# APPENDIX

# E

## Geotechnical Review Memo

# Technical Memo

To: Mir Talpur, Environmental Planning

From: Dirka U. Prout/Nazmur Rahman, Geotechnical

Date: May 2, 2024

File: IM20104013.2002.7

Re: Geotechnical Desktop Study
Ojibway Wildlife Crossings: Municipal Class Environmental Assessment – Schedule ‘C’
Ojibway Parkway, Windsor, Ontario

## 1.0 INTRODUCTION

WSP Canada Inc. (WSP, formerly Wood Environment and Infrastructure Solutions Canada Limited), was retained by City of Windsor (the “City”) to conduct a Schedule ‘C’ Municipal Class Environmental Assessment (Class EA) for a proposed ecological connection between the Black Oak Heritage Park and Ojibway Park. As part of the Class EA, WSP’s geotechnical team was requested to conduct a geotechnical desktop study for proposed wildlife crossings of Ojibway Parkway and the Essex Terminal Railway (ETR) tracks in Windsor, Ontario. The geotechnical desktop study examined the subsurface conditions at the proposed crossing locations and assessed each currently proposed alternative for feasibility, and technical and other related constraints from a geotechnical perspective. This information is required by WSP’s EA team in order to fully evaluate the alternative solutions (Phase 2).

WSP understands that the City’s goal is to provide a safe, attractive, fiscally responsible and minimally environmentally impactful wildlife crossing. The purpose of this structure is to facilitate the safe traverse of the animals and reduce the collisions between vehicles and animals along the busy Ojibway Parkway. The subject section of the parkway is surrounded by a complex of parks and nature reserves that are notable for its high diversity of plants and animals including over 160 provincially rare species. Due to a high wildlife vehicular collision rate, an animal crossing is proposed.

The general limits of the Study Area are shown in Figure 1-1. The Study Area initially included a portion of the Ojibway Park and Ojibway Parkway south of Broadway Boulevard. However, the Study Area was expanded to span across ETR tracks and lands, and a portion of the Black Oak Heritage Park (Black Oaks Woods) to consider a Wildlife Crossing across Ojibway Parkway as well as ETR tracks. The limits of the study area are shown on Figure 1-1. The original study area is delineated by a yellow line and the expansion area is bounded by the red line.

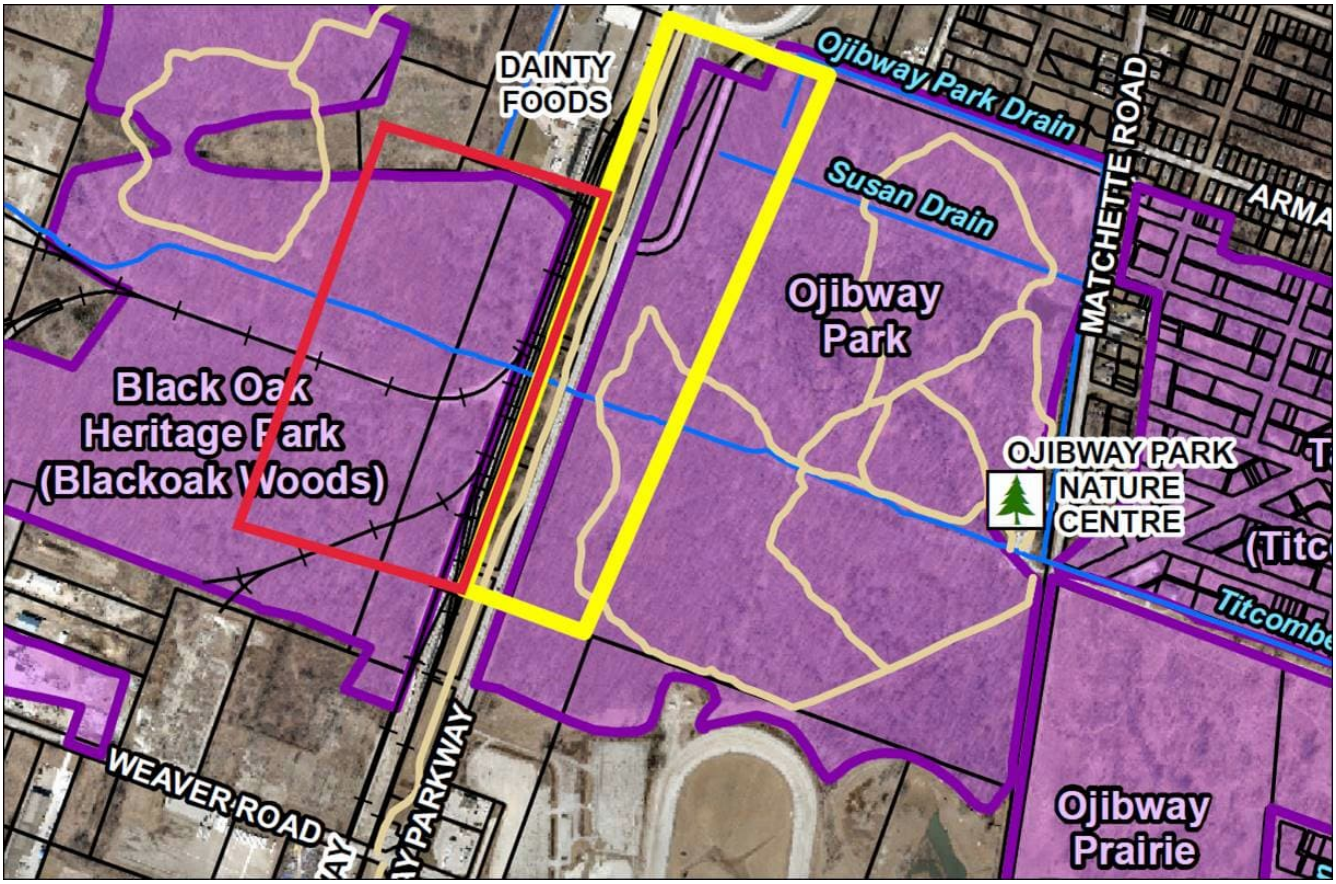

Figure 1-1 Study Areas

A rendering of the proposed crossing and preferred structure type is provided in Figure 1-2.

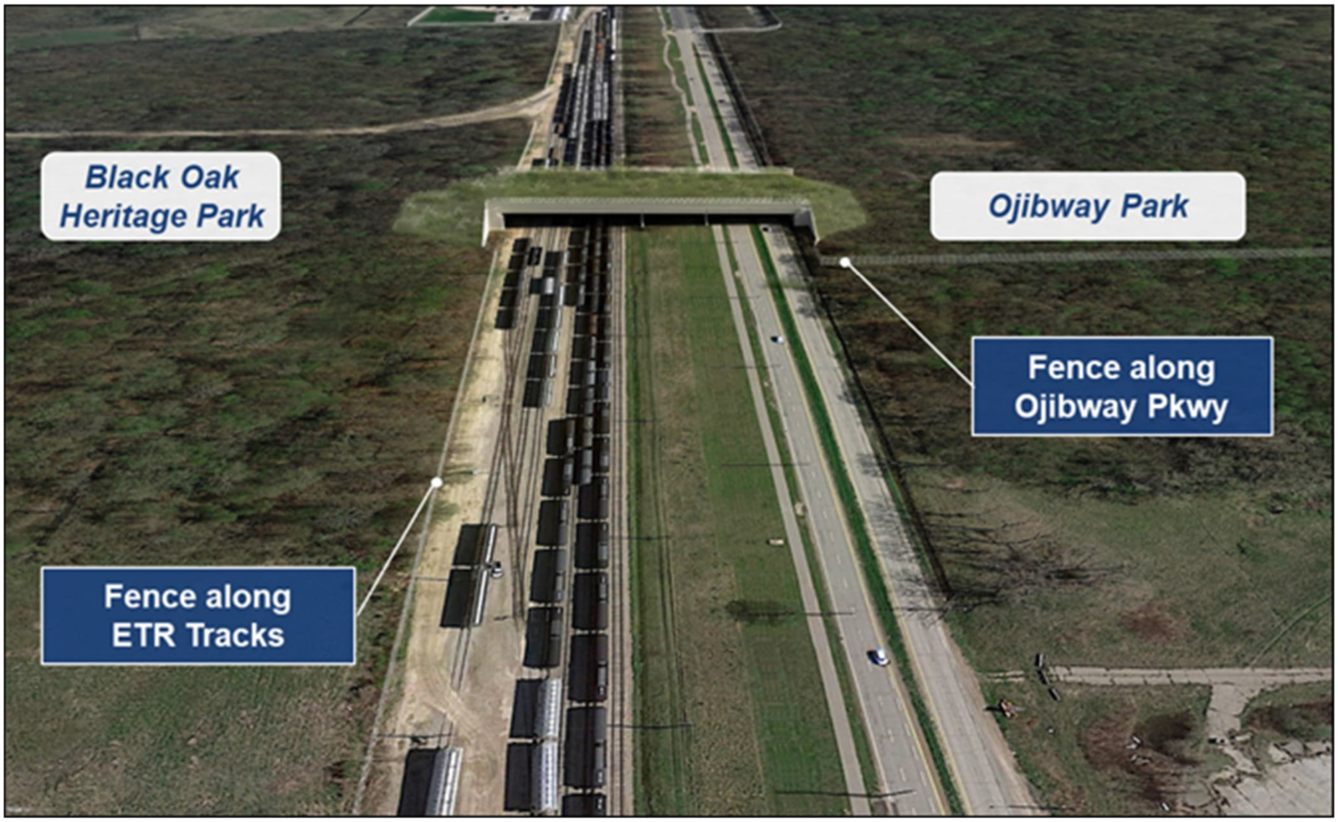

Figure 1-2 Rendering of preferred structure type and location

As per the communications, the alternative planning solutions for consideration includes three options listed below:

1. Do Nothing
2. Underpass Wildlife Crossing
3. Overpass Wildlife Crossing

Due to the environmental constraints, Alternatives 2 and 3 for crossing Ojibway Parkway have sub-alternatives A (North Option) and B (South Option) associated with two specific locations within the study area. The North and South Options are situated approximately 475 metres (m) and 670 m south of Broadway Street, respectively. Alternative B with an overpass is the preferred crossing location.

This geotechnical memo provides a summary of the subsurface conditions based on previous geotechnical investigations carried out in the region, and a comparison of the different structural alternatives for the proposed wildlife crossing locations. The comparison accounted for the geotechnical constraints that may affect each structure type.

## 2.0 SITE DESCRIPTION

The site is generally located along the stretch of Ojibway Parkway extending approximately 950 m south from its intersection with Broadway Street in Windsor, Ontario. The main ETR right-of-way has up to eight (8) tracks and runs parallel to the west side of Ojibway Parkway along the entire stretch.

Ojibway Parkway is a four-lane roadway with a pair of northbound and southbound lanes. There is a grassed centreline median and a multi-use pathway along the west side of Ojibway Parkway. The Titcombe Road Drain runs east-west across the entire site. Ojibway Park Drain and Susan Drain also run east-west along the northern side of Ojibway Park. The site generally has little relief. The ground surface elevation is near Elevation (El.) 180 m. The Study Area is well covered with trees and other vegetation.

The Study Area includes a portion of Ojibway Park and Black Oak Heritage Park south of Broadway Boulevard. In between the two parks, the Study Area also includes Ojibway Parkway, a boulevard area, the ETR tracks and a 90m wide stretch of ETR-owned lands. The northern boundary for the Ojibway Park section is the Ojibway Park Drain and the southern boundary is the southern extent of the park's trail system (Wildlife Trail) near the southern boundary of Lot 49, Concession 1, Petite Cote Sandwich Township. The Study Area includes the eastern portion of Black Oak Heritage Park extending from the northern park boundary adjacent to Ojibway Parkway to about 610 m south. Spur lines of the ETR extend across the southern part of Black Oak Heritage Parks. Much of the eastern and southern parts of the Black Oak Heritage Park has been mapped as wetland.

## 3.0 REGIONAL SURFICIAL GEOLOGY

According to the Ontario Geological Survey, Map 2556[1], the site is located within an area of coarse textured lacustrine deposits comprising glaciolacustrine deposits of silt and clay with minor sand as well as basin and quiet water deposits.

According to Map 2441[2], the Palaeozoic (bedrock) geology of this area consists of Detroit River Group referred to as the Onondaga Formation in the Niagara Peninsula. The most common deposit associated with the bedrock unit in the area is limestone and dolostone.

## 4.0 PREVIOUS GEOTECHNICAL INVESTIGATIONS

Previous investigations carried out on the subject site were provided to WSP by the City. It should be noted that with the exception of boreholes advanced for Golder Report 07-1130-207-0, the majority of the boreholes referenced for this report were advanced along the Ojibway Parkway right-of-way. The geologic mapping indicates that the surficial soils are the same across the western and eastern study areas. As such, the subsurface conditions have been presented without distinction between the two study areas. Subsurface information pertinent to the stretch of Ojibway Parkway was obtained from the reports listed below. No additional boreholes were advanced as part of this design memo. Descriptions of the subsurface conditions are provided in the following reports:

- Report titled "Geotechnical Investigation, Proposed Sanitary Sewer Replacement, Ojibway Parkway, City of Windsor, Ontario", by Golder Associates Ltd. (Golder, now part of WSP Canada Inc.), Project Number 07-1140-0023, dated March 30, 2007. A total of six (6) boreholes BH1 to BH6 were advanced to depths ranging from 1.2 to 5.0 m below grade. Additionally, to

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[1] Barnett, P.J., Cowan, W.R. and Henry, A.P.1991. Quaternary geology of Ontario, southern sheet; Ontario Geological Survey, Map 2556, scale 1:1 000 000.

[2] Freeman, E.B. 1979. Geological highway map, southern Ontario; Ontario Geological Survey, Map 2441, 1:800 000.

supplement the investigation for this report, the subsurface information obtained from two relevant boreholes during the earlier investigations in the study area were also studied.

- The Geotechnical Data Report prepared for the Windsor-Essex Parkway (WEP) by Golder with Project No. 07-1130-207-0. The City provided the relevant Record of Borehole sheets from this report for boreholes drilled along the WEP in close proximity to the subject site. This data report included boreholes carried out for other Golder projects.

Borehole location plans and Record of Borehole sheets for the Golder boreholes cited for this desktop study are presented in Appendix A. The above-mentioned information provided by the City was supplemented with information from the Ontario Geotechnical Boreholes database belonging to the Ontario Geological Survey (OGS).[3] The information was obtained from a total of seven (7) boreholes situated within the study areas. The logs of each borehole are presented in Appendix B.

## 5.0 SUBSURFACE CONDITIONS

This section presents a summary of the subsurface soil conditions encountered as per the previous investigation reports. The detailed description of the subsoil is presented on the Record of Borehole sheets in Appendix A. The subsurface soils in the region generally comprise silty sand/sandy silt deposits overlying an extensive silty clay layer, which is in turn underlain by limestone bedrock.

A summary of the available borehole details are shown in Table 5-1 below.

