DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 30M11-196

DIST. CR REGION

W.P. No.

CONT. No.

W. O. No. 95-11009

STR. SITE No.

HWY. No. Q.E.W

LOCATION Hanlan Feedermain Tunnel Under Q.E.W. East of Cawthra Rd.

No of PAGES - —

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

GEOCRES No 30M11-196

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REPORT ON

SUPPLEMENTAL GEOTECHNICAL INVESTIGATION
HANLAN FEEDERMAIN
TUNNEL UNDER THE QEW - CONTRACT 2C
MISSISSAUGA, ONTARIO

COPY

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Brampton, Ontario
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Attention: Mr. R.D. Fleeton, P.Eng.

RE: SUPPLEMENTAL GEOTECHNICAL INVESTIGATION
HANLAN FEEDERMAIN
TUNNEL UNDER THE QEW - CONTRACT 2C
MISSISSAUGA, ONTARIO

Dear Sirs:

This report presents the results of a supplemental geotechnical investigation carried out along the alignment of the proposed tunnel crossing of the Hanlan Feedermain under the QEW. The purpose of the investigation was to obtain additional subsurface information along the proposed alignment and based on the data obtained, to provide recommendations on the geotechnical aspects of design of the proposed works.

Contract 2C is approximately 130 m in length and forms part of the section of the Hanlan Feedermain extending from Lakeview Filtration Plant to Whitney Drive, just north of the QEW. The results of the geotechnical investigation carried out for the remainder of this section of the Hanlan Feedermain are presented in our report number 901-1403-1, dated November 1993, which is contained in the attached Appendix A. This supplemental report contains only the results of the recently completed boreholes and reference should be made to the previous report for the remainder of the data. The results of boreholes completed prior to November 1993 are contained in Appendix A.

INVESTIGATION PROCEDURES

The fieldwork for the initial phase of this investigation was carried out between December 6, 1994 and January 5, 1995 at which time Boreholes 131, 132, 133 and 134 were put down at the locations shown on Figure 1. These boreholes were put down to better define the bedrock surface along the alignment of the tunnel. A second phase of investigation was carried out between May 24 and June 2, 1995, at which time Boreholes 131A, 132A, 135 and 136 were put down at the locations shown on Figure 1. Boreholes 135 and 136 are located at the north and south shaft, respectively; Boreholes 131A and 132A were put down for the purpose of installing additional piezometers within the overburden.

Boreholes 131 and 132 were advanced using PQ coring techniques to obtain continuous soils core samples. The coring operations were extended about 3 m into the bedrock underlying the overburden. The remaining boreholes were advanced using hollow stem augers and soil samples were obtained at variable intervals of depth using 50 mm outside diameter split-spoon samplers in accordance with the Standard Penetration Test (SPT) procedures. Bedrock core samples were obtained in NQ core size in Boreholes 133 to 136 for depths ranging from 3 m to 20.5 m below the bedrock surface.

Piezometers and/or wells were installed in selected boreholes to permit monitoring of the groundwater levels at the borehole locations. Details of the installations are given on the Record of Borehole sheets following the text of this report. Rising head tests were carried out on the wells installed in Boreholes 131A and 132A to provide data on the mass permeability of the sand and gravel deposits within which the wells were sealed. Pressure packer testing was carried out within the bedrock in Boreholes 135 and 136 to obtain data on the hydraulic conductivity of the rock mass.

The fieldwork was supervised throughout by our geotechnical engineers who located the boreholes in the field, cleared these locations for buried utilities, directed the drilling, sampling and testing operations, and logged the boreholes. The soil samples were identified in the field, placed in labelled containers and returned to our laboratory for further examination and geotechnical classification testing. The bedrock core samples were logged and wrapped in the field and returned to our laboratory for further examination and point load testing.

The ground surface elevations at the borehole locations were estimated based on previous survey data carried out at the site by KMK Consultants. The elevations are assumed to be referenced to Geodetic Datum.

SUBSURFACE CONDITIONS

The detailed subsurface conditions encountered in each of the borings, together with the results of the laboratory tests carried out on representative soil samples, are given on the attached Record of Borehole sheets and Figures 4 to 7. A simplified stratigraphic section is shown on Figure 2. It should be noted that the stratigraphic boundaries shown on the Record of Borehole sheets are generally inferred from non-continuous sampling and represent transitions between soil types rather than exact planes of geological change. Conditions will vary between and beyond the borehole locations.

Subsoil Stratigraphy

In general, the subsoils encountered in the boreholes on the north side of the QEW consist of surficial fill materials overlying a silty clay till deposit which contains interlayers of sand to sand and gravel. The cohesionless sand/sand and gravel layers become more prevalent within the southern two-thirds of the tunnel alignment. Within the QEW right-of-way and to the south, the subsoils typically consist of interlayered silt, silty sand, sand and sand and gravel deposits with frequent interlayers of silty clay/clayey silt till deposits. Boulders were encountered relatively frequently in the boreholes and were noted both within the cohesive till deposits and within the cohesionless deposits. In some of the boreholes, the boulders were inferred by resistance to augering; in Boreholes 131 and 132, the boulders were noted within the core samples obtained - typically within the sand/gravel strata.

Generally below about 2 m depth below ground surface, measured SPT 'N' values are greater than 50 blows per 0.3 m indicating a hard consistency for the cohesive deposits and a very dense state of packing for the cohesionless deposits. Grain size distribution curves for selected samples of the cohesionless deposits are shown on the attached Figures 4 to 7 as well as in Figures 10 and 11 of our previous report.

The composition of the sand and gravel deposits is not uniform across the site or with depth. The silt content and the uniformity coefficient are variable and some of the strata encountered are more open than others. The deposit has been classified as a till at some locations due to the silt content and the broadly graded nature of the samples as obtained. It was found that the PQ coring operations carried out in Boreholes 131 and 132 were useful in retrieving samples of the cohesive till deposits; however, the fines tended to be washed out of the cohesionless strata. The stratigraphic descriptions on the borehole logs are based on the samples as obtained and may not therefore be representative of the insitu composition of the sand/sand and gravel deposits.

Rising head tests were carried out on the wells which were sealed into the sand and gravel till deposits encountered in Boreholes 131A and 132A. The results of this testing indicated permeability coefficients of about 2×10^{-5} cm/sec to 3×10^{-5} cm/sec.

Rock Conditions

Shale bedrock of the Dundas/Georgian Bay Formation was encountered at variable depths in the boreholes put down along the alignment. The surface of the bedrock was encountered at depths ranging from about 11 m to 21.9 m below ground surface. These depths correspond to 7.3 m to 17 m above the proposed crown of the tunnel. Bedrock core samples were obtained in Boreholes 131, 132, 133, 134, 135 and 136 at the locations shown on Figure 1. The bedrock samples obtained consist of fine grained, thinly bedded, grey shale with bands of limestone and occasional clay seams. The limestone bands are typically 25 mm to 100 mm in thickness but can be up to 330 mm in thickness. The location and thickness of limestone bands and clay seams is given, for Boreholes 135 and 136, in the Record of Borehole sheets. Fracture index and RQD information is also presented in the Record of Borehole sheets and RQD information is summarized on Figure 2.

Overall, rock conditions are quite variable in that several zones of more fractured bedrock exist within otherwise quite competent shale. Generally the rock is highly to moderately weathered near surface, becoming fresh with depth. RQD values vary significantly with fracture zones; some areas of high relative permeability were also identified and were associated with more broken, fractured areas within the deeper rock mass. Typically, RQD values range from about 60 per cent to 80 per cent; however, values as low as zero per cent were measured near the bedrock surface in Borehole 136 RQD values of 20 to 30 per cent were measured at depth in Boreholes 135 and 136 in significantly fractured areas fairly close to tunnel crown level, as shown on Figure 2.

Point Load tests were carried out on the core samples retrieved from the boreholes. The diametral Point Load Indices, $Is_{(50)}$, measured on the shale samples ranged from about 0.13 MPa to 0.5 MPa and in the limestone samples from about 1.6 MPa to 6.7 MPa. The results of the point load tests are given on the Record of Boreholes. Based on an empirical relationship between point load index and uniaxial compressive strength, these results correspond to unconfined compressive strengths ranging from about 3.1 MPa to 12 MPa for shale samples and 38.4 MPa to 160.8 MPa for limestone.

Pressure packer hydraulic conductivity testing was carried out in Boreholes 135 and 136 at selected depths and the results are given in the Record of Boreholes. The results indicate rock mass permeability ranges from about 2×10^{-4} cm/s to 5×10^{-6} cm/s.

Groundwater Conditions

Details of the piezometer and well installations are shown on the Record of Borehole sheets following the text of this report. The water levels measured in the piezometers and wells were generally at about 3 m to 5 m below ground surface corresponding to about Elevations 98.4 m to 100.2 m. Based on these observations, the groundwater table appears to be sloping slightly downwards towards the south over the tunnel length.

ENGINEERING RECOMMENDATIONS AND DISCUSSION

This section of the report provides our interpretation of the factual geotechnical data obtained during the investigation and is intended for the guidance of the design engineer only. Where comments are made on construction, they are provided only in order to highlight aspects of construction which could affect the design of the project. Contractors bidding on or undertaking the works should make their own interpretation of the subsurface information provided as it affects their proposed construction methods equipment selection, scheduling and the like.

All of the boreholes were grouted on completion of drilling and installation of the piezometers/wells. The Contractor should take note of the locations of the boreholes as shown, locate the boreholes in the field and satisfy himself that they will not adversely affect his proposed operations. It should also be noted that a 3 m length of drill rods and packer testing equipment was left at the base of the hole in Borehole 135, which was put down at the north shaft location

Details of the proposed tunnel alignment were provided on preliminary contract drawings dated March 31, 1995 prepared by KMK Consultants Limited. It is understood that the proposed feedermain will be 2.1 m finished internal diameter and has an invert at about Elevation 172 m along the tunnelled section. The shafts for tunnel construction will therefore be extended to at least 31.5 m below ground surface.

Possible Fault Zone

The topography of the bedrock surface under the QEW, as established at the borehole locations on the south side suggests the presence of a deep bedrock valley. Such valleys have been found to be controlled by geological structure (such as faulting) within the shale bedrock. Typically, these zones are characterized by increased jointing and blocky ground conditions even if no actual fault has developed. In some areas, an actual fault plane or a discrete series of clay infilled fault shears have been identified. These zones are typically fairly narrow and are therefore difficult to pinpoint by means of vertical drilling. Two examples of the morphology of such faults are shown on Figure 3. In both cases, rock conditions within the immediate vicinity of the fault (± 2 or 3 m) were very poor with typical block sizes of the order of 150 mm. In one case, ravelling ground was experienced which necessitated consolidation grouting. In both of the cases illustrated in Figure 3, the fault geometry suggested that the faults were thrusts, based on the geometry of the contortion of the beds and the dip of the shear plane.

Such fault zones tend to be permeable if there is not substantial clay coating on the fragments. In consequence, either poor ground with clay filled shears will be encountered with little or no water, or pervious ground with more blocky conditions will occur. In the latter case, significant water inflows may develop whereas there could be virtually no inflow in the former case.

The depth of rock cover over the crown of the tunnel has not been defined for the full length of the tunnel; the minimum cover at the borehole locations is at Borehole 132 with about 7 m cover. The potential however exists for encountering a deeper trough in the bedrock profile associated with an actual fault plane. Such a zone could potentially ravel if of small block size, such that chimneying up from the crown could extend up and into the base of the overburden.

As the bedrock is immediately overlain by a sand and gravel deposit this chimneying effect could allow significant water inflow to develop, possibly also associated with surface inflow of materials. It is essential, therefore, that some means be provided for achieving advance warning of the location and attitude of any possible major fracture zone associated with faulting that may exist associated with the deep sections of the valley under the QEW. Forward probe hole drilling using coring techniques should be undertaken ahead of the face within the length of the tunnel under the QEW. Small bar and arm mounted, air driven rigs or small mining type flat-feed hydraulic rigs would be suitable for undertaking limited length, NQ sized or open hole pilot hole drilling from with the tunnel, or larger capacity rigs could be utilized from the shafts at both ends of the tunnel to provide full horizontal HQ core coverage of the entire 100 metre length of tunnel alignment. For the HQ hole detailed core logging and downhole TV camera observations could be completed that would then allow assessment of likely ground conditions ahead of the full length of the drivage so that early precautions can be taken for dealing with zones of potential inflow and/or ravelling ground.

As a precaution to avoid flooding of the underground workings in the case of intersecting a fracture zone that is connected directly to the saturated overburden, forward cored or uncored pilot holes should be equipped with stuffer boxes that will allow subsequent grouting on completion of each hole.

Tunnelling Conditions and Methodology

Based on the borehole information, the shale close to or just above the crown of the tunnel at the shaft locations is relatively highly fractured with numerous clay seams. Elsewhere, the tunnel may be advanced through moderately fractured shale of fair to good quality. The tunnel may be advanced either by hand excavation methods using tractor mounted excavators and pneumatic tools or using a Tunnel Boring Machine (TBM). Drilling and blasting methods should not be used due to the limited thickness of rock cover, the proximity to existing services and the settlement sensitivity of the QEW. A TBM is technically feasible for this crossing, but may be uneconomical for the tunnel length.

The likely presence of limestone interbeds within the shale may tend to slow down the rate of progress during excavation if a TBM is used. In addition, the possibility of faulting will have to be considered in developing support for a TBM drivage. Due to the presence of joints and fractures, the limestone interbeds and the fissile nature of the shale, the shale may break apart in blocks or slabs making it difficult to control the tunnel profile, particularly in close proximity to any encountered fault zone. If hand excavated, perimeter holes drilled at a spacing of 0.2 m will likely be necessary in order to produce the required tunnel profile with a minimum of overbreak.

Temporary Support - Rock Tunnel

In this section of this supplementary report, comments are provided that amplify the recommendations previously given in report 901-1403-1, in Section 6.1.3 with relation to construction sequence, monitoring, primary support and dewatering. They are also more specifically addressed to the issue of possible faulting and zones of highly fractured permeable ground.

As discussed in the previous report, temporary tunnel support requirements need to be based on factors such as the amount of rock cover and the rock quality above the tunnel. Heavy support will be needed in the central section beneath the QEW since the crown of the tunnel may be located within rock where the fracture frequency is high and the rock quality is low, and may also be intersected by faulting.

Either a system of steel liner plates can be used for primary support of the tunnel or alternatively, the entire tunnel cross-section could be stabilized using steel sets and spiling ahead of the face. Shotcreting of the entire cross-section together with rock bolts and mesh at the crown and on the sidewalls would likely be required with this method of support. Such a rock bolt/wire mesh/shotcrete system may be used to support the tunnel only if there is at least 3 m of relatively unfractured, good quality rock above the crown of the tunnel. The rock conditions must therefore be inspected in the field by qualified geotechnical personnel during construction to ascertain that the actual level of support provided is appropriate for the conditions being encountered in the tunnel.

Where liner plate is used, because ravelling ground conditions could be intersected which may not readily "arch", the system should be designed to support the full weight of the overburden plus any surcharge along the alignment. If liner plate is used, it has to be well seated and regularly placed in order to provide continuous support. Liner plate must be installed right up to the face and not left to lag more than one or two plates (0.5 m±) behind the face (corresponding with the zone currently being mined), otherwise the ground above the tunnel, in the most critical region remains unsupported. Grouting will also need to be carried out on a continuous basis to ensure integrity of the liner plate with the rock. Such grouting once, completed behind the liner may also assist in reducing water seepage into the tunnel through the more fractured and weathered rock sections. Grouting between the liner plate and the surrounding ground must however, also be carried out as soon as possible after the liner plates are installed to prevent rock loosening.

As there is likelihood of intersecting intensely fractured ground associated with faulting, groundwater inflows may become significant. These, therefore, must be controlled at all times during construction. Seepage from the weathered zone and through joints in the bedrock should also be anticipated. There should be provision for continuous pumping from localized sumps within the tunnel along its entire length and there may be a need for forward probe holes and face cover grouting if inflows become significant in more fractured zones close to the bedrock depression where faulting is suspected.

Ground Support Considerations

It is anticipated that in addition to problems created by fracturing and possible faulted ground, tunnel stability will be affected by spalling due to overstressing in the haunches and the sidewalls of the tunnel and delamination along horizontal bedding planes within the shale units and between the shale and limestone layers, clay seams or broken zones in the crown. Because of this, it may be difficult to maintain a neat circular arched profile in the roof of the tunnel and the final roof profile will likely be in the form of a stepped arch. For tunnel stability, it is important that the arched profile in the haunches be maintained as this helps to reduce the free span of the roof. Where fractured zones and faulted ground or where closely spaced cross joints or sub-vertical joints are present between the horizontally bedded units close to the tunnel crown, blocky ground conditions could develop. In these areas it is essential that loosening of the adjacent ground be prevented.

Based on the anticipated modes of failure of the rock, the permanent rock support system should be designed to minimize loosening of the rock mass and to allow arching to develop in the roof of the tunnel. Primary tunnel support in the roof and haunches should be based on ground conditions and may consist of tensioned, fully resin grouted rock anchors, lattice girders and mesh reinforced shotcrete in relatively poor ground to simple patterned untensioned bolting where the ground is better. Spiling ahead of the tunnel may even be required if very poor, faulted and weathered ground is encountered. In such cases rock bolts may need to be installed on the sidewalls as well, and extra mesh may be needed on an as required basis.

The length and spacing of the rock bolts (and anchors) should be designed to assist in the development of arching in the roof of the tunnel. In most of the tunnel, it is anticipated that bolts would be untensioned, as loading would develop as the face is advanced. However, if severely broken ground is encountered beneath the deep bedrock valley associated possibly with faulting, tensioned reinforcement may be needed along with mesh and probably shotcrete. Lattice girders can be used integrally with the bolts and shotcrete to aid the support system in retaining any slabs which may loosen in the roof.

During tunnelling, the primary ground support described above should be installed to the face upon completion of each advance, with the length of individual advances restricted to 1 to 2 m depending on rock conditions. Any shotcreting required for rock support purposes must follow installation of the bolts, mesh and girders, and be kept within 4 m of the face.

In the sections of the tunnel where the rock quality at and above the crown is poor (where faulting, fracturing or clay seams are more likely) in addition to the need for lattice griders or similar rib support, provision should be made for the use of spiling ahead of the tunnel face to minimize the potential for rock delamination and chimneying of the roof up to and into the overburden. Such spiling should be installed from behind the lattice girder closest to the face and should extend at least 2 advance lengths ahead of the face to minimize the potential for rock delamination in the roof. Adjacent spiles should overlap to form a continuous reinforced rock umbrella over the tunnel.

In general, as the tunnel will have to be left for some 60-90 days after excavation before final lining (in this case placing the pipe and grouted infill), a protective skin of shotcrete will likely be required in both the roof and sidewalls of the tunnel to prevent small blocks from loosening and to prevent slaking of the shale due to drying.

Shafts - Temporary Support through the Rock

Rock support for the shafts again will depend on ground conditions, but normally would be anticipated to consist of fully resin grouted rock bolts with wire mesh and shotcrete. For the shafts, as the majority of the geological structure will be horizontal bedding, the rock bolts should generally be inclined at a slight (5°) downward or upward angle to cross bedding planes. Additional rock bolts may need to be provided to secure the brows and periphery of the intersections of the tunnel with the shaft excavations.

Final Structural Lining - Design Considerations

For this tunnel the permanent structural lining is envisaged to be formed by the pipe surrounded by an annular ring of infill concrete. This composite lining must be cast at a sufficient time after excavation that cracking and deformation of the lining will not be induced by long term, time-dependent movement of the rock mass. In this light, the lining design should focus on the following factors:

a. The pressure on the lining (due to rock loading, both from loose rock and stress effects) and hydrostatic pressure; and

b. The pressure that may develop onto the lining due to time-dependent deformation of the rock mass.

(a) Pressure on Lining due to Rock Load and Hydrostatic Pressure

The tunnel and shafts will be stabilized by the primary rock support prior to construction of the linings, thus the pressure on the lining due to rock load alone should be minimal. However, the tunnel and shaft linings should be designed for the full hydrostatic pressure if no drainage is provided around the tunnel or shaft. Based on the results of the investigation, groundwater levels are significantly above the tunnel invert and a head of 27 m should be considered in the design.

(b) Pressure on Lining due to Time-dependent rock Deformation

As discussed in the previous report (901-1403-1), the bedrock shales of the Dundas/Georgian Bay Formation are known to exhibit time-dependent deformation upon stress relief. Test results indicate that the shale, under laboratory testing conditions, exhibits long term deformation, but the deformation can be suppressed if sufficient pressure is applied.

Results of semi-confined swelling tests typically indicate that vertical swelling of the rock is essentially suppressed at about 0.4 MPa; that the swelling potential is minimal at 0.2 MPa and that under an applied pressure of 0.1 MPa the swell is between 0.065% to 0.11% per log cycle of time (in days) (ref. Lo, et al. and other workers). On the basis of previous data, the suppression pressures for swelling in the vertical and horizontal directions for typical shales are of the order of 0.40 MPa and 0.56 MPa respectively. In terms of lining design, therefore, these are the likely maximum pressures that could develop on a rigid structure in the vertical and horizontal directions due to long term shale deformation.

- **Tunnel Linings**

When the tunnel is excavated, elastic rock deformation will occur in response to the relief of the in situ stresses. In fractured ground, loosening due to release of clamping on individual blocks will also occur. If the rock is locally overstressed, some plastic movements may develop. With the provision of adequate rock support, displacements should rapidly stabilize. The time-dependent deformations around the tunnel which follow are long term rock deformation, characteristic of the shaly rock formations in Southern Ontario. Based on the swelling characteristics of the rock and an assumed in situ stress of about 2 MPa at the tunnelling horizon, estimates of long term rock deformations would suggest that maximum convergence, could reach 15-20 mm (radially inward) for the poorer types of rocks and for the diameter of this tunnel.

These values assume that the rock is allowed to swell freely. By leaving the tunnel unlined for a relatively short period of time (2-3 months), most of the long term deformation would be dissipated such that if the lining is then cast against the rock, the rock will only deform a minimal amount as it continues to swell. In this way no significant pressures will build up on the lining.

Alternatively, the lining could be constructed with a material such as polyurethane foam placed between the rock and the lining to absorb the rock deformation. A minimum of 50 mm of foam would need to be sprayed onto the perimeter of the tunnel before grouting of the annulus around the feedermain pipe, or before casting of the infill concrete lining, In such a case, the composite foam/grout lining can sustain a substantial amount of deformation without building up pressure onto the final concrete pipe or lining arrangements.

A third option would be to double form the lining such that the structure would be isolated from the rock except for the portion in the invert, and the space between the rock and the concrete could be utilized for drainage.

- **Shaft Lining in Rock**

For the shaft linings, the effect of time-dependent rock deformation is not as significant as for the tunnel, as the in situ stresses in the horizontal plane are approximately equal. Thus the zone of stress relief around the shaft would be smaller. The estimated long term, unrestricted rock deformation for the design of the shaft lining would be approximately 4 mm for the size of shafts being considered for this project. The final lining pressure would depend on the rigidity of the lining, but the pressure would not exceed the maximum horizontal swelling suppression pressure of 0.56 MPa.

It should be noted that the above assessment of the time-dependent rock deformation has been based on limited laboratory data from other sites; therefore it will be important to monitor rock deformation during construction (of the tunnel particularly) to verify the assumptions made of the predicted trends of rock movement. The monitoring program should include the use of convergence points to measure the surficial movements and possibly extensometers to measure the depth of movement in the rock, if significant fractured zones are encountered.

Tunnelling Under the QEW

The effects of the tunnel excavation on the QEW will depend on whether any fault/fracture zone intersection problems develop which lead to ravelling to the overburden/bedrock interface. The horizontal probe hole will be drilled prior to commencing the tunnelling and will, therefore, provide data on the possibility of encountering fault/fracture zones. Depending on the results of the probe hole, pre-drilling and grouting measures and other provisions should be considered if the horizontal probe hole reveals the likelihood of a significant problem zone.

From the rock viewpoint, elsewhere than the possible fault locations, no other long-term time-dependent deformations due to tunnel excavation would be expected after the tunnel has been completed. Thus, where the rock is competent and once an adequate permanent lining is in place no settlement effects will be evident. The potential for adverse settlements depends on the a) rock mass conditions and b) the overburden/bedrock profile, both of which will be checked by pre-drilling prior to tunnelling.

Seepage into the Shafts and Tunnel

For the shafts, seepage through the bedrock could occur at the shaft sidewalls due to seepage along open fractures, close to the bedrock surface. Such seepage should be able to be controlled by pumping from the shaft pit. Depending on the chosen form of liner within the overburden, significant water inflows could occur through the sand and gravel deposits.

On the basis of the permeability tests, seepage into the tunnel within the bedrock is expected to be small, except if significant open fractures are encountered (associated with potential fracturing) which connect the tunnel excavation with the overburden infilling the bedrock valley. Provisions should therefore be included for forward cover grouting and other such seepage control measures as may be necessary to allow tunnelling to continue. In the interim, if such conditions are encountered, prior to achieving grouting control, adequate pumping capacity should be available to cope with significant water inflows. Water discharge from both the shaft and tunnel should however be disposed of in accordance with Ministry of the Environment Regulations.

Drop Shafts

Based on the results of Borehole 135, the overburden at the location of the north shaft could be about 16.7 m thick and the groundwater level is at about Elevation 100.2 m (about 3.3 m below ground surface). The overburden consists of about 1.8 m of fill underlain by about 15 m of a hard clayey silt to silty clay till. The till contained two interlayers of dense gravelly sand to sand up to 2 m in thickness. The shaft will be extended about 15.5 m below the bedrock surface.

Based on the results of Borehole 136, the overburden in the vicinity of the south shaft could be about 12.2 m thick and the groundwater level is at about Elevation 98.9 m (about 4.6 m below ground surface). The overburden consists generally of interbedded granular deposits ranging from a very dense sand and gravel till to a very dense sand and silt. The shaft will be extended about 20 m below the bedrock surface.

It should be noted that boulders were encountered in the boreholes put down at the shaft locations. Boulders should be anticipated during installation of the temporary support system and during excavation of the shaft.

- **Design of Permanent Shafts**

The design of permanent shaft walls through the overburden should take into account the horizontal soil loads, hydrostatic pressure and any surcharge loading. A triangular pressure distribution should be assumed for the soil loading. The following parameters may be assumed for design of the shafts within the overburden:

unit weight of soil	21 kN/cu.m.
coefficient of earth pressure at rest	0.5
groundwater level	Elevation 100.5 m (North Shaft)
	Elevation 99.0 m (South Shaft)

References should be made to the previous section titled "Shaft Lining in Rock" for permanent shaft design in the bedrock.

- **Temporary Support and Excavation**

North Shaft

A braced soldier pile and lagging wall system may be used for temporary support although some groundwater control will be required. Soldier piles should be placed in pre-augered holes socketed into the bedrock and backfilled with concrete. The lagging should be installed between the soldier piles as soon as sufficient space has been excavated. It may be possible to dewater the granular interlayers from within the shaft during excavation. The upper granular layer encountered in Borehole 135, however, is an open gravelly sand which could result in a higher inflow making dewatering from within the shaft not feasible. Groundwater lowering using deep wells installed outside the shaft may be required prior to excavation of the granular layers. Granular material or lean mix concrete packing should be provided behind the lagging.

The soldier piles should be maintained an adequate distance from the edge of the excavation and be extended into the rock to prevent loss of ground if slabs of shale break out from under the shoring during rock excavation (see Appendix A, Figure 15). Additional rock bolts may be required at the interface to provide support to the rock face in front of the soldier piles.

The support system should be designed to resist the lateral earth and water pressure distributions shown in Appendix A, Figure 17. A soil unit weight of 20 kN/cu.m., a coefficient of lateral earth pressure equal to 0.3 and a groundwater level at Elevation 100.5 m may be assumed for design.

South Shaft

Groundwater lowering for construction of the south shaft would require an extensive dewatering system given the variable nature of the granular deposits and the cohesive interlayers. It is considered that a braced contiguous caisson or diaphragm wall, penetrating at least 2 m into the bedrock to provide a cutoff, would be a feasible method of support for construction of the shaft.

The support system should be set back from the edge of the rock shaft, as described above. The support system should be designed to resist the lateral earth and water pressure distributions shown in Appendix A, Figure 16. A soil unit weight of 21 kN/cu.m., a coefficient of lateral earth pressure equal to 0.25 and a groundwater level at Elevation 99.0 m may be assumed for design shown in Appendix A, Figure 17.

Geotechnical Inspection

In view of the relatively shallow rock cover, and the potential for low rock mass quality above the proposed crown of the tunnel, particularly in the centre of the section under the QEW, it is considered essential that experienced geotechnical input be available throughout construction of the tunnel. A full time geotechnical site engineer may even be needed if data from horizontal probe drilling proves to be of very poor quality. Some assurance must be provided to make certain that the excavation methods used by the Contractor are adequate for the ground and that a timely switch is made to use liner plate steel sets, lattice girders, or spiling etc. without incurring unnecessary delay that could lead to severe ground control problems This geotechnical input will be most critical to ensuring that rock support systems are properly installed if adverse ground conditions are encountered. It will also be key that exposed rock conditions are properly mapped and documented as a means of correlating and assessing the results of forward probe drilling. Requirements to make modifications to the excavation method and the rock support in response to any localized variations associated with fracturing can then be evaluated and resolved on site with minimal delay to the contract. In addition, interpretation of the results of shotcrete quality control tests, rock bolt pull tests and the rock deformations measured with installed instrumentation will require geotechnical input.

We trust that this report is sufficient for your immediate requirements. Should you have any questions or require any additional information, please do not hesitate to contact us.

Yours truly,

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED BY

A. S. Poschmann, P. Eng.
Principal

T. G. Carter, P. Eng.
Principal

ASP/TGC/se

Attachments:

- List of Abbreviations and Symbols
- Lithological and Geotechnical Rock Description Terminology
- Record of Boreholes - 131, 131A, 132, 132A, 133, 134, 135 and 136
- Figures 1 to 7
- Appendix A - Report No. 901-1403-1

The abbreviation commonly employed on each "Record of Borehole," on the figures and in the text of the report, are as follows:

I. SAMPLE TYPES

AS auger sample
CS chunk sample
DO drive open
DS Denison type sample
FS foil sample
RC rock core
ST slotted tube
TO thin-walled, open
TP thin-walled, piston
WS wash sample

II. PENETRATION RESISTANCES

Dynamic Penetration Resistance:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 0.3 m (12 in.).

Standard Penetration Resistance, *N*:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 0.3 m (12 in.).

WH sampler advanced by static weight—weight, hammer

PH sampler advanced by pressure—pressure, hydraulic

PM sampler advanced by pressure—pressure, manual

III. SOIL DESCRIPTION

(a) *Cohesionless Soils*

Relative Density	*'N'* Blows/0.30m or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) *Cohesive Soils*

Consistency	*'Cu'* kPa	psf.
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1000
Stiff	50 to 100	1000 to 2000
Very stiff	100 to 200	2000 to 4000
Hard	over 200	over 4000

IV. SOIL TESTS

C consolidation test
H hydrometer analysis
M sieve analysis
MH combined analysis, sieve and hydrometer[1]
Q undrained triaxial[2]
R consolidated undrained triaxial[2]
S drained triaxial
U unconfined compression
V field vane test

NOTES:
[1]Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.
[2]Undrained triaxial tests in which pore pressures are measured are shown as $\bar{Q}$ or $\bar{R}$.

Form G.A.-R-1

LIST OF SYMBOLS

I. GENERAL

$\pi = 3.1416$

e = base of natural logarithms 2.7183

$\log_e a$ or $\ln a$, natural logarithm of a

$\log_{10} a$ or $\log a$, logarithm of a to base 10

t time

g acceleration due to gravity

V volume

W weight

M moment

F factor of safety

II. STRESS AND STRAIN

u pore pressure

σ normal stress

σ' normal effective stress ($\bar{\sigma}$ is also used)

τ shear stress

ϵ linear strain

ϵ_{xy} shear strain

ν Poisson's ratio (μ is also used)

E modulus of linear deformation (Young's modulus)

G modulus of shear deformation

K modulus of compressibility

η coefficient of viscosity

III. SOIL PROPERTIES

(a) *Unit weight*

γ unit weight of soil (bulk density)

γ_s unit weight of solid particles

γ_w unit weight of water

γ_d unit dry weight of soil (dry density)

γ' unit weight of submerged soil

G_s specific gravity of solid particles $G_s = \gamma_s/\gamma_w$

e void ratio

n porosity

w water content

S_r degree of saturation

(b) *Consistency*

w_L liquid limit

w_P plastic limit

I_P plasticity index

w_S shrinkage limit

I_L liquidity index $= (w - w_P)/I_P$

I_C consistency index $= (w_L - w)/I_P$

e_{max} void ratio in loosest state

e_{min} void ratio in densest state

D_r relative density $= (e_{max} - e)/(e_{max} - e_{min})$

(c) *Permeability*

h hydraulic head or potential

q rate of discharge

v velocity of flow

i hydraulic gradient

k coefficient of permeability

j seepage force per unit volume

(d) *Consolidation (one-dimensional)*

m_v coefficient of volume change $= -\Delta e/(1+e)\Delta\sigma'$

C_c compression index $= -\Delta e/\Delta \log_{10} \sigma'$

c_v coefficient of consolidation

T_v time factor $= c_v t/d^2$ (d, drainage path)

U degree of consolidation

(e) *Shear strength*

τ_f shear strength

c' effective cohesion intercept; ϕ' effective angle of shearing resistance, or friction — in terms of effective stress $\tau_f = c' + \sigma' \tan \phi'$

c_u apparent cohesion*; ϕ_u apparent angle of shearing resistance, or friction — in terms of total stress $\tau_f = c_u + \sigma \tan \phi_u$

μ coefficient of friction

S_t sensitivity

*For the case of a saturated cohesive soil, $\phi_u = 0$ and the strength $\tau_f = c_u$ is taken as half the undrained compressive strength.

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING STATE

Fresh: no visible sign of weathering.

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock texture and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	> 2 m
Thickly bedded	0.6 m to 2m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	< 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	> 3 m
Wide	1 - 3 m
Moderately close	0.3 - 1 m
Close	50 - 300 mm
Very close	< 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	> 60 mm
Coarse Grained	2 - 60 mm
Medium Grained	60 microns - 2 mm
Fine Grained	2 - 60 microns
Very Fine Grained	< 2 microns

Note: * Grains >60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to (W.R.T.) Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviated description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

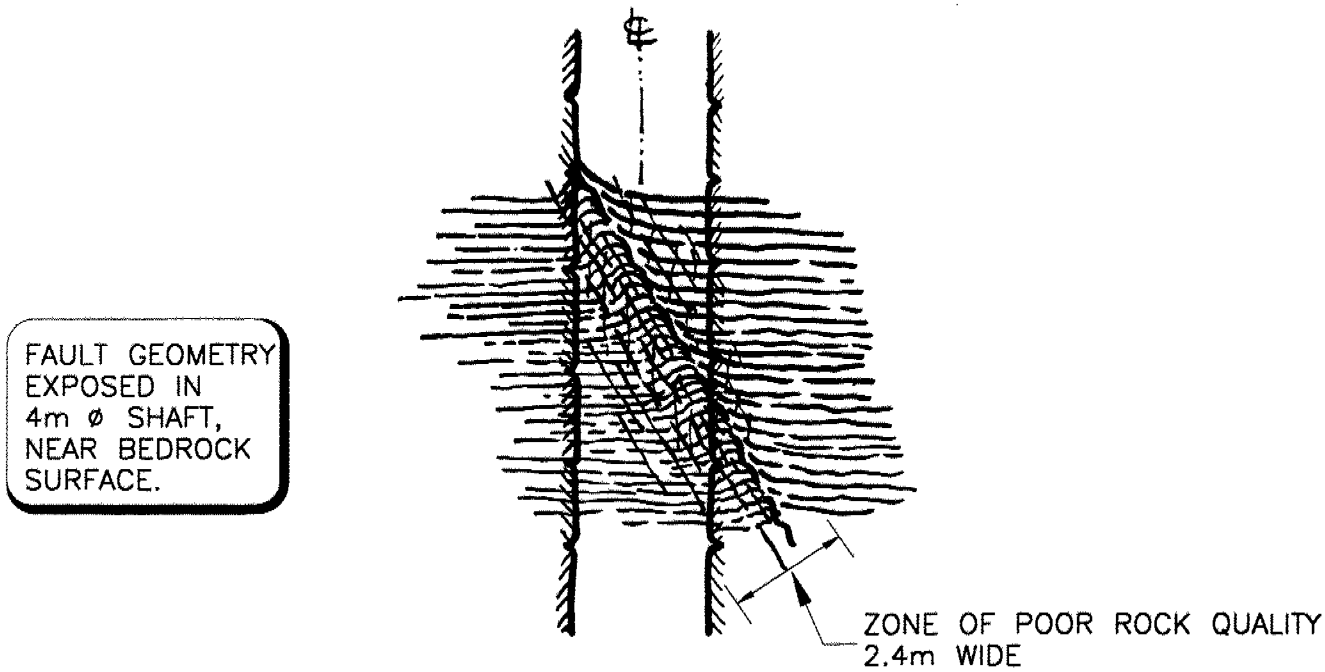
Abbreviations

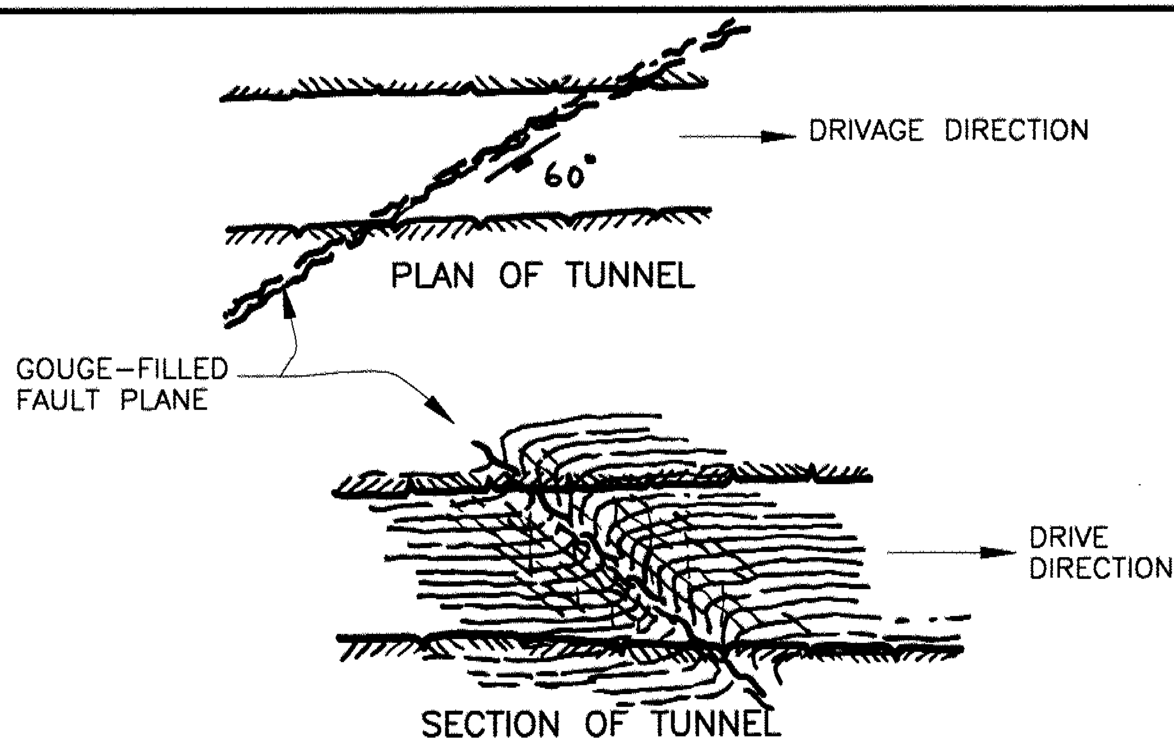
B - Bedding	P - Polished
FO - Foliation/Schistosity	S - Slickensided
CL - Cleavage	SM - Smooth
SH - Shear Plane/Zone	R - Ridged/Rough
VN - Vein	ST - Stepped
F - Fault	PL - Planar
CO - Contact	FL - Flexured
J - Joint	UE - Uneven
FR - Fracture	W - Wavy
MF - Mechanical Fracture	C - Curved
II - Parallel To	
⊥ - Perpendicular To	

Form...G.A.-R-3 (m)

