December 2009

GEOTECHNICAL ASSESSMENT

East Bayfront Transit Environmental Assessment

Submitted to:
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REPORT

Report Number: 06-1111-014

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1.0 INTRODUCTION

Toronto Transit Commission (TTC) is preparing the Class Environmental Assessment (EA) Studies to identify transit improvements required to support the planned development in the Eastern Waterfront. The studies are undertaken in cooperation with Waterfront Toronto and the City of Toronto. A preferred approach will ultimately be identified to provide an effective transit network to serve the new waterfront communities which are comprised of the East Bayfront, West Don Lands and Port Lands precincts.

The overall objective of each EA is to identify feasible and cost effective solutions to the challenges faced in expanding Toronto's transit system through the study area and to support planned growth while minimizing its effects on the environment. The transit expansion will need to integrate transit service through the West Don Lands, the East Bayfront Lands and the Port Lands.

The purpose of this report is to provide preliminary information on the overburden stratigraphy and recommendations with regards to general construction methods, soil and rock excavation and disposal options and potential groundwater control measures for the proposed transit line in the East Bayfront Lands. The discussion herein will focus on the construction of a potential underground transit tunnel to be extended east from the existing Harbourfront Line at Bay Street and Queens Quay West.

The reader is referred to the "Important Information and Limitations of This Report" that follows the text of this report but forms an integral part of this document. In this regard, it should be noted that the professional services provided by Golder Associates Ltd. (Golder Associates) for this assignment address only the geotechnical (physical) aspects of the subsurface conditions at this site. The geo-environmental (chemical) aspects, including consequences of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources, are outside the terms of reference for this report and have not been investigated or addressed by Golder.

2.0 PROJECT BACKGROUND

The proposed East Bayfront transit alignment is approximately 1.9 km in length and consists of a new streetcar line which runs from Union Station to Parliament Street via Bay Street and Queens Quay East. The streetcars will travel from the present Union Station using the existing tunnel under Bay Street and then continue along a new tunnel, approximately 330 m in length including a tunnel portal under Queens Quay West east of Bay Street, before surfacing just before Freeland Street. The new streetcar alignment will then travel on the existing road just east of Freeland Street in a dedicated Right-Of-Way (ROW). An interim streetcar loop is proposed at Parliament Street to allow the streetcars to turn around and return to Union Station until such time that the transit line on Queens Quay East is extended to Cherry Street. The Queens Quay/Parliament intersection will then be re-aligned and shifted to the Parliament Street Slip where the slip will be partially filled to accommodate the reconfigured Queens Quay/Parliament intersection.

Several portal locations were considered during the feasibility study: two on Bay Street and three between Yonge Street and Freeland Street on Queens Quay. However, it is understood that the preferred portal alternative will be “Option Q2” and, therefore, the discussions included within this report will mainly be associated with the vertical alignment and portal location as provided in the “Option Q2” drawing in April 2009.

3.0 INFORMATION RESOURCES

The review of subsurface conditions for the proposed transit alignment was based on the following information:

- Geologic mapping of “Surficial Geology of Southern Ontario”, Ontario Geological Survey, Miscellaneous Release (Data 128), Ministry of Natural Resources, Ontario Geological Survey (2003);
- York-Peel-Durham-Toronto (YPDT-CAMC) geologic database;
- “Geotechnical Investigation Report on Proposed Entrance to Queen’s Quay Station, Harbourfront Light Rail Transit Line”, Report No. 901-1317, March 1990, Golder Associates; and
- "Geotechnical Investigation and Environmental Subsurface Investigation, Proposed External Sanitary Sewer Upgrades, Toronto, Ontario", Report No. 09-1181-1008 (5010), October 2009, Golder Associates.

4.0 REGIONAL AND LOCAL GEOLOGY

The Quaternary deposits of the Toronto region consist predominantly of glacial till, glaciolacustrine and glaciofluvial sand, silt and clay deposits and beach sands and gravels[1]. These deposits were laid down by glaciers and associated glacial rivers and lakes. Recent deposits of alluvium are found in river and stream valleys and their flood plains. The Quaternary soil deposits overlie bedrock of the Georgian Bay Formation which consists predominantly of shale with interbeds of limestone and siltstone. The bedrock surface found within the study area is generally between Elevation 63 m and 68 m.

The native Quaternary soil deposits overlying the bedrock are believed to have been deposited during the Wisconsinan glacial period which saw several glacial advances and retreats over the course of time. These fluctuations of the glacier front resulted in a complex distribution of glacial till layers separated by interstadial deposits of sands, silts and clays. After the retreat of the last ice sheet from the Toronto region, the meltwaters ponded and created shallow lakes and the resulting lacustrine deposits consist of thin, localized accumulations of sand, silt and clay which overlie the uppermost till sheet. However, the last major glacially related event to affect the shoreline of Toronto was the occupation of the Lake Ontario basin by Lake Iroquois which had a much higher water level than the current Lake Ontario. The study area is located within the former glacial Lake Iroquois and close to the present day Lake Ontario.

4.1 Local Subsurface Conditions

The subsurface conditions along the alignment are likely dominated by the presence of miscellaneous fill materials. Since the mid- to late-1800s, the shoreline of Toronto has been extended as much as 1 km into Lake Ontario by fill placement. The project is situated in a filled area and buried wharfs have been found nearby. It is expected that above the bedrock, the subsurface materials will consist of a melange of building debris (wood, concrete, brick, glass, etc.), reworked native soils, aged municipal debris and ashes, among other materials.

The subsurface profile illustrated on Figure 1 was developed using the YPDT geologic database information. Data point locations related to the bedrock surface topography are illustrated on Figure 1 associated with the Harbourfront LRT and local building construction. The water surface of Lake Ontario typically varies from approximately Elevation 74.5 to 75.3 m. Groundwater within the fill materials may be within about 1 m of the ground surface in this area.

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[1] Chapman, L. J. and Putnam, D. F. “The Physiography of Southern Ontario”, 3rd Edition, 1984 and accompanying Map 2226, Scale 1:253,440

5.0 INFLUENCE OF SUBSURFACE CONDITIONS ON DESIGN AND CONSTRUCTION

The new underground section of the proposed transit line will be constructed along Queens Quay east of Bay Street. This alignment is also located south of the natural shoreline of Lake Ontario and within the filled areas created to construct the Toronto waterfront and its working piers since the late 1800s and early 1900s. Figure 1 shows the simplified subsurface profile along the Queens Quay from Bay Street to slightly west of Freeland Street.

5.1 Temporary and Permanent Earth Retaining Systems

The character of fill materials, the potential permeable zones within the fill and native soils/lake-bed sediments and the relatively shallow bedrock must be taken into consideration for the excavation support system due to the proximity of the Yonge Street slip and Lake Ontario to the underground section of alignment. Due to the high groundwater level at this project site, continuous support walls are considered necessary in order to minimize the use of active groundwater control measures during construction. To control groundwater within the excavations, it is likely that the continuous wall systems will have to penetrate to bedrock for the majority of the tunnel length. Furthermore, it will also likely be necessary to complete end walls for the support systems to limit inflow of groundwater, thus completing a full perimeter cut-off wall system for the excavations.

On the existing TTC Harbourfront LRT tunnel, the “slurry wall” method, also known as “cast-in-place concrete diaphragm” walls, was used. Other techniques such as “secant pile” walls, sometimes referred to as “caisson walls”, would also be suitable for constructing continuous wall systems at this location. Any of these systems can be adapted either to provide temporary support to the excavation (with a separate permanent structure constructed within the walls) or to form the permanent structural tunnel wall (as the case for the existing Harbourfront LRT tunnel).