Table 5-1 Summary of Borehole Details

| SOURCE/PROJECT NUMBER | BOREHOLE NUMBER | DEPTH (M) | GROUND ELEVATION (M) | BOTTOM ELEVATION (M) |
|---|---|---|---|---|
| Golder/07-1140-0023 | 1 | 5.03 | 179.10 | 174.07 |
| | 2 | 5.03 | 179.10 | 174.07 |
| | 3 | 1.52 | 179.00 | 177.48 |
| | 4 | 5.03 | 178.80 | 173.77 |
| | 5 | 1.52 | 178.80 | 177.28 |
| | 6 | 1.22 | 178.90 | 177.68 |
| Golder/754002 | 1 | 5.64 | 178.73 | 173.10 |
| Golder/764112 | 2 | 15.24 | 178.86 | 163.62 |
| Golder/07-1130-207-0 | 164 | 27.48 | 179.06 | 151.58 |

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[3] Ontario Geological Survey, 2023. Ontario Geotechnical Boreholes database. Accessed through OGSEarth (gov.on.ca) on May 12, 2023.

| SOURCE/PROJECT NUMBER | BOREHOLE NUMBER | DEPTH (M) | GROUND ELEVATION (M) | BOTTOM ELEVATION (M) |
|---|---|---|---|---|
| | 164A | 12.19 | 179.06 | 166.87 |
| | 166 | 26.92 | 179.00 | 152.08 |
| | 166A | 15.39 | 179.00 | 163.61 |
| OGS/- | 620803 | 9.0 | 177.2 | 168.2 |
| | 620758 | 14.8 | 175.8 | 161.0 |
| | 620773 | 4.1 | 179.0 | 174.9 |
| | 620775 | 4.1 | 178.8 | 174.7 |
| | 620767 | 4.1 | 177.8 | 173.7 |
| | 620768 | 4.1 | 178.8 | 174.7 |
| | 620769 | 4.1 | 179.1 | 175.0 |

## 5.1 TOPSOIL

Topsoil was encountered at the surface of boreholes 164, 166, 1 (754002), 2 (764112) and all seven of the OGS boreholes. The topsoil was 100 to 760 mm thick. The fill in borehole 5 was underlain by 0.7 m of buried topsoil.

## 5.2 PAVEMENT STRUCTURE

Boreholes 1 to 6 (07-1140-0023) were drilled through the Ojibway Parkway pavement structure. The asphalt thickness varied between 200 and 300 mm. The asphalt at boreholes 1 and 2 (07-1140-00230), and 6 were underlain by 160 to 230 mm of granular road base. The asphalt in boreholes 3, 4 and 5 was underlain by concrete 180 to 360 mm thick.

## 5.3 FILL

The concrete at borehole 5 and the pavement structure at boreholes 2 (07-1140-0023) and 6 was underlain by 20 mm to 0.5 m of granular fill.

## 5.4 SANDS AND SILTS

Beneath the surficial topsoil, deposits of silty sand, sand, sandy silt, silt and sand and gravel were noted boreholes 1 to 6 (07-1140-0023), 1 (754002), 2 (764112) and OGS Boreholes 620803, 620758, 620773, 620775, and 620767 to 620769, extending to depths of 2.3 to 4.4 m below the ground surface (mbgs). Where fully penetrated, the sands and silts were 1.7 m to 3.7 m thick. Boreholes 3, 5 and 6 were terminated in a sand deposit. The measured ‘N’ values from Standard Penetration Test ranged from 4 blows to 26 blows per 0.3 m penetration, indicating a very loose to compact state. The moisture content of these deposits ranged from approximately 9% to 30%.

## 5.5 SILTY CLAY/CLAYEY SILT

Silty clay/clayey silt deposits were encountered beneath the sands and silts in all boreholes except 3, 5 and 6. These deposits were found to extend to depths of 23.3 to 23.5 mbgs in the deepest boreholes (borehole 164 and 166). The remaining boreholes were terminated in the silty clay/clayey silt.

In situ field shear vane tests completed in the firm to very stiff clayey deposits indicate the undrained shear strength ranges from approximately 35 to greater than 144 kPa typically decreasing with depth to approximate elevation 164 m. Below this elevation, the shear strength generally increases from 50 to greater than 95 kPa. SPT N values in the silty clay/clayey silt ranged from 0 (weight of hammer) to 9 blows per 0.3 m penetration, indicating very soft to stiff consistencies.

## 5.6 LIMESTONE BEDROCK

Boreholes 164 and 166 encountered limestone bedrock underlying silty clay till at depths of 23.5 and 23.7 mbgs, respectively. The composition was described as grey, medium strong, very fine to fine grained limestone with whitish, light grey and brown zones. The measured ‘RQD’ values in the bedrock ranged from 62 to 100 indicating fair to excellent quality rock.

## 5.7 GROUNDWATER CONDITIONS

Details of the water levels observed in the open boreholes at the time of drilling are presented on the Record of Borehole sheets in the original investigation reports and summarised in the table below. Groundwater conditions will vary subject to weather and seasonal fluctuations. Groundwater conditions were not reported for any of the OGS boreholes.

It should be noted that previous geotechnical studies in the area (for example at the Highway 401 bridge over the Ojibway Parkway, Golder Project No. 13-1132-0053-1000-R01[4] and Luczaj et al.[5]) have encountered hydrogen sulphide and methane dissolved in the groundwater. Where encountered, hydrogen sulphide was typically found near the overburden/bedrock interface and in boreholes where artesian groundwater conditions exist. Flowing artesian conditions were encountered at the overburden-bedrock interface during drilling for some WEP boreholes and during rock coring for borehole BH-166 (Golder 2016, Geocres No. 40J6-71).

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[4] Golder Associates Ltd. 2016. Foundation Investigation and Design Report, Ojibway Parkway/ETR Overpass, Sites 6-600/1 & 2 (Bridge B-1), Highway 401 (Rt. Hon. Herb Gray Parkway), GWP 3028-14-00, Ministry of Transportation, Ontario, West Region. Geocres No: 40J6-71.

[5] Luczaj et al 2006. *Fractured hydrothermal dolomite reservoirs in the Devonian Dundee Formation of the central Michigan Basin*. AAPG Bulletin, V. 90. No. 11 (November 2006) pp 1787-1801.

Table 5-7 Summary of Groundwater data

| BOREHOLE NO. | GROUND SURFACE ELEVATION (M) | ELEVATION OF GROUNDWATER UPON COMPLETION OF DRILLING (M) | WATER LEVEL MEASURED IN THE MONITORING WELL (M) | DATE (MM/DD/YYYY) |
|---|---|---|---|---|
| 01 (07-1140-0023) | 179.10 | 176.97 | - | 02/28/2007 |
| 02 (07-1140-0023) | 179.10 | 177.73 | - | 02/28/2007 |
| 03 | 179.00 | Open & dry | - | 02/28/2007 |
| 04 | 178.80 | 177.43 | - | 02/28/2007 |
| 05 | 178.80 | Open & dry | - | 02/28/2007 |
| 06 | 178.90 | Open & dry | - | 02/28/2007 |
| 1 (754002) | 178.73 | 177.36 | 177.52 | 01/22/1975 |
| 2 (165112) | 178.80 | 177.03 | Standpipe dry | 10/23/1976 |
| 164 | 179.06 | Open & dry | - | 08/28/2008 |
| 164A | 179.06 | Open & dry | 179.96 | 09/19/2009 |
| 166 | 179.00 | 180.6* | - | 09/17/2008 |
| 166A | 179.00 | - | 178.43 | 01/28/2009 |

* Artesian water flow during rock coring measured at 1.6 m above ground surface.

## 6.0 IMPACT OF SUBSURFACE CONDITIONS ON PROPOSED WORKS

The stratigraphy beneath the surficial topsoil, pavement structure and fills along the subject section of Ojibway Parkway generally consists of 2.0 m to 4.4 m of very loose to compact sands and silts overlying an extensive soft to very stiff silty clay/clayey silt layer. Bedrock is at approximately 23 mbgs. The sands and silts are partially saturated with the ground water level within 1.2 to 2.1 m of the ground surface.

The ground conditions along Ojibway Parkway are relatively uniform within the project's limits. In the absence of a site-specific investigation, the geological mapping and our experience in this area suggests that no significant difference in subsurface conditions between the areas at west and east of Ojibway Parkway are anticipated. As such, there are no geotechnical constraints on the locations of the proposed wildlife crossings across Ojibway Parkway or the ETR tracks. In the absence of site-specific boreholes advanced at the locations of the North and South Options for the Ojibway Parkway crossing, there is currently no geotechnical reason to prefer one option above another.

Geotechnical conditions that will affect the proposed works are:

1. the presence of very loose to compact surficial sands and silts that are partially saturated;
2. a relatively high groundwater level. In addition to a groundwater level at or very near to the ground surface, wetland areas within the Black Oak Heritage Park may contain surficial deposits of peat, organic soils and other wet, soft and unconsolidated deposits;
3. an extensive deposit of silty clay/clayey silt which is normally consolidated to slightly over consolidated for most of its depth. This deposit is considered to be of moderate to moderately high compressibility;
4. artesian groundwater pressures at and below the overburden/bedrock interface; and
5. presence of hydrogen sulphide and methane gases near the bedrock interface.

The table below presents an overview assessment of geotechnically feasible structure and foundation options based on the available information about the subsurface conditions and wildlife crossing alternatives. It should be noted that the definitions of underpass and overpass adopted for this assessment were in accordance with Wildlife Crossing Structure Handbook, Design and Evaluation in North America (Publication No. FHWA-CFL/TD-11-003; March 2011). An underpass is defined as the structure that goes under a road (Ojibway Parkway) or railway, while an overpass is defined as the structure that is built over a road/railway. The type and minimum dimensions of the proposed underpass and overpass structures are taken from the same reference. Where tunnelling (trenchless) options has been provided as an underpass option, a comparison of suitable tunnelling methodologies has been provided in Table 6-2 in Section 6.1 below.

Table 6-1 Evaluation of the Alternative Solutions

| ALTERNATIVE SOLUTION | STRUCTURE DIMENSIONS | DISCUSSION OF VARIOUS FOUNDATION OPTIONS |
|---|---|---|
| 1. Do Nothing | N/A | No disruption to groundwater regime. |
| 2. Underpass Wildlife Crossing<br>(Large Mammal Underpass) | Width – 7 m<br>Height – 4 m | <u>Cut & Cover Tunnel</u><br>• May not be permissible for an undercrossing of the ETR tracks.<br>• Disruption of traffic along Ojibway Parkway may be reduced using staged construction.<br>• Temporary and permanent walls must be internally braced since the relatively low shear strength of surficial soils precludes use of earth anchors/tie-backs.<br>• Most of the earthworks is in cut and eliminates settlement related problems with use of approach embankments.<br>• Temporary dewatering during construction and permanent drainage measures required. |

| ALTERNATIVE SOLUTION | STRUCTURE DIMENSIONS | DISCUSSION OF VARIOUS FOUNDATION OPTIONS |
|---|---|---|
| | | • Depending on the elevation of the excavation base, vertical members of the excavation support structure may need to extend to bedrock. In this case, precautions need to be taken to mitigate against artesian flows and gases emanating from the overburden/bedrock interface.<br>• In comparison with cut and cover underpass in depressed roadway, the magnitude of earthworks will be confined to the crossing location. |
| | | <u>Trenchless Tunnel</u><br>• 'Shallow' foundation option with lowest bearing pressure due to efficiency of structural form.<br>• Suitable methods include jacked box tunnelling, and sequential excavation method (SEM).<br>• Underpass option for ETR and Ojibway Parkway offering least impact on traffic.<br>• Most suitable method for undercrossing of the ETR tracks as owner may not permit cut and cover tunnelling.<br>• Internal bracing of temporary and permanent walls limited to entrance/exit shafts only. Internal bracing required due to the very low shear strength of surficial soils precludes use of earth anchors/tie-backs.<br>• Settlement related problems with use of approach embankments avoided. Depending on selected tunnelling method, settlement and heave may still occur.<br>• Temporary dewatering during construction and waterproofing or permanent drainage measures required.<br>• Approach involving the least amount of earthworks.<br>• Method with least impact on the environment. |
| 3. Overpass Wildlife Crossing (Large Wildlife Overpass) | Width – 50 m<br>Height – 5.5 m | <u>Bridge founded on Shallow Foundations with approach embankments with sideslopes of 3 horizontal (H) to 1 vertical (V) maximum approach grade 5H:1V (17%) or flatter</u><br>• Suitable for spanning both Ojibway Parkway and ETR tracks.<br>• Excavations adjacent to ETR tracks may have more stringent permitting and shoring |

| ALTERNATIVE SOLUTION | STRUCTURE DIMENSIONS | DISCUSSION OF VARIOUS FOUNDATION OPTIONS |
|---|---|---|
| | | requirements compared to Ojibway Parkway.<br>• Compared to overpass for Ojibway Parkway, embankments for the ETR track overpass may need to incorporate more costly lightweight fill and other settlement mitigation measures as railway tracks are more settlement sensitive.<br>• Strip/spread footings not feasible due to relatively low shear strength of surficial soils and shallow groundwater conditions particularly if large structure required.<br>• Presence of moderately to moderately high compressible soils means ettlement mitigation measures will be required for approach embankments including use of staged construction and ground improvement. |
| | | Bridge founded on Deep Foundations with approach embankments with sideslopes of 3H:1V maximum approach grade 5H:1V (17%) or flatter<br>• Deep foundations feasible.<br>• Suitable for spanning both Ojibway Parkway and ETR tracks.<br>• Compared to overpass for Ojibway Parkway, embankments for the ETR track overpass may need to incorporate more costly lightweight fill and other settlement mitigation measures as railway tracks are more settlement sensitive.<br>• Option requiring least dewatering effort.<br>• Deep foundations such as steel driven piles, micropiles or caissons extending to the bedrock can be used to support the structure.<br>• Due to artesian groundwater conditions and methane and hydrogen sulphide gases at depth, precautions need to be implemented when using driven steel pipe piles or H-piles as groundwater could migrate along the annuli. Use of caissons and micropiles are not preferred as these require open holes which may present stabilization difficulties in addition to groundwater and gas migration concerns.<br>• Mitigation measures needed for driven steel H-piles to limit artesian flow to surface. |

| ALTERNATIVE SOLUTION | STRUCTURE DIMENSIONS | DISCUSSION OF VARIOUS FOUNDATION OPTIONS |
|---|---|---|
| | | Settlement mitigation measures required for construction of approach embankments.<br>• Approach with most extensive earthworks and longest construction time due to need for settlement mitigation.<br>• Presence of moderately to moderately high compressible soils means that that downdrag must be considered for deep foundations and settlement mitigation measures will be required for approach embankments including use of staged construction and ground improvement |
| | | Depressed Roadway with cut and cover overpass structure at wildlife crossing<br>• This option is suitable only for crossings of Ojibway Parking and operational requirements for trains favour grade restrictions.<br>• Temporary and permanent walls must be internally braced since the relatively low shear strength of surficial soils precludes use of earth anchors/tie-backs.<br>• Most of the earthworks is in cut and eliminates settlement related problems with use of approach embankments.<br>• Temporary dewatering during construction and permanent drainage measures required.<br>• Depending on the elevation of the excavation base, vertical members of the excavation support structure may need to extend to bedrock. In this case, precautions need to be taken to mitigate against artesian flows and gases emanating from the overburden/bedrock interface.<br>• Approach with second most extensive earthworks but less construction time than a bridge with deep foundations and approach embankments. |

## 6.1 Tunnelling (Trenchless) Methodologies

Trenchless methodologies considered suitable for installing underpasses beneath either Ojibway Parkway or the ETR tracks are jacked box, and tunnelling using the Sequential Excavation Method (SEM). Geotechnical conditions that will present challenges for trenchless operations are:

1. the presence of very loose to compact surficial sands and silts that are partially saturated;

2. relatively high groundwater level; and
3. the presence of very soft to soft silty clay.

Dewatering of the saturated surficial sands and silts will be required for construction of the entry and exit pits based on conditions 1 and 2 noted above. Where the cover of the tunnels is quite low, partially saturated sands and silts will be encountered in and along the tunnel roof. This means that the tunnel alignment may need to be dewatered prior to and during tunneling activities to enhance the face stability of the granular deposits. In addition, where very loose and loose granular deposits exist, the tunnel roof may have to be stabilized using forepoling/spiling, or ground improvement techniques. Sand tables or breasting boards will have to be employed to enhance face stability in the granular deposits. If the loose granular deposits are inadequately stabilized the railway tracks/roadway could be disturbed. No significant problems with respect to stability of the face or crown are anticipated with tunneling though the firm to very stiff silty clay to clayey silt deposits. Stability problems within the tunnel face and crown will occur if very soft to soft silty clays are encountered. In this case, pre-support measures such as spiling, forepoling and the like will have to be executed to support soft cohesive soils in the crown and face stabilization measures such as face bolts, wedges and shorter round lengths will be required during advancement of the tunnel.