TYPICAL SECTIONS THROUGH RECENTLY ENCOUNTERED FAULTS

FIGURE 3





FAULT EXPOSED IN 3.5m DIA. TUNNEL

Date JULY 1995

Project 941-1376

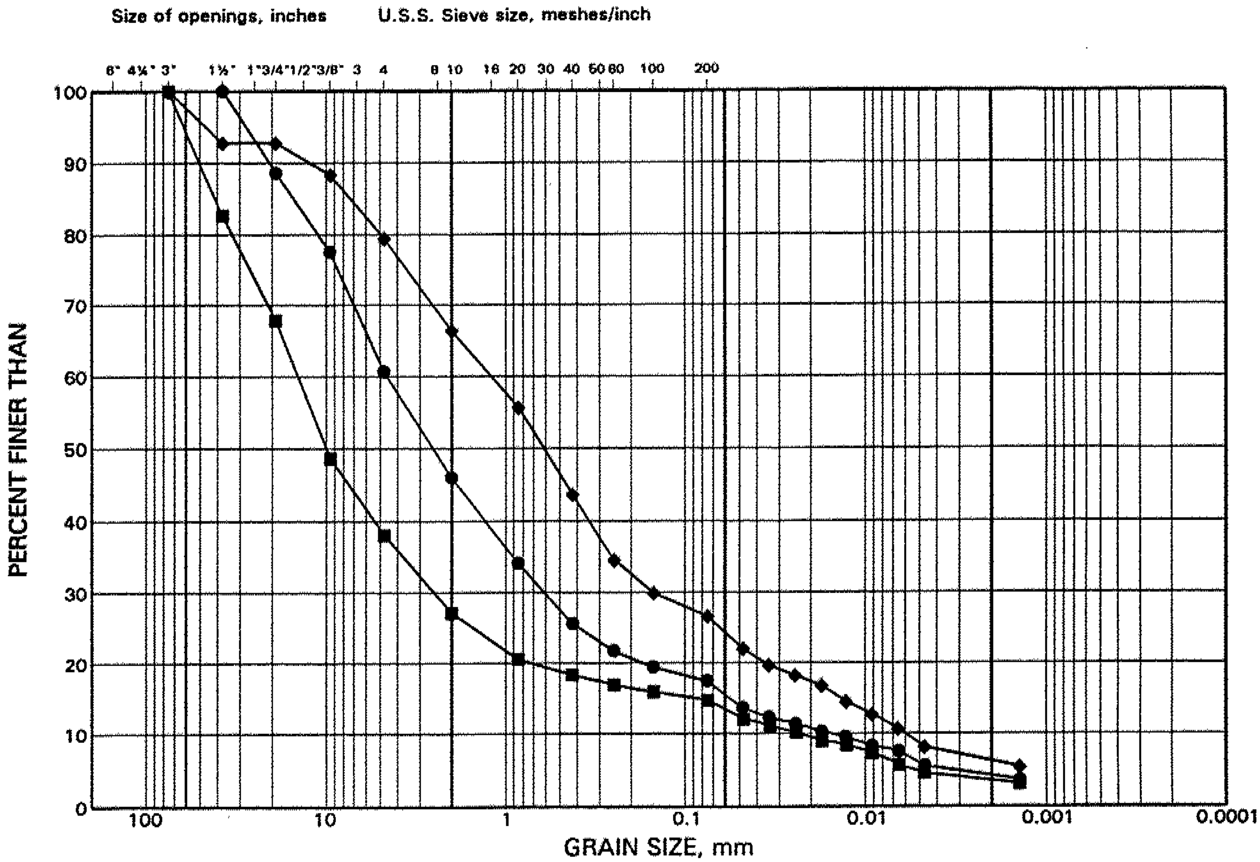
Golder Associates

Drawn TDR

Chkd AJW

GRAIN SIZE DISTRIBUTION
SAND and GRAVEL (TILL)

FIGURE 4



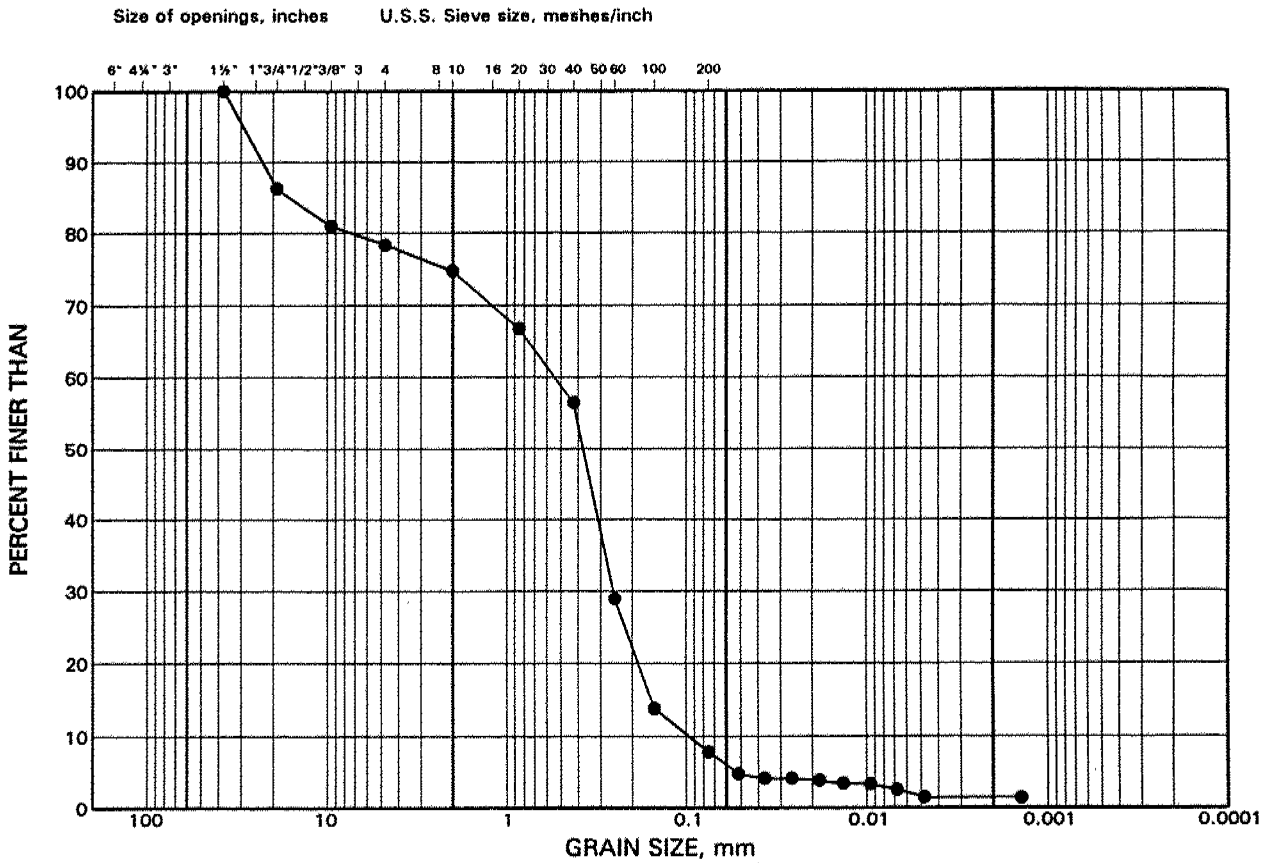
COBBLE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE
SIZE	GRAVEL SIZE			SAND SIZE			FINE GRAINED	

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	131A	3	5.0
■	132A	3	10.7
◆	136	9B	8.8

GRAIN SIZE DISTRIBUTION
GRAVELLY SAND

FIGURE 5



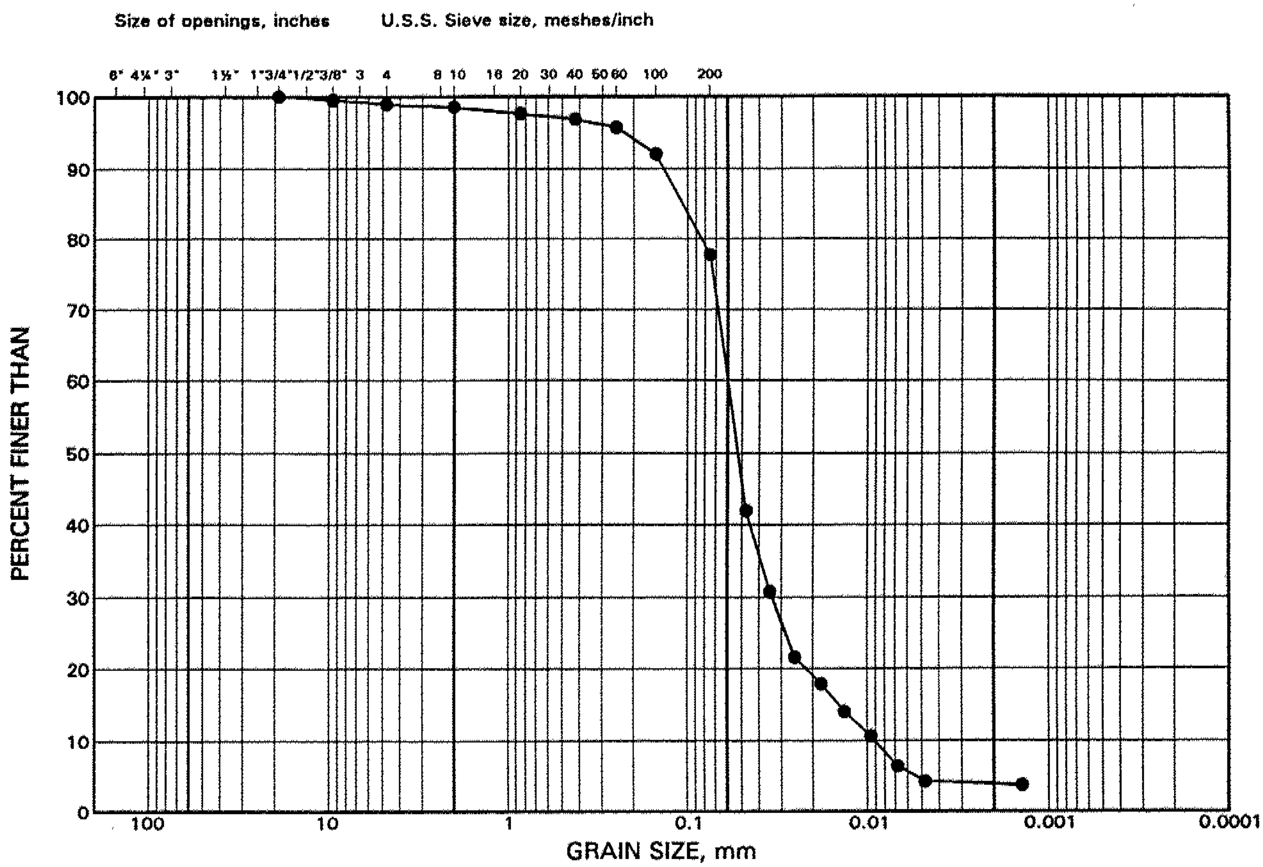
COBBLE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE
SIZE	GRAVEL SIZE			SAND SIZE			FINE GRAINED	

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	135	7	6.4

GRAIN SIZE DISTRIBUTION
SAND and SILT

FIGURE 6



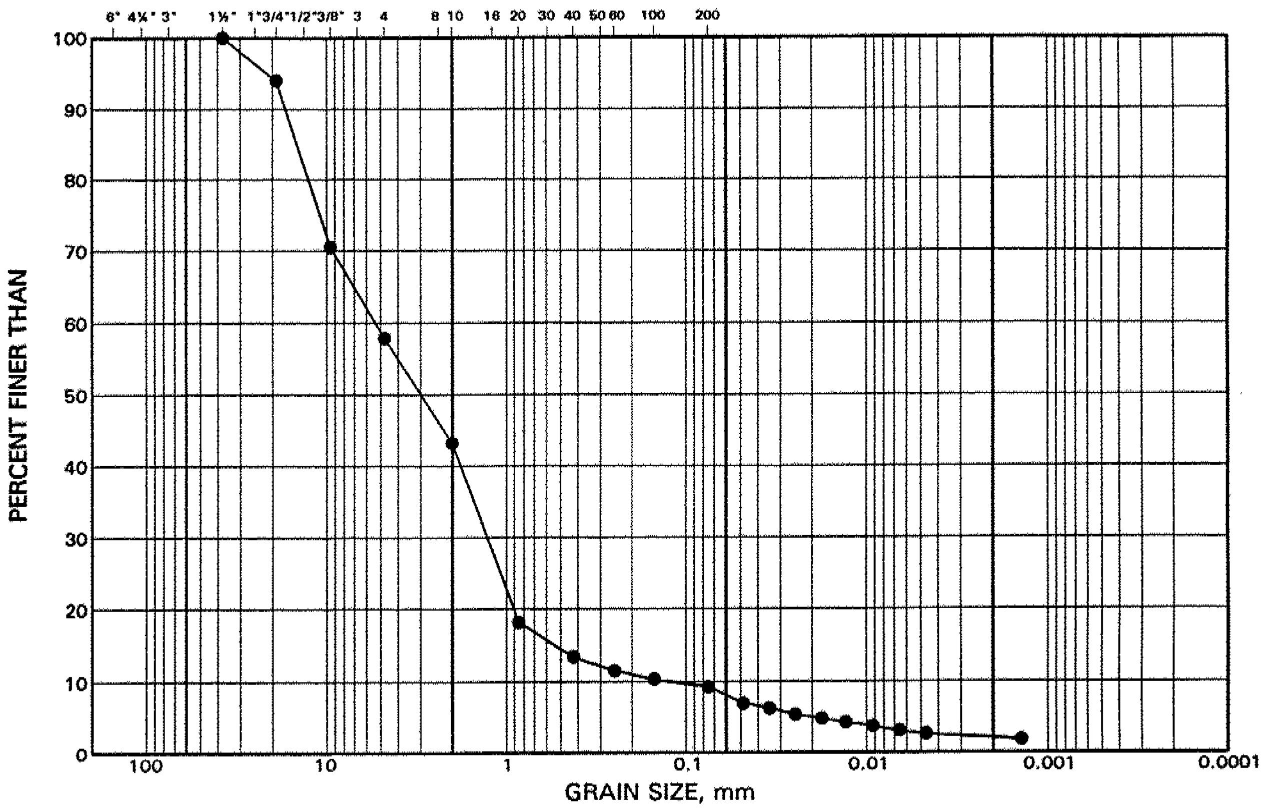
COBBLE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE
SIZE	GRAVEL SIZE			SAND SIZE			FINE GRAINED	

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	136	5	3.5

GRAIN SIZE DISTRIBUTION
SAND and GRAVEL

FIGURE 7



COBBLE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE
SIZE	GRAVEL SIZE			SAND SIZE			FINE GRAINED	

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	136	7	6.3

Project 941-1376

Golder Associates

A

APPENDIX A

REPORT 901-1403-1

July 1995

941-1376

RECORD OF BOREHOLE 131

PROJECT: 941-1376
SHEET 1 OF 3
LOCATION: SEE FIGURE 1
BORING DATE: DEC. 6-8, 1994
DATUM: GEODETIC
SAMPLER HAMMER, 63.5kg; DROP, 760mm
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
0	POWER AUGER, 108 mm DIA HOLLOWSTEM AUGERS	GROUND SURFACE	103.60 0.00				
		100 mm topsoil overlying compact to dense sand and gravel (FILL)		1	50 DO	39	
2		Compact to very dense, brown to grey SILTY SAND to SANDY SILT; occasional silty clay seams.	101.93 1.67	2	50 DO	11	
				3	50 DO	104	
3	WASH BORING, 108 mm DIA. PQ CORING	Hard, grey SILTY CLAY to CLAYEY SILT, some sand and gravel, some cobbles, occasional boulders (TILL).	100.45 3.15	4	100 CC		▽
				5	100 CC		
5		Gravel, some sand.	98.88 4.72				CEMENT GROUT
				6	100 CC		
6		Hard grey SILTY CLAY, some sand and gravel, some cobbles (TILL).	97.43 6.17	7	100 CC		
9		Sand and gravel to GRAVEL, some sand, some silt.	94.51 9.09	8	100 CC		
				9	100 CC		
10		CONTINUED ON NEXT PAGE					

Columns also present (no data recorded): DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - O); HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp —O W— Wl); ADDITIONAL LAB. TESTING; STRATA PLOT.

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: S.C.
CHECKED: A.P

DATA INPUT: DS JULY 13/95

PROJECT: 941-1376

RECORD OF BOREHOLE 131

SHEET 2 OF 3

LOCATION: SEE FIGURE 1

BORING DATE: DEC. 6-8, 1994

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

Column headings: DEPTH SCALE METRES | BORING METHOD | SOIL PROFILE (DESCRIPTION, STRATA PLOT, ELEV. DEPTH (m)) | SAMPLES (NUMBER, TYPE, BLOWS/0.3m) | DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - +, Q - ●, rem.V - ⊕, U - O) | HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp —O W— Wl) | ADDITIONAL LAB. TESTING | PIEZOMETER OR STANDPIPE INSTALLATION

Boring method: WASH BORING, 108 mm DIA. PQ CORING

CONTINUED FROM PREVIOUS PAGE

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE
	92.93 / 10.67	9	100 CC
Hard, grey to brown SILTY CLAY to CLAYEY SILT, trace to some sand and gravel, occasaional cobbles (TILL).	91.38 / 12.22	10	100 CC
GRAVEL, some cobbles	90.80 / 12.80		
Probably sand or silt (no sample recovered)	89.90 / 13.70	11	100 CC
LIMESTONE BOULDER	89.27 / 14.33		
COBBLES and GRAVEL	88.67 / 14.93	12	100 CC
SAND/GRAVEL/COBBLE mixture with sandy silt zones and clay seams.	86.30 / 17.30	13	100 CC
		14	100 CC
CLAYEY SILT, some sand and gravel (TILL).	17.47		
Slightly weathered, thinly bedded, grey fine grained SHALE, with interbedded limestone. (GEORGIAN BAY FORMATION)		15	100 CC
		16	100 CC
		16	100 CC

Piezometer installation: CEMENT GROUT (to approx. 19 m); PEA GRAVEL (approx. 19–20 m)

CONTINUED ON NEXT PAGE

DATA INPUT: DS JULY 13/95

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: S.C.

CHECKED: A.P

PROJECT: 941-1376

RECORD OF BOREHOLE 131

LOCATION: SEE FIGURE 1

BORING DATE: DEC. 6 -8, 1994

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT (Wp W Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20	WASH BORING 108 mm DIA. PQ CORING	CONTINUED FROM PREVIOUS PAGE									
				83.13 20.47	16	100 CC					PEA GRAVEL
		END OF BOREHOLE									WATER LEVEL IN PIEZOMETER AT ELEV. 100.2m ON DEC. 9, 1994.
21											
		NOTE: GROUND SURFACE ELEVATION IS APPROXIMATE.									
22											
23											
24											
25											
26											
27											
28											
29											
30											

DATA INPUT: DS JULY 13/95

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: S.C.

CHECKED: A.P

RECORD OF BOREHOLE 131A

PROJECT: 941-1376
SHEET 1 OF 2
LOCATION: NORTH SIDE OF W/B QEW AT CAWTHRA RD.
BORING DATE: MAY 29, 1995
DATUM: GEODETIC
SAMPLER HAMMER, 63.5kg; DROP, 760mm
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

BORING METHOD: POWER AUGER, 108 mm ID HOLLOWSTEM AUGERS

Depth (m)	Description	Elev. / Depth (m)	Sample No.	Type	Blows/0.3m	Water content (%)	Additional lab testing	Piezometer or standpipe installation
0	GROUND SURFACE	103.60 / 0.00						CONCRETE & FLUSH SURFACE CAP
0.00–1.85	Compact, red-brown SAND, some silt, trace gravel.	101.75 / 1.85	1	50 DO	34			BENTONITE SEAL
1.85–3.15	Dense to very dense grey silty SAND, some gravel, trace clay with occ. shale fragments, boulder encountered at about 2.4m depth inferred by resistance to augering. (TILL)	100.45 / 3.15	2	50 DO	80/.08			
3.15–4.45	Hard, grey SILTY CLAY, some sand and gravel with cobbles and boulders, inferred from auger cuttings and very slow rate of auger advance. (TILL)	99.15 / 4.45						CAVED; BENTONITE SEAL
4.45–5.80	Very dense, grey SAND and GRAVEL, some silt, trace clay, with occ. silty clay pockets. (TILL)	97.80 / 5.80	3	50 DO	140/.25	~5	MH	SAND; PIEZOMETER
5.80–9.40	Hard grey SILTY CLAY, some sand and gravel, frequent shale and limestone gravel sizes, cobbles inferred from augering. (TILL)	94.20 / 9.40	4	50 DO	100	~7		BENTONITE SEAL
			5	50 DO	100/.25	~7		
			6	50 DO	44	~20		
			7	50 DO	100/.25	~7		SAND
			8	50 DO	100/.15	~7		WELL
9.40–	Very dense grey SAND and GRAVEL, some silt, trace clay with occ. cobbles and silty clay pockets. (TILL)		9	50 DO	100/0.03	~8		
10	CONTINUED ON NEXT PAGE							

DATA INPUT: DS JULY 7/95

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: G.B
CHECKED: A.J.W

PROJECT: 941-1376

RECORD OF BOREHOLE 131A

SHEET 2 OF 2

LOCATION: NORTH SIDE OF W/B QEW AT CAWTHRA RD.

BORING DATE: MAY 29, 1995

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT Wp W Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10		CONTINUED FROM PREVIOUS PAGE									
				93.40 10.20							SAND
		Hard grey SILTY CLAY, some sand and gravel. (TILL)		92.91 10.69	16	50 DO	100/.03		O		CAVED
		END OF BOREHOLE									WATER LEVEL IN PIEZOMETER AT ELEV. 99.9m AND IN WELL AT ELEV. 99.1m ON JUNE 14, 1995.
11											
		NOTE: GROUND SURFACE ELEVATION IS APPROXIMATE.									RISING HEAD TEST CARRIED OUT IN WELL ON JUNE 5, 1995;k=3x10-5 cm/s OVER DEPTH INTERVAL 8.9m TO 10.4m.
12											
13											
14											
15											
16											
17											
18											
19											
20											

DATA INPUT: DS JULY 7/95

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: G.B
CHECKED: A.J.W

RECORD OF BOREHOLE 132

PROJECT: 941-1376
LOCATION: SEE FIGURE 1
SAMPLER HAMMER, 63.5kg; DROP, 760mm
BORING DATE: DEC 9-14, 1994

DATUM: GEODETIC
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - +, Q - ●, rem.V - ⊕, U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		103.60 0.00							
0–3	POWER AUGER 108 mm DIA HOLLOWSTEM AUGERS	(UNSAMPLED)									
3	WASH BORING 108 mm DIA. PQ CORING	Hard, grey SILTY CLAY to CLAYEY SILT, some sand and gravel, some cobbles, occasional boulders (TILL).		100.55 3.05	1	100 CC					
4.27		GRAVEL TO SAND AND GRAVEL, some cobbles; probably some silt. Boulder noted between 7.2m and 7.8m depth.		99.33 4.27	2	100 CC					
					3	100 CC					
					4	100 CC					
					5	100 CC					
					6	100 CC					
					7	100 CC					
					8	100 CC					
10		CONTINUED ON NEXT PAGE									

DATA INPUT: DS JULY 13/95

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: S.C.
CHECKED: A.S.P

PROJECT: 941-1376

RECORD OF BOREHOLE 132

LOCATION: SEE FIGURE 1

BORING DATE: DEC.9-14, 1994

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - +, Q - ●, rem.V - ⊕, U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10	WASH BORING 108 mm DIA. PQ CORING	CONTINUED FROM PREVIOUS PAGE									
				93.30 10.30	8	100 CC					
		Grey SILTY CLAY, some sand and gravel. (TILL)		92.90 10.70							
11		SAND and GRAVEL; probably some silt.		91.60 12.00	9	100 CC					
12		Grey SILTY CLAY, some sand gravel. (TILL)		91.10 12.50	10	100 CC					
13–16		SAND and GRAVEL, probably some silt.		87.50 16.10	11, 12, 13	100 CC					
17		Hard grey SILTY CLAY, some sand and gravel, some cobbles (TILL).		86.23 17.37	14	100 CC					
18		SAND and GRAVEL, occasional cobbles; weathered shale/residual soil from 17.9m to 18.9m depth.		84.70 18.90	15, 16	100 CC					
19		SAND AND GRAVEL, some cobbles, occasional silty clay till seams.			17	100 CC					
20		CONTINUED ON NEXT PAGE									

DATA INPUT: DS JULY 13/95

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: S.C.
CHECKED: A.S.P

PROJECT: 941-1376

RECORD OF BOREHOLE 132

LOCATION: SEE FIGURE 1

BORING DATE: DEC.9-14, 1994

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE - DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES - NUMBER	SAMPLES - TYPE	SAMPLES - BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - +, rem.V - ⊕, Q - ●, U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		CONTINUED FROM PREVIOUS PAGE									
20	WASH BORING 108 mm DIA. PQ CORING	SAND AND GRAVEL, some cobbles, occasional silty clay till seams.			18	100 CC					
					19	100 CC					
21					20	100 CC					
				81.81 / 21.79							
22		CONTINUED ON NEXT SHEET									
23											
24											
25											
26											
27											
28											
29											
30		CONTINUED ON NEXT PAGE									

DATA INPUT: DS JULY 13/95

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: S.C.
CHECKED: A.S.P

PROJECT: 941-1376

RECORD OF BOREHOLE: 132

LOCATION: SEE FIGURE 1
DRILLING DATE: DEC. 21, 1994
DATUM: GEODETIC
INCLINATION: AZIMUTH:
DRILL RIG:
DRILLING CONTRACTOR:

FR-FRACTURE, F-FAULT, SM-SMOOTH, FL-FLEXURED, BC-BROKEN CORE
CL-CLEAVAGE, J-JOINT, R-ROUGH, UE-UNEVEN, MB-MECH. BREAK
SH-SHEAR, P-POLISHED, ST-STEPPED, W-WAVY, B-BEDDING
VN-VEIN, S-SLICKENSIDED, PL-PLANAR, C-CURVED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (m/min.)	FLUSH COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER m	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	HYDRAULIC CONDUCTIVITY k, cm/sec	DIAMETRAL POINT LOAD INDEX (MPa)	NOTES WATER LEVELS INSTRUMENTATION
		CONTINUED FROM PREVIOUS PAGE														
20																
21																
		CONTINUED FROM SHEET 3		81.81												
22		Grey SILTY CLAY, some sand and gravel. (TILL)		21.79	21											
				81.33 22.27												
23		Slightly weathered, thinly bedded, grey fine grained SHALE interbedded with limestone. (GEORGIAN BAY FORMATION)			22											
24					23											
25				78.58 25.02												
		END OF BOREHOLE NOTE: GROUND SURFACE ELEVATION IS APPROXIMATE														
26																
27																
28																
29																
30																

DEPTH SCALE:
1 to 50

Golder Associates

LOGGED: G.B
DATE: DEC. 21, 1994
CHECKED: A.S.P

PROJECT: 941-1376

RECORD OF BOREHOLE 132A

SHEET 1 OF 2

LOCATION: MEDIAN ON S. SIDE OF E/B QEW AT CAWTHRA RD. BORING DATE: MAY 29, 1995 DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - +, rem.V - ⊕, Q - ●, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT Wp W Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	POWER AUGER; 108 mm ID HOLLOWSTEM AUGERS	GROUND SURFACE		103.70 / 0.00							CONCRETE & FLUSH SURFACE CAP
0–7		UNSAMPLED : frequent cobbles and boulders encountered, inferred by resistance to augering, 0.9m thick boulder encountered at a depth of 5m.									GROUT; BENTONITE SEAL; SAND
7		Hard, grey SILTY CLAY, some sand and gravel, frequent shale gravel sizes, occ. cobbles inferred from augering. (TILL)		96.70 / 7.00	1	50 DO	100/.15		○		PIEZOMETER
7.6		Very dense, grey SAND and GRAVEL, some silt, trace clay. (TILL)		96.10 / 7.60							BENTONITE SEAL
8.6		Hard, grey SILTY CLAY, some sand and gravel, frequent shale gravel sizes, occ. cobbles inferred from augering. (TILL)		95.10 / 8.60	2	50 DO	100/.1		○		WELL; SAND
9.7				94.00 / 9.70							
10		CONTINUED ON NEXT PAGE									

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: G.B

CHECKED: A.J.W

DATA INPUT: DS JULY 7/95

PROJECT: 941-1376

RECORD OF BOREHOLE 132A

SHEET 2 OF 2

LOCATION: MEDIAN ON S. SIDE OF E/B QEW AT CAWTHRA RD. BORING DATE: MAY 29, 1995

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - +, rem.V - ⊕, Q - ●, U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT Wp —O W— Wl (10, 20, 30, 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		CONTINUED FROM PREVIOUS PAGE									
10		Very dense, grey SAND and GRAVEL, some silt, trace clay. (TILL)									
		Hard, grey SILTY CLAY, some sand and gravel. (TILL)		92.90 / 10.80	3	50 DO	174		O	MH	CAVED
11		END OF BOREHOLE		92.57 / 11.13							
12											
13											
14											
15											
16											
17											
18											
19											
20											

WATER LEVEL IN PIEZOMETER AT ELEV. 98.4m AND IN WELL AT ELEV. 98.5m ON JUNE 14, 1995.

RISING HEAD TEST CARRIED OUT IN WELL ON JUNE 5, 1995; k=2x10-5 cm/s OVER DEPTH INTERVAL 8.8m TO 10.4m.

DATA INPUT: DS JULY 7/95

DEPTH SCALE 1 to 50

LOGGED: G.B

CHECKED: A.J.W

Golder Associates

PROJECT: 941-1376

RECORD OF BOREHOLE 133

SHEET 1 OF 3

LOCATION: SEE FIGURE 1 | BORING DATE: JAN. 3 - 5, 1995 | DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm | PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - + Q - ●; rem.V - ⊕ U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp —o W— Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		103.40							
	POWER AUGER, 200 mm DIA HOLLOW STEM AUGERS	Probably 1 m fill overlying SANDY SILT to SILTY CLAY TILL, with some cobbles and boulders.		0.00	1	50 DO	11				
3					2	50 DO	105/10mm				
6					3	50 DO	100/8mm				
7.5					4	50 DO	104/15mm				
9.5					5	50 DO	62				
10		CONTINUED ON NEXT PAGE									

CONTINUED ON NEXT PAGE

DATA INPUT: DS JULY 13/95

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: S.C.

CHECKED: A.S.P

PROJECT: 941-1376

RECORD OF BOREHOLE 133

SHEET 2 OF 3

LOCATION: SEE FIGURE 1

BORING DATE: JAN. 3 - 5, 1995

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - +, Q - ●, rem.V - ⊕, U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10	POWER AUGER, 200 mm DIA HOLLOW STEM AUGERS	CONTINUED FROM PREVIOUS PAGE									
11											
12					6	50 DO	103/ 8mm				
13				90.30 / 13.10							
		SILTY SAND to SAND and GRAVEL, occasional boulders, cobbles.		89.38 / 14.02							
14	WASH BORING, 108 mm DIA. NQ CORING	CONTINUED ON NEXT SHEET									
15											
16											
17											
18											
19											
20		CONTINUED ON NEXT PAGE									

DATA INPUT: DS JULY 13/95

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: S.C.

CHECKED: A.S.P

J1376133.BHR

PROJECT: 941-1376

RECORD OF BOREHOLE: 133

SHEET 3 OF 3

LOCATION: SEE FIGURE 1

DRILLING DATE: JAN. 4, 1994

DATUM: GEODETIC

INCLINATION: AZIMUTH:

DRILL RIG:

DRILLING CONTRACTOR:

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, BC-BROKEN CORE, MB-MECH. BREAK, B-BEDDING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (m/min)	FLUSH COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER m	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
		CONTINUED FROM PREVIOUS PAGE														
14		SILTY SAND to SAND AND GRAVEL; occasional boulders, cobbles. (27% core recovery)		14.02	7											
15																
16	NQ ROCK CORE	Moderately to slightly weathered, grey fine grained SHALE with interbedded limestone. (GEORGIAN BAY FORMATION)		16.20	8											
17																
18					9											
19		END OF BOREHOLE		19.51												
20																
21																
22																
23																
24																

DATA INPUT: DAS JULY 13/95

ROCKMV5

DEPTH SCALE: 1 to 50

Golder Associates

LOGGED: G.B

DATE: JAN. 4, 1994

CHECKED:

PROJECT: 941-1376

RECORD OF BOREHOLE 134

LOCATION: SEE FIGURE 1

BORING DATE: JAN. 3 - 5,1995

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

Boring method: POWER AUGER, 200 mm DIA HOLLOW STEM AUGERS

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE	103.50				
0	UNSAMPLED Probably sandy silt/sand and gravel.	0.00				GROUT
3			1	50 DO	87	
6	Hard grey SILTY CLAY, some sand and gravel, occasional boulders (TILL).	97.40 6.10	2	50 DO	100/ 13mm	
8			3	50 DO	100/ 26mm	
9			4	50 DO	110/ 15mm	BENTONITE SEAL
		94.06 9.44				SAND
10	CONTINUED ON NEXT PAGE					

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; HYDRAULIC CONDUCTIVITY, k, cm/s; SHEAR STRENGTH Cu, kPa (nat.V - +, rem.V - ⊕, Q - ●, U - ○); WATER CONTENT, PERCENT (Wp —○W— Wl); ADDITIONAL LAB. TESTING

DATA INPUT: DAS JULY 13/95

DEPTH SCALE 1 to 50

LOGGED: S.C.

CHECKED: A.S.P

Golder Associates

PROJECT: 941-1376

RECORD OF BOREHOLE 134

LOCATION: SEE FIGURE 1

BORING DATE: JAN. 3 - 5,1995

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT Wp —O W— Wl	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		CONTINUED FROM PREVIOUS PAGE									
10–12.5	POWER AUGER 200 mm DIA HOLLOW STEM AUGERS	Probably SILTY SAND to SAND and GRAVEL, with silty clay till interlayers.			5	50 DO	100/ 10mm				PEA GRAVEL
		CONTINUED ON NEXT SHEET		91.00 12.50							CAVED
12.5–15.5	WASH BORING 108 mm DIA. HQ CORING										
20		CONTINUED ON NEXT PAGE									

DATA INPUT: DAS JULY 13/95

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: S.C.

CHECKED: A.S.P

PROJECT: 941-1376

RECORD OF BOREHOLE: 134

LOCATION: SEE FIGURE 1
INCLINATION: AZIMUTH:

DRILLING DATE: JAN. 4, 1994
DRILL RIG:
DRILLING CONTRACTOR:

DATUM: GEODETIC

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, BC-BROKEN CORE, MB-MECH. BREAK, B-BEDDING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (m/min.)	COLOUR % RETURN FLUSH	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER m	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 PREVIOUS PAGE														
12.50		CONTINUED FROM SHEET 2		91.00 / 12.50												
12.50–15.54		Moderatly to slightly weathered, grey, fine grained SHALE with interbedded limestone. (GEORGIAN BAY FORMATION).			6											
					7											
15.54		END OF BOREHOLE		87.96 / 15.54												
		NOTE: GROUND SURFACE IS APPROXIMATE.														

DEPTH SCALE:
1 to 50

Golder Associates

LOGGED: G.B
DATE: JAN. 4, 1994
CHECKED: A.S.P

RECORD OF BOREHOLE 135

PROJECT: 941-1376 — SHEET 1 OF 4

LOCATION: NORTH SHAFT; NORTH SERVICE RD. — BORING DATE: MAY 30, 1995 — DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm — PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

Boring method: POWER AUGER, 108mm ID HOLLOWSTEM AUGERS

Description	Elev. / Depth (m)	Sample Number	Type	Blows/0.3m	Additional Lab. Testing	Piezometer or Standpipe Installation
GROUND SURFACE	103.50 / 0.00					CONCRETE AND ELEVATED CAP
Compact, orange-brown sand, some silt, trace gravel with occ. brick fragments. (FILL)		1	50 DO	20		
	101.75 / 1.75	2	50 DO	37		
Hard, red-brown SILTY CLAY, trace sand and gravel, with frequent red shale fragments. (TILL)		3	50 DO	55		
		4	50 DO	49		BACKFILL
		5	50 DO	91		
		6	50 DO	83		
Dense, brown, gravelly SAND, trace silt, with occ. sand and gravel layers and cobbles, inferred from augering.	97.70 / 5.80	7	50 DO	32	MH	
Hard, red-brown SILTY CLAY, trace sand and gravel, with occ. shale fragments and sand and gravel layers. (TILL)	95.75 / 7.75	8	50 DO	107/.2		
		9	50 DO	104/.2		BENTONITE SEAL

CONTINUED ON NEXT PAGE

Column headings: DEPTH SCALE METRES; BORING METHOD; SOIL PROFILE (DESCRIPTION, STRATA PLOT, ELEV. DEPTH (m)); SAMPLES (NUMBER, TYPE, BLOWS/0.3m); DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - +, Q - ●, rem.V - ⊕, U - ○); HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10, 20, 30, 40); ADDITIONAL LAB. TESTING; PIEZOMETER OR STANDPIPE INSTALLATION

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

DATA INPUT: DS JULY 7/95

DEPTH SCALE 1 to 50 — Golder Associates — LOGGED: P.S. — CHECKED: A.J.W

RECORD OF BOREHOLE 135

PROJECT: 941-1376
LOCATION: NORTH SHAFT; NORTH SERVICE RD.
SAMPLER HAMMER, 63.5kg; DROP, 760mm

BORING DATE: MAY 30, 1995

DATUM: GEODETIC
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - +, Q - ●, rem.V - ⊕, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10	POWER AUGER; 108mm ID HOLLOWSTEM AUGERS	CONTINUED FROM PREVIOUS PAGE									
				92.60 10.90	10	50 DO	99		○		
11		Hard, grey SILTY CLAY, trace sand.		91.90 11.60							SAND
12		Grey, SAND, trace silt and gravel; 1.2m sand blowback into augers occurred during sampling at 12.2m depth.		90.90 12.60	11	50 DO	46				
13–16		Hard, grey SILTY CLAY, trace sand and gravel with occ. shale fragments, boulder inferred by augering at a depth of 14.8m. (TILL)		86.75	12	50 DO	101/.2		○		BENTONITE SEAL
					13	50 DO	100/.2				
		Highly weathered, grey SHALE.		86.60 16.90	14	50 DO	102/0.08				GROUT
17		Hole continued; (refer to sheet 3 for bedrock coring details)									
20		CONTINUED ON NEXT PAGE									

DATA INPUT: KD JUNE 23, 1995

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: P.S.
CHECKED: A.J.W

RECORD OF BOREHOLE 135

PROJECT: 941-1376
LOCATION: NORTH SHAFT; NORTH SERVICE RD.
INCLINATION: -90 AZIMUTH: 000

DRILLING DATE: JUNE 1, 1995
DRILL RIG: DIEDRICH D90
DRILLING CONTRACTOR: MASTER SOIL INVESTIGATIONS LTD.

DATUM: GEODETIC

Legend: 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

Columns: DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | PENETRATION RATE (m/min.) | COLOUR % RETURN FLUSH | RECOVERY (TOTAL CORE %, SOLID CORE %) | R.Q.D. % | FRACT. INDEX PER 0.3 m | DISCONTINUITY DATA (DIP w.r.t. CORE AXIS; TYPE AND SURFACE DESCRIPTION) | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (MPa) | NOTES WATER LEVELS INSTRUMENTATION

Drilling record: NW (approx. 16.90–17.25 m); NQ ROCK CORE (below)

CONTINUED FROM PREVIOUS PAGE

ELEV. 86.60 / DEPTH 16.90

Slightly weathered, thinly bedded, dark grey, fine grained SHALE interbedded with limestone. (GEORGIAN BAY FORMATION)

Limestone interbeds noted in the core samples at the following depths:

19.07-19.19
19.95-20.11
20.13-20.25
20.35-20.49
20.88-21.23
23.00-23.06
23.33-23.38
25.75-25.87
26.00-26.33
26.58-26.67
26.72-26.83
26.98-27.11
27.32-27.33
27.69-27.82
28.17-28.25
28.26-28.34
29.26-29.38

Run No.	Flush colour / % return
1	LIGHT GREY 75
2	LIGHT GREY 75
3	LIGHT GREY 75
4	LIGHT GREY 75
5	LIGHT GREY 75
6	LIGHT GREY 75

Discontinuity type and surface description (top to bottom):

B, PL, SM
B, PL, SM
J, UE, R
B, FL, SM
J, FL, SM
B, FL, SM
B, FL, SM
B, FL, SM
J, UE, R
B, PL, SM
B, FL, R
J, FL, R
B, PL, SM
J, PL, R
B, PL, SM
B, FL, SM
J, PL, R
B, FL, SM
B, PL, R
J, UE, R
B, PL, SM
B, FL, SM
B, FL, SM
B, PL, SM
J, PL, R
B, PL, SM
B, UE, SM
J, FL, R

Notes: >5.74 (at approx. 19 m); GROUT; BENTONITE SEAL; SAND

CONTINUED ON NEXT PAGE

DEPTH SCALE: 1 to 50

Golder Associates

LOGGED: P.S
DATE: JUNE 1, 1995
CHECKED: A.J.W

DATA INPUT: KD JUNE 8, 1995

RECORD OF BOREHOLE: 135

PROJECT: 941-1376
LOCATION: NORTH SHAFT; NORTH SERVICE RD.
INCLINATION: -90 AZIMUTH: 000

DRILLING DATE: JUNE 1, 1995
DRILL RIG: DIEDRICH D90
DRILLING CONTRACTOR: MASTER SOIL INVESTIGATIONS LTD.

SHEET 4 OF 4
DATUM: GEODETIC

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, BC-BROKEN CORE, MB-MECH. BREAK, B-BEDDING

Columns: DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | PENETRATION RATE (m/min.) | FLUSH COLOUR % RETURN | RECOVERY (TOTAL CORE %, SOLID CORE %) | R.Q.D. % | FRACT. INDEX PER m | DISCONTINUITY DATA (DIP w.r.t. CORE AXIS; TYPE AND SURFACE DESCRIPTION) | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (MPa) | NOTES WATER LEVELS INSTRUMENTATION

CONTINUED FROM PREVIOUS PAGE

Drilling record: NQ ROCK CORE; JUN.1/95; JUN.2/95

Description (26.00–33.67 m):

Slightly weathered, thinly bedded, dark grey, fine grained SHALE interbedded with limestone. (GEORGIAN BAY FORMATION)

Clay seams noted in the core samples at the following depths :

18.63-18.65
18.79-18.81
20.11-20.13
20.65-20.73
20.79-20.88
21.23-21.25
24.26-24.27
25.97-25.99
29.53-29.55
29.85-29.89
31.19-31.20
31.92-32.05
33.19-33.20
26.51-26.52
26.85-26.87
26.91-26.95
27.12-27.20
27.29-27.32
28.05-28.07
28.14-28.15
28.25-28.26
28.35-28.42
28.50-28.55
28.59-28.63

Run No.	Flush colour / % return
7	LIGHT GREY 75
8	LIGHT GREY 75
9	LIGHT GREY 75
10	LIGHT GREY 70
11	LIGHT GREY 90

Discontinuity type and surface description (top to bottom): B, UE, SM; B, FL, R; J, FL, R; B, PL, R; B, FL, R; J, FL, R; J, PL, R; J, PL, R; B, FL, SM; B, FL, SM; J, FL, R; B, PL, SM; B, FL, SM; B, FL, R; B, FL, R; J, FL, R; B, FL, R; B, FL, SM; B, FL, R

69.83
33.67

END OF BOREHOLE

Notes:

SAND

WATER LEVEL IN DEEP PIEZOMETER AT ELEV. 100.22m ON JUNE 14, 1995.

