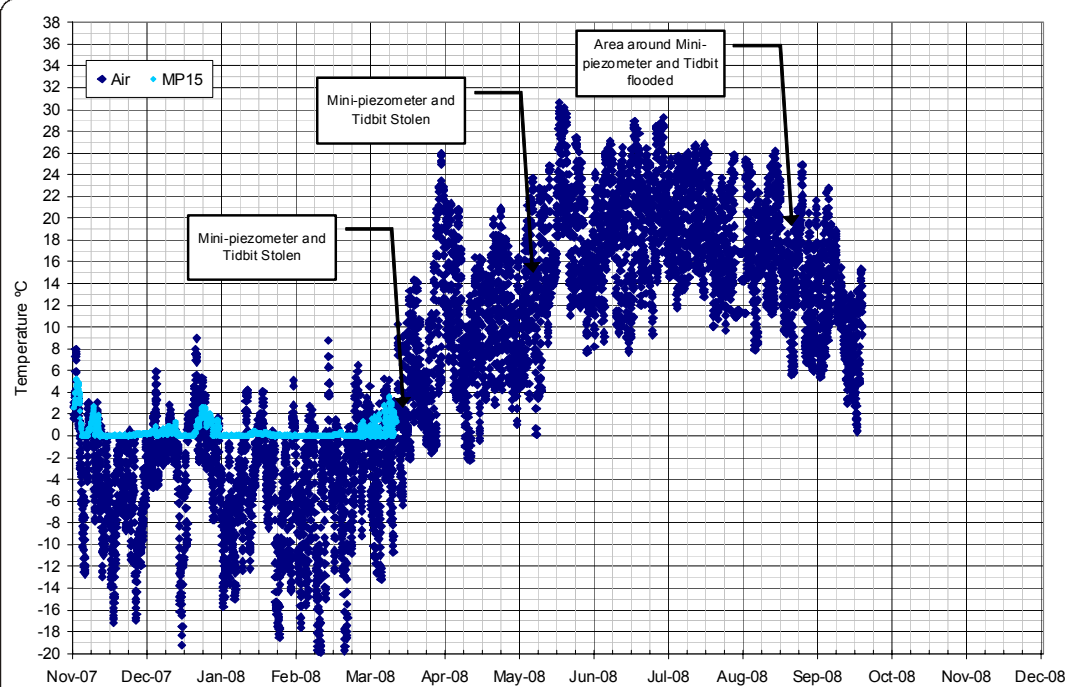


# Appendix D

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## Stream Temperature Monitoring Results