### 6.1.1 Jacked Box

Jacked box tunnelling is similar to pipe jacking but uses a box-shaped tunnel. The span of a jacked box could be in excess of 20 m. The front of the lead box section is typically fitted with a tunnelling shield. Shield tunnelling techniques are used to control ground loss and maintain face stability. Spoil is removed manually or with the assistance of an excavator or road header within the box. The reinforced concrete boxes are designed to carry the dead and live load. They can be manufactured in an offsite pre-cast site or cast on site.

Operations begin in a jacking pit with a jacking base slightly longer than the selected box sections. The jacking base provides the reaction needed for the jacking rig to push the box forwards. High-capacity jacks are placed at the back of the lead box and the box is pushed into the ground. Advancement is through repeated cycles of excavating the face in small increments, typically 150 mm, then jacking the box forward by an equal length. Anti-drag systems (ADS) must be employed to counteract dragging of ground at the box underside which could cause the box to dive, and displacement of the ground above the box roof which could disrupt infrastructure above and adjacent to the jacking operations.

The size of the entry/jacking pit is a function of the box size. While an undercrossing of a single ETR spur line is short enough to employ a single box, undercrossing of Ojibway Parking and the main ETR right-of-way may require a series of box sections due to their lengths. Multiple box sections can be used to where space is limited, or to reduce the footprint of the jacking pit and base for environmental reasons. A berm or portal structure is constructed at the reception area to stabilize the ground. Once the box is in the final position, the interface between the box and the ground are grouted. The shield and jacking arrangement are removed permitting construction of portals and approach roads and final box finishes.

### 6.1.2 Sequential Excavation Method

Tunnels have been historically constructed between two shafts by excavating soil from the front cutting face and installing a liner to form a continuous ground support structure. The size of the access pit varies between 2.7 m and 7.5 m. Additional space will be required for material storage.

Excavation during conventional tunnelling typically occurs within a protective shield using hand-mining or open-face mechanical excavation. Alternatively, the New Austrian Tunnelling Method (NATM), also known as SEM, could be used. The SEM is a modification of conventional tunnelling which utilizes a flexible tunnel support system that permits the surrounding ground to deform just enough to permit mobilization of its shear strength. This method has been defined as 'a support method to stabilize the tunnel perimeter by means of sprayed concrete, anchors and other support, and uses monitoring to control stability'[6]. Throughout the entire tunnelling process the ground and support system is continuously monitored and visually observed. Ground improvement must be implemented where the ground is not self-supporting for the length of time required to install the ground support. The typical construction process according to Chapman et. al (2018) consists of:

1. Excavation. The face is generally subdivided to provide better control of face stability, convergence and settlement.
2. Sealing the exposed ground.
3. Mucking.
4. Installation of lattice girders and the first layer of reinforcing bars or mesh reinforcement.
5. Potential installation of a second layer of reinforcement and application of more sprayed concrete.
6. Installation of anchors (if necessary) and tightening of anchors one day later with spray concreting of the anchor heads.
7. Construction of the inner lining.

The SEM technique has been used to construct tunnels as long as 5 km or more and can be used to create non-circular geometries or caverns. Some of the largest openings created used SEM to date have been in the order of 12.5 m to 13.7 m wide.

Table 6-2 Comparison of Trenchless Methodologies

| TRENCHLESS METHODOLOGY | ADVANTAGES | DISADVANTAGES |
|---|---|---|
| Jacked Box | • Temporary and permanent tunnel support installed in a single step (one pass system).<br>• Low cover in the order of a couple of metres can be used.<br>• Pre-excavation of jacking pits not required. | • Higher costs than other tunnelling methods due to need for skilled crews.<br>• Excavation face must be self supporting or ground improvement implemented where loose or soft soils are present.<br>• Unsuitable for curved alignments. |

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[6] Chapman, D., Metje, N. and Stark, A. 2018. Introduction to Tunnel Construction, Second Edition. CRC Press, Boca Raton, Fl. Pg. 185.

| TRENCHLESS METHODOLOGY | ADVANTAGES | DISADVANTAGES |
|---|---|---|
| | • Often faster than conventional cut-and-cover methods.<br>• Good method for protection of the environment. | • Few specialist contractors available in Ontario.<br>• Specialized operation requiring great deal of planning and coordination.<br>• Can be difficult to control line and grade especially if invert is relatively hard or soft relative to material in tunnel face.<br>• Steerable shields ineffective for large boxes. |
| Sequential Excavation Method (SEM) | • Ideal for large spaces or caverns.<br>• Ideal for complex geometries creating tunnel that can change diameter or shape along its length.<br>• Cost competitive with cut and cover construction if tunnel depth is not more than one and a half times the tunnel height.<br>• Depending on proposed geometry of undercrossing, launch and exit pits may not be required.<br>• Good method for protection of the environment. | • Design and construction monitoring and supervision must be carried out by SEM/NATM specialists.<br>• Slowest progress due to high need for coordination, cooperation and communication with designers and tunnelling contractor. |

## 6.2 Site-Specific Investigation

The scope of the Class EA for the Ojibway Parkway Wildlife Overpasses requires development and assessment of various alternative designs, selection of a preferred alternative and completion of a preliminary (30%) design of the preferred alternative. The preliminary design is based on geotechnical desktop studies only. A site-specific geotechnical investigation should be completed for the detailed design phase under a separate design assignment.

Sincerely,
WSP Canada Inc.

Prepared by:

LICENSED PROFESSIONAL ENGINEER
D. U. PROUT
05/02/24
PROVINCE OF ONTARIO

Dirka U. Prout, P.Eng.,
Lead Geotechnical Engineer

Reviewed by:

Nazmur Rahman, M.A.Sc., PE, P.Eng.,
Senior Principal Engineer - Geotechnical

Enclosure: Appendix A – Borehole Locations and Record of Borehole Sheets (Golder)
Appendix B – OGS Boreholes

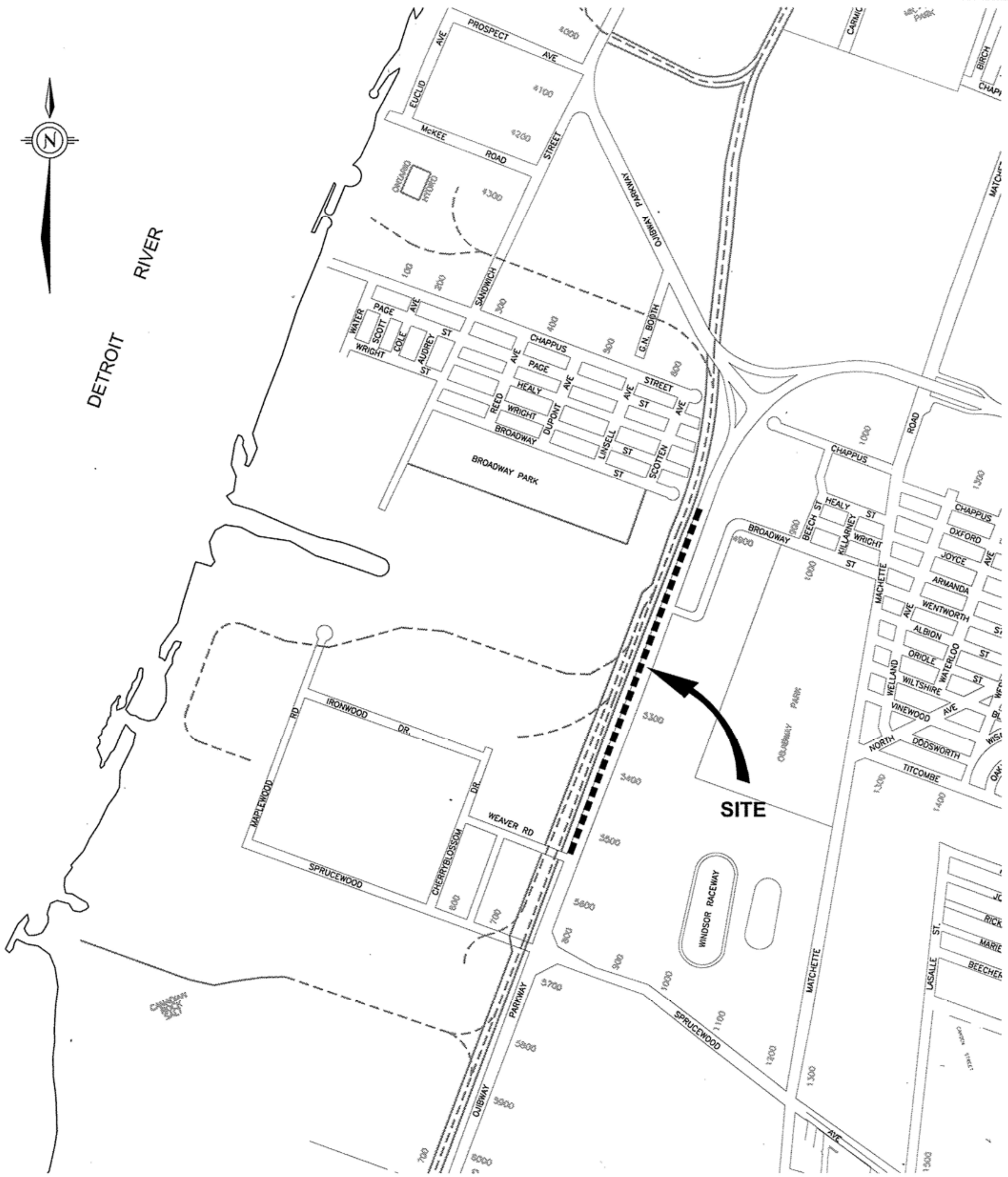
DUP/NR/dup

X:\CA\CABRL300-BRL\PROJECT\2020\Projects\IM20104013 - Ojibway Wildlife Passage\05_DEL\01_RPT-TECHMEM\4-Geotechnical Memo\03_2024 Final Geotech Memo\IM20104013-M01 2024 05 02 (FINAL) Ojibway Parkway Wildlife Crossing geo memo_DP1-NR1.docx

# APPENDIX

# A

## BOREHOLE LOCATIONS AND RECORD OF BOREHOLE SHEETS (GOLDER)



PROJECT THE CORPORATION OF THE CITY OF WINDSOR
OJIBWAY PARKWAY SANITARY SEWER
REHABILITATION - PHASE 4, WINDSOR, ONTARIO

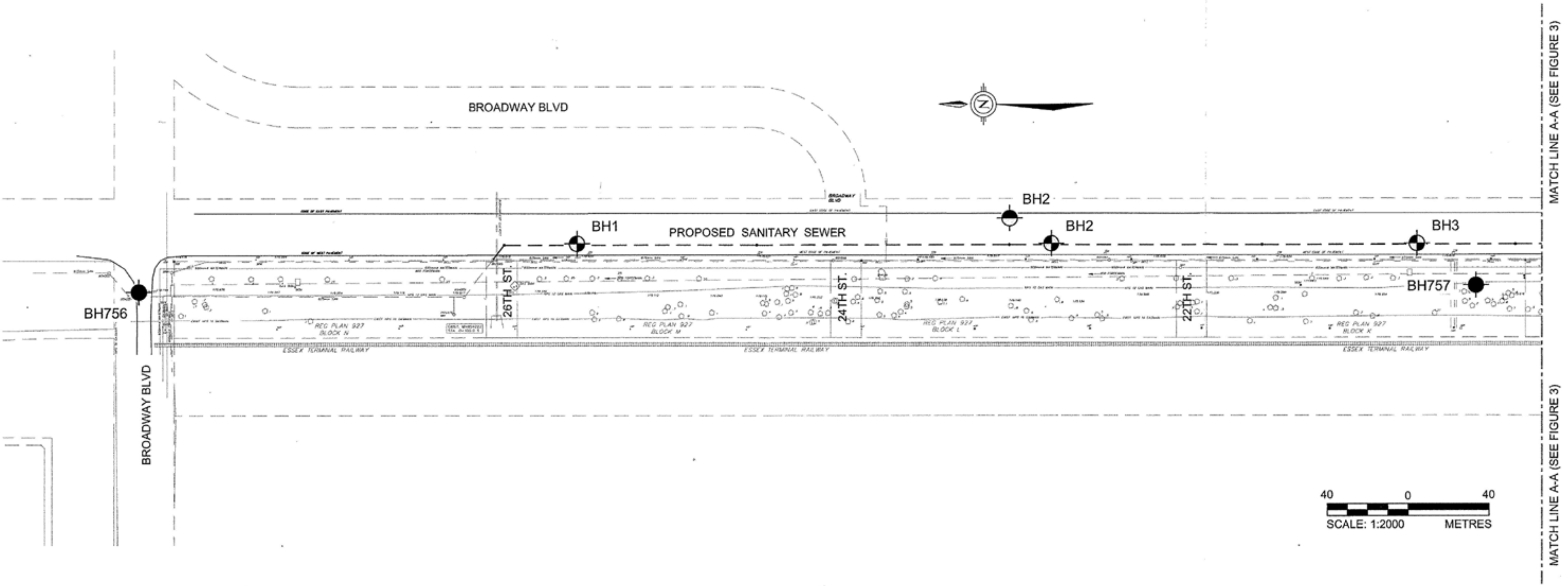
TITLE

## KEY PLAN

Golder Associates
Windsor, Ontario

| | | | |
|---|---|---|---|
| PROJECT No. 07-1140-0023 | | | FILE No. 0711400023D001.dwg |
| DESIGN | | | SCALE N.T.S. REV. 0 |
| CADD | T.M. | MAR/13/07 | **FIGURE 1** |
| CHECK | BG | | |
| REVIEW | | | |

Drawing file: 0711400023d001.dwg Mar 13, 2007 - 10:02am



## LEGEND

- ◍ BOREHOLE LOCATION ( Current Investigation )
- ⊕ BOREHOLE LOCATION ( Previous Investigation ) Report Number 764112
- ● BOREHOLE LOCATION ( Previous Investigation ) Report Number 754139
- ◐ BOREHOLE LOCATION ( Previous Investigation ) Report Number 754002
- ◒ BOREHOLE LOCATION ( Previous Investigation ) Report Number 70461

## NOTES

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT.

ALL LOCATIONS APPROXIMATE.