WATER LEVEL IN SHALLOW PIEZOMETER AT ELEV. 100.21m ON JUNE 14, 1995.

ONE DOUBLE N-SIZE PACKER, 2.44m IN LENGTH AND ONE AW ROD, 3.05m IN LENGTH, LODGED IN HOLE BETWEEN DEPTHS 28.18m AND 33.67m.

DEPTH SCALE: 1 to 50

Golder Associates

LOGGED: P.S
DATE: JUNE 1, 1995
CHECKED: A.J.W

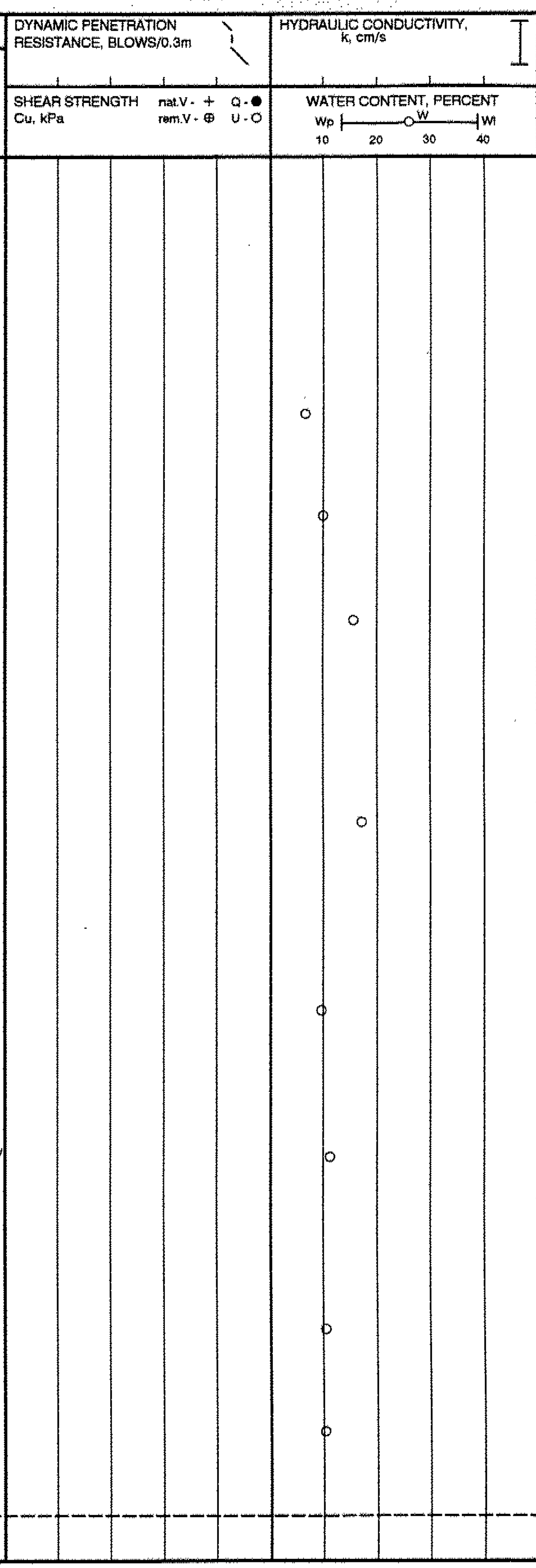
J1376135.BHR
DATA INPUT: DS JULY 7/95
ROCKMV5

RECORD OF BOREHOLE 136

PROJECT: 941-1376
SHEET 1 OF 5
LOCATION: SOUTH SHAFT; SOUTH SERVICE RD.
BORING DATE: MAY 24, 1995
DATUM: GEODETIC
SAMPLER HAMMER, 63.5kg; DROP, 760mm
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

BORING METHOD: POWER AUGER, 108 mm ID HOLLOWSTEM AUGERS

DEPTH SCALE METRES	SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE	103.50 / 0.00					CONCRETE & ELEVATED CAP
	Loose, brown sand and silt, some gravel, occ. cobbles inferred by augering. (FILL)		1	50 DO	7		
	Black, organic silt, with sand and occ. roots. (TOPSOIL)	102.59					
1	Compact, red-brown silty SAND, trace gravel.	102.50 / 1.00	2	50 DO	15		BACKFILL
	Compact, grey SAND and GRAVEL, some silt, trace clay.	102.00 / 1.50	3	50 DO	26		
2	Very dense, grey-brown SAND and SILT, trace gravel and clay.	101.10 / 2.40	4	50 DO	74		
3			5	50 DO	76	MH	BENTONITE SEAL
5			6	50 DO	68		
	Very dense, grey SAND and GRAVEL, trace silt, trace clay, 0.6m thick boulder inferred by resistance to augering at a depth of 6.2m.	98.15 / 5.35	7	50 DO	57/0.2	MH	SAND, PIEZOMETER
7	Hard, grey SILTY CLAY, some sand and gravel, frequent shale gravel sizes with cobbles and boulders inferred by resistance to augering. (TILL)	96.65 / 6.85	8	50 DO	137/.25		BENTONITE SEAL
8	Very dense, grey SAND and GRAVEL, some silt, trace clay with shale fragments and occ. silty clay seams. (TILL)	94.95 / 8.55	9	50 DO	94	MH	SAND, WELL
9			10	50 DO	66		
10	CONTINUED ON NEXT PAGE						



DATA INPUT: DS JULY 7/95

DEPTH SCALE 1 to 50

LOGGED: P.S.
CHECKED: A.J.W

Golder Associates

PROJECT: 941-1376

RECORD OF BOREHOLE 136

LOCATION: SOUTH SHAFT; SOUTH SERVICE RD.

BORING DATE: MAY 24, 1995

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - +, Q - ●, rem.V - ⊕, U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl) 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		CONTINUED FROM PREVIOUS PAGE									
10	POWER AUGER 108 mm ID HOLLOWSTEM AUGERS	Very dense, grey SAND and GRAVEL, some silt, trace clay, with shale fragments, and occ. silty clay seams. (TILL)			11	50 DO	106/.3				CAVED
11											
12		Highly weathered, grey SHALE. (BEDROCK)		91.30 / 12.20	12	50 DO	83/0.1				BENTONITE SEAL
		Hole continued; (refer to sheet 3 for bedrock coring details).		90.90 / 12.60							
13											
14											
15											
16											
17											
18											
19											
20		CONTINUED ON NEXT PAGE									

DATA INPUT: DS JULY 7/95

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: P.S.

CHECKED: A.J.W

J1376136.BHR

PROJECT: 941-1376

RECORD OF BOREHOLE: 136

SHEET 3 OF 5

LOCATION: SOUTH SHAFT, SOUTH SERVICE RD.

DRILLING DATE: MAY 24, 1995

DATUM: GEODETIC

INCLINATION: -90 AZIMUTH: 000

DRILL RIG: DIEDRICH D90

DRILLING CONTRACTOR: MASTER SOIL INVESTIGATIONS LTD.

FR-FRACTURE	F-FAULT	SM-SMOOTH	FL-FLEXURED	BC-BROKEN CORE	
CL-CLEAVAGE	J-JOINT	R-ROUGH	UE-UNEVEN	MB-MECH. BREAK	
SH-SHEAR	P-POLISHED	ST-STEPPED	W-WAVY	B-BEDDING	
VN-VEIN	S-SLICKENSIDED	PL-PLANAR	C-CURVED		

Column headings: DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | 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 m (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) 1 2 3 4 | NOTES WATER LEVELS INSTRUMENTATION

CONTINUED FROM PREVIOUS PAGE

Depth scale: 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21

CONTINUED FROM PREVIOUS PAGE

Elev. 90.90 / Depth 12.60

Drilling record: NW; MAY 24/95; NQ ROCK CORE

Slightly weathered, thinly bedded, dark grey, fine grained SHALE interbedded with limestone. (GEORGIAN BAY FORMATION)

Limestone interbeds at the following depths :

13.80-13.90
15.00-15.06
19.51-19.56
19.65-19.71
20.45-20.51
20.65-20.72
20.82-20.97
21.69-21.77
26.69-26.76
27.18-27.25
27.53-27.58
27.75-27.87
28.30-28.38

RUN No.	FLUSH COLOUR	% RETURN
1	LIGHT GREY	75
2	LIGHT GREY	75
3	LIGHT GREY	75
4	LIGHT GREY	75
5	LIGHT GREY	75
6	LIGHT GREY	75
7	LIGHT GREY	75

Type and surface description:

J, FL, SM
B, PL, SM
R, FL, R
B, PL, SM
B, PL, SM
J, FL, SM
B, PL, SM
BC
B, PL, SM
J, FL, R
B, FL, R
B, PL, SM
B, PL, SM
B, PL, SM
J, FL, SM
B, FL, R
B, FL, R
B, PL, SM
B, FL, R
B, FL, SM
B, W, R
B, PL, SM
B, PL, SM
J, FL, R
B, PL, SM

Notes: BENTONITE SEAL

CONTINUED ON NEXT PAGE

DATA INPUT: DS JULY 7/95

ROCKMV5

DEPTH SCALE:
1 to 50

Golder Associates

LOGGED: P.S.
DATE: MAY 24, 1995
CHECKED: A.J.W

RECORD OF BOREHOLE: 136

PROJECT: 941-1376
LOCATION: SOUTH SHAFT; SOUTH SERVICE RD.
INCLINATION: -90 AZIMUTH: 000

DRILLING DATE: MAY 24, 1995
DRILL RIG: DIEDRICH D90
DRILLING CONTRACTOR: MASTER SOIL INVESTIGATIONS LTD.

DATUM: GEODETIC

J1376136.BHR

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, BC-BROKEN CORE, MB-MECH. BREAK, B-BEDDING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	RUN No.	FLUSH COLOUR / % RETURN	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	NOTES / WATER LEVELS / INSTRUMENTATION
		CONTINUED FROM PREVIOUS PAGE				
21	NQ ROCK CORE	Slightly weathered, thinly bedded, dark grey, fine grained SHALE interbedded with LIMESTONE (GEORGIAN BAY FORMATION) Clay seams noted in the core samples at the following depths : . 15.61-15.62 15.89-15.91 17.37-17.38 18.77-18.79 19.24-19.25 20.19-20.22 20.61-20.63 21.60-21.61 21.65-21.68 22.55-22.56 23.16-23.26 23.36-23.38 26.17-26.61 26.93-26.95	7	LIGHT GREY 75	B, PL, SM B, FL, R	
22			8	LIGHT GREY 75	B, FL, R J, PL, SM B, FL, R B, PL, SM	
23			9	LIGHT GREY 75	B, FL, R B, W, R B, PL, SM B, W, R	
25			10	LIGHT GREY 75	J, FL, R B, PL, SM B, PL, SM	
26			11	LIGHT GREY 75		GROUT ->6.67
28			12	LIGHT GREY 75	B, FL, R B, PL, SM B, PL, R B, PL, SM B, PL, SM	->5.18
29			13	LIGHT GREY 75	B, FL, SM B, PL, SM B, FL, SM B, PL, SM	
31			14	LIGHT GREY 75	J, FL, R B, PL, SM	
		CONTINUED ON NEXT PAGE				

DEPTH SCALE:
1 to 50

Golder Associates

LOGGED: P.S.
DATE: MAY 24, 1995
CHECKED: A.J.W

DATA INPUT: DS JULY7/95
ROCKMV5

RECORD OF BOREHOLE: 136

PROJECT: 941-1376
LOCATION: SOUTH SHAFT; SOUTH SERVICE RD.
INCLINATION: -90 AZIMUTH: 000

DRILLING DATE: MAY 24, 1995
DRILL RIG: DIEDRICH D90
DRILLING CONTRACTOR: MASTER SOIL INVESTIGATIONS LTD.

SHEET 5 OF 5
DATUM: GEODETIC

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, BC-BROKEN CORE, MB-MECH. BREAK, B-BEDDING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	FLUSH COLOUR % RETURN	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	NOTES WATER LEVELS INSTRUMENTATION
		CONTINUED FROM PREVIOUS PAGE					
31	NQ ROCK CORE			14	LIGHT GREY 75	B, PL, S	
						J, W, R	
32						B, PL, SM	GROUT
	MAY 25/95	Slightly weathered, thinly bedded, dark grey, fine grained SHALE interbedded with limestone. (GEORGIAN BAY FORMATION)		15	LIGHT GREY 75	J, FL, R	
						J, FL, SM	
33		END OF BOREHOLE	70.42 33.08				
34							WATER LEVEL IN DEEP WELL AT ELEV. 98.93m ON JUNE 14, 1995. WATER LEVEL IN SHALLOW PIEZOMETER AT ELEV. 98.80m ON JUNE 14, 1995.
35							
36							
37							
38							
39							
40							
41							

DEPTH SCALE: 1 to 50

Golder Associates

LOGGED: P.S.
DATE: MAY 24, 1995
CHECKED: A.J.W

J1376136.BHR
DATA INPUT: DS JULY 10/95
ROCKMVS

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REPORT ON

GEOTECHNICAL INVESTIGATION
MINISTRY OF THE ENVIRONMENT
SOUTH PEEL WATER AND SEWAGE SYSTEMS
HANLAN FEEDERMAIN - SOUTHERN SECTION
PROJECT 5-0020-53
MISSISSAUGA ONTARIO

Submitted to:

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2 copies	-	Golder Associates Ltd. Mississauga, Ontario

November 1993 901-1403-1

ABSTRACT

Golder Associates Ltd. has been retained by Knox Martin Kretch Limited on behalf of the Ministry of the Environment to carry out geotechnical investigations for the southern section of the 2.1 m diameter Hanlan Feedermain. The south section of the feedermain extends from the Lakeview Filtration Plant to Whitney Drive, just north of the Queen Elizabeth Way (Q.E.W.). This report presents the results of our initial and supplementary investigations, our interpretation of the geotechnical data obtained, and recommendations on the geotechnical aspects of design of the works for the currently proposed alignment.

The soil conditions along the route generally consist of silty clay glacial till overlying shale bedrock at about 3 m depth. In the vicinity of the Q.E.W., however, the bedrock surface drops and extensive granular soils were encountered in the boreholes at and north of the Q.E.W..

The majority of the pipeline will be constructed using cut and cover techniques. Significant volumes of shale excavation will be required. Shale excavation should generally be possible by mechanical methods using heavy equipment designed for rock excavation. Excavation in the hard silty clay glacial till will also require above average effort.

Excavated inorganic soil will generally be suitable for use as structural backfill and prepared subgrade for pavement structures. Shale is not recommended for use as structural backfill as the backfill may undergo unacceptable long term settlement. If large magnitudes of settlement can be tolerated, such as within park areas, the excavated shale may be used for trench backfill.

The excess excavated soil should generally be accepted for disposal as restricted lakefill; native soils may be suitable for open water lakefill disposal. Some areas along the route will require detailed evaluation during excavation. Additional chemical testing will be required during construction to confirm the material classification and for acceptance at specific fill sites. Testing for pesticides is currently required for lakefill disposal. The MOE should be consulted regarding the procedures to be adopted to evaluate potential fill materials and fill sites on land.

The proposed tunnel crossings at Lakeshore Road and the Canadian National Railway will be entirely in rock with rock cover above the crown generally less than one tunnel diameter. The tunnel crossing at the Q.E.W. will encounter sand and gravel and silty clay till under some 6 m head of water. Use of an earth pressure balance or a slurry shield TBM is recommended for this tunnel to control flowing ground conditions at the face of the tunnel which, if uncontrolled, could would lead to unacceptable settlements. Provision should be made to deal with and remove boulders from within the tunnel.

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1.0 INTRODUCTION

Golder Associates has been retained by Knox Martin Kretch Limited (KMK), on behalf of the Ontario Ministry of the Environment, to carry out a geotechnical investigation for the southern section of the proposed Hanlan Feedermain project. The proposed feedermain is an approximately 2.1 m inside diameter watermain which extends north from the Lakeview filtration plant some 8.2 km to Burnhamthorpe Road, at the Little Etobicoke Creek (see Figure 1). The southern section, which is the subject of this report, extends from the filtration plant to just north of the Queen Elizabeth Way (Q.E.W.) as shown on Figures 1 and 2.

The purpose of the investigation is to determine the subsurface soil, rock and groundwater conditions for the various components of the project by means of a limited number of boreholes and laboratory testing on selected samples. Based on our interpretation of this information, geotechnical design recommendations are made. Comments on anticipated construction problems, where they may affect design of the proposed feedermain, are provided. A preliminary preconstruction assessment of the disposal of excess excavated material is also included in this report.

Interim and draft reports were issued in December 1990 and February 1992, respectively, presenting the factual information from the initial field work and preliminary recommendations on the initial proposed alignment.

2.0 REGIONAL GEOLOGY

The southern section of the Hanlan Feedermain lies within the physiographic region known as the Iroquois Plain. The Iroquois Plain is the strip of land between the present Lake Ontario shoreline and the former shoreline of glacial Lake Iroquois which formed against the retreating ice sheet at the end of the last period of glaciation. The former Lake Iroquois shoreline coincides approximately with Dundas Street within the study area.

The surficial soils generally consist of granular silts and sands deposited over clayey glacial till. In some places the granular deposits have been eroded to expose the underlying till; in other locations, the till has been eroded and the sandy soils have been deposited directly on the bedrock.

Grey shale bedrock of the Georgian Bay Formation underlies the overburden deposits over the entire study area. The shale is interbedded with layers of limestone. The surface of the bedrock generally dips to the south at a slope of about 5 m per km.

3.0 LAND USE REVIEW

This section of the report provides a brief summary of land use adjacent to the proposed alignment of the southern section of the Hanlan Feedermain, as far as can be determined from readily available information. The purpose of the review was to identify land uses which could be identified as a potential cause of chemical contamination of the soil or groundwater along the route. The results of the review were to be used to refine the locations of boreholes and types of chemical analyses carried out during the field investigation program (Section 4.0). The review was based on available airphotos, Mights Business Directories and a site reconnaissance visit. The local office of the Ministry of the Environment was consulted but did not provide any information on the subject properties.

The references consulted together with the industries identified are listed in Appendix A. This review is not intended to be a comprehensive history of year to year activities carried out on the properties along the route.

The earliest air photo available is dated 1939; it provides good coverage of the area south of Atwater Avenue for that year. At that time, the major land uses were orchard and market garden farms and residential development. A series of rifle ranges existed along the shore of Lake Ontario south of Lakeshore Road.

Airphoto coverage of the entire route is available starting in 1950. Land use similar to 1939 is evident in the 1950 photos; however, the proportion of residential development increased from 1939 to 1950. Other than the rifle range the only commercial land use evident is house wrecking and construction supply yards located on the east side of Northmount Avenue near the Q.E.W. A large hardwood wood lot existed south of the Q.E.W. east of Cawthra.

By 1978, the land use along the route was almost entirely residential with some commercial or industrial areas. No orchard lands or market garden farms remained. The rifle ranges along the lake had been replaced with a school and the Lakeview Filtration Plant. East of the site the rifle range lands had been developed as light industrial units. The lands between the CN Rail lines and Atwater Avenue had been developed as a Department of National Defence base by 1978. St. Paul's Separate School was built on the north side of Atwater Avenue in the early 1970's. The wood lot east of Cawthra Road, south of the Q.E.W. remained as the only large tract of undeveloped land; however, it had been cut back to make way for the Cawthra Road interchange and an ice rink.

The present land use is largely unchanged from 1978. Some fill-in residential development has occurred in vacant lots. The National Defence base had been closed and turned over to the Department of Supply and Services; it has since been sold and is proposed to be developed as residential properties.

The review of previous land use through the area did not identify activities with particular potential for being a source of subsurface contaminants, with the possible exception of the former Department of National Defense lands south of Atwater Avenue. The use of these lands is understood to have been as a truck depot and training centre; however, no specific documentation of the activities of the base were obtained. Likely impacts from these known activities include potential spills of fuel, lubricants and antifreeze from vehicles.

Excavation in the areas outside of the former DND lands could encounter random occurrences of materials associated with agricultural land use, such as pesticides, fertilizers and gasoline storage leaks/spills; and materials associated with residential land use such as heating oil storage leaks/spills. Additionally, the rifle range lands could possibly contain live ammunition at various stages of decomposition.

4.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out between October 4 and October 23, 1990, January 2 and 7, 1991 and October 21 to October 29, 1991; thirty boreholes were put down along the route (numbered 101 to 130) at the locations shown on Figure 2. The initial twenty-four borehole locations were selected to provide general coverage of the route and specific coverage of areas for proposed tunnel shafts and areas of known industrial activities (identified in Section 3.0). Five of the boreholes put down in 1991 were located to investigate the soil and groundwater conditions at the Q.E.W. crossing in greater detail, as had been recommended in the interim report. The sixth borehole put down in 1991 was located at the Lakeview Water Filtration Plant.

Boreholes in areas of proposed open cut were put down to between 5.5 m and 9.0 m depth, sufficiently deep to be generally 1.5 m below the initially proposed maximum depth of invert of the proposed pipe. Boreholes at shaft and tunnel locations were put down to between 7.5 m and 14.7 m depth, some 1.5 m to 7.5 m below the initial proposed maximum depth of invert. The deepest holes were put down at the Q.E.W. crossing, where extensive granular deposits were encountered. Two boreholes, numbers 110 and 112, were put down to about 4 m depth to provide closer spacing for the investigation of potential contamination in the former Ministry of Natural Defense property south of Atwater Avenue.

The boreholes were drilled using drill rigs supplied and operated by specialist drilling contractors. Within the overburden the boreholes were generally advanced using solid stem augers. When the hole would not stay open due to the presence of wet sandy soils, hollow stem augers were used. Where bedrock was encountered within the depth of excavation, augering was continued until refusal. Bedrock drilling below the depth of auger refusal was carried out using diamond coring techniques.

In each boring, samples were obtained at 0.75 m intervals of depth through the augered depth of the hole. Samples were obtained as part of the Standard Penetration Test (SPT) using conventional 50 mm O.D. split barrel sampling equipment. Bedrock core samples were obtained in most holes using NQ double tube core barrels.

Piezometers (12 mm diameter) were installed into Boreholes 101 to 127 to permit monitoring of the groundwater levels at the borehole locations. A piezometer was not installed in Borehole 128 which was drilled on the median of the Q.E.W. Two observation wells (50 mm diameter) were installed in Boreholes 129 and 130 for use in the preliminary pump test. The groundwater levels were observed during drilling operations, and on one or more of November 12 and 13, 1990; January 14, 1991; and November 21, 1991. All boreholes were backfilled to the ground surface upon completion. Most piezometer installations were completed with a 50 mm I.D. steel pipe protective cap concreted in place at the ground surface. Where the tunnel profile at the time of the investigation was such that the tunnel would be within bedrock, the boreholes were backfilled above the piezometer installations with grout or were entirely filled through the rock zone with bentonite gravel.

A pump test to determine the feasibility of dewatering the sand and gravel deposits at the Q.E.W. crossing was recommended in the interim report. The pump test was planned to incorporate two stages. The first stage involved putting down two boreholes (numbered 129 and 130) in which 50 mm diameter well screens were installed. These boreholes were located in between Boreholes 122 and 125 on the east side of the Q.E.W. The observation wells installed in Boreholes 129 and 130 were pumped by airlift using compressed air. The volume of water removed and the effect of the pumping on adjacent piezometers in the area was assessed.

Stage 2 was to have included installation and testing of a 150 mm diameter well screen and casing and a full scale pump test. Stage 2 was not carried out because little yield of groundwater or drawdown was measured during Stage 1 in the monitoring wells.

The field work was supervised throughout by our engineers who located the boreholes in the field, cleared the locations of buried services, directed the drilling and sampling operations and logged the boreholes. The samples were identified in the field and transported to our laboratory for further examination and classification testing.

The locations and ground surface elevations of the completed boreholes were obtained by Knox Martin Kretch Limited. We understand that the elevations are referenced to Geodetic datum.

Twelve overburden samples were selected from various depths along the route for chemical analysis. The analyses covered the parameters required by the Metro Toronto and Region Conservation Authority (MTRCA) manual for an improved lakefill quality control program in effect at the time of the initial investigation (1989), to determine the suitability of the soil for disposal as open water lakefill. These samples were submitted to Barringer Laboratories Ltd. of Mississauga, Ontario for analysis.

5.0 SUBSURFACE CONDITIONS

The detailed subsurface conditions encountered in each of the borings, together with the results of the laboratory testing carried out on representative samples are given on the attached Record of Borehole sheets, on Figures 3 to 12, on Table 1 and in Appendix B. It should be noted that the stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and represent a transition between soil types rather than an exact plane of geological change. Conditions will vary between and beyond the borehole locations.

The Hanlan Feedermain follows the general alignment of the existing Silverthorn Feedermain (1.5 m diameter) from about Seventh Street to the North Service Road. The geotechnical investigation for design of the Silverthorn main was carried out for the Ontario Water Resources Commission by Terra Scan Limited of Toronto. The investigation was reported in Terra Scan Report Number 69TS38 dated November 14, 1969.

The pertinent boreholes from the Terra Scan report have been included at their estimated locations on the profile drawings included with this report (Figures 3, 4, 5 and 6). This information is provided only as supplementary information. Golder Associates has not verified the accuracy or reliability of the borehole records. It is anticipated that the groundwater levels and the stratigraphy shown will have been affected by the construction of Silverthorn Feedermain.

For discussion of the subsurface conditions along the route, the site can be conveniently divided into two sections with the split at about Station 1+950. South of that point, the subsurface conditions generally consist of shale bedrock overlain by clayey silt glacial till which is in turn overlain by sandy silt or fill. The sandy silt deposit overlying the clayey silt till was only encountered north of Station 1+700.

North of about Station 1+950 the soil conditions become more complex. The bedrock surface drops off beyond Borehole 120 (Station 2+200) and was not encountered within the borehole depths until Borehole 201 at Station 3+010. The soil stratigraphy through this area consists of interbedded deposits of sand and gravel, sand, silty sand, silt, and silty clay to clayey silt glacial till.

The following sub-sections describe each of the soil types encountered in the boreholes along the route.

5.1 Topsoil and Fill

Topsoil and or fill was noted at the ground surface in twenty-one of the thirty boreholes put down along the southern section of the Hanlan Feedermain. The topsoil is generally 0.1 to 0.2 m thick. The fill materials, where encountered, appear generally to be derived from excavation and replacement of the natural soils in the area of each borehole. The exception to this observation is Boreholes 108, 109 and 112 put down in the parking area on the former Department of National Defence (DND) property and Borehole 128 located close to the centreline of Q.E.W. The fill at these locations was a brown sand with some gravel which appears to have been imported to construct the parking area and the road, respectively.

5.2 Silt

Samples of silt with some sand and a trace of clay were recovered from Borehole 121 at about 8 m depth and from Borehole 129 at about 4.6 m. The SPT N-value for this material was 15 blows per 0.3 m penetration in Borehole 121, but greater than 100 blows per 0.3 m of penetration in Borehole 129. The measured water content of the samples was 21 percent in Borehole 121 and about 15 percent in Borehole 129. A typical grain size distribution curve for this material is shown on Figure 7.

5.3 Silty Sand and Sandy Silt

With the exception of a shallow surficial deposit of sandy silt at Borehole 106, silty sand or sandy silt materials were not encountered south of about Station 1+700. However, from that point north these materials were encountered in Boreholes 121 through 126, 129 and 130, and were reported in most of the Terra Scan boreholes. These soils are in a very dense state when encountered below the zone of frost action, typically having N-values of 50 blows or greater. The measured water content of samples was typically about 15 percent but ranged from 9 to 20 percent. Grain size distribution test results for samples of silty sand and sandy silt are shown on Figure 8.

5.4 Sand

Deposits of sand were encountered near the ground surface in Boreholes 119, 120, 121, 122, 124 and 201, and beneath the shale slab at about 7.3 m depth in Borehole 130. Typically the sand deposits are compact at the ground surface (N-values of 8 to 14 blows) and become dense to very dense with depth (N-values in excess of 30 blows per 0.3 m of penetration). The measured water content of samples of sand was typically about 13 percent but ranged from 4 to 21 percent. Grain size distribution curves for two samples of sand are provided on Figure 9.

5.5 Sand and Gravel

Sand and gravel deposits were encountered at depth in Boreholes 121 to 126, and 128 to 130 during the present investigation and were reported in Terra Scan Boreholes 19, 20, 21, 24 and 25. Generally, the sand and gravel deposit is very dense (N-values of 48 blows to greater than 100). Boulders were commonly encountered in this deposit. Grain size distribution test results for split barrel samples of this material are presented on Figures 10 and 11. At the Borehole 124 location, the sand and gravel had a higher silt content and a till-like structure. A grain size curve for this material is shown on Figure 12.

5.6 Silty Clay

Grey silty clay till with some sand and a trace of gravel was encountered in every borehole along the route except for Boreholes 121 and 122 and Terra Scan Boreholes 20, 21 and 25. The consistency of the till is generally hard, however, some softer zones were encountered. SPT N-values in this material ranged from 16 blows to greater than 100 blows per 0.3 m penetration. The natural water content of samples of the grey silty clay till was typically determined to be about 14 percent, with a range of 5 to 17 percent. The plasticity index and liquid limit of this material ranged from 13 to 20 per cent and 34 to 40 per cent, respectively. Grain size distribution analysis results for two samples of grey silty clay till are shown on Figure 13. Grinding and difficulty advancing the augers at some levels in Boreholes 106 and 115 are considered to be indications of boulders or limestone slabs within the till.

In Borehole 123, north of the Queen Elizabeth Way, an upper deposit of silty clay till was encountered. This deposit is reddish grey, contains some sand and gravel and has a hard consistency. The water content of samples of the reddish till was determined to be 8 percent. The plasticity index and liquid limit were determined to be 9 per cent and 26 percent, respectively.

5.7 Shale Bedrock

Grey shale bedrock was encountered between 1.8 m and 5.8 m depth in each borehole put down for this investigation except for Boreholes from 121 through 124 and 126, 128, 129, in the vicinity of the Queen Elizabeth Way. Shale slabs were, however, encountered in Boreholes 125 and 130 at 8.8 m and 6.6 m depths, respectively. Borehole 129 may have been terminated within a shale slab, based on the stratigraphy of the adjacent Boreholes 125 and 130. Grey shale was encountered at 14.3 m and 11.0 m depths in Borehole 125 and 130, respectively. These holes were terminated at 14.7 m and 11.7 m depth in the shale.

The core samples retrieved from the boreholes are from the Georgian Bay Formation and consist of grey shale interbedded with frequent thin layers of shaley limestone. Generally, the total limestone component is less than about 15 percent of rock cored, however, it comprised up to 22 per cent (Borehole 109). The limestone layers are typically less than 25 mm thick but can be up to 300 mm thick (Borehole 101).

The rock is weathered at its interface with the soil. In some boreholes the weathering had resulted in more than 4.0 m of residual soil (Borehole 128 was terminated in the residual soil deposit). Generally, the upper 1 m of the rock is highly to completely weathered, but becomes slightly weathered by about 3 m below the bedrock surface.

The bedrock surface is depressed between about Station 2+200 (Borehole 120) and Station 3+00 (Borehole 201). Immediately south of the Q.E.W. crossing, the bedrock surface also appears to undulate. The undulation and major depression of the bedrock surface may be indicative of a meandering stream which was cut into the bedrock surface and subsequently infilled.

5.8 Groundwater Conditions

Piezometers were installed in all the boreholes put down along the southern section of the feedermain, except in Borehole 128. The stabilized groundwater levels as measured on November 12 or 13, 1990; January 14, 1991; or November 21, 1991, are shown on the Record of Borehole sheets and on the profile drawings (Figures 3, 4, 5 and 6).

The groundwater table is generally at about 2 m depth below ground surface and follows the ground surface topography. Groundwater flows in a general southerly direction toward Lake Ontario.

5.9 Pump Test

Pump tests were performed on November 21, 1991, by members of our staff to determine the extent, nature and hydraulic characteristics of the granular deposits at the Q.E.W. crossing. The 50 mm diameter well installed in Borehole 130 was pumped by airlift using compressed air. The volume of water removed, together with the effect of pumping on the other wells and piezometers in the area (Boreholes 121, 123, 125, 126, 129), were recorded. During 3 hours of pumping, the yield of water from the well was only about 370 litres. The effect of pumping on the other wells was insignificant; the water levels were only lowered 1 cm to 3 cm from the initial readings.

The same procedure was applied to the observation well installed in Borehole 129. The volume of water removed from the well was only 23 litres during 72 minutes of pumping. No effect on water levels in adjacent piezometers or observation wells was noted. When pumping from Borehole 129 was stopped, the water level rose from 7.1 m depth to its initial level of 3.8 m within 160 minutes.

Since the yield and the radius of influence of the first stage of the pump test was so limited, the second stage of the test was not initiated.

Boreholes 129 and 130 were put down to intercept the water-bearing sand and gravel zones that were encountered in Boreholes 122 and 125. The thickness of the sand and gravel zones in Boreholes 129 and 130 was much less than the thicknesses encountered in Boreholes 122 and 125. Pump tests could not be carried out on any holes north of BH 129 due to access restrictions imposed by Q.E.W., its ramps and service roads.

5.10 Chemical Analyses

Twelve soil samples were submitted to an independent chemical laboratory for a suite of analyses to determine the suitability of the soil for disposal as unconfined lakefill. The results of these analyses are summarized on Tables 1 and 2. The report from the testing laboratory is included in Appendix B.

Tests for pH, chloride and sulphate content were performed on samples of sandy silt from Borehole 122 and silty clay till from Borehole 123 to investigate the potential for deterioration of concrete and steel building materials in contact with the natural soils along the route. The analyses determined that the samples had pH's of 8.70 and 8.38, chloride contents of 9.2 ppm and 10.7 ppm, and sulphate contents of 142 ppm and 457 ppm, respectively. These levels of pH, chloride and sulphate do not indicate ground chemistry which would be unusually corrosive.

6.0 ENGINEERING RECOMMENDATIONS

This section of the report provides our interpretation of the factual geotechnical data obtained during the investigation and it is intended for the guidance of the design engineer only. The extent of fieldwork completed may not be adequate for construction and where comments are made on construction, they are provided only in order to highlight aspects of construction which could affect the design of the project. Contractors bidding on or undertaking the works must make their own interpretation of the factual data as it affects their proposed construction methods, equipment selection, scheduling and the like.

6.1 Feedermain Alignment

The initially proposed feedermain alignment was provided on a drawing titled "Hanlan Feedermain Alignment, Section 1, Plan-Profile 0+000.0 to 3+150.0, Plan 1" File 1677.02-B-1, Drawing No. 1, dated October 1990. Subsequent to the investigation, the profiled was revised as shown on the above revised drawing File 1677.02 -B-3, dated January 1991 and on two separate drawings with revisions titled "M.O.E. Project No. 5-0020-53 and 5-0020-49, Hanlan Feedermain Contract 1, Station 2+580 to 2+820 and Station 0+840 to 1+120", dated October 1991, prepared by Knox Martin Kretch Ltd. The proposed horizontal alignment is shown on Figure 2, and the later version of the proposed vertical alignment is shown on Figures 3, 4, 5 and 6. It should, however, be noted that the chainages as shown on Figures 3 to 6 will not necessarily correspond to the chainages shown on the contract drawings.

6.1.1 Depth of Feedermain

There is significant advantage to maintaining the vertical alignment as shallow as possible where the feedermain is to be constructed in open cut (cut and cover). Obviously, this minimizes the total quantity of excavation, and it minimizes the volume of rock excavation. Additionally, since shale is not recommended for use as backfill beneath roadways (Section 6.3) minimizing shale excavation also reduces disposal and granular borrow costs. Where the feedermain is to be constructed using tunnelling techniques in rock, there is advantage to maintaining the alignment as deep as possible to permit tunnel advancement with enough rock cover to minimize support requirements.

6.1.2 Plant to Ninth Street

The section of the feedermain from Station 0+000 to about Station 1+950 is proposed to be constructed using cut and cover techniques except at the Lakeshore Road and CNR crossings, where tunnelling will be required. The proposed invert along this section is at between about Elevations 71 m and 95 m. Based on the results of Boreholes 101 through 118, inclusive, 127 and Terra Scan Boreholes 14 to 19 (see Figures 3 and 4), the excavation will be extended to about 0.5 m to 5 m depths below the bedrock surface.

The bedrock is typically overlain throughout this section by a layer of residual soil (completely weathered shale) and/or a layer of silty clay till. The silty clay till extends to the ground surface in some areas; in others it is overlain by layers of fill, silty sand and sandy silt and occasionally sand and gravel. The groundwater level measured within the shale was between about 1 m and 5 m above the invert level.

The excavation for the feedermain could be made in open cut using the side slopes and setbacks recommended in Section 6.2. Alternatively, the excavation through the overburden could be carried out as a braced, shored vertical excavation, also following the recommendations made in Section 6.2. Some water flow into the excavation through water-bearing sands to sand and gravel, and fractures in the bedrock should be expected where the excavation is extended below the groundwater level. It is anticipated that the quantity of seepage can be handled by pumping from properly filtered sumps located at the base of the excavation.

6.1.3 Lakeshore Road Tunnel

The proposed vertical alignment at the crossing of Dundas Street will require construction of a tunnel about 33 m in length extending through shale with an invert at about Elevation 75.5 m (about 7 m below the road grade) (see Figure 3). Based on the results of Boreholes 103 and 104, the crown of the tunnel will be about 2 m to 2.5 m below the bedrock surface.

The shale was penetrated by augering to Elevations 79.3 m and 79.6 m in Boreholes 103 and 104, respectively. The rock core samples obtained below the level of auger penetration consisted of shale which is highly to moderately weathered, becoming fresh with depth. RQD values of between 50 percent and 80 percent were measured within the depth of the proposed tunnel. At and above the crown of the tunnel, the RQD values of about 20 percent were measured. Groundwater levels as measured in piezometers sealed in the shale bedrock are at between Elevations 80.3 m and 81.2 m, or about 2.3 m to 3.2 m above the crown.

Based on the borehole information, the shale just above the crown of the tunnel is completely to moderately weathered. The tunnel will generally be advanced through moderately fractured shale of fair to good quality. The tunnel may be advanced by hand excavation using tractor mounted excavators and pneumatic tools. The likely presence of limestone interbeds within the shale would tend to slow down the rate of progress during excavation. Due to the presence of joints and fractures, the limestone interbeds and the fissile nature of the shale, the shale may break apart in blocks or slabs making it difficult to control the tunnel profile. A line of perimeter holes drilled at a spacing of 0.2 m may be required in order to produce the required tunnel profile with a minimum of overbreak.

Drilling and blasting methods should not be used due to the limited thickness of rock cover, and the proximity to existing services. A Tunnel Boring Machine (TBM) is technically feasible for this crossing, but is likely to be uneconomical for such a short tunnel.

Temporary tunnel support requirements are based on factors such as the amount of rock cover and the rock quality above the tunnel. Since the crown of the tunnel is located within the weathered part of the bedrock where the fracture frequency is generally high and the rock quality is low, it is recommended that a system of steel liner plates be used for primary support of the tunnel. The system should be designed to support the full weight of the overburden plus any surcharge along the alignment. The tunnel liner plates would provide continuous support, permit grouting to be carried out on a continuous basis and may assist in reducing water seepage into the tunnel through fractured and weathered rock. The liner plates should be installed immediately behind the face. Grouting between the liner plate and the surrounding ground must be carried out as soon a possible after the liner plates are installed to prevent rock loosening from taking place.

Alternatively, the entire tunnel cross-section could be stabilized using steel sets and spiling ahead of the face. Shotcreting of the entire cross-section together with rock bolts and mesh at the crown and on the side walls may be required with this method of support. A rock bolt/wire mesh/shotcrete system may be used to support the tunnel only if there is at least 3 m of relatively unfractured, good quality rock above the crown of the tunnel. The rock conditions must be inspected in the field by qualified geotechnical personnel during construction to ascertain that the actual level of support provided is appropriate for the conditions encountered in the tunnel.

The shale bedrock of the Georgian Bay Formation is known to exhibit time dependent deformation due to stress relief. The rate of deformation for these shales is sufficient to cause distress in permanent concrete tunnel linings. Since the tunnel section is being excavated near the surface of the Georgian Bay Shale Formation, it is anticipated that the rock movements associated with relief of the horizontal stresses will be relatively small (tunnel convergence in the order of 1 cm to 2 cm). The rock movement due to stress relief can be accommodated by applying 50 mm of compressible foam between the pipe and the rock surface and/or primary liner. If thrust resistance for the feedermain (developed between the pipe and the surrounding ground) is needed along this tunnelled portion, compressible foam cannot be used to accommodate the movement as it would not provide thrust resistance. In this case, the deformation of the rock must be permitted to take place prior to installing the pipe.

It is anticipated that the rock deformations will occur relatively quickly, within two to three months. The rock tunnel walls should be monitored to ensure that the rock movements have ceased prior to grouting the feedermain in place. The monitoring should consist of arrays of 5 surface monitoring pins as shown on Figure 14, installed in the rock at two stations along the tunnel. It should be noted that the details shown on Figure 14 assumes a rock bolt/wire mesh/shotcrete system for temporary supported (primary liner) of the tunnel. Provision should be made for installation of the monitoring pins through the liner plate system where used as primary liner. These surface monitoring pins would be monitored by Golder Associates using a tape extensometer to measure between the pins. The construction contract should require the Contractor to: provide 25 mm diameter holes, 0.5 m deep, at the locations shown on Figure 14; protect the pins by installing approved protective sleeves; and provide Golder Associates access to the pins to carry out the movement monitoring program. The feedermain pipes can be installed after consecutive measurements and the trend of measurements indicates that the movement has ceased.

Groundwater inflows must be controlled at all times during construction. Seepage from the weathered zone and through joints of bedrock should be anticipated. There should be provision for continuous pumping from localized sumps within the tunnel along its entire length.

