

**DATE** November 21, 2014**PROJECT No.** 13-1184-0171**TO** Dennis Baxter, P.Eng.  
AECOM**GEOCRES No.** 30M14-399**CC** David Leblanc, P.Eng.**FROM** Kevin J. Bentley**EMAIL** kbentley@golder.com**DESKTOP STUDY FOUNDATION ASSESSMENT  
PROPOSED BRIDGE REPLACEMENT AT SITE NO. 37-326/1  
HIGHWAY 401/404 BRIDGE REHABILITATION  
TORONTO, ONTARIO  
GWP#2029-13-00**

This technical memorandum summarizes the results of a desktop study of available subsurface information and provides preliminary foundation recommendations for the existing structure at Site No. 37-326/1, which carries the Highway 401 Westbound Collector lanes over the off-ramp from the Highway 401 Express lanes to Highway 404 / Don Valley Parkway (DVP) Northbound and Southbound. The geotechnical recommendations provided in this technical memorandum are intended to support the structural design of the proposed replacement/rehabilitation options being considered at this site.

A memorandum was prepared by AECOM titled "Feasibility Study for Accelerated Bridge Construction / Rapid Bridge Replacement Alternatives – Site 37-326/1", dated May 15, 2014, which presents six alternatives for the proposed rehabilitation / replacement of the bridge. The alternatives considered conventional construction and accelerated construction methods, and also Rapid Bridge Replacement (RBR) techniques to minimize construction duration and impacts to traffic. Subsequent correspondence between MTO and AECOM suggests that the site is not conducive to RBR options due to limited space for laydown areas and the high costs for grading and shoring required for RBR techniques. The preferred option, at this stage, from a logistics and structural perspective is to replace the superstructure and the west pier using conventional methods with an accelerated construction schedule. The draft General Arrangement (GA), Drawing R2-1 (dated October 2014), was provided to us by AECOM and is attached following the text of this memorandum.

## **1.0 REVIEW OF AVAILABLE INFORMATION**

The following report and design drawings have been obtained and reviewed to carry out the required foundation engineering assessment for the bridge structure:

- MTO GEOCRES No. 30M14-081: Report titled "D.H.O. Foundation Investigation Report – Proposed Don Valley Parkway Interchange, Hwy. 401 and Woodbine Rd., N. York County, District No. 6, W.J. 63-F-19, W.P.253-61", prepared by the MTO Foundations Section, dated April 2, 1963.



- General Arrangement, Drawing D5220-1 prepared by the Department of Highways Ontario – Bridge Division, titled "W.B. Collector Rd. over Ramp from W.B. Centre Core to N.B. and S.B. Don Valley Parkway", Site No. 37-326, Bridge#7, dated September 1964; provided by AECOM.
- Foundation Layout 1 and 2 drawings prepared by the Department of Highways Ontario – Bridge Division, titled "Don Valley Parkway Bridges #7 and #10", Site No. 37-326, Bridge#7, dated September 1964; provided by AECOM

Based on the 1964 design drawings and previous investigation, the original ground surface at the site was at approximately Elevation 174.1 m. Referring GA Drawing R2-1 prepared by AECOM, the existing Hwy 401 Collectors road surface is at about Elevation 178 m, and the off-ramp road surface below the bridge ranges from about Elevation 172.5 m at the south side to about 171.3 m at the north side.

Golder visited the site on August 28, 2014 and observed no visual evidence to suggest that the west pier foundation is not performing satisfactorily. The west pier columns appeared to be vertical and there was no indication of settlement/displacement near the base of the columns and the existing ground.

## 2.0 SUBSURFACE CONDITIONS

One borehole (Borehole No. 11) was advanced within the bridge footprint as part of the previous investigation at the interchange in 1963, as shown on a copy of the original Bore Hole Locations Drawing 63-F-19A, attached. A copy of Record of Borehole No. 11 is also attached following the text of this memorandum.

Based on Borehole No. 11, the subsurface soils at the bridge site consist of glacial tills that extend from ground surface to the termination of the borehole at a depth of about 8 m below ground surface. The glacial tills are described as consisting of a heterogeneous mixture of very stiff to hard clayey silt and compact to dense sand and gravel (Standard Penetration Test values between 14 and 42 blows per 0.3 m of penetration) to a depth of 3.4 m below ground surface (Elevation 170.7 m). Below this depth, the glacial till transitioned to a very dense (Standard Penetration Test values greater than 100 blows per 0.3 m of penetration) silty fine sand to the termination depth of the borehole at 8.1 m below ground surface (Elevation 166.0 m).