Several continuous wall types should be feasible for construction of the below ground section of this transit line. Slurry walls or secant pile walls may both be suitable for supporting the excavation and possible incorporation into permanent structural components of the tunnel. Brief discussions of these two wall systems are provided below. The presence of buried debris and miscellaneous (and unpredictable) fill materials inhibit the use of driven sheet-pile excavation support systems. Clearing obstructions to the driving of sheet piles is anticipated to be sufficiently problematic to render this wall system inappropriate for this site.

Geotechnical design parameters for estimation of lateral loading on temporary structures should be determined based on future site-specific investigation and testing.

Construction of all earth retaining structures for the excavation support will induce displacements of the surrounding ground. The magnitude of displacements will be related to the type and structural design of the excavation support system, depth of the excavation, local ground conditions and construction workmanship. A sequence of progressively detailed approaches to analyses of similar situations have been developed and identified within TTC design manuals for underground structures. During subsequent phases of design, it will be necessary to assess such retaining systems and ground displacements and the effects that these displacements may or may not have on neighbouring structures, utilities and other facilities.

5.1.1 Cast-in-place Concrete Diaphragm Wall Method

Slurry, or concrete diaphragm, walls are suitable for excavation support on this cut and cover project. Sufficient work area at the site will be necessary in order to house the slurry processing equipment and manage the soil/bedrock material removed from the ground during excavation.

This wall system can also be used to support decking to carry the traffic on Queens Quay during excavation. If the slurry walls are to provide permanent support for the roof slab and backfill, the walls must be extended into bedrock either as a continuous wall or with selected wall panels taken to bedrock to carry the vertical loads, depending on the need for groundwater cut off.

If a slurry wall excavation support system is to also be used as or incorporated into the permanent structural tunnel wall, it is recommended that an internal facing wall be provided. Drainage facilities should then be provided between the two walls to control post-construction leakage, if any, and the associated aesthetic and maintenance issues. Insulation may also be required near the portal to prevent freezing of the ground behind the permanent wall or freezing of seepage water between the permanent and facing walls. It is understood that the difficulties encountered during construction of the slurry walls for the existing Harbourfront light rail line were mainly related to the character of the fill materials and penetration of the slurry wall into the bedrock. There were numerous wood piles and buried wharfs encountered within the excavation which had to be removed as well as old utilities where slurry was lost into old abandoned pipes. Similar conditions with miscellaneous debris/structures within the fill should be anticipated for the proposed construction. Construction quality control and post-exposure remediation of joints between slurry walls will also be critical for successful wall performance. Construction of slurry walls will require diversion of utilities or other structures that cross the wall line .

5.1.2 Secant or Caisson Wall Method

Secant or caisson walls, when properly constructed, would also be suitable for excavation support for this cut and cover project. The walls can form an adequate barrier to the groundwater inflow though some localized seepage should be expected. These walls can also be designed to carry the loadings coming from the roof slab and backfill and also to support the temporary decking to carry traffic during construction. If the secant pile (caisson) wall excavation support system is to also be used as or incorporated into the permanent structural tunnel wall, it is recommended that an internal facing wall be provided. Drainage facilities should then be provided between the two walls to control post-construction leakage, if any, and the associated aesthetic and maintenance issues. Insulation may also be required near the portal to prevent freezing of the ground behind the permanent wall or freezing of seepage water between the permanent and facing walls.

Secant pile wall construction techniques may cope better with the uncertainties associated with the miscellaneous fill conditions beneath the site than slurry wall techniques. If full-depth temporary liners are installed during or prior to drilling secant piles, loss of drilling fluids may be minimized. Some drilling and coring techniques may also be more adaptable than slurry wall construction systems to removing the variety of obstructions that may be found in the fill. Construction quality control and post-exposure remediation of joints between secant piles will be essential to limit leakage of groundwater into the excavation. Construction of secant pile walls also requires diversion of existing utilities or other structures that cross the line of the wall.

5.2 Excavation and Groundwater Control

Control of excavation sequencing and groundwater will be critical for successful construction of the proposed tunnel. The planned excavations will penetrate through existing fill materials that were likely placed with little control over material constituents or compaction and will likely contain rubble and other debris. Once the excavation support system is completed, and thereby cutting off or minimizing groundwater flow through the perimeter wall, it may be necessary to provide supplemental groundwater control through use of internal dewatering well systems installed into the bedrock. The potential for groundwater flow through bedrock fractures to influence base stability (where the excavation is not carried fully to the rock surface) should be evaluated in detail during subsequent phases of design. The influence of groundwater draw-down on local features should also be evaluated during subsequent phases of design. Based on our knowledge of the area, most of the buildings in the vicinity are supported on deep foundations and many major utilities are also supported on driven piles. However, the potential for groundwater control to influence surrounding facilities will need to be assessed pending further detail on the local ground conditions and existing facilities. Without adequate control or cut-off of groundwater prior to excavation, the existing fill materials may become unstable and flow into the excavation upon first exposure. It is, however, anticipated that groundwater control may be completed using conventional means applicable to similar types of construction. Basements and underground parking facilities have successfully be constructed in the area using secant pile walls coupled with appropriate groundwater control systems.

5.3 Considerations for Permanent Tunnel Structure Design

The present planning indicates that the proposed tunnel will depart from the existing tunnel grades (approximate top of rail Elevation 69 m) and decline toward the existing Yonge Street storm sewer. Near Station 0+225, the top of rail elevation may be at or near (above or below) the bedrock surface elevation in this area. Between the Yonge Street storm sewer and Freeland Street, the rail grade rises from near the bedrock surface to the ground surface.

For preliminary planning purposes, it should be assumed that the subgrade materials above the bedrock are relatively weak and consist of uncontrolled fill materials. In practice, the design of underground box structures is generally not governed by bearing failure because the construction of such structures typically results in a net unloading of the founding materials (soil, fill and bedrock). In such cases, depending on the results of future explorations and testing, it may prove feasible to remove and replace zones of the existing fill such that satisfactory support and performance of the new structure is achieved without removing all fill materials or use of deep foundation systems. Alternatives for box structure support and their respective advantages and disadvantages should be evaluated in detail during future phases of planning and design.

If the permanent tunnel is constructed as a separate box structure and does not incorporate the excavation support system, the box should be provided with appropriate seepage control (“waterproofing”, though some leakage should still be expected).

Geotechnical design parameters for estimation of lateral loading on permanent structures should be determined based on future site-specific investigations and testing.

5.4 Yonge Street Culvert

With the preferred portal location, it is understood that the new tunnel structure would interfere with an existing 2 m x 2.3 m storm sewer culvert that runs north to south along the west side of Yonge Street and ends at the Yonge Street slip on Lake Ontario. As indicated on the portal alternative “Q2” drawing provided in April 2009, the proposed realigned sewer will be located at approximately Station 0+248 with its base sitting slightly above the roof of the new transit tunnel.

It is understood that the existing culvert is supported on timber piles that may have been driven to found on the bedrock. It was indicated that the culvert invert at this location is at about Elevation 72.0 m or about 4.2 m below ground surface.

Construction of the slurry walls or caisson walls will require measures to support or divert the existing culvert during construction. Possible methods for constructing the new tunnel wall, either by a sewer diversion or by maintaining the current sewer alignment, are discussed below.

If it is possible to realign the sewer, then the wall construction can proceed up to, or close to the edges of the existing culvert, leaving a “gap” in the new wall where the existing culvert crosses it. Alternatively, wall construction can be phased such that the sewer is diverted before continuing the wall at and beyond the existing culvert location. A pre-planned “cut-out” location would also need to be included in the completed wall where the proposed diverted sewer pipe will be crossing through. The existing sewer can be demolished after the construction and activation of the new culvert and the slurry wall can then be continued after the removal of the timber piles.