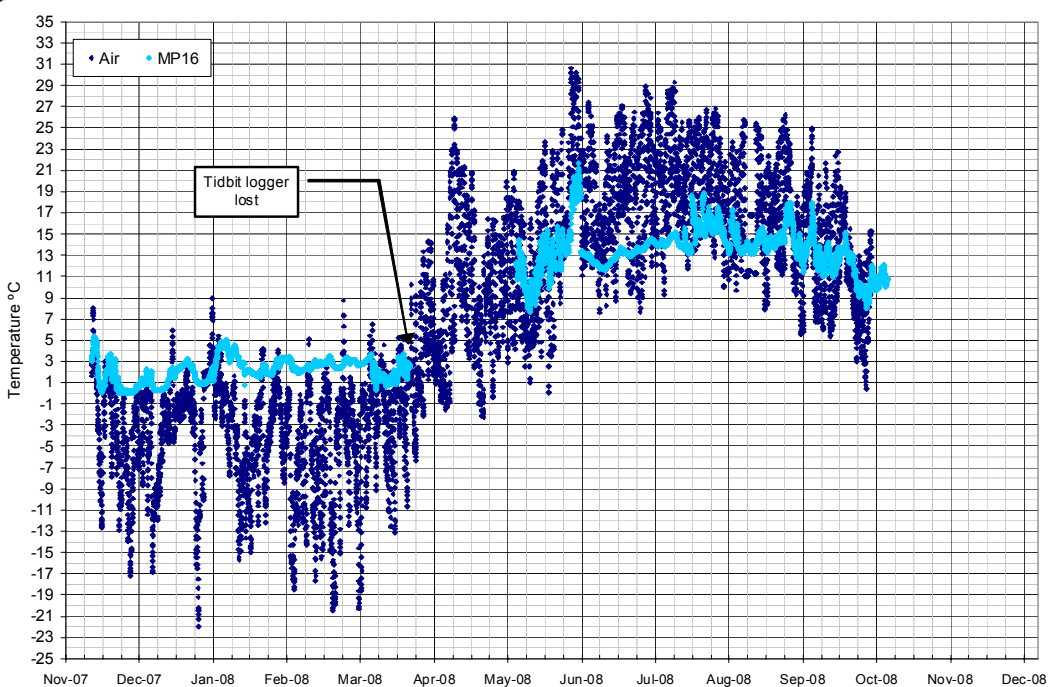
AECOM

MP15 Stream Temperature

407 EAST Foundations  
Seasonal Monitoring - Hydrogeology

FIGURE D1

Project 50613



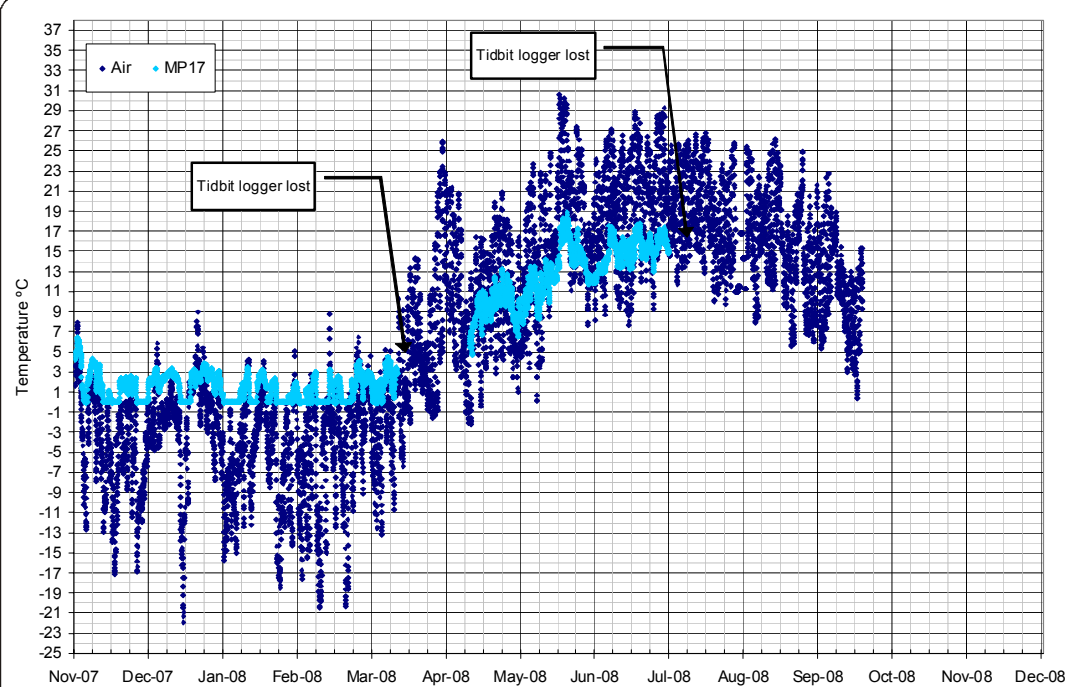
AECOM

MP16 Stream Temperature

407 EAST Foundations  
Seasonal Monitoring - Hydrogeology

FIGURE D2

Project 50613



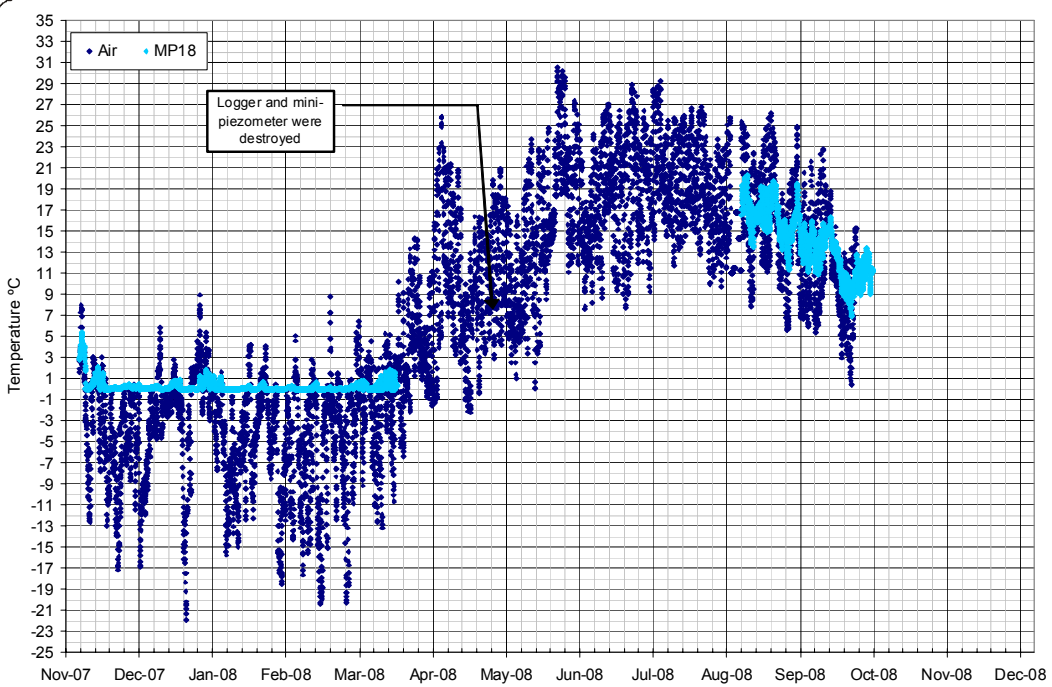
AECOM

MP17 Stream Temperature

407 EAST Foundations  
Seasonal Monitoring - Hydrogeology

FIGURE D3

Project 50613



AECOM

MP18 Stream Temperature

407 EAST Foundations  
Seasonal Monitoring - Hydrogeology

FIGURE D4

Project 50613



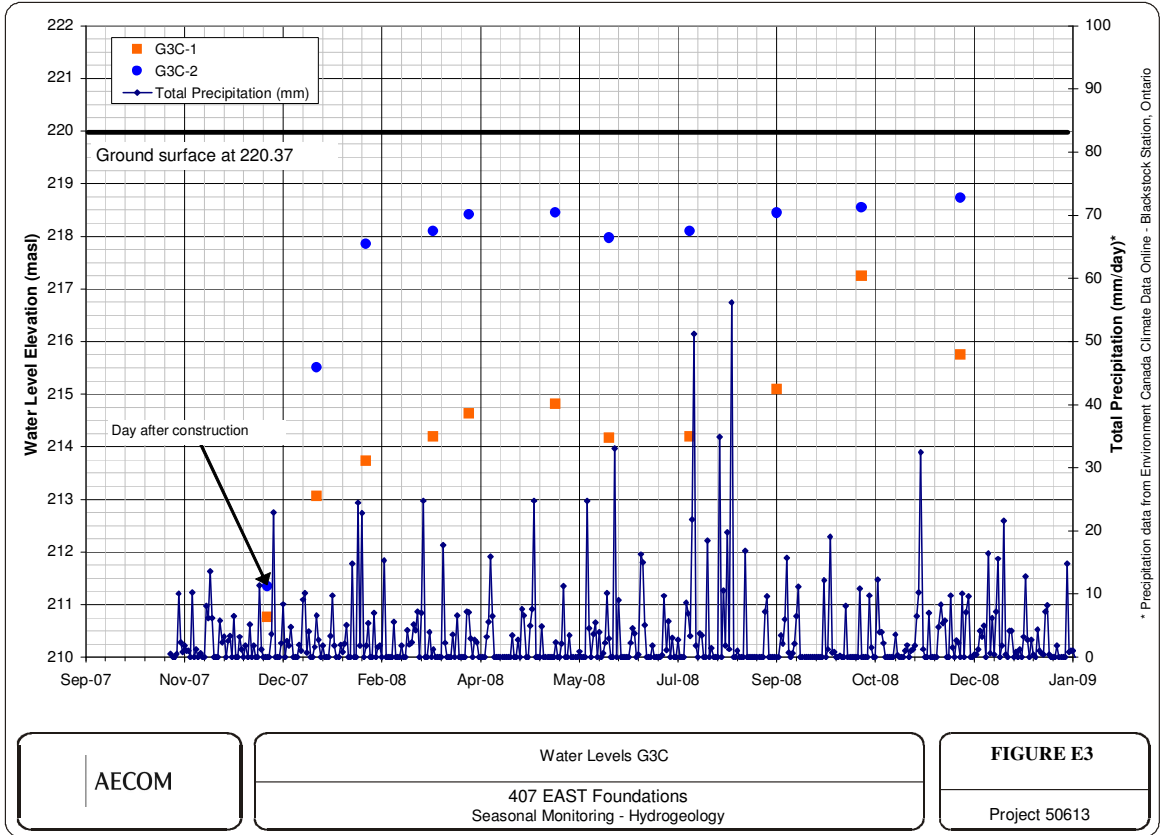
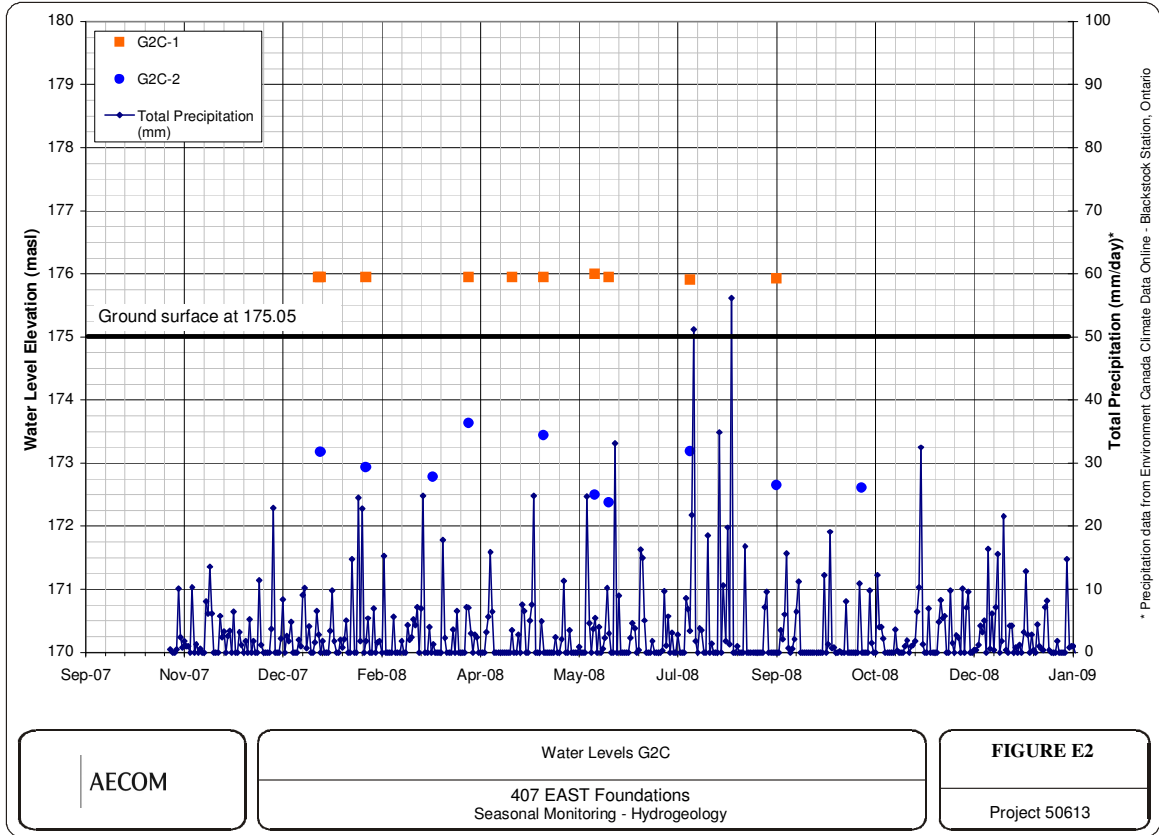
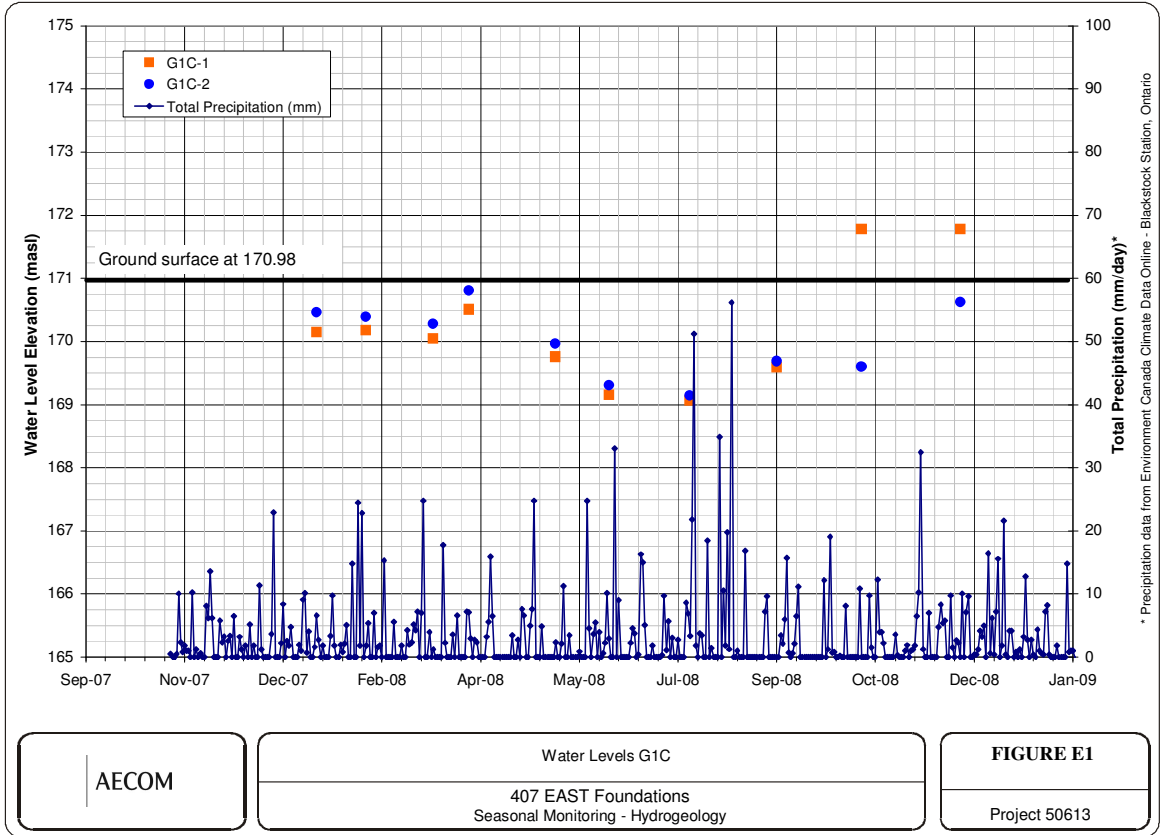


# Appendix E

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## Groundwater Monitor Hydrographs







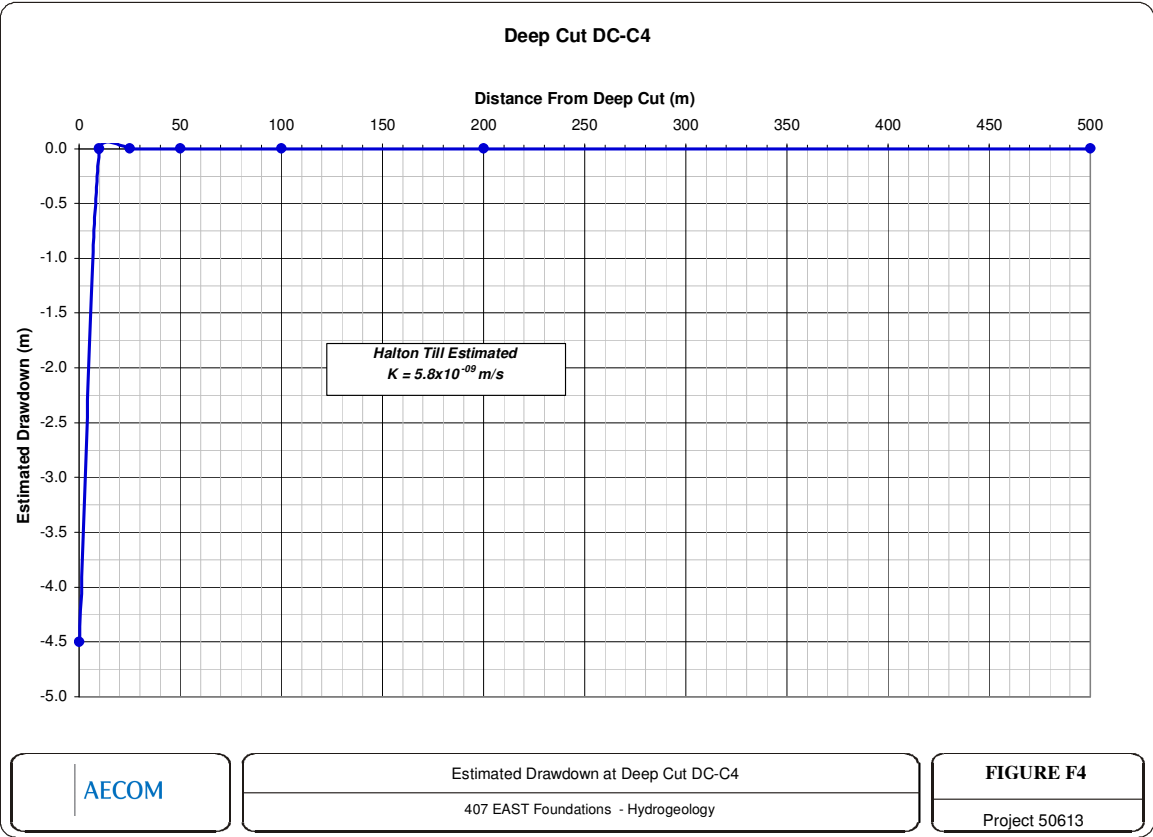
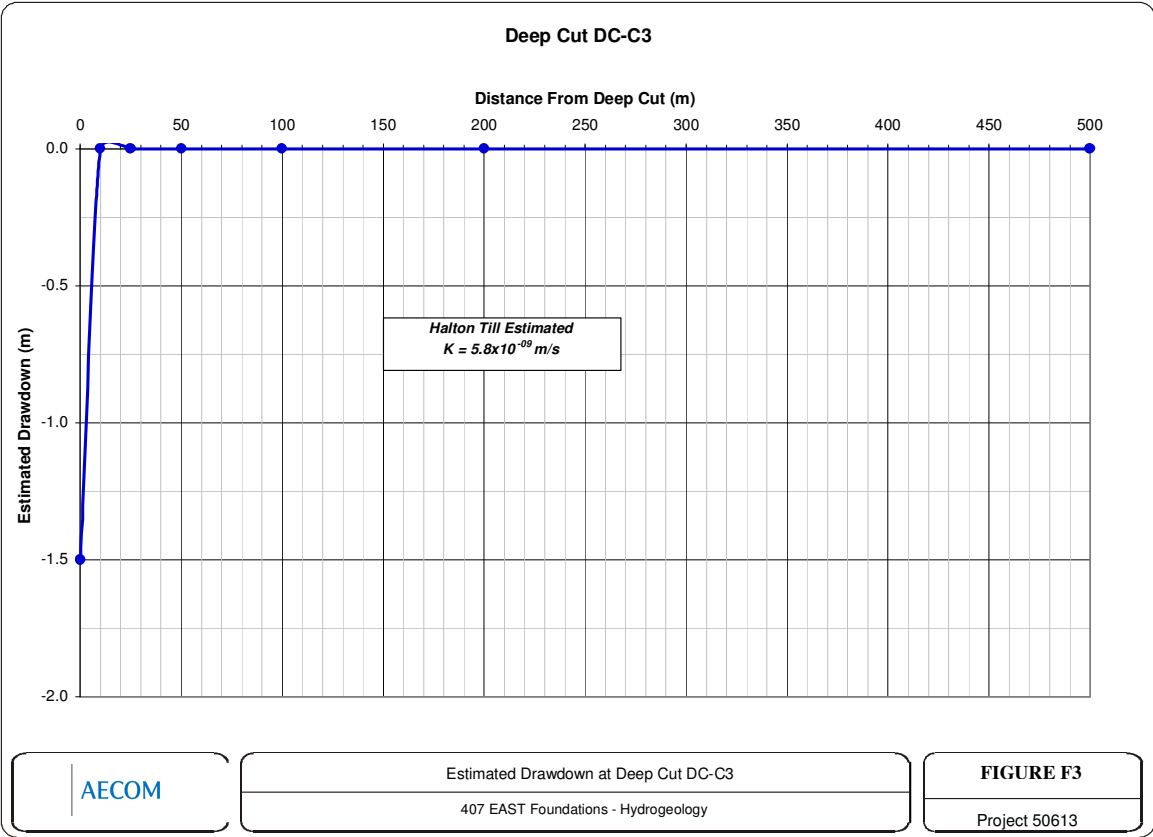
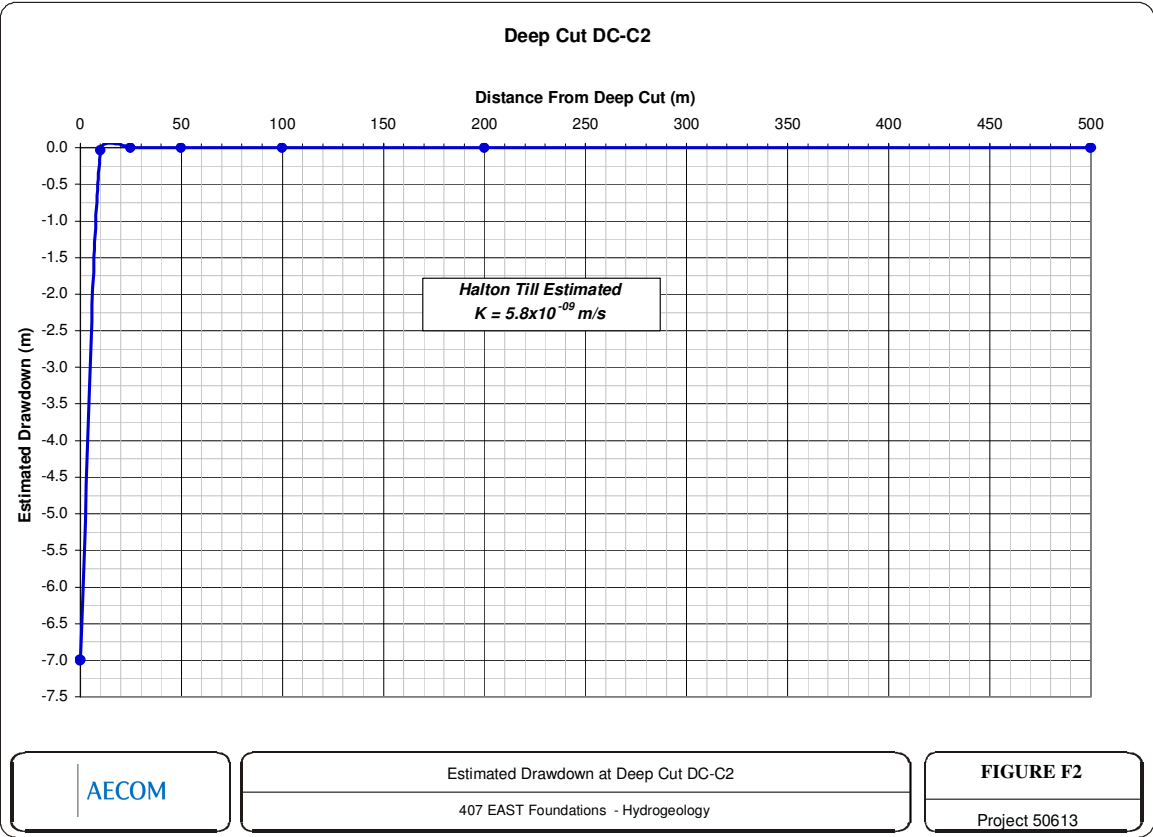
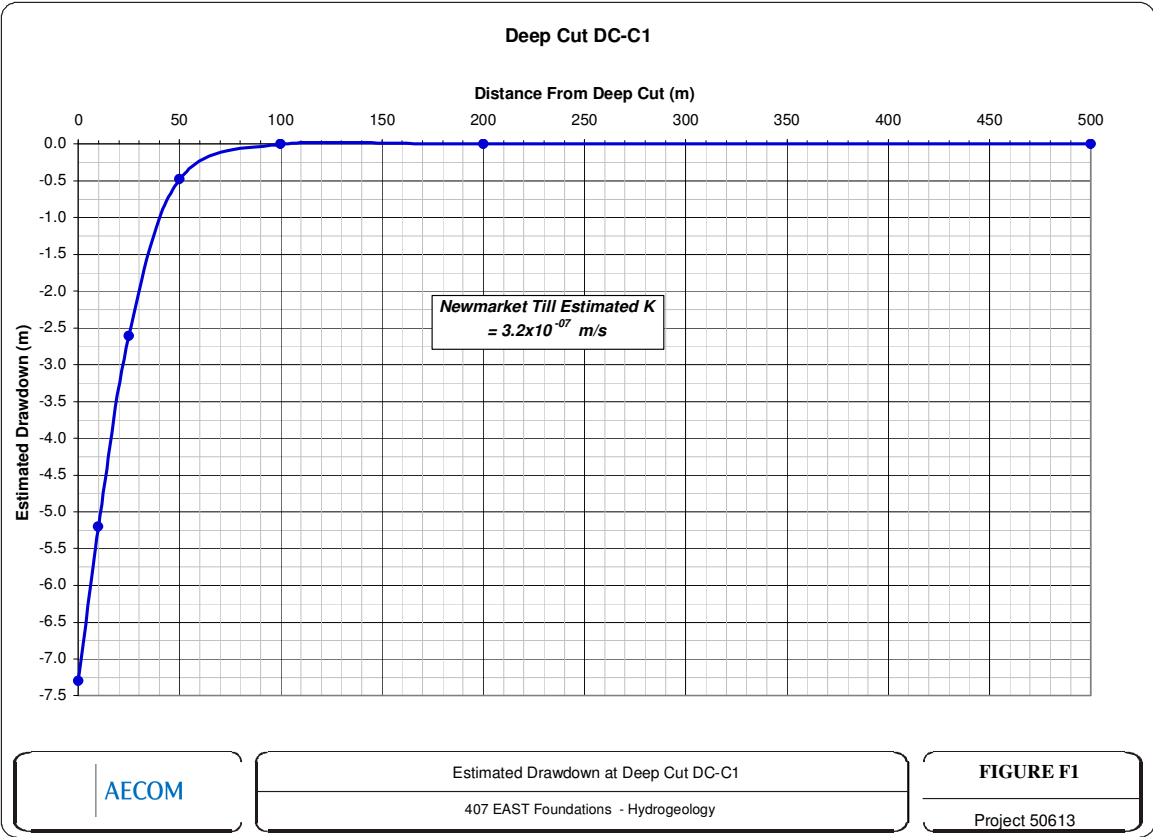