The subsurface conditions encountered in surrounding boreholes drilled as part of the 1963 investigation for nearby bridge sites as part of the Highway 401 / 404 interchange were consistent with Borehole No. 11 and indicate that predominantly compact to very dense glacial tills are present.

The presence of groundwater was not indicated on Borehole No. 11, however, groundwater levels encountered in surrounding boreholes drilled as part of the 1963 investigation indicated groundwater was observed to range from about 3 m to 9 m below ground surface (Elevations 170 m to 160 m) in the vicinity of the Highway 401/404 interchange. The groundwater level(s) at the bridge site should be expected to fluctuate seasonally in response to changes in precipitation and snow melt, and should be expected to be higher during the Spring season or during periods of heavy precipitation. Considering the groundwater level measurements were taken in 1963, it is likely that the static groundwater level in the area has changed over the past 50 years.



### 3.0 PRELIMINARY FOUNDATION RECOMMENDATIONS

We understand that AECOM requires preliminary geotechnical resistances value for the existing foundations at the Site No. 37-326/1 structure for the proposed rehabilitation/replacement design. Based on the GA drawing for the proposed replacement of the bridge deck and west pier, the existing foundations are shown to remain in place and there is no indication that new foundations will be constructed, or that the existing foundations will need to be supplemented to accommodate additional design loads.

#### 3.1 ASSESSMENT OF EXISTING FOUNDATIONS

Based on the 1964 design drawings, the existing Site No. 37-326/1 bridge is a three-span structure with a total length of approximately 76 m. The west abutment, west pier, east pier, and east abutment are shown to consist of reinforced concrete supported on conventional spread footings. The "General Notes" section of one of the original design drawings states that "concrete in spread footings to be placed against undisturbed ground" for foundations.

The 1964 Foundation Layout design drawings indicate the west and east piers are founded on 3 m wide spread footings founded at about Elevation 170.1 m and 170.5 m respectively. The west and east abutment footings are shown to be 3.7 m wide and founded at about Elevation 172.7 m. Although the foundation design bearing capacities are not indicated on the original General Arrangement drawing, the 1963 Foundation Investigation Report recommends a safe bearing capacity of 4 tons/ft<sup>2</sup> (about 400 kPa) provided that at least 1.5 m of soil cover is available for frost protection.

Based on information provided by AECOM and MTO, it is understood that in September 2008, a transport truck driving in the left ramp lane lost control and collided into the west guardrail, caught fire, and continued to slide along the asphalt pavement until it came to rest below the west portion of the central span near the west pier. Apparently, the heat from the fire caused damage to the bridge and columns nearest the fire. Although it is not likely that the integrity of the existing foundations was compromised as a result of the fire, it is recommended that, at this time, a visual assessment be made of any portion of the columns that are to remain in place and the top of the foundations (possibly during construction), to identify any sign of cracking, delamination, or weakening of the existing concrete. If the foundation / column elements shows signs of distress, additional investigation should be performed (e.g. concrete cores) to confirm that the strength / integrity of the foundation structure is acceptable from a structural perspective for the proposed rehabilitation design.

The preliminary foundation design resistances provided below assume the structural integrity of the existing foundation structure (below ground) has not been compromised and will act as a rigid structure.

Based on the existing subsurface information (Borehole No. 11), the existing foundations are assumed to be founded within the dense to very dense glacial till deposits. For spread footings (approximately 3 m wide at the piers and 3.7 m wide at the abutments) founded on the dense to very dense glacial till soils at the design elevations stated above, the factored geotechnical axial resistance at Ultimate Limit States (ULS) and the geotechnical reaction at Serviceability Limit States (SLS) for 25 mm of settlement provided below may be used for preliminary design.