Support to the new culvert could be provided by the tunnel structure itself; however, this would require Toronto Transit Commission’s approval regarding the use of their permanent structure as a structural support for the City’s diversion sewer.

In the case where the sewer culvert is to remain in its current alignment and no replacement culvert will be constructed, some form of underpinning would be required. Following construction of the excavation support wall up to the sides of the culvert, a program of jet grouting could then be used to fill the gap in the wall under the culvert. It should be expected that the existing timber piles under the culvert will “shadow” (limit the effectiveness of) the grout injection. However with multiple points of drilling and grout injection, this method should be able to produce an adequately grouted area to permit construction of the permanent wall as part of the tunnel construction. The nature of existing fill materials will complicate any form of grouting used for underpinning. Voids, abandoned utilities and large sections of timber or other rubble will lead to loss of grout or “shadowing” of grout. Therefore, additional investigation at close spacing around the existing culvert will be necessary to assess the suitability of this approach.

6.0 SOIL AND GROUNDWATER MANAGEMENT

Surplus soils excavated for the new tunnel section and portal must be managed and disposed of according to appropriate regulatory guidelines with respect to environmental quality.

Analysis of the environmental quality and chemistry of soil and groundwater is beyond the scope of this report, but must be undertaken during final design. Therefore, it is recommended that a detailed soil and groundwater management and disposal plan be developed to include the following:

- Land use history along and immediately adjacent to the alignment with respect to the potential existence for environmental contaminants present within the soils or groundwater and the potential presence of buried structures;
- Reuse of excavated soils for construction and landscaping purposes;
- Hauling and disposal of volumes of the excavated earth materials that may not be suitable for reuse on this project as a result of the physical consistencies or environmental contamination, either due to the in-situ condition or the construction processes (e.g. during slurry trench excavation); and
- Management and disposal of water collected during construction that could include potential contaminants from existing fill materials and construction processes.

Based on the available information, it is anticipated that a Permit to Take Water (PTTW) would be required for construction.

7.0 RECOMMENDATIONS FOR FUTURE WORK

Prior to completion of preliminary or final design, subsurface exploration and testing will be required. The overall nature of the fill matrix materials and character of rubble, debris or any other fill constituents will be crucial in determining the appropriate construction techniques to be used for the excavation support and the underpinning of existing culvert.

Defining the quality and structure of the bedrock beneath the site will be critical for clarifying the need for and type of groundwater control systems that may be required during construction as well as for determining the methods and effort that may be required for rock removal to achieve desired rail grades beneath the Yonge Street storm sewer. Due to the proximity of Lake Ontario to this site, defining the hydraulic conductivity of the overburden (materials above bedrock) and the local bedrock should be given particular attention during future exploration and testing programs.

The exploration and testing programs should be developed in a manner consistent with recent practices undertaken for the Sheppard Subway in the mid-1990s and for the current Toronto-York Spadina Subway Extension as identified in the current TTC’s “Direction for Conducting Subsurface Investigation”. These programs typically include several phases of work with boreholes located at progressively closer distances along the alignment and at critical design or construction locations as the design develops.

For preliminary design, at least three detailed geotechnical boreholes should be completed and each of these should include a minimum of 8 m of coring into bedrock. As part of the preliminary design investigations, two groundwater pumping tests should be carried out including one within the overburden (fill and native soils) and the second within the bedrock. Pressure packer testing should also be carried out in each of the boreholes to help quantify the potential hydraulic conductivity of the bedrock. A series of observation wells would also have to be installed in close proximity to the pumping wells to observe drawdown of the groundwater.

Depending on the results of the preliminary investigations and testing, additional geotechnical explorations should be completed with the final borehole spacing ranging between about 30 to 50 metres. During the preliminary geotechnical explorations and testing, soil and groundwater samples should be subjected to chemical analyses to determine the environmental quality of the subsurface materials for excavation, dewatering and subsequent disposal or treatment.

Following the completion of the preliminary geotechnical investigations, detailed analyses should be undertaken to estimate the potential groundwater control requirements and to develop appropriate excavation support design and construction system criteria. As part of these analyses, an outline dewatering assessment should be undertaken to estimate the steady-state groundwater volumes that may be extracted during construction so as to develop documents in support of obtaining a PTTW from the MOE.

In addition, it will be necessary to review records that may be available regarding the foundation types of the nearby buildings and the nearby major utilities. It is understood that some of the nearby major utilities may be supported on piles, similar to the Yonge Street culvert. It will also be beneficial to review any historical or archaeological records of the area to determine what materials or former structures might be within the planned zone of construction so as to develop designs that are more likely to be successfully constructed while minimizing subsurface difficulties. Data arising from such reviews will also assist in development of designs that limit the effects of constructing the tunnel and portal on the existing structures and facilities in the area.

8.0 LIMITATIONS AND USE OF REPORT

This report was prepared for the exclusive use of the Toronto Transit Commission, Waterfront Toronto and the City of Toronto. Any use that a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of the third party. The report is based on existing data and information collected during the preparation of this geotechnical report by Golder Associates.

The report is based solely on a review of historical and publicly available information and data obtained by Golder Associates as described in this report. No soil, water, liquid, gas, product or chemical sampling or analytical testing at or in the vicinity of the study area was conducted as part of this work. Evaluation of soil and groundwater environmental chemistry was not part of the scope of work undertaken for this report and must be addressed by others during subsequent phases of work on this project.

The discussions found in this report provide preliminary geotechnical comments with regards to constructability of one of the portal alternatives ("Q2") based on the data available at this time. Further geotechnical investigation and recommendations will be required consistent with the progress of the project through design.

GOLDER ASSOCIATES LTD.

Storer J. Boone, Ph.D., P. Eng. Associate	Anne S. Poschmann, P.Eng. Principal

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IMPORTANT INFORMATION AND LIMITATIONS
OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder can not be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client can not rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder can not be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

IMPORTANT INFORMATION AND LIMITATIONS
OF THIS REPORT (cont'd)