# Appendix F

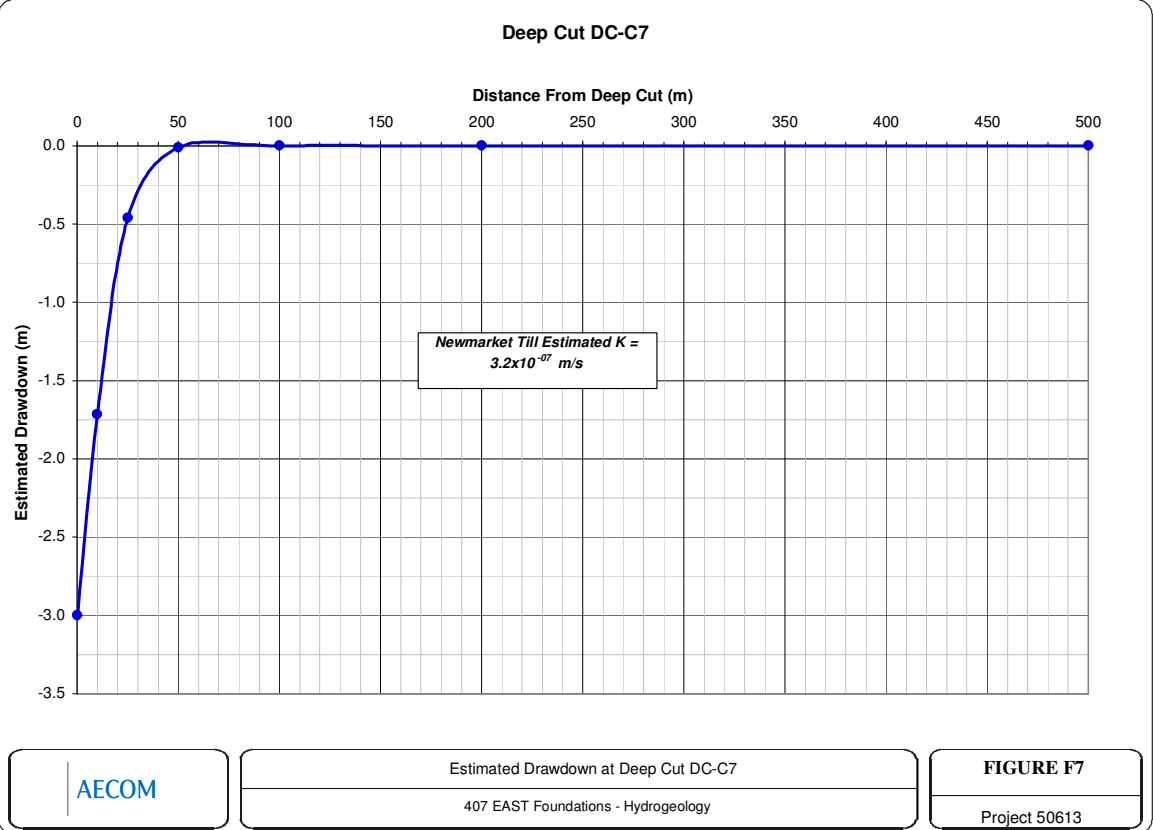
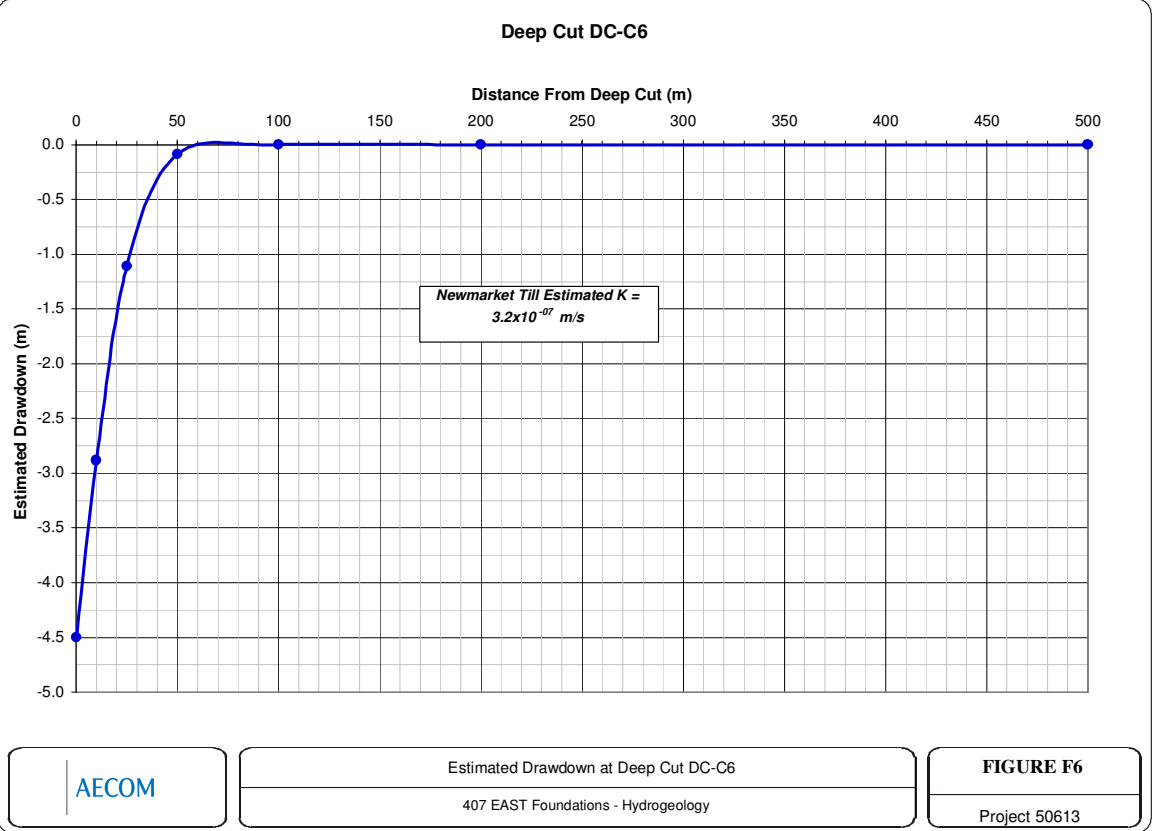
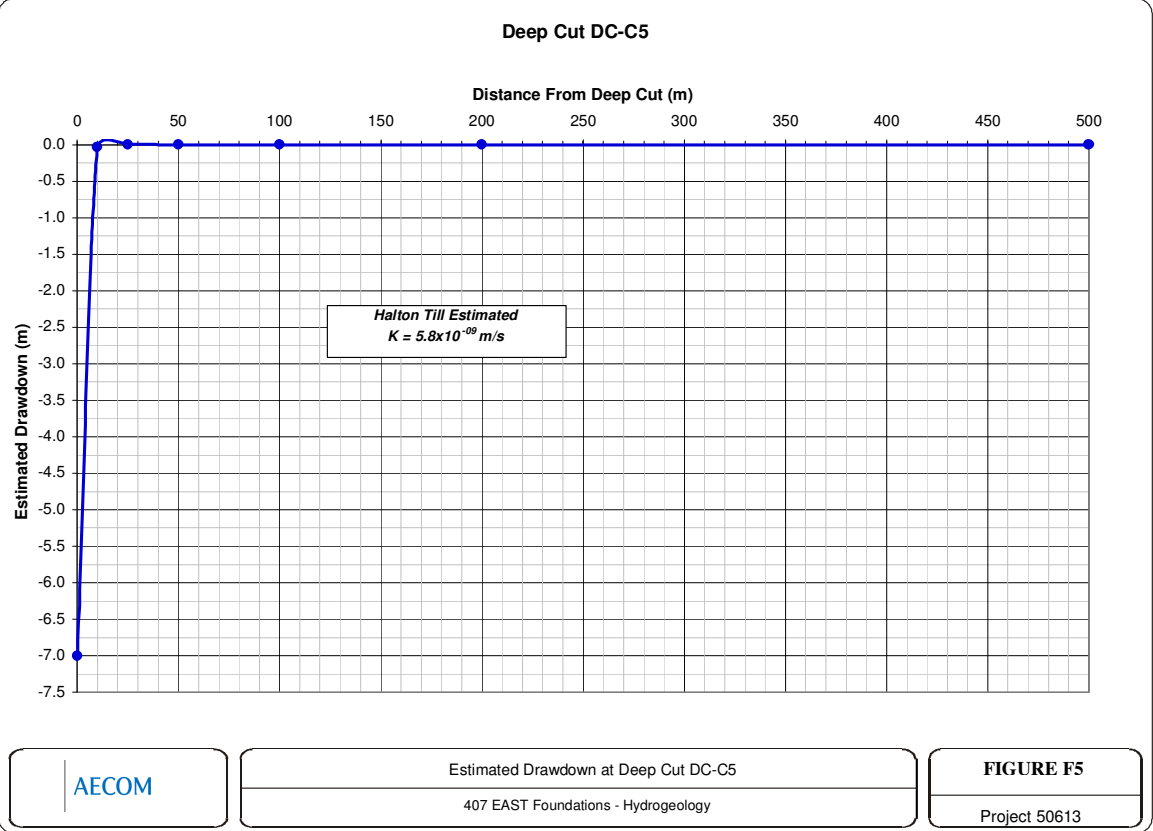
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## Deep Cut Drawdown Analysis