## REFERENCES

CAD PLAN SUPPLIED BY:
THE CORPORATION OF THE CITY OF WINDSOR
ENGINEERING & CORPORATE PROJECTS
GEOMATICS DIVISION
RECEIVED; Fri 09/03/2007 2:39 PM

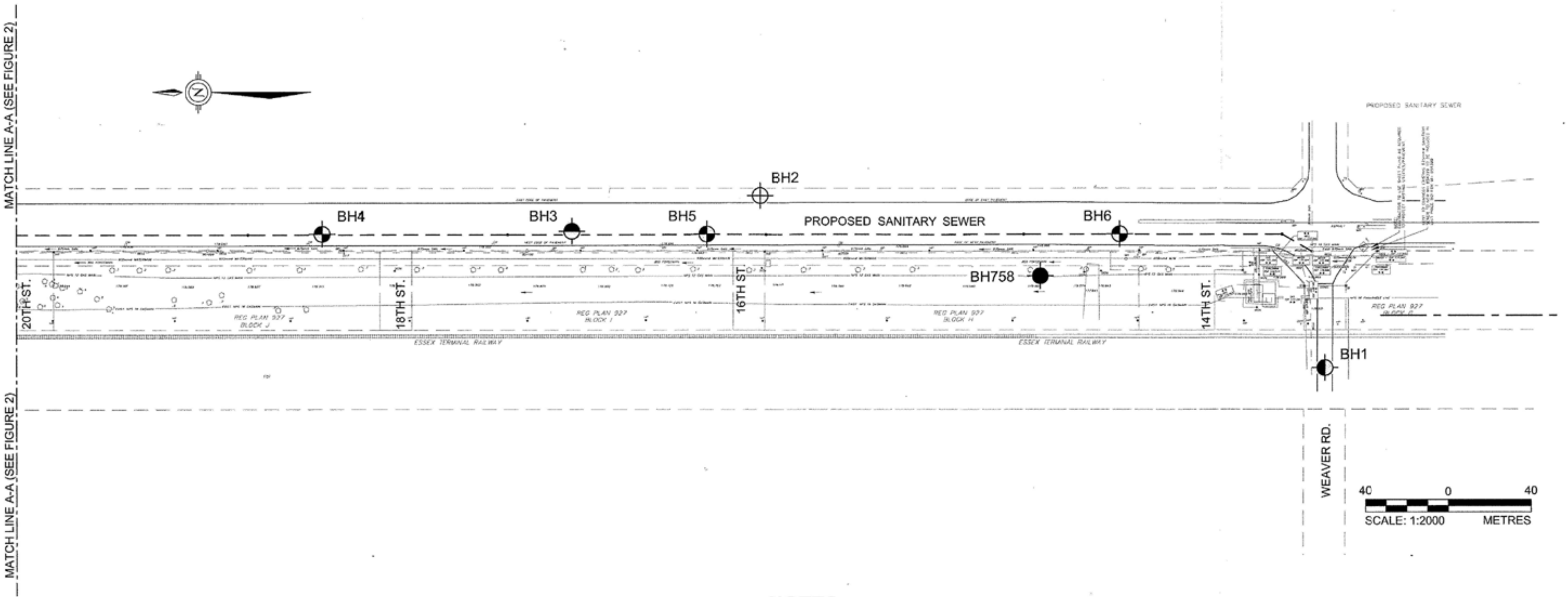
PROJECT THE CORPORATION OF THE CITY OF WINDSOR
OJIBWAY PARKWAY SANITARY SEWER
REHABILITATION - PHASE 4, WINDSOR, ONTARIO

TITLE

## LOCATION PLAN

Golder Associates
Windsor, Ontario

| | | | |
|---|---|---|---|
| PROJECT No. 07-1140-0023 | | | FILE No. 0711400023D001.dwg |
| DESIGN | | | SCALE AS SHOWN REV. 0 |
| CADD | T.M. | MAR/13/07 | FIGURE 2 |
| CHECK | BG | | |
| REVIEW | | | |



## LEGEND

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- ● BOREHOLE LOCATION ( Previous Investigation ) Report Number 754139
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## NOTES

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RECEIVED; Fri 09/03/2007 2:39 PM

PROJECT THE CORPORATION OF THE CITY OF WINDSOR
OJIBWAY PARKWAY SANITARY SEWER
REHABILITATION - PHASE 4, WINDSOR, ONTARIO

TITLE

## LOCATION PLAN

Golder Associates
Windsor, Ontario

| | | | | |
|---|---|---|---|---|
| PROJECT No. 07-1140-0023 | | | FILE No. 07114000230001.dwg | |
| DESIGN | | | SCALE AS SHOWN | REV. 0 |
| CADD | T.M. | MAR/13/07 | FIGURE 3 | |
| CHECK | BG | | | |
| REVIEW | | | | |

PROJECT: 07-1140-0023

LOCATION: SEE LOCATION PLAN

SAMPLER HAMMER, 63.5kg; DROP, 760mm

# RECORD OF BOREHOLE 1

BORING DATE: FEBRUARY 28, 2007

SHEET 1 OF 1

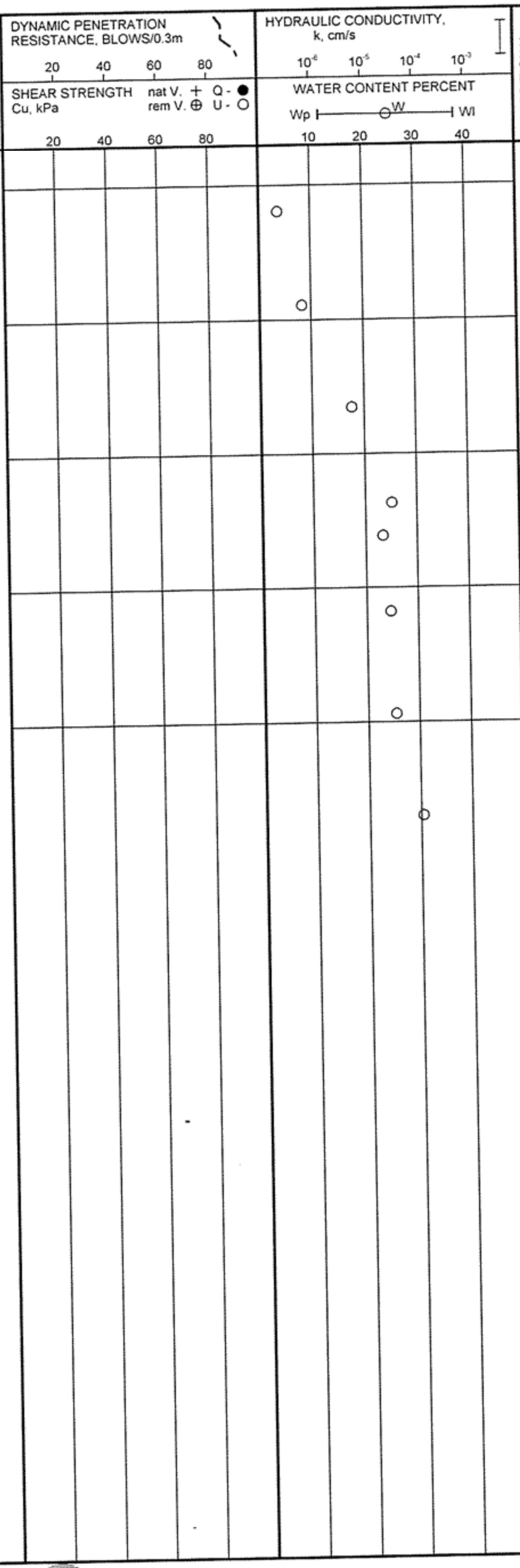
DATUM:

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

BORING METHOD: POWER AUGER, HOLLOW STEM

| SOIL PROFILE DESCRIPTION | ELEV. / DEPTH (m) |
|---|---|
| PAVEMENT SURFACE | 179.10 |
| **ASPHALT** | 0.00 |
| **CONCRETE** | 178.90<br>0.20 |
| Compact, brown, **FINE SAND**, some silt | 0.38 |
| Loose, grey, **FINE SAND**, some silt | 176.97<br>2.13 |
| Loose, grey, **SILT**, some clay, trace sand | 176.43<br>2.67 |
| Firm, grey, **SILTY CLAY**, trace sand, numerous silt seams/partings | 175.44<br>3.66 |
| END OF BOREHOLE | 174.07<br>5.03 |

| SAMPLES NUMBER | TYPE | BLOWS/0.3m |
|---|---|---|
| 1 | AS | |
| 2 | SS | 21 |
| 3 | SS | 22 |
| 4 | SS | 8 |
| 5 | SS | 6 |
| 6 | SS | 4 |
| 7 | SS | 5 |



ADDITIONAL LAB. TESTING

INSTALLATION AND GROUNDWATER OBSERVATIONS

▽ *water seepage*

Water seepage into borehole encountered at about elevation 176.97m during drilling on February 28, 2007.

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: B.G.

CHECKED: BG

PROJECT: 07-1140-0023

# RECORD OF BOREHOLE 2

SHEET 1 OF 1

LOCATION: SEE LOCATION PLAN

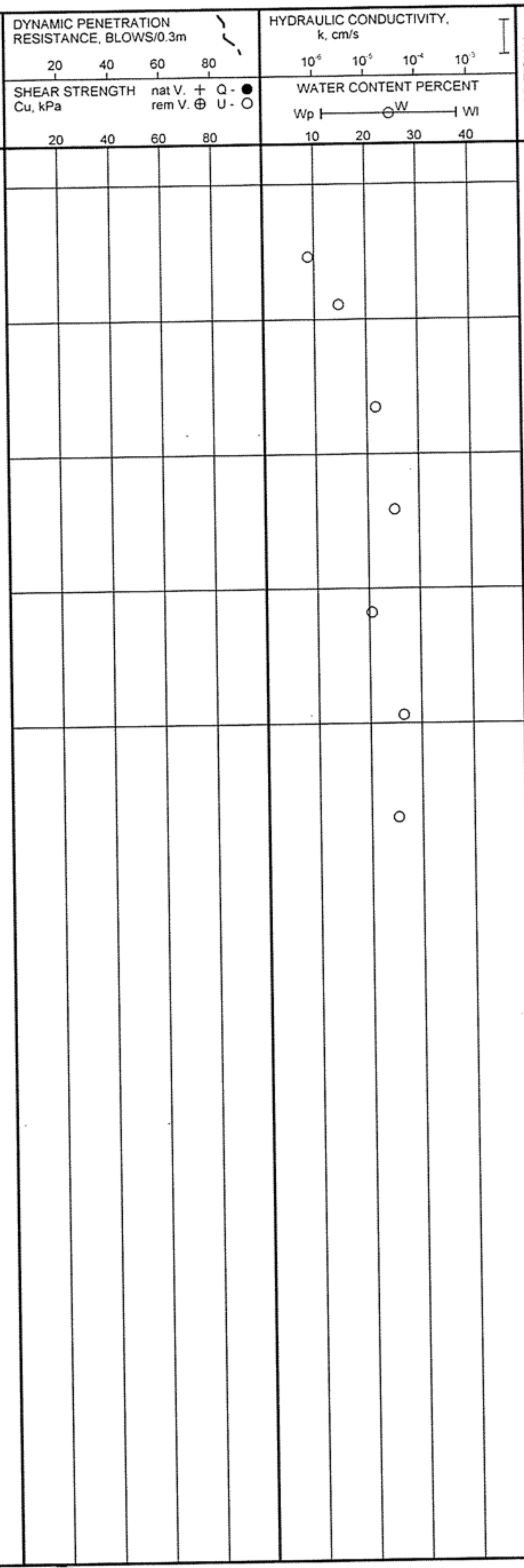
BORING DATE: FEBRUARY 28, 2007

DATUM:

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

| BORING METHOD | SOIL PROFILE DESCRIPTION | ELEV. DEPTH (m) | SAMPLES NUMBER | TYPE | BLOWS/0.3m | ADDITIONAL LAB. TESTING |
|---|---|---|---|---|---|---|
| | PAVEMENT SURFACE | 179.10<br>0.00 | | | | |
| POWER AUGER<br>HOLLOW STEM | **ASPHALT** | 178.82<br>0.28 | | | | |
| | Crushed, granular road base ( **FILL** ) | 178.59<br>0.51 | | | | |
| | Brown, sand, some gravel ( **FILL** ) | 178.34<br>0.76 | 1 | AS | | |
| | Compact, brown, **FINE SAND**, some silt | 176.97<br>2.13 | 2<br>3 | SS<br>SS | 15<br>25 | MH |
| | Compact, grey, **SILTY SAND** to **SANDY SILT** | 176.20<br>2.90 | 4 | SS | 13 | |
| | Compact to loose, grey, **SILT**, layered with clayey silt seams | 174.68<br>4.42 | 5<br>6 | SS<br>SS | 13<br>6 | |
| | Firm, grey, **SILTY CLAY**, trace sand, occ. silt seams/partings | 174.07<br>5.03 | 7 | SS | 8 | |
| | END OF BOREHOLE | | | | | |



INSTALLATION AND GROUNDWATER OBSERVATIONS

water level

water seepage

Water level in borehole encountered at about elevation 177.73m upon completion of drilling on February 28, 2007.

Water seepage into borehole encountered at about elevation 177.19m during drilling on February 28, 2007.

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: B.G.

CHECKED: BG

LDN_BHS 07-1140-0023.GPJ GLDR_CAN.GDT 27/3/07 DATA INPUT: Brent Gusba

PROJECT: 07-1140-0023

LOCATION: SEE LOCATION PLAN

SAMPLER HAMMER, 63.5kg; DROP, 760mm

# RECORD OF BOREHOLE 3

BORING DATE: FEBRUARY 28, 2007

SHEET 1 OF 1

DATUM:

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

| DEPTH SCALE METRES | BORING METHOD | SOIL PROFILE | | | SAMPLES | | | ELEVATION | DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m<br>20 40 60 80<br>SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○<br>20 40 60 80 | HYDRAULIC CONDUCTIVITY, k, cm/s<br>10⁻⁶ 10⁻⁵ 10⁻⁴ 10⁻³<br>WATER CONTENT PERCENT<br>Wp ⊢ ○W ⊣ Wl<br>10 20 30 40 | ADDITIONAL LAB. TESTING | INSTALLATION AND GROUNDWATER OBSERVATIONS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DESCRIPTION | STRATA PLOT | ELEV.<br>DEPTH (m) | NUMBER | TYPE | BLOWS/0.3m | | | | | |
| | | PAVEMENT SURFACE | | 179.00 | | | | | | | | |
| 0 | POWER AUGER<br>HOLLOW STEM | **ASPHALT** | ■ | 0.00<br>178.77<br>0.23 | | | | | | | | |
| | | **CONCRETE** | ▨ | 0.41 | | | | | | | | Borehole dry during drilling on February 28, 2007 |
| 1 | | Brown, **FINE SAND**, trace silt | ░ | 177.48<br>1.52 | 1 | AS | - | 178 | | ○ | | |
| | | END OF BOREHOLE | | | | | | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | |

LDN_BHS 07-1140-0023.GPJ GLDR_CAN.GDT 27/3/07 DATA INPUT: Brent Gusba

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: B.G.

CHECKED: BG

PROJECT: 07-1140-0023

LOCATION: SEE LOCATION PLAN

SAMPLER HAMMER, 63.5kg; DROP, 760mm

# RECORD OF BOREHOLE 4

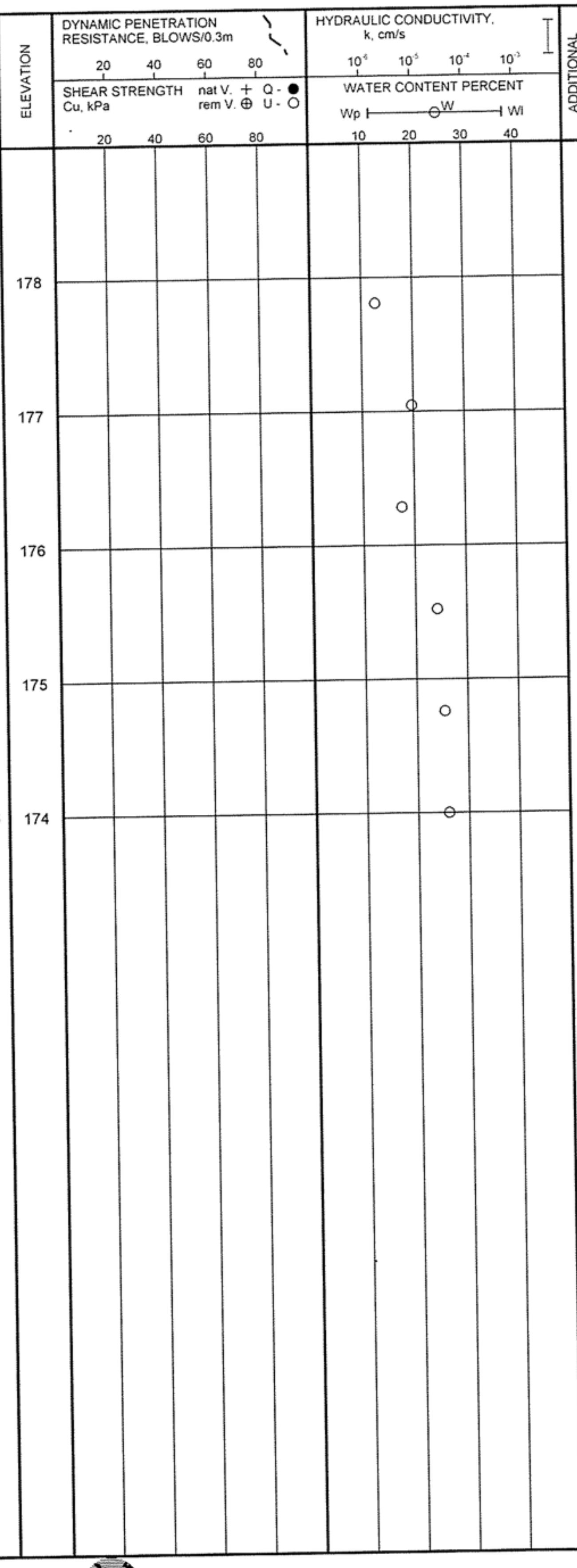
BORING DATE: FEBRUARY 28, 2007

SHEET 1 OF 1

DATUM:

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

| BORING METHOD | SOIL PROFILE DESCRIPTION | ELEV. DEPTH (m) | SAMPLES NUMBER | TYPE | BLOWS/0.3m |
|---|---|---|---|---|---|
| POWER AUGER<br>HOLLOW STEM | PAVEMENT SURFACE | 178.80<br>0.00 | | | |
| | **ASPHALT** | 178.55<br>0.25 | | | |
| | **CONCRETE** | 178.19<br>0.61 | | | |
| | Compact to loose, brown, **FINE SAND**, some silt, trace clay | 176.67<br>2.13 | 1<br>2 | SS<br>SS | 12<br>7 |
| | Compact, brown to grey, fine to medium, **SAND** | 175.75<br>3.05 | 3 | SS | 14 |
| | Loose, grey, **SILT**, trace sand, trace clay | 175.14<br>3.66 | 4 | SS | 9 |
| | Firm, grey, **SILTY CLAY**, trace sand, occ. to numerous silt seams/partings | 173.77<br>5.03 | 5<br>6 | SS<br>SS | 6<br>5 |
| | END OF BOREHOLE | | | | |



INSTALLATION AND GROUNDWATER OBSERVATIONS

water level

water seepage

Water level in borehole encountered at about elevation 177.43m upon completion of drilling on February 28, 2007.