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

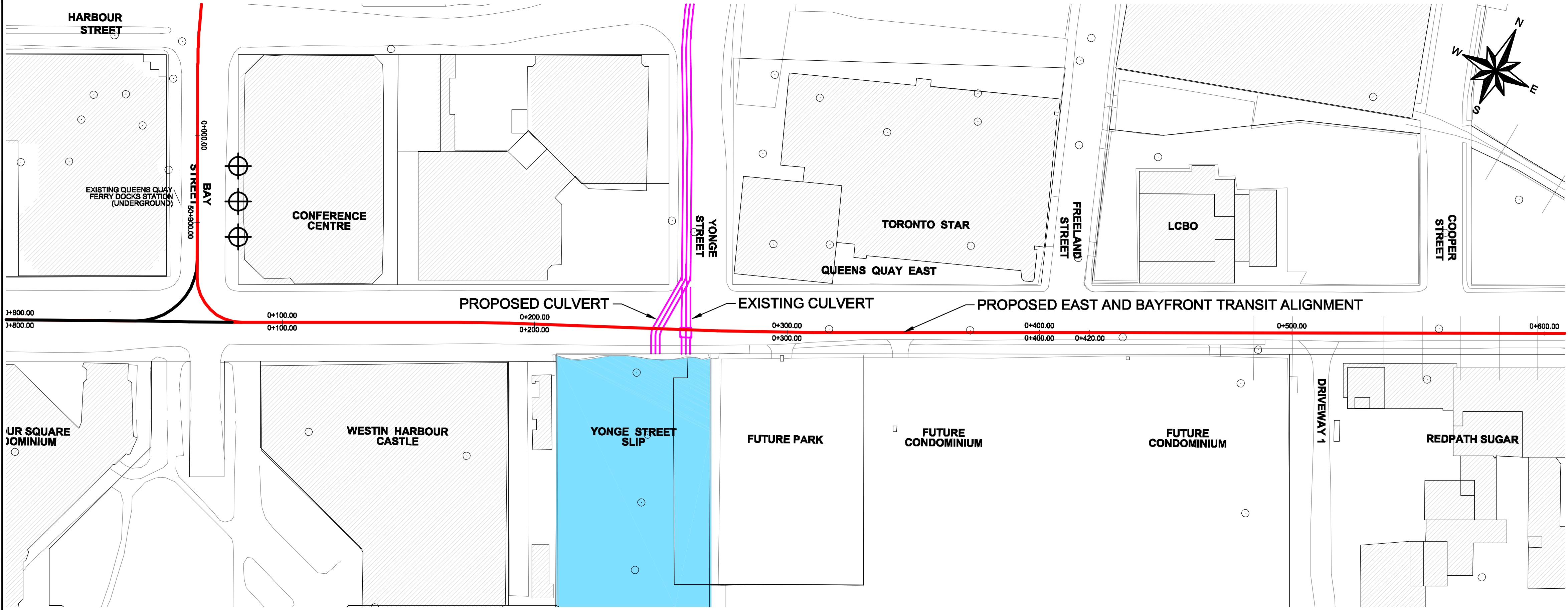
Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

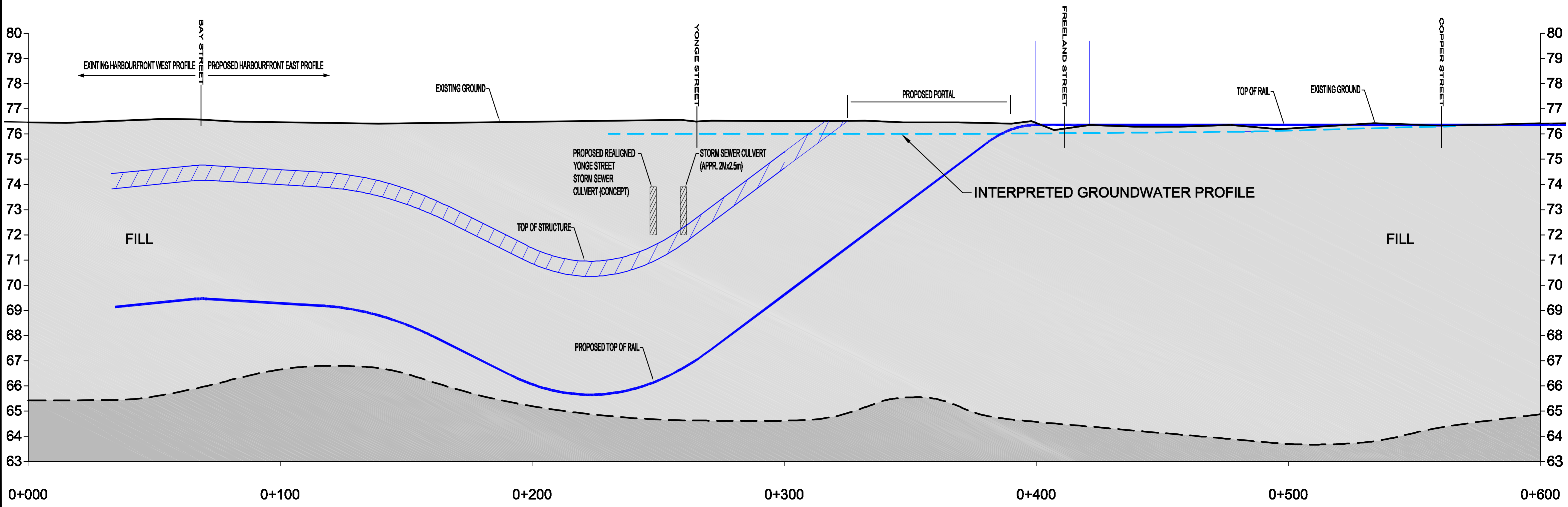
Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

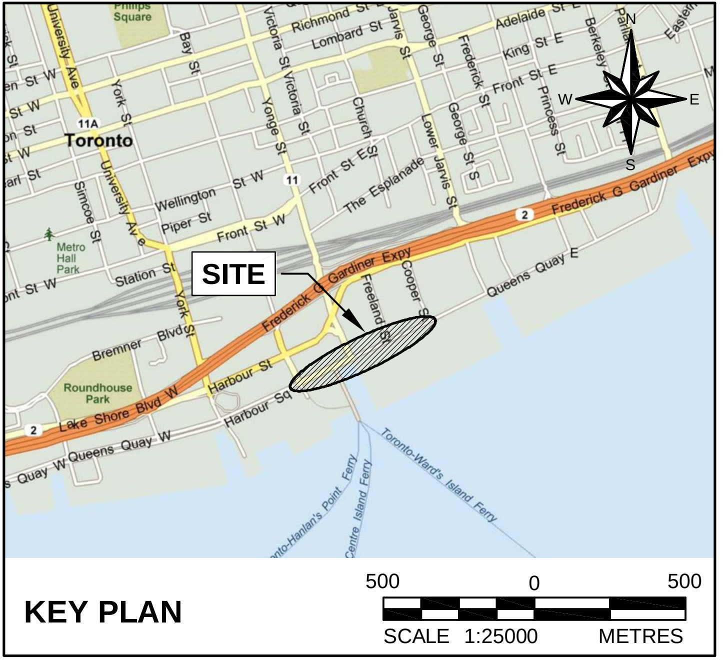
During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.







KEY PLAN

LEGEND:

/// ‡	PROPOSED AND EXISTING YONGE STREET STORM SEWER CULVERT
━	PROPOSED TRANSIT ALIGNMENT
– – –	INTERPRETED GROUND WATER PROFILE
━	PROPOSED TUNNEL TOP OF RAIL
▭	MAINLY FILL AND LACUSTRINE DEPOSITS
▬	BEDROCK
— — —	APPROX. BEDROCK/OVERBURDEN INTERFACE
○	BOREHOLE IN YPDT DATA BASE REACHING BEDROCK
⊕	PREVIOUS GOLDER BOREHOLE (PROJECT 901-1317)

REFERENCES:

1. GEOLOGIC PROFILE DATA BASE AS PROVIDED BY YPDT-CAMC PROGRAM.
2. INTERPRETED WATER LEVEL PROFILE BASED ON WATER LEVEL DATA PROVIDED BY YPDT-CAMC PROGRAM.
3. BASE PLAN AND PROFILE PROVIDED IN DIGITAL FORMAT BY MRC, FILE NO. 6377 - PLATE.dwg, RECEIVED APRIL 29, 2009.