6.1.4 CNR Tunnel

The proposed vertical alignment along this portion of the route will require construction of a 35 m long tunnel crossing under the Canadian National Railway (CNR) corridor. The pipe invert is at about Elevation 78.5 m (about 9 m below the surface of the railway embankment) (see Figure 3). Based on the results of Boreholes 107 and 108, the crown of the tunnel will be about 1.3 m to 2.7 m below the bedrock surface. The shale in Boreholes 107 and 108 was penetrated by augering to Elevations 81.9 m and 83.0 m, respectively. The bedrock core samples obtained below these elevations consist of moderately weathered to fresh shale with interbedded shaley limestone. RQD values range from 20 percent to 70 percent within the proposed tunnel depths. The lower RQD values are attributed to the presence of zones of broken core with thicknesses varying between 25 mm and 100 mm. Above the crown of the tunnel, the RQD values range from 60 to 90 percent. Groundwater levels as measured in piezometers sealed in the shale bedrock are at about Elevations 84.5 m, or about 3.5 m above the crown of the pipe.

Based on the borehole information, the shale above the crown is of fair to good quality, whereas the tunnel will be advanced through shale of very poor to fair quality. Since there is a lack of rock cover above the crown (less than one tunnel diameter) for part of the tunnel length, it is recommended that steel liner plates be provided as primary support to the tunnel. The recommendations for the Lakeshore Road Tunnel in Section 6.1.3 regarding construction sequence, monitoring, primary support and dewatering should be followed for the CNR tunnel.

6.1.5 Ninth Street to Q.E.W.

The section of the feedermain extending from Ninth Street to Q.E.W., from Station 1+950 to Station 2+520, is proposed to be constructed using cut and cover techniques. The proposed invert of this section of the alignment is typically about 5 m below the existing ground surface. Based on our Boreholes 119 to 121 and Terra Scan Boreholes 20 to 22 the bottom of the excavation will be mostly in overburden except in the vicinity of Borehole 120, where shale bedrock will be encountered. The soil conditions are variable and typically consist of interlayered sandy silt, silty sand, sand and gravel and silty clay till (see Figures 4 and 5). The groundwater level within this area is typically about 2.5 m to 3.5 m above the proposed pipe invert.

South of Borehole 120, the bottom of the excavation will likely be in sand to sand and gravel, which will become loosened by upward seepage if excavation is carried out without prior groundwater control. Provision should be made to lower the groundwater level within these soils to below the base of the excavation by means of pumping from wells installed to below the base and screened through the coarse granular deposit. For the rest of this section, the bottom of the excavation will be in sandy silt to silty sand. Dewatering of these finer granular soils could be accomplished by means of vacuum well points or eductor systems. All dewatering systems should be designed, installed and maintained by an experienced groundwater control firm.

Dewatering operations can affect off-site properties in terms of structure settlement and water wells. It is not anticipated that any private wells exist adjacent to the site; this should be confirmed prior to commencing any groundwater lowering. Due to the dense nature of the soils encountered at depth in this investigation, we do not consider it likely that dewatering will cause settlement damage to off-site structures properly founded on the dense soils. However, it would be prudent to conduct a preconstruction survey of private properties adjacent to the site for use in evaluating any complaints which may be registered both during and following completion of construction.

The excavation for this section of the feedermain could be carried out in open cut using the side slopes recommended in Section 6.2 provided that adequate dewatering is implemented prior to excavation. The excavation could be safely carried out within trench boxes or within a braced, close sheeted timber shoring vertical excavation, following the recommendations made in Section 6.2, again provided that the groundwater level is lowered to below the base of the excavation.

6.1.6 Q.E.W. Tunnel

The Q.E.W. crossing will require construction of a 113 m long tunnel extended through overburden materials (see Figure 5 and 6). Based on the results of our Boreholes 122, 123, 125, 126, 128 to 130 and Terra Scan boreholes 23 to 25, the tunnel excavation will be within variable soils ranging from water bearing sand to sand and gravel, silty clay or clayey silt till and silty clay residual soil. Throughout most of its length, the tunnel may have a cover of variable thickness of hard silty clay to clayey silt till although water bearing sand/sand and gravel deposits will be present at the tunnel crown for portions of the tunnel length. Boulders were encountered in both the sand and gravel and the silty clay to clayey silt till deposits. Shale bedrock slabs were encountered within the sand and gravel deposits in two boreholes. The groundwater levels measured in the piezometers installed along the proposed tunnel alignment were at between Elevations 100.3 m and 101 m, some 3.5 m above the crown of the tunnel.

Tunnelling in the very dense sand to sand and gravel below the groundwater table will result in "flowing" tunnelling conditions (Tunnelman's Ground Classification System). The hard silty clay to clayey silt till will result in "hard" tunnelling conditions. Provision must be made for dealing with and removing boulders from within the tunnel and for stabilizing the tunnel face as the excavation proceeds.

Dewatering at this site will be difficult because the water-bearing deposits are extremely variable in composition and thickness, do not have any regular pattern which would indicate horizontal continuity, and are often silty, which impedes dewatering. The results of the preliminary pump tests suggest that conventional "deep wells" cannot be depended on to effectively dewater the entire tunnel alignment because the Q.E.W. (which cannot be affected by the construction) restricts the possible locations of dewatering wells, and because the bulk of the sand and gravel deposits may be too silty to drain freely to the wells. In addition, there may be concern for potential settlement of existing services if dewatering procedures are adopted.

As deep well dewatering is not considered feasible in this case, alternative methods of controlling the groundwater have to be considered. Such methods could include:

- local dewatering ahead of the face by pressure relief pipes installed from the face;
- ground treatment by grouting;
- use of compressed air;
- use of a full face slurry or earth pressure balance tunnelling machine.

We would not recommend compressed air in this case. There is a general concern about the health of workers exposed to compressed air, and this leads to enhanced labour costs. The ground also contains pockets and lenses of extremely open gravels. Air losses in these gravels are likely to be very high. Air losses could lead to:

- drying out of the soil, resulting in "running" ground conditions;
- a complete loss of air pressure in the tunnel, which would be followed rapidly by complete inundation.

Dewatering or grouting from within the tunnel would be slow and difficult, particularly given the limited size of the tunnel. Although this type of work has been carried out successfully in the past, there is always a concern that a window in the treatment or a poorly placed pressure relief pipe would lead to problems developing during tunnelling.

For tunnelling under the Q.E.W. in difficult ground, there would appear to be significant advantages in using a TBM of either the slurry or earth pressure balance type. A slurry machine uses a bentonite slurry to balance the water and soil pressure at the face. The pressure in the chamber is maintained either by direct pressurisation of the slurry line or by a reservoir of compressed air. In an earth pressure balance shield, the excavated soil, possibly with some added bentonite, acts in the same way as the slurry in the slurry machine. However, pressure is maintained by controlling the rate of extraction of excavated soil against the rate of shield advance. The major concern in using such a machine on this work is the ability of the machine to excavate and transport boulders; it must be ensured that the machine proposed by the Contractor for this work can handle and accommodate shale slabs up to 1 m in size and boulders of variable size. Consideration could also be given to pipe jacking techniques for construction of the feedermain tunnel although the concerns for handling boulders and control of the face must as well be addressed with the proposed construction procedures.

If the contractor elects to use conventional hand mining techniques, he should be required to demonstrate, by monitoring the groundwater levels in piezometers installed along the alignment, that the groundwater levels have been lowered to and maintained below the springline of the tunnel prior to beginning tunnelling in any section.

Groundwater control will be required at the shaft locations for this crossing regardless of the method of tunnelling employed. The method of dewatering will depend on the subsoil conditions at the proposed shaft locations. Dewatering will probably require a combination of deep wells installed into the cleaner sand and gravel layers (if located in the vicinity of Boreholes 122 and 123) and eductor wells in the less permeable silty sand and sandy silt soils. All groundwater control systems used for this crossing should be designed, installed and maintained by a specialist groundwater control firm.

Dewatering/groundwater control operations can affect off-site properties in terms of structure settlement and water wells. It is not anticipated that any private wells exist adjacent to the site. Due to the dense nature of the soils encountered in this investigation, we do not consider it likely that dewatering will cause settlement damage to off-site properties. However, it may be prudent to conduct a preconstruction survey of private properties adjacent to the site to properly evaluate any complaints which may be registered both during and following completion of construction. It is also recommended that the location of existing utilities be established to determine if the proposed dewatering will affect the utilities.

The primary support for the tunnel could consist of conventional ribs and lagging which is typical for local tunnelling projects. Due to the groundwater levels and relatively permeable nature of the soils which may be encountered along some sections along the tunnel, there could be considerable flow into the tunnel through a rib and lagging system. Additionally, the potential exists for fine particles of soil to be washed into the tunnel through the joints between the lagging boards, by the flow of groundwater causing additional settlement of the ground surface along the alignment. In this regard, consideration should be given to the use of a liner plate system for temporary support.

6.1.7 Q.E.W. to End of Contract

The section of the feedermain extending from north of the Q.E.W. to the end of the contract is proposed to be constructed using cut and cover techniques. The proposed invert of the pipe is typically between 5 m to 7 m below the existing ground surface. Based on Boreholes 123, 124 and 201, the bottom of the excavation will generally be in overburden south of Breezy Brae Drive and will be in shale bedrock north of Breezy Brae Drive. The soils along this section could consist of sandy silt to silty sand, sand and gravel and silty clay to clayey silt till. The groundwater level along this section is typically 4 m above the proposed invert.

The excavation for the feedermain could be made in open cut using the side slopes and setbacks recommended in Section 6.2. Alternatively, the excavation through the overburden could be carried out as a braced, shored vertical excavation, also following the recommendation made in Section 6.2.

Groundwater control will be required along this section of feedermain due to the presence of waterbearing sands, gravels and silts forming the excavation sides and base. Dewatering of the sandy soils may be carried out by using a combination of wells and eductor wells. The depth of dewatering required is beyond the normal limit vacuum well points. The dewatering system should be designed, installed and maintained by a specialist groundwater control firm. In the vicinity of Borehole 201, it is anticipated that the quantity of seepage through the bedrock and clayey deposits can be handled by pumps used in conjunction with properly filtered sumps.

Dewatering operations can affect off-site properties in terms of structure settlement and water wells. It is not anticipated that any private wells exist adjacent to the site; this should be confirmed prior to commencing any groundwater lowering. Due to the dense nature of the soils encountered at depth in this investigation, we do not consider it likely that dewatering will cause settlement damage to off-site structures properly founded on the dense soils. However, it would be prudent to conduct a preconstruction survey of private properties adjacent to the site for use in evaluating any complaints which may be registered both during and following completion of construction.

6.2 Excavations

Temporary unsupported trench excavations in hard or dense glacial till and in hard clayey silt residual soil can be made at 1 horizontal to 1 vertical. It should be noted that glacial till deposits inherently contain boulders, and boulders should be expected within the trench excavation. Temporary unsupported excavations in stiff clayey soils and in granular soils above the water table can generally be made with side slopes maintained no steeper than 1.5 horizontal to 1 vertical. Where wet sandy soils, soft or fine clayey soil or organic soil is encountered, side slopes to the trench should not be steeper than 2 horizontal to 1 vertical provided that adequate groundwater measures are implemented. Discussion on where requirements for groundwater control measures should be anticipated is provided in Sections 6.1.2 to 6.1.7.

Excavations in the shale bedrock can be made in vertical cut; however, the shale excavation face must be carefully scaled to remove loose material prior to allowing workers in the trench. Mechanical excavation of the shale bedrock should be possible with a large backhoe properly equipped with rock teeth and hydraulic hoe ram to break up the limestone layers. The rate of progress will be governed by the frequency and thickness of limestone layers within the shale bedrock. Particular difficulty in excavation of the rock occurs where vertical penetration of the horizontally layered rock structure is required within confined spaces, such as at the beginning of a trench or at a drop in trench invert and where the depth of rock excavation is greater than the width of the trench. Excavation of the bedrock will cause accelerated wear on the excavator.

The shale bedrock will tend to break horizontally into blocks and slabs due to its layered nature. This will be particularly evident in areas where thicker layers of limestone exist within the shale near the bedrock surface. If pre-splitting (by line drilling or hydraulic hoe ram) along the proposed edges of the trench is not carried out, the shale blocks and slabs may break beyond the trench lines. This overbreak may result in undermining of the open cut slopes above the bedrock or of the soil behind the trench support system as shown in Figure 15. Allowance should be made to leave an approximately 1 m wide ledge at the bedrock surface on either side of the excavation to minimize the potential for undermining.

Where the excavation in the rock is less than 2 m, the ledge may be made narrower. For deeper excavations into rock, the ledge may also be narrower with controlled splitting of the bedrock and where the overburden materials consist of cohesive soils and dry sands. In these cases, however, there should be provision for providing support of the rock face in the form of rock bolts, wire mesh and shotcrete should the quality of the bedrock warrant.

Construction in open cut will require more excavation and restoration over a wider area and will cause a greater restriction on traffic than would construction within a vertically supported excavation. However, these considerations may be offset by the advantages of open cut construction which is typically faster in dry conditions than installing shoring. An open excavation would provide the room required for conventional compaction equipment. Reduced lift thicknesses and suitably sized compaction equipment are required to adequately compact backfill within a vertical sided, supported excavation.

The options available for support of the excavation include trench boxes, strutted soldier pile and lagging walls and timber shoring. Of these methods, a properly designed and constructed soldier pile and lagging system will induce the least ground movement adjacent to the excavation. The trench box will allow the greatest amount of ground movement adjacent to the excavation and is not recommended where movement is a concern such as where the excavation is made in close proximity to settlement sensitive structures or utilities. As a guide, it is recommended that soldier pile and lagging temporary support be used where existing services are within the zone defined by a line drawn at 60° to the horizontal outward and upward from the base of the trench. In the case of soldier pile and lagging walls, movement adjacent to the excavation can be further minimized by preloading struts to a load 20 per cent in excess of their design load.

Temporary shoring systems should be designed taking into account the horizontal earth loads, hydrostatic pressure and surcharge loadings as shown in Figures 16 and 17. The groundwater level may be assumed at an average of 2 m depth below existing ground surface. The following parameters may be assumed for the design of the shoring systems.

Sandy Silt to Silty Sand (compact to dense) - Figure 16

$K = 0.24$

$\gamma = 21\ kN/m^3$

$\gamma_w = 9.8\ kN/m^3$

Clayey Silt to Silty Clay (stiff to hard) - Figure 17

$K = 0.3$

$\gamma = 20 \text{ kN/m}^3$

$\gamma_w = 9.8 \text{ kN/m}^3$

Shale Bedrock (weathered) - Figure 16

$K = 0.22$

$\gamma = 22 \text{ kN/m}^3$

$\gamma_w = 9.8 \text{ kN/m}^3$

Notwithstanding the above recommendations, all excavations should be carried out in accordance with the current Occupational Health and Safety Act.

6.3 Pipe Bedding and Granular Surround

It is understood that consideration is being given to the use of concrete pressure pipe and/or concrete encased welded steel pipes for the feedermain. The pipe should be bedded on 300 mm of OPSS Granular A compacted to 100 percent of its Standard Proctor maximum dry density.

The trench should be backfilled to 500 mm above the crown of the pipe with OPSS Granular B, Type II compacted to 95 percent of its Standard Proctor maximum dry density. Excavated native granular soils may be re-used as trench backfill subject to certain conditions (see Sections 6.5.1. and 6.5.4). Care must be taken to adequately compact the bedding near the pipe haunches. The granular surround should be placed and compacted in regular lifts maintaining the surface of the granular evenly on both sides of the pipe. The lifts should be no thicker than 200 mm loose thickness.

The following material properties can be used for final design:

	γ_D (Mg/m³)	γ_{SAT} (Mg/m³)	ϕ (deg.)	δ_{Steel} (deg.)	$\delta_{concrete}$ (deg.)
Granular "A"	2.2	2.4	39	22	28
Granular "B" Type I	2.0 - 2.2	2.2 - 2.4	30 - 36	N.A.	N.A.
Granular "B" Type II	2.2	2.4	39	22	28
Native Sand Backfill	1.9	2.1	32	N.A.	N.A.

LEGEND

ϕ - design angle of internal friction
δ_{Steel} - design angle of friction between steel and material listed
$\delta_{concrete}$ - design angle of friction between concrete and material listed
γ_D - design dry unit weight
γ_{SAT} - design saturated unit weight

6.4 Thrust Restraint

Preliminary horizontal bearing capacities for thrust blocks for the bend locations for this project are shown in the following table. These values (except Station 2+800) are based upon estimated material properties (based upon published test results for Georgian Bay shale in the Metro Toronto Area), the physical condition of the core recovered at the bend locations, and a two dimensional boundary element model of the reaction of the ground to a thrust block load. The thrust values should be confirmed in the field by means of load tests at, say, three locations if thrust blocks are incorporated into the design. One of the load tests should be carried out at the bend at approximately 2+800.

There must be some deformation of the rock to develop any resistance. The thrust values tabulated are for two cases of movement (5 mm and 15 mm) that may be considered acceptable. The amount of movement that will occur will be a function of the load, the soil and rock conditions, and the method of constructing the excavation for the thrust block interface with the shale or silty clay till (Station 2+800 only). To obtain the stiffest reaction, the bearing surface should be line drilled on close (300 mm) centres and excavated mechanically.

PRELIMINARY ESTIMATES OF LOAD AND DISPLACEMENTS ON THRUST BLOCKS

STN	BH	THRUST BLOCK TYPE	DEPTH OVERBURDEN (m)	DEPTH ROCK (m)	RQD ON PIPE AXIS	AVERAGE RQD	DESIGN THRUST (kPa) DISPLACEMENT 5 mm	DESIGN THRUST (kPa) DISPLACEMENT 15 mm
0+020	127	A	2.4 *	2.5 *	90 %	65 %	350	800
		B	2.4 *	4.6 *	40 %	40 %	300	700
0+070	101	A	2.3	2.0	90 %	65 %	600	1200
		B	2.3	4.1	90 %	75 %	700	1400
0+640	106	B	4.2 *	1.6 *	40 %	35 %	250	325
0+670	106	B	4.3	1.6	40 %	35 %	250	325
0+740	107	B	5.0	1.6	90 %	90 %	700	1400
0+790	108	A	2.7	0.9	55 %	60 %	500	1000
		B	2.7	3.0	70 %	65 %	650	1300
1+165	113	A	2.1	2.0	65 %	55 %	500	1000
		B	2.1	4.1	65 %	60 %	650	1300
1+235	114	A	2.2	1.3	60 %	40 %	350	800
		B	2.2 *	3.4 *	70 %	50 %	500	1000
1+420	115	B	4.3 *	0.3 *	20 %	20 %	250	325
1+590	116	B	4.2	-0.4	20 %	20 %	200	275
2+800	124	C	Full Depth	N.A.	N.A.	N.A.	200	275
3+000	201	A	3.2	1.3	20 %	10 %	250	325
		B	3.2	3.3	40 %	20 %	300	375

NOTES:
(1) Depth of rock refers to amount of rock above top of thrust block
(2) Type "A" thrust block is built at the pipe bend; the axis of the thrust block is coincident with the pipe axis. Type "B" thrust block is built below the pipe and is structurally fastened to the pipe. Type "C" thrust block is similar to Type "A", but is supported by soil.
(3) * indicates interpolated condition.
(4) Estimates to be confirmed in the field by load tests at selected sites.

6.5 Trench Backfill

6.5.1 Excavated Soil Backfill

We understand that it is proposed to reinstate the open cut excavations on residential streets (collectors and residential) to the pavement subgrade level and to ground surface within the park, using as much of the excavated soil from the feedermain trenches as possible. The material excavated from open trenches during construction of the feedermain will include most of the materials listed in Sections 5.1 through 5.7.

The excavated soils will be suitable as structural backfill only where the material is free of organic material and debris and where the material is at a water content suitable for compaction. Soils are considered suitable for compaction if the materials' water content at the time of placement is within ± 2 percent of the optimum value. The estimated optimum water content and typical in situ water content (as measured on samples obtained in the boreholes) for the acceptable backfill materials are tabulated in Table 3 following the text of the report. In general, the soils encountered have natural in situ water contents suitable for compaction. The sandy soils below the groundwater and the clayey soils tend to be wet of the estimated optimum water content for compaction. Some drying of the granular soils may be possible during warm weather construction.

If drying of soils with water contents higher than the optimum values is not possible, it will be very difficult to compact these materials, if at all possible. The degree of compaction that may be achieved could range between about 80 per cent and 90 per cent. For the depth of backfill typically required to the pipe, ground surface settlement in the range of 100 mm to 150 mm may result from this degree of compaction. If this magnitude of settlement can be tolerated within areas not sensitive to settlement (such as park areas) the saturated sandy soils and the cohesive (clayey silt and silty clay) materials may be used as backfill to the trench.

Silty soils are very sensitive to changes in water content. Excavated silty material may become saturated due to rainfall. Saturated silt, organic silt, clayey silt or silty clay as well as material which is contaminated by organic matter and other debris are not suitable as structural backfill. Such materials should be wasted or used only for landscaping purposes.

Excavated shale is not considered suitable for use as structural backfill under roads or other settlement sensitive areas. The excavated shale has a coarse and extremely variable particle size distribution which makes it very difficult to monitor compaction. Excavated shale generally has a gap-graded grain size distribution. The shale structure deteriorates into clay and silt sizes which migrate downwards filling the voids which form as a result of the uneven distribution of particle sizes. Intolerable long term settlements are generally associated with shale backfill under settlement sensitive areas. If excavated shale is used for trench backfill and considering the depth of backfill required to the pipe, ground surface settlement in the range of 150 mm to 200 mm or greater may result. The shale may be used as trench backfill within park areas if this magnitude of settlement can be tolerated.

6.5.2 Imported Trench Backfill Material

If it is proposed to reinstate the open cut sections on arterial / industrial roads using compacted imported granular material, OPSS Granular B Type 1 should be used for this application. Granular B Type 1 can also be used where there is a shortage of excavated material for use as backfill.

6.5.3 Compaction

All trench backfill placed beneath roadways should be compacted in lifts not exceeding 200 mm loose thickness to at least 98 percent Standard Proctor maximum dry density. Backfill placed in less settlement sensitive areas should be compacted in lifts not exceeding 300 mm loose thickness to 95 percent of its Standard Proctor maximum dry density.

Strict control of material selection and of the degree of compaction is necessary during all phases of pipeline installation and backfilling. Inspection and testing should be carried out by qualified personnel to establish and ensure construction procedures that will provide satisfactory results for the future performance of the works and properties.

6.5.4 Freezing Conditions

If backfilling operations are carried out in freezing temperature conditions, frozen soils, snow and ice should not be incorporated into the backfill zone. The amount of excavated native material suitable for use as backfill in freezing conditions will also be reduced as drying out of these materials becomes quite difficult in these temperature conditions; the soil will usually freeze before it dries out. Close quality control of the backfill material will, therefore, be required during "winter" construction. To ensure quality backfill and satisfactory long term performance of the backfill zone (i.e. minimization of surface settlements), consideration should be given to the use of only approved, select, imported granular fill containing less than 8 percent by weight passing the 75 μm sieve for backfill material during any cold weather construction.

If frozen soils are included in the backfill, large voids may be formed between frozen lumps. As the weather becomes warmer and the frozen soil thaws, non-uniform settlement in the form of large and deep depressions may be created at the ground surface. The magnitude of settlement will depend on the amount and nature of the frozen soils incorporated into the backfill and is not possible to predict.

6.6 Pavement Restoration

The following minimum pavement sections are required by the City of Mississauga for the road reconstruction on top of trenches backfilled as described in Sections 6.3 and 6.5. The actual restorations carried out on site should match the asphalt thicknesses in situ if the existing asphalt thickness exceeds the values in the table.

	MATERIALS			
CLASS OF ROAD	HL 3 ASPHALT	HL 8 ASPHALT	GRANULAR "A"	GRANULAR "B"
Arterial / Industrial	40 mm	100 mm	150 mm	Full Depth
Collectors	40 mm	100 mm	150 mm	410 mm
Residential	40 mm	85 mm	150 mm	330 mm

6.7 Disposal of Excess Excavated Material

Construction of the south section of the Hanlan Feedermain will produce a large volume of excess excavated material which must be disposed. The excavated material could be subject to three guidelines: MOEE Regulation 347, the Ontario Decommissioning and Clean-Up Guidelines, and the Metropolitan Toronto and Region Conservation Authority (MTRCA) Improved Lakefill Quality guidelines.

Disposal of excavated material is generally considered under three categories: hazardous, registerable and non-registerable. The classification of a particular soil as hazardous or non-hazardous and registerable or non-registerable is determined by comparison of the results of standard testing according to MOEE Regulation 347 of the Environmental Protection Act schedule 4 criteria. (The concentration from the schedule 4 criteria originate from the Ontario Drinking Water Objectives).

If Regulation 347 test results exceed the criteria by one hundred times, the material is classified as hazardous and must be registered with the MOEE and disposed of in a licensed hazardous waste disposal site. If Regulation 347 test results exceed the criteria by ten times, the material must be registered with the MOEE and disposed of at a licensed landfill site. Soils with concentrations below ten times the criteria are classified as non-registerable. These soils should then be analyzed for lakefill and Ontario Decommissioning guidelines to determine disposal location acceptability. Approval to dispose of the excess soil must be obtained from the site receiving the soil.

Disposal of materials at the Leslie Street spit or other shoreline works in Toronto is regulated by the MTRCA. It should be noted that the guidelines have been updated effective October 1, 1992 after the time of chemical testing for this investigation. Additional testing (mainly for pesticides) may be required if lakefill disposal is under consideration. Application to MTRCA must be carried out prior to commencing construction to obtain Bills of Lading for Disposal. Additional samples from the areas proposed for lakefill disposal would have to be obtained and submitted for chemical testing prior to applying to MTRCA.

Should the soil not be suitable for lakefill disposal, the soil should be analyzed and compared to the Guidelines for Decommissioning and Clean-Up of Sites in Ontario[1]. This document determines the limiting concentrations of various substances above which the existing ground conditions should be cleaned up or investigated in more detail. It also lists the upper limits of normal concentrations of various naturally occurring elements and compounds in Ontario surface soils.

Placement of "inert fill" (soil with parameter concentrations below schedule 4 guidelines of the MOEE Regulation 347, not putricable or decomposable and within the Decommissioning Guidelines) in land based sites which require borrow material is presently unregulated.

Based on the results of the site history review, the probability of encountering materials requiring disposal in licensed hazardous or non-hazardous landfill sites was considered to be low. This assessment was reinforced by visual examination of the samples obtained during drilling; no unusual staining or odorous evidence of contamination of the samples was noticed. Since no evidence of contaminated soil was found, twelve samples of the overburden soils were submitted to an analytical laboratory for lakefill analyses. The results of these analyses are summarized in Tables 1 and 2. Table 1 contains the results for 5 samples which were taken from within the former DND lands and which were taken adjacent to the rail lands immediately to the south of the DND property. Table 2 contains the results for seven samples taken from other boreholes along the route.

a) With the exception of a very minor exceedance of the oil and grease parameter for a surficial sample within the former DND lands (Table 1, Borehole 109, Sample 1) all of the samples tested meet the requirements for restricted lakefill. Additional testing would be required to determine whether "protected" lakefill or "confined" restricted lakefill would be required. It is recommended that this testing be carried out, if the lakefill option is likely, after completion of final design. The materials meet decommissioning guidelines and may be re-used on site if they are suitable as trench backfill (Section 6.5.1). The excavated soils may also be accepted at Keele Valley or Brock West Landfill Sites as cover material pending application and approval.

[1] Guidelines for the Decommissioning and Clean Up of Sites in Ontario published by Waste Management Branch, Ontario Ministry of the Environment, February 1989.

If a restricted lakefill disposal site is available and is selected, a separate lakefill report must be prepared and a lakefill application to the MTRCA will be required. Additional testing for pesticide concentrations in accordance with the updated guidelines must be carried out. Should a restricted lakefill site not be available when the Hanlan Feedermain is being constructed, disposal of the excess material would then be required at a land based fill site and further testing/classification will be required.

b) The guidelines for open water (unconfined) lakefill (i.e. Leslie Street spit or other shoreline works) are subdivided into two categories by the MTRCA: parameters under strict control and parameters to be assessed on a case-by-case basis. The parameter concentrations measured on samples from boreholes located outside the DND and railway lands (see Table 2) meet the guidelines for parameters under strict control, except for Borehole 102, Sample 1 (topsoil). The parameters which exceed the 'case by case' guidelines (cobalt, chromium, copper, iron, nickel and zinc) fall below the upper limits of normal concentrations for Ontario soils and well below any clean up guidelines (see Table 2). Soil other than topsoil from areas outside the DND and railway lands may therefore be acceptable for disposal as open water lakefill. Additional testing for pesticide concentrations in accordance with the updated guidelines must be carried out.

A large portion of the excess material may consist of shale since it is recommended that excavated shale not be used as structural backfill (although a proportion could potentially be used as trench backfill in the Park). Representative samples of this shale materials should therefore be submitted for chemical analyses to determine its classification and suitability for lakefill or land based disposal.

The type and condition of soil excavated during construction should be monitored visually as it is excavated. Material which is stained or odorous should be set aside in a separate area for further evaluation by submitting representative soil samples for chemical analyses. The excavation in the area adjacent to the railway and through the former Department of National Defense property should be monitored on a full time basis by personnel with experience in evaluating soil quality. Additional chemical analyses may be required at the time of disposal.

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TABLE 1

RESULTS OF CHEMICAL ANALYSIS ON SELECTED SOIL SAMPLES

SAMPLES IN AREA OF RAILWAY AND FORMER DND LANDS

SOIL INFORMATION	UNITS	LAKEFILL LIMITS(3)		UPPER LIMITS OF NORMAL	RESIDENTIAL DECOMMISSIONING	SAMPLE IDENTIFICATION				
		UNCONFINED	RESTRICTED	CONCENTRATION (4)	GUIDELINES (4)	BH107 SA2	BH109 SA1	BH110 SA2	BH112 SA1	BH112 SA2
Elevation	m	-	-	-	-	86.21	86.50	86.00	86.20	85.40
Soil Type	-	-	-	-	-	Fill	Fill	Silty Clay	Fill	Silty Clay
PARAMETER										
Arsenic	ppm	8	20	10	20	2.3	1.8	2.4	3.0	2.0
Total CN-	ppm	0.1	N.A	N.A	N.A	0.23	<0.05	<0.05	<0.05	<0.05
Hg	ppm	0.3	0.5	0.15	0.8	0.100	0.083	0.067	0.100	0.067
Oil & Grease	ppm	1500	5000	N.A	10000	320	5040	<100	3940	200
Ammonia	ppm	100	N.A	N.A	N.A	340	50	50	60	50
TKN	ppm	2000	N.A	N.A	5000	3250	370	540	480	560
Volitile Solids	%	6	N.A	N.A	N.A	16.66	2.67	4.83	4.21	4.63
PCB	ppm	0.05	2	N.A	N.A	<0.01	<0.01	<0.01	<0.01	<0.01
Ag	ppm	0.5	N.A	N.A	20	<0.2	<0.2	<0.2	<0.2	<0.2
Cd	ppm	1	3	3	3	<0.3	<0.3	1.1	<0.3	<0.3
Co	ppm	25	50	25	40	7	6	23	9	21
Cr	ppm	25	120	50	750	16.2	9.0	26.3	16.2	21.9
Cu	ppm	25	100	60	150	29.6	35.9	34.2	32.6	40.5
Fe	ppm	10000	35000	35000	N.A	16500	12400	27700	12100	28200
Ni	ppm	25	60	60	150	20	2	34	3	30
P	ppm	1000	N.A	N.A	N.A	770	320	740	280	700
Pb	ppm	50	375	150	500	11	20	26	40	17
Zn	ppm	100	500	500	600	75.1	56.8	92.5	143.0	89.9
Mo	ppm	4(2)	4	2(2)	40	<3	<3	<3	<3	<3
V	ppm	NA	70	70	200 (2)	26.4	25.1	29.3	21.0	25.0

NOTES

(1) Shaded values exceed Restricted Lakefill Criteria

(2) Provisional Limit.

(3) Manual for an Improvel Lakefill Quality Program - March 1989.

(4) Guidelines for the decommissioning and clean-up of sites in Ontario - February 1989.

TABLE 2

RESULTS OF CHEMICAL ANALYSIS ON SELECTED SOIL SAMPLES

SAMPLES OTHER THAN RAILWAY AND FORMER DND LANDS

INFORMATION	UNITS	LAKEFILL LIMITS (3)		UPPER LIMITS OF NORMAL	RESIDENTIAL DECOMMISSIONING	SAMPLE DESCRIPTION						
		UNCONFINED	RESTRICTED	CONCENTRATION (4)	GUIDELINES (4)	BH102 SA1	BH104 SA2	BH115 SA2	BH117 SA4	BH122 SA1	BH123 SA1	BH124 SA4
Elevation	m	-	-	-	-	80.50	81.81	92.30	93.70	101.65	103.40	103.80
Soil Type	-	-	-	-	-	Fill	Fill	Fill	Silty Clay	Sand	Top soil	Clayey Silt
PARAMETER												
Arsenic	ppm	8	20	10	20	1.8	1.4	1.3	2.5	1.3	4.0	2.0
Total CN-	ppm	0.1	N.A	N.A	N.A	0.19	0.10	0.08	<0.05	<0.05	0.10	<0.05
Hg	ppm	0.3	0.5	0.15	0.8	0.108	0.092	0.075	0.075	0.092	0.092	0.092
Oil & Grease	ppm	1500	5000	N.A	10000	567	<100	800	<100	250	200	160
Ammonia	ppm	100	N.A	N.A	N.A	200	70	70	60	90	160	50
TKN	ppm	2000	N.A	N.A	5000	1710	480	450	540	510	840	400
Volitile Solids	%	6	N.A	N.A	N.A	10.07	5.03	3.47	4.91	3.54	4.70	2.95
PCB	ppm	0.05	2	N.A	N.A	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ag	ppm	0.5	N.A	N.A	20	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cd	ppm	1	3	3	3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Co	ppm	25	50	25	40	11	12	6	32	3	3	16
Cr	ppm	25	120	50	750	18.2	30.5	15.8	36.6	12.7	9.3	18.8
Cu	ppm	25	100	60	150	31.1	27.2	19.3	73.6	9.2	11.6	34.3
Fe	ppm	10000	35000	35000	N.A	20300	21500	14200	33900	10900	7210	24600
Ni	ppm	25	60	60	150	21	26	14	39	9	8	25
P	ppm	1000	N.A	N.A	N.A	710	620	690	710	560	590	650
Pb	ppm	50	375	150	500	36	33	18	27	11	35	14
Zn	ppm	100	500	500	600	135.0	75.1	54.2	105.0	32.8	40.2	75.6
Mo	ppm	4(2)	4	2(2)	40	<3	<3	<3	<3	<3	<3	<3
V	ppm	NA	70	70	200 (2)	30.40	33.1	26.3	36.2	21.9	18.9	26.3

NOTES

(1) Shaded values exceed Restricted Lakefill Criteria
(2) Provisional Limit.
(3) Manual for an Improved Lakefill Quality Control Program - March 1989.
(4) Guidelines for the Decommissioning and Clean-up of Sites in Ontario - February 1989.

TABLE 3

SUMMARY OF NATURAL WATER CONTENTS AND ESTIMATED OPTIMUM WATER CONTENTS FOR COMPACTION

MATERIAL TYPE PROCTOR	TYPICAL NATURAL WATER CONTENT %	ESTIMATED STANDARD OPTIMUM WATER CONTENT %
Sand and Gravel	11	8
Sand	15	9
Silty Sand	15	10
Sandy Silt	14	11
Silty Clay Till	15	16

The abbreviation commonly employed on each "Record of Borehole," on the figures and in the text of the report, are as follows:

I. SAMPLE TYPES

AS auger sample
CS chunk sample
DO drive open
DS Denison type sample
FS foil sample
RC rock core
ST slotted tube
TO thin-walled, open
TP thin-walled, piston
WS wash sample

II. PENETRATION RESISTANCES

Dynamic Penetration Resistance:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 0.3 m (12 in.).

Standard Penetration Resistance, *N*:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 0.3 m (12 in.).

WH sampler advanced by static weight—weight, hammer

PH sampler advanced by pressure—pressure, hydraulic

PM sampler advanced by pressure—pressure, manual

III. SOIL DESCRIPTION

(a) *Cohesionless Soils*

Relative Density	*'N'* Blows/0.30m or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) *Cohesive Soils*

Consistency	*'Cu'* kPa	psf.
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1000
Stiff	50 to 100	1000 to 2000
Very stiff	100 to 200	2000 to 4000
Hard	over 200	over 4000

IV. SOIL TESTS

C consolidation test
H hydrometer analysis
M sieve analysis
MH combined analysis, sieve and hydrometer[1]
Q undrained triaxial[2]
R consolidated undrained triaxial[2]
S drained triaxial
U unconfined compression
V field vane test

NOTES:
[1]Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.
[2]Undrained triaxial tests in which pore pressures are measured are shown as $\bar{Q}$ or $\bar{R}$.

LIST OF SYMBOLS

I. GENERAL

$\pi = 3.1416$

e = base of natural logarithms 2.7183

$\log_e a$ or $\ln a$, natural logarithm of a

$\log_{10} a$ or $\log a$, logarithm of a to base 10

t time

g acceleration due to gravity

V volume

W weight

M moment

F factor of safety

II. STRESS AND STRAIN

u pore pressure

σ normal stress

σ' normal effective stress ($\bar{\sigma}$ is also used)

τ shear stress

ϵ linear strain

ϵ_{xy} shear strain

ν Poisson's ratio (μ is also used)

E modulus of linear deformation (Young's modulus)

G modulus of shear deformation

K modulus of compressibility

η coefficient of viscosity

III. SOIL PROPERTIES

(a) *Unit weight*

γ unit weight of soil (bulk density)

γ_s unit weight of solid particles

γ_w unit weight of water

γ_d unit dry weight of soil (dry density)

γ' unit weight of submerged soil

G_s specific gravity of solid particles $G_s = \gamma_s/\gamma_w$

e void ratio

n porosity

w water content

S_r degree of saturation

(b) *Consistency*

w_L liquid limit

w_P plastic limit

I_P plasticity index

w_S shrinkage limit

I_L liquidity index $= (w - w_P)/I_P$

I_C consistency index $= (w_L - w)/I_P$

e_{max} void ratio in loosest state

e_{min} void ratio in densest state

D_r relative density $= (e_{max} - e)/(e_{max} - e_{min})$

(c) *Permeability*

h hydraulic head or potential

q rate of discharge

v velocity of flow

i hydraulic gradient

k coefficient of permeability

j seepage force per unit volume

(d) *Consolidation (one-dimensional)*

m_v coefficient of volume change $= -\Delta e/(1+e)\Delta\sigma'$

C_c compression index $= -\Delta e/\Delta \log_{10} \sigma'$

c_v coefficient of consolidation

T_v time factor $= c_v t/d^2$ (d, drainage path)

U degree of consolidation

(e) *Shear strength*

τ_f shear strength

c' effective cohesion intercept
ϕ' effective angle of shearing resistance, or friction
} in terms of, effective stress $\tau_f = c' + \sigma' \tan \phi'$

c_u apparent cohesion*
ϕ_u apparent angle of shearing resistance, or friction
} in terms of total stress $\tau_f = c_u + \sigma \tan \phi_u$

μ coefficient of friction

S_t sensitivity

*For the case of a saturated cohesive soil, $\phi_u = 0$ and the strength $\tau_f = c_u$ is taken as half the undrained compressive strength.

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING STATE

Fresh: no visible sign of weathering.

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock texture and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	> 2 m
Thickly bedded	0.6 m to 2m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	< 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	> 3 m
Wide	1 - 3 m
Moderately close	0.3 - 1 m
Close	50 - 300 mm
Very close	< 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	> 60 mm
Coarse Grained	2 - 60 mm
Medium Grained	60 microns - 2 mm
Fine Grained	2 - 60 microns
Very Fine Grained	< 2 microns

Note: * Grains >60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to (W.R.T.) Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviated description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

B - Bedding	P - Polished
FO - Foliation Schistosity	S - Slickensided
CL - Cleavage	SM - Smooth
SH - Shear Plane Zone	R - Ridged/Rough
VN - Vein	ST - Stepped
F - Fault	PL - Planar
CO - Contact	FL - Flexured
J - Joint	UE - Uneven
FR - Fracture	W - Wavy
MF - Mechanical Fracture	C - Curved
II - Parallel To	
⊥ - Perpendicular To	

PROJECT: 901-1403

RECORD OF BOREHOLE 101

SHEET 1 OF 2

LOCATION: SEE FIGURE 2

BORING DATE: OCT. 16,1990

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT, PERCENT (Wp, W, Wl)	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		78.66					
0	POWER AUGER BORING, SOLID STEM AUGERS	TOPSOIL		78.51					PROTECTIVE CAP
		Compact, dark brown sandy silt, trace clay. (FILL)		0.15	1	50 DO	10	o	
				78.05 / 0.61					BENTONITE SEAL
1		Very stiff to hard, greenish-grey SILTY CLAY, some sand, trace gravel. (TILL)			2	50 DO	16	o	
					3	50 DO	73/.2	o	
2				76.32	4	50 DO	60/.08		PEA GRAVEL
		Highly weathered, grey SHALE.		2.34					
3				75.61					
		BOREHOLE CONTINUED. FOR BEDROCK CORING DETAILS, SEE SHEET 2.		3.05					

Other column headings: SOIL PROFILE; SAMPLES; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - +, rem.V - ⊕, Q - ●, U - O); HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT Wp W Wl 10 20 30 40; ADDITIONAL LAB. TESTING

Depth scale: 0 1 2 3 4 5 6 7 8 9 10

15 0 5 10 PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: SK DEC. 13/90

DEPTH SCALE 1 to 50

LOGGED: SC

Golder Associates

CHECKED: MRA

RECORD OF BOREHOLE: 101

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
INCLINATION: -90 AZIMUTH:

DRILLING DATE: OCT. 16,1990
DRILL RIG: DIAMOND DRILL
DRILLING CONTRACTOR: K & S DRILLING

SHEET 2 OF 2
DATUM: GEODETIC

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 COLOUR % RETURN	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	NOTES WATER LEVELS INSTRUMENTATION
0			78.66 0.00					
1		Refer to sheet 1 for stratigraphic description.						
3		CONTINUED FROM SHEET 1	75.61 3.05					
3–4.5	NQ RC	Moderately weathered to fresh, grey, fine grained SHALE (84%) with interbedded slightly weathered to fresh, light grey SHALEY LIMESTONE (16%).		5	0.056	75	Broken Core (150mm) Broken Core (75mm) Joints generally R,PL	
4.5–6	NQ RC	Shaley limestone layers were present at the following Elevations: 74.8m : 25mm 74.7m : 50mm 74.6m : 50mm 73.7m : 25mm 72.0m : 25mm 71.9m : 25mm 71.8m : 300mm 71.4m : 50mm 71.2m : 150mm		6	0.049	75	Mud Seam (25mm) Broken Core (50mm)	PEA GRAVEL
6–7.62	NQ RC OCT. 16/90		71.04 7.62	7	0.076	75		
		END OF BOREHOLE						WATER LEVEL IN PIEZOMETER AT ELEV. 77.2m ON NOV. 12/90.