Water seepage into borehole encountered at about elevation 176.97m during drilling on February 28, 2007.

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

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: B.G.

CHECKED: BG

PROJECT: 07-1140-0023

LOCATION: SEE LOCATION PLAN

SAMPLER HAMMER, 63.5kg; DROP, 760mm

# RECORD OF BOREHOLE 5

BORING DATE: FEBRUARY 28, 2007

SHEET 1 OF 1

DATUM:

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

| DEPTH SCALE METRES | BORING METHOD | SOIL PROFILE DESCRIPTION | ELEV. DEPTH (m) | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES BLOWS/0.3m | ELEVATION | INSTALLATION AND GROUNDWATER OBSERVATIONS |
|---|---|---|---|---|---|---|---|---|
| | | PAVEMENT SURFACE | 178.80 | | | | | |
| 0 | POWER AUGER<br>HOLLOW STEM | **ASPHALT** | 0.00 | | | | | |
| | | **CONCRETE** | 178.57<br>0.23 | | | | | |
| | | Brown, sand ( **FILL** ) | 0.41 | | | | | Borehole dry during drilling on February 28, 2007 |
| | | Black, sandy **TOPSOIL** | 0.43 | 1 | AS | - | 178 | |
| 1 | | Brown, **FINE SAND**, some silt, trace clay | 177.68<br>1.12 | 2 | AS | - | | |
| | | END OF BOREHOLE | 177.28<br>1.52 | | | | | |

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

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80

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

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

ADDITIONAL LAB. TESTING

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: B.G.

CHECKED: BG

LDN_BHS 07-1140-0023.GPJ GLDR_CAN.GDT 27/3/07 DATA INPUT: Brent Gusba

PROJECT: 07-1140-0023

# RECORD OF BOREHOLE 6

SHEET 1 OF 1

LOCATION: SEE LOCATION PLAN

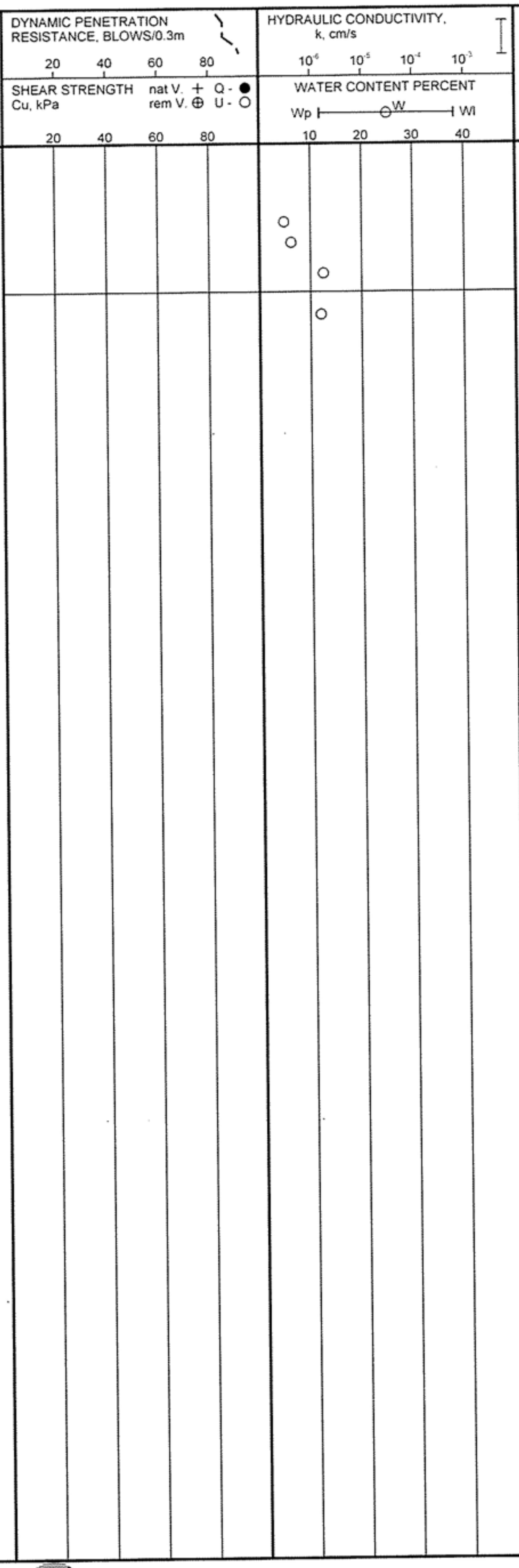
BORING DATE: FEBRUARY 28, 2007

DATUM:

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

| DEPTH SCALE METRES | BORING METHOD | SOIL PROFILE<br>DESCRIPTION | STRATA PLOT | ELEV.<br>DEPTH (m) | SAMPLES<br>NUMBER | TYPE | BLOWS/0.3m | ELEVATION | ADDITIONAL LAB. TESTING | INSTALLATION AND GROUNDWATER OBSERVATIONS |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  | PAVEMENT SURFACE |  | 178.90 |  |  |  |  |  |  |
| 0 | POWER AUGER<br>HOLLOW STEM | **ASPHALT** | ■ | 0.00<br>178.60 |  |  |  |  |  |  |
|  |  | Crushed, granular road base ( **FILL** ) | ▩ | 0.30 | 1 | AS | - |  |  | Borehole dry during drilling on February 28, 2007 |
|  |  | Brown, sand, some gravel ( **FILL** ) | ▩ | 0.46 | 2 | AS | - |  |  |  |
|  |  | Brown to black, sand, trace gravel, clay brick fragments ( **FILL** ) | ▩ | 0.61<br>177.99 | 3 | AS | - | 178 |  |  |
| 1 |  | Brown, silty, **FINE SAND** | ▨ | 0.91<br>177.68 | 4 | AS | - |  |  |  |
|  |  | END OF BOREHOLE |  | 1.22 |  |  |  |  |  |  |
| 2 |  |  |  |  |  |  |  |  |  |  |
| 3 |  |  |  |  |  |  |  |  |  |  |
| 4 |  |  |  |  |  |  |  |  |  |  |
| 5 |  |  |  |  |  |  |  |  |  |  |
| 6 |  |  |  |  |  |  |  |  |  |  |
| 7 |  |  |  |  |  |  |  |  |  |  |
| 8 |  |  |  |  |  |  |  |  |  |  |
| 9 |  |  |  |  |  |  |  |  |  |  |
| 10 |  |  |  |  |  |  |  |  |  |  |



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: B.G.

CHECKED: BG

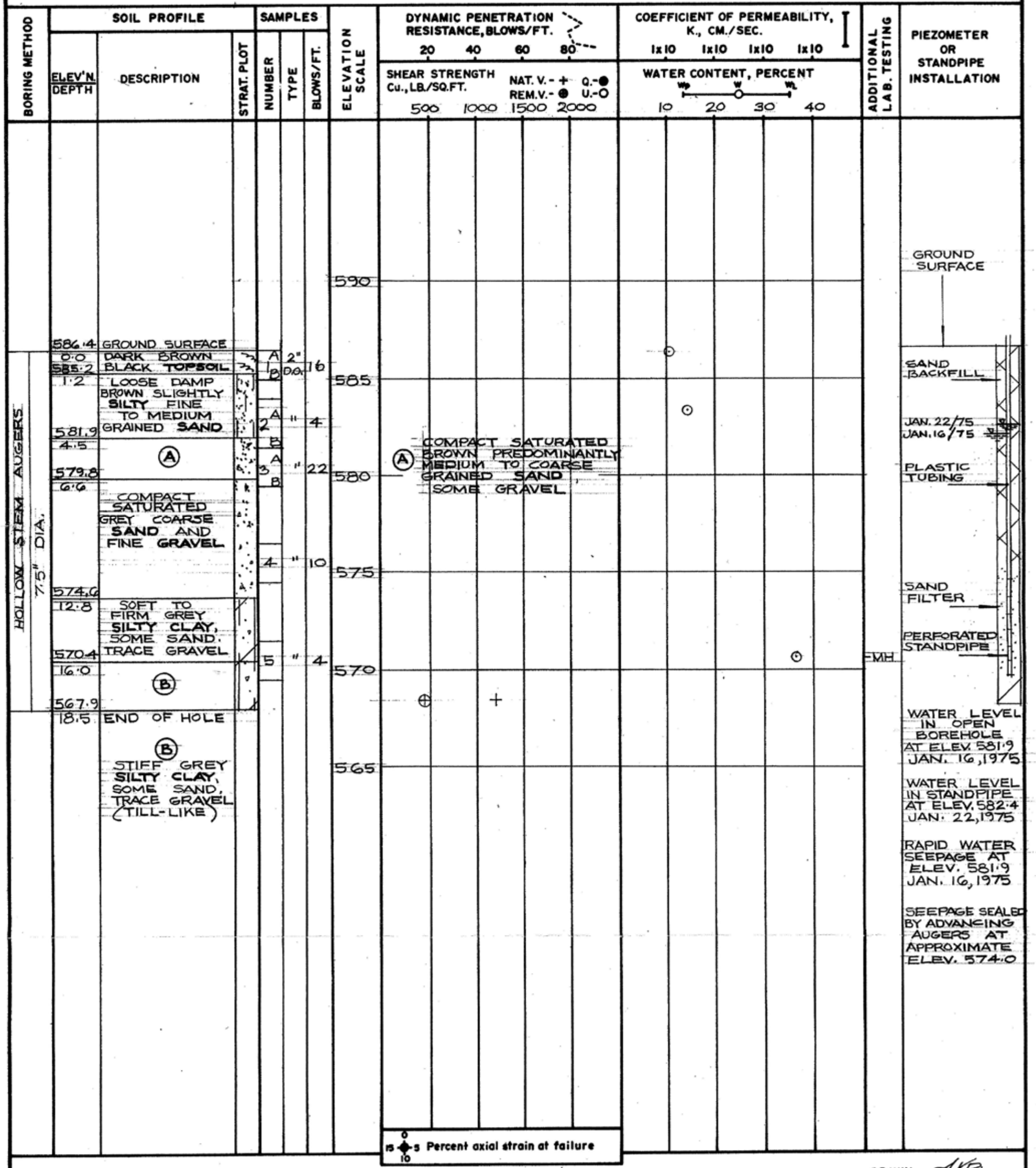
Form G.A. - D - I

Project No. 754002

# RECORD OF BOREHOLE 1

LOCATION See Figure 1 BORING DATE JANUARY 16, 1975 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.



| BORING METHOD | ELEV'N. / DEPTH | DESCRIPTION | STRAT. PLOT | NUMBER | TYPE | BLOWS/FT. |
|---|---|---|---|---|---|---|
| HOLLOW STEM AUGERS 7.5" DIA. | 586.4 | GROUND SURFACE | | | | |
| | 0.0 | DARK BROWN BLACK **TOPSOIL** | | 1 A<br>B | 2" D.O. | 16 |
| | 585.2<br>1.2 | LOOSE DAMP BROWN SLIGHTLY **SILTY** FINE TO MEDIUM GRAINED **SAND** | | 2 A<br>B | " | 4 |
| | 581.9<br>4.5 | Ⓐ | | 3 A<br>B | " | 22 |
| | 579.8<br>6.6 | COMPACT SATURATED GREY COARSE **SAND** AND FINE **GRAVEL** | | 4 | " | 10 |
| | 574.6<br>12.8 | SOFT TO FIRM GREY **SILTY CLAY,** SOME SAND. TRACE GRAVEL | | 5 | " | 4 |
| | 570.4<br>16.0 | Ⓑ | | | | |
| | 567.9<br>18.5 | END OF HOLE | | | | |

Ⓐ COMPACT SATURATED BROWN PREDOMINANTLY MEDIUM TO COARSE GRAINED **SAND**, SOME GRAVEL

Ⓑ STIFF GREY **SILTY CLAY,** SOME SAND, TRACE GRAVEL (TILL-LIKE)

PIEZOMETER OR STANDPIPE INSTALLATION

GROUND SURFACE

SAND BACKFILL

JAN. 22/75

JAN. 16/75

PLASTIC TUBING

SAND FILTER

PERFORATED STANDPIPE

WATER LEVEL IN OPEN BOREHOLE AT ELEV. 581.9 JAN. 16, 1975

WATER LEVEL IN STANDPIPE AT ELEV. 582.4 JAN. 22, 1975

RAPID WATER SEEPAGE AT ELEV. 581.9 JAN. 16, 1975

SEEPAGE SEALED BY ADVANCING AUGERS AT APPROXIMATE ELEV. 574.0

VERTICAL SCALE
1 IN. TO 5 FT.