40 0 40 80
SCALE HORIZONTAL 1:2000 METRES

4 0 4 8
SCALE VERTICAL 1:200 METRES

PROJECT
TTC - TWRC
EAST BAYFRONT TRANSIT EA

TITLE
SIMPLIFIED SUBSURFACE PROFILE ALONG QUEENS QUAY WEST BETWEEN BAY STREET AND COOPER STREET

Golder Associates
Mississauga, Ontario, Canada

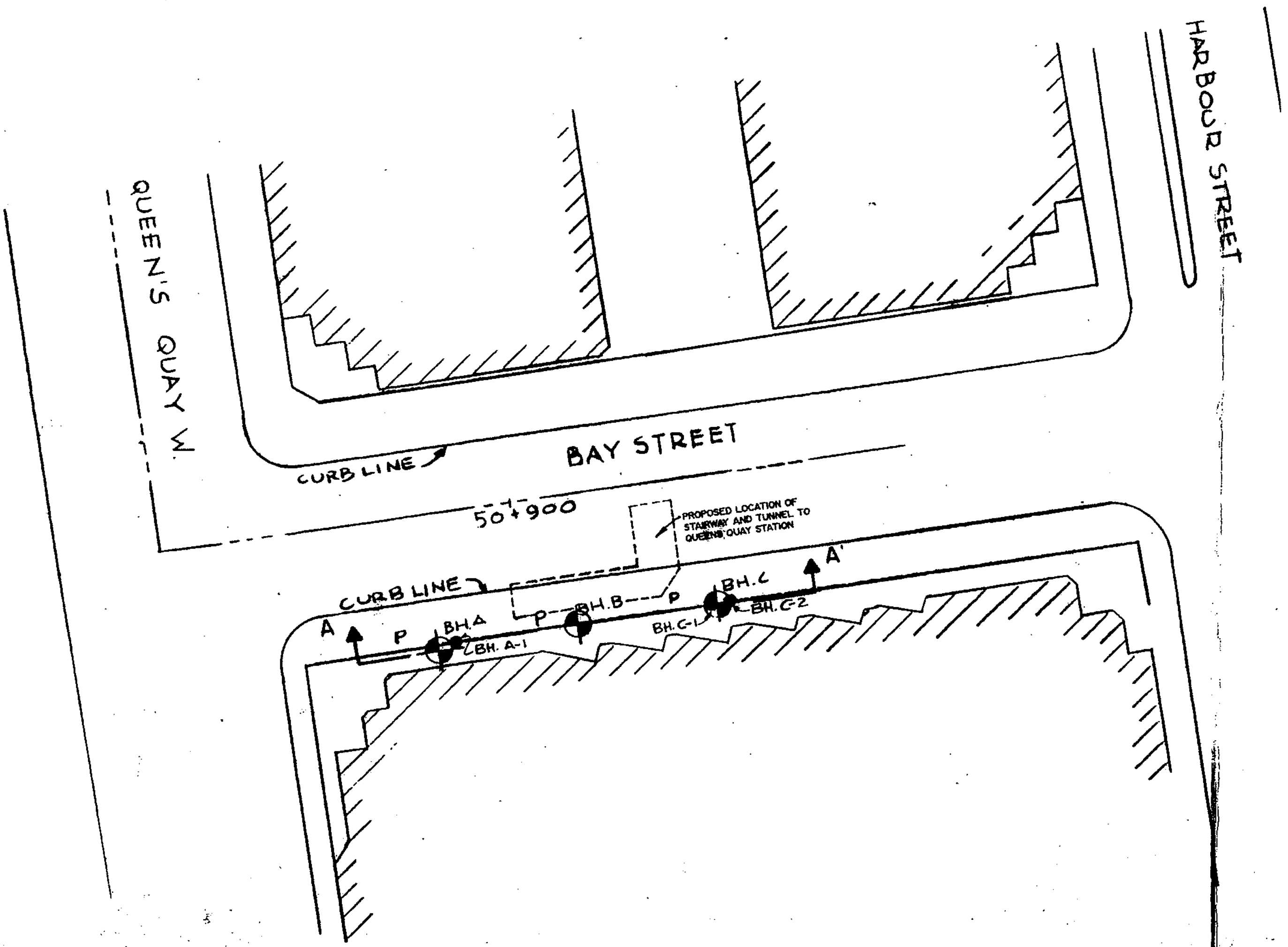
PROJECT No.		06-1111-014
DESIGN		
CAD	DD	May 26, 2009
CHECK	BLT	May 26, 2009
REVIEW	SJB	May 26, 2009

FILE No. 061111014AA001.dwg
SCALE AS SHOWN REV. A
FIGURE No.
1

PLOT DATE: May 26, 2009
FILENAME: T:\Projects\2006\06-1111-014 (MRC, Harbour Front, Toronto)\-AA- TTC-TWRC East Bayfront Transit EA\061111014AA001.dwg

APPENDIX A

Existing Borehole Records


QUEEN'S QUAY W.
HARBOUR STREET
BAY STREET
CURB LINE
50+900
PROPOSED LOCATION OF STAIRWAY AND TUNNEL TO QUEENS QUAY STATION
CURB LINE
A
A'
P
BH.A
BH. A-1
P
BH.B
P
BH.C
BH.C-1
BH.C-2