# Appendix G

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## Geotechnical Borehole Logs





RECORD OF BOREHOLE No CM3-1															1 OF 2		METRIC		
G.W.P. W.O. 07-20016		LOCATION N 4 867 724.7 E 348 719.7			ORIGINATED BY SLL														
HWY 407		BOREHOLE TYPE Solid Stem Augers			COMPILED BY ES														
DATUM Geodetic		DATE 2008.03.03 - 2008.03.03			CHECKED BY MEF														
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS		ELEVATION SCALE		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES														
148.0	TOPSOIL, trace roots and rootlets: (175mm) Dark Brown Wet																		
0.0																			
0.2	SAND and SILT, trace roots, trace gravel Loose Dark Brown Wet		1	SS	5														
146.5																			
1.4	SAND and GRAVEL, trace silt Loose to Compact Dark Brown Wet		2	SS	5														
			3	SS	24														
145.0																			
3.0	Silty SAND, trace gravel Compact Brown Wet		4	SS	25														
			5	SS	26														
142.2																			
5.8	SAND and SILT, some clay, trace gravel Dense to Very Dense Brown Moist (TILL)		6	SS	32														
	cobble at 7.35 to 7.52m		7	SS	100														
	cobble at 8.53 to 8.63m		8	SS	100														
	cobble at 9.75 to 9.85m																		

Continued Next Page

ONTM74S 0510.GPJ 8/12/08



RECORD OF BOREHOLE No CM3-1															2 OF 2		METRIC		
G.W.P. W.O. 07-20016		LOCATION N 4 867 724.7 E 348 719.7			ORIGINATED BY SLL														
HWY 407		BOREHOLE TYPE Solid Stem Augers			COMPILED BY ES														
DATUM Geodetic		DATE 2008.03.03 - 2008.03.03			CHECKED BY MEF														
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS		ELEVATION SCALE		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES														
137.2	Continued From Previous Page																		
10.7	SAND and SILT, some clay, trace gravel Dense Brown Moist (TILL)																		
	cobble at 10.21 to 10.31m																		
	END OF BOREHOLE AT 10.7m. BOREHOLE OPEN AND WATER LEVEL AT 0.9m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.2m AND AUGER CUTTINGS TO SURFACE																		

Continued Next Page

ONTM74S 0510.GPJ 8/12/08

DN1MT4S 0510.GPJ 2/12/08

Continued Next Page

4, 3, X 3 Numbers refer to Sensitivity

ONTM4S C510GPJ 8/12/08

+ 3, x 3: Numbers refer to Sensitivity





RECORD OF BOREHOLE No CM3b-1										1 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 857 733.5 E 348 614.6				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES							
DATUM Geodetic		DATE 2008.03.03 - 2008.03.03				CHECKED BY MEF							
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS		ELEVATION SCALE		DYNAMIC CONE PENETRATION RESISTANCE PLOT		REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	T <sub>N</sub> VALUES	WATER CONTENT (%)	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
152.5	TOPSOIL, trace roots and rootlets: (200mm)												
0.0	Dark Brown Moist												
0.2	Gravelly SAND, trace silt Compact Brown Moist		1	SS	14								
			2	SS	10								
150.3	Silty CLAY, trace gravel Firm Brown		3	SS	7								
2.2	SAND, some silt Loose Brown Moist		4	SS	6								
149.6	becoming Very Dense trace to some gravel		5	SS	60								
			6	SS	44								
146.4	Gravelly SAND, trace silt Dense to Very Dense Brown Wet		7	SS	72								
0.1	silt seams		8	SS	100								
143.0	Silty SAND, some gravel Dense Gray												
9.4													

Continued Next Page

+<sup>3</sup>, x<sup>3</sup>: Numbers refer to Sensitivity  
20  
15-5  
10 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM3b-1										2 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 857 733.5 E 348 614.6				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES							
DATUM Geodetic		DATE 2008.03.03 - 2008.03.03				CHECKED BY MEF							
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS		ELEVATION SCALE		DYNAMIC CONE PENETRATION RESISTANCE PLOT		REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	T <sub>N</sub> VALUES	WATER CONTENT (%)	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
	Continued From Previous Page												
	Moist to Wet (TILL)		9	SS	45								
140.3	SAND, trace silt, trace gravel Very Dense Gray Moist		10	SS	71								
12.2	Silty SAND, trace gravel Very Dense Gray Moist (TILL)		11	SS	100								
13.4	SAND and SILT, some clay, trace gravel Very Dense Gray Moist (TILL)		12	SS	100								
130.0			13	SS	100								
14.5	END OF BOREHOLE AT 16.9m Piezometer installation consists of 19mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2007.04.28 4.6 147.9												
136.6													
16.9													

+<sup>3</sup>, x<sup>3</sup>: Numbers refer to Sensitivity  
20  
15-5  
10 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM3b-2 1 OF 2 METRIC																
G.W.P. W.O. 07-20016		LOCATION N 4 857 742.9 E 348 642.2			ORIGINATED BY JM											
HWY 407		BOREHOLE TYPE Solid Stem Augers			COMPILED BY ES											
DATUM Geodetic		DATE 2008.03.13 - 2008.03.13			CHECKED BY MEF											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS		ELEVATION SCALE		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	T <sub>N</sub> VALUES											
146.6	TOPSOIL, with roots: (300mm) Brown Moist															
148.5	SAND, some gravel to gravelly, trace silt Loose to Compact Brown Moist		1	SS	4											
			2	SS	13											
			3	SS	15											
			4	SS	26											
144.7	Silty SAND, trace gravel Very Dense Grey Moist (TILL)		5	SS	100/125											
142.7	Sandy SILT, some clay, trace gravel Very Dense Grey Moist (TILL)		6	SS	100/175											
			7	SS	100/233											
140.4	Silty SAND, trace gravel Very Dense Grey Moist (TILL)															
139.3	END OF BOREHOLE AT 9.5m. BOREHOLE OPEN TO 1.1m AND WATER LEVEL AT 1.0m UPON		8	SS	100/175											

Continued Next Page

+<sup>3</sup>, x<sup>3</sup>: Numbers refer to Sensitivity  
20  
15 10  
(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM3b-2 2 OF 2 METRIC																
G.W.P. W.O. 07-20016		LOCATION N 4 857 742.9 E 348 642.2			ORIGINATED BY JM											
HWY 407		BOREHOLE TYPE Solid Stem Augers			COMPILED BY ES											
DATUM Geodetic		DATE 2008.03.13 - 2008.03.13			CHECKED BY MEF											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS		ELEVATION SCALE		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	T <sub>N</sub> VALUES											
	Continued From Previous Page															
	COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE															

ONTM14S 0510.GPJ 8/12/08

+<sup>3</sup>, x<sup>3</sup>: Numbers refer to Sensitivity  
20  
15 10  
(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM6-1															1 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 858 012.8 E 349 677.0, Thickson Road					ORIGINATED BY SLL											
HWY 407		BOREHOLE TYPE Solid Stem Augers					COMPILED BY ES											
DATUM Geodetic		DATE 2008.03.06 - 2008.03.06					CHECKED BY MEF											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	T <sub>v</sub> VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W <sub>L</sub>	W <sub>p</sub> W <sub>L</sub>	W <sub>p</sub> W <sub>L</sub>	γ	GR SA SI CL			
165.7	TOPSOIL, with roots: (30mm)																	
165.4	Dark Brown Moist																	
0.3	Silty CLAY, some sand, trace gravel Stiff to Hard Brown (TILL)(CL)		1	SS	14													
	becoming Grey		2	SS	31													
			3	SS	80													
			4	SS	46													
161.6	inferred cobble at 4.04 to 4.11m																	
4.1	SAND and SILT, some clay, trace gravel Very Dense Grey Moist (TILL)		5	SS	107													
	inferred cobble at 5.33 to 5.49m																	
			6	SS	100													
			7	SS	100													
	inferred cobble at 8.31 to 8.43m																	
156.5	END OF BOREHOLE AT 9.2m. BOREHOLE OPEN TO 8.8m AND WATER LEVEL AT 8.8m UPON COMPLETION. BOREHOLE BACKFILLED WITH		8	SS	100													
9.2																		

ONTM7-4S 0510 GPJ 8/12/08

+<sup>3</sup>, x<sup>3</sup>: Numbers refer to Sensitivity  
20  
15 10 5 10  
(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM6-1															2 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 858 012.8 E 349 677.0, Thickson Road					ORIGINATED BY SLL											
HWY 407		BOREHOLE TYPE Solid Stem Augers					COMPILED BY ES											
DATUM Geodetic		DATE 2008.03.06 - 2008.03.06					CHECKED BY MEF											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	T <sub>v</sub> VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W <sub>L</sub>	W <sub>p</sub> W <sub>L</sub>	W <sub>p</sub> W <sub>L</sub>	γ	GR SA SI CL			
	Continued From Previous Page																	
	BENTONITE HOLEPLUG TO 0.3m and AUGER CUTTINGS TO SURFACE.																	

ONTM7-4S 0510 GPJ 8/12/08

+<sup>3</sup>, x<sup>3</sup>: Numbers refer to Sensitivity  
20  
15 10 5 10  
(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM6-2										1 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 858 035.5 E 349 726.8, Thickson Road				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES							
DATUM Geodetic		DATE 2008.03.04 - 2008.03.04				CHECKED BY MEF							
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa						WATER CONTENT (%)
167.0	TOPSOIL, with roots (50mm) Brown Moist												
	Silty SAND, trace gravel Compact to Dense Brown Moist	1	SS	25									
		2	SS	33								1 72 26 (SI+CL)	
164.4		3	SS	100									
2.5	SAND and SILT, some clay, trace gravel, occasional oxide staining Very Dense Brown to Gray Moist (TILL)	4	SS	100								0 20 70 10	
		5	SS	100									
		6	SS	100									
		7	SS	100								0 42 39 19	
167.7	END OF BOREHOLE AT 9.3m. BOREHOLE OPEN TO 9.1m AND WATER LEVEL AT 1.2m UPON COMPLETION. Piezometer installation consists of	8	SS	100									
9.3													

+ 3, x 3: Numbers refer to  
Sensitivity

20  
15 10 5  
(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM6-2										2 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 858 035.5 E 349 726.8, Thickson Road				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES							
DATUM Geodetic		DATE 2008.03.04 - 2008.03.04				CHECKED BY MEF							
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa						WATER CONTENT (%)
	Continues From Previous Page												
	100mm diameter schedule 40 PVC pipe with a 1.52m skirted screen WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2008.03.07 4.8 162.2 2008.03.12 5.5 161.5												

+ 3, x 3: Numbers refer to  
Sensitivity

20  
15 10 5  
(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM6b-1										1 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 868 060.4 E 349 661.6, Thickson Road				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES							
DATUM Geodetic		DATE 2008.03.04 - 2008.03.04				CHECKED BY MEF							
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER			TYPE	"N" VALUES						SHEAR STRENGTH kPa
166.3	TOPSOIL, with roots (50mm) Brown Moist Clayey SILT, trace sand, trace gravel Stiff Brown		1	SS	14								
164.8	Silty CLAY, some sand, trace gravel Very Stiff to Hard Brown (TILL)(CL)		2	SS	19								
			3	SS	50								
			4	SS	60								
			5	SS	35								
166.2	SAND and SILT, some clay, trace gravel Very Dense Grey Moist (TILL)		6	SS	100/125								
			7	SS	100/0.75								
			8	SS	100/.150								
	inferred cobble at 8.97 to 9.12m												

Continued Next Page

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



RECORD OF BOREHOLE No CM6b-1										2 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 868 060.4 E 349 661.6, Thickson Road				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES							
DATUM Geodetic		DATE 2008.03.04 - 2008.03.04				CHECKED BY MEF							
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER			TYPE	"N" VALUES						SHEAR STRENGTH kPa
	Continued From Previous Page												
155.5	SAND and SILT, some clay, trace gravel Very Dense Grey Moist (TILL)		9	SS	100/.150								
10.8	END OF BOREHOLE AT 10.8m. Piezometer installation consists of 19mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH (m) ELEV. (m) 2008.03.07 8.6 157.7 2008.03.12 2.3 164.0												