DATA INPUT: SK NOV. 29/90

DEPTH SCALE:
1 to 50

Golder Associates

LOGGED: SC
DATE: OCT. 16/90
CHECKED: MRA

RECORD OF BOREHOLE 102

PROJECT: 901-1403
SHEET 1 OF 2
LOCATION: SEE FIGURE 2
BORING DATE: OCT. 16,1990
DATUM: GEODETIC
SAMPLER HAMMER, 63.5kg; DROP, 760mm
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

Boring method: POWER AUGER BORING, SOLID STEM AUGERS

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT (%)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE	80.85						BACKFILL
TOPSOIL	80.70 / 0.15	1	50 DO	7			
Loose, brown silty sand, trace clay and gravel. (FILL)	80.15 / 0.70						
Very stiff to hard, greenish-grey SILTY CLAY, some sand, trace gravel. (TILL)		2	50 DO	25	○		
		3	50 DO	40	○	MH	
	78.11 / 2.74	4	50 DO	62/.05	○		
Highly weathered, grey SHALE.	77.65 / 3.20	5	50 DO	60/.05			
BOREHOLE CONTINUED. FOR BEDROCK CORING DETAILS, SEE SHEET 2.							

Chart headings: DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; HYDRAULIC CONDUCTIVITY, k, cm/s; SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - ○); WATER CONTENT, PERCENT Wp —○W— Wl (10 20 30 40)

15 ◆ 5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: SC
CHECKED: MRA

DATA INPUT: SK DEC. 12/90

RECORD OF BOREHOLE: 102

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
INCLINATION: -90 AZIMUTH:

DRILLING DATE: OCT. 16,1990
DRILL RIG: DIAMOND DRILL
DRILLING CONTRACTOR: K & S DRILLING

DATUM: GEODETIC

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	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (m/min.)	FLUSH COLOUR % RETURN	RECOVERY TOTAL CORE % / SOLID CORE %	R.Q.D. %	FRACT. INDEX PER .3 m	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				80.85 / 0.00											
1		Refer to sheet 1 for stratigraphic description.													
2															
3		CONTINUED FROM SHEET 1		77.65 / 3.20											
4	NQ RC	Moderately weathered to fresh, grey, fine grained SHALE (94%) with interbedded slightly weathered to fresh, light grey SHALEY LIMESTONE (6%).			6	0.053	80					Mud Seam (125mm); Joints generally R,PL			BACKFILL
5	NQ RC	Shaley limestone layers were present at the following Elevations: 77.2m : 100mm; 76.9m : 50mm; 76.7m : 100mm; 75.1m : 25mm			7	0.059	80					Broken Core (75mm); Broken Core (75mm)			BENTONITE SEAL
6–7	OCT. 16/90 NQ RC			73.38 / 7.47	8	0.058	80								PEA GRAVEL
		END OF BOREHOLE													WATER LEVEL IN PIEZOMETER AT ELEV. 76.3m ON NOV. 12/90.
8															
9															
10															

DATA INPUT: SK NOV. 29/90

DEPTH SCALE: 1 to 50

Golder Associates

LOGGED: SC
DATE: OCT. 16/90
CHECKED: MRA

RECORD OF BOREHOLE 103

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
BORING DATE: OCT. 15,1990
SHEET 1 OF 2
DATUM: GEODETIC
SAMPLER HAMMER, 63.5kg; DROP, 760mm
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT, PERCENT (Wp–W–Wl)	PIEZOMETER OR STANDPIPE INSTALLATION
0	POWER AUGER BORING / SOLID STEM AUGERS	GROUND SURFACE	82.36					
		TOPSOIL	82.21 / 0.15	1	50 DO	18	o	BACKFILL
		Compact, dark brown sandy silt, trace gravel and clay. (FILL)	81.45 / 0.91					
1		Compact, grey sand, trace silt. (FILL)	80.68 / 1.68	2	50 DO	14	o	
2		Very stiff to hard, greenish-grey SILTY CLAY, some sand, trace gravel. (TILL)	79.72 / 2.64	3	50 DO	21	o	
				4	50 DO	125 /.2	o	
3		Highly weathered, grey SHALE.	79.31 / 3.05					
		BOREHOLE CONTINUED. FOR BEDROCK CORING DETAILS, SEE SHEET 2.						

Other column headings: STRATA PLOT; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - O); HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT Wp W Wl (10 20 30 40); ADDITIONAL LAB. TESTING

Depth scale: 0 1 2 3 4 5 6 7 8 9 10

15-◆-5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

DATA INPUT: SK DEC. 13/90

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: SC
CHECKED: MRA

RECORD OF BOREHOLE: 103

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
INCLINATION: -90 AZIMUTH:

DRILLING DATE: OCT. 15,1990
DRILL RIG: DIAMOND DRILL
DRILLING CONTRACTOR: K & S DRILLING

DATUM: GEODETIC

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	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (m/min.)	FLUSH COLOUR % RETURN	RECOVERY (TOTAL CORE % / SOLID CORE %)	R.Q.D. %	FRACT. INDEX PER .3 m	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				82.36 0.00											
1		Refer to sheet 1 for stratigraphic description.													
3		CONTINUED FROM SHEET 1		79.31 3.05								Broken Core (100mm)			BACKFILL
4	NQ RC	Highly to moderately weathered, grey SHALE (85%) with interbedded slightly weathered, light grey SHALEY LIMESTONE (15%).			5	0.051	75					Mud Seam (100mm) Broken Core (75mm) Broken Core (50mm) Joints generally R,PL			
5	NQ RC	Moderately weathered to fresh, grey SHALE (96%) with interbedded slightly weathered to fresh, light grey SHALEY LIMESTONE (4%).		77.80 4.57	6	0.056	80					Broken Core (25mm)			BENTONITE SEAL
6–7	NQ RC OCT. 16/90	Shaley limestone layers were present at the following Elevations: 78.7m : 50mm 78.5m : 125mm 77.8m : 50mm 76.4m : 75mm 75.9m : 25mm 75.7m : 25mm 75.6m : 25mm			7	0.056	85								PEA GRAVEL
		END OF BOREHOLE		74.74 7.62											WATER LEVEL IN PIEZOMETER AT ELEV. 80.3m ON NOV. 12/90.

DATA INPUT: SK NOV. 29/90

DEPTH SCALE:
1 to 50

Golder Associates

LOGGED: SC
DATE: OCT. 15/90
CHECKED: MRA

RECORD OF BOREHOLE 104

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
BORING DATE: OCT. 11,1990
SHEET 1 OF 2
DATUM: GEODETIC
SAMPLER HAMMER, 63.5kg; DROP, 760mm
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

BORING METHOD: POWER AUGER BORING, SOLID STEM AUGERS

DEPTH SCALE METRES	DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT, PERCENT (Wp / W / Wl)	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE	82.81					
	TOPSOIL	82.81 / 0.00					BENTONITE GROUT
	Stiff, brown clayey silt, some sand, trace gravel. (FILL)	0.20	1	50 DO	8	○ (~27)	
1			2	50 DO	13		
	Hard, greenish-grey SILTY CLAY, some sand, trace gravel. (TILL)	81.44 / 1.37	3	50 DO	42	○ (~15)	▽
2			4	50 DO	125 /.2	○ (~10)	
	Completely weathered, grey SHALE.	80.14 / 2.67					
3		79.61 / 3.20	5	50 DO	62/ .15		
	BORHOLE CONTINUED. FOR BEDROCK CORING DETAILS, SEE SHEET 2.						

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
SHEAR STRENGTH Cu, kPa — nat.V - + Q - ● rem.V - ⊕ U - ○
HYDRAULIC CONDUCTIVITY, k, cm/s
WATER CONTENT, PERCENT: Wp —○W— Wl (10, 20, 30, 40)
ADDITIONAL LAB. TESTING

15 ◆ 5 (0, 10) PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: SK DEC. 13/90

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: SC
CHECKED: MRA

RECORD OF BOREHOLE: 104

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
INCLINATION: -90 AZIMUTH:

DRILLING DATE: OCT. 11,1990
DRILL RIG: DIAMOND DRILL
DRILLING CONTRACTOR: K & S DRILLING

DATUM: GEODETIC

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 COLOUR % RETURN	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	NOTES WATER LEVELS INSTRUMENTATION
0			82.81 / 0.00					
0–3		Refer to sheet 1 for stratigraphic description.						
3		CONTINUED FROM SHEET 1	79.61 / 3.20					
3.20–4.42	NQ RC	Completely to moderately weathered, grey SHALE (76%) with interbedded slightly weathered, light grey SHALEY LIMESTONE (24%).	78.39 / 4.42	6	0.041	80	Broken Core (175mm) Broken Core (225mm) Mud Seam (50mm) Joints generally R,PL	
4.42–5.9	NQ RC	Moderately weathered to fresh, grey SHALE (89%) with interbedded, slightly weathered to fresh, light grey SHALEY LIMESTONE (11%).		7	0.049	90		BENTONITE GROUT
5.9–7.5	NQ RC	Shaley limestone layers were present at the following Elevations: 79.6m : 75mm 79.3m : 100mm 78.7m : 100mm 78.4m : 50mm 78.2m : 100mm 77.9m : 25mm 76.4m : 75mm 76.0m : 25mm 75.7m : 75mm		8	0.053	90		BENTONITE SEAL PEA GRAVEL
7.5–8.10	NQ RC, OCT. 11/90		74.71 / 8.10	9	0.042	90		
8.10		END OF BOREHOLE						WATER LEVEL IN PIEZOMETER AT ELEV. 81.2m ON NOV. 12/90.

DATA INPUT: SK NOV. 29/90

DEPTH SCALE: 1 to 50

Golder Associates

LOGGED: SC
DATE: OCT. 11/90
CHECKED: MRA

PROJECT: 901-1403

LOCATION: SEE FIGURE 2

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE 105

BORING DATE: OCT. 11,1990

SHEET 1 OF 2

DATUM: GEODETIC

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT, PERCENT (Wp – W – Wl; 10 20 30 40)	PIEZOMETER OR STANDPIPE INSTALLATION
0	POWER AUGER BORING / SOLID STEM AUGERS	GROUND SURFACE	84.59					
		TOPSOIL	0.00 / 84.39					
		Firm, brown clayey silt, trace gravel, sand and organics(roots). (FILL)	0.20 / 83.98	1	50 DO	8	O (~11)	BACKFILL
1		Hard, greenish-grey SILTY CLAY, trace sand and gravel with occasional sand seams. (TILL)	0.61	2	50 DO	31	O (~13)	▽
2				3	50 DO	55	O (~11)	
			81.69	4	50 DO	33	O (~10)	
3		Hard, grey SILTY CLAY, trace sand. (RESIDUAL SOIL)	2.90 / 80.89	5	50 DO	69		
4		Completely weathered, grey SHALE.	3.70 / 80.48	6	50 DO	60/ .08		
		BORE HOLE CONTINUED. FOR BEDROCK CORING DETAILS, SEE SHEET 2.	4.11					
5								
6								
7								
8								
9								
10								

Other column headings: STRATA PLOT; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - O); HYDRAULIC CONDUCTIVITY, k, cm/s; ADDITIONAL LAB. TESTING

15 0 5 10 PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: SK DEC. 13/90

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: SC

CHECKED: MRA

RECORD OF BOREHOLE: 105

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
INCLINATION: -90 AZIMUTH:
DRILLING DATE: OCT. 11,1990
DRILL RIG: DIAMOND DRILL
DRILLING CONTRACTOR: K & S DRILLING
DATUM: GEODETIC

Legend: 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 COLOUR % RETURN	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	NOTES WATER LEVELS INSTRUMENTATION
0			84.59 / 0.00					
1–4		Refer to sheet 1 for stratigraphic description.						
4		CONTINUED FROM SHEET 1	80.48 / 4.11					
4–5.5	NQ RC	Highly to faintly weathered, fine grained, grey SHALE (87%) with interbedded slightly weathered to fresh, light grey SHALEY LIMESTONE (13%).		7	0.048	75	Broken Core (75mm); Broken Core (50mm); Broken Core (100mm); Joints generally R,PL	BACKFILL
5.5–7.1	NQ RC	Shaley limestone layers were present at the following Elevations: 80.4m : 150mm; 80.3m : 50mm; 80.2m : 25mm; 79.7m : 50mm; 79.3m : 100mm; 79.0m : 75mm		8	0.064	85	Broken Core (50mm)	BENTONITE SEAL; PEA GRAVEL
7.1–7.77	NQ RC, OCT. 11/90		76.82 / 7.77	9	0.024	85	Broken Core (75mm); Broken Core (50mm)	
7.77		END OF BOREHOLE						WATER LEVEL IN PIEZOMETER AT ELEV. 83.7m ON NOV. 12/90.

DATA INPUT: SK NOV. 29/90

DEPTH SCALE: 1 to 50

Golder Associates

LOGGED: SC
DATE: OCT. 11/90
CHECKED: MRA

RECORD OF BOREHOLE 106

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
SAMPLER HAMMER, 63.5kg; DROP, 760mm

BORING DATE: OCT. 12,1990

SHEET 1 OF 2
DATUM: GEODETIC
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

Boring method: POWER AUGER BORING, SOLID STEM AUGERS

DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT, PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE	88.29						
Loose, brown SANDY SILT, trace gravel, clay and organics(roots).	0.00	1	50 DO	9			
	85.68 / 0.61						
Stiff to hard, greenish-grey to grey SILTY CLAY, some sand, trace gravel. (TILL)		2	50 DO	10			BENTONITE GROUT
		3	50 DO	30			
		4	50 DO	70			
		5	50 DO	29		MH	
		6	50 DO	78/ .23			
	81.98 / 4.30						
Highly weathered, grey SHALE.	81.72 / 4.57	7	50 DO	60/ .02			
BOREHOLE CONTINUED. FOR BEDROCK CORING DETAILS, SEE SHEET 2.							

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
HYDRAULIC CONDUCTIVITY, k, cm/s
SHEAR STRENGTH Cu, kPa — nat.V - + Q - ● rem.V - ⊕ U - ○
WATER CONTENT, PERCENT — Wp W Wl — 10 20 30 40

15 0 5 10 PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: SK DEC. 20/90

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: SC
CHECKED: MRA

RECORD OF BOREHOLE: 106

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
INCLINATION: -90 AZIMUTH:

DRILLING DATE: OCT. 12,1990
DRILL RIG: DIAMOND DRILL
DRILLING CONTRACTOR: K & S DRILLING

SHEET 2 OF 2
DATUM: GEODETIC

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 COLOUR % RETURN	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	NOTES WATER LEVELS INSTRUMENTATION
0			86.29 / 0.00					
2		Refer to sheet 1 for stratigraphic description.						
		CONTINUED FROM SHEET 1	81.72 / 4.57				Joints generally R,PL	
5–6	NQ RC	Moderately weathered to fresh, grey, fine grained SHALE (84%) with interbedded slightly weathered to fresh, light grey SHALEY LIMESTONE (16%).		8	0.044	80	Broken Core (50mm)	BENTONITE GROUT
6–7.5	NQ RC	Shaley limestone layers were present at the following Elevations: 80.3m : 100mm 79.8m : 25mm 79.5m : 275mm 79.2m : 125mm 79.0m : 75mm 78.8m : 50mm 78.7m : 25mm		9	0.061	80	Broken Core (50mm)	BENTONITE SEAL
7.5–8.84	NQ RC, OCT. 12/90		77.45 / 8.84	10	0.041	85	Broken Core (50mm)	PEA GRAVEL
9		END OF BOREHOLE						WATER LEVEL IN PIEZOMETER AT ELEV. 83.9m ON NOV. 12/90.
10								

DATA INPUT: SK NOV. 29/90

DEPTH SCALE: 1 to 50

Golder Associates

LOGGED: SC
DATE: OCT. 12/90
CHECKED: MRA

RECORD OF BOREHOLE 107

PROJECT: 901-1403
SHEET 1 OF 2
LOCATION: SEE FIGURE 2
BORING DATE: OCT. 15,1990
DATUM: GEODETIC
SAMPLER HAMMER, 63.5kg; DROP, 760mm
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

Boring method: POWER AUGER BORING – SOLID STEM AUGERS

Depth scale (metres)	Description	Elev. / Depth (m)	Sample number	Type	Blows/0.3m	Water content (%)	Piezometer or standpipe installation
0	GROUND SURFACE	87.21 / 0.00					BENTONITE SEAL
0–2.13	Very loose, brown to black sandy silt to silty sand, trace gravel, clay and organics(roots, wood fragments). (FILL)		1	50 DO	3		
			2	50 DO	3		PEA GRAVEL
			3	50 DO	4	o	A
2.13–5.03	Very stiff to hard, greenish-grey to grey SILTY CLAY, some sand, trace gravel. (TILL)	85.08 / 2.13	4	50 DO	18		BENTONITE GROUT
			5	50 DO	28	o	
			6	50 DO	35		
			7	50 DO	105 /.2		
5.03–5.33	Highly weathered, grey SHALE.	82.18 / 5.03	8	50 DO	82/ .08		
5.33	BOREHOLE CONTINUED. FOR BEDROCK CORING DETAILS, SEE SHEET 2.	81.88 / 5.33					

Column headings: DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; HYDRAULIC CONDUCTIVITY, k, cm/s; SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - O); WATER CONTENT, PERCENT Wp —O W— Wl (10 20 30 40); ADDITIONAL LAB. TESTING

WATER LEVEL IN PIEZOMETER A AT ELEV. 86.5m AND IN PIEZOMETER B AT ELEV. 84.5m ON NOV. 12/90.

15 ◆ 5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

DATA INPUT: SK DEC. 13/90

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: SC
CHECKED: MRA

RECORD OF BOREHOLE: 107

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
INCLINATION: -90 AZIMUTH:

DRILLING DATE: OCT. 15,1990
DRILL RIG: DIAMOND DRILL
DRILLING CONTRACTOR: K & S DRILLING

SHEET 2 OF 2
DATUM: GEODETIC

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 COLOUR % RETURN	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	NOTES WATER LEVELS INSTRUMENTATION
0			87.21 0.00					
0–5		Refer to sheet 1 for stratigraphic description.						
5		CONTINUED FROM SHEET 1	81.88 5.33					
5.33–6.8	NQ RC	Moderately weathered to fresh, grey, fine grained SHALE (87%) with interbedded slightly weathered to fresh, light grey SHALEY LIMESTONE (13%).		9	0.034	85	Broken Core (50mm) Joints generally R,PL	BENTONITE GROUT
6.8–8.3	NQ RC	Shaley limestone layers were present at the following Elevations: 81.2m : 50mm 79.4m : 50mm 78.8m : 50mm 78.7m : 175mm 78.5m : 75mm 78.0m : 100mm		10	0.048	80	Broken Core (50mm) Broken Core (100mm)	BENTONITE SEAL PEA GRAVEL
8.3–9.47	NQ RC (OCT. 15/90)		77.74 9.47	11	0.051	85		B
		END OF BOREHOLE						
10								

DEPTH SCALE: 1 to 50

Golder Associates

LOGGED: SC
DATE: OCT. 15/90
CHECKED: MRA

DATA INPUT: SK NOV. 29/90

RECORD OF BOREHOLE 108

PROJECT: 901-1403
SHEET 1 OF 2
LOCATION: SEE FIGURE 2
BORING DATE: OCT. 24,1990
DATUM: GEODETIC
SAMPLER HAMMER, 63.5kg; DROP, 760mm
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE – DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES – NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa (nat.V - +, rem.V - ⊕, Q - ●, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		86.47							
	POWER AUGER BORING / SOLID STEM AUGERS	Compact, brown sand, some gravel, trace silt and organics(roots). (FILL)		0.00 / 85.86 / 0.61	1	50 DO	11		○		
1		Hard, greenish-grey SILTY CLAY, some sand, trace gravel. (TILL)			2	50 DO	41		○		
					3	50 DO	55		○		BENTONITE GROUT
2				83.78	4	50 DO	114		○		
3		Highly weathered, grey SHALE.		2.69	5	50 DO	80/.08				
				83.02 / 3.45							
		BOREHOLE CONTINUED. FOR BEDROCK CORING DETAILS, SEE SHEET 2.									

4 5 6 7 8 9 10

15-◆-5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

DATA INPUT: SK DEC. 13/90

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: MK
CHECKED: MRA

RECORD OF BOREHOLE: 108

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
INCLINATION: -90 AZIMUTH:

DRILLING DATE: OCT. 24,1990
DRILL RIG: DIAMOND DRILL
DRILLING CONTRACTOR: MASTER SOILS INVESTIGATIONS

DATUM: GEODETIC

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 COLOUR % RETURN	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	NOTES WATER LEVELS INSTRUMENTATION
0			86.47 0.00					
0–3.45		Refer to sheet 1 for stratigraphic description.						
3.45		CONTINUED FROM SHEET 1	83.02 3.45					
3.45–5.0	NQ RC	Moderately weathered to fresh, grey, fine grained SHALE (81%) with interbedded slightly weathered to fresh, light grey SHALEY LIMESTONE (19%).		6	0.051	20	Joints generally R,PL Mud Seam (25mm)	BENTONITE GROUT
5.0–6.5	NQ RC	Shaley limestone layers were present at the following Elevations: 81.6m : 100mm 81.3m : 200mm 80.8m : 50mm 80.2m : 125mm 79.6m : 125mm 79.0m : 125mm 78.7m : 100mm 78.3m : 125mm		7	0.038	20	Broken Core (100mm)	
6.5–7.2	NQ RC			8	0.028	30	Mud Seam (25mm) Broken Core (75mm)	BENTONITE SEAL
7.2–8.74	NQ RC OCT. 24/90		77.72 8.74	9	0.031	30	Broken Core (50mm) Broken Core (50mm)	PEA GRAVEL
8.74		END OF BOREHOLE						WATER LEVEL IN PIEZOMETER AT ELEV. 84.6m ON NOV. 12/90.

DATA INPUT: SK NOV. 29/90

DEPTH SCALE: 1 to 50

Golder Associates

LOGGED: MK
DATE: OCT. 24/90
CHECKED: MRA

RECORD OF BOREHOLE 109

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
BORING DATE: OCT. 23,1990
SHEET 1 OF 2
DATUM: GEODETIC
SAMPLER HAMMER, 63.5kg; DROP, 760mm
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

BORING METHOD: POWER AUGER BORING, SOLID STEM AUGERS

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE	86.80 / 0.00				
Compact, brown gravelly sand with pockets of clayey silt. (FILL)	86.20 / 0.60	1	50 DO	19	BACKFILL
Hard, greenish-grey SILTY CLAY, trace to some sand, trace gravel. (TILL)	84.67 / 2.13	2	50 DO	45	
		3	50 DO	45	
Highly weathered, grey SHALE.	83.35 / 3.45	4	50 DO	80/.08	
		5	50 DO	80/.05	
BORHOLE CONTINUED. FOR BEDROCK CORING DETAILS, SEE SHEET 2.					

Water content, percent (Wp–W–Wl, scale 10–40): sample 1 ≈ 12; sample 2 ≈ 8.

Columns: DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; HYDRAULIC CONDUCTIVITY, k, cm/s; SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - ○); WATER CONTENT, PERCENT; ADDITIONAL LAB. TESTING

15-◆-5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

DEPTH SCALE 1 to 50

DATA INPUT: SK DEC. 13/90

Golder Associates

LOGGED: MK/AJW
CHECKED: MRA

RECORD OF BOREHOLE: 109

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
INCLINATION: -90 AZIMUTH:

DRILLING DATE: OCT. 23,1990
DRILL RIG: DIAMOND DRILL
DRILLING CONTRACTOR: MASTER SOILS INVESTIGATIONS

DATUM: GEODETIC

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 COLOUR % RETURN	DISCONTINUITY TYPE AND SURFACE DESCRIPTION	NOTES WATER LEVELS INSTRUMENTATION
0			86.80 / 0.00					
1–3		Refer to stratigraphic description on sheet 1.						
		CONTINUED FROM SHEET 1	83.35 / 3.45					
4	NQ RC	Moderately weathered to fresh, grey, fine grained SHALE (78%) with interbedded slightly weathered to fresh, light grey SHALEY LIMESTONE (22%).		6	0.051	20	Joints generally R,PL; Mud Seam (25mm)	BACKFILL
5	NQ RC	Shaley limestone layers were present at the following Elevations: 83.1m : 150mm; 82.1m : 25mm; 81.5m : 50mm; 81.0m : 75mm; 80.5m : 125mm; 80.2m : 175mm; 80.0m : 75mm; 79.5m : 125mm; 79.3m : 75mm; 79.1m : 100mm		7	0.036	20	Broken Core (75mm); Mud Seam (25mm)	
6–7	NQ RC			8	0.030	20		BENTONITE SEAL; PEA GRAVEL
7	NQ RC OCT. 23/90		78.95	9	0.027	20		CAVED
8		END OF BOREHOLE	7.85					WATER LEVEL IN PIEZOMETER AT ELEV. 85.1m ON NOV. 12/90.
9								
10								

DATA INPUT: SK NOV. 29/90

DEPTH SCALE:
1 to 50

Golder Associates

LOGGED: MK/AJW
DATE: OCT. 23/90
CHECKED: MRA

RECORD OF BOREHOLE 110

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
SAMPLER HAMMER, 63.5kg; DROP, 760mm

BORING DATE: OCT. 23,1990

SHEET 1 OF 1
DATUM: GEODETIC
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT, PERCENT (W)	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		87.00					
0	POWER AUGER BORING / SOLID STEM AUGERS	Very stiff to hard, brown to grey SILTY CLAY, some sand, trace gravel. (TILL)		0.00	1	50 DO	16	o (~17)	BACKFILL
1					2	50 DO	52		
				85.25 / 1.75	3	50 DO	70/.08	o (~11)	▽
2		Highly weathered, grey SHALE with occasional shaley limestone layers (inferred by augering).			4	50 DO	80/.13		BENTONITE SEAL
3					5	50 DO	80/.08		PEA GRAVEL
				83.17 / 3.83	6	50 DO	60/.01		CAVED
4		END OF BOREHOLE							BOREHOLE DRY ON COMPLETION OF DRILLING. WATER LEVEL IN PIEZOMETER AT ELEV. 85.2m ON NOV. 12/90.

Column headings also include: DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; HYDRAULIC CONDUCTIVITY, k, cm/s; SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - O); WATER CONTENT, PERCENT Wp —O^W— Wl (10, 20, 30, 40); ADDITIONAL LAB. TESTING.

Depth scale: 0 1 2 3 4 5 6 7 8 9 10

15 ◆ 5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

DATA INPUT: SK NOV. 21/90

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: MK/AJW
CHECKED: MRA

RECORD OF BOREHOLE 111

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
SAMPLER HAMMER, 63.5kg; DROP, 760mm

BORING DATE: OCT. 25,1990

SHEET 1 OF 2
DATUM: GEODETIC
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT, PERCENT (W)	PIEZOMETER OR STANDPIPE INSTALLATION
0	POWER AUGER BORING / SOLID STEM AUGERS	GROUND SURFACE		88.59					BACKFILL
		Stiff to hard, brown to grey SILTY CLAY, some sand, trace gravel with occasional sand seams. (TILL)		0.00	1	50 DO	8		
1					2	50 DO	15		
2					3	50 DO	18		
					4	50 DO	106		
3		Highly weathered, grey SHALE.		85.70 / 2.89	5	50 DO	80/.15		
4					6	50 DO	90/.08		
					7	50 DO	90/.08		
5		BOREHOLE CONTINUED. FOR BEDROCK CORING DETAILS, SEE SHEET 2.		83.56 / 5.03					

Column headings also include: DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; HYDRAULIC CONDUCTIVITY, k, cm/s; SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - O); WATER CONTENT, PERCENT (Wp ⊢ W ⊣ Wl; 10 20 30 40); ADDITIONAL LAB. TESTING.

15-◆-5 PERCENT AXIAL STRAIN AT FAILURE (0 / 10)

DATA INPUT: SK NOV. 21/90

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: MK
CHECKED: MRA

RECORD OF BOREHOLE 111

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
INCLINATION: -90 AZIMUTH:

DRILLING DATE: OCT. 25,1990
DRILL RIG: DIAMOND DRILL
DRILLING CONTRACTOR: MASTER SOILS INVESTIGATIONS

SHEET 2 OF 2
DATUM: GEODETIC

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 COLOUR % RETURN	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	NOTES WATER LEVELS INSTRUMENTATION
0			88.59 / 0.00					
2–3		Refer to sheet 1 for stratigraphic description.						
5		CONTINUED FROM SHEET 1	83.56 / 5.03				Mud Seam (25mm)	
5–6.5	NQ RC	Highly to moderately weathered, grey SHALE (96%) with interbedded slightly weathered, light grey SHALEY LIMESTONE (4%).		8	0.038	20	Broken Core (75mm); Joints generally R,PL	BACKFILL
6–8	NQ RC	Moderately weathered to fresh, grey SHALE (90%) with interbedded slightly weathered to fresh, light grey SHALEY LIMESTONE (10%). Shaley limestone layers were encountered at the following Elevations: 83.2m : 25mm; 82.2m : 25mm; 81.3m : 50mm; 80.8m : 25mm; 80.6m : 50mm	82.04 / 6.55	9	0.034	30	Broken Core (25mm)	BENTONITE SEAL; PEA GRAVEL
8	OCT. 25/90	END OF BOREHOLE	80.51 / 8.08					BACKFILL. BOREHOLE DRY ON COMPLETION OF DRILLING. PIEZOMETER PLUGGED AT 1.7m DEPTH.
9								
10								

DATA INPUT: SK NOV. 29/90

DEPTH SCALE: 1 to 50

Golder Associates

LOGGED: MK
DATE: OCT. 25/90
CHECKED: MRA

PROJECT: 901-1403

RECORD OF BOREHOLE 112

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: OCT. 23,1990

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

BORING METHOD: POWER AUGER BORING, SOLID STEM AUGERS

DEPTH SCALE METRES	SOIL PROFILE: DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE	86.40				
	Compact, brown silty sand, some gravel. (FILL)	0.00	1	50 DO	20	BACKFILL
1	Hard, greenish-grey SILTY CLAY, some sand, trace gravel. (TILL)	85.80 / 0.60	2	50 DO	38	
			3	50 DO	67	
2	Highly weathered, grey SHALE.	84.51 / 1.88	4	50 DO	80/.08	BENTONITE SEAL
3			5	50 DO	80/.05	PEA GRAVEL; CAVED
	END OF BOREHOLE	82.89 / 3.50				BOREHOLE DRY ON COMPLETION OF DRILLING. WATER LEVEL IN PIEZOMETER AT ELEV. 83.6m ON NOV. 12/90.

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

HYDRAULIC CONDUCTIVITY, k, cm/s

SHEAR STRENGTH Cu, kPa — nat.V - + Q - ● rem.V - ⊕ U - O

WATER CONTENT, PERCENT — Wp ⊢—O W —⊣ Wl — 10 20 30 40

ADDITIONAL LAB. TESTING

15 - 0 - 5 - 10 PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: SK DEC. 12/90

DEPTH SCALE 1 to 50

LOGGED: MK

CHECKED: MRA

Golder Associates

PROJECT: 901-1403

RECORD OF BOREHOLE 113

SHEET 1 OF 2

LOCATION: SEE FIGURE 2

BORING DATE: OCT. 17,1990

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

BORING METHOD: POWER AUGER BORING, SOLID STEM AUGERS

DEPTH SCALE METRES	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT, PERCENT (Wp — W — Wl; 10 20 30 40)	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE	90.35					
	TOPSOIL	90.15 / 0.00					
	Loose, brown sandy silt, trace clay and organics(roots). (FILL)	0.20	1	50 DO	5	o	BACKFILL
1	Very stiff to hard, greenish-grey SILTY CLAY, trace sand and gravel. (TILL)	89.59 / 0.76	2	50 DO	17	o	
			3	50 DO	104 /.2	o	
2	Completely weathered, grey SHALE.	88.22 / 2.13	4	50 DO	70/ .15	o	▽
	BOREHOLE CONTINUED. FOR BEDROCK CORING DETAILS, SEE SHEET 2.	87.91 / 2.44					

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

HYDRAULIC CONDUCTIVITY, k, cm/s

SHEAR STRENGTH Cu, kPa — nat.V - + Q - ● rem.V - ⊕ U - O

ADDITIONAL LAB. TESTING

15-◆-5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

DATA INPUT: SK DEC. 13/90

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: SC

CHECKED: MRA

RECORD OF BOREHOLE: 113

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
INCLINATION: -90 AZIMUTH:

DRILLING DATE: OCT. 17,1990
DRILL RIG: DIAMOND DRILL
DRILLING CONTRACTOR: K & S DRILLING

SHEET 2 OF 2
DATUM: GEODETIC

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 COLOUR % RETURN	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	NOTES WATER LEVELS INSTRUMENTATION
0			90.35 0.00					
1–2		Refer to sheet 1 for detailed stratigraphy.						
		CONTINUED FROM SHEET 1	87.91 2.44					
3	NQ RC	Completely to moderately weathered, grey SHALE (81%) with interbedded, slightly weathered, light grey SHALEY LIMESTONE (19%).		5	0.053	75	Broken Core (200mm) Broken Core (125mm) Joints generally R,PL Broken Core (125mm)	BACKFILL
4	NQ RC	Moderately weathered to fresh, grey SHALE.	86.39 3.96	6	0.048	80	Mud Seam (25mm)	BENTONITE SEAL
5–6	NQ RC OCT. 17/90	Shaley limestone layers were present at the following Elevations: 87.5m : 50mm 87.4m : 25mm 87.1m : 75mm 86.7m : 50mm 86.4m : 50mm	83.72 6.63	7	0.050	80	Broken Core (75mm)	PEA GRAVEL
7–10		END OF BOREHOLE						WATER LEVEL IN PIEZOMETER AT ELEV. 88.3m ON NOV. 12/90.

DATA INPUT: SK NOV. 29/90

DEPTH SCALE:
1 to 50

Golder Associates

LOGGED: SC
DATE: OCT. 17/90
CHECKED: MRA

PROJECT: 901-1403

RECORD OF BOREHOLE 114

SHEET 1 OF 2

LOCATION: SEE FIGURE 2

BORING DATE: OCT. 17,1990

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT, PERCENT (Wp–W–Wl)	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		90.90					
	POWER AUGER BORING, SOLID STEM AUGERS	TOPSOIL		90.75 0.15					
		Loose, dark brown silty sand, trace organics(roots). (FILL)		90.44 0.46	1	50 DO	9	○	
1		Very stiff, greenish-grey SILTY CLAY, trace sand and gravel. (TILL)		89.53 1.37	2	50 DO	16	○	BACKFILL
2		Hard, greenish-grey SILTY CLAY, trace sand. (RESIDUAL SOIL)		88.41 2.49	3	50 DO	101	○	
					4	50 DO	65/.05	○	
		BOREHOLE CONTINUED. FOR BEDROCK CORING DETAILS, SEE SHEET 2.							

Column headings also include: SOIL PROFILE; SAMPLES; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - ○); HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT Wp W Wl, 10 20 30 40; ADDITIONAL LAB. TESTING.

Depth scale: 0 1 2 3 4 5 6 7 8 9 10

15 -◆- 5 PERCENT AXIAL STRAIN AT FAILURE (0 / 10)

DATA INPUT: SK DEC. 13/90

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: SC

CHECKED: MRA

RECORD OF BOREHOLE: 114

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
INCLINATION: -90 AZIMUTH:

DRILLING DATE: OCT. 17,1990
DRILL RIG: DIAMOND DRILL
DRILLING CONTRACTOR: K & S DRILLING

DATUM: GEODETIC

Legend: 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	Discontinuity Data: Type and Surface Description	Notes / Water Levels / Instrumentation
0			90.90 / 0.00					
1–2		Refer to sheet 1 for detailed stratigraphy.						
		CONTINUED FROM SHEET 1	88.41 / 2.49					
3–4	NQ RC	Completely to moderately weathered, grey SHALE (85%) with interbedded slightly weathered to fresh SHALEY LIMESTONE (15%).	86.79 / 4.11	5	0.032	65	Broken Core/ Residual Soil(450mm); Broken Core (75mm); Joints generally R,PL	BACKFILL
4–5	NQ RC	Moderately weathered to fresh, grey SHALE (91%) with interbedded slightly weathered to fresh SHALEY LIMESTONE (9%).		6	0.060	80		BENTONITE SEAL
6	NQ RC; OCT. 17/90	Shaley limestone layers were present at the following Elevations: 88.0m : 25mm 87.9m : 50mm 87.3m : 100mm 87.0m : 75mm 86.8m : 75mm 86.6m : 50mm 86.5m : 75mm 86.2m : 50mm	84.04 / 6.86	7	0.060	80		PEA GRAVEL
7		END OF BOREHOLE						WATER LEVEL IN PIEZOMETER AT ELEV. 87.3m ON NOV. 12/90.
8–10								

DATA INPUT: SK NOV. 29/90

DEPTH SCALE: 1 to 50

Golder Associates

LOGGED: SC
DATE: OCT. 17/90
CHECKED: MRA

RECORD OF BOREHOLE 115

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
SAMPLER HAMMER, 63.5kg; DROP, 760mm
BORING DATE: OCT. 17,1990
SHEET 1 OF 2
DATUM: GEODETIC
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

BORING METHOD: POWER AUGER BORING, SOLID STEM AUGERS

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT (approx.)	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE	93.30					
	TOPSOIL	93.15 / 0.15	1	50 DO	10	~15	BACKFILL
1	Compact, brown silty sand, trace gravel, clay and organics(roots). (FILL)	91.93 / 1.37	2	50 DO	13		BACKFILL
2	Very stiff to hard, greenish-grey SILTY CLAY, some sand, trace gravel. (TILL)	90.40 / 2.90	3	50 DO	16	~17	BACKFILL
			4	50 DO	42	~12	Water level
3	Hard, greenish-grey SILTY CLAY, trace sand. (RESIDUAL SOIL)	89.64 / 3.66	5	50 DO	65/.05		
	Highly weathered, grey SHALE.	89.39 / 3.91	6	50 DO	65/.10		BENTONITE SEAL
4	BOREHOLE CONTINUED. FOR BEDROCK CORING DETAILS, SEE SHEET 2.						

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
SHEAR STRENGTH Cu, kPa — nat.V - + Q - ● rem.V - ⊕ U - O
HYDRAULIC CONDUCTIVITY, k, cm/s
WATER CONTENT, PERCENT Wp —O W— Wl 10 20 30 40
ADDITIONAL LAB. TESTING

15-◆-5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

DATA INPUT: SK DEC. 13/90

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: SC
CHECKED: MRA

RECORD OF BOREHOLE: 115

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
INCLINATION: -90 AZIMUTH:

DRILLING DATE: OCT. 17,1990
DRILL RIG: DIAMOND DRILL
DRILLING CONTRACTOR: K & S DRILLING

DATUM: GEODETIC

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	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (m/min.)	FLUSH COLOUR % RETURN	RECOVERY TOTAL CORE % / SOLID CORE %	R.Q.D. %	FRACT. INDEX PER .3 m	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				93.30 0.00											
2		Refer to sheet 1 for detailed stratigraphy.													
		CONTINUED FROM SHEET 1		89.39											
4–5	OCT. 17/90 NQ RC	Highly to slightly weathered, grey SHALE (94%) with interbedded slightly weathered SHALEY LIMESTONE (6%). Shaley limestone layers were present at the following Elevations: 89.3m : 75mm 88.0m : 50mm		3.91 87.81	7	0.066	80					Broken Core (100mm) Joints generally R,PL Broken Core (50mm)			BENTONITE SEAL PEA GRAVEL
		END OF BOREHOLE		5.49											WATER LEVEL IN PIEZOMETER AT ELEV. 90.8m ON NOV. 12/90.

DEPTH SCALE:
1 to 50

Golder Associates

LOGGED: SC
DATE: OCT. 17/90
CHECKED: MRA

DATA INPUT: SK NOV. 29/90

RECORD OF BOREHOLE 116

PROJECT: 901-1403
SHEET 1 OF 1
LOCATION: SEE FIGURE 2
BORING DATE: OCT. 19,1990
DATUM: GEODETIC
SAMPLER HAMMER, 63.5kg; DROP, 760mm
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

BORING METHOD: POWER AUGER BORING, SOLID STEM AUGERS

Description	Elev. / Depth (m)
GROUND SURFACE	95.11 / 0.00
Very stiff to hard, grey SILTY CLAY, trace sand and gravel. (TILL)	92.21 / 2.90
Hard, greenish-grey SILTY CLAY, trace sand and gravel with occasional shale fragments. (RESIDUAL SOIL)	90.84 / 4.27
Completely to highly weathered, grey SHALE with occasional layers of shaley limestone (inferred from augering).	87.39 / 7.72
END OF BOREHOLE	

Sample Number	Type	Blows/0.3m
1	50 DO	20
2	50 DO	37
3	50 DO	36
4	50 DO	70/.05
5	50 DO	70/.08
6	50 DO	80/.05
7	50 DO	83/.08
8	50 DO	80/.10
9	50 DO	80/.02

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
SHEAR STRENGTH Cu, kPa nat.V - + Q - ● rem.V - ⊕ U - O
HYDRAULIC CONDUCTIVITY, k, cm/s
WATER CONTENT, PERCENT Wp —O W— Wl 10 20 30 40
ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION: BACKFILL; BENTONITE SEAL; GRANULAR BACKFILL

BOREHOLE DRY ON COMPLETION OF DRILLING.

WATER LEVEL IN PIEZOMETER AT ELEV. 93.5m ON NOV. 12/90.