PLAN

PROJECT 901-1317

RECORD OF BOREHOLE A

SHEET 1

LOCATION SEE FIGURE 2

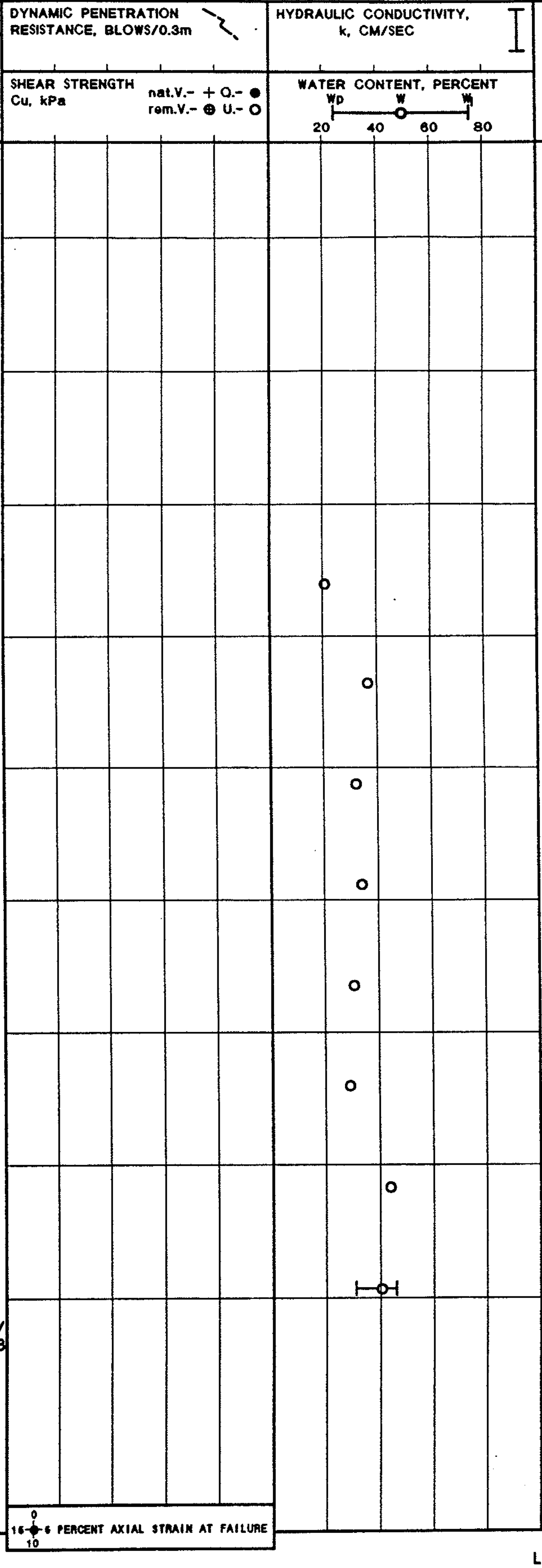
BORING DATE FEB. 20,1990

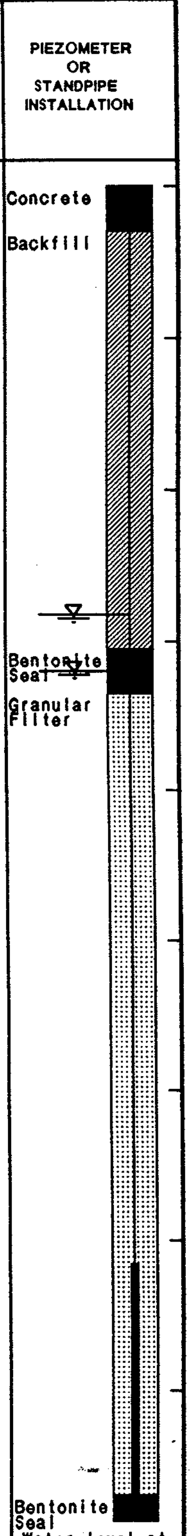
DATUM GEODETIC

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
	GROUND SURFACE	76.53					
CME-55 POWER AUGER BORING 83mm I.D. HOLLOW STEM AUGERS	BRICK		0.06				
	SAND AND GRAVEL. (Crushed Limestone Fill)		0.25				
	Firm to loose, brown, black, grey and orange CLAYEY SILT to SILTY SAND, with organics, brick, coal, cinders, asphalt and ashes. (FILL)	74.09		1	50 DO	7	
				2	50 DO	8	
				3	50 DO	5	
	Very loose to loose, grey, SAND, trace silt; becoming SILTY SAND, trace organics with depth. (HYDRAULIC FILL)		2.44	4	50 DO	7	
				5	50 DO	2	
				6	50 DO	4	
				7	50 DO	5	
		69.98		8	50 DO	4	MH
	Loose, grey, interlayered SILTY SAND, trace organics and organic SILT.	69.22	6.55	9	50 DO	4	
	Firm, brown and black layered organic CLAYEY SILT with numerous intact shell fragments in isolated layers.		7.31	10	50 DO	3	
		67.74		11	50 DO	5	
	LIMESTONE			12	50 DO	50/.08	
	END OF BOREHOLE		8.86 8.79				





Water level at Elev. 73.33m during drilling

Water level at Elev. 73.71m on Mar. 2,1990.

DEPTH SCALE 1 : 50

Golder Associates

LOGGED JW

CHECKED JW

RECORD OF BOREHOLE A-1

SHEET 1 of 2

LOCATION SEE FIGURE 2
INCLINATION VERTICAL AZIMUTH

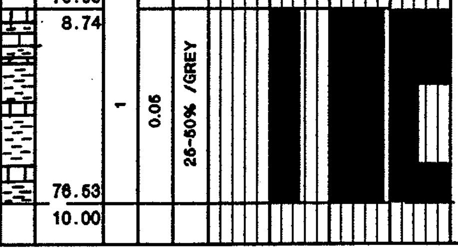
DRILLING DATE FEB. 27,1990
DRILL RIG CME 75 POWER AUGER
DRILLING CONTRACTOR MALONE'S SOIL SAMPLES

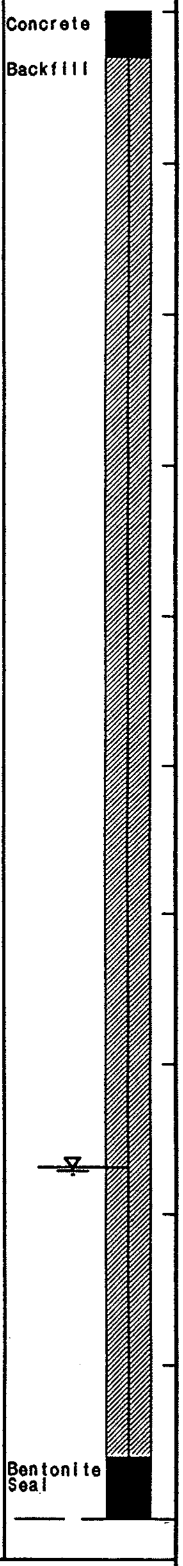
DATUM GEODETIC

PROJECT 901-1317

FR-FRACTURE
CL-CLEAVAGE
SH-SHEAR
VN-VEIN
F-FAULT
J-JOINT
P-POLISHED
S-SLICKENSIDED
SM-SMOOTH
R -ROUGH
ST-STEPPED
PL-PLANAR
FL-FLEXURED
UE-UNEVEN
W -WAVY
C -CURVED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (M)	RUN No.	PENETRATION RATE (M/MIN)	FLUSH % RETURN COLOUR	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.5M	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
0		GROUND SURFACE		76.53 0.00												Concrete Backfill
1–8		OVERBURDEN (Borehole not sampled, for overburden stratigraphy, refer to Borehole A.)														
9	NXL RC	Highly to moderately weathered becoming slightly weathered to fresh below about Elev. 66.5m, dark grey, very fine grained fissile SHALE, containing layers of fossiliferous crystalline limestone and calcareous siltstone.		76.53 8.74	1	0.06	26-50% /GREY									Bentonite Seal
10		CONTINUED ON SHEET 2		76.53 10.00												





DEPTH SCALE
1 : 50

Golder Associates

LOGGED JW
DATE FEB. 27,1990
CHECKED JW

RECORD OF BOREHOLE A-1

SHEET 2 of 2

LOCATION SEE FIGURE 2
INCLINATION VERTICAL AZIMUTH

DRILLING DATE FEB. 27,1990
DRILL RIG CME 75 POWER AUGER
DRILLING CONTRACTOR MALONE'S SOIL SAMPLES

DATUM GEODETIC

PROJECT 901-1317

FR-FRACTURE
CL-CLEAVAGE
SH-SHEAR
VN-VEIN
F-FAULT
J-JOINT
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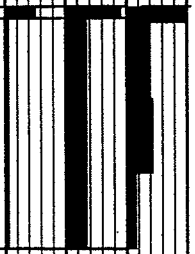
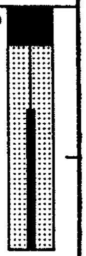
S-SLICKENSIDED
SM-SMOOTH
R -ROUGH
ST-STEPPED
PL-PLANAR
FL-FLEXURED
UE-UNEVEN
W -WAVY
C -CURVED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (M)	RUN No.	PENETRATION RATE (M/MIN)	FLUSH % RETURN COLOUR	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3M	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
10		CONTINUED FROM SHEET 1		76.53	1											
	NXL RC	FOR DETAILED DESCRIPTION, SEE SHEET 1.		76.53 10.00	2	0.06	25-50% /GREY									Bentonite Seal Granular Filter
11				76.53												
		END OF BOREHOLE		11.61												Water level at Elev. 68.84m on Mar. 2,1990.
12		NOTE: Location of limestone and siltstone layers. Elev. 67.79-67.69m 67.64-67.56m 67.49-67.48m 67.16-67.09m 66.78-66.65m 66.07-66.01m 65.93-65.92m 65.72-65.71m 65.33-65.28m 65.16-65.02m														
13																
14																
15																
16																
17																
18																
19																
20																