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



+<sup>3</sup>, X<sup>3</sup>: Numbers refer to Sensitivity

+ <sup>3</sup> , × <sup>3</sup>	Numbers refer to Sensitivity	20 15-0-5 15	(%) STRAIN AT FAILURE
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RECORD OF BOREHOLE No CM9-1															2 OF 2		METRIC	
G.W.P. W.O. 07-20016			LOCATION N 4 858 640.5 E 350 373.3			ORIGINATED BY SLL												
HWY 407			BOREHOLE TYPE Solid Stem Augers			COMPILED BY SM												
DATUM Geodetic			DATE 2007.12.05 - 2007.12.05			CHECKED BY MEF												
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	
Continued From Previous Page																		
	SAND and SILT, trace to some clay, trace gravel, occasional cobbles Dense to Very Dense Gmy Moist (Till.)		8	SS	55		161											
			9	SS	42		159											
	becoming Compact		10	SS	25		158											
			11	SS	14		150											
	becoming Very Dense		2	SS	100		150											
154.6	BOREHOLE CONTINUED ON CM9-1A.																	
17.1	END OF BOREHOLE AT 17.1m. BOREHOLE OPEN TO 15.4m. Piezometer installation consists of 15 mm diameter Schedule 40 PVC pipe with a 1.52 m Skirted Screen. WATER LEVEL READINGS: DATE DEPTH(m) ELEV (m) 2007.12.10 11.2 160.5 2007.12.21 10.2 161.5 2008.01.16 9.9 161.8																	

+ 3, x 3 Numbers refer to Sensitivity 20 15 10 (% STRAIN AT FAILURE)



RECORD OF BOREHOLE No CM9-1a															1 OF 3		METRIC	
G.W.P. W.O. 07-20016			LOCATION N 4 858 640.5 E 350 373.3			ORIGINATED BY SLL												
HWY 407			BOREHOLE TYPE Solid Stem Augers			COMPILED BY ES												
DATUM Geodetic			DATE 2007.12.10 - 2007.12.10			CHECKED BY MEF												
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	
171.7																		
0.0																		
							171											
							170											
							169											
							168											
							167											
							166											
							165											
							164											
							163											
							162											

Continued Next Page

+ 3, x 3 Numbers refer to Sensitivity 20 15 10 (% STRAIN AT FAILURE)



RECORD OF BOREHOLE No CM9-1a															2 OF 3		METRIC	
G.W.P. W.O. 07-20016			LOCATION N 4 888 640.5 E 350 373.3			ORIGINATED BY SLL												
HWY 407			BOREHOLE TYPE Solid Stem Augers			COMPILED BY ES												
DATUM Geodetic			DATE 2007.12.10 - 2007.12.10			CHECKED BY MEF												
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC FACT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60					20 40 60	Y	GR SA SI CL			
Continued From Previous Page																		
BOREHOLE CONTINUED FROM CM9-1. No Sampling until 15.24m.																		
156.4	SAND and SILT, trace clay, trace gravel, occasional cobbles Dense to Very Dense Grey Moist (TILL)	1	SS	39														
152		2	SS	100/														
154.1	Gravelly SAND, trace silt Very Dense Grey Wet	3	SS	100/														
17.6																		
Continued Next Page																		

+ 3, X 3; Numbers refer to Sensitivity 20 15 10 (% STRAIN AT FAILURE



RECORD OF BOREHOLE No CM9-1a															3 OF 3		METRIC	
G.W.P. W.O. 07-20016			LOCATION N 4 888 640.5 E 350 373.3			ORIGINATED BY SLL												
HWY 407			BOREHOLE TYPE Solid Stem Augers			COMPILED BY ES												
DATUM Geodetic			DATE 2007.12.10 - 2007.12.10			CHECKED BY MEF												
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC FACT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60					20 40 60	Y	GR SA SI CL			
Continued From Previous Page																		
151.5	Gravelly SAND, trace silt Very Dense Grey Wet	4	SS	100/														
20.2																		
END OF BOREHOLE AT 20.2m BOREHOLE OPEN TO 15.4m. WATER LEVEL AT 9.4m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.2m AND ASPHALT TO SURFACE.																		
151																		

+ 3, X 3; Numbers refer to Sensitivity 20 15 10 (% STRAIN AT FAILURE



RECORD OF BOREHOLE No CM9-2															1 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 858 557.6 E 350 406.6				ORIGINATED BY SLL												
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY SM												
DATUM Geodetic		DATE 2007.12.06 - 2007.12.10				CHECKED BY MEF												
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W P	W	W L	W P	W	W L	γ	GR SA SI CL		
171.3	ASPHALT (150mm)																	
0.0																		
0.2	SAND, some gravel, trace silt Brown Moist (FILL)		1	AS														
170.7																		
0.6	Clayey SILT, some sand to with sand, trace gravel Hard Brown (TILL)(CL)		1	SS	33													
			2	SS	37													
			3	SS	48													
			4	SS	51													
			5	SS	32													
165.8	SAND and SILT, trace to some clay, trace gravel Very Dense Grey Moist (TILL)		6	SS	80													
5.5																		
			7	SS	101													
162.6	Gravelly SAND, some silt Very Dense Grey Moist BOREHOLE CONTINUED ON CM9-2A.		8	SS	100													
8.7																		
161.7	END OF BOREHOLE AT 9.6m BOREHOLE OPEN TO 9.5m AND																	
9.0																		

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RECORD OF BOREHOLE No CM9-2															2 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 858 557.6 E 350 406.6				ORIGINATED BY SLL												
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY SM												
DATUM Geodetic		DATE 2007.12.06 - 2007.12.10				CHECKED BY MEF												
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W P	W	W L	W P	W	W L	γ	GR SA SI CL		
	Continued From Previous Page																	
	DRY ON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.2m AND ASPHALT TO SURFACE																	

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ONTM4S 0510.GPJ 2/12/03

ONTM74S 0510 GP1 842576



ONTM4S C5:C.GPJ 9:2023

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$\cdot S, \times 3$ : Numbers refer to Sensitivity

+ 3, X 3. Numbers refer to Sensitivity



RECORD OF BOREHOLE No CM10b-2 1 OF 2 METRIC																
G.W.P. W.O. 07-20016		LOCATION N 4 888 991.9 E 350 815.3			ORIGINATED BY JM											
HWY 407		BOREHOLE TYPE Solid Stem Augers			COMPILED BY ES											
DATUM Goodelle		DATE 2008.03.05 - 2008.03.07			CHECKED BY MEF											
SOIL PROFILE		SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL MOISTURE CONTENT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV. DEPTH	DESCRIPTION	STRAIT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	W.P. W L	W.P. W L	Y	GR SA SI CL		
158.0	TOPSOIL, with roots: (150mm)						158									
0.2	Brown Moist SAND, some silt, trace gravel, trace clay, trace to some rootlets Loose Brown Moist		1	SS	10		155									
153.8			2	SS	10		154									
2.1	SAND and SILT, trace clay Loose to Very Loose Brown to Grey Wet		3	SS	8		153							0 46 46 7		
151.9			4	SS	2		152									
4.1	Silty SAND, trace gravel Compact Grey Wet		5	SS	11		151							1 69 29 (SI+CL)		
149.9			6	SS	27		150									
148.8	Sandy SILT, some clay Compact Grey Moist						149									
7.2	Silty CLAY, trace sand, trace gravel Hard Grey (TILL)(CL)		7	SS	52		148									
147.3							147									
8.7	Silty SAND, trace gravel Very Dense Grey Moist		8	SS	100											

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+<sup>3</sup>, X<sup>3</sup>, Numbers refer to Sensitivity 75 15-5 10 (%) STRAIN AT FAILURE

ONTM-T-5 0510.GPJ 8/12/08



RECORD OF BOREHOLE No CM10b-2 2 OF 2 METRIC																
G.W.P. W.O. 07-20016		LOCATION N 4 888 991.9 E 350 815.3			ORIGINATED BY JM											
HWY 407		BOREHOLE TYPE Solid Stem Augers			COMPILED BY ES											
DATUM Goodelle		DATE 2008.03.05 - 2008.03.07			CHECKED BY MEF											
SOIL PROFILE		SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL MOISTURE CONTENT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV. DEPTH	DESCRIPTION	STRAIT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	W.P. W L	W.P. W L	Y	GR SA SI CL		
	Continued From Previous Page						140									
143.8	Silty SAND, trace gravel Very Dense Grey Moist		9	SS	100		145								4 72 23 (SI+CL)	
12.2	Sandy SILT, some clay, trace gravel Very Dense Grey Moist (TILL)		10	SS	100		144									
141.9			11	SS	100		143									
14.0	END OF BOREHOLE AT 14.1m. Piezometer installation consists of 19mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2008.04.28 2.35 153.7 2009.07.28 2.17 153.8						142									

+<sup>3</sup>, X<sup>3</sup>, Numbers refer to Sensitivity 75 15-5 10 (%) STRAIN AT FAILURE

ONTM-T-5 0510.GPJ 8/12/08



RECORD OF BOREHOLE No CM11-1										1 OF 3		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 869 206.2 E 351 033.7				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY SM							
DATUM Geodetic		DATE 2007.12.06 - 2007.12.06				CHECKED BY MEF							
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	"N" VALUES						20
171.3	ASPHALT (60 mm)												
170.7	SAND, some gravel, some silt Brown Moist (FILL)		1	AS								15 71 14 (SH+CL)	
169.1	Silty CLAY, some sand, trace gravel Very Stiff Brown (TILL)		1	SS	16								
			2	SS	17								
168.1	SILT, trace clay, trace sand Dense to Very Dense Brown Moist		3	SS	30							0 3 91 7	
			4	SS	52								
167.1	Silty CLAY, trace thin sand seams Hard Brown to Grey Moist (Cl)		5	SS	54							0 7 28 65	
165.5	Silty CLAY, some sand, trace gravel Hard Grey Moist (TILL)		6	SS	94								
164.2	SAND and SILT, some clay, trace gravel, occasional inferred cobbles Very Dense Grey Moist (TILL)		7	SS	72							4 44 35 17	
			8	SS	100/								
					125								

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+<sup>3</sup>, x<sup>3</sup> Numbers refer to Sensitivity  
20  
10-5  
10 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM11-1										2 OF 3		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 869 206.2 E 351 033.7				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY SM							
DATUM Geodetic		DATE 2007.12.06 - 2007.12.06				CHECKED BY MEF							
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	"N" VALUES						20
	Continued From Previous Page												
161.0	Silty CLAY, trace sand seams Hard Grey Moist (Cl)		9	SS	59								
			10	SS	75							0 0 34 66	
158.2	SAND, trace to some silt Very Dense to Compact Grey Wet		11	SS	57								
			12	SS	25							0 61 9 (SH+CL)	
154.9	SILT, some sand, trace clay Very Dense Grey Moist to Wet		13	SS	100/								
					150								
			14	SS	100/								
					150								
151.4			15	SS	100/								

Continued Next Page

+<sup>3</sup>, x<sup>3</sup> Numbers refer to Sensitivity  
20  
15-5  
10 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM11-1															3 OF 3		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 669 206.2 E 351 033.7			ORIGINATED BY SLL													
HWY 407		BOREHOLE TYPE Solid Stem Augers			COMPILED BY SM													
DATUM Geodetic		DATE 2007.12.05 - 2007.12.06			CHECKED BY MEF													
SOIL PROFILE		SAMPLES		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	W	P	W	P	W	P	Y	GR	SA	SI	CL			
20.0	Continued From Previous Page END OF BOREHOLE AT 20.0m. BOREHOLE OPEN TO 9.4m AND WATER LEVEL AT 8.8m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.15m AND ASPHALT TO SURFACE																	

Numbers refer to Sensitivity  
20  
15  
10  
(%) STRAIN AT FAILURE

ONTM14S 0510.GPJ 8/2008



RECORD OF BOREHOLE No CM11-2															1 OF 3		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 669 120.2 E 351 059.4			ORIGINATED BY SLL													
HWY 407		BOREHOLE TYPE Solid Stem Augers			COMPILED BY SM													
DATUM Geodetic		DATE 2007.12.07 - 2007.12.07			CHECKED BY MEF													
SOIL PROFILE		SAMPLES		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	W	P	W	P	W	P	Y	GR	SA	SI	CL			
171.1	ASPHALT (50 mm)																	
0.1	SAND, some gravel (FILL)		1	AS														
0.6	ASPHALT (50 mm)																	
	SAND, some gravel, trace silt Brown Moist (FILL)		1	SS							34							
	Silty CLAY, some sand, trace gravel Hard Brown Moist (FILL)		2	SS							37							
169.9																		
2.2	SILT, trace sand, trace clay Very Dense Brown Wet		3	SS							55							
			4	SS							86							
166.9																		
4.3	SAND and SILT, some clay, trace gravel Very Dense Grey Moist (FILL)		5	SS							100/175							
			6	SS							100/175							
164.2																		
6.9	Silty CLAY, with sand, trace gravel Hard Grey Moist (FILL/CL)		7	SS							100							
			8	SS							75							

Numbers refer to Sensitivity  
20  
15  
10  
(%) STRAIN AT FAILURE

ONTM14S 0510.GPJ 8/2008





RECORD OF BOREHOLE No CM11-2															2 OF 3		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 889 120.2 E 351 059.4				ORIGINATED BY SLL												
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY SM												
DATUM Geodetic		DATE 2007.12.07 - 2007.12.07				CHECKED BY MEF												
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	"N" VALUES					20	40	60	80	100	GR	SA
Continued From Previous Page																		
159.5	Silty CLAY, with sand, trace gravel Hard Grey (TILL)(CL)		9	SS	62							0 24 43 32						
11.7	Silty CLAY, trace sand Hard Grey Moist (Cl-CH)		10	SS	54													
			11	SS	64							0 1 23 76						
			12	SS	52													
154.8	SAND, some silt Very Dense to Dense Grey Wet		13	SS	70													
			14	SS	49							0 81 19 (Si+Cl)						
151.5	SILT, some clay, trace sand																	