15 0 5 10 PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: SK DEC. 13/90

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: MK
CHECKED: MRA

RECORD OF BOREHOLE 117

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
SAMPLER HAMMER, 63.5kg; DROP, 760mm

BORING DATE: OCT. 19,1990

SHEET 1 OF 1
DATUM: GEODETIC
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES | BORING METHOD: POWER AUGER BORING, SOLID STEM AUGERS

SOIL PROFILE

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT
GROUND SURFACE	96.92 / 0.00				
Hard, greenish-grey SILTY CLAY, some sand, trace gravel. (TILL)		1	50 DO	31	O
		2	50 DO	50	O
Hard, greenish-grey SILTY CLAY, trace sand. (RESIDUAL SOIL)	94.79 / 2.13	3	50 DO	100 /.2	O
		4	50 DO	50/ .13	
Highly weathered, grey SHALE with occasional layers of shaley limestone (inferred by augering).	93.26 / 3.66	5	50 DO	80/ .05	
		6	50 DO	80/ .10	
		7	50 DO	80/ .10	
		8	50 DO	80/ .05	
		9	50 DO	80/ .05	
		10	50 DO	80/ .05	
END OF BOREHOLE	89.25 / 7.67				

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

SHEAR STRENGTH Cu, kPa — nat.V - + Q - ● rem.V - ⊕ U - O

HYDRAULIC CONDUCTIVITY, k, cm/s

WATER CONTENT, PERCENT — Wp ⊢—O W—⊣ Wl — 10 20 30 40

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

BACKFILL

BENTONITE SEAL

PEA GRAVEL

CAVED

BOREHOLE DRY ON COMPLETION OF DRILLING.

WATER LEVEL IN PIEZOMETER AT ELEV. 95.4m ON NOV. 12/90.

15-◆-5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

DATA INPUT: SK DEC. 13/90

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: MK
CHECKED: MRA

PROJECT: 901-1403

RECORD OF BOREHOLE 118

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: OCT. 19,1990

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

Column headings: DEPTH SCALE METRES | BORING METHOD | SOIL PROFILE (DESCRIPTION, STRATA PLOT, ELEV. DEPTH (m)) | SAMPLES (NUMBER, TYPE, BLOWS/0.3m) | DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m | SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - O) | HYDRAULIC CONDUCTIVITY, k, cm/s | WATER CONTENT, PERCENT (Wp ——O W—— Wl; 10 20 30 40) | ADDITIONAL LAB. TESTING | PIEZOMETER OR STANDPIPE INSTALLATION

Boring method: POWER AUGER BORING — SOLID STEM AUGERS

ELEV. / DEPTH (m)	DESCRIPTION
98.67	GROUND SURFACE
0.00	Loose, grey sand with pockets of silty clay. (FILL)
97.30 / 1.37	Very stiff, grey SILTY CLAY, trace sand and gravel. (TILL)
96.54 / 2.13	Hard, grey SILTY CLAY, trace sand. (RESIDUAL SOIL)
95.22 / 3.45	Completely to highly weathered, grey SHALE with occasional layers of shaley limestone (inferred by augering).
90.97 / 7.70	END OF BOREHOLE

NUMBER	TYPE	BLOWS/0.3m
1	50 DO	6
2	50 DO	20
3	50 DO	93
4	50 DO	60/.13
5	50 DO	60/.15
6	50 DO	60/.10
7	50 DO	60/.15
8	50 DO	60/.10
9	50 DO	60/.08

Piezometer installation: BACKFILL; BENTONITE SEAL; PEA GRAVEL; CAVED

BOREHOLE DRY ON COMPLETION OF DRILLING.

WATER LEVEL IN PIEZOMETER AT ELEV. 97.0m ON NOV. 13/90.

15 —◆— 5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

DATA INPUT: SK NOV. 21/90

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: MK

CHECKED: MRA

PROJECT: 901-1403

LOCATION: SEE FIGURE 2

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE 119

BORING DATE: OCT. 18,1990

SHEET 1 OF 1

DATUM: GEODETIC

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

Boring method: POWER AUGER BORING, SOLID STEM AUGERS

SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE	100.37 / 0.00					BACKFILL
Compact to dense, brown to grey SAND, trace to some silt.		1	50 DO	12		
		2	50 DO	47		BENTONITE SEAL
Hard, grey SILTY CLAY, trace sand and gravel. (TILL)	98.01 / 2.36	3	50 DO	50/.13		
		4	50 DO	84		
Very dense, grey SAND, some gravel, trace silt and clay with occasional boulders (inferred by augering).	96.71 / 3.66	5	50 DO	91		PEA GRAVEL/ CAVED GRANULAR
		6	50 DO	94	MH	
		7	50 DO	60/.15		
Completely to highly weathered, grey SHALE with occasional layers of shaley limestone (inferred by augering).	94.58 / 5.79	8	50 DO	70/.08		
END OF BOREHOLE AUGER REFUSAL	92.75 / 7.62					

Chart columns: DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - +, rem.V - ⊕, Q - ●, U - ○); HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10, 20, 30, 40).

15 ◆ 5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

WATER LEVEL AT ELEV. 97.9m ON COMPLETION OF DRILLING.

WATER LEVEL IN PIEZOMETER AT ELEV. 98.7m ON NOV. 13/90.

DATA INPUT: SK NOV. 29/90

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: AJW/MK

CHECKED: MRA

PROJECT: 901-1403

LOCATION: SEE FIGURE 2

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE 120

BORING DATE: OCT. 17,1990

DATUM: GEODETIC

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - +, rem.V - ⊕, Q - ●, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		101.23							
0	POWER AUGER BORING, SOLID STEM AUGERS	Loose to compact, brown SAND, trace to some silt.		0.00							
1					1	50 DO	9				
					2	50 DO	19				
2		Stiff to hard, grey SILTY CLAY, trace sand and gravel. (TILL)		99.10 / 2.13	3	50 DO	14				BACKFILL
3					4	50 DO	49				
4		Completely weathered, grey SHALE.		97.42 / 3.81	5	50 DO	54				
		BOREHOLE CONTINUED. FOR BEDROCK CORING DETAILS, SEE SHEET 2.		96.86 / 4.37							
5											
6											
7											
8											
9											
10											

15 -◆- 5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

DATA INPUT: SK NOV. 21/90

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: SC

CHECKED: MRA

RECORD OF BOREHOLE: 120

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
INCLINATION: -90 AZIMUTH:

DRILLING DATE: OCT. 17,1990
DRILL RIG: DIAMOND DRILL
DRILLING CONTRACTOR: MASTER SOILS INVESTIGATIONS

SHEET 2 OF 2
DATUM: GEODETIC

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

Columns: DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | PENETRATION RATE (m/min.) | FLUSH COLOUR % RETURN | RECOVERY (TOTAL CORE %, SOLID CORE %) | R.Q.D. % | FRACT. INDEX PER .3 m | DISCONTINUITY DATA (DIP w.r.t. CORE AXIS; TYPE AND SURFACE DESCRIPTION) | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (MPa) | NOTES WATER LEVELS INSTRUMENTATION

101.23
0.00

Refer to sheet 1 for detailed stratigraphy.

CONTINUED FROM SHEET 1

98.86
4.37

Completely to moderately weathered, fine grained, grey SHALE (93%) with interbedded slightly weathered, light grey SHALEY LIMESTONE (7%).

Shaley limestone layers were present at the following Elevations:
96.9m : 25mm
96.7m : 75mm
96.2m : 25mm
96.1m : 25mm
96.0m : 50mm

93.90
7.34

END OF BOREHOLE

Drilling record	Run No.	Penetration rate (m/min.)	Flush % return
NQ RC	6	0.040	30
NQ RC	7	0.016	10
NQ RC	8	0.025	30

OCT. 17/90

Discontinuity type and surface description:
- Broken Core (25mm)
- Broken Core (25mm)
- Broken Core (150mm)
- Mud Seam (75mm)
- Mud Seam (25mm)
- Broken Core (50mm)
- Joints generally
- R,PL
- Broken Core (75mm)

Notes / instrumentation:
- BACKFILL
- BENTONITE SEAL
- PEA GRAVEL
- WATER LEVEL IN PIEZOMETER AT ELEV. 98.6m ON NOV. 13/90.

DATA INPUT: SK NOV. 29/90

DEPTH SCALE:
1 to 50

Golder Associates

LOGGED: SC
DATE: OCT. 17/90
CHECKED: MRA

RECORD OF BOREHOLE 121

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
SAMPLER HAMMER, 63.5kg; DROP, 760mm
BORING DATE: OCT. 22,1990
SHEET 1 OF 1
DATUM: GEODETIC
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

Depth (m)	Boring Method	Soil Profile Description	Elev. / Depth (m)	Sample No.	Type	Blows/0.3m	Water Content (%)	Additional Lab. Testing	Piezometer or Standpipe Installation
0		GROUND SURFACE	102.11 / 0.00						
0.00–3.66	Power Auger Boring – Solid Stem Augers	Compact to very dense, red-brown to grey SAND, trace to some silt.	98.45 / 3.66	1	50 DO	35			BACKFILL
				2	50 DO	19			Water level symbol (~1.9 m)
				3	50 DO	106			
				4	50 DO	92			
3.66–7.01	Power Auger Boring – Solid Stem Augers	Very dense, grey SILTY SAND, trace gravel and clay.	95.10 / 7.01	5	50 DO	95/.15			
				6	50 DO	60/.15		MH	
				7	50 DO	80/.08			
				8	50 DO	111			
7.01–8.38	Power Auger Boring – Hollow Stem Augers	Compact, grey SILT, some sand, trace clay.	93.73 / 8.38	9	50 DO	15			BENTONITE SEAL; PEA GRAVEL
8.38–9.37	Power Auger Boring – Hollow Stem Augers	Very dense, grey GRAVELLY SAND, trace silt.	92.74 / 9.37	10	50 DO	80/.08			CAVED
		END OF BOREHOLE							

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

HYDRAULIC CONDUCTIVITY, k, cm/s

SHEAR STRENGTH Cu, kPa — nat.V - + Q - ● rem.V - ⊕ U - O

WATER CONTENT, PERCENT — Wp, W, Wl — 10 20 30 40

15 -◆- 5 PERCENT AXIAL STRAIN AT FAILURE (0 / 10)

WATER LEVEL IN OPEN BOREHOLE AT ELEV. 99.6m ON COMPLETION OF DRILLING. WATER LEVEL IN PIEZOMETER AT ELEV. 100.2m ON NOV. 13/90

DATA INPUT: SK NOV. 29/90

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: AJW/MK
CHECKED: MRA

RECORD OF BOREHOLE 122

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
SAMPLER HAMMER, 63.5kg; DROP, 760mm
BORING DATE: OCT. 17,1990
SHEET 1 OF 1
DATUM: GEODETIC
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

BORING METHOD: POWER AUGER BORING, SOLID STEM AUGERS

DEPTH SCALE METRES	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE	102.65 / 0.00						BACKFILL
	Compact to dense, red-brown to grey SAND, trace silt and gravel.		1	50 DO	14			
			2	50 DO	43	o		
2	Dense to very dense, grey SANDY SILT, trace clay.	100.52 / 2.13	3	50 DO	53	o		BENTONITE SEAL
			4	50 DO	39	o	MH	
			5	50 DO	59/.15	o		PEA GRAVEL
			6	50 DO	55/.10	o		
5	Very dense, grey SANDY GRAVEL, trace silt with shale fragments and frequent boulders (inferred by augering).	97.47 / 5.18						
			7	50 DO	76	o	MH	CAVED
			8	50 DO	80/.15	o		
			9	50 DO	80/.13			
			10	50 DO	100/.1			
			11	50 DO	68/.15			
9.3	END OF BOREHOLE	93.35 / 9.30						

WATER LEVEL IN PIEZOMETER AT ELEV. 100.6m ON NOV. 13/90.

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
HYDRAULIC CONDUCTIVITY, k, cm/s
SHEAR STRENGTH Cu, kPa — nat.V - + Q - ● rem.V - ⊕ U - O
WATER CONTENT, PERCENT — Wp — W — Wl (10, 20, 30, 40)

15-◆-5 PERCENT AXIAL STRAIN AT FAILURE (10)

DATA INPUT: SK NOV. 29/90

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: AJW/MK
CHECKED: MRA

PROJECT: 901-1403

LOCATION: SEE FIGURE 2

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE 123

BORING DATE: OCT. 18,1990

SHEET 1 OF 2

DATUM: GEODETIC

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. / DEPTH (m)
0	POWER AUGER BORING; SOLID STEM AUGERS	GROUND SURFACE	103.56
		TOPSOIL	103.41 / 0.15
		Compact to dense, brown SANDY SILT to SAND, trace gravel.	102.04 / 1.52
		Hard, red-grey SILTY CLAY, trace sand and gravel. (TILL)	98.38 / 5.18
	POWER AUGER BORING; HOLLOW STEM AUGERS (from 6 m)	Very dense, brown GRAVELLY SAND, trace silt.	96.25 / 7.31
		Hard, grey SILTY CLAY, trace sand and gravel with occasional sand pockets. (TILL)	
10		CONTINUED ON NEXT PAGE	

SAMPLES: NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
1	50 DO	11	
2	50 DO	32	
3	50 DO	50	
4	50 DO	130	
5	50 DO	82	
6	50 DO	118/.2	
7	50 DO	75/.15	
8	50 DO	80	
9	50 DO	64	MH
10	50 DO	76/.15	
11	50 DO	107	
12	50 DO	98/.25	
13	50 DO	58/.13	
14	50 DO	140/.2	

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

SHEAR STRENGTH Cu, kPa — nat.V - + Q - ● rem.V - ⊕ U - ○

HYDRAULIC CONDUCTIVITY, k, cm/s

WATER CONTENT, PERCENT — Wp W Wl — 10 20 30 40

PIEZOMETER OR STANDPIPE INSTALLATION: BACKFILL; BENTONITE SEAL; BACKFILL; PEA GRAVEL; BENTONITE SEAL; PEA GRAVEL; CAVED

15-0-5 PERCENT AXIAL STRAIN AT FAILURE (10)

DATA INPUT: SK DEC. 20/90

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: SC

CHECKED: MRA

RECORD OF BOREHOLE 123

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
SAMPLER HAMMER, 63.5kg; DROP, 760mm
BORING DATE: OCT. 18,1990
SHEET 2 OF 2
DATUM: GEODETIC
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - +, Q - ●, rem.V - ⊕, U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp —O W— Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10		CONTINUED FROM PREVIOUS PAGE									
				93.30 / 10.26	14	50 DO	140 /.2				CAVED
		END OF BOREHOLE									WATER LEVEL IN OPEN BOREHOLE AT ELEV. 98.4m ON COMPLETION OF DRILLING. WATER LEVEL IN PIEZOMETER AT ELEV. 101.0m ON NOV. 13/90.
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

15 -◆- 5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

DATA INPUT: SK NOV. 22/90

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: SC
CHECKED: MRA

RECORD OF BOREHOLE 124

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
SAMPLER HAMMER, 63.5kg; DROP, 760mm

BORING DATE: OCT. 19,1990

SHEET 1 OF 1
DATUM: GEODETIC
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

BORING METHOD: POWER AUGER BORING, SOLID STEM AUGERS

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
GROUND SURFACE	106.24				
TOPSOIL	106.08 / 0.15				
Loose to compact, light brown SAND, trace silt.		1	50 DO	4	
		2	50 DO	27	
	104.87 / 1.37				
Hard, grey SILTY CLAY, trace sand and gravel. (TILL)		3	50 DO	33	
		4	50 DO	76	
		5	50 DO	91	
		6	50 DO	47	
		7	50 DO	78/.13	
	101.05 / 5.18				
Very dense, grey SILTY SAND, trace gravel and clay.		8	50 DO	51	MH
	100.14 / 6.10				
Very dense, grey SAND AND GRAVEL some silt, trace clay. (TILL)		9	50 DO	52/0	
		10	50 DO	68/.15	MH
	98.76 / 7.47				
Very dense, grey SANDY SILT, trace gravel and clay. (TILL)		11	50 DO	66	
	98.16 / 8.08				
END OF BOREHOLE					

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

SHEAR STRENGTH Cu, kPa — nat.V - + Q - ● ; rem.V - ⊕ U - O

HYDRAULIC CONDUCTIVITY, k, cm/s

WATER CONTENT, PERCENT — Wp ⊢—O W —⊣ Wl — 10 20 30 40

15-◆-5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

PIEZOMETER OR STANDPIPE INSTALLATION:

- BACKFILL
- BENTONITE SEAL
- PEA GRAVEL
- CAVED

WATER LEVEL IN OPEN BOREHOLE AT ELEV. 101.7m ON COMPLETION OF DRILLING.

WATER LEVEL IN PIEZOMETER AT ELEV. 103.5m ON NOV. 13/90.

DATA INPUT: SK DEC. 20/90

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: SC
CHECKED: MRA

RECORD OF BOREHOLE 125

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
BORING DATE: JAN. 2,1991
SHEET 1 OF 2
DATUM: GEODETIC
SAMPLER HAMMER, 63.5kg; DROP, 760mm
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

Boring method: POWER AUGER BORING, HOLLOW STEM AUGERS

Soil Profile Description	Elev. / Depth (m)	Sample Number	Type	Blows/0.3m	Water Content (%)	Additional Lab. Testing	Piezometer or Standpipe Installation
GROUND SURFACE	103.28						
ASPHALT	0.00 / 0.08						
Loose to compact, black to brown SILTY SAND, trace clay with occasional clayey silt and sand seams and some organic material.		1	50 DO	16			GROUT
	101.18 / 2.10	2	50 DO	9			
Hard, brown to grey CLAYEY SILT, some sand, trace gravel with occasional silty sand seams. (TILL).		3	50 DO	69	~10		
		4	50 DO	50/.10			BENTONITE SEAL
	99.09 / 4.19	5	50 DO	92	~10		
Hard, grey SILTY CLAY, some sand, trace gravel, with frequent sand and gravel seams, shale fragments and boulders (inferred by augering). (TILL).		6	50 DO	50/.10			
		7	50 DO	90/.15	~9		
	96.78 / 6.50	8	50 DO	60/.15			CAVED
Very dense, grey SAND and GRAVEL, some silt, trace clay with occasional silty clay seams and shale fragments.		9	50 DO	60/.15	~10		
		10	50 DO	52/.10			
	94.48 / 8.80	11	50 DO	55/.15	~10	MH	
Weathered SHALE slab.	93.43 / 9.85	12	50 DO	61/.13			PEA GRAVEL
FOR DESCRIPTION SEE NEXT PAGE							

CONTINUED ON NEXT PAGE

15-◆-5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

Column headings: DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; HYDRAULIC CONDUCTIVITY, k, cm/s; SHEAR STRENGTH Cu, kPa (nat.V - +, rem.V - ⊕, Q - ●, U - ○); WATER CONTENT, PERCENT Wp —O W— Wl (10, 20, 30, 40)

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: MK
CHECKED: MRA

DATA INPUT: SK FEB. 26/92

PROJECT: 901-1403

RECORD OF BOREHOLE 125

SHEET 2 OF 2

LOCATION: SEE FIGURE 2

BORING DATE: JAN. 2,1991

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

Boring method: POWER AUGER BORING, HOLLOW STEM AUGERS

Depth (m)	Description	Elev. / Depth (m)	Sample No.	Type	Blows/0.3m	Water content (%)	Additional lab testing	Piezometer or standpipe installation
10	CONTINUED FROM PREVIOUS PAGE							
	Very dense, grey SAND and GRAVEL, trace to some silt and clay.		13	50 DO	60	o	MH	
			14	50 DO	50/.13	o		
	Hard, grey SILTY CLAY, trace sand and gravel. (TILL).	90.48 / 12.80	15	50 DO	90	o		CAVED
	Weathered grey SHALE.	88.98 / 14.30	16	50 DO	60/.08			
	END OF BOREHOLE	88.57 / 14.71						

WATER LEVEL IN OPEN BOREHOLE AT ELEV. 100.5m DURING DRILLING. WATER LEVEL IN PIEZOMETER AT ELEV. 100.4m ON NOV. 21/91

Column headings: DEPTH SCALE METRES; BORING METHOD; SOIL PROFILE (DESCRIPTION, STRATA PLOT, ELEV. DEPTH (m)); SAMPLES (NUMBER, TYPE, BLOWS/0.3m); DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - +, rem.V - ⊕, Q - ●, U - O); HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp —O W— Wl; 10 20 30 40); ADDITIONAL LAB. TESTING; PIEZOMETER OR STANDPIPE INSTALLATION

Depth scale: 10 11 12 13 14 15 16 17 18 19 20

15-◆-5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

DATA INPUT: SK FEB. 26/92

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: MK

CHECKED: MRA

PROJECT: 901-1403

RECORD OF BOREHOLE 126

SHEET 1 OF 2

LOCATION: SEE FIGURE 2

BORING DATE: JAN. 7,1991

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

Column headings: DEPTH SCALE METRES | BORING METHOD | SOIL PROFILE (DESCRIPTION, STRATA PLOT, ELEV. DEPTH (m)) | SAMPLES (NUMBER, TYPE, BLOWS/0.3m) | DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m | SHEAR STRENGTH Cu, kPa — nat.V - + Q - ● rem.V - ⊕ U - O | HYDRAULIC CONDUCTIVITY, k, cm/s | WATER CONTENT, PERCENT Wp ⊢—O W—⊣ Wl (10, 20, 30, 40) | ADDITIONAL LAB. TESTING | PIEZOMETER OR STANDPIPE INSTALLATION

Boring method: POWER AUGER BORING, HOLLOW STEM AUGERS

Depth scale (m)	Description	Elev. / Depth (m)	Sample number	Type	Blows/0.3m	Additional lab. testing
0	GROUND SURFACE	103.68 / 0.00				
0–2.10	Loose to compact, brown SILTY SAND, trace gravel.		1	50 DO	16	
			2	50 DO	6	
2.10–2.90	Dense, grey SANDY SILT, trace clay and gravel. (TILL).	101.58 / 2.10	3	50 DO	32	
2.90–4.25	Hard, grey CLAYEY SILT, some sand, trace gravel. (TILL).	100.78 / 2.90	4	50 DO	52/ .10	
			5	50 DO	60/ .13	
4.25–5.80	Very dense, grey SAND and GRAVEL, some silt, trace clay with occasional silty clay seams.	99.43 / 4.25	6	50 DO	62/ .15	MH
			7	50 DO	55/ .08	
5.80–8.20	Hard, grey SILTY CLAY to CLAYEY SILT, trace to some sand, trace gravel. (TILL).	97.88 / 5.80	8	50 DO	70/ .10	
			9	50 DO	50/ .08	
			10	50 DO	70/ .15	
8.20–9.00	Dense, grey SILT.	95.48 / 8.20	11	50 DO	46	
9.00–	Hard, grey SILTY CLAY to CLAYEY SILT, trace to some sand, trace gravel. (TILL)	94.68 / 9.00	12	50 DO	65/ .15	
10	CONTINUED ON NEXT PAGE					

Piezometer or standpipe installation: CEMENT GROUT; BENTONITE SEAL; PEA GRAVEL

15 ◆ 5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

DATA INPUT: SK JAN. 10/91

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: MK

CHECKED: MRA

PROJECT: 901-1403

RECORD OF BOREHOLE 126

SHEET 2 OF 2

LOCATION: SEE FIGURE 2

BORING DATE: JAN. 7,1991

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa (nat.V - + Q - ● rem.V - ⊕ U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT Wp W Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10		CONTINUED FROM PREVIOUS PAGE									
11	POWER AUGER BORING HOLLOW STEM AUGERS	Hard, grey or reddish brown SILTY CLAY to CLAYEY SILT, trace to some sand, trace gravel. (TILL)			13	50 DO	52/ .15		O		
12					14	50 DO	75				CAVED
13				89.81 13.87	15	50 DO	70/ .15		O		
14		END OF BOREHOLE									WATER LEVEL IN OPEN BOREHOLE AT ELEV. 101.7m DURING DRILLING. WATER LEVEL IN PIEZOMETER AT ELEV. 100.8m ON NOV. 21/91.
15											
16											
17											
18											
19											
20											

0 15 5 10 PERCENT AXIAL STRAIN AT FAILURE

DATA INPUT: SK JAN. 10/91

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: MK

CHECKED: MRA

PROJECT: 901-1403

RECORD OF BOREHOLE 127

LOCATION: SEE FIGURE 2

BORING DATE: JAN. 3,1991

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT, PERCENT (Wp 10 20 30 40 Wl)	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		79.06					
0	POWER AUGER BORING, HOLLOW STEM AUGERS	Firm to hard, grey SILTY CLAY, trace sand and gravel. (TILL).		0.00					
1					1	50 DO	7	○	
					2	50 DO	71	○	
2		Hard, grey- green SILTY CLAY, trace sand. (RESIDUAL SOIL).		77.23 / 1.83					BACKFILL
				76.67 / 2.39	3	50 DO	60/ .13		
3		Completely weathered grey SHALE.			4	50 DO	70/ .05		∇
4				74.54 / 4.52					
5		Borehole continued. For bedrock coring description, see sheet 2.							
6									
7									
8									
9									
10									

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

HYDRAULIC CONDUCTIVITY, k, cm/s

SHEAR STRENGTH Cu, kPa — nat.V - + Q - ● rem.V - ⊕ U - ○

ADDITIONAL LAB. TESTING

0 / 15 - 5 PERCENT AXIAL STRAIN AT FAILURE / 10

DATA INPUT: SK FEB. 26/92

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: MK
CHECKED: MRA

PROJECT: 901-1403

LOCATION: SEE FIGURE 2

INCLINATION: -90 AZIMUTH:

RECORD OF BOREHOLE 127

DRILLING DATE: JAN. 3,1991

DRILL RIG: DIAMOND DRILL

DRILLING CONTRACTOR: K & S DRILLING

DATUM: GEODETIC

Legend: 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.	FLUSH % RETURN	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	NOTES WATER LEVELS INSTRUMENTATION
0			79.06 0.00				
2		Refer to sheet 1 for detailed stratigraphy.					
4		CONTINUED FROM SHEET 1	74.54 4.52			Jnts. generally R,Pl	BACKFILL
5	NQ RC	Moderately weathered to fresh, grey fine grained SHALE (85%) with interbedded slightly weathered to fresh, light grey SHALEY LIMESTONE (15%).		5	90	Broken Core(50mm)	BENTONITE SEAL
6–7	NQ RC	Shaley limestone layers were present at the following depths: (see below)		6	90	Vert. joint (900mm)	PEA GRAVEL
8	NQ RC JAN. 3/91		70.09 8.97	7	90	Broken Core (50mm)	
9		END OF BOREHOLE					WATER LEVEL IN OPEN BOREHOLE AT ELEV. 76.0m DURING DRILLING. WATER LEVEL IN PIEZOMETER AT ELEV. 76.01m ON JAN.14,1991.
10							

Thickness(mm)	Depth(m)
25	4.95
25	5.36
50	6.05
50	6.64
25	6.71
100	7.14
125	7.24
100	7.77
100	8.43
25	8.53
50	8.53

DATA INPUT: SK FEB. 26/92

DEPTH SCALE: 1 to 50

Golder Associates

LOGGED: MK

DATE: JAN. 3/91

CHECKED: MRA

PROJECT: 901-1403

LOCATION: SEE FIGURE 2

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE BH 128

BORING DATE: OCT.20&21/91

DATUM: GEODETIC

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

BORING METHOD: POWER AUGER BORING, SOLID STEM AUGERS

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT (approx. %)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE	103.79						
CONCRETE	103.61 / 0.18						
GRANULAR BASE	103.26 / 0.53						
Loose, brown silty sand, trace gravel, trace organics, occ. silty clay seams, trace cinders. (FILL)	101.39 / 2.40	1	50 DO	6			
		2	50 DO	16	○		
Dense to very dense, brown SAND and GRAVEL trace silt, occ. silty clay pockets.	98.79 / 5.00	3	50 DO	48			▽
		4	50 DO	60/.13	○	MH	
Hard, grey CLAYEY SILT, some sand and gravel (TILL)	97.85 / 5.94	5	50 DO	60/.08	○		
Hard grey CLAYEY SILT with some sand and gravel and shale fragments (RESIDUAL SOIL) becoming weathered grey SHALE. (BEDROCK)	93.88 / 9.91	6	50 DO	50/.13			
		7	50 DO	75/.10	○		
		8	50 DO	60/.13			WATER LEVEL IN OPEN HOLE AT ELEV. 101.1m ON COMPLETION OF DRILLING.
		9	50 DO	63/.13			
END OF BOREHOLE							

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

SHEAR STRENGTH Cu, kPa — nat.V - + Q - ● rem.V - ⊕ U - ○

HYDRAULIC CONDUCTIVITY, k, cm/s

WATER CONTENT, PERCENT — Wp ├──○W──┤ Wl — 10 20 30 40

15 ◆ 5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

DATA INPUT: PL/SK FEB. 26/92

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: RF

CHECKED: MRA

RECORD OF BOREHOLE BH 129

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
SAMPLER HAMMER, 63.5kg; DROP, 760mm
BORING DATE: OCT. 28/91
SHEET 1 OF 1
DATUM: GEODETIC
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

BORING METHOD: POWER AUGER BORING, SOLID STEM AUGERS

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m
GROUND SURFACE	102.92			
TOPSOIL	0.10	1	50 DO	23
Compact, brown sand, trace silt, trace gravel (FILL)	102.32 / 0.60			
Compact to loose, brown to grey SAND to SILTY SAND, trace gravel, trace rootlets at 2.4m depth.	100.02 / 2.90	2	50 DO	18
		3	50 DO	8
		4	50 DO	2
Very dense, grey SILT, some sand trace clay, occ. gravel.	97.92 / 5.00	5	50 DO	51
		6	50 DO	58
		7	50 DO	60/.10
Hard, grey SILTY CLAY, some sand and gravel, occ. oxidized sand pockets. (TILL)	97.12 / 5.80	8	50 DO	50/.15
Very dense, grey SAND and GRAVEL, some silt, trace clay, occ. shale fragments and boulders.	96.22 / 6.70	9	50 DO	60/.15
Hard, grey CLAYEY SILT, some sand and gravel, occ. shale fragments and boulders. (TILL)	95.20 / 7.72	10	50 DO	69/.15
		11	50 DO	80/.15
Weathered, grey SHALE.	94.18 / 8.74	12	50 DO	79/.13
END OF BOREHOLE REFUSAL				

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
SHEAR STRENGTH Cu, kPa — nat.V - + Q - ● rem.V - ⊕ U - ○
HYDRAULIC CONDUCTIVITY, k, cm/s
WATER CONTENT, PERCENT — Wp ├──○W──┤ Wl — 10 20 30 40
ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION:
CONCRETE SEAL
BENTONITE SEAL
BACKFILL
50mm DIA PVC CASING
BENTONITE SEAL
SAND FILTER
50mm DIA PVC WELL SCREEN
BENTONITE SEAL
PEA GRAVEL
CAVED MATERIAL

WATER LEVEL IN OPEN BOREHOLE AT ELEV. 100.8m DURING DRILLING

WATER LEVEL IN MONITORING WELL AT ELEV. 101.5m ON COMPLETION OF INSTALLATION AND AT ELEV. 100.3m ON NOV.21, 1991.

15 -◆- 5 PERCENT AXIAL STRAIN AT FAILURE (0 / 10)

DEPTH SCALE 1 to 50

DATA INPUT: PL/sk FEB.26/92

LOGGED: AP
CHECKED: MRA

Golder Associates

RECORD OF BOREHOLE BH 130

PROJECT: 901-1403
LOCATION: SEE FIGURE 2
SAMPLER HAMMER, 63.5kg; DROP, 760mm
BORING DATE: OCT. 28&29/91
SHEET 1 OF 2
DATUM: GEODETIC
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

Boring method: POWER AUGER BORING, SOLID STEM AUGERS

DEPTH SCALE METRES	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	WATER CONTENT (approx. %)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE	102.85						
	Compact, brown sandy silt, trace organics and gravel. (TOPSOIL)	0.00 / 102.39	1	50 DO	12			CONCRETE SEAL
1	Compact, brown sand, trace silt, occ. pieces of topsoil. (FILL)	0.46 / 101.45	2	50 DO	10			BENTONITE SEAL
	Compact to dense, brown to grey, SAND to SILTY SAND, trace gravel, occ. oxidized sand lenses.	1.40	3	50 DO	27	~10		
2			4	50 DO	38			BACKFILL
3	Very dense, grey SANDY SILT to SILT, trace gravel.	99.65 / 3.20	5	50 DO	102	~15		
4			6	50 DO	65/.15			50mm DIA. PVC Casing
			7	50 DO	62/.15			
5	Hard, grey CLAYEY SILT, some sand and gravel, occ. silty sand seams. (TILL)	97.65 / 5.20	8	50 DO	60/.13	~9		
6	Very dense, grey SAND and GRAVEL, some silt occ. shale fragments.	97.05 / 5.80	9	50 DO	60/.15	~10		
7	Completely weathered, grey SHALE slab	96.25 / 6.60	10	50 DO	60/.08			
8	Very dense, grey SAND, trace clay, some silt.	95.55 / 7.30	11	50 DO	88	~20	MH	BENTONITE SEAL
			12	50 DO	79	~19		SAND FILTER
9	Very dense, grey SAND and GRAVEL, trace silt, occ. shale fragments. (TILL)	94.15 / 8.70	13	50 DO	60/.05			50mm DIA. PVC WELL SCREEN
10			14	50 DO	79/.15			

CONTINUED ON NEXT PAGE

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
HYDRAULIC CONDUCTIVITY, k, cm/s
SHEAR STRENGTH Cu, kPa — nat.V - + Q - ● rem.V - ⊕ U - ○
WATER CONTENT, PERCENT Wp —○W— Wl 10 20 30 40
15 —◆— 5 PERCENT AXIAL STRAIN AT FAILURE (0, 10)

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: RF
CHECKED: MRA

DATA INPUT: PL/sk FEB.26/92

RECORD OF BOREHOLE BH 130

PROJECT: 901-1403
SHEET 2 OF 2
LOCATION: SEE FIGURE 2
BORING DATE: OCT. 28&29/91
DATUM: GEODETIC
SAMPLER HAMMER, 63.5kg; DROP, 760mm
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat.V - +, rem.V - ⊕, Q - ●, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl) 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		CONTINUED FROM PREVIOUS PAGE									
10		See descriptions on previous page.		92.45 10.40	14	50 DO	79/.15				
		Hard, grey CLAYEY SILT, some sand and gravel, frequent shale fragments (RESIDUAL SOIL)		91.85 11.00	15	50 DO	72/.15				BENTONITE SEAL
11		Weathered, grey SHALE BEDROCK.		91.12 11.73	16	50 DO	80/.03				BACKFILL
		END OF BOREHOLE									
12											WATER LEVEL IN OPEN BOREHOLE AT ELEV. 99.6m DURING DRILLING AND AT ELEV. 98.5m ON COMPLETION OF DRILLING.
13											WATER LEVEL IN MONITORING WELL AT ELEV. 100.5m ON NOV. 21,1991.
14											
15											
16											
17											
18											
19											
20											

DATA INPUT: PL/sk FEB.26/92

15 (0, 10) 5 PERCENT AXIAL STRAIN AT FAILURE

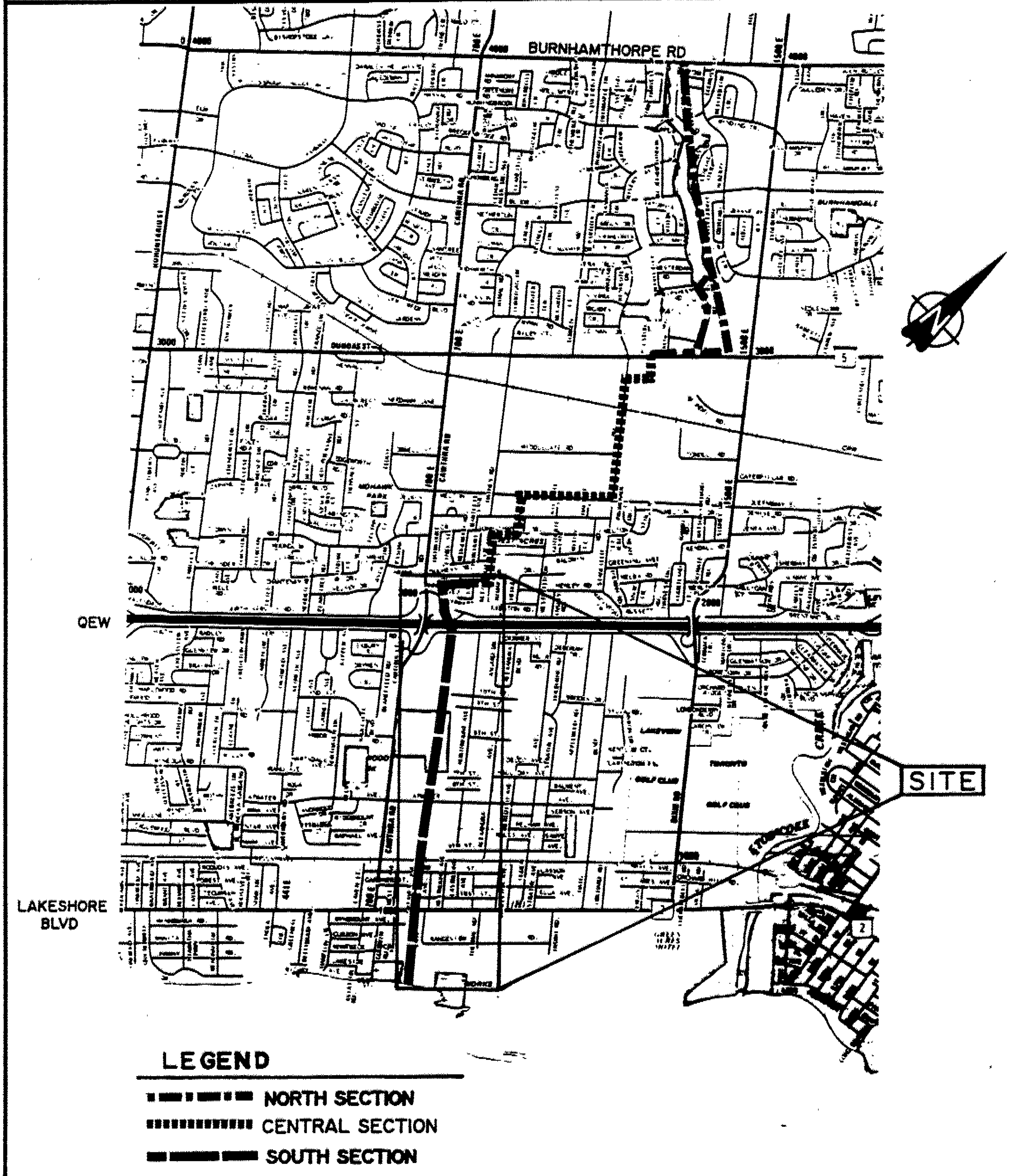
DEPTH SCALE
1 to 50

Golder Associates

LOGGED: RF
CHECKED: MRA

KEY PLAN
HANLAN FEEDERMAIN

FIGURE 1



Date NOV/90

Project 901-1403-1

Golder Associates

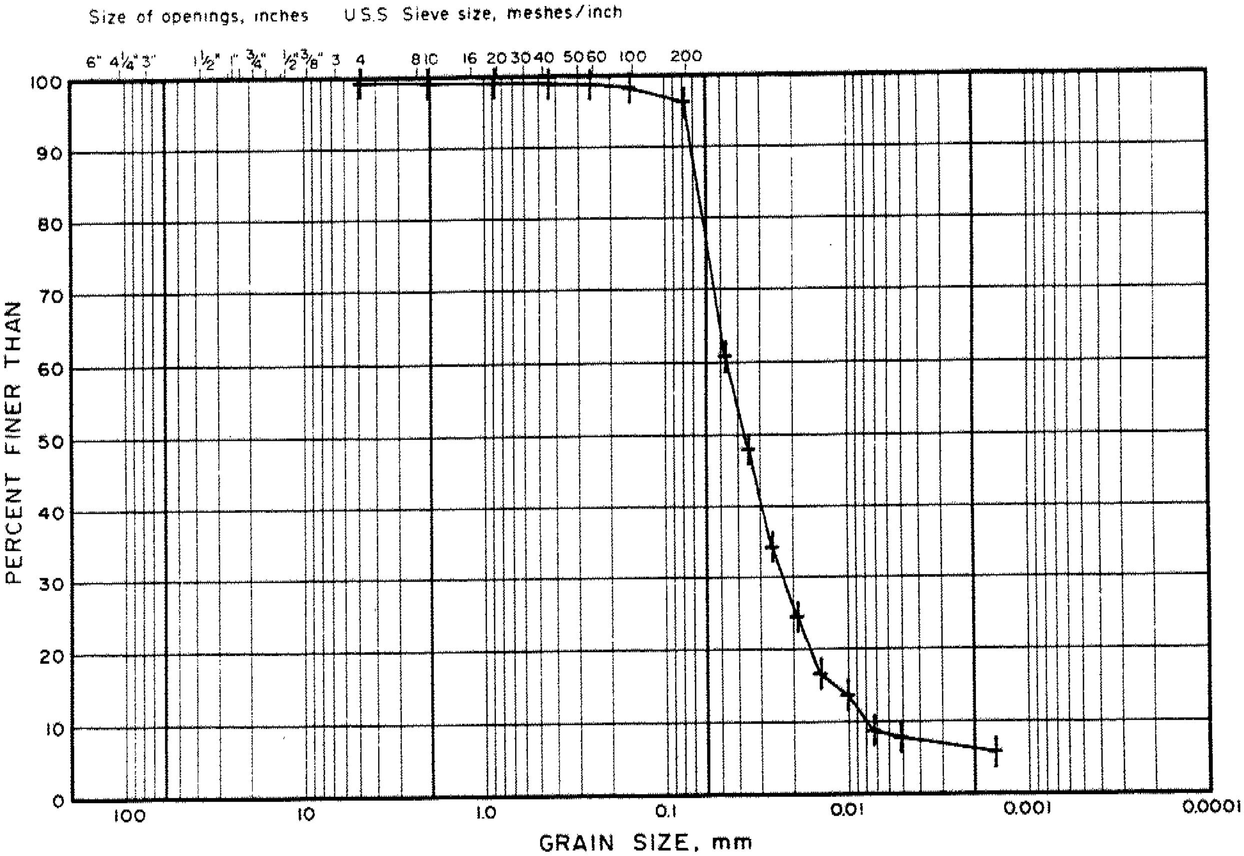
Drawn DV

Chkd.