**Golder Associates**

DRAWN A.V.
CHECKED

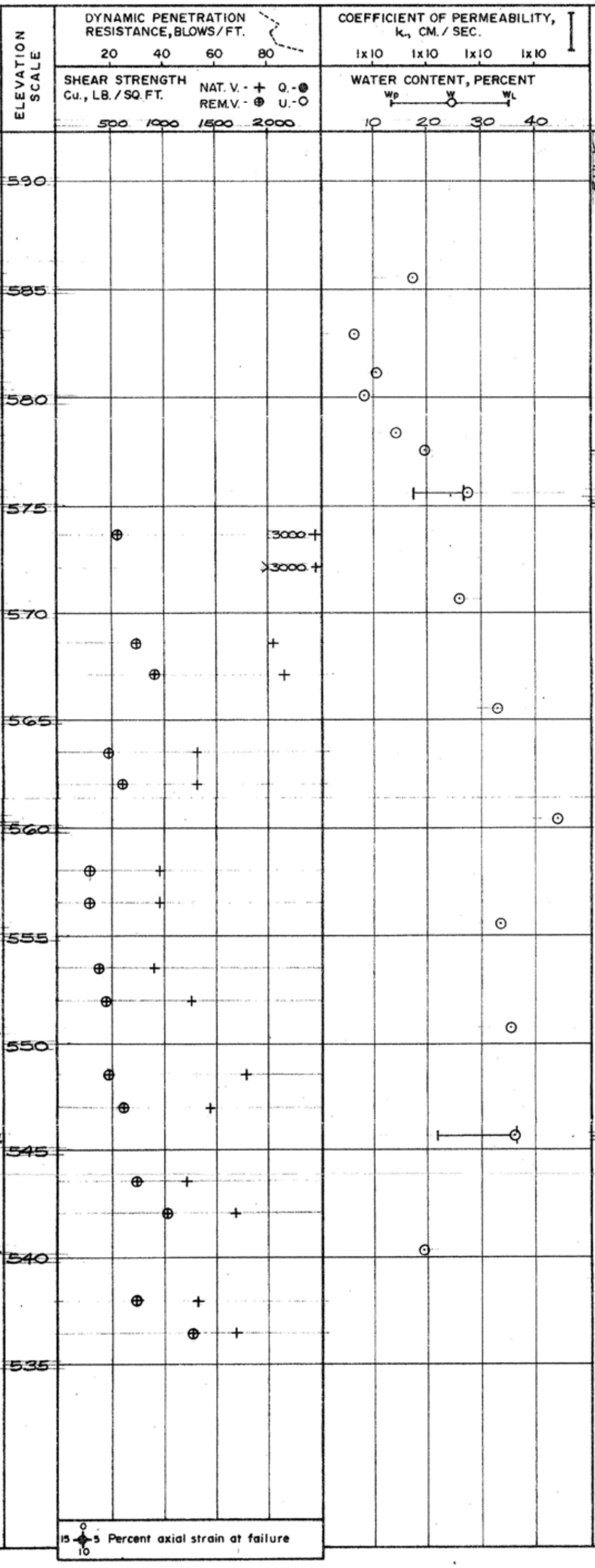
Form G.A.-D-1. Project No. 764112

# RECORD OF BOREHOLE 2

LOCATION See Figure 1 BORING DATE OCT. 4 & 5, 1976 DATUM GEODETIC

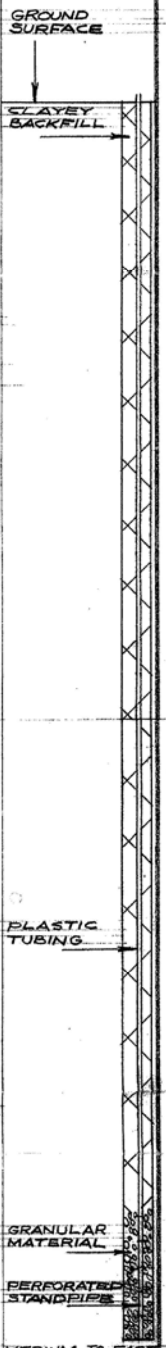
SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

| BORING METHOD | ELEV'N. DEPTH | DESCRIPTION | NUMBER | TYPE | BLOWS/FT. | ADDITIONAL LAB. TESTING |
|---|---|---|---|---|---|---|
| POWER AUGER 7.5" DIA. HOLLOW STEM | 586.8 | GROUND SURFACE | | | | |
| | 0.0 | BLACK **TOPSOIL** | 1 | 2"<br>O.O | 7 | |
| | 584.3<br>2.5 | COMPACT BROWN FINE TO MEDIUM GRAINED **SAND** TRACE SILT | 2 | " | 26 | |
| | | | 3 | " | 24 | |
| | 581.0<br>5.8 | COMPACT GREY WELL GRADED **SAND** AND FINE **GRAVEL** | 4 | " | 21 | MH |
| | 578.1<br>8.7 | COMPACT GREY **SANDY SILT** | | | | |
| | 576.8<br>10.0 | STIFF TO VERY STIFF GREY PARTIALLY LAMINATED **SILTY CLAY** TRACE SAND WITH OCC. THIN SILT SEAMS | 5 | " | 8 | 124<br>MH |
| | | | 6 | " | 5 | |
| | 566.8<br>20.0 | FIRM TO STIFF GREY **SILTY CLAY** TRACE SAND | 7 | " | 3 | |
| | | | 8 | 3"<br>T.O. | P.H. | |
| | | | 9 | 2"<br>O.O. | 5 | |
| | 551.8<br>35.0 | STIFF GREY WITH RED FLECKS **SILTY CLAY** TRACE SAND | 10 | " | W.H. | |
| | | | 11 | " | W.H. | MH |
| | | | 12 | 3"<br>T.O. | P.H. | |
| | 536.8<br>50.0 | END OF HOLE | | | | |



PIEZOMETER OR STANDPIPE INSTALLATION

BULK DENSITY P.C.F.



MEDIUM TO FAST SEEPAGE AT ABOUT 6.0' BELOW GROUND SURFACE OCT. 5, 1976

STANDPIPE DRY OCT. 23, 1976

VERTICAL SCALE 1 IN. TO 5 FT.

**Golder Associates**

DRAWN A.V.D.

CHECKED

MINISTRY OF TRANSPORTATION, ONTARIO

**METRIC**
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

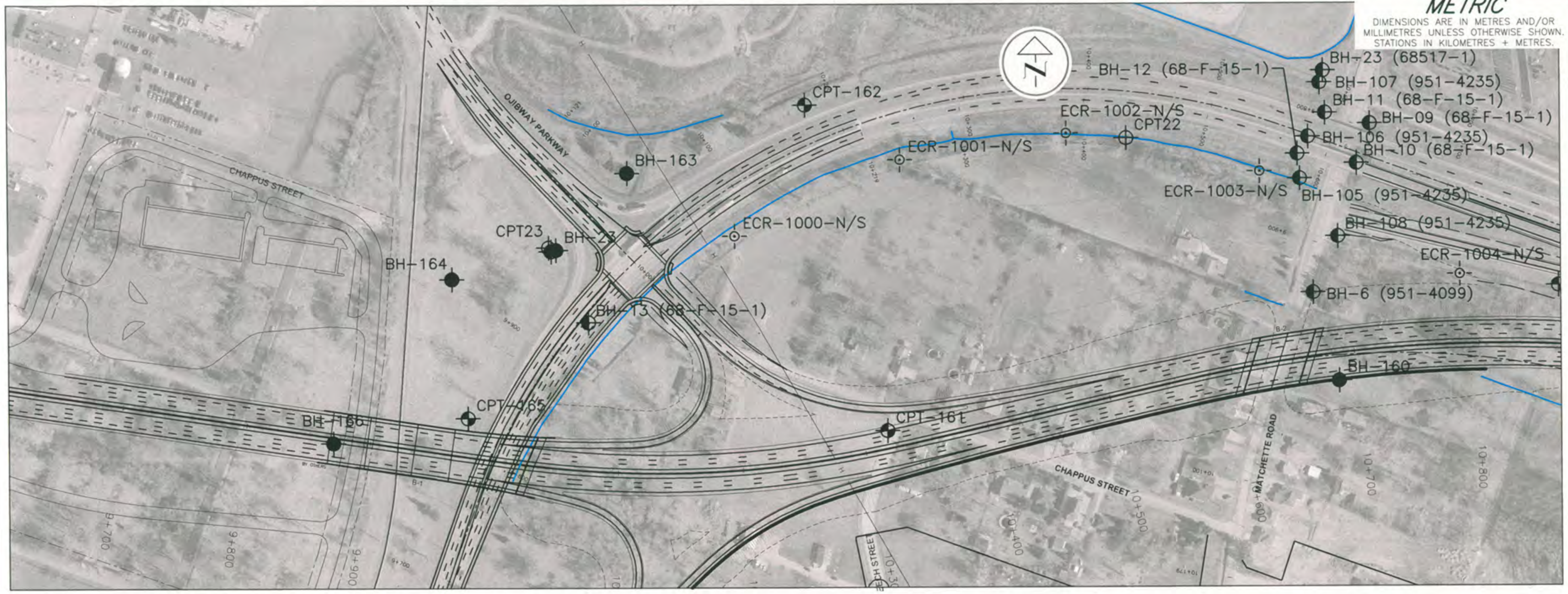
CONT No. –
WP No. –

## WINDSOR – ESSSEX PARKWAY
Windsor, Ontario

## BOREHOLE LOCATION MAP

SHEET
1

**Golder Associates Ltd.**
LONDON, ONTARIO, CANADA



0 80 160

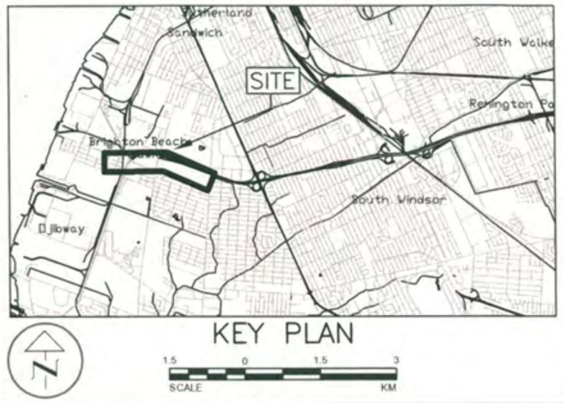
## STN 9+800 TO STN 10+800

### NOTE
Horizontal and vertical alignment of road ways and general structure alignments shown are based on drawings provided by URS during conceptual design. Final alignments and structure arrangements may differ.

0 80 160

## STN 10+800 TO STN 11+800

### REFERENCE
Base plans provided in digital format by URS.



KEY PLAN

## LEGEND

| | |
|---|---|
| ● | Borehole – Current Investigation |
| ◐ | Borehole – Previous Investigations |
| ⊙ | Borehole – Pavement Holes |
| ◕ | Borehole and Cone Penetration Test |
| ⊕ | Cone Penetration Test |

| No. | ELEVATION | CO-ORDINATES (UTM, NAD83 ZONE 17) | |
|---|---|---|---|
| | | NORTHING | EASTING |
| BH23 | 178.92 | 4682323.0 | 328529.0 |
| BH-154 | 180.87 | 4681959.9 | 330200.6 |
| BH-156 | 179.52 | 4682106.6 | 329876.3 |
| BH-158 | 179.30 | 4682144.3 | 329769.9 |
| BH-160 | 178.51 | 4682216.8 | 329156.2 |
| BH-163 | 178.77 | 4682384.7 | 328586.3 |
| BH-164 | 179.06 | 4682299.7 | 328445.6 |
| BH-166 | 179.00 | 4682168.3 | 328349.6 |
| BH-23 (68517-1) | 178.92 | 4682465.8 | 329144.3 |
| BH-6 (951-4099) | 178.79 | 4682287.6 | 329135.6 |
| BH-105 (951-4235) | 179.05 | 4682379.2 | 329125.0 |
| BH-106 (951-4235) | 184.35 | 4682412.8 | 329132.0 |
| BH-107 (951-4235) | 178.97 | 4682456.2 | 329141.5 |
| BH-108 (951-4235) | 178.50 | 4682332.6 | 329155.7 |
| BH-05 (68-F-15-1) | 180.69 | 4682005.8 | 330193.3 |
| BH-06 (68-F-15-1) | 180.75 | 4682042.1 | 330185.3 |
| BH-07 (68-F-15-1) | 180.53 | 4682056.5 | 330145.1 |
| BH-08 (68-F-15-1) | 180.93 | 4682020.2 | 330165.6 |
| BH-09 (68-F-15-1) | 178.46 | 4682423.2 | 329181.5 |
| BH-10 (68-F-15-1) | 178.55 | 4682391.3 | 329170.8 |
| BH-11 (68-F-15-1) | 178.46 | 4682431.9 | 329145.8 |
| BH-12 (68-F-15-1) | 178.37 | 4682399.1 | 329123.4 |
| BH-13 (68-F-15-1) | 178.43 | 4682264.9 | 328554.7 |
| CPT-20 | 179.76 | 4681775.0 | 329868.0 |
| CPT-21 | 179.89 | 4682147.0 | 329759.0 |
| CPT-22 | 178.89 | 4682412.0 | 328986.0 |
| CPT-23 | 178.93 | 4682325.0 | 328523.0 |
| CPT-154 | 180.75 | 4681963.3 | 330191.0 |
| CPT-155 | 179.69 | 4682065.8 | 329981.7 |
| CPT-159 | 178.77 | 4682292.8 | 329332.1 |
| CPT-161 | 179.06 | 4682177.6 | 328793.9 |
| CPT-162 | 178.99 | 4682439.2 | 328729.1 |
| CPT-165 | 178.98 | 4682188.2 | 328457.7 |
| ECR-1000-N/S | Grnd | 4682334.0 | 328672.0 |
| ECR-1001-N/S | Grnd | 4682395.0 | 328805.0 |
| ECR-1002-N/S | Grnd | 4682416.0 | 328938.0 |
| ECR-1003-N/S | Grnd | 4682385.0 | 329093.0 |
| ECR-1004-N/S | Grnd | 4682302.0 | 329253.0 |
| ECR-1005-N/S | Grnd | 4682259.0 | 329419.0 |
| ECR-1006-N/S | Grnd | 4682210.0 | 329560.0 |
| ECR-1007-N/S | Grnd | 4682167.0 | 329706.0 |
| ECR-1008-N/S | Grnd | 4682114.0 | 329864.0 |
| ECR-1009-N/S | Grnd | 4682055.0 | 330004.0 |
| ECR-1010-N/S | Grnd | 4681980.0 | 330216.0 |
| MAL-1 | Grnd | 4681961.0 | 330170.0 |
| MAL-2 | Grnd | 4681959.0 | 330166.0 |
| MAL-3 | Grnd | 4681954.0 | 330160.0 |
| MAL-4 | Grnd | 4681952.0 | 330160.0 |

Geocres No.

| | | | |
|---|---|---|---|
| HWY. | | PROJECT NO.07-1130-207-0 | DIST. |
| SUBM'D. SJB | CHKD. SJB Jun/09 | DATE: MAY 30/09 | SITE: |
| DRAWN: JDR | CHKD. | APPD. | DWG. 1 |

PLOT DATE: June 30, 2009
FILENAME: N:\active\2007\1130 - Geotechnical\1130-2000\07-1130-207-0 URS - DRIC APPROACH GBR - WINDSOR\Drafting\AutoCAD files\0711302070-R010001.dwg

Golder Associates
London, Ontario

# RECORD OF BOREHOLE No 164

2 OF 3 **METRIC**

PROJECT 07-1130-207-0
W.P.
DIST WEST HWY 401/3
DATUM GEODETIC
LOCATION N 4682299.7 ;E 328445.6
BOREHOLE TYPE POWER AUGER, MUD ROTARY WITH HQ TRICONE, NQRC
DATE August 27, 2008 - August 28, 2008
ORIGINATED BY NG
COMPILED BY LMK
CHECKED BY SJS

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT W<sub>P</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W<sub>L</sub> / WATER CONTENT (%) 10 20 30 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | |
| | SILTY CLAY, trace sand, trace gravel<br>Soft to stiff<br>Grey | | | | | | | + 1.4 | | | |
| | | | 15 | TO | PH | | 163 | | | | |
| | | | | | | | 162 | + 1.0 | | | |
| | | | 16 | SS | 9 | | 161 | | ○ | | |
| | | | | | | | | (>95.76) + | | | |
| | | | 17 | TO | PH | | 160 | | | | |
| | | | | | | | 159 | | | | |
| | | | 18 | SS | WH | | | | ├──○ 45 | | 0 1 46 53 |
| | | | | | | | 158 | + 1.5 | | | |
| | | | 19 | TO | PH | | 157 | | | | |
| | | | | | | | 156 | | | | |
| 155.59<br>23.47 | LIMESTONE, fresh, medium strong, weakly laminated to laminated, very fine to fine grained, faintly porous to porous<br>Brown and grey<br>(FOR DETAILED DESCRIPTIONS REFER TO RECORD OF DRILLHOLE) | | 20 | SS | 118/ 75mm | | | | | | |
| | | | 21 | NQ RC | | | 155 | T.C.R (%) 75 S.C.R. (%) 67 R.Q.D. (%) 62 | | | |
| | | | 22 | NQ RC | | | 154 | 97 97 95 | | | |
| | | | 23 | NQ RC | | | 153<br>152 | 100 98 98 | | | |
| 151.58<br>27.48 | END OF BOREHOLE<br>Borehole dry during drilling on August 27 and 28, 2008. | | | | | | | | | | |