Continued Next Page

+ 3, x 3: Numbers refer to  
Sensitivity

20  
15-10-5  
10 (% STRAIN AT FAILURE



RECORD OF BOREHOLE No CM11-2															3 OF 3		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 889 120.2 E 351 059.4				ORIGINATED BY SLL												
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY SM												
DATUM Geodetic		DATE 2007.12.07 - 2007.12.07				CHECKED BY MEF												
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	"N" VALUES					20	40	60	80	100	GR	SA
Continued From Previous Page																		
	SILT, some clay, trace sand Very Dense Grey Wet		15	SS	100													
			16	SS	100													
			17	SS	100							0 0 01 19						
147.8	END OF BOREHOLE AT 23.4m. Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted Screen WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 2008 01 16 9.9 161.3																	

+ 3, x 3: Numbers refer to  
Sensitivity

20  
15-10-5  
10 (% STRAIN AT FAILURE



RECORD OF BOREHOLE No CM17-1										1 OF 2		METRIC								
G.W.P. W.O. 07-20016		LOCATION N 4 870 854.8 E 353 677.7				ORIGINATED BY SLL														
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES														
DATUM Geodetic		DATE 2007.12.11 - 2007.12.11				CHECKED BY MEF														
SOIL PROFILE		SAMPLES		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION								
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20	40	60	80	100	W.P.	W	W.L.	WATER CONTENT (%)	GR	SA	SI	CL
173.4	ASPHALT (135 mm)		1	AS																
172.5	SAND, some gravel, trace silt Dark Brown Moist (FILL)		1	SS	47															
171.2	SAND, some gravel, some silt Dense Brown Moist		2	SS	30															
170.4	Sandy SILT, trace gravel, trace clay Dense Brown Moist (TILL)		3	SS	38															
169.4	SAND, some silt, trace gravel Compact to Very Dense Brown Wet		4	SS	21															
168.4			5	SS	54															
167.4			6	SS	55															
166.4			7	SS	100															
165.4			8	SS	100															
164.4	becoming Grey																			

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Continued Next Page

Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM17-1										2 OF 2		METRIC								
G.W.P. W.O. 07-20016		LOCATION N 4 870 854.8 E 353 677.7				ORIGINATED BY SLL														
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES														
DATUM Geodetic		DATE 2007.12.11 - 2007.12.11				CHECKED BY MEF														
SOIL PROFILE		SAMPLES		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION								
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20	40	60	80	100	W.P.	W	W.L.	WATER CONTENT (%)	GR	SA	SI	CL
162.5	SAND, some silt, trace gravel Very Dense Grey Wet		9a	SS	100															
161.9	Sandy SILT, trace gravel, trace clay Very Dense Grey Moist (TILL) BOREHOLE CONTINUED ON CM17-1A		9b	SS	275															
161.1	END OF BOREHOLE AT 11.1m. Piezometer installation consists of 15 mm diameter Schedule 40 PVC pipe with a 1.52 in slotted Screen. WATER LEVEL READINGS: DATE DEPTH(m) ELEV(m) 2007.12.12 3.0 170.5 2008.01.16 2.1 171.4																			

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Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

Continued Next Page

(%) STRAIN AT FAILURE

+ 3, X 3: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM17-2															1 OF 2		METRIC		
G.W.P. W.O. 07-20016		LOCATION					ORIGINATED BY WB												
HWY 407		BOREHOLE TYPE Solid Stem Augers					COMPILED BY ES												
DATUM Geodetic		DATE 2008.05.26 - 2008.05.26					CHECKED BY MEF												
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	TR VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			GR	SA	SI	CL
								20	40	60	80	100	20	40	60				
0.0	TOPSOIL, peat, sandy, roots		1	AS															
0.3	Silty SAND, trace clay, trace gravel Compact to Dense Brown-grey Moist		1	SS	13														
			2	SS	31														
2.2	Silty SAND, trace clay, trace gravel Compact to Very Dense Grey Moist		3	SS	26														
			4	SS	18														
			5	SS	100/ 275														
5.5	SAND and SILT, trace clay, trace gravel Very Dense Grey Moist (TILL)		6	SS	100														
			7	SS	68/ 100														
			8	SS	100/ 225														
9.5	END OF BOREHOLE AT 9.53m. WATER LEVEL AT 0.3m UPON COMPLETION																		

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+<sup>3</sup>, X<sup>3</sup> Numbers refer to Sensitivity  
20  
15 10 5 0 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM17-2															2 OF 2		METRIC		
G.W.P. W.O. 07-20016		LOCATION					ORIGINATED BY WB												
HWY 407		BOREHOLE TYPE Solid Stem Augers					COMPILED BY ES												
DATUM Geodetic		DATE 2008.05.26 - 2008.05.26					CHECKED BY MEF												
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	TR VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			GR	SA	SI	CL
								20	40	60	80	100	20	40	60				
	Continued From Previous Page BOREHOLE BACKFILLED WITH HOLEPLUG AND AUGER CUTTINGS TO SURFACE.																		

+<sup>3</sup>, X<sup>3</sup> Numbers refer to Sensitivity  
20  
15 10 5 0 (%) STRAIN AT FAILURE

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CONTINUED ON PG. 18/12/08



ONTM74S 0510.GPJ 2/12/08

+ 3, X 3; Numbers refer to Sensitivity

ONTARIO 0510 GPJ SY12009

+ 3, X 3: Numbers refer to Sensitivity



RECORD OF BOREHOLE No CM17b-1										1 OF 3		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 870 893.4 E 353 665.0				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES							
DATUM Geodetic		DATE 2007.12.12 - 2007.12.12				CHECKED BY MEF							
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER			TYPE	"N" VALUES						20
174.4	ASPHALT (100 mm)												
173.9	SAND, some gravel, trace silt Brown Moist (FILL)		1	AS									
173.8	ASPHALT (75 mm)												
172.9	SAND, some gravel, trace silt Brown Moist (FILL)		1	SS	41								
172.9	Silty CLAY, some sand, trace gravel Very Stiff Brown (TILL)		2	SS	20								
172.6	Sandy SILT, trace clay, trace gravel Dense Brown Moist (TILL)		3	SS	30								
171.8	SAND, some silt, trace gravel Compact Brown Moist to Wet		4	SS	27							4 77 15 (SI+CL)	
			5	SS	26								
			6	SS	90								
166.0	Sandy SILT, some clay Very Dense Grey Moist (TILL)		7a	SS	100/								
166.0	SAND, some silt to silty, trace clay Very Dense to Dense Grey Wet		7b	SS	225							0 33 53 15	
			8	SS	100/								
					250								

Continued Next Page

Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM17b-1										2 OF 3		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 870 893.4 E 353 665.0				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES							
DATUM Geodetic		DATE 2007.12.12 - 2007.12.12				CHECKED BY MEF							
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER			TYPE	"N" VALUES						20
	Continued From Previous Page												
	SAND, some silt to silty, trace clay Dense to Very Dense Grey Wet		9	SS	47							0 66 32 2	
			10	SS	100/								
					275								
160.7	Sandy SILT, trace clay Dense to Very Dense Grey Wet		11	SS	42							0 29 65 6	
13.7													
			12	SS	30								
			13	SS	100/								
					225								
156.4	Silty CLAY, trace sand Hard Grey (CL)		14	SS	100/							0 2 55 43	
18.0					150								

Continued Next Page

Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

+ 3, X 3      Numbers refer to Sensitivity      26  
15 5 5      (% ) STRAIN AT FAILURE  
10

4.3. X.3. Numbers refer to Sensitivity



RECORD OF BOREHOLE No CM17b-3										1 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 870 921.4 E 353 736.5				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES							
DATUM Geodetic		DATE 2007.03.12 - 2007.03.12				CHECKED BY MEF							
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER			TYPE	TN-VALUES						20
170.7	TOPSOIL, with roots. (275mm)												
170.4	Brown Moist												
0.3	SAND, trace gravel Compact Brown Moist		1	SS	17								
166.3	Silty SAND, trace clay, trace gravel Compact to Very Dense Brown to Grey Moist (TILL)		2	SS	12								
1.4			3	SS	31								
			4	SS	60								
			5	SS	60								
164.9	SAND and SILT, trace clay, trace gravel Very Dense Grey Moist to Wet		6	SS	100/200								
5.8			7	SS	100/250								
162.2	SILT and SAND, some clay, trace gravel Hard Grey (TILL)		8	SS	100/150								
8.5													

Continued Next Page

+ 3, X 3, Numbers refer to Sensitivity 20 15 10 (% STRAIN AT FAILURE

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RECORD OF BOREHOLE No CM17b-3										2 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 870 921.4 E 353 736.5				ORIGINATED BY SLL							
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES							
DATUM Geodetic		DATE 2007.03.12 - 2007.03.12				CHECKED BY MEF							
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER			TYPE	TN-VALUES						20
160.3	Continued From Previous Page												
10.4	Gravelly SAND, with weathered shale fragments Very Dense Grey Wet		9	SS	105								
158.6													
11.1	END OF BOREHOLE AT 11.1m. BOREHOLE OPEN TO 9.8m AND WATER LEVEL AT 1.6m UPON COMPLETION. Piezometer installation consists of 19mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS. DATE DEPTH (m) ELEV. (m)												

+ 3, X 3, Numbers refer to Sensitivity 20 15 10 (% STRAIN AT FAILURE

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RECORD OF BOREHOLE No CM20b-2															1 OF 1		METRIC			
G.W.P. W.O. 07-20016		LOCATION N 4 871 583.0 E 355 287.2					ORIGINATED BY SLL													
HWY 407		BOREHOLE TYPE Solid Stem Augers					COMPILED BY ES													
DATUM Geodetic		DATE 2008.03.07 - 2008.03.07					CHECKED BY MEF													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT			NATURAL MOISTURE CONTENT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	20	40	60	80	100	W.P.	W.L.	W.P.	W.L.	Y	GR	SA	SI	CL
210.6	TOPSOIL, with roots (250mm) Brown Moist																			
210.6	Sandy SILT, trace gravel Loose Brown Moist to Wet		1	SS	2	210														
209.6			2	SS	10	209														
209.6	SAND and SILT, some clay, trace gravel Dense to Very Dense Grey Moist (TILL)		3	SS	30	209														
209.6			4	SS	167/225	209														
209.6			5	SS	178/225	209														
204.0	Silty CLAY, sandy, trace gravel Hard Grey (TILL)		6	SS	100/100	205														
204.0			7	SS	075	204														
203.1	END OF BOREHOLE AT 7.7m BOREHOLE OPEN AND WATER LEVEL AT 0.5m UPON COMPLETION. Piezometer installation consists of 15mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV (m) 2008.03.12 0.3 210.5																			

+ 3, X 3, Numbers refer to Sensitivity 20 10 10 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM20b-3															1 OF 1		METRIC			
G.W.P. W.O. 07-20016		LOCATION					ORIGINATED BY WB													
HWY 407		BOREHOLE TYPE Solid Stem Augers					COMPILED BY ES													
DATUM Geodetic		DATE 2008.05.26 - 2008.05.26					CHECKED BY MEF													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT			NATURAL MOISTURE CONTENT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	20	40	60	80	100	W.P.	W.L.	W.P.	W.L.	Y	GR	SA	SI	CL
0.0	TOPSOIL, trace gravel, trace clay Brown Moist		1	AS																
0.6	SAND and SILT, some clay, trace gravel Stiff to Hard Brown (TILL)		1	SS	12															
0.6			2	SS	56															
0.6			3	SS	19															
0.6			4	SS	38															
0.6			5	SS	49/107															
0.6			6	SS	100/175															
7.8	END OF BOREHOLE AT 7.77m WATER LEVEL AT 3.05m UPON COMPLETION. BOREHOLE BACK-FILLED WITH HOLEPLUG AND AUGER CUTTINGS TO SURFACE		7	SS	100/150															

+ 3, X 3, Numbers refer to Sensitivity 20 10 10 (%) STRAIN AT FAILURE





RECORD OF BOREHOLE No CM21-1															1 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 871 578.4 E 355 414.6					ORIGINATED BY SLL											
HWY 407		BOREHOLE TYPE Solid Stem Augers					COMPILED BY ES											
DATUM Geodetic		DATE 2008.03.05 - 2008.03.06					CHECKED BY MEF											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
217.8	TOPSOIL, trace roots: (150mm)																	
0.2	Brown Moist Silty CLAY Stiff Brown		1	SS	14													
216.4	Silty CLAY, sandy, trace gravel Stiff to Very Stiff Brown (TILL) (CL)		2	SS	12													
1.4			3	SS	28													
			4	SS	13													
			5	SS	20													
211.7	Silty CLAY, trace sand Stiff Gray (CL)		6	SS	8													
6.1			7	SS	13													
209.1	Silty SAND Compact Gray Wet		8	SS	16													
8.7																		

Continued Next Page

+ 3 . X 3 Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No CM21-1															2 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 871 578.4 E 355 414.6					ORIGINATED BY SLL											
HWY 407		BOREHOLE TYPE Solid Stem Augers					COMPILED BY ES											
DATUM Geodetic		DATE 2008.03.05 - 2008.03.06					CHECKED BY MEF											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
207.5	SAND and SILT, trace clay, trace gravel Very Dense Gray Moist (TILL)		9	SS	100/													
10.3					153													
	occasional cobbles at 12.3 to 12.5m		10	SS	100/													
					100													
204.0	END OF BOREHOLE AT 14.1m. BOREHOLE OPEN AND WATER LEVEL AT 4.1m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.		11	SS	100/													
13.8					075													