GRAIN SIZE DISTRIBUTION

FIGURE 7

SILT



COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE
	GRAVEL SIZE			SAND SIZE			FINE GRAINED	

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
+	129	7	98.3

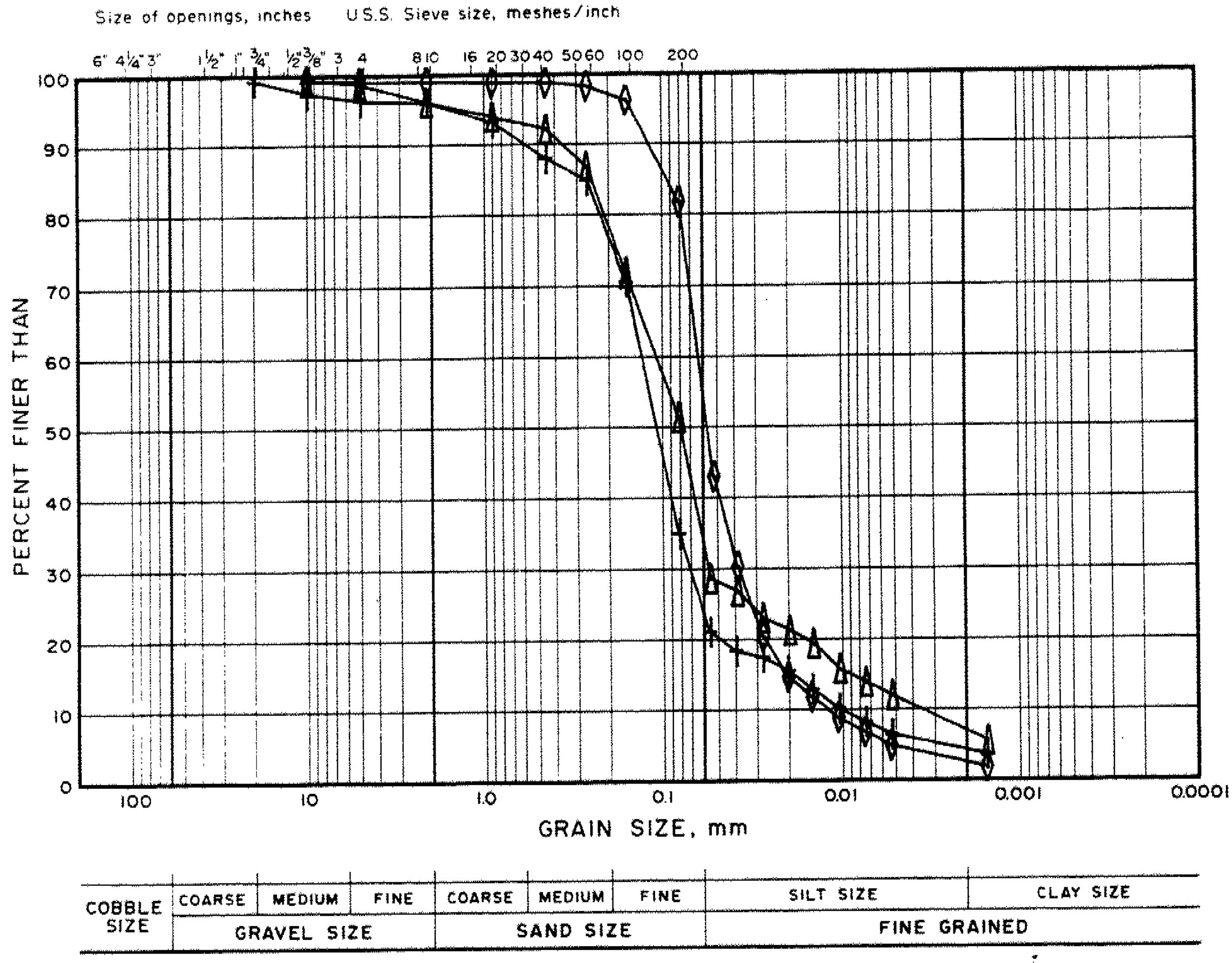
Project 901-1403

Golder Associates

GRAIN SIZE DISTRIBUTION

FIGURE 8

SILTY SAND and SANDY SILT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
+	121	6	97.4
◊	122	4	99.1
Δ	124	8	100.4

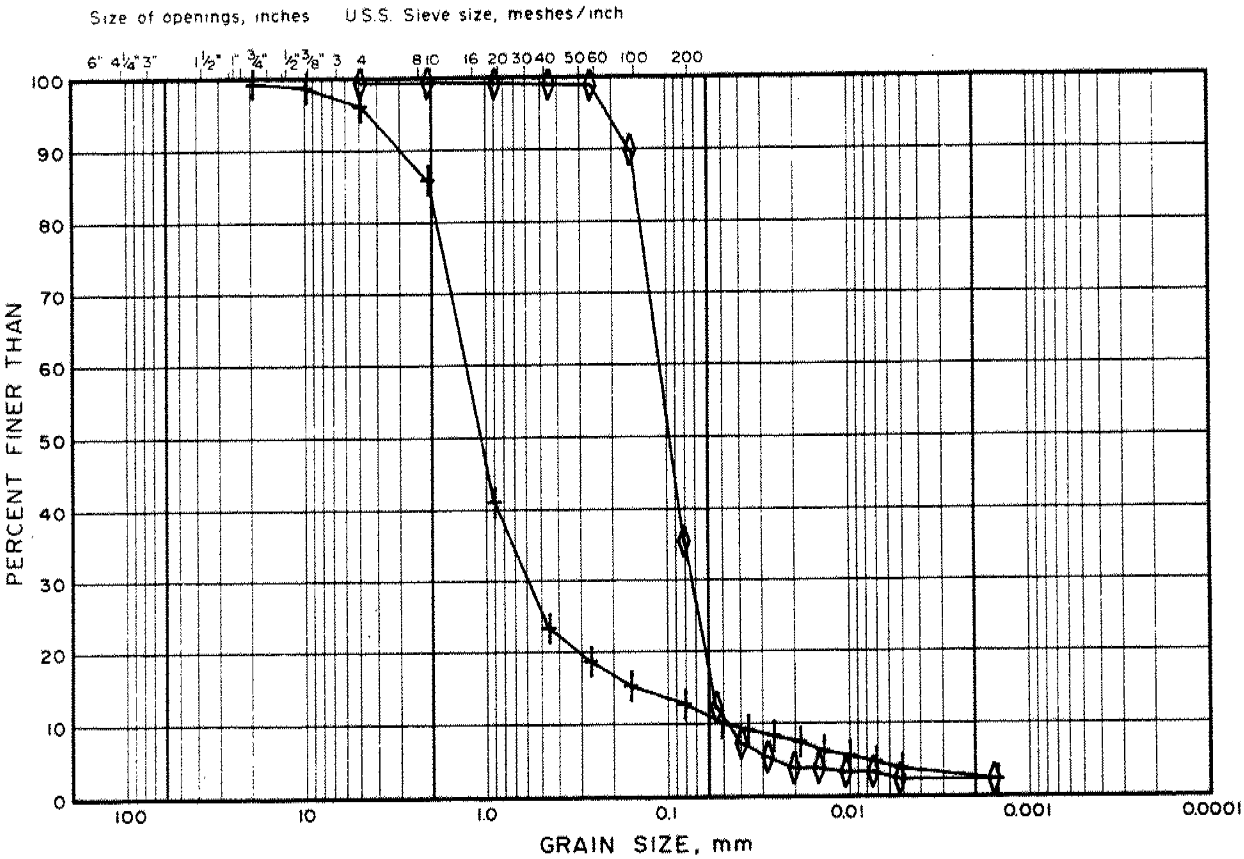
Project 901-1403

Golder Associates

GRAIN SIZE DISTRIBUTION

FIGURE 9

SAND, some silt



COBBLE SIZE	GRAVEL SIZE			SAND SIZE			FINE GRAINED	
	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
+	119	6	95.3
◊	130	11	95.0

Project 901-1403

Golder Associates

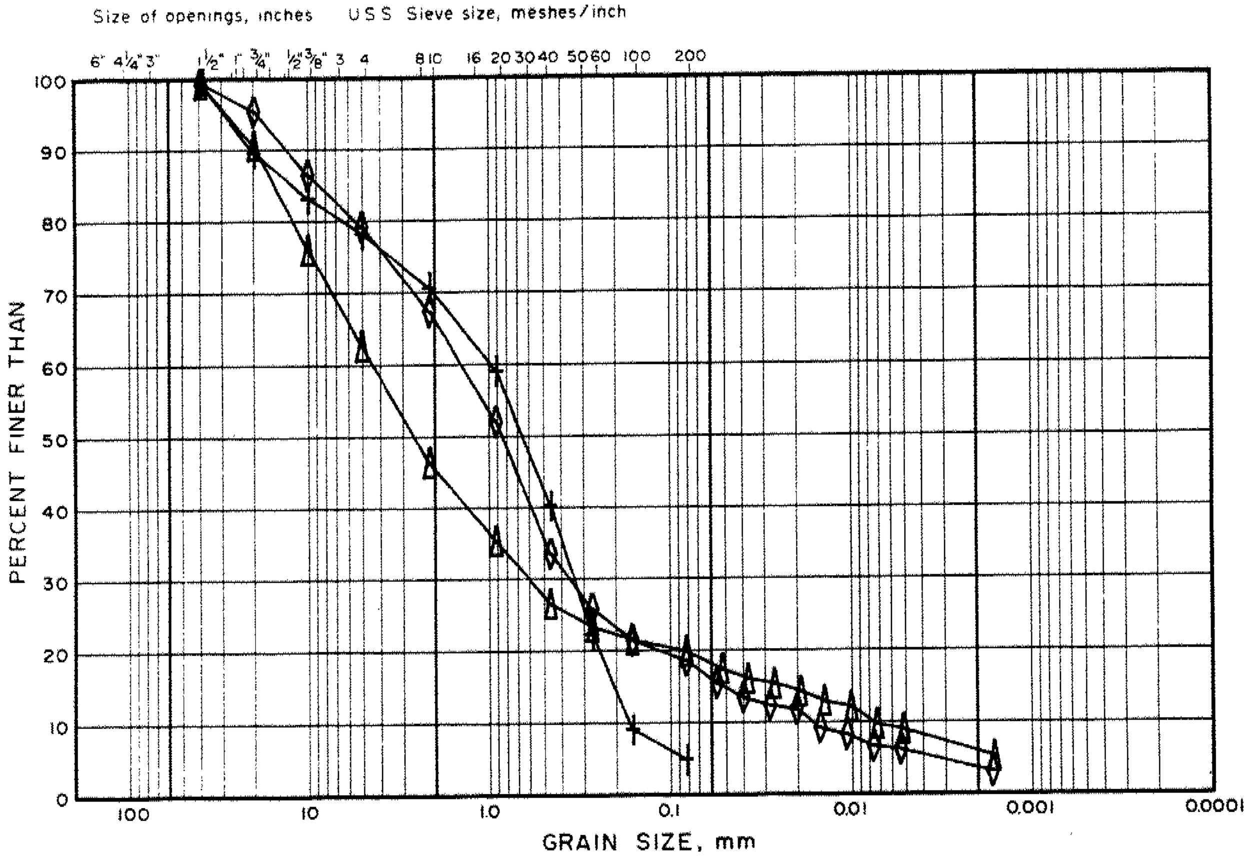
FORM PRODUCED MAY 1986

Form GA-C-1 (imperial)

GRAIN SIZE DISTRIBUTION

FIGURE 10

SAND and GRAVEL



COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE
	GRAVEL SIZE			SAND SIZE			FINE GRAINED	

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
+	123	9	97.0
◊	125	13	92.2
Δ	126	6	98.8

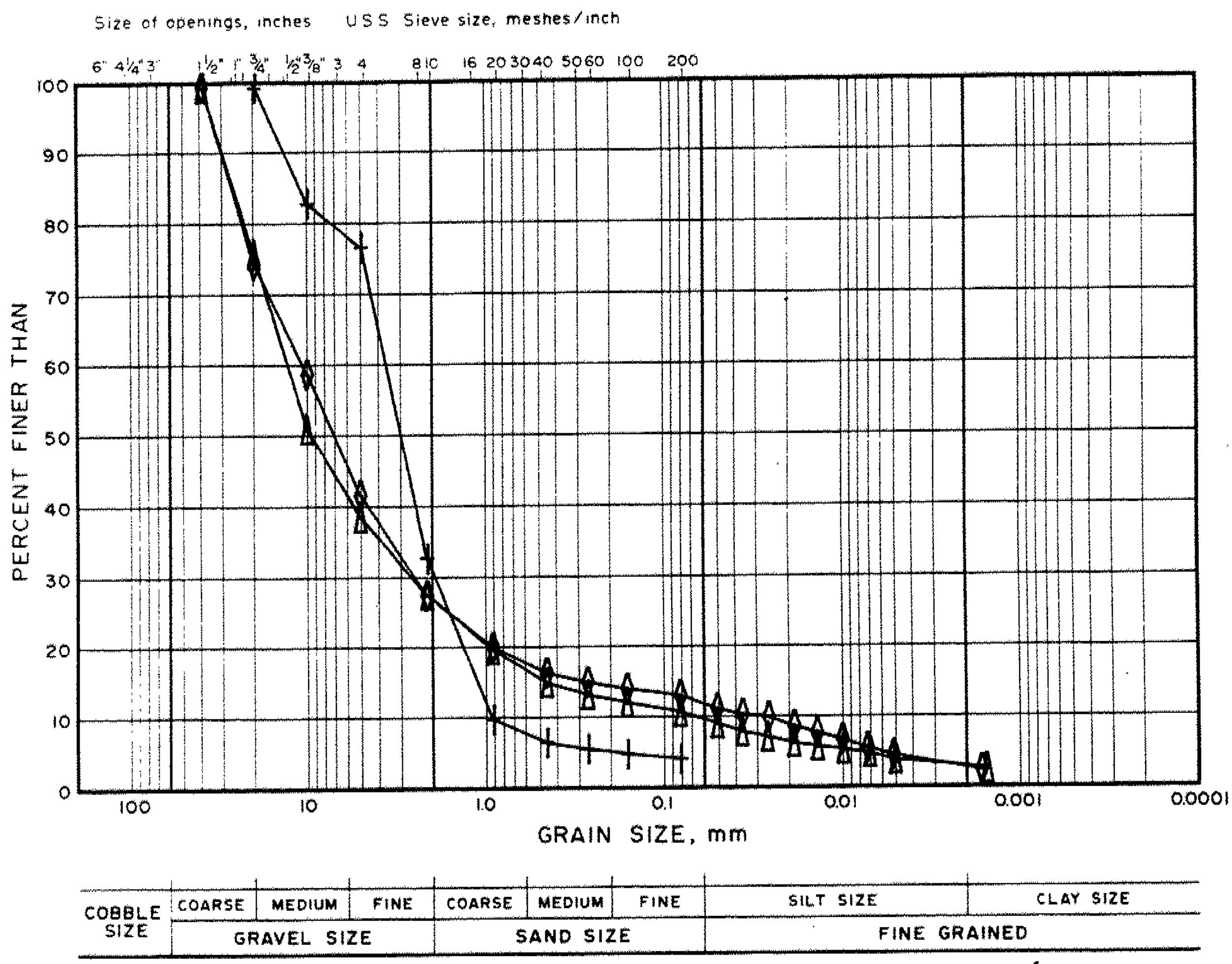
Project 901-1403

Golder Associates

GRAIN SIZE DISTRIBUTION

FIGURE 11

GRAVEL and SAND



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
+	122	7	96.1
◊	125	11	94.8
Δ	128	4	99.3

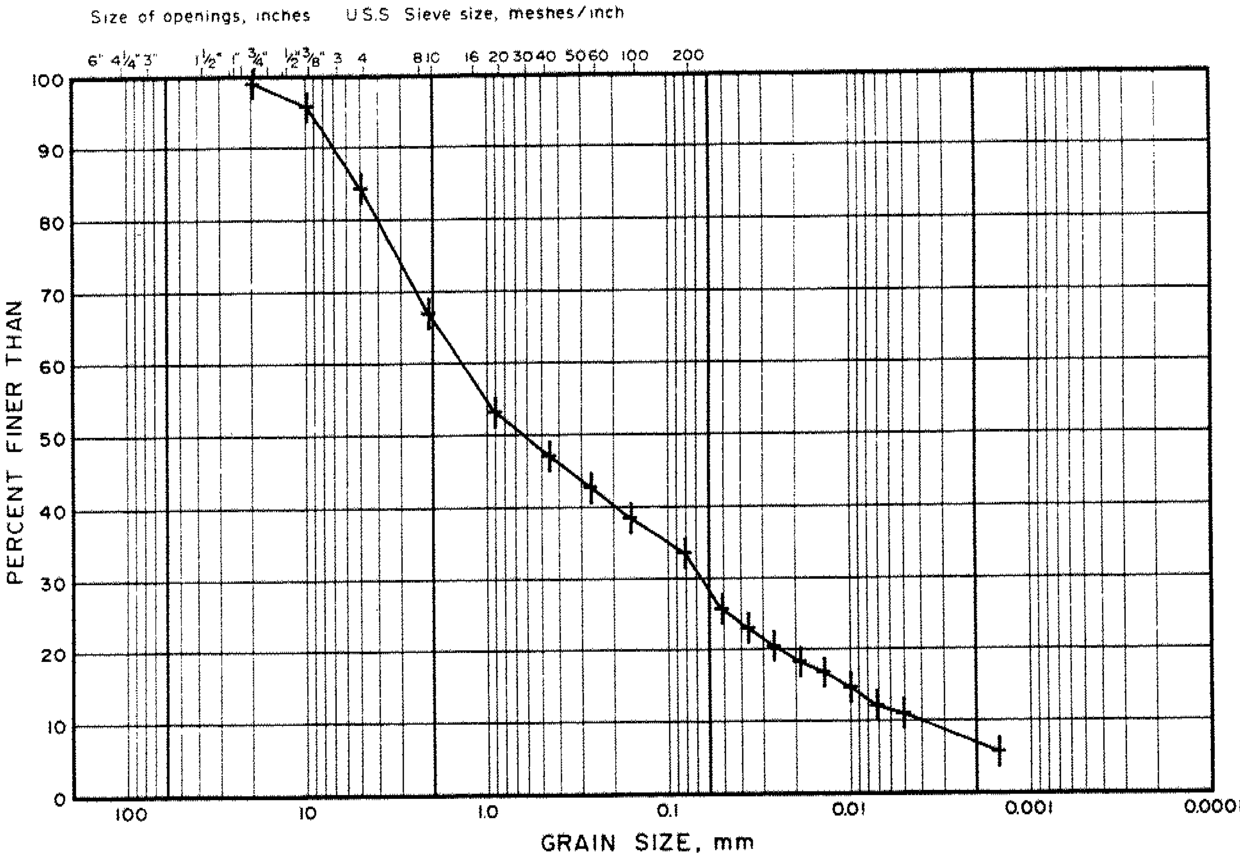
Project 901-1403

Golder Associates

GRAIN SIZE DISTRIBUTION

FIGURE 12

SAND and GRAVEL (TILL)



COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE
	GRAVEL SIZE			SAND SIZE			FINE GRAINED	

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
+	124	10	99.2

Project 901-1403

Golder Associates

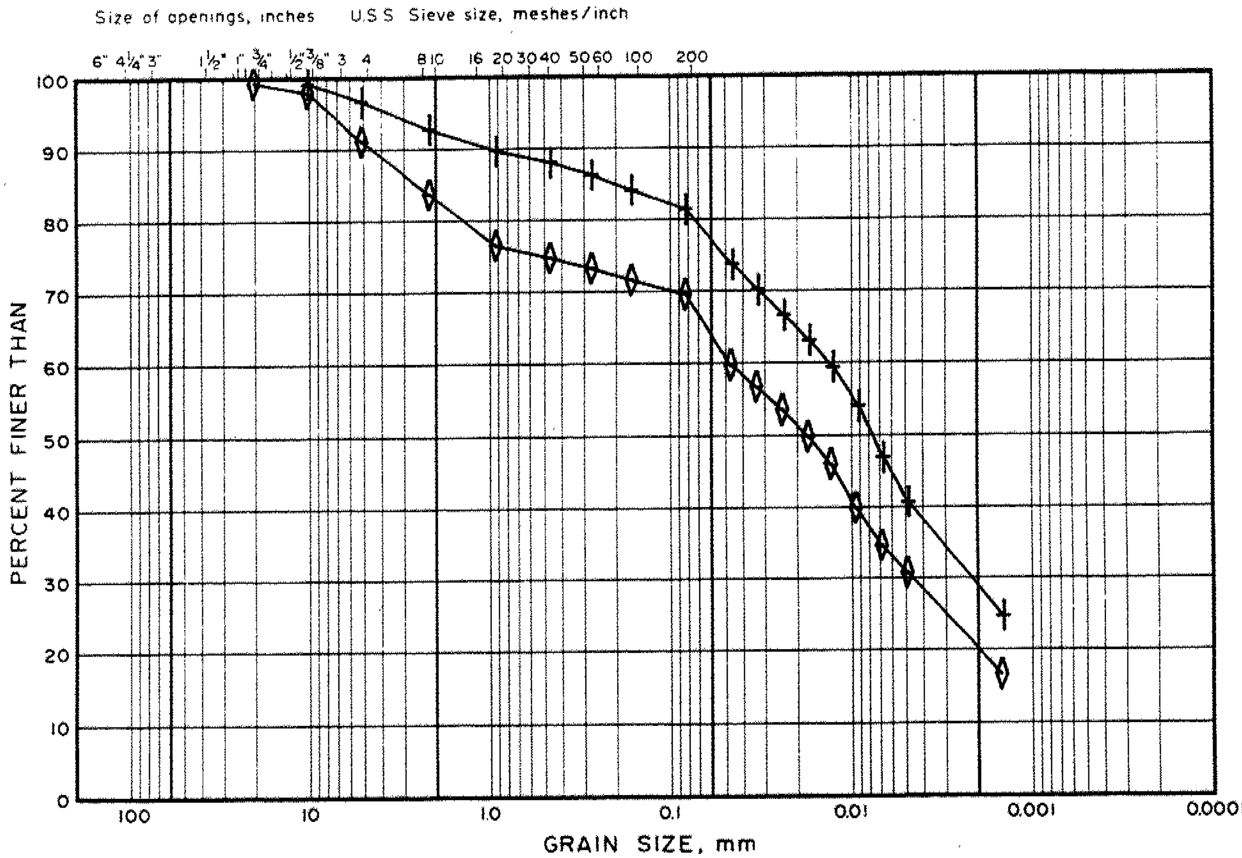
FORM PRODUCED MAY 1986

Form G.A.-C-1 (imperial)

GRAIN SIZE DISTRIBUTION

FIGURE 13

SILTY CLAY (TILL)



COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE
	GRAVEL SIZE			SAND SIZE			FINE GRAINED	

LEGEND

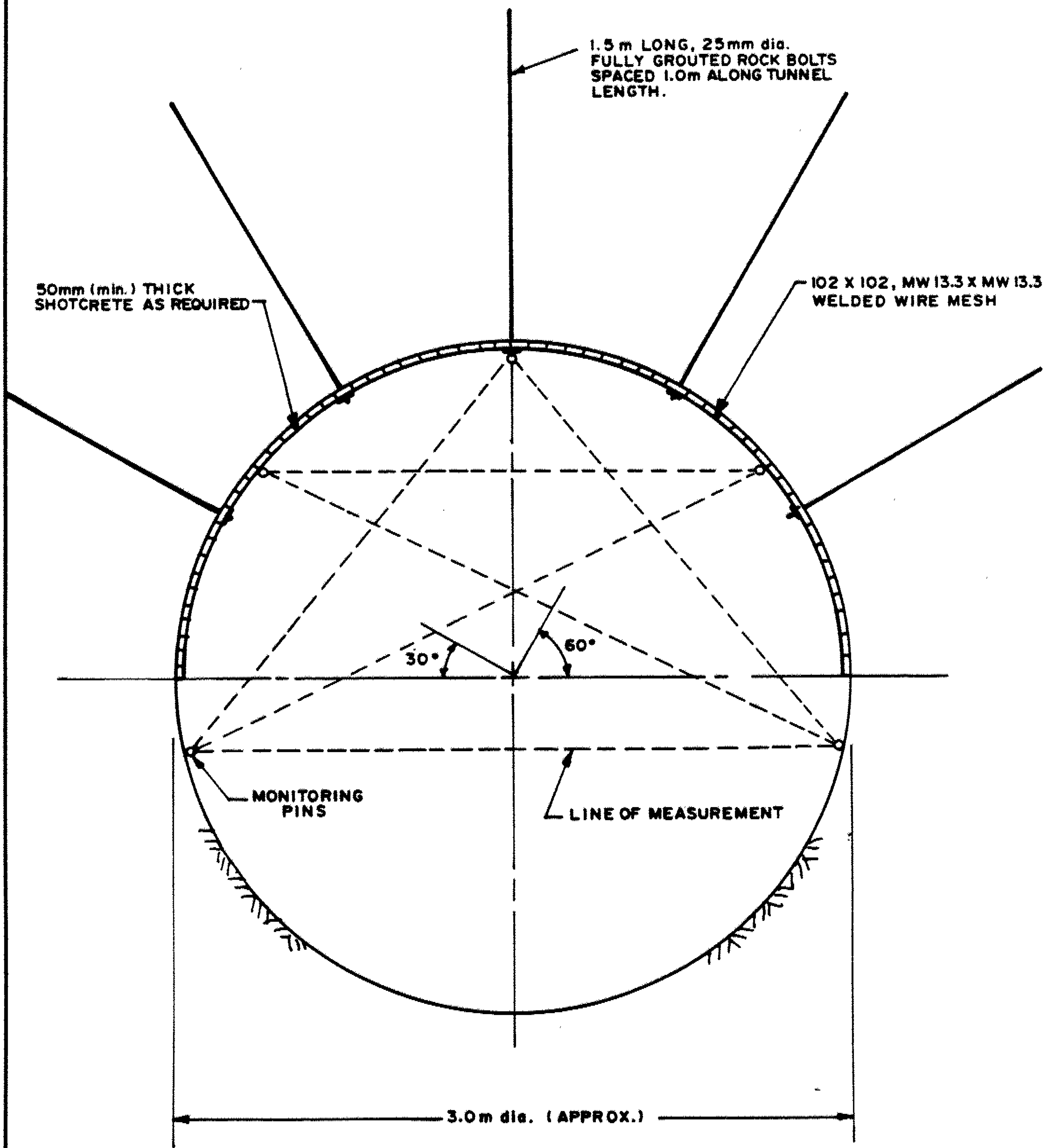
SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
+	102	3	78.9
◊	106	5	82.8

Project 901-1403

Golder Associates

TUNNEL SUPPORT AND MONITORING DETAILS

FIGURE 14



Date NOV / 1993

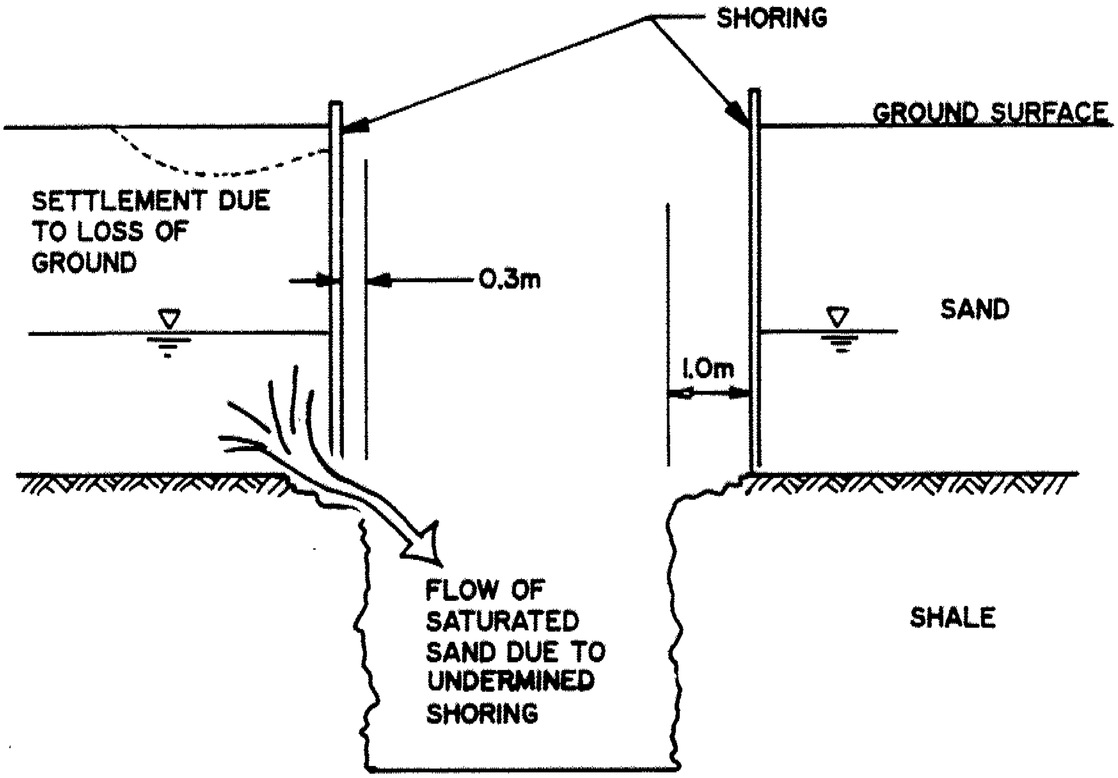
Project 901-1403-1

Golder Associates

Drawn MHW

Chkd.

SHORING SETBACK ROCK TRENCH EXCAVATION	FIGURE 15



NOTE : ADEQUATE SET BACK FOR EDGE OF ROCK EXCAVATION FROM LINE OF SHORING IS REQUIRED TO PREVENT LOSS OF GROUND WHEN SLABS OF SHALE BREAK OUT FROM UNDER THE SHORING DURING ROCK EXCAVATION.

NOT TO SCALE

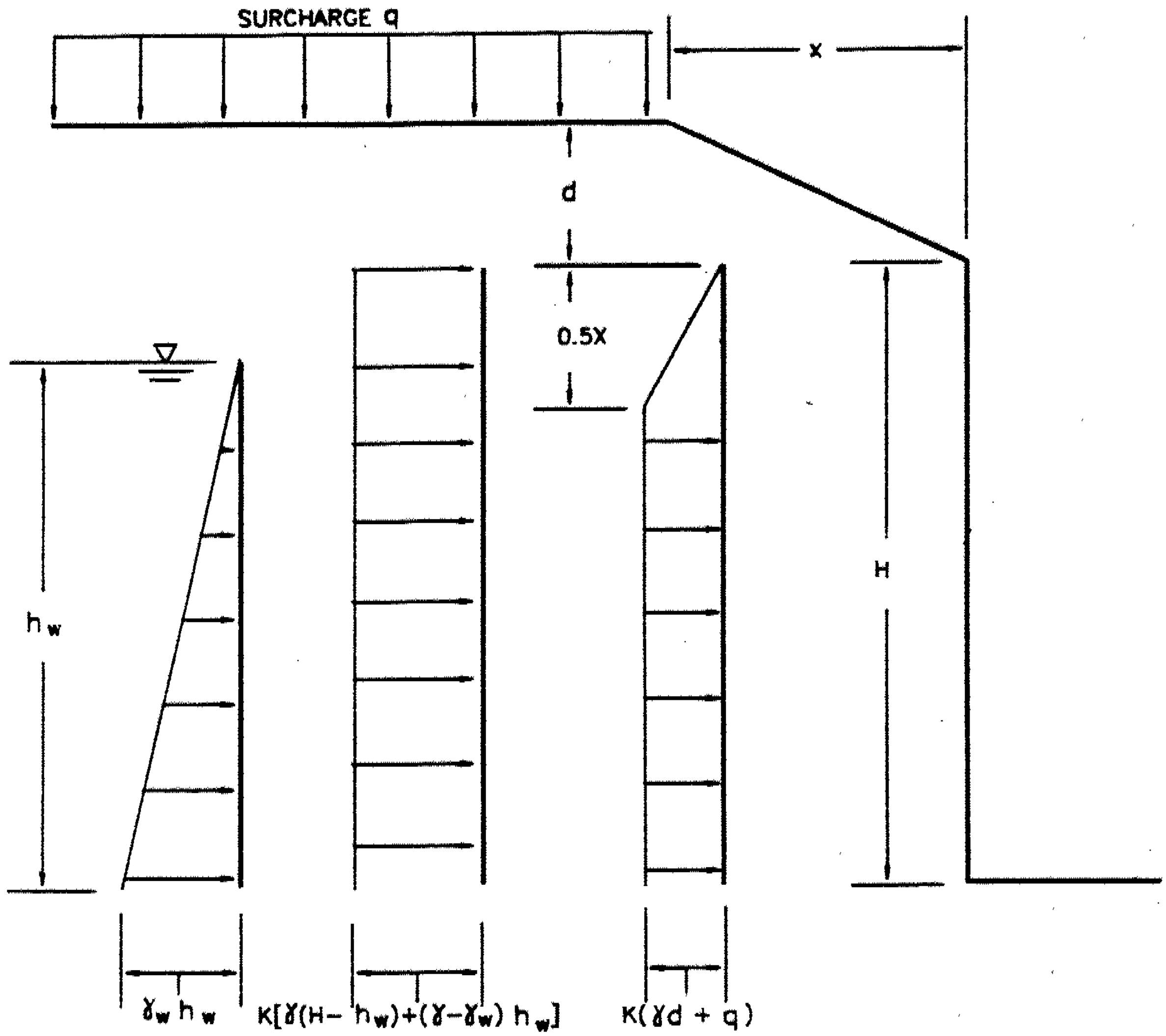
Date NOV / 1993
Project 901-1403-1

Golder Associates

Drawn DV
Chkd. MMA

DESIGN LATERAL EARTH PRESSURES FOR BRACED EXCAVATION IN GRANULAR SOILS

FIGURE 16



γ = UNIT WEIGHT OF SOIL

γ_w = UNIT WEIGHT OF WATER

K = EARTH PRESSURE COEFFICIENT

(REFER TO TEXT OF REPORT FOR DESIGN VALUES)

N.B. FOR HORIZONTAL GROUND BEHIND WALL, d = 0

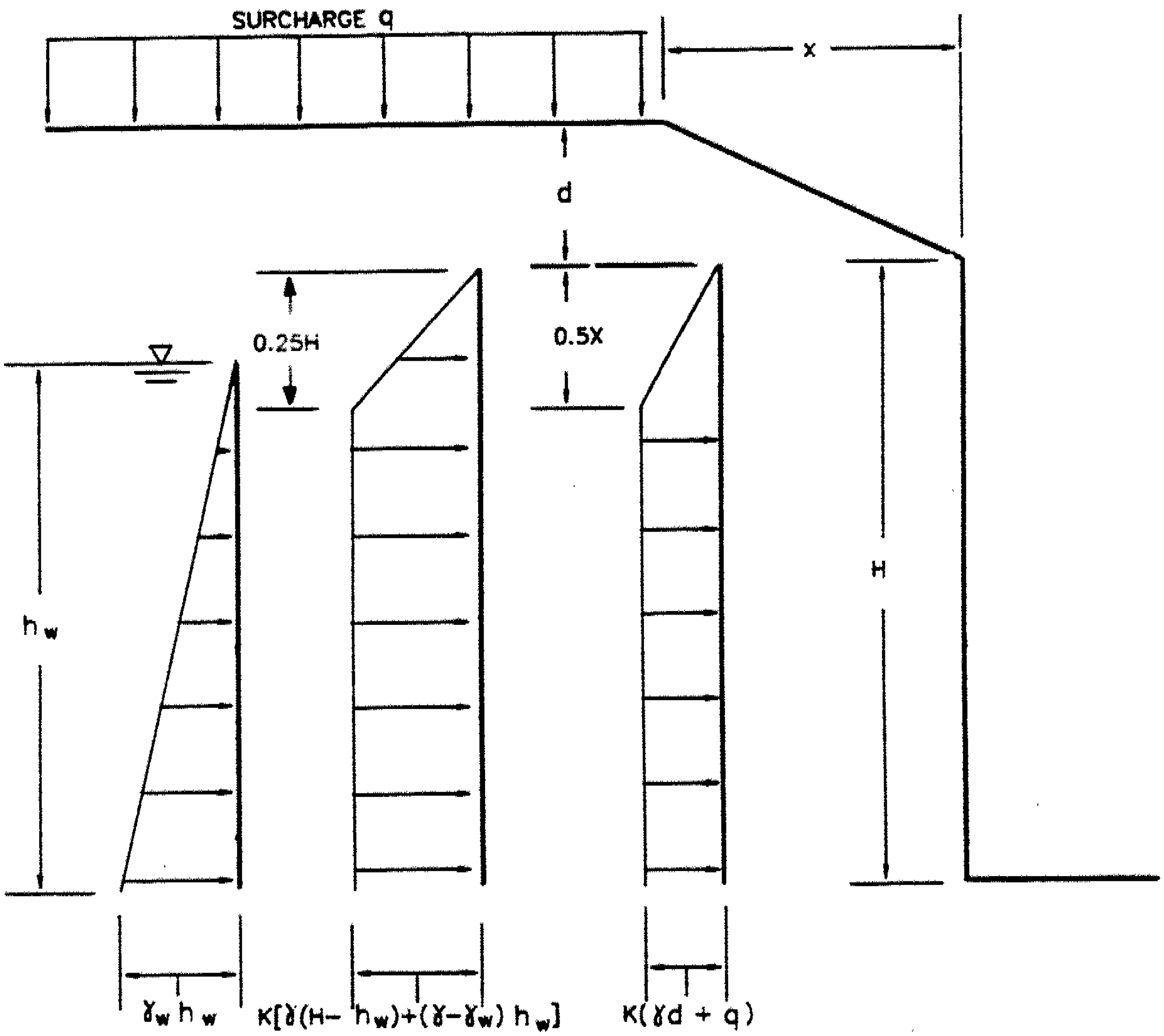
Date NOV / 1993
Project 901-1403-1

Golder Associates

Drawn TDSR
Chkd S.P.

DESIGN LATERAL EARTH PRESSURES FOR BRACED EXCAVATION IN COHESIVE SOILS

FIGURE 17



γ = UNIT WEIGHT OF SOIL

γ_w = UNIT WEIGHT OF WATER

K = EARTH PRESSURE COEFFICIENT

(REFER TO TEXT OF REPORT FOR DESIGN VALUES)

N.B. FOR HORIZONTAL GROUND BEHIND WALL, d = 0

Date NOV / 1993

Project 901-1403-1

Golder Associates

Drawn TDSR

Chkd S.P.