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

PROJECT: 07-1130-207-0

# RECORD OF DRILLHOLE: 164

SHEET 3 OF 3

LOCATION: N 4682299.7 ;E 328445.6

INCLINATION: -90° AZIMUTH: —

DRILLING DATE: August 27, 2008 - August 28, 2008

DRILL RIG: MUD ROTARY WITH HQ TRICONE, NQRC

DRILLING CONTRACTOR: AARDVARK DRILLING INC

DATUM: GEODETIC

JN - Joint
FLT - Fault
SHR - Shear
VN - Vein
CJ - Conjugate

BD - Bedding
FO - Foliation
CO - Contact
OR - Orthogonal
CL - Cleavage

PL - Planar
CU - Curved
UN - Undulating
ST - Stepped
IR - Irregular

PO - Polished
K - Slickensided
SM - Smooth
Ro - Rough

Br - Broken Rock

**NOTE**: For additional abbreviations refer to list of abbreviations & symbols.

| DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | ELEVATION | TYPE AND SURFACE DESCRIPTION |
|---|---|---|---|---|---|---|---|
| | | ROCK SURFACE | | 155.59 | | | |
| | MUD ROTARY<br>NO ROCK CORE | LIMESTONE, medium strong, brown and grey | | 23.47 | | | Zone of broken core |
| 24 | | LIMESTONE, fresh, medium strong, weakly laminated, fine grained, porous nearly hydrocarbon staining and odour, fossiliferous (up to 4 cm diameter), mottled grey - brown to black | | 23.59 | 1 | 155 | |
| 25 | | LIMESTONE, fresh, medium, strong, laminated, very fine to fine grained, faintly porous, occasional stylolites, minor hydrocarbon staining, grey with whitish grey zones | | 154.58<br>24.48 | 2 | 154 | |
| 26 | | | | | | 153 | |
| 27 | | LIMESTONE, fresh, medium strong, weakly laminated, very fine to fine grained, faintly porous with occasional pits, fossiliferous (up to 1 cm diameter), zones with heavy hydrocarbon staining, light grey with dark grey to brown zones | | 152.39<br>26.67 | 3 | 152 | |
| | | END OF DRILLHOLE | | 151.58<br>27.48 | | | |
| 28 | | | | | | | |
| 29 | | | | | | | |
| 30 | | | | | | | |
| 31 | | | | | | | |
| 32 | | | | | | | |
| 33 | | | | | | | |
| 34 | | | | | | | |
| 35 | | | | | | | |
| 36 | | | | | | | |
| 37 | | | | | | | |
| 38 | | | | | | | |

PENETRATION RATE (m/min) | FLUSH | COLOUR % RETURN

RECOVERY: TOTAL CORE % 80 60 40 20 | SOLID CORE % 80 60 40 20

R.Q.D. % 80 60 40 20

FRACT INDEX PER 0.3: 5 10 15 20

DISCONTINUITY DATA: DIP w.r.t. CORE AXIS 0 30 60 90 | TYPE AND SURFACE DESCRIPTION

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

DIAMETRAL POINT LOAD INDEX (MPa): 2 4 6

NOTES WATER LEVELS INSTRUMENTATION

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: SG

CHECKED: SSB

Golder Associates
London, Ontario

# RECORD OF BOREHOLE No 164A

1 OF 1 **METRIC**

PROJECT 07-1130-207-0
W.P.
DIST WEST HWY 401/3
DATUM GEODETIC

LOCATION N 4682300.0 ,E 328446.0
BOREHOLE TYPE POWER AUGER, HOLLOW STEM
DATE August 28, 2008

ORIGINATED BY NG
COMPILED BY LMK
CHECKED BY SJB

SOIL PROFILE

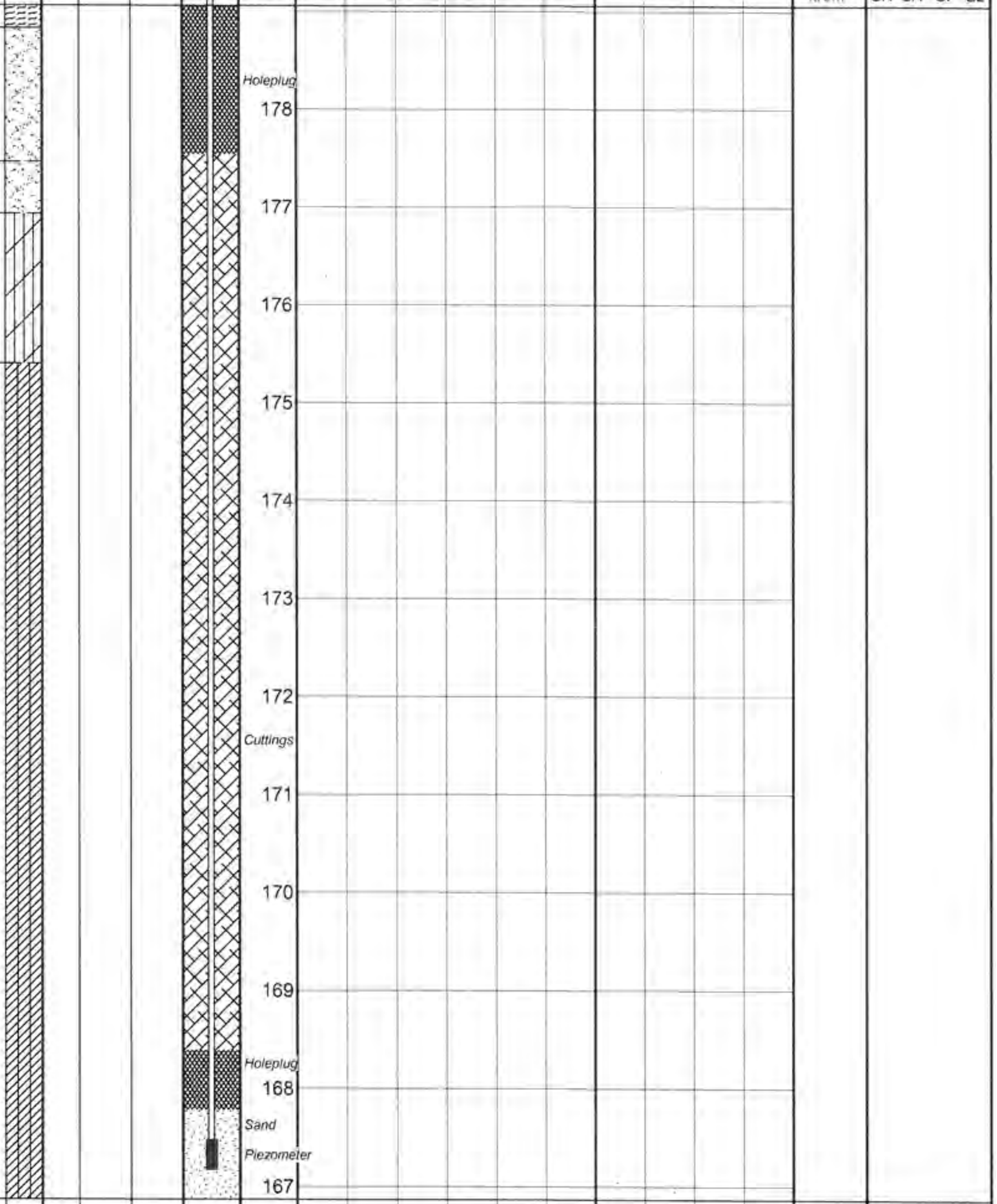
| ELEV<br>DEPTH | DESCRIPTION<br>SOIL CONDITIONS INFERRED FROM BOREHOLE No. 164 |
|---|---|
| 179.06 | GROUND SURFACE |
| 0.00 | TOPSOIL, sandy<br>Black |
| 0.23 | SAND, fine to medium, trace silt<br>Compact<br>Brown |
| 177.46<br>1.60 | SAND, medium to coarse, trace silt<br>Loose<br>Brown |
| 176.93<br>2.13 | CLAYEY SILT, trace sand<br>Firm to stiff<br>Grey |
| 175.40<br>3.66 | SILTY CLAY, trace sand, trace gravel<br>Soft to stiff<br>Grey |
| 166.87<br>12.19 | END OF BOREHOLE |

Borehole dry during drilling on August 28, 2008.

Water level measured in piezometer at elev. 179.96m on September 19, 2008.

Water level measured in piezometer at elev. 179.48m on January 28, 2009.

| STRAT PLOT | SAMPLES: NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100<br>SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT $W_P$ NATURAL MOISTURE CONTENT $W$ LIQUID LIMIT $W_L$<br>WATER CONTENT (%) 10 20 30 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|



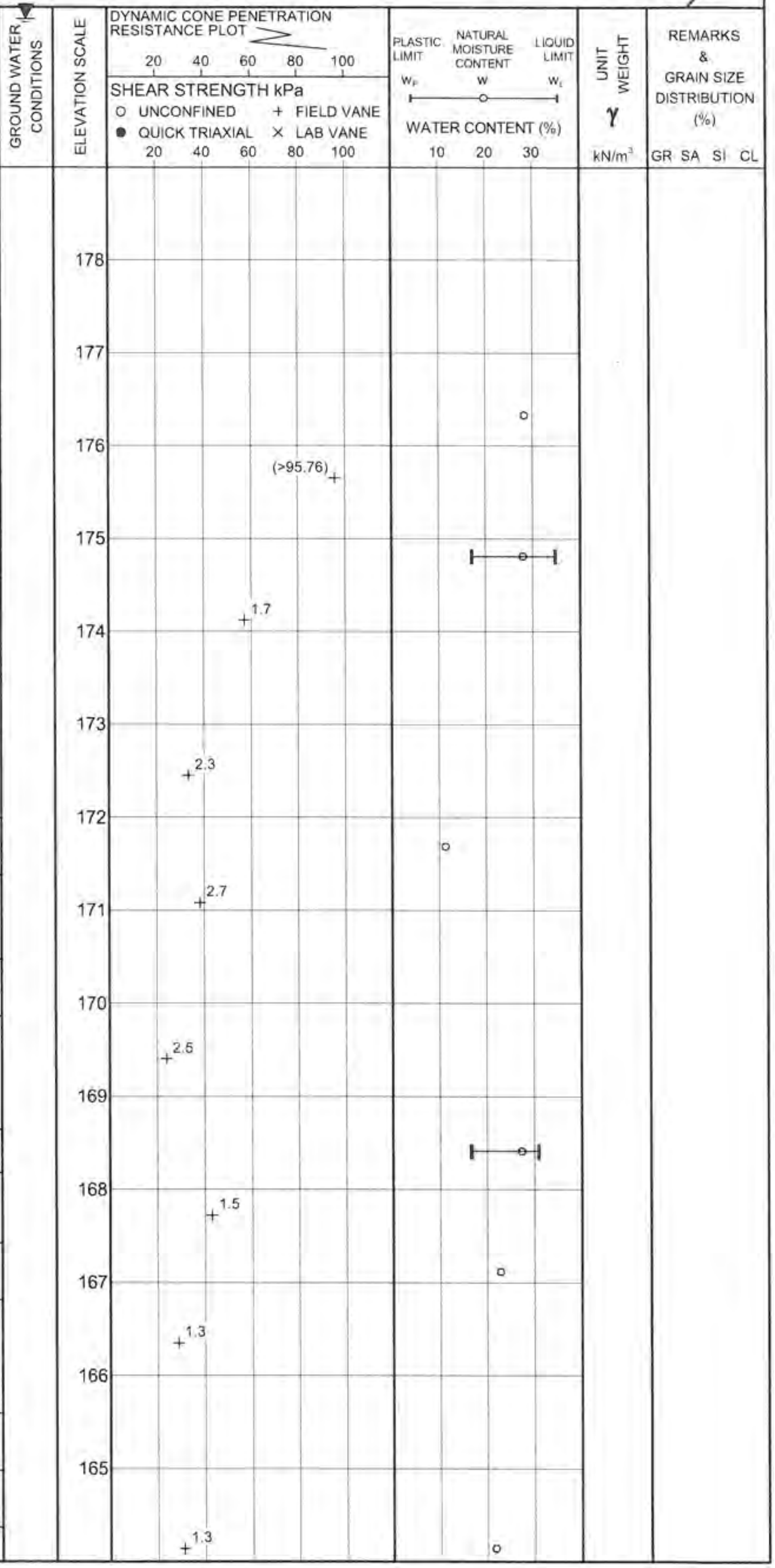
$+^3, \times^3$: Numbers refer to Sensitivity    $\bigcirc^{3\%}$ STRAIN AT FAILURE

# RECORD OF BOREHOLE No 166

1 OF 3 **METRIC**

PROJECT 07-1130-207-0
W.P.
DIST WEST HWY 401/3
DATUM GEODETIC
LOCATION N 4682168.3 ;E 328349.6
BOREHOLE TYPE POWER AUGER, MUD ROTARY WITH HQ TRICONE, NQRC
DATE September 11, 2008 - September 17, 2008
ORIGINATED BY CC
COMPILED BY LMK
CHECKED BY SJB

| ELEV<br>DEPTH | DESCRIPTION | NUMBER | TYPE | "N" VALUES |
|---|---|---|---|---|
| | SOIL CONDITIONS (0 TO 2.44M) INFERRED FROM BOREHOLE NO. 166A | | | |
| 179.00 | GROUND SURFACE | | | |
| 0.00 | TOPSOIL, sandy<br>Black | | | |
| 0.28 | SILTY SAND, fine to medium<br>Loose<br>Brown | | | |
| 177.48<br>1.52 | SILT, trace sand, trace clay<br>Compact<br>Grey | | | |
| 177.02<br>1.98 | CLAYEY SILT, trace sand, with silt partings<br>Firm to stiff<br>Grey | | | |
| 176.56<br>2.44 | CLAYEY SILT, some sand with silt partings<br>Soft to firm<br>Grey | 1 | SS | 4 |
| | | 2 | SS | 5 |
| 174.58<br>4.42 | CLAYEY SILT, trace to some sand, trace gravel<br>Soft to stiff<br>Grey | 3 | TO | PH |
| | | 4 | SS | 4 |
| | | 5 | TO | PH |
| | | 6 | SS | 3 |
| | | 7 | SS | PH |
| | | 8 | TO | PH |
| | | 9 | SS | PM |