+ 3 . X 3 Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No CM21-2										1 OF 2		METRIC		
G.W.P. W.O. 07-20016		LOCATION N 4 071 584.2 E 355 499.9		ORIGINATED BY SLL										
HWY 407		BOREHOLE TYPE Solid Stem Augers		COMPILED BY ES										
DATUM Geodetic		DATE 2008 03 07 - 2008 03 07		CHECKED BY MEF										
SOIL PROFILE		SAMPLES		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60	W P	W	V L	Y	GR SA SI CL
221.1	TOPSOIL, with roots and rootlets: (500mm) Brown Moist						221							
220.5	Sandy SILT, some clay, trace gravel Loose Brown Wet		1	SS	8		220							
219.6	SAND and SILT, some clay, trace gravel Compact to Very Dense Brown Moist (TILL)		2	SS	18		219							
218.6			3	SS	24		218							
217.6			4	SS	49		217							
216.6	becoming Grey		5	SS	81		216							4 41 38 17
215.4	Silty CLAY, sandy, trace gravel Hard Grey (TILL)(CL)		6	SS	33		215							1 22 38 38
213.8	Silty SAND, trace gravel Loose Grey Wet		7	SS	7		213							
212.2	SAND, some gravel, trace silt Loose Grey Wet		8	SS	4		212							14 79 6 (SI+CL)

Continued Next Page

+ 3 X 3 Numbers refer to Sensitivity 20 15 10 (% STRAIN AT FAILURE)



RECORD OF BOREHOLE No CM21-2										2 OF 2		METRIC		
G.W.P. W.O. 07-20016		LOCATION N 4 071 584.2 E 355 499.9		ORIGINATED BY SLL										
HWY 407		BOREHOLE TYPE Solid Stem Augers		COMPILED BY ES										
DATUM Geodetic		DATE 2008 03 07 - 2008 03 07		CHECKED BY MEF										
SOIL PROFILE		SAMPLES		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60	W P	W	V L	Y	GR SA SI CL
	Continued From Previous Page													
211	SAND, some gravel, trace silt Loose Grey Wet		9	SS	38		211							
209.6	SILT and SAND, some clay, trace gravel Very Dense Grey Moist (TILL)		10	SS	100/150		209							3 40 45 12
208.6			11	SS	100/150		208							
207.6			12	SS	100/125		207							
205.7	END OF BOREHOLE AT 15.4m. BOREHOLE OPEN TO 14.0m AND WATER LEVEL AT 2.5m UPON COMPLETION. Piezometer installation consists of 19mm diameter schedule 40 PVC pipe with a 1.37m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV (m) 2008.03.12 7.0 214.1						205							

+ 3 X 3 Numbers refer to Sensitivity 20 15 10 (% STRAIN AT FAILURE)

Continued Next Page

+3, x3; Numbers refer to Sensitivity

ONTARIO 05-10 GPJ B/2028

+ 3, x 3: Numbers refer to Sensitivity



RECORD OF BOREHOLE No CM21b-3															1 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION					ORIGINATED BY											
HWY 407		BOREHOLE TYPE					COMPILED BY											
DATUM Geodetic		DATE 2008.05.27 - 2008.05.27					CHECKED BY											
SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT		NATURAL MOISTURE CONTENT		UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		SHEAR STRENGTH kPa				WATER CONTENT (%)		WATER CONTENT (%)						
0.0	TOPSOIL		1	AS														
0.3	Silty CLAY, some sand, trace gravel Very Stiff to Hard Brown to Grey (TILL)		1	SS	19													
			2	SS	24													
			3	SS	25													
			4	SS	53													
	50 mm layer is sand																	
			5	SS	51													
			6	SS	26													
7.0	Silty CLAY, trace sand, trace gravel Very Stiff Grey		7	SS	28													
9.5	SAND and SILT, trace gravel, trace clay Very Dense Grey Moist (TILL)		8	SS	43													

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Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM21b-3															2 OF 2		METRIC	
G.W.P. W.O. 07-20016		LOCATION					ORIGINATED BY											
HWY 407		BOREHOLE TYPE					COMPILED BY											
DATUM Geodetic		DATE 2008.05.27 - 2008.05.27					CHECKED BY											
SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT		NATURAL MOISTURE CONTENT		UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		SHEAR STRENGTH kPa				WATER CONTENT (%)		WATER CONTENT (%)						
	Continued From Previous Page																	
	SAND and SILT, trace gravel, trace clay Very Dense Grey Moist (TILL)		9	SS	50/125													
11.6	Sandy GRAVEL, trace silt, trace clay Very Dense Grey Wet (TILL)		10	SS	83													
13.3	SAND, some gravel, trace silt Compacted Brown to Grey Moist		11	SS	25													
14.0	Sandy SILT, some clay, trace gravel Very Dense Grey (TILL)		12	SS	100/050													
			13	SS	100/100													
			14	SS	100/075													
18.4	END OF BOREHOLE AT 18.36 m Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen				075													
WATER LEVEL READINGS: DATE DEPTH (m)																		

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Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

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+ 3, X 3 Numbers refer to Sensitivity

CONTINUED ON 0517 CSPJ 811210A

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to Sensitivity





RECORD OF BOREHOLE No CM24-1															1 OF 3		METRIC		
G.W.P. W.O. 07-20016		LOCATION N 4 870 999.6 E 357 392.3				ORIGINATED BY JM													
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES													
DATUM Geodetic		DATE 2008.03.14 - 2008.03.14				CHECKED BY MEF													
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS		ELEVATION SCALE		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES														
218.9																			
0.0	TOPSOIL, with roots: (150mm)																		
0.2	Brown, Moist Sandy SILT, trace clay, trace gravel Loose Brown Moist		1	SS	4														
217.2																			
1.7	Sandy SILT, some clay, trace gravel Dense Light Brown to Grey Moist (CL-MI)		2	SS	14														
			3	SS	31														
			4	SS	44														
214.8																			
4.1	Sandy SILT, some clay, trace gravel Dense Grey Moist (TILL)		5	SS	33														
			6	SS	43														
211.7																			
7.2	Silty CLAY, some sand to sandy, trace gravel, occasional cobbles Very Stiff to Hard Grey (TILL)(CL)		7	SS	36														
			8	SS	28														
209																			

Continued Next Page

+ 3, X 3, Numbers refer to Sensitivity  
20 15 10 (% STRAIN AT FAILURE)



RECORD OF BOREHOLE No CM24-1															2 OF 3		METRIC		
G.W.P. W.O. 07-20016		LOCATION N 4 870 999.6 E 357 392.3				ORIGINATED BY JM													
HWY 407		BOREHOLE TYPE Solid Stem Augers				COMPILED BY ES													
DATUM Geodetic		DATE 2008.03.14 - 2008.03.14				CHECKED BY MEF													
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS		ELEVATION SCALE		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES														
	Continued From Previous Page																		
	Silty CLAY, some sand to sandy, trace gravel, occasional cobbles Very Stiff to Hard Grey (TILL)(CL)		9	SS	16														
208.7																			
12.2	Sandy SILT, some clay, trace gravel, trace cobbles Very Dense Grey Moist (TILL) cobble at 12.34m		10	SS	53														
205.6																			
13.3	Silty CLAY, trace sand Stiff Grey (TILL)		11	SS	12														
204.1																			
14.8	Sandy SILT, trace gravel, trace clay Compact to Very Dense Grey Moist (TILL)		12	SS	27														
			13	SS	100/250														
201.4																			
17.5	Silty SAND, trace gravel Very Dense Grey Moist (TILL)		14	SS	100														
			15	SS	100														
199.9																			

Continued Next Page

+ 3, X 3, Numbers refer to Sensitivity  
20 15 10 (% STRAIN AT FAILURE)



RECORD OF BOREHOLE No CM24-1															3 OF 3		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 870 999.6 E 357 302.3					ORIGINATED BY JM											
HWY 407		BOREHOLE TYPE Solid Stem Augers					COMPILED BY ES											
DATUM Geodetic		DATE 2008.03.14 - 2008.03.14					CHECKED BY MEF											
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			"N" VALUES	20	40	60						80	100	W.P.
							SHEAR STRENGTH kPa				WATER CONTENT (%)							
							○ UNCONFINED + FIELD VANE											
							● QUICK TRIAXIAL x LAB VANE											
							20	40	60	80	100	20	40	60				
19.9	END OF BOREHOLE AT 19.9m. Piezometer installation consists of 10mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV (m) 2008.03.20 13.9 205.0				125													
Continued From Previous Page																		

+ 3 x 3 Numbers refer to Sensitivity  
20 15 10 5 0 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM24-2															1 OF 4		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 870 915.6 E 357 422.8					ORIGINATED BY JM											
HWY 407		BOREHOLE TYPE Solid Stem Augers					COMPILED BY ES											
DATUM Geodetic		DATE 2008.03.17 - 2008.03.18					CHECKED BY MEF											
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			"N" VALUES	20	40	60						80	100	W.P.
							SHEAR STRENGTH kPa				WATER CONTENT (%)							
							○ UNCONFINED + FIELD VANE											
							● QUICK TRIAXIAL x LAB VANE											
							20	40	60	80	100	20	40	60				
219.4	TOPSOIL, with roots: (150mm)																	
0.2	Brown Moist Sandy SILT, trace clay, trace gravel, trace roots Loose Brown Moist		1	SS	4													
218.0																		
1.4	SAND, some silt, trace gravel																	
217.6	Compact Brown Moist		2	SS	12													
1.8	Sandy SILT, some clay, trace gravel																	
	Compact Brown Moist		3	SS	13													
			4	SS	18										4 40 40 17			
216.3																		
4.1	Sandy SILT, trace clay, trace gravel																	
	Compact Grey Moist (TLL)(CL-ML)		5	SS	24													
			6	SS	23													
			7	SS	28										3 41 41 18			
210.8	Silty CLAY, some sand, trace gravel																	
8.7	Very SHI Grey (TLL)(CL)		8	SS	21													

Continued Next Page

+ 3 x 3 Numbers refer to Sensitivity  
20 15 10 5 0 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM24-2										2 OF 4		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 870 915.6 E 357 422.8		ORIGINATED BY JM		COMPILED BY ES		CHECKED BY MEF					
HWY 407		BOREHOLE TYPE Solid Stem Augers											
DATUM Geodetic		DATE 2008 03 17 - 2008 03 18											
SOIL PROFILE		SAMPLES		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL MOISTURE LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	T <sub>N</sub> VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60	WATER CONTENT (%)	GR SA SI CL		
Continued From Previous Page													
	Silty CLAY, some sand, trace gravel Very Stiff Grey (TILL) (CL)		9	SS	28		209				2 18 35 44		
							208						
			10	SS	23		207						
206.2													
13.3	Sandy SILT, trace clay, trace gravel Very Dense Grey Moist (TILL)		11	SS	100		200						
							205						
204.1													
15.4	Silty CLAY, trace sand, trace gravel Very Stiff Grey (TILL)		12	SS	20		204				0 8 44 47		
203.1							203						
10.3	Sandy SILT, trace clay, trace gravel Compact to Very Dense Grey Moist (TILL)		13	SS	16		202						
							201				5 57 31 7		
			14	SS	70		200						

Continued Next Page

+ 3, X 3 Numbers refer to Sensitivity 20 15 10 (% STRAIN AT FAILURE



RECORD OF BOREHOLE No CM24-2										3 OF 4		METRIC	
G.W.P. W.O. 07-20016		LOCATION N 4 870 915.6 E 357 422.8		ORIGINATED BY JM		COMPILED BY ES		CHECKED BY MEF					
HWY 407		BOREHOLE TYPE Solid Stem Augers											
DATUM Geodetic		DATE 2008 03 17 - 2008 03 18											
SOIL PROFILE		SAMPLES		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL MOISTURE LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	T <sub>N</sub> VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60	WATER CONTENT (%)	GR SA SI CL		
Continued From Previous Page													
	Sandy SILT, trace clay, trace gravel Very Dense to Dense Grey Moist (TILL)		15	SS	100		199						
							198				1 13 74 12		
			16	SS	31		197						
190.6													
22.9	Silty SAND, trace gravel Very Dense Grey Moist (TILL)		17	SS	100		196						
							195						
			18	SS	51		194						
194.0													
25.5	Silty SAND, trace gravel Very Dense Grey Moist		19	SS	100		193						
							192						
192.5													
26.9	Sandy SILT, some clay, trace gravel Very Dense Grey Moist (TILL)		20	SS	100		192						
							191						
190.4													
29.0	BOREHOLE ENDED AT 29.0m. BOREHOLE OPEN TO 16.5m AND WATER LEVEL AT 1.1m UPON COMPLETION BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.5m AND AUGER		21	SS	100		190						

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+ 3, X 3 Numbers refer to Sensitivity 20 15 10 (% STRAIN AT FAILURE

4<sup>3</sup>, X<sup>3</sup>: Numbers refer to Sensitivity

	26	(%) STRAIN AT FAILURE
+ 3 . X 3 . Numbers refer to Sensivity	15 - 18	

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+ , × : Numbers refer to Sensitivity

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+ 3, X 5. Numbers refer to Sensitivity