APPENDIX A

LIST OF REFERENCES CONSULTED FOR LAND USE REVIEW

LIST OF INDUSTRIES AND BUSINESSES IN LAND USE REVIEW

LIST OF REFERENCES CONSULTED

AIR PHOTOS

DATE	FLIGHT LINE & ROLL DATA	PHOTO NO.	SCALE	AGENCY
1939	A6588	26	-	EMR
1950	A12562	142	1"=800'	EMR
1950	A12510	43	1"=800'	EMR
1978	78-4340-91	270	1:10,000	MNR
1978	78-4341-91	153	1:10,000	MNR

BUSINESS DIRECTORIES

- Might's Business Directory - West Section (Toronto) 1990
- Might's Criss-Cross Directory for Satellite Cities around Metro Toronto 1989, 1985, 1981, 1979, 1970-71

LIST OF INDUSTRIES AND BUSINESSES

(Identified from site reconnaissance and directories)

DATE IDENTIFIED	NAME	STREET	
1990	H.B. Fuller Canada Ltd.	880	Rangeview
1990	Romac Products Ltd.		Rangeview
1990	Roby Industries of Canada Ltd.	865	Rangeview
1990	Moving & Storage Ltd.	861	Rangeview
1990	Lakeview Filtration Plant	920	East
1989	Rocha Landscaping		Greaves
1979	Post Office		Cawthra
1979, 81	Crown Assets Disposal Corp.		Cawthra
1989, 85	Regent Steel Industries		Cawthra
1989, 85	Halton Peel Natural Gas Service		Cawthra
1990, 89, 85	Lakeview Lumber & (House) Wrecking Co.	1619	Northmount
1990, 89, 85	ACME House Wrecking & Lumber Co.	1619	Northmount

APPENDIX B

RESULTS OF CHEMICAL LABORATORY TESTING

BARRINGER LABORATORIES

5735 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
PHONE: (416) 890-8566
FAX: (416) 890-8575

16-Nov-90

GOLDER ASSOCIATES
2180 Meadowvale Boulevard
Mississauga, ON
L5N 5S3

Attn: Mr. Andrew J. Walker
Project: 901-1403

Received: 5-Nov-90 17:10

PO #:

Job: 907450

Status: Final

Soil samples

Sample Id	As HGAAS ppm	Total CN- A. Col. ppm	Hg CVAAS ppm	Oil & Grs. Grav. ppm	NH3-N Titr. ppm	TKN Titr. ppm	Vol. Sol. Heat %	PCB's GC/ECD ppm
BH2 SA1	1.8	0.19	0.108	567	200	1710	10.07	<0.01
BH4 SA2	1.4	0.10	0.092	<100	70	480	5.03	<0.01
BH7 SA2	2.3	0.23	0.100	320	340	3250	16.66	<0.01
BH9 SA1	1.8	<0.05	0.083	5040	50	370	2.67	<0.01
BH10 SA2	2.4	<0.05	0.067	<100	50	540	4.83	<0.01
BH12 SA1	3.0	<0.05	0.100	3940	60	480	4.21	<0.01
BH12 SA2	2.0	<0.05	0.067	200	50	560	4.63	<0.01
BH15 SA2	1.3	0.08	0.075	800	70	450	3.47	<0.01
BH17 SA4	2.5	<0.05	0.075	<100	60	540	4.91	<0.01
BH22 SA1	1.3	<0.05	0.092	250	90	510	3.54	<0.01
BH23 SA1	4.0	0.10	0.092	200	160	840	4.70	<0.01
BH24 SA4	2.0	<0.05	0.092	160	50	400	2.95	<0.01
Blank	<0.2	<0.05	<0.002	<333	<30	<30	nan	<0.01
QC Standard (actual)	2.3	1.02	0.066	567	294	2120	8.65	s99.0
QC Standard (expected)	2.6	1.00	0.062	577	286	2000	nan	100.
Repeat BH2 SA1	1.9	0.17	0.108	633	210	1770	10.21	<0.01

BARRINGER LABORATORIES
5735 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
PHONE: (416) 890-8566
FAX: (416) 890-8575

16-Nov-90

GOLDER ASSOCIATES
2180 Meadowvale Boulevard
Mississauga, ON
L5N 5S3

Attn: Mr. Andrew J. Walker
Project: 901-1403
PO #:
Received: 5-Nov-90 17:10

Job: 907450 Status: Final

Soil samples

Sample Id	Ag ICAP ppm	Cd ICAP ppm	Co ICAP ppm	Cr ICAP ppm	Cu ICAP ppm	Fe ICAP ppm	Ni ICAP ppm	P ICAP ppm
BH2 SA1	<0.2	<0.3	11	18.2	31.1	20300.	21	710
BH4 SA2	<0.2	<0.3	12	30.5	27.2	21500.	26	620
BH7 SA2	<0.2	<0.3	7	16.2	29.6	16500.	20	770
BH9 SA1	<0.2	<0.3	6	9.0	35.9	12400.	2	320
BH10 SA2	<0.2	<0.3	23	26.3	34.2	27700.	34	740
BH12 SA1	<0.2	1.1	9	16.2	32.6	12100.	3	280
BH12 SA2	<0.2	<0.3	21	21.9	40.5	28200.	30	700
BH15 SA2	<0.2	<0.3	6	15.8	19.3	14200.	14	690
BH17 SA4	<0.2	<0.3	32	36.6	73.6	33900.	39	710
BH22 SA1	<0.2	<0.3	3	12.7	9.2	10900.	9	560
BH23 SA1	<0.2	<0.3	3	9.3	11.6	7210.	8	590
BH24 SA4	<0.2	<0.3	16	18.8	34.3	24600.	25	650
Blank	<0.2	<0.3	<2	1.4	<0.3	25.6	<2	<20
QC Standard (actual)	<0.2	<0.3	11	28.3	24.1	20700.	24	920
QC Standard (expected)	<0.2	0.3	10	21.0	20.8	22000.	21	935
Repeat BH2 SA1	<0.2	<0.3	11	20.6	30.1	18000.	20	680

BARRINGER LABORATORIES

5735 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
PHONE: (416) 890-8566
FAX: (416) 890-8575

16-Nov-90

GOLDER ASSOCIATES
2180 Meadowvale Boulevard
Mississauga, ON
L5N 5S3

Attn: Mr. Andrew J. Walker
Project: 901-1403
PO #:
Received: 5-Nov-90 17:10

Job: 907450
Status: Final

Soil samples

Sample Id	Pb ICAP ppm	Zn ICAP ppm	Mo ICAP ppm	V ICAP ppm
BH2 SA1	36	135.	<3	30.4
BH4 SA2	33	75.1	<3	33.1
BH7 SA2	11	75.1	<3	26.4
BH9 SA1	20	56.8	<3	25.1
BH10 SA2	26	92.5	<3	29.3
BH12 SA1	40	143.	<3	21.0
BH12 SA2	17	89.9	<3	25.0
BH15 SA2	18	54.2	<3	26.3
BH17 SA4	27	105.	<3	36.2
BH22 SA1	11	32.8	<3	21.9
BH23 SA1	35	40.2	<3	18.9
BH24 SA4	14	75.6	<3	26.3
Blank	<2	0.4	<3	<0.3
QC Standard (actual)	31	103.	<3	32.2
QC Standard (expected)	27	90.0	<3	23.9
Repeat BH2 SA1	33	121.	<3	27.3

BARRINGER LABORATORIES

5735 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
PHONE: (416) 890-8566
FAX: (416) 890-8575

16-Nov-90

GOLDER ASSOCIATES
2180 Meadowvale Boulevard
Mississauga, ON
L5N 5S3

Attn: Mr. Andrew J. Walker
Project: 901-1403

Received: 5-Nov-90 17:10
PO #:

Job: 907450 Status: Final

Signed:

....
Agnes Love, B.Sc.
Supervisor, Environmental Inorganic Services

APPENDIX C

TERRA SCAN BOREHOLE LOG INFORMATION SHEETS
BOREHOLES 14 TO 25

TERRA SCAN LIMITED

BOREHOLE LOG INFORMATION

BOREHOLE NO. 14

JOB NO. 69TS38 ELEVATION 319.7 BORING DATE Oct.15/69

CLIENT Gore and Storrie Ltd. BOREHOLE TYPE Auger

LOCATION Stn. 56+10 COMPILED BY D.J.

60" Ø main CHECKED BY P.L.

DEPTH ELEV.	STRATIGRAPHY	SOIL DESCRIPTION	GROUND WATER	SAMPLES NO.	SAMPLES TYPE	SAMPLES BLOWS/FOOT	LABORATORY RESULTS
0'6"		TOPSOIL					
4'0"		Med. br. si. m-f sand	moist	1	SS	8	M/C 15.5%
7'0"		Grey br. sa.si till - some cl. content	very moist	2	SS	15	M/C 14.4%
10'6"		Grey weathered shale		3	SS	55/6"	M/C 10.0%
		Terminated at 10'6" on B/R					Dry and open on completion

TERRA SCAN LIMITED

BOREHOLE LOG INFORMATION

BOREHOLE NO. 15

JOB NO. 69TS38　　ELEVATION 322.4　　BORING DATE Oct. 16/69

CLIENT Gore and Storrie Ltd.　　BOREHOLE TYPE Auger

LOCATION Stn. 58+29　　COMPILED BY D.J.

60" Ø main　　CHECKED BY P.L.

DEPTH ELEV.	STRATIGRAPHY	SOIL DESCRIPTION	GROUND WATER	SAMPLES NO.	SAMPLES TYPE	SAMPLES BLOWS/FOOT	LABORATORY RESULTS
1'6"		Blk.org.tpsl.					
4'0"		Mottled gr.& br. v.f. sa. si.	moist	1	SS	8	M/C 17.1%
7'0"		Grey brown clayey silt till	moist	2	SS	11	M/C 15.4%
9'9"		Grey weathered shale					
		Terminated at 9'9" on B/R					Dry and open on completion

TERRA SCAN LIMITED

BOREHOLE LOG INFORMATION

BOREHOLE NO. 16

JOB NO. 69TS38 ELEVATION 326.2 BORING DATE Oct.16/69

CLIENT Gore and Storrie Ltd. BOREHOLE TYPE Auger

LOCATION Stn. 61+41 COMPILED BY D.J.

60" Ø main CHECKED BY D.L.

DEPTH ELEV.	STRATI-GRAPHY	SOIL DESCRIPTION	GROUND WATER	SAMPLES NO.	SAMPLES TYPE	SAMPLES BLOWS/FOOT	LABORATORY RESULTS
0'6"		Blk. topsoil					
4'0"		Mottled gr. & br. f. to v.f. sa. si.	moist	1	SS	7	M/C 17.6%
7'6"		Br. gr. si. f. sa.	sat.	2	SS	30	M/C 21.6%
8'6"		Gr.cl.si.till	moist	3	SS	18	M/C 12.0%
		Terminated at 8'6" on B/R					Cave at 5'10", hole dry on completion

TERRA SCAN LIMITED

BOREHOLE LOG INFORMATION

BOREHOLE NO. 17

JOB NO. 69TS38 ELEVATION 326.9 BORING DATE Oct 16/69

CLIENT Gore and Storrie Ltd. BOREHOLE TYPE Auger

LOCATION Stn. 62+33 COMPILED BY D.J.

60" Ø main CHECKED BY P.L.

DEPTH ELEV.	STRATIGRAPHY	SOIL DESCRIPTION	GROUND WATER	SAMPLES NO.	TYPE	BLOWS/ FOOT	LABORATORY RESULTS
0'4"		Blk. tpsl.					
5'0"		Grey mixed with some brown silty fine sand	wet	1	SS	8	M/C 23.0%
		Grey clayey silt till	moist	2	SS	32	M/C 7.1%
				3	SS	25	M/C 9.9%
11'0"				4	SS	60/ 6"	M/C 6.3%
11'6"		Gr. weath shale					
		Terminated at 11'6" on B/R					
							Dry and caved at 9'10" on completion

TERRA SCAN LIMITED

BOREHOLE LOG INFORMATION

BOREHOLE NO. 18

JOB NO. 69TS38 ELEVATION 327.0 BORING DATE Oct.16/69

CLIENT Gore and Storrie Ltd. BOREHOLE TYPE Auger

LOCATION Stn. 63+28 COMPILED BY D.J.

60" Ø main CHECKED BY P.L.

DEPTH ELEV.	STRATI-GRAPHY	SOIL DESCRIPTION	GROUND WATER	SAMPLES NO.	SAMPLES TYPE	SAMPLES BLOWS/FOOT	LABORATORY RESULTS
0'6"		Blk.tpsl.					
3'6"		Mixed gr.&br. si.f.sa.	V.moist to wet	1	SS	7	M/C 22.3%
6'0"		Grey si.fine sand	sat.	2	SS	23	M/C 14.3%
		Grey clayey silt till some fine gravel	moist	3	SS	25	M/C 6.6%
12'0"				4	SS	47	M/C 9.4%
14'10"		Grey weathered shale		5	SS	72	M/C 8.0%
		Terminated at 14'10" on B/R					Dry and caved at 12'8" on completion

TERRA SCAN LIMITED

BOREHOLE LOG INFORMATION

BOREHOLE NO. 19

JOB NO. 69TS38 ELEVATION 327.1 BORING DATE Oct.16/69

CLIENT Gore and Storrie Ltd. BOREHOLE TYPE Auger

LOCATION Stn. 64+27 COMPILED BY D.J.

60" Ø main CHECKED BY P.L.

DEPTH ELEV.	STRATI-GRAPHY	SOIL DESCRIPTION	GROUND WATER	SAMPLES NO.	SAMPLES TYPE	SAMPLES BLOWS/FOOT	LABORATORY RESULTS
0'3"		Blk. tpsl					
2'3"		Grey sa. si. till	moist				
5'9"		Mixed grey & br. si. f. sa.	moist wet from 4'6"	1	SS	19	M/C 16.0%
6'6"		Gr.cl.si.till	moist	2	SS	15	M/C 11.0%
12'0"		Grey co. sa. m-f grav. balls of wea. shale	very moist to wet	3	SS	97	M/C 4.7%
				4	SS	71.	M/C 8.0%
13'0"		Gr.si.till	moist	5	SS	65/6"	M/C 6.1%
		Terminated at 13'0" on refusal (Assumed B/R)					Water at 5'3" and cave at 6'1" on completion

TERRA SCAN LIMITED

BOREHOLE LOG INFORMATION

BOREHOLE NO. 20

JOB NO. 69TS38 ELEVATION 329.4 BORING DATE Oct.17/69

CLIENT Gore and Storrie Limited, BOREHOLE TYPE Auger

LOCATION Stn. 67+10 COMPILED BY D.J.

60" Ø main CHECKED BY P.L.

DEPTH ELEV.	STRATI-GRAPHY	SOIL DESCRIPTION	GROUND WATER	SAMPLES NO.	SAMPLES TYPE	SAMPLES BLOWS/ FOOT	LABORATORY RESULTS
0'3"		Blk. Topsl.					
1'6"		Dk.br.f.sa.si. grits &pebbles	moist				
5'9"		Medium br. fine sandy silt	moist wet from 4'0"	1	SS	20	M/C 15.4%
				2	SS	24	M/C 11.2%
7'0"		Gr.si.sa.grav.	moist				
9'0"		Grey very fine sandy silt	sat.	3	SS	26	M/C 21.0%
11'6"		Grey sandy silt till	moist	4	SS	38/6"	M/C 4.2%
18'0"		Grey coarse sand, fine gravel	wet to moist	5	SS	80/6"	M/C 7.2%
				6	SS	36/6"	M/C 6.7%
				6A	WS		
		Terminated at 18'0" on Refusal (Assumed B/R)					Water level at 6'0"

TERRA SCAN LIMITED

BOREHOLE LOG INFORMATION

BOREHOLE NO. 21

JOB NO. 69TS38 ELEVATION 331.9 BORING DATE Oct. 17/69

CLIENT Gore and Storrie Ltd. BOREHOLE TYPE Auger

LOCATION Stn. 71+14 COMPILED BY D.J.

60" Ø main CHECKED BY P.L.

DEPTH ELEV.	STRATI-GRAPHY	SOIL DESCRIPTION	GROUND WATER	SAMPLES NO.	SAMPLES TYPE	SAMPLES BLOWS/FOOT	LABORATORY RESULTS
0'5"		Topsoil					
		Red br.f.to v.f. sa. si.	moist				
5'6"		Medium brown fine to very fine sa. si.	moist	1	SS	8	M/C 9.4%
5'9"		Red br.wdy peat "		2	SS	40	M/C 6.2%
7'6"		Gr. br.f.grav co-f. sa.	moist	3	SS	9	M/C 30.2%
10'6"		(mottled) Gr.si.cl.	WTPL	4	SS	16	M/C 9.7%
15'3"		Gr. f. grav. co. sa.	sat.	5	SS	34/6"	M/C 8.0%
19'3"		Grey f. to v. fine sandy silt	sat.	6	SS	60/4"	M/C 12.9%
		Terminated at 19'3" on Refusal (assumed B/R)					Water at 5'8" and cave at 6'6" on completion

TERRA SCAN LIMITED

BOREHOLE LOG INFORMATION

BOREHOLE NO. 22

JOB NO. 69TS38 ELEVATION 335.3 BORING DATE Oct.21/69

CLIENT Gore and Storrie Ltd. BOREHOLE TYPE Auger

LOCATION Stn. 77+17 COMPILED BY D.J.

60" Ø main CHECKED BY P.L.

DEPTH ELEV.	STRATI-GRAPHY	SOIL DESCRIPTION	GROUND WATER	SAMPLES NO.	TYPE	BLOWS/FOOT	LABORATORY RESULTS
1'0"		Blk. Topsoil					
4'6"		Grey brown very fine sandy silt	Sat.	1	SS	36	M/C 19.9%
7'3"		Grey fine co. sa. grav.	moist	2	SS	60/6"	M/C 5.8%
8'6"		Grey silt	moist	3	SS	20/6"	M/C 16.3%
11'0"		Gry. v.f. sa. si. till, stony	moist				
20'0"		Gry. v. f. sa. si.	sat.	4	SS	33/6"	M/C 5.9%
				5	SS	38/6"	M/C 18.2%
				6	SS	39/6"	M/C 16.7%
		Terminated at 20'0"					Water at 4'8", cave at 5'5" on completion

TERRA SCAN LIMITED

BOREHOLE LOG INFORMATION

BOREHOLE NO. 24

JOB NO. 69TS38 ELEVATION 339.2 BORING DATE Oct. 22/69

CLIENT Gore and Storrie Ltd. BOREHOLE TYPE Auger

LOCATION Stn. 83+60 COMPILED BY D.J.

60" Ø main CHECKED BY P.L.

DEPTH ELEV.	STRATI-GRAPHY	SOIL DESCRIPTION	GROUND WATER	SAMPLES NO.	TYPE	BLOWS/ FOOT	LABORATORY RESULTS
1'2"		Blk. Topsoil					
4'0"		Mixed grey & br. f. to v.f. sa. si. to si. v.f. sa.	wet	1	SS	13	M/C 27.1%
7'3"		Gr. si. dense	very moist to wet at 6'6"	2	SS	41	M/C 11.4%
13'0"		Grey fine sandy silt grits and pebbles		3	SS	56/ 6"	M/C 3.4%
				4	SS	80/ 5"	M/C 7.9%
				5	SS	70/ 4"	M/C 6.2%
20'6"		Grey sandy silt till dense	moist	6	SS	58/ 6"	M/C 5.0%
24'6"		Grey clayey silt	DTPL	7	SS	48	M/C 21.1%
25'3"		Gr. wea. shale					
30'6"		boulders or ledge with limestone, hard bands with gravel matrix		8	SS	70/3"	Diamond Drilled
				9	SS	60/6"	Water at 8'5", cave at 13'4" (Oct. 22) Water at 6'3", (Nov. 13)
37'2"		very dense, stony, silty clay, grey till, moist		10	SS	>100	
		Borehole terminated at refusal					

TERRA SCAN LIMITED

BOREHOLE LOG INFORMATION

BOREHOLE NO. 25

JOB NO. 69TS38 ELEVATION 338.5 BORING DATE Oct. 23/69

CLIENT Gore and Storrie Ltd. BOREHOLE TYPE Auger

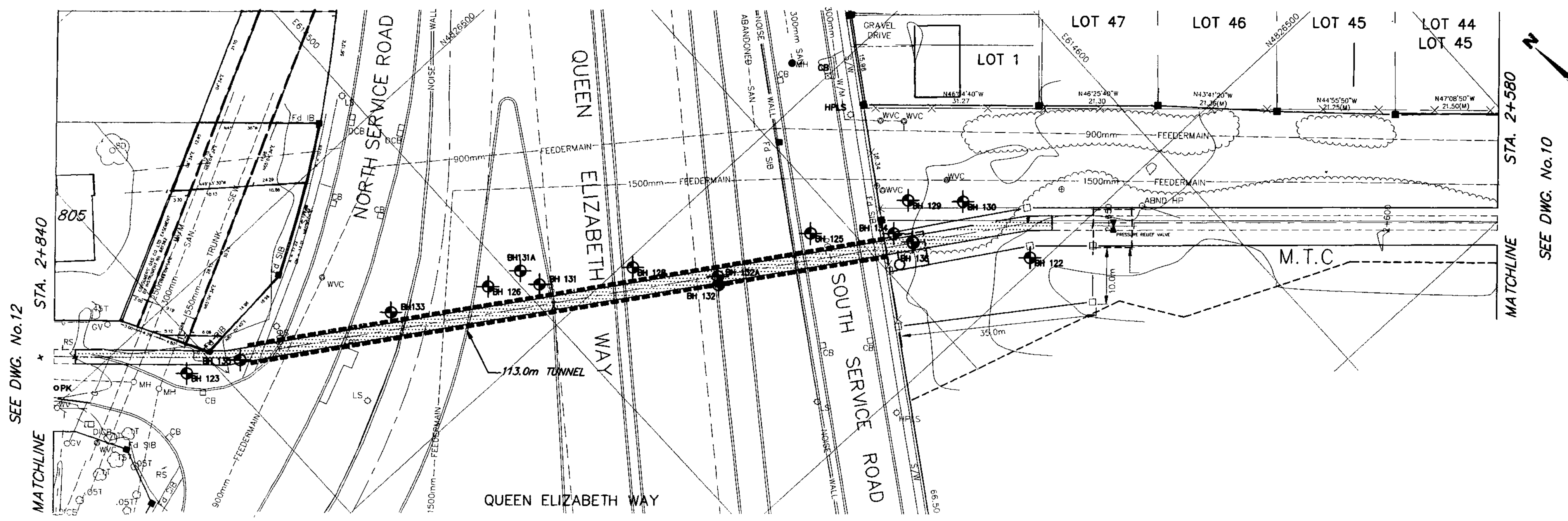
LOCATION Stn. 85+65 COMPILED BY D.J.

60" Ø main CHECKED BY P.L.

DEPTH ELEV.	STRATI-GRAPHY	SOIL DESCRIPTION	GROUND WATER	SAMPLES NO.	TYPE	BLOWS/FOOT	LABORATORY RESULTS
10"		Blk. v. f. sa. si.	Tps1				
3'0"		Med. br. si. f. sa.	moist	1	SS	23	M/C 17.0%
4'6"		Med. br. f. sa. si	wet				
7'9"		Gry. v. f. sa. si.	moist	2	SS	60/6"	M/C 8.3
				3	SS	60/6"	M/C 6.7%
12'0"		Gr. si. m-f sa.	moist sat. from 9'0"	4	SS	65	M/C 13.7%
		Gry. si. fine gravel coarse sand	Sat.	5	SS	87	M/C 13.7%
				6	SS	108	M/C 13.4%
21'6"				7	SS	30/3"	
22'5"		Gr. weath. shale					
		Terminated at 22'5" on Refusal (assumed B/R)					Water at 8'10" and cave at 10'0" on completion

BOREHOLE LOCATION PLAN
HANLAN FEEDERMAIN
TORONTO,ONTARIO

FIGURE 1



LEGEND

BH 130 BOREHOLE LOCATION IN PLAN

PROPOSED FEEDERMAIN

REFERENCE

BASE DRAWING SUPPLIED BY KMK CONSULTANTS LIMITED IN DIGITAL FORMAT TITLED 16772A77.DWG.

SCALE
1 : 500
0 5 10 20 metres

Date JULY 1995

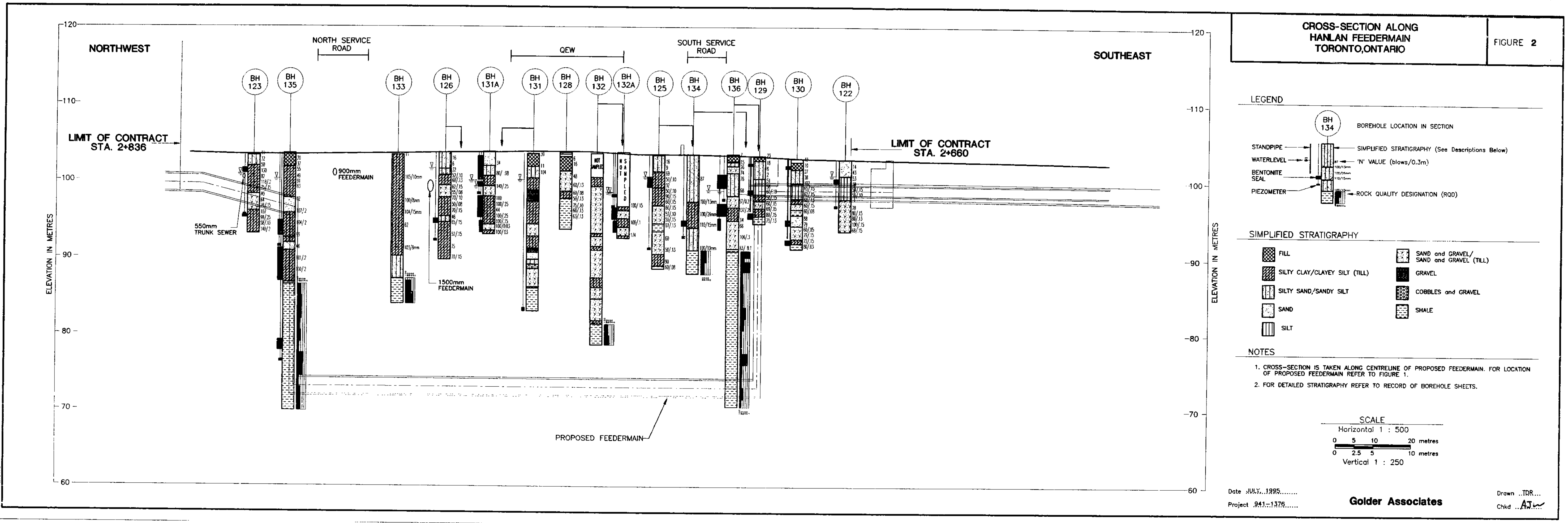
Project 941-1376

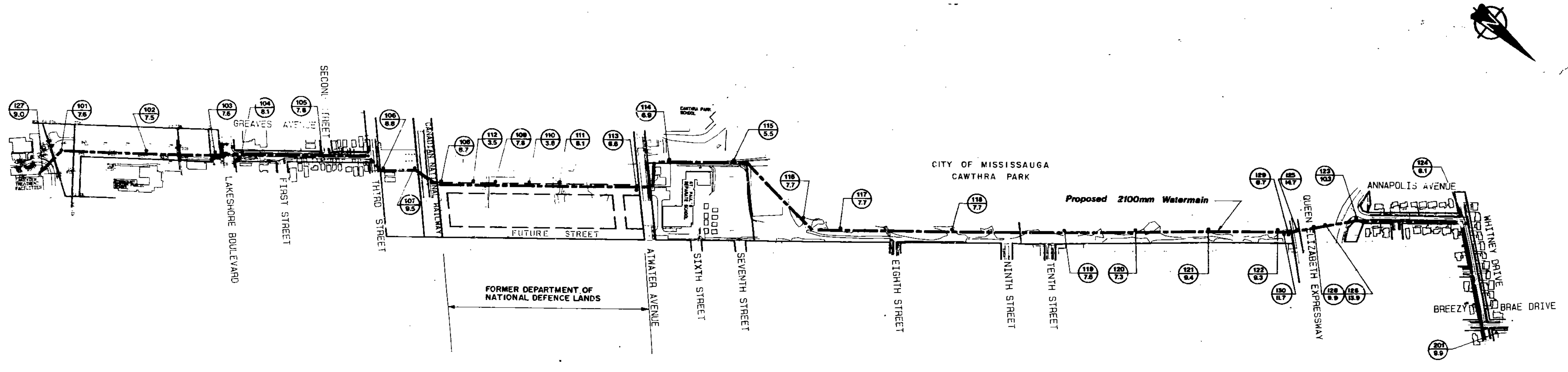
Golder Associates

Drawn TDR

Chkd AJ

J1376001.DWG


CROSS-SECTION ALONG HANLAN FEEDERMAIN TORONTO,ONTARIO
FIGURE 2
NORTHWEST
SOUTHEAST
NORTH SERVICE ROAD
QEW
SOUTH SERVICE ROAD
LIMIT OF CONTRACT STA. 2+836
LIMIT OF CONTRACT STA. 2+660
BH 123
BH 135
BH 133
BH 126
BH 131A
BH 131
BH 128
BH 132
BH 132A
BH 125
BH 134
BH 136
BH 129
BH 130
BH 122
900mm FEEDERMAIN
550mm TRUNK SEWER
1500mm FEEDERMAIN
PROPOSED FEEDERMAIN
ELEVATION IN METRES
LEGEND
BOREHOLE LOCATION IN SECTION
STANDPIPE
WATERLEVEL
BENTONITE SEAL
PIEZOMETER
SIMPLIFIED STRATIGRAPHY (See Descriptions Below)
'N' VALUE (blows/0.3m)
ROCK QUALITY DESIGNATION (RQD)
SIMPLIFIED STRATIGRAPHY
FILL
SILTY CLAY/CLAYEY SILT (TILL)
SILTY SAND/SANDY SILT
SAND
SILT
SAND and GRAVEL/ SAND and GRAVEL (TILL)
GRAVEL
COBBLES and GRAVEL
SHALE
NOTES
1. CROSS-SECTION IS TAKEN ALONG CENTRELINE OF PROPOSED FEEDERMAIN. FOR LOCATION OF PROPOSED FEEDERMAIN REFER TO FIGURE 1.
2. FOR DETAILED STRATIGRAPHY REFER TO RECORD OF BOREHOLE SHEETS.
SCALE
Horizontal 1 : 500
0 5 10 20 metres
0 2.5 5 10 metres
Vertical 1 : 250
Date JULY, 1995
Project 941-1376
Golder Associates
Drawn TDR
Chkd AJ



BOREHOLE LOCATION PLAN | **FIGURE 2**

LEGEND

6 — BOREHOLE NO.
5 — DEPTH IN METRES

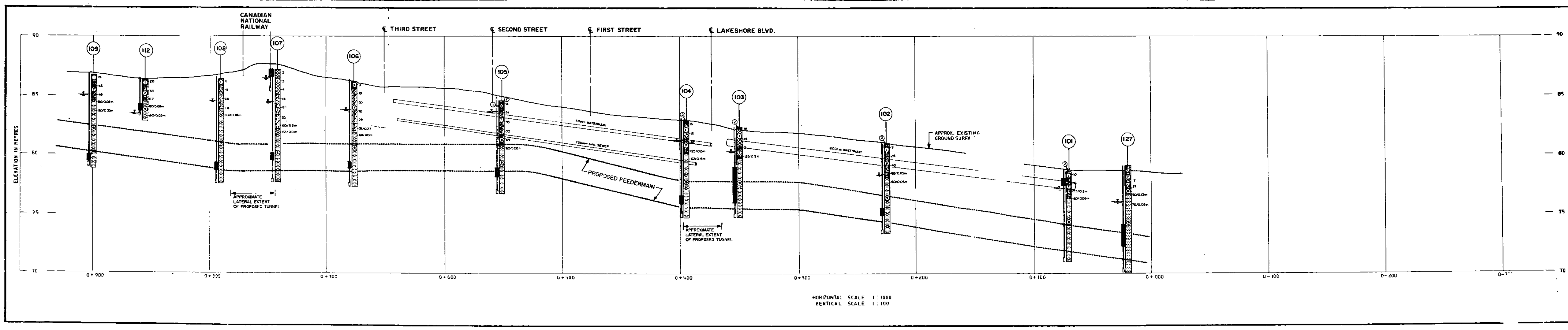
REFERENCE : DRAWING NUMBER 1677-02-B-3
KNOX MARTIN KRETCH LIMITED
DATED : NOV. 12, 1990.

SCALE 1:3000

Date FEB 26, 1992
Project 901-1403-1

Golder Associates

Drawn BV
Chkd



PROFILE ALONG FEEDERMAIN
0-300 TO 0+900

FIGURE 3

LEGEND

(101) BOREHOLE (BY GOLDER ASSOC.) IN ELEVATION
(100 SERIES NUMBERS FOR THIS STUDY)
(200 SERIES NUMBERS FROM ADJACENT STUDY)

"N" VALUES, BLOWS/0.3 m
STRATA PLOT, SEE DESCRIPTIONS BELOW
BENTONITE SEAL
WATER LEVEL, NOV.,1990
PIEZOMETER TIP

(20) BOREHOLE (BY TERRA SCAN LIMITED) IN ELEVATION

STRATIGRAPHY

- FILL
- TOPSOIL OR PEAT
- SILT
- SANDY SILT OR SILTY SAND
- SAND
- SAND AND GRAVEL
- SILTY CLAY TILL
- SILTY CLAY (RESIDUAL SOIL)
- SHALE BEDROCK

NOTES

1. THE ABOVE STRATA DESCRIPTIONS HAVE BEEN SIMPLIFIED FOR THIS PRESENTATION. FOR DETAILED STRATIGRAPHY, REFER TO THE INDIVIDUAL RECORD OF BOREHOLE SHEETS.
2. THIS DRAWING TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT.
3. FOR FINAL VERTICAL AND HORIZONTAL ALIGNMENTS, REFER TO RELEVANT CONTRACT DRAWINGS.

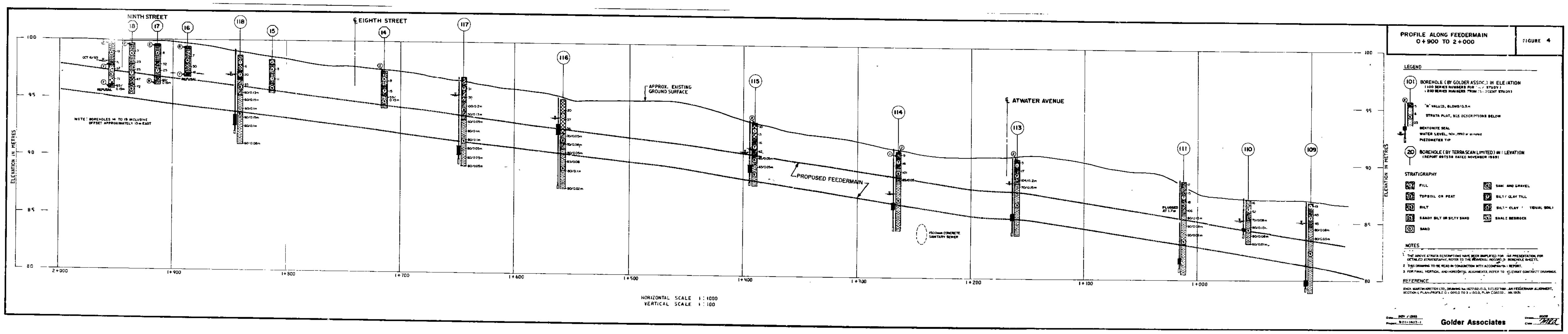
REFERENCE

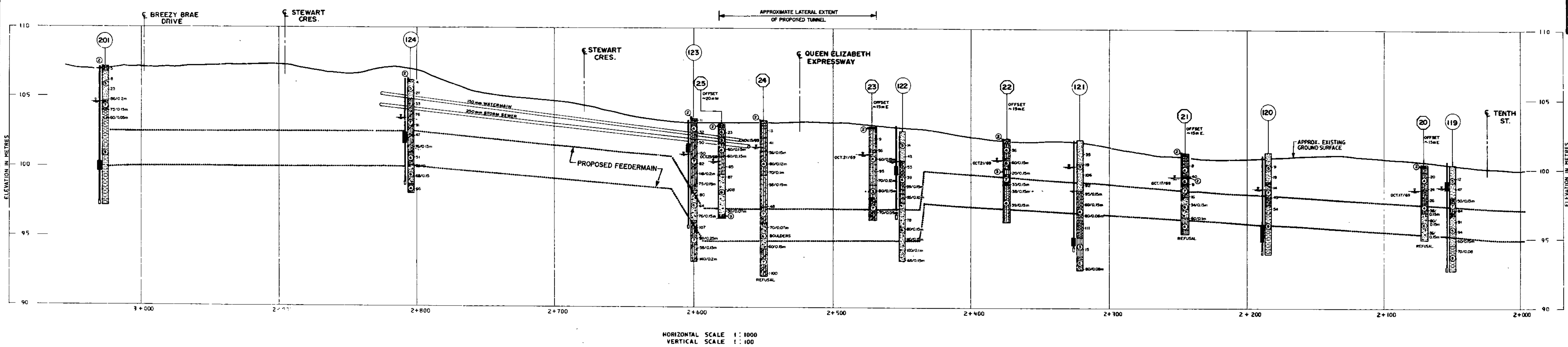
[illegible]

Date NOV / 1993
Project 901-1403-1

Golder Associates

Drawn MHW
Chkd [illegible]


NINTH STREET
℄ EIGHTH STREET
APPROX. EXISTING GROUND SURFACE
PROPOSED FEEDERMAIN
℄ ATWATER AVENUE
ELEVATION IN METRES
HORIZONTAL SCALE 1 : 1000
VERTICAL SCALE 1 : 100
PROFILE ALONG FEEDERMAIN
0 + 900 TO 2 + 000
FIGURE 4
LEGEND
BOREHOLE (BY GOLDER ASSOC.) IN ELEVATION
'N' VALUES, BLOWS/0.3m
STRATA PLOT, SEE DESCRIPTIONS BELOW
BENTONITE SEAL
WATER LEVEL
PIEZOMETER TIP
BOREHOLE (BY TERRASCAN LIMITED) IN ELEVATION
STRATIGRAPHY
FILL
TOPSOIL OR PEAT
SILT
SANDY SILT OR SILTY SAND
SAND
SHALE BEDROCK
NOTES
2 THIS DRAWING TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT.
REFERENCE
Golder Associates



PROFILE ALONG FEEDERMAIN 2+000 TO 3+100

FIGURE 5

LEGEND

(101) BOREHOLE (BY GOLDER ASSOC.) IN ELEVATION
(100 SERIES NUMBERS FOR THIS STUDY)
(200 SERIES NUMBERS FROM ADJACENT STUDY)

'N' VALUES, BLOWS/0.3m

STRATA PLOT, SEE DESCRIPTIONS BELOW

BENTONITE SEAL

WATER LEVEL, NOV.,1990 or as noted.

PIEZOMETER TIP

(20) BOREHOLE (BY TERRA SCAN LIMITED) IN ELEVATION
(REPORT 69TS38 DATED NOVEMBER 1969)

STRATIGRAPHY

1. FILL
2. TOPSOIL OR PEAT
3. SILT
4. SANDY SILT OR SILTY SAND
5. SAND
6. SAND AND GRAVEL (OFTEN WITH BOULDERS)
7. SILTY CLAY TILL
8. SILTY CLAY (RESIDUAL SOIL)
9. SHALE BEDROCK

NOTES

1. THE ABOVE STRATA DESCRIPTIONS HAVE BEEN SIMPLIFIED FOR THIS PRESENTATION, FOR DETAILED STRATIGRAPHY, REFER TO THE INDIVIDUAL RECORD OF BOREHOLE SHEETS.
2. THIS DRAWING TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT.
3. FOR FINAL VERTICAL AND HORIZONTAL ALIGNMENTS, REFER TO RELEVANT CONTRACT DRAWINGS.

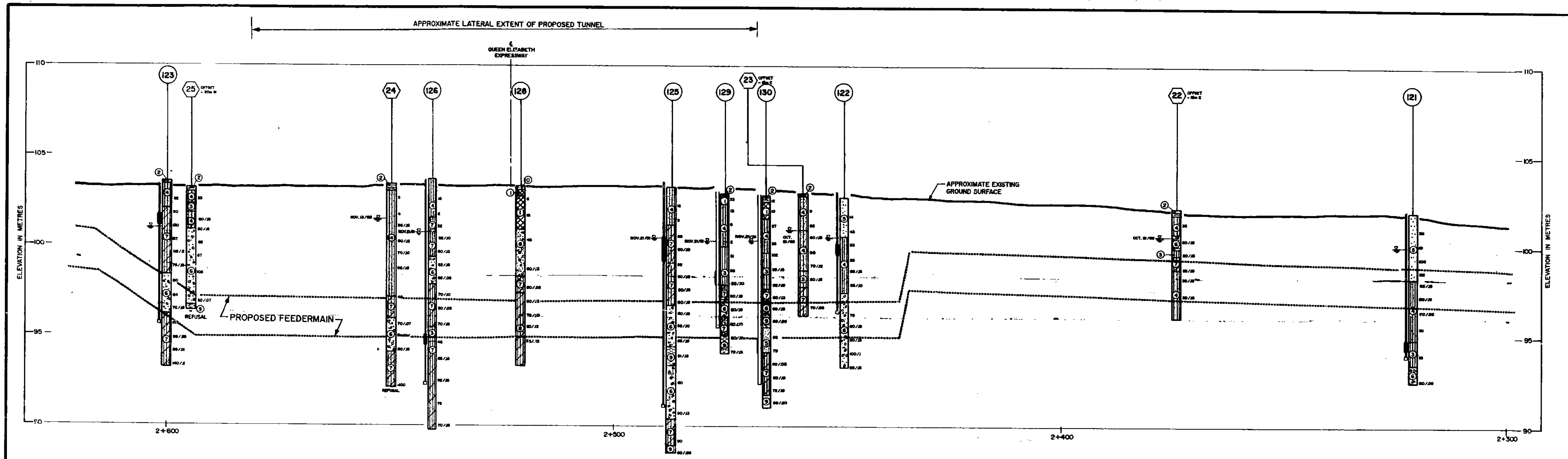
REFERENCE

DRAWING No. 1677.02-B-3 TITLED "HANLAN FEEDERMAIN ALIGNMENT, SECTION I, PLAN-PROFILE 0 + 000.0 TO 3 + 150.0 PLAN I" DATED JAN., 1991, AND DRAWING No. 1677.02-A-34, SHEET 10 TITLED "M.O.E. PROJECT No. 5-0020-45, HANLAN FEEDERMAIN CONTRACT I, STATION 2 + 880 TO 2 + 620", DATED OCT., 1991 (PRELIMINARY) PREPARED BY KNICK MARTIN KRETCH LIMITED.

Date: NOV / 1993
Project: 901-1403-1

Golder Associates

Drawn: MHW
Chkd: [illegible]



PROFILE ALONG FEEDERMAIN
2 + 300 TO 2 + 600
(SHOWING SUPPLEMENTARY BOREHOLES)

FIGURE 6

LEGEND

121 — BOREHOLE (BY GOLDER ASSOC.) IN ELEVATION

8 — 'N' VALUES, BLOWS / 0.3m
STRATA PLOT, SEE DESCRIPTIONS BELOW
BENTONITE SEAL
WATER LEVEL
PIEZOMETER TIP / WATER WELL SCREEN

22 — BOREHOLE (BY TERRA SCAN LIMITED) IN ELEVATION (Report 69TS38 dated Nov. 19/69)

STRATIGRAPHY

1. FILL
2. TOPSOIL or PEAT
3. SILT
4. SANDY SILT or SILTY SAND
5. SAND
6. SAND and GRAVEL (often with boulders)
7. SILTY CLAY or CLAYEY SILT (TILL)
8. SILTY CLAY (residual soil)
9. SHALE BEDROCK
10. CONCRETE

NOTES

1. THE ABOVE STRATA DESCRIPTIONS HAVE BEEN SIMPLIFIED FOR THIS PRESENTATION. FOR DETAILED STRATIGRAPHY, REFER TO THE INDIVIDUAL RECORD OF BOREHOLE SHEETS.
2. THIS DRAWING TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT.
3. FOR FINAL VERTICAL AND HORIZONTAL ALIGNMENTS, REFER TO RELEVANT CONTRACT DRAWINGS.

REFERENCE

DRAWING No. 1677.02-B-3 TITLED "HANLAN FEEDERMAIN ALIGNMENT, SECTION 1, PLAN-PROFILE 0 + 000.0 TO 3 + 150 PLAN I", DATED JAN., 1991, AND DRAWING No. 1677.02-A-34, SHEET 10 TITLED "M.O.E. PROJECT No. 5-0020-43, HANLAN FEEDERMAIN CONTRACT (STATION 2 + 580 TO 2 + 820", DATED OCT., 1991 (PRELIMINARY) PREPARED BY KNOX MARTIN KRETCH LIMITED.

SCALE

HORIZONTAL : 1:400
VERTICAL : 1:100

Date: NOV / 1993
Project: 901-1403-1

Golder Associates

Drawn: P.L.
Chkd: MMO