DEPTH SCALE
1 : 60

Golder Associates

LOGGED JW
DATE FEB. 27,1990
CHECKED JW

RECORD OF BOREHOLE B

SHEET 1

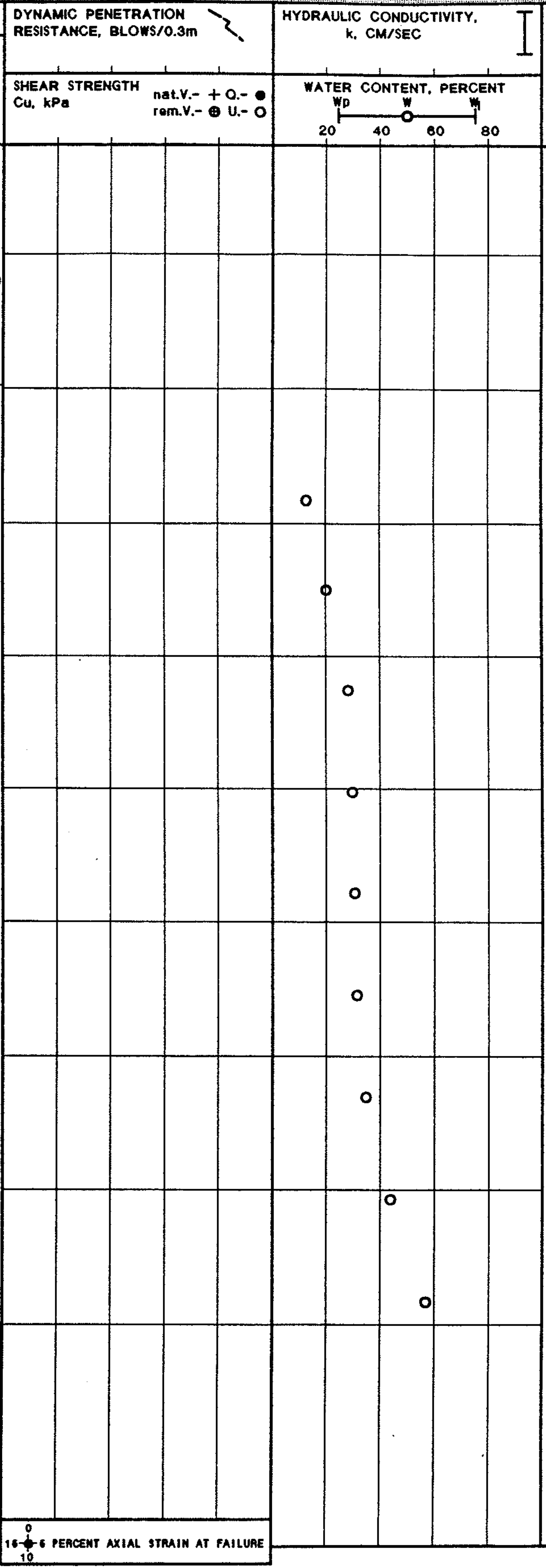
LOCATION SEE FIGURE 2
BORING DATE FEB. 19,1990
DATUM GEODETIC
SAMPLER HAMMER, 63.5kg, DROP, 760mm
PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

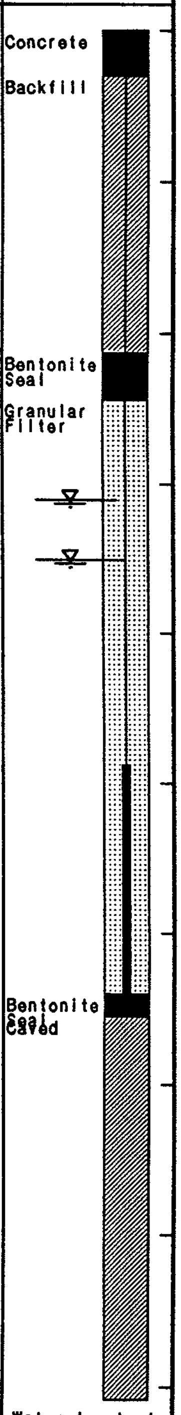
PROJECT 901-1317

BORING METHOD: CME-55 POWER AUGER BORING, 83mm I.D. HOLLOW STEM AUGERS

SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (M)
GROUND SURFACE	76.63
BRICK	0.06
SAND AND GRAVEL. (Crushed Limestone Fill)	0.30
Very stiff to compact, brown, black, grey and orange CLAYEY SILT to SILTY SAND with organics, wood pieces, brick, coal, ballast, cinders and ash. (FILL)	74.19 2.44
Very loose to loose, grey, SAND, trace silt; becoming SANDY SILT with depth, trace organics throughout. (HYDRAULIC FILL)	70.08 6.55
Very loose to very soft, light and dark grey layered SILTY SAND and organic CLAYEY SILT.	69.16 7.47
Soft, brown and black layered organic CLAYEY SILT with numerous intact shell fragments in isolated layers.	67.84
LIMESTONE and SHALE.	
END OF BOREHOLE	9.08

SAMPLES NUMBER	TYPE	BLOWS/0.3M	ADDITIONAL LAB. TESTING
1	50 DO	29	
2	50 DO	24	
3	50 DO	13	MH
4	50 DO	5	
5	50 DO	4	
6	50 DO	3	
7	50 DO	2	
8	50 DO	3	MH
9	50 DO	1	
10	50 DO	3	
11	50 DO	4	
12	50 DO	50/.08	





Water level at Elev. 73.12m during drilling

Water level at Elev. 73.52m on Mar. 2,1990.

DEPTH SCALE
1 : 50

Golder Associates

LOGGED JW
CHECKED JW

RECORD OF BOREHOLE C

SHEET 1

LOCATION SEE FIGURE 2

BORING DATE FEB. 19-20,1990

DATUM GEODETIC

SAMPLER HAMMER, 63.5kg, DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

PROJECT 901-1317

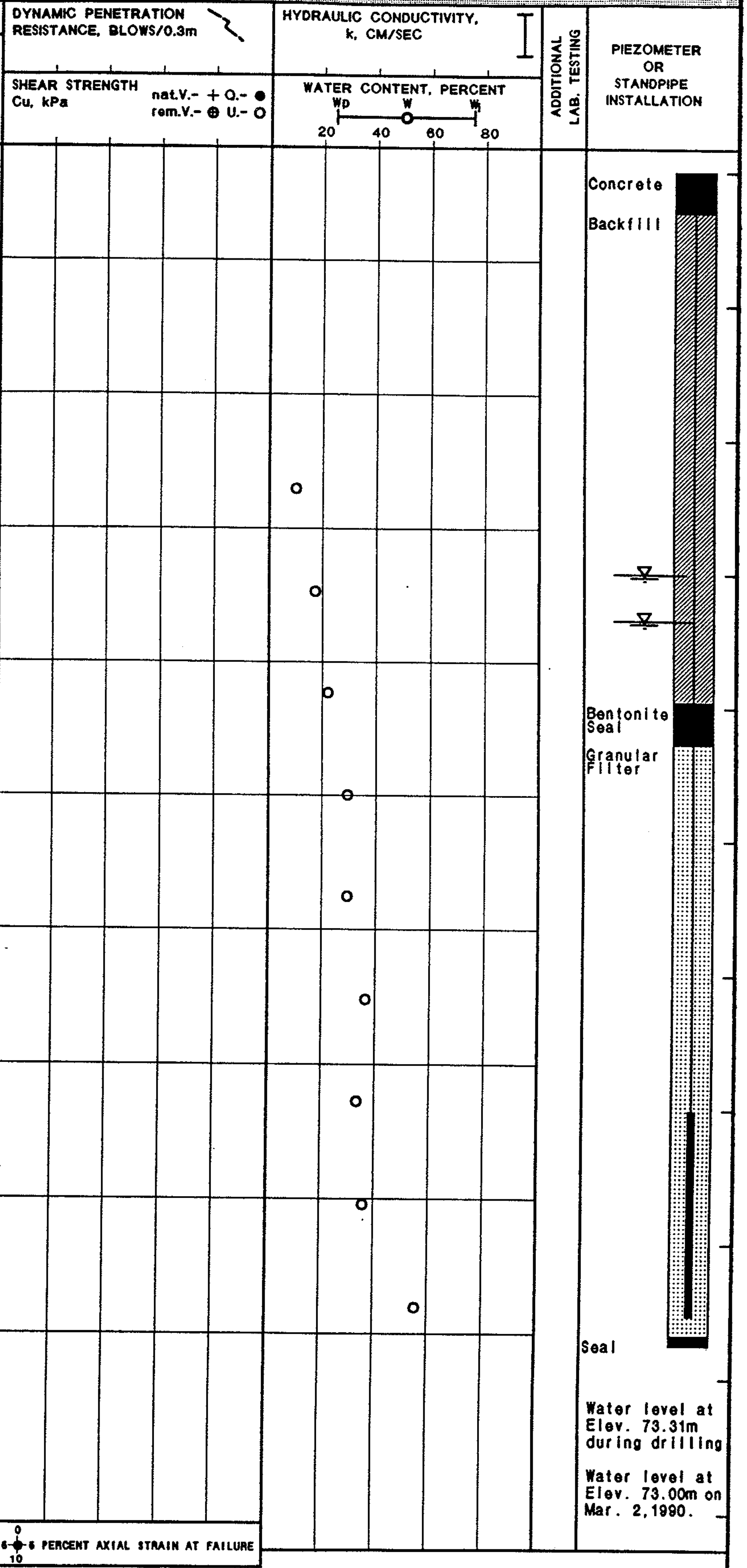
BORING METHOD: CME-55 POWER AUGER BORING; 83mm I.D. HOLLOW STEM AUGERS