Foundation Element	Founding Elevation (m)	Inferred Founding Stratum (based on Borehole No. 11)	Factored Geotechnical Axial Resistance at ULS	Geotechnical Resistance at SLS <sup>1</sup>
West Abutment	172.7	Predominantly compact to dense mixture of clayey silt, sand and gravel till	600 kPa	400 kPa
West Pier	170.1	Predominantly very dense silty sand till	700 kPa	450 kPa
East Pier	170.6	Predominantly very dense silty sand till	700 kPa	450 kPa
East Abutment	172.7	Predominantly compact to dense mixture of clayey silt, sand and gravel till	600 kPa	400 kPa

<sup>1</sup> For 25 mm of settlement

The geotechnical resistance values provided above are given for loads applied perpendicular to the surface of the footing. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Sections 6.7.4 and C6.7.4 in the CHBDC.

### 3.2 REQUIRED FOUNDATION RESISTANCE FOR REHABILITATION OPTION

Based on the foundation evaluations carried out by AECOM in accordance with Section 6 of the 2006 Canadian Highway Bridge Design Code, the required foundation resistances for the existing and proposed future bridge loads (and % difference), and the preliminary design geotechnical resistances (adjusted for inclined loading where applicable) have been estimated as summarized below.

Foundation Element	Ultimate Limit State			Serviceability Limit State <sup>2</sup>		
	Existing Load / Required Resistance (kPa)	Proposed Load / Required Resistance (kPa) (% difference)	<sup>1</sup> Preliminary Design Geotechnical Resistance (kPa)	Existing Load / Required Resistance (kPa)	Proposed Load / Required Resistance (kPa) (% difference)	<sup>1</sup> Preliminary Design Geotechnical Reaction (kPa)
West Abutment	226	231 (+2%)	342	224	228 (+2%)	400
West Pier	228	243 (+6%)	630	226	242 (+7%)	450
East Pier	228	243 (+6%)	630	226	242 (+7%)	450
East Abutment	258	263 (+2%)	309	270	274 (+1%)	400

<sup>1</sup> Adjusted to account for inclination of load in accordance with Sections 6.7.4 and C6.7.4 in the CHBDC

<sup>2</sup> For 25 mm of settlement

As shown above, the preliminary design geotechnical resistances are considered adequate for the support of the existing and proposed new loads at the abutments and pier locations for the proposed rehabilitation option. It is noted that the preliminary geotechnical resistances provided above are based on the results of a single borehole (Borehole No. 11) that was advanced within the bridge footprint as part of the original design and the extent of the geotechnical investigation does not meet the current standard MTO Terms of Reference for foundation requirements for new bridge structures. However, considering that the rehabilitation option being proposed



results in less than a 2% and 7% increase in loading at the abutment and pier foundation elements, respectively, and provided that the structural integrity of the existing foundation at the west pier is confirmed to be adequate, consideration could be given to modifying the standard MTO Foundations requirements for new bridge structures to accept the information from the 1963 shallow borehole and the preliminary design geotechnical resistance values can be used for detail design, subject to the agreement of MTO.

If the proposed new design loadings change and exceed the preliminary design geotechnical resistances provided, new foundation elements may be required or the existing foundations may need to be modified or supplemented to resist the additional loads. If this is the case, additional subsurface investigation is recommended consistent with the Terms of Reference outlined in "Attachment 6.8 - Minimum Requirements for Foundation Engineering Applications" contained in the original MTO Request for Proposal.

## **4.0 CONSTRUCTION CONSIDERATIONS**

### **4.1 TEMPORARY SUPPORT STRUCTURES**

Based on the proposed rehabilitation strategy, temporary structures are required to support the superstructure under live traffic in order to replace the west pier cap and columns as shown on the GA Drawing R2-1.

Various foundation options for the temporary support structure have been evaluated, including: timber pad systems; conventional spread footings; and deep foundation units. Given that the existing piers are supported on shallow footings, deep foundations are not considered necessary (practical).

If relatively lightly loaded, non-settlement sensitive conventional falsework or proprietary pipe-frame shoring systems are used, these temporary support systems could be founded on timber pads placed directly on a properly prepared and compacted granular pad placed on the fill at ground surface.

Intermediate-strength or settlement sensitive shoring systems should be supported on timber pads founded on the native till soils or positioned on the existing footings. Heavily loaded shoring systems should be supported on the existing footings or new shallow footings placed on the competent native till soils as necessary.

The selected foundation type will depend on the ground conditions, magnitude, and duration of the proposed loading and required shoring system.