Continued Next Page

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

$\circ^{3\%}$ STRAIN AT FAILURE

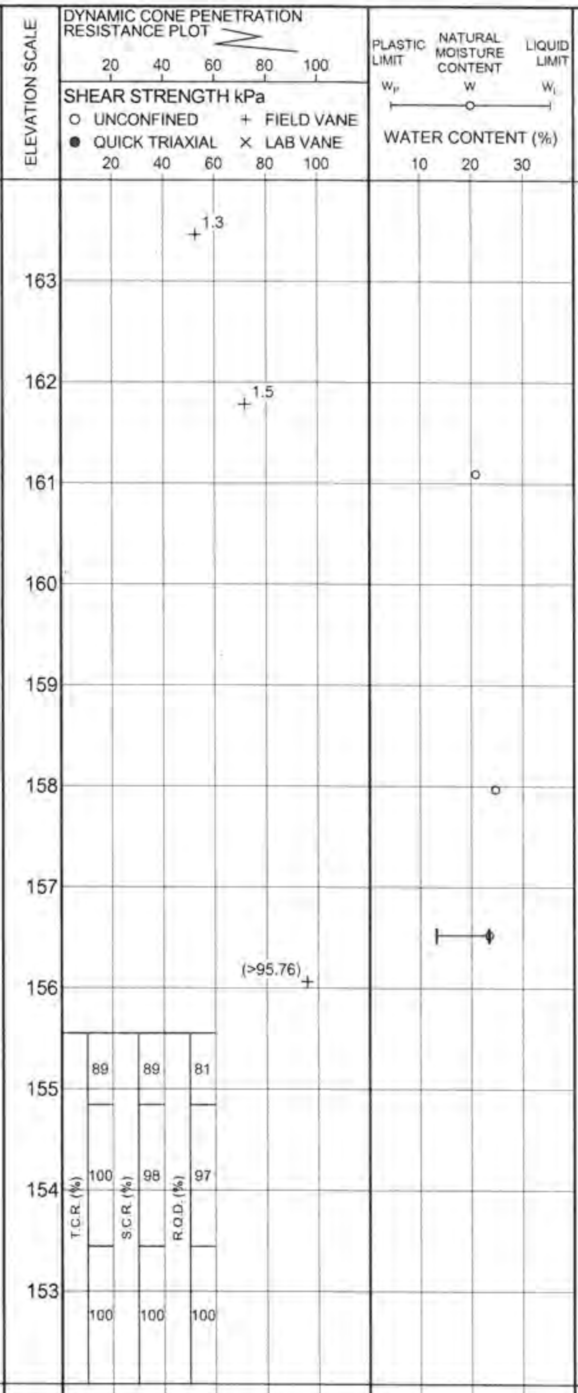
Golder Associates
London, Ontario

# RECORD OF BOREHOLE No 166

2 OF 3 **METRIC**

PROJECT 07-1130-207-0
W.P.
DIST WEST HWY 401/3
DATUM GEODETIC
LOCATION N 4682168.3 ;E 328349.6
BOREHOLE TYPE POWER AUGER, MUD ROTARY WITH HQ TRICONE, NQRC
DATE September 11, 2008 - September 17, 2008
ORIGINATED BY CC
COMPILED BY LMK
CHECKED BY SJS

| ELEV DEPTH | SOIL PROFILE DESCRIPTION | SAMPLES NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|
| | CLAYEY SILT, trace to some sand, trace gravel<br>Soft to stiff<br>Grey | | | | | |
| | | 10 | TO | PH | | |
| | | 11 | SS | 15 | | |
| | | 12 | TO | PH | | |
| | | 13 | SS | 9 | | |
| | | 14 | SS | 9 | | |
| 155.73<br>23.27 | LIMESTONE, fresh, medium strong, weakly to thinly laminated, very fine to fine grained, faintly porous<br>Mottled brown and grey<br>(FOR DETAILED DESCRIPTION REFER TO RECORD OF DRILLHOLE) | 15 | NQ RC | | | |
| | | 16 | NQ RC | | | |
| | | 17 | NQ RC | | | UC |
| 152.08<br>26.92 | END OF BOREHOLE<br>Water level in borehole at about elev. 180.6m during drilling on September 17, 2008.<br>Artesian water flow during rock coring measured at 1.60m above ground surface. | | | | | |



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

PROJECT: 07-1130-207-0

# RECORD OF DRILLHOLE: 166

SHEET 3 OF 3

LOCATION: N 4682168.3 ;E 328349.6

INCLINATION: -90° AZIMUTH: —

DRILLING DATE: September 11, 2008 - September 17, 2008

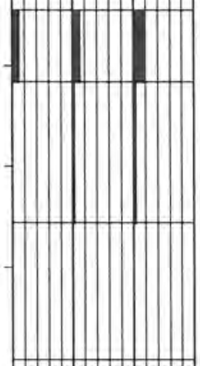
DRILL RIG: MUD ROTARY WITH HQ TRICONE, NQRC

DRILLING CONTRACTOR: AARDVARK DRILLING INC

DATUM: GEODETIC

| | | | | | |
|---|---|---|---|---|---|
| JN - Joint | BD - Bedding | PL - Planar | PO - Polished | Br - Broken Rock | |
| FLT - Fault | FO - Foliation | CU - Curved | K - Slickensided | NOTE: For additional abbreviations refer to list of abbreviations & symbols | |
| SHR - Shear | CO - Contact | UN - Undulating | SM - Smooth | | |
| VN - Vein | OR - Orthogonal | ST - Stepped | Ro - Rough | | |
| CJ - Conjugate | CL - Cleavage | IR - Irregular | | | |

| DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | PENETRATION RATE (m/min) | FLUSH COLOUR % RETURN | ELEVATION | RECOVERY TOTAL CORE % | RECOVERY SOLID CORE % | R.Q.D. % | FRACT INDEX PER 0.3 | DISCONTINUITY DATA DIP w.r.t. CORE AXIS | DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (MPa) | NOTES WATER LEVELS INSTRUMENTATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ROCK SURFACE | | 155.73 | | | | | | | | | | | | | |
| 24 | MUD ROTARY<br>NQ ROCK CORE | LIMESTONE, fresh, medium strong, weakly laminated, fine grained, porous to pitted with occasional vuggs, fossiliferous, hydrocarbon staining, mottled brown and grey | | 23.27 | 1 | | | 155 | | | | | | JN,PL,Ro CI | | | |
| 25 | | LIMESTONE, fresh, medium strong, weakly laminated, fine grained, faintly porous, hydrocarbon staining, brown, mottled brown and grey zone at 25.3m | | 154.29<br>24.71 | 2 | | | 154 | | | | | | | | | |
| 26 | | LIMESTONE, fresh, medium strong, thinly laminated, very fine grained to fine grained, faintly porous, stylolitic, occasional fossils, grey with light grey inclusions | | 153.63<br>25.37 | 3 | | | 153 | | | | | | JN,PL,Ro CI<br>JN,UN,Ro CI | | | |
| 27 | | END OF DRILLHOLE | | 152.08<br>26.92 | | | | | | | | | | | | | |
| 28 | | | | | | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | | | | | | |
| 31 | | | | | | | | | | | | | | | | | |
| 32 | | | | | | | | | | | | | | | | | |
| 33 | | | | | | | | | | | | | | | | | |
| 34 | | | | | | | | | | | | | | | | | |
| 35 | | | | | | | | | | | | | | | | | |
| 36 | | | | | | | | | | | | | | | | | |
| 37 | | | | | | | | | | | | | | | | | |
| 38 | | | | | | | | | | | | | | | | | |



DEPTH SCALE

1 : 75

LOGGED: SG

CHECKED: SJB

PROJECT 07-1130-207-0

# RECORD OF BOREHOLE No 166A

1 OF 2

**METRIC**

W.P.

LOCATION N 4682168.3 ;E 328349.6

ORIGINATED BY CC

DIST WEST HWY 401/3

BOREHOLE TYPE POWER AUGER, HOLLOW STEM

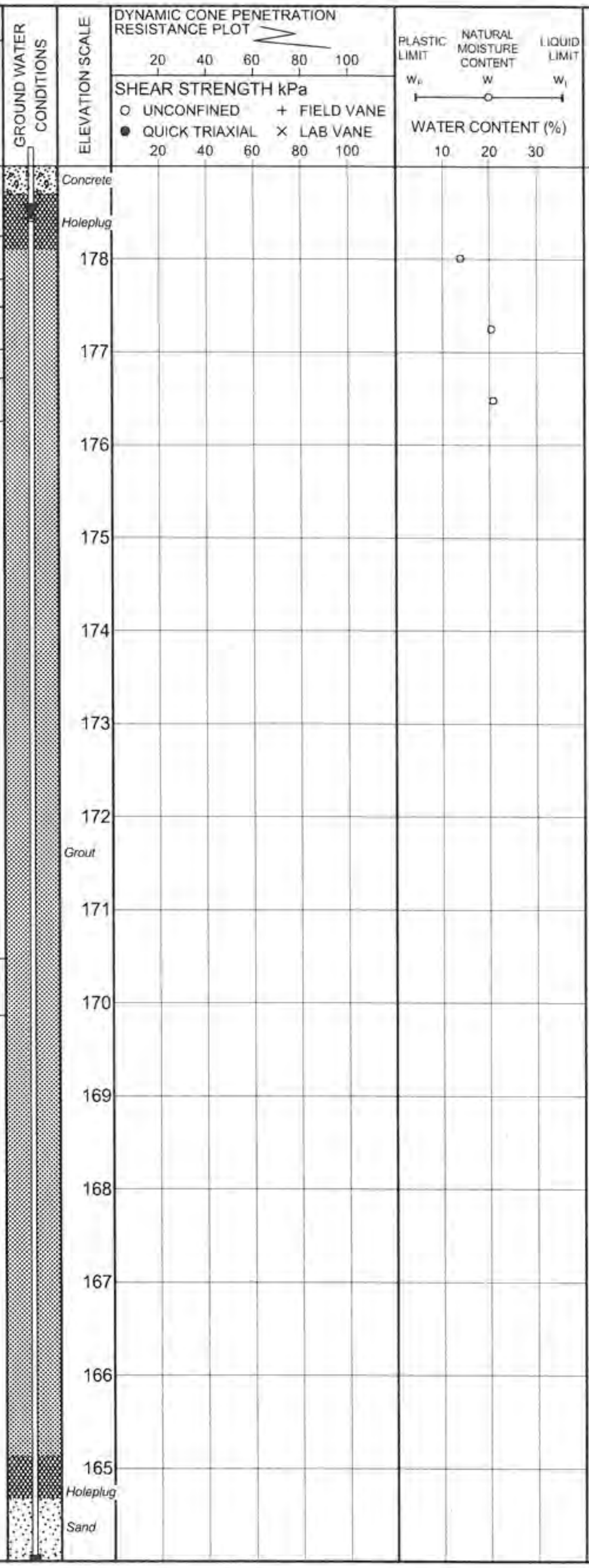
COMPILED BY LMK

DATUM GEODETIC

DATE September 17, 2008

CHECKED BY SJB

| SOIL PROFILE | | SAMPLES | | | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---|---|---|---|---|---|
| ELEV DEPTH | DESCRIPTION<br>SOIL CONDITIONS (2.75 TO 15.39M) INFERRED FROM BOREHOLE NO. 166 | NUMBER | TYPE | "N" VALUES | GR SA SI CL |
| 179.00 | | | | | |
| 0.00 | TOPSOIL, sandy<br>Black | | | | |
| 0.28 | SILTY SAND, fine to medium<br>Loose<br>Brown | 1 | SS | 9 | |
| 177.48<br>1.52 | SILT, trace sand, trace clay<br>Compact<br>Grey | 2 | SS | 16 | 0 3 89 8 |
| 177.02<br>1.98 | CLAYEY SILT, trace sand, with silt partings<br>Firm to stiff<br>Grey | 3 | SS | 8 | |
| 176.25<br>2.75 | CLAYEY SILT, some sand with silt partings<br>Soft to firm<br>Grey | | | | |
| 174.58<br>4.42 | CLAYEY SILT, trace to some sand, trace gravel<br>Soft to stiff<br>Grey | 4 | TO | PH | |



UNIT WEIGHT γ kN/m³

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

O 3% STRAIN AT FAILURE

Golder Associates
London, Ontario

PROJECT 07-1130-207-0

# RECORD OF BOREHOLE No 166A

2 OF 2

**METRIC**

W.P.

LOCATION N 4682168.3 ;E 328349.6

ORIGINATED BY CC

DIST WEST HWY 401/3

BOREHOLE TYPE POWER AUGER, HOLLOW STEM

COMPILED BY LMK

DATUM GEODETIC

DATE September 17, 2008

CHECKED BY SJB

| ELEV<br>DEPTH | SOIL PROFILE<br>DESCRIPTION | STRAT PLOT | SAMPLES<br>NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100<br>SHEAR STRENGTH kPa<br>O UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE<br>20 40 60 80 100 | PLASTIC LIMIT $W_p$ NATURAL MOISTURE CONTENT W LIQUID LIMIT $W_L$<br>WATER CONTENT (%)<br>10 20 30 | UNIT WEIGHT γ<br>kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%)<br>GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 163.61<br>15.39 | END OF BOREHOLE<br>Water level measured in shallow piezometer at elev. 163.76m on September 19, 2008.<br>Water level measured in shallow piezometer at elev. 165.19m on September 22, 2008.<br>Water level measured in shallow piezometer at elev. 178.43m on January 28, 2009. | | | | | | Piezometer | | | | |

+ $^3$, × $^3$: Numbers refer to Sensitivity

O $^{3\%}$ STRAIN AT FAILURE

LDN_MTO_01 07-1130-207-0.GPJ LDN_MTO.GDT 6/29/09

# APPENDIX

# B

## OGS
## BOREHOLES

# APPENDIX

## Borehole ID 620758

**Completion Year :** 1968
**Elevation (DEM) :** 175.8 m
**Total Depth :** 14.8 m
**Static Water Level :** m

**Borehole Log (metres)**
0 ~ 0.2 m soil
0.2 ~ 2.4 m sand, silt, gravel, yellow, loose
2.4 ~ 3 m sand, silt, green, compact
3 ~ 5.6 m clay, silt, sand, green, firm
5.6 ~ 13.3 m clay, silt, sand, gravel, green, firm
13.3 ~ 14.8 m clay, silt, sand, gravel, green, firm

## Borehole ID 620767

**Completion Year :** 1970
**Elevation (DEM) :** 177.8 m
**Total Depth :** 4.1 m
**Static Water Level :** m

**Borehole Log (metres)**
0 ~ 0.2 m soil
0.2 ~ 1.8 m sand, brown, compact, coarse grained
1.8 ~ 2.9 m sand, green, compact, coarse grained
2.9 ~ 4.1 m silt, clay, green, firm

## Borehole ID 620768

**Completion Year :** 1970
**Elevation (DEM) :** 178.8 m
**Total Depth :** 4.1 m
**Static Water Level :** m

**Borehole Log (metres)**
0 ~ 0.2 m soil
0.2 ~ 1.4 m sand, brown, compact, coarse grained
1.4 ~ 2.3 m sand, green, compact, coarse grained
2.3 ~ 4.1 m silt, clay, green, firm

## Borehole ID 620769

**Completion Year :** 1970
**Elevation (DEM) :** 179.1 m
**Total Depth :** 4.1 m
**Static Water Level :** m

**Borehole Log (metres)**
0 ~ 0.2 m soil
0.2 ~ 1.4 m sand, brown, loose, coarse grained
1.4 ~ 2.4 m sand, green, compact, coarse grained
2.4 ~ 4.1 m silt, clay, green, stiff

# APPENDIX

## Borehole ID 620773

**Completion Year :** 1970
**Elevation (DEM) :** 179 m
**Total Depth :** 4.1 m
**Static Water Level :** m

**Borehole Log (metres)**
0 ~ 0.2 m soil
0.2 ~ 2 m sand, compact, coarse grained
2 ~ 2.9 m sand, green, compact, coarse grained
2.9 ~ 3.1 m silt, green, loose
3.1 ~ 4.1 m silt, clay, green, firm

## Borehole ID 620775

**Completion Year :** 1970
**Elevation (DEM) :** 178.8 m
**Total Depth :** 4.1 m
**Static Water Level :** m

**Borehole Log (metres)**
0 ~ 0.2 m soil
0.2 ~ 1.6 m sand, brown, loose, coarse grained
1.6 ~ 2.9 m sand, green, compact, coarse grained
2.9 ~ 4.1 m silt, clay, green, firm

## Borehole ID 620803

**Completion Year :** 1969
**Elevation (DEM) :** 177.2 m
**Total Depth :** 9 m
**Static Water Level :** m

**Borehole Log (metres)**
0 ~ 0.1 m soil
0.1 ~ 2.7 m sand, gravel, silt, brown, compact
2.7 ~ 3.8 m sand, gravel, brown, compact
3.8 ~ 9 m clay, silt, green, firm