SOIL PROFILE

DESCRIPTION	ELEV. DEPTH (M)
GROUND SURFACE	76.66
BRICK	0.06
SAND AND GRAVEL. (Crushed Limestone Fill)	76.36 0.30
Stiff to compact, brown, black, grey and orange CLAYEY SILT to SILTY SAND with organics, brick, coal, ballast, cinders, ash and asphalt. (FILL)	74.37 2.29
Loose to very loose, brown to grey, SAND, trace silt; becoming SAND and SILT with depth, trace organics throughout. (HYDRAULIC FILL)	70.87 5.79
Very loose to very soft, light and dark grey layered SILTY SAND and organic CLAYEY SILT.	69.35 7.31
Firm, brown and black layered organic CLAYEY SILT with numerous intact shell fragments in isolated layers.	67.97
Probably SHALE BEDROCK.	
END OF BOREHOLE	8.75

SAMPLES

NUMBER	TYPE	BLOWS/0.3M
1	50 DO	32
2	50 DO	11
3	50 DO	9
4	50 DO	8
5	50 DO	7
6	50 DO	4
7	50 DO	3
8	50 DO	5
9	50 DO	2
10	50 DO	5
11	50 DO	5
12	50 DO	50/.08



Water level at Elev. 73.31m during drilling

Water level at Elev. 73.00m on Mar. 2,1990.

DEPTH SCALE

1 : 50

Golder Associates

LOGGED JW

CHECKED JW

RECORD OF DRILLHOLE C-2

SHEET 1 of 2

LOCATION SEE FIGURE 2
INCLINATION VERTICAL AZIMUTH

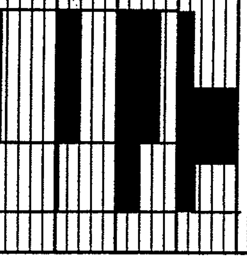
DRILLING DATE FEB. 27,1990
DRILL RIG CME 75 POWER AUGER
DRILLING CONTRACTOR MALONE'S SOIL SAMPLES

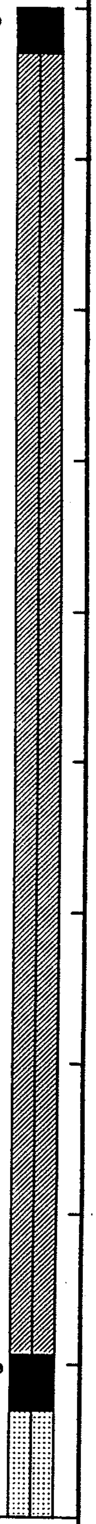
DATUM GEODETIC

PROJECT 901-1317

FR-FRACTURE, CL-CLEAVAGE, SH-SHEAR, VN-VEIN, F-FAULT, J-JOINT, P-POLISHED, S-SLICKENSIDED, SM-SMOOTH, R -ROUGH, ST-STEPPED, PL-PLANAR, FL-FLEXURED, UE-UNEVEN, W -WAVY, C -CURVED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (M)	RUN No.	PENETRATION RATE (M/MIN)	FLUSH % RETURN COLOUR	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.5M	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
0		GROUND SURFACE		76.66 0.00												Concrete Backfill
4		OVERBURDEN (Borehole not sampled, for overburden stratigraphy, refer to Borehole C.)														
9	NXL RC	Highly to moderately weathered becoming slightly weathered to fresh below about Elev. 66.6m, dark grey, very fine grained, fissile SHALE, containing layers of fossiliferous crystalline limestone and calcareous siltstone.		76.66 8.69	1	0.03	50-75% /GREY									Bentonite Seal Granular Filter
	NXL RC				2	0.05										
10		CONTINUED ON SHEET 2		76.66 10.00												





DEPTH SCALE
1 : 50

Golder Associates

LOGGED JW
DATE FEB. 26+27,1990
CHECKED JW

RECORD OF DRILLHOLE C-2

SHEET 2 of 2

LOCATION SEE FIGURE 2
INCLINATION AZIMUTH

DRILLING DATE FEB. 27,1990
DRILL RIG CME 75 POWER AUGER
DRILLING CONTRACTOR MALONE'S SOIL SAMPLES

DATUM GEODETIC

PROJECT 901-1317

FR-FRACTURE
CL-CLEAVAGE
SH-SHEAR
VN-VEIN

F-FAULT
J-JOINT
P-POLISHED
S-SLICKENSIDED

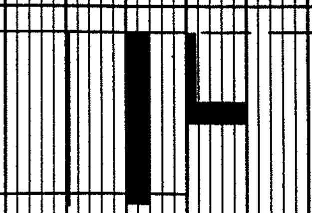
SM-SMOOTH
R -ROUGH
ST-STEPPED
PL-PLANAR

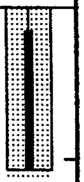
FL-FLEXURED
UE-UNEVEN
W -WAVY
C -CURVED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (M)	RUN No.	PENETRATION RATE (M/MIN)	FLUSH % RETURN COLOUR	NOTES WATER LEVELS INSTRUMENTATION
10		CONTINUED FROM SHEET 1	66.66				
	NXL RC	FOR DETAILED DESCRIPTION, SEE SHEET 1.	10.00 65.59	2	0.05	50-75% /GREY	Granular Filter
11		END OF BOREHOLE	11.07				Water level at Elev. 68.80m on Mar. 2,1990.
		NOTE: Location of limestone and siltstone layers. Elev. 67.95-67.54m 67.14-67.11m 67.02-66.93m 66.88-66.87m 66.31-66.28m 66.24-66.23m					
12							
13							
14							
15							
16							
17							
18							
19							
20							

STRATA PLOT

RECOVERY — TOTAL CORE % — SOLID CORE % — R.Q.D. % — FRACT. INDEX PER 0.5M — DISCONTINUITY DATA — DIP W.R.T. CORE AXIS — TYPE AND SURFACE DESCRIPTION — HYDRAULIC CONDUCTIVITY k, cm/sec — DIAMETRAL POINT LOAD INDEX (MPa)





DEPTH SCALE
1 : 60

Golder Associates

LOGGED JW
DATE FEB. 26+27,1990
CHECKED JW

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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