Based on the GA Drawing R2-1 provided, the temporary shoring system is proposed to be founded on the existing west pier footing. Temporary shoring systems should be designed to distribute the loads across the width of the footings and eccentric loading should be accounted for in the design. The preliminary geotechnical resistance values provided in Section 3.1 may be used for design of the foundations of the temporary support systems.

Supplemental resistance, if required, could be provided using timber pads / new spread footings founded on the native till as required. Additional geotechnical investigation should be performed in accordance with MTO Foundation requirements if settlement sensitive temporary support systems are to be founded at the ground surface or within the inferred fill soils that may have been placed on the native tills.

### **4.2 TEMPORARY EXCAVATION / DEWATERING**

Temporary excavations for the replacement of the west pier columns will typically extend through the existing inferred fill materials up to 2 m deep to expose the top of the existing footing. All excavations should be carried out in accordance with the guidelines outlined in the latest edition of the Ontario Occupational Health and Safety



Act and Regulations for Construction Projects (OHSA). Provided the fill materials were properly compacted during original construction, they are assumed to be classified as Type 3 soils, however this should be confirmed during construction. As such, temporary open cut slopes within the fill materials should be made no steeper than 1H:1V. Localized slope flattening may be required within cohesionless fill soils near the ground surface. Perched water within the fill soils and above the native till soils should be expected.

Excavations that penetrate below the groundwater level or in areas where perched water levels are present will require dewatering methods such as pumping from properly filtered sumps to ensure that construction of the new columns and column / footing connection is carried out in the dry. Surface water runoff should be directed away from the excavations at all times.

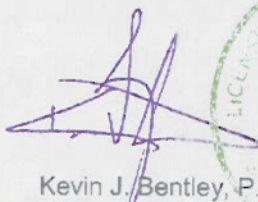
#### 4.3 TEMPORARY SHORING

Temporary shoring may be required if there is insufficient space for open cut excavation to be made near the existing ramp or near utilities. Any temporary excavation support system should be designed and constructed in accordance with OPSS 539 (Temporary Protection Systems). The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS 539, provided that any adjacent utilities can tolerate this magnitude of deformation.

#### 5.0 CLOSURE

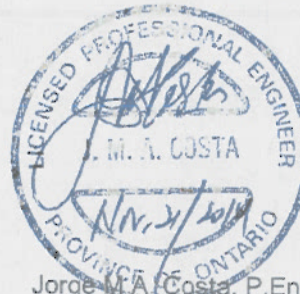
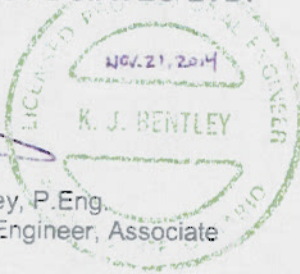
This technical memorandum was prepared by Mr. Kevin J. Bentley, P.Eng., a geotechnical engineer and Associate with Golder. Mr. Jorge Costa, P.Eng., a Designated MTO Contact and Principal of Golder, conducted an independent review of the technical memorandum. We trust the above information meets with your current requirements; should you have any questions, please do not hesitate to contact us.