RECORD OF BOREHOLE No CM24-4															1 OF 3		METRIC	
G.W.P. W.O. 07-20016		LOCATION										ORIGINATED BY WB						
HWY 407		BOREHOLE TYPE Solid Stem Augers										COMPILED BY ES						
DATUM Geodetic		DATE 2008.05.20 - 2008.05.20										CHECKED BY MEF						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	IN VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)	Wp	W	WL	Y	GR SA SI CL
								20	40	60	80	100						
0.0	TOPSOIL, trace clay, trace gravel Brown Moist		1	AS														
0.5	Clayey SILT, sandy, trace gravel Firm Brown to Grey (TILL)		1	SS	22													
			2	SS	29													
			3	SS	30													
			4	SS	37													
			5	SS	26													
			6	SS	70													
			7	SS	100/ 250													
			8	SS	50													

Continued Next Page

Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No CM24-4															2 OF 3		METRIC	
G.W.P. W.O. 07-20016		LOCATION										ORIGINATED BY WB						
HWY 407		BOREHOLE TYPE Solid Stem Augers										COMPILED BY ES						
DATUM Geodetic		DATE 2008.05.20 - 2008.05.20										CHECKED BY MEF						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	IN VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)	Wp	W	WL	Y	GR SA SI CL
								20	40	60	80	100						
	Continued From Previous Page																	
	Clayey SILT, sandy, trace gravel Firm Brown to Grey (TILL)		9	SS	35													
			10	SS	35													
13.1	Silty CLAY, some sand, trace gravel Hard Grey		11	SS	49													
			12	SS	47													
16.2	Clayey SILT, some sand, trace gravel Hard Grey (TILL)		13	SS	75													
			14	SS	54													
19.2	Sandy SILT, some clay, trace gravel Very Dense Grey Moist (TILL)																	

Continued Next Page

Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE



+ 3, X 3: Numbers refer to Sensitivity

RECORD OF BOREHOLE No P13 1 OF 1 METRIC														
W.P. 282-86-01		LOCATION N 4 867422.8 E 348100.7			ORIGINATED BY DK									
DIST 6 HWY 407		BOREHOLE TYPE H.S. Auger, Cone Test			COMPILED BY DT									
DATUM Geodetic		DATE 93 12 13			CHECKED BY BI									
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC MOISTURE CONTENT		UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	'N' VALUES	20 40 60 80 100	WATER CONTENT (%)			W <sub>p</sub>	W <sub>L</sub>	GR SA SI CL
158.8	Ground Surface													
0.0	Granular Fill		1	SS	8									
0.5	Clayey Silt, Trace Sand, with Organic Inclusions (Fill)		2	SS	20									
1.4	Heterogeneous Mixture of Clayey Silt, Gravel, Brown, Very Stiff		3	SS	37									
156.7	Brown, Dense Grey, Very Dense		4	SS	123									
2.1	Heterogeneous Mixture of Silt, Sand and Gravel, Occasional Cobbles and Boulders (Glacial Till)		5	SS	120									
152.7			6	SS	103									
6.1	Heterogeneous Mixture of Clayey Silt, Trace Gravel Occasional Sand layers, Cobbles and Boulders, Grey, Hard (Glacial Till)		7	SS	117									
			8	SS	120									
146.4			9	SS	120									
12.4	End of Borehole		10	SS	100									
• Unstabilized water level measured upon completion of drilling on 93 12 13														

+3, x<sup>3</sup>: Numbers refer to Sensitivity  
20  
15-5 (%) STRAIN AT FAILURE  
10

RECORD OF BOREHOLE No P14 1 OF 1 METRIC														
W.P. 282-86-01		LOCATION N 4 867482.6 E 348937.8			ORIGINATED BY DK									
DIST 6 HWY 407		BOREHOLE TYPE H.S. Auger, Cone Test, BW Coating			COMPILED BY DT									
DATUM Geodetic		DATE 93 12 06 - 93 12 10			CHECKED BY BI									
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC MOISTURE CONTENT		UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	'N' VALUES	20 40 60 80 100	WATER CONTENT (%)			W <sub>p</sub>	W <sub>L</sub>	GR SA SI CL
158.8	Ground Surface													
0.0	Granular Fill		1	SS	6									
0.8	Clayey Silt, Trace Gravel Brown, Firm (Fill)		2	SS	30									
1.3	Heterogeneous Mixture of Clayey Silt		3	SS	33									
	Trace Sand and Gravel		4	SS	39									
	Occasional Silt and Sand		5	SS	30									
	Cobbles and Boulders		6	SS	72									
	Brown, Hard Occasional Sand layers and Silt zones (Glacial Till)		7	SS	104									
			8	SS	65									
145.4			9	SS	100									
11.4	Silty Sand with Gravel Occasional Cobbles and Boulders Grey, Very Dense		10	SS	58									
			11	WS	-									
			12	SS	100									
			13	SS	113									
			14	WS	-									
136.2			15	SS	160									
20.6	Heterogeneous Mixture of Clayey Silt, Trace Sand & Gravel Grey, Hard (Glacial Till)		16	SS	150									
133.8			17	SS	150									
23.0	End of Borehole													
• Unstabilized water level measured 1.5 hours after completion of drilling on 93 12 10														

+3, x<sup>3</sup>: Numbers refer to Sensitivity  
20  
15-5 (%) STRAIN AT FAILURE  
10

RECORD OF BOREHOLE No P15 1 OF 1 METRIC											
W.P. 282-86-01		LOCATION N 4 868335.2 E 350382.7				ORIGINATED BY DK					
DIST 6		HWY 407		BOREHOLE TYPE H.S. Auger, Cone Test				COMPILED BY DT			
DATUM Geodetic		DATE 93 12 06 - 93 12 07		CHECKED BY BL							
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID MOISTURE CONTENT		UNIT WEIGHT $\gamma$ $\text{KN/m}^3$	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE		VALUES	SHEAR STRENGTH kPa $\bullet$ UNCONFINED $\bullet$ QUICK TRIAXIAL $\circ$ FIELD VANE $\times$ LAB VANE	WATER CONTENT (%)	W <sub>p</sub> W <sub>n</sub> W <sub>L</sub>		
172.2	Ground Surface										
171.4	Granular Fill		1	SS	31						
0.8	Heterogeneous Mixture of Clayey Silt, Trace Sand & Gravel Occasional Sand layers, Cobbles and Boulders, Hard		2	SS	38						7 37 42 14
			3	SS	37						
			4	SS	48						
			5	SS	40						
			6	SS	89						
163.8			7	SS	70						
8.4	Heterogeneous Mixture of Silt, Sand and Gravel Occasional Cobbles and Boulders Grey, Very Dense		8	SS	71						28 41 25 6
			9	SS	58						
			10	SS	50						
			11	SS	100						
			12	SS	110						
			13	SS	100						46 42 9 3
155.2			14	SS	100						
17.0	End of Borehole										
	• Unstabilized water level measured 5 hours after completion of drilling on 93 12 07										

RECORD OF BOREHOLE No P21 1 OF 1 METRIC																
W.P. 326-88-01		LOCATION Coords.: N 4 868 931.8 E 351 038.5			ORIGINATED BY LO											
DIST 6 HWY 407		BOREHOLE TYPE Solid Stem / Hollow Stem			COMPILED BY LO											
DATUM Geodetic		DATE 1984 05 30			CHECKED BY KA											
SOIL PROFILE		SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT		NATURAL MOISTURE CONTENT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N-VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
172.0	Ground Surface															
0.0	Clayey Silt Some Sand, Trace Gravel Hard (Glacial Till)		1	SS	31											
	Sandy Silt		2	SS	31											
			3	SS	41											
			4	SS	57											
			5	SS	104											
162.5	End of Borehole		6	SS	128											

4, 3, x<sup>5</sup> Numbers refer to Sensitivity 20 15-5 (X) STRAIN AT FAILURE 10

RECORD OF BOREHOLE No P23 1 OF 1 METRIC																
W.P. 326-88-01		LOCATION Coords.: N 4 869 724.6 E 354 258.5			ORIGINATED BY LO											
DIST 6 HWY 407		BOREHOLE TYPE Solid Stem			COMPILED BY LO											
DATUM Geodetic		DATE 1984 05 27			CHECKED BY KA											
SOIL PROFILE		SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT		NATURAL MOISTURE CONTENT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N-VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
166.3	Ground Surface															
0.0	Silty Clay to Clayey Silt Some Sand, Trace Gravel V. Stiff to Hard (Glacial Till)		1	SS	16											
			2	SS	52											
			3	SS	27											
160.8	Silty Sand to Sandy Silt Trace of Clay, Trace of Gravel Dense to V. Dense (Glacial Till)		4	SS	76											
			5	SS	46											
156.7	End of Borehole		6	SS	53											

4, 3, x<sup>5</sup> Numbers refer to Sensitivity 20 15-5 (X) STRAIN AT FAILURE 10

RECORD OF BOREHOLE No P22 1 of 1 METRIC																
W.P. 326-B6-01		LOCATION Coords.: N 4 869 896.0 E 352 482.8				ORIGINATED BY LO										
DIST 6 HWY 407		BOREHOLE TYPE Solid Stem / Hollow Stem				COMPILED BY LO										
DATUM Geodetic		DATE 1994 05 26				CHECKED BY KA										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			VALUES	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	10 20 30	10 20 30			10 20 30
184.9	Ground Surface															
0.0	Clayey Silt Some Sand, Trace Gravel Hard (Glacial Till)		1	SS	74											
			2	SS	100											
179.4			3	SS	39											
5.5	Silty Sand to Sandy Silt Trace of Clay, Trace of Gravel Dense to V. Dense (Glacial Till)		4	SS	41											
			5	SS	108											
			6	SS	100											
172.3			7	SS	101											
12.6	End of Borehole															

+3, x 5 Numbers refer to  
Sensitivity

20  
15-25 (X) STRAIN AT FAILURE  
10

RECORD OF BOREHOLE No P24 1 of 1 METRIC																
W.P. 326-B8-01		LOCATION Coords.: N 4 859 574.1 E 356 028.6				ORIGINATED BY LO										
DIST 6 HWY 407		BOREHOLE TYPE Solid Stem				COMPILED BY LO										
DATUM Geodetic		DATE 1994 05 27				CHECKED BY KA										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			VALUES	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	10 20 30	10 20 30			10 20 30
203.2	Ground Surface															
0.0	Clayey Silt Some Sand, Trace Gravel Hard (Glacial Till)		1	SS	44											
			2	SS	78											
			3	SS	120											
			4	SS	85											
			5	SS	104											
193.6			6	SS	105											
9.8	End of Borehole															

+3, x 5 Numbers refer to  
Sensitivity

20  
15-25 (X) STRAIN AT FAILURE  
10

RECORD OF BOREHOLE No P25 1 of 1 METRIC															
W.P. 326-B8-01		LOCATION Coords: N 4 869 427.6, 357 821.1			ORIGINATED BY LO										
DIST 6 HWY 407		BOREHOLE TYPE Solid Stem			COMPILED BY LO										
DATUM Geodetic		DATE 1994 05 25			CHECKED BY KA										
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			VALUES	20	40	60	80	100	W <sub>p</sub>		
213.2	Ground Surface														
0.0															
	Sandy Silt to Silty Trace Clay, Trace Gravel V. Dense (Glacial Till)		1	SS	58										
			2	SS	150	/8cm									
	Clayey Silt		3	SS	150	/8cm									
			4	SS	150	/18cm									
			5	SS	111										
199.3			6	SS	150	/10cm									
13.8	End of Borehole														

4, 5, 6 Numbers refer to  
Sensitivity 20  
15-25 (%) STRAIN AT FAILURE  
10

RECORD OF BOREHOLE No P26 1 of 1 METRIC															
W.P. 326-B8-01		LOCATION Coords: N 4 869 399.7, E 358 124.9			ORIGINATED BY LO										
DIST 6 HWY 407		BOREHOLE TYPE Solid Stem			COMPILED BY LO										
DATUM Geodetic		DATE 1994 05 25			CHECKED BY KA										
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			VALUES	20	40	60	80	100	W <sub>p</sub>		
210.8	Ground Surface														
0.0															
	Silty Sand to Sandy Silt Trace of Clay, Trace of Gravel V. Dense (Glacial Till)		1	SS	135										
			2	SS	150										
			3	SS	138										
			4	SS	150	/15cm									
200.8															
9.8			5	SS	150	/16cm									
	Clayey Silt Some Sand, Some Gravel Hard (Glacial Till)		6	SS	150	/18cm									
			7	SS	138										
			8	SS	150	/15cm									
193.6			9	SS	150	/15cm									
15.9	End of Borehole														

4, 5, 6 Numbers refer to  
Sensitivity 20  
15-25 (%) STRAIN AT FAILURE  
10



RECORD OF BOREHOLE No P27														1 OF 1		METRIC	
W.P. 326-88-01		LOCATION Coords: N 4 889 259.2 E 360 032.5				ORIGINATED BY LO											
DIST 6 HWY 407		BOREHOLE TYPE Solid Stem / Hollow Stem				COMPILED BY LO											
DATUM G odelic		DATE 1994 05 30				CHECKED BY KA											
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	VALUES	20	40	60	80	100	W <sub>p</sub>			W	W <sub>L</sub>
205.4	Ground Surface																
0.0																	
			1	SS	33												
			2	SS	105												
			3	SS	150												
			4	SS	80												
			5	SS	70												
195.8			6	SS	116												
9.6	End of Borehole																