#### GOLDER ASSOCIATES LTD.



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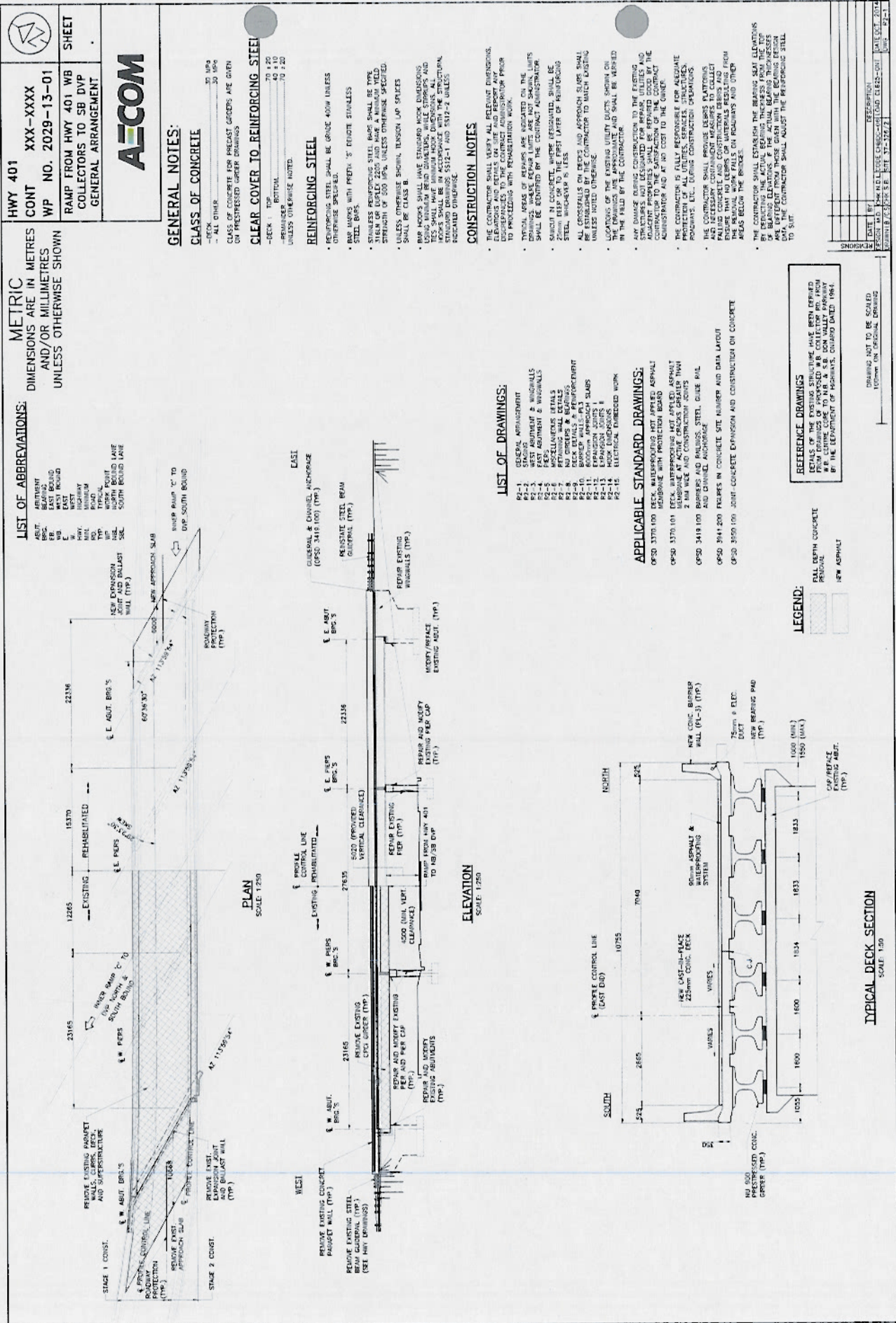


Jorge M.A. Costa, P.Eng.  
Designated MTO Contact, Principal

#### Attachments:

1. Drawing R2-1 titled "Hwy 401 WB Collectors Over Ramp (Hwy 401 WB Core to NB & SB DVP) General Arrangement", dated Oct 2014, provided by AECOM.
2. Drawing 63-F-19A titled "Bore Hole Locations, Don Valley Parkway (8 Structures)", dated March 20, 1963
3. Copy of Record of Borehole No. 11









DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & RESEARCH DIVISION

## RECORD OF BOREHOLE NO. 11

FOUNDATION SECTION

JOB 63-P-19 LOCATION 221-40 267' It. ORIGINATED BY V.K.  
 W.P. — BORING DATE March, 1963. COMPILED BY V.K.  
 DATUM Geodetic BOREHOLE TYPE Penndrill CHECKED BY M.D.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES		ELEV SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT — W <sub>L</sub> PLASTIC LIMIT — W <sub>P</sub> WATER CONTENT — W		BULK DENSITY P O F	REMARKS
			NUMBER	TYPE		SHEAR STRENGTH P S F		W <sub>P</sub>	W <sub>L</sub>		
571.14	Groundlevel										
0.0	Heterogeneous mixture of clayey silt, sand and gravel Compact to dense (Glacial Till)		1	SS 14	570						
			2	SS 30							
560.14			3	SS 42	560						
11.0	Brown silty fine sand V. dense (Glacial till)		4	SS >100							
			5	SS >100	550						
544.64			6	SS >100							
26.5	End of borehole				540						